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Effects of Wind on Background Particle Concentrations at Truck Freight Terminals

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Truck freight terminals are predominantly located near highways and industrial facilities. This proximity to pollution sources, coupled with meteorological conditions and wind patterns, may affect occupational exposures to particles at these work locations. To understand this process, data from an environmental sampling study of particles at U.S. trucking terminals, along with weather and geographic maps, were analyzed to determine the extent to which the transportation of particles from local pollutant sources elevated observed occupational exposures at these locations. To help identify potential upwind sources, wind direction weighted averages and speed measurements were used to construct wind roses that were superimposed on overhead photos of the terminal and examined for upwind source activity. Statistical tests were performed on these "source" and "nonsource" directions to determine whether there were significant differences in observed particle levels between the two groups. Our results provide evidence that nearby upwind pollution sources significantly elevated background concentrations at only a few of the locations sampled, whereas the majority provided little to no evidence of a significant upwind source effect.

Keywords air pollution, diesel emissions, occupational exposures, wind, wind roses

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INTRODUCTION

Diesel particle exposures at trucking terminals throughout the United States have been measured as part of a study to determine if exposure to diesel emissions is associated with lung cancer within the trucking industry. Previous research

in the railroad industry has shown an association between lung cancer and exposure to diesel emissions,^(1–3) and diesel particles have caused mutations, DNA damage, and lung tumors in rats.⁽⁴⁾ Several international and national health agencies including the International Agency for Research on Cancer⁽⁵⁾ have labeled diesel exhaust or emissions as a probable human carcinogen. Diesel emissions or fumes have potential toxicological significance and have been suspect in producing mutagenic and carcinogenic effects such as lung cancer, respiratory diseases such as bronchitis and asthma, and possible mortality.^(6–11) An elevated risk of lung cancer within the range of 20–50% has been observed in more than 35 studies of workers exposed to diesel exhaust.^(12,13)

The Trucking Industry Particle Study is a retrospective cohort study of approximately 55,750 long-term trucking company workers employed in four large, union, less-than-truckload companies in 1985. The objective of the study is to determine the association between diesel exhaust and other particle exposures and lung cancer mortality. As part of this study, an extensive exposure assessment was started in 2001 to determine current exposure levels in the cohort, as well as factors that may have influenced historical exposure levels. Current sampling of particulate matter less than 2.5 micrometers (PM_{2.5}), elemental carbon (EC), and organic carbon (OC) in particulate < 1.0 micrometer as markers for diesel emissions exposures at trucking terminals has been performed. Information from the exposure assessment will be used to assign cumulative exposure levels to members of the study cohort.

The study sampled terminals across the nation included in multiple work environments, including the freight dock area, mechanic shop, inside the truck cab, and in the yard at an upwind location on the perimeter of the property.

The yard sampler is placed upwind to obtain background concentrations of PM_{2.5}, EC, and OC for the surrounding area. These background concentrations can add to occupationally related exposures and elevate the total exposure for the worker. Furthermore, it has been shown that urban terminals have higher yard concentrations and thus higher background concentrations than rural terminals.⁽¹⁴⁾

Environmental and meteorological factors can profoundly influence background concentrations in and around highways.⁽¹⁵⁾ Open-air trucking terminals are predominantly located around highways and are likely to be influenced by environmental and meteorological factors. Meteorological factors that could potentially modulate the background concentrations and exposures seen in and around the terminals include temperature, humidity, and wind patterns. Wind is a highly variable climatic element that can vary in direction and speed, potentially transporting particles from outside sources into the terminal. Some studies have determined that during light wind speeds and stable atmospheric conditions, pollutants tend to accumulate in the stagnant air around emission sources and can elevate background concentrations.⁽¹⁶⁾ Strong winds are typically associated with low PM_{2.5} concentrations because there is intensive atmospheric mixing and dilution. The high temperatures in summer are usually correlated with higher smog and increased PM_{2.5} concentrations.^(17,18)

However, the effects of wind on occupational exposures have seldom been analyzed, and it has yet to be determined whether it is an important factor in exposures in and around the terminal operations. We propose that areas in the yard that are downwind from an off-site pollutant source such as another nearby terminal, highway, or industrial operation may have higher levels of particles due to wind transport. We also propose that on-site pollutant sources such as trucking activity in the yard may produce higher concentrations of PM_{2.5}, EC, and OC in the dock and shop areas due to wind transporting particles from these high pollutant activities.

METHODS

City Selection

The terminals and cities for the Trucking Industry Particle Study were selected to be representative of all company terminals by number of employees and regions of the United States and then sampled in random order. Where there was more than one large terminal (>100 employees) in a region for the participating companies, one was chosen at random. Each terminal was classified as either rural or urban as defined by the U.S. Bureau of the Census.⁽¹⁹⁾ Out of the 17 terminals visited through October of 2003, complete wind information from an onsite weather station was available for 11 terminals (see Table I).

Weather Data

Weather data consisting of wind direction, wind speed, temperature, and relative humidity for each of the terminals was collected by a portable weather recording station (Davis

TABLE I. Listing of Analyzed Terminal Locations

City	Census Designation	Month Sampled
Strafford, MO	Rural	July 2002
Pico Rivera, CA	Urban	August 2002
Kansas City, MO	Urban	November 2002
Kernersville, NC	Rural	December 2002
Richland, MS	Urban	January 2003
Valdosta, GA	Rural	March 2003
Dallas, TX	Urban	April 2003
Buffalo, NY	Urban	May 2003
Minneapolis, MN	Urban	June 2003
Indianapolis, IN	Urban	July 2003
Saint Louis, MO	Urban	August 2003

Weather Monitor II; Davis Instruments, Wayward, Calif.). The weather station was located upwind of the terminal and was placed with the upwind yard sampler for PM_{2.5}, EC, and OC. The weather station location was noted for each trip on an overhead picture of the terminal. If the prevailing winds changed during the course of sampling at the terminal, the weather station was moved to the new upwind location. However, it was not practical to move the weather station every time the wind shifted. If the predominant direction changed by more than 45 degrees, then the station was moved to a new location. When winds were light (<5 mph) and variable, the station was not moved because the prevailing direction was not evident. Hourly information on precipitation was available from the nearest airport weather station.

The sixteen sectors of wind directions used in the field and in the analysis consisted of north (N), north northeast (NNE), north east (NE), east northeast (ENE), east (E), east southeast (ESE), southeast (SE), south southeast (SSE), south (S), south southwest (SSW), west southwest (WSW), west (W), west northwest (WNW), northwest (NW), and north northwest (NNW). For each trip, all the wind data collected for each session was compiled into one data file. The data structure was a listing of the observation time and an associated wind direction and speed. The averaging time of the wind-recording instrument was every 5 minutes.

Weighted Concentration Average and Category Graphs

The collection methods for the PM_{2.5}, elemental carbon, and organic carbon have been presented in detail previously.⁽²⁰⁾ Briefly, we collected active 12-hour integrated particle samples upwind of the trucking terminal using the Harvard Field Monitor (FHM). PM_{2.5} samples were collected using a cyclone preselector (BGI Inc., Waltham, Mass.), and a 37-mm Telfo Filter (Pall Co, Ann Arbor, Mich.) at a flow of 4 L/min. Filters

were weighed before and after sampling to determine the mass of particles collected.

