Sensitivity of Sub-ice-shelf Melting to Changes in Wind, Topographic Features and Surface Heat Fluxes

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Melting in sub-ice-shelf cavities can accelerate the thinning of ice shelves, potentially increasing the discharge of grounded ice into the ocean and resulting in sea level rise. Temporal variability in Antarctic sub-ice-shelf melt rates has been attributed to changes in the wind pattern over the continental shelf slope, with weak easterly winds promoting intrusions of Circumpolar Deep Water through bathymetric troughs. An additional mechanism proposes that changes in surface buoyancy forcing can also control shelf water properties and consequent sub-ice-shelf melting. However, it is not clear which of these mechanisms can affect sub-ice-shelf melting more effectively. Here, we investigate the sensitivity of sub-ice-shelf melting to changes in wind, topographic features and surface heat fluxes using idealized numerical simulations. The experiments are conducted using an isopycnal ocean model (MOM6) coupled with a sea ice model (SIS2) and a thermodynamically active ice shelf. Our results show that sub-ice-shelf melting is mostly sensitive to changes in wind pattern over the continental shelf slope when a topographic trough is present. As the prevailing easterly winds change direction, an undercurrent develops near the upper part of the slope. The interaction of this undercurrent with a topographic trough allows warm waters to penetrate into the sub-ice-shelf cavity, leading to high melting rates near the grounding line. This result is consistent with previous studies that highlight the link between undercurrent strength and wind forcing, with important consequences to sub-ice-shelf melting.

Keywords: ice shelf melting, Antarctica, ocean circulation, undercurrent