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Investigating hydrological forcing of fast glacier flow in Greenland using passive seismology

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Ice loss from the Greenland Ice Sheet is currently the single largest cryospheric contributor to global sea level rise. The two most significant factors influencing ice loss are the acceleration of fast-flowing, marine-terminating glaciers, and surface run-off, which has increased steadily over the last several decades. Since almost all water from the surface is routed to the bed, hydrological systems at the base of the glacier are inherently conditioned by surface processes. Unpicking the relationships between surface (melt)water input, basal hydrology, and ice velocity is therefore key to understanding the effects of global warming on the contribution of marine-terminating glaciers to global sea level rise.

Passive seismology enables the continuous observation of a range of phenomena occurring within and underneath glaciers, such as icequakes, crevassing, and tremors associated with water transport. This technique is therefore ideally suited to studying the effects of variations in surface water input over the duration of a melt season. Over the course of two field campaigns in May and June–July 2018, a network of 12 near-surface and 3 deep borehole geophones was deployed on Store Glacier, a large marine-terminating glacier in West Greenland, as part of the multidisciplinary RESPONDER project. The stations have recorded continuously since early May, capturing a wide range of phenomena including the onset and duration of the surface melting season, regional earthquakes, impulsive microseismic activity, and the drainage of a supraglacial lake. Here, we present findings in the form of spectrograms and the locations of microseismic events recorded by the network. The spectrograms show a clear and sudden transition between relative seismic quiescence and increased mid–high frequency activity on 5 June, corresponding to the onset of significant surface melting. The seismic signatures of meteorological events such as prolonged rainfall are also captured in the spectrograms. This dataset is therefore uniquely suited to investigating links between the input of surface water, microseismicity and basal hydrology.