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Antarctic ice-shelf basal melting in a variable resolution Earth System Model

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The processes that govern freshwater flux from the Antarctic Ice Sheet (AIS)—ice-shelf basal melting and iceberg calving—are generally poorly represented in current Earth System Models (ESMs). The processes governing ocean flows onto the Antarctic continental and into ice-shelf cavities can only be captured accurately at resolutions significantly higher than those in typical CMIP-class ESMs. The Energy Exascale Earth System Model (E3SM) from the US Department of Energy supports regional refinement in all components, allowing global modeling with high resolution in regions of interest. Here, we present fully coupled results from an ocean/sea-ice mesh that has high resolution (12 km) on the Antarctic continental shelf and much of the Southern Ocean and low resolution (~30 to 60 km) over the rest of the globe. E3SM includes Antarctic ice-shelf cavities with fixed geometry and calculates ice-shelf basal melt rates from the heat and freshwater fluxes computed by the ocean component. In addition, E3SM permits prescribed forcing from a climatology of iceberg melt, providing a more realistic representation of these freshwater fluxes than found in many ESMs. With these new capabilities, E3SM version 2 produces realistic and stable ice-shelf basal melt rates across the continent. We show preliminary results of modeled ice-shelf basal melt rates across a range of Antarctic ice-shelves under pre-industrial and historical climate forcing, as well as the impacts of these added capabilities on the region's climate. We show that the use of a mesoscale eddy parameterization, tapered with the mesh resolution, reduces biases even in the 12-km region where some eddies are resolved. The accurate representation of these processes within a coupled ESM is an important step towards reducing uncertainties in projections of the Antarctic response to climate change and Antarctica's contribution to global sea-level rise.