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Comment on "How effective and efficient are multiobjective evolutionary algorithms at hydrologic model calibration?" by Y. Tang et al., Hydrol. Earth Syst. Sci., 10, 289–307, 2006

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In a recent paper by Tang, Reed and Wagener (2006, hereafter referred to as TRW) a comparison assessment was presented of three state-of-the-art evolutionary algorithms for multiobjective calibration of hydrologic models. Through three illustrative case studies, TRW demonstrate that the Strength Pareto Evolutionary Algorithm 2 (SPEA2) and Epsilon Dominance Nondominated Sorted Genetic Algorithm (ε-NSGAII) achieve a better performance than the Multi-objective Shuffled Complex Evolution Metropolis algorithm (MOSCEM-UA), previously developed by us and presented in Vrugt et al. (2003). I would like to congratulate TRW with their paper, which I believe provides a strong and valuable contribution to the field of hydrologic model calibration. However, I wish to differ in opinion about some of the main conclusions presented in their paper, especially with respect to the seemingly inferior performance of the MOSCEM-UA algorithm.

The results presented in TRW were obtained using uniform random sampling of the initial parameter space. Such a sampling strategy is widely used within the water resources and computational science literature, and expresses a situation where very little prior information is available about the location of the Pareto optimal solution set. The initial sample is subsequently iteratively improved using the various algorithmic steps in the employed evolutionary algorithm. It is however possible to significantly improve the efficiency and robustness of evolutionary search for case studies (2) and (3) reported in TRW if we first attempt to create an initial sample that approximates the Pareto tradeoff surface as closely as possible. In our original paper (Vrugt et al., 2003) we suggest such an innovative approach by first locating the theoretical ends of the Pareto set using classical single objective optimization, and to use uniform random sampling over this hypercube of optimized solutions to create the initial population of points. The results presented in Vrugt et al. (2003) have demonstrated that this search strategy provides a computational efficient and robust alternative to multiobjective optimization.

It is surprising however that TRW have not considered this second or alternative optimization strategy in their paper. If correctly implemented, this search strategy

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would have provided the entire Pareto trade-off surface as depicted in Fig. 5, at far less computational costs than the SPEA2 and ε-NSGAII algorithms. For example, preliminary analyses of the identification problem discussed in Fig. 5, suggest that state-of-the-art single objective search algorithms can identify the single criterion solutions of $RMSE(R)$ and $RMSE(T)$ in less than 20 000 function evaluations. Experience further suggests that about 2000 additional function evaluations would have been needed to sample the entire Pareto front using this prior information. This is considerably less than the 15 000 000 number of SAC-SMA model evaluations used to construct the results presented in TRW. Thus, in practice, this alternative search strategy using prior information from the single criterion ends of the Pareto front would have consistently received superior performance to the SPEA2 and ε-NSGAII algorithms. This would especially be true for the hydrologic model calibration problems, discussed in case study (2) and (3). I therefore argue that TRW should have considered this alternative optimization strategy in their paper to provide an accurate reflection of the ideas and methods presented in Vrugt et al. (2003).

Nevertheless, the work presented in TRW will stimulate the hydrologic community to critically rethink the strengths and weaknesses of current available evolutionary optimization algorithms. In response to this, we (Vrugt and Robinson, 2007) have recently developed a new method called **A** **M**ulti-**AL**gorithm **G**enetically **A**daptive **M**ultiobjective or AMALGAM method, that combines two new concepts, simultaneous multi-method search, and self-adaptive offspring creation, to ensure a fast and computationally efficient solution to multiobjective optimization problems. Experiments conducted using standard, synthetic multi-objective test problems have shown that the AMLAGAM method is on the order of 3–10 times more efficient than the SPEA2 and ε-NSGAII multiobjective optimization algorithms, and provides a final population that closely approximates the Pareto solution space. We are currently in the progress of extending the concept of genetically adaptive offspring creation to single objective optimization and Markov Chain Monte Carlo (MCMC) methods combining ideas of subspace parameter estimation, and block updating. The results of this research will be reported in due course.

References

Tang, Y., Reed, P., and Wagener, T.: How effective and efficient are multiobjective evolutionary algorithms at hydrologic model calibration?, Hydrol. Earth Syst. Sci., 10, 289–307, 2006, http://www.hydrol-earth-syst-sci.net/10/289/2006/.

Vrugt, J. A., Gupta, H. V., Bastidas, L. A., Bouten, W., and Sorooshian, S.: Effective and efficient algorithm for multiobjective optimization of hydrologic models, Water Resour. Res., 39(1214), doi:1210.1029/2002WR001746, 2003.

Vrugt, J. A. and Robinson, B. A.: Improved evolutionary search from genetically adaptive multi-method search, Proceedings of the National Academy of Sciences of the United States of America, 104(3), 708–711, doi:10.1073/pnas.0610471104, 2007.

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