Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

STT53-01 Room:202 Time:May 24 16:15-16:30

Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) (3)

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Huge tsunami, which was generated by the 2011 off the Pacific Coast of Tohoku Earthquake (Mw9.0), attacked the coastal areas in the north-eastern Japan and gave severe casualties and property damages. Before this disaster, there were poor on-line read-time seismic and tsunami observation networks in sea area around Japan, and information of ground motion and tsunami heights were very limited. To break this serious situation, the project to construct a large-scale seafloor network of cable-linked observatories around Japan Trench and Kuril Trench, named Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net), started in 2011. This network is for earthquakes, tsunamis and vertical crustal deformations. Such real-time data from the seafloor observatories make it possible to forecast the next-generation early tsunami warning which could precisely predict coastal tsunami height. Also the data may make it possible to forecast an earthquake warning much earlier than the present system.

The network consists of about 150 ocean bottom observation stations. Ocean bottom fiber optic cables, about 5,700 km in total length, connect the stations to land. Observation stations with tsunami meters and seismometers will be placed on the seafloor off Hokkaido, off Tohoku and off Kanto, in a spacing of about 30 km almost in the direction of East-West (perpendicular to the trench axis) and in a spacing of about 50 - 60 km almost in the direction of North-South (parallel to the trench axis). Two or more sets of tsunami meters and seismometers will be installed in one station for redundancy. The digitized data will be transmitted to the data centers, JMA (Japan Meteorological Agency), and so on, using IP network.

This cable system is divided into 6 subsystems. The sea floor part of the coast off Boso subsystem was deployed by C/S Subaru from 9 July, 2013 to 24 October, 2013. The northern part of the coast off Sanriku subsystem was deployed by C/S KDDI Pacific Link from 4 April, 2014 to 13 August, 2014. The coast off Iwate and Miyagi subsystem is now under construction and the deployment will be finished by April 2015. Another subsystems and entire land part systems estimate completion in FY 2015.

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STT53-02 Room:202 Time:May 24 16:30-16:45

Systematic monitoring of broadband seismometer and strong-motion velocitymeter conditions in F-net

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Broadband seismometer data are essential for the development of seismological studies such as those investigating earthquake sources and the Earth's structure. However, these data types are possible to be contaminated by instrumentation response errors that are often difficult to recognize from visual waveform checks. Kimura et al. [2014] developed a systematic method of assessing the seismometer's conditions for recording ground motions at a period range of 50-200 sec in observation networks whose station intervals are as small as 200 km. The method was based on comparisons between teleseismic surface wave records at a target station and those at multiple surrounding reference stations, from which we calculated three index parameters and evaluate in-situ instrumentation conditions, including amplitude and phase responses against input ground motions. Kimura et al. [2014] applied the proposed method to F-net broadband seismometers covering the Japanese Islands, where station intervals are approximately 100 km, and assessed the sensor conditions. However, instrumentations at stations in isolated islands and edges of network could no be evaluated because the number of surrounding reference stations was insufficient.

In this study, we applied the systematic assessing method to not only the broadband seismometers but also the strong-motion velocitymeters which are installed at all the F-net stations. We could evaluate the seismometer conditions using surface wave records with amplitudes larger than 2.0E+4 nm for VSE-355G3 sensors and 2.0E+5 nm for TSM-1 sensors at a period range of 50-100 sec, and 1.0E+5 nm for VSE-355G3 and 5.0E+5 nm for TSM-1 at a period range of 100-200 sec. This extension made the density of sensors higher, and allowed us to check broadband seismometer conditions at isolated stations and strong-motion velocitymeter conditions.

Keywords: broadband seismometer, strong-motion velocitymeter, seismometer response

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STT53-03 Room:202 Time:May 24 16:45-17:00

Automatic Event Detection by AVM method and Measurement of P- and S- arrival times for MeSO-net data

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We have installed and been maintaining the Metropolitan Seismic Observation network (MeSO-net) which consists of 296 seismic stations in Tokyo metropolitan area. The advantage of the network is that we continuously record wide frequency band and dynamic rage seismic data. We developed an autonomous cooperative transfer protocol (ACT) to use a relatively low cost communication line. We have developed a new automatic event detection method, the apparent velocity matching (AVM) method.

