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Susceptibility of the Antarctic ice sheet to changes in ice shelf buttressing

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Higher surface air temperatures over the Antarctic Peninsula are hypothesised to have caused melt-pond formation, destabilisation and sudden disintegration of the Larsen B ice shelf in 2002. The almost total removal of the shelf resulted in an acceleration of the extant glacier fronts, upstream thinning and unabated ice loss up to this day. Similar thinning is observed for Thwaites and Pine Island Glaciers in the Amundsen Sea sector, but here, ocean warming is suspected for enhancing the shelf melting. In both cases, shelf geometries were altered in a way that upstream buttressing was reduced, an explanation for the observed accelerations. Since more than half of all Antarctic glaciers extend into floating shelves and since most of them showed no significant accelerations in the recent past, it remains unclear how susceptible the upstream ice sheet is to geometric changes of the corresponding shelves under further warming in the future.

In this context, we aim at quantifying the dynamic susceptibility using ice geometry and surface velocities inferred from observations. To obtain the stress distribution near the grounding line, the shelf viscosity field is determined using a variational inverse method that optimises the mismatch between observed and modelled surface velocities. This allows us to compute a buttressing factor along the grounding line. Using this factor as one criterion, we succeed to a priori discern the segments of the grounding line in the Amundsen Sea sector that, in fact, retreated by now. An abrupt drop-off in buttressing across the main trunk of Thwaites Glacier can explain its asymmetric retreat pattern. Moreover, other regions in this sector are recognised as susceptible to further loss of shelf buttressing, where, for now, perturbations remain too weak for a distinct migration of the grounding line. With the chosen criteria, we are able to localise the regions that are prone to changes in the downstream shelves. This identification enables us to classifying each Antarctic glacier and ice stream according to the retreat susceptibility.