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

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 2 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 the tropospheric aerosol particles that are produced within or transported to a particular region affect regional air quality and aerosol radiative forcing of climate?

Linkages to the NOAA Strategic Plan and Research Plan

NOAA **Strategic** Plan - Performance Objectives:

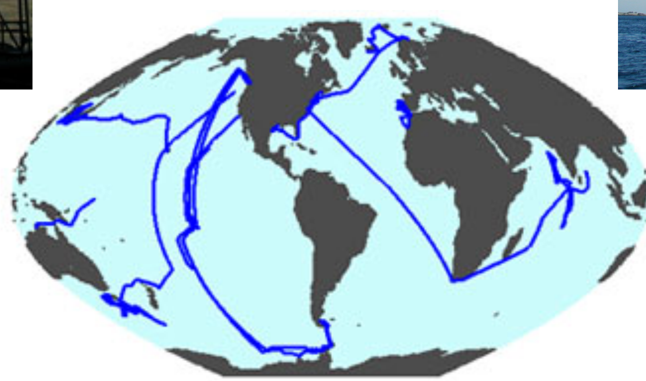
- Describe and understand the state of the climate system through integrated observations, analysis and data stewardship.
- Improve predictability of the onset, duration, and impact of hazardous and high-impact severe weather and water events.

NOAA **Research** Area and Milestones

- Document and understand changes in climate forcings and feedbacks, thereby reducing uncertainty in climate projections.
    - Execute filed 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.
    - Initiate cloud/aerosol interaction field study.
    - Reduce uncertainty in model simulations of the influence of aerosols on climate.
- 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.
    - Conduct field campaign in California to characterize drivers of poor air quality.

Research Strategy

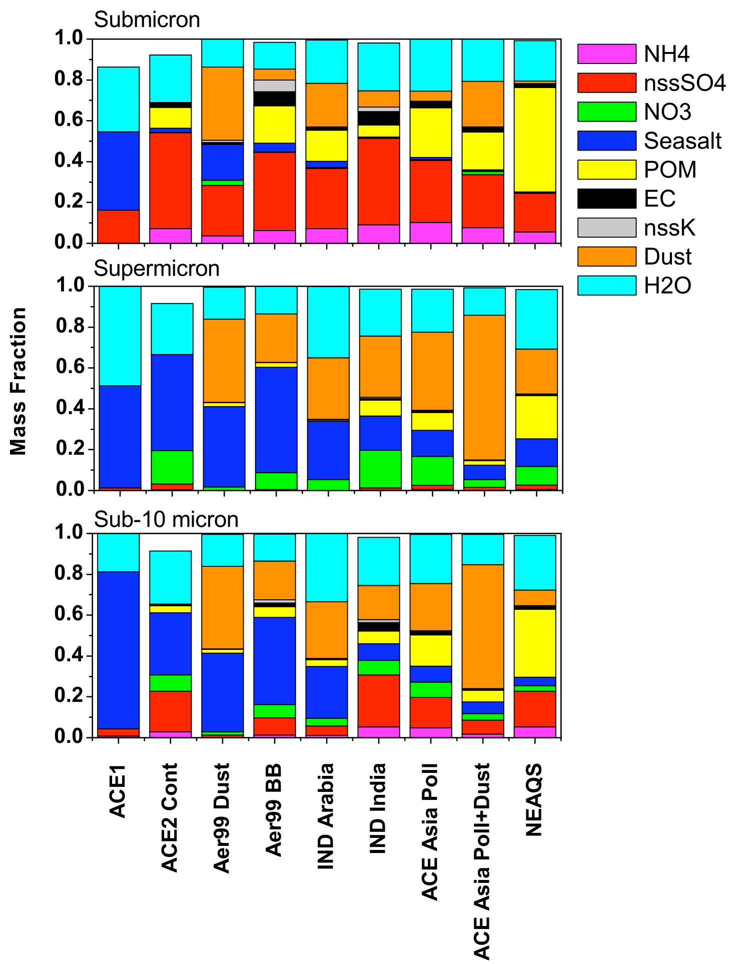
We are addressing these questions with shipboard observations of aerosol properties around the world. These measurements provide our customers (air quality and climate modelers) with web based data sets of aerosol properties which allows for the parameterization of key aerosol processes in air quality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



