



A swarm intelligence-based method for hydrological model calibration through a simulated solution space

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Hydrological models are widely used for flood forecasting, continuous streamflow simulation and water resources management. The success of a hydrological model depends on different factors such as its formulation, data availability and parameter optimization. There are many approaches to identify the optimal parameter sets, which can be categorized in 1) Local search methods and 2) Global search methods. In the group of global search methods, swarm intelligence could provide an alternative to improve the application of surrogate models and to provide robust calibration. In the present study we evaluate the latter approach using a physically-based lumped model applied to 10 years of hydrologic data divided in 3 periods: 1) five years for calibration, 2) three years for validation (both statistically similar), and 3) two years for prediction. The prediction period is statistically non-similar to the calibration and validation periods. A Montecarlo simulation with 1000 parameter sets is run, and 4 goodness-of-fit coefficients are calculated for each parameter set in the calibration period: Nash-Sutcliffe Efficiency (NSE), adapted for peaks Nash-Sutcliffe Efficiency (ANSE), Kling & Gupta Efficiency (KGE), and adapted for peaks Kling & Gupta Efficiency (AKGE) coefficients. The parameter sets and its correspondent goodness-of-fit coefficients are configured as the training set of an artificial neural network surrogate model in order to generate a simulated solution space. Once the surrogate model is trained, a swarm intelligence-based approach is adapted in order to search in the simulated space. The swarm intelligence-based approach consists on an adaptation of the Artificial Bee Colony algorithm (ABC), which introduces a random variation in a parameter randomly selected in order to evaluate if there is any improvement in the goodness-of-fit values. The adaptation includes criteria to count improvements and non-improvements in the goodness-of-fit values to stop the search of solutions and a threshold criterion for selection of parameter sets. Only those sets that are above the threshold of the goodness-of-fit coefficients are selected to apply the swarm intelligence-based method.

The obtained parameter sets are evaluated with the hydrological model in order to calculate the goodness-of-fit values in the three stages (calibration, validation and prediction). In this step, those sets that provide wrong simulations are used as samples to update the neural network surrogate model for a new search iteration, and those that provide higher goodness-of-fit coefficients are saved. Preliminary results show that this technique can provide a boost on the optimization problem with improvement ratios between 1.08 and 1.27 in the goodness-of-fit coefficients.

Moreover, the parameter sets found applying this technique outperform those obtained with a local search method, especially in validation and prediction stages. Specifically, in the prediction stage, NSE of 0.77 and ANSE of 0.83 were obtained against NSE of 0.45 and ANSE of 0.57 for the local search parameter set.

Keywords: Artificial neural networks, artificial bee colony, surrogate modelling-based methods, global search methods, swarm intelligence.