EC and OC in particles less than 1.0 μm were collected using a cyclone preselector (BGI, Inc.) and a 25-mm quartz tissue filter (Omega Speciality Instruments Co, Chelmsford, Mass.) at a flow of 4 L/min. After sampling, the filters were stored at -20°C and analyzed at the University of Wisconsin, Madison, using the NIOSH 5040 thermo-optical analyzer method.⁽²¹⁾

Wind Roses

Wind roses are radial graphs for a specific location that summarizes the occurrence of winds by direction and speed. The length of each direction line shows the percentage of time (frequency) that the wind blew from a particular wind direction; connecting the ends of the direction lines produces the characteristic pattern of the wind rose. The direction lines are divided into segments that represent the frequency of different wind speeds for that wind direction. The shading of the wind rose line segments depicts speed categories (mph). Wind roses were used to visualize the frequency of the incoming winds for the yard sampler for the duration of all the usable sessions of the trip. Wind roses were produced using the radial graph function in Microsoft Excel.

Geographic Maps

Overhead photographs of each sampled terminal were obtained from GlobeXplorer (Walnut Creek, Calif.). The wind rose was then laid on top of the overhead photograph of the terminal at the location site for the yard sampler to depict the predominant wind patterns of the terminal during the sampling time.

Upwind Emissions Source Identification

Each overhead picture of a terminal with the wind rose placed on top of the yard sampler location was visually inspected to identify potential emission sources, such as other truck terminals, industrial operations, commercial activities, or major highways. We were looking for major local pollutant sources that might potentially influence the background concentrations collected by the yard sampler. All of the wind directions with potential source contributions were identified, and the direction weighted mean for those winds was calculated (as indicated below). Similarly, the direction weighted mean was calculated for the remaining nonsource wind directions, which was compared with the source directions for significant differences.

Statistical Analysis

We used wind direction weighted concentrations of $\text{PM}_{2.5}$, EC, and OC to detect the influence of upwind sources on yard concentrations. The weighting factor used for the concentrations for each wind direction for the trip was the frequency of that wind direction. Because the wind direction is rarely steady, each 12-hr sampling session is associated

with a variety of wind directions. For example, out of 100 total measurements, the wind blew 30 times from the N, 20 times from the NNE, and 16 times from the NE, etc. The method for calculating the average concentration for each wind direction is shown in Eq. 1 below. All of these frequencies during a session will be associated with a single time-weighted average exposure measured during that session. To determine if there was evidence of an association of concentrations with wind direction, we calculated an average $\text{PM}_{2.5}$, EC, and OC concentration for each wind direction.

$$\text{Directional Mean} = \sum_i^{N_{\text{sessions}}} f_{ij} \text{TWA}_i / N_{\text{sessions}} \quad (1)$$

where f is number of times wind noted from each specific direction, TWA is 8-hour time-weighted average concentration, i is session, and j is wind direction.

The results gave 16 wind directions with an associated weighted average of $\text{PM}_{2.5}$, EC, and OC concentrations. Graphs for each trip were then generated (see Figure 1 as an example) with wind direction on the X axis and concentration on the left-hand Y axis and frequency of the wind on the right-hand Y axis.

Each of the 11 terminal visits was analyzed in this descriptive fashion to characterize any influence the wind may have had on the background concentrations measured by the yard sampler. Because the particle concentration data are not normally distributed, we used the nonparametric Wilcoxon rank-sum test to identify significant differences in concentrations from the source and non-source directions. All statistical tests were performed using Intercooled Stata Version 8.2 (StataCorp).

RESULTS

Analysis of the eleven terminals showed that the results could be grouped into three categories: (1) Terminals that showed elevated background concentration levels due to wind effects, which included Pico Rivera, Calif.; Richland, Miss.; and Indianapolis, Ind. (wind effects positive category). (2) Terminals that showed a questionable effect of the wind on background concentrations, which were Kansas City, Mo.; Kernersville, N.C.; Dallas, Texas; and Strafford, Mo. (mixed results category). (3) Terminals that showed little to no effects from the wind on background concentrations, which included Valdosta, Ga.; Buffalo, N.Y.; Minneapolis, Minn.; St Louis, Mo.; and Dallas, Texas (wind effects absent category).

In the following section, we discuss findings from three terminals that were representative of the three categories of results. The terminals selected were Indianapolis, Indiana (wind effects positive); Kernersville, North Carolina (mixed results category); and Valdosta, Georgia (wind effects absent categories).

Indianapolis, Indiana

The terminal was classified as being in an urban setting by the U.S. Census Bureau. It was located in an industrial complex

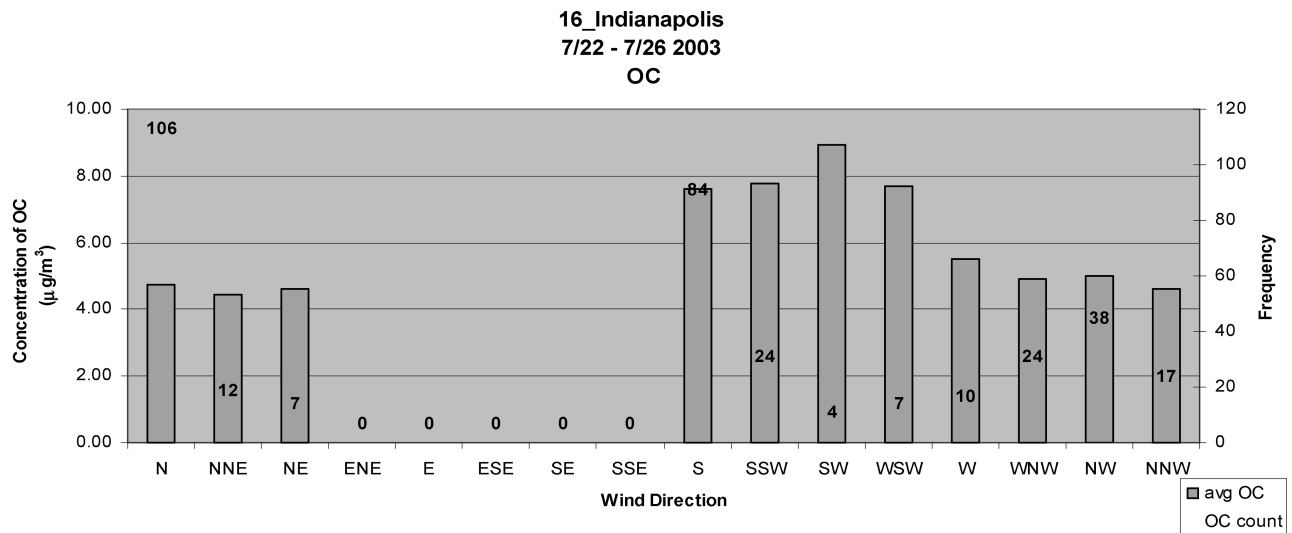
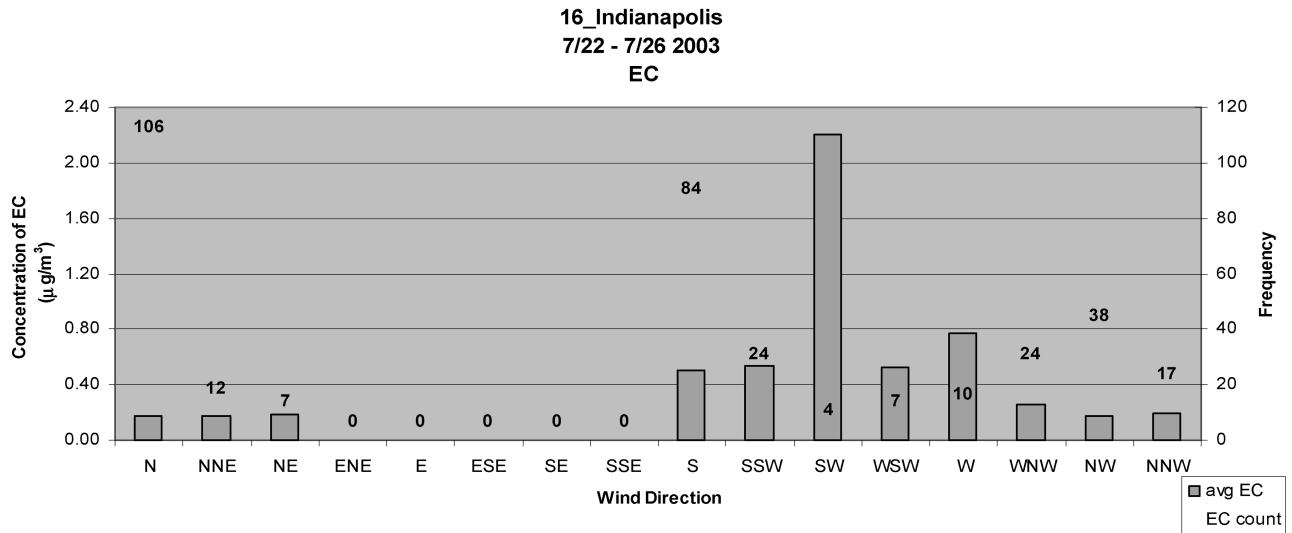
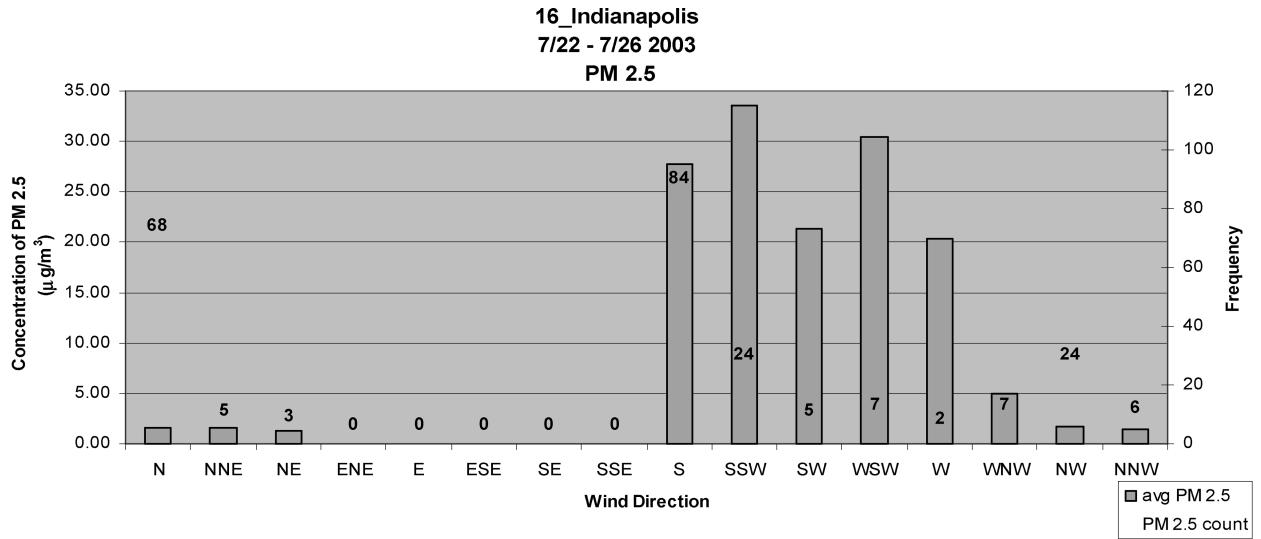


