A new efficient radar forward operator for weather radar networks in the COSMO model

Ulrich Blahak
Deutscher Wetterdienst, Germany

Zeng, Yuefei (Deutscher Wetterdienst, Germany)
Jerger, Dorit (Inst. for Meteorology and Climate Research, KIT, Germany)
Stephan, Klaus (Deutscher Wetterdienst, Germany)

E-mail: ulrich.blahak@dwd.de

Radar data can help to improve NWP-based QPF by a) providing spatially and temporally dense reference data for NWP model verification and b) radar data assimilation.

Radar data (radial wind, reflectivity, etc.) are not equivalent to the prognostic variables of NWP models (hydrometeor densities, 3D wind components, temperature, pressure), and to diagnose the latter from radar data is very difficult. Contrariwise it is advantageous to derive synthetic radar measurements from model data (``radar forward operator'') for a meaningful comparison in model verification. Also, modern ensemble based data assimilation methods can process data in the observation space.

To this end, a new Efficient Modular RADar SCanning forward OPErator (EMRADSCOPE) for radial wind and reflectivity has been developed at the Karlsruhe Institute of Technology (KIT) and the German Meteorological Service (DWD). It is designed to simulate entire ground-based heterogeneous scanning weather radar networks online during NWP model forecasts (currently: COSMO-model of DWD with its 1-moment- and 2-moment cloud microhpyscial schemes). The code is MPI-parallel and runs efficiently on vector machines.

Efficiency is a major design criterion, dictated by the large data amount. However, we also implemented physically quite accurate state-of-the-art methods in an ``as-efficient-as-possible way'', which can be optionally chosen. Thus it is possible to take into account the most important radar measuring characteristics/errors (e.g., beam bending, pulse volume averaging, Mie-Scattering, attenuation), but to balance accuracy vs. efficiency by choosing different levels of approximation in a modular way for each application (e.g., ``pencil''-beam, 4/3-earth-beam-propagation, Rayleigh-Approximation). For Mie-scattering, efficient lookup tables are implemented, and many options for the refractive index of melting hydrometeors can be chosen - one aspect of physical uncertainty in bright-band-simulations. Along these lines, polarisation parameters are currently worked on.

One year of continuous operation in the COSMO-DE monitoring system at DWD demonstrated good efficiency and, as a side, identified certain problems in observational data.

The 17 German C-Band radars allowed extensive case studies for model microphysics verification (vertical profile of reflectivity). First, the effects of different operator approximation levels on CFADS (contoured frequency by altitude diagrams) have been investigated. Then, it has been found, for example, that in convective precip COSMO-DE overestimates reflectivity below the melting level and underestimates above, allowing conclusions about PSD-assumptions in the model microphysics.

The presentation gives an overview on EMRADSCOPE and on the above applications. Two accompagnying presentations focus on further aspects of radar-based COSMO-model verification (D. Zhang et al.) and on radar data assimilation (Y. Zeng et al.).