Seismic harmonic tremors and their origins from cryosphere dynamics in the Lützow-Holm Bay, East Antarctica

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POSTER

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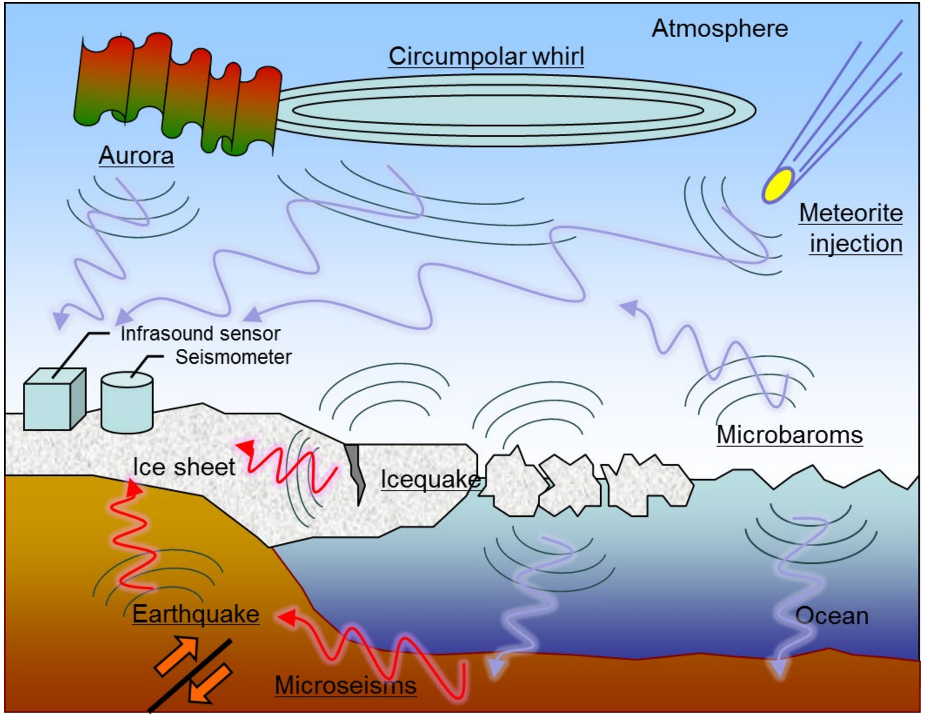
ABSTRACT

Characteristics of seismic tremors in April 2015 were investigated at Syowa Station, in Lützow-Holm Bay (LHB), of East Antarctica. To examine relationship between surface environment in particular cryosphere, MODIS images were utilized for comparison with tremors.

Since a large volume of sea ice was discharged, large icebergs passed through the northern edge of LHB, it was supposed to detect seismic tremors involving cryosphere dynamics.

In particular, strong amplitude tremors with harmonic seismic overtones occurred from meteorological condition. The most plausible candidate of origins is the collisions between bottom of drifting icebergs with top of seabed sediments/crystalline rocks at northern edges of continental shelf of LHB.



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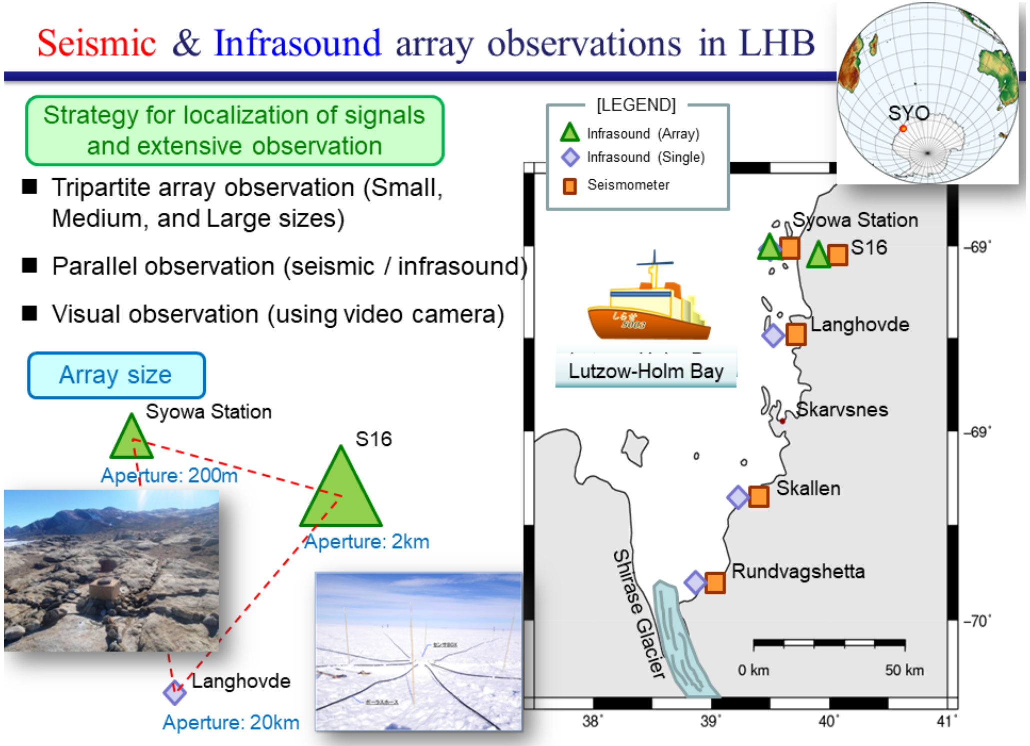
INTRODUCTION

