A Web Site for NCEP's Global Ocean Data Assimilation System (GODAS): Date Link, Data Validation and Global Ocean Monitoring Products

Yan Xue
NOAA Climate Prediction Center/NCEP/NWS, Camp Springs MD

1. PROJECT SUMMARY

The mission of the project is to maintain and improve a comprehensive web site for the operational Global Ocean Data Assimilation System (GODAS) developed by the National Centers for Environmental Prediction (NCEP). The web site, hosted by the Climate Prediction Center (CPC) of NCEP, provides the user community an easy access to the GODAS data, the GODAS validation skill, and the global ocean monitoring products based on GODAS. The web site contains numerous plots of climatology and anomalous fields of various oceanic variables in different basins of the global ocean and cover time scales from weekly to interannual to decadal from 1979 to present.

A recent significant advance of the project was the implementation of "Monthly Ocean Briefing" at CPC in May 2007. The ocean briefing is composed of a conference call and PPT presentation and participated by both internal and external colleagues. The PPT provides a comprehensive review and interpretation of the recent evolutions and current conditions of the state of the global ocean, its interactions with atmosphere, and model SST predictions. The PPT is freely accessible on the web site and is downloaded by a broad national and international community.

The GODAS was developed by the Environmental Modeling Center (EMC) of NCEP for the initialization of the oceanic component of the NCEP's Climate Forecast System (CFS). The retrospective ocean analysis since 1979 and the near real time updates have been made available for dissemination to the general public through the GODAS web site supported by this project. CPC acts as the "Point of Contact" for the GODAS user community, and strives to provide national and international communities timely and comprehensive information on oceanic variability in support of climate research, attribution and prediction.

1.1. Background

The in situ ocean observation network managed by the NOAA's Climate Observation Division (COD) has greatly enhanced our knowledge of the state of the global ocean and is critical for the ocean reanalysis efforts in the past decade. The operational Global Ocean Data Assimilation System (GODAS) developed by the National Centers for Environmental Prediction (NCEP) assimilates in situ observations into an oceanic general circulation model forced by atmospheric fluxes. Currently, assimilated observations include temperature profiles from XBT**,** profiling floats and TAO moorings. The GODAS is used to initialize the oceanic component of the NCEP's Climate Forecast System (CFS) (Saha et al. 2007) and was implemented in 2003 (Behringer and Xue 2004). The retrospective global ocean reanalysis for 1979-2004, and its real time updates, constitute a unique dataset that can be used to diagnose the past

oceanic variability and to monitor the recent trend and current oceanic conditions in support of climate research, attribution and prediction.

To gain a broader dissemination of GODAS data products, and to increase research community's involvement in the assessment of GODAS towards increasing the effectiveness of the NOAA's ocean observing systems, the NOAA's COD currently supports the CPC to maintain and improve a comprehensive web site for GODAS. The web site contains data link, data validation, and global ocean monitoring products.

1.2.Website

http://www.cpc.ncep.noaa.gov/products/GODAS/

1.3. Partnership

The project is coordinated with the production and improvement of GODAS by the Environmental Modeling Center (EMC) of NCEP. CPC also envisions to work with the expert team members supported by the Climate Observation Division (COD) to validate, and to enhance, the GODAS products with in situ observations. The project also contributes to the "Bulletin of the American Meteorological Society" (BAMS) Annual Climate Review Report by providing authors month-to-month oceanic variability within the calendar year through "Monthly Ocean Briefing". The PI will contribute to the section of the BAMS report on sea surface temperature with Dr. Richard Reynolds.

