

MEASUREMENTS OF THE AEROSOL LIGHT-SCATTERING COEFFICIENT AT AMBIENT AND 85% RELATIVE HUMIDITY ON THE ONR PELICAN DURING ACE-2

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LONG TERM GOALS

The ultimate goal of this project is to elucidate the impact of ambient relative humidity (RH) on the optical properties of the aerosols encountered in and above the Marine Boundary Layer (MBL), and to do it in such a manner as to provide a basis for the parameterization of the impact of RH on satellite retrievals of aerosol properties. For example, several recent papers have suggested that the total light scattering from MBL aerosols will be a function not only of their composition but also of their initial dry size distribution (cf., Hegg et al., 1992). Hence, one would expect considerable variability in the scattering hygroscopic growth factor and a need for measurements in a number of different MBL scenarios (e.g., polluted, clean background, dust-impacted, etc.) to fully characterize the importance of RH on MBL aerosol scattering. In a similar vein, Boucher and Anderson (1996) have pointed out that, contrary to assumptions commonly made in simple two-stream radiative transfer models, the various aerosol optical parameters necessary to estimate radiative forcing by aerosols can have considerable covariance and thus must be measured jointly to produce valid parameters. There are few such measurements in the marine atmosphere. These issues can best be resolved by measurements under a variety of conditions encompassing all of the aerosol types likely to be encountered in the MBL. Simultaneous with such in-situ measurements, remote retrieval of aerosol properties by (for example) AVHRR will permit assessment of the impact of aerosol hydration on satellite retrievals and thus support development of the parameterizations alluded to above. Recent studies have shown that water of hydration can dominate the aerosol optical properties in the marine atmosphere (Hegg et al., 1997). The refinement of aerosol retrievals by explicitly accounting for the impact of water of hydration will constitute a significant advance in large-scale assessment of the impact of aerosols on radiative transfer in the marine atmosphere.

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OBJECTIVES

The objectives of the project during the first year were: 1) the fabrication and testing of a continuously sampling humidigraph to characterize the RH dependence of aerosol light-scattering, 2) the deployment of this humidigraph during ACE-2 and the acquisition of data from several different aerosol loading scenarios, 3) preliminary analysis of the ACE-2 data set. The first objective, which involved fabrication of a device compatible with the Pelican research aircraft, involved several ancillary tasks. For example, the Pelican did not have an adequate aerosol sampling inlet and it was therefore necessary, together with various other Pelican investigators, to design such an inlet. More generally, the humidigraph had to be compatible with the other instruments aboard the aircraft and with the aircraft data acquisition system.

APPROACH

Two distinct issues had to be dealt with in the course of the project during the first year. The first was the design of a humidigraph that was compatible with the light payload of the Pelican. The second was the development of a sampling strategy to address the questions we wished to answer. To deal with the humidigraph issue, we utilized two light-weight nephelometers measuring the scattering coefficient simultaneously at two different RH's, one close to ambient and the other well above ambient - the above ambient RH being achieved by a humidifier in front of the above-ambient (or "wet") nephelometer. This approach indeed produced a small, light package with the added advantage of 1 Hz continuous measurement capability (a distinct improvement on the batch sampling approach previously used on aircraft) but at the sacrifice of being able to measure the complete humidification curve. For our purposes, this trade-off was acceptable.

The sampling strategy adopted was to obtain vertical profiles of the wet and dry scattering of the aerosol over the operational altitude range of the Pelican for several different sources of aerosol and for several different concentration levels. Locations and times were selected which would coincide with the field of views of operational satellites with remote sensors capable of remote aerosol retrievals. This strategy had previously been successfully employed on other aircraft during TARFOX.

WORK COMPLETED

The Pelican humidigraph was successfully built, tested and flown during the ACE-2 experiment. Preliminary analysis suggests that 6-7 useful vertical profiles were obtained.

RESULTS

Given the brief (two months) interval since the completion of ACE-2, it is really premature to speak of conclusions and even results must be discussed in only general terms. Nevertheless, some accomplishments can be listed. The humidigraph itself operated successfully during ACE-2 and acquired data on virtually all of the missions flown. Some problems arose due to noisy power aboard the aircraft which produced spurious low flow measurements resulting in a shut down of

the system on one flight (July 9). More significantly from the standpoint of analysis, it was found that, as we had feared, the heat from the instruments in the nose pod raised the pod temperature well above ambient and thus lowered our "ambient" RH measurement well below ambient on several flights. However, while irritating, the "ambient" reading can be corrected to true ambient with the hygroscopic scattering factor we measure and measurements of the ambient temperature from the Pelican external temperature probe.

From the standpoint of our own objectives, the most useful data were the 6-7 vertical profiles obtained. These encompass clean background conditions, polluted conditions and , most interestingly, a polluted layer overlain by a dust layer out of Africa. The profiles for wet and dry scattering for this case show the polluted aerosol to be typically hygroscopic but the dust aerosol to be essentially hydrophobic (minimal RH dependence to the light scattering). It will be interesting to appraise the impact of this vertical variability in aerosol hydration on the column properties retrieved by satellite.

Concurrent with our measurements of the RH dependence of aerosol light scattering, measurements of aerosol composition were being made by Prof. Lynn Russell, of aerosol optical depth (by sun photometer) by Dr. Phil Russell, and of dry aerosol light scattering and the dry back scatter fraction by Prof. Kevin Noone. Additionally, Prof. Phil Durkee obtained satellite data for several of the vertical profiles which should permit satellite aerosol optical depth retrievals. It is our intention to collaborate with these colleagues in the interpretation of our data base.

IMPACT

Given the very preliminary state of the analysis of the ACE-2 data, we feel that it is premature to discuss impacts of this research in the sense indicated here.

TRANSITIONS

Once again, discussion of this issue would be premature.

RELATED PROJECTS

Shortly after the completion of the ACE-2 project, a field study of the aerosols in the Los Angeles Basin was undertaken with the Pelican aircraft. While not officially a part of this effort, at the request of both participants in the experiment and project officers at ONR, we left the humidigraph on the Pelican and instructed Pelican support staff in the operation of the device. We have now had a chance to look at selected samples of the data obtained in this study and a considerable amount of valid data appears to have been obtained. As time allows (we have no support for this effort) we shall reduce the data and provide project participants with information on the hygroscopic scattering factor for the Los Angeles aerosol.

Another project whose goals are related to those we had for ACE-2 is the TARFOX project. During this field experiment, measurements of the hygroscopic scattering factor for aerosols on

and just off shore of the Eastern Seaboard of the United States were obtained. We shall utilize this data for comparison with the ACE-2 data.

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