Ensemble Data Assimilation without Ensembles with Application to Ocean Data Assimilation

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Two methods to estimate background error covariances for data assimilation are introduced. While both share properties with the ensemble Kalman filter (EnKF), they differ from it in that they do not require the integration of multiple model trajectories. Instead, all the necessary covariance information is obtained from a single model integration. The first method is referred-to as SAFE (Space Adaptive Forecast error Estimation) because it estimates error covariances from the spatial distribution of model variables within a single state vector. It can thus be thought of as sampling an ensemble in space. The second method, named FAST (Flow Adaptive error Statistics from a Time series), constructs an ensemble sampled from a moving window along a model trajectory. The underlying assumption in these methods is that forecast errors in data assimilation are primarily phase errors in space and/or time.

SAFE and FAST are applied to the assimilation of Argo temperature profiles into version 4.1 of the Modular Ocean Model (MOM4.1) coupled to the GEOS-5 atmospheric model and to the CICE model developed at Los Alamos National Laboratory. The results are validated against un-assimilated Argo salinity data. They show that SAFE and FAST are competitive with the ensemble optimal interpolation (EnOI) used to produce the latest ocean analysis by the Global Modeling and Assimilation Office (GMAO). Further, when only temperature data are assimilated, FAST is better able to improve the model salinity field than SAFE or EnOI.