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Surrogate-based Multi-Objective Optimization and Uncertainty Quantification Methods for Large, Complex Geophysical Models

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Parameterization scheme has significant influence to the simulation ability of large, complex dynamic geophysical models, such as distributed hydrological models, land surface models, weather and climate models, etc. with the growing knowledge of physical processes, the dynamic geophysical models include more and more processes and producing more output variables. Consequently the parameter optimization / uncertainty quantification algorithms should also be multi-objective compatible. Although such algorithms have long been available, they usually require a large number of model runs and are therefore computationally expensive for large, complex dynamic models. In this research, we have developed surrogate-based multi-objective optimization method (MO-ASMO) and Markov Chain Monte Carlo method (MC-ASMO) for uncertainty quantification for these expensive dynamic models. The aim of MO-ASMO and MC-ASMO is to reduce the total number of model runs with appropriate adaptive sampling strategy assisted by surrogate modeling. Moreover, we also developed a method that can steer the search process with the help of prior parameterization scheme derived from the physical processes involved, so that all of the objectives can be improved simultaneously. The proposed algorithms have been evaluated with test problems and a land surface model - the Common Land Model (CoLM). The results demonstrated their effectiveness and efficiency.