Hydrological Modeling of Ice-Sheet Outlet Glaciers

G. E. Flowers and S. Pimentel
Department of Earth Sciences, Simon Fraser University
Burnaby, British Columbia, Canada V5A 1S6
E-mail: gflowers@sfu.ca

Outlet glacier stability is recognized as a key control on ice-sheet mass balance. Observation of the development, drainage and dynamic effects of surface meltwater ponds near the equilibrium line of the Greenland ice sheet and on other polar ice caps has ignited interest in the coupling between surface climatology, englacial/subglacial hydrology and outlet glacier dynamics. Toward a more comprehensive model description of the hydromechanical processes that link surface conditions with basal processes, we present a two-dimensional flowband model of glacier hydraulics intended for coupling with a high-order thermomechanical ice-flow model. Surface meltwater is assumed to be stored primarily in ponds, which drain englacially if stress conditions permit. Water that reaches the bed encounters a dynamic subglacial drainage system, whose capacity evolves in response to water input. The impact of meltwater delivery to the bed therefore depends on the state of the subglacial drainage system and may vary in the presence of a seasonally evolving drainage system. The model is tailored to Belcher Glacier, a large tidewater outlet glacier of the Devon Island ice cap, Arctic Canada. As a polar tidewater glacier featuring the seasonal development and drainage of surface meltwater ponds, Belcher Glacier has much in common with some of the better- known outlet glaciers along the western margin of the Greenland ice sheet. We demonstrate the model behavior under conditions appropriate to ice-sheet outlet glaciers, and attempt to quantify the supraglacial water fluxes required to produce a significant impact on basal dynamics as a function of glacier geometry and thermal structure.