A Fast, Physically Based Subglacial Hydrology Model

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ABSTRACT: In this project, a physically-based basal hydrology model was created using Darcy flow to represent the flow of water in a distributed drainage system and a down gradient solver for water flow is used to simulate channelized flow of water when the conditions for channel flow is met. The Darcy flow is simulated with a robust combination of the Heun and leapfrog-trapezoidal predictor-corrector schemes. The numerical schemes are applied to a set of flux-conserving equations cast over a staggered grid with water thickness at the centres and fluxes defined at the interface. There are several parameters in the basal hydrology model that make it adaptable to various ice sheets such as the till thickness and hydraulic conductivity which will differ for various compositions of bedrock underneath different ice sheets. Since the model is meant to be ran at continental scales and for full glacial cycles, the basal water pressures are limited to ice overburden pressures and a dynamic time-steeping is used to ensure that the maximum basal water velocity is lower than the CFL condition to help prevent any numerical instabilities.

The model is validated by creating a synthetic ice sheet and placing it over different bed topographies such as a inclined plane to test basic water flow properties and to show symmetry in the evolution of the basal water distribution , an inclined plane in a valley to further test water flow properties with a restriction to where the water can flow, a dilating bed to test if the model can form subglacial lakes in the areas of lower hydraulic potential, and a on a flat bed to test mass balance without tunnel flow as the down gradient solver is known to be slightly non-conservative. model validation with the synthetic ice sheet shows that the water behaves as expected with water flowing down gradient where it forms a lake in a potential well or reaches the terminus and exits the ice sheet. Channel formation occur periodically over different sections of the ice sheet and, when sizable enough to distinguish, display an arborescent pathway that is expected of Rothlisberger Channels.

ALL ARE WELCOME!!!