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# hydroMOPSO: A versatile Particle Swarm Optimization R package for multi-objective calibration of environmental and hydrological models

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In this work we introduce hydroMOPSO, a novel multi-objective R package that combines two search mechanisms to maintain diversity of the population and accelerate its convergence towards the Pareto-optimal set: Particle Swarm Optimisation (PSO) and genetic operations. hydroMOPSO is model-independent, which allows to interface any model code with the calibration engine, including models available in R (e.g., TUWmodel, airGR, topmodel), but also any other complex models that can be run from the system console (e.g. SWAT+, Raven, WEAP). In addition, hydroMOPSO is platform-independent, which allows it to run on GNU/Linux, Mac OSX and Windows systems, among others.

Considering the long execution time of some real-world models, we used three benchmark functions to search for a configuration that allows to reach the Pareto-optimal front with a low number of model evaluations, analysing different combinations of: i) the swarm size in PSO, ii) the maximum number of particles in the external archive, and iii) the maximum number of genetic operations in the external archive. In addition, the previous configuration was then evaluated against other state-of-the-art multi-objective optimisation algorithms (MMOPSO, NSGA-II, NSGA-III). Finally, hydroMOPSO was used to calibrate a GR4J-CemaNeige hydrological model implemented in the Raven modelling framework (http://raven.uwaterloo.ca), using two goodness-of-fit functions: i) the modified Kling-Gupta efficiency (KGE') and ii) the Nash-Sutcliffe efficiency with inverted flows (iNSE).

Our results showed that the configuration selected for hydroMOPSO makes it very competitive or even superior against MMOPSO, NSGA-II and NSGA- III in terms of the number of function evaluations required to achieve stabilisation in the Pareto front, and also showed some advantages of using a compromise solution instead of a single-objective one for the estimation of hydrological model parameters.