Plenary I: Clarkson Institute for a Sustainable Environment (ISE) Lecture
Exposure to Airborne Particles - Health Effects and Mechanisms: Where Are We and Where Are We Headed?
MARK UTELL, *University of Rochester Medical Center, Rochester, NY*

Remarkable progress has been made in the science of particulate matter (PM) health effects and their mechanisms. Many of the scientific questions about PM health effects posed in a report of the National Academy of Sciences in 1998 have been or are being addressed. We know that PM exposure at levels experienced outdoors in urban environments has effects on the blood and the heart and increases risk for pulmonary and cardiovascular events in susceptible people. These findings have revolutionized our understanding of interactions between the lungs and the heart, and of the ability of inhaled particles to deposit in the respiratory system and gain access to the circulation and even the brain. This presentation will focus on our current understanding of mechanism of PM toxicity such as systemic inflammation, vascular function and dysfunction, and cardiac events and look into our crystal ball for the future as we consider susceptibility genes and the potential to use the tools of molecular epidemiology to examine susceptibility at the population level.

Plenary II: AEESP Lecture
Application of Aerosol Science to Engineered Nanomaterials. LINSEY MARR, *Virginia Tech*

Nanotechnology is touted as the basis for the next industrial revolution, yet the health and environmental impacts of engineered nanomaterials are not fully known. The history of asbestos and combustion-generated ultrafine particles suggests that we should be concerned about exposure to novel nanoscale particles. To gain insight into the emissions, transformation, transport, and fate of engineered nanomaterials in the atmosphere, we can apply knowledge and tools from aerosol science and engineering. The exchange is two-way, as methods used in nanoscience research can provide detailed characterization of airborne particles. Engineered nanomaterials can be released into the atmosphere at every step in the product life cycle: production at a commercial manufacturing facility, use by consumers in the home, and disposal via incineration. Although we may envision a puff of pure, monodisperse, separated particles, engineered nanomaterials released into air are typically aggregated with other particulate matter, such ingredients in the parent product or soot, and the size of such aggregates may range from smaller than 10 nanometers to larger than 10 micrometers. Like many aerosols, engineered nanomaterials are subject to chemical transformations in the atmosphere that may modify the nanomaterials' environmental fate and toxicity. From the opposite perspective, engineered nanomaterials can be used as model aerosols in laboratory studies or as components of environmental sensors to inform aerosol science. Further research is needed to determine whether airborne engineered nanomaterials present a novel hazard.

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Plenary III: Friedlander Lecture
Science and Public Policy: Past, Present and Future of the PM NAAQS. PHILIP K. HOPKE, *Clarkson University*

Since the passage of 1970 Clean Air Act Amendments and the imposition of the first National Ambient Air Quality Standards in 1972, there have been substantial improvements in ambient air quality leading to improved public health and diminished environmental impacts. The setting of such standards is done with a combination of science, science policy, and politics with a variety of competing interests vying to manipulate the process to the extent possible. This talk will be presented from the viewpoint of someone who has interacted in the process for more than 30 years in multiple roles including as a member and then chair of the Clean Air Scientific Advisory Committee and present some of the good, bad and ugly parts of the regulatory process.

Plenary IV
Intersection of Aerosols with Climate Change: Why Policy Makers Should Include Aerosols at the UN Paris-2015 Summit. RAMANATHAN VEERABHADRAN, *Scripps Institute of Oceanography*

The role of anthropogenic activities in emissions of greenhouse gases is well known. The buildup of over one billion tons of greenhouse gases already in the atmosphere in conjunction with business as usual emissions during the next few decades have set the planet on a course for a 2.5C warming by mid-21st century and as much as 4C by end of the 21st century. By sheer coincidence, human activities have also simultaneously polluted the air with emissions of aerosols, which have offset about 40% of the committed warming by reflecting the incoming solar radiation. The best analogue is, if we can think of the greenhouse gases as a blanket covering the planet (keeping it warm by trapping the infrared energy), aerosols have acted like mirrors and reflected sunlight and cooled the planet. This is at best a Faustian bargain since these particles have also led to global dimming at the surface thus altering in a fundamental way the hydrological cycle of the planet. One simulated impact of the dimming is to cause droughts and disruption of the major precipitation systems in the tropics, particularly affecting the poorest three billion. Another double jeopardy is that, not all particles have a cooling effect. Some like black and brown carbon are efficient absorbers of solar radiation and when they are deposited on snow and ice lead to accelerated melting of arctic sea ice and glaciers in the Alps and the Himalayas. The fundamental policy mistake that is being made is to assume that aerosols are minor players in climate change or even if they are taken seriously to adopt the view that they are lessening the impacts of global warming through their cooling effect. One evidence of this flawed thinking is the geo-engineering proposal of releasing sulfate particles in the stratosphere. They do indeed can cause cooling but they are equally likely to reduce global precipitation affecting the water security which in many parts of the planet is a more serious problem than temperature change. The effect of aerosols on the water security of the planet deserves serious consideration at the UN Paris summit of 2015 and we need to drastically reduce their emissions. Unlike the case of reducing CO2 emissions, cost-effective and proven technologies are readily available to cut most manmade aerosols.

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1AC.1
Role of Semi- and Low-Volatile Organic Compounds and Particle Phase Processes in Nanoparticle Growth - a Modeling Study. TAINA YLI-JUUTI, Ilona Riipinen, Ulrich Poeschl, Manabu Shiraiwa, *University of Eastern Finland*

The climatic effects of atmospheric secondary aerosol particles depend on how many of the freshly formed nanometer sized particles grows enough large to act as cloud condensation nuclei instead of being scavenged by coagulation. Atmospheric nanoparticle growth is largely due to uptake of organic and inorganic trace gases, organics often being major contributors. To contribute to nanoparticle mass significantly, the organics need to be low-volatile and uptake of organic compounds on aerosol particles can be divided roughly in two: condensation of low-volatile organic compounds (LVOC) formed in the gas phase and uptake of gas phase semi-volatile organic compounds (SVOC) followed by production of LVOCs in the particle phase or at the particle surface. This study aims at identifying the groups of organic compounds and the processes that are important for atmospheric nanoparticle growth. The focus is on four processes: salt formation and oligomerization in the particle phase, condensation of LVOCs and particle phase mass transport which can affect the particle phase reactions.

We studied the processes using a newly developed particle growth model KM-GAP-T (KM-GAP with Thermodynamics) which combines the detailed kinetics of mass transport in and between gas phase, particle surface and particle bulk with the thermodynamics of particle phase acid-base chemistry. The model simulations were designed to represent boreal forest environment and condensing vapors included sulfuric acid, ammonia, water and organic model compounds representing organic acids, SVOCs that can form oligomers in the particle phase (two model compounds), and LVOCs. Based on the simulations we found that condensation of LVOCs is important, especially at the smallest particle sizes. Oligomerization may contribute to the growth if the reaction rate of SVOCs is high, e.g. due to acidity of the particles at low base concentrations, and organic salt formation may be important at elevated base concentrations.

1AC.2
Surface Tension Modeling of Binary and Multicomponent Atmospheric Aqueous Aerosols. HALLIE BOYER, Cari Dutcher, *University of Minnesota, Twin Cities*

Surface properties of aqueous solutions are an important diagnostic of atmospheric aerosol behavior because of their effect on particle interactions with the ambient, such as condensation of water vapor and radical species uptake, as well as optical properties and particle morphology. Previously, a predictive model was developed using a statistical mechanical approach for surface tension of both electrolyte and non-electrolyte aqueous solutions across the entire solute concentration range (Wexler and Dutcher, J. Phys. Chem. Lett., 2013). While the adjustable model parameters had statistical mechanical interpretations, in practice they remained largely empirical.

In this talk, the parameters in this surface tension model are related to solute molecular properties of aqueous solutions, reducing the number of free parameters down to one for both organic and electrolyte solutions in binary solutions. For organics, sorption tendencies suggest the importance of hydrophilic functional group spacing and number of methyl groups. For electrolytes, surface adsorption of ions follows the simulations of Pegram and Record, J. Phys. Chem. B 2007. In order to apply the model to more complex systems, the model approach is extended to multi-component aqueous solutions containing solutes of varied molecular sizes, where competitive adsorption between solute species is expected at the surface. Noteworthy agreement between multicomponent and binary models is found for a NaCl-NaNO3 system, where the size-related model parameters for a NaCl-NaNO3 system are consistent with the respective parameters from the single solute cases. Partition functions for solutes of varying size are also identified with the potential of addressing the different solute sizes of multicomponent systems. Excellent agreement has been found between the model predictions and experimental data obtained both from literature and using a new microfluidic tensiometry method developed by our group.

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1AC.3
Global Transformation and Fate of SOA: Implications of Low Volatility and Gas Phase Fragmentation Reactions.
MANISHKUMAR SHRIVASTAVA, Richard Easter, Xiaohong Liu, Alla Zelenyuk, Singh Balwinder, Kai Zhang, Po-Lun Ma, Duli Chand, Steven Ghan, Jose-Luis Jimenez, Qi Zhang, Jerome Fast, Philip Rasch, Petri Tiitta, *Pacific Northwest National Laboratory*

Secondary organic aerosols (SOA) are large contributors to fine particle loadings and radiative forcing, but are often represented crudely in global models. We have implemented three new detailed SOA treatments within the Community Atmosphere Model version 5 (CAM5) that allow us to compare the semi-volatile versus non-volatile SOA treatments (based on some of the latest experimental findings), and to investigate the effects of gas-phase fragmentation reactions. The new treatments also track SOA from biomass burning and biofuel, fossil-fuel, and biogenic sources. For semi-volatile SOA treatments, fragmentation reactions decrease the simulated annual global SOA burden from 7.5 Tg to 1.8 Tg. For the non-volatile SOA treatment with fragmentation, the burden is 3.1 Tg. Larger differences between non-volatile and semi-volatile SOA (upto a factor of 5) exist in areas of continental outflow over the oceans. According to comparisons with observations from global surface Aerosol Mass Spectrometer measurements and the US IMPROVE network measurements, the FragNVSOA treatment, which treats SOA as non-volatile and includes gas-phase fragmentation reactions, agrees best at rural locations. All three revised treatments show much better agreement with aircraft measurements of organic aerosols (OA) over the North American Arctic and sub-Arctic in spring and summer, compared to the standard CAM5 formulation. This is mainly due to the oxidation of SOA precursor gases from biomass burning, not included in standard CAM5, and long-range transport of biomass burning OA at high altitudes. The non-volatile and semi-volatile configurations with fragmentation predict the direct radiative forcing of SOA as -0.5 W m-2 and -0.26 W m-2 respectively, at top of the atmosphere, which are higher than previously estimated by most models, but in reasonable agreement with a recent constrained modeling study.

1AC.4
Simulation of Atmospheric Organic Aerosol Using Volatility-Oxygen Content during the PEGASOS Southern and Northern Europe Campaigns.
ELENI KARNEZI, Benjamin Murphy, Spyros Pandis, *Carnegie Mellon University*

Two major field campaigns (under the PEGASOS project) took place in southern and northern Europe during the summers of 2012 and 2013. The campaigns characterized organic aerosol (OA) both at the ground with a combination of stationary and mobile measurements and aloft using a Zeppelin in two very different environments (Po Valley in Italy and Finland in Scandinavia) with different characteristics (e.g., industrial pollution, agricultural sources, clean environment with biogenic emissions, etc.). These measurements are used to evaluate and constrain the uncertain parameters of a Lagrangian chemical transport model (PMCAMx-Trj) that describes OA using a two-dimensional volatility basis set (2D-VBS). The OA module simulates the primary and secondary OA mass as a function of volatility and oxygen to carbon ratio (O:C).

For the polluted Po Valley atmosphere in Italy simulations suggest that anthropogenic secondary OA (SOA) from volatile and intermediate volatility organic compounds and biogenic SOA were the major OA components. PMCAMx-Trj reproduces reasonably well the OA concentrations and O:C for the ground, with an average predicted OA mass equal to 2.92 μg m-3 versus 2.9 μg m-3 observed and an average predicted O:C 0.63 versus 0.58 observed. Both PMCAMx-Trj and observations suggest relatively oxidized OA with little average diurnal variation.

The sensitivity of the PMCAMx-Trj predictions to the assumed organic compound vaporization enthalpy and homogeneous chemical aging schemes was examined. The sensitivity of the OA concentration and O:C to the vaporization enthalpy was surprisingly modest. This is due to the interplay between the gas-to-particle partitioning and the homogeneous gas-phase chemical aging rates. In general the higher vaporization enthalpies (around 100 kJ mol-1) were more consistent with the vertical OA and O:C profiles. The evaluation of the different aging schemes in the two environments will be discussed.

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1AC.5
Constraining Condensed-Phase Kinetics of Secondary Organic Aerosol Components from Isoprene Epoxydiols.
THERAN P. RIEDEL, Kevin Chu, Tianqu Cui, Ying-Hsuan Lin, Sri Hapsari Budisulistiorini, Zhenfa Zhang, Joel A. Thornton, Avram Gold, Jason Surratt, *University of North Carolina at Chapel Hill*

The formation of epoxide products from isoprene photooxidation is known to be critical precursor of significant secondary organic aerosol (SOA) mass. Isoprene epoxydiols (IEPOX) have been shown to produce substantial amounts of SOA mass and are therefore considered major isoprene-SOA precursors. Heterogeneous reactions of IEPOX on atmospheric aerosols form various aqueous-phase components or "tracers" that contribute to the SOA mass burden. A limited number of the reaction rate constants for these acid-catalyzed aqueous-phase tracer formation reactions have been constrained through bulk laboratory measurements. Namely, only IEPOX tetrol and organosulfate formation have been characterized. While these tracers are responsible for a sizeable fraction of IEPOX-derived SOA, there are a number of other tracer formation reactions have yet to be examined and are of equal importance. To this end we have designed a chemical box model with numerous experimental constraints to explicitly simulate gas- and aqueous-phase reactions during chamber experiments of SOA growth from IEPOX uptake onto acidic sulfate aerosol. Specifically, the model is constrained by recent measurements of the IEPOX reactive uptake coefficient, the few aforementioned experimentally obtained aqueous-phase rate constants, chamber-measured aerosol mass and surface area concentrations, aerosol thermodynamic model calculations, and offline filter measurements of SOA tracer species. Through the use of the offline filter measurements collected during the chamber experiments, we are able to place estimates on the aqueous phase tracer formation rate constants that have yet to be measured for bulk solutions. In this way we obtain valuable constraints on particle-phase species that have been quantified through offline techniques but lack formation rate information.

1AC.6
Adsorption-Based Chemical Thermodynamics of Atmospheric Aerosols: Electrostatic Interactions and Weakly Dissociating Organic Acids.
CARI DUTCHER, Peter Ohm, *University of Minnesota, Twin Cities*

The calculation of gas-liquid-solid equilibrium partitioning of water, electrolyte, and soluble organic components is critical to accurate determination of atmospheric chemistry properties and processes such as new particle formation and activation to cloud condensation nuclei. The partitioning of the molecular species between the gas and particle phase can be predicted using thermodynamic models. Previously, a transformative model for capturing thermodynamic properties of multicomponent aqueous solutions over the entire concentration range (Dutcher et al. JPC 2011, 2012, 2013) was developed using statistical mechanics and multilayer adsorption isotherms. That model needed only a few adsorption energy values to represent the solution thermodynamics of each solute.

In this work, the energetic values are related to the dipole-dipole electrostatic forces in solute-solvent and solvent-solvent interactions, leaving the solvent-solute intermolecular distance as a lone fully adjustable parameter. The model was successfully validated using thirty-seven 1:1 electrolytes and twenty non-dissociating organic solutions (Ohm et al. JPC 2015). However, careful attention is needed for weakly dissociating semi- volatile organic acids. Dicarboxylic acids such as malonic and glutaric acid are treated here as a mixture of non-dissociated organic species (HA) and dissociated organic species (H+ + A-). It was found that the apparent dissociation was greater than that predicted by known dissociation constants alone, emphasizing the effect of dissociation on activity coefficient predictions. To avoid additional parameterization from the mixture approach, an expression was used to relate the Debye-Hückel hard-core collision diameter to the adjustable solute-solvent intermolecular distance. This work results in predictive correlations for estimation of solute and solvent solution activities for which there are little or no activity data.

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1AC.7
Acid Dissociation in Organic-Solvent/Water Mixtures and Its Relevance to Gas/Particle Partitioning to Atmospheric OPM. JULIA DEGAGNE, James F. Pankow, *Portland State University*

The gas/particle partitioning behavior of organic compounds to atmospheric particulate matter (PM) is affected by atmospheric conditions, the volatilities of the partitioning compounds, and the composition of the particular PM. The acidity characteristics of the PM affect the dissociation equilibria of organic acids as well as ammonium and protonated organic bases. Each conjugate acid/base pair is distributed between a neutral and ionic form. Organic salts can precipitate under certain conditions. The gas/particle partitioning behavior of organic acids and bases, which depends on volatility, is highly dependent on this speciation. Descriptions of acid dissociation behavior and volatility in atmospheric PM have, to date, focused primarily on mostly aqueous phases. However, atmospheric PM is a generally very complex, and includes water, inorganics, and up to 90% organic matter. Non-aqueous acid/base chemistry is not adequately represented in current atmospheric aerosol formation models.

We present data describing the acid dissociation behavior of organic acids and protonated amines in mixtures composed of a single organic solution (chosen to approximate the characteristics of one type of organic PM) with varying levels of water content. In such mixtures, the preferential solvation of ions and neutral molecules (by the aqueous portion or the organic portion, respectively) affects the acid-base equilibria of the solutes. We show how the pK_a values differ from those of an aqueous solution and how they can vary with water content. As water content decreases, in general pK_a values of organic acids, including acetic, maleic, and oxalic acids, will increase. In contrast, pK_a values of certain protonated amines can first decrease to a local minimum and then increase, but more gradually than for organic acids. This situation can result in a drastically different speciation than would be expected in an aqueous solution, a consideration with important implications for the gas/particle partitioning of atmospheric organic PM.

1HA.1
The Influence of Particulate and Gas-Phase Pollutants on Markers of Acute Airway Oxidative Stress in Active Adolescents. ROBY GREENWALD, Shiwei Gao, *Georgia State University*

The Study of Air Pollution and Physical Activity investigates the influence of physical activity on air pollution exposure and consequent health effects in adolescents. High school students who participate in extra curricular athletic activities were recruited from two high schools in the Atlanta area, one near a major freeway and the other in a suburban area distant from roadways and other sources. Participants performed a suite of health outcome measurements before and after sports practice, including measurement of lung function and exhaled nitric oxide (eNO), and collection of exhaled breath condensate (EBC) samples. The concentration of both reduced and oxidized glutathione (GSH, GSSG) was measured in EBC, and %GSSG, the percent ratio of GSSG/(GSH+GSSG), was used as a marker of airway anti-oxidant capacity and acute oxidative stress. Air pollution exposure and inhaled dose was measured on site during sports practice and included PM2.5 mass, black carbon, particle number concentration (PNC) as well as ozone and other gas phase pollutants. Linear mixed models (both single and multi-pollutant) were used to assess the association between pollutant exposure and the change (post- compared to pre-practice) in eNO and %GSSG. In the case of eNO, no significant association was observed for any exposure variable. This could be due to the fact that post-exposure outcome measurements occurred immediately following practice while previous studies have suggested that eNO peaks approximately 1-2 hours post-exposure. Changes in %GSSG are expected to be observed immediately following exposure, and in the case of %GSSG, a significant association was observed for ozone and PNC exposure, but not for other particulate pollutants. Analysis of pollutant inhaled dose is ongoing, but at the present time, study results suggest that ozone has a more pronounced influence on acute airway oxidative stress than particulate pollutants in this panel of active adolescents.

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1HA.2

Isoprene-derived Secondary Organic Aerosol Induces Expression of Nuclear Factor Erythroid 2-like 2 (NRF2)-mediated Oxidative Stress Response Genes in Human Lung Cells. Ying-Hsuan Lin, Amanda Kramer, Maiko Arashiro, Weruka Rattanavaraha, Elizabeth Martin, Zhenfa Zhang, Kenneth Sexton, Avram Gold, Ilona Jaspers, Rebecca Fry, JASON SURRATT, *University of North Carolina at Chapel Hill*

Isoprene-derived secondary organic aerosol (SOA) has been estimated to contribute to a significant mass fraction of tropospheric fine particulate matter (PM2.5). In particular, the isoprene-derived epoxides, isoprene epoxydiols (IEPOX) and methacrylic acid epoxide (MAE), have been recently identified as the key gaseous intermediates leading to isoprene SOA formation through heterogeneous reactions under low-NOx and high-NOx pathways, respectively. To date, there is scant information about the potential toxicity and impact of isoprene-derived SOA on human health. This study seeks to characterize the potential toxicogenomic effects of isoprene-derived SOA in an in vitro model of human airway epithelial cells (BEAS-2B). Pathway-focused oxidative stress-associated gene expression assays were performed. Oxidative potential of isoprene-derived SOA generated in smog chamber experiments were also assessed by the rate of dithiothreitol (DTT) consumption. We found that the resultant SOA constituents enrich for the expression of nuclear factor erythroid 2-like 2 (NRF2)-mediated oxidative stress response genes in human lung cells under non-cytotoxic conditions, with MAE-derived SOA showing greater potency than IEPOX-derived SOA. The relative oxidative potential assessed by the dithiothreitol (DTT) assay indicates MAE-derived SOA has greater oxidizing potential relative to IEPOX-derived SOA. These results suggest chemical composition and reactivity of the stressors play a key role in the observed differential toxicogenomic responses.

1HA.3

Estimating Lung Deposition Fraction of Mold Spores with the ICRP and BAIL Models. JESSICA SAGONA, Leonardo Calderón, Zuocheng Wang, Jennifer Senick, MaryAnn Sorensen-Allacci, Richard Wener, Clinton J. Andrews, Gediminas Mainelis, *Rutgers, The State University of New Jersey*

Inhalation exposure to mold spores is associated with negative health effects, such as allergies and asthma. The location of spore deposition in the airways is especially important, as it largely defines health effects. To better understand the health risks associated with exposures to mold, we applied different lung deposition models to calculate lung deposition fraction of spores that were commonly seen in our recent investigation of indoor air quality in a multi-apartment residential green building in the Northeastern US. Samples were taken in 16 apartments in three separate sampling campaigns during different seasons. We compare the ICRP (International Commission on Radiation Protection) model with the Bioaerosol Adaptation of ICRP's Lung-deposition model, or BAIL, which includes specific adjustments for bioaerosols.

Aspergillus (spherical, diameter of 3 microns), Cladosporium (diameter of 5 microns), Physarum (Myxomycetes class, diameter of 10 microns), Ascospores (~15 x 7 microns), and Basidiospores (~3 x 2 microns) species were ubiquitous in the collected samples. Our results show that, for sitting adults, the BAIL model calculates 75 to 91% higher deposition in the tracheobronchial region for the larger spores (Physarum and Ascospores) compared to the ICRP model and 62 to 99% higher deposition in the alveolar region, for the smallest spores (Aspergillus, Basidiospores, and Cladosporium) compared to the ICRP model. Total deposition is calculated to be 1 to 19% higher in the ICRP model than in the BAIL model among all five species. The data from the models suggest that calculation of deposition location is highly dependent on particle size, and that the estimate of mold-associated health risks, especially mold penetration into the alveoli, highly depends on a particular model, thus indicating the need to improve our ability to assess risks due to environmental exposures.

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1HA.4

Economic Input-Output Life Cycle Assessment of PM2.5 Health Impacts and Environmental Injustice.

CHRISTOPHER TESSUM, Kimberley Mullins, Julian Marshall, Jason Hill, *University of Minnesota*

Background: Economic input-output life cycle assessment (EIO LCA) tracks life-cycle environmental impacts by sector of the economy. Prior EIO LCA research has not investigated spatially detailed air pollution health effects.

Aim: We quantify air quality health impacts attributable to primary and secondary $PM_{2.5}$ caused by economic activity in the U.S., and the differential impacts among demographic groups.

Methods: We add spatial detail to an existing EIO LCA model that splits the U.S. economy into 428 sectors and calculates emissions of $PM_{2.5}$ and its precursors directly and indirectly caused by economic activity in each sector. We model impacts to ambient $PM_{2.5}$ concentrations and public health using InMAP (Intervention Model for Air Pollution), a novel reduced-form air quality model.

Results: $PM_{2.5}$-mediated health effects vary by 2-3 orders of magnitude among the 428 sectors, with $1 billion in economic activity causing between <1 and 400 deaths (median value: 15 deaths), depending on the sector. The largest impacts are caused by carbon black manufacturing, electricity generation, and cement manufacturing. In 60% of all sectors, including the three most damaging, secondary $PM_{2.5}$ accounts for more than 70% of total health impacts. For 23 sectors, monetized health damages are larger than the life cycle economic value added by that sector. For the eighth most damaging sector, aluminum smelting and alloying, emissions indirectly caused by demand generated in other sectors cause 2 orders of magnitude more damage than direct emissions do. Pollution from most sectors impacts non-white people more than white people (70% of sectors) and low-income people more than high-income people (90% of sectors).

Conclusion: Air pollution health damages per economic value added, and demographic disparities in those impacts, vary among the sectors of the U.S. economy.

1HA.5

Outdoor Aerosols and Respiratory Health Outcomes in Two Saskatchewan Communities.

SHELLEY KIRYCHUK, George Katselis, Wojciech Dawicki, Olasaji Awoyera, Josh Lawson, Donna Rennie, Donald Cockroft, Akwasi Owusu-Kyem, Brian Graham, John Gordon, Niels Koehncke, *University of Saskatchewan*

Background: Outdoor air can impact respiratory health. Coal mining and coal fired power plants contribute potentially different respiratory exposures than agricultural activities. We sought to investigate the effects of outdoor aerosols on respiratory health in populations in two small urban communities from southern Saskatchewan, Canada with differing regional industries.

Methods: Community A with coal strip mining, power plants and agriculture, and Community B with primarily agricultural activities were studied. A sample of adults aged 50 years and older were studied over 4 separate time periods. Daily forced expired volume in 1 second (FEV1) and symptom recording were undertaken for each period. Sulfur dioxide, nitrogen dioxide and particulate matter of 2.5 micron size (PM2.5, µg/m3) were monitored continuously during each panel. Weekly size selective filter samples were assessed gravimetrically and for endotoxin, protein, and inflammatory potential.

Results: An average of 40 adults from each community took part in each of the panels. Residents from communities A and B were similar in age [65.2 (SD=9.1) vs 61.8 (9.6) years], sex (63.8% female vs. 67.4% female), current smoking (10.6% vs. 6.7%), and baseline FEV1 [92.2% (SD=20.1) vs 98.2% (SD=22.3) percent predicted]. Residents of community A reported increased chest tightness at night compared to Community B (OR=6.4, 95%CI=1.4-29.9, p=0.02). Levels of air contaminants differed by community. Endotoxin in PM2.5 was significantly higher in community B than community A. Cellular response was greater with community B aerosol stimulation as compared to community A. Air contaminant levels were not associated with degree of symptom disturbance or daily FEV1 levels.

Conclusions: Results indicate lower levels of airborne contaminants as compared to larger urban centres. Respiratory symptoms differed between the two communities but were not explained by the measured aerosols. Ongoing research into the constituents within the dusts from each community may assist in further explaining respiratory differences.

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1HA.6

A Portable and Automated On-Line Instrument to Quantify Health-Relevant Aerosol-Bound Reactive Oxygen Species (ROS). FRANCIS WRAGG, Markus Kalberer, *University of Cambridge, UK*

Epidemiological studies have linked urban aerosol levels with mortality and hospital admissions due to respiratory and cardiovascular disease. It is often hypothesised that these negative health effects could be due to particle-bound reactive oxygen species (ROS), and subsequent oxidative stress of lung cells.

Fuller et al. (2014) presented a first version of our on-line instrument, based on fluorescence spectroscopy and a reaction system combining 2,7-dichlorofluorescein (DCFH) fluorescence probe with catalytic enzyme horseradish peroxidase, and demonstrated that traditional off-line techniques might severely underestimate total ROS concentrations. This instrument furthered concepts previously described by Wang et al (2011) and King and Weber (2013) in that it allowed both fully continuous measurement and capture of ROS components under mild conditions.

This study describes the further development of our instrument into a compact on-line ROS instrument capable of automated and un-manned continuous measurement over 12 hours. It exists in a compact structure, is designed for field deployment, allows capture of aerosol under mild conditions, and requires minimal or no user interaction. The instrument has a detection limit of under 2 nm[H_2O_2] equivalents per m^3 air and a time resolution of under 10 minutes, values which should be suitable for detection at many measurement sites in polluted and urban areas. Examples of ROS concentration data obtained in laboratory-generated secondary organic aerosol experiments, as well as at an urban ambient site, are presented.

1HA.7

Source Impacts on Reactive Oxygen Species Generated by Water-Soluble PM2.5 in Atlanta and Associations with Cardiorespiratory Effects. JOSEPHINE BATES, Rodney J. Weber, Joseph Abrams, Vishal Verma, Ting Fang, Mitchel Klein, Matthew Strickland, Stefanie Ebelt Sarnat, Howard Chang, James Mulholland, Paige Tolbert, Armistead G. Russell, *Georgia Institute of Technology*

The catalytic generation of reactive oxygen species (ROS) by atmospheric aerosols may induce oxidative stress in the body and is a suspected mechanism of particle toxicity. A dithiothreitol (DTT) assay was used to measure ROS generation potential of ambient water-soluble $PM_{2.5}$ in Atlanta during June 2012 - June 2013 alongside a comprehensive suite of speciated $PM_{2.5}$ measurements. $PM_{2.5}$ source impacts, estimated using the Chemical Mass Balance method with ensemble-averaged source impact profiles, were related to DTT activity using a linear regression model that was further used to develop a time series of daily DTT activity over a ten year period for use in an epidemiologic study of acute health effects. Light-duty gasoline vehicles exhibited the highest intrinsic DTT activity, followed by biomass burning and heavy-duty diesel vehicles (0.11, 0.069, and 0.052 nmol min^{-1} μg^{-1}_{source}, respectively). Biomass burning contributed the largest fraction to total DTT activity, followed by gasoline and diesel vehicles (45%, 20% and 14%, respectively). High day-to-day correlations between DTT activity and gasoline vehicle and biomass burning impacts (R = 0.54 and R = 0.61, respectively) support these results. Epidemiologic analyses found significant associations between estimated DTT activity and hospital visits related to congestive heart failure and asthma/wheezing attacks in the 5-county Atlanta area. Estimated DTT activity was the only pollutant measure out of several pollutants ($PM_{2.5}$, O_3, elemental carbon, organic carbon) that exhibited a significant link to congestive heart failure. In two-pollutant models, DTT activity was significantly associated with asthma/wheeze and congestive heart failure while $PM_{2.5}$ was not, even though DTT activity was likely not estimated as well as $PM_{2.5}$ was measured. These results support the hypothesis that $PM_{2.5}$ health effects are, in part, due to oxidative stress and suggest that DTT activity may be a better indicator of some aerosol-related health effects than $PM_{2.5}$ mass.

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1IF.1

Viable Influenza Virus in Cough and Exhaled Breath Aerosol Particles. WILLIAM LINDSLEY, Francoise Blachere, Donald Beezhold, Robert Thewlis, Bahar Noorbakhsh, Sreekumar Othumpangat, William Goldsmith, Cynthia McMillen, Carmen Burrell, John Noti, *National Institute for Occupational Safety and Health*

Many infectious viral respiratory diseases are thought to spread at least in part by aerosol transmission. However, aerosol transmission often is difficult to prove: these diseases typically can spread by multiple pathways, the amount of virus expelled in aerosols is usually small and varies over the course of the illness, and viable airborne viruses can be difficult to collect and culture. Our group has studied the aerosol transmission of influenza by collecting cough and exhalation-generated aerosol particles from influenza patients, and then using PCR and culture-based methods to detect the virus and measure its viability. In one study, we detected influenza virus RNA in the cough aerosols from 32 of 38 influenza patients (84%), and showed that 65% of the viral RNA was in aerosol particles with an aerodynamic diameter of 4 micrometer or less. In a second study, we were able to culture influenza virus from the cough aerosols of 7 of 17 influenza patients (41%). Further, almost all of the viable influenza virus was detected in small particles (0.3 to 8 micrometer), demonstrating that the aerosol could remain airborne for an extended time, be easily inhaled, and potentially infect other people. In our most recent study, 61 volunteer subjects were recruited from patients presenting at a student health clinic with influenza-like symptoms. Nasopharyngeal swabs were collected from the subjects, and they were asked to cough three times and exhale three times into a modified rolling-seal spirometer. The aerosol particles produced by each cough or exhalation were collected in modified HBSS using an SKC BioSampler. The samples were then analyzed for viable influenza virus. The results provide information about the possible role of infectious aerosol particles in influenza transmission, especially in the immediate vicinity of an influenza patient.

1IF.2

Influenza Virus in Respiratory Droplets from Humans with Community Acquired Infection. JING YAN, Jovan Pantelic, Michael Grantham, Barbara Albert, Fengjie Liu, Sheryl Ehrman, Donald Milton, *University of Maryland School of Public Health*

Influenza virus causes from 3000 to 49000 deaths each year in the U.S. and pandemics can cause deaths in the 100,000s to millions. An understanding of influenza virus transmission is crucial for public health interventions. Influenza virus has three transmission routes: direct contact, large droplet spray, and aerosol transmission. The relative importance of these routes of transmission has been debated in recent years, although droplet transmission has traditionally been considered to be most important. Here, we report the results of a study of characterization of respiratory droplets from infected individuals. Recruitment of students, staff, and neighbors of the University of Maryland, College Park, MD took place from December 2012 to March 13, 2013. If subjects had either a positive rapid test or fever 37.8°C plus a cough or sore throat and were within the first 3 days of onset of symptoms, we collected nasopharyngeal (NP) swabs, throat swabs and 30 minutes exhaled breath samples obtained using the Gesundheight-II exhaled breath aerosol collection device. Each sample was cultured for influenza virus by both blind passage and a fluorescent focus assay using low passage MDCK cells. We used RT-qPCR with CDC primer and probe sets to type and quantify the viral RNA in each sample.

278 samples were obtained from 178 subjects. We cultured influenza virus from 81.9% of NP samples, 77.5% of throat samples, and most importantly 44.1% of fine aerosol samples were culture positive. At the time of this report, we have completed RNA assays for 87 coarse (> 5 μm diameter) and 88 fine (≤ 5 μm) aerosol samples from persons with H3 subtype influenza A. We detected viral RNA in 37% (32/87) of the coarse aerosol samples and 77% (68/88) in the fine aerosol samples. Additional results investigating the relationship between culturability and other study variables, including coughing frequency, will be presented. The high rate of RNA detection in and especially the frequent recovery of influenza virus by culture of fine aerosol samples in this study suggest a contribution of fine particle aerosols in the transmission of influenza.

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1IF.3
Aerosolization of Ebola Virus Surrogate in Wastewater Systems. MARI TITCOMBE LEE, Amy Pruden, Linsey Marr, *Virginia Tech*

Aerosol transmission of Ebola virus between humans remains controversial; however, studies with animal models have shown that inhalation exposure to Ebola virus can lead to infection. Patients with Ebola Virus Disease expel large volumes of diarrhea, containing high concentrations of live virus, and western flushing toilets and sanitary sewer systems are known to produce bioaerosols. The combination of these two factors suggests that hospitals and sanitary sewer workers may potentially be exposed to Ebola virus bioaerosols. To gain mechanistic insight into the potential for aerosolization of the virus, we are investigating the partitioning of Ebola virus surrogates between biosolids, the aqueous phase, and surfaces likely to be encountered in western wastewater systems (porcelain, PVC, and concrete). We are characterizing the bioaerosol plume produced by flushing toilets and a recirculating model sanitary sewer containing biosolids spiked with Ebola virus surrogates. We are measuring the resulting particle size distributions with a scanning mobility particle sizer (SMPS) and an aerodynamic particle sizer (APS) (10 nanometers - 20 micrometer total range). We are also collecting size selected surrogate bioaerosol by cascade impaction for analysis by plaque assay and quantitative polymerase chain reaction (q-PCR), to characterize the inactivation of surrogate virus and total viral genome copies, respectively.

1IF.4
Survival of Ebolavirus in Aerosols. STEVE LEVER, Sophie Smither, Lin Eastaugh, Jackie Steward, *Dstl Porton Down*

The recent ebolavirus epidemic in West Africa has confirmed previous knowledge that filoviruses are associated with high morbidity and mortality rates in humans, are capable of human-to-human transmission, via infected material such as blood and other body fluids and are believed to have low infectious doses for humans. In experimental animal model systems, filoviruses are able to infect via the respiratory route and are lethal at very low doses, but there is minimal information on how well filoviruses are able to survive within aerosol particles. There is also little known about how well filoviruses survive in liquids or on solid surfaces which is important in the management of patients or samples that have been exposed to filoviruses. In this presentation, data will be presented to show the relative survival of filoviruses in aerosols and the potential infectivity of filoviruses and the implications in epidemic situations.

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1IF.5
Development of a Sampling Strategy for Detecting Infectious Ebola Virus Aerosols. SHANNA RATNESAR-SHUMATE, Michael Schuit, Jill Matus, Stewart Wood, Kristin Bower, Paul Dabisch, *NBACC*

The potential for Ebola virus to be spread via aerosols is not well understood. Current best practices for preventing the spread of the virus in health care settings may be insufficient if aerosols containing the virus are being mechanically generated by manipulation of virus contaminated materials. Additionally, there is a concern that the Makona variant of Zaire Ebola virus associated with the current outbreak may be more stable in the environment than previous variants, potentially increasing the risk of infection via inhalation of mechanically generated aerosols. To assess the risk associated with Ebola virus containing aerosols in a laboratory or field setting, the best methods for detecting infectious aerosols need to be identified. NBACC is performing a study to assess the ability of a range of aerosol sampling technologies to preserve Ebola virus infectivity during aerosol collection. Ebola virus containing aerosols are being generated and delivered to two categories of samplers for evaluation – personal air samplers and high-volume air samplers. The sampling efficiency and concentration factors for each sampler are being evaluated using fluorescent microspheres prior to testing with virus. The retention of viral infectivity during sampling are being evaluated for each sampler as a function of time and collection media. Preliminary results of this study will be presented. The results of this study will aid in the development of an optimized sampling strategy for Ebola virus containing aerosols, which will be useful to inform future studies with the virus, including potential field sampling, and identify limitations in previous data generated with other sampling devices.

1IF.6
Characterization of the Performance of Personal Sampling Devices for Detecting Infectious Aerosols Containing Burkholderia pseudomallei. JILL MATUS, John Yeager, Jeremy Boydston, Kristin Bower, Paul Dabisch, *NBACC*

Recently it was reported that aerosolized Burkholderia pseudomallei, the causative organism of melioidosis, was detected in air samples collected during severe weather events in an endemic region, providing evidence that inhalation of bacterial aerosols may be a natural route of infection for this disease. This study relied on PCR to identify the bacteria, which does not provide information on the viability of the collected microorganisms. To assess the risk associated with inhalation of infectious B. pseudomallei aerosols in a laboratory or field setting, sampling methodologies capable of maintaining the viability of collected microorganisms are needed. However, few data exist on the efficiency of aerosol sampling devices for collecting and maintaining B. pseudomallei in a viable state. Therefore, NBACC is performing a study to assess the ability of a range of aerosol sampling technologies to preserve the viability of collected B. pseudomallei. Preliminary results will be presented that focus on personal sampling devices, including gelatin filters, SKC Biosamplers, and midget impingers. The results of this study will identify potential limitations of the various sampling devices, and will be useful to inform sampling strategies for B. pseudomallei containing aerosols in both the laboratory and future field sampling studies.

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1IF.7
Electro-hydrodynamically-Assisted Non-Thermal Plasmas as a Barrier Against Airborne Disease Transmission into Animal Confinement Buildings. HEREK CLACK, *University of Michigan*

Conventional bio-security measures have long been established to prevent surface or mechanical transmission of pathogens into confined animal operations such as hog or poultry barns. However, pathogenic aerosols such as fomites can transmit over hundreds of meters diseases such as avian flu and infectious laryngotracheitis for poultry and swine flu and porcine reproductive and respiratory syndrome (PRRS) for hogs. Retrofitting barns to filter intake ventilation air can be costly in terms of capital costs of the filter system and increased operating costs associated with filter replacement and increased fan power, particularly in hot and humid climates where insufficient ventilation rates can quickly lead to animal heat stress. Equally important, conventional filters only address one of the two factors of airborne disease transmission: aerosol transport and aerosol infectivity. This study uses numerical simulation to demonstrate how non-thermal plasmas (NTPs) can be engineered to leverage their electro-hydrodynamic (EHD) secondary fluid flow phenomena to effect a two-factor barrier against airborne disease transmission. A simplified NTP configuration is shown to achieve twice the pathogen inactivation (76%) with electric body forces included than without (39%). Further optimization of this patent-pending process has the potential to provide filter-less airstream disinfection of intake ventilation air, which would allow easier retrofits of barns and the possibility of portable units for temporary use during local outbreaks or seasonal conditions that promote long-range transport and survival of pathogenic aerosols.

1IM.1
Characterization of a Universal Fluid Condensation Particle Counter to Rapidly Measure Sub 3 Nanometer Atmospheric Clusters. CHONGAI KUANG, Fan Mei, *Brookhaven National Laboratory*

Atmospheric particle nucleation is an important environmental nano-scale process, with field measurements and modeling studies indicating that freshly nucleated particles can contribute significantly to the global population of aerosol and cloud condensation nuclei. Our understanding of atmospheric nucleation and its influence on climate, however, is limited, as few ambient measurements have been made of either the nucleation rate or the chemical composition of the freshly formed clusters, both of which are necessary to gain process-level understanding. Recent advances in the development of condensation particle counters (CPCs) have enabled the detection of gas-phase single molecules and molecular clusters down to 1 nanometer diameter and below through the use of new working fluids and/or varying operating conditions. This new capability has enabled the direct measurement of aerosol nucleation from trace-gas precursors in both laboratory experiments and the ambient environment, providing information necessary to understand and constrain the nucleation mechanism. While there have been an increasing number of atmospheric cluster measurements from surface-based platforms, there have been very few measurements of the vertically-resolved ambient cluster size distribution from aerial platforms, which are needed to connect atmospheric nucleation with large-scale boundary layer transport processes. To address this measurement need, a UF (universal fluid) CPC from the Department of Energy Atmospheric Radiation Measurement Aerial Facility has been adapted to rapidly measure (~ 1 Hz sampling time resolution) the cluster size distribution through pulse height analysis. Characterizations of the UF CPC size-dependent counting efficiency and analysis of the resulting droplet size spectra to recover the sampled aerosol size distribution will be presented using electrical mobility classified ammonium sulfate aerosol and ambient aerosol.

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1IM.2

An Inversion Routine to Determine a Two Dimensional Mass-Size Distribution Function from DMA-APM Measurements of Non-Spherical Particles and Externally Mixed Aerosols. VIVEK RAWAT, David Buckley, Shigeru Kimoto, Nobuhiko Fukushima, Christopher Hogan Jr., *University of Minnesota*

Two dimensional mass and mobility measurement techniques are essential for analysis of highly aggregated soot particles, to identify structurally or chemically dissimilar particle populations in an aerosol with multiple modes and to study particle formation/synthesis in realtime. A differential mobility analyzer (DMA) coupled with an aerosol particle mass analyzer (APM) and a condensation particle counter (CPC) can be employed to classify these complex nanoparticles based on their electrical mobility and mass to charge ratio, with an advantage that classification in the APM is typically independent of the particle shape. However, to accurately infer useful quantitative information from these measurements, it is necessary to have an appropriate inversion routine. In this work, we develop and test an inversion routine to deconvolute the measurement data from DMA and APM transfer functions while correcting for appropriate charge distribution, CPC detection efficiency and transport losses in the system. Specifically, we recover a two dimensional distribution in particle mobility diameter and mass from the experimental data which can be later used to establish a relationship between mobility diameter and mass for non-spherical particles or distinctively identify the particles of different modes in a mixed population. The inversion technique used here is similar to the Twomey-Markowski approach used for DMA-CPC inversion. We test this inversion routine with experimental measurements of diffusion flame generated soot particles and oleic acid particles generated using a nebulizer. These two populations are allowed to mix together in a coagulation chamber and the evolution of the two dimensional distribution is observed as a function of residence time in the chamber.

1IM.3

Resolution Limitations to Tandem Differential Mobility Analyzer-Aerosol Particle Mass Analyzer Measurements. JAMES RADNEY, Christopher Zangmeister, *National Institute of Standards and Technology*

The use of a tandem differential mobility analyzer (DMA), aerosol particle mass analyzer (APM) and condensation particle counter to measure the mass and effective density of aerosol particles is becoming increasingly common; in some studies, including an optical measurement provides another level of classification. Both DMAs and APMs separate particle by net charge in the form of electrical mobility and the balance of electrostatic and centripetal forces, respectively. Here, we provide an in-depth study of how net charge can affect measurement interpretation using 3 aerosols with unique physical characteristics: ammonium sulfate (AS), soot and Aquadag which represent a dense, nearly spherical particle; a lacey fractal agglomerate and a medium density oblate to prolate spheroid. In the case of AS, multiple charging does not affect measurement resolution or interpretation. For soot, multiple charging severely affects measurement resolution and can cause the measured peak mass and extinction cross-section to deviate by as much as 21% and 160%, respectively, versus when only the singly charged particle is isolated. For Aquadag, multiple charging does not affect peak mass, but the range of morphologies does affect the interpreted relationship between mass and optical signal which could have serious implications when being used for calibrations as is common with the single particle soot photometer.

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1IM.4
Particle Classification by the Tandem Differential Mobility Analyzer – Particle Mass Analyzer System. MIKINORI KUWATA, *Nanyang Technological University*

Particle mass analyzers, such as the aerosol particle mass analyzer (APM) and the Couette centrifugal particle mass analyzer (CPMA), are frequently combined with a differential mobility analyzer (DMA) to measure particle mass mp and effective density ρeff distributions of particles with a specific electrical mobility diameter dm. Combinations of these instruments, which are referred as the DMA-APM or DMA-CPMA system, are also used to quantify the mass-mobility exponent Dm of non-spherical particles, as well as to eliminate multiply charged particles. This study investigates the transfer functions of these setups, focusing especially on the DMA-APM system. The transfer function of the DMA-APM system was derived by multiplying the transfer functions of the DMA and APM. The APM transfer function can be calculated using either the uniform or parabolic flow models. The uniform flow model provides an analytical function, while the parabolic flow model is more accurate. The resulting DMA-APM transfer functions were plotted on log(mp)- log(dp) space. A theoretical analysis of the DMA-APM transfer function demonstrated that the resolution of the setup is maintained when the rotation speed ω of the APM is scanned to measure distribution. In addition, an equation was derived to numerically calculate the minimum values of the APM resolution parameter λc for eliminating multiply charged particles.

1IM.5
A DMA Train for Precision Quantification of Nanoparticle Growth Rates in the sub-10 nm Size Range. Dominik Stolzenburg, Gerhard Steiner, PAUL M. WINKLER, *University of Vienna*

Measurements of nanoparticle growth rates in the sub-10nm size range are difficult to perform due to high particle losses and low detection efficiencies, especially below 3nm. Also time resolution of conventional SMPS limits the quantitative evaluation of growth rates (Winkler et al (2012), Geophys. Res. Lett. 39, L20815).

Here we present the development of a Differential Mobility Analyzer - Train (DMA-Train) operating six DMAs in parallel for high time resolution quantification of nanoparticle growth rates down to 1.5 nm. To this end, each DMA channel is operated at a fixed voltage allowing precise measurement of the evolution of individual particle sizes. For the detection of classified particles we use five butanol based condensation particle counters (CPC) (TSI3776) and one water based CPC (TSI3788). For the smallest size channels at 2 nm and below, two Airmodus A10 particle size magnifiers (PSM) (Vanhanen et al. (2011), Aerosol Sci. Technol. 45, 533) are used. The setup follows the classical scanning mobility particle sizer (SMPS) design but with six distinct channels. Therefore no voltage adjustment at the DMA is necessary during standard operation. This provides a much higher time resolution by avoiding voltage scanning and signal retention due to voltage changes. Furthermore, the data inversion procedure for the extraction of the spectral data is simplified and a full statistical approach is used to determine the growth rates, significantly reducing measurement uncertainties.

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1IM.6

Performance of a Prototype Radial Opposed Migration Ion/Aerosol Classifier (ROMIAC). WILTON MUI, Andrew Downard, Daniel Thomas, Huajun Mai, Amanda Grantz, Jesse Beauchamp, John Seinfeld, Richard Flagan, *California Institute of Technology*

The radial opposed migration ion/aerosol classifier (ROMIAC) is a novel differential mobility analyzer that was designed for classification of sub-20 nm particles. Initial design simulations were based on 2-dimensional finite element and Monte-Carlo particle tracing simulations. Here we report on 3-dimensional, finite element simulations that that have been performed to explore particle transmission through the ROMIAC. The modeled performance of the ROMIAC is verified through mobility and transmission efficiency calibration measurements with two nominally identical ROMIACs in tandem classifier methods. The measurements were performed at non-diffusive resolving powers (R_{nd}) ranging from 4 to 20 using 1 to 20 nm diameter tetra-alkyl ammonium halide ions and sodium chloride particles. Particle mobilities transmitted show direct relationships to the applied voltage and operating cross flow rate, while particle transmission efficiency is related to the operating resolution. Measured transmission efficiencies and resolution agreed well with modeled predictions, including observations of relative resolutions (R/R_{nd}) that slightly exceed unity. Reasons for this seemingly counterintuitive performance will be discussed.

1IM.7

Experimental Study of Mini-Plate Differential Mobility Analyzers (Mini-plate DMAs) with Expansion/Contraction Flow Channel. QIAOLING LIU, Da-Ren Chen, *Virginia Commonwealth University*

To conduct the tempo-spatial ultrafine particle monitoring either on the ground/unmanned aerial vehicles, or even at the personal level, miniature, cost-effective ultrafine particle sizers based on the particle electrical mobility technique, i.e., mini-plate DMA, has recently been developed and its performance has been evaluated in our laboratory. To further extend the measurable particle size range of a mini-plate DMA without increasing its overall size much, two prototype mini-plate DMAs, one with the expansion flow channel and the other with the contraction flow channel, were designed constructed and tested in this study.

Two studied prototypes are in the plate-to-plate configuration, where polydisperse aerosol and clean sheath flows travel in the spacing (of 1/16”) between two parallel metal plates. One of two plates is on a High DC voltage and the other on the electrical ground to establish an electrical field for particle classification/sizing. The overall particle classification length in the two studied DMAs is 2 1/16”. In the expansion flow version the width of particle classification channel in the DMA is the same width as the length of aerosol entrance slit in the first half of the channel and the channel width is increased in the last half of the flow channel. The length of aerosol exit slit is designed the same as that of the entrance slit. The opposite flow channel geometry with the identical dimensions as the expansion flow channel DMA was designed in the contraction flow version of mini-plate DMA. Tandem DMA (TDMA) experiments were performed to evaluate the performance of two prototypes at different particle sizes and aerosol-to-sheath flowrate ratios. The piecewise-linear deconvolution scheme (Li et al., 2006) was applied to obtain the real transfer function of studied mini-plate DMAs. The detail result of this study will be presented in this talk.

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1RA.1
Tracking Ambient New Particle Formation by an Expansion-type CPC. TAMARA PINTERICH, Paul M. Winkler, Tuukka Petäjä, Markku Kulmala, Paul E. Wagner, *Universitaet Wien, Vienna, Austria*

We report on new particle formation (NPF) measurements obtained by the versatile Size Analyzing Nuclei Counter (Pinterich, T. et al. (2013), AIP Conf. Proc. 1527, 161-164). The vSANC is a new expansion-type CPC based on its predecessor SANC (Wagner et al., (2003) Phys. Rev. E 67, 021605). It was designed to allow maximum flexibility for its application in field as well as laboratory studies. Particle number concentrations are obtained by optical means using the multi-angle Constant Angle Mie Scattering method. Counting efficiency measurements have shown that vSANC detects 10-20% of the particles at 1.5 nm in diameter. Thus vSANC can be used as particle counter for sub-3nm clusters.

During spring 2014 we participated in the spring campaign at the SMEAR II station in Hyytiälä, Finland. Our main goal was to detect smallest possible clusters at the very beginning of NPF. To this end, vSANC was operated in a three-stage cycle where we chose three different expansion ratios to achieve size-dependent particle activation at different vapour supersaturations. Accordingly, measurements in the size bins 2-6nm, 6-10nm and >10nm were performed sequentially. Since homogeneous nucleation was observed to start at the highest expansion ratio basically all clusters can be considered activated.

Using n-propanol as working fluid, NPF was observed only when the nucleation temperature was low enough suggesting that nucleation temperature may play an important role in nanoparticle detection (Kupc, A. et al. (2013) Aerosol Sci. Technol.47, i-iv).

Diurnal concentration evolution during NPF showed that particle concentrations as high as 10^4 cm^{-3} were detected in the smallest size bin of vSANC about 2-3 hours before the NPF signal appeared in a DMPS. The lower DMPS detection limit of 3nm suggests that the high vSANC signals can be attributed to the appearance of newly formed sub-3 nm particles.

1RA.2
Low Hygroscopic Scattering Enhancement of Boreal Aerosol and the Implications for a Columnar Optical Closure Study. PAUL ZIEGER, Pasi Aalto, Veijo Aaltonen, Mikko Äijälä, John Backman, Juan Hong, Mika Komppula, Radek Krejci, Laborde Marie, Janne Lampilahti, Gerrit de Leeuw, Anne Pfüller, Bernadette Rosati, Matthias Tesche, Peter Tunved, Riikka Väänänen, Tuukka Petäjä, *Stockholm University*

Ambient aerosol particles can take up water and thus change their optical properties depending on the hygroscopicity and the relative humidity (RH) of the surrounding air. Knowledge of the hygroscopicity effect is of importance for radiative forcing calculations and is also needed for the comparison of remote sensing or model results with in-situ measurements. Specifically, the particle light scattering depends on RH and can be described by the scattering enhancement factor f(RH), which is defined as the particle light scattering coefficient at defined RH divided by its dry value.

Here, we present results of an intensive field campaign carried out in summer 2013 at Hyytiälä, Finland. Ground-based and airborne measurements of aerosol optical, chemical and microphysical properties were conducted. The f(RH) measured at ground is found to be in general lower than observed at other European sites. One reason is the high organic mass fraction of the aerosol encountered at Hyytiälä to which f(RH) is clearly anti-correlated. A trajectory analysis revealed that elevated values of f(RH) and the corresponding elevated inorganic mass fraction are partially caused by transported hygroscopic sea spray particles.

By combining the ground-based measurements with aircraft measurements of the particle number size distribution, columnar values of the particle extinction coefficient are determined and compared to direct measurements of a co-located AERONET Sun photometer. The water uptake is found to be of minor importance for the column averaged properties due to the low particle hygroscopicity and the low RH during the daytime of the summer months. The in-situ derived aerosol optical depth (AOD) clearly correlates with directly measured values, but is significantly lower compared to the Sun photometer AOD. The disagreement between in-situ derived and directly measured AOD is hypothesized to originate from losses of coarse and fine mode particles through dry deposition within the canopy, elevated layers above 3 km, and losses in the in-situ sampling lines.

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1RA.3

Dynamics of Aromatic-Derived SOA in the South Coast Air Basin of California. MATT DAWSON, Jialu Xu, Robert Griffin, Donald Dabdub, *University of California, Irvine*

This research aims to incorporate an updated mechanism for secondary organic aerosol (SOA) formation from toluene and m-xylene oxidation into a state of the art regional air quality model, the University of California, Irvine - California Institute of Technology (UCI-CIT) Airshed model. The model domain covers the South Coast Air Basin (SoCAB) of California, a region containing high NOx urban areas, as well as relatively low NOx areas. Thus, the impact of this new aromatic oxidation chemical mechanism, which was developed for use over a range of NOx conditions, can be evaluated. Initially, the new SOA forming chemistry is limited to toluene and m-xylene, then extrapolated to other aromatic compounds to evaluate their potential contributions to SOA in the SoCAB region. Additionally, the effects of changing emissions scenarios on aromatic-derived SOA is evaluated by using both current and projected future emissions inventories compiled as part of the 2012 Air Quality Management Plan by the South Coast Air Quality Management District.

Finally, the propensity for SOA species formed as part of this new aromatic oxidation mechanism to partition to both the aqueous and organic phase is explored by updating the equilibrium partitioning based SOA mechanism with newly calculated vapor pressures, UNIFAC parameters, and Henry's Law coefficients for the new SOA species. As part of this work, the entire SOA module of the UCI-CIT model has been updated to use recalculated vapor pressures for SOA species using the SIMPOL.1 method of Pankow & Asher (ACP, 2008), as well as an updated SOA 'lumping' scheme, which groups SOA species based on similar physical properties. Details of this work will be described, and implications for this new aromatic oxidation chemistry related to air quality in the SoCAB region under varying NOx conditions and emissions scenarios will be discussed.

1RA.4

Observational Constraints on Terpene Oxidation in the Amazon Using Speciated Measurements from SV-TAG. LINDSAY YEE, Gabriel Isaacman-VanWertz, Rebecca Wernis, Nathan Kreisberg, Yingjun Liu, Karena McKinney, Suzane Simoes de Sa, Scot Martin, Lizabeth Alexander, Brett Palm, Weiwei Hu, Pedro Campuzano-Jost, Douglas Day, Jose-Luis Jimenez, Juarez Viegas, Stephen Springston, Florian Wurm, Joel Brito, Paulo Artaxo, Antonio O. Manzi, Luiz Machado, Maria Oliveira, Rodrigo A. F. Souza, Susanne Hering, Allen H. Goldstein, *University of California at Berkeley, Berkeley, CA, USA*

Biogenic volatile organic compounds (BVOCs) from the Amazon forest represent the largest regional source of organic carbon emissions to the atmosphere. These BVOC emissions dominantly consist of volatile and semi-volatile terpenoid compounds that undergo chemical transformations in the atmosphere to form oxygenated condensable gases and secondary organic aerosol (SOA). We have deployed the Semi-Volatile Thermal desorption Aerosol Gas Chromatograph (SV-TAG) at the rural T3 site located west of the urban center of Manaus, Brazil as part of the Green Ocean Amazon (GoAmazon) 2014/5 field campaign to measure hourly concentrations of semi-volatile BVOCs and their oxidation products during the wet and dry seasons. Primary BVOC concentrations measured by the SV-TAG include sesquiterpenes and diterpenes, which have rarely been speciated with high time-resolution. Several sesquiterpenes present in ambient data were found to overlap with the sesquiterpene composition in essential oils from the Copaiba tree (Copaifera officinalis Jacq. L.), commonly known as the "diesel tree" in the Amazon, suggesting that it and related vegetation may be potential sources of BVOC emissions in the Amazon. We observe sesquiterpenes at levels of tens of pptv, and they are anti-correlated with ozone. We estimate that from the observed sesquiterpene and monoterpene concentrations, sesquiterpenes would account for more olefin-channel ozone sink (loss). We then compare the ambient data with that from laboratory focused sesquiterpene oxidation experiments to identify new tracers for ambient sesquiterpene oxidation. We report gas-particle partitioning of speciated terpene oxidation products and explore relative contributions of isoprene and terpene oxidation products to SOA formation by combining SV-TAG measurements with those from an additional suite of VOC and particle measurements deployed in the Amazon.

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1RA.5

Processes Controlling the Seasonal Cycle of Arctic Aerosol Number and Size. BETTY CROFT, Jeffrey R. Pierce, W. Richard Leaitch, Stephen D'Andrea, Randall V. Martin, *Dalhousie University, Halifax, Canada*

Measurements at high Arctic sites show a strong seasonal cycle in aerosol number and size. The number of aerosols larger than 20 nm (N20) exhibits a maximum in late spring (dominant accumulation mode), and a second maximum in the summer (dominant Aitken mode). Seasonal mean aerosol effective diameter ranges from about 160 nm in summer to about 250 nm in winter. This study interprets these Arctic seasonal cycles with the GEOS-Chem-TOMAS model. We find improved agreement with in situ measurements (SMPS) of aerosol size at Alert, Nunavut, Canada and Zeppelin Mountain, Svalbard following model developments: 1) to increase the efficiency of wet scavenging in the Arctic summer and 2) to represent coagulation between interstitial aerosols and aerosols activated to form cloud droplets. We present Arctic regional-mean budgets for the processes controlling simulated aerosol number. Increased efficiency of wet removal during summer is shown to limit the number of larger aerosols (despite ongoing transport into the Arctic) and promotes new particle formation. We find an important role of interstitial coagulation in clouds, which limits the number of Aitken mode particles in non-summer seasons when cloud cover is persistent, and direct wet removal of these particles is inefficient. Implementation of this process in the model reduces the simulated Arctic-mean N20 by a factor of 2 in the non-summer months. We recommend that the key processes of aerosol wet removal, interstitial coagulation and new particle formation be carefully considered in size-resolved aerosol simulations of the Arctic.

1RA.6

Long-term Comparison of Thermal-optical Transmittance Elemental Carbon and Optical Black Carbon in the Arctic. Philip K. Hopke, YUANYUAN ZHANG, *Clarkson University*

Black carbon (BC) is carbonaceous particles that strongly absorb light. Thus BC has a significant effect on climate change and global warming. Often in the literature, the term BC is used interchangeably with the term elemental carbon (EC). However, BC and EC are different because each is defined operationally. For BC, light absorption measures the “blackness” of the particle while for EC; the measurement is by a thermal-optical method. BC is important in the Arctic because the deposited BC particles can decrease the albedo and cause ice and snow melting. Limited Arctic black carbon projects had been developed long-term black carbon concentrations ([BC]) to explore the trends in BC. Generally, these projects used light absorption (Aethalometer or OT-21). In the current study, we used the NIOSH thermal-optical transmittance (TOT) protocol to measure thermal [EC] in samples collected at Alert, Nunavut, Canada (82.5°N, 62.5°W) from 1981 to 2008. The samples were collected on 8” x 10” Whatman 41 filters that were cut into 1” strips for analysis. Each strip was dissolved in 70% ZnCl2 solution and filtered onto baked quartz filters for EC analysis. These data permit the comparison of the long-term thermal [EC] results with [BC] measured at Alert since 1989 using an Aethalometer. These results will provide additional data on carbonaceous particles (EC) relative to the long-term black carbon aerosol in the Arctic. Such information will be useful for better understanding global atmospheric chemistry and climate change, particularly with respect to Arctic warming.

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1RA.7

Antarctic Aerosols: Sources and Meteorological Influences on Aerosol Composition as Measured with High Resolution Aerosol Mass Spectrometry. Michael Giordano, Lars Kalnajs, Terry Deshler, Anita Johnson, Sean Davis, PETER DECARLO, *Drexel University*

Antarctica, like most of the high latitudes, remains a source of uncertainty for the aerosol community. Access to the continent and an unforgiving climate make maintaining aerosol instrumentation difficult. Despite this, a number of studies have used filters to collect and analyze continental aerosol in Antarctica. Shipboard studies in the southern ocean have used real-time mass spectrometry data to determine Antarctic outflow aerosol composition. However, real-time, high-resolution aerosol composition data is still missing from the Southernmost Continent. The Two-Season, Ozone Depletion and Interaction with Aerosols Campaign (2ODIAC) deployed the first Aerodyne high resolution aerosol mass spectrometer (HR-AMS) to the continent to measure the size and composition of non-refractory aerosol. In addition, a full suite of meteorological, aerosol, and gas-phase instruments were also deployed near McMurdo station, Antarctica. Aerosol composition varied with air masses and from meteorological regime. High wind speed events from either the interior of the continent or the southern ocean influenced the gas and aerosol phase measurements. Data presented will primarily focus on the differences in aerosol composition between the two air mass regimes. The differences in particulate iodine, chloride, and sulfates (MSA and non-sea-salt) will also be discussed. The relationship between aerosol composition and particle number concentrations and ozone concentrations will be highlighted, and both particle bursts and ozone depletion events were observed during the campaign and will be discussed in relation to the “steady-state” (low wind speed) aerosol population. Finally, preliminary data in regards to the role of photochemistry, differences between Austral winter and summer aerosols in Antarctica, will be presented.

1UA.1

Volatility Profile, Low Volatile Core and Mixing State of Ultra-fine Particles in the Midwestern United States. ASHISH SINGH, Robert Bullard, Matthew Johnson, Charles Stanier, *University of Iowa*

Volatility measurement of ultrafine particles (10-100 nm) provides important information about particle growth pathways and thermodynamic properties, and can assist in constraining chemical composition. Bondville, Illinois is a Midwestern United States site where particle nucleation and extensive secondary sulfate and organic aerosol formation has been reported. Furthermore, the volatility of UFPs using V-TDMA has not been reported for many sites in the Midwestern U.S. Consequently, the relative contributions of organic and inorganic constituents to particle growth in the UFP size ranges, and the presence or absence of low-volatile particle cores in 10-100 nm particles, has not been determined.

This study will present size-resolved volatility analysis of ultrafine particles from a yearlong field campaign in Bondville, IL. Analysis of volatility profiles is performed using K-means cluster analysis. The cluster analysis reveals three types of profiles for 15, 30, 50 and 80 nm particles. These profiles vary in the low volatile core, and in their resemblance to a pure ammonium sulfate volatility profile.

Aerosol mass resistant to evaporation (i.e. residue) is consistently observed at 200°C in all sizes from 15 to 80 nm. The amount of residue increases with particle size and ranges from 10-15% in 15 nm to 30-40% of the volume in 80 nm particles. V-TDMA at high temperature also reveals 20-30% of samples are external mixed, especially at the larger sizes of 30, 50 and 80nm. The timing and characterization of the external mixture with respect to different mode is analyzed.

Significant correlation between residue and ozone (O3), sulfur dioxide (SO2) and solar radiation is observed. The association of residue is further explored at different atmospheric conditions such as particle burst and growth events, local combustion and regional background, as well as across different sampling months, and also during consecutive particle formation and growth events.

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1UA.2

Spatial Distribution, Chemical Composition, and Sources of Atmospheric Gases and Aerosols in Estonia. MIRIAM ELSER, Carlo Bozzetti, Imad El Haddad, Rene Richter, Marek Maasikmets, Erik Teinemaa, Urs Baltensperger, Andre Prévôt, *Paul Scherrer Institute*

The spatial distribution, chemical composition and sources of infectious and climate relevant gases and aerosols were examined during March 2014 at three contrasted sites in Estonia (Tartu, Kohtla- Järve/Kiviõli and Tallinn), using a mobile platform. This constitutes to the best of our knowledge the first detailed in-situ measurements in the Baltic region, whose air-quality remains poorly characterized. The chemical composition of the non-refractory aerosols in the PM2.5 fraction was measured with a High Resolution Time of Flight Aerosol Mass Spectrometer, equipped with a newly developed high pressure lens. A 7-wavelength Aethalometer was used to monitor equivalent black carbon concentrations and a condensation particle counter to measure particle number concentrations. The concentrations of trace gases, including ammonia, carbon monoxide, carbon dioxide and methane were also measured. All measurements were performed with high time resolution (seconds), critical for the identification of source regions using a mobile platform.

The average measured concentrations in both particle and gas phase are overall relatively low, but stagnant conditions, which occur frequently, induce the accumulation of locally emitted primary aerosols. In Tartu and Tallinn (the two major cities in Estonia) organics and black carbon dominate the particle-phase composition. The contribution of primary sources to organic matter strongly depends on the sampling location, with wood burning dominating in residential areas, whereas the contribution of oxygenated organic aerosols is spatially homogeneous. Urban increments of the different pollutants have been assessed by combining measurements outside and inside these cities. In Kohtla-Järve and Kiviõli sulfate is dominant, mostly produced from the two shale-oil factories present in the area. The contribution of different industrial processes, including shale oil and energy production could be assessed using factor analysis.

1UA.3

Comparative Assessment of the Oxidative Potential of Daytime and Nighttime Secondary Organic Particles in Los Angeles. ARIAN SAFFARI, Sina Hasheminassab, Martin Shafer, James Schauer, Constantinos Sioutas, *University of Southern California*

Oxidative potential, induced following the interaction of reactive oxygen species (ROS) with cells, is known as one of the major pathways leading to the adverse health effects of exposure to particulate matter. Secondary organic species comprise a substantial fraction of fine and ultrafine particulate matter in the Los Angeles basin and therefore quantification of the toxicological properties of these particles is important from a public health perspective. Secondary organic aerosols can be formed through gas-phase photochemical reactions in the atmosphere followed by condensation of the products in the particle phase during daytime, as well as through aqueous-phase reactions in the nighttime. Differences in formation mechanism and chemistry of daytime and nighttime secondary organic aerosols can, potentially, lead to variations in their oxidative potential and thus toxic properties. In this study, fine and ultrafine particles were studied throughout the warm season (August through October) and cold season (December through February) in central Los Angeles, during episodes of daytime and nighttime secondary organic aerosol (SOA) formation. SOA concentrations were quantified based on the EC tracer method, by continuous monitoring of organic and elemental carbon. Moreover, physical properties of particles (including mass and number concentrations, total volume and condensational sink) were assessed and compared during these two periods by continuous measurement of particle size distributions. Parallel to the continuous monitoring, time-integrated fine and ultrafine samples were also collected using a hi-volume impactor sampler, in order to quantify the chemical composition, as well as the oxidative potential of particles during different episodes of SOA formation.

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1UA.4

Overview of Surface Measurements of Submicron Particulate Matter in the Greater Houston Area during the DISCOVER-AQ 2013 Field Campaign. YU JUN LEONG, Nancy Sanchez, Henry Wallace, Basak Karakurt Cevik, James Flynn, Yan Han, Paola Massoli, Cody Floerchinger, Edward Fortner, Scott Herndon, Barry Lefer, Robert Griffin, *Rice University*

Submicron particulate matter (PM_1) has strong climate and health impacts and remains poorly characterized, particularly in the industrialized city of Houston. Semi-Lagrangian and factor analyses were applied to non-refractory PM_1 chemical composition data collected in September 2013 during the DISCOVER-AQ field mission in Houston, TX. Submicron PM and trace-gas measurements made using the University of Houston/Rice and Aerodyne Research, Inc. mobile laboratories were analyzed for spatial trends, focusing on PM_1 chemical composition measured by high-resolution time-of-flight aerosol mass spectrometers (HR-ToF-AMS). Applying a two-step cluster analysis on PM_1 composition data, the Houston area was divided into three pollution zones with distinct PM_1 chemical composition and photochemical age: Zone 1 in the northwestern forested residential area, Zone 2 in central metropolitan Houston, and Zone 3 in the southeastern industrial/ship channel area. A semi-Lagrangian analysis was conducted using HR-ToF-AMS PM_1 datasets collected by the two mobile laboratories to characterize the aging and transformation processes of PM_1 during downwind transport. Positive Matrix Factorization (PMF) of organic aerosol (OA) mass spectral data collected by the HR-ToF-AMS yielded at least three distinct OA factors. The first OA factor represents fresh primary aerosol; it is elevated on roadways and near industrial sources. The second and third OA factors are oxygenated OA (OOA-1, OOA-2) factors that have distinct mass spectra. The less-aged and semi-volatile OOA-1 factor is ubiquitous throughout Houston and is likely secondary OA (SOA) that is produced locally, while the processed and less volatile OOA-2 factor has higher spatial variability and likely represents SOA from long-range transport. The OOA-1 factor dominates total averaged OA mass in Zone 1 (59%) and Zone 3 (68%), indicating strong SOA influence from biogenic and anthropogenic precursor emissions in each respective zone. Zone 2 shows highest OOA-2 influence (26%) likely due to aged outflow influence from other zones.

1UA.5

Influence of Urban Aerosols on the Chemistry of Stormwater Runoff from Building Roofs. ALEXANDER JOHNSON, Cliff Davidson, *Syracuse University*

Atmospheric aerosols are continually depositing onto urban surfaces such as streets, sidewalks, lawns, and building roofs. A fraction of these deposited aerosols are mobilized during rainstorms and may contaminate stormwater runoff. However, not much is known about the origins of the chemical constituents. Besides washoff of dry deposited aerosol, other possible sources of contaminants include chemical species in the falling rain (wet deposition), washoff of debris from the surface, erosion of surface coatings, and erosion of the surface material itself. In these experiments, we investigated the chemical composition of stormwater runoff from two adjacent rooftops: a 1.5 acre green roof on the Onondaga County Convention Center and a similarly sized traditional roof on the War Memorial Sports Arena, both located in downtown Syracuse, New York. The primary objective was to compare concentrations of different chemical species in runoff samples collected from both roofs to determine if the green roof acted as a filter to remove species from stormwater runoff or if the growth medium and vegetation on the green roof contributed to contamination. A second objective was to determine the relative contributions of wet deposition and dry deposition as well as debris and surface erosion to runoff contamination from both roofs. Falling rain was collected and analyzed for the same chemical species to determine the contribution of contamination from wet deposition. For dry deposition, fluxes of aerosols onto aerodynamic surfaces during antecedent dry weather were determined as a surrogate for deposition onto the roofs. The flux for each metal was multiplied by the duration of the antecedent dry period and surface area of the roof to obtain the dry deposition mass loading. Ambient airborne concentrations were also measured. All of these data were used to develop a model for contaminants in stormwater runoff from the roofs.

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1UA.6

Understanding the Character and Dynamics of Organic Aerosol in the Houston Area Using Multi-way Factor Analysis. NANCY SANCHEZ, Yu Jun Leong, Henry Wallace, Basak Karakurt Cevik, James Flynn, Barry Lefer, Robert Griffin, *Rice University*

Organic aerosol (OA) has been identified in several previous studies as the dominant constituent of particulate matter (PM) in different rural and urban locations. Investigation of the sources, formation pathways, transformation processes and chemical character of this fraction is crucial to better elucidate the impacts of submicron aerosol on climate and human health. Furthermore, as more stringent standards for PM concentration are promulgated by the EPA, the formulation of public policies intended to reduce/control PM levels in cities like Houston, where nonattainment zones for PM have been identified, requires an improved understanding of the evolution of this pollutant in the atmosphere. Although factor analysis techniques such as positive matrix factorization (PMF) provide information on the components of the organic fraction of submicron aerosol, the extension of PMF to multi-way analyses such as 3-D parallel factor (PARAFAC) analysis in order to incorporate information on the size distribution of the OA, offers an improved approach to aerosol apportionment. In this work, PARAFAC analysis was applied to size-resolved organic aerosol composition data sets collected with an Aerodyne high-resolution time-of-flight aerosol mass spectrometer in the Greater Houston area (GHA) during the DISCOVER-AQ 2013 campaign and the Houston Aerosol Characterization and Health Experiment, a comprehensive field study covering multiple locations in the GHA conducted from 2013 to 2015. The PARAFAC-based analysis of these data sets provided information on (i) the main fractions present in the OA in Houston and their specific size distribution, (ii) the spatial and temporal distribution of the constituents of the OA across the GHA and (iii) the variation in the OA fraction size distribution associated with aerosol processing during specific periods/events. The results obtained in this study provide further insight on the dynamics of OA in Houston and might support future policies oriented to control PM levels in the GHA

1UA.7

Aerosol Optical Properties Retrieved Using Actinic Flux and Irradiance during DISCOVER-AQ Texas: In-situ Comparisons and Photochemical Impacts. CHELSEA CORR, Jungbin Mok, Nickolay Krotkov, Barry Lefer, Bruce Anderson, John Barrick, Andreas Beyersdorf, Gao Chen, Richard Moore, Michael Shook, Kenneth Thornhill, Edward Winstead, Luke Ziemba, Sasha Madronich, James Crawford, Jack Dibb, *ORAU*

Single scattering albedo (SSA) was retrieved using actinic flux (AF SSA) measured with a scanning actinic flux spectrometer (SAFS) and the direct-to-diffuse irradiance ratio (DDR SSA) measured with multifilter shadowband radiometers (MFRSRs). Measurements were made atop the Moody Tower (MT) in Houston, TX during NASA DISCOVER-AQ (Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality) mission in September 2013. Retrievals were performed at four wavelengths (332, 368, 415, and 500 nm) shared by the instruments for three days that met cloudscreening and aerosol optical depth (AOD) criteria: 09/03/13, 09/25/13, and 09/26/13. AF SSAs were consistently lower than DDR SSAs with largest differences when AOD was less than 0.2. However, DDR SSAs were within 0.05 of values retrieved using MT MFRSR irradiance and an independent inversion technique. DDR SSAs also agreed within the uncertainty of SSAs reported by the AErosol RObotic NETwork (AERONET) at 441 nm as well as with column-average values at 450 and 550 nm calculated from aerosol scattering and absorption coefficients measured aboard the NASA P3-B aircraft. Though AF SSAs were lower than both AERONET and column-averaged values, absorption Angstrom exponent (AAE) values calculated from AF SSAs were within 0.4 of AERONET and column-averaged AAEs for all retrieval days suggesting actinic flux retrievals can correctly resolve the spectral dependence of aerosol absorption. These measured and retrieved optical properties were used to assess the impact of aerosols on photochemistry during DISCOVER-AQ TX. Specifically, photolysis rates modeled using a radiative transfer code for an aerosol-free case and using measured and retrieved optical properties were compared to photolysis rates measured at MT and aboard the P3-B. Deviations of measured photolysis rates from either modeled profile type were quantified; relationships between both the magnitude and direction of these deviations and aerosol composition and size are discussed.

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2AC.1

Comparison of NO2 Effects on Secondary Organic Aerosol (SOA) Formation from Ozonolysis of Four Monoterpenes.

DANIELLE C DRAPER, Delphine Farmer, Yury Desyaterik, James N. Smith, Juliane L. Fry, *Reed College*

The effect of NO_2 on secondary organic aerosol (SOA) formation from ozonolysis of alpha-pinene, beta-pinene, Delta-carene, and limonene was investigated in unseeded experiments using a dark flow-through reaction chamber. Each monoterpene exhibited different aerosol formation trends from pure ozonolysis compared to ozonolysis with increasing NO_2 concentrations: number concentrations and mass yields both systematically decreased with increasing [NO_2] for alpha-pinene; number concentrations decreased with increasing [NO_2] for beta-pinene and Delta-carene while mass yields remained comparable; and both number concentrations and mass yields increased with increasing [NO_2] for limonene. Kinetics modeling of the first generation gas-phase chemistry suggests that differences in observed aerosol yields at different NO_2 concentrations is likely caused by the formation of NO_3, which competes with O_3 to oxidize the monoterpene and has been shown to produce different aerosol yields. SOA from each experiment was collected and analyzed offline by HPLC-ESI-MS, enabling comparisons between aerosol product distributions for each system. For all monoterpenes studied except for alpha-pinene, experiments influenced by NO_3 oxidation contained more high molecular weight products (MW > 400 amu) relative to ozonolysis, suggesting the importance of oligomerization mechanisms in NO_3-initiated SOA formation. The lack of oligomers observed from alpha-pinene may explain its anomalously low aerosol yield with NO_3. Through direct comparisons of mixed-oxidant systems, this work suggests that NO_3 is likely to dominate nighttime oxidation pathways in most regions with both biogenic and anthropogenic influences.

2AC.2

Design and Application of Aerosol Optical Tweezers to Investigate Organic Aerosol Morphology.

KYLE GORKOWSKI, Mark Aboff, Hassan Beydoun, Michael Polen, Jim Walker, Neil Donahue, Ryan Sullivan, *Carnegie Mellon University*

Atmospheric aerosols containing multiple organic and/or inorganic components can phase separate into distinct liquid phases, resulting in either a core-shell or a partial-shell particle structure. Understanding and predicting when each of these structures forms is critical to understanding the gas/particle partitioning of organic compounds, water uptake and cloud droplet activation, and chemical reactions involving atmospheric aerosols. Liquid-liquid phase mixing and the resulting morphology of organic aerosols is also important when interpreting smog chamber experiments where SOA coatings onto existing particles are usually assumed to form a core-shell structure.

We have constructed a new aerosol optical tweezers (AOT) system to investigate the thermodynamic properties of organic aerosols in Carnegie Mellon University's Center for Atmospheric Particles Studies. The AOT system is a highly accurate real-time probe for studying individual particles larger than 4 microns. The retrieved Cavity Enhanced Raman Spectrum allows us to measure the trapped particle's size and composition (via the refractive index) with high accuracy and sensitivity. We constructed a unique AOT chamber that enhances the probability of tweezed droplet-particle coagulation and trapping stability. The chamber was also designed to deliver a highly uniform conditioned air flow to the tweezed particle, making it ideal for probing particle-gas interactions.

We have investigated the phase mixing of multicomponent organic and aqueous inorganic particles. Experiments were conducted by first trapping the core particle and then the second organic component was added through coagulation of smaller particles or condensation of vapor. The morphology and any phase separations of the resulting multicomponent particle were then determined from the presence or absence of the Cavity Enhanced Raman Spectrum. Using this technique has enabled us to uniquely distinguish between core-shell, partial-shell, and internally mixed morphologies for a series of multicomponent (inorganic/organic/aqueous) particle systems, and how this morphology changes with changes in particle composition and relative humidity.

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2AC.3
Pressure Dependence of Criegee Intermediate Stabilization for a Sequence of Alkenes. JANI HAKALA, Neil Donahue, *Carnegie Mellon University*

Alkenes are the most abundant organic species in the atmosphere after methane. These include such species as isoprene and vast selection of different terpenes. Alkene ozonolysis is a major pathway for removal of alkenes from the atmosphere and an important step for the formation of Secondary Organic Aerosols. Stabilized Criegee Intermediates (sCI) are a species of atmospheric oxidizer, which are formed by alkene ozonolysis via Criegee mechanism. Particularly their ability to oxidize sulfur dioxide into sulfuric acid is important for predicting the rate of new particle formation in the atmosphere.

The role of sCIs in atmospheric chemistry is not yet fully understood. To deepen our knowledge, we have studied the pressure dependence of criegee intermediate stabilization of several symmetrical trans-alkenes and monoterpenes. We measured the criegee intermediate stabilization in a pressure controlled flow reactor indirectly by measuring the sulfuric acid formed by sulfur dioxide oxidation by sCIs using a Chemical Ionization Mass Spectrometer (CIMS). The results indicate collisional stabilization of criegee intermediates, and for some alkenes, also some stabilization without a need for a third body.

2AC.4
Control of Ozonolysis Kinetics and Aerosol Yield by Nuances in the Molecular Structure of Volatile Organic Compounds. REBECCA HARVEY, Giuseppe Petrucci, *University of Vermont*

Secondary organic aerosol (SOA) plays integral roles in climate and human health, yet there remains a limited understanding of the mechanisms that lead to its formation and ultimate fate. The disparity between modeled atmospheric SOA loadings and field measurements highlights the need for a more accurate representation of the molecular level interactions between SOA sources and oxidative pathways. Atmospheric models generally predict SOA loadings using structure activity relationships generalized to classes of SOA precursors. However, the kinetics and SOA forming potential of molecules are nuanced by seemingly minor structural differences in parent molecules.

We measured SOA yields and ozonolysis rate constants for several atmospherically relevant linear, cyclic and oxygenated C_5-C_7 alkenes whose molecular structure varies slightly in the site of unsaturation and/or the presence/position of functional groups. For 1-alkenes, SOA yield increased with carbon number but was also dependent on the position of the double bond, confirming previously reported trends. We also found greater SOA yields for cyclic compounds compared to their linear analogs, a comparison that has not explicitly been explored.

The presence of oxygenated functional groups influenced SOA yield and kinetics. For example, cis-3-hexene (3-HXN) had a lower SOA yield than its methyl ester- (cis-3-hexenyl acetate, CHA) and hydroxyl-substituted (cis-3-hexenol, HXL) analogs. The ozonolysis rate constant for 3-HXN was also 70% and 115% greater than CHA and HXL, respectively. The position and presence of oxygenated functional groups was found to impact SOA formation through steric and electronic effects.

We demonstrate the nuanced behavior of these ozonolysis reactions and discuss relationships between parent compound molecular structure and SOA yield and kinetics. We demonstrate that these key molecular features (location of double bond, presence and identity of substituents, linear vs cyclic geometry) must be considered to accurately model the impact of unsaturated VOCs in atmospheric oxidative cycles and SOA burden.

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2AC.5
Modeling the Chemistry and Growth of Organic Aerosol in Biomass Burning Plumes at Local and Regional Scales.
CHANTELLE LONSDALE, Matthew Alvarado, Robert J. Yokelson, Katherine Travis, Sheryl K. Akagi, Donald Blake, Ian Burling, Hugh Coe, Emily Fischer, David Griffith, Timothy Johnson, Sonia Kreidenweis, Taehyoung Lee, Andrew May, Gavin McMeeking, Simone Meinardi, Isobel Simpson, Amy P. Sullivan, Jonathan Taylor, Shawn P. Urbanski, David R. Weise, Cyle Wold, *AER*

Biomass burning is a major source of atmospheric trace gases and particles that impact regional air quality. Within minutes after emission, complex photochemistry in smoke plumes can cause large changes in the concentration, size distribution, composition, and optical properties of fine particles (PM2.5). Being able to understand and simulate this rapid evolution under a wide variety of conditions is thus a critical part of modeling or forecasting the impact of these fires on local and regional air quality. The Aerosol Simulation Program (ASP) has been previously used within a Lagrangian parcel model to simulate the formation of secondary organic aerosol (SOA) and ozone within several African and North American plumes, including an in-depth study of a biomass smoke plume sampled over California. Here we will present ASP simulations of South Carolina prescribed fires sampled in October and November of 2011. This experiment provided more detailed measurements of the non-methane organic compounds (NMOCs) in the smoke plume, allowing for more detailed evaluation of the interactions between the gas- and particle-phase chemistry. Additionally, we will discuss our work using the ASP model's sub-grid scale parameterization of the near-source chemistry of biomass burning plumes for use in regional and global air quality models, with examples using GEOS-Chem. Finally we will present preliminary work on the implementation of ASP into a stochastic Lagrangian air quality model, STILT-Chem.

2AC.6
A Stochastic Reaction Diffusion Kinetics Model of the Fragmentation Processes during Heterogeneous Oxidation of Organic Aerosol.
AARON WIEGEL, Kevin Wilson, William Hinsberg, Frances Houle, *Lawrence Berkeley National Laboratory*

While progress has been made in understanding the heterogeneous oxidation of atmospheric organic aerosols, a more detailed understanding of the underlying chemical mechanisms is crucial for improving models of their chemical evolution in the atmosphere, particularly in regard to the effect of phase on evaporation rates. Previous experimental work in our lab has shown two general reaction pathways for organic aerosol upon oxidation: functionalization, which adds additional oxygen functional groups to the carbon skeleton, and fragmentation, which leads to C-C bond scission and lower molecular weight oxidized products. A kinetics model for the OH + Squalane model system can describe the underlying molecular processes behind these two pathways with the particle treated as a uniformly mixed volume. Using a lumped species approach to describe the free radical chemistry, the model can predict the measured aerosol mass, volume, density, carbon number distribution of fragmentation products, and the elemental composition of the aerosol over 10 oxidation lifetimes. The functionalization chemistry is found to be primarily controlled by the site preference of the initial hydrogen abstraction by OH radicals. The fragmentation chemistry is found to be driven by "activated" alkoxy radicals with a functional group on the adjacent carbon. As a result, as the O/C ratio of the aerosol increases, the decomposition of these radicals is the primary pathway leading to lower volatility products.

While useful, this model does not explore where in the particle functionalization and fragmentation are most likely to occur. Extension of the lumped species approach to a full coupled reaction-diffusion model provides full spatial information about the particle as a function of time. This model is explored to understand the liquid, well-mixed case of OH + Squalane system and then is extended to study the solid, diffusion-limited case of OH + Triacontane. Several hypothetical cases with intermediate diffusion coefficients are also tested to investigate how the chemistry and evaporation rates change as the diffusion within the particle gets progressively slower. This approach provides insight into the issues with climate and air quality models that over-predict the partitioning of volatile components into and out of the particle phase.

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2AC.7
Measurement of IVOC and SVOCs as Intermediates to SOA Using Online Electron-impact Mass Spectrometry.
JONATHAN FRANKLIN, Gabriel Isaacman-VanWertz, Jesse Kroll, *MIT*

Intermediate-volatility organic compounds (IVOCs) and semivolatile organic compounds (SVOCs) are believed to serve as efficient precursors to secondary organic aerosol (SOA). However, a detailed understanding of the amounts and properties of such compounds in the atmosphere has been limited by the lack of fast and reliable measurements targeting I/SVOCs. A novel method has been developed to provide volatility separated bulk measurements of I/SVOCs. Samples are cryo-collected and then thermally desorbed into an electron impact high resolution time-of-flight mass spectrometer. The high resolution mass spectrometer quantifies volatility-resolved I/SVOCs as well as provides ensemble chemical composition (e.g., elemental analysis) with fast time resolution (one measurement every10 minutes). This technique was applied during atmospheric aging experiments using the environmental chamber at MIT in order to characterize gas-phase oxidation products of many typical SOA precursors in an attempt to close the carbon budget in SOA production.

2AC.8
Photochemical Generation of OH Radicals in Secondary Organic Aerosols.
RACHEL HEMS, Jenny Wong, Shouming Zhou, Jonathan Abbatt, *University of Toronto, Canada*

Aerosol aging processes have been shown to lead to oxidation of the organic components of aerosol. Oxidation can increase aerosol hygroscopicity leading to an increase in the loss of aerosol particles through wet deposition. Heterogeneous oxidation of organic aerosols is often assumed to be the dominant chemical aging process. However, in viscous aerosol particles, heterogeneous oxidation is limited by diffusion and so restricted to the surface. In this regime, condensed phase oxidation processes may be significant. Secondary organic aerosol (SOA) formation under low NOx conditions is known to generate significant amounts of organic peroxides in the condensed phase. When exposed to sunlight, peroxides can photodissociate to produce hydroxyl and alkoxyl radicals which can initiate oxidation of organics. The relevance of this condensed phase source of radicals within the larger context of oxidative aging processes is largely unknown and is the focus of this work. In particular, it is not known if OH radicals are formed, and, if formed, whether they participate in chemical modification of the particles. Particle phase photochemical OH radical generation is investigated within SOA formed by terpene ozonolysis in an environmental chamber. The oxidation of levoglucosan, a reactive bicyclic sugar that is often associated with biomass burning aerosol particles, is used as a tracer for condensed phase OH radical formation, where the levoglucosan is mixed with the SOA material. Preliminary results will be presented.

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2AC.9

Ozone and Secondary Organic Aerosol Formation from Ethylene-NOx-NaCl Irradiations under Different Relative Humidity Conditions. LONG JIA, Yongfu Xu, *Institute of Atmospheric Physics, Chinese Academy of Science*

The formation of ozone and secondary organic aerosol (SOA) from ethylene-NOx-NaCl(aerosol) irradiations was studied under various relative humidity (RH) conditions in an indoor smog chamber. In the absence of NaCl seed aerosols, SOA was hardly formed and peak O3 concentrations decreased linearly with increasing RH in ethylene irradiations. For the irradiations with NaCl seed aerosols, when RH <48% (efflorescence relative humidity of NaCl), NaCl existed as solid phase and had little effect on peak O3 concentrations. The infrared spectra from sampled particles showed that SOA was rarely formed on solid NaCl particles. However, when NaCl was in the aqueous phase as RH ≥ 48%, the peak O3 concentration was sharply reduced by over 20% as compared to experiments without NaCl aerosol, and the absorption of NaNO3 in aerosols was coincidently increased with RH. Model results indicated that the heterogeneous reaction of N2O5 with aqueous NaCl aerosols was the main cause for the sharp decrease of O3.

Besides, the absorptions from C - H, C = O, ONO2 and COO groups all greatly increased with RH. Our results show that SOA from ethylene-NOx irradiations was mainly formed through aqueous reactions. The yields of SOA from ethylene were measured to be 1.5% and 2.3% at RH of 65% and 84%, respectively.

2AC.10

Multiphase Chemistry of Biomass Burning Markers and Its Relevance in Cold Regions. VIKRAM PRATAP, Shunsuke Nakao, *Clarkson University*

There is considerable interest in multiphase chemistry of organic aerosol. It is certainly important to consider multiphase chemistry of organic markers to correctly account for their atmospheric decay and establish lifetime. This study builds upon previous works on decay of levoglucosan with the focus on low temperature conditions as wood burning is used as a major heating source in winter in north-eastern United States. The condensed phase chemistry may become essential to consider in low temperature conditions due to significantly lower volatility of organics. In this study, levoglucosan decay was theoretically considered with focus on relative importance of gas-phase and condensed phase reactions. The effect of temperature variation of diffusion rates, rate constants, and partitioning coefficients on the life time of levoglucosan is studied. Preliminary calculations suggest that volatility is the dominant parameter affecting lifetime of levoglucosan in well-mixed particles. The approach will be extended to discuss decay of other markers and secondary organic markers such as methylnitrocatechols.

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2AC.11
Modeling Nitrate Radical Oxidation of Biogenic Volatile Organic Compounds Above and Below the Canopy during CABINEX 2009. BEN SCHULZE, Henry Wallace, Robert Griffin, *Rice University*

We developed a zero-dimensional model to investigate nitrate radical (NO_3) oxidation of isoprene and alpha-pinene above and below the forest canopy during the CABINEX 2009 field campaign in northern Michigan. Predicted NO_3 concentrations, while relatively low, are two-to-three times higher below the canopy than above during the day. As expected, the hydroxyl radical (OH) is the primary oxidant of isoprene during the day (60-95%) both above and below the canopy. NO_3 accounts for 0-40% of nighttime isoprene oxidation but has virtually no influence during the day. Ozone (O_3) is the main oxidant of alpha-pinene (40-70%) in all modeled ambient conditions. Still, NO_3 contributes 25-40% of nighttime and up to ~10% of daytime oxidation of alpha-pinene below the canopy. In artificially polluted conditions, created by increasing O_3 and NO_x profiles by factors of two and five, respectively, below canopy NO_3 oxidation of alpha-pinene increases to 60-80% of the nighttime total and 20% or more of the daytime total. Midday OH and NO_3 alpha-pinene oxidation rates are similar in modeled polluted conditions. The pathway for organic nitrate (ON) formation is divided between OH- and NO_3-initiated oxidation in below canopy ambient conditions; however, in polluted conditions NO_3 oxidation dominates.

2AC.12
Organic Nitrogen Formation by Aqueous Processing of Condensed Carbonyls and Ammonium Sulfate. CHRIS STANGL, Murray Johnston, *University of Delaware*

Ambient measurements of atmospheric nanoparticles suggest sulfuric acid vapor to be the main driver of daytime new particle formation (NPF), with neutralization by ammonia/amines the primary cluster stabilization process leading to early particle growth. Much less is known about the chemical mechanisms underlying later stages of particle growth, and recent ambient measurements of NPF events utilizing single particle mass spectrometry have shown evidence of nitrogen-containing species in ~20 nm particles unassociated with sulphate neutralization and unaccounted for by current aerosol models. A potential source of this “excess nitrogen” is thought to be nitrogen-containing organics (i.e. organo-nitrogen) formed via aqueous processing of condensed organics with ammonia/amines. We assess this possibility through a series of simulated droplet-drying experiments, and compare measured elemental ratios of the remaining nonvolatile material with those observed during NPF. Aqueous solutions containing varying amounts of multifunctional volatile carbonyls (e.g. glyoxal, methylglyoxal, glycolaldehyde and hydroxyacetone) and ammonium sulfate were atomized into droplets and subsequently dried to a low (~30%) relative humidity by sending the particles through a silica gel diffusion dryer, which initiated aqueous-processed secondary organic aerosol formation. Collection of the dried particles onto a quartz microfiber filter allowed for offline analysis by high-resolution electrospray ionization mass spectrometry, which revealed various organo-nitrogen species including imidazoles and imidazole derivatives as major products formed from the drying process. Online measurements were also taken by sending particles directly from the dryer to the inlet of a single particle mass spectrometer, allowing for determination of the elemental mole fractions of the particles produced from each system. Current work entails elucidating the correlation between organic functionality and organo-nitrogen production, as well as investigating the effect of UV exposure on particle composition.

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2AC.13
Highly Oxidized Species in Fresh and Aged Secondary Organic Aerosol (SOA). PEIJUN TU, Murray Johnston, *University of Delaware*

Secondary Organic Aerosol (SOA) is produced by the oxidation of volatile organic compounds (VOC). Both the freshly formed and further oxidized SOA (also called aged SOA) have great impact on both environment and human health. Among the chemical species leading to formation of SOA is a class of highly oxidized, nonvolatile organic molecules that have molecular formulas consistent with low-volatility oxidized organic aerosol i.e. LV-OOA observed in ambient aerosol.

In this work, we have performed molecular analysis of fresh and aged SOA samples using high performance mass spectrometry to explore the characteristics of highly oxidized species in the particle phase both before and after aging. Fresh SOA was made by mixing ozone with the biogenic precursor in a flow tube reactor. Aged SOA was made by passing the fresh SOA through a photochemical reactor (PC) to simulate atmospheric aging. Both fresh and aged SOA samples were collected and then analyzed by electrospray ionization on a Q Exactive™ Hybrid Quadrupole-Orbitrap Mass Spectrometer for molecular level analysis.

Through high resolution mass analysis, we found that the highly oxidized species in the negative mode spectra of fresh SOA generated from beta-pinene were mostly composed of low molecular weight monomers ($C_{5\text{-}8}H_{8\text{-}12}O_{4\text{-}8}$). These species are most likely formed in the gas phase by the autoxidation of the gas-phase precursor after abstraction of a hydrogen atom by OH. Aging forms many new types of highly oxidized products (e.g. $C_{10}H_{10\text{-}16}O_{8\text{-}10}$ and larger) that are fundamentally different from the highly oxidized species that naturally exist in fresh SOA. These products are consistent with oxidation of oligomers, which is more likely to occur in the particle phase than the gas phase. In addition, tandem MS was utilized for the structure elucidation of highly oxidized species both before and after aging to provide information on functional groups and molecular connectivity.

2AC.14
Constraining IEPOX and IEPOX-derived SOA Formation in CMAQ with the Use of SOAS Observations. PETROS VASILAKOS, Havala Pye, Yongtao Hu, Lu Xu, Hongyu Guo, Aikaterini Bougiatioti, Kate Cerully, Lindsay Yee, Allen H. Goldstein, Nga Lee Ng, Rodney J. Weber, Matthieu Riva, Jason Surratt, Abigail Koss, Alex Guenther, Joost de Gouw, Kevin Olson, Armistead G. Russell, Athanasios Nenes, *Georgia Institute of Technology*

Biogenic aerosol has important impacts on climate and air quality. There are large uncertainties, however, on the magnitude of their impacts, largely because of the incomplete understanding of their production mechanisms and interactions with health and climate.

The 2013 Southern Oxidant Aerosol Study (SOAS) campaign was aimed towards addressing major uncertainties around the formation of biogenic secondary organic aerosol (SOA) production and the synergistic role of anthropogenic pollutants. A major focus of SOAS was the SOA forming from IEPOX through acid-mediated reactions in the aerosol aqueous phase.

In this study, we utilize the rich SOAS dataset collected at the Centerville, Alabama site to evaluate and constrain the mechanisms of IEPOX-mediated SOA (Pye et al., 2013) implemented in the Community Multi-scale Air Quality (CMAQ) model. For this, forecasted meteorology from the Weather Research and Forecasting (WRF) model specific for the SOAS period was used to drive WRF. Biogenic emissions and land use were provided from the Biogenic Emissions Inventory System version 3 (BEIS3), adjusted to match the observations of isoprene collected during the SOAS period. Both ground and aloft measurements were used for comparison.

A wide range of sensitivity studies were carried out to understand the main sources of uncertainty in all the steps of conversion of isoprene, through the pathway of isoprene epoxydiols (IEPOX) to SOA. Using the available observations of key intermediate species observed (isoprene, IEPOX, ISOPOOH, MVK, MACR, methyltetrols, organosulfates and others), adjustments were made in many of the highly uncertain reaction rate constants, partitioning coefficients and deposition coefficients of the relevant species. The Henry's law coefficient for IEPOX in water was found to be one of the most important of parameters that control aqueous isoprene OA products SOA, while the simulations reproduce the diurnal trends of all measured species available for evaluation.

Finally, the simulations suggest a strong correlation of isoprene OA with sulfate, and almost no correlation with acidity or liquid water content, consistent with correlations derived from the SOAS data set. The underlying reasons for this behavior are identified and the implications are discussed for the SE US.

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2AC.15

Aging of Alpha-pinene First-Generation Ozonolysis Products Formed under High NO_x Conditions by Reactions with OH. NINGXIN WANG, Neil Donahue, Spyros Pandis, *Carnegie Mellon University*

Secondary organic aerosol (SOA) formation from volatile organic compounds in the atmosphere can be thought of as a succession of oxidation steps. The production of later-generation SOA via continued oxidation of the first-generation products is defined as chemical aging. Our work investigates the hypothesis that while first-generation monoterpene SOA mass yields are generally lower at high-NO_x (largely because formation of organonitrates terminates oxidation sequences), later-generation (aging) SOA formation could be enhanced. This could be due to three reasons: increased radical cycling, less fragmentation of later-generation SOA products, and reduced photolysis of SOA species.

A series of experiments was conducted in the environmental chamber at Carnegie Mellon University. SOA was first formed through reaction of alpha-pinene and ozone under high NO_x conditions. During the second step, the first-generation products were allowed to react further with hydroxyl radicals (OH) generated via HNO_2 photo-dissociation. The SOA was characterized by a High-Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-AMS). Attenuated total reflectance (ATR-FTIR) was also employed to identify and quantify organonitrate functional groups. A second-generation aerosol mass yield was defined to quantify the aging effects. Potential hydrolysis effects of organonitrate compounds were also explored by performing experiments at low and high RH.

2AC.16

Secondary Organic Aerosol from Gas Phase Methylsiloxane Oxidation. YUE WU, Murray Johnston, *University of Delaware*

Ambient nanoparticles (<100 nm) can influence global climate and human health. To better understand these effects, knowledge of chemical components of nanoparticulate matter is needed. Recently, silicon was reported as a frequent component in ambient nanoparticles and the results showed that Si was often observed in urban and suburban environments but rarely detected in a remote environment, which may indicate that those particles have a man-made source. One possible source is photo-oxidation of airborne siloxanes, organic silicon compounds that are commonly used in personal care products. Owing to high vapor pressure, siloxanes are easily to be released into atmosphere and react with hydroxyl radical in the presence of light to form products that could condense on the existing nanoparticles.

In this work, secondary organic aerosol (SOA) obtained from siloxane oxidation is studied in detail for the first time. Decamethylcyclopentasiloxane (D_5, $C_{10}H_{30}O_5Si_5$) was chosen as the precursor and D_5-derived SOA was generated through a Photo-oxidation Chamber (PC) to simulate photo-oxidation in the atmosphere by reaction with hydroxyl radical. Molecular compositions of the products are characterized by Q Exactive TM Plus Hybrid Quadrupole-Orbitrap Mass Spectrometer. The ESI-MS spectra reveal a large number of both monomeric ($300 < m/z < 470$) and dimeric ($700 < m/z < 870$) products of oxidation. Most of the signal intensity comes from saturated substituted compounds in SOA samples (e.g. $C_9H_{28}O_6Si_5$). Mass weighted intensity fraction (MIF) analysis of assigned molecular formulas show that gas phase D_5 is oxidized to form SOA with an average O/Si ratio of 1.35 and C/Si ratio of 1.75. High resolution ESI-MS/MS is used to give strong evidence for major substitution types along the siloxane ring and the linkages of two siloxane rings to produce dimers. The results show that OH and CH_2OH (possibly CH_2OOH) substitutions on the siloxane ring are the dominant types, and dimers are linked by O, CH_2 and CH_2CH_2 groups. High resolution GC-MS is performed as well to confirm that among the substitutions and linkages identified above, that the major building blocks of siloxane-derived SOA are D_5 (presumably linked in a dimer), D_5 containing one OH substitution for a methyl group, and dimers linked by either an O or CH_2 group. Current work is focused on SOA yield measurements in presence and absence of seed aerosol.

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2AC.17
Enhancements in Secondary Organic Aerosol Formation in the Presence of Preexisting Organic Particles. JIANHUAI YE, Greg J. Evans, Bruce Urch, Arthur Chan, *University of Toronto*

Secondary organic aerosol (SOA) produced from atmospheric oxidation of organic vapors, comprises a large fraction of ambient particulate matter. Currently, all modeling frameworks make one key assumption that all organic species, including both primary organic aerosol (POA) and SOA form a well-mixed liquid phase. Oxidation products are assumed to partition into POA similarly as into SOA; and it follows that SOA yields (mass of SOA formed per mass of hydrocarbon reacted) are enhanced in the presence of preexisting organic aerosol.

In this work, we study the enhancement in SOA yields from preexisting organic aerosol. SOA formation from alpha-pinene ozonolysis is investigated in the presence of different organic particles, including squalane, hexadecanol, tetraethylene glycol (TEG), citric acid, and erythritol. The seeds were chosen based on their polarity and phase state at room temperature. Yield enhancement is only observed with TEG or citric acid as seed. The lack of enhancement for other seeds is attributed either to their high viscosity (hexadecanol, erthyritol), which inhibits mixing at experimental timescales, or to their low polarity (squalane), leading to immiscibility. Here we develop a method using Hansen solubility framework to determine organic miscibility and predict SOA yield enhancements. This method provides a simple predictive parameter for different types of SOA for use in atmospheric models. We also hypothesize that aerosol liquid water decreases the viscosity, leading to more mixing between organics and increased SOA yields.

In conclusion, there is a strict mixing criterion for organic aerosols in the atmosphere. It is not realistic to simply treat aerosol as a well-mixed liquid phase. Our results highlight the need to fully understand the aerosol phase state in the atmosphere in order to better parameterize SOA formation.

2AC.18
Effect of Particle Acidity on the Yield and Chemical Composition of Secondary Organic Aerosol from OH-Initiated Photooxidation of Alpha-Pinene under Low- and High-NO Conditions. YUEMEI HAN, John Liggio, Shao-Meng Li, Craig A. Stroud, *Environment Canada*

Atmospheric oxidation of biogenic hydrocarbons emitted from terrestrial vegetation contributes to a substantial amount of secondary organic aerosol (SOA). The production of SOA may be enhanced with increased aerosol acidity through acid-catalyzed heterogeneous reactions. However, the dependency of SOA on aerosol acidity has not been considered in most atmospheric chemistry models to date. In this study, experiments on SOA formation from OH-initiated photooxidation of alpha-pinene were performed in a photochemical reaction chamber to investigate the effect of aerosol acidity on the yield and chemical composition of SOA under low- and high-NO conditions. The concentrations of alpha-pinene and formed SOA were measured in real-time using a proton-transfer-reaction time-of-flight mass spectrometer and a high-resolution time-of-flight aerosol mass spectrometer, respectively. The SOA yields derived from the alpha-pinene photooxidation in low-NO experiments were substantially higher than those in high-NO experiments and did not vary significantly with aerosol acidity. In contrast, under high-NO conditions, the SOA yields increased with the increase of aerosol acidity, especially during the initial period of irradiation. The chemical composition of the SOA did not change substantially with the irradiation time once it was formed, which is evidenced by the minor changes of fragmentation patterns in the organic mass spectra during each experiment. The fraction of N-containing organic fragments increased with aerosol acidity under high-NO conditions, suggesting that organic nitrates may be heterogeneously reacting through a mechanism catalyzed by aerosol acidity. The dependence of the SOA yield from alpha-pinene photooxidation on aerosol acidity revealed from this study will be parameterized and utilized in a lagrangian box model equipped with a modified SAPRC-07 chemical mechanism to evaluate the significance of aerosol acidity in the real atmosphere, which is downwind of sulfur dioxide emission sources and over terrestrial vegetation.

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2AC.19
Bacterial Metabolism in the Atmospheric Aerosol Microbiome: Missing Sink of Oxalate? ALISON FANKHAUSER, Asher M. Krell, Simone J. Alston, Scott Banta, V. Faye McNeill, *Columbia University*

Live bacteria have been identified in cloud droplets, rainwater, and, more recently, small atmospheric aerosol particles at high altitudes. It is not known how the atmospheric environment impacts the life-cycle of these cells, or whether the metabolic activities of these cells have a meaningful impact on the chemistry of the aerosol particles. For example, oxalate is a common chemical component of atmospheric aerosols and cloud water, which is also a potential nutrient for bacteria which have been observed in aerosols aloft. Oxalate concentrations in marine boundary layer clouds have been observed to be an order of magnitude lower than model predictions based on molecular photochemistry alone (Crahan et al., 2004; Sorooshian et al., 2013). Metabolic activity of bacteria in aerosols or cloudwater may be a significant, as-yet uncharacterized sink of oxalate.

In order to investigate these issues, we performed laboratory experiments using model species which have been detected previously in atmospheric aerosol samples (Ralstonia eutropha, Cupriavidus oxalaticus), and modeling work. Bacteria tolerance to UV and fluctuations in physical conditions corresponding to different stages in the aerosol life cycle was tested. A flow cell system with constant circulation of fresh media was used to induce steady-state growth under a range of conditions relevant to atmospheric aerosols and quantify the metabolism of oxalate for different media conditions. The reaction rates and kinetics obtained from these experiments and literature studies have been implemented into GAMMA (McNeill et al. 2012), a kinetic model of atmospheric aerosol and cloudwater chemistry, in order to assess the impact of the bacterial metabolism on the composition of the atmospheric condensed phase.

2AC.21
Formation of Highly Oxidized Multifunctional Organic Compounds in the OH-Initiated Heterogeneous Oxidation of Squalene under Environmental Conditions. NADJA HEINE, Kevin Wilson, *Lawrence Berkeley National Laboratory*

As an abundant compound on human skin squalene plays an important role for indoor air quality, but it also serves as a proxy for unsaturated hydrocarbons relevant in combustion and atmospheric chemistry. Once released into the air, photochemical transformation can occur, e.g. via reaction with O3 or OH, leading to fragmentation, isomerization and/or functionalization. Recent studies have shown that in particular the formation of highly oxidized multifunctional molecules (HOM) contribute to extremely low-volatile organic compounds which may ultimately account for new particle formation and the promotion of nanodroplets to cloud condensation nuclei.

Continuous Flow Stirred Tank Reactor (CFSTR) experiments in combination with vacuum ultraviolet (VUV) photoionization aerosol mass spectrometry is used to monitor the kinetics of an OH-initiated reaction and to determine the chemical composition of an aerosol in the course of the reaction. The influence of varying OH concentration [OH] ($10^5 – 10^7$ molec./cm^3) on the effective uptake coefficient is investigated, as well as the effect of trace gases on the reaction rate and product formation.

The present study shows that the effective uptake coefficient increases as a function of decreasing [OH]. While at high [OH] ($2x10^8$ molec./cm^3) chain termination reactions involving OH radicals result in an effective uptake coefficient of 1.9, particle-phase secondary chain chemistry prevails at environmental [OH] (~10^6 molec./cm^3) thus increasing the effective uptake to over 100. The reaction appear to form highly oxidized multifunctional reaction products with O/C ratios greater than 0.6. Preliminary analysis suggest that these products are multifunctional hydroperoxides.

In contrast to a previous study with saturated hydrocarbons, the uptake coefficient shows little influence upon the addition of trace gases. However, the formation of HOM is increased by a factor of two.

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2AC.22

A Simple and Fast Approach to Determine Aldehyde-amine Reactions of Trace Compounds in the Atmosphere by Mass Spectrometry. GEOFFROY DUPORTE, Jevgeni Parshintsev, Luis Barreira, Kari Hartonen, Marja-Liisa Riekkola, *University of Helsinki*

Amines are emitted to the atmosphere from industry, combustion, biomass burning, animal husbandry and oceans. In addition, soil and vegetation act as important sources of amines, especially during periods with high biological activity. Despite the high vapor pressures of low-molecular weight amines, these compounds can affect the chemistry and lifecycle of atmospheric aerosols, especially due to their unique acid-neutralizing capacity. The reactions between amines and organic acids or carbonyl compounds may contribute to nanoparticle growth, and more knowledge is needed to estimate their role in the chemistry and lifecycle of atmospheric aerosols.

In this context, the objective of this study was to provide mechanistic data describing amine reactivity with oxidation products of monoterpenes, to improve our understanding of amines reactions in the atmosphere and assess the potential of these reactions in the formation and growth of secondary organic aerosols.

In this work, the reactivity between amine and aldehyde was investigated by a simple and fast approach, based on mass spectrometry. The original approach proposed here is based on the chemical analysis at the molecular level of both volatile and condensable products. This approach allows to study elementary reactions in highly controlled and repeatable conditions.

New products were determined and identified for the first time in this study and mechanistic pathways for aldehyde-amine reactions are proposed. Atmospheric implications of these results will be discussed. Currently, a sampling campaign is being conducted in the boreal forest at Hyytiälä, in Finland, in order to identify these compounds under ambient conditions.

2AC.23

Comprehensive Characterization of Organic Carbon in Diesel Exhaust and Wood Smoke Particulate Matter and Its Correlation to the Toxicity. KLARA ONDRUSOVA, Jana Rousova, Richard Cochran, Alena Kubatova, Annike Irene Totlandsdal, Johan Øvrevik, Per E Schwarze, Marit Låg, *University of North Dakota*

In atmospheric studies, light absorbing elemental carbon is being blamed for its substantial impact on climate, particularly, on climate cooling. However, many particulate matter-bound organic compounds are also light absorbing, yet this portion of particulate matter (PM), i.e., organic carbon, has not been adequately quantified. Therefore the goal of this study is to estimate the light absorbing portion of several representative PM samples (e.g., wood smoke, diesel exhaust) including a standard reference material and additionally investigate its relationship to the overall organic and elemental carbon content, particularly with regards to their toxicity.

Various methods are used for the characterization of the organic portion of PM. The majority of methods typically start with an extraction, which is often an insufficient sonication with dichloromethane. In this study, representative PM samples were extracted using two different sequences of pressurized organic solvent extractions of varying polarities in addition to hot pressurized water extractions that yielded extracts containing organics of different polarities and functionalities. The PM samples targeted represented matrices of a broad polarity range and of differing organic carbon content. By analyzing all extracts with multiple analytical techniques (GC-FID-MS, thermal optical analysis, UV-Vis spectroscopy), a comprehensive characterization of each sample/extract and subsequent quantification of individual classes of compounds such as acids, aldehydes, alkanes, and polycyclic aromatic hydrocarbons were accomplished. Furthermore, a range of toxicology analyses using bronchial cell lines were performed by Norwegian Institute of Public Health revealing the toxicity of individual extracts.

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2AC.24

Effect of Titanium Dioxide Particles on Secondary Organic Aerosol Formation from Photooxidation of Toluene.

TIANQU CUI, Richard Kamens, Joe Pedit, Jason Surratt, Ilona Jaspers, Kenneth Sexton, *University of North Carolina at Chapel Hill*

Nanomaterials represent an emerging field of technological innovation and industrial manufacture. Most synthetically produced nanomaterials are particles that have at least one dimension on the order of 1 to 100 nm, which are designed to possess enhanced catalytic activities compared to atmospheric particulate matter. Because most engineered nanoparticles are made through gas-phase processes, industrial emissions of these reactive materials, such as metal oxides, will be present in the local troposphere. Subsequently, these nanoscale catalysts may rapidly coagulate with pre-existing ambient aerosol, or serve as aerosol surfaces for heterogeneous nucleation of secondary organic aerosol (SOA). However, the atmospheric role of engineered nanoparticles and their detrimental health effect remain unclear due to the lack of systematic experimental studies conducted under more realistic atmospheric conditions of full spectrum sunlight and natural variation of temperature and humidity.

Since engineered nanoparticles are expected to have unique enhanced reactivity and potential photocatalytic properties as a nucleation surface in urban and rural environments, in this study, outdoor smog chamber experiments using natural diurnal sunlight, temperature and humidity, of toluene photooxidation in presence of nitric oxide were systematically conducted to investigate the effect of the pre-existing titanium dioxide (TiO2) seed aerosol, as an instance of widely used engineered metal oxide nanomaterials. Our preliminary results indicate that compared with ammonium sulfate as pre-existing particles, TiO2 enhanced and accelerated SOA formation from toluene photooxidation, potentially due to the photocatalytic formation of the reactive oxygen species, for example, hydroxyl radicals as the primary oxidant in lower atmosphere, when TiO2 is exposed to near-ultraviolet light.

2AC.25

A New Oxidation Flow Tube for Measuring Secondary Aerosol of Rapidly Changing Emission Sources.

PAULI SIMONEN, Erkka Saukko, Panu Karjalainen, Miikka Dal Maso, Topi Rönkkö, Jorma Keskinen, *Tampere University of Technology*

Both diesel and gasoline engines emit gaseous compounds that may form secondary aerosol mass through atmospheric oxidation. The formation of secondary aerosol mass from engine exhaust is often studied using large smog chambers by injecting exhaust to the chamber and oxidizing the sample thereafter. This kind of measurement does not give information on how different driving conditions affect the level of secondary aerosol mass, because the sample is either a mixture of exhaust from different driving conditions or exhaust of an idling engine.

Oxidation flow tubes afford faster oxidation, shorter residence time and thus a faster response time than smog chambers. A new oxidation flow tube, TSAR (TUT Secondary Aerosol Reactor), was designed at Tampere University of Technology to measure the potential secondary aerosol mass of engine exhaust. The laminar flow and short residence time enables the measurement of secondary aerosol mass of engine exhaust even in transient driving conditions.

The working principle of TSAR is similar to the PAM chamber. The flow tube is a quartz glass cylinder and there are two UV lamps outside the cylinder. The UV lamps emit only 254 nm radiation, so the lamps do not produce ozone. Ozone is mixed to the sample before exposure to the UV lamps. Based on CO2 residence time distributions, the flow in TSAR is nearly laminar, and losses of 10-100 nm particles are negligible. The oxidant exposure can be controlled by humidity and the amount of ozone injected to the flow tube. The maximum exposure is equivalent to the oxidation that takes place in the atmosphere in approximately one week. Dynamometer experiments showed that TSAR can be applied to differentiate between different driving conditions during a standardized 30-minute driving cycle.

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2AC.26

Deliquescence and Hygroscopic Properties of Organosulfates. ARMANDO ESTILLORE, Anusha Priyadarshani Silva Hettiyadura, Zhen Qin, Timothy Humphry, Vicki Grassian, Elizabeth Stone, *University of Iowa*

Organosulfates (OS) are important secondary organic aerosol (SOA) that have been identified in numerous field studies. This class of SOA can potentially affect aerosol physicochemical properties such hygroscopicity because of their acidic and amphiphilic nature. Currently, there is a dearth of information on how aerosol particles that contain OS interact with water vapor in the atmosphere. Herein we report laboratory investigations on the hygroscopic properties of several OS salts using Hygroscopicity-Tandem Differential Mobility Analyzer (H-TDMA) at varying relative humidity (RH). The OS studied include the potassium salts of: glycolic acid sulfate, hydroxyacetone sulfate, benzylsulfate, methyl-, ethyl-, propyl-, epoxybutanol-, and butenediol sulfate. In addition, mixtures of OS and sodium chloride were also studied. The results showed continuous uptake and evaporation of water in both hydration and dehydration processes for the OS while the mixture showed prompt deliquescence (DRH) and effloresce (ERH) point, albeit at a lower DRH and ERH relative to pure sodium chloride salt. Modeling of the hygroscopic growth of these OS at 85% RH were also conducted. This new information has important implications about the atmospheric lifetime, light scattering properties, and the role of OS in cloud formation. Moreover, results of these studies can ultimately serve as a basis for the development and evaluation of thermodynamic models for these compounds in order to consider their impact on the atmosphere.

2AC.27

Secondary Organic Aerosols from Oil Spills: Wind Tunnel Evaporation and Flow Tube Oxidation Experiments. OMAR AMADOR-MUNOZ, Haofei Zhang, Pawel Misztal, Dave Worton, Greg Drozd, Allen H. Goldstein, *University of California, Berkeley*

The Deepwater Horizon (DWH) oil spill in the Gulf of Mexico in April-August of 2010 has unfortunately provided an important case for which we need to study production of secondary organic aerosol (SOA) from evaporating oil. Little is known about the atmospheric production of SOA from oil spills which can affect human health and climate. SOA is formed in the atmosphere through oxidation of gas phase compounds forming lower volatility products that can partition into the particulate phase. We studied SOA formation from evaporation of Macondo (MC 252) oil using a wind tunnel coupled to a flow tube oxidation reactor. Ozone, UV lights, and water vapor were used to make OH radicals. SOA mass was determined by a scanning mobility particle sizer. Species specific evaporation rates and gas phase photochemical products were observed using proton-transfer-reaction mass spectrometry (PTR-qMS and PTR-TOF-MS). Chemical characterization of particle phase organics were determined using comprehensive two dimensional gas chromatography with mass spectrometry utilizing both vacuum-ultraviolet ionization and electronic impact ionization (GCxGC-VUV/EI-ToF-MS). Oil evaporation experiments were carried out at wind speeds of 2 m/s over 30 hour periods. 25% of the SOA formed in 1 h, 50% in 2 h, 75% in 5 h and 90% in 15 h. An inverse linear relationship ($r>-0.7$) between some hydrocarbons ($MW \leq 100$ Da) and SOA generation was observed in the first 90 min. After this time, a positive correlation (linear and logarithmic) was observed. Evaporation of hydrocarbons containing less than 16 carbon atoms (C16) produced around 90% of the oxidized hydrocarbons observed in the particle phase in GCxGC. We will show the implications on the production of SOA related with the number of carbons of several species with different reactivity, as well as the connection between diesel-related hydrocarbons and the hydroxyl radical reactivity.

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2AC.28

Characterization of Secondary Organic Aerosols Formed from the Photolysis of 2-Iodooctane/Air Mixtures Using 254nm Light. Iftikhar Awan, W. SEAN MCGIVERN, *National Institute of Standards and Technology*

The photolysis of alkyl iodides in air has been shown to be an excellent means to produce particles containing complex mixtures of oxygenated hydrocarbons in the laboratory. Previous work in our group has shown that photochemistry of peroxy radicals formed from the reaction of photolytically generated alkyl radicals with ambient oxygen has a significant impact on the condensed-phase product spectrum. This work focuses on the use of 2-octyl radicals formed via 254 nm photolysis of the C-I bond in 2-iodooctane in the presence of oxygen in a laminar flow cell. Condensed-phase oxidation products were collected on a microquartz filter and extracted in acetonitrile via sonication. The extract was chemically characterized using derivatization techniques to examine the hydroxyl and carbonyl functional group distributions with high-performance liquid chromatography (HPLC) coupled to UV-Vis absorption detection and ESI/MS-MS to selectively probe carbonyl- and hydroxyl-containing molecules. The observed carbonyl- and hydroxyl-substituted products are derived in part from peroxy-peroxy reactions, as expected in such a NO¬x-free environment. However, in addition, photochemically induced reactions, which include direct 2-octyl peroxy radical isomerization via internal H-abstraction and reverse dissociation to form 2-octyl radical and O2, play a key role. The complexity of the product spectrum is derived from these various channels, which scramble radical sites and further propagate the oxidation than expected in the absence of light. A comparison of the product distribution obtained from the present study with the condensed-phase product distribution of 1-octyl radical reactions with oxygen under the same experimental conditions will also be presented, particularly noting the differing carbonyl distributions that likely reflect the relative stabilities of the initial radical species and carbonyl products.

2AC.29

Characterizing the Oxidation by Nitrate Radicals of Alcohol Amines Used in Carbon Dioxide Control Technologies. PAUL VAN ROOY, Derek Price, Jackson Dulla, Dana Pierce, Tatissa Zunguze, Kathleen Purvis-Roberts, David R. Cocker III, *University of California, Riverside*

Alcohol amines are used in control technologies designed to capture and sequester carbon dioxide from the flue gas of coal-fired power plants. As this carbon capture process becomes more common, it is important to understand the detrimental environmental and human health impacts associated with the release and subsequent reaction of these compounds in the atmosphere. A number of environmental chamber experiments were conducted to characterize the oxidation of alcohol amines, including monoethanolamine, 2-methylaminoethanol, and dimethylethanolamine, with the nitrate radical. A scanning mobility particle sizer was used to determine the size distribution and concentration of the produced aerosol. A high resolution – time of flight – aerosol mass spectrometer was used to measure the particle-phase composition. A selected ion flow tube mass spectrometer was used to measure the gas-phase chemical composition. Alcohol amines formed a significant amount of particulate matter during experiments. The chemical composition of the formed aerosol varied with each amine. Gas-phase nitramines, possible carcinogens, were observed in some of the experiments. Amine nitrate salts were the dominant aerosol produced. Amine oligomers were also observed.

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2AP.2
Investigation of Particle and Vapor Wall-loss Effects on Controlled Wood-smoke Smog-chamber Experiments.
Qijing Bian, Andrew May, Sonia Kreidenweis, JEFFREY R. PIERCE, *Colorado State University*

Smog chambers are extensively used to study processes that drive gas and particle evolution in the atmosphere. A limitation of these experiments is that particles and gas-phase species may be lost to chamber walls on shorter timescales than the timescales of the atmospheric processes being studied in the chamber experiments. These particle and vapor wall losses have been investigated in recent studies of secondary organic aerosol (SOA) formation, but they have not been systematically investigated in experiments of primary emissions from combustion. Losses of vapors to the walls may impact particle evaporation in these experiments, and potential precursors for SOA formation from combustion may be lost to the walls, causing underestimates of aerosol yields. Here, we conduct simulations to determine how particle and gas-phase wall losses contributed to the observed evolution of the aerosol during experiments in the third Fire Lab At Missoula Experiment (FLAME III). We use the TwO-Moment Aerosol Sectional (TOMAS) microphysics algorithm coupled with the organic volatility basis set (VBS) and wall-loss formulations to examine the predicted extent of particle and vapor wall losses. We limit the scope of our study to the dark periods in the chamber before photo-oxidation to simplify the aerosol system for this initial study. Our model simulations suggest that over half of the initial particle-phase organic mass was lost during the experiments, and roughly half of this particle organic mass loss was from direct particle wall loss with the remainder from evaporation of the particles driven by vapor losses to the walls. We perform a series of sensitivity tests to understand uncertainties in our simulations. Finally, we discuss how our findings may influence interpretations of emission factors and SOA production in wood-smoke smog-chamber experiments.

2AP.3
Windblown Dust Characterization in the Canadian Oil Sands Region.
XIAOLIANG WANG, Judith Chow, Steven Kohl, Laxmi Narasimha Yatavelli, Kevin Percy, Allan Legge, John Watson, *Desert Research Institute*

This study characterized the generation and chemical composition of windblown dust from various sources in the Athabasca Oil Sands Region (AOSR) in Alberta, Canada. The Portable In-Situ Wind Erosion Laboratory (PI-SWERL) equipped with two real-time dust monitors and a nine-channel filter sampler was used to simulate wind-driven erosion and measure dust emissions. Sixty four sites were measured, including oil sands mining facilities, quarry operations, and roadways around Ft. McMurray and Ft. McKay. Key parameters related to windblown dust generation were characterized including: threshold friction velocity, reservoir type, and emission potential. The threshold wind speed (measured at 10 m above ground level) for particle suspension varies from 11-21.5 km/h, and saltation occurred at >32 km/h. All surfaces have limited dust supplies at lower wind speeds of <27 km/h, but have unlimited dust supplies at the highest wind speed tested (56 km/h). Unpaved roads, parking lots, or bare land with high abundances of loose clay and silt materials along with frequent mechanical disturbances are the highest dust emitting surfaces. Paved roads, stabilized or treated (e.g., watered) surfaces with limited loose dust materials are the lowest emitting surfaces. Surface watering proved effective in reducing dust emissions, with potential emission reductions of 50-99%. Surface disturbances by traffic or other activities were found to increase PM10 emission potentials 9-160 times. Other cost-effect dust control methods with longer stabilization periods merit considerations. Distinct differences in chemical composition were observed between the facility and forest sites, particularly in the abundances of sulfur, sulfate, lead isotopes, and organic compounds, indicating the alteration of natural soils by industrial activities. These data will improve the accuracy of emission inventories, dust dispersion, transport, and source apportionment models, and help design and evaluate dust control measures.

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2AP.4
Impact of Crystallization Kinetics on Spray Dried Microparticles Properties. ALBERTO BALDELLI, Reinhard Vehring, *University of Alberta, Canada*

The influence of the crystallization process on spray dried microparticles was investigated theoretically and validated experimentally. A piezoceramic dispenser was used to generate a chain of monodisperse droplets with an initial diameter in the range of 60 to 80 µm. Sodium nitrate (NaNO3) was chosen as solute for its crystallinity and strong presence in atmospheric aerosol. A broad range of solutions of NaNO3 with deionized water were prepared in a concentration range from 5 mg/ml to 5 × 10-5 mg/ml. The solution droplets were ejected into a laminar flow with temperatures of 25, 50, 75, 100, 125 and 150 °C, varying the evaporation rate and droplet temperature, accordingly. Dried particles with particle diameters between 0.3 to 18 µm were collected. A time dependent theoretical model was developed to determine saturation and crystallization time. The theoretical model introduced a dependence of the diffusion coefficient of NaNO3 in water to the droplet viscosity. The viscosity trend was experimentally determined with respect to the increase of NaNO3 mass fraction during the evaporation process. The theoretical model also considered the influence of the change of NaNO3 mass fraction on evaporation rate. The combination of theoretical derivations and experimental results showed that a higher amount of time available for crystallization lead to a larger crystal size and higher degree of crystallinity in the final microparticles.

2AP.5
Diffusive Filtration Efficiency of Granular Activated Carbons for Nanoparticles. CHANG HYUK KIM, David Y. H. Pui, *University of Minnesota*

Granular activated carbons (GACs) are widely used materials to eliminate gaseous contaminants in the air by adsorption. When gas molecules come to GACs, they move into the pores of GACs by diffusion and adhere on the inner surface of the pores. Because diffusion is also an important filtration mechanism of fibrous filters for nanoparticles, GACs can be applied to remove nanoparticles as packed-beds filters. Moreover, if the particle size approaches to 1 nm (molecular levels), the diffusive filtration efficiency of GACs may be enhanced by the internal deposition of nanoparticles on the pores of GACs.

In this study, the diffusive filtration efficiency of GACs for nanoparticles were investigated using three kinds of nanoparticles, such as silver, sulfuric acid and ammonium sulfate. They were synthesized by the condensation and evaporation method with a mini tube furnace (sliver) and by the soft X-ray assisted gas-to-particle conversion (sulfuric acid and ammonium sulfate). The monodisperse nanoparticles were introduced into the GAC holder after classifying the particle size from 3 to 30 nm using a differential mobility analyzer. The particle number concentrations upstream and downstream the GAC holder were measured by an ultrafine condensation particle counter. The diffusive filtration efficiency was calculated from the penetration ratio with the measured particle number concentrations, and increased with the inverse of the particle size. The diffusive filtration efficiency did not change with the composition of the nanoparticles, but did significantly with the face velocity. The single sphere efficiency of GACs was a function of the peclet number (Pe). The exponent of the power-law of Pe was about -0.5, which was between those of the single fiber (-0.43) and sphere (-2/3) theories by others. This implicates that the large surface area of the GAC enhanced the filtration efficiency by the internal deposition of nanoparticles on the pores surfaces.

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2AP.6

Volatility of Source Apportioned Wintertime Organic Aerosol in the City of Athens. Evangelos Louvaris, Kalliopi Florou, ELENI KARNEZI, Spyros Pandis, *University of Patras, Patra, Greece*

This work focuses on measuring the volatility distribution of ambient organic aerosols (OA). A thermodenuder (TD) with temperature ranging from 25-400 ºC and 15.8 s center-line residence time coupled to a High Resolution Time-of-Flight Aerosol Mass Spectrometer (AMS) and a Scanning Mobility Particle Sizer (SMPS) was used to measure the volatility of OA during a winter campaign carried out from 10 of January 2013 until 10 of February 2013 in an urban background site in the center of Athens. Positive Matrix Factorization (PMF) analysis of both the ambient and thermodenuder AMS spectra resulted in a four factor solution for the OA: hydrocarbon-like OA (HOA), biomass burning OA (BBOA), cooking OA (COA), and oxygenated OA (OOA). The thermograms of the four factors were fitted using the approach of Karnezi et al. (2014) and the corresponding volatility distributions were estimated. The volatility basis set of Donahue et al. (2006) using logarithmically spaced volatility bins was used for the fitting. The analysis suggested that all factors included compounds with a wide range of volatilities, from 10 to less than 10^{-4} micro-g m^{-3}. Approximately 40% of the OOA, 25% of the HOA and 10% or less of the COA and BBOA was extremely low volatile organic material (ELVOCs). At the same time around 35% of the BBOA, 30% of the HOA, 20% of the OOA had effective saturation concentration of 10 micro-g m^{-3}.

By incorporating our results in the 2-D-VBS analysis framework of Donahue et al. (2012) we concluded that HOA and BBOA were in the expected region but also include an ELVOC component. COA is in the same range as HOA but it is slightly more oxidized and less volatile. The OOA in these wintertime conditions had a moderate O:C and included both semi-volatile and extremely low volatility components.

2AP.7

The Effect of Hygroscopicity and Oxidation on the Phase State of Ambient SOA Particles in the Southeastern US. AKI PAJUNOJA, Weiwei Hu, Yu Jun Leong, Nathan Taylor, Pasi Miettinen, Don Collins, Jose-Luis Jimenez, Annele Virtanen, *University of Eastern Finland*

During the summer 2013 SOAS field campaign in a rural site in the Southeastern United States, a set of measurements including data from a hygroscopic tandem differential mobility analyzer (HTDMA), aerosol bounce instrument (ABI), and a high resolution time-of-flight aerosol mass spectrometer (AMS) were used to interpret an effect of hygroscopicity and composition on the phase state of the secondary organic aerosol (SOA) particles. In addition to sampling directly from ambient through a silica gel dryer, particles were sent through an OH-radical potential aerosol mass (PAM) flow reactor to simulate longer atmospheric aging times, up to two weeks.

Hygroscopicity and bounce behaviour of the SOA particles were found to have a clear relationship which agrees well with earlier laboratory studies; a bounce of less hygroscopic semisolid particles stays high even at high relative humidity (RH). Based on the HTDMA and AMS results, hygroscopicity parameter K was derived for organic fraction of the SOA particles assuming K-mixing rule for organic and inorganic fractions. At typical ambient relative humidities and temperatures, organic-dominated SOA particles stay mostly liquid in the atmospheric conditions in Southeastern US, but they often turn semisolid when dried below 50%RH in the sampling. While the liquid phase state suggests ideal solution behavior and instantaneous equilibrium partitioning for the SOA particles in the ambient, phase change in the drying process highlights the importance of thoroughly considered sampling techniques of SOA particles. Additional UV-oxidation of the SOA particles in the PAM chamber was found to increase the oxidation level and decrease the viscosity of the particles as seen earlier in laboratory studies.

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2AP.8

Molecular Dynamics of Evaporation and Ion Emission Process of Aqueous Nanodroplet. HIDENORI HIGASHI, Takuya Tokumi, Yasuaki Mukai, Christopher Hogan Jr., Hiroshi Suda, Mikio Kumita, Takafumi Seto, Yoshio Otani, *Kanazawa University*

A combination of tandem ion mobility spectrometry (IMS-IMS, with differential mobility analyzers), molecular dynamics (MD) simulations, and analytical models was adopted to investigate the process of both evaporation and ion (solvated Na+) emission from aqueous sodium chloride nanodroplets. Nanodroplets were produced via electrospray ionization (ESI) of a sodium salt solution in the experiment, while two nanodroplets were examined in MD simulations: (1) a 2,500 water molecule nanodroplet with 68 Na+ and 60 Cl- ions (an initial net charge of z = +8), and (2) a 1,000 water molecule nanodroplet with 65 Na+ and 60 Cl- ions (an initial net charge of z = +5). Specifically, we used MD simulations to examine the validity of a model for the evaporation rate incorporating both the Kelvin (surface curvature) and Thomson (electrostatic) influences, while both MD simulations and experimental measurements were compared to predictions of the ion evaporation rate equation of Labowsky et al. The excellent agreement between simulated and modeled evaporation rates for nanodroplets by a single fit parameter with solute volume fractions below 0.30. Similarly, MD simulation inferred ion emission rates are in excellent agreement with predictions based on the Labowsky et al equation. Measurements of the sizes and charge states of ESI generated NaCl clusters suggest that the charge states of these clusters are governed by ion emission, however, ion emisson appears to have occurred with lower activation energies in experiments than was anticipated based on analytical calculations as well as MD simulations.

2AP.9

Enhanced Growth of n-propanol Nanodroplets in the Free Molecular Regime. YENSIL PARK, Shinobu Tanimura, Barbara Wyslouzil, *The Ohio State University*

Investigations by Pathak et al. [Aerosol Sci. Technol., 2013, 14, 1310-1324] on the growth of nanodroplets in a supersonic nozzle, found that for nonane experimental and theoretical non-isothermal growth rates agreed quantitatively when condensation (q_c) and evaporation coefficient (q_e) were both equal to 1. In contrast, for D_2O nanodroplets, quantitative agreement between experiment and theory during rapid particle growth was only achieved by reducing the evaporation coefficient to ~0.5 while maintaining $q_c = 1$. One concern with the D_2O experiment was that the droplets were highly supercooled, thereby introducing uncertainty into the analysis since the physical properties for D_2O were extrapolated by up to 50K below the equilibrium melting point. Here we report on similar experiments conducted with n-propanol under conditions where droplets are not supercooled. As was observed for D_2O, we find that setting $q_c=q_e=1$ yields theoretical droplet temperatures up to ~4K lower than those estimated from mass and energy balances, and growth rates that are distinctly below those observed experimentally. Again, better agreement was found by setting $q_e=0.6$ with $q_c= 1.0$ or, alternatively, setting $q_c=\sim1.3$ and $q_e = 1.0$. Possible reasons for these differences will be discussed.

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2BA.1

Diversity and Difference of Bacteria in PM2.5 before and during the APEC Meeting Days in Beijing City. PENGRUI DU, Rui Du, Zedong Lu, Pingqing Fu, *University of Chinese Academy of Science*

Particulate matters with aerodynamic diameter <2.5μm (PM2.5) have been a significant air pollutant in Beijing city. Bacteria in PM2.5 are thought to be the important cause for various allergies and respiratory diseases. People feel uncomfortable and the number of patients increases when the air quality condition is poorer, especially during the haze weather processes. However, the differences of bacterial communities in PM2.5 under different air quality conditions have not been reported. In the present study, we collected PM2.5 samples from15 Oct to 12 Nov. Due to the government's strong control about the air quality, APEC blue sky appeared during the meeting opened days. The weather conditions of sampling days were divided into three levels according to the Air Quality Index (AQI) (AQI=0-100, 101-200, 201-300) and analyzed the dissimilarities of bacteria between them through the 16s rRNA gene high-throughput sequencing using the Ilumina Miseq PE250 platform. A total of 429 different kinds of bacteria in genus level were detected and Sphingomonas (7.94%), Paracoccus (6.60%), kocuria (5.13%), Rubellimicrobium (3.86) and Arthrobacter (3.18%) were the primary groups in the 80 thousand gene sequences. The majority of the inhalable microorganisms were nonpathogenic to human. Similarities of bacterial communities in different samples were more than 60% and no obvious significant differences were discovered either good or poor air qualities. The results suggest that during the severe haze pollution episodes, the role of bacteria in PM2.5 to human health should be reconsidered.

