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Efficient Calibration of Computationally Expensive SWAT Watershed Models with a Parallel Surrogate Optimization Algorithm: SOP-Hybrid

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Efficient parallel computing and surrogate optimization can be a powerful tool for improving watershed model forecasting by accurate parameter estimation for computationally expensive hydrological and watershed models. This paper uses a new synchronous parallel surrogate-based global optimization method, called SOP-Hybrid, for automatic flow calibration of a SWAT watershed model developed for the Cannonsville and Townbrook watersheds in upstate New York. SOP-Hybrid is a novel modification of the recent Surrogate Optimization with Pareto center selection (SOP) algorithm that improves SOP's parallel optimization efficiency when a large number of parallel cores are available. The original SOP integrates concepts from multi-objective optimization and Tabu search into a single objective synchronous parallel surrogate optimization framework to propose multiple new points for simultaneous expensive evaluations, and is effective (as per prior literature and experiments) for up to 32 processors. SOP-Hybrid incorporates a modification in SOP's criterion for selection of new points for synchronous parallel evaluation in each algorithm iteration and is applied to the watershed models with between 12 and 96 processors. Results indicate that SOP-Hybrid is up to two times more efficient than SOP with 48 and 96 processors. Furthermore, comparative experiments on the watershed models show that SOP and SOP-Hybrid are more efficient than Dynamically Dimensioned Search (DDS) and Shuffled Complex Evolution (SCE-UA), for automatic calibration within a limited computational time budget.