Ocean Sci. Discuss., 8, C776–C784, 2011
www.ocean-sci-discuss.net/8/C776/2011/

Ocean Science Discussions

Interactive comment on "The impacts of physical processes on oxygen variations in the North Sea-Baltic Sea transition zone" *by* L. Jonasson et al.

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Received and published: 18 November 2011

We would like to thank referee 2 for his/her comprehensive review of the manuscript. We have tried to answer all of the comments and have followed most of her/his suggestions to improve the paper.

We have summarized the review report into 12 major points (plus the minor corrections) and answers to these points are given in below.

A complete summarize of all changes (including suggestions from ref. 1) will be submitted together with the updated version of the manuscript.

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1) Unorthodox English style, mixing past and present tenses and proof reading

We do not fully agree with the reviewer's opinion that the Method and Result section must be written in past tenses. However, since the reviewer thinks that the distinction between what is already known and what we did could be made clearer, we will carefully read through the text and try to improve this. Also, we will try to avoid mixed tenses when describing our work. Furthermore, we will correct the language mistakes and carefully polish the manuscript before we submit an updated version.

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2) "In relation to this comment, Section 3.1 and 3.2 are model results. Why are they being presented in the Methods section?"

Section 3.1 and 3.2 are presented in the Model assessment section. We have chosen to separate the model validation and the results of the sensitivity analysis. The reason for this is to reserve the Method and Result section for the process studies.

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3) More information on spin-up, initial coniditions, vertical resolution, simulation periods and wind speed experiments

More information about the model setup, initial condition etc. will be given (see answer 5 to reviewer 1). For the wind speed experiment see answer 7 to reviewer 1.

The simulation periods are:

20020101-20061231 for the validation.

20020101-20041231 for simulation 1 and simulation 2

20020701-20021130 for simulation 3

20040701-20041130 for simulation 4

OSD

8, C776–C784, 2011

A table to summarize all sensitivity experiment is a good idea and it will be added to the revised ms.

There is a mistake in the caption to figure 5

Old caption: “Average spatial variation of the (a) oxygen bias and (b) average error during autumn for the years 2002–2006 (units in μmol l$-$1).”

Corrected caption: “Average spatial variation of the (a) oxygen bias and (b) average error during autumn for the years 2002–2007 (units in μmol l$-$1).”

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4) “What is the justification and criteria for simplifying the biogeochemical model as much as possible (P1726,L5)?

This question corresponds to question 4) from reviewer 1:

In the updated ms we will add a discussion about the motivation for using a simplified model together with a discussion about the model’s limitation.

In short, the motivation for choosing the simplified model is two-fold: 1) That a simple model can resolve the oxygen variations in this region highlights the importance of physical processes 2) The model is simple but sufficient to carry out the designed experimental simulations

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5) “The assumption that constant pools of organic matter are available is in contrast with known dynamics of temperate systems where carbon dynamics are highly seasonal. Moreover, it is well known that respiration is limited by substrate concentration rather than O2”

We agree that this assumption may at first appear a little bit odd and we agree that the production of organic carbon is highly seasonal in the study area as well as in most

OSD

8, C776–C784, 2011

other temperate systems. The assumption is based on the following:

OXYCON is parameterised specifically for the bottom water in the modelled area. The water column is stratified and the concentration of suspended particulate organic carbon (POC) in the bottom water is balanced by an input due to a continuous flux of sinking organic particles from the productive surface layer (0 -15 m) on the one hand, and removal due remineralisation and deposition of POC onto the sediment on the other hand. As the remineralisation rate is assumed to be about 2-3 times higher in summer than in the winter due to the seasonal temperature cycle (Q10 =3 and a seasonal temperature range from 5 -13 °C). In order to maintain a constant concentration of POC in the bottom layer this implies a corresponding increase in the sedimentary input of POC from the surface layer from 150 mg C m-2d-1 in winter to 320 mg C m-2d-1 in summer. This is consistent with the only seasonal study of POC and sedimentation in the area by Olesen and Lundsgaard 1995 showing more or less constant concentrations of about 0.15 μM POC in the bottom water during March - October. The seasonal pattern in the sedimentation rate is also consistent with Olesen and Lundsgaard 1995 showing that the sedimentary flux across the halocline ranged between by 200 mg C m-2d-1 in spring to 400 C m-2d-1 in the late summer.

However, sedimentation of the spring bloom in the study area leads to a distinct seasonal peak in the flux of POC across the halocline and we agree that this contradicts our assumption of constant POC concentration in the bottom water. However, a number of studies indicate that the input of POC is not accompanied by a corresponding increase in the bottom water respiration and as the duration of this phenomenon is relatively short the spring bloom have generally limited effect on the oxygen dynamics. Furthermore, as observed elsewhere the material from the spring bloom sinks faster through the water column than POC during the rest of the year (Olesen 1991, Kiørboe et al. 1994) and therefore the peak in the concentration of POC in the bottom water is not as pronounced as the peak in flux. The degradation of the diatomaceous has recently been studied. About 60% of the diatom biomass of the spring bloom sinks as

OSD
8, C776–C784, 2011

live cells and can be found in the surface sediment one month after the spring bloom (Hansen and Josefson 2001, 2003, Josefson & Hansen 2003). After the sediment deposition the mortality has been estimated to be as low as about 0,007 d-1 (Hansen and Josefson 2003). Furthermore, the diatoms in the sediment survive the gut passage of deposit feeding invertebrates (Hansen and Josefson 2004). These studies shows that the oxygen consumption in the sediment and in the bottom water associated with the sedimentation of spring bloom is much less than suggested by the total amount of material sinking during this relatively short period.

