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Modelling subglacial hydrology and its effect on calving at a large Greenland outlet glacier

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The structure of subglacial hydrological drainage systems beneath large Greenlandic tidewater glaciers influences ice velocity due to its effect on basal traction, and it may also influence calving by its control on melting at the ice-ocean interface. Understanding these systems is critical to being able to accurately predict the evolution of the Greenland Ice Sheet and the resulting sea-level rise, as the fifteen largest Greenland outlet glaciers are responsible for 77% of the ice sheet's mass loss. In this study, we use numerical modelling and observations of Store Glacier in West Greenland to determine the morphology and dynamics tied to different types of basal hydrology, and we specifically investigate the latter's effect on calving, of which little is known.

Store Glacier in Uummannaq Fjord is the second-largest outlet glacier on the west coast of Greenland, and has been the subject of investigation under the auspices of the RESPONDER project (www.erc-responder.eu), as well as several other studies. As such, its seasonal dynamics are well-characterised and several high-quality datasets exist, making it a suitable target for numerical modelling studies. Its terminus position is currently stable, except a seasonal advance/retreat cycle of a few hundred metres, and has remained so for at least several decades, meaning it is possible to examine the natural behaviour of its subglacial hydrological system and its calving dynamics without having to disentangle the effects from perturbations tied to frontal retreat and acceleration, which have become widespread in Greenland over the last several decades.

Here we investigate the evolution of Store Glacier's subglacial hydrology over the course of a melt season (March to August), with a representative winter scenario for comparison, and how this evolution influences calving, using the open-source, full-Stokes model Elmer/Ice and its GlaDS hydrological module. Preliminary results based on monthly investigations of ice flow and hydrology suggest that efficient channels can extend up to 20 km inland beneath Store Glacier at the height of the melt season (July), with meltwater preferentially exiting from two to three large, plume-forming channel outlet regions of the terminus. Further work will look to improve the coupling between flow and hydrology, and explicitly link this to calving processes, with the ultimate objective of comparing modelled magnitude-frequency distributions of icebergs to observations as a way of validating the model.