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Project Summary

Trends in Sulfur Dioxide Emissions from the Electric Utility Industry and Ambient Sulfur Dioxide Concentrations in the Northeastern United States, 1975 to 1982

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Trends in monthly power plant SO_2 emissions and monthly average ambient SO_2 concentrations are determined for 21 northeastern states and the District of Columbia. Due to the recession of the late 1970's, power plant emissions in most of the industrialized states decreased by up to 30%. Meanwhile, for more than half of the states, there is evidence of a downward trend in the ambient concentrations, even though many of the monitoring sites were located in urban areas.

Correlations of the seasonally adjusted emissions and ambient concentrations were calculated at the local, state, and regional levels. In general, higher correlations are observed in those states with higher levels of emissions. In the six-state region of the Ohio River Valley the correlation between the seasonally adjusted emissions and ambient concentrations was 0.75.

This Project Summary was developed by EPA's Atmospheric Sciences Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

A key issue in the debate over legislated SO_2 emissions reductions is the extent to which acidic deposition and precursors of acidic deposition, e.g., ambient SO_2, will be reduced as a result of reductions in emissions. For example, will a 50-percent decrease in SO_2 emissions result in a 50-percent decrease in ambient SO_2 and sulfate concentrations and a 50-percent decrease in acidic deposition, or only a 25-percent decrease? Considerable effort is being expended in sophisticated mathematical model development and in the design of field measurement programs to attempt to answer this and related questions.

Another approach is considered in this report. As a result of the economic recession in the late 1970s, actual sulfur dioxide emissions were reduced. Data from the late 1970s and early 1980s, then, can be used to examine the results of actual decreases in SO_2 emissions. The purpose of this study is to examine recent trends in sulfur dioxide emissions and acid deposition precursors, specifically ambient SO_2, and to assess the degree of correlation between the two. This work is seen as the first step in a two-step process, in which the second step would be

to examine the association between reductions in SO_2 emissions and/or ambient SO_2 and sulfate concentrations and sulfate deposition.

In this report we address the first step, reporting on our examination of trends in (1) sulfur dioxide emissions from electric power plants, and (2) ambient SO_2 concentrations from 1975 to 1982. The region of study is the heavily industrialized northeastern United States, extending to Wisconsin and Illinois on the west and to Tennessee and North Carolina in the south. Twenty-one states plus the District of Columbia (hereafter referred to as 22 states for simplicity) are included in the study.

Power Plant Sulfur Dioxide Emission Trends

The power plant emissions for most states have a regular yearly pattern, with a summer peak in July and August and an even higher winter peak in December and January. In those states which have high SO_2 emissions, such as Ohio, Illinois, and Kentucky, significant decreases can be seen. In states with relatively few power plants and low emissions, such as Connecticut and Delaware, trends in emissions are difficult to detect apart from the large seasonal variability.

The power plant emissions for 1975 and 1976 did not change significantly for any of the high emission states. After 1976 or 1977, however, a general decline in the emissions was observed for the District of Columbia, Illinois, Kentucky, Michigan, New York, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and Wisconsin. The largest decline in emissions was observed for Tennessee (about 30% from 1977 to 1982). On the other hand, power plant emissions in Massachusetts increased sharply after 1977.

Ambient Sulfur Dioxide Trends

Trends in monthly mean and average daily maximum SO_2 concentrations were calculated for each of the 22 states. The monthly averages were based on averages across all reporting sites for each state; because the monitoring sites tend to be clustered in urban areas, monthly average values usually reflected concentration levels of those urban monitors rather than those of background or rural monitors. Although the absolute levels of the concentrations within a state may reflect higher urban concentrations, the relative levels (i.e., the increases and decreases observed) may be more representative of all areas in the state.

SO_2 concentrations for the urban-representative averages are highest in the winter when (1) the SO_2 emissions from low-elevation, sulfur-containing-fueled heating sources are highest, (2) the air is relatively stagnant, and (3) mixing volumes are small; and lowest in the hot summer months when emissions from low-elevation sources are less and there is greater mixing. Sometimes one observes a secondary "peak" in the summer season, with an amplitude that is about 10 percent of the winter peak.

The states where downward trends in monthly average ambient SO_2 concentrations were detected during 1975-1982 were Delaware, Illinois, Indiana, Kentucky, Michigan, Ohio, Pennsylvania, Virginia, and Wisconsin. Maryland was the only state where monthly average concentrations increased throughout the period. No trend was apparent in the remaining states.

