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Combining hydrological multi-model ensemble forecasts

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The number of available different meteorological forecasts has increased significantly for the operational usage in real-time flood forecasting within the last few years ranging from deterministic forecasts with high spatial and temporal resolution to lower resolution EPS. The easiest way to manage this huge amount of information is to convert each single meteorological forecast into a hydrological discharge forecast through rainfall-runoff models. For example the multi-model ensemble of the European Flood Alert System (EFAS) consists of the high resolution deterministic forecast of ECMWF, the COSMO EU and the GME of DWD, the 51 members of the EPS of ECMWF and the 16 members of the higher resolution COSMO-LEPS, which are all taken as input for the hydrological model LISFLOOD. The initial conditions for each day are derived from observed meteorological and hydrological measurements collected in real-time and are the same for each forecast system.

In order to get maximum benefits from this multi-model forecast system it would be necessary to derive the overall predictive probability distribution by assigning different weights to the different actual forecasts according to the forecast performance of the previous days. But the estimation of the model weights and the combination of the forecasts itself is not that trivial for several reasons:

• Some of the forecasts are nested, e.g. the COSMO-LEPS takes the boundary conditions from the EPS and therefore these two systems are serially and temporally correlated.

• The various forecasts have different spatial and temporal resolution and therefore show different details of information.

• The members of the EPS and of the COSMO-LEPS are exchangeable, i.e. indistinguishable and therefore the application of methods incorporating past forecast performance criteria, like the Bayesian Model Averaging (BMA) method, is not straightforward.

In EFAS the combination of the forecasts and the assignment of the weights will follow a post-processing step, which is necessary to minimize the error between the predicted and observed stream-flow values at selected stations with real-time discharge data. Therefore the observed and the simulated (forecasted) discharge series are transformed into the Gaussian space first. Thus in order to derive the overall predictive probability distribution it is necessary to estimate the mean and the variance of the total predictive normal distribution.

In this study various methods of weighting and combining the different forecasts have been investigated like the (Gaussian) heteroscedastic regression model, the Ensemble MOS, Generalized Additive Models and a modified BMA method.

First results indicate the superior performance of the heteroscedastic regression model, which is computationally efficient and therefore most adequate for operational usage.