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The Effect of Anthropogenic Eutrophication and Climate Warming on Shelves in a Global Coupled Ocean - Biogeochemistry Model

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Shelves have been estimated to account for more than one fifth of the global marine primary production. It has been also conjectured that shelves may account for 20 – 50% of the global net annual uptake of atmospheric CO_2. We here apply a global OGCM coupled to marine carbon cycle and biogeochemistry model to study the response of shelf productivity and carbon uptake to the climate warming projected for the 21st Century. In particular the NW European shelves are investigated for which riverine inputs of dissolved nutrients, DIC, Si, Fe, and suspended matter were implemented using available data provided by the Institute for Oceanography, Hamburg (Paetsch, J., and Lenhart: Daily loads of nutrients, total alkalinity, dissolved inorganic Carbon and dissolved organic Carbon of the European continental rivers for the years 1977-2002, Reports Center for Marine und Climate Research - Series B: Oceanography 2004)

In hindcast simulations for the 20th Century the anthropogenic eutrophication by dissolved phosphate and nitrate caused by intense industrial agriculture stimulated both, the biologival productivity as well as carbon uptake compared to model runs in which these effect was neglected.
In climate projections following SRES Scenarios A1B and A2, however, we find that already a moderate warming of about 2.0 K of the sea surface reduces biological production on the NW European shelf by $\sim$32% or even more if reductions of riverine eutrophication are considered. The decline of shelf productivity is twice as strong as the decline in the open oligotrophic ocean ($\sim$15%). The underlying mechanism is a spatially well confined stratification feedback along the continental shelf break which reduces the nutrient supply from the deep Atlantic by $\sim$50%. In turn, the reduced productivity draws down CO_2 absorption on the NW European shelf by $\sim$34% at the end of the 21st century compared to the end of the 20th century implying a strong weakening of shelf carbon pumping. Sensitivity experiments with diagnostic tracers indicate that not more than 20% of the carbon absorbed on the shelf contributes to the long term carbon uptake of the world ocean whereas the rest remains within the ocean mixed layer where it is exposed to the atmosphere.