Ph.D. Defense Announcement
Kathryn Moore
Monday, October 16, at 12:00 pm

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Defense
CIRA Commons or Teams

Post Defense Meeting
ATS West Conference Room (215 ATS West)

Committee:
Sonia Kreidenweis (Advisor)
Paul DeMott (Co-advisor)
Jeffrey Pierce
Susan van den Heever
Delphine Farmer (Chemistry)

Marine ice nucleating particles: sources, composition, emissions, and model parameterizations

Sea spray aerosol has received increasing attention over the last decade as a source of ice nucleating particles (INPs) to the atmosphere. Sparse measurements in remote marine regions indicate both marine INP concentrations and ice nucleating efficiency are several orders of magnitude lower than those of mineral or soil dusts, which dominate the INP budget on a global scale. The Southern Ocean (SO) surrounding Antarctica is thought to be the only region where marine INPs are the predominant INP type due to its remoteness from continental and anthropogenic aerosol sources and persistent strong westerlies, although several recent studies have suggested this may also be true of the high Arctic seasonally or intermittently. INPs are critical for initiating cloud glaciation at temperatures warmer than ~-36 °C and can thus have an outsize effect on cloud phase and related climate feedbacks due to their relative scarcity. This is particularly true over the polar oceans, where low and mid-level mixed phase and supercooled clouds are ubiquitous and especially sensitive to aerosols due to the generally low background particle concentrations.

The research presented here aimed to improve our understanding of the factors influencing marine INP emissions and the sources and composition of INPs in remote marine regions, as well as to evaluate and improve current INP model parameterizations. This was accomplished using observations made in the Southern Ocean, one of the few remaining pristine aerosol environments, during the Southern Ocean Cloud Radiation Aerosol Transport Experimental Study (SOCRATES) aircraft campaign on the NSF/NCAR G-V, and the second Clouds, Aerosols, Precipitation, Radiation and atmospherIc Composition Over the southeRN ocean (CAPRICORN-2) ship campaign on the R/V Investigator in 2018. Ambient observations were supplemented by measurements from the CHaracterizing Atmosphere-Ocean parameters in SOARS (CHAOS) mesocosm experiment in the new Scripps Ocean-Atmosphere Research Simulator (SOARS) wind-wave channel. CHAOS measurements allowed for isolation of the role of wind speed in marine INP production, which had not previously been characterized through controlled experiments.

SOCRATES and CAPRICORN-2 are notable for collecting the first vertically resolved INP measurements over the Southern Ocean, including the first in situ observations in and above cloud in the region. Both aerosol and INP concentrations showed excellent agreement between G-V and R/V Investigator observations during overflights of the ship, supporting the use of such a multi-platform measurement approach for future campaigns interested in aerosol and INP vertical profiles. New techniques for estimating marine aerosol surface area and the number of particles >0.5 µm, key quantities often used in INP parameterizations, were developed based on lidar and nephelometer measurements. An additional parameterization for marine INPs is proposed, which uses both wind speed and activation temperature, and reduces bias compared to the existing parameterization based solely on temperature. Marine boundary layer (MBL) and above cloud INP concentrations from the same SOCRATES flight support the

hypothesis suggested by several modeling studies that marine INPs dominate at low altitudes, and mineral dust becomes increasingly important with height. Unexpectedly, enhanced INP and aerosol iron concentrations, but low iron solubilities, were observed for samples collected south of 60 °S during CAPRICORN-2. Antarctica is suggested as a potential source of both biological and inorganic INPs to the Southern Ocean marine boundary layer through the emission of mineral and soil dusts from ice-free areas. Similar high latitude dust sources in Iceland and Svalbard have been observed to contribute to INPs in the Arctic atmosphere, and are anticipated to increase in importance as the climate warms.