

1. Highlights of the program of the JARE in the field of geosciences

1.1 Absolute gravity measurements in Sør-Rondane region

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Summary:

In order to detect the gravity changes due to ice sheet mass changes, Glacial Isostatic Adjustment (GIA) and other effects, we have conducted absolute gravity measurements at Princess Elisabeth Station (PES) near the Sør-Rondane Mountains, Antarctica, as part of the 55th Japanese Antarctic Research Expedition (JARE-55). In addition, the first absolute gravity measurements using a field absolute gravimeter, A10 have also been conducted on the Selungen near the Asuka station, where the gravity reference point (No.26-01) established by JARE-26 is located.

The absolute gravimeters employed were FG5#210 and A10#017, and a relative gravimeter LaCoste #805 was also used for dg/dz measurements and gravity connections. Using DROMLAN (Dronning Maud Land Air Network), we moved to PES with the instruments via Novolazarevskaya from Cape Town in South Africa. The length of our stay in PES was for 18 days from Nov. 29 to Dec. 16, 2013. Belgian researchers have already conducted absolute gravity measurements using a FG5 in North Shelter (NS), a small observation hut built on an outcrop a few hundred meters apart from the main base of PES. One of the main purposes of this project is to monitor long-term gravity changes by means of successive absolute gravity measurements at the same gravity point in NS. Since NS has not enough space for adjusting the gravimeters before measurements, we borrow a room in the main base for the purpose of test measurements as well. We established a tentative gravity point in the room and compared the gravity values measured by A10 and FG5. The result showed the discrepancy was within 2 micro-Gals. This means that A10 was well calibrated. Unfortunately a crucial fault arose in the dropping chamber of the FG5, and it could not be recovered to the last. For this reason, the measurements in NS were carried out with A10. The gravity value measured by JARE-55 will be compared with that measured by Belgian researchers, and this result will be published in collaboration with Belgian researchers.

The gravity measurements on Selungen have been conducted on Dec. 5th and 6th. Since No.26-01 is located near the summit of Selungen, where strong wind blows constantly, it is very difficult to conduct absolute gravity measurements there even using A10. Therefore a tentative gravity point was set up at the foot of Selungen, and measurements with A10 were conducted at the point. Then gravity connection to No.26-01 was conducted with the LaCoste gravimeter. The gravity value thus obtained at No.26-01 was 982406109.0 micro-Gals with the accuracy of about 15 micro-Gals including the errors due to the gravity connection. The gravity values of No.26-01 so far obtained were 982405.33mgal by JARE-26 (GSI, 2002), and 982402.817mgal by JARE- 27 (Fukuda, 1986). Although these values have been used as a reference value for the gravity surveys so far conducted in the Sør-Rondane area, the revisions of those values should be required from now on.

We also established seven gravity points which were connected to the absolute gravity measurements with the LaCoste gravimeter as tabulated in Table 1.

Point	Longitude	Latitude	Ellip. H. [m]	Gravity [mGal]	Date
NIPR G01	23° 20' 46.615" E	71° 56' 48.046" S	1389.12	982300.622	11, 12 Dec.
NIPR G02	24° 03' 57.03"E	71° 31' 29.10"S	974	982310.317	01 Dec.
NIPR G03	23° 18' 02.73"E	71° 56' 55.92"S	1382	982308.566	11, 12 Dec.
NIPR G04	23° 30' 42.90"E	71° 59' 46.80"S	1497	982279.953	12 Dec.
NIPR G05	23° 26' 44.12"E	72° 00' 16.28"S	1380	982305.433	12, 13 Dec.
NIPR G06	23° 18' 22.99"E	72° 02' 26.33"S	1444	982291.211	13 Dec.
NIPR G07	23° 16' 45.62"E	72° 05' 53.52"S	1419	982304.428	13 Dec.

Table 1: Gravity points established by JARE-55.

