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Validation of the Global Ocean Data Assimilation System (GODAS) data in the NOAA National Centre for Environmental System (NCEP) by theory, comparative studies, applications and sea truth

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Abstract

The Global Ocean Data Assimilation System (GODAS) data published by the NOAA's National Centre for Environmental System (NCEP), have been applied in various areas in oceanography and fisheries worldwide. In the IOTC, they have been applied for CPUE standardization (STD CPUE) works for swordfish, yellowfin tuna and bigeye tuna. As there are no synthetic validation studies on the GODAS data, we attempted to do such validations by theory, case studies, application and sea truth. As a conclusion we suggest that GODAS data except salinity data in the NOAA-NCEP can be used for various studies such as fisheries oceanography and CPUE standardization in our case with caution as there are some degrees of errors by year, season and depth in the estimated data. Thus we suggesting use the GODAS data through sea truth (validation). As for the salinity data we need to wait to use until the new assimilated data available by the next generation (better) model because the current salinity data have uncertainty in accuracy due to deficits in the present model for salinity.

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1. Introduction

The Global Ocean Data Assimilation System (GODAS) data published by the NOAA's National Centre for Environmental System (NCEP), have been applied in various areas in oceanography and fisheries worldwide. In the IOTC, they have been applied for CPUE standardization (STD CPUE) works for swordfish, yellowfin tuna and bigeye tuna. As there are no synthetic validation studies on the GODAS data, we attempted to do such validations by theory, case studies, application and sea truth.

2. Validation

2.1 Theory

(1) Overview

GODAS stands for Global Ocean Data Assimilation System and it has been developed by the National Center for Environmental System (NCEP), NOAA, USA. The purpose of this model is "for initialization of the new global coupled ocean-atmospheric model that will be used for operational ENSO prediction".

The model is based on the Modular Ocean Model version 3 (MOM3) developed at Geophysical Fluid Dynamics Laboratory (GFDL), NOAA, USA with three-dimensional variation data assimilation. This model is externally forced by momentum flux (wind forcing) estimated by satellite measurements and heat and fresh water flux obtained from NCEP–DOE Reanalysis 2(http://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis2.html).

The model domain is from 75˚S to 65˚N and the meridional spacial resolution is 1˚ poleward of 30˚ increasing to 1/3˚ within 10˚ of the equator. There are 40 vertical levels and the resolution is 10m in the upper 200m. NCEP is planning to replace GODAS by Climate Forecast System Reanalysis (CFSR) in the future. There was a predecessor of this model in the past but limited only to the Pacific Ocean.

(2) Assimilated data

Temperature and salinity

Initially the assimilated data were “temperature and synthetic salinity that is constructed from temperature and local T-S climatology. The temperature data includes those from XBTs, profiling floats and Tropical Atmosphere Ocean (TAO) moorings". It is noted that the salinity assimilated in this model is not observed value although the method itself, estimating salinity from temperature with climatological T-S profile, is used quite often for various purposes in the past.

The primarily reason of doing it is probably because number of available temperature data far exceeds that of salinity due to the wide use of XBT. The SST is from Reynolds reanalysis that uses in situ and satellite measurements and is presumably the one computed by NCEP (http://www.emc.ncep.noaa.gov/cmb/sst_analysis). The subsurface temperature data for 1980 through 1989 are the XBT data in WOD98 Version 2 obtained from National Oceanographic Data Center (NODC) and from the archive of MEDS after 1990 (ftp://ftp.nodc.noaa.gov/pub/gtspp/ best or ftp://ftp.nodc.noaa.gov/pub/gtspp/realtime).

TAO moorings data are mostly located in the tropical region as it name suggests and obtained from http://www.pmel.noaa.gov/tao. Figure 1 in the paper [1] (see below) shows number of temperature data as a time series plot. Lately some other mooring data such as TRITON and PIRATA as well as ARGO float data are incorporated.

After 2007 satellite altimetry data are also incorporated (see paper [2] below). There were some experiments assimilating salinity data from ARGO floats and several articles mentioned that assimilating observed salinity improves accuracy of GODAS substantially. Observed salinity will be assimilated officially in the next generation model.

