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Connective strength between model parameters and performance criteria - A new concept towards precise parameter identification for sensitivity and uncertainty analysis

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To obtain reliable results in analyzing the sensitivity and uncertainty of model parameters, a precise identification and understanding of these parameters is required. The parameter identification strongly depends on the selection of the performance criteria. With multiple and complementary performance criteria, different aspects of the hydrological behavior are represented in models. A distinct connection of each relevant model parameter to one corresponding performance criteria would significantly facilitate the handling of parameters in models and would improve the interpretation of results of sensitivity and uncertainty analyses.
Our study investigates the relationship between model parameters and performance criteria, by calculating ten performance criteria for a high number of model simulations in two contrasting study catchments. These performance criteria include the NSE, the KGE as well as the three components of KGE. Moreover, signature measures are calculated, which are represented by the RSR for different segments of the flow duration curve.
Based on this, regression trees are calculated to firstly detect, the most relevant model parameters for each performance criterion. Secondly, each model parameter is used as target variable for regression trees to derive the performance criterion which is mostly impacted by changes in the model parameters. In this way, the most appropriate performance criterion is identified for each model parameter.
To enhance the hydrological knowledge on the relationship between model parameters and performance criteria, we introduce the notion of connective strength which is defined as the intensity how model parameters and performance criteria are inter-related. The connective strength is high a) if a performance criterion is strongly controlled by a certain model parameter and b) if this model parameter strongly affects this performance criterion significantly. This means that there is a high bijective relationship between model parameters and performance criteria which allows a precise parameter identification.
Our results provides a high bijective connective strength between model parameters and performance criteria related to low and mid flow as well as to water balance conditions. In contrast, the connective strength is lower for high flow conditions. In this way, the benefit of each single criterion in comparison to the other performance criteria is highlighted. At least three to four different performance criteria are required for a precise identification of distinct model parameters depending on the process complexity in the catchments. Overall, this study shows how precisely a model parameter is identified by the different performance criteria.
This leads to the conclusion that the identification of the connective strength enables a more consistent handling of model parameters and performance criteria for sensitivity and uncertainty analysis.