Multi-objective vs. single-objective calibration of a hydrologic model using single- and multi-objective screening

Matthias Cuntz, Juliane Mai

Geophysical Research Abstracts
Vol. 18, EGU2016-8997-1, 2016
EGU General Assembly 2016

Multi-objective vs. single-objective calibration of a hydrologic model using single- and multi-objective screening

Juliane Mai (1), Matthias Cuntz (1), Mahyar Shafii (2), Matthias Zink (1), David Schäfer (1), Stephan Thober (1), Luis Samaniego (1), and Bryan Tolson (2)

(1) Helmholtz Centre UFZ Leipzig, Comp. Hydrosystems, Leipzig, Germany (juliane.mai@ufz.de), (2) University of Waterloo, Waterloo, Canada

Hydrologic models are traditionally calibrated against observed streamflow. Recent studies have shown however, that only a few global model parameters are constrained using this kind of integral signal. They can be identified using prior screening techniques. Since different objectives might constrain different parameters, it is advisable to use multiple information to calibrate those models. One common approach is to combine these multiple objectives (MO) into one single objective (SO) function and allow the use of a SO optimization algorithm. Another strategy is to consider the different objectives separately and apply a MO Pareto optimization algorithm. In this study, two major research questions will be addressed: 1) How do multi-objective calibrations compare with corresponding single-objective calibrations? 2) How much do calibration results deteriorate when the number of calibrated parameters is reduced by a prior screening technique?

The hydrologic model employed in this study is a distributed hydrologic model (mHM) with 52 model parameters, i.e. transfer coefficients. The model uses grid cells as a primary hydrologic unit, and accounts for processes like snow accumulation and melting, soil moisture dynamics, infiltration, surface runoff, evapotranspiration, subsurface storage and discharge generation. The model is applied in three distinct catchments over Europe.

The SO calibrations are performed using the Dynamically Dimensioned Search (DDS) algorithm with a fixed budget while the MO calibrations are achieved using the Pareto Dynamically Dimensioned Search (PA-DDS) algorithm allowing for the same budget. The two objectives used here are the Nash Sutcliffe Efficiency (NSE) of the simulated streamflow and the NSE of the logarithmic transformation. It is shown that the SO DDS results are located close to the edges of the Pareto fronts of the PA-DDS. The MO calibrations are hence preferable due to their supply of multiple equivalent solutions from which the user can choose at the end due to the specific needs.

The sequential single-objective parameter screening was employed prior to the calibrations reducing the number of parameters by at least 50% in the different catchments and for the different single objectives. The single-objective calibrations led to a faster convergence of the objectives and are hence beneficial when using a DDS on single-objectives. The above mentioned parameter screening technique is generalized for multi-objectives and applied before calibration using the PA-DDS algorithm. Two different alternatives of this MO-screening are tested. The comparison of the calibration results using all parameters and using only screened parameters shows for both alternatives that the PA-DDS algorithm does not profit in terms of trade-off size and function evaluations required to achieve converged pareto fronts. This is because the PA-DDS algorithm automatically reduces search space with progress of the calibration run. This automatic reduction should be different for other search algorithms. It is therefore hypothesized that prior screening can but must not be beneficial for parameter estimation dependent on the chosen optimization algorithm.