Towards an efficient polarimetric radar forward operator for NWP frameworks

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With their high sensitivity to precipitation-sized particles and their high resolution and coverage in both space and time, radar observations play a crucial role in detecting and measuring precipitation and in short-term numerical weather prediction (NWP). Accurate quantitative precipitation estimation (QPE) remains a challenge, though, and the variability of particle size distributions (PSDs) is, arguably, the most important error source -- even for domains well covered by a weather radar. More specifically, the relationships between radar reflectivity and rain rate can be highly ambiguous -- the same radar reflectivity measurement can result from a wide range of rain rates. Despite the remarkable progress made recently in the estimation of liquid precipitation (i.e., pure rain) exploiting radar polarimetry, very little has been achieved yet to improve the quality of QPE in mixed-phase or frozen (e.g., snow) precipitation because of the high variability of snow density as well as the large diversity of snow habits on top of the variability of snow PSDs. Extending the radars to dual-polarization measurements opens up for the exploitation of a number of polarimetric variables, like differential reflectivity, specific differential phase, depolarization ratio, and co- and cross-polar correlation coefficients. These carry information regarding the properties of hydrometeors that result from differences in the scattering and propagation of horizontally and vertically polarized radiation.

The additional polarimetric information improves precipitation measurements, and it can be used to verify and improve NWP models. Comparing radar measurements to NWP output is complicated, however, by the fact that radar observables are not prognosed by the microphysics schemes used in NWP models. Consequently, methods to derive synthetic radar observations from NWP fields, so-called forward operators, are required. It is crucial that these operators can accurately simulate corresponding observations in order to exploit the rich information content of polarimetric measurements. That is, extending forward operators to polarimetry requires to rewrite and solve solve the radiative transfer problem in vector form. In addition, hydrometeor characteristics (e.g., non-spheroidal shapes and more diverse canting/orientations) that were typically neglected in non-polarimetric operators but that have strong impacts on the hydrometeors ‘ polarimetric properties need to be handled and modelled in a realistic way to produce accurate simulated radar fields.

We are extending the efficient modular volume-scanning radar forward operator EMVORADO, which is applied in the COSMO and ICON model frameworks, with polarimetric capabilities. Here we will present the current state and further plans for this extension.

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