Ocean Data Assimilation for Seasonal to Interannual Prediction

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Current Status

The NCEP Global Ocean Data Assimilation System (GODAS) became operational in August 2003 and the Coupled Forecast System (CFS03) became operational in September 2004. With these two new systems in place NCEP has a greatly improved seasonal to annual forecasting capability.

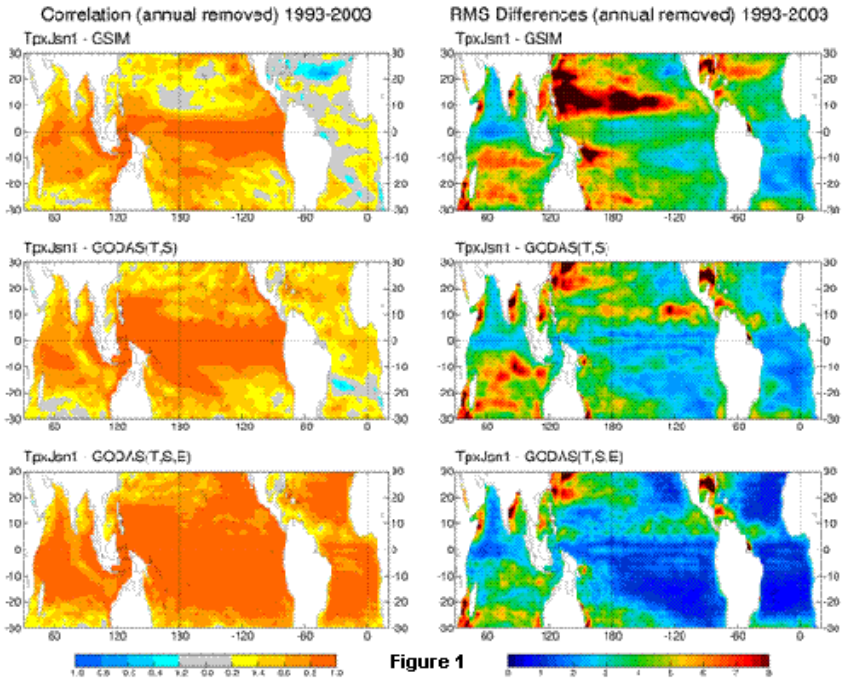

Figure 1

Credibility

The role of the GODAS is to provide an accurate estimate of the ocean state that is used to initialize the seasonal forecasts made with the CFS. To estimate the ocean state the GODAS combines ocean observations with an ocean model (the Modular Ocean Model, version 3, MOM3, developed at GFDL).

Figure 1 illustrates the impact of assimilating data into the ocean model in terms of the correlation and RMS difference between the sea surface height in the model and the sea surface height observed by the TOPEX and Jason I satellite missions. The top panels show the results for MOM3 forced by surface fluxes from the NCEP atmospheric Reanalysis 2 with no data assimilated. The middle panels show the results for the same model and forcing, but with temperature and salinity data assimilated. The bottom panels show the results when the TOPEX and Jason1 data are assimilated as well. The impact of the data on model sea surface height is clear.

The current operational version of GODAS corresponds the middle panels of the figure.

Problems

- Warm Biases

The GODAS is based on GFDL's MOMv3. When that model is forced by the same surface forcing as used in GODAS, but no data is assimilated, the temperature climatology is biased. In the tropics that bias is mostly positive. The GODAS corrects most of the bias by assimilating temperature profile data. Thus, Figure 2 illustrates the bias in the average temperature of the upper 400 meters of MOMv3 by subtracting the corresponding field from GODAS.

In the Atlantic the bias is small on the equator, but as large as 2^{o}C at 10^{o}N. In the tropical Pacific the warm bias is mostly confined to the eastern half of the basin. The entire tropical Indian Ocean is warm with the largest values of about 1.5^{o}C at 10^{o}S.

In principal, a model used in data assimilation should be unbiased, i.e., an assimilation system should be used to correct the model variability, not the model mean state. While this ideal is rarely achieved, it is a goal worth pursuing.

