

Ice front variations of Heilprin Glacier in northwestern Greenland controlled by the ocean and glacier bed geometries

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The Greenland ice sheet is losing mass under the influence of increasing surface melting and ice discharge from marine-terminating outlet glaciers. Better understanding of mechanisms controlling ice dynamics of marine-terminating glaciers is crucial for predicting future mass loss from the ice sheet. However, processes controlling rapid retreat of the glaciers are not well explained. As many Greenlandic glaciers thinned recent years, ice thickness near the current front position is possibly close to the hydrostatic equilibrium condition. Therefore, we hypothesize that a possible cause of recent rapid retreat of marine-terminating glaciers is surface lowering below the flotation level (ice surface elevation at which buoyancy and gravitational forces balance). Validation of this hypothesis requires detailed ice surface and bed elevation data near the calving front.

In this study, we measured bed topography and surface elevation of Heilprin Glacier in northwestern Greenland. Heilprin Glacier has a 6 km-wide terminus, which is currently separated to three calving fronts. The front position advanced by 800 m from 1990 to 2000, and retreated by 1 km from 2000 to 2009. We measured the ocean bed topography near the one of the calving front situated in the north, using a sonar fixed on a boat from 13 to 15 August, 2018. The surface elevation change from 2001 to 2012 was analyzed by using digital elevation models generated from satellite images acquired by an optical sensor ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) mounted on the Terra satellite. We computed the flotation level from the bed elevation, and compared it with glacier surface elevation before and after the rapid retreat.

Near the studied glacier front, the fjord is deeper in the northern side of the glacier, and the maximum water depth in the region was 340 m. The glacier retreated by 1 km over this deepest area from 1998 to 2008. Analysis of the data showed that the glacier surface near the front in 2000 was 10 m below the flotation level, suggesting significant ice thinning prior to the rapid retreat. It is likely that the retreat of northern front of Heilprin Glacier was driven by thinning and ice flotation at the deepest area of the fjord.

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