Examining the Impact of Regional-Scale Air Quality Regulations on Human Health Outcomes

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Abstract The NO_x State Implementation Plan Call was issued by the U.S. Environmental Protection Agency to reduce the emissions of nitrogen oxides from the electric power sector to curtail the regional transport of the secondarily-formed pollutant, ozone. As emission control actions often come at a significant economic cost, it is important to understand whether such regulations have reduced air pollution and improved public health and the environment as originally anticipated. In this paper, we examine the relationships among meteorological transport patterns, ozone concentration levels and respiratory-related hospital admissions across New York State using trajectory analysis and other spatial and statistical approaches. Preliminary results from this analysis are presented in the paper.

1. INTRODUCTION

The Clean Air Act requires that the U.S. Environmental Protection Agency (EPA) set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. Previous research has shown that high ambient ozone concentrations are harmful to humans (e.g., Bell et al. 2005, Ito et al. 2005). While ozone is not directly emitted, the formation and distribution of ozone is driven by chemical reactions involving nitrogen oxides (NO_x) and Volatile Organic Compounds (VOCs), as well as interactions with meteorological factors. NOx and the secondarily formed ozone can be transported downwind, contributing to pollutant levels at locations much farther from the emission sources, potentially impacting human health in downwind areas. As a result, the NO_x State Implementation Plan (SIP) Call was issued by the EPA to reduce the transport of ozone. This study investigates methods to characterize the transport of ozone from the Ohio River Valley (ORV) region, a major source area experiencing significant emission reductions resulting from the NOx SIP Call, into a domain encompassing New York State (NYS). Back-trajectories were performed from several sites within this domain across eight summers (1999 – 2006) to iden-

tify predominant meteorological patterns. These meteorological patterns were investigated for associations with ozone concentrations and respiratory-related hospital admissions. This paper presents the preliminary results from this analysis.

2. APPROACH

Daily maximum 8-hour ozone concentrations were calculated from hourly measurements for the summers (June 1 through August 31) of 1999 through 2006 obtained from the EPA's Air Quality System database (http://www.epa.gov/oar/data/aqsdb.html) and the Clean Air Status and Trends Network (http://www.epa.gov/castnet/). Daily 8-hour maximum ozone concentrations were interpolated to provide estimates for each county to coincide with the hospital admissions data. Back trajectories from selected sites were computed using the HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) model (Draxler and Hess, 1997) for 48 hours back in time, producing a total of 736 trajectories for each site. Health data for the summers of 1999 through 2006 were obtained from the NYS Statewide Planning & Research Cooperative (SPARCS). These data included daily hospital admissions for respiratory-related diseases, including asthma, chronic bronchitis, chronic obstructive pulmonary disease (COPD), emphysema, and pneumonia and influenza.

3. DISCUSSION AND RESULTS

The transport of ozone into NYS was examined by performing back-trajectories during the summers of 1999 through 2006 at selected sites in Albany (Figure 3.1), Buffalo, New York City (NYC) and southwestern NYS. Based on these back-trajectories, each day was categorized as having a wind flow pattern originating from the ORV or not originating from the ORV (Figure 3.2). These days were then matched to the corresponding daily maximum 8-hour ozone concentrations and daily respiratory-related hospital admissions. In addition, ozone concentrations and hospital admissions were examined before the implementation of the NOx SIP Call (1999 – 2000) and after the implementation of the NOx SIP Call (2004 – 2006).

The results of this analysis indicate that the mean levels for ozone concentrations and respiratory-related hospital admissions were significantly higher for those days when the sites were downwind from the ORV versus those days that the sites were not downwind from the ORV. In addition, the mean levels for ozone concentrations were found to be significantly higher before the implementation of the NOx SIP Call versus after the implementation of the NOx SIP Call. Furthermore, there were fewer extreme ozone events after the implementation of the NOx SIP Call as compared to before the implementation of the NOx SIP Call,

particularly for those days that the wind originated from the ORV. While there was not a significant difference in the mean hospital admissions before and after the implementation of the NOx SIP Call , a crude analysis using a cumulative distribution function for the southwestern site indicates that a decrease in ozone concentrations is associated with a decrease in hospital admissions at the higher ozone percentiles (>75%). Because of many confounding factors (e.g., temperature, human behavior), the health signal associated with the implementation of the NOx SIP Call will be difficult to discern at best. This study presents a promising approach for identifying such impacts through the use of meteorological conditions as an indicator of exposure.

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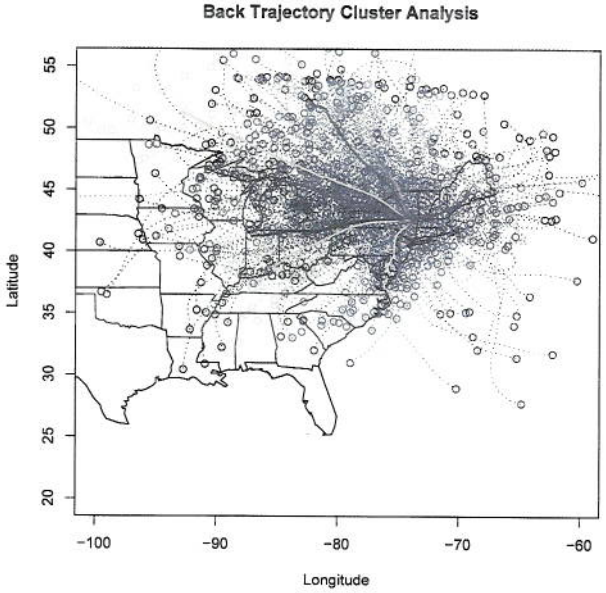

Figure 3.1: Example of back-trajectories performed for selected sites (Albany, NY shown here) for summers of 1999 - 2006 (dashed lines), clustered into 12 major meteorological patterns (solid lines).

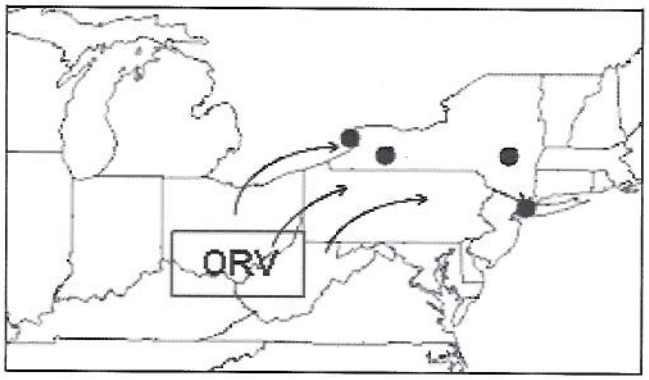

Figure 3.2: Rectangle shows Ohio River Valley as defined for this study. Arrows indicate wind direction for downwind sites. From left to right, circles represent approximate location of Buffalo, the southwestern site, Albany and NYC.

Speaker: Garcia

Questioner:

Question: Try to include other time varying determinants of hospital admission in the analysis.

Answer: This paper presents a preliminary analysis on the use of meteorological conditions as a variable in examining associations between transported pollution and respiratory-related hospital admissions. A full epidemiology study with other time varying determinants of hospital admissions is also being performed in a companion study (see paper entitled "Impact of the NOx SIP Call on Respiratory Hospitalizations in New York State").