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Estimating predictive uncertainty: towards an ensemble-only framework?

Why move towards ensembles?

Increasingly often, operational hydrologic forecasts are expressed as estimates of predictive hydrologic uncertainty. These estimates are produced using either post-processing methods or ensemble techniques. We pose that ultimately, uncertainty estimates should be produced using ensemble techniques only. The role of post-processing is then limited to bias-correction and estimation of residual uncertainty.

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Plausible traces	Computationally intensive
Separately address individual sources of uncertainty	Additional research required

Ensemble techniques allow for separately addressing individual sources of uncertainty. These sources include atmospheric forcings, model structure and parameters and observational data. In theory, multiple plausible realisations of any of these sources can be routed through a hydrologic model, thus yielding ensemble traces that are consistent with the physical processes that are simulated. Contrary to quantiles from a predictive distribution, these traces can be used as boundary conditions for subsequent model runs.

The experiment

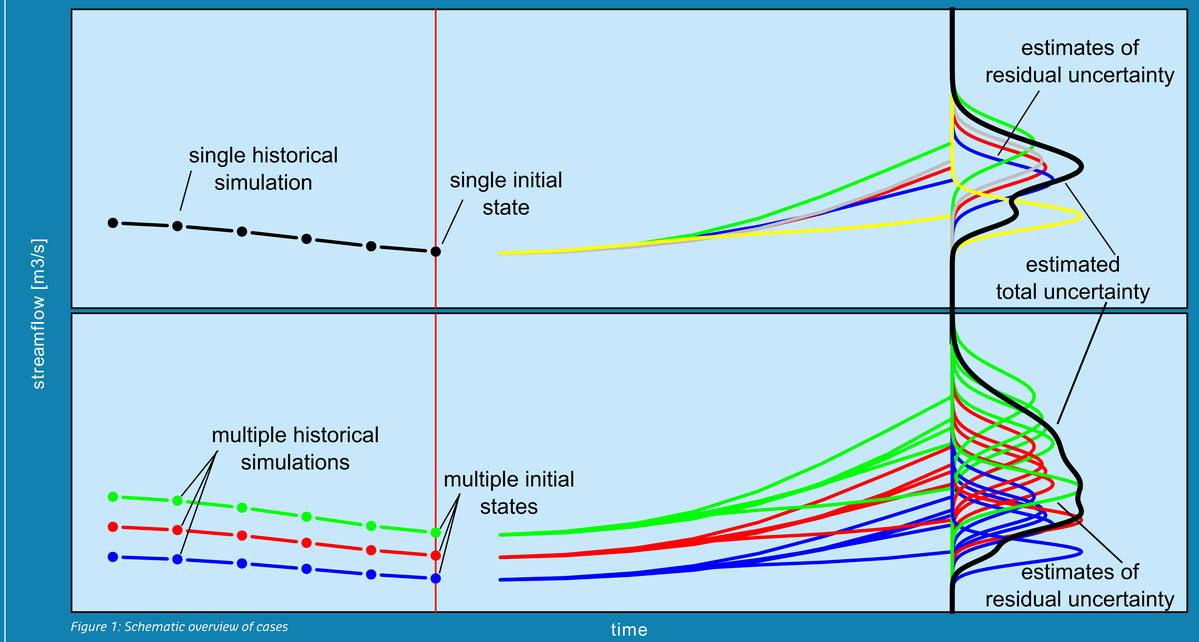

Figure 1: Schematic overview of cases

The theory is tested in the present experiment, where two sources of uncertainty are addressed separately through ensembles:

- Uncertainty originating in the spatial interpolation of precipitation;
- Uncertainty in future atmospheric forcings.

In both cases, residual uncertainty is addressed through (separately calibrated!) statistical post-processors based on the Quantile Regression technique. Ensembles are 'dressed' with this residual uncertainty.

The predictive quality of two sets of hindcasts is compared. In case A, uncertainty of precipitation interpolation is included in the residual uncertainty. In case B, this uncertainty is addressed through ensemble techniques.

Figure 1 gives a schematic overview of the cases. Top panel shows the case where a single precipitation field is used, resulting in a single historical streamflow simulation. Line colours denote the process of 'ensemble dressing'. The bottom panel shows the case where multiple precipitation fields result in multiple historical streamflow simulations and multiple historical states. Here, line colours denote the process of dressing ensembles resulting from multiple initial states. The black distribution is the posterior, 'total uncertainty' distribution.

Materials and methods

Study basin: Ourthe @ Tabreux

Data:
- Observed precipitation at ~16 stations
- COSMO-LEPS precipitation, temp ensembles
- Observed streamflow at Tabreux

Techniques:
- Ensemble dressing (Pagano et al., 2012)
- Quantile Regression (Weerts et al., 2011)
- Precipitation ensembles (Rakovec et al., 2012)

Tools:
- Delft-FEWS forecast production system (Werner et al., 2012)
- Distributed HBV model (Rakovec et al., 2012)
- Ensemble Verification System (Brown et al., 2010)

Selected references

- Brown et al., 2010. *'The Ensemble Verification System (EVS)...'*. DOI: 10.1016/j.envsoft.2010.01.009
- Pagano et al., 2012. *'Ensemble Dressing for Hydrological Applications'*. DOI:10.1002/hyp.9313.
- Rakovec et al., 2012. *'Generating Spatial Precipitation Ensembles...'*. DOI:10.5194/hess-16-3419-2012.
- Weerts et al., 2011. *'Estimation of Predictive Hydrological Uncertainty Using Quantile Regression...'*. DOI:10.5194/hess-15-255-2011
- Werner et al., 2012. *'The Delft-FEWS Flow Forecasting System'*. DOI: 10.1016/j.envsoft.2012.07.010

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