We tested the AVM method for the MeSO-net data durng a period of 13 days from September 4, 2011. An event detection rate of 94% and a correct answer rate of 98 % have been achieved after manual inspection of an operator. 24 % of the detected events are not listed in Japan Meteorology Agency (JMA) unified catalogue. However, still 12% events that are judged as an earthquake by the AVM method are noises that are verified by a manual inspection. We propose a method to reduce the noise ratio by calculating cross correlation of waveforms between a target event and a reference event that is estimated to occur near the target event. The method works well and reduces the noise ratio dramatically.

We are now developing a total system that consists of automatic event detection, estimating absolute arrival times, measuring relative arrival times, verification of measurements by manual inspection, and reporting. The system will be implemented in the MeSO-net and tested under real time processing.

Keywords: event detection, automatic processing, Locally stationary AR model, waveform corelation

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STT53-04 Room:202 Time:May 24 17:00-17:15

Improvement of the JMA's hypocenter determination program

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Seismic stations of the integrated seismic network of Japan are in the elevation range from -4000 to 2000m. However, station elevation is ignored in a calculating traveltime and partial derivatives of travel time with respect to hypocentral coordinates in the Japan Meteorological Agency's (JMA's) hypocenter determination program. The traveltime in the program is based on the condition that station elevation is fixed to 0m. Further, sedimentary layer with extremely low seismic velocity under OBS station affects a traveltime at OBS station. But the effects of it on OBS stations are neglected. Therefore, hypocenters in the JMA's seismic catalogue (the JMA's catalogue) have an absolute error which is caused by station elevation and sedimentary layer under OBS stations.

Considering station elevation and station correction for OBS, we have improved the JMA's hypocenter determination program without significantly changing algorithm. In the new program, traveltime tables of each station elevation are used. Each traveltime in these tables was calculated by Pseudo-bending method [Um and Thurber (1987)] and seismic velocity structure of JMA2001 [Ueno et al. (2002)]. In order to shorten the processing time of calculation, these tables are stored in the memory of a server in advance. The values of station correction at each OBS station were estimated from one-dimensional seismic velocity model and arrival time differences between P and PS wave converted from P wave at the base of sedimentary layer. These values are stored in the memory, too.

We calculated hypocenters listed in the JMA's catalogue using the new program. One in the border region of Nagano and Gifu Prefecture where stations are at higher area above sea level, new hypocenters became shallower, the other in the Kanto Plain where most of stations are at around and below sea level, new hypocenters became deeper than that of the JMA's catalogue. Around the Sanriku-oki OBS stations, hypocenters became shallower than that of the JMA's catalogue.

The absolute error caused by station elevation and sedimentary layer can be reduced by using the new program. Further, it is expected that hypocenters around offshore region under OBS stations are made more accurate, too.

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STT53-05 Room:202 Time:May 24 17:15-17:30

Development of a laser strain gradiometer: reduction in thermal noise

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We are developing an instrument to detect slow earthquakes with duration of 200 seconds to 1 day, which are not observed yet. Obstacles for detection include not only an instrumental noise but also background motion. By comparing strain measured at Inuyama Observatory in Aichi prefecture and Kamioka Observatory in Gifu prefecture, and comparing the data of seismometer and that of strainmeter, background motion is estimated to have large sources whose spatial scale is more than hundreds of kilometers. On the other hand, the focal area of a slow earthquake and the distance between hypocenter and an observatory will be several kilometers to tens of kilometers. For these reasons, intensifying small scale phenomena will make detecting slow earthquakes possible.

The instrument will directly measure the second derivative of displacement of the ground. We name it a strain gradiometer. Since spatial derivative intensifies small scale phenomenon, this strain gradiometer will make it possible to detect slow earthquakes. This instrument includes a symmetric laser interferometer. The advantages of using a symmetric laser interferometer are that it directly measures the gradient of strain of the ground, and that it reduces common-mode noise such as the instability of the laser frequency.