Characteristic tremors with harmonic overtones were recorded in LHB. Seismographs recognized 120 tremors at SYO. Most tremors represented features of clear harmonic overtones, with the frequency content over 1 Hz and duration times for a few tens of minutes.

These overtones are implied by natural repetitive sources; inter-glacial asperities among cryosphere environment. These harmonic tremors could be generated by collision mechanism between icebergs and sea-ices, otherwise those between icebergs and oceanic bottom (oceanic floor) of the Bay.

In this presentation, source locations both for the seismic tremors and infrasound events independently determined were compared with discussion about their source origins.



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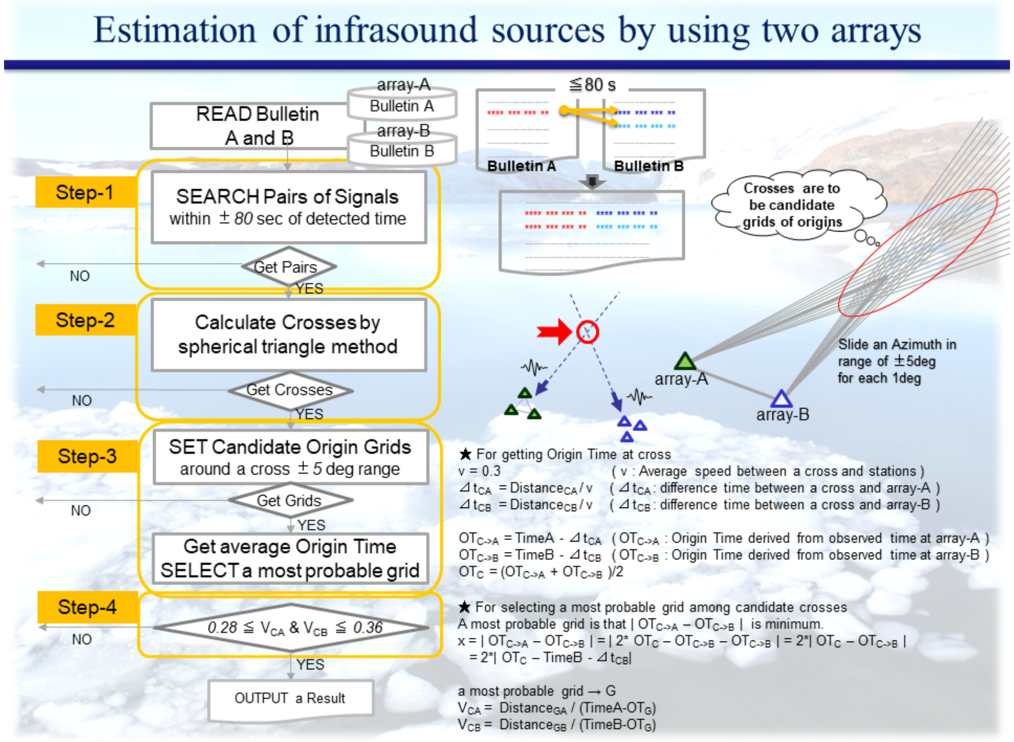
METHODS

Detection and classification of seismic tremors were conducted on the bases of waveform features and timeline variation of the detected events. The seismic tremors were determined as the events with non-clear arrivals for P and S waves within 5 minutes of the duration-times.

430 tremors were identified during 2013-2015. These tremors were classified into three types; A) Long duration ones (over ten thousand of seconds) having small amplitudes; B) Dominant frequency variations non-linear trends over the wavelets; C) Dominant frequency gradually decreasing with overtone characteristics.

On the contrary, infrasound source locations were also determined by combining two arrays deployed in LHB by using the PMCC method as shown in this panel.



