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A Reduced Basis Ensemble Kalman Method

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In the process of reproducing the state dynamics of distributed-parameter systems, data from physical measurements can be incorporated into the mathematical model to reduce the parameter uncertainty and, consequently, improve the state prediction. This process, referred to as Data Assimilation, must deal with the data and model misfit arising from experimental noise as well as model inaccuracies and uncertainties. In our study, we focus on the ensemble Kalman method (EnKM) [1], an iterative Monte Carlo method indicated for the a posteriori analysis of time series. The method is gradient free and, just like the ensemble Kalman filter, relies on a sample of parameters or particles ensemble to identify the state that better reproduces the physical observations, while preserving the physics of the system as described by the model.

In this context, for physical problems described by non-linear parabolic partial differential equations, we employ reduced order modeling (ROM) techniques [2] to generate surrogate models of different accuracy. These are combined with the EnKM to study its behavior in the presence of increasing levels of experimental noise and for model errors of different magnitude. We also experimentally investigate the role of the ensemble size on the reconstruction error and extend the method by implementing a poll-voting feature for improved parameter estimation. We emphasize that such experiments, involving unknown distributed parameters in two or more spatial dimensions, are potentially very expensive and are made possible by the remarkable efficiency provided by the surrogate models.

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