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Project Summary

Comprehensive Field Study Plan to Relate Pollutant Sources to Acidic Deposition: A Preliminary Study of Uncertainties

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An experimental program was designed to empirically relate acidic deposition to precursor emissions. Several technical issues requiring further study prior to field experiments were raised. Preliminary estimates of uncertainty were made in order to assess confidence in the experimental design. The five general areas studied included uncertainties in measurements, local scale data analyses, regional scale data analyses, model simulations and data analyses for regional experiments.

Measurement uncertainties are large compared to deposition losses for gases on the local scale. On a regional scale, the existing ambient sulfate measurement network has a resolution of order 500 km which is adequate, but characteristic spacing of SO_2 patterns requires resolution of less than 100 km. Model simulations indicated the frequency of tracer detectability at a receptor from a specific source was small and limited by meteorology. Also, the frequency of detectability is dependent on source strength. Local source modulations were modeled and attainable modulation signals were found to be of insufficient magnitude to be detected over background concentrations when measurement uncertainties were considered. Results from these analyses of the effects of uncertainty were considered in the final experimental design.

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

The Atmospheric Sciences Research Laboratory of U.S. Environmental Protection Agency funded a program to design an experimentally based study to provide empirical relationships relating acidic deposition in ecologically sensitive areas to sources of precursor emissions. In addition, the experiments are to provide a data base for evaluation of regional acidic deposition models. The program has been named the comprehensive experiment or COMPEX and the design plan is presented in a companion report entitled, "Comprehensive Experimental Design Plan to Relate Pollutant Sources to Acidic Deposition." In the course of designing the program, several questions arose on technical issues requiring further study prior to conducting the experiments. This report describes preliminary studies performed to clarify these issues and increase the confidence in success of the COMPEX plan. Studies are divided into five general areas: 1) summary of measurement uncertainties, 2) local scale data analyses, 3) regional scale data analyses, 4) model

simulations, and 5) data analyses from the regional experiments.

Measurement Uncertainties

A primary consideration in COMPEX is the ability to design a program which would provide empirical source/receptor relationships within reasonable uncertainty levels. The first component of the uncertainty studies is a review of uncertainties associated with measurement techniques required in the design. COMPEX requires new experimental techniques or new applications of previously used techniques. The report summarizes information on uncertainties associated with systems to be used in the study with the exception of PMCP perfluorocarbon tracer measurements proposed for use. Feasibility experiments proposed in the COMPEX design include studies of this tracer.

Local Scale Analysis Uncertainties

The second element of the uncertainty studies involved examination of local scale data to better understand the temporal and spatial characteristics of concentrations and the relationships among pollutants and tracers. The study analyzed data from the Electric Power Research Institute's (EPRI) Plume Model Validation and Development (PMV+D) experiments within 20 km of the Kincaid power plant. Results can be summarized as follows:

- Within local scale distances (< km), ambient concentrations of sulfur dioxide, oxides of nitrogen, and inert tracers are strongly related when there is no interference from background. Ambient concentrations respond to variations in emission rates.
- Close agreement of concentration data among pollutants and tracers indicates that depositional losses within 20 km of sources are negligible and within the measurement uncertainty.
- Uncertainty in experimental measurements is large.

Primarily, the results indicate the difficulty in detecting deposition effects over short distances and the need, when simulating sources, to match the tracer release rates to the actual source emissions rates.

Regional Scale Analysis Uncertainties

Ambient concentration data are available on a regional scale from the EPRI Sulfate Regional Experiment (SURE) and the data provides a data base for studying concentration relationships on a regional scale. The primary product of the regional data analysis is an evaluation of the scale of the spatial concentration patterns and the required resolution for sampling in a program such as COMPEX. The spatial resolution of the ambient sulfate concentrations is of the order of 500 km which indicates the adequacy of both the SURE network and the proposed COMPEX monitoring grid. SURE data were not of adequate resolution to determine the characteristic spacing of the SO_2 patterns. Data indicate that the scale of patterns is less than 100 km. The SURE data analysis also allowed an estimate of the uncertainties in representing spatial concentrations with mean values from point measurements. The analysis provided a means of studying the errors involved with spatial averaging but also indicated difficulties in detecting concentrations changes resulting from local source modulation experiments.

Model Simulations

Numerous uncertainty questions were studied using regional model simulations. First, relative to the long range tracer experiments, the simulations indicated that point source releases of tracers in transport studies did not adequately describe the resultant tracer or emissions distributions from large emission areas. In addition, the simulations suggested tracer release rates which are adequate to assure detection at large source/receptor separation distances. The frequency of detectability was analyzed as a function of these rates and multiples of concentration over background levels. The frequency of detectability or the frequency of source receptor interactions is in general small and limited by meteorology. The frequency is reduced when emission levels for the tracers are reduced. The rate of reduction is larger for tracer releases which are intermittent rather than continuous.

Small scale simulations were performed to evaluate the feasibility of local source modulation and deposition experiments. Results indicated that planned emissions modulation may not be of sufficient magnitude to be detected over background concentrations. Supplementary results indicate that the time series analyses of the modulation patterns may likewise be insufficient to provide a detectable modulation signal over temporal cycles in the concentration data. Model simulations relative to source depletion and mass balance techniques for estimation of dry deposition rates may also be hampered by problems with the detectability of deposition losses over local to mesoscale distances.

Data Analysis from Regional Experiments

Analyses of data from other more specialized experimental programs were performed to evaluate aspects of the COMPEX design. Limited data available for analysis from the CAPTEX program was used to evaluate the feasibility of using ground level tracer concentration data to estimate trajectories for the transmittance approach described in the COMPEX plan. The CAPTEX tracer data indicated that the tracer data could be used to provide trajectory information using a sampler network with the resolution of that proposed for the COMPEX experiments.

Data from the SURE program and the MAP3S precipitation chemistry program were analyzed to examine the representativeness of a one year experimental program in generating empirical source/receptor relationships and potential categories for use in statistical analyses. The data suggest that the use of a single year period for an empirical analysis may not be satisfactory. Meteorological categorization schemes require additional study and need to consider broad classes of data to provide adequate sample sizes. Data collection activities in the COMPEX program require both modifications to increase the statistical data base and to relate the program to previous data collection efforts.

The last element of the uncertainty analysis is an analysis of data from the ACURATE experimental program to determine the frequency of source/receptor interactions. ACURATE examined the long-range transport of krypton-85 releases over a one and one half year period. The data show a surprisingly small frequency of interaction between a point release and single receptors. The relationship decreases with distance which emphasizes the need for program modifications to increase the sample size of the COMPEX data base.

Conclusions

The uncertainty studies were performed in parallel with modifications of the COMPEX plan. Numerous suggestions from the studies were incorporated in the plan, particularly in the areas of distributed tracer releases, release rates, release configuration, and sampling resolution.

Some of the studies undertaken in support of the preliminary plan my incorporate assumptions which differ slightly from those of the final experimental plan but the general results still provide a valuable contribution in determining feasibility and expected results of the experiments.

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The complete report, entitled "Comprehensive Field Study Plan to Relate Pollutant Sources to Acidic Deposition: A Preliminary Study of Uncertainties," (Order No. PB 87-140 943/AS; Cost: $24.95, subject to change) will be available only from:

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