FIGURE 1. Categorical graph of concentrations of PM_{2.5}, OC, and EC by wind direction with frequency counts for Indianapolis, Indiana

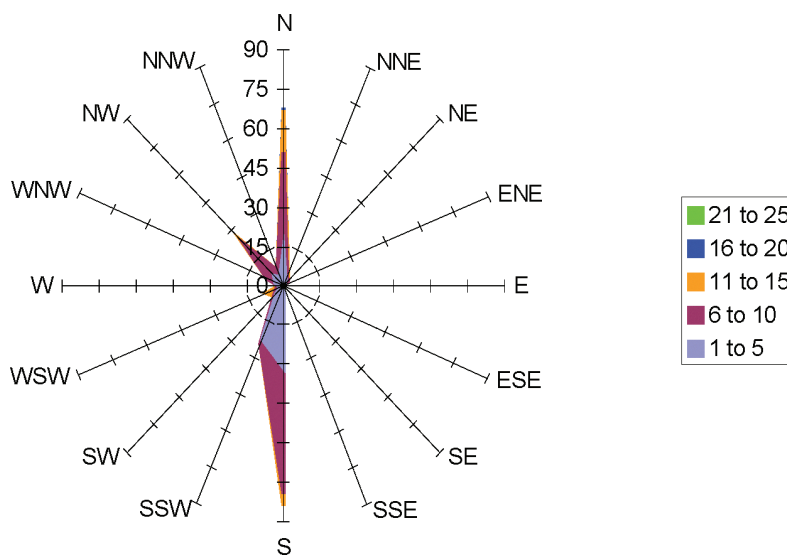


FIGURE 2. Wind rose depicting direction of wind and frequency for all sessions of the Indianapolis, Indiana trip

