Geophysical Research Abstracts, Vol. 9, 09660, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-09660

How does oceanic acidification affect the biological carbon pump? A model study

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The formation of calcareous skeletons by marine biota in the upper ocean causes a reduction in alkalinity and increases the partial pressure of CO_2. Consequently, calcification by marine planktonic organisms and the subsequent export of calcite shells towards the deep ocean leave the sea surface enriched in CO_2. Therefore, calcification was assumed to counteract the biological soft tissue carbon pump. However, by analyzing sediment trap data Klaas and Archer (2002) found a statistically significant correlation between the export fluxes of particulate organic carbon (POC) and mineral $CaCO_3$ particles. They conclude that most of the POC flux reaching the deep ocean could be accounted for by fast sinking $CaCO_3$ particles acting as mineral ballast. Hence, the existence of biogenic calcification is assumed to be a necessary precondition to sustain the biological carbon pump. Raising atmospheric pCO_2 levels, however, will lead to a gradual acidification of most of the surface ocean. Since biogenic calcification rates will drop under lower pH conditions, the biological carbon pump could become less effective in the future. This describes a positive feedback mechanism between atmospheric pCO_2 levels and the biological carbon pump: higher atmospheric pCO_2 levels will tend to inhibit the biological carbon pump and reduce the oceanic uptake of atmospheric CO_2. Employing the Ocean General Circulation Model MOM-3 coupled to an energy moisture balance model of the atmosphere, which was recently combined with a state of the art marine ecosystem/carbon cycle model and the ballast model by Klaas and Archer (2002), we have quantitatively investigated the possible impacts of reduced calcification rates on the efficiency of the biological carbon pump under growing atmospheric pCO_2 levels from preindustrial times up to 2400AD. Utilizing the IPCC SRES A1FI CO_2 emissions scenario, we will discuss the spatio- temporal pattern of changing biogeochemical variables such as pH, calcifica-

tion rates and biological export production. We also report on the simulated impacts of anthropogenic CO_2 emissions on the large-scale ocean circulation.

Reference: K. Klaas and D. Archer: Association of sinking organic matter with various types of mineral ballast in the deep sea: Implications for the rain ratio, Global Biogeochem. Cycles, 16, 1116, doi:10.1029/2001GB001765, 2002