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Achieving hydrological consistency of models by combining a multi-metric model evaluation with a temporal parameter sensitivity analysis

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To ensure reliable results of a hydrological model, it is essential that the model reproduces the hydrological processes adequately. In general, modelling studies are focused on satisfying model performance as the key criterion for plausible and realistic results. However, good model results in terms of one or more performance metrics are certainly required but do not prevent that the model produces the observed hydrological time series for the wrong reason. To overcome this uncertainty, there is the demand to investigate the functioning of the model to decide about the plausibility of the simulated processes of the hydrological system.
In our study, we present the verification of hydrological consistency by combining a diagnostic model evaluation with a temporal parameter sensitivity analysis. In a first step, the presented verification framework makes use of a multi-metric model evaluation. A number of performance metrics are combined to evaluate all phases of the hydrograph simultaneously. We perform the multi-metric evaluation to investigate the model's ability to simulate the whole hydrograph appropriately as a basis for satisfying model results.
In a second step, we ensure that proper hydrograph simulation was achieved for the right reason. We apply a temporal parameter sensitivity analysis to investigate the process representation within the model structure and the functioning of the model. The temporal dynamics of parameter sensitivity are used to characterise the dominance of parameters for each time step. This characteristic parameter dominance is then related to the corresponding hydrological process. In addition to satisfying model performance, the analysis of the temporal parameter sensitivity is used to ensure that the modelled hydrological processes match the expectations of real-world hydrological processes.
Our results show that the investigated model provides hydrological consistency which is described with satisfying discharge simulation due to plausible process simulation. We conclude that the analysed model structure is appropriate to simulate the hydrological processes of the studied catchment. In general, we see the applicability of the presented verification framework in a much broader context. We hypothesise that the combination of a multi-metric model evaluation and a temporal parameter sensitivity analysis helps to effectively develop more realistic model structures and to finally reduce the uncertainty of process simulation of hydrological models.