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Physically-based stochastic perturbations in the boundary layer to represent the effect of lateral terrestrial water flow on precipitation predictability

Joel Arnault (1), Thomas Rummler (2), Stephan Rasp (3), Mirjam Hirt (3), George Craig (3,4)

(1) Karlsruhe Institute of Technology, IMK-IFU, Garmisch-Partenkirchen, Germany (joel.arnault@kit.edu), (2) Augsburg University, Institute of Geography, Augsburg, Germany, (3) Ludwig-Maximilian Universität München, Fakultät für Physik, Meteorologie, Munich, Germany, (4) Deutsches Zentrum für Luft und Raumfahrt, Institut für Physik der Atmosphäre, Oberpfaffenhofen-Wessling, Germany

Traditional meteorological models, like the Weather Research and Forecasting model (WRF), neglect the lateral redistribution of soil moisture according to topography and ground water depth. This constraint is relaxed in coupled atmospheric hydrological modeling systems, such as in the hydrologically enhanced version of WRF referred as WRF-Hydro. Both WRF and WRF-Hydro can be used for precipitation forecasting. Furthermore, the hydrological enhancement of WRF-Hydro makes this model suitable for river streamflow and flood forecasting. Forecast uncertainty is usually evaluated with a model ensemble. The Planetary Boundary Layer (PBL) Physically-based Stochastic Perturbation (PSP) scheme was originally developed in the Consortium for Small-scale Modeling (COSMO) by Kober and Craig, 2016, in order to represent forecast uncertainty in convective precipitation. This PSP scheme has recently been adapted to the WRF / WRF-Hydro modeling system. The first aim of this study is to investigate the potential of the PSP scheme to represent both forecast uncertainties in precipitation and streamflow. The second aim of this study is to compare the impact of PBL uncertainty and terrestrial water flow uncertainty on the precipitation ensemble spread. The case of the upper Iller river basin, 960 km2, Germany, during the summer 2010, is chosen as an example application. The selected WRF-Hydro setup uses a grid at 2 km horizontal resolution to represent atmospheric processes, and a grid at 100 m resolution to describe lateral terrestrial water flow. An ensemble of WRF and WRF-Hydro forecast simulations is operated using the ECMWF deterministic forecast data and varied PBL schemes. This ensemble is compared with another WRF / WRF-Hydro ensemble based on varied PSPs. Results are validated with the hourly precipitation dataset REGNIE from the German Weather Service (DWD), and with the hourly discharge dataset from the Bavarian Hydrological Service (GKD). The relative effects of varied PBL scheme, PSPs and lateral terrestrial water flow on precipitation predictability are assessed with the ensemble spread.