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Reactive transport modeling of the impact of ocean acidification on global carbon fluxes in coastal marine sediments

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Because of relatively high productivity of both calcifying and non-calcifying phytoplankton in coastal zones, coastal sediments can act as a significant carbon sink. Ocean acidification is likely to impact productivity of these groups differently, raising the question of the overall effect of ocean acidification on carbon burial in coastal sediments. We modeled the effect of varying depositional fluxes of particulate organic carbon (POC) and particulate inorganic carbon (PIC) on carbon cycling in coastal marine sediments using a one-dimensional reactive transport model. Transport processes include sediment burial, advection, diffusion, bioturbation and bioirrigation. The model incorporates the hydrolysis of macromolecular organic matter, the redox pathways of POC oxidation, re-oxidation reactions of the reduced compounds produced during POC decomposition, the acid-base chemical equilibria, and the dissolution of PIC (calcite, aragonite, and Mg-calcite) in the upper 50 cm of sediment. The following processes are also included: precipitation of iron sulfide and iron carbonate, sorption of Fe(II), ammonium and phosphate, sulfidization of organic matter, and pyritization.

The global return fluxes of dissolved inorganic carbon (DIC) and alkalinity are estimated by modeling sediments at 25 m, 75 m, and 150 m depths, and multiplying by the global area of seafloor depths 0-50 m, 50-100 m, and 100-200 m, respectively. We determined the sensitivity of carbon and nutrient return fluxes to changes in pH, PIC and POC fluxes, as well as to poorly constrained Fe(III) deposition fluxes. Inorganic carbon return fluxes are influenced most by the particulate organic and inorganic carbon depositional fluxes; the seawater pH has a limited effect. Modeled sediment pH profiles and PIC dissolution are also sensitive to the iron deposition flux. The overreaching goal of the research is to forecast the global response of coastal sediment return fluxes as a result of anthropogenic ocean acidification.