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The formation of ice rises, their dynamics and role in the deglaciation of the Antarctic ice sheet

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Numerous underwater mountains emerge from the edge of the continental shelf around the Antarctic ice sheet. During the last deglaciation, those features gave birth to ice rises, each being small scale copies of a continental ice sheet characterised by an ice divide and a local flow going outwards embedded within the fringing ice shelves. The well-known millenium-scale stability of ice rises can be strong indicators for the past deglaciation termination. However, the interpretation of physical measurements of an ice rise is not straightforward due to unknown past ice dynamics. Here, using the Bisicles ice-sheet model, we investigate for the first time the formation of an ice rise on top of an underwater mountain during the retreat of an ideal Antarctic-like ice sheet (i.e. including both grounded and floating ice flow). Prior to the retreat, the underwater mountain is barely detectable from the ice surface geometry and velocity. During the ice sheet retreat, induced by an increase of the sea level, an ice divide develops quickly above the underwater mountain. Within a short period of hundreds of years, the ice rise adopts a thousand years stability along with two main features: (i) a shifted upstream position of the ice rise compared to the mountain underneath and (ii) a geometrical asymmetry of the ice rise showing a gentle slope upstream and a steep slope downstream. We also investigate the influence of a non uniform surface mass balance on the migration of the ice divide. Our results provide additional ice dynamical constraints to facilitate numerical reconstructions of the last deglacial history in Antarctica as we demonstrate that ice rises are stable, but transient features of the ice shelf, stabilizing fast outlet flow. The timing of pinning and unpinning therefore becomes crucial in simulating the episodes of slow and fast grounding line retreat, respectively.