2BA.2

Influence of Storm Origin and Type on Biological Ice Nucleation Activity in Louisiana Precipitation. RACHEL JOYCE, Heather Lavender, Jennifer Farrar, Mickaël Vaitilingom, Juliana D'Andrilli, Brent Christner, *Louisiana State University*

Certain microorganisms are ice nucleation active and initiate ice formation at temperatures much warmer than most mineral dust particles in the atmosphere. As such, these bioaerosols may significantly contribute to precipitation formation processes at mid tropospheric altitudes. To better characterize biological ice nuclei (IN) in the atmosphere, we collected and analyzed samples from 54 precipitation events in Louisiana from May 2013 to March 2015. Biological IN activity of the samples was measured between -4°C and -15°C using an immersion freezing assay, and microbial cell abundance was quantified using epifluorescence microscopy. Major ion (NO_3^-, SO_4^{2-}, Cl^-, Na^+) and dissolved organic carbon (DOC) concentrations, pH, and conductivity of collected precipitation were also measured. Storm origin and classification was determined by examining NEXRAD reflectivity, GOES-East satellite imagery, NOAA's HYSPLIT trajectories and WPC surface analyses. Biological IN concentrations at -15°C ranged from 52 to 12,000 IN L^{-1} of precipitation, with cell concentrations remaining relatively constant at ~10^4 to ~10^5 cells L^{-1} of precipitation and independent of IN activity. Analysis of 72-hr backwards trajectories indicated air masses at 5000, 6000, and 8000 mAGL that originated over the tropical Pacific ocean correlated strongly with high biological IN activity (MANOVA, $p = 0.0355$, $p = 0.0067$, and $p = 0.0208$, respectively), when compared to other North American air masses. Additionally, precipitation from frontal nimbostratus storms contained significantly higher biological IN activity than that of convective storms (MANOVA, $p = 0.0141$), with snow and sleet from nimbostratus clouds yielding the highest detected biological IN activity (MANOVA, $p < 0.001$). Concentrations of Cl^-, Na^+, NO_3^- and pH showed moderate correlations with biological IN active between -6°C and -9°C. Collectively, our data suggest that variation of biological IN activity in precipitation is connected to air mass origin, storm type, and precipitation type.

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2BA.3

Observations of Fluorescent Aerosol at the Maido Observatory on La Reunión. ANNE PERRING, Ellis Shipley Robinson, Mark T. Hernandez, Odessa Gomez, David O'Connor, J. Alex Huffman, Joshua P. Schwarz, Jerome Brioude, Stephanie Evan, Aurelie Colomb, Valentin Duflot, Jean-Marc Metzger, Pierre Tulet, Ru-Shan Gao, David Fahey, *CU CIRES- NOAA ESRL*

Primary Biological Aerosol Particles (PBAP) may impact atmospheric processes in a number of ways; as a component of aerosol and via potential roles in cloud formation and precipitation. Current observations, however, are inadequate to assess the true atmospheric importance of PBAP on global or regional scales especially in remote marine environments and the Southern Hemisphere. Here we present measurements of fluorescent aerosol (a proxy for PBAP) made at the Maido Observatory on the French island of La Reunión in the southern Indian Ocean. Two Wide-Band Integrated Bioaerosol Sensors (WIBS 4A) were run at staggered gain to detect particles of diameter ~0.3 um to 15 um. Strong diurnal cycles in both total particle and fluorescent particle loadings were observed. The fraction of fluorescent particles was 2-20%. Particle concentrations were much higher during the day than at night, however the fluorescent fraction often varied inversely. We examine the relationship of fluorescent aerosol loadings and characteristics to meteorological conditions and other particle- and gas-phase tracers. We also use the measured single-particle fluorescent signals and optical size distributions to infer relative contributions of bacteria and fungal spores to the observed loadings. Typical diurnal flow patterns at the observatory result in sampling predominantly local island sources during the day and airmasses from a larger geographical area at night. We use this to examine fluorescent aerosol loadings and characteristics from both local island sources and the larger surrounding marine environment.

2BA.4

Correlations of Airborne Microbial Community with Air Pollutions in Beijing. WEIZHUO YAN, Buying Wang, Changyi Xie, Yunfeng Yang, Jingkun Jiang, *Tsinghua*

Airborne microorganisms are ubiquitous in the atmosphere and may have substantial impacts on atmospheric physics, chemistry, and human health. On the other hand, airborne microbes may also be affected by other species in the atmosphere. The potential influence of the severe air pollutions in urban environment on airborne microorganisms remains unexplored. In this study, we examined the response of microbial communities to gaseous pollutants, chemical components in particulate matter, and meteorology parameters. Twenty-three daily PM10 samples were collected in Beijing during the winter of the past three years. Airborne microbial communities were characterized by 16S rRNA sequencing and metagenomic sequencing. Chemical components of these PM samples were also analyzed. It was found that temperature and relative humidity have strong influence on the structure of microbial community ($P<0.01$). The relative abundances of 18% genera of bacteria are strongly correlated with temperature, while the biodiversity becomes high when relative humidity increase. Both NOx and water-soluble NH4+ in PM appear to be strongly correlated with the community structure and the relative abundance of several kinds of microorganisms ($P<0.01$), especially some genera which play crucial roles in the process of nitrogen cycle.

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2BA.5

Screening of Biosurfactants from Cloud Microorganisms.

Isabelle Canet, Martine Sancelme, Pascal Renard, Mounir Traikia, Yveta Uhliarikova, Peter Capek, Maria Matulova, Pierre Amato, ANNE-MARIE DELORT, *Université Clermont Auvergne, france*

The formation of cloud droplets from aerosol particles in the atmosphere is still not well understood and a main source of uncertainties in the climate budget today. One of the principal parameters in these processes is the surface tension of atmospheric particles, which can be strongly affected by trace compounds called surfactants.

Within a project devoted to bring information on atmospheric surfactants and their effects on cloud droplet formation, we focused on surfactants produced by microorganisms present in atmospheric waters.

From our unique collection of microorganisms, isolated from cloud water collected at the Puy-de-Dôme (France) (1), we undertook a screening of this bank for biosurfactant producers. After extraction of the supernatants of the pure cultures, surface tension of crude extracts was determined by the hanging drop technique. Results showed that a wide variety of microorganisms are able to produce biosurfactants, some of them exhibiting strong surfactant properties as the resulting tension surface decreases to values less then 35 mN.m-1.

Preliminary analytical characterization of biosurfactants, obtained after isolation from overproducing cultures of Rhodococcus sp. and Pseudomonas sp., allowed us to identify them as belonging to two main classes, namely glycolipids and glycopeptides.

Reference
(1) Vaïtilingom, M.; Attard, E.; Gaiani, N.; Sancelme, M.; Deguillaume, L.; Flossmann, A. I.; Amato, P.; Delort, A. M. Long-term features of cloud microbiology at the puy de Dôme (France). Atmos. Environ. 2012, 56, 88-100.

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2BA.6

Resistant Microorganisms Present in Cattle Feedlots in Airborne in Tijuana, Mexico.

LILIA HURTADO, Guillermo Rodriguez, Javier Emmanuel Castillo-Quiñones, Luisa Molina, Penelope Quintana, Jonathan Lopez, Marvic Carrillo, *Universidad Autonoma de Baja California, Tijuana, Mexico*

Cattle industries are an important source of particulates and bioaerosols material. These substances have a detrimental effect on both public health and the environment. In Mexico the use of drugs in animal production has been an unregulated; following practice favors the inappropriate use of drugs causing the development of antimicrobial resistant strains of pathogenic and non-pathogenic bacteria. Feedlots were ideal place to study antibiotic resistance because bacteria are exposed to high levels antibiotics.

Air samples were taken with the M Air T (Millipore) at different distances from the center of activity at each site. Cultivation methods based on the viable counts of mesophilic bacteria, total and fecal coliforms, enterococci and other pathogenic bacteria. During air sampling, temperature, solar radiation, relative humidity and wind speed were measured.

The determination of antibiotic resistance was performed as follows instruction for CLSI 2015. The classification of strains was conducted according to data from the disc manufacturer (BBL).

The results of the studies on the resistance to antibiotics showed that the bacteria isolated were in quite a significant percentage resistant to antibiotics. In the case of penicillin, the sensitivity to 50% in the case of bacteria isolated.

The bacteria resistant to erythromycin were observed in 63%. A highest number of strains resistant to streptomycin (58%).

The number of strains resistant to tetracycline varied from 9% to 29%.

The number of strains resistant to vancomycin varied from 4% to 23%. A high proportion of antibiotic-resistant bacteria suggest that these strains had contact with antibiotics in the past and have acquired resistance to them or the resistance genes were transferred to them from other antibiotic-resistant bacteria. The highest number of resistant strains was selected if penicillin was used. This finding may be related to a long-term application of this antibiotic in medicine.

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2BA.7

Multi-instrument Inter-comparison of Fluorescent Bioaerosol Measurement Techniques during Summer 2014 in Saclay, France. WALFRIED LASSAR, Kyle Pierce, Roland Sarda-Esteve, Jean Sciare, Ian Crawford, Martin Gallagher, David O'Connor, John Sodeau, Marie Prass, Christopher Pöhlker, Ulrich Poeschl, Sampo Saari, Jorma Keskinen, J. Alex Huffman, *University of Denver, CO*

The real-time measurement of biological aerosols has been a field of growing interest due to the desire to obtain particle information at greater time resolution compared to traditional collection techniques, i.e impaction followed by microscopy analysis. High time resolution is needed, e.g., in biological aerosol emission flux measurement or in early warning systems against bio-warfare threats. However, with this growing interest the number of light-induced fluorescence (LIF) instruments capable of online measurements applied to bioaerosol detection has also increased. Relatively little work has been done to study the comparison of such instrumentation techniques with regard to their ability to detect particle concentrations, their fluorescence properties, and even size and shape characteristics.

From late June through early August 2014, a comprehensive international campaign (BIODETECT-2014) took place at the CEA/LSCE SUPERSITE in Saclay, France (15 km south from central Paris). The LIF instruments deployed included multiple WIBS (wideband integrated bioaerosol sensors: 3, 4 and 4A, DMT Inc.), a UV-APS (ultraviolet aerodynamic particle sizer, TSI Inc.), a MBS (multi-parameter bioaerosol spectrometer, University of Hertfordshire), and a Bioscout (Environics Ltd.). Alongside the LIF instruments, filter samples were collected on a single-stage impactor, stained with DAPI, and analyzed with fluorescence microscopy. Particle concentrations and their fluorescence properties were compared across the various LIF instruments. The presence of multiple WIBS versions allowed for the first ever comparison between generations and units of this one instrument type. The LIF measurements were also compared to the particle concentrations calculated via fluorescence microscopy. Preliminary findings will be presented.

2BA.8

Design and Development of a Portable Electrostatic Bioaerosol Sampler (PEBS) with High Sampling Flow Rate. TAEWON HAN, Gediminas Mainelis, *Rutgers, The State University of New Jersey*

The objective of this exploratory research is to develop a novel portable electrostatic bioaerosol sampler (PEBS), where bioaerosols are drawn into an open channel collector, electrically charged and deposited onto a removable plate covered with a superhydrophobic substance. The new sampler will allow a more accurate monitoring of personal exposures to even low microorganism concentrations and thus improve the ability to identify the exposure risks and protect affected populations. Since this personal bioaerosol sampler will be light, self-contained and battery-operated, it will be easy to wear and apply for occupational and environmental studies and field deployments.

The prototype of PEBS was designed and optimized using computational fluid dynamics (CFD) simulation. It has a shape of a cylinder of 1 inch in diameter and is made of static dissipative material. The collection chamber is split in two by a stainless steel rectangle collection plate (1×1.75 inches) and each half has a charger (e.g., carbon fiber) located 0.75 inches downstream of the collection plate front; this configuration allows collection of duplicate samples. The sampler features a 3D-printed air blender positioned at its inlet to improve mixing of the incoming aerosol particles with ions. When the sampler was tested at different sampling flow rates (10 to 30 L/min) and collection/charging voltages (-3 to -5 kV) with 1 micron polystyrene latex particles, it showed collection efficiency as high as 90%. In the next stage, the sampler will be further modified to improve its performance at higher flow rates and then it will be challenged with bacteria and fungi.

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2BA.9
Fluctuation of Viable and Non-viable Bacterial Concentration in the Air Associated with Weather Changes: Observations on the Southwestern Coast of Japan. KOTARO MURATA, Daizhou Zhang, *Prefectural University of Kumamoto*

Our group is trying to reveal the dynamics of airborne bacteria over East Asia. Air masses in East Asia are quickly replaced by thermodynamically different air due to moving cyclones and anticyclones in the Northern Hemisphere Mid-latitude westerly winds, which results in the worldwide transport of desert dust particles and air pollutants from upwind areas to downwind areas. In a previous study, we had developed a method to investigate the evolution of the concentration of viable and non-viable bacteria during air mass changes, using LIVE/DEAD BacLight Bacterial Viability Kit and fluorescence microscopy. We conducted a series of short-term observations to address the evolution of bacterial concentration and viability (the ratio of viable ones) in thermodynamically different air masses at two sites on the southwestern coast of Japan. The results showed that (1) the sum of viable and non-viable bacterial concentrations in the air ranged on the order of 10^5 cells m^{-3}; (2) the highest median of the concentration and the lowest median of the viability (the ratio of viable ones) were observed after the passage of cyclones, i.e. when particle-loading cold air arrived from the Asian continent; (3) at the seaside site the viable one momentarily increased when airflow shifted between land and sea breezes under anticyclones. Our results showed comparably the low viability of bacterial cells via aerial transport and suggested the necessity of the careful consideration of synoptic weather changes as well as local weather conditions for further researches on bioaerosol dynamics.

2BA.10
Evaluation of the Wide-Band Integrated Bioaerosol Sensor (WIBS) as an Automated Pollen and Fungal Spore Monitor vs Traditional Hirst-Type Impactors: Payerne, Switzerland in 2013. DAVID O'CONNOR, Natalie Lemonis, Bernard Clot, Santiago Fernández-Rodríguez, Rafael Tormo-Molina, John Sodeau, *University College Cork*

Recently there has been increasing scientific interest in the determination of the airborne concentrations of Primary Biological Aerosol Particles (PBAP) of all types including pollen, fungal spores and bacteria. The reason is due, in part, to their known capacity to directly induce and/or exacerbate health conditions such as hay fever, asthma and Farmers' Lung. Hay fever in particular has been seen to affect significant portions of the population with many displaying sensitivity to certain pollen species.

Traditional techniques of pollen identification and concentration determination have focused on the impaction of pollen on to a suitable substrate before later using optical microscopy for analysis. This method however is very labour intensive and has data that is usually available after a delay of several days. Recently however, newer on-line, real-time, single particle fluorescence spectrometers such as the Widband Integrated Bioaerosol Sensor (WIBS) have begun to use fluorescent particle concentrations as a proxy for the measurement of PBAP.

In this study a WIBS-4 instrument was co-located with a number of Hirst-type volumetric traps on the roof of the MeteoSwiss meteorological station sited in Payerne, a rural area, for a four month period in the summer of 2013. Total pollen concentrations, measured by the contrasting techniques, were compared and size-resolved diurnal distributions were constructed. Similarly fungal spore concentrations were also compared to fluorescent counts established by the WIBS.

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2BA.11
Detection of Fluorescent Particles with a Wideband Integrated Bioaerosol Sensor (WIBS-4A) at CEA Atmospheric Super Site in the Region of Paris.
DOMINIQUE BAISNEE, Roland Sarda-Esteve, Michel Thibaudon, Gavin McMeeking, Ian Crawford, Martin Gallagher, J. Alex Huffman, David O'Connor, John Sodeau, Virginia E. Foot, Jean-Maxime Roux, Christophe Bossuet, *CEA*

In the frame of the Bio Chemical Collectors (BCC) research project from the French Atomic Energy Commission (CEA) a Wideband Integrated Bioaerosol Sensor model 4A has been deployed during the summer and winter period at the CEA Atmospheric Super Site. The first objective of this study was to investigate the ability of this type of instrument to detect bioaerosols in a complex environment often impacted by pollution events. The second was to refine the relationship between meteorological parameters and the observed fluorescence. A spore trap has been used to identify the presence of aerosols and their concentration. Optical counting and identification of pollens and fungal spores has been done by the National Network of Survey for Airborne Contaminants (RNSA). During these two periods of the year the type and the nature of the particles are different. In the summer period, the abundance of microorganisms including fungal spore ranges from 1000 to 5000 nb#/m3 while during the winter the concentrations were less than 200 Nb#/m3. In the winter period the major sources were due to local combustion processes or pollution from long range transport. These sources comprised aerosols mostly from wood burning, fossil fuel combustion or inorganic and Secondary Organic Aerosol (SOA) during severe pollution events. The concentration of Particulate Matter less than 10 µm (PM10) varied from 1 to 150 µg/m3. The signal observed on the WIBS4A was mostly correlated with the presence of Black Carbon and Polycyclic Aromatic Hydrocarbons (PAH). During the summer period, high concentrations of Biogenic Volatile Organic Carbon (BVOC) were also observed. The Particulate Organic Matter (POM) measured was more functionalized and originated from atmospheric processing leading to the formation of fine particulate HUmic Like Substances (HULIS). More work is needed to understand the fluorescence associated with these fine particles.

This work is supported by the CBRN-E R&D research program from CEA/DAM.

2BA.12
Relationship Between Allergy Symptoms Pollen Grain Concentration and Atmospheric Pollution Events in the Region of Paris.
ROLAND SARDA-ESTEVE, Michel Thibaudon, Vincent Auvigne, Dominique Baisnee, Benjamin Guinot, Jean-Maxime Roux, *CEA*

The Network of Survey for Airborne contaminants (RNSA) monitors pollen concentrations for all the identifiable species since 1985. This monitoring is based on a dense network of 400 sensors spread all over France. The technique used in the network allows getting a concentration of pollen grains every two hours. These data have been since the beginning associated with records from a panel of doctors to give a second level of information on allergic symptoms. OpenHealth.fr designed and is publishing a health indicator aiming to monitor allergic rhinitis using drug sales data (mainly antihistamines) from over 4600 pharmacies. Data is available since 2010. The relationship between allergy symptoms and the presence of pollens in the atmosphere has been well established by combining all the data. The concept is based on the comparison on the day mean of pollen concentration and the health indicator. To date, the relationship between pollution events, meteorological parameters and the allergic rhinitis has not been achieved. Our study aims to understand their respective relevance according three distinct pollution events in the search of new triggers to prevent sanitary risks. We present here preliminary results on the relationship between allergic rhinitis, pollen concentration and pollution events.

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2BA.13

A Novel Bioaerosol Sampler for the Preservation of Viral Infectivity. DANIEL VERREAULT, Caroline Duchaine, Solange Levesque, Samira Mubareka, *Sunnybrook Health Sciences Centre and Research Institute*

Viral particles may be aerosolized through various means. Once airborne, these viruses are exposed to environmental factors that may affect their potential to cause infection in susceptible hosts. The infectious potential of an aerosol may be underestimated if the viral particles are damaged during sampling. A novel bioaerosol sampler was developed to capture airborne particles while maintaining viral infectivity. Four bacteriophages (MS2, Phi6, PhiX174 and PR772) were used. These viruses were nebulized and sampled with the novel sampler and compared with 37 mm diameter 0.3 µm polytetrafluoroethylene (PTFE) membrane filters. Material from both samplers was recovered and analysed by culture and quantitative polymerase chain reaction. The proportion of infectious particles to total genomic quantification was compared. Preliminary data revealed that phages MS2, PhiX174 and PR772 retain their infectivity more efficiently when sampled with the novel sampler, whereas Phi6 viability was more efficiently preserved with the control PTFE filter. Although non-enveloped viruses seem to respond positively to the novel sampler, more enveloped viruses will need to be put to the test before any general conclusions can be drawn regarding the influence of the envelope. The novel sampler could allow better estimations of viral integrity in aerosols.

2CA.1

Spatial Patterns and Temporal Trends of Black Carbon in Boston MA. GEORGE ALLEN, *NESCAUM*

Spatial patterns and temporal trends of black carbon soot (BC) in Boston, MA were evaluated using Aethalometer data from multiple sites and years. BC data were corrected for known artifacts from spot loading and instrument configuration changes over the 15-year period of data collection. Concentrations of BC decreased by almost a factor of 2 between 2002 and 2004; during this time period, the entire Boston school bus and city public transit bus fleets were either replaced or retrofitted with diesel particle filters, and State diesel Inspection and Maintenance programs were implemented. The large decrease in BC is likely due to these programs, and demonstrates their effectiveness and benefits. From 2005 to 2014, BC concentrations in Boston have not decreased at two of the three long term monitoring sites. Annual average BC at the new Boston near-road site is 1.5 micro-grams/m^3 (2014), similar to neighborhood scale BC in 1999-2001 and twice as high as BC now measured at the urban-scale NCore site in Boston. BC is substantially higher in late summer compared to late winter, fitting the pattern of inverse monthly wind speed. There were substantial spatial gradients of annual average BC, with concentrations at core downtown sites 3 times higher than at the upwind suburban site. BC was associated with time of day and day of week traffic patterns, consistent with mobile source activity. Within the core urban area, there was substantial local scale heterogeneity. Diurnal day of week analysis identified the influence of a local emergency genset's weekly testing operation on BC at one of the urban sites. Non-parametric wind regression analysis identified a commuter rail hub as a large source of BC.

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2CA.2

Detection of Carbonaceous Aerosols by Using Laser Induced Breakdown Spectroscopy (LIBS). GIBAEK KIM, Myoseon Jang, Kihong Park, *Gwangju Institute of Science and Technology*

Carbonaceous aerosols that mainly comprise black carbon (BC) and organic carbon (OC) are ubiquitous in the atmosphere. They can affect visibility, radiation balance, and human health. Laser-induced breakdown spectroscopy (LIBS) can be used for multi-elemental analysis of diverse samples either in solid, liquid, or gas phase. In this study, feasibility of the LIBS technique as a tool to determine elemental compositions of carbonaceous aerosols was tested. After various aerosols were collected on the silver membrane filter, the Q-switched Nd:YAG laser was employed as the excitation source (40 mJ/pulse with a pulse width of 4-5 ns at a wavelength of 1064 nm). Repetition rate and delay time were set to be 1 Hz and 1 us, respectively. After laser-induced plasma was generated, the light emitted from the plasma was collected and was then delivered to the spectrometer (190 nm to 884 nm). Emission lines of carbon (247.856 nm), hydrogen (656.286 nm), and oxygen (777.421 nm) were analyzed. During the measurements, argon (99.999%) was used as the surrounding gas to avoid chemical interference caused by pre-existing elements in air. Relationship between nominal atomic ratios (H/C and O/C) of aerosols and LIBS responses were investigated. Chemometric tools such as principal component analysis (PCA) and partial least squares discriminant analysis (PLS-DA) were applied for further analysis. The data suggest that LIBS coupled with Chemometrics can be used to detect elemental compositions of carbonaceous aerosols and to classify various carbonaceous aerosols according to their classes.

2CA.3

Oxidative Potential of Ambient Ultrafine Particulate Matter in the Los Angeles Air Basin: Possible Impact of Atmospheric Aging. ARIAN SAFFARI, Sina Hasheminassab, Dongbin Wang, Martin Shafer, James Schauer, Constantinos Sioutas, *University of Southern California*

There is growing literature supporting the hypothesis that the most important pathway underlying the adverse health effects of exposure to particulate matter (PM) is the oxidative stress derived from the interaction of PM with cells. Differences in the chemical and physical properties of particles from secondary and primary sources can potentially lead to differences in their oxidative potential. The effect of aging on PM oxidative potential, measured by chemical (abiotic) assays (e.g. DTT assay), has been investigated in previous chamber studies and increased ROS activity for photochemically-aged particles compared to fresh particles was reported. Other than smog chamber measurements, previous dynamometer studies imply the possible effect of aging on the ROS activity as well. This study aims to investigate the effect of atmospheric aging on the oxidative potential using field measurement techniques, in order to provide much-needed insight regarding the toxicity of airborne particles in the real-world urban atmosphere rather than laboratory conditions. To this end, ultrafine particles were collected at 3 locations along the prevailing air trajectory across the Los Angeles south coast air basin at three specific time periods of the day (morning rush hour at the source location, followed by mid-day and afternoon at the two further downwind regions) and oxidative potential of the particles were quantified. Furthermore, comprehensive chemical analysis was conducted on the collected samples, followed by source apportionment of organic carbon (OC) using Chemical Mass Balance (CMB) Receptor Modeling. Secondary organic aerosol (SOA) and vehicular emissions were by far the two most dominant sources of OC at all three locations, with increased concentration of SOA at the downwind regions. Univariate and Multivariate regression analysis between the ROS activity and the CMB-derived sources indicated an increased contribution from SOA as the particles move along the basin and get aged throughout the mid-day and afternoon periods.

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2CA.4

Characteristics and Major Sources of Carbonaceous Aerosols in PM2.5 from Sanya, China. JINGZHI WANG, Steven Sai Hang Ho, Junji Cao, Rujin Huang, Jiamao Zhou, Youzhi Zhao, Hongmei Xu, Suixin Liu, Gehui Wang, Zhenxing Shen, Yongming Han, *Institute of Earth Environment, Chinese Academy of Sciences*

PM2.5 samples were collected in Sanya, China in summer and winter in 2012/2013. Organic carbon (OC), elemental carbon (EC), and non-polar organic compounds including n-alkanes (n-C14-n-C40) and polycyclic aromatic hydrocarbons (PAHs) were quantified. The concentrations of these carbonaceous matters in winter generally were higher than in summer. The estimated secondary organic carbon (OCsec) accounted for 38% and 54% of the total organic carbon (TOC) in winter and summer, respectively. The higher value of OCsec in summer proves that photochemical conversions of organics are much active at the higher air temperatures and with stronger intense solar radiation. Calculations of carbon preference index (CPI) and percent contribution of wax n-alkanes suggest that anthropogenic sources were more dominant than derivation from terrestrial plants in this tourist city. Diagnostic ratios of atmospheric PAHs indicate that there was a wide mix of pollution sources in winter while fossil fuel combustion was the most dominant in summer. Positive Matrix Factorization (PMF) analysis for 18 PAHs in the winter samples show that motor vehicle emissions and biomass burning were the two main pollution sources, contributing 37.5% and 24.6% of the total quantified PAHs, respectively.

2CA.5

Chemical Characterization of Organic Aerosol in Greater London Area Using High Resolution Aerosol Mass Spectrometry: Aerosol Volatility and Spatial Distribution. LU XU, Leah Williams, Dominique Young, James Allan, Hugh Coe, Paola Massoli, Edward Fortner, Puneet Chhabra, Scott Herndon, Allison Aiken, Kyle Gorkowski, Manvendra Dubey, Zoe Fleming, Nga Lee Ng, *Georgia Institute of Technology*

The Clean Air for London (ClearfLo) project aimed to study boundary layer pollution in the greater London area through comprehensive measurements of meteorology, gaseous and particulate composition. Two High-Resolution Time-of-Flight Aerosol Mass Spectrometers (HR-ToF-AMS) were deployed at one rural site (Detling, UK) and one urban site (North Kensington, London, UK) to perform simultaneous characterization of non-refractory submicron particles during winter 2012. The high-temporal resolution comparison between the two sites suggests that the source of sulfate is regional, but the major source of nitrate is local production. The sources of organic aerosol (OA) are more complex. In order to determine the sources of OA, we performed positive matrix factorization (PMF) analysis on the OA mass spectra and resolved multiple OA subtypes, including hydrocarbon-like OA, solid fuel OA, and oxygenated OA. These factors show different behavior between the rural and urban sites.

In addition to the spatial distribution of OA, the volatility of OA was also investigated by using a thermal denuder at the Detling site. An HR-ToF-AMS, a soot-particle AMS (SP-AMS), a single particle soot photometer (SP2), and a scanning mobility particle sizer (SMPS) were deployed in parallel and downstream of the thermal denuder. A large fraction of mass remains in the particle-phase even after thermal-denuding at 250°C. Our instrumentation setup allows us to directly characterize the non-volatile residual at 250°C. In addition, we investigated the relationship between the O:C ratio and OA volatility. On one hand, the O:C ratio of the thermally-denuded OA increases with heating temperature, suggesting that the O:C is inversely correlated with the OA volatility. On the other hand, the mass fraction remaining of OA after heating only shows weak correlation with the O:C of ambient OA, suggesting a lack of relationship between O:C and OA volatility. Possible explanations to these observations will be discussed.

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2CA.6

Optical and Physical Characterization of Coal Fly Ash and Powdered Activated Carbon Agglomerates. TIAN XIA, Herek Clack, *University of Michigan*

The most mature technology for controlling mercury emissions from coal combustion is the injection into the flue gas of powdered activated carbon (PAC) adsorbents having chemically treated surfaces designed to rapidly oxidize and adsorb mercury. However, carbonaceous particles are known to have low electrical resistivity, which contributes to their poor capture in electrostatic precipitators (ESPs), the most widely used method of particulate control for coal-fired power plants worldwide. Thus, the advent in the U.S. and other countries of mercury emissions standards for power plants has the potential for increased emissions of PAC.

Our previous analyses have provided estimates of PAC emission rates resulting from PAC injection in the U.S. and extrapolated these estimates globally to project their associated climate forcing effect. The present work continues the examination of the potential climate forcing effects of such mercury sorbents by conducting the first comparative measurements of optical scattering and absorption of aerosols comprised of varying mixtures of coal combustion fly ash and PAC. A partially fluidized bed (FB) containing fly ash-PAC admixtures with varying PAC concentrations elutriates aerosol agglomerates. A photo-acoustic extinctiometer (PAX) extractively samples from the FB flow, providing measurements of optical absorption and scattering coefficients of fly ash alone and fly ash-PAC admixtures. Extracted aerosol samples from the FB flow provide particulate loading measurements and SEM images of the collected aerosols provide qualitative insight into size distributions and agglomeration state, useful in determining optical absorption and scattering efficiency values. Soot from an oil lamp flame provides a comparative benchmark. The results indicate that the addition of 1% PAC to fly ash yields agglomerates having ~20 times greater absorption, ~1/5 of the value for soot. Results for optical scattering suggest no significant impact of PAC. These results can enhance optical property data and emissions inventories used in models of climate forcing by particulate carbon.

2CA.7

Seasonal Variations in the Carbonaceous Composition of Size-Resolved Particles Collected in Tempe, Arizona. DENISE NAPOLITANO, Pierre Herckes, *Arizona State University*

Atmospheric processing (chemical and physical) and variations in aerosol sources both affect the composition of particles in different size fractions. However, few studies exist that examine individual organic compounds in size-resolved aerosol samples, and fewer still characterize these types of samples using isotopic analysis. In this study, total carbon (TC) and individual n-alkanes were quantified and analyzed for stable carbon isotopic composition to determine variations in particle composition among different seasons and different size fractions.

Aerosol samples were collected on the Tempe campus of Arizona State University in January, April, June, and October of 2014. High-volume samplers were equipped with five cascade impactor stages to collect particle size fractions with cutoff diameters of 7.2, 3, 1.5, 0.95, and 0.49 microns, and a backup filter to collect particles smaller than 0.49 microns. Samples were analyzed by thermal optical transmittance for TC concentration, and isotopic analysis of TC was performed using elemental analysis – isotope ratio mass spectrometry. n-alkanes were quantified by GC/MS, and compound-specific isotope analysis was performed by gas chromatography-combustion-isotope ratio mass spectrometry.

Samples collected in January were found to be more concentrated and lighter in total isotopic composition by 0.5-1.7 per mil, indicating a dominant emission source in the winter that is less significant in warmer months. Changes in isotopic composition with particle size during a single sampling period were observed for bulk carbon and n-alkanes in all seasons, signifying varying source contributions with particle size. The carbon preference index (CPI) of long-chain n-alkanes in April, June, and October, as well as the depletion of carbon-13 in odd-chain n-alkanes during the spring and summer months, indicate dominance of biogenic sources during these sampling times, while a CPI < 2 in January suggests a dominance of anthropogenic emissions.

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2CA.8
Evaluation of Modeled Organic Aerosol Formation in the Houston Region Using Measurements from the 2013 DISCOVER-AQ Campaign. BONYOUNG KOO, Lea Hildebrandt Ruiz, Rebecca Sheesley, Sascha Usenko, Greg Yarwood, *Ramboll Environ*

Ambient fine particulate matter (PM2.5) in the Houston area is influenced by diverse sources including natural sources, motor vehicles, petrochemical industry, marine vessels, and other anthropogenic sources. Organic aerosol (OA) frequently makes an important contribution to Houston's PM2.5. OA has been traditionally classified as primary or secondary OA (POA or SOA): POA is directly emitted into atmosphere as particles while SOA is formed when hydrocarbon precursors undergo one or more chemical transformations in the gas phase, forming less volatile compounds that partition to the particle phase. The gas-phase precursors of SOA are classified (in decreasing order of volatility) as volatile organic compounds (VOC), intermediate volatility organic compounds (IVOC) and semivolatile organic compounds (SVOC). Early SOA modeling focused on the VOC precursors but more recent modeling using a volatility basis set (VBS) has shown that SOA formation from IVOC precursors is important. Current emission inventory methods essentially omit IVOC emissions making it necessary to add IVOCs to modeling inventories using approximations. In this study, a photochemical grid model is applied to simulate OA formation in the Houston region during the 2013 DISCOVER-AQ campaign. SOA formation from both VOC and IVOC is modeled using a recently developed 1.5-dimensional VBS model. IVOC emissions are added to the TCEQ's latest 2013 emission inventory using IVOC fractions determined from smog chamber studies. The model results are evaluated against detailed ambient OA measurement data collected during DISCOVER-AQ.

2CA.9
Wintertime Secondary Organic Aerosol Over an Oil and Natural Gas Producing Region of the U.S. from an Air Quality Model Perspective. RAVAN AHMADOV, Stuart McKeen, Michael Trainer, Joost de Gouw, Jessica Gilman, Carsten Warneke, Timothy Bates, James Johnson, Patricia Quinn, *CU CIRES- NOAA ESRL*

The rapid development of the oil and natural gas production across the United States in recent years has been associated with significant amounts of methane and other volatile organic compounds (VOCs) released to the atmosphere. Unexpectedly, the highest ground level ozone concentrations during 2013 year within the entire country were detected in winter over a remote area the Uinta Basin in Utah, which is densely populated by oil and natural gas wells. During these pollution episodes significant levels of particulate matter were also observed. The high photochemistry and abundance of the volatile organic compounds emitted by the oil and natural gas sector make the formation of secondary organic aerosols very likely in the UB region.

In this study, we simulate primary and secondary organic aerosols (SOA) and elemental carbon over the Uinta Basin during winter of 2013. We use the state of the art air quality model WRF-Chem with an updated SOA parameterization based on the volatility basis set framework. The unique signature of the anthropogenic emissions dominated by the oil/gas sector provides an unprecedented opportunity to study and improve the secondary organic aerosol parameterizations used in air quality models. Here we discuss different processes that contribute to SOA formation, such as the composition of VOCs, mutligenerational aging, and dry deposition of condensable organic vapors characterized by the WRF-Chem model. Finally, we compare our results with organic and elemental carbon measurements taken during winter of 2013 in the UB.

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2CA.10
Characterization of Fresh and Aged Emissions from a Marine Vessel Fueled with Diesel and Biodiesel. DEREK PRICE, Kevin Sanchez, Jun Liu, Raghu Betha, Lynn Russell, David R. Cocker III, J. Wayne Miller, *Scripps Institution of Oceanography*

Emissions from ocean going vessels are a significant contributor to atmospheric aerosol pollution. Large shipping ports, such as the LA and San Diego ports, are major pollution sources for their respective cities. Additionally, ship exhaust has the ability to influence cloud formation, creating "shipping trails" that can be observed in satellite images. As alternative shipping fuels are being investigated, it is important to understand the effects these fuels will have on atmospheric chemistry. This study investigates the fresh and aged emissions from a marine vessel operated under two different fuels, diesel and biodiesel. Engine emissions were measured directly from the exhaust stack and indirectly through the inlet of an ambient sampling trailer. A suite of instruments were utilized to measure both the gas and particle-phase components. The concentrations of NO_x, CO, CO_2, SO_2, and H_2O were measured by a NO_x analyzer, a CO analyzer, a PG-250 five gas analyzer, and a Licor CO_2/H_2O analyzer. Total particle concentration and size distribution were measured by a scanning electrical mobility spectrometer (SEMS), an aerosol particle sizer (APS), and an optical particle sizer (OPS). The black carbon concentration and size distribution was measured by a single particle soot photometer (SP2) and an aethalometer. The chemical composition of the non-refractory components of the particle-phase was measured by a high resolution – time of flight – aerosol mass spectrometer (HR-ToF-AMS). Particles were also collected on quartz and Teflon filters for mass loading and offline EC/OC and FTIR analysis.

2CO.1
Evolution of Fine Organic Aerosol Emitted from Residential Coal Combustion. WEI ZHOU, Jingkun Jiang, Jianguo Deng, Lei Duan, Jiming Hao, *Tsinghua University*

This study reported the evolution of submicron organic particle formed during a complete residential coal combustion process, i.e., from fire start to fire extinction. A residential coal combustion system includes a clean air supply system, a typical Chinese stove, a chamber collection system, and a dilution system. An Aerosol Chemical Speciation Monitor (ACSM) was used to in-situ measure non-reflective components of submicron particles (NR-PM_1). $PM_{2.5}$ and PM_1 samples were collected on quartz filters for off-line analysis. Gaseous pollutants (e.g., CO, CO_2, NO_x, and SO_2) were also measured. Three commonly used coal types were tested, i.e., bituminous, anthracite, and semi-coke coals.

For all three types of coals, the emission of organic particles showed distinct characteristics in terms of four stages, i.e., the heating and ignition stage, fiercely combustion stage, stable combustion stage, and ember combustion stage. For anthracite coals, more than half of total organic particle emission happened during the heating and ignition stage. For bituminous and semi-coke coals, the fractions of organic particles emitted during this first stage are higher than 90%. The mass spectra were dominated by ions from hydrocarbon organic aerosol during this first stage. Concentrations of organic particles decrease rapidly during the fiercely combustion stage and stay at a relative low level during the stable combustion stage. During these two complete combustion stages, significant ion peaks of organic acids were observed. The oxidation degrees of organic particles gradually increases the four stages and organic particles emitted during the last ember combustion stages are the most oxidized. Possible mechanisms for organic aerosols during residential coal combustion were also discussed.

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2CO.2

Impacts of Co-firing Biomass on Emissions of Particulate Matter to the Atmosphere. IBRAHIM AL NAGHEMAH, Elizabeth Stone, *University of Iowa*

Biomass co-firing is the process of replacing part of the coal supplied to the boiler with biomass. Co-firing in existing boilers is a practical approach for increasing the use of biomass as fuel because it draws upon widely-available, existing infrastructure and presents immediate opportunity for the production of low cost renewable energy. Biomass is renewable and sustainable source of energy that holds significant potential for electricity generation, and has environmental benefits of reducing the emissions of carbon dioxide and other air pollutants.

In this study, gas and particle emissions from co-firing coal with two types of biomass compared to coal only was evaluated in a circulating fluidized-bed boiler at the University of Iowa Power Plant. Coal only and co-firing either 50% oat hulls or 3.8% wood chips (by weight) were fueled to the boiler at a constant energy input. Co-firing 50% oat hulls with coal significantly reduced the emission of atmospheric pollutants, including particulate matter by 90%, polycyclic aromatic hydrocarbons by 40%, and metals by 51%. In addition, co-firing oat hulls reduced fossil carbon dioxide emission by 40%. In contrast, co-firing small fraction of wood chips shows a negligible impact on theses atmospheric pollutants. Meanwhile, the emissions of two biomass burning markers—levoglucosan and retene—increased with addition of biomass. Fuel-based emission factors for PM, metals, and organic species were determined for each fuel condition. Other changes to the metal composition and distributions across PM, fly ash, and bottom ash are discussed. Co-firing oat hulls as a renewable source of energy offers several benefits to air quality.

2CO.3

Electrical Charges on Particles Generated by Combustion. Sergey A. Grinshpun, SHUANG GAO, Michael Yermakov, Tiina Reponen, *University of Cincinnati*

Electric charges acquired by aerosol particles during their generation affect the particle transport, sampling, filtration efficiency, and respiratory deposition. Therefore, information is needed about the particle charge distribution. While laboratory-generated aerosols, which are conventionally used for the evaluation of aerosol measurement instruments, air purification units and other devices, are usually charge-neutralized/equilibrated by radioactive sources, aerosol particles in the field often carry substantial electric charges. Aerosols generated by open-space combustion and by traffic emission have long been recognized as an environmental hazard, but not sufficiently well characterized, especially in regard to their particle charge distribution. In this effort, we deployed an Electric Low Pressure Impactor (ELPI, Dekati, Ltd., Kangasala, Finland) for measuring electric charges on particles aerosolized by burning materials such as paper, wood and plastic, as well as by emission from a diesel engine. For comparison, similar measurements were also performed with NaCl and KCl aerosols generated using a Collison nebulizer. Major differences were observed between the charge distributions of combustion-originated particles (including diesel) and salt particles. In the ultrafine range (<100 nm), the particles released from burning as well as diesel particles were essentially neutral while KCl and especially NaCl particle carried measurable negative charges. Larger combustion particles (>100 nm) were negatively charged with the charge increasing as the particle size increased. The salt particles changed their polarity from negative to positive as the size increased above 100 nm. The differences were attributed to the aerosolization process. The particle charge-to-volume ratio was utilized to interpret the experimental results. The measured charges were compared to the maximum acquirable electrical charges calculated using the diffusion charging model. The data obtained in this study are presently being used for assessing the efficiency of indoor air purifiers.

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2CO.4
The Effect of Sampler Design on Nanoparticle Sizing.
EIRINI GOUDELI, Arto Groehn, Sotiris E. Pratsinis, *ETH Zurich*

The properties (e.g. transport, optical) and final product performance of nanoparticles made by gas-phase processes depend strongly on their composition, size and morphology. The size and structure of such particles that typically have fractal-like nature need to be closely controlled as they do not only find a score of applications (catalysts, sensors, biomaterials) that require well-defined characteristics but are also found in the atmosphere impacting health and climate. Measurements of aerosol characteristics, however, depend on the design of the sampling system as they change by deposition, coagulation and/or fragmentation in the sampling lines.

Here the effect of different sampler configurations (straight-tube and pinhole samplers of varying hole diameter and orientation) on real-time flame-made ZrO_2 particle characterization (mobility size distribution and morphology-structure) is elucidated at fuel-rich and -lean flame conditions at 10 – 60 cm above the burner. The sampling system affects little the shape and spread of the mobility size distributions, but most importantly it affects the mean mobility size. All samplers in downstream orientation result in larger mobility diameters than in upstream or sidestream orientation, especially at fuel-lean spray flames.

In addition, the structure (fractal dimension, mass-mobility exponent) and size (radius of gyration, mobility and volume-equivalent radius) evolution from spherical to fractal-like particles formed by agglomeration in the absence of coalescence, sintering or surface growth is investigated by discrete element modeling simulations and is compared to the above online experimental results and literature data. The evolution of structure and quasi self-preserving number-based geometric standard deviation is quantified by simple relationships that can be readily used in detailed particle dynamics simulations coupled to fluid mechanics for industrial process design, air pollution, meteorology and climate dynamics.

2CO.5
Drift Tube Ion Mobility Measurements of Sub-10 nm Soot Particles Produced in Flames.
DAVID BUCKLEY, Christopher Hogan Jr., *University of Minnesota*

The sampling of soot nanoparticles formed in flames is often challenging, as without proper dilution particles grow in sampling lines via coagulation, and because most combustion systems produce a time varying aerosol. In this study, we apply a novel drift tube ion mobility spectrometer coupled with a condensation particle counter (DTIMS-CPC) to measure the size distributions of sub 10 nm soot particles formed in a non-premixed methane flame. Unlike differential mobility analyzers (DMAs), a DTIMS samples particles all derived from an identical sample location and at a specific time, hence DTIMS-CPC measurements enable direct examination of temporal variation in soot formation. In addition to size distribution measurements, we apply tandem mobility analysis with a DMA-DTIMS-CPC system to examine to extent of vapor (water, aromatic compounds, and alkanes) uptake by soot particles, and infer vapor binding coefficients as a function of particle size. This work shows the DTIMS-CPC measurement is a viable alternative to DMA measurement for combustion generated nanoparticles, and that DTIMS measurements have advantages over DMAs in examination temporal variation in size distributions.

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2CO.6

Optical Properties of Aerosols Emitted from Laboratory Peat Combustion. Madhu Gyawali, Laxmi Narasimha Yatavelli, Adam Watts, Vera Samburova, Rajan Chakrabarty, Joseph Knue, L.-W. Antony Chen, Ian Arnold, Xiaoliang Wang, Andrey Khlystov, Judith Chow, Barbara Zielinska, John Watson, HANS MOOSMULLER, *Desert Research Institute, Reno*

Globally, organic soils and peats may store as much as 600 Gt of terrestrial carbon, representing 20 – 30% of the planet's terrestrial organic carbon mass. This is approximately the same carbon mass as that contained in Earth's atmosphere, despite peatlands occupying only 3% of its surface. Effects of increasing fire frequency and size in these ecosystems are of global concern due to the potential for enormous carbon release into the atmosphere with significant implications for the global carbon cycle and radiative forcing. Combustion of peat mostly takes place in the low temperature, smoldering phase of a fire. It consumes carbon that may have accumulated over a period of hundreds to thousands of years. In comparison, combustion of aboveground biomass fuels releases carbon that has accumulated much more recently, generally over a period of years or decades.

Here, we present the aerosol optical properties from the controlled laboratory combustion of peat soil samples from three regions, Siberia (Russia) and Alaska and Florida (USA). Aerosol absorption and scattering coefficients measured using a three-wavelengths photoacoustic instrument were analyzed for single scattering albedo (SSA) and absorption Ångström coefficient (AAC) and compared with previously reported values for other common wildland fuels. The mean organic mass-normalized absorption cross-section (MAC) of peat samples was found to be quite low, ranging from as low as 0.001 m2g-1 at 781 nm to as high as 0.32 at 405 nm; however, combustion emissions from all peat samples depicted large AAC. While SSA values (0.9-1.0 at 405 nm) were similar to those from other wildland fuels, AAC values, (4.5-7.2 range at 405-870 nm) were substantially higher for emissions from peat combustion. These results have important implications for radiative forcing, actinic fluxes driving photochemistry, and optical source apportionment. Three fuel moisture levels were used in this work to enable us to determine whether peat sources or fuel moisture content were more important for the optical characteristics of combustion emissions. Results showed that SSA and AAC vary with moisture content—higher moisture content results in higher SSA values and lower spectral dependence of AAC. Florida lake peat (at 10% moisture level) exhibited the highest AAC value (~7.2).

2CO.7

Combustion Process Apportionment of Carbonaceous Particulate Emission from a Diesel Fuel Burner. LAARNIE MÜLLER, Jürgen Schnelle-Kreis, Gert Jakobi, Lianpeng Jing, Jürgen Orasche, Francesco Canonaco, Andre Prévôt, Ralf Zimmermann, *Helmholtz Zentrum München*

Carbonaceous particulate matter from combustion processes are of current interest due to their environmental impacts and energy conservation implications. Carbonaceous particle emissions from combustion processes are being regulated mainly due to their potential health and climate effects. Combustion conditions impact the characteristics and temporal evolution of carbonaceous emissions [Mueller et al., 2015]. The formation of health-relevant compounds such as polycyclic aromatic hydrocarbons in a flame soot generator depended on the fuel-air equivalence ratio [Mueller et al., 2015]. In this study, with a mini diesel Combustion Aerosol STandard (mini diesel CAST 5201D, Jing CAST Ltd., Switzerland), different flame settings were applied to study the characteristics of resulting emitted carbonaceous particles. We investigated the emitted organic matter (OM), black carbon (BC), and brown carbon (BrC), exhaust gas, and physical properties produced from varying flowrates of oxidizing air and diesel fuel (DF) with and without additives (lubricant, Fe, Mn, S, and V) using the high resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS, Aerodyne Research Inc, USA), aethalometer (Magee Scientific, Slovenia), scanning mobility particle sizer (TSI, USA), aerodynamic particle sizer (APS, TSI, USA), and condensation particle counter (CPC, TSI, USA). The combustion processes were unmixed based on the high resolution mass spectra of OM ions by applying the SoFi program [Canonaco et al., 2013], a source apportionment tool using multilinear engine (ME-2). The separated factors differ in terms of OM:OC and O:C ratios, and temporal evolution. These observations will be correlated to the changes in the raw gas and optical properties from the aethalometer data to get a better picture of the combustion processes that occured

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2CO.8
Automated Primary Particle Sizing of Nanoparticle Aggregates by TEM Image Analysis. Ramin Dastanpour, STEVEN ROGAK, *University of British Columbia*

Nanoparticle aggregates formed in colloidal or aerosol processes have complex morphology that is commonly characterized by Transmission Electron Microscopy (TEM). Soot, for example, is formed as aggregates of primary particles. Soot properties are influenced by the diameter and the arrangement of its constitutive primary particles. TEM is an accurate method commonly used for the characterization of soot morphology, but manual analysis of the micrographs is extremely labour-intensive. Here, a new method is developed for automatic determination of the average primary particles diameter based on the variation of the 2-D pair correlation function at different distances measured from the main skeleton of the aggregates. It is assumed that the value of the pair correlation function at the average radius of the primary particles is nearly constant. The method has been applied to real soot particles collected from several operating conditions of a gasoline direct injection engine and a heavy-duty compression-ignition engine. Using a constant value for the pair correlation function at the radius of the primary particles (determined from the analysis of TEM images) results in primary particle sizing errors (relative to manual sizing) of ~13% for single aggregates. Correlating the value of the pair correlation function at the radius of the primary particles to the particle shape yields ~14% error in the primary particle sizing. The ensemble-mean average primary particle diameter for manual and automatic sizing differed by ~4%.

2CT.1
A Numerical Study for Fine Particle Removal Gadget with Low Pressure Drop and Superior Efficiency for Industrial Application. YOUNGJIN SEO, *Kumoh National Institute of Technology*

Air quality is an issue of increasing concern as it is directly related to human health. Thus, environmental regulations for air quality have been stringent over the past few decades. This study is focused on providing a possible solution that could remove fine particles with superior efficiency. Consequently, the final goal is to fabricate and to operate in a plant. In order to do so, the pressure drop must be maintained as low as 500 mmH2O, which is the typical pressure drop through a commercial bag filtration system. Most plants utilize bags to capture generated particulate matters such as fume and dust; however the bags must be replaced periodically. Worse still, aerosol removal efficiencies across bags vary widely depending on types of bags. This study determines the aerosol removal efficiency of the most widely used commercially available bags. For instance, particles larger than 7.5 micro-meters are 100 percent filtered by a glass fiber filter, while the efficiency with a polyester filter is significantly lower than that with the fiber filter. In addition, an alternative that doesn't require any bags for filtration is announced and preliminary results by CFD (computational fluid dynamics) are introduced. According to the CFD study, the alternative removes 100 percent of particles larger than 3 micro-meters with a pressure drop of less than 500 mmH2O. The air flow-rates could be as high as 500 cubic meters per minute.

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2CT.2
Experimental Determination of the Effective Vortex Length of Cyclones. HSIAO-YI HUNG, Chih-Wei Lin, Sheng-Hsiu Huang, Chih-Chieh Chen, *National Taiwan University*

In a conventional cyclone, the outer vortex flow weakens and changes its direction at a certain axial distance from the vortex finder. This axial magnitude has been called the “natural vortex length” of the cyclone. Since the space below the vortex will not be used for particle collection, cyclone designs with a natural vortex length equal to or greater than the physical length of a cyclone is recommended. Although some studies have investigated this parameter and obtained its empirical formula, there are contradictions among these models. Therefore, the main purpose of the present study was to experimentally measure the effective vortex length, from the perspective of aerosol penetration and pressure drop across the cyclone.

To characterize the cyclone performance, an ultrasonic atomizing nozzle was used to generate micrometer-sized potassium sodium tartrate particles. An Am-241 radioactive source was employed to neutralize the particles to the Boltzmann charge equilibrium. Aerosol size distributions and number concentrations upstream and downstream of the cyclones were measured using an aerodynamic particle sizer. Each aerosol penetration measurement was repeated five times. The pressure drop across the cyclone was measured using an inclined manometer. All types of sampling cyclones developed in this work were based on the Very Sharp Cut Cyclone designed for PM2.5 sampling. The effective vortex length of a cyclone was analyzed by using both the aerosol penetration and the pressure drop across the cyclone. The results showed that the body diameter and the sampling flow rate are significant parameters affecting the effective vortex length of cyclone. However, inlet diameter, outlet diameter, and cyclone with or without a cone do not significantly influence the effective vortex length. Until now, the model for estimating the effective vortex length is yet to be developed.

2CT.3
The Micro-particle Capture by a Cylindrical Fiber in a Particulate Aerosol Channel Flow. MING DONG, Lin-ying Bai, Jun Xie, Su-fen Li, *Dalian University of Technology*

A soft-sphere discrete element method(DEM) is used for three-dimensional simulations of micro-particle capture by an individual fiber in a laminar channel flow. An inlet-outlet boundary condition is introduced for the particles along the direction of flow and a periodic boundary condition is imposed in the other two directions. The paper foucus on understanding the complex dynamics of the near-fiber particle aggregates, which is observed to include collision of aggregates with the fiber, capture of colliding aggregates by fiber-attached aggregates, bending of fiber-attached aggregates in the direction of the flow, break-up of both fiber-attached and freely transported aggregates, and break-off and re-entrainment of fiber-attached aggregates. These various processes are observed over long time to achieve a state of balance. A dimensionless adhesion parameter is defined and shown to have a dominat effect on the predicted particle capture rate. Particle capture is enhanced by decrease in either fluid viscosity or velocity, such that change in flow Reynolds number can have pultiple effects depending on the variation of the other parameters.

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2CT.4
An Experimental Study on the Effect of Particle Concentration on Air Filtration. RAHELEH GIVEHCHI, Zhongchao Tan, *University of Waterloo*

The objective of this research is to investigate the effect of particle concentration on airborne nanoparticle filtration. Bimodal tungsten oxide nanoparticles in the range of 0.8-4 nm with mode diameters of 1.07 and 2.54 nm were used as test aerosol particles. Emission sampling system (ESS) was employed to dilute aerosol. Polyvinyl alcohol (PVA) electrospun nanofibrous filters were testes for air filtration. A scanning mobility particle sizer coupled with a Faraday cup electrometer (SMPS+E) was used for measuring the nanoaerosol size distributions downstream of the filter holder, both with and without the filter. With this method, the error due to particle loss is minimized because of the identical sampling lines. Results showed aerosol concentration has a great effect on the filtration efficiency of sub-2 nm particles.

2CT.5
The Change of Pressure Drop during Dust Loading at Different Relative Humidity. MYONG-HWA LEE, Jeong-Uk Kim, *Korea Institute of Industrial Technology*

Bag house is generally used to remove particulate matters and to recover valuable powders from a gas stream. Bag filter is the most important component to determine the system performance. However, its performance depends on relative humidity in a gas stream. Therefore, the change of pressure drop by relative humidity during dust loading in a filter was investigated in this study. Fly ash particles were used as test particles, and a polyester filter was used to collect those test particles under different relative humidity. We found that pressure drop decreased with increasing relative humidity at the same mass areal density. Adhesive force between particles increased with increasing relative humidity, which changed the dust cake structures. At high relative humidity, dendritic structure by adhesive force lowered the pressure drop because it decreased drag force. Furthermore, overall collection efficiency increased with increasing relative humidity, resulting from enhanced condensation of fly ash particles.

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2CT.6
Micro- and Ultra-filtration of Polystyrene Latex Nanoparticles through Nuclepore Filters: Experiments and Models. HANDOL LEE, Sheng-Chieh Chen, David Y. H. Pui, *University of Minnesota*

Micro- and ultra-filtration are being widely applied to remove nanoparticles in drinking water and chemicals for their purifications. Up to date, the micro- and ultra-filtration filters are usually characterized by their geometric pore size. However, significant discrepancies between the prediction and experimental data are often observed especially for nanoparticles due to the complex surface interactions between filter and particle. For investigating the reason causes the discrepancy, nanoparticle retention efficiency under unfavorable conditions was carried out experimentally and theoretically simultaneously using Nuclepore filters and monodisperse standard PSL particles as model systems. In the experiments, PSL particles with 60~500 nm were used to challenge 50, 200 and 400 nm rated Nuclepore filters with different ionic strengths. The particle penetration was determined by taking the ratio of downstream particle concentration of the filter to that of upstream measured by nanoparticle tracking analysis (NTA) technique. In the theoretical modeling, capillary tube model was used to calculate the initial efficiency which latter was modified by considering the reentrainment. The former was mainly governed by the flow condition and the latter was by the DLVO surface interactions. Primary- and secondary-minimum deposition determined from the Maxwell approach were calculated to obtain the sticking coefficient, and the real deposition efficiency is then equal to the initial efficiency multiplied by the sticking coefficient. The torques analysis showed that the adhesion torque of a particle located in the primary minimum (0.3 nm) will be slightly larger than the drag torque, which resulted in the particle deposition on the pore walls. However, experimental data showed that the deposited particles on the pore wall most likely detached, indicating that particles should locate at a separation distance longer than the primary-minimum distance. By this assumption, the data are in very good agreement with model for all tested filter, particle and ionic strength conditions.

2CT.7
Control of Respirable Crystalline Silica Exposure from Cutting Fiber-cement Siding. CHAOLONG QI, Alan Echt, Amy Feng, Micheal Gressel, *NIOSH*

Workplace exposure to respirable crystalline silica can cause silicosis, a progressive lung disease marked by scarring and thickening of the lung tissue. Fiber-cement products can contain as much as 50% crystalline silica and cutting this material has been shown to cause excessive exposures to respirable crystalline silica. NIOSH scientists conducted this study to develop engineering control recommendations for respirable crystalline silica from cutting fiber-cement siding.

Detailed characterization of the dust generated from cutting fiber-cement siding was conducted in a laboratory setting. Respirable dust was sampled and analyzed using a variety of instruments. The dust size distribution and the silica distribution in the dust of different sizes were analyzed in detail for cutting fiber-cement siding from four major manufacturers. The generation rate of respirable dust was analyzed and compared for cutting fiber-cement siding using different power tools (a power shear, four miter saws, and three circular saws), different blades, differing saw cutting feed rate, and cutting different numbers of boards in the stack. The results from the laboratory evaluation suggested that connecting a dust-collecting circular saw to a basic shop vacuum with built-in air filters had the potential to provide a simple and low-cost engineering control measure for the dust generated from cutting fiber-cement siding.

Four field surveys were conducted to validate the effectiveness of the engineering control measure. The survey results showed that the 10-hour time weighted average (TWA) exposure to respirable crystalline silica for the workers who mainly cut fiber-cement siding on the job sites was well under control, with the 95% upper confidence limit being only 24% of the NIOSH Recommended Exposure Limit (REL) of 0.05 mg/m3. This engineering control measure effectively reduced occupational silica exposures, and provided an effective, simple and low cost solution for workers cutting fiber-cement siding.

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2CT.8
Modeling of Nanoparticle Penetration through Electret Filter Media. DREW THOMPSON, Sheng-Chieh Chen, Deqiang Chang, Min Tang, David Y. H. Pui, *University of Minnesota*

Single fiber efficiencies for electret filter media with circular cross-section and bipolar surface charge distribution were calculated for combined mechanical and electrostatic collection mechanisms. The electrostatic interactions considered were Coulombic, polarization, and image forces. Single fiber efficiency was assumed to be the product of independent deterministic mechanisms (e.g., interception, Coulombic, polarization, and image forces) and stochastic mechanisms (i.e., diffusion). Deterministic efficiencies were calculated from the particle flux between limiting trajectories of inertialess particles which were solved numerical using an explicit Runge-Kutta formula. Diffusional efficiency was determined using an empirical power law relation. Model results were compared to experimental results obtained which isolated mechanical, Coulombic, and polarization collection mechanisms through control of particle charge state and/or discharging of the electret media.

2CT.9
Physical and Biological Characterization of Porous Media for Indoor Air Quality Control. LUPITA MONTOYA, Anne Wrobetz, Ahu Aydogan Akseli, *University of Colorado Boulder*

Volatile Organic Compounds (VOCs) are important indoor contaminants (Wolkoff, 2003) and formaldehyde is among the most common indoor VOCs, which has been shown to be toxic and carcinogenic (Nielsen 2010). It is found in commercial, residential, and occupational spaces and its removal is usually achieved by augmenting ventilation rates, an approach that is energy-intensive. Biological systems that rely on plants and microorganisms to remove VOCs have been proposed as alternative IAQ control systems (Aydogan, 2011; Aydogan 2012). An important component in such systems is the porous media supporting plant and microbial life. The objective of this research was an initial physical and biological characterization of Growstone, expanded clay, coco coir, and activated carbon. Results showed average sorption potentials of 0.24, 0.57, 42.4, and 174.1 mg/g media, respectively. Microbial communities extracted from several soils and porous media were also tested for their potential to survive on various levels of formaldehyde. Coco coir exhibited colony growth at 1 mM formaldehyde before exposure and a 156.7% increase in colony counts on 1 mM plates after exposure to gaseous formaldehyde. The use of low-cost porous media such as coco coir should be further investigated as an alternative for the removal and degradation of VOC and the potential removal of particles in indoor environments.

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2IA.1
Mathematical Models for Bioinformed Design of Indoor Spaces: Integrated CFD Simulation of Fungi Sporulation and Transport. SHAMIA HOQUE, *USC*

Bioinformed design is centered on understanding the indoor microbial population and intends to direct the change of this in a way that will be beneficial to the residents. To understand how the microbial population in a building will respond to a perturbation, the fundamental interactions between a bioaerosol and its indoor habitat has to be investigated and the relationship among them defined. The objective of the current study is to determine the influence of the indoor environment on the fate and transport of fungal spores from mold. The study consists of the building of a validated computational fluid dynamics (CFD)-sporulation model, designing a series of numerical simulations and extracting a user – friendly mathematical model from the simulation results. The CFD – sporulation model was developed to simulate spore growth and transport in an indoor space with walls infected by mold (due to dampness). The CFD model consists of sub-modules for hygrothermal analysis which accounts for the effect of temperature change, relative humidity effects of the outdoor on the indoor ambience, air flow (Large Eddy Simulation) which simulates the air flow pattern in the ventilated space and spore transport (Lagrangian method) which tracks the spores once released from the infected location in the room. Any spore which deposits is treated as another source for continuing mold growth on the surface if the spore falls on a surface with the right temperature and humidity conditions. The sporulation module simulates the spore growth i.e. how many spores will be released given the conditions obtained from the hygrothermal module. Laboratory experiments are being conducted for model validation. It is anticipated that this work will be a framework to be applied for other bioaerosols.

2IA.2
Application of ISO 14644 as an Indoor Air Quality (IAQ) Metric. ELLIOTT HORNER, Nate Sanders, *UL Environment*

ISO standard 14644-1 establishes count concentration limits of airborne particulate matter (PM) to characterize environments by levels of air cleanliness. The PM limits for each cleanliness class vary according to PM size. Classes 1 (lowest limits) through 9 (highest PM concentrations) are defined in the standard. Although ISO 14644 is primarily used for controlled environments such as clean room manufacturing or research facilities, classes 8 and 9 overlap with clean, well-maintained indoor spaces. PM measures are increasingly focused on smaller size PM, at and below 1 µm. Mass concentration becomes less useful in this size range and requires impractically high sample volumes for indoor spaces.

We applied the high end of the ISO 14644 range to characterize indoor spaces. Count concentration data were collected with an optical particle counter while monitoring renovation activities adjacent to occupied healthcare spaces. PM readings from 185 observations (5 locations, 37 occurrences) were assessed for conformance to ISO 14644 criteria for 0.5 micrometer and for 5 micrometer particle sizes. For 0.5 micrometer size PM, 43% of observations were Class 9 and 57% were Class 8. For 5 micrometer size PM 30% of observations were Class 9, 64% were Class 8 and 6% were cleaner than Class 8.

These empirical findings classified the spaces within the highest three Classes (of nine) outlined in ISO 14644. These were not controlled environments, but were clean, well-maintained buildings with high ACH and good quality filtration. This demonstrates that ISO 14644 Class ratings can be used as an IAQ metric to characterize the PM burden on a count concentration basis in occupied buildings. The optimal particle size for characterization should be considered and a three tier system (not rated, rated as Class 9, cleaner than Class 9) may be the limit of utility however.

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2IA.3

Characterization of a Commercial Synthetic Jet Actuator for Air Quality Applications. Miles Abarr, Denise Mauney, Jean Hertzberg, LUPITA MONTOYA, *University of Colorado, Boulder*

About 40 percent of the energy used in the U.S. is associated with buildings and heating, ventilating and air conditioning (HVAC) systems account for about 25 percent of the energy used by buildings. Conventional centralized HVAC systems controlled by thermostats are usually installed in selected spaces of a building but often provide sub-optimum environmental quality solutions. Airflow supplied by centralized systems may also be blocked by cubicle partitions, cabinets and furniture resulting in less efficient removal of heat and contaminants within the building. In the study reported here, a commercial electromagnetic synthetic jet actuator (SJA) was characterized to determine its flow patterns and sphere of influence within a room. A comparison was also made to a computer fan with a similar power level. The purpose of this work is to investigate the potential application of this commercial SJA for indoor air quality control and its limitations for such application. These experiments showed that the SJA uses a small power input to impact the airflow far downstream (over 1 m) from the jet exit. Further, while SJA showed less flow output than the fan in this study, it had significantly greater dynamic pressure per unit energy, which may prove valuable for directing the flow within a room.

2IA.4

Characterizing VOC Emissions from Human Occupants in a University Classroom. XIAOCHEN TANG, Pawel Misztal, Allen H. Goldstein, William Nazaroff, *University of California, Berkeley*

Little is known about the chemical emissions associated with human occupants, even though this source can make important contributions to indoor airborne particles and volatile organic compounds (VOCs).

In this work, we characterize gaseous occupant-related emissions in a university classroom by measuring real-time concentrations and calculating per person emission rates for hundreds of VOCs using a proton transfer reaction time-of-flight mass spectrometer (PTR-ToF-MS). Among the more than 300 ions detected in 19 class sessions, more than 80% were in the range m/z = 30-150. Among the ions detected are those with well-known human emissions, such as isoprene, acetone, and acetic acid. For each ion, we assign a proposed chemical formula and/or structure when reporting the indoor and supply air concentration and the emission rate (ug h^{-1} $person^{-1}$). Remarkably, these ions with low to moderate m/z ratios only comprise about half of the total emitted mass. The other half was dominated by three organic cyclic siloxanes: D4 (octamethylcyclotetrasiloxane), D5 (decamethylcyclopentasiloxane) and D6 (dodecamethylcyclohexasiloxane). The inferred emission rate of D5 is one to two orders of magnitude greater than that of D4 and D6. The emissions of D5 and D6 show relatively strong correlation ($r>0.7$) with each other, suggesting similar sources, which we believe to be personal care products used by classroom occupants. This study represents the first broad characterization of VOCs emitted from human occupants using the highly sensitive PTR-ToF-MS over the mass range m/z 30-500. The research findings will broaden knowledge about indoor air chemistry and advance understanding of the relationship between humans and their everyday environment.

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2IA.5

Volatile Organic Compounds and Aerosol Emissions from a Low-Cost Desktop 3-D Printer. JUN WANG, Evan Floyd, James Regens, *University of Oklahoma*

3-D printing is an additive fabrication and replication technology. The 3-D printing process involves injection of melted filament material, mostly thermoplastic polymer. The injected material is laid down in different layers to achieve a pre-designed shape. The heat-assisted deposition process raises concern on potential volatile organic compounds (VOCs) and aerosol emission and exposure. In recent years, the cost of desktop 3-D printer were significantly lowered, and more applications were found in small business and garage projects, where sufficient ventilation and personal respiratory protection often lack. Meanwhile, little was known about 3-D printing fume from emerging types of filaments. The goal of this study was to characterize VOCs and aerosol generated from a low-cost 3-D printer with various new filaments. A 3-D printer was set in an environmental chamber. The printer printed out a pre-designed object using eight different types of filaments. Real-time VOC concentration was recorded by a photo-ionization detector. Fume samples were collected onto absorbent and subsequently analyzed by a thermodesorption gas chromatograph mass spectrometer. Scanning mobility particle sizer and aerodynamic particle spectrometer were employed to measure the particle size distribution from fine (16.8 nm) to coarse (20 μm) range. The results showed an average VOC generation rate of 25.3±3.6 μl/min. Speciated VOC information was acquired: ABS-based polymers produced mostly styrene, while acrylic acid dimers are the predominant products from PLA-based polymers. Time-resolved particle size distribution indicated high concentration (~10E7) of nanoparticles (geometric mean size from 41~83 nm) were formed during the initial heating and printing stages, then the particle concentration dropped following a first-order decay. The coarse particle shows a similar trend at much lower concentration (~10E4). Overall, the information extracted is essential to the 3-D printer development. Fume hood is recommended for ABS-based 3-D printing jobs, since they emitted higher concentration of toxins.

2IA.7

Evaluating and Controlling Human Exposure to Ultrafine Particle and VOC Emissions from Desktop 3D Printers. PARHAM AZIMI, Dan Zhao, Brent Stephens, *Illinois Institute of Technology*

Desktop 3D printers are rapidly increasing in popularity. The majority of commercially available 3D printers utilize a fused deposition modeling (FDM) technique in which a solid thermoplastic filament is forced through a heated extrusion nozzle. In a previous pilot study, this process was shown to emit large numbers of ultrafine particles (UFPs: particles less than 100 nm in size). Moreover, users often complain of pungent odors during operation, suggesting likely VOC emissions as well. However, several questions remain regarding: (1) What is the magnitude of emissions of both UFPs and VOCs from various printers, filaments, and temperature settings? (2) What do those emissions mean for exposures in typical indoor environments, and (3) What are the most effective methods for controlling emissions and exposures? Therefore, in this work we characterized time resolved emission rates of UFPs and TVOCs from five popular commercially available FDM desktop 3Dprinters operating with a variety of thermoplastic filaments in a medium sized (3.6 m3) stainless steel chamber and evaluated the efficacy of multiple aerosols and gas control strategies (including spot ventilation, a custom enclosure, and a custom filtration system) in both chamber and field experiments. More than 20 printer and filament combinations were used to print a standardized 10 cm2 object with one centimeter thickness. Preliminary results demonstrate the following: (1) UFP emission rates are highly varying in time, commonly ranging from ~10^{13} #/min at the beginning and ending peak periods and ~10^{11} #/min in the middle of operation; (2) TVOC emission rates are relatively constant; and (3) UFP and TVOC emission rates are highly dependent on the make and model of both the printer and the filament. The laboratory and field studies also demonstrate that a custom sealed enclosure was a simple and effective solution to mitigating exposures to emissions from 3D printers

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2IA.8

Particle Tracking Velocimetry Analysis of Flow Patterns in Showers. Carlos Estrada, Michal Ziv-El, Yassin Hassan, Kerry Kinney, MARIA D. KING, *Texas A&M University*

The objective of this study is to determine the source and delineate potential human allergens and pathogens in the bioaerosols that are released during showering and potentially form a biofilm on surfaces. We are currently analyzing the microorganisms that naturally colonize residential water systems and showers as a function of key parameters (water flow rate, showerhead design). Initial results show significant difference in diversity in the bioaerosol and biofilm microbiome between different (one low-flow and one high-flow) showerheads in the occupied shower unit, indicating that the showerhead pattern and flow rate contribute significantly to the microbial community.

To analyze the differences in the water flow pattern of the shower units and its effect on the bioaerosol and biofilm composition Particle Imaging/Tracking Velocimetry (PIV/PTV) has been used. The experimental double shower stall that is set up in a full-scale bioaerosol chamber with two different showerheads and two identical mannequins on each side was actuated daily for 20 min to model routine shower events. Periodic (weekly for eight weeks then once a month) sampling was performed in the experimental shower units. Bioaerosol samples were collected before, during and after shower operation with a high throughput (100 L/min) wetted wall cyclone (WWC). Biofilm (from showerhead, shower stall walls and floor) and tap water samples were collected. Parallel with the PIV/PTV experiments, DNA was extracted from the bioaerosol and biofilm samples and analyzed by Illumina metagenomics analysis.

The results for the two different showerheads show significant difference in liquid flow patterns and diversity in bioaerosol and biofilm microbiome, indicating that the showerhead design and flow rate contribute significantly to the microbial community in shower stalls.

This study provides new insight into the risks of bioaerosol exposure due to changes in liquid flow patterns affecting the re-aerosolization and deposition of microbes in the shower biofilms.

2IA.9

Human Occupants as Sources of Airborne Particles in a Neonatal Intensive Care Unit. DUSAN LICINA, Seema Bhangar, Brandon Brooks, Robyn Baker, Brian Firek, Xiaochen Tang, Michael Morowitz, Jillian Banfield, William Nazaroff, *University of California, Berkeley, CA*

Premature infants in neonatal intensive care units (NICUs) have underdeveloped immune systems that would likely make them highly susceptible to adverse health consequences from air pollutant exposure. Little is known about the sources of indoor airborne particles and the mechanisms by which they are transmitted to premature infants in the NICU environment. To investigate the sources of airborne particles within a NICU, we monitored the spatial and temporal variations of indoor environmental parameters and human occupancy. The experiments were conducted over one year period in a private-style NICU of a large hospital building in the United States. The NICU was served with central heating, ventilation and air-conditioning (HVAC) system equipped with an economizer and a high-efficiency particle filtration system. The following parameters were measured continuously during weekday with 1-min resolution: particles larger than 0.3 microns resolved into 6 size groups, CO2 level, dry-bulb temperature and relative humidity, and presence or absence of occupants. Over periods of a few weeks each, measurements were conducted in total of 16 rooms occupied with premature infants. In parallel, a second monitoring station was operated in a nearby hallway or at the local nurses' station, providing more than 5 million data points in total. Initial analysis of the data suggests a strong link between the indoor particle concentration and human occupancy in the infant rooms. The detected particle peaks were more discernible among larger particles compared to smaller particles. The large particle (5.0 – 10 microns) concentration levels averaged across all babies were 2.7 times higher when the human occupancy was detected, compared to unoccupied baby rooms. Ongoing data analysis will provide more detailed insights for interpreting the data collected. This study is expected to contribute to a better understanding of the sources and concentrations of airborne particles in the NICU.

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2IA.10

Physical and Chemical Characterization of Indoor Dusts: A Critical Review. ALIREZA MAHDAVI, Jeffrey Siegel, *University of Toronto*

Physical and chemical characterization of indoor particles deposited on surfaces and on heating, ventilation and air conditioning (HVAC) filters offer novel insights about particle exposures. The current investigation reviews the literature regarding the physical and chemical analysis of indoor dust samples, as well as the impact of environmental conditions on the sample analysis. We first conducted a broad and deep literature review in the Science Citation Index. On physical analysis, the main focus was given to the properties such as particle size and size distribution, as well as particle morphology. A similar search was also done for chemical analysis with the main focus on the analyte type (e.g., PAHs, SVOCs, metals), concentrations, distributions, detection frequencies and indoor/outdoor ratios. Where available, we included relevant metadata including building characteristics, meteorological, and geographical conditions. The review revealed various size distribution patterns depending on the environmental conditions, including bimodal or unimodal distributions. Morphological information often provided insight on the source of particles. In some investigations, concentration of various analytes decreased with particle size suggesting that a reasonable relationship between chemical and physical properties could be inferred. An example is the detection frequency of specific analytes in different size fractions. The literature also suggested the significant impact of environmental conditions such as the number of occupants inside the buildings as well as the geographic location on both chemical and physical characterizations of the indoor dusts. The results suggest that indoor dust is an untapped resource for characterizing exposure to indoor particles.

2IA.11

Emissions from Consumer 3-D Printers. Qian Zhang, Marilyn Black, Aika Davis, RODNEY J. WEBER, *Georgia Institute of Technolgy*

Consumer-level 3-D printers are relatively inexpensive and widely available. Despite little knowledge on the emissions of either VOCs or aerosols, 3D printers are being operated in both public and private settings that could lead to substantial exposures to susceptible populations (e.g., residential, Primary and Secondary Schools, Libraries, University design labs, etc). We report on tests to quantify emissions of VOCs and particles from 3D printers following existing protocols used for establishing compliance standards for emissions from hard copy devices (Blue Angel Ecolabel). The goal is to understand factors that influence emissions, including type of printer, filament composition and color, printer operating parameters, shape of object printed, and printing interval. Measurements include a range of VOCs and particle size distributions, chemical composition and toxicity. Preliminary findings and challenges associated with assessing 3D printer emissions, in terms of implications for assessing health risks and establishing compliance standards, will be presented.

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2IA.12
Evaluation of Particulate Matters and Total VOC Emissions from Binder Jetting 3D Printers. NIMA AFSHAR-MOHAJER, Chang-Yu Wu, Thomas Ladun, Didier Rajon, Yong Huang, *University of Florida*

Binder jetting 3D printing is a popular type of additive manufacturing and a powerful tool for creating parts as well as prototypes, especially in medical research labs and architectural workshops. Due to continuous movement of dry powders inside printer chambers and injection of resin-like binder fluid during printing, binder jetting 3D printers are a potential emission source of fine particulate matters (PM) and volatile organic compounds (VOCs). In this study, real-time measurements of total volatile organic compounds (TVOCs) and aerosol (10 nm to 10 µm) during a 2-hr continuous operation of a binder jetting printer were incorporated into a time-varying mass balance model to obtain the emission rates. Results showed that the highest number- and mass-based particulate and gaseous concentrations corresponded to when the printer was just turned off and the top cover was removed for ejecting the printed object. The most emitting range of particle sizes was identified to be 205 to 407 nm. Time weighted average PM2.5 and PM10 and TVOC over a 24-hr period all exceeded the USEPA ambient air quality standards. Continuous operation of the 3D printer led to PM2.5 level 10 times greater than the standard (344 vs 35 µg/m3) and PM10 level 3 times higher than the standard (474.3 vs 150 µg/m3). TVOC concentrations with a maximum value of 1725 µg/m3 exceeded maximum allowable concentration levels of 500 and 300 µg/m3 almost throughout the printing task based on regulations set by the Environment institute of European Commission, and USGBC-LEED. As compared, ultrafine particles emitted from the binder jetting 3D printer was 104 to 105 times smaller than those from typical fused deposition modeling (FDM) type of 3D printers using PLA, but production of particles larger than 200 nm was significantly higher. The results suggest installing binder jetting 3D printers in an enclosure, implementing a proper overhead hood and/or operating the device next to well-ventilated structures for the better mitigation of the health risks.

2IA.13
Identifying Optimum Indoor Space Design and Ventilation System for Reducing Second-hand Exposure between Office Occupants. FIROZA OMAR, Shamia Hoque, *USC*

The objective of this study is to identify the parameters in designing indoor space so as to ensure a healthy indoor environment and reduce second hand exposure. In the past the focus has been that the ventilation system will ensure ‘clean air’ for all occupants in an office space or in a school room through sufficient number of air changes. This process ensures continuous outdoor air introduction into indoor spaces but it has not eliminated ‘dead zones’ and while HVAC filters keep outdoor particles such as allergens out, indoor transmission from occupant to occupant through sneezing, coughing, smoking (if occurring) is not stopped. Also new sources of indoor air pollution are introduced such as the rising popularity of electronic cigarettes (EC) which emit aerosols such as propylene glycol, carbonyls, glycerol, nicotine, metal and silicate particles. This study investigates the velocity profile, trajectory and behavior of aerosols released in an office space from an occupant with computational fluid dynamics (CFD) simulation. An Eulerian – Langrangian framework is applied for the simulations of a three dimensional office room for multiple occupants. Large Eddy Simulation was applied to compute the airflow. Aerosols were modeled using the Lagrangian treatment. The particle movement pattern is analyzed for different outlet locations for multiple work space designs. The results were evaluated to determine the optimum space distribution in indoor work zones associated with the position of the outlet with the objective of minimizing second hand exposure. The results show that the air inlet and outlet locations and safe space distribution between the working zones can be useful to determine the most effective and healthy indoor layout without increasing building ventilation costs.

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2IA.14

Evaluation of Self-pollution Inside School Buses Using a CFD and Multi-zone Coupled Model. Fei Li, EON LEE, Junjie Liu, Yifang Zhu, *University of California, Los Angeles*

The in-cabin environment of a school bus is important for children's health. The pollutants from its own exhaust can penetrate into the school bus cabin and increase children's overall exposure to air pollutants. In this study, we adapted a coupled model, originally developed for building environment, to determine the relative contribution of the bus own exhaust to the in-cabin pollutant concentrations. The coupled model uses CFD (computational fluent dynamics) model to simulate for concentration outside the school bus and CONTAM (a multi-zone model) for the inside. The model was validated with experimental data in the literature. Using the validated model, we analyzed the effects of vehicle speed and tailpipe location on self-pollution inside the bus cabin. We confirmed that the pollution released from the tailpipe can penetrate into the bus cabin through gaps in the back emergency door. We found the pollutant concentration inside school buses was the highest when buses were driven at a medium speed. In addition, locating the tailpipe on the side, behind the rear axle resulted in less self-pollution since there is less time for the suction effect to take place. The developed theoretical framework can be generalized to study other types of buses. These findings can be used in developing policy recommendations for reducing human exposure to air pollution inside buses.

2IA.15

Reduction of Residential Indoor Particulate Matter Concentration Using a Portable Air Cleaner Equipped with Wireless Sensors: Big Data Analysis. BYONG HYOEK LEE, Jong Cheol Kim, Kyung Hwan Lee, Yoon Hyuk Choi, Sanghyeon Kang, Sun Yong Lee, *Environmental Technology Institute, Coway R&D Center*

With increase in time people spend indoors, the control of indoor air quality has become essential. The most effective way to reduce indoor particulate matter concentrations is ventilation. Ventilation, however, may not be effective since the concentrations of particulate matters outdoor may exceed that of the indoor concentrations. Portable Air cleaning devices have been proven to efficiently control the particulate matters In the study, a portable air cleaner equipped with HEPA filter is used to reduce the residential indoor particulate matter concentrations. Moreover, the device is equipped with air quality sensors, including particulate matter sensor, which monitor and transfer the data to a remote server every five seconds unless a wifi connection is disconnected. More than 1100 households in Seoul, Korea were provided with the air cleaners and indoor particulate matter concentrations were monitored for 38 days. The overall average PM10 and PM2.5 concentrations were 39.9 microgram per cubic meters and 17.9 microgram per cubic meters, respectively. The PM10 and PM2.5 concentrations were approximately 16% and 21% lower when the air cleaners were operational. Moreover when the outdoor PM concentrations were relatively high, due to migration of Asian Yellow Dusts, the effectiveness of the air cleaners was greater. With a vast expansion of Internet of Things, air cleaning device equipped with wireless particulate matter sensors may provide valuable information on the indoor particulate matters

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2IA.16

Applying a Low-Cost Wireless Particulate Matter Sensor for Indoor Air Quality Monitoring: Calibration and Verification. BYONG HYOEK LEE, Jong Cheol Kim, Kyung Hwan Lee, Sanghyeon Kang, Sun Yong Lee, *Environmental Technology Institute, Coway R&D Center*

People, on average, spend approximately 90 percent of their time indoors. Yet, often the concentrations of indoor particulate matters exceed that of the outdoor concentrations. Moreover, people who are more susceptible to the adverse effects of particulate matters are likely to spend more time indoors. For the following reasons, it is necessary for residents to monitor current air quality and take actions to control (i.e. eliminating the source or ventilating or operating an air cleaner) of the indoor air quality. In the study a low-cost wireless particulate matter sensor, based on light scattering method, have been developed to measure both particulate matters (PM10) and fine particulate matters (PM2.5). As particles scatter light inside the sensor, a receptor transforms the light into a pulse signal. Based on the length of the signal, particles are categorized as either PM10 or PM2.5. Due to the low detecting limits of the sensor few factors, such as multiplying measured concentrations by a factor to represent the particulate matters whose sizes are below the detectable range of the sensor, are applied to make more accurate measurements. The wireless sensor is tested in both chamber and field with particulate matters from various sources, including Arizona dusts, burning of a tobacco smoke, heating of soybean oil, and Asian yellow dusts. The correlation coefficients between the sensor and a particulate measurement instrument for PM10 and PM2.5 in field tests are 0.937 and 0.928 respectively. Although the correlation coefficients are relatively low, the cost-effective wireless sensors could be applicable for monitoring residential indoor particulate matters. With increase in the growth of Internet of Things, the sensor may provide valuable information on the indoor particulate matters.

2IA.17

Crustal and Toxic Metal Emissions from Fuel Sources Used on the Navajo Nation. MARIEL PRICE, Brian Majestic, Wyatt Champion, Jason Schenandoah, Lupita Montoya, Joanna Gordon, Benton Cartledge, Michael Hannigan, *University of Denver*

PM2.5 emissions from the combustion of various fuel sources used in homes on the Navajo Nation were analyzed to determine the concentration of select crustal (Na, Mg, Al, K, Ca, Ti, Fe, Rb, Sr, Ba, and U) and combustion (V, Cr, Mn, Co, Ni, Cu, Zn, As, Se, Mo, Cd, Sb, Cs, Ce, and Pb) elements. PM2.5 was collected inside and outside of homes around Shiprock, NM and Tsaile, AZ that use wood, coal, pellet, natural gas, propane, electricity, or combinations of the fuels for heating and cooking. Results from the study indicate that the average amount of total PM2.5 collected outside of homes in Shiprock was 12.5 ± 6.5 ug m-3 and in Tsaile was 18 ± 11 ug m-3. The average indoor PM2.5 concentration in Shiprock was 20.1 ± 5.5 ug m-3 and in Tsaile was 47 ± 21 ug m-3. Indoor PM2.5 concentrations in both locations were highest during the use of wood based fuels. In Tsaile, the indoor concentrations of all elements were far greater than what was measured outside of the homes, suggesting a significant source of trace elements indoors. The concentration of crustal elements observed indoors in Shiprock, however, was always less than or similar to the outdoor concentrations. This suggests that other aerosol species (e.g., carbon or major ions) are responsible for the increased indoor PM2.5 concentrations. Wood based fuels were the greatest contributors to potassium and iron concentrations inside of homes at both sites. In addition, zinc, copper, and manganese were the combustion elements observed in greatest concentrations in both Tsaile and Shiprock. Aside from the association of potassium with wood, there were no obvious associations between trace element composition and fuel type, which suggests that other sources are important.

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2IA.18

Assessment of Biological and Non-biological Aerosol Concentrations in Two Green Multi-unit Residential Buildings in the Northeastern US. NIRMALA THOMAS, Leonardo Calderón, Mengyang Guo, Brian Pavilonis, Prarthana Raja, MaryAnn Sorensen-Allacci, Deborah Plotnik, Jennifer Senick, Jie Gong, Clinton J. Andrews, Gediminas Mainelis, *Rutgers, The State University of New Jersey*

Green buildings are developed with the notion of environmental conservation in terms of energy and resources. Since green buildings often have lower air exchange rate than regular buildings, it may have an impact on their indoor air quality. Here, a case study was conducted in one Energy-star certified (C) and one non-certified (N) green buildings to compare the aerosol and bioaerosol concentrations . The following Indoor Air Quality (IAQ) parameters were measured: (1) various particulate matter (PM) size fractions, (2) concentrations of airborne culturable bacteria, mold and total mold, and (3) endotoxins and allergen levels in the settled dust. In addition, the residents were administered a questionnaire about cooking, smoking, cleaning products and other potential IAQ factors. In the N building, $PM_{2.5}$ ranged from 2 to 123 $\mu g/m^3$; PM_{10} from 2 to 126 $\mu g/m^3$; total mold from 480 to 53,000 $\#/m^3$; culturable bacteria from 60 to 710 $\#/m^3$; and endotoxins from 850 to 270,000 EU/gram . In the C building, $PM_{2.5}$ ranged from 6 to 666 $\mu g/m^3$; PM_{10} from 10 to 670 $\mu g/m^3$; total mold from 60 to 2600 $\#/m^3$; culturable bacteria from 60 to 630 $\#/m^3$; and endotoxins from 460 to 2,300,000 EU/gram. The median $PM_{2.5}$, PM_{10} and PM_{total} were not significantly different in buildings C and N (p=0.06). The allergen concentrations were lower in C compared to the N type (p=0.04). The average value of total indoor mold concentration ($\#/m^3$) in building N was higher by a factor of 25 than in building C. Initial correlation of IAQ data, building operating parameters and questionnaire data indicate that building operating parameters and residents' behavior (e.g., cooking, cleaning habits) are at least partially responsible for the IAQ difference in the two buildings.

2IA.19

The Field-Potential Aerosol Mass (F-PAM) Reactor: Development and Preliminary Lab Measurements of Cook-stove Emissions. STEPHEN REECE, Roshan Wathore, Provat Saha, Andrew Grieshop, *North Carolina State University*

Combustion in rudimentary and improved cook-stoves used by billions in developing countries emits organic aerosols (OA) and black carbon (BC) with vast health and climate implications. Recently, research has focused on the formation of secondary organic aerosols (SOA) that results from photo-oxidation and atmospheric aging of primary emissions. Here we present the initial development and characterization of a field portable potential aerosol mass reactor (F-PAM) designed to assess aging of cook-stove emissions in both laboratory and rural field settings. The F-PAM was characterized to quantify hydroxyl radicals (OH) exposures as function of external OH reactivity (OHR), Ozone (O_3), and residence time. To assess the impact of varying stove activity, initial lab testing will compare emissions from the standard water boiling test (WBT) protocol and a protocol which includes low power combustion to simulate field operation not present in the WBT.

In this study diluted biomass emissions from a distinct phase of stove operation will be injected into a smog chamber to provide a fixed emission population. These emissions will then be exposed to a range of OH and O_3 concentrations in the F-PAM. OH exposure is measured in real time by monitoring the decay of carbon monoxide (CO) through the F-PAM. Various particle (SMPS, ACSM, PAX) and gas-phase (CO, CO_2, O_3) instruments will measure up and down stream of the FPAM. Primary emissions are measured during the injection period using the Stove Emission Measurement System (STEMS), a portable instrument which measures real-time concentrations of carbon dioxide (CO_2), CO, $PM_{2.5}$ along with integrated samples for offline analysis. Emission factors will be derived before and after aging for emissions from different burn conditions via carbon balance. Results from this study will help assess the F-PAM reactor's operating range for incorporating the high and variable aerosols concentrations observed during the varying cook-stoves activity.

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2IF.1
Evaluation of Methods for Collecting Aerosolized Bacillus Spores. SERGEY A. GRINSHPUN, Michael Yermakov, Reshmi Indugula, Yousef Elmashae, Tiina Reponen, Angela M. Weber, *University of Cincinnati*

Various sampling techniques have been used for collecting airborne Bacillus anthracis spores in the field, but no standard method or protocol has yet been established. In this study, we evaluated the performance of two inhalable aerosol sampling devices, the IOM Sampler and the Button Inhalable Sampler (SKC Inc., Eighty Four, PA, USA). Both were equipped with 25-mm collection filters; four filters featuring different characteristics were evaluated. The study aimed at generating experimental data for selecting the most suitable sampling method and protocol. The tests were conducted with aerosolized spores of Bacillus thuringiensis kurstaki, Bt(k), which is a well-recognized simulant of B. anthracis. The spores were aerosolized using a Collison nebulizer (BGI Inc., Waltham, MA, USA) from a suspension. The aerosol concentration was measured using a real-time aerosol spectrometer (Models 1.326 and 1.108 combined, Grimm Technologies Inc., Ainring, Germany). The following characteristics were investigated: the filter collection efficiency, pressure drop, recovery of the collected spores, and the overall sampling efficiency of the samplers. The IOM and Button samplers yielded comparable results while operated with the same filter, although the concentration levels measured with the IOM sampler were slightly greater (the difference was not a statistically significant). The PC filter was identified as the best choice for assessing the personal inhalation exposure to Bacillus spores in indoor air; the PTFE 3-micro-meter filter also demonstrated a good performance; however, it is more expensive. The study results contribute to standardization of the personal exposure assessment in indoor environments contaminated with aerosolized biological agents.

This effort was supported by the US Centers for Disease Control and Prevention and the US Defense Threat Reduction Agency. The findings and conclusions in this presentation are those of the presenters and do not necessarily represent the views of the Centers for Disease Control and Prevention.

2IF.2
Customized Solar Simulation for Biological Aerosol Agent Fate Experimentation. DANIEL HAHN, *JHU/APL*

Commonly used solar simulator specifications, such as the ASTM E927-10, are derived from reference spectra, such as the ASTM G173-03, each of which are intended for silicon photovoltaic testing applications. These reference spectra and specifications emphasize irradiance in the visible spectrum, but not in the ultraviolet. Conversely, action spectra related to the damage of biological materials generally have a logarithmically decreasing relationship with linearly increasing wavelength and can be more than four orders of magnitude higher at 300 nm (approximate lower cutoff of ultraviolet solar irradiation on the surface of the earth) than at 400 nm (lower cutoff of the visible spectrum). Proposed herein are an alternate reference spectrum (ASTM G177-03) and customized solar simulator specifications that are better matched to the action spectra of biological materials, including aerosolized spores. Solar simulator design concepts based on these specifications are also presented.

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2IF.3
Measuring Changes over Time in Bioaerosol Spectral Signatures with the WIBS. ELIZABETH CORSON, Jonathan Eshbaugh, *Johns Hopkins University Applied Physics Laboratory*

As biological aerosols are exposed to atmospheric processing, changes in viability and spectral signatures may occur. Interrogating particle fluorescence is a common method for detecting biological aerosol. Therefore, understanding changes in spectral signature over time is critical for accurate bioaerosol detection. The Wideband Integrated Bioaerosol Sensor (WIBS-4A, Droplet Measurement Technologies Inc.) provides measurements of particle fluorescence at two excitation wavelengths, 280 nm and 370 nm, and two emission spectra, 310-400 nm and 420-650 nm. This multichannel approach to fluorescence measurement produces informative data about the state of a bioaerosol population over time. Two bioaerosol aging campaigns were completed using a rotating drum to maintain an aerosol population and expose the aerosol to aging factors such as water vapor, ultraviolet light, and ozone. The aerosol was measured over time using a WIBS-4A and an Ultraviolet Aerodynamic Particle Sizer (UVAPS, TSI Inc.). Changes in spectral signatures over time were observed in a vegetative bacteria and a protein, especially when exposed to ozone and water vapor. Fluorescence data will be presented with an emphasis on methodology for investigating bioaerosol fate and how to interpret raw WIBS data in this context.

2IF.4
Atmospheric Fate of Individual Aerosol Particles. ERIN M. DURKE, Matthew B. Hart, *EXCET Inc./Edgewood Chemical Biological Center*

The study of individual aerosol particles is highly important yet significantly challenging. With respect to studies of chemical warfare agent (CWA) aerosols, knowledge of the basic physical and chemical properties, such as shape and reactivity, are imperative to appropriately address such threats. In order to study CWA particles, a collaborative effort between researchers at the Edgewood Chemical Biological Center (ECBC) and the Naval Research Laboratory (NRL) has resulted in the development of a device to levitate single aerosol particles for extended periods of time. The device, a linear electrodynamic quadrupole, is equipped with optical imaging and light scattering measurement capabilities. The most recent studies performed with the levitation device focused on CWA simulants, such as DMMP and DIMP. Using the levitation device, we were able to take direct measurements of simulant evaporation rates as well as investigate how simulant aerosols are affected by ambient humidity. Understanding these properties will aid in determining how these aerosols transport, transform, and persist in the environment.

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2IF.5
Understanding How Exosporium Hairs Affect Spore Adhesion on Simple Surfaces. JANA KESAVAN, Pamela Humphreys, Craig Knox, Erica Valdes, Vipin Rastogi, Babak Nasr, Suresh Dhaniyala, *US ARMY ECBC*

Microorganism adhesion plays an important role in a broad range of processes, including re-aerosolization, surface contamination, fouling, and cleaning. Several pathogenic members of the Gram-positive endospore-forming Bacillus genus of bacteria have evolved a thin and highly-deformable outer layer, known as the exosporium, which consists of nanometer-scale hair-like glycoprotein filaments protruding from a crystalline basal layer and which is believed to play a critical role in spore hydrophobicity and adhesion, both in the environment and in vivo. Studies have suggested that the flexibility of the exosporium helps increase surface contact area, thus promoting adhesion, but an in-depth study to understand this behavior has not been reported. Our hypothesis is that the hairs of the exosporium respond to different chemical environments to orient and change surface patterning at the nanoscale, affecting the contact area and thus spore adhesion. To test our hypothesis, we have performed the following experimental and computational modeling studies: air flow experiments, atomic force microscopy, and molecular dynamics simulations. Polystyrene latex microspheres and Bacillus spores with exosporium as well as similar spores without exosporium have been used to quantitatively assess the role of the exosporium in spore adhesion. Test results indicate that PSL reaerosolization results agree with the theory; however, more experiments need to be conducted to explain the results obtained with the bacteria. These results may help provide insight into the mechanism of how the exosporium enhances spore adhesion and determine stickiness factors for systems modeling approaches to predict agent fate of bio-threats in the environment.

2IF.6
A Design of Experiments Approach for Conducting Bioaerosol Aging Studies in Rotating Drum Aerosol Chambers. MICHAEL SCHUIT, Shanna Ratnesar-Shumate, Artemas Herzog, Jonathan Eshbaugh, Paul Dabisch, *NBACC*

Studies examining the effect of environmental conditions on bioaerosol persistence play an important role in both the public health and biodefense fields. Data on the effects of ambient factors on the persistence of an aerosolized pathogen over time can inform disease outbreak prediction and response as well as consequence management planning in biodefense scenarios. The studies necessary to obtain these data, however, can be cumbersome to execute, lengthy, and expensive, particularly when specialized biocontainment systems are required. For this reason, bioaerosol aging studies are excellent candidates for multifactorial design of experiments approaches, which facilitate examination of the effects of multiple parameters, as well as the interaction of those parameters, in an efficient manner. Here we present a design of experiments approach for bioaerosol aging studies where particle size, temperature, relative humidity, and simulated solar radiation are varied simultaneously to develop a predictive model for the persistence a bioaerosol at any combination of conditions within the tested design space. Additionally, characterization data on two novel rotating drum aerosol chambers capable of executing such studies in biocontainment facilities will be presented.

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2IF.7
Evaporation and Transport of Bodily Fluid Aerosol Droplets. JONATHAN THORNBURG, Quentin Malloy, James Hanley, Jerome Gilberry, Howard Walls, *RTI International*

Researchers have determined the typical aerosol generated by a coughing person, such as an Ebola infected patient, has a size distribution spanning 1 to 500 micrometers with a mass median diameter of approximately 100 micrometers. The apparently large size of the expelled droplets leads to the assumption that rapid gravitational settling to surfaces will occur. However, spaces with the proper environmental and ventilation conditions may cause aerosol droplets to evaporate and their airborne residence time increases substantially. The aerosol droplet evaporation rate as a function of particle and environmental conditions is important for designing the proper safety procedures.

We used published aerosol equations to calculate droplet evaporation and transport. The equations accounted for impurities in the aerosol droplets, and aerosol dynamics in the Stokes and non-Stokes regimes. Expected values for temperature, RH, and air velocity within an isolation system were used as inputs. We modeled cough events at 1 or 1.5 meters above the floor. Horizontal air velocities in the direction of airflow of 250 cm/s and 13 cm/s were selected.

Modeling results identified the drop sizes that will evaporate to minimum diameter before depositing on a surface. At 250 cm/s and 1 meter height, the maximum drop size that will evaporate to a cluster of biological agent before traversing a horizontal distance of 3 meters is 26 micrometers. Cough droplets between 26 to 155 micrometers will completely traverse 3 meters before traveling 1 meter vertically and depositing. Cough droplets larger than 155 micrometers will vertically travel 1 meter and deposit on the floor before traversing 3 meters. As the air velocity decreases, the maximum drop size that will evaporate increases before gravitational deposition occurs. Our modeling showed expelled bodily fluid droplets may travel a significant distance before depositing onto a surface or remain an aerosol because of evaporation.

2IF.8
Accurate and Adaptive Test and Evaluation of Biological Aerosol Detection Systems - The Aerosol Challenge Simulator. JAMES S. BURKE, Nigel Pomeroy, Maurice W. Walker, Virginia E. Foot, *DSTL*

Bio-aerosol detection instruments need to be able to respond to aerosol clouds of biological agents against a background of particulates present in the natural environment. An advanced test capability has been developed over the past decade at Dstl. The Aerosol Challenge Simulator (ACS) enables far greater levels of control over the aerosol test parameters than previously possible. Aerosols containing simulants to biological agents can be generated using a variety of instrumentation to provide well characterized challenges on a clean background. The resulting aerosol is mixed with a background aerosol (either natural or synthetically aerosolized) to provide the test aerosol. Computer control of the independent particle filtration of the challenge and background aerosols enables standardized test profiles to be replayed against a relevant representation of the ambient aerosol. This passes into a test section for sampling with aerosol detectors and collectors.

The ACS is being used extensively at Dstl for bio-aerosol detection instrumentation tests, during which target challenge profiles that have been obtained in field trials are replicated with a high level of repeatability from test to test. The ACS has also been used to collect data for sensitivity tests of sensors, correlated with a suite of reference aerosol instrument measurements, and to acquire training and test datasets for instrument analysis algorithms.

The facility has potential application in multiple cross-disciplinary areas involving bio-aerosols and atmospheric and health related aerosols; such as supporting agricultural, urban and waste management aerosol studies, aiding the understanding of source components within fluctuating aerosols, and characterizing the response of novel prototype aerosol instrumentation.

This poster will present examples of results obtained using the ACS facility.

This work is supported by the UK MoD CBR R&D research program.

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2IF.9

Particle Removal from Substrates with an Impinging Air Jet. BABAK NASR, Jana Kesavan, Andrea R. Ferro, Goodarz Ahmadi, Suresh Dhaniyala, *Clarkson University*

Resuspension of chemical and biological particles from surfaces is a concern from a human health perspective. The net adhesive force acting on particles depends on particle and surface properties and the nature of the external force field. While several theoretical particle adhesion models exist, their implementation is made challenging by the uncertainties in the particle/surface properties and in calculating the external force fields. Here, we use a combination of computational fluid dynamics (CFD) simulations and experimental testing to validate the predictions of classical adhesion models. Particle removal from surfaces is possible when acted upon by flow with a velocity larger than a critical shear velocity. For removal of particles smaller than 10 μm, the critical shear velocities required are large, and one possible way to obtain these large shear velocities is by using jets directed at substrates. In this study, CFD simulations were conducted to determine the characteristics of flow exiting a nozzle and impinging on a substrate. The simulation results were analyzed to determine shear velocities along the surface and the calculated values were compared against theoretically-predicted critical values. The spatial extent of removal of particles of different sizes was then determined. The CFD-predicted removal regions for particles of different sizes were compared against experimental data obtained at ECBC for a range of particle sizes and relative humidities. The modeling details and experimental approach will be discussed in this presentation.

2IF.10

Wind Tunnel Detachment of Bacillus Thruingiensis Spores. JING QIAN, Meilu He, Babak Nasr, Minyard Morgan, Andrea R. Ferro, Goodarz Ahmadi, Suresh Dhaniyala, *Clarkson University*

The resuspension of Bacillus anthracis in outdoor environments is of particular concern because of its pathogenicity and potential for use as a biological weapon. However, quantitative understanding of the resuspension mechanism for bacterial spores is lacking, which deters us from modeling real-world outdoor biological particle resuspension processes. This study concludes the initial experimental stage of a research project that investigates spore resuspension under various environmental conditions. Bacillus thuringiensis, a nonpathogenic surrogate for Bacillus anthracis, were deposited on various substrates and then resuspended in a high-speed wind tunnel operated with varying humidity conditions. The detachment of particles was determined as a function of shear velocity for each set of conditions. The study verifies a series of instrumentation and experimental methods for the deposition, resuspension, and analysis of biological particles. The experiments provide critical data to estimate particle adhesion parameters necessary to predict the resuspension fate of spores from real-world substrates under conditions of variable air flow velocity and humidity. This presentation will describe the experimental methodology for the resuspension studies and the major results obtained from our experiments.

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2IF.11
A Vibrating-mesh Nebulizer is an Alternative to the 'Gold Standard' Collison Nebulizer for Generating Experimental Aerosols Containing Infectious Agents. Jennifer Bowling, DOUGLAS REED, *University of Pittsburgh*

Animal studies to demonstrate efficacy of medical countermeasures against respiratory disease or biodefense threats require exposure of animals to aerosolized viruses and bacteria. Prior studies have shown that the choice of culture media and relative humidity in the aerosol chamber can impact the dose of infectious agent delivered to animals. Most infectious aerosol studies have involved the use of Collison jet nebulizers which create a small, relatively monodisperse aerosol that targets the deep lung. Collison nebulizers require a relatively large volume of infectious agent and the jets that create the aerosol can damage the agent being aerosolized. These factors can impact agent infectivity and virulence as well as study reproducibility. We compared the Aeroneb, a vibrating-mesh nebulizer, to the existing 'gold standard' Collison nebulizer for generation of small particle aerosols containing either a bacterium, F. tularensis, or a virus, influenza. Aerosol performance was assessed by comparing the ratio between the aerosol concentration of an agent and the concentration of the agent in the nebulizer (the spray factor, or SF). Initial aerosols focused on evaluating the Aeroneb and the Collison nebulizer using a nose-only tower. For F. tularensis the Aeroneb achieved a SF of 5.34x10-6 while the Collison achieved 1.69x10-6. The Aeroneb similarly achieved a better SF than the Collison with a seasonal influenza virus (4.1x10-6 vs 1.1x10-6, respectively). The Aeroneb also achieved a higher relative humidity in a whole-body chamber. This suggests that the Aeroneb may be a superior choice to the 'gold standard' Collison for use in the aerosolization of infectious agents, particularly in studies where a high concentration of an infectious agent is needed to achieve a desired inhaled dose in an animal. We are continuing to evaluate other parameters and other pathogenic agents to compare the two nebulizers and this data will be presented.

2IM.1
The Sensitivity of a Thermal Desorption Mass Spectrometer to Molecular Weight. DANIEL MURPHY, *NOAA CSD*

In free molecular flow, the lower speed of heavier or cooler molecules means that they spend more time in the ion source of a thermal desorption mass spectrometer. Therefore, the sensitivity of a thermal desorption mass spectrometer should scale as the square root of the molecular weight, although thermal fragmentation on the vaporizer may reduce this effect. Residence time in the ion source also depends on the translational temperature of the desorbed molecules. The dependence of sensitivity on molecular weight, fragmentation, and temperature has important implications for interpreting both field and laboratory data from the AMS and similar instruments.

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2IM.2
Evaluation and Modification of a Cost-effective DMA for Sub-5 nm Aerosol Classification. RUNLONG CAI, Da-Ren Chen, Jingkun Jiang, *Tsinghua University*

Effective classification is one of the limitations in sub-5 nm aerosol measurement. A cost-effective differential mobility analyzer (cDMA) was previously developed for nanoparticle classification which reduces manufacture and maintenance cost. In this study, we evaluated the transfer function and penetration of the cDMA in classifying 1-2 nm monodisperse molecular ions generated by an electrospray and a high resolution half-mini DMA. Tetra-alkyl ammonium ions with electrical mobility diameters of 1.16, 1.47 and 1.78 nm, respectively, were generated and tested. A data inversion routine based on an empirical diffusive transfer function was used to obtain the true transfer function of the cDMA. Comparing to theory, significant broadening in the transfer function was observed when classifying these sub-2 nm monomobile ions. Broadening is more severe at higher aerosol and sheath flowrate combinations. An effective length was estimated to account for the penetration efficiency of the cDMA. Modifications were made to this cDMA to decrease broadening in the transfer function and to increase the penetration efficiency for classifying sub-5 nm particles.

2IM.3
Nebulization of Microliter-sized Environmental Samples: Aerosol Mass Spectrometry as an Offline Analytical Technique. RACHEL O'BRIEN, Kelsey Boulanger, Gabriel Isaacman-VanWertz, Manjula Canagaratna, John Jayne, Philip Croteau, Jesse Kroll, *MIT*

The Aerodyne Aerosol Mass Spectrometer (AMS) provides detailed information on the chemical composition of aerosol particulate matter with high time resolution. Traditionally, the AMS inlet samples directly from the air, but, nebulization of aqueous samples can also be used to produce aerosols for analysis with the AMS. Typical nebulizers require tens to hundreds of milliliters of solution, limiting this technique to large samples. Here, we demonstrate a micro-nebulizer that requires only small volumes (tens of microliters) of sample for chemical analysis with an AMS. With this technique, ultra-sonic vibrations are passed through a water reservoir. Samples loaded onto a thin film stretched over this reservoir are nebulized and transferred to the AMS with a carrier flow of clean air. We characterize this technique by exploring the elemental ratios, aerosol component ratios, and mass spectra for standards and filters. We also compare AMS data collected using standard on-line techniques with our offline analysis, demonstrating the applicability to filter samples collected from field sites and chamber studies. This technique is especially promising for the analysis of small environmental samples, such as filters collected in remote locations.

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2IM.4
Characterization of the 8-stage Rotating Drum Impactor under Low Concentration Conditions. MELISSA VENECEK, Yongjing Zhao, Jose Mojica, Charles McDade, Peter Green, Michael Kleeman, Anthony Wexler, *University of California, Davis*

The Rotating Drum Impactor (RDI) is designed to collect samples of airborne particulate matter that are resolved by aerodynamic particle diameter as a function of time. The purpose of this study is to characterize the performance of the RDI sampler for use in relatively low concentration environments. Airborne particulate matter was collected at the University of California, Davis during the winter and summer of 2013 by two IMPROVE samplers, two RDI samplers and two MOUDI samplers. X-ray fluorescence (XRF) and inductively coupled plasma mass spectrometry (ICP-MS) were used as the chemical analyses. The IMPROVE XRF analysis gave similar repeated measurements for 78% of the elements present above stated Minimum Detection Limits (MDLs) in winter and 42% in summer. The MOUDI XRF analysis gave similar repeated measurements for 33% and 37% of the elements in winter and summer, respectively. The MOUDI, ICP-MS analysis was the most repeatable method tested, yielding similar repeated measurements for 62% and 91% of elements above stated MDLs in winter and summer, respectively. The RDI, XRF analysis was the least repeatable method tested, yielding similar repeated measurements for 35-40% and 5-20% in winter and summer, respectively. These results indicate that MDLs should be reassessed for all methods and a longer collection time should be considered under low concentration conditions. PM2.5 measurements from IMPROVE samplers were in better agreement with integrated size-resolved measurements made by MOUDI samplers than RDI samplers, suggesting that the absolute accuracy of the RDI method needs further improvement. Also, the RDI size distributions were implausible because they had a consistent gap between 0.34 – 0.56 μm that was not present in MOUDI measurements and does not match expected size distribution patterns in the atmosphere. The collection efficiency of all RDI stages should be verified before this instrument is used for size distribution measurements.

2IM.5
Development of a Dilutor for Flue Gas Aerosol Sampling under High Water Vapor and High Temperature Conditions. JIANGUO DENG, Yueyun Fu, Jingkun Jiang, *Tsinghua University*

High water vapor are often encountered when sampling aerosols from flue gas after the desulfurization unit. During the sampling, water vapor may condense onto particle surface and change the size distribution which leads to inaccurate measurement. High temperature sampling after the selective catalytic reduction unit is another challenge. An on-site dilutor was developed to address these challenges. A vacuum layer was used for insulation. Using computational fluid dynamics simulation, we tested the mixing of dilution gas with sampled flue gas. Evaporation of large droplet was theoretically estimated and experimentally evaluated using laboratory generated aerosol. The performance of the dilutor was tested in a power plant flue gas system. It was found that the dilutor was effective in sampling aerosol from the wet flue gas and has low particle loss rate. The vacuum layer kept the dilutor at low temperature which simulates the release and mixing of flue gas in the ambient environment.

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2IM.6
A New Method to Measure Aerosol Particle Bounce and Estimating the Phase State of Atmospheric Aerosols.
SHASHANK JAIN, Giuseppe Petrucci, *University of Vermont*

Organic aerosol (OA) is a ubiquitous component of atmospheric particulate that influences both human health and global climate. A large fraction of OA is secondary in nature (SOA), being produced by oxidation of volatile organic compounds (VOCs) emitted by biogenic and anthropogenic sources. Recent studies have shown that atmospheric SOA could be liquid or solid in phase and can affect the global climate in multiple and complex ways through its interactions with radiation and clouds. SOA can either scatter or absorb solar radiation, thereby modifying the Earth's radiative balance. Such scattering or absorbing largely depends on aerosol physical properties and environmental conditions. Moreover, the physical state of particles can affect particulate phase chemical reactions, and thus the growth rates of newly formed atmospheric particles. Hence understanding the phase state of aerosol is a key to understanding the global climate change.

In the present work, we describe a simplified method to measure the phase state (liquid or non-liquid) of organic aerosol by estimating the bounce factor of polydisperse SOA using only a multi-stage cascade electrical low pressure impactor (ELPI). The method eliminates the need for an independent measure of the particle size distribution (for example, as with an SMPS) and relies on comparison of absolute ion currents at each impactor stage under conditions that favor or reduce particle bounce. We validated the proposed method with solid, liquid and non-liquid aerosols, namely ammonium sulfate (AS), dioctyl sebacate (DOS), oleic acid (OA) and ozonized OA, and present bounce factor evolution of aging alpha-pinene-derived SOA.

This simplified method helps us to determine the real-time SOA phase state for polydisperse aerosols and establish a relationship between SOA phase, oxidative formation and chemical aging. This method will also helps us to understand the impact that various parameters, such as SOA precursor, oxidation type and mixing ratio, can have on the phase of atmospheric organic particulate.

2IM.7
Limitation of Current SMPS Transfer Function Theories.
MEILU HE, Suresh Dhaniyala, *Clarkson University*

Scanning mobility particle size spectrometer (SMPS) is widely used for particle size distribution measurement. Calculation of the particle size distributions from an inversion of the instrument signal requires consideration of the instrument transfer function. For fixed voltage operation, transfer function expressions ignoring diffusion (Knutson & Whitby,1975) and considering diffusion (Stolzenburg, 1988) are well established theoretically, while the influence of voltage scanning operation on the transfer functions has recently been introduced (Collins et al., 2004; Dubey and Dhaniyala, 2011). Typically, particle size distribution calculation from SMPS data has ignored this diversity in the details of the DMA transfer functions. In this study, we obtain SMPS signals as a function of scan time and operating flowrates and compare these signals to model predictions considering different transfer function expressions. The comparisons suggest that accurate calculation of SMPS signals, and hence size distributions, requires accurate consideration of particle residence time in the DMA and downstream tubing. Using the scanning transfer function of Dubey and Dhaniyala (2011) along with an optimal value of tubing transport offset time and smearing time results in accurate signal prediction over the range of scan time studied. We will present the relative performance of the different transfer functions in predicting the signal and their implication for size distribution calculations.

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2IM.8

Performance Study of a Cylindrical Thermal Precipitator with a Particle Size-Selective Inlet. BIN WANG, Shu Su, Qisheng Ou, Shu Tao, Da-Ren Chen, *Peking University*

We designed a thermal precipitator in a cylindrical configuration with a size-selective inlet, and investigated its performance in experiments using differential mobility analyzer (DMA)-classified particles of sodium chloride (NaCl) and polystyrene latex (PSL). Our investigation was performed in three parts: (1) using the sizes elective inlet to determine the best inlet-to-wall distance for optimal impaction of 1 μm particles; (2) using a simple inlet tube to measure particle collection via thermophoresis over a size range from 40 nanometer to 1000 nanometer; (3) investigating the collection performance for polycyclic aromatic hydrocarbons (PAHs) of ambient PM. The results showed that the inlet had a particle cut-off curve, with a 50% particle cut-off Stokes number of 0.238, resulting in removing particles with sizes larger than 1 micrometer at an aerosol flow rate of 1.5 lpm. The thermophoretic particle collection efficiency in the prototype was measured without the size-selective inlet installed. The size dependence of the collection efficiency was negligible for particles with diameters ≤300 nanometer and became noticeable for those with diameters >300 nanometer. An analytical model was further developed to estimate the particle collection efficiency due to thermophoresis of the prototype under various aerosol flow rates and temperature gradients. For particles with diameters less than 400 nm, reasonable agreement was obtained between the measured data and the collection efficiency calculated from the developed analytical model. The thermal precipitator was effective for collecting particulate phase PAHs in ambient air, which are dominantly associated with fine PM. The recoveries of all particulate phase PAHs ranged from 91.5 to 100%. It was further concluded that the derived formula for the calculation of thermophoretic particle collection efficiency could serve as the backbone for future design of thermal precipitators in any configuration, when combined with the proper formula for the dimensionless thermophoretic particle velocity.

2IM.9

Modeling and Simulation of Droplet Breakup: A Lagrangian Volume-of-Fluid Approach to Turbulent Spray Formation. EVERETT WENZEL, WanJiao Liu, Sean Garrick, *University of Minnesota*

Liquid aerosol formation, or atomization, is important to a variety of industrial applications, including inhalation aerosols, agricultural sprays, and power generation. Tools capable of predicting atomization – droplet size distributions, break-up lengths, penetration depths, etc. – are useful for the design of these processes. In turbulent flows, liquid break-up involves primary and secondary atomization. Primary atomization encompasses the initial instability-induced breakup of the liquid into large ligaments and droplets, and secondary atomization encompasses the subsequent breakup of the ligaments and droplets by fluid shear stress. Current modeling and simulation methods require prodigious amounts of compute time, fail to satisfy conservation laws, or introduce numerical artifacts which decrease accuracy. We present a new approach – termed the Lagrangian volume of fluid – for the simulation of turbulent, multiphase flows. The method achieves conservation and provides accurate interface curvature and sub-grid-scale phase information by coupling a Lagrangian phase-identifying particle domain with an Eulerian computational mesh. The method propagates phase interfaces without oscillation or artificial diffusion on structured and unstructured grids because they are treated in a Lagrangian sense. Kernel approximations from smoothed particle hydrodynamics are used to produce the surface tension force from the Lagrangian particles, which is inserted into the Eulerian Navier-Stokes solver. The result is an approach capable of accurately and robustly capturing primary and secondary atomization, which lends itself to engineering applications.

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2IM.10

Development and Evaluation of New Hy-NPS. Kang-Ho Ahn, HONG-KU LEE, Gun-Ho Lee, Hee-Ram Eun, Yong-Hee Park, Jinhong Ahn, *Hanyang University, R. of Korea*

Measuring particle size distribution is one of the primary concerns in aerosol studies. For a nano-particle size distribution measurement, many scientists use a combination of a differential mobility analyzer (DMA) and a condensation particle counter (CPC) system, which is a called scanning mobility particle sizer (SMPS). Although it has a very high particle size resolution, some issues still remain. One of a main problem is a long scanning time during the measurement. Long scanning time is not adequate for measuring unsteady particle concentration condition. Previous effort to overcome these problems has been performed by some researchers (Chung et al. 2006; Chen et al. 2007; Kim et al. 2007; Lee et al. 2013). They tried to improve DMA performance by increasing the number of sampling port. However, It necessarily needs excessive longitudinal extension of DMA and many commercial CPCs along with sampling ports. Then, it makes the system complicated and larger.

In this study, we developed a Hanyang nano-particle sizer (Hy-NPS) with no scanning time and relatively compact size to measure real-time particle size distribution. This system consists of multi-condensation particle counter (M-CPC), which has its own condenser and saturator, and multi-port DMA (MP-DMA), which has a variable cross sectional area electrode. We also performed an evaluation of the system using mono-dispersed particle. Then, the system performance is compared with the SMPS (TSI 3776 with customized standard DMA). The performance test was conducted under steady and unsteady particle concentration conditions.

As a result of this research, it is considered that Hy-NPS is more suitable for measuring rapidly changing aerosol concentrations than SMPS.

Acknowledgements: This research is supported by Korea Ministry of Environment as “The Eco-Innovation project”.

2IM.11

Toward the Development of Particle-number Standard Wafers for Calibrating Wafer-Surface-Scanners. Naoko Tajima, KENJIRO IIDA, Kensei Ehara, Hiromu Sakurai, Sommawan Khumpuang, Shiro Hara, *AIST*

National Institute of Advanced Industrial Science and Technology (AIST), Japan developed a technique to make a reference material for calibrating the counting efficiencies wafer surface scanner (WSS). It is a silicon-wafers which has known number of polystyrene latex (PSL) spheres on its surface. The number of PSL particles on the wafer can be controlled, and the uncertainty of the particle number is well characterized. In our approach, aerosolized PSL particles are deposited onto a wafer by inertial impaction. In order to deposit PSL particles in submicrometer-range and below, we enlarge the particle size up to micrometer range by condensing working fluid vapor on the particle sphere. We currently use water-based growth tube (GT) developed by Aerosol Dynamics Inc. The particle number concentration fed into the GT is measured by an optical particle counter that is placed in parallel with the GT. In order to specify the particle number on a standard wafer the efficiency of particle deposition and its uncertainty need to be evaluated. The actual particle number on the wafer was determined by taking scanning electron microscope images over the deposited area and by subsequently counting the PSL particles in the images. Then the actual particle number was divided by the total particle number fed to the GT to calculate deposition efficiencies. The average value and standard uncertainty of the deposition efficiency were 0.922 and 0.068, respectively. Examples of particle-number-standard wafer are presented. The standard wafers were made using PSL spheres whose diameter was 0.8 um. The particle number were varied from 1000 to 4000, and the wafer was used to evaluate the counting efficiencies of a WSS.

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2IM.12
DMA Transfer Functions under Down Scan Operation.
MARK KANAPARTHI, Suresh Dhaniyala, *Clarkson University*

Aerosol size distribution measurements are routinely made using a Scanning Electrical Mobility Analyzer (SEMS). The SEMS operation involves an exponential increasing voltage step (up-scan) followed by a voltage decay step (down-scan). Under up-scan operation, the mobility transfer function of the SEMS can be accurately calculated using a semi-theoretical approach, allowing for the subsequent accurate calculation of size distributions from SEMS data. The DMA transfer functions for the down scan operation are, however, not well understood and thus the down scan data is often ignored in the size distribution calculation. Using the arrival-time transfer function (ATF) approach of Dubey and Dhaniyala (2011), the DMA classification properties are investigated theoretically and a model for calculation of down-scan transfer functions as a function of DMA operating conditions is established. The details of the calculation approach and implication for size distribution calculation will be presented. Preliminary experimental validation of our calculation will also be discussed.

2IM.13
Evaluation of Combined Electrical Mobility and Optical Sizing Techniques for Deriving Aerosol Refractive Index.
Stephen Zimmerman, RICHARD MOORE, Bruce Anderson, Andreas Beyersdorf, Chelsea Corr, Michael Shook, Kenneth Thornhill, Edward Winstead, Luke Ziemba, *NASA Langley Research Center*

The next generation of aerosol satellite instruments will include multi-spectral polarimetric measurements to retrieve aerosol size distributions and complex refractive index (RI) at several wavelengths (Hasekamp et al., 2011; NRC, 2007), which is the "only means of constraining aerosol chemical composition from space" for passive sensors (Mischenko et al. 2007). Over past decades a number of methods have been developed to derive refractive index from combined optical and electrical mobility sizing instruments. For example, the so-called "Alignment Method" of Hand and Kreidenweis, 2002, combines joint differential mobility analyzer and optical particle counter size distributions to estimate the aerosol real refractive index. Moteki et al, 2010, used the SP2-derived scatting cross section, OPC-derived size distribution, and APM-derived mass-mobility form factor to constrain the complex refractive index of black carbon aerosols. Lack et al., 2012, present an iterative method for finding the refractive index of brown carbon coating on black carbon (BC) using SP2 and photoacoustic absorption spectrometric techniques. Finally, Mie theory can be used with DMA-derived size distributions and absorption or extinction measurements to theoretically constrain the complex refractive index of aerosols.

In this work, we evaluate the sensitivity of two commercially available, high-resolution optical particle counters for determining the size-resolved real refractive index of laboratory-generated aerosols when used with a DMA via a modified form of the "Alignment Method". We focus on characterizing the Ultra-High Sensitivity Aerosol Size Spectrometer (UHSAS) from Droplet Measurement Technologies and the Laser Aerosol Spectrometer (LAS) from TSI, Inc. using model aerosol species whose real refractive indices range from 1.3 to 1.6. Absorbing BC and BC-surrogates are also explored. While the scattering geometries of both instruments are the same, the principal difference between the instruments relates to the laser wavelengths. The sensitivity of each instrument to changes in compositionally-driven aerosol refractive index will be discussed.

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2IM.14

Development of CPC Calibration Technique at Low Flow Rate. SHIGERU KIMOTO, George Mulholland, Miles Owen, David Y. H. Pui, *University of Minnesota*

Condensation particle counters (CPCs) are widely used to measure the number concentration by means of light scattering from single particles after growth by condensation. There is interest in a calibration method for low particle concentration . We previously developed a calibration method for the optical particle counter (OPC) at ultra-low concentration of 0.01-1 particle/cm3 using wafer surface scanning (WSS) technique for 3 µm PSL spheres. However, several issues limiting the accuracy of the previous measurements 1. Large flow rate uncertainty at the low flow of 0.1 L/min. 2. Large uncertainty in the sampling bias, 3. Possibility of particle losses in the diluter.

In this work, we developed a calibration methods for condensation particle counter (CPC) using WSS for four monodisperse PSL calibration spheres over the size range of 0.1 µm to 3 µm. We improved our calibration system by accurately measuring the flow using high sensitivity electronic manometers for the laminar flow elements, by extensively assessing the slitter bias, and by developing a new diluter to reduce the particle losses.

2IM.15

Number-size Distribution of Nano-TiO2 Agglomerates Measured by NanoScan SMPS: Dispersion of Agglomerates across the Orifice Inlet. MAROMU YAMADA, Mitsutoshi Takaya, Isamu Ogura, *Japan National Institute of Occupational Safety and Health*

Nanomaterial particles exhibit a wide range of sizes because of the formation of agglomerates/aggregates. While measuring the size distribution of agglomerated particles, real-time aerosol instruments may output unexpected results because these instruments are generally calibrated using polystyrene latex particles, which are ideal particles that are monodisperse and spherical. In this study, we evaluated the performance of a recently commercialized instrument, a portable SMPS (NanoScan SMPS, Model 3910, TSI Inc.), which has an inlet composed of a cyclone with a 50% cut-off diameter of 0.5 micrometer and an orifice, by using polydispersed, agglomerated aerosol particles. The aerosol particles were generated from nano-TiO_2 powder (P25, Evonik Industries) using a vortex shaker method. 1 cm^3 of the powder was placed in a glass test tube and agitated using a vortex shaker at a constant rotational speed (2750 rpm). Then, the suspended particles were delivered to the aerosol sizers using HEPA-filtered air. We compared the data obtained using the NanoScan SMPS to a research-grade SMPS (Model 3936L10, TSI Inc.) with a cyclone that had a 50% cut-off diameter of 3 micrometer. The results showed obvious differences in the size distributions of the generated nano-TiO_2 aerosol particles as measured by these instruments. However, the size distributions that were obtained from these instruments for indoor aerosol particles were similar. A possible reason for the observed differences is that the orifice of the NanoScan inlet acted as a disperser for the weakly agglomerated particles due to the higher-pressure loss (about 5.0 kPa) across its inlet. Consequently, the number concentration increased due to the breakup of the agglomerates.

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2IM.16

Comparison of the Grimm 11-R Mini Laser Aerosol Spectrometer to the TSI 3321 Aerodynamic Particle Sizer.

CHIH-HSIANG CHIEN, Alex Theodore, Chang-Yu Wu, Yu-Mei Hsu, Brian Birky, *University of Florida*

A new optical particle counter (OPC), 11-R Mini Laser Aerosol Spectrometer, was compared with the TSI 3321 aerodynamic particle sizer (APS) for particle sizing. The new OPC is the next generation of Grimm 1.109 Portable Aerosol Spectrometer which has been broadly used in environmental, industrial and occupational aerosol monitoring due to its portable design, real-time monitoring, and cost effectiveness. However, not only the particle size but also the refractive index of material influences the scattering response, resulting in concern about the accuracy of particle sizing. Furthermore, while the OPC reports size distribution in optical diameter, it is widely assumed that the optical diameter is equivalent to its volume equivalent diameter. For example, the count size distribution has been integrated to compare with mass-based measurement such as $PM_{2.5}$.

Monodisperse liquid oleic acid and solid sodium chloride aerosols in the range of 1 to 20 micro-meter generated separately by a vibrating orifice aerosol generator were measured by the OPC and the APS in parallel to compare their performance. The results showed that the OPC's optical diameter was not equivalent to the volume equivalent diameter converted from the APS' aerodynamic diameter, and the relationship was in a non-linear fashion. For oleic acid aerosol, the volume equivalent diameter was generally slightly larger than its optical diameter. However, the optical diameter for sodium chloride was much larger than the volume equivalent diameter. For example, the optical diameter of 9.9 micro-meter for sodium chloride was reported as a volume equivalent diameter of 7.3 micro-meter via APS. Experimental calibration equations for oleic acid and sodium chloride from 1 to 20 micro-meter were established to quantify the difference. With such a calibration, the OPC reported the same penetration profile of a commercial respirable sampler as prior studies using the APS did, proving the effectiveness of the calibration.

2IM.17

Particle Mass Concentration Determined from Single-Particle Mass Spectrometry Number Concentrations: Stability of Number Scaling Factors over Multiple Seasons.

LISA AU, Aurora Janes, Ernesto Polania-Gonzalez, Jumaanah Flowers, Elizabeth Grubb, Deborah Gross, *Carleton College*

Single-particle mass spectrometers provide detailed information about the number-concentration, chemical composition and mixing state of individual aerosol particles. Procedures exist to convert the number-concentration to mass-concentration, based upon calibrating the data for particle transmission losses, and assuming an average particle density or composition-dependent densities. These methods have allowed the determination of total mass concentration of the sampled aerosol, and have been used to predict the mass concentration of different observed particle types, in ambient experiments. We have applied these methods to reproduce the total PM2.5 mass concentration in the vicinity of Northfield, MN and to apportion mass to different particle types identified through K-means clustering. Here we test this approach to reconstructing the PM2.5 mass concentration using single-particle mass spectrometry data acquired over four seasons, giving us the ability to examine the applicability of one set of scaling factors to an aerosol composed of differing particle sources and sampled under vastly different ambient conditions. Results for the seasonal variation of the particle types observed, and the reliability of the number- to mass-concentration scaling with a variety of particle-density selections, will be presented.

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2IM.18

Identification of Organic Components in Aerosols Sampled with Electrostatic Precipitation-Electrospray Ionization Mass Spectrometry (EP-ESI-MS). JUMAANAH FLOWERS, Elizabeth Grubb, Lisa Au, Siqin He, Lin Li, Hongxu Duan, Amir Naqwi, Christopher Hogan Jr., Deborah Gross, *Carleton College*

Electrospray ionization (ESI) coupled with tandem mass spectrometry enables the detailed exploration of the structure of organic compounds, due to its ability to generate intact pseudo-molecular ions which are then isolated and fragmented. The use of ESI and tandem mass spectrometry to investigate the organic components of aerosol particles will be described here. The aerosol particles will be sampled using an Electrostatic Precipitation-Electrospray Ionization (EP-ESI) source that we have recently described. This source uses a charged tungsten rod to electrostatically sample charged aerosols for a fixed period of time before exposing the sampled particles to a flowing electrospray solvent. By application of an appropriate voltage, an electrospray is generated in which dissolved molecular species from the collected aerosols are introduced into the gas-phase, and sampled into the mass spectrometer. In combination with an ion trap mass spectrometer that enables multiple stages of isolation/fragmentation, this source provides a powerful tool to sample and identify complex organic compounds found within aerosol particles, whether generated from laboratory experiments or sampled from the ambient air. To demonstrate the capabilities of this system, we will investigate its performance when coupled to a commercial mass spectrometer using laboratory generated aerosols of a variety of organic precursors and their oxidation products.

2IM.19

An Electrospray / Differential Mobility Analysis / Inductively Coupled Plasma / Mass Spectrometry (ES/DMA/ICP-MS) Based Method for the Quantification of Engineered Nanoparticles in Environmentally-Relevant Water Matrices. MARK ELLEFSON, Charlie Chan, Christine Loza, Sue Wolf, Brian Mader, *3M Company*

An electrospray-differential mobility analysis-inductively coupled plasma mass spectrometry (ES/DMA/ICP-MS) methodology was evaluated for the measurement of the size distribution and quantitative number concentration of manufactured nanoparticles (MNs) in environmentally relevant aqueous matrices. Reference materials (some having NIST traceability for size) consisting of SiO2, TiO2, gold, and silver and having diameters from nominally 20 to 75 nm were used in the evaluation. The reference materials were spiked into different environmentally relevant aqueous matrices; algae and daphnia growth media used in ecotoxicology testing as well as semiconductor grade ultra pure water, groundwater, and an industrial wastewater. A comparison of the mean measured particle diameters of the reference materials to the expected NIST-traceable size range for the materials will be presented. In addition matrix matched calibration curves were prepared to determine the individual response factors of each reference material in each media. Response factors were used to quantify the levels of the reference materials spiked into each aqueous matrix and the matrix spike recovery was determined as well as the limit of detection. The method requires the use of a gas-exchange system to exchange the air stream used in electrospray and DMA sections of the instrument with argon that is required for the ICP-MS analysis. The transmission efficiency and gas exchange efficiencies of the system were in excess of 99%. Overall this method looks promising for the evaluation of inorganic MNs in environmental matrices.

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2IM.20

Optimizing Nuclepore Filter Penetration for Length and Fractal Dimension Characterization of Non-spherical Particles. SHENG-CHIEH CHEN, Jing Wang, Heinz Fissan, David Y. H. Pui, *University of Minnesota*

By combination of a DMA (differential mobility analyzer) with a filter with uniform pores, namely a filter sensor, a new method for differentiating nanoparticles with various mass-mobility fractal dimensions, Dfm, was developed and validated experimentally and theoretically. The sensor is also able to measure the effective length (or maximum projected length) of nanoparticles with different shapes, which is an important parameter responsible for the lung deposition due to interception. At the same mobility diameter, it was observed that the compact NaCl had the highest penetration followed by partially sintered silver (Ag) aggregates and then the loose Ag and soot agglomerates. The result indicates that the stronger interception by the filter is correlated to the more elongated shape of the particles. A modified capillary tube model for predicting the penetration of Ag nanoparticles with different mass-mobility fractal dimensions was validated by experimental data. By using the validated model, this study found that the sensor could have a further enhanced sensitivity if the porosity and thickness of the filter were adjusted to 0.01 and 5 um, respectively. The penetration differences obtained from the model are as high as 7-18%, 14-35% and 24-40% between spheres and loose agglomerates (Dfm= 2.1) for 50-100, 100-300 and 300-1000 nm particles as the filter pore sizes are 0.4, 1 and 3 um, respectively. This new filter sensor can measure the effective length and mass-mobility fractal dimension in nearly real-time and may be applied in nanotoxicity studies and quality control of nanomaterial productions (e.g. by flame reactors).

2IM.21

Development of an Ultrafine Condensation Particle Counter (UCPC) for Measurements of Particles Down to 1 nm in Diameter. JUN ZHAO, Hee-Siew Han, Ashish Karn, Peter H. McMurry, *University of Minnesota*

Atmospheric nanoparticles formed by nucleation and their subsequent growth to cloud condensation nuclei may significantly affect cloud formation and global climate. To better understand this process will need to have the ability to measure particles down to the size of a nucleus (about 1-1.5 nm). In some industrial applications such as deposition in semiconductor and production of engineering nanoparticles, measurements of particles down to 1 nm are also needed. Conventional butanol or water-based ultrafine condensational particle counter (UCPC) can only measure particles as small as about 2.5 nm (D50=2.5 nm, mobility diameter) due to limitation of the physical properties of the working fluid. Here we present development and application of a diethylene glycol based UCPC (DEG-UCPC) that can measure atmospheric particles down to 1 nm in diameter. The DEG-UCPC was prototyped from a TSI UCPC 3776 with some noticeable modifications inside the hardware framework. The performance of the instrument was evaluated with several sets of saturator/condenser temperatures and with different saturator/capillary flows. The detection efficiencies of 1-30 nm NaCl particles were measured to determine the minimum size (D50, the size corresponds to 50% detection efficiency) and to invert the concentrations for data analysis. A minimum size of about 1.1 nm geometry diameter was achieved with saturator/capillary flows of 850/150 ccm and saturator/condenser temperatures of 62ºC/12ºC. Application of a prototyped DEG-SMPS (combined a TSI nano-DMA and a DEG-UCPC) for measurements of atmospheric nanoparticles in recent field campaigns was also presented.

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2IM.22

Investigation of Dust Dynamics Using Imaging Techniques. WING-TAK LAI, Seungkoo Kang, Sheng-Chieh Chen, David Y. H. Pui, *TSI Inc*

The dust dynamics in terms of its size, concentration and velocity are important information for many different applications. For example, the use of the dusts for calibrating particle instruments, for correlating the dust size with health effect in exposure studies as well as using the dusts to challenge different purpose filters all rely on these dynamics. In situ measurements for these dynamics of dusts using particle instruments usually do not take the transport loss into account, especially for dusts larger than 5 microns, which can lead to a severe error on sizing and concentration measurements. This study proposes a non-intrusive imaging technique to determine the dust dynamics, which can avoid the error due to the transport in the experimental system. The system is made up of a 8 Mpixel CCD camera with 5.5 micron pixel size, x12 micro-lens, a 532 nm light source double-pulsed laser and a commercial software, Insight 4G (TSI Inc., Shoreview, MN). By using the x12 lens, the pixel size of the camera is reduced to ~0.4 microns, allowing the ability to measure dust particles of size down to 2 micron when a 5 x 5 pixel region is considered to determine the size. Since the system is based on the measurement of “shadow” of the dust particle with laser illumination in the forward scatter direction, the size of the shadow is measured directly without any assumption pre-conceived shape of the dust particle. The concentration is estimated based on the inspection area size and the number of dusts detected over a time period. In addition to the size and concentration of the dusts, velocity is also measured by the system to provide flux information.

2IM.23

Development of Aerosol-LIBS (Laser Induced Breakdown Spectroscopy) for Real Time Detection of Chemical Elements in Process-induced Particles. Kyoungtae Kim, Hoseong Chae, GIBAEK KIM, Kihong Park, *Memory Business, Samsung Electronics Co., LTD, South Korea*

The Laser induced breakdown spectroscopy (LIBS) is a useful tool for rapid detection of elemental composition of particles (Park et al. 2009). In the LIBS, a high power pulse laser hit the single particle or collected particle sample to generate microplasma (excited state), and the excited atoms and ions emit light with specific wavelengths during their cooing down to ground state, which can be used to detect elements in the single particle or ensemble sample. In this presentation, the Aerosol-LIBS has been developed to determine elemental composition of process-induced particles (contaminants) in real time.

An aerosol chamber with a shear air focusing system was constructed to continuously introduce particles into the laser focal point, to generate microplasma after particles were hit by a pulse laser, and to detect light emissions from the microplasma. Various laboratory-generated particles (MgCl2, Ca(NO3)24H2O, KCl, and NaCl) were tested for determination of their major elements (Mg, Ca, K, and Na). Optimization of laser, optics, spectrometer, delay time, and particle focusing was also performed. Effects of particle number concentration and size on the hitting efficiency were examined by using particles of known sizes or concentrations. Also, both free-firing and triggering laser systems were applied to significantly improve the hitting efficiency of airborne single particles.

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2IM.24
Experimental Characterization of Microfabricated Virtual Impactor Efficiency. TROY CADOS, Omid Mahdavipour, Dorsa Fahimi, Seiran Khaledian, Richard White, Paul A. Solomon, Igor Paprotny, Lara Gundel, Thomas Kirchstetter, *Lawrence Berkeley National Laboratory*

The Air-Microfluidics Group is developing a micro-electromechanical systems-based direct reading particulate matter (PM) mass sensor. The sensor consists of two main components: a microfabricated virtual impactor (VI) and a PM mass sensor. The VI leverages particle inertia to separate coarse and fine particles into two airstreams: a minor flow of 0.6 cc/min and a major flow of 5.4 cc/min. This presentation highlights the novel methods developed to experimentally evaluate the particle separation efficiency of the microfabricated VI.

Experiments are carried out inside a well-mixed chamber. Polystyrene latex spheres (PSLs) are collected on membrane filters near the inlet of the VI and downstream of the VI's major and minor flow channels. A microscope is used to image and count PSLs on less than 10% of each filter, and the total number of particles collected on each filter is estimated using an extrapolation model. The model is validated using three different methods, including collecting replicate samples and by comparing the mass concentration of PSLs in the chamber calculated from the number of PSLs on each filter to the mass concentration measured with a calibrated DustTrak aerosol monitor. The particle separation efficiency of the VI has thus far been evaluated experimentally for 0.5, 1.5, and 2.5 micrometer (diameter) PSLs and compared to the efficiency predicted using a computational fluid dynamics model. Counting particles on filters at the VI's inlet and outlet and deposited within the VI's flow channels (wall loss) allows for a nearly complete mass balance to be obtained and calculation of the VI collection efficiency curve.

