Seismic-infrasound monitoring of a tidewater calving glacier (Bowdoin, Greenland)

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Greenland is the second largest ice-covered area worldwide, where recent dramatic recession of outlet glaciers is known to be a key driver for accelerated ice-sheet mass loss. Bowdoin Glacier in northwestern Greenland (~120 km from Thule) is a grounded tidewater calving glacier that has been rapidly retreating since 2008. An observational seismic-infrasound network was installed in July 2015 near the 3-km-wide calving front of the glacier to enable near-source monitoring of frontal dynamics.
One Güralp CMG40T triaxial broadband seismometer was installed on the rocky coast in advance of the calving front, together with a time-lapse camera and a water pressure sensor in the fjord (for recording micro-tsunamis generated by calving). Four Lennartz LE-3D short- and long-period seismometers were arranged on the glacier ice in a triangle-shaped array, ~250 m from the marginal ice cliff, where icebergs are discharged into the fjord. An infrasound array comprising four pressure sensors was installed on a hill located ~3 km behind the calving front. Another two infrasound sensors were collocated with the central station of the on-ice seismic array and the broadband station. The aperture of both arrays was ~150 m. Additionally, three GPS on-ice stations with an on-rock reference station were established along the longitudinal profile of the Bowdoin Glacier to record ice-flow speed. Finally, an automatic weather station was used to record meteorological parameters near a base camp east of the glacier.
Multiple seismic and infrasound events were recorded and linked to surface crevassing, calving, presumably hydrofracturing, iceberg rotations, teleseismic earthquakes, helicopter-induced tremors, etc. Using classic seismological and array approaches (i.e., “Short Term Averaging / Long Term Averaging” and “f-k” analysis), as well as image processing, we explore and inter-compare this unique dataset. The most striking feature of the records is the temporal variability of microseismic events, which were continuously recorded over a period of two-weeks. The results show a double-peak diurnal oscillation in the number of events (up to 600 events per hour). Using high-resolution surface displacement GPS measurements, we show that the correlation between the number of events and tides is relayed through strain-rate variation. The strain rate corresponds to local extensional stretching of the glacial surface, mainly in response to increases in air temperature and falling tide velocity, which reduces back-pressure on the ice cliff.

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