PROJECT UPDATE

August 2005

New York State Energy Research and Development Authority

Environmental Monitoring, Evaluation, and Protection Program

Effects of Transboundary Pollution on New York's Air Quality

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For more information on this project see:

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Keywords

- Fine particulate matter ($PM_{2.5}$)
- Ozone (O_3)
- NAAQS
- Nitrogen oxides (NO_x)
- Trajectory analysis
- Volatile organic compounds (VOCs)

PROJECT FOCUS

Combining data analysis and air-quality modeling techniques, this project examined spatial and temporal trends in ozone and its precursors in the region, and the impact of Ontario emission controls on transboundary pollution in New York State (NYS). Researchers also assessed the most advanced meteorological and photochemical modeling systems used to design emission control strategies for meeting the national standards. They considered the uncertainties associated with model predictions of ozone concentrations and developed methods for the use of models in evaluating control strategies with an increased degree of confidence.

This project and a related NYSERDA-funded study "Modeling and Analysis of Ozone and Fine Particulate Matter in the Northeastern United States" aimed to assist policymakers and state regulatory agencies in designing optimal control measures for reducing ambient ozone and fine particulate pollution. Methods were proposed for integrating observations and model predictions into an overall framework that draws on the strengths of both approaches while also providing a measure of the uncertainties involved. The analysis undertaken is an important advance in increasing the reliability of modeling tools in the policymaking process.

CONTEXT

In July 1997 the U.S. Environmental Protection Agency (EPA) set new National Ambient Air Quality Standards (NAAQS) for ozone (O_3) and fine particulate matter ($PM_{2.5}$; diameter < 2.5 microns), pollutants that have major adverse consequences for human and ecosystem health and productivity. When the new ozone standards come into effect in 2004, they will likely be exceeded in several locations throughout NYS. The attainment of ambient ozone levels that are compliant with the NAAQS may require new emissions regulations. Therefore, improvements in the identification of the sources of NYS ozone concentrations and the modeling of the transport of O_3 and its precursors would considerably benefit policymakers in formulating a control regime and New York's attainment of consistent compliance with the new standards.

Ground-level ozone is produced through a series of chemical reactions involving its precursors, nitrogen oxides (NO_x) and volatile organic compounds (VOCs). These chemicals are generally released into the lower atmosphere as a consequence of combustion processes. Major sources include fossil-fuel electric power generation, industrial processes, industrial boilers, incinerators, and motor vehicles. While ozone and its precursors may be produced locally, they are also transported regionally. The long-range transport of ozone and its precursors from sources in the Midwest and Canada is an important factor in addressing air-quality problems in NYS.

METHODOLOGY

Data Analysis

This project expanded the database used by the NYS DEC to assess the impacts of ozone transport in the region covering Ontario, Canada and NYS. Pertinent meteorological, source-emission, and air-quality data reflecting conditions in Ontario, Canada and the eastern United States were assembled in collaboration with the Ontario Ministry of the Environment. These expanded databases were subsequently analyzed in order to determine spatial and temporal trends in ozone and its precursors over the region and to examine the impact of Ontario emission controls on transboundary pollution in NYS. A Memorandum of Understanding between the NYS DEC and the Ontario Ministry of the Environment, developed as part of this project, facilitated the exchange of scientific information between NYS and Ontario.

Modeling

- Three regional air-quality models developed in the US and Canada, MODEL3/CMAQ (U.S. EPA), UAM-V (SAI), and CHRONOS (Canada) were compared in terms of their ability to predict ozone air quality. For evaluation, simulation results from these models were compared to actual observations from 1995.
- Methods were developed for using modeling results in a regulatory setting with an increased degree of confidence.
- The effects on ozone concentrations in Ontario and NYS were simulated for two scenarios in which (1) Ontario and (2) NYS anthropogenic emissions were eliminated.