2. ACCOMPLISHMENTS:

2.1. GODAS web site statistics

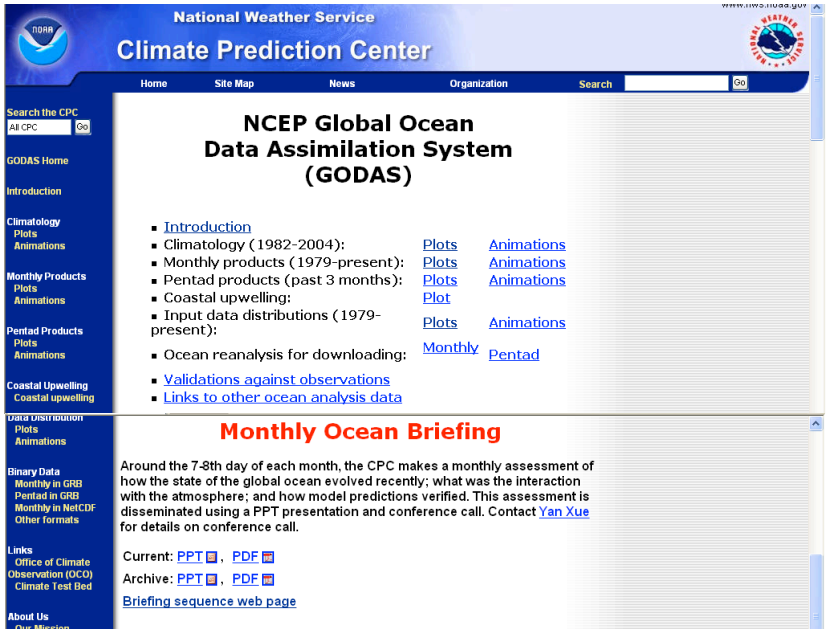

Figure 1. The home page of the GODAS web site.

The home page of the GODAS web site, shown in Figure 1, has been revised to include a section on "Monthly Ocean Briefing" (MOB). Details about MOB are described in the next section. The ocean briefing PPT presentations are displayed on the home page as "Current" and "Archive". The "Current" is for the latest PPT presentation, while the "Archive" is for those PPT presentations made since May 2007. One significant addition to the GODAS web site is the "Briefing Sequence Web Page" (BSWB), which contains all the plots used in MOB and other additional plots. All the plots on BSWB are updated in near real time. Having those plots available on the web is particularly useful for users who want to monitor the evolution of the state of the global ocean closely in time.

The GODAS web site statistics have been monitored since January 2008 (Figure 2) and the web site receives about 50,000.00 hits per month by September 2008.

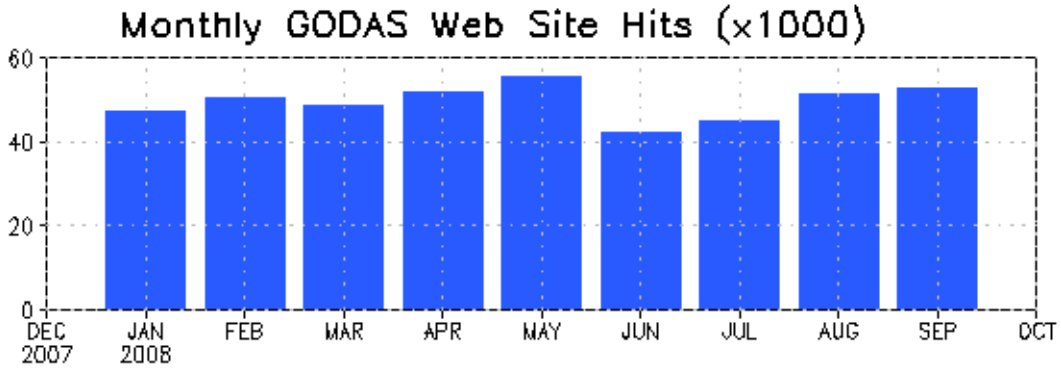

Figure 2. The accumulative hits within a month on the GODAS web site for 2008-present.

