NOAA Pacific Marine Environmental Laboratory
Atmospheric Chemistry Group

Determining the Impact of Tropospheric Aerosol Particles on Climate and Air Quality using Shipboard Observations

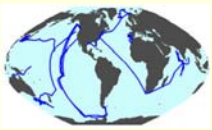
Scientific Questions

PMEL's Atmospheric Chemistry Program addresses NOAA's mission to understand and predict changes in Earth's environment to meet our Nation's economic, social and environmental needs. Our research is driven by two main scientific questions:

- How do aerosols evolve as they are transported away from the source region and what impact does this evolution have on the remote atmosphere?
- How do tropospheric aerosol particles that are produced within or transported to a particular region affect regional air quality and aerosol radiative forcing of climate?

Research Strategy

We are addressing these questions with shipboard observations of aerosol properties around the world. These measurements provide our customers (air quality and climate modelers) with web based data sets of aerosol properties which allows for the parameterization of key aerosol processes in air quality and climate models and the reduction of model uncertainties.



Atmospheric Chemistry Group research cruises 1992-2008

Linkages to NOAA's Strategic and Research Plans

NOAA **Strategic** Plan - Performance Objectives

- Describe and understand the state of the climate system through integrated observations, analysis and data stewardship.

NOAA **Research** Area and Milestones

Document and understand changes in climate forcings and feedbacks, thereby reducing uncertainty in climate projections.

- Execute field missions to understand the transport and properties of absorbing aerosols and their precursors to the Arctic polar region as a part of the International Polar Year. [Participated in ICEALOT onboard RV Knorr]
- Initiate cloud/aerosol interaction field study. [Performed *in situ* aerosol and cloud condensation nuclei measurements during GoMACCS and ICEALOT]
- Reduce uncertainty in model simulations of the influence of aerosols on climate. [See Recent Accomplishments]

Provide information to air quality decision makers and improve NOAA's national air quality forecast capability.

- Conduct field campaign to characterize wintertime particulate matter formation and growth. [Participated in LIAQS onboard RV Knorr]
- Conduct field campaign in California to characterize drivers of poor air quality. [Will lead shipboard component of CalNex2010 – see Future Directions]

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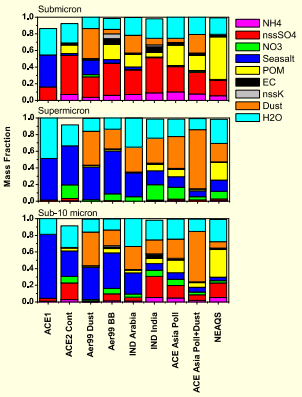
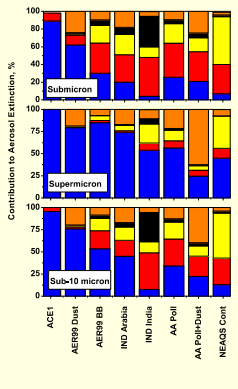
Recent Accomplishments

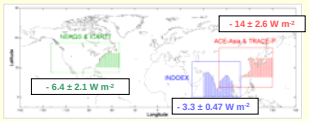
Comparison of regional aerosol properties to constrain climate models



Comparing aerosol properties measured on cruises since 1995 (ACE 1, ACE 2, Aerosols99, INDOEX, ACE-Asia, and NEAQS) has improved our understanding of the relative importance of aerosol sources that impact each region and the resulting aerosol chemical and optical properties. Compilation and publication of the regional data on web-based servers has allowed for easy access to the data for use as input to or validation of chemical transport and radiative transfer models (Quinn and Bates, 2005).

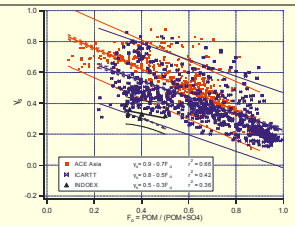


As part of the Climate Change Science Program (CCSP), measurements made during intensive field campaigns were used to constrain radiative transfer calculations of direct climate forcing. The resulting top of the atmosphere direct climate forcings were on average, 37±7% larger than those obtained using *"a priori"* optical properties (Bates et al., 2005).



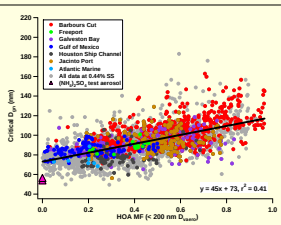
Development of aerosol parameterizations for use in air quality and climate models

Measurements made during intensive field campaigns (INDOEX, ACE Asia, ICARTT) have been used to develop quantitative parameterizations of the humidity dependence of scattering by sulfate-organic (POM) mixtures for input to or assessment of radiative transfer models. Through this approach knowledge gained from field campaigns has led to improved estimates of direct climate forcing (Quinn et al., 2005).



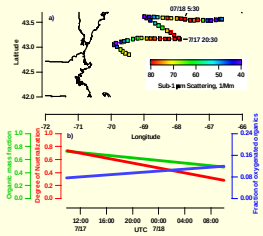
The relative humidity dependence of aerosol light scattering decreases with increasing mass fraction of particulate organic matter (POM).

In situ measurements that determine the role of aerosol properties in particle activation are needed to improve estimates of cloud droplet formation by global climate models. The measurements made during GoMACCS showed that both composition and size are required for accurate estimates of cloud condensation nuclei (CCN) concentrations. Including the HOA (organic) mass fraction in models can increase the accuracy of estimates of CCN by more than 50% over the assumption of a fixed global mean organic aerosol concentration (Quinn et al., 2008).



The critical size for particle activation increases with increasing mass fraction of hydrocarbon-like organic aerosol.

Results from NEAQS 2004 and TexAQS 2006 have improved our understanding of the effects of aerosol sources and aging on aerosol properties that impact direct climate forcing and regional air quality (Quinn et al., 2006; Bates et al., 2008).



The top panel shows the NEAQS cruise track colored by aerosol light scattering. The red portion indicates plume location. The bottom panel shows changes in aerosol properties along the cruise track as the distance from the source region increases. These data, which are available on our web-based server, are ideal for chemical transport model validation.

Future Directions

We will continue bi-annual air quality/climate cruises to investigate aerosol distributions, properties, and processes in new regions around the globe. The 2010 experiment will take place off the coast of California in conjunction NOAA/ESRL/CSD and NOAA aircraft. We will be working with the California Air Resources Board and the California Energy Commission to assess regional air quality and climate. The data we collect will be made available through our web-based data server.

We are working toward expanding our sea-level based measurements to the atmospheric column above the ship using unmanned aircraft systems (UASs). We currently are developing technology to launch and retrieve the UAS from a moving ship and instruments to measure aerosol properties from the UAS platform.