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Impact of alkalinity fluxes on the carbon cycle in the southern North Sea between 1970 and 2006

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Rising atmospheric and oceanic CO_2 concentrations cause an ongoing acidification of the marine environment. pH-variations in coastal- and shelf regions can be up to an order of magnitude higher than in the open ocean. The nearshore effects of acidification are difficult to determine, because of their shallow water column and the tight coupling to the benthic environment. Strong variations in fluxes of Total Alkalinity (TA) exist in association with inflow of nutrients from rivers and from pore water exchange in sediments. TA is an essential part of the carbonate system and hence vital to understand and reliably attribute the observed decreasing pH values. Recent studies in the south-eastern bight of the North Sea, as part of the north-east North Atlantic shelf, reveal increasing TA values from spring to late summer, which buffer the seasonally decreasing pH and also increase the CO_2 buffer capacity.

Studying the TA-variations requires reliable estimations of TA–fluxes. The latter depend on physical, chemical and biological processes. For budgeting TA in the southern North Sea we applied the ecosystem model ECOHAM (Pätsch and Kühn, 2008) with a prognostic treatment of TA and the corresponding TA-fluxes for the years 1970 - 2006. Dissolution of $CaCO_3$, the release of ammonium into the water column and the uptake of nitrate are processes that increase TA. Vice versa, $CaCO_3$ formation, uptake of ammonium and the release of nitrate reduce TA. Additionally, the external sources of nitrate and ammonium are identified as TA-fluxes.

First one-dimensonal model simulations (without riverine input) were carried out to study internal processes in the water column. They showed only small seasonal variations in TA-concentration of about 7 mmol m^{-3}. In a recent study by Thomas et al. (2009) annual TA-export rates were estimated within the North Sea. Based on field data collected in 2001/2002, an annual TA-export of about 190 Gmol from the south-eastern bight into the adjacent North Sea was calculated. About 120 Gmol can be attributed to riverine input of TA and nitrate and in a smaller part to atmospheric nitrate inputs. The remaining 70 Gmol were referred to anaerobic processes in the Wadden Sea.

In our three-dimensional model-study we investigate two different sources of TA, riverine input and atmospheric nitrogen deposition, initially ignoring the Wadden Sea generated TA. We quantify their contributions to TA within the southern North Sea and compare them to internal processes in the water column. We finally address the following questions:

1. Are there noticeable trends in the external sources and how do they contribute to the TA concentration?
2. Do the different TA fluxes react on periods of high eutrophication?
3. How does the carbonate system react on these TA variations and increasing pCO_2?
4. Does our model reproduce reliable TA concentrations within the southern North Sea?
5. Is it necessary to include the Wadden Sea as a source of TA in the model?
6. Is it necessary to include additional TA-contributors like phosphate or sulphate in the model?

References:

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