2.2 Comparative studies

[1] Behringer D. , and Y. Xue, 2004: Evaluation of the Global Ocean Data Assimilation System at NCEP: The Pacific Ocean. Preprints, Eighth Symp. on Integrated Observing and Assimilation Systems for Atmosphere, Oceans, and Land Surface, Seattle, WA, Amer. Meteor. Soc., 2.3. (http://ams.confex. com/ams/84Annual/techprogram/paper_70720.htm)

This study is aimed to compare between GODAS and another model rather than GODAS and actual data. In this paper [1], authors described the results of their validation effort by comparing with 4 different information, i.e., (a) sea surface height with Topex/Poseidon (T/P) satellites sea level data and tide gauge data, (b) temperature with observed temperature data in the tropical Pacific region and (c) the surface current with estimated surface current based on satellite observed sea level and (d) surface wind field derived from scatter meter data (Ocean Surface Current Analyses-Real Time; OSCAR; http://www. oscar.noaa.gov). The validation of OSCAR data is described in http://www.esr.org/~bonjean /oscar/global_ validation/. The direct comparison between GODAS salinity and observed salinity is not included in this paper [1].

Sea surface height

At the time when this paper [1] was published, satellite altimetry data were not assimilated yet. The root mean square (RMS) differences between sea level anomalies of GODAS and tide gauge data (not assimilated) at 27 Pacific islands are shown in Figure 2 in the paper [1] and the value is ranged from 2.2 to 8.2cm. The comparison between GODAS and T/P is shown in Figure 4 of the paper [1] as time-longitude (averaged between 2˚S and 2˚N) plot in the paper [1]. Qualitatively, agreement appears to be good but there are times when the differences are 6cm or more. T/P data are assimilated now as mentioned above.

Temperature

The RMS differences between GODAS temperature and the data at 8 TAO moorings located along 2˚N in the tropical Pacific is shown in Figure 6 in the paper [1]. The maximum value is about 1˚C and the maximum tends to appear near the thermocline. Slight difference of the vertical position of thermocline between GODAS and actual data might produce relatively large temperature difference between them at depths near the thermocline because temperature varies a lot at those depths.

Current

Mean zonal and meridional currents computed by GODAS and observed at 4 TAO moorings along the equator in the Pacific are shown in Figure 7 in the paper [1]. These figure show that the zonal currents are reproduced fairly well except at 165˚E. One of the prominent features of the equatorial pacific is Equatorial under current, and the vertical position and the strength of it appears to be well reproduced. The meridional current in the equatorial Pacific is order(s) of magnitude smaller than zonal current and the agreement between GODAS and the observation appears to be poor. The differences between the surface current of GODAS and of OSCAR in the tropical Pacific are shown in Figure 9 in the paper [1] and they are fairly large in equatorial region unlike subsurface current observed by TAO moorings.

[2] Xue Y., A. Kumar, B. Huang and D. Behringer, 2009, Upper Ocean Heat Content Simulated by NCEP GODAS, in OceanObs'09 Conference as a poster Venice, Italy, 21-25 September 2009

Temperature

In this paper [2] authors compared upper ocean heat content, that is mean temperature in upper 300m, computed by GODAS and the result of objective reanalysis based on observed data alone produced by NODC as well as other model products. We omit the description of other models in this document.

They showed the time series of upper ocean heat content averaged over relatively wide area in Figure 1 in [2] (GODAS is red line and NODC reanalysis is black line). The descriptions in the following paragraph are basically copied from this paper [2] but they were slightly edited by removing descriptions of other models. GODAS 3 is the name of GODAS data open to general public and the one we use.

"In the tropical Indian Ocean, GODAS3 agreed well with NODC except during 1979-1984 and 1996-2001. In the tropical Atlantic, GODAS3 was slightly warmer than NODC before 2002, but became close to NODC afterwards. In the North Pacific, GODAS3 agreed very well with NODC prior to 2005, but started to have cold biases afterwards. Note that all the little bumps in the time series around spring 2007 were due to errors in the R2 winds, which have been corrected retrospectively and reflected in GODAS3.

This suggests that including the Arctic Ocean in the ocean model is important for realistically simulating the North Atlantic heat content. In the South Pacific, GODAS3 had large warm biases prior to 1986. In the South Indian Ocean, the downward trend in GODAS3 was largely due to the warm biases prior to 1995. In the South Atlantic, large discrepancies existed among the four ocean reanalysis products prior to 2005, and since then they started to converge.

They also showed the time series of heat content anomaly over relatively wide area in Figure 2. They wrote that "once the climatological mean differences were removed, the agreement among the ocean reanalysis products was significantly improved'.

