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Ice rise and ice rumple dynamics, and the consequences for ice sheet evolution

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The Antarctic contribution to sea level projections remains poorly constrained, particularly due to the complex dynamical response of the ice sheet to changes in external forcing in coastal regions. In our study we investigate ice rises and ice rumples, features which form in ice shelves where ice is locally grounded due to elevated bed topography. As a consequence, upstream ice is buttressed, regulating the flow of ice. Ice rises and ice rumples differ from one another in their characteristic flow regimes, with ice rises having a local, radial flow regime and ice rumples having a flow regime predominantly aligned with that of the surrounding ice shelf. Ice rises cause the surrounding ice shelf to flow either side of the feature and thereby cause a greater degree of buttressing.

Using a three-dimensional, isothermal, full Stokes, idealised model setup (Elmer/Ice), we investigate the response of ice rises and ice rumples to sea level change, mimicking a glacial cycle. During sea level increase, a transition from ice rise to ice rumple occurs, and with a subsequent decrease in sea level, hysteretic behaviour is observed, i.e. the current grounded area, dome position and flow regime are dependent on the past state of the system. The hysteretic behaviour seen in the ice rise-rumple system is reflected in the upstream ice shelf and is likely to have an effect on continental grounding line dynamics. These findings have important implications for the initialisation and transient simulation of ice rises and ice rumples within continental-scale ice sheet models given that the evolution of these features is important for the timing and magnitude of sea level projections.