We will therefore claim that even though OXYCON is a very simplified description of the carbon dynamics it is consistent with observations in the literature from this area.

We agree that the remineralization processes is limited by concentration of the labile organic carbon and therefore the oxygen consumption rate in the water column has been parameterized as almost independently of the oxygen concentration (in order to avoid negative oxygen concentration we use saturation kinetics with a very low half saturation constant of ~ 5 μM O2). In contrast, the annual input of organic carbon ($\sim$33 g C m-2y-1) to the sediment is very low compared to the standing pool of organic C in the surface sediment (>1000 g C m-2) and even though most of it is probably refractory there is always organic material present to fuel the benthic respiratory processes. Here the remineralization is limited by diffusive supply of oxygen to the sediment which is limited by the concentration in the bottom water.

The differences in the kinetics for the oxygen consumption in the sediment and in the water column are a very important for determining the spatial and temporal distribution of the oxygen consumption in the area.

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6) That the model error is less then 63umol/l does not mean that the model can simulate hypoxia

OSD

8, C776–C784, 2011

Agreed. See answer 8) to reviewer 1

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7) Why is the spatial validation only carried out during the autumn month?

In the transition zone hypoxia usually occurs in late autumn. During winter and spring the bottom DO is almost fully saturated because of the large supply of oxygen from wind mixing and advective transport, the respiratory sink is negligible compared to the oxygen supply. Even a model with poorly described oxygen dynamics would be able to predict the DO at this time. By only assessing the model in autumn we do not include these “easy modelled month” in the skill scores.

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8) I think the authors should at least comment why the model does not capture the O2 dynamics in Arkona Basin. If this a failure of the physical or biogeochemical model, or both?

We will add two reasons for the low performance in Arkona: 1) The physical model performs better in the Danish Straits than in Arkona Basin. 2) The oxygen model is too simple to completely resolve the oxygen dynamics this region. For instance, coupling between bottom water respiration and primary production and the occurrence of nitrogen fixating cyanobacteria blooms.

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9) O2 looks higher in winter and lower in summer, which is expected due to higher mineralization rates in summer

Sorry for this misleading sentence. What we tried to say is that in the two experimental simulations the DO concentrations is lower in winter and higher in summer compared to the reference simulation.

Old sentence: “As expected the DO concentration is lower in winter and higher in

OSD

8, C776–C784, 2011

summer in both the experimental simulations."

New sentence: "As expected, the seasonal variation is lower in both experimental simulations compared to the reference simulation."

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10) Why assumed? I thought that respiration depends on temperature? If respiration is quasi-fixed, it is little wonder that transport processes account for the inter-annual variability

Old sentence: "The simulated respiration was assumed to be almost constant from year to year and the modelled interannual variation is mainly caused by the physical processes"

New sentence: "Since the simulate respiration depends on temperature and is almost constant from year to year, the modelled interannual variation is mainly caused by the physical processes."

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11) Spatial validation is binned in a 0.5x0.5 box degree resolution. Why is not a finer resolution chosen. The fact that the results also include land area is poor presentation of the data

One could of course have binned the mod-obs pars into finer bins (or larger). We choose this resolution for two reasons: 1) Smaller resolution would create a lot of boxes without observations. It would also be more difficult to overview the figure if it were cluttered with tiny coloured boxes. 2) This resolution is enough to get an idea how the spatial error is distributed.

In the revised ms figure 5 has been modified so that the results only cover water. We agree with the reviewer that this is a better representation of the data. The figure quality has also been improved.

OSD

8, C776–C784, 2011

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12) Why average O2 concentrations over the whole transition zone, rather than compare to the individual stations (fig 4)?

The reason for choosing the average oxygen concentration is that we try to find the dominating processes for the transition zone as a whole. If we only looked at the four stations in fig 4, there is a chance that some of them might not be representative for the average response to the perturbations.

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All minor corrections will be considered in the new version of the ms.

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References

Jørgen L. S. Hansen & Alf B Josefson (2004) Ingestion by deposit feeding macrozoobenthos in the aphotic zone does not affect the pool of live planktonic diatoms in the sediment. J. Exp. Mar. Biol. Ecol., 308: 59-84

Alf B. Josefson & Jørgen L. S. Hansen (2003) Quantifying plant pigments and live diatoms in aphotic sediments of Scandinavian coastal waters confirms a major route in the pelagic-benthic coupling. Mar. Biol., 142: 649-658

Jørgen L. S. Hansen & Alf B Josefson 2003 Accumulation of algal pigments and live planktonic diatoms in aphotic sediments during the spring bloom in the transition zone of the North and Baltic seas. Mar. Ecol. Prog. Ser. 248: 41-54

Jørgen L. S. Hansen & Alf B Josefson (2001) Pools of chlorophyll and live planktonic diatoms in aphotic marine sediment. Mar. Biol., 139: 289-299

Kiørboe, Thomas, Lundsgaard, Claus., Olesen, Michael, Jørgen L. S. Hansen (1994) Aggregation and sedimentation processes during a phytoplankton spring bloom: A field

OSD

8, C776–C784, 2011

experiment to test coagulation theory. J. Mar. Res. 52, 297-323

Olesen, M. & Lundsgaard C. (1995) seasonal sedimentation of Autochthonouos Material from the euphotic zone of a coastal system. Estuar. Cont. Shelf. Res 41: 475-490

Interactive comment on Ocean Sci. Discuss., 8, 1723, 2011.