Improving the Representation of Solid Ice Mass Flux From Ice Sheets to Ocean in the Energy Exascale Earth System Model (E3SM)

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Abstract

Icebergs represent approximately half of the mass flux from the Antarctic ice sheet to the ocean, and yet are poorly represented in Earth System Models (ESMs). Calved icebergs transport freshwater away from the coast and exchange heat with the ocean, thereby affecting ocean stratification and circulation, with subsequent indirect thermodynamic effects on the sea ice system. Icebergs also have a direct effect on sea ice through dynamic interaction, as well as dispersing land-sourced nutrients, the effects of which impact marine biogeochemistry. Icebergs typically move in a similar direction as sea ice, although much slower, and hence are an obstacle for the upstream sea ice field. Sea ice ridges behind icebergs, leaving an open lead in front of the iceberg, facilitating increased sea ice production. ESMs typically spread freshwater due to icebergs near the coast at the surface, which causes overly thick coastal sea ice, thereby blocking coastal polynya formation, suppressing ocean overturning, and reducing sub-ice-shelf melting. Conversely, iceberg freshwater fluxes deposited farther offshore and at depth enhance vertical mixing, bringing heat to the surface that locally inhibits sea ice growth. We are developing a parameterization for icebergs in two frameworks, Lagrangian and Eulerian, within the new Energy Exascale Earth System Model (E3SM) being developed at the Department of Energy. The Lagrangian framework will be useful in forecasting trajectories of particular 'giant' (¿10 nautical miles) iceberg events, which may have highly localized impacts on ocean and sea ice, while the Eulerian framework allows us to model a realistic population of Antarctic icebergs without the computational expense of individual particle tracking. The icebergs will be embedded into the sea ice and ocean components, which are based on the unstructured grid framework Model for Prediction Across Scales (MPAS), so as to represent the physical based iceberg processes as well as deposit iceberg fluxes at depth in the ocean. Future work will also couple the iceberg model to the land and land-ice models to model calving fluxes that would otherwise be instantly distributed at the surface of coastal ocean cells, allowing for an end-to-end representation of solid ice mass flux from the ice sheets through the climate system.

References

1. D. Comeau and A.K. Turner and E.C. Hunke. An Eulerian Iceberg Model in the Energy Exascale Earth System Model (E3SM). In preparation.