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Subglacial Meltwater Drainage at Paakitsoq, West Greenland: Insights from a Distributed, Physically Based Numerical Model

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Recent studies indicate that surface meltwater is reaching the bed of the Greenland Ice Sheet (GrIS) and modulating glacier sliding rates at the ice sheet margin. However, the hydrological characteristics of this drainage system and the degree to which variations in subglacial water pressure enhance or impede ice flow remain uncertain. As the subglacial hydrological system beneath the GrIS is physically inaccessible and beyond the resolution of geophysical imaging techniques, numerical models are an important tool for investigating the stability of plausible hydrological systems. We present preliminary results of a numerical model that investigates theoretically-constructed hydrological systems of the Paakitsoq region of W. Greenland, north of Jakobshavn Isbrae. Subglacial drainage system structures (the location, alignment and interconnection of major drainage channels) are defined from patterns of subglacial hydrological potential derived from surface and bed DEMs. Discharge and hydraulic head within subglacial channels are modelled using a component of the US EPA Storm Water Management Model (SWMM), modified to allow for enlargement and closure of ice walled channels (Arnold et al., Hydrol. Processes, 12, 1998). We assess the model's ability to deal with two types of input: rapid lake drainage events; and diurnally varying melt inputs calculated from a degree-day model. We perform sensitivity tests to determine the effects of individual model parameters on modelled channel cross-sectional area, water pressure and subglacial flow. Finally, we simulate drainage beneath the ice sheet for a summer melt season and compare the results with measured proglacial stream discharges. Through a recent code modification allowing subglacial water pressures to reach values in excess of ice overburden pressures, we find that consistently high inland subglacial water pressures assist with keeping marginal conduits full and counteract the effects of creep closure, allowing conduits to stay open. Although channelised flow is often assumed to only be possible close to the ice sheet margin where ice is thin and water inputs are large, we show that channelised flow is also possible further inland than expected if inland water pressures are kept consistently high by high rates of recharge to constricted conduit systems.