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The impacts of eutrophication and biological feedbacks on the variability of the carbon shelf pump in the North Sea from 1970 to 2006

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ECOHAM4, a 3D coupled biogeochemical-physical ecosystem model for the North Sea (511,725 km^2), was used to generate a hindcast from 1970-2006 for the Northwest European Shelf (47° 41‘ – 63° 53’ N, 15° 5’ W – 13° 55’ E) to analyze the carbon budgets and the variability of the transport of atmospheric carbon via biological fixation into the North Atlantic. Together with the lateral advection and the vertical export of carbon, this process is often referred to as the carbon shelf pump. The model treats, partly decoupled, the marine carbon cycle, the nutrient cycles for N, P and Si, oxygen, two phytoplankton and two zooplankton groups as well as marine bacteria and detritus. A set of forcings is included, among others 6-hourly meteorological fields by NCEP reanalysis, annual atmospheric nitrogen deposition (EMEP) and daily riverine input of nutrients and carbon.

The simulated primary production for diatoms varied between 2900 Gmol C yr^{-1} in 1996 and 3650 Gmol C yr^{-1} in 1988 while the primary production of non-diatoms ranged between 5500 Gmol C yr^{-1} and 6000 Gmol C yr^{-1}. Both phytoplankton groups exhibited high production rates in the mid-80s. This corresponds with riverine nutrient input peaking also in the mid-80s. The simulated Net Ecosystem Production (NEP) varied from an unusually low value of 25 Gmol C yr^{-1} in 1996 up to 673 Gmol C yr^{-1} in 2000. A very low winter NAOI and low riverine inputs of nitrogen and DIC coincided with the low NEP in 1996. For the total water column the Northern North Sea could be characterized by a changing positive and negative NEP with strictly positive near-surface values while the Southern North Sea exhibited a positive NEP during the whole period.

In our simulation, the whole North Sea is characterized by an uptake of atmospheric CO_2 ranging from about 430 to 743 Gmol C yr^{-1} during the years. While the Northern North Sea was a sink for atmospheric CO_2 during the whole period, taking up between 470 Gmol C yr^{-1} in 1997 and 715 Gmol C yr^{-1} in 1981, the Southern North Sea showed a higher variability and changed between being a source (e.g. 1976) or a sink (e.g. 1990) for atmospheric CO_2.