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Project Summary

Data Reduction Techniques for Aerosol Size Distribution Measuring Instruments

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Data reduction methods for the electrical aerosol analyzer (EAA) and the diffusion battery+condensation nuclei counter (DB+CNC) are presented. Both the EAA and DB+CNC can be modeled by the Fredholm Integral Equation of the First Kind. Thus, the data reduction methods for both the instruments are similar.

For the EAA, four data reduction methods are presented. First, an optimized EAA channel method is presented, in which the channel boundaries are chosen such that the response matrix can be approximated by an identity matrix. This method is applicable only for specialized applications of the EAA. The next two methods are based on two non-linear algorithms (NLIA). When using the NLIA's, no assumption regarding the form of the aerosol size distribution must be made. Finally, a curve-fitting procedure based on a simplex minimization algorithm is investigated. This method gives the parameters of unimodal or bimodal log-normal distribution which best fits the data.

The data reduction methods for both the instruments were analyzed with simulated and experimental data. For the EAA, the comparison between the different data reduction methods for the number distribution is excellent. However, for the surface and volume distributions, the agreement was only satisfactory in the size range of 0.316 to 1.0 μm. The agreement between the number distribution retrieved by the three data reduction methods for the DB+CNC was found to be good.

This Project Summary was developed by EPA's Environmental 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

In recent years, considerable interest and concern has been expressed regarding submicron aerosols. Automobile exhaust and photochemical conversion of gaseous pollutants in the atmosphere usually produce aerosols in the submicron range. These aerosols affect human health, visibility, and climate As a first step in understanding the various phenomena associated with submicron aerosols, it is essential to know their size distribution and concentration

Various methods and instruments are available for measuring the concentration and size distribution of aerosols. The diffusion battery (DB) and the condensation nuclei counter (CDC) and

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the electrical aerosol analyzer (EAA) have been used for measuring the aerosol size distribution for some time now, but no systematic comparison of their measurement capabilities has been carried out to date, due to lack of a generalized data reduction procedure which could be applied to such instruments

The objectives of this thesis are to make a systematic study of the several procedures which can be used for data reduction for aerosol size measurement instruments that can be modeled mathematically and to compare the various data reduction techniques using simulation and experimental data for the diffusion battery and the EAA. To achieve the objectives, data reduction techniques were developed both for the diffusion battery system and the EAA, and the utility of these data reduction methods was determined

During this investigation, a non-linear iterative algorithm was developed, which was faster than previous methods Another method, developed for solving the set of linear equations, consists of fitting either a unimodal or a bimodal log-normal aerosol size distribution to the measured data using a simplex minimization method. This method has also been adapted to solve the DB and EAA data reduction problem For the EAA, an optimized channel method was also developed, but it can be used only for specialized applications of the EAA, specifically only when the particle diameter is between 0.0075 μm to 0 19 μm for the aerosol.

These data reduction procedures were tested in two simulation studies. For the first, the data reduction procedures for the EAA were tested with several simulated unimodal and log-normal distributions For the second, normal random noise (mean 0, and a standard deviation of 5%, 10%, and 15%) to simulate the measurement error and the instability of the aerosol being measured was added to the expected response of the instruments for the simulated aerosol This modified response was then used as input to the EAA and DB data reduction procedures. The retrieved distributions for the second set were compared with results obtained from the first set of simulations and were found to be within +10%

Finally, submicron aerosols of di-octyl phthalate (DOP) and NaCl, generated using a Collison atomizer, were simultaneously measured by the EAA and DB+CNC The data thus obtained were analyzed using the data reduction methods developed during the course of this project For the EAA, the agreement between the various data reduction techniques for the number distribution was good For the surface and volume distributions, however, a non-linear iteration logarithm and the monodisperse sensitivity method of Liu and Pui consistently overestimated the surface and volume concentration in the last two channels The simplex minimization curve-fitting procedure, however, gave satisfactory results for all of the three weightings

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The complete report, entitled "Data Reduction Techniques for Aerosol Size Distribution Measuring Instruments," (Order No. PB 81-214 298, Cost $21 50, subject to change) will be available only from.
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