Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

STT57-01 Room:423 Time:April 30 16:15-16:30

Development of a laser strain gradiometer and reduction in its thermal noise.

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An earthquake is essentially a shear slip on a fault. Because the rupture velocity is roughly constant for most earthquakes, the length, the width, and the slip distance of a fault are respectively proportional to the duration of the rupture, and therefore an earthquake follows the scaling law that its seismic moment is proportional to the cube of its duration. In addition to the ordinary earthquakes, slow earthquakes have been discovered recently. Slow earthquakes include short-term and long-term slow slip events, non-volcanic tremors, low-frequency earthquakes, and very low-frequency earthquakes. They are known to be also shear slips but have slower rupture velocity than the ordinary earthquakes (see the reference [Beroza and Ide, 2011]). Ide et al. (2007) proposed that every slow earthquake has the same mechanism with a new scaling law that its seismic moment is proportional to its duration.

However, no middle-term slow earthquakes with duration of 200 s to 1 day have been reported so far. To understand the reason, we conducted analytical calculations including comparisons of expected signals of slow earthquakes and background seismic noise. It was shown that the middle-term slow earthquakes cannot be observed by a single accelerometer, a strainmeter, or a tiltmeter due to the background seismic motion.

AIST's synthetic analysis using the network of strainmeters, tiltmeters, and groundwater pressure gauges [Itaba et al, 2009] detected smaller slow slips.

Let us take the second spatial derivative of displacement, "the strain gradient". Analytical calculations showed that the signals of slow earthquakes with duration of 200 seconds to 1 day can directly be detected from the strain gradient of the ground. The spatial scale of the background ground motion is larger than the typical distance between a hypocenter and an observatory and the typical size of the fault. Taking spatial derivative emphasizes the small-scale crustal deformation, and makes the detection of local slow earthquakes easier. Thus, measuring the strain gradient will be effective to detect them.

We made a prototype instrument of measuring the strain gradient, "strain gradiometer," with laser interferometry. Before installing it on the ground, we measured its instrumental noise in the atmosphere and found the noise following power spectral density of 10^{-12}[m^{2}s] at 10^{-5}Hz and tendency of 1/f^2 below 0.1Hz. This noise was caused by changes in optical path lengths due to the fluctuation of air pressure. Subsequently, the noise of the interferometer in vacuum was measured; the noise was reduced by 1/10 and had the tendency of 1/f below 0.1Hz. This noise could be reduced by adjusting the optical path difference because it was estimated to be caused by frequency fluctuations of the laser source, which was frequency stabilized by the two-mode method. After the adjustment, there remained noises that had the power spectrum of 1/f^6 in the period between 5000s and 20000s and same power in the period longer than 20000s. This noise had similar waveform to temperature in time-domain. This noise was estimated to be caused by thermal expansion of the optical devices and the optical breadboard. Assuming this noise will be reduced in proportion to the square of the baseline length in terms of the strain gradient, the necessary baseline will be more than 300m. In the presentation, analyses of the noise of the interferometer with thermal insulation by ceramics and the future development will be explained.

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Keywords: laser interferometer, strainmeter, strain gradiometer

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STT57-02 Room:423 Time:April 30 16:30-16:45

Compact Ocean Bottom Cabled Seismic and Tsunami Observation System Using ICT and Installation Plan

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The Pacific plate is subducting below the northeastern Japan islands arc. The 2011 Tohoku earthquake occurred at the plate boundary between the Pacific plate and the landward plate below landward slope of the Japan Trench. In 1996, Earthquake Research Institute (ERI), University of Tokyo had installed seismic and tsunami observation system using seafloor optical fiber in the off-Sanriku area. The continuous real-time observation has been carried out since the installation. The system observed seismic waves and tsunamis generated by the 2011 Tohoku earthquake, and the data from the system are indispensable to estimate accurate position of the source faults and the source process of the 2011 event. However, the landing station of the system was damaged by huge tsunami 30 minutes after the mainshock, and the observation is discontinued. Because the data from the real-time system on seafloor are important, we decide to restore the existing system and install newly developed Ocean Bottom Cabled Seismic and Tsunami (OBCST) observation system off Sanriku for additional observation and/or replacement of the existing system. In this paper, we present a system of the new OBCST in detail, and installation plan.