The noises of a symmetric interferometer were measured in laboratory. The interferometer was set in a vacuum chamber and adjusted to have its optical path difference below 0.5mm. Noises were caused by thermal expansion or contraction of the optical board and the optical devices. Then the spectrum of thermal fluctuation of the air in an observatory was estimated. Quartz-tube strainmeter in Inuyama observatory was used as a thermometer, assuming that its extension or contraction was caused by variation in temperature. The value of 4.5 x 10^{-4}[K^2/Hz] at f=3.2 x 10^{-5}[Hz] was obtained. Since the value also included the extension of the ground and the noises of sensors, actual temperature fluctuation should be smaller. To detect slow earthquakes with duration of 10,000 seconds (fc=3.2 x 10^{-5}[Hz]) at the distance of 50km, the noise level of 1.4 x 10^{-25} [/m^2Hz] must be achieved. From these figures, temperature fluctuation of an optical board and optical devices must be suppressed to 1/90 of the temperature fluctuation in an observatory. This can be achieved by thermal coupling of a vacuum chamber with the ground, and thermal insulator which covers the chamber. Our previous study assumed that high vacuum, radiation shields, and a ceramic column will reduce heat transfer from the vacuum chamber to the optical board. However, these were not needed, and there was difficulty in preparing an optical board with large heat capacity.

In addition to thermal noises, laser intensity fluctuation, current noise of trimmer resistors, thermal coefficient of them, ADC noise, and axis deviation of laser beam noise were important factors. Except ADC noise, these noises were reduced by introducing a photosensor that monitored the laser intensity, replacing trimmer resister with fixed resistors, using lens that concentrated a beam to photosensors.

As a future plan, we will measure how much the heat transfer from the air to vacuum chamber can be reduced both in the laboratory and in Nokogiriyama Observatory. In Nokogiriyama Observatory, we will also conduct an experiment that what type of noise will arise when the interferometer is set as a strain gradiometer. Then we will construct a strain gradiometer which is 15m long, measuring the noises caused by local inhomogeneity.

Keywords: strain meter, laser interferometer

STT53-06 Room:202 Time:May 24 17:30-17:45

New sensors for improved disaster warning systems and geodetic measurements

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New Quartz Crystal Resonator pressure sensors, accelerometers, and tiltmeters have been developed for disaster warning systems and geodetic measurements. Earthquake, tsunami, and extreme weather warning systems require high-resolution, high-speed, high-range sensors to measure events occurring from a fraction of a second to many hours. Nano-resolution technology allows the measurement of water level fluctuations to microns with absolute deep-sea depth sensors, acceleration and Earth's gravity to nano-g's, tilt to a fraction of a nano-radian, and absolute barometric pressure fluctuations to nano-bars for infrasound detection. Uplift, subsidence, and the slow strain build-up leading to earthquakes, tsunamis and volcanic eruptions require long-term geodetic measurements stable to better than 1 cm/year. These long-term measurements are now possible with new in-situ calibration methods for pressure sensors referenced to atmospheric pressure and triaxial accelerometers referenced to Earth's 1 G gravity vector.

Keywords: extreme events, tsunami, earthquake, eruption, geodesy

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Hypocenter location in an inhomogeneous velocity structure with three-dimensional traveltime table

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An inhomogeneous velocity structure has considerable effect on the accuracy of the earthquake locations in complicated tectonic setting areas like the Japanese Islands. Calculation time is still one of the problems for hypocenter location in a three-dimensional velocity structure. We show a evaluation of calculation time of event location in a three-dimensionally (3D) inhomogeneous velocity structure with lookup tables for each seismic station on the Japanese Islands.

We made 3D traveltime tables for each station to reflect the 3D velocity structure in the event location. The traveltime tables were prepared beforehand for each station. Traveltimes for a station were calculated at grid points of three-dimensional coordinate with a ray-tracing method by Um and Thurber (1987). Traveltimes were calculated for blocks of (1 deg.)X(1 deg.)X(50km) where events had been detected. The grid interval in the block was set depending on distance from the station. The number of stations and blocks are 1,813 and about 250 thousand, and it took about one month of elapsed time on a 128-core cluster machine.

