Oceanic Subsurface Impact on Tropical Convection

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Abstract:

In India the summer monsoon rainfall occurs owing to large scale convection with reference to ITCZ. It was found that convection over tropical ocean increases with SST from 26 to 28 degree C and when SST is above 29 degree C it sharply decreases for warm pool areas of Indian and for monsoon areas of West Pacific ocean. The reduction in convection can be influenced by large scale subsidence forced by nearby or remotely generated deep convection, thus it was observed that under the influence of strong large scale rising motion convection does not decreases but increases monotonically with SST even if SST value is higher than 29.5 degree C. Since convection is related to SST gradient that helps to generate low level moisture convergence and upward vertical motion in the atmosphere. Strong wind fields like cross equatorial low level jet stream on equator ward side of the warm pool are produced due to convection initiated by SST gradient. Areas having maximum SST have low SST gradient and that result in feeble convection. Hence it is imperative to mention that the oceanic role (other than SST) could be prominent in influencing convection. Since warm oceanic surface somewhere or the other contributes to penetrate the heat radiation to the subsurface of the ocean and as there is no studies seen related to oceanic subsurface role in convection, in the present study, we are concentrating on the oceanic subsurface contribution in convection by considering the SST, mixed layer depth (MLD), thermocline, barrier layer. The present study examines the probable role of subsurface ocean parameters in influencing convection.

Data and methodology

- **The OLR data studied is for the time period 1997 to 2016 is of National Oceanic and Atmospheric Administration (NOAA) interpolated outgoing long wave radiation obtained from Asian Pacific Data Research Centre (APDRC). The OLR data is downloaded on a daily basis with resolution 2.40 x 2.40 grids.**
- **The SST data used for calculating spatial correlation is downloaded from AVHRR with resolution 0.250 x 0.250 grid.**
- **The temperature and salinity data is downloaded is of NCEP Global Ocean Data Assimilation System (GODAS) from APDRC with resolution 0.90 x 0.90 grid with the depth of 225m for both temperature and salinity. MLD and D20 are calculated using temperature and salinity data.**
- **Data studied for the period during cyclone activity as well as during no cyclone dates.**
- **Statistical methods such as Standard deviation and Correlation technique were used in this study.**
- **Spatial plots with correlation between MLD,D20,OLR,SST for entire period, cyclone and no cyclone dates is been studied.**

Area of study

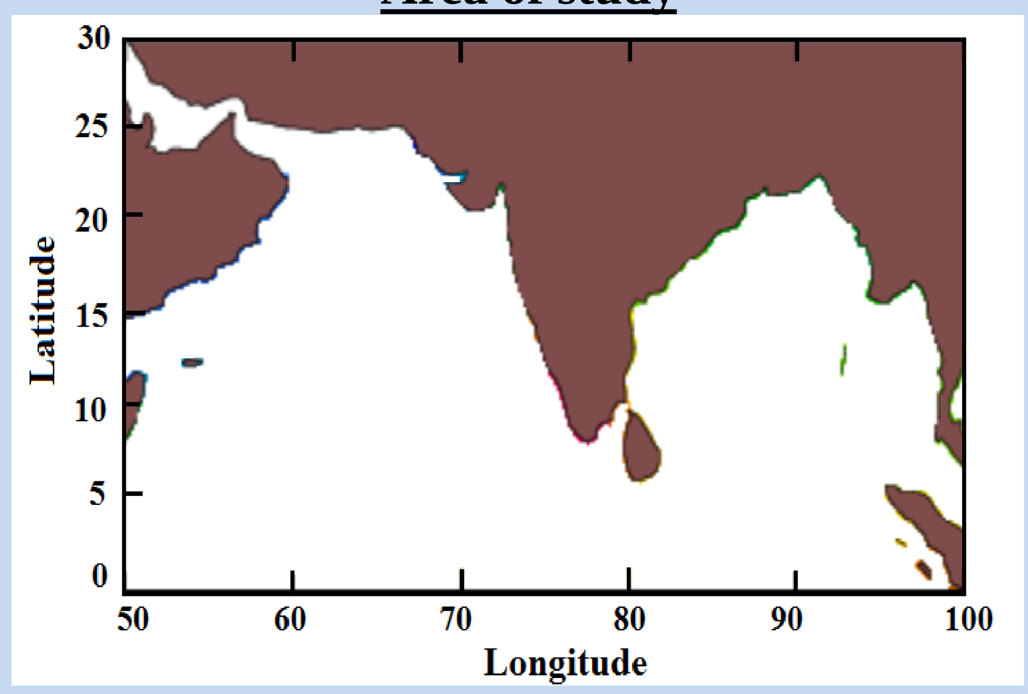
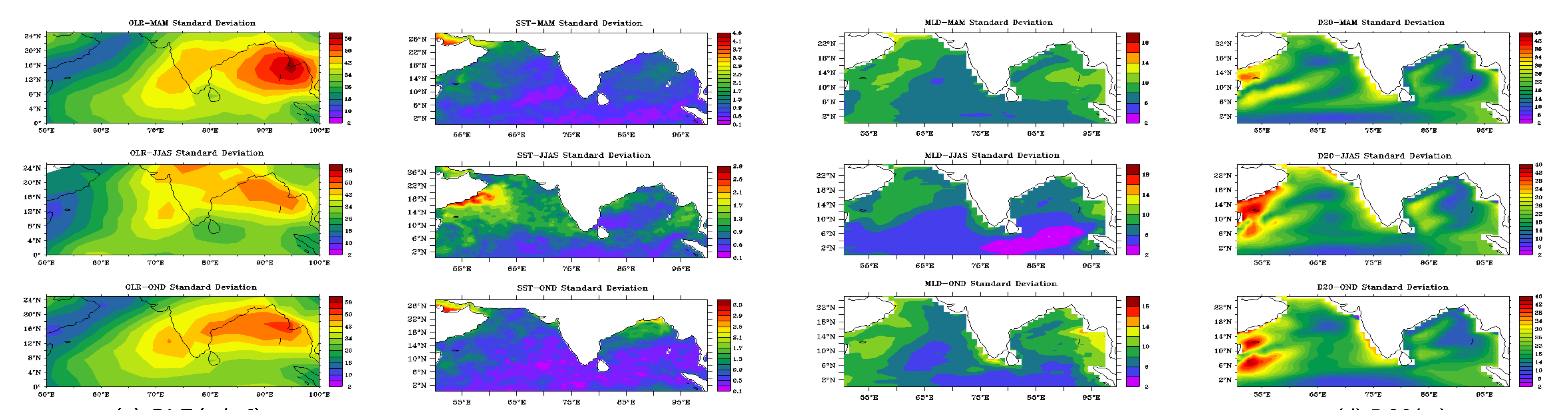


