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# Ensemble hydro-meteorological forecasting for early warning of floods and scheduling of hydropower production

Stian Solvang Johansen (1,2), Ingelin Steinsland (3), and Kolbjørn Engeland (4)

(1) Statkraft Energi AS Lilleakerveien 6, 0283 Oslo, Norway, (2) Department of Geosciences Postaddress: P.O. Box 1047 Blindern, 0316 Oslo, Norway, (3) Department of Mathematical Sciences, Norwegian University of Science and Technology, 7491 Trondheim, Norway, (4) Norwegian Water Resources and Energy Directorate (NVE) Po box 5091 Majorstuen, Oslo, Norway

Running hydrological models with precipitation and temperature ensemble forcing to generate ensembles of streamflow is a commonly used method in operational hydrology. Evaluations of streamflow ensembles have however revealed that the ensembles are biased with respect to both mean and spread. Thus postprocessing of the ensembles is needed in order to improve the forecast skill.
The aims of this study is (i) to to evaluate how postprocessing of streamflow ensembles works for Norwegian catchments within different hydrological regimes and to (ii) demonstrate how post processed streamflow ensembles are used operationally by a hydropower producer. These aims were achieved by postprocessing forecasted daily discharge for 10 lead-times for 20 catchments in Norway by using EPS forcing from ECMWF applied the semi-distributed HBV-model dividing each catchment into 10 elevation zones. Statkraft Energi uses forecasts from these catchments for scheduling hydropower production. The catchments represent different hydrological regimes. Some catchments have stable winter condition with winter low flow and a major flood event during spring or early summer caused by snow melting. Others has a more mixed snow-rain regime, often with a secondary flood season during autumn, and in the coastal areas, the stream flow is dominated by rain, and the main flood season is autumn and winter. For post processing, a Bayesian model averaging model (BMA) close to (Kleiber et al 2011) is used. The model creates a predictive PDF that is a weighted average of PDF′s centered on the individual bias corrected forecasts. The weights are here equal since all ensemble members come from the same model, and thus have the same probability. For modeling streamflow, the gamma distribution is chosen as a predictive PDF. The bias correction parameters and the PDF parameters are estimated using a 30-day sliding window training period. Preliminary results show that the improvement varies between catchments depending on where they are situated and the hydrological regime. There is an improvement in CRPS for all catchments compared to raw EPS ensembles. The improvement is up to lead-time 5-7. The postprocessing also improves the MAE for the median of the predictive PDF compared to the median of the raw EPS. But less compared to CRPS, often up to lead-time 2-3.
The streamflow ensembles are to some extent used operationally in Statkraft Energi (Hydro Power company, Norway), with respect to early warning, risk assessment and decision-making. Presently all forecast used operationally for short-term scheduling are deterministic, but ensembles are used visually for expert assessment of risk in difficult situations where e.g. there is a chance of overflow in a reservoir. However, there are plans to incorporate ensembles in the daily scheduling of hydropower production.