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Global Ocean Monitoring: A Synthesis of Atmospheric and Oceanic Analysis

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1. Introduction

Given the importance of the El Nino and Southern Oscillation (ENSO) on global climate variability on seasonal-to-interannual time scale, NOAA's Climate Prediction Center (CPC) actively engages in the real-time monitoring of oceanic and atmospheric conditions in the equatorial tropical Pacific (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/enso.shtml). An important component of monitoring and predicting ENSO evolution is the oceanic sub-surface conditions. The subsurface ocean monitoring at CPC is based on the Global Ocean Data Assimilation System (GODAS; Behringer and Xue 2004). The GODAS is one component of the NCEP Climate Forecast System (CFS), and it provides the oceanic initial conditions for CFS (Saha et al. 2006).

The retrospective global ocean analysis for 1979-2004 and its near real-time extension (with a 7-day delay) produce pentad and monthly mean ocean fields on a 1x1 degree grid. To gain a broader dissemination of the GODAS data, and to increase involvement of the research community in the assessment of GODAS, the Climate Observation Division of Climate Program Office of NOAA supports CPC to maintain and to enhance a web based dissemination for the GODAS products for the purpose of ocean monitoring (http://www.cpc.ncep.noaa.gov/products/GODAS). The web site provides the users interested in various aspects of the evolution of the ocean state an easy access to the documentation, data link, data validation and global ocean monitoring products derived from GODAS.

To support CPC's mission in monitoring, assessing and predicting short-term climate variability, the ocean monitoring at CPC has been significantly expanded recently, from monitoring the tropical Pacific ENSO alone to monitoring the global oceanic variability on intraseasonal-to-interannual time scales. The global ocean monitoring efforts have two components: 1) the real time plots and animations and 2) Monthly Ocean Briefing (MOB), which was initiated in May 2007. The MOB provides a synthesis view of the current state of the global ocean based on the GODAS and the NCEP/NCAR atmospheric analysis. This synthesis includes a real time assessment of the state of the global ocean and its interaction with atmosphere. The MOB is composed of a conference call and PowerPoint Presentation and is usually held around the 7th day of each month. Both internal and external colleagues are encouraged to participate and contribute to the MOB, which is becoming a valuable product for both operational and research communities.

2. GODAS web site

CPC's subsurface ocean monitoring for the ENSO was initially based on the Pacific Ocean Data Assimilation System (ODAS) (Ji et al. 1995). The Pacific ODAS was replaced by a Global Ocean Data Assimilation System (GODAS) (Behringer and Xue 2004). The major changes included 1) an extension to a quasi-global domain (75^{O}S-65^{O}N), 2) replacement of the Geophysical Fluid Dynamics Laboratory's Modular Ocean Model version 1 with version 3, 3) change from momentum flux forcing only to momentum flux, heat flux and fresh water flux forcings of the NCEP/DOE reanalysis, and most importantly, 4) data input changes

from temperature only to temperature and synthetic salinity that is constructed from temperature and a local temperature/ salinity climatology. Currently only temperature observations are assimilated into GODAS and they are from XBTs, Argo profiling floats and TAO moorings.

An extensive validation of GODAS against independent observations suggests that the temperature field in the GODAS is closer to observations than that in the Pacific ODAS, and the poor salinity field in the latter is dramatically improved. Although this version of the GODAS does not assimilate the Altimetry sea level, GODAS compares reasonably well with the Altimetry and tide gauge sea level records. Note that the operational GODAS has been updated in March 2007 with inclusion of the Altimetry sea level. Large biases still exist in velocity fields, probably due to assimilation of synthetic salinity that severely underestimates salinity variability. The results on the validation of GODAS can be accessed at the GODAS web site.

A comprehensive web site (http://www.cpc.ncep.noaa.gov/products/GODAS) has been constructed to display the extensive information that is available from the GODAS. The web site contains numerous plots and animations that describe not only the seasonal-to-interannual variability but also the subseasonal variability. In addition, the web site provides a technical report describing the GODAS, a link to the GODAS binary data, a validation of GODAS, a climatology calculated for the base period 1982-2004 and the observational data distribution for each month in 1979-present. Since the goal of the web site is to serve a broad user community that includes operational forecast centers, scientific research groups, and the general public, we solicit feedback from all users, strive to answer their questions in a timely manner, and improve the web site based on the suggestions from the user community.

3. Monthly Ocean Briefing

Although the GODAS web site provides extensive set of plots and animations that are updated in near real time, a synthesis of the available information connects various aspects of the ocean-atmosphere coupled variability, and is a succinct way to summarize a wide array of available information. In addition, such a synthesis also highlights the roles of the ocean beyond the tropical Pacific ENSO on climate variability and predictability, and raises questions about the climate variability that not well understood, Such an expert assessment synthesizes what has happened, whether the atmospheric and oceanic analysis are consistent in describing what has happened, whether the recent evolution is within the normal range, and what are the potential impacts of the ocean on atmospheric circulations. This product is expected to be useful for researchers, forecasters, and the general public.

