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

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Low level mixed-phase clouds occur frequently in the Arctic, and are known to be important for the surface energy balance while not well represented in climate models. The aim of our work is to gain understanding of micro-physical processes in Arctic mixed-phase clouds (MPC) by evaluating features of the cloud radar Doppler spectra. The high resolution cloud radar observations were carried out at the Arctic Research Base AWIPEV in Ny-Ålesund, Svalbard. We also utilized in situ cloud observations from the holographic imager HOLIMO3B that was deployed on a tethered balloon during the Ny-Ålesund Aerosol Cloud Experiment [1].

In single-liquid-layer MPCs, we found features in the Doppler spectrum skewness profiles that relate to changes in the partitioning between liquid and ice, similarly to the case study by Kalesse et al. [2]. 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.

In complex multilayered cloud scenes the interpretation of the cloud radar Doppler spectra is more challenging. We have analyzed contrasting case studies to take advantage of the detailed description of hydrometeor properties provided by HOLIMO3B, which we used to guide the evaluation of the radar Doppler spectra. To facilitate the comparison of the cloud radar and in situ measurements, we also used the Passive and Active Microwave radiative TRAnsfer tool (PAMTRA). Synthetic cloud radar Doppler spectra were produced based on in situ measured particle size distributions, and compared to the corresponding radar measurements. We find that the main challenges for obtaining closure between HOLIMO3B and cloud radar are the different sampling volumes and the description of scattering properties for complex ice particle structures.

The work presented contributes to the understanding on how the features of the cloud radar Doppler spectra, especially Doppler spectrum skewness, can be used for interpreting micro-physical properties and processes in mixed-phase clouds.

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References

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