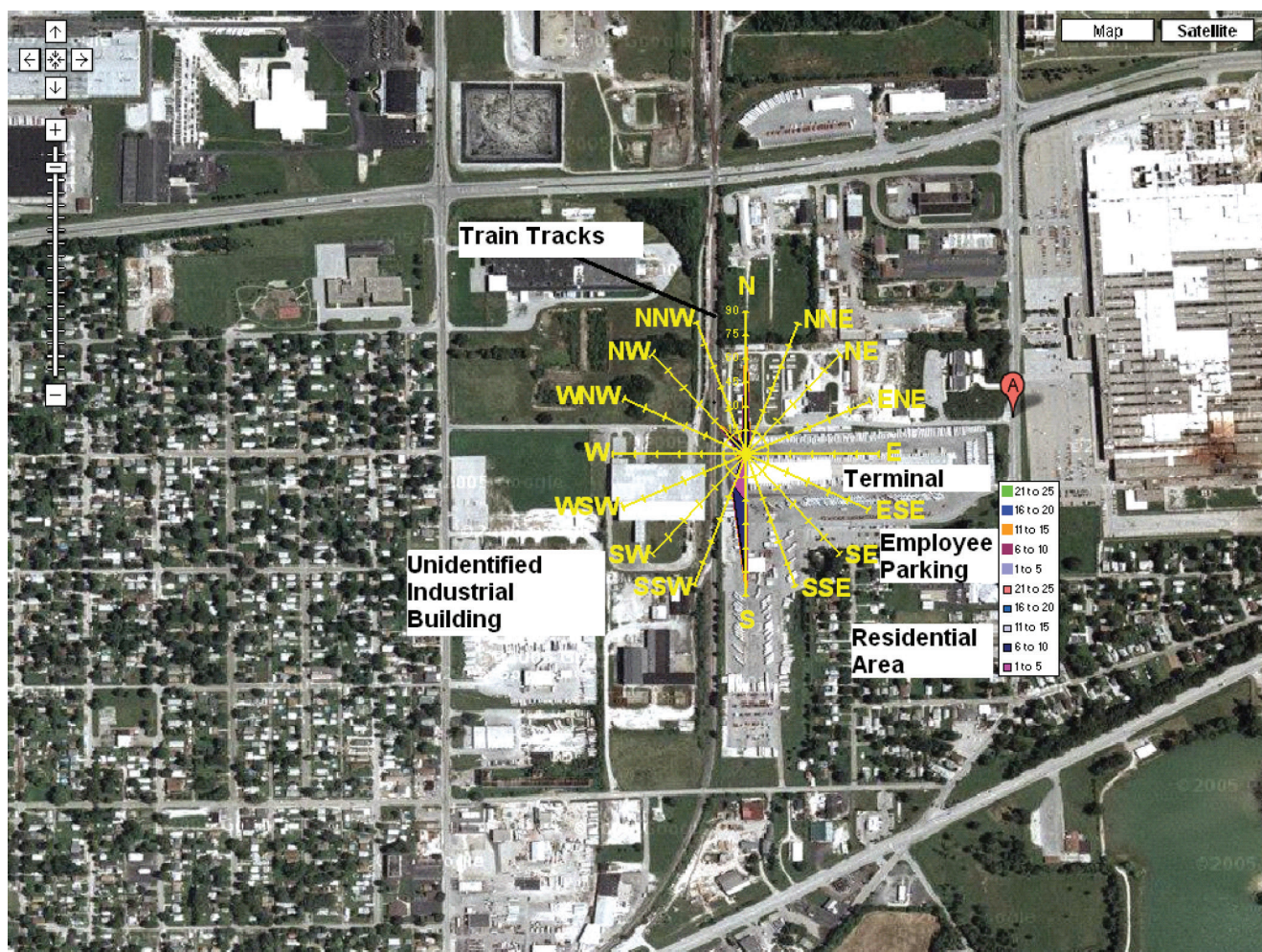


FIGURE 3. Overhead photograph of the Indianapolis, Indiana terminal with wind rose superimposed on yard sampler location. Image courtesy of GlobeXplorer.

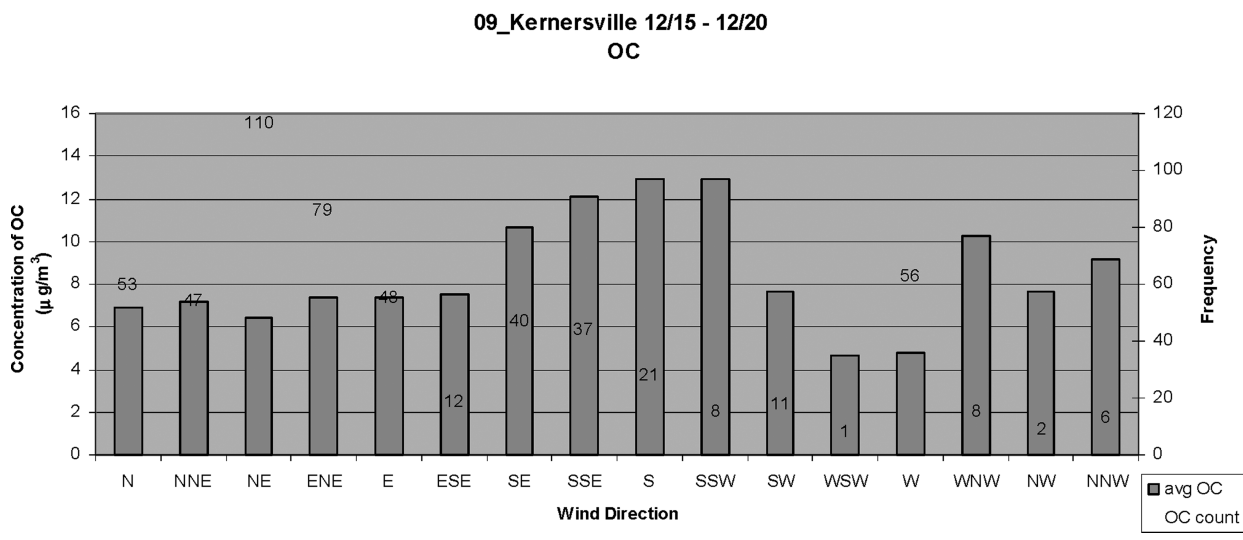
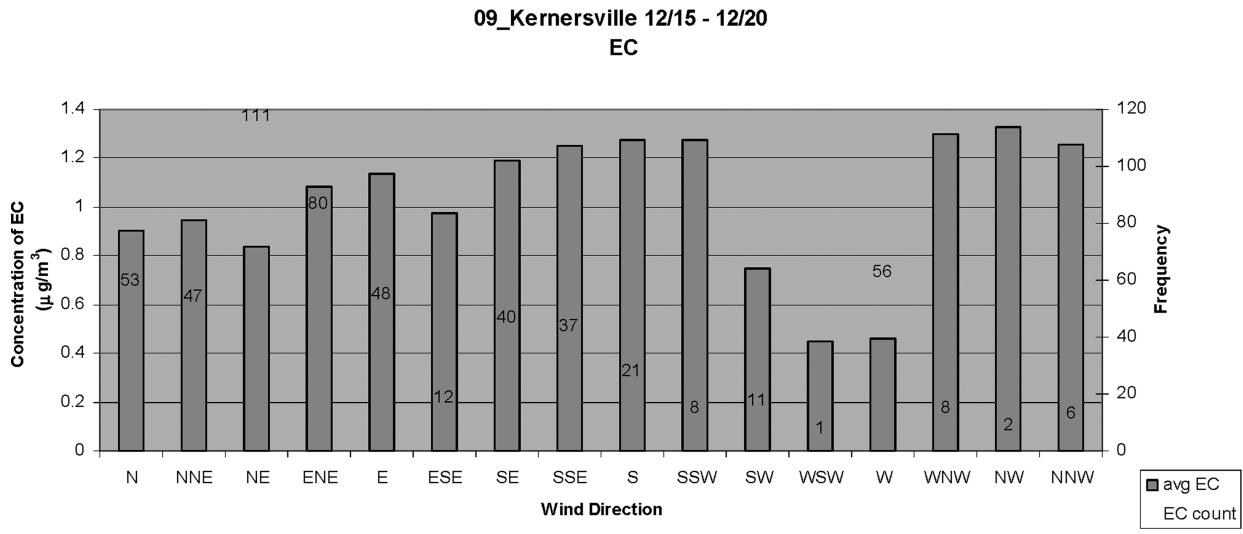
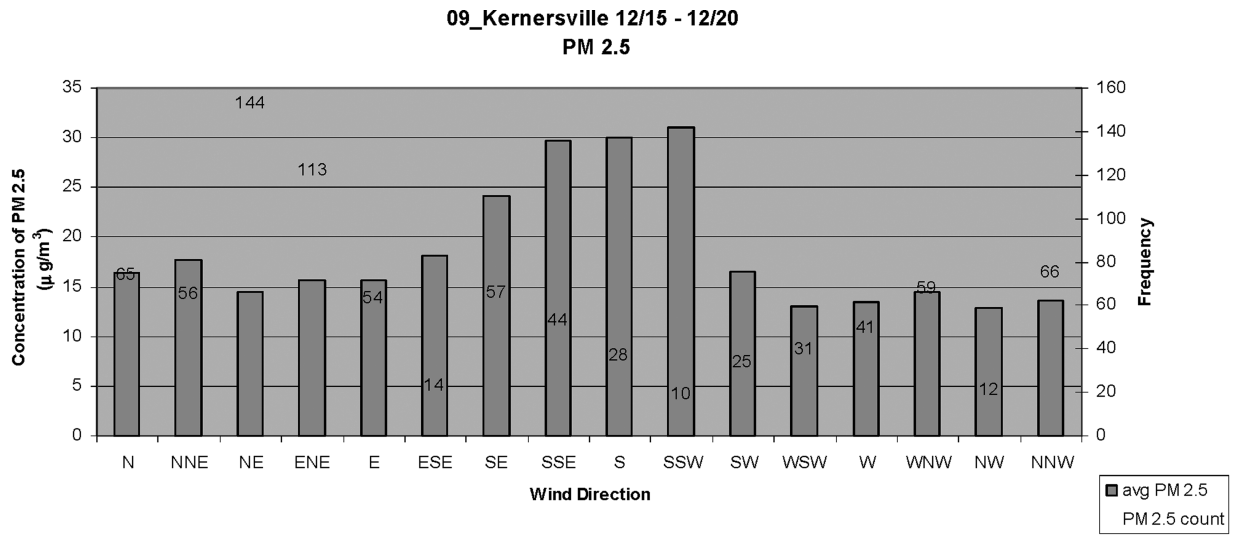


