

Source Strength and Scattering Properties of Organic Marine Aerosols

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LONG-TERM GOAL

My long term goal is to quantify the role played by sea salt in radiative scattering in the marine environment. This project studies the number of aerosol particles produced from sea salt under different marine conditions. Studying the chemical composition of those particles provides important information about their behavior in the atmosphere.

OBJECTIVES

I would like to see whether the number of sea salt particles observed in field projects can be predicted by current parameterizations of particle flux based on wind speed. We will test this assumption with aircraft measurements of vertical salt gradients.

To accomplish this, I also want to improve measurements of the compositions of sea salt particles. To this end, I have developed two methods of measuring sea salt by sodium mass distributions and by filter analysis for chemical composition.

APPROACH

We have deployed a new salt particle counter to make direct measurements of sea salt more accurately as part of the PELTI field experiment. We are continuing calibrations and are evaluating ways to improve the time response and sensitivity of the instrument.

We have compared the results of the salt particle counter to the chemical composition determined by chemical analysis with Fourier Transform Infrared (FTIR) spectroscopy and x-ray fluorescence (XRF) from the PELTI experiment.

WORK COMPLETED

This year we have completed a set of field measurements from the NCAR C130 at multiple altitudes near St. Croix during June 2000. The measurements indicate sea salt concentrations from sodium mass distributions and from chloride by XRF. The presence of organics in sea salt is measured by FTIR. These results are included in a manuscript that is currently being prepared.

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Additional sea salt composition measurements were collected for XRF and FTIR analysis during DYCOMS II in July 2001 near San Diego aboard the NCAR C130.

Calibrations of the XRF/FTIR technique are completed. Efficiency of particle concentration by virtual impactors in series has been characterized. Calibration of the salt particle counter has yielded initial data on the time response and sensitivity; modifications are underway to improve the sensitivity for shipboard deployment.

A model describing the interactions of organic compounds and electrolytes has been constructed to predict the hygroscopic properties of organic-containing sea salt particles.

RESULTS

Our measurements of sea salt particles from PELTI show that organic species account for significant fractions of the particle mass. These measurements were collected with a three-stage particle concentrator to allow detection of particles at low concentrations from aircraft. The composition was then analyzed by FTIR and XRF and is summarized in Fig. 1.