[3] *Huang B, Y Xue, D. Zhang, A. Kumar and M. J. McPhaden, 2010, The NCEP GODAS Ocean Analysis of the Tropical Pacific Mixed Layer Heat Budget on Seasonal to Inter-annual Time Scales, J. Climate, 23. 4901-4925*

SST

In this paper [3], authors tried to demonstrate "the feasibility of an ocean data assimilation product, that is, GODAS, for the analysis of the evolution of the mixed layer in the tropical Pacific" and "that the analysis of the mixed layer heat budget from an operational ocean assimilation system is an effective tool to monitor and understand SST variability on ENSO time scales" where "operational ocean assimilation system" is GODAS.

Surface current

As in the paper [1], authors of this paper [3] repeated comparison between GODAS data and OSCAR data. Since T/P altimetry data were not assimilated in GODAS at the time of [1] but they were assimilated at the time of [3], descriptions of these comparisons are quoted below:

"Compared to OSCAR currents, GODAS has a westward bias in the far western and eastern equatorial Pacific and an eastward bias in the central Pacific between 180˚ and 120˚W (Fig. 1c) of the paper [3]. Biases in the western and central Pacific are likely associated with the assimilation of synthetic salinity, as these biases are dramatically reduced in an experimental GODAS assimilation run in which observed salinity from Argo floats is also assimilated"

Authors in the paper [3] also repeated comparison among GODAS, OSCAR and TAO current data. Because OSCAR only derives surface current, following descriptions are limited to the surface current (Figure 1, Figure 2, Table 1 and Table 2 in [3]). Regarding to the zonal current," both GODAS and OSCAR have large mean biases in zonal currents in the western (165˚E) and central (170˚W) Pacific, and GODAS has much larger mean biases than OSCAR in the eastern (140˚ and 110˚W) Pacific. Once the mean biases are removed, both OSCAR and GODAS simulate TAO observations reasonably well" and "that GODAS is quite adequate in simulating anomalous zonal advective heat flux in the central–eastern tropical Pacific associated with ENSO". Regarding to the meridional current, "GODAS currents have amplitudes comparable to those of observations. GODAS meridional currents are superior to OSCAR meridional currents in the western (165˚E) and the central–eastern (170˚ and 140˚W) Pacific".

Thermocline (Mixed layer) depth

In the paper [3] authors compared mean seasonal cycle of mixed layer depth (MLD) computed from 1982-2004 GODAS data and monthly climatological fields of temperature and salinity obtained from World Ocean Database 2001 (WOD01). They wrote that "Compared to the WOD01, the MLD based on GODAS is about 20–30 m deeper in the west-central Pacific through the calendar year and 10–20 m deeper in the eastern Pacific during boreal fall" (Figure 3 in [3]).

Seasonal cycle of MLD

Authors analyzed seasonal cycle of heat budget within the mixed layer and they showed that there are some discrepancies between GODAS and observation based past studies. The authors pointed out that these are probably due to the fact that certain aspect of equatorial variations (Tropical Instability Wave) is not well reproduced by GODAS due to the assimilation scheme utilized in GODAS, wind forcing might be inaccurate (which might cause inaccurate surface current) and heat flux might be too low.

Despite of these discrepancies authors claimed that "the interannual variability of the mixed layer heat budget has been simulated reasonably well by GODAS", "suggest that GODAS provides a reasonable estimate of both the seasonal cycle and interannual variability in the mixed layer heat budget" and 'We conclude, therefore, that it is a useful tool for real-time monitoring of mixed layer variability and for further understanding coupled ocean–atmospheric interactions."

[4] GODAS web site, http://www.cpc.ncep.noaa.gov/products/GODAS/validation.shtml

The GODAS web site has several figures showing differences between results of GODAS and observed data (http://www.cpc.ncep.noaa.gov/products/GODAS/validation.shtml). Although it is possible to guess what they are, there is no document describing detail of those figures.

2.3 Applications

[5] Seo, K and Y. Xue, 2005, MJO-related oceanic Kelvin waves and the ENSO cycle: A study with the NCEP Global Ocean Data Assimilation System, Geophys. Res. Lett, 32, L07712

Temperature

In [5] authors studied relationships between El Nino index derived from sea surface temperature, heat content in the upper ocean and equatorial Kelvin wave activity represented by variance of 20˚C isotherm depth anomalies in the eastern equatorial Pacific computed from band-pass filtered GODAS data during major El Nino-La Nina events in the past. The GODAS data used in this study were temperature alone. The authors proposed to use seasonal variance of Kelvin waves index "as a real time monitoring tool to support the official ENSO forecast at NCEP".