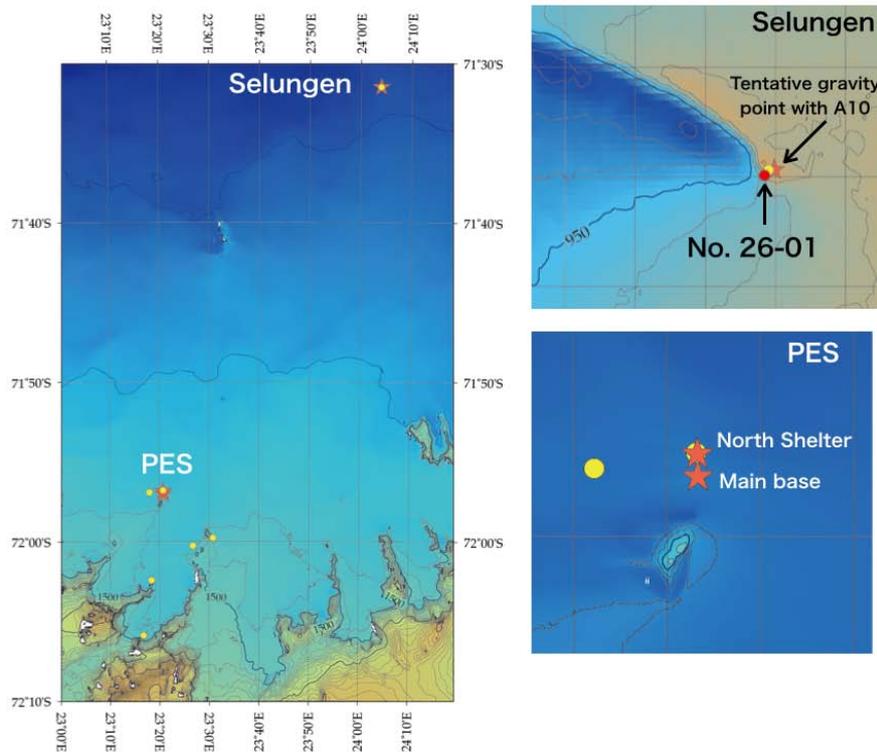


Figure 1: Map of the gravity measurement points. Red star shows the absolute gravity measurement point. The gravity survey with the LaCoste gravimeter were conducted at seven points as shown by yellow circle.



Figure 2: Absolute gravity measurements at North Shelter, PES, main base of PES, and the foot of Selungen.

1.2 Measuring ice flows and strain of ice sheet in Sør-Rondane Mountains

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Summary:

With objective of studying dynamics of ice sheet, we have conducted GPS measurements on ice sheet about 10 km apart from Princess Elisabeth Station (PES) near the Sør-Rondane Mountains, Antarctica, as part of the 55th Japanese Antarctic Research Expedition (JARE-55). For measuring ice flows and strain field of the ice sheet, dual frequency GPS receiver and antenna were installed at the following two sites as shown in Figure 1 on Dec. 10, 2013:

Site A, bare ice close to the large crevasse, (23°35'16.522"E, 71°55'00.260"S, 1353.650m)

Site B, ice covered by deep snow, (23°34'39.651"E, 71°54'29.728"S, 1328.151m).

The measurements were conducted continuously until 16 Dec., so that we obtained about 5.5 days GPS data sets with their sampling interval of 1 second. These data sets were resampled at 30 seconds interval, and analyzed by kinematic precise point positioning method using RTKLIB, where the 10 minutes averaging window was applied. Figure 2a shows three dimensional motions of GPSs which are attributed to the ice flows at Site A and B. Applying a linear regression, the ice flow velocity of each component was estimated. The ice sheet at Site A flowed to N9°W at the speed of 7 mm/day, while that at Site B flowed to N5°W at the speed of 3 mm/day horizontally. The estimated ice flow velocities exhibit the different ice flow between Site A and B, although a distance between both sites is only about 1 km. We also calculated a strain vector between Site A and B by the kinematic relative GPS method with RTKLIB as shown in Figure 2b. We plan to evaluate the stress field of the ice sheet by comparing the obtained strain rate of each component with experimental knowledge.

