Biogeosciences Discuss., 5, S12–S16, 2008
www.biogeosciences-discuss.net/5/S12/2008/

Biogeosciences Discussions

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 #1

Received and published: 23 January 2008

Interactive comment on "Nitrogen and carbon dynamics in the Scheldt estuary at the beginning of the 21st century – a modelling study" (www.biogeosciences-discuss.net/5/83/2008/) by A. F. Hofmann, K. Soetaert, and J. J. Middelburg

Hofmann et al. present their modeling results of nitrogen, oxygen and carbon in the highly urbanized Scheldt estuary, which is among those well-studied estuaries in the world. One could expect they will present a clear synthesis on biogeochemical processes in the complicated heterotrophic system. However, I find their presentation to some extent retrogresses from two of their references, i.e., the Vanderborght et al. (2002; 2007) works, especially on the issue of CO_2 outgassing.

They give prominence to a point that their output CO_2 degassing flux is much lower than floating chamber flux measurements such as Frankignoulle et al. This is understandable. The question is, why their result is also much lower than Vanderborght et al. (2002)? The later is also a modeling study and also noticed modeled CO_2 air-water exchange values much smaller than Frankignoulle et al. (1998) whereas similar to Hellings et al. (2001), see their Table 14 for reference. The authors try to attribute the difference to air-water transfer velocities used differently in field measurement and modeling studies. However, the air-water transfer velocity used by Hellings et al. (2001) is actually small and comparable to that used in this work. So, air-water transfer velocity is not a remarkable reason to be directed.

As a mechanistic model with emphasis on CO_2 budget, I think they may overlook some meaningful carbon related processes in the Scheldt estuary:

1. $CaCO_3$ precipitation. Hellings et al. (2001) proposed that $CaCO_3$ precipitation might be the specific process responsible to 8 percent of observed DIC decrease in their Zone 2, i.e., upstream waters of Hofmann et al.'s study. Zhai et al. (2005) also suggested that $CaCO_3$ precipitation need to be investigated so as to answer the question why AOU of 200-350 μmol O_2 kg^{-1} in upstream waters of the Scheldt estuary is at any rate insufficient to support the excess CO_2 of 300-450 μmol kg^{-1} over there (based on Hellings et al. 2001).

2. Other anaerobic processes than denitrification and sulfate reduction. In some anaerobic environments, methanogenesis (CH_2O –> CH_4 + CO_2) might be an important process to support high concentration of excess CO_2 (e.g. Richey et al. 1988). Middelburg et al. (2002) reported highly supersaturation of methane in many European tidal estuaries, including the Scheldt estuary. So, I think methanogenesis should be considered as a potential CO_2 emission process over there.

3. Primary production (PP). Although Hofmann et al. have explained why they don't consider PP (bottom of page 87), I can't agree with them, especially after seeing their

BGD
5, S12–S16, 2008

results of modeling sulfate reduction and denitrification. Factually, they have found that sulfate reduction accounts for <2 percent of NH_4^+ loss and only 2 percent of TCO_2 production and is negligible (pages 103-104). Denitrification also gives a small effect on N budget of only 8 percent (pages 112 and 117). As a comparison, PP in the Scheldt estuary might be one of tenth of the respiration (see bottom of page 87), at the same level of the upper processes. Hellings et al. (2001) reported a significant Chl.a level of about 100 mg m^{-3} in summers of 1997 and 1998 in upstream waters of Hofmann et al.'s study. Gazeau et al. (2005) showed significant planktonic gross primary production in both freshwater end and seawater end based on field measurements. I think, it is understandable at the beginning to assume that PP is negligible. However, after the first run of their model, they should find deficits of their primary assumptions and make necessary revisions. In my opinion, compared with sulfate reduction and denitrification, PP may have more effects on carbon and nitrogen biogeochemistry in the Scheldt estuary, and need to be substantially considered.

In case those revisions might be too hard and the final paper might be too long, I think one of solution for this problem is to focus. The authors claim in their abstract that their aim is to determine nitrogen cycling problems. So, most of carbon related statements and discussions might be unnecessary. If they don't touch carbon too much, their paper will be much easier to be organized and less of uncertainties. In fact, their validation of modeling results is strong for nitrogen and oxygen but weak for carbon. Maybe the title could also be slightly revised so as to focus on nitrogen and oxygen dynamics in the Scheldt estuary.

Another important issue is, the authors must clearly discuss what is really new in their presentation and why it is essential to be published as a research paper. My suggestions are:

1. A good modeling research paper needs forecast and/or synthesis other than result presentation. They should try to bring into play the advantages of this modeling study over those field studies. For example, Vanderborght et al. (2007) ran their model

BGD

5, S12–S16, 2008

on several scenarios to assess the influence of wastewater management policy on the biogeochemistry of the estuary. This is of course one of those interesting issues that modeling is able to work. Another interesting issue of this study is the potential influences of riverine discharge on elemental biogeochemistry in the Scheldt estuary (Fig. 12). How to understand its mechanism? What implication could be extracted for the changing environment of the Scheldt estuary? The authors have a great of space to discuss.

2. They should expand their vision field out of the specific estuary. They should try to find good lessons from their studies, so that the other estuaries could learn much from the Scheldt estuary. A good example is the Pearl River estuary, China. Unlike the Scheldt, the Pearl River is one of largest rivers in the world. Limited but emerging researches have shown that its estuary is also highly urbanized in the upstream waters and charactered with high NH_4^+ and low oxygen and high excess CO_2 (Dai et al., 2006; Zhai et al., 2005), all of which are similar to the Scheldt estuary. It is imaginable that many processes in the Scheldt estuary could also be seen in the Pearl River estuary. So, they could establish the essentiality of their study on the basis of this point.

In summary, I find this presentation needs very substantial revisions before being published as a research paper in BG . As my opinion, at present they only obtain a model and do some calibration and validation. Their wording is pretty good but their science is still ongoing.

References:

Dai, M.H., et al., 2006. Oxygen depletion in the upper reach of the Pearl River estuary during a winter drought. Mar. Chem. 102, 159-169.

Frankignoulle, M., et al., 1998. Carbon dioxide emission from European estuaries. Science 282, 434-436.

Gazeau, F., et al., 2005. Planktonic and whole system metabolism in a nutrient-rich

BGD

5, S12–S16, 2008

estuary (the Scheldt estuary). Estuaries 28, 868-883.

Hellings, L., et al., 2001. Dissolved inorganic carbon in a highly polluted estuary (the Scheldt). Limnol. Oceanogr. 46, 1406-1414.

Middelburg, J.J., et al., 2002. Methane distribution in European tidal estuaries. Biogeochemistry 59, 95-119.

Richey, J.E., et al., 1988. Biogenic gases and the oxidation and reduction of carbon in Amazon River and floodplain waters. Limnol. Oceanogr. 33, 551-561.

Vanderborght, J.-P., et al., 2007. Reactive-transport modelling of C, N, and O_2 in a river-estuarine- coastal zone system: Application to the Scheldt estuary. Mar. Chem. 106, 92-110.

Vanderborght, J. P., et al., 2002. Application of a transport-reaction model to the estimation of biogas fluxes in the Scheldt estuary. Biogeochemistry 59, 207-237.

Zhai, W.D., et al., 2005. High partial pressure of CO_2 and its maintaining mechanism in a subtropical estuary, the Pearl River estuary, China. Mar. Chem. 93, 21-32.

Interactive comment on Biogeosciences Discuss., 5, 83, 2008.