Adaptive ensemble Kalman filtering of nonlinear systems

Tyrus Berry[a] and Timothy Sauer[a]

[a] *Department of Mathematical Sciences, George Mason University, USA, tsauer@gmu.edu.*

A necessary ingredient of an ensemble Kalman filter is covariance inflation [1], used to control filter divergence and compensate for model error. There is an ongoing search for inflation tunings that can be learned adaptively. Early in the development of Kalman filtering, Mehra [2] enabled adaptivity in the context of linear dynamics with white noise model errors by showing how to estimate the model error and observation covariances. We propose an adaptive scheme, based on lifting Mehra's idea to the nonlinear case, that recovers the model error and observation noise covariances in simple cases, and in more complicated cases, results in a natural additive inflation that improves state estimation. It can be incorporated into nonlinear filters such as the Extended Kalman Filter (EKF), the Ensemble Kalman filter (EnKF) and their localized versions. We test the adaptive EnKF on a 40-dimensional Lorenz96 model and show the significant improvements in state estimation that are possible. We also discuss the extent to which such an adaptive filter can compensate for model error, and demonstrate the use of localization to reduce ensemble sizes for large problems.

References

[1] Anderson, J. and S. Anderson. "A Monte-Carlo implementation of the nonlinear filtering problem to produce ensemble assimilations and forecasts." Mon. Wea. Rev., 127, 2741– 2758, 1999.

[2] Mehra, R. "On the identification of variances and adaptive Kalman filtering." IEEE Trans. Auto. Cont., 15, 175–184, 1970.