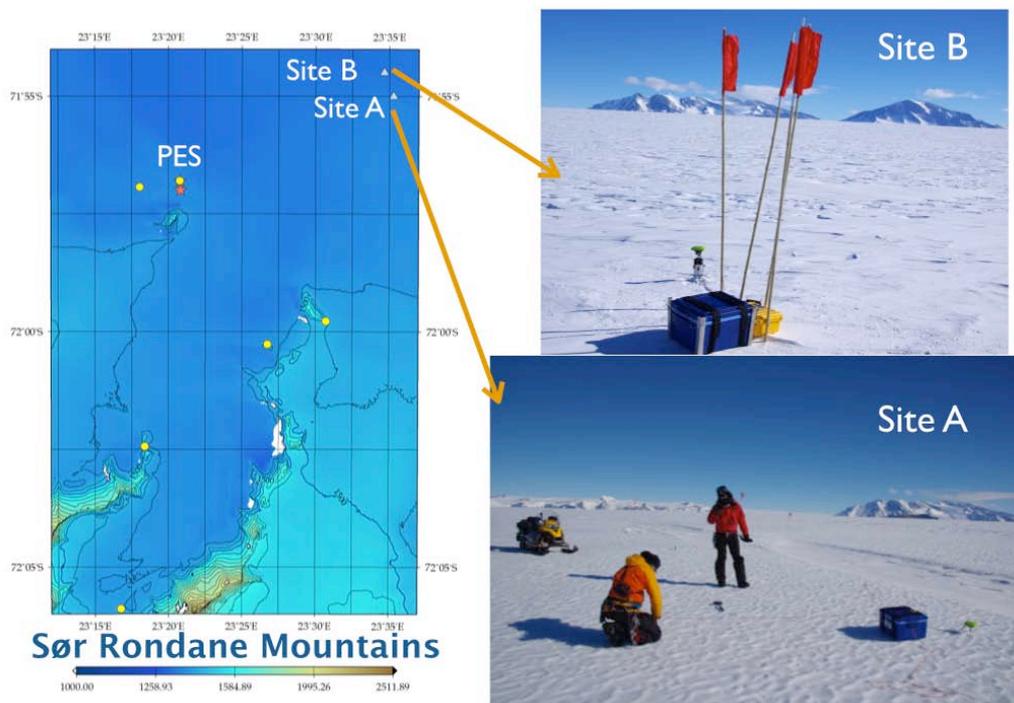


Figure 1: Map (left) and photos (right) of the GPS measurement points. The GPS antennas were fixed to ice or snow surface directly. Blue boxes, which involved the GPS receiver and 12V40Ah Pb battery inside, were put on the surface 1 m apart from the antenna.

