Geophysical Research Abstracts
Vol. 14, EGU2012-7465, 2012
EGU General Assembly 2012

Seismology on the Greenland ice sheet: results from the deployment of a high-density campaign seismic network in 2011

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The effect of the observed increase in surface melt on the dynamics of the Greenland ice sheet is not fully understood. Specifically, it is not clear to what extent the subglacial hydraulic system can respond to changes in melt water input. Depending on its adaptability, the subglacial drainage system may help enhance or diminish ice flow during warming air temperatures.

In order to gain a better understanding of the subglacial drainage system, we installed a high-density campaign seismic network during summer 2011 on the Greenland ice sheet. The goal of the passive seismic monitoring is the detection and characterization of dislocation mechanisms, such as englacial fracturing and basal stick-slip motion. A better understanding of these processes will elucidate the englacial and subglacial drainage system and its role in ice dynamics. The seismic deployment was part of an international deep drilling project. In the vicinity of the seismic network seven boreholes were drilled to the glacier bed and equipped with scientific instruments to measure englacial deformation, temperature, basal water pressure and glacier sliding rates.

In our presentation we describe the seismological experiment and offer a first impression of the 'icequake' waveform variety, which we have recorded. The installation consisted of 17 three-component seismometers, including three deep (150 – 400 m) borehole sensors and two broadband seismometers. The aperture of the array was about one kilometre. It was operated over a time span of six weeks. Data were recorded continuously at high sampling frequencies (500 Hz). Due to high ablation rates surface sensors had to be re-leveled daily. As expected from previous studies of Alpine icequakes we recorded a large number of surface crevassing events and found evidence for deeper (more than 100 m depth) fracture events most likely due englacial hydrofracturing. In addition, we recorded relatively low-frequency (0.3-1.5 Hz) transients, with high signal correlation and little dispersion throughout the array. These seismic events show an activity burst near the beginning of the seismometer deployment period, when they occur up to once every minute. We discuss the possible sources of these events and how they may be related to ice sheet flow and subglacial hydraulics.