Characteristic seismic tremors with harmonic overtones in the Lützow-Holm Bay, East Antarctica: 2014-2015

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At the International Polar Year (IPY2007-2008), the 'Polar Earth Observing Network (POLENET)' was the largest contributions in establishing seismic network in the Antarctic. Several kinds of seismic signals associated with environmental variations within the atmosphere - ocean –cryosphere - solid earth system had been detected in continental margins and surrounding Southern Ocean. Ice-related seismic motions for small magnitude events are generally named ice-quakes (ice-shocks) and can be generated by glacially related dynamics. Such kinds of cryoseismic sources are classified into several kinds; movements of ice sheets, sea-ice, oceanic tide-cracks, oceanic gravity waves, icebergs and the calving fronts of ice caps. Hypocenters of these local events nearby Syowa Station were identified as their location along the coast and edges of the fast-ice in the Lützow-Holm Bay (LHB) region.
In this study, characteristic features of seismic tremors observed around LHB are demonstrated, by taking into consideration a relationship between surface environmental changes in vicinity of the area. 121 seismic tremors are recognized in both the three-component short-period seismographs (HES) and broadband seismographs (STS-1) deploying at Syowa Station, during the period from October 2014 to April 2015. Many of the tremors hold characteristics of strong harmonic overtones, in their frequency content over the 1 Hz, representing nonlinear features (upward and/or downward frequency contents) with duration times from few minutes till few hours. These tremors occur independently with the arrivals of teleseismic phases, as well as are recorded by both the type of sensors (HES and STS-1) simultaneously. The harmonic overtones can be explained by a repetitive source (Powell and Neuberg, 2003), suggesting existence of several inter-glacial asperities which generate the characteristic tremors. It implies the tremor signals might be involved in the local origins, presumably the cryosphere dynamics; discharge of fast-ice from the Bay, collision of icebergs and fast-ices, calving of glaciers.
In the austral winter in 1997, actually, a few tens of hours duration tremor of harmonic overtones were strikingly observed involving the discharge of a large volume of sea-ice (fast-ice) from LHB (Kanao et al., 2012). The similar nonlinear harmonic tremors associated with the glacial earthquakes have been reported at Whillans Ice Stream, West Antarctica (Winberry et al., 2011, 2013), with the colliding icebergs in the Ross Sea (MacAyeal et al., 2008) and nearby the Neumayer Station of Dronning Maud Land (Eckstaller et al., 2007), respectively. In contrast, relatively small tremor signals are estimated to have very local origins, such as ice-shocks in relation to the sea-ice revel changes in relation to oceanic tide variation in LHB. It is noticed that the laming signals by an ice-breaker ship "Shirase" are clearly identified around 11-13 January 2015, when the ship approach nearby Syowa Station. The laming signals hold frequency contents over few Hz with 10-15 min. intervals.
In summary, seismic tremors in terms of cryosphere dynamics are likely to be involved with variations in surface environments, and continuous monitoring of their time-space variability provides indirect evidence of climate change in the Antarctic.

Keywords: seismic tremors, harmonic overtones, cryosphere dynamics

