Along-stream evolution of melt under the Pine Island Glacier ice shelf, West Antarctica

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Thinning ice in West Antarctica, resulting from acceleration in the flow of outlet glaciers, is at present contributing about 10% of the observed rise in global sea level. Pine Island Glacier in particular has shown nearly continuous acceleration and thinning throughout the short observational record. The floating ice shelf that forms where the glacier reaches the coast has been thinning rapidly, driven by changes in ocean heat transport beneath it. However details about the ice-ocean interaction in such dynamical environments remain largely elusive. Here, high resolution space- and air-borne ice surface velocity and digital elevation models are used to estimate melt rates under the ice shelf and the associated dynamical adjustment of the ice flow. At the ice shelf scale, melt rates up to 100 m/yr dominate near the grounding line, tapering down to 10 m/yr 15 km downstream. At smaller scales, a network of sinuous sub-glacial channels originating upstream from the grounding line, typically 500 m to 3 km wide, and up to 300 m high, is coupled with the melt. Melting enhances the sub-glacial channel signatures where the ice goes afloat and diminishes it downstream. Bridging stresses in the ice smooth the surface expression of sub-glacial melt, but near grounding line dynamical adjustments are visible in observations of surface ice velocity where convergences (divergences) coincide with channel crests (keels) as ice columns sink under the melt-induced loss of hydrostatic support.