Hypocenter calculation times of 11,448 event locations in January, 2014 were compared for 1D traveltime table (1D-TT), 3D traveltime table (3D-TT), and 3D ray-tracing method (3D-RT). Arrival times in the unified seismic catalogue in Japan were used. The calculation time of one event was within one second for 1D-TT and 3D-TT with an ordinary workstation. The maximum calculation time for 3D-TT was quick enough to be used in interactive processing. On the other hand, some of the calculation time of 3D-RT were more than 10,000 seconds. The time of the 3D-TT was about 1,800 times shorter than that of 3D-RT as an average of logarithmic calculation times. The difference between 1D-TT and 3D-TT is four times as an average of logarithmic calculation times.

An interpolated traveltime is different from that calculated with ray-tracing method at the grid point of the blocks in our method. The difference was checked at every grid point in the blocks. The maximum differences of 82% blocks were less than 0.1 second. However, those of 0.01% of blocks exceeded one second. The large difference was usually caused by stepwise traveltime variation due to ray-path scattering.

Hypocenter locations were compared among ray-tracing, three-dimensional traveltime table, and one-dimensional traveltime table. Whereas the locations of 3D-TT of 98.3% events were close to that of 3D-RT than that of 1D-TT, 3D-TT locations were very close to those of 1D-TT for some events. Many of those events are offshore events or inland events with small differences. It is considered that the location difference were partly caused by the unstable condition in hypocenter location.

Acknowledgments.

We used seismic data from the National Research Institute for Earth Science and Disaster Prevention, Hokkaido University, Hirosaki University, Tohoku University, the University of Tokyo, Nagoya University, Kyoto University, Kochi University, Kyushu University, Kagoshima University, the National Institute of Advanced Industrial Science and Technology, the Tokyo metropolitan government, the Shizuoka prefectural government, the Kanagawa prefectural government, the City of Yokohama, the Japan Marine Science and Technology Center, and the Japan Meteorological Agency.

Keywords: hypocenter location, inhomogeneous velocity structure, three-dimensional travel time table

STT53-P02 Room:Convention Hall Time:May 24 18:15-19:30

Temporal change of transfer functions of seismic waves caused by an air-injection into the underground.

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The Summary for Policymakers (SPM) of the Working Group I contribution to the IPCC's Fifth Assessment Report reported that warming of the climate system was unequivocal and concentrations of greenhouse gases had increased. The SPM of the Working Group III contribution to the AR5 recognized that Carbon Dioxide Capture and Storage (CCS) contributed to reduce CO_2 emission. Since CCS has a risk of CO_2 leakage into the underground, it needs a monitoring of CO_2 reservoirs continuously for long term.

In this study we examined the temporal change in a transfer function of seismic waves by an air injection into the underground in order to monitor the geophysical structure. Previous study for CCS showed that the temporal changes during the injection in Nagaoka City, Niigata Prefecture in 2003 about once a month.

This study researched effects to seismic waves caused by injecting air. We used ultra-stable seismic source called ACROSS for the continuous monitoring. ACROSS had been developed by Kumazawa *et al.* (2000) at Nagoya University and Tono Geoscience Center. ACROSS source accurately controls and transmits seismic or electromagnetic waves to the underground continuously. We monitor a small change of geophysical structure of the underground by estimating the transfer function between the transmitted waves and observed data. We conducted the experiment with ACROSS sources and about 30 geophones near the Nojima Fault in Awaji Island from February to March in 2011. An amount of injected air was about 81 ton into the underground during 5 days.

We analyzed the transfer functions focusing on the temporal variations of the amplitude and frequency which may effectively change corresponding to the changes in the underground structure. Source characteristics (in a unit of force (N)) was estimated from geophone data set near the source and transfer functions (in a unit of m/N)were calculated by deconvolution between observed displacement data and source function. We attempted to detect the temporal changes of transfer functions by comparing the variations of amplitude and frequencies in a target travel-time window before and after the injection. We analyzed some arbitrary travel time windows, in which a particular seismic phase arrive from the particular range in the underground assuming as an isochronal scattering shell, after first arrival of transfer function.

As a result, we found that spectral amplitude at the particular frequencies (e.g. 12Hz and 14Hz) increased over 300% after a day from the start of the air injection at a few observation sites in the eastern side of the injection well. Since such temporal changes were observed at several observation sites and seemed to move towards the up-dip direction site in the eastern area of Mt. Odo, we considered that it might be caused by injected air movements.

