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Full Wavefield Numerical Simulations of Sub-glacial Seismic Tremor at Vatnajökull Glacier, Iceland

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The volcanic systems, including the central volcanoes Bárðarbunga and Grimsvötn in South-East Iceland lie beneath the Vatnajökull glacier and are covered by up to 700 m of ice. This ice layer inhibits the recording of the seismic signal close to the source and acts as a wave guide, significantly modifying the seismic wavefield. Recordings of local earthquakes or tremor will therefore be modified by a potentially strong and unknown path effect.
We tackle this problem with full wavefield numerical simulations, (2D and 3D) using the Spectral Element method. This allows for the introduction of viscoelasticity in the sub-surface geology and captures all wave conversions and scattering.
We employ a 3D model of the glacier thickness and subglacial topography and insert a source wavelet at different depths and locations in order to simulate the wavefield recorded at the location of the field seismometers, in the region of Vatnajökull. Furthermore we calculate sensitivity kernels which show us which part of the model creates a specific part of the simulated seismogram, yielding a deeper understanding of tremor seismogram composition. Our findings show that path effects play a very significant role in determining the overall character of the tremor wavefield and must be removed or suppressed in order to gain a better understanding of the tremor source process itself.