FIGURE 4. Categorical graphs for average concentrations at the Kernersville, North Carolina terminal by wind direction weighted by frequency

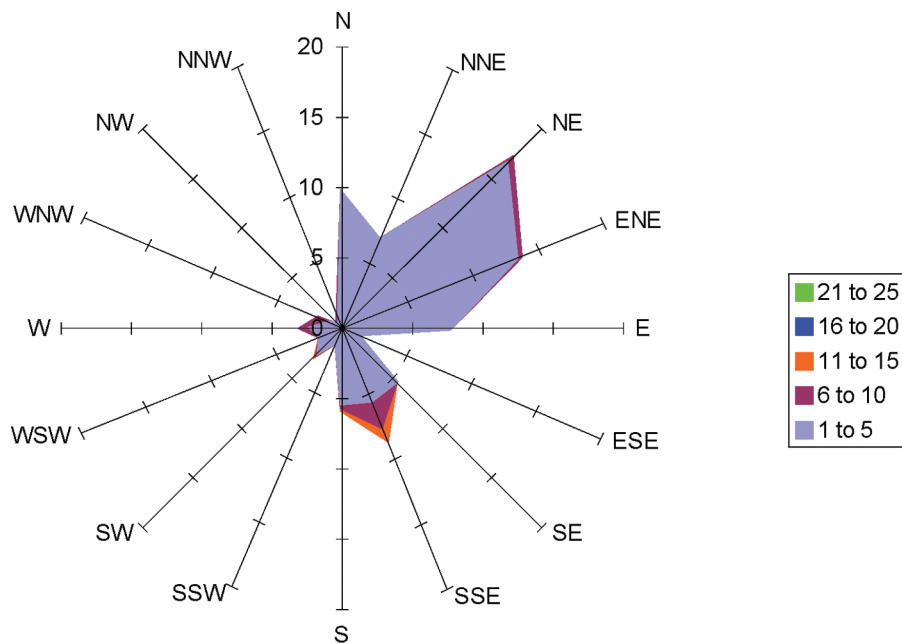


FIGURE 5. Wind rose for Kernersville, North Carolina for all sampling sessions

and was sampled in July 2003. The weather conditions were mostly cloudy for the sampling period with brief periods of clear skies during the second day of sampling. The average temperature was 76°F for the 5 days of sampling. The sampler was located 160 meters NW of the terminal on the periphery of the terminal property. The prevailing winds during the trip were light to moderate winds (0.45 to 6.7 m/sec) from the S, SSW, SW, WSW, W, N, NNE, NE, WNW, NW, and NNW. See Figure 2 for wind rose of all the winds detected during the sampling sessions.

Potential pollutant sources included a train track that ran along a set of tracks located 16 meters due west to the terminal property; the mechanic shop located due southwest of the terminal; the employee parking lot with exhaust from entering, departing, and idling cars located due south of the terminal; and an unidentified industrial building approximately 32 meters due west of the terminal property. See Figure 3 for an overhead terminal picture with the wind rose superimposed.

The overall average concentrations and standard deviation for PM_{2.5}, EC, and OC from the trip are shown in Table II. The calculated weighted concentrations with each direction showed elevated concentrations of PM_{2.5}, EC, and OC from the southwestern directions (S, SW, W), which averaged 26.7 μg/m³, 0.91 μg/m³ and 7.51 μg/m³, respectively. Furthermore, a Wilcoxon rank-sum test showed that the southwestern concentrations were significantly higher than the concentrations from the nonsource wind directions for all particulates studied (see Table III results).

Based on the prevailing winds patterns from the wind rose, the elevated concentrations could potentially be due to the wind blowing PM_{2.5}, EC, and OC particles from the direction of

the train when trains were passing during the trip. The train passed several times during each sampling session. However, the times when trains were passing were not noted, so the correlation with the direction of the wind during that period could not be examined. The distances from the train tracks and the unidentified industrial building to the yard sampler were 16 and 32 meters, respectively. Either or both of these appear to significantly impact background particle concentrations at this terminal.

Kernersville, North Carolina

The terminal was classified as being in a rural setting by the U.S. Census Bureau. It was located in an industrial complex and was sampled in December 2002. The weather conditions were clear to partly cloudy for the first 3 days of the trip, and there was some light precipitation on the last 2 days of the trip. The average temperature was 44.5°F for the 5 days of sampling. The sampler was located 50 meters SW of the terminal on the periphery of the terminal property. The prevailing winds during the trip were light (0.45 to 2.24 m/sec) from the NE, ENE, W, and WNW and light to moderate (0.45 to 6.7 m/sec) from the S, SE, SSE, and SSW directions (Figure 4 and Table II). Potential pollutant sources included a major street to the W, a neighboring larger trucking terminal approximately 100 meters to the ESE, a parking lot to the S, and from the NE, the terminal of interest. These are identified in Figures 5 and 6 in the terminal overhead photograph.

The overall average concentrations and standard deviation for PM_{2.5}, EC, and OC from the trip are shown in Table II. Figure 4 shows the average concentrations weighted by frequency and stratified by wind direction. From the

TABLE II. Summary Statistics for Selected Trips

City	Overall Trip Average Concentration And Std. Dev. ($\mu\text{g}/\text{m}^3$)		Prevailing Winds and Speed ^A	
	Avg	Std Dev		
Indianapolis, IN				
PM _{2.5}	9.11	12.63	N,NNE, NE, WNW,NW, NNW	Light to Moderate
EC	0.36	0.55	SE, SSE,S, SSW,SW	Light to Moderate
OC	4.12	3.17		
Kernersville, NC				
PM _{2.5}	18.57	6.40	NE, ENE	Light
EC	1.03	0.29	S, SE, SSE, SSW	Light to Moderate
OC	8.47	2.61	W, WNW	Light
Valdosta, GA Site 1				
PM _{2.5}	11.23	0.85	All Wind directions were light	
EC	0.25	0.05		
OC	4.67	0.39		
Valdosta, GA Site 2				
PM _{2.5}	14.71	6.69	N, NNE	Light
EC	0.58	0.09	SE, S, SSW	Light to Moderate
OC	6.06	0.07		

^AWind Speed Classification: Light (0.45 to 2.23 m/s); Moderate (2.23 to 6.70 m/sec).

prevailing winds and potential pollutant sources, there were elevated levels of concentrations of PM_{2.5}, EC, and OC from the SE, SSE, S, and SSW wind direction which averaged 28.74 $\mu\text{g}/\text{m}^3$, 1.25 $\mu\text{g}/\text{m}^3$, and 12.13 $\mu\text{g}/\text{m}^3$ respectively. The results suggest possible influences from the parking lot and maybe

the larger terminal. Elevated concentrations of EC and OC were seen from the general northwestern direction (WNW, NW, NNW), which averaged 1.29 $\mu\text{g}/\text{m}^3$ and 9.03 $\mu\text{g}/\text{m}^3$, respectively. The statistical results suggest that wind influenced the background concentrations for EC and OC, but there is no

TABLE III. Analysis of Source vs. Non-Source Concentration Values for Selected Trips

City	Potential Source Wind Directions	Median Concentration			Median Differences in Source and Nonsource Concentrations
		Source	Wind Directions	Nonsource Wind Directions	
Indianapolis, IN	S, SSW,SW, WSW, W	PM _{2.5}	27.73	1.32	26.41***
		EC	0.54	0.17	0.37***
		OC	7.68	4.45	3.23***
Kernersville, NC	S, SE, SSE	PM _{2.5}	19.36	16.05	3.31
		EC	1.27	0.92	0.35***
		OC	10.48	7.30	3.18***
Valdosta, GA Site 1	ESE, SE, SSE, S, SSW, SW, WSW, W	PM _{2.5}	11.86	11.78	0.08
		EC	0.30	0.29	0.01
		OC	4.20	4.16	0.04*
Valdosta, GA Site 2	E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, NNW	PM _{2.5}	6.75	13.11	-6.36
		EC	0	0.57	0.57
		OC	0	6.61	-6.61

Note: All concentration values expressed in $\mu\text{g}/\text{m}^3$. Wilcoxon Rank-Sum Test used to determine statistical significance in concentrations from source and nonsource wind directions (***= 0.01, **= 0.05, *= 0.10).

