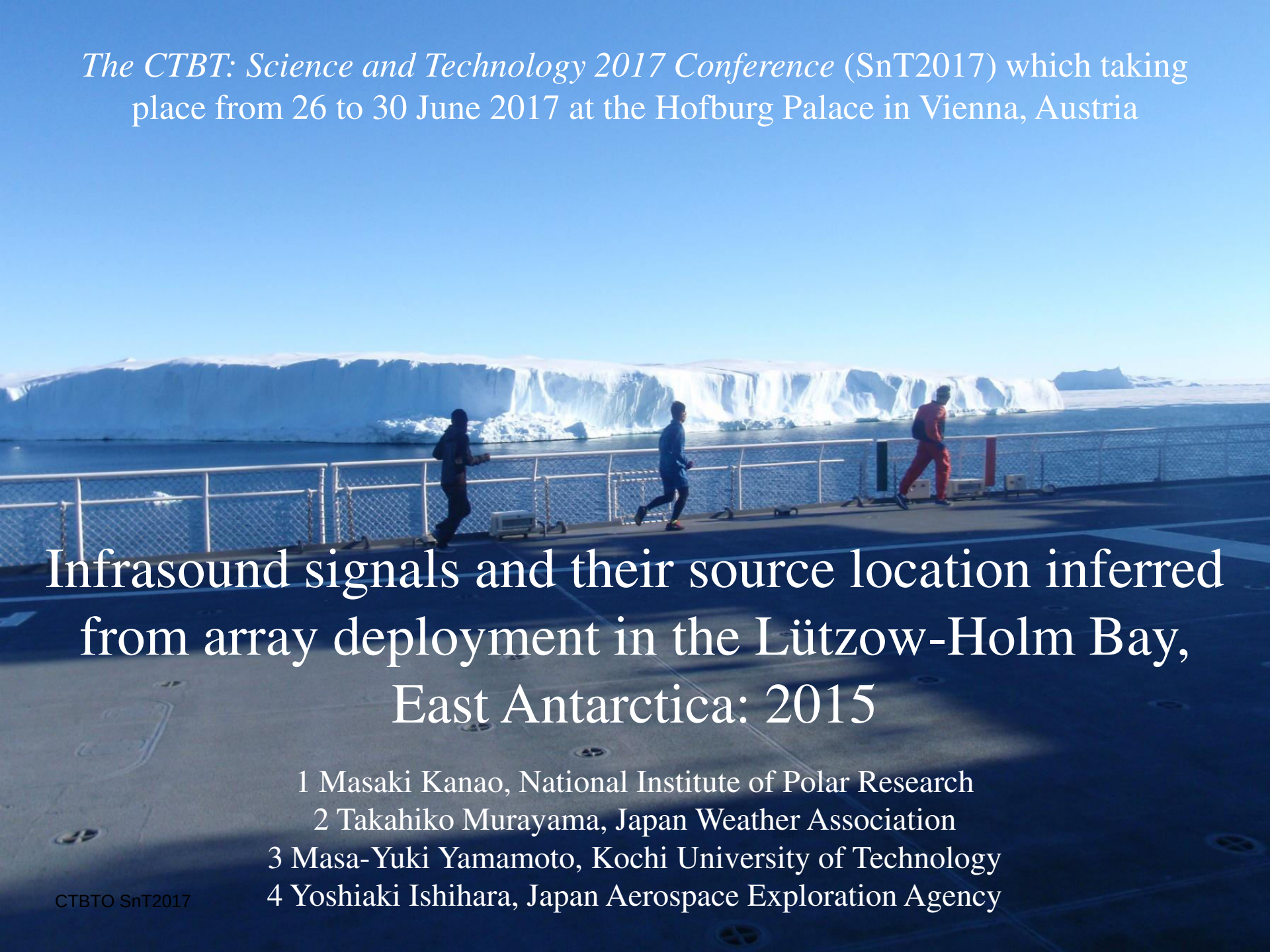
The CTBT: Science and Technology 2017 Conference (SnT2017) which taking place from 26 to 30 June 2017 at the Hofburg Palace in Vienna, Austria



Infrasound signals and their source location inferred from array deployment in the Lützow-Holm Bay, East Antarctica: 2015

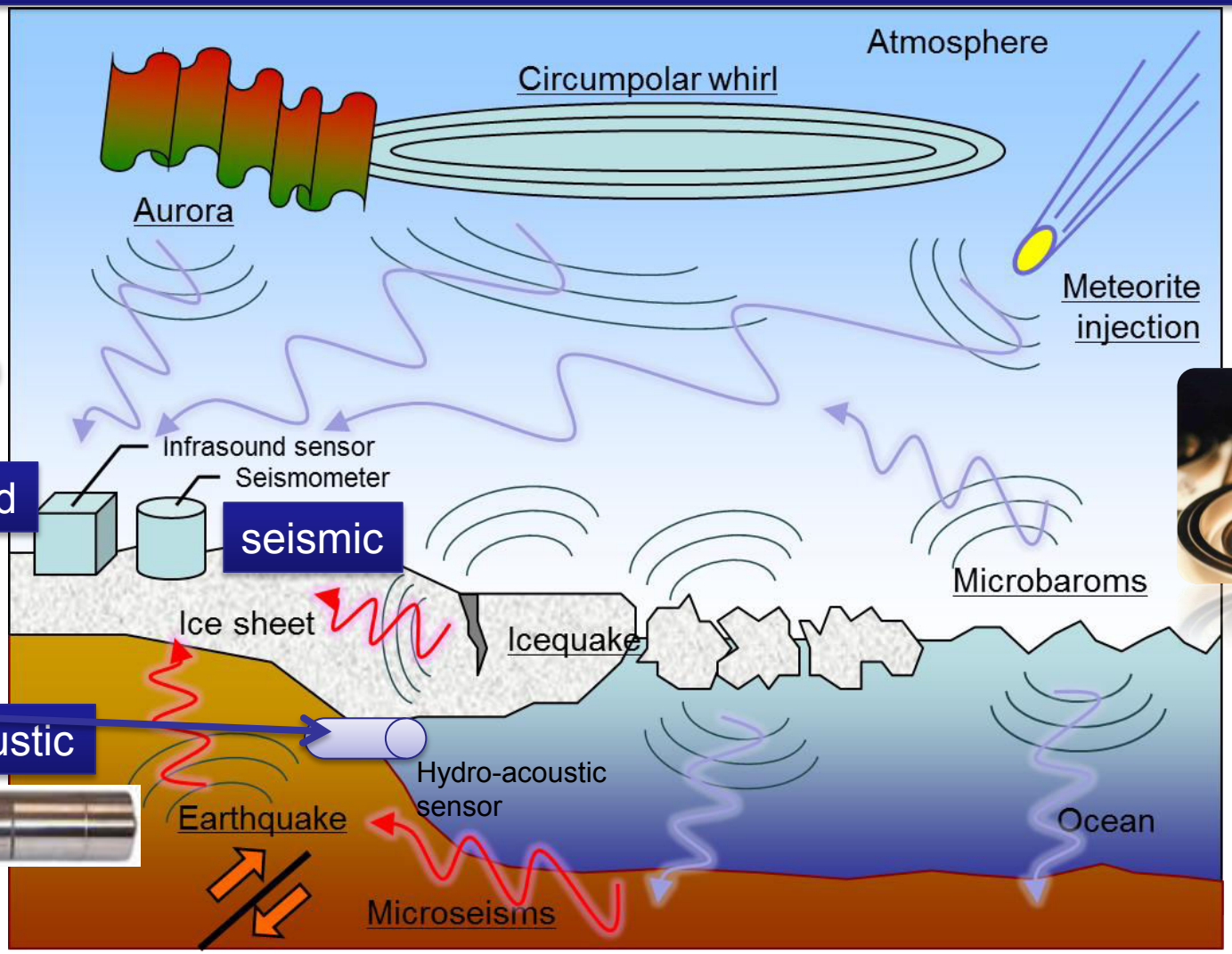
1 Masaki Kanao, National Institute of Polar Research
2 Takahiko Murayama, Japan Weather Association
3 Masa-Yuki Yamamoto, Kochi University of Technology
4 Yoshiaki Ishihara, Japan Aerospace Exploration Agency

Abstract

Characteristic features of infrasound waves observed in the Antarctic represent a physical interaction relating to the surface environment in the continental margin and surrounding Southern Ocean. Source location of several infrasound events are demonstrated using a combination of two array deployments along the coast of the Lützow-Holm Bay (LHB), East Antarctica, for the period January - June 2015.

These infrasound arrays established during January 2013 clearly detected temporal variations in frequency content and propagation direction of the seven large events identified. Many of these sources are assumed to have cryoseismic origins by comparison with the MODIS satellite data such as ice-quakes associated with calving of glaciers, discharge of sea-ice, collision between sea-ice and icebergs around the LHB. Moreover, several notable infrasound waves are recorded by locally originating signals contaminated with high-frequency content, which may include regional earthquakes. Detailed and continuous measurements of infrasound waves in the Antarctic is a proxy for monitoring regional surface environmental variation as well as temporal climate change in high southern latitudes.

Inter-disciplinary physical phenomena within the multi-spheres in the polar regions



infrasound



seismic



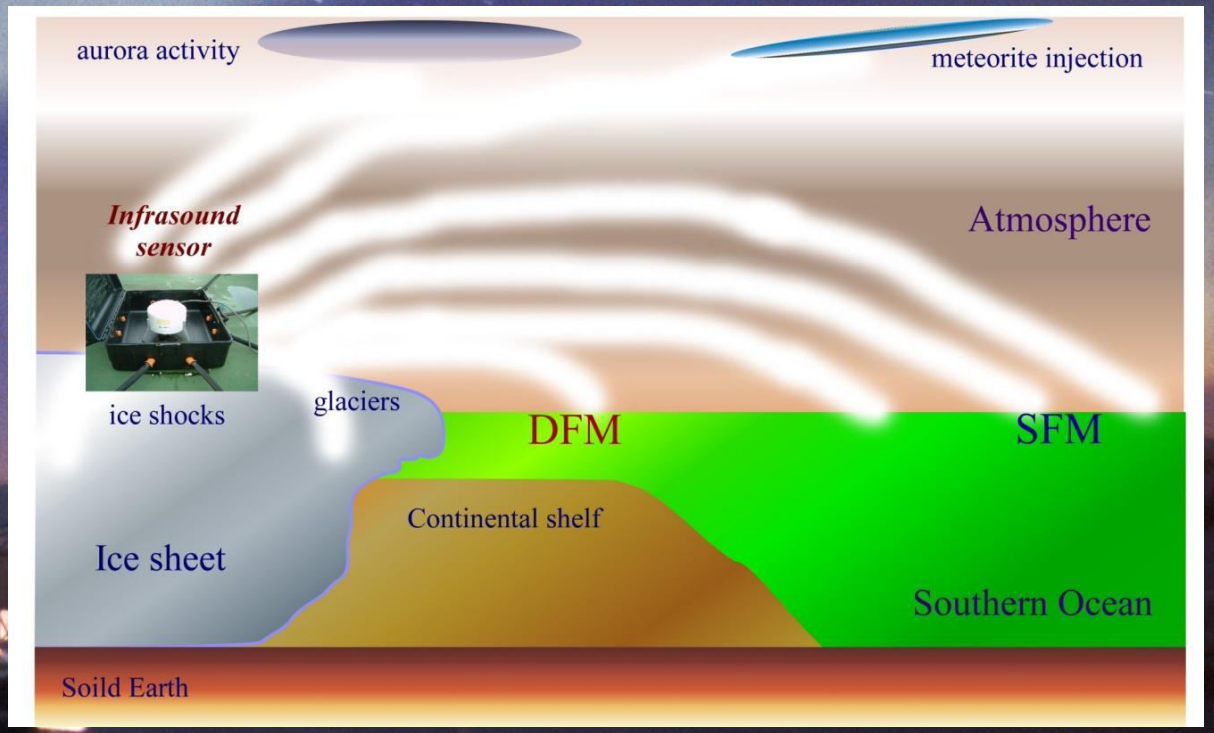
Hydro-acoustic



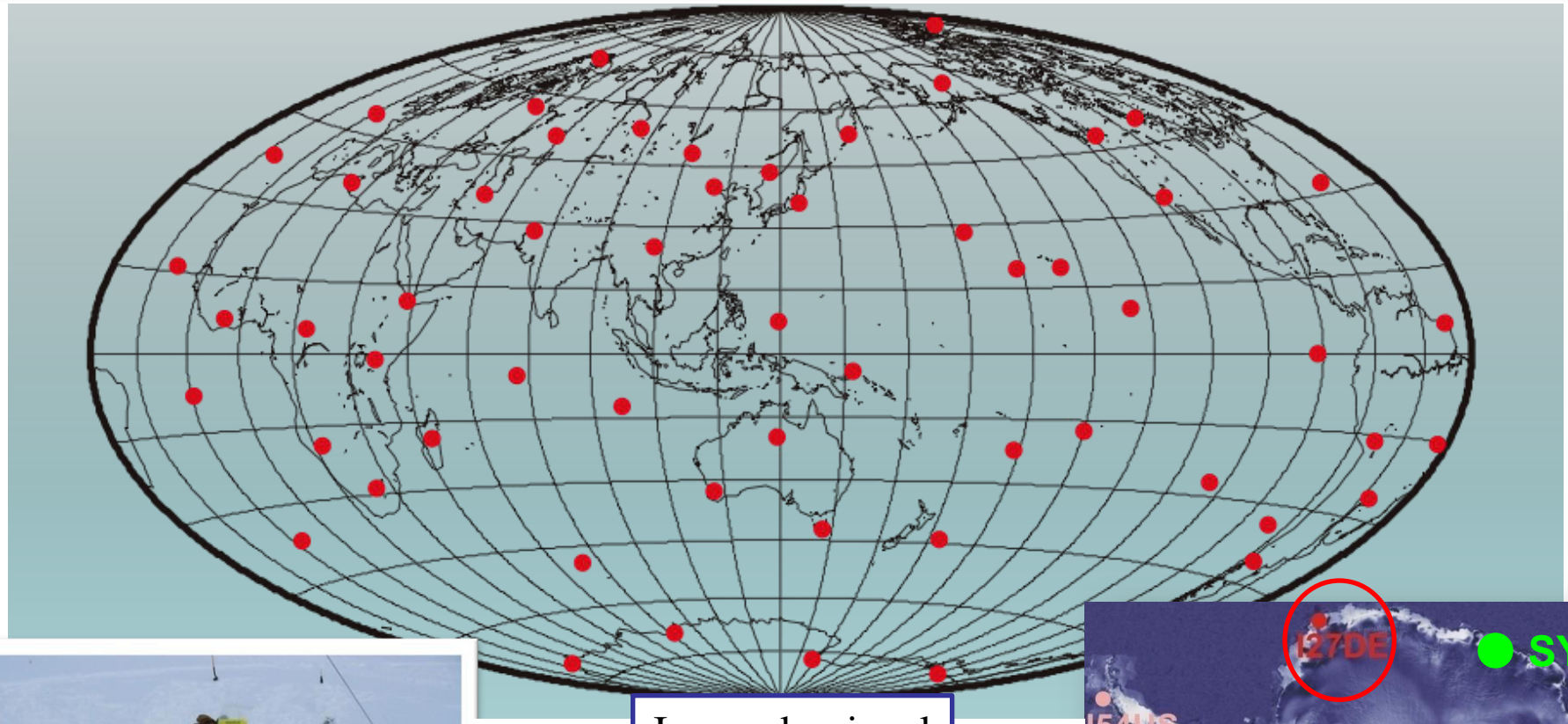
- Several kind of seismic, infrasonic & hydro-acoustic waves generate from various surface environmental sources have been detecting, indicating time-space variations in polar regions

Infrasound Monitoring in the Antarctic

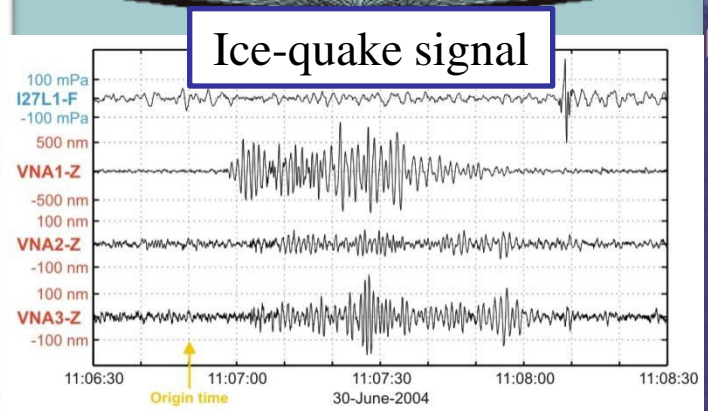
- Seismic waves, Tsunami waves
- Volcanic explosions
- Sunder, Sprite
- Huge volume of clouds
- Oceanic waves,
- Microbaroms
- Meteoroid injection shock waves
- Large ice-quakes
- Aurora shock waves
- & others …

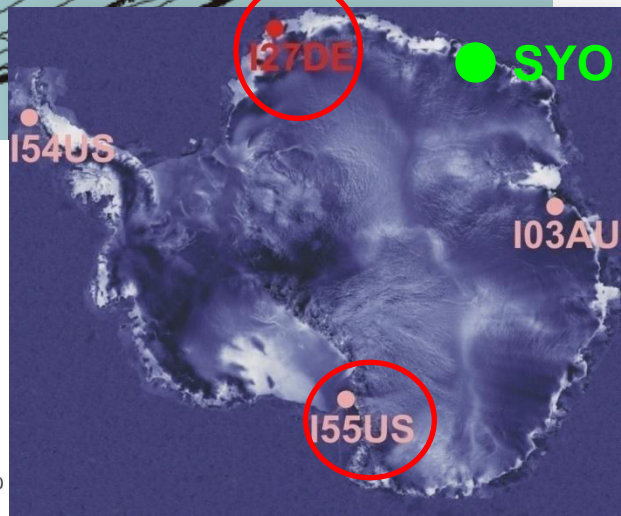


Comprehensive Nuclear Test-Ban Treaty Organization (CTBTO)







