Investigating micro-physical processes in Arctic mixed-phase clouds using cloud radar Doppler spectrum skewness

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Low-level mixed-phase clouds occur frequently in the Arctic. They are known to be important for the surface energy balance but are not well represented in climate models. Our work aims to gain understanding of how features of the cloud radar Doppler spectra can be used to evaluate micro-physical processes in shallow mixed-phase clouds (MPC). The study utilized 94 GHz vertically pointing cloud radar observations, which were carried out at the Arctic Research Base AWIPEV in Ny-Ålesund, Svalbard.

Higher moments of the cloud radar Doppler spectra have rarely been utilized for Arctic MPCs. Similar to the case study in Kalesse et *al.* (2016; https://doi.org/10.1175/MWR-D-16-0155.1), we found features in the skewness profiles that relate to changes in the partitioning between liquid and ice. An algorithm to detect the positive-turning-negative skewness profile, describing the change from liquid- to ice-dominated radar signal when moving downwards from cloud top, was developed. The feature was found in 60% of the persistent low-level MPCs identified in the 2.5-year data set. We further evaluated the occurrence and variation of the skewness feature in combination with other radar parameters, the liquid water path, and cloud top temperature. Our investigation suggests that close to cloud top, ice depositional growth is likely impacting skewness. We conclude that skewness can provide insights into the early stages of precipitation formation.

The work presented contributes to the understanding of how the moments of the Doppler spectra, especially skewness, can be used for interpreting micro-physical properties and processes in MPCs. Furthermore, by using a radar forward operator we will be able to evaluate model simulations of MPCs directly in the observational space.