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Does the application of multiple hydrological models improve seasonal streamflow forecasting skill?

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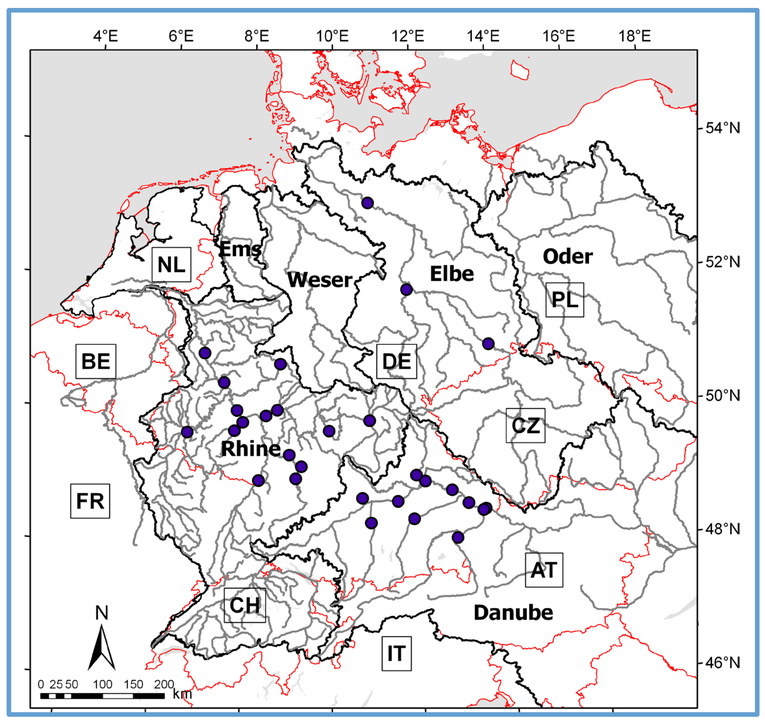
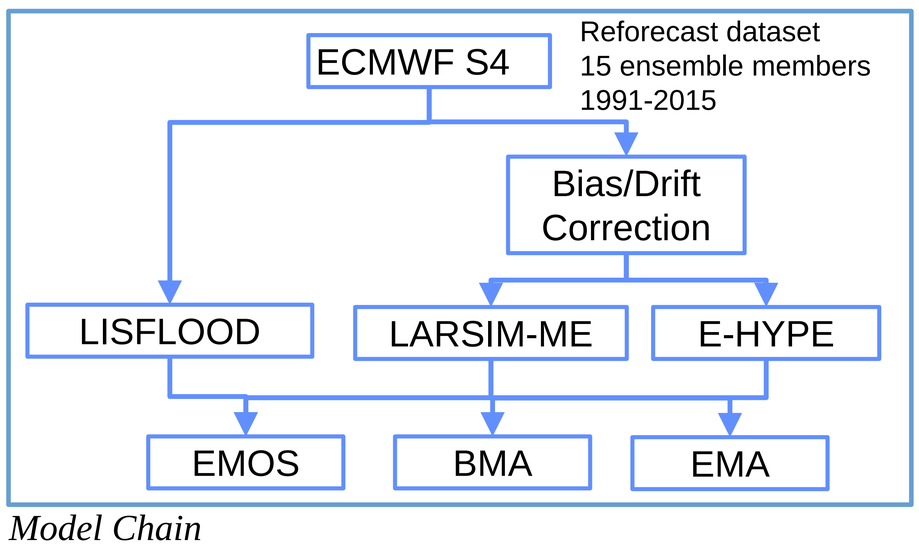
Introduction

