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# Quantitative precipitation forecast verification of short range ensemble systems over southern Germany

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Short range predictability of precipitation is very limited due to the chaotic nature of involved processes. The approach of ensemble forecasting leads more useful predictions by providing inherent forecast uncertainty. Which factor leads this ensemble forecast more skillful? whether the model resolution or the initial conditions or the model physics?. To answer this question, we examined the performance of four short range limited area Ensemble Prediction Systems (EPS) with respect to quantitative precipitation forecast over southern Germany for summer 2007. The skill of EPS is evaluated for the Complete Probability Density (CPD) function, and, also for the 90% quantile (90Q) of the distribution, which is representative for strong event.

Probabilistic forecasts were collected in summer 2007 during the forecast demonstration experiment MAP D-PHASE in the Alpine region which comprises both the results from deterministic models and ensemble systems. The four ensemble systems we selected for this analysis includes CLEPS, LAMEPSAT and CSREPS from MAP D-PHASE experiment and a Poor-man Ensemble Prediction System (PEPS) which we have developed from 10 different deterministic MAP D-PHASE models with resolutions ranging from 2.2 km to 15 km. CLEPS and LAMEPSAT are 16 member ensemble systems based on 10 km and 18 km resolution COSMO and ALADIN model respectively, with initial conditions from the ECMWF EPS. CSREPS is a 16 member ensemble system based on 10 km resolution COSMO model but, with initial conditions from four different global models. To evaluate the EPS, an hourly rain product immersed from radar and gauges is obtained from the University of Mainz at 7 km resolution over southern Germany. For a better comparison of these four EPS, we have up-scaled both the probabilistic forecast and the observation to 21 km horizontal resolution and the verification is performed for three hour accumulations.

The PEPS show best skill for CPD with continuous ranked probability score (CRPS) of 0.31 mm/3h, while LAMEPSAT show the least skill with CRPS of 0.45 mm/3h. The resolution component of CRPS shows PEPS have the highest forecast resolution while LAMEPSAT have the least. PEPS and CLEPS reflect most of the forecast uncertainty with reasonable ensemble spread, however CSREPS and LAMEPSAT are under-dispersive but the later show the least spread. Overall, all EPS show a significant positive bias.

For 90Q, PEPS is most skillful with brier score (BS) of 0.034 mm/3h and CLEPS is least skillful with BS of 0.044 mm/3h. However, both PEPS and CLEPS show the highest forecast resolution with resolution component of BS is 0.004 mm/3h, but LAMPSAT show the least resolution. For 90Q most of the EPS show less reliability with significant deviation of reliability curve from diagonal except for PEPS, but all the EPS significantly underforecast. PEPS show better performance for both CPD and 90Q as it consists of four convection resolving models having better diurnal cycle representation. CSREPS is more skillful than CLEPS as it is initiated with four global models. LAMEPSAT is least skillful in both analysis which may be due the coarser horizontal resolution and model physics. However, CRPS for all the EPS is smaller than 0.45 mm/3h and BS is of 0.044 mm/3h suggest that all the EPS are skillful. Over regions with complex orogarphy all EPS show less skill which confirms the weakness of EPS for accurate prediction of precipitation over these regions. Finally, the significance of these results along with performance of EPS with forecast lead time will be discussed.