**Exploring Aerosol-Cloud Interactions in Arctic Mixed-Phase Clouds Using ICON-LEM**

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The contribution of Arctic mixed-phase clouds (MPCs) to the accelerated climate warming in the Arctic, known as Arctic amplification, remains uncertain due to complex microphysical and environmental interactions. Cloud condensation nuclei (CCN) concentrations influence MPC properties; however, current models often prescribe CCN levels much higher than Arctic observations suggest. To address this, we investigate the sensitivity of MPC properties to CCN concentrations using 600-m ICON-LEM simulations around Ny-Ålesund.

The CCN sensitivity studies are based on typical CCN concentrations observed at the Zeppelin Observatory, serving as a benchmark for Ny-Ålesund conditions. We select simulation days by analyzing aerosol optical depth (AOD) measurements in Ny-Ålesund to represent high and low aerosol loading regimes, which are confirmed by Micro-Pulse Lidar (MPL) observations.

Our initial studies, spanning mimicked Arctic, maritime, and polluted CCN regimes, reveal clear CCN effects: lower CCN concentrations reduce liquid water path (LWP) and increase radar reflectivity (Ze), mainly due to enhanced rain and graupel formation. However, the model underestimates the observed Ze, indicating shortcomings in the representation of phase partitioning. The results suggest that microphysical sensitivity varies with cloud height, with low-level MPCs responding more strongly than higher layers. We further explore this by separating cloud layers relative to the melting layer and analyzing their CCN sensitivity.

To increase robustness, additional summer and winter low-level MPC cases are included. Complementing CCN sensitivity, ice nucleating particle (INP) sensitivity studies constrained by observed INP concentrations from the Gruvebadet observatory assess INP influence on phase-partitioning and precipitation in low-level MPCs. Identifying suitable CCN–INP combinations may improve MPC representation in ICON-LEM and deepen understanding of the aerosol-cloud interactions driving Arctic amplification.

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