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Ice streams and subglacial lakes – the crucial impact of basal hydrology on ice sheet modeling

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The discovery of many subglacial lakes provides clear evidence for the presence of water beneath the Antarctic ice sheet. Recent observations also indicate interactions between lakes over several hundred kilometers. It is important to understand this widespread subglacial hydrologic network as it is a key parameter with respect to basal lubrication in ice flow modeling and hence, crucial to predict the impact of climate change on sea level rise.

Earlier models already estimated the basal melting and routed subglacial water by applying simple balance flux algorithms, but none was mass conservative on typical mountainous bedrock topographies. They weren't able to model the evolution of subglacial lakes or route water through sinks in the hydraulic potential resulting from bedrock topography and ice pressure.

Here we present a new algorithm balancing the subglacial meltwater, provided by the numerical thermodynamic ice flow model RIMBAY, and routing it iteratively along the hydraulic potential. This new flux algorithm is fully mass conservative. We can estimate the balance of melted water, water stored in subglacial lakes, and basal water, which is routed out of the sub-ice-sheet domain. The amount of fresh-water entering the oceans is of fundamental importance for the ocean circulation, in particular in the Weddell Sea, Antarctica and southern Greenland. Furthermore the water flux is coupled to the basal friction law in the ice model RIMBAY, lubricating the base of the ice sheet and thereby accelerating the overburden ice.

In the present study we thoroughly investigate the impact of the subglacial water flux on the ice flow dynamics in an idealized setup. We are able to model the evolution of subglacial lakes, ice streams and a mass conservative hydrologic basal flux system. The comparison with earlier balance flux algorithms indicates the significance of our advanced incorporation of hydrological processes at the bedrock-ice interface in ice sheet modeling because of considerable impacts on ice volume and dynamics.