AIR QUALITY

PROJECT FOCUS

This project explores the use of ensemble forecasting to improve the accuracy of air quality predictions for New York State. Ensemble forecasting uses multiple predictions based on a collection of slightly different initial conditions, and/or on an assortment of differing models. The primary goal is to construct an ensemble model to forecast ozone ($O_3$) and fine particulate matter ($PM_{2.5}$) concentrations over New York State. Ensemble model use will also aid in investigating the impact of fluctuations in power plant emissions on air quality predictions; performing diagnostic evaluations of simulated $O_3$ and $PM_{2.5}$ concentrations; and providing New York State Department of Environmental Conservation (NYSDEC) forecasters with improved air quality guidance products.

New York State currently relies on comprehensive, grid-based, one-atmosphere modeling systems to manage air quality and to provide guidance to state air quality forecasters. For example, NYSDEC uses the Community Multiscale Air Quality (CMAQ) model. In past applications, CMAQ has exhibited a tendency to overestimate low concentrations and underestimate high concentrations of $O_3$. It has also exhibited a tendency for strong overpredictions of $PM_{2.5}$ concentrations for the New York City metropolitan area and underpredictions of $PM_{2.5}$ concentrations in other areas of the state. Applying ensemble techniques may improve the accuracy of air quality forecasting; it may also help to determine whether uncertainties in air quality forecasting are primarily attributable to uncertainties in weather forecasting, to incomplete emissions rate data, or to our limited understanding of atmospheric chemistry. Ensemble forecasting has been used to create accurate meteorological forecasts, but its application to air quality forecasting is in the formative stages.

PROJECT IMPLICATIONS

This research will inform and improve model-based air quality forecasting in New York State, particularly with regard to concentrations of $O_3$ and $PM_{2.5}$. It will help resolve gaps in the current forecast models by incorporating more subtle analyses of spatial and temporal variations, and it will aid in diagnosing which components of the current modeling systems may lead to uncertainties in forecasting. Results are expected to be applied to air quality planning, aiding State policymakers in creating better emissions-control strategies. This will also help sources regulated under the EPA-administered State Implementation Plan (SIP) to stay within mandated emissions limits so that fewer violations occur.
PROJECT STATUS
Ongoing

Ground-level ozone, fine particles, and other pollutants can contribute to poor air quality and create a public health hazard. Improved forecasting models will not only allow more accurate air quality predictions, but will aid policymakers in regulating emissions from sources such as power plants and industrial facilities. Source: ©iStockphoto.com/Abalcazar.

Since 1975, the New York State Energy Research and Development Authority (NYSERDA) has developed and implemented innovative products and processes to enhance the State’s energy efficiency, economic growth, and environmental protection. One of NYSERDA’s key efforts, the Environmental Monitoring, Evaluation, and Protection (EMEP) Program, supports energy-related environmental research. The EMEP Program is funded by a System Benefits Charge (SBC) collected by the State’s investor-owned utilities. NYSERDA administers the SBC program under an agreement with the Public Service Commission.

METHODOLOGY

The project team will construct an ensemble model using some of the existing models currently in use in New York State. Predictions made using this Air Quality Ensemble Forecasting System (AQEFS) will be compared to observations in order to assess model performance as well as to determine the impacts of meteorological forecast errors on air quality predictions. The project team will also conduct case studies, comparing results from different models, and explore the potential for the future addition of more models to the AQEFS.

In order to improve modeling of PM$_{2.5}$ concentrations in the New York City region, the project team will study the effects of grid resolution on the urban scale, and spatially apportion emissions to a high-resolution modeling grid. These emission inventories will be processed through the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system, and results will be used in high-resolution simulations.

The project team will also analyze the effect of temporal variations in power plant emissions on air quality forecasts, as well as the relationship between near real-time or forecast meteorological data and point source emissions. To determine whether the New York Independent System Operator’s (NYISO) load distribution forecasts can be used in models, instead of advanced emissions forecasts, emissions data will be correlated with load distribution forecasts from NYISO. The project team will also perform retrospective air quality simulations for a summertime high-ozone case study.

The quality of all of the model simulations will be subjected to multiple analyses, such as comparing simulations with real-time data, and performing retrospective diagnostic analyses using data from past summers. The project team will also design, test, and implement data integration approaches for integrated air quality forecasts.

FINDINGS

The current ensemble air quality forecast system consists of five daily CMAQ-based air quality simulations, and one Comprehensive Air Quality Model with Extension (CAMx)-based simulation. For the past year, the project team has made its multi-model air quality forecast guidance available to state and regional forecasters. It makes a range of model-based guidance products available to NYSDEC forecasters, and results from the ensemble model simulations are distributed daily to air quality forecasters from the Northeast States for Coordinated Air Use Management (NESCAUM), the regional U.S. EPA office, and the northeastern states. A preliminary Web page (http://asrc.albany.edu/research/aqf/aqvis/) has been developed to disseminate the forecast products. The weather forecast products are also made available online by the participating institutions, at http://chaos.msrc.sunysb.edu/NEUS/nwp_graphics.html and http://asrc.albany.edu/research/aqfms/arw-wrf/.

A major part of this project is the ongoing effort to evaluate and improve model performance. For example, O$_3$ and PM$_{2.5}$ air quality forecasts for eight NYS regions were compared against observations for the summer of 2008. The multi-model system provided good O$_3$ forecasts, especially for Long Island and the NYC metro area; however, forecasts for summertime PM$_{2.5}$ were characterized by a negative bias for all areas except the NYC metro area. To correct bias errors, the project team is evaluating the use of weighting or bias correction approaches prior to ensemble averaging. Preliminary results show that use of a simple 7-day bias correction reduces errors significantly. Based on these results, a running seven-day bias correction has been implemented for PM$_{2.5}$ forecasts on a daily basis, and is being evaluated. Bayesian Model Averaging (BMA), another approach that has been shown to be helpful in improving weather forecast accuracy, is also being explored for possible application to post-processing air quality forecasts.

The project team has also explored collaborative opportunities. For example, the National Oceanic and Atmospheric Administration (NOAA) has begun to provide NYSDEC with daily ozone forecasts. These data are used in model evaluation and could be considered as an additional ensemble member. The project team is participating in ongoing workgroups to review and improve the representation of temporal fluctuations in power plant emissions for air quality modeling. The project team is also collaborating with researchers at City College of New York in comparing LIDAR (Light Detection and Ranging) measurements in the NYC area with the aerosol forecast from the model.