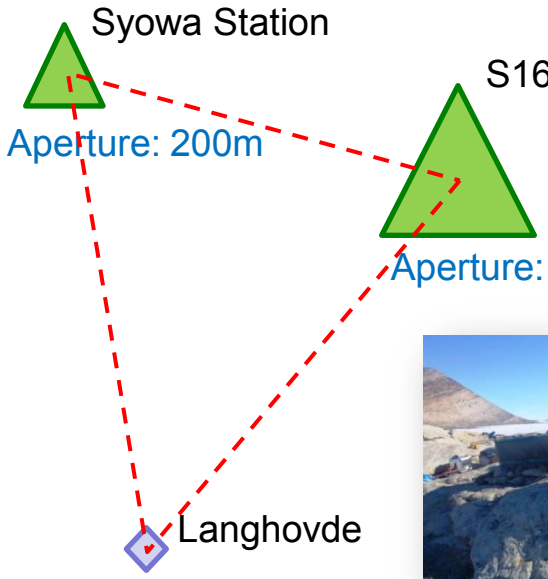


Infrasound & seismic array observations in LHB

Strategy for localization of signals and extensive observation

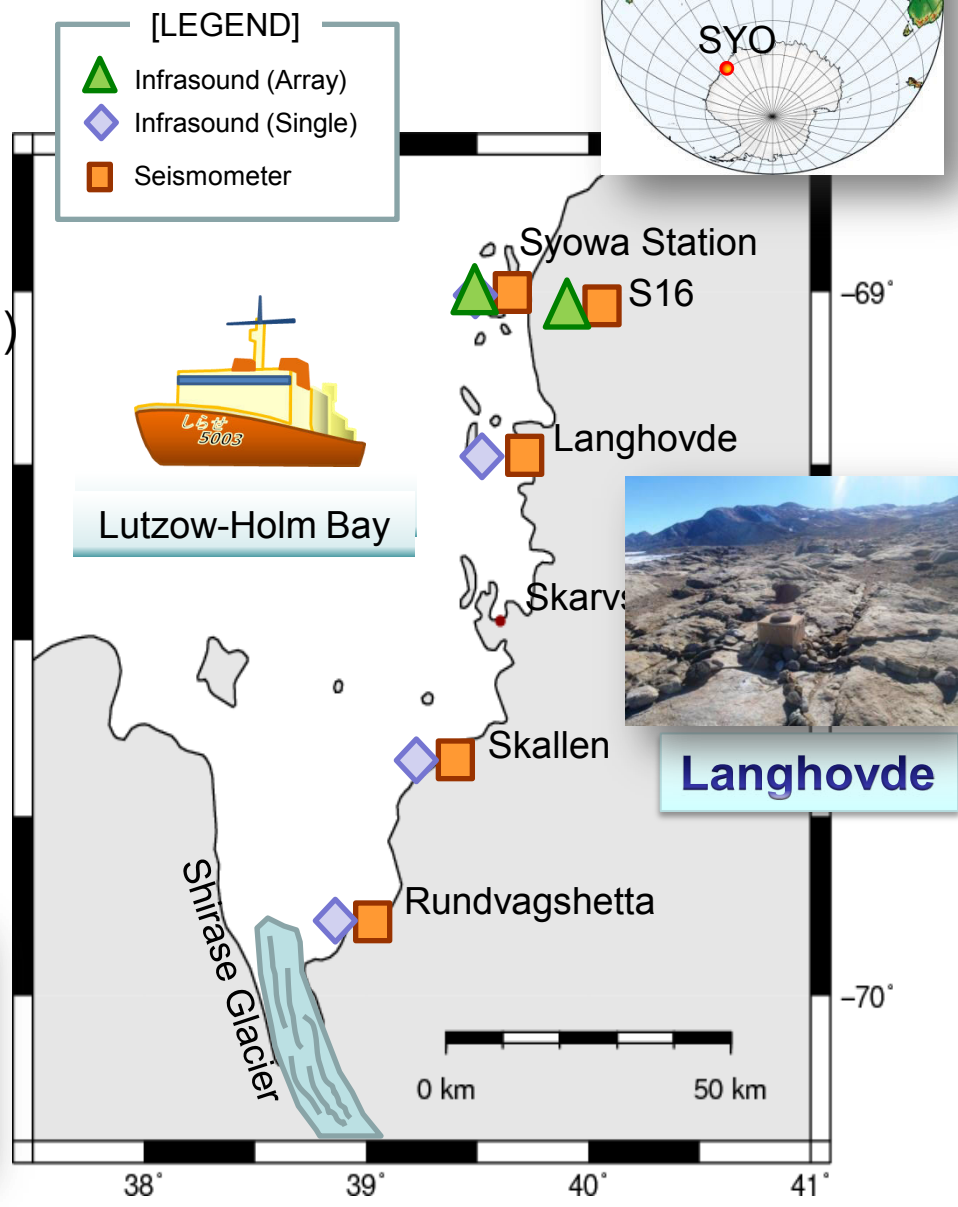
- Tripartite array observation (Small, Medium, and Large sizes)
- Parallel observation (seismic / infrasound)
- Visual observation (using video camera)

Array size



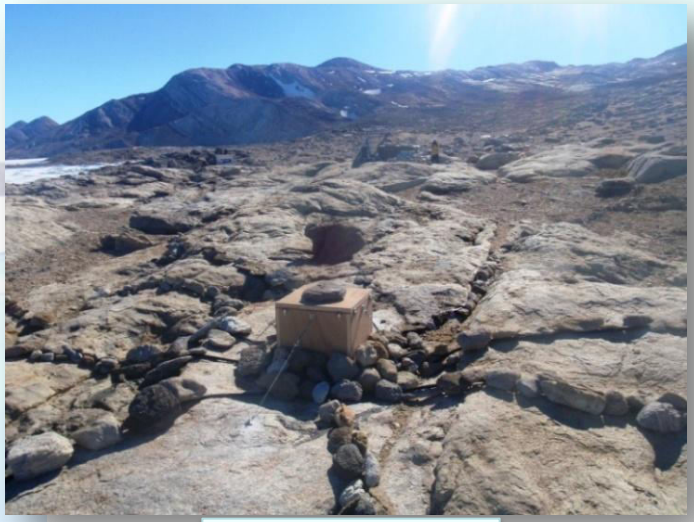


Langhovde



Langhovde

Field station image of seismic & infrasound observations



Langhovde



MOBOTIX
M24

Video camera

Solar panel

GPS antenna

External
battery box

Equipments
box

Seismometer
box

Signal / Power cable
(40m)

Porous hose
(30m)

Infrasound
sensor box

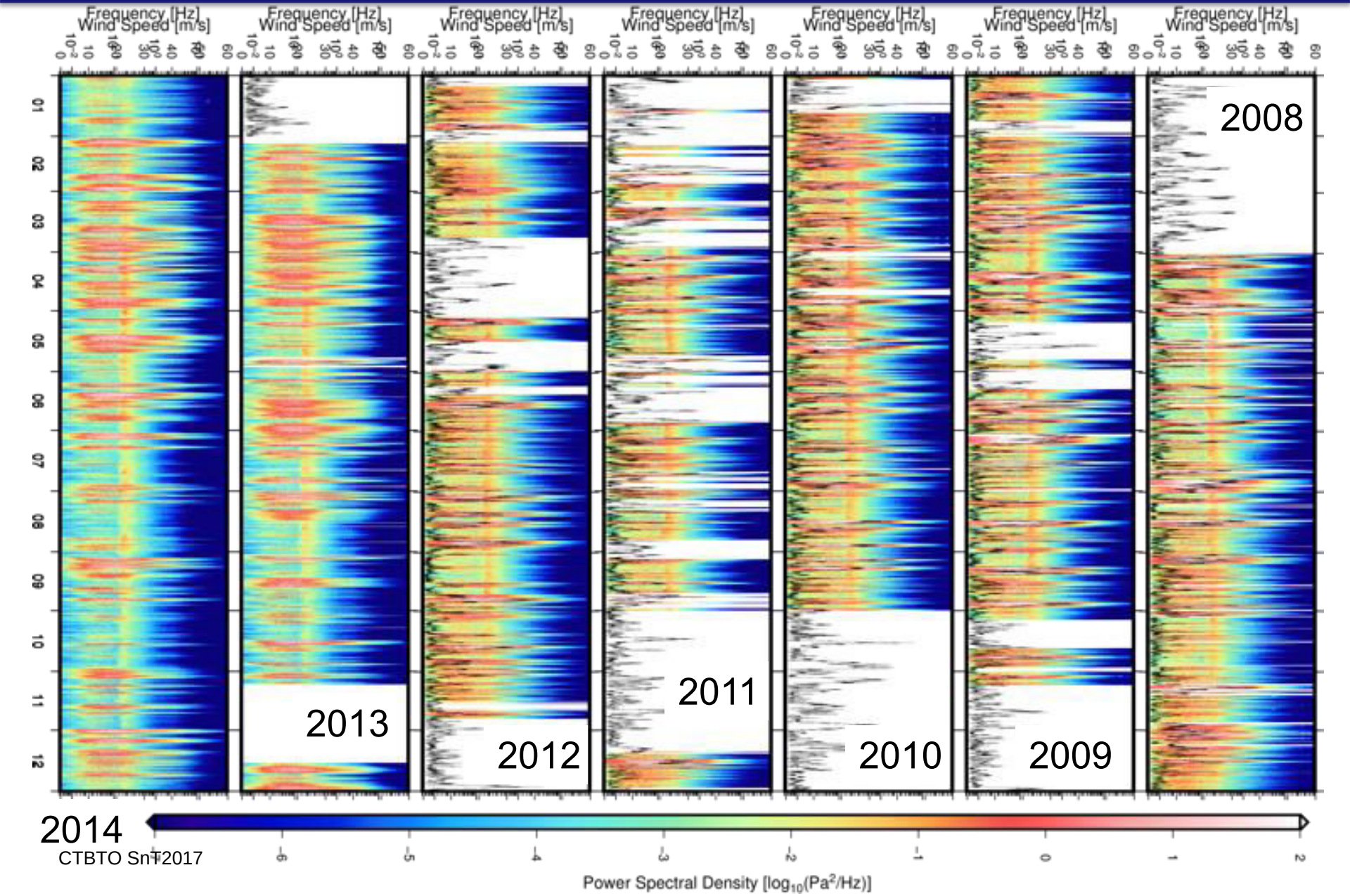




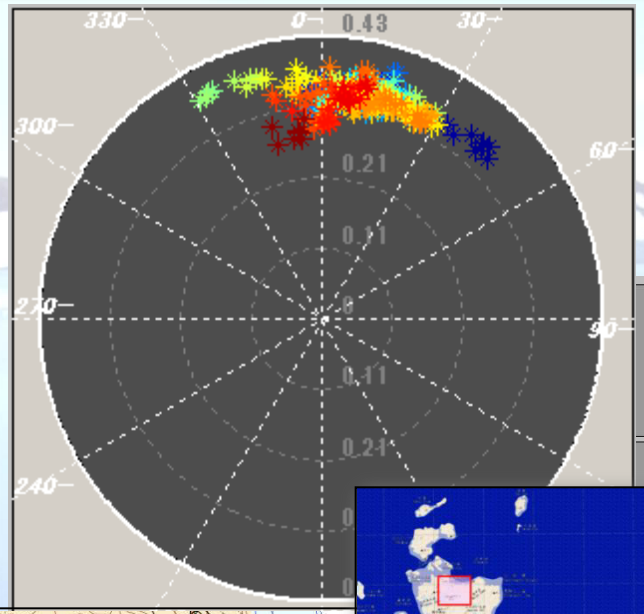


Infrasound Spectrum at Syowa, 2008-2014

+ JMA wind data



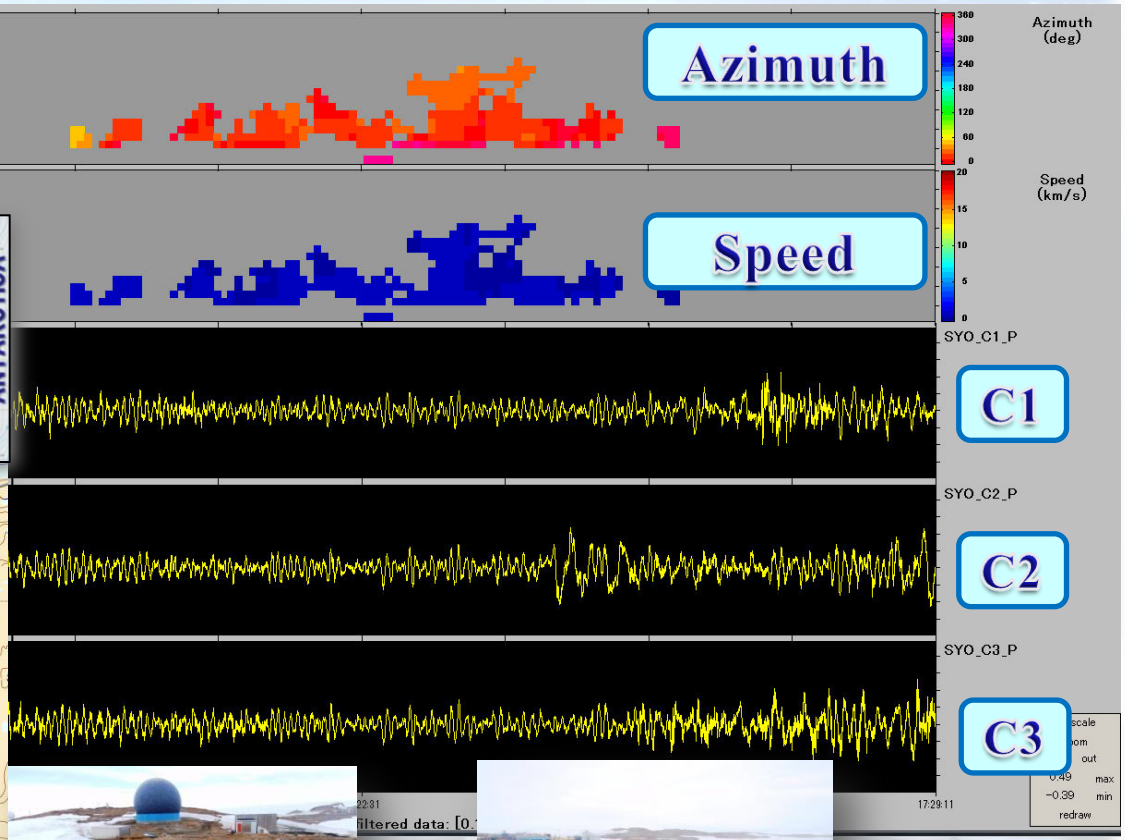
What's the origins of coherent wavelets in 0.2Hz ?

