EGU24-2611, updated on 08 Dec 2024
https://doi.org/10.5194/egusphere-egu24-2611
EGU General Assembly 2024

Modelling the Impact of Surfactants on Anthropogenic CO_2 Transfer between the Ocean and Atmosphere

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During the industrial revolution, anthropogenic carbon dioxide (CO_2) emissions have rapidly increased, raising worries about their impact on global climate change. The oceans are an important sink of anthropogenic CO_2, taking in about 30% of emissions. Despite the important role of surfactants in reducing gas exchanges between the atmosphere and the ocean, their effect on oceanic intake of CO_2 has received limited attention in ocean models. In this exploratory work, we examine the impact of a parameterization of surfactants on CO_2 fluxes between the ocean and the atmosphere using the NEMO (Nucleus for European Modelling of the Ocean) ocean engine in the ORCA2-LIM-PISCES configuration. Understanding and quantifying the potential effect of surfactants on the ocean's absorption of anthropogenic CO_2 is the main goal of our modelling. Using documented atmospheric CO_2 concentrations from 1750 till present, we carried out three simulations of the intake of anthropogenic CO_2 by the ocean, one in which the presence of surfactants was ignored and two in which different formulations of the impact of surfactants on air-sea gas exchange were used. According to the simulations, the impact of the presence of surfactant on net, basin-scale anthropogenic CO_2 fluxes into the ocean is rather small, on the order of just a few percent. However, in regions where, in the model, the intake of anthropogenic CO_2 is largest, such as the Southern Ocean and the Kuroshio and Gulf Stream region, the reduction in these fluxes can attain between 10% and 40%. On seasonal timescales, the global effect of surfactants is to slightly enhance the amplitude of the annual cycle of fluxes by between 10% and 15%. The presence of surfactants leads to a reduction in the total mass of anthropogenic dissolved inorganic carbon (DIC) in the global ocean by about 6% at the end of the integration. Regionally, the concentrations of anthropogenic DIC in the water column (mass of DIC per unit area) are up to 10% lower in the Southern Ocean and in the northern branch of the Kuroshio when surfactants are present.