2IM.25
Direct Ultraviolet Photoionization and Charge Recombination of Aerosol Nanoparticles. Robert Nishida, Simone Hochgreb, ADAM M BOIES, *University of Cambridge*

Aerosol nanoparticles are more efficiently charged by direct ultraviolet photoionization than with other charging mechanisms such as corona discharge. The charged nanoparticles can more easily be manipulated for detection, capture, or control in many aspects of aerosol and materials science. For example, newly generated particles can be charged to prevent/promote agglomeration or to control the formation of nanostructures.

Photoionization behaviour is not well characterized for different particle types or larger sizes into the accumulation mode. Existing models for photoionization yield include empirical 'constants' which vary for particle size and type. Mechanisms of particle charge recombination with gaseous ions are well understood, but models often neglect particle and ion wall losses and 3D effects. The aim of this work is to understand the fundamental aerosol charging and charge recombination mechanisms from the free molecular to continuum regimes.

Equations capturing both photoionization and recombination of ions/particles are modelled in 3D computational fluid dynamics for the first time. The model incorporates ion/particle advection/diffusion, wall losses, electric field transport. Upwards of 50 simultaneous species transport equations are solved to allow the resolution of local charge distribution and average charges per particle for multiple charge states.

The model is compared with experimental results for charge efficiency for a range of particle types (e.g. soot, silver), diameters, and concentrations showing good quantitative agreement. The effects of adsorbed volatiles on photoionization are explored by incorporating a catalytic stripper for a range of soot types. Results demonstrate the limitations of fundamental photoionization theory and previous continuum scale models.

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2NM.1

A Study on Nanoparticle Formation Events at Urban and Coastal Sites in Korea. KWANGYUL LEE, Hoseong Chae, Hee-joo Cho, Ji Yeon Park, Peter H. McMurry, Kihong Park, *Gwangju Institute of Science and Technology, Gwangju, Korea*

Nanoparticle formation (NPF) events in the ambient atmosphere have been reported at many places in the world. The freshly formed nanoparticles can grow into the optically important size range affecting radiation balance and cloud formation. In this study, the NPF events and particle growth were examined at urban (Gwangju) and coastal (Boseong) sites in Korea. Continuous measurements of particle size distributions in a wide size range were made with the diethylene glycol-scanning mobility particle sizer spectrometer (DEG-SMPS) (1-12 nm), Nano-SMPS (3-80 nm) (DMA 3080. CPC 3776), NanoScan-SMPS (10-420 nm) (TSI 3910), SMPS (20-600 nm) (DMA 3080, CPC 3022), and/or optical particle sizer (OPS) (0.3-25 um) (Grimm, 1.107). Also, black carbon (BC) concentration and chemical components of non-refractory submicrometer particles were occasionally measured with the aethalometer (AE-51) and aerosol mass spectrometer (Aerodyne Inc, USA), respectively. Several NPF events with subsequent growth were observed. The intensity of the NPF and the growth rate of the nanoparticles were much higher in urban site than coastal site. Also, the intensity of NPF event was much stronger in summer than winter at the urban site. More thorough analysis will be conducted, and their results will be presented.

2NM.2

Examining the Physicochemical Properties of Silver Nanoparticles in Simple and Complex Simulated Gastric Fluid. JESSICA AXSON, Diana Stark, Amy Bondy, Justin Keeney, Sonja Capracotta, Andrew Maynard, Martin Philbert, Ingrid Bergin, Andrew Ault, *University of Michigan, Ann Arbor MI*

Silver nanoparticles (AgNPs) are present in a wide variety of commercial products and can enter the human body through oral exposure. Examining the fundamental physicochemical changes in nanoparticle size under conditions representative of the gastrointestinal (GI) tract is important for elucidating the impacts of AgNP on the human body. This work examines the kinetics of AgNP in simple (NaCl + HCl) simulated gastric fluid (SGF) as a function of pH (SGF at pH 2, 3.5, 4.5 and 5), size (20 nm and 110 nm AgNPs), and coating (Citrate and PVP). Rapid AgNP growth was observed on 30 second timescales using Nanoparticle Tracking Analysis (NTA), which is explained by the generation of Ag+ in acidic environments that precipitates with Cl-, leading to particle growth and facilitating particle aggregation by decreasing their repulsion in solution. Additionally we explore the use of Surface Enhanced Raman microspectroscopy (SERs) as a useful tool for examining protein corona formation on AgNP in more complex (NaCl+ HCl+ pepsin) SGF as proteins with in the human body can bind to the AgNP surface potentially altering their function within the body. This study indicates a need to further understand the importance of initial size, physicochemical properties, and kinetics of AgNPs after ingestion to assess their potential toxicity.

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2NM.3

Controlled Morphology of Nanostructured Metal Oxide Films for ACVD and FLAR Methodologies. KELSEY HADDAD, Tandeep Chadha, Pratim Biswas, Nalin Katta, Barani Raman, *Washington University in St. Louis*

Nanostructured film synthesis has attracted enormous interest for both fundamental research as well as technical applications. These applications span a number of industrial sectors, including corrosion protection, pollutant decomposition, and solar energy storage and transformation. The morphology of these thin films plays an integral role in their performance and should be tailored for the specific application of interest. Aerosol chemical vapor deposition (ACVD) and flame aerosol reactors (FLAR) are two single-step aerosol methodologies commonly employed for the deposition of thin films. Three typical film morphologies—dense, columnar, and granular—are observed in both systems. While the aerosol phase dynamics are highly complex, the different morphologies can be reduced to three major deposition regimes: vapor-dominant regime, vapor-particle mixed regime, and particle-dominant regime[1]. The deposition regime is controlled by the relationship between four characteristic times, including residence time (τres), reaction time of the precursor (τrxn), sintering time (τsin), and particle-particle collision time (τcoll)[2]. Through the analysis of experiments conducted on TiO2 thin film deposition, using titanium tetraisopropoxide (TTIP), a morphology map of thin film deposition as a function of the characteristic times was created. The consolidation of these characteristic times to form a morphology diagram allows for the efficient control of thin film morphology across the broad spectrum of input parameters and even precursors. The results were then used to aid in the optimization of nanostructured SnO2 films through ACVD for applications in room-temperature gas sensing.

1. An, W.-J., E. Thimsen, and P. Biswas, Aerosol-chemical vapor deposition method for synthesis of nanostructured metal oxide thin films with controlled morphology. The Journal of Physical Chemistry Letters, 2009. 1(1): p. 249-253.
2. Thimsen, E. and P. Biswas, Nanostructured photoactive films synthesized by a flame aerosol reactor. AIChE journal, 2007. 53(7): p. 1727-1735.

2NM.4

Crumpled Graphene-Encapsulated Si Composites as Anode Materials for Li Ion Batteries. KIM HYEKYOUNG, Kil Dae Sup, Chang Hankwon, Choi Ji-Hyuk, Kim Hansu, Hee Dong Jang, *University of Science and Technology*

Rapid growth of the semiconductor and PV industry has led to a shortage of silicon and has also increased the price of silicon. Over 40% of silicon is consumed as a slurry waste during wafer slicing process. In this study, we present effective recovery of the Si particles from the waste silicon sludge by the ultrasonic spray drying after acid treatment. The Si-GR composites that Si nanoparticles wrapped by crumpled graphene shells were fabricated with recovered Si and graphene for anode material of Li ion battery. The morphological, crystallinity, composition of silicon particles and Si-GR composites were analyzed by SEM, XRD, PSA, ICP and STEM. Galvanostatic charge/discharge measurements for the electrochemical performance were conducted at various current densities between voltages of 0.0 and 2.0 V (V versus Li/Li+). The ultrasonic spray drying was found as effective methods to recover silicon particles and metallic impurities were effectively removed by acid treatment. The Si-GR composites were successfully prepared by aerosol process and heat treatment. The composite capsules have greatly improved performance as Li ion battery anodes in terms of capacity, cycling stability, and Coulombic efficiency by comparison with the native Si particles.

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2NM.5
Generation of Controlled Fluxes of Nanoparticles to a Substrate by Pulsed Radio-Frequency Hydrogen-Silane Dusty Plasmas. PARTH SHAH, Carlos Larriba-Andaluz, Steven Girshick, *University of Minnesota*

Silicon nanoparticle deposition onto a substrate can be a means to epitaxial film growth at low temperature. It is hypothesized that this can be achieved if the nanoparticles' impact energy and size can be controlled by pulsing the plasma and by applying a positive DC bias to the substrate during the afterglow phase of each pulse in order to accelerate and collect the negatively charged nanoparticles. In recent work (1) this concept was explored using a 1D numerical model of an argon-silane plasma. However hydrogen-silane plasmas are more widely used for deposition of silicon thin films, because hydrogen promotes film crystallization. Hydrogen and argon differ in important respects that affect this process, including both clustering chemistry and particle charging. Compared to argon, hydrogen tends to suppress nucleation. Also, because of the lighter mass of H ions compared to Ar, nanoparticles are less negatively charged in the hydrogen case. Here we use a similar model as in Ref. 1, but with more detailed hydrogen plasma chemistry, to conduct numerical simulations for the hydrogen-silane case. Conditions include 13.56-MHz frequency, total pressure of 2 Torr, and a 2-cm electrode gap. Simulations were conducted for a range of pulse parameters, including pulse frequency and duty cycle, and DC bias voltage during the afterglow phase of each pulse.

This work was partially supported by the National Science Foundation (CHE-124752), Dept. of Energy Office of Fusion Energy Science (DE-SC0001939), and the Minnesota Supercomputing Institute.

(1) C. Larriba-Andaluz and S. L. Girshick, AAAR 2015, abstract.

2NM.6
Thin Film Deposition of Self-assembled Carbon Nanotubes. Jean de La Verpilliere, ADAM M BOIES, *University of Minnesota*

For properties of carbon nanotubes (CNTs) to be transferred into commercial products, control of the organisation at the nano, micro, and macro scales needs to be controlled. Gas-phase processes are inherently scalable, while the power of self-assembly allows for a precise control of the final structure at the microscale and nanoscale. The present work proposes a novel illustration of this concept: so-called self-assembled CNT sea urchins are synthesized (Kim 2010), and continuously deposited on a substrate. The resulting nanomaterial presents interesting properties in terms of nanostructure, porosity, electrical and thermal conductivity. Properties of the final material being largely influenced by particle deposition parameters.

An aqueous solution of Al(NO3)3 and Fe(NO3)3 was atomized in a nitrogen flow using a nebulizer. Upon droplet evaporation in a drier, both metallic salts precipitate, forming spherical nanoparticles with an aluminium-enriched surface consisting of small iron nitrate patches in an aluminium nitrate matrix. A first tube furnace thermally decomposes the metal nitrates in a reducing atmosphere, thus producing Al-Fe nanoparticles. These nanoparticles form the core of the CNT sea urchins that are grown in a subsequent step, whereby a carbon source catalytically decomposes on the iron at the surface of the particles in another furnace, enabling CNT growth. Characterisation was performed in order to optimize the process to synthesize a high density of small diameter, long, straight CNTs on the surface of the cores. A thermophoretic precipitator allowing for high-efficiency controlled thin film deposition on a silicon wafer over a 5 cm2 area was designed with the help of three dimensional simulations on COMSOL Multiphysics®. Theoretical and experimental deposition efficiencies and uniformities are compared. The thermophoretic precipitator was then used to deposit thin films of CNT sea urchins. Preliminary characterisation of the resulting thin films is discussed.

Kim et al. (2010). J. Nano Res, 13(1).

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2RA.1

Physiochemical Characterization of Ambient Aerosols and Insoluble Residues in Snow. JESSICA AXSON, Jessie Creamean, Hongru Shen, Amy Bondy, Rebecca Craig, Nathaniel May, Kerri Pratt, Andrew Ault, *University of Michigan, Ann Arbor MI*

Aerosol physical and chemical properties have a profound impact on cloud microphysical properties which influence precipitation patterns and, ultimately, water supply. To improve our understanding of these effects, it is important to examine particle sources. We present analysis of the size, chemical composition, and sources of aerosol particles and residues at two mountain locations, the California Sierra Nevada Mountains and the Colorado San Juan Mountains, using a variety of analytical techniques. Insoluble and soluble residues from nucleating and scavenged aerosols in snow collected in the Sierra Nevada Mountains during the 2012/2013 winter season showed that snow at each location was impacted by variable sources, leading to vastly different physiochemical properties of the snow residues. Using these methods we were able to determine temporal and spatial trends of species in the insoluble residues. Further, during the Colorado snow and aerosols study conducted in the spring of 2015, we were able to combine the insoluble residue data with that of ambient aerosol to examine dust deposition on snow. Improving our understanding of the spatial variation of aerosols sources through the physiochemical analysis of precipitation residues along with ambient aerosol measurements is important for remote mountainous regions where snowpack provides a steady, vital supply of water.

2RA.2

10-Month Characterization of the Aerosol Number Size Distribution and Related Air Quality and Meteorology at a Reference Site in the Central U.S. Robert Bullard, Ashish Singh, CHARLES STANIER, *University of Iowa*

Aerosol size distribution measurements at the Bondville environmental and atmospheric research site (BEARS) in Bondville, IL during 2013 and 2014 are reported together with a summary of related air quality variables. The instrumentation, data analysis, and quality assurance procedures involved in creating a final publically-released aerosol size distribution dataset for this site are presented. The size distributions are intercompared with public monitoring records from the same site, including passively and actively sampled ammonia, NOAA aerosol particle number and scattering and absorption, PM2.5 mass and composition, EPA NCore gas measurements (NO, NO2, SO2, O3, NOy). We further place the aerosol microphysics measurements into context with back trajectory analysis, correlations with locals wind direction and wind speed, K-means clustering of the size distribution, and summary of ultrafine volatility profile by tandem differential mobility analysis. Strengths of the dataset include the coverage of multiple seasons over 10 months, the full range of the size distribution from 3-500 nm, and the supplementing of the long-term record at this site (reaching back over a decade for many of the monitoring programs) with the full aerosol size distribution. Weaknesses of the dataset include instrument downtime problems due to instrument failures and extreme cold events during the 2014 winter “polar vortex” conditions when ambient temperatures reached -25 degrees C. Access procedures for using this valuable dataset for model evaluation are presented.

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2RA.3

A PAM Reactor Investigation on Physiochemical Properties of Transported Chinese Haze at Gosan Climate Observatory. XIAONA SHANG, Eunha Kang, William Brune, Jihyun Han, Saehee Lim, Sang-Woo Kim, Meehye Lee, *Korea University, South Korea*

A PAM (potential aerosol mass) reactor was deployed with a SMPS (scanning mobility particle sizer) to investigate secondary aerosol forming potential of haze air masses at Gosan Climate Observatory (GCO), South Korea, in Nov., 2010. PAM reactor is designed to simulate the atmospheric oxidation process in a laboratory and field by producing a highly oxidizing environment.

The haze was transported from China and two types of haze were identified based on chemical characteristics of aerosols. The first phase was impacted by biomass combustion and characterized by great enhancements of potassium and organic compounds. The second phase was the mixed plume of biomass and coal combustion, during which SO2 and sulfate concentration was remarkably elevated. Of the two, PAM produced more number of particles both in nucleation and condensation mode for second phase. Particularly, the mode diameter of number was found at 200 ~ 300 nm, at which mass increase was also distinguished.

2RA.4

Characterization of Local and Long-range Transported Arctic Aerosol Particles in Wintertime. RACHEL KIRPES, Amy Bondy, Bingbing Wang, Alexander Laskin, Andrew Ault, Kerri Pratt, *University of Michigan*

The Arctic region is a drastically changing environment due to climate change resulting in rapid transformation and loss of sea ice. It is crucial to understand atmospheric composition under these changing conditions in order to predict future climate. One major contributor to Arctic atmospheric chemistry that has not been extensively studied is due to increased sea ice fracturing generating open sea ice leads that expose the ocean surface, resulting in the emission of sea spray aerosol. This sea spray aerosol generated in the Arctic can influence climate through impacts on cloud formation and snow composition, following deposition. Few studies have been conducted on aerosol particle composition prior to polar sunrise, a time when particle impacts on clouds are expected to be significant. Atmospheric aerosol particle samples were collected near Barrow, Alaska in January and February 2014. Elemental composition and morphology of single particles were characterized by computer-controlled scanning electron microscopy with energy dispersive X-ray spectroscopy (CCSEM-EDX), and k-means clustering was used to determine individual particle types. Raman microspectroscopy was also used to characterize organic and inorganic functional groups and spatial distribution of these species in individual particles at ambient temperature and pressure. The extent and form of atmospheric aging at the single particle level was determined. Meteorological data and sea ice images from the sampling period were used to determine how factors such as wind speed, the presence of open leads, and solar radiation impact particle chemistry. Understanding the chemical composition of Arctic particles in wintertime and particle influence on Arctic climate will inform predictions for the future climate of a rapidly changing environment.

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2RA.5

Characterization of Lake Spray Aerosol Produced from the Great Lakes. NATHANIEL MAY, Jessica Axson, Andrew Ault, Kerri Pratt, *University of Michigan*

While the production of sea spray aerosols has been well studied, little is known about the production of aerosols from freshwater bodies such as the Great Lakes, which we refer to as lake spray aerosol (LSA). With certain regions of the Great Lakes currently experiencing a historic rise in the occurrence and severity of harmful algal blooms, this LSA could pose a public health risk due to inhalation of aerosolized toxic bloom products. Therefore, it is imperative to determine the physiochemical factors controlling LSA production from the Great Lakes and the extent to which harmful algal bloom byproducts are incorporated into the LSA population during bloom events. To study this phenomenon, a laboratory LSA generator was constructed based off previously published sea spray aerosol generator designs. The generator was used to compare the differences in aerosol production when using salt composition of seawater versus freshwater by analyzing the bubble and aerosol size distributions generated from these representative salinities. Additionally, single particle techniques, including electron microscopy and single-particle mass spectrometry, were used to determine particle composition and morphology. To determine the components of harmful algal blooms that are incorporated into LSA population, the LSA produced in the generator using freshwater samples collected from nine locations with and without harmful algal blooms around the Great Lakes were examined. Seasonal variations were examined from water samples collected at these sites during fall 2014, spring 2015, and summer 2015. By understanding how the composition of the Great Lakes affects the production of lake spray aerosol, this study will provide novel insights into the impacts of the Great Lakes aquatic environment on the region's atmosphere.

2RA.6

Long-term Observations of Ammonia, Nitric Acid, Ammonium, and Nitrate in a Rural Gas Production Region. AMY P. SULLIVAN, Yi Li, Mark Tigges, Cassie Archuleta, Jeffrey Collett, *Colorado State University*

Ammonia is the most abundant basic gas in the atmosphere. It is an important contributor to nitrogen deposition and one of its most important sources includes agricultural activities. Ammonia can react with nitric acid, formed from the oxidation of NOx (nitrogen oxides), to form submicron particulate ammonium nitrate. This ammonium nitrate formed can contribute to visibility impairment. Class 1 areas in the United States have been identified for protection from visibility impairment through the Regional Haze Rule. In the western U.S., many of these visibility-protected areas are near oil and gas production activities, which are large emitters of NOx. Western Wyoming is one region of recent active gas development. However, there are few measurements of ammonia in this region (or much of the western U.S.), meaning that when estimating the impacts of NOx emissions from gas development on visibility and regional haze in this region a background ammonia mixing ratio is often assumed. Therefore, long-term measurements of ammonia, nitric acid, ammonium, and nitrate using URG denuder and filter packs were started in 2007 in Boulder, Wyoming, located in the midst of the Jonah and Pinedale Anticline Gas Fields. Results from these measurements will be presented and discussed to examine the seasonal variability in these species, provide insights into typical ammonia concentrations, and better understand the role of the ammonia-ammonium-nitric acid-nitrate system in this region.

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2RA.7

Characteristics of Cloud Condensation Nuclei in Barrow, Alaska. GARRETT WELSHOFER, Nathaniel May, Anne Jefferson, Patricia Quinn, Peter Peterson, William Simpson, Kerri Pratt, *University of Michigan*

Water condensation on particles in the atmosphere leads to cloud droplet formation, and the physical and chemical properties of these particles impacts their ability to form clouds and lead to precipitation. Submicron atmospheric particles and cloud condensation nuclei (CCN) concentrations were measured near Barrow, Alaska from 2007 to 2010 at the NOAA Observatory. Concurrent measurements of ozone and bromine monoxide (BrO) concentrations in Barrow, Alaska allowed examination of CCN activity as a function of atmospheric oxidant concentrations. Additionally, we compared CCN and aerosol chemistry (inorganic ion concentrations) while examining air mass trajectories to identify potential sources influencing the CCN properties. Lastly, we examined seasonal variability of cloud condensation nuclei over the four-year period. This analysis will provide insights into the interactions between changes in Arctic surface properties (e.g. sea ice, snowpack) and cloud properties as the Arctic undergoes rapid climate change.

2RA.8

Chemical Composition of PM2.5 at Sanya: Effects from Regional Transport. JIAMAO ZHOU, *Institute of Earth Environment, Chinese Academy of Sciences*

Intensive observation of PM2.5, organic and elemental carbon (OC and EC), water-soluble ions and elemental were conducted from January 8th to February 8th, 2012 at Sanya, Hannan Province, China. Average PM2.5 mass concentration was 20.4±7.6μg.m-3. The air quality of Sanya was good than most of other Chinese cities and the PM2.5 concentration accorded with the newly national PM2.5 standards. Carbonaceous aerosol, water-soluble ions and continental matter account for 30.44%, 37.08% and 9.14% in PM2.5 respectively.

Gasoline motor vehicle exhaust was identified as the major local source for PM2.5 at Sanya using Principal Component Analysis, followed by biomass burning, diesel exhaust and coal combustion. Two air pollution episodes were observed during the sampling time. The concentration of SO42- and NH4+ were 3 times than normal days, however other composition were twice compared with normal days. HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory) has been used to see the air mass trajectory in these two days which showed the air mass came from northeast where Pearl River Delta located. The result indicated that PM2.5 at Sanya, the most southern city were affected by regional transport

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2RA.9

Mass Size-segregated of Sub-urban Aerosol of Continental Part of Balkans. DRAGANA ĐORđEVIć, *ICTM*

The atmospheric aerosols impacts on human health, the earth's radiation budget, the global climate and the effect of the planet energy balance and yet their mass size distributions and chemical characteristics are still inadequately understood. As a result of the various atmospheric lifetimes arising from the variety of the particle sizes of atmospheric aerosols, their global distribution shows large regional differences and their properties are poorly known. Urban areas are rich in anthropogenic sources of fine particles containing harmful substances.

Size-segregated sub-urban aerosol of continental part of Balkans' was studied in the period March 2012 – December 2013. Aerosols were measured at the Observatory Zeleno Brdo – Belgrade (44049'N, 20027'E). The representative location is the highest point near Belgrade surrounded by wooded vegetation. Sampling device is away from other objects around it in a radius of 50 meters and ground covered with grass was chosen for investigating physical characteristics of collected particles. The influence of urban atmosphere of Belgrade on the selected measuring locations is minimized.

Low-pressure cascade impactor by Prof. Dr. Berner on 11 stages was used for samples collection. Next ranges (in μm) of size distributions PM0.0085 - 0.018, PM0.018 - 0.035, PM0.035 - 0.07, PM0.07 - 0.138, PM0.138 - 0.27, PM0.27 - 0.53, PM0.53 - 1.06, PM1.06 - 2.09, PM2.09 - 4.11, PM4.11 - 8.11, PM8.11 – 16 were measured. Aerosol samples were submitted to gravimetric measurements.

Distribution of masses shows the domination in the range PM0.53 - 1.06. Also in this interval are the highest extreme and outliers.

2RA.10

Centrifugal Separator for Micron Size Aerosol Particles. SHU NAKAO, Hiromu Matsubara, Mikio Kumita, Hidenori Higashi, Osamu Akasaka, Yoshiki Hayasaki, Takafumi Seto, Yoshio Otani, *Kanazawa University*

Simple and low-pressure loss centrifugal separator of micron-sized aerosol particle was developed. The separator is composed of a cylinder, two rotary joints and a motor. When the cylinder is rotated at the rotation speed of 500 to 3,000 rpm, swirl flow is generated in the cylinder. The aerosol particles introduced to the separator was transported by the centrifugal force with traveling by the swirl flow. As a result, the particles larger than the critical diameter are trapped on the wall of the cylinder depending on the particle size, gas velocity and rotation speed.

In order to evaluate classification performance, the polystyrene latex (PSL) particles of 0.5-5.0 micron-meter in diameter were used as test particles. The test particles generated by nebulizer were introduced in the cylinders at a flow rate of 1 and 5 L/min. The collection efficiency was determined by measuring the particle number concentrations before and after the cylinders by an optical particle counter (OPC). Pressure drop was also measured by differential pressure gauge.

The collection efficiencies for 0.5-2.5 micron-meter particles by the separator without rotation were as low as 25 (1 L/min) to 20% (5 L/min). Significant increase in the collection efficiencies of micron-particles was observed when the cylinder is rotated and the collection efficiency increased with rotation speed. At the maximum rotation speed of 3,000 rpm, more than 95 % of the 2.5 micron-meter particles were collected by the separator at 1 L/min. Therefore the centrifugal separator is considered to be effective to control the cut-off diameter by changing the rotation speed. On the other hand, the pressure drops of the separator were as low as 3 Pa (1 L/min) to 15 Pa (5L/min) and they did not change significantly with the rotation. Therefore the aerosol centrifugal separator is expected to be a size-tunable and low pressure loss classifier which can be used as a pre-filter of various kinds of aerosol instruments.

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2RA.11

Halogenated and Organophosphorus Flame Retardants on Particles in the Arctic Atmosphere. MARK HERMANSON, Amina Salamova, Ronald Hites, *University Center on Svalbard*

The use of most polybrominated diphenyl ether (PBDE) flame retardants (FRs) in consumer products and construction materials was banned by the European Union and phased out in the United States by 2008. However, there is a continuing need for FRs due to stringent flammability standards both in the USA and Europe and, as a result, there is a shift to using non-regulated FRs. Several replacement FRs have been detected in the environment, including brominated benzoate and phthalate esters and organophosphorus esters.

We collected high-volume air particle samples at an Arctic site (78.22ºN, 15.65ºE, on Svalbard) during 2012-2013 for analysis of brominated FRs (BFRs) and organophosphorus FRs. Sample volumes typically ranged from 600 ñ 750 m^3. BDEs and other BFRs have been observed in this region in earlier research. The BFRs found most often and in greatest average abundance include BDE congeners 47 (0.69 pg m^3), 99 (0.56 pg m^3) and 209 (1.10 pg m^3), collectively representing ~44% of total BDE; other halogenated FRs found included 2-ethylhexyl-2,3,4,5-tetrabromobenzoate (TBB), bis(2-ethylhexyl)-tetrabromophthalate (TBPH), decabromodiphenyl ethane (DBDPE) and Dechlorane plus (DP). The concentrations ranged from 0.3 pg m^3 for DBDPE to 6 pg m^3 for TBB. The organophosphorus FRs found most often and in greatest abundance include tris(2-chloroethyl)phosphate (TCEP), tris(1-chloro-2-propyl)-phosphate (TCPP), tris(1,3-dichloro-2-propyl)phosphate (TDCPP), triphenyl phosphate (TPP), tri-n-butyl phosphate (TnBP), tri(butoxyethyl)phosphate (TBEP), tris(2-ethylhexyl)phosphate (TEHP), and 2-ethylhexyl diphenyl phosphate (EHDPP). The concentrations of the OPFRs were often about 10 times or more greater than any of the halogenated FRs. The highest OPFR average concentration was TnBP (145 pg m^3) and ranged from 9 pg m^3 to 788 pg m^3.

BDEs with concentration <0.05 pg m^3 were congeners 10, 7, 30, 71, 85, 126, 154, 153, 138, 184, 181, 201, 204, 203, 196, 205, 208, 207; non-BDE BFRs <0.05 pg m^3 included tetrabromo-p-xylene (pTBX) and pentabromo ethylbenzene (PBEB).

2RA.12

Water-Soluble Dicarboxylic Acids, Ketocarboxylic Acids, Alpha-Dicarbonyls, and Fatty Acids in Association with Biogenic Secondary Organic Aerosol over a Forest Site in Japan. YUEMEI HAN, Kei Nosaka, Yoko Iwamoto, Kaori Kawana, Kimitaka Kawamura, Tomoki Nakayama, Mochida Michihiro, *Graduate School of Environmental Studies, Nagoya University*

Water-soluble organic carbon (WSOC) constitutes a significant proportion of organic aerosol mass in the atmosphere. One important class of WSOC compounds is dicarboxylic acids and other bifunctional compounds, which are originated from primary emission sources and formed secondarily through atmospheric oxidation processes in aqueous phase. Due to their highly hygroscopic nature, the presence of dicarboxylic acids and other bifunctional compounds in the atmosphere may alter the capability of aerosol to retain water and to act as cloud condensation nuclei, thereby affecting hydrological cycles and other climate-related impacts. In this study, samplings of atmospheric aerosol particles (TSP and PM0.95) on quartz fiber filters together with real-time measurements of submicron aerosol particles were performed at a forest site in Wakayama Prefecture, Japan, from 20 to 30 August 2010. The aerosol filter samples were extracted and analyzed for the quantification of dicarboxylic acids, oxocarboxylic acids, alpha-dicarbonyls, and fatty acids using gas chromatography (GC) and GC/mass spectrometry. WSOC accounted for, on average, 30% and 75% of total carbon mass in TSP and PM0.95, respectively. The mean mass concentrations of the quantified organic molecular groups in TSP (or PM0.95) on non-event days were 2.4–14.2 (or 1.8–7.4) times higher than those on new particle formation (NPF) event days. The day/night variations showed that the mass concentrations of the quantified water-soluble organics in the nighttime were close to those in the daytime, which was probably resulted from the partitioning of semivolatile species into the particle phase at high relative humidity and/or from aqueous phase reactions. The relatively low fractions of WSOC in the daytime on NPF event days suggest that freshly formed biogenic SOA was more water-insoluble. Low-volatility oxygenated organic aerosol (LV-OOA) had stronger correlations with WSOC and dicarboxylic acids than semivolatile OOA (SV-OOA), suggesting that LV-OOA was more water-soluble than SV-OOA.

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2UA.1

Houston Aerosol Characterization and Health Experiment: A Two-year Health Impacts Survey of Chemically Resolved, Non-refractory PM1 in the Houston, TX Metropolitan Area. HENRY WALLACE, Yu Jun Leong, Nancy Sanchez, Ben Schulze, James Flynn, Barry Lefer, Robert Griffin, *Rice University*

Houston is the fifth largest metropolitan area in the United States, with over seven million people living in the greater metropolitan area and a rapidly expanding population, The city is coming up against the National Ambient Air Quality Standard (NAAQS) for fine particulate matter (PM). Houstonians are exposed to a wide variety of air pollutants, including PM, as a result of the many emission sources in the region. In the Southeast, particularly near the Houston Ship Channel, resides one of the largest petrochemical refining complexes in the world, accounting for 40% of the US base petrochemical capacity. The northern part of Houston is heavily influenced by biogenic emissions, and emissions from vehicles are found throughout, with Houston area drivers logging an average of 183 million vehicle miles traveled per day.

We present measurements and analysis of sub-micron PM (PM_1) during the two-year (2013-2015) Houston Aerosol Characterization and Health Experiment (HACHE). This work is the first of its scope and magnitude in the city and will help air quality managers site future PM monitors and mitigate PM as Houston comes up against the NAAQS. During this extended campaign we quantified the chemical composition of non-refractory, PM_1 using an Aerodyne high-resolution time-of-flight aerosol mass spectrometer at over twelve stationary locations spanning the Houston metropolitan area. Initial findings indicate that there is significant variability in particle composition and concentration both spatially and seasonally. We will present our observations of PM_1 loadings, PM_1 composition, O:C and H:C ratios, organic and inorganic particulate nitrate, particle acidity, positive matrix factors and diurnal variability at each of the sites. These measurements will help to better understand how this variability impacts Houstonians.

2UA.2

Direct Measurements of Ozone Sensitivity to NOx and VOC Controls in Los Angeles. Toshihiro Kuwayama, Peter Green, Christopher Cappa, Anthony Wexler, MICHAEL KLEEMAN, *University of California, Davis*

Modeling studies suggest that NOx emissions controls provide an efficient method to reduce surface ozone concentrations in Los Angeles, California. Here we demonstrate a technique to directly measure ozone sensitivity to NOx or VOC changes in the ambient atmosphere as an independent check of those predictions. Three identical 1 m3 FEP bags (smog chambers) were placed in a mobile trailer. Automated pumps and valves were configured to fill each chamber with ambient air, and then to additionally perturb the chambers with: (1) NOx addition, (2) VOC addition, and (3) no change (baseline). Chambers were then exposed to UV radiation representative of summer conditions in California over a time period of 3 hrs while ozone and NOx concentrations were measured.

Results from the direct measurements of ozone sensitivity are reported from a field campaign at three locations in southern California during the summer/fall of 2014. Data was collected at each site over a time period that included both weekdays and weekends to determine how changing emissions altered the optimum ozone control strategy. The measurements in Los Angeles indicate that the baseline chamber followed the ambient concentrations reasonably well over the 3 hr experiment. NOx and VOC perturbations produced changes in ozone formation rates that could be detected with +90% statistical certainty relative to the baseline behavior. 11 out of 13 weekday measurements indicated that the atmosphere had excess NOx (small NOx increase gave lower O3). 5 out of 6 weekend measurements indicated that the atmosphere had limited NOx (small NOx increase gave greater O3). 19 out of 19 measurements indicated that increasing VOC will increase O3. Taken together, these findings suggest that optimized future emissions control programs for ozone reduction in LA should include some amount of VOC control in addition to NOx control.

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2UA.3

Missing Urban Aerosol Source: Secondary Organic Aerosol Formation from Glycol Ethers Photooxidation under Low NOx Conditions. LIJIE LI, Mary Kacarab, David R. Cocker III, *University of California, Riverside*

Missing SOA precursor sources may significantly contribute to the underestimation of urban SOA. Glycol ethers are widely used as a solvent in the consumer product industries. It is observed that even glycol ethers (e.g. Diethylene glycol ethyl ether) categorized as low vapor pressure-volatile organic compounds (LVP-VOCs) are available for atmospheric oxidation and SOA formation. Previous studies only focus on the gas phase oxidation of ethers and seldom address the potential of SOA formation from ethers. This study investigates SOA formation from selected glycol ethers and their structurally related ethers photooxidized in UCR CE-CERT environmental chamber under low NOx conditions (~20-40 ppb NO_x or <1ppb NO_x). Further, chemical composition, volatility and particle density of ether SOA measured by HR-ToF-AMS, VTDMA, and APM-SMPS respectively are reported. First, SOA yields from these ethers are observed to vary from <1 $e^{-}4$ to 2 $e^{-}2$. Glycol ethers with HO-CH_2CH_2-O-CH_2-R are observed to have higher SOA formation potential compared those without. Representative dioxolane ring fragment m/z73 $C_3H_5O_2^+$ is observed in aerosol phase of HO-CH_2CH_2-O-CH_2-R containing ethers. Significant ester fragments (e.g. m/z61 $C_2H_5O2^+$ and m/z87 $C_4H_7O_2^+$) are also found in SOA formed by different ethers. Effect of photooxidation conditions on SOA yields and SOA composition from ethers are discussed. The important SOA formation pathways from glycol ethers are then proposed.

2UA.4

Impact of Multi-generational Aging of Secondary Organic Aerosol Species In Regional PM Simulations. SHANTANU JATHAR, Christopher Cappa, Michael Kleeman, *University of California, Davis*

Multi-generational oxidation of volatile organic compound reaction products can significantly alter the mass, chemical composition and properties of secondary organic aerosol (SOA). However, the current state-of-the-science multi-generational oxidation schemes used in 3D regional or global models consider functionalization reactions but do not consider fragmentation reactions and have not been constrained to experimental data. In this work, we used the Statistical Oxidation Model (SOM) of Cappa and Wilson (2012) constrained by experimental “smog” chamber data to evaluate the regional implications of multi-generational chemistry. SOM was implemented into the regional UCD/CIT air quality model and applied to air quality episodes in California and the eastern US. Results show that SOA mass concentrations predicted by the UCD/CIT-SOM model were very similar to those predicted by a traditional “two-product” model when both models used parameters that were derived from the same chamber data. Despite the similarity in total SOA mass, the SOM model predicted modest changes in the SOA composition where contributions from anthropogenic (alkane, aromatic) and sesquiterpene SOA increased while those from isoprene and monoterpene SOA decreased relative to the two-product model calculations. The SOA predicted by SOM had a much lower volatility than that predicted by the two-product model and was in better qualitative agreement with volatility measurements of ambient OA. On account of its lower-volatility, the SOA mass produced by SOM did not appear to be as strongly influenced by the inclusion of oligomerization reactions whereas the two-product model relies heavily on oligomerization to form low volatility SOA products. Finally, an unconstrained contemporary scheme to model multi-generational oxidation within the framework of a two-product model formed at least three times more SOA than the SOM during regional simulations. This finding suggests that regional models need to care reconsider the use of these “hybrid” multi-generational schemes in the future.

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2UA.5

Simulating Secondary Organic Aerosol in a Regional Air Quality Model Using the Statistical Oxidation Model: Assessing the Influence of Vapor Wall Losses.

CHRISTOPHER CAPPA, Shantanu Jathar, John Seinfeld, Anthony Wexler, Michael Kleeman, *University of California, Davis*

Losses of organic vapors to chamber walls during secondary organic aerosol (SOA) formation experiments can potentially bias the observed SOA formation. Here, the influence of such vapor wall losses on ambient SOA concentrations and properties have been assessed in the UCD/CIT regional air quality model using the statistical oxidation model (SOM), which was explicitly parameterized using chamber observations both with and without accounting for vapor wall losses. Two scenarios were considered: a “low” and a “high” wall-loss scenario. Simulations were run for the southern California/south coast air basin (SoCAB) and the eastern US. Only SOA from traditional VOCs was considered. Accounting for vapor wall losses led to substantial increases in the simulated SOA concentrations in both domains, by factors of ~2-5 for the low scenario and ~5-10 for the high scenario. The magnitude of the increase scaled inversely with the absolute SOA concentration. In SoCAB, the simulated SOA fraction of total OA increased from ~0.2 (basecase) to ~0.5 (low) and to ~0.7 (high), and the high wall-loss scenario provides best agreement with observations. In the eastern US, the SOA fraction was large even in the base model simulations and nearly all OA was SOA for the low and high wall-loss scenarios. The simulated O:C atomic ratio for SOA and for total OA increased when vapor wall losses were accounted for, and the O:C for total OA for the high wall-loss scenarios were in good agreement with observations. Accounting for vapor wall losses has only a minor influence on simulated SOA volatility. These results overall demonstrate that vapor wall losses in chambers have the potential to have a large influence on simulated SOA concentrations in the atmosphere, and further suggest that accounting for such effects in models can help explain a number of different observations and model/measurement discrepancies.

2UA.6

Particles and VOCs Emissions from DPF Diesel Engine during Regeneration.

HIROYUKI YAMADA, Satoshi Inomata, Hiroshi Tanimoto, *National Traffic Safety and Environment Laboratory*

Exhaust emissions during a regeneration cycle of Diesel Particulate Filter (DPF) from diesel trucks were measured using chassis dynamometer. The tested trucks were three and all of them meets most recent Japanese exhaust gas regulations. Two of them have DPF and Urea-SCR system and the other have only the DPF for after treatment devices. As for the emissions, Addition to regulated emissions (CO, Non-methane hydrocarbon, NOx, CO2 and PM), solid particles numbers were measured using three particle counters which cut off diameters were 2.5, 10 and 23 nm respectively. VOCs emissions were also monitored simultaneously using proton transfer reaction plus switchable reagent ion mass spectroscopy (PTR + SRI - MS).

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2UA.7

Analysis of Particle Number Concentrations in Houston.

CARLOS HERNANDEZ, Yu Jun Leong, Robert Griffin, *Rice University*

In many urban areas, high concentrations of aerosols, especially those within the ultrafine region (<100 nm), present a significant risk to human respiratory health. To better understand the number of ultrafine aerosol particles in the Houston atmosphere, a butanol-based condensation particle counter was deployed to measure particle number concentrations (PNC) over a one-year time span during 2012 and 2013. The study first considers a statistical evaluation of this dataset. During the sampling period, PNCs averaged 11,000 ± 7,700 cm^{-3}, with higher concentrations coinciding with peak motor vehicle traffic during weekday mornings and afternoons. We then evaluate the sources of the PNCs via two methods. The first method utilizes principal component analysis (PCA) to develop source profiles for the measured PNC. In order to account for variations in the PNC source profile, the dataset was segregated by season and time of day. Preliminary PCA results indicate motor vehicle traffic and photochemical activity as significant sources. The second method involves a cluster analysis of daily backward trajectories generated using the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model. In order to identify the regional emission sources and meteorological patterns that lead to high ultrafine aerosol concentrations, each backward trajectory developed corresponds to what has been defined as an extreme PNC event (value in excess of the 90th percentile). Preliminary results indicate that airmass transport from the Gulf of Mexico and Northeast Texas is related to increases in PNC.

2UA.8

Short and Long Term Temporal Patterns and Chemical Profile of Airborne Urban Road Dust near a Major Road.

CHEOL-HEON JEONG, Nathan Hilker, Jon M Wang, Angela Huang, Dennis Herod, Ewa Dabek-Zlotorzynska, Luc White, Tony Munoz, Greg J. Evans, *SOCAAR, University of Toronto*

Urban road dust is a complex mixture of mineral dust and metals from non-exhaust emissions originating from paved road surface, brake, and tire wear. This dust can be a major source of airborne metals in urban areas and may contribute to oxidative stress related adverse health impacts. Due to the strong influence of meteorology and traffic patterns on the emission, re-suspension, and mitigation of urban road dusts, the temporal and spatial variations of the non-tailpipe sources can be highly varied. However, the short-term and long-term temporal variability and chemical profile of urban road dusts in PM2.5 are not well characterized.

The hourly contribution of urban road dust to PM2.5 beside a major urban road was elucidated by applying a receptor model, Positive Matrix Factorization (PMF). Trace metals were measured by a continuous metals monitor (Copper Environ., Xact 625) in late winter and spring at a near road site in Toronto, located 15 m from a roadway, and at an urban background site located 5 km south of the near road site. In addition, long-term variation in the contribution of road dust was elucidated by applying PMF to twenty-four hour integrated PM2.5 chemical speciation data collected from 2004 to 2014. Road dust episodic days were further identified and characterized by analyzing meteorological conditions, traffic patterns, and the mixing state of traffic-related road dust particles obtained by using an aerosol time-of-flight mass spectrometer (ATOFMS, TSI 3800). In this presentation, the chemical profiles and temporal patterns for road dust revealed through these three complementary approaches will be compared and contrasted.

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2UA.9

Urban and Suburban Intermodal Fraction of Atmospheric Aerosol. JANA KOZAKOVA, Jan Hovorka, Jaroslav Schwarz, *Charles University in Prague*

Fine (PM1) and coarse (PM10-2.5) aerosols differ not only in size but in chemical composition and type of sources, among others. A clear separation between fine and coarse aerosol is obscurely defined. These fractions overlap in the aerodynamic particle size range 1-2.5 micro-meter, also called the intermodal fraction. Sources of both coarse and fine aerosols contribute to the intermodal fraction to a different extent relating to different meteorological conditions and types of location. The aim of this study was to characterize the intermodal fraction in urban and suburban localities and estimate to what extent fine/coarse aerosol sources contribute to this fraction.

We carried out a monthly measuring campaign in Ostrava city at an urban and a suburban site (Radvanice, Plesna) during winter 2014 and two 15-day campaigns in Prague (Benatska, Suchdol) during summer 2014 and winter 2015 in the Czech Republic. At all sites, five minute aerosol size distributions from 0.014-20 micrometers were recorded and daily samples of size resolved aerosol particles were sampled by Personal Cascade Impactor Sampler (PCIS).

The results from PCIS showed that the intermodal fraction represented an average mass range of 6-10% of the total PM10 in all locations. The highest average concentrations of coarse, intermodal and fine fraction (5, 4, 40 micrograms per cubic meter) were observed in the urban residential locality Radvanice situated near an industrial zone. In Ostrava, there was a similar ionic composition of the intermodal fraction with the coarse fraction observed at Radvanice, while the intermodal fraction was closer to the fine fraction at the Plesna site. In-depth aerosol source identification of the intermodal fraction will be conducted with the help of inductively coupled plasma mass spectrometry and scanning electron microscopy applied to aerosol samples.

The project is supported by the Czech Grant Agency (P503/12/G147) and Charles University Grant Agency (274213).

2UA.10

Source Apportionment of the Carbonaceous Aerosols at an Urban Background Site of Vilnius (Lithuania) during January 2014. KRISTINA PLAUSKAITE, Steigvile Bycenkiene, Carlo Bozzetti, Roman Frohlich, Genrik Mordas, Vidmantas Ulevicius, *SRI Center for Physical Sciences and Technology*

Carbonaceous aerosols are one of the most important constituents in the atmosphere, formed by different types of processes. During winter biomass burning is one of the major sources of organic aerosol (OA) in many parts of Europe. Typically OA comprises 20 – 90% of the submicron particulate mass. An intensive one month long field campaign aiming at the real-time monitoring of non-refractory submicron (NR-PM1) aerosol species including organics, sulfate, nitrate, ammonium, and chloride was performed at an urban background site in Vilnius (Lithuania, 54°38'N, 25°10'E, 197 m a.s.l.) during winter. Meteorological conditions varied along the studied period due to the transition from moderately cold (~2ºC) weather to extreme cold with lowest temperature up to -25°C. An Aerosol Chemical Speciation Monitor (ACSM) was deployed. The average submicron non-refractory particle mass concentration (± standard deviation) for the whole period was 46.2 ± 29.6 micro-grams m^{-3}. During moderately low temperatures aerosol particles were composed mainly of organics 43%, followed by nitrate, ammonium, sulfate and chloride with contributions of 24, 16, 15 and 2%, respectively, whereas the amount of organics during extreme low temperature period increased up to 55%, while nitrate, ammonium, sulfate and chloride contributions decreased to 19, 15, 10 and 1%, respectively. Positive Matrix Factorization (PMF) analysis of ACSM mass spectra of OA identified four components, i.e., hydrocarbon-like OA (HOA, likely to be related to traffic and residual fuel oil combustion during extreme low temperatures), secondary OA (SOA, indicating more aged oxidized aerosol), N-containing organic aerosol (NOA) and biomass burning OA (BBOA, mostly originated from residential wood burning). This work was supported by the Lithuanian-Swiss Cooperation Programme “Research and Development” project AEROLIT (No. CH-3-ŠMM-01/08).

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2UA.11

Particle Number Concentrations at a Traffic Impacted Site: Precision and Temporal Patterns. Oliver Rattigan, H. Dirk Felton, James Schwab, ROBERT ANDERSON, *New York State Dept. of Environmental Conservation*

Concern over increased exposure has been a driving force in requiring air pollutants be measured at near road locations for large urban centers. Here we interpret ambient measurements of pollutants including particle number concentration and black carbon from a traffic impacted site in western New York. A matched pair of water based particle counters, model 651 and a black carbon, model 633 (Teledyne API) were operated on a 1 min sample time. The black carbon provides data at seven wavelengths with auto correction for spot loading. Collocated precision of particle number data (ranging from 10E3-10E5 counts/cm3) was within 10%. Instrument data is used in the analysis of temporal patterns versus auto and truck counts and meteorological parameters on a seasonal basis.

Both particle number and black carbon show a high temporal variability with higher concentrations on weekdays versus weekends. Weekday black carbon generally shows an early morning peak between 6 and 9 AM which is absent on weekends. Particle number also shows a weekday morning peak coincident with the black carbon peak, but a larger and broader particle number peak is observed from noon into the afternoon. Particle number appears better correlated with truck traffic counts than is black carbon, perhaps indicating particle emissions from diesel particulate filters (metals or sulfur based species) could be important. In addition nucleation of semi-volatile emissions external to the vehicle is also possible. The extent of how these temporal patterns vary across seasons will be examined.

2UA.12

Chemical Characterization and Redox Activity of Roadside Trash Burning Particulate Matter (PM) Emissions in Bangalore, India. VREELAND HEIDI, Michael Bergin, Akihiro Fushimi, Armistead G. Russell, Grishma Jain, Karthik Sethuraman, James Schauer, Ana Villalobos, S.N. Tripathi, Julian Marshall, *Duke University*

Open waste burning is a prevalent yet under-examined source of particulate matter (PM) emissions. In order to make initial assessments of PM characteristics associated with the common practice of roadside trash burning, emissions from smoldering roadside trash piles (n=24) as well as samples from ambient air (n=6) were collected in Bangalore, India for fine particulate matter (particles that have diameters less than 2.5 μm). Samples were analyzed for organic and elemental carbon (OC/EC), water- and methanol-soluble brown carbon, and redox activity (measured according to the DTT assay); some samples (n=8) were further assessed for biological redox activity (according to the macrophage assay) and were also analyzed by GC/MS for organics (PAHs, levoglucosan, alkanes, di-acids, and alkanoic acids). Results show that trash-burning emissions are highly variable in chemical composition and redox activity, and significant differences are observed between the trash-burning and ambient samples. Trash-burning OC/EC ratios range from 0.80 to 1500, while ambient OC/EC ratios are observed at 5.44 ± 1.81. Roadside trash-burning emissions do not appear to significantly contribute to ambient fine particulate mass. However, people passing by these roadside burn piles are exposed to concentrated PM masses with high per-volume redox activity, suggesting that exposure could be dominated by short bursts of highly variable burning. Interestingly, on a per-mass basis, results suggest that trash-burning emissions are innately less redox-active than ambient air (13.4 ± 14.8 pmol/min/μg for trash burning, and 107.1 ± 25.0 n pmol/min/μg for ambient), which may indicate that toxicity increases over time as aerosols in the atmosphere are aged and processed.

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2UA.13

Seasonal and Temporal Variation in Real-world Vehicle Emission Factors in Toronto, Canada. JON M WANG, Naomi Zimmerman, Cheol-Heon Jeong, Robert Healy, Nathan Hilker, Greg J. Evans, *SOCAAR, University of Toronto*

Measurements were made at a near-road field sampling site located 15 m from a major roadway in downtown Toronto, Canada. Five seasonal measurement campaigns were made each lasting approximately four weeks; November 7 – December 7, 2013 (fall); February 14 – March 25, 2014 (winter); April 20 – May 27, 2014 (spring); July 22 – September 8, 2014 (summer); January 12 – February 6 (winter). These campaigns spanned a broad range of meteorological conditions with ambient temperature and relative humidity ranging from -18 to +31 °C and 20% to 94%, respectively. A suite of high time resolution instrumentation was utilized including a Fast Mobility Particle Sizer for particle number (PN) concentration and size distribution, a photoacoustic soot spectrometer for particle scattering and absorption, and a proton transfer reaction time-of-flight mass spectrometer for VOCs. Other pollutant measurements included black carbon (BC), CO, and NOx.

This study utilized an individual plume approach to estimate emission factors (EFs) from vehicles, which at higher time resolution were used to interpret diurnal, weekday vs. weekend, and seasonal trends. Results show diurnal variation in emission factors dependent on fleet composition and traffic density. Early morning NOx, PN, and BC mean EFs are nearly two times higher than EFs in the late evening. For PN EFs, a daytime noon increase is observed with mean EFs almost four times higher than at night, which has been linked more with effects of ambient conditions on vehicle exhaust post-tailpipe. Seasonal variation in emission factors was observed for several pollutants including PN, methanol, and toluene, but not for BC EFs. Results highlight the importance of including different EFs with higher resolution models that represent vehicle emissions.

2UA.14

Particulate Air Pollution in Qatar and the Air Quality Index. TERRANCE MURPHY, Syed Abbas Mehdi, Nourhan ElKhatib, *Carnegie Mellon University-Qatar*

Due to a growing concern for Qatar's ambient air quality, this study analyzed particulate matter ($PM_{2.5}$ and PM_{10}) concentrations for 379 days from March 2014 until early April 2015. These concentrations were measured hourly by two Met One BAM-1020 instruments and 24-hour averages were determined. The Air Quality Index (AQI) was calculated from these 24-hour averages using the U.S. Environmental Protection Agency (USEPA) AQI standards. The results showed that there were 0% Good days, 37% Moderate days, 42% Unhealthy for Sensitive People days, 16% Unhealthy days, and 5% Very Unhealthy or Hazardous days. The annual PM average exceeded annual guidelines of WHO, USEPA, and Qatar's National Standards.

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3AC.1
Surface Enhanced Raman Spectroscopy Enabled Observations of Previously Undetectable Secondary Organic Aerosol Functional Groups and Intra-Particle Variation at the Individual Particle Level. ANDREW AULT, Rebecca Craig, Amy Bondy, *University of Michigan*

Surface enhanced Raman spectroscopy (SERS) analysis of ambient particles from a forested region provides the first direct, spectroscopic observation of the complexity of organic species resulting from secondary organic aerosol (SOA) formed by oxidation of biogenic volatile organic compounds (BVOCs) at the single particle level. An array of spectral features resulting from organic functional groups due to SOA material were observed in individual atmospheric particles impacted on silver nanoparticle-coated substrates. SERS improves the detection of critical trace components, permits < 1µm spatial information to be obtained, and facilitates the probing of particle phase and internal structure. Enhanced Raman scattering was detected, particularly in the fingerprint region, allowing for the detection of moieties present in femtogram to attogram quantities. These measurements represent the first application of SERS to study ambient atmospheric particles. Additionally, compositional differences on ~ 500 nm spatial scales were observed with Raman microspectroscopy for the first time. These differences are believed to be related to viscosity-limited diffusion of species within particles leading to complex internal structure. While SOA composition is frequently assumed to be homogeneous between and within individual particles, substantial particle-to-particle variability in SOA composition was observed, which must be understood for accurate modeling of SOA production and climate effects.

3AC.2
Exploring the Physical and Chemical Properties of Aerosol Using Aerosol Optical Tweezers. JAMES F. DAVIES, Kevin Wilson, *Lawrence Berkeley National Laboratory*

The use of single particle methods in the analysis of aerosol allows for an exploration of their microscopic physical and chemical properties in the absence of complicating particle-particle and particle-surface interactions. For instance, precise information on the hygroscopicity, viscosity, vapor pressure, freezing, and surface tension of aerosol may be derived from measurements on aerosol droplets made using optical tweezers.

Using the newly developed Aerosol Optical Tweezers (Biral AOT100), we demonstrate the expansive capabilities of the technique for exploring heterogeneous oxidation and photo-chemistry of model aerosol and flow-tube derived SOA. Confining and reacting particles over long time periods allows progressive changes in the particle radius to be resolved over the course of reaction, from which changes in hygroscopicity and mass may be inferred.

Specifically, we address a gap in the field of aerosol science relating to the use of single particle methods for the investigation of OH-initiated oxidation chemistry. Using chemical and photo-chemical pathways, we generate hydroxyl radical in-situ in the AOT trapping chamber and monitor the course of the reaction of organic aerosol over timescales inaccessible to flow-based techniques. Furthermore, we explore new methods for chemical analysis of optically confined droplets in order to better understand their developing composition during reaction.

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3AC.3
Laboratory Evaluation of a Commercial Spot Sampler.
ARANTZAZU EIGUREN-FERNANDEZ, Gregory Lewis, Susanne Hering, Christopher Hare, Patricia Keady, *Aerosol Devices Inc.*

The Spot Sampler is a commercially-available instrument that uses laminar flow, water-based condensational growth to enable the concentrated capture of fine and ultrafine airborne particles. Sequential aerosol samples may be collected as dry, 1-mm diameter “spots” within the individual wells of a multi-well plate. Alternatively, particles can be collected as a concentrated suspension in a small, liquid-filled vial. These Spot Samples are ‘ready to analyze’, without user extraction or manipulation. The inherent pre-concentration of the collection method saves labor, improves analysis sensitivity and enhances data quality. By using a “moderated” condensation approach the temperature of the majority of the sample never exceed 28°C, and the exiting water content is subsaturated at room temperature. This allows volatile material such as ammonium nitrate to be collected as a dry spot without significant loss. Reported here is the laboratory evaluation of this instrument using inorganic aerosols.

3AC.4
Microfluidic Measurements of Atmospheric Aerosol Mimic Rheology.
ANDREW METCALF, Cari Dutcher, *University of Minnesota, Twin Cities*

The phase state and viscosity of atmospheric aerosol particles is of great interest due to physicochemical interactions that could influence gas-particle partitioning, chemical reactions, and water accommodation. Although aerosols have traditionally been treated as well-mixed, liquid spheres in modeling studies, recent experimental evidence suggests that ambient particles, particularly aged secondary organic aerosol (SOA), can be phase-separated into multiple liquid phases and/or in a highly viscous, glassy state. The mixing state and chemical composition of the aerosol and ambient conditions necessary to produce a distinct glassy state are an active area of current study and more information about the rheology of aerosol constituents will aid in our understanding of the occurrence of this phenomenon.

In this talk, our microfluidic platform will be used to probe rheological properties, such as viscosity, of atmospheric aerosol chemical mimics. Previously, the microfluidic platform in our group has utilized high-speed imaging to monitor interfacial phenomena at the microscale in order to derive interfacial tension between immiscible phases. Additional functionality on the microfluidic device works in conjunction with existing capabilities to probe additional rheological properties, such as viscosity, that provide a more complete description of the rheology of atmospheric aerosol constituents. The chemical mimics studied here include solutions of sucrose and dicarboxylic acids, commonly used as SOA surrogates, as well as pinene-derived SOA compounds found in biogenic aerosol. These systems will be compared to our previous work on a reacting, aqueous methylglyoxal—ammonium sulfate system. From these observations of the rheological properties of aerosol chemical mimics, the behavior of atmospheric aerosols due to interactions of liquid-liquid phase-separated interfaces within aerosol particles and possible transitions to a glassy state will be inferred.

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3AC.5

Oxidation Flow Reactors (OFRs): Highlights of Recent Modeling and Field Studies. BRETT PALM, Rui Li, Zhe Peng, Weiwei Hu, Amber Ortega, Pedro Campuzano-Jost, Douglas Day, Harald Stark, Jason Schroder, Joost de Gouw, William Brune, Jose-Luis Jimenez, *University of Colorado*

Oxidation flow reactors (OFRs) are popular tools for studying SOA formation and aging. In an OFR, high oxidant concentrations (OH, O_3, or NO_3) can be reached, leading to hours–months of equivalent atmospheric oxidation during the several-minute OFR residence time. We present highlights from recent OFR modeling studies and use them to interpret OFR field measurements of SOA formation and aging. HOx, Ox, and photolysis chemistry was modeled for two common OH production methods (utilizing 185+254 nm UV light, or 254 nm only). OH exposure (OH_{exp}) can be estimated within a factor of ~2 using model-derived equations, and is strongly dependent on external OH reactivity, which may cause significant OH suppression in some circumstances (e.g., lab/source studies with high precursor concentrations). UV light photolysis and reaction with oxygen atoms are typically not major reaction pathways. Modeling the fate of condensable low-volatility organic gases (LVOCs) formed in an OFR suggests that LVOC fate is dependent on particle condensational sink. E.g., for remote pine forest field measurements with OH_{exp}<1 week, 20-80% of produced LVOCs were predicted to condense onto aerosols with the remainder lost to OFR or sampling line walls. A correction is needed to relate OFR sampling to the atmosphere, where condensation onto aerosols is the dominant LVOC fate. At high OH_{exp} (>20 days), LVOCs are predicted to be oxidized faster than they can condense, forming volatile fragmentation products, so changes to preexisting OA should be predominantly a result of heterogeneous oxidation. SOA yields specific to OFR oxidation were investigated using standard addition of individual VOCs into ambient air within an OFR. SOA yields in the OFR were consistent with chamber yields. In the context of these model and experimental results, we present OFR field measurements suggesting that typically unmeasured S/IVOCs play a significant and dynamic role in ambient SOA formation.

3AC.6

The Relative Roles of Solubility, Adsorption and Mixture Effects in Predicting the Hygroscopic Behaviour of Complex Organic Mixtures. Narges Rastak, Aki Pajunoja, Yu Jun Leong, Annele Virtanen, ILONA RIIPINEN, *Stockholm University*

Organic aerosol particles often consist of thousands of compounds with different properties. One of these properties is solubility, which affects the hygroscopic growth and cloud condensation nucleus (CCN) activation of the organic particles. We investigate the hygroscopic behaviour of complex organic aerosols accounting for the distribution of solubilities present in these mixtures. We use the SPARC method to estimate the solubility distributions of isoprene (IP) and monoterpene (MT) SOA based on their chemical composition, as predicted by the Master Chemical Mechanism (MCM). Combining these solubility distributions with the adsorption theory, we predict the expected hygroscopic growth factors (HGFs), CCN activation behavior and the related hygroscopicity parameters kappa for these mixtures. The predictions are compared to laboratory measurements as well as field data from MT- and IP-dominated measurement sites. The predicted solubility distributions do a good job in explaining the water uptake of these two mixture types at high relative humidities (RH around 90%), as well as their CCN activation – including the potential differences between the kappa values derived from HGF vs. CCN data. At lower relative humidities, however, the observed water uptake is higher than predicted on solubility alone, particularly for the MT-derived SOA. The data from the low RHs are further used to discuss the relative importance of surface adsorption and the non-ideality of the organic mixture in governing the water-uptake in these conditions.

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3AC.7
Sorption of Semi-volatile α-Pinene SOA into Non-volatile Polyethylene Glycol Seeds. PENGLIN YE, Neil Donahue, *Carnegie Mellon University*

Semi-volatile organic compounds (SVOCs) play an essential role in the formation and chemical ageing of secondary organic aerosol (SOA), and also the mixing of organic aerosol (OA) from different sources. Studying the sorption of SVOCs into particles is very important for understanding the potential contribution of SVOCs to the global aerosol budget. The gas-particle partitioning of SVOCs is influenced by the saturation concentration of the SVOC, the total amount of OA and the viscosity of OA. PEG400 may be a very good organic seed with special prosperities, liquid, water-soluble, nearly non-volatile, good solvent for SOA and relatively stable during oxidation with OH radicals and ozone. The mass spectrum of PEG400 can be easily separated from the SOA mass spectrum with a unique fragment $C_4H_9O_2^+$ at m/z = 89. We injected PEG400 particles into a smog chamber after SOA formation from a-pinene onto ammonium sulfate seeds had reached completion, with no sign of ongoing condensation. We then measured mass spectra of individual particles using a high resolution Aerosol Mass Spectrometer including light scattering single particle detection. Significant sorption of semi-volatile α-pinene SOA into the PEG400 particles was evident based on a significant SOA mass increase, a shift of the particle size distribution and also single-particle composition. The results also demonstrated that SOA prepared from α-pinene oxidized with OH radicals produced more semi-volatile SOA vapors than α-pinene oxidized by ozone. More semi-volatile SOA vapors were observed in the gas phase with higher SOA loadings. This method allows further investigation of properties such as volatility and composition of semi-volatile SOA vapors using well established measurement methods for particles.

3IA.1
Simultaneous Experimentation for Indoor Aerosol Transport Studies Using DNATrax. CYNTHIA J. KAESER, George R. Farquar, Joanne J. Osburn, A. Daniel Jones, Elizabeth K. Wheeler, *Lawrence Livermore National Laboratory*

Developed as a safe, traceable material for indoor aerosol transport studies, DNA Tagged Reagents for Aerosol eXperiments (DNATrax) allows multiple aerosol transport experiments to be performed in the same space either sequentially or simultaneously without intermediate decontamination and under identical conditions. Comprised of a synthetic, non-coding DNA oligonucleotide as a unique barcode and a food-grade carrier, DNATrax is both safe for human exposure and has near-limitless potential for barcode variation. In this presentation, we show the results of a multiple aerosol release experiment in an occupied indoor space. In addition, the presentation will detail the progress on developing simple passive sampling methods for aerosol experiments.

To fully understand the effect of complex airflow on aerosol dispersion in occupied locations, experimentation should be done with high spatial resolution and in a reproducible way. Passive sampling of deposited aerosols provides high spatial resolution without disruption of the test space's natural airflow. The low detection limits of the TaqMan polymerase chain reaction (PCR) assay used for barcode-specific detection allows quantification of nanogram quantities of collected DNATrax material and quantifies each individual barcode without interference from additional barcodes present. The low detection limit and clear barcode differentiation allows multiple particle releases to be simultaneously performed and decoupled at the end, ensuring the same conditions for all released aerosols and eliminating costly decontamination of the space between experiments.

In the experiment detailed in this presentation, a total of four DNATrax barcodes were used with two aerosolized in each of two directions and collected using passive sampling. This yielded two individual data sets for each direction that were generated under identical release and airflow conditions, demonstrating reproducibility of the deposition pattern with one meter sampling resolution. With the airflow in the space undisturbed, the effect of the release direction on particle dispersion was clearly observed.

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3IA.2
Microbial Colonization of HVAC Filters in Homes. Juan Pedro Maestre, Wiley Jennings, Sandra Dedesko, Sharon Horner, Jeffrey Siegel, KERRY KINNEY, *The University of Texas at Austin*

Delineating biological exposures in residential homes is essential for understanding the relationship between exposures and adverse health outcomes such as childhood asthma. One "filter forensics" approach for assessing microbial exposures is to use the heating, ventilation and air conditioning (HVAC) filters in homes as integrated, long-term samplers of particle-bound contaminants, including microorganisms. The objectives of the current study are to: (1) investigate the microbial communities present in residential HVAC filters and (2) evaluate how the HVAC filters are colonized over time in manufactured and detached homes.

The six houses (3 manufactured, 3 detached) included in this investigation represent a subset of 60 homes enrolled in a larger study in rural Texas. In that study, the dust recovered from HVAC filters is being used to assess the microorganisms and allergens present in homes. In the current investigation, composite dust samples were collected weekly from HVAC filters over a five week period. Surface samples were collected from two outdoor and ten indoor locations within the homes. Microbial DNA extracted from the samples is being used to delineate bacterial communities via Illumina sequencing.

Results to date indicate that composite samples randomly collected from different areas on a given HVAC filter yielded very similar bacterial communities suggesting that it provides a consistent measure of the community present. However, the diversity of the bacterial communities on the filters differs between homes although most were found to contain a significant fraction of human-associated bacteria. Within a few weeks of installation in HVAC systems that are in use, the filter provides a time-integrated sample of the bacterial communities present in a given house. Analysis is underway to assess if the communities in the manufactured homes differ from detached homes and to identify the potential sources (indoor and out) of the bacterial communities recovered in HVAC filters.

3IA.3
Fungal Diversity in the Indoor Environment of Green vs. Non-Green Homes. Kanistha Coombs, Doyle Ward, Diana Taft, Brett Green, Jaroslaw Meller, Reshmi Indugula, TIINA REPONEN, *University of Cincinnati*

Environmental movements striving to improve energy efficiency, create healthy indoor environments, and reduce environmental degradation are leading to the increased use of green building materials within the built environment. Green renovation modifies physical attributes of the structure to improve the indoor air and environmental quality of a building. These changes can affect ventilation rates and moisture levels, which can have an effect on the indoor environmental microbiome. However, little is known about the role of green building materials and how fungal diversity is influenced.

Particles from indoor air, in 40 green homes and 32 non-green homes, were collected on 37 mm, 2.0 µm pore-size PTFE membrane filters using single-stage Personal Modular Impactors (SKC, Inc.). Additionally, vacuumed dust was collected from beds and floors in both green and non-green homes. Sampling was conducted immediately post-renovation and twelve months thereafter. Control samples from non-green homes were concurrently collected.

DNA was extracted from the air filters and dust samples prior to sequencing on the Illumina MiSeq platform. ITS sequencing was performed and reads were classified by mapping read data to the UNITE 12_11 taxonomy using UPARSE. Diversity analysis was performed in QIIME and categorical analysis was performed using LEfSe.

Analysis of beta diversity showed fungal diversity from air, bed and floor samples to be distinctly separate from each other. Chao1 richness and Shannon's diversity indices showed air samples to have the lowest overall richness and diversity followed by bed and floor dust samples. Additionally, there was a higher number of enriched and relatively abundant taxa in air, bed and floor samples collected from green homes relative to simultaneous samples collected from non-green homes. Details on phylogenetic differences between renovation status' (green vs. non-green) and sampling time-points will be presented.

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3IA.4
Influence of Relative Humidity on Indoor Bacterial and Fungal Communities. KAREN C. DANNEMILLER, Charles Weschler, Jordan Peccia, *Yale University*

Carpeted floors are a major source of bacteria and fungi suspended in indoor air. The origin of microbes in carpeting is known to include tracked-in and settled dust and growth in water damaged areas, but it is unclear if bacterial and fungal growth occurs indoors under normal building conditions where humidity levels fluctuate with time. We hypothesize that water absorbs from the air, providing sufficient moisture for microbial growth in carpets. An experimental chamber study was conducted on carpet samples loaded with house dust to measure microbial growth under controlled relative humidity conditions varying from 50%-100%. Total fungal and bacterial concentrations were measured by quantitative polymerase chain reaction (qPCR), and we explored microbial community changes associated with increased indoor moisture using DNA sequencing of the16S (bacteria) and ITS (fungi) regions. In chamber experiments, the moisture content of the carpet samples stabilized within 24 hours. Based on one week growth experiments, fungal growth was observed at ≥80% relative humidity, and bacterial growth was observed only at 100% relative humidity. During this initial week, the 100% relative humidity conditions resulted in 27 times increase in fungal concentration and 2.7 times increase in bacterial concentration compared to the starting concentrations. About half (44-51%) of fungal growth occurred within the first week after a change in relative humidity. Fungal growth rates after the initial week were 8,500 (±3,050) spore equivalents•day^{-1}•mg $dust^{-1}$ at 85% relative humidity and 113,000 (±13,700) spore equivalents•day^{-1}•mg $dust^{-1}$ at 100% relative humidity. Microbial communities changed under conditions when growth occurred. While previous studies have assumed that bacterial and fungal growth does not contribute to microbial communities in carpets in building without overt moisture damage, we demonstrate that growth significantly impacts these communities at ≥80% relative humidity.

3IA.5
Investigation of the Correlation between Indoor Air Quality (IAQ) Parameters and Spatial Thermal Imaging in Two Multi-Apartment Residential Buildings in Northeastern US. LEONARDO CALDERÓN, Nirmala Thomas, Mengyang Guo, Brian Pavilonis, Prarthana Raja, MaryAnn Sorensen-Allacci, Deborah Plotnik, Jie Gong, Clinton J. Andrews, Gediminas Mainelis, *Rutgers, The State University of New Jersey*

Concerns about health when living in urbanized environments with high population density have encouraged researchers to study and understand the interior workings of buildings. This study investigated two multi-apartment residential buildings in the Northeastern US owned and operated by a non-profit organization.
The efficacy of integrated laser scanning and thermal imaging to determine housing-related health and safety hazards as well as its relationship with IAQ parameters was compared with traditional building assessment strategies.

In each building as well outdoors, viable bacterial and fungal aerosols, total fungal spores, carbon dioxide, carbon monoxide, formaldehyde, $PM_{2.5}$, ultrafine airborne particles, endotoxins, allergens, air velocity at return vents, temperature and humidity were measured. Terrestrial laser scanning in conjunction with infrared thermography were used to examine potential deficiencies in building structure, insulation and moisture on surfaces. Interviews helped to understand the residents' behavior and find out their concerns about housing conditions.

The bioaerosol concentrations in the apartments were below 1,000 CFU/m^3; total fungi from 65 to ~2,500 count/m^3. CO_2 and CO levels were generally less than 1,500 ppm and 1 ppm, respectively. 24 hour gravimetric measurements of $PM_{2.5}$ concentrations were below 100 micro-gram/m^3, while one hour total PM mass concentrations ranged from 11 to 687 micro-gram/m^3. Formaldehyde results varied from non-detected to 115 ppb. Endotoxins up to 2,300,000 EU/g and mouse and cockroach allergens were detected. These data were then correlated with building defects identified in laser scan and infrared data for each apartment and entire buildings.

Although the comparison between the two used methods are based on a small sample size, it shows that there is a correlation between the measured IAQ and observations of moisture, heat, and outside air infiltration signatures by spatial and thermal imaging. It was also apparent, that residents' behavior is one of the main factors contributing to IAQ variability.

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3IA.6
How Does Reducing Air Exchange Rate Affect Indoor Microbial Communities and Air Quality? JUAN PEDRO MAESTRE, Josh Aldred, Wiley Jennings, Shahana Khurshid, Chloe Wooldridge, Atila Novoselac, Kerry Kinney, *The University of Texas at Austin*

Approximately 40% of energy consumption in the U.S. is due to buildings. Lowering ventilation rates can reduce building energy demand, but the impact of these reductions on indoor air quality must be considered. The objective of this study was to determine how decreasing ventilation rates in a building affects contaminant concentrations and the composition of microbial communities present within the building.

The effect of ventilation rate was investigated in a LEED certified building that typically operates at a high air exchange rate (AER). The effect of reducing the AER from 6 h-1 to 4 h-1 was investigated in two indoor spaces: one normally high occupancy room (HOR) and one normally low occupancy room (LOR). Neither room was occupied at the time of sampling. Airborne, settled dust, HVAC filter dust and surface wipe samples were collected to assess the microbial communities present at each ventilation condition. Microbial DNA extracted from the samples was analyzed via qPCR and Illumina sequencing to characterize the bacterial communities present. QIIME and SourceTracker were used to elucidate relationships between communities.

Results indicate that at reduced ventilation rates, indoor ozone concentrations increased by 50% and total VOC concentrations increased by 70%. At both AERs, human-associated taxa were more abundant indoors than outdoors. The HOR had a higher proportion of human-associated bacteria than did the LOR. The diversity of the airborne microbial community in both rooms decreased when the AER was reduced. Interestingly, at both AERs tested, the diversity of the microbial communities were similar in the HOR and the LOR suggesting that at the high ventilation rates investigated in this study, occupancy level is less important than ventilation with respect to microbial diversity. The study results indicate that while some indoor contaminant concentrations increase with reduced ventilation rates, the effects on indoor microbial communities is more complex.

3IA.7
Size-resolved Particle Emissions from Seated Occupants. YILIN TIAN, Seema Bhangar, William Nazaroff, *University of California, Berkeley*

Human occupancy is known as a source of indoor inhalable particles, mainly attributable to a combined process of shedding and resuspension. Previous studies have focused on occupant emissions associated with walking, whereas little is known about the emissions from seated occupants. This work investigates particle emissions from seated occupants obtained via observational measurements and chamber study conducted under controlled conditions. The observational measurements were made in a university classroom. Optical particle counters were applied to measure size- and time-resolved concentrations for 44 lecture periods. Size-resolved emission rates were estimated using a one-compartment mass-balance model applied for steady-state conditions. Geometric mean (GSD) of per-person emission rates were 3.0×10^6 (2.0) particles/h per person for particles with optical diameters in the range 2-5 microns and 8.7×10^5 (1.6) particles/h per person for particles larger than 5 microns. The number of occupants did not significantly influence per-person emission rates. The complementary chamber study will further investigate the emissions from the human envelope and from the floor while participants are seated, undertaking scripted activities. The results of this work are of potential use in indoor air quality models and can lead to a better understanding of human occupants as sources of airborne coarse particles.

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3IF.1
Priorities and Implications for Aerosol Research in Biological Hazard Assessments. MATTHEW MOE, Morgan Minyard, *Department of Homeland Security*

The Department of Homeland Security (DHS) and the Defense Threat Reduction Agency (DTRA) have unique but similar missions. DHS supports risk-based decision making across the United States Government on response and recovery from Chemical, Biological, Radiological, or Nuclear (CBRN) incidents. DTRA's main mission is to protect the warfighter by providing better understanding of potential threats that can inform decision making and countermeasures. Both DHS and DTRA produce assessments that combine the best available information on threat agent properties with other inputs to model the consequences of myriad plausible scenarios. Critical to many of these assessments is a prediction of the downwind plume and associated residual hazards of a biological release. While some aspects of plume modeling are well understood (e.g., the impact of particle size on transport and deposition), other factors are much less clear (e.g., the influence of particle size on pathogenesis or environmental factors on agent fate and particle size). Therefore, both DHS and DTRA support research to provide a better understanding of and develop data to support hazard modeling efforts for CBRN incidents of concern. This presentation will focus on the current needs and priorities of the DHS biological hazard assessment program and DTRA's threat agent science bioaerosol program, discussing how the programs inform hazard predictions associated with a biological release.

3IF.2
A Novel Test Apparatus and Method for the Measurement of Biological Aerosol Viability Decay Under Controlled Environmental Conditions Using Synthetic Microfibers. Kevin Hommema, KENT HOFACRE, Michael Kuhlman, Traci Jordan, *Battelle*

A key parameter of interest when modeling the downwind hazard of bioaerosols is the decay rate – the loss of viability with time while exposed to environmental conditions during transport. Previous studies designed to assess bioaerosol decay rates often do not permit quantitative conclusions to be drawn. Reasons for this include the inherent experimental difficulties associated with maintaining a stable aerosol and exposure conditions over necessary time durations (particularly for large particles), and many of the studies were performed at a time when the impacts of organism growth conditions and particle composition were not well understood.

Through recently completed efforts, a new test apparatus and methodology has been developed at Battelle where particles are captured onto 2-micrometer diameter microfibers and then remain affixed while exposed to controlled environmental conditions, rather than as free-floating particles. Once affixed to the microfibers, the particles can be exposed to well-controlled environmental conditions (e.g., solar radiation, ozone, and relative humidity) for any necessary time duration. The approach developed is based on and advances that of previous researchers using spider webs or artificial microfibers. The updated methodology significantly reduces the effort and variability associated with those environmental exposure methods and techniques.

Testing has demonstrated that this approach allows for individual organisms and agglomerate particles up to at least 10 micrometers in diameter to remain airborne for at least 72 hours without the confounding issues of particle loss by physical phenomenology such as gravitational setting, diffusion and adherence to test chamber surfaces, and dilution effects associated with aerosol sampling and/or dynamic control of the environmental conditions.

Test results will be presented demonstrating the ability to evaluate the decay of organism viability in bioaerosols when exposed to environmental conditions such as relative humidity, simulated solar light, and ozone. Recommendations for future work and applications will also be introduced.

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3IF.3
Novel Aerosol Particle Image Velocimetry Measurement Method for Rotating Drum Systems. Kelly Brinkley, Jonathan Eshbaugh, DANIEL SIMON, Michael House, *The Johns Hopkins Applied Physics Laboratory*

The fate of a biological aerosol released into the outdoor environment is uncertain. The viability, chemical composition, and physical properties of a biological aerosol may be altered in reactions with volatile organic compounds (VOC), ozone, solar irradiance, or water vapor. Reactions between a biological aerosol and environmentally relevant chemical components are often time, concentration, and temperature dependent. In the laboratory, larger aerosol particles stay suspended within a typical chamber for a limited amount of time making the study of slow reactions challenging. Previous researchers have increased the aerosol suspension time by using rotating drums. However, the physics of particulate suspensions inside rotating drums are poorly understood. Models of particle dynamics do not agree with experimental observations and observations of aerosol behavior have been limited to flow altering point measurements of particle concentrations. As a result of these deficiencies, experimental planning, test execution, and data analysis are currently conducted using gross approximations of aerosol behavior and extrapolations from previous tests. A novel technique using a Particle Image Velocimetry (PIV) system has been employed to measure the aerosol particle positions, trajectories, and concentrations within a model rotating drum system. Since the PIV system measurements minimally disrupt the aerosol suspending rotational flow, aerosol suspension decay rates can be accurately measured in real-time. The PIV measurement method can be used to validate computational fluid dynamics (CFD) simulations to accurately predict size dependent particle suspension behavior to aid in the design of new rotating drum systems, optimize the use of current systems, and inform the design of experiments. The PIV method and preliminary data will be discussed.

3IF.4
Changes in the Detectability and Viability of Biological Particles Aged in the Presence of Ozone, Humidity, and UV Irradiation. SEAN KINAHAN, Yong-Le Pan, Crystal Glen, Andres Sanchez, Steven Hill, Matthew Tezak, Steven Storch, Gabriel Lucero, Mark Coleman, Chatt Williamson, Jonathan Eshbaugh, Joshua Santarpia, *Sandia National Laboratories*

Biological aerosols, particles containing bacteria, viruses, pollen, fungal spores, algae, or proteins, are modified by their environment after release. The changes in viability, infectivity, and detectability of the bacteria and viruses in these particles are dictated by their unique local atmospheric conditions and exposure. In order to better understand the persistence of biological pathogens in the environment, which dictates risk assessment and hazard response, it is essential to study how combinations of atmospheric conditions affect these particles. The team utilized a Goldberg rotating drum to age biological particles under controlled relative humidity, ozone, temperature, and simulated solar light conditions. A test matrix of environmental conditions allows for comparing how these variables affect particles both individually and in combination. The fluorescence spectra, viability, and polymerase chain reaction assay sensitivities were studied for Bacillus Thuringiensis al Hakam spores and MS-2 bacteriophage particles, generated through an ultrasonic nozzle at a particle diameter of 2-3 microns. Fluorescent spectra were evaluated using a Single Particle Fluorescence Spectrometer (351 and 263 nm excitation) and TSI UV-APS, while particles were sampled for subsequent assaying using AGI-30 impingers. The individual and combined effects of ozone, UV irradiation, and humidity on both detection signatures and viability of these species are presented here.

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3IF.5
Particle Resuspension from Surface, Current State of the Art. BABAK NASR, Jing Qian, Meilu He, Morgan Minyard, Andrea R. Ferro, Goodarz Ahmadi, Suresh Dhaniyala, *Clarkson University*

The resuspension rate of particles from surfaces via rolling detachment depends on the properties of the particles, surface, and environmental airflow as well as other conditions. In this study, a large collection of results of experimental particle resuspension studies have been assimilated into a GUI program to visualize and analyze the data. In addition, the different existing physics-based theoretical approaches for particle removal were integrated into the GUI to allow for a direct comparison of data with the models. A sensitivity analysis was conducted to determine the sensitivity of the critical shear velocity to the particle/substrate material properties and roughness parameters. The results of this sensitivity analysis are presented, along with the current state of the resuspension data and its comparison against different model predictions. Also, the critical particle-substrate parameters determined from this comparison are described. The analysis of the experimental data suggests that the diversity of the available results is best predicted theoretically using models that include the surface roughness and non-spherical “bumpy” particles.

3IF.6
Inactivation of Aerosolized Bacillus Thuringiensis Spores by Combustion of Powderized Materials Containing Boron and Iodine. SERGEY A. GRINSHPUN, Michael Yermakov, Reshmi Indugula, Tiina Reponen, Edward Dreizin, Mirko Schoenitz, *University of Cincinnati*

An explosion or fire at a bio-weapon facility may release highly pathogenic bio-agents into the atmosphere. Some especially resistant species such as Bacillus anthracis spores can remain viable even after exposure to extensive heat and chemicals. As part of the bio-agent defeat program, novel reactive materials are being developed to neutralize stress-resistant viable microorganisms during their release. In this effort, we tested two materials, Mg•Al•I_2 and Al•B•I_2 prepared using high-energy mechanical milling, with respect to the biocidal capability of their combustion products against Bacillus thuringiensis kurstaki (Btk) spores – a well-established surrogate of Bacillus anthracis. A state-of-the-art experimental facility was used to investigate the survival of aerosolized spores. Both powderized materials are capable of retaining substantial quantities of iodine stabilized in the metal matrix and released upon heating in a combustion environment. The spores were dispersed in dry airflow and exposed to the tested combustion products in a temperature-controlled environment. The bioaerosol inactivation factor was determined as a function of the aerosolized powder concentration that ranged from 0 to about 40 mg/L. For both materials, the inactivation factor increased exponentially with the powder concentration. Both materials having the same weight ratio (40:40:20) showed statistically the same inactivation capabilities. It was demonstrated that the main reason of the spore viability loss observed in the tests was the spore interaction with iodine in the air flow rather than exposure to heat. Boron was found to enhance the inactivation. The data generated in this study help understand the kinetics of the spore inactivation by combustion products of halogen-containing reactive materials. The effort also creates the foundation for developing new materials for efficient neutralization of viable microorganisms in combustion environments.

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3IF.7
Influence of Aerosol Particle Size on Inhalational Pathogenesis. RICHARD THOMAS, *Dstl*

Aerosolization of a biological material will produce aerosols comprising a range of different particle sizes commensurate to the method of generation. These will rapidly evaporate to their final particle size which will dictate where within the respiratory tract the particles will deposit. Small particles (e.g. 1 - 3 micro-meter) will deposit in the alveolar region of the lung, whilst larger particles (e.g. 10 - 30 micro-meter) will impact further up the respiratorytract. Deposition site has been demonstrated to influence pathogenesis with infection initiating in the upper respiratory tract involving the nasal cavity and upper respiratory tract lymphoid tissues whilst the lung is the primary focus of infection after deposition of small particle aerosols. In addition, for the large particle inhalational infections, alternative pathogenesis was observed dependent on the inhaled micro-organism; for example gastrointestinal pathology or invasion of the olfactory neuronal pathway. Particle size dependent inhalational infections will be described using pathogenesis data obtained from a range of Select Agents including Yersinia pestis, Bacillus anthracis and Burkholderia pseudomallei.

This presentation will describe the development of capabilities in high level microbiological containment, experimental progress and draw on the literature to assess the influence of aerosol particle size on pathogenesis on inhalational infections to better inform consequence analysis models.

3IM.1
Optimizing Design for Oxidative Flow Tube Reactors. DHRUV MITROO, Yujian Sun, Boung Wook Lee, Andrew Lambe, William Brune, Brent Williams, *Washington University in St. Louis*

Oxidative flow reactors (OFRs) have gained popularity in recent years as a laboratory means of studying secondary organic aerosol (SOA) formation, and the oxidation of primary aerosols during heterogeneous reactions with ozone or OH radicals. These reactors are designed for a high degree of conversion of starting material in a short residence time, while avoiding significant wall losses. Can we do a better job of operating OFRs to allow for the highest and most uniform exposure possible, based on kinetic properties of starting material such as reaction rate constants?

Here, we look at geometry configurations and operating conditions such as flowrate and wall temperature for compounds of different reactivity to OH to determine if there is an optimal residence time distribution (RTD) for the study of these compounds with the Potential Aerosol Mass (PAM) reactor, an OFR. If the RTDs are compared to the characteristic reaction time (e.g., short reaction time for terpenes vs. long reaction time for primary soot particles with OH), a different flowrate or different wall temperature may be chosen, as well as different inlet configurations (e.g., presence of an inlet sparger or short honeycomb segment for flow dispersion and stabilization). For heterogeneous reacting systems, such properties maybe of importance since the process may be either reaction or transport limited. A common limitation of OFRs, whilst studying heterogeneous chemistry, is that the short physical residence time does not allow the study of mass-transfer effects to reactive uptake. With an appropriate design and full characterization, we can suggest appropriate operation parameters (e.g., flowrates and wall temperatures) to the community to study SOA formation vs. heterogeneous chemistry in OFRs.

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3IM.2
Evaluation of Combined Electrical Mobility and Optical Sizing Techniques for Deriving Aerosol Refractive Index.
Stephen Zimmerman, RICHARD MOORE, Bruce Anderson, Andreas Beyersdorf, Chelsea Corr, Michael Shook, Kenneth Thornhill, Edward Winstead, Luke Ziemba, *NASA Langley Research Center*

The next generation of aerosol satellite instruments will include multi-spectral polarimetric measurements to retrieve aerosol size distributions and complex refractive index (RI) at several wavelengths (Hasekamp et al., 2011; NRC, 2007), which is the "only means of constraining aerosol chemical composition from space" for passive sensors (Mischenko et al. 2007). Over past decades a number of methods have been developed to derive refractive index from combined optical and electrical mobility sizing instruments. For example, the so-called "Alignment Method" of Hand and Kreidenweis, 2002, combines joint differential mobility analyzer and optical particle counter size distributions to estimate the aerosol real refractive index. Moteki et al, 2010, used the SP2-derived scatting cross section, OPC-derived size distribution, and APM-derived mass-mobility form factor to constrain the complex refractive index of black carbon aerosols. Lack et al., 2012, present an iterative method for finding the refractive index of brown carbon coating on black carbon (BC) using SP2 and photoacoustic absorption spectrometric techniques. Finally, Mie theory can be used with DMA-derived size distributions and absorption or extinction measurements to theoretically constrain the complex refractive index of aerosols.

In this work, we evaluate the sensitivity of two commercially available, high-resolution optical particle counters for determining the size-resolved real refractive index of laboratory-generated aerosols when used with a DMA via a modified form of the "Alignment Method". We focus on characterizing the Ultra-High Sensitivity Aerosol Size Spectrometer (UHSAS) from Droplet Measurement Technologies and the Laser Aerosol Spectrometer (LAS) from TSI, Inc. using model aerosol species whose real refractive indices range from 1.3 to 1.6. Absorbing BC and BC-surrogates are also explored. While the scattering geometries of both instruments are the same, the principal difference between the instruments relates to the laser wavelengths. The sensitivity of each instrument to changes in compositionally-driven aerosol refractive index will be discussed.

3IM.3
Imaging Nonspherical Particles and Measuring their Extinction Cross Section with Digital Holography.
MATTHEW BERG, Nava Subedi, *Mississippi State Univeristy*

In recent work, we have discovered an inherent link between a particle's extinction cross section and the integral of its in-line hologram, i.e., the intensity pattern formed by the interference of the incident and scattered light. Using Mie theory, we have shown this relationship for a variety of spherical particles. The generality of the concept, however, suggests that it applies to nonspherical particles as well. In this presentation we will show that, indeed, the extinction cross section can be extracted from the holograms produced by such particles. Specifically, we investigate prolate and oblate spheroids and cubical particles in the wavelength size range. Using both the discrete dipole approximation and the T-Matrix method, when applicable, we are able to simulate the holograms and then perform a simple integration to yield the cross sections. A powerful additional ability of this technique is that an unambiguous image of the particle can be reconstructed from the exact same hologram via the Fourier transform. In an experimental context, the simplicity of the measurements involved and the technique's high potential for application to complex-shaped coarse-mode particles will also be discussed.

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3IM.4
Effects of Laser Fluence Non-Uniformity on Black Carbon Measurements Using the Auto-Compensating Laser-Induce Incandescence Technique. FENGSHAN LIU, Steven Rogak, David Snelling, Kevin Thomson, Gregory Smallwood, *National Research Council Canada*

Laser-induced incandescence (LII) has been utilized to measure soot or black carbon (BC) concentrations in many applications, such as in flames, in the exhausts of automobile and aero engines, and in ambient environments. In LII, a pulsed laser of nanoseconds duration is used to rapidly heat the BC particles to temperatures much higher than the initial ambient temperature, typically to 3000 to 4000 K. Detection and analysis of the incandescence signals can reveal the BC particle concentration at the measurement location. In LII measurements, it is preferred to use a uniform laser fluence since it greatly simplifies the interpretation of the LII signals to arrive at the BC particle concentration. In practice, however, there is always some degree of laser fluence non-uniformity, depending on the laser and the optical setup, and such the non-uniformity must be accounted for in establishing the quantitative relationship between the LII signal and the BC concentration.

The traditional approach was to consider the spatial averaged laser fluence profile based on the multi-pulse averaging of individual laser pulse distributions. Due to the randomness of hot spots, such averaging tends to result in a fairly good top-hat laser fluence distribution, even though each individual profile displays the presence of some hot spots. Because LII signals are highly sensitive to particle temperatures, the detected LII signals are biased towards the highest particle temperatures associated with the hot spots. As a result, the traditional approach of multi-pulse averaging significantly underestimates the effects of non-uniform laser fluence in LII measurements.

This study proposes to analyze the laser fluence non-unifomity effects using the histogram or probability density function of laser fluence. It is shown through LII measurements and modelling that the soot volume fraction anomaly can be explained to a large extent by the laser fluence non-uniformity.

3IM.5
Effect of Particle Properties on Relative Response of Real Time Black Carbon Mass Concentration Instruments. Ali Momenimovahed, KEVIN THOMSON, Mark Johnson, Jason S. Olfert, Matthew Dickau, Andrew Crayford, Yura Sevcenco, Paul Williams, Benjamin Brem, Gregory Smallwood, *National Research Council Canada*

Nanoparticle aerosols in the atmosphere can have a significant effect on climate by scattering and absorbing solar radiation. Highly absorbing particles, like those composed of black carbon (BC), can absorb and re-emit solar radiation causing a net heating effect (Forster et al., 2007). There are a number of commercially available mass measurement instruments that are used to measure the BC concentration from different sources such as engines and burners in real-time. However, the effect of the physical and chemical properties of the particles on mass concentrations measured by different instruments is not fully understood yet. This study focusses on particles produced by two nominally identical gas turbines to investigate the influence of particle properties on relative response of several mass measurement techniques including photo acoustic spectroscopy (PAS), laser induced incandescence (LII), and cavity extinction with total scattering (Ex-Sc). The mass concentrations are measured at both low and high power operating conditions where different particle characteristics are observed. Cavity extinction with total scattering at three different wavelengths (450, 530 and 780 nm) was employed to study the variation of the particle optical properties with power condition and measurement wavelength. To evaluate the effect of particle size, a centrifugal particle mass analyzer (CPMA) upstream of the measurement instruments was employed as an impactor by changing its rotational speed to progressively remove large particles, lowering the median diameter of the measured particles. Finally, the ratio of elemental to organic carbon was quantified by thermal optical analysis, and by comparing mass and number concentration of non-volatile versus volatile material using a catalytic stripper with a DMA and a CPMA.

Forster, P., et al. (2007). Climate Change 2007: The Physical Science Basis, Chapter 2. Cambridge University Press.

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3IM.6
Design and Characterization of a Multiwavelength Thermal/Optical Carbon Analyzer. XIAOLIANG WANG, Benjamin Sumlin, Sierra Mayorga, Steven Gronstal, L.-W. Antony Chen, Judith Chow, John Watson, *Desert Research Institute*

A multiwavelength thermal/optical carbon analyzer (DRI Model 2015) was developed. Seven lasers in the wavelength range of 405-980 nm are used to monitor the spectral reflectance (R) and transmittance (T) signals of filter samples during thermal analysis. The R and T signals are calibrated with transfer standards traceable to absolute R and T measured by a UV/VIS spectrometer. It is demonstrated that R and T calibration is independent of the sample type using ambient and source (e.g., diesel exhaust, flaming biomass, and smoldering biomass) samples with a wide range of optical depth. Tests on ambient and source samples show that total carbon (TC), organic carbon (OC), and elemental carbon (EC) are equivalent to those from legacy thermal/optical carbon analyzers (DRI Model 2001) using the earlier hardware design and 633 nm laser for pyrolysis correction. The thermal spectral analysis provides additional information that evaluates black carbon (BC) and brown carbon (BrC) contributions and their optical properties in the near-ultraviolet to near-infrared solar spectrum. It provides insight into the charring process and improves the charring correction, leading to more accurate OC and EC measurements for climate, visibility, or health studies.

3IM.7
Infrared Spectroscopy Calibration Models for Prediction of Thermal Optical Reflectance (TOR) OC and EC in IMPROVE Monitoring Network Sites: Interpretation and Extended Evaluation. Matteo Reggente, SATOSHI TAKAHAMA, Ann Dillner, *Ecole Polytechnique Federale de Lausanne, Switzerland*

Dillner and Takahama (2015a, 2015b) developed and evaluated partial least squares (PLS) calibration models with infrared spectra for prediction of TOR-equivalent OC and EC in 2011 US IMPROVE ambient samples collected on Teflon (PTFE) filters. This method uses ambient samples (analyzed inexpensively and without damaging the sample) as calibration standards to allow prediction in other ambient samples, and its capability for prediction of OC and EC concentrations to within measurement precision was demonstrated when sample loading and composition of evaluation samples were well represented in the calibration sample set.

In this presentation, we introduce several sparse calibration methods that allow us to isolate the most relevant absorption bands in the calibration model; thereby aiding interpretation with regards to the vibrational modes of molecules present in aerosol mixtures that allow us to quantify TOR OC and EC from infrared spectra. Furthermore, we evaluate the applicability of our calibration models developed from the 2011 sample set to new samples analyzed from 17 sites in 2013. These new sites include one in South Korea, sites that experienced significant smoke impact, and several additional rural sites and urban sites. The rural and smoke-impacted sites are predicted with acceptable accuracy, but predictions for the South Korean site (with high sample loadings) and one new US urban site show degraded performance. We discuss means for anticipating prediction errors a priori based on the examination of similarity of new infrared spectra to those in the calibration model, and strategies for constructing better models with improved prediction accuracy.

Dillner, A. M., Takahama, S., Predicting Ambient Aerosol Thermal Optical Reflectance (TOR) Measurements from Infrared Spectra: Organic Carbon, Atmospheric Measurement Techniques, 8, 1097-1109, 2015a. doi: 10.5194/amt-8-1097-2015.

Dillner, A. M., Takahama, S., Predicting Ambient Aerosol Thermal Optical Reflectance (TOR) Measurements from Infrared Spectra: Elemental Carbon, Atmospheric Measurement Techniques, submitted, 2015b.

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3RA.1

Cloud Particle Precursors in and around West Coast U.S. Storm Systems. MARKUS PETTERS, Hans Taylor, Nicholas Rothfuss, Paul DeMott, Samuel Atwood, Christina S. McCluskey, Thomas Hill, Sonia Kreidenweis, Kimberly Prather, Andrew Martin, *North Carolina State University*

Extratropical storms approaching the West Coast from the Pacific Ocean are responsible for the majority of the annual precipitation in the west coast states. Aerosol-cloud interactions in those storms are complex. Long-range transport of dust and biological particles aloft can initiate ice in mid-level clouds which in turn can seed lower lying clouds with ice crystals. The low lying clouds are formed on marine aerosols that are embedded within the approaching airmass and may be augmented by local pollution sources. Understanding the spatiotemporal distribution of cloud particle precursor concentrations during landfalling storms is important for understanding the role of aerosols in modulating precipitation amounts. The interagency CalWater-2/ACAPEX campaign took place from Jan-March 2015 and included comprehensive multiplatform characterization of landfalling atmospheric rivers and of cloud-active particles that can influence precipitation. Here we report observations of the aerosol characteristics observed at the Bodega Bay Marine Laboratory research site. These include size- and supersaturation resolved cloud condensation nuclei activity (CCN), ice nucleating particle (INP) concentration measured from aerosol-into-liquid sampling and rainwater collections, as well as fluorescent particles concentration measured with online (WIBS-4A) and offline (fluorescence microscopy) methods. First results show that the hygroscopicity parameter of aerosol at Bodega Bay typically ranged between 0.1 and 0.3 and remained low even for “clean marine” periods when aerosol number, surface area, and volume concentration (D < 0.5 micro-m) dropped below 100 cm-3, 2 micro-m2 cm-2, and 0.2 micro-m3 cm-3, respectively. Total fluorescent particle concentrations at the site ranged between 0.01 and 1 cm-3. This work presents a first analysis toward combining ground-based, ship-, and aircraft-based data to develop a four-dimensional view of cloud particle precursor concentrations for CalWater-2/ACAPEX case studies.

3RA.2

Physical Characterization and Modeling of Particle Nucleation and Particle Growth in the Central U.S. CHARLES STANIER, Robert Bullard, Can Dong, Ashish Singh, *University of Iowa*

New particle formation (NPF) and growth control the concentration of aerosols and cloud droplets, which in turn play an important role in both global climate and human health. While atmospheric nucleation has been examined world-wide in many urban as well as remote forested locations, it has not been studied extensively in the non-forested Midwestern United States, where SO2 from coal-fired power plants as well as ammonia from agricultural activity are prevalent. Furthermore, the annual average particles counts, seasonal pattern of particle counts and nucleation activity, and ratio of sulfur to ammonia is changing as SO2 emissions in the region decrease and agricultural patterns change. Ten months of aerosol size distributions measured from 3 nm to 5 microns at Bondville, IL, a station with a long-term record of many radiation, meteorology, and aerosol variables, are reported and related to the long-term record at the site. Enhanced particle numbers in the nuclei size range (3-10 nm) followed by particle growth to larger sizes occurred during approximately 41% of the study days during summer and fall months. Average diurnal patterns of size-resolved particles at this site have 3-10 nm particles peaking at 10 AM local standard time, and total particle concentrations peaking at 11 AM local standard time. Monthly particle growth rates are reported. Finally, the strengths and weaknesses of the nucleation explicit version of the WRF-Chem regional coupled meteorology / atmospheric chemistry model to reproduce the absolute number, timing, frequency and size of the nuclei and ultrafine particles are discussed.

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3RA.3

Observed and Modeled Particle Size Distributions at Rural and Urban New York Sites. JAMES SCHWAB, G. Garland Lala, Fangqun Yu, H. Dirk Felton, Oliver Rattigan, *University at Albany, SUNY*

For six months in 2012 we measured particle number concentrations and size distributions at two locations in New York State separated by a little over 300 km. The sites are Pinnacle State Park in Addison, NY in southwestern upstate New York, and Queens College in the borough of Queens, New York City. Relevant measurements at the Addison site consisted of paired nano- and long-tube SMPS systems to cover the size range from 5 to ~700 nm mobility size, an Aerodynamic Particle Sizer for the range 0.3 -20 µm, and a 3783 water-based Environmental Particle Counter (EPC) for concentrations of particles greater than 7 nm diameter. At the Queens College site the size distributions were measured with a Fast Mobility Particle Sizer, an Optical Particle Sizer (TSI Model 3330) for part of the period, and an identical 3783 EPC. Simultaneous measurements at the two sites were carried from April through September 2012.

Observed particle size distributions and number concentrations are analyzed to identify new particle formation and growth events, and other phenomena influencing these measurements at the two sites. Additionally, model simulations showing PSDs and CN concentrations are presented and compared for the PSP site using the GEOS-Chem plus APM (Advanced Particle Microphysics) modeling tools.

Measurements and simulations at PSP both show frequent new particle formation (NPF) and growth events in April, and very few in the summer months of July and August. Overall, there appear to be more simulated than observed NPF events. The GEOS-Chem grid spacing is too coarse to adequately capture particle dynamics at the New York City site, but other tools (including recently available GEOS-Chem/APM nested grid simulations at 0.25 degrees x 0.3125 degrees horizontal resolution) will be investigated to see if they are up to the task.

3RA.4

The Contributions of Amines to Ambient Wintertime Aerosol as Measured by High-Resolution Aerosol Mass Spectrometry. COURTNEY L. HERRING, Graham VanderSchelden, Manjula Canagaratna, Donna Sueper, Paola Massoli, Serena H. Chung, B. Thomas Jobson, Timothy M. VanReken, *Washington State University*

We present the results of a three week winter-time campaign conducted in Yakima, Washington during January 2013 to investigate the gas- and particle-phase properties contributing to high winter-time particulate concentrations. Yakima is a mid-size city located in a semi-arid region with significant agricultural activities. The surrounding topography forms an enclosed valley that restricts horizontal air flow. The organic aerosol composition was characterized during the study using an Aerodyne High-Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS). Gas-phase organics were measured with a Proton Transfer Reaction Mass Spectrometer (PTR-MS) fitted with an IVOC sampler. Supporting measurements include the particle size distribution, black carbon mass, and meteorological data.

Analyses using positive matrix factorization of the organic aerosol signal revealed two time independent amine factors that have not been previously reported. Major contributing ions for these factors are associated with amine fragments $C_3H_8N^+$, $C_4H_{10}N^+$, $C_5H_{12}N^+$, and $C_6H_{14}N^+$. The presence of these factors in the organic aerosol were strongly episodic. We will present the results of our analyses investigating the sources of these amines and their connections with other atmospheric chemical and meteorological properties.

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3RA.5

Human Particulate Matter Exposure Implications from Regional Pollutant Transport. Fatema Parvez, Carmen Lamancusa, KRISTINA WAGSTROM, *University of Connecticut*

The intake fraction (iF) from a variety of sources provides a means to determine the relative impact between emissions sources. For instance, emissions from an elevated stack will likely have a lower iF than ground-level emissions. In this study, we use two different approaches to quantify the impacts of exposure from pollutant transport in the continental United States. First, we estimate the ground level concentration contributions and iF for different height point source emissions. Next, we use the same metrics to quantify exposure variation with distance from different source regions.

We employ a regional chemical transport model, CAMx, to extend this analysis over an entire region. We use the Particulate Matter Source Apportionment Technology (PSAT), available in CAMx, to specifically track the contributions from each group of point sources (differentiated by height) and source regions within the domain. This allows us to more thoroughly estimate the total potential exposure because we account for the transport and transformation of pollutants on regional scales. In addition to estimating iF of primary pollutants, we also estimate the iF for secondary pollutants. The iF for secondary pollutants is calculated based on the commonality between the precursor and product. For instance, the iF of SO_2 and particulate sulfate are calculated as the iF of the sulfur atom – treating SO_2-sulfate as a complete system.

We have found that when investigating iF variation among different height point sources, it is important to consider population distributions. We have used an approach to decouple the population distribution and pollutant dispersion to consider the impacts of each on iF from point sources. We have also found that the majority of pollution emitted in urban areas is inhaled within the same urban area and that, among particulate matter species, sulfate has the highest percent of intake occurring outside the urban area.

3RA.6

Long-term Variation and Chemical Characteristics of Long-range-transported Aerosols at Background Site, Korea. KWANGYUL LEE, Young Joon Kim, Chang-Hee Kang, Jeong-soo Kim, Lim-seok Chang, Kihong Park, *Gwangju Institute of Science and Technolgy*

In northeast Asia, natural and anthropogenic sources contribute to the complex chemical components and mixing state of aerosols and affect local/regional air quality. In this study, chemical components of PM2.5 along with air mass backward-trajectory analyses and satellite-retrieved aerosol optical depth (AOD) at Gosan, Jeju Island, in Korea for 4 years were measured to investigate characteristics of long-range-transported (LTP) PM2.5 according to their chemical components and air mass trajectory. No significant increase or decrease in PM2.5 observed in recent years (2008-2012). Sulfates and OC were higher in the fall than in the spring due to more dominant northwest air masses (polluted). Distinct types of LTP events were identified. In the sulfate-dominant LTP events, the air masses directly arrived at Gosan without passing over the Korean Peninsula from the industrial area of China within 48 hours, and the acidic fraction of sulfate was found to be predominant. In the OC-dominant LTP events, the air masses arrived at Gosan, across the Korean Peninsula, from China. The much slower air mass (arriving at Gosan within 60-80 hours from mainland China and across Korea) suggests that the OC can be highly aged during transport.

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3RA.7
What Shapes the Aerosol Size Distribution at High Altitude? - Insights from the Alpine Site Jungfraujoch.
ERIK HERRMANN, Martin Gysel, Ernest Weingartner, Stephan Henne, Nicolas Bukowiecki, Emanuel Hammer, Zsofia Juranyi, Martine Collaud Coen, Laurent Vuilleumier, Martin Steinbacher, Franz Conen, Urs Baltensperger, *Paul Scherrer Institute*

Continuous aerosol measurements at Jungfraujoch date back more than 20 years. Located at 3580 m a.s.l., the aerosol at the site is often considered to represent free tropospheric conditions. Observation have shown that Jungfraujoch is inside clouds for about 40% of the time, making it an ideal site to study cloud formation and properties.

Since 2008, SMPS measurements of the aerosol size distribution between 20 and 600 nm have been performed continuously at the site. In order to describe conditions at Jungfraujoch, a parameter based on long-wave radiation measurements has been applied to evaluate if the measurement station is inside clouds. Over the years, many approaches have been suggested to determine boundary layer influence at Jungfraujoch. We have performed a comprehensive evaluation of a variety of methods with respect to the aerosol size distribution. These methods include gas tracers (Radon-222), tracer ratios, and FLEXPART simulations. Their synthesis allowed for a description of the free tropospheric background aerosol and how significantly transport from the boundary layer affects air masses at Jungfraujoch. Finally, the size distribution data together with measurements of the total aerosol above 10 nm have been analyzed with respect to new particle formation. While the lower cutoff of this setup does not allow for an investigation of nucleation specifics, it is possible to determine the effect of particle formation on cloud condensation nuclei concentrations.

A main finding can be summarized as follows: the aerosol at Jungfraujoch is strongly influenced by injections from the PBL. This applies to CCN-sized particles which mostly originate at lower altitudes, and it applies to the formation of new particles which depends on the supply of vapors from the boundary layer. Our results imply that mountains very significantly modify what probably should not be called the free troposphere in their vicinity.

3UA.1
Characterizing the Volatility of Near-road Submicron Organic Aerosols Near a North Carolina Interstate Freeway.
PROVAT SAHA, Andrey Khlystov, Andrew Grieshop, *North Carolina State University*

Motor vehicles are a dominant source of primary and secondary submicron particulate matter (PM) in urban areas. There are steep gradients in concentrations of primary gas- and particle-phase species, including black carbon (BC), organic aerosols (OA) and other species within 10s to 100s of meters from the roadway. Here, we discuss a novel field measurement approach and preliminary data from an ongoing effort designed to improve our understanding of the dynamic nature of OA in near-road environments, derive a set of parameterizations to model the evolution of OA, and exposure concentrations in a near road environment.

A field study is designed for a site near Interstate 40 (I-40), outside of Durham, North Carolina which includes, (i) 4 weeks of continuous measurements in a near road regulatory monitoring station, located within 10 m from highway; (ii) one week intensive downwind transects measurements on a minor roadway perpendicular to I-40, running parallel to the dominant wind direction; and (iii) simultaneous intensive upwind background measurements from a stationary site. For high time resolution OA volatility measurement, a multi-channel thermodenuder (TD) system is developed and deployed at this field study which consists of four parallel lines those can be independently operated at various set temperatures and residence time conditions. A van is equipped for transects measurement with newly developed multi-channel TD, various aerosols (e.g., SMPS, ACSM, PAX, SP2) and gaseous (CO, NOx, O3) instruments and consecutively sample at different distances (10, 50, 100, 200 m) downwind of the highway and repeated several times a day. A set of volatility parameterizations (e.g., volatility distribution) is derived following the volatility basis set (VBS) framework from the measured OA volatility at different downwind distance from highway. Preliminary results from this study will be presented here. Result from this study will help us to model gas-particle partitioning of OA in a near road environment to better understand exposure to OA and other primary emissions in a near-road setting.

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3UA.2
Incremental Secondary Organic Aerosol Formation and Composition at Simulated Urban Atmospheric Reactivities.
MARY KACARAB, Lijie Li, William P. L. Carter, David R. Cocker III, *University of California, Riverside*

Two surrogate reactive organic gas (ROG) atmospheric mixtures of anthropogenic and biogenic volatile organic compounds (VOCs) were developed to represent simulated urban atmospheres with different levels of anthropogenic and biogenic influences (i.e. Los Angeles reactivity versus Atlanta reactivity). Previous chamber studies have focused on the oxidation of single aerosol precursors, which may not provide an accurate representation of aerosol yield in different urban environments. The incremental aerosol yields from select anthropogenic (aromatic) and biogenic (terpene) hydrocarbon precursors were studied in the UC Riverside/CE-CERT dual $90m^3$ environmental chambers under these two simulated urban conditions. It was found that the aerosol precursors behaved differently under the two differing reactivity conditions, with more incremental aerosol being formed in the anthropogenically dominated mixture than in the biogenically dominated mixture. Further, the biogenic reactivity condition inhibited the oxidation of added anthropogenic aerosol precursors, such as m-xylene. Aerosol properties such as density, volatility, and bulk chemical composition (from Aerodyne high resolution time of flight aerosol mass spectrometer (HR-ToF-AMS)) data will be presented and compared between the two reactivity systems and with data from previous single VOC/NOx photo-oxidation studies. Data from incremental aerosol yield experiments at different atmospheric reactivities are paramount in the attempt to extrapolate environmental chamber observations to the ambient atmospheric measurements.

3UA.3
Secondary Organic Aerosol Formation from Aircraft Turbine Engine Exhaust.
Dogushan Kilic, Ru-Jin Huang, Benjamin Brem, Lukas Durdina, Imad El Haddad, Felix Klein, Avi Lavi, Simone Pieber, Theo Rindlisbacher, Yinon Rudich, Jing Wang, JAY SLOWIK, Urs Baltensperger, Andre Prévôt, *Paul Scherrer Institute*

Aircraft engine emissions include both primary organic aerosol (POA) and volatile organic compounds (VOCs) which can react in the atmosphere to produce secondary organic aerosol (SOA). These emissions include compounds known or suspected to cause adverse health effects. While it is thus possible that airports may adversely affect local air quality, such an assessment requires detailed characterization of the primary and secondary emissions. In particular, quantitative investigation of aircraft SOA and its dependence on engine operating conditions has received little study and its atmospheric importance is poorly constrained.

We present measurements of VOCs, POA, and SOA from 7 aircraft engine models operated under simulated flight conditions representative of idling, taxiing, approach, climb, and take-off. Experiments were conducted at the SR Technics engine test facility at the Zürich International Airport. Particle composition is measured by a high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS), while the VOCs are characterized by a proton transfer reaction time-of-flight mass spectrometer (PTR-TOF-MS). SOA is produced by oxidation of engine emissions in a potential aerosol mass (PAM) flow tube and characterized as a function of OH exposure in the PAM, a surrogate for photochemical age.

VOC emissions are highest at low thrust levels and decrease by more than an order of magnitude at maximum thrust. The composition of the emissions changes, with aromatics and hydrocarbons enhanced at low thrust and a higher fraction of organic acids and carbonyls at maximum thrust. These trends correspond to changes in the SOA production potential, with the highest SOA emission factors observed at low thrust. We investigate the relationship between the emitted VOCs and produced SOA, and assess the likely influence of aircraft emissions on local air quality.

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3UA.4
Characterization of Fine Particulate Matter and Black Carbon Emissions from an Urban Bus Fleet: Emissions Measurements and High Spatial-resolution Inventory Development. Timothy Dallmann, Eric Lipsky, Richa Khosla, Andrea Polli, ALBERT A. PRESTO, *Carnegie Mellon University*

This study investigates the air quality impact of diesel-powered urban transit buses in Pittsburgh, PA through near-road emissions measurements and high spatial-resolution emission inventory development. Concentrations of fine particulate matter (PM2.5), black carbon (BC), and carbon dioxide were measured in December 2014 at a near-road site in downtown Pittsburgh as part of the Particle Falls public art installation, an artwork designed to raise awareness of urban air pollution issues through visualization of real-time air quality data. Sampling inlets were located 3 m from a roadway with high levels of bus activity, and pollutant concentrations were measured at a time resolution of 1 s. These high time-resolution measurements supported analysis of the impact of passing diesel buses on near-road air quality and enabled quantification of fuel-specific BC and PM2.5 emission factors for individual buses using a carbon balance method.

Preliminary results show diesel buses contributed to elevated concentrations of BC measured at the near-road sampling site. Weekday diurnal patterns of BC concentrations were well correlated with bus activity, with peaks in each parameter observed from 6-9 AM and 3-6 PM. Short-term (< 30 s) peak events associated with passing buses frequently elevated BC concentrations to levels greater than 20 micrograms per meter-cubed and accounted for between 3 and 30 percent of the daily mean BC concentration measured on weekdays. An initial analysis of 100 individual bus exhaust plumes yielded a fleet-average BC emission factor of approximately 0.40 g/(kg fuel), which is comparable to results from recent real-world measurements of heavy-duty diesel vehicle emissions, though significantly greater than the current PM emission standard for new heavy-duty vehicles. Fleet-average emission factors will be used along with detailed activity data to develop an inventory for BC and PM2.5 emissions from transit buses in the City of Pittsburgh at a spatial resolution of 500 m.

3UA.5
Characterizing Aerosol Emissions from Light Duty Gasoline Vehicles. ROYA BAHREINI, Jian Xue, Kent C. Johnson, Thomas D. Durbin, David Quiros, Shaohua Hu, Tao Huai, Alberto Ayala, Heejung S. Jung, *University of California, Riverside*

In an effort to characterize aerosol emissions from light duty gasoline vehicles, three vehicles equipped with traditional port-fuel injection engine (PFI) or the more modern direct injection engines (wall-guided, WG-GDI, or spray-guided, SG-GDI) were tested on the FTP (Federal Test Procedure) and US06 (Supplemental FTP Test Procedure) driving cycles. Tests were carried out at UC- Riverside's College of Engineering- Center for Environmental Research and Technology's light-duty chassis dynamometer facility. We used measurements of black carbon (BC) mass and aerosol optical extinction coefficient (at 632 nm) to determine emission factors of BC (EF_{BC}) and extinction coefficient (EF_{ext}) as well as single scattering albedo (SSA) of the emitted particles during different phases of the driving cycles. Highest EFs were observed for the WG-GDI engine, regardless of the driving cycle. During the FTP cycle, cold-start EF_{BC} and EF_{ext} of GDI vehicles were at least an order of magnitude higher than hot-transient phase values while for the PFI vehicle, the ratios of the cold-start to hot-transient EFs were at most a factor of 4. The lowest SSA value was observed for the WG-GDI during the cold-start phase of the FTP cycle. We present further analysis on the observed EFs and SSA in different phases of the driving cycles to understand the impact of different engine technologies on emissions.

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3UA.6
Chemical Evolution of Emissions from Meat Charbroiling. CHRISTOS KALTSONOUDIS, Evangelia Kostenidou, Evangelos Louvaris, Magdalini Psichoudaki, Epameinondas Tsiligiannis, Kalliopi Florou, Spyros Pandis, *University of Patras, Patra, Greece*

Meat charbroiling can be a significant source of organic aerosol in urban areas and cooking organic aerosol (COA) may contribute up to 20% to the total organic aerosol (OA). COA emissions once released at the atmosphere may also undergo various oxidation steps, making their identification difficult. In this study we present results of smog chamber experiments and ambient measurements focusing on the characterization of the particulate and gas phase emissions from meat charbroiling and their atmospheric evolution.

Source-sampling chamber experiments were conducted in the ICE-HT environmental chamber facility at Patras, Greece. Emissions from pork meat charbroiling were introduced into a 8 m^3 Teflon (PTFE) chamber. A High Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS) and a Scanning Mobility Particle Sizer (SMPS) measured the aerosol composition and size distributions. A Proton Transfer Reaction Mass Spectrometer (PTR-MS, Ionicon Analytik) measured the Volatile Organic Compounds (VOCs). Ozone and Black Carbon measurements were also available. UV illumination was used in some experiments to promote oxidation of the cooking emissions. The emitted particulate matter was mainly composed of organics and the fresh OA had an O:C ratio of around 0.1. After 8 hours of photo-oxidation the O:C ratio increased to approximately 0.25 while ozone, OH radicals and many oxygenated VOCs were produced. The fresh and aged AMS OA spectrum differed considerably.

Ambient data were collected during summer and winter in urban centers of Greece, including Fat Thursday where traditionally meat is charbroiled in the streets. Positive Matrix Factorization (PMF) revealed that COA contributed up to 85% of the OA from 10:00 to 12:00 that day and the ambient COA factor had a mass spectrum similar to the aged COA chamber spectrum. Winter measurements from Athens, Greece showed that the spectrum of the COA factor found was similar to the fresh aerosol spectrum of the chamber experiments.

3UA.7
Micro-environmental Air Quality Impact of a Biomass Boiler with and without PM Emission Control. ZHEMING TONG, Bo Yang, Kui Wang, Devraj Thimmaiah, Philip K. Hopke, Thomas Whitlow, Andrew Landers, K. Max Zhang, *Cornell University*

Initiatives to displace petroleum and climate change mitigation have driven a recent increase in space heating with biomass combustion in New York State and elsewhere in the Northeast. However, there is ample evidence that biomass combustion emits significant quantities of known health damaging pollutants. We investigated the micro-environmental air quality impact of a biomass-fueled combined heat and power system equipped with an electrostatic precipitator (ESP) in Syracuse, NY. Emission factors are derived based on in-stack measurement both upstream and downstream of ESP with EPA Method 5/202. In tandem with the stack testing, two rooftop stations with PM2.5 and CO2 analyzers were set up in the way that one can capture the plume while the other one serves as the background in comparison depending on the wind direction. Four sonic anemometers were deployed around the stack to quantify highly spatially and temporally resolved local wind pattern. A computational fluid dynamic-based micro-environmental model was applied to simulate the experimental conditions, and a good agreement between predicted and on-site measurement is observed for both flow fields and plume dispersion. Our analysis shows that the absence of ESP could lead to an almost 7 times increase in near-ground PM2.5 concentrations with a maximum concentration >50 μg m-3 in the surrounding environment. This result demonstrates the critical role of air pollution controls for biomass combustion systems. In addition, we explored various physical parameters including stack temperature/height, ambient wind, and surrounding structures to provide recommendations for siting biomass-fueled heating equipment in order to minimize local air pollution.

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4AC.1

Secondary Organic Aerosol Yields from Isoprene under High NO Conditions. REBECCA SCHWANTES, Tran Nguyen, Kelvin Bates, Xuan Zhang, Yuanlong Huang, Richard Flagan, John Seinfeld, *Caltech*

Recently, many advances have been made to improve our understanding of how chamber conditions influence Secondary Organic Aerosol (SOA) yields. These improvements warrant relooking at SOA yields previously done on isoprene under high NO conditions to tease out what regimes and conditions are most important for SOA growth. The effect of seed surface area, NO2/NO ratio, temperature, and Relative Humidity on isoprene SOA yields under high NO conditions will be explored. Experiments were run in a very controlled manner such that differences in SOA growth can be attributed directly to changing chamber conditions. Additionally, the gas-phase and particle-phase chemistry was monitored throughout these experiments by a chemical ionization mass spectrometer and aerosol mass spectrometer, respectively. The specific chemistry causing differences in the SOA yield will be discussed in detail.

4AC.2

Secondary Organic Aerosol Yields from Isoprene Oxidation under Low-NO Conditions. KELVIN BATES, Rebecca Schwantes, Tran Nguyen, Xuan Zhang, Yuanlong Huang, Richard Flagan, John Seinfeld, *Caltech*

The oxidation mechanisms of isoprene, in both the gas and particle phases, have been the subject of substantial research in recent years, which has elucidated the importance of a number of previously underappreciated key factors (e.g. radical lifetimes, particle acidity, etc.) in determining the secondary organic aerosol (SOA) composition and yield from isoprene. In the environmental chamber experiments detailed here, we comprehensively study SOA formation from isoprene in a low-NO atmosphere under a wide variety of conditions to determine the dependence of SOA yields on a number of these variables, including temperature, particle salt composition, relative humidity, and particle acidity. In order to avoid excessive particle phase oxidation from H2O2 photolysis in aqueous particles, we use tert-butylhydroperoxide as an oxidant source. We report SOA yields as measured by a differential mobility analyzer, SOA composition as measured by an aerosol mass spectrometer, and gas-phase oxidation products as measured by a CF3O- chemical ionization mass spectrometer, and compare all results to both previously reported isoprene SOA yields and those measured under various high-NO regimes in concurrent experiments.

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4AC.3
Efficient Organic Aerosol Formation from Isoprene Photooxidation in Pristine Conditions. JIUMENG LIU, Ben H. Lee, Emma D'Ambro, Felipe Lopez-Hilfiker, Becky Alexander, Rahul Zaveri, Jean C. Rivera-Rios, Frank Keutsch, Siddharth Iyer, Theo Kurten, Ying-Hsuan Lin, Jason Surratt, Pattanun Achakulwisut, Loretta Mickley, Joel A. Thornton, John Shilling, *Pacific Northwest National Laboratory*

With a global flux of ~500 Tg/year, emission of isoprene by vegetation is the largest source of non-methane hydrocarbons to the atmosphere, where its photochemical oxidation is a potentially substantial source of secondary organic aerosol (SOA) mass. The pathways by which isoprene converts to SOA, and how anthropogenic pollutants such as nitrogen oxides and sulfur affect this process, are a subject of intense research, in part because atmospheric particles profoundly affect Earth's climate and regional air quality. In the absence of nitrogen oxides and acidic seed particles, we measure SOA mass yields from isoprene photochemical oxidation of up to 15%, which are factors of 2, or more, higher than previously reported. Direct online measurements of aerosol molecular composition and the controlled addition of nitrogen oxides show that di-hydroxy di-hydroperoxides are major contributors to such efficient SOA formation. These insights allow for improved quantitative estimates of SOA formation in the pre-industrial atmosphere and in biogenic-rich regions with limited anthropogenic impacts with consequences for calculating a robust estimate of an anthropogenic forcing of aerosol-climate effects.

4AC.4
Oxidation Chemistry and Secondary Organic Aerosol Yields from Isoprene when Alkylperoxyl Radical (RO2) Lifetimes Approach Ambient Values. TRAN NGUYEN, Rebecca Schwantes, Kelvin Bates, Xuan Zhang, Yuanlong Huang, Richard Flagan, Paul Wennberg, John Seinfeld, *California Institute of Technology*

The fate of the alkylperoxyl radicals (RO2) produced by the photooxidation of hydrocarbons is of fundamental importance to atmospheric chemistry. RO2 radicals in the atmosphere react with NO or HO2 on a timescale exceeding 10 seconds in biogenic regions. Yet, most chamber studies of hydrocarbon oxidation are investigated with radical levels that limit the RO2 lifetime to less than 0.1 second. A number of recent works have demonstrated the large impact of RO2 lifetime to gas-phase product distribution and, possibly, secondary organic aerosol (SOA) yields. For example, when RO2 lifetimes reach the ambient limit, the thermodynamic isomer distribution of first-generation products is favored over the kinetic distribution. Furthermore, isomerization of the RO2 radical followed by reaction with O2 (i.e., autoxidation), becomes a significant fate under this chemical regime. The isomerization mechanism rapidly incorporates oxygen into the hydrocarbon structure and is thought to be responsible for the prompt generation of "extremely low-volatility" SOA components in the monoterpene oxidation systems. These findings would suggest that longer RO2 lifetimes increase SOA yields, but the effect has not yet been investigated for isoprene. In this work, we explore the oxidation product distribution and SOA yields from isoprene when RO2 lifetimes are on the order of 50 seconds. We examine a variety of atmospheric conditions (T = 25 – 40 °C, RH = 4 – 85%, low – high seed particle area, a range of seed particle composition, etc.) and discuss the consistency of SOA yield data derived from isoprene when comparing the chamber to the atmosphere.

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4AC.5

Explicit Simulation of the Secondary Organic Aerosol Formation of Isoprene from Partitioning and Aerosol Phase Reactions. ROSS BEARDSLEY, Myoseon Jang, *University of Florida*

The atmospheric photooxidation of volatile organic compounds (VOC) leads to the formation of an array of semi volatile organic compounds (SVOC) with added functionality and reduced volatility. These SVOC either remain in the gas phase and undergo further oxidation, or partition into the aerosol phase to form secondary organic aerosol (SOA). The amount which partitions into the aerosol phase will depend on the thermodynamic properties of the SVOC and the aerosol phase. Moreover, once in the aerosol phase, SVOC may be further chemically transformed through oligomerization, acid catalyzed reactions, and organosulfate formation leading to large increases in SOA mass. Conventional SOA models avoid the complexity of SOA formation processes by lumping SVOC into a small number of representative products of a certain vapor pressure. The stoichiometric mass and equilibrium partitioning coefficients of each representative product are then fit to SOA chamber data under certain oxidative conditions (VOC/NOx). While these models are computationally efficient, they are limited in their ability to handle gas phase aging and aerosol phase reactions due to the fitting of parameters at max SOA mass under certain conditions and the loss of individual product structures, which determine reactivity in the gas and aerosol phase. In this study, the UNIfied Partitioning-Aerosol phase Reaction model (UNIPAR), which predicts SOA formation from partitioning and aerosol phase reactions, was modified and coupled with the Master Chemical Mechanism to explicitly simulate the gas phase photooxidation and SOA formation of isoprene in the presence of acidic seeds and varying VOC/NOx. The high volatility and reactivity of isoprene SVOC make its SOA yields very sensitive to both gas phase aging and aerosol phase reactions, and an ideal candidate for testing the explicit model. The improvements over lumping models in simulating outdoor chamber SOA data and the implications for future SOA modeling efforts are discussed.

4AC.6

Photochemical Aging of a-Pinene and b-Pinene Secondary Organic Aerosol Formed from Nitrate Radical Oxidation. THEODORA NAH, Javier Sanchez, Christopher Boyd, Nga Lee Ng, *Georgia Institute of Technology*

The nitrate radical (NO_3), one of the most important oxidants in the nocturnal atmosphere, can react rapidly with a variety of BVOCs to form high mass concentrations of SOA and organic nitrates. Since NO_3 is derived almost exclusively from the reaction of NO_2 with O_3, SOA production from NO_3-BVOC reactions represents a mechanism for positively correlating anthropogenic pollutants with biogenic emissions. Organic nitrates, which account for a large fraction of ambient nighttime SOA, play important roles in the atmosphere as their fates may influence the global nitrogen budget and ozone production. Despite the importance of NO_3-BVOC reactions, their reaction mechanisms and products remain poorly characterized. There is also a dearth in knowledge on how SOA and organic nitrates formed from NO_3-BVOC reactions evolve as they age in the atmosphere. Aerosol lifetimes in the atmosphere typically range between 1 and 2 weeks; half of it is in the day where OH photochemical oxidation is likely dominant.

We investigated how the composition and mass loading of a-pinene and b-pinene SOA formed from NO_3 oxidation under dark humid conditions changes when they are photochemically aged with OH through a series of chamber experiments performed at the Georgia Tech Environmental Chamber (GTEC). The a-pinene and b-pinene SOA are characterized using real-time gas- and particle-phase measurements, which are used to propose mechanisms for SOA and organic nitrate formation and aging. Using a Filter Inlet for Gases and AEROsols (FIGAERO) coupled to a High-Resolution Time-of-Flight Chemical Ionization Mass Spectrometer (HR-ToF-CIMS), we observed the formation of highly oxygenated particle-phase organic nitrates (possessing 6 to 8 oxygen atoms) during the NO_3-b-pinene reaction, but not during the NO_3-a-pinene reaction. Results from this study aims to explain ambient observations from the recent Southern Oxidant and Aerosol Study (SOAS), which showed that the NO_3-monoterpenes reactions account for a substantial fraction of nocturnal SOA and organic nitrates in the southeastern US, as well as provide new insights into how the transition from night to day oxidation environments affects the fates of nocturnal monoterpene SOA and organic nitrates.

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4AC.7
Effect of Temperature and Dilution on Secondary Organic Aerosol (SOA) Formed from NO3 Oxidation of Monoterpenes: A Case Study for Aerosol Evaporation during the Night-to-Day Transition. CHRISTOPHER BOYD, Theodora Nah, Lu Xu, Nga Lee Ng, *Georgia Institute of Technology*

Oxidation of biogenic volatile organic compounds (BVOCs) by nitrate radical (NO3) is an important pathway in producing secondary organic aerosol (SOA) at night. Since NO3 is produced by the reaction of ozone with anthropogenic NO2, reaction of BVOCs with NO3 represents a direct link between anthropogenic pollution enhancing aerosol produced by biogenic emissions. During the night-to-day transition, SOA produced at night can undergo physical changes that lead to aerosol evaporation. These changes include dilution induced by the increase in ambient boundary layer height as well as rising ambient temperatures. Limonene and β-pinene are important biogenic precursors due to their high abundance at night and high aerosol mass yields when oxidized by NO3. In this study, chamber experiments focusing on limonene+NO3 and β-pinene+NO3 chemistry are performed at the Georgia Tech Environmental Chamber (GTEC) facility. Reactions are carried out under dry conditions in the presence of ammonium sulfate seed at either 25 °C or 40 °C. O3 and NO2 are pre-reacted in a flow tube to generate N2O5, which is then injected into the chamber to initiate oxidation of BVOCs. A few hours following peak aerosol growth for each reaction, aerosol evaporation is promoted either by isothermal dilution or by increasing the temperature from 25 °C to 40 °C. The mass of aerosol evaporation is determined using a Scanning Mobility Particle Sizer (SMPS) while changes in bulk aerosol composition are determined using a High Resolution-Time of Flight-Aerosol Mass Spectrometer (HR-ToF-AMS). From this study, we calculate an effective enthalpy of vaporization for the products formed by monoterpene+NO3 reactions. Additionally, preliminary results indicate that aerosol produced at 25 °C and subsequently heated to 40 °C have different mass and composition compared to aerosol produced at 40 °C. Possible reasons for this observation as well as its atmospheric implications will be discussed.

4BA.1
Biotransformation of Various Saccharides and Production of Exopolymeric Substances (EPSs) by Cloud-borne Bacillus SP. 3B6. ANNE-MARIE DELORT, Maria Matulova, Slavomira Husarova, Martine Sancelme, Peter Capek, *Université Clermont Auvergne, France*

The ability of Bacillus sp. 3B6, a bacterial strain isolated from cloud waters, to biotransform saccharides present in the atmosphere was evaluated using in situ 1D and 2D NMR spectroscopy. Bacillus is one of a genus most frequently described in the air and atmospheric waters. Sugars present in these environments have a biogenic origin; they include alditols, monosaccharides, disaccharides, oligosaccharides, and polysaccharides.

Bacillus sp. 3B6 was able to efficiently metabolize sugars, which could thus provide sources of energy for this bacterium and allow it to live and to be metabolically active in warm clouds. In addition, a number of these saccharides (L-arabitol, D-fructose, sucrose, D-glucose, cellotetraose, cellulose, and starch) were transformed to EPSs (ExoPolymeric Substances). We have clearly identified the structure of two EPSs as 1,6-alpha-galactan and partially acetylated polyethylene glycol (AcPEG). 1,6-alpha-galactan is a newly described polymer. The production of EPSs might protect this bacterium under hostile cloud environment conditions, including low nutrient availability, cold temperature and freeze-thaw processes, UV and radical exposure, and evaporation–condensation processes and thus to desiccation and osmolarity changes. EPSs could also have a potential role in atmospheric processes because they can be considered as secondary organic aerosols and efficient cloud condensation nuclei (1).

Acnowledgement:
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Reference:
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4BA.2
Aerosolization of Two Strains (Ice+ and Ice-) of Pseudomonas Syringae in a Collison Nebulizer at Different Temperatures. RENEE PIETSCH, Ray David, Linsey Marr, Boris Vinatzer, David Schmale, *Virginia Tech*

The aerosolization of microorganisms from aquatic environments is understudied. In this study, an ice nucleation active (ice+) strain and a non-ice nucleation active (ice-) strain of the bacterium Pseudomonas syringae were aerosolized from aqueous suspensions under artificial laboratory conditions using a Collison nebulizer. The aerosolization of P. syringae was not influenced by water temperatures between 5 degrees and 30 degrees C. In general, the culturability (viability) of P. syringae in aerosols increased with temperature between 5 degrees and 30 degrees C. The ice+ strain was aerosolized in greater numbers than the ice- strain at all temperatures studied, suggesting a possible connection between the ice nucleation phenotype and aerosol production. Together, our results suggest that P. syringae has the potential to be aerosolized from natural aquatic environments, such as streams, rivers, ponds, and lakes; known reservoirs of P. syringae. Future work is needed to elucidate the mechanisms of aerosolization of P. syringae from natural aquatic systems.

4BA.3
Hygroscopicity and Cloud Condensation Nuclei Activity of Bacterial Cells. Natasha DeLeon-Rodriguez, Aikaterini Bougiatioti, Nimmy Mathew, Arnaldo Negron-Marty, Sara Purdue, Samantha Waters, Michael Bergin, Konstantinos Konstantinidis, ATHANASIOS NENES, *Georgia Institute of Technology*

The abundance of bacterial cells in the atmosphere can reach relatively high numbers, but more rigorous research is needed to investigate the extent to which they play a role in atmospheric chemistry, cloud formation, and precipitation. It has been known for decades that bacteria are among the most efficient ice nuclei in the atmosphere, and there have been several immersion freezing studies of various bacterial isolates. However, the ability of bacteria to initiate cloud droplet formation remains poorly characterized. There are a few existing studies that have measured the cloud condensation nuclei (CCN) activity of different bacteria, but the underlying mechanism(s) of this activity, how it is related to bacterial cell hygroscopicity, and the physiological state of the cell, remain unknown. The objective of this study was to determine whether the affinity of different bacterial cells to water might be related to CCN activity. To this end, we collected samples from rainwater and ambient air at different locations (urban cities and rain forest) and altitudes (~10 km and surface air). Over 20 bacterial isolates were obtained from these samples using different minimal and rich media, and were identified based on sequencing of the 16S rRNA gene. The hydrophobicity of different bacterial cell lawns was evaluated by contact angle measurements with water. A wide range of contact angles was observed among our isolates, ranging from very hydrophilic to very hydrophobic; the majority of the isolates, however, were found to be hydrophilic. The CCN activity of each isolate was studied by introducing aerosolized bacteria into a continuous flow stream-wise thermal gradient CCN counter. These data show that the hydrophilic bacteria used here have a critical supersaturation of 0.06% compared to the hydrophobic bacteria, which had a critical supersaturation of 0.15% or higher. These supersaturation conditions are relevant for certain areas of the planet, indicating the potential of hydrophilic bacteria to influence cloud formation and precipitation in these regions.

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4BA.4
The Hygroscopic Properties of Pollenkitt and Its Importance for Regulating Water Uptake by Pollen Particles. SARA PURDUE, Nonne Prisle, Haisheng Lin, Carson Meredith, Athanasios Nenes, *Georgia Institute of Technology*

Pollen is an important class of bioaerosol that exhibits a remarkable breadth of complex solid surface features. In addition, many pollen grains are coated with a viscous liquid, “pollenkitt”, thought to play important roles in pollen dispersion and adhesion. The formation of adhesive forces associated with pollenkitt mainly depends on the volume and wetting properties of the fluid. However, the influence of relative humidity and water absorption by pollenkitt on these capillary forces and the biological function of pollen is virtually unknown, but may be critically important for its activation and allergenicity, and may regulate its atmospheric lifetime and ability to nucleate cloud droplets and ice crystals. In the present work, we present a comprehensive characterization of the hygroscopicity of pollenkitt for a wide range of water vapor saturations. For this purpose, pollenkitt extracted from a variety of pollen species is aerosolized, dried and size selected by a Differential Mobility Analyzer to obtain a monodisperse aerosol composed of the material. The cloud condensation nuclei (CCN) activity and hygrosocopicity of the pollenkitt is then quantified using a DMT Continuous-Flow Streamwise Thermal Gradient CCN Counter. The subsaturated water uptake and hygroscopicity is also measured with Atomic Force Microscopy (AFM), by observing the shifts in the fundamental resonance frequency of an AFM cantilever bearing pollen. We then present the derived pollenkitt hygroscopicity and determine its contribution to water uptake of pollen as a function of humidity. The implications of this water uptake for the adhesive properties of pollen, nucleation of droplets and ability to freeze ice is then presented.

4BA.5
Bacterial Aerosol Concentration Associated with Dust Passage at Southwestern Japan Observed in 2010-2014. KOTARO MURATA, Kazutaka Hara, Daizhou Zhang, *Prefectural University of Kumamoto*

Bacteria as prominent biological particles in the atmosphere affect climate and global hydrological cycles by acting as nuclei of ice-cloud formation, and the constant dispersal of viable bacteria is regarded as a link between disjunctive bacterial communities in distant areas. In this presentation, we present the measurements in southwestern Japan to show that concentrated bacteria are widespread with Asian dust plumes. Airborne particulate matter was collected in the campus of the Prefectural University Kumamoto, Kumamoto, Japan (32°48'N, 130°45'E) and at a seaside in Amakusa, Japan (32°19'N, 129°59'E) during dust and non-dust periods in 2010-2014. Collected samples were stained with LIVE/DEAD BacLight Bacterial Viability Kits for separately labeling viable and non-viable bacterial cells. Coarse particles (>1 μm) measured with an optical particle counter were used to show the arrival of Asian dust. The number concentration of bacteria in dust plumes varied between 1.0×10^6 and 1.6×10^7 cells m^{-3}, which was one to two orders larger than that in non-dust air and was proportional to and comparable to the concentration of particles larger than 1 μm. The viability of bacteria was 16-40% in dust plumes, which was quite smaller than the 76-91% viability in non-dusty air. However the absolute concentration of viable bacteria in dust plumes, 2.5×10^5-3.8×10^6 cells m^{-3}, was similar to or larger than those in non-dusty air. Dust is thus a substantial medium for bacteria to link the isolated communities in addition to ice nucleating activities.