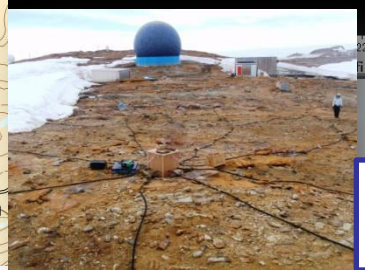


Microbaroms propagated from the Southern Ocean

15 min. data





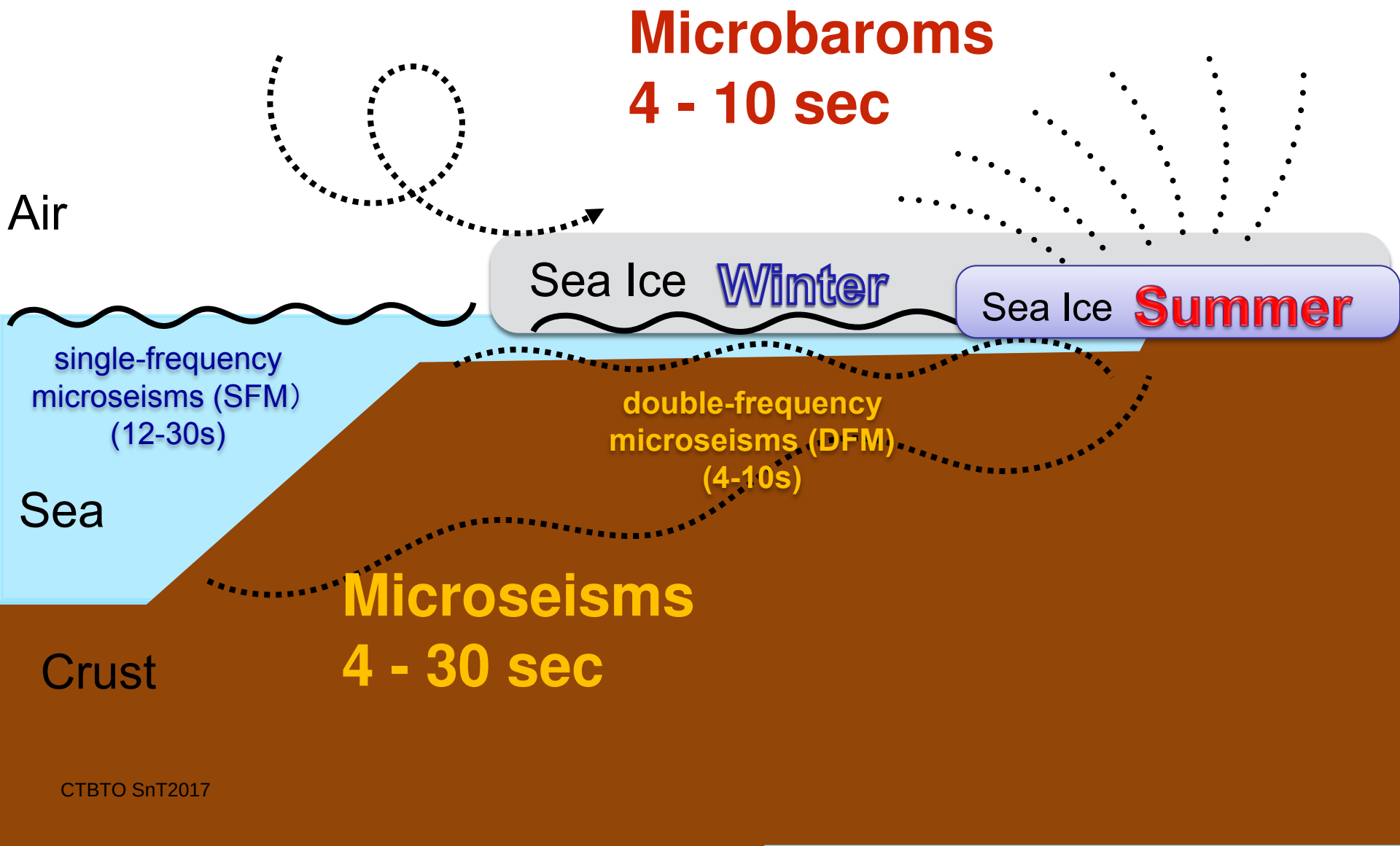


C1

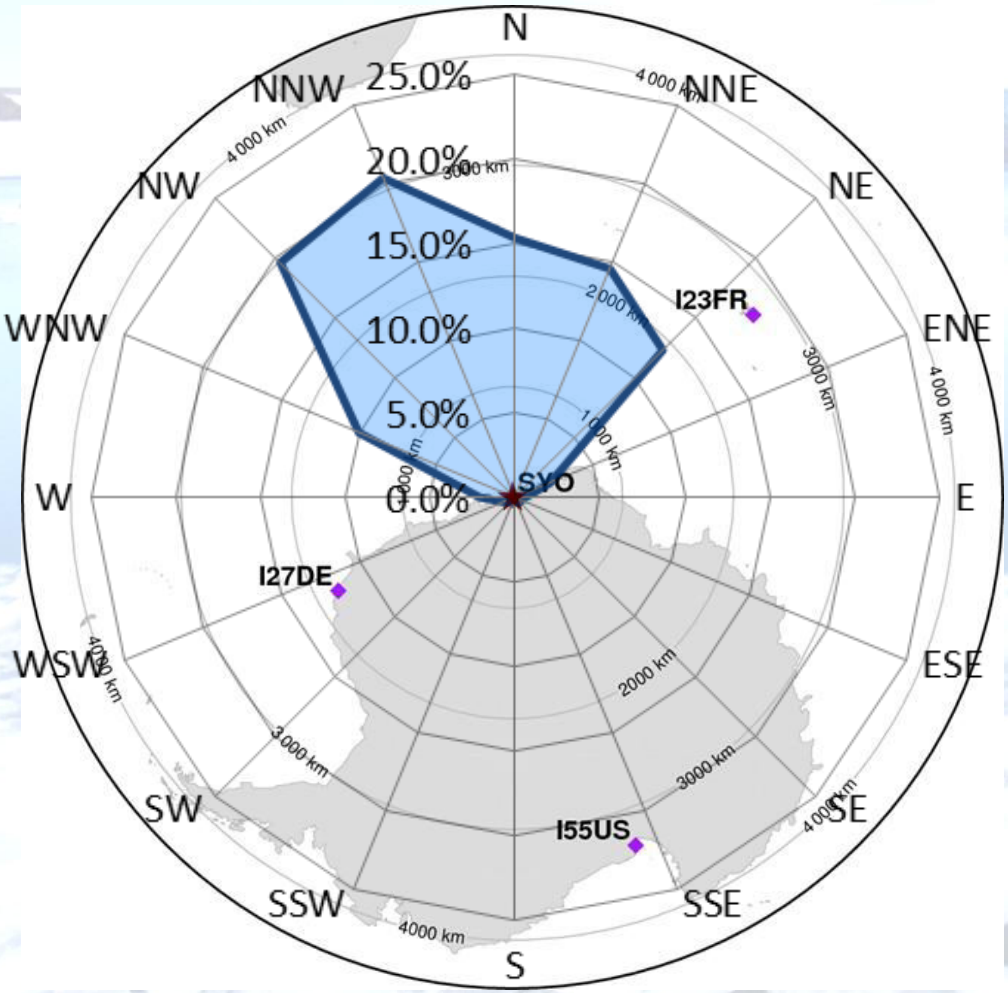


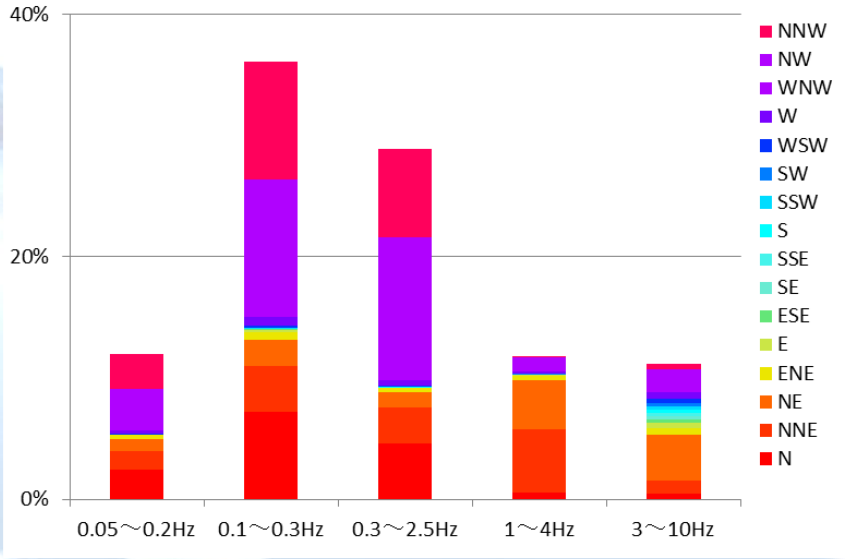
C2

Atmosphere-Ocean-Solid Earth Interactions



Occurrence rate (%) of detected predominant signals at SYO from 10 February to 31 March, 2013



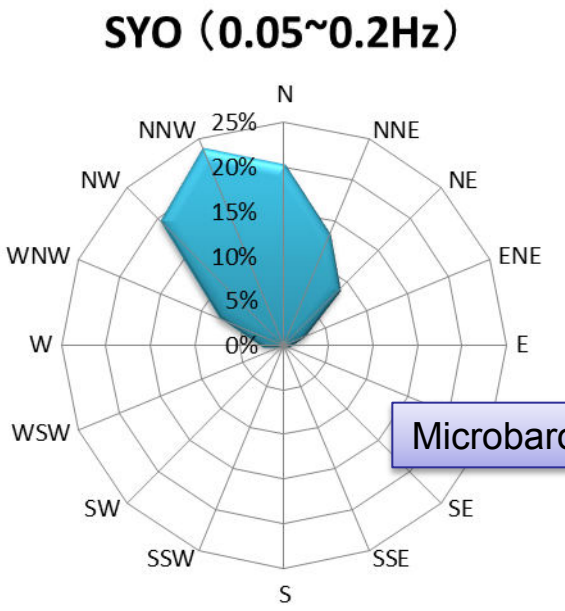


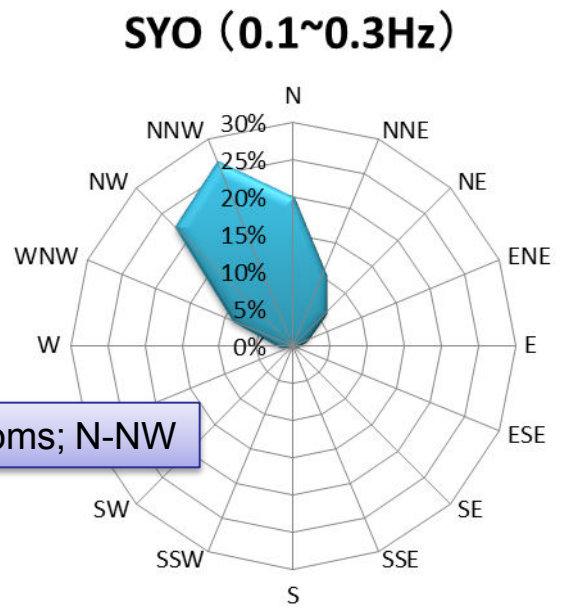
Occurrence rate (%) of the detected predominant signals by different frequency ranges & azimuths

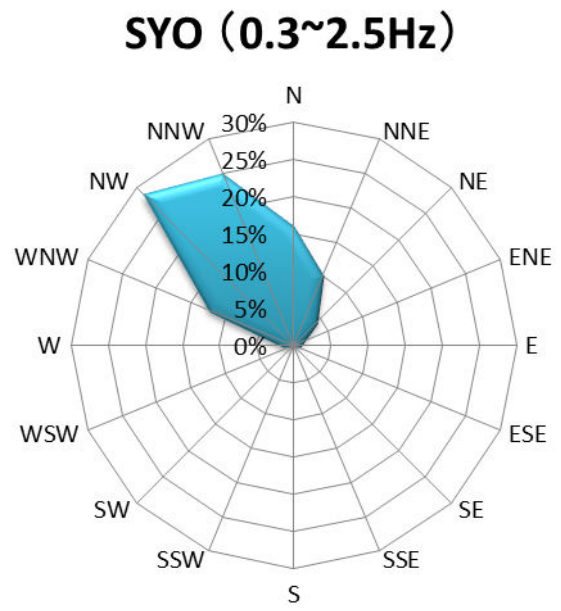
Occurrence rate (%) of the detected predominant signals at SYO from 10 February to 31 March, 2013; left) the polar plot of all frequency bands. right) the histogram of the five frequency bands, shown by different colors for each directions.

Murayama et al., 2014. Infrasound Array Observations in Lützow-Holm Bay, East Antarctica, *Polar Science,* 10.1016/j.polar.2014.07.005.

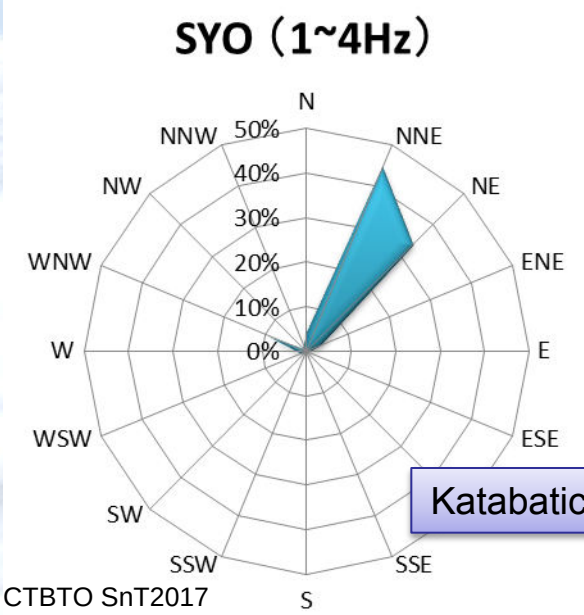
Infrasound source arrivals in different azimuths

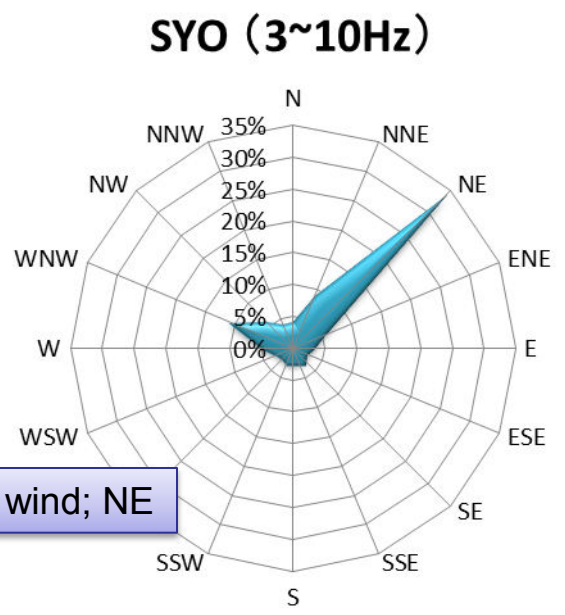






Microbaroms; N-NW





Katabatic wind; NE

10 Feb. - 31 March, 2013

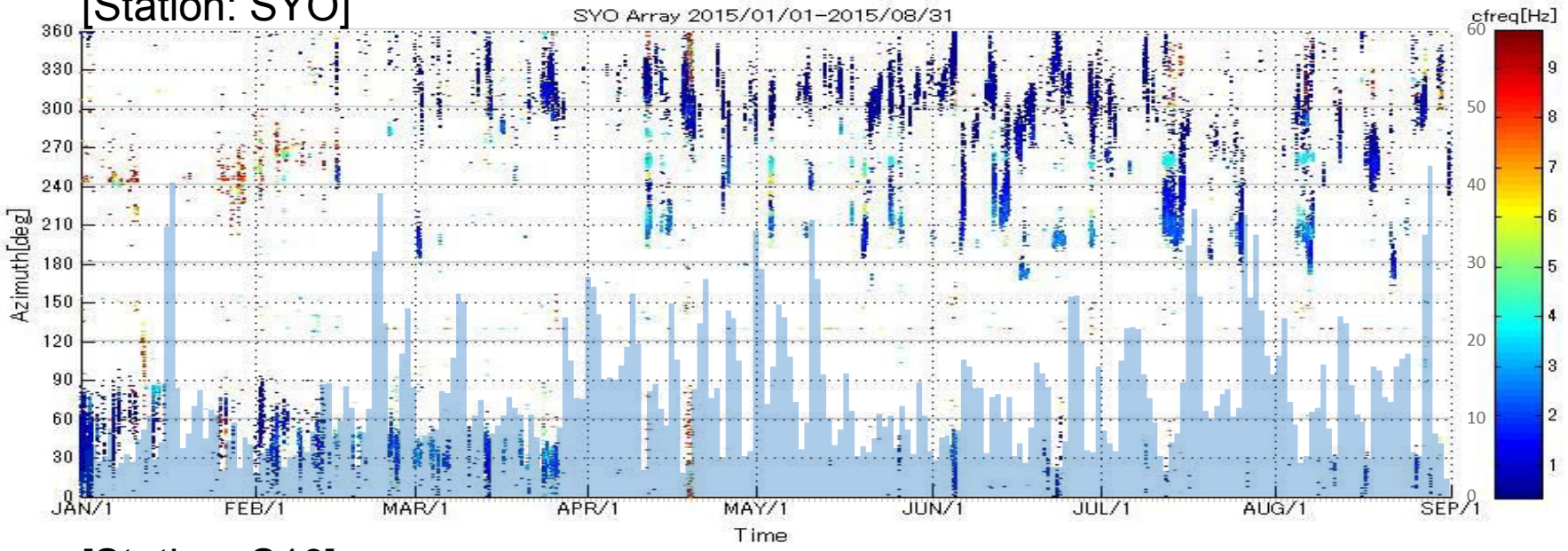
Occurrence rate (%) of the detected predominant signals by different frequency ranges & azimuths

Murayama et al., 2014
Polar Science,
10.1016/j.polar.2014.07.005.

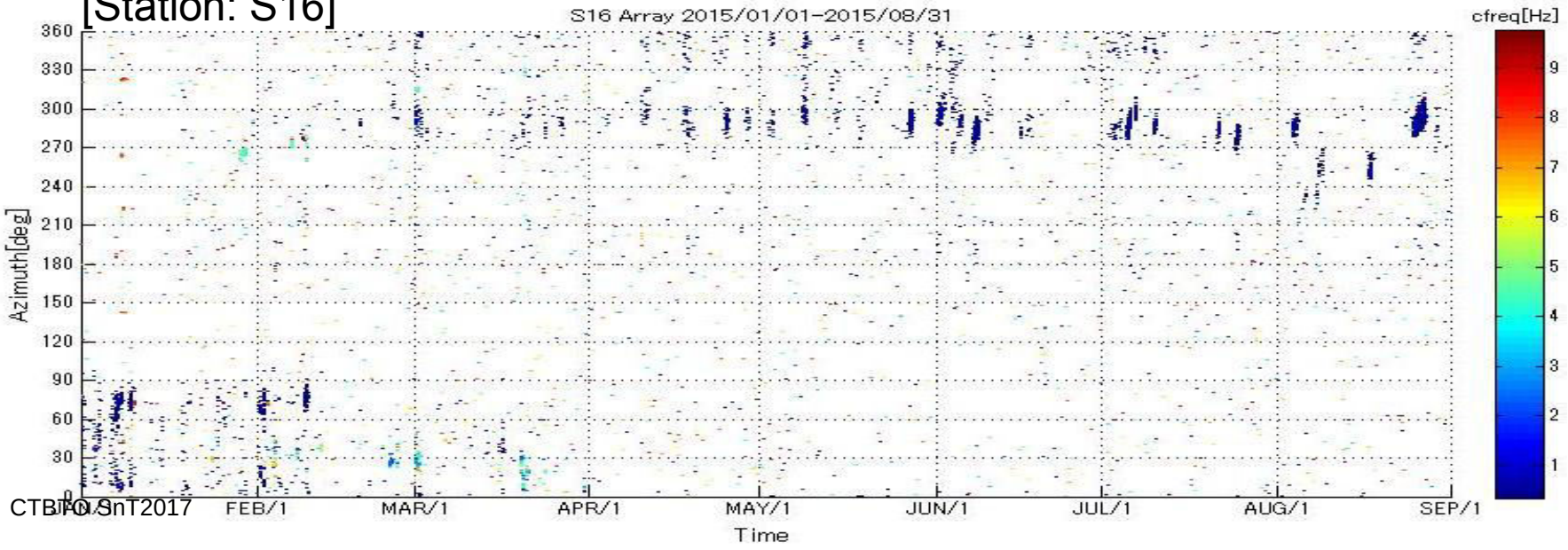
Signals detected by PMCC (2015/01/01-2015/08/31)

+ wind speed data

[Station: SYO]



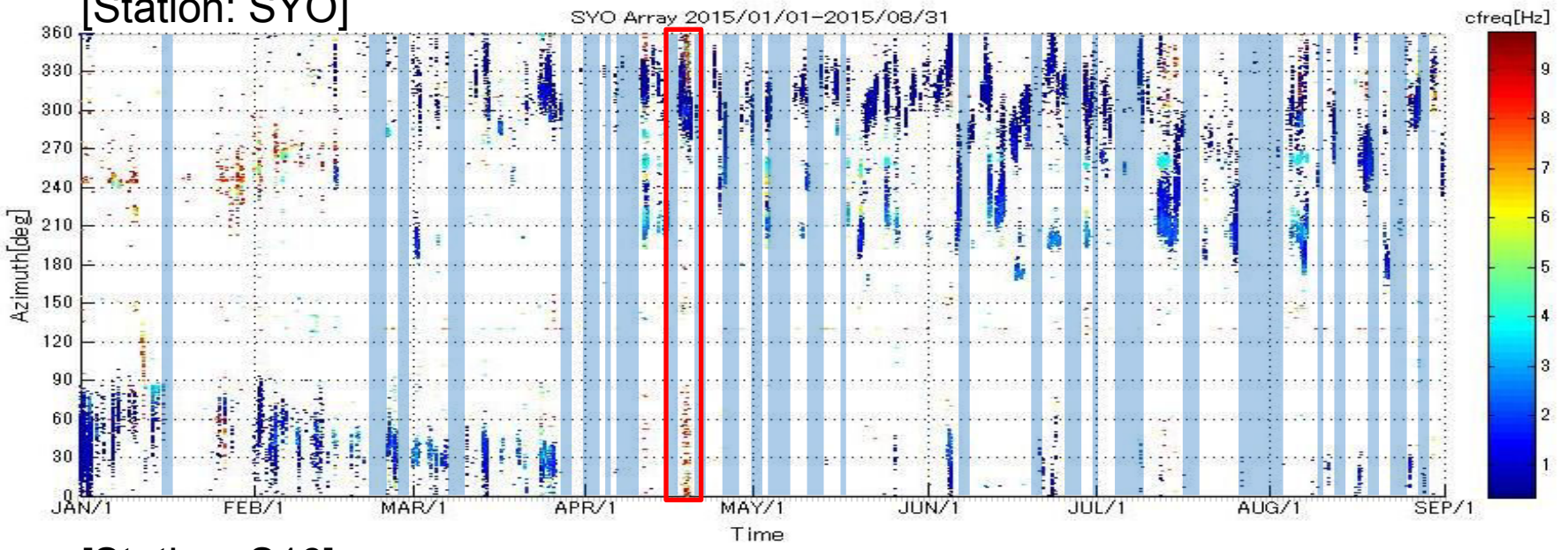
[Station: S16]



