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Exploring and reducing biases in sub-ice-shelf melt rates in an Earth system model

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Sub-ice-shelf melting plays a critical role in the dynamics of the Antarctic Ice Sheet and also feeds back on the regional climate, transforming ocean properties (e.g., affecting deep-water production and sea-ice formation). A full understanding of these processes, as well as the ability to project their response to a changing climate, requires Earth System Models (ESMs) that include coupling with ice-sheet processes. However, biases in regional Antarctic climate can be amplified through sub-ice-shelf melting, and biased melt rates can have significant adverse effects on ice-sheet model initialization and evolution. In preparation for inclusion of dynamic ice sheets in ESMs, this presentation discusses our recent experience in understanding the causes of biases in ocean properties on the Antarctic continental shelf and their relationship to ice-shelf melting. Differences in model behavior across configurations and simulations using the Energy Exascale Earth System Model (E3SM) demonstrates a sensitivity of melt rates to climate. We assess the sensitivity of those melt rates to changes in the region's climate, including freshening on the continental shelf and shoaling of the thermocline. We also show that ice-shelf meltwater feeds back onto the climate, for example, by affecting melting under neighboring ice shelves, sometimes dramatically so. We demonstrate that significant reductions in melt-rate biases can be achieved through modifications to ocean model mixing parameterizations. This work charts a path forward for configuring ESMs to produce realistic Antarctic melt rates.