



Interrogating crevasse icequake source physics at an alpine glacier using Distributed Acoustic Sensing

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Crevasse plays an important role for the stability of glaciers and ice shelves. While dry crevasses are limited in their depth of propagation by the surrounding stress field, crevasses filled with water can become unstable and propagate far deeper, providing a route for meltwater to reach the glacier bed. Hydrofracture-driven crevasse therefore has the potential to destabilise glaciers and has also been shown to cause rapid ice shelf disintegration. However, the physical mechanisms associated with hydrofracture are seldom observed. Icequakes generated by crevasse fracture provide an ideal tool to directly interrogate the process. Here, we present crevasse-driven icequakes observed using a dense 2D grid Distributed Acoustic Sensing (DAS) deployment of fibre at Gornergletscher, Switzerland. This dataset was collected during a time of high meltwater production, providing an ideal opportunity to study the fundamental physical mechanisms associated with hydrofracture failure.

We detect and locate 951 icequakes. We then use new full-waveform inversion methods to refine event depths and obtain focal mechanisms. Furthermore, we quantify fracture mode and volumetric opening extent. We find that events typically exhibit tensile crack opening, consistent with expected crevasse fracture mechanisms. As well as direct P-wave and surface-wave energy, the waveforms contain strong coda. We attempt to isolate the spatial origin of this coda, to decipher if it is associated with either: fluid resonance at the crevasse fracture site, or wavefield scattering off other crevasses within the wider crevasse field. While we cannot definitively confirm that individual crevasse failure is caused by hydrofracture, the dense sampling provided by fibreoptic sensing allows us to interrogate the fracture mechanisms in detail. These results therefore help us understand what controls crevasse fracture propagation. Our results also highlight the application of a new generation of tools for interrogating seismic sources using fibreoptic sensing techniques in other settings.