2.2. Monthly Ocean Briefing

The GODAS web site contains various plots and animations that are updated in near real time, and are used by forecasters and researchers to monitor the recent evolutions and the current conditions of the state of the global ocean. However, users can be better served by providing a synthesis of plethora of such products and by summarizing (a) how the state of the ocean evolved recently, (b) what is its interactions with the atmosphere, and (c) how it will likely evolve in near future. Since CPC has access to the operational oceanic and atmospheric reanalysis data and the seasonal climate outlooks made by the NCEP's CFS, CPC is well positioned to provide the user community with a timely and accurate assessment and interpretation of the evolution of the state of the global ocean, its interaction with the atmosphere, and its prediction by CFS. To accomplish this, an operational product referred to as "Monthly Ocean Briefing" (MOB) was implemented in May 2007 at CPC. The MOB is composed of a conference call and a PPT presentation, and is held around the 7th day of each month. The schedule of MOB is sent by email to a growing distribution list that contains both internal and external colleagues. The distribution list and conference call are open to anyone who is interested in the ocean briefing. During the past year so, the ocean briefing has been well received by internal and external participants, and feedback received so far indicates that the ocean briefing is very informative and useful, and further, is becoming a valuable tool for both research and operational community.

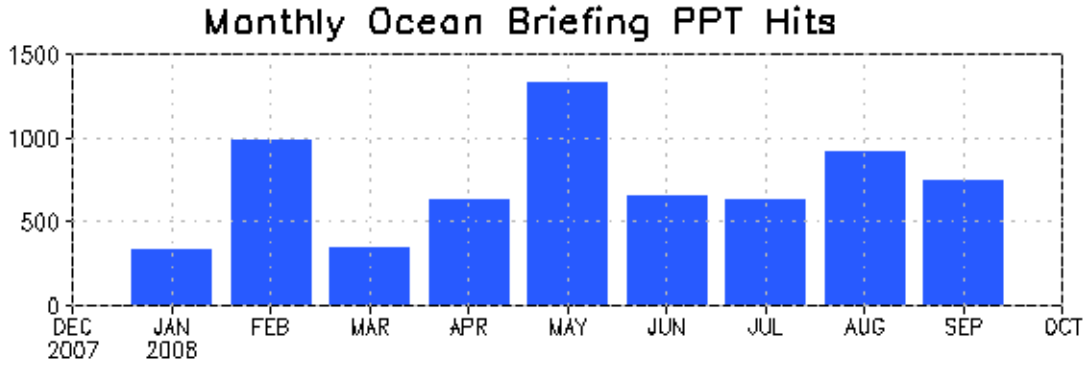

Figure 3. The accumulative hits within a month on the current "Monthly Ocean Briefing" PPT for 2008-present.

Through interactions with the user community, the content of the PPT presentation has improved with time. A major improvement made in FY08 included an expansion and improvement of the plots used in MOB, making the plots available in near real time on the web, standardizing the ocean briefing PPT to include a fixed set of plots, while keeping the provision to address unique climate events of interest, e.g. the 07/08 La Niña cycle.

Contributions from external community have been highly encouraged. Dr. Mike McPhaden from the NOAA's Pacific Marine Environmental Laboratory (PMEL) has been participating MOB regularly, and helped us monitor the biases of the GODAS subsurface temperature by providing us their real time TAO subsurface temperature analysis, and also assisted us in interpreting the tropical Pacific oceanic variability related to ENSO. Dr. Frank Schwing from the NOAA's the Southwest Fisheries Science Center (SWFSC) has been participating MOB regularly, and helped us monitor the coastal upwelling along the western coast of North America, and assisted us in evaluating the effects of physical forcing on boundary ecosystems such as the California Current Ecosystem (CCE). Dr. David Enfield from the NOAA's Atlantic Oceanographic and Meteorological Laboratory (AMOL) has been actively involved in MOB, and has helped us design plots to monitor and assess the SST variability in the Atlantic Hurricane Main Development Region and to study ocean's impacts on hurricane. Regular participants also include folks from the International Research Institute for Climate and Society, NOAA's Earth System Research Laboratory, NASA's Global Modeling and Assimilation Office, Center for Ocean-Land-Atmosphere Studies, NCAR and NOAA headquarters.

