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Forecast error analysis of limited data assimilation schemes using perturbed and multi-model ensembles

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Data assimilation tools are now widely used by both atmosphere and ocean prediction systems as a way to improve their consistency, hence reducing their prediction errors. However, these methods only reduce errors in areas determined by the correlation length and time scales of the observations, or through specific state vector paths of influence, designated by adjoints. When only sparse and occasional data are available for assimilation into the modeling systems, one can then pose two questions: What is the reduction in error due to the assimilation of the data, and where and when should limited observation systems be deployed to minimize the prediction errors for a specific output (also know as the adaptive sampling problem)?

The ocean interior is generally under-sampled, and ocean model errors are strongly affected by the cascade of uncertainty from the forcing fields (atmospheric models) and initial and boundary conditions (nested schemes). These facts make error tracking of ocean forecasts a rather complex problem, and suggest the use of full stochastic methods for ocean dynamic prediction purposes; i.e., a single model run should be thought of as a single ensemble member of a stochastic variable. Using this approach, the output of the ocean prediction system should no longer be single-valued state vectors, but probability distribution functions or moments, or state vector intervals with associated likelihoods.

This work will describe some on-going efforts on the use of a stochastic approach, based on perturbed ensemble and multi-model ensembles, to track local ocean uncertainty and to measure the impact of local data assimilation. The models used were

high resolution nests of the Navy Coastal Ocean Model (NCOM), forced with perturbed high resolution wind fields of the Coupled Ocean and Atmosphere Mesoscale Prediction System (COAMPS), off the New Jersey coast during the spring of 2006. The analysis and discussion are based on a reanalysis control run, assumed to be the ground-truth, and from which virtual data were selected for assimilation. The same methodology is also used to analyze the evolution of the state variability, providing insight on the adaptive sampling problem.