Interruption of the Whillans Ice Stream stick-slip cycle by a subglacial lake discharge event

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Understanding the mechanisms that control ice velocity in Antarctica is intrinsically important for predicting future ice sheet mass balance and therefore sea level rise. While the significance of water at the ice-bed interface to ice velocity changes has long been known, there have only been two observations of the extensive dynamic hydrological system beneath Antarctica considerably altering ice dynamics. Unique tidally-paced stick-slip motion, which is sensitive to small changes in stress regime, combined with an extensive active subglacial hydrological system make the confluence of lower Whillans Ice Stream (WIS) and Mercer Ice Stream (MIS), West Antarctica, an ideal location to investigate the relationship between subglacial water and ice dynamics. Here we used data from a four-year, semi-continuous GPS experiment on WIS and MIS to observe a subglacial lake discharge event cascade from Subglacial Lake Mercer (SLM) to Lake 7 (L7), and the subsequent effect of these two floods on both the basal environment and regional ice flow. In addition to a basin-dependent acceleration, we observed a significant interruption to the timing of the slip-stick cycle during the initial discharge event from SLM. Furthermore, during both the SLM and the L7 event, we discovered two slip-event types that do not appear elsewhere during the experiment. These changes to the stick-slip regime suggest a rapidly evolving subglacial hydraulic system which can fundamentally alter both the slip and inter-slip velocities. These results demonstrate the complexity of the subglacial system and the difficulties of accurate long-term monitoring of ice dynamics.

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