Keywords: monitoring, ACROSS

STT53-P03 Room:Convention Hall Time:May 24 18:15-19:30

Sophistication of the cloud type microtremor observation system

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We have been seeking an efficient way to maximize the potential of the microtremor methods for shallow surveys. It is considered that a practical approach has been gained in the observation by the development of portable seismometers (Senna, 2006, 2012) and by the finding of the full usability of the data obtainable by a miniature array (radius less than 1m), optionally together with a small irregular-shaped array (radius less than 10 m) consisting of three seismometers (Cho et al., 2013a).

As an efficient way to infer an S-wave velocity structure, we consider that a classical, simple profiling method (SPM), where a dispersion curve is directly converted into an S-wave velocity structure (e.g., Heukelom and Foster, 1960), is a good scheme from a view point of simplicity, thus, the balance between the efforts and the information to be extracted. It is true, however, that we frequently like to increase to resolution. Facing this dilemma, we suggested a simple tool H/V depth conversion (Cho et al., 2013). We found that the use of an H/V depth conversion followed by a simplified inversion method (SIM) of Pelekis and Athanasopoulos (2011) can in fact increase the resolutions (e.g., Senna et al., 2013; Yoshida et al., 2013).

The current challenge is to further promote the efficiency in the data processing procedure. A visual reading of analysis results, which we take at the current time, is time consuming to deal with a vast mount of microtremor data, now obtainable by a streamlined observational procedure. The reproducibility and biases depending on analyst constitute other kinds of problem of visual reading.

Keywords: microtremor, miniture array, cloud system, underground structure model, S-wave vlocity

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Construction of the seismic observation network around Shimokita Peninsula (2)

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[1]Association for the Development of Earthquake Prediction

In Japan, dense seismic observation networks have been installed including high-sensitivity seismograph network (Hi-net) operated by NIED. While these networks were relatively thin around northern Tohoku and southeastern Hokkaido. It decreased the earthquake detection capability in this region compared to other regions. Under the circumstance, we installed high-sensitivity seismic network (AS-net) in this region, Shimokita, Tsugaru and southeastern Hokkaido, and started real-time monitoring for earthquake activity (Sekine et al., 2014). In this presentation, we report the first fruits by AS-net system after the completion of network installation and data release.

We have completed the installation of AS-net which consists of 36 observation sites at August 2014, in addition to 20 stations already installed in 2013. Seismic data recorded by AS-net are distributed at the nation-wide real-time distribution network for seismic data, JDX-net. From January 2015, it became able to download the seismic data by AS-net via continuous seismic data download web service managed by NIED. It would contribute to enhance the precision of seismic monitoring and any other researches for seismology.

We estimated the level of background noise for each AS-net station. As a noise level, we calculated the root-mean-square (RMS) value for the amplitude of 1 hour ambient noise waveform. As a result, the noise level in daytime exceeds 50 micro-cm/s at 11 stations. On the other hand, the noise level in daytime was around 10 micro-cm/s or less at 14 stations. At the stations with higher noise level, the ambient noise were dominant at 0.5-1 Hz. The measured average S-wave velocity (Vs) for soil layer between the seismometer at borehole bottom (~20 m depth) and ground surface was related to the noise level for each station; the stations with averaged Vs of 300 m/s or less tended to show higher noise level. It indicates that the noise level at each station depends on the soil condition.

Then we relocated earthquakes around Shimokita region during 2014 automatically using AS-net data in addition to the other stations nearby. Up to 4616 events were determined by our relocation, which are 2.5 times as many as JMA hypocenter catalogue (1846 events). Of course, our result contains some artificial events; blasts, seismic exploration and so on. For natural earthquake, we caught 375 events during a swarm around Towada from 20 to 31 January 2014 (287 events in JMA catalogue). To distinguish these various events we got, we will check them in detail with manual measurement. Frequency-magnitude diagram for our catalogue peaks out at around M0.6 while that for JMA catalogue peaks out at around M1. It implies that the AS-net enhanced earthquake detection capability around Shimokita region.

Reference;

Sekine, S., S. Sawada, K. Kasahara, S. Sasaki, Y. Tazawa, H. Yajima, 2014, Construction of the seismic observation network around Shimokita Peninsula, Jaman Geoscience Union Meeting 2014, Yokohama, STT57-P09, April 2014.

