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A three-dimensional dynamical model of Amundsenisen icefield, Svalbard

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Amundsenisen is an icefield, 80 km2 in area, located in Southern Spitsbergen, Svalbard. Radio-echo sounding measurements at 20 MHz show high intensity returns from a nearly flat basal reflector at four zones, all of them with ice thickness larger than 500 m. These reflections suggest possible subglacial lakes. To determine whether basal liquid water is compatible with current pressure and temperature conditions, we aim at applying a thermomechanical model with a free boundary at the bed defined as solution of a Stefan problem for the interface ice-subglacial lake. The complexity of the problem suggests the use of a bi-dimensional model, but this requires that well-defined flowlines across the zones with suspected subglacial lakes are available. We define these flowlines from the solution of a three-dimensional dynamical model, and this is the main goal of the present contribution. We apply a three-dimensional full-Stokes model of glacier dynamics to Amundsenisen icefield. We are mostly interested in the plateau zone of the icefield, so we introduce artificial vertical boundaries at the heads of the main outlet glaciers draining Amundsenisen. At these boundaries we set velocity boundary conditions. Velocities near the centres of the heads of the outlets are known from experimental measurements. The velocities at depth are calculated according to a SIA velocity-depth profile, and those at the rest of the transverse section are computed following Nye's (1952) model. We select as southeastern boundary of the model domain an ice divide, where we set boundary conditions of zero horizontal velocities and zero vertical shear stresses. The upper boundary is a traction-free boundary. For the basal boundary conditions, on the zones of suspected subglacial lakes we set free-slip boundary conditions, while for the rest of the basal boundary we use a friction law linking the sliding velocity to the basal shear stress, in such a way that, contrary to the shallow ice approximation, the basal shear stress is not equal to the basal driving stress but rather part of the solution.