<u>Reply to reviewer 1</u>
We would like to thank the anonymous reviewer for the valuable comments and suggestions. The reply to reviewer's queries are listed below.

In this context, how your study is different from their study. You need to justify it. Explain the mechanism and processes which lead to the asymmetrical warming, and how it favors the formation of frequent positive IOD years.
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 meant 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.

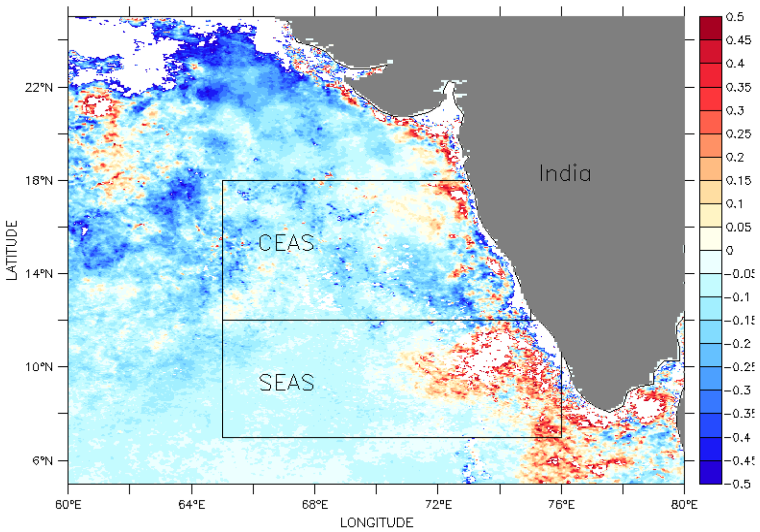

Fig. 1 Chlorophyll trend for the Sep-Nov months durring the period 1981-2018. area 1 (65° E-75° E 12° N-18° N) represents the central eastern Arabian Sea (CEAS), area 2 (65° E-76° E, 7° N-12° N) represents the south eastern Arabian Sea (SEAS).

Abstract P1, line 15: Why you limited your study period up to 2014 when chlorophyll data is available up to the end of 2018 ?
We have now extended our analysis till 2018 making use of OC-CCI chlorophyll data version 4. In the previous manuscript we had used OC-CCI chlorophyll data version 3.1 which does not cover 2018 entirely.

P1, lines 22-15: How you can say that the occurrence of positive IOD years under a global warming regime affect the chlorophylla trend

The DMI index is significantly and negatively correlated with the surface chlorophyll concentration during fall. In the event of occurrence of frequent positive IOD years under a global warming regime, the surface chlorophyll concentration is likely to decrease during fall.

To confirm that find the rate of warming and associated chlorophyll variations when the IOD events are absent and compare it with the period when IOD events are frequent.
We have computed the difference between positive IOD and negative IOD years (left panel Fig. 2) and the difference between positive IOD and IOD neutral years (right panel, Fig. 2). Negative chlorophyll concentration is clearly visible along the entire west coast when compared to that of neutral IOD years. From this figure it is clear that during the positive IOD years when the western equatorial Indian Ocean is warmer than its eastern counterpart chlophyll shows a negative anomaly. This is due to the increased stratification and reduced vertical mixing associated with the increased SSTs (Behrenfeld et al., 2006). Coastally trapped Kelvin waves generated by equatorial wind anomalies also influence the thermocline depth along the west coast of India (Parvathi et al., 2017).