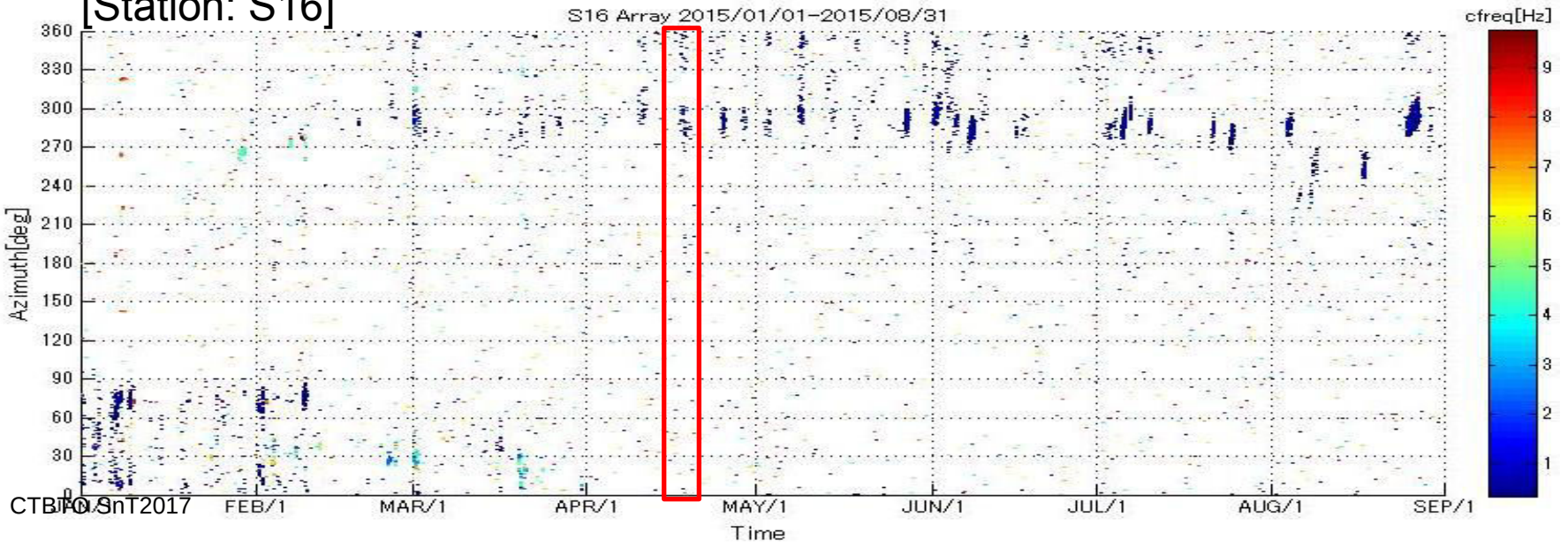
Signals detected by PMCC (2015/01/01-2015/08/31)

wind speed over 15 m/s

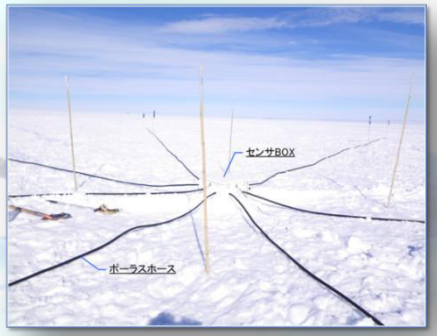
[Station: SYO]

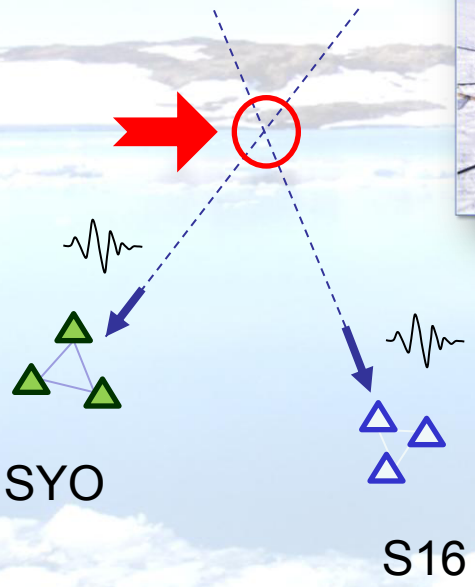


[Station: S16]



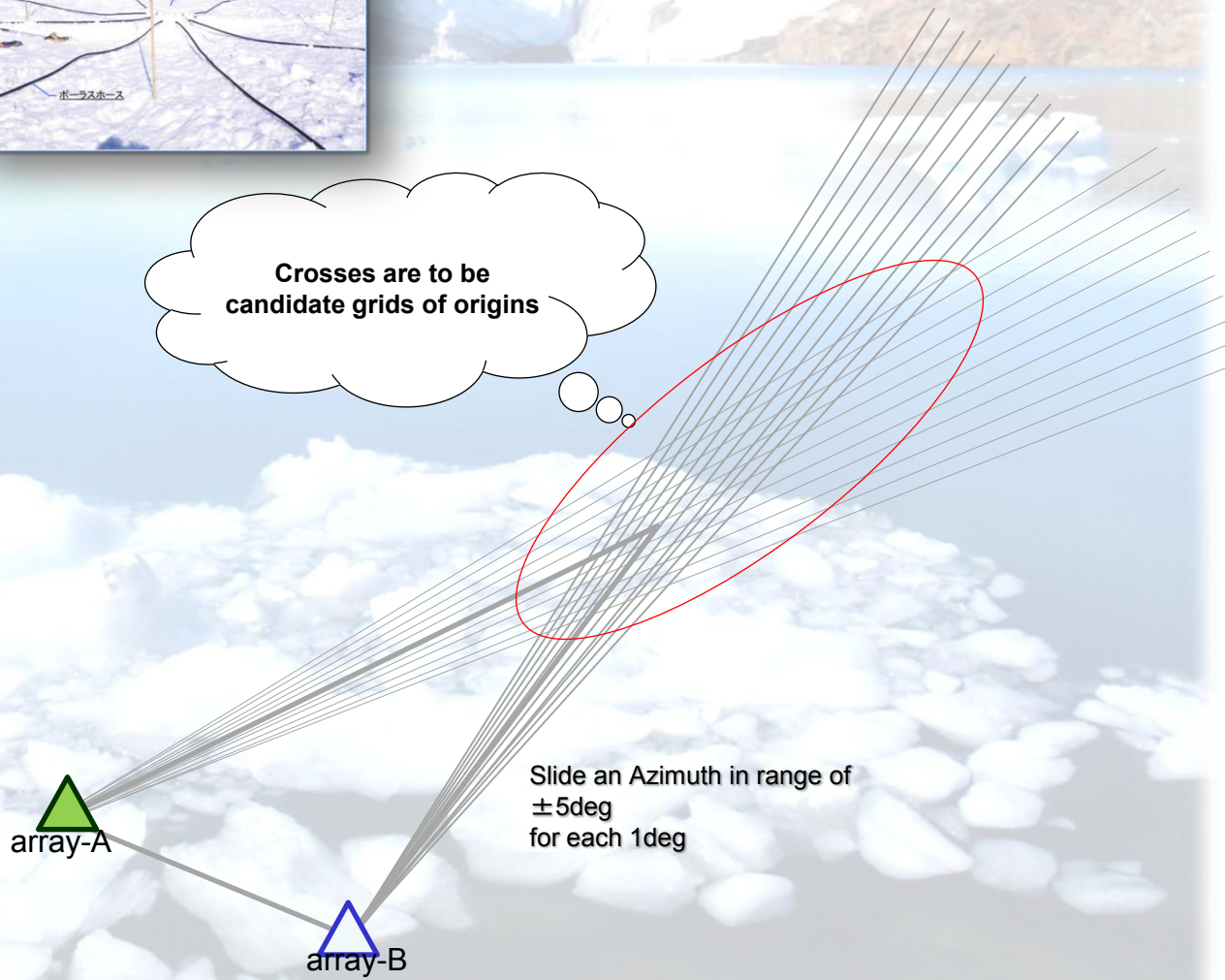
Estimation of infrasound sources by using two arrays



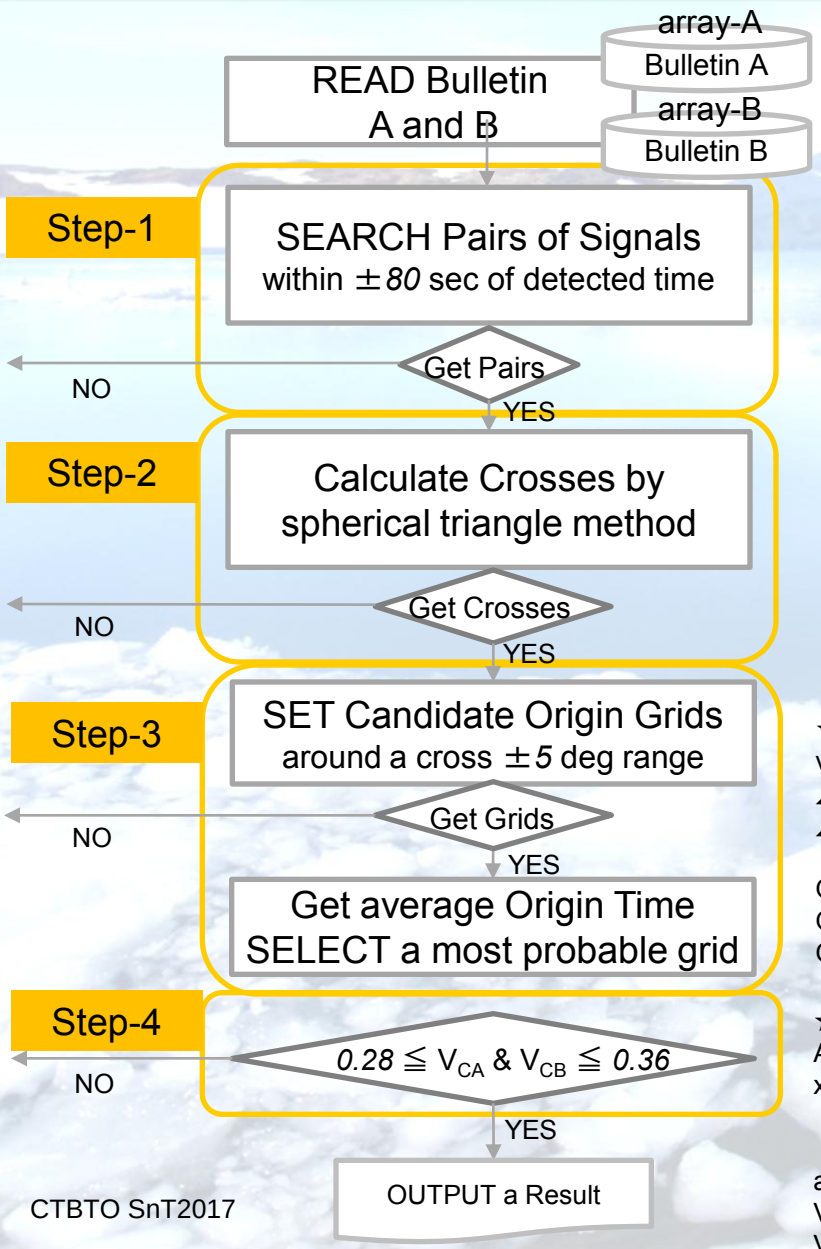


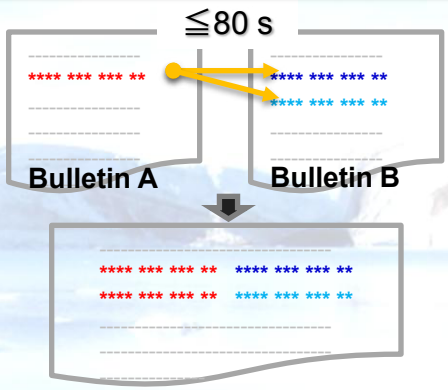
Crosses are to be candidate grids of origins

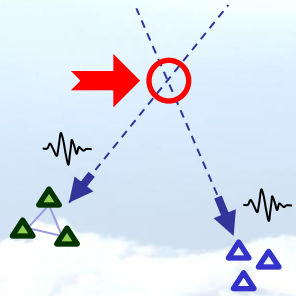


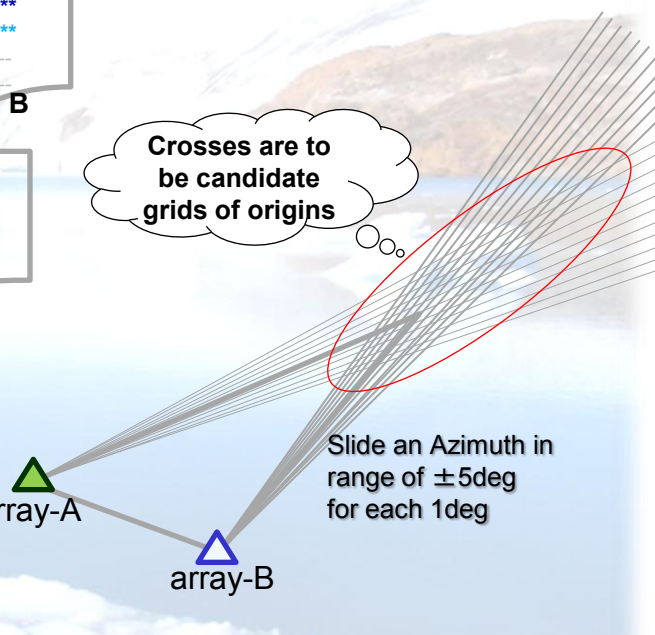


Method for estimating source origin









★ For getting Origin Time at cross

v = 0.3 (v : Average speed between a cross and stations)

Δt_{CA} = Distance$_{CA}$ / v (Δt_{CA} : difference time between a cross and array-A)

Δt_{CB} = Distance$_{CB}$ / v (Δt_{CB} : difference time between a cross and array-B)

$OT_{C->A}$ = TimeA - Δt_{CA} ($OT_{C->A}$: Origin Time derived from observed time at array-A)

$OT_{C->B}$ = TimeB - Δt_{CB} ($OT_{C->B}$: Origin Time derived from observed time at array-B)

$OT_C = (OT_{C->A} + OT_{C->B})/2$

★ For selecting a most probable grid among candidate crosses

A most probable grid is that $|OT_{C->A} - OT_{C->B}|$ is minimum.

$x = |OT_{C->A} - OT_{C->B}| = |2*OT_C - OT_{C->B} - OT_{C->B}| = 2*|OT_C - OT_{C->B}|$

$= 2*|OT_C - TimeB - \Delta t_{CB}|$

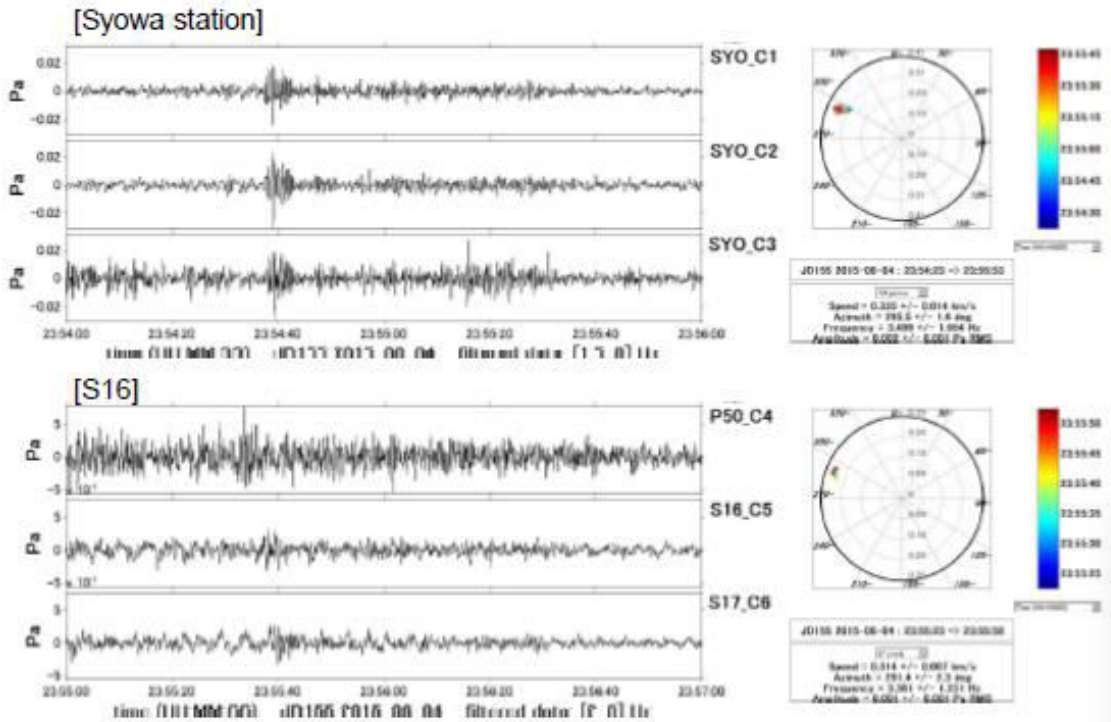
a most probable grid → G

V_{CA} = Distance$_{GA}$ / (TimeA-OT_G)

V_{CB} = Distance$_{GB}$ / (TimeB-OT_G)

Source location from infrasound arrays

- from the edge of fast-sea-ice ? -



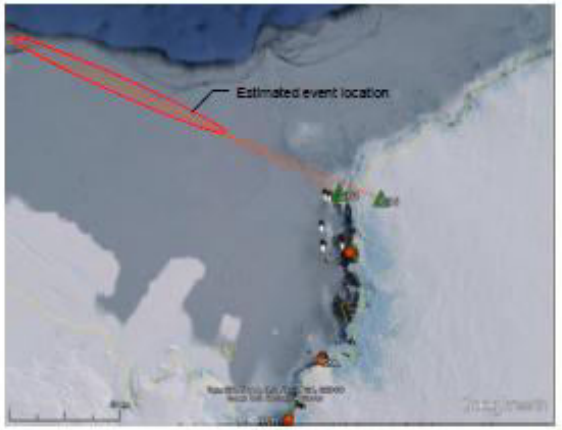


Fig.8 Detection of infrasonic signals generated by the calving of the iceberg in the Lütz
(forcasted origin time: 23:50h UTC). the left panels are band-pass-filtered waveforms o
The middle panels are results of the PMCC analysis. The diagram shows the backazim
apparent velocities. The right panel is regional map (Google) of the estimated event loc
of both the Syowa station and S16.

