

Channelized melting drives thinning under a rapidly melting Antarctic ice shelf

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The majority of meteoric ice that forms in West Antarctica leaves the ice sheet through floating ice shelves, many of which have been thinning substantially over the last 25 years. A significant proportion of ice-shelf thinning has been driven by submarine melting facilitated by increased access of relatively warm ($>0.6^{\circ}\text{C}$) modified Circumpolar Deep Water (CDW) to sub-shelf cavities. Ice shelves play a significant role in stabilising the ice sheet from runaway retreat and regulating its contribution to sea level change. Ice-shelf melting has also been implicated in sustaining high primary productivity (PP) in Antarctica's coastal seas. However, these processes vary regionally and are not fully understood. Under some ice shelves, concentrated melting leads to the formation of inverted channels. The channels may potentially lead to heightened crevassing, which in turn affects ice-shelf stability. Meanwhile, numerical studies suggest that buttressing loss is sensitive to the location of ice removal within an ice-shelf.

Dotson Ice Shelf (DIS) is a 70 km long by 50 km wide ice shelf in the Amundsen Sector of West Antarctica which buttresses Kohler (KG) and Smith Glaciers (SG). In recent decades, KG and SG have exhibited significant thinning and retreat. Between 1994 and 2012, DIS thinned at a constant rate of 2.6 m yr⁻¹, a rate 37% above the Amundsen Sea sector mean, and ice discharge across the grounding line into the ice shelf increased by 180%, 30% above the Amundsen Sea sector mean. The surface ocean in front of DIS is cooled to the surface freezing point in the winter and the upper ocean remains at or near the freezing point year round; but a deep trough traverses the continental shelf, which facilitates CDW access to the sub-shelf cavity, promoting high submarine melt rates. To date only a handful of estimates of melt rates under Dotson have been made and none provide a detailed spatial pattern of melt, and thus offer little capability for assessing the role of channels and small-scale features in defining basal melt concentration. This is important as understanding how Dotson Ice Shelf thins and is melted by the ocean is critical to predicting the future contribution to sea level of the grounded ice draining through Kohler and Smith glaciers.

Here we use high-resolution altimetry measurements from 2010 to 2016 to show that the Dotson Ice Shelf (DIS), West Antarctica, thins in response to basal melting focussed along a single 5 km-wide and 60 km-long channel extending from the ice shelf's grounding zone to its calving front. We show that the coupled effect of geostrophic circulation of CDW in the ice shelf cavity, and ice-shelf topography leads to the observed concentration of basal melting. If focused thinning continues at present rates, the channel will melt through, within 40-50 years, almost two centuries before this is projected from the average thinning rate. Our findings provide evidence of basal melt-driven sub-ice shelf channel formation and its potential for accelerating the weakening of ice shelves.