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4BA.6
Production of Siderophores by Cloud Microorganisms: Occurrence and Potential Impact on Cloud Chemistry.
Nolwenn Wirgot, Virginie Vinatier, Martine Sancelme, Muriel Joly, Magali Abrantes, Laurent Deguillaume, ANNE-MARIE DELORT, *Université Clermont Auvergne, France*

Iron plays a key role in cloud aqueous phase chemistry as it is a major source hydroxyl radical (HO•) due to Fenton and Photo-Fenton reactions. In cloud waters it has been shown that, although the environment is highly oxidant, both Fe (II) and Fe(III) are present. This result suggests that most of iron is under the form of organic complexes. These complexes would stabilize iron in its reduced form Fe(II) preventing it to be re-oxidized. In atmospheric chemistry models, the iron-oxalate complex is used to as a model of organic complexes. However iron could be chelated by other organic ligands from biological origin in cloud waters such as HULIS, EPSs or siderophores as observed in sea waters and more recently in rainwaters.

As it has been shown that living microorganisms are present in cloud waters, they potentially need to acquire iron from this environment by synthetizing siderophores.

In order to test this hypothesis we have isolated 458 strains (bacteria and yeast) from clouds collected at the puy de Dôme station (1465 m, France). These strains have been identified and screened for their in-lab production of siderophores. For this purpose the CAS (Chrome Azurol S) method has been adapted for 96 wells microplates in order to get a high-throughput detection method. This test allowed a quantitative evaluation of the siderophore production and a qualitative determination of the chelating functional groups (catechol, hydroxamate, carboxylate). 42% of the tested microbial isolates were able to produce siderophores.
Our results as discussed in terms of the implication of the presence of siderophores in clouds for atmospheric chemistry.

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4BA.7
The Relationship between Fluorescent Particles and Ice Nuclei Measured at Two Contrasting Sites: A Coastal Marine Site (Ucluelet, Canada) and a Semi-urban Location (Saclay, France).
DAVID O'CONNOR, Ryan H. Mason, Meng Si, Jixiao Li, Cédric Chou, Robin Dickie, Allan Bertram, Walfried Lassar, Kyle Pierce, Dominique Baisnee, Roland Sarda-Esteve, J. Alex Huffman, *University of Denver, CO*

Recently there has been an increasing scientific interest in the evaluation and concentration determination of biological particles (pollen, fungal spores and bacteria) in the atmosphere. Such particles can indirectly affect the environment through their ability to act as ice nucleating particles (INPs), thereby influencing the formation of clouds, their lifetimes and properties such as precipitation potential. However few field studies have been performed to gauge the possible contributions of biological particles to such phenomena.

In this work a wideband integrated biological sensor (WIBS-4a) and a micro-orifice uniform-deposit impactor (MOUDI) were co-located at two sampling locations; one situated in Ucluelet, Canada (rural coastal site) and the other in Saclay, France (semi-urban site). Using the WIBS instrument, fluorescent particles were counted and categorized into classes defined by the channels of fluorescence each particle exhibited. Unique trends in size-resolved diurnal distributions were observed for the seven categories. Particle concentrations from each of the seven WIBS particle categories were compared to corresponding INP concentrations obtained using the MOUDI instrument. The quality of fit between fluorescent particle number and INP number varied significantly depending on the fluorescent particle categories used for the correlation, suggesting that not all fluorescent particle types exhibit the same ice nucleating ability. These data will present the beginning point for discussion regarding what particle types may contribute overall INP loading.

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4CO.1
Secondary Organic Aerosol Production from Intermediate Volatility Organic Compound Emissions from On-road Vehicles. YUNLIANG ZHAO, Ngoc Nguyen, Albert A. Presto, Christopher Hennigan, Andrew May, Allen Robinson, *Carnegie Mellon University*

Results from smog chamber experiments with dilute exhaust from on-road vehicles, both gasoline and diesel vehicles, have shown that the amount of secondary organic aerosol (SOA) produced during experiments can not be explained by traditional SOA precursors such as single-ring aromatic compounds. Intermediate-volatility organic compounds (IVOCs) have been proposed as the major cause for the discrepancies between measured SOA in chamber experiments and estimated SOA from single-ring aromatic compounds. To examine the importance of IVOCs in SOA production, IVOC emissions were directly measured from gasoline and diesel on-road vehicles during chassis dynamometer testing. The mass of IVOCs is dominated by an unresolved complex mixture (UCM). The UCM is quantified into 22 lumped groups based on molecular structure and volatility. SOA production from IVOCs, both speciated IVOCs and the UCM, are estimated and compared to SOA production measured in the smog chamber experiments with dilute exhaust. Our results show that SOA production from IVOCs is the dominant contributor to SOA produced from diesel exhaust, and a major contributor to SOA produced from gasoline exhaust. Finally we use the new data to re-examine the contribution of gasoline and diesel on-road vehicles to atmospheric SOA

4CO.2
An Investigation of How Well Aerosol Instruments Estimate Solid Particle Number and PM Mass in Vehicle Emissions. MATTI MARICQ, *Ford Motor Company*

Recent LEVIII, Tier 3, and EU6 regulations have dramatically increased the stringency of PM and PN emissions standards. Developing new engine technology to meet these standards requires measurement tools with higher capabilities than prescribed in the regulations. To meet the combined targets of CO2, HC, NOx, and PM emissions, as well as many other design targets, the development engineer really needs more detailed information: when in the cycle do the emissions occur, are the particles solid or liquid, how large are they, etc.?

New PM instruments have been developed with the combustion engine community in mind. Three seeing significant use are: the Dekati Mass Monitor (DMM), the Engine Exhaust Particle sizer (EEPS) / DMS500, and the Micro Soot Sensor (MSS). These provide mobility/aerodynamic, electrical mobility, and optical absorption measurements of the PM respectively. Furthermore, with suitable assumptions their data can be converted to estimate particle number and mass emissions.

Separately, or in combination, these instruments provide significant useful information to help guide engine and aftertreatment design. None follow the regulatory definition of PM or PN, but it is possible to derive from them the regulated quantities. The present work examines the performance and inter-relationships of these instruments, as well as filter based PM mass and solid particle number, for about 35 tests done with 7 vehicles. The vehicles range from a diesel emitting an order of magnitude above current standards, several gasoline direct injection vehicles with varying emissions levels, and a PFI vehicle with emissions at ~1 mg/mi. This study examines instrument performance for the FTP drive cycle, where sensitivity and artifacts are a concern, as well as for the US06 drive cycle, where interferences arising from the aggressive nature and high exhaust temperature associated with this cycle are a concern.

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4CO.3
Emission Characterization of a Large Scale Wood Pellet Combined Heat and Power System. KUI WANG, Philip K. Hopke, Devraj Thimmaiah, *Clarkson University*

SUNY_ESF has installed an 8 MMBTU wood pellet combined heat and power (CHP) system. Premium wood pellets were supplied by New England Wood Pellet (GHV=8500 btu/lb, 3~5% moisture, 0.4~0.6% ash). The present study focused on the efficiency determination of an electrostatic precipitator (ESP) that was installed to control PM emissions given its location in an urban area. Emissions (including particulate and gaseous emissions) of the boiler were characterized at 3 different loads: low, medium and high.

The tests were performed during a typical winter heating season using both EPA Method 5/202 and CTM-039 sampling trains operating at both upstream and downstream of the ESP. Particle mass concentrations were measured using a TEOM 1400a series and size distributions were obtained using a Fast Mobility Particle Sizer (TSI model 3091). Concentrations of gaseous species including CO, SO2 and NO were measured using Thermo gas analyzers. For each test, multiple filters were collected: 47 mm quartz, 47 mm Teflon, a 142 mm quartz, with PUF back-up.

Studies have shown that wood pellet boilers tend to have increasing thermal efficiency with increasing load. The boiler thermal efficiency determined in this case for 3 different loads are: 89.8%, 90.7% and 90.7%. The PM collection efficiencies of the ESP determined with the method 5/202 for the three loads were as: 96.3%, 92.6% and 85.1%. The PM2.5 emission rate at full load was determined at 0.114 lbs/MMBTU or 0.861 lbs/hr. Total particle number concentration was at the magnitude of 107/cm3 at high load. The NO emissions followed the steam production rate quite well with peak concentration at around 135 ppm at high load. CO emissions determined at about 150 ppm for high load with peak concentration at over 300 ppm.

The collected PM samples have been analyzed for their chemical constituents and these results will be presented.

4CO.4
Combustion Emissions from Biomass Cookstoves vs. Operational Firepower: Lab and Field Observations. KELSEY BILSBACK, Kelley Hixson, Michael Johnson, Jack Kodros, James Liacos, Eric Lipsky, Christian L'Orange, Jeffrey R. Pierce, Brooke Reynolds, Allen Robinson, R. Subramanian, John Volckens, *Colorado State University*

Solid fuel combustion in cookstoves is known to have negative effects on air quality, climate, and human health as a result of the emission of incomplete combustion products. Because stoichiometry, temperature, and mixing dynamics may have considerable local variations within a cookstove, the emissions rates are unsteady and difficult to quantify. The temporal variabilities in emissions are typically not accounted for because of restrictive laboratory testing practices and the fact that typical testing procedures rely heavily on integrated measurements. In the current study, a laboratory protocol was developed that varied firepower, a proxy for cookstove operation, to quantify how emissions characteristics and quantities vary due to changes in cookstove combustion parameters. To represent typical field combinations, approximately fifteen different stove types and seven different fuel types (24 stove/fuel combinations) were tested. An extensive suite of real-time and integrated aerosol instrumentation was used during the study to characterize the fresh cookstove aerosols. Modified combustion efficiency and firepower were calculated using gas measurements from a 5-Gas Analyzer (CO2, CO), and particle characteristics were quantified using gravimetric measurements, a transmissometer and a Photoacoustic Exinctiometer. Emissions rates were parameterized using cookstove combustion variables to understand how the characteristics of biomass combustion influence emissions. The results of the tests demonstrate that firepower can describe a significant amount of variance in black carbon emissions (Spearmen correlation between 0.35-0.96) and total particulate matter emissions (Spearmen correlation between 0.32-0.85). Finally, during two field campaigns, in Honduras and China, the characteristics of uncontrolled cookstove emissions were monitored using similar instrumentation. Preliminary results from the field tests indicate that firepower can explain a considerable amount of emissions variation under field conditions. Initial validation of the laboratory parameterizations with data from the field campaigns shows promise.

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4CO.5
Size Resolved High Temperature Oxidation Kinetics of Nano-Sized Metal Particles. R. Jacob, Y. Zong, S. Li, MICHAEL ZACHARIAH, *University of Maryland*

While ultrafine metal particles offer the possibility of very high energy density fuels, there is considerable uncertainty in the mechanism by which metal nanoparticles burn, and few studies that have examined the size dependence to their kinetics at the nanoscale. In this work we quantify the size dependence to the burning rate of titanium and zirconium nanoparticles. Nanoparticles in the range of 20-150 nm were produced via pulsed laser ablation, and then in-flight size-selected using differential electrical mobility. The size-selected oxide free metal particles were directly injected into the post flame region of a laminar flame to create a high temperature (1700 - 2500K) oxidizing environment. The reaction was monitored using high-speed videography by tracking the emission from individual nanoparticles. We find that sintering occurs prior to significant reaction, and that once sintering is accounted for, the rate of combustion follows a near ~ (diameter)1 power-law dependence. Additionally, Arrhenius parameters for the combustion of these nanoparticles were evaluated by measuring the burn times at different ambient temperatures. The optical emission from combustion was also used to model the oxidation process, which we find can be reasonably described with a kinetically controlled shrinking core model.

4CO.6
Observations of Two Reverse Particle Growth Pathways during the Char Burning Stage of Residential Coal Combustion. QING LI, Jingkun Jiang, Jianguo Deng, Lei Duan, Wei Zhou, Jiming Hao, *Tsinghua University*

Particle formation mechanism during residential coal combustion, a key anthropogenic source when addressing air quality and climate issues, has not been well understood. Particle formation and emission were characterized when burning Chinese bituminous and anthracite chunks in a typical residential stove. Aerosol size distributions in the range of 1 nm to 10 μm were monitored after a dilution tunnel that collects and dilutes flue gas from the stove chimney. Residential coal combustion can be divided into three stages, i.e., coal pyrolysis, burning of volatile compounds, and char burning. During the first two stages, accumulation mode particles (0.1 – 1 μm) and coarse mode particles (> 1 μm) are dominant in the aerosol mass based size distribution. Although most particulate mass (> 90%) are emitted in the first two stages, the char burning stage commonly lasts more than 80% time of a full residential coal combustion period and emits ultrafine particles with high number concentrations. Two reverse particle growth pathways were observed for all tested coal samples in the char burning stage when the burning temperature was decreasing. Nucleation mode particles (1 – 10 nm) and Aitken mode particles (10 – 100 nm) are dominant in both aerosol number and mass based size distribution. The first reverse growth pathway terminates at the burning temperature of about 600 oC, while the other pathway lasts till fire extinction (the burning temperature is close to ambient temperature). Offline chemical analysis of size-segregated particle samples helps to identify key inorganic species contributing to these two reverse particle growth pathways, i.e., alkali metal and ammonium salt appear to be high during the first and second pathways, respectively.

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4CO.7

Generation of Particulate Matters (PM) by Burning Pulverized Coals and Biomasses for In-Vitro Toxicity Study. HUNGSOO JOO, Shila Maskey, Mustafa Mamun, Arom Seo, KwangYul Lee, Kihong Park, *Gwangju Institute of Science and Technology*

The aims of this study are to construct PM generation systems (coal burning and biomass burning PM), to control the level of PM concentrations, to determine physical and chemical properties of the generated PM, and to expose the well-controlled PM directly to cells by using the air-liquid interface (ALI) cell exposure system, or to collect PM samples for measurements of oxidative potential (OP) without cell exposure. A bench scale high temperature (up to 1,200°C) drop-tube furnace (Lindberg/Blue M, Model HTF55342C, Thermo Electron Corp., USA) with an alumina tube by using pulverized coals was used to produce coal burning PM. For generation of various biomass burning aerosols (many types of forest trees and agricultural crop residues), a combustion chamber, a chimney, a primary and secondary dilution chambers were constructed. The PM generation systems were evaluated to produce PM of desired concentration levels which are appropriate for in-vitro toxicity test (i.e., for determination of dose-response relationship). Before in-vitro toxicity tests of the generated PM, particle size distribution, PM2.5 mass concentration, black carbon (BC) concentration, chemical components of non-refractory submicrometer particles, and hygroscopicity and volatility of size-selected particles were measured with the scanning mobility particle sizer (SMPS) (DMA 3088 and CPC 3022, TSI, USA), DustTrack DRX (TSI, USA), Aethalometer (Aethlabs, USA), aerosol mass spectrometer (AMS)(Aerodyne Inc., USA), and hygroscopicity and volatility tandem differential mobility analyzer (HVTDMA). Results for the evaluation of PM generation systems, characteristics of PM emitted from coal burning and biomass burning, and oxidative potential for PM will be presented.

4IA.1

Indoor Secondary Organic Aerosol Formation due to α-Terpineol Ozonolysis. Yanan Yang, MICHAEL WARING, *Drexel University*

Secondary organic aerosol (SOA) owing to reactive organic gas (ROG) ozonolysis can be an important indoor particle source in some settings. However, the SOA formation potential due to ozonolysis of α-terpineol, which is emitted by consumer product usage and reacts strongly with ozone indoors, has not been systematically quantified. Therefore, we conducted 21 experiments to investigate the SOA formation initiated by α-terpineol ozonolysis for three typical conditions of the air exchange rate (AER), which is the frequency with which indoor is replaced by outdoor air. Initial α-terpineol concentrations, ranging from 6.39 to 226 ppb, were combined with high ozone (~25 ppm) to ensure rapid and complete oxidation. No reactants were replenished so SOA peaked quickly and then decreased due to AER and surface losses, and loss-corrected peak SOA ranged from 2.03 to 281 µg/m3 at unit density. SOA mass formation was parameterized with the aerosol mass fraction (AMF), a.k.a. the SOA yield, which is the ratio of SOA mass formed to ROG mass converted. The AMFs ranged from 0.05 to 0.23 and were similar in magnitude to AMFs due to α-pinene ozonolysis. The α-terpineol AMFs strongly and positively correlated with larger SOA peak mass concentrations, whereas they weakly and negatively correlated with higher AERs. One-product, two-product, and volatility basis set (VBS) models were fit to the experimental AMFs at each AER for future modeling, and the efficacy of those three formulations at reproducing experimental AMFs was evaluated. Predictive cases demonstrated that α-terpineol ozonolysis can meaningfully form SOA in indoor air when certain consumer products are used indoors.

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4IA.2
Investigation of the Reactivity of Model and Genuine Organic Surface Layers in the Indoor Environment.
SHOUMING ZHOU, Matthew Forbes, Jonathan Abbatt, *University of Toronto, Toronto, Canada*

It is well known that indoor surfaces are covered by inorganic materials and semi-volatile organics arising from gas-surface partitioning and deposition of aerosol particles. However, it is not known how reactive this organic surface layer is under typical indoor environments. Given that these substances can be transferred to humans through dermal contact, inhalation or by hand-to-mouth ingestion, it is important to understand the reactivity of the organic surface layer as a function of indoor environmental conditions.

In this work, we present results from the heterogeneous ozone reactivity of organic surfaces layers that develop indoors, in both laboratory and residential settings, and from model surfaces comprised of a reactive PAH in a variety of organic matrices. The chemical composition of the organic surface layers is determined by direct analysis in real time-mass spectrometry (DART-MS). Reactivity to gas-phase ozone is established by exposing the organic layers to ozone using glass flow tubes. The effects of typical indoor environmental conditions, e.g. the relative humidity and light, on the reactivity will be investigated.

4IA.3
The Formation of Indoor Secondary Pollutants and Their Potential Health Effects.
YU HUANG, Junji Cao, Shun-Cheng Lee, *Institute of Earth Environment, Chinese Academy of Sciences*

D-limonene is one of the dominant terpenoids in indoor environment, which can be emitted from cleaning products and air fresheners. D-limonene is prone to oxidation resulting in the formation of secondary pollutants including secondary organic aerosol (SOA), hydrogen peroxide and organic peroxide which can pose health risks on residents. In this study, we investigated the effect of ammonia (NH3) on the formation of indoor SOA, hydrogen peroxide and organic peroxide from ozone/d-limonene reactions. The effects of coexisted ammonia on secondary pollutants formation from the ozonolysis of d-limonene were investigated via a large environmental chamber method. The experimental results demonstrated that the presence of NH3 (maximum concentration is 240 ppb) could significantly enhance the yields of SOA from the ozonolysis of d-limonene, but it could reduce the production of hydrogen peroxide and organic peroxide. The maximum total particle number concentration generated from the oxidation reactions was up to 1.3×105 #cm-3 in the presence of NH3, while it was 5.7×104 #cm-3 which was 43% lower without NH3. The total peroxides concentration was approximately 0.7 ppb without NH3, while it was 0.5 ppb in the presence of NH3. The mechanism regarding to the NH3 effect on the generation of indoor secondary pollutants from ozone/d-limonene reactions was further discussed.

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4IA.4
Model Framework to Predict Indoor Aerosol Concentrations based on Composition, Volatility, Water Uptake, and Mechanical Losses. MICHAEL WARING, Peter DeCarlo, *Drexel University*

Indoor aerosol models typically treat outdoor and indoor-emitted aerosols as static entities acted on by mechanical forces (i.e., deposition or filtration). However, indoor aerosol can also be transformed as a function of temperature (due to volatility changes) or relative humidity (due to changes in water content and subsequent aqueous phase chemistry). As such, we developed a comprehensive model framework to predict indoor aerosol concentrations with sources due to outdoor-to-indoor transport, secondary organic aerosol (SOA) formation by oxidative chemical reactions occurring indoors, and direct indoor emission. In this framework, the indoor aerosol is transformed by standard mechanical losses of envelope, surface, or filtration deposition, but also due to volatility and water content states occurring as a function of outdoor and indoor temperature and relative humidity. The model treats the total aerosol as internally and externally mixed ensembles containing these broad aerosol species: sulfate, nitrate, ammonium, chloride, black carbon, and organic aerosol (OA), which has component subgroups based on volatility. These OA components' volatility set distinctions relate to source type, and the model considers: hydrocarbon-like OA (HOA), oxygenated organic aerosol (OOA) that is further separated into semivolatile (OOA-SV) and low-volatile (OOA-LV) components, indoor-generated SOA, etc. Aerosol behavior is modeled with the volatility basis set (VBS) for OA and component-specific factor changes due to temperature gradients for inorganic aerosol, and aerosol mass changes due to water uptake are modeled with Koehler theory. Model predictions and implications will be presented.

4IA.5
Performance of Wearable Ionization Air Cleaners: Ozone Emission and Particle Removal. Shanshan Shi, Shihao Zhu, Eon Lee, Bin Zhao, YIFANG ZHU, *University of California, Los Angeles*

Wearable ionization air cleaners are compact in size and marketed for personal respiratory protection by removing air pollutants from users' breathing zone. In this study, ozone emission and particle removal rates of four wearable ionization air cleaners (namely, AC1 through AC4) were evaluated in a 0.46 m^3 stainless steel chamber with a typical indoor air exchange rate of 0.5 h^{-1}. Ozone emission rates of the wearable ionization air cleaners were determined from continuous measurements of ozone concentration inside the chamber. Particle size distribution within measured size range (18.1-289 nm) and mass concentration of $PM_{2.5}$ were also measured to estimate the particle removal rates. This study found two of the four wearable air cleaners (i.e., AC1 and AC2) had notable ozone emissions. The ten-hour average ozone emission rates were substantially different (i.e., 0.67 and 0.03 mg/h) between AC1 and AC2; however, the ozone emission was not detected from the other two tested devices (i.e., AC3 and AC4). The averaged particle number removal rates were highly variable (i.e., 2.39, -0.07, 5.66, and 16.3 h^{-1} for AC1 through AC4, respectively). The corresponding $PM_{2.5}$ mass removal rates of AC1 through AC4 were 1.85, 0.48, 1.52, and 5.37 mg/h, respectively. These findings can assist the public for informed decision-making when using wearable air cleaners.

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4IA.6
Effects of Environmental Factors on Chemically-Specific Indoor-Outdoor Ratios. ANITA JOHNSON, Michael Waring, Peter DeCarlo, *Drexel University*

Aerosols transported to the indoor environment from outdoors undergo changes to physical and chemical properties, dependent on the original aerosol composition and conditions in each environment. Volatilization or condensation of aerosol components, including water, can have a significant impact on the concentration and composition of indoor aerosol of outdoor-origin. Differences in temperature and relative humidity (RH) are a result of occupant activity or operation of an HVAC system for comfort. This study measured real-time aerosol composition and size distribution of both indoor and outdoor air using an Aerodyne aerosol mass spectrometer (AMS), Magee Scientific aethalometer (AE-33), and a Brechtel scanning electrical mobility system (SEMS). Measurements were made in Philadelphia, PA in April 2013 and August 2014. Differing seasons for the studies allowed the investigation of aerosol composition with different gradients in temperature and RH. Distinct changes in indoor-outdoor (I/O) ratio were observed for the chemical species measured and factors determined by positive matrix factorization (PMF). PMF components included hydrocarbon-like organic aerosol (OA), oxygenated OA, and cooking OA. The water content of aerosols was estimated using Koehler Theory and the measured RH in each environment. The resulting differences in I/O ratio were then quantified as a function of temperature and RH gradients between indoors and outdoors. After accounting for mechanical losses using non-volatile aerosol sulfate, volatilization or condensation of aerosol of semi-volatile aerosol components were quantified as a function of the temperature gradient. During conditions when temperature was higher indoors and RH was higher outdoors, the losses of several aerosol species was observed. When the temperature indoors was lower and RH similar or lower, increases in several aerosol species (e.g. nitrate) was observed. These and other results will be presented.

4IA.7
Experimental Study of Active Flow and Photocatalytic Materials for Indoor Air Quality Applications. Denise Mauney, Christella Suwongso, Wil Srubar, LUPITA MONTOYA, *University of Colorado, Boulder*

The effect of airflows generated from an annular, multi-orifice synthetic jet actuator (SJA) on the degradation of nitrogen dioxide was studied in an experimental chamber. A mortar substrate (reactor) coated with titanium dioxide was used to remove nitrogen dioxide in the chamber. An axial computer fan (ACF) was also studied in the same manner to compare the impact of flow regimes and surface velocity on the removal rate at a distance of 10mm from the reactor. Results indicated that the optimum distance between the annular, multi-orifice synthetic jet and the surface of the titanium dioxide reactor was approximately 315mm, and a surface velocity of approximately 0.1 m/s. The ACF removal rate was found to be equivalent to the SJA removal rate when the surface velocities were not equal, but the flow regimes had the same apparent shape. Therefore, in this initial study, nitrogen dioxide removal rate by titanium dioxide was found to be driven by both surface velocity and quality of flow regime.

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4IM.1
Evaluation of a Low Flow Particle Concentrator for Atmospheric Aerosols. LEAH WILLIAMS, Philip Croteau, John Jayne, Thorsten Hohaus, Douglas Worsnop, Susanne Hering, Gregory Lewis, *Aerodyne Research, Inc.*

We present the evaluation of a low flow particle concentrator developed by Aerosol Dynamics for use with the Aerodyne aerosol mass spectrometer (AMS) and aerosol chemical speciation monitor (ACSM). These instruments sample at a flow rate of less than 0.1 lpm. The low flow concentrator uses a single, continuous-wick growth tube with three temperature stages and has a low output temperature and dew point. A focusing nozzle separates the concentrated aerosol particles from the excess flow and results in a concentration factor of 8 to 10. We characterized the concentrator in laboratory experiments with particles of known concentration and size. We also evaluated the concentrator for ambient measurements by sampling for three weeks with two AMS instruments, one behind the concentrator and one on a bypass line. The concentrator provided a stable concentration factor over this time period and required no maintenance. We observed no significant changes in the particle chemical composition or size distribution after concentrating. The low flow concentrator will provide a valuable enhancement for AMS and ACSM measurements in environments with very low ambient mass loadings.

4IM.2
Enhanced Concentration and Charging of Ultrafine Particles. NATHAN KREISBERG, Steven Spielman, Gregory Lewis, Susanne Hering, Michael J. Lawler, James N. Smith, Peter H. McMurry, *Aerosol Dynamics Inc.*

This work aims to improve the electrical charging, and hence the efficiency of the mobility size selection and particle collection process. Even with a unipolar charger, the fraction of sub-10nm particles that carry an electrical charge is small (a few percent), and decreases rapidly with decreasing particle diameter. Our approach is a condensationally-enhanced charging and evaporation method for increased efficiency of particle charging. In contrast to other condensation approaches, our method greatly reduces the time for the entire condensation-charging-evaporation process to a few tens of milliseconds, thereby minimizing the opportunity for chemical artifacts.

Our system consists of a bipolar ion source coupled to a parallel plate growth tube equipped with an ion scavenger and concentrator. It samples at 15 L/min and outputs 1.5L/min of concentrated, charge-enhanced aerosol. Nanometer sized particles are enlarged through condensation to form droplets that acquire electrical charge more efficiently. Once activated, a small electric field reduces multiple charging. A cool-walled moderator section removes excess water vapor to reduce the exiting dew point to around 14°C. Finally, droplets are concentrated by an array of aerodynamic focusing nozzles. Constructed only of stainless steel and PTFE, the system allows for aggressive cleaning options where build-up of organic compounds must be controlled. Heat and moisture are delivered by filtered, recirculating water to minimize the accumulation of water soluble compounds on the wetted surfaces.

We have demonstrated 10-fold concentration enhancements of particles as small as 10 nm, and a 30-50 fold enrichment in the charged fraction, as compared to bipolar charging. Size recovery is within 10% of the original mobility size when sampling ammonium sulfate aerosol. The potential for chemical artifacts is being investigated with a TD-CIMS (thermal desorption chemical ionization mass spectrometer). Measurements to date show little uptake of organic species from the vapor phase with this system.

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4IM.3
Aerosol Microconcentration for Aerosol Measurement Using Optical Spectroscopies. LINA ZHENG, Pramod Kulkarni, Huayan Liang, Konstantinos Zavvos, G.J. Deye, M. Eileen Birch, Dionysios Dionysiou, *Centers for Disease Control and Prevention, NIOSH*

Efficient microconcentration of aerosols to a substrate is essential for effective coupling of the collected particles to microscale optical spectroscopies such as laser-induced or spark microplasma and Raman spectroscopy. The spatial extent of the microplasma or the laser beam is on order of few hundred micrometers, requiring efficient microconcentration of aerosols to allow sensitive detection of analytes. Further, for effective microconcentration in a portable instrument, the following key operating requirements are important: i) the efficiency of collection must be independent of particle size, ii) the pressure drop must be low, and iii) the entire collected particulate mass must be available to the laser or microplasma to achieve high signal-to-noise ratio and analytical sensitivity. We present design, characterization, and optimization of an electrostatic aerosol concentration method for portable analytical instrumentation. The method involves a set of coaxial electrodes separated by few millimeters, one held at high potential and the other grounded. The particles are collected on the ground electrode from a coaxial flow in a one-step charge-and-collect scheme using corona on the high voltage electrode. Collection characteristics of this system were investigated as a function of operating parameters such as flow rate, corona current, particle size, and electrode diameter. Atomic emission signal from spark microplasma was used as a metric representing analytical signal-to-noise ratio. Electrohydrodynamic simulations were conducted to obtain insights into particle transport and deposition. Scanning electron microscopy was used to probe distribution of collected particles on the electrode. We show that optimum combination of flow rate and electrode diameter exists that provides highest analytical sensitivity that is independent of particle size in the submicrometer size range. We also show that the electrostatic microconcentration used in this work provides highest sensitivity compared to similar collection using aerodynamic lens or filters, especially with respect to the pressure drop incurred in respective system.

4IM.4
Performance Comparison of Aerosol Corona-based Mini-chargers for Miniature Ultrafine Particle Sizers. DI LIU, Qiaoling Liu, Da-Ren Chen, *Virginia Commonwealth University*

The concern of adverse heath effect resulted from ultrafine particles has led to the development of portable/miniature particle sizers for tempo-spatial measurements of ultrafine particles. Electrical-mobility-based technique has been applied in aerosol community to characterize the size distribution of ultrafine particles. Particles are required to be electrically charged to a known charge distribution in order to run the sizers and to retrieve the particle size distribution from measured raw data. Aerosol chargers are thus one of key components in electrical mobility based sizers. In our group we had previously developed the nanoparticle charger (in the cylindrical configuration) for miniature particle sizers (Qi et al 2008). It is a corona-discharge-based charger in which the discharge occurs at the tip of corona needle. The charge distribution of particles with the sizes less than 60 nm for Qi's charger has been reported in the publication. The charge distribution data for particles with the sizes larger than 60 nm are however not given.

More recently, a mini-plate aerosol charger has further been developed for mini-sizers. Different from the Qi's charger, the plate design is implemented and the wire is used for corona discharge in the mini-plate charger. More, no ion-driving voltage is applied in the mini-plate charger. In this study we performed the experiments to compare the performance of two mini- aerosol chargers, especially on the charge distribution of particles with the sizes larger than 50 nm. The comparison allows us to identify the suitable aerosol charger for mini-EAA and Mini-EAA applications. The detail design of both aerosol chargers and the comparison result will be presented in this talk.

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4IM.5
Bipolar Diffusion Charging Efficiencies of Particles Ranging from 100 to 900nm. HUADONG YANG, Meilu He, Suresh Dhaniyala, *Clarkson University*

Bipolar diffusion charging is commonly used with electrical mobility techniques for particle size distribution measurements. For accurate particle size distribution calculation, the charge distribution acquired by particles sent through these chargers must be known. While theoretical charge distributions for bipolar charging are well established, recent studies have shown that the charge distributions of particles smaller than 50 nm are a strong function of particle size, charger type and charger operating conditions. In this study, we experimentally examine the aerosol charge efficiencies of particles ranging from 100 to 900 nm. The charge distributions are determined using mobility classified particles sized by a downstream Ultra-High Sensitive Aerosol Spectrometer (UHSAS). This study only focuses on singly charged, doubly charged and uncharged Ammonium Sulfate particles. The influence of charger type, particle concentration, and aerosol flow rate on particle charging efficiency is studied. In measuring the charge fractions, particular care is taken to ensure accurate consideration of UHSAS counting efficiencies and DMA transfer functions. We will present a comparison of the obtained charge distribution results against those reported by other studies and that predicted by theory.

4IM.6
Optical Trap for Both Transparent and Absorbing Particles in Air Using a Single Shaped Laser Beam for Measuring Raman Spectra. YONG-LE PAN, Brandon Redding, Chuji Wang, Steven Hill, Joshua Santarpia, *US Army Research Lab*

There is a need for improved real-time on-line instruments for studying and monitoring aerosols, especially bio- and chemical threats. Although spectra-based technology (mass, fluorescence, laser-induced-breakdown) have been developed, Raman spectra can provide more information for better discrimination but its emission is very weak. Collecting an adequate Raman spectrum from a single micron-sized particle requires measurement times of at least seconds. Trapping the particle in a very small region then is highly desired.

Existing optical traps are designed for either absorbing or transparent particles, primarily relying on either photophoretic or radiative pressure force, respectively. Absorbing particles are trapped in the low intensity region, while transparent particles are trapped near the highest intensity spot. To our knowledge, a single optical trap capable of capturing particles of either types has not been demonstrated. However, many applications require the ability to trap particles regardless of their morphology and absorptivity. In addition, high numerical aperture (NA) optics (typically >0.9) are required to produce a strong enough gradient force to trap transparent airborne particles (e.g. laser tweezers), which complicates system integration.

We present a technique that enables trapping both absorbing and transparent particles in air using a single shaped laser beam. The optical geometry produces a low-light-intensity region for photophoretic trapping of absorbing particles while simultaneously reducing the scattering force near the focal spot to enabling radiative pressure trapping of transparent particles using relatively low NA optics (~0.55 for a particle with a refractive index of 1.5). Experiments demonstrated trapping of both absorbing and transparent particles with either spherical or spatially irregular morphologies. Raman spectra from a variety of trapped bioaerosol particles were also measured.

This general purpose optical trapping scheme could improve the versatility of laser trapping systems designed for airborne particles, and enable extensive on-line characterization of aerosols when coupled with particle interrogation techniques. This research was supported by the Defense Threat Reduction Agency (DTRA) and ARL mission funds.

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4IM.7
The Use of Pneumatic Nebulization to Enable Aerosol Based Measurements of 5-50 nm Particles in Liquid Suspensions. SEONGHO JEON, Gary Van Schooneveld, Derek Oberreit, Christopher Hogan Jr., *University of Minnesota*

Size distribution measurement is not only important in aerosol science, but is also critical for nanomaterials synthesized or dispersed in liquids. Unfortunately, existing liquid phase analytical techniques (namely, photon correlation spectroscopy) are problematic to apply to multimodal distributions of particles and additionally, do not readily yield nanoparticle number concentrations. Conversely, for aerosol particles, scanning mobility particle spectrometers (SMPSs) can facilitate the measurement of multimodal distributions and with proper size distribution inversion, they enable better estimate of nanoparticle concentrations. While electrosprays have been used previously to aerosolize nanomaterials, enabling SMPS measurements, the suspension conductivity and chemical composition requirements for electrosprays are extremely restrictive, and are hence not appropriate for a number of nanomaterials (i.e. those suspended in high non-volatile salt concentration environments). In this work, we apply a newly developed pneumatic nebulization system with online high-purity water dilution to aerosolize nanomaterials with diameters as small as 5 nm, and show that with this technique it is possible to make SMPS measurements of a variety of nanoparticles. Results are specifically shown for gold and silver particles and particle mixtures, proteins, particles in phosphate buffered saline, and gold nanorods. In all situations, minimal solution preparation is needed. Importantly we show that with fixed nebulization conditions, SMPS inferred size distribution functions can be used to yield a size, material, and suspension composition independent calibration curve to directly determine concentrations (with a dynamic range of five orders of magnitidue) in the liquid phase. Overall, this work demonstrates the potential of aerosol technology for quantitative measurements of nanomaterial suspensions.

4UA.1
Health and Air Quality Benefits of Reduced Primary Ultrafine Particulate Matter Associated with the No-Burn Day Rule in the San Joaquin Valley, California. Jianlin Hu, MICHAEL KLEEMAN, David Lighthall, *University of California, Davis*

The San Joaquin Valley (SJV) in California has the most severe PM2.5 pollution in the US during the winter season due to its unique topography and strong stagnant meteorology that traps the emissions inside the shallow surface layer. Previous studies have identified that residential wood combustion contributed a large fraction of PM2.5 in the SJV. Starting from 2003 November, the no-burn day rule has been implemented to mitigate wintertime PM2.5 pollution in the SJV. Studies showed that this rule has improved the air quality in the SJV by reducing PM2.5.

Residential wood combustion also emits large amount of ultrafine particles (UFP). Toxicology studies indicate that UFP may be more harmful to public health than PM2.5. The purpose of this study is to investigate the benefits of the no-burn day rule on the primary UFP ambient concentrations and consequently on the public health in the SJV during 2006-2010. The source oriented UCD_P model was used to predict the UFP concentrations with a horizontal grid resolution of 4 km. The predicted UFP concentrations are in good agreement with measured concentrations. The predicted UFP source contributions were also compared to source apportionment results estimated from the receptor-oriented Chemical Mass Balance (CMB) model. The relative source contributions predicted by the two methods are in general agreement in most of the episodes considering the uncertainties in measurements, even though the UCD_P model predicts higher wood combustion UFP concentration. UCD_P calculations suggest that the average UFP concentration was reduced by 43% on the no-burn days in the SJV. County-specific population weighted concentrations of UFP are calculated and used to estimate the health benefit of the no-burn rule in the SJV based on established exposure-health relationships.

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4UA.2
Impact of Global Climate Change on Ozone, Particulate, and Secondary Organic Aerosol Concentrations in California: a Model Perturbation Analysis. JEREMY HORNE, Donald Dabdub, *University of California, Irvine*

Air quality simulations are performed to determine the impact of changes in future climate and emissions on regional air quality in the South Coast Air Basin of California (SoCAB). The perturbation parameters considered in this study include (1) increased temperatures, (2) increased absolute humidity, (3) increased biogenic VOC emissions due to increased temperatures, and (4) increased pollutant concentrations at the western inflow boundary. All parameters are first perturbed individually. In addition, the impact of simultaneously perturbing more than one parameter is analyzed. Air quality is simulated over a three-day period with meteorology representative of a summertime ozone pollution episode using both a baseline 2005 emissions inventory and a future emissions projection for the year 2023. Different locations within the modeling domain exhibit varying degrees of sensitivity to the perturbations considered. In addition to ozone, particulate matter (PM) and secondary organic aerosol (SOA) concentrations are examined in detail. Afternoon domain wide average ozone concentrations are project to increase by 13-18% as a result of changes in future climate and emissions. Afternoon increases at individual locations range from 10-36%. The change in afternoon PM levels is a strong function of location in the basin, ranging from -7.1% to +4.7% when using 2005 emissions and -8.6% to +1.7% when using 2023 emissions. Afternoon SOA concentrations for the entire domain are projected to decrease by over 15%, and the change in SOA levels is not a strong function of the emissions inventory utilized. Previous studies have shown that temperature is the most important meteorological variable determining the overall impact of future climate change on ozone concentrations. We find that temperature increases also play the dominant role in determining the overall impact on PM and SOA concentrations in both the individual and combined perturbation scenarios.

4UA.3
Air Quality Co-Benefits of Climate Mitigation Strategies in California. CHRISTINA ZAPATA, Hongliang Zhang, Sonia Yeh, Christopher Yang, Michael Kleeman, *University of California, Davis*

California has set the goal to reduce greenhouse gas (GHG) emissions to a level 80% below 1990 levels by the year 2050. Meeting this target will require drastic changes in energy production/consumption for basic needs (transportation, goods movement, industry, residential heating/cooling). In addition to releasing significant GHGs, these same sources emit the majority of the criteria pollutant emissions in California. Major changes to energy production/consumption will therefore lead to significant changes in air pollution exposure for California residents across the entire spectrum of socio-economic classes.

In this study we used results from the CA-TIMES economic optimization model to predict future energy portfolios in California in 2050 under a business as usual scenario (BAU) and an optimized Greenhouse Gas mitigation scenario (GHGAi). Criteria pollutant emissions under each scenario were estimated for the entire state and then spatially allocated with 4km resolution. Meteorological patterns in California during the year 2050 were dynamically downscaled from the CESM climate model RCP8.5 scenario using the Weather Research and Forecasting (WRF) model. A 10 year window was chosen for analysis (2046-2055) to ensure results were statistically significant.

Results from the BAU simulation demonstrate that climate change produces conditions that are more conducive to ozone formation in California but climate change by itself has a very small impact on population exposure to airborne particulate matter. Climate mitigation strategies implemented under the GHGAi scenario have significant co-benefits in the reduction of PM2.5 concentrations with associated public health improvement. The detailed changes in exposure patterns to PM2.5, PM0.1, and various PM chemical components will be presented and the overall economic co-benefits of avoided air pollution will be summarized.

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4UA.4
Evaluation of Ozone and PM2.5 Model Performance from the Incorporation of Temporally and Spatially Resolved Real-Time Traffic Profiles. SCOTT A. EPSTEIN, Xinqiu Zhang, Kalam Cheung, Sang-Mi Lee, Joe Cassmassi, *South Coast Air Quality Management District*

The South Coast Air Basin of California is an area of 10,743 square miles with nearly 17 million residents. Topographical barriers to pollutant transport outside of the Basin along with intense photochemistry, emissions from a strong industrial presence, and a transportation infrastructure reliant on fuel combustion lead to significant pollution problems. Portions of the Basin do not attain federal 8-hr ozone and $PM_{2.5}$ standards. For informed science-based policy-making, we employ the Community Multiscale Air Quality Modeling System, the Weather-Research-Forecast, and an emission processing model to simulate air quality in Southern California. In the 2012 emissions inventory, on-road vehicles were responsible for 35% of the total VOC emissions and 60% of the total NOx emissions within the basin. Currently, these emissions are processed with a county-wide time-of-day profile that varies with the day-of-week. We have incorporated comprehensive vehicle flow data from a network of 9,000 traffic monitoring stations and 11 truck weight-in-motion monitoring stations maintained by the California Department of Transportation. This extensive data-set captures changes in emission patterns due to day-specific weather conditions, holidays, and special events. Model predictions from the incorporation of spatially-resolved hourly automobile and truck traffic patterns will be evaluated against real-time ozone and $PM_{2.5}$ composition measurements from a comprehensive network of 38 monitoring stations.

4UA.5
Linking High Time Resolution Particle Size Distribution Measurements to Real-world Emission Factors: Variability in Pollutant Emissions Relating to Particle Characteristics. JON M WANG, Naomi Zimmerman, Cheol-Heon Jeong, Robert Healy, Nathan Hilker, Greg J. Evans, *SOCAAR, University of Toronto*

On-road motor vehicles are one of the largest sources of air pollutants in urban environments. Regulatory test protocols have included particle number concentration emissions from vehicles, however the protocols typically include thermodilution to remove volatile particles in vehicle exhaust. Although this facilitates reproducibility and repeatability of the method, it excludes particles smaller than 23 nm and the volatile fraction that may otherwise exist in real-world urban exposure environments.

Five month-long campaigns in 2013-2015 were conducted at a near-road field sampling site located 15 m from a major roadway in downtown Toronto, Canada. A Fast Mobility Particle Sizer and photoacoustic soot spectrometer were utilized for high time resolution measurements of particle size distribution, and particle absorption and scattering, respectively, in addition to typical pollutant measurements (i.e., CO, NOx, CO2, BTEX, particle-bound PAH). These pollutant emission factors (EFs), which were measured on an individual plume basis were categorized depending on the mean mode diameter of each plume so as to classify different emission types. Coincident total particle number concentration measurements were made before and after a thermodenuder operating at 250 °C as a simple method to test for particle loss due to the removal of the volatile particle fraction.

Results show five general categories based on size distribution of plumes, with substantial differences in BC, NOx, and BTEX EFs influenced by different vehicle types. It was found that for the majority of plumes only a small fraction of the particles make it through the thermodenuder. Plumes where few to no particles made it through the thermodenuder had higher particle scattering coefficients on average, inferring the presence of non-refractory material. On average, the use of a thermodenuder resulted in a 90% lower particle number EF vs. when including the volatile fraction.

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4UA.6

Effects of After-Treatment Control Technologies on Heavy-Duty Diesel Truck Emissions. CHELSEA PREBLE, Timothy Dallmann, Nathan Kreisberg, Susanne Hering, Robert Harley, Thomas Kirchstetter, *University of California, Berkeley*

Diesel engines are the largest source of nitrogen oxides (NO_x) emissions nationally and a major contributor to the black carbon (BC) fraction of fine particulate matter (PM). Recently, diesel particle filter (DPF) and selective catalytic reduction (SCR) emission control systems that target exhaust PM and NO_x have become standard equipment on new heavy-duty diesel trucks. There is concern that DPFs may promote the formation of ultrafine particles (UFP) and increase total particle number emissions while reducing PM mass emissions. Also, the deliberate catalytic oxidation of engine-out nitric oxide (NO) to nitrogen dioxide (NO_2) in continuously regenerating DPFs may lead to increased tailpipe emission of NO_2 and near-roadway concentrations that exceed the new 1-hour national ambient air quality standards. Increased NO_2 emissions can also promote formation of ozone and secondary PM.

We report results from ongoing on-road studies of heavy-duty diesel truck emissions at the Port of Oakland and the Caldecott Tunnel in California's San Francisco Bay Area. Emission factors (g pollutant per kg of diesel) were linked via recorded license plates to individual truck attributes, including engine model year and installed after-treatment controls. At the Port of Oakland, average NO_x, BC, and UFP emission factors from new trucks equipped with both DPF and SCR emission controls were 69 ± 15%, 92 ± 32%, and 66 ± 35% lower, respectively, than modern trucks without these emission control devices. DPF use significantly increased the NO_2/NO_x emission ratio. DPFs also significantly increased NO_2 emissions when installed as retrofits on older trucks with higher baseline NO_x emissions. SCR systems effectively reduce total NO_x emissions and mitigate these undesirable DPF-related NO_2 emissions, but such systems can lead to the emission of N_2O, a potent greenhouse gas.

4UA.7

Spatiotemporal Comparison of Highly-Resolved Emissions and Concentrations of Carbon Dioxide and Criteria Pollutants in Salt Lake City, Utah. DANIEL MENDOZA, John Lin, Logan Mitchell, James Ehleringer, *University of Utah*

This study addresses the need for robust highly-resolved emissions and concentration data required for planning purposes and policy development aimed at managing pollutant sources. We show a reproducible approach to estimating human exposures with a systematic quantification of uncertainties. We present emissions inventories and modeled concentrations for carbon dioxide (CO2) and criteria pollutants: carbon monoxide (CO), lead (Pb), nitrogen oxides (NOx), particulate matter (PM2.5 and PM10), and sulfur oxides (SOx) for Salt Lake County, Utah. We compare the resulting concentrations against stationary and mobile measurement data.

The emissions inventory for CO2 is based on the Hestia emissions data inventory which resolves emissions at an hourly, building and road link resolution and also includes hourly gridded emissions at a 0.002o x 0.002o spatial resolution. Two methods were used to derive emissions inventory for the criteria pollutants. One was constructed using methods similar to Hestia but bases total emissions on the 2011 National Emissions Inventory (NEI). The other used Emission Modeling Clearinghouse spatial and temporal surrogates to downscale the NEI data from annual and county-level resolution to hourly and 0.002o x 0.002o. The gridded emissions from both criteria pollutant methods were compared against the Hestia CO2 gridded data to characterize spatial similarities and differences between them. Correlations were calculated at multiple scales of gridded emissions aggregation.

The CALPUFF puff dispersion models was used to transport emissions and estimate air pollutant concentrations at an hourly 0.002o x 0.002o resolution. The resulting concentrations were spatially compared in the same manner as the emissions. Modeled results were compared against stationary measurements and from equipment mounted atop a light rail car in the Salt Lake City area. The comparison between both approaches to emissions estimation and resulting concentrations highlights spatial locations and hours of high variability and uncertainty.

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5AC.1

Phase Equilibration Timescales of Engine Exhaust SOA Generated in a Photo-oxidation Reactor. Mariam Fawaz, Mohamad Baassiri, Nareg Karaoghlanian, ALAN SHIHADEH, *American University of Beirut*

Secondary organic aerosols (SOA) constitute a major fraction of particle pollutants in the atmosphere, and they exert important influences on human health and global climate. When predicting atmospheric SOA concentrations, regional air quality models commonly assume that gas-particle partitioning is rapid relative to atmospheric timescales, and that semi-volatile species therefore follow thermodynamic equilibrium partitioning between the condensed and vapor phases. Based on recent evidence from single-particle studies that SOA particles exist in a glassy, amorphous state for which mass transfer is intrinsically slow compared to atmospheric time scales, the assumption that SOA is well-described by equilibrium thermodynamics has been called into question. In this work, we studied the evaporation kinetics of SOA when an ensemble of nanoparticles was perturbed from an initial equilibrium state via isothermal dilution in a 20˚C and 12-15% RH Teflon chamber. Changes in particle size were observed as the SOA system was allowed to return to phase equilibrium by evaporation. SOA was generated in a well stirred photo-oxidation reactor using diluted engine exhaust (5000:1) from a single-cylinder gasoline engine, and then injected into the Teflon chamber. Initial SOA mass loading in the chamber was 10 micrograms/m^3, and initial condensation sink diameter was approximately 100 nm. In repeated measurements, it was found that SOA particles approached equilibrium with a characteristic e-folding time of 11-14 min. Wall-corrected particle size versus time was well-fit by a theoretical model of particle evaporation treating the aerosol as a single lumped species, where the effective evaporation coefficient ranged from 0.05 to 0.1 depending on the assumed ranges of molecular mass and effective binary diffusion coefficient. These results support the notion that mass transfer in fresh engine exhaust derived SOA is not greatly inhibited by intra-particle diffusion, and that its atmospheric phase partitioning behavior can be treated using thermodynamic equilibrium.

5AC.2

Laboratory Study of Secondary Organic Aerosol Mixing at Low and High Relative Humidity: Implication for Moisture-induced Phase Change. QING YE, Ellis Shipley Robinson, Ryan Sullivan, Neil Donahue, *Carnegie Mellon University*

Whether secondary organic aerosol (SOA) from different sources can mix into a single phase via vapor uptake within atmospherically relevant timescales is a key question towards understanding how various sources of SOA combine to form air pollution. This mixing process is determined by the thermodynamic properties of SOA, e.g. volatility and activity coefficients of organics in mixtures, as well as kinetic properties, e.g. high viscosity that might hinder diffusion of guest vapors into the particles. This study aims to probe any moisture-induced phase change of SOA and how it affects this mixing process. Laboratory generated alpha-pinene-derived SOA and toluene-derived SOA are used as proxies for biogenic and anthropogenic SOA. A High resolution time-of-flight aerosol mass spectrometer coupled with a light-scattering module that is able to perform single particle measurement is used in this study to probe mixing behavior on a single-particle level. Our results show that under dry conditions, alpha-pinene-derived SOA can uptake vapor from d8-toluene-derived SOA, but alpha-pinene oxidation products do not show up in particles of pure d8-toluene derived SOA. In addition, toluene-derived SOA and d8-toluene-derived SOA do not exchange vapors when it is dry, even though toluene derived vapors do appear in alpha-pinene derived particles. These results demonstrate that alpha-pinene-derived SOA and toluene-derived SOA are thermodynamically miscible and that the toluene SOA system has sufficient volatility to drive mixing, but the toluene-derived SOA exists in a glassy state that impedes mixing. However, at elevated RH, the presence of mass from the guest vapors in toluene-derived SOA indicates the disappearance of diffusion limitation in the particle, suggesting a phase change from a glassy state to a softer, liquid state in the condensed phase. Our finding is crucial for improving description of SOA's formation, and hence its impact on health and climate.

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5AC.3
Rethinking Secondary Organic Aerosol Formation from Aromatic Hydrocarbons: Role of NOx, ·OH and Substitute.
LIJIE LI, Ping Tang, Chia-Li Chen, Shunsuke Nakao, Li Qi, David R. Cocker III, *University of California, Riverside*

Aromatic hydrocarbons account for 20%-30% of the VOC in the urban atmosphere and are major contributors to anthropogenic SOA. Yet, prediction of SOA from aromatic hydrocarbons as a function of structure, NO_x and OH radical level remains elusive. This study generalizes the relationship between aromatic alkyl groups (number and location on aromatic ring) and SOA formation from aromatic hydrocarbon under both low NO_x and H_2O_2 only conditions based on hundreds of chamber experiments from 18 different aromatic precursors. First, the relationship of SOA yields with the number of alkyl group is quantified and presented in a novel manner. Second, the concept of low and high yield of aromatics is revisited and modified accordingly. Third, SOA chemical compositions among these aromatics are unified by analyzing elemental ratio measured by ToF-HR-AMS. Finally, ^{13}C isotope enriched aromatics are used to confirm the contribution of alkyl group to SOA formation. Three mass spectrometers including ToF-HR-AMS, PTR-MS (Proton Transfer Reaction – Mass Spectrometry) and SIFT (Selected-ion flow-tube mass spectrometry) are used to study alkyl group impacts on SOA formation and composition during photooxidation. Finally, a general mechanism of SOA formation from aromatic hydrocarbon is proposed.

5AC.4
Formation and Growth of Secondary Organic Aerosol Particles from the Ozonolysis of α-cedrene: Contributions from High Molecular Weight Products.
YUE ZHAO, Lisa M. Wingen, Veronique Perraud, Barbara J. Finlayson-Pitts, *University of California, Irvine*

Sesquiterpenes are an important class of biogenic volatile organic compounds (BVOCs) and have a high secondary organic aerosol (SOA) forming potential. However, SOA formation from the oxidation of sesuqiterpenes has received less attention compared to other BVOCs such as monoterpenes and the underlying mechanisms remain poorly understood. Recent work has shown that high molecular weight oligomeric compounds contribute a significant fraction of SOA mass from the oxidation of BVOCs, but to date no such data are available for the oxidation of sesquiterpenes. In this work, we present a detailed experimental investigation of ozonolysis of α-cedrene, with an emphasis on the formation mechanisms of oligomers and their role in initial formation and subsequent growth of SOA particles. The ozonolysis experiments were conducted both in a glass flow reactor (30-35 s reaction times) and in a static Teflon chamber (30-60 min reaction times) in the absence and presence of OH or stabilized Criegee intermediates (SCI) scavengers and at different relative humidities. The chemical composition of SOA particles is characterized as a function of size using different mass spectrometric techniques and infrared spectroscopy. The possible structures and formation mechanisms of selected oligomers are elucidated in light of their fragmentation mass spectra, size-dependent SOA composition, and the effects of water vapor, OH and SCI scavengers. In addition, the identity and formation mechanism of some newly observed monomeric oxidation products, as well as the phase state of SOA particles are examined. Insights into the particle formation and growth mechanisms compared to SOA formation from smaller alkenes are presented.

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5AC.5
SOA Formation from Photooxidation of Naphthalene and Methylnaphthalenes with m-Xylene and Surrogate Mixtures. Chia-Li Chen, Lijie Li, DAVID R. COCKER III, *University of California, Riverside*

SOA from photooxidation of individual PAHs such as naphthalene, 1-methylnaphthalene, 2-methylnaphthalene and mixed with m-xylene or an atmospheric surrogate mixture under low NO_x condition and extremely low NO_x (H_2O_2) was explored in the UCR CE-CERT environmental chamber. Different mixing ratios between PAHs and m-xylene (PAHs (ppb): m-xylene (ppb) = 1.5:1 ~1:1:4) indicate that the addition of m-xylene to PAH photooxidation experiments suppressed SOA formation from the PAH precursor. The SOA growth rate relationship of aerosol mass concentration (ΔM_0) versus hydrocarbon reacted (ΔHC) from different PAHs-m-xylene mixture is correlated with initial m-xylene/NO, PAHs/NO, $[OH]/[HO_2]$ ratio, $[NO]/[HO_2]$ ratio and $[HO_2]/[RO_2]$ ratio. It is observed that higher m-xylene/PAHs ratios and higher initial m-xylene/NO ratios lead to less net SOA formation. The chemical composition characteristics such as f44 versus f43, H/C ratio, O/C ratio, and the oxidation state of the carbon (OS_c) showed that PAHs-m-xylene SOA continuously ages and the SOA exhibits characteristics of both individual precursors. The atmospheric surrogate mixture chosen for the surrogate/PAH mixtures was based on the surrogate used to develop the Carter O_3 reactivity scales. Our results showed that the surrogate mixture photooxidation also suppressed SOA formation from PAHs by influencing gas-phase chemical reactivity.

5AC.6
Secondary Organic Aerosol from Chlorine-Radical Initiated Oxidation of Volatile Organic Compounds: Organic Aerosol Mass Yields, Composition, and Gas-Phase Products. Dongyu Wang, Surya Dhulipala, LEA HILDEBRANDT RUIZ, *University of Texas at Austin*

Ambient measurements have detected atmospheric reactive chlorine concentrations much higher than predicted by state-of-the-art air quality models, suggesting that chlorine radicals, which form from photolysis of reactive chlorine species, are more important to atmospheric chemistry than previously assumed. Chlorine radicals can initiate the oxidation of volatile organic compounds (VOCs), leading to the formation of secondary organic aerosol (SOA). Formation of SOA from chlorine-radical initiated oxidation of VOCs is currently not included in air quality models and could present a missing source of SOA.

Laboratory chamber experiments were conducted on the formation of SOA from chlorine-radical initiated oxidation of VOCs. A High-Resolution Time-of-Flight Chemical Ionization Mass Spectrometer (HR-ToF-CIMS) was used to quantify the VOCs and detect oxidation products. An Aerosol Chemical Speciation Monitor (ACSM) was used in conjunction with a Scanning Electrical Mobility System (SEMS) to quantify organic aerosol concentrations. Major gas-phase products identified in the isoprene system included methyl vinyl ketone, chloro methyl vinyl ketone, methacrolin, 1-chloro-3-methyl-3-butene-2-one (CMBO), 2-methylene-3-butenal, and 3-methylfuran; products detected in the toluene system included benzaldehyde and benzyl alcohol in addition to ring opened di-carbonyls. Toluene SOA formed in these experiments was much more oxidized than toluene SOA formed in previous studies using hydroxyl radical (OH) as oxidant. Aerosol mass yields from the oxidation of isoprene and toluene were comparable to yields from OH - initiated oxidation of these VOCs, suggesting that chlorine-radical initiated oxidation can significantly alter atmospheric chemistry and should be considered in air-quality modeling efforts.

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5AC.7
Secondary Organic Aerosol Formation from the Photochemical Oxidation of Fuels: Quantifying the Impact of Fuel Composition and Environmental Variables. TERRY LATHEM, *Phillips 66*

Increasingly stringent environmental regulations on particulate matter are requiring a more advanced understanding of the emission, formation, and evolution of atmospheric particles. The emission of particulate matter is complex and dynamic, with emissions arising from both primary and secondary sources. Advanced knowledge on these particle sources and particle formation pathways is critical for cost-effective regulatory compliance. This presentation will introduce the current challenges and uncertainties in quantifying and measuring secondary particulate matter from fuel sources and will present development of indoor and outdoor environmental chambers for improved understanding of secondary particle formation. Secondary organic aerosol (SOA) formation resulting from the atmospheric photo-oxidation of different gasoline and gasoline/ethanol blends will be presented, including fuels of varying aromatic content (30 - 50 weight percent) and varying ethanol blends (E10, E15, E85). The influence of environmental variables on the SOA formation will be discussed by comparing indoor and outdoor environmental chamber experiments, including a comparison of yields at outdoor temperatures ranging from -10 to +40 degrees Celsius. It will be shown that fuel composition and environmental variables (temperature and solar radiation) can have significant influences on SOA formation potential.

5AP.1
Heterogeneous Nucleation Experiments of n-Butanol Vapor at Varying Nucleation Temperature. PAUL M. WINKLER, Robert McGraw, Paul E. Wagner, *Universitaet Wien, Vienna, Austria*

Recent experiments on the temperature dependence of heterogeneous nucleation have yielded quite unexpected results. While the nucleation of water vapor on silver (Ag) particles has shown a theoretically unpredicted maximum in the onset saturation ratio as a function of temperature (Kupc et al. (2013) Aerosol Sci. Technol. 47, i), the nucleation of n-propanol on sodium chloride (NaCl) particles in the temperature range between 262K and 287K has even revealed a reversed trend compared to the Kelvin equation (Schobesberger et al. (2010) Chem. Phys. Chem. 11, 3874). The close chemical similarity of propanol and butanol suggests that such behavior depending on the nucleation temperature may also play a role in the detection efficiency of condensation particle counters (CPC) using butanol as working fluid. In fact, Ankilov et al., Atmos. Res. 62, 209 (2002) and Hermann et al., J Aerosol Sci. 38, 674 (2007) reported significantly lower counting efficiencies for NaCl compared to Ag particles using butanol CPCs.

In this study we report measurements of the heterogeneous nucleation of butanol at variable nucleation temperature. To this end, monodisperse NaCl and Ag particles were passed into an expansion type CPC to measure heterogeneous nucleation at well-defined supersaturations. In parallel we operated a commercial TSI 3776 butanol CPC whose counting efficiency was analyzed with respect to changing condenser and saturator temperature. It is notable that by reducing the nucleation temperature only by 8 K we find counting efficiencies for NaCl particles exceeding those of Ag particles. The heterogeneous nucleation of butanol on NaCl seed particles thus indicates a strong dependence on nucleation temperature. This finding is of immediate relevance for nanoparticle detection in CPCs and raises questions on the fundamental mechanisms leading to this behavior.

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5AP.2
Heterogeneous Nucleation of CO2 on H2O Ice Particles.
SHINOBU TANIMURA, Yensil Park, Barbara Wyslouzil, *The Ohio State University*

Heterogeneous nucleation of CO_2 on H_2O ice particles is thought to provide a possible pathway for the formation of CO_2 clouds in the Martian atmosphere. The same process, when combined with inertial separation, may provide a way to capture CO_2 from flue gas expanding in a supersonic nozzle. In this work we investigated the heterogeneous nucleation of CO_2 on H_2O ice particles in the steady supersonic flows by means of pressure trace measurement and small angle x-ray scattering experiments, and determined the onset conditions for the nucleation of CO_2 on the H_2O ice particles as a function of the particle size. The ice particle radius was about 2 to 5 nm and the temperatures at onset ranged from 120 to 150 K. The experimental results suggest that the nucleation of CO_2 on the H_2O ice particles starts in the supercooled liquid state, and the subsequent condensation proceeds in the solid state in a time scale of a few tens of micro-seconds.

5AP.3
MD Simulation of Surface Tension of Organic Droplets Based on Energy Different Method and Evaporation Correction.
XIAOXIANG WANG, Hang Su, Ulrich Poeschl, Yafang Cheng, *Max Planck Institute for Chemistry*

Organic aerosols are ubiquitous in the atmosphere and exert a highly effect on health and climate. The properties and behaviours of organic aerosol particles are still poorly understood. Surface tension is one of the important properties for a compound that markedly influences the organic aerosol. In this study, we performed molecular dynamics simulation to determine the surface tension of six n-butanol particles with different radius based on the energy different method. surface tension=$(H^{combine}-(H^{droplet}+H^{gas}))/A$, where, H represents the enthalpy of different systems in simulation, i.e., n-butanol droplet, nitrogen gas and the combined whole system, and A is the contact surface area between particles and air. This method has been used in some previous studies involved water solution. However, the evaporation process may result in the irregular fluctuations of the enthalpy. To cope with this problem, we introduce an evaporation correction into former equation. surface tension=$(H^{combine}-(H^{droplet\text{-}vapor}+H^{gas+vapor}))/A$.

Here 'vapor' means the equilibrium number of n-butanol molecules in vapour state. The comparison between values of surface tension with or without evaporation emphasizes the significance of evaporation correction in the calculation.

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5AP.4
Linking Vapor Uptake Coefficients to Shifts in Mobility for Cluster Ions and Nanoparticles. Vivek Rawat, Hui Ouyang, Derek Oberreit, Jikku Thomas, Carlos Larriba-Andaluz, CHRISTOPHER HOGAN JR., *University of Minnesota*

Tandem mobility analysis has been used for several decades to examine the extent of heterogeneous vapor uptake by nanoparticles. Traditionally, results have been quantified in terms of a dimensionless growth factor, i.e. the ratio of the particle mobility diameter at a particular saturation ratio to the mobility diameter under dry (zero saturation) conditions. However, for sub 2.0 nm clusters, the transient binding of a single vapor molecule can shift mobilities by an amount which is detectable with recently developed tandem ion mobility spectrometry-mass spectrometry systems. To better quantify such measurements, rigorous models linking mobility shifts to the binding of individual vapor molecules are required. In this presentation, we discuss the development of such models, in which we account for the change in mobility brought about by both the direct binding of vapor molecules as well as the change in gas composition associated with increasing saturation ratio. We show that it is possible to directly compare experimental measurements to predictions based upon classical nucleation theory as well as adsorption isotherms, and further that direct calculation of mobilities from all-atom models can be incorporated into calculations. Model predictions are compared to ion mobility spectrometry-mass spectrometry measurements of water vapor uptake by iodide salt ions and dimethylammonium bisulfate ions, as well as isopropanol uptake by polypeptide ions.

5AP.5
Interpreting Heterogeneous Nucleation Probability Measurements: Molecule-Level Cluster Properties and Unusual Temperature Dependence. ROBERT MCGRAW, Paul M. Winkler, Paul E. Wagner, *Brookhaven National Laboratory*

In this study we analyze the unusual temperature dependence seen in the heterogeneous nucleation of water vapor on silver (Ag) nano seeds [Kupc et al. (2013), Aerosol Sci. Technol. 47, i]. Molecular-level cluster properties are obtained from the measurements in the following sequence: direct determination of critical nucleus molecular content, from the 1st nucleation theorem; determination of microscopic contact angle, from the Kelvin relation, seed particle size, and critical nucleus molecular content; direct determination of adsorbed cluster energy, from the 2nd nucleation theorem; and model-based determination, using classical heterogeneous nucleation theory, of the temperature derivative of the microscopic contact angle from adsorbed cluster energy.

The fundamental connection between contact angle derivative and cluster energy is shown to provide an important clue as to the origin of unusual temperature dependence, which we describe here in terms of the molecular-level cluster properties. For example, it is shown analytically that increasing microscopic contact angle with temperature is a necessary condition for unusual temperature dependence. Exceedingly good agreement between laboratory measurements and classical heterogeneous nucleation theory (Fletcher theory) was found in studies of the heterogeneous nucleation of tungsten oxide nano-particles in the presence of water vapor [Winkler et al. (2008), Science 319, 1374]. In the present study we extend Fletcher theory to accommodate the analysis of cluster energy, which is needed to make contact with the 2nd nucleation theorem. Consistent agreement between contact angles from the Kelvin relation, which are obtained independently of one another at several different temperatures, and the microscopic contact angle derivative, obtained from the 2nd nucleation theorem and adsorbed cluster energy, provides new and independent evidence of the surprising utility of Fletcher theory in the nano-regime.

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5AP.6
Freezing of Supercooled n-decane Nanodroplets in a Supersonic Nozzle. VIRAJ MODAK, Barbara Wyslouzil, *The Ohio State University*

Crystallization is a common physical process that is encountered in industrial as well as natural settings. In case of systems with free surfaces, whether freezing is initiated in the bulk or on the surface is still a matter of much debate in the scientific community. Intermediate chain n-alkanes ($16 < n < 50$) are known to form an ordered monolayer up to 3 K above the equilibrium melting point (Tm). Our recent experiments have shown that even the short chain n-alkanes n-octane and n-nonane appear to freeze at the surface of supercooled ($T \approx Tm - 30$) nanodroplets within the size range of 6-9 nm. In this work we extend this study to n-decane. Using multiple starting conditions, we try to identify the size and temperature limits under which surface freezing can be observed experimentally. In our experiments, a carrier gas-alkane vapor mixture cools rapidly in a supersonic nozzle, and beyond a critical supersaturation, the alkane vapor condenses forming supercooled nanodroplets. These droplets can freeze if the temperatures are cold enough. We use static pressure measurements to calculate the flow parameters. We characterize the droplets for size, number density and composition using Small Angle X-ray Scattering and Fourier Transformed Infrared (FTIR) Spectroscopy. Finally, we also estimate the surface and the bulk freezing rates for these droplets.

5AP.7
Molecular Dynamics Simulation of Water Vapor Forming Aerosols on Solid Precursor Particles. DONGUK SUH, Kenji Yasuoka, *Keio University*

Molecular dynamics was used to simulate aerosol growth from water vapor. This is an important topic because solid particles in the atmosphere directly influence air quality. Seed particles with various shapes and sizes were inserted into multiple supersaturated water vapor systems. The objective is to find how the shape of particles from gas emissions will affect heterogeneous nucleation. A constant number, volume, temperature ensemble was used. Two different seed configurations (sphere and cube) made of aluminum were investigated. Three different sizes were tested for each shape. The Yasuoka-Matsumoto method was used to calculate how quickly condensation occurs on the particle surface. Previous studies have shown that though the different shapes have similar surface areas, condensation is faster for the cube by several factors. This result is consistent with monatomic vapor systems. The findings show that the heterogeneous nucleation rate changes simply by altering the precursor solid seed shape.

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5BA.1

On-line Fluorescence Detection of Primary Biological Aerosol Particles (PBAP) in an Urban Environment Heavily Impacted by Black Carbon Particles. Stig Hellebust, David O'Connor, JOHN SODEAU, Dominique Baisnee, Roland Sarda-Esteve, Michel Thibaudon, Gavin McMeeking, Ian Crawford, Martin Gallagher, J. Alex Huffman, Virginia E. Foot, Jean-Maxime Roux, Christophe Bossuet, Walfried Lassar, Kyle Pierce, *University College Cork*

A Wideband Integrated Bioaerosol Sensor (WIBS-4) was deployed on the roof of LHVP, Paris, France over two time periods, July 4 to July 13 and July 22 to August 8, during 2014. (BIODETECT2014 campaign). The instrument was co-located with an Aethalometer (AE 33, Magee Scientific) for measuring Black Carbon aerosol mass (BC) and a Hirst-type impaction trap (VPPS 2000, Lanzoni) to provide off-line counting and identification of airborne fungal spores present.

In total, 10,476,537 individual particles were detected and sized. Approximately 12% of these (1,273,356) particles gave rise to fluorescence signals in at least one of the WIBS-4 emission wavebands, 310-400 nm or 420-650 nm, when irradiated with UV light at either 280 nm or 370 nm. The basis of the detection method is that pollen and fungal spores contain biofluorophores, such as tryptophan, NAD(P)H and flavins, that give signals in at least one of these two wavebands. Hence the instrument allows real-time monitoring of airborne PBAPs. However confounding signals from fluorescent chemicals such as Poly Aromatic Hydrocarbons that are present in urban polluted atmospheres from sources such as traffic exhausts and domestic fuel burning need filtering out. The role of Black Carbon particles acting as a source of confounding signals is less well-established because in its pure state the material is non-fluorescent. However in polluted atmospheres there exists the potential for fluorescent chemicals to “piggy-back” on BC.

In the current study the real-time results, as verified by off-line data on the airborne PBAP present, show that it is possible to both identify and remove the confounding contribution of “BC”. This novel achievement was made possible here by applying a signal filtering procedure based on a combination of particle sizing, “shaping” and individual channel fluorescence.

This study is supported by the CBRN-E research program of CEA/DAM and EPA Ireland.

5BA.2

Mobile Sampling of Bioaerosols around Animal Feeding Operations. ELLIS SHIPLEY ROBINSON, Anne Perring, Eilerman Scott, Jeff Peischl, J. Andrew Neuman, Holloway Maxwell, Aikin Kenneth, Joshua P. Schwarz, Ru-Shan Gao, Thomas Ryerson, David Fahey, *CU-CIRES - NOAA ESRL*

Measurements of fluorescent biological aerosol particles (FBAP) were conducted from a mobile sampling platform using a Wideband Integrated Bioaerosol Sensor (WIBS-4A, Droplet Measurement Technologies) around animal feeding operations (AFO) in the Front Range region of central Colorado. Data were collected from the perimeters of 5 AFOs (3 dairies, 1 sheep AFO, and 1 beef AFO) on 24-hour cycles during summer, fall, winter, and spring to assess diurnal and seasonal variations of FBAP. While FBAP represent a non-negligible fraction of background aerosol loadings measured by WIBS-4A in this region (size-range 0.7 to 10 um), significant enhancements in FBAP concentration above the background were present in plumes downwind of a number of AFOs. The spectral signatures and size distributions of FBAP in these AFO plumes were largely consistent with bacterial and fungal spore attribution based on WIBS-4A profiles of biological aerosols measured in controlled laboratory settings. In our analysis we present FBAP concentrations measured down-wind of AFOs and their correlations with gas-phase tracers of agricultural activity (e.g. NH3, CH4). Examining multiple gas and particle-phase tracers of agricultural pollution allows us to quantify pollutant concentrations up- and down-wind of AFOs, but also to probe how these different pollutants may vary spatially within an AFO and/or be affected differently by meteorology. The approach we present here highlights the utility of real-time measurements coupled to a mobile sampling platform as a means to quantify bioaerosol concentrations around AFOs. This technique can be applied both to assess emissions from a number of AFOs on short timescales, and to provide spatial concentration profiles for the perimeters of AFOs.

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5BA.3

Fluorescent Biological Aerosol Particle Concentrations and Size Distributions Measured with the Waveband Integrated Bioaerosol Spectrometer WIBS-4 in Nanjing China. Xiawei Yu, Zhibin Wang, Zhengning Xu, J. Alex Huffman, Christopher Pöhlker, Uwe Kuhn, Aijun Ding, Yafang Cheng, Ulrich Poeschl, Zhouqing Xie, HANG SU, *MPIC*

Biological aerosol particles are a crucial subset of atmospheric particles. They affect the Earth's radiation balance directly by absorbing and scattering solar radiation and serve as cloud condensation nuclei and ice nuclei. In addition, some of them can cause human diseases like asthma and allergy. The abundance of bacteria has been found to be correlated with PM2.5 pollution levels, which might pose health threats to the susceptible population. However, most online aerosols measurements were focusing on non-biological compounds while characterization of biological particles was limited to traditional filter-based methods. In order to have a deeper insight into the ambient biological aerosol in China, WIBS-4 was used for on-line biological particle measurements at a sub-urban sampling site at Nanjing University (32.05°N, 118.79°E) in October and November 2013. A 2×2 excitation (280 nm and 370 nm)-emission (310-400 nm and 420-650 nm) matrix is recorded along with the particle optical size and shape factor. The detected fluorescent particles are considered as fluorescent primary biological aerosol particles. Preliminary results show mean number concentration of total particles was 18 cm^{-3}, higher than in earlier reports. High number concentrations were observed specifically at size modes of 1µm<=Do<=1.75µm and 2µm<=Do<=3µm. Mean number concentrations of the fluorescent particles detected by channels FL1 (fluorescence exited at 280 nm and recorded at 310-400 nm), FL2 (fluorescence exited at 280 nm and recorded at 420-650 nm) and FL3 (fluorescence exited at 370 nm and detected at 420-650 nm) were 0.6 cm^{-3}, 4.2 cm^{-3} and 2.5 cm^{-3}, respectively. Strong diurnal cycles were observed. The number concentration of fluorescence particles increased during night and peaked at early morning (FL1: 0.9 cm^{-3}, FL2: 5.8 cm^{-3}, FL3: 3.6 cm^{-3}), then decreased to a minimum in the middle of the afternoon.

5BA.4

The Effect of the Atlanta Urban Meteorological Variability in the Abundance and Behavior of Bioaerosols: A Fluorescence and Molecular Biology Approach. ARNALDO NEGRON-MARTY, Natasha DeLeon-Rodriguez, Samantha Waters, Luke Ziemba, Bruce Anderson, Michael Bergin, Konstantinos Konstantinidis, Athanasios Nenes, *Georgia Institute of Technology*

The abundance of airborne cells (primary biological aerosols, PBAs) in the atmosphere has been of great interest due to their potential impact on human health and cloud formation. Over the years, the identification and quantification of microorganisms in the atmosphere has been a challenge. Previously, culture-dependent techniques and epifluorescence microscopy (EPM) have been the common methods for such studies, but each of these methods has its own inherent biases. Also, EPM requires long hours of analysis and there does not exist a standard means to distinguish major microbial taxa. As a result, other fluorescence techniques have been applied such as flow cytometry (FCM) and Wideband Integrated Bioaerosol Sensor (WIBS). To consider FCM as a reliable and sensitive technique to count airborne cells, Lange and colleagues (AEM, 1997) compared FCM and EPM. In recent years, several papers applied FCM but have been unsuccessful in separating microbial populations from one another. This work focuses on the development of an effective protocol for the identification and quantification of different types of PBAs by flow cytometry and the routine application of the protocol to study the effects of meteorological variability on the abundance and behavior of PBAs. Samples were collected using a SpinCon II in the urban Atlanta area and analyzed in an ACCURI C6 Flow Cytometer with the addition of SYTO-13 (green fluorescent nucleic acid stain). In parallel, WIBS measurements have been taken during the SpinCon II sampling times for comparison. The protocol is capable of discriminating between fungal spores, bacteria, and pollen, and quantifying microorganism abundance and dynamics over time. Furthermore, the consistency of the FCM protocol has been validated by its comparison with EPM and qPCR analysis on SpinCon II samples. Our results compare WIBS and flow cytometry results to better understand the seasonal variability of airborne microbial populations in the Atlanta area.

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5BA.5

Meteorological Influences on the Size and Concentration of Airborne Pollens. CHATHURIKA RATHANYAKE, Josh Kettler, Thilina Jayarathne, Elizabeth Stone, *University of Iowa*

Bioaerosol (e.g. plant pollens, fungal spores, bacteria, and viruses) are aeroallergens, exacerbating asthma and respiratory conditions. This study focuses on defining the temporal variation, size distribution, and mass contribution of bioaerosols to ambient particulate matter in the Midwestern US. The size of pollens was determined by microscopy and chemical profiles were developed for dominant pollen types in the Midwestern US, including red oak, pin oak, corn and ragweed. Glucose, fructose and sucrose accounted for 5 - 14% of pollen mass, supporting their use as chemical tracers of airborne pollens. Each pollen type had a unique ratio of glucose : sucrose : fructose, indicating that the relative abundance of these saccharides may be used for identifying pollen types in atmospheric PM samples. Saccharides were measured in fine and coarse particulate matter ($PM_{2.5}$ and $PM_{10-2.5}$, respectively) during tree pollen season (spring) and ragweed season (late summer) in Iowa City, IA in 2013. Pollen tracers were predominantly observed in coarse PM. However, during heavy spring rain, ambient concentrations of pollens significantly increased ($p<0.001$) and decreased in particle size, such that they were dominant in the fine mode. The decrease in the pollen size is likely due to osmotic rupture of pollen grains upon saturation with rainwater, causing them to burst and release pollen fragments less than 2.5 microns. This decrease in particle size is significant, because the pollen fragments can penetrate more deeply to the human respiratory tract and exhibit enhanced health effects. Red oak was identified as the likely pollen type contributing fine mode pollen fragments and was estimated to account for 73% of $PM_{2.5}$ and 15% of $PM_{10-2.5}$. Overall, human exposure to fine pollen particles, which can reach deeper in to the respiratory tract can be enhanced during rain events, increasing respiratory symptoms, even when total particle levels are low.

5BA.6

Bioaerosol Emissions and Detection of Airborne Antibiotic Resistance Genes from a Wastewater Treatment Plant. Jing Li, Liantong Zhou, Xiangyu Zhang, Caijia Xu, Liming Dong, MAOSHENG YAO, *Peking University*

This study was designed to investigate the bioaerosol emissions and airborne antibiotic resistant genes from a wastewater treatment plant (WWTP) in Beijing. Here, the biological contents from air samples of 12 sampling sites shown in Fig 1, office building and the boundary of plant in downwind area) and 4 downwind sites (200 m, 1 km, 5 km and 10 km away from the boundary of plant, respectively) were studied by using the Reuter Centrifugal Sampler High Flow (RCS) and high-throughput gene sequence. The viable bioaerosol concentrations of 7 intra-plant sites were also monitored using an ultraviolet aerodynamic particle sizer (UV-APS) for 30 min. Seven resistant genes and three integrons from both air and water samples collected from the plant were screened by PCR coupled with gel electrophoresis. The results showed that the air near sludge thickening basin was laden with a level of culturable bacterial aerosol (up to 1697 CFU/m3) and fungal aerosol (up to 930 CFU/m3). Almost 300 unique bacterial species, including human opportunistic pathogens, such as Comamonas Testosteroni and Moraxella Osloensis, were detected from the air samples. Fluorescent peaks around 3-4 μm were observed (except the office building) with a concentration level up to 1233-6533 #/m3. In this work, we have detected the sul2 gene resisted to cotrimoxazole (also known as septra, bactrim and TMP-SMX) and class 1 integrase gene in the air samples collected from the screen room and the aerated grit chamber.

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5BA.7

Further Development of a Passive Bioaerosol Sampler Using Ferroelectric Polymer. JENNIFER THERKORN, Jerry Scheinbeim, Gediminas Mainelis, *Rutgers, The State University of New Jersey*

A passive bioaerosol sampler can reduce costs of field sampling campaigns and provide finer spatiotemporal sampling resolution than what is currently achievable with active samplers. Here we report on further development of polyvinylidene fluoride (PVDF)-based passive bioaerosol sampler – the first passive bioaerosol sampler using a pair of polarized ferroelectric polymer films to electrostatically attract airborne particles. PVDF is a ferroelectric polymer, which has been permanently polarized by application of an external electric field. Using 3D printed lattices, particle collection efficiency of parallel-oriented sets of PVDF were tested using air channel spacing of 1, 3, 5 and 7 mm versus control materials. A slurry of Arizona Road Dust in water was aerosolized using 3-jet Collison nebulizer to produce polydisperse particles in size ranges of interest for viral, bacterial and fungal microbes. Tests were done with aerosol exhibiting Boltzmann charge equilibrium and with aerosol having charge similar to that reported in the literature for indoor/outdoor bioaerosol. With 3 mm air channels, PVDF had higher collection efficiency than controls: 25 – 50% for highly charged particles ranging in size from 14 to 5000 nm. For charge neutralized aerosol particles of the same size, PVDF consistently provided 25 – 30% collection efficiency with no significant difference from controls suggesting both electrostatic and mechanical collection mechanisms at work. PVDF lattices were also used to capture airborne 2 and 5 micrometer fluorescent polystyrene latex particles and the location of collected particles on the surface of PVDF was determined by microscopy; compared to non-polarized materials, results suggest that PVDF may provide significantly improved collection of bioaerosol particles in PM2.5 range with uniform deposition of collected particles across the PVDF surface. Next, field sampling will be performed in agricultural and office settings to compare bioaerosol collection performance of PVDF to that of other passive aerosol samplers and active filter samplers.

5CA.1

Aerosol Characterization over the Southeastern United States Using High Resolution Aerosol Mass Spectrometry: Spatial and Seasonal Variation of Aerosol Composition, Sources, and Organic Nitrates. NGA LEE NG, Lu Xu, Sriram Suresh, Hongyu Guo, Rodney J. Weber, *Georgia Institute of Technology*

We performed year-long comprehensive characterization of ambient aerosol in both rural and urban sites in the southeastern US as part of Southeastern Center for Air Pollution and Epidemiology (SCAPE) study and Southeastern Oxidant and Aerosol Study (SOAS) by using a High-Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS) and an Aerosol Chemical Speciation Monitor (ACSM). Organic aerosol (OA) accounts for more than half of NR-PM1 mass concentration regardless of sampling sites and seasons. Positive matrix factorization (PMF) analysis on the HR-ToF-AMS data resolved various OA sources. More-oxidized and less-oxidized oxygenated organic aerosol are dominant fractions (47-79%) of OA in all sites. Isoprene-derived OA is only deconvolved in warmer months and contributes 18-36% of total OA. Hydrocarbon-like OA and cooking OA are important but not dominant sources of total OA in urban sites. Biomass burning OA concentration has a larger enhancement in winter and correlates well with brown carbon.

We applied three independent methods to estimate the contribution of particulate organic nitrates to ambient OA in the SE US based on the HR-ToF-AMS measurements. The nitrate functionality from organic nitrates is estimated to contribute 63-100% of total measured nitrates in summer. Further, the contribution of organic nitrates to total OA is estimated to be 5-12% in summer, suggesting that organic nitrates are important components in the ambient aerosol in the southeastern US. The spatial distribution of OA is investigated by comparing simultaneous HR-ToF-AMS measurements with ACSM measurements at two different sampling sites. OA is found to be spatially homogeneous in summer. However, the homogeneity is less in winter. Finally, results from our short-term measurements with advanced instruments are compared to results from long-term measurements of basic air quality indicators from the SEARCH network. This comparison not only tests the robustness of the short-term measurements but also provides insights in interpreting long-term measurements.

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5CA.2

Organosulfates in Centreville, Alabama: Quantification and Insights to Their Formation. ANUSHA PRIYADARSHANI SILVA HETTIYADURA, Thilina Jayarathne, Elizabeth Stone, *University of Iowa*

Organosulfates ($R\text{-}O\text{-}SO_3^-$) are suggested to be tracers of anthropogenically-influenced biogenic SOA that form under acidic conditions. Hydrophilic interaction liquid chromatography (HILIC) and tandem mass spectrometry (MS/MS) in combination with synthesized authentic standards were used to quantify organosulfates collected from Centreville, Alabama in summer 2013 during the Southeast Atmosphere Study (SAS). Glycolic acid sulfate, lactic acid sulfate and hydroxyacetone sulfate were the three most abundant organosulfates quantified in $PM_{2.5}$ collected from Centreville, Alabama from July 07 to 11, 2013. Their atmospheric concentrations ranged from 2.4 - 25.7 ng m^{-3}, 1.3 – 22.4 ng m^{-3} and 0.4 - 7.5 ng m^{-3} respectively. Average contributions of these organosulfates to $PM_{2.5}$ organic carbon were 0.09%, 0.10% and 0.04%, respectively. Positive artifacts during sample collection were found to have upper limits of 3%, 5% and 8% of the ambient concentration, respectively. In addition, organosulfates with major contributions to the observed bisulfate anion signal were identified using high-resolution and tandem mass spectrometry. These additional organosulfates were semi-quantified using structurally-matched organosulfate standards. Correlation analysis of organosulfates with one another and $PM_{2.5}$ constituents (e.g. water soluble organic carbon, sulfate, nitrate) was used to gain insights to formation of organosulfates in the atmosphere. In addition, time series analysis was used to examine the temporal and meteorological influences to their ambient concentrations.

5CA.3

Sources and Composition of Aerosol Measured near Houston, TX: Anthropogenic-biogenic Interactions. JEFFREY BEAN, Cameron Faxon, Puneet Chhabra, Manjula Canagaratna, Lea Hildebrandt Ruiz, *University of Texas at Austin*

Particulate matter was measured in Conroe, TX (~ 70 km north of downtown Houston) during the September 2013 DISCOVER-AQ campaign. The measurement site is influenced by high biogenic emissions as well as transport of anthropogenic pollutants from the Houston metropolitan area and is therefore an ideal location to study anthropogenic-biogenic interactions. Data from and Aerosol Chemical Speciation Monitor (ACSM) suggest that on average 72 percent of non-refractory PM1 was organic material, including a high fraction of organic nitrates. There was little diurnal variation in the concentrations of ammonium sulfate; however, concentrations of organic and organic nitrate aerosol, were consistently higher at night than during the day. Potential explanations for the higher organic aerosol loadings at night include increased partitioning to the particle phase at lower temperatures and differences between daytime and nighttime chemical processes. We discuss and analyze these and other possibilities.

Positive matrix factorization applied to the organic aerosol mass spectra measured by the ACSM suggest that the measured aerosol was well mixed and highly processed, which is not surprising considering the distance of the site to major aerosol sources, as well as the high photochemical activity. While the organic aerosol was mostly composed of oxygenated organic aerosol, the influence of OA from biomass burning activity is also noticed, as also evidenced from gas-phase species measured by a High Resolution Time of Flight Chemical Ionization Mass Spectrometer (HR-ToF-CIMS) using negative (IH2O-) ionization.

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5CA.4

Aircraft Measurement of Isoprene-derived Organic Aerosol during the Southeast Nexus (SENEX) Campaign Using an Aerosol Mass Spectrometer. LU XU, Ann M. Middlebrook, Jin Liao, Joost de Gouw, Andre Welti, Hongyu Guo, Jack J. Lin, Aikaterini Bougiatioti, Rodney J. Weber, Athanasios Nenes, Ben H. Lee, Joel A. Thornton, John Holloway, Jessica Gilman, Brian Lerner, Martin Graus, Carsten Warneke, Michael Trainer, Nga Lee Ng, *Georgia Institute of Technology*

We investigated the effects of anthropogenic emissions on biogenic SOA formation through airborne measurements above the southeastern US. A suite of instruments, including an Aerodyne Aerosol Mass Spectrometer (AMS), was deployed aboard the NOAA WP-3D aircraft during the Southeast Nexus (SENEX) field campaign to characterize the chemical composition of both gas-phase and particle-phase. Measurements downwind of two coal-fired electrical generating units (Scherer and Harllee Branch), which have distinctly different NOx and SO2 emissions, provided an ideal case for examining the influence of these anthropogenic pollutants on SOA formation. We only observed substantial OA production downwind of Harllee Branch, whose NOx and SO2 emissions are 2 - 5 times higher than those of Scherer. Positive matrix factorization (PMF) analysis on the organic aerosol mass spectra suggests that the majority of OA production downwind of Harllee Branch plume is due to isoprene SOA, which likely arise from the reactive uptake of isoprene epoxydiols (IEPOX). The isoprene-derived OA factor (i.e., Isoprene-OA) correlates well with sulfate, which is consistent with results from recent ground measurement in Centreville, AL and the greater Atlanta area. The coupled effects of sulfate, particle acidity, and particle water content on Isoprene SOA formation are investigated. The time scale and favorable conditions for IEPOX uptake will also be discussed.

5CA.5

Atmospheric Observations of Secondary Aerosol Formation from Isoprene in the St. Louis Region during SLAQRS 2013. YAPING ZHANG, Raul Martinez, Dhruv Mitroo, Michael Walker, Christopher Oxford, Xiaochen Zuo, David Hagan, Jay Turner, Li Du, Dylan Millet, Munkhbayar Baasandorj, Lu Hu, Rodney J. Weber, Laura King, Brent Williams, *Washington University in St. Louis*

Organic aerosol dominates global fine particulate matter composition. The contribution of secondary organic aerosol (SOA), which is not fully understood in terms of formation and transformation processes, to the total organic aerosol loading is typically substantial, even in urban regions. The global production of biogenic SOA is higher than anthropogenic SOA. In recent years it has been documented through laboratory and field studies that while the aerosol yield from isoprene is small in comparison to other biogenic precursors, it is emitted globally in large concentrations and can lead to large amounts of isoprene-derived SOA. Here, we present a study of field observations of SOA formation from isoprene measured by the thermal desorption aerosol GC/MS (TAG) during the St. Louis Air Quality Regional Study (SLAQRS) campaign that took place in East St. Louis, IL during the summer of 2013 (a site downwind of the Ozarks Plateau oak forests, known for high isoprene emissions). Factor analysis is applied to entire chromatograms, which includes thermal decomposition signal, resolved compounds, and unresolved complex mixtures (UCM), to investigate the major components of observed mass. Various pollutant impact periods (e.g., presence or absence of NOx, sulfate, isoprene SOA precursor gases, etc.) are contrasted and linked to the different formation pathways of isoprene SOA. These observations offer insights into the behaviors of isoprene SOA formation in/upwind the St. Louis region.

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5CA.6
Quantification of Organic Molecules as Potential Tracers for Anthropogenic Secondary Organic Aerosol.
ELIZABETH STONE, Ibrahim Al Naghemah, Josh Kettler, *University of Iowa*

Aerosols come from a combination of natural and anthropogenic sources, yet the human contribution to ambient aerosol loadings is not well defined, particularly for carbonaceous aerosol. The current knowledge of the precursors, mechanisms of formation, and properties of secondary organic aerosol (SOA) is incomplete, leaving major gaps in understanding how and to what extent SOA impacts air quality and climate. The roles of natural and anthropogenic precursors in SOA formation are highly uncertain, and report varying roles of biogenic and anthropogenic volatile organic compounds (VOC) as precursors to SOA. In elucidating aerosol sources, receptor measurements of organic molecular markers have proven useful. However, anthropogenic SOA tracers are currently limited to very few molecules for which analytical standards are not commercially available. Hence, there is a need to develop and evaluate tracers of anthropogenic SOA and more accurately quantify its contribution to ambient aerosol. New approaches to quantifying products of benzene, toluene, naphthalene, and methyl-napthalene SOA in ambient fine particulate matter (PM2.5¬) have been developed. Specifically, gas chromatography-based methods have been developed to quantify monoaromatic nitro-compounds and furandiones and liquid chromatography-based methods have been developed to quantify organosulfur compounds (sulfonates and organosulfates). Method development, validation, and results from recent field studies will be discussed.

5CA.7
Measurements of In-situ SOA Formation Using an Oxidation Flow Reactor at GoAmazon2014/5.
BRETT PALM, Suzane Simoes de Sa, Pedro Campuzano-Jost, Douglas Day, Weiwei Hu, Roger Seco, Jeong-Hoo Park, Alex Guenther, Saewung Kim, Joel Brito, Florian Wurm, Paulo Artaxo, Lindsay Yee, Gabriel Isaacman-VanWertz, Allen H. Goldstein, Rodrigo A. F. Souza, Antonio O. Manzi, Oscar Vega, Julio Tota, Matt Newburn, Lizabeth Alexander, Scot Martin, William Brune, Jose-Luis Jimenez, *University of Colorado*

During GoAmazon2014/5, ambient air was exposed to controlled concentrations of OH or O_3 in-situ using an oxidation flow reactor (OFR). Oxidant exposures ranged from hours–several weeks of equivalent atmospheric oxidation. Oxidized air was sampled by several instruments (e.g., HR-AMS, ACSM, PTR-TOFMS, SMPS, CCN) at both the T3 site (IOP1: Feb 1–Mar 31, 2014, and IOP2: Aug 15–Oct 15, 2014) and T2 site (between IOPs and into 2nd IOP). Oxidation of ambient air in the OFR led to significant and dynamic SOA formation. In general, more SOA was produced during the nighttime than daytime, and more in the dry season (IOP2) than wet season (IOP1). The maximum amount of SOA produced during nighttime from OH oxidation ranged from less than 1 microgram/m^3 to greater than 10 micrograms/m^3. O_3 oxidation of ambient air also led to SOA formation, although much less than from OH oxidation. Variations in the amount of SOA formation often, but not always, correlated with measured gas-phase biogenic and/or anthropogenic SOA precursors (e.g., SV-TAG sesquiterpenes, PTR-TOFMS aromatics, isoprene, and monoterpenes). PMF factor analysis and comparisons to SOA precursors measured at GoAmazon2014/5 will be discussed in order to investigate anthropogenic vs biogenic SOA formation. The total SOA mass formed in the OFR was ~10x larger than could be explained by aerosol yields of measured primary VOCs, suggesting that most SOA was formed from intermediate sources such as S/IVOCs (e.g., VOC oxidation products or evaporated POA), consistent with previous OFR field and lab studies. To verify the SOA yields of VOCs under OFR experimental conditions, atmospherically-relevant concentrations of several monoterpenes, sesquiterpenes, isoprene, or toluene were added into ambient air in the OFR and oxidized by OH or O_3. SOA yields were similar to published yields from chamber studies. Results will be compared to observations from other recent campaigns.

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5IA.1
Physical Characterization of Indoor Dust. Haaland Daniel, Alireza Mahdavi, JEFFREY SIEGEL, *University of Toronto*

Indoor particle characterization tends to focus on short-term measurements of airborne particulate matter. A complete picture of exposure requires a longer-term assessment of particles. Such investigations are traditionally done with samples of settled dust and occasionally with the dust that collects on filters in central HVAC systems. Physical characterization of dust samples is typically completed with sieving or microscopy techniques, which provide the most information on the largest particles (>10 µm) in the sample. This presentation describes an alternate approach where a laser diffraction particle sizer is used with a liquid extract of dust to size particles from dust extracted from a filter. First test dusts with known size distributions were used to generate optical properties for indoor dusts. Next, test dusts were artificially loaded on to filters and extracted using chemical (surfactant addition) and physical (sonication) means to test and optimize dust extraction protocols. The optimized method is then used for two applications to demonstrate the utility and the uncertainties associated with the test method. The first application is assessing the particle size of particles collected on the filters of 10 portable air cleaners deployed for one week in different residential settings. These dust samples are compared to contemporaneous airborne particle measurements to elucidate differences between airborne and dust-based measurement approaches. The second application is used to validate in-situ filter efficiency measurements by comparing upstream downstream concentration measurements to the actual size distribution and mass removed to the filter. The results in general suggest that the approach has several applications to the investigation of indoor particles. The largest uncertainties arise from the agglomeration of dust particles, the variations in optical properties between dusts collected in different environments, and the very wide range of particle sizes present in typical dusts.

5IA.2
Continuous PM2.5 Monitor for Commercial Indoor Environments in China. James Farnsworth, Siva Iyer, ROB CALDOW, *TSI Incorporated*

Air pollution in urban China has received significant attention in recent years. Annual PM2.5 averages in Beijing are nearly three times higher than the target of 35 µg/m3 recommended by the World Health Organization. Public awareness of PM2.5 exposure is growing due to wider data availability. Although Chinese citizens can access data from hundreds of outdoor PM2.5 monitoring stations across the country, indoor PM2.5 is largely unmonitored. On average, adults spend 90 percent or more of their time indoors (US EPA), and indoor PM2.5 levels differ from outdoor levels depending on HVAC system characteristics and building construction, making indoor levels important to monitor separately.

In this paper we present a wall-mount, low-maintenance PM2.5 monitor for continuous monitoring of air quality in commercial indoor environments, and a web application for network configuration, visualization, and data logging. Using the monitor and web application, building owners can network sensors together, log data, and make decisions based on the data. NIST traceable calibration and patent-pending autozero capabilities ensure accuracy over the range 5-300 µg/m3.

Extensive validation testing of the PM2.5 monitor has been completed. A comprehensive review of the validation test results is presented, including response comparison for a variety of aerosols; sensor calibration accuracy; measurement stability over time, temperature and RH; and agreement with TEOM during multi-week field testing in Beijing. Stress testing such as impact, vibration, and Highly Accelerated Life Testing (HALT) were employed to understand limitations of the device, and results are correlated to device robustness.

For demonstration and for continuous engineering monitoring, a network of 10 devices has been installed in TSI facilities located in Shoreview, MN and Beijing, China. Data is compared with outdoor measurements from nearby outdoor PM2.5 monitoring stations. Correlation results will be discussed.

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5IA.3

Laboratory Evaluation and Calibration of Three Low-cost Particle Sensors for Particulate Matter Measurement. Yang Wang, JIAYU LI, He Jing, Qiang Zhang, Jingkun Jiang, Pratim Biswas, *Washington University in St Louis*

Compared to conventional instruments for particulate matter (PM) concentration measurements, particle sensors offer the significant advantages of compact size and low cost, and have drawn great attention during recent years in portable particle monitoring. However, due to the lack of a standardized calibration protocol, most sensor systems have not been thoroughly evaluated, and data quality is not well documented. In this work, three low-cost particle sensors based on light scattering (Shinyei PPD42NS, Samyoung DSM501A, and Sharp GP2Y1010AU0F) were evaluated by calibration methods adapted from the US EPA 2013 Air Sensor Workshop recommendations. With a SidePak (TSI Inc.) and a scanning mobility particle sizer (SMPS) as reference instruments, six performance aspects were examined: linearity of response, precision of measurement, limit of detection, dependence on particle composition, sensitivity to the particle size, and relative humidity (RH) and temperature influences. Throughout the experiments, GP2Y1010AU0F demonstrated the highest linearity against results measured by the SidePak. Some common characteristics were observed, such as saturated outputs under higher particle concentrations of around 4 milligram/m3, high dependence on the composition and size of particles, and minimal dependence on temperature. The applicability of the sensors in clean environments is low, since the standard deviations of the three tested sensors typically had values higher than 15 microgram/m3, which is above the EPA-regulated annual average PM2.5 index of 12 microgram/m3. Although less accurate than more complicated and expensive measurement devices, these particle sensors were still able to report particle concentrations with moderate linearity and repeatability. The compact size and low cost of the sensors favor their wide application in tracking air quality in developing countries and heavily polluted areas, where the demand for monitoring particulate matter is especially urgent for the sake of public health.

5IA.4

A Method to Rapidly Measure Size-Resolved Particle Penetration Factors in Residences. HAORAN ZHAO, Brent Stephens, *Illinois Institute of Technology*

Human exposure to particles of outdoor origin is dependent on their infiltration into buildings. In order to improve our knowledge of particle infiltration inside a wide variety of residences where people spend most of their time, methods to more rapidly measure particle penetration factors are required. Therefore, we refined existing test methods into a new method to measure size-resolved envelope penetration factors and applied it in an unoccupied apartment unit in Chicago, IL. The test procedure involves the following steps to yield estimates of both penetration factors (P) and deposition loss rate coefficients (k): (1) introduce outdoor particles through temporary increases in natural ventilation to elevate indoor particle concentrations, (2) measure the subsequent decay of indoor particles during a 30-60 minute indoor-only measurement period, and (3) alternately measure indoor and outdoor particle concentrations during normal infiltration conditions over a period of ~2 hours. An automatic switching system was used with a TSI NanoScan SMPS and Optical Particle Sizer to demonstrate the utility of this method. Estimates of P and k were made for 18 particle size ranges from 0.01 µm to 2.5 µm using multiple mathematical solutions to a time-varying mass balance on indoor particles of outdoor origin. Repeated measurements were made and results were explored to evaluate the accuracy and repeatability of the test procedure and solution methods. Preliminary results demonstrate that mean estimates of P ranged from 0.39±0.07 to 0.79±0.17 across the range of particle sizes, while estimates of k ranged from 0.53±0.02 to 1.65±0.15 hr-1. Additionally, these data were aggregated to provide estimates of P and k for ultrafine particles and PM2.5 mass (assuming spherical shape and unit density). This work provides a test method that minimizes the duration of testing without sacrificing accuracy for further application in field measurements.

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5IA.5
Computational Fluid Dynamics Application for the Prediction of the Evolution of Aerosol Transport in an Indoor Space: Effect of Furniture and Different Surface Types. Andrew Clohessey, Tanvir Farouk, SHAMIA HOQUE, *USC*

Extensive computational fluid dynamics (CFD) simulations of aerosol dispersion in ventilated indoor spaces have been reported in the literature. The results however do not provide guidelines regarding the indoor space design such as furniture orientation, choice of materials for floor covering, office equipment placement etc. Such guidelines will not only ensure a healthy indoor environment (such as lesser dead zones) but also a safer one by reducing the opportunities for re-aerosolization after disinfection (if required in case of the release of an infectious aerosol). This study investigates the evolution of the transport pattern of aerosols with respect to multiple release locations in a furnished office room. The impact of different types of surfaces is also investigated. The objective is to predict the number and pattern of the aerosols remaining in the space after a certain amount of time has elapsed given the furniture orientation, room size, ventilation pattern and surface characteristics. Multiple scenarios were simulated using a comprehensive CFD model. Large eddy simulation with the Smagorinsky subgrid scale model was applied to compute the airflow. Aerosols were modeled as a dispersed solid phase using a Lagrangian treatment. Initially release location is shown to determine the characteristics of the dispersion pattern but after a quarter of an hour the aerosol mixing pattern appears to become similar. The number count relates to the distance of the location of the release to the location of the ventilation outlet. Sticking surfaces resulted in nearly 50% of the aerosols remaining in the room while nearly all aerosols had left the room after ~90 min when surfaces were ‘non-stick’.

5IA.6
Sampling Indoor Aerosols on the International Space Station. MARIT MEYER, Gary Casuccio, *NASA Glenn Research Center*

In a spacecraft cabin environment, the size range of indoor aerosols is much larger and they persist longer than on Earth because they are not removed by gravitational settling. A previous aerosol experiment in 1991 documented that over 90% of the mass concentration of particles in the NASA Space Shuttle air were in particle size fractions between 2.5 μm and >100 μm, based on measurements with a multi-stage virtual impactor and a nephelometer (Liu et al. 1991). While the now-retired Space Shuttle had short duration missions (less than two weeks), the International Space Station (ISS) has been continually inhabited by astronauts for over a decade. High concentrations of inhalable particles on ISS are potentially responsible for crew complaints of respiratory and eye irritation and comments about 'dusty' air. Air filtration is the current control strategy for airborne particles on the ISS, and filtration modeling, performed for engineering and design validation of the air revitalization system in ISS, predicted that PM requirements would be met. However, aerosol monitoring has never been performed on the ISS to verify PM levels. A flight experiment is in preparation which will provide data on particulate matter in ISS ambient air. Particles will be collected with a thermophoretic sampler as well as with passive samplers which will extend the particle size range of sampling. Samples will be returned to Earth for chemical and microscopic analyses, providing the first aerosol data for ISS ambient air.

Reference: Liu, B. Y., Rubow, K. L., McMurry, P. H., Kotz, T. J., & Russo, D. (1991). Airborne particulate matter and spacecraft internal environments (No. 911476). SAE Technical Paper.

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5IA.7

A Comparative Controlled Study for the Characterization of PM2.5 Emitted during Heating Corn Oil and Ground Beef (PM2.5, OC, EC and Elemental Concentrations). Soudabeh Gorjinezhad, Mehdi Amouei Torkmahalleh, Hedyie Sumru Ünlüevcek, E. Cihan, B. Tanış, N. Soy, N. Özaslan, M. Keleş, Fatma Öztürk, PHILIP K HOPKE, *Middle East Technical University Northern Cyprus Campus*

This study investigated size segregated mass concentrations and emission rates of particulate matter (PM), organic carbon (OC), elemental carbon (EC) as well as elemental composition generated during heating corn oil. Also, the impact of table salt on PM emissions from heated corn oil was investigated. Experiments were conducted using an electric stove in an on-campus house at Middle East Technical University Northern Cyprus Campus during January 2015. Fine mode particles were collected in this study. A statistically significant reduction of 56% ($P<0.05$) in total particle mass concentration was observed when salt was added to the heated oil compared to the heated pure corn oil. The size segregated average mass emission rate and emission flux values of OC emitted during heating pure corn oil showed a peak at 0.65-1.1 µm. Total OC emission rate and flux values were 5.83×101 mg.min-1 and 1.96×103 mg.min-1.m-2, respectively. A uimodal OC size distribution was observed when salt was added to the oil resulted in total OC emission rate and flux to be 2.35×101 mg.min-1 and 7.58×102 mg.min-1.m-2, respectively. The total EC emission fluxes for heated pure oil and pure oil with salt were measured to be 6.07×101 and 2.26×101 mg.m-2.min-1, respectively. The three most abundant heavy metals emitted during heating pure corn oil and corn oil with salt were Fe, Ti, Sr and Fe, Ti, Zn, respectively. The total metal concentrations decreased from 6.04 to 4.01 mg.m-3 in the presence of salt compared to the pure oil.

5NM.1

Nanosilver Toxicity: Enhanced Ag+ Ion Release from Aqueous Nanosilver Suspensions by Absorption of Ambient CO_2. Kakeru Fujiwara, Georgios A. Sotiriou, SOTIRIS E. PRATSINIS, *ETH Zurich*

Nanosilver is the largest engineered nanomaterial by volume and value after carbon black and fumed silica, alumina and titania as it is present in many consumer products. Here nanosilver with closely controlled average particle diameter (7 - 30 nm) immobilized on nanosilica aerosols is prepared and characterized by X-ray diffraction and transmission electron microscopy. The presence of Ag_2O on the metallic nanosilver surface is confirmed by UV-vis spectroscopy and quantified by thermogravimetric analysis and mass spectrometry. The dissolved Ag as Ag^+ ions, $[Ag^+]$, from nanosilver in de-ionized water exposed to ambient laboratory air containing 580 ppm of CO_2 is monitored electrochemically. For all air compositions, the [Ag+] instantly reaches the level that corresponds to the dissolved preexisting Ag_2O layer on the nanosilver surface. Under CO2-free synthetic air, the [Ag+] levels for all nanosilver sizes do not change for seven days indicating that only metallic Ag remains. In contrast, under laboratory air (CO_2 580 ppm), the $[Ag^+]$ of all three nanosilver suspensions slowly increases indicating additional release of Ag^+ ions from the metallic Ag core that depends on solution pH. The pH rapidly increases during preexisting Ag_2O dissolution by the released OH^- species along with Ag^+ ions resulting in basic pH solutions. This prevents further Ag^+ ion release by metallic Ag dissolution resulting in constant [Ag+]. When these solutions are exposed to CO_2-containing atmospheres, absorption of CO_2 in the host solution leads to its acidification and facilitates metallic Ag dissolution. So the pH of nanosilver solutions increases first rapidly by dissolution of preexisting Ag_2O and release of OH^-. Thus, metallic Ag dissolution in water exposed to CO2-containing ambient air during its prolonged storage is enhanced by acidification resulting from atmospheric CO_2 absorption in solution, which significantly increases the risk to environment.

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5NM.2
Evaluating the Evolution of Silver Nanoparticles in Gastrointestinal Tract through Application of State-of-the-Art Methods to Simulated Gastric Fluids of Increasing Complexity. ANDREW AULT, Jessica Axson, Diana Stark, Amy Bondy, Sonja Capracotta, Justin Keeney, Andrew Maynard, Martin Philbert, Ingrid Bergin, *University of Michigan*

Uncertainty remains regarding the evolution and fate of ingested silver nanoparticles (AgNPs) after exposure from an array of commercial products. Thus, it is important to understand the fundamental chemical and physical processes leading to decreases (dissolution) or increases (aggregation) in AgNP size under high salt and acidic conditions of the gastrointestinal (GI) tract, as well as in the presence of proteins such as pepsin and pancreatin. In this study, particle growth was observed on the timescale of seconds-to-minutes for simulated gastric fluid (SGF) replicating the salt content and pH of the human stomach. High time resolution data from Nanoparticle Tracking Analysis (NTA) (30 second) combined with transmission electron microscopy (TEM) were used to explore the kinetics as a function of pH, size, and coating. In addition, a USP 2 apparatus was constructed and modified to study the long-term dissolution of nanoparticles in the presence of different proteins and fasted/fed conditions of the GI tract. This apparatus was then expanded to study the evolution of AgNPs using a multi-compartment system representing the stomach, duodenum, and jejunum. The resulting solutions were aerosolized with electrospray ionization to generate protein-coated AgNP aerosol for size and chemical analysis with an SMPS and single particle mass spectrometry. Taken together, the results of this multi-faceted study of AgNP evolution are providing key insights into the modification of AgNPs during passage through the GI tract.

5NM.3
Aerosol Synthesis of 3D Silver-Graphene-Titanium Oxide Composite. HEE DONG JANG, Sun Kyung Kim, Hankwon Chang, Eun Hee Jo, *Korea Institute of Geoscience and Mineral Resources*

A sensitive glucose biosensor was developed based on the adsorption of glucose oxidase by a three-dimensional (3D) silver (Ag) graphene (GR)-titanium dioxide (TiO2) composite electrode. Aerosol spray pyrolysis (ASP) was employed to synthesize the 3D Ag-GR-TiO2 composite using a colloidal mixture of a silver acetate precursor (C2H3AgO2), graphene oxide (GO), and TiO2 nanoparticles. The effect of the operating temperature on the particle properties, including the morphology and crystal structure, was investigated. The particle morphology of all 3D Ag-GR-TiO2 composites was spherical in shape, with an average size of about 500 nm. Ag nanoparticles less than 10 nm in diameter were deposited on the surfaces of the TiO2 nanoparticles and GR after a reduction process. A higher intensity of the crystallinity of Ag was measured at a higher operating temperature. The characteristics of the glucose biosensor fabricated with the as-prepared 3D Ag-GR-TiO2 composite were assessed through cyclic voltammetry measurements. The biosensor exhibited a high current flow as well as clear redox peaks, resulting in a superior ability of the catalyst in terms of the electrochemical reactions. The highest sensitivity obtained from the amperometric response of the glucose biosensor was 12.2 μA/mM•cm2.

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5NM.4
Studying the Charging Characteristics of Flame Generated Particles below 3 nm with a Condensation Particle Counter Battery (CPCB). YANG WANG, Jiayu Li, Jiaxi Fang, Nathan Reed, Pratim Biswas, *Washington University in St Louis*

Flame synthesis is a dominant method for producing nanoparticles in large quantities. The charging characteristics of nanoparticles in flames significantly affect the nucleation, coagulation, and further growth of nanoparticles. For sub-3 nm particles generated in flames, the charging mechanism is not resolved due to the complex interaction of diffusion charging, thermionization, chemical ionization, and the interference of flame-generated ions (Jiang et al., 2007). Conventional instruments for determining charge distributions rely on external chargers that may introduce contaminant ions below 3 nm, further complicating the determination of charge distributions (Wang et al., 2014). Recent advances in modifying the working conditions of condensation particle counters (CPCs) achieved a shift in the cutoff size for detecting nanoparticles, thus enabling the measurement of particles below 3 nm. Information on particle size distribution and composition can be obtained through a condensation particle counter battery (CPCB), which operates CPCs with different cutoff sizes and working fluids in parallel. This study used a CPCB composed of three CPCs with different cutoff sizes below 3 nm to investigate the size distribution and charging characteristics of freshly nucleated particles generated from a premixed flat flame. The CPCB detected high concentrations of sub-3 nm particles, possibly formed through chemical ionizations in the flame. The concentrations of neutral particles were measured when we applied a charged particle remover (CPR) before particles entered the CPCB, through which the charging efficiencies of sub-3 nm particles were obtained. The effects of introducing synthesis precursors into the flame, the precursor loading rate, and the flame equivalence ratio on the size distributions and charging characteristics of flame-generated particles below 3 nm will be presented.

References:
Jiang, J., Lee, M.-H., Biswas, P. (2007). Journal of Electrostatics 65:209-220.
Wang, Y., Fang, J., Attoui, M., Chadha, T. S., Wang, W.-N., Biswas, P. (2014). Journal of Aerosol Science 71:52-64.

5NM.5
Plasmonic Properties of Phosphorus-doped and Boron-doped Silicon Nanocrystals. Nicolaas J. Kramer, KATELYN SCHRAMKE, Uwe R. Kortshagen, *University of Minnesota*

Gas phase synthesis of nanomaterials is a desirable alternative to liquid chemistry approaches due to the continuous production of high quality, ligand-free crystalline materials with no chemicals needed. Precursors, all of which are gaseous, are fed into a low pressure chamber where particles nucleate in the glow discharge of a nonthermal plasma. This technique is used to produce phosphorus-doped and boron-doped silicon nanocrystals (SiNCs) which exhibit localized surface plasmonic resonance (LSPR). Doped nanomaterials are interesting due to their potential for exciting optical and electronic properties. Argon is used for the bulk plasma, silane is used to produce silicon particles, and phosphine and diborane are flown as dopant precursors. The total flow rate ranges from 20 to 50 sccm with a synthesis pressure in the range of 1-2 Torr yielding very monodisperse nanocrystals around 8nm in size.

Plasmonic properties of semiconductor nanocrystals are unique in that they are able to be tuned not only by size, shape and composition but also by free carrier concentration. In this work, very different plasmonic behavior is observed for the two different dopant types. As synthesize phosphorus doped SiNCs exhibit plasmon resonance while the boron doped nanocrystals require post synthesis treatment before a LSPR is seen. The oxidation mechanism plays a key role in dopant dynamics in the nanomaterials as it leads to plasmon resonance in b-doped SiNCs and suppression of the plasmon resonance in p-doped SiNCs.

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5NM.6
Quantitative Measurement of Nanoparticle Concentration by Electron Microscopy Techniques. KRISTIN BUNKER, Traci Lersch, Gary Casuccio, *RJ Lee Group, Inc.*

As the field of nanotechnology continues to progress, there is a need to determine quantitative information on physiochemical properties of engineered nanoparticles, including size and concentration. Presently, the field is limited by the lack of standards and reference materials as well as industry accepted analytical methodologies used for characterization. For example, there is no direct way to determine nanoparticle concentration in particles/mL. Therefore, bulk chemistry techniques such as ICP-MS are used as a surrogate to determine the mass concentration of nanoparticles in solution (mg/mL) which is then converted to the desired concentration metric based on particle size data provided by electron microscopy measurements. In an attempt to provide a direct measurement of nanoparticle number concentrations, research is being performed using high-resolution electron microscopy techniques. Results including information on the development of a sample preparation technique and analysis protocols will be discussed. In addition, the quantitative electron microscopy results will be compared to other techniques used to obtain number concentration information.

5NM.7
Selective Oxidation of Carbon on Silicon Kerf using Furnace Aerosol Reactor (FuAR) aided by TGA Kinetic Estimations. MIGUEL VAZQUEZ PUFLEAU, Tandeep Chadha, Gregory Yablonsky, Henry Erk, Pratim Biswas, *Washington University in St. Louis*

Silicon is the most widely used semiconductor in the electronics and photovoltaics (PV) industry. Current manufacturing processes are expensive and (for thin PV wafers) more than 40% of the silicon is lost during the cutting process as kerf. Efforts have been made to recycle kerf, but have been futile due to high impurities in the kerf. As a result, kerf is a disposed waste stream. A single-step route for recycling kerf is paramount to reduce the cost of PV wafers as well as eliminating a significant waste stream.

Previous studies have focused on removing the major contaminant, SiC, from the slurry-based cutting process. However, advanced diamond fixed-abrasive slicing process produces less waste and no free abrasive is used, hence it should be possible to recover silicon more easily. Chemical analysis shows that carbon (3.5%) is the main contaminant in this type of kerf. SEM and TEM characterization have shown that this kerf is composed of highly aggregated thin-layer flakes formed by the plastic deformation of Si into damaged and amorphized silicon.

In this work we used a furnace aerosol reactor (FuAR) process for selective carbon oxidation in kerf. Total organic carbon (TOC) measurements have shown that all carbon in kerf is in the organic form. Silicon oxidation and carbon elimination kinetics were studied using Thermo Gravimetric Analysis (TGA). Apparent kinetic orders of volatilization for carbonaceous compounds for air and nitrogen were found. Temperature dependences for total carbon reduction were presented and apparent activation energies were determined. The process mechanism was discussed qualitatively.

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6AC.1
Temperature Effects on Secondary Organic Aerosol Formation, Composition, and Phase State. MARY KACARAB, David R. Cocker III, *University of California, Riverside*

Temperature has been shown to have a profound effect on secondary organic aerosol (SOA) yield. Several terpene, aromatic, and cyclic alkene ozonolysis and photooxidation secondary organic aerosol systems were studied in the UC Riverside/CE-CERT dual 90m^3 environmental chambers under different temperature cycles ranging from 278K to 313K. A non-reversible hysteresis effect was observed when cycling the temperature of experiments, demonstrating that the temperature at formation of the aerosol dictates the overall aerosol yield, with cold temperature experiments having drastically greater yields. Semi-volatile wall losses were explored for each system at different temperatures by comparing seeded and non-seeded experiments. Gas phase mass spectra were provided in real-time with a SYFT Technologies Selected Ion Flow Tube Mass Spectrometer (SIFT-MS). Bulk aerosol chemistry was monitored by an Aerodyne High Resolution Time of Flight Aerosol Mass Spectrometer (HR-ToF-AMS), finding that temperature has a noticeable effect on bulk elemental ratios and oxidation state. Physical properties of aerosol were also measured throughout experiments. Temperature has a noticeable effect on both particle volatility and hygroscopicity. Particle density, monitored with a Kanomax APM-SMPS, remains largely unaffected by temperature. It is hypothesized that at low temperature, aerosol may be in a glassy state and thus not follow traditional gas-particle partitioning models. Aerosol phase state is explored with an aerosol particle bounce instrument. The severe hysteresis effects seen in aerosol yields at different temperatures have strong implications for aerosol equilibration time and pose a challenge to current aerosol formation assumptions.

6AC.2
Effect of Oxidant Concentration, Exposure Time and Seed Particles on Secondary Organic Aerosol Chemical Composition and Yield. ANDREW LAMBE, Puneet Chhabra, Timothy Onasch, William Brune, James Hunter, Jesse Kroll, Molly Cummings, James Brogan, Yatish Parmar, Douglas Worsnop, Charles Kolb, Paul Davidovits, *Aerodyne Research, Inc.*

We performed a systematic intercomparison study of the chemistry and yields of secondary organic aerosol (SOA) generated from OH oxidation of a common set of gas-phase precursors in an aerosol flow reactor and several environmental chambers. In the flow reactor, SOA precursors were oxidized using OH concentrations ranging from 2×10^8 to 2×10^{10} cm^{-3} over exposure times of 100 sec. In the environmental chambers, precursors were oxidized using OH concentrations ranging from 2×10^6 to 2×10^7 cm^{-3} over exposure times of several hours. The OH concentration in the chamber experiments is close to that found in the atmosphere, but the integrated OH exposure in the flow reactor can simulate atmospheric exposure times of multiple days compared to chamber exposure times of only a day or so. A linear correlation analysis of the mass spectra and carbon oxidation state of SOA produced in the flow reactor and environmental chambers for OH exposures of approximately 10^{11} cm^{-3} sec suggests that the composition of SOA produced in the flow reactor and chambers is the same within experimental accuracy as measured with an aerosol mass spectrometer. This similarity in turn suggests that both in the flow reactor and in chambers, SOA chemical composition at low OH exposure is governed primarily by gas-phase OH oxidation of the precursors, rather than heterogeneous oxidation of the condensed particles. In general, SOA yields measured in the flow reactor are lower than measured in chambers for the range of equivalent OH exposures that can be measured in both the flow reactor and chambers. The influence of sulfate seed particles on isoprene SOA yield measurements was examined in the flow reactor. The studies show that seed particles increase the yield of SOA produced in flow reactors by a factor of 3 to 5 and may also account in part for higher SOA yields obtained in the chambers, where seed particles are routinely used.

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6AC.3
Influence of Vapor Wall Loss in Laboratory Chambers on Secondary Organic Aerosol (SOA) Formation from Select Low Vapor Pressure-Volatile Organic Compounds (LVP-VOCs). WEIHUA LI, Lijie Li, Mary Kacarab, David R. Cocker III, *University of California, Riverside*

A low vapor pressure-volatile organic compound (LVP-VOC) is defined by regulations as a chemical "compound" or "mixture" that has relatively low vapor pressure (0.01mm Hg) and high boiling point (>216°C). LVP-VOCs are essential components in consumer products used to meet product functionality and also volatile organic compound (VOC) limits. However, LVP-VOCs may still be present in the atmosphere through evaporation over extended periods of time contributing to VOC emissions and subsequently forming secondary organic aerosol (SOA) after photo-chemical oxidation. Therefore predicting the LVP-VOCs' behavior in the atmosphere and their contribution to ambient fine particulate matter is important and contributes to our understanding of the poorly characterized and understood IVOC emissions and their role in SOA formation.

Teflon chambers are ubiquitous in the study of gas phase atmospheric chemistry and SOA formation from oxidation of VOCs. However, SOA formation can be significantly underestimated due to deposition of particles and SOA-forming vapors to chamber walls. Losses of particles to chamber walls are taken into account by current SOA formation models. However, there have only been a few studies evaluating the chamber surfaces in influencing lower vapor pressure VOC oxidation products availability for SOA formation. The goal of this study is to understand vapor wall loss effects on SOA forming-potential and growth from C_{17}-C_{23} alkanes as they partition between gas-phase, chamber surfaces, and particle surfaces. This study will provide a firm experimental foundation for evaluating current VOC exemption rules.

6AC.4
The Effects of Long-Wavelength UV Light on Photochemically Generated Organic Aerosols. Iftikhar Awan, W. SEAN MCGIVERN, *National Institute of Standards and Technology*

Recent work in our group has shown that photochemistry of peroxy radicals affects product distributions in organic aerosols formed from photochemically generated alkyl radicals at 254 nm. In this study, we utilize a photochemical flow reactor to examine the effects of longer-wavelength UV light on the particles formed. The reaction is initiated with a short initial exposure of 1-iodooctane to 254 nm light in air at room temperature, which forms octyl radicals that rapidly react with ambient oxygen to form octylperoxy radicals. This short-wavelength region is followed by a long region of the cell that is either nonirradiated or irradiated with (311 ± 5) nm light. In the absence of the 311 nm light, a small number of particles are formed, but we observe a substantial increase in particle size and mass in the presence of the longer wavelength light. We utilize a previously developed derivatization methodology coupled with HPLC/UV-Vis and MS-MS to examine the changes in the functional group distributions of particles generated using the (254 nm/nonirradiated) and (254 nm/311 nm) combinations. Substantial differences in the complexity of the resulting particle compositions have been observed, which we attribute to photochemistry of the peroxy radicals at the longer wavelengths, a wavelength region for which little peroxy radical absorption data is available. Utilizing a lumped chemical kinetics model previously applied to the single wavelength system, we demonstrate how such compositional variations can be manifested and consider possible atmospheric implications of peroxy radical absorption at longer wavelengths.

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6AC.5

Composition and Photochemistry of Biodiesel and Diesel Fuel SOA. SANDRA BLAIR, Amanda MacMillan, Greg Drozd, Allen H. Goldstein, Peng Lin, Julia Laskin, Alexander Laskin, Sergey Nizkorodov, *University of California, Irvine*

The physical and chemical properties of "fresh" versus "aged" secondary organic aerosol (SOA) strongly depend on the type of aging. This study focuses on SOA aging arising from the condensed-phase photolysis of laboratory-generated particulate organic compounds in photooxidized biodiesel (BDSL) and diesel (DSL) fuel SOA. The presence of NOx, SO_2, NH_3, and relative humidity (RH) may change the composition and absorption properties of this SOA and, furthermore, may have an effect on its photochemistry. SOA composition before and after direct photolysis of particulate organic compounds was measured using several analytical techniques including: aerosol mass spectrometry (AMS), high-resolution nanospray desorption electrospray ionization mass spectrometry (nano-DESI), and 2D gas chromatography mass spectrometry. This paper will discuss the effect of SO_2, NH_3, RH, and UV photolysis on (1) particle mass concentration, (2) chemical composition, and (3) mass absorption coefficient (MAC) of BDSL, DSL, and BDSL/DSL SOA. Preliminary results show that addition of SO_2 produces organosulfates in the condensed-phase. The mass absorption coefficients show different trends between the BDSL and DSL samples, but a much smaller change was observed for SOA generated from a BDSL/DSL mixture. There was a larger photolytic loss of organic material relative to inorganic sulfate and mass absorption coefficients decreased upon irradiation. After photolysis, little change was observed in average composition, but significant change was observed in molecular composition.

6AC.6

Effective Absorption Cross Sections and Photolysis Rates of Model Secondary Organic Aerosol. DIAN ROMONOSKY, Nujhat Ali, Mariyah Saiduddin, Sergey Nizkorodov, *University of California, Irvine*

Prevalent mechanisms for secondary organic aerosol (SOA) aging involve heterogeneous oxidation and fog photochemical processes involving the OH radical as well as various other oxidants in the atmosphere. In addition to condensed phase oxidation, SOA can also age in the atmosphere upon exposure to radiation. To estimate the time scales of these condensed-phase photochemical processes, this study focuses on the optical properties of SOA produced by flow-tube ozonolysis and smog chamber photooxidation, during both low- and high-NO_x oxidation conditions. The volatile organic compound precursors for these SOA samples include isoprene, alpha-pinene, beta-pinene, beta-myrcene, d-limonene, linalool, ocimene, farnesene, p-xylene, 1-methylpyrrole, 2-methylpyrrole, guaiacol, and imidazole. Mass absorption coefficient values were measured for all SOA samples created, and then converted into effective molecular absorption cross sections. Photolysis rates of the SOA compounds were calculated by assuming that the SOA compounds have the photolysis quantum yields of H_2O_2 (unity, providing the upper limit for the photochemical rates) or acetone (wavelength dependent, providing a more realistic estimate) and convoluting the absorption cross section data with time-dependent solar flux density. Results of this study suggest that the condensed phase photolysis of SOA can occur with effective lifetimes ranging from minutes to hours, and therefore represents a potentially important aging mechanism for SOA.

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6AC.7
The Effect of Hydrophobic Organics on Nucleation, Formation Yield, Volatility, Viscosity, and Oligomer Content of SOA Particles. ALLA ZELENYUK, Dan Imre, Jacqueline Wilson, David Bell, Josef Beranek, ManishKumar Shrivastava, *Pacific Northwest National Laboratory*

A number of field measurements provided evidence that significant fraction of atmospheric secondary organic aerosol (SOA) mass forms from biogenic precursors through pathways that are either driven by or enhanced by anthropogenic pollution, in a phenomenon that has been termed anthropogenic-biogenic interactions. Thus far, the laboratory studies attempting to reproduce this phenomenon of focused on the effect of acidic sulfate seeds, NOx, and SO2 exert on SOA formation mechanisms and yields.

We have previously shown that when SOA particles are formed from biogenic precursors in the presence of the vapors of polycyclic aromatic hydrocarbons (PAHs), which are common atmospheric anthropogenic pollutants, these PAHs become incorporated and trapped inside the formed SOA particles. While PAHs comprise only a small fraction of the total particle mass, their presence during particle formation, drastically changes the SOA particle properties. Compared with pure SOA particles, particles formed in the presence of PAHs evaporate significantly slower, and have higher viscosity and oligomer content.

Most recently, we found that the presence of PAHs during SOA formation also significantly increases particles number concentrations and mass loadings. For example, ozonolysis of α-pinene in the presence of pyrene yields significantly higher loadings and particle number concentrations compared to pure α-pinene SOA, especially at low precursor concentrations. For 20 ppb α–pinene, the presence of pyrene increases mass loading by a factor of 1.7 and particle number concentration by a factor of 1.2, while for 5 ppb α–pinene, the presence of pyrene increases mass loading by a factor of 5 and particles number concentration by a factor of 200.

We will discuss the chemical reactions responsible for these new findings, which provide direct evidence related to field data indicating that biogenic-anthropogenic interactions could be responsible for an increase in SOA loadings.

6AE.1
Characterization of Ambient Residential Woodsmoke PM Exposures in Upstate New York. GEORGE ALLEN, *NESCAUM*

Exposures to woodsmoke from residential heating can be a substantial concern in areas where wood stoves and furnaces are a common source of space heating in cold weather seasons. Typical central site urban compliance-oriented monitoring does not provide information on the range of exposures in smaller rural valley towns. To better characterize potential concentrations of ambient woodsmoke PM, two temporary woodsmoke monitoring systems were deployed in yards of houses during the winter of 2014-2015 in Saranac Lake, a small town in upstate New York. One system was run at one location for the duration of the winter, and the other was run for six weeks at each of two other locations. Each system measured PM2.5 (Thermo pDR-1500 nephelometer), black carbon and UV-carbon (Aethalometer), particle bound PAH (Ecochem PAS), and sonic wind speed/direction measurements, all at one-minute intervals. Peak 1-hour PM concentrations up to 400 micrograms/m^3 were observed; peak concentrations did not occur at the same time across sites, consistent with impact of very local sources. Mean PM ranged from 10 to 13 micrograms/m^3. Non-WS average PM was estimated to be between 3 and 4 micrograms/m^3 using Aethalometer data and regression analysis. Non-parametric wind regression was used to determine direction of sources of elevated PM and related pollutants. Two scenarios were observed where PM did track across sites: regional transport events and strong night-time inversion conditions, with PM concentrations of 20 to 30 micrograms/m^3. Diurnal patterns of particle measurements had peaks overnight and minimums during mid-day, consistent with emission and dispersion daily patterns. Various techniques for communicating potential health risk from sub-daily recurring woodsmoke PM are explored, including the new EPA AIRNow “NowCast” approach.

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6AE.2
Multipollutant Analysis of Microenvironmental Exposures.
KIRSTEN KOEHLER, Nicholas Good, Christian L'Orange, Anna Molter, Jennifer Peel, John Volckens, *Johns Hopkins School of Public Health*

Air pollutant concentrations vary temporally and spatially and, as such, regional outdoor air monitors do a poor job of representing personal exposures indoors and outdoors. Because particles from different sources may have different toxicity in terms of human health, the ability to apportion human exposure to different sources of air pollutants is desired. The goal of this study was to assess variability of microenvironmental exposures in Fort Collins, Colorado, a typical small city. Participants of the Fort Collins Commuter Study were outfitted with a backpack containing direct-reading monitors to estimate concentrations of fine particulate matter (PM2.5 mass), PM2.5 black carbon, carbon monoxide and ultrafine particle number concentration for 24 hours. By pairing personal monitors with a GPS receiver, we are able to map exposures to microenvironment, sources and activities. Additionally, participants filled out daily surveys about building characteristics and exposure sources in different microenvironments.

We apportioned personal exposures from 44 participants on a total of 350 sampling days into five commonly visited microenvironments: home, work, transit, eatery and other. Exposures tended to be highest in transit and at eateries and lowest at work for all pollutants. An exposure amplification factor (EFa) was defined as the ratio of the fraction of 24-hour cumulative exposure apportioned to a given microenvironment divided by the fraction of time spent in that microenvironment. Transit and Eatery microenvironments tended to have values greater than one for black carbon, carbon monoxide, and particle number concentration exposures, indicating that although these microenvironments account for a relatively small fraction of time, they can be important to cumulative exposures. Additionally, models were developed to describe the distributions of personal exposures and the factors that contribute to within- and between- person variability. Ambient concentrations, geographic covariates, and ventilation characteristics were most predictive of personal exposures.

6AE.3
Variability of Size-segregated PM Mass and Submicrometer Particle Numbers during Perambulations in a Small City.
JAN HOVORKA, Martina Pisova, Cecilia Leoni, Nikola Kuzelova, *Charles University in Prague*

Urban air quality and appropriate personal exposure to PM are usually determined using a network of fixed-site monitors. Nevertheless, true personal exposure to PM may differ from the exposure derived from the fixed-site measurements due to variability of urban microenvironment.

Therefore, an intensive campaign of mobile measurements for PM10, PM2.5, PM1 and submicrometer particle number concentration - PNC was conducted in February 2015 in urbanised area of small city Celakovice, 30 km northeast of Prague, Czech Republic. A person carried two monitors with vertical omnidirectional inlets protruding about 20cm from the backpack. The PM data a GPS position were recorded every 10 second during the perambulation of length 3.2 km conducted at an average speed 5km/h. Totally, 38 perambulations were conducted. Large spatial and temporal variability of the PM was recorded. The highest values of PNC, up-to 40000cm-3, were recorded while crossing and walking alongside of busy streets or passing by cigarette smoker. Also, PNC exhibited large diurnal variation reflecting traffic density. Concentrations of PM1 and PM2.5, up-to 100 micrograms m-3, varied similarly to the PNC though they did not mark traffic such clearly. The highest concentration of PM10, up-to 250 micrograms m-3, reflected pavement surface and proximity to transportation while concentrations of coarse particles, up-to 40 micrograms m-3, was the best tracer of fugitive PM sources at the streets.

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6AE.4
Personal Air Pollution Intake: Combining Spatio-temporally Resolved Exposure and Inhalation Metrics.
NICHOLAS GOOD, Taylor Carpenter, Brooke Anderson, Kirsten Koehler, Anna Molter, Ray Browning, Jennifer Peel, John Volckens, *Colorado State University*

Exposure metrics which account for the amount of pollution inhaled may better elucidate the relationships between air pollution and it's health effects. Personal exposures to black carbon (BC), carbon monoxide, particulate mass and particle number, were assessed alongside biometric measurements (heart rate and activity level) over 30-hour periods of online sampling by members of the public during their daily routine (including pre-designed commutes by car or bicycle). In a follow-up study, minute ventilation was measured during a range of activities, performed in the laboratory and in the real-world with the aim of developing a validated predictive ventilatory model based on simultaneously measured biometric parameters including heart rate and activity.

106 subjects completed exposure or ventilated assessment, resulting in 381 days of exposure data. Participant's location was recorded via GPS and apportioned into different microenvironments (e.g. home, work, commute) using a geospatial algorithm. Exposure was then determined accounting for both duration and inhalation of the pollutants.

Validation of the predictive ventilatory models of varying complexity, based on heart rate and anthropometric variables, showed accuracy from 10% to 30% (RMSE). Our results demonstrate how personal monitoring and estimated inhalation can be used to better assess the relative contributions of different activities to air pollution intake. For example, mean BC exposure was found to be 13% [95% CI, 3%-24%] higher when commuting by bicycle compared to car, however, when ventilation rate and commute duration were accounted for, cycling exposures were estimated to be between 2 and 8 times higher. While only 2-7% (interquartile range) of the day was spent in transit, the combination of enhanced BC levels (1.39 [95% CI, 1.34, 1.44] times higher than the home) and accounting for minute ventilation meant approximately 25% of daily BC intake occurred when commutes were undertaken by bicycle.

6AE.5
Spatial Patterns and Environmental Justice of Traffic Related Pollutants in Pittsburgh, PA.
Yi Tan, Timothy Dallmann, Allen Robinson, ALBERT A. PRESTO, *Carnegie Mellon University*

Our mobile monitoring campaign in Pittsburgh, PA showed substantial spatial variability of traffic related pollutants. The highly time resolved data indicated that pollutant plumes from high emitting vehicles (HEVs) contributed a disproportionately large fraction of the on-road exposures of particle-bound polycyclic aromatic hydrocarbons (PB-PAH) and black carbon (BC). Pollutant concentrations measured at the 42 mobile monitoring sites were the sum of the contribution of HEVs and the non-plume background. In this study, we aimed to develop novel statistical models to understand spatial patterns and environmental justice of PB-PAH and BC. The model consist of a plume layer that described the near road decay of emissions from high emitting vehicles using kernel interpolation, and a background layer that predicted the spatial pattern of the non-plume background using land use regression (LUR). The performance of models was examined using measurements from 36 hold-out validation sites which covered the outer suburbs of Pittsburgh. We employed pollutant concentrations at each house and its fair market value (FMV) to understand environmental justice in residential outdoor exposure. The two-layer model described 76% of PB-PAH variation and 61% of BC variation. The plume layer performed well at validation sites, but the background layer showed little transferability due to the large difference in land use between the city and outer suburbs. On average, HEVs contributed at least 32% of residential outdoor PB-PAH and 14% of BC. Pollutant concentrations at houses with FMV lower than $20k were slightly higher (7% for PB-PAH and 10% for BC) than houses with FMV in the top 10th percentile. The inequality was not driven by emissions from HEVs. The two-layer model developed in this work better predicted pollutant spatial patterns than traditional models. The model indicated that controlling emissions from HEVs could considerably reduce residential outdoor exposure to PB-PAH and BC.

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6AE.6

Diesel Particulate Matter and Coal Dust from Trains. DAN JAFFE, Jon Hee, Francisco Gabela, Juliane L. Fry, Benjamin Ayres, Makoto Kelp, *University of Washington, Bothell, WA, USA*

We have examined the emissions of diesel particulate matter (DPM) and coal dust from trains in the Columbia River Gorge (CRG) of Washington State. This was in response to several proposals to substantially increase rail shipments of coal from the Powder River Basin through the Pacific Northwest enroute to Asia. To support this work we raised funds directly from the public via the crowd-funding platform Experiment.com. In the 2014 measurement campaign, we measured PM1, PM2.5, CO2, and black carbon (BC), along with videos to identify the train type and speed.

During the two-month period, we identified 293 freight trains and 74 coal trains that gave a PM2.5 enhancement of more than 3.0 μg/m3. We found an average PM2.5 enhancements of 8.8 and 16.7 μg/m3, respectively, for freight and coal trains. For most freight trains (52%), and a smaller fraction of coal trains (11%), we found a good correlation between PM2.5 and CO2. Using this correlation, we calculated a mean DPM emission factor (EF) of 1.2 gm/kg fuel consumed, with an uncertainty of 20%. For four coal trains, the videos revealed large plumes of coal dust emanating from the uncovered coal cars. These trains also had the highest peak PM2.5 concentrations recorded during our study (53–232 μg/m3). Trains with visible coal dust were observed for 5.4% of all coal trains, but 10.3% when the effective wind speed was greater than 90 km/h. We also found that nearly all coal trains emit coal dust based on several indicators.

