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Bayesian inverse modeling for quantitative precipitation estimation

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Polarimetric radars provide us with a richness of precipitation related measurements. Especially the high spatial and temporal resolution make the data an important information, e.g. for hydrological modeling. However, uncertainties in the precipitation estimates are large. Their systematic assessment and quantification is thus of great importance.

Polarimetric radar observables like horizontal and vertical reflectivity Z_H and Z_V, cross-correlation coefficient ρ_{HV} and specific differential phase K_{DP} are related to the drop size distribution (DSD) in the scan. This relation is described by forward operators which are integrals over the DSD and scattering terms. Given the polarimetric observables, the respective forward operators and assumptions about the measurement errors, we investigate the uncertainty in the DSD parameter estimation and based on it the uncertainty of precipitation estimates.

We assume that the DSD follows a Gamma model, $N(D) = N_0 D^{\mu} \exp(-\Lambda D)$, where all three parameters are variable. This model allows us to account for the high variability of the DSD. We employ the framework of Bayesian inverse methods to derive the posterior distribution of the DSD parameters. The inverse problem is investigated in a simulated environment (SE) using the COSMO-DE numerical weather prediction model. The advantage of the SE is that - unlike in a real world application - we know the parameters we want to estimate. Thus, building the inverse model into the SE gives us the opportunity of verifying our results against the COSMO-simulated DSD-values.