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Numerical Studies of Glacier Surface Evolution above a subglacial Heat Source

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Geothermal and volcanic heat sources beneath glaciers can produce large scale changes in ice flow and surface geometry, as testified by numerous transient to semi-permanent depressions found in ice-covered volcanic regions in Iceland. Such depressions, occurring on the surface of 200-800 m thick ice, are commonly a few hundred to over a thousand metres in diameter and may be 10-200 m deep. In order to explore the interaction of ice geometry, intensity of heat flux and aerial extent of a basal heat source, numerical modeling of ice flow has been applied. A two-dimensional finite element model is used to solve the full system of equations, which consists of conservation of mass, momentum and angular momentum as well as Glen's Flow law as a constitutive equation. Temperate ice is assumed and the heat source at the base is implemented as outflow of ice at the base, representing the commonly encountered case of continuous drainage of meltwater away from the heat source. The model results show the disturbance of the local flow field by a heat source and how surface depressions evolve in response to heat source variations. The model is applied to the study of the post-eruption evolution of the Gjálp eruption site in Vatnajökull, Iceland, where a 200 m deep and 6-8 km wide depression formed in 1996.