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Hydraulics within a Greenland Ice Sheet model

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Recent research suggests that the Greenland Ice Sheet (GIS) is losing a substantial volume of ice through dynamic thinning (Rignot and Kanagaratnam, 2006). This process must be taken into account to accurately assess the contribution of the GIS to sea level in response to future warming scenarios. A key control on dynamic thinning is the presence of liquid water at the ice-bed interface; Zwalley et al. (2002) highlight the importance of basal water on ice dynamics, a process now confirmed by Das et al. (2007). Here, we couple a 3D thermodynamic ice sheet model (GLIMMER) with a subglacial hydrology model to investigate the seasonal evolution of subglacial water pressures as driven by basal and surface melt.

The hydrology model solves a diffusion equation over a Cartesian grid where diffusivity is a proxy for the bulk effect of the hydrological configurations, such as a thin film or channels, over appropriate spatial scales. Basal melt can either be prescribed or provided by estimates from the ice body thermal calculations. Surface melt inputs derive from the surface mass-balance scheme and are assumed to penetrate directly to the bed. Model output is the subglacial water pressure and effective pressure distributions which are used to modify the basal traction and thus investigate the dynamic response of ice to hydrology.

Preliminary results are encouraging and show high basal effective pressures where fast ice streams, such as the Jakobshavn Isbræ and Kangerlussuaq, exist. The sensitivity of the system to surface melt inputs is also examined. Future work requires the prescription of different subglacial drainage conditions to determine the sensitivity of the model (and thus the GIS) to the likely seasonal evolution of the subglacial drainage system in response to surface-derived melt-water inputs.