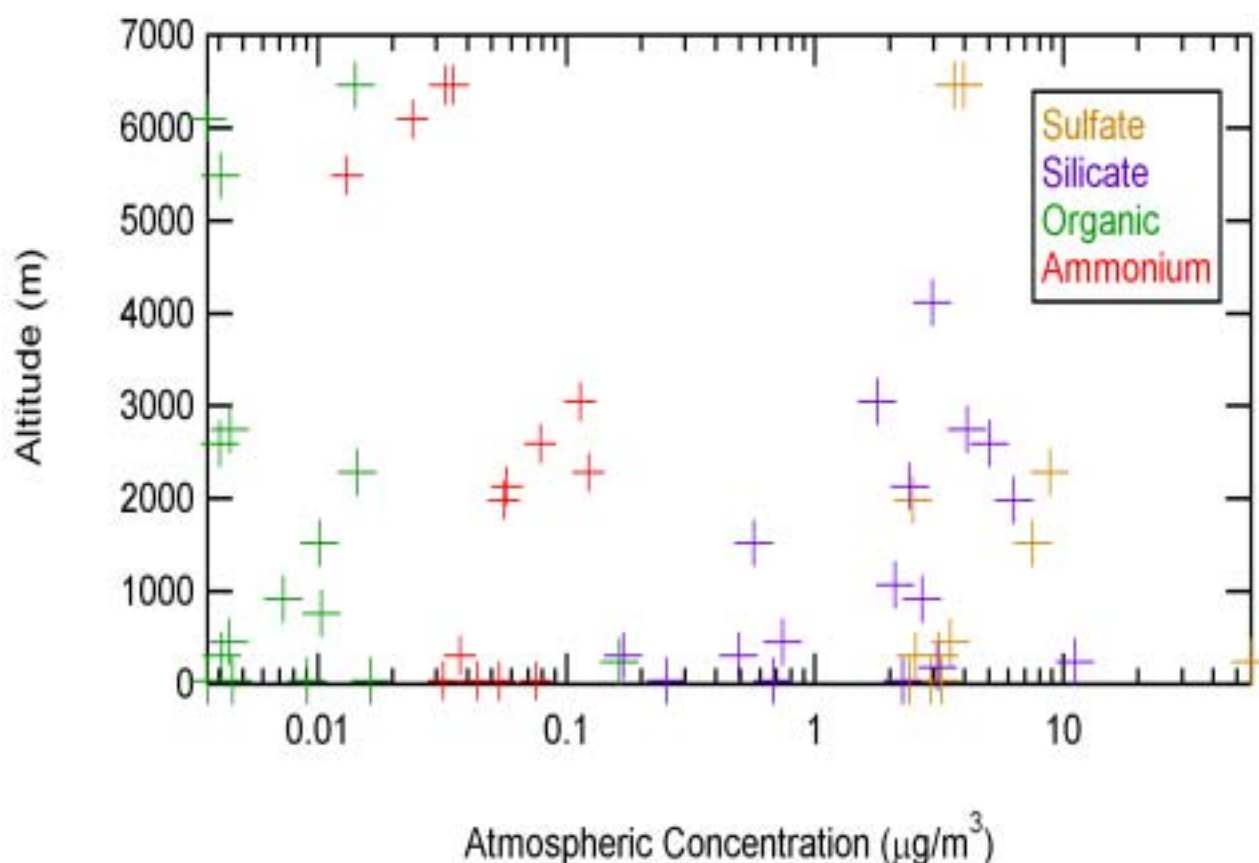


Figure 1. Composition of particles with altitude measured from the NCAR C130 with a three-stage particle concentrator. Composition shows significant organic concentration at low altitudes in clean marine conditions.