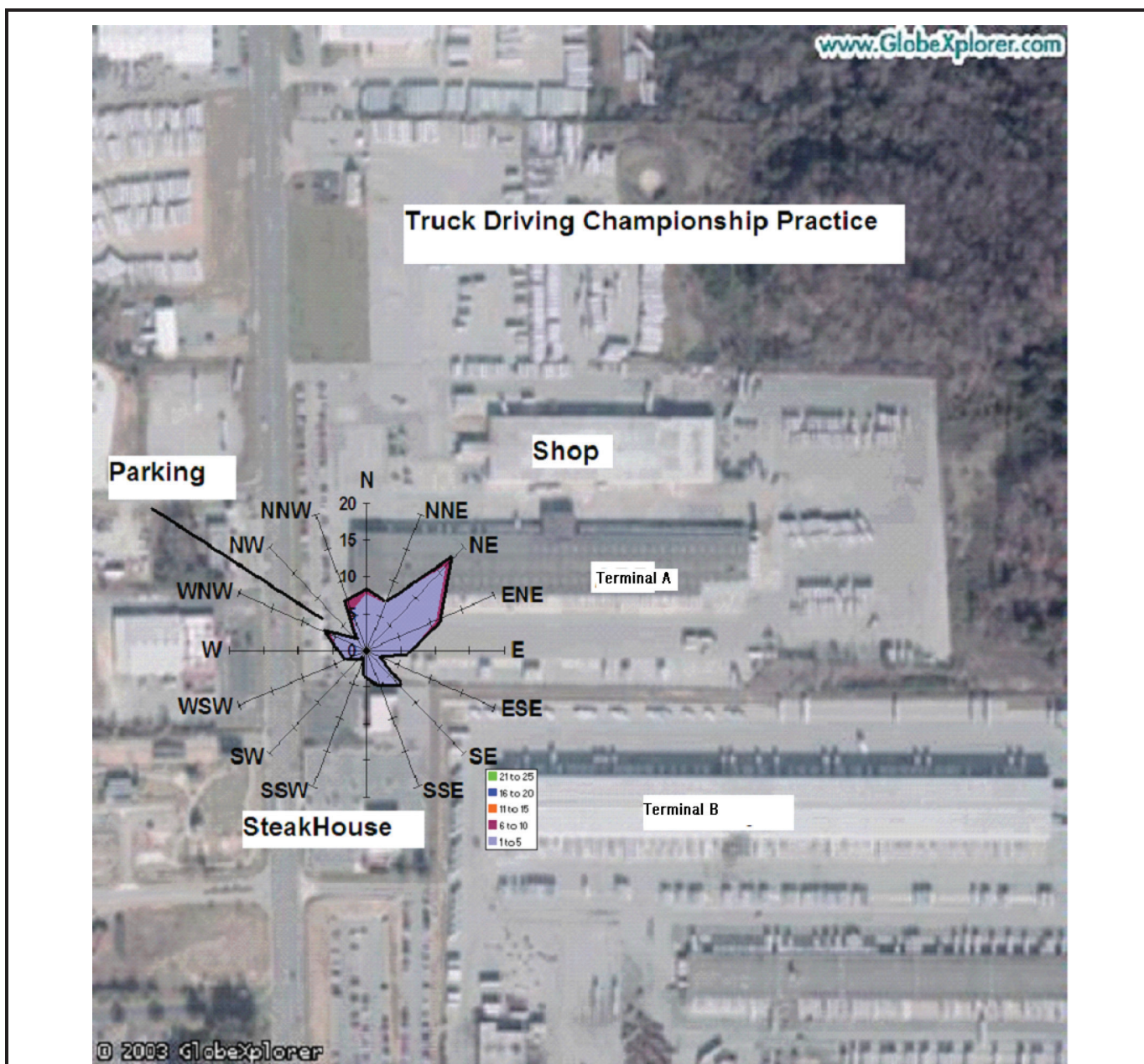


FIGURE 6. Kernersville, North Carolina Terminal (A) overhead photograph with wind rose superimposed. Image courtesy of GlobeXplorer.

evidence to suggest the same effect for $PM_{2.5}$. The wind blew frequently from the NE and ENE without a significant increase in $PM_{2.5}$ concentrations relative to the other directions with potential influencing sources.

Valdosta, Georgia

This terminal was set in a rural setting as designated by the U.S. Census Bureau and was sampled in March 2003. Weather conditions were overcast and cloudy for all sessions except for a brief thunderstorm during Session 2 around 4:00 p.m. to 4:30 p.m. The average temperature was 70°F for the 5 days of sampling.

The sampler was located at two different sites during the trip to keep the yard sampler upwind from the terminal. This terminal shows the difficulty in choosing upwind sampling sites because of the variability of the winds and the complexities of the sites themselves. Site 1 was located approximately 100 meters to the SE of the terminal on the periphery of the terminal property for Sessions 1–3. Site 2 was approximately 69 meters SW of the terminal for Sessions 4–7. See Figure 7 for overhead terminal photograph with wind roses superimposed for Sites 1 and 2.

The prevailing winds measured at Site 1 were light to moderate winds (0.45 to 6.70 m/sec) from the NE, ENE, E, and SE (Figure 8). The wind was calm 11% of the time. During

