# Ocean Data Assimilation Research at GFDL

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## Project Summary

Estimating the state of the Earth System is critical for monitoring our planet's climate and for predicting changes to it on time scales from months to decades. Toward these ends, the vast number of atmospheric observations and the growing number of ocean observations must be combined with model estimates of the state of the Earth System by means of data assimilation systems. This project explores the development of new data assimilation techniques using state-of-the-art coupled climate models and applies these techniques to detecting climate change, improving forecasts on seasonal to interannual time scales while providing estimates of their uncertainty, and improving our understanding of predictability at decadal time scales in order to provide a foundation for the development of a NOAA capability for decadal forecasts. This capability will provide the Nation's decision and policy makers with the best possible climate information on critical problems such abrupt climate change, changes in hurricane activity, drought, and sea-level rise.

The feasibility of seasonal to decadal predictions largely stems from the role the ocean plays in the predictability of slowly evolving modes of variability. The challenge then is to have the capability to represent this low frequency climate variability within our climate models so that initializing them would offer the potential to predict internal variability in addition to externally-forced climate change. Initialization has three main components: the observing system, the assimilation method, and the model. These three components are combined to produce initial conditions for the climate model. One needs to keep in mind that the initialization problem is different from the state estimation problem.

Historically the sub-surface ocean has been very sparsely observed, and some of the data appear to be significantly biased, making the development and testing of ocean initialization schemes difficult. Studies of historical periods are important in order to assess the likely skill of forecasts over a range of different climate states. However, recent and planned improvements to the observational network promise significant improvements in future forecast skill. Perhaps, most important among these is the recent (2003) deployment of a global array of profiling floats by the ARGO program. These provide for the first time contemporaneous measurements of both temperature and salinity over the upper 2km of the world's oceans, potentially offering a step change in our ability to initialize ocean heat and density anomalies. For example, in the coming decades, can we make useful predictions in the Atlantic Meridional Overturning Circulation? The non-stationary nature of the ocean observing system, particularly due to the paucity of salinity data as well as XBT data only going to 500m, can give rise to spurious decadal variability making it difficult in the assessment of forecasts.