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Competing processes for Antarctica's ice discharge: Reduced buttressing versus elevation change

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A major difficulty encountered in estimating future sea-level rise is the potentially changing dynamic contribution from the Antarctic Ice Sheet. One of the most critical factors determining the Antarctic mass budget, if not the decisive one, is the melting below ice shelves which influences the ice flow across the grounding line. Recent observations (e.g. Pritchard et al., 2012) and model simulations (e.g. Bindschadler et al., 2013) show that subshelf melting induced by a warming ocean caused additional ice flow across the grounding line and dominated the sea-level contribution from Antarctica in the past decades.

The physical link between enhanced basal melt and accelerated ice loss has however not been fully understood, much less quantified: On the one hand, the buttressing effect due to friction of the ice shelf at the bedrock, which slows down the ice flow of the inland ice, weakens when the ice shelf melts from underneath. On the other hand, ice shelf thinning occurs mainly near the grounding line. This steepens the surface gradient at the grounding line, and thus increases the driving stress. Both, reduced buttressing and the elevation change therefore result in increased ice flow across the grounding line but it is unclear which of these effects dominates the ice-sheet response.

Here, we assess the influence of both effects based on simulations with the Parallel Ice-Sheet Model (Bueler and Brown, 2009; Winkelmann et al., 2011). In a simplified setup (MISMIP-3D, Pattyn et al., 2013; Gudmundsson et al., 2012), we systematically analyse the importance of various parameters, e.g. the geometry of the bay, the topography of the ice shelf as well as temperature and salinity of the ocean water. In our experiments, we compare the separate and combined effects of reduced buttressing and the surface gradient change to assess which of them dominates the response of Antarctica to potential future ocean warming.