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Real-time hydrologic probability forecasting using ensemble dressing, with application to river Rhine

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Hydrologic forecasts are affected by inherent uncertainties. These originate from multiple sources including atmospheric forcing, hydrologic model schematisation and its parameters, and observations used in the forecasting process. Hydrologic streamflow forecasts are often produced using ensemble forcing predictions without additional hydrologic post-processing. As a result, the streamflow ensembles can be underdispersive or overconfident because the estimated predictive distribution does not take into account hydrologic uncertainties.

Under the assumption that the meteorological ensemble forecasts is unbiased, “ensemble dressing” constitutes a promising method for estimating combined forcing and hydrologic uncertainties. Hydrologic uncertainties are estimated from the joint distribution of streamflow simulations and observations, whereby simulations are produced using observed meteorological forcings. Each of the predicted streamflow ensemble members is then dressed using these estimates of hydrologic uncertainties. From the dressed ensembles, the combined predictive uncertainty distribution, i.e. the probability forecast is determined.

The present paper describes a study for river Rhine where ensemble dressing is applied at multiple forecasting locations. Hydrologic uncertainties are characterised using the Hydrologic Uncertainty Processor. Streamflow ensembles are produced by routing the 5 member ECMWF reforecast ensembles of precipitation and temperature through a conceptual HBV rainfall-runoff model. The ensemble members are used to create conditional estimates of hydrologic uncertainty. The posterior predictive distribution is produced by averaging probability distributions of each of the dressed ensemble members.

From a record of approx. 2,900 hindcasts, a number of verification metrics is determined. These include correlation coefficient, relative mean error, the Brier skill score, the continuous ranked probability skill score, and the relative operating characteristic score. Results show that forecast quality increases when moving from raw to dressed ensembles, both in the Type-I and the Type-II sense.