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Do existing theories explain seasonal to multi-decadal changes in glacier basal sliding?

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The sliding of glaciers and ice sheets over their bed strongly controls their dynamics, and thus the convey of ice towards warmer areas with faster melt. Theories for friction and water flow beneath glaciers have largely been used to predict sea-level rise driven by climate warming. However, our inability to test these theories against observations at the natural scale has prevented us to be confident in their domain of validity. As a consequence, physical parameters in state-of-the-art models remain widely tuned, causing large spreads in predictions. Here we provide a unique observational framework that allows, for the first time, to fully test basal sliding and subglacial hydrology predictions for glaciers over a hard bed and at multi-decadal timescales. Measurements are made out of a bicycle wheel placed below the Argentière Glacier (French Alps), from which glacier basal sliding speeds have been measured nearly continuously from the 1980s, when basal shear stresses were much higher due to the glacier being much thicker. We find that, despite crude assumptions made in seminal theories, those are in striking agreement with observations. We observe a Weertman-type scaling at low shear stresses, with an exponent consistent with friction being controlled by enhanced creep and pressure dissolution, and a transition to a Lliboutry-type scaling as shear stress increases, consistent with subglacial cavity growth. We also verify Iken's prediction that shear stress is bounded by a maximum value. Surprisingly, however, glacier basal conditions are observed to stabilize every summer at that maximum stress value, instead of undergoing instability as predicted by theory. This causes basal effective normal stress during the melt season to be set by the Iken's bound rather than by the complex evolution of the subglacial hydrology network, as previously thought. These findings may drastically simplify the prediction of hard-bedded glacier response to climate change.