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Inland tidal stress propagation observed at Bowdoin Glacier, Northwest Greenland

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The observed acceleration, thinning and retreat of marine-terminating outlet glaciers of the Greenland ice sheet account for about half of its mass loss. This so-called dynamic thinning, which has now propagated along much of the ice margin, nevertheless involves feedback processes between ice thickness, basal sliding, subglacial water and oceanic tides, that are not yet fully understood.

Here, we present a three-year record of ice pressure measured en-glacially at Bowdoin Glacier, a small and relatively accessible tidewater glacier in Northwest Greenland which has been monitored continuously since 2014. Although Bowdoin Glacier appears to have been very stable since its frontal position was first documented by late 19th century explorers, its calving front has recently experienced a rapid retreat of ca. 2 km between 2007 and 2013, followed by a continued surface lowering since then.

About 2 km upstream from the calving front, two boreholes were drilled and equipped with thermistors, inclinometers and pressure sensors. Although pressure sensors were meant to locate instruments in the water-filled boreholes immediately after the drilling, they continued to record after the complete refreezing of the boreholes and the stabilisation of ice temperatures well below the pressure melting point. All sensors recorded in-phase pressure variations with clear 12-hour and 14-day periodicities, leaving no doubt on the tidal nature of the signal. Surprisingly, the amplitude of pressure variations recorded in ice is comparable to that of sea level tides measured 130 km away at Pituffik. This lets us conclude, that tidal stresses applying to marine calving fronts can propagate several kilometres upstream in subfreezing glacier ice.