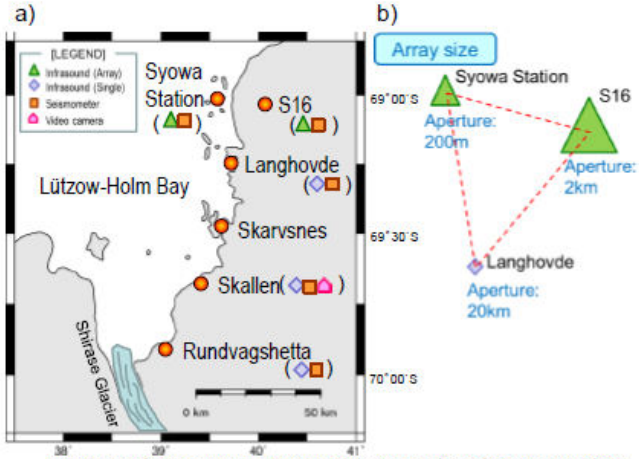
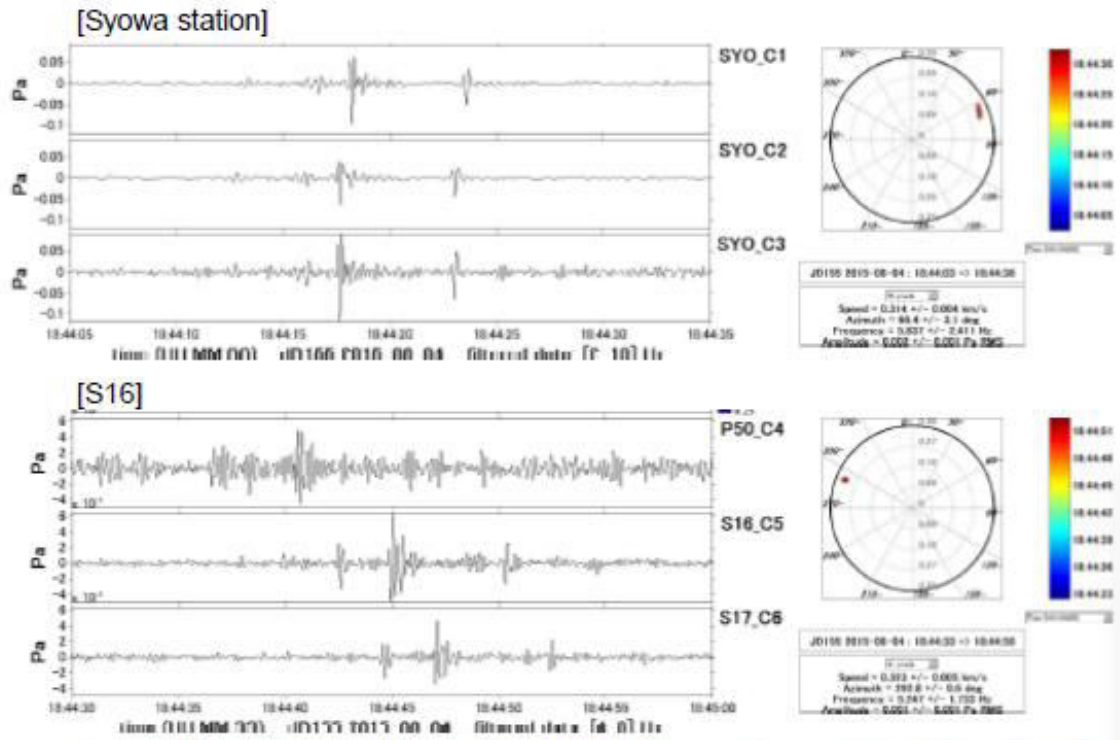


Fig.2 Locations and measurement elements of the observation network the Lützow-Holm Bay (LHB), East Antarctica.

Murayama, T., M. Kanao, M.-Y. Yamamoto and Y. Ishihara, Infrasound signals and their source location inferred from array deployment in the Lützow-Holm Bay region, East Antarctica: 2015 January - June, Inter. J. Geosci.. 8, 181-188, 2017

Source location from infrasound arrays

- Calving of ice-sheet, or glacier ? -



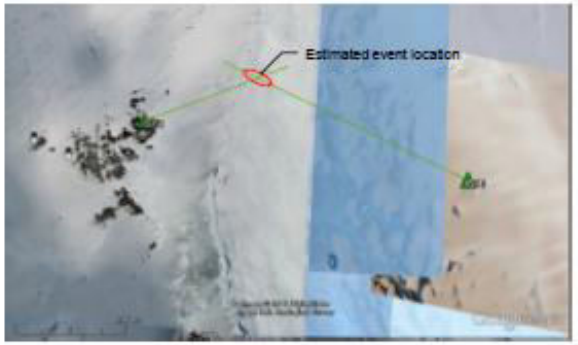


Fig.7 Detection of infrasonic signals generated by the calving of the ice sheet on June 4, the left panels are band-pass-filtered waveforms observed at the Syowa statin (SYO) an PMCC analysis. The diagram shows the backazimuth (station-to-source) direction and t regional map (Google) of the estimated event location. Lines show the backazimuth dire

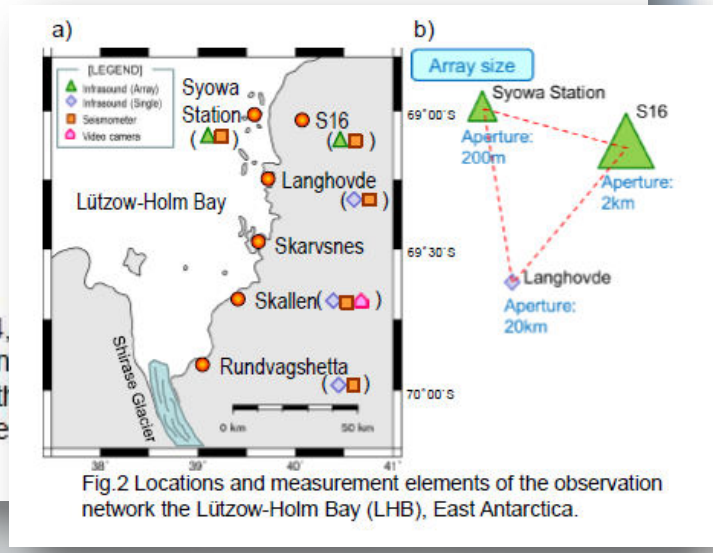
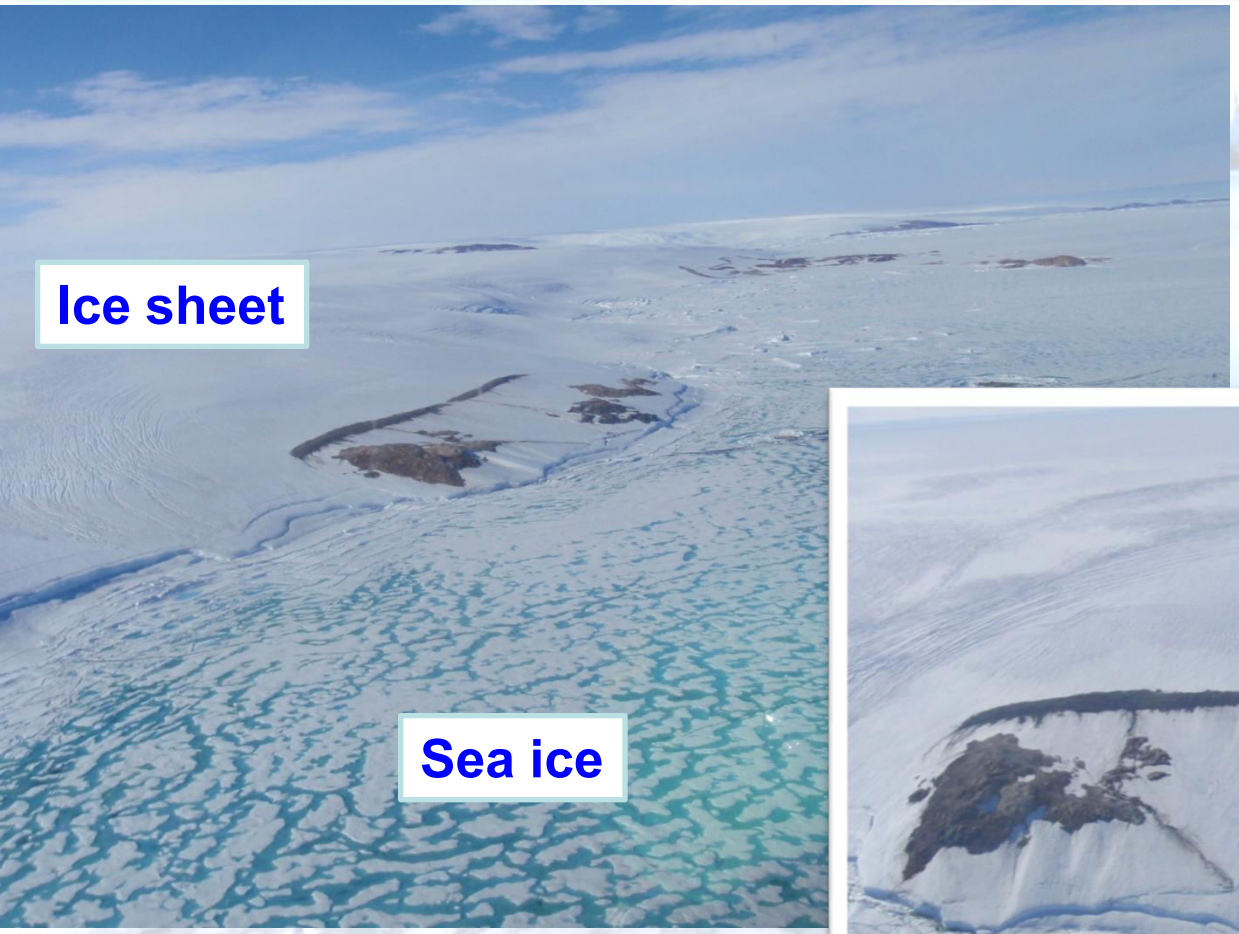


Fig.2 Locations and measurement elements of the observation network the Lützow-Holm Bay (LHB), East Antarctica.

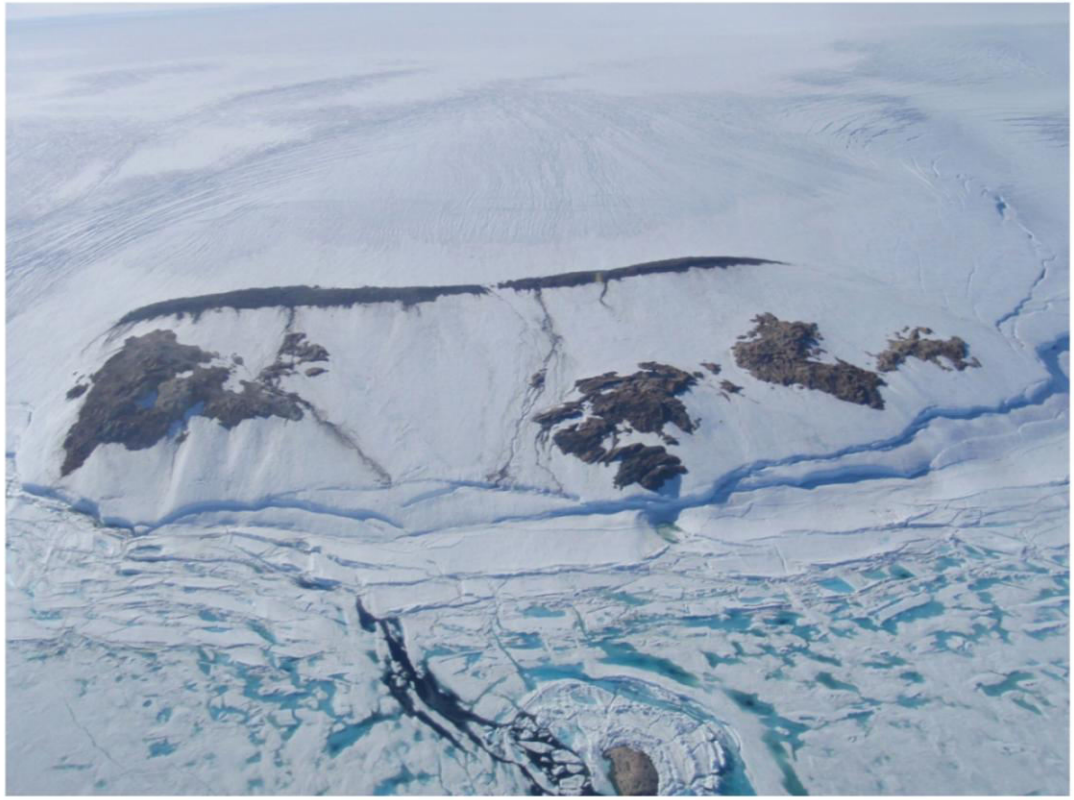
Murayama, T., M. Kanao, M.-Y. Yamamoto and Y. Ishihara, Infrasound signals and their source location inferred from array deployment in the Lützow-Holm Bay region, East Antarctica: 2015 January - June, Inter. J. Geosci.. 8, 181-188, 2017

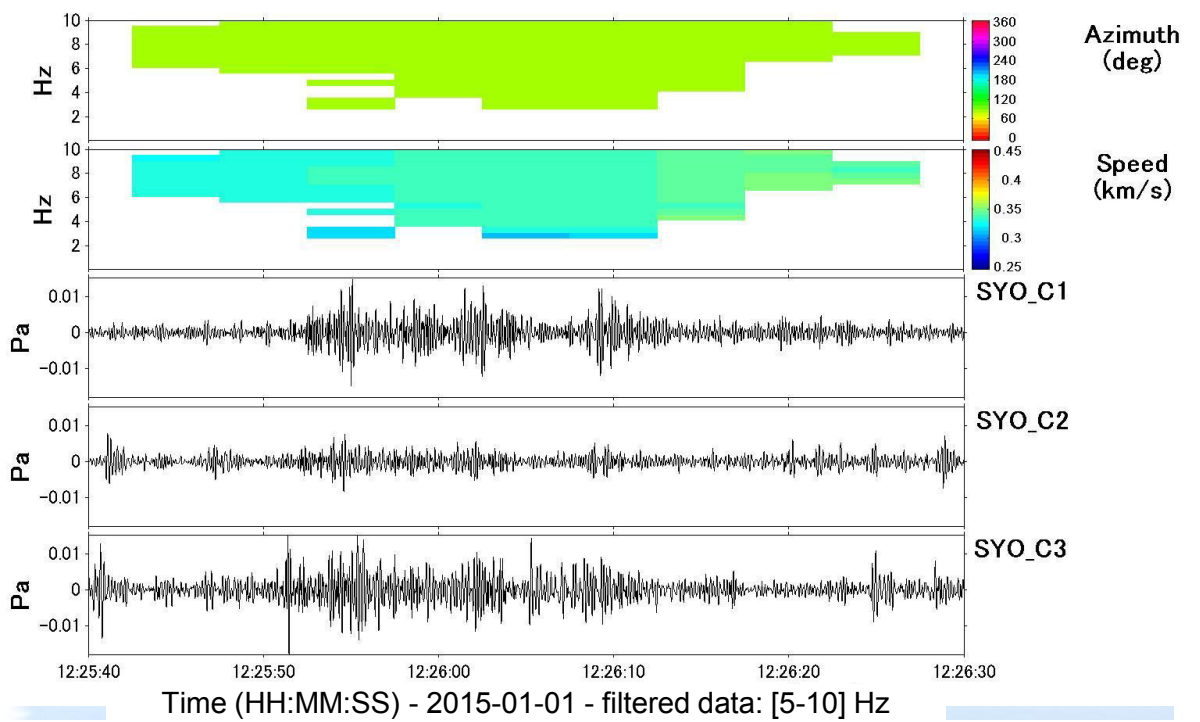
Source location from infrasound arrays

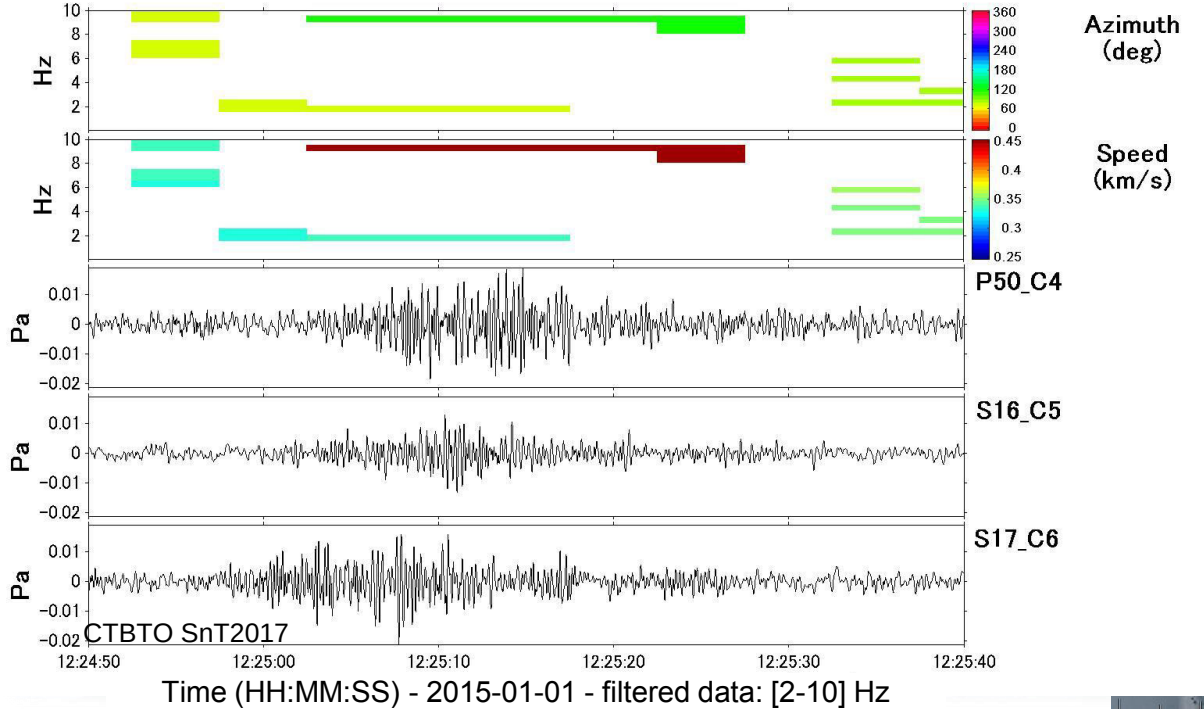
- Calving of ice-sheet, or glacier ? -

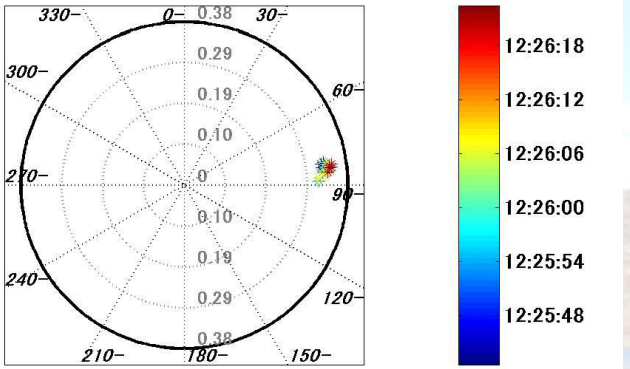


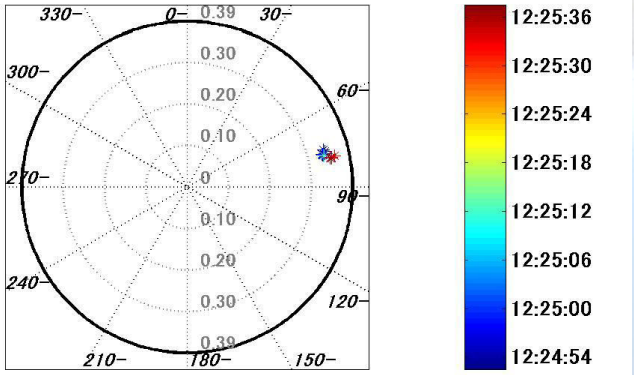
Tide cracks, crevasses are developed at the coastal margins







