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High-resolution numerical modelling of seasonal volume, freshwater, and heat transport along the Indian coast

Kunal Madkaiker et al.

Correspondence to: Kunal Madkaiker (kunal.ajit.madkaiker@cas.iitd.ac.in)

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Text S1: Climatological characteristics of SST in the AS and BoB

In the NIO, the MAM season is the warmest and we observe BoB to be warmer than AS. This is a cumulative effect of heat being stored in the upper few meters of the ocean due to strong stratification and increased surface net heat flux. The WBC advects warmer waters from the southwest up into the northwestern BoB. During JJAS, the temperature difference between the South Asian landmass and ocean causes the Intertropical Convergence Zone to shift northward (Gadgil, 2003). The strong southwesterly winds exceeding the speed of more than 10 m/s cause latent heat to release in the AS, cooling surface waters. We observe a cold tongue flowing from AS into BoB, also called a 'cold pool', which is maintained by advection and mixing due to entrainment (Vinayachandran et al., 2020). This coastally upwelled cold water along the southeastern AS is further advected into BoB by the southwest monsoon current. During the transition season of ON, wind direction reverses and becomes north-easterly. We observe a warming signal along the western coast of India during this period. In DJF, we observed SST cool in the northern AS and BoB. Cold and dry winds blowing from the northeast cool the surface waters by releasing latent heat through evaporation. This along with strong convective mixing causes a reduction in net heat flux (Kumar and Prasad, 1999). During this period, we observe warmer temperatures along the southeastern AS. This can be attributed to the westward propagating downwelling Rossby wave, which traps heat beneath the deepened thermocline and prohibits ventilation (Kushwaha et al., 2022).

Text S2: Climatological characteristics of SSS in the AS and BoB

Similar to SST, climatological patterns of SSS has certain characteristic features in NIO. During MAM season, the poleward WBC brings saltier water from the southwestern up into the head BoB region. As the JJAS season commences, the Indian peninsula receives huge amounts of freshwater as a cumulative effect of precipitation as well as the melting of snow in the Himalayan regions. This increases the riverine discharge into the head BoB making it less saline. The equatorward flow of freshwater is limited up to 18°N due to divergence between the EICC and a weaker WBC. In AS, the surface waters experience huge evaporation due to strong winds thereby increasing the salinity. Higher evaporation over precipitation and vertical mixing with subsurface waters make sure that AS salinity remains well above 35 psu (Kumar and Prasad, 1999). The equatorward-flowing WICC brings relatively salty water into BoB via the southwest monsoon current (Vinayachandran et al., 2013). By ON season, EICC flows to conform to the southeastern coast of India. During DJF, we observe that the relatively fresher water flowing from BoB influences the salinity variations in the southeastern AS.

Text S3: Validation of ocean temperature

The statistical validation of model ocean temperature has been done with RAMA and gridded ARGO datasets and correlation, bias and RMSD have been evaluated over monthly climatology. We have considered 3 locations each in the AS and BoB. The model shows a high positive correlation with both observations over the top 50 meters at all locations. It seems to perform quite well in the southern AS and BoB (4°N latitude). We observe that the model correlates well with ARGO than RAMA data. In the AS, RAMA buoy data is available for a shorter span (3-4 years) as compared to BoB. Thus, the climatology may not capture the long-term mean signal within this span. We observe the bias does not exceed ±1°C except over two locations in the AS. Similarly, the RMSD value is very low (two orders less) which is to be expected. This shows that the model is able to capture the mixing processes and net heat flux well to simulate ocean temperature.

Text S4: Validation of ocean salinity

The statistical validation (till 100 meters) of model ocean salinity has been done with RAMA and gridded ARGO datasets and correlation, bias and RMSD have been evaluated over monthly climatology. Comparison has been done at the same locations as that with temperature. Model salinity too performs very well at 4°N latitude with high positive correlation, and almost zero bias and RMSD. The model shows a high positive correlation with both observations over the top 50 meters. Overall, the bias and RMSD do not exceed ±0.5 psu. This shows that the model is able to capture the effects of evaporation, precipitation, and river runoff well to simulate ocean salinity.

