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Improving Coupled Climate Model using EnKF for Parameter Optimization

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The uncertainty in physical parameters is a major source for model biases in a coupled climate models. Here, we explore the optimization of model parameters using the Ensemble Kalman Filter in coupled ocean-atmosphere models. First, in a fully coupled ocean-atmosphere general circulation model, we demonstrate a first successful parameter estimation using a new scheme called Adaptive Spatial Average scheme (ASA). The ASA uses the ensemble spread as the criterion for selecting "good" values from the spatially varying posterior parameter estimations; the "good" values are then averaged to give the final global uniform posterior parameter. In comparison with some previously proposed estimation methods, the ASA is shown to give more accurate estimation with a faster convergence rate. Second, in an intermediate atmosphere-ocean-land coupled climate model, we introduced a geographic-dependent parameter optimization scheme (GPO) that allows the optimized parameter values to vary geographically. The impacts of the geographic dependence of model sensitivity and observing system on parameter optimization are investigated first in the perfect model scenario. It is found that GPO is able to significantly improve climate prediction compared to the traditional parameter optimization scheme with constant parameters. The GPO scheme is then applied to an coupled model with biased physics. It is found that the GPO can significantly enhance the accuracy of climate estimation and prediction, especially for low-frequency signals in the deep ocean. This result helps us gaining some insights for improving decadal predictions in coupled general circulation models that include imperfect physics.