Enhanced Ocean Climate Products from NCEP

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1. Project Summary

The Global Ocean Data Assimilation System (GODAS) at the National Centers for Environmental Prediction (NCEP) uses a statistics based algorithm to combine a numerical ocean model with ocean observations to provide a global estimate of the ocean state (the three dimensional fields of temperature, salinity, velocity, plus sea surface height). In effect, the GODAS uses the model ocean dynamics to interpolate in time and space between the locations of individual observations and to compute those parts of the ocean state that may not be directly observed. For example, there are currently many more observations of temperature and salinity in the ocean than there are of velocity. Assimilation of these data adjusts the model temperature and salinity fields to be in accord with the observations (within specified statistical bounds) and the model then computes a velocity field in balance with the distribution of mass established by the temperature and salinity. The GODAS assimilates temperature profile observations from eXpendable BathyThermographs (XBTs), fixed moorings, and autonomous Argo floats, salinity profiles from Argo floats and synthetic salinity profiles from temperature observations and the observed correlation between temperature and salinity, and sea surface altimetry observations from TOPEX/Poseidon, Jason-1 and Jason-2 satellite missions. NASA's Aquarius instrument was successfully launched in June, 2011, and a "first look" image of the global sea surface salinity has been released. These data look very promising and we expect to begin experimenting with them as well as the SMOS data soon. Tide gauge and velocity observations are reserved for validation.

The work covered by this project is the construction, maintenance and development of the NCEP GODAS. The GODAS uses the Modular Ocean Model (MOM) developed over the last several decades at NOAA's Geophysical Fluid Dynamic Laboratory (GFDL). The current uncoupled operational GODAS uses the MOM version 3 (GODAS/MOM3), while the new version of the GODAS incorporated into version 2 of the operational coupled Climate Forecast System (CFSv2) uses the MOM version 4 (GODAS/MOM4). The assimilation algorithm is a sequential 3-Dimensional Variational (3DVAR) method that estimates the ocean state through minimization of a cost function that balances statistically weighted contributions from the model and from the

observations. The original purpose of the GODAS was to provide initial conditions for the ocean component of the coupled CFS used for operational seasonal to interannual (S-I) prediction At NCEP. S-I prediction has a well-established social benefit and it remains the primary rationale for the maintenance and further development of the GODAS. The GODAS has a second important use as a means for monitoring the changing ocean state, which derives from its operational, near real-time, 3D synthesis of global ocean observations. Within NCEP the CFSv2 and the GODAS are fundamental tools used by the Climate Prediction Center (CPC) to prepare the official seasonal outlooks disseminated by the National Weather Service. Internationally the GODAS is an established member of an ensemble of ocean analyses produced by governmental and academic institutions worldwide that provides researchers with the means to study the evolution of the ocean state over past decades, including a measure of the uncertainty associated with the observed evolution.

2. Scientific and Observing System Accomplishments

As stated above ocean state estimation is fundamental to forecasting and monitoring climate variability. An important part of the National Weather Service mission is to produce operational numerical forecasts of the seasonal to interannual climate variability. GODAS provides the initial condition of the ocean state for those forecasts.

In collaboration with the Climate Prediction Center (CPC) and GFDL we completed the first stage of an OSE experiment to evaluate the impact of profile observing systems on seasonal forecasts made with coupled ocean-atmosphere models. A publication on the impact of tropical moorings and the Argo array by means of data denial experiments has been submitted to Climate Dynamics and is currently undergoing revision.

As part of a long-term strategy we are collaborating with the University of Maryland on the development of a hybrid assimilation system based on GODAS and the Local Ensemble Transform Kalman Filter (LETKF) developed at the university. In broad terms the GODAS 3dvar component provides the stability of an assimilation based on climatological covariance estimates while the LETKF component responds to local variations in model uncertainties and data distributions. Overall the hybrid system makes better use of the observing system than our current operational 3dvar GODAS. The hybrid is also well suited to NCEP's long-term goal of a coupled forecast system with superior skill at time scales from days though to seasons. A publication describing an OSSE experiment demonstrating the improved performance of the hybrid versus 3dvar system was submitted to the Monthly Weather Review in FY14 and is currently being revised.

Web pages for the operational GODAS and the operational CFSv2 (which incorporates a version of GODAS) are at http://www.cpc.ncep.noaa.gov/products/GODAS and http://nomads.ncdc.noaa.gov respectively.

2. Outreach and Education

The outreach associated with the GODAS takes the form of an interactive, public web page (http://www.cpc.ncep.noaa.gov/products/GODAS/) developed and maintained by NCEP's Climate Prediction Center. Users can select views of the GODAS analyses with interactive tools available on the site. The site also provides links for downloading the data.

Data from the CFS is available at http://nomads.ncdc.noaa.gov/

3. Publications and Reports

3.1. Publications by Principal Investigators

Penny, S. G., D. Behringer, J. Carton, and E. Kalnay (2014) A Hybrid Ocean Data Assimilation System at NCEP. Mon. Wea. Rev. (in press)

Xue, Y., C. Wen, X. Yang, D. Behringer, A. Kumar, G. Vecchi, A. Rosati (2014) Evaluation of Tropical Pacific Observing Systems Using NCEP and GFDL Ocean Data Assimilation Systems. Clim. Dyn. (in revision)