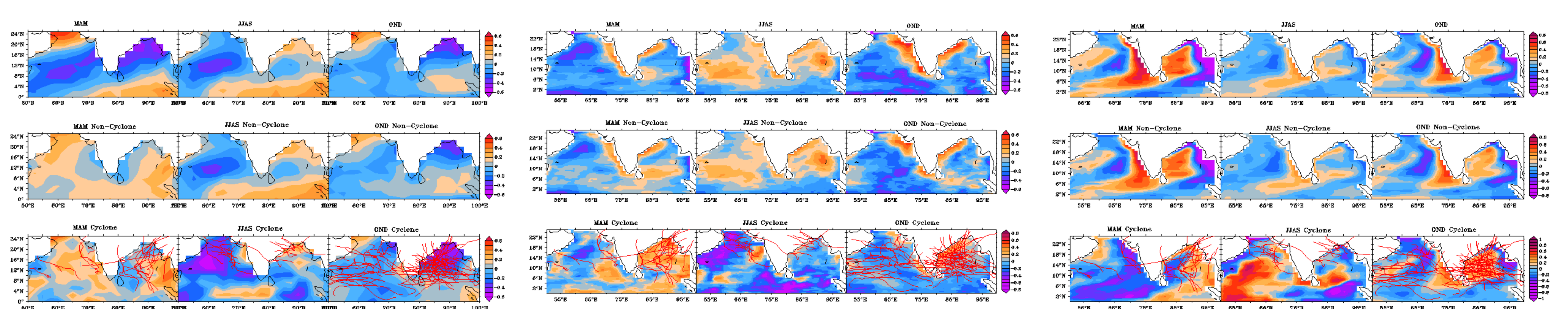
Figure 1: Indian Ocean

Results and Discussions



(a) OLR(w/m²) (b) SST(ºC) (c) MLD(m) (d) D20(m)

Figure2: Standard deviation for the Season's pre-monsoon(MAM), southwest monsoon(JJAS) and post monsoon(OND)



(a) (b) (c)

Figure 3: Correlation: SST-OLR (a), MLD-OLR (b), D20-OLR (c)

