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Simulating detailed spatial patterns of ice shelf basal melt

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The contact between ice shelves and relatively warm ocean waters causes basal melt, ice shelf thinning, and ultimately ice sheet mass loss. This basal melt, and its dependence on ocean properties, is poorly understood due to an overall lack of direct observations and a difficulty in explicit simulation of the circulation in sub-shelf cavities. In this study, we compare a number of parameterisations and models of increasing complexity, up to a 2D ‘Layer’ model. Each model is aimed at quantifying basal melt rates as a function of offshore temperature and salinity. We test these models in an idealised setting (ISOMIP+) and in a realistic setting for the Amundsen Sea Embayment. All models show a comparable non-linear sensitivity of ice-shelf average basal melt to ocean warming, indicating a positive feedback between melt and circulation. However, the Layer model is the only one which explicitly resolves the flow direction of the buoyant melt plumes, which is primarily governed by rotation and by the basal topography of the ice shelves. At 500m resolution, this model simulates locally enhanced basal melt near the grounding line, in topographical channels, and near the western boundary. The simulated melt patterns for the Amundsen Sea ice shelves are compared to satellite observations of ice shelf thinning and to 3D numerical simulations of the sub-shelf cavity circulation. As detailed melt rates near the grounding line are essential for the stability of ice sheets, spatially realistic melt rates are crucial for future projections of ice sheet dynamics. We conclude that the Layer model can function as a relatively cheap yet realistic model to downscale 3D ocean simulations of ocean properties to sub-kilometer scale basal melt fields to provide detailed forcing fields to ice sheet models.