Tidally induced icequake swarms at the grounded margins of the Ross Ice Shelf, Antarctica

Hank Cole, Richard C. Aster, Michael Baker, Julien Chaput, Peter D. Bromirski, Peter Gerstoft, Ralph A. Stephen, Andrew Nyblade, Douglas A. Wiens

Repeating icequake swarms near the grounding line of the Ross Ice Shelf (RIS) were recorded by broadband seismometers deployed from late 2014 to early 2017. The swarms are readily observed at 5 of the 34 stations. Swarms occur diurnally and in phase with falling ocean tides throughout the year. Most swarms consist of 1000's of events occurring over the course of a few hours. During a swarm progression, there is a steady increase in the rate of events and their amplitude until the activity abruptly ends. Near a swarm's peak, events are so frequent that they will sometimes overlap in the seismogram. The total energy of a swarm is primarily correlated to the tidal range and slope. However, non-diurnal tide components, seasonal effects, and environmental conditions all affect the swarm expression and our detection threshold. Signals from individual events are dominated by Rayleigh wave energy in the ~4-10 Hz band, but weaker body wave arrivals are also observed in the ~20-30 Hz band with a few seconds of separation between the two. We use the STA/LTA method to detect events then estimate their origin using only a single station by constraining back azimuth with surface wave polarization and constraining distance with arrival time differences. Events also display clean dispersion due to the velocity gradient of the firn which may provide additional constraint on the distance to source. Examination of events reveals highly similar, repeating waveforms that trigger within and between swarms. There is also evidence of azimuthal migration of sources within and between swarms. We hypothesize that swarms originate from surface crevasse propagation caused by increased tensile stress at the surface from tidal flexure and extension of the ice shelf during falling tide. Satellite imagery confirms the presence of crevasse fields near stations where swarms are observed. We catalog icequake swarm events, infer a seismogenic process, and analyze swarm aggregate statistics to examine links between environmental parameters and swarm activity. We anticipate that this research will provide insight into the workings of the RIS system and that it will guide efforts to passively monitor ice shelf stability with seismic instrumentation.