Correlations at the State Level

Plots of monthly statewide ambient SO_2 mean average daily maximum concentrations and power plant emissions revealed, in general, long-term reductions in ambient SO_2 concentrations in addition to long-term reductions in emissions; however, no clear pattern emerged with respect to short-term correlations between changes in emissions and changes in ambient SO_2. Short-term correlations are not clearly apparent because of the highly seasonal nature of both emissions and ambient concentrations: ambient SO_2 concentrations peak during the winter, whereas emission levels have a winter peak as well as a summer peak.

The correlations of interest are between the seasonally adjusted emissions and the seasonally adjusted SO_2 concentrations. If the differences between actual and typical seasonal emissions are correlated with the differences between actual and typical seasonal SO_2 concentrations, then short-term changes in ambient SO_2 levels are related to short-term changes in emissions.

These correlations are highest in those states with greater power plant SO_2 emissions. The degree of correlation depends to some extent on the number of SO_2 monitors and the amount of data at each of the monitors; the more monitoring data there are, the less variability there is in average monthly SO_2 concentrations and the more likely it is that actual correlations between emissions and ambient SO_2 concentrations will be seen. In addition, the degree of the correlation depends on the locations of the SO_2 monitoring stations relative to the locations of the power plants with sizeable SO_2 emissions.

Correlations at the Local Level

Relationships between individual power plant emissions and monitored SO_2 concentrations were examined for a few selected sites. Such relationships, however, are inherently difficult to analyze because of missing data at most SO_2 monitoring stations. Very few stations were in existence during the entire 8-year period under study, and even when monitors are operating they rarely record measurements for all of the hours in a given year. From the set of monitors with at least 4 years of at least 50 percent of the total possible hours each year, we selected three with power plants nearby for further analysis; two of the monitor pairs are in New York near the Pennsylvania border, and the third is in eastern Virginia.

The correlations between emissions and SO_2 concentrations in these local sites can be summarized as follows:

- Correlations are highest for point-source monitors near large power plants;
- Correlations between monthly emissions from power plants and monthly average daily maximum SO_2 concentrations are somewhat higher than correlations between emissions and mean SO_2 concentrations;
- Correlations between power plant emissions and ambient SO_2 concentrations are improved when the monthly data are aggregated to yearly averages; and
- Correlations between power plant emissions and ambient SO_2 concentrations are higher when just the subset of summer months is considered. This is a period in which emissions are high and mixing of emissions from elevated sources is greatest.

Correlations at the Regional Level

Regional power plant SO_2 emissions and ambient SO_2 concentrations decreased substantially after 1976 along the Ohio River Valley states (Illinois, Indiana, Ohio, Pennsylvania, West Virginia, and Kentucky). From 1975 to 1982, total six-state SO_2 emissions from power plants decreased 22 percent, average ambient SO_2 concentrations decreased

33 percent, and average daily maximum SO_2 concentrations decreased 32 percent, which indicates that emission reductions from sources other than power plants have occurred.

Seasonally adjusted statewide SO_2 emissions and ambient concentrations were compared for the Ohio River Valley states. There was a correlation of 0.749 between changes in emissions from the seasonal pattern and changes in monthly average SO_2 from seasonal patterns; for monthly average daily maximum SO_2 concentrations, the correlation is 0.766. Simple regression analyses reveal that an emissions decrease of 100,000 tons of SO_2 from power plants in the region in a given month from what would normally be expected for that month of the year is associated with a decrease of 0.031 ppb in monthly average SO_2 (from what would normally be expected for monthly average SO_2 for that month) and a decrease of 0.084 ppb in monthly average daily maximum SO_2 (from what would normally be expected for the month).

Conclusions

Substantial decreases in both SO_2 emissions and ambient concentrations occurred in the northeastern quadrant of the United States during the 1975-1982 study period. Annual power plant emissions from the six-state Ohio River Valley region decreased 22 percent from 1975 to 1982, while annual average daily maximum ambient concentrations decreased 32 percent during the same period. In this region the correlation between seasonally adjusted monthly power plant emissions and seasonally adjusted monthly average ambient concentrations was 0.75. Correlations at the state and local levels were lower.

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The complete report, entitled "Trends in Sulfur Dioxide Emissions from the Electric Utility Industry and Ambient Sulfur Dioxide Concentrations in the Northeastern United States, 1975 to 1982," (Order No. PB 85-200 244/AS; Cost: $16.00, subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
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The EPA Project Officer can be contacted at:

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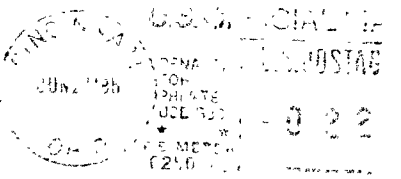

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