CPC started to make a real time expert assessment of the global ocean, referred to as Monthly Ocean Briefing (MOB), in May 2007. We invite outside colleagues to participate in MOB through a conference call. A PowerPoint Presentation is prepared and distributed through an email list one day before the ocean briefing, which is held around the 7th day of each month. Anyone who is interested in the ocean briefing can join the conference call, or access the PPT archive through the GODAS web site.

The following data sets are used in the construction of the ocean briefing PPT:

- NCEP/NCAR atmospheric analysis: 850 mb winds, 200 mb velocity potential, latent and sensible heat flux, short and long wave radiation at the surface
- NOAA's Outgoing Longwave Radiation
- Weekly Optimal Interpolation SST version 2 (Reynolds et al. 2002)
- NCEP Global Ocean Data Assimilation System: subsurface temperature, heat content (temperature average in the top 300 meters), Tropical Cyclone Heat Potential

- TAO subsurface temperature gridded analysis (personal communication with Dr. Mike McPhaden at PMEL)
- Aviso Altimetry Sea Surface Height (http://www.jason.oceanobs.com/html/donnees/welcome_uk.html)
- Ocean Surface Current Analyses – Realtime (OSCAR, http://www.oscar.noaa.gov/datadisplay)

The briefing PPT contains two parts. The first part describes the recent evolution and current conditions of the ocean in different basins. An SST heat budget analysis is used to explain the SST tendencies for the major air-sea coupled modes such as ENSO. The influences of the MJO-related winds on oceanic Kevin waves and ENSO are discussed. The impacts of extra-tropical winds on the ocean are monitored in the North Pacific and North Atlantic. The second part discusses the biases in GODAS and their potential impact on the recent performance of ENSO predictions by NCEP's CFS. Some of the plots used in the latest ocean briefing, January 2008 Ocean Briefing, are presented below.

Global Ocean

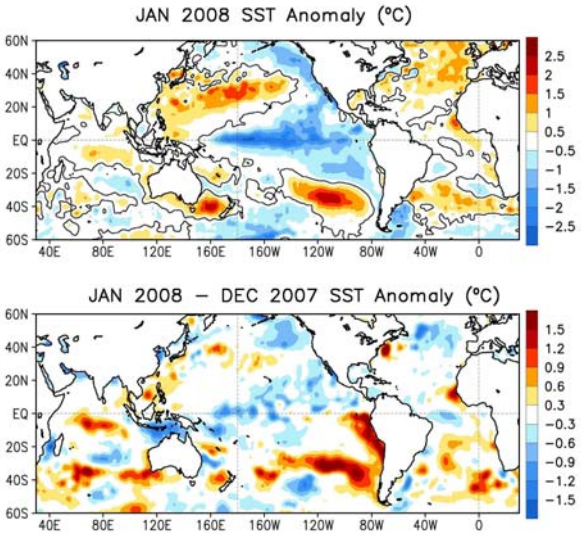

Figure 1. Global SST anomaly in January 2008 (top) and its tendency (low).

Pacific Ocean

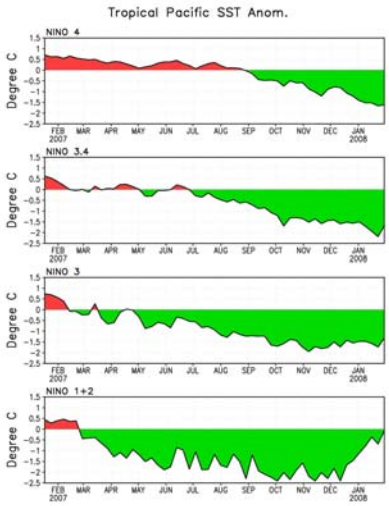

Figure 2. NINO indices.

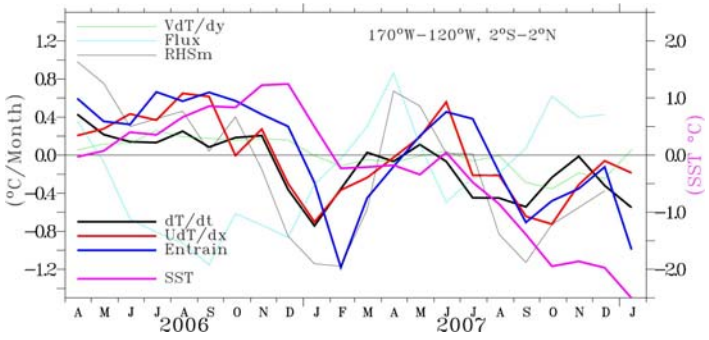

Figure 3. Mixed layer heat budget analysis derived with GODAS (Courtesy of Dr. Dongxiao Zhang from PMEL).

