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Identifying Antarctic Ice Sheet Tipping Points

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Warmer atmospheric and oceanic temperatures have led to a six-fold increase in mass loss from Antarctica in the last four decades. It is difficult to predict how the ice sheet will respond to future warming because it is subject to positive feedback mechanisms, which could lead to destabilisation. Observational and modelling work has shown that ice streams in West Antarctica may be undergoing unstable and possibly irreversible retreat due to increased basal melting beneath their ice shelves. Being able to identify and predict stability thresholds in ice streams draining the Antarctic Ice Sheet could help establish early warning indicators of near-future abrupt changes in sea level.

Here, we use the shallow-ice flow model Úa to investigate the stability of an idealised ice stream from the third Marine Ice Sheet Model Intercomparison Project (MISMIP+). Initial results show that a gradual variation in ice viscosity, which corresponds to a change in temperature, causes the ice stream to undergo hysteresis across an overdeepened bed. This hysteresis means there are two tipping points, one for an advance phase and one for a retreat phase, both of which lie off the retrograde sloping bedrock. Beyond these tipping points, changes in ice stream grounding line position are unstable and irreversible. This behaviour is also apparent in wider ice streams although there is a change to the onset of instability and the location of tipping points. Further studies will investigate the additional effects of basal melting on these tipping points.