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Aerosol-cloud interactions near the North Pole

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The Arctic is warming more than twice as fast as the global average (Arctic amplification) and it plays a crucial role for global climate evolution as well as mid-latitude weather patterns. Aerosols influence Arctic climate via three main processes thereby changing the radiative balance: (1) modification of cloud radiative properties, (2) direct scattering and absorption of sunlight, and (3) change of surface albedo. Especially the first process is important for the Arctic surface energy budget: For example, a low cloud cover over the summertime high Arctic pack ice can move the temperature from below freezing to the melting regime. Aerosols play a critical role here, because the cloud regime is cloud condensation nuclei (CCN) limited.

Here, we present an overview and first results of cloud and aerosol observations performed within the MOCCHA project (Microbiology Ocean Cloud Coupling in the High Arctic) that was carried out during the Arctic Ocean 2018 expedition onboard the Swedish I/B Oden in August and September 2018. The ship drifted for more than five weeks with an ice floe in the vicinity of the North Pole.

We conducted a large suite of high time-resolution measurements of aerosol microphysical and chemical properties, covering a size range from clusters to supermicron particles. This included various aerosol mass spectrometers, aerosol sizing and counting instrumentation, cloud condensation nuclei counters, and a bioaerosol spectrometer. A strong focus was set on the investigation of particle activation to cloud droplets. For this purpose, we operated three different air inlets: a whole-air inlet, sampling all particles including cloud droplets and ice crystals, an interstitial inlet selecting particles < 1 μm, and a counter-flow virtual impactor inlet probing droplets > 7.8 μm. In addition, thermodenuder experiments were carried out behind the whole-air and interstitial inlets. We found differences in the chemical composition between activated and non-activated particles.

Furthermore, clear differences in particle composition and size distribution were observed as a function of location (marginal ice zone versus high Arctic pack ice) and season. Particularly, new particle formation increased dramatically towards the fall. In the high pack ice region, particle properties were generally very variable and were modulated by air mass origin and meteorological factors such as wind speed and temperature. For example, concentrations of the total particle population ranged between 1.6 cm-3 and > 4000 cm-3.