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Modelling coccolithophores in the North Sea: Their impact on the carbon budget

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Coccolithophores play an important role in the global marine carbon cycle. They affect the biological pump via primary production and are the most important pelagic calcifiers that contribute to the carbonate counter pump. Their calcification influences the Total Alkalinity and DIC concentration of marine ecosystems and thus the pCO_2 of seawater and uptake capacity of atmospheric CO_2. While calcification is increasing the pCO_2 the primary production and other mechanisms like enhanced vertical export due to combined calcite -organic carbon - agglutination is decreasing pCO_2. To obtain a reasonable carbon budget it has to be determined which effect matters most under different environmental conditions.

Therefore, a coccolithophore module was implemented in the biogeochemical ecosystem model ECOHAM. The implemented calcification was made dependent on light, temperature and the calcite saturation state of seawater (Ω). The model consists of three phytoplankton groups, namely diatoms, coccolithophores and flagellates, two zooplankton groups, bacteria, two detritus fractions, DOM and inorganic nutrients. It resolves the biogeochemical cycles of carbon, nitrogen, phosphorus, silicate and oxygen. To capture the effect of calcification on the carbonate system, Total Alkalinity is computed prognostically. The model was coupled to HAMSOM for the hydrodynamic calculations and applied to the North European Continental Shelf (47° 41‘ – 63° 53’ N, 15° 5’ W – 13° 55’ E).

The focus of our investigations is lying on the carbon budget and especially the air-sea flux of carbon dioxide of the North Sea. Blooms of coccolithophores mainly occur in the deeper and seasonally stratified northern North Sea. This region is characterised as a strong sink for atmospheric carbon dioxide with a mean uptake of 2.12 mol C $yr^{-1}m^{-2}$ during 1970 to 2006 in a former ECOHAM simulation without coccolithophores. The comparison of these results with the corresponding application including the new coccolithophore – module reveals the effects of calcification on the carbonate system, which occur in the range of hours and days, and on the annual carbon budgets. When TEP-building processes including clustering of carbonate and organic carbon are included into the model we see also a significant change in the strength of the carbon pump on longer time scales.