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Impact of internal and external Alkalinity fluxes on the carbonate system in the German Bight / SE North Sea - A model study for the years 2001 - 2009

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Rising atmospheric CO_2 concentrations may cause enhanced oceanic CO_2 concentrations and thus ongoing acidification of the marine environment. Effects of acidification on the coastal ocean exhibit large variabilities due to shallow water column, tight benthic-pelagic coupling, nutrient cycling, and discharge from land. As a result of enhanced biogeochemical processes, seasonal pH variations in coastal and shelf regions can be up to an order of magnitude higher than in the open ocean and may potentially mask the decadal trend of decreasing pH. Total Alkalinity (TA) is an essential part of the carbonate system as it regulates the oceanic CO_2 buffer capacity. Variations in TA are vital to understand observed pH variations. In the coastal zone variations in TA are particularly pronounced because of diverse external sources like river discharge, anaerobic degradation of organic material or methane fluxes in tidal flats in association with pore water exchange across the sediment-water interface. Beside these external fluxes TA also changes due to physical, chemical and biological processes.

To better understand and quantify the effect of acidification in the southern North Sea as part of the northwest European Shelf we applied the ecosystem model ECOHAM with a prognostic treatment of TA. For the first step we included monthly varying TA and DIC concentrations of the main continental rivers draining to the North Sea. For the Dutch rivers we calculated these data from other parameters of the carbonate system (bicarbonate and pH) that have been measured in the respective estuaries. For the river Elbe we used data of TA and DIC concentrations that have been measured in the estuary. Simulation results reveal that the river contribution to TA flux is insufficient to explain the seasonal variations observed in the German Bight. As high summer concentrations remain unresolved in this model setup, elevated TA concentrations during summer in that area must originate from sources other than the river loads.

In a second step, we considered the Wadden Sea as an additional source and sink for TA and DIC. Exchange rates between North Sea and Wadden Sea were calculated. For this we included differences in measured concentrations during flood and ebb tide in the Wadden Sea and simulated tidal exchange volumes. With this new approach it was possible to reproduce the observed high TA variations and especially the high concentrations in the German Bight in summer. Modelled TA concentrations in different scenarios were 20 to 60 μmol kg^{-1} higher than in previous simulations. The simulated export rates were approximately 40 Gmol yr^{-1}.