1.16 IMPACT OF RIMED AND UNRIMED SNOW ON SNOWFALL RETRIEVALS AT X, KA AND W BAND

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The correlation between the snowfall rate S and the radar equivalent reflectivity factor Z_e is challenging due to their dependence on the microphysical properties of snowfall. The variability of the Z_e-S and S-Z_e relations at millimetre and centimetre wavelengths is largely affected by microphysical snow growth processes. When a Ze-S power-law relation is assumed, its coefficients depend on different parameters such as the snow type, degree of riming and aggregation, density and terminal velocity (e.g., Von Lerber et al., 2017). The Z_e-S relation is also strongly dependent on radar frequency since various electromagnetic wavelength are more sensitive to different parts of the particle size distribution (PSD).

The radar-based snowfall intensity retrieval at X, K_a and W band has been investigated in previous works (e.g., Falconi et al., 2018) in terms of Z_e-S relation using data from four snowfall events, recorded during the Biogenic Aerosols Effects on Clouds and Climate (BAECC) campaign in Finland. The dataset was divided in rimed and unrimed snow on a daily basis using the total liquid water equivalent (LWE) and the minimum and maximum temperature for each event as an indicator of riming occurence. This classification highlighted two different Z_e-S relations for rimed and unrimed snow on temporal scales larger than few minutes.

In this work, the four case studies of the 2014 winter from BAECC are used to illustrate the impact of the microphysical processes on the snowfall retrieval every 5 minutes. This time-window is selected to average data in order to avoid spurious results and detect changes in the prevailing particle habit or type. Here, we firstly apply a more accurate snowfall classification based on quantification of the riming effect using the retrieval of the rimed mass fraction (FR), as in Moisseev et al., 2017. A particle video imager, the NASA Particle Imaging Package (PIP) is used to compute the particle volume flux to retrieve the FR. An independent evaluation of the proposed approach is obtained by estimating particle-effective liquid water paths (ELWP) and comparing these to microwave radiometer (MWR) observations. The two-channel MWR is located on the BAECC site 20 m away from PIP.

Based on the new classification approach, the estimation of Z_e-S coefficients is carried out by dividing the 5-minute periods to rimed and unrimed snow. The reflectivity Z_e is measured by the AtmosphericRadiation Measurement (ARM) vertically-pointing cloud radars operating at X, K_a and W frequency bands, collocated with the other measuring instruments. S is derived from PIP using the measured mass, velocity, particle size distribution and liquid water density. To improve the estimation of S, the Z_e-S relation is compared with a direct S-Z_e regressive relation. Defining the error as the difference between S estimated from radars and observed

from PIP, the uncertainty of the two approaches is evaluated in terms of the root mean square error (RMSE) and normalized RMSE. Improvements in the snowfall retrieval and classification at multi-frequency are discussed proposing two sets of coefficients for rimed and unrimed snow for both Z_e-S and S-Z_e relations.