Sub-annual renewal of a Greenland glacial fjord driven by subglacial fresh water discharge

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Over the past decade Greenland's Jakobshavn Isbræ has accelerated and retreated, delivering ever more ice to the head of the Ilulissat Icefjord and increasing its global sea level contribution. Underlying this acceleration was the arrival in the late 1990's of warm subsurface water at the open ocean outside the fjord. Using novel hydrographic observations from 2009 to 2012, we show that sub-surface waters in the Ilulissat Icefjord have consistently tracked changes outside the fjord mouth. In particular, a temporary reversal to cooler temperatures observed in summer of 2010 shows that the fjord is renewed on a sub-annual timescale, despite the shallow sill at the mouth, which tends to inhibit water exchange. Inland of the fjord, warming air temperatures over the glacier produce supra-glacial meltwater that enters the glacial hydrological system and is widely thought to eventually enter the fjord at depth. We demonstrate with a model that a reasonable flux of fresh-water discharged into the fjord at the glacier's grounding line could drive the observed renewal of deep fjord water on a sub-annual timescale. Such dynamics imply a more complex sensitivity of sill-terminated outlet glaciers as their response to warming ocean waters is tied also to warming air temperatures controlling the amount of sub-glacial discharge of freshwater. Fully quantifying the effect of this type of buoyancy input on heat transport in fjords like Jakobshavn Isbræ and incorporating the associated ice-ocean interaction into global climate models will be critical to sea-level change projections.