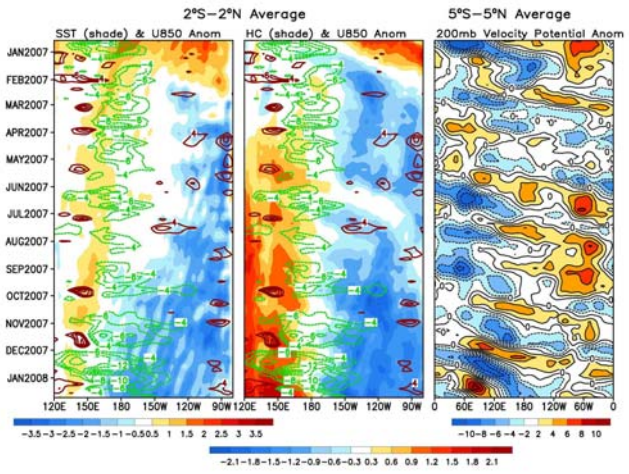

Figure 4. Time-Longitude of SST (shade) and 850 mb zonal wind (contour) anomaly (left), heat content (shade) and 850 mb zonal wind (contour) anomaly (middle), and 200 mb velocity potential anomaly (right).

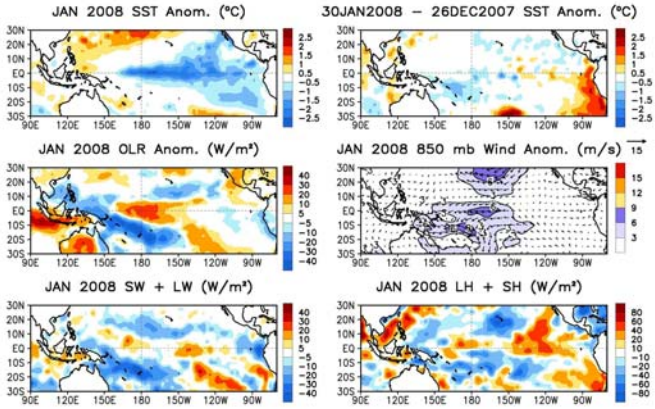

Figure 5. SST (upper left), SST tendency (upper right), OLR (middle left), 850 mb wind (middle right), short and long wave (lower left) and latent and sensible heat flux (lower right) anomalies in January 2008.

Indian Ocean

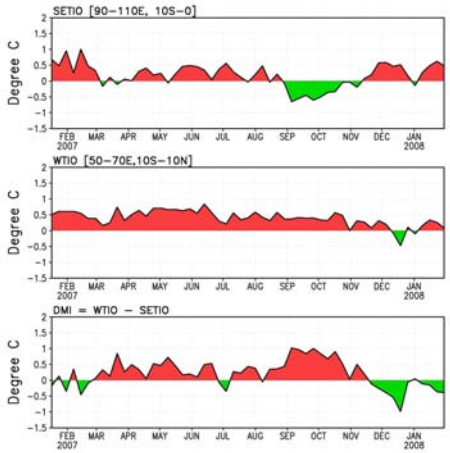

Figure 6. Indian Ocean Dipole indices.

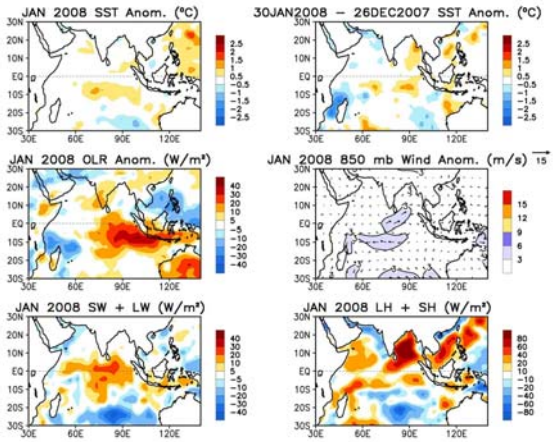

Figure 7. Same as Figure 5 except for the tropical Indian.

Atlantic Ocean

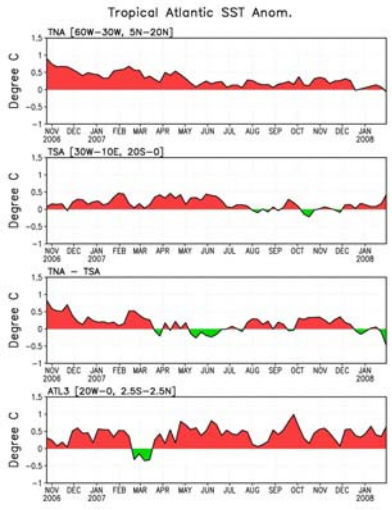

Figure 8. Atlantic Ocean SST indices.

