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A numerical glance into subglacial channel evolution

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Hydrological complex systems underneath glaciers and ice sheets have a strong influence on the dynamics of the ice itself, providing strong control on basal sliding. In addition, they produce catastrophic flood risks in the form of subglacial and marginal lakes that demand attention from both regional and national planners.

Even though much progress in the understanding of such hydrological systems has been made in the last four decades, several complex interactions can neither be observed nor reproduced by existing models. In the attempt to advance our understanding of such systems, I present a coupled simulation approach which combines the principal physical processes at play during subglacial hydrological system evolution, fully numerically resolved. Incompressible turbulent flow of meltwater is carried out by large eddy simulation (LES), utilizing the WALE turbulence model to solve the Navier-Stokes equations. Coupled to the flow an entropy based energy conservation approach represents the thermodynamics of the system. Thus being able to fully resolve the wall heat flux for any complex geometry in the hydrological system, phase transition at the boundary walls (wall ice melting) can be incorporated in the simulation. This combined, fully resolved approach allows the simulation to predict evolving ice wall geometries based on the principal governing physics and compute, among other key system parameters, time evolving water flux throughout the model domain.

As an application example, I will present results for the onset of drainage from a subglacial lake forming the initial stage of a jökulhlaup flood. Based on my numerical results, I propose a different heat transfer parametrization to be used in existing jökulhlaup models.