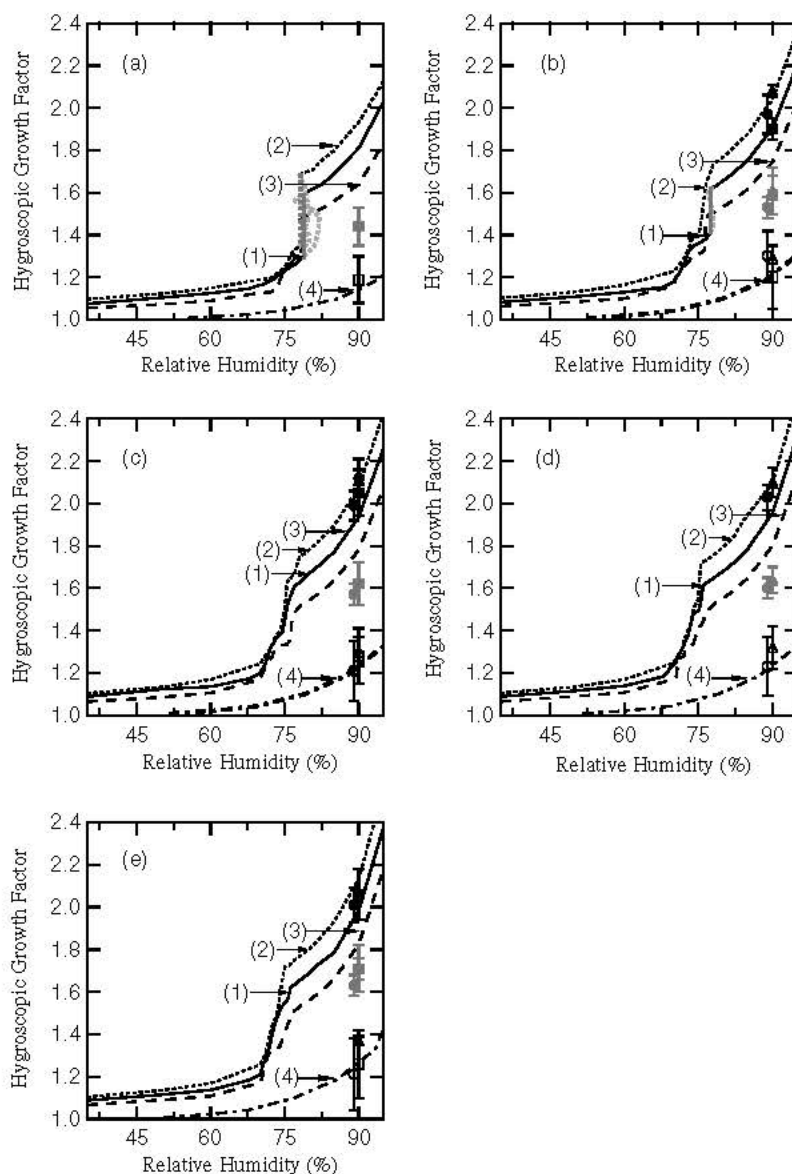


Figure 2. Predicted hygroscopic growth of particles with varying organic contents at a range of particle sizes. The sizes shown are (a) 15 nm, (b) 35 nm, (c) 50 nm, (d) 75 nm, and (e) 165 nm. The compositions shown are (1) 30% organic species and 70% inorganic salts (base case, solid line), (2) a lower organic content case of 10% organic species and 90% inorganic salts (dashed-dotted-dotted line), (3) a higher organic content case of 50% organic species and 50% inorganic salts (dashed line), and (4) a 100% organic content case (dashed-dotted line). For curves with multiple equilibria near deliquescence in Figures a and b, shaded lines show the deliquescence path and shaded dotted lines show unstable equilibria. In addition, the plot illustrates recent measurements of ambient particle growth from field project data reported by Berg et al.[1998] (ACE1, triangles), Swietlicki et al.[2000] (ACE2, circles), and Zhou et al.[2001] (AOE, squares). The particles were grouped by those authors as particles similar to sea salt (solid symbols), particles that are more hygroscopic than sulfate (shaded symbols), and particles that are less hygroscopic than sulfate (open symbols). The error bars on the symbols indicate the standard deviation for each category during the project.

For the seawater organic species found in sea salt, our modeling shows that the presence of only 30% organic species in atmospheric particles at relative humidities higher than 50% reduces the predicted hygroscopic growth for an equilibrium internal mixture by 15% from the growth predicted for purely inorganic sea salt (shown in Fig. 2). Organic mass fractions of 50% or higher reduce growth by 25% compared to inorganic sea salt or eliminate water uptake entirely in subsaturated conditions. This effect may have important implications for particle behavior used for calculating global aerosol optical depths, since the magnitude is comparable to the inorganic composition differences studied by Adams et al. [1999]. Comparison to ambient hygroscopic growth factor measurements suggests that organic fractions of 10% to 30% are consistent with measured hygroscopic growth of ambient particles. Significant uncertainties remain in the identification of the exact speciated composition of organic particles of marine origin. In addition, the behavior of the majority of existing organic species are not well characterized in complex mixtures with electrolytes in water. The sensitivity studies suggest that while the magnitude of the effect will vary with the exact speciated composition, the largest uncertainty lies in identifying the fraction of organic mass in the particle and the proportion of that organic mass that is soluble, slightly soluble, or insoluble.

IMPACT/APPLICATION

The primary application of our instrument development work is that we will now be able to measure simultaneous mass and sodium distributions. This technique provides us with an unambiguous way to measure the ambient concentrations of sea salt particles.

Our new particle concentrator will be useful for a number of chemical composition measurements, including the FTIR/XRF techniques employed here.

TRANSITIONS

Our filter data will be published and distributed via project databases.

RELATED PROJECTS

No new related projects.

REFERENCES

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PUBLICATIONS

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