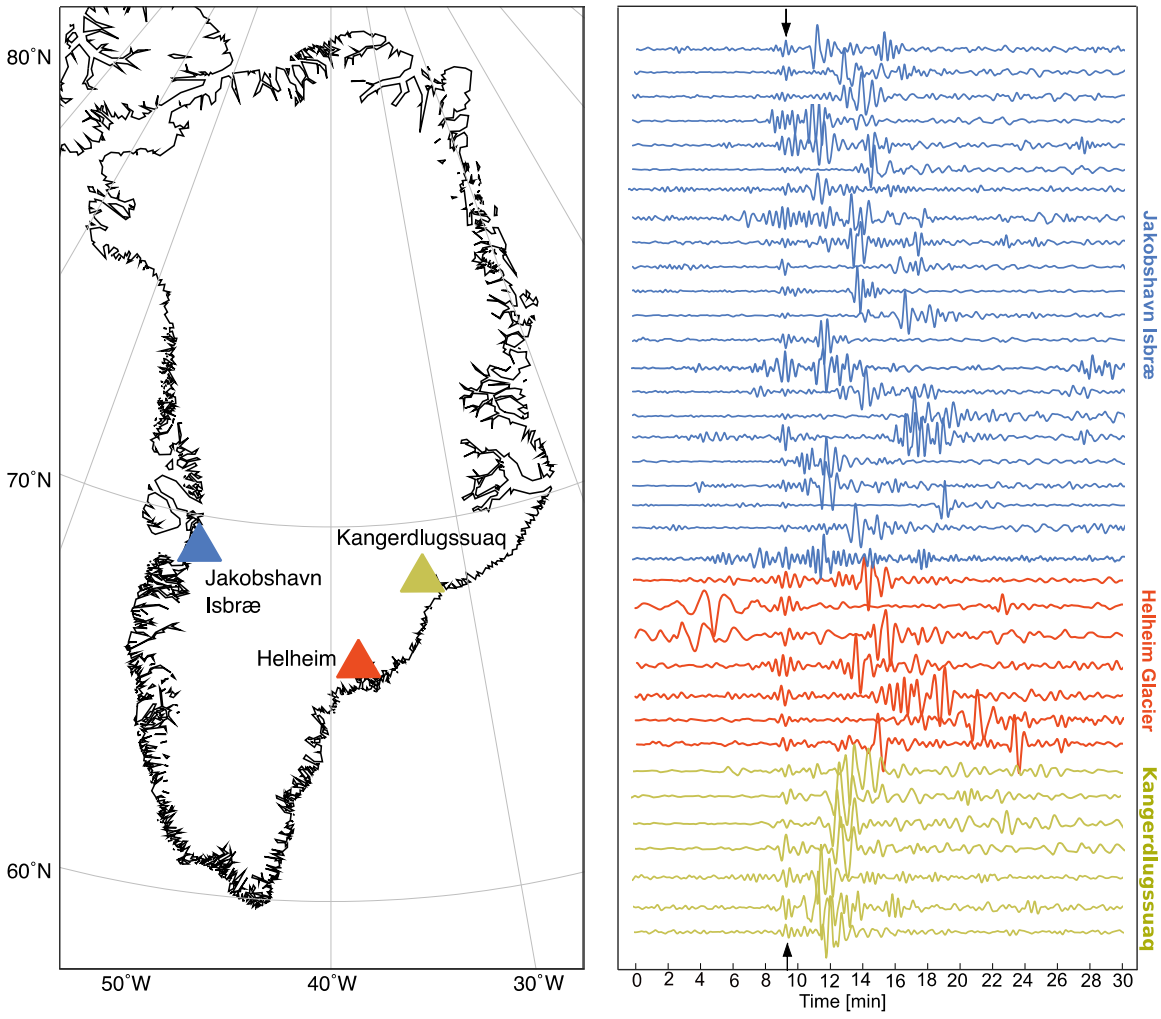
Seismic precursors to iceberg calving events

Kira G. Olsen[1], Meredith Nettles[1]
[1]Lamont-Doherty Earth Observatory of Columbia University

Glacial earthquakes generated by rotational iceberg calving produce the largest seismic events (M_{SW} ~5) recorded in Greenland. The intermediate-period, teleseismic data used to study these events allow us to resolve the orientation and amplitude of the primary force acting on the glacier during calving, but they do not recover low-amplitude or high-frequency seismic information. Here we employ data from the closest permanent seismic stations to three of Greenland's major glaciers: Jakobshavn Isbræ, Helheim Glacier, and Kangerdlugssuaq Glacier, to perform the first systematic investigation of high-frequency and intermediate-period seismic signals generated before, during, and after glacial earthquakes. In 50% of events we observe an intermediate-period signal preceding the main glacial earthquake by 2-13 minutes. We find the best-fit model for the generation of these precursory signals to be a sub-horizontal force, similar to the force generated by glacial earthquakes. In the 3-10 Hz frequency band, we observe elevated signal amplitude for up to 15 minutes before the onset of a glacial earthquake, and high-frequency signals outlasting the main glacial-earthquake signal in all 76 events we analyze. We combine seismic observations, high-frame-rate images of calving events, and model results to explore possible source mechanisms for these precursory signals.



Left: Locations of the three glaciers analyzed in this study. Right: Glacial-earthquake signals at the three glaciers aligned based on the timing of each precursor pulse. Arrows point to precursor signal for each event; the highest amplitude signal in each seismogram is a glacial earthquake. Data are filtered to 35-100 seconds.