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What can radars tell us about snowfall microphysics? Insights from a MCMC framework

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Multi-frequency and Doppler spectral radars are valuable tools to retrieve information on the microphysics of precipitation, and snowfall in particular. However, estimating ice phase microphysics from radar measurements is an ill-posed problem, meaning that different sets of microphysical properties may correspond to the same radar observations. For most retrieval approaches, the uncertainty related to this ill-posedness is difficult to quantify; furthermore, they typically rely on assumptions regarding microphysics or scattering properties, whose impact on the retrieval is usually unknown. In this work, we use simulated radar measurements and the Markov chain Monte Carlo (MCMC) framework to retrieve microphysical information from triple-frequency radar Doppler spectra, with minimal assumptions on the mathematical and physical properties of the system. While this approach is not designed for operational implementation because of its computational cost, it allows to gain insights into the sources of uncertainty and ill-posedness of this radar retrieval problem. We analyze the posterior distributions retrieved from 10 representative examples of simulated measurements. Our results show that certain microphysical variables like the effective diameter may be relatively well constrained, while others are far more uncertain, such as the shape parameter when a gamma particle size distribution (PSD) is assumed. The analysis also reveals relevant correlations in the multivariate posterior distribution, showing how microphysical descriptors are entangled in the retrieval. We then use this Bayesian framework to analyze the sensitivity of the retrieval to assumptions regarding atmospheric effects, radar vertical alignment, microphysical properties such as the mass-size relation or PSD shape, or scattering approximations. We also investigate the special case of bimodal Doppler spectra, where information regarding two hydrometeor populations is merged, and discuss to which extent this information may be recovered. With this work, we improve our understanding regarding the information content of radar Doppler spectra and the intrinsic limitations of microphysical retrievals.

VAT

Session

From Classical to Integrated Remote Sensing: New retrieval and estimation techniques (e.g. fusion, Bayesian)

Preferred Contribution Type

Oral Presentation

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