SULFATE AND MSA AEROSOL DYNAMICS IN THE MARINE BOUNDARY LAYER

P.I. - Barry J. Huebert
Department of Oceanography
University of Hawaii
1000 Pope Rd., MSB 407
Honolulu, HI., 96822
(808) 956-6896 phone; (808) 956-9225 fax
E-mail: huebert@soest.hawaii.edu

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LONG TERM GOALS

The goal of our work is to improve the Navy's ability to model the formation, processing, and removal of aerosols in the marine boundary layer, by 1) improving measurement technology, 2) characterizing (littoral) mixtures of continental and marine aerosols, and 3) making process submodels in aerosol/visibility models more realistic.

SCIENTIFIC OBJECTIVE

The importance of predicting visibility for naval operations is obvious: both targeting and concealment are major tactical concerns, for which accurate predictions are critical to battlefield superiority. Since airmass changes can make targets more visible or enable the concealment of our own resources, theater commanders need to have accurate visibility predictions upon which to base tactical decisions.

Although it has been known for centuries that marine aerosols affect visibility, we still cannot quantitatively forecast light scattering by particles in coastal areas. In part this is because small changes in relative humidity can cause huge changes in particle size and light extinction. Modeling these changes requires precise knowledge of the chemical composition of the particles vs size (and equally precise measurements against which to test the models). Coastal zone visibility is particularly complex, since mixtures of relatively clean marine air with polluted continental air create wide swings in conditions that can suddenly expose or conceal ships.

While the Navy clearly needs the capability to accurately model the optical properties of aerosols in coastal zones, predictive visibility models are presently limited by our lack of understanding of aerosol formation, transformation, and removal processes. Our group's objective is to use high-quality observations to characterize marine aerosols and to quantify the rates of processes that control their concentrations. This

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process information will then be used to make predictive models much more realistic and accurate.

APPROACH

Measuring composition vs size: We have submitted two papers (in press or in revision) to journals relating to this topic: one compares cascade impactors that are used to measure composition vs size (Howell et al., 1998); and the other uses inverted data to predict growth with humidity and light scattering for marine aerosols under a variety of conditions (Howell & Huebert, 1998). Both will be of direct use to the Navy for making accurate aerosol measurements and then using the data for improving visibility models.

ACE-1 data analysis: Although ONR did not support our participation in ACE-1 (it was a clean-marine aerosol experiment), a variety of modeling groups (including at NRL) have asked to use our data in improving their marine aerosol models. Such models are by far the Navy's best tools for predicting aerosol/visibility changes, especially in coastal and polluted regions where visibility is low. By using our data from a clean region, groups are testing their models and improving their process submodels. (The same physics operates in both clean and dirty environments, but can be quantified better in the simplicity of a clean region.) We are assembling ACE-1 data from many PIs to use in this model-improvement effort.

Coastal modifications of aerosols: We are measuring sulfate aerosols from the Kilauea Volcano as they move out over the Pacific Ocean, to understand what happens to marine and continental aerosols when they mix. This dataset will serve as a more understandable surrogate for the aerosol mixtures the Navy has to contend with in littoral combat zones.

TASKS COMPLETED OR TECHNICAL ACCOMPLISHMENTS

We published five ASTEX/MAGE papers, one Xmas Island paper, one coastal/stratiform clouds paper, and have two additional papers in press or revision concerning measurements and modeling of marine aerosols, all citing ONR support. The ASTEX/MAGE data analysis is completed. We have refurbished the Bellows AFS sampling tower and compund, so that it is now supporting the UH/ONR marine aerosol lidar and associated coastal aerosol experiments.

RESULTS

We have found that the measurement of marine aerosols is frequently plagued by artifacts, so that extra care must be taken with inlet systems to samplers. We also found that in some cases, dynamical effects like dilution can play a major role in changing particle concentrations. In the case of DMS, we found that only about 1/3 of it ultimately forms sulfate aerosols.

IMPACT

Our understanding of marine sulfur chemistry has been greatly improved by this work. Also, since our modeling of optical properties emphasized that in many cases supermicron seasalt particles do most of the light scattering, it is critical that Navy operational systems for measuring aerosols are capable of accurately measuring this difficult size range.

RELATION TO OTHER PROJECTS

We are making data and process information available to the NRL aerosol modeling group of Fitzgerald and Hoppel. We are also using data from non-ONR supported projects like ACE-1 to improve process models.