Geophysical Research Abstracts
Vol. 16, EGU2014-2655, 2014
EGU General Assembly 2014

A one year long continuous record of seismic activity and surface motion at the tongue of Rhonegletscher (Valais, Switzerland)

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A critical gap in our current understanding of glaciers is how high sub-glacial water pressure controls the coupling of the glacier to its bed. Processes at the base of a glacier are inherently difficult to investigate due to their remoteness. Investigation of the sub-glacial environment with passive seismic methods is an innovative, rapidly growing interdisciplinary and promising endeavor. In combination with observations of surface motion and basal water pressure, this method is ideally suited to localize and quantify frictional and fracture processes which occur during periods of rapidly changing sub-glacial water pressure with consequent stress redistribution at the contact interface between ice and bed.

Here we present the results of the first one-year-long glacier seismic monitoring performed on an Alpine glacier to our knowledge. Together with records of surface motion and hydrological measurements, we examine whether seasonal changes can be captured by seismic recording. Experiments were carried out from June 2012 to July 2013 on Rhonegletscher (Valais, Switzerland), by means of 3 three-components seismometers settled close to the tongue in 2 meters boreholes. An additional array of eleven sensors installed at the ice surface was also maintained during September 2012, in order to achieve more accurate icequakes locations.

A high seismic emission is observed on Rhonegletscher, with icequakes located close to the surface or in the vicinity of the bedrock. The temporal distribution of seismic activity is shown to nicely reflect the seasonal evolution of the glacier hydrology, with a dramatic seismic release in early spring. During summer, released seismic activity is generally driven by diurnal ice/snow melting cycle. In winter, snow-cover conditions are associated with a reduced seismic release, with nevertheless some unexpected activity possibly related to snow-pack metamorphism. Based on icequake locations derived from data recorded in September, we discuss seasonal changes of the icequakes hypocenters distribution and possible source mechanisms are proposed.