[6] Hart, R. E., R. N. Maue and M. C. Watson, 2007, Estimating Local Memory of Tropical Cyclones through MPI Anomaly Evolution. Mon. Wea. Rev., 135, 3990-4005

Salinity

Authors studied the effect of tropical cyclones before and after their passages on the local atmosphere and the surface ocean within the 35˚ of the equator in the Pacific and Atlantic Ocean in [6]. The primarily data set they have used do not include GODAS but they used salinity at 5m (shallowest depth) from GODAS in one of the subsection to describe possible effect on the salinity in the upper ocean due to the tropical cyclone. The low salinity water in the upper ocean due to local rainfall or river run off might reduce mixing in the upper ocean and that might be favorable for warming up upper ocean more rapidly after the passage of tropical cyclone.

[7] Wu. R and S Yeh, 2010, A further study of the tropical Indian Ocean asymmetric mode in boreal spring , J. Geophys. Res. , 115 , D08101, doi:10.1029/2009JD012999

SST

Authors studied tropical Indian Ocean SST changes in relation to the evolution of the Indian Ocean asymmetric mode, which appears as asymmetric precipitation and wind anomalies over the tropical Indian Ocean during boreal spring. Authors performed mixed layer heat budget analyses with current and temperature obtained from GODAS data set for evaluating advection and mixed layer depth in this paper.

[8] Bigelow, K. A. and M. N. Maunder, 2007, Does habitat or depth influence catch rates of pelagic species? Can. J. Fish. Aquat. Sci., 64, 1581-1594

Authors compared "depth- and habitat-derived catch rate estimates to ascertain if catch is estimated better by modeling the vertical distribution with a variety of environmental conditions or in a stereotyped depth preference". The catch rate estimates were from monitored longline fishery (hook depth known) in the central North Pacific (0~800m) as well as from Japanese distant-water fishery data (hook depth estimated). The monitored fisheries were done with time-depth recorder (TDR), which records depth and temperature, but those temperature data were not sufficient for authors' study.

Instead of using these actual measured temperature data, authors used GODAS temperature data. Authors compared result of TDR measurements with GODAS and they mentioned, "estimated temperature profile from the TDR monitoring agreed well with the GODAS model values". The environmental variables used in this study for habitat-derived catch model were temperature at depths and thermocline gradient, both derived from GODAS, and climatological dissolved oxygen profile data. Applying these data into statistical models, authors showed that the catch rate was best reproduced by habitat-derived catch model although relative importance of each variable to others differs depending on the region.

[9] Soto M., E. Chassot and F. Marsac, 2008, STANDARDIZED CATCH RATES FOR YELLOWFIN (Thunnus albacares) AND SKIPJACK (Katsuwonus pelamis) FOR THE EUROPEAN PURSE SEINE (PS) FLEET OF THE INDIAN OCEAN, 1984-2007. A document presented to the Indian Ocean Tuna Commission Working Party on Tropical Tunas in 2008, IOTC-2008-WPTT-26

In [9] authors attempted standardize catch rate of skipjack and yellowfin using statistical models with environmental variables. The main objectives of [9] are "define a standard protocol for standardizing PS CPUE in the case of free and FAD-associated school fishing", "assess the environmental effects on PS CPUE" and "estimate CPUE time series for SKJ and YFT during 1984-2007", FAD for fishing aggregating devices, SKJ for skipjack and YFT for yellowfin, respectively. The areas concerned in this document are 0-10˚N, 40-80˚E and 0-10˚S, 40-80˚E. GODAS data were utilized to obtain depth of 20˚C isotherm as environmental data. Other environmental data used are chlorophyll-a concentration from SeaWIFS.

The authors mentioned that the effect of 20˚C isotherm on statistical models is statistically significant although it is small regarding to skipjack and yellowfin weights of those are less than 10kg while "the depth of 20° isotherm did not explain any variability" regarding to those yellowfin heavier than 30 kg. In the conclusion, authors wrote that "The different spatio-temporal scales of logbook data and environmental variables make difficult to show the effects of the environment on tuna abundance, especially in recent years, where the accessibility of the resources could have been increased due to favorable oceanographic conditions. This makes necessary to investigate further how relating fishing data to environmental data".

[10] Summary of 2009 Physical and Ecological Conditions In the California Current LME, PaCOOS QUARTERLY UPDATE OF CLIMATIC AND ECOLOGICAL CONDITIONS IN THE CA CURRENT Large Marine Ecosystem (LME)

This paper [10] is a sort of annual report regarding to the physical and ecological condition in and around the California current published by Pacific Coast Ocean Observing System (PACOOS). GODAS temperature data were used to compute upper ocean heat content to describe ENSO status. Description regarding to the general pattern of heat content in the entire Pacific is also given. Other than heat content upwelling along the west coast of North America using vertical velocity at 55m obtained from GODAS was also described. Similar publication in 2010 by PCOOS also uses GODAS data almost in the same manner except heat content in the entire Pacific.