Keywords: Seismic observation network, Shimokita Peninsula

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Azimuth verification of the MeSO-net accelerographs: towards the imaging of ground motions in the Kanto area

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In the Tokyo metropolitan area of Japan, large plate boundary earthquakes repeatedly occurred with intervals ranging from 200 to 400 years in the case of M 8 class, and with an interval of approximately 27.5 years in the case of M 7 class. Rapid prediction of damages on constructions due to such a large earthquake is important to quickly decide the priority order in recovery actions without waiting for on-site reports. Such a rapid prediction system requires an image of ground motion in the target area as an input, which is to be estimated from seismograms of dense seismological observation networks. A dense seismic array called MeSO-net (Metropolitan Seismic Observation network), in which 296 accelerometers are installed with several kilometer intervals, was established in 2007 for the purpose of the disaster mitigation for forthcoming large earthquakes. Whether the actual azimuths of MeSO-net seismometers newly installed after 2009 were really in the magnetic north or not have not been verified yet, while the azimuths of three of the seismometers installed before 2008 were already confirmed to be in the opposite direction. Since such obvious errors in the azimuths badly affect subsequent data processing, we evaluate the azimuths of all seismometers based on the cross-correlation with seismograms recorded at nearby Hi-net tiltmeters and F-net broadband seismometers. Our result suggest that the northward components at more than 80 % of stations are determined to be within 10 degrees from the magnetic north, while those at the three stations are reconfirmed to rotate more than 90 degrees as the previous study pointed out.

Keywords: MeSO-net, sensor azimuth, cross correlation, Hi-net, F-net

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Difference of availability between the F-net and the Hi-net seismograph networks before the 2011 Tohoku earthquake

SUE, Yoshiki[1]*

[1]No institution affiliation

1. Introduction

It was reported that number of missing waveform images of the F-net, the broadband seismograph network of NIED, increased before the subject earthquake (Sue, 2013).

With the aid of a document of the Headquarters for Earthquake Research Promotion, where availability of the F-net and the Hi-net, high sensitivity seismograph network are shown, we do further investigation.

2. Investigation results

Fig.1 shows availability of the F-net and the Hi-net from April 2009 to March 2012. It shows the following phenomena.

- During the period of longer than 1.5 years from April 2009 to November 2010, availability of the F-net was close to 100%, though it became worse a little several times.
- Starting from December 2010, it became worse continuously, and it took minimum value in January 2011.
- Then it recovered, but it was worse than normal value.
- From February 2011, availability became worse again, and it took minimum value again.
- Then it recovered, though it was worse than normal values, and the 3.11 earthquake occured.
- It returned to normal state in May 2011.
- Availability of the Hi-net was almost constant, except for the days and one month after of the earthquake.

3. Issues

The following points to be discussed.

- For the duration of longer than 1.5 years, high availability of the F-net has been achieved. Why did it become worse starting from around 3 months before the 3.11 earthquake?
- Why did availability vary up and down during the worse period?
- Why was there difference in stability between the F-net and the Hi-net at the 3.11 earthquake?

4. Discussion

For several months before the earthquake of magnitude = 9.0, it is believed that the F-net seismographs had been affected in some way by the crust at their locations. Difference in stability between the F-net and the Hi-net could be because of difference in natural period of the seismographs. Natural period of the F-net seismograph is 360 seconds (STS-1 type) and 120 seconds (STS-2 type), whereas that of the Hi-net is 1 seconds. There were some sort of movements before the earthquake, which were relatively slow. Thus only the F-net seismographs were affected.

The major cause for long-lasting trouble of the F-net is "electric power supply trouble" according to the official information of the F-net.

Gratitude: We thank NIED for the use of data for the F-net and the Hi-net.

