EGU22-6634
https://doi.org/10.5194/egusphere-egu22-6634
EGU General Assembly 2022

Shear-margin melting causes stronger transient ice discharge than ice-stream melting according to idealized simulations

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Basal ice-shelf melting is the key driver of Antarctica's increasing sea-level contribution. In diminishing the buttressing force of the ice shelves that fringe the ice sheet the melting increases the solid-ice discharge into the ocean. Here we contrast the influence of basal melting in two different ice-shelf regions on the time-dependent response of an idealized, inherently buttressed ice-sheet-shelf system. Carrying out three-dimensional numerical simulations, the basal-melt perturbations are applied close to the grounding line in the ice-shelf's 1) ice-stream region, where the ice shelf is fed by the fastest ice masses that stream through the upstream bed trough and 2) shear margins, where the ice flow is slower. The results show that melting below one or both of the shear margins can cause a decadal to centennial increase in ice discharge that is more than twice as large compared to a similar perturbation in the ice-stream region. We attribute this to the fact that melt-induced ice-shelf thinning in the central grounding-line region is attenuated very effectively by the fast flow of the central ice stream. In contrast, the much slower ice dynamics in the lateral shear margins of the ice shelf facilitate sustained ice-shelf thinning and thereby foster buttressing reduction. Regardless of the melt location, a higher melt concentration toward the grounding line generally goes along with a stronger response. Our results highlight the vulnerability of outlet glaciers to basal melting in stagnant, buttressing-relevant ice-shelf regions, a mechanism that may gain importance under future global warming.