- From Figure 2, A high value of standard deviation represents the high variation in cloud cover and low values of standard deviation depict less variation in cloud cover. Highest values for standard deviation in OLR can be found over northern Bay of Bengal during the pre-monsoon season (figure 2(a)).
- From the figure 2(b), it is clear that most parts of Bay of Bengal, south-eastern Arabian Sea are characterized by very less standard deviation (<0.6 °C). These regions are part of Indo-Pacific warm pool, where the SST is high (>27 °C) most of the time in an year. Since the surface waters are warmer, even a slight variation in SST could impact or trigger convection over these regions. Due to stratification higher variation in SST during the post-monsoon season over head of the BoB is observed.
- High variability in MLD can be observed (figure 2(c)), during JJAS over central and western parts of Arabian Sea due to monsoon induced mixing. The vicinity of inter-basin mass transport has evidenced higher values in MLD variations during all the seasons. In OND wind are not that favourable but here due to north easterly winds the BoB have high level of variability. MAM is the season with clam winds so the standard deviation found here is of less value.
- The strongest variations in D20 are observed off Somalia coast region which is subjected to upwelling during south-west monsoon season.

- It is clear from figure 3(a) that most of the regions over north Indian Ocean are confined by negative correlations during all the seasons. The negative correlation between SST and OLR infers that the convection increasing with increase in SST. The relation is strong over the central and head of the BoB during pre and post monsoon seasons, where the fresh water influx has strong role in determining SST.
- In general, increase in MLD should decrease SST and increase OLR and vice-versa. According to the conceptual relation, the MLD-OLR should positively correlated, which is true for the south-west monsoon season. Positive MLD-OLR correlations are observed over western Bay of Bengal and eastern Arabian Sea during the pre-monsoon and post-monsoon period. These regions are also subjected to higher standard deviation values in MLD (*Figure 2(c)*) during post-monsoon season and supporting convection.
- The standard deviation in D20 (*Figure 2(d)*) didn't reported marked variations from season to season in the same way the D20-OLR correlations (*Figure 3(c)*) have not shown significant variations between season to season. The observed correlations are positive over western and central Bay of Bengal, eastern Arabian Sea and south eastern Arabian Sea. The D20-OLR relation is not supportive to the convection

Relation			
	SST	OLR	Convection
OLR			
↑	↓		↓
↓	↑		↑
MLD			
↑	↓	↑	↓
↓	↑	↓	↑
D20			
↑	↑	↓	↑
↓	↓	↑	↓

Table Description: A conceptual view of the linear relation between MLD, D20, SST with OLR (or convection). In general the relation is multi-variant, however here we have assumed the relation as co-variant. ↓ infers decrease in magnitude of the variable and ↑ to denote increase in magnitude of the variable. Hence, the particular oceanic parameter examined here is the only controlling variable on OLR and the effects of rest of the variables is zero. Note that the OLR and convection are inversely proportional to each other.

Summary

- The oceans have prominent role in influencing convection, the dynamics of cloud cover (convection) has key role in precipitation over land.
- As shown above the study is been carried out for Indian ocean region from 0ºN-30ºN to 50ºE-100ºE. Here we considered the entire season with cyclone and non cyclone dates.
- In this study, we have presented the nature of variability of the oceanic parameters viz. SST, MLD, D20 and OLR by examining their standard deviation for the region of north Indian Ocean. We observed OLR is in cope with the seasonal migration of ITCZ.
- The SST over warm-pool has less standard deviation for all the seasons. The head of the Bay of Bengal is showing the highest standard deviation in SST due to fresh water influx.
- High variability in MLD can be observed, during JJAS over central and western parts of Arabian Sea due to monsoon induced mixing.
- The spatial patterns in D20 standard deviation have not reported higher seasonal variations.
- The observed correlations are positive over western and central Bay of Bengal, eastern Arabian Sea and south eastern Arabian Sea. In these regions the MLD-OLR relation is supportive to convection, whereas the D20-OLR relation is not supportive to the convection. Most of these regions are in strong influence of inter-basin mass transport.
- Hence the D20-OLR relation is not supportive to convection over these regions, unlike the MLD-OLR relation which is supportive to convection.
- The SST – OLR relation is very strong during active cyclone period (Figure 3(a), lower panels) during JJAS and post-monsoon periods, the strong negative correlations infers the role of increased SST in decreasing (increasing) OLR (convection). When we suppress the dates of cyclones in computing the correlations, there is not much impact for southwest monsoon and post-monsoon seasons (*Figure 3(a)*, middle panels). However, the pre-monsoon season is showing positive correlations with OLR.
- During the post-monsoon season, the MLD-OLR relation is reduced when we suppress the days with cyclone activity (*Figure 3(b)*, upper and middle panels) over the eastern Arabian Sea and Western Bay of Bengal regions. There is no noticeable alterations in D20-OLR relation when the dates with cyclone activity is suppressed (*Figure 3(c)*).
- With future perspective this will help in studying the cyclogenesis of the cyclones occurring in tropical belt with the help of subsurface parameters.

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