Environmental Monitoring and Modeling Needs in the 21st Century

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It is well-known that adverse weather conditions and high-levels of air pollutants affect human health and the environment. Over the past four decades, there has been a significant increase in the number of locations where air quality and meteorological observations are taken. Also, there has been a substantial improvement in the techniques for modeling the various physical and chemical processes occurring in the atmosphere. Despite this progress, currently available observations are still spatially and temporally sparse and the predictions of current generation of air quality models are still uncertain. Uncertainties in air quality models stem from our inadequate understanding of the relevant atmospheric processes, numerical methods employed, errors in model input data (e.g., meteorology, land-use, emissions). Therefore, observations and model outputs can be combined to create high-resolution spatio-temporal maps of air quality. For example, the spatial distribution of fine particle pollution on July 22, 2004 at 22:00 hrs GMT due to wildfires in Alaska is derived by combining satellite and ground-based monitoring data (Figure 1).

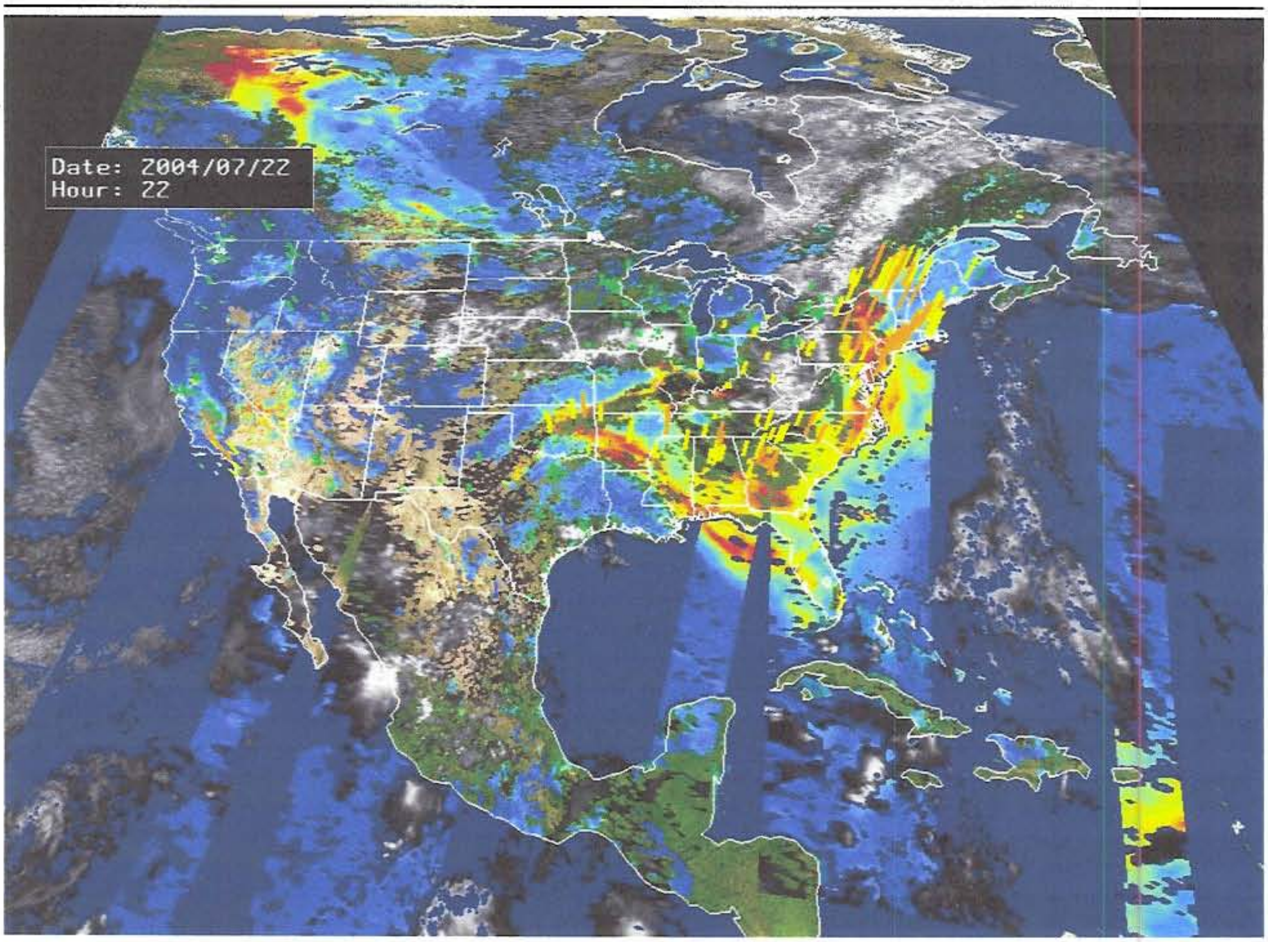

Figure 1. Observations from the satellite, ground-based lidars, and surface monitoring network are combined to develop a spatial view of fine particle pollution due to the wildfires in Alaska. Source: Jim Szykman

Ambient concentrations of fine particles in the eastern United States for the same day and hour have also been estimated using the Community Multiscale Air Quality (CMAQ) mode (Figure 2). The model calculations reveal that the Alaskan fires have contributed 10-16 $\mu g/m^3$ to the pollutant burden east of the Appalachian Mountains.

