We thank Dr. Vinu Valsala for his comments and suggestions on the manuscript. The comments are reproduced in black font and the replies are given in blue below each comment.

This is an excellent and timely review of the Indian Ocean's physical and biogeochemical processes associated with the upwelling zones. There has been a considerable amount of observational and modeling studies in this area and are very well covered in this comprehensive review.

However, the Biogeochemistry about the carbon cycle in the upwelling zones is somewhat found less emphasized despite a considerable number of studies and research has gone into it. These studies are also useful to highlight potential gap areas in the observations of the Indian Ocean carbon cycle, pCO2, and acidification. A few are mentioned below, kindly incorporate them also in this review and synthesis effort.

We completely agree with Dr. Vinu Valsala that items in the above list are important topics. However, they are somewhat beyond the scope of this review. A reviewer has also recommended that the description be focussed on upwelling regions so as to reduce the length of the paper and increase its readability. Nevertheless, we have made our best efforts to include them. Please see replies to specific questions given below:.

Lines-1034:1035: Being 1034 limited with very few studies on carbon dynamics over both east and west coasts, the temporal evolution of surface ocean acidification is still not clear.

Takahahsi et al, (2014) compilation show the clear seasonal cycle of pH in the western Arabian Sea. Further, modeling studies show that the western Arabian Sea has been acidified from a pH of 8.12 (in 1960) to a pH of 8.05 (in 2010). The trend in pH over the western Arabian Sea is due to contributions from dissolved inorganic carbon (DIC) and SST at a value of 109% and 16%, respectively. The effect of alkalinity (ALK) is to buffer the trend in pH by -36% while salinity contribution is only +7%. Collectively, DIC and ALK contribute up to 73% to the net pH trend. SST warming alone contributes another 16%, which is quite alarming considering the intense warming of the western Indian Ocean (Roxy et al., 2016). This calls for the sustained observational efforts required for the Indian Ocean upwelling zones to monitor and model ocean acidification.

We have already cited Takahasi et al (2014) in the sentence previous to this line (i.e., line 1033). Detailed discussion on the factors acidifying the oceans is beyond the scope of this synthesis as our main focus is on ecosystem response. Moreover, our interest is more on coastal upwelling systems while the suggested papers mostly result from the studies conducted in the open ocean. To make this more clear, the term ‘surface ocean acidification’ at lines 1034-1035 will be changed to ‘coastal acidification’.

Lines-1401-1403: Efforts to develop and improve biogeochemical models of the 1401 upwelling systems are also in progress (e.g., Sreeush et al., 2018).

In addition, Sreeush et al., (2020) showed improving biogeochemical models in upwelling zones using inversion of surface observation such as pCO2 and imposed constraints that can cascade through solubility and the biological pump in the upwelling zones to retrieve valuable subsurface ocean parameters such as community compensation depth in models.

Thanks for this suggestion. We have updated the text as follows:

"Recent in-situ observations in the Sumatra-Java upwelling region conducted during the IIOE-2 period indicate different phytoplankton composition and assemblages between upwelling and non-upwelling regions (Gao et al., 2018) and physical and biological processes that determine aragonite saturation state (Xue et al., 2016). Efforts to develop and improve biogeochemical model of the upwelling systems are also in progress (e.g. Sreeush et al., 2018). These researches on biogeochemistry are important to understand key processes operating in the Sumatra-Java upwelling system. However, these results are rather fragmentary at this stage and integrated studies on biophysical interactions, ecosystem dynamics, and marine food web in the Sumatra-Java upwelling region are needed."

