



## Preface

# Applications of remote sensing and GIS for monitoring of coal fires, mine subsidence, environmental impacts of coal-mine closure and reclamation

This Special Issue of the International Journal of Coal Geology is named “Applications of remote sensing and GIS for monitoring of coal fires, mine subsidence, environmental impacts of coal-mine closure and reclamation”. The main aim in this special issue is to promote efficient and effective exploitation of coal resources with the use of remote sensing (RS) and geographical information systems (GIS). In this special issue, a multitude of research studies spanning from coal fire monitoring, coal-fire related greenhouse gas emission estimation, underground-mining related land subsidence mapping, the analyses of chemical changes in lignite mining lakes, pollution monitoring of abandoned mine sites to reclaimed land are addressed by application of RS and GIS.

Worldwide, 40% of electricity generation relies on coal. In addition to electricity generation, coal is extensively used to produce household heat through combustion as well as an important resource for the chemical industry. Even though coal consumption is increasing largely due to the rapid development of emerging economies, worldwide coal supply is predicted to be sufficient for many years as one of the main commodities for energy generation. According to the International Energy Agency (IEA) and the World Coal Association (WCA), the global total hard coal production was 5990 Mt, whereas lignite production was around 913 Mt in 2009. China, the US, India, Australia and Indonesia were the top five hard coal producing countries, with China accounting for about 50% of the global production with 2971 Mt. In lignite mining, Germany ranks first, followed by Canada and India. According to IEA and WCA, the top coal exporters are Australia, Indonesia and Russia, where the leading importers are Japan, China, and South Korea, which is also demonstrating the steep increase in coal consumption. However, the largest coal consumer in the world is also the largest coal producer: China. The energy demand of approximately 1.3 billion people in China, of whom over 40% live in cities, is mainly provided by coal (by as much as 75%).

Despite the importance of coal in the world energy market and as a feedstock to the chemical industry, quality of mines, mining equipment and safety standards in their coal mines are highly variable in different countries ranging from small-scale private, or even partially illegal mines, to highly modernized national state mines. Partially due to these facts, various coal mining regions face the challenges of controlling the impacts of mining operations by preserving the coal resources using efficient and effective engineering planning, protecting them against uncontrolled fires, protecting the environment, and exploring better and more effective ways to monitor and reclaim affected areas.

Uncontrolled coal seam fires are an environmental and economic problem of international magnitude. The fires occur in many countries worldwide including China, India, Russia, the United States, Indonesia, Venezuela, Australia and South Africa, but also at a smaller scale for example in Germany, Romania or the Czech Republic. Coal fires can be human induced, when coal seams in areas of mining activity start to burn or they can occur naturally, when the fire is a result of natural spontaneous combustion. Besides the economic loss of the valuable resource, coal fires pose many environmental threats. The fires produce large amounts of greenhouse and partially toxic gasses including CO<sub>2</sub>, CH<sub>4</sub>, NO<sub>x</sub>, N<sub>2</sub>O, CO and SO<sub>2</sub>. These gases pose a threat to the health of the local inhabitants. In addition, land subsidence can occur due to the loss of volume underground, when a coal seam and several layers of overlying strata turn into ash. The resulting slow or very sudden subsidence can be a threat to infrastructure, local inhabitants and to miners.

Increased focus on global warming and sustainable development necessitates prioritizing environmental responsibility while maximizing economical benefits to the energy industry fed by coal mining. In order to satisfy these requirements coal mine monitoring is essential to evaluate environmental impacts associated with mining activities. Environmental impacts and associated risks can be mitigated effectively by implementing safeguards and monitoring the mine environment continuously. Earth Observation data with employing remote sensing based image analyses and GIS approaches provide important information products, which can support monitoring, planning and decision making processes along these lines. More specifically, remote sensing coupled with GIS analysis tools provides decision makers, mine managers and engineers with assessing the performance of reclamation activities and controlling the risk associated with the environmental impacts of mining by monitoring the vegetation health, chemical and physical stability of mine environment such as chemistry of mine waters, and the degree of subsidence.

Remote sensing is a powerful tool to observe and monitor large areas, or areas that are difficult to access in-situ, in a timely and cost effective manner. Low resolution optical/multispectral satellite sensors such as MODIS, AVHRR, or MERIS, gathering data at a spatial resolution of 1-km to 250-m, allow for a large scale observation of complete coal mining provinces and districts to support geologic mapping, assess mining-related land cover and land use change, or temperature patterns. Higher resolution sensors, such as Landsat or Aster enable more precise optical or thermal analyses with a spatial resolution of 90 to 15 m. Such data can be employed to support local geologic mapping, derive coal fire related hot spots, assess the water

composition of mining lakes, or to map mining related fly-dust pollution. Even higher resolution data of space-borne sensors such as Ikonos or QuickBird with 2.4- to 0.6-m pixel size, as well as air-borne optical, or even hyper-spectral data allow for detailed geologic mapping, the delineation of land subsidence related features, the extraction of even smaller polluted regions, and the detection of mining related infrastructure. Radar data, such as Envisat ASAR or especially TerraSar-X data, also allow for the delineation of land subsidence and structural changes in overburden bedrock layers. Furthermore, the current German TanDEM-X mission creates a global elevation model of 1-m resolution, which will be of great value for the mining industry. In combination with GIS vector data of socio-economic context, in-situ mappings of mining hazards, or point source information on petrology, temperature, gas exhausts, as well as mining cadastres, geospatial information offers the chance to support authorities in the remediation of mining related environmental issues and land reclamation.

This special issue aims to document the use of RS and GIS techniques for the above mentioned problems of coal fires and coal-mining related environmental issues. This issue presents 12 scientific papers that cover these topics. As guest editors of this special issue, we

would like to thank all contributing authors and reviewers, who made this special issue possible. We hope that these papers will serve to demonstrate the use of these techniques for coal related issues of all kinds, and will help to advance the science and engineering of coal fires and coal-mining environmental control.

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