Characterization of Ice Nucleating Particles at the Western US Coast

Katherine Rocci[1], Christina McCluskey[2], Thomas Hill[2], Paul DeMott[2], and Sonia Kreidenweis[2]

[1]Department of Earth Sciences, University of New Hampshire, Durham, NH, [2]Department of Atmospheric Science, Colorado State University, Fort Collins, CO

Overview and Significance

Our Project

• Characterize ice nucleating particles (INPs) at a coastal site in the Western US with particular focus on variability attributed to air mass types

Significance

•The Western US depends on winter precipitation for water resources

• INPs influence the formation and distribution of precipitation by clouds, even during Atmospheric River events[1, 2, 3]

•INPs are a significant factor in the role of cloud forcing in changing climate, and thus have an important effect on model outcomes[2]

Data Collection

Bodega Bay, CA
January 15-March 9, 2015

Figure 1: View of Bodega Marine Laboratory from G1 aircraft

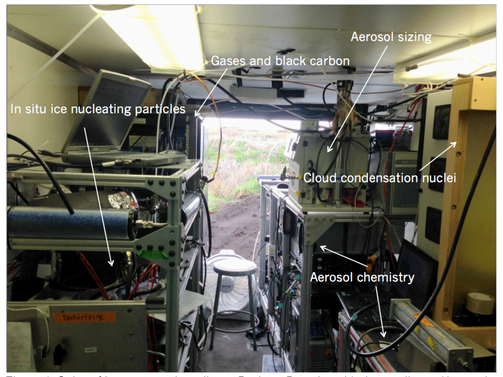


Figure 2: Suite of instruments in trailer at Bodega Bay site with data collected by each

Instruments Used:

- Aerosol Time-of-Flight Mass Spectrometer
- Scanning Mobility Particle Sizer Spectrometer
- Aerodynamic Particle Sizer Spectrometer
- Aethalometer
- Continuous Flow Diffusion Chamber
- Aerosol Filters for INP Measurement

Methods

Characterizing Air Masses

•Analyzed on-line data from site to determine dominant aerosols types during each filter period

Ice Spectrometry

•Filters analyzed on CSU's Ice Spectrometer

•Heat treatment (95°C) to test for biological INPs

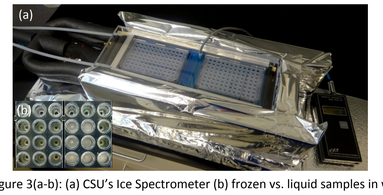


Figure 3(a-b): (a) CSU's Ice Spectrometer (b) frozen vs. liquid samples in wells of IS

HYSPLIT Trajectories

- NOAA's HYSPLIT model to determine source locations of air masses

References:

[1] Creamean and Suski et al., Dust and Biological Aerosols from the Sahara and Asia Influence Precipitation in the Western US. *Science*. **339**, 6127, (2013). [2] DeMott et al., Predicting global atmospheric ice nuclei distributions and their impacts on climate, *PNAS*. **107**, 25, (2010). [3] Pöschl et. al, Rainforest aerosols as biogenic nuclei of clouds and precipitation in the Amazon, *Science*. **329**, 17, (2010).

Results and Discussion

Overall Findings

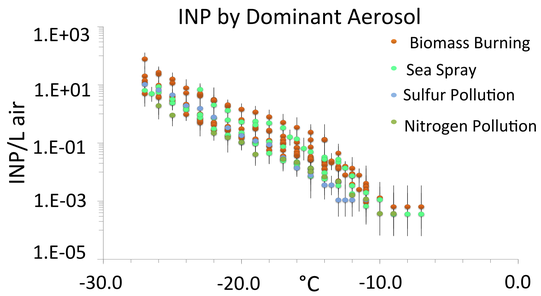


Figure 4: Concentration of INP versus temperature grouped by the dominant aerosol.

- 20-fold range in INP concentrations
- INP number concentrations in polluted air lower
- Biomass burning exhibits largest variability

Coastal Sea Spray INPs

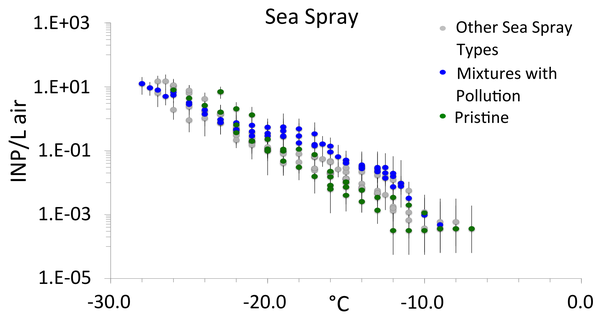


Figure 5: Concentration of INP versus temperature for filters dominated by sea spray.

