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Bayesian modeling of rainfall-runoff uncertainty to improve probabilistic forecasts

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Probabilistic forecasts aim at accounting for uncertainty by producing a predictive distribution of the quantity of interest instead of a single best guess estimate.

With regard to river flow forecasts, uncertainty is mainly due (a) to the unknown future rainfalls and temperatures, (b) to the possible inadequacy of the deterministic model mimicking the rainfall-runoff transformation. The first source of uncertainty can nowadays be taken into account using ensemble forecasts as inputs to the rainfall-runoff model (RRM). However, the second source of uncertainty due to the possible RRM misrepresentation remains. A simple way to integrate it consists in adjusting the forecast's density as much as necessary to get a prediction consistent with the observations. This step is called "post-processing".

Our work focuses on series of river flow forecasts routinely issued at EDF (Electricity of France) and at Hydro-Québec. We aim at reducing the sharpness loss in the post-processing step while guaranteeing point-wise and temporal consistency.

To do so, we write a joint model on the RRM errors along the whole trajectory to be predicted.

Point-wise and temporal consistency are then obtained relying on a Bayesian approach. As in Krzysztofowicz's works, we first consider the prior behavior of the natural river flow and then update it by taking into account the likelihood of the information conveyed through RRM's outputs. In the spirit of Markov switching models, we establish a classification of time periods remaining on RRM's state variables through a Probit model. Conditioning on such a classification yields a mixture model of RRM errors.

We finally compare the results to EDF's present operational forecasting system.

Key words : probabilistic forecasts, sharpness, rainfall-runoff, post-processing, river flow, model error.