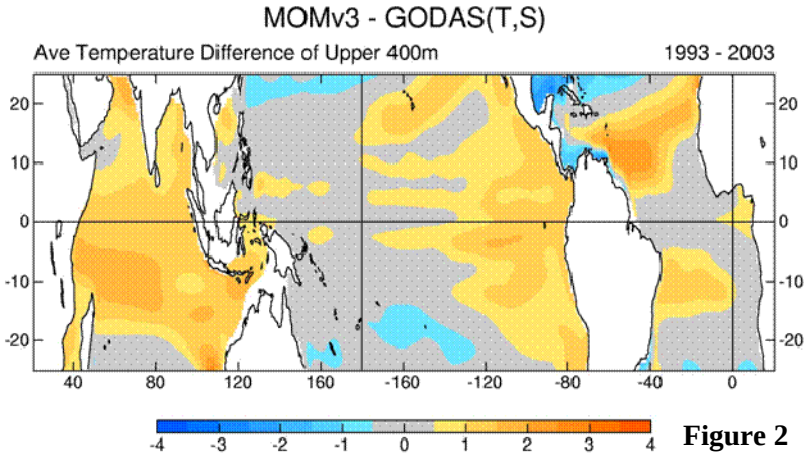

Figure 2

- Surface Current Errors

At present the GODAS has some errors in its representation of surface currents in the tropical Pacific Ocean. Figure 3 compares two climatologies of the surface zonal currents in the tropical Pacific for the period 1993-2003. The top panel shows currents derived from surface drifters deployed and managed by the Global Lagrangian Drifting Buoy Project at the Atlantic Oceanographic and Meteorological Laboratory. The bottom panel shows the equivalent currents from GODAS. The blank patches in the drifter image occur where there is insufficient drifter data to compute a reliable average. While there are sampling differences between the two images, some general comparisons are useful. Off the equator the overall pattern of the currents is much the same in each picture, although the Equatorial Counter Current appears to be too strong in the GODAS in the far western Pacific. A more serious error occurs on the equator and west of the dateline. Here the drifter data indicate eastward flow while the GODAS data indicate a strong westward flow. The same error in the GODAS currents appears in comparisons with current meter data at 165E on the equator (not shown).

The GODAS assimilates temperature and salinity, thereby correcting the mass field in the model. However, the GODAS does not assimilate current data. Thus, off the equator, where the flow is essentially geostrophic, the GODAS is able to represent the currents accurately. On the equator, where geostrophy breaks down, the GODAS has difficulty computing the surface currents correctly.

Progress

- Assimilation of synthetic salinity improves the salinity climatology in GODAS, but underestimates the sea surface salinity (SSS) variability. An improved estimate of the SSS variability could contribute to improved surface currents.
- Surface currents are slightly improved when more weight is given to the model's own computation of the salinity in the mixed layer than to the synthetic salinity data.
- Assimilation of altimetry appears to improve sea level analysis significantly in the Atlantic and Indian Ocean. The next step is to conduct a set of hindcast experiments to evaluate

