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Temperature-dependent remineralization of organic matter – small impacts on the carbon cycle

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The temperature dependence of remineralization of organic matter is regularly mentioned as important but unconstrained factor, with the potential to cause considerable uncertainty in projections of marine export production, carbon sequestration and oceanic carbon uptake. We have recently presented evidence for a temperature dependence of the particulate organic matter (POC) flux to depth, based on a compilation of observations.
Here, we explore the impacts of the new temperature dependence on net primary production, POC flux and oceanic carbon uptake in the ecosystem model COBALT coupled to GFDL's ESM2M Coupled Climate–Carbon Earth System Model. We have implemented two remineralization schemes: COBALT-R1 includes a temperature dependence using parameter values according to our data analysis. COBALT-R1 shows very high remineralization in warm surface waters. The data used to constrain
it, however, comes from colder water below 150m. Colonization of sinking material occurs
throughout the euphotic zone, potentially reducing remineralization in the immediate vicinity of the ocean surface relative to R1 rates [Mislan et al., 2014]. We thus considered a second
model version (COBALT-R2) that decreases remineralization towards the surface but ramped
up remineralization rates to R1 values below 150m.
After 1300 years of spin-up, the effects of the temperature dependence are most visible in the intermediate part of the water column (150 – 1500m), with stronger remineralization in the warmer upper water but weaker remineralization below, such that the carbon flux at 2000m is barely affected. Also, both COBALT-R1 and COBALT–R2 simulate lower POC flux in the low latitudes and higher POC flux in high latitudes compared to the original model version.
In terms of future changes, COBALT-R1 projects an increase in NPP while COBALT-R2 projects a moderate decrease. However, the percentaged decrease in POC flux at 100m is identical in both model versions and the original COBALT, strongly suggesting that the temperature dependence of remineralization has a negligible effect on carbon export at 100m. Likewise, the projected changes in POC flux at 2000m show only moderate differences, resulting in differences in oceanic carbon uptake of at most 0.4 PgC/year at the end of the century. We thus conclude that the temperature dependence of remineralization does only play a moderate role in oceanic carbon uptake.