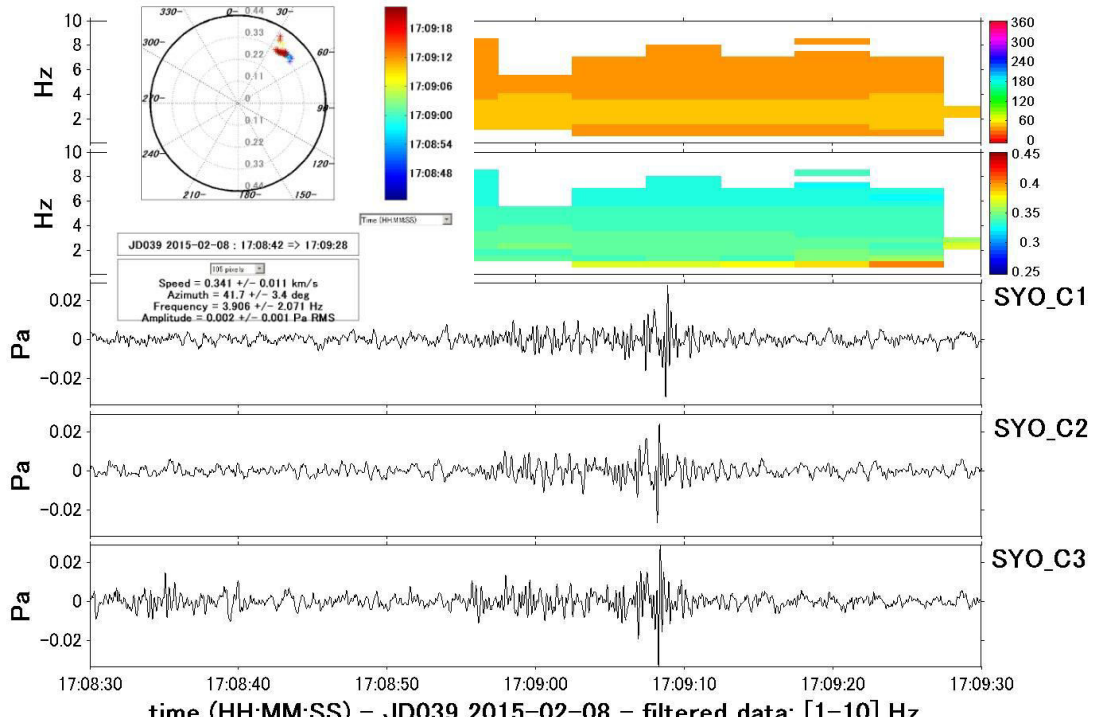


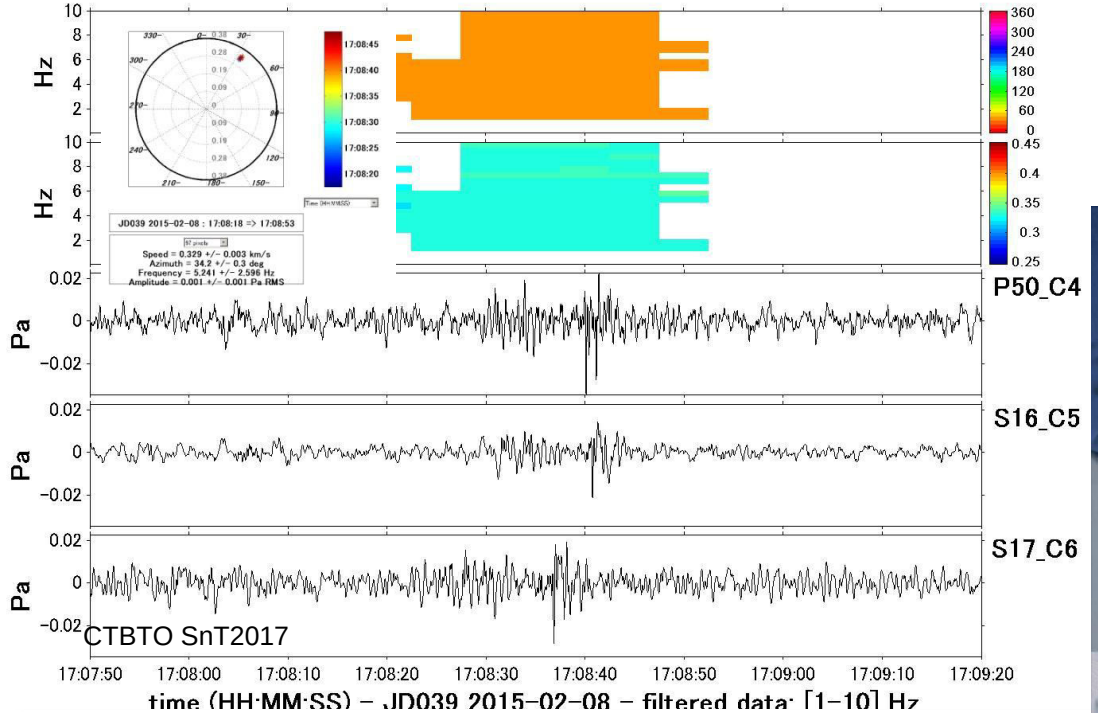


Over the ice sheet
（crevasse？）



CTBTO SnT2017

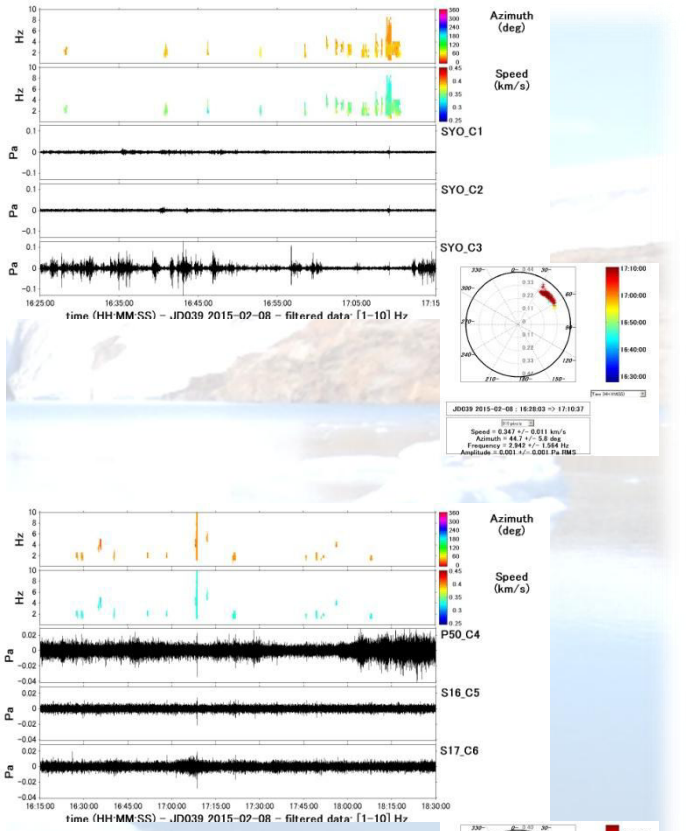




CTBTO SnT2017

Azimuth (deg)

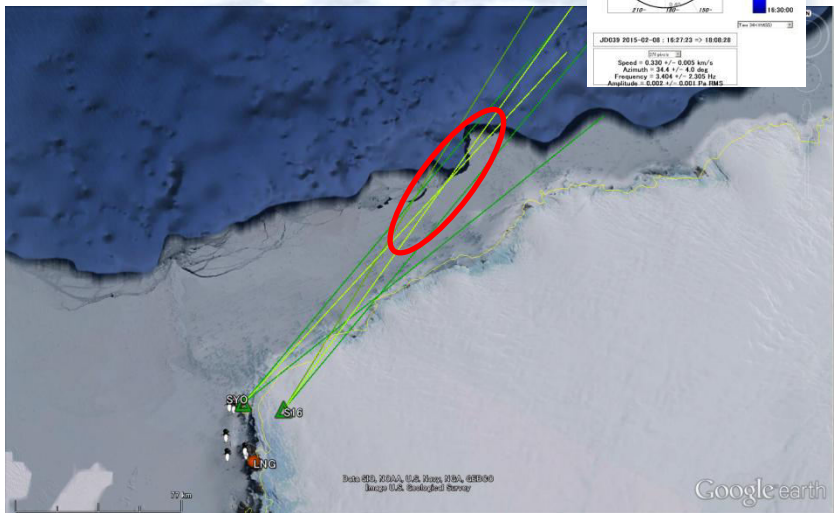
Speed (km/s)

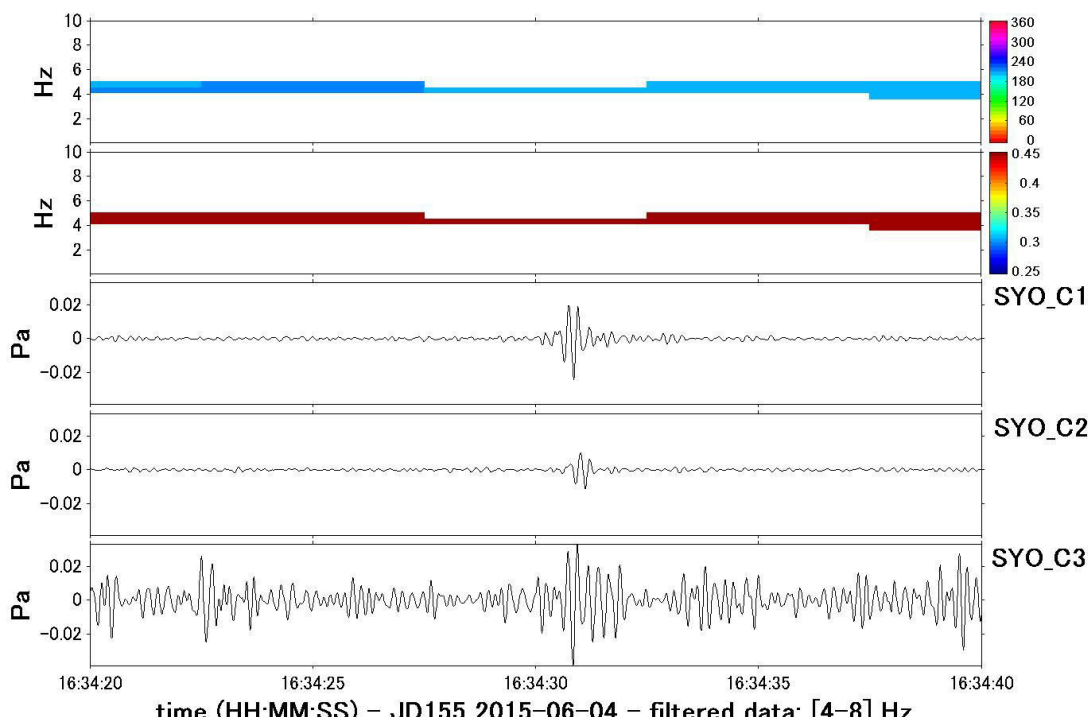


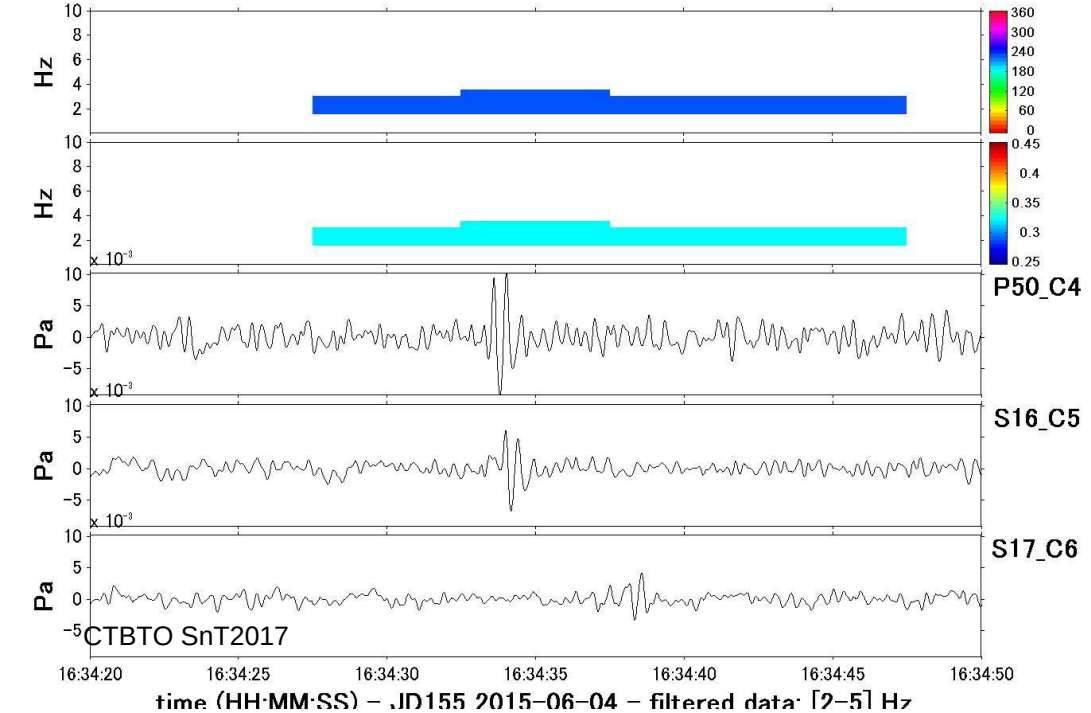
Azimuth (deg)

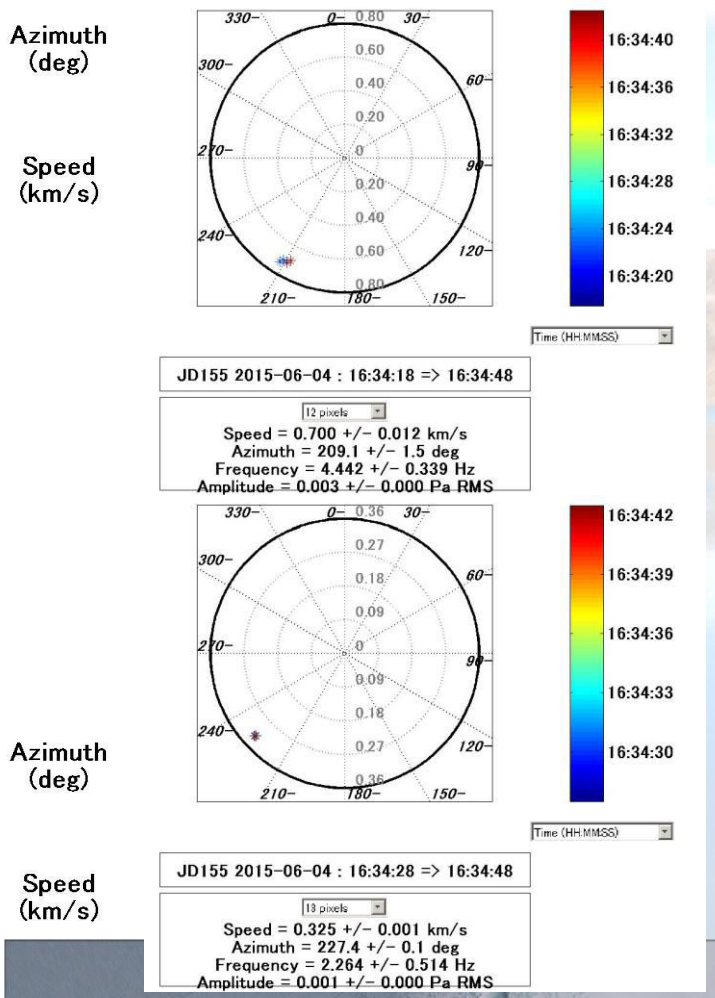
Speed (km/s)

