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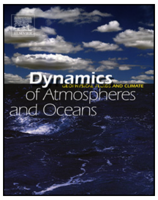

An assessment of TropFlux and NCEP air-sea fluxes on ROMS simulations over the Bay of Bengal region

Dipanjan Dey[a,c], Sourav Sil[a,*], Sudip Jana[b], Saikat Pramanik[a], P.C. Pandey[a]

[a] *School of Earth, Ocean and Climate Sciences, Indian Institute of Technology Bhubaneswar, Odisha, India*
[b] *Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, USA*
[c] *Department of Meteorology (MISU), Stockholm University, Sweden*

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ABSTRACT

This study presents an assessment of the TropFlux and the National Centers for Environmental Prediction (NCEP) reanalysis air-sea fluxes in simulating the surface and subsurface oceanic parameters over the Bay of Bengal (BoB) region during 2002–2014 using the Regional Ocean Modelling System (ROMS). The assessment has been made by comparing the simulated fields with in-situ and satellite observations. The simulated surface and subsurface temperatures in the TropFlux forced experiment (TropFlux-E) show better agreement with the Research Moored Array for African-Asian-Australian Monsoon Analysis (RAMA) and Argo observations than the NCEP forced experiment (NCEP-E). The BoB domain averaged sea surface temperature (SST) simulated in the NCEP-E is consistently cooler than the satellite SST, with a root mean square error (RMSE) of 0.79 °C. Moreover, NCEP-E shows a limitation in simulating the observed seasonal cycle of the SST due to substantial underestimation of the pre-monsoon SST peak. These limitations are mostly due to the lower values of the NCEP net heat flux. The seasonal and interannual variations of SST in the TropFlux-E are better comparable to the observations with correlations and skills more than 0.80 and 0.90 respectively. However, SST is overestimated during summer monsoon periods mainly due to higher net heat flux. The superiority of TropFlux forcing over the NCEP reanalysis can also be seen when simulating the interannual variabilities of the magnitude and vertical extent of Wyrtki jets at two equatorial RAMA buoy locations. The jet is weaker in the NCEP-E relative to the TropFlux-E and observations. The simulated sea surface height anomalies (SSHA) from both the experiments are able to capture the regions of positive and negative SSHA with respect to satellite-derived altimeter data with better performance in the TropFlux-E. The speed of the westward propagating Rossby wave along 18°N in the TropFlux-E is found to be about 4.7 cm/s, which is close to the theoretical phase speed of Rossby waves.

1. Introduction

Air-sea interactions play a significant role in determining the weather and climate at various time scales. El Niño–Southern Oscillations (ENSO) affect the weather patterns (McPhaden et al., 2006) globally; Madden Julian Oscillations (Madden and

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[*] Corresponding author at: School of Earth, Ocean and Climate Sciences, Indian Institute of Technology Bhubaneswar, Argul Campus, Jatni 752 050, Odisha, India.
E-mail address: souravsil@iitbbs.ac.in (S. Sil).

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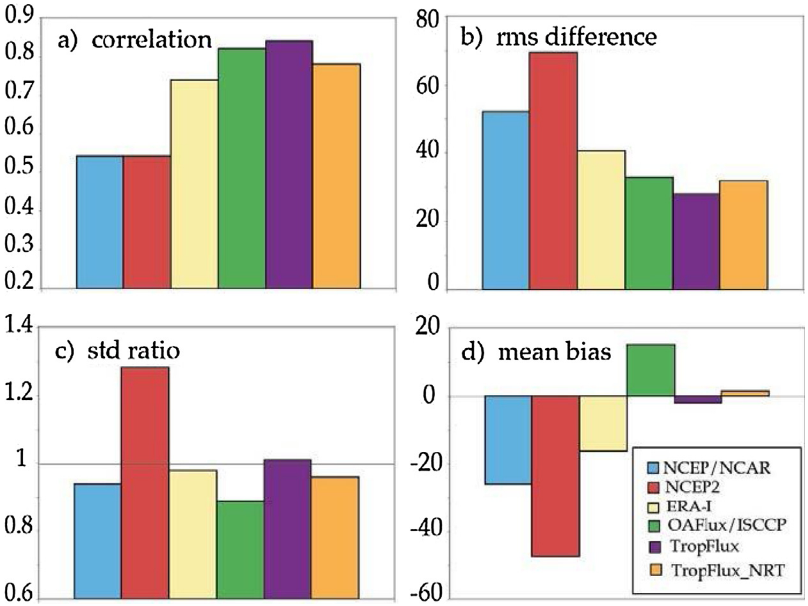