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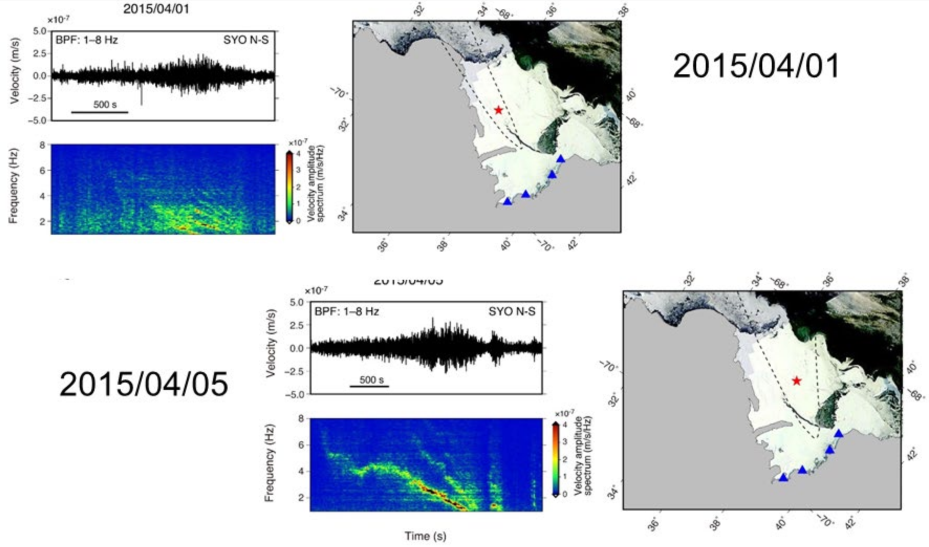
RESULTS

Source location estimation for two ice-tremor events (type C) on 1 April and 5 April, 2015 (after Tanaka et al., 2018). Upper-left panels for each figure correspond to waveforms and spectrograms at SYO. Upper-right panels indicate red stars for which represent source locations of the detected events.

The areas enclosed by dashed lines are the 95% confidence areas for estimation of the occurring locations; the blue triangles represent seismic stations utilized for the determination of locating seismic source points.

Both the source locations were determined inside LHB, where a significant volume of sea-ice was discharged caused by the collision of drifted large icebergs together with the effects on injection of warm water produced by coastal ocean current toward the LHB.

Hypocenters of type C events: Tremors with harmonic overtones



TANAKA Yuya; HIRAMATSU Yoshihiro; ISHIHARA Yoshiaki; KANAO Masaki
(Polar Science, 2018)

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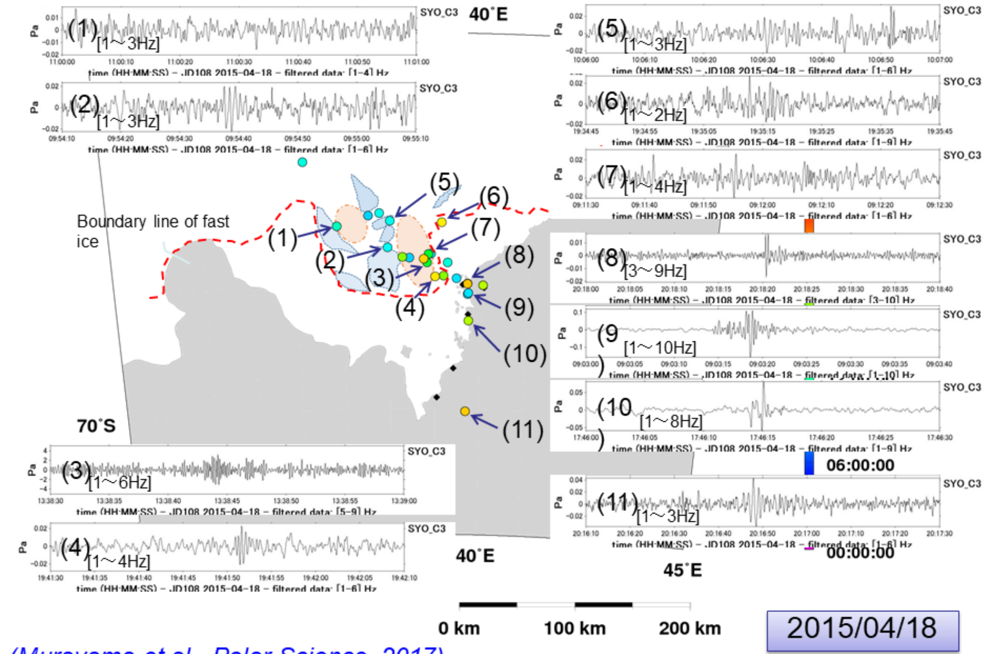
RESULTS

Infrasound arrays cleared temporal changes in frequency context and propagation back azimuth from the source events in April 2015 (Murayama et al., 2017). Majority of sources had frequency contents of a few Hz. Since the “microbaroms” from ocean have 0.2 dominant frequency contents, most events are supposed to be cryosphere origin around LHB.

