Geophysical Research Abstracts
Vol. 15, EGU2013-1981, 2013
EGU General Assembly 2013


# On the impact of nonlinearity on ensemble smoothing

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Ensemble smoothing can be used as a cost-efficient addition to ensemble square root Kalman filters to improve a reanalysis in data assimilation. To correct a past state estimate, the smoother utilizes the cross-covariances between the filtered state ensemble at the present time and a past ensemble at the time where the smoothing is performed. Using the cross-covariances relies on the assumption that the dynamics of the system under consideration are linear. For nonlinear models, it can be expected that the smoothing is suboptimal. We discuss the influence of nonlinearity on the performance of ensemble smoothing based on numerical experiments with the Lorenz-96 model and a realistic ocean circulation model. The experiments show that there exists an optimal smoothing time interval (lag), which depends on the strength of the nonlinearity. For very long lags, the smoothing can result in a deterioration of the state estimate compared to the filtered result. In the case of multivariate assimilation, different fields show distinct optimal smoother lags. In practice, one will have to choose either a compromise for all fields, or one needs to smooth over different lags specific for each field.