Fig. 1. Bar diagrams showing evaluation of net flux over 2000–2007 periods. All time series are subjected to 5-day smoothing before doing the statistics. Here blue color denotes NCEP/NCAR, red denotes NCEP2, yellow denotes ERA-I, green denotes OAFlux/ISCCP, purple denotes TropFlux and orange denotes TropFlux_NRT (Source: Fig. 13, Kumar et al., 2012). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Julian, 1972) modulate monsoons at intraseasonal time scales. Oscillations in the Atlantic Meridional Mode (AMM) are responsible for ocean-atmosphere variability over the Atlantic Ocean (Xie and Carton, 2004). Over the Tropical Indian Ocean, an irregular oscillation of sea surface temperatures (SST) with interannual variability has been widely recognized due to its climatic consequences (Indian Ocean Dipole, Saji et al., 1999). A precise determination of intraseasonal to interannual variabilities in the air-sea fluxes and their implementation in ocean models are thus an important requirement for understanding the variabilities in the tropical oceans.

Several efforts were made in the past to produce a better air-sea flux product with different spatio-temporal scales for the global oceans, e.g., Objectively Analyzed Flux (OAFlux), Comprehensive Ocean Atmosphere Data Set (COADS), ERA-Interim, National Centers for Environmental Prediction (NCEP) etc. The COADS (da Silva et al., 1994) provides appropriate input parameters for the calculation of air-sea fluxes across the globe. But, interpolation of ship route gaps caused uncertainty in this product. The atmospheric reanalysis products somewhat overcome this disadvantage with the help of atmospheric general circulation models. The NCEP/NCAR (National Center for Atmospheric Research) (Kalnay et al., 1996), NCEP2 (Kanamitsu et al., 2002) reanalysis products provide long-term data but suffer from model errors. NCEP turbulent heat fluxes were observed to be largely underestimated during the monsoon season, but reasonably comparable during the pre-monsoon period (Swain et al., 2009). Further, limited duration of satellite measurements is one of the major drawbacks for satellite-based air-sea flux products. In OAFlux, satellite measurements and model reanalysis were combined (Yu and Weller, 2007; Yu et al., 2008). It used daily shortwave and longwave radiations from the International Satellite Cloud Climatology Project (ISCCP; Zhang et al., 2004), since it is unable to provide its own calculated radiative fluxes. To overcome the above mentioned difficulties, Kumar et al. (2012) came up with an assimilated and bias-corrected product called "TropFlux" for global Tropical Ocean by combining Era-Interim surface meteorological parameters and longwave radiation, ISCCP shortwave radiation, and NOAA outgoing longwave radiation. Era-Interim flux data capture the temporal variability, but it still has a systematic error when compared with buoy data. They found that NCEP and NCEP2 derived daily air-sea fluxes suffer from a systematic bias and weaker correlation when compared with Global Tropical Moored Buoy data (Fig. 1). The TropFlux and the OAFlux perform best with systematic biases lower than 15 W m^{-2} and correlations above 0.8 (Fig. 1). The TropFlux hence provides a valuable choice for studying air-sea heat flux variability, oceanic heat budgets and climate scale oscillations in the tropics (Kumar et al., 2012).

The Bay of Bengal (BoB) is a unique basin in the North Indian Ocean (NIO) with SST above 28 °C (Vinayachandran and Shetye, 1991), which is the threshold for active initiation of large-scale convection (Gadgil et al., 1984) for most of the months in a year. In addition, the excess precipitation over evaporation (Prasad, 1997) and huge freshwater influx from the adjacent rivers (Subramanian, 1993) make the upper surface features very stratified (Jana et al., 2015). Therefore, a careful selection of air-sea flux products for the ocean model simulations in this region is worth studying.

Recently, numerical ocean modeling with air-sea flux components from different sources over the Indian Ocean has gained more attention. Agarwal et al. (2007a) showed that, in the Tropical Indian Ocean, sea level anomalies (SLA) simulated using QuikSCAT forced simulation had a lower root mean square error (RMSE) and higher correlation with respect to observations