Predictive uncertainty estimation at ungauged basins in a Bayesian framework

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In this work, an approach based on the Bayesian *Model Conditional Processor* (MCP) combined with a statistical regression is tested to assess Predictive Uncertainty (PU) estimation at ungauged basins. A second alternative approach was the *Mutually Interactive State - Parameter Estimation* (MISP) algorithm, which is based on the application of two interacting Kalman filters coupled in parallel seeking to improve the historical flow predictions made with a hydrologic distributed model in some ungauged catchments. As a case study, the basins included in the second phase of the DMIP2 inter-comparison project were selected.

The MCP methodology allows estimating the conditional pdf of a hydrological predictand, such as flow or water level, conditioned on the predicted flows by one or more hydrological models. In this approach, first, the nonparametric Normal Quantile Transform (NQT) is applied to the observations and simulations by fitting to each series the empirical Weibull Plotting Position cdf. Once transformed into the Gaussian field we hypothesized that the resulting joint density is Bivariate Normal in the case of one single hydrological model or Multivariate Normal for more than one model. Under these assumptions, the residuals should be Normal distributed, and therefore, the conditional predictive uncertainty (PU) will also result to be Normal distributed.

Since the proposed research seeks to extrapolate the MCP to ungauged sites, in the first approach we have tested some parametric cdf's, instead of the empirical Weibull Plotting Position, aimed to do a subsequent regionalization of its parameters. This regionalization was done by a statistical regression of the observed L-moments, using as independent variables the simulated L-moments and some representative basin descriptors as the drainage area and the topographic index. A similar regression model was also required to estimate the parameters of the joint distribution in the Gaussian Field.

In the MISP approach, two coupled filters allow representing the dynamic behavior of a discrete linear system in order to estimate the discharges at the ungauged sites. Further, the MISP approach allows a direct assessment of the uncertainty linked to these predictions. The state variables included in the state vector were the observed and model simulated flows at the basin outlet, used as a pivot site to transfer information to an ungauged sub-catchment within it, as well as the simulated flows in the latter. Additionally, the same variables at the previous time step were also included to account for autocorrelation in the process.

The results obtained in both approaches suggest that the proposed methodologies are robust and useful tools for the uncertainty assessment linked to flow predictions with one or more hydrological models at ungauged catchments.