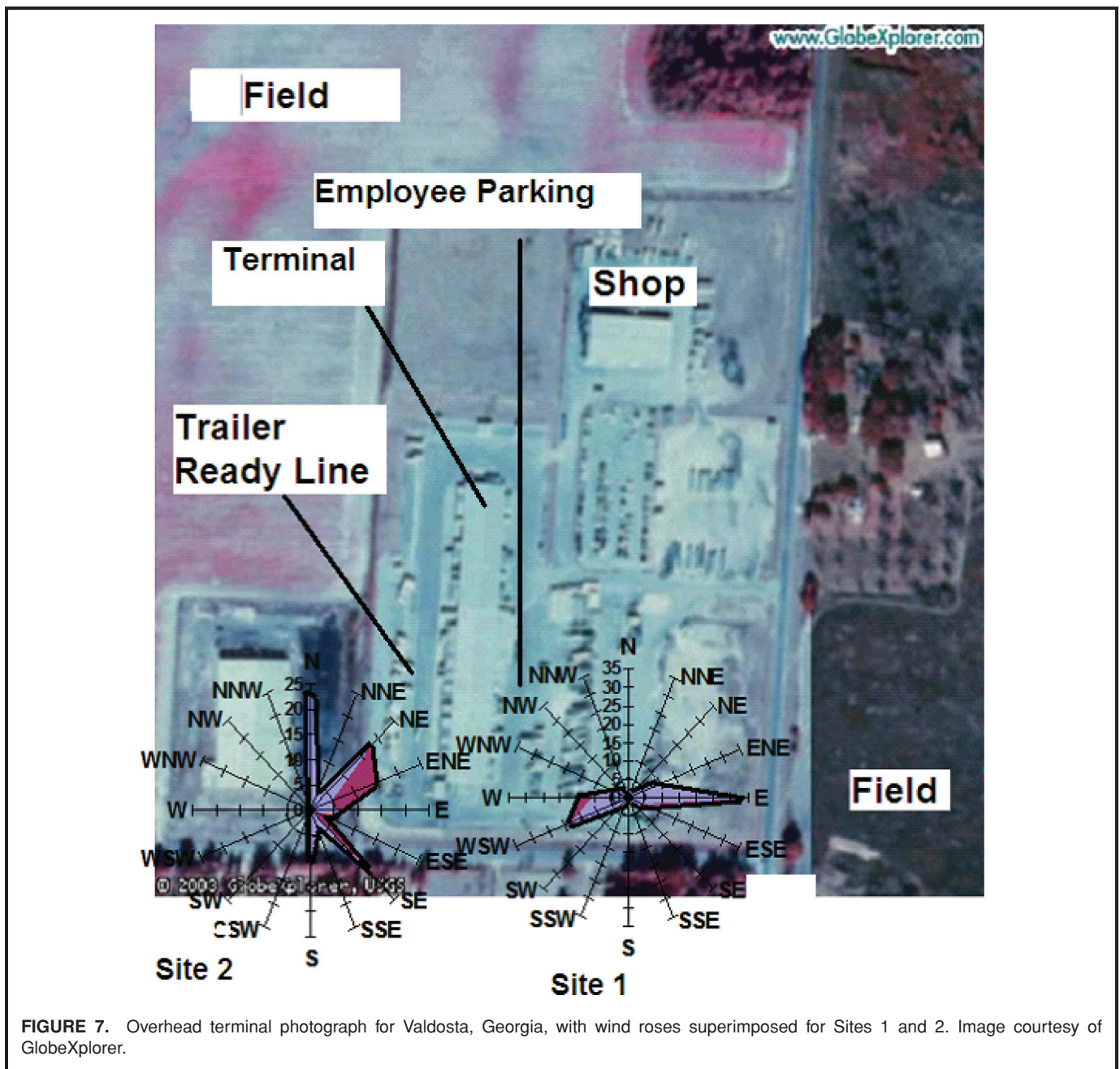


FIGURE 7. Overhead terminal photograph for Valdosta, Georgia, with wind roses superimposed for Sites 1 and 2. Image courtesy of GlobeExplorer.

Session 3 the wind changed to the W. The prevailing winds measured at Site 2 were light to moderate winds from the NE, ENE, E, and WSW (Figure 9).

During the beginning of the sampling session for Site 2 (Session 4) light winds (0.45 to 4.47 m/sec) wind came from the W and WSW. The wind was calm 4% of the time. The terminal property was flanked by a two-lane road along the eastern and western sections. Both yard sampler locations were within 10 meters due south of the two-lane road. The other sides of the terminal (western and northern sides) were surrounded by open fields. Potential outside pollutant sources included the two-lane road, the employee parking lot located WNW of Site 1, and the trucking traffic in the yard. Site 2 for the sampler was

located approximately 30 meters from the ready line (where trucks are placed after loading), and a parking area for truck tractors.

The average concentrations and standard deviations for PM_{2.5}, EC, and OC for Sites 1 and 2 are shown in Table II. The concentrations when stratified by wind directions showed little variance with the exception of Site 1 for OC, which had spikes in the S, SE, and SSE directions (Figure 10). This could have been due to the influence of the two-lane road.

A statistical test of the weighted concentrations for the source vs. nonsource directions for Site 1 showed no differences across the two groups for PM_{2.5} and EC, with

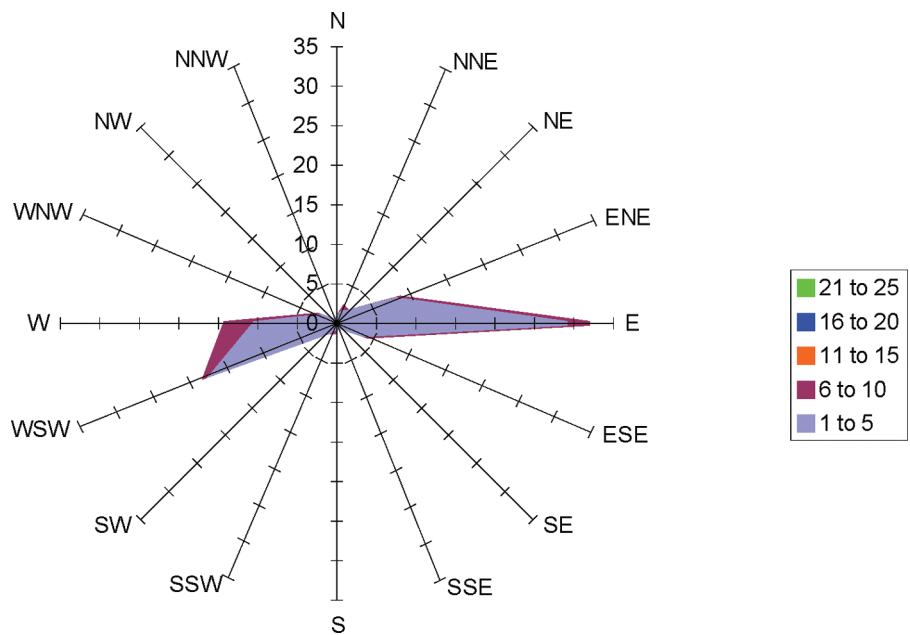


FIGURE 8. Wind rose for Valdosta, Georgia, Site 1

marginally significant differences for OC. There were no significant differences across the groups for Site 2 (see Table III results). Despite the potential pollutant sources nearby (two-lane road and employee parking lot) and the light level winds, background concentrations were not effected by the local sources.

DISCUSSION AND CONCLUSIONS

In this study we used a descriptive analysis of the weather, geographic maps, and particle data from environmental sampling to determine if the transportation of particles from local pollutant sources elevates upwind yard concentration

