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Multi-objective calibration and uncertainty analysis of hydrologic models; A comparative study between formal and informal methods

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Hydrologic modeling has benefited from significant developments over the past two decades. This has resulted in building of higher levels of complexity into hydrologic models, which eventually makes the model evaluation process (parameter estimation via calibration and uncertainty analysis) more challenging. In order to avoid unreasonable parameter estimates, many researchers have suggested implementation of multi-criteria calibration schemes. Furthermore, for predictive hydrologic models to be useful, proper consideration of uncertainty is essential. Consequently, recent research has emphasized comprehensive model assessment procedures in which multi-criteria parameter estimation is combined with statistically-based uncertainty analysis routines such as Bayesian inference using Markov Chain Monte Carlo (MCMC) sampling. Such a procedure relies on the use of formal likelihood functions based on statistical assumptions, and moreover, the Bayesian inference structured on MCMC samplers requires a considerably large number of simulations. Due to these issues, especially in complex non-linear hydrological models, a variety of alternative informal approaches have been proposed for uncertainty analysis in the multi-criteria context. This study aims at exploring a number of such informal uncertainty analysis techniques in multi-criteria calibration of hydrological models. The informal methods addressed in this study are (i) Pareto optimality which quantifies the parameter uncertainty using the Pareto solutions, (ii) DDS-AU which uses the weighted sum of objective functions to derive the prediction limits, and (iii) GLUE which describes the total uncertainty through identification of behavioral solutions. The main objective is to compare such methods with MCMC-based Bayesian inference with respect to factors such as computational burden, and predictive capacity, which are evaluated based on multiple comparative measures. The measures for comparison are calculated both for calibration and evaluation periods. The uncertainty analysis methodologies are applied to a simple 5-parameter rainfall-runoff model, called HYMOD.