Until 2010, we had already developed and installed the new compact Ocean Bottom Cabled Seismometer (OBCS) system near Awashima-island in the Japan Sea. After the installation, the OBCS system is being operated continuously and we have continuous seismic data for more than 3 years at the present. The new OBCST system for off-Sanriku area is based on this system, and is characterized by system reliability using TCP/IP technology and down-sizing of an observation node using up-to-date electronics. The new OBCST has three accelerometers as seismic sensors. Signals from accelerometers are 24-bit digitized with a sampling rate of 1 kHz and sent to a landing station using standard TCP/IP data transmission. A precise pressure gauge is also equipped as a tsunami sensor. The tsunami data with a sampling rate of 1ms are also transmitted by TCP/IP protocol. In addition, an observation node can equipped with an external port for additional observation sensor instead of a pressure gauge. Additional sensors on seafloor are supplied the power using Power over Ethernet technology. Clock is delivered from the GPS receiver on a landing station using simple dedicated lines. In addition, clocks in observation nodes can be synchronized through TCP/IP protocol with an accuracy of 200 ns (IEEE 1588). The data will be stored on the landing station and sent to ERI in the real-time. A simple canister for tele-communication seafloor cable is adopted for the observation node, and has diameter of 26cm and length of about 1.3m. This small size of the canister has an advantage for burying the system below seafloor.

At the present, we are producing the observation nodes of the new OBCST. The new system has three observation nodes; two have three-component seismometer and a pressure gauge, one has seismometers and an external port by using the PoE technology. We have a plan to connect a pressure gauge and hydrophone via the PoE external port of the third observation node. Total length of the practical system is approximately 100 km and an interval of the observation node is about 30 km. We have a plan to install the practical system in 2015.

Keywords: Cabled ocean bottom seismometer and tsunami gauge, Sanriku, Japan Trench, seafloor observation

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STT57-03 Room:423 Time:April 30 16:45-17:00

Long-period duration of the teleseismic events reported to ISC from Syowa Station since 1967

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Phase identifying procedure for teleseismic events at Syowa Station, East Antarctica have been carried out since 1967 after the International Geophysical Year (1957-1958). From the development of INTELSAT telecommunication link, digital waveform data have been transmitted to the National Institute of Polar Research for utilization of phase identification. Arrival times of teleseismic phases, P, PKP, PP, S, SKS have been reported to the International Seismological Centre (ISC), and published by JARE Data Reports from NIPR. In this paper, hypocentral distribution and time variations for detected earthquakes are demonstrated over the last four decades in 1967-2010. Characteristics of detected events, magnitude dependency, spatial distributions, seasonal variations, together with classification by focal depth are demonstrated. Besides the natural increase in number for occurrence of teleseismic events on the globe, a technical advance in observing system and station infrastructure, as well as the improvement of procedure for reading seismic phases, could be efficiently combined to produce the increase in detection number in last few decades. Variations in teleseismic detectability for longer terms may possibly by associate with meteorological environment and sea-ice spreading area around the Antarctic continent. Recorded teleseismic and local seismic signals have sufficient quality for many analyses on dynamics and structure of the Earth's as viewed from Antarctica. The continuously recorded data are applied not only to lithospheric studies but also to Earths deep interiors, as the significant contribution to the Federation of Digital Seismological Network from high southern latitude.

Keywords: Syowa Station, teleseismic events, detection capability, monitoring observation, global network

Japan Geoscience Union Meeting 2014
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STT57-04 Room:423 Time:April 30 17:00-17:15

Seismic observation on Greenland Ice Sheet by the Japanese GLISN team (2011-2013), and a plan for the 2014 season

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Melting of the Greenland ice sheet is now in progress accompanying the global climate change. Recently, a new type of seismic event called "glacial earthquakes", which are generated by the movement of a large mass of ice within the glacial terminus, has been realized as a new way to monitor current ice sheet dynamics. In 2009, the multinational GreenLand Ice Sheet monitoring Network (GLISN), a large broadband seismological network in and around Greenland was initiated to monitor these events.

