Geophysical Research Abstracts
Vol. 13, EGU2011-6137, 2011
EGU General Assembly 2011

Surface Seismicity on Gornergletscher, a Swiss Alpine Glacier

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In recent years, seismic measurements in relation to glacier motion have offered new and valuable insights into cryospheric processes. Glacier-related seismic sources can span several magnitudes, often driven by surface crevasse openings, englacial water flow and iceberg calving events. Given this, glacier seismology is evolving into a useful tool to investigate ice dynamic processes, which are often difficult to access with other geophysical measurement techniques. Here, we present results from four temporary high-density seismic network deployments on Gornergletscher, Switzerland, during four summers (2004-2007). The resulting catalogs include well over 100,000 recorded icequake events. Using recently developed location techniques based on surface wave coherency, we reliably locate surface icequakes (>10,000) related to crevassing activity. The locations agree well with the local surface crevasse pattern observed from aerial photography. Although the recording periods are limited to 1-2 months during each summer, we can identify temporal changes in icequake activity and locations. These transient changes can be attributed to changes in glacier flow, which are substantially influenced by the subglacial drainage of a nearby ice-marginal lake. Furthermore, the seismic emission of individual crevasses is subject to diurnal fluctuations in melt water-induced ice flow changes, which vary depending on the crevasse location. Examining the time-of-day of rupture of surface icequakes, we find 'daytime' quakes tend to locate in the northeast of our study region (closer to the ice-marginal lake) and 'nighttime' quakes tend to populate the southwest region (farther from the lake). This partitioning is consistent in all years of data. Analogous to the lake drainage, we suggest that the diurnal melt cycle affects changes in basal water pressure. This in turn, induces changes in basal motion, thus giving rise to the diurnal cycle in icequake activity. These results demonstrate how seismic monitoring can complement measurements of glacier surface motion and subglacial water pressures to detect and characterize glacier flow perturbations. These findings elucidate how seismic monitoring of surface icequakes can help to track processes at depth, such as the interaction of basal water pressure changes and basal motion. This type of glacial flow mechanism carries major glaciological importance, as changing climate directly affects the production of surface melt water.