Balance between calibration objectives in hydrological modelling

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Abstract

The robustness of hydrological models is determined by issues such as model performance under different calibration and validation conditions, extrapolation behaviour and propagation of uncertainties. Different conditions are commonly expressed by different objective functions such as the Nash-Sutcliffe coefficient and the root mean square error of peak flows. These different objective functions can be combined into multi-objective functions for calibration purposes. However, it is generally not known which balance between different objectives should be used, i.e. which weights should be assigned to the different objective functions. Most multi-objective approaches in the literature assume a certain balance between objectives depending on the simulation purpose of the model user. An alternative way is to assess the optimum balance based on an aggregated measure, for instance a fuzzy measure or a scaled multi-objective function. This avoids the selection of weights and makes the process less subjective. In this study, three different measures to assess the optimal balance between objectives are compared: combined rank method, parameter identifiability and model evaluation. Four objectives (water balance, hydrograph, high flows, low flows) are included in each measure. The contributions of these objectives to the specific measure are varied to find the optimal balance between the objectives for each measure. The methods are applied to nine middle-sized catchments (350-2500 km^2) and using a typical conceptual hydrological model. Results indicate that differences in the optimal balance between the combined rank method and parameter identifiability on the one hand and model evaluation on the other hand are considerable. The theoretically optimal balance would be a situation without trade-off between single objectives. For some catchments and measures, this situation is almost obtained. On average, the combined rank method's performance is somewhat better than the parameter identifiability's performance (respectively 3.6% and 5.0% from theoretical optimum), where the model evaluation's performance is considerably less (22.4% from theoretical optimum).