NOAA Pacific Marine Environmental Laboratory
Atmospheric Chemistry Group

Arctic Chemistry and Climate

Scientific Questions

PMEL's Arctic Chemistry and Climate research 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:

- ❑ What are the sources and concentrations of short-lived pollutants in the Arctic and how are these changing with time?
- ❑ What is the role of these pollutants in the accelerated warming of the Arctic?

Research Strategy

Monitor and Observe. We conduct long-term measurements of aerosol chemical composition at sites in Alaska to identify sources of pollutants to the Arctic and how sources and concentrations are changing over time. These sites include Barrow, Denali National Park, Poker Flat Rocket Range, and Homer.

Understand and Describe. We led an intensive field campaign known as ICEALOT onboard the RV Knorr (joint with ESRL) to study processes controlling the aerosol chemical composition in the Arctic.

Assess and Predict. With international colleagues we have led workshops and written state of knowledge papers on the impacts of Short Lived Pollutants on Arctic Climate. In addition, we contributed to the 2006 AMAP (Arctic Monitoring and Assessment Programme) assessment of Acidifying Pollutants, Arctic Haze, and Acidification in the Arctic.

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 ICEALOT]
- Reduce uncertainty in model simulations of the influence of aerosols on climate.

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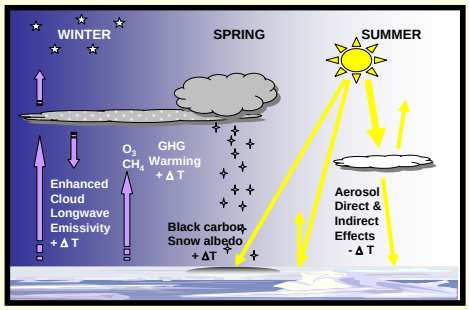


Forcing mechanisms in the Arctic environment resulting from the poleward transport of mid-latitude gas and particulate phase pollutants. ΔT indicates the surface temperature response.

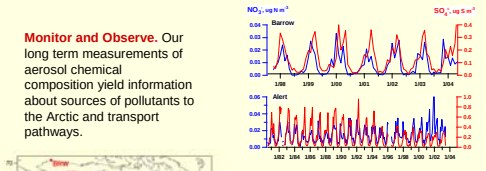
Background

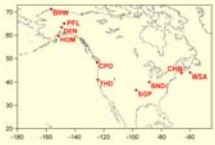
Arctic temperatures have increased at almost twice the global average rate over the past 100 years (IPCC, 2007). Arctic warming is primarily a manifestation of global warming, such that reducing global-average warming will reduce Arctic warming and the rate of melting. Reductions in the atmospheric burden of CO_2 are the backbone of any meaningful effort to mitigate climate forcing. But even if swift and deep reductions were made, given the long lifetime of CO_2 in the atmosphere, the reductions may not be achieved in time to delay a rapid melting of the Arctic. Hence, the goal of constraining the length of the melt season may best be achieved by targeting shorter-lived climate forcing agents. Addressing these species has the advantage that emission reductions will be felt immediately.

These species include methane, tropospheric ozone, and tropospheric aerosols. Calculations indicate that the forcings due to these short-lived pollutants lead to a positive surface temperature response indicating the need to reduce emissions of these species within and outside the Arctic (Quinn et al., 2008). Additional aerosol species may also lead to surface warming if the aerosol is coincident with thin, low lying clouds.

Recent Accomplishments

Monitor and Observe. Our long term measurements of aerosol chemical composition yield information about sources of pollutants to the Arctic and transport pathways.





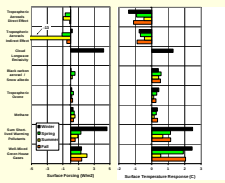
North American NOAA/PMEL aerosol sampling stations

Seasonality in particulate concentrations of nitrate and sulfate at Barrow, AK and Alert, Canada are shown above. Concentrations are at a maximum each winter and spring when pollutant transport to the Arctic is most efficient. These long term records show that sulfate concentrations are decreasing in the Arctic due to cleaner coal burning technologies. In contrast, nitrate concentrations are increasing due to increasing numbers of motor vehicles in source regions.

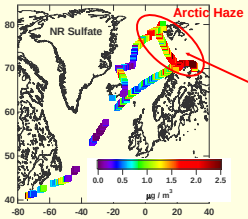
Assess and Predict. The PMEL Atmospheric Chemistry Group has participated in the Arctic Monitoring and Assessment Programme in preparing assessments on pollution in the Arctic with the goal of guiding policy decisions of nations within the Arctic Council.

In addition, we have helped organize international workshops focused on defining the role of short lived pollutants in the accelerated warming of the Arctic and determining mitigation strategies

Shown in the figure to the right are seasonally averaged values of radiative forcing and temperature response at the surface averaged over 60º to 90ºN due to short-lived pollutants. The forcing and response due to the sum of short-lived warming pollutants is compared to that of the sum of the well-mixed greenhouse gases. Although these calculations are in need of refinement, they indicate the potentially significant role of short-lived pollutants in the accelerated warming of the Arctic (Quinn et al., 2008).



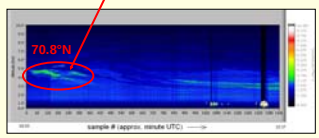
Understand and Describe. ICEALOT, the International Chemistry Experiment in the Arctic Lower Troposphere, was led by PMEL onboard the RV Knorr during March and April of 2008. The cruise track (see figure to the right) included regions of the Greenland, Norwegian, and Barents Seas. Measurements of atmospheric gas and particulate phase species were made to determine springtime sources and transport pathways of pollutants to the Arctic, chemical evolution of aerosols and gases within the Arctic, and the climate impacts of particulate haze and tropospheric ozone in the Arctic.



ICEALOT cruise track colored with the concentration of particulate sulfate. Concentrations of sulfate were largest in the high Arctic indicating the presence of Arctic Haze or pollution from the northern mid-latitudes.

ICEALOT March – April 2008

- Smelter emissions from Kola Peninsula
- Marine vessel emissions
- Calipso (spaceborne lidar) validation
- **Arctic Haze**
- **Biomass burning from E. Europe**



Future Directions

- Continue long-term measurements at all Alaska sites to document changes in sources and concentrations of short-lived pollutants in the Arctic.
- Continue working with our customers (climate modelers, AMAP, the Arctic Council, policy makers) to provide a solid science foundation for climate predictions and short-lived pollutant mitigation strategies.