Multiphase Chemistry Within Arctic Fog Droplets Explains Unexpected Growth Of Aitken Mode Particles To CCN Sizes

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New particle formation and early growth are efficient processes generating high concentrations of potential cloud condensation nuclei (CCNs) precursors within the Arctic marine boundary layer (AMBL). Due to the low particle concentrations in the AMBL, even the smallest amount of Aitken mode particle growth is capable to significantly increase the CCN budget and, thus, influence the albedo of low-level clouds. During the PASCAL campaign in 2017, measurements of aerosol particles were performed and an unexpected rapid growth of Aitken mode particles was observed right after fog episodes. This can be a critical process, because Arctic low-level clouds have a warming instead cooling effect. Thus, if CCN number concentrations increase due to fog interactions, a positive feedback on Arctic climate change can be expected. Since fog events will occur more frequently in the Arctic as a result of climate change, this process and a deeper knowledge on its feedbacks is essential to understand Arctic warming.

Therefore, detailed multiphase chemistry box model simulations with MCM/CAPRAM were performed to study the underlying processes. A new mechanism is proposed explaining how particles with a diameter < 50 nm are able to grow into CCN size range in the Arctic. The rapid particle growth is related to chemical and partitioning processes of Arctic fogs. The redistribution of semi-volatile acidic (e.g., methanesulfonic acid) and basic (e.g., ammonia) compounds between different particle sizes leads to a rapid particle growth of non-CCNs after fog evaporation enabling them to grow towards CCN size. Thus, chemical in-fog processes and subsequent post-fog repartitioning are key processes (i) contributing to the increase in the number of CCNs and cloud droplets, and (ii) finally leading to an increased albedo of Arctic clouds.