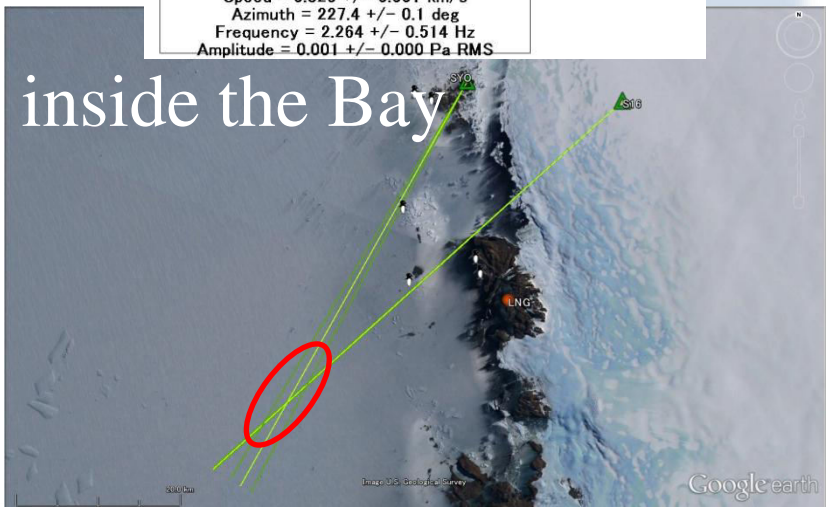
edge of fast-ice

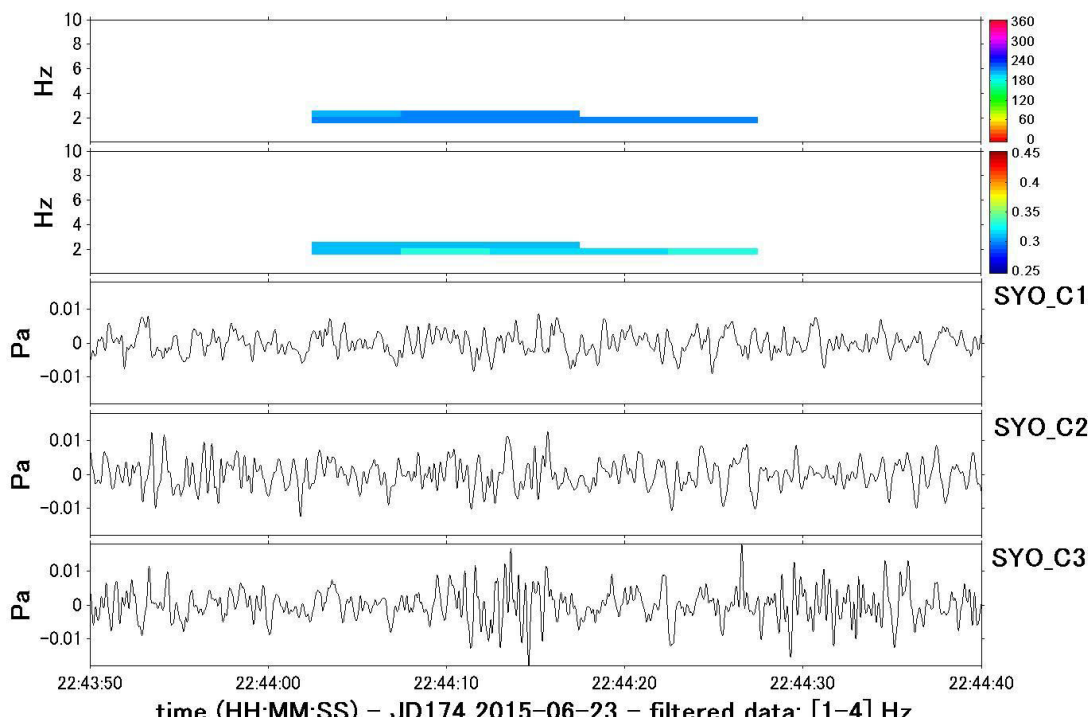


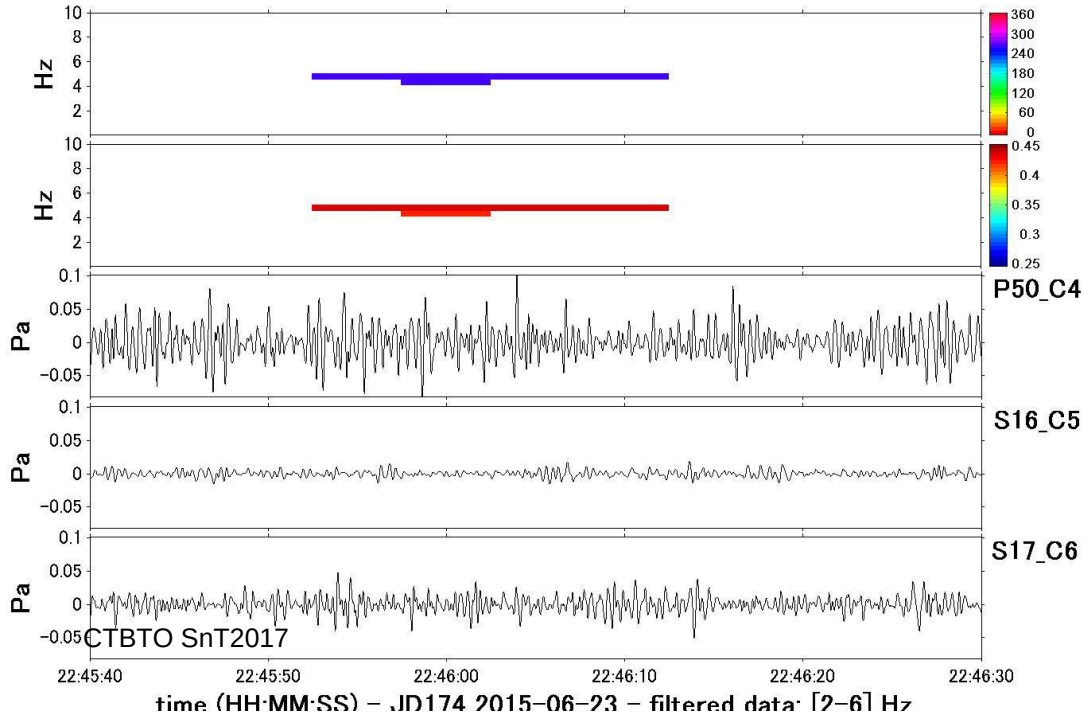

Hz
Pa
SYO_C1
SYO_C2
SYO_C3
16:34:20
16:34:25
16:34:30
16:34:35
16:34:40
time (HH:MM:SS) – JD155 2015-06-04 – filtered data: [4–8] Hz

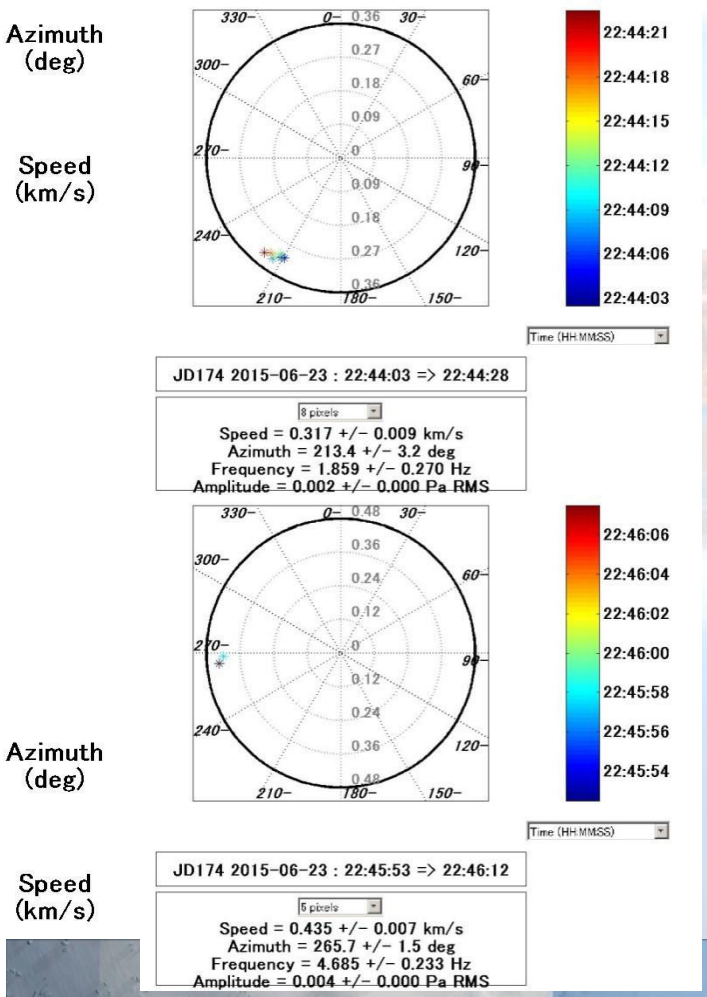

Hz
Pa
P50_C4
S16_C5
S17_C6
CTBTO SnT2017
16:34:20
16:34:25
16:34:30
16:34:35
16:34:40
16:34:45
16:34:50
time (HH:MM:SS) – JD155 2015-06-04 – filtered data: [2–5] Hz

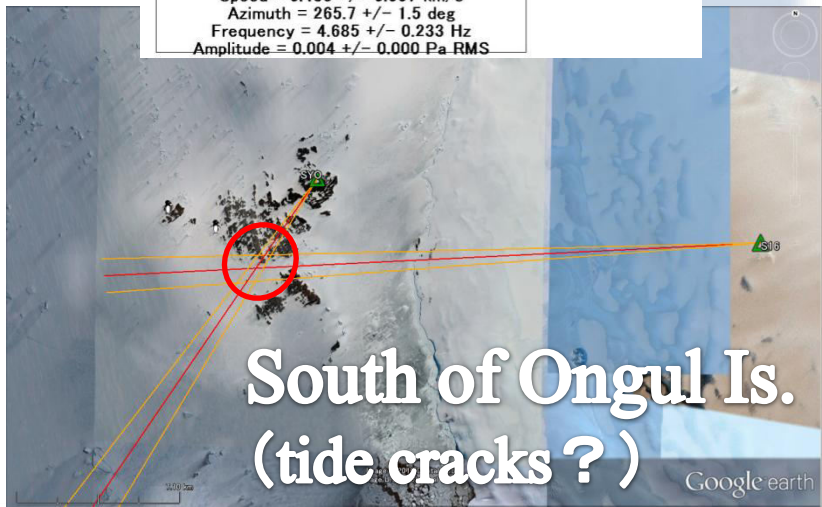

Azimuth (deg)
Speed (km/s)
JD155 2015-06-04 : 16:34:18 => 16:34:48
Speed = 0.700 +/- 0.012 km/s
Azimuth = 209.1 +/- 1.5 deg
Frequency = 4.442 +/- 0.339 Hz
Amplitude = 0.003 +/- 0.000 Pa RMS
Azimuth (deg)
Speed (km/s)
JD155 2015-06-04 : 16:34:28 => 16:34:48
Speed = 0.325 +/- 0.001 km/s
Azimuth = 227.4 +/- 0.1 deg
Frequency = 2.264 +/- 0.514 Hz
Amplitude = 0.001 +/- 0.000 Pa RMS


inside the Bay
SYO
S16
LNG
Google earth







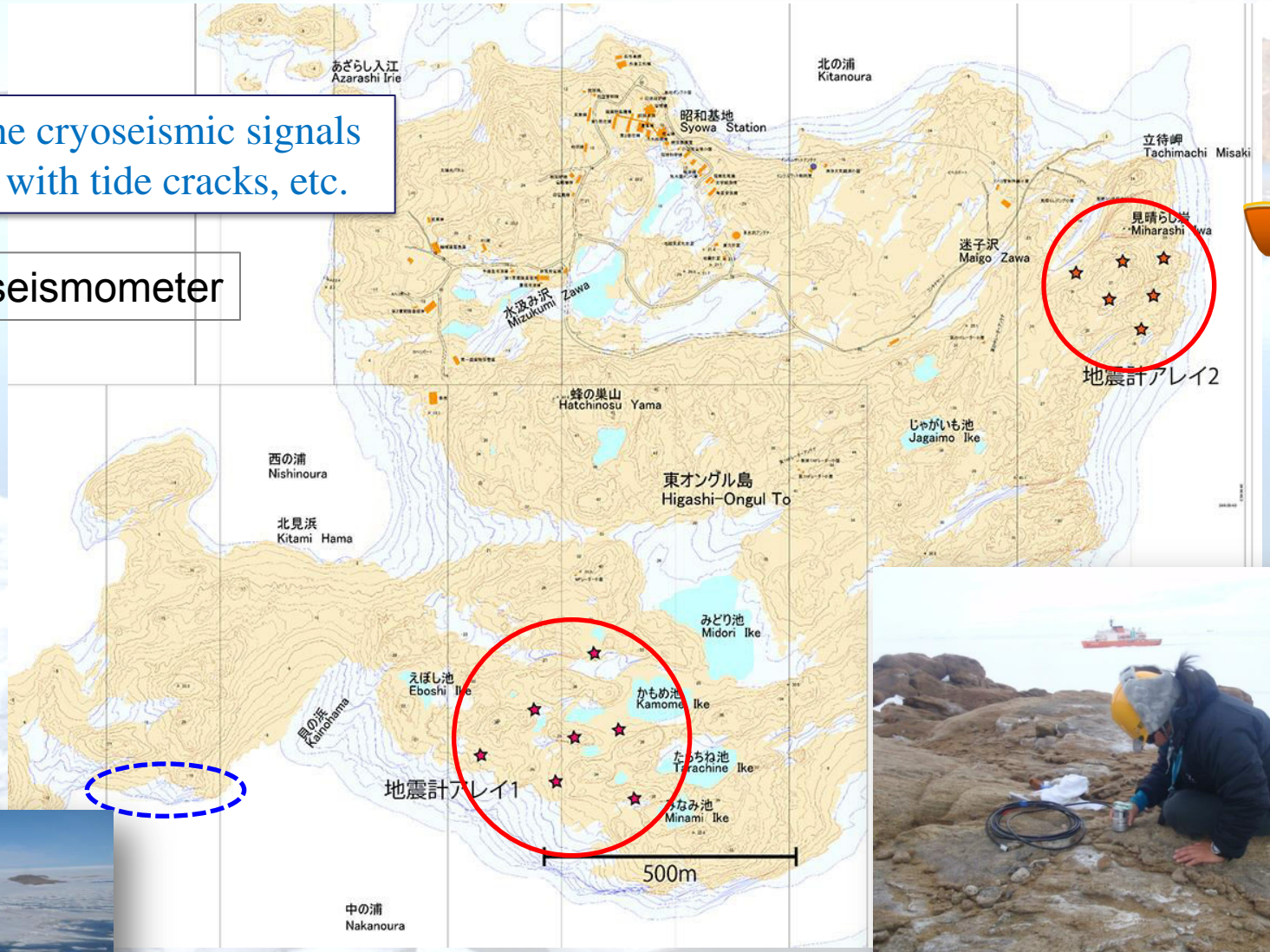


CTBTO SnT2017

Seismic array observations inside East Ongul Island; started from January 2017

To detect the cryoseismic signals associated with tide cracks, etc.

★seismometer

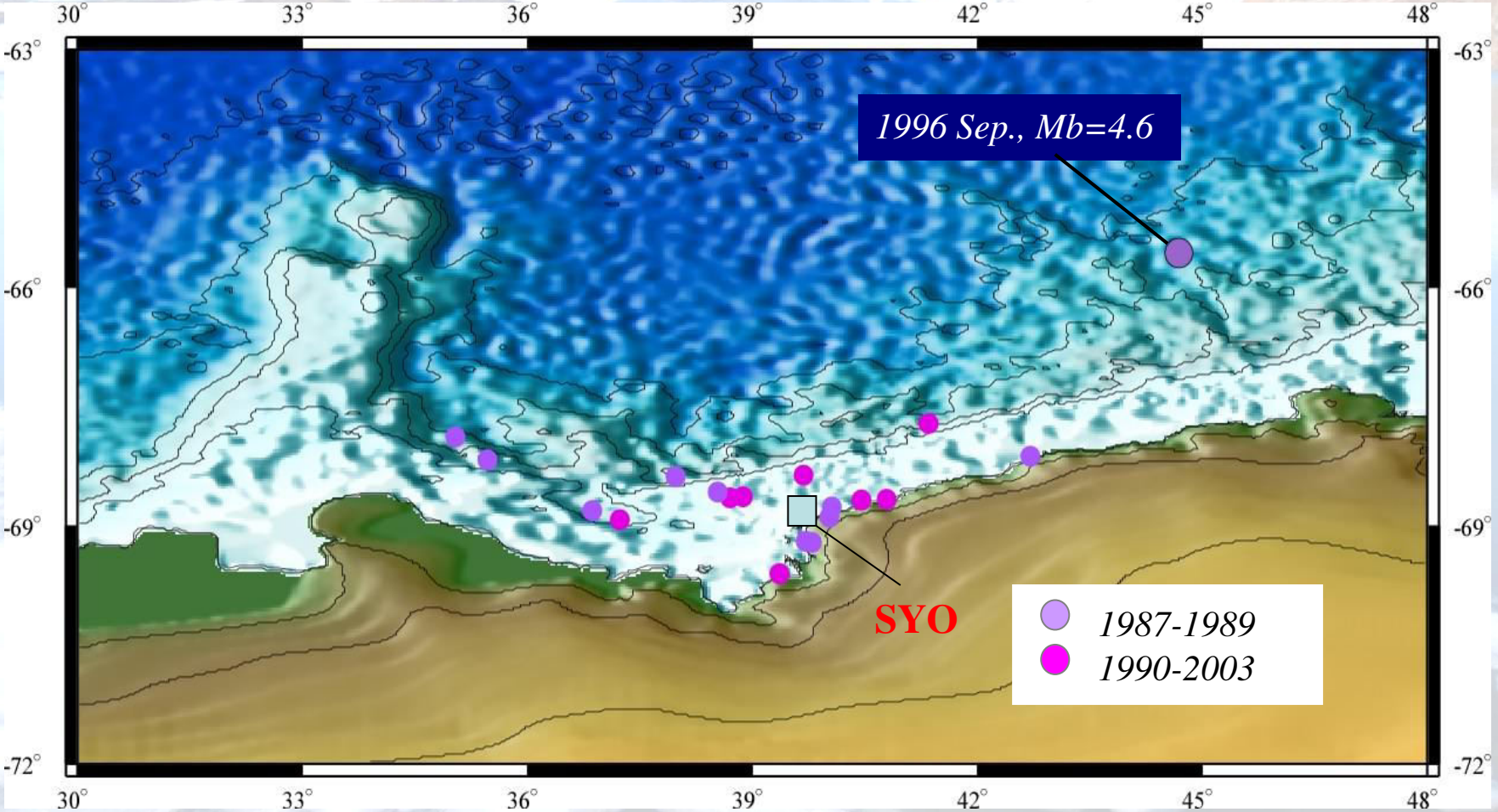






CTBTO SnT2017

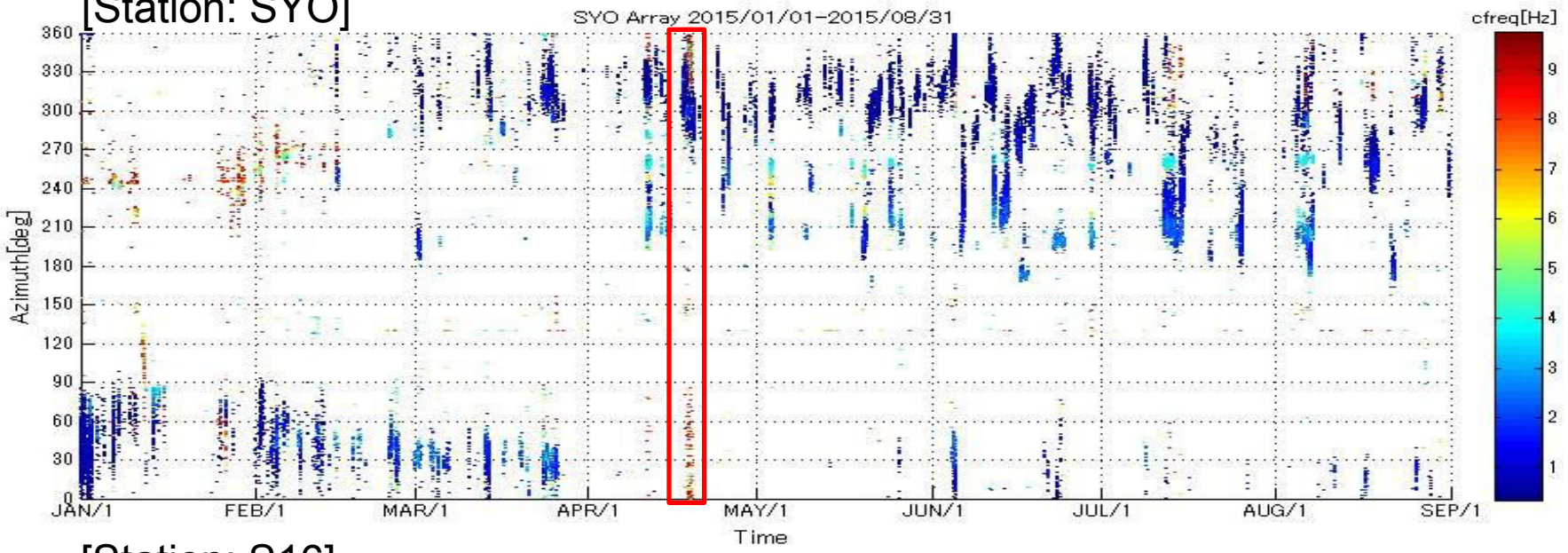
Local seismicity around the LHB, Eastern Dronning Maud Land, East Antarctica



