The role of sea ice in the carbon cycle of polar seas: 1D to 3D modeling

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Sea ice participates actively in the biogeochemical cycle of carbon of polar Oceans, yet to which extent is not clear. We investigated the role of sea ice in polar Seas carbon dynamics through 1D to 3D modelling developments. First, we constrained all major physical and biogeochemical processes with respect to sea ice CO_2 dynamics (carbonate chemistry, biological activity, ikaite precipitation and ocean-ice-air CO_2 fluxes) in a one-dimensional sea ice model. The CO_2 budget in sea ice is driven by the CO_2 uptake during ice growth and release by brine drainage, whereas other processes such as brine-air CO_2 fluxes, despite significant, are secondary. Subsequently, based on these preliminary conclusions, we evaluated the role of sea ice in the carbon dynamics of polar Oceans by using the ocean-ice coupled Global Earth System Model NEMO. Physical processes, i.e. the drainage of DIC (total dissolved inorganic carbon) by sea ice, participates in the export of DIC to the deep waters of the Arctic and Southern Oceans (by, respectively, ~1.8 and 2 Pg C after 500 years) but this contribution is low. Sea ice biogeochemical processes have a large impact on the surface ocean pCO_2 and, thus, on CO_2 fluxes. The sea ice transport determines how sea ice biogeochemistry influences carbon cycling in both polar Oceans. Overall, sea ice biogeochemistry enhances the uptake of CO_2 by the Global Ocean, i.e. by ~1.9 Pg C after 500 years.