Moulins Detected as Ambient Noise Sources at the Kaskawulsh Glacier

*Naofumi Aso[1,2], Victor C Tsai[1], Christian Schoof[3], Arran Whiteford[3], Gwenn E Flowers[4]

1. Seismological Laboratory, California Institute of Technology, 2. Department of Earth and Planetary Science, The University of Tokyo, 3. Department of Earth and Ocean Sciences, University of British Columbia, 4. Department of Earth Sciences, Simon Fraser University

Hydrology is important for glacier dynamics, but it is difficult to monitor the subsurface drainage systems of glaciers by direct observations. Since meltwater drainage generates seismic signals, passive seismic analysis has the potential to be used to monitor these processes. To study continuous seismic radiation from the drainage, we analyze geophone data from six stations deployed at the Kaskawulsh Glacier in Yukon, Canada during the summer of 2014. The confluence of the north and central arms of the Kaskawulsh Glacier is an especially attractive place to study such phenomena not only because of the confluence but also because a nearby ice-dammed lake fills and drains rapidly every summer. We determine ambient noise source locations by back-projecting cross-correlated seismogram. Most of the ambient noise sequences are located in two clusters, with each cluster located in the vicinity of a moulin identified at the surface. Stronger seismic radiation is observed during the day, consistent with expected variability in melt rates. We interpret this ambient noise as being produced by meltwater drainage at moulins. We also found that precipitation controls the moulin activity at timescales longer than a day. The necessary condition of the observable seismic radiation at these moulins is that either the temperature is below its daily average or the precipitation is less than 1mm/day. We also suggest that significant rainfall may have changed the geometry of one of the moulins. Our result implies the potential of passive seismic observations to monitor water flow into subglacial channels through moulins with an affordable number of seismic stations, but quantification of the flow rate still remains a challenge. This cross-correlation back-projection technique is suitable for monitoring moulin activity, but it can potentially be applied to any localized source of ambient noise such as ocean noise, tectonic tremor, and volcanic tremor.

Keywords: Ambient noise interferometry, Subglacial drainage, Moulins

