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Investigating Spatio-temporal Changes in Subglacial Hydrology from Dense Array Seismology.

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Subglacial hydrology strongly modulates glacier basal sliding, and thus likely exerts a major control on ice loss and sea-level rise. However, the limited direct and spatialized observations of the subglacial drainage system make difficult to assess the physical processes involved in its development. Recent work shows that detectable seismic noise is generated by subglacial water flow, such that seismic noise analysis may be used to retrieve the physical properties of subglacial channelized water flow. Yet, investigating the spatial organisation of the drainage system (e.g. channels numbers and positions) together with its evolving properties (e.g. pressure conditions) through seismic observations remains to be done. The objective of this study is to bring new insights on the subglacial hydrology spatio-temporal dynamics using dense array seismic observations.

We use 1-month long ground motion records at a hundred of sensors deployed on the Argentière Glacier (French Alps) during the onset of the melt season, when the subglacial drainage system is expected to strongly evolve in response to the rapidly increasing water input. We conduct a multi-method approach based on the analysis of both amplitude and phase maps of seismic signals. We observe characteristic spatial patterns, consistent across those independent approaches, which we attribute to the underlying subglacial drainage system.

The phase-driven approach shows seismic noise sources that focuses in the along-flow direction as the water input increases. We identify this evolution as the development of the main subglacial channel whose position is coherent with the one expected from hydraulic potential calculations. During periods of rapid changes in water input (5 days over 31) and concomitant glacier acceleration the amplitude-driven approach shows spatial pattern highly consistent with the seismic noise sources location. At this time, we suggest that the spatial variations in the amplitude are representative of the water pressure conditions in subglacial channels and surrounding areas. Our spatialized observations therefore reveal the spatio-temporal evolution of the subglacial drainage system together with its changing pressure conditions. We observe, for instance, that channels develop at the very onset of the melt-season and rapidly capture the water from surrounding areas. Such unique observations may allow to better constrain the physics of subglacial water flow and therefore strengthen our knowledge on the dynamics of subglacial environments.

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