Precipitation during cold-air outbreaks as observed by airborne radar observations over the Fram Strait

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Low-level Arctic clouds are a critical component of the Arctic climate system, contributing to positive radiative forcing and driving Arctic amplification. Further, they are an important part of the hydrological cycle, but precipitation estimates in the Arctic remain highly uncertain due to a lack of observations, particularly during marine cold-air outbreaks (CAOs). During these events, low-level clouds often produce light snowfall over the open ocean, which is challenging to detect from satellites due to the blind zone of spaceborne radars.

Focusing on the Fram Strait, a region frequently affected by these outbreaks, we retrieve snowfall rates using airborne radar reflectivity data collected near Svalbard during three aircraft campaigns in spring from 2017 to 2022. This dataset spans 45 flight hours and 13000 km. To optimize the derivation of the relation between measured radar reflectivity Z and snowfall rate S, we make use of the long-term measurements of collocated radar and precipitation gauge at Ny-Ålesund. Applying this relation to the airborne data, resampled to match ERA5 reanalysis snowfall estimates, allowed for a direct comparison. The mean snowfall rate during marine CAOs is 330 mm/year, and the analysis of the data with respect to the traveling time over open ocean (fetch) reveals increasing values up to 140 km fetch. With the retrieved data, we can evaluate reanalysis datasets such as ERA5 and CARRA, enabling a comprehensive assessment of their accuracy and reliability. ERA5 overestimates light snowfall, while CARRA underestimates medium and high snowfall rates, highlighting discrepancies in reanalysis limitations.

Looking ahead, the upcoming airborne campaign COMPEX-EC (Clouds over cOMPlEX environment - EarthCARE) in April 2025 aims to refine Arctic snowfall retrievals further and validate EarthCARE observations. Starting in Kiruna, Sweden, it will assess the quality of EarthCARE measurements similar to what has been performed for CloudSat in the past (Schirmacher et al., 2023). This is particularly interesting with respect to EarthCARE's blind zone, improving snowfall representation and understanding shallow precipitation processes.