By comparison with MODIS images, excitation sources were considered involving features depending on sources. Relatively low-frequency contents of a few Hz from Bay orientation represent the events associated with discharge of sea-ice, laming/collisions signals between fragmentation of sea-ices and icebergs. In contrast, events with higher-frequency contents of 5-10 Hz came from coastal area by existing glaciers and ice-streams.

Waveform examples for detected events (1 min. of data)



(Murayama et al., Polar Science, 2017)

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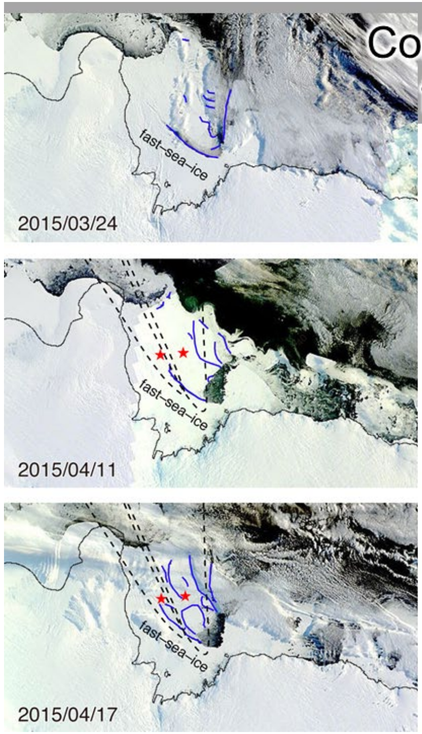
RESULTS

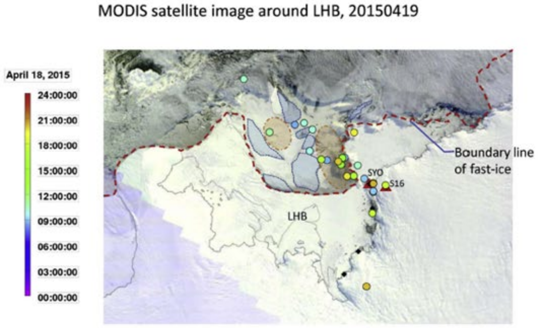
Compared with estimated source locations of infrasound excitation by two arrays in LHB on April, 2015 overlapping on MODIS image, two ice-tremor events (type C; Tanaka et al., 2018) have different wavelet features.

For instance, seismic tremors with harmonic overtones have larger energy. On the contrary, infrasound sources have smaller energy with predominant frequency contents of few Hz. Source locations determined by both seismic and infrasound arrays are also identified as the different positions to each other.

That is, at the northern edges of fast-sea-ices in LHB for seismic harmonic tremors, in contrast, an open-sea area with the mixture by fragmentation of sea-ices, icebergs in the middle of LHB for infrasound source locations, respectively.



Comparison of source locations from seismic & infrasound



(Murayama et al., Polar Science, 2017)

2015 April; large sea-ice discharge events

Short period (1–10 Hz) infrasound sources are similar to those by seismic hypocenters

(Tanaka et al., Polar Science, 2018)

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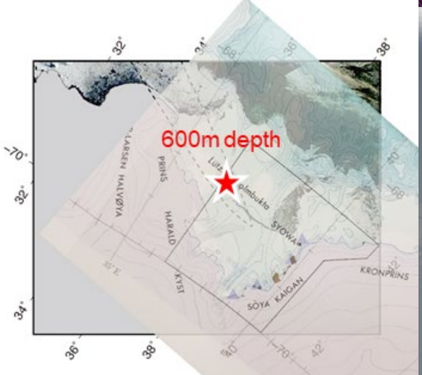
CONCLUSIONS

- ✓ Hypocenters of harmonic seismic tremors are determined around 600m depth in bathymetry image (caused by the same iceberg?)
- ✓ This suggests that the source origin of these tremors might be involved in collision between the roots(bottoms) of drifting iceberg(s) and the top of ocean-floor of the Bay.
- ✓ The locations indicate that the collision places are the northern edges of continental shelf in LHB.
- ✓ Further investigation for detecting detail image of ocean floor topography will be necessary by using multi-narrow beam system, etc..
- ✓ Synthetic modelling of seismic wave propagation by assuming collision mechanism is required.



2015/04/01 event

2015/04/05 event