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Mechanisms Driving abrupt shifts in West Antarctic ice stream direction during the Holocene

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Determining the behaviour of the marine-based West Antarctic Ice Sheet over millennia is critical to place recent rapid changes in context and better predict Antarctic's future contribution to sea-level rise. Here, we reconstruct the geometry of two major ice streams entering the Weddell Sea over 20,000 yrs, using terrestrial geologic constraints and high-resolution ice-sheet simulations, to understand the effect enhanced flow has on regional ice dynamics and mass balance.

We reconstruct terrestrial ice surface elevations through time by measuring multiple cosmogenic nuclides (in situ 14C and 10Be) in glacially transported erratics from four sites – the Flower Hills and Union Glacier, and the Patriot and Marble Hills – to record elevation changes in catchments of the Rutford and Institute ice streams. Glacial erratics sampled from steep exposed bedrock surfaces serve as 'dipsticks' that allow us to reconstruct past surface elevation changes in the Rutford and Institute ice streams as they decayed from their proposed extent at the Last Glacial Maximum (LGM) to their modern configuration. To test the dynamic glaciological changes predicted by our geological interpretation we assessed the changes to geometry and ice-flow pattern triggered by post-LGM increases in oceanic heat flux and sea level as predicted from high-resolution ice sheet modelling using the Parallel Ice Sheet Model (PISM). In our simulations of the whole LGM Antarctic ice sheet we implement PISM at 5 km resolution in order to resolve at a fine scale the geometry and dynamics of the ice sheet and to predict its response to sea-level rise and ocean warming.