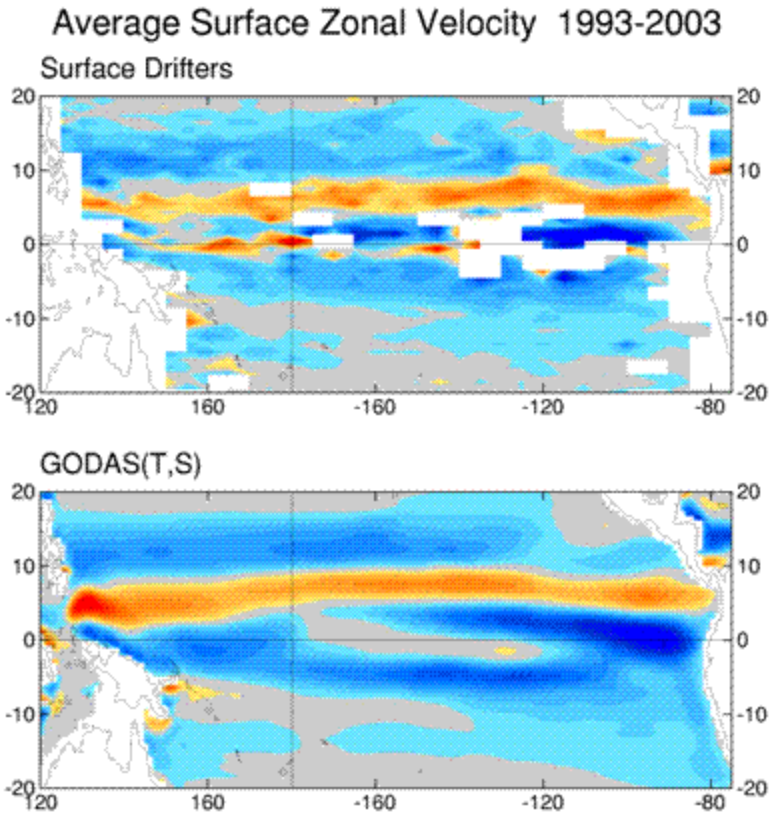

Figure 3

its potential impact on Seasonal to Interannual forecasting.

- Assimilation of altimetry, however, does not improve deficiencies in GODAS surface currents.

Work is underway to incorporate the satellite data assimilation into the operational GODAS. There are, in addition, other potential ways to improve GODAS and these will also be explored.

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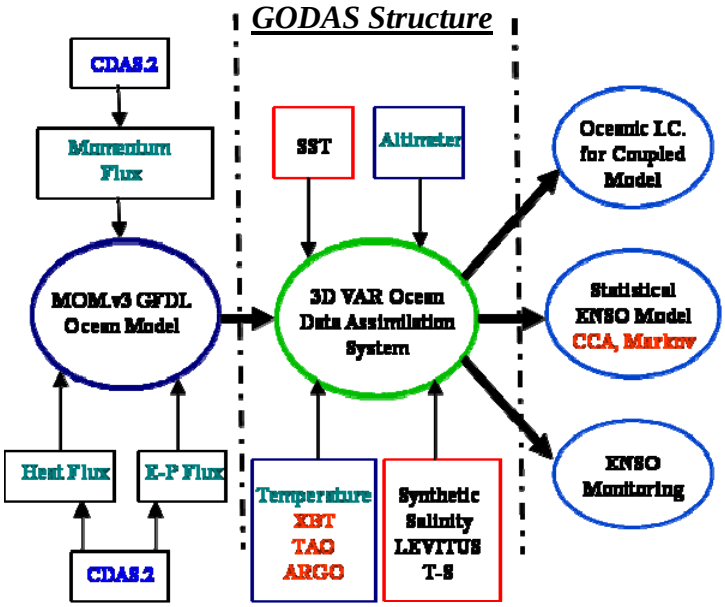

System Specifications

Model: MOM v.3

Grid: Quasi-global, 1x1 degree horizontal resolution enhanced to 1/3 degree in the tropics, 40 vertical levels

Physics: KPP boundary layer mixing scheme, free surface

Forcing: Wind stress, heat flux, E-P from Reanalysis 2, surface salinity relaxed to Levitus monthly SSS climatology

Assimilation method: 3D VAR, analyzes temperature and salinity, error covariance varies geographically and temporally

Assimilation data: Temperature profile data from XBTs, profiling floats (Argo), moorings (TAO), synthetic salinity from local Levitus T-S climatology

Applications of GODAS at Climate Prediction Center

- CFS model uses GODAS as oceanic initial conditions.
- "Weekly ENSO Update" uses GODAS pentad temperature and sea level fields to monitor intraseasonal oceanic variability.
- "Climate Diagnostic Bulletin" uses GODAS monthly temperature and sea level fields to assess interannual oceanic variability.
- Markov model uses GODAS monthly sea level field as predictor.
- CCA ENSO model uses GODAS monthly sea level and depth of 20 degree as predictors.
- Study relationship between ENSO and MJO-related oceanic Kelvin waves.
- Study coupled ocean-atmospheric modes in the Tropical Atlantic Ocean, and improve forecast skill of SST and precipitation there.