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A numerical meltwater-channel evolution model for glaciers

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Meltwater channels form an integral part of a glacier's hydrological system. Their evolution is important to understand meltwater drainage on the surface as well as from the surface to the interior of a glacier. Processes of interest span from seasonal meltwater lubrication of the glacier bed all the way to meltwater drainage from volcanic eruptions within glaciers. Incision of supraglacial stream channels and subsequent roof closure by ice deformation has been proposed in recent literature as a possible englacial conduit formation process. Field evidence for supraglacial stream incision has been found in Svalbard and Nepal. In Iceland, where volcanic activity provides warm ($T > 0$ °C) meltwater, rapid enlargement of supraglacial channels has been observed. I couple a numerical ice dynamic model to a hydraulic model which includes heat transfer to investigate the evolution of supraglacial channels into englacial conduits. Ice deformation is simulated by a finite element model of a Stokes-Glen fluid, often referred to as a full Stokes model. The hydraulics of open channel flow are approximated by the well known Manning formula and a simple heat transfer model from water to ice walls is assumed. I will present model results for different, constant meltwater fluxes which result in different incision depths of the modelled meltwater channel. Temporal variations in meltwater flux lead to another set of results, which form a more realistic representation of seasonal changes in surface meltwater production. A crucial part of the model is the distribution of heat transfer along the ice-water boundary within the channel. Likely distributions stem from well mixed thermal conditions or from temperature gradients in the meltwater and I will show model results for both.