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A framework for visualizing the convergence performance of global optimization algorithms for hydrological models

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The convergence performance of global optimization algorithms determines the reliability of the optimized parameter set of hydrological models, thereby affecting the prediction accuracy. This study applies advanced data analysis and visualization techniques to design a novel framework for characterizing and visualizing the convergence behavior of the optimization algorithms when used for the parameter calibration of hydrological models. First, we utilize violin plots to assess the convergence levels and speeds in individual parameter spaces (ECP-VP). The density distributions of violin plots match the possible properties of fitness landscapes. Then, the parallel coordinates techniques are used to simulate the dynamic convergence behavior and assess the convergence performance in multi-parameter space (ECP-PC). Furthermore, the possible mechanism for the effect of linear or nonlinear relationships between the parameters on the convergence performance is investigated using the maximal information coefficient (MIC) and the Pearson correlation coefficient (Pearson r). Finally, the effect of the parameter sensitivity on the convergence performance is analyzed. The proposed framework is applied in multi-period and multi-basin dynamic conditions as case studies. The results showed that the ECP-VP and ECP-PC techniques were well suited for the evaluation of the convergence performance of global optimization algorithms for hydrological models. The evaluation results provided valuable information on determining the reliability of the final optima, as well as the dominant response modes of hydrological models. It is also demonstrated that the convergence levels and speeds in pairwise parameter spaces depend on the linear correlations but not on the nonlinear correlation between the parameters. Additionally, there is no significant relationship between the sensitivity of the parameters and their convergence performance.