- 20-fold range in INP concentrations
- Mixtures exhibit higher INP concentrations than pristine aerosols

Influence of Aerosol Abundance and Type

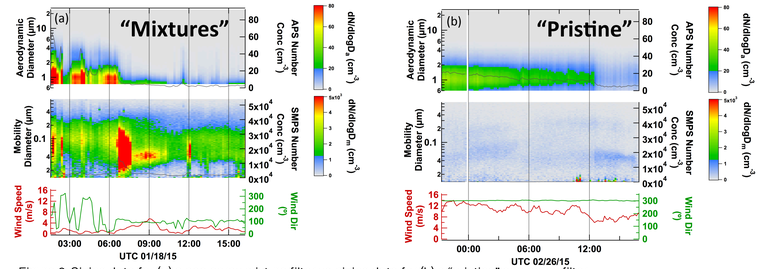


Figure 6: Sizing data for (a) a sea spray mixture filter vs. sizing data for (b) a "pristine" sea spray filter.

Influence of Air Mass Origin

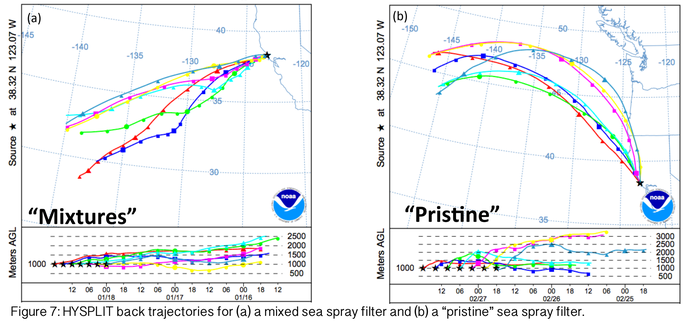
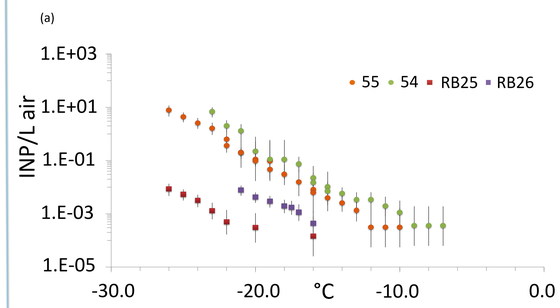


Figure 7: HYSPLIT back trajectories for (a) a mixed sea spray filter and (b) a "pristine" sea spray filter.

- Aerosol origin, type, and abundance accounts for some variability in sea spray dominated filters

Coastal Sea Spray INP vs. Open Ocean INP



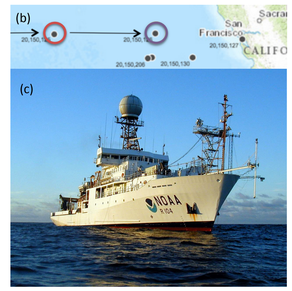


Figure 8(a-c): (a)Number of INP vs. temp for two filters dominated by "pristine" sea spray. "RB" series (squares) represent ship samples of relatively pure sea spray. (b) Ship's path, red circle corresponds to ships position at the end of the sampling period for the red squares and the purple circle does the same for the purple squares. (c) Photo of the ship sampling was done on, named "Ron Brown".

- Possible contributions of terrestrial INP to "pristine" sea air
- Ocean has lower emissions per area than land

Effect of Biological Aerosols on INP in Sea Spray

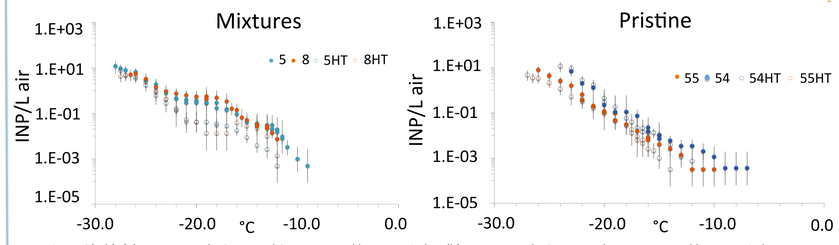


Figure 9(a-b): (a) Heat-treated BOBA5 and 8 represented by open circles. (b) Heat-treated BOBA54 and 55 represented by open circles.

- Lower concentrations of INPs in heat-treated samples indicate biological influence
- Mixed air masses possess more biological INP (active to -21°C) than pristine sea spray (active to ~-15°C)

Conclusions

•Terrestrial sources tend to have higher concentrations of INPs than marine sources

•Terrestrial influence may impact marine INP concentrations

•Ocean-specific INP parameterization likely needed for oceanic emissions

•Greater variability within air mass types than between types

•Variability within possibly due to mixed air masses and/or aerosol loading

•More biological INPs in mixed air masses than in pristine sea spray aerosols

Acknowledgments

Thank you to Kaitlyn Suski for her help decoding the ATOFMS. Thank you to all the people who worked on the CalWater2 field campaign. This work has been supported by National Science Foundation grants No. AGS-1450760, AGS-1450690, and AGS-1451347. Ship collections were supported by the Office of Biological and Environmental Research of the U.S. Department of Energy as part of the Atmospheric Radiation Measurement Climate Research Facility. This work has been supported by the National Science Foundation Research Experiences for Undergraduates Site in Climate Science at Colorado State University under the cooperative agreement No. AGS-1461270.