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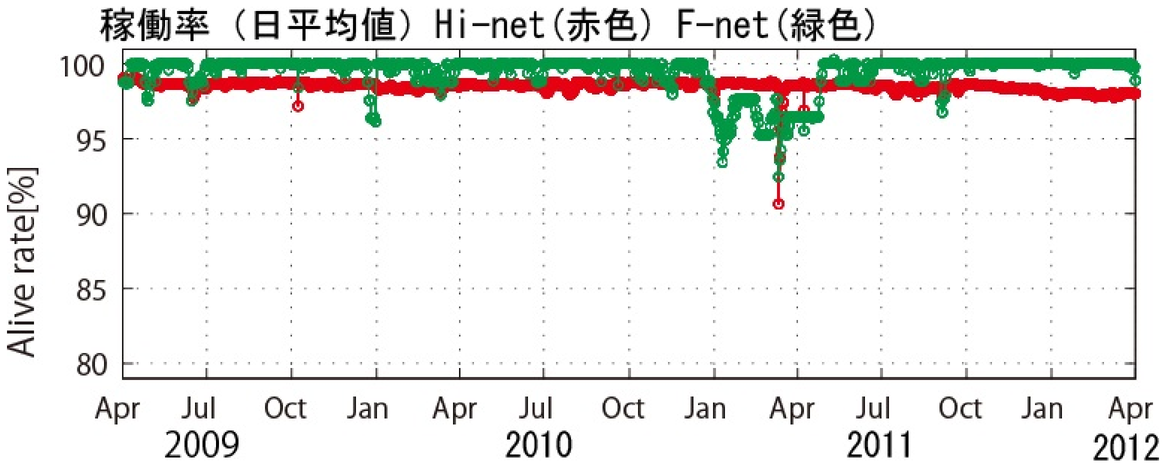
Caption of figure
Fig.1 Availability of the F-net(green) and Hi-net(red) Source: NIED
Availability of the F-net shows deterioration continuously from around 3 months before to after the 2011 Tohoku earthquake. While that of the Hi-net does not show such a change.

Keywords: F-net, Hi-net, Seismograph, Availability, Seismograph network



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Characteristic evaluation of the most suitable seismic exploration array to detect a seafloor topography change

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Generally typical large-scale seismic exploration is not so suitable for isolated, small-scale areas. We expect that a marine exploration with AUV (Autonomous Underwater Vehicles) can solve this problem because of its portability. In order to obtain the dense and high-quality data, various exploration sources may require new type receivers array design.

In this study we therefore assessed the characteristics of survey design for optimum seismic exploration for a target near/under a sea-bottom by using an elastic wave simulation with an elastic finite-difference method (Larsen, 2000). We assumed that a survey target was a stair-casing transformation at the sea bottom as long as 6 m. The model space was 1000m long and, 300m long in horizontal and vertical directions, respectively, and water depth was 150m. The model space was divided into 0.2m-0.2m staggered grids. We gave the parameter of P and S wave velocities (Vp, Vs), attenuation factor (Qp, Qs), and density (ρ). We used a Ricker wavelet as a source time function with a central frequency of 100Hz and 50 receivers installed on the single receiver cable. We calculated 54 cases of seismic records using 6 fixed sources and 9 receivers arrays. We found two important seismic phases, that is, secondary P-waves (called X-phase) and S-waves (Y-phase) that were excited by the target as a secondary source in order to detect the changes of bathometry and understructure. The X-phases were observed in all cases of receiver arrays, but the amplitudes were small and they may be lost in background noises. The Y-phases had larger amplitudes than X-phase but could not be observed by the undersea receiver. In a case of X-phase, the amplitudes became larger when the source was located at a lower area of the bathometry than that at a high area. In the case of X-phase, the largest amplitude was excited by the sea bottom receivers array which was 4˜20 times as large as the other X-phases. In the case of Y-phase, the largest amplitude was observed at the receivers array at the sea bottom. We found that since the source on the sea bottom had the largest amplitude, it was good to obtained high-quality data. It however noticed that an interval between the target and the source is required to be a appropriate distance not to overlap the secondary waves and the primary waves each other.

The location of bathometry change point in horizontal can be detected easily by using the seismic records of the X and the Y phases. But S/N ratio might be smaller because the amplitude of the X-phase and the Y-phase are small. Vertical array is divided into the marine part and the underground part, so it can observe larger amplitude of those phases simultaneously. A vertical array is good to detect the bathometry change in the vertical direction and to obtain a high S/N ratio when the secondary waves and boundary waves with large amplitude can be observed. It however notices that this type of vertical array needs a high cost of the installing and the difficulty of the transport.

