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New Multi-objective Uncertainty-based Algorithm for Water Resource Models' Calibration

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Water resource models are powerful tools to support water management decision making process and are developed to deal with a broad range of issues including land use and climate change impacts analysis, water allocation, systems design and operation, waste load control and allocation, etc. These models are divided into two categories of simulation and optimization models whose calibration has been addressed in the literature where great relevant efforts in recent decades have led to two main categories of auto-calibration methods of uncertainty-based algorithms such as GLUE, MCMC and PEST and optimization-based algorithms including single-objective optimization such as SCE-UA and multi-objective optimization such as MOCOM-UA and MOSCEM-UA. Although algorithms which benefit from capabilities of both types, such as SUFI-2, were rather developed, this paper proposes a new auto-calibration algorithm which is capable of both finding optimal parameters values regarding multiple objectives like optimization-based algorithms and providing interval estimations of parameters like uncertainty-based algorithms. The algorithm is actually developed to improve quality of SUFI-2 results. Based on a single-objective, e.g. NSE and RMSE, SUFI-2 proposes a routine to find the best point and interval estimation of parameters and corresponding prediction intervals (95 PPU) of time series of interest. To assess the goodness of calibration, final results are presented using two uncertainty measures of p-factor quantifying percentage of observations covered by 95PPU and r-factor quantifying degree of uncertainty, and the analyst has to select the point and interval estimation of parameters which are actually non-dominated regarding both of the uncertainty measures. Based on the described properties of SUFI-2, two important questions are raised, answering of which are our research motivation: Given that in SUFI-2, final selection is based on the two measures or objectives and on the other hand, knowing that there is no multi-objective optimization mechanism in SUFI-2, are the final estimations Pareto-optimal? Can systematic methods be applied to select the final estimations? Dealing with these questions, a new auto-calibration algorithm was proposed where the uncertainty measures were considered as two objectives to find non-dominated interval estimations of parameters by means of coupling Monte Carlo simulation and Multi-Objective Particle Swarm Optimization. Both the proposed algorithm and SUFI-2 were applied to calibrate parameters of water resources planning model of Helleh river basin, Iran. The model is a comprehensive water quantity-quality model developed in the previous researches using WEAP software in order to analyze the impacts of different water resources management strategies including dam construction, increasing cultivation area, utilization of more efficient irrigation technologies, changing crop pattern, etc. Comparing the Pareto frontier resulted from the proposed auto-calibration algorithm with SUFI-2 results, it was revealed that the new algorithm leads to a better and also continuous Pareto frontier, even though it is more computationally expensive. Finally, Nash and Kalai-Smorodinsky bargaining methods were used to choose compromised interval estimation regarding Pareto frontier.