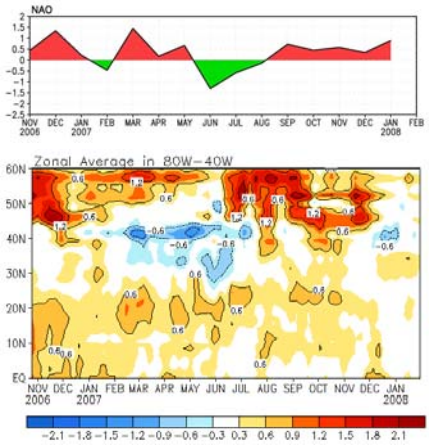

Figure 9. North Atlantic Oscillation index (top) and zonal average of SST anomaly as functions of latitude and time (low).

GODAS biases

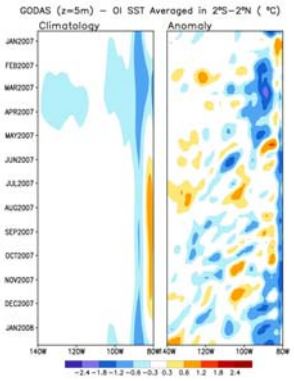

Figure 10. Differences between GODAS temperature at 5 meter depth and OI SST. Climatology (left) and anomaly (right).

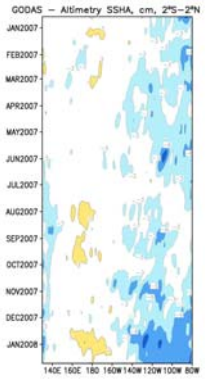

Figure 11. Differences between GODAS and Altimetry sea surface height anomaly.

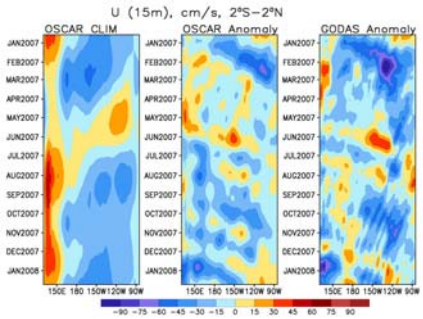

Figure 12. Zonal current at 15 meter depth. OSCAR climatology (left) and anomaly (middle), and GODAS anomaly (right).

CFS ENSO prediction

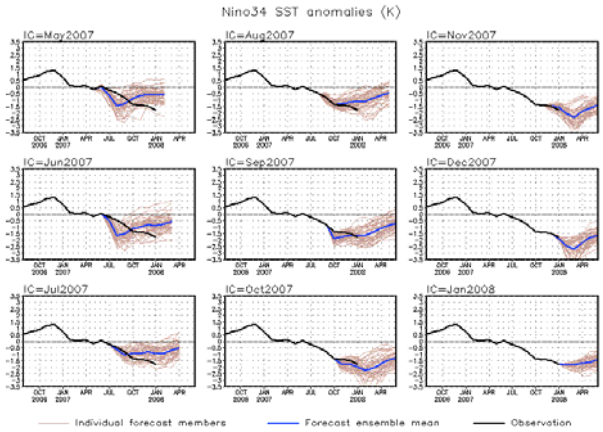

Figure 13. NINO3.4 SST forecast by the NCEP CFS model in the past nine months.

4. Annual Ocean Briefing

CPC conducted its first Annual Ocean Briefing on February 8, 2008. The purpose of the briefing was to provide an overview of oceanic variability in the past year, and its potential impacts on annual mean atmospheric circulations. The PPT can be accessed at http://www.cpc.ncep.noaa.gov/products/GODAS/ocean_briefing_gif/ocean_briefing_annual_2007.ppt

5. Future additions

We will continue to add new items to MOB, some of which are listed below:

- GODAS/TAO subsurface temperature and salinity comparison in real time
- Indonesian Throughflow
- Integrated meridional transports along 9S and 9N in Pacific
- Meridional Overturning Circulation in Atlantic
- Atmospheric impacts of SST anomalies
- Intercomparison with other ocean analysis products

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Saha, S., S. Nadiga, C. Thiaw, J. Wang, W. Wang, Q. Zhang, H. M. van den Dool, H.-L. Pan, S. Moorthi, D. Behringer, D. Stokes, G. White, S. Lord, W. Ebisuzaki, P. Peng, P. Xie (2006), The NCEP climate forecast system, *J. Climate*, **19**, 3483-3517.