Reply to reviewer 2

We would like to thank the anonymous reviewer for the valuable comments and suggestions. The reply to reviewer's queries are listed below.

My major concern is that I do not understand what the motivation and purpose of the present study is. Neither do I understand what the authors want to convey to the reader.
In the 11 lines of abstract there is no substantial result that is worth reporting. As indicated under general comment the first result is inconsequential as the decreasing trend in surface chlorophyll is not statistically significant. The 2nd result is already known as previous authors have already reported declining trend in the chlorophyll concentration using long term data as well as model simulation

We have tried to address the chlorophyll trend for the period 1998 to 2018 during the Sep-Nov months when IOD is in its mature phase. We found that the chlorophyll trend in the CEAS box shows a decreasing trend that is statistically significant at the 95% confidence level. In the SEAS box, however there no statistically significant trend (Fig. 1). Close to the coast in the SEAS there are regions with positive chlorophyll trends whereas away from the coast chlorophyll mostly shows a decreasing trend. The increased warming trend in the eastern Arabian Sea is a major factor to influence the negative chlorophyll trend in the area CEAS. The chlorophyll concentration close to the coast in the SEAS is greatly influenced by local as well as remotely forced winds. Further studies are needed to ascertain the reasons for the increasing trend of chlorophyll concentration just off the south west coast of India and along the tip of the subcontinent. We have modified the text accordingly in the revised manuscript. We have also modified the abstract appropriately.
We have also addressed the asymmetrical warming in the equatorial Indian Ocean region. The western equatorial Indian ocean region is warming at a rate faster than the eastern equatorial Indian Ocean. The increased warming of the colder western equatorial Indian Ocean (when compared to the eastern equatorial Indian Ocean) may result in the increased frequency of formation of IOD years. This has been reported by Roxy et al. (2014) in their study.

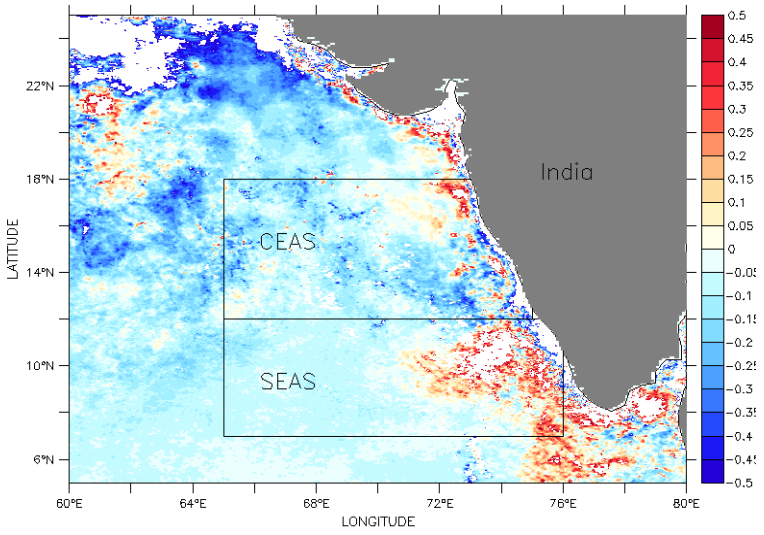

Fig. 1 Chlorophyll trend for the Sep-Nov months durring the period 1981-2018. area 1 (65° E-75° E 12° N-18° N) represents the central eastern Arabian Sea (CEAS), area 2 (65° E-76° E, 7° N-12° N) represents the south eastern Arabian Sea (SEAS).

Why the authors have chosen only 3 tiny boxes close to the coast along the eastern boundary to examine the role of IOD.

We have increased the size of the boxes to extend further off coast and also reduced the number of boxes to 2 in the revised manuscript. The south eastern Arabian Sea is a major upwelling zone and a major source of several commercially important pelagic fish. Any long term changes to the chl-a concentration can adversely affect the pelagic fishery of the region.

October is a transition month from summer monsoon to winter monsoon. What is the rationale in selecting only the month of October for the study? Why not consider the coastal upwelling months of June to September?

We had selected October as it is the month in which the strength of the IOD is maximum. The months Jun-Aug can be considered as the developing phase of the IOD whereas Sep-Nov can be considered as the mature phase of IOD. In the revised manuscript we have used the average of the months Sep-Nov, when IOD is in its mature phase, instead of October for analysis.

What is the role of EICC in bringing about the variability in chlorophyll concentrations?

During fall (Oct-Dec) EICC flows equator-ward and moves around Sri Lanka and brings low saline nutrient rich water into the southeastern Arabian Sea.

How IOD, surface chlorophyll and Kelvin wave is connected? It is not clear from the manuscript.