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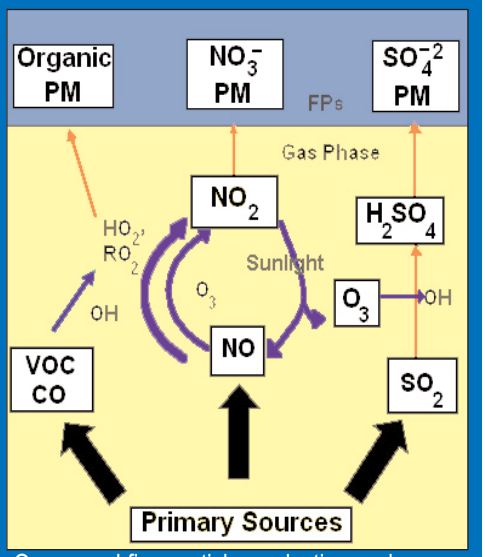

Ozone and fine particle production cycle.

Project Status

- Initiated 1999
- Completed 2003

New York Energy Smart℠
Public Service Commission — NYSERDA

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 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.

PROJECT FINDINGS

Data Analysis

- Concentrations of ozone precursors have been decreasing throughout Ontario and the New York City (NYC) metropolitan area (1983–1998). These decreases are consistent with the emissions control programs implemented in both areas. Ozone itself has been decreasing in the NYC metropolitan area, but increasing throughout Ontario.
- Higher than average ozone concentrations in the Northeast are associated with winds from the Ohio River Valley and the industrial Midwest.

Modeling

Model sensitivity analysis reveals that even with the same inputs, O_3 concentrations predicted by different modeling systems can vary by as much as 20–30%. Thus, the uncertainty in predicting the daily peak ozone concentration is on the order of 20% for the models studied.

Current-generation modeling systems perform best at predicting ozone fluctuations on timescales longer than one day. The reliability of model results in the regulatory context would benefit considerably from:

- Simulation periods longer than 2–3 episodic-type modeling days;
- Model outputs that are averaged over all simulation days, to build confidence in results; and
- Interpreting the modeling results in a probabilistic manner, in assessing the effectiveness of emission control strategies in meeting and maintaining the relevant air quality standards.

The probabilistic framework proposed in these studies, which aimed at integrating the spatial and temporal provided by observations with model predictions, was applied to ozone concentrations for demonstration purposes. It should be expanded to address multipollutant problems based on an ensemble of multiple models.

Results of Simulations Eliminating Ontario and NYS Emissions

- No Ontario emissions: Ontario peak O_3 concentrations decreased 15% or more. NYS peak O_3 concentrations decreased 6% or more throughout most of NYS.
- No NYS emissions: NYS peak O_3 concentrations decreased 3–15%. Even in southern Ontario, the ozone decreased ~6%.

Since the above percentage reductions reflect seasonal averages, they are not representative of the ozone changes on any particular day. These simulations reaffirm the results of the analysis of observational data: the O_3 and $PM_{2.5}$ problem crosses state and international boundaries. Therefore, out-of-state versus in-state contributions of reactive pollutants like O_3 and $PM_{2.5}$ cannot be distinguished from just a few monitoring sites, as the pollutant concentrations are interdependent among several states within the 600 km airshed.

PROJECT IMPLICATIONS

The analyses conducted through this project underscore the fact that ground-level ozone pollution is a multistate, regional, and international problem that requires the implementation of regional air-quality management partnerships and control strategies, rather than isolated efforts of individual states. As higher spatial and temporal resolution and better $PM_{2.5}$ speciation become available, further analysis should investigate whether different components of $PM_{2.5}$ have different spatial scales.

The insights derived from this research will substantially strengthen the technical basis of air-quality management and its application in NYS and Ontario, Canada. The resulting advances in modeling have improved the ability to assess the impacts of transboundary pollution and to compare different regulatory options for controlling ozone precursors. This project has also contributed to achieving these goals by fostering improved communication on the international level with regard to the ozone issue.

The reliable use of models is vital in the evaluation of control strategies, for example, in determining the comparative benefits of controls affecting different geographical areas and of controls affecting different polluting sectors, such as electrical utilities. Strengthening our ability to predict the effectiveness of airshed-based emission control strategies will provide considerable benefits to the policymaking process.

Credit: US EPA

Industrial stack emissions.