Assessment of BoB Upper Ocean features in NCMRWF NEMO

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Abstract

The Bay of Bengal [BoB] upper-ocean physical parameters are examined in the two ocean analysis such as Modular Ocean Model [MOM] Global ocean data assimilation system [GODAS] and Nucleus for European Modelling of the Ocean [NEMO]. The daily temperature and salinity profiles from both analysis were used to study the upper ocean stability structure and also investigates its intraseasonal variability with respect to the in-situ observation [ARGO]. The dominant intraseasonal current variability regions i.e., East coast of India [84°E-86°E, 15°N-18°N; R1] and Sri Lanka Dome [SLD] [83°E-86°E, 5°N-8°N; R2] is well captured in NEMO whereas in GODAS is failed do same for 2016-18. The vertical profile of temperature and salinity bias for both analysis shows the less bias in NEMO compared to MOM GODAS especially up to 0-100m in R1 and R2 regions. This bias leads to the more MLD bias in pre-monsoon season for GODAS. Our study concludes that NEMO could represent the oceanic parameters more realistically for the north BoB which is a challenging region to capture the monsoonal intraseasonal variability. This may lead to realistic and better East India coastal processes [currents, waves, ecological system] for NEMO than GODAS.

1 Introduction

In the BoB, improper stratification can significantly weaken the convective mixing and wind driven processes which are responsible for transport of nutrient to the euphotic zone thus affecting the coastal processes. The variability of BoB is governed by a seasonal reversal of surface wind [1,2] and high fresh water flux input via precipitation and river runoff with contrast relatively lesser evaporation [2,3]. The shallow halocline and enhanced stratification in the upper ocean are maintaining the high heat content and SST in the BoB [4]. In June 2016, the southern BoB was under the influence of a convectively active phase of the Boreal Summer Intraseasonal Oscillation [BSISO] [5]. Simulation of BoB upper ocean properties is one of the challenging issues to the modeling community due to the complexity arising from the unique physical and dynamical processes in this basin. The strong stratification of BoB causes rapid variations in SST that influences the deviation of monsoon rainfall forecast system. This stratification is driven by salinity difference the northern bay and salty water of SMC. So the realistic representation of SMC in ocean models is a challenging issue for modelling community.

In this study, characteristics and mechanisms of BoB upper-ocean [100 m] physical parameters are analyzes in two ocean model outputs from MOM and NEMO ocean model. These models are widely used for various diagnostic studies and also initializing the ocean component of coupled forecasting system. It is very important to see that these ocean analyses can capture the oceanic features properly or not. The present study analyzes the vertical structure of temperature, salinity and currents compared to INCOIS-ARGO and ocean surface current analysis real time [OSCAR] over BoB.

2 Dataset used

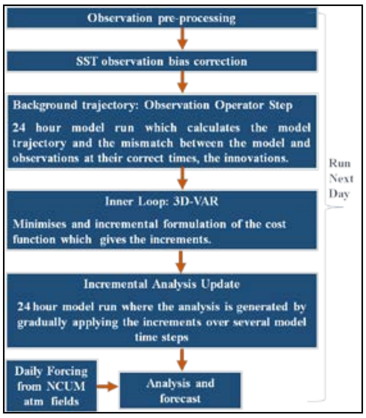
In the present study the following ocean analysis used.

2.1 MOM [NCEP-GODAS]

GODAS is based on the Modular Ocean Model version 3 with a three-dimensional variational [3DVAR] data assimilation scheme. It assimilates profiles of temperature and synthetic salinity. It is forced by the momentum flux, heat flux, and freshwater flux from the NCEP atmospheric reanalysis version 2 with horizontal resolution 1° × 1° [1/3° meridional at the tropics] and 40 vertical levels.

2.2 NEMO [NCMRWF]

NCMRWF-NEMO ocean analysis uses Nucleus for European Modeling of the Ocean [NEMO] model. Three dimensional variational assimilation [3D-Var] algorithms with FGAT scheme [NEMOVAR] is used to produce reanalysis of the global ocean. It is forced by the high resolution NCMRWF Unified Model (NCUM N1024; ~12 km) atmospheric boundary fluxes. It has horizontal resolution of 0.25°x0.25° and 75 vertical levels. NEMOVAR assimilates temperature and salinity profiles, surface temperature from in-situ and satellite, and along-track altimeter-derived sea-level anomalies. Figure 1 shows the flowchart of NEMOVAR analysis and forecast system.



3 Comparison of NEMO and MOM ocean analysis

3.1 Intraseasonal variability of BoB

The furrier analysis of surface current over the BoB region shows the dominant intraseasonal variability in southwest monsoon current (SMC) and Eastern coast of India [figure not displayed]. NEMO current could capture the variability more realistically for R1 and R2 whereas NCEP-GODAS is failed to do same. NEMO is 0.25x0.25° eddy permitting and higher vertical resolution model so the R1 eddy system captured well in it.