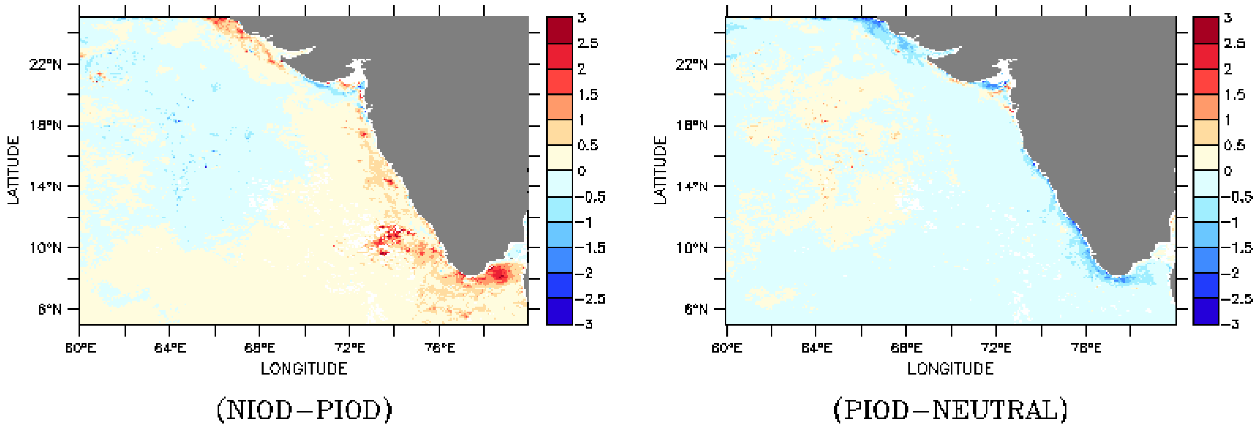

Fig. 2 The difference in chlorophyll concentration for the Sep-Nov months during (left) NIOD-PIOD years and (right) PIOD-neutral IOD years

Data and Methodology You are discussing about IOD and El Nino–Southern Oscillation in the Introduction, but ENSO contribution towards the Chla variability is not addressed in the ms.
We have mentioned that the influence of IOD on the chlorophyll concentration is higher when compared to that of El Nino on the eastern Arabian Sea (Currie et al., 2013). We have not separated out the influence of El Nino and IOD in our study.

Why your study is restricted only up to 2014 ?
We have extended our study till 2018.

P 5, lines 15-23: replace "p" with "rho"
Modified appropriately in the revised manuscript.

Similarly, symbol used for wind curl and geostrophic current is also wrong. Please use correct symbol.
We have now corrected the symbols of wind curl and geostrophic current in the modified manuscript.

Result P5, line 27: What basis you have taken SST trends from 1981 onwards; not before 1981; and why it is restricted up to 2014 when data is available up to the recent year?
Previous studies have reported accelerated warming in the tropical Indian Ocean post the mid-1970s

(eg: Kumar et al., 2009; Trenary and Han, 2008 Saji and Yamagata, 2003). Hence we have chosen the 1980s decade as the first decade for our analysis.

What basis you said that 2012 is the strongest IOD year during the study period. I feel 2006 is the strongest. Cross check it with DMI index.
The reviewer is correct, based on the DMI the 2006 IOD is stronger than the IOD of 2012, we have modified accordingly in the revised manuscript.

P7, line lines 1-2 : Sentence is not correct.
We have removed that sentence.

P8, line 20: Can you show time series of D20 in your boxes ?
Unfortunately the subsurface temperature data used in this analysis extends only 2012 and hence making use of this data is not feasible when the analysis is extended till 2018. So in the revised manuscript we are not making use of this data.

P8, line 10: conductive?
We have replaced that word with the word “favorable” in the modified manuscript.

I think wrongly written Conclusion In your conclusion you have mentioned that asymmetrical warming favoring the formation of frequent positive IOD years. Is it your result ? If so, I have not seen this part discussed elsewhere in the ms. Which is very important.

We meant 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 previously by Roxy et al. (2014) in their study.

Why EAS shows higher warming than the western AS ? Can you show an SST trend of western AS in the same period?
We have analyzed the trend of the SSTs of western Arabian Sea (WAS - 55E-65E, 8N-18N) and eastern Arabian Sea (EAS – 65E-7E, 8N-18N). It was found that the mean SSTs of EAS (28. 56 C) is higher than that of WAS (27.49 C) . The annual average SSTs showed an increasing trend of 0.57 C in the EAS whereas it was 0.46 C in the WAS, during the period 1981 to 2018. This means that the zonal gradient of SSTs has increased in the Arabian Sea during the study period (See Fig. 3 & Fig. 4). 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 becomes more intense. The increased upwelling off the coast of Africa result in reduced SST trends along the western Arabian Sea. (See fig. 4).