2.4 Sea truth (in situ validation)

For the situ validation, we use the real observed information (temperature and salinity) available in the World Ocean Data (WOD) (NOAA, USA). They are actually measured data by the oceanographic observation in past 100 year but majority came from last 30 years as there are many Satellite and ARGO data. We selected the comparable data to the GODAS (NCEP) at 15m, 205m and 459m in the Indian Ocean.

As there are almost no data in the exactly same point in terms location (lat and long), month and depth (**Red point**), we searched the real data in slightly wider ranges in time and space as shown in Table 1 and Fig 1.

Table 1 Search range of the NODC data corresponding to the GODAS (NCEO) data

Time-area unit	GODAS data used for validation (resolution)	Search range of the NODC data
Area	Indian Ocean 1 deg (long) x 1/3 deg (lat)	2 degrees in lat and long from the GODAS data point
Depth	15m	5-25m
	205m	145-255m
	459m	409-509m
time	All period (Month)	1 month before & after the GODAS data If GODS data in June We search the NODC data in May and July

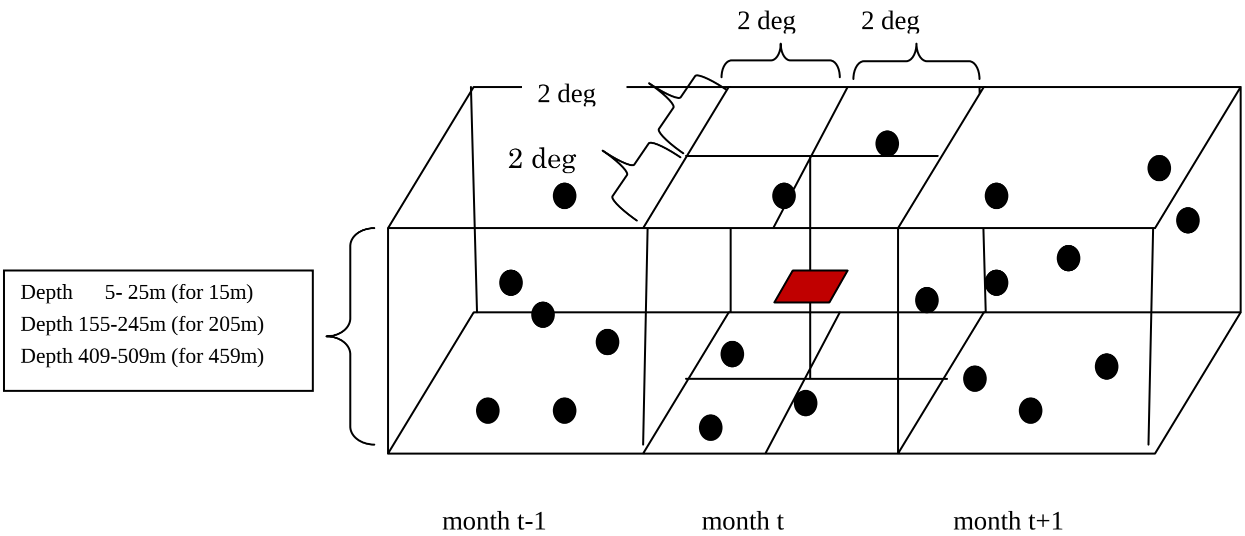
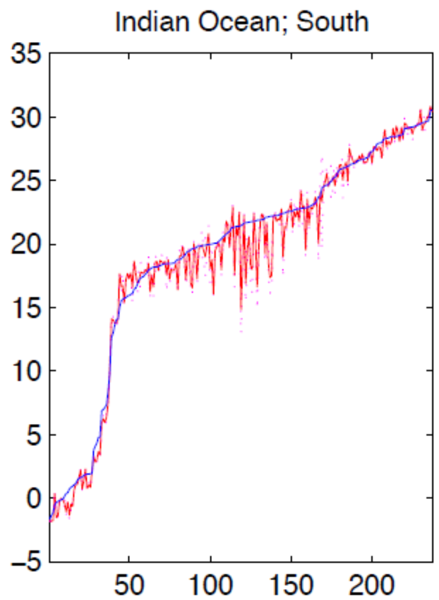


