Session: C19 Poster: T110B

Comparison of Ensemble Kalman Filter and 4D-Var on a simple ""coupled ocean-atmosphere system""

Eugenia Kalnay[†]; Tamara Singleton
[†] University of Maryland, USA
Leading author: ekalnay@atmos.umd.edu

The coupled ocean-atmosphere system has instabilities that span time scales from a few minutes (e.g. cumulus convection) to years (e.g. El Niño). Fast time scales have stronger growth rates and within linear approximations used in data assimilation, they do not saturate and may distort the slower longer time-scale solution. Therefore, it is not clear whether a data assimilation focused on long-term variability should include smaller time scales. To study this problem, we perform sequential and variational data assimilation experiments with 3 coupled Lorenz (1963) models, simulating a coupled ocean- atmosphere model. We aim to better understand the abilities of different data assimilation methods for coupled models of varying time scales and aid in the development of data assimilation systems for larger coupled ocean-atmosphere models such as a general circulation models. We compare several possible data assimilation approaches for this problem: the Ensemble Transform Kalman Filter (ETKF) without localization, the Local ETKF (LETKF), where the localization is done in submodel space, their 4D versions, where all observations are assimilated at their right time, an LETKF with Quasi-Outer Loop (LETKF-QOL), a fully coupled 4D-Var, ocean only 4D-Var, and an Estimating Circulation and Climate of the Ocean ECCO-like 4D-Var, where the control variables include surface fluxes in addition to the initial state. All experiments were done assuming a perfect model and observing all variables. We find that EnKF-based algorithms without a quasi-outer loop or model localization experience filter divergence for long assimilation windows. As expected, their accuracy depends on the covariance inflation and number of ensemble members (we used a full-rank ensemble of 9 members, since the model has 9 dof). The fully coupled 4D-Var analyses provided a good estimate of the model states, but required the implementation of the Quasi-static Variational Analysis (QVA) as well as the tuning of the amplitude of the background error covariance. When comparing the EnKF analyses with the 4D-Var analyses, we find that the filters with a QOL and model localization compete with the fully coupled 4D-Var analyses for short windows, but the fully coupled 4D-Var method with QVA outperforms the EnKFs for long windows. The ECCO-like 4D-Var improves the 4D-Var ocean analysis that only use the initial ocean state as control variables, but the fully coupled 4D-Var outperforms the ECCO-like and ocean 4D-Var analyses. The data assimilation experiments offer insight on developing and advancing sequential and variational data assimilation systems for coupled models.