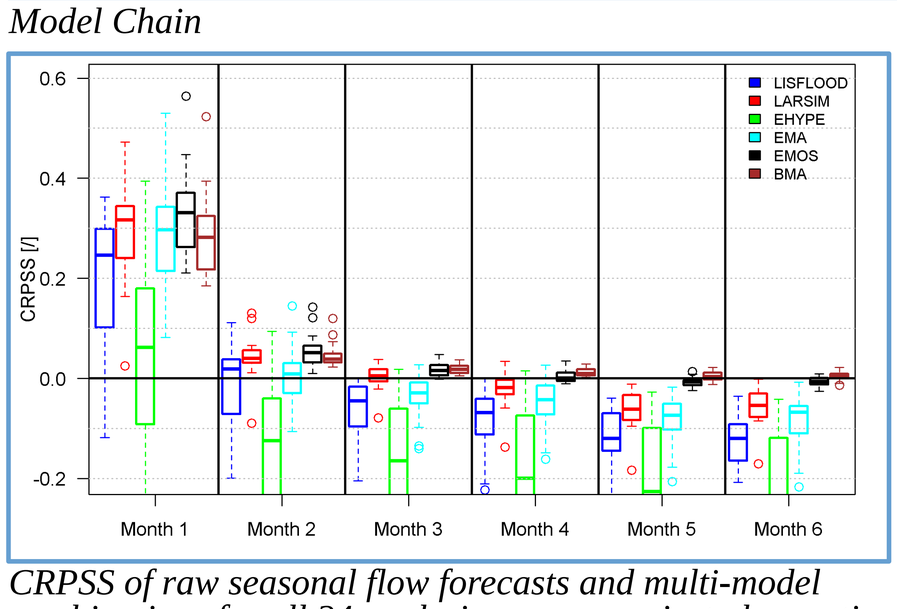
Seasonal flow forecasts have a great potential to be an important tool to optimize decision processes of many sectors, such as hydropower, agriculture, water supply and waterway transport on a long term. However, despite great advances in sub-seasonal to seasonal streamflow forecasting in the last decade, the current skill of seasonal flow forecasting in Europe and especially in Central Europe, study area in this analysis, is limited due to a low inherent predictability (of the atmosphere and hydrosphere) and limited quality of models and observations. Here, we analyze if hydrological skill can be improved by the multi-model combination of three hydrological models with different model structures forced by ECMWF S4 seasonal forecasts. Two statistical forecasting methods - Ensemble Model Output Statistics EMOS (Gneiting et al. 2005) and Bayesian Model Averaging BMA (Fraley et al. 2010) – have been applied together with a simple model averaging method (EMA) to post-process the forecasts. These results presented are part of the Horizon2020 project IMPREX www.imprex.eu (Weerts et al. 2019).



