Evaluating the Effectiveness of Regulatory Actions from the Source-to-Outcome Perspective

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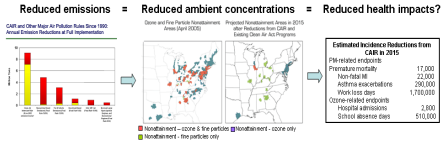
Environmental Issue

Given the significant costs associated with emission control programs and to ensure that the public is adequately protected, it is critical that we understand if we are achieving the expected results from regulatory control actions.[9]



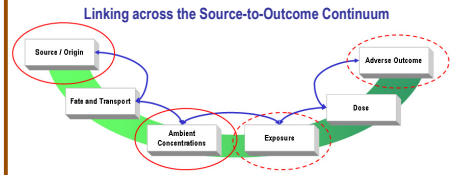
This research will help identify approaches to systematically track and periodically assess our progress in pursuit of national, state and local air quality goals—particularly those related to criteria pollutants regulated under the National Ambient Air Quality Standards and the Clean Air Rules. The research discussed here examines changes in and the relationships among emissions of pollutants and their precursors and ambient pollutant concentrations, and then links this information to human exposure and human health outcomes.

Research Objectives

The objectives of this research fall into two broad categories:

(1) Examining changes in ambient pollutant concentrations stemming from the implementation of emission reductions; and

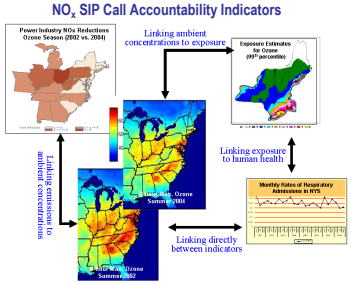
(2) Investigating the relationships among emissions, ambient pollutant concentrations, human exposure and human health endpoints.



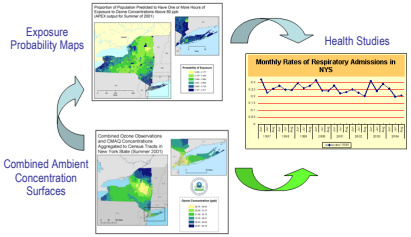
An understanding of the indicators (measured or modeled values that elucidate change across the continuum) and processes connecting these indicators allows us to connect the major components of the source-to-outcome continuum in the forward and backward directions.[13] The red circles shown above represent indicators used in this study. Solid circles are the indicators of focus for AMAD; dashed circles represent a secondary role. Arrows represent the processes connecting the indicators.

Approach

The figure below summarizes preliminary work being done to assess the impact of the NO_x SIP Call to illustrate the development of indicators and the evaluation of linkages among changes in emissions, ambient concentrations, human exposure and health endpoints.[1] In this case, NO_x levels emitted from electric generating units were evaluated before and after the implementation of the NO_x SIP Call emissions reductions.[4,12] Changes in ambient ozone concentrations were also evaluated by examining both observed and modeled daily 8-hour maximum ozone concentrations.[2,12] Community Multiscale Air Quality (CMAQ) model simulations were used to better understand the linkages between NO_x emissions and ambient ozone concentrations by examining the role of meteorology versus emissions reductions in the changes seen in ambient ozone concentrations.[5-7]



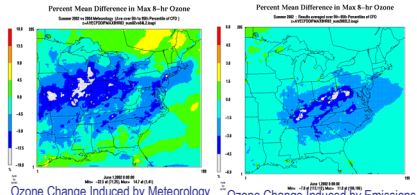
Research is underway to combine observed and modeled concentrations to produce improved surfaces of ambient concentrations.[8-3] These concentration surfaces are being used to drive exposure models that simulate the movement of people through time and space to estimate the probability of exposure by age, gender and other cohort characteristics of relevance to health studies.



Both the ambient concentration and exposure maps are being used in an epidemiology and risk assessment study in New York State to investigate the value of using probability-based exposure factors versus ambient concentrations as a surrogate of exposure.[10,11] Thus, the last indicator (epidemiology studies) is linked directly to ambient concentrations and exposure probability maps to investigate improvements, if any, in health outcomes attributable to the NO_x SIP Call.

Results

Because the formation and accumulation of ozone is controlled by weather conditions (dry, hot days produce more ozone than cool, wet days), meteorology was taken into account when evaluating changes between the pre- and post- NO_x SIP Call periods. Ozone observations were meteorologically-adjusted using the KZ Filter technique and other statistical methods.[2,8] Meteorology and emissions were held constant for the model simulations to extract the meteorological versus emission signals in the modeled ozone concentrations.[5,7]

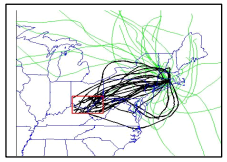


Ozone Change Induced by Meteorology (2002 -2004)

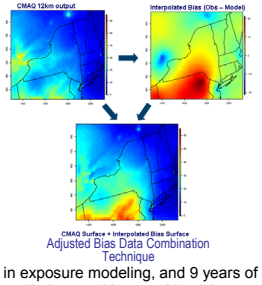
Ozone Change Induced by Emissions (2002 -2004)

Modeling simulations shown above substantiate that meteorology swamps the ozone signal by a factor of 2 to 3. However, when meteorology is held constant across years, NO_x emission reductions account for as much as a 6% decrease in ambient ozone concentrations. This finding was supported by the analysis of the meteorology-adjusted observations, although the model results showed less of a reduction in ozone across the two time periods than the observations did.[2,6]

In addition, analyses using the HYSPLIT model to perform back-trajectories from selected sites in the Northeast supported that the Ohio River Valley (a targeted region of the NO_x SIP Call) was a predominant source of high ozone concentrations at downwind sites.



Back-trajectories from a Source Region



Adjusted Bias Data Combination Technique

Research has also been conducted to assess various statistical methods to combine observed and modeled pollutant concentrations to provide improved air quality surfaces for use in exposure modeling and health studies. Currently, 5 summers of combined daily ozone surfaces are being used in exposure modeling, and 9 years of combined ozone surfaces are being used in an epidemiology study.

Conclusions

- Ozone concentrations decreased in the Northeast between the pre- and post- NO_x SIP Call time period studied. The most significant reductions in ambient ozone concentrations occurred in the Ohio River Valley.
- Observational and modeling studies support that NO_x emission reductions resulting from the NO_x SIP Call did reduce the transport of NO_x and ozone to downwind regions.
- Models can be used in conjunction with observations to generate indicators for assessing regulatory actions and to understand the processes that link indicators.

Future Directions

- Expanding NO_x SIP Call assessment to include additional years (1997-2006) for an epidemiology study and risk assessment.
- Developing approach for assessing future regulations to include metrics (predictions of changes associated with the promulgation of a rule) and indicators (actual levels of the same or closely related parameters observed during implementation) established *a priori*.
- Investigating ability to embed hybrid fine-scale modeling within CMAQ grid structure to better assess the effect of air quality on human health endpoints.

Impact

- Understanding whether costly regulatory actions are having the impact intended is critical economically, but also in ensuring that the public is adequately protected from exposure to harmful pollutants.
- This research has resulted in several methods aimed at discerning a relatively small signal of change in ambient pollutant levels embedded in a highly confounded set of outcomes (e.g., secondary pollutant levels, exposure levels).
- In addition, this research has led to the development of indicators and methods to link among indicators, with a focus on the source-to-exposure portion of the risk paradigm continuum.

Contributors/Collaborators

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- Pat Kinney, Columbia University
- Steve Porter and Edith Gego, University of Idaho