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Optimal combinations of specialized conceptual hydrological models

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In hydrological modelling it is a usual practice to use a single lumped conceptual model for hydrological simulations at all regimes. However often the simplicity of the modelling paradigm leads to errors in represent all the complexity of the physical processes in the catchment. A solution could be to model various hydrological processes separately by differently parameterized models, and to combine them.

Different hydrological models have varying performance in reproducing catchment response. Generally it cannot be represented precisely in different segments of the hydrograph: some models performed well in simulating the peak flows, while others do well in capturing the low flows. Better performance can be achieved if a model being applied to the catchment using different model parameters that are calibrated using criteria favoring high or low flows. In this work we use a modular approach to simulate hydrology of a catchment, wherein multiple models are applied to replicate the catchment responses and each “specialist” model is calibrated according to a specific objective function which is chosen in a way that forces the model to capture certain aspects of the hydrograph, and outputs of models are combined using so-called “fuzzy committee”.

Such multi-model approach has been already previously implemented in the development of data driven and conceptual models (Fenicia et al., 2007), but its perfomance was considered only during the calibration period. In this study we tested an application to conceptual models in both calibration and verification period. In addition, we tested the sensitivity of the result to the use of different weightings used in the objective functions formulations, and memberbship functions used in the committee.

The study was carried out for Bagamati catchment in Nepal and Brue catchment in United Kingdoms with the MATLAB-based implementation of HBV model. Multi–objective evolutionary optimization genetic algorithm (Deb, 2001) was used to find Pareto-optimal solutions, and Adaptive cluster covering algorithm (Solomatine, 1999) was used to find the globally optimal solution.

The study confirmed the validity of the multi-model approach that lead to much better performance in calidation period (compared to the use of a single model), and 1.3-16.7% better performance in validation.