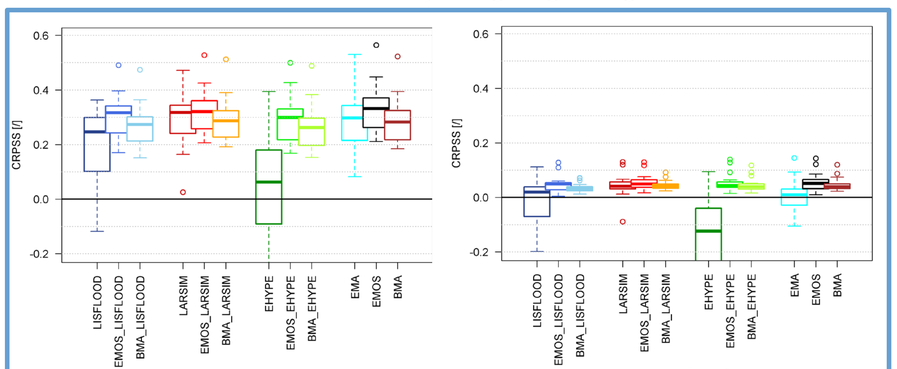
Study area Central Europe



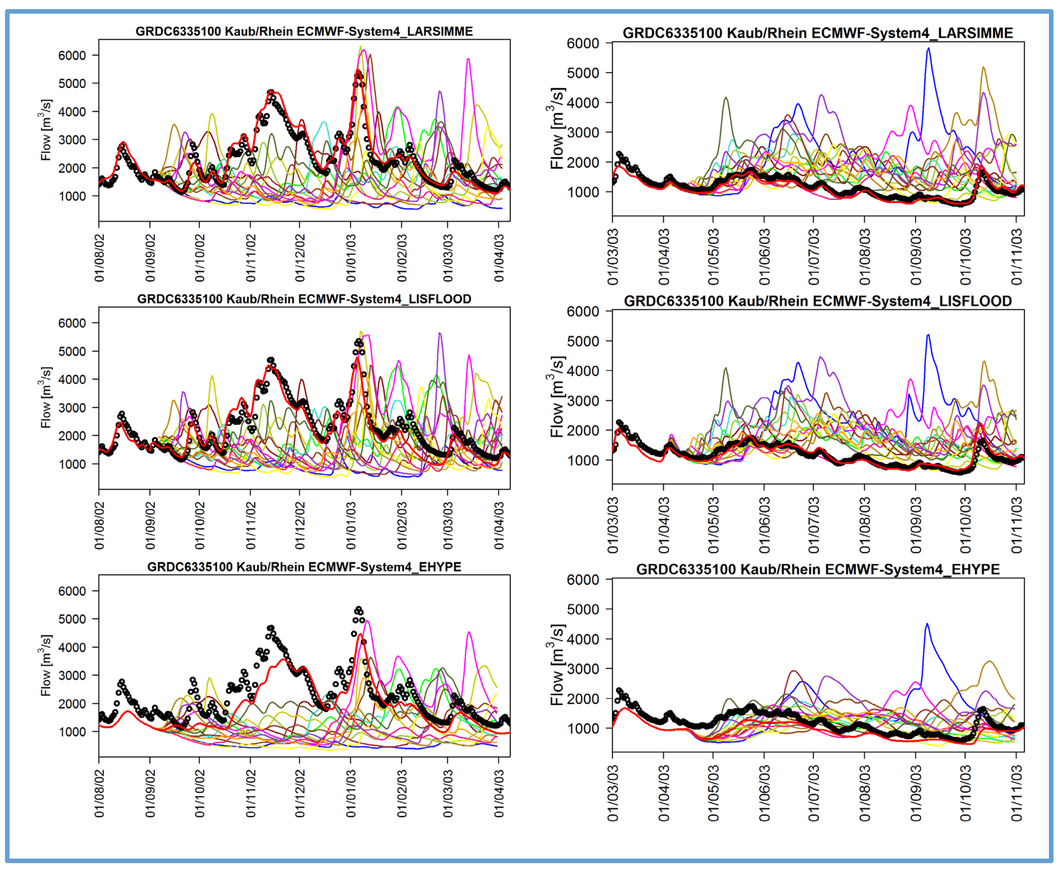
Model Chain



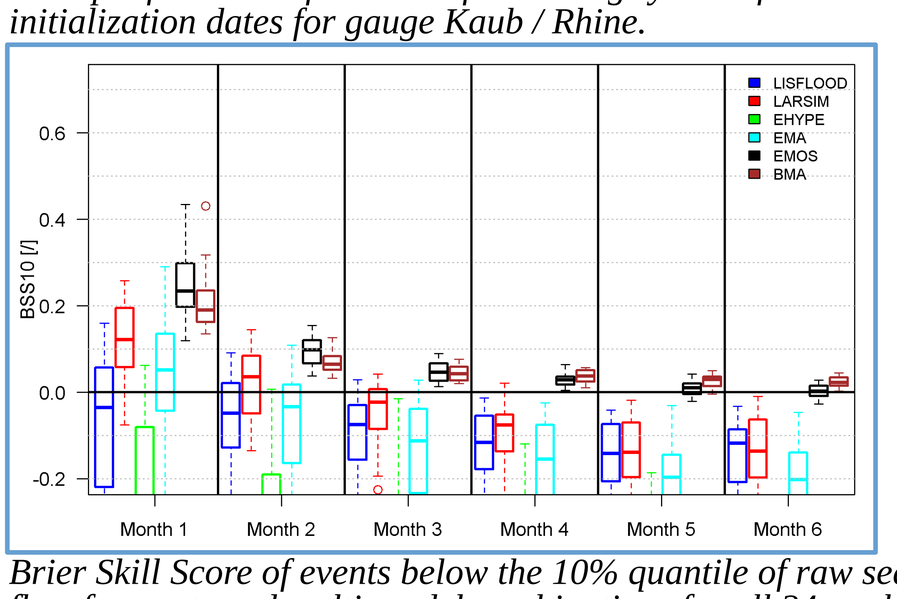
CRPSS of raw seasonal flow forecasts and multi-model combinations for all 24 analysis gauges against observations



CRPSS of raw seasonal flow forecasts and multi-model combinations for all 24 analysis gauges against observations for the first two forecast months



Example forecasts of the three forecasting systems for two initialization dates for gauge Kaub / Rhine.



Brier Skill Score of events below the 10% quantile of raw seasonal flow forecasts and multi-model combinations for all 24 analysis gauges against observations

Results

Seasonal flow forecast skill is limited in Central Europe before and after post-processing with a predictability of 1-2 months. Post-processing of raw forecasts is necessary when observations are used as reference. Combination of multiple models improves forecast skill significantly for all gauges, lead times and seasons. EMOS outperformed BMA and EMA for the forecast months with a significant skill compared to climatology.

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Gneiting, T., A. E. Raftery, A. H. Westveld & T. Goldman (2005): Calibrated probabilistic forecasting using ensemble model output statistics and minimum CRPS estimation. Monthly Weather Review 133(5), 1098-1118

Fraley, C., A. E. Raftery & T. Gneiting (2010): Calibrating Multimodel Forecast Ensembles with Exchangeable and Missing Members Using Bayesian Model Averaging. Monthly Weather Review 138(1), 190-202

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