PARTICULATE MATTER PREDICTION AND SOURCE ATTRIBUTION FOR U.S. AIR QUALITY MANAGEMENT IN A CHANGING WORLD

Research Challenge
The research examines global changes in climate and emissions, primary particulate matter and ozone. The study’s objectives are to better understand how global changes impact U.S. air quality, to project future trends, and to quantify pollution sources and assign their attributions: natural vs. human-influenced, national vs. international agents, natural variations vs. climate change. Researchers can then provide actionable data for U.S. environmental planners and decision makers for use when designing management strategies, including local controls, domestic regulations, and international policies. A state-of-the-science prediction system will be used for three primary experiments: historical simulations to validate the system, future projections to quantify impact of changes in global climate and emissions, and sensitivity analyses to determine future changes in pollution sources and their relative contributions each sources’ attributions.

Methods & Codes
The dynamic system couples a global climate–chemical transport model with regional climate and air-quality models over North America, to determine individual and combined impacts of global climate and emissions changes on U.S. air quality. These include uncertainty evaluations, from the present to 2050, under multiple climate and emission scenarios. The results from the global and regional model simulations for the past are evaluated with observational data to assess the capabilities of the model simulation and impacts of emissions change, climate change, and long-range transport on future U.S. air pollution.

Why Blue Waters
The computational demand of high-resolution climate models used in this project is very extensive. In addition, we are using a fully coupled model of the Earth’s climate system with interactive chemistry, which is also computationally expensive even when not run at high resolution. Blue Waters, with its petascale computational facility, large number of nodes, and storage capability for the output from the high-resolution model simulation, is essential for our project. Blue Waters has given us the computational resource, data management, and support staff to perform our research.

Results & Impact
The system’s models were used to simulate major air pollutants from 1980 to 2005. Evaluation of the system using historic EPA measurements showed that it can capture the distribution of ozone pollution with substantial underestimations in urban and suburban areas, and the pollution pattern of particulate matter, while some isolated sites had substantial discrepancies. These results show the capability of the system. Further improvements planned by the researchers will improve the predictive capability of the system, and produce a more complete scientific understanding of global climate and emissions changes imposed on U.S. air quality management and a more reliable projection of future pollution sources and attribution changes.

Comparison of EPA Air Quality Standards observations and Community Multiscale Air Quality (CMAQ) simulations. Ozone values are from summer JJA MDA8 and PM2.5 measurements are the annual mean. Dots shows AQS/CASTNET/IMPROVE observations and background shows CMAQ results (upper panel). Lower panel shows the ratio of observations to CMAQ results.