EGU2020-9101
https://doi.org/10.5194/egusphere-egu2020-9101
EGU General Assembly 2020

Parameterizing heat and freshwater exchanges driven by subglacial discharge in Greenland's proglacial fjords

Adam Stanway[1], Andrew Wells[1], Helen Johnson[2], and Jeff Ridley[3]
[1]Atmospheric, Oceanic and Planetary Physics, University of Oxford, United Kingdom
[2]Earth Sciences, University of Oxford, United Kingdom
[3]Met Office, United Kingdom

Freshwater flux from the melting of Greenland's Ice Sheet is thought to account for 25% of the observed rise in global mean sea level between 1992 and 2011, with a significant proportion of this associated with increased freshwater flux from marine terminating glaciers within coastal fjords. It has been suggested that increased ocean temperatures have triggered the retreat of Greenland's outlet glaciers, with the melting of submarine glacier termini leading to an acceleration of inland regions of the ice sheet. Global climate models currently operate at resolutions too coarse to resolve ice-ocean interaction on the length scales typical of coastal fjords. Therefore, a parameterization scheme is required to incorporate the relevant physics into such models.

As a first step towards such a parameterisation scheme, we develop theoretical understanding of the first order controls on heat and freshwater exchanges in Greenland's proglacial fjords, guided by computational simulations in MITgcm. Fjords are modelled with idealised geometries, considering cases with and without bathymetric sills. The model parameterises melting at the glacier terminus, and non-hydrostatic flow in one or more buoyant plumes that form from fresh subglacial discharge at the glacier grounding line. We systematically explore how the overturning circulation and heat transport through a fjord respond to varying subglacial discharge.

In a subglacial-discharge dominated regime with flat bathymetry, we find that the horizontally integrated vertical flow structure set by buoyant plumes at the ice face remains unmodified along the length of the fjord, and is independent of the fjord width. For cases with either single or multiple subglacial-discharge plumes, we derive scaling laws for the heat and freshwater exchanges using buoyant plume theory, finding that the water in contact with the ice face mirrors that outside the fjord. This picture is complicated in the presence of a bathymetric sill, which can inhibit the transportation of deep coastal waters into the fjord. We conclude by discussing how our scaling laws might be used as a simple parameterisation of proglacial fjord dynamics in regimes where subglacial discharge controls the flow strength. We discuss how these results might be extended to incorporate the competing effects of circulation driven by along-fjord and along-shelf winds.