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Biogeosciences Discussions

Interactive comment on "Intensification and deepening of the Arabian Sea Oxygen Minimum Zone in response to increase in Indian monsoon wind intensity" *by* Zouhair Lachkar et al.

Anonymous Referee #1

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General Comments

This manuscript examines how changes in monsoon winds could impact the ocean ventilation, the biological activity and ultimately the oxygen minimum zone in the Arabian Sea. This work is based on an ocean regional model coupling ocean physics to biogeochemistry. This topic is crucial to our understanding of climate-induced changes in ocean biogeochemistry and the possible impacts for ecosystems and is highly relevant for Biogeosciences. The future of the Arabian Sea's OMZ is still unclear. Available observations of the past decades are too sparse to get a full picture in this region and previous modeling studies either did not capture the main features of this OMZ (coarse

resolution climate models) or did not cover long enough periods to tackle this issue. This study, although idealized in the monsoon wind changes, gives perspective on the changes to be expected in the Arabian Sea.

I really enjoyed reading this manuscript. The approach is sound, the results are clearly presented (figures and text), the authors analyzed extensively the processes at play using numerous sensitivity model experiments and discussed the implications and limitations of their results.

I recommend this manuscript for publication in Biogeosciences. Nevertheless, I have a few comments, mostly about the discussion. In particular, I would like to see the results on the denitrification placed in a broader and global context (comment #1). I also would like to see a slight increment in the discussion on the relative role of NEM vs. SWM (comment #3). Finally, I have a question about the discussion of N2O (comment #2).

Specific Comments

1) P15, P17 and other places in the manuscript: "On the other hand, the changes in the OMZ intensity have the potential - via denitrification - to alter the marine nitrogen budget, and hence the efficiency of the biological pump of carbon and climate, on the longer timescales." "Therefore, the enhanced denitrification in the Arabian Sea has the potential to significantly reduce biological productivity at the basin scale (and beyond) on timescales of decades to centuries."

We usually consider that on long time scales, denitrification and nitrogen fixation compensate each other at the global scale. Water masses where denitrification occurs at depth present an excess in available phosphate. When this excess in phosphate makes it back to the surface it can support nitrogen fixation. Could you please discuss your result in this context? On what temporal and spatial scales is your result pertinent? Do you expect a global compensation of this increase in denitrification on longer timescales? How would this impact your conclusion on biological productivity, locally and globally? You briefly discuss the limitation of not having nitrogen fixation in

your model but my comment here is more general and calls for some discussion and perspectives on how your results fit in the more global climate change context.

2) In P18, you discuss the production of N2O. Based on previous work on O2 and N2O production, could you compute a first order back of the envelope estimate of how much N2O could be produced by your O2 changes? How does that compare to previous estimates and to the global production of N2O in the ocean and out of the ocean?

3) P19: "Here we show that the changes in the SW monsoon winds dominate the response of the Arabian Sea ecosystem and that the changes in the NE monsoon play a relatively smaller role. Therefore, our results validate previous paleo studies that assign the dominant role of OMZ oscillations control to the Indian SW summer monsoon (e.g. Schulz et al., 1998; Altabet et al., 2002)."

You should discuss why the dominance of the SWM is to be expected: 1) the biological production during the SWM dominates the total annual production and 2) in your model NEM winds primarily increase MLD, ventilation and provides O2 to the region, as shown by the higher increase in the suboxic volume in your SWM+/NEM- simulation than in your SWM+/NEM+ simulation (Fig 5).

Technical Corrections

Figure 4: could you make the numbers on panel b more visible.

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