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Performance Comparison Between Particle and Ensemble Kalman Filters in Data Assimilation with Nonlinear Observation System

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The Ensemble Kalman Filter(EnKF)1 was invented and is used in sequential data assimilation. This procedure is based on the second order statistics and it cannot deal with these systems directly if observed data are nonlinear transformation of states. This problem is resolved by extending the state vector, but this cannot reflect ensemble states completely. On the other hand, it is well known that the Particle Filter(PF), which is developed in statistical field, can deal with higher order statistics and nonlinear transformed states without extension. Both of them are ensemble-based filtering methods and can be extended to fixed lag smoother(the EnKS and the Particle Smoother(PS)). This research demonstrates that the PF and the PS are superior to the EnKF and the EnKS in assimilating nonlinear observation by numerical experiments.

The contents of the experiments are as follows. Simulation data are generated by the system that has nonlinear observation.2 Firstly, we examined how accurate the estimated states are with the EnKF, the EnKS, the PF and the PS. An example of recovered state series is showed in Figure 1. The result shows the PF can recover state more accurately than the EnKF. In the second experiment, variance of the system noise is treated as unknown parameter to be estimated, and it is estimated for the EnKF with modification of Evensen1. Estimated parameter is plotted in Figure 1. In the case using the PF, parameter approaches true value zero faster than in the case using the EnKF. This demonstrates the PF can estimate parameters more efficiently.

Keywords: Data assimilation; nonlinear observation system; Particle Filter; Ensemble Kalman Filter.

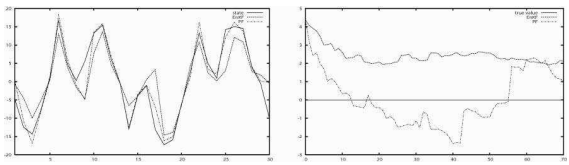

Figure 1: Recovered state and estimated parameter

References

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