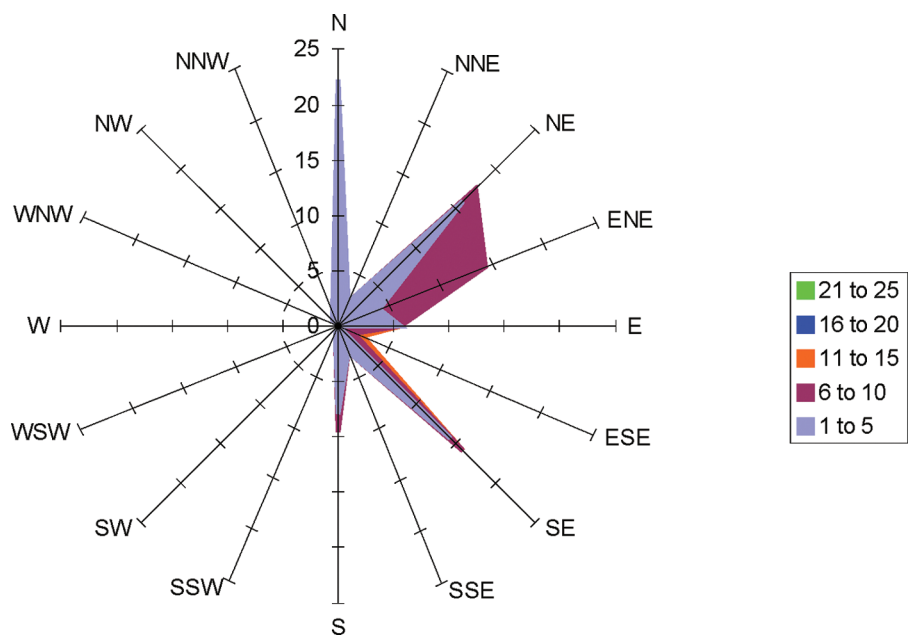


FIGURE 9. Wind rose for Valdosta, Georgia, Site 2

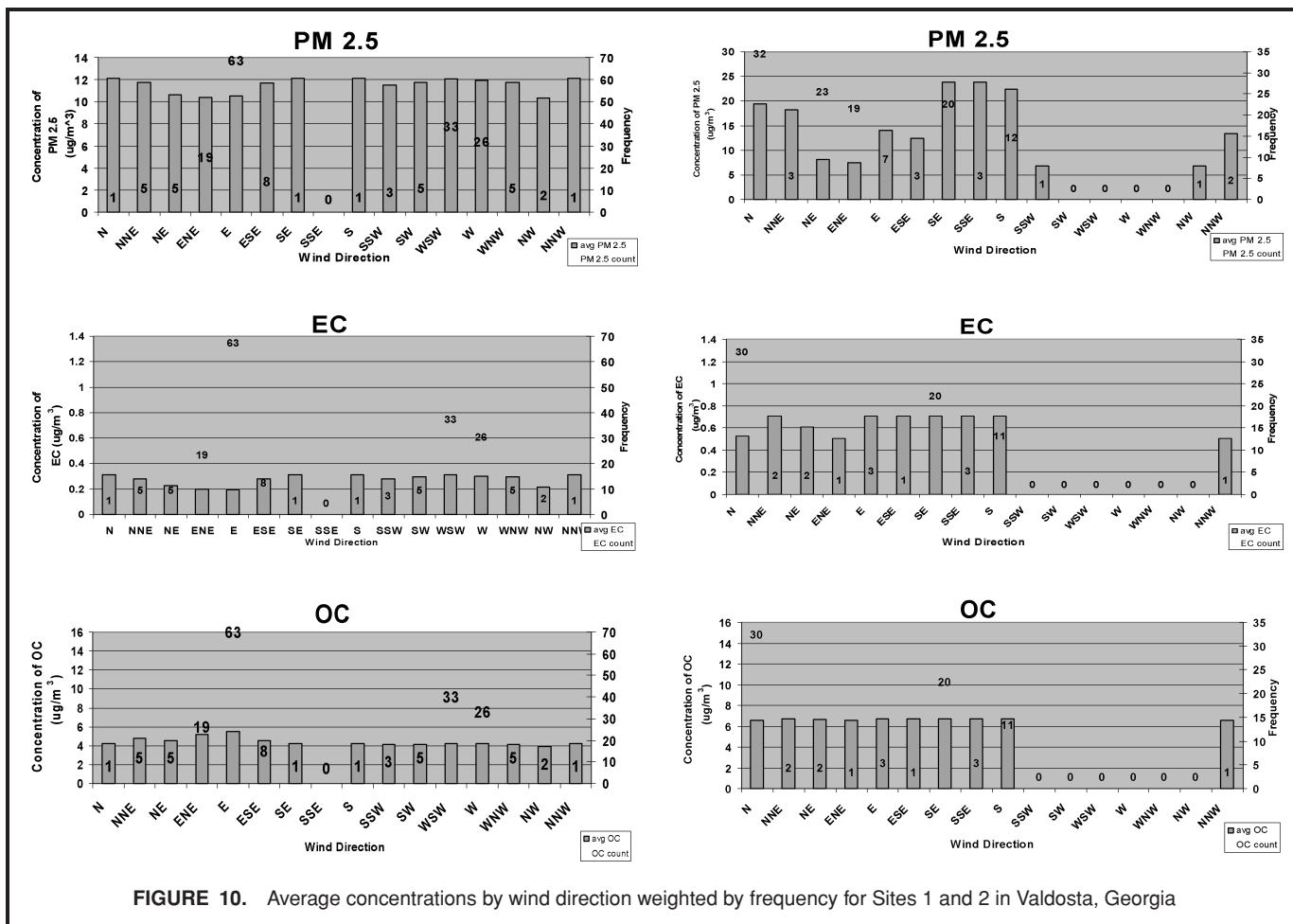


FIGURE 10. Average concentrations by wind direction weighted by frequency for Sites 1 and 2 in Valdosta, Georgia

levels of PM_{2.5}, EC, and OC for trucking terminals. Another objective of this study was to determine how often nearby sources within 100 meters affect background concentrations of PM_{2.5}, EC, and OC around the terminal, as opposed to those farther away. Other particle studies have shown that ultrafine particle concentration decays by about half of their maximum at a distance of 100–150 m from the source.^(15,22,23) Wind direction weighted averages were calculated for PM_{2.5}, EC, and OC based on the frequency of wind directions during each sampling session, plus an analysis of potential local sources based on overhead photos of the terminal to determine if there were significant effects of wind transport from nearby sources affecting background concentrations in the yard.

Our descriptive analysis provided some support for our hypothesis that nearby upwind sources have the effect of elevating background concentrations at 3 of the 11 facilities. Results for the other seven terminals could be stratified into two categories: (1) a mixed results category in which the effect of nearby upwind sources on the background was questionable, and (2) a category in which the upwind sources did not have an effect on background concentrations.

It was noted that all of the terminals that showed influences of upwind sources were located in urban settings and had

light winds (0.45 to 4.47 m/sec) during the sampling. This finding was consistent for studies of particle concentrations at rural and urban terminals,⁽¹⁴⁾ as well as studies that found that concentrations in the atmosphere can become elevated under light winds with stagnant atmospheric conditions.⁽¹⁶⁾ There was no rain at these terminal sites except for a brief thunderstorm at Indianapolis. The terminals that showed no wind direction influence were in rural settings, with the exception of Dallas. The rest of the five terminals that showed questionable effects by the wind on background concentrations were categorized as urban with the exception of Kernersville, North Carolina.

Distance from a pollution source to the yard sampler was a determinant of the influence of the wind on background concentrations. All terminals with positive wind effects had pollutant sources within 100 m of the yard sampler. This finding was consistent with published literature in regard to distances from pollutant sources that are relevant to background concentrations of particles. However, not all terminals that had pollutant sources within 100 m were influenced by the wind.

The primary limitation of this study was the use of concentrations from 12-hr integrative sampling in association with wind data averaged over 1-min intervals. A more accurate

portrayal of the influence of wind on the concentrations in the yard would be obtained by using real-time sampling of the concentrations along with the wind data. Whereas this was a major limitation on the sensitivity, this pilot study was able to detect large effects from some nearby sources. Given limited information on the sources, this was necessarily crude; however, as a pilot study it demonstrated that there were local influences from nearby sources. It also demonstrated the utility of aerial photographs of study sites to identify potential sources and map their relationship to the location of interest. Geographic Information System (GIS) linkage of EPA source databases and surrounding topographical features may greatly improve this type of assessment.

Another limitation of the study was the reliance on information from local airports for cloud conditions and precipitation during the trip. These sources of weather data were not at the terminal sites but were located within a few miles of the freight terminal. Therefore, using these weather data for the terminals may not be accurate due to the variability of the atmospheric conditions at different locations in the region. However, all of the wind data was obtained onsite by the use of a weather station set up during the sampling trip and so should provide an accurate measure for this variable.

It appears that we can represent background air levels as a combination of a relatively uniform regional background plus directional contributions that are a function of wind direction, speed, weather conditions, and distance to source. This study indicates that wind and distance from pollutant source should be accounted for when studying the background concentrations and determining the overall occupational exposures to PM_{2.5}, EC, and OC at trucking terminals.

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