The role of subglacial drainage and basal freeze-on for ice streams

Marianne Haseloff, Christian Schoof

The Siple Coast ice streams are major discharge routes for ice in the West Antarctic. Observations suggest that their fast flow is due to sliding along a water-saturated bed, with variations in velocities and ice stream width on decadal to centennial time scales. These variations include the migration of ice stream margins, where the fast flow slows down to the speed of the surrounding ice, which in contrast appears to be frozen to the underlying bed.

Using a coupled ice-sediment model we investigate the roles of basal freeze-on, subglacial drainage, and feedbacks between fast flow and heat dissipation for ice-stream evolution. The ice is modeled as a vertically uniform plug flow. The sediment model allows for lateral motion of melt water in the sediment and changes in the thickness of the water-saturated sediment layer due to melting and freezing processes. Dynamical feedbacks in the energy balance include both frictional heating along the bed and lateral shear heating.

We study the evolution and possible steady states of ice streams, which are typically reached on timescales of several hundreds of years. We find that no steady-state ice stream configurations are possible in the absence of subglacial drainage. Moreover, the bed outside of the fast flowing region will eventually freeze onto the ice, which prohibits outward migration of ice stream margins due to subglacial drainage. Possible steady state configurations are investigated in detail.

Hence, subglacial drainage must play an important role for ice stream behaviour, but drainage-driven margin migration is possible to a limited extent only, as the margin is believed to coincide with the boundary between a frozen and temperate bed.