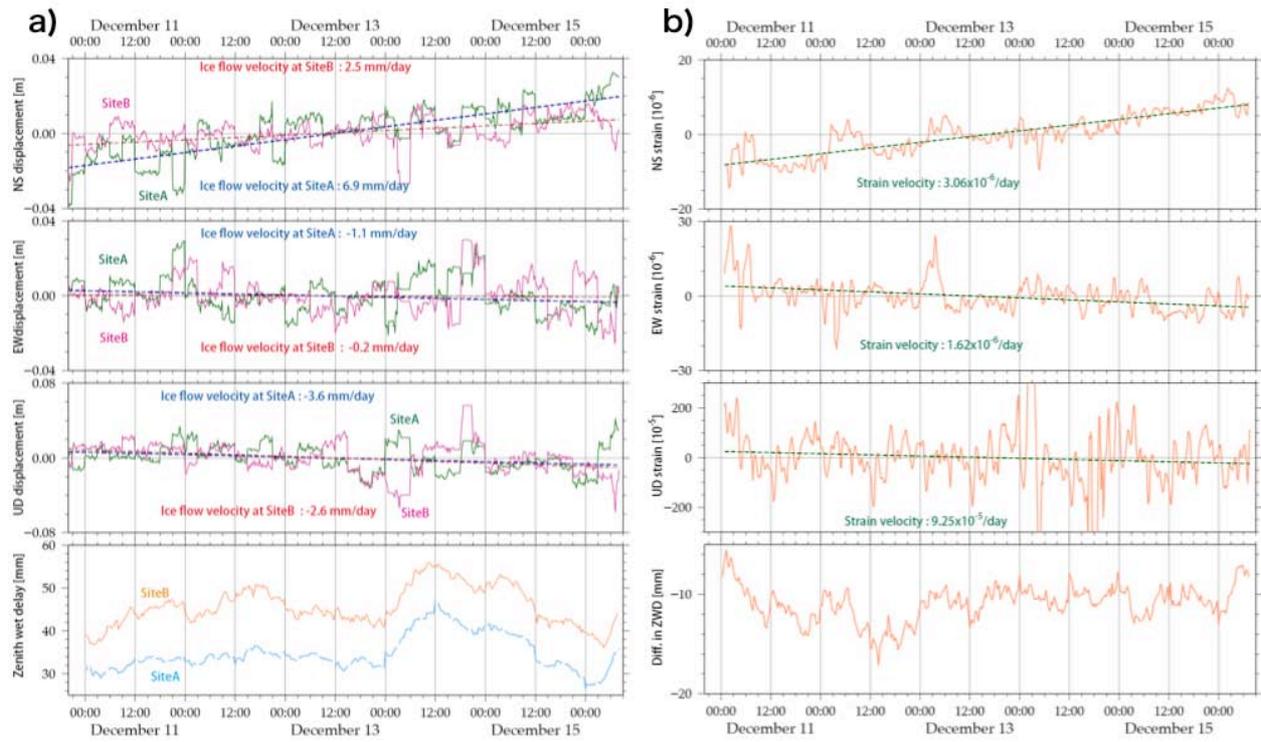


Figure 2: Ice flows and strains of the ice sheet. a) Three dimensional ice flows and the zenith wet delay (ZWD). Green and pink lines indicate the displacements at Site A and B, respectively. Blue and red dotted lines show the ice flow velocities at Site A and B, respectively. b) Strains and difference in ZWD between Site A and B. Orange line and green dotted line display the strains and strain velocity between Site A and B, respectively.

1.3 Establishing the Infrasound Arrays in the Lützow-Holm Bay Region, East Antarctica, for Monitoring the Surface Environmental Variations

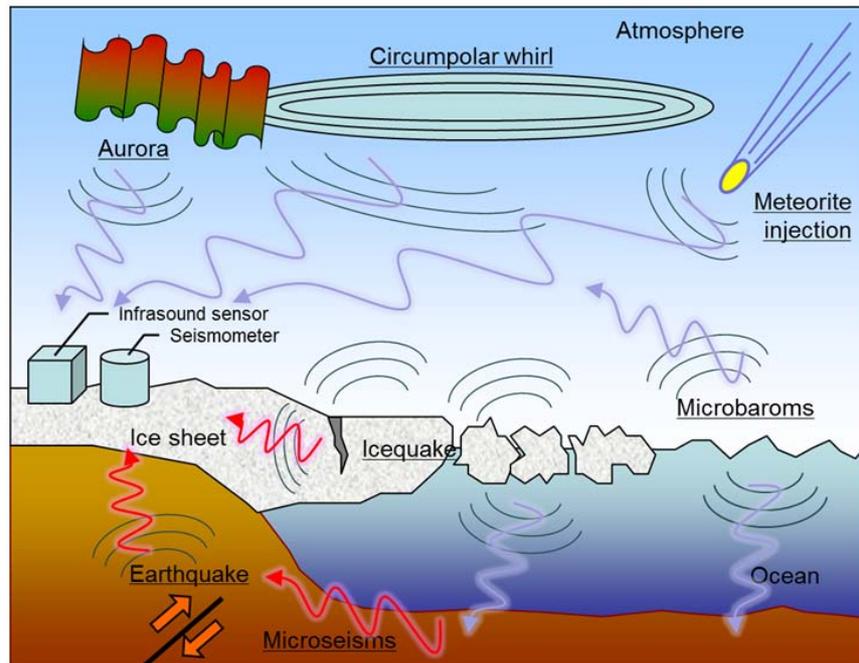
Summary:

The characteristic features of infrasound waves observed in Antarctica reveal a physical interaction involving surface environmental variations in the continent and the surrounding Southern Ocean. A single infrasound sensor has been making continuous recordings since 2008 at Syowa Station (SYO; 69.0S, 39.6E) in the Lützow-Holm Bay (LHB) of East Antarctica. The continuously recorded data clearly show the contamination of background oceanic signals (microbaroms) throughout all seasons. In austral summer 2013, several field stations with infrasound sensors were established along the coast of the LHB. Two infrasound arrays of different diameters were set up: one at SYO (with a 100-m spacing triangle) and one in the S16 area on the continental ice sheet (with a 1000-m spacing triangle). In addition to these arrays, isolated single stations were deployed at two outcrops in the LHB. These newly established arrays clearly detected the propagation direction and frequency content of microbaroms from the Southern Ocean. Microbarom measurements are a useful tool for characterizing ocean wave climates, complementing other oceanographic and geophysical data from the Antarctic. In addition to the microbaroms, several other remarkable infrasound signals were detected, including regional earthquakes, and airburst shock waves emanating from a meteoroid entering the atmosphere over the Russian Republic on 15 February 2013. Detailed and continuous measurements of infrasound waves in Antarctica could prove to be a new proxy for monitoring regional environmental change as well as temporal climate variations in high southern latitudes.

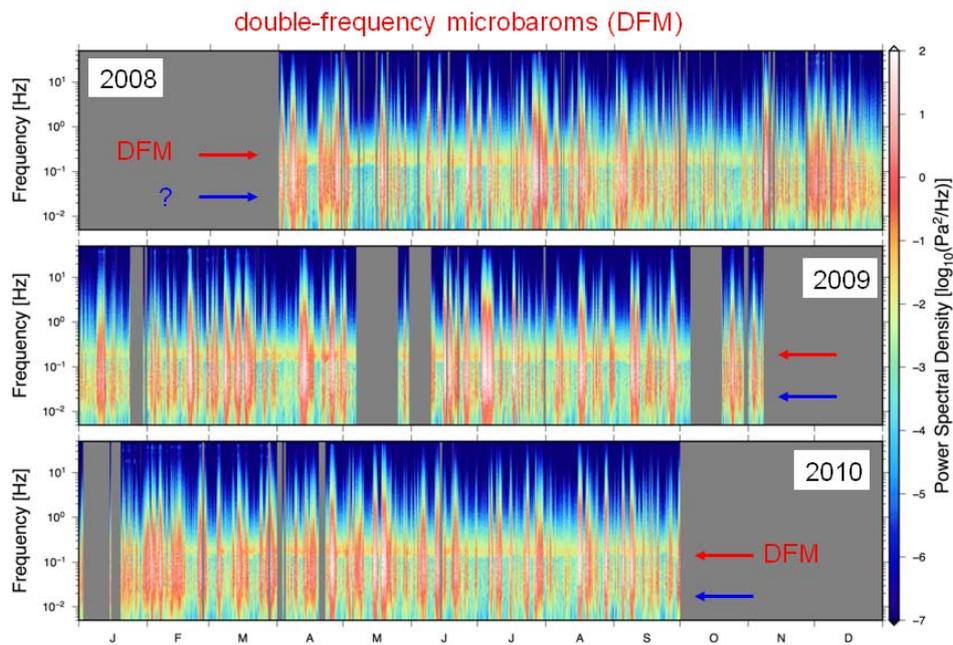
Publication:

Murayama, T., M. Kanao, M.-Y. Yamamoto, Y. Ishihara, T. Matshushima and Y. Kakinami, 2014. Infrasound Array Observations in the Lützow-Holm Bay region, East Antarctica, *Polar Science*, 10.1016/j.polar.2014.07.005.

Ishihara, Y., M. Kanao, M.-Y. Yamamoto, S. Toda, T. Matshushima and T. Murayama, 2014. Infrasound Observations at Syowa Station, East Antarctica - An Implication for Detecting the Surface Environmental Variations in Polar Region -, *Geoscience Frontiers*, 10.1016/j.gsf.2013.12.012.



Conceptual diagram of the excitation of atmospheric pressure changes and seismic waves in the Antarctic. Physical interaction between solid earth, atmosphere, ocean and cryosphere systems can be detected by infrasonic waves propagate through surface environments around the coastal area and Southern Ocean.



Power spectral densities (PSD) of the infrasound signals at Syowa Station. The gray colored time-zones represent the lack of data, otherwise any kinds of errors during the PSD processing. Predominant frequencies corresponding to the microbaroms are represented by red arrows (the double-frequency microbaroms; DFM) and blue arrows (more longer period waves), respectively.