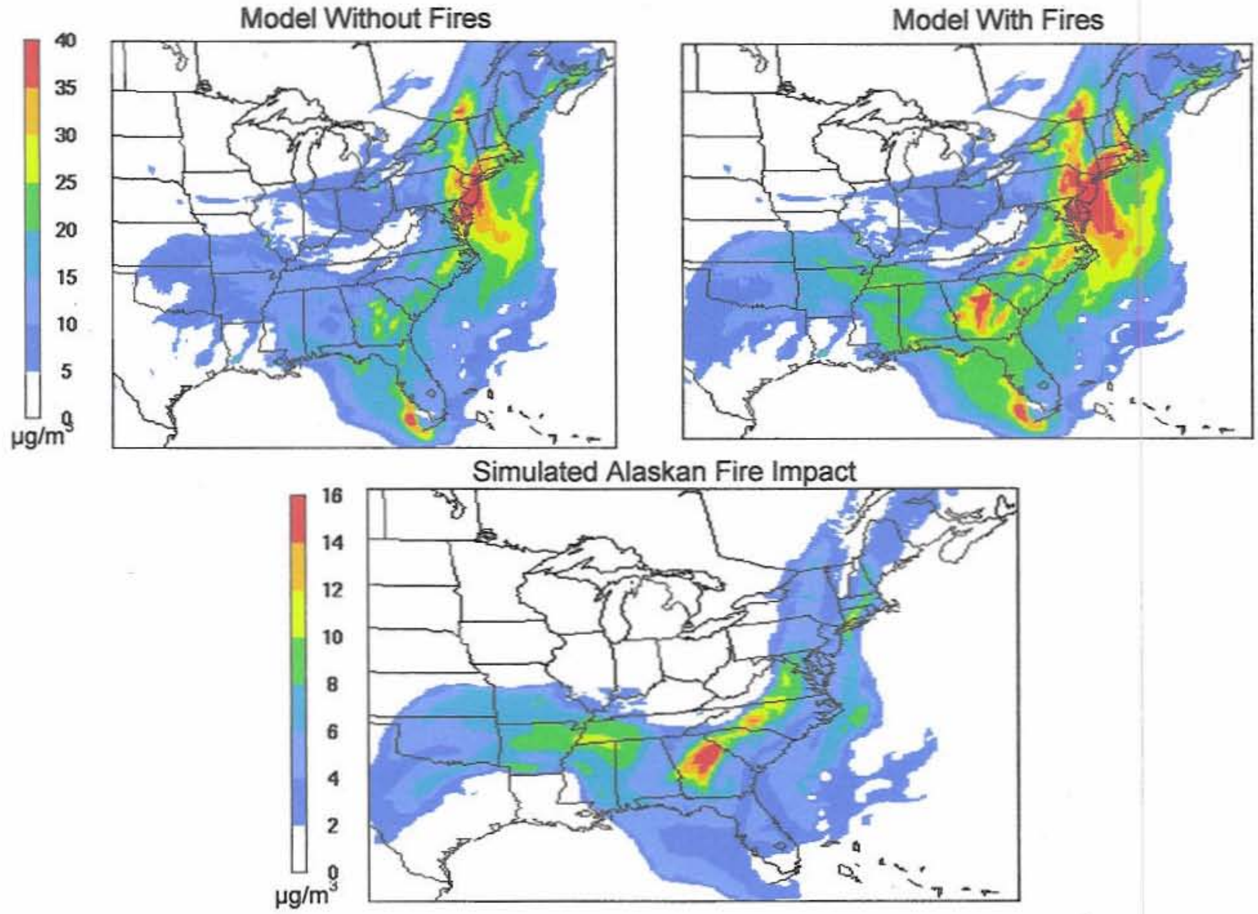

Figure 2. Ambient fine particle concentrations simulated by the Community Multiscale Air Quality (CMAQ) model without and with emissions from Alaskan fires, and pollutant levels attributable to the wildfires in the eastern United States.

As noted before, the limitation associated with available observations, the so-called "ground truth" is that they are sparse. Air quality models can provide pollutant concentrations that are spatially-rich, but their predictions are uncertain. One can take advantage of the strengths of both types of data in creating a high-resolution map of pollutant concentrations by statistically combining model predictions and observations[2]. However, our ability to produce such maps on operational basis for better understanding the relationships between ambient air quality and human health is hampered by the lack of dense and continuous observations of air quality and meteorological variables at the ground-level and aloft. NRC[1] stressed the need for atmospheric and related environmental observations both at the ground-level and above the atmospheric surface layer, and recommended a coordinated network of networks to properly address the inadequacies in current observations, and meteorological and air quality model outputs.

This EM issue covers current and future opportunities for obtaining 3-dimensional air quality observations on scales ranging from urban to inter-continental to properly assess atmospheric pollution problems and to better evaluate multi-scale atmospheric models. It also covers the observational and modeling needs for improving our understanding of the exposures to humans and ecosystems and of the relationships between ambient air quality and human/ecosystem health. Emissions and meteorological inputs needed for high-quality applications of the models are also addressed. This issue contains two overarching articles on the monitoring and modeling needs by Scheffe et al. and Georgopoulos et al., respectively, followed by several short articles on information needs to properly assess the adverse impacts of air pollution on human health and ecosystems.

Disclaimer

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References

1. National Research Council, Observing Weather and Climate from the Ground Up - A Nationwide Network of Networks; The National Academy press, Washington, Dc, 2009.
2. Garcia, V.C.; Foley, K.M.; Gego, E.; Holland, D.M.; Rao, S.T. A comparison of statistical techniques for combining modeled and observed concentrations to create high-resolution air quality surfaces; J. Air & Waste Mange. Assoc., Submitted, June 2009.

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