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Sensitivity of air-sea CO2-exchange and calcite saturation depth to the remineralization depth of marine particulate organic and inorganic carbon

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The present study addresses the question of what would happen to air-sea CO2 exchange and the depth of the calcite saturation horizon (CSH) if the remineralization depth of particulate organic and inorganic carbon (POC, PIC) was changing. Therefore, a biogeochemical ocean circulation model (PISCES) was run with four different parameterizations for vertical particle fluxes, starting from the same initial conditions. Particle fluxes undergo strong changes induced by a combination of the respective mechanistic formulation of the vertical particle flux and the resulting ecosystem response. Reorganizations in dissolved properties are caused by (i) changed fluxes of POC and PIC; (ii) advection; (iii) air-sea CO2 exchange (DIC). The results show that the more (less) efficient the vertical transport of POC (PIC) from the surface toward depth, the lower the surface ocean pCO2, the higher the air-sea CO2 flux, and the stronger the increase in the oceanic inventory of DIC, and vice versa. Consequently, in one experiment the ocean is turning into a CO2 source to the atmosphere, in two cases it becomes a weak sink and in one simulation it turns into a strong sink. Surprisingly, results for changes in the CSH are more similar among the simulations at larger scale with a general deepening in the North Pacific and a shoaling elsewhere. In most areas the readjustment of the CSH is controlled by DIC and alkalinity acting both towards the simulated CSH shifts, however, in some cases DIC (alkalinity) is overcompensating for an effect that would occur due to changes in alkalinity (DIC), alone. In detail, the differences found between the experiments can be well explained by the respective particle flux responses. The current study shows that reorganizations in the vertical flux of particulate matter in the ocean may have immediate and longer-term effects on the marine carbon cycle which could potentially feedback on the climate system.