Lines-1665:167: biogeochemical modeling results indicate that neither phytoplankton biomass nor carbon export from the euphotic zone changes significantly in response to seasonal and interannual variability of the SCTR thermocline depth (Resplandy et al., 2009)

Lines-1673:1674: Finally, there is still considerable uncertainty in whether the Indian Ocean is a net source or sink of carbon to the atmosphere because the variability in pCO2 fluxes across the air-sea interface is poorly constrained by existing observations, particularly in active upwelling zones like the SCTR

Other studies also highlighted the variability of seasonal and interannual cycles of sea-to-air CO2 fluxes, pCO2 in the upwelling regions of the Indian Ocean. Valsala and Maksyutov (2013) identified that the interannual variability of western Arabian Sea sea-to-air CO2 fluxes and pCO2 are complementarily controlled by ENSO and IOD-related forcing and dynamics. In the south of Sri-Lanka, the interannual variability of the carbon cycle is controlled by variability in wind-induced upwelling dynamics of the dissolved inorganic carbon (Valsala and Maksytov, 2013). The western Arabian Sea is also home to intra-seasonal variability in sea-to-air CO2 fluxes and pCO2 due to the eddy dynamics associated with Great Whirl and Southern Gyre (Valsala and Murtugudde, 2015) as verifiable with limited observations of surface ocean pCO2. More observational efforts are required to understand such fine-scale variability of pCO2 in the Indian Ocean.

Recent studies pointed out that the south Java-Sumatra coast also exhibits interannual variability in sea-to-air CO2 fluxes and pCO2 due to upwelling variability linked to IOD, as identifiable from gap-filled observations using neural networks (Valsala et al., 2020, Lanschutzer al., 2016). The sea-to-air CO_2 fluxes, surface ocean partial pressure of CO_2 (pCO_2), the concentration of dissolved inorganic carbon (DIC), and ocean alkalinity (ALK) range as much as ±1.0 mole m^{-2} yr^{-1}, ±20 µatm, ± 35 µmole kg^{-1}, and ± 22 µmole kg^{-1} within 80^{o}E-105^{o}E, 0-10^{o} S due to IOD. The DIC and ALK are significant drivers of pCO_2 variability associated with IOD. The roles of temperature (T) and biology are found negligible. A relatively warm T and extremely high freshwater forcing make the southeastern tropical Indian Ocean carbon cycle variability submissive to DIC and ALK evolutions in contrast to the tropical eastern Pacific where changes in DIC and T dominate the pCO_2 interannual variability (Valsala et al., 2020).

Thanks for these suggestions. We do agree that these are very important topics. However, We are unable to include details about CO2 fluxes in this paper as this is beyond the scope of this review. Reviewer-2 has also suggested minimizing this section.

Lines-733-736: On the other hand, studies with the help of more complex models, in the last couple of decades, suggest that phytoplankton growth in this region are prone to iron limitation (Wiggert et al., 2006; Wiggert and Murtugudde, 2007) and also likely to be silicate stressed (Kone´ et al., 2009; Resplandy et al., 2011).

Anju et al, (2020) used a 13-component silicate limiting biogeochemistry ecosystem model to study the impact of Silicate limitation in the western Arabian Sea. The new production represents 80% of the total primary production in the AS and implicitly controls 70% of total zooplankton production annually. The regenerated production augments small phytoplankton (by ~50%; e.g., flagellates) and small zooplankton (by ~20%; e.g., ciliates) growth with negligible effects on large phytoplankton (e.g., diatom) and predatory zooplankton (e.g., copepods). The diatom production remains within the observed range due to silicate limitation, which is fundamental in the models for realistic simulation of sub-surface chlorophyll maxima.

Thanks for pointing out the silicate limitation. We have revised the paragraph as follows:

"Observations of the coastally upwelled water off Oman during US JGOFS indicates iron stress with N:Fe ratio ranging between 20,000-30,000 during the early phase of the summer monsoon. Later, this Fe limitation was also confirmed based on in-situ observations off the Oman shelf by Moffett et al. (2007) and Naqvi et al. (2010). Naqvi et al. (2010) further argued that this iron limitation fueled a shift in the phytoplankton communities from diatoms to smaller phytoplankton species which favours vertical export to the offshore deep ocean via lateral advection by the offshore currents (McCreary et al. 2013). In contrast, Rixen et al. (2006), based on sediment transport observations, suggests intense grazing in the silicon-rich near-shore upwelled water limits the diatom bloom off Oman coast. Further, modelling studies based on coupled physical-biogeochemical ocean models, suggests that iron (Wiggert et al., 2006 and Wiggert and Murtugudde, 2007) and silicate (Końe et al., 2009) are the most limiting nutrients that inhibit the growth of diatoms off the coast of Arabia.

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