



Using dense array seismology to observe glacier dynamics: the RESOLVE-Argentière project

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Glacier dynamics controls the advection of ice towards warmer areas with faster melt, and thus glacier response to climate change. Although certain key processes at play in glacier dynamics are relatively well understood (e.g. ice viscous flow), yet others such as glacier fracturing, glacier basal sliding and englacial or subglacial hydrology remain poorly known mainly as a result of lacking observations. Here we present an innovative field instrumentation strategy that evaluates glacier seismic motion with unprecedentedly high temporal and spatial definition in order to unravel the specifics of those poorly known, highly intermittent and spatially heterogeneous processes. Field instrumentation was conducted on the Argentière Glacier (Mont Blanc, France) during the early melt season (month of May 2018) and consisted in a quite unique set of instruments including an array of about 100 three-component seismic sensors evenly spaced 40-m from each other (covering an area of about 0.5x0.5 km² in the ablation zone), about 12 sensors placed in and below the glacier thanks to boreholes and subglacial tunnels drilled into bedrock, respectively, as well as a succession of complementary observations of glacier bed geometry (using ground penetrating radar), subglacial water pressure (using pressure sensors in boreholes) and glacier surface velocities (using GPS and ground radar interferometry). Analysis of the seismic wave field allows retrieving hundreds of thousands of sources, most of which are hidden within the background noise. We discuss the spatio-temporal variations of these sources, and the potential processes that they may be associated with, such as ice fracturing, glacier basal sliding and the flow of water. Our seismic observations nicely add to the other complementary observations, and their combined analysis should yield new insights into our understanding of glacier dynamics in a near future.