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Understanding long-term grounding line retreat and stability from combining numerical modelling with the palaeo record of a marine ice stream

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Regarding the potential instability and the recent rapid changes of marine ice streams, understanding the controls of grounding line retreat is crucial in improving our ability to predict ice sheet change and consequently assess future sea level rise. Records of dynamic changes and grounding line retreat of contemporary ice streams are, however, short (decade) and may not reflect ice stream behaviour over longer time scales. We address this issue by combining numerical modelling with the longer-term post-LGM retreat-record of a palaeo ice-stream in Marguerite Bay (Antarctica). High-resolution geomorphological mapping of the seabed set into a chronological framework indicating rapid deglaciation is used to constrain a 1-D flowband model of ice stream dynamics that incorporates basal, lateral and longitudinal stresses and a robust treatment of grounding-line motion using a moving spatial grid. Model response to different external forcings including sea-level, temperature and accumulation is explored. Our modelling suggest that rapid grounding-line retreat across the outer 200 km of Marguerite Bay was a response to climatic warming and sea level rise in the setting of a bed that deepens upstream, as expected from theories on marine-based ice-stream instability. However, within this retreat regime a robust pattern of slow-downs and quasi-stabilizations of the grounding line occurs, often in locations of a reverse bed slope and importantly, coinciding with mapped positions of grounding zone wedges. We find that these restabilizations are partly controlled by variations in cross-channel width and conclude that beside the criteria of reverse bed slope, variations in ice stream width may be crucial when assessing the future retreat and stability of marine-based ice streams in Antarctica.