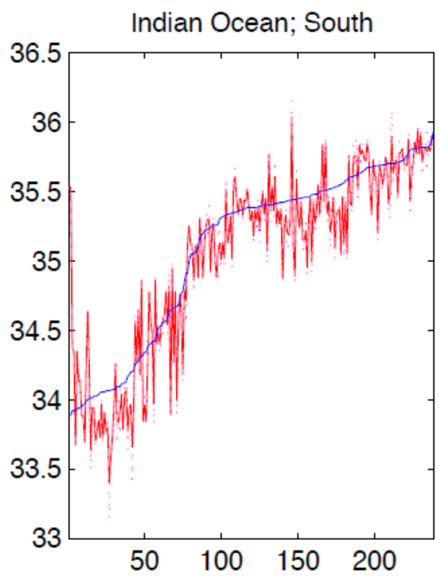
Fig. 1 Illustration showing search ranges of the NODC data to validate the GODAS (NCEP) data (red point).

As a result of comparisons, we recognized difficulties to compare two data sets as there were almost no exactly matched data and even in the data located in the wider range (in terms and space), we could find a small number of data points. However we found that temperature data are likely reasonable values because majority data are located not far from the NODC data. But for salinity there are large ranges in NODC around the GODAS (NCEP) data, thus we consider that accuracy of salinity data are more uncertain than in the temperature data.

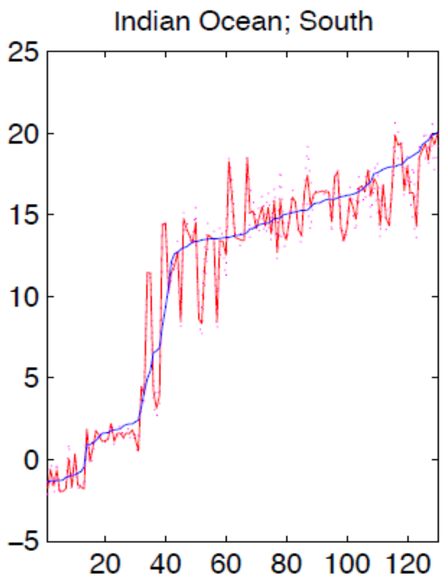
Southern Indian Ocean

Temparture15m (search range :10-25m)	*Salinity 15m (search range : 10-25m)*





Temparture15m (search range :10-25m)	*Salinity 15m (search range : 10-25m)*



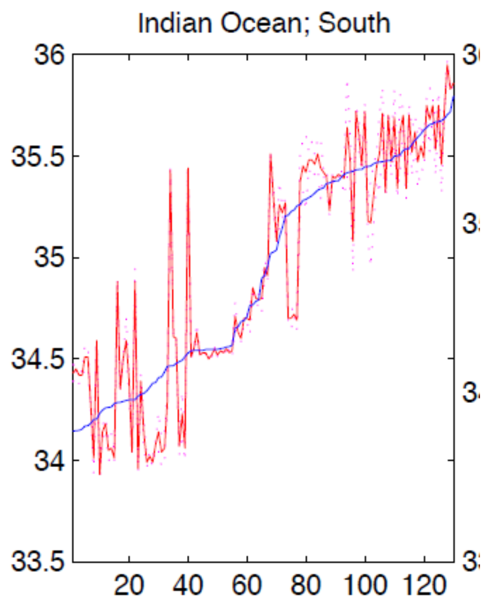


Fig. 2. Results of comparisons of the temperature (left) and salinity (right) data between GODAS (NCEP) (**blue**) (estimated/assimilated data at 15 m) and actually measured data (**red)** by the oceanographic observation available in the NODC database in NOAA (USA). The NODC data are selected from neighboring time -space ranges of the GODAS data point (for details refer to Table 1 and Figure 1).

Y axis: (left) sea temperature (C^{o}) and (right) PSU (Practical Salinity Unit).

Red lines shows mean values of the each data set and red points are the real data.

X axis: ID number of the data used for comparison (data has been sorted by magnitudes of temperature/salinity).

