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Passive seismic monitoring of the subglacial drainage system of Glacier de la Plaine Morte, Switzerland

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Outburst floods of glacier-dammed lakes pose a severe threat to human infrastructure as large volumes of water can be suddenly and often unexpectedly released within a few days. Moreover, subglacially draining lakes impact ice flow by changing subglacial hydraulic conditions. Consequently, glacier outburst floods have attracted attention in various sub-disciplines of glaciology. However, detailed observations of subglacial water flow are hard to come by, because conventional approaches are typically laborious and expensive and often provide point measurements, only.

Here, we use passive seismic measurements from Glacier de la Plaine Morte in the Swiss Alps to monitor seismic vibrations caused by turbulent water flow in subglacial conduits. In particular, we investigate the subglacial drainage system by focusing on the 2016 drainage process of Lac des Faverges, an annually draining ice-marginal lake. Our seismic deployment consisted of over 20 stations which collected continuously data for up to 4.5 months. These data were complemented by observations of lake level, proglacial stream discharge and GPS based ice-surface motion. This setup allows for a detailed study of subglacial hydraulics and a perturbation constituted by the lake drainage.

Prior to the lake drainage, ambient vibrations are predominantly man-made but discharge peaks are captured in the seismic records. With the initiation of the lake drainage and the associated opening of subglacial channels, we observe strong seismic tremors which are correlated with discharge, especially once the lake has fully drained. During the lake drainage, englacial storage of lake water and resonances in the drainage moulin seem to suppress this correlation. These first results suggest that the seismometers detect efficient water transport through glaciers. Consequently, on-ice seismic recordings are promising measurements in order to monitor the drainage system of glaciers.