During a positive IOD anomalous easterlies are seen in the equatorial Indian Ocean. These easterlies forces upwelling Kelvin waves that propagate eastwards. Once these Kelvin waves reach the eastern equatorial Indian Ocean, they bifurcate into two. One part moves northward as a coastally trapped Kelvin wave and propagate along the Bay of Bengal boundary and finally reaches the eastern Arabian Sea thereby influencing the thermocline depth of the region. We have added this in the text of the revised manuscript.

Why study period was restricted to 2014 from 1998, when the chlorophyll data is available until 2018?

We have now extended our study period from 2014 to 2018 in the revised manuscript.

In the study area (2 tiny boxes along the eastern boundary) data on D20 is mostly not available as could be seen from Figs. 8 & 9. In such case how reliable are the inferences that the authors draw based on these diagrams?

The D20 data that we used in this analysis extends only till 2012 and hence in the revised manuscript with extended period, we have not made of this data.

How the asymmetric warming favours formation of more frequent formation of positive IOD?

The western equatorial Indian ocean (WEIO) is warming at a rate higher than that of eastern equatorial Indian Ocean (EEIO) and this results in the modification of the zonal gradient of temperature. The increased warming trend of the WEIO when compared to that of EEIO favors the development of frequent positive IOD years. This has been reported previously by Roxy et al. (2014) in their study.

What is/are the reason/s for the higher warming of the eastern Arabian Sea compared to the western Arabian Sea? This is not explained anywhere in the ms.
Modelling studies by (eg: Decastro et al, 2016; Praveen et al., 2016) have shown that in a global warming scenario, the upwelling along the western Arabian Sea becomes more intense. The increased upwelling off the coast of Africa results in reduced SST trends along the western Arabian Sea. We have now included these points in the revised manuscript.

If the steady declining trend in surface chlorophyll in all the 3 small boxes along the eastern Arabian Sea is statistically insignificant

Now we have replaced the 3 small boxes with 2 larger boxes. In one box (CEAS) the negative trend of surface chla is statistically significant whereas in the other box (SEAS) the chla has marginally increased, though not statistically significant.

What is the purpose of lines 13 to 32 in page 3? It can be deleted as it do not contribute to the theme of the ms.
We have deleted those lines as suggested by the reviewer.

What is "indigenous" IOD (line 19, page 2)
We meant that IOD develops within the Indian Ocean basin.

What is the "marine biological activity"? (line 5, page 4)
It is meant to be "marine biological productivity". We have corrected it in the manuscript.

In equations 3, 4 & 5, the notations for curl, zonal and meridional component of geostrophic current respectively are incorrect.
We have corrected the notations in the revised manuscript.

What is "standardized anomalies"
Standardized anomalies are calculated by dividing anomalies by the climatological standard deviation.

Page 6: The authors cannot brush aside this by simply saying that our nterest is only in positive IOD. The authors need to address "Why Seas chlorophyll anomaly alone showed a negative value while others were positive"
We have now modified the boxes and accordingly the explanations.

Lines 23-25, Page 6: What is the basis for this statement? If it is so why such drivers are not being considered during positive phase of IOD?
We have removed this statement from the revised manuscript.

Line 30, Page 7: How this is possible? During transition the winds over the Arabian Sea is weak and variable
We have rewritten this sentence in the manuscript.

Line 4, Page 8: What is "vertical component"? This is not Ekamn mass transport. Authors may like to consult standard Oceanographic text book.
We have modified the sentence in the revised manuscript.

Lines 22-23, page 8: Upwelling is not the only process that brings about the up-sloping and down-sloping of isotherms. Modify.

We have modified the manuscript.

Lines 5-10, Page 9: I cannot understand what authors wish to communicate? This is well documented by previous authors. How this is relevant in the present context.
We have removed these sentences from the manuscript.

Lines 12-14, page 9: This is ambiguous. Authors need to provide a robust mechanism that unambiguously addresses how WICC would impact change in chlorophyll.

The coastal Kelvin waves generated in the east coast of India drive a poleward coastal current (WICC) along the west coast of India. This current advects low-salinity water to the eastern Arabian Sea and inhibits convective mixing. This inhibition of mixing reduces the entrainment of nutrients into the mixed layer and leads to low chlorophyll concentration. Previous studies (eg: Vijith et al, 2016) have shown how remotely forced coastal Kelvin waves impact the biology in the Arabian Sea.

References:

Roxy, M.K., Ritika, K., Terray, P. and Masson, S., 2014. The curious case of Indian Ocean warming. *Journal of Climate*, *27*(22), pp.8501-8509.

Vijith, V., Vinayachandran, P.N., Thushara, V., Amol, P., Shankar, D. and Anil, A.C., 2016. Consequences of inhibition of mixed-layer deepening by the West India Coastal Current for winter phytoplankton bloom in the northeastern Arabian Sea. *Journal of Geophysical Research: Oceans*, *121*(9), pp.6583-6603.