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Relating differences in conceptual model accuracy to climatic forcing, catchment characteristics and model structure

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In any catchment, the interaction between climatic forcing and the catchment itself (e.g. geographical features, topography and human influences) determines the catchment's hydrological response. In a modelling study, the complexity of a catchment is expressed through a mathematical model that attempts to represent those catchment features and/or hydrological processes that are influential in the catchment's hydrological response. Many different model types are available, differing in spatial and temporal resolution, which processes and/or catchment characteristics are included in the model, and the mathematical formulas used to create the model. It is often not straightforward to choose the most appropriate model for a given catchment. Here we present a large-sample study that investigates to what extent a catchment's climatic forcing and physical characteristics can help to choose an appropriate model structure for streamflow simulation.

We define model or streamflow simulation accuracy as the degree of agreement between observed and simulated streamflow for a catchment, expressed as the value of an objective function. For 671 catchments across the contiguous USA, we first investigate the streamflow simulation accuracy of up to 40 lumped conceptual models through extensive parameter sampling. Per catchment, data uncertainties are constant for all models and differences between the models' streamflow simulation accuracy are thus assumed to result from differences between the models' structures. Next, on a per-model basis we investigate whether differences in each model's performance across all 671 catchments can be related to differences in climatic conditions and/or catchment characteristics across all catchments. Finally, given that each model attempts to simulate a different selection of hydrological processes, we investigate whether there are any relations between processes included in each model, and the catchments where each model performs well. Our results are intended to help direct future conceptual model improvement efforts and be of direct use as a guide for model users.