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Reevaluating progress and uncertainties associated with projections of ocean net primary production and acidification

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Net primary production (NPP) by marine phytoplankton transfers organic matter and energy to higher tropic levels, supporting ocean food webs, as well as enhancing ocean carbon sequestration. Conversely, ocean acidification is a consequence of anthropogenic carbon uptake and alongside wide-ranging ecosystem impacts, reduces the capacity of the ocean to absorb future anthropogenic emissions. Multi-model projections of NPP (including those of CMIP exercises) have typically had very high associated uncertainty, with model uncertainty generally exceeding scenario uncertainty and limited confidence in even the sign of twenty-first century change. In contrast, projections of acidification have often been portrayed as having almost no associated uncertainty for a given emissions scenario. Here I will reassess these divergent characterizations. Can we say anything about projected changes in ocean NPP with confidence? And do we have any novel insights into projected ocean acidification? Efforts to constrain model projections of NPP have been challenging, with a dramatic increase in global projection uncertainty in CMIP6. Past efforts, which used the observable sensitivity of NPP to ENSO variability to constrain the multi-model NPP response to climate change, have been shown to have their limitations. Notably, parameterizations of marine diazotrophy and phytoplankton iron requirements can both limit the applicability of such emergent constraints. Nonetheless, at regional scales there is often broad agreement across multi-model NPP projections. With respect to acidification, the apparent lack of projection uncertainty is often a result of focusing on the annual mean global surface ocean. Numerous recent advances have been made in understanding regional and subsurface acidification as well as characterizing how the temporal variability of the ocean carbonate system is likely to respond. Particularly notable is the Arctic Ocean, where the amplitude and phasing of the seasonal cycle of CO_2 partial pressure are projected to modify in response to both the geochemical and radiative impacts of anthropogenic emissions.