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Investigating Arctic Clouds over Sea Ice: Airborne Passive Microwave Observations during HALO-(AC)³

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Clouds play a critical role in the water and energy budget of the Arctic. However, observations of cloud properties over sea ice are sparse due to a limited number of ground-based observations. Passive microwave observations from satellites provide high sensitivity to cloud liquid water. However, retrievals suffer from high uncertainties due to sea ice emissions, which depend on sea ice and snow properties.

This work presents a liquid water path optimal estimation retrieval for clouds over sea ice observed by the HALO Microwave Package (HAMP) on the HALO aircraft during the HALO-(AC)³ field campaign in spring 2022 in the Fram Strait and central Arctic. The nadir-viewing HAMP measures along two water vapor bands (22.24 and 183.31 GHz), two oxygen bands (50-60 and 118.75 GHz), and the atmospheric windows at 31 and 90 GHz. The sea ice-atmosphere forward operator consists of sequential simulations with the Snow Microwave Radiative Transfer (SMRT) and Passive and Active Microwave Radiative Transfer (PAMTRA) models. The retrieval adjusts to varying surface emissions by modifying snow layer parameters and young ice fraction. Additional instrumentation onboard HALO from lidar, radar, dropsondes, and infrared cameras provides unique reference observations for retrieval evaluation.

Synthetic retrieval experiments demonstrate a high sensitivity to liquid water at 90 GHz and dual oxygen absorption bands. Applying the retrieval HALO flights allows us to assess the spatial and temporal variability of the retrieved cloud properties under various atmospheric and surface conditions, especially during warm air intrusion events. The HAMP observations will improve the characterization of clouds in the Arctic and the use of passive microwave satellite observations over sea ice.