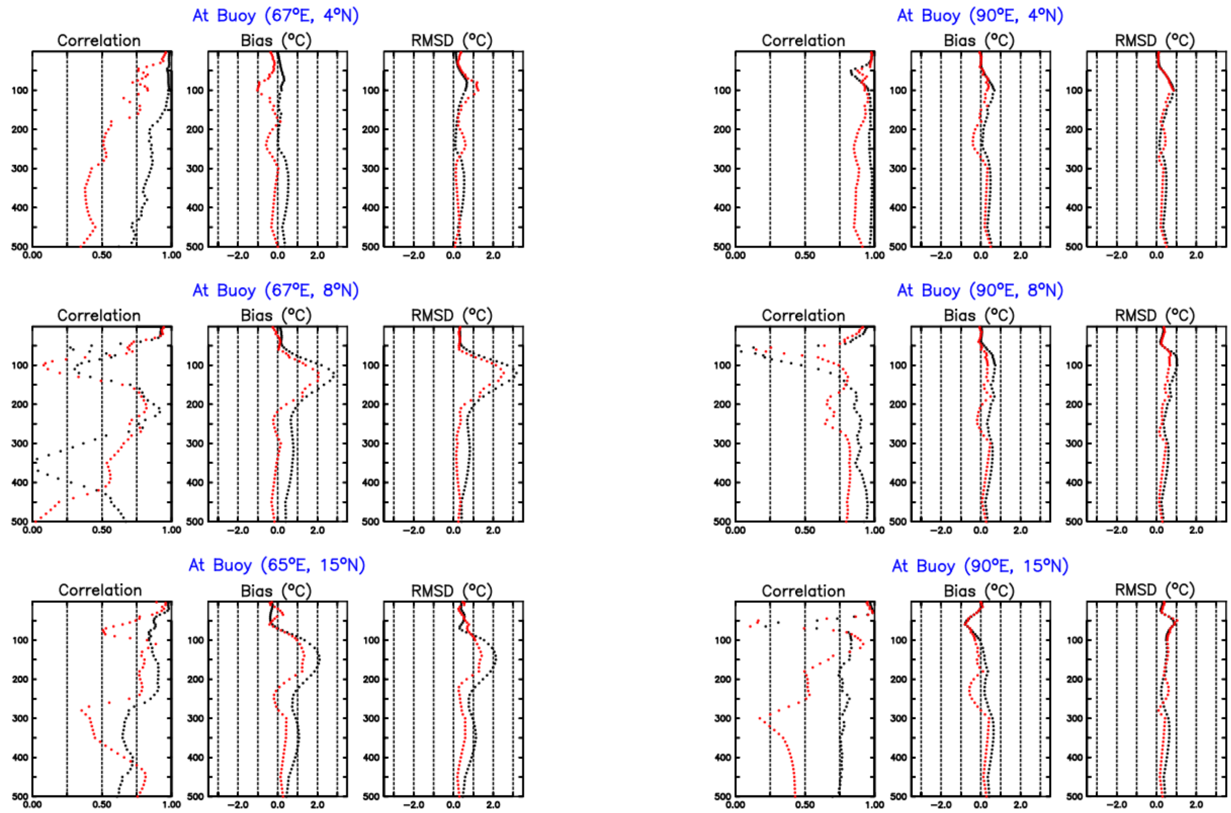

Figure S1: Statistical validation (till 500 meters) of ocean temperature (in °C) with gridded ARGO (black dots) and RAMA buoy (red dots) locations in the Arabian Sea and the Bay of Bengal.