Our results demonstrate that, on average, passage of a diesel powered open-top coal train result in nearly twice as much respirable PM2.5 compared to passage of a diesel-powered freight train. Our work also shows the substantial interest of the public in legitimate investigations on important environmental issues.

6AE.7

In Harm's Way: High-Resolution Modeling of Wildfire Plumes in the Western US for Use in Human Health Studies. WILLIAM LASSMAN, Bonne Ford, Gabriele Pfister, Emily Fischer, Jeffrey R. Pierce, *Colorado State University*

Exposure to high concentrations of particulate matter (PM) present during acute pollution events is associated with adverse health effects. While many anthropogenic pollution sources are regulated in the United States, emissions from wildfires are difficult to characterize and control. With wildfire frequency and intensity in the western U.S. projected to increase [1-2], it is important to more precisely determine the effect that wildfire emissions have on human health, and whether improved forecasts of these air pollution events can mitigate the health risks associated with wildfires.

One of the challenges associated with determining health risks associated with wildfire emissions is that the low spatial resolution of surface monitors means that surface measurements may not be representative of a population's exposure, due to steep concentration gradients. To obtain better estimates of ambient exposure levels for health studies, a chemical transport model (CTM) can be used to simulate the evolution of a wildfire plume as it travels over populated regions downwind. In addition, we intend to use this modelling framework to develop an improved forecasting framework that can be used by decision makers to estimate and potentially mitigate future health impacts.

We use the Weather Research and Forecasting model with online chemistry (WRF-Chem) to simulate the dispersion and chemistry of wildfire plumes from several historic fires in the western United States. We use a coarse grid of 12x12km for the large domain with nested regions close to the wildfire of 4x4km. We will show results from model simulations and comparisons with surface measurements and remote sensing observations from MODIS and GASP satellite products. Using these high resolution data, we can more easily estimate population exposure levels to better characterize the effects wildfire emissions have on human health.

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6AP.1

Scanning Supersaturation CPC Applied as a Nano-CCN Counter for Size-resolved Analysis of the Hygroscopicity and Chemical Composition of Nanoparticles. Zhibin Wang, HANG SU, Xin Wang, Nan Ma, Alfred Wiedensohler, Ulrich Poeschl, Yafang Cheng, *Max Planck Institute for Chemistry*

Knowledge on the chemical composition and hygroscopicity is essential for understanding the formation and evolution of atmospheric aerosol particles. However, relatively little information is available for nanoparticles due to experimental difficulties. We present the design of a nano-cloud condensation nuclei (nano-CCN) counter for the purpose of measuring size-resolved hygroscopicity and interpreting chemical compositions of sub-10 nm particles. Advanced than the previous study, here we extend the use of counting efficiency spectra of condensation particle counter (CPC) and link it to the analysis of CCN activation spectra, which provides a theoretical basis for the modification of CPC to a nano-CCN counter. Since CCN hygroscopicity has been demonstrated as an effective parameter reflecting organic and inorganic mass fractions, the nano-CCN counter may thus provide size-resolved information on the chemical composition of sub-10 nm nanoparticles.

By using calibration aerosols, we show the importance of using activation fraction of aerosol samples to calibrate supersaturation distribution inside CPC and its use in further retrieval of aerosol hygroscopicities. Measurement procedures and data analysis methods are demonstrated through laboratory experiments with monodisperse particles of diameter down to 2.5 nm, where sodium chloride, ammonium sulfate, sucrose and tungsten oxide can be easily discriminated by different characteristic supersaturations of water droplet formation. A near-linear relationship between hygroscopicity parameter kappa and organic mass fraction is also found for sucrose-ammonium sulfate mixtures. Though named nano-CCN counter, the design is not limited to the water-CPC, but also applies to CPCs of other working fluid. We suggest that a combination of scanning supersaturation CPCs with multiple working fluids may provide further insight into the chemical composition of nanoparticles and the role of organic and inorganic compounds in the initial steps of atmospheric new particle formation and growth.

6AP.2

The Crystal Structure of Nanosized Ice Particles Formed in a Supersonic Nozzle. ANDREW AMAYA, Viraj Modak, Harshad Pathak, Michael Bogan, Hartawan Laksmono, Claudiu Stan, Duane Loh, Jonas Sellburg, Raymond Sierra, Sebastien Boutet, Garth Williams, Marc Messerschmidt, Soenke Seifert, Randy Winans, Barbara Wyslouzil, *The Ohio State University*

Supersonic nozzle with cooling rates of about 10^5 K/s are able to probe both vapor-liquid and liquid-solid phase transitions at extreme nucleation rates of ~10^{17} $cm^{-3}s^{-1}$ for vapor-liquid and up to ~10^{22} $cm^{-3}s^{-1}$ for liquid-solid. To examine the structure of ice nanocrystals requires wide angle x-ray scattering experiments with scattering vectors, q, between 1.5 A^{-1} and 3.5 A^{-1}. Experiments at the Free Electron Laser, LCLS, generated 2-D x-ray scattering patterns of ice with concentric rings located at q = 1.72 A^{-1}, 2.79 A^{-1}, and 3.27 A^{-1}. The position and the relative intensities of the peaks suggest that nanometer sized ice crystals created in a supersonic nozzle have a crystal structure that is close to pure cubic ice. To support the FEL experiments, Fourier Transform Infrared Spectroscopy (FTIR) followed the liquid-solid transition for water in more detail, and Small Angle X-ray Scattering (SAXS) determined the size of the ice particles. The SAXS experiments, completed at the Advanced Photon Source (Argonne National Laboratory) on the BESSC 12-ID beamline, found particle sizes of ~10 nm radius. The spectra from FTIR are used to find the fraction of ice, F_{ice}, and together with the particle size to calculate the volume-based nucleation rates, $J_{ice,V}$. The nucleation rates measured here lie between 1.12 x 10^{22} $cm^{-3}s^{-1}$ and 3.17 x 10^{22} $cm^{-3}s^{-1}$. The formation of cubic ice is favored in a supersonic nozzle because of the extreme liquid-solid nucleation rates and the small size of the particles.

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6AP.3
Tandem Mobility-Mass Measurements of Bipolar Ions Generated in a Po-210 alpha Radiation Source. ANNE MAISSER, Jikku Thomas, Carlos Larriba-Andaluz, Siqin He, Christopher Hogan Jr., *University of Minnesota*

Aerosol measurements, especially of particles in the nanometer size range, commonly rely on electrostatic manipulation and measurement. Therefore, particles need to be charged in a controlled way prior to their measurement. A common charging technique is the exposure of particles to ions generated by weak radiation (alpha-, or beta- radiation). The radiation ionizes the gas via electron loss and attachment of the electrons to neutral gas molecules. This leads to equal concentrations of positively and negatively charged ions. As pointed out by previous studies (Steiner et al.) the physical and chemical properties of the ions generated in this manner can vary between experiments; the composition depends upon gas composition and is also influenced by impurities evaporating from tubing walls. To better characterize such ions, we applied differential mobility analysis-mass spectrometry (DMA-MS, with a SEADM P5 DMA and a time of flight mass spectrometer) to measure the ion mass and mobility of Po-210 generated charger ions. Charger ions of both polarities were chemically identified. We used density function theory calculations (DFT) for minimum local energy structure determination of the identified molecules and a non-specular scattering model (Larriba et al.) to calculate mobilities for DFT structures. This enabled direct comparison of the mass-mobility relationship calculated to that found experimentally. Subsequently, the bipolar charge distribution was calculated applying Brownian dynamic simulations (Gopalakrishnan et al.) for varying ion distribution input parameters to determine the dependency of the particle charge state on the ion population.

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6AP.4
Superaggregate Structure in Diffusion Limited Cluster-Cluster Aggregation (DLCA). WILLIAM HEINSON, Chris Sorensen, Amit Chakrabarti, *Kansas State University*

We explore, through Diffusion Limited Cluster-Cluster Aggregation (DLCA) simulations, the structure of superaggregates created in the continuum regime. A superaggregate is a cluster made up of smaller clusters and exhibits different structural properties than its constituent clusters. DLCA superaggregates are made up of many clusters of fractal dimension 1.8 but the superaggregate as a whole has fractal dimension 2.5. We examine how the scaling prefactor k0 develops as clusters crossover from fractal dimension 1.8 to fractal dimension 2.5. We find that as the initial volume fraction decreases the crossover occurs at smaller cluster sizes in a predictable fashion. Moreover by rescaling the super-aggregate size and mass by the average constituent cluster's values, a universal scaling prefactor k0 becomes evident.

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6AP.5
Surface Charge Effects on the Dynamics of Electrodynamically Confined Particles. MATTHEW B. HART, Vasanthi Sivaprakasam, Lee J. Johnson, Jay D. Eversole, *Naval Research Laboratory*

While studying evaporation rates of electrodynamically confined droplets we have observed several phenomena linked to the surface charge of the droplets. These include the sudden reduction in total charge of the droplet and dynamic instabilities in the scattering of light from the droplet leading up to the moment of this sudden change in charge. Among other possible influences, it is theorized that surface charge affects the surface tension of liquids, and thus may play an important role in the evaporation of aerosol droplets and their overall fate in the atmosphere. We use a linear quadrupole apparatus that confines charged particles at the center of a horizontally oriented plane within an environmentally controlled enclosure. The particles are held steady in the vertical dimension by balancing forces that result from the particle mass, an airflow and electrostatic repulsion. The mechanisms of this technique, such as the airflow and electrodynamic confinement, may also play a part in what we observe. We present data showing the observed phenomena and discuss possible aspects in which surface charge may play a role.

6AP.6
Aerosol Morphology Transformations from Humidity Cycling. Thuong Phan, Hemanta Timsina, Dabrina Dutcher, TIMOTHY RAYMOND, Ryan Snyder, *Bucknell University*

The magnitude of aerosol effects on climate strongly depends on size, morphology, and interaction with water. An investigation of these characteristics is essential to both assess the impacts of aerosols as well as their laboratory generation methods. In this work, we investigated the impact on the size and morphology of several compounds through the use of mobility sizing and an atomic force microscopy (AFM) imaging combined with humidification cycling. Some pure chemical species exhibited a change in size and morphology after the humidity cycling process while others did not. Some chemicals formed different types of crystals and/or morphologies depending on the drying and rewetting process.

Dry particles were also collected using a PIXE impactor and analyzed under the AFM. For one chemical species, a bimodal size distribution was produced from fast drying of dilute, atomized aerosol. The AFM image of the 28 nm mode of dry particles shows mostly spherical particles while the 110 nm mode image shows a mixture of rounded and sharp-edged particles. The humidity cycled particles were also collected and analyzed under the AFM. These particles consistently produced 50 nm unimodal size distributions. In other words, the particles crystallize to different forms when they are rehumidified and redried, re-arranging their structures and forming only one type of crystal. The effect occurred both when size-selected 28 nm or 110 nm particles were individually sent through the rehumidification and redrying process - the resulting mode was always 50 nm. We conclude that the 28 and 110 nm modes were simply different mobility shapes of the same total mass that were able to restructure to a common 50 nm mobility size upon exposure to a humid atmosphere. These results have implications for all laboratory aerosol generation methods, interpretations from these laboratory studies, and atmospheric aerosol processing transformations.

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6AP.7

Control of Condensation onto 1-2 nm Particles in Laminar Growth Tubes via Lewis Number Modulation in He-CO2 Gas Mixtures. JIKKU THOMAS, Anne Maisser, Christopher Hogan Jr., *University of Minnesota*

Condensation particle counters (CPCs) can detect particles down to sizes of a few nanometers by exposing them to a supersaturated vapor and growing these particles to macroscopic sizes, followed by optical detection. The supersaturation achieved determines the lowest particle size that can be activated and thus detected. In many laminar flow CPCs, a flow with saturated vapor is introduced into a condenser tube maintained at a cooler temperature, and variable amounts of radial transport of heat and vapor leads to supersaturation in the growth tube. The saturation profile thus achieved strongly depends on the Lewis number (Le), i.e. the ratio between thermal diffusivity of the gas and mass diffusivity of the vapor molecules. When Le > 1, heat transfer occurs faster, leaving supersaturated vapor in the center of the tube. Increasing Le, therefore, directly increases the saturation ratio, enabling condensation onto smaller particles. In this study, we show it is possible to control the Lewis number in a commercially available CPC (TSI 3025 butanol based) by operating the CPC in a gas mixture of CO2 and helium. The Lewis number in He exceeds that in air, while the Le in CO2 is lower; hence, a large range of Le can be achieved by employing He-CO2 mixtures. We show computationally and experimentally (via experiments with tetra-alkylammonium ions), by operating at different gas ratios, the saturation profile inside the growth tube can be changed while all other operation parameters can be kept constant. This shifts the activation efficiency curves of the instrument and thus, is a promising method to use for particle sizing employing only a CPC without requiring any pre-classification.

6BA.1

Bioaerosols Composed of Bacteria or Proteins: A Model of Their Fluorescence and Its Variations with Size and Water Content. STEVEN HILL, David Doughty, Chatt Williamson, Yong-Le Pan, Joshua Santarpia, *US Army Research Lab*

We use a mathematical model of fluorescent bioaerosols composed of bacteria and/or proteins to investigate the size-dependence of the total fluorescence from these and its variation with water content. The model applies to particles which have negligible reabsorption of fluorescence within the particle. The specific particles modeled here are composed of ovalbumin and of a generic Bacillus. The particles need not be spherical, and in some cases need not be homogeneous. The results shown are of spherical homogeneous particles excited at 266 nm. Light absorbing and fluorescing molecules included in the model are amino acids, nucleic acids, and coenzymes. Emission from tryptophan is emphasized. We investigate power law (Ad^y) approximations to for the fluorescence cross section (C_F), where d is diameter, and A and y are parameters adjusted to fit the data, and examine how y varies with d and composition, including the fraction as water. The particle's fluorescence efficiency ($Q_F = C_F$ / geometric-cross-section) can be written for homogeneous particles as $Q_{abs}R_F$, where Q_{abs} is the absorption efficiency of the particle in its specific orientation, and RF, the fraction of the absorbed light emitted as fluorescence, is independent of size and shape. When Q_F is plotted vs. $m_i d$ or $m_i(m_r - 1)d$, where $m = m_r + i\, m_i$ is the complex refractive index, the plots for different fractions of water in the particle tend to overlap, a feature that can help in extracting m_i from a set of measured values.

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6BA.2
Measurements of Changes in the Fluorescence and Viability of Biological Particles Exposed to Outdoor Conditions Outside of Houston, TX. JOSHUA SANTARPIA, Sean Kinahan, Crystal Glen, Andres Sanchez, Matthew Tezak, Steven Storch, Gabriel Lucero, Kevin Crown, Danielle Rivera, Bryce Ricken, Keiko Salazar, Yong-Le Pan, Steven Hill, Mark Coleman, Chatt Williamson, Don Collins, Manuel Salgado, Hawkyard Thomas, *Sandia National Laboratories*

Biological aerosols are studied for many reasons, including their effects on cloud properties as both cloud condensation and ice nuclei. Predominantly, however, biological aerosols are studied for their effects on human, plant and animal health. This can range from allergy to disease and is often concerned with the detection and characterization of bioaerosols used as biological weapons. A variety of methods have been used to study atmospheric bioaerosols. The most common of these are PCR, Immunoassay and the natural ultraviolet fluorescence, the process by which ultraviolet (UV) light is absorbed and re-emitted at a lower energy. In this study, biological particles were examined for changes in the dual-wavelength UV laser-induced-fluorescence (LIF) spectra, viability/infectivity, PCR and immunoassay sensitivity, by seeding particles into a chamber exposed to ambient summer conditions outside of Houston, TX for periods of several hours. The chambers used in this study employ a rotating drum constructed with an exterior FEP Teflon film to allow sunlight to penetrate and an inner ePTFE membrane to allow ambient air and trace gasses to permeate the drum, while still containing the biological particles being studied without any exchange of particles above 50 nm between the chamber and outside air. Biological aerosol particles were sampled with a TSI UV-APS (ex. 355 nm), a Single Particle Fluorescence Spectrometer (ex. 351 and 263 nm) and AGI-30 impinger. Solar intensity, relative humidity and ozone concentration were measured locally, and other meteorological data and air quality measurements were retrieved from a local air quality monitoring site. Early results from this study and comparison to a past study in Adelphi, MD will be discussed.

6BA.3
Real-time Monitoring of Total and Biologically Viable Aerosol Particles in Cleanroom Environments. Boaz Granot, PETER HAIRSTON, Darrick Niccum, *TSI Inc*

Manufacturing of injectable pharmaceuticals, biologic therapeutics, and medical devices must be done in controlled clean areas that are practically free of viable airborne bacteria, and that have low total particle concentrations. Viable and total particle concentration limits in these areas are dictated by regulatory standards created by the U.S. Pharmacopeia (USP) and International Standards Organization (ISO) and similar organizations. These standards set concentration limits that are aligned with the criticality of the process, and include requirements for aerosol monitoring to confirm that the environment is safe for performing the designed tasks. This presentation provides representative results from aerosol measurements in several clean room environments. The data were acquired in real-time with a TSI BioTrak(tm) instrument that samples air at 28.3 L/min and simultaneously measures the optical size and concentration of particles from 0.5 to 25 micrometers, and the size and concentration of viable biological particles from 2.0 to 10 micrometers based on ultraviolet induced fluorescence. In addition, the instrument collects particles from the sampled air onto a gelatin filter for subsequent incubation, growth, and identification of bacterial species. The data show that viable particles tend to arrive in short duration bursts that may not be correlated with the short term total particle concentration. This demonstrates that continuous, real-time total and viable particle monitoring is a useful method to assure clean room quality, to enable quick reaction to contamination events, and to support identification of any contamination sources.

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6BA.4
Protein Biomarkers on Airborne Fungal Spores are Modified by Ozone During Environmentally Relevant Exposures. ODESSA GOMEZ, Anne Perring, Darrel Baumgardner, Mark T. Hernandez, *University of Colorado Boulder*

Microbiological aerosols (bioaerosol) can contribute to a significant portion of atmospheric and indoor particulate matter, and the extent to which gaseous air pollutants can modify surface characteristics of environmentally relevant bioaerosols remains unclear. This work evaluated the potential for common gaseous air pollutants to modify the surfaces of ubiquitous types of airborne fungal spores using established techniques for characterizing the quantity and activity of sentinel proteins in fungal spore coats, including important allergens.

We obtained independent lines of direct evidence for oxidative protein modifications to the cell walls of microbial bioaerosols (pure cultures of young Aspergillus spp. spores) in controlled chamber studies (24 cubic meters) that were maintained under conditions that mimic summer exposures to ground-level ozone at different relative humidity levels. Results show decreases in both particle fluorescence intensity and enzymatic cell wall activity (normalized to spore counts) after only a few hours of ozone exposure. As judged by a portable wideband integrated bioaerosol sensor (WIBS (IV)), differences in specific fluorescence begin to appear within approximately an hour of ozone exposure. Intrinsic enzyme activity also decreased in response to ozone exposure where beta-N-acetylhexosaminidase (NAHA) was used as a biomarker (Mycometer). The NAHA activity was found to decrease after exposure to an average ozone concentration of 200 ppb for less than 2hours. Surface allergen modification assessed by the multiplex array for indoor allergens (MARIA) will also be presented. Preliminary results outlined in this presentation will contribute to limited existing evidence of the impact of atmospherically relevant oxidation processes on bioaerosols present in the outdoor and indoor environments.

6BA.5
A Novel Technology to Study the Longevity of Bioaerosol as a Function of Atmospheric Conditions. ALLEN E. HADDRELL, Mara Otero, Alice Barber, Richard Thomas, Jonathan P. Reid, *University of Bristol*

The need for a detailed understanding of the factors that determine the lifetime of aerosolized microorganisms is crucial to predict and mitigate the outbreak of disease. Although critical, the study of bioaerosol while suspended in air is challenging for a number of reasons: (a) the stable, reliable and gentle generation of a bioaerosol is key to producing consistent results(1); (b) the bioaerosol must be suspended for prolonged periods of time in a stable and controllable environment(2); and (c) the bioaerosol must be readily removed from the gas phase and deposited onto a substrate for further analysis (e.g. to test viability). As a consequence, there is a demand for novel robust technologies to study the viability of bioaerosol.

The ideal device to study bioaerosol would produce and suspend single bioaerosol droplets in a controllable fashion to probe their viability as a function of atmospheric conditions. The absence of a comprehensive tool capable of making reliable measurements while minimizing the amount of damage caused to the microorganism during generation has limited the understanding in this field.

In this study, a novel technology (utilizing electrodynamic levitation) and methodology is presented to reproducibly and gently generate bioaerosol, suspend it in a controlled environment for a prolonged period of time before gently extracting it onto a substrate. Studies of the influence of variables such as relative humidity (RH), gas phase ozone/oxidant concentration, light intensity, aerosol composition and temperature on the longevity and infectivity of various aerosolized bacterial species are possible with this technique. We will report the first demonstration of the utility of this technique and will focus on how RH and aerosol composition affect the longevity of Escherichia coli.

(1) Zhen, H. J.et al, G. J Aerosol Sci 2014, 70, 67.
(2) Verreault, D.; et al. Inhal Toxicol 2014, 26, 554.

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6BA.6
Raman Spectra of Individual Particles for Characterization of Atmospheric Aerosol. STEVEN HILL, David Doughty, Alan Wetmore, *US Army Research Lab*

There is a need for improved instruments which can help characterize individual atmospheric particles without requiring reagents. Intrinsic-fluorescence-based instruments are being used for such characterization. Raman spectra of particles can be far more informative than fluorescence about the chemical composition of individual particles. Although single-particle Raman measurements of atmospheric aerosol have been reported by various researchers, single-particle Raman measurements are not routinely used in atmospheric research.

An instrument which collects particles from air onto a tape, and then measures individual-particle Raman spectra of the collected particles has been developed by Battelle. This instrument is termed the REBS (Resource Effective Bioidentification System). Because the Raman spectra are offset spatially using an image-preserving spectrograph, spectra of several particles can often be recorded simultaneously. Typical measurement times required to measure adequate spectra are within the range of 1 to 60 seconds, depending upon particle size and composition. The REBS can run for up to one month unattended, collecting particles and measuring their spectra. We are exploring the use of this instrument for characterizing harmful aerosols such as infectious particles, allergenic particles such as pollens, fungal spores, and cat allergens, and combustion aerosols generated by burn pits, biomass burning, etc., as well as potentially harmful inorganic particles. Here we illustrate the spectra obtained with laboratory-generated particles and indoor and outdoor combustion generated particles.

6BA.7
On-line Quantification of Anhydrosugars Emitted in the Atmosphere by High Performance Anion Exchange Chromatography with Pulsed Amperometric Detection (HPAEC-PAD). ROLAND SARDA-ESTEVE, Jason Vivarnick, Dominique Baisnee, Christophe Bohard, Olivier Favez, Jean-Maxime Roux, Christophe Bossuet, *CEA*

Online analysis of chemical targets with simple methods is a big challenge. A few sophisticated methods have been recently developed for in-situ analysis of bio-aerosol targets and/or biomass burning tracers, using systems like Particle Into Liquid Sample coupled to Mass spectrometers (PILS-MS). However, such MS-based techniques are cost effective, require complex maintenance, and cannot be easily deployed in the field. In the frame of the Bio Chemical Collectors (BCC) CBRN-E research project, funded by the French Atomic Energy Commission department of Military Application (CEA-DAM), we developed a novel and simpler method to detect atmospheric targets at very low levels. Our concept is to couple a PILS-like collector to a Pulsed Amperometric Detector (PAD). Atmospheric air is firstly injected in a supersaturated water growth chamber. Then, the jet of micrometric droplets which contains the analyst is cooled and collected by a microfluidic device. The liquid sample obtained can finally be injected on any analytical system for the on line analysis of dissolved particles. Our system is also efficient to collect insoluble material like mineral dusts or microorganisms. To test our concept of this new atmospheric collector/concentrator we choose to detect major's anions and biomass burning tracers at low concentration during the winter period at the CEA Atmospheric Observatory in the suburb of Paris. The collection/concentration of liquid samples has been tested on a modified PILS and a small volume of sample collected has been simultaneously injected on Ion Chromatography Systems: ICS 2000 for anions and IC-PAD ICS 5000+, Thermo Fischer Scientific, France for ions and sugars. In our configuration, the Limit of Detection is estimated to be around 10 ng/m3 for Levoglucosan.

This work is supported by the CBRN-E R&D research program from CEA/DAM.

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6CA.1

The Mixing State of Urban Black Carbon: From Single Particles to an Ensemble View. ALEX K. Y. LEE, Megan D. Willis, Robert Healy, Jon M Wang, Cheol-Heon Jeong, Matthew West, Nicole Riemer, Greg J. Evans, Jonathan Abbatt, *University of Toronto*

Black carbon (BC) particles emitted from incomplete fossil fuel combustion and biomass burning can result in a significant warming effect on climate. However, the magnitude of black carbon's impact on the global scale remains highly uncertain and is closely related to its particle-scale physical and chemical properties. In this study, we quantify refractory black carbon (rBC) mixing state in an urban environment using both single particle and bulk measurements from an Aerodyne soot-particle aerosol mass spectrometer (SP-AMS). Cluster analysis of single particle data indicates that rBC is internally mixed with hydrocarbon-like organic aerosol (HOA) in two distinct particle classes: rBC-rich and HOA-rich particles that contain > 60% and < 10% rBC by mass, respectively. Assuming a core-shell particle structure, it is estimated that rBC-rich particles are thinly coated by HOA and have much larger rBC core sizes compared to HOA-rich particles. Positive matrix factorization (PMF) analysis of bulk SP-AMS measurements in a roadside environment demonstrate the presence of two traffic-related source profiles containing different mass fractions of rBC, in agreement with the single particle results. With the support of single particle observations, the PMF results indicate that ~90% of rBC and ~40% of HOA emitted from local sources are contributed by rBC-rich particles in an urban environment dominated by primary emissions. This work provides quantitative insight into the physical and chemical nature of BC-containing particles near emission sources and can be used as a basis for developing our understanding of BC mixing state and its evolution in the atmosphere. The impacts of mixing state on aerosol properties such as cloud condensation nuclei (CCN) activity and single scattering albedo (SSA) will be evaluated based on modeling results.

6CA.2

Long-term Airborne Black Carbon Measurements on a Lufthansa Passenger Aircraft. Jeannine Ditas, Hang Su, Dieter Scharffe, Gavin McMeeking, Yuxuan Zhang, Carl Brenninkmeijer, Ulrich Poeschl, YAFANG CHENG, *MPIC*

Aerosol particles containing black carbon are the most absorbing component of incoming solar radiation and exert a significant positive radiative forcing thus forming next to CO2 the strongest component of current global warming. Nevertheless, the role of black carbon particles and especially their complex interaction with clouds needs further research which is hampered by the limited experimental data, especially observations in the free and upper troposphere and lower stratosphere.

In August 2014, a single particle soot photometer (SP2) was included in the extensive scientific payload of the CARIBIC (Civil Aircraft for the Regular Investigation of the atmosphere Based on an Instrument Container) project. CARIBIC is in operation since 1997 and carries out systematic observations of trace gas and aerosol sampling and on-line analyses at 10-12 km altitude. For this a special air freight container combining different instruments is transported on a monthly basis using a Lufthansa Airbus A340-600 passenger aircraft with destinations from 120°W to 120°E and 10°N to 75°N. The integration of a SP2 offers the possibility for the first long-term measurement of global distribution of black carbon and so far flights up to April 2015 have been conducted.

Up to date the SP2 measurements have been analyzed for flights over four continents from Munich to San Francisco, Sao Paulo, Tokyo, Beijing and Cape Town. The first measurements show promising results of black carbon including periods when background concentrations in the UTLS were encountered. Beside a general distribution of number and mass of black carbon particles, peak events were detected with up to 20 times higher concentrations compared to the background. Moreover, high concentration plumes have been observed continuously over a range of 10,000 km. Interestingly, our results show also a generally lower amount of black carbon mass in the tropics compared to the mid latitude northern hemisphere.

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6CA.3
A 3D Particle-resolved Model to Quantify the Importance of Black Carbon Mixing State for CCN Properties.
JEFFREY H. CURTIS, Nicole Riemer, Matthew West,
University of Illinois at Urbana-Champaign

Field observations show that black carbon is mixed with other aerosol species on an individual particle level. These mixtures evolve in the atmosphere as a result of aerosol aging processes, which impacts the black carbon optical properties and CCN activation properties, and hence the black carbon climate impact. To deal with such high-dimensional and multi-scale data, aerosol models have traditionally made simplifying assumptions regarding the particle composition. While this makes computation much cheaper, it introduces errors, since it artificially averages the composition of individual particles over a certain size range.

Recently, particle-resolved aerosol models have been introduced to avoid making a priori assumptions about the evolution of particle composition. These stochastic models simulate a representative group of particles distributed in composition space, treating coagulation, condensation/ evaporation, and other important processes on an individual particle level. Here we show the first simulation of the particle-resolving aerosol physics and chemistry model PartMC-MOSAIC, fully coupled to the Weather Research and Forecast model (WRF). We apply this model to investigate the aging of black carbon particles in a plume, where aerosol microphysics and chemistry interact with transport.

To quantify the importance of black carbon mixing state on CCN properties, differences in CCN concentrations between particle-resolved and composition-averaged simulations are evaluated as a function of mixing state parameter chi, which is a metric to characterize the degree of internal mixing of the aerosol population. It varied from 50% internally mixed near the emission sources to 100% downwind of the plume. For chi values larger than 90%, composition-averaging introduced only small errors in CCN concentrations. For chi lower than 60% the CCN concentrations were overestimated by as much as 90%.

6CA.4
Unconstrained Climate Impacts of Biofuel Combustion Due to Uncertain Carbonaceous Radiative and Cloud Effects.
JOHN KODROS, Catherine Scott, Salvatore Farina, Lee Yunha, Christian L'Orange, John Volckens, Jeffrey R. Pierce,
Colorado State University

Prevalent combustion of biofuel as a source of energy for domestic tasks emits large quantities of black carbon and organic aerosol, causing potentially large impacts to air quality and climate. While reducing aerosol emissions through improving technologies is a necessary step for improving health and lifestyle in developing regions, the net effect on climate is largely unconstrained due to large uncertainties surrounding black carbon's radiative and cloud effects. We use the chemical transport model, GEOS-Chem, with TOMAS microphysics to explore the sensitivity of the direct and cloud-albedo indirect effects due to uncertainties from black and organic carbon emission factors, optical mixing state, and modeled nucleation and background secondary organic aerosol. We find the direct radiative effect is strongly dependent on assumed mixing state, absorptivity of organic aerosol (brown carbon), and the emissions BC to OA ratio, while the cloud-albedo indirect effect is strongly dependent on emissions mass, aerosol size distribution, and choice of model nucleation and secondary organic aerosols. In the global average, the direct effect ranges from -0.02 to +0.06 W m^{-2} and the indirect effect ranges from +0.01 to -0.02 W m^{-2}, with larger magnitude effects in source regions. We find the sign of the net climate effect from biofuel combustion emissions uncertain, thus substantially limiting our ability to introduce mitigation strategies aimed at reducing black carbon to counter warming effects from greenhouse gases.

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6CA.5

Measurements of Absorption Enhancement at High Relative Humidity Using Short-Pulse Photoacoustic Spectroscopy. JAMES RADNEY, Christopher Zangmeister, *National Institute of Standards and Technology*

The absorption strength of aerosols is enhanced at high relative humidity compared to dry conditions. This enhancement can arise from multiple mechanisms ranging from the development of a core-shell morphology or the particle growth through water uptake. While this enhancement is well documented, its direct measurement using photoacoustic spectroscopy has remained elusive; to date, photoacoustic measurements of humidified aerosols have observed minimal enhancement relative to expectations. In many instances, signal depression is actually observed. Photoacoustic signals are generated from the heating and concomitant cooling of aerosols by a high intensity source. This heating and cooling generates a pressure wave that can be detected by a microphone. At high humidity, some of the absorbed energy volatizes particle bound water instead of being transferred completely into thermal energy for the acoustic wave. While volatizing water does generate some signal (as an increase in pressure), it represents only a fraction of the thermal energy that should have been released. Here, we will demonstrate a photoacoustic technique using a short-pulse supercontinuum laser with a high repetition rate (78 MHz, 650 ps pulse width) that allows for the measurement of absorption enhancement at high relative humidity (> 75%). We will also show that for ethylene soot, the absorption enhancement can be greater than 50% even when a change in particle mass (as measured using an aerosol particle mass analyzer) is not detectable and that significant changes in the absorption Angstrom exponent are also observed.

6CA.6

Seasonal Variation of Urban Carbonaceous Aerosols in Nanjing, a Typical City in Yangtze River Delta, China. Jie Zhang, YU ZHAO, *Jiangsu Provincial Academy of Environmental Science*

PM2.5 samples were collected by season to characterize the carbonaceous component in urban Nanjing, a typical city in the west part of Yangtze River Delta (YRD, one of the regions with the most developed economy and severe atmospheric pollution in China). The organic carbon (OC) and elemental carbon (EC) was differentiated using the thermal optical reflectance method. The average concentrations of PM2.5, OC and EC during the study periods were observed to be 117.6, 13.8, and 5.3 μg/m3 respectively, with all the highest levels in winter. The mass fraction of the total carbonaceous aerosol (TCA) in PM2.5 was estimated at 23% on average, lower than those reported for other cities in the YRD. The OC and EC correlated well in all the seasons, especially in spring and winter, implying that OC and EC were attributed to common emission sources. Good correlation was observed between OC and estimated K+ from biomass burning in the harvest season in autumn and summer, indicating biomass burning a significant source of carbonaceous aerosols. With EC-tracer method, the ratios of primary OC to EC, (OC/EC)pri, were estimated to range 1.27-1.85 by season, with an annual average at 1.59, higher than the ratio from a bottom-up emission inventory for the city at 1.38. Secondary organic carbon (SOC) was the highest in winter (7.3 μg/m3) followed by autumn (6.7 μg/m3), summer (3.7 μg/m3) and spring (2.0 μg/m3). However, the SOC/OC in winter was not as high as that in summer and autumn, implying the high concentration of OC in winter was probably due to the stable weather but not mainly caused by SOC formation. The high SOC/OC ratio in summer was attributed to stronger oxidation, which could be suggested by higher sulfur oxidation ratio (SOR).

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6CA.7
Comparison of Ambient Absorption Measured Using a CAPS PMssa Monitor and AE33 Aethalometer at DEM GAW Athens. Stergios Vratolis, Timothy Onasch, Kostas Eleftheriadis, ANDREW FREEDMAN, *Aerodyne Research, Inc.*

Direct in situ measurements of the aerosol absorption coefficient are difficult to achieve with high accuracy and confidence for ambient conditions. Among all available optical absorption or light attenuation methods, the Aethalometer is the most frequently used technique to measure real-time BC mass concentrations and subsequently atmospheric absorption coefficients. In contrast, a newly available instrument, the CAPS PMssa, which simultaneously measures the total aerosol extinction and scattering coefficients on the same sample volume, has the capability of directly providing the absorption coefficient by subtraction. We present absorption measurements obtained using this instrument and those obtained by a new Aethalometer model (AE33), which attempts to correct the “spot loading effect” evident in previous models. These continuing measurements were performed at the DEM GAW station in Athens, Greece starting in August 2014. During this period, the station was mainly influenced by local contamination sources (predominantly vehicle emissions from the city center and Piraeus port). For the most part, within the uncertainties associated with the both instruments, the agreement is good. A notable diurnal cycle is observed in data from both instruments corresponding to the morning and evening traffic rush hours. This is a result partly explained by the formation and transport mechanisms known to govern the occurrence of carbon containing particles

6CT.1
A Mini-baghouse to Control Respirable Crystalline Silica Dust Generated by Sand Movers. EMANUELE CAUDA, Art Miller, Barbara Alexander, Eric Esswein, Micheal Gressel, Jerry Kratzer, Amy Feng, Bradley King, *NIOSH*

Exposure risks to workers at oil and gas extraction sites include respirable crystalline silica (RCS). Repeated exposure to respirable crystalline silica can cause serious or even fatal diseases, including silicosis and lung cancer. To reduce exposures, National Institute for Occupational Safety and Health (NIOSH) researchers have developed a mini-baghouse assembly prototype, to be mounted on the thief hatches on top of sand movers, one of the largest sources of dust generation. This contribution presents the results of the performance evaluation of the NIOSH mini-baghouse prototype. The performance of the mini-baghouse was tested by collecting respirable dust samples on and around the sand mover operating with and without the control technology installed. A single trial test was repeated several times to minimize the effect of variable atmospheric condition, especially wind, around the mini-bag house by collecting sufficient data for statistical analysis. Two approaches were used to analyze the samples. The majority of the samples were analyzed by an accredited laboratory for respirable dust and RCS. Results indicate that use of the mini-baghouse effectively reduced both respirable dust and RCS downwind of the thief hatches. Reduction of airborne respirable dust concentrations ranged from 85% to 98%, and reductions in airborne RCS concentrations ranged from 79% to 99%. In addition, a small portion of the collected samples was analyzed on the field right after collection by using an innovative field-based silica monitoring solution currently investigated by NIOSH. The finding generated by the two analytical approaches were compared and the field-based monitoring solution showed accurate assessment the performance of the mini-baghouse.

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6CT.2
Characterizing the In-Situ Size-Resolved Removal Efficiency of Residential and Light-Commercial HVAC Filters for Particle Sizes between 0.01 and 10 Micro-meter.
TORKAN FAZLI, Brent Stephens, *Illinois Institute of Technology*

The majority of human exposure to airborne particles occurs inside buildings. Higher efficiency particle air filtration in heating, ventilating, and air-conditioning (HVAC) systems is increasingly being relied upon to reduce indoor exposures to particulate matter, but most filtration rating systems evaluate the particle removal efficiency of filters only for particles 0.3–10 micro-meter in diameter. Because the vast majority of particles in indoor environments (by number) are smaller than 0.3 micro-meter in size, including ultrafine particles (UFPs: particles less than 0.1 micro-meter), our current filtration rating systems fail to address a key portion of indoor aerosols. Therefore in this project, an in-situ test method is used to measure the particle removal efficiency of a wide range of commercially available HVAC filters in 28 particle size ranges from 0.01-10 micro-meter in diameter. The test procedure involves measuring particle concentrations upstream and downstream of an HVAC filter installed in a residential air-handling unit in a controlled and unoccupied residential apartment unit. Size-resolved particle removal efficiency is calculated by subtracting the average ratio of downstream-to-upstream pollutant concentrations from unity. A combination of TSI NanoScan SMPS and TSI Optical Particle Sizer are used for this purpose. We also characterize the impacts of filter pressure drop on system airflow rates using a flow plate device. Different filters with various minimum efficiency rating values (MERV) ranging from MERV <5 to HEPA are being tested from a variety of manufacturers. Preliminary results demonstrate that the removal efficiency of filters with MERV <5 ranged from only 0% to 30% for all particle sizes, while the removal efficiency of MERV 8 filters ranged from 0% to 44% for all particle sizes. These data are now being compiled into a database for engineers and exposure scientists to use to improve modeling efforts and decision-making.

6CT.3
Low-Pressure Particle Filtration Measurements.
Meilu He, SURESH DHANIYALA, Matthew Wagner, *Clarkson University*

Pall metal filters are widely used in semiconductor industry for inline control of contamination in high-purity precursor gases. These filters are usually deployed with gas lines operated at low pressures, but their performance characteristics have only been studied under atmospheric pressure because of the challenges of sub-atmospheric filter testing. In this project, the particle capture performance of the filter was studied experimentally and theoretically as a function of its operating pressure. The experiments were designed to minimize artifacts associated with multiple charging effect that can be amplified under low pressure conditions. The filter penetration results show that the penetration is lower with non-spherical particles compared to spherical particles and the measurement difference between the two type particles increases with increasing particle size and decreasing operating pressure. Measurements were made to a minimum pressure of 4.5 kPa with a commercial condensation particle counter (CPC; TSI 3010) modified for low pressure operation. The experimental results together with the classical filtration theory were used to obtain effective filter parameters. Using these effective filter parameters, acceptable agreement between theoretical predictions and experimental results under ambient and sub-ambient pressures when the inhomogeneous filtration model of Dhaniyala & Liu (2001) is applied for the prediction. In aerodynamic slip flow regime the slip boundary condition is applied for the prediction, while in the transition flow regime the prediction based on non-slip boundary condition has better agreement than that from the slip boundary condition. Using a universal geometric standard deviation of the packing density distribution, filter penetration performance can be calculated at any flowrate and operating pressure with high accuracy.

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6CT.4
Effect of Relative Humidity and Particle Material on Filter Loading. QISHENG OU, David Y. H. Pui, Allan Ouyang, *University of Minnesota*

The filter dust holding capacity depends on the properties of the particles that are trapped in/on the filter as well as the environmental conditions where the filter is in operation. In the standard test method, such as the ISO 5011 and ASHRAE 52.2, dry coarse dust particles are typically used, and the relative humidity is only regulated at a wide range. However, depending on the application and service location, many filters are used in an environment where particles exhibit much smaller size distribution in sub-micrometer range and various chemical compositions. In order to more precisely predict the lifetime of the filters utilized in the practical conditions, these filters need to be tested with particles with similar size, morphological and chemical properties and under similar humidity condition. In this study, filter loading behaviors were tested with several types of particles in both super-micrometer and sub-micrometer size range, under a wide range of relative humidity condition. Factors that affect the filter loading behaviors were investigated.

Two different methods were used to generate submicrometer particles, which may mimic fine mode particles from different emission sources. A home-made atomizer followed by diffusion drier was used to generate nearly spherical particles. A propane flame was used to generate fractal-like agglomerates. ISO 12103-1 A2 dust was dispersed to present the coarse mode aerosol in the atmosphere, which is the standard test aerosol specified in ISO 5011:2014. These laboratory generated particles were loaded on a 57-mm diameter flat filter media. The relative humidity in the system was controlled and monitored during the experiments. A wide range of relative humidity from 10% to 90% was tested to investigate its effect on loading together with particle properties. The pressure drop of the tested filter media was monitored during the loading. The penetration evolution during the loading were measured by Scanning Mobility Particle Sizer (SMPS) for fine particles and Aerodynamic Particle Sizer (APS) for coarse particles. More results with different filter media, particle types and size ranges will be presented in the talk.

6CT.5
PM2.5 Loading Characteristics of Commercial Indoor Electret HVAC and Air Cleaner Filter Media. MIN TANG, Sheng-Chieh Chen, De-Qiang Chang, David Y. H. Pui, *South China University of Technology, University of Minnesota*

Particulate matter, PM, a major component of outdoor air pollution, has been classified as carcinogenic to humans in October of 2013 by the World Health Organization specialized cancer agency, the International Agency for Research on Cancer, IARC. Noticeably, PM2.5 contributes the essential toxicity of ambient PM, which not only can easily infiltrate into indoor environment but also get into deeper human lung. China and its sounding countries, Korea and Japan are frequently hit by high PM2.5 pollutions and filtration techniques such as indoor air cleaners and central HVAC systems are more and more widely applied to mitigate the human exposure. In these equipment, electret filter media are used but the existing test standard, ASHRAE 52.2-2012, only challenges the filter with particles larger than 300 nm. Therefore it's urgent to challenge these electret media with PM2.5 and nanoparticles to get a more accurate performance of these media against the existing smaller indoor particles.

In this work, penetrations of commercial electret media used in HVAC and air cleaners against simulated PM2.5 down to 3 nm were tested along different loading mass of PM2.5. Results show that the electrostatic effect is more significant for particles larger than 20 nm. In comparison, the mechanical diffusion deposition plays an important role for nanoparticles smaller than 20 nm. The PM2.5 holding capacity varies significantly with the mass concentration of the PM2.5 in the feed. The lower PM2.5 concentration results in a higher PM2.5 holding capacity, which is expected to be associated with the collapse and formation dynamics of the particle dendrite. For acquiring a more realistic loading characteristic for the widely used electret media, it is recommended that the test method in ASHRAE 52.2-2012 might be modified.

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6CT.6
Numerical Simulation of N95 FFR Efficiency Relative to Aerosol Size Distribution. PATRICK O'SHAUGHNESSY, Joel Ramirez, *University of Iowa*

The “95” in the designation “N95” of a filtering facepiece respirator (FFR) refers to the lowest efficiency provided by the respirator occurring at any one airborne particle diameter. It therefore does not indicate the percent reduction in aerosol concentration; a quality of a respirator that is referred to as a protection factor. The objective of this study was to use numerical simulations to determine a protection factor that occurs without leaks for an N95 subjected to aerosols derived from a range of lognormal size distributions. The simulations were also conducted to determine those factors that influence FFR efficiency relative to breathing resistance. Using the best available equations that model the performance of an N95 FFR, including fiber charging effects, an overall model of N95 efficiency across a wide range of particle sizes (1 nm to 100 micrometers) was developed. This effort resulted in an efficiency curve relative to particle size for a typical N95 FFR with a minimum efficiency of exactly 95%. With that curve, the mass of all particles collected by the filter could be computed to determine a protection factor of the FFR. The protection factor was determined for 42 spherical, unit-density aerosols with mass median aerodynamic diameters (MMAD) ranging from a 2 – 14 and geometric standard deviations (GSD) from 1.6 - 3.6. The worst-case aerosol occurs when then the MMAD is low and the GSD is high. This results in a wide distribution of small particles that overlap the N95 efficiency curve in the region where it dips to 95%, which occurs between 0.01 – 0.3 micrometers. Regardless, this FFR has a PPF of 99.86% for all mass and 99.79% for respirable mass for the lowest MMAD (2) and highest GSD (14) analyzed. Dusts with MMAD’s > 4 micrometers had protection factor values above 99.96% regardless of GSD.

6CT.7
Inactivation of Bacteria by Nanotechnology-Based Consumer Spray Products. JENNIFER THERKORN, Leonardo Calderón, Benton Cartledge, Brian Majestic, Gediminas Mainelis, *Rutgers, The State University of New Jersey*

Nanoparticles are being increasingly incorporated into everyday consumer spray products, like household cleaners and cosmetics. The impacts of these aerosolized nanomaterials on the bacteria to which we are exposed are currently unknown. This research investigates bacterial inactivation caused by consumer nanospray products. Six commercially available Ag-based nanospray products, including cosmetic and antifungal sprays, were investigated. Minimal inhibitory concentration (MIC) tests were performed using agar plate dilution method for two bacteria commonly used for hardy vs. sensitive species in bioaerosol studies (Escherichia coli and Bacillus atrophaeus). Some nanoproducts with advertised antimicrobial properties were found to be ineffectual while other nanoproducts inhibited microbial growth with MIC’s ranging from 40,000 to 160,000 ppm. Nanoproducts and controls were aerosolized using 3-jet Collison nebulizer and released particles were sampled out of a chamber using an Andersen six-stage cascade impactor onto spread-plated bacterial films of E. coli and B. atrophaeus. Controls included 20 nm and 1 micrometer inert polystyrene latex particles in ethanol to mimic impaction stress of agglomerated nanoproduct particles. By observing inactivation spots in bacterial films post plate incubation, one deodorizing product and one lime scale removing product caused inactivation on impactor stages for particles > 2.1 micrometer. As inactivation was not seen for controls nor other nanoproducts sampled with higher mass than the inactivating products, inactivation appeared to be nanoproduct-specific. ICPMS explored metals present in these nanoproducts and single-particle-ICPMS explored the size distribution of nanosilver once aerosolized. Inactivating products typically had lower total silver concentration compared to ineffectual products. However, as determined by single-particle-ICPMS, inactivating nanoproducts had smaller mean diameter of silver particles (20 – 30 nm) vs. ineffectual nanoproducts (40 – 50 nm). The relationships between liquid and aerosol phase particle size and nanoparticle inactivation efficacy requires further investigation. Future tests will investigate inactivation of bacteria by nanospray particles in airborne phase.

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7AG.1

Creating and Evaluating a New National Inventory for Livestock Ammonia Emissions in the United States.

ALYSSA MCQUILLING, Peter Adams, *Carnegie Mellon University*

As sulfur dioxide and nitrogen oxide emissions have decreased in recent years, the role of ammonia in particulate matter formation has come under greater scrutiny. In order to understand the role of ammonia in PM formation, we must first accurately estimate the amount of ammonia emitted in the United States, paying particular attention to its spatiotemporal distribution. In the United States, livestock account for roughly 70% of all ammonia emissions (UESPA, 2004); thus, capturing the variability in these emissions is critical to accurately modeling their impacts. The seasonal cycle of the emissions is especially important as PM generally is more sensitive to ammonia in colder, winter months. In order to estimate these emissions from major livestock sectors (cattle, swine and poultry) we have developed and evaluated a set of farm emissions models (FEMs), semi-empirical process-based models. A national emissions inventory is developed based on these FEMs, in conjunction with important regionally-specific animal practices data from US Department of Agriculture (USDA), and animal population data from the most recent USDA Agricultural Census, and meteorological inputs from the National Climate Data Center (NCDC). This is the first time that an inventory has been done with process-based modeling underlying all the major livestock sectors. This simulated inventory is being evaluated through its implementation in a chemical transport model to predict gas and particulate ammonia and ammonium concentrations. The model will be run using emissions from the National Emissions Inventory from 2011, version 2 as a base case in CAMx, and our livestock ammonia inventory (from our process-based model) will be used to evaluate the changes observed due to spatiotemporal variability in emission factors related to meteorology and manure management. Additionally, the inventory will be evaluated by comparing predicted concentrations to observations from the National Atmospheric Deposition Program and the Ammonia Monitoring Network.

7AG.2

Characterization of the Oxidation Chemistry of Secondary Aliphatic Amines Under Dry and Humid Conditions.

DEREK PRICE, David R. Cocker III, *University of California, Riverside*

Secondary aliphatic amines are observed in the emissions from agricultural processes. It is important to understand the chemistry occurring from these emissions to improve atmospheric modelling in rural areas and in locations where rural and urban emissions may mix. A set of well characterized environmental chamber experiments were conducted on four secondary aliphatic amines (dimethylamine, diethylamine, dipropylamine, and dibutylamine). In these experiments, an amine was injected into the environmental chamber followed by an oxidant such as hydroxyl radical or nitrate radical. The experiments were repeated at 30% relative humidity. The chemical composition of the gas phase species was measured with a selected ion flow tube – mass spectrometer (SIFT-MS). A scanning mobility particle sizer (SMPS) was employed to measure the concentration and size distribution of the secondary organic aerosol produced. The chemical composition of the particle phase was measured with a high resolution – time of flight – aerosol mass spectrometer (HR-ToF-AMS) and a particle into liquid sampler – time of flight – mass spectrometer (PILS-ToF-MS). Differences were observed in the resultant aerosol properties (density, size, composition) among the secondary aliphatic amine precursors. The type of oxidant influenced the particulate matter and ozone concentration, as well as the reaction chemistry. For instance, the formation of carcinogenic nitramines was observed in the reactions with nitrate radical. Additionally, particulate matter concentration was greater with nitrate radical oxidation. The presence of water in the humid experiments provided alternate reaction pathways with select secondary aliphatic amine precursors.

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7AG.3

Investigating the Regional Scale Impacts of Amine-Sulfuric Acid New Particle Formation. JAN JULIN, Benjamin Murphy, Tinja Olenius, Oona Kupiainen-Määttä, Lars Ahlm, Saeed Falahat, David Patoulias, Christos Fountoukis, Hanna Vehkamäki, Spyros Pandis, Ilona Riipinen, *Stockholm University*

New particle formation (NPF) is an important contributor to atmospheric particle number concentration, and therefore an accurate description of the NPF process is essential for large-scale models to be able to correctly predict atmospheric particle number and its sensitivity to available gas phase species. Sulfuric acid is a central compound involved in atmospheric NPF, but to account for observed formation rates other compounds such as ammonia or dimethylamine are needed. Since both ammonia and amines are base compounds, they act to stabilize the sulfuric acid containing clusters and thus to enhance nucleation rates. Agricultural activities, specifically animal husbandry, are an important emission source of both ammonia and methylamines. While atmospheric amine concentrations are much smaller than the ammonia concentration, the role of amines in atmospheric NPF cannot be neglected as they have been shown to enhance formation rates over thousand-fold compared to ammonia.

PMCAMx-UF is a three-dimensional regional chemical transport model, which includes detailed aerosol microphysics and simulates both number and mass/composition size distributions. Thus far PMCAMx-UF has included two NPF pathways: ternary sulfuric acid-ammonia-water and binary sulfuric acid-water. For the present work we have updated PMCAMx-UF to include amines. As a central feature the updated version now also includes the sulfuric acid-dimethylamine NPF pathway in addition to the two aforementioned NPF mechanisms. The model has previously used a semi-empirical description for the ammonia NPF pathway, but in the updated version we treat both the ammonia and dimethylamine NPF pathways with an approach based on first-principles theory. The implemented NPF schemes are based on formation rate data produced by the Atmospheric Cluster Dynamics Code, which utilizes state-of-the-art quantum chemistry results to calculate cluster evaporation rates. We will present results where the updated version of PMCAMx-UF is applied to the European domain to assess the impacts of sulfuric acid-dimethylamine NPF.

7AG.4

Inhalable Particle Exposures in Northern Colorado Dairies. KIMBERLY ANDERSON, Josh Scaeffer, John Mehaffy, Jessy Tryon, Amanda VanDyke, Mary Bradford, Stephen Reynolds, T. Renee Anthony, Darrah Sleeth, John Volckens, *Colorado State University*

Exposure to bioaerosols is associated with adverse health effects such as cross-shift and longitudinal lung function decline, asthma, chronic bronchitis, wheeze, and cough. Agricultural workers are at particularly high risk of exposure to bioaerosols. Traditional methods to assess exposure to particles rely on the 37-mm closed faced cassette (CFC) sampler. However, the CFC undersamples particles >20 microns. The Personal Inhalable High-Flow Sampling Head (PHISH) sampler is a new low-cost, disposable inhalable sampler that operates at 10 L/min. This study evaluated worker exposures in four dairy parlors using PHISH and 37-mm CFC samplers. Sampling was conducted over the winter and spring. Samples were analyzed gravimetrically and compared between the PHISH and CFC. Mass concentrations for the PHISH sampler were on average 2.5 times higher than those observed for the CFC. Ratios between the PHISH and CFC sampler ranged from 0.54 to 3.39. Mass concentrations from area samples using the PHISH sampler were 1.4 times higher compared to the CFC samplers. Size distribution data collected during several of these field visits confirmed the presence of large airborne particles (> 20 microns aerodynamic diameter). This work highlights the importance of large particle exposures in several Colorado dairies and the need for improved exposure assessment (and control) technologies in agricultural settings.

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7AG.5
Viability and Particle Size Distribution of Airborne Influenza Virus from Acutely Infected Pigs. Montserrat Torremorell, CARMEN ALONSO, Peter Raynor, Peter Davies, *College of Vet Med, University of Minnesota*

Transmission of airborne influenza A virus (IAV) depends in part, on the particle size that the virus associates with. This association will influence the distance the particles (and associated viruses) are transported, the location of deposition within the respiratory tract after inhalation, and the survivability and infectivity of IAV in aerosols. Thus, the objective of this study was to characterize the size distribution of the particles that transport airborne IAV, and assess the virus viability for each particle size range.

A group of 10 out of 12 pigs were intra-nasally and intra-tracheally infected with an H1N1 IAV (4.4x106 TCID50/ml). Pigs were sampled daily for shedding and air samples were collected for 1 hour using an Andersen cascade impactor (ACI) sampler able to collect particles as a function of particle size (8 stages that measure particles from 10 to 0.4 microns). Total airborne particles were analyzed using an optical particle counter. Oral fluids, clinical signs, coughing and lethargy scores were collected at each air sampling event. Samples were analyzed by quantitative RT-PCR IAV, and virus viability tested on MDCK cell culture. Total quantity of virus RNA per volume of air (m3), and total particle counts by size (0.3-10 µm) and day were analyzed during the study.

IAV was detected in air samples collected for 9 days after infection. IAV was detected in all particle size ranges in quantities ranging from 4.2x102 RNA copies/ m3 in the smallest particles (0.4-0.7µm) to 3.63x106 in the largest particles (9.0-10.0µm). Results from virus viability demonstrated the presence of infectious IAV in particles larger than 2.1µm.

Our results indicate that IAV can be found in a wide range of particle sizes while airborne. There was higher quantity of virus in larger particles and virus viability was dependent on the size particle the IAV viruses associated with. This information is important to assess the risk of airborne transmission of IAV.

This project was founded by the National Pork Board and University of Minnesota Signature Program

7AG.6
Filter Evaluation Methodology for Swine Barn Applications. JOHN HORNS, Christine Loza, Kelly Sater, Scott Dee, *3M*

Intake air filtration in swine barns has been shown to reduce disease outbreaks at the facility. While standardized test methodologies exist for evaluating filter performance, e.g., ASHRAE 52.2, the challenge aerosol and air flow conditions are not representative of a barn environment. A new filter performance test methodology was developed using a test duct configuration amenable to use in a biosafety containment facility, air flow rates relevant to a swine barn, and an organic/viral challenge bioaerosol. The test methodology evaluates filter performance for particle diameters 10 nm to 10 microns, a larger size range than typically used for such filter performance evaluations, to match conditions observed at existing swine facilities. Details of the methodology and performance of various filter types will be discussed.

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7AG.7
Identification of Meteorological Predictors of Spore Release of Fusarium Graminearum. RAY DAVID, Amir BozorgMagham, David Schmale, Shane Ross, Linsey Marr, *Virginia Tech*

The global food supply is being stressed by changing climate, a growing population, and harmful diseases. One risk to vital cereal crops such as wheat and barley is Fusarium head blight, which is caused by the plant pathogen Fusarium graminearum, whose spores can be transported long distances through the atmosphere. The overall goal of this research is to improve the ability to predict and control the spread of Fusarium head blight. Our specific research objectives are to identify the meteorological conditions that favor spore release and to quantify the emission rate of spores; this rate can then be used in a transport model to predict the spread of the disease.

We obtained spore release data from field experiments in which a wheat field was artificially inoculated with F. graminearum, and we applied correlation and causality analyses to determine relationships between meteorological conditions and spore concentrations. While correlation analysis reveals statistical relationships between variables, causality analysis recognizes the causal agent and direction of influence within a relationship. Correlation and causality analyses identified significant relationships between spore release and solar radiation, wind speed, air temperature, and relative humidity.

We further described the relationship between spore release and meteorological conditions through controlled laboratory experiments. We assessed spore release in a chamber with controlled temperature, relative humidity, and light. Results show the sensitivity of spore release to relative humidity (75%, 85%, and 95%) and temperature (15°C and 25°C). The knowledge gained from these studies will inform growers about the likelihood of spore release events, allowing them to make timely field management decisions and enabling improved land management decisions.

7CC.1
Surfactant Effect on Cloud Condensation Nuclei for Two-Component Internally Mixed Aerosols. SARAH SUDA PETTERS, Markus Petters, *North Carolina State University*

Cloud condensation nuclei (CCN) are essential for the formation of clouds. Their abundance, size, and chemical composition of can affect the cloud's microphysical properties and albedo. Thus the ability of aerosols to serve as CCN is central to their role in climate. The CCN activity of internally mixed particles can be predicted from the averaged CCN activity of the chemical components. However, surface active compounds alter a particle's CCN activity by reducing droplet surface tension and partitioning to the droplet surface. Here we present experimental data on the CCN activity of particles composed of two-component mixtures of surfactants and non-surfactants. We tested eleven binary systems using strong ionic (sodium dodecyl sulfate) and non-ionic surfactants (Zonyl FS-300 and Triton X-100) and three non-surfactant compounds (glucose, ammonium sulfate, and sodium chloride), with 20–30 mixing fractions per system. We also tested for kinetic limitations to surfactant partitioning in nascent droplets by introducing a humidification and delay pre-treatment before some CCN activation measurements, allowing additional time for the surfactant to equilibrate. Our results show that kappa values for cloud droplet activation can deviate up to 100% relative to predictions made from measurements of bulk surface tension and simplified versions of Köhler theory that account for surface tension reduction and surface partitioning. The data obtained with and without humidification were indistinguishable within measurement uncertainty, suggesting that dynamic surface tension does not need to be considered in Köhler theory. We anticipate our results describing the CCN activity of mixed aerosols including surfactants may be used to improve the understanding of CCN activity for complex ambient aerosols.

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7CC.2

CCN Activity of Amazonian Aerosols: Diel and Seasonal Variations. Ryan Thalman, Chongai Kuang, Stephen Springston, Gunnar Senum, Arthur J. Sedlacek, Thomas Watson, JIAN WANG, Suzane Simoes de Sa, Scot Martin, Lizabeth Alexander, Brett Palm, Weiwei Hu, Douglas Day, Pedro Campuzano-Jost, Jose-Luis Jimenez, Henrique Barbosa, Paulo Artaxo, Rodrigo A. F. Souza, Antonio O. Manzi, Mira Krüger, Ulrich Poeschl, *Brookhaven National Laboratory*

During the Green Ocean Amazon (GoAmazon) 2014/5 campaign size-resolved cloud condensation nuclei (CCN) spectra were collected and characterized at a measurement site (T3) 5 hours downwind of the city of Manaus (pop. 2 million). These measurements ran from March 12, 2014 to March 3, 2015. Particle hygroscopicity (κ_{CCN}) and chemical mixing state were derived from the particle activation spectrum measured by size selecting aerosols and exposing them to a wide range of supersaturation in the CCN counter. The supersaturation was varied between 0.07 and 1.1% by changing a combination of both total flow rate and temperature gradient in the CCN counter. During October 2014, measurements were also made in combination with the Oxidation Flow Reactor (OFR) system coupled to an Aerosol Mass Spectrometer (AMS). This enabled evaluation of a range of measured organic particle hygroscopicities with respect to indicators of oxidation (f_{44} and O:C) as measured by the AMS and the Aerosol Chemical Speciation Monitor (ACSM). We observe overall diel trends in κ_{CCN}, its dispersion ($\sigma_\kappa/\kappa_{CCN}$), hygroscopicity of the organic components of the aerosol (κ_{org}), and f_{44} for all of the seasons and air mass sources. We discuss the factors contributing to the changing particle hygroscopicity throughout the day with respect to air mass sources and relative to the regional background aerosol. The annual κ_{CCN} trend ($\kappa_{CCN} = 0.14 \pm 0.04$ (wet season), 0.12 ± 0.04 (dry season)) can, for the most part, be explained by the changing aerosol composition and contributions from the various air mass sources encountered by the T3 site; that is, regional background changes during the transition from the wet to dry season from clean to heavily influenced by biomass burning. Background conditions are sampled in ~19% of the available data while polluted and biomass burning conditions each make up ~40% of the available data.

7CC.3

How will Modern Light-Duty Diesel Vehicles Modify CCN? DIEP VU, Daniel Short, Georgios Karavalakis, Thomas D. Durbin, Akua Asa-Awuku, *University of California, Riverside*

Emission control technologies are globally used to mitigate air pollution from anthropogenic sources. Control technologies, such as diesel particulate filters (DPFs), efficiently filter and remove particulate mass. However, the number of ultrafine particles emitted during the regeneration of a DPF can increase by several orders of magnitude. In addition, these regenerated aerosols may have different chemical and physical composition from the original emissions source. The change in physicochemical aerosol properties during the filtering and regeneration process may greatly affect their potential to serve as cloud condensation nuclei (CCN). While the CCN activity of emissions during normal vehicle operation has been characterized, the CCN activity of aerosols derived from the regeneration of DPFs has not been investigated. This research measures the CCN activity of aerosols derived from the regeneration of DPFs. Modern light duty diesel vehicles equipped with DPFs before and during regeneration were tested on a chassis dynamometer. Real-world vehicle conditions are simulated with the highway fuel economy test cycle (HWFET). Baseline testing (non-regeneration) was completed using a federal ultra-low sulfur diesel (ULSD) over a HWFET cycle. Regeneration testing was completed over the HWFET for both a ULSD and a soy based biodiesel blend to ascertain fuel effects. Results show that both changes in fuel and the regeneration process can modify the CCN activity of vehicle emissions. The global impact of the changes in hygroscopicity will be discussed.

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7CC.4

The Relationship of Hygroscopicity Parameter of Organic Aerosols to Their Oxidation Level. FAN MEI, Jian Wang, Qi Zhang, Jose-Luis Jimenez, Shan Zhou, Ari Setyan, Patrick Hayes, Amber Ortega, Jianzhong Xu, Jonathan Taylor, James Allan, *Pacific Northwest National Laboratory*

Atmospheric aerosols strongly influence the global energy budget by scattering and absorbing sunlight (direct effects) and by changing the microphysical structure, lifetime, and coverage of clouds (indirect effects). Currently, the indirect effects of aerosols remain the most uncertain components in forcing of climate change over the industrial period. This large uncertainty is in part due to our incomplete understanding of the ability of aerosol particles to form cloud droplets under climatically relevant supersaturations. The physical and chemical properties of organic aerosols (OA) are highly complex, due to complicated atmospheric processes, and making their characterization challenging.

During three field campaigns, size-resolved cloud condensation nuclei (CCN) spectrum and aerosol chemical composition were characterized, at an urban supersite (Pasadena, CA, CalNex-LA in 2010), and two urban downwind supersites (Cool, CA, CARES in 2010 and Upton, NY, ALC-IOP in 2011). At west coast sites, monodispersed aerosol particles were first classified using a differential mobility analyzer at sizes ranging from 25 to 320 nm. The activation efficiency of the classified aerosol, defined as the ratio of its CCN concentration (characterized by a DMT CCN counter) to total CN concentration (measured by a condensation particle counter, TSI 3771), is derived as a function of both particle size and supersaturation, which ranges from 0.08% to 0.39% during CalNex-LA and 0.15% to 0.45% during CARES. At east coast site, the characterized size range focused on 70-250 nm and the supersaturation range was from 0.11% to 0.78%. Aerosol chemical composition was characterized using a high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS).

At three sites, the overall hygroscopicity of particles (κCCN, Petters and Kreidenweis, 2007, ACP) is derived from the size-resolved CCN measurements and ranges from 0.15 to 0.35 under the measured supersaturations. Positive matrix factorization (PMF) analyses of HR-ToF-AMS measurements are carried out and the organics O:C ratios are examined in a relatively wide range (0.3-0.7). Based on the particle hygroscopicity and aerosol chemical composition, the organics hygroscopicity (κOrg) is also derived. And we will examine the correlation between organic aerosol hygroscopicity and oxidation level and compare them to other laboratory studies.

7CC.5

Size-Resolved Measurements of Ice Nucleating Particles at North American and European Sites. RYAN H. MASON, Meng Si, Cédric Chou, Victoria Irish, Robin Dickie, Pablo Elizondo, Rachel Wong, Miranda Brintnell, Michael Elsassar, Walfried Lassar, Kyle Pierce, Kaitlyn J. Suski, Jonathan Abbatt, Paul DeMott, Thomas Hill, J. Alex Huffman, W. Richard Leaitch, Annie-Marie Macdonald, Andrew Platt, Roland Sarda-Esteve, Corinne L. Schiller, Desiree Toom-Sauntry, Allan Bertram, *University of British Columbia*

Ice nucleating particles (INPs) are a small fraction of the total aerosol population capable of catalyzing ice formation under atmospheric conditions. The formation, albedo, and lifetime of mixed-phase and cirrus clouds may be influenced by the presence of such particles. Compared to ambient measurements of the total number concentration of INPs, relatively little data exists on the size distribution of INPs in the atmosphere. This size information may be useful in source identification, modeling the transport of INPs in the atmosphere, and for determining if common instrumentation captures the majority of the atmospheric INP population. Measured using the micro-orifice uniform deposit impactor-droplet freezing technique (MOUDI-DFT), we report immersion-mode INP number concentrations as a function of particle size at several ground-level sites across North America and Europe, including Arctic, alpine, coastal, marine, agricultural, and suburban environments. More than 91 % of INPs active at -15 °C were found to be supermicron in size and 62 % were in the coarse mode (> 2.5 μm). While these percentages decreased with decreasing temperature, supermicron INPs remained important with nearly half of those active at -25 °C belonging to the coarse mode.

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7CC.6
Contact Freezing of Water by Simple Ionic Compounds.
JOSEPH NIEHAUS, Will Cantrell, *Michigan Technological University*

Heterogeneous freezing is responsible for the initial formation of ice in the lower to mid troposphere, where temperatures are rarely low enough for homogeneous freezing. Heterogeneous freezing at such temperatures is typically through the immersion/condensation mode, where the catalyzing substance is immersed within bulk water. Contact freezing, so-called because the catalyzing substance is at the air-water interface (i.e. in contact with it), is also possible. Published results (Niehaus et al., 2014; Hoffman et al., 2013) show that ice nucleating particles become active in the contact mode before the immersion mode. Particles which are effective ice nucleators in the contact mode are assumed to be good immersion ice nuclei as well. We will present results which contradict that assumption. In tests using water droplets at moderate supercoolings (-9 to -16 C), we see freezing initiated by particles composed of the ionic compounds NaCl, NaI, KCl, KI, NaOH, and KOH. Although soluble substances typically depress the freezing and melting point, if the water is previously supercooled then the impact of the particles with the surface of the liquid can trigger freezing. We have ruled out the endothermic cooling hypothesis (Knollenberg, 1969) by demonstrating that NaOH and KOH, which have exothermic heats of dissolution, cause freezing. The warmest temperature at which contact freezing occurs in these tests exhibit a composition dependence; for example, NaCl is a less efficient nucleator than NaI. The highest freezing temperature achievable by the compounds also scales with the density of the compound. We will discuss these experimental results in light of various mechanisms for contact freezing which have been proposed.

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7CC.7
The Effect of Particle Size, Shape, and Composition on Ice Nucleation.
DAVID BELL, Jacqueline Wilson, Naruki Hiranuma, Ottmar Möhler, Harald Saathoff, Josef Beranek, Gourihar Kulkarni, Dan Imre, Alla Zelenyuk, *Pacific Northwest National Laboratory*

Aerosol particles affect the Earth's radiation balance directly by scattering and absorbing solar radiation and indirectly, by serving as cloud condensation nuclei (CCN) and ice nuclei (IN), thus determining properties of clouds. The relationship between the properties of aerosol particles and clouds remains the most uncertain aspect in our current understanding of climate change.

Here we present the results of recent studies, in which we applied our single particle mass spectrometer (miniSPLAT) to investigate the effect of particle size, shape, and composition on its ability to serve as ice nuclei (IN). The IN studies were conducted in the Aerosol Interaction and Dynamics in the Atmosphere (AIDA) chamber at the Karlsruhe Institute of Technology and in our laboratory, using compact ice chamber (CIC).

The experiments in the AIDA chamber were conducted on a large number of aerosol types that include illite, kaolinite, feldspar, Saharan dust, Argentinian soil dust, soot, pollen, bacteria, cellulose, SOA-coated feldspar, sulfuric acid coated illite, feldspar, and soot, and others. Prior to cloud formation miniSPLAT was used to characterize the compositions and vacuum aerodynamic diameters (dva) of overall aerosol population and the size-dependent effective densities and dynamic shape factors of mobility- and mass-selected particles.

Following cloud formation, the compositions and dva distributions of activated and un-activated particles are characterized and compared with the overall population. Preliminary results indicate that IN residuals are larger and have slightly increased Pb content. These findings bear a close resemblance to our observations for the experiments conducted in CIC chamber on size-selected Arizona Test dust and volcanic ash particles.

Furthermore, we find that when activated, soot particles underwent a dramatic change in morphology, as the fractal particles collapsed into compact structures.

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7CH.1

Effects of Sulfate Seed Particles on Secondary Organic Aerosol Formation from α-pinene Photooxidation. JIMING HAO, Biwu Chu, Hideto Takekawa, John Liggio, Shao-Meng Li, *School of Environment, Tsinghua University*

Understanding of the effects of inorganic seed particles on secondary organic aerosol (SOA) formation is important for revealing SOA formation mechanisms. In this work, α-pinene/NOx and α-pinene/HONO photooxidation as well as α-pinene ozonolysis experiments were conducted in smog chambers in the presence or absence of different sulfate seed particles. SOA yields were significantly influenced by the presence of sulfate seed aerosols in both photooxidation and ozonolysis of α-pinene. Under similar conditions, less SOA with a higher oxidation degree as indicated by its O/C ratio was generated from both ozonolysis and OH-oxidation experiments in the presence of ferrous or ferric sulfate (FeSO4 or Fe2(SO4)3) seed aerosols compare to that in the presence of zinc sulfate or ammonia sulfate (ZnSO4 or (NH4)2SO4).

This decreasing effect of FeSO4 seed particles on SOA mass varied with humidity in the chamber experiments. FeSO4 seed particles decrease SOA mass as long as water was present on the seed particle surface, but have no decreasing effect on SOA under dryer conditions at 12% relative humidity (RH). The decreasing effect of FeSO4 seed particles on SOA mass is proposed to be related to metal-mediated oxidation of organics in the surface layer of water on the seed particles. Free radicals, including OH, can be formed from catalytic cycling of Fe2+ and Fe3+ in the aqueous phase. These radicals can react further with the organic products of α-pinene oxidation on the seed particles. It is hypothesized that both functionalization and fragmentation of organics may happen during the metal-mediated aerosol-phase oxidation, resulting in the increase of oxidation level and the decrease of mass concentration of the SOA.

The gap in the SOA yields between experiments with different seed aerosols was more significant in OH-oxidation experiments compare to ozonolysis experiments. The different degrees of the mass decreasing and oxidation level increasing between the ozonolysis and OH-oxidation experiments may be resulted from the different oxidation levels of the generated SOA from gas-phase reaction in the two systems.

7CH.2

Importance of Water to Heterogeneous Reaction of Peroxides on Authentic Particles. Qinqin Wu, Liubin Huang, Hao Liang, Yue Zhao, Dao Huang, ZHONGMING CHEN, *Peking University*

Peroxides, including hydrogen peroxide (H2O2) and organic peroxide, play important roles in the oxidative capacity of atmosphere and the formation of secondary aerosols formation. Here we present the laboratory study of the heterogeneous reaction of H2O2 and peroxyacetic acid (PAA, an important organic peroxide) on authentic PM2.5 particles, and we compare their heterogeneous behaviors on PM2.5 particles with those on authentic Asian Mineral Dust (AMD) particles and Arizona Test Dust (ATD) particles. It is found that the uptake coefficient (γ) of H2O2 and PAA on authentic particles (PM2.5 and AMD) has a positive correlation with relative humidity (RH), while γH2O2 and γPAA on ATD show a negative correlation with RH. Moreover, on PM2.5 particles, γPAA is more sensitive to RH variation than H2O2 does. Considering the larger Henry's law constant of H2O2 than that of PAA, we suggest that the chemical process dominate the uptake of peroxides on PM2.5, rather than the physical process. The composition analysis result shows that the concentrations of NO3- and SO42- in PM2.5 and AMD particles are 1-3 order of magnitudes larger than those in ATD particles. We suggest that in addition to the traditionally recognized the surface active sites (e.g., OH groups, lattice oxygen), the soluble ions have potential effects on the heterogeneous reaction of peroxides on authentic particles. The existence of soluble ions might promote the formation of aqueous film with RH increasing and enhance the aqueous reaction of peroxides. The reaction on the standard test dust particles could not well represent the real atmospheric heterogeneous reaction, especially under humid conditions.

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7CH.3
Chemical and Optical Properties of Carbonaceous Aerosol in China. MEI ZHENG, Caiqing Yan, Jing Cai, Xiaoying Li, Yanjun Zhang, *Peking University*

The strong correlation between high concentrations of $PM_{2.5}$ with low visibility has been found in cities in China where haze episodes occur. Sources of carbonaceous aerosol can be classified into two major source types based on the ^{14}C analysis (fossil and modern source). A few methods are combined in order to confirm and quantify the importance of fossil carbon in megacities in China (Beijing and Shanghai). The ^{14}C method provides quantitative estimate of contribution from modern and fossil source to organic carbon and water-soluble organic carbon (WSOC). During winter, about 75% to WIOC (water-insoluble organic carbon) and about 50% of WSOC are due to fossil source in Beijing. Low-temperature residential coal combustion is non-negligible during the colder season in this region. Functional groups of organic aerosol can be identified by Fourier-transform infrared transmission spectroscopy (FTIR). The contribution from aromatic CH in Beijing is much higher than that observed in samples in the U.S., where aromatic CH is rarely reported due to its low concentration. The high aromatic CH in the Beijing samples indicates the importance of anthropogenic sources in Beijing.

Therefore, carbonaceous aerosol in China is not only often associated with much higher concentration, but also higher fraction of anthropogenic sources. The light absorption of water-soluble organic carbon is measured. The spatial and temporal analyses show that the highest light absorption of WSOC is found in Beijing during winter. The comparison with chemical and optical properties of Chinese coal samples from source tests indicates that coal is an important contributor to brown carbon in Beijing during winter. A single particle aerosol mass spectrometer (SPAMS) is used to identify the mixing state of BC and the relationship with its optical properties is also examined. This presentation aims to identify several unique characteristics of carbonaceous aerosol in megacities in China compared to other countries such as the United States. These characteristics includes sources, light absorption, mixing state, etc.

Keywords: Carbonaceous Aerosol, Sources, Chemical and Optical Properties, Megacities, China

7CH.4
Vertical Profiles of Aerosol Optical Properties and NO_2 during two Severe Haze Episodes in Beijing. QINGQING WANG, Wei Du, Chen Chen, Weiqi Xu, Tingting Han, Dongsheng Ji, Zifa Wang, Yele Sun, *Inst. of Atmospheric Physics, Chinese Academy of Sciences*

The formation of severe haze episodes interacts closely with atmospheric boundary layer (ABL). However, our knowledge of vertical profiles of aerosol characteristics and gas precursors in urban Beijing is rather limited. Here we report the results from two vertical experiments that were conducted from Nov. 19th to 21st, 2014, and Jan. 12th to 16th, 2015, at an urban site in Beijing. The vertical profiles of particle extinction, absorption, and gaseous NO_2 from ground surface to 260 m were measured by a Cavity Attenuated Phase Shift (CAPS) extinction monitor, an Aethalometer, and a CAPS NO_2 monitor, respectively. Collocated measurements of submicron aerosol composition (organics, sulfate, nitrate, ammonium, and chloride) were also carried out at ground surface with a high-resolution time-of-flight aerosol mass spectrometer and 260 m on the Beijing 325 m meteorological tower with an aerosol chemical speciation monitor. We observed very dynamic vertical evolution of aerosol optical properties and NO_2 during the two severe haze episodes indicating a complex vertical mixing process and aerosol chemistry in the ABL. The vertical profiles of aerosol and gaseous were also found to interact closely with those of meteorological variables. Based on the vertical profiles from the two experiments, a concept framework describing the vertical evolution of ABL and its interactions with air pollution in Beijing was established. There are two special heights, the height of ABL and the height of the surface aerosol layer. Air pollution usually has significant differences at the height of the surface aerosol layer and the height of ABL respectively during daytime and nighttime.

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7CH.5

A Modeling Study of Secondary Organic Aerosol in China: Spatial and Temporal Variations and Precursor Contributions. PENG WANG, Hongliang Zhang, Jianlin Hu, Qi Ying, *Texas A&M University*

In this study, a modified SAPRC-11 photochemical mechanism with more detailed treatment of isoprene oxidation chemistry and additional secondary organic aerosol (SOA) formation through surface-controlled reactive uptake of dicarbonyls (glyoxal and methylglyoxal), isoprene epoxydiol and methacrylic acid epoxide was incorporated in the Community Multiscale Air Quality Model (CMAQ) to quantitatively determining the spatial and temporal distribution of SOA in China in the entire year of 2013. The modified model utilizes a precursor-origin resolved approach to determine secondary glyoxal and methylglyoxal produced by oxidation of isoprene and other major volatile organic compounds (VOCs) such as long chain alkanes and aromatic compounds. The anthropogenic emissions are based on the Multi-resolution Emission Inventory for China (MEIC) and the biogenic emissions are estimated using the Model of Emissions of Gases and Aerosols from Nature (MEGAN) v2.1. Seasonal variations of SOA in different regions of China will be determined and regions with high SOA concentrations will be identified. In each region, relative contributions of different precursors to SOA will be quantified. The predicted PM2.5 concentrations will be evaluated using all available PM2.5 measurements across China and predicted SOA concentrations will be evaluated using published oxygenated organic aerosol (OOA) concentrations derived from data collected by aerosol mass spectrometers (AMS). This is the first regional SOA modeling study which uses the best available emission data and includes recent updated understanding of SOA formation pathways.

7CH.6

Simulation of Organic Aerosols in China with Two-dimensional Volatility Basis Set. Shuxiao Wang, BIN ZHAO, Neil Donahue, Xiaofeng Huang, Jiming Hao, *Tsinghua University*

Organic aerosols (OA) account for about 20-50% of the PM2.5 concentrations across China, and 20-80% of them are secondary organic aerosol (SOA). However, most widely-used chemical transport models cannot explain either the amount or the degree of oxidation of SOA. In this study, we improved the simulation of OA and SOA in China with a state-of-the-art two-dimensional volatility basis set (2D-VBS). Firstly, we simulated a series of photo-oxidation experiments using the 2D-VBS box model in order to determine the parameterization of 2D-VBS for application in three-dimensional chemical transport models. The simulation results indicate that the first-generation oxidation of traditional SOA precursors should be treated explicitly, and three parallel layers of 2D-VBS with different configurations should be applied to simulate the aging of anthropogenic SOA, the aging of biogenic SOA, and the multi-generation oxidation of primary organic aerosol (POA)/Intermediate Volatility Organic Compounds (IVOC). Based on the configuration above, we developed the CMAQ/2D-VBS chemical transport model, and evaluated its simulation results against field measurements. The evaluation results indicate that CMAQ/2D-VBS significantly improved the simulation results of OA and SOA concentrations, and the simulated O:C, which reflects the oxidation state of OA, agrees well with the observations in most sites. According to CMAQ/2D-VBS, the aging of traditional SOA, the aging of POA, and the oxidation of IVOC together enhance the OA and SOA concentrations in eastern China by about 40% and 10 times, respectively. Anthropogenic non-methane volatile organic compounds (NMVOC), biogenic NMVOC, POA, and IVOC contribute 9%, 5%, 40%, and 46% of the average OA concentrations in eastern China, respectively, and 11%, 7%, 24%, and 58% of the average SOA concentrations, respectively. The results imply that we should pay special attention to the control of IVOC and POA emissions in order to reduce SOA concentrations.

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7CH.7

Sources of Organic Aerosol during Severe Haze Episodes in Beijing. CAIQING YAN, Mei Zheng, Orjan Gustafsson, Carme Bosch, August Andersson, Xiaoying Li, Huaiyu Fu, *Peking University*

Organic aerosol (OA), a substantial fraction of fine particles, plays an important role on human health and climate. Due to its abundance in atmospheric aerosol and its optical properties, significantly high concentration OA in China could contribute to air quality deterioration, health impact, and visibility reduction. Severe haze episodes occurred frequently in the past few years in Beijing, China. The objective of this study is to better understand sources of OA and its evolution during haze episodes. Dual carbon isotope (radiocarbon isotope ^{14}C and stable carbon isotope ^{13}C) measurements were performed on total organic carbon (OC) and water-soluble organic carbon (WSOC) in fine particles collected in summer and winter haze episodes of 2013 in Beijing. Thus, contributions from biomass/biogenic and fossil sources to different sub-fractions of OA (WSOC and water-insoluble organic carbon, WIOC) can be determined. Our results showed that fossil source contributed more than biomass/biogenic source to WIOC (~75%) as well as WSOC (~56%) during winter, while biomass/biogenic source contributed more to WSOC (~65%) and WIOC (~68%) in summer. With the dual carbon isotope signatures ($\Delta^{14}C$ and $\delta^{13}C$), fuel types of biomass/biogenic and fossil sources as well as atmospheric processing of organic aerosol during haze episodes were investigated. To further explore the evolution of OA during haze episodes, high-time resolution single particle aerosol mass spectrometry (SPAMS) was also applied to examine variation of its sources as well as its size distributions. Results from the offline and online measurements will be also compared and integrated to characterize OA during summer and winter haze episodes.

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7IM.1

Aerosol Surface Area as an Alternative Metric for Source Testing, Ambient Air Monitoring, and Health Effect Study. HEEJUNG S. JUNG, *University of California Riverside*

Measurement of aerosol (or particle) surface area has been interest of aerosol community. Aerosol surface area is a good measure of adsorbed (toxic) material particles carry into the lung, therefore it should provide a good correlation with particle health effects. While BET surface area is an ideal measure, it is not practical for routine air monitoring purpose due to the sophisticated set up and procedure required for the measurement.

The presentation will re-illuminate definition of different types of aerosol (or particle) surface areas such as BET, Fuchs, and active surface area and discuss limitation and capability of aerosol surface instruments. Some suggestions will be made with respect to what the best surface area would be if we consider to use it as an alternative metric for ambient monitoring and source testing. If time allows measurement data from source testing for light duty vehicles, on-road air monitoring, and ambient air monitoring will be presented as well with respect to evaluating usefulness of aerosol surface area measurement as an alternative metric.

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7IM.2
Design and Performance Improvements of the Miniature Electrical Aerosol Spectrometer. ISHARA JAYASURIYA, Suresh Dhaniyala, *Clarkson University*

The Miniature Electrical Aerosol Spectrometer (MEAS) (M. Ranjan and S. Dhaniyala, 2007, 2008) is an electrical mobility based particle sizing instrument that is compact in size (~10cm x 2cm x 5cm), and has fast response (<1s). In the MEAS, charged particles are size segregated based on their electrical mobility and these particles are captured on different collection plates. The resulting current signal from the collected particle population is measured by using a high end electrometer or a source meter. Since sampling and detection are simultaneous operations, real-time size distribution measurements are possible with MEAS. Special electrostatic filtration system in the instrument enables single flow, low pressure drop instrument. In this study, design and performance of the MEAS is revisited and improved upon for a field deployable real time mobility instrument. The MEAS performance improvements are made in three areas: aerosol classification, signal detection, and charged conditioning. The latest technology on 3D printing and low current measurements techniques are implemented to eventual miniature, portable, and sensitive design. While establishing the theoretical principles of these improvements, the design criteria and performance improvements will be discussed in detail.

7IM.3
Aerosol Mobility Imaging for Rapid Size Distribution Measurements. Steven Spielman, Susanne Hering, Chongai Kuang, Jian Wang, TAMARA PINTERICH, *Aerosol Dynamics Inc.*

The Aerosol Mobility Imaging (AMI) system aims to provide an aircraft-deployable electrical mobility particle sizing system that spans the 10nm – 500 nm size in a single snapshot. The AMI builds on two established technologies: the Fast Integrated Mobility Size Spectrometer developed by Kulkarni and Wang, and laminar flow water-based condensation methodology of Hering and co-workers. As with conventional scanning mobility particle spectrometers, the AMI system has a drift tube to separate particles of differing electrical mobility. The mobility-separated particles are enlarged through water condensation along their flow trajectories, and their positions and concentration within the channel are captured via a digital image. The growth region is designed using a “moderator” stage (Hering et al, 2014) to remove excess water vapor so as to provide the necessary condensational enlargement without risking condensation on the downstream optical components. Rather than sampling one size fraction at a time, as done with traditional mobility sizing systems, all particles are captured at once, with data acquisition rates of 10Hz.

Initial experiments were done using a single electrode, with a constant voltage across the plates of the mobility drift tube. This has now been adapted to the wide-range mobility separation concept outlined by Wang. The wide range mobility sizing uses a complex electrode, with multiple separation voltages at different positions along the width of the electrode. This provides a two-dimensional size separation. Mono-mobility particles are separated in an arc across the channel, with the higher mobility particles distinguished at one end of the channel, and the lower mobility particles separated at the other end. This approach provides simultaneous size separation of particles from 10 to 500 nm.

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7IM.4
Classifying Nanoparticles with the Aerodynamic Aerosol Classifier: Monodisperse Classification without Particle Charge Artifacts. JASON S. OLFERT, Charlie Lowndes, Jonathan Symonds, Kingsley Reavell, Mark Rushton, *University of Alberta*

The Aerodynamic Aerosol Classifier (AAC) classifies particles by their relaxation time (or aerodynamic diameter). The AAC consists of two rotating coaxial cylinders. The aerosol enters through a gap in the inner cylinder and is carried axially by particle-free sheath flow. Between the rotating cylinders, the centrifugal force causes the particles to move in the radial direction. Particles with a narrow range of aerodynamic diameters exit the classifier through a gap in the outer cylinder with the sample flow. Particles with larger aerodynamic diameters impact and adhere to the outer cylinder and particles with smaller aerodynamic diameters exit the classifier with the exhaust flow.

Unlike the differential mobility analyser (DMA) or centrifugal particle mass analysers (CPMA or APM) the classification does not depend on the electrical charge state of the particles. Therefore, the AAC is a preferred classifier where a truly monodisperse aerosol is desired.

Previously work has shown theoretical models of the transfer function of the AAC, experimental validation of those transfer functions, and tandem measurements using an AAC and DMA to measure particle mass, effective density, mass-mobility exponent, and dynamic shape factor.

In previous work most of the measurements were made between ~100–1000 nm in aerodynamic diameter due to the limited rotational speed of the first prototype AAC. Recently, a new prototype AAC has been developed with a much higher maximum rotational speed.

The AAC was tested using a scanning mobility particle sizer (SMPS). Atomized NaCl was passed through the AAC operating at a fixed rotational speed. Aerodynamic diameters ranging down to 23 nm were successfully measured.

7IM.5
Development of a Geometrical Surface Area Monitor for Nanoparticles: Experiments and Models. LEO N.Y. CAO, Jing Wang, Heinz Fissan, David Y. H. Pui, *University of Minnesota*

Compared to particle size, number, or mass concentration, geometric surface area (GSA) correlates better to catalytic activity, drug delivery, particle reactivity, and human health for ultrafine particles. However, there is no cheap, portable instrument which can measure it.

We are developing a portable instrument to deliver GSA for arbitrarily shaped particles in the range of 25 to 400 nm in real time by unipolar charging method.

A unipolar diffusion charger is used to charges particles and an electrometer measures the final electrical current generated by the collection of those charged particles. Between them, a custom-built electrostatic precipitator (ESP) is used to control the penetration of charged particles by applying different voltage such that the final current is proportional to GSA. A CFD simulation of the penetration of charged particles through the ESP was conducted via Fluent.

We found the measured current is proportional to the diameter to the power of 2.03 and 1.98 (or effectively GSA) for monodisperse particles from 25 to 100 nm and from 100 to 400 nm for ESP applied voltages of 0.15 and 1 kV, respectively. Numerical simulations show similar penetration results for the ESP compared to experimental data.

For particles in the range of 25 to 400 nm, current results validate our proposed design for an instrument to measure GSA for spherical particles. Future work will focus on extending the instrument's capability towards arbitrarily shaped nanoparticles.

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7IM.6
Traceable Calibration of Detection Efficiencies of Optical Particle Counters using Inkjet Aerosol Generator.
KENJIRO IIDA, Kensei Ehara, Hiromu Sakurai, *AIST*

National institute of advanced industrial science and technology (AIST), Japan, launched a calibration service for evaluating the counting efficiencies of optical particles counters (OPCs). The values are evaluated using a monodisperse aerosol generator which can precisely control the particle generation rates. The device is called AIST-inkjet aerosol generator (AIST-IAG) which is the primary standard for particle count rates of OPCs at AIST. In the menu for the calibration serve, particle count rates range from 10 /s to 100 /s, particle diameter ranges from 0.5 um to 10 um, sampling flowrates of OPC, Q, range from 0.3 L/min to 30 L/min, and particle materials are sodium chloride, ammonium sulfate, and water soluble ionic liquid. Aerosol flowrate of AIST-IAG cannot exceed 1 L/min; therefore, when the value of Q is greater than 1 L/min, clean sheath-air is added at a sampling inlet to complement the value of Q. The value of Q can be measured traceably upon request to express the values of E in terms of particle number concentration. For example, the ranges of concentrations are 0.02-0.2 /cm3 and 2-20 /cm3 when the value of Q are 30 L/min and 0.3 L/min, respectively. In this presentation calibration results for four OPCs whose sampling flowrates are 0.3, 0.5, 2.83, and 28.3 L/min. The expanded uncertainties of the counting efficiencies, U(k=2), were evaluated in the plateau region of the size-dependent counting efficiency curve when the particle generation rate of the AIST-IAG was fixed at 100 /s. The values of U(k=2) based on particle count rates ranged from 0.0025 to 0.0027. In terms of the particle number concentration the values ranged from 0.0044 to 0.0046. The results demonstrates that the AIST-IAG can calibrate OPCs accurately. This calibration method can potentially become an alternative to the calibration methods documented in ISO 21501-4 or JIS B 9921.

7IM.7
Theoretical Modeling of Aerosol Lifetimes in a Rotating Drum Aerosol Chamber. MATTHEW BROWN, Steven Cevaer, Erin M. Durke, Suresh Dhaniyala, *Clarkson University*

Understanding the fate of airborne particles in the atmosphere requires knowledge of their long-term transformation on exposure to different environmental effects such as gases, sunlight, etc. Often such studies have involved particle measurements in large-volume chambers with controlled environments, where the life-times of large particles are often limited to a few hours. For longer term measurements of a wide-range of particle sizes, we investigate the usage of a rotating-drum aerosol chamber, as first proposed by Goldberg (1958). In a rotating drum, Gruel el al. (1987) theorized that a steady-state balance between gravity-induced settling and centrifugal forces resulted in an optimal drum rotation rate as a function of particle size. The method was further explored and built upon by Asgharian and Moss (1992), accounting for transient particle loss due to gravity at extremely low rotation rates (~1e-3 rpm). In revisiting these calculations with numerical simulations, we determine that calculations of Asgharian and Moss (1992) do not accurately capture particle loss in the first rotation of the drum. We derive a new theoretical approach to accurately predict the motion of the particle population within the drum as a function of particle size, drum rotation speed, and rotation time. The new model allows for the calculation of the real-time changes in aerosol size distributions within a rotating drum.

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7RW.1
Laboratory and Field Constraints on Water Driven Multi-phase Chemistry. JOEL A. THORNTON, *University of Washington, Seattle, WA*

The dissolution, diffusion, and reaction in aqueous aerosol particles influences the lifetime of nitrogen and hydrogen oxide radicals as well as the abundance of secondary organic aerosol and particulate nitrate. We have conducted a suite of laboratory experiments that probe the fundamental parameters governing uptake and reaction of both inorganic and organic compounds in sub-micron particles, including liquid water content and its availability due to particle morphology and phase. Complimentary field observations of reactants and particle phase products provide constraints on the main controls as well as continuing sources of uncertainty in how best to parameterize these processes in regional and global scale models. A consistent framework can explain the rates of processing under a variety of conditions in laboratory studies. However, field observations demonstrate that ultimately, our quantitative understanding of reactive uptake of both inorganic and organic compounds is limited by an unresolved role of particulate organic matter in setting the phase, morphology and even fate of accommodated trace gases.

7RW.2
Understanding Aqueous-Phase Isoprene-epoxydiol (IEPOX) Secondary Organic Aerosol (SOA) Production during SOAS 2013. Sri Hapsari Budisulistiorini, V. Faye McNeill, Havala Pye, JASON SURRATT, *University of North Carolina at Chapel Hill*

The suspected importance of aqueous pathways of secondary organic aerosol (SOA) formation in the Southeastern United States in summer, and the combination of biogenic and anthropogenic influences on these processes, helped motivate the 2013 Southern Oxidant and Aerosol Study (SOAS). Measurements at the Look Rock, TN site during SOAS included high-resolution time-of-flight chemical ionization mass spectrometry (HR-ToF-CIMS) measurements of gas-phase IEPOX/ISOPOOH, IEPOX-OA PMF factor derived from aerosol mass spectrometric data acquired using an Aerosol Chemical Speciation Monitor (ACSM), and offline measurements of known particle-phase tracers for isoprene SOA, including IEPOX-derived organosulfates and 2-methyltetrols. On average, IEPOX-derived SOA tracer mass comprised ~26% of the IEPOX-OA factor mass, which accounted for 33% of the total OA (Budisulistiorini et al., 2015).

No correlation was observed between IEPOX-derived SOA and local aerosol liquid water or acidity at either the Look Rock or Centerville ground sites during SOAS, suggesting that these were not limiting factors in IEPOX SOA formation during the campaign. This was somewhat contrary to expectations, especially considering the positive correlations observed between IEPOX-derived SOA and aerosol sulfate. Detailed mechanistic modeling studies are needed to unravel these effects, in order to fully elucidate the lessons the valuable SOAS datasets provide regarding biogenic and anthropogenic impacts on aqueous SOA formation.

We will present the results of a detailed intercomparison study between the IEPOX-derived SOA predictions of the Community Multiscale Air Quality (CMAQ) model (Pye et al., 2013) and those of a recently introduced photochemical box model, simpleGAMMA (Woo and McNeill, 2015). This study was designed to characterize the impact of differences between the two model formulations on predictions, and agreement with ambient measurement data. Sensitivity to aerosol sulfate, aerosol liquid water, aerosol pH, and VOC precursor concentrations in both models was analyzed in order to provide mechanistic insight into the SOAS observations.

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7RW.3
Trends in Oxygenated Organic Compound Composition and Water Content in Atmospheric Particles during SOAS.
KERRI PRATT, Eric Boone, Alexander Laskin, Julia Laskin, Hongyu Guo, Rodney J. Weber, Victor Nhliziyo, Andrew Ault, Steve Bertman, *University of Michigan*

The combination of significant biogenic and anthropogenic emissions in the humid southeastern United States has resulted in a cooling haze, consisting of aqueous particles. A substantial mass fraction of these submicron atmospheric particles corresponds to secondary organic aerosol formed from the oxidation of biogenic volatile organic compounds. Aqueous-phase reactions in deliquesced aerosol particles are suggested to increase secondary organic aerosol mass and change the chemical composition of the atmospheric particles. In this study, atmospheric particles were collected at the Centreville, Alabama ground site during the summer 2013 Southern Oxidant and Aerosol Study (SOAS). We utilized nanospray desorption electrospray ionization (nano-DESI) and direct electrospray ionization coupled with high resolution mass spectrometry to probe the organic molecular composition of the collected particles. Our results indicate several hundred unique compounds identified in the atmospheric particles, with significant fractions of CHO and CHOS-containing compounds. In particular, the diversity of oxygenated compounds across time will be investigated and compared to measured aerosol liquid water content. These data provide insights into the diversity of organic compounds present in the aqueous atmospheric particles in the southeastern United States; this information will improve our understanding of atmospheric organic particle budgets and climate impacts.

7RW.4
The Salty World of Aqueous Aerosols: Biogenic OVOC Partitioning over the South Eastern US.
RAINER VOLKAMER, Eleanor Waxman, Neha Sareen, Paul Ziemann, Elm Jonas, Theo Kurten, Annmarie Carlton, *University of Colorado*

Recent field observations suggest that aerosol sulfate (SO_4^{2-}) directly controls a significant fraction of secondary organic aerosol (SOA) mass over biogenic environments such as the South Eastern US. Setschenow salting-constants, K_S, describe the exponential dependence of the gas- / aqueous phase partitioning (Henry's Law constant) on the salt concentration. Knowledge about K_S is of particular importance to predict SOA formation in aerosol water, where the salt concentrations are typically very high. Such salt-induced activity is not typically captured by activity coefficients, and can modify SOA formation rates by altering (1) the effective Henry's Law partitioning coefficient (by several orders of magnitude), (2) changing the multiphase chemical reaction rates; and (3) the volatility of products through the formation of complexes and/or organo-sulfate/nitrate products. This talk discusses laboratory measurements combined with quantum calculations to better understand the values of K_S for biogenic OVOC, such as glyoxal, methyl glyoxal and isoprene epoxide in a range of atmospherically relevant salts, incl. $(NH_4)_2SO_4$, NH_4NO_3, $NaNO_3$ and NaCl. We find that glyoxal 'salts-in' (negative K_S) consistently, while methyl glyoxal 'salts-out'. The Gibbs Energy of the chemical bonds of glyoxal, methyl glyoxal and isoprene epoxide with SO_4^{2-}, NO_3^-, and Cl^- is compared, and used to interrogate their salting-behavior. Our best estimates of K_S values for glyoxal, methyl glyoxal and isoprene epoxide have been incorporated into the CMAQ model, and a range of simulations were conducted to predict the effect of salts on their partitioning and potential to form SOA over the continental US.

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7RW.5
Link between Aerosol Liquid Water and Organosulfur Compounds in the Continental U.S. ANNMARIE CARLTON, Thien Khoi Nguyen, Virendra Ghate, *Rutgers University*

Organosulfate compounds are products of secondary organic aerosol formation. They are important sulfur reservoirs in the atmosphere and are found in fog, rain, and ambient particulate matter samples. Averaged across the U.S. at sites that are part of the Interagency Monitoring of Protected Visual Environments (IMPROVE) network, these compounds comprise 5-10% of fine particle organic matter. In biogenically influenced areas of the eastern U.S., submicrometer particulate organic mass can be dominated (up to 65%) by organosulfates that have been found in laboratory studies to only form in aerosol liquid water. Despite their important contribution to the atmospheric particulate matter burden and the formation link to water, the relationship of organosulfates to ambient aerosol liquid water is poorly constrained. The latter is an abundant and ubiquitous component of atmospheric aerosols and influences a variety of critical atmospheric processes. Here we aim to better understand the spatial and temporal link between aerosol liquid water and organosulfates for different geographical regions across the continental U.S. We analyze discrepancies in collocated sulfur measurements at IMPROVE sites where both X-ray fluourescence (XRF) and ion chromatography (IC) techniques are used to estimate organosulfate contribution to fine particle mass. We employ the thermodynamic model ISORROPIA (v2.1) to estimate aerosol water mass concentrations at the same sites using measured speciated ion mass concentrations and NCEP North American Regional Reanalysis (NARR) meteorological data. We find that organosulfate contribution to organic mass is highest during the summer, corresponding with peak sulfur emissions and the highest aerosol water mass concentrations. Our findings suggest that discrepancies in collocated sulfur measurements are explained, in part, by aerosol water-mediated chemistry that forms organosulfates. These findings elucidate important feedbacks in anthropogenic-biogenic interactions that contribute to particle mass in the atmosphere.

7RW.6
Direct Atmospheric Evidence for the Irreversible Formation of Aqueous Secondary Organic Aerosol (aqSOA). Marwa El-Sayed, Yingqing Wang, CHRISTOPHER HENNIGAN, *University of Maryland, Baltimore County*

The reversible nature of aqueous secondary organic aerosol (aqSOA) formation was characterized for the first time through direct atmospheric measurements. Water-soluble organic carbon in the gas- and particle phases (WSOCg and WSOCp) was measured simultaneously to quantify aqSOA formation in Baltimore, MD. During both daytime and nighttime periods, aqSOA formation was evident as WSOCg increasingly partitioned to the particle phase with increasing relative humidity (RH). To characterize the reversible/irreversible nature of this aqSOA, the WSOCp measurement was alternated through an unperturbed ambient channel and through a ‘dried’ channel maintained at ~40% RH to mimic the natural drying particles may undergo over the course of a day. Across the entire ambient RH range encountered, there was no statistically-significant difference in the WSOCp concentrations measured through the dry and ambient channels. This included the periods of active aqSOA formation, indicating that the aqSOA remained in the condensed phase upon the evaporation of aerosol water. This strongly suggests that the observed aqSOA was formed irreversibly and has important implications for our understanding of organic reactions in fine particle water.

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7RW.7

Evidence for Ambient Dark Aqueous SOA Formation in the Po Valley, Italy. AMY P. SULLIVAN, Natasha Hodas, Barbara Turpin, Kate Skog, Frank Keutsch, Stefania Gilardoni, Marco Paglione, Matteo Rinaldi, Stefano Decesari, M. Cristina Facchini, Laurent Poulain, Hartmut Herrmann, Alfred Wiedensohler, Eiko Nemitz, Marsailidh Twigg, Jeffrey Collett, *Colorado State University*

Laboratory experiments suggest that water-soluble products from the gas-phase oxidation of volatile organic compounds can partition into fogs, clouds, and aerosol water where they are further oxidized forming low volatility products. These products can remain in the particle phase after water evaporation forming aqueous secondary organic aerosol (aqSOA). Prior evidence for ambient aqSOA includes (1) an apparent missing source of SOA based on the underestimation of model-predicted vs. measured OA and (2) smog chamber experiments form SOA via gas-phase chemistry that is less hygroscopic and oxygenated than atmospheric SOA. However, few studies have attempted to observe ambient aqSOA. Therefore, a suite of measurements, including near real-time measurements of PM2.5 WSOC (water-soluble organic carbon), inorganic anions/cations, and organic acids, and gas-phase glyoxal, was made during the PEGASOS (Pan-European Gas-AeroSols-climate interaction Study) 2012 campaign in the Po Valley, Italy to search for evidence of aqSOA. Our results suggest local aqSOA formation. When this was observed, a correlation of WSOC with organic aerosol, aerosol liquid water, relative humidity, and aerosol nitrate was found. Comparisons of WSOC with oxygenated organic aerosol (OOA) factors determined from application of positive matrix factorization analysis on aerosol mass spectrometer data suggested that the WSOC in the first and second parts of the study were different. When aqSOA formed locally, a high O/C (oxygen/carbon) ratio was observed. Key factors for local aqSOA production appear to include: air mass stagnation, the formation of substantial local nitrate during the overnight hours which promotes aerosol liquid water formation, and the presence of significant amounts of ammonia.

7SA.1

A Novel Strategy for Long-term Source Apportionment of Aerosol Mass Spectra. Francesco Canonaco, Kaspar Daellenbach, Imad El Haddad, Monica Crippa, JAY SLOWIK, Yuliya Sosedova, Carlo Bozzetti, Ru-Jin Huang, Urs Baltensperger, Christoph Hueglin, Hanna Herich, Andre Prévôt, *Paul Scherrer Institute*

Positive matrix factorization (PMF) analysis of organic aerosol mass spectra provides important information regarding ambient aerosol sources. Investigation of long-term data presents special challenges, as the chemical fingerprint of primary and secondary sources can evolve in response to seasonal changes. Here we present a new method for PMF analysis of long term datasets using the multilinear engine. PMF is applied to a 4-week rolling window across the dataset, with a step size of one day. For each PMF analysis, exploration of the solution space and selection of the optimal solution are executed automatically according to predefined criteria that can be adapted to the studied dataset. This automatic rolling window is implemented within the SoFi toolkit ("AuRo-SoFi") and applied to one year of organic aerosol mass spectra collected by an aerosol chemical speciation monitor (ACSM) Zürich from February 2011 to February 2012.

The model is constrained using the a-value approach to return three primary organic aerosol factors: hydrocarbon-like organic aerosol (HOA), cooking-influenced organic aerosol (COA), and biomass burning organic aerosol (BBOA). In addition, 1-2 oxygenated organic aerosol (OOA) factors related to secondary aerosol formation were retrieved. Each PMF analysis (i.e. window centered at a given time point) consists of 2 sets of PMF runs respectively assuming 1 or 2 OOA factors, where each set consists of 100 PMF runs in which the a-values for the primary factors a-values are varied. The optimal solution is selected automatically according to criteria such as correlation with external tracers and physically reasonable diurnal patterns. Results indicate an enhanced biomass burning fraction in winter and a reduction in OOA oxygenation in summer. We will discuss seasonal trends in factor profiles and contributions. Additionally, the AuRo-SoFi approach allows for 28 replicate PMF analyses of each time point, providing an estimate of the source variation and measurement error.

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7SA.2

Chemical Characterization of Atmospheric Fine Aerosol Collected from Atlanta, GA, and Centreville, AL Using the Aerodyne Aerosol Chemical Speciation Monitor (ACSM). WERUKA RATTANAVARAHA, Sri Hapsari Budisulistiorini, Philip Croteau, Karsten Baumann, Eric Edgerton, Manjula Canagaratna, John Jayne, Douglas Worsnop, Stephanie Shaw, Jason Surratt, *University of North Carolina at Chapel Hill*

Atmospheric fine aerosol ($PM_{2.5}$) is associated with adverse effects on human health as well as on air quality and climate. In order to understand the formation, sources and behavior of $PM_{2.5}$, long-term continuous chemical characterization is essential, especially to aid in the development of effective control strategies. In this study, the Aerodyne Aerosol Chemical Speciation Monitor (ACSM) was deployed at the Jefferson Street (JST) site in Atlanta, GA for 1 year (February 08th, 2014 – February 08th, 2015) and at the Centreville, AL (CTR) site for 1 year starting on March 16th, 2015. The JST and CTR sites are part of the Southeastern Aerosol Research and Characterization (SEARCH) network and are equipped with a suite of real-time instruments making continuous collocated gas, particle, and meteorological measurements. In addition to the continuous SEARCH measurements, high-volume filter samplers were periodically operated to collect $PM_{2.5}$ for subsequent off-line chemical analyses of organic aerosol constituents to help identify organic aerosol sources in the ACSM data. The datasets were analyzed separately by season. Positive matrix factorization (PMF) was applied to the organic mass spectral data provided by the ACSM in order to resolve potential sources. Preliminary results indicate that organic constituents dominate the mass fraction of fine particulate matter in all seasons. Application of PMF yielded at least six potential factors: hydrocarbon-like organic aerosol (HOA), low-volatility oxygenated organic aerosol (LV-OOA), semi-volatile oxygenated organic aerosol (SV-OOA), biomass burning organic aerosol (BBOA), isoprene-epoxydiol organic aerosol (IEPOX-OA), and 91Fac. The preliminary PMF results will be interpreted in the context of the JST and CTR collocated measurements and OA tracers measured from the filter samples using off-line gas and liquid chromatographic methods interfaced to mass spectrometry. In addition, the results will be interpreted in terms of urban (local) versus rural (regional) sources of organic aerosol in the southeastern U.S.

7SA.3

Source Apportionment of PM2.5 in St. Louis Using Chemical Speciation Network Data. LI DU, Jay Turner, *Washington University in St. Louis*

The USEPA Chemical Speciation Network (CSN) was implemented in 1999 to provide insights into fine particulate matter (PM2.5) chemical composition in urban areas and to support air quality standard compliance and health related studies. In this presentation, positive matrix factorization implemented by EPA PMF v5.0 was utilized to identify and apportion local and regional source contributions to PM2.5 mass at five CSN/CSN-protocol sites in metropolitan St. Louis with temporal coverage varying from 2 to 15 years. Regional sources collectively accounted for ~72-91% of the observed PM2.5 mass with secondary sulfate as the major contributor followed by biomass burning and secondary nitrate. A factor characterized by high calcium loading was resolved which exhibited characteristics of a regional-scale source instead of point sources as was concluded in previous studies for St. Louis. Impacts from local point sources such as a steel mill and a brass works were resolved in certain single site analyses. Source apportionment analysis using data pooled from multiple sites exhibited both advantages and disadvantages in resolving sources and quantifying their impacts at individual sites. For example, a traffic factor at the suburban sites was better defined upon pooling with data from an urban site. In contrast, the ability to identify point sources at a given site was diminished by the multisite analysis. Multisite analyses led to source contribution estimates that are biased from those derived by single-site analyses, especially for local point sources. In addition to the conventional methods of determining the optimal solutions, perturbation of the input uncertainty matrix was also applied and shown to provide information on the stability of the solutions. Modeling uncertainties were evaluated by bootstrap, displacement and bootstrap-displacement methods as implemented in the EPA PMF tool. The sensitivity of the outcomes from these uncertainty estimation methods to the structure of the solutions was explored.

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7SA.4

Sensitivity of Ambient PM2.5 Concentration to Prescribed Burning and Fire Weather Forecast Data Using Principal Components Regression Analysis. KARSTEN BAUMANN, Sivaraman Balachandran, Jorge Pachon, James Mulholland, Armistead G. Russell, *Atmospheric Research & Analysis*

Fire weather forecasts published daily by NOAA's National Weather Service, are used by land and wildlife managers to determine when meteorological and fuel conditions are suitable to conduct prescribed burning (PB). In this work, we investigate the sensitivity of ambient $PM_{2.5}$ to various fire and meteorological parameters in a spatial setting that is typical for the Southeast. We use the method of principle components regression (PCR) to estimate the sensitivity of $PM_{2.5}$, measured at a regulatory monitoring site in Jacksonville, North Carolina, to fire data and, to observed and forecast meteorological parameters. Fire data was gathered from routine PB operations at Marine Corps Base Camp Lejeune, extending 10-50 km south from Jacksonville. Principal components analysis (PCA) was run on ten data sets that included PB activity data along with meteorological forecast data alone or in combination with observations. For each data set, PCA scores from the first seven principal components (explaining > 80% of total variance) were regressed against observed $PM_{2.5}$. $PM_{2.5}$ showed significant sensitivity to PB, with a unit-based sensitivity of 3.6 ±1.1 μg m^{-3} per 1000 acres burned at the investigated distance scale. Applying this sensitivity to the available PB activity data revealed a PB source contribution to measured $PM_{2.5}$ of up to 25%. As expected, $PM_{2.5}$ had a negative sensitivity to dispersive parameters, and was sensitive to wind direction. The PCR method showed positive sensitivity to forecast precipitation, likely reflecting land managers' decision to conduct PB on days where rain can naturally extinguish fires. Perhaps most importantly for land managers, our PCR analysis suggests that instead of relying on the forecasts from a day before, their PB decisions should be based on the forecasts released the morning before the burn, since these data were more stable to PCR treatment and yielded more statistically robust results.

7SA.5

Evaluation of PM2.5 Source Apportionment Methods using Spectral Analysis. SIVARAMAN BALACHANDRAN, Heather Holmes, James Mulholland, Armistead G. Russell, *Georgia Institute of Technology*

Three receptor sites that measure fine particulate matter (PM2.5) composition are evaluated for variation of source apportionment (SA) results. Variation from spatio-temporal differences and from use of different SA methods are evaluated. Four SA methods are evaluated: a chemical mass balance with gas constraints (CMB-GC) method using three sets of source profiles and positive matrix factorization (PMF). Source profiles used in CMB-GC include measurement-based source profiles (MBSPs), and two sets of profiles from ensemble-averaging multiple models using a standard and a Bayesian technique. SA is conducted at two urban sites in Atlanta, GA: the Jefferson St. (JST) SEARCH site and the South Dekalb (SDK) CSN site, and, for a rural SEARCH site in Yorkville, GA (YRK). Source impacts from the four SA methods at three sites are compared for temporal trends using spectral analysis using the Lomb-Scargle Periodogram Method (LSPM). Results across sites and methods are used to evaluate spatial and method-specific variation, respectively. All SA methods, species and source profiles/factors show a strong power spectra peak at one year. Gasoline vehicle impacts using CMB-GC at JST and both CMB-GC and PMF at SDK have statistically significant peaks (α =0.05) for the frequency associated with one week. CMB-GC and PMF at JST and SDK have peaks (α =0.05) for the frequency associated with one week for diesel vehicle impacts. The greatest variability across methods and locations was seen with biomass burning profiles/factors, especially with PMF factors and source profiles derived using the Bayesian technique. Across the three sites, the variability in OC to EC ratios in biomass burning profiles corroborate power spectra analysis that emissions from biomass burning are more spatially variable than other sources.

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7SA.6
Source-resolved Simulation of Fresh and Chemically-aged Biomass Burning Emissions. LAURA POSNER, Georgia Theodoritsi, Ksakousti Skyllakou, Bonyoung Koo, Matthew Mavko, Spyros Pandis, Allen Robinson, *Carnegie Mellon University, University of Patras*

Biomass burning can be a significant source of organic aerosol, both locally and far downwind. Most previous modeling work assumes that biomass burning primary organic aerosol (POA) is non-volatile, but as the emissions travel and dilute, the oxidation of evaporated semi-volatile POA forms secondary organic aerosol (SOA). In this study, the 3D chemical transport model PMCAMx was used to simulate the emission and evolution of biomass burning organic aerosol (bbOA) to determine its predicted contribution to total organic aerosol (OA) concentrations in the continental U.S. PMCAMx simulates the evolution of semi-volatile POA and the formation of SOA using the volatility basis set framework. A source-resolved emission inventory for the continental U.S. was used as input for PMCAMx to simulate three representative months with significant biomass burning for the modeling year 2008. Corresponding zero-out simulations were then performed to determine the predicted contribution of bbOA to total OA concentrations. The zero-out results were compared to the results of PSAT, a source-tracking module within PMCAMx.

A source-resolved version of PMCAMx (PMCAMx-SR) was then used to simulate the same representative months to investigate the importance of the volatility representation of bbOA. PMCAMx-SR allows bbOA emissions and their oxidation products to be represented and tracked separately from other OA sources and to have their own volatility distribution and chemical aging scheme. The sensitivity of the predicted contribution of biomass burning OA to assumptions about the emissions of unknown VOCs, IVOCs, and the assumed volatility distribution of bbOA emissions was investigated. These results were used to estimate the importance of biomass burning as an OA source in the U.S.

7SA.7
CTM-Based Regression for Social Cost Accounting of Individual Emission Sources for PM2.5 Pollution. JINHYOK HEO, Peter Adams, H. Oliver Gao, *Cornell University*

Due to long-distance transport and secondary formation, fine particulate matter (PM2.5) and its precursor emissions originated from numerous external or cross-regional sources generally account for a significant fraction of the social costs (or public health burden) of PM2.5 pollution within a region or an urban area. For quantifying the contribution of individual sources to the social costs, state-of-the-art chemical transport models (CTMs), though most desirable for accurate quantification of the relationship between an emission source and its social costs, are less than ideal and practical due to their technical complexity and extremely high computational costs, hence too cumbersome for practitioners and policy makers. Recently, CTM-based regression models (with robust out-of-sample validation after calibrated to a CTM-generated database) have been developed, which require minimal computation without sacrificing the technical rigor and accuracy of CTMs. Using such models, this study aims to provide space-and-time resolved social cost accounting of emission sources for PM2.5 pollution at a receptor location. Specifically, we focus on quantifying the fractional contributions of four species (elemental carbon (EC) and inorganic particulate matter precursors (SO2, NOx, and NH3)) emitted anywhere in the United States. As an application, we estimate the fractional public health burden in New York City attributable to inorganic PM2.5 pollution from local and regional emission sources. Preliminary results indicate that local emissions (i.e. emissions within New York City) are responsible for 9% of the total burden, showing its dominant fraction is originated from external sources. Emission sources that cumulatively account for 50% of the burden are as far as 880 km away. Accounting for 90% needs to include sources up to 1,700 km away. Such detailed social cost accounting with improved space-and-time resolution of individual emission sources are critical for successful identification and design of cost-effective and equitable air quality control strategies at various levels.

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8AC.1
Multiple New-Particle-Growth Pathways at the DOE Southern Great Plains Field Site in Oklahoma. ANNA HODSHIRE, Jeffrey R. Pierce, James N. Smith, Peter H. McMurry, Jun Zhao, Michael J. Lawler, John Ortega, David Hanson, Kelley C. Barsanti, *Colorado State University*

New-particle formation (NPF) is a significant source of aerosol particle number in the atmosphere. However, these particles are initially too small to have climatic importance and must grow, primarily through net uptake of low-volatility species, from diameters 1 nm to 30-100 nm in order to impact climate. There are currently uncertainties in the physical and chemical processes associated with the growth of these particles that lead to uncertainties in aerosol-climate modeling. The 2013 campaign at the DOE Southern Great Plains (SGP) field site in Oklahoma provided measurements of gas-phase growth precursors, size distributions of new-particle growth events, and the composition of the growing aerosols. We show that the gas-phase and particle-phase compositions during new-particle growth events suggest three distinct growth pathways: (1) growth by sulfuric-acid/amines/organics; (2) growth by organics alone; (3) and growth by sulfuric-acid/ammonia. These event-specific mechanisms correspond to back trajectories that indicate different source regions (e.g. agriculture vs. cities). Finally, we show vertical aerosol number concentrations obtained from tethered balloon experiments demonstrating that nucleation likely starts aloft, at least on some days at SGP. We discuss potential hypotheses why the nucleation starts aloft and implications for nucleation/growth modeling.

8AC.2
Size-resolved CCN Activity in Winter Season at a Polluted Site, Kanpur in India. DEEPIKA BHATTU, S.N. Tripathi, *IIT Kanpur*

Atmospheric aerosols can act as cloud condensation nuclei, based on their size and chemical composition, thus indirectly affecting the microphysical properties, lifetime and coverage of clouds (Albrecht, 1989). Past studies suggested that the precise quantification is required when CCN/CN is non-linearly correlated with total aerosol concentration and involves complexity due to ageing processes (Deng et al., 2013). Size-resolved CCN activity studies provide information on the relative influence of chemical composition and aerosol size distribution on CCN prediction, mixing state of aerosols and the processes affecting their hygroscopic growth (Padró et al., 2012). They also help in understanding the origin of hygroscopicity of ambient aerosols by studying the activation kinetics of organic compounds. The information on chemical composition and mixing state should be carefully incorporated in the CCN closure studies specifically where anthropogenic emissions are high.

Size-resolved CCN measurements were conducted in winter, 2012 for particles in the size range from 20 to 280 nanometer for SS=0.2% -1.2%. The chemical composition of organics and inorganics (NH_4^+, NO_3^-, SO_4^{2-}, Cl^-) was obtained from HR-ToF-AMS using a chemically dependent CE of 0.45. The aim of this study is to characterize the aerosol hygroscopic properties and infer mixing state of aerosols. The accumulation mode (>100 nanometer) particles are more hygroscopic (κ_{CCN}=0.24) than Aitken mode (40-100 nanometer) particles (κ_{CCN}=0.13). In hygroscopicity closure, $\kappa_{AMS} > \kappa_{CCN}$ at lower diameter due to the presence of refractory aerosols which were not measured by AMS. However, at higher diameter, $\kappa_{CCN} > \kappa_{AMS}$ due to presence of externally mixed organic aerosols which are not CCN active. Higher differences in κ_{AMS} and κ_{CCN} at higher diameter at night because of the presence of high organic fraction. Further, a transition period is examined for the change in total aerosol properties like, activation diameter, oxidation state, aerosol mixing state and hygroscopicity of aerosols.

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8AC.3
Laboratory Studies of Biomass Burning Aerosol Oxidation at the Bulk and Molecular Level. CLAIRE FORTENBERRY, Michael Walker, Yaping Zhang, Dhruv Mitroo, William Brune, Brent Williams, *Washington University in St Louis*

The atmospheric chemical aging of biomass burning organic aerosol (BBOA) is highly complex and often difficult to characterize. In this study, a thermal desorption aerosol GC/MS (TAG) was used in parallel to a high-resolution time-of-flight aerosol mass spectrometer (AMS) to analyze the chemical composition of photochemically aged oak wood and oak leaf BBOA. Primary BBOA was created in a combustion chamber and oxidized in a potential aerosol mass (PAM) flow reactor to simulate different levels of atmospheric aging.

Traditional chromatography utilizes a “solvent delay” at the beginning of the analysis to prevent detector damage from large solvent signals. In the TAG, much of the solvent can be purged prior to sample injection and the solvent delay is no longer applied. This allows volatile components and thermal decomposition products to reach the detector during thermal sample transfer from the TAG collection cell to the GC column. The TAG thermal decomposition signal was studied in conjunction with AMS spectra to analyze the most highly oxidized fraction of collected BBOA. We have observed a rise in m/z 44 (CO2) signal in the TAG desorption window with increasing oxidation, consistent with an increase in aerosol aging. Previous BBOA mass spectral aging studies have identified the m/z 60 fragment (CH3COOH) as a reliable tracer for freshly emitted BBOA, attributing a decrease in m/z 60 signal to the oxidative degradation of lignin combustion products over time. We instead observed an overall rise in m/z 60 abundance with oxidation of oak wood in both the AMS data and the TAG decomposition period, demonstrating that the occurrence of m/z 60 in a sample is dependent on multiple factors and does not solely result from freshly emitted BBOA. Finally, the oxidative evolution of key molecular marker compounds will be presented.

8AC.4
The Effect of Relative Humidity on the Composition and Structure of Ambient Secondary Organic Aerosol Particles from the SOAS Field Campaign. AMY BONDY, Sydney Niles, Rachel O'Brien, Victor Nhliziyo, Steve Bertman, Paul Shepson, Ryan Moffet, Kerri Pratt, Andrew Ault, *University of Michigan*

During the summer of 2013, atmospheric particles were collected during the Southern Oxidant and Aerosol Study (SOAS) to improve our understanding of how these particles are contributing to a relative cooling regionally through light scattering. Measurements focused on single particle analysis of aerosols collected in Centreville, Alabama, a rural forested location. Secondary organic aerosol (SOA) in particular has been found with varying compositions and liquid-liquid phase separation of components leading to a range of internal structures. These phase separations and structures have been probed using chemical imaging techniques including scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), and scanning transmission X-ray microscopy with near edge X-ray absorption fine structure spectroscopy (STXM-NEXAFS). The effect of varying relative humidity (RH) and specifically the number of RH cycles were studied to determine how these factors impacted SOA structure. For this lab-based study, optical microscopy and Raman microspectroscopy were used to image single particles to study size and morphology, as well as analyze the change in functional group signals while the RH was varied. Initially inorganic salts, organonitrate, and organosulfate standards, compounds likely to be present in ambient SOA, were tested in a RH-controlled cell to investigate which functional groups changed as the RH changed. In the second phase of the experiment, SOA particles collected on substrates during SOAS were examined to determine how ambient particles containing multiple chemical species behave under changing RH conditions. The improved understanding of these aerosol particles can be used to explore how sources and atmospheric processing change particle structure, and how the altered optical properties impact air quality and climate on a regional scale.

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8AC.5
Experimental and Computational Fluid Dynamics Study of Nucleation in a Flow Reactor: Sulfuric Acid with Ammonia and Trimethylamine. IMANUEL BIER, David Hanson, Coty Jen, Peter H. McMurry, *Augsburg College*

Nucleation of particles with sulfuric acid, water, ammonia (NH_3), and trimethylamine was studied in a flow reactor and also simulated with computational fluid dynamics. Nucleation was quantified experimentally using a DEG-SMPS and computationally via a combination of computational fluid dynamics and the kinetic formation and decomposition of small clusters of sulfuric acid and base molecules. Base nucleation capabilities of sulfuric acid with NH_3 and/or trimethylamine were simulated to predict particle concentrations at the given flow reactor conditions. The thermodynamics of the acid-base nucleating system were adjusted until the predicted particle concentrations agreed with the measured concentrations. Temperature and relative humidity dependencies were also explored experimentally and computationally. Comparisons of the energy of the acid-base clusters derived here with those of recent quantum chemical calculations show an overall agreement but some quantitative differences stand out. The thermodynamics determined in the computational fluid dynamics methods facilitate the comparison of results of experiments of widely disparate conditions. Also, measurements show that the presence of NH_3 significantly enhances particle formation rates in the sulfuric acid-trimethylamine system. Potential mechanisms for this synergistic effect will be presented.

8AC.7
Heterogeneous Oxidation of Organic Coatings on Submicron Aerosol Particles. CHRISTOPHER LIM, Eleanor Browne, Rebecca Sugrue, Jesse Kroll, *MIT*

Heterogeneous oxidation of organic aerosol (OA) can significantly transform the chemical and physical properties of particulate matter in the atmosphere, potentially leading to volatilization of oxidized volatile organic compounds and/or changes to particle composition. It has become increasingly apparent that the heterogeneous oxidation kinetics of OA depend strongly on the viscosity and morphology of the particles. However, the impact of particle morphology on the evolution of the chemical composition of OA resulting from chemical aging remains poorly characterized. In this work, squalane ($C_{30}H_{62}$), a model compound for primary OA, is coated onto 200 nm dry ammonium sulfate particles at various thicknesses (2-20 nm) and exposed to hydroxyl radical (OH) in a flow tube reactor. The resulting changes in chemical composition are monitored online with an Aerodyne High Resolution Time-of-flight Aerosol Mass Spectrometer (AMS). We show that thin organic coatings can undergo dramatic changes in oxidation state and lose a significant amount of organic mass after relatively low OH exposures (the equivalent of hours to days in the atmosphere). This implies that for morphologically complex particles, heterogeneous oxidation has the capability to greatly alter the surface composition and properties of atmospheric OA.

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8AC.8
Contribution of Organic Nitrogen to Secondary PM at a Semi-Rural Site in the Southeastern US. QUENTIN MALLOY, Prakash Doraiswamy, R.K.M. Jayanty, Jonathan Thornburg, *RTI International*

Previous studies have reported significant contributions of organic nitrogen (ON) species to aerosol in rural and urban regions throughout the world. The role of ON within the total atmospheric aerosol budget is important to understand because of its potential to alter terrestrial and aquatic nitrogen balances. These previous studies have not distinguished between secondary ON and primary ON. This issue is especially relevant in areas known to have large amounts of secondary particulate matter (PM) such as the southeastern US. The lack of data about the contribution of ON to secondary PM is currently a large gap in determining critical nitrogen loads needed for an ecosystem. A part of this critical gap is the role human land management practices (such as cutting) have in cycling of nitrogen within an ecosystem.

Preliminary analysis of data from this mid-summer field study indicate that a significant amount (~11%) of ON can be classified as secondary in nature. Furthermore, data collected immediately after the grass cutting episodes shows no significant deviation from background aerosol with regards to the NO_3^- or NH_4^+ concentrations. The strong correlation between NO_3^- and total organics coupled with the high degree of oxidation (f44/f43 = 1.6) indicate the most likely source of NO_3^- in the aerosol is from secondary processing. Measured NH_4^+ concentrations show a high degree of correlation with SO_4^{2-}, indicate the majority of ammonium and sulfate are bound together in the aerosol as ammonium sulfate.

8AC.9
Chamber Simulation of Photochemistry of Mineral Dust Particles in the Presence of SO2. JIYEON PARK, Myoseon Jang, *University of Florida*

Mineral dust particles are one of the largest contributors to global aerosol mass loading, and yet the role of mineral dust particles in atmospheric photochemical process is not fully understood. In this study, heterogeneous photochemistry of Arizona test dust (size ranges: 0-3 μm) in the presence of SO2 were investigated with varying relative humidity (RH) and trace gas (e.g., NO2 and O3) concentrations using both a 2 m3 indoor Teflon film chamber with UV lamps, and dual 52 m3 outdoor chamber under natural sunlight. To evaluate the effect of surface functionalization of mineral dust particles (e.g., O-H stretching bands) on heterogeneous photochemistry, untreated and baked Arizona test dust were used. In addition, control experiments were conducted with various types of laboratory-generated particles such as SiO2, MgSO4, and (NH4)2SO4. Data represent that new particle formation was clearly observed for the Arizona test dust and SiO2 particles in the presence of SO2 under the natural sunlight with a significant increase of sulfate up to 10 μg/m3, whereas sulfate formation was negligible for inorganic salt aerosols (e.g., MgSO4 and (NH4)2SO4). Under weak or no UV light, little sulfate was observed for the Arizona test dust particles in the presence of SO2 at the low and high RH conditions. This suggests that SO2 is photochemically oxidized into sulfate ions via the heterogeneous chemistry of SO2 with dust surface-origin OH radicals, which are generated through electron-hole pairs on the surface of dust particles. The resulting chamber data are used to determine the reaction rate constant of SO2 in the presence of mineral dust particle. Further analyses for determining effects of natural dusts on the heterogeneous reaction in the presence of SO2 using various types of mineral dusts sampled from Gobi deserts, Mongolia are in progress, and will be presented.

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8AC.10

Chemical Characteristics of Submicrometer Particles at a Coastal Site in Korea. Jiyeon Park, KwangYul Lee, Min Soo Kang, HungSoo Joo, Hyunji, Kim Kim, Seunghee Han, Leah Williams, MINHAN PARK, Dohyung Kim, Kihong Park, *Gwangju Institute of Science and Technology*

Chemical components (organics, sulfate, nitrate, ammonium, chloride, methane sulfonic acid (MSA), and black carbon (BC)) of submicrometer particles in the coastal atmosphere were measured with an aerosol mass spectrometer (AMS) and an Aethalometer at the sampling site of Boseong, South Korea in the fall of 2012. Also, concentrations of chlorophyll-a, bacteria, and viruses in seawater were determined to find any relationship between the production of marine organic aerosols and biological materials in seawater. The organics was found to be the most dominant species (33.9%) with an average concentration of 1.44±0.50 μg/m3 in the ambient particulate matter less than 1 μm (PM1). Average mass concentrations of sulfate, ammonium, nitrate, chloride, MSA, and BC were 1.15±0.59, 0.65±0.52, 0.44±0.29, 0.06±0.02, 0.10±0.02, and 0.40±0.27 μg/m3, respectively. The PM1 concentration and the characteristics of organics were strongly dependent on the air mass type. The highest PM1 was observed with the northwest continental air mass (nitrate, ammonium, sulfate, and organics increased 3-7 times compared to average values during the whole sampling period, but the increase of BC was not so high as other chemical components). Also, the less volatile-oxidized organic aerosols (LV-OOA) became dominant with the northwest continental air mass, suggesting that the organics were highly aged during the long-range transport. The AMS mass spectra of laboratory-cultured marine bacteria (e.g., Vibrio litoralis, Flavobacterium sp., and Pseudomonas aeruginosa) and natural seawater were determined after being sprayed from bubble bursting chamber. The m/z 54 and 95 were selected as biological organic markers to determine the biological fraction in the organic aerosols. The biological fraction varied from 1.2% to 6.8% with an average of ~2.8% and had low correlations with concentrations of chlorophyll-a and bacteria, and a moderate correlation with viruses (r=0.6) in seawaters. This might occur due to the low biological activities in seawater during the current sampling period (the average mass concentration of chlorophyll-a in seawater was 1.1 μg/l, and number concentrations of bacteria and viruses in seawater were 4.6×105 bacteria/ml and 1.1×107 viruses/ml, respectively).

8AC.11

Real-time Measurements of Airborne Fluorescent Single Particles at Fukue Island, Japan. FUMIKAZU TAKETANI, Hisahiro Takashima, Kohei Ikeda, Yugo Kanaya, *JAMSTEC*

Real-time measurements of ambient auto-fluorescent suspended particles were conducted from 17 September to 14 December, 2011 using the WIBS-4 instrument at Fukue Island (32.75N, 128.68E) in Japan. We detected more than 0.2 billion particles whose diameter is larger than 0.8um during the observation period, and the ratio of the fluorescent particles which were sum of seven categorized fluorescent particles in fine (Dp = 0.8 -2.5um) and coarse (Dp > 2.5um) modes to those total varied in the range of 2.0 – 65.5% with average of 19.9% and 11.3-96.2% with average of 47.8%, respectively. Of those particles, fluorescent bioaerosol particles (FBAPs) defined in the WIBS-4 instrument were in the range of 2.7 – 86.1% with average of 12.7% in coarse mode particles. By comparison of signal intensities detected as a FBAP, there are two types FBAPs (tryptophan and NADH types). It was suggested that tryptophan type of FBAPs concentration increased in ambient relative humidifies, implying that these FBAPs might be attributed to a kind of fungal spores emitted from around observed station.

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8AC.12
The Absorption Enhancement of Soot Particles from Biomass Burning in the Presence of Aromatic SOA.
ANTONIOS TASOGLOU, Georges Saliba, R. Subramanian, Spyros Pandis, *Carnegie Mellon University*

Smog chamber experiments were conducted to investigate the changes of the physical properties and chemical composition of soot particles from biomass burning emissions exposed to aromatic secondary organic aerosol (SOA) and to their further chemical aging. A major focus of the study was the absorption enhancement of black carbon (BC) particles due the coating of the soot particles with aromatic SOA. This coating and the change of the oxidation state of the organic aerosol can result in the enhancement of the absorption of solar radiation by biomass burning BC particles and the production of brown carbon (BrC). In our experiments we investigated emissions from the burning of European white birch bark using an environmentally efficient cook stove. Aromatic SOA was produced by the addition of aromatic volatile organic compounds (VOCs) and their reaction with hydroxyl radicals under high and low NOx conditions. A suite of instruments was used including a Soot Particle Aerosol Mass Spectrometer (SP-AMS) and a Single Particle Soot Photometer (SP2), for the mass concentration and the chemical characterization of the particles. For the study of the optical properties of the particles, we used an aethalometer and a green and a blue photoacoustic extinctiometer (PAX). The changes in particle mass concentration and the chemical composition of the particles in comparison to the absorption enhancement were investigated. Changes in the absorption wavelength dependence were examined for the possible existence of BrC.

8AC.13
Influence on PM10 of Air Mass Origin and Sea Spray Contribution at an Industrial Sampling Station.
LUIS NEGRAL, Eugenia Zapico, Laura Megido, Beatriz Suárez-Peña, Yolanda Fernández-Nava, Elena Marañón, Leonor Castrillón, *University of Oviedo*

The PM10 composition was measured over a period of a year at a sampling station situated in an industrial area in the north of Spain. The chemical composition of PM10 was determined on 52 days during this period. This information was assessed in terms of air-mass back-trajectories to study the relation between PM10 levels and air-mass origin. Transport scenarios were classified as northern Atlantic, northwestern Atlantic, western Atlantic, southwestern Atlantic, northern African, Mediterranean, European and regional. Northwestern Atlantic advections and regional episodes were predominant throughout the sampling period, comprising 51.6% of the days of the study. As regards each air mass origin, the highest mean PM10 levels were found in the course of northern African advections (37.3 micro-gram/m3). However, only one of the eleven episodes of exceeding the daily limit value (50 micro-gram/m3) occurred during this last scenario. As to Na+, Mg2+ and Cl-, the contribution of sea spray clearly increased in northwestern Atlantic advections, when these species comprised up to 31% of PM10. As expected, the correlation between Cl- and Na+ was notably improved under these advections (R = 0.92). The highest Cl-/Na+ weight ratios (up to 5.9) were mainly found under regional episodes, exceeding the ratio of these ions in seawater. Apart from poor dispersion leading to the accumulation of pollutants, the burning of coal and a nearby ceramics factory might explain this excess chloride.

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8AC.14
Kinetic Model for Nanoparticle Growth Relevant to New Particle Formation. MICHAEL APSOKARDU, Douglas Ridge, Murray Johnston, *University of Delaware*

Ambient measurements of the chemical composition of nanoparticles during new particle formation (NPF) show that the three main components involved in particle growth are sulfate, base (usually ammonia), and carbonaceous matter. Measurements with the nano aerosol mass spectrometer (NAMS) show that the sulfate mass fraction in the particle is adequately explained by condensation of gas phase sulfuric acid, and the mass fraction of base closely follows changes in the sulfate mass fraction. The mass fraction of carbonaceous matter varies with location and time of year, and the factors influencing its contribution to particle growth are poorly understood.

We have developed a kinetic model that iteratively calculates the volume and composition of a particle as a function of time when exposed to gas phase species. The model takes into account sulfuric acid condensation, ammonia neutralization of condensed sulfuric acid, and the condensation and/or partitioning of organic molecules including the effect of surface curvature (i.e. Kelvin effect) on these processes. The model is capable of simultaneously including a variety of organic molecular species having different physical properties (e.g. saturation vapor pressure) and gas phase concentrations. The model is being used to explore how organic molecular properties influence growth in different particle size ranges, and in particular the molecular properties required to “turn on” particle growth by carbonaceous matter in the 2-5 nm size range. Initial studies with this model will be presented.

8AE.1
Evaluation of a Thermophoretic Nanoparticle Sampler. TRACI LERSCH, Kristin Bunker, David Leith, John Volckens, Gary Casuccio, *RJ Lee Group, Inc.*

A portable thermophoretic nanoparticle sampler has been developed that deposits airborne ultra-fine particles onto an electron microscopy (EM) grid. The particles on the grid can be subsequently measured and speciated using EM techniques to provide an assessment of exposures. Particle collection efficiencies associated with the sampler were initially evaluated in laboratory experiments that involved simultaneous collection with a scanning mobility particle spectrometer (SMPS) using a salt aerosol (phosphate-buffered saline). These experiments, along with theory of thermophoretic velocity, were used to establish the collection efficiency of the sampler. From these studies, a transfer function was developed that relates the size distributions and number concentrations of the collected particles to the aerosol.

In an effort to evaluate the ability of the thermophoretic sampler to provide an accurate measure of airborne nanoparticle concentrations, additional chamber studies were performed using different materials. Also, the sampler was employed in field studies representative of real world conditions. Data are provided illustrating the comparison of thermal precipitator sampler results to SMPS data with a focus on the validity of the transfer function. Data are also provided from field studies illustrating the potential of the sampler for use in exposure assessment.

