EGU24-11414, updated on 20 May 2024
https://doi.org/10.5194/egusphere-egu24-11414
EGU General Assembly 2024

Single vs. multi-objective optimization approaches to calibrate an event-based conceptual hydrological model using model output uncertainty framework.

Muhammad Nabeel Usman[1], Jorge Leandro[2], Karl Broich[1], and Markus Disse[1]
[1]Technical University of Munich, Chair of Hydrology and River Basin Management, TUM School of Engineering and Design, München, Germany (nabeel.usman@tum.de)
[2]Chair of Hydrodynamics and Hydraulics Engineering, University of Siegen, Germany.

Flash floods have become one of the major natural hazards in central Europe, and climate change projections indicate that the frequency and severity of flash floods will increase in many areas across the world and in central Europe. The complexity involved in the flash flood generation makes it difficult to calibrate a hydrological model for the prediction of such peak hydrological events. This study investigates the best approach to calibrate an event-based conceptual HBV model, comparing different trials of single-objective, single-event multi-objective (SEMO), and multi-event-multi-objective (MEMO) model calibrations. Initially, three trials of single-objective calibration are performed w.r.t. RMSE, NSE, and BIAS separately, then three different trials of multi-objective optimization, i.e., SEMO-3D (single-event three objectives), MEMO-3D (mean of three objectives from two events), and MEMO-6D (two events six objectives) are formulated. Model performance was validated for several peak events via 90 % (confidence interval) CI-based output uncertainty quantification. The uncertainties associated with the model predictions are estimated stochastically using the 'relative errors (REs)' between the simulated (Q_{sim}) and measured (Q_{obs}) discharges as a likelihood measure. Single-objective model calibration demonstrated that significant trade-offs exist between different objective functions, and no unique parameter set can optimize all objectives simultaneously. Compared to the solutions of single-objective calibration, all the multi-objective calibration formulations produced relatively accurate and robust results during both model calibration and validation phases. The uncertainty intervals associated with all the trials of single-objective calibration and the SEMO-3D calibration failed to capture observed peaks of the validation events. The uncertainty bands associated with the ensembles of Pareto solutions from the MEMO-3D and MEMO-6D (six-dimensional) calibrations displayed better performance in reproducing and capturing more significant peak validation events. However, to bracket peaks of large flash flood events within the prediction uncertainty intervals, the MEMO-6D optimization outperformed all the single-objective, SEMO-3D, and MEMO-3D multi-objective calibration methods. This study suggests that the MEMO_6D is the best approach for predicting large flood events with lower model output uncertainties when the calibration is performed with a better combination of peak events.