Subglacial conditions as inferred from small repeating earthquakes

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The Whillans Ice Stream, West Antarctica, is notable for its regular and periodic sliding events. During these sliding events, Winberry et al. (2013) observe a low-amplitude seismic signal that is recorded on seismometers located on the ice stream. The seismic signal consists of sets of gliding spectral lines that increase and decrease with observed ice surface velocities as measured by GPS. Similar signals in the field of volcano seismology have been attributed to the occurrence of small repeating earthquakes. When such events are sufficiently closely spaced, their spectral signature appears as a fundamental frequency with overtones, with the fundamental frequency being inversely proportional to the inter-event time.

We investigate the occurrence of small repeating earthquakes using a force balance model that incorporates rate- and state-variable friction laws. Together, the earthquake inter-event time and velocity amplitude measured at seismometers constrain the mechanical conditions at the sliding interface. In particular, we use these observations to constrain basal shear stress, pore pressure and the rigidity of the seismic sliding interface. This inversion is under-determined and such parameter constraints are inherently non-unique. Nevertheless, this analysis provides an independent estimate of these quantities that may be compared to classical glaciological methods.

Modeling of ice and polar ocean (California Dreamin')