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8AE.2

Perception, Cultural, and Technical Assessment of Heating Alternatives to Improve Indoor Air Quality on the Navajo Nation. Wyatt Champion, Perry Charley, Barbara Klein, Avery Denny, James McKenzie, Kathleen Stewart, Paul A. Solomon, LUPITA MONTOYA, *University of Colorado Boulder*

It is estimated that 62 percent of households in the Navajo Nation use wood as their primary heating source, while 25 percent use gaseous fuels, 11 percent use electricity, and the remaining 2 percent use coal, kerosene, other fossil fuels, or solar energy. A 2010 study by the U.S. Geological Survey (USGS) and Diné College found that in Shiprock, NM, the largest city in the NN, heating is often done with wood stoves that are old, in poor condition, improperly vented, or inappropriate for the fuel used. The USGS study suggested that the burden of respiratory disease in Shiprock may be reduced by changing indoor home heating behavior and by improving stove quality. This paper presents the results of a three-pronged study that included perception, cultural, and technical assessments to evaluate seven heating options for the Navajo. The ultimate goal of this study is to identify the most feasible options to reduce public health and environmental impacts related to wood and coal use in the Navajo Nation. Results indicate that natural gas furnaces and wood stove replacement provide the greatest benefits per cost. Gaseous fuels are not widely accepted in the community, while wood combustion is ancestral to the Navajo. The other five heating options included in this study are propane gas and electrical furnaces, wood pellet stove, wood stove improvement, and passive solar heating. Cultural experts at the Diné College identified potential limitations to adoption of each alternative. Results of these assessments are presented along with recommendations and proposed educational initiatives for addressing the heating needs of the Navajo Nation. The methods and results of this study may be useful for decision makers in other communities heavily reliant on solid fuels for heat, particularly in rural communities and other Native American nations.

8AE.3

Space and Seasonal Evaluation of Hydrogen Sulfide Levels in Surrounding Cerro Prieto Geothermal Plant at Mexicali, B.C., Mexico. LIZETH AGUILAR, Guillermo Rodríguez-Ventura, Penelope Quintana, Miguel Zavala, Luisa Molina, *Universidad Autónoma de Baja California*

Geothermal plants can be an important source of alternative energy. However, one concern is the potential for toxic emissions. Cerro Prieto Geothermal Plant (CPGP) is located on the US-Mexican border at Mexicali, Baja Calfornia and is reported to release 4.9 tons per hour of hydrogen sulfide (H2S), which could affect the health of people that live in surrounding towns. H2S is an important pollutant gas in the low atmosphere, which is oxidized by photochemical species and produces sulfur dioxide and eventually sulfates. Measurements of hydrogen sulfide levels in 2010 showed an average daily concentration of 41 µg/m3 inside the plant and a range of 1-45 µg/m3 at surrounding towns. This new study characterized H2S levels around CPGP to investigate the factors affecting the spatial distribution of H2S and to provide information needed for mapping air quality levels for nearby towns. H2S measurements (n = 177) were carried out from November 2013 to June 2014 at three towns: SS-1 (Delta), SS-2 (Chimi) and SS-3 (Nuevo Leon). H2S sampling was carried out using Radiello passive absortion cartridges (Sigma Aldrich) impregnated with zinc acetate which formed zinc sulfide, extracted by deionized water and analyzed visible spectrophotometry by the methylene blue method. Average H2S concentrations from autumn-winter 2013 were 90.9,61.9 and 20.1 µg/m3 for SS-1, SS-2 and SS-3 respectively, and during spring-summer 2014 were 46.9, 62.5 and 23.1 µg/m3 respectively. H2S peak concentrations were 172.6 and 257.2 µg/m3 for SS-1 during autumn-winter 2013 and 192.3 µg/m3 for SS-2 during spring-summer 2014, which are higher than the standard established by WHO (150 µg/m3). Higher wind speeds were associated with elevated concentrations. These results indicate that nearby towns could potentially experience adverse levels of H2S due to the emissions from of the geothermal plant.

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8AE.4
Understanding Emissions from Wastewater Treatment Processes and Their Impact on Regional Air Quality and Health. PEDRO PIQUERAS, Akua Asa-Awuku, Mark Matsumoto, *University of California, Riverside*

As water resources become scarce and population grows, the construction and use of wastewater treatment plants is increasing significantly. Wastewater treatment plants (WWTPs) are common in urban environments and their aerosol emissions have been associated with local and regional health burden. Known toxic compounds, bacteria, fungi, endotoxins and viruses have been observed in WWTP aerosols in the past, but their concentration and classification are still dubious. The airborne exposure route is also still poorly established due to the lack of information on aerosol characterization and transport.

In this study, we measure particle concentration and size distributions from two laboratory scale bioreactors; a bioreactor with an air diffuser and a bioreactor with only a mixer. These bioreactors simulate both aerobic and anaerobic biological processes in the secondary stage of water treatment. The inside of the bioreactors contains sludge from an aeration basin from a WWTP in Redlands, California. They are fed 3,000 mg/L of COD every two days by using a dilution of molasses as the influent. This COD is fully degraded after the two-day cycle.

Results suggest that aerobic processes generate more particles through bubble bursting. Increasing the aeration flow rate increases the particle number, however the size distributions of particles produced remains the same. The results will later be extrapolated to real field measurements at Orange County Sanitation District aerated basins.

To our knowledge, these are the first real-time measurement of ultrafine particles measured from WWTPs systems and it will attempt to fill some of the gaps in scientific literature so that regulatory laws can be implemented in order to establish a safe and non-polluting environment when treating wastewater.

8AE.5
Human Exposure Risk to Polycyclic Aromatic Hydrocarbons: A Case Study in Beijing, China. YANXIN YU, Qi Li, Hui Wang, Bin Wang, Xilong Wang, Aiguo Ren, Shu Tao, *Beijing Normal University*

Polycyclic aromatic hydrocarbons (PAHs) can cause adverse health effects on human health. The relative contributions of their two main intake routes (diet and inhalation) to population PAH exposure are still under discussion. We modeled the concentrations of diet and inhalation to the total PAH exposure for Beijing population in China, and and assess their human incremental lifetime cancer risks (ILCR) using Mont Carlo Simulation, considering food consumption, breathing rate, human body weight, and concentrations of the 15 U.S. EPA priority-controlled PAHs in varied foods ambient air. The estimated median daily total exposure levels (ETs) of th sum of low-molecular weight PAHs (ΣL-PAHs), sum of high-molecular weight PAHs (H-PAHs), sum of the 15 PAHs (ΣPAH_{15}), and benzo[a]pyrene equivlent PAH (BAP_{eq}) were 1.93×10^{4}, 2.37×10^{3}, 2.16×10^{4}, and 7.97×10^{2} ng person^{-1} d^{-1}, respectively. Diet mainly accounted for the L-PAH exposure (84.7% for ΣL-PAHs), while inhalation mainly for the H-PAH (57.4% for ΣL-PAHs). Meat and cereals were the main contributors to dietary PAH exposure. Gaseous- and particulate-phase PAHs both contributed to the inhaled doses of L-PAHs, whereas inhaled doses of H-PAHs were almost exclusively from particulate-phase PAHs. About 3.4% of Beijing population with ILCR of the total PAH exposure was above the serious risk level (10^{-4}) and almost 90% of them above the acceptable risk level (10^{-6}). Protective measures to control L-PAHs levels in foods should be taken in Beijing, and more importantly, greater attention should be paid for the inhaled particulate-phase PAHs with more carcinogenic potential for reducing population cancer incidence.

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8AE.6

Characterization of Local Particulate Matter Concentration Gradients Using Mobile Platform and Fixed-site Monitors and Comparison with R-LINE and CMAQ Air Quality Models. XINXIN ZHAI, James Mulholland, Armistead G. Russell, Yongtao Hu, Timothy Larson, Elena Austin, Christopher Simpson, Timothy Gould, Kris Hartin, Sasakura Miyoko, Mike Yost, *Georgia Institute of Technology*

Spatial gradients in ambient pollutant concentrations affect human exposure, and the strength of those gradients vary by source type. For example, pollutant concentrations decrease rapidly from heavily trafficked roads. Both measurements and simulations can be used to estimate local scale gradients. As part of a study to better characterize exposure fields in Atlanta, detailed monitoring and modeling were used to characterize spatial gradients in pollutant fields to assess the accuracy of various modeling approaches and the representativeness of monitors for use in health studies. Fixed site and mobile monitors were used to measure a number of pollutants, including PM2.5 species and mass, ozone and NOx, from September 7 to September 17, 2013. We compared observations with simulation results developed using the Research LINE source model (R-Line) at 200-m resolution and simulations from the chemical transport model CMAQ at 4-km resolution. Comparison between the measurements of monitors and the mobile platform surrounding the monitors were in good agreement, indicating relatively low spatial gradients within the area. R-LINE simulations yield larger spatial gradients and temporal variations than measurements, due, in part, to the sharp diurnal trends and spatial changes in the emissions. This led to a low correlation between the fine scale R-LINE results ($R<0.2$). Spatial gradients derived from CMAQ were lower, reflecting the coarser resolution. Our combined model and measurement analysis found that the routine (e.g., CSN and SEARCH) monitors in Atlanta are generally representative of the areas surrounding the monitoring sites. Comparison of the fine resolution simulations with chemical mass balance model results and the PM2.5 monitors in the region suggest that the R-LINE results need to be re-scaled.

8AE.7

Yearlong Air Quality Simulation and Population Exposure Estimation in China. HONGLIANG ZHANG, Jianlin Hu, Qi Ying, *Louisiana State University*

China has been experiencing severe air pollution in recent decades due to fast growth of economy and urbanization as well as lack of emission control measures. Although ambient air quality monitoring networks for the criteria pollutants have been constructed in more than 100 cities in China since 2013, studies associating human health outcomes with air pollution exposure are still limited due to the temporal and spatial insufficiency and lack of particulate matter (PM) components in the monitoring dataset. In this study, a yearlong (2013) air quality simulation is conducted in China to provide detailed ozone, PM concentrations and chemical components for population exposure estimation.

The Community Multi-scale Air Quality model (CMAQ) is used with meteorological inputs from the Weather Research & Forecasting model (WRF). Multi-resolution Emission Inventory for China (MEIC, http://www.meicmodel.org) is used to generate anthropogenic emissions. The public available observation data obtained from the air quality monitoring networks and PM chemical measurements at several sites will be used to validate the model performance. Then, an inverse distance weighting based method will be applied to estimate exposure using observation-fused concentration fields based on differences between observations and predictions at grid cells where air quality monitors are located. The temporal variations (seasonal, weekday-weekend, diurnal) of population exposure will also be discussed. This study will provide enhanced exposure information for the understanding of adverse effects of air pollutants.

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8AE.8

Dust and Radioactivity Concentrations Emitted from Radiocesium-contaminated Soil during Decontamination Work by a Heavy Vehicle. MAROMU YAMADA, Mitsutoshi Takaya, Norio Tsujimura, Tadayoshi Yoshida, Seiichiro Kanno, Yasushi Shinohara, Kenji Nakamura, Shigeki Koda, *Japan National Institute of Occupational Safety and Health*

It is necessary to estimate the internal exposure to radiocesium-containing dust associated with the decontamination work after the accident at the Fukushima Daiichi Nuclear Power Station (NPS). However, the size distribution of the dust and the radiocesium concentrations emitted during the decontamination work are unknown. The aim of this study was therefore to clarify the relationship between the size distribution of airborne dust and the 137Cs concentration by field observation and a laboratory experiment. The observation was carried out at the Joban highway located about 7 km from the NPS, on May 30, 2014. The contaminated surface soil was removed by a heavy vehicle (W200Hi, Wirtgen). The inhalable dust was collected on filters (T60A20) with IOM samplers (SKC Inc.) in the personal breathing zone (PBZ) of three workers. Additionally, the dust was collected at a fixed point with an Andersen sampler (Tokyo Dylec Corp.) that is able to collect nine different sizes of particles. The filters were weighed by an ultra-microbalance to determine the dust concentration (mg/m^3). The airborne ^{137}Cs concentrations (Bq/m^3) were subsequently quantified with a Ge semiconductor detector (installed at the Japan Atomic Energy Agency). Additionally, to complete the samples that were below the detection limit of ^{137}Cs, we conducted dust resuspension experiments in our laboratory with a dust feeder (DF-3, Shibata), using the contaminated soils collected at the observation site. The results indicated that the ^{137}Cs concentrations in the PBZ were from 0.10 to 0.44 Bq/m^3. The internal exposure was estimated at approximately 0.9×10^{-5} to 4.1×10^{-5} mSv/day, assuming that the working time was eight hours and the respiration volume was 1.8 m^3/hr. The size-segregated samples from the Andersen sampler showed that the ^{137}Cs concentration per unit weight increased with the decreasing of the diameter of the particles.

8AE.9

Estimating Smoke Exposure Concentrations in Fort Collins, CO from Local and Transported Wildfire Plumes. BONNE FORD, Jeffrey R. Pierce, William Lassman, Gabriele Pfister, Emily Fischer, *Colorado State University*

Smoke from wildfires can lead to significantly degraded air quality in the western United States and the exposure to high concentrations of particulate matter (PM) poses a growing threat to human health. Smoke plumes from the local High Park fire in June 2012 and transported smoke from fires in western Canada in July 2015 both produced surface concentrations over 150 microgram m^{-3} in Fort Collins, CO. Predicting and managing smoke exposure during these events is a challenge due to the episodic nature of wildfires and the potentially sharp concentration gradients within smoke plumes. In this study, we use the Weather Research and Forecasting model with online chemistry (WRF-Chem) output to estimate smoke concentrations in Fort Collins, CO associated with both concentrated plumes from a nearby wildfire (High Park) and diluted plumes from wildfires in western Canada. We validate these results against surface and satellite observations and discuss different model sensitivities and how they impact smoke forecasts for these two cases.

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8AE.10
Effects of Pulse Parameters on Welding Fume Aerosol Size Distribution and Respiratory Deposition. MARCIO BEZERRA, Jun Wang, James Regens, *University of Oklahoma*

Welding fume contains various inhalation toxins such as hexavalent chromium and manganese. Occupational exposure to welding fume can cause various carcinogenic and neurological effects. The high-temperature welding process creates high concentrations of nano- to submicron-sized metallic aerosols composed of toxic metals. Pulse welding targets on reducing the heat input to the welding arc zone by high-frequency voltage fluctuation, in opposed to the steady voltage in non-pulse welding. Pulse welding was hypothesized to improve the weld quality, while decreasing the metal vaporization. The objective of this study is to investigate the pulse parameters (voltage, frequency, and percentage) on formation and characteristics of welding fume aerosols. A pulse metal inert gas welder was placed in a metal fume chamber. Welding with different combinations of pulse parameters as well as baseline (non-pulse) were conducted through beading on 308L stainless steel plates. Particle size distribution was measured by a scanning mobility particle sizer and an aerodynamic particle sizer for fine and coarse particles, respectively. Respiratory deposition fractions for head airways (HA), tracheobronchial (TB), and alveolar (AL) regions were estimated based on a simplified International Commission on Radiological Protection (ICRP) model. The results indicated the dominant parameter of particle emission characteristics was pulse voltage. Pulse welding did not drastically change the geometric distribution of the particle sizes comparing to the non-pulse welding. However, pulse welding reduced the particle emissions in both fine and coarse regimes, without compromising the weld quality. Use low pulse voltage can produce the least particle number concentrations (3.0E7 #/cm3 fine particles and 0.7E4 #/cm3) and in favor of more upper respiratory tract deposition. Hence, we suggest the welder should operate at a low pulse voltage to minimize the potential particle exposures.

8AE.11
Characterization of Ventilation and Ultrafine Particles Clearance in a Closed Firing Range during Firing of Lead Free Frangible Ammunition. CHRISTIN GRABINSKI, Trevor Tilly, Claude Grigsby, Saber Hussain, Darrin Ott, *Air Force Research Laboratory*

Range instructors have reported respiratory symptoms during firing of lead free frangible (LFF) ammunition. However, exposure assessments have detected chemicals and particulate matter (PM) in amounts much lower than their respective exposure limits. We hypothesize that ultrafine PM comprise a large fraction of firing emissions, which does not contribute to mass concentration, but may be related to respiratory symptoms due to high particle number concentration. We further plan to characterize the ventilation in the closed environment using ultrafine PM as a dynamic real-time metric. We measured PM emissions in the breathing area of instructors at an indoor small arms firing range using LFF ammunition. Real-time measurement of particle number concentration and size distribution was completed using direct reading instruments. PM was collected onto substrates for morphology and elemental analysis using electron microscopy and energy dispersive X-ray spectroscopy. PM was also collected onto mixed cellulose ester membranes, which were weighed for mass measurements, then digested and analyzed for key metals using inductively-coupled plasma mass spectrometry. The real-time measurements indicated the emission of ultrafine PM during firing and indicated a dynamic response to variations in the ventilation system. The PM coalesced and cleared the range at different rates depending on the weapon. Distinct morphologies in the ultrafine size range were observed, and the composition was found to include many elements, such as carbon, copper, zinc, bismuth and sulfur. The mass of key metals was several orders of magnitude below mass-based exposure limits. Number-based exposure limits may be more relevant for exposures where ultrafine PM is emitted. Further, ventilation design and particle filtering techniques in small arms firing ranges should be optimized for clearance of firing emissions. Therefore, a personal monitoring size direct read ultrafine particle instrument is recommended for future assessment of ventilation health and firing emission clearance in closed firing ranges.

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8AG.1

Diet Formulation Impact on Ammonia Emission from Swine Production. STEVEN TRABUE, Brian Kerr, Kenwood Scoggin, *USDA-ARS*

A study was conducted to determine the impact of crude protein (CP) levels and source of CP in the diets has on the emissions of ammonia (NH3). All diets were balanced for energy with CP levels ranging between 8.7-17.6% and fiber levels ranging between 8.3-19.6%. The CP source material included the following: 1) soybean meal; 2) corn gluten meal; 3) canola meal; and 4) poultry meal. Ammonia emissions were normalized for both size of animal (500 kg animal unit) and feed consumed. Crude protein levels in the diet significantly increased levels of NH3 in manure as well as pH of the manure. Emissions of NH3 decreased12.2 g d-1 AU-1 or 2.9% of N consumed for each unit percent decrease in CP. Protein source impacted crusting and crusting of manure significantly reduced NH3. Fiber levels in the diet significantly reduced NH3 emissions. Emissions of NH3 decreased 7.1 g d-1 AU-1 or 2.2% of N consumed for each unit percent increase in fiber.

8AG.2

Bioaerosols Emitted from Manure Application Sites: What are the Risks? MICHAEL JAHNE, Shane Rogers, Thomas Holsen, Stefan Grimberg, Ivan Ramler, Seungo Kim, *Clarkson University*

Land application of livestock manure is an important agriculture practice, providing the two-fold benefit of waste disposal and crop fertilization. However, zoonotic pathogens that are frequently detected in land-applied materials present concern of public health impacts. While exposure through waterways contaminated by surface runoff has received considerable attention, the health risk of bioaerosols containing manure pathogens that are emitted following land application has not been well documented. The objective of this study was to determine the human health risk associated with inhalation exposure and downwind deposition of airborne bacterial pathogens emitted from land application sites. To do so, edge-of-field aerosol samples were collected following manure application at dairy CAFOs in northern New York and analyzed by real-time qPCR in order to determine the ambient concentration, size distribution, and deposition rates of total and fecal indicator bacteria immediately downwind of their source. Bioaerosol emissions and transport were then modeled using the USEPA's AERMOD dispersion model. Results were coupled with manure pathogen contents reported by the USEPA, relevant exposure pathways, and pathogen-specific dose-response relationships to estimate a range of realistic downwind risks using Monte Carlo simulation and a quantitative microbial risk assessment approach. Exposure pathways included direct public inhalation as well as downwind deposition to food production plots. Results indicate that bioaerosols emitted from manure application sites may present significant public health risks, and should be considered in a thorough assessment of CAFO manure management practices. Information resulting from this study will allow farm operators, regulators, and other stakeholders to make informed decisions regarding manure management practices and the risks that they present.

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8AG.3
Primary and Secondary Aerosols from a Non-road Diesel Engine and the Role of Alternative Fuels and After Treatment. SHANTANU JATHAR, Abril Galang, Patrick Brophy, Beth Friedman, Gregory Schill, Paul DeMott, Delphine Farmer, Sonia Kreidenweis, Anthony Marchese, Daniel Olsen, John Volckens, *Colorado State University*

Non-road diesels, as used on agricultural and construction vehicles amongst many other, account for about a quarter of the nitrogen oxides and primary aerosol emissions from mobile sources in the United States. While a lot is understood about primary emissions, very little work has been done to characterize the atmospheric formation and evolution of secondary aerosols from non-road diesel engines. Further, little is understood about how secondary aerosols respond to the use of alternative fuels and after treatment devices. To address this gap, we will perform experiments on diluted emissions from a Tier 3 4.5 L John Deere tractor diesel engine and simulate atmospheric photochemistry on those emissions using a potential aerosol mass (PAM) reactor. The PAM reactor will be used to simulate photochemical ages between three hours and seven days. Aerosol size, mass and composition will be collectively measured using a scanning mobility particle sizer, photoacoustic extinctiometer, single particle soot photometer and high resolution aerosol mass spectrometer. The ice-nucleating capability of the aerosols will be measured using a continuous flow diffusion chamber. The potential of the aerosols to form reactive oxygen species (a proxy for the toxicity of aerosols) will be measured by collecting aerosols on filters and performing a dithiothreitol chemical assay offline. In this talk, we will communicate our findings on primary aerosol emissions and secondary aerosol formation and discuss the findings in light of their climate- and health-relevant implications. Furthermore, we will also describe how the aerosol system responded to the use of soy-based biodiesel (B100) and the inclusion of a diesel particulate filter, diesel oxidation catalyst and selective catalytic reduction unit.

8AG.4
Single-particle Fluorescence Measurements for Bioaerosol Exposure Monitoring. GAVIN MCMEEKING, Kimberly Anderson, Nicholas Good, John Volckens, *Droplet Measurement Technologies*

Agricultural workers are at particular risk to high levels of bioaerosol exposure, which have been linked to a wide range of adverse health effects. Inhalation risks from agricultural bioaerosols include endotoxins, bacteria, and fungi – all of which can be present at high concentrations in agricultural environments. Current methods for assessing bioaerosol exposure require long sampling times and do not provide time-resolved measurements, making it difficult to link activities to exposure. Here we evaluate a single particle aerosol fluorescence instrument, the DMT Wideband Integrated Bioaerosol Sensor (WIBS-4A), against conventional filter-based measurement techniques to examine the utility of the instrument for bioaerosol exposure assessment. The study focused on a series of measurements performed in dairy parlors located along the Colorado Front Range region in the spring and summer of 2015. Individual particles measured by the WIBS-4A were classified according to fluorescence signature, size and shape and compared with filter-measurements in addition to being evaluated for trends in diurnal patterns and potential relationships with different activities in the parlor (e.g., milking, rotating of livestock). Measurements were also performed in different locations at the dairy parlors including pens, milking sheds and waste treatment areas. Finally additional testing and evaluation of the instrument response and detection efficiency for particles in the size range 10-90 μm were performed using a dry particle dispersal chamber available during the study.

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8AG.5
Factors Affecting Particle and Gas Concentrations in Swine Production Facilities. PETER RAYNOR, Shannon Engelman, Darby Murphy, Gurumurthy Ramachandran, Jeff Bender, Bruce Alexander, *University of Minnesota*

Swine industry workers face inhalation exposures to endotoxin, organic dusts, microorganisms, and gases. In response to consumer and food industry preferences, production practices in the swine industry are evolving to allow gestating sows to be housed in pens that permit greater movement relative to sows housed in individual gestation stalls that restrict movement. The extent to which the type of gestation housing influences concentrations of particles and gases is unclear. The objective of this research was to characterize particle and gas concentrations in spaces that used different types of gestation housing, and to determine factors that affect worker exposures in these operations. Eight-hour time-weighted average respirable dust and endotoxin concentrations were measured using area samples approximately twice per month for a year in an operating swine facility with parallel gestation stall and pen housing systems for sows. Over the same eight-hour intervals, respirable dust, hydrogen sulfide, ammonia, and carbon dioxide concentrations, and temperature and relative humidity were measured with direct-reading instruments. Due to ventilation changes, season affected concentrations more than other factors. For example, average respirable dust concentrations were greater than 300 micrograms per cubic meter during the winter versus being below the limit of detection, about 60 micrograms per cubic meter, during the summer. Respirable endotoxin levels were approximately ten times higher in winter than during the summer. Respirable dust and endotoxin were 43% and 67% higher, respectively, on average, in the room with gestation pens than in the room with gestation stalls. While individual contaminant concentrations were generally below occupational exposure limits, the effects of combined exposures should be considered further. Elevated levels of respirable endotoxin and hydrogen sulfide were observed during power washing; this task warrants additional characterization.

8AG.6
Potential Secondary Aerosol Formation from Volatile Organic Compounds Emitted in Waste Handling. PHILIP SILVA, David R. Cocker III, Nanh Lovanh, John Loughrin, *USDA - Agricultural Research Service*

Agricultural emissions impact particulate mass concentrations through both primary and secondary processes. Primary contributions of aerosol have focused on wind-blown dust and similar sources. Secondary aerosol contribution is well known for ammonia as a precursor. Evidence from previous laboratory and field work suggests that some volatile organic compounds may contribute secondary chemistry leading to aerosol formation as well. Given that temporal emissions of gases from agricultural facilities are not constant and that some of the chemical species show rapid reactivity in the atmosphere, the need for more real-time and online data to understand emissions and chemistry of agricultural emissions is necessary. In support of this, the Food Animal Environmental Systems Research Unit of the Agricultural Research Service has assembled a suite of instrumentation for field studies to more precisely determine emissions and fate of relevant compounds. Laboratory results suggest rapid formation of secondary aerosol for nitrogen and sulfur containing compounds. Field results confirm the presence of secondary components of particulate matter even very near source. A discussion of the complexity in understanding the net agricultural contribution to secondary aerosol will be included in the presentation.

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8AG.7
Inorganic PM in Poultry House Using Rice Hull Bedding.
NANH LOVANH, John Loughrin, Philip Silva, *USDA - Agricultural Research Service*

The persistence and long life expectancy of ammonia, odors and toxic pollutants from poultry houses may be due to the ability of suspended particulate matters (SPM) to serve as carriers for odorous compounds such as ammonium ions and volatile organic compounds. SPM is generated from the feed, animal manure, and the birds themselves. A large portion of odor associated with exhaust air from poultry houses is SPM that have absorbed odors from within the houses. Understanding the fate and transport processes of particulate emissions in poultry house is a necessary first step in utilizing the appropriate abatement strategies. In this study, the examination of the association of various polyatomic anions with ammonium ion in various particle sizes (inhalable fraction, PM_{10}, and $PM_{2.5}$) was carried out. Fractionated SPM (< 2.5 micron, <10.0 micron, and total inhalable fraction or TIH) were collected from broiler houses using particle trap impactors. The SPM from the particle trap impactors were extracted and analyzed for various inorganic species using ion chromatography (IC). The results showed that fractions of ammonium ions in SPM were highly correlated with sulfate, phosphate, and nitrate anions, and increased in magnitude over several successive flocks during a four-flock total cleanout cycle. The magnitude of correlation increased as the PM sizes decreased. Sulfate appeared to be highly associated with ammonium over phosphate and nitrate anions.

8AG.8
Particle Burst and Growth Observed from a PAM Reactor at Taehwa Forest Observatory.
XIAONA SHANG, Eunha Kang, Hyunjin An, Meehye Lee, William Brune, *Korea University, South Korea*

A Potential Aerosol Mass (PAM) reactor was coupled with a Scanning Mobility Particle Sizer (SMPS) and measurements were made at Taehwa forest observatory near Seoul metropolitan area, South Korea in April, May, and Oct., 2014. Secondary aerosol forming potential was investigated by comparing the particulate number and mass difference in PAM and ambient air, modulated every six minutes. In PAM reactor, SO2 was enough to produce new particles, of which number concentration was over 10^4 cm^{-3} in nucleation mode. For PAM aerosols, the mass increase in nucleation and Aitken mode was comparable to mass loss in condensation mode. In ambient air, two types of particle bursts were distinct in the morning and afternoon. While the former was coincident with EC peak and regularly observed in the morning, the latter took place in the afternoon and lasted for several hours. The mode of morning burst was 20 ~ 30 nm, which is believed to be soot particles emitted from cars. In contrast, the particles of ~10 nm grew to ~40 nm with 3 ~ 4 hours in the afternoon, during which isoprene increased and reached the maximum.

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8AP.1
Discovery of a Scaling Law and a Natural Anisotropy Shape Factor from Polarizability. MINGDONG LI, George Mulholland, Michael Zachariah, *University of Maryland*

We find a universal relationship between the polarizability and hydrodynamic radius. Remarkably the relationship holds for all particle shapes we have evaluated including, the torus, prolate and oblate spheroids, linear random-walk polymers and fractal aggregates. This scaling law is found to be valid for cluster-cluster and particle-cluster generated fractals, with different pre-factors and fractal dimensions. The pre-factor in the scaling law is solely determined by the particle shape, and appears to be a natural anisotropy shape factor.

8AP.2
Particle Mobility Dependence on the Frequency of Applied Electric Field. MINGDONG LI, George Mulholland, Michael Zachariah, *University of Maryland*

The mobility of a nonspherical particle is a function of both particle shape and orientation. In turn the higher magnitude of electric field causes nonspherical particles to align more along the field direction, thus increasing their mobility. In our previous works [Li et al. 2013; Li 2012], we studied this effect on nanorods and doublets of spheres in DC electric fields, and showed that the experimental measurements were in excellent agreement with our developed theory for the orientation-averaged mobility and the dynamic shape factor applicable to any axially symmetric particles in an electric field.

In this work we find that when using a pulsed electric field that the measured mobility depends on the frequency of the field. More specifically and surprisingly we find that this effect is only true for non-conducting particles (e.g. PSL dimers). Conversely, the mobility of conducting particles, such as gold nanorods and soot, is independent of frequency.

This surprising result suggests it may be possible to separate conducting from non-conducting materials.

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8AP.3
Q-Space Analysis of Light Scattering from Gaussian Random Spheres. JUSTIN MAUGHAN, Chris Sorensen, Amit Chakrabarti, *Kansas State University*

Q-space analysis is applied to the light scattered intensity from Gaussian Random Spheres (GRS). Q-space analysis involves plotting the scattered intensity vs. the scattering wave vector q=2ksin(theta/2) where k = 2pi/lambda and theta is the scattering angle on a log-log plot. The light scattering properties of GRS with sigma = 2 and nu =3, where sigma is the relative standard deviation in the radial direction, and nu describes fluctuations in the angular direction, were systematically studied with size parameters ranging from 10 to 30, with a relative index of refraction, m, ranging from 1.01 to 1.5. The scattered intensity was calculated using a Discreet Dipole Approximations (DDA). The results show, as has been found previously in spheres and a variety of other irregular shapes, power law descriptions of the scattering and a Rayleigh functionality of the forward scattered intensity that depend upon the modified phase shift parameter rho' = $2kR|(m^2 - 1)/(m^2 + 2)|$ where R is the volume equivalent radius. These results continue the implication that there is a comprehensive description of light scattering for all particles that can be uncovered with the application of Q-space.

8AP.4
Optical Properties of Suspended Mineral Dusts from Desert Source Regions. Johann Engelbrecht, HANS MOOSMULLER, Samuel Pincock, David Campbell, R.K.M. Jayanty, Gary Casuccio, *Desert Research Institute*

On a global scale, mineral dust aerosol has the largest mass emission rate, average column mass burden, and average optical depth of all aerosol types, with its single scattering albedo (SSA) determining the sign (heating or cooling) and influencing the magnitude of its radiative forcing. Previously, we had suspended surface soil samples from ten desert sites and characterized their optical properties, especially SSA at two visible wavelengths, concluding that mineral dust SSA was controlled by iron content (Moosmüller et al.; 2009). Here we have extended this work to 65 samples, including sample locations in Africa, Arabian Peninsula, Asia, North and South America, and Australia.

A sieved fraction of each sample was suspended in an entrainment facility, from which the airborne particulate matter (PM) was sampled and analyzed. Instruments integrated into the entrainment facility included PM filter samplers, a beta attenuation gauge for the continuous measurement of PM mass fractions, an aerodynamic particle size (APS) analyzer, and a three-wavelength (405, 532, 781 nm) photoacoustic instrument with integrating reciprocal nephelometer for monitoring aerosol absorption and scattering coefficients of suspended PM2.5. Filter sample media included PTFE membrane and quartz fiber filters for chemical analysis (71 species), and nucleopore filters for individual particle analysis by scanning electron microscopy (SEM). Sieved fractions were also analyzed by X-ray diffraction for their mineral content and further mineralogically characterized by optical microscopy.

We will be presenting results on the optical measurements, showing the relationship between PM optical properties including SSA at different wavelengths and chemical as well as mineralogical properties of the entrained dust samples.

References
Moosmüller, H., J. P. Engelbrecht, M. Skiba, G. Frey, R. K. Chakrabarty, and W. P. Arnott (2012). Single Scattering Albedo of Fine Mineral Dust Aerosols Controlled by Iron Concentration. J. Geophys. Res., 117, doi:10.1029/2011JD016909.

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8AP.5
Mineral Dust Deposition and Solar Cell Spectral Performance. Nicholas Beres, Patricio Piedra, Vicken Etyemezian, W. Patrick Arnott, HANS MOOSMULLER, *Desert Research Institute*

We have deposited already well-characterized mineral dust samples onto glass slides and to determined the spectral reduction of light transmitted into the forward hemisphere (i.e., into the solar cell) due to absorption and backscattering. This results in determination of the reduction of the spectral flux reaching the solar cell as function of dust mass per area deposited and as function of physical, chemical, mineralogical, and optical characteristics of the dust sample. This is significant for (1) understanding the role of deposited mineral dust absorption and scattering properties on solar cell deterioration; this enables to model the deterioration of solar cell performance as function of dust source and transport properties; (2) deterioration of the performance of PV and any solar panels with known spectral response; this is possible due to our spectrally resolved optical observations which can be convoluted with any solar panel spectral response to yield efficiency deterioration; and (3) modeling of solar cell performance deterioration enabled by the measured physical, chemical, and optical characteristics of the deposited dust to plan and optimize panel cleaning procedures, and to improve the design of dust repellent solar panels, thereby reducing water use for cleaning.

8AP.6
Evaluation of Nanoparticle Collection Efficiency for Nonwoven Textiles. DONNA VOSBURGH, Levi Mines, Jae Hong Park, Stephanie Alami, Ozgur Yavuzcetin, Thomas Peters, T. Renee Anthony, *University of Wisconsin-Whitewater*

New personal nanoparticle samplers have been developed to streamline nanoparticle exposure assessment using a variety of size-selective collection substrates. Nonwoven textiles have the potential to serve as the collection substrate for a personal nanoparticle sampler as theoretical models indicate that collection efficiency can be varied to meet desired criteria depending on textile characteristics such as fiber diameter, basis weight, fiber composition, and textile thickness. However, before nonwoven textiles can be used in the design of a nanoparticle sampler, the theoretical collection efficiency should be verified with nonwoven textiles. The collection efficiency of test materials consisting of various commercially available nonwoven textiles from two manufacturers were measured and compared to theory.

Test materials were placed into a 25 mm conductive polypropylene cassette. One and two layers of test materials were challenged with a polydispersed NaCl aerosol (number median diameter = 124 nm). A Fast Mobility Particle Sizer was used to measure the particle concentration with and without the test materials in line and the collection efficiency was calculated. The theoretical collection efficiency was calculated using the Payen et al. (2012) theoretical model. The coefficient of determination (R-squared) was used to compare the measured collection efficiencies to the theoretical collection efficiencies.

For all test materials, the theoretical collection efficiencies overestimated the measured collection efficiencies. The R-squared values for one layer of test material ranged from 0.20 to 0.89 while the R-squared values for two layers ranged from -0.30 to 0.72. Fiber shape and composition may explain the large variability in R-squared values. Additional research is needed to improve the theoretical collection efficiency model for nonwoven textiles.

References
Payen, J., et al. (2012). Influence of fiber diameter, fiber combinations and solid volume fraction on air filtration properties in nonwovens. Textile Research Journal. 82: 1948-1959.

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8AP.7

Equivalent-Diameter Relationships for Cluster-dense Soot in the Continuum Regime. Saif Kazi, PAI LIU, Ian Arnold, Rajan Chakrabarty, *Washington University in St. Louis*

Past studies showed that a negative gravity (-g) co-flow diffusion flame forms cluster-dense soot super aggregates (SAs) with their physical size reaching the sub-millimeter scale. However the corresponding aerodynamic size of these particles could be significantly smaller owing to the porous nature of gel materials. In this study, experiments were conducted to determine the relationships between aerodynamic radius (Ra), radius of gyration (Rg), and projected area equivalent radius (Rp) of soot SAs produced using a –g ethylene flame. The Ra was estimated from the gravitational settling behavior of SAs in stagnant air, while Rg and Rp were measured using image analysis of optical micrographs. Results showed that for cluster-dense soot SAs, Ra was approximately one order of magnitude smaller than Rg and Rm. Empirical equations between the three equivalent sizes in the continuum regime have been formulated.

8AP.8

Simulation of Particle Charging and Transport in Corona-induced Electrohydrodynamic Flows. HUAYAN LIANG, Pramod Kulkarni, Lina Zheng, Milind Jog, *Centers for Disease Control and Prevention, NIOSH*

We present computational simulation of fluid flow, particle transport, and electrical charging in electrohydrodynamic (EHD) flows in electrical coronas created by a coaxial system of electrodes, with application to aerosol microconcentration. The simulated system involves a set of coaxial electrodes separated by few millimeters, one held at high potential and the other grounded. The particles acquire charge in the corona discharge created around the energized electrode and subsequently collected on the ground electrode from a coaxial flow. This allows efficient aerosol collection on the tip of the electrodes for subsequent analysis by microscale spectroscopies.

The EHD flow of electrically neutral gas is caused by the momentum exchange with the high velocity ions generated in the corona. The simulation, to solve coupled momentum and charge transport, and electrostatics were developed to account for movement of neutral gas species, distribution of charge and electric field, and fluid dynamics in this system using COMSOL multiphysics software. Particle transport was simulated using Brownian dynamics simulation, accounting for appropriate local flow and electrical field. Diffusion charging of particles was modeled to probe the evolution of particle charge during its transport. Details of simulation approach will be presented. Simulations were used to determine collection characteristics of this system as a function of operating parameters such as flow rate, corona current, particle size, and electrode diameter. Comparison with experimental results will be presented and discussed.

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8BA.1
SenseNet – Performance Modeling of an Outdoor Biothreat Detection System. WILLIAM HARRIS, Ray Pierson, Cody Niese, Egbert Tse, Dave Wasson, Jonathan Thornburg, Quentin Malloy, Prakash Doraiswamy, Robert Serino, *Northrop Grumman Inc.*

SenseNet is a city-wide system designed to detect biothreats. Detection is determined through the use of advanced learning algorithm which leverages a large number of low cost sensors to improve detection and confidence. A system performance model was developed to understand the detection capability and aid in determining the optimum number and placement of sensors to improve detection and confidence. The model is built around a simulator that runs the advanced learning algorithm for a given sensor configuration along with a simulated plume and a statistical background model. The background was provided by correlating sensor performance outdoors with data obtained from EPA's AirNow sensors. Supported sensors include fluorescence single particle counters, aerosol LIDAR, and the MicroPEM point sensor. The system performance model was run for a range of environmental conditions and plume release scenarios to give the overall estimated performance of the system. Typically the system performance model runs one hundred simulations for a given number of randomly located sensors. The average time-to-detection and probability of detection were calculated. These results were used to determine the SenseNet's initial sensor density and diversity for deployment based on a given area.

8BA.2
Seasonality of Bacteria and Viruses in the Air of a Daycare Center. AARON PRUSSIN II, Amit Vikram, Kyle Bibby, Linsey Marr, *Virginia Tech*

Daycare centers are foci for the spread of certain infectious diseases, some of which are transmitted via aerosols. Outbreaks of certain diseases are seasonal, but the seasonal dynamics of the bacterial and viral microbiome in indoor air have not been investigated. Filters from the heating, ventilation, and air conditioning (HVAC) system were collected every two weeks over the course of a year in a daycare center. Bacteria and viruses were extracted from the filters, and the communities were analyzed through 16S sequencing and metagenomic analysis respectively. Microbial community structure relationships with season and building parameters (temperature, relative humidity, and air flow through the HVAC system) were quantified. A relatively large abundance of human-associated microbes, specifically fecal associated bacteria (Enterobacteriales and Clostriales), was found in the air. Although daycare centers are commonly thought of as "dirty" when it comes to microbes, not all microbes found in the air were harmful. Approximately 6% of airborne bacteria were Lactobacillus, which are considered beneficial for human health. There were no significant differences observed between microbial community structure and season or building parameters. A sample collected when the daycare center was closed had a significantly different community structure from the others. These results indicate that children and occupants in the daycare, and not environmental conditions, are the major drivers of the microbial communities.

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8BA.3
Size Amplification of Viral Aerosol by a Batch Adiabatic Expansion System. HAORAN YU, Chang-Yu Wu, Nima Afshar-Mohajer, John Lednicky, Hugh Fan, Alex Theodore, *University of Florida*

Transmission of airborne pathogenic viruses is of great concerns because of the serious impact on human health, agriculture and homeland security. Sampling is a critical step in risk assessment of the exposure to the airborne viruses. However, conventional bioaerosol sampling devices are based on inertia of sampled aerosol and therefore are inefficient in collecting viral particles, which are generally less than 300 nm. In this study, a novel batch adiabatic-expansion for size intensifying by condensation (BASIC) device is developed as an assisting tool for efficient sampling of viral particles. BASIC relies on the principle of heterogeneous nucleation to amplify the size of viral aerosol through condensation of water vapor under supersaturation condition after rapid pressure loss, which induces adiabatic expansion. Physical and viable efficiencies of BASIC were optimized through sensitivity analyses of key parameters, including dwell time, compression pressure and water temperature etc., on paired trials of before-and-after use of BASIC. Preliminary results demonstrated that after adiabatic expansion the number concentration of supermicron-sized particles increased 10^2 folds for PSL particles and 10^4 folds for MS2 phage. Viable efficiency of BASIC and the complete results of the physical efficiency testing will be presented at the conference.

8BA.4
A Global Overview of Fluorescent Biological Particles Using UVAPS and WIBS. J. Alex Huffman, Ulrich Poeschl, Niall Robinson, Ian Crawford, Martin Gallagher, Hang Su, David Healy, David O'Connor, John Sodeau, Miia Hiltunin, Tuukka Petäjä, Markku Kulmala, Carolyn J. Schumacher, Paulo Artaxo, Meinrat O Andreae, KYLE PIERCE, *University of Denver, CO*

Biogenic bioaerosols are relevant for the public health and may play an important role in the understanding of the climate system, but their atmospheric abundance, properties, and sources are not well understood. Systematic global measurements of airborne bioaerosols have been relatively sporadic, however, contributing significant uncertainty to our understanding of their properties and effects. The recent development of instruments capable of detecting biological aerosols in real-time have enabled detailed ambient observations.

The ultraviolet aerodynamic particle size (UV-APS) and wideband integrated bioaerosol sensor (WIBS) were deployed at a variety of measurement sites on five continents over the last decade to observe trends in fluorescent biological aerosol particles (FBAP) in a host of different environments. Most studies showed exhibited average peaks at ~3 micro-meter in size and diurnally in the early morning, with an average mass concentration on the order of 1 microgram m-3. This continuity suggests that the number concentration of bioparticles over vegetated regions may be dominated by fungal spores or agglomerated bacteria within a relatively narrow size range. An overview of global measurements and trends will be shown.

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8BA.5

Development of a Novel Microscope Spectrofluorometer for Individual Bioparticle Characterization. BENJAMIN E. SWANSON, Donald R. Huffman, J. Alex Huffman, *University of Denver*

Primary biological aerosol particles (PBAPs), such as pollen, spores, bacteria and their fragments are a ubiquitous presence within indoor and outdoor atmosphere and are related to a variety of human health and environmental effects. Most bioparticles contain biological fluorophores which can be readily detected via fluorescence spectroscopy, even without the use of fluorescent stains. Previous work has shown that broad categories of bioparticles can be differentiated based on the fluorescence signals of individual particles. Many methods exist to detect and characterize these particle types. However, these methods are often large and expensive. Recently a number of single-particle fluorescence spectrometers have been developed to characterize bioparticles in real-time in the field, however these instruments typically cost >$100k. Here we discuss the development of a novel instrument (patent pending) designed to simultaneously characterize fluorescence spectra from many individual bioparticles, but with a goal of drastically reducing instrument and analysis costs and increasing the spatial coverage of samples collected in parallel. We have developed a working prototype and will discuss here the current state of operation, including examples of spectra achievable by the technique and application to atmospheric samples.

8BA.6

Effect of Seasonal Variability and Co-Pollutants on Fine Bioaerosol Abundance in Urban and Rural Airsheds in Michigan. PEARL M. NATHAN, Alexander H. Rickard, J. Timothy Dvonch, *University of Michigan, Ann Arbor*

Particulate matter (PM) pollution has been studied in great depth with respect to its chemical composition. Outdoor air is made up of chemical as well as biological components. However, bioaerosols in PM2.5 (particles less than 2.5 micrometers in aerodynamic diameter) have not been fully explored to understand their composition and interactions in different airsheds. This study investigates the abundance of fine bioaerosols over seasons in urban (Dearborn, MI) and rural (Dexter, MI) airsheds in Michigan and also the possible associations with gaseous co-pollutants. The urban site is located downwind of several steel processing plants, meat-processing facilities and near a large municipal wastewater treatment facility. The rural site is located significantly upwind of any large anthropogenic point sources. Samples were collected in 30-min durations each day over a two-week period each season from Summer 2013 until Summer 2014 to account for seasonal variability. The sampling method employed gelatin membrane filters and polycarbonate filters to collect total fine bioaerosols present, both culturable and non-culturable. The analysis involved a thorough characterization of fine bioaerosols using culture based assays, pyrosequencing and epifluorescent microscopy techniques to characterize the species present and also to understand both the viable and non-viable components. Preliminary results suggest that the bacterial composition at the urban site exhibits greater diversity as compared to the rural site. The results of this study provide insight to the bacterial diversity in different airsheds as it relates to sources in the vicinity.

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8BA.7
Spectral Intensity Bioaerosol Sensor (SIBS): Description and Initial Characterization of a Novel Commercial Instrument for Spectrally-Resolved Fluorescence Measurements of Individual Particles. NICOLE SAVAGE, Tobias Könemann, Gary Granger, Gavin McMeeking, Ulrich Poeschl, Christopher Pöhlker, J. Alex Huffman, *University of Denver, CO*

Until recently the understanding of bioaerosol properties had been limited by the lack of instrumentation capable of characterizing biological particles with high time and size resolution. The Wideband Integrated Bioaerosol Sensor (WIBS) developed by the University of Hertfordshire and recently licensed by Droplet Measurement Technologies (DMT) provides information about fluorescence of individual particles in two excitation and two emission channels. The Spectral Intensity Bioaerosol Sensor (SIBS) is a new instrument developed by DMT that improves upon the spectral resolution of the WIBS and other commercial bioaerosol sensors by providing higher resolution spectral information. The SIBS measures time-resolved fluorescence following sequential excitation at 280 and 370 nm over 16 emission channels spanning a range of approximately 300-720 nm. The instrument provides single particle fluorescence measurements, fluorescence lifetime, as well as particle size for each interrogated particle.

We performed an initial instrument comparison between the SIBS, WIBS, and Ultraviolet Aerodynamic Particle Sizer (UVAPS) instruments using polystyrene and bioparticle standards. Initial sizing and fluorescence spectral properties reported by the SIBS and other instruments will be reported.

8BA.8
Investigating the Interaction Between Airborne Proteins and Urban Pollutants. EMMALEE BIESIADA, Amani Alhalwani, J. Alex Huffman, *University of Denver, Denver, CO*

Allergies and other respiratory problems have been on the rise in urban areas across the world, but the cause for this is largely unknown. One hypothesis for this is related to the presence of airborne proteins that have undergone nitration reactions due to interactions with ambient vehicular emissions and other air pollutants. It is thought that reactions involving airborne proteins and reactive nitrogen species (NO_x) have the capacity to increase the severity of allergic reactions by making the protein less recognizable to the human body and evading a key step in the immune system response. The concentration of these nitrated species in urban areas is not well understood, however. Here we discuss an immunoassay technique for the detection of nitrated and non-nitrated pollen proteins relevant to urban exposure (Franze et al., 2003). The poster will present initial work towards developing the ability to quantify specific proteins in airborne samples of particulate matter.

References:
Franze, T., Weller, M., Niessner, R., & Poschl, U. (2003). Enzyme Immunoassays for the Investigation of Protein Nitration by Air Pollutants. Analyst, 128(7), 824. doi:10.1039/b303132b

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8BA.9

Highly Efficient Collection of Viable Influenza Virus A/Mexico/4108/2009 (pdmH1N1). John Lednicky, MAOHUA PAN, Julia Loeb, Hsin Hsieh, Arantzazu Eiguren-Fernandez, Nima Afshar-Mohajer, Susanne Hering, Chang-Yu Wu, Hugh Fan, *University of Florida*

Influenza infections pose significant public health threat, yet the measurement of airborne viable virus concentrations is difficult. Reported here is a new, efficient method for the viable capture of airborne influenza virus, referred to as "SESI". Using a laminar flow, water-condensational growth, airborne particles as small as 10 nm are enlarged to form micrometer droplets that are gently deposited into liquid via low-velocity impaction. The condensational growth occurs in a straight, wide-bore, wet walled tubes with two temperature regions, ~8° and 40°C. Air is sampled at 7 L/min, with collection into 1.5 mL of water.

In controlled laboratory experiments, we evaluated the viable capture of H1N1 influenza virus by the SESI system, with comparison to a BioSampler impinger that collects into ~14 mL of liquid, and comparison to airborne virus concentrations calculated from experimental parameters. Pathogenic Influenza Virus A/Mexico/4108/2009 (pdmH1N1). (80-120 nm) was aerosolized using a Bioaerosol Nebulizing Generator and sampled using the SESI and a BioSampler, both of which operated at the same air flow rate. The concentration of viable virus in each sample was measured using Madin Darby canine kidney (MDCK) cells and a standard median tissue culture infectious dose (TCID50) assay to provide the virus titer (#/mL) of H1N1. This value was multiplied by the liquid sample volume to give the total number of viable viruses collected.

For collection times ranging from 5 min to 15 min, the viable H1N1 captured by the SESI was 9 times higher than for the BioSampler, with inferred airborne concentrations of 4200±380 viruses/L of air as compared with 470±160/L for the BioSampler. The SESI measurement of the airborne viable H1N1 concentration is 85% of that calculated from the virus concentration and consumed volume of the nebulizer solution, and the air volume into which it was diluted. As there could be generation losses as well, this indicates that the SESI efficiency for viable H1N1 capture was at least 85%.

8BA.10

BioaerosolResearch.org: Towards a Web-Based Community Resource. J. ALEX HUFFMAN, Viviane Després, Janine Fröhlich-Nowoisky, Christopher Kampf, David O'Connor, Christopher Pöhlker, Ulrich Poeschl, *University of Denver, CO*

Various communities of researchers represented within AAAR and beyond have demonstrated an increased interest in the study of bioaerosols in the last several years. AAAR has recently added a bioaerosol working group to capitalize on this growing interest and, in part, to galvanize discussion and collaboration towards broader cross-communication among disciplines. However, the disparate interests and approaches represented by the researchers often makes it difficult for an individual to have a broad understanding of activities in other areas of bioaerosol science.

In response to suggestions and discussions over the last few years we have begun a pilot project to create a web-based community resource at the address: http://BioaerosolResearch.org. A primary goal of the site will be to collect and broadly organize key publications (new and old) related to bioaerosol research for community members new to the field and to those interested in learning across their traditional boundaries. The site will also provide: an overview of technical information related to bioaerosol research, a message board forum for community discussion, and an email list for broader communication. The development of this resource is in its infancy; however we will present an outline of goals and strategies to be included. The website is planned to be active in preliminary form before the conference so researchers can view and provide comments. The poster will provide an overview of these activities and will engage the AAAR community in discussion about the most useful components to be included in this effort. Additional partners will be strongly encouraged to participate, with the goal forming a steering committee to ensure the resource can be broadly beneficial.

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8CA.1

Brown Carbon Lifetime and Chemistry Following Wildfires. HAVILAND FORRISTER, Jiumeng Liu, Eric Scheuer, Jack Dibb, Luke Ziemba, Kenneth Thornhill, Bruce Anderson, Glenn Diskin, Anne Perring, Joshua P. Schwarz, Pedro Campuzano-Jost, Douglas Day, Jose-Luis Jimenez, Athanasios Nenes, Rodney J. Weber, *Georgia Institute of Technology*

Brown carbon (BrC) aerosol in the atmosphere absorbs light in the UV and visible wavelengths, and has the potential to have large climate forcing impacts. Most BrC is produced from biomass burning, but its lifecycle and atmospheric stability following emission from wildfires is largely unknown. Wildfires are projected to increase dramatically in a warmer and drier future climate. Therefore, ascertaining the extent to which BrC will remain in the atmosphere and affect light-absorption, and thus climate forcing, is crucial. Toward this end, we measured BrC collected on filters from plumes transported for over two days from two fires in the western USA, during the 2013 NASA SEAC4RS mission. Using measurements of organic aerosol mass (OA), black carbon mass (BC), BC coating thickness, aerosol absorption Angström exponent (AAE), oxygen-to-carbon ratio (O/C), and f60 (tracer of biomass burning primary OA), we determine that the BrC emitted from the wildfires was largely unstable. Based on the atmospheric transport time of the smoke calculated using HYSPLIT back trajectories, we found that BrC aerosol light absorption decreased exponentially after emission, with a half-life of 9 to 15 hours. Although most of the BrC was lost within a day, likely due to chemical loss and/or evaporation, a persistent fraction remained, which likely affects the background BrC levels most relevant for climate forcing. Though only the transport times of the two longest data sets could be calculated, we compare data from two other wildfire plumes from the NASA SEAC4RS mission to show BrC light absorption variability from wildfires, as correlated with O/C, f60, and AAE. We also explore the relationship between water-soluble and methanol-soluble BrC to understand the relationship between polarity and aging of light-absorbing compounds in the aerosol.

8CA.2

Determination of Accommodation Coefficients for Organic Aerosol with Thermodenuder Measurements. JAMES HITE, Tianyu Shi, Athanasios Nenes, *Georgia Institute of Technology*

Thermodeunders (TD) are commonly used in laboratory and ambient studies of aerosols to provide information about aerosol volatility. These uses range from qualitatively separating relatively volatile from relatively nonvolatile fractions of the sampled aerosol to quantitatively determining properties that describe the volatility and/or evaporation kinetics behavior of an aerosol sample. When utilized for the latter purpose, the data are often interpreted with a model of the aerosol evaporation kinetics within the TD – outside of conditions where a simplified treatment of the aerosol response within the instrument can reliably be deployed (i.e. the “thermodynamic” versus “kinetic” limits). These kinetic models require information about the aerosol accommodation (or evaporation) coefficient (alpha), often treated as a representation of all kinetic limitations to aerosol evaporation, and typically assume a value of unity.

In light of more recent developments in research concerning secondary organic aerosol (SOA), the likelihood that SOA can exhibit characteristics that would act as kinetic limitations to volatilization (alpha < 1) presents a challenge for the interpretation of data collected with TDs and demonstrates the need for experimental methods to probe this critical unknown. Although some work has been done to constrain α for ambient aerosol, current approaches come with considerable limitations (e.g., long measurement timescales required) that prohibit their use in rapidly varying environments found in airborne measurements and environmental chamber experiments. We present here a combined measurement and modeling strategy that can be utilized to constrain alpha independently of the aerosol thermodynamic properties by probing the response of laboratory-generated aerosol to a variety of instrument conditions.

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8CA.3

Shootout at the CSU Corral: Soot Composition and Optical Properties for 23 Cookstove/Fuel Combinations. R. SUBRAMANIAN, Antonios Tasoglou, Adam Ahern, Eric Lipsky, Christian L'Orange, Kelsey Bilsback, Brooke Reynolds, Kelley Hixson, Jack Kodros, Jeffrey R. Pierce, Michael Johnson, John Volckens, Allen Robinson, *Carnegie Mellon University*

Biofuel-burning cookstoves are significant sources of carbonaceous aerosols in Asia, Africa, and Latin America (Bond et al. 2004.) In addition to effects on indoor air quality, these aerosols contribute to climate change through the co-emission of black carbon (BC) and organic matter (OM.) Intervention efforts seek to reduce PM emissions from cooking and heating activities to improve indoor air quality. We seek to determine the resulting change on the climate impacts of these emissions, first through characterization of the physical and chemical properties of fresh cookstove emissions. To ensure comparability of emissions from different cook stove designs and fuels, a shootout was organized at Colorado State University. Fifteen different stove designs and seven different fuels (23 stove/fuel combinations) were tested, over a protocol incorporating a firepower sweep, as well as transitions between different firepower steps. The cookstove particulate emissions were characterized using an SP-AMS for organic aerosol mass, an SP2 for black carbon mass and number concentrations, photoacoustic extinctiometers for particulate light absorption and scattering at 405 nm and 532 nm, a seven-wavelength Aethalometer for filter-based aerosol absorption, and an SMPS for aerosol mobility size distributions. Preliminary results show that mass absorption cross-sections (MAC) of fresh cookstove soot from a three-stone fire and a Plancha stove, both burning Douglas fir, were similar to the canonical Bond and Bergstrom (2006) values (7.5 m^2/g at 550 nm), at 8 m^2/g and 6.9 m^2/g at 532 nm respectively. However, the high time-resolution data from the SP2 and SMPS showed a shift in the aerosol size distribution for a portion of the Plancha cookstove test, from a distribution dominated by sub-100 nm aerosol (MAC-532 6.9 m^2/g) to a distribution dominated by mobility sizes between 100-300 nm (MAC-532 12.7 m^2/g.) Results from further investigations of this data set will be presented.

8CA.5

Characterization of Carbonaceous Aerosol in the Southeastern Baltic Sea Region (Event of Grass Fires). STEIGVILE BYCENKIENE, Kristina Plauskaite, Vadimas Dudoitis, Carlo Bozzetti, Roman Frohlich, Vidmantas Ulevicius, *SRI Center for Physical Sciences and Technology*

Non-refractory submicron aerosol (NR-PM1) species measured by an Aerodyne Aerosol Chemical Speciation Monitor (ACSM) have been successfully used to evaluate the impact of biomass burning on the composition of aerosol during wildfires in the marine background of South Eastern Baltic region in March 2014. Biomass burning aerosol (BBOA) was quantified from the ACSM data using a positive matrix factorization (PMF) analysis, while it spatial distribution was evaluated using air mass clustering approach. The aerosol chemical composition in air masses affected by large vegetation fires transported from the Kaliningrad region (Russia) and southeast (Belarus and Ukraine) during early spring (March 2014) was characterized. Non-fossil organic carbon was the dominant fraction of PM1, with primary fraction contributing 26-44% and a secondary fraction contributing 13-23%. By classifying the source regions of air masses it was possible to establish the dependence of the aerosol chemical composition on the type of air mass. The concentration weighted trajectory (CWT) maps shows a great influence of the Russia, Belarus, Ukraine and Poland areas to BC and PM concentration in spring. About half of the potentially PM1 organic aerosol particles were internally mixed with more oxidised particles and were presumed to be transported mainly from Russia, Belarus and Ukraine. Observed new particle formation (NPF) events were attributed to the grass burning and secondary biomass burning product transformation and contributed to an increase in particle number concentration.

This work was supported by the Lithuanian-Swiss Cooperation Programme “Research and Development” project AEROLIT (No. CH-3-ŠMM-01/08).

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8CA.6

Predicting Ambient Aerosol Thermal Optical Reflectance (TOR) OC and EC in the Chemical Speciation Network (CSN) and the PM2.5 Federal Reference Method Network (FRM). ANN DILLNER, Mohammed Kamruzzaman, Andrew Weakley, Satoshi Takahama, *University of California, Davis*

The two large particulate matter speciation networks in the United States, the Interagency Monitoring of Protected Visual Environments (IMPROVE) network in pristine areas and the Chemical Speciation Network (CSN) in urban areas use thermal optical reflectance (TOR) to quantify organic (OC) and elemental carbon (EC) (Solomon et al., 2014). Previously we showed that infrared spectra of PTFE filter samples and partial least squares (PLS) regression can be used to predict TOR OC and EC (Dillner and Takahama, 2015a, 2015b) in the IMPROVE network inexpensively and without damaging the samples. The objective of this work is to extend the method to the CSN and Federal Reference Method (FRM) networks, which pose additional considerations given the diversity in site types and aerosol composition. The FRM network is used for assessing compliance with the PM2.5 National Ambient Air Quality Standard and has approximately 900 sites compared to fewer than 200 sites each for CSN and IMPROVE. However, the FRM network does not routinely obtain speciated data. Using sites with collocated CSN and FRM samplers, TOR analysis of quartz filter samples collected in the CSN network are used to calibrate infrared spectra of PTFE filter samples from CSN and FRM network. We discuss the feasibility of using FT-IR and PLS to predict TOR OC and EC in the CSN and FRM networks and provide guidance on developing the calibration models.

Dillner, A. M., Takahama, S., Predicting Ambient Aerosol Thermal Optical Reflectance (TOR) Measurements from Infrared Spectra: Organic Carbon. Atmospheric Measurement Techniques, 8, 1097-1109, 2015a.
Dillner, A. M., Takahama, S., Predicting Ambient Aerosol Thermal Optical Reflectance (TOR) Measurements from Infrared Spectra: Elemental Carbon. Atmospheric Measurement Techniques, submitted, 2015b.
Solomon P. A., Crumpler, D., Flanagan, J. B., Jayanty, R.K.M., Rickman, E. E., McDade, C. E., U.S. National PM2.5 Chemical Speciation Monitoring Networks—CSN and IMPROVE: Description of networks, Journal of the Air & Waste Management Association 64:12, 1410-1438, 2014.

8CA.7

Chemical Composition and Volatility Distributions of Organic Compounds Emitted from Cooking Sources. MOHAMMAD ASIF IQBAL, Craig A. Stroud, Jianhuai Ye, Kevin Goodman-Rendall, Arthur Chan, *University of Toronto*

Primary organic aerosol (POA) is a major component of atmospheric particulate matter. Food cooking has been identified as an important source of POA in indoor and outdoor air. However, there is limited understanding of emissions from cooking sources as they are not well studied compared to vehicular or wood burning emissions. A recent modeling study conducted in Southwestern Ontario reports a large contribution of food cooking to ambient POA [1], but there are significant uncertainties associated with the treatment of food cooking emission sources in the models, particularly their chemical composition and volatility distribution.

Our main goal is to determine the chemical composition and volatility distribution of food cooking emission sources. A source sampler was constructed to measure particle size distributions (using scanning mobility particle sizer) from different cooking activities (e.g., beef and chicken pan frying), and collection of particle- and gas-phase organics onto a quartz fibre filter and Tenax TA-sorbent tubes, respectively. Samples are analyzed offline using thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS). Here we develop an approach to characterize the volatility distribution of POA emitted through cooking using GC retention time. This approach is similar to that by Presto et al. [2] for internal combustion engines, but will use in-situ derivatization for polar organic compounds commonly found in food cooking aerosol (e.g. saturated fatty acids). The volatility distributions derived are used to understand the atmospheric evolution of food-cooking related organic compounds. Molecular markers of food cooking are also speciated for source apportionment of ambient POA in Toronto, Ontario.

References

[1] Stroud, C. A., et al., Atmospheric Chemistry and Physics 12 (2012) 8297.
[2] Presto, A. A., et al., Aerosol Science and Technology 46 (2012) 1129.

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8CA.8
Evaluation and Characterization of Carbonyl Compounds in Ambient Air, Refuge Area, Tijuana, Baja California, Mexico. DEISY SUGEY TOLEDO ARANGURE, Guillermo Rodriguez, Ernesto Velez-Lopez, Alejandro Gomez, Mariela Ruiz, *Universidad Autonoma de Baja California, Tijuana, Mexico*

Carbonyl compounds in the atmosphere are emitted from natural, anthropogenic or photooxidation products are volatile organic compounds (VOCs) (P. Carlier, 1986) sources. The formation of these pollutants is through photochemical oxidation of hydrocarbons such as methane, and other precursors with OH radicals. (P. Armando Baez, 2009) (ATSDR, 1999).

It has been found that formaldehyde is the most abundant in polluted atmospheres and its health effects are manifested in irritation of eyes and respiratory tract, in addition to headache, (A. Campos, 1995). According to the International Agency for Research on Cancer it is it classified as carcinogenic to humans (IARC, 2006), however, have not been established permissible limits air concentrations for this group of pollutants in the country.

In Tijuana, Baja California, there is monitoring program for air quality criteria pollutants (SPA, 2012-2020), with five monitoring stations for air basin -Rosarito Tijuana, reports of PM10 concentrations are published, PM2.5, ozone (O3), nitrogen oxides (NOx), sulfur oxide (SOx).

The method used is US EPA.- TO -11 Ambient air is sucked through Cartridges Sep- Pak silica chromatographic grade. These are coated with 2,4 dinitrophenylhydrazine (DNPH) acidified as derivatizing agent. (The sampling rate was 0.7L / m for a period of 24 hours. (SOP MLD 022, 2001)

In general, average concentration of formaldehyde (8.4 µg/m3) appeared to be the most abundant CCs, followed by butaraldehyde (5.85 µg/m3) and crotonaldehyde (4.94 µg/m3). These results are preliminary and correspond to the fall-winter season, even lack perform sampling Spring - Summer and to compare both periods. It is expected to increase by a high photochemical activity in summer.

8CA.9
Global Changes in Aerosol Concentration, Radiative Effects, and Health Impacts Due to Open Combustion of Domestic Waste. JOHN KODROS, Rachel Cucinotta, Bonne Ford, Christine Wiedinmyer, Jeffrey R. Pierce, *Colorado State University*

Open combustion of domestic waste is a potentially significant source of pollutants in developing countries; however, it is not currently included in many emissions inventories. Globally, open waste burning emits 9.2 Tg yr^{-1} of organic aerosol and 0.6 Tg yr^{-1} of black carbon (Wiedinmeyer et al., 2014). The proximity to largely populated urban areas has created concerns for both local air quality and climate. We incorporate the Wiedinmeyer et al. (2014) open waste burning inventory into GEOS-Chem-TOMAS, a chemical transport model with online aerosol microphysics, and estimate the direct radiative effect (DRE), cloud-albedo indirect effect (AIE), and excess mortality rates. Due to uncertainties regarding mixing state and brown carbon, we estimate the globally averaged DRE to range from -0.008 to +0.006 W m^{-2}. We estimate a globally averaged AIE of -0.002 W m^{-2}; however, in the source regions of South-East Asia, Western Africa, and Central America the AIE ranges from -0.2 to -0.3 W m^{-2}. We show that including this inventory improves model comparison to AERONET aerosol optical depth and SPARTAN $PM_{2.5}$ measurements, and we discuss our estimated excess mortality due to regional $PM_{2.5}$ from trash burning.

Wiedinmyer, C., Yokelson, R. J. and Gullett, B. K.: Global emissions of trace gases, particulate matter, and hazardous air pollutants from open burning of domestic waste., Environ. Sci. Technol., 48(16), 9523–30, doi:10.1021/es502250z, 2014.

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8CA.10

Measurement of In-Use Freight and Passenger Locomotive Black Carbon Emissions in California. Trevor Krasowsky, Nicholas Tang, Nancy Daher, Joshua Apte, Constantinos Sioutas, Philip Martien, George Ban-Weiss, THOMAS KIRCHSTETTER, *University of California, Berkeley*

Black carbon (BC) emission factors were measured for diesel-electric passenger and line-haul freight locomotives along the San Francisco peninsula and near the Ports of Long Beach/Los Angeles, respectively. The emission factors are based on 1 Hz measurements of BC and carbon dioxide (CO2) concentrations in the exhaust plumes of passing locomotives, which were measured from pedestrian and roadway overpasses using portable analyzers. Average emission factors, expressed as g BC emitted per kg diesel consumed, were nearly the same for both fleets (0.9 ± 0.7 g/kg for passenger locomotives (n= 362 samples) and 0.9 ± 0.5 g/kg for freight locomotives (n = 88 samples)).

These values were compared to BC emission factors previously measured for on-road light-duty vehicles (i.e., cars) and heavy-duty trucks. In most cases freight locomotives emit less BC pulling an intermodal freight container over a given distance than diesel trucks. However, continual decreases in diesel truck BC means that unless emissions from locomotives are decreased in the near future, emissions associated with hauling a container could become lower for diesel trucks than locomotives. Per passenger mile, diesel-electric locomotives emit only 20% of the CO2 but ten times more BC than emitted by typical gasoline powered cars. Therefore, the reduction in carbon footprint (expressed in terms of CO2 equivalents) due to CO2 emissions avoidance from a passenger commuting by train rather than car is appreciably offset by the locomotive's higher BC emissions.

8CA.11

Enhanced Light Absorption and Wavelength Dependency Due to Coating and Mixing States of Black Carbon. RIAN YOU, James Radney, Christopher Zangmeister, Michael Zachariah, *University of Maryland*

Black carbon (BC) can warm the atmosphere through absorption of solar radiation. Internal mixing of BC with other aerosol materials has been previously shown to enhance the magnitude of light absorption of BC and, therefore, amplify the particles' radiative heating potential. To investigate this effect we have measured the spectral dependence of BC particles mixed with both absorbing and non-absorbing materials. Black aqueous pigment particles are used as a surrogate for BC and ammonium sulfate and sodium chloride were used as non-absorbing coatings. The BC particles were also coated with brown carbon (BrC) to investigate the enhancement effect from a light absorbing coating. Aerosol absorption spectra were measured for particles with a ~10% mass ratio of BC, mimicking particles observed in the atmosphere. Data was collected using a photoacoustic spectrometer with a supercontinuum laser spanning lambda=500 nm to 840 nm. The size and the mass of particles were classified using differential mobility analyzer (DMA) and aerosol particle mass analyzer (APM), respectively. For clear coatings, the absorption of BC absorption cross-section is enhanced relative to non-coated particles. The enhancement is wavelength dependent, ranging from 20% to 60% and is highest at the shortest wavelength. Mixed BC/BrC particles also showed enhancements and changes in spectral shape. Using the T-matrix method we calculated the absorption of coating aggregates and successfully mapped the mixing states of coated BC. The modeling data is also consistent with findings from transmission electron microscopy.

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8CA.12

Aging Diesel Black Carbon with SOA Coatings and Coagulation to Probe Morphology-dependent Aerosol Absorption Enhancements (Eabs). ALLISON AIKEN, Manvendra Dubey, Shang Liu, Rahul Zaveri, John Shilling, Claudio Mazzoleni, Swarup China, Noopur Sharma, Alla Zelenyuk, Jacqueline Wilson, Gourihar Kulkarni, Mikhail Pekour, Duli Chand, R. Subramanian, *Los Alamos National Lab*

Climate warming due to BC has large uncertainties, specifically due to morphology and mixing state, e.g. Cappa et al., 2012. Classic core-shell coated BC is expected to enhance light absorption (Eabs) by up to a factor of 2, while non-core shell BC morphologies, observed in wildfire emissions (Sedlacek et al., 2012), are predicted to have little to no Eabs. The Soot Aerosol Aging Study (SAAS at PNNL's Environmental Chamber) was designed to investigate the relationship between internally-mixed BC with different morphologies (coated vs. coagulated) and the measured BC Eabs for visible light. 3 different types of experiments were conducted using size-selected diesel BC (120 nm diameter) and secondary organic aerosol (SOA): (1) BC coated with SOA, (2) BC coagulated with SOA, (3) BC coagulated then coated with SOA. Direct on-line BC measurements with the single particle soot photometer (SP2) are coupled with photoactoustic measurements across multiple wavelengths spanning the visible range to probe Eabs in BC when mixed with SOA. Eabs at 781 nm are tracked throughout SOA growth on BC and quantified with SP2 coating thickness. BC coagulated with SOA produces minimal absorption enhancement (<1.1), whereas coatings have significant enhancement at 300 degrees C, up to 1.7 +/- 0.4 for thickly coated BC. Thermal denuder (TD) experiments are conducted and Eabs are calculated from 2 different methods that agree well with each other, confirming observed results. BC measurements are also compared with co-located measurements from SPLAT-II and filter analysis using SEM and TEM. Since we did not observe appreciable Eabs for coagulated BC, we expect ambient emissions dominated by this particle type to have enhancements due co-emission and or mixing with other sources, e.g. brown carbon (BrC; Saleh et al., 2014, Liu et al., submitted 2015).

8CC.1

On the Hygroscopicity of Laboratory Generated Inorganic Sea Spray Aerosol. PAUL ZIEGER, Matthew Salter, Juan-Camillo Acosta Navarro, Joel Corbin, Martin Gysel, Evelyne Hamacher-Barth, Magnus Johnson, Caroline Leck, Douglas Nilsson, Daniel Partridge, Narges Rastak, Ilona Riipinen, Bernadette Rosati, Johan Ström, Olli Väisänen, Annele Virtanen, Josephina Werner, *Stockholm University*

Sea spray aerosol particles were generated using both a temperature-controlled continuous plunging-jet sea spray aerosol chamber, and using nebulisers. The sea spray chamber was filled with artificial seawater free of organics whilst the nebulisers were used to generate aerosol from the same artificial seawater as well as solutions composed solely of the component salts of seawater such as NaCl and $MgCl_2$. The hygroscopicity of the generated particles was determined using a Humidified Tandem Differential Mobility Analyser (HTDMA) and a humidifed nephelometer system (WetNeph). To complement these measurements, images of the particles were obtained using a scanning electron microscope (SEM), the size-segregated inorganic ion composition of the sea spray aerosol generated was determined using a 13-stage cascade low pressure impactor (LPI), and the dynamic shape factor (χ) of the generated particles was determined by measuring the mass of mobility-classified particles using a particle mass analyser.

The results are compared to theory as well as output from the E-AIM aerosol thermodynamics model using the composition of the bulk artificial seawater. Sea spray aerosol generated from the artificial seawater in the sea spray chamber exhibits 5-10% lower hygroscopic growth than both pure NaCl and the E-Aim output for particles between 50nm and 250nm. This is after correction for shape and ruling out the influence of organics.

Coincident to the laboratory experiments the sensitivity of radiative forcing to the hygroscopicity of sea spray aerosol in two large-scale earth system models has been tested. The results suggest that the lower hygroscopicity observed in our laboratory measurements has important implications for calculations of the radiative balance of the Earth given that most large-scale models currently use NaCl as a model for the hygroscopic growth of sea spray aerosol.

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8CC.2
The Importance of Arctic Seabird Colony Emissions in New Particle Formation and Summertime Arctic Clouds.
BETTY CROFT, Greg Wentworth, W. Richard Leaitch, Jennifer Murphy, Jack Kodros, Jonathan Abbatt, Randall V. Martin, Jeffrey R. Pierce, *Dalhousie University, Halifax, Canada*

Measurements at Alert, Nunavut, Canada, with local influences filtered out, show evidence for periodic bursts of new particle formation during the months of May through September. This is indicated by episodes when the measured number of aerosols larger than 10 nm (N10) but less than 20 nm (N20) exceeds 300 cm^{-3}, which happens about 20% of the time during May to September and about 1% of the time during the other months. Our simulations with the GEOS-Chem-TOMAS model using a ternary nucleation scheme show that the amount of free ammonia required to simulate these bursts of new particle formation can only be reached when Arctic seabird colony emissions are implemented in the model. Between May and September, Arctic seabird colonies emit in total about 35 Gg of NH_3. In this study we use the GEOS-Chem-TOMAS model to examine the budget of the precursors for new particle formation in the Arctic. We compare the GEOS-Chem-TOMAS model with measurements at Alert, Canada and also with recent shipboard measurements taken during the 2014 NETCARE summer campaign. This study provides evidence for the key role of Arctic seabird colony emissions in new particle formation during the high-Arctic summer. The aerosol indirect effect due to the additional nucleation in the Arctic is calculated to be more than -0.25 W m^{-2} throughout much of the Arctic, and about -1 W m^{-2} near some bird colonies.

8CC.3
Modification of Droplet Sizes Due to Mixing in Anthropogenic Aerosols.
EMMANUEL FOFIE, Diep Vu, Akua Asa-Awuku, *University of California, Riverside*

Cloud droplet size influences the optical depth of clouds and hence particle scattering and the resulting estimates of global cloud radiative forcing. Yet, the sizes of droplets formed from the activation of aerosols either in their pure states, externally or internally mixed is not well characterized. In this study, we explore the effects of organic anthropogenic aerosol such as succinic acid, malonic acid, ammonium sulfate and soot (Black carbon) on cloud droplet sizes. The final droplets sizes are measured from pure and mixed aerosol species. Aerosol activate, form cloud condensation nuclei (CCN) and their droplet growth is characterized according to their mass accommodation coefficient and mixing states. A custom built flowtube was employed to achieve the different mixing states of the aerosol and NIST-certified borosilicate glass beads were used to verify the sizing of the optical particle sizer of the DMT, Inc. cloud condensation nuclei counter (CCNc). A coupled analysis of laboratory CCN experiments and simulation data from the continuous-flow streamwise thermal gradient CCN (CFSTGC) model showed a distinguishable and repeatable divergence in the sizes of CCN when exposed to the same supersaturation and time, with water vapor depletion effects considered. The results suggest that the final droplet sizes of activated aerosol depends on the chemistry of the aerosol represented by the hygroscopicity parameter, κ, as well as the mass accommodation coefficient. The amount of each aerosol species in the atmosphere and their mixing states may therefore have to be considered when computing the earth's radiative forcing.

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8CC.4
Direct Measurements of Water Transport Kinetics and Viscosity of Glassy Organic Aerosol. Young-Chul Song, Andrew Rickards, ALLEN E. HADDRELL, Rachael E.H. Miles, Frances Marshall, Jonathan P. Reid, *University of Bristol*

Quantifying the interactions between glassy aerosol and water vapour is crucial for understanding the formation of cloud condensation nuclei and ice nuclei in the atmosphere, and the partitioning of semi-volatile species between the particle and gas phases. A glassy aerosol is defined as a non-crystalline material and a disordered amorphous solid. Often, the Stokes-Einstein equation is assumed to relate molecular diffusion constants and viscosity and, at the viscosities typical of glasses (where timescales to reach equilibrium can be up to weeks (Shiraiwa et al., 2012)) suggest that the composition of atmospheric particles may be governed by kinetic rather than thermodynamic factors. We will assess the validity of the Stokes-Einstein equation through direct measurements of the relative humidity (RH) dependence of the viscosity of organic aerosol and the timescale for water transport during condensation and evaporation.

Measurements of the water transport in organic aerosol were made on single particles using the aerosol optical tweezers technique (Bones et al.). The response in size of an individual aerosol droplet (3 - 6μm radius) to stepwise changes in RH was measured. The water activity dependence of the diffusion constant of water can be determined from measurements made over transitions between many pairs of RH values.

The viscosity of an aerosol droplet can be inferred from measurements of the timescale for the binary coalescence of two individual trapped aerosol particles using holographic optical tweezers (viscosities measured over a range of 12 orders of magnitude (Power et al., 2014)).

A comparison of the diffusion constants of water and the viscosity of the organic particle at the same water activity will be used to illustrate the significant errors in assuming the validity of the Stokes-Einstein equation.

Bones, D. L., et al, PNAS, 2012.
Power, R. M., et al, Rep.Prog.Phys., 2014.
Shiraiwa, M., et al, Geophys.Res.Lett. 2012.

8CC.5
Dispersion of Aeolian Aerosols in Atmospheric Boundary Layer Following Dust Emission from Source Areas. BORIS KRASOVITOV, Itzhak Katra, Tov Elperin, Andrew Fominykh, Hezi Yizhaq, *Ben-Gurion University of the Negev, Israel*

Mineral dust is a key agent involved in a wide range of physical, chemical and biological processes of the Earth system. It has been recognized that dust as aerosol has significant impacts on the atmosphere composition as well as on human health. In the present investigation, we suggested a two-dimensional model for particulate matter (PM) dispersion due to dust emission from soils. The study is focused on the local spatial scale (10 km), which is the most important for the process of dust loading to the atmosphere. Aeolian field experiments were performed at a dust source site (loess soil in Northern Negev, Israel) with a portable boundary layer wind tunnel to determine the emitted PM fluxes for different wind speeds and varying soil conditions. The numerical model is formulated using parametrization based on the aeolian experiments. The wind velocity profiles used in the simulations were fitted from data obtained in field measurements with wind mast. Size distribution of the emitted dust particles in the numerical simulations was taken into account using a Monte Carlo method. The numerical simulations enabled to determine the particulate matter concentration distributions under specific shear velocities and dust fluxes from the soil. The calculations were performed for particulate matter PM5, PM10, and PM20 emitted from uniform and limited source areas. The calculated concentrations are supported by PM data recorded over time in a standard environmental monitoring station. The model enhances our capacity of quantification of dust processes to support climate models as well as health risk assessment.

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8CC.6

Ice Nucleating Particles at a Coastal Marine Boundary Layer Site: Correlations with Aerosol Type and Meteorological Conditions. RYAN H. MASON, Meng Si, Jixiao Li, Cédric Chou, Robin Dickie, Desiree Toom-Sauntry, Christopher Pöhlker, Jacqueline Yakobi-Hancock, Luis A. Ladino, Keith Jones, W. Richard Leaitch, Corinne L. Schiller, Jonathan Abbatt, J. Alex Huffman, Allan Bertram, *University of British Columbia*

Ice nucleating particles (INPs) catalyze ice formation at temperatures above -37 °C, thereby affecting cloud microphysical properties and lifetime. In order to improve our understanding of how INPs affect climate, information on what aerosol particle types are acting as INPs in the atmosphere is needed. To determine the major sources of INPs active in the immersion mode at a coastal site in British Columbia, Canada, we investigated correlations between INP concentrations and both aerosol type and meteorological conditions. The concentrations of INPs active at freezing temperatures of -15 to -25 °C are strongly correlated with fluorescent bioparticle concentrations, and the size distribution of INPs is most consistent with the size distribution of fluorescent bioparticles. We therefore conclude that biological particles were likely the major source of ice nuclei between -15 and -25 °C. At -30 °C, concentrations of INPs and total aerosol particles ≥ 0.5 μm are also well correlated, suggesting that non-biological particles such as mineral dust may have had an important contribution to the population of INPs active at this temperature. Furthermore, we found that black carbon particles were unlikely to be a major source of INPs during the studied period. Finally, six empirical parameterizations of ice nucleation were tested to determine if they accurately predict the measured INP concentrations at our coastal site. None of the parameterizations selected are capable of predicting our INP concentrations, indicating that INP parameterizations that are appropriate for this complex environment still require development.

8CC.7

Critical Time for CCN Activation of Biogenic Precursors. ASHLEY VIZENOR, Akua Asa-Awuku, *University of California, Riverside*

Particles that can uptake water and form cloud droplets are referred to as cloud condensation nuclei (CCN). The hygroscopicity, or ability of a particle to activate is traditionally quantified by a single parameter, kappa. Here we examined the photooxidation of two biogenic compounds, isoprene and longifolene using the UCR CE-CERT Environmental Chamber. A TSI SMPS ran in parallel with a Droplet Measurement Technologies Cloud Condensation Nuclei Counter (CCNC) was used to observe the hygroscopicity of resulting secondary organic aerosol (SOA). Traditional CCN analysis is performed by dividing the number of particles activated by the total number of particles (condensation nuclei, CN). The point at which the ratio equals 0.5 is used to identify the critical supersaturation at which 50% of the particles activate for a given diameter. Alternatively, the critical diameter at which 50% of particles for a given supersaturation can be identified. This critical supersaturation and the corresponding dry diameter are then used to calculate kappa. However, this calculation assumes that the hygroscopicity of particles stays constant for a given precursor gas. The CCN to CN ratio at given diameters and supersaturations was calculated and plotted against photooxidation time to observe if this assumption holds true.

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8CC.8
In-cloud Observations of Aerosol Hygroscopicity and Cloud Droplet Activation. OLLI VÄISÄNEN, Pasi Miettinen, Arttu Ylisirniö, Sami Romakkaniemi, Kari Lehtinen, Annele Virtanen, *University of Eastern Finland*

Simultaneous measurements of aerosol hygroscopicity and cloud droplet activation were carried out in Kuopio, Finland during the autumn 2014. The measurement station was located at the top floor of the Puijo observation tower approximately 240 m above the surrounding lake level, providing a possibility to study the aerosol-cloud interactions in real atmospheric conditions. By using the special inlet setup with a switching valve system, we were able to separate the non-activated (interstitial) particles from the total aerosol.

The hygroscopic tandem differential mobility analyzer (HTDMA) was attached to the changing inlet and it was operated to measure the hygroscopic growth factors (GF) at 90 % relative humidity for three different dry sizes (80, 120 and 150 nm). Overall, the measured GF distributions (GF-PDF) appeared bimodal with main peaks around 1.05 and 1.5. However, the fraction of more hygroscopic particles increased substantially with size, causing an increasing trend for overall hygroscopicity. Also, the interstitial particles turned out considerably less hygroscopic (e.g. $GF_{Int,150} = 1.28$) compared to residual particles ($GF_{Res,150} = 1.41$).

By using the non-normalized GF-PDFs, we managed to estimate the activation efficiencies of low ($0.8 \leq GF \leq 1.2$) and high hygroscopicity ($1.2 \leq GF \leq 1.8$) particles separately. Since the 80 nm particles didn't usually activate into cloud droplets, the average activation efficiencies were around 20 % regardless of hygroscopicity. However, the 120 and 150 nm particles already showed distinctive differences between different hygroscopicity populations. On average, the activation efficiencies of more hygroscopic particles were approximately 65 % (120 nm) and 78 % (150 nm) while the corresponding values for less hygroscopic particles remained well below 20 %.

8CC.9
Laboratory Measurements of Contact Freezing by Clay Minerals. WILL CANTRELL, Jyoti Thapa, Joseph Niehaus, *Michigan Technological University*

Pure water is unlikely to freeze unless it is supercooled by approximately 34 K. The presence of a solid surface within the water can reduce the necessary supercooling dramatically. Many mineral dusts will catalyze freezing at supercoolings of 25 to 30 K if they are immersed within the liquid while some biological materials require less than 10 K of supercooling to initiate freezing. If those same substances are presented at the air-water interface, the characteristic freezing temperature is higher. Though theories have been proposed for this enhancement, none have been proven due, in part, to the fact that quantitative data by which those theories could be tested has been lacking.

We have developed a technique to measure the fraction of particles which act as freezing nuclei in the contact mode, and have measured contact freezing efficiencies (both by number and surface area of the particles) for a series of clay minerals: illite, kaolinite, montmorillonite, nontronite-brown, and nontronite-green (all acquired from the Clay Mineral Society). Kaolinite has the highest activity in the contact mode; approximately one in one thousand kaolinite aerosol particles catalyzes contact freezing at -20 C, dropping to one in thirty thousand at -15 C. Nontronite-brown has a freezing efficiency comparable to kaolinite at -20 C, but is more sensitive to temperature. The remaining minerals are much less sensitive to temperature, exhibiting essentially no variation in the measured efficiency with temperature.

We will discuss these measurements in light of the theories put forward to explain contact freezing. In particular, we will use this series of clay minerals to evaluate the hypothesis that a substance's chemical composition contributes to its ability to serve as a contact nucleus.

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8CC.10
Radiative and Climate Impacts of Concurrent Stratospheric Sulfur Geoengineering and a Large Volcanic Eruption. ANTON LAAKSO, Antti-Ilari Partanen, Harri Kokkola, Ulrike Niemeier, Claudia Timmreck, Kari Lehtinen, Hannele Korhonen, *Finnish Meteorological Institute*

Solar radiation management (SRM) by stratospheric sulfur injection is one of the most discussed and probably the most cost effective geoengineering method. Injecting sulfur to the stratosphere could be seen as an analogy of large volcanic eruptions, where large amounts of sulfur dioxide are released into the stratosphere. In the atmosphere SO2 oxidizes and forms aqueous sulfuric acid aerosols which reflect incoming solar radiation back to space. If SRM is ever used to cool the climate it is possible that a huge volcanic eruption could happen also during the SRM, which would lead temporally to a very strong cooling.

Simulations have been performed in two steps. In the first step, we have used the aerosol-climate model MAECHAM5-HAM-SALSA to define aerosol fields. In the second step of the study we have performed climate simulations using Max-Planck-Institute's Earth system model (MPI-ESM) by using aerosol fields defined by MAECHAM5-HAM-SALSA. We studied scenarios of volcanic eruptions in two different locations and seasons and during the SRM sulfur injections and without injections.

Sulfate burden and radiative forcing after the volcanic eruption decrease clearly faster if volcanic eruption happens during the geoengineering injections. In this situation, sulfur from the eruption does not only form new particles but it also condenses into pre-existing particles. This leads to larger particles which lifetime is shorter. Because there is less and larger particles, the effect to the shortwave radiation is smaller. Thus the global mean temperature would have returned to the level before the eruption faster after volcanic eruption during SRM than normal atmospheric conditions. This also means that observations of strong volcano eruptions cannot be applied when estimating the consequences of an eruption during geoengineering. If the eruption took place in the high latitudes, the resulting global forcing would be highly dependent on the season of the eruption.

8CC.11
The North Atlantic Aerosols and Marine Ecosystems Study (NAAMES): A 5-Year Investigation of Ocean, Aerosols, and Clouds. Michael Behrenfeld, Chris Hostetler, RICHARD MOORE, NAAMES Science Team, *NASA*

We present an overview of the recently-selected NAAMES mission concept, which is the first NASA Earth Venture – Suborbital mission focused on studying the coupled ocean ecosystem and atmosphere. Ocean ecosystem changes in a warmer world will likely induce significant changes in the chemical, physical, and optical properties of aerosols within the marine boundary layer. However, these consequences remain highly uncertain. Understanding the changes in the burden and properties of atmospheric aerosols is important because these aerosols can act as cloud condensation nuclei (CCN) to form clouds that alter Earth's radiation balance, and hence, climate.

NAAMES focuses on the subpolar North Atlantic where models indicate particularly strong cloud sensitivity to aerosol perturbations, making this an excellent test region for process-level studies on ocean ecosystem-CCN-cloud linkages that are also relevant to other remote regions. The large spatiotemporal range in plankton stocks and species diversity in the North Atlantic improves distinction between biologically-impacted and non-impacted areas. This variability has contributed to previously observed correlations between chlorophyll and organic aerosol transported to coastal measurement stations and changes in remotely-sensed cloud reflectivity. However, a pressing need remains for interdisciplinary field campaigns that directly connect in situ measurements of ocean ecosystem properties to in situ atmospheric measurements with high spatial resolution. Only by doing so, can a mechanistic understanding be achieved of the ocean ecosystem-CCN-cloud relationships required for physics-based parameterization of Earth system models.

NAAMES utilizes a combination of ship-based, airborne, and remote sensing measurements that directly link ocean ecosystem processes leading to aerosol precursors, emissions of ocean-generated aerosols and precursor gases, and subsequent atmospheric evolution and processing. In this way, the NAAMES observational strategy is an end-to-end approach that quantifies the contribution of each aerosol component during each of the major phytoplankton lifecycle events. The NAAMES science objectives, instrumentation, and ship and aircraft capabilities will be discussed.

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8CC.12
Coefficients of an Analytical Aerosol Forcing Equation Determined with a Monte-Carlo Radiation Model. Taufiq Hassan, HANS MOOSMULLER, Chul Chang, *Desert Research Institute*

Simple analytical equations for global-average aerosol radiative forcing are useful to understand how aerosol forcing depends on key atmosphere, surface and aerosol parameters (Chýlek and Wong, 1995). The surface and atmosphere parameters in these analytical equations are the globally uniform atmospheric transmittance and surface albedo, and have so far been estimated from simplified observations under untested assumptions. In the present study, we take the state-of-the-art analytical equation and modify it to be a function of the single scattering albedo and the asymmetry parameter. Then we determine the surface and atmosphere parameter values of this equation using the output from the global MACR (Monte-Carlo Aerosol Cloud Radiation) model, as well as testing the validity of the equation. The MACR model incorporated spatio-temporally varying observations for surface albedo, cloud optical depth, water vapor, stratosphere column ozone, etc., instead of assuming as in the analytical equation that the atmosphere and surface parameters are globally uniform, and should thus be viewed as providing realistic radiation simulations.

The modified analytical equation needs globally uniform aerosol parameters that consist of aerosol optical depth, single scattering albedo, and asymmetry parameter. The MACR model is run here with the same globally uniform aerosol parameters. The MACR model is also run without cloud to test the cloud effect. In both cloudy and cloud-free runs, the equation fits in the model output well. This means the equation is an excellent approximation for the atmospheric radiation. On the other hand, the determined parameter values are realistic for the cloud-free runs but not realistic for the cloudy runs. The global atmospheric transmittance, one of the determined parameters, is found to be around 0.74 in case of the cloud-free conditions and around 1.03 with cloud. The surface albedo, another determined parameter, is found to be around 0.18 and 0.28 in case of cloud-free and cloudy-sky conditions respectively. Because the cloudy-sky runs yield unrealistic parameter values, we conclude that the equation is more adequate for cloud-free conditions.
References:

Chýlek, P., and J. Wong (1995). Effect of Absorbing Aerosol on Global Radiation Budget. Geophys. Res. Lett., 22, 929-931.

8CC.13
Exploring the Relation between Aerosol Mixing State Metrics and Droplet Number Concentration. RICARDO MORALES BETANCOURT, Athanasios Nenes, *Georgia Institute of Technology*

Aerosol-cloud interactions remain as one of the largest contributors to the uncertainty in global radiative forcing estimates. Both, the characteristics of the aerosol population, i.e., its size distribution, size resolved chemical composition and mixing state, as well as dynamic factors involved in the aerosol activation process play an important role in determining the number of aerosol particles that activate into cloud droplets. The mixing state of an aerosol population is often size dependent and evolves over time, and can have an important impact on the CCN activity. Because of its complexity, the development of an effective metric able to quantify aerosol mixing state has been elusive. Some such metrics capable of quantifying the type and extent of the mixing state of atmospheric particles have been recently developed (Riemer and West, 2013) through the use of a particle diversity index and a mixing state index. In this work we explore the relationship between particle diversity and mixing state index to the CCN activity of an aerosol population. This is performed using two aerosol models of different complexity. Firstly, we utilized the size resolved, two-moment aerosol model (TOMAS) to simulate the temporal evolution of the mixing state index in the aging aerosol population. The resulting aerosol size distributions where then used as input to an aerosol activation parameterization (Morales and Nenes, 2014) to determine the relation between mixing state and droplet number concentrations. In order to evaluate the global changes in aerosol mixing state, we utilized the Community Atmospheric Model version 5.1 (CAM5.1) with the 3 mode lognormal aerosol model to quantify the regional distribution of the changes in the mixing state metrics between present day and pre industrial times. The simulation results show that the mixing state index has increased over continental regions, dominated by the injection of sulfate aerosol.

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8CC.14
Organic Aerosol-sulfate Interaction: Evaluation of Thermodynamic Effects. GAUTHAM SEKAR, Shunsuke Nakao, *Clarkson University*

Recent studies suggest that biogenic SOA formation is enhanced by anthropogenic emissions. One of the possible mechanisms is the interaction between organics and sulfate. A number of experimental studies investigated organic-inorganic interaction through chamber experiments using different kinds of seed particles in different conditions. However, the complex interplay of thermodynamics and kinetics of organic-inorganic containing system, such as effects of water, pH, sulfate, ionic-strength, mass-transfer, remains uncertain.

We aim at improving the understanding of thermodynamics of organic aerosol-sulfate interaction with the focus on salting-in and salting-out, theoretically and experimentally. In order to reduce complexities of coupled thermodynamics and kinetics in typical chamber experiments, we will develop a new experimental approach that isolates thermodynamic partitioning between external mixtures of aerosol within a smog chamber. Hygroscopicity measurements will be used to track partitioning of organics into inorganic particles. We developed a theoretical emulator of size-resolved cloud condensation nuclei measurements to evaluate feasibility of the new approach. We will present results of proof-of-concept experiments and comparison with the emulator model. We will use AIOMFAC model to estimate activity coefficients of organic-sulfate-water mixture.

8CC.15
Investigation of the Physical and Chemical Changes of Atmospheric Aerosols during Fog in Baengyeong Island, South Korea Using High Resolution Time of Flight Aerosol Mass Spectrometry. TAEHYOUNG LEE, Taehyun Park, Alexandra Boris, Yongjae Lim, Junyoung Ahn, Haejin Jung, Youngkyo Seo, Donghee Jung, Seokjun Seo, Jeffrey Collett, *Hankuk University of Foreign Studies*

Fogs/clouds can play both a physical and chemical role in the fate of atmospheric species. Fogs/clouds act as processors of atmospheric aerosol particles and trace gases by aqueous oxidation of gas phase precursors and the interaction of aerosol with atmospheric water and also cleansing of the atmosphere by scavenging and removal of atmospheric particles. In addition to playing a central role in the hydrologic cycle and influencing atmospheric radiative transfer, clouds interact with a variety of chemical species. Together with gases and particles, clouds and fogs comprise a complex multiphase system.

To understand the interaction of aerosol with fogs/clouds better, we conducted a fog sampling campaign and physical and chemical measurements of aerosol at the Baengyeong Island (Intensive Air Quality Monitoring Station), South Korea, during June – July, 2014 and 2015 using a compact version of the Caltech Active Strand Cloudwater Collector known as the CASCC2 and a two-stage fog/cloud water collector (sf-CASCC) that collects “small” and “large” drops. The chemical composition and physical properties of aerosol particles before, after and during fog were characterized by a high resolution time of flight aerosol mass spectrometer (HR-ToF-AMS, Aerodyne), an Aerodynamic Particle Sizer (APS, TSI), a Scanning Mobility Particle Sizer (SMPS, TSI) and Fog Monitor (FM-100, DMT). The presentation will provide an overview of the chemical composition of aerosol and examine changes in particle chemical composition and microphysics by fog/cloud processing in the boundary layer.

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8CC.16
Metrics to Quantify the Importance of Mixing State for CCN Activity. Joseph Ching, NICOLE RIEMER, Jeffrey H. Curtis, Jerome Fast, *University of Illinois at Urbana-Champaign*

The mixing state of the aerosol population is the distribution of chemical compounds across the population. Field observations reveal that ambient aerosol mixing states can be complex. Even freshly emitted particles can contain multiple chemical species depending on the source characteristics, and the initial particle composition is further modified in the atmosphere as a result of aging processes such as coagulation, condensation of secondary aerosol species, and heterogeneous reactions. This has profound impacts on the evolution of cloud condensation nuclei (CCN) activity of aerosol populations.

It is commonly assumed that models are more prone to errors in predicted CCN concentrations when the aerosol populations are externally mixed. However, it has been difficult to rigorously investigate this assumption because appropriate metrics for mixing state were lacking and metrics needed to quantify the error in CCN concentrations due to mixing state effects were unavailable.

In this work we use the mixing state index (chi) proposed by Riemer and West (ACP, 13, 11423-11439, 2013) to rigorously quantify the degree of external/internal mixing of aerosol populations. This mixing state index is a scalar quantity, and varies between 0 (for completely external mixtures) and 1 (for completely internal mixtures) for any given aerosol population. We combine this metric with particle-resolved model simulations to quantify error in CCN predictions when mixing state information is neglected, exploring a range of scenarios that cover different conditions of aerosol aging. We show that mixing state information does indeed become unimportant for more internally-mixed populations, more precisely for populations with chi larger than 0.6. For more externally-mixed populations (chi below 0.2) the relationship of chi and the error in CCN predictions is not unique, and ranges from lower than 10% to about 150%, depending on the underlying aerosol population. We explain the reasons for this behavior with detailed process analyses.

8CC.17
SOA Formation, CCN Activity and PAH Products during Aging of Diesel Exhaust in a Laboratory Chamber. HUMPHREY CHUKWUTO, Da' Nay Lacey, Alexis Tupy, Frank Bowman, *Univeristy of North Dakota*

Diesel exhaust soot particles emitted into the atmosphere undergo aging that changes their physical and chemical properties, but these processes are complex and not well understood. Laboratory chamber experiments were conducted to investigate the aging of diluted diesel exhaust with and without UV light. Particle growth and changes in number concentration and size distribution were monitored with an SMPS. CCN Activity measurements helped detect changes in particle composition. Particle and gas-phase samples were also collected at the beginning and end of the experiment for quantitative GC-MS analysis of PAHs and PAH products. Aging experiments with UV light resulted in significant particle growth due to formation of SOA. Freshly emitted diesel soot particles and particles aged in the dark showed little or no CCN activity, but particles in the UV irradiated mixture showed increasing CCN activity over time. UV exposure also led to increased concentrations of hydroxy PAH products and higher oxy-PAH/PAH ratios relative to experiments in the dark. These results demonstrate that photooxidation of diesel exhaust leads to formation of more polar SOA mass, including oxidation of PAH compounds.

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8CC.18
Response of Clouds to Aerosol Concentration: Results from Mixing Clouds in a Multiphase, Turbulent Reaction Chamber. WILL CANTRELL, Kamal Kant Chandrakar, Kelken Chang, David Ciochetto, Dennis Niedermeier, Raymond Shaw, *Michigan Technological University*

The microphysical properties of liquid water clouds are influenced by aerosol properties such as the number concentration, chemical composition, and size. In turn, a cloud's microphysical properties play a dominant role in its optical properties and in the likelihood that it will produce precipitation. For example, an increase in the number of aerosol particles can lead to an increase in the number that will serve as cloud condensation nuclei, which can increase cloud droplet number and decrease the effective droplet radius, which results in an increase in the cloud's albedo for a constant liquid water path. This logical chain is difficult to quantify in natural clouds because changes in microphysical properties caused by aerosol are almost always entangled with those caused by dynamics.

We have developed a multiphase, turbulent reaction chamber which is uniquely suited to address this problem. It is capable of pressures ranging from sea level to ~ 100 mbar, and can sustain temperatures of +40 to -55 C. More importantly, we can independently control the temperatures on the surfaces of three heat transfer zones, which allows us to establish a temperature gradient between the floor and ceiling inducing Rayleigh-Benard convection and a turbulent environment. The mixing cloud which forms when the boundaries are wet has a constant forcing – i.e. the dynamics are fixed. We can thus explore both the transient and steady state response of cloud microphyiscs to changes in aerosol concentration, composition, and size.

Our initial results show that the cloud droplet effective radius and concentration respond quickly to changes in the aerosol number concentration. Furthermore, if the aerosol in the chamber are not replenished as droplets are removed from sedimentation and collisions with the walls, the fraction of large droplets (> 40 micron diameter) increases, leading to a rapid collapse of the cloud.

8CC.19
Statistical Analysis of Aerosol, Cloud Condensation Nuclei (CCN), Cloud Base Temperature and Pressure in Summer-time North Dakota. JAMIE EKNESS, David Delene, *University of North Dakota*

Aerosols affect cloud micro-physical properties and enhance the formation of precipitation. Understanding aerosol properties, such as CCN concentration, is key to determining precipitation formation. North Dakota has a wide range of aerosol concentrations which makes it an ideal location to test how environmental properties such as cloud base CCN concentration, temperature and cloud base pressure affect surface based precipitation. North Dakota has been the location of four Polarimetric Cloud Analysis and Seeding Test (POLCAST) field projects. During the summers of 2008, 2010, and 2012 aircraft measurements were made during 30 flights in eastern North Dakota.

During the summer of 2012, both the Droplet Measurement Technologies (DMT) and University of Wyoming (UWyo) CCN counters were used to make measurements. The DMT CCN counter measured at three supersaturations (0.2%, 0.3%, and 0.6%), while the UWyo CCN counter measured at 0.6%. Average cloud base CCN concentration measurements from the three POLCAST projects varied between 300#/cm^3 and 3000#/cm^3, with an overall average near 1400#/cm^3. The mean temperature at cloud base ranged from 5C to 16C with an average of 11.45C. Measurements of the mean cloud base pressure are between 998m to 1886m and an average of 1568m. Each of these micro-physical properties affect precipitation efficiency.

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8CH.1
Implications of the Tibetan Plateau for Haze in China.
TIANLIANG ZHAO, Xiangde Xu, Xuhui Lee, Feng Liu, David Kristovich, Chungu Lu, Yudi Guo, Xugeng Cheng, Yinjun Wang, Hongxiong Xu, *Nanjing University of Information Science and Technology*

Rapid increases in pollutant emissions in conjunction with stagnant meteorological conditions result in haze pollution in China. Recent frequent haze in China has attracted worldwide attention. Here we show a relationship between the haze events and Tibetan Plateau (TP)'s environment and climate changes. Based on observational data taken over recent decades, we identify central-eastern China (CEC) as a climatological large-scale "susceptible region" of frequent haze, which is harbored by the TP with its impact on mid-latitude westerly winds. The observational and modeling studies demonstrate that the interannual variation in the heat source over the TP is positively correlated with the incidences of wintertime haze over the CEC. Further analysis indicates that the TP-climate warming induced changes in atmospheric circulation driving frequent haze events in the CEC. The increasingly haze in the CEC is consistent with decreasing winter monsoon winds, intensifying descending air and increasing atmospheric stability in the lower-troposphere over the CEC in association with plateau's thermal anomalies. Therefore, climate change in the TP is found to be closely related to modulate the frequency of haze occurrence in China. Our results also suggest that climate modulation of the large TP-topography should be taken into account for air pollution mitigation policies in China.

8CH.2
Insights into the 2013-14 Winter Haze in Shanghai: Composition and Acidity of Size-Fractionated Inorganic Aerosols and Associated Health Risk.
Sailesh Behera, Jinping Cheng, Xian Huang, Qiongyu Zhu, Ping Liu, RAJASEKHAR BALASUBRAMANIAN, *NUS*

Shanghai, located on the east coast of China, with a population of over 23 million, is one of the megacities of the world with high economic growth and rapid industrialization. During the recent years, air quality in Shanghai has markedly deteriorated. Among the key air pollutants, high levels of airborne particulate matter (PM), emitted by anthropogenic sources and formed by gas-to-particle conversion, are of major concern as they contribute to atmospheric visibility reduction (haze) and its related impacts. The severe winter haze episode that occurred in Shanghai from December 2013 to January 2014, characterized by elevated levels of particulate matter (PM), received considerable international attention because of its impacts on public health and disruption of day-to-day activities. To examine the characteristics of PM during this haze episode and to assess the chemistry behind formation of secondary inorganic aerosols (SIA) and associated health impacts, we characterized eight water soluble inorganic (WSI) ions and twenty four trace elements in twelve size-fractionated PM (10 nm to 9.9 µm). The in-situ pH (pHIS), as predicted by the Aerosol Inorganic Model (AIM-IV) in all sizes of PM, was observed to be lower during hazy days than that during non-hazy days; there was an increased acidity in haze aerosols. Based on the measured concentrations of particulate-bound toxic elements, health risk assessment was conducted, which revealed that the excess lifetime carcinogenic risk to individuals exposed to fine particles under haze events increased significantly ($P < 0.05$). The qualitative source attribution analysis suggested that the haze events during the measurement campaign could be due to a combination of increased emissions of PM from multiple anthropogenic sources followed by its accumulation under unfavorable meteorological conditions with lower mixing heights and less wind speeds and the formation of secondary aerosols.

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8CH.3

Air Quality in the Beijing-Tianjin-Hebei Region before, during and after 2014 Beijing APEC Economic Leaders' Meeting. YANG HUA, Shuxiao Wang, Jiandong Wang, Jingkun Jiang, Wei Zhou, Xiaoqing Tang, *Tsinghua University*

A strict air pollution control plan was carried out for 2014 Beijing APEC (Asia-Pacific Economic Cooperation) Economic Leaders' Meeting in the Beijing-Tianjin-Hebei (BTH) Region. Joint field campaigns were conducted from October to November, 2014, to observe the impact of control plan on the air quality. Particulate matter samples ($PM_{2.5}$), PM_{10}, gaseous pollutants and meteorology data were collected at eight stations in Beijing, Tianjin, Langfang, Baoding and Shijiazhuang of the BTH Region. Chemical compositions of $PM_{2.5}$ were analyzed. Four pollution episodes during this period were selected and investigated. It was found the average $PM_{2.5}$ mass concentrations before and during the control plan were 73-128 $\mu g/m^3$ and 47-99 $\mu g/m^3$, respectively. Mass concentrations of NO_x, CO, SO_2 decreased during the APEC meeting while concentration of O_3 increased. Concentration of nitrate, sulfate, ammonium and organic matters of $PM_{2.5}$ decreased the most during the APEC meeting. Concentration of $PM_{2.5}$ were 52-137$\mu g/m^3$ after the APEC meeting when the control plan ended. Different characteristics of pollutants during different episodes illustrated the great influence of control plan on air quality.

8CH.5

Impact of Mixing State on Black Carbon Mass Absorption Cross Section. JIANDONG WANG, Shuxiao Wang, Jing Cai, Mei Zheng, Jingkun Jiang, Zhen Li, Runlong Cai, *Tsinghua University*

The effects of black carbon (BC) on the Earth's radiative balance remain a major uncertainty in climate models. Mass absorption cross section (MAC) is a key parameter for BC radiative effect, which characterizing the absorption properties of BC, and affected by the mixing state of BC with other particulate matter (PM) species. The purpose of this study is to investigate the effect of mixing state on MAC. The observation campaign was done in March 2015 in Peking University, Beijing, China. A suite of real-time instruments, including an Single particle aerosol mass spectrometer (SPAMS), a Scanning Mobility Particle Sizer (SMPS), a Photoacoustic Extinctiometer (PAX), a semi-continuous OC-EC analyzer, an Aerosol Chemical Speciation Monitor (ACSM), was employed to determine the MAC and PM mixing state. MAC is measured at 870 nm and varied from 4.3 m^2g^{-1} to 11.6 m^2g^{-1}. The quantified mass concentration of each particle was determined by SPAMS and the calibrated by the results of SMPS, ACSM and semi-continuous OC-EC analyzer. The results show that MAC is positive correlated with OC mass concentration and negative correlated with EC mass concentration. The variation of MAE was found to coincide with the OC to EC ratio, perhaps due to the enhancement by coating. The results indicate that the mixing state of PM should be included in the optical calculation, especially in climate model.

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8CH.8
Measurements on Emission Factors of Gaseous and Particulate Pollutants for Offshore Diesel Engine Vessels in China. FAN ZHANG, Yingjun Chen, Chongguo Tian, Jun Li, Gan Zhang, *Yantai Institute of Coastal Zone Research, CAS*

Rapid developments of ports, international trade, and the shipbuilding industry in China have negatively affected the ambient air quality of the coastal zone due to shipping emissions. However, there is still lack of on-board measurement data about the emission factors for gaseous species and particulate matters.

In this study, three diesel engine-power vessels (including one engineering vessel and two scientific research vessels) and two fishing vessels in offshore China were tested to investigate the emission factors (EFs) of various gaseous and particulate pollutants and to estimate their total emissions in China. Gaseous species were measured online and included CO2, CO, NOx, HC and SO2, and particulate matter samples were collected onboard and analyzed for OC, EC, water-soluble ions, as well as various metal elements.

For the engine power vessels, the measured EFs of CO, NOx, HC, PM, and SO2 were 30.2, 115, 23.7, 9.40 and 1.60 g per kg fuel for the engineering vessel, and 6.93-9.20, 31.6-35.7, 1.24-4.18, 0.16-0.72 and 0.92-2.62 g kg-1for the two research vessels, respectively. While for the fishing vessels, the EFs were 27.0-43.9, 48.9-63.6, 0.33-0.61, 4.79-9.74, and 1.32 g kg-1, respectively. Operating modes also significantly affected the emissions factors for all vessels. OC and EC were the main constituents of the PM emitted from the fishing vessels, while water-soluble ions and metal elements accounted for only a small part. Based on these data, a total of 231, 368, 3.10, and 47.6 thousand tons of CO, NOx, HC, and PM, respectively, as well as 2,016 million tons of CO2 were estimated to emit from marine fishing vessels in China in 2010.

8CH.9
Seasonal Differences in Ambient Particulate Matter Pollution in the Tibetan Plateau. ELLISON CARTER, Kun Ni, Scott Archer-Nicholls, Alex Lai, James Schauer, Majid Ezzati, Christine Wiedinmyer, Xudong Yang, Jill Baumgartner, *University of Minnesota*

Cooking and heating with biomass fuels emits high concentrations of pollutants that are both damaging to health and potentially important contributors to regional air quality and climate change. Though cooking emissions and exposures have been well studied, the relationships between household air pollution and ambient air quality are poorly understood. We measured continuous ambient fine particulate matter (PM2.5) during three months in summer (June, July, August 2014) and two months in winter (December 2014, January 2015) at a field site in rural Sichuan, China. At this same field site, we enrolled 201 rural Chinese women who primarily cook and heat their homes with biomass fuels, and measured their 48-hr personal exposure to PM2.5 during the same months in summer (non-heating) and winter (heating) seasons. Real-time and integrated kitchen PM2.5 concentrations were simultaneously collected, along with detailed information on housing characteristics and energy and fuel-use patterns. Average monthly ambient PM2.5 concentrations ranged from 30 ± 27 μg/m3 in June to 13.4 ± 10 μg/m3 in December. Women's geometric mean personal PM2.5 exposure and kitchen PM2.5 concentrations were 81 μg/m3 (95% CI: 74, 88) and 159 μg/m3 (95% CI: 141, 179), respectively. We evaluated a series of regression models with different covariates including village location, kitchen ventilation, and measurement season to estimate relationships between personal, household, and ambient PM2.5 concentrations. We anticipate that results from this study and our approach can be applied in future work to estimate the impacts of cooking and heating activities on ambient air pollution concentrations, and ultimately improve our estimates of regional air quality and climate impacts.

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8CH.10

Light-absorbing Properties of Brown Carbon Emitted from Chinese Residential Sources. CAIQING YAN, Mei Zheng, Xiaoying Li, Xiaoshuang Guo, *Peking University*

Atmospheric brown carbon (BrC) has been widely observed in emissions of biomass/biofuel burning and fossil fuel combustion sources. Inclusion of light absorption contributions of BrC emitted from different sources in climate and chemical transport models could improve simulations of aerosol light absorption and modeling their climate effects. Knowledge of optical properties of source specific BrC are still limited and essential. Previous studies indicated that light-absorbing properties of organic carbon might be dependent on factors such as fuel types and combustion conditions. However, BrC studies are quite limited in China, where sources of fine particulate matter and organic matter are extremely complicated. To investigate light absorption properties of BrC from different sources, identify the potential key sources of brown carbon in China, and determine influencing factors of light absorptivity, source testing in laboratory for simulating residential source emission of fine particulate matter were conducted. Source samples were collected using offline dilution chamber connected with filter samplers and online Aethalometer (AE31). Light absorptivity of brown carbon emitted from residential biomass (crop straw and wood) burning and coal combustion were investigated and compared. Influencing factors of source specific light-absorbing properties of brown carbon will be further discussed from the aspects of fuel types, combustion conditions (smoldering or flaming), as well as co-emitted chemical components. Our results indicated that coal combustion source emission could be an important contributor to atmospheric BrC in China besides biomass burning emission, especially in winter. Light-absorbing properties of biomass burning and coal combustion source emitted BrC exhibited strong dependence on fuel types, respectively, as well as burning state.

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8HA.1

Source-oriented, Micro-environmental Modeling of Cerium Oxide Nanoparticles in an Urban Environment. ALESHKA CARRION-MATTA, K. Max Zhang, Havala Pye, Brett Gantt, Kathleen Fahey, Robert Willis, *Cornell University*

Cerium oxide nanoparticles have been used as fuel-borne catalyst in the bus fleet in Europe as a way to promote clean combustion. Despite decreasing NOx and PM mass emissions, the use of these additives increases the number emission of cerium-containing nanoparticles. Level of human exposure to these particles and the environmental impacts associated with the use of these additives are still unknown. In this study, we simulated the exhaust emission of ceria particles by using a 3-dimensional (3D), multicomponent source-oriented aerosol model to predict the size distribution, chemical composition and mixing state of the exhaust particles. This model coupled aerosol dynamic processes with transport of exhaust particles from its source to ambient background, simulated using a computational fluid dynamics (CFD) model in an urban environment in UK where extensive field measurements were conducted. The advantage of using this model is to provide a realistic representation of near-road processes. Outcomes from this model will help determine the level of exposure to the cerium-containing nanoparticles in microenvironments.

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8HA.2

Contrasting Oxidative Potential of Ambient Water-Soluble PM2.5 Measured by Dithiothreitol (DTT) and Ascorbic Acid (AA) Assays: Spatiotemporal Distribution, Source Apportionment, and Health Impacts. TING FANG, Vishal Verma, Josephine Bates, James Mulholland, Armistead G. Russell, Rodney J. Weber, *Georgia Institute of Technology*

The mechanisms of PM health effects are uncertain, however, it has been hypothesized that a possible route is the ability of PM to induce oxidative stress via catalytic generation of reactive oxygen species (ROS). Thus aerosol oxidative potential might be a better predictor of PM toxicity than more generic aerosol properties, such as mass. We developed a semi-automated system to quantify oxidative potential of filter aqueous extracts utilizing the dithiothreitol (DTT) assay and have recently adapted it to the Ascorbic Acid (AA) assay. We analyzed approximately 500 $PM_{2.5}$ samples collected at contrasting environments in southeastern US using both assays, and found that DTT activity on a per air volume basis was spatially uniform and had higher levels in winter than in summer ($winter_{avg}/summer_{avg}$=1.5). In contrast, AA activity was heterogeneously distributed, with highest levels near traffic, and higher in summer compared to winter ($summer_{avg}/winter_{avg}$=1.9). In contrast to DTT, which is sensitive to organic and metal species, AA activity was only correlated with water-soluble metals (especially Cu, r=0.70-0.91). Source apportionment models suggest a strong contribution from secondary processes and traffic emissions to both DTT and AA activities in urban Atlanta. Biomass burning was a large source for DTT activity, but not AA. DTT activity was generally well correlated with $PM_{2.5}$ mass (r=0.49-0.88), while AA activity did not co-vary with mass. Time series epidemiological analyses using reconstructed oxidative potential based on the past 10-year source impacts suggest that DTT activity was associated with emergency department visits for both asthma/wheeze and congestive heart failure, while AA activity was not linked to any investigated health outcomes (Bates et al., 2015). The lack of correlation of AA with $PM_{2.5}$ and greater chemical selectivity of AA assay (specific to Cu) may explain these results. We conclude the DTT assay is a more comprehensive multi-pollutant ROS indicator.

8HA.3

Cellular Assays for Measuring Reactive Oxygen Species (ROS) Production of Particulate Matter Mixtures. WING-YIN TUET, Vishal Verma, Meghan Knight, Julie Champion, Anna Grosberg, Nga Lee Ng, *Georgia Institute of Technology*

The health effects of particulate matter (PM) have received considerable attention with an increasing number of epidemiological studies associating PM exposure with increases in cardiovascular and respiratory diseases. Furthermore, the World Health Organization (WHO) has classified PM as a Group I carcinogen, meaning there is sufficient evidence that it causes cancer in humans. Despite these findings, the mechanism by which PM exposure results in adverse health effects is unclear. Toxicology studies have suggested that PM-induced reactive oxygen species (ROS) production can initiate inflammatory cascades and that prolonged stimulation of these cascades can lead to oxidative stress and cellular damage. This provides a possible link between PM exposure and adverse health effects as PM can directly generate ROS and induce cellular pathways that produce ROS.

Here we present ROS measurements of ambient PM samples collected in the greater Atlanta area as part of the Southeastern Center for Air Pollution and Epidemiology (SCAPE) study. Murine alveolar macrophages and neonatal rat ventricular myocytes were used to measure cellular oxidative stress via particle-induced ROS production using a fluorescent probe. These cell types were chosen to represent the respiratory and cardiovascular system respectively. Briefly, the probe is non-fluorescent until it reacts with ROS and the measured fluorescence is proportional to ROS produced. For each cell type, various assay parameters (cell number, sample incubation time, etc.) were optimized to give the maximum signal separation between positive and negative controls. Finally, after optimization, filter dose responses were obtained by measuring ROS production in a series of dilutions for filters collected at rural (Yorkville) and urban (Jefferson Street) sites to compare ROS activity and composition between the two.

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8HA.4

Development of a Rabbit Deposition Model to Study Inhalation of Anthrax. BAHMAN ASGHARIAN, Owen Price, Senthil Kabilan, Daniel Einstein, Andrew Kupart, Richard Jacob, Richard Corley, *Applied Research Associates, Inc.*

Despite using rabbits in several inhalation exposure experiments to study diseases such as anthrax, there is a lack of understanding regarding deposition characteristics and fate of inhaled particles (bio-aerosols and viruses) in the respiratory tracts of rabbits. Such information allows dosimetric extrapolation to humans to inform human outcomes. The lung geometry of the New Zealand white rabbit was constructed using recently acquired scanned images of the conducting airways of rabbits and available information on its acinar region. In addition, functional relationships were developed for the lung and breathing parameters of rabbits as a function of body weight. The lung geometry and breathing parameters were used to extend the existing deposition model for humans and several other species to rabbits. Confirmation of the deposition model for rabbits was made by comparing predictions with available measurements in the literature. Particle deposition fraction in the lungs of rabbits was found to be relatively low (under 0.2), which was consistent with reported deposition measurements. Together with the deposition model for humans, the rabbit deposition model is a useful tool to interpret collected data in the lab in rabbits or real-life scenarios of human exposure to bio-aerosols and predict disease outcome in people.

8HA.5

Effect of Electrostatic Charge on the Deposition of Inhaled Aerosols in Infant, Child and Adult Extrathoracic Airways. Mehdi Azhdarzadeh, Jason S. Olfert, Reinhard Vehring, WARREN H. FINLAY, *University of Alberta*

An in vitro study was performed to study the effect of electrostatic charge on the deposition of monodisperse uniformly charged particles in extrathoracic airways. An atomizer was designed to generate monodisperse particles all having the same charge by using controlled Plateau-Rayleigh breakup with induction charging. Experiments were conducted in adult oral-extrathoracic, child oral-extrathoracic (children aged 6-14 years), and infant nasal-extrathoracic (infants aged 3-18 months) airways.

The Alberta idealized mouth-throat, the Alberta idealized child mouth-throat, and the Alberta idealized infant nose-throat models were used to mimic the extrathoracic airways for the three aforementioned cases. Aerosol particles with aerodynamic diameters of 3-6 μm were generated, and studied at inhalation flow rates of 15-30 L/min for the adult, 10-20 L/min for the child, and 7.5-15 L/min for the infant cases, respectively. Charge per particle was controlled over the range of 0-25,000 elementary charges for the adult and 0-10,000 elementary charges for the child and infant tests.

The in vitro results showed deposition enhancement for the charged particles due to electrostatic effects. A nonlinear least squares minimization was used to develop empirical dimensionless equations to predict particle deposition in the extrathoracic airways in infants, children and adults, including electrostatic charge, flow rate, and aerodynamic diameter of the particles.

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8HA.6

Temperature and Humidity Effects on Pressurized Metered Dose Inhaler Sprays. James Ivey, Chelsea Morin, Farzin Shemirani, Jonathan Suderman, Jordan Titosky, Susan Hoe, Reinhard Vehring, WARREN H. FINLAY, *University of Alberta, Canada*

Results of recent studies assessing the effects of ambient temperature, ambient humidity, and device temperature on the performance of solution and suspension pressurized metered dose inhalers (pMDIs) are presented. A selection of commercial and research pMDI formulations were evaluated using the Alberta Idealized Throat to measure the in vitro lung dose. A custom enclosure with temperature and humidity control was utilized to vary ambient temperature, ambient humidity, and device temperature. For low temperature tests, a heating device was utilized on the Alberta Throat to simulate extrathoracic heat transfer. Filtration followed by gravimetric or chemometric assay was used to quantify the in vitro lung dose. It was found that a reduction in either ambient or device temperature resulted in a reduction in in vitro lung dose, as did an increase in ambient humidity. Further, the severity of the effects on lung dose were found to vary across the tested pMDI formulations and devices. These findings bring to light potential difficulties faced by patients who may use their pMDIs in a wide variety of environmental conditions. Further research is needed to fully understand the interactions among device, formulation, and environmental variables and to enable more robust pMDI performance for drug products with a global market.

8HA.7

What Is the Toxicity of the Photooxidation Products of Atmospherically Relevant Volatile Organic Compounds?HUANHUAN JIANG, Myoseon Jang, Sarah Robinson, Tara Sabo-Attwood, *University of Florida*

Secondary organic aerosols (SOAs) comprise a major fraction of atmospheric organic aerosol and can influence the pulmonary system due to their small size in diameter. However, the pulmonary health effects of SOA are still relatively unknown. One of possible mechanisms of SOA toxicity is the reaction of SOA products with thiol groups in cell materials producing reactive oxygen species (ROS), which trigger inflammation in cells. In this study, various SOAs were produced via the photooxidation of four different VOCs [toluene, 1,3,5-trimethylbenzene (TMB), isoprene and alpha-pinene] in the presence of NO_x using a large outdoor photochemical smog chamber (UF-APHOR). The resulting SOAs were efficiently collected using a Particle Into Liquid Sampler (PILS). In order to investigate oxidative potential in cells due to SOAs, dithiothreitol (DTT), a model thiol compound, was reacted with PILS samples and the depletion rate of DTT was observed. The depletion rate of DTT is proportional to the concentration of the catalytic redox-active species in the aerosol sample. Toluene SOA and isoprene SOA showed 2-7 times higher DTT response compared to TMB SOA or α-pinene SOA. Quinones in toluene SOA is believed to cause the depletion of DTT. However, the high DDT response in the isoprene SOA that contains no quinone, suggests that there is other mechanisms that can affect oxidative potential. Both toluene SOA and TMB SOA were applied to studies of biological responses using in vitro human airway epithelial cells (small air epithelial cells, SAEC). Toluene SOA also showed the higher inflammation response (IL-8) using in vitro SAEC than TMB SOA. The dose-response relationship between inflammation response and dose-mass of SOA will be measured. The mechanism behind the toxicity of SOA will also be further investigated in the future.

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8HA.8
Investigation of Screen Collection Efficiency of Airborne Glass Fibers. BON KI KU, G.J. Deye, Leonid Turkevich, *Centers for Disease Control and Prevention, NIOSH*

Collection efficiency of airborne fibers such as asbestos and elongated mineral particles on a screen is of interest from a health perspective because this information could be used to classify airborne fibers by length for toxicology studies. In this study, we investigated collection efficiency of airborne glass fibers using nylon mesh screens. A well-dispersed aerosol of glass fibers (a surrogate for asbestos) was generated by vortex shaking of a sample of glass fiber powder (mean length ~ 20 um and mean fiber diameter 0.88 um) provided by Japan Fibrous Material Research Association (JFMRA). With nylon mesh screens (10, 20, and 60 um mesh sizes), screen collection efficiency, defined as one minus a ratio of downstream to upstream concentrations of screens, was measured using an aerodynamic particle sizer under different screen configurations. These included screens with or without entrance length in a sampling cassette and a centrally blocked screen without entrance length. The results showed that screen collection efficiency increased as screen mesh size decreases from 60 to 10 um for both cases with and without entrance lengths. However, for the screen configuration without entrance length, higher collection efficiency was obtained than in the case with entrance length. The collection efficiency increased from 0.1 to 1.0 as aerodynamic diameter increased 0.5 to 10 um. The difference between the collection efficiencies for the different configurations was small in the aerodynamic size range below 3 um while it increased in the size range from 3 to about 7 um. Based on these results, it is believed that it will be possible to use a screen collection process with different configurations to prepare short fibrous aerosol controls free from longer fiber contaminants.

8HA.9
Thermodynamic and Kinetic Behavior of the Glycerin/Propylene Glycol/H2O Aerosol System. TIMOTHY WRIGHT, Chen Song, Steven Sears, Markus Petters, *North Carolina State University*

Glycerin and propylene glycol mixtures are the common carrier solutions in electronic cigarettes. Aerosols produced from this mixture will evaporate quickly due to their high volatility and gain or lose water until they reach equilibrium with the moisture content of the surrounding atmosphere. Due to these effects, enhanced particle condensation growth can occur within the human lungs where the instantaneous relative humidity values can exceed 100%. The high volatility of glycerin and propylene glycol has made precise kinetic measurements challenging. Here we use a temperature and relative humidity controlled tandem differential mobility analyzer system to study the growth and evaporation kinetics of glycerin and propylene glycol aerosols in a variety of environmental conditions and at various residence times. Initial results suggest that the glycerin aerosol can evaporate within seconds at T>20C and that the accommodation coefficient of glycerin vapor on dry glycerin particles is less than unity. The combined results will help constraining computational modules to model the evolution of glycerin aerosols along a prescribed thermodynamic trajectory.

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8HA.10
Size-Segregated Chemical and Morphological Analysis of Three Gold Mine Dusts. Lauren Chubb, EMANUELE CAUDA, Traci Lersch, Gary Casuccio, *NIOSH*

Characterization of physicochemical attributes of discrete size ranges of mine-generated dust can facilitate the development and improvement of monitoring techniques and control technologies with regard to crystalline silica exposure. Detailed characterization of size-segregated airborne dust as well as of individual particles can be accomplished using a combination of Fourier transform infrared spectroscopy (FTIR), X-ray diffraction spectroscopy (XRD), and scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDS).

Three gold mine dusts were each aerosolized in a calm air chamber and their size distributions characterized via aerodynamic and scanning mobility particle sizers (APS, SMPS). Particles were size-segregated using a ten-stage micro-orifice uniform deposit impactor (MOUDI). Samples were collected on PVC filters for the quantification of silica via FTIR and XRD analyses, and on Nuclepore filters or copper mesh carbon film TEM grids for single particle analysis of morphology and elemental composition via SEM-EDS. An automated SEM-EDS method facilitated the analysis of approximately 1500 particles on each MOUDI stage, in contrast to manual acquisition where significantly fewer particles could be analyzed in a similar period of time. The automated approach yields a more complete data set that is representative of the particular dust and size fraction, and enables comparison between characteristics of silica-containing particles and non-silica-containing particles from each size fraction.

Initial FTIR and XRD results indicate that silica is not uniformly distributed in all size ranges of dust particles, and comprises a higher proportion of some size fractions than of others; the contribution will give comparisons of this trend across the three different dusts. SEM-EDS analysis is underway, and the contribution will summarize single-particle elemental composition and morphological characteristics for each size fraction, highlighting characteristics that distinguish silica from non-silica particles.

8HA.12
Artifacts and Stability of Fine Particle Oxidative Potential Determined with Dithiothreitol (DTT) Assay on Filter Extracts. DONG GAO, Ting Fang, Vishal Verma, Rodney J. Weber, *Georgia Institute of Technology*

Artifacts and stability of fine particulate matter ($PM_{2.5}$) oxidative potential (OP), measured via the dithiothreitol (DTT) assay were studied. Particles were collected in urban Atlanta with high-volume samplers (HiVol, ~1.13 m^3 min^{-1}) and particle composition monitors (PCM, 16.7L min^{-1}) on two different types of filter substrates, i.e. quartz and Teflon, and also with or without activated charcoal denuders. HiVol quartz filter DTT activity was in good agreement with PCM denuded quartz filters (R=0.78, N=14) and also PCM undenuded Teflon filters (R=0.94, N=13), indicating measurement of water-soluble DTT activity was unaffected by filter type or sampling method, when analyzed soon after collection. HiVol quartz filters collected in January 2015 were analyzed periodically to quantify the effects of storage time (frozen at -20 degrees Celsius) on the stability of DTT-active compounds. No significant variation in DTT activity was observed in the first half year after collection. However, the filters collected and archived (frozen at -20 degrees Celsius) in a previous campaign indicated decay in DTT activity by 53% over a period of about two years. Solid phase extraction with a C-18 column showed that the loss in DTT activity was mainly associated with the hydrophobic fraction (DTT activity driven by organic species), whereas the hydrophilic fraction (DTT activity driven by redox-active metals) was stable. These results can be used to set ROS sampling protocols and the extent to which archived filters can be used to quantify the oxidative potential of ambient aerosols for retrospective health studies.

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8HA.13

Biological Effects of Combustion Aerosols on Human Lung Cells Exposed at the Air Liquid Interface: Comparison Between Ship Engine and Wood Combustion Aerosols. Ralf Zimmermann, Gunnar Dittmar, Tamara Kanashova, Jeroen Buters, Sebastian Öder, Marco Dilger, Carsten Weiss, Horst Harndorf, Benjamin Stengel, Karsten Hiller, Sean Sapcariu, Kelly BeruBe, Anna Julia Wlodarczyk, Bernhard Michalke, Thorsten Streibel, Erwin Karg, Jürgen Schnelle-Kreis, Martin Sklorz, Jürgen Orasche, Patrick Richthammer, Johannes Passig, Ahmed Reda, Olli Sippula, Jorma Jokiniemi, LAARNIE MÜLLER, *Helmholtz Zentrum München*

The dosis, chemical composition, size, morphology and surface of aerosols affect their transport in the human lung and interaction with the biological interface. Within the framework of Virtual Institute of Helmholtz (HICE), the observed aerosol properties were combined with the observed biological effects from human lung epithelial cell exposed for 4 hours at a similar dilution above the detection limit of cytoxicity to ship engine (heavy fuel oil (HFO) and diesel fuel (DF)) and wood combustion (logwood and pellet) emissions in an Air-Liquid Interface (ALI) system. State-of-the art instrumentations (SMPS, ELPI, AMS, GC-MS, ICP-MS, TEM, XRF…) were used to comprehensively characterize the emissions. Multi-omics techniques (transcriptome, metabolome, and proteome) were applied to study the cellular responses at the molecular level to determine induction of mechanisms leading to toxicity. We found short term biological response in terms of multi-omics induction strength as follows: DF>HFO>pellet>logwood. From the chemical and physical data, the DF aerosol contained mainly of agglomerated elemental carbon (EC) while the others are mostly compact internally mixed with organics or metals/inorganics. The encounter of the EC-rich DF aerosols with the proteins, DNA, and RNA in cells led to synergistic phenomena outstandingly, protein changes which may have caused by their hydrophobicity that can directly interfere with the lipid-protein interphase in the cell membrane and high surface area causing broader interactions. The HFO and logwood aerosols having organic coatings activated the xenobiotic metabolism may be due to their complex organic functionalities. This study shows that looking at the bulk properties especially of surface chemistry of the aerosols may link the observed biological responses. It also follows that although EC-rich aerosols had shown immediate toxicity, the toxicity of the internally-mixed aerosols may increase with time due to the eventual release/metabolism of the inner components such as EC and heavy metals.

8HA.14

Intersubject Variability in Regional Deposition of Aerosols in Nasal Airways of Children 2-6 Years Old. RYAN MEEKINS, Gregory Vorona, Ammie White, Michael Hindle, Laleh Golshahi, *Virginia Commonwealth University*

Deposition of aerosols in the nasal airways reduces the dose of therapeutics reaching the lungs, but if it could be controlled is beneficial for treatment of nasal disorders such as sinusitis as well as systemic delivery for nose-to-brain drug delivery. Current pediatric nasal drug delivery methods for children 2-6 years old of age, who are not old enough to comfortably hold a mouthpiece for oral delivery have low efficacy and the delivered dose is highly variable due to inter/intrasubject variability among children. Previously Golshahi et al (JAS, 42 , 2011, 474–488) have proposed correlations to predict total deposition in the extrathoracic airways of ten children 4-14 years old. Our current in vitro study involves developing tools to quantify variation of deposition in anterior, turbinate, and posterior regions of children's airways. We have currently produced 5 nasal airway models of children 2 to 6 years old (three normal and two congested airways). These airway models were made by segmenting nasal airways from archived neck CT scans from VCU's Department of Radiology. The models also consist of face for mask attachment. These airways were 3D printed in ABS plastic at a resolution of 100 microns and have currently been verified to give appropriate pressure drops (0.56-0.92 in/H2O) at a steady flow rate of 10 lpm. Our experimental setup includes a Pari SinuStar aerosol delivery system for the generation of aerosol, delivered to our 3D printed models through a Pari pediatric face mask. An INGMAR MEDICAL ASL 5000 Breathing Simulator simulates appropriate pediatric breathing patterns. We use high performance liquid chromatography to quantify deposition in three different regions of each airway model. The deposition data and the airway dimensions could be linked together to develop a correlation for the prediction of regional nasal deposition in children aged 2 to 6 years old.

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8IM.1

Surface Enhanced Raman Spectroscopy (SERS): Enhanced Detection of Organic Species in Individual Aerosol Particles. REBECCA CRAIG, Amy Bondy, Joel Rindelaub, Paul Shepson, Andrew Ault, *University of Michigan*

Surface enhanced Raman spectroscopy (SERS) provides direct, spectroscopic observation of the chemical complexity of individual atmospheric aerosol particles at ambient pressure and temperature. SERS improves the detection of low concentration analytes by using metal nanoparticles to enhance the Raman signal of functional groups present. SERS analysis of ambient particles from a forested region impacted on silver nanoparticle coated quartz substrates allowed for observation of an array of spectral features previously undetectable through Raman microspectroscopy. Of particular interest were organic functional groups due to secondary organic aerosol (SOA) material formed by oxidation of biogenic volatile organic compounds (BVOCs) at the single particle level. With hundreds to thousands of different chemical species present in individual particles, species present at femtogram to attogram levels were detected using SERS. While SOA composition is often assumed to be homogenous between and within individual particles, SERS analysis revealed substantial particle-to-particle variability, as changes on scales less than 1 micron were observed. Experimentally collected spectra, along with density functional theory (DFT) calculations, of standards of low-volatility organic species predicted to be in the particle phase have been used to gain insight into the functional groups from different species present in these aerosol particles. SERS has great potential to improve analysis of aerosol particles, specifically composition, mixing state, and internal structure, which affect a particle's optical properties and water uptake.

8IM.2

A Shrouded Cell with Magnetic Passive Aerosol Sampler to Determine Particle Penetration through Protective Clothing Materials. PETER JAQUES, Pengfei Gao, *National Institute for Occupational Safety and Health, CDC*

The risk of worker's exposures to aerosol particles has increased with the increase of industrial production of engineered nano-materials. Current test methods for measuring particle penetration through protective clothing materials are based on active filtration principles (e.g., downstream vacuum), which deviate from "real world" experiences, because particle penetration is most commonly driven by upstream wind. To test this, a previously developed multidomain magnetic passive aerosol sampler housed in a shrouded cell was evaluated in a recirculation aerosol wind tunnel against paramagnetic Fe3O4 particles. Particles were collected on PVC substrate and quantified using a computer-controlled scanning electron microscope. Particle penetration levels were determined by taking the ratio of particle number collected on the substrate with a fabric to that without a fabric (control). Results for each fabric obtained by this passive method were compared to previously collected results using an automated active fractional efficiency tester (TSI 3160) that used sodium chloride particles for the challenge aerosol. Several nonwoven fabrics with different thicknesses, porosity, and air permeability were evaluated. Particle penetration levels obtained by using the active sampling method were higher than those by the passive method. The lower the air permeability, the greater the difference in measured penetration as indicated by the ratio of active:passive sampling. For example, for the fabric with the highest air permeability (0.0035 m/sec-Pa) at a face velocity of 0.3 cm/s, the difference in measured penetration levels was about 1.5 times in the most penetrating particle size range of 300 nm. However, the difference was as high as 5.5-fold for the fabric with the lowest air permeability (0.00067 m/sec-Pa). The results suggest that the active sampling method overestimated particle penetration, since it can force particles through a fabric despite low air permeability.

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8IM.3
Optimization of Air-Microflidic Circuits for Microfabricated Direct-Read Mass PM2.5 Sensors. SEIRAN KHALEDIAN, Dorsa Fahimi, Troy Cados, David Woolsey, Omid Mahdavipour, Paul A. Solomon, Thomas Kirchstetter, Lara Gundel, Richard White, Igor Paprotny, *University of Illinois at Chicago*

This work continues the development of our small portable particulate matter (PM) sensing platform that can be incorporated into lightweight, low-power devices with PM levels communicated through wireless networks for community-based monitoring of air pollution, as well as other aerosol instrumentation. The micro-electromechanical systems (MEMS)-based direct reading PM mass sensor measures fine (<2.5 micron aerodynamic diameter, [AD]) PM mass concentrations in real-time, with a limit of detection of a few micrograms/m^3. Microfabrication techniques have reduced the area of the sensor to few cm^2 and its weight to about 27 gm including its housing, enabling portable (perhaps wearable) real-time monitoring of airborne particles. The sensor consists of two main components: a virtual impactor (VI) that removes coarse (>2.5 micron AD) particles, and a deposition area where a film bulk acoustic resonator (FBAR) measures the mass of the particles that have been driven from the airstream to the surface of the resonator by thermophoresis.