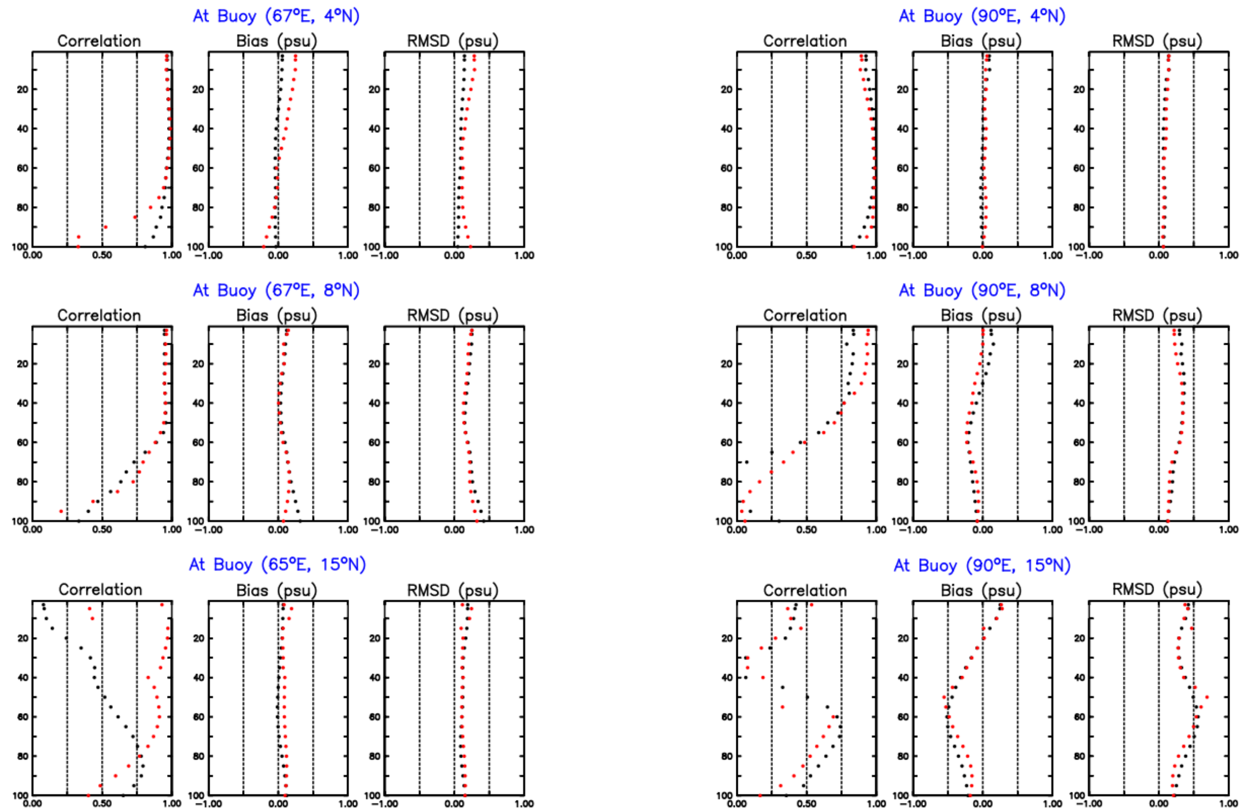

Figure S2: Statistical validation of ocean salinity (in psu) with gridded ARGO (black dots) and RAMA buoy (red dots) locations in the Arabian Sea and the Bay of Bengal.

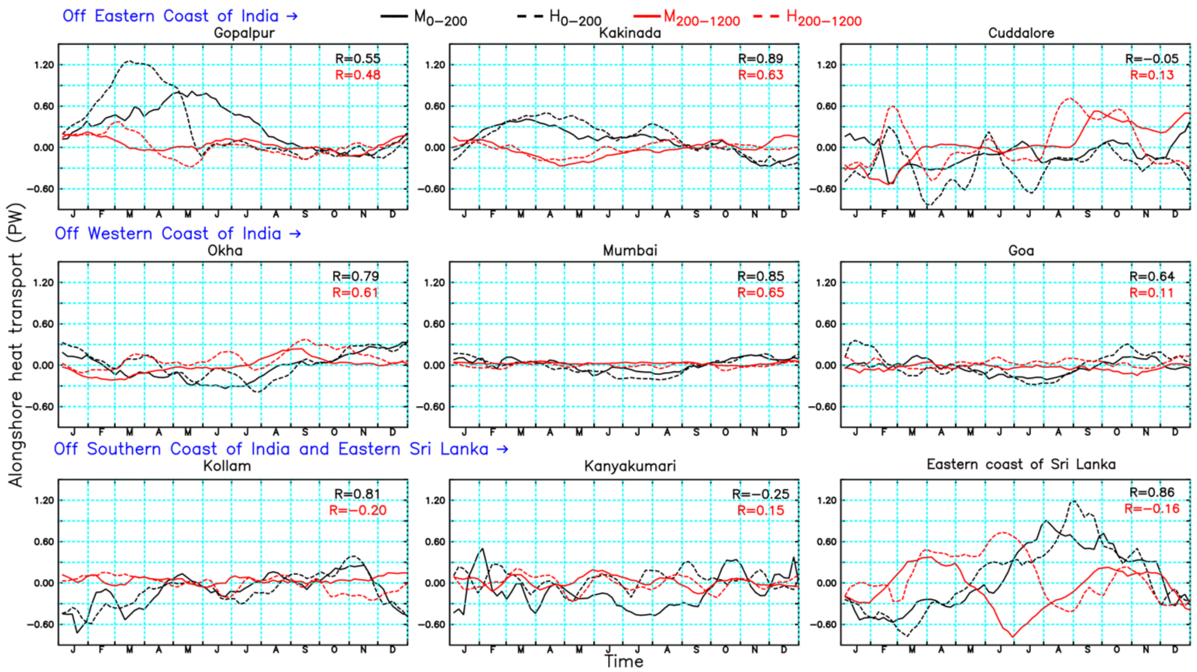

Figure S3: AHT (in PW) of the MITgcm model (solid lines) and INC-HYC (dashed lines). R represents the Pearson's correlation coefficient between the MITgcm model and INC-HYC.

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