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Evolutionary-based multi-objective meta-model approach for rainfall-runoff model calibration

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It is well recognized that the multiple objective (MO) approach in the calibration of hydrologic and environmental models offers distinct advantages over the single objective (SO) approach in that the resulted model results can capture the system's responses better. However, the simulation time required to perform MO calibration is often longer than SO calibration. This makes MO calibration infeasible for complex models or for simulating large catchments/ systems.

Recently, the authors presented an efficient and effective approach that can reduce the required calibration time by 35% when the approach is used for single objective calibration (Khu et al., 2004). An evolutionary-based meta-model calibration methodology was developed using a coupled genetic algorithm - radial basis function neural network. The neural network served to periodically approximate the objective function value without the need to run the simulation model, and this is the primary reason for the savings in calibration time. It was later recognized that this is difficult to implement for multi-objective calibration due to the complex mapping between the parameters space and the objectives space.

This paper presents a new evolutionary-based meta-model approach that can handle MO calibration. The proposed methodology relies on the coupled multi-objective genetic algorithm (MOGA) and k-nearest-neighbour (kNN) technique. kNN was used to approximate the Pareto ranks of the MOGA population in each generation and was

periodically updated by computing the actual ranks of some solutions. In this way, the assignment of ranks to a population of solution can be performed swiftly without resorting to running the simulation model.

The proposed calibration approach was used to calibrate the NAM rainfall-runoff model and applied to a Danish Tryggevaelde catchment. The available measurements consist of 12 years of daily runoff from the catchment of which 4 years of data was used for calibration and 2 sets of 4 years of data for validation. Four objective functions were used and they were similar to those used in previous studies such as Madsen (2000) and Khu and Madsen (2005). The MOGA used for the study is a well-known method known as NSGA-II in the optimization community.

The results obtained were comparable to those presented in an earlier work (Madsen, 2000) but requiring on less than 50% of the simulation time. This is due to the successful approximation of the Pareto ranks using kNN and the periodic updating of the kNN. This technique is demonstrated that the evolutionary-based meta-model approach presents a credible method to resolve the issue of long (and sometimes, infeasible) calibration time. However, this method, like others, have to be demonstrated for more complicated models and this will be conducted in due coarse (Jin et al, 2002).

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