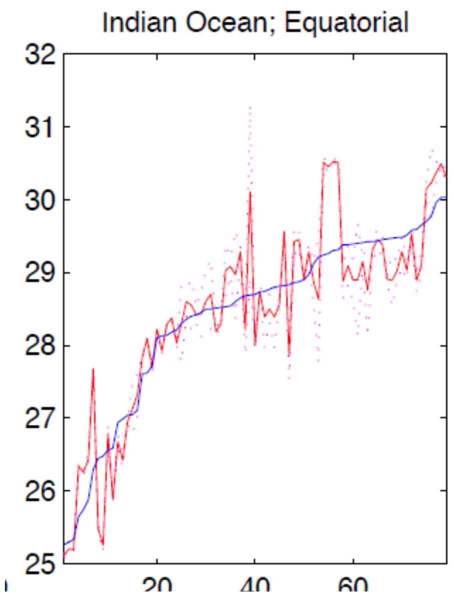
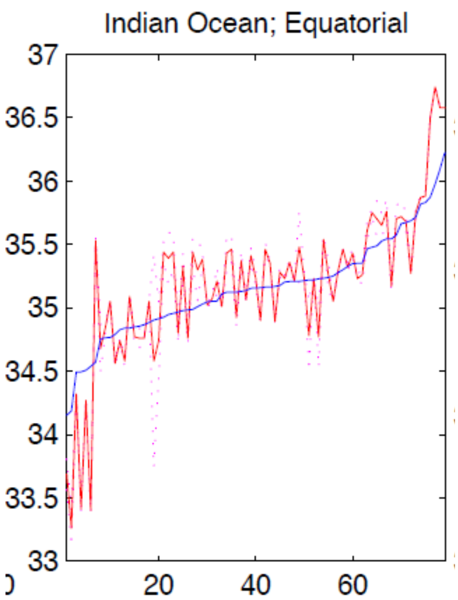
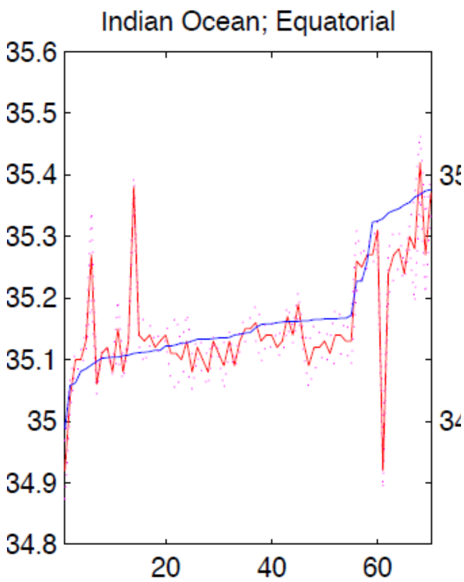
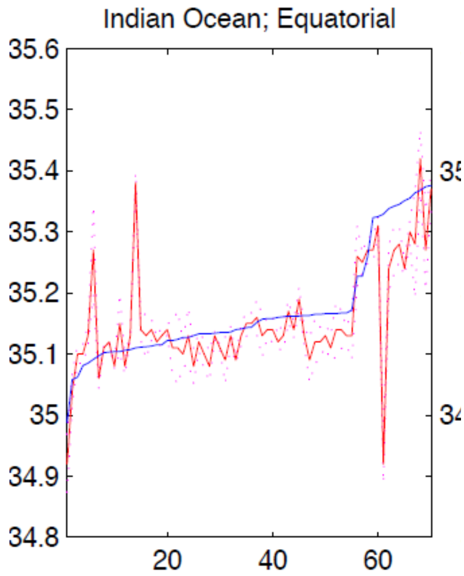
Equatorial Indian Ocean	
TEMP 15m	*SALINITY 15m*
	
TEMP 205m	*SALINITY 205m*
	

Fig. 3. Results of comparisons of the temperature (left) and salinity (right) data between GODAS (NCEP) (**blue**) (estimated/assimilated data at 15 m) and actually measured data (**red)** by the oceanographic observation available in the NODC database in NOAA (USA). The NODC data are selected from neighboring time -space ranges of the GODAS data point (for details refer to Table 1 and Figure 1).

Y axis: (left) sea temperature (C^{o}) and (right) PSU (Practical Salinity Unit).

Red lines shows mean values of the each data set and red points are the real data.

X axis: ID number of the data used for comparison (data has been sorted by magnitudes of temperature/salinity).

