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High-frequency Surface Wave Measurements of Micro-tunamis generated by Glacier Calving

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Calving plays a key role in recent rapid retreat of glaciers in Greenland, Alaska and Patagonia. However, processes related to calving are poorly understood since direct observations are difficult. When calving occurred at the glacier front, ice hits water surface and generates surface wave or micro-tsunami. Because characteristics of the micro-tsunami are dependent on the impact on water, it is expected that analysis of the wave provides useful information on the size and type of calving. To study the calving processes from surface wave, we performed field observations at Glaciar Perito Moreno, a freshwater calving glacier in the Southern Patagonia Icefield. We measured the surface level by recording water pressure every 2 s (0.5 Hz), using a sensor installed in a lake 300 m from the calving front. Spectral and statistical analyses were performed on the wave data. We also carried out time-lapse photography, ice speed and water temperature measurements. The time-lapse photographs were used to identify the types of observed calving events (1. Subaqueous, 2. Topple, 3. Drop, 4. Small serac failure). During summer (15 December 2013–4 January 2014) and spring (6–20 October 2014) field campaigns, 640 (30 events d^{-1}) and 195 (12 events d^{-1}) calving events were recorded by the pressure sensor, respectively. The number of calving events varied in time (from 0 to 6 events h^{-1}) and this variation correlates well with lakewater temperature. Subaqueous calving account for only 2.4 % of calving events recorded during the field campaigns (7 out of 364 events). These results imply importance of melting at/under water surface as a triggering mechanism of calving. Waves generated by subaerial calving events (type 2, 3 and 4) showed similar frequency spectrums, whereas those by subaqueous calving had smaller power in frequency range between 0.12–0.25 Hz. The amplitude of the surface waves increased with size of calving, which was quantified by the time-lapse photographs. Our results demonstrate the potential of surface wave for investigating calving processes.