Seismic Studies of Glacier Calving

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In order to better constrain glacier and ice sheet mass balance changes as a response to global climate changes, a large number of glaciological studies have been centered around the phenomenon of iceberg calving. However, to this point calving is still poorly understood and has therefore not been included in ice flow models used to predict large-scale mass balance changes. Fracture propagation, failure mechanism and the role of the proglacial melange are some of the factors whose role in the calving process have to be clarified in order to derive a physically-based quantitative description of calving. Observations from a variety of calving environments are needed as local conditions like the effective water pressure and stretching rates near the glacier's terminus affect the calving rate and style. In this context, seismic measurements are a valuable tool to monitor and characterize glacier calving.

The seismic signals associated with glacier dynamics show a large variety of characteristics. Related to very big calving events, 'glacial earthquakes' can have a moment magnitude of up to 5 and are thus detectable on global seismic networks. On the other hand, material fractures inside glacier ice emit much weaker signals, which can only be detected on or near the glacier. Whereas the seismograms of individual tensile crack openings inside a glacier are of very short duration (<0.1 seconds), calving events can produce seismic waveforms that can last for several minutes. Recent studies have furthermore revealed the presence of seismic tremors most likely emitted by scraping icebergs inside the melange in the proglacial fjord. These observations reflect that large numbers of individual migrating and connecting fracturing events occur during the detachment of icebergs. Here we present seismic records from a variety of calving environments such as an Alaskan tidewater glacier, an Alpine mountain glacier and Antarctic ice shelves. The seismic signatures elucidate differences and similarities in calving styles and thus contribute to a better understanding of calving mechanisms.