

Interactive comment on “Nitrogen and carbon dynamics in the Scheldt estuary at the beginning of the 21st century – a modelling study” by A. F. Hofmann et al.

Anonymous Referee #2

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General comments

The paper submitted by Hofmann et al. describes estuarine processes in the Scheldt (Northern Europe) related to carbon, nitrogen and oxygen and introduces a new model to quantify these processes along the river sea-continuum in the present situation. A comparison with situations prevailing in the 70's and 80's is proposed in order to assess the consequences of nitrogen load reduction in the river on the source of nitrogen to the North Sea. In this respect the paper addresses relevant scientific questions since the non-linearity of the processes affecting nitrogen and their multiple dependencies to organic carbon input or oxygen level in the water column makes it difficult to find an

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answer to this important question without a comprehensive modelling effort.

The paper presents a novel tool with a 1D time-averaged model which includes advective-dispersive transport along the river axis with differential volume correction and major biogeochemical processes. The paper does not present new concepts (as most of the processes in the model are known for long like nitrification-denitrification and their dependencies) but helps synthesizing the state of knowledge on this estuary concerning these processes. Substantial conclusions regarding the fate of nitrogen in this estuary are reached: a decrease of denitrification since the 80's which counterbalances reduction of nitrogen load in the Scheldt drainage basin, making the source of nitrogen to the North Sea quite similar today as in the 80's. It must be noticed that similar conclusions were reached in another study published in 2007 (Vanderborght et al., Marine Chemistry, 106, 92-110) with another transport-reaction estuarine model.

The scientific methods and assumptions of this paper are clearly described except the benthic/pelagic nature of biogeochemical processes (see specific comments).

The paper is well written and fully understandable. It is a thick paper (19 printed pages and 35 BGD pages) which should be reduced in size for its final version. Especially the result section should be modified (numbers in Tables, and text easier to read).

Specific comments

The title of the paper does not fully reflect the content of the paper. I would suggest removing the reference to 21st century since I find it misleading. Indeed, when I first received the paper, I thought from the title that the authors were doing projections up to 2020-2030 (which will still be the beginning of the 21st century). In fact they do not cover that time range, and I would suggest simply removing “at the beginning of the 21st century”. I would also introduce in the title the comparison with previous situations in the 70's and 80's as I personally find it a strong point of the paper. A proposed title would be “Present nitrogen and carbon dynamics in the Scheldt estuary using a new 1D model – comparison with historical data from the 1970's and 1980's”.

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The credits to Vanderborcht et al. (2007) which covered a very similar topic with a different model should be increased in the introduction. Indeed, on page 85 (lines 17-24) a better reference to this newly published work (which might have been done in parallel to the present study) and especially to its results should be made. It is not enough to say that a 2D model is fine for seasonal dynamics because the Vandeborcht et al. paper also deals with longer time scale featuring forecast for the 2010 situation. It should be clearly expressed in this paragraph of the introduction what conclusions were reached by this study and how this new work is different.

On page 88 (line 26-27), the authors state that “denitrification, although pelagically modelled, is a proxy for benthic denitrification”. The total (or partial) benthic nature of the processes might be true for several other processes (especially anoxic, sulphate reduction) but also for oxic mineralization which might be located substantially in sediment in these shallow organic rich environments. To me, this represents one of the strongest assumptions of the model and it is not discussed whether it makes a difference to have these processes advected with the water or to have them fixed geographically. I understand that a model coupling sediment and water column is out of reach, but a discussion on the consequence for the results of decoupling advection of the estuarine water and reaction in the sediments for some processes should be made. I therefore require from the authors that they provide such a section in the discussion on pelagic/benthic processes and the way it would affect the conclusions of this study.

On page 88 (line 22-23), the authors present the way they model denitrification. They should insist there on the fact that they model denitrification as a source of both N_2 and NH_3 . It is stated in their biochemical equation Table (#1) but denitrification can be modelled in several ways. In this case, denitrification is a significant source of NH_3 , and the authors should insist on that particular point. This would help explain the large source of NH_3 (as expressed at page 103, line 19).

Concerning the “results” section (pages 100-107), I think it needs a **large rewriting** as all numbers are already put in the Tables 7-11 and are repeated in text which makes the

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reading difficult for this part. Numbers should be kept to Tables and only a presentation of them stated in text.

Section 3.3 (Estuarine budgets): The numbers are clearly written on the graph and should not be repeated in the text. This would make the text easier to read.

Technical corrections

page 84, line 11 : this is a strange sentence, should be changed to consuming more oxygen than oxic mineralization (1.7 Gmol O₂/Y versus 1.4 ...).

page 96, line 2: ionic strengths rather than strengthes

page 109, line 12: The plots in Fig. **12**

page 112, line 1: replace “there are no data to constrain its rate” by “of the lack of direct measurements”.

page 116, line 1: Title of the section 4.4 do not fit with its content. It should contain “comparison with earlier budgets (70’s and 80’s)”

page 116, line 8: Title of the section 4.4.1 Nitrogen (Fig. 15 **and Table 13**)

page 118, line 21: replace “an overestimation” by “a former overestimation”

page 119, line 18: replace “inert” by “neutral”

Summary

The paper is acceptable by the journal after the required changes have been made:

- change the title
- add a paragraph in the discussion on the pelagic/benthic nature of the processes and its consequence on the calculations
- rewrite the whole result section by removing the numbers in text.

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