2.5 Summary (Tables 2-4)

Table 1 Validation (Theory and comparative studies)

Reference	SSH (shear current)	current	Salinity	Temperature	Thermocline depth
NCEP			There were some experiments assimilating salinity data from ARGO floats and several articles mentioned that assimilating observed salinity improves accuracy of GODAS substantially. Observed salinity will be assimilated officially in the next generation model.		
[1]	Qualitatively agreement appears to be good but there are times when the differences are 6cm or more.	vertical position and the strength of it appears to be well reproduced and the zonal currents are reproduced fairly well Vertical position and the strength appear to be well reproduced.		Slight difference of the vertical position of thermocline between GODAS and actual data	
[2]		“In the tropical Indian Ocean, GODAS3 agreed well with NODC except during 1979-1984 and 1996-2001. In the tropical Atlantic, GODAS3 was slightly warmer than NODC before 2002, but became close to NODC afterwards			
[3]		GODAS is quite adequate in simulating anomalous zonal advective heat flux in the central–eastern tropical Pacific associated with ENSO".		analysis of the mixed layer heat budget from an operational ocean assimilation system is an effective tool to monitor and understand	Compared to the WOD01, the MLD based on GODAS is about 20–30 m deeper in the west-central Pacific through the calendar year and 10–20 m deeper in the eastern Pacific during boreal fall We conclude that it is a useful tool for real-time monitoring of mixed layer variability and for further understanding coupled ocean– atmospheric interactions."
[4]	Quantitative comparisons and no specific comments				
[5]	The GODAS data used in this study were temperature alone. The authors proposed to use seasonal variance of Kelvin waves index "as a real time monitoring tool to support the official ENSO forecast at NCEP				
Evaluation	Fair to use		Do not use until more accurate estimates available by the next generation model	Fair to use	

Table 3 Validation (application/case studies)				
Reference	SSH (Shear current)	salinity	Temperature	Thermocline depth
[5]	The GODAS data used in this study were temperature alone. The authors proposed to use seasonal variance of Kelvin waves index "as a real time monitoring tool to support the official ENSO forecast at NCEP"			
[6]		Application only and no specific comment on validation		
[7]			Application only and no specific comment on validation	
[8]			Estimated temperature profile from the TDR monitoring agreed well with the GODAS model values".	
[9]				Application only and no specific comment on validation
Evaluation	Fair to use	Not enough information to evaluate	Fair to use	Not enough information to evaluate

Table 4 In situ Validation of GODAS (NCEP) data using the NODC database (USA)		
	salinity	Temperature
NODC data	Validation was conducted for the data in the southern and equatorial Indian Ocean	
Evaluation	As a result of comparisons, we recognized difficulties to compare two data sets as there were almost no exactly matched data and even in the data located in the wider range (in terms and space), we could find a small number of data points. However we found that temperature data are likely reasonable values because majority data are located not far from the NODC data. But for salinity there are large ranges in NODC around the GODAS (NCEP) data, thus we consider that accuracy of salinity data are more uncertain than in the temperature data.	

3. Discussion and conclusion

Based on the extensive reviews, we understand that salinity data in the GODAS (NCEP) have problems in the current estimation methods while for others (temperature, thermocline depth and shear currents) are fairly realistic although they are not perfectly accurate, i.e., there are some degrees of errors by year, season and depth. Thus we suggest not to use salinity data but to continue to use with cautions by validating with the real data (sea truth).

Provost Awaji and Professor Ishikawa (Kyoto University) are the world outstanding experts on assimilate oceanographic data using the super computers available in Japan Agency for Marine-Earth Science and Technology (JAMSTIC). They have been creating historical data in various waters using the similar methods applied by NCEP. They also provided similar comments and emphasized the sea truth before applications (*personal communications*).

Furthermore, several scientists in IRD, France (Maury, Dueri and others) have been developing APECOSM-E (Apex Predator Ecosystem Model-Estimation). In that model they also use assimilated data similar to GODAS data but estimated by different methods. Table 5 shows the comparisons of the data between two products. The paper on APECOSM-E was discussed last WPTT12 (2010) which suggested also the need of the validation (sensitivity) using in situ data.

Table 5 Comparisons of two assimilated oceanographic data between GODAS and APECOSM-E

Features		GODAS (NCEP)	ENV data in APECOSM-E
Year		1980-	1950-
Resolution	Temporal	Month	Daily
	Spatial	1/3 deg (long) and 1/2 deg (lat)	1deg x 1deg
	Depth	28 layers	20 layers
Parameters	Temperature	yes	yes
	Salinity	yes	no
	(shear) current	yes	no
	Thermocline depth	yes	yes

As a conclusion we suggest that GODAS data except salinity in the NOAA-NCEP can be used for various studies such as fisheries oceanography, CPUE standardization in our case with caution as there are some degrees of errors by year, season and depth in the estimated data. Thus we suggest using the GODAS data through sea truth (validation).

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