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Modelling frontal melt rates on West Greenlandic tidewater glaciers

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Frontal melt has emerged in recent years as a significant component in the mass balance of tidewater glaciers, and has been identified as a precipitating factor in calving events. Frontal melt rates are not widely documented, but significant efforts are currently put into the measurement of this particular process. Here, we present a theoretical model of the convective plume at the glacier front, and derive accompanying melt rates. Validation exercises based on previously published measurements of melt rates yield results consistent with observations.

Using new sets of hydrographic data collected in August 2010, we investigate the melt rates at two adjacent glaciers in West Greenland, Store and Lille Glaciers. We calculate predicted melt rates in the range 1.4–2.0 meters per day in areas of plume flow. Melt rates are highly sensitive to the presence of warm water in the fjord, and we find that an increase in ambient temperature of 1K results in up to 50% increase in melt rate. Sensitivity to increased runoff is smaller, with a doubling of runoff resulting in only a 20% increase in melt rate.

Our results show that frontal melt is a significant contributor to the mass balance of Greenlandic glaciers, and is amenable to numerical modelling, assuming the availability of relevant hydrographic data. We find that both oceanic temperatures and subglacial discharge of meltwater are significant controls on frontal melting, with oceanic factors dominating the melt rates, while subglacial discharge determines the spatial distribution.