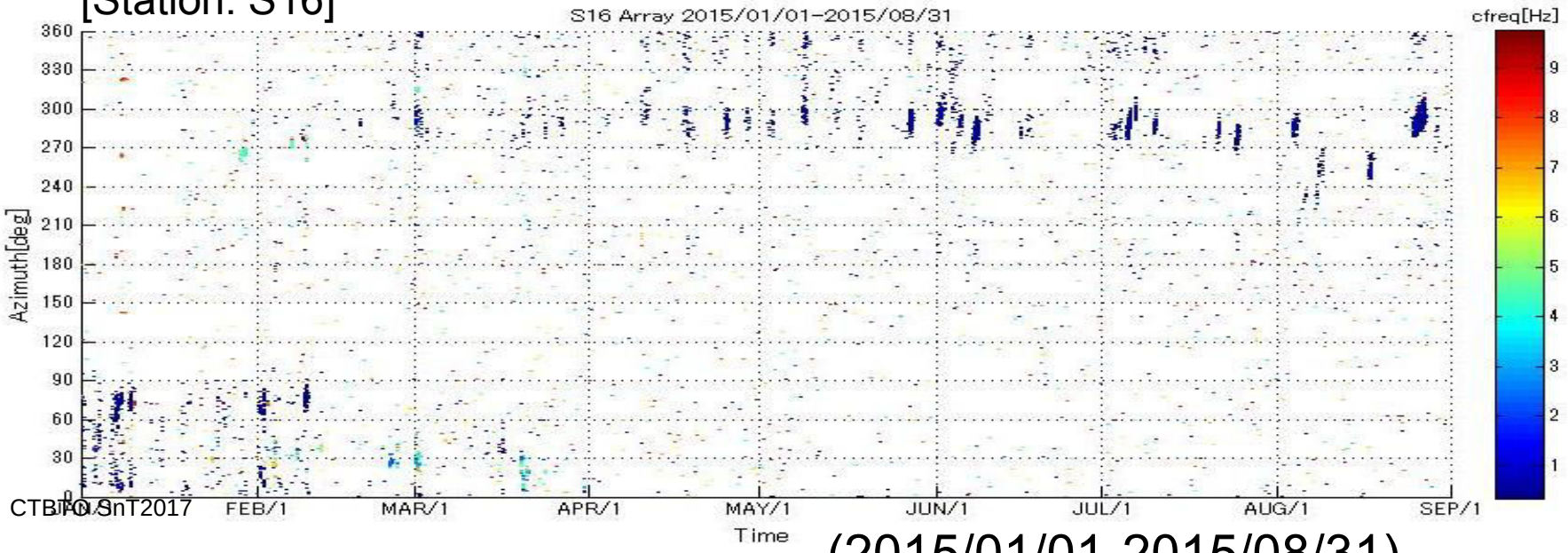
Kanao and Kaminuma, 2006

Time-tine of azimuthial variations for infrasound sources

[Station: SYO]

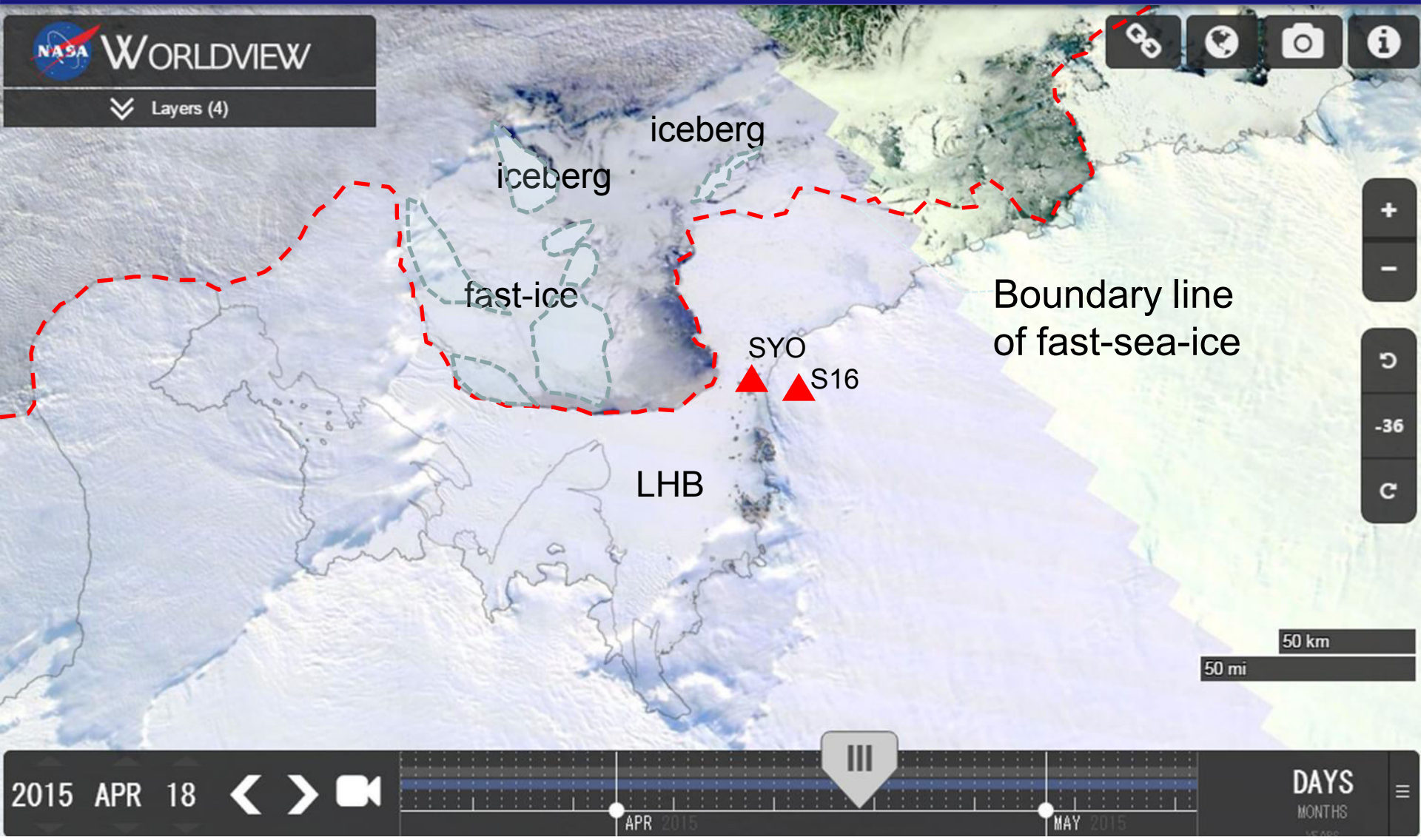


[Station: S16]



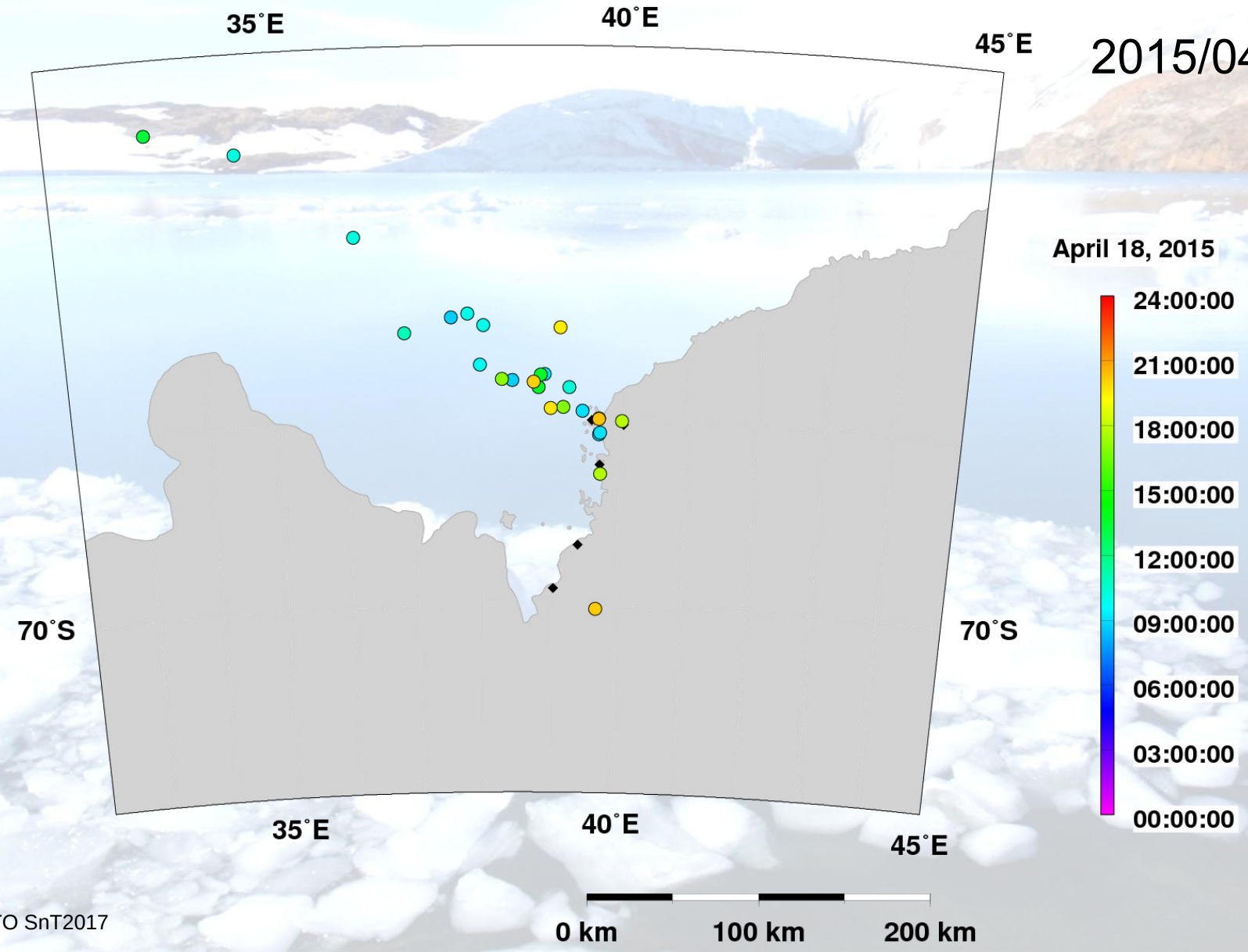
(2015/01/01-2015/08/31)

MODIS satellite image around LHB, 20150418

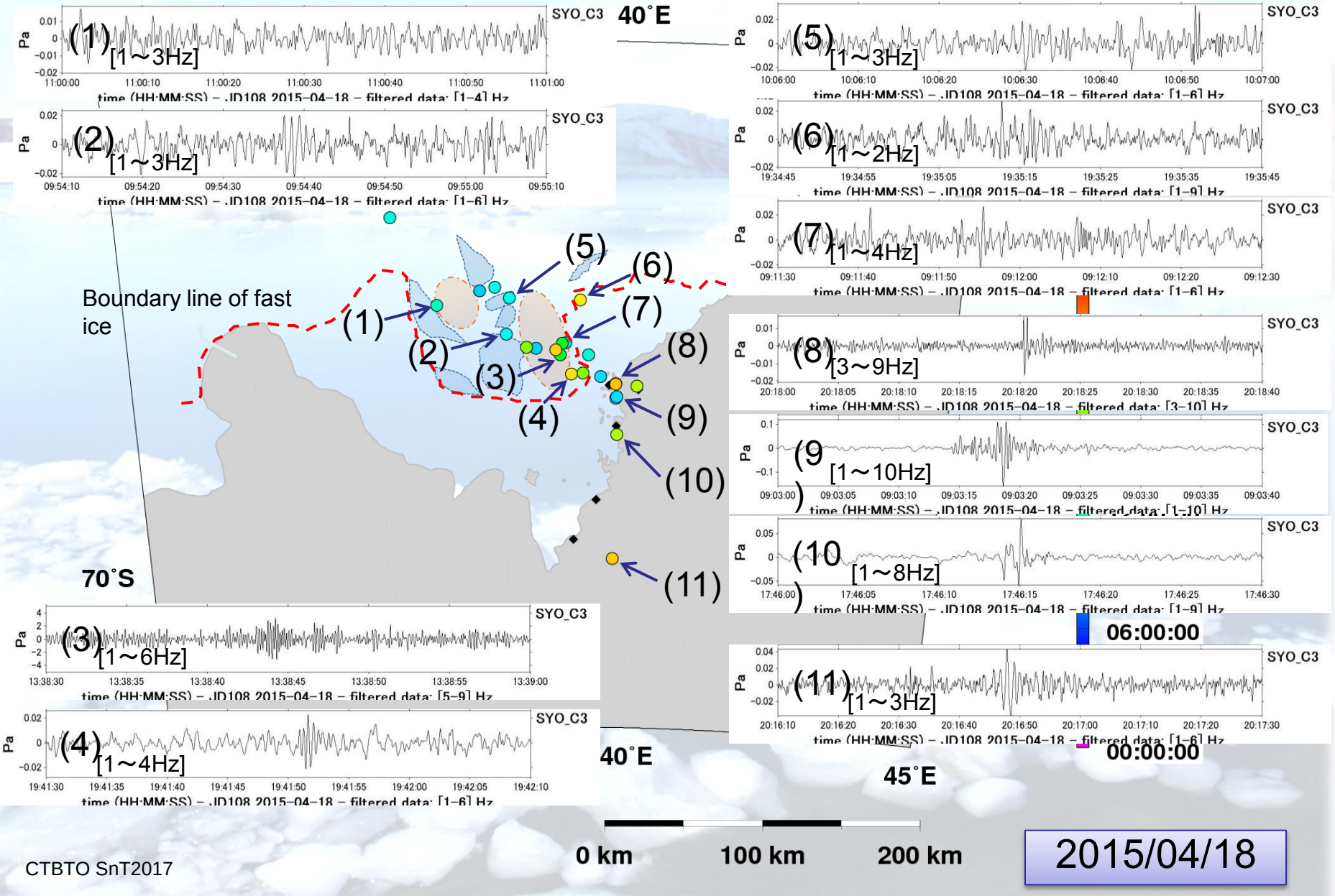


- Occurrence of the massive fast-ice discharge from LHB associated with iceberg collision from 2015/04/18 to 2015/04/19

Source location from infrasound arrays in LHB

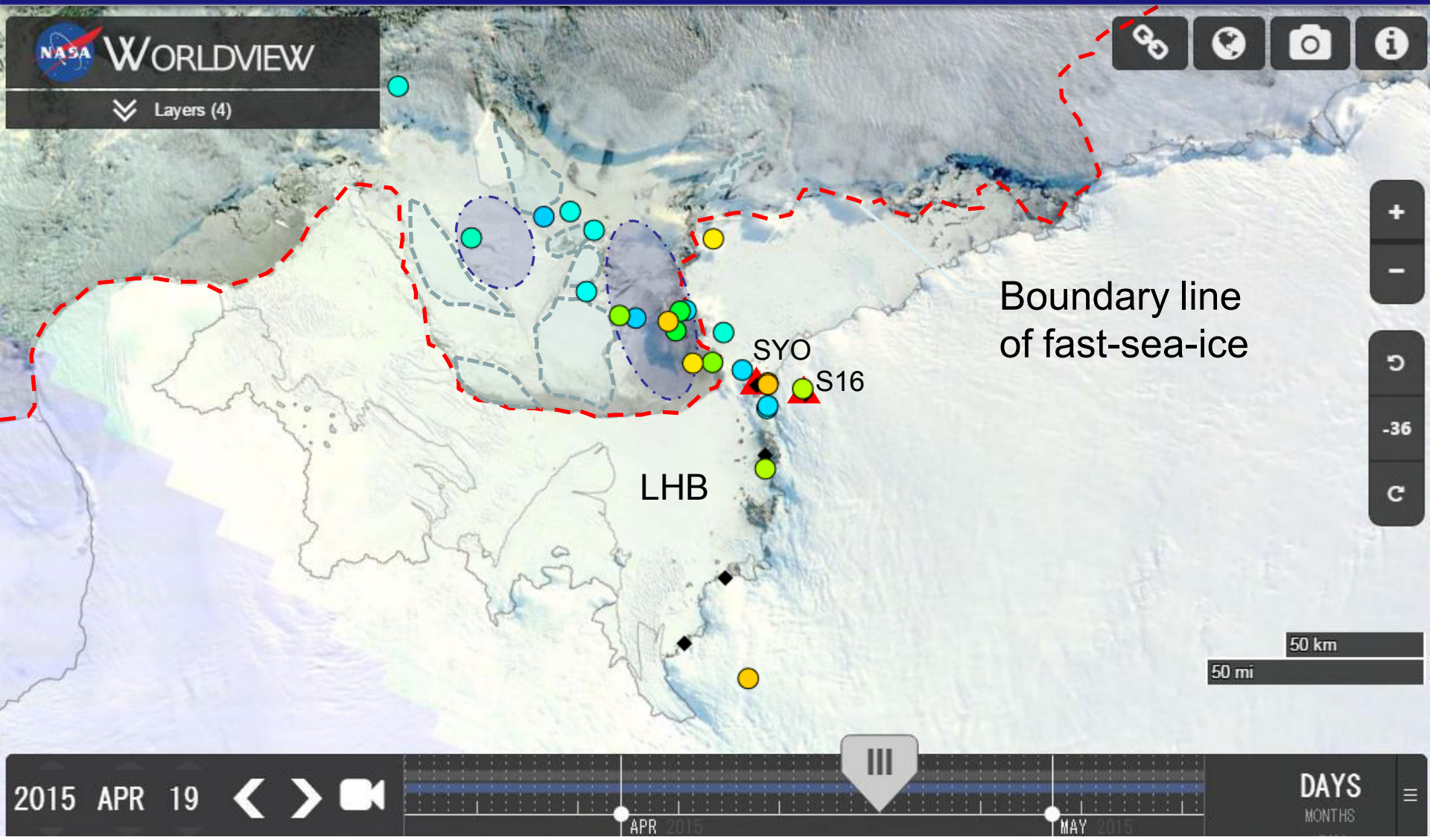


Waveform examples for detected events （1 min. of data）



CTBTO SnT2017

MODIS satellite image around LHB, 20150419



- Occurrence of the massive fast-ice discharge from LHB associated with iceberg collision from 2015/04/18 to 2015/04/19