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Large increase in glacier sliding during subglacial flooding

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It is important to understand how glaciers respond to subglacial floods as several geological hypotheses about subglacial landforms presume that ice sheets are lifted during cataclysmic floods. Here we use a high-precision global positioning system (GPS) mounted on Iceland's Skeiðarárjökull glacier to constrain surface motion during a subglacial flood that exceeded a flow of 3×10^3 m^3 s^{-1}. In November 2004, 0.5 km^3 of meltwater drained from lake Grímsvötn to Skeiðarárjökull over a 5-day period. Partway through this event, a volcanic eruption occurred at Grímsvötn, resulting in an extra 0.3 km^3 of meltwater input to the lake and a prolongation of the flood. Subglacial arrival of floodwater 1 km from the glacier terminus caused surface-parallel (horizontal) motion to increase from 0.03 m h^{-1} to 0.2 m h^{-1} and temporary, decimetre-scale uplift of the glacier surface was associated with periods of low horizontal velocity. At a flood discharge of 2×10^3 m^3 s^{-1}, 0.3 m of permanent glacier uplift occurred due to vertical strain-rates approaching 5×10^{-7} s^{-1}. Following a 2-hour episode of vertical straining, horizontal velocities of up to 0.3 m h^{-1} ensued over a 10-hour period. At the peak of the flood, horizontal motion at the GPS datum had returned to pre-flood levels and the elevation of the glacier surface remained constant. Five speed-up events occurred during the remainder of the flood, each resulting in a tenfold increase in horizontal velocity that was sustained for up to 4 hours. The time-span between these events ranged 4–24 hours, shortening progressively over time. We propose that pressurised floodwater forced the glacier base to lift at the beginning of the flood,

thereby reducing effective-pressure to allow enhanced basal sliding. Close to maximum discharge, anomalous vertical straining led to pronounced stick-slip sliding. Our observations reveal unexpected glacier motion that enables new tests of theories about floodwater flow through glaciers.