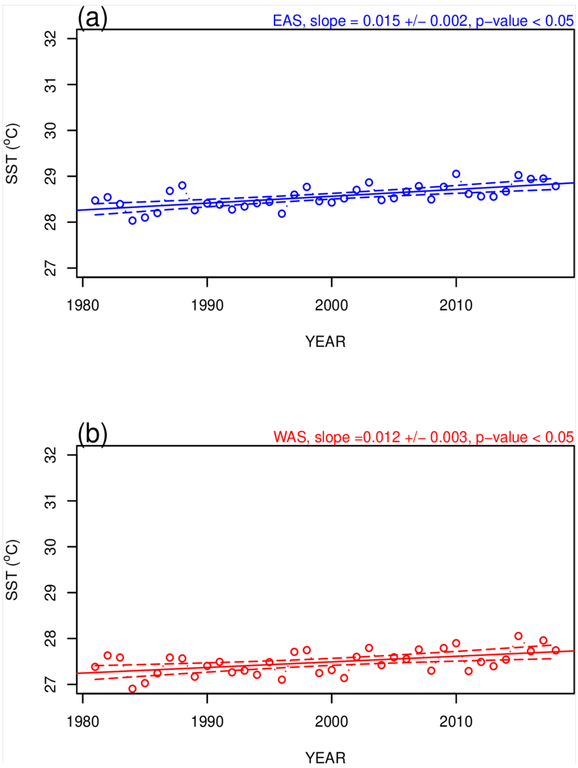

Fig. 3 a) The SST trend in the eastern Arabian Sea area (65E-75E, 8N-18N) and b) SST trend in the western Arabian Sea (55E-65E, 8N-18N) during the study period 1981-2018.

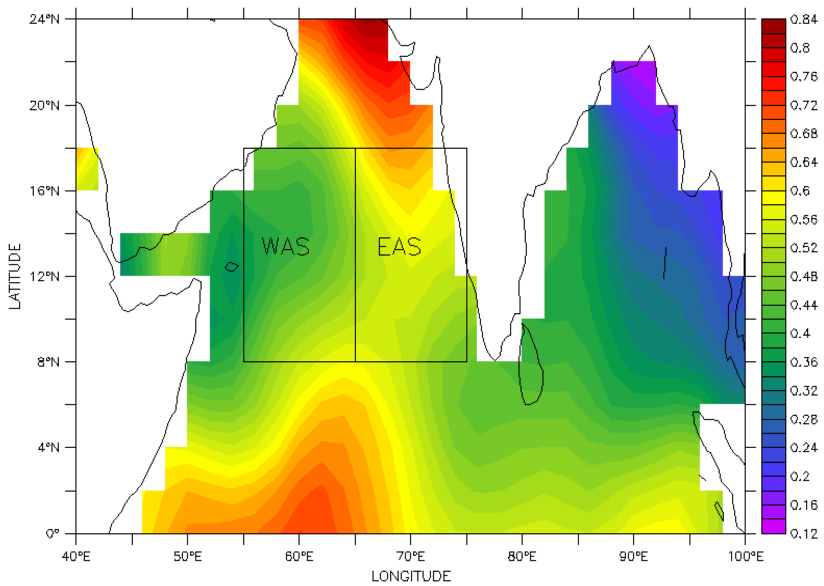

Fig. 4 The map of tropical Indian Ocean highlighting the study area. WAS represents the western Arabian Sea (55° E–75° E , 8° N–18° N, EAS represents the eastern Arabian Sea (65° E–75° E, 8° N–18° N). The annual SST trend (°C) during the period 1981 to 2018 is also shown in the image.

References:

Behrenfeld, M. J., O'Malley, R. T., Siegel, D. A., McClain, C. R., Sarmiento, J. L., Feldman, G. C., Milligan, A. J., Falkowski, P. G., Letelier, R. M. and Boss, E. S.: Climate-driven trends in contemporary ocean productivity, Nature., 444(7120), pp. 752-756, 2006.

Decastro, M., Sousa, M.C., Santos, F., Dias, J.M. and Gómez-Gesteira, M., 2016. How will Somali coastal upwelling evolve under future warming scenarios?. *Scientific reports*, *6*, p.30137.

Kumar, M.R., Krishnan, R., Sankar, S., Unnikrishnan, A.S. and Pai, D.S., 2009. Increasing trend of "break-monsoon" conditions over India—role of ocean–atmosphere processes in the Indian Ocean.*IEEE Geoscience and Remote Sensing Letters*, *6*(2), pp.332-336.

Parvathi, V., Suresh, I., Lengaigne, M., Ethé, C., Vialard, J., Levy, M., Neetu, S., Aumont, O., Resplandy, L., Naik, H. and Naqvi, S.W.A., 2017. Positive Indian Ocean Dipole events prevent anoxia off the west coast of India.

Praveen, V., Ajayamohan, R.S., Valsala, V. and Sandeep, S., 2016. Intensification of upwelling along Oman coast in a warming scenario. *Geophysical Research Letters*, *43*(14), pp.7581-7589.

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.

Saji, N.H. and Yamagata, T., 2003. Structure of SST and surface wind variability during Indian Ocean dipole mode events: COADS observations. *Journal of Climate*, *16*(16), pp.2735-2751.

Trenary, L.L. and Han, W., 2008. Causes of decadal subsurface cooling in the tropical Indian Ocean during 1961–2000. *Geophysical Research Letters*, *35*(17).