In this work, we present an optimization of the microfluidic circuit with aim to increase the sensitivity of the sensor to $PM_{2.5}$. Computational Fluid Dynamic (CFD) modeling is used to design the new optimized version while opto-gravimetric and microscopy results from microfabricated test show experimental results in a good agreement with simulation. The characterization of the opto-gravimetric method is presented, enabling highly accurate sampling of the collection efficiencies of the devices at flow rates below 10 L/min. Cut-point analysis for $PM_{2.5}$, which consists of the convolution of the cut-point due to upstream VI, inertial concentration of particles, particle settling, and the thermophoretic efficiency, is presented, resulting in an optimized microfluidic circuit.

8IM.4
Performance of Wireless Distributed Sensors for Automated Control of Float Dust in Underground Coal Mines. OMID MAHDAVIPOUR, Timothy Mueller-Sim, Dorsa Fahimi, Croshere Skot, Pilatsch Pit, Jusuf Merukh, Valentino Zegna, Paul A. Solomon, Paul Wright, Richard White, Lara Gundel, Igor Paprotny, *University of Illinois at Chicago*

Underground coal mining produces finely divided coal dust, called ‘float dust’, which deposits throughout the coal mine. This combustible material can be feedstock for coal dust explosions. Limestone powder, known as ‘rock dust’, is used widely as an inerting agent, which when dispersed throughout the mine will quench a potential explosion at its onset. The ratio of total incombustible mass (rock dust + incombustible content of coal dust) divided by total mass of the deposited dust is called the Total Incombustible Content (TIC) of the deposited dust stack. Mine safety regulations specify minimal TIC for both intake and return airways.

We present a low-cost/low-power wirelessly enabled distributed sensing system that can be located throughout the underground coal mine to continuously monitor the TIC of the dust. The sensors use continuous optical, gravimetric, and dielectrometric methods to measure the TIC of the deposited stack of float dust/rock dust. A low power design has been developed to enable the sensors to operate for extended periods underground on a single battery charge. The sensors have been designed to periodically refresh the collection surface to mitigate dust accumulation impairing the optical path. The sensor housing has been designed to optimize the efficacy of the sensors, and a prototype has been developed and constructed using fused deposition modeling (FDM). We also present the experimental results from testing the sensor prototypes in a realistic test bed, subjected to the deposition of the coal dust/rock dust mixture. The sensor performance and stability at different humidity levels is evaluated, and the accuracy of the results are compared to the currently established best practices for measuring TIC in underground coal mines.

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8IM.5
Gas/particle Partitioning of Organic Acids during the Southern Oxidant and Aerosol Study (SOAS): Measurements and Modeling. SAMANTHA THOMPSON, Laxmi Narasimha Yatavelli, Harald Stark, Joel Kimmel, Jordan Krechmer, Weiwei Hu, Brett Palm, Pedro Campuzano-Jost, Douglas Day, Gabriel Isaacman-VanWertz, Allen H. Goldstein, Manjula Canagaratna, Rupert Holzinger, Felipe Lopez-Hilfiker, Claudia Mohr, Joel A. Thornton, John Jayne, Douglas Worsnop, Jose-Luis Jimenez, *University of Colorado, Boulder*

Gas/Particle partitioning measurements of organic acids were carried out during the Southern Oxidant and Aerosol Study (SOAS, 2013) at the Centerville, AL Supersite in the Southeast US during summertime, in a region with strong isoprene and terpene emissions. A Chemical Ionization High Resolution Time-of-Flight Mass Spectrometer (HRToF-CIMS), with acetate (CH3COO-) as the reagent ion was used to selectively analyze acids. The gas/particle partitioning was measured in near-real time using a Filter Inlet for Gases and AEROsols (FIGAERO). We investigate both individual species and bulk organic acids. The partitioning measurements are compared with those of three other instruments that can also quantify gas/particle partitioning with high time resolution: another HRToF-CIMS using I- as the reagent ion to ionize acids and other highly oxidized compounds, a Semivolatile Thermal Desorption Aerosol GC/MS (SV-TAG) and a Thermal Desorption Proton Transfer Time-of-Flight Mass Spectrometer (TD-PTRMS). This allows for comparison of the directly measured partitioning to models of partitioning to organic and water phases in the aerosol. The partitioning measurements for three of the instruments are generally consistent, with results in the same range for most species and following similar temporal trends and diurnal cycles. The TD-PTRMS measures on average ½ the partitioning to the particle phase of the acetate CIMS. Both the measurements and the model of partitioning to the organic phase respond quickly to temperature, and the model agrees with the measured partitioning within the error of the measurement for multiple compounds.

8IM.6
A Novel Aerosol-into-Liquid Collector for Online Measurements of Trace Metal and Elements in Ambient Particulate Matter (PM). DONGBIN WANG, Martin Shafer, James Schauer, Constantinos Sioutas, *University of Southern California*

A novel monitor for online, in-situ measurement of several important metal species (i.e. Fe, Mn and Cr) in ambient fine and ultrafine particulate matter (PM) is developed based on a recent published high flow rate Aerosol-Into-Liquid Collector. This Aerosol-Into-Liquid Collector collects particles directly as highly concentrated slurry samples, and the concentrations of target metals in slurry samples are subsequently determined in a Micro Volume Flow Cell (MVFC) coupled with absorbance spectrophotometry to detect colored complexes comes from the reaction between target metals and specific reagents. Laboratory tests are conducted to evaluate the performance of the MVFC-absorbance system. The calibration curves of the system are determined using standard solutions prepared by serial dilution. As part of the evaluation, the effects of reaction time, reagent amount and interferences on the system are also evaluated. Field evaluations of the online monitor validate the ability of this new online sampler in near-continuous collection and measurements. Both laboratory and field evaluations of the novel monitor will indicate that it is an effective and valuable technology for PM collection and characterization of important metal species in ambient aerosols.

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8IM.7
Assessment of PM Measurements Used in the US-EPA Residential Wood Heating Appliance Emission Test Method. GEORGE ALLEN, Lisa Rector, *NESCAUM*

The US EPA issued revisions to the New Source Performance Standards (NSPS) for residential wood heaters in February, 2015 that tightened PM emission limits for new wood heaters. Changes to regulatory test methods were part of this NSPS rule, and included the option of using Teflon coated glass fiber filter media in addition to the glass fiber media that has been used for several decades. The addition of Teflon media was in response to concerns regarding possible acid gas artifacts when glass fiber filters are used for measuring PM emissions for residential wood combustion, which could bias test results and degrade reproducibility of tests. While EPA test method 5 specifies use of inert filter media when sampling stack PM containing acidic gases, methods 5G and 28 for wood heaters specified glass fiber filters (a basic media) be used. The implicit assumption that woodsmoke does not have acidic gases is not always correct, at least for eastern wood like red oak which can have more than 100 ppm sulfur content and thus SO2 in the stack gas. Twenty-six sets of gravimetric dilution tunnel PM samples from a 1988 NSPS-compliant wood stove burning red oak were collected using glass fiber, Teflon coated glass fiber, and Teflon membrane filters under a range of burn conditions. PM sample concentrations ranged from 3 to 200 milligrams/m^3; sample duration was usually between 15 and 90 minutes. Teflon membrane and Teflon coated samples agreed well (slope=1.06) and were well correlated (R2=0.97). Glass fiber samples were inconsistently higher than Teflon coated samples (10 > 30%, 2 > 200% higher), with slope=1.19, R2=0.89. These results are consistent with a positive acid gas artifact on glass fiber filter media.

8IM.8
A One-Nanometer, Water-Based Laminar-Flow Condensation Particle Counter. SUSANNE HERING, Gregory Lewis, Steven Spielman, Chongai Kuang, Arantzazu Eiguren-Fernandez, Nathan Kreisberg, *Aerosol Dynamics Inc.*

A new, water-based condensation particle counter has been developed to detect particles in the 1-nm size range. This nano-WCPC is a laminar flow instrument, and uses a three-stage growth tube system. Flow at 0.3 L/min passes through a wet walled tube, the first portion of which is cooled to 1 °C, the second portion is heated to 90-96 °C, and the third is cooled to 32 °C. The optics are held at 50 °C. The warmed second portion provides the water vapor to create the supersaturation necessary for particle activation, while the third stage removes much of the excessive water vapor while maintaining the supersaturation. Modeling indicates Kelvin diameters approaching 0.9 nm. Calibrations with molecular ions and ammonium sulfate aerosol demonstrate detection of negatively charged particles with mobility diameters as small as 1.1nm.

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8IM.9
Tropospheric Vertical Aerosol Measurement System Development. Kang-Ho Ahn, HEE-RAM EUN, Hong-Ku Lee, Gun-Ho Lee, Yong-Hee Park, Jinhong Ahn, *Hanyang University, R. of Korea*

It is important to understand the atmospheric aerosols compositions and size distributions since they greatly affect the environment and human health. Particles in the convection layer have been a great concern in global climate changes. To understand these characteristics satellite, aircraft, and radio sonde measurement methods have usually been used. An aircraft aerosol sampling using a filter and/or impactor was the method commonly used (Jay, 2003). However, the flight speed particle sampling had some technical limitations (Hermann, 2001). Moreover, the flight legal limit, altitude, prohibited airspace, flight time, and cost was another demerit. To overcome some of these restrictions, Tethered Balloon Package System (T.B.P.S.) controlled by electrical winch was developed with a very light optical particle counter (OPC), impactor, and condensation particle counter (CPC). Not only does it collect and measure atmospheric aerosols depending on altitudes, but it also monitors the atmospheric conditions, temperature, humidity, wind velocity, pressure, GPS data, during the measurement (Eun, 2013).

In this research, atmospheric aerosol measurement using T.B.P.S. in Ansan area is performed and the measurement results will be presented. The system can also be mounted to an unmanned aerial vehicle (UAV) and create an aerial particle concentration map. Finally, we will present measurement data from Dangjin area using R.P.S (Recovery Package System).

This research is supported by Korea Ministry of Environment as “The Eco-Innovation project”.

8IM.10
Assessing the Accuracy and Reliability of Low-Cost Counters for Determining Loadings of Fine Particulate Matter. DAVID HAGAN, Eben Cross, Jesse Kroll, *MIT*

The past few years have seen the emergence of many low-cost commercial devices for measuring particulate matter (PM) for the monitoring of both indoor and outdoor air quality. Although these devices are beginning to see widespread use, very little is known about the accuracy and reliability of their data. In particular, the extent to which such monitors can be used to estimate particle mass concentration, the quantity on which most health-based assessments and PM regulations are based, is unclear. Low-cost PM sensors typically are based on particle counting by light scattering, presenting certain challenges when trying to calculate mass loadings of accumulation mode aerosols (0.1 – 1 mm). Here we describe a systematic laboratory assessment and calibration of several low-cost PM sensors (Alphasense OPC-N2, Dylos DC1100, Shinyei PPD60PV, Shinyei PPD42NJ, Sharp GP2Y1023, Sharp GPY1012), in which outputs are compared to measurements from higher-grade PM monitors (a scanning mobility particle sizer and DustTrak aerosol monitor). The overall accuracy and reliability of each sensor is reported for a variety of aerosol types, aerosol shapes, particle compositions (density and refractive index), and size distributions in order to better understand the extent to which each sensor can estimate mass concentrations based on measured aerosol number concentration and other pertinent parameters.

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8IM.11
Ambient Inlet Ionization for On-Line Molecular Characterization of Aerosols. ANDREW J. HORAN, Murray Johnston, *University of Delaware*

The ability to determine the molecular composition of aerosol particles in near real-time is crucial to understanding the rates and mechanisms of reactions leading to their formation. In order to perform such an analysis, factors contributing to ionization efficiency reduction need to be thoroughly mitigated. To this end, a novel on-line source has been developed by modifying several inlet ionization techniques. Drawing from elements of Extractive Electrospray Ionization (EESI) and Solvent Assisted Inlet Ionization (SAII), an aerosol sample is passed over the evaporating droplets of a SAII liquid flow containing only solvent. The interaction between the aerosol and the SAII 'plume' is fully contained within the heated inlet of a quadrupole-time-of-flight (QTOF) mass analyzer and both positive and negative ions can be detected. The positive ion spectrum is typically dominated by $M+Na^+$ ions, while the negative ion spectrum is dominated by $M-H^-$ ions. In this setup, the entirety of the aerosol passes into the mass spectrometer, reducing losses from inefficient ionization that are present in other on-line methods. The use of a QTOF mass analyzer not only produces molecular information, but MS/MS can also be employed to determine structural information in real time. In this way, a sensitive technique is developed that allows for real-time characterization, of atmospherically relevant aerosol systems. The method is demonstrated by analyzing standard aerosols as well as a sample of secondary organic aerosol created by the ozonolysis of volatile organic carbon precursors. The effect of changing the composition of the SAII solvent is also examined.

8IM.12
Characterization of Air Velocity Patterns Downstream of Pleated Filters Using Particle Image Velocimetry (PIV). SEUNGKOO KANG, Noah Bock, David Y. H. Pui, Jacob Swanson, *University of Minnesota*

Air flow patterns across pleated filters are affected by a number of parameters such as filter media properties and pleat geometry. Research has been devoted to numerically examining the effects of different pleated filter properties and pleat geometries on airflow patterns in order to develop optimal conditions for pleated filters, minimizing pressure drop and increasing filtration efficiency. Experimental investigation of air flow patterns, however, has only been given a little attention.

Particle Image Velocimetry (PIV) is an experimental technique used to measure velocity fields within fluid flow. In PIV, a laser light sheet is pulsed to illuminate the seeding particles in order for them to be captured by the camera. The computer software tracks particle displacements during the time between two laser pulses, (~10 micro-seconds for this study), to produce instantaneous two dimensional velocity fields.

In this study, a method was developed for characterizing airflow patterns directly downstream of pleated filters using a PIV system consisting of a 200 mJ/pulse Nd:YAG laser, 11 MP digital camera, synchronizer, and computer software operating TSI's INSIGHT 4G. Seeding particles, approximately equal to the most penetrating particle size of the filter media, were generated and flowed through a pleated filter. Velocity fields near the surface of pleated filters were measured to study the effects of pleat locks and pleat density at different flow rates. The velocity variation with time, as well as the time average of the velocity fields at selected planes along the filter, was determined. Also, the feasibility of using PIV to detect pinholes in filter media was evaluated. The design and experimental results of this study will be presented.

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8IM.13

Development of Multivariate Calibration Approach for Measurement of Aerosol Elemental Concentration Using Microplasma Spectroscopy. LINA ZHENG, Pramod Kulkarni, M. Eileen Birch, Dionysios Dionysiou, *Centers for Disease Control and Prevention, NIOSH*

A method for conducting multivariate calibration for elemental measurement of aerosols using microplasma spectroscopy is presented. Conventionally, the univariate approach is widely used for calibration of spectroscopic methods to determine elemental concentration. However, bias from matrix effects can be significant depending on the characteristics of the plasma and the nature of matrix containing the analyte. The measured concentration of target element can depend on the presence of other elements and their abundance in the aerosol particle. This can sometimes lead to large uncertainties in the measured concentration of elements using an univariate approach. The objective of this study was to investigate effectiveness of multivariate calibration approaches, such as partial least square regression (PLS) and principal components regression (PCR), to account for matrix effects and thereby minimize measurement uncertainties. A large training set was developed consisting of 25 orthogonal aerosol samples with 9 factors (elements: Cr, Mn, Fe, Ni, Cu, Zn, Cd, Pb, Ti) and 5 levels (elemental concentrations). Elemental concentrations in the aerosolized samples were measured with Aerosol Spark Emission Spectrometer (ASES) at a time resolution of 1 minute. Simultaneous filter samples were collected at every 30 minutes for determination of elemental concentration using inductively coupled plasma mass spectrometry (ICP-MS). Calibration curves were developed using PLS and PCR algorithms with the mass spectrometry measurements as the reference values. The performance of the multivariate calibration model was then tested for near real-time prediction of concentration of Cr, Mn, Fe, and Ni in the aerosol emitted from welding processes in an actual workplace. We will present the comparison with simultaneous ICP-MS measurements, and discuss implications for uncertainty of measured elemental concentration using ASES.

8IM.14

Experimental Verification of the Classification Accuracies for the Aerosol Particle Mass Analyzer(APM). Nobuhiko Fukushima, YUSUKE OGIHARA, Yoshiko Murashima, Hiromu Sakurai, *AIST*

The APM (Aerosol Particle Mass Analyzer) can measure the effective density of particles by using a differential mobility analyzer (DMA) together, and furthermore, for example, the fractal dimension analysis and the evaluation of volatility of the particles have also been reported as the APM application studies. In this study, we confirmed the classification accuracy at high λc values by reducing the flow rate of APM such as 0.1 L/min, and checked the dependence of transmission efficiencies against particle diameter under the static operating condition. To clarify the classification accuracies of the APM for particle sizes below 30 nm, we firstly measured the particle size distributions classified by the APM to confirm the figures of transfer function, and then compared the number-averaged mass of the DMA-classified particles with the estimated particle mass from the DMA-classified diameter and the density of the test particles. This test was carried out under several operating conditions of the APM by setting a pair of different rotation speeds and flow rate for the same DMA-classified particles, and it was found that the measured masses of the DMA-classified particles were almost the same to the particles in spite of changing the APM operating conditions. It indicates that the APM can consistently operate to classify the particles according to the APM mass classification theory. Meanwhile, the gap between the measured and estimated particle mass as the particle size gets smaller was also reconfirmed for the range of particle sizes from 12 nm to 30 nm, and this difference expanded as the particle size decreased. In addition, we also investigated the transmission efficiencies of the APM based on the diffusion theory. For the differences of particle mass at the lower particle size range, we think that this reason should make clear but will be an issue in the future.

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8IM.15
Portable Air Quality Monitoring Systems for Responding to Highly Localized Pollution Concerns. JOSEPH P. MARTO, Maxime Gorson, James Schwab, H. Dirk Felton, Patricia Fritz, *University at Albany, SUNY*

Mobile air quality monitoring systems allow for rapid assessment of air quality concerns. By building eight portable monitoring enclosures we are creating a flexible system to address extremely localized—and often undetected—air quality, such as temporally and spatially unique rural air quality events including response to wood smoke from wood-fired heating technologies. All eight weatherproof enclosures will have the capacity to continuously detect PM2.5 scatter using pDR1500 DataRam nephelometers as well as wind speed and direction, temperature, and humidity using LUFFT weather sensors. Data collected by the units over periods of days to months will be automatically recorded to enclosed Toughbook computers for analysis.

To adapt for various scenarios all of the units will have the option of being equipped with additional sensors, which will be deployed when appropriate; and enclosures will have separate inlets to allow for simultaneous monitoring of gases and particles. These additional optional sensors include RAEGuard 2 PID toxic gas detectors, Alphasense Electrochemical detectors for both CO and NO2, Alphasense NDIR CO2 sensors, Brechtel Manufacturing TAP black carbon sensors, and Xonteck 901 canister samplers to allow for follow-up detection of toxic gases. Additionally, two of the units will also be outfitted with Magee AE33 black carbon PM2.5 sensors. In this poster we will highlight information on the construction, calibration, and testing of these enclosures as well as any preliminary data collected.

8IM.16
Arctic Haze and Stratospheric Aerosol Studies Using POPS, a Small, Sensitive, and Light-weight Optical Particle Spectrometer. HAGEN TELG, Ru-Shan Gao, Timothy Bates, Terry Deshler, Steven Ciciora, David Fahey, James Johnson, Richard McLaughlin, Anne Perring, Andrew Rollins, Joshua P. Schwarz, Troy Thornberry, Laurel Watts, *CIRES/NOAA*

In-situ sampling with particle size spectrometers is an important method to provide detailed size spectra for atmospheric aerosol in the troposphere and stratosphere. Recently we developed a sensitive, light weight, and low cost optical particle spectrometer. The name of the instrument is Printed Optical Particle Spectrometer (POPS), where "Printed" stands for the fact that structural components where made with a 3D printer. Here we present the first scientific data recorded by POPS from an unmanned aircraft system (UAS) during the Soot Transport, Absorption and Deposition Study (STADS) campaign on Svalbard, Norway, in April 2015. As part of a payload composed of five different aerosol instruments - a photometer, condensation particle counter, a filter sampler, an upwards looking solar radiometer and POPS - we collected particle size distributions from 0 to 3000 m altitude using a Manta UAS. Furthermore, we present data from a stratospheric balloon flight out of Larimar, Wyoming. This study includes an inter comparison of POPS and other optical particle counters.

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8IM.17
Macro-Raman Spectroscopy on Respirable Particles Collected by a Single-nozzle Cascade Impactor. HUI WANG, Lisa Williams, Susan Hoe, David Lechuga-Ballesteros, Reinhard Vehring, *University of Alberta*

A Monte-Carlo model was developed to predict the minimum sample volume required for representative sampling from potentially heterogeneous microparticle-based powder samples, characterized by different particle size distributions and compositions. Simulation on commercial carrier free pressurized metered dose inhaler (pMDI) Seretide® 50, containing 50 µg fluticasone propionate (FP) and 25 µg salmeterol xinafoate (SX) each dose, and lactose-carrier based dry powder inhalers (DPI) Seretide®, consisting of 100, 250, or 500 µg FP and additional 25 µg SX each dose, indicated that at least millions of particles need to be sampled to achieve less than 3% relative sampling error with high confidence (95%) after 5 independent sampling events. A single-nozzle impactor, utilizing standard scanning electron microscopy (SEM) stub as its impaction plate, was then designed and manufactured for the collection of highly dispersed respirable aerosols for subsequent bulk property analysis. One single dose of pMDI Seretide® 250, containing 250 µg FP and 25 µg SX, was actuated into the impactor, and particles were concentrated onto a stage with selected cutoff diameter of 1.05 µm. The new single nozzle impactor successfully collected about 200 µg of the 275 µg dose. Collected particles were directly transferred for ultramicroscopic morphology characterization and also filled into a 0.16µL-sample cavity of a custom designed dispersive macro-Raman instrument for spectroscopic analysis. In comparison to the spectrum of powders extracted from the pMDI canister by a traditionally used freezing-cutting-evaporation method, a separate spectrum with less than 3% spectral differences was acquired, indicating representative impactor sampling and macro-Raman measurement.

8IM.18
Quantifying and Improving the Performance of a new Single Particle Mass Spectrometer. MARIA ZAWADOWICZ, Philip Croteau, Fabian Mahrt, Nicholas Marsden, Daniel Cziczo, *MIT*

Single particle mass spectrometers (SPMS) have contributed to in-situ chemical characterization of atmospheric aerosols and studies related to cloud droplet formation and ice nucleation, both in field and in laboratory, for well over a decade. SPMS instruments combine precise aerodynamic optical particle sizing with UV laser desorption and ionization followed by time of flight mass spectrometry. The advantage of SPMS instruments for atmospheric research, especially related to cloud formation, is the single particle resolution and high sensitivity to trace chemical species. The Laser Ablation Aerosol Particle Time-of-Flight mass spectrometer (LAAPTOF) is the newest member of this diverse instrument class, aiming for a miniaturized package and simplicity for the end user. This presentation will discuss the results of a comparison of this new instrument to established SPMS instruments, such as Particle Analysis by Laser Mass Spectrometry (PALMS) and Aerosol Time of Flight Mass Spectrometry (ATOFMS), carried out at the Aerosol Interaction and Dynamics in the Atmosphere (AIDA) facility at Karlsruhe Institute of Technology. The comparison aimed for quantifying the optical and mass spectrometry performance in characterizing a wide variety of atmospherically-relevant aerosols. This presentation will also detail the engineering challenges encountered in improving the particle detection limit of the optical region of LAAPTOF and the general challenges and performance benchmarks in designing robust optics for SPMS applications.

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8IM.19
Characterization of a Nucleation-Mode Aerosol Size Spectrometer with Ammonium Sulfate and Oxidized Organics. CHRISTINA WILLIAMSON, Frank Erdesz, Charles Brock, *NOAA ESRL and CIRES, University of Colorado Boulder*

High time-resolution measurements of nucleation-mode aerosol size distributions are necessary for understanding the spatial distribution, sources and importance of secondary aerosol in the free troposphere. The nucleation-mode aerosol size spectrometer (NMASS), a fast-time response airborne instrument measuring size distributions between 5 and 60nm, will sample the remote marine free troposphere on pole-to-pole flights with NASA's Atmospheric Tomography mission (ATom). In preparation for this, it has been calibrated with known compounds pertinent to free tropospheric measurements, namely oxidized organics from limonene ozonolysis and ammonium sulfate particles produced at small sizes using an evaporation-nucleation method.

The variation of condensation particle counter (CPC) counting efficiencies with respect to the chemical composition of the sample has recently been shown to be important for accurate data analysis and can be used to give indirect information about the chemical composition of samples. This variation is strongly dependent on the CPC working fluid. The five parallel CPCs, of which the NMASS is comprised, use perfluoro-tributylamine as a working fluid. The absolute responses and associated variations of these CPCs to ammonium sulfate and limonene ozonolysis products are compared to those of butanol, diethylene-glycol and water based CPCs reported in recent studies.

The potential and limitations of data from the NMASS and the inversion techniques applied to it are evaluated. To provide a solid basis for comparison with chamber and field-station data, this is compared to a scanning mobility particle sizer (SMPS), the standard technique for ground-based measurements of nucleation-mode particle size distributions.

8IM.20
Zero Temperature Gradient Operation of a CCN Counter in SFCA Mode. SARA PURDUE, Jack J. Lin, Athanasios Nenes, Tomi Raatikainen, Greg Kok, *Georgia Institute of Technology*

The Droplet Measurement Technologies Continuous Flow Streamwise Thermal Gradient Cloud Condensation Nuclei (CCN) Counter is an instrument widely used to study CCN and hygroscopicity properties of aerosols. Under its normal mode of operation supersaturation is generated by a creating a linear temperature gradient along a wetted column[1]. However, when the instrument is operated in the Scanning Flow CCN Analysis (SFCA) mode, supersaturation is generated by changing the flow rate over a short period of time, creating transient pressure fluctuations within the column[2]. Previously, some work has looked at the capabilities of this method while there is still a temperature gradient in the column[3] but the use of the CCN counter with a zero temperature gradient along the column while in SFCA mode has yet to be studied in laboratory experiments.

This work will provide a first look at the capabilities of the DMT CCN counter with a zero temperature gradient along the column while in SFCA mode. We have run experiments with inlet pressures from 600 to 900mb, scan times from 20 to 60 seconds, and total column temperatures from 25ºC to 35ºC. We will present the effect that these variables have on the supersaturation generated in the column, as well as offer a recommendation for the best operating procedure when using the instrument with a zero temperature gradient. Furthermore, the work in this project will be used in the development of a smaller version of the current CCN counter, which can more easily and cost-effectively be deployed in the field and on aircraft.

1. Roberts and Nenes, Aerosol Sci. Tech., 2005
2. Raatikainen et al., Aerosol Sci. Tech., 2014
3. Moore and Nenes, Aerosol Sci. Tech., 2009

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8IM.21

Calibration Uncertainties in Cloud Condensation Nuclei Counters. KURT HIBERT, David Delene, *University of North Dakota*

Cloud condensation nuclei (CCN) counters have been calibrated regularly for use in field projects and laboratory work for many decades. However, the calibration uncertainties of CCN counters are not well understood. The objective of this research is to determine CCN counter calibration uncertainties for different CCN counters under different conditions. Specifically, the CCN counter's concentration and supersaturation calibration uncertainties are determined for several University of Wyoming (UWyo) and Droplet Measurement Technologies (DMT) CCN counters. Previous research has determined calibration uncertainties for a single supersaturation; however, this project addresses uncertainties over a range of supersaturations, the calibration drift with time, and the dependency of the supersaturation calibration on pressure in the DMT CCN counter. The purpose of analyzing these calibration uncertainties is to determine how well different types of CCN counters agree. In order to determine the calibration uncertainties, the standard deviation is calculated from a series of calibrations on the UWyo and DMT CCN counters. The calibrations made over several years are also evaluated to determine if there is a drift in time. Quantifying the calibration uncertainties allows for accurate comparisons to determine if there are real atmospheric differences in CCN concentration or if differences are a result of different methodology and instrumentation. Preliminary results indicate that the UWyo and DMT CCN counter's concentration calibrations have not drifted over a period of several years. The supersaturation calibrations in the DMT CCN counter have also not drifted with time. DMT CCN counter supersaturation calibrations have been done at reduced pressures and agree with ambient pressure supersaturation calibrations. This research is expected to confirm that measurements made with different CCN counters in different years, and with different calibrations agree within the calculated calibration uncertainties.

8IM.22

Charging and Collection Performance of a Novel ESP with an Indirect Particle Charging Method against Submicron Particles. HAK-JOON KIM, Bangwoo Han, Chang-gyu Woo, Yong-Jin Kim, Seong-Jin Park, Jong-Pil Yoon, *Korea Institute of Machinery and Materials*

A novel two-stage ESP for IT manufacturing industries was developed that uses a mixing type carbon brush charger which is located outside of a main gas flow duct to achieve perfect separation from contact of polluted gases, and imposes additional electric field between upper and bottom plates of the charging stage to enhance collisions between ions and particles thus increase particle charges. The performance of the ESP was evaluated experimentally for ultrafine particles with a mean diameter of 100 nm based on number, and of 200 nm based on surface area by varying the voltages for chargers and for additional electric field imposing, and number of the chargers. Finally, the collection efficiencies of the ESP were compared with those obtained from the Deutch’s collection theory using experimental particle average charges. The total air flow rate for the test were approximate 110 L/min with 10:1 ratio of main and mixing flows in the ESP, and applied voltages for chargers and additional electric field were from -10 to -22 kV, and from -5 to -10 kV, respectively. Collection efficiencies in the ESP were linearly proportional to increase in number of chargers and applied voltage to chargers, while those were inversely proportional to increase in applied voltage for additional electric field. The collection efficiency of the ESP for 110 L/min corresponding to flow speeds of approximate 0.19 m/s through the charging stage and 0.23 m/s through the collection cell was reached to over 90% based on total particle number at the applied voltage to triple chargers of -15 kV and additional electric field between upper and bottom plates in charging stage of -6 kV/ 100 mm.

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8NM.1

Mobility and Charging Characteristics of Crumpled Reduced Graphene Oxide Synthesized by Aerosol Process. YAO NIE, Yang Wang, Yi Jiang, Pratim Biswas, *Washington University in St. Louis*

Graphene nanosheets, with their excellent electronic conductivity and extremely large specific surface area, have recently attracted great interest. Aerosol process of converting the flat 2D structure to a 3D crumpled one has broadened the application of graphene materials by overcoming the restacking of these nanosheets.[1] In this study, crumpled graphene oxide (C-GO) was synthesized using a furnace aerosol reactor (FuAR) in which graphene oxide was thermally reduced. By using a differential mobility analyzer (DMA), C-GO nanoparticles of uniform mobility sizes were classified and collected. The morphology and sizes of these C-GO nanoparticles were characterized by transmission electron microscopy (TEM) and scanning electron microscopy (SEM). The projection size of C-GO calculated from offline measurements was correlated to the electrical mobility size of C-GO measured by a DMA. Due to the unique crumpled structure of C-GO, the projection size deviated from the electrical mobility size. In addition, the effects of morphology (flat, wrinkled, or crumpled) on the mobility size were compared. Further, the bipolar diffusion charging characteristics of C-GO synthesized with different temperatures were studied with a tandem DMA system, from which the multiply charged fraction of C-GO could be determined. The neutral fraction of C-GO was thus calculated by considering the multiply charged fraction. The synthesis temperature significantly affected the neutral fraction of C-GO with the same mobility, which may be attributed to the different conductivities of C-GO (thermally) reduced at different temperatures. The correlation between the electrical capacitance deduced from the neutral fraction and the conductivity of C-GO will be discussed in this work.

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8NM.2

Establishing the Relationship between Precursor Feed Rate and Materials Composition during the Combustion Aerosol Synthesis of Metal Oxide Nanoparticles. NATHAN REED, Jiaxi Fang, Sanmathi Chavalmane, Pratim Biswas, *Washington University in St Louis*

Composite nanoparticles are widely used as components in paints, pigments, and health and beauty products. Many developing applications for composite nanoparticles including catalysis, drug delivery, and energy storage require increasingly fine control of properties and composition. While composite nanoparticles have been widely synthesized and characterized (1,2), little work has systematically looked at correlation between the initial concentration of precursors and final concentration of the nanoparticles. In this work, we study the mechanisms of composite nanoparticle formation in a diffusion flame aerosol reactor by investigating the relationship between the initial precursor concentration for different elements and the final nanoparticle composition at various precursor molar ratios. The particle composition of each element concentration is measured by direct injection of the synthesized nanoparticles into an inductively coupled- optical spectrometer (ICP-OES) plasma (in-situ characterization) for an Fe and Si composite system. Real time measurements from direct injection will be compared to the results of ex situ measurements for elemental concentrations in the collected nanoparticles. Further investigation of precursor fate within flame aerosol synthesis systems that elucidate the mechanisms of composite particle formation will be discussed. This will provide a road map to more controllable synthesis with tunable particle properties.

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8NM.3
Aerosol Synthesis of 3D Crumpled Graphene and Their Application to Dye-Sensitized Solar Cells. EUN HEE JO, Hankwon Chang, Jiwoong Kim, Ki-Min Roh, Hee Dong Jang, *University of Science and Technology*

Since dye sensitized solar cells (DSSCs) were found by the Gratzel group, they have been attracting interest because of its low cost, simple process and relatively high energy conversion efficiency. Among all the components of DSSC, a photoanode, which is a nanocrystalline TiO_2 film, plays important roles of loading dye, seperating and transporting electrons. However, the low electron transport in disordered nanocrystalline TiO_2 film represents a major limitation of such nanostructured photoanodes.

In this study, we prepared the three dimensional crumpled graphene (3D CGR) from a colloidal solution of graphene oxide (GO) via an aerosol spray drying process. As-prepared 3D CGR was introduced in a nanocrystalline TiO_2 photoanode for DSSCs. Effect of the weight ratio of 3D CGR in the TiO_2 on the properties of DSSC was investigated. The morphology of as-prepared 3D CGR and 3D CGR/TiO_2 film were characterized by FE-SEM. Also, photovoltaic performances and charge recombination kinetics of DSSCs were measured using a solar simulator under simulated solar light and electrochemical impedance spectroscopy (EIS) analysis. The DSSC fabricated with the 3D CGR/TiO_2 photoanode (3D CGR/TiO_2=0.01) showed the highest conversion efficiency of 6.1%, which was approximately 140% higher than that of DSSC fabricated with a pure TiO_2 photoanode without 3D CGR.

8NM.4
Silicon Particle Formation and Growth in Silane Pyrolysis Reactors. MIGUEL VAZQUEZ PUFLEAU, Martin Yamane, Shalinee Kavadiya, Thimsen Elijah, Pratim Biswas, *Washington University in St. Louis*

Crystalline silicon devices comprise the majority (>70%) of the photovoltaic market. A key cost driver in the manufacture of silicon PV is the energy-intensive chemical vapor deposition (CVD) step in the refining process, which produces polysilicon in a highly pure state. Alternate fluidized-bed reactors (FBR) have been proposed for the production of the silicon. While Fluidized-bed CVD reactor operation is more economically viable than the conventional Siemens process, it is plagued by issues related to aerosol nucleation that results in ultrafine particle formation. This is an unwanted side reaction that occurs in parallel to the desired reaction for condensational/ surface reaction growth of the desired larger particles. Despite decades of research, the silane pyrolysis mechanism under industrially-relevant conditions, which is the key to understanding the formation of ultrafine particles, is still under debate. In this work, we propose to measure the formation and growth rates for silane pyrolysis using both online and offline characterization methods. Online methods include scanning mobility particle size distribution measurements, while offline methods include analysis of scanning and transmission electron micrographs for primary particle characterization within agglomerates. Material and temporal balances will be solved simultaneously to determine the growth rates. Characterization results from industrial scale FBRs will also be presented. A discrete-sectional model to describe the different mechanistic pathways will be presented.

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8NM.5
One Step Aerosol Synthesis of Pt/Graphene/Carbon Nanoparticles via Microwave Plasma and Methanol Oxidation Reaction. HANKWON CHANG, Eun Hee Jo, Sun Kyung Kim, Hee Dong Jang, *Korea Institute of Geoscience and Mineral Resources*

Graphene (GR) has drawn much attention due to its excellent physical and chemical properties, which makes it promising for potential applications in various fields, such as transparent conducting electrodes, batteries, biosensors and supercapacitors. Especially, graphene has potential application as a catalyst support in direct methanol fuel cell (DMFC) due to its excellent electrical conductivity and extremely high specific surface area. The platinum (Pt) catalyst has been used as electrocatalysts in DMFCs because it is very effective in reducing oxygen in cathodes and methanol oxidation in anodes. Thus, graphene-supported Pt nanoparticles can be a promising materials for the enhanced methanol oxidation reaction.

Here we report the one-step aerosol synthesis of Pt/graphene/carbon nanoparticles from a solution of hexachloroplatinic acid and alcohol (ethanol or isopropanol) via microwave plasma system, which consisting of an ultrasonic nebulizer for the feeding of precursor droplets, a plasma reactor for the synthesis of Pt/graphene/carbon nanoparticles, and a filter for the particles sampling.

The as-prepared Pt/graphene/carbon nanoparticles were characterized by HR-TEM, XRD and Raman. Further, the electocatalytic applications of the Pt/graphene/carbon nanoparticles are examined through methanol oxidation reaction. The Pt/graphene/carbon nanoparticles exhibit the high electrocatalytic activity for methanol oxidation reactions compared with commercial Pt/carbon black.

8NM.6
High Throughput Carbon Nanotubes Aerosol Synthesis. Christian Hoecker, Fiona Smail, Martin Pick, ADAM M BOIES, *University of Minnesota*

The decomposition of ferrocene and the nucleation of iron catalyst nanoparticles for carbon nanotube (CNT) synthesis in a continuous gas phase process are studied. The production of iron catalysts from ferrocene occurs in a horizontal tube furnace at 300–1300°C, in a hydrogen atmosphere and at atmospheric pressure. The iron nanoparticles act as a catalyst to form CNTs from methane or other carbon sources. The resulting CNTs agglomerate to form an annulus concentric within the reactor. To date few studies have examined the phenomena associated with the ferrocene breakdown, catalyst nucleation and growth within the reactor. These phenomena are critical to the quality and throughput of the CNT production.

Studies along the axis of the furnace tube are carried out by means extractive analysis with a scanning mobility particle size spectrometer. Products of reactions inside the tube are analyzed by Fourier transform infrared spectroscopy.

The decomposition of ferrocene and nucleation and agglomeration of iron nanoparticles are modelled numerically by solving the general aerosol dynamic equation with inclusion of ferrocene decomposition, iron particle nucleation, coagulation and diffusion. The effect of different conditions (temperature, flow rate, gas chemistry and tube diameter) on the decomposition, nucleation and agglomeration processes is studied to increase iron catalyst density for purposes of increasing CNT production.

Experimental measurements indicate that particles form within a narrow axial location that is influenced by the ferrocene time and temperature history. Our results indicate that ferrocene decomposition is also influenced by background gas properties, whereby higher particle mass and number concentrations are present in non-hydrogen atmospheres. Axial measurements downstream indicate that particles disappear very abrupt; a phenomenon which cannot be predicted by the modelled results including thermophoretic and diffusional forces.

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8RW.1
Hygroscopic Properties of Alkyl Aminium Sulfates at Low Relative Humidities (RH). YANGXI CHU, Meike Sauerwein, Chak K. Chan, *Hong Kong University of Science and Technology*

Alkyl aminium sulfates (AAS) can affect the physicochemical properties of atmospheric aerosols such as hygroscopicity. Previous laboratory experiments have shown that water contents in AAS bulk solutions are higher than in aqueous ammonium sulfate solution in the range of 60–95% RH. Furthermore, amine was found to evaporate from the solution during the preparation of AAS from the parent amine and sulfuric acid solutions. Here we report the hygroscopicities of deposited particles of four AAS at different aminium-to-sulfate mole ratios (A/S) in the range of <3–90% RH using air-flow cells coupled with in situ micro-Raman spectroscopy. Normalized areas of O–H stretching peaks in the Raman spectra were converted to water-to-solute mole ratios (WSR) at various RH. Amine evaporation was also observed and the exact A/S of sample particles or solutions were determined by ion chromatography. Mono-methylaminium sulfate (MMAS) and mono-ethylaminium sulfate (MEAS) particles were stable at A/S=2.0 but di-methylaminium sulfate (DMAS) and tri-methylaminium sulfate (TMAS) suffered from DMA and TMA evaporation and eventually equilibrated to A/S of 1.5 and 1.0, respectively. Besides, an approach to estimate the hygroscopicities of DMAS and TMAS particles at initial A/S larger than that of the stable compositions was presented. In the range of 60–95% RH, the WSR of all the studied AAS particles were consistent with a previous study based on experimental values and the extended Zdanovskii-Stokes-Robinson equation. In general, all the studied AAS were more hygroscopic than their corresponding ammonium counterparts within the studied RH range therefore they can enhance the water uptake of aerosols if they exist in appreciable amounts in the particle phase.

8RW.2
Photochemical Aging of 2-Methyltetrol in Aqueous Aerosols. ALISON FANKHAUSER, V. Faye McNeill, *Columbia University*

2-methyltetrol (2-MT) is a well-known particle-phase tracer for isoprene photooxidation, yet very little is known about the rates, mechanisms, and products of the photochemical aging of this species in the atmosphere. To this end, we conducted a series of laboratory experiments using an aerosol flow tube reactor coupled with an Aerosol Chemical Ionization Mass Spectrometer (Aerosol-CIMS) for analysis of the gas and particle phase composition and a scanning-mobility particle sizer (SMPS) to monitor particle size distributions. First, gas-particle partitioning experiments were conducted on aqueous sulfate particles containing 2-MT in order to measure the effective Henry's Law constant. Then we exposed these particles to hydroxyl (OH) radicals in a continuous flow photocell reactor in order to study the photooxidation of 2-MT. In the presence of OH, 2-MT particles decreased in size, indicating a volatilization of organic material, and small-molecule products such as formic acid were observed in the gas phase. Although the reaction between OH and 2-MT takes place in both the gas and particle phases, kinetic analysis shows that the dominant effect is reaction at the particle surface, allowing us to model the loss process as reactive uptake with gamma ~ 0.02. We model this multiphase process using GAMMA (Gas-Aerosol Model for Mechanism Analysis) [McNeill et al. 2012] in order to provide additional mechanistic insight.

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8RW.3
Physical State of Secondary Organic Material Affects the Production of Brown Carbon. PENGFEI LIU, Yong Jie Li, Yan Wang, Adam Bateman, Yue Zhang, Zhaoheng Gong, Mary Gilles, Scot Martin, *Harvard University*

Secondary organic material (SOM) can become light-absorbing (i.e. brown carbon) via multiphase reactions. The physical states of SOM, however, potentially slow the diffusion of reactant molecules in an organic matrix under conditions where semisolids or solids prevail, thus inhibiting the browning reaction pathways. In this study, the kinetic limitations of in-particle diffusion were investigated by measuring the evaporation of water from several types of SOM using a quartz-crystal-microbalance (QCM). At sufficiently low relative humidities (< 20% RH) at 293 K, the diffusion of water was significantly impeded in SOMs derived from aromatic precursors toluene and m-xylene, suggesting that these materials became solid (glassy). For < 5% RH, water diffusivity in the solid aromatic-derived SOMs ranged from 10^{-17} to 10^{-16} m^2 s^{-1}, which was 100 to 1000 times lower than that of the semi-solid SOM derived from α-pinene. Optical properties were measured for toluene-derived SOM after ammonia exposure at varied RHs. The results suggest that multiphase reactions with ammonia were kinetically limited in the glassy organic matrix, which otherwise produce brown carbon. These results have significant implications for understanding the production pathways and optical properties of brown carbon in urban atmospheres, and ultimately their influences on regional climate and tropospheric photochemistry.

8RW.4
Chemical Characterization of Gas- and Aerosol-Phase Products from Isoprene Ozonolysis in Presence of Acidic Aerosol: Re-examination of Secondary Organic Aerosol Formation. MATTHIEU RIVA, Sri Hapsari Budisulistiorini, Zhenfa Zhang, Avram Gold, Jason Surratt, *University of North Carolina at Chapel Hill*

Atmospheric fine aerosols (PM2.5) are critical in many environmental processes. It is now recognized that the largest mass fraction of PM2.5 is generally organic, mostly dominated by secondary organic aerosol (SOA) formed from the oxidation of volatile organic compounds (VOCs). Isoprene is the most abundant non-methane hydrocarbon emitted into the Earth's atmosphere and is derived from terrestrial vegetation. Most studies have focused on the hydroxyl radical (OH)-initiated oxidation of isoprene and have demonstrated that certain highly oxidized compounds, such as isoprene-derived epoxides, enhance the formation of SOA by heterogeneous reactions in a presence of acidified sulfate aerosol. Although less well documented, the contribution of isoprene ozonolysis to the SOA budget has been concluded to be negligible. However, the potential importance of isoprene ozonolysis as a pathway for SOA formation is supported by recent studies documenting the formation of highly oxidized products, including oligomers, in both gas and particulate phases.

In this work we explored SOA formation in an indoor smog chamber from isoprene ozonolysis under various conditions. Characterization of gas-phase components was performed using high-resolution time-of-flight chemical ionization mass spectrometry. Chemical characterization of SOA was investigated using ultra performance liquid chromatography coupled to electrospray ionization high-resolution quadrupole time-of-flight mass spectrometry and gas chromatography interfaced with electron ionization mass spectrometry with prior trimethylsilylation. Insights have been gained from investigation of the influence of environmental conditions (OH radicals, aerosol acidity, seed particle composition, relative humidity) on SOA formation and composition and chemical mechanisms are proposed. Finally, organosulfates that have been identified as tracers in chamber experiments were also observed and quantified in summertime PM2.5 collected from two rural locations in the southeastern United States during the 2013 Southern Oxidant and Aerosol Study (SOAS).

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8RW.5
Vapor Wall Deposition of Isoprene Photooxidation Products: RH, Mixing Status and Isomer Structure Effect.
XUAN ZHANG, John Crounse, Alex Teng, Paul Wennberg, Richard Flagan, John Seinfeld, *Caltech*

The wall-induced deposition of isoprene photooxidation products was investigated at a range of RHs (5 – 90 %) and different turbulent mixing status in the Caltech 24 m3 Teflon Chamber. Four species of which the deposition rate increases with increasing RHs were identified, as categorized as C4 – C5 carbonyls, epoxides, and nitrates. The lifetime of these organic vapors with respect to wall deposition was measured as low as ~ 1 h at 90% RH. We suggest that the hydrolysis reactions on the wall surface significantly enhance the deposition rate of these organic vapors, which otherwise are too volatile to partition substantially on the chamber wall. For the organic nitrate investigated here, the wall deposition rate varies with different structural isomers: the 2-methyl-2-nitroxybut-3-ene-1-ol isomer exhibits a much faster decay rate, which potentially results from the formation of stabilized tertiary alkyl radical via the unimolecular nucleophilic substitution (SN1) mechanism. The influence of the chamber mixing status on the measured vapor wall deposition rate is inappreciable in the RH range of 10 – 80%. In other words, the limiting process that governs the overall wall deposition rate of organic vapors investigated in this study is the wall accommodation, rather than gas-phase transport.

8RW.6
Distribution, Influential Factors, and Sources of Aerosol Liquid Water during the DISCOVER-AQ 2013 Campaign in Houston, TX.
ALEXANDER BUI, Yu Jun Leong, Nancy Sanchez, Henry Wallace, Robert Griffin, *Rice University*

Aerosol liquid water content (ALW) affects the size, optical properties, and chemical behavior of aerosols. Specifically, ALW has been shown to play a role in secondary organic aerosol (SOA) formation via the partitioning of gas-phase water-soluble organic compounds to the condensed phase. Here, ALW mass concentrations in Houston during the September 2013 DISCOVER-AQ campaign are calculated using two thermodynamic equilibrium models: (1) the Extended Aerosol Inorganics Model IV (E-AIM) and (2) ISORROPIA1. These models also allow an evaluation of aerosol acidity. In both models, the partitioning of water to the aerosol phase is calculated using ambient temperature, ambient relative humidity, and mass concentrations of inorganic aerosol components (sulfate, nitrate, ammonium, and chloride). Inorganic sub-micron aerosol data were collected using an Aerodyne high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) deployed on a mobile laboratory.

In this study, the spatial and temporal distributions of ALW in Houston are evaluated, as is the sensitivity of ALW to the relative abundances of sulfate, nitrate, ammonium, and organics. Identification of the dominant aerosol components that drive ALW in Houston is also important for determining potential mechanisms for SOA formation. As such, ALW concentrations are compared to factors derived from a factor analysis applied to the HR-ToF-AMS data. Furthermore, the regions and local anthropogenic sources in Houston that contribute to variability in ALW are characterized.

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8SA.2
Fine and Ultrafine Particulate Organic Carbon in the Los Angeles Basin: Trends in Sources and Composition.
FARIMAH SHIRMOHAMMADI, Sina Hasheminassab, Arian Saffari, James Schauer, Ralph J. Delfino, Constantinos Sioutas, *University of Southern California*

In this study, $PM_{2.5}$ and $PM_{0.18}$ (particles with aerodynamic diameter less than 2.5 and 0.18 micro-meter, respectively) were collected during 2012-2013 in Central Los Angeles (LA) and 2013-2014 in Anaheim. Samples were chemically analyzed for carbonaceous species (elemental and organic carbon) and individual organic compounds. Concentrations of organic compounds were reported and compared with many previous studies in Central LA to quantify the impact of emissions control measurements that have been implemented for vehicular emissions and to provide a current understanding of the sources of carbonaceous aerosols in the LA Basin. A novel hybrid approach of molecular marker-based chemical mass balance (MM-CMB) analysis was conducted, in which a combination of source profiles that were previously obtained from a Positive Matrix Factorization (PMF) model in Central LA, were combined with some traditional source profiles. The model estimated the relative contributions from mobile sources (including gasoline, diesel, and smoking vehicles), wood smoke, primary biogenic sources, and anthropogenic secondary organic carbon (SOC). Mobile sources contributed to 0.65±0.25 micro-gram/m^3 and 0.32±0.25 micro-gram/m^3 of $PM_{2.5}$ OC in Central LA and Anaheim, respectively. Primary biogenic and anthropogenic SOC sources were major contributors to OC concentrations in both size fractions and sites. Un-apportioned OC from MM-CMB ("other OC") accounted for an average 8.0 and 26 % of $PM_{2.5}$ OC concentration in Central LA and Anaheim, respectively. A comparison with previous studies in Central LA revealed considerable reduction of EC and OC, along with tracers of mobile sources (e.g. PAHs, hopanes and steranes) as a result of implemented regulations on vehicular emissions. Given the significant reduction of the impacts of mobile sources in the past decade in the LA Basin, the impact of SOC and primary biogenic emissions have a larger relative impact and the new hybrid model allows the impact of these sources to be better quantified.

8SA.3
Nature and Sources of Measurement Error in the USEPA PM2.5 Chemical Speciation Network.
KELSEY HADDAD, Li Du, Jay Turner, *Washington University in St. Louis*

The USEPA PM2.5 Chemical Speciation Network (CSN) was established to provide insights into the chemical composition of ambient PM in urban areas across the United States. These data have been used for State Implementation Plan (SIP) development for $PM_{2.5}$ nonattainment areas, source apportionment modeling, and health effects studies. Understanding the nature and sources of measurement error in CSN data is important to inform its proper use in all of these applications.

Measurement error in the CSN was examined using collocated data that is routinely collected at six sites. The data were censored to include only those samples with both concentration values >3xMDL. Root mean square (RMS) precision and percentile precision were calculated using the collocated data. These top-down estimates were compared to the predicted precision which is a bottom-up estimate generated from the reported measurement uncertainties. For most site-species combinations, both the RMS and percentile precisions were greater (less precise) than the predicted precision. The differences were especially large for species such as Ca, Fe and Si which are typically associated with crustal material. There was also large site-to-site variability in the top-down precision estimates for these species. Bias between the collocated samplers proved to be a significant contributor to the imprecision with long (often one year or more) periods of persistent bias. For example, for calcium the site-specific maximum in the one-year rolling mean bias ranged from 6% to 53% across the six sites while for sulfur the range was 3% to 11%. This suggests that for some species pooling the collocated precision data across the sites might not represent the precision at a given site within the network. Potential sources of bias include inadequate maintenance of sampler inlets, flow rate calibration error and flow rate deviations from the setpoint even when the flow rate is properly measured.

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8SA.4

Aerosol Composition, Oxidative Properties, and Sources in Beijing during 2014 Asia-Pacific Economic Cooperation (APEC) Summit. WEIQI XU, Chen Chen, Wei Du, Zifa Wang, Tingting Han, Qingqing Wang, Yele Sun, *Inst. of Atmospheric Physics, Chinese Academy of Sciences*

China implemented strict emission controls measures in Beijing and surrounding regions to ensure good air quality during the 2014 Asia-Pacific Economic Cooperation (APEC) summit. To investigate the impacts of emission controls on composition, oxidative properties, and sources of aerosol particles, a High-Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS) along with a suite of collocated instruments was deployed at an urban site in Beijing from 5 October to 12 November, 2014. The size-resolved non-refractory submicron aerosol composition (NR-PM_1) was measured in-situ at a time resolution of 5 min. Our results showed large reductions of secondary inorganic aerosol (SIA = sulfate + nitrate + ammonium) during APEC owing to emission controls, whereas the changes of organics were much smaller. Positive matrix factorization analysis of high resolution mass spectra of OA further showed that oxygenated organic aerosol (OOA) including semi-volatile OOA and low-volatility OOA had similar reductions to SIA. However, the concentrations of primary OA from cooking and biomass burning were comparable to those before APEC. These results elucidate the dominant impacts of emission controls over regional scales on secondary aerosols. The routine circulation of mountain valley winds played another critical role in reducing fine particles and achieving “APEC Blue” that was commonly referred to the blue skies. The changes of size distributions and oxidative properties of submicron aerosols during APEC due to emission control will be also discussed.

8SA.5

Biodiesel Effects on Black Carbon Emissions from a Diesel Engine. YUAN CHENG, Shao-Meng Li, John Liggio, Katherine Hayden, Tak Chan, Marie-Josee Poitras, *Environment Canada*

More than 50 countries have set goals to replace a substantial fraction of transport fuel with biofuels (mainly biodiesel and bioethanol). Therefore, the impacts of biofuel on emissions from the transportation sector require careful evaluation. This is particularly true for black carbon (BC) emissions from diesel engines due to the strong radiative forcing on global and regional climate associated with BC. An experimental system capable of achieving dilution ratios representative of ambient conditions was used to measure the emission factors of particulate matter components, where BC was measured by a single particle soot photometer. Using this system, we investigated the effect of biodiesels on BC emissions from a light-duty diesel engine. Three biodiesels, based on soybean, tallow/waste fry oil, and canola oil, were investigated under three driving modes representing aggressive, highway and city average driving behaviors. Apart from the use of baseline ultra low sulphur diesel (ULSD), four blend levels (B5, B20, B50 and B100) were used in the biodiesel tests. In general, decreases in the BC emission factor were observed with increasing biodiesel content in the blends. Moreover, large reductions in BC emissions were found with the low blending level of B05; increasing the blending level higher brings incremental reductions in BC emissions but not proportional to the blending level. For example, a 70% BC emission reduction was achieved with the B5 soybean biodiesel blend versus a 90% reduction seen with the B100 soybean biodiesel at the highway mode. Higher load engine operation conditions lead to larger BC emission reductions; for example, a 60% emission reduction with B20 canola oil was observed at the city average driving mode, versus an 85% reduction achieved at the aggressive driving mode. These results are important for modeling and regulating the impacts of vehicle emissions into the future.

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8SA.6

Development of Fine Particulate Matter Source Profiles Using a Nonlinear Optimization Approach. Cesunica Ivey, Nabil Abdurehman, Xinxin Zhai, Yongtao Hu, James Mulholland, ARMISTEAD G. RUSSELL, *Georgia Institute of Technology*

In previous studies, a nonlinear optimization approach was used to estimate daily fine particulate matter (PM2.5) source impacts over continental U.S. (36-km). This hybrid approach takes into account observed speciated PM2.5 concentrations, chemical transport model estimates of PM2.5, as well as uncertainty of both data sources, in order to minimize the discrepancy between the two. Optimized source impacts capture regional and seasonal trends in PM2.5 concentrations. In this work, a similar nonlinear optimization approach is used to estimate PM2.5 source profiles for primary emissions from twenty sources of interest, including mobile sources (both diesel and gasoline), open biomass burning, aircraft, and non-road sources. Optimized source impacts are used as inputs in the calculation of new source profiles. The profiles estimate relative contributions of elemental and organic carbon, major ions, and 17 trace metals. Newly optimized source profiles are evaluated by implementation in CMB at various monitoring locations and comparing results to observed concentrations. Optimizing source profiles using chemical transport model results captures ambient processes that are not often considered in traditional source profile estimation methods. The optimization approach can be applied regionally to capture differences in source composition over continental U.S.

8SA.7

Characterization of Ambient Aerosol Concentration, Composition, and Aging during the Southern Oxidant and Aerosol Study. BASAK KARAKURT CEVIK, Yu Jun Leong, Carlos Hernandez, Robert Griffin, *Rice University*

The Southern Oxidant and Aerosol Study (SOAS) took place in Centerville, AL, over a six-week period during June and July 2013 and included ground and elevated measurements that aimed to improve the understanding of biosphere-atmosphere interactions and their impacts on air quality and climate. As part of SOAS, an Aerodyne high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) was deployed. The HR-ToF-AMS provided quantitative measurement of non-refractory submicron aerosol composition with high temporal resolution. The average aerosol concentration over the campaign was dominated by organic aerosol (OA) (72.6%). The time series of the ratio of the mass concentration of OA to the increase of carbon monoxide over background (ΔCO) (OA/ΔCO) and the relationships between OA/ΔCO and metrics of photochemical airmass age (based on oxidation of nitrogen oxides and sulfur dioxide) are reported. The OA/ΔCO diurnal profile shows a photochemical profile with an increase starting at ~0700 CST, a peak at ~1300 CST, and a decrease until ~1630 CST. Increases in OA/ΔCO are observed with increasing -log (NO_x/NO_y) values, up to a threshold value. The OA/ΔCO values decrease after this point, which might mark a point where further aging leads to a decrease in OA due to fragmentation and volatilization. A larger initial slope was observed with lower $SO_4^{2-}/(SO_2 + SO_4^{2-})$ values, which may signify more rapid OA processing under fresh plume conditions. For a better understanding of OA sources and processing, PMF source attribution analysis is investigated.

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8SA.8

Temporally-Refined Sources of Light-Absorbing Species in Arctic Snow. KATRINA M. MACDONALD, Lin Huang, Andrew Platt, Sangeeta Sharma, Desiree Toom-Sauntry, Jonathan Abbatt, Greg J. Evans, *University of Toronto*

The deposition of pollutants in Arctic snow strongly contributes to albedo decrease and subsequent melting. As such, understanding the sources of these pollutants is a critical step in the development of control and mitigation strategies to protect the Arctic environment. Light-absorbing species such as black carbon, brown carbon and soil particles are of particular concern due to their impact on snow and ice albedo. While extensive research has been completed to identify likely sources of pollutants within the Arctic atmospheric, facilitated by the relative abundance of long-term atmospheric sampling campaigns, only a limited number of studies have directly focussed on the sourcing of Arctic snow pollutants and these are dominated by short-term, spatially-distributed snow sampling. An intensive temporally-refined sampling campaign of Arctic snow at Alert, Nunavut is underway. High frequency sampling at an average of 4.5 day intervals is being conducted from September, 2014 to May, 2015 (expected end date). Broad speciation of these samples coupled with stringent quality assurance will measure carbonaceous species, metals, organics, major ions, and single-particle composition for a temporal profile of light-absorbing species fluxes and co-emitted species indicative of different source types. The sourcing technique positive matrix factorization (PMF) will be applied to this dataset, as the first application of this technique to temporally-refined Arctic snow measurements of light-absorbing species. This presentation will summarise initial results from this integrated analysis of Arctic snow along with the preliminary insight into the sources that are thereby revealed.

8SA.9

Investigation of the Impact of Anthropogenic Pollution on Isoprene-derived Secondary Organic Aerosol (SOA) in PM2.5 Collected at Birmingham, AL during the 2013 Southern Oxidant and Aerosol Study (SOAS). WERUKA RATTANAVARAHA, Kevin Chu, Sri Hapsari Budisulistiorini, Matthieu Riva, Ying-Hsuan Lin, Theran P. Riedel, Eric Edgerton, Karsten Baumann, Hongyu Guo, Rodney J. Weber, Elizabeth Stone, Zhenfa Zhang, Avram Gold, Jason Surratt, *University of North Carolina at Chapel Hill*

Isoprene is the most abundant biogenic volatile organic compound (BVOC) emitted into the atmosphere. Studies have also shown that isoprene-derived SOA accounts for a substantial mass fraction of fine particulate matter (PM2.5). Recent work suggests that composition may affect PM2.5 toxicity, raising concerns with the effectiveness of current air quality standards in protecting human health. Chamber studies provide evidence that SOA formation is enhanced by the interaction of BVOC oxidation products with acidic sulfate aerosols from anthropogenic sources. Since control is practical only for anthropogenic contributions, understanding of how anthropogenic emissions impact biogenic SOA formation is critical for the development of effective control strategies.

In this study, high-volume PM2.5 filter samples were collected during the 2013 SOAS campaign at the Birmingham, AL ground site to investigate the impact of anthropogenic pollution on isoprene-derived SOA. Two sampling protocols were employed: (1) collection of day-time and nighttime filters and (2) collection of four filters per day to better resolve diurnal variations. Samples were chemically characterized by ultra-performance liquid chromatography/electrospray ionization high-resolution quadrupole time-of-flight mass spectrometry and gas chromatography/electron ionization mass spectrometry (GC/EI-MS) with prior trimethylsilylation. PM2.5 sample analysis was supplemented by meteorological data and air quality measurements from collocated instruments operated by the South-Eastern Aerosol Research and Characterization (SEARCH) network. Our results indicate that isoprene-derived SOA constituents contribute significantly to the PM2.5 mass, with isoprene epoxydiol (IEPOX)-derived SOA contributing ~13% and methacrolein (MACR)-derived SOA contributing ~1% to the total organic carbon loading. Preliminary findings indicate only weak correlation between SOA tracers and aerosol acidity. Multivariate linear regression on the correlation between MACR-derived organosulfate, production rate of NO_3, liquid water content (LWC), and particle acidity (H+ activity) suggests that the production rate of NO_3 is a significant predictor of the MACR-derived organosulfate formation ($p < 0.05$), while LWC and particle acidity are not.

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8SA.10
Black Carbon in Beijing: Mixing State, Sources and Optical Properties. JING CAI, Mei Zheng, Jiandong Wang, Yanjun Zhang, Shuxiao Wang, *Peking University*

Sources and mixing state have significant influence on the properties of black carbon (BC) such as mass absorption cross-section (MAC), lifetime and health effects. Single particle aerosol mass spectrometry (SPAMS) can provide information of chemical species that BC is mixed with for particles in the size range of 200-2000 nm. With SPAMS, mixing state and sources of BC-containing particles can be obtained in high-time resolution. During March 9 - 31, 2015, online water-soluble ions, organic matter and BC concentration of fine particles in Beijing were obtained by Gas Aerosol Collector (GAC), Aerosol Chemical Speciation Monitor (ACSM) and OCEC analyzer, respectively. Optical properties of BC were obtained by aethalometer and Photoacoustic Extinctiometer (PAX). The count and spectra of particles by SPAMS were calibrated with scanning mobility particle sizer (SMPS) and aerosol particle sizer (APS), GAC, ACSM and OCEC analyzer.

In this study, the sources and mixing state of BC particles were analyzed by quantitative SPAMS data. It is found that most BC particles of 200-2000 nm in Beijing during the campaign were internally mixed with secondary species such as sulfate and nitrate. The ratio of externally/internally mixed BC particles was higher in early March and aged BC particles were more likely to be internally mixed with sulfate. When externally/internally mixed ratio of BC particles was low in late March, these aged BC particles were more internally mixed with nitrate. It is likely due to different BC sources and aging process, which will affect the optical properties of BC. A quantitative single particle diversity model developed recently is also used to quantify mixing state of BC-containing particles and the extent of aging. The relationship of MAC, sources and mixing state of BC will be discussed in detail in the presentation.

8SA.11
Integration of Source Apportionment Methods to Understand the Local and Regional Source Contributions to Fine Particulate Matter: A Case Study in a Coastal City in Southern China. YANJUN ZHANG, Jing Cai, Zifa Wang, Junyu Zheng, Limin Zeng, James Schauer, Mei Zheng, *Peking University*

Source apportionment, with and understanding of local and regional source contributions, is needed for policy makers to mitigate fine particulate matter pollution but all source apportionment models have pros and cons. To address the shortcomings of source apportionment models, we have examined an integrated approach for source apportionment. This study employs spatial discrepancies and correlations in chemical species and sources of PM2.5 to understand local sources and regional contribution of PM2.5 using data from a one-year study conducted in the southern city of China of Zhongshan in Guangdong province. Samples were collected from May 2014 through April 2015 across five sites (two urban sites, QZ and ZML, and three suburban sites, XL, MZ and SX) within 50 km simultaneously.

Sources of PM2.5 was investigated with Positive Matrix Factorization (PMF) and seven factors were identified including secondary sulfate, secondary nitrate, vehicle emission, coal combustion, industry, dust and oil combustion. Similar trends in PM2.5 mass concentration and chemical composition were observed across all sites. The component sulfate, ammonium, OC and nitrate and secondary sources like secondary sulfate, secondary nitrate and coal combustion source all showed high correlation coefficients (R2) among different sites with different distances, indicating for regional impact. Temporal trends of incremental excess of different components and sources were also investigated to infer local sources (e.g. dust in urban sites and industries in suburban sites) and regional transport. Back trajectory analysis was conducted to show the potential area of regional pollution. More details about the results will be discussed in the presentation along with a comparison to a source-oriented 3D air quality model for the region.

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8UA.1

Mobile Measurements of 10 nm to 10 µm Particles and Black Carbon in Amman, Jordan. BRANDON BOOR, Vanessa Nogueira dos Santos, Huthaifa Abedallah Ahmad, Tareq Hussein, *University of Helsinki*

Amman is the capital and most populous city in Jordan, with a population in excess of 2 million. The city is experiencing a period of rapid growth, urbanization, and industrial development. There is limited research on air pollution in Amman and infrastructure for routine air quality monitoring does not exist. To improve understanding of human exposure to urban aerosols, we conducted the first mobile aerosol measurement campaign in Amman from May-June 2014. We employed a combination of portable instrumentation to record geo-located particle number (PN) and mass (PM) concentrations, including two condensation particle counters (CPCs, 0.01 and 0.02 µm cutoffs), an optical particle counter (OPC, 0.3-25 µm, six size fractions), a laser photometer (PM1, PM2.5, PM4, PM10), and an aethalometer (black carbon, BC). Concurrent stationary measurements were made with an OPC at an urban background site at the University of Jordan campus. Five walking and three in-vehicle tracks in different regions of Amman and it's neighboring city, Zarqa, were studied. PN, PM, and BC concentrations showed strong spatial variability along each track. Mean concentrations across the five walking paths were: PN[0.01-0.02 µm]=$3.2x10^4$ cm^{-3}, PN[0.02-0.3 µm]=$5x10^4$ cm^{-3}, PN[0.3-1 µm]=49 cm^{-3}, PN[1-2.5 µm]=2.7 cm^{-3}, PN[2.5-10 µm]=1.2 cm^{-3}, PM2.5=70 µg m^{-3}, PM10=107 µg m^{-3}, and BC=9.95 µg m^{-3}. On average, mean PN concentrations along the walking paths, as measured with the mobile OPC, were 1.3-2.6 times greater than those measured with the stationary OPC at the urban background site.

8UA.2

Air Quality Assessment in the Surrounding Holy Places of Mecca, Saudi Arabia During Hajj. HAIDER KHWAJA, Omar S Abu-Rizaiza, Azhar Siddique, Mirza M. Hussain, Fida Khatib, Jahan Zeb, Donald Blake, *Wadsworth Center, University at Albany*

The associations of exposure to air pollution and adverse human health effects have been demonstrated in many epidemiological studies. Hajj, an annual pilgrimage of Islam, draws millions of pilgrims from more than 200 countries for religious rituals in Mecca, Saudi Arabia. The city centers on the Grand Mosque (Masjid Al-haram), which is connected with the network of tunnels. The main Hajj pilgrimage route for five days extends 20 km to the east and includes "Mina", "Arafat", and "Muzdalifah". A detailed study was conducted in Mecca, its tunnels, and surrounding holy places during Hajj of the year 2013 (October 13-17). Spatial and temporal variations in total suspended particulate (TSP), PM10, PM7, PM2.5, PM1, ozone (O3), and black carbon (BC) levels along the route were recorded using portable monitors and GPS to assess the status of air quality. This is the first study to elucidate the exposure to air pollutants among pilgrims. Extremely high levels of all pollutants were observed during the intensive measuring periods. For example, the PM7, PM2.5, O3, and BC concentrations of up to 9,433 microgram/cubic meter, 484 microgram/cubic meter, 444 ppb, and 468 microgram/cubic meter, respectively, were observed. Results of this investigation revealed that most routes had on average exceeded the World Health Organization (WHO) recommended standards for PM10 and PM2.5. The reasons for the high air pollutants concentrations are most probably high volume of traffic, construction work, re-suspension of particles, and geographical conditions (arid regions). The pilgrim's longer trip duration lead to their highest whole trip exposure to air pollutants, which indicate that they are subject to higher health risk. Better understanding of air pollution exposure and their determinants in the environments will contribute to the development of more appropriate exposure reductive strategies and have significant public health meanings.

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8UA.3
Spatial Variation of PM2.5 Components with Mobile Sampling Strategy in Pittsburgh. ZHONGJU LI, Timothy Dallmann, Albert A. Presto, *Carnegie Mellon University*

Long-term exposure to particulate matter (PM) is the major contributor to air pollution related death in the 21st century. Evidence indicates that metals play an important role in harming health with their redox activity. A mobile sampling campaign was conducted in 2014 fall and 2015 winter in Pittsburgh to characterize spatial variations in PM2.5 mass and its components. Thirty-six sites were chosen based on three stratification variables—traffic density, proximity to point source and elevation. Filter samples were collected in three time sessions (morning, afternoon, and night) in each season. X-ray fluorescence was used to analyze concentrations of 16 elements: Na, Al, Si, S, Cl, K, Ca, Ti, Cr, Fe, Co, Ni, Cu, Zn, Se, Sb. Concentrations generally ranged from 0 to 300 ng/m3 and indicated spatial heterogeneity.

Land-use regression (LUR) models were developed for metals and other trace species. Three categories of independent variables were extracted using Arcgis-10.1: traffic factors, land-use zoning, and Toxic Release Inventory (TRI) facility data. Various regression diagnostics were performed to validate LUR models. The number of predictors in final LUR models ranged from 1 to 5, and the models had an average R2 of 0.53(0.10).

Metal source profiles were also derived using positive matrix factorization (PMF) at each of the 36 sites. We will develop LUR models based on the specific emissions sources determined by PMF. The spatial variations informed by the PMF-derived LUR models will be compared to species-specific LUR models for species commonly used as source tracers to determine the effectiveness of each approach to apportioning source-resolved exposures.

8UA.4
Assessment of Diurnal and Seasonal Variability in Near-Road Dispersion. Fatema Parvez, KRISTINA WAGSTROM, *University of Connecticut*

Near road emissions of different pollutants, adversely affect both human health and the environment. Vehicular emissions are one of the primary sources of air pollution in cities and lead to elevated morbidity and mortality rates in individuals living near roadways. The complex interactions between meteorology, traffic volume, road structures and regional air pollution makes assessment of human exposure to vehicular emissions difficult. In this study, we compare the temporal variation in the dispersion of near roadway particulate matter in an urban area.

We employ a steady state Gaussian plume dispersion model, R-LINE, to simulate near road concentrations in Hartford, CT. R-LINE simulates the dispersion from line sources by numerically integrating the point source emissions along multiple road configurations.

We explore the seasonal and diurnal variability of vehicular emission dispersion under a variety of meteorological conditions. Variation in meteorological parameters such as wind speed, wind direction, atmospheric stability can play an important role in roadway dispersion.

We estimate the monthly averaged pollutant concentration in different seasons and compare the impact of changes in meteorology and seasonal conditions on pollutant concentration. We also evaluate the diurnal variation of roadway dispersion. This approach leads to improved understanding of roadway pollution dispersion and how it varies with meteorology and different time periods.

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8UA.5

Black Carbon, Particle Number Concentration and Nitrogen Oxide Emission Factors of Random In-Use Vehicles Measured with the On-Road Chasing Method. Irena Jezek, Tomaz Katrasnik, Dane Westerdahl, GRISA MOCNIK, *Aerosol d.o.o., Slovenia*

The chasing method was used in an on-road measurement campaign, and emission factors (EF) of black carbon (BC), particle number (PN) and nitrogen oxides (NOx) were determined for 139 individual vehicles of different types encountered on the roads. We report EFs for BC, NOx and PN for three vehicle categories: goods vehicles, gasoline and diesel cars. This is the first on-road measurement study where BC EFs of numerous individual diesel cars were determined in real-world driving conditions. We found good agreement between EFs of goods vehicles determined in this campaign and the results of previous studies (chasing, remote sensing). The composition of the sampled car fleet determined from the national vehicle registry information is reflective the Slovenian and European vehicle fleets. The median BC EF of diesel and gasoline cars that were in use for less than 5 years, decreased by 60% and 47% from those in use for 5 – 10 years, respectively, the median NOx and PN EFs, of goods vehicles that were in use for less than five years, decreased from those in use for 5 – 10 years by 52% and 67%, respectively. Surprisingly, we found and increase of BC EFs in newer goods vehicle fleet compared to 5 – 10 year old one. The influence of engine maximum power on the measured EFs showed an increase in NOx EF from least to more powerful vehicles with diesel engines. A disproportionate contribution of high emitters to the total emissions of the measured fleet was found; the top 25% of emitting diesel cars contributed 63%, 47% and 61% of BC, NOx and PN emissions respectively. With the combination of relatively simple on-road measurements with sophisticated post processing individual vehicles EF can be determined and useful information about the fleet emissions can be obtained by exactly representing vehicles which contribute disproportionally to vehicle fleet emissions; and monitor how the numerous emission reduction approaches are reflected in on-road driving conditions.

8UA.6

Leaf Blower Dust Resuspension Characterization. JOSE MORENO, Stella Moreno, Antonio García-Sanchez, Belen Elvira-Rendueles, Maria Jose Martinez-Garcia, *Technical University of Cartagena*

During the last few years there is a growing use of leaf blowers to assist the street-sweepers on their duties. From outside it looks clever; they blow the dirt from the isolated corners to the open street where a road vacuum-sweeper removes the dirt. When asked, the responsible of the municipal service states that it is a matter of efficiency. With one leaf blower they advance three times faster than with conventional rakes or brooms, he affirms.

Even though ample references are available in the literature about the negative effects of leaf blowers both on the worker side and on the general population health; very little is available from European cities, and particularly scarce from Spanish cities. Due to the growing concern about the use of leaf blowers as ordinary tools in our streets, in our group we have started a project to determine the nature of the hazards for the general population.

We have been collecting settleable particulate matter and characterizing its heavy metal content from the last 3 decades; together with the aerobiological samples where we have an extensive database of pollen and spores from 1993. So we have an idea on what it is present on the re-suspended dust by leaf blowers. But we lack of information on many others components that may be present and may pose a health hazard to the inadvertent population.

In this poster the preliminary results of the study are presented. A set of samples were collected on different parts of our municipality where the leaf blowers are used. From the first observations, we found that all samples showed the presence of insect faeces and mercury was present in different degrees. We hope to forewarn the media about the risk of leaf blowers and limit their use in our cities.

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8UA.7
Spatial Distribution of Aerosols in Four U.S. Regions: Impacts on Satellite Measurements. ANDREAS BEYERSDORF, Luke Ziemba, Timothy A. Berkoff, Sharon P. Burton, Gao Chen, James Collins, Anthony L. Cook, Chelsea Corr, Suzanne Crumeyrolle, Marta Fenn, Richard Ferrare, Johnathan Hair, David B. Harper, Chris Hostetler, Jack J. Lin, Robert Martin, Richard Moore, Raymond R. Rogers, Amy Jo Scarino, Shane Seaman, Michael Shook, Kenneth Thornhill, Edward Winstead, Bruce Anderson, *NASA Langley Research Center*

Aerosol measurements from satellites in geosynchronous orbit allow a unique opportunity to measure urban air quality at high spatial and temporal resolution. Typical measurements of air quality are based on ground sites spaced sporadically within urban areas. While these offer high quality temporal measurements of air quality, their spatial coverage is limited. Conversely, satellites in low earth orbit can provide measurements over the entire globe but give limited information on the temporal nature of air pollution. However, geosynchronous satellites will be able to measure air quality throughout the day for a specific region of interest (such as North America for the planned NASA TEMPO satellite). A key constraint of satellite measurements is the spatial resolution of the retrieved data products. As the satellite footprint increases, the precision of aerosol properties improves; however, the ability of the satellite to measure small-scale variations in pollution diminishes. Currently, TEMPO is planned to measure aerosol optical depth (AOD) with a spatial resolution of 36 square-km. In this study, sub-pixel variability is used as a metric of how representative the satellite measurement is of ground-based air quality.

Data from the DISCOVER-AQ airborne project are used to determine the sub-pixel variability in AOD, boundary layer extinction and other aerosol properties in four U.S. regions: Baltimore, Maryland, Houston, Texas, Denver, Colorado, and California's San Joaquin Valley. Sub-pixel variability in boundary layer extinction was lowest in Denver (one sigma variability of 3 /Mm at 36 square-km spatial resolution) due to low aerosol loadings and highest in the San Joaquin Valley (19 /Mm) due to variable boundary layer depths and stagnant conditions. Variability in AOD (measured by an airborne high-spectral resolution lidar) was more consistent amongst the sites (0.017 to 0.035) because it is a measure of column loadings and hence not dependent on boundary layer depth changes.

8UA.8
In-situ Investigation of Near-highway Secondary Aerosol Formation in a Potential Aerosol Mass (PAM) Flow Reactor. PROVAT SAHA, Stephen Reece, Andrew Grieshop, *North Carolina State University*

Motor vehicles are a major source of primary aerosols and aerosol precursors that are linked with adverse health and climate effects. Here we present an in-situ investigation of near-highway secondary aerosol formation using a Potential Aerosol Mass (PAM) oxidation flow reactor at a site 10 m from Interstate 40 (I-40), outside Durham, North Carolina. In July, 2015, ambient air at this near-highway site was exposed to high oxidant (O3 and OH; hydroxyl radical) concentrations in a newly developed PAM reactor. The reactor is constructed of stainless steel, has a short, large-diameter inlet and was operated with a residence time of ~70 s. Online OH exposure in the reactor was measured via the decay of externally injected carbon-monoxide (CO); estimated OH exposure ranged from 0.3-14 days of equivalent atmospheric aging assuming an atmospheric OH concentration of 1.5e6 molec cm-3. PAM-processed and ambient air (bypass) were alternately sampled by several instruments (e.g., ACSM, SMPS, PAX). The volatility of PAM-oxidized and ambient aerosol were measured using a multi-tube thermodenuder (TD)-SMPS system at 60 and 120 ˚C temperature with a 30 s TD residence time. Additional measurements included black carbon, NOx and CO2 concentration, meteorological conditions and traffic volume and speed. Oxidation produced substantial additional mass of organic and nitrate species, whereas secondary sulfate production was not observed. Secondary aerosol concentrations varied strongly with OH exposure and between day and night time. Night time enhancement was significantly higher than day time measurements, despite the higher daytime traffic volume. Peak mass enhancement of aerosol mass by a factor of 2 to 4 was observed with 2-5 days of equivalent atmospheric aging, while aerosol mass was lost during very high exposures. The volatility and optical properties of ambient and PAM-oxidized aerosol will be discussed and results will be compared from other recent campaigns.

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8UA.9
Evaluation and Characterization of PM 2.5 (Metals and EC-OC) in Site Cecyte on the Basin Tijuana, Baja California, Mexico. RITA ZURITA FRIAS, Guillermo Rodriguez, Javier Emmanuel Castillo-Quiñones, Deisy Sugey Toledo Arangure, Nina Bogdanchikova, *Universidad Autónoma de Baja California, Tijuana, Mexico*

Tijuana, Baja California, Mexico has a monitoring program for air quality criteria pollutants (SPA, 2012-2020). It includes five monitoring stations within the Tijuana –Rosarito air basin and it reports concentrations of PM10, PM2.5, ozone (O3), nitrogen oxides (NOx), sulfur oxide (SOx).
Studies have identified pollutant transport patterns where plumes originated in Tijuana moved southeast and east during the day. Exposure to atmospheric particulate matter (PM) has been previously linked to several adverse health effects, including but not limited to respiratory and cardiovascular diseases. A particular PM fraction that is known to exert toxic effects is transition metals.

In this study, PM2.5 samples were collected in the southeast of the Tijuana basin using the US EPA-S.O.P.–MDL-016 method, during the period April to October 2014. To measure the total concentration of trace metals, filters were analyzed following EPA-S.O.P.-MLD 005 method. The digested extracts were then analyzed by ICP-OES. Organic Carbon and Elemental Carbon (EC-OC) we analyzed following the NIOSH EC-OC method.

Results show that the average concentration of PM2.5 was 16.8 µg/m3. The total concentration of metals was 319 ng/m3. Aluminum (81.78 ng/m3) was the most abundant , followed by Cooper (40.90 ng/m3), Zinc (32.94 ng/m3) and Lead (30.92 ng/m3). These high concentrations of metals could also be associated with generation of reactive oxygen species (ROS) in cellular studies being conducted. For EC-OC, results show that the Organic Carbon (9.83 µg/m3) is higher than the Elemental Carbon (2.05 µg/m3) and they may help determine the sources of this pollution.

8UA.10
Effect of Pollution Control on Atmospheric Aerosol in Shenzhen, China. IBRAHIM AL-NAIEMA, Yaqin Wang, YuanXun Zhang, Elizabeth Stone, *University of Iowa*

Shenzhen, a megacity with 11 million residents, is located in the southern part of China in the Pearl River Delta adjacent to Hong Kong. Shenzhen experiences elevated levels of fine particulate matter (PM2.5) as a result of intensive anthropogenic activities. In 2011, Shenzhen held the 26th summer Universiade attracting more than 10,000 university athletes from 170 countries. During Universiade, strict air quality controls were implemented leading up to and during the games, providing the opportunity to assess ambient air quality under controlled and uncontrolled emissions scenarios. Our specific objectives were to: i) assess the effect of pollution control on local combustion of fossil fuels and biomass using molecular markers and ii) determine the effect of pollution control on secondary organic aerosol (SOA) formation using a tracer-based approach. PM2.5 was collected daily from two locations (Longgang and Peking University) for 24 days, of which the first half was a subject to emission controls. Results of the study show that PM2.5 concentrations were significantly reduced and visibility was markedly improved during the controlled period. Emission controls were effective in reducing the ambient concentration of organic carbon by half, while elemental carbon was not significantly different. Molecular markers for primary organic carbon sources including polycyclic aromatic hydrocarbons (PAHs), hopanes, steranes, and levoglucosan showed a significant reduction during the controlled period. This indicated reductions in PM from combustion, fossil fuel use, and biomass burning. Tracers of SOA from biogenic and anthropogenic volatile organic compounds were also reduced, as a result of controlling precursors to its formation. In summary, the strict emissions controls on primary sources of PM and gases significantly affected primary aerosol and SOA formation in Shenzhen during Universiade.

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8UA.11

Application of Big Data Technologies for Aerosol Modeling: A Perspective. SATISH VUTUKURU, *Independent Researcher*

Computational modeling has become indispensable to study and help solve our environment, energy, and climate challenges. The first generation computer models for air quality were developed in 1980s and 1990s. This period also saw great advances in large-scale parallel computing especially for scientific computing applications. Consequently, computational modeling, most notably air quality and aerosol modeling, benefited from such advances. Most of the models used today still use parallel computing paradigms developed in 1990s. In recent years, large-scale computing has been widely adopted by data-driven consumer internet companies. This has led to the development of a suite of technologies, most notably the Apache Hadoop ecosystem, to handle large amounts of data and perform robust parallel computing using commodity hardware. In this paper we propose research directions to develop next-generation models that take advantage of these web-scale technologies. We primarily focus on the following three major themes: (a) Application of the map-reduce paradigm of parallel computing using Hadoop and associated technologies, (b) Large scale data management, analysis, and visualization tools, and (c) Mobile and cloud computing technologies. We discuss how these new methodologies can be used for air quality, aerosol, and exposure modeling.

8UA.12

Climatology of PM10 Metals in St. Louis from Hourly Data. Clara Veiga Ferreira de Souza, JAY TURNER, *Washington University in St. Louis*

The commercialization of semicontinuous monitors for ambient measurements of particulate matter elemental composition is an important advancement towards meeting the need for continuous, high time resolution measurement of air quality parameters. This presentation will summarize our experience with the Cooper Environmental Services (CES) Ambient Metals Monitor (Xact 620) which is one in a series of XRF-based monitors for stack, fence-line and ambient measurements. In 2008 the Missouri Department of Natural Resources purchased a Xact 620 that was tuned for measurement of air toxics metals – especially arsenic and lead – in ambient air in urban and remote environments. Starting in November 2012 the instrument has been deployed at the City of St. Louis (MO) Blair Street station which is both an NCore site and a National Air Toxics Trends Station (NATTS). This presentation will briefly summarize Xact performance by comparing to NATTS 24-hour integrated PM10 air toxics metals data, and then focus on insights into the climatology of more than a dozen elements through the analysis of more than 13,000 valid one-hour samples collected over a twenty-month period. High time resolution (e.g. hourly) measurements better align the data to the timescales for variability in surface winds and thereby dramatically improve the ability to resolve local sources. The high data density permits analyses that condition the data on time (e.g. hour of day, weekday/weekend) and surface wind directions, or air mass transport patterns. The various measured species exhibit distinct patterns that reflect contributions ranging from local emissions to regional-scale transport. Weekday enhancement above weekend concentration values is most prevalent for the daytime hours. Nonparametric wind regression for data stratified into weekdays and weekends identifies bearings for sources which operate on both weekdays and weekends (e.g., iron from the local steelworks) and other sources that have reduced or no operations on weekends.

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9AG.1

Sharing the Air Space in the Great State of Texas: Aerosol Sources over Agricultural Operations. SARAH D. BROOKS, John Zenker, Gunnar Schade, Geoffrey Roest, Naruki Hiranuma, *Texas A&M University*

Housing ~10 million cattle in the Southwest United States, open air cattle feedlots represent a significant but poorly constrained source of atmospheric particles. While cattle ranches are much less densely populated than feedlots, many ranches in Texas are now also sites of unconventional oil and gas extraction. Hence, former agricultural-only emissions now coexist with primary and secondary aerosol emissions arising from drilling, fracking, and flaring processes. This presentation will include previous aerosol measurements conducted at concentrated feedlots and ongoing measurements at a ranch in southwest Texas. At the feedlots, two instruments, a GRIMM Sequential Mobility Particle Sizer (SMPS) and a GRIMM Portable Aerosol Spectrometer (PAS), were used to measure particle size distributions over the range of 0.01 to 25 μm diameter. Raman microspectroscopy (RM) was used to determine the chemical composition of particles on a single particle basis, and Environmental Scanning Electron Microscopy (ESEM) was used to determine the water uptake by individual particles in our field samples as a function of relative humidity. Volume size distributions of fugitive dust were dominated by coarse mode particles. Twenty-four hour averaged concentrations of PM10 (particulate matter with a diameter of 10 μm or less) were as high as 1200 μg/m3. The primary constituents of the particulate matter were carbonaceous materials, such as humic acid, water soluble organics, and less soluble fatty acids, including stearic acid and tristearin. While the majority of particles were only slightly hygroscopic, a significant fraction of particles took up water and deliquesced at ~75% RH. Our results to date demonstrate that the characteristics of agricultural aerosols are found to be different than the properties of those found in urban and semi-urban aerosols. Failing to account for such differences will lead to serious errors in estimates of aerosol effects on climate, visibility, and public health.

9AG.2

Particulate Matter Concentration of Mono-slope Beef Cattle Facilities. MINDY SPIEHS, Erin Cortus, Greg Holt, Kris Kohl, Beth Doran, Ferouz Ayadi, Scott Cortus, Md Rajibul Al Mamun, Stephen Pohl, Richard Nicolai, Richard Stowell, David Parker, *USDA ARS*

In the Northern Great Plains, mono-slope beef cattle facilities are an increasingly common housing system. Producers may remove all bedding and manure from the pens weekly (Scrape), maintain a deep-bedded manure pack (Pack), or use a combination of management styles. The objectives of the research were to identify relationships between management practices and PM concentrations, and to determine baseline particulate matter (PM) concentrations around the immediate perimeter of the barn. To determine differences in PM concentration between routine operations and a bedding event, PM was measured over two five-day periods at one Pack barn. Overall mean concentration of total suspended particulates (TSP) in the Pack barn during bedding events was 702.2 micro-grams per m^3 and during routine operation was 58.6 micro-grams per m^3. Average concentrations of PM less than 10 micro-meters in diameter (PM_{10}) and PM less than 2.5 micro-meters in diameter ($PM_{2.5}$) were 4.9 and 17.5 micro-grams per m^3, respectively, during routine operation, and 29.7 and 141.7 micro-grams per m^3, respectively, during a bedding event. Within 18 hours following a bedding event, PM concentrations returned to baseline. Twenty-four hour collections of PM_{10} and $PM_{2.5}$ occurred at least twice during each quarter during a 14-month period in two Scrape barns. Daily mean concentrations of $PM_{2.5}$ and PM_{10} in Scrape barns ranged from 10 to 14 micro-grams per m^3 and 25 to 28 micro-grams per m^3, respectively. This indicated relatively low PM concentrations from mono-slope beef facilities. Ambient air temperature affected PM concentration, while relative humidity, number of cattle, and wind speed were less influential to overall dust in the facilities.

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9AG.3
Contribution of Windblown Dust to Atmospheric Nitrogen in the Columbia Plateau. BRENTON SHARRATT, *USDA-ARS*

Wind erosion contributes to the atmospheric dust load and environmental degradation in the Columbia Plateau of the Pacific Northwest United States. This region has historically exceeded the PM10 (particulate matter ≤10 micrometers in diameter) National Ambient Air Quality Standard due to windblown dust. Nitrogen contained in windblown dust also depletes the soil of a nutrient essential for growth of crops and is of economic importance to farmers. Wind erosion was measured from agricultural fields during 1999-2012 using samplers that trapped sediment at various heights above the eroding surface. Although field sites changed each year, erosion was monitored during the summer fallow phase of a winter wheat - summer fallow rotation when soils are most erodible. Sediment collected in the samplers was analyzed for N by dry combustion. Averaged across years, windblown sediment contained 0.08% N of which a smaller percentage (0.005%) was nitrate/nitrite/ammonia. Nitrogen loss from the field approached 2 kg/ha during singular high wind events. This loss of N represents about 5% of that applied for crop production in the region.

9AG.4
Emissions of Ice Nucleating Particles from Agricultural Lands. THOMAS HILL, Kaitlyn J. Suski, Ezra Levin, Anthony Prenni, Elvin Garcia, Sonia Kreidenweis, Paul DeMott, *Colorado State University*

Agricultural landscapes and farming activities (plowing, harvesting and burning) are strong potential sources of ice nucleating particles (INP). Those reaching cloud altitudes may modify precipitation formation processes and impact the transfer of solar and thermal energy through them. To define the numbers and compositions of INP emitted by these anthropogenically-transformed landscapes, we sampled representative western U.S. agricultural regions, including at the Southern Great Plains DOE-ARM site (OK), an organic farm (CO), and during the harvesting of corn, sorghum, soybean and wheat (NE and KS). Real-time measurements of INPs were made using a continuous flow diffusion chamber (CFDC), and fluorescent biological particles were profiled using a Wideband Integrated Bioaerosol Sensor (WIBS-4A). INP concentrations were also measured via immersion freezing of filtered aerosols in an ice spectrometer, and characterized chemically, biochemically and biologically by their sensitivities to heat, hydrogen peroxide and enzymatic digestions, and DNA profiling. Boundary layer INP ranged from <0.005 to ~1 per L at -12°C, and 0.1 to 20 per L air at -20°C. Heat sensitivity tests conducted in real-time and on filtered aerosols revealed an often high proportion of organic INP in air above these lands. Harvesting generated INP-enriched plumes of pulverized plant tissue and soil dust. Since most crops support substantial populations of ice nucleation active (INA) bacteria, harvesting provides an effective means for their emission en masse. Next-generation profiling of bacteria in the aerosol downwind of corn harvesting showed that 20% of all bacteria were potential INA species of Pseudomonas and Pantoea, and quantitative PCR and sequencing of the ina gene (coding for the ice-active protein) confirmed that INA Pantoea agglomerans (11% of all bacteria in the aerosol) was abundant both in the aerosol and on the crop. Unexpectedly, post-harvest fields continued to emit INP at raised levels due to re-suspension of surface material.

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9AG.5
On-line Monitoring of Airborne Bioaerosols Released from a Composting/Green Waste Site. JOHN SODEAU, David O'Connor, Shane Daly, Stig Hellebust, *University College Cork*

This study is the first to employ the on-line WIBS-4 (Wideband Integrated Bioaerosol Sensor) technique for the monitoring of bioaerosol emissions and non-fluorescing “dust” released from a composting/green waste site. The purpose of the research was to provide a “proof of principle” for using WIBS to monitor such a location continually over days and nights in order to construct comparative “bioaerosol site profiles”. The real-time data obtained was then used to assess variations of the bioaerosol counts as a function of size, “shape”, site location, working activity levels, time of day, relative humidity, wind speeds and wind directions.

Three short campaigns were undertaken, one classified as a “light” workload period, another as a “heavy” workload period and finally a weekend when the site was closed. One main bioaerosol size regime was found to predominate: 0.5 micron to 3 micron with morphologies ranging from elongated to elipsoidal/spherical. The real-time number-concentration data provides a long-term “video” record of the site and were consistent with the Andersen sampling protocol performed that provides only a single “snapshot” for bioaerosol release. The number-concentration of fluorescent particles as a proportion of total particle counts amounted, on average, to ~1% for the “light” workday period, ~7% for the “heavy” workday period and ~18% for the weekend. The bioaerosol release profiles at the weekend were considerably different from those monitored during the working weekdays.

9CH.1
Estimate Mortality Attributable to PM2.5 Exposure in China with Assimilated PM2.5 Concentrations Based on Ground Monitoring Network and a Regional Air Quality Model. Jun Liu, Yiqun Han, Xiao Tang, Jiang Zhu, TONG ZHU, *Peking University*

Significant progresses have been made to estimate the health burden attributable to exposure to ambient air pollutants, such as retrieval of surface PM2.5 concentrations from satellite observed aerosol optical depth. While in China, surface monitoring network of air pollutants has been expanding drastically. Assimilating the concentrations of ground monitoring network with regional air quality model could provide surface concentrations of PM2.5 with much higher spatial and temporal resolution.

PM2.5 concentrations in 2013 were estimated with the Nested Air Quality Prediction Modeling System (NAQPMS) using measured concentrations of air pollutants from more than 300 monitoring stations, data assimilation method based on ensemble Kalman filter was used to improve surface PM2.5 simulation. The provincial permanent population and age-specific mortalities were obtained from statistical year book in China at both central and provincial levels. Attributable mortalities including ischemic heart disease (IHD), cerebrovascular disease (stroke), chronic obstructive pulmonary disease (COPD), and lung cancer (LC) in adults were estimated using the integrated exposure-response (IER) model.

In 2013 in China, exposure to PM2.5 was associated with 0.69, 0.35, 0.14 and 0.14 million of premature deaths from stroke, IHD, LC and COPD disease. All together, about 1.33 million premature deaths were attributed to PM2.5 exposure. Northern China and Yangtze River Delta have the highest mortality attributable to PM2.5.

Assimilation results of PM2.5 concentration from monitoring network with regional air quality model has been successfully used to estimate mortality attributable to PM2.5, the results are comparable to that of the Global Burden of Disease Study 2010.

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9CH.2
Formation and Sources: Seasonal Haze Episodes in Beijing, China in 2013. YANJUN ZHANG, Jing Cai, Mei Zheng, *Peking University*

China, especially North China Plain, nowadays frequently gets hit by haze episodes characterized with high PM2.5 concentration. Due to significant visibility decrease and health threat during hazy days, there is an urgent need to better understand sources and formation mechanisms of haze. This study will present seasonal characteristics of PM2.5 chemical components from Beijing in 2013, and reveal causes for haze episodes in four seasons.

Both major and trace components of PM2.5 are analyzed using multiple techniques. As PM2.5 concentration in Beijing increases, the fraction of sulfate and nitrate increase while that of organic matter decreases significantly. One episode in each season is selected for detailed analysis according to its PM2.5 mass concentration. Beside chemical characterization, source apportionment by chemical mass balance (CMB) and positive matrix factorization (PMF) are also conducted to understand sources of these episodes. Measured and PMF-calculated source profiles agree well with each other. Results of both CMB and PMF analyses indicate coal combustion, traffic emission, road dust, biomass burning and secondary sources are major contributors. Different sources show distinct characteristics in seasonal episodes.

To better understand the contribution of local emission and regional transport in an episode, back trajectory analysis, potential source function (PSCF) and concentration weighted trajectory (CWT) are also applied in this study. During haze periods, the frequency of southward winds is found to increase significantly, especially in summer. More discussion about differences of episodes in four seasons based on its chemical characteristics, sources and the degree of regional transport will be discussed and presented.

9CH.3
Chemical Apportionment of Aerosol Optical Properties during the Asia-Pacific Economic Cooperation (APEC) Summit in Beijing. TINGTING HAN, Weiqi Xu, Chen Chen, Wei Du, Qingqing Wang, Zifa Wang, Ting Yang, Xingang Liu, Yele Sun, *Inst. of Atmospheric Physics, Chinese Academy of Sciences*

The particle extinction was measured in-situ by a Cavity Attenuated Phase Shift extinction monitor along with size-resolved non-refractory submicron aerosol composition by a high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) at an urban site in Beijing from 15 October to 12 November 2014. The average extinction coefficient (b_{ext}) and absorption coefficient (b_{ap}) were 509.6±473.1 Mm^{-1} and 52.4±40.8 Mm^{-1}, respectively, before APEC, which were more than twice higher than those observed during APEC when strict emission controls were implemented in Beijing and surrounding regions. The chemical composition and size distributions had significant changes during APEC, as a response, the mass scattering efficiency of PM_1 was decreased from 5.0 to 3.7 during APEC. The empirical relationships between chemical composition and particle extinction were established using a multiple linear regression model. Our results showed the largest contribution of ammonium nitrate to particle extinction before and during APEC, accounting for 35.5% and 29.1%, respectively. This result highlights the important role of ammonium nitrate in the formation of severe haze episodes in this study. The contributions of primary and secondary OA (SOA) to particle extinction were also separated and quantified. The contribution of SOA to total particle extinction showed a clear decrease from 17.8% before APEC to 13.8% during APEC. In contrast, the POA extinction contribution increased from 12% to15.8%. These results suggested an enhanced role of POA in visibility degradation during APEC. Finally, a link of SSA and extinction with chemical composition, size distributions, and emission controls were established.

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9CH.4
PM2.5 Aerosol Composition and Sources in China during Extreme Haze Events. MIRIAM ELSER, Imad El Haddad, Robert Wolf, Jay Slowik, Junji Cao, Urs Baltensperger, Ru-Jin Huang, Andre Prévôt, *Paul Scherrer Institute*

In the last decades China has been facing increasing air pollution levels in response to fast industrialization and economic growth. Large parts of the country are frequently affected by heavy smog, causing extensive environmental and health problems. The severe high pollution events occur mostly during wintertime, caused by a combination of primary emissions of gas- and particle-phase pollutants, generation of secondary aerosol, and stagnant meteorological conditions that confine the pollutants near ground level.

A High Resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS) was deployed to characterize the aerosol chemical composition and size distribution during winter 2013-2014 in two major cities of China: Xi'an and Beijing. The AMS was equipped with a recently developed aerodynamic lens, extending the measured particle size fraction to PM2.5. The contributing sources to non-refractory (NR) organic aerosols (OA) were identified by means of positive matrix factorization using the multi-linear engine.

During the measurements in Xi'an, an extreme haze covered the city for about a week. According to many broadsheet journals, Xi'an was rated those days the city with highest pollution in the world, with total NR-PM2.5 reaching peak concentrations of over 1000 micrograms per cubic meter. Source apportionment results indicate that during the haze events, secondary inorganic and organic aerosol dominates the composition. This contrasts with a larger fraction of primary OA during non-haze periods, with major contributions from traffic, coal, wood-burning, and cooking emissions. The influence of different sources and processes under haze and non-haze conditions on the particle size, composition, concentration and diurnal trends will be discussed.

9CH.5
Exposure to Polycyclic Aromatic Hydrocarbons and Associated Oxidative Damage: A Natural Experiment between Los Angeles and Beijing. YAN LIN, Xinghua Qiu, Yifang Zhu, *University of California Los Angeles*

Polycyclic aromatic hydrocarbons (PAHs) are major toxic components of PM2.5. It was estimated that the PAHs concentration in the air was one magnitude higher in Beijing compared with Los Angeles. In this study, the urinary concentration of hydroxylated PAHs (HOPAHs) and malondialdehyde (MDA) in a panel of young healthy volunteers, who travelled between Los Angeles and Beijing in summer, was investigated to assess their exposures to PAHs and associated oxidative damage, respectively. The urinary level of total hydroxylated PAHs (∑HOPAHs) in Beijing (geometric mean, same as below, 9.16 microgram per gram creatinine) was 2.1 folds higher than that in Los Angeles (4.23 mcirogram per gram creatinine), indicating higher exposure in Beijing. The characteristic ratios of HOPAHs isomers also changed significantly between the two cities, indicating a shift in the metabolism pathways of PAHs. Based on a mixed-effect model, all the measured HOPAHs was significantly associated with MDA ($p<0.05$), except for 1-hydroxypyrene ($p=0.07$) and naphthols ($p=0.11$). However, no significant difference in MDA was observed between the two cities (33.7 microgram per gram creatinine in Beijing and 35.1 microgram per gram creatinine in Los Angeles, $p=0.94$). Our study provided evidence showing a higher PAHs exposure and a significant shift in PAHs metabolism pathways in Bejing compared with Los Angeles. Future studies revealing the potential mechanism for non-elevated MDA levels in Beijing (i.e. the inducement of anti-oxidation system) are needed.

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9IM.1

Development a PM2.5-Capable Aerosol Chemical Speciation Monitor. WEN XU, Philip Croteau, Leah Williams, Timothy Onasch, Manjula Canagaratna, Douglas Worsnop, John Jayne, *Aerodyne Research, Inc.*

The Aerodyne Aerosol Chemical Speciation Monitor (ACSM) measures the real-time mass loading and chemical composition of non-refractory PM1. However, since there may be interesting chemical information in particles between 1 and 2.5 µm and since air-quality standards worldwide are generally based on PM2.5, an ACSM capable of measuring PM2.5 has been developed. To achieve this, three fundamental challenges were addressed: delivery of PM2.5 to the aerodynamic focusing lens, delivery of PM2.5 through the lens to the detector, and detection of the mass from these particles. The original ACSM sampling inlet was designed to accurately sample PM1 and is less efficient for particles between 1 and 2.5 µm. Like its progenitor the Aerosol Mass Spectrometer (AMS), the ACSM size-range has been limited to about 1 µm by the aerodynamic focusing lens. And, as with the AMS, calculating mass loadings from ACSM data requires accounting for the loss of particles which are not vaporized, which is often as much as 50% of the mass and can vary with relative humidity and chemical composition, leading to uncertainty. Furthermore, this loss is greater for particles larger than 1 µm than it is for particles smaller than 1 µm. Thus, for accurate mass and chemical measurements of non-refractory PM2.5 with the ACSM three major design changes have been implemented: a sampling system which minimizes losses of large particles in transport to the aerodynamic focusing lens, a new particle lens which transmits particles up to 3 µm in diameter, and a redesigned particle vaporizer which enables detection of up to 100% of the non-refractory particle mass. Here we present the results of laboratory and ambient measurements characterizing the performance of the PM2.5 ACSM.

9IM.2

Characterization and Application of a Mini Aerodyne Aerosol Mass Spectrometer. PETER DECARLO, Guan Yu Lin, Anita Johnson, J. Doug Goetz, Urs Rohner, Michael Cubison, Joel Kimmel, Marc Gonin, John Jayne, Douglas Worsnop, *Drexel University*

The Aerodyne mini-Aerosol Mass Spectrometer (mAMS) is a recently developed aerosol mass spectrometer utilizing a more compact form factor, reduced weight, and lower power demand. The instrument is integrated into a vibration isolating rack and is more portable than previous full-size versions of the instrument. The mAMS has similar sampling modes as previous AMS instruments including bulk aerosol composition and size resolved composition measurements. As a new development the mAMS includes an improved data acquisition card and the possibility for efficient particle-time-of-fligth mode (ePTOF). The mAMS has been tested in laboratory, ambient measurement, and source measurements studies. Results from these studies show detection limits bulk composition measurements for the mAMS similar to TOF-ASCM instrument. ePTOF provides a high-signal to noise method for determination of particle sizing and bulk composition measurements. For high concentration source measurements ePTOF is a preferred method for sampling, providing high time resolution and continuous sampling. Ambient and laboratory measurements provide unit mass resolution data sets which can be used for source apportionment methods such as positive matrix factorization (PMF). PMF results from ambient data taken in Philadelphia in April 2013 and February 2014 find standard PMF factors related to cooking, traffic, wood burning, and oxidized organic aerosol. These and other instrument operating parameters will be presented.

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9IM.3
Effect of Secondary Organic Aerosol Coating Thickness on the Detection and Characterization of Biomass-burning Soot by Particle Mass Spectrometry. ADAM AHERN, R. Subramanian, Georges Saliba, Eric Lipsky, Allen Robinson, Neil Donahue, Ryan Sullivan, *Carnegie Mellon University*

Biomass burning is a large source of highly light absorptive black carbon (BC) particles with a wide range of morphologies and sizes. The net radiative forcing from these particles is strongly dependent on the amount of internally mixed secondary material, such as secondary organic aerosol (SOA) that can condense as a biomass-burning plume ages in the atmosphere. Accurate real-time measurements of BC in aging plumes are important to constrain mass absorption enhancements, particle lifetimes, and emissions.

Past studies have shown that for BC surrogates and urban emissions, changing the amount of organic mass on nascent soot can affect the sensitivity of real-time instrumentation, like particle mass spectrometers. The fractal-like BC particles increase in size and also become more spherical with the condensation of secondary material. Both of these changes decrease the particle beam divergence (thereby increasing particle collection efficiency) in instruments like Aerodyne's aerosol mass spectrometer (AMS) and the laser ablation aerosol particle mass spectrometer (LAAPTOF).

We investigate the response of three commercial particle mass spectrometers to monodisperse biomass-burning particles as they are coated with SOA from alpha-pinene ozonolysis in the CMU smog chamber. Particles from biomass burning are less spherical than the surrogate BC, and contain inorganics (e.g. K^+) that may have important ion plume effects for laser desorption ionization, as used in the LAAPTOF. Three soot core sizes, each with three successive coatings of SOA, were investigated. The soot particle (SP)-AMS measured particle beam divergence (as a function of size and shape) and the light scattering (LS)–AMS measured particle bounce off the vaporizer. The LAAPTOF showed a highly linear mass spectral response to the OC/EC mass ratio in individual particles. This demonstrates the capacity to obtain quantitative mass measurements of aged soot particle composition from single-particle mass spectrometry, using realistic particles with complex morphologies and composition.

9IM.4
A Direct HO2 Measurement Method Using Chemical Ionization Mass Spectrometry (CIMS) for the Study of Peroxy Radical Fate. JAVIER SANCHEZ, David Tanner, Greg Huey, Nga Lee Ng, *Georgia Institute of Technology*

Secondary organic aerosols (SOA) make up a large fraction of ambient submicron aerosol. SOA composition and yields are strongly dependent on the fate of the alkyl peroxy radical (RO_2). Traditional SOA chamber experiments have used hydrocarbon/NO_x ratio as a proxy for RO_2 fate or restricted RO_2 fate in "high NO_x" and "low NO_x" experiments. However, such definitions do not capture the fate of RO_2 radicals, limiting applicability of laboratory results to ambient conditions. Understanding of aerosol formation at atmospherically relevant RO_2 fates requires measurements of HO_2. However, HO_2 measurements in SOA laboratory characterizations are rare and generally conducted by titration methods that convert HO_2 to OH through NO additions. Such methods have been shown to suffer from significant positive artifacts. Here we demonstrate a direct method for the measurement of HO_2 radicals using negative ion chemical ionization mass spectrometry (NI-CIMS). We will discuss instrument performance including sensitivity, accuracy, detection limit, and integration time. Sample ambient data collected in Atlanta will also be presented to demonstrate instrument capability.

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9IM.5
Time Resolved Molecular Characterization of Water-Soluble Organic Aerosols by PILS + UPLC/ESI-ToF/MS.
XUAN ZHANG, Nathan Dalleska, Dan D. Huang, Kelvin Bates, Armin Sorooshian, Richard Flagan, John Seinfeld, *Caltech*

We introduce a combination of two techniques, Particle into Liquid Sampler (PILS) and Ultra Performance Liquid Chromatography/Electrospray Ionization Time-of-Flight High-Resolution Mass Spectrometry (UPLC/ESI-ToF/MS), for time-revolved molecular-level characterization of SOA formation and evolution during laboratory chamber experiments. This technique is particularly suited to polar or water-soluble organic molecules, and potentially high molecular weight species. Advantages of this technique mainly include: 1) Molecular-level quantification of particle-phase constituents is available and 2) Temporal profiles of particle composition can be obtained on a time scale consistent with that of SOA evolution. We demonstrate that the PILS+UPLC/ESI-ToF/MS method is suitable to measure water-soluble organic carbon (WSOC), as well as less hydrophilic or slightly water-soluble compounds. A collection efficiency of > 0.6 can be achieved for chamber-derived SOA systems with average O:C ratios > 0.3. We illustrate the application of this technique to 1) the reactive uptake of isoprene epoxydiols (IEPOX) on wet and acidic ammonium sulfate aerosols and 2) formation of dimer esters from ozonolysis of alpha-pinene.

9RW.1
Aerosol pH Buffering in the Southeastern US: Fine Particles Remain Highly Acidic Despite Large Reductions in Sulfate.
ATHANASIOS NENES, Hongyu Guo, Armistead G. Russell, Rodney J. Weber, *Georgia Institute of Technology*

pH is a primary aerosol property which controls various atmospheric processes, including secondary organic aerosol formation, gas-particle phase partitioning, and mineral dust or redox metal mobilization. Using a comprehensive data set from the Southern Oxidant and Aerosol Study (SOAS) as the basis for the thermodynamic modeling, we found that particles are highly acidic year around in the southeastern US, with pH typically ranging between 0 and 3. SO42- and NH4+ are the main acid-base components that determine particle pH, however atmospheric concentrations are changing in response to emissions controls. More than 15 years network data have shown a ~70% decrease of SO42- over the southeastern US. This has led to a view that particles will approach neutralization. However, sensitivity analysisto changing SO42- concentrations using thermodynamic modeling, and both detailed SOAS data and longer term monitoring data in the southeastern US indicates that on average particles have remained highly acidic over the past decade, despite the large reductions of SO42-. Gas-phase NH3 is predicted to be fairly constant in the past decade as deposition roughly balances emissions, consistent with observed data. With reductions of SO42- and relatively constant emissions of NH3 in the future, particle acidity will continue to be a highly buffered system with pH predicted to be close to current levels, until SO42- drops to a very low continental background, about 0.3 micro-g per cubic meter. The result reshapes our expectation of future particle pH and implies that present particle acidity related atmospheric processes will remain effective for some time into the future.

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9RW.2
Tracking Water Diffusion Fronts in a Highly Viscous Aerosol Particle. SANDRA BASTELBERGER, Ulrich Krieger, Thomas Peter, *ETH Zurich*

Field measurements indicate that atmospheric secondary aerosol particles can be present in a highly viscous, glassy state [1]. In contrast to liquid state particles, the gas phase equilibration is kinetically limited and governed by condensed phase diffusion. In recent water diffusion experiments on highly viscous single aerosol particles levitated in an electrodynamic balance (EDB) we observed a characteristic shift behavior of the Mie whispering gallery modes (WGM) indicative of the changing radial structure of the particle, thus providing us with an experimental method to track the diffusion process inside the particle.

When a highly viscous, homogeneous particle is exposed to an abrupt increase in relative humidity, the rapid gas phase diffusion and strong concentration dependence of the diffusion coefficient in the condensed phase lead to extremely steep water concentration gradients inside the particle, reminiscent of diffusion fronts. The resulting quasi step-like concentration profile motivates the introduction of a simple core-shell model describing the morphology of the non-equilibrium particle during humidification. The subsequent particle growth and reduction of the shell refractive index can be observed as red- and blueshift behavior of the WGM, respectively. The shift pattern can be attributed to a core-shell radius ratio and particle radius derived from model calculations [2]. If supplemented with growth information obtained from the WGM redshift and thermodynamic equilibrium data, we can infer a comprehensive picture of the time evolution of the diffusion fronts in the framework of our core-shell model. The measured time dependent concentration profile is then compared with simulations solving the non-linear diffusion equation [3].

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[3] Zobrist, B., Soonsin, V., Luo, B.P., Peter, T. et al., Phys. Chem. Chem. Phys., 13,3514-3526, 2011

9RW.3
The Role of Water in Controlling Heterogeneous Transformations of Viscous Oxygenated Organic Aerosol. JAMES F. DAVIES, Kevin Wilson, *Lawrence Berkeley National Laboratory*

Understanding the role played by water in the heterogeneous chemistry and physical dynamics of secondary organic aerosol is important given the large uncertainty in their influence on global climate. Water may influence reactivity directly, due to its role as a reactant, or indirectly, due to the dependence of particle phase and viscosity on water content. Chemical processing also leads to changes in hygroscopicity and, thus, understanding the dynamics of cloud formation is predicated on understanding the chemistry.

Aerosol flow-tube measurements in combination with high resolution mass spectrometry allow the chemical composition of an aerosol to be determined and monitored over the course of chemical processing. In this study, the influence of relative humidity (RH) on the OH-initiated oxidation of organic aerosol is explored and, through measurements on citric acid aerosol, the role of water on the chemistry of model oxygenated organic aerosol is investigated.

At high RH, the chemical decay kinetics exhibit exponential behavior, as expected for well-mixed droplets undergoing oxidative aging. Under low RH conditions, however, non-exponential decay kinetics are observed and a limited portion of the aerosol is reacted, defined by an accessible depth which scales with the viscosity, falling from around 50 nm at 50% RH to 7 nm at 20% RH. The effective reactive uptake coefficient, $Gamma_{eff}$, also exhibits a complex dependence on RH. We show that $Gamma_{eff}$ initially increases as the RH decreases from saturation, attributed to the decreasing concentration of water at the surface, before reaching a maximum at around 50% RH. A further decrease in RH results in a sharp decrease in $Gamma_{eff}$, attributed to the increasing viscosity of the aerosol. An exploration of oxidation products reveals selective reaction of the most mobile species, with functionalized products becoming less available for reaction due to their slower diffusion in viscous solution.

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9RW.4

Laboratory Studies of In-particle Aqueous Oxidation of Organic Species. JESSE KROLL, Kelly Daumit, Anthony Carrasquillo, Rebecca Sugrue, *MIT*

The atmospheric aqueous phase (cloud droplets and deliquesced submicron particles) has received considerable attention as a potentially important medium for the oxidation of organic species, and thus for the formation and evolution of organic aerosol. While laboratory studies have shown aqueous-phase oxidation to be an efficient process for the rapid generation of highly oxidized organic species, most studies have been carried out in bulk solution only. As a result, the effect that partitioning between the gas and aqueous phases may have on such oxidation processes is not well understood. Here we describe a series of chamber experiments in which the oxidation of organic species occurs within deliquesced particles, allowing for gas-particle partitioning to occur during the oxidation process. Organic aerosol is generated either by atomization of water-soluble species or by secondary organic aerosol formation (alpha-pinene or isoprene ozonolysis), and in-particle oxidation is initiated by dark Fenton chemistry (FeSO4/H2O2); particle chemistry and mass is monitored using high-resolution aerosol mass spectrometry. In all cases, the particulate organic species undergo dramatic chemical changes upon oxidation, leading to the formation of highly oxidized species (most notably oxalate). In addition, a substantial fraction of the particulate carbon is lost during oxidation, presumably by fragmentation (C-C bond breaking) reactions followed by evaporation. Thus this work shows that aqueous-phase oxidation can lead to the rapid formation, as well as degradation, of highly oxidized organic aerosol; however the atmospheric importance of such processes depends critically upon the concentrations of oxidants (e.g., OH) within the atmospheric aqueous phase, values which are poorly constrained at present.

9RW.5

What is the Meaning of "Non-liquid" or "Liquid" Applied to Secondary Organic Material? Highlighting Differences in the Effects of Absorbed Water on Physical Properties Compared to Chemical Reactivity. SCOT MARTIN, Yong Jie Li, Pengfei Liu, Zhaoheng Gong, Yan Wang, Adam Bateman, *Harvard University*

Ammonia uptake was studied for secondary organic material (SOM) of variable viscosity, ranging from non-liquid to liquid physical states. The SOM was produced in aerosol form from six precursors, including three terpenoid and three aromatic species. The viscosity of the hygroscopic SOM was adjusted by increasing the relative humidity (RH) in steps of 10% from <5% to >90% RH at 293 +/- 2 K in a plug-flow configuration. In a follow-on continuously mixed flow reactor, the aerosol was exposed to 5 ppm NH3 for average reaction times of 30, 370, or 5230 s. The ammonium-to-organic ratio of mass concentrations was < 0.03 for toluene SOM below a threshold RH. Above this threshold RH, ammonium-to-organic ratio increased to > 0.03 for toluene SOM, implicating an increase in NH3 chemical diffusivity in the SOM and suggesting a transition to a less diffusion-limited regime. The transition with respect to chemical diffusivity was <5% RH for SOM derived from isoprene (i.e., liquid SOM even to low RH), 40% RH for SOM derived from alpha-pinene, toluene, m-xylene, and 1,3,5-trimethylbenzene, and 80% for SOM derived from beta-caryophyllene. These values related to chemical reactivity differ from the RH transitions for physical behavior. For instance, for alpha-pinene-derived SOM the transition for chemical reactivity of 40% RH can be compared to the transition from rebounding to non-rebounding particles of 80% RH, calling attention to the limitations in inferring chemical behavior from physical behavior. The implication is that chemical transport models directly calibrated to the RH transitions for chemical reactivity could be more accurate than models calibrated to surrogates for reactivity based on physical properties.

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9SA.1

Spatial and Temporal Variability of Sources of Ambient Fine Particulate Matter (PM2.5) in California. SINA HASHEMINASSAB, Nancy Daher, Arian Saffari, Dongbin Wang, Bart Ostro, Constantinos Sioutas, *University of Southern California*

To identify major sources of ambient fine particulate matter (PM2.5, dp< 2.5 µm) and quantify their contributions in the state of California, positive matrix factorization (PMF) receptor model was applied on Speciation Trends Network (STN) data, collected between 2002 and 2007 at 8 distinct sampling locations, including El Cajon, Rubidoux, Los Angeles, Simi Valley, Bakersfield, Fresno, San Jose, and Sacramento. Between five to nine sources of fine PM were identified at each sampling site, several of which were common among multiple locations. Secondary aerosols, including secondary ammonium nitrate and ammonium sulfate, were the most abundant contributor to ambient PM2.5 mass at all sampling sites, except for San Jose, with an annual average cumulative contribution of 26 to 63%, across the state. On an annual average basis, vehicular emissions (including both diesel and gasoline vehicles) were the largest primary source of fine PM at all sampling sites in southern California (17-18% of total mass), whereas in Fresno and San Jose, biomass burning was the most dominant primary contributor to ambient PM2.5 (27 and 35% of total mass, respectively), in general agreement with the results of previous source apportionment studies in California. In Bakersfield and Sacramento, vehicular emissions and biomass burning displayed relatively equal annual contributions to ambient PM2.5 mass (12 and 25%, respectively). Other commonly identified sources at all sites included aged and fresh sea salt as well as soil, which contributed to 0.5-13%, 2-27%, and 1-19% of the total mass, respectively, across all sites and seasons. In addition, few minor sources were exclusively identified at some of the sites (e.g. chlorine sources, sulfate-bearing road dust, and different types of industrial emissions). These sources overall accounted for a small fraction of the total PM mass across the sampling locations (1 to 15%, on an annual average basis).

9SA.2

Long-term Trends of PM2.5 Sources at Metropolitan Areas in Canada: Identifying Factors that Contributed to Improved Air Quality. CHEOL-HEON JEONG, Kelly Sabaliauskas, Dennis Herod, Ewa Dabek-Zlotorzynska, Greg J. Evans, *SOCAAR, University of Toronto*

One third of Canada's population lives in or in the regions surrounding Toronto, Edmonton and Montreal. A source apportionment study in these three metropolitan areas was conducted based on the chemical characterization of PM2.5 collected from 2008 to 2014 and the use of a Positive Matrix Factorization (PMF). In order to provide a historical prospective on how PM2.5 has evolved and improved over the last decade, PMF was applied to 11-year comprehensive aerosol chemical speciation data from 2004 to 2014 in Toronto. A particular focus in Toronto was resolving the influences of reduced coal combustion emissions vs. the post-recession decline in industry and manufacturing in Canada and the USA. In Edmonton, the contribution of oil refining related sources was examined, given the increase in this industrial activity in the intermittent years. In Montreal, the focus was on emissions from wintertime biomass burning in support of municipal interventions being implemented. Secondary sulphate was found still to be the most important factor contributing to the PM2.5 mass in all of the cities. In Edmonton, secondary sulphate was associated with local sources, whereas long-range transport of emissions from coal combustion was the dominant factor in Toronto and Montreal. The influence of long-range transport sources appeared to have declined over the last decade in Toronto. Wintertime PM2.5 was identified as a major issue in Edmonton, arising from increases in the contributions of secondary sulphate, secondary nitrate, biomass burning, and industrial sources. In Montreal, winter time PM2.5 was also higher than in summer, with residential biomass burning still making a substantial contribution. Overall, the landscape of sources contributing to PM2.5 evolved substantially over this period. While the contributions from many traditional sources of PM2.5 declined over this period in all three cities, contributing to improved air quality, these reductions caused increased contributions new sources to emerge.

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9SA.3
Seasonally and Spatially-resolved Source Contributions to Organic Aerosol in Switzerland. Kaspar Daellenbach, Giulia Stefenelli, Imad El Haddad, Carlo Bozzetti, Athanasia Vlachou, Paula Fermo, Raquel Gonzalez, Andrea Piazzalunga, Christina Colombi, JAY SLOWIK, Federico Bianchi, Francesco Canonaco, Urs Baltensperger, Andre Prévôt, *Paul Scherrer Institute*

Field deployments of the Aerosol Mass Spectrometer (AMS) have advanced the real-time measurement of organic aerosol (OA). Subsequent application of positive matrix factorization (PMF) quantifies the contribution of primary emissions sources such as biomass burning (BBOA), traffic, cooking and secondary oxygenated OA (OOA). However, investigation of regional and seasonal differences by long-term, systematic deployment of the AMS on a dense measurement network is impractical because of instrument cost and maintenance requirements. To overcome these limitations and in order to access also coarse particulate matter (PM), we have developed a method of using the AMS for the analysis of conventional aerosol filters collected worldwide. The analysis consists of water extraction of PM from filters and subsequent atomization of the resulting solutions into the AMS. The recovery of bulk organics is approximately 70% and the retrieved mass spectra are comparable to the corresponding online measurements.

We present offline PM10 AMS measurements at 9 stations in Switzerland with different exposure characteristics for the entire year of 2013 (819 samples). To the best of our knowledge, this is the first spatially resolved long-term AMS dataset. Estimates of source contributions (from PMF) are combined with back-trajectory analysis for the determination of source regions. We demonstrate that the dominant factors governing air quality can be region-specific, e.g. BBOA is strongly enhanced in Alpine valleys relative to urban centers. We observe an OOA factor that is dominant in summer and follows the increase in biogenic emissions with temperature. In addition, two long-range transported OOA factors could be extracted, including a winter OOA correlating with anthropogenic secondary inorganic species seen when the site is affected by air masses from continental Europe, and a marine influenced OOA, advected from the Atlantic.

9SA.4
A Rigorous Examination of the Impact of Modern Gasoline Vehicles on the Use of CMB to Determine the Gasoline/Diesel Split. ANDREW HIX, Andrew May, Christopher Hennigan, Allen Robinson, Neil Donahue, Albert A. Presto, *Carnegie Mellon University*

PM source apportionment results obtained with the chemical mass balance (CMB) model are highly sensitive to the choice of source profiles. Source profiles for gasoline and diesel vehicle emissions have often been constructed from relatively small vehicle fleets (N<10), and in some cases published source profiles represent the emissions of a single vehicle. Additionally, many of the vehicle sampling campaigns in the published literature are dated and do not include modern vehicles.

This study addresses the variability in gasoline vehicle fleet using bootstrap resampling to generate probability distributions of the population mean marker/OC ratios from a variety of sampling campaigns including the EPA's Kansas City Study and a recent campaign performed in cooperation with the California Air Resources Board (CARB; May et al, Atmos. Environ., 2014). These probability distributions are inputs to a Monte Carlo implementation of CMB to determine the impact of gasoline source profile variability on CMB predictions. While the EPA's Kansas City Study produced a larger data set (~270 vehicles), the CARB study contains the first large-scale measurements of molecular marker emissions from Tier 2/LEV-2 (e.g., model years 2003-2013) vehicles. Regardless, the gasoline apportionment results, calculated using both data sets, were statistically insignificant.

Historically, due to differences in engine design, elemental carbon was the key species for splitting gasoline and diesel vehicles; diesel engines produced EC/OC ratios significantly greater than 1, and gasoline engines produced EC/OC ratios significantly less than 1. However, the gasoline source profiles calculated using the CARB and Kansas City Campaigns yielded EC/OC ratios ~1, making them "diesel-like," and causing the gasoline and diesel source profiles to become degenerate. Comparisons by model year suggest that these results are influenced by gasoline vehicles built after 1996. This study will rigorously test this observation.

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9SA.5
Evidence for Unrecognized Anthropogenic Sources of Organosulfates: Gas-Phase Oxidation of Anthropogenic Precursors in the Presence of Sulfate Aerosol. MATTHIEU RIVA, Tianqu Cui, Avram Gold, Jason Surratt, *University of North Carolina at Chapel Hill*

Organosulfates are important components of atmospheric fine organic aerosol. However, chemical structures, abundance and sources of many organosulfates remain unclear. Formation of organosulfates from the oxidation of biogenic compounds (isoprene, monoterpenes) in the presence of acidified sulfate aerosol has been characterized in both laboratory-generated and ambient secondary organic aerosol (SOA). Enhancement of SOA mass by increased aerosol acidity has been explained in part by the presence of organosulfates in the aerosol phase. Recent studies have identified and quantified aromatic and aliphatic organosulfates in the fine aerosol collected from several major urban locations, although the sources of compounds remain unknown.

The aim of the present study was to examine the potential for organosulfate formation from the photooxidation of intermediate volatility organic compounds (IVOCs) such as polycyclic aromatic hydrocarbons (PAHs) and long-chain alkanes, which are recognized to be a "missing" source of SOA, particularly in urban areas. Low-molecular weight PAHs (naphthalene and 2-methyl-naphthalene) and C10-C12 alkanes (dodecane, cyclodecane, decalin) were selected for photooxidation experiments in the UNC outdoor smog chamber in the presence of non-acidified and acidified sulfate seed aerosol. These IVOCs are representative of anthropogenic compounds abundantly emitted into the urban atmosphere and could contribute substantially to SOA formation. Impacts of relative humidity, acidity and structure of the IVOCs on organosulfur compound formation were examined. Organosulfates in SOA collected onto filters from smog chamber experiments were chemically characterized by ultra performance liquid chromatography coupled to electrospray ionization high-resolution quadrupole time-of-flight mass spectrometry (UPLC/ESI-HR-QTOFMS).

Organosulfur compounds identified in the smog chamber experiments were also measured in urban fine aerosols from Lahore, Pakistan, and Pasadena, USA. This work suggests that the gas-phase oxidation of anthropogenic precursors in the presence of sulfate aerosol is a hitherto unrecognized source of anthropogenic secondary organosulfur, and provides new anthropogenic SOA tracers.

9UA.1
Assessing the Quantitative Potential of Distributed Low-cost Air Quality Sensor Networks. EBEN CROSS, David Hagan, David Ogutu, Jonathan Franklin, Gary Adamkiewicz, Ann Backus, Jose Vallarino, Douglas Worsnop, John Jayne, Colette Heald, Jesse Kroll, *MIT*

Because of the large expense and expertise required to set up and maintain air quality (AQ) monitoring stations, our understanding of communities' exposures to air pollutants is generally based upon an extremely limited number of measurements. Such measurements (typically no more than 1-4 monitoring stations per urban area, reporting concentrations on hourly or daily basis) do not capture the enormous temporal and spatial variability of air pollutants across densely populated areas. This greatly limits our ability to estimate spatiotemporal variation in air quality in community-based health studies and inform the public about local sources and levels of air pollution. In this presentation, we will describe results from two low-cost air quality sensor networks: [1] CLAIRITY, a 25-node network designed, built, and deployed across the MIT campus and [2] the Dorchester Air Quality Sensor System (DAQSS) a 5-node network distributed in the south Boston neighborhood of Dorchester. Each network provides an opportunity to assess the quantitative potential of electrochemical sensors (Alphasense model B4) for measurement of criteria gas pollutants (carbon monoxide, nitric oxide, nitrogen dioxide, and ozone), as well as low-cost (~$200-$400/unit) Optical Particle Counters (Dylos DC1100; Alphasense OPC-N2) for measurement of particulate matter. Presented work will highlight the need for laboratory calibration and/or in-field co-location with research grade instrumentation to ensure robust, quantitative, low-cost air pollution measurement outputs. Characterizing sensor response across a range of ambient temperature, relative humidity, and interfering gas concentrations is especially important. Ultimately, low-cost AQ sensor networks with improved spatiotemporal resolution can complement existing regulatory monitoring networks - enabling community members to exercise data-driven decisions that minimize their exposure to harmful air pollution, and researchers to better understand pollutant emissions, transport, and chemistry.

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9UA.2
Assessing the Spatial Representativeness of Central Monitor Measurements of Fine Particulate Matter in California for Exposure Estimation. Jianlin Hu, MICHAEL KLEEMAN, Bart Ostro, *University of California, Davis*

Particulate matter (PM) central monitor measurements (CMM) are commonly used for exposure assessment during investigations of the health effects of PM in the general population. Therefore, the spatial representativeness of PM CMM (i.e., what area is actually well-represented by the measurements) affects the accuracy of exposure assessment and needs to be carefully examined. In this study, we assessed the spatial representativeness of PM CMM by comparing to PM concentration fields predicted by a chemical transport model (UCD/CIT model) over a 9-year period (2000-2008). Measurements and model predictions were in good agreement at the measurement locations, but model predictions accounted for spatial variability around each measurement site. Population weighted concentrations (PWC) in different zones around the central monitors were calculated using the spatial distributions of PM and population and then compared to CMM estimates. The confidence intervals (CI) of the ratios of PWC/CMC were calculated as a function of distance to the central monitors for total PM mass as well as different components of PM in different seasons.

The results indicate that the PM2.5 total mass CMM is generally spatially representative (with CI of PWC/CMC of 0.9~1.1, same for thereafter) over distances of 8-20 km from the measurement site at Sacramento, San Jose, Riverside, and El Cajon, but less than 8 km at Fresno, Bakersfield, and Los Angeles. The spatial representativeness varies strongly among PM components. The secondary components (nitrate, ammonium, etc.) have more uniform spatial distribution and therefore have larger spatial representativeness than the primary components (EC and POA). The spatial representativeness of primary components is generally less than 8 km, and at some locations (e.g., Fresno) even less than 4 km, due to the sharp spatial gradient in their concentrations. The spatial representativeness of CMM also varies among seasons. CMM in general tends to have larger spatial representativeness in warmer season (April to September) and smaller spatial representativeness in cold season (October to March) for both the primary and secondary PM components. The results have important implication for use and interpretation of PM CMM in health effect studies.

9UA.3
Changes in Black Carbon Outdoors and Indoors at Near-Roadway Schools in Las Vegas: 2008 to 2013. Steven G. Brown, LYLE CHINKIN, Paul Roberts, David Vaughn, *Sonoma Technology, Inc*

Ambient concentrations of black carbon (BC) at three schools adjacent to highway US 95 in Las Vegas, Nevada, decreased between 2008 and 2013. The total traffic volume, volume of large vehicles such as diesel trucks, and vehicle speeds on US 95 remained similar between the two years, however, indicating that emissions per vehicle and/or background BC concentrations decreased between 2008 and 2013. Vehicle emissions in the U.S. have been trending downward, suggesting much of the decrease in ambient BC may be due to decreased emissions in the vehicle fleet. Indoor concentrations at all three schools were much lower than ambient concentrations. Filtration efficiencies of the heating, ventilation, and air conditioning systems at two schools were similarly high (greater than 90% efficiency) between 2008 and 2013; at one school, doors were left open more frequently in 2013, leading to higher indoor BC concentrations and correspondingly lower calculated filter efficiencies.

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9UA.4

Characterization of Traffic Emissions Exposure Metrics in the Dorm Room Inhalation to Vehicle Emissions (DRIVE) Study: Spatial and Temporal Dynamics in an Urban Area.

JENNIFER L. MOUTINHO, Donghai Liang, Rachel Golan, Chandresh Ladva, Karoline Johnson, Joseph Abrams, Roby Greenwald, Stefanie Ebelt Sarnat, Vishal Verma, Rodney J. Weber, Dean Jones, Jeremy Sarnat, Armistead G. Russell, *Georgia Institute of Technology*

A 13-week intensive sampling campaign was conducted at 6 ambient and 2 indoor monitoring sites surrounding Atlanta's busiest highway with the study area focusing on the Georgia Institute of Technology campus. 54 college students living in dorms near (20 m) or far (1.4 km) from the highway were recruited for personal exposure monitor sampling and biomonitoring which included saliva and blood sampling. Traffic-related contaminant indicators selected to capture the heterogeneity of primary traffic emissions were measured at each site, including particle mass and number, elemental and organic carbon, nitrogen oxides, and carbon monoxide. Measurements collected at the sampling sites were further compared to AERMOD modeling results to determine pollutant gradients across the sampling area. In addition, the suitability of two multipollutant traffic exposure indicators were quantified and evaluated for use in small cohort epidemiological studies. Measurements of nitrogen oxides, carbon monoxide, and particulate matter were collected using low cost sensors to also assess their applicability in epidemiological studies. Results indicate a substantial impact from the highway on surrounding concentrations of primary traffic pollutants leading to prominent spatial and temporal variability at each sampling location, though the gradients were highly species dependent. The results are being used to identify which exposure metrics are most predictive of biologically-relevant primary traffic exposures for panel-based epidemiologic studies.

9UA.5

Comparing Real-time Simultaneous In-car and Outdoor Particulate and Gaseous Concentrations with a Range of Ventilation Scenarios, Road-types and Traffic Densities.

ANNA LEAVEY, Nathan Reed, Sameer Patel, Kevin Bradley, Pramod Kulkarni, Pratim Biswas, *Washington University in St Louis*

Increasing commuting times is a modern trend. Advanced automobile technology, improved communication routes, and increases (or decreases) in wealth have enabled (or forced) people to travel increasing distances to work. In the US, average one-way commutes are approximately 30 minutes. Traffic is a major source of particulates and organic pollutants and consequently peak concentrations tend to occur near to or on roads. This is where an individual may receive a disproportionately large fraction of their total daily personal exposures. While there have been numerous commuter exposure studies assessing multiple commuting modes, few studies have focused on car commutes, and fewer still have sought to understand where and why the highest exposures occur.

The objective of this study was to collect real-time simultaneous particulate and gaseous measurements outside and inside of an on-road car operating with either windows open or closed, fan on or AC on, and traveling along different road types with varying traffic densities. The parameters effecting both outside concentrations and outdoor : indoor ratios were then examined. Fifty-four commutes were conducted between September and November, 2014. Mean (SD) indoor total particle counts, $PM_{2.5}$, lung-deposited surface area and carbon monoxide concentrations were 13,245 (7,615)ptcm^{-3}, 30.4 (6.5)micro-grams m^{-3}, 84.9 (55.6) micro-meter^{2}m^{-3} and 1.1 (2.4)ppm respectively, although mean CO concentrations as high as 11ppm were observed. Indoor particle number size distributions demonstrated geometric mean diameters of between 20-30nm, smaller than what is currently reported in the literature. Indoor concentrations were lower and less variable when windows were closed, however travelling behind a gross polluter, for example a school bus, significantly increased exposure levels. Results indicate that a car's ventilation significantly influences indoor pollutant levels, and that a driver can mitigate their own exposure even whilst traveling through high concentration hotspots.

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10AC.1
Nucleation of Sulfuric Acid Particles with Various Atmospherically Relevant Bases. COTY JEN, Ryan Bachman, Jun Zhao, Peter H. McMurry, David Hanson, *University of Minnesota*

Atmospheric nucleation is the formation of stable aerosol particles from trace precursor gases and accounts for up to half the global cloud condensation nuclei. Thus, accurate predictions of global climatic cooling by aerosols and clouds require understanding the chemical processes that lead to nucleation. Atmospheric nucleation typically correlates with sulfuric acid concentrations, but clusters formed from water and sulfuric acid alone are unstable and require stabilizing compounds to reduce cluster evaporation rates and form stable particles. Here, we present evidence from flow reactor studies on the ability of various basic gases to react with and stabilize sulfuric acid clusters that ultimately form particles. We show which basic gases produce the most particles given equivalent sulfuric acid and base concentration. In addition, we show that the ratio of base to sulfuric acid concentration ([B]/[A]) is a useful parameter to compare the relative importance of acid and base uptake rates. At low [B]/[A], sulfuric acid has a higher collision rate than the base molecules; in this regime, the ability of a base molecule to stabilize sulfuric acid cluster limits the particle formation rates. Our experiments primarily operate in this low [B]/[A] and give us the sensitivity to determine the relative stability of clusters formed from sulfuric acid and various base molecules. At high [B]/[A], growth rates are limited by sulfuric acid collision rates and evaporation is unimportant, at least for most amines.

10AC.2
Multiple New-Particle-Growth Pathways at the DOE Southern Great Plains Field Site in Oklahoma. ANNA HODSHIRE, Jeffrey R. Pierce, James N. Smith, Peter H. McMurry, Jun Zhao, Michael J. Lawler, John Ortega, David Hanson, Kelley C. Barsanti, *Colorado State University*

New-particle formation (NPF) is a significant source of aerosol particle number in the atmosphere. However, these particles are initially too small to have climatic importance and must grow, primarily through net uptake of low-volatility species, from diameters 1 nm to 30-100 nm in order to impact climate. There are currently uncertainties in the physical and chemical processes associated with the growth of these particles that lead to uncertainties in aerosol-climate modeling. The 2013 campaign at the DOE Southern Great Plains (SGP) field site in Oklahoma provided measurements of gas-phase growth precursors, size distributions of new-particle growth events, and the composition of the growing aerosols. We show that the gas-phase and particle-phase compositions during new-particle growth events suggest three distinct growth pathways: (1) growth by sulfuric-acid/amines/organics; (2) growth by organics alone; (3) and growth by sulfuric-acid/ammonia. These event-specific mechanisms correspond to back trajectories that indicate different source regions (e.g. agriculture vs. cities). Finally, we show vertical aerosol number concentrations obtained from tethered balloon experiments demonstrating that nucleation likely starts aloft, at least on some days at SGP. We discuss potential hypotheses why the nucleation starts aloft and implications for nucleation/growth modeling.