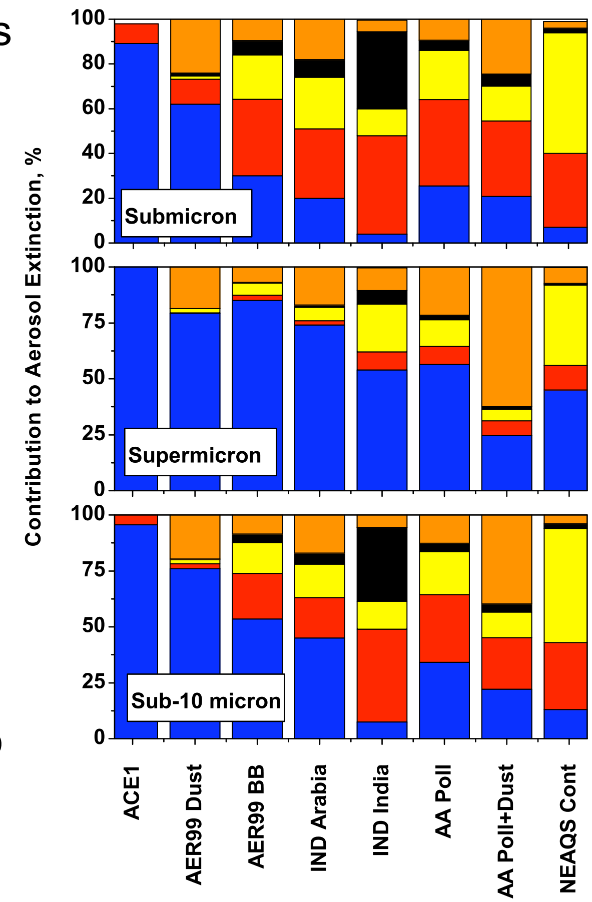
Atmospheric Chemistry Group research cruises 1992-2008

Recent Accomplishments:

- **Comparison of regional aerosol properties to constrain climate models:**



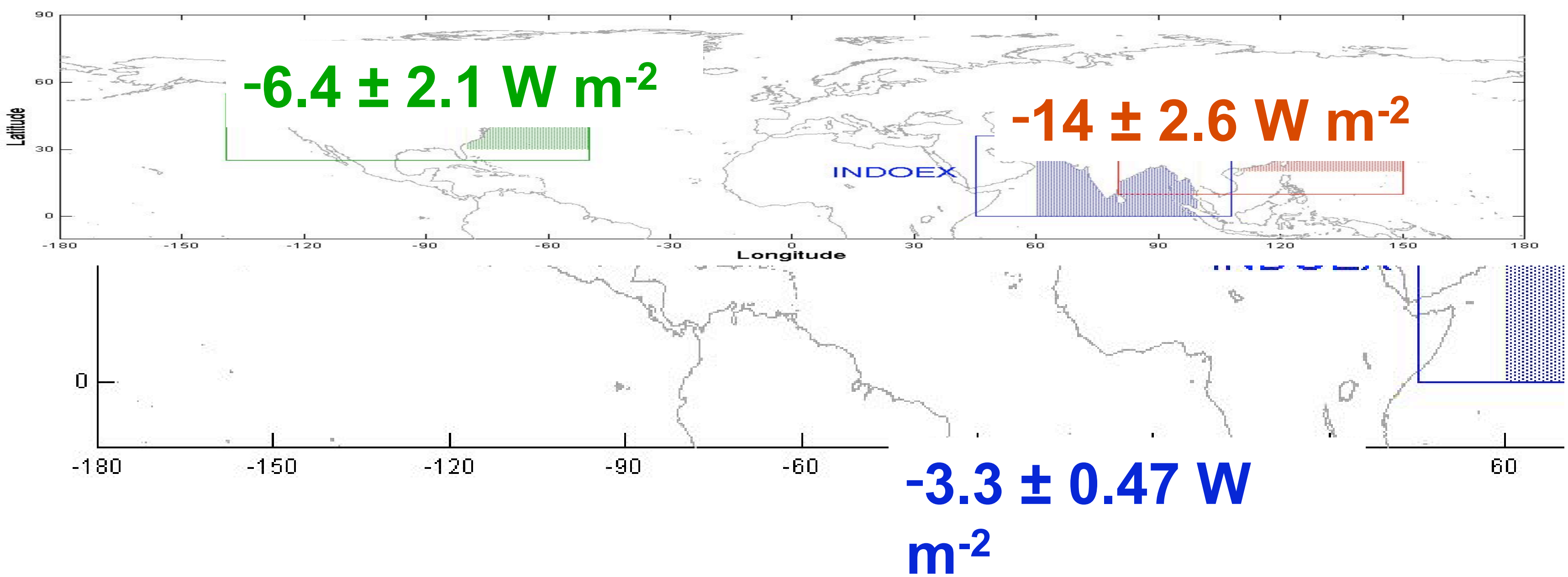
Comparing aerosol properties measured on cruises since 1995 (ACE 1, ACE 2, Aerosols99, INDOEX, ACE-Asia, and NEAQS) has improved our understanding of the relative importance of aerosol sources that impact each region and the resulting aerosol chemical and optical properties. Compilation and publication 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 models (Quinn and Bates, 2005).



