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Project Summary

Local Source Impact on Wet Deposition

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Precipitation chemistry measurements over a network of samplers upwind and downwind of Philadelphia, PA, show that a major contribution of the local sources can be discerned under certain conditions. For winter frontal storms with low-level winds from the southeast, up to as much as a factor of two increase over upwind values has been observed for downwind nitrate deposition. Sulfate deposition shows an increase of about a factor of one and one half. The nitrate deposition increases toward the downwind direction away from the urban-industrial sources, indicating that the maximum is likely to have been beyond the sampling network for these case studies. One storm had no increase in nitrate or sulfate deposition but did have an increase in total sulfur content in the precipitation. Reasons for this difference are being sought.

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

Sources in the local and intermediate range from receptors are expected to contribute more to deposition than comparable sources at greater distances due to the dilution of pollution with distance. Knowing the deposition-to-distance relationship is important in developing effective and efficient control strategies on nearby sources for protection of particular sensitive receptor regions. Furthermore, since wet deposition monitoring networks are sparse, with sites located away from source areas, knowledge of near source deposition is important in evaluating the wet deposition sink for budgets of acidic substances.

Local and intermediate-range transport was the principal focus in the history of air quality management. Recently, attention has been focused on the long-range contributions from multiple sources of sulfur in regions many hundreds of kilometers upwind from sensitive receptor areas, i.e., the long-range transport hypothesis. Furthermore, studies around large point sources indicated relatively small contribution to total sulfate and nitrate deposition. However, studies around urban pollution sources indicated substantial impacts on wet deposition. With the relative importance of local and intermediate-range sources appearing unclear, Work Group 2 of the U. S.-Canada Memorandum of Intent (MOI) study recommended further studies of this issue. The National Acid Precipitation Assessment Program (NAPAP) has instituted the Mesoscale Acid Deposition Studies Program to address this problem.

Key Findings

A review of past literature and the original results of the recent Philadelphia Mesoscale Acid Deposition Study yield the following key findings:

- The impact of tall stacks (point sources with stack heights greater than 50 m) is small in the local range (source-to-receptor distances less than 30 km), with less than 5% of the emitted SO_x and NO_x scavenged by precipitation (for most regions this corresponds to a

0.5% annual removal) during precipitation events. Percentages for chloride and trace metals are much higher.

- The impact of area sources such as large urban and industrial complexes is significant in the intermediate range. This conclusion is based on limited but reliable field data for summer precipitation and winter storms. The summer data were for the METROMEX study in St. Louis, MO; the winter data were for the Philadelphia Mesoscale Field Study. The nitrate impact is dominant in the cold season; the warm season effect is comparable for nitrate and sulfate.

In both cases, more than 50% of the emissions may be oxidized and deposited in acid form within 100 km. The winter cases demonstrated a gradual increase of the nitrate impact, with distance from the source peaking beyond 60 km. The nitrate effect implicates the significant transportation sources which are diffuse and at low heights.

- Preliminary indications, based on limited but reliable field data, suggest a minimal impact of primary sulfates on intermediate-scale deposition.
- The local scale effect within the area source is presumably dominated by below-cloud scavenging of higher urban sulfur and nitrate air pollutants, resulting in higher sulfate and nitrate wet deposition. However, no clear effect on pH is evident, due to an urban excess of neutralizing agents such as calcium.

The above results are consistent with a conceptual model in which point source plumes require time to mix with oxidant-rich air, thus promoting faster transformations. Emitted SO_2 and NO require time for transformation to more readily scavenged forms (H_2SO_4 and HNO_3); for SO_2 the process may be accelerated by reactive scavenging, which is enhanced under conditions permitting strong vertical mixing, e.g., convective storms. For NO, the gas phase transformation is an order of magnitude faster than for SO_2 and may continue, via a different pathway; during the night for SO_2 this transformation shuts off at night.

Using emission rates for NOx and SOx of 200,000 metric tons year^{-1}, approximate values of 2 and 8 mmol m^{-2} are estimated for sulfate and nitrate deposition in the environs of area sources. In areas of low to moderate background deposition, the increases above regional background levels are relatively large, especially for nitrate (50% or more). For point source, the inferred upper bound of 0.5% on wet removal fraction translates to a rather significant bound (16 mmol m^{-2} of sulfate) for a large source. This value is not small in comparison with regional values, especially in remote regions. Experimental difficulties make the evaluation of the impact of point sources on intermediate-range wet deposition difficult.

To gain a total picture of local and intermediate-scale deposition impacts, dry deposition needs to be considered. An empirical picture comparable to that for wet deposition is not possible but dry deposition may be just as important in the delivery of material to the surface. Although quantitative estimates are generally unreliable, on the local scale it is accepted that dry deposition contributions exceed those of wet deposition. Depending on effective stack height, terrain, and meteorological conditions, anywhere from less than 1 percent to 50 percent might be removed within the first 30 km. A complication in estimating local dry deposition is the diurnal variation in the dry deposition process rate, which may create a lag between the time of maximum susceptibility and maximum concentration, depending on the source release height.

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The complete report, entitled "Local Source Impact on Wet Deposition," (Order No. PB 86-167 756/AS; Cost: $11.95, subject to change) will be available only from:

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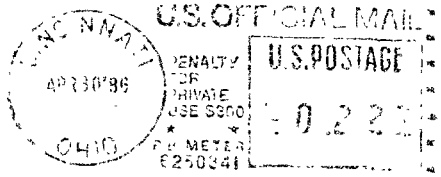

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