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STAFF EVALUATION OF A DRAFT RESEARCH FINAL REPORT

TITLE:	Aircraft Sampling to Determine Atmospheric Concentrations and Size Distributions of Particulate Matter and Other Pollutants over the South Coast Air Basin
CONTRACTOR:	California Institute of Technology
PRINCIPAL INVESTIGATOR:	Professor John H. Seinfeld
AMOUNT:	$199,663
DURATION:	24 Months

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I. SUMMARY

Mathematical air pollution models play an important role in the assessment of the impacts of proposed air pollution control strategies. Those models require three-dimensional inputs of air quality, meteorology, and emissions data. Surface monitoring networks offer an indication of the horizontal variability of the pollutant distribution. However, they cannot provide information on the vertical structure, which is necessary for determination of, among other things, concentrations of pollutants that may have been left over from the previous day. Such information is critical to accurate model representation of air pollution sources, transformation, and transport.

In this study, part of the 1997 Southern California Ozone Study (SCOS97-NARSTO), 12 flights were conducted with an aircraft instrumented to characterize the chemical and physical properties of aerosols in the Los Angeles basin. Collectively, the data obtained in this sampling program provide further insight into microphysical processes that govern the size, composition, and spatial and temporal behavior of aerosols in the Los Angeles basin. Coupled with the vast database collected during SCOS97-

NARSTO, these data will facilitate development of increasingly powerful atmospheric models.

II. TECHNICAL SUMMARY

Objective

The objective of this project was to determine vertical distributions, concentrations, and size distributions of particulate matter (PM) and its constituent chemical species, and to measure parameters related to visibility reduction, such as the light scattering coefficient, above the South Coast Air Basin (SoCAB).

Background

Southern California has long struggled to comply with State and federal air quality standards. Faced with a steadily increasing population and tightening ozone and particulate matter standards, further emissions reductions will be necessary. Extensive atmospheric modeling efforts have provided a means for linking specific emission control scenarios with probable air quality outcomes. However, the complex terrain and meteorology associated with southern California, coupled with inherent uncertainties in model input fields, complicates these efforts. Previous aircraft-based measurements have demonstrated that vertical transport in the Los Angeles area is not consistent with the simple representation of a mixed layer trapped below a temperature inversion. Recently, three-dimensional meteorological models have provided further insight into mechanisms responsible for formation of distinct pollution layers that exist for extended periods of time above the Los Angeles basin. Successful prediction of ground-level concentrations can only be accomplished if the behavior and nature of material aloft are adequately described.

The SCOS97-NARSTO study was conducted primarily to improve our understanding of ozone and its gas-phase precursors. A smaller, but still extensive, component of the study focused on understanding the formation and evolution of the atmospheric aerosol. The expanded monitoring network in place for the ozone study facilitated interpretation of aerosol measurements. As part of the aerosol component of

SCOS97-NARSTO, a research aircraft was utilized during August and September of 1997 to provide a three-dimensional characterization of the Los Angeles aerosol. This report presents a description of the measurements obtained by that aircraft during the study period, and an analysis of the impact the aerosol column may have on key gas-phase photolysis rates involved in ozone production.

Project Summary

Between August 27 and September 12, the Pelican aircraft was operated by the Center for Interdisciplinary Remotely-Piloted Aircraft Studies (CIRPAS), a consortium that included the Office of Naval Research, the Naval Postgraduate School, the California Institute of Technology, and Princeton University. To address a number of issues related to aerosol properties and distribution, a range of flight plans were employed. Although flight patterns varied, each entailed a combination of ascending and descending spirals, and constant altitude orbits and traverses. Aerosol composition (elemental carbon, organic carbon, sulfates, nitrates, ammonium, chloride, and trace elements) was determined using three parallel filter samplers. Filter sampling for aerosol composition was performed on a 1-hour sampling duration. For a typical 8-hour flight mission, this allowed for about 7 to 8 series of filter samples per mission.

Aerosol size distributions for particles between approximately 10 nanometers (nm) and 20 micrometers (μm) were measured with ~ 1 minute time resolution by a differential mobility analyzer and two optical particle counters. Direct measurement of aerosol optical properties was achieved through the use of an absorption photometer and three integrating nephelometers. To test the consistency of the various measures of the aerosol, a range of closure comparisons were performed.

The results of this research project indicate that the aerosol present over the Los Angeles Basin exhibits a complex three-dimensional structure. Vertically resolved data suggest that pronounced elevated layers present over the inland areas were formed through injection of aerosol above the ground-level polluted layer along the southern edge of the San Gabriel Mountains, followed by advection towards the coast through incorporation into the sea breeze return flow. Additional layers were observed about 500 meter (m) above sea level (asl) off the coast of Santa Monica, and approximately 2500 m asl over El Monte and Long Beach. Data from spirals flown over El Monte, Fullerton, and Riverside, on several flights, over the three-week sampling period were used to provide a limited statistical description of the vertically-resolved aerosol at each location. In general, it was found that variability over time exceeded variability among locations. Constant altitude circles flown over Diamond Bar, Mira Loma, and Riverside yielded evidence of gradients in aerosol concentration sufficient to cause over 50 percent variability within a 5 x 5 kilometer computational grid cell commonly used in atmospheric models.

Data from spirals flown over El Monte during several flights, as well as from spirals flown over several locations on August 28, were used as input to a one-dimensional radiative transfer model to analyze the impact of the aerosol on important photolysis rates in the photochemical generation of ozone. On average, the aerosol was predicted to cause a slight decrease (0-2%) in photolysis rates in the first 100 m above ground-level, relative to aerosol-free conditions, but led to a more pronounced (up to ~5%) increase above that height. Collectively, the data obtained in this sampling program provide further insight into microphysical processes that govern the size, composition, and spatial and temporal behavior of the Los Angeles aerosol.

III. STAFF COMMENTS

The results of the SCOS97-NARSTO Caltech aircraft sampled aerosols exhibited a complex vertical structure possessing multiple elevated aerosol layers. The overall picture that has been obtained from these airborne observations is of a highly complex aerosol structures which is not consistent with the simple consideration of a mixed layer, in contact with the ground, that is trapped below a temperature inversion. Additional measurements are necessary to determine whether the presence of these strong gradients follows a diurnal pattern.

Staff from the Research Division and Planning Technical Support Division reviewed a previous draft of this final report and changes were made in accordance with staff's suggestions. This project was well conceived and executed. The report is well written and complete, with careful attention to detail.

IV. STAFF RECOMMENDATIONS

Staff recommends the Research Screening Committee accept this draft final report, subject to the any further changes that may be required by the Committee.