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The Impact of Warm-Rain Microphysical Processes on Rain Rate and Polarimetric Observables at X-Band

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Microphysical processes govern the evolution of drop size distribution (DSD) during the development of precipitating systems. Thus, an accurate knowledge on precipitating systems from a microphysical perspective is required for better quantitative precipitation estimates (QPE). Additionally, detection of microphysical processes in 3D polarimetric radar volumes paves the way for better parameterizations in numerical weather predictions (NWP).

In this study, we focus on the impact of different microphysical processes on rain rate (RR) and polarimetric observables at X band. Microphysical processes during the evolution of warm-rain precipitating systems, including size sorting, evaporation, coalescence and breakup, are taken into account. Assuming that vertical rain shaft is composed of liquid spheroids distributed in a normalized Gamma size distribution, microphysical processes are reconstructed. The variation of RR governed by microphysical processes is also examined.

Unique fingerprints caused by microphysical processes have been identified in polarimetric radar observations. For size sorting, large rain drops concentrating near ground surface or at leading edge induce strong Zdr (differential reflectivity) accompanied by small Zh (reflectivity). A larger mean size in DSD results in stronger Zdr during size sorting. The increasing mean size due to evaporation and coalescence enhances Zdr, while Zh during evaporation is reduced by the depletion of small rain drops. The reduction of Zh ranges between -10 dB and 0 dB considering different DSDs during evaporation. Zh, Zdr and Kdp (specific differential phase) all decrease when large rain drops break up.

The evolution of DSD which depends on the ongoing microphysical processes results in a variation in RR. Though size sorting due to differential sedimentation occurs, RR approaches stable within 15 min. Suffering from vertical wind shear, RR is reduced because of the categorization of rain drops with different terminal velocity. Especially for wider rain drop spectra, RR decreases more than 60 percent. The evaporation of small rain drops also reduces RR. A relative humidity of 50% at ground surface reduces RR up to 90 percent. For coalescence and breakup RR stays constant.

On one hand, the subtle change of polarimetric observables during microphysical processes requires instruments with a high accuracy to observed DSD. On the other hand, microphysical processes during the lifecycle of precipitating systems should be identified first when retrieving DSD by polarimetric radar observation. This will benefit the retrieval accuracy and QPE. Further work will focus on full physics of DSD evolution since only one single microphysical process is considered and thermodynamics is not taken into account.