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10AC.3

New Particle Formation in the Boreal Forest: Characterizing the Molecules Responsible for Growth.
MICHAEL J. LAWLER, Nina Sarnela, Mikko Sipilä, Tuukka Petäjä, Douglas Worsnop, James N. Smith, *National Center for Atmospheric Research*

Size-resolved chemical composition measurements of recently formed ambient nanometer-sized particles were made during the spring 2014 Biogenic Aerosols: Effects on Clouds and Climate (BAECC) campaign in the Finnish boreal forest using the Time-of-Flight Thermal Desorption Chemical Ionization Mass Spectrometer (TOF-TDCIMS). Molecules and and fragments from recently formed 15-60 nm particles were observed during two new particle formation events. Collected particle samples were analyzed alternately in positive and negative polarity chemical ionization modes, enabling the detection of a diverse array of compounds. The observed molecular ions and fragments were primarily indicative of oxidized organics that were in many cases unsaturated or cyclic. These compounds were similar to those detected in TDCIMS observations of nanoparticles formed by the ozonolysis of alpha-pinene in a chamber study. Up to 47% of the detected ions from sampled nanoparticles were species with O:C ratios greater than 2:3. This result supports previous findings linking highly oxidized gas phase compounds with new particle formation in this environment. The observed nanoparticles also contained reduced nitrogen compounds that suggest the importance of biogenic sources of nanoparticle mass which have not been widely considered.

10AC.4

Spring and Summer Contrast in New Particle Formation over Nine Forest Areas in North America.
Fangqun Yu, Gan Luo, Viney Aneja, Kenneth Demerjian, Anna Gannet Hallar, Olga Hogrefe, W. Richard Leaitch, Shanhu Lee, John Ortega, Priya Pillai, Sara Pryor, JAMES SCHWAB, James N. Smith, John Walker, *University at Albany*

Recent laboratory chamber studies indicate a significant role for highly oxidized low volatile organics in new particle formation (NPF) - but the actual role of organics in NPF in the real atmosphere remains to be clarified. Here NPF events and non-events based on particle size distributions (PSDs) measured in nine forest areas in North America are analyzed and compared to model simulations with and without the involvement of extremely low volatile organics in nucleation. This study focuses on contrasting spring and summer months. On average NPF occurred on ~ 70% of days in a spring month for the four forest sites with spring time PSD measurements, while it occurred only on ~ 8% of days in a summer month for all nine forest sites. Two different nucleation schemes appear to capture the frequent NPF in the spring month. Yet the nucleation scheme considering the role of organics significantly over-predicts NPF and particle number concentrations in the summer month. The two schemes also predict quite different spatial patterns in nucleation rates in the spring over North America. Statistical analysis indicates that the scheme without organics agrees better overall with observations. The two nucleation schemes predict quite different concentrations of cloud condensation nuclei and aerosol first direct radiative forcing in North America, highlighting the necessity to reduce uncertainty in the NPF calculation in regional and global climate models.

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10AC.5
Atmospheric Oxidation Products Pertinent to New Particle Formation. JUN ZHAO, Coty Jen, Mark Stolzenburg, James N. Smith, Peter H. McMurry, *Sun Yat-Sen University*

Nanoparticles formed by nucleation and their subsequent growth to cloud condensation nuclei may significantly affect cloud formation and global climate. Atmospheric boundary layer nucleation rates are usually well correlated with gas-phase sulfuric acid, though sulfuric acid (plus water) alone cannot explain the high formation and growth rates of new particles that are routinely observed. Thus far, several other species including ammonia, amines, and, more recently, highly oxidized organic compounds have been identified as the key contributors to new particle formation and early growth. Here we present results from the 2013 Southern Great Plains New Particle Formation Study (2013 NPFS), which took place at a remote continental site in the US. The atmosphere at the site is impacted by large-scale industrial agriculture and petroleum extraction. The measurements provide concentrations of gaseous species (100-500 amu) and particles (2-500 nm) measured by the Cluster CIMS and scanning mobility particle sizers, respectively. In contrast to our 2009 Cluster CIMS measurements in Atlanta (NCCN09), signals for sulfuric acid clusters larger than dimer were mostly below detection limits due to interferences of organic compounds. We hence developed an analytical method to divide the signal of each mass into two components: one was associated with the formation of sulfuric acid and the other with malonic acid, a representative secondary organic gas phase product. Sulfuric acid and malonic acid followed distinctly different diurnal profiles. With this method, we found that several high molecular weight oxidation products were highly correlated to the formation of new particles (<10nm) by comparing data obtained during nucleation events and non-events. However, identifying the molecular composition of those products requires higher mass resolution than the Cluster CIMS can provide.

10AE.1
Inhalation Exposure to Aerosol Emitted when Using Electrocautery during Surgery: Operation Room Simulation Setting. SHUANG GAO, Michael Yermakov, Richard Koehler, Tiina Reponen, Sergey A. Grinshpun, *University of Cincinnati*

Surgical smoke generated from the use of thermal energy during surgical dissection has been previously recognized as an aerosol hazard. However, the inhalation exposure to aerosols generated in operating rooms remains insufficiently evaluated. Electrocautery is the most common energy source in surgical dissection. The smoke emitted from the tissue can be inhaled by the medical personnel and patients. In this effort, we deployed an electrocautery unit (Force FX, Covidien Ltd., Boulder, CO) in a room-size ventilated exposure chamber. The subjects applied the unit to an animal tissue (fresh pork) mimicking a conventional surgical procedure. The surgical smoke generated during this process was measured with a real-time aerosol spectrometer (NanoCheck, Model 1.326, Grimm Technologies Inc., Ainring, Germany). The aerosol sampling probe was placed in a subject's breathing zone. The measurements were initially performed on ten subjects; the data from six subjects with 3–15 particle size-specific scans per subject were selected to generate a conservative inhalation exposure estimate. The concentrations and particle size distributions in the breathing zone varied from subject to subject; however, subject had no statistically significant effect on the total aerosol concentration, which in some tests exceeded 10^6 particles per cm^-3 (about three orders of magnitude higher than the background level). In most cases, the peak of the particle size distribution fell between 60 and 145 nm, which is consistent with the previously reported data obtained in a laboratory setting. The size-selective particle characterization achieved in this investigation creates the foundation for assessing the inhalation exposure to surgical smoke in hospital operating rooms; it will help quantify the associated health risks and consequently improve the available control strategies.

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10AE.2
Towards a Better Characterization of E-Cigarette Effluent.
Jordan Berger, Mark Daley, Timothy Raymond, James Baish, DABRINA DUTCHER, *Bucknell University*

Electronic cigarettes are relatively new devices, are rapidly increasing in their market adoption and yet have not been thoroughly characterized. These factors force regulators to make decisions regarding their use with minimal information. In this work, we will describe a device that has been built to operate the e-cigs at adjustable power, flow, and time. We have characterized the aerosol produced using this device and a commercially available e-cigarette. Particles were sized using a Scanning Mobility Particle Sizer and an Engine Exhaust Particle Sizer, due to the rapid response time. The aerosol was sized as a function of several different parameters such as filament power, e-liquid composition, and humidity of the eluent environment. Mass balance of the e-liquid with the particle and gas phase also has been explored. Gas chromatography-mass spectrometry has been used to characterize the products of vaping and their distribution in the aerosol. Results indicate that the factors investigated have a significant impact on the resulting aerosol size distributions, total mass, and ultimately deposition/absorption in the human airway.

10AE.3
Effects of Electronic Cigarette Puff Topography on Heating Coil Temperature and Mainstream Particle Characteristics.
Tongke Zhao, Shi Shu, Qiuju Guo, YIFANG ZHU, *UCLA*

Electronic cigarette (EC) is a battery operated device, which consists of a metal heating coil that vaporizes a mixture solution to produce vapors and aerosols. There is limited knowledge about how EC usage may affect the heating coil temperature and subsequently affect mainstream aerosol generation. This study examined the effects of variable puff duration (i.e., 2, 3, 4 and 5 s) and puff flow rates (i.e., 0.5, 1, 1.5, and 2 L/min) on EC heating oil temperature and related mainstream particle size distributions. The heating coil temperature was measured by inserting a thermocouple probe through the tip hole on the EC cartridge under normal working conditions. Particle size distributions were measured by a scanning mobility particle sizer (SMPS). To study the relationship between heating coil temperature and particles generation, mass consumption of the e-liquid in the cartridge was also quantified. The results show that the peak heating coil temperature increases as the puff duration increases and puff flow rate decreases. Similar trend was observed for the count median diameter of the mainstream aerosol. The particle number concentration is greater for longer puff duration and/or higher puff flow rate. These results provide better understanding of how an EC works and highlight the need to carefully characterize exposures in future EC related health effect studies.

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10AE.4
Source Emission Rates of Indoor Ultrafine Particles Considering Coagulation, Deposition, and Ventilation.
DONGHYUN RIM, Lance Wallace, Andrew Persily, Jung-il Choi, *Pennsylvania State University*

Human exposure to airborne ultrafine particles (UFP, < 100 nm) has been shown to have deleterious pulmonary, cardiovascular, and premature health effects. Indoor UFP emissions from combustion appliances and consumer products lead to elevated human exposure to UFP. The particles emitted from the sources undergo aerosol transformation processes such as coagulation and deposition. Coagulation effect can be significant and much larger than particle deposition during the source emission. However, few studies estimated indoor UFP source emission strengths by considering coagulation effects. The objective of this study is to characterize size-dependent emission strength indoor UFP sources by considering coagulation in addition to deposition and ventilation.

Experiments monitored size-resolved concentrations of UFP ranging from 2 nm to 100 nm using a Scanning Mobility Particle Sizer (SMPS) in a full-scale test house. Time-dependent particle size distribution was monitored for two indoor sources: a natural gas burner and a candle. Using the monitoring data of source emission and decay period, UFP source emission strength was determined based on an analytical model that considers coagulation in addition to deposition and ventilation based on the moment method of log-normal size distribution functions.

The results indicate that UFP source emission strength varies with source type and particle size. The results suggest that neglecting coagulation could largely underestimate the emission strength as coagulation accounts for the emission and initial decay period. Larger errors are observed with missing coagulation effect for smaller particles and higher concentrations. The discrepancy in estimate of source strength due to coagulation effect was observed up to factor of 10 or more. This result implies that previous studies on indoor UFP source strengths considering only deposition and ventilation might have underestimated the true values of UFP source strengths.

10AE.5
Modeling the Impact of Residential HVAC Filtration on Indoor PM2.5 of Outdoor Origin and Associated Chronic Health Risks.
DAN ZHAO, Parham Azimi, Brent Stephens, *Illinois Institute of Technology*

Because outdoor particles can penetrate indoors where people spend most of their time, much of human exposure to fine particulate matter (PM2.5) of outdoor origin actually occurs inside buildings and in particular, inside residences. High efficiency particle air filters in central heating, ventilating, and air-conditioning (HVAC) systems are increasingly being relied upon to reduce indoor particle concentrations in homes. However, questions remain regarding the effectiveness of central HVAC filtration in reducing indoor PM2.5 of outdoor origin and associated adverse health effects given the wide variations of the underlying mechanisms that govern indoor concentrations of outdoor particles in homes, including differences in envelope construction and HVAC system sizing that influence air exchange rates, HVAC airflow rates, and HVAC system runtimes. Therefore, in this work we modeled the impact of HVAC filtration (from MERV <5 to HEPA) on indoor concentrations of PM2.5 of outdoor origin in three types of residential buildings (i.e., older, existing, and new homes) located in 22 U.S. cities using hourly simulations. Results demonstrate that the average infiltration factor for PM2.5 ranges from 0.4 with a MERV 5 filter to around 0.25 with a HEPA filter in an older, inefficient home with a poorly sealed envelope. The average PM2.5 infiltration factor in typical existing homes ranged from just under 0.20 with a MERV 5 filter to around 0.15 with a HEPA filter. Finally, the average PM2.5 infiltration factor was consistently less than 0.03 with all filters in a typical new home with a very tight envelope. Model results were then combined with various methods to estimate the impact of HVAC filtration on the chronic health risk of PM2.5 of outdoor origin in homes using a variety of models and concentration-response functions from the recent literature.

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10HA.1

Inflammatory Response to Chronic Exposure of Secondary Organic Aerosol. ARTHUR CHAN, Jianhuai Ye, Xiaomin Wang, Sepehr Salehi, Chung-Wai Chow, *University of Toronto*

Chronic lung diseases, such as asthma and chronic obstructive lung disease, are a significant cause of morbidity and mortality. Air pollutants not only exacerbate conditions of patients with pre-existing disease, but also lead to de novo disease development that is related to chronic cumulative exposures over time. Here we present work focused on studying the pulmonary response to low-dose chronic exposure. We developed a system to expose mice to laboratory-generated aerosol for 2 hours a day over a 2-week period. Characterization tests using fluorescent zinc silicate particles show uniform deposition in the lobes at ambient concentrations. For exposure experiments, we use secondary organic aerosol generated from photooxidation of naphthalene, a representative organic compound in engine exhaust. SOA from naphthalene has been shown in previous work to be highly redox active, and to produce significant levels of reactive oxygen species. The amount and composition of the pollutant mixture are reproducible across many days of exposure. The chemical composition of particles is monitored using GC/MS, and we focus on measuring the concentrations of quinones, which are known redox active compounds. Gas-phase species are selectively removed in some exposures using a honeycomb charcoal denuder, such that mice are exposed to particles only. Results from preliminary experiments will evaluate the physiological response (respiratory mechanics) and inflammatory and immune response (production of inflammatory mediators) from this chronic exposure setup. The difference in responses between particle-only and gas and particle exposures are studied to identify physical mechanisms by which pollutants are delivered.

10HA.2

Unified Predictive Model for Particle Deposition in the Respiratory Tract. CHONG KIM, Shu-Chieh Hu, *USEPA*

Particulate matter in the air is known for causing adverse health effects and one of the key factors for such effects is the deposition dose in the lung. Particle deposition in the lung is determined primarily by particle size and breathing pattern (tidal volume and breathing frequency, or flow rate/respiratory period) besides lung morphology. In the past, lung deposition data was analyzed without a full consideration of breathing pattern and as a result, deposition data showed a wide scatter at a given particle size and derived empirical relationships were under subject to large uncertainties. In the present study we compiled in vivo experimental data for both ultrafine and micron sized particles in normal adults and analyzed the data to derive a single expression for each of total and regional deposition as a function of both particle size and breathing patterns. Deposition was expressed by combination of two composite parameters; $X1= (DTm)^p.Vt^q$ for ultrafine particles and $X2= dp^m.Q^n.Vt^s$ for micron particles. Here, D is diffusion coefficient, Tm is mean respiratory time, Vt is tidal volume, dp is particle diameter, Q is mean respiratory flow rate. We found that total deposition fraction (TDF) can be expressed by a single function in the form of $TDF = 1-1/(1+aX1 + bX2)$. Extrathoracic (ET) and tracheobronchial (TB) deposition can also be expressed with similar functions. Alveolar deposition then is obtained by AL = TDF-(ET+TB). Therefore, both total and regional deposition values can be estimated for a wide range of exposure conditions using four simple empirical equations. This is particularly useful when or where mathematical models are not available or inaccessible. This is an abstract of a proposed presentation and does not necessarily reflect EPA policy.

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10HA.3

Airborne Particulate Matter Exposure in Green Multi-family Buildings. Allison Patton, Leonardo Calderón, Youyou Xiong, Zuocheng Wang, Jennifer Senick, MaryAnn Sorensen-Allacci, Deborah Plotnik, Richard Wener, Clinton J. Andrews, Uta Krogmann, GEDIMINAS MAINELIS, *Rutgers, The State University of New Jersey*

Limited data exist on air quality in residential green buildings, which are increasing in prevalence and may trap particulate matter (PM) indoors due to reduced ventilation. Since Americans spend most of their time in homes, residential exposures may substantially contribute to airborne PM exposure. We evaluated PM exposure in two multi-family high-rise green buildings in the northeastern United States: an Energy Star building with natural ventilation (E) and a LEED platinum building with mechanical ventilation of filtered outdoor air (L). Our objectives were to (1) measure PM longitudinally in apartments in these buildings; (2) compare indoor/outdoor PM concentrations and their ratios (I/O), taking occupant behavior into account; and (3) summarize evidence for an effect of green building designs on indoor PM. We measured PM (DustTrak DRX, TSI Inc., Shoreview, MN) and administered a questionnaire between September 2011 and September 2013. Using these data, we evaluated the effects of ventilation and smoking on PM concentrations and I/O. We compared our observations with data from studies in green and conventional buildings using meta-analysis and summary statistics. Median PMTOTAL was higher in building E (56 micrograms/m^3) than in building L (37 micrograms/m^3); I/O was higher in building E (1.3-2.0) than in building L (0.5-0.8) for all particle size fractions. The differences could be explained by different ventilation systems, but not by outdoor concentrations, which were higher near building E. I/O ratio of PM in both buildings increased with I/O ratio of temperature, particularly in apartments with smokers. While the literature showed similar or slightly lower residential PM2.5 concentrations in green buildings relative to conventional buildings, PM2.5 in our study and others varied both within and between green buildings. Our data show that ventilation systems and occupant behaviors (e.g., smoking and cleaning practices) are important factors affecting exposure to PM in residential green buildings.

10HA.4

Temporal and Spatial Variability of Polycyclic Aromatic Hydrocarbons in Fresno, California, 2014-2015. HILARY MINOR, Betsey Noth, David Vaughn, Jaymin Kwon, Charles Perrino, S. Katharine Hammond, Fred Lurmann, *Sonoma Technology, Inc.*

Polycyclic aromatic hydrocarbons (PAHs) are combustion byproducts that are known carcinogens and toxic air contaminants associated with adverse respiratory health effects and birth outcomes. We have measured airborne PAHs in Fresno, California, using continuous analyzers and filter samplers since 2001. During winter 2014-2015, PAHs were measured daily in Fresno during four 3-to-4 day sampling waves as part of the Children's Health Air Pollution Study–San Joaquin Valley (CHAPS-SJV). The instrumentation was deployed at 14 sampling locations that were selected to capture exposure to high and low traffic activity as well as high and low likelihood of residential wood-burning activities.

The long record of PAH measurements with consistent sampling and analysis techniques in a single community affords an opportunity to report long-term trends in ambient levels, specifically winter average PAH levels. We evaluate the extent to which the observed spatial patterns match the study design. To characterize the spatial variations statistically, we compare the daily spatial coefficients of variation across days in 2014 and with similar data for 2002-2003. We examine how the magnitude of spatial variation varies with mean concentration level and meteorology. The purpose of these analyses is to address the importance of incorporating within-community spatial and temporal variations in models of CHAPS-SJV participants' personal PAH exposure.

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10HA.5
Quantification of Released Carbon Nanotubes from an Epoxy-based Nanocomposite during Abrasion and Particle Toxicity. Lukas Schlagenhauf, Tina Buerki-Thurnherr, Yu-Ying Kuo, Adrian Wichser, Peter Wick, Frank Nüesch, JING WANG, *ETH Zurich/Empa*

A new measurement method was established to quantify the amount of free standing and protruding multi-walled carbon nanotubes (MWCNTs) in the respirable fraction of particles abraded from a MWCNT/epoxy nanocomposite. The quantification approach involves the pre-labeling of MWCNTs with lead ions, nanocomposite generation, abrasion and collection of the inhalable particle fraction and quantification of free standing and protruding MWCNTs by measuring the concentration of released lead ions. In vitro toxicity studies for genotoxicity, reactive oxygen species formation and cell viability were performed using A549 human alveolar epithelial cells and THP-1 human monocytic leukemia cells.

The quantification experiment revealed that in the respirable fraction of the abraded particles, approximately 4000 ppm of the MWCNTs were released as exposed MWCNTs which could contact lung cells upon inhalation, and approximately 40 ppm were released as free standing MWCNTs in the worst case scenario. The toxicity tests revealed that the abraded particles did not induce any acute cytotoxic effects.

10IM.1
Unraveling the Development of Supersaturation under Dynamic Flow Operation of CCN Counters. JACK J. LIN, Sara Purdue, Tomi Raatikainen, Athanasios Nenes, *Georgia Institute of Technology*

The Droplet Measurement Technologies Continuous Flow Streamwise Thermal Gradient Cloud Condensation Nuclei (CCN) Counter[1] is widely used to measure CCN concentrations and study aerosol hygroscopicity. When operated in Scanning Flow CCN Analysis (SFCA) mode, the instrument is capable of scanning across a wide range of supersaturations in a short amount of time[2]. Recent work has shown that pressure field transients that develop inside the CCN growth chamber can significantly affect instrument supersaturation. These effects arise from the flow rate changes and the resulting compressive heating and expansive cooling[3] occurring during an SFCA flow cycle. Work to date has not systematically explored the effect of these pressure transients on the supersaturation fields for a variety of flow scan forms. Pressure effects on supersaturation, if taken advantage of, can considerably augment the ability to measure CCN spectra.

In this work, we present a comprehensive characterization of the supersaturation cycles that develop during SFCA operation for a wide range of operating conditions, including pressure, temperature gradient, scan time, and flow rate waveform. Supersaturation was characterized by flowing ammonium sulfate calibration aerosol into a DMT CCN-100 unit operating under SFCA mode. For precise flow control, a specialized hardware module consisting of an Arduino microcontroller coupled to a modified mass flow controller was developed and attached to the CCN unit. The new module can be easily programmed to follow any arbitrary flow scan profile and waveform. Here we present results using triangular and sinusoid SFCA cycles. The use of the new hardware module reduces the uncertainty in supersaturation compared with traditional SFCA operation. For both waveforms, the dynamic supersaturation range was 0.2-0.9% at 900 mb and 0.1-0.8% at 600 mb for flow cycles ranging between 30 and 60 seconds. The results of the calibrations are interpreted with a comprehensive model[3] and an optimum sampling and SFCA flow cycle strategy is developed for ground-based or aircraft instrument deployments.

1. Lance at al., Aerosol Sci. Tech., 2006.
2. Moore and Nenes, Aerosol Sci. Tech., 2009.
3. Raatikainen et al., Aerosol Sci. Tech., 2014.

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10IM.2
Aerosol Measurement Artefacts using High-Volume Cascade Impactors with Polyurethane Foam and Their Implications. ELISABETH GALARNEAU, Megha Patel, Jeff Brook, Jean-Pierre Charland, Marianne Glasius, Hayley Hung, *Environment Canada*

The ChemVol® is a high-volume cascade impactor (HVCI) designed to separate airborne particles of different sizes. Polyurethane foam (PUF) rings are typically used as impaction substrates.

The ChemVol® sampler was originally designed to capture involatile aerosols for use in toxicity studies. Due to its high flow rate and large sample volumes, there has been interest in using it to study the organic fraction of airborne particulate matter. This fraction includes semivolatile organic compounds (SVOCs).

We have tested the hypothesis that PUF's inherent sorption capacity makes it unsuitable as a ChemVol® substrate when SVOCs are among the target compounds. Results of experiments using side-by-side measurements with alternate samplers, pre-filtering of incoming air, and spiking of substrates with known amounts of analyte confirm that SVOCs measured on ChemVol® substrates do not faithfully represent size-segregated particle-phase concentrations.

We present the details of our experiments with attention on options for correcting observations. We also discuss consequences for evaluating SVOC size distributions and implications for assessing toxicity of size-distributed airborne particulate matter.

10IM.3
Laboratory Characterization of a Volatility and Polarity Separator (VAPS) for Analysis of Oxidized Organic Aerosol. MICHAEL WALKER, Raul Martinez, Claire Fortenberry, Christopher Oxford, Dhruv Mitroo, Nathan Kreisberg, Brent Williams, *Washington University in St. Louis*

Currently, gaps in our knowledge concerning the oxidative aging of organic aerosol (OA) limit our understanding of the climate and human health impacts of OA. Despite recent advances in atmospheric organic aerosol measurements, several challenges remain with the in situ measurement of oxidized organic aerosol (OOA). A novel Volatility and Polarity Separator (VAPS) has recently been developed that couples thermal desorption – two-dimensional gas chromatography (TD-GCxGC) with high resolution mass spectrometry. Particularly, some chromatographic resolution has been sacrificed compared to typical GCxGC separations in order to maximize throughput of oxygenated material. Following two initial field campaigns, several modifications have been made to improve VAPS measurements. The traditional GC oven has been replaced by two mini GCs that function equally well as the larger oven, improving portability through minimized instrument size and power consumption. Additionally, monitoring the eluate during the thermal desorption phase allows for detection of OOA that is not traditionally suitable for analysis by GC due to its thermal instability. A series of laboratory studies have been conducted to better determine the capabilities of the VAPS for analysis of OOA. Comparison of OOA analysis with more established methods, including measurements by an aerosol mass spectrometer (AMS) and a thermal desorption aerosol gas chromatograph (TAG), highlights the strengths of each method.

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10IM.4
Organic and Inorganic Decomposition Products from the Thermal Desorption of Atmospheric Particles. BRENT WILLIAMS, Yaping Zhang, Xiaochen Zuo, Raul Martinez, Michael Walker, Claire Fortenberry, Dhruv Mitroo, Allen H. Goldstein, Kenneth Docherty, Jose-Luis Jimenez, *Washington University in St. Louis*

Atmospheric aerosol composition is often analyzed using thermal desorption techniques to evaporate samples and deliver organic or inorganic molecules to various designs of detectors for identification and quantification. The organic fraction is composed of thousands of individual compounds, some with nitrogen- and sulfur-containing functionality, and often contains oligomeric material, much of which may be susceptible to decomposition upon heating. Here we analyze thermal decomposition products as measured by a thermal desorption aerosol gas chromatograph (TAG) capable of separating thermal decomposition products from thermally transferable molecules.

Analysis of the TAG instrument's sample introduction (thermal decomposition) period reveals contributions of NO (m/z 30), NO2 (m/z 46), SO (m/z 48), and SO2 (m/z 64), derived from either inorganic or organic particle-phase nitrate and sulfate. CO2 (m/z 44) makes up a major component of the decomposition window, along with smaller contributions from other organic components that vary with the type of aerosol being analyzed. Ambient observations of these decomposition products compared to organic, nitrate, and sulfate mass concentrations measured by an aerosol mass spectrometer (AMS) reveal good correlations, with improved correlations for organics signal when compared to the AMS oxygenated organic aerosol component.

10IM.5
A Direct Method for Measuring the pH of Individual Aerosol Particles Using Raman Microspectroscopy. JOEL RINDELAUB, Amy Bondy, Rebecca Craig, Paul Shepson, Andrew Ault, *Purdue University*

Currently, there is a great need for the direct measurement of aerosol pH, due to the impact of acidic aerosols on environmental health and climate. Deposition of acidic particulate matter can negatively affect ecosystems while the inhalation of acidic particles has been linked to serious health issues. Also, many aerosol phase chemical processes, such as hydrolysis reactions and organosulfate formation, are highly dependent on particle acidity and may influence a particle's ability to uptake water. Common methods of estimating aerosol pH are often indirect and can also jeopardize the integrity of samples, as in the case of filter collection methods. In addition, current thermodynamic models used to predict aerosol pH, such as the E-AIM and ISORROPIA-II, are frequently in disagreement with laboratory methods, calling for more refined techniques for the measurement of aerosol acidity. Thus, we developed a non-destructive spectroscopic method capable of directly measuring the pH of individual aerosol particles. The pHs of several laboratory-generated particles were measured as a function of relative humidity and aerosol composition at ambient pressure and temperature. We use Raman microspectroscopy to identify the ratios of peaks representing acids in different protonation states, which are clearly distinguishable in vibrational spectra. Results indicate that laboratory-generated particles may be much more acidic than previously estimated, providing important information into the conditions that govern aerosol phase processing. This technique also has the potential for pH measurement within ambient particles.

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10NM.1
Nanoparticle Synthesis by Laser Pyrolysis: Recent Advances in Production and Application of Multicomponent Materials. Parham Rohani, Seongbeom Kim, MARK SWIHART, *University at Buffalo (SUNY)*

Laser pyrolysis is a versatile aerosol process that has been used to prepare many types of nanoparticles (NPs) since its development more than 30 years ago. In this approach, a CO_2 laser beam is used to very rapidly heat a gas mixture, initiating decomposition of precursor molecules from which solid particles then nucleate. Rapid cooling of the particles by mixing with unheated gases quenches particle growth and sintering. If the precursor does not absorb the laser beam, a photosensitizer (e.g. SF_6) can be added to the precursor mixture. Even for gases that adsorb at the laser wavelength, a photosensitizer can be used to provide additional control of the reaction temperature. Precursor flow rates, laser power, and carrier gas flow rates determine the residence time, reaction temperature, and reactant concentrations. By varying these parameters, primary particle diameters can typically be tuned from about 5 to 50 nm. Alloy and doped nanoparticles can often by prepared using mixed precursor gases. Here, we will present recent results from our laboratory on synthesis of silicon, boron, carbon, and germanium-containing NPs. Silane-germane, silane-diborane, silane-ethylene and silane-germane-ethylene mixtures are being employed to produce Si-Ge alloy NPs, boron-doped Si NPs, silicon carbide NPs and Si-Ge-C ternary alloy NPs respectively. With proper control of size, composition, and surface chemistry, these NPs can be used as reagents for chemical water splitting to produce hydrogen, as anode materials in lithium-ion batteries, as photoluminescent contrast agents for biological imaging, and as light absorbers or emitters in printable electronics. In this presentation, we will summarize our recent progress in producing binary and ternary alloy NPs by laser pyrolysis and present examples of their use in select applications.

10NM.2
Single Step Synthesis of Tin Oxide Nanopillar Arrays by Aerosol Chemical Vapor Deposition. TANDEEP CHADHA, Kelsey Haddad, Pratim Biswas, *Washington University in St. Louis*

The aerosol chemical vapor deposition (ACVD) process has been established as a viable route for the synthesis of nanostructured thin films of titanium dioxide and nickel oxide. The ability to control morphology and to synthesize single crystal structures in a single-step, atmospheric pressure process make it a promising methodology for scaled up synthesis of thin film nanomaterials. However, using the ACVD process to synthesize different metal oxides presents several challenges because the process relies on a number of different process parameters, including the physical and chemical properties of the organometallic precursor, the sintering characteristics of the desired material and particle size.

In this study, we present direct, gas phase synthesis of nanostructures of tin oxide using the ACVD process. The effect of process parameters on the gas phase particle dynamics and the nanostructure morphology has been explored. Further, thin films were synthesized on stainless steel substrates and were tested for use as lithium ion battery anodes. This binder free approach provides several advantages[1], including control of the final nanostructure morphology on the current collector; the direct attachment of each column to the current collector providing enhanced electrical contact; and scalable manufacturing capabilities.

Control over the morphology of the nanostructured tin oxide was demonstrated by changing the process conditions in the ACVD reactor. For specific process conditions, unique single crystal nanopillars of tin oxide oriented along the (110) plane were observed and confirmed by SEM images, HR-TEM images and the SAED pattern. Control over the length of these nanopillars was achieved in the range of 0.5 – 15 µm. These nanopillars were also used for electrochemical characterization and the bare tin oxide nanopillars yielded an initial cycle discharge capacity of 780 mAh/g. The growth mechanism of these single crystal nanopillars by the ACVD process will be discussed.
References:

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10NM.3

Gas-Phase Production of Aluminum-Doped Zinc Oxide Nanocrystalline Thin Films. BENJAMIN GREENBERG, Shreyashi Ganguly, Eray Aydil, Uwe R. Kortshagen, *University of Minnesota*

Doped semiconductor nanocrystals (NCs) can serve as low-cost building blocks for a myriad of optoelectronic devices, including solar cells, light-emitting diodes, and electrochromic windows. Although many of these NCs can be synthesized in the liquid phase, a number of challenges arise: as-synthesized NC surfaces are covered with electrically insulating ligands, dopants are often nonuniformly distributed within an NC, doping efficiencies are often low, and NC size and dopant concentration are difficult to control simultaneously. All of these issues can be attributed to inherent limitations of colloidal synthesis: the ligands are necessary for preventing agglomeration, and difficulties in doping result from solvation forces which render impurity incorporation energetically unfavorable.

We demonstrate that gas-phase synthesis is a promising route to circumventing and overcoming these challenges by exploring nonthermal plasma synthesis of aluminum-doped zinc oxide (AZO) NCs, a prototypical and industrially relevant material. Using diethylzinc (DEZ) and trimethylaluminum (TMA) as precursors, we have developed a scalable high-throughput process for synthesizing transparent conductive AZO NCs with diameters between 4 and 12 nm. By varying the TMA-to-DEZ ratio in the feed gas, we control the doping fraction and thus the free electron concentration in the 10^{19}-to-10^{20}-cm^{-3} range, as indicated by the localized surface plasmon resonance (LSPR) absorption features in the Fourier transform infrared (FTIR) spectra. We calculate doping efficiencies by comparing electron concentrations determined from the LSPRs to Al concentrations measured by inductively coupled plasma mass spectroscopy; we find that, over a wide range of dopant concentrations, our doping efficiencies are significantly higher than those typically achieved in colloidal synthesis. Importantly, doping efficiency and dopant concentration do not decrease as NC size is reduced from 12 to 4 nm. Finally, combining plasma synthesis with supersonic impaction deposition, we produce nanocrystalline thin films and achieve doping-tunable resistivities on the order of 10^{-3} ohm-cm.

This work was supported primarily by the National Science Foundation through the University of Minnesota MRSEC under Award Number DMR-1420013. Part of this work was carried out in the College of Science and Engineering Characterization Facility, University of Minnesota, which has received capital equipment funding from the NSF through the UMN MRSEC program.

10NM.4

Synthesis of Titanium Dioxide Aerosol Gel Using a Negative Gravity Diffusion Flame Reactor. PAI LIU, Ian Arnold, Yang Yu, Rajan Chakrabarty, *Washington University in St Louis*

Aerosol gels are a novel material with potential on serving various energy and environmental applications. In this work, we demonstrated the synthesis of a TiO2 aerosol gel using a diffusion flame aerosol reactor operated in a negative gravity configuration. Control of the material properties, such as primary particle size and crystal phase, was achieved with properly adjusting flame conditions. The methane-oxygen flame temperature was measured to be 1250 degree Celsius without nitrogen dilution; the addition of nitrogen dilution gas decreased the flame temperature to as low as 590 degree Celsius without losing its distinct structure and aerosol trapping effect, which favors aerosol gelation. TiO2 aerosol gels were synthesized by delivering titanium isopropoxide(TTIP) to the flame for high and low temperature conditions. Properties of the TiO2 aerosol gel were investigated with a wide variety of characterization methods. Results showed that TiO2 aerosol gels synthesized in those two conditions demonstrate distinct primary particle size and crystal phase.

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10NM.5
Pulsed Radio-Frequency Argon-Silane Plasmas for Controlled Deposition of Silicon Nanoparticles. CARLOS LARRIBA-ANDALUZ, Steven Girshick, *University of Minnesota*

Reactive plasmas are extensively used in the industry due to their ability to produce large amounts of reactive radicals and of energetic ions. When a nanoparticle precursor, such as silane is introduced into such systems, nanoparticles nucleate and grow in what is referred in literature as “nanodusty” plasmas. Recently, it has been hypothesized that plasma-enhanced deposition of Silicon nanoparticles can be a means to provide fully crystalline silicon films if the impact energy and size of the nanoparticles is accurately controlled to allow amorphization of the nanoparticle and subsequent recrystallization without damaging the substrate film. In order to achieve such conditions, here we numerically model an RF silane-containing plasma that is pulsed at a known frequency with the goal to provide suitable markers that will be used in the future as experimental guidelines. Among the possible testing parameters, one has several candidates, including RF voltage, pressure, pulsing frequency, duty cycle and DC bias voltage. This DC bias voltage is applied during the OFF phase of the pulsing to recollect nanoparticles and control their impact energies. This complex set of possible parameters is tested to maximize silicon film growth while maintaining the impact energy within the desired boundaries.

For such undertaking, we utilize a previously developed 1-D numerical model, modified to consider general chemistry, pulsing and applied substrate bias. This model self-consistently solves for the coupled behavior of plasma, chemistry, and aerosol. An aerosol sectional model is used to model the evolution of particle size and charge distributions which includes nucleation (rate of formation of anions containing three Si atoms is taken as a surrogate for the particle nucleation rate), surface growth, size and charge dependent coagulation, ion and electron attachment based on Orbital Motion Limited theory as well as ion drag and Brownian Diffusion.

10UA.1
Spatial and Temporal Variability in Chemical Composition of Ambient Fine Particulate Matter in the Megacity of Karachi, Pakistan. HAIDER KHWAJA, Lurie Kelly, Zafar Fatmi, David Carpenter, Daniel Malashock, Azhar Siddique, Kamran Khan, Mirza M. Hussain, Fida Khatib, *Wadsworth Center, University at Albany*

Air quality was assessed for Karachi, Pakistan using 24-hour fine particulate matter (size is 2.5 micro-meter) samples collected from two sites, Korangi (industrial/residential) and Tibet Center (commercial/residential). Spatial and temporal characteristics and sources of pollution were evaluated from August 2008 through August 2009 using samples analyzed for PM2.5, black carbon (BC), trace metals, and water-soluble ions. Enrichment factors were calculated, and a receptor model was used to identify anthropogenic and natural source contributions. The mass concentration of the sampled PM2.5 exceeded the WHO Guideline of 20 microgram/cubic meter ranging from 30 to 279 microgram/cubic meter. The average for Korangi (102 microgram/cubic meter) was greater than that for Tibet Center (77 microgram/cubic meter). PM2.5 concentrations were higher in the winter, suggesting increased burning and decreased air dispersion. Average BC concentration ranged from 0.04 to 28.7 microgram/cubic metre. Enrichment factors suggest abundant seasonal contributions of trace metals from anthropogenic activities. Concentrations of pollutants were higher at the Korangi site as compared to Tibet Center, indicative of emissions from industrial activities near the site. Chemical mass reconstruction exhibited that fine particulate matter in Karachi consisted of 35% crustal material, 13% secondary ions (SI), 7.6% sea spray, 4.9% BC, 2.7% trace metals, and 37% others (organic matter), on a yearly average basis. The PM2.5 data sets were analyzed using Positive Matrix Factorization (PMF) to identify possible sources and estimate their contributions to the fine particulate matter. Five and seven sources were identified of particulate matter viz., vehicular emissions, secondary aerosols, sea spray, industrial, diesel, crustal material, and re-suspension of dust. Major air pollution concerns for the megacity of Karachi were identified, highlighting the need for stringent laws on PM2.5 emission control to protect human health and the environment.

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10UA.2
Woodsmoke Pollution in Southern Chile. HECTOR JORQUERA, Francisco Barraza, Johanna Heyer, *Pontificia Universidad Catolica de Chile*

In Southern Chile climate conditions and market fuel prices promote generalized residential wood burning for heating and cooking. However most households have poor thermal insulation and use inefficient stoves so wood smoke is a widespread problem. In this work we consider Temuco (38°44' S, 72°35' W), one of most polluted cities in Chile. In 2012 there were 125 exceedances of the 24h Ambient Chilean Standard for PM2.5, the worst being 291 μg/m3; the annual average PM2.5 concentration was 59 μg/m3, also exceeding the Chilean Annual Ambient Standard.

We report here the results of indoor PM2.5 measurements carried out in 60 households in Temuco during winter 2014. A pair of TAS samplers (Airmetrics, Eugene, OR, USA, 5 L/min) was placed inside each household studied and an additional pair of samplers (Partisol 2000i Thermo Scientific, USA, 16.67 L/min) was placed at a fixed outdoor location for measuring trace elements and elemental and organic carbon in Teflon and quartz filters, respectively. Outdoor PM2.5 samples were highly correlated with an official PM2.5 ambient monitor (beta attenuation, Model MP101M, Environnement, France) located a few blocks away. Indoor PM2.5 concentrations closely follow the outdoor ones meaning households infiltration factors are high; the worst values were recorded when smokers were present, with an I/O PM2.5 ratio near 2.0.

Chemical analysis of outdoor samples show that wood smoke is the dominant PM2.5 source, which is also confirmed by modeling PM2.5 dispersion in the city using CALPUFF. Current regulations and contingency measures aimed at curbing down wood smoke are also discussed.

10UA.3
Episodic Ambient PM2.5 in Beijing and Delhi. JOSHUA APTE, Shahzad Gani, Douw Steyn, S.N. Tripathi, *University of Texas at Austin*

Very high levels of ambient $PM_{2.5}$ in Beijing, China and Delhi, India have attracted widespread media attention. We employ publicly available ambient monitoring datasets to compare the magnitude and temporal variability of $PM_{2.5}$ episodes in these two megacities. For the period from January 2013 – January 2015, arithmetic mean (10th – 90th percentile) hourly $PM_{2.5}$ levels in Beijing and Delhi were respectively 99 (13-230) and 140 (39-290) micro-g m^{-3}. Winter pollution concentrations in both cities substantially exceed summertime levels. However, winters in Delhi are especially striking for sustained, extreme $PM_{2.5}$ levels: mean (p10-p90) hourly concentrations are ~220 (90-380) micro-g m^{-3} for the months of November-January. Episodic winter $PM_{2.5}$ in Beijing reaches similar peaks, although most frequently during a shorter period in January-February, with concentrations of 150 (14-360) micro-g m^{-3} in those months. In contrast to Delhi, occasional conditions of low-to-moderate $PM_{2.5}$ levels are common in Beijing. The monthly 10th percentile of daily-averaged $PM_{2.5}$ ranged between 14-36 micro-g m^{-3} for Beijing, compared with 32-160 micro-g m^{-3} in Delhi. For the two-year period analyzed here, 85 days in Beijing had 24h average $PM_{2.5}$ levels below the World Health Organization guideline concentration of 25 micro-g m^{-3}, in contrast with only 3 such days in Delhi. Regional-scale meteorological patterns and shifts in wind direction may explain these cleaner conditions in Beijing. Large diurnal variability in ambient $PM_{2.5}$ concentrations is typical of both cities, which may indicate that locally-emitted primary $PM_{2.5}$ or locally-formed secondary $PM_{2.5}$ contribute a high fraction of total $PM_{2.5}$ concentrations.

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10UA.4

Characteristics and Sources of Submicron Aerosols above Urban Canopy (260 m) in Urban Beijing, China during 2014 APEC Summit. CHEN CHEN, Wei Du, Weiqi Xu, Zifa Wang, Tingting Han, Qingqing Wang, Zhiqiu Gao, Yele Sun, *Inst. of Atmospheric Physics, Chinese Academy of Sciences*

Beijing, the capital of China, experiences frequent severe haze pollution in recent years. Despite extensive efforts in characterization of fine particles at ground surface, real-time characterization of aerosol particle composition above urban canopy has never been performed in megacity Beijing. Here we conducted the first real-time measurements of submicron aerosol composition using an Aerodyne Aerosol Chemical Speciation Monitor (ACSM) at 260 m on a 325-m meteorological tower from 5 October to 12 November, 2014. Simultaneously, a High-resolution Time-of-Flight Aerosol Mass Spectrometer (HR-ToF-AMS) was deployed at the ground surface to measure size-resolved non-refractory submicron aerosol composition at the same location. The Asia-Pacific Economic Cooperation (APEC) summit with the most strict emission controls in Beijing and surrounding regions provides a great opportunity to study the impacts of emission controls on aerosol chemistry. The measurements above canopy are ideal to evaluate the roles of emission controls in reducing particulate matter levels by minimizing the influences of local point sources. The average mass concentration of NR-PM_1 showed a significant decrease from 65.8 micrograms per cubic meter to 24.8 micrograms per cubic meter during APEC, suggesting that emission controls over regional scales reduced the particulate matter levels substantially. However, the bulk NR-PM_1 compositions was rather similar before and during APEC, both of which were dominated by organics followed by nitrate and sulfate. These results elucidate the impacts of synergistic controls of precursors over regional scales on reducing secondary organic and inorganic aerosols. In addition, the roles of meteorological conditions, particularly mountain valley breeze, in affecting PM levels were also explored. Finally, the comparisons of aerosol particle composition between the ground surface and 260 m will be discussed.

10UA.5

Modeling Study of the 2010 Regional Haze Event in the North China Plain. MENG GAO, Gregory Carmichael, Yuesi Wang, Pablo Saide, Man Yu, Jinyuan Xin, Zirui Liu, Zifa Wang, *University of Iowa*

The North China Plain (NCP) region is experiencing heavy haze pollution with record-breaking high concentrations of particulate matters. Because haze influences visibility, human health and climate, numerous studies have used multiple methods to investigate physical, chemical and seasonal characteristics of aerosols during haze. The online coupled Weather Research and Forecasting-Chemistry (WRF-Chem) model was applied to simulate a haze event happened in January 2010 in the NCP, and validated against various types of measurements. The evaluations indicate that WRF-Chem provides reliable simulations for the 2010 haze event in the NCP. This haze event is mainly caused by high emissions of air pollutants in the NCP and stable weather conditions in winter. Secondary inorganic aerosols also played an important role and cloud chemistry had important contributions. The underestimation of sulfate and organic aerosols might be due to missing reactions in current model. Air pollutants outside Beijing contributed about 47.8% to the PM2.5 levels in Beijing during this haze event, and most of them are from south Hebei, Shandong and Henan provinces. In addition, aerosol feedback has important impacts on surface temperature, RH and wind speeds, and these meteorological variables affect aerosol distribution and formation in turn. In Shijiazhuang, PM2.5 increased more than 20μg/m3 and Planetary Boundary Layer (PBL) decreased about 300m due to aerosol feedback. Black Carbon (BC) accounts for about 50% of the PM2.5 increases and 50% of the PBL decreases in Shijiazhuang, indicating more attention should be paid to BC from both air pollution control and climate change perspectives.

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11AC.1

Partitioning and Selectivity of Organic Molecules in Nascent Sea Spray Aerosol. RICHARD COCHRAN, Thilina Jayarathne, Olga Laskina, Camille Sultana, Christopher Lee, Kimberly Prather, Elizabeth Stone, Vicki Grassian, *University of Iowa*

Atmospheric aerosols have long been known to have both direct and indirect impacts on the Earth's energy balance (i.e., radiative forcing). Sea spray aerosol (SSA) are a major component and have recently been shown to not only be composed of sea salt (i.e., NaCl) but are rather a complex and variable mixture of inorganic and organic compounds as well as biological components. While the organic fraction of SSA has been shown to be size-dependent, the molecular composition of this fraction and how the transfer of the organic species from the sea water to SSA occurs are still unclear. In addition, correlating ocean chemistry to the composition of SSA collected in the field is difficult due to the influence of secondary atmospheric processes in marine environments. This limits the ability of current models to predict the extent of the organic fraction in SSA across the globe and its overall impact on radiative forcing. In this work the molecular composition of the organic fraction of nascent sea spray generated during a waveflume mesocosm experiment was investigated using high resolution mass spectrometry. The levels of naturally derived organic components in SSA were found to depend on SSA particle size, indicating that size-selective mechanisms are involved in the transfer of organic molecules from the bulk seawater to SSA. To further investigate the influence of the chemical and physical properties on the enrichment of organics, a novel technique was used to simulate the generation of SSA under controlled laboratory conditions. Using a representative body of compounds (fatty acids and dicarboxylic acids), enrichment in SSA was found to be affected by the presence of inorganic salts and dependent on the surface activities of the individual acids.

11AC.2

Understanding the Role of Aerosols in the Lifecycle of Organic Carbon through Multiple Generations of Aging. GABRIEL ISAACMAN-VANWERTZ, Jonathan Franklin, Christopher Lim, Paola Massoli, Andrew Lambe, John B. Nowak, Timothy Onasch, Manjula Canagaratna, Joseph Roscioli, Scott Herndon, John Jayne, Douglas Worsnop, Luping Su, Daniel Knopf, Pawel Misztal, Caleb Arata, Allen H. Goldstein, Jesse Kroll, *Massachusetts Institute of Technology*

Emissions of organic carbon to the atmosphere undergo oxidation reactions to yield hundreds of products, forming a multiphase, chemically dynamic system of organic aerosol and gas-phase products that span a wide range of volatilities. Throughout atmospheric aging, organic aerosol acts as an intermediate reservoir for carbon, formed by condensation of low-volatility gases and eventually deposited or re-volatilized through fragmentation. A complete understanding of the fate and transformations of organic carbon in the atmosphere therefore requires a detailed quantitative description of both gas- and particle-phase carbon, but attempts to understand the evolution of carbon through atmospheric oxidation has in nearly all cases resulted in a large fraction of "missing" or unidentified carbon. This has resulted in significant uncertainty in the budget and fluxes of organic aerosol, due in part to difficulties measuring semi-volatile organic compounds, which partition easily between the gas phase and the organic aerosol mass and are therefore susceptible to sampling-related losses. In our work, a large suite of state-of-the-art mass spectrometric and spectroscopic instrumentation was brought to bear on the simulated multi-day atmospheric aging of common biogenic emissions. Organic carbon across all volatilities and functionalities was measured, from aerosols to high-volatility gases, including CO and CO2. New chemical ionization and electron-impact ionization mass spectrometric instruments allowed for the characterization and quantification of low-volatility gases and semi-volatile compounds to understand both their transition into and their formation from organic aerosols. By observing all carbon through multiple generations of oxidation, we examine the relationships between particles and lower-volatility gases with unprecedented detail and place them in the context of current simplified (i.e. two-dimensional) model frameworks, providing a more complete understanding of the evolution of organics in the atmosphere.

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11AC.3
Chemical and Hygroscopic Characterization of Photochemically Processed Laboratory Generated Aerosol.
CHRISTOPHER OXFORD, Michael Walker, Claire Fortenberry, Dhruv Mitroo, Eric Sussman, William Brune, Brent Williams, *Washington University in St. Louis*

Key gaps exist in our understanding of the relationship between particle chemical composition and resulting hygroscopicity. Here, expressions relating the evolution of particle hygroscopicity as a function of oxidative age for several laboratory generated aerosols have been developed. Test aerosols are generated by nebulization of simple standard solutions, by combusting various fuels, or by oxidizing volatile organic precursors to produce a range of secondary organic aerosols (SOA). A Potential Aerosol Mass (PAM) reaction chamber acts to produce SOA or oxidizes the primary aerosols to simulate atmospheric aging. A Tandem Differential Mobility Analyzer (TDMA) measures the hygroscopicity of the aerosol while a Thermal desorption Aerosol Gas chromatograph (TAG), a Volatility And Polarity Separator (VAPS), and an Aerosol Mass Spectrometer (AMS) measures chemical speciation information. The resulting measurements are used to predict the evolution of hygroscopicity in a simulated atmospheric environment.

11AC.4
Size Dependence of Phase Transitions in Aerosol Nanoparticles. Yafang Cheng, HANG SU, Thomas Koop, Eugene Mikhailov, Ulrich Poeschl, *MPIC*

Phase transitions of nanoparticles are of fundamental importance in atmospheric sciences. Current understanding is insufficient to explain observations at the nano-scale. In particular, discrepancies exist between observations and model predictions of deliquescence and efflorescence transitions and the hygroscopic growth of salt nanoparticles. Here we show that these discrepancies can be resolved by consideration of particle size effects with consistent thermodynamic data. We present a new method for the determination of water and solute activities and interfacial energies in highly supersaturated aqueous solution droplets. Our analysis reveals that particle size can strongly alter the characteristic concentration of phase separation in mixed systems, resembling the influence of temperature. Due to similar effects, atmospheric secondary organic aerosol particles at room temperature are expected to be always liquid at diameters below ~20 nm. We thus propose and demonstrate that particle size should be included as an additional dimension in the equilibrium phase diagram of aerosol nanoparticles.

Ref:
Cheng, Y., Su, H., Koop, T., Mikhailov, E., and Pöschl, U.: Size dependence of phase transitions in aerosol nanoparticles, Nature Communications, 6, 10.1038/ncomms6923, 2015.

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11AC.5
Formation of Hydroxyl Radical from Photolysis of Aqueous Secondary Organic Aerosol Material. SHOUMING ZHOU, Katie Badali, Dana Aljawhary, Maria Antiñolo, Crystal Chen, Appana Lok, Emma Mungall, Jenny Wong, Ran Zhao, Jonathan Abbatt, *Univerisity of Toronto, Canada*

A considerable number of lab and field studies have focused on the formation pathways and chemical composition of SOA. However, less attention has been paid to its reactive properties and photochemical aging processes. Although it is known that the photolysis of SOA contributes to its atmospheric aging, it is unclear whether the photochemical aging occurs through only primary reactions or secondary reaction of SOA with radicals produced from a primary photolysis of SOA materials.

In this work, using benzoic acid as OH radical trap, the OH formation rates from ultraviolet photolysis of aqueous SOA, collected from ozonolysis of α-pinene and limonene in an environmental chamber, have been determined by the formation rate of p-hydroxybenzoic acid, measured using offline HPLC analysis. To evaluate whether the OH is formed by photolysis of H2O2 or organic hydroperoxides (ROOH), the peroxide content was measured using the horseradish peroxidase-dichlorofluorescein assay. The experimental results indicate that the OH formation from SOA is likely due to photolysis of ROOH species that are part of the SOA material. Relative to the peroxide level in the SOA, the quantum yield for OH generation from α-pinene SOA is reported to be close to unity.

11AP.1
IMoS: An Efficient Algorithm to Calculate Ion Mobilities from All Atom Models. CARLOS LARRIBA-ANDALUZ, *University of Minnesota*

The application of Ion Mobility Spectrometry-Mass Spectrometry to analyze the structures of large gas phase organic ions continues to be of great interest. From a numerical perspective, ion mobility measurements are linked to model ion structures through the collision cross section (CCS). This CCS is strongly dependent mainly on two major constituents: 1)the Physical Cross Section and 2)the manner in which gas molecules effectively interact with ion surfaces through potential interactions. The Physical Cross Section is a property based on the ion structure while potential interactions are exchanges between vibrational, rotational and translational degrees of freedom of ion and gas molecules. In order to make numerical algorithms efficient, structural atoms must be kept fixed and therefore gas molecule impingement-reemission rules need to be established to make up for potential exchanges. These rules are rarely known a priori and hence introduce a degree of ambiguity in ion mobility based analyses. A set of momentum transfer algorithms are then employed on structures to explore the validity of specular vs. diffusive scattering laws in contrast to purely potential interaction laws. Simultaneously, a description of various very efficiently parallelized algorithms (thousands of times faster than existing methods) that make up IMoS suite of algorithms will be given. These include 1)Projection Approximation, 2)Elastic/Diffuse Hard Sphere Scattering, 3)Trajectory Methods that include ion induced dipole and/or Lennard-Jones potentials, 4)Diatomic gas molecules simulations that make up for rotational degrees of freedom in diatomic molecules and 5)Momentum Transfer studies for larger macromolecules, such as large viruses/bacteria or nanoparticles, where the simple scenario in which the ion does not perturb the gas flow is relaxed and the probability of gas molecule-gas molecule collision rarefaction and compression starts to become significant. In such scenario, the Mason-Schamp approximation is not valid and the system starts to deviate from the free molecular regime.

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11AP.2
Effect of Particle Rotation on the Drift Velocity for Non-Spherical Aerosol Particles. GEORGE MULHOLLAND, Charles Hagwood, Mingdong Li, Michael Zachariah, *University of Maryland*

The drift velocity of a randomly oriented non-spherical aerosol particle in an external field has been previously computed both in the limit of slow rotation and in the limit of fast rotation but not in the intermediate interval. The low rotation limit has been widely used for a range of non-spherical particles including sphere doublets, straight chain clusters of spheres, nanorods, prolate and oblate spheroids, and fractal agglomerates. A 1- D model equation containing the particle acceleration and an orientation dependent friction coefficient is proposed to predict the drift velocity between the two limits. This model has the essential physical phenomena without the complications of the 3-D treatment of the combined translation and rotation behavior. The long time average linear drift velocity is computed as a function of the rotation velocity and the aspect ratio parameter. As an example, the drift velocity is computed for the model parameters based on the friction coefficient and the rotational diffusion coefficient for circular cross section nanorods in the free molecular regime. The transition region between the slow and fast rotation limits occurs over the reduced rotation velocity interval of 0.2 to 3.0. Results on the effects of the nanorod dimensions, the accommodation coefficient, and the particle density on deviations from the low rotation velocity limit will be presented. For a momentum accommodation coefficient of 0.9 and a particle density of 1000 kg/m^3, the largest percent deviation from the low rotation limit is 20 % and the deviation is at most 1 % for nanorods of any length for diameters of 20 nm diameter or larger. The effect of the rotation rate on the translational diffusion coefficient will also be discussed.

11AP.3
Prediction of the Alignment, Preferred Orientation and Electrical Mobility of Nanoparticle Agglomerates during Electrical Mobility Classification. RANGANATHAN GOPALAKRISHNAN, *University of Iowa*

Non-spherical Nanoparticles (NPs) such as agglomerates experience an electrical force as well as a net torque about their center of rotation when they move in electric fields. To separate such particles by their size and shape, Differential Mobility Analyzers (DMAs) are operated at field strengths that are high enough to induce various degrees of alignment with the electric lines of force due to the competition between random thermal rotational motion (Brownian diffusion) and dielectrophoresis induced by polarization forces. By using exact relationships between particle shape and the potential energy of polarization, Fuchs has predicted the average orientation of prolate and oblate spheroids in electric fields. Following Fuchs' approach and by using accurate computations of the polarization energy of agglomerates of arbitrary shape (number, position and size of primary spheres), the propensity of such particles to align in the presence of electric fields is predicted here. Further, the orientation averaged mobility is computed for each shape by combining the mobility of a particle at a specific orientation and the orientation probability distribution. Calculations are presented for dimers, linear chains of tangential spheres as well as fractal aggregates of practical importance. The results presented here enable reconciliation of observed electrical mobilities with shape parameters of agglomerated particles at various operating field strengths used in DMAs.

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11AP.4
Evaluating the Mobility of Soot Aggregates: Role of Electric Fields in Alignment. MINGDONG LI, George Mulholland, Michael Zachariah, *University of Maryland*

The mobility of a nonspherical particle is a function of both particle shape and orientation. In turn the higher magnitude of electric field causes nonspherical particles to align more along the field direction, thus increasing their mobility. In our previous works, we studied this effect on nanorods and doublets of spheres, and showed that the experimental measurements were in excellent agreement with our developed theory for the orientation-averaged mobility and the dynamic shape factor applicable to any axially symmetric particles in an electric field. In this work, we extend our study to fractal aggregates. The mobility of combustion generated soot was measured at various electric fields and compared with spherical lamp wick smoke particles. The measured mobility of these soot particles showed an effect of electric field induced alignment, which results in smaller mobility diameters (i.e. higher mobility) with higher electric fields, while the spherical lamp wick smoke demonstrated no such alignment effect. The alignment dependence of electric field of the soot aggregates showed roughly the same behavior as a spheroidal particle with aspect ratio between 1.2 and 1.3.

11AP.5
Effect of Fractal Morphology on Aggregates Mass Mobility Relationship. Pai Liu, RAJAN CHAKRABARTY, *Washington University in St Louis*

Past studies have shown that the diffusion limited cluster aggregation (DLCA) mechanism yields clusters with a fractal dimension of around 1.8 and prefactors ranging between 1.2 and 2.5. For a fixed cluster mass, an increasing prefactor physically manifests as a decrease in anisotropy or “stringiness” of the particle morphology. In this talk, we explore the effects of changing fractal prefactor and monomer diameter on DLCA aggregate mass-mobility relationship. Our simulation results showed that the mass-mobility exponent of a statistically significant number of aggregates with a fixed fractal dimension = 1.8 was around 2.2. This is in good agreement with previous experimental observations. The mass-mobility prefactor, on the other hand, was shown to be sensitive to variations in monomer size and fractal prefactor. The correctness of the empirical exponent 1.08, used for estimating number of monomers in 3 dimensions (3D) from 2 dimensional projection images, was also evaluated. It was found that the exponent was only valid for aggregates with a fractal prefactor = 1.3. With increasing fractal prefactor, use of the 1.08 exponent caused underestimation of monomer number in 3D.

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11CA.1

Detailed Analysis of Brown Carbon Constituents in Biomass Burning Emissions. ANDREY KHLYSTOV, Vera Samburova, Madhu Gyawali, Laxmi Narasimha Yatavelli, Rajan Chakrabarty, Adam Watts, Joseph Knue, Anna Cunningham, Jessica Connolly, Hans Moosmuller, Barbara Zielinska, *Desert Research Institute*

Recent evidence indicates that some organic compounds (the so-called brown carbon, BrC) can efficiently absorb solar radiation and thus contribute significantly to the positive aerosol radiative forcing. Very little is known about this important aerosol fraction, with most research being concentrated either on searching for individual chemical compounds responsible for light absorption or characterizing bulk light absorption properties of different ambient and laboratory-generated aerosols. Water-soluble aerosol fraction has received most attention, with only a few studies investigating BrC in the non-water soluble fraction. To our knowledge, no attempt has been made so far to quantify the relative contribution of different compounds to light absorption by atmospherically relevant aerosols. We will present an attempt of closing optical properties of biomass burning aerosols using detailed chemical composition data. Five peat fuels collected in different regions of the world (Russia, USA) were burned under controlled conditions (e.g., relative humidity, combustion efficiency, fuel-moisture content) at the Desert Research Institute Biomass Burning facility (Reno, NV, USA). The collected aerosol samples were extracted separately with (a) water and (b) dichloromethane followed by acetone and analyzed using gas chromatography mass spectrometry (GC-MS; Varian 4000 Ion Trap and Scion Triple Quad MS/MS) and Total Organic Carbon analyzer (TOC; Shimadzu TOC-VCSH). Absorption spectra of the extracts and the most prominent compounds were recorded between 190 and 900 nm with a UV/VIS spectrophotometer (PerkinElmer, Lambda 650). Spectra and concentrations of individual compounds were then combined to estimate the total light absorption by the extracts.

11CA.2

Single Particle Characterization of Biomass Burning Organic Aerosol: Evidence of High Molecular Weight Organics with Low Potassium Content. ALEX K. Y. LEE, Megan D. Willis, Robert Healy, Jon M Wang, Cheol-Heon Jeong, Greg J. Evans, Jonathan Abbatt, *University of Toronto*

Biomass burning is one of the major global sources of black carbon and organic aerosol. There is increasing evidence that atmospheric brown carbon is strongly associated with biomass burning organic aerosol (BBOA), introducing significant impacts to regional visibility degradation and climate. The mixing state of BBOA can play a critical role in the prediction of aerosol optical properties and warrants further investigation. In this work, single particle measurements from an Aerodyne soot-particle aerosol mass spectrometer coupled with a light scattering module were used to examine the mixing state of BBOA, potassium and refractory black carbon in a biomass burning influenced air mass. Cluster analysis of the single particle measurement dataset identified five BBOA-related particle types. Only one particle type, associated with small diameters, exhibited a strong signal for potassium, with mass spectra also characterized by low molecular weight organics. The remaining four particle types were classified based on the apparent molecular weight of the BBOA constituents. In particular, there are two particle types with significant amounts of high molecular weight organic fragments in their mass spectra (i.e. > 50% of total ion signal contributed by fragments > m/z 100), which may be the key contributor of low volatility brown carbon in BBOA. These observations provide insights into the sources and chemical properties of atmospheric brown carbon and the input parameters for the current atmospheric models. Relationships between the optical properties and the chemical composition of the aerosol associated with this air mass will also be assessed.

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11CA.3

Investigating Biomass Burning Contribution to Brown Carbon in Beijing. CAIQING YAN, Mei Zheng, Yury Desyaterik, Amy P. Sullivan, Jeffrey Collett, *Peking University*

Biomass burning has been recognized as one of important sources of brown carbon, which plays an important role on regional air quality, radiative forcing and climate change. Agricultural residues and residential biofuel burning are two major types of biomass burning activities, which can contribute significantly to fine particulate matter ($PM_{2.5}$) in some cities during episodic events in China. However, investigation of biomass burning contribution to brown carbon is very limited in Beijing, the capital city of China. This city has frequently experienced severe haze episodes during the last two years, especially during harvest and colder seasons. In this study, ambient $PM_{2.5}$ samples were collected at an urban site in summer and winter 2013 in Beijing. Light absorption properties of water extracts of these offline samples were measured. Carbohydrates (biomass burning markers) were analyzed using high-performance anion-exchange chromatography with pulsed amperometric detection (HPAEC-PAD). And high performance liquid chromatography equipped with a UV/Vis absorbance detector and a time-of-flight (ToF) mass spectrometer (LC/DAD-ESI-HRTOFMS) was applied to determine elemental compositions of light absorbing compounds, especially those from primary and secondary biomass burning sources. High levoglucosan concentrations have been found in some summer samples but it consistently remained a high level in almost all winter samples. Abundant nitrophenols and aromatic carbonyls have also been found in these offline samples especially during days under significant biomass burning influence. In addition, high-time resolution single particle aerosol mass spectrometry (SPAMS) will be used to identify the types (fresh or aged) of biomass burning aerosols. Contribution of primary and secondary biomass burning aerosols to brown carbon in Beijing will be further discussed based on their light-absorption properties, light-absorbing compounds, smoke markers, types of biomass burning aerosols, as well as types of biomass.

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11CA.4

Laboratory and Field Measurements of Physical and Optical Properties of Open Biomass Burning and Cook Stove Aerosols. CHRISTIAN CARRICO, Oluwatobi Oke, Sonia Kreidenweis, Paul DeMott, Ezra Levin, Gavin McMeeking, Chelsea Stockwell, Robert J. Yokelson, *New Mexico Institute of Mining and Technology*

Biomass smoke from wild land fires and cook stove emissions are both growing air quality concerns of global significance. Laboratory experiments in 2012 (Fire Lab At Missoula Experiment, FLAME IV) focused on the effects of fuel type, stove type, and modified combustion efficiency (MCE) in real-time in-situ measurements of both cook stove and open burning emissions. Additionally, we examined these same properties using ambient measurements during several western US smoke events including the High Park Fire in Colorado. Measurement of the particle light scattering and absorption coefficients employed a photoacoustic extinctiometer (PAX, DMT, Inc., Model 870nm). Using a fast mobility particle sizer (FMPS, TSI, Inc., Model 3091), we also measured the 1-sec particle size distribution over particle diameters from 5.6 to 560 nm. Excess concentrations of CO and CO2, which quantify the MCE, were measured in parallel with an open-path Fourier transform infrared spectrometer (OP-FTIR). We observed light absorbing aerosols, often associated with a dominant flaming phase, were emitted in a soot mode with diameters of approximately 20 nm. Interestingly, some highly absorbing aerosols also featured much larger modes with diameters approaching 100 nm. Overall, measurements demonstrated dynamic shifts in particle sizing and accompanying shifts in optical properties during combustion dynamics. Flaming vs. smoldering combustion, as quantified by the MCE, strongly influenced both particle size distribution and optical properties, while fuels combusted were of less importance to size distributions. Such aerosol physical properties, and their relation to combustion characteristics, determine the resulting aerosol impacts on human health, visibility, and significance to climate.

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11CA.5
Absorption Enhancement of Cook Stove Soot Coated with SOA: Measurements and Modeling. GEORGES SALIBA, Adam Ahern, Antonios Tasoglou, Rawad Saleh, Eric Lipsky, Ryan Sullivan, Janarjan Bhandari, Claudio Mazzoleni, Allen Robinson, R. Subramanian, *Carnegie Mellon University*

Direct radiative forcing by black carbon (BC)-containing aerosols (BCA) is affected by the relative fraction of non-BC material and the morphology of individual particles – collectively referred to as "mixing state". Uncertainties in absorption properties of atmospherically aged BC particles, due to their mixing state, complicates its quantitative assessment. Some studies show absorption enhancement of coated BC while others suggest a lack of enhancement in ambient aerosols. We conducted BC coating experiments, in a smog chamber, using cook-stove soot coated with secondary organic aerosol from the ozonolysis of alpha-Pinene or from oxidation of primary vapors. Emissions from a range of cook-stoves and fuels were used during the study. A suite of instruments measuring aerosol absorption, size distribution, mass, and black carbon concentrations, were used to characterize fresh and aged cook-stove emissions. TEM/SEM images were collected to explore morphology changes before and after aging of BC fractals. We report a mass absorption cross section (MAC) of fresh cook-stove emissions of 10.14 $m^2.g^-1$ (±1.43) at 405 nm. Rayleigh-Debye-Gans (RDG) calculations (monomer size of 33.2 ± 5.4 nm) reproduced the measured absorption enhancement. However, Mie theory over-predicted absorption enhancement for non-BC to BC ratios less than 10. Mie theory reproduced the data at higher ratios, suggesting substantial collapse of BC particles with heavy coatings.

11CC.1
The Effect of Climate Change on Future PM2.5 Concentrations. DANIEL WESTERVELT, Larry Horowitz, Vaishali Naik, Denise Mauzerall, *Princeton University*

Climate change can influence fine particulate matter concentrations ($PM_{2.5}$) through changes in precipiation, temperature, and other meteorological variables. The extent of which climate change will exacerbate or alleviate air pollution in the future is an important aspect of robust climate and air pollution policy decision-making. To determine the influence of climate on $PM_{2.5}$, we use the Geophysical Fluid Dynamics Laboratory Climate Model version 3 (GFDL CM3), a fully-coupled chemistry-climate model, coupled with future emissions and concentrations provided by the four Representative Concentration Pathways (RCPs). For each of the RCP future simulations, emissions of aerosols and their precursors are held fixed such that only climate (and thus meteorology) can influence $PM_{2.5}$ surface concentrations. We find a spatially consistent but minimal increase in global $PM_{2.5}$ of 0.24 μg m^{-3} for RCP8.5, the most realistic future scenario based on current emissions. Changes in global $PM_{2.5}$ are at a maximum in the fall and are mainly controlled by sulfate followed by organic carbon with minimal influence of black carbon. RCP2.6 is the only scenario that projects a decrease in global $PM_{2.5}$ with future climate changes, albeit only by -0.03 μg m^{-3} by the end of the 21st century. Regional and local changes in PM2.5 are larger, reaching upwards of 2 μg m^{-3} for certain locations on an annually averaged basis in RCP8.5. Using multivariate linear regression, we find that future $PM_{2.5}$ are most sensitive to precipitation, temperature, and wind. Fine particulate matter concentrations and temperature are found to be robustly positively associated, while negatively related with precipitation and wind speed. We conclude that the hypothesized "climate penalty" of future increases in fine particulate matter is relatively minor on a global scale compared to the influence of emissions on $PM_{2.5}$ concentrations. Our projected larger regional changes may exacerbate local air pollution related mortality, suggesting that climate policies reducing greenhouse gas emissions will be beneficial for human health in addition to policies reducing traditional air pollutants.

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11CC.2
The Importance of Interstitial Particle Scavenging by Cloud Droplets in Shaping the Remote Aerosol Size Distribution and Global Aerosol-climate Effects. JEFFREY R. PIERCE, Betty Croft, Jack Kodros, Stephen D'Andrea, Randall V. Martin, *Colorado State University*

In this paper, we investigate the coagulation of interstitial aerosol particles (particles too small to activate to cloud droplets) with cloud drops, a process often ignored in aerosol-climate models. We use the GEOS-Chem-TOMAS global chemical transport model with aerosol microphysics to calculate the changes in the aerosol size distribution, cloud-albedo aerosol indirect effect, and direct aerosol effect due to the interstitial coagulation process. We find that inclusion of interstitial coagulation in clouds lowers total particle number concentrations by 15–21% globally, where the range is due to varying assumptions regarding activation diameter, cloud droplet size, and ice cloud physics. The interstitial coagulation process lowers the concentration of particles with dry diameters larger than 80 nm (a proxy for larger CCN) by 10–12%. These 80 nm particles are not directly removed by the interstitial coagulation, but are reduced in concentration because fewer smaller particles grow to diameters larger than 80 nm. The global aerosol indirect effect of adding interstitial coagulation varies from +0.4 to +1.3 W m^{-2} where again the range depends on our cloud assumptions. Thus, the aerosol indirect effect of this process is significant, but the magnitude depends greatly on assumptions regarding activation diameter, cloud droplet size, and ice cloud physics. The aerosol direct effect of interstitial coagulation process is minor (<0.01 W m^{-2}) due to the shift in the aerosol size distribution at sizes where scattering is most effective being small. We recommend that this interstitial scavenging process be considered in aerosol models when the size distribution and aerosol indirect effects are important.

11CC.3
The Effects of Model Spatial Resolution on Cloud Condensation Nuclei and Ultrafine Number Concentrations Simulated in a Global Model. MARGUERITE COLASURDO MARKS, Peter Adams, *Carnegie Mellon University*

The aerosol indirect effect is considered the largest source of forcing uncertainty in current climate models. Assessing levels of the atmospheric particles responsible for this effect (cloud condensation nuclei, or CCN) requires knowledge of aerosol levels and their global distribution, size distributions, and composition.

A key tool for advancing our understanding of CCN is the use of global aerosol microphysical models. These models seek to simulate the physical processes that control aerosol size distributions: nucleation, condensation/evaporation, and coagulation. Previous studies have found important differences in CO (Chen, D. et al., 2009) and ozone (Jang, J., 1995) modeled at different spatial resolutions, and it is reasonable to believe that short-lived, highly localized aerosol species will be similarly – or more – susceptible to model resolution effects. Therefore, detailed evaluation of these models against observations will depend on achieving sufficiently high spatial resolution in the model to allow meaningful comparisons.

The goal of this modeling study is to determine how the predicted number concentrations of CCN and ultrafine particles are affected by model spatial resolution. We examine both the enhanced spatial and temporal variability captured with higher model resolutions and how this affects comparisons against observations. Simulations were performed using the global chemical transport model GEOS-Chem (v9-02). The years of 2008 and 2009 were simulated at 4° x 5° and 2° x 2.5° globally, as well as at 0.5° x 0.667° over both Europe and North America. Results were evaluated against surface-based particle size distribution measurements from the European Supersites for Atmospheric Aerosol Research project.

Results suggest that the coarse model simulations predict systematically lower CCN levels than do the fine-resolution simulations. The fine-resolution model simulates more spatial and temporal variability in CCN and ultrafine concentrations, better resolving topographic features and demonstrating time variability much more consistent with observations. As a result, significant differences are evident with respect to model-measurement comparisons.

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11CC.4

Impacts of New Particle Formation on Midwestern Climate and Air Quality as Determined by the NPF-explicit WRF-Chem. CAN DONG, Charles Stanier, Robert Bullard, Ashish Singh, *University of Iowa*

New particle formation (NPF) and growth can influence the concentration of aerosols and cloud droplets, which have been acknowledged to play an important role in both global climate and human health. Several mechanisms have been proposed to explain secondary particle formation and growth. In this study, the NPF explicit version (Matsui et al, Journal of Geophysical Research, 116(D19208), 2011) of the Weather Research and Forecasting Chemistry (WRF-chem) model was used to simulate the particle number distribution in the Midwest.

The three-dimensional chemical transport model has a total of 20 size bins ranging 1-10000 nm in diameter. Particle number concentration, aerosol size distribution, and cloud droplet concentration were simulated in spring and summer 2008 and evaluated versus aircraft and surface measurements in the Midwest. Impacts of NPF on downward solar radiation, surface temperature, relative humidity, PBL height, condensation nuclei (CN), cloud condensation nuclei (CCN), COD, PM2.5 and SO2 will be evaluated. Sensitivity of model prediction to selection of empirical nucleation schemes (activation and kinetic) and the binary homogeneous nucleation will be investigated in the boundary layer and the free troposphere, respectively.

Differences between nucleation-on and nucleation-off simulations in summer show that contributions of NPF to the surface CN10 (> 10 nm in diameter) and CCN (at S =1%) concentrations are 20% and 2.5%, respectively. Aspects to be discussed include the selection of activation and kinetic coefficients, and impacts of NPF to climate and air quality in different seasons.

11CC.5

Measurements of Organic Species within a Greenland Ice Core from 269-2013 AD. CHRISTOPHER LIM, Eleanor Browne, Edward Fortner, Paola Massoli, Monica Arienzo, Nathan Chellman, Daniel Pasteris, Audrey Yau, Timothy Onasch, Leah Williams, John Jayne, Douglas Worsnop, Joseph McConnell, Jesse Kroll, *MIT*

Chemical analyses of trace species present in ice cores are routinely used to investigate the impact of natural variation and anthropogenic influence on past environment and climate. Much of this previous work has focused on characterizing the inorganic species in the cores, including sulfate, nitrate, ammonium, and black carbon, while the organic species have received relatively less attention. This is due in part to the chemical complexity and low abundance of the organic species, which makes identification and quantification difficult. In this work, we use high-resolution mass spectrometry to characterize the bulk chemical composition of organic species present in ice cores at sub-annual resolution. This is achieved by coupling an Aerodyne Soot Particle Aerosol Mass Spectrometer (SP-AMS) to an ultrasonic nebulizer downstream of a continuous ice-melter system. Using the SP-AMS, we measure the black carbon, inorganic, and organic species present in an ice core from Northern Greenland that spans from 269 AD to 2013 AD. We discuss how the bulk organic composition changes over this time period, and use tracer ions and co-variance with inorganic species to identify how the organic matter is influenced by biomass burning, marine emissions, and anthropogenic emissions. Additionally, we compare selected time periods to results from a different Greenland ice core, and discuss how the similarities and differences inform our knowledge of atmospheric composition and transport.

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11HA.1

Effect of Liquid Composition on Particle Size Distribution and Nicotine Yield of Electronic Cigarette Aerosols.

Mohamad Baassiri, Soha Talih, Nareg Karaoghlanian, Rola Salman, Najat A. Saliba, Rachel El Hage, ALAN SHIHADEH, *American University of Beirut*

Electronic cigarettes (ECIGs) heat and vaporize a solution of nicotine in propylene glycol (PG) and vegetable glycerin (VG). Reports of nicotine delivery associated with ECIG use vary widely. Some studies report negligible boosts in plasma nicotine levels while others report combustible cigarette-like delivery. Variables affecting nicotine delivery may include the total mass and particle size distribution (PSD) of the ECIG aerosol from a given product. The aim of this study was to analyze the effect of PG/VG ratio on nicotine yield and PSD of ECIG mainstream aerosol. Aerosols were machine-generated from a tank-type ECIG using 10 solutions spanning a range of 100/0 to 0/100 PG/VG. The ECIG power and puffing regimen were held constant. Total particulate matter (TPM) was measured gravimetrically and PSD produced using 3 different solvent ratios (100/0, 70/30, and 0/100) were measured using a fast electrical mobility spectrometer and a cascade impactor. Nicotine yields were measured using GC-MS. It was found that TPM and nicotine yields increased with greater liquid PG concentration. On average, 76±7% of the aerosol mass fell in the 0.5-1µm size range, and mass mean diameter ranged between 700-880 nm for the three solvent ratios. The particle number distribution mode was approximately 200 nm in the 0/100 case and 100 nm in the 100/0 case. It can be concluded that for a given nicotine liquid concentration, electrical power input, and puff regimen, greater PG content will result in greater nicotine emissions and aerosol concentration. Measured variations in PSD are likely not large enough to impact aerosol delivery.

11HA.2

Reactive Oxygen Species (ROS) Associated with the Ambient Particulate Matter – Insights from Southeastern Center for Air Pollution and Epidemiology (SCAPE) Study.

VISHAL VERMA, Ting Fang, Josephine Bates, Robert Devlin, Armistead G. Russell, Rodney J. Weber, *Georgia Institute of Technology*

Ambient particulate matter (PM) exerts adverse health effects by generating reactive oxygen species (ROS) in-vivo. To examine this hypothesis and to delineate the PM components and sources associated with ROS, a multi-institutional campaign was conducted in the southeastern United States. The campaign was part of a joint research project between Georgia Tech and Emory University (SCAPE) that involved PM2.5 sampling at multiple sites in the southeast.

The uniquely large dataset on the ROS activity measured by dithiothreitol (DTT) assay and speciated chemical components allowed the use of receptor modeling techniques, which yielded biomass burning and secondary aerosol formation from vehicular emissions as the major sources contributing to the ROS activity of ambient particles. The specific components present in these sources, which were associated with the ROS activity appear to be large molecular weight aromatics (humic-like substances, called HULIS) and metals (Cu and Mn). Further fractionation of HULIS based on the solubility of its compounds in different solvents of varying polarity indicates that the ROS active organic species are polar in nature, which included oxygenated derivatives of quinones or quinone-type compounds.

The receptor model was then used to estimate historical levels of ROS activity for use in an epidemiologic analysis in Atlanta. ROS activity was more strongly associated with emergency department visits for asthma/wheezing and congestive heart failure than PM2.5 mass. In addition, a study of human subjects to concentrated ambient particles showed ROS was at least as correlated to various observed biological responses as PM2.5 mass. Collectively, these results indicate the importance of both primary vehicular emissions and biomass burning, and products following atmospheric processing, to ROS activity of ambient particles. The results suggest oxidative stress is a biologically plausible mechanism supporting the associations of adverse health outcomes and ambient PM2.5 mass.

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11HA.3
Impact of Height and Filtration Media on Size Distribution of Inhalable Fraction of Waterpipe Tobacco Smoke Using a TSI NanoScan. CINDY DEFOREST HAUSER, Kate Cerully, *Davidson College*

Hookah or waterpipe is increasing in popularity among college students in the US. Waterpipe Tobacco Smoke (WTS) is perceived to be less harmful than cigarette smoke as it passes through a filtration media prior to inhalation by the user. Previous studies have shown that relative to cigarettes, the waterpipe is associated with 4.7 times the number of puffs and 48.6 times the amount of smoke. First pass studies analyzing mainstream hookah smoke found significant concentrations of ultrafine particles, nicotine and polycyclic aromatic hydrocarbons. More recent studies have focused on more complex compound classes including primary aromatic amines, furanic compounds and humectants. Fewer studies have focused on the physical characteristics of the particulate component. There are many variables that may play a role in the physical and chemical characteristics of the particulate component of WTS including the type of charcoal and shisha, the height of the waterpipe, the amount and type of filtration liquid in the bowl and the material and length of hose used to inhale the smoke. Here we present the use of a TSI NanoScan SMPS Nanoparticle Sizer to explore the size and number of particles between 10 and 420 nm in WTS as a function of some of the aforementioned variables. These physical characteristics of the particulate component of WTS are important in evaluating the potential health hazards to water pipe users.

11HA.4
Particulate Matter Oxidative Potential as an Additional Metric of Pollutant Exposure. ANGELA HUANG, Jandi Kim, Greg J. Evans, Scott Weichenthal, Krystal G. Pollitt, *SOCAAR, University of Toronto*

Particulate matter (PM) is able to induce adverse health effects through an oxidative stress mechanism. PM is comprised of a complex mixture of chemical components. The composition of PM, which is dependent on the emission source, dictates its surface reactivity and is an important factor in determining particle toxicity. Whether these particles result in oxidative damage depends on the initial interactions between inhaled PM and the respiratory tract's extracellular antioxidant network.

Experiments were conducted using particles collected from air quality monitoring sites across Canada and a lab-based concentrator used to collect size-fractionated urban ambient PM. The organic species, metals, and carbonaceous fraction of PM was determined. The oxidative potential, a measure of the capacity of pollutants to oxidize biological molecules, of PM samples was evaluated using a synthetic respiratory tract lung fluid. This chemical model of human respiratory tract lung fluid was comprised of antioxidants (ascorbate, glutathione and urate) at physiological concentrations. Antioxidant depletion was measured over 4 hours.

Composition related variability in the depletion of the antioxidants was observed. Antioxidant depletion and PM chemical composition correlation results will be discussed. Increased variability was observed across oxidative potential measurements as compared to PM mass. This enhanced variability may be related to PM composition and sources. Thus oxidative potential may be able to provide a valuable additional metric for use in of air pollution exposure studies.

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11HA.5
Contrasting Oxidative Potential of Ambient Water-Soluble PM2.5 Measured by Dithiothreitol (DTT) and Ascorbic Acid (AA) Assays: Spatiotemporal Distribution, Source Apportionment, and Health Impacts. TING FANG, Vishal Verma, Josephine Bates, James Mulholland, Armistead G. Russell, Rodney J. Weber, *Georgia Institute of Technology*

The mechanisms of PM health effects are uncertain, however, it has been hypothesized that a possible route is the ability of PM to induce oxidative stress via catalytic generation of reactive oxygen species (ROS). Thus aerosol oxidative potential might be a better predictor of PM toxicity than more generic aerosol properties, such as mass. We developed a semi-automated system to quantify oxidative potential of filter aqueous extracts utilizing the dithiothreitol (DTT) assay and have recently adapted it to the Ascorbic Acid (AA) assay. We analyzed approximately 500 $PM_{2.5}$ samples collected at contrasting environments in southeastern US using both assays, and found that DTT activity on a per air volume basis was spatially uniform and had higher levels in winter than in summer ($winter_{avg}/summer_{avg}$=1.5). In contrast, AA activity was heterogeneously distributed, with highest levels near traffic, and higher in summer compared to winter ($summer_{avg}/winter_{avg}$=1.9). In contrast to DTT, which is sensitive to organic and metal species, AA activity was only correlated with water-soluble metals (especially Cu, r=0.70-0.91). Source apportionment models suggest a strong contribution from secondary processes and traffic emissions to both DTT and AA activities in urban Atlanta. Biomass burning was a large source for DTT activity, but not AA. DTT activity was generally well correlated with $PM_{2.5}$ mass (r=0.49-0.88), while AA activity did not co-vary with mass. Time series epidemiological analyses using reconstructed oxidative potential based on the past 10-year source impacts suggest that DTT activity was associated with emergency department visits for both asthma/wheeze and congestive heart failure, while AA activity was not linked to any investigated health outcomes (Bates et al., 2015). The lack of correlation of AA with $PM_{2.5}$ and greater chemical selectivity of AA assay (specific to Cu) may explain these results. We conclude the DTT assay is a more comprehensive multi-pollutant ROS indicator.

11IM.1
Measurement of Gas and Aerosol Phase Absorption Spectra across the Visible and Near-IR Using Supercontinuum Photoacoustic Spectroscopy. James Radney, CHRISTOPHER ZANGMEISTER, *National Institute of Standards and Technology*

We demonstrate a new method to measure the absorption spectra of gas and aerosol species across the visible and near-IR (500 nm to 840 nm) using a photoacoustic spectrometer (PA) and a pulsed supercontinuum laser source. Gas phases absorption spectra were demonstrated using H2O(g) as a function of relative humidity (RH). The measured absorption intensities and peak shapes were able to be quantified and compared to spectra calculated using the HITRAN2012 database. Size and mass selected nigrosin aerosol was used to measure absorption spectra acoss the visible and near-IR. Spectra were measured as a function of aerosol size/mass and show good agreement to Mie theory calculations. Lastly, we measured a broadband spectrum of aerosol as a function of RH using flame generated soot. The data illustrate the utility of using a broadband pulsed laser source for the measurement of aerosol absorption data.

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11IM.2
Portable Near-real Time Spectrometer for Measurement of Elemental Concentration of Aerosols. PRAMOD KULKARNI, Lina Zheng, G.J. Deye, M. Eileen Birch, *Centers for Disease Control and Prevention, NIOSH*

Compact, field-portable sensors that can provide real-time information about chemical and physical properties of aerosols are valuable tools for exposure measurement. Real-time instruments are an important driver for the future of exposure sciences. An Aerosol Spark Emission Spectrometer (ASES) has been developed for near real-time measurement of elemental concentration of aerosols in the personal breathing zone. The instrument employs atomic emission spectroscopy using spark microplasma as the excitation source. Particles are collected on the tip of the electrode and then subject to ablation and excitation by the microplasma, which leads to significant improvement in measurement precision, limits of detection, and time resolution of measurement. The compact instrument can simultaneously measure most elements in the periodic table at a time resolution of few seconds to few minutes. Algorithms were developed for real-time spectral analysis to obtain quantitative elemental information as well as qualitative insights via chemometric techniques. The instrument was calibrated for various elements, including carbon, and their detection limits were determined and were found to be in the range of few tens to hundreds ng/m^3. Its performance was evaluated using parallel samples collected using filters and analyzed using mass spectrometry. Field measurements were conducted to characterize aerosols in the breathing zone of a mobile person and compared with those from the filter samples. We will present the overall design and development of the instrument, as well as results from the laboratory and field studies designed to evaluate analytical figures of merit of this new instrument.

11IM.3
Electrospray-Differential Mobility Hyphenated with Single Particle-Inductively Coupled Plasma Mass Spectrometry for Characterization of Nanoparticles and Their Aggregates. JIAOJIE TAN, Jingyu Liu, Mingdong Li, Hind El Hadri, Vincent Hackley, Michael Zachariah, *National Institute of Standards and Technology*

The hyphenation of electrospray-differential mobility analysis with single particle-inductively coupled plasma mass spectrometry (ES-DMA-spICPMS) was demonstrated with the capacity for real-time size, mass and concentration measurement of nanoparticles (NPs) on a particle-to-particle basis. The ES delivers an aerosolized sample to a customized DMA system, which achieves size discrimination with high resolution by controlling the applied voltage in step mode. Coupled by a gas exchange column, the downstream spICPMS, operates in time-resolved mode and detects element-specific NP mass as single particle events.

In this proof-of-principle study, the feasibility of this technique was validated through both concentration and mass calibration using NIST reference gold NPs. A detection limit of 10^7 NPs/mL was determined, which is about two orders of magnitude lower in comparison to a traditional ES-DMA setup using a condensation particle counter as the principal detector. Furthermore, independent and simultaneous quantification of both size and mass of NPs provides information regarding nanoparticle aggregation states. Two demonstrative applications include gold NP mixtures with a broad size range (30nm to 100nm), and aggregated NPs with a primary size of 40 nm.

Overall, this new hyphenated technique demonstrated the capacity for: 1) Clearly resolving nanoparticle populations from a mixture containing a broad size range; 2) Defining a linear relationship between mobility size and one-third power of intensity ($Au^{+}97$ in our case) for spherical NPs; 3) Monitoring propagation of NP aggregation with well characterized oligomers; and 4) Differentiating aggregated NPs and non-aggregated states based on the “apparent density” derived from both DMA size and spICPMS mass.

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11IM.4

Chemical Analysis of Ambient Air In Real Time by Secondary Electrospray Ionization High-Resolution Mass Spectrometry. XUE LI, Pablo M.-L. Sinues, Renato Zenobi, *Jinan University; ETH Zurich*

Secondary organic aerosol (SOA) is a worldwide concern due to its significant influence on the global climate change, air quality and human health. The atmospheric chemistry of volatile organic compounds (VOCs) is intimately involved in the formation of SOA in ambient air under both clean and polluted atmospheric conditions. In this study, ambient air was directly monitored with a time resolution of 1.5 minute using an ambient mass spectrometry-based technique, secondary electrospray ionization high-resolution mass spectrometry (SESI-HRMS). Hundreds of positive and negative ions were detected in the range of m/z 40–350, and identified as C_xH_v, $C_xH_yO_z$, $C_xH_yN_mO_z$ and $C_xH_yO_zS_n$ (e.g., C_5H_8, C_3H_7O, $C_3H_4O_4$, $C_6H_{11}NO_3$, $C_{13}H_{24}O_4S_2$) based on the HRMS and isotope distribution data. This results imply the presence of alkenes, alcohols, ketones, aldehydes, aliphatic acids as well as other organic compounds in ambient air. Significant changes of intensity of individual signal within minutes during a field measurement period (9:00–14:30 on December 27, 2013, at the Hönggerberg campus of ETH Zürich) have been successfully captured, even for isobaric compounds that can be distinguished thanks to the high mass resolution, e.g., $C_3H_6N_3O_2$ (m/z 116.0460) and $C_4H_{10}N_3O$ (m/z 116.0824). In conclusion, SESI-HRMS is a promising tool for studying the atmospheric chemistry of VOCs by providing accurate identification of signals obtained from non-targeted analysis and time-resolved characterization of atmospheric VOCs.

11IM.5

The Development of Electrostatic Precipitation-Electrospray Ionization Mass Spectrometry (EP-ESI-MS) for Aerosol Analysis. SIQIN HE, Lin Li, Hongxu Duan, Amir Naqwi, Christopher Hogan Jr., *University of Minnesota*

Electrospray ionization (ESI) is a suitable mode of ion generation for mass analysis of many organic species for which alternative ionization techniques can lead appreciable analyte fragmentation. For this reason, ESI is an ideal method for the analysis of species within aerosol particles. However, low concentrations of aerosol particles in most environments has limited ESI application in aerosol particle analysis; aerosol mass spectrometers typically employ thermal or laser volatilization followed by electron ionization or chemical ionization, which can lead to a considerable degree of analyte fragmentation. In this presentation, the development of an approach to apply ESI to molecules within submicrometer and nanometer scale aerosol particles is discussed. This technique, which we term electrostatic precipitation-ESI-MS (EP-ESI-MS), utilizes unipolar ionization to charge particles, electrostatic precipitation to collect particles on the tip of a Tungsten rod, and subsequently, by flowing liquid over the rod, ESI and mass analysis of the species composing collected particles. EP-ESI-MS is shown to enable analysis of nanogram quantities of collected particles composed of cesium iodide, levoglucosan, and levoglucosan within a carbon nanoparticle matrix. With EP-ESI-MS, the integrated mass spectrometric signals are found to be a monotonic function of the mass concentration of analyte in the aerosol phase. We additionally show that EP-ESI-MS has a dynamic range of close to 5 orders of magnitude in mass, making it suitable for molecular analysis of aerosol particles in laboratory settings with upstream particle size classification, as well as analysis of PM 2.5 particles in ambient air.

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12AC.1
Source Apportionment of Pb-containing Particles by Multiple Methods during January 2013 in Beijing, China.
JING CAI, Jiandong Wang, Yanjun Zhang, Hezhong Tian, Shuxiao Wang, Deborah Gross, Mei Zheng, *Peking University*

Though leaded gasoline has been banned in Chinese megacities since 1997 and nationally since 2000, lead (Pb) is still an important issue in China as its concentration in megacities like Beijing remains high. Traditionally, Pb source apportionment studies have been conducted with receptor models or emission inventories (EI), which results in low-time resolution and large variability of results. In this study, both receptor-oriented and source-oriented methods were used to identify the major sources of Pb in Beijing in January 2013.

Samples were collected using online and offline techniques in downtown Beijing. The 24-h concentration of Pb was analyzed by ICP-MS while the number-count, particle size (in the range of 0.2-2 μm) and mixing state of Pb-containing particles were provided by Single Particle Aerosol Mass Spectrometry (SPAMS) with 1-h time resolution. In addition, the EI and Community Muti-Scale Air Quality (CMAQ) model were used to support the findings. The hourly Pb concentration simulated by CMAQ model was in good agreement with the Pb counts measured by SPAMS.

The Pb-containing particles sampled with SPAMS were classified into 3 major particle types: Pb mixed with secondary ions (68%), Pb mixed with carbonaceous compounds (18%), and Pb mixed with crustal compounds (14%). Primary emissions, assigned to sources such as coal combustion and dust, were in good agreement with the EI. On days with relatively low Pb counts, Pb-containing particles tended to be mixed with carbonaceous compounds, suggesting primary emissions sources such as coal combustion. During episodes with extremely high Pb counts, Pb-containing particles were more likely to be mixed with secondary inorganic species (nitrate and sulfate), suggesting a greater contribution from secondary formation and/or regional transport. Based on the single-particle analysis, about 64±18% of the daily Pb-containing particles in Beijing were from transported/aging process, which is comparable with that of CMAQ.

12AC.2
Field Observation of Heterogeneous Formation of Secondary Organic Aerosols on Asian Mineral Dust Surfaces.
GEHUI WANG, Chunlei Cheng, Jiayuan Wang, *Institute of Earth Environment, Chinese Academy of Sciences*

To understand the formation mechanism of secondary organic aerosols (SOA) on dust surfaces, this study investigated the concentrations and compositions of dicarboxylic acids, keto-carboxylic acids, alpha-dicarbonyls and inorganic ions in size-segregated aerosols (9-stages) collected in Xi'an, China during the nondust storm and dust storm periods of 2009 and 2011. During the events the ambient particulate dicarboxylic acids were 932-2240 ng m-3, which are comparable and even higher than those in nondust periods. Molecular compositions of the above SOA are similar to those in nondust periods with oxalic acid being the leading species. In the presence of the dust storms, all the above mentioned SOA species in Xi'an were predominantly enriched on the coarse particles (>2.1 micro-meter), and oxalic acid well correlated with NO3- ($R^2=0.72$, $p<0.001$) rather than SO42-. This phenomenon differs greatly from the SOA in any other nondust period that is characterized by an enrichment of oxalic acid in fine particles and a strong correlation of oxalic acid with SO42-. Our results further demonstrate that NO3- in the dust periods in Xi'an was mostly derived from secondary oxidation, whereas SO42-during the events was largely derived from surface soil of Gobi deserts. We propose a formation pathway to explain these observations, in which nitric acid and/or nitrogen oxides react with dust to produce Ca(NO3)2 and form a liquid phase on the surface of dust aerosols via water vapor-absorption of Ca(NO3)2, followed by a partitioning of the gas-phase water-soluble organic precursors (e.g., glyoxal and methylglyoxal) into the aqueous-phase and a subsequent oxidation into oxalic acid. To the best of our knowledge, we found for the first time the enrichment of glyoxal and methylglyoxal on dust surface. Our data suggest an important role of nitrate in the heterogeneous formation process of SOA on the surface of Asian dust.

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12AC.3

Secondary Organic Aerosol Formation in a Forested Environment with Limited Anthropogenic Influence. ALEX K. Y. LEE, Jonathan Abbatt, W. Richard Leaitch, Shao-Meng Li, John Liggio, Annie-Marie Macdonald, Steve Sjostedt, Jeremy Wentzell, *University of Toronto*

A biogenic secondary organic aerosol (BSOA) episode was observed in a forested mountain region at Whistler, British Columbia, providing a unique opportunity to investigate BSOA formation in a forested environment without significant anthropogenic influence. Positive matrix factorization of aerosol mass spectrometry (AMS) measurements identified two BSOA factors (namely BSOA-1 and BSOA-2), which were predominantly generated by gas-phase oxidation of monoterpenes and perhaps sesquiterpenes. The diurnal cycles of BSOA-1 and 2 observed at the later period of the campaign can be explained by gas-particle partitioning of BSOA materials in response to ambient temperature and the relative importance of different oxidation mechanisms between day and night. Gas-phase ozonolysis at night will be one of the production pathways of BSOA-1, whereas BSOA-2 consisted of products formed also through gas-phase oxidation by OH radical and ozone during the day. In addition, BSOA-1 was likely more volatile than BSOA-2 due to a smaller contribution of organic acids, resulting in a decreased concentration of BSOA-1 during the day when temperatures are higher. The mass spectra of BSOA-1 and 2 have much higher values of the mass fraction of m/z 91 (f91) compared to the aged background organic aerosol, suggesting that f91 can be used as a tracer to evaluate BSOA formation pathways. A comparison between our observations and previous laboratory investigations highlights the potential importance of gas-phase formation of BSOA-2 type materials that may not be captured in smog chamber experiments, perhaps due to the wall loss of gas-phase intermediate products.

12AC.4

Organic Nitrogen and Carbon in Atmospheric Aerosols: Concentration, Chemical Composition, and Properties. TIANQU CUI, Paul Selleck, Ying-Hsuan Lin, Kelsey Boulanger, Rachel O'Brien, Zhenfa Zhang, Avram Gold, Melita Keywood, Jesse Kroll, Jason Surratt, *University of North Carolina at Chapel Hill*

Organic nitrogen (ON) and carbon (OC) represent major components of the global N and C cycles, respectively. A large fraction of ON and OC is found in particulate matter, and as such, is subject to local formation and long-range transport, potentially from anthropogenically-influenced areas to more remote regions. However, very little is known about the sources, transformations, or properties of particulate ON and OC, limiting our understanding of how changes in anthropogenic activity and atmospheric organic chemistry may be affecting the cycling of these important nutrients.

The work presented here involves the determination of the identities, quantities, and key properties of particulate ON and OC in atmospheric aerosols, over a wide geographical and temporal range. Coverage of such a range will be achieved by analyzing previously-collected, archived filter samples from a number of locations worldwide. Sites associated with air-studying campaigns vary greatly in terms of geographical conditions and anthropogenic influence, ranging from an urban/polluted area (CalNex 2010, Pasadena, CA), to suburban/rural areas influenced by urban outflow or biomass burning (SOAS 2013, Look Rock, TN) to a very remote marine site (Cape Grim, Tasmania, Australia). At this last site, PM10 high-volume filter samples collected continuously since 1978, to our knowledge are the longest-running continual archive of aerosol particles monitored under clean background conditions. Samples are chemically characterized by (1) ultra performance liquid chromatography coupled to electrospray ionization high-resolution quadrupole time-of-flight mass spectrometry and diode array detection, (2) gas chromatography interfaced with electron ionization mass spectrometry with prior trimethylsilylation, and (3) aerosol mass spectrometry. Preliminary findings show excellent identification of particulate ON species and a number of known secondary organic aerosol (SOA) tracers derived from biogenic and anthropogenic volatile organic compounds at the molecular level, enabling us to further investigate their quantities, trends and properties.

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12AC.5
Detection and Quantification of Reactive Oxygen Species in Ambient and Laboratory-generated Organic Aerosols.
MANABU SHIRAIWA, Andrea Arangio, Haijie Tong, Fobang Liu, Christopher Kampf, Ulrich Poeschl, *Max Planck Institute for Chemistry*

Reactive oxygen species (ROS) and other related free radicals exist widely in the atmospheric environment. They play multifunctional roles in atmospheric chemistry, influencing formation and chemical aging of organic aerosols and adverse health effects of particulate matter in air pollution. Recent studies have found that aerosol particles can contain stable radicals such as semiquinone radicals and long-lived reactive oxygen intermediates. However, little is known on formation and abundance of ROS within atmospheric aerosol particles.

In this study we have detected and quantified ROS and related radicals in ambient particles and laboratory-generated secondary organic aerosols (SOA). Ambient particles have been sampled with a 24 h time resolution using a rotatory multi-stage cascade impactor (MOUDI) on the roof of the Max Planck Institute for Chemistry in Mainz, Germany. SOA were formed in a 2 m long quartz flow tube reactor by ozonolysis of pinenes and limonene as well as OH photooxidation of naphthalene. The collected particles were analyzed using a continuous wave Electron Paramagnetic Resonance (CW-EPR) spectrometer, allowing non-destructive analysis of collected particle on filters. We found that ambient particles with diameter of 100 - 300 nm contain substantial amount of stable organic radicals with concentrations on the order of 1010-1011 spin/μg of particles. The EPR spectra of each sample have a broad signal indicating the presence of multiple radical species in the particle phase. Combined with a spin trap technique, the formation of OH and other related radicals were observed upon extraction of SOA particles in water. We found that such formation can be accelerated in the presence of iron ions due to the Fenton reaction. These results may have interesting implication on cloud processing of organic aerosols and multiphase chemical processes in the lung lining fluid upon deposition of organic aerosols.

12AP.1
A Light-Scattering Study of the Scattering Matrix Elements of Irregularly Shaped Particles.
YULI HEINSON, Amit Chakrabarti, Chris Sorensen, *Kansas State University*

We report measurements of the light scattering from several irregularly shaped particles such as Arizona Road Dust, Al_2O_3 abrasives, soot particles, and processed soot particles. Our experimental apparatus used photodiode arrays to detect scattered light simultaneously at 31 angles including small angles which allows for characterizing the sizes of particles. Q-space analysis is applied and reveals a comprehensive description of scattering in terms of power laws with quantifiable exponents. The exponents of power laws show a functionality with respect to rho prime where rho prime is $2kR((m^2-1)/(m^2+2))$ universal to all these shapes. The exponents start from 4 and decrease to 1.5 with increasing rho prime.

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12AP.2
On the Contribution of Raman Lidar-derived Aerosol Backscatter and Humidity Profiles for Understanding Boundary Layer Mixing Processes and Aerosol Swelling.
SANDIP PAL, *University of Virginia*

The convective boundary layer (CBL) turbulence is the key mechanism for exchanging heat, moisture, and mass between the earth's surface and the lower part of the troposphere. The turbulence parameterization of the CBL is a challenging but important component in numerical models. In particular, correct estimation of CBL turbulence features, parameterization, and the determination of the contribution of eddy diffusivity are important for accurate simulations of convection initiation, aerosol distribution, and development of clouds.

In general, measurements of higher-order moments of moisture and aerosol backscatter variability yield unique estimates of turbulence in the CBL. To this end, water vapor and aerosol backscatter-based turbulence profiles will be derived using Raman lidar measurements of water vapor mixing ratio. The U.S. Department of Energy Atmospheric Radiation Measurement (ARM) program's Raman lidar at the Southern Great Plains site in north central Oklahoma is one of the few (<5) truly operational water vapor Raman lidar in the world. In particular, impact of the swelling of hygroscopic aerosols on the derived turbulence features will be investigated. Using ground based in situ and lidar observations, a conceptual framework based on bottom up approach is proposed for a robust characterization of the turbulent structure of the CBL so that our understanding on the physical mechanisms governing CBL aerosol and water vapor turbulence could be improved. In particular, we categorize the forcing mechanisms into four interconnected topics: (1) near-surface meteorological forcing and dynamics, (2) thermodynamic features within and above the CBL, (3) dynamical processes taking place in the entrainment zone near the CBL top, and (4) CBL dynamics and moisture regimes.

12AP.3
Optical Trap, Manipulation, and Characterization of Light-absorbing Single Aerosol Particles in Air.
CHUJI WANG, Yong-Le Pan, Zhiyong Gong, Brandon Redding, *Mississippi State University*, *US Army Research Laboratory*

We report on light-absorbing particle trap and transport in air using a simply focused Gaussian beam. Trapping a single particle at a point, several particles in a line, and many particles on a plan is demonstrated at 488 nm. Furthermore, transporting a single stably trapped particle in three dimensions in air is achieved. In addition to the normally observed pulling force on light-absorbing particles, we show strong pushing force that shoots particles along the propagation direction of the laser beam. This phenomenon is wavelength independent at the wavelengths of 266 nm, 409 nm, and 532 nm used in this work.

These latest experimental observations pose a big challenge in explanation of the forces, torques, and motions of the light-absorbing particles, e.g. Bermuda grass spores, small wall carbon nanotubes, multi-wall carbon nanotubes, and carbon blacks. An extensive literature survey shows that there is no single theory that can be universally applicable to explanation of the observed phenomena of the light absorbing particles under light illumination. Tentative speculation and discussion with regard to trapping forces and motions of the particles are presented.

Finally, some preliminary results of Raman and cavity ringdown spectroscopy of single particles trapped in air are also reported.

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12AP.4
Quantum Cascade Laser Cavity Ring Down Spectroscopy: New Method for the Characterization and Detection of Aerosols. ANGELA M. BUONAUGURIO, John M. Nilles, Erin M. Durke, Tiffany Sutton, *EXCET Inc./ Edgewood Chemical Biological Center*

Aerosolized chemical warfare agents (CWAs) and toxic industrial chemicals (TICs) are potential threats for the Warfighter, resulting in the need for aerosol identification and detection for further developments in protection and mitigation. One of the most reliable techniques for the identification of trace gas species is absorption spectroscopy. Cavity ring down spectroscopy (CRDS) is a highly sensitive and selective absorption method with the ability to detect trace levels of chemical species. Its advantage is based on the extremely long effective path length, providing precise detection of the rate of decay of light from a high finesse optical cavity to directly measure the absorption of the trace gas. The mid-wave (MWIR) and long-wave (LWIR) infrared regions are of particular interest due to the characteristic rotovibrational absorption bands exhibited in these regions for identification of a species. Quantum cascade lasers (QCLs) have the capability of emitting both infrared wavelength regions of 3-8 μm and 8-15 μm, respectively. We have developed a new method for the characterization of aerosols by combining the highly powerful spectroscopic method of CRDS and the ability to detect in the infrared (IR) fingerprint region using QCLs for identification. This novel technique results in in-situ investigations of chemical aerosols. The development of this method and preliminary data on accepted test vapors and simulants, leading up to aerosols of CWAs, are presented.

12AP.5
Backscatter from Liquid Drop Aeorsol. BRENDAN HEFFERNAN, Yuli Heinson, Justin Maughan, Amit Chakrabarti, Chris Sorensen, *Kansas State University*

We have successfully built and calibrated an apparatus to measure the backscattering phase function from 165 to 182 degrees, possibly the first of its kind. Measurements on liquid water droplets generated from an atomizer continue to disagree with Mie calculation, leading us to conclude non-sphericity in the droplets due to oscillations or “ringing”. These conclusions are consistent with the measured S22/S11 scattering matrix elements measured from 0.3 to 157 degrees and with theoretical calculations showing extreme sensitivity of the phase function on sphericity, particularly in the near backscattering direction.

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12BA.1
SenseNet: An Outdoor Monitoring System for Biothreats. Ray Pierson, WILLIAM HARRIS, Cody Niese, Egbert Tse, Dave Wasson, Jonathan Thornburg, Quentin Malloy, Prakash Doraiswamy, Robert Serino, *Northrop Grumman Inc.*

A scalable environmental monitoring system called SenseNet was designed to detect the presence of airborne biological hazards in outdoor urban environments by means of a distributed sensor network. SenseNet is a multi-tiered and multi-component system which combines mature, low-cost bioaerosol sensors with existing environmental, security and human activity sensors and data streams. The information gathered from the distributed sensor network is processed using innovative data fusion methods to provide greater situational awareness and rapid, high-confidence detection of outdoor releases of hazardous bioaerosols, enabling an informed and more effective response.

SenseNet is sensor agnostic and uses open-architecture network standards which allow the system to be configurable, adaptable and sustainable. Extensive modeling based on historical environmental data was used to identify the optimum architecture and sensor density. Modeling results included time-to-detect, probability of detection, and contamination mapping.

Modeled release scenarios from a group of six representative days for a “target city” using available historical data sets were “injected” with a modeled biological burst release. These scenarios were used as a training set for the system performance model. The plume PM mass concentration blended into ambient background within 600 meters (15 min) of release, meteorology dependent. The modeled ACPLA concentrations were 10^4 when PM reaches background. As expected, the plume shape varied on meteorological conditions.

The system performance model was developed around a simulator which runs the learning algorithm for a given sensor configuration along with simulated inputs. The system performance model evaluated the diversity and density of the sensors, usefulness of the data, and data stream cost. The result was an optimum system design with a 95% probability of detection and suggested, low-cost collaborative environmental sensors reduced the need for the number of biological sensors.

12BA.2
Development of an Experimental System for Assessing Indoor Bioaerosol Transport and Control. STEPHANIE KUNKEL, Parham Azimi, Brent Stephens, *Illinois Institute of Technology*

Many microbial pathogens are transmitted via airborne routes in indoor environments. Breathing, sneezing, and coughing are important sources of many of these viral, bacterial, and fungal species, with microbes being aerosolized and dispersed in droplets. Knowledge of how this dispersion is affected by outdoor air ventilation, particle deposition, and central HVAC or stand-alone particle filtration is critical to understanding how the diseases caused by these microbes are spread and controlled. Here we report on the development of a custom nebulizer-based respiratory activity simulator that, when combined with size-resolved bioaerosol sampling and DNA extraction, can be used to aerosolize model organisms and measure their transport and control indoors. Measurements of airflow rates from the compressor main airflow (lung flow) and the nebulizer (aerosol flow) were conducted for two different simulated lung volume settings. Airflow rates ranged from ~2.7 L/s to ~7.5 L/s, demonstrating accurate reproductions of human lung flows similar to those observed in previous investigations of human respiratory activities. The respiratory activity simulator was then used to aerosolize three model organisms in an unoccupied test facility: (1) Escherichia coli K12, a gram negative bacterium (size ~1 micro-meter), is used as a model for Bordella and Neisseria, (2) Bacillus subtilis, a gram positive bacterium (size ~3 micro-meter), is used as a model for Cornybacterium, Mycobacterium, and Streptococcus, (3) Neurospora crassa, a ~4 micro-meter fungus, is used as a model for Aspergillus and Cryptococcus. Air samplers collected sufficient biomass on the filters to perform both PCR and qPCR amplification and quantification, demonstrating that the organisms can be successfully aerosolized and collected in a manner that realistically reflects human coughing and breathing. Next we will test phages MS2 and T4 to model viral particles, and all model organisms will then be evaluated under a variety of ventilation and filtration conditions.

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12BA.3
The Microbiology of Indoor Air Quality in a University Dormitory and Impacts on Student Health. JULIA LUONGO, Noah Fierer, Shelly Miller, *University of Colorado Boulder*

The air we breathe indoors is home to an enormous amount of microbial diversity. We have a limited understanding of what bacteria we inhale and the factors that influence this microbial diversity. Some of these microbes are pathogens or allergens and may negatively impact health, while others may be beneficial. We do not know how changes in building design or operation to increase energy efficiency will impact the amounts and types of microbes found in indoor air. We expect that increases in energy efficiency will come at the cost of increased microbial loads in indoor air due to reductions in outdoor air ventilation rates. This study investigates how changes in ventilation rates may alter the health of building occupants and the amounts and types of bacteria found in indoor air. Ventilation rates were measured in a subset of rooms in a dormitory using various techniques: direct measurement of outdoor air supply, tracer gas decay, and equilibrium carbon dioxide analysis. Passive air samples and HVAC filters were collected from the majority of rooms in the dorm. We sequenced the bacterial 16S rRNA gene (V4-V5 region) from these samples for community analysis. A cohort of 50 students living in the dorm was contacted every other week over the course of one semester for self-reports of illness incidence. Differences in microbial community composition will be investigated spatially across the dormitory, across various room and HVAC system characteristics, and with self-reported health data. Associations between ventilation rates and health are also investigated.

12BA.4
Design and Performance Evaluation of a Ferret Exposition Chamber for the Study of Airborne Virus Transmission. NATHALIE TURGEON, Daniel Verreault, Dan Zegan, Matthieu Girard, Martin Belzile, Caroline Duchaine, *Université Laval, Canada*

Several viruses can be transmitted by the airborne route. However, the importance of aerosols in the spread of viruses like influenza is still a subject of debate. Indeed, most viruses can also be transmitted through direct contact and droplets. Therefore, the importance of the airborne route in a clinical context is difficult to determine and requires the use of animals in laboratory settings. Indeed, it allows controlling several parameters like exposure, direct contact, and air flow. The aim of this study is to design a chamber system to study airborne transmission of viruses between ferrets.

We designed a system composed of three chambers connected in series, each one hosting one ferret and preventing direct contact. The chambers are designed to house the ferrets for several days. The ferret placed in the first chamber is infected with a virus using intranasal instillation. The two other chambers house healthy ferrets. The system is designed to study the transmission of viruses from the infected ferret to the two naïve ferrets via aerosols and droplets or aerosols only. The air flow is directed through the system from the HEPA filter at the inlet of the first chamber to the HEPA filter at the exhaust of the third chamber. We designed a particle separator that can be used to modulate the size of the particles traveling between the chambers. An Aerodynamic Particles Sizer was used to validate the efficiency of the particle separator. The 50% efficiency cut off of our separator can be modulated between 5µm to 10µm aerodynamic diameter.

This communication describes the first system designed to study the transmission of airborne viruses between ferrets with particle size control. It can be used to study viruses like influenza. Indeed, ferrets are the most widely used animal model for human influenza studies.

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12BA.5

A Novel Sampler for Viral Aerosols through Water-based Condensation Particle Growth. MAOHUA PAN, Arantzazu Eiguren-Fernandez, Nima Afshar-Mohajer, Susanne Hering, Chang-Yu Wu, John Lednicky, Hugh Fan, Hsin Hsieh, *University of Florida*

Respiratory and other infections can be acquired through the inhalation of aerosolized virus particles. Cases of severe acute respiratory syndrome (SARS) in 2003 and pandemic H1N1 influenza in 2009 sparked global concerns and are recent examples of serious outbreaks that required investigations of airborne transmission of the causative agents. Existing air samplers collect viral aerosols (20 - 100 nm) with low efficiencies (5 – 10%). A laminar flow water-based condensation particle growth technology has been demonstrated to have a cut-off size of 4.5 nm for ambient aerosols by introducing the aerosol into a wetted-wall tube held at higher temperature. In this study, the performance of an Aerosol into Suspension Collector (ASC) based on this technology to amplify the size of viral particles for enhanced physical and biological sampling efficiency was evaluated. MS2 bacteriophage (diameter = 28 nm) was aerosolized using a Collison Nebulizer and then dried to imitate viruses in ambient air. Afterwards, viral aerosols were collected by both the ASC and SKC® BioSampler. Condensation particle counter (CPC) and optical particle counter (OPC) were used to determine the number concentration and size distribution of viral particles before and after collection, while the single-layer bioassay method was used to determine the plaque forming unit (PFU) of MS2. Experimental results demonstrated that the nanometer viral particles were amplified to 2 to 4 μm particle size range and the physical collection efficiency was more than 90% using the ASC compared to less than 10% by the BioSampler. For the collection media, tryptic soy broth collected more viable MS2 than DI water. The viable collection efficiency of this new collection system for MS2 viral particles was approximately 10 times greater than that of SKC® BioSampler. This is the first time water-based condensation technology has been effectively used for viral aerosol sampling.

12CA.1

Gas-Particle Partitioning of Primary Organic Aerosol from Vehicles Measured in a Traffic Tunnel. XIANG LI, Timothy Dallmann, Albert A. Presto, *Carnegie Mellon University*

Motor vehicles are a major contributor of carbonaceous particulate matter (PM), which consists of organic aerosol (OA) and elemental carbon (EC), in the urban environment. Primary organic aerosols (POA) emitted by vehicles are semivolatile. Accurate representations of POA gas-particle partitioning are required to estimate the aerosol burden in the atmosphere. Although several dynamometer studies were conducted to determine the volatility of vehicle emitted POA, little work has been done to show whether the dynamometer results can reproduce POA partitioning in the atmosphere.

In this work we studied the volatility of vehicle emitted PM in a traffic tunnel in Pittsburgh, PA. PM size from 7-400nm and nonrefectory PM composition were measured by a pair of scanning mobility particle sizers and an Aerosol Chemical Speciation Monitor, respectively. The gas-particle partitioning of vehicle emitted POA was determined using three independent approaches: 1) heating by a thermodenuder (TD) cycling between 40-100C with a residence time about 19s, 2) quartz filter samples analyzed by thermal desorption/gas chromatography/mass spectrometry (TD-GC-MS), 3) bare quartz and quartz behind Teflon filter samples analyzed by the Sunset OCEC.

Results from three independent approaches consistently show the vehicle emitted POA is semivolatile. The PM evaporation inside the TD can be adequately described by the TD model using the volatility distribution from May et al (2013); and the volatility distribution determined using TD-GC-MS in this study is similar with that of May et al (2013). The variability of volatility distributions measured in different time periods with large difference on fleet compositions is very limited, which suggests that a single volatility distribution may be adequate to describe the vehicular PM volatility in the urban environment.

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12CA.2
Particle Rebound and Phase State in Amazonia. ADAM BATEMAN, Zhaoheng Gong, Antonio O. Manzi, Paulo Artaxo, Rodrigo A. F. Souza, Scot Martin, *Harvard University*

The effect of relative humidity (RH) on the extent of semisolidity of particulate matter during GoAmazon 2014/15 was investigated through the use of particle rebound (or lack thereof) during impaction. The physics governing particle rebound has been previously modeled and can be attributed to the surface and material properties. The phase state of secondary organic material is regulated by the local relative humidity (RH), the recent history of RH in the case of hysteresis, and chemical composition, among other factors. Across the range of atmospheric RH, hygroscopic water uptake can occur and transitions from higher to lower viscosity phases are possible.

By varying the particulate matter water content and observing particle rebound as a function of RH, the hygroscopic response and phase state of the organic material under investigation can be determined. Custom made impactors were employed to study the effects of RH (up to 95%) on the particle phase. Results inferred from the particle rebound measurements indicate that under ambient conditions (RH > 70%) particles in Amazonia can be considered in a liquid phase state. However, during certain time periods, a fraction (10 - 30%) of the particles is found to rebound during the highest RH conditions, an indication of hydrophobic particles in a semi-solid or solid phase state. The origin and chemical composition of this particle subset is further investigated.

12CA.3
Simulation of the Size-Composition Distribution of Atmospheric Nanoparticles over Europe. David Patoulias, Christos Fountoukis, Ilona Riipinen, SPYROS PANDIS, *University of Patras, Greece*

In this work, we continue the development of a three-dimensional chemical transport model, PMCAMx-UF, focusing on the simulation of the ultrafine particle size distribution and composition. The Volatility Basis Set (VBS) approach is used for the simulation of organic aerosol. PMCAMx-UF is applied to Europe to quantify the contribution of organic vapors to total number concentrations and fresh particles' growth. PMCAMx-UF uses the new version of the Dynamic Model for Aerosol Nucleation and the Two-Moment Aerosol Sectional algorithm to track both aerosol number and mass concentration using a sectional approach. We evaluate the model predictions for the European domain against field observations collected in the PEGASOS campaigns during spring 2012 and 2013. The measurements include both ground stations across Europe and airborne measurements from a Zeppelin.

PMCAMx-UF reproduces reasonably well the N10 (number concentration of particles larger than 10 nm) hourly observations both aloft (over the Po Valley in Italy) as well as at the ground level. The ground level concentrations of N100 are well predicted (normalized mean error of -16%, normalized mean bias 27%) while there is tendency to overestimate N10 is overestimated by approximately 50%. The sensitivity of the model predictions to various processes and parameters is examined. The condensation of organics increases the N100 concentration mainly in central and northern Europe by 50-200% while, on the other hand, it decreases by 10-40% the N10 concentration. This counterintuitive result can be explained by an increase of the aerosol surface area leading to an increase of the rate of coagulation and then to a decrease of the nucleation rate. Sensitivity tests highlight the importance of chemical aging reactions of secondary organic aerosol for the ultrafine particle growth and total particle number concentration.

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12CA.4
Raman Spectra of Individual Ambient Particles. DAVID DOUGHTY, Steven Hill, Alan Wetmore, *US Army Research Lab*

It is important to quantify temporal and spatial distributions of supermicron particles in the atmosphere, including fungal spores, pollens, dust, soot, and other organic and inorganic materials. We evaluate the Resource Effective Bioidentification System (REBS) for the purposes of understanding particle composition. The REBS is designed for field operation, and semi-continuously measures Raman spectra of individual particles, by capturing particles on a metallized polymer film and then taking Raman spectra of these particles.

A goal of this preliminary study is to compare the ambient Raman spectra measured by the REBS at different locations, primarily in the Mid-Atlantic region of the USA. We examine the fraction of single-particle spectra which can be categorized, and examine the differences between the spectra seen in various locations and wind directions. Spectra obtained near the Atlantic Ocean, and at inland locations will be illustrated.

12CA.5
Study of Ambient Solid Particle Size Distribution in Riverside California. YUE LIN, Kihong Park, Heejung S. Jung, *University of California, Riverside*

There is an increased interest to monitor temporarily and spatially resolved ultrafine particle concentrations in ambient air. Total particle number (TPN) concentrations measured by earlier studies showed an anti-correlation with PM2.5 therefore not appropriate as a metric for monitoring. Solid particle counting method is a well-established technique to measure emissions from vehicle exhaust. It eliminates contribution of semivolatiles using a volatile particle remover and achieves more consistent and repeatable measurement for vehicle exhaust particle emissions. This study applied a similar approach to measure solid particle size distributions in ambient air in Riverside, CA. A catalytic stripper (CS) was used with a SMPS system to remove volatile component in ambient aerosol for size distribution measurement. Particle size distributions measured with and without CS over a week period will be presented. Particle effective density was also measured semi-continuously at the same location. The study aims to relate the density and solid vs total particle size distribution measurement to the mixing state of the aerosol and estimation of potential health effects from volatile and non-volatile particles.

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12CC.1
Toward the Minimal Representation of the Aerosol Mixing State. LAURA FIERCE, Nicole Riemer, Tami Bond, *University of Illinois at Urbana-Champaign*

One challenge in the simulation of atmospheric aerosols is the representation of particle composition. Tracking particle-level composition is computationally expensive, so global models approximate the representation of the aerosol mixing state, that is, the manner in which chemical species are distributed across the particle population. In this study, we used a particle-resolved aerosol model to evaluate representations of the aerosol mixing state that are commonly applied in global models.

The evolution of the aerosol mixing state was simulated in a series of scenarios with PartMC-MOSIAC. Each simulation started with an external mixture of two particle types: particles containing black and organic carbon, representing fresh combustion emissions, and hygroscopic background aerosol comprised of ammonium sulfate. As the simulations proceeded, we computed cloud condensation nuclei concentrations and aerosol absorption for the same particle population, but with different representations of the aerosol mixing state. The size distribution and bulk aerosol composition was the same for all treatments, and they differed only in the assumed distribution in chemical species between individual particles.

The full internal mixture approximation, the simplest representation of the mixing state, was suitable for modeling cloud condensation nuclei activity of aged aerosol. We show that the timescale for particles to become internally mixed with respect to their hygroscopic properties depends on the characteristics of the chemical environment, with timescales on the order of hours in urban areas. On the other hand, the full internal mixture was not suitable for modeling aerosol absorption, even for highly aged populations. We found absorption by aged aerosol populations was overestimated for both the full internal mixture and sectional treatments of aerosol composition. Error in modeled absorption was lowest if the composition of separate particle types was tracked, which is possible in modal models.

12CC.2
Aerosol Optics, Radiative Forcing, and Climate Change. HANS MOOSMULLER, *Desert Research Institute*

The common perception of climate change is dominated by the greenhouse effect due to gases such as carbon dioxide. Aerosols influence the earth's direct radiative forcing and climate largely through modifying the planetary albedo, which is the whiteness of the planet as seen from space. If aerosols are whiter than the underlying scene, they increase the planetary albedo, have a negative radiative forcing and cause cooling (more solar energy is scattered back into space); otherwise if they appear darker, they decrease the planetary albedo, have a positive radiative forcing and cause heating (more solar energy is retained by earth). In addition, aerosols can continue to cause radiative forcing after deposition. In particular, dark aerosols can strongly decrease surface albedo after deposition on high-albedo surfaces such as snow and ice.

The dominant aerosol optical property that determines radiative forcing is the aerosol single scattering albedo (SSA) integrated over the solar spectrum with an additional contribution from the asymmetry parameter or hemispherical backscatter ratio (Chýlek and Wong, 1995). The SSA is the ratio of scattering to extinction coefficient, with the extinction coefficient being the sum of scattering and absorption coefficient. The ambient aerosols with the most uncertainty in their SSA spectra are carbonaceous aerosols emitted by combustion processes and entrained mineral dust.

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Chýlek, P., and J. Wong (1995). Effect of Absorbing Aerosol on Global Radiation Budget. Geophys. Res. Lett., 22, 929-931.

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12CC.3
New Optical Experiments "Shed Light" on Role of Particle Morphology and Chemical Composition in the Absorption Enhancement of Coated Soot Particles. LINDSAY RENBAUM-WOLFF, Andrew Lambe, Timothy Onasch, Andrew Freedman, Leah Williams, Taylor Helgestad, Christopher Cappa, Al Fischer, Geoff Smith, Swarup China, Claudio Mazzoleni, Arthur J. Sedlacek, Eleanor Browne, Gabriel Isaacman-VanWertz, Jesse Kroll, James Brogan, Yatish Parmar, Andrew Lee, Noopur Sharma, Janarjan Bhandari, John Jayne, Douglas Worsnop, Paul Davidovits, *Boston College*

Atmospheric black carbon (BC), mostly in the form of soot particles, absorbs light and produces local heating of the atmosphere and may contribute to warming of the Earth's climate. Models that include radiative forcing by BC assume internal mixing with non-BC aerosol components that can substantially enhance BC absorption. However, such model estimates have yet to be clearly validated by atmospheric or laboratory measurements. The extent to which absorption by BC can theoretically be enhanced via lensing depends critically on the ratio of non-refractory coating to refractory black carbon as well as on the morphology of the coated particles and the refractive index of the coating material.

To systematically examine the influence of atmospherically relevant non-refractory coatings on BC chemical composition, morphology, and optical properties, a methane diffusion flame was used to generate soot particles that subsequently entered an oxidative flow reactor. Secondary organic aerosol (SOA) and sulfuric acid coatings were produced in situ via gas phase OH oxidation of alpha-pinene, naphthalene, or SO_2 that were added to the carrier gas flow. Absorption enhancements of up to a factor of two were observed across ten measured wavelengths ranging from 301 to 687 nm. At a specific coat:core ratio the absorption enhancement was of similar magnitude regardless of coating type, suggesting a simple parameterization for predicting absorption enhancements in ambient particles. Soot particle – aerosol mass spectrometer (SP-AMS), single particle soot photometer (SP2), and TEM results are used to elucidate how particle morphology and chemical composition govern absorption enhancement behavior.

12CC.4
Sensitivity of Aerosol Optical Depth to Aerosol and Meteorological Parameters in the Summertime Continental Boundary Layer. CHARLES BROCK, Nick Wagner, Bruce Anderson, Andreas Beyersdorf, Pedro Campuzano-Jost, Annmarie Carlton, Douglas Day, Glenn Diskin, Timothy Gordon, Jose-Luis Jimenez, Daniel Lack, Jin Liao, Ann M. Middlebrook, Mathews Richardson, Rebecca Washenfelder, Andre Welti, Luke Ziemba, Daniel Murphy, *NOAA Earth System Research Laboratory, Boulder, CO*

Earth system models that simulate aerosol processes are typically evaluated by comparing model-calculated aerosol optical depth (AOD) with satellite and ground-based remote sensing observations. However, the relationship between the primary modeled aerosol parameter, particulate mass, and AOD is a complex function of aerosol composition, size, and hygroscopicity, convolved with meteorology. To examine which factors are most important in controlling AOD, aircraft observations of meteorological, trace gas, and aerosol microphysical, chemical, and optical properties were made in summer 2013 in the southeastern United States. Representative vertical profiles were produced by aggregating data from 37 individual aircraft profiles made in the afternoon under conditions of a well-mixed boundary layer with typical fair-weather cumulus. A simple aerosol model based on these observations was used to calculate the sensitivity of AOD to changes in specific aerosol and meteorological parameters. These observationally based sensitivity calculations show that the AOD produced for a fixed column abundance of dry aerosol mass in these conditions can be highly variable, and is especially sensitive to meteorological factors such as relative humidity and the depth of the planetary boundary layer. For example, calculated AOD ranged from 0.137 to 0.305, a factor of 2.2, as the relative humidity was varied between the observed 10th and 90th percentile profiles with all other parameters, including dry aerosol mass, held constant. This range in AOD associated with variable RH may be compared with the variation in AOD of 0.082 to 0.253, a factor of 3.1, due to the observed range in dry aerosol mass holding all other parameters constant. Calculated AOD was also sensitive to the boundary layer depth, less sensitive to the observed range in aerosol hygroscopicity, mean size, and size distribution width, and least sensitive to observed variations in dry and wet aerosol refractive index. These sensitivity studies emphasize that, in addition to predicting aerosol mass, models must accurately simulate relative humidity and boundary layer structure, as well as aerosol hygroscopicity and size distribution, to properly calculate AOD and aerosol direct radiative effects.

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12CC.5
Assessing the Accuracy of Parameterized Aerosol Extinction Estimates during the HAGiS (Hygroscopic Aerosol Growth in winter Study) Field Campaign.
TIMOTHY GORDON, Nick Wagner, Bernard Mason, Ann M. Middlebrook, Charles Brock, Mathews Richardson, Frank Erdesz, Daniel Murphy, *CU CIRES - NOAA ESRL*

In situ measurements of ambient aerosol extinction are essential for validating aerosol optical depth (AOD) estimates from ground-, lidar- and space-based remote sensors, which are in turn used to constrain earth system models. Typically, ambient extinction is calculated by multiplying measured dry extinction by a hygroscopic growth factor. Various growth factor parameterizations (e.g., the so-called gamma and kappa parameterizations) have been employed, but relatively few studies have assessed the closure between growth-factor derived ambient extinction and direct ambient extinction measurements. Furthermore, obtaining robust growth-factor derived extinction estimates in near-saturated conditions is notoriously difficult because these parameterizations asymptotically approach infinity. During the March-April 2015 HAGiS (Hygroscopic Aerosol Growth in winter Study) field campaign in Boulder, Colorado, direct ambient extinction measurements from a novel open-path aerosol extinction cavity ringdown spectrometer (AECRDS) were compared with different growth-factor derived extinction estimates from a closed-path AECRDS to evaluate the accuracy of these growth factor parameterizations. We present comparisons for a range of atmospheric conditions, including ambient humidities between 10%-100% and both organic- and inorganic-dominated aerosol.

12IM.1
Design and Optimization of an Optical Detector for the Portable Inhalable Particle Sizer.
KIMBERLY ANDERSON, Sean Walsh, Azer Yalin, John Volckens, *Colorado State University*

Inhalable particles are defined as those that penetrate into the head airway region and beyond. Exposure to large inhalable particles (dp>10 microns) occurs in many industries including agriculture, construction, manufacturing, and mining. Although exposure to inhalable particles is prevalent in many workplaces, few instruments exist to count and size large particles. One instrument capable of characterizing the size distribution and concentration of inhalable aerosols (from 20 to 100 microns) is the portable inhalable particle sizer (PIPS). The PIPS relies on the principles of virtual impaction combined with vertical elutriation to separate large particles from quiescent air as a function of aerodynamic diameter. The latest design iteration of the PIPS incorporates a laser and detector for real-time counting of particles as they pass through the detection region. The laser beam is formed into a thin sheet through which the particles pass generating Mie scatter signals measured by a detector. This work describes a numeric model to predict scattering signal levels and guide instrument design. For typical experimental conditions, the model predicts signal voltages of ~ 0.05-1 V for particles of diameter ~30-90 microns. The model is compared against experimental findings using a 785 nm laser diode with power 100 mW that is formed into a sheet using a cylindrical lens. The optical system is incorporated into the prototype sampler and tested in a quiescent air chamber with particles of diameter 10-100 microns particles. Scatter signals are collected with a photodiode detector. Several experimental designs are considered with different laser sheet forming optics and detector positions. Mie scattering is spectrally coincident with the laser wavelength so that spectral filtering cannot be used to discriminate scatter signals from background scatter light. Reduction of stray scatter light is thus found to be critical to enable detection of the needed signals.

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12IM.2
Evaluation of a Low-cost Direct Reading Instrument for Fine and Coarse Aerosol Particles. SINAN SOUSAN, Kirsten Koehler, Geb Thomas, Jae Hong Park, Michael Hillman, Thomas Peters, *University of Iowa*

Inhalation exposures of hazardous aerosol have been associated with severe adverse health outcomes. Fine (<2.5 µm) and coarse (<10 µm) aerosol particles are considered an occupational hazard in workplaces. Direct reading instruments (DRIs) can be used to monitor aerosol concentration. The development and evaluation of low-cost DRIs can help establish a dense network of aerosol measurement devices to directly link health-related workplace exposure to elevated toxic levels of aerosols. Our research investigates the feasibility of aerosol measurements using a low-cost DRI. We evaluated the low-cost DRI ($425; DC1700, Dylos, US) for its accuracy in measurements of fine and coarse aerosols. Tests were conducted with monodispersed salt and oleic acid particles at various sizes and polydispersed salt particles. Total number concentration measured by DC1700 was compared with those measured by reference instruments, a handheld condensation particle counter (CPC; 3007, TSI, US), a scanning mobility particle sizer (SMPS; 5.402, Grimm, Germany), and an aerodynamic particle sizer (APS; 3321, TSI, US). The counting efficiency was calculated from the number concentration of monodispersed particles and ranged from 0.04% at 0.1 µm to 108% at 5µm. Total mass concentration was also calculated from total number concentration of polydispersed particles. Total mass concentration estimated with DC1700 was highly correlated with those estimated with reference instruments (R^2=0.99). The DC1700 shows good agreement with reference instruments for particles larger than 1 µm, but caution should be exercised when the DC1700 measures particles smaller than 0.5 µm.

12IM.3
Air Pollution Measurements Employing Multiple Mobile Platforms in Denver, CO, Summer 2014. MELISSA M. LUNDEN, Nick Staubach, Davida Herzl, Paul A. Solomon, Melinda Beaver, Surender Kaushik, *Aclima Inc.*

Characterizing the detailed interplay between air pollutant sources, transport of air pollutants, and their eventual exposure to human populations and the environment can be improved by the use of networks of small inexpensive air quality sensors. These systems enable greater spatial resolution than provided by routine, stationary air monitoring sites. In the current study, three automobiles were instrumented with a suite of small air quality sensors as well as reference-grade equipment to measure pollutants of interest, such as O_3, NO, NO_2, CO_2, and particulate matter. A series of supplemental measurements that included temperature (T), relative humidity (RH), wind speed (WS), and wind direction (WD) was also included. These three instrumented automobiles were driven concurrently in a variety of spatiotemporal patterns in Denver, Colorado from mid-July to mid-August 2014, including dense driving around stationary air monitoring sites. Routes were designed to make use of simultaneous sampling from three mobile platforms, including interconnected and overlapping patterns. This presentation will give an overview of the project and focus on two primary science questions: (1) validation of the reference monitors and sensors as applied to mobile platforms and (2) additional information gained by use of multiple mobile platforms relative to stationary air monitoring sites.

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12IM.4
Air Quality Sensors Applications for Emissions Factors and Health Studies. KAROLINE JOHNSON, Michael Bergin, Armistead G. Russell, Jennifer L. Moutinho, Jeremy Sarnat, Donghai Liang, Roby Greenwald, Joseph Abrams, Rachel Golan, *Duke University*

Emerging air quality sensors have the potential to drastically change the air quality monitoring field. Sensors may allow data to be collected at a fraction of the price with lower upkeep and personnel costs than convention methods. This work focuses on sensor applications for estimating emissions factors and for health studies. A variety of sensors including light scattering PM, non-dispersive infrared CO2, and electrochemical, O3, CO, NO, and NO2 sensors were used. By locating a sensor package at the roadside, emissions factors for the road can be calculated by paring a CO2 sensor with other sensors. This is especially exciting as fleet emissions vary regionally and over time as regulations change. Studies were performed both in Atlanta, GA and Durham, NC to estimate freeway emission factors. We found that the inexpensive sensors provided emissions factors estimates similar to those derived using traditional monitors, and the results were consistent with literature values for mobile source emissions. Sensor packages like the ones deployed during these studies could be deployed at roadside sites all over the U.S. and even internationally to provide valuable information about the emissions at these sites. These sensors have also been used with promising results during the Dorm Room Inhalation to Vehicle Exhaust (DRIVE) study on Georgia Tech's campus. During this study sensors were rotated between locations on campus including indoor and outdoor sites at a dorm. The sensors were also compared with many of the research grade instruments used during the study with positive results. The siting of multiple sensors showed varying concentrations over time and over the Georgia Tech campus. They also provided indoor outdoor contrasts. Air quality sensors like the ones used in this study can assist in providing significantly greater spatial and temporal coverage of air quality exposure information for use in future health studies.

12IM.5
A New and Inexpensive Tool for Aerosol, AOD, and O3 Vertical Profiling. RU-SHAN GAO, Jack Elston, Daniel Murphy, Irina Petropavlovskikh, John Ogren, *NOAA*

Frequent vertical profile measurements of aerosol, AOD, and O3 are highly desired for emission, pollution transport, and monsoon studies. Three requirements necessary for a successful program are: Low equipment cost, low operation cost, and reliable measurements of known uncertainty. Conventional profiling using aircraft provides excellent data, but is cost prohibitive on a large scale. Here we describe a new tool (a new platform and instruments) meeting all three requirements. The platform consists of a small balloon and an auto-homing glider. The glider is released from the balloon at a preset altitude (nominally 5 km), returning the light instrument package to the launch location, and allowing for consistent recovery of the payload. Atmospheric profiling can be performed either during ascent or descent (or both) depending on measurement requirements. We will present the specifications for two instrument packages currently under development. The first measures O3, RH, p, T, dry aerosol particle number and size distribution, and aerosol optical depth. The second measures dry aerosol particle number and size distribution, and aerosol absorption coefficient. Results of test flight series for the proof of concept will be shown.

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