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Coupled ice shelf-ocean modeling and complex grounding line retreat for Pine Island Glacier

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Recent observations and modeling work have shown a complex mechanical coupling between Antarctica's floating ice shelves and the adjacent grounded ice sheet. A prime example is Pine Island Glacier, West Antarctica, which has a strong negative mass balance caused by a recent increase in ocean-induced melting of its ice shelf. The mass loss coincides with the retreat of the grounding line from a seabed ridge, on which it was at least partly grounded until the 1970s. At present, it is unclear what has caused the onset of this retreat, and how feedback mechanisms between the ocean and iceshelf geometry have influenced the ice dynamics. To address these questions, we present results from an offline coupling between a state-of-the-art shallow-ice flow model with grounding line resolving capabilities, and a three-dimensional ocean general circulation model with a static implementation of the ice shelf. A series of idealized experiments simulate the retreat from a seabed ridge in response to changes in the ocean forcing, and we show that the retreat becomes irreversible after 20 years of warm ocean conditions. A comparison to experiments with a simple depth-dependent meltrate parameterisation demonstrates that such parameterizations are unable to capture the details of the retreat process, and they overestimate mass loss by more than 40% over a 50-year timescale.