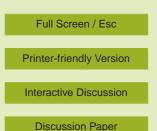**Biogeosciences
Discussions**

Interactive
Comment

Interactive comment on "Enhanced ocean carbon storage from anaerobic alkalinity generation in coastal sediments" *by* H. Thomas et al.

Anonymous Referee #2

Received and published: 27 October 2008

The authors exploit their comprehensive, seasonally resolved data set of the carbonate system in the North Sea that was raised during the period from fall 2001 to summer 2002 to explore the role of benthic processes that contribute to the shelf pump. Here they describe the effect of benthic processes (denitrification and sulphide mineral formation) on alkalinity and on the North Sea's uptake capacity for CO_2, extrapolating to other shelf sea areas.

While I think that the paper is well suited for publication in BG, because it contains relevant information and is interesting to a large community, it needs some additional work to make methods, results, and arguments more clear to the casual reader. I also believe that style (mainly average length of sentences more precise wording) could be improved.

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Interactive Discussion

Discussion Paper

My major problem arose from failing to fully grasp the methods (from page 3578 line 10 ff) even after repeated reading, and as a result I found the results and discussion section difficult to follow; the paper in general struck me as rather inconsistent in its use of terminology. The method of calculation must definitely be better conveyed to the casual reader, and most importantly the information should be complete.

Methods

General: Please give the information in the methods more clearly, possibly in the form of supplementary material.

Formula 1: In the text (page 3578, line 10), DeltaA$_T$ is introduced as the "variability of A$_T$" (alkalinity should always be lower case unless used as a first word in the sentence), but in my reading it should rather be "sum of factors contributing to A$_T$ variability"? If I am correct, each of the deltas is a deviation from some (annual?) average (see also below), and the entire formula stands for something like a box-model of AT fluxes? Where do the data for the atmospheric and river fluxes and water-column nitrate nitrate pool come from (equation 1)? Some of the pertinent information is given in Table 1, but you should give it here. From the Y2-axis label in Figure 2 I gather/assume that the deltas were calculated for 6-week intervals (before and after the measurements?). I found the explanation given for the term deltaA$_T$ (mix) enigmatic and/or incomplete: With "ventilation" (page 3578 line 14), I assume that you mean residence time (water flowing into the box/water in the box) and by delta ATmix accompanying alkalinity transport into the box from an adjacent box? Don't you need an additional box to the North of the SE bight to calculate the outflow term? The dynamics of mixing are quite variable in the seasonal cycle in the SE bight: How do you justify using the gross average of 6 weeks for the residence time at all seasons? Figure 2: The time step here seems to be the 6 weeks, and I can see how you derive the delta estimates for atmosphere and rivers from model data. But how do you estimate the delta(mix) and delta (column) at that time resolution, for which you don't have/did not introduce the data? I must have missed something there, or you need to be more explicit in the way you calculated

these figures.

Results and discussion:

In figure 1, the data plotted are introduced as the "seasonality of alkalinity", and I assume that these are deviations from some reference level – is it the annual average of 4 measurements at each station for each data point of measured data?

Figure 1 does not leave the impression of a relatively homogeneous distribution of A_T with me, and only slowly did it dawn on me that you mean in comparison to DIC (give that range for comparison). Neither did figure 1 impress me much in terms of high spring values of A_T in the SE Bight. You claim that the negative anomaly in the Skagerrak is due to enhanced river outflow (besides Baltic Sea water), but are there significant rivers in the area?

The summer maximum of AT appears to be situated at an odd place if the Wadden Sea is indeed the origin: Firstly, it is too far north and pretty far removed from the mud flats. Secondly, the part of the SE Bight where Figure 1 shows the highest summer A_T anomaly appears to coincide (difficult to see on the figure) with the coastal water mass (below 34 salinity). That coastal water mass is bypassed by the counter-clockwise general flow and is a backwater where residence times are much longer, particularly during summer, and which accumulates river outflow and pools Wadden Sea "emanations". Does that affect your calculations/interpretations? What was the salinity distribution in summer 2001 like? What were inflows/outflows from the adjacent boxes (deltaATmix) for the periods of your seasonal measurements?

3579 line 13: "unravel" is a poor word for what you do: You evaluate the individual contributions of the relevant drivers to the seasonal variability.

Line 19: I don't see the A_T(mix) term in Table 1.

Line 22ff and Table 1: Define new nitrogen, or do you mean "Assimiliation of nitrate"? The mass of "Water column nitrate" in Table 1 appears to not be balanced. How did

you calculate the inventories for 2001-2002 anyway? Does Eq. 1 not need a term for δA_T(mix NO3)?

Page 3580

Line 3: "...can irreversibly generate AT: They yield products....."

line26: "shells that could be dissolved" sounds more logical to me.

Line 28: "would equal more or less....over the annual cycle."

Page 3581, line 24: low pCO2 concentrations not shown

3582, line 7 "permanently mixed" or "under permanently oxic condition"?

Line 11: "..atmosphere. This is in contrast..."

Line 20: I suggest that you give the stoichiometrics of denitrification and sulphate reduction here.

3583, line 6 (Explain or) delete "Revelle factor of 11"

Line 8: atmospheric reactive nitrogen

Line 10: "may therefore constitute an anaerobic pump that is a major...."

Line 15 ff: Significantly more important than CO2-stimulated OM production should be enhanced temperature stratification and subsequent oxygen depletion/decrease in oxygen penetration depths by intensifying/expanding anaerobic processes.

Caption Figure 1: The figures do not show seasonality of alkalinity, but seasonal anomalies relative to an unspecified reference value for each data point. I suggest you mark the sampling locations on at least 1 of the panels. Why do you include the area/volume infos in the caption (should be in the text or in supplement).

Caption Table 1. What do you mean by seasonality of alkalinity in the Southern Bight? That is not what the table is about. How large is δA_T(mix) by comparison with Wadden

Sea fluxes and how large is the uncertainty for that term? If Wadden Sea fluxes are computed as closing term, this is of crucial importance! You refer to it in line 19 of page 3579, but it is not included in the table!

Caption Figure 3: The figures do not show seasonality of pH, but seasonal anomalies relative to an unspecified reference value for each data point.

PS: I read the comments by referee Hofmann only after doing my own review – most of the things I noted here have indeed been pointed out in his excellent review already.

Interactive comment on Biogeosciences Discuss., 5, 3575, 2008.

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