

Modelling the evolution of ice streams

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The evolution of the West Antarctic ice sheet has been identified by many authors as a key unknown in future sea-level change. The vast majority (> 90%) of mass lost from the ice sheet flows through a relatively small number of ice streams. An understanding of the long-term behaviour of these ice streams is therefore vital if we are to predict future sea level accurately. Here we use a numerical model of a generic ice stream to investigate the coupled evolution of ice-stream flow, temperature and form, with the particular aim of identifying internal sources of variability within this system.

The model comprises three main components. These are a first-order model of the stress regime (incorporating all stress components in the horizontal force balances but assuming that the vertical stress balance is hydrostatic) within the ice stream and adjoining slow-flowing ice; the temporal evolution of the internal temperature structure of the ice mass incorporating dissipation, diffusion and advection; and effects of the changing flow field on the geometry of the ice mass (thickness evolution).

We employ the model to investigate the equilibrium thermal regime of a generic Siple Coast ice stream. Using the range of temperature and stress parameters appropriate to the Siple Coast, we find that a generic ice stream cannot sustain a wet bed at equilibrium. The presence of ice streams along the Siple Coast can be reconciled with this result in one of three ways. First, a net influx of basal water from upstream buffers the basal thermal regime. Second, the ice streams are currently in the active phase of surge cycles and will eventually stagnate. Third, the existence of ice streams is a temporary phase through which the ice sheet is passing perhaps as a consequence of decay from the Last Glacial Maximum.