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Integration of Hydrologic Signatures for Model Evaluation in Gauged and Ungauged Catchments

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Rainfall-runoff models are widely used tools in catchment hydrology. Their evaluation is mostly based on comparing observed and simulated discharge values and various statistical objective functions have been proposed to evaluate the agreement between these time series. However, model evaluations that are based on statistical objective functions often does not provide the modeller with much insight on why the model fails to represent the hydrology of the real-world system. Other, hydrologically meaningful indices or signatures have been proposed instead that quantify the hydrologic response characteristics of the catchment. They can also be regionalized and thus provide a potential opportunity for model evaluation in ungauged basins.

Our study investigates how to best integrate hydrological signatures in an objective function for model evaluation to shift the focus of objective functions to evaluate basic hydrological functions of catchments. We propose a signature-based hydrologic efficiency metric that can be derived from locally observed or regionalised hydrologic signatures. The metric improves upon the Kling-Gupta Efficiency (KGE) metric by replacing its three components with hydrologic signatures characterising the water balance (or bias), the damping (or variance) and the timing of flows (or correlation). Additionally, we use these hydrologic signatures with the physical characteristics (i.e. catchment attributes) in some regionalization approaches such as linear, nonlinear regression and random forests for streamflow predictions in ungauged catchments. We test our ideas on a large and diverse sample of 582 UK catchments using the CAMELS-GB dataset and show that the performance of the proposed metric works well.