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The representation of alkalinity and calcium carbonate cycling from CMIP5 to CMIP6 models and the potential influence on carbon cycle projections

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The ocean carbonate pump influences the vertical gradient in ocean carbon content alongside the soft tissue pump. However unlike the soft tissue pump, the production of calcium carbonate, its export and subsequent dissolution are also the primary drivers of the vertical gradient in ocean alkalinity. Often overlooked, alkalinity is a key conservative tracer in the ocean, critical to the uptake of atmospheric carbon in surface waters and the extent of associated acidification. Within the context of model projections of future ocean carbon uptake and potential ecosystem impacts, the representation of the calcium carbonate cycle and alkalinity are a persistent uncertainty. Here we present an assessment, conducted alongside the international ocean biogeochemistry modelling community, reviewing trends in the representation of the calcium carbonate cycle and the associated biogeochemical tracer alkalinity, in the Earth system models involved in CMIP5 and CMIP6. Model representation of calcium carbonate production, sinking, dissolution and sedimentation is highly diverse. No model represents benthic calcification, and none of the CMIP5 and CMIP6 models have an explicit representation of pelagic planktonic calcifiers. Implicit pelagic calcification schemes are highly variable, with models typically representing calcite and not aragonite. In contrast, the representation of $CaCO_3$ sinking and dissolution can be either implicit or explicit and variably includes sensitivity to the local seawater saturation state. Between CMIP5 and CMIP6 there is a clear improvement in the representation of both surface ocean alkalinity and its vertical gradient when compared to observations. This appears to be driven by an increase in the export of calcium carbonate in the CMIP6 ensemble however it is difficult to attribute this increase to specific model developments. Ongoing work is focussing on how the improved representation of ocean alkalinity in CMIP6 may affect model representation of the ocean CO_2 system and projections of future ocean carbon uptake.