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Remote-sensing of ice particle density and riming processes in mixed-phase cloud using Doppler radar

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Our understanding of the water cycle in polar regions is limited by a lack of reliable satellite estimates of snowfall rate. The density of precipitating ice is related to a range of highly variable microphysical processes; the resulting mass-size relations of ice particles are a major contributor to uncertainties in remote-sensed estimates of ice water content and snow rate. Riming in mixed-phase clouds cannot presently be diagnosed from spaceborne active sensors, but future satellites such as EarthCARE will aim to employ Doppler and/or multiple-frequency radar techniques to improve uncertainties in estimates of global cloud ice water content and precipitation.

In a novel optimal estimation retrieval, “CAPTIVATE”, we exploit Doppler radar measurements to retrieve a parameter modulating the mass, area and terminal velocity of ice particles according to their degree of riming. Retrievals of the density of ice and snow are made from two zenith-pointing Doppler radars at Hyytiala, Finland during the snow experiment (SNEX) component of the BAECC 2014 field campaign. The retrieved snow rate, particle size distribution parameters and ensemble mean ice density compare well with in-situ particle imaging and bulk measurements at the surface; and while Doppler measurements are essential to the retrieval, dual-frequency radar measurements provide a strong constraint on particle size which significantly improves the retrieval of ice density. Improved remote-sensing of precipitating ice will provide insights into the rates of microphysical processes in mixed-phase cloud.