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Imaging the poro-elastic properties of glacier beds using ambient seismic noise monitoring : application to Whillans ice stream, Antarctica

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Part of the movement that occurs on all glaciers in Antarctica is a continuous and stable movement that unloads the ice into the sea. The Whillans Ice Plain (WIP) is a portion of the Whillans ice stream that measures 8000 km² for an ice thickness of 800 meters. This glacier has a unique characteristic of moving thanks to tidally modulated stick-slip events twice a day. The slip speed varies laterally across the glacier. We measured surface wave velocity variations computed from ambient seismic noise cross-correlation. The cross-correlations make it possible to monitor temporally and spatially the seismic velocities at the bed of the glacier, associated with changes in poro-elastic parameters and frictional properties of the glacial till. We averaged our observations for the 78 stick-slip events of our dataset and managed to achieve a 5 min temporal resolution along the 45 min long slip events. The results show a decrease in velocity of about 9% of the S-wave velocity in the subglacial sediment layer about 30 minutes after the initiation of the slip. This velocity drop mainly affects the central part of the glacier. A 10% increase in porosity could induce this velocity decrease due to dilatancy. Dilatant strengthening results from this porosity increase, which in turn keeps the glacier in a slow-sliding regime. The high rate of seismic cycles on such a large scale makes the Whillans ice stream a unique laboratory to study transient aseismic slips in glacial context but also in active tectonic faults one.