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The Microseismicity of Glacier Sliding

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Our understanding of glacier and ice sheet basal motion remains incomplete. The past decades have witnessed a shift away from initially proposed hard bed theories towards soft, till-laden beds, which deform and thus participate in basal motion. The theoretical treatment of deformable beds is subject to debate, yet our capability to predict ice sheet flow and ultimately sea level rise is contingent upon correct parameterization of basal motion (Ritz et al., 2015).

Both hard and soft bed theories neglect frictional sliding across distinct basal fault planes and elastic deformation in response to sudden dislocation. Over recent years, this view has been repeatedly challenged as more and more studies report seismogenic faulting associated with basal sliding. For instance, large parts of the Whillans Ice Stream at Antarctica's Siple Coast move nearly exclusively during sudden sliding episodes (Wiens et al., 2008). This "stick-slip motion" is difficult to explain with traditional glacier sliding theories but more analogous to earthquake dislocation on tectonic faults. Although the Whillans Ice Stream motion may be an extreme example, there exists evidence for much smaller microseismic stick-slip events beneath the Greenland Ice Sheet and non-polar glaciers (Podolskiy and Walter, 2016). This raises the question how relevant and widespread the stick-slip phenomenon is and if it is necessary to include it into ice sheet models.

Here we discuss recent seismic deployments, which focused on detection of stick-slip events beneath the Greenland Ice Sheet and European Alpine Glaciers. For all deployments, a considerable challenge lies in detection of stick-slip seismograms in the presence of a dominant background seismicity associated with surface crevassing. Nevertheless, automatic search algorithms and waveform characteristics provide important insights into temporal variation of stick-slip activity as well as information about fault plane geometry and co-seismic sliding direction.

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