In summary, I suggest a seismic exploration array that has both a horizontal array and a vertical array. First, by using a towing horizontal receivers array, the target location can be identified in a horizontal direction in a large area and then by using the vertical array to explore in detail. Before installing the vertical array, we suggest the use of AUV shoots near the sea bottom because it can excite the large amplitude by boundary waves that can record X-phase more correctly. The vertical array is expected to be installed at the upper side of the staircase at 100m away from the target. To observe the records with a higher S/N ratio and to identify the location of the bathometry change in vertical direction. In future, there is an issue to calculate the geometry and size of bathometry change by using the characteristics of frequency dependency.

Keywords: geophysical exploration, seafloor topography change, exploration array evaluation

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Broadband Seismic Array in Micronesia Zone, the South Western Pacific Region

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Although seismic network is well developed in continental and island arc region recently, oceanic region has still very sparse seismic network. For further research of ocean plate, its substructure and geodynamic in the ocean region, seismic network in the ocean are required. OHP/Pacific21 network is focusing Micronesia, the south western Pacific region. In this region only some OHP/Pacific21 stations and USGS stations are under operation and still sparse network. JAMSTEC and ERI, Univ. of Tokyo have started to deploy Broadband Ocean Bottom Seismic (BBOBS) array for about two years around Ontong-Java Plateau where is dynamic evidence of Earth's history. Micronesia islands locate north edge of Ontong-Java Plateau. Then our group has installed some seismic stations in Micronesia islands to place complement of BBOBS network.

In this program, we performed three items as follows, (1) Restart of measurement in Majuro, Marshall islands (2) Installation in Chuuk island and Kosrae island, FSM (3)Relocation of Palau station. Majuro station had long interval of measurement due to permission of land usage. We restarted observation in small island on Majuro atoll after negotiation. Fortunately this site is very silent because this site is out of place of residence. Chuuk and Kosrae stations are installed as temporal stations jointing BBOBS array supported by local residence. Last Palau station located in downtown, so that measurement condition was not fine. We relocated new site where is silent filed area.

All stations listed above are off-line recording. Our group retrieves data on site about every six month. To reduce the risk of data gap by power supply trouble, line trouble, GPS trouble and system trouble, we installed observation system multiply for all parts.

As for new temporal stations, Chuuk and Kosrae stations, we retrieved the data last December. We evaluated noise signal level and checked seismic event data. Generally seismic station is ocean island has high noise level and unstable recording. In these new stations, both stations record stable data and low noise signal except oceanic wave origin's signal. Especially horizontal component of Chuuk station is close to low noise model in long period component. PKP phase excited by distant deep earthquake is recorded in original raw data. The performance of these stations expects more fine quality data in long-term operation to our research.

Keywords: Broadband seismic observation, Ontong-Java Plataeu

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Use of fuel cell system as a power source for seismic observation

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Observation of earthquake or crustal deformation often deployed at sites where commercial power supply is not available. For example, temporal observation after large earthquakes or observation area that is not covered by existing observation network. Even at the site with commercial power supply, backup of power supply is essential in preparation for power cut caused by disasters. In order to acquire continuous data before and after a large earthquake is

Battery or solar cell have been used for observations at the site where commercial power supply is not available. Batteries are usually heavy and unsuitable for transportation. Solar cells cannot produce power during cloudy or rainy weather and night. Although observation system with smaller power have been developed, a certain amount of power is still needed for particular sensors and telemetry.

Fuel cell systems that can be used for seismic and crustal deformation observation is recently developed. Fuel cell systems stably supply power for long time. We made seismic observation at the Yagi observatory (DP.YGI) using a fuel cell system as power supply to test feasibility of the fuel cell system. The system consists of a seismimoter, data logger (LS-7000XT, Hakusan Corporation), fuel cell (TOYOBO ProtonCube(R)), solar cell, power controller, and mobile router (MR03LN, NEC Platforms). The observation was began from December, 2014. The observation system satisfactorily operates in spite of poor power production of solar cell because of snow and bad weather. The fuel cell equipped with two fuel tank of 10L, which can continue the observation for a half year. Increase of number of the fuel tank extends the observation period without exchange of the tank. We have plan to make test observations using the fuel cell system at other sites sensors and with different sensors.

Keywords: fuel cell, seismic observation, crustal deformation observation, temporal observation, power supply