A Reduced Basis Ensemble Kalman Method

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In the process of estimating the state dynamics of distributed-parameter systems, data from physical measurements can be incorporated into the mathematical model to reduce the uncertainty in the parameter estimates and, consequently, improve the state prediction. This process of data assimilation must deal with the data and model misfit arising from experimental noise as well as from model inaccuracies. In our study, we focus on the ensemble Kalman method (EnKM) [1], an iterative Monte Carlo method for the solution of inverse problems. The method is gradient-free and, just like the ensemble Kalman filter, relies on an ensemble of "particles" (here, a sample of parameter values) to identify the state that better reproduces the physical observations, while preserving the physics of the system as described by the model.
In this talk, we show how model order reduction can be combined with the EnKM to greatly accelerate the EnKM solution of inverse problems. In addition, we experimentally study the latter's performance with respect to different levels of noise and model error. Such numerical experiments, e.g., involving unknown distributed parameters in two or more spatial dimensions, can be very expensive and are (here) enabled only by the computational efficiency of the surrogate models. For a physical problem governed by non-linear parabolic partial differential equations, we investigate the role of the ensemble size on the reconstruction error and extend the method by introducing a measurement bias correction to improve the parameter estimate.

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References

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