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Volcanic-like long-period seismic events at a tidewater glacier in Greenland

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Discrimination of volcanic and glacial seismic signals remains one of the key challenges for studies on volcano-glacier interactions. Here we show that even in the absence of any active volcano, interpretation of so-called Long-Period (LP) seismic events of glacial origin is truly challenging.

Discoveries of LP seismic events in volcanic, tectonic and glacial environments have led to a decades-long debate on their source mechanisms, which could be either fluid-driven rupture or slow-slip. LP events in volcanic environments are of pivotal importance for eruption forecasting because they can provide information on fluid migration beneath the volcanic edifice. LP events in environments of fast glacier flow may also correspond to the resonance of fluid-filled cracks or represent sliding. However, other sources have to be ruled out before making such an assertion.

Here we present observations from three comprehensive experiments at a tidewater Bowdoin Glacier, northwest Greenland, where thousands of apparently hybrid LP events were recorded. We conducted a detailed analysis of their properties by applying advanced seismological approaches and using a novel-to-glaciology GPS-stacking technique. The events are found to be highly repetitive, year-round events that are localized near the calving front, with tide-modulated amplitudes that increased with waiting time and an occurrence rate that exhibited a temporal dependence on ice speed. The emergent onset of the events is polarized, with a mixed polarity that is primarily in the horizontal plane.

Taken together, the records suggest that the source of the LP events, which is sensitive to ice speed and meltwater supply, may correspond to localized slip with fluid resonance. However, further research is necessary to fully resolve the source mechanism of these LP events since we cannot dismiss the possibility of pure fluid-filled cracking due to a complex link between basal-water pressure and ice speed.