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Uncertainty analysis of a low flow model for the Rhine River

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It is widely recognized that hydrological models are subject to parameter uncertainty. However, little attention has been paid so far to the uncertainty in parameters of the data-driven models like weights in neural networks. This study aims at applying a structured uncertainty analysis to a data-driven model for low flow forecasting with a lead time of 14 days in the Rhine River. In the modeling phase, the Rhine basin is divided into seven major sub-basins. Each sub-basin is modeled separately with a data-driven model and the output discharges were routed to Lobith with another data-driven model. Basin averaged precipitation, basin averaged potential evapotranspiration, basin averaged fresh snow depths, basin averaged groundwater levels and major lake levels in the sub-basins are selected as low flow indicators and used as inputs to the models. The basin discretization and the selection of low flow indicators were not arbitrary since the dominant processes were considered by applying seasonality analysis to discharge time series from 108 sub-basins. Moreover, the correlations between indicators and low flows with varying temporal resolution and varying lags were used to identify appropriate temporal scales of the model inputs.

The structure of the model can inherit uncertainty too due to many factors, including the lack of a robust hydrological theory at the spatial scale of the seven sub-basins. However, the parameter uncertainty is assumed to be the largest uncertainty source compared to other uncertainty sources. The effects of the input uncertainty were not assessed since averaging over sub-basins significantly reduces the measurement uncertainties. The model parameter sets were estimated using inverse modeling. The uncertainty of each weight is expressed as a probability distribution. Sensitivity analysis was applied for reducing the dimension and size of parameter space before uncertainty analysis. Finally, Monte Carlo Simulation was used to estimate the posterior distributions of the model outputs. The results in this study provide the effects of uncertainties in low flow model parameters on the model outputs. It has also been shown that the explicit assessment of uncertainties in the data-driven model parameters can lead to significant improvements in the information supply for low flow forecasting.