Recent Accomplishments:

- **Comparison of regional aerosol properties to constrain climate models:**

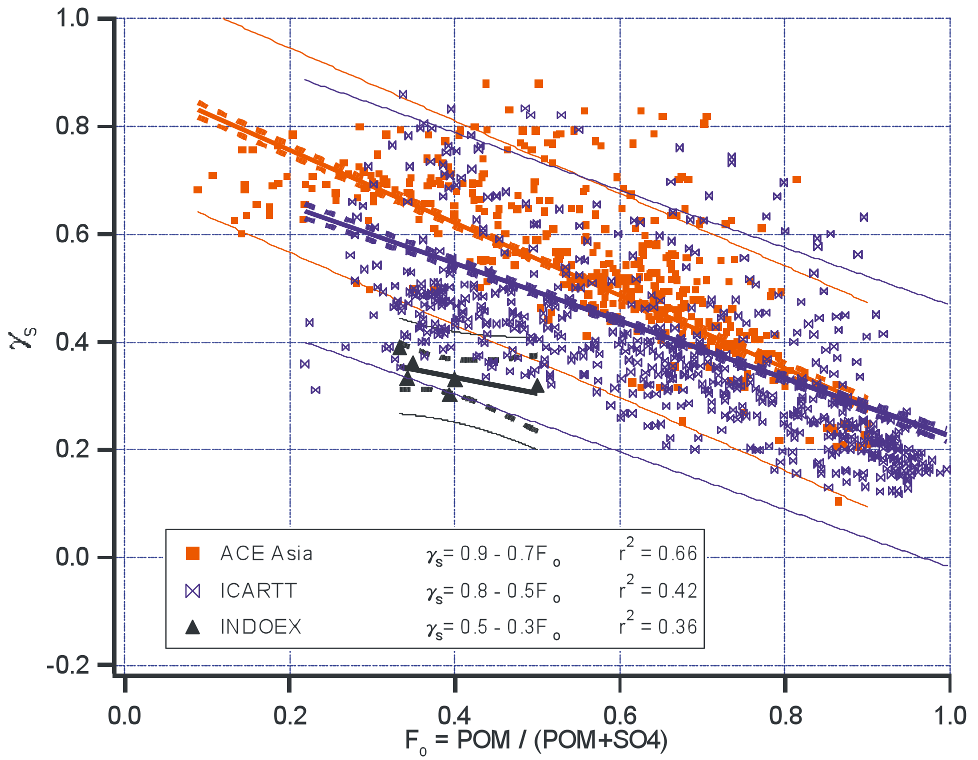
  As part of the Climate Change Science Program (CCSP), these measurements were used to constrain radiative transfer calculations of direct climate forcing. The resulting top of the atmosphere direct climate forcings were on average, 37±7% larger than those obtained using the *"a priori"* optical properties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



Recent Accomplishments:

- **Development of aerosol parameterizations for 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).