3.2 The Vertical structure of Temperature, Salinity and MLD bias with gridded ARGO

Temperature and salinity bias for both models with respect to gridded ARGO for R1 and R2 are displayed in figure 1 [a-h]. R2 [SLD] NEMO temperature bias [Figure1a-b] is greater than 1°C upto 0-60m. GODAS show strong positive bias [1-2°C] during 2016 and 2018 JJA for upper 60m. At subsurface 60-150m GODAS display both negative and positive bias ranging from 2-3°C. For R1 [Figure1 c-d] NEMO displayed an upper ocean [0-40m] warming bias periods and subsurface [40-150m] cold bias during winter monsoon [JFM] of 2016-2018. GODAS display strong cold and warm subsurface bias 60-150m [>2°C]. Figure 1[e-h] showed salinity bias for R1 and R2 for NEMO and GODAS with respect to ARGO observations. SLD region [R1] NEMO display mostly negative bias at upper ocean 0-40m [0.5psu]. GODAS also display strong negative bias for upper ocean 0.5psu. R2 displays stronger bias than the SLD region [R1] as it is near to the head bay region. NEMO display lesser bias compare to GODAS with respect to ARGO. GODAS display salinity bias >1 psu for upper BoB 0-100. This salinity bias contributes in most stratification issue of BoB.

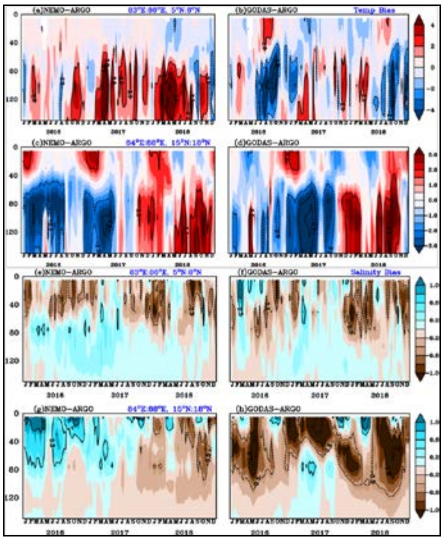


Figure 1. Temperature (a-d) and Salinity bias (e-h) for NEMO and GODAS with respect to ARGO for 2016-18.

3.3 Associated upper oceanic processes

MLD represents upper ocean homogeneous layer, which interacts with the atmosphere above and exchanges moisture and heat fluxes. MLD bias in SLD region both models showing similar kind of bias pattern though GODAS is mostly displaying 10-20m deeper bias than NEMO. For R2 GODAS showing upto 40m deeper bias whereas NEMO MLD is closer to observations. This indicates the major mixing problem with the both models in which NEMO performs better Intraseasonal variability compared with observed one.

To understand the role of vertical stability processes to upper ocean biases, square of the Brunt–Vaisala frequency (BV) with respect to ARGO studied. To understand the role of vertical stability to the upper ocean biases, square of the Brunt–Vaisala frequency (BV) with respect to ARGO has computed. Figure 2 display the BV frequency from NEMO and GODAS with respect to ARGO. Figure 2 (c-d) showed the biases in R2 region and fig4 (g-h) from both ocean analysis data. The BV frequency normally is high in the BoB than any other basin of Indian Ocean. The negative difference in the BV at surface clearly indicates that both ocean analyses underestimate stability of the region R2 for the upper 30–40 m bottom of this strong positive bias noticed for GODAS on 2016 summer monsoon period (JJAS). Region R1 shows relatively lesser bias in NEMO whereas GODAS display strong negative bias upper 60-70m and beneath that strong positive BV bias observe till 100m depth. Overall upper ocean stability is weaker in GODAS in both region specially R1 w.r.t the ARGO data.

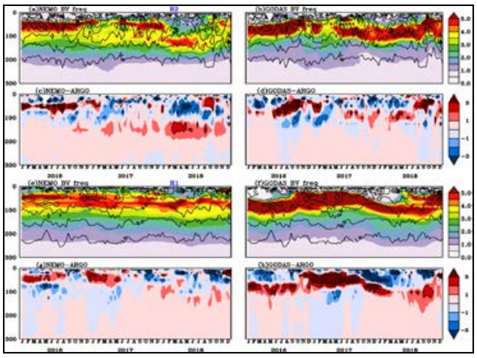


Figure 2. Depth-time diagram of BV frequency and its bias with respect to ARGO for R2 region (a-d) and for R1 region (e-f).

4 Effect of NEMO coupling [CNCUM]

The current coupled configuration implemented at NCMRWF include the UM as the atmospheric model, the Joint United Kingdom Land Environment Simulator [JULES] to represent land-surface, NEMO as ocean component and sea-ice dynamics and thermodynamics are computed by subroutines in Los Alamos National Laboratory community-driven sea ice model [CICE]. Each week forecasts are generated by running the coupled model for 36-days of simulation to facilitate preparation of weekly-mean anomalies up to 4-week of lead times.

Figure 3 display the bias of SSS and MLD from week1 and week2 CNCUM forecast during JJAS 2019. For BoB SSS and MLD bias is increased from week1 to week2 forecast. Mostly the head bay is showing positive salinity bias ~0.4psu. Similarly MLD bias has positive bias is ~8m.

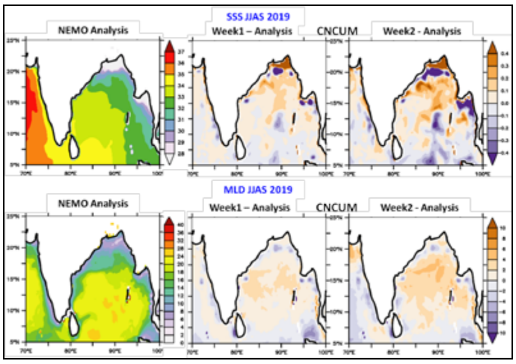


Figure 3. SSS and MLD from NEMO analysis and CNCUM week1 and week2 forecast bias during JJAS 2019.

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