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Arctic Ocean acidification over the 21st century co-driven by anthropogenic carbon increases and freshening in the CMIP6 model ensemble

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The uptake of anthropogenic carbon (C_{ant}) by the ocean leads to ocean acidification, causing the reduction of pH and the calcium carbonate saturation states of aragonite (Ω_{arag}) and calcite (Ω_{calc}). The Arctic Ocean is particularly vulnerable to ocean acidification due to its naturally low pH and saturation states and due to ongoing freshening and the concurrent reduction in alkalinity in this region. Here, we present projections of C_{ant} and ocean acidification in the Arctic Ocean over the 21st century across Earth System Models (ESMs) from the latest Coupled Model Intercomparison Project Phase 6 (CMIP6). Compared to the previous model generation (CMIP5), the inter-model uncertainty of projected end-of-century Arctic Ocean $\Omega_{arag/calc}$ is reduced by 44–64 %. The strong reduction in projection uncertainties of $\Omega_{arag/calc}$ can be attributed to compensation between C_{ant} uptake and alkalinity reduction in the latest models. Specifically, ESMs with a large increase in Arctic Ocean C_{ant} over the 21st century tend to simulate a relatively weak concurrent freshening and alkalinity reduction, while ESMs with a small increase in C_{ant} simulate a relatively strong freshening and concurrent alkalinity reduction. Although both mechanisms contribute to Arctic Ocean acidification over the 21st century, the increase in C_{ant} remains the dominant driver. Even under the low-emissions shared socioeconomic pathway SSP1-2.6, basin-wide averaged aragonite undersaturation occurs before the end of the century. While under the high-emissions pathway SSP5-8.5, the Arctic Ocean mesopelagic is projected to even become undersaturated with respect to calcite. An emergent constraint, identified in CMIP5, which relates present-day maximum sea surface densities in the Arctic Ocean to the projected end-of-century Arctic Ocean C_{ant} inventory, is found to generally hold in CMIP6. However, a coincident constraint on Arctic declines in $\Omega_{arag/calc}$ is not apparent in the new generation of models. This is due to both the reduction in $\Omega_{arag/calc}$ projection uncertainty and the weaker direct relationship between projected changes in Arctic Ocean C_{ant} and $\Omega_{arag/calc}$. In CMIP6, models generally better simulate maximum sea surface densities in the Arctic Ocean and consequently the transport of C_{ant} into the Arctic Ocean interior, with simulated historical increases in C_{ant} in improved agreement with observational products.