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Synergy of triple-frequency cloud radar and polarimetric X-Band radar for snow and ice microphysics

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While snowfall is undoubtable of major importance for the water cycle at high latitudes and for our understanding of cold rain formation, snowfall microphysics is still a big challenge for atmospheric models and observations. The enormous variations in particle size, density and habit not only affect the actual snowfall rate but also influence the particle interaction with electromagnetic radiation. Although single-frequency radars like the W-band radar onboard CloudSat opened new avenues to observe the global distribution of snowfall, the large variability of snowfall properties always limits the accuracy of derived snowfall products.

Numerous studies have demonstrated the potential of radar polarimetry to provide valuable information about e.g. particle shape and ice particle concentration but so-called polarimetric fingerprints also hint to ongoing prevalent microphysical processes. Additionally, the increasing number of snow and ice particle scattering models suggest that a combination of three radar frequencies which cover the Rayleigh and Mie scattering regime could help to distinguish at least between certain classes of snowfall like aggregates or graupel-like particles. Recent observations from airborne and ground-based campaigns including comparison to in-situ data corroborated the predicted triple-frequency signatures related to habit classes, particle size distribution parameters, and particle density.

In this contribution we will show first results from the two-month TRIple-frequency and Polarimetric radar Experiment for improving process observation of winter precipitation (TRIPEx) campaign which took place at the Research Center Jülich (Germany) in winter 2015/2016. Vertically pointing ground-based triple-frequency (X-, Ka-, and W-band) radar observations were combined with observations from two nearby scanning polarimetric X-Band radars. To the author’s knowledge, this combination is the first ever recorded and has been made possible thanks to the cooperation of four German research institutions. We analyze several cases studies of frontal mid-latitude clouds in terms of their signatures in the multi-frequency space, Doppler spectra, and polarimetry. This first analysis concentrates on well-known structures like the dendritic or needle growth zone, the aggregation zone above the melting layer, but also addresses supercooled liquid water layers. The results show clearly the benefit of synergistically combining the different observation approaches and reveal new avenues how to better constrain ice microphysical processes, such as depositional growth, aggregation, and riming using a combination of different radar observations.