Although MOB has been regularly attended by 15-30 folks from internal and external institutions, the PPT presentation displayed on the web site is usually reviewed by 500-1000 folks by the national and international community. The monthly hits on the current month PPT has an upward trend (Figure 3). The hits had peaks in February and May 2008 that coincided with our "Annual Ocean Review" in early spring and a significant expansion of MOB in late spring. The hits on the ocean briefing PPT has settled down at the level of about 700-1000 hits per month by fall 2008 (Figure 3).

2.3. Real time heat budget analysis for ENSO

We have implemented a near real time heat budget analysis based on GODAS. The methodology of Stevenson and Niller (1983) is used in which surface advection and vertical entrainment terms are explicitly calculated with the GODAS velocity and GODAS mixed layer depth. The heat budget analysis has been used to analyze the evolution of the 07/08 La Niña cycle, and the results have been presented at the 33rd Climate Diagnostics and Prediction Workshop held in Lincoln, Nebraska. The heat budget analysis not only helps us understand the physical mechanism for the past ENSO events, and but also assists us to monitor, understand and predict ENSO in real time.

2.4. Estimation of Atlantic MOC with GODAS

The Atlantic Meridional Overturning Circulation (MOC) has been selected as one of the metrics for the CLIVAR Ocean Synthesis Evaluation Project. Here we present the capability of GODAS in simulating MOC and its sensitivity to data assimilation schemes. We estimated MOC using (a) the operational GODAS that assimilates temperature down to 750m, (b) the deep ocean GODAS, identical to the operational GODAS except it assimilates temperature down to 2200m, and (c) the Argo GODAS which assimilates the Argo salinity in addition to in situ temperature above 750m.

The averaged (1982-2004) MOC in the operational GODAS is 17 Sv at 26N, consistent with other observed analyses and model simulations. The averaged (1982-2004) MOC in the deep GODAS is 26 Sv. The larger MOC is associated with a northward density gradient between 1000-2000m depth. The averaged (2001-2006) MOC in the Argo GODAS is about the same as that of the operational GODAS. The AMOC in the deep GODAS has two upward trends, one during the first 5 year starting from the operational GODAS in January 1979 and another during 2000-2005 when the Argo temperature started to be assimilated. Therefore, it is important to constrain the model with observed temperature and salinity in the deeper ocean for a period of more than 5 years to allow the model to adjust to an equilibrium state.

2.5. Validation of heat content variability in GODAS

Since heat content variability in the top 300m in the tropical Pacific is closely linked to ENSO variability, its simulation by GODAS has been carefully validated using the TAO temperature and Altimetry sea level data. However, heat content variability beyond the tropical Pacific has not been systematically validated. Here we present a comparison of heat content variability simulated by GODAS, two other ocean analyses, and Altimetry sea level. The annual mean heat content analysis from the NOAA's National Oceanographic Data Center (NODC) in 1979-2003 (http://www.nodc.noaa.gov), the monthly mean heat content analysis from Coriolis in 2002-2008 (http://www.coriolis.eu.org), the Altimetry sea surface height analysis from AVISO in 1993-2008 (http://www.aviso.oceanobs.com) were used in our comparison. In addition, the monthly mean climatology from the World Ocean Atlas (WOA) 2005 was used.

The inter-annual and monthly variability between GODAS and the other analyses only match in regions with a large number of observations. Although the number of

observations has increased from 1979 to 2003, the spatial correlation between NODC heat content and GODAS doesn't increase much over the years. There is a clear relationship between the number of observations and the agreement in heat content between GODAS and the NODC/Coriolis analyses. GODAS does not show the warming of the global oceans over the past 30 years, which is evident in NODC and supported by the satellite Altimetry since 1993.

2.6. BAMS Annual Climate Review Report

The PI has been invited by Dr. Richard Reynolds to contribute to the section of the 2007 BAMS Annual Climate Review Report on sea surface temperature.

3. REFERENCES

Levinson, D. H. and others, 2008: State of the climate in 2007, 3.1 Sea Surface Temperatures in 2007. *Bull. Amer. Meteor. Soc.*, **89,** p37-39.