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Interactive comment on “Impact of global change on coastal hypoxia” by L. Meire et al.

Anonymous Referee #2

Received and published: 10 January 2013

Synopsis

The aforementioned study uses a 1D benthic-pelagic coupled biogeochemical model forced by a 1D $k-\epsilon$ hydrodynamic model to evaluate oxygen and nutrient concentrations in the water column and the first 20 cm of the sediment. The model was calibrated to yr 2007 and, based on future scenario runs from the atmospheric ESSENCE model, simulations were performed over yr 2000-2100. Results reveal that Oyster Ground (North Sea) may become seasonally hypoxic in the latter part of the century, especially if an increase in nutrient input occurs. The study also concludes that the most important factors controlling this oxygen drawdown is the increase in temperature leading to a decrease in the oxygen solubility, an increase in the water stratification, and, to a lesser extent, an increase in the metabolic oxygen consumption of organisms. The manuscript presents the ideas clearly and the model is adequately described. I think that this paper is suitable for biogeosciences, however, I have some comments that

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require addressing.

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Major comments

Hypoxia is extensively discussed in the introduction and mentioned several times throughout the manuscript. Yet, the hypoxic threshold is barely reached during the yearly oxygen minimum at Oyster Ground in the future simulations. This is not so much a criticism of the work but rather the way it is presented. The title itself refers to hypoxia. There is plenty of merit and information in the study and no need to extensively discuss hypoxia when it is only encountered in a very minor portion of the simulations. The allusion toward increasing the "risk of hypoxia" is also a bit of a stretch. A decrease in oxygen concentrations ultimately increases the risk of hypoxia. The manuscript deals with a summer-stratified oxic site, and thus the title should reflect the nature of the site (something in the lines of "investigating the role of future climate forcings on bottom water O₂ dynamics"). If the influence of climate change on hypoxia is indeed the focus of this paper, this site should be compared with a hypoxic (or seasonally hypoxic) site. Perhaps this is meant for future work, but as is, hypoxia should be discussed mainly in the context of the simulations in Figure 11.

The manuscript emphasizes the importance of a decrease in oxygen concentrations due to a decrease in the oxygen saturation concentration resulting from an increase in temperature. While this effect is noteworthy, a 3-4 °C increase in temperature only produces a ca. 5% decrease in the oxygen inventory (Figure 10). This seems to imply that oxygen drawdown due to a change in oxygen saturation is not likely to induce hypoxia, but that other factors are more important.

The benthic-pelagic coupling is an important part of the paper, yet very little is mentioned about the feedback of sedimentary processes on the nutrient and oxygen dynamics in the water column. Are these effects are negligible? Also, no results are shown for the benthic simulations. What is the oxygen penetration depth? What are the trends in nutrient profiles? Do these agree with measured and/or reported data?

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What are the ammonium flux values required to maintain a constant nitrogen pool?

Oyster Ground is located in a specific region within the North Sea and should not be equated to a generic site in the "Central North Sea". It is characterized by muddy sedimentation and influenced by the nutrient-rich south North Sea and English Channel waters. Just northeast of this location, however, within and north of the Dogger Bank, sedimentation, bathymetry, and currents are different. Furthermore, the benthic-pelagic feedback at Oyster Ground should be remarkably different from semi-enclosed shelves (e.g. in the Baltic Sea, Black Sea) where stratification and nutrient release from the sediments may become more important factors in terms of oxygen depletion. Upwelling sites will also be characterized by very different physical and biochemical dynamics. The results from Oyster Ground should thus be placed in the proper environmental context.

An increase in temperature is the major driver of the oxygen drawdown in future scenarios. How does temperature (seasonality) affect the predicted turbulent mixing coefficient? What is the magnitude of this value?

Fig. 10 deserves a more objective interpretation. I understand that the authors do not believe in the plausibility of a 10% increase in the wind intensity over the coming 100 years, but as they have performed the simulations and other studies have predicted an increase in the wind intensity, they should address these results appropriately. It is evident that during winter and spring the oxygen drawdown is not attenuated by an increase in the wind intensity, but in these periods the stratification is minor (Figure 8). Nevertheless, this increased wind intensity greatly reduces the late summer stratification (the time when future hypoxia is predicted to occur). This needs to be discussed in the text.

Specific comments

Page 14892, lines 13-14: "... the coastal zone is affected by the nutrient delivery ..."

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Page 14893, line 4: remove the sentence "Here we use... quantitatively" as it is just repeated in the following sentence.

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Page 14910, line 19: remove "on hypoxia" from the subtitle.

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Page 14910, line 26: remove "still".

Page 14911, line 19: the present situation.

Page 14914, line 24: A "potentially hypoxic area" is extremely vague. Every spot on the earth could be "potentially hypoxic" given the right conditions.

Figure 10: "Artificially induced wind" shows a strong bias. Just like you do not use "artificially induced nutrient loads" for the simulations in Figures 11 and 12 I think you should refrain from such terminology. I suggest changing to 110% wind intensity.

Interactive comment on Biogeosciences Discuss., 9, 14889, 2012.

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