Investigating snow aggregation close to the melting layer using novel ground-based triple-frequency observations

*Jose Dias Neto[1], Stefan Kneifel[1], Davide Ori[1]

1. University of Cologne

Ice and mixed-phase cloud microphysical processes are involved in the majority of precipitation forming around the globe. These processes, such as nucleation, depositional growth, riming, and aggregation belong the least understood processes in clouds. Numerical models have still difficulties to realistically simulate ice and snow processes. During recent years, model resolution largely increased and more precise/complex ice parameterizations have been developed which demand comprehensive observational constraints.

Previous studies have shown that the combination of multi-frequency radar observation covering the transition between Rayleigh and Mie scattering regimes allow distinguishing between different classes of snowflakes (e.g., aggregates and rimed), and also provide information about the mean size of the snowflake particle size distribution. In-situ measurements have confirmed that the observed multi-frequency signatures can be related to the particle size distribution, density, and habit classes of snowflakes.[s1] An additional source of information is the mean Doppler velocity (MDV), which under certain conditions allows categorizing the ice crystal according to their degree of riming.

The field campaign TRIple-frequency and Polarimetric radar Experiment for improving process observation of winter precipitation (TRIPEx) was taking place between November of 2015 and January of 2016 at the Jülich Observatory for Cloud Evolution Core Facility (Germany). During this experiment, three Doppler radars (X-, Ka-, and W-Band) operated in vertical pointing mode. A publicly available quality-controlled dataset has been generated including corrections for absolute radar calibration, attenuation and several data quality flags. The radar data have been combined with auxiliary sensors at the site including distrometers, ceilometer, and microwave radiometer.

The large dataset of quality controlled triple-frequency observations allowed for the first time a statistical analysis of the triple-frequency signatures. In this contributions we put our focus on aggregation because the majority of clouds during TRIPEx indicated that aggregation is a dominant growth mechanism. Looking at the dual wavelength ratios (DRW) stratified with cloud temperature, we find two preferential regions where DWRs are enhanced. The first region is located between -20 and -10 ˚C with a sharp increase of Ka-W DWRs (up to 10 dB) at the well-known dendrite growth zone around -15 ˚C. The second aggregation zone, associated with strongly increasing X-Ka DWRs, starts around -5 ˚C with the maximum X-Ka DWRs (up to 20 dB) found close to the freezing level. We used our triple-frequency information together with Doppler velocity and linear depolarization ratio (LDR) in order to investigate where the maximum of the X-Ka DWR occurs. In this way we aim to shed light on the question, where in the cloud do we find the largest average snowflakes sizes to appear. Similar to previous studies, we use LDR and mean Doppler velocity to define top and bottom of the melting layer. We find the largest X-Ka DWR close to the melting layer top sometimes reaching values of up to 20 dB. According to the LDR, these particles did not yet start any melting. If we look at the location of the maximum in X-Ka DWR in each profile, we find that 70% of all DWR maxima occur in the first quarter of the melting layer. Further inside the melting layer the DWRs rapidly decrease. As expected, the Doppler velocity in the rain is strongly correlated to the magnitude of the DWR above. Since our results are based on a large number of cases, they might provide valuable observational constraints for melting layer modelling.

Keywords: triple-frequency observations, melting layer, aggregation