

# Seismology at the calving, sliding and hydrologic frontiers of glaciology

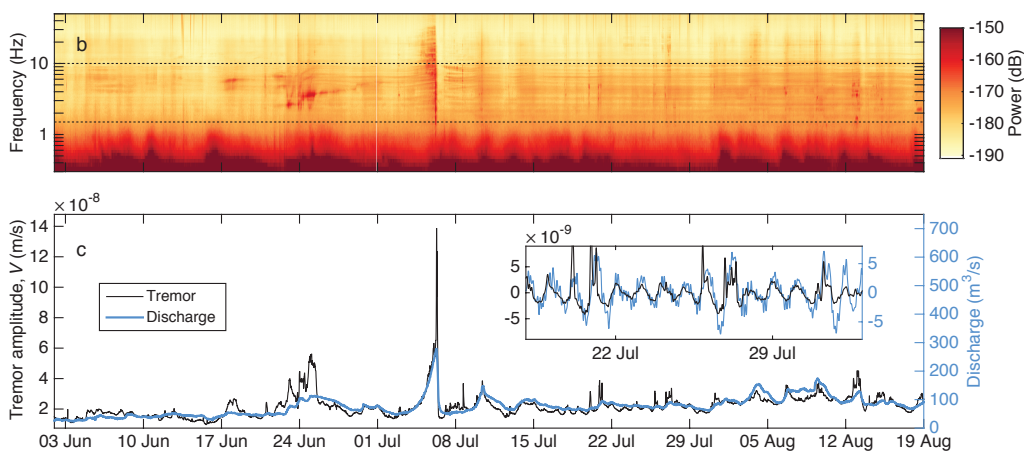
Timothy Bartholomaus (U Idaho)

Jason Amundson (U Alaska Southeast), Ginny Catania (U Texas), Florent Gimbert (CNRS), Chris Larsen (U Alaska Fairbanks), Shad O'Neel (USGS), Leigh Stearns (U Kansas), Victor Tsai (Caltech), Jake Walter (U Texas), Michael West (U Alaska Fairbanks)

Only one decade ago, the changes in glacier and ice sheet mass loss and velocity now reported regularly were almost entirely unanticipated. Predictions of future changes remain insufficiently constrained because the processes responsible for these changes are poorly understood. Improved understanding requires new observations with high temporal resolution, multi-year durations, and at locations sensitive to rapidly fracturing and flowing basal ice and calving termini. Seismology meets these requirements and offers new observations that can motivate and test theory.

Iceberg calving, water discharge along glacier beds, and motion between glacier ice and underlying sediment and rock are active frontiers in glaciological research, as well as areas where seismology has proved valuable. For example, icequakes are produced when icebergs interact vigorously with the ocean surface, following detachment from the terminus face<sup>1</sup>. These calving icequakes demonstrate that calving occurs more frequently during falling and low tides, especially for the largest calving events<sup>2</sup>. Furthermore, these calving icequakes indicate that calving fluxes are up to twice as great during fall, when submarine melt of glacier ice by warm ocean water is greatest, than during winter or spring. These observations support emerging theories regarding the stability of calving glaciers.

Tremor produced by water flow at the base of glaciers can also be used to infer rates of subglacial discharge, a critical unknown at many locations due to the influence of water on glacier motion, sediment transport and submarine melt where glaciers terminate in the ocean<sup>3</sup>. These tremor observations reveal changes in the pressure gradient, size, and sediment transport within high flux conduits<sup>4</sup>. Finally, I will report observations of unusually consistent basal icequakes from a glacier in Greenland that inform our view of the factors controlling glacier motion.



Spectrogram of seismic data recorded adjacent to Mendenhall Glacier, Alaska, and the integrated tremor amplitude show excellent correspondence with water flowing from the terminus.

<sup>1</sup> Bartholomaus et al., 2012, JGR-ES <sup>2</sup> Bartholomaus et al., 2015, JGR-ES

<sup>3</sup> Bartholomaus et al., 2015, GRL <sup>4</sup> Gimbert et al., 2016, GRL