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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 #2

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The authors used a ROMS, which was coupled to an NPZD model to study impacts of changing monsoon winds on the OMZ and the marine nitrogen cycle in the Arabian Sea. The results indicate that changes in the summer monsoon winds exert the main control on productivity, the OMZ and finally the marine nitrogen cycle. Intensification of the summer monsoon winds increases the productivity, expands the OMZ at depth, and increases denitrification, while an enhanced intrusion of oxygen-enriched surface water weakens the intensity of the upper OMZ at water-depth between 100 and 200 m. Since there are indications that the Indian summer monsoon intensifies in response to global warming, the topic addressed within the manuscript is of great relevance. The manuscript is, moreover, well-written. However, the presented model results and

parameterizations of important processes deviate from conclusions drawn from field data. This in addition to some other aspects needs clarification before publication of the manuscript can be recommended.

As stated in the abstract the main conclusion is as follows: 'We show that the Arabian Sea productivity increases and its OMZ expands and deepens in response to monsoon wind intensification. These responses are dominated by the perturbation of the summer monsoon wind, whereas the changes in the winter monsoon wind play a secondary role'. Here it should be mentioned explicitly that winds are generally weak and winter cooling drives productivity during the winter monsoon (e.g. Madhupratap et al. 1996). In its present form it is misleading because it could imply that wind mixing is a dominant factor because it was selected to run the sensitivity experiment. This assumption would furthermore suggest that model results show that the summer monsoon is more important for the productivity as the winter monsoon. The discussion of various paleoceanographic studies shows that warming increases wind speeds, expands the OMZ and increases denitrification. This, furthermore supports the impression that the summer monsoon is the main driver, and the winter monsoon of lower importance. This was not studied in the model and it should also be considered that these paleoceanographic results were obtained by comparing glacial and interglacial periods. During the Holocene a weakening of the summer monsoon strength seems to be accompanied by an intensification the OMZ (see e.g. Rixen et al. 2014) suggesting that ventilation plays a more important role than implied by the model output.

2) The occurrence of the secondary nitrite maximum is generally assumed to indicate active denitrification in the water column of the Arabian Sea (see Naqvi et al. 1991, 1998 and more recently Bulow et al., 2010, Gaye et al. 2013). The secondary nitrite maximum occurs a water depth between 100 and 400 m which implies that denitrification is absence or at least of minor importance in the deeper part of the OMZ. The model results show exactly the opposite as summarized in the abstract: 'The increased productivity and deepening of the OMZ also lead to a strong intensification of denitrifi-

cation at depth, resulting in a substantial amplification of fixed nitrogen depletion in the Arabian Sea'. This needs to be clarified as well as the ignored N-fixation as pointed out by reviewer #1.

3) The parameterization of the carbon export into the deep sea should be described in more detail. Since sinking speeds and respiration rates are provided I assume that a model similar to those introduced by Banse (1990) was used. The considered sinking speeds of 1 and 10 m per day are an order of magnitude lower as those derived from sediment trap studies (see e.g. Berelson, 2001). Please clarify.

4) Among others satellite-derived chlorophyll concentrations were used to validate the model, which to my understanding do not agree well to model outputs. (The months given in Fig. 2 bottom need to be corrected). However, satellite data especially during the summer monsoon are problematic but there are a number of sediment trap data from the Arabian Sea (see e.g. Honjo et al. 1997 and Lee et al. 1997). Considering the importance of carbon export model data should be compared to sediment trap data to make the main conclusions convincing.

5) Considering the overall importance of the selected topic, which will probably attract a wider readership, I recommend to avoid Taylor diagrams and use simple xy scatter plots. They are clear and easy to interpret. Please include also data from the deeper part of the OMZ in the data / model comparison.

6) Moel et al. 2009 is missing in the reference list

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