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Rapid increase in melt rates of Pine Island Glacier ice shelf during early stages of its retreat

Jan De Rydt, Paul Holland, Pierre Dutrieux, and Adrian Jenkins
British Antarctic Survey, United Kingdom (janryd69@bas.ac.uk)

Observations beneath the floating section of Pine Island Glacier have revealed the presence of a subglacial ridge which rises up to 300m above the surrounding bathymetry. This topographic feature has likely served as a steady grounding line position, and Pine Island Glacier was at least partially grounded on the ridge until the early 1970s. Today the grounding line is situated approximately 40km further upstream, following an ongoing phase of rapid retreat. As a result, a large ocean cavity has formed behind the ridge, strongly controlling the ocean circulation beneath the ice shelf and modulating the ocean water properties that cause melting of the ice shelf in the vicinity of the grounding line. In order to understand how melt rates have changed during various phases of cavity formation, we use a high resolution ocean model to simulate the cavity circulation for a series of synthetic geometries. We show that the gap between the ridge and the bottom of the ice shelf strongly controls the inflow of warm bottom waters into the cavity, and hence influences the melt rates. Model results provide evidence for rapidly increasing melt rates at the onset of ice shelf thinning, but a weak change in melt rates once the gap between the ridge and the ice shelf has passed a threshold value of $\approx$150m. At present the gap is well over 150m, suggesting that observed variability in melt rates is primarily controlled by other factors such as the depth of the thermocline.