Japan, a partner country of the GLISN project, has been sending a field team every year since 2011. The joint U.S. and Japanese team first constructed a seismic station (station code: ICESG) on the Greenland ice sheet. In 2012, we serviced two ice sites (ICESG, DY2G) and one rock site (NUUK). In 2013, the same team spent 11 days on ice for maintenance of ICESG and DY2G, and helped rogistics for another ice site (NEEM). This presentation summarizes our field activities on the GLISN project for three years, and show a plan for the 2014 season.

Our activity is supported by JSPS KAKENHI 24403006.

Keywords: Greenland, glacial earthquake, GLISN network

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STT57-05 Room:423 Time:April 30 17:15-17:30

Development and Operation of Wide-area Observation Monitoring (WONM) System

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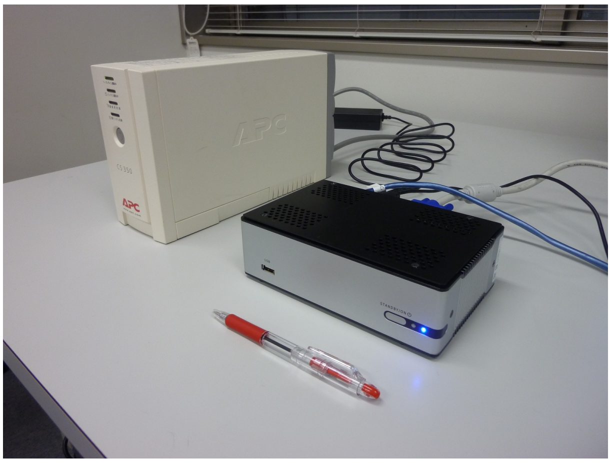
This paper is devoted to present an operation system to acquire, to transfer and to storage data for world-wide observation networks, which is named as WONM (Wide-area Observation Network Monitoring) system, developed in NICT (National Institute of Information and Communications Technology). This system provides us with easier management of data collection than legacy systems by means of autonomous system recovery, periodical state monitoring, and dynamic warning procedures. We have equipped world-wide observatories for space weather prediction and research works with this system connected with the NICT Science Cloud. Demonstration and discussion will be presented concerning with this challenging system, especially from the viewpoint that we easily operate world-wide observatories on a web application.



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STT57-06 Room:423 Time:April 30 17:30-17:45

Development of hypocenter location method using envelopes: Application to B-type earthquakes at Miyakejima volcano

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B-type earthquakes are frequently observed in active volcanoes, but it is difficult to locate them by using traditional phase picking methods because most of B-types show emergent onsets of P- and S-waves. We applied the envelope correlation method of Obara (2002) to B-type earthquakes at Miyakejima volcano, but the located hypocenters shifted towards the south-east by 0.5 - 1 km compared to those determined by phase picking method. Such systematic difference is caused by some assumptions such as that the envelope waveforms at each station are all the same. Actually, the envelope waveform broadens as hypocentral distance increases because of the scattering, or the waveform strongly depends on the site condition. In this study, therefore, we develop a new envelope correlation method in which a small number of the B-type earthquakes whose S-wave arrival times are manually picked are used as reference events. The method estimates S-wave arrival times by taking cross-correlations between envelopes of reference events and that of target event at each station. To find appropriate reference events effectively, we use the similarity of concatenated envelopes: the envelopes of all stations are connected in order keeping the amplitude ratios and time differences of envelopes between stations. The similarity of the concatenated envelopes means that the hypocenters and path effects on the envelope waveform at each station are almost the same with those of the reference events. By applying this method to B-type earthquakes at Miyakejima volcano observed from August 2010 to April 2011, we determine 71 % of the observed ones in an automated way. The B-type earthquakes are located within a 1 km diameter centered on the southern part of the summit caldera, where continuous gas emission occurs. On the other hand, A-type earthquakes, which show clear onsets of P- and S-waves, are distributed from southern part to western part of the summit caldera. To check the reliability, we also compare the result to the hypocenters located by picking P- and S-onset times, and there is no systematic difference between them as seen in the comparison to the result of Obara (2002) method. Our new method is applicable to volcanic earthquakes recorded at other seismic networks that consist of at least several stations surrounding hypocenter regions, which will help us to monitor and understand volcanic activity.

Keywords: hypocenter determination, envelope correlation, Miyakejima volcano