QPE-QPF ENSEMBLE PREDICTION SYSTEM BASED ON WRF-NOAH-MP INCLUDING POLARIZATION RADAR DATA ASSIMILATION

Volker Wulfmeyer[1], Thomas Schwitalla[1], Hans-Stefan Bauer[1], Uwe Ehret[2]

[1]*Institute of Physics and Meteorology, University of Hohenheim, Stuttgart, Germany*
[2]*Karlsruhe Institute of Technology, Karlsruhe, Germany*

ABSTRACT

Quantitative Precipitation Estimation (QPE) and Quantitative Precipitation Forecasting (QPF) is key for many hydrological applications. Within the new Research Unit 1598 of the German Research Foundation (DFG) entitled Catchments as Organized Systems (CAOS), advanced QPE will be applied for building hydrological models that allow a much more realistic representation of the surface and especially subsurface architecture of catchments at the lower mesoscale (10–200 km^2). For this purpose, we are developing an ensemble prediction system for QPE, probabilistic nowcasting, and short-range QPF based on WRF-NOAH-MP. Ensemble members are perturbed with respect to initial conditions, physics, and boundaries. In additional to standard observations, GPS slant total delays, lidar, as well as radar Doppler wind and polarization data will be assimilated. Verification is performed by densified surface station data and two micro rain radars. We present the concept of this model system and first results.

1. SET UP OF MODEL SYSTEM

Merging probabilistic forecasting based on mesoscale models in combination with advanced data assimilation techniques is a very promising methodology for advancing QPE and nowcasting.

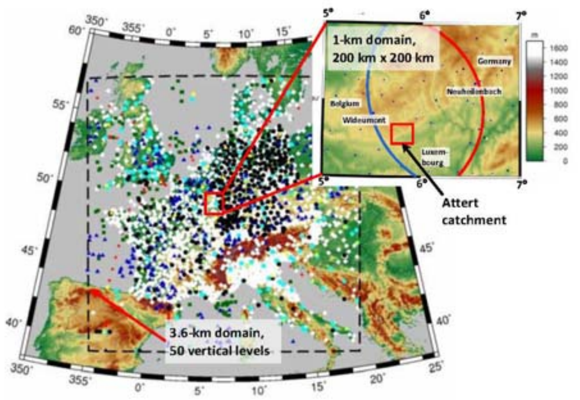

Fig.1: Model domain. Grid resolutions of 3.6 km in the outer and 1 km in the inner domains are used, respectively. The symbols indicate various routine observations for data assimilation. The upper right panel presents the central domain with radar coverage.

We are operating the WRF-NOAH-MP model system, which offers a variety of options with respect to parameterizations of convection, turbulence, and land-surface processes (Niu et al. 2011, Jiménez et al. 2012). Based on sophisticated process and verification studies within the scope of WWRP projects such as COPS (Wulfmeyer et al. 2011), we operate the model on the convection-permitting scale (Bauer et al. 2011).

The domain of the model encompasses central Europe in order to reduce error propagation from the boundaries to the central domain of interest. This region can be adapted in a very flexible manner. Within this project, the target region is the Attert catchment within Luxembourg where the hydro-meteorological observations are taken. Figure 1 shows the model domains and coverage of observations in central Europe.

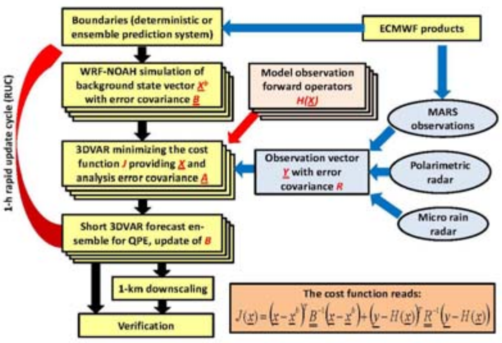

Fig.2: Model configuration for ensemble-based QPE.

If mesoscale models are used for approaching the nowcasting range, likely the most important problem is the reduction of model imbalances at initial time. We address this challenge by a combination of digital filtering, ensemble perturbations, and data assimilation. We are focusing on the perturbation of boundary layer and land-surface parameterizations, soil moisture, and boundaries, the latter if large-scale forcing is important for the case of interest. The set up of the ensemble prediction system (EPS) is presented in Fig.2.

2. DATA ASSIMILATION TECHNIQUE

For probabilistic nowcasting and short-range QPF, the choice and investigation of the data assimilation system is a key science topic, which is also addressed by the WWRP WGs on Nowcasting and Mesoscale Weather Forecasting Research (MWFR).

Within our project, we are focusing on variational techniques such as 3DVAR. An important innovation is the combination of this technique with an EPS and a rapid update cycle (RUC). The EPS permits to derive an update of the model background error covariance matrix ***B*** for the next forecast cycle. Before each analysis step, a suitable reduction of ***B*** is necessary for its inversion. Currently, this is performed by a series of unitary transformations with respect to a set of control variables.

3. OBSERVATIONS AND OBSERVATION OPERATORS

For accurate simulations the state of the dynamics and thermodynamics in the environment of convective systems must be analyzed. This extremely challenging topic is addressed by the simultaneous assimilation of an advanced system of observations in clear air, clouds, and precipitation with appropriate observation system error covariance matrices. Particularly, huge gaps in the observation of atmospheric humidity need still to be closed. For this purpose, we developed a new GPS slant total delay operator including the bending of the GPS satellite signal propagation (Zus et al. 2011). Furthermore, we are preparing the assimilation of polarization radar observations. Their coverage is increasing more and more in Europe with consistent and well-defined data formats.

4. FIRST RESULTS

During COPS IOP9c, the performance of the WRF 3DVAR using Doppler wind and conventional reflectivity data of radars has been investigated. A strong positive impact on short-range QPF was found. The simulation of the temporal-spatial structure of a prefrontal squall-line was considerably improved.

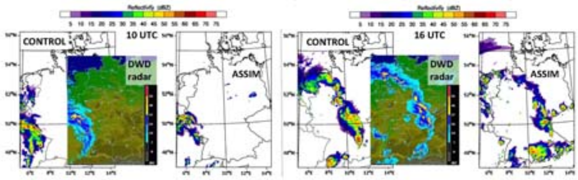

Fig.3: First WRF 3DVAR RUC using DWD radar data. CONTROL: simulation without assimilation; DWD radar: German DWD radar composite; ASSIM: DA experiment during COPS IOP 9c on July 20, 2007.

However, an overprediction of precipitation and model imbalances in the nowcasting range were found. Approaches to reduce these effects are currently investigated. Further details are presented at the conference.

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