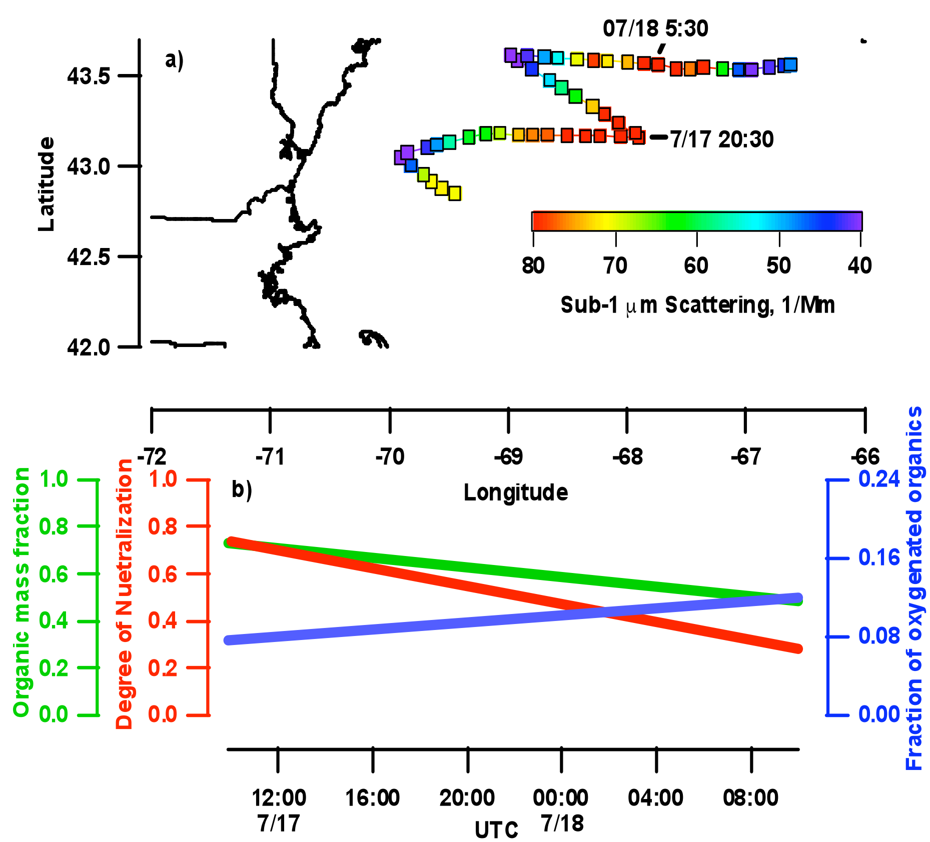


The relative humidity dependence of aerosol light scattering decreases with increasing mass fraction of particulate organic matter (POM).

Recent Accomplishments:

- **Development of aerosol parameterizations for air quality and climate models:**

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).

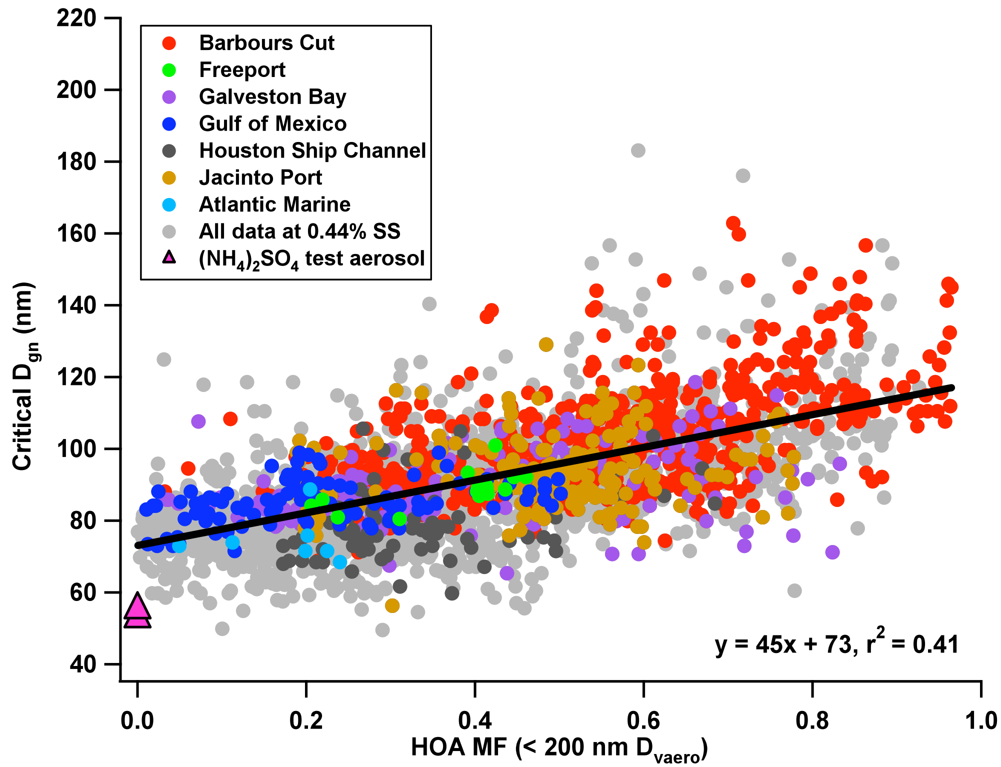


Top panel shows the NEAQS cruise track colored by aerosol light scattering. The red portion indicates plume location. Bottom panel shows changes in aerosol properties along the cruise track as the distance from the source region increases.

Recent Accomplishments:

- **Development of aerosol parameterizations for air quality and climate models:**

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 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.

Future direction:

- Continue bi-annual air quality/climate cruises to explore aerosol distributions, properties, and processes in new regions around the globe. The 2010 experiment will take place off the coast of California.
- Expand our sea-level based measurements to the atmospheric column above the ship using unmanned automatic systems (UASs).