Seismic Monitoring System using Optical Fiber and DAS (Distributed Acoustic Sensing) Technology

*Tsunehisa KIMURA[1], Gareth LEES[1], Arthur HARTOG[1]

1.Schlumberger Fiber-Optic Technology Center

DAS (Distributed Acoustic Sensing) technology has been introduced more than 5 years ago for the demands of pipeline monitoring and intrusion detection in Oil & Gas business. The latest optical fiber sensing technology using ‘Phase’ data now allows DAS to record Seismic signal including VSP (Vertical Seismic Profiling). The system is called ‘hDVS’ (heterodyne Distributed Vibration Sensing) in order to distinguish from pipeline monitoring system.
Unlike conventional seismic recording system, which usually use electro-magnetic sensor or Geophone, hDVS/DAS uses optical fiber as vibration sensor. It measures dynamic strain of the optical fiber, either SMF (Single-Mode Fiber) or MMF (Multi-Mode Fiber) for entire length or the section defined by the system. In case of SMF, the maximum length of the optical fiber is around 50km with current system, while the maximum length is reduced to around 10km for MMF, depending on the level of optical signal loss and optical sampling frequency. We are currently developing new system, which would be able to record over 50km length of SMF (100km is theoretical maximum length for hDVS/DAS).
There are several advantages of hDVS/DAS system compare with current seismic monitoring system such as:
a) Able to use existing optical fiber installations as seismic sensor instantly.
b) One system can measure line sensor as long as 50km rather than dot sensor.
c) Easier to expand as monitoring network by using existing optical fiber network.
d) Spatial resolution and gauge length can be set as parameters.
e) Core part of optical fiber is made of high-silica glass which can be installed at harsh environment over 200 degC where conventional sensors cannot be used.
f) Optical fiber is a passive component and no high risk of failure.
There would be more benefits can be identified.
During the presentation, mechanism of hDVS/DAS system will be explained followed by examples of seismic data recorded during Field trials last few years.

Keywords: DAS, hDVS, Optical Fiber, Laser, Seismic Monitoring

Seismic velocity change in Tokai region detected by Morimachi ACROSS

*Shuhei Tsuji[1], Koshun Yamaoka[2], Ryoya Ikuta[1], Toshiki Watanabe[3], Akio Katsumata[4], Takahiro Kunitomo[2]

1.Faculty of Science, Sizuoka University, 2.Graduate school of Environmental Studies, Nagoya University, 3.ERI, University of Tokyo, 4.Meteorological Research Institute, JMA

In this study, we monitored seismic waves generated by Morimachi ACROSS using High sensitivity seismograph network Japan (Hi-net) stations in Tokai region, and detected two types of temporal travel time changes, secular change and co-seismic change at the time of the 2011 Tohoku-oki Earthquake. We associated the secular and co-seismic changes to closing and opening of the cracks beneath the region due to tectonic strain and strong shaking of the ground, respectively.
ACROSS (Accurately Controlled Routinely Operated Signal System) is a kind of artificial seismic source system for monitoring the temporal variation in propagation properties of seismic waves in the crust. We measured temporal variation in the travel time of S-wave during a period from 2007 to 2014 at five Hi-net stations within 35km away from the ACROSS source. The temporal variation of each component was fit by secular, annual, half-annual and offset at the time of the 2011 Tohoku-Oki earthquake (Fig.1).
In all stations, the secular changes were advance in contrast that the co-seismic changes were delay. The secular advances ranged from 0 to 1 ms/yr and the co-seismic delays ranged from 0 to 5 ms. Both the secular and co-seismic changes showed significant polarization anisotropy. The secular advances were larger in NW component in the five stations. On the other hand, the co-seismic delays were larger also in the same NW component (Fig.2).
If we assume travel time was changed by closing or opening of cracks, the anisotropic changes suggest the selective closing and opening of the cracks in the NE direction. We analyzed the crustal strain during the observation period using GNSS earth observation network system (GEONET). This region showed NW-SE compression and NE-SW extension as the inter-seismic and co-seismic strain, respectively. For the secular changes, inter-seismic strain is well-matched to suggested crack closing. Thus the secular changes may reflect the stress changes in the crust due to tectonic stress buildup. In the co-seismic changes, the co-seismic strain don't match to suggested crack opening. Thus we give the following interpretation. In this region, the crack density in the strike of NE is larger than that in other directions. The strong shaking of 2011 Tohoku-Oki earthquake caused spontaneous opening of all cracks due to increase of pore pressure. So the observed anisotropy should reflects persistently existing preferred orientation of cracks. Considering the geological structure of Tokai region, the interpretation may possible.

Acknowledgments.
We used the data by Hi-net, provided by National Research Institute for Earth Science and Disaster Prevention.

Reference

Ryoya Ikuta et al., 2014, Monitoring of seismic velocity change in Tokai region underground by using ACROSS, Seismological Society of Japan Fall meeting, S19-P07
Takahiro Kunitomo, 2014, An improvement in the Precision of Measuring Seismic Travel Time Changes with the Use of the Hi-net Data, ZISIN, SECOND SERIES, Vol.66, No.4 97-112
Yasuhiro Yoshida, 2011, Crustal activity monitoring by using Accurately Controlled Routinely Operated Signal System (ACROSS), Technical Reports of the Meteorological Research Institute, Vol.63, 88-114

Figure Caption
Fig1. Travel time advance at Kakegawa Hi-net station

Blue and red open circles show observed and predicted travel time advance with reference to Feb 28, 2007.
Predicted one is expressed by linear combination of secular, annual, half-annual variations and offset at the time of the 2011 Tohoku-Oki earthquake (red vertical line).
Fig2. Co-seismic (top) and Secular (bottom) travel time changes
Star shows the location of Morimachi ACROSS source. Ellipses show travel time variations with uncertainty expressed by their width of the arc colored by red (advance) and blue (delay). The axes of each ellipse correspond to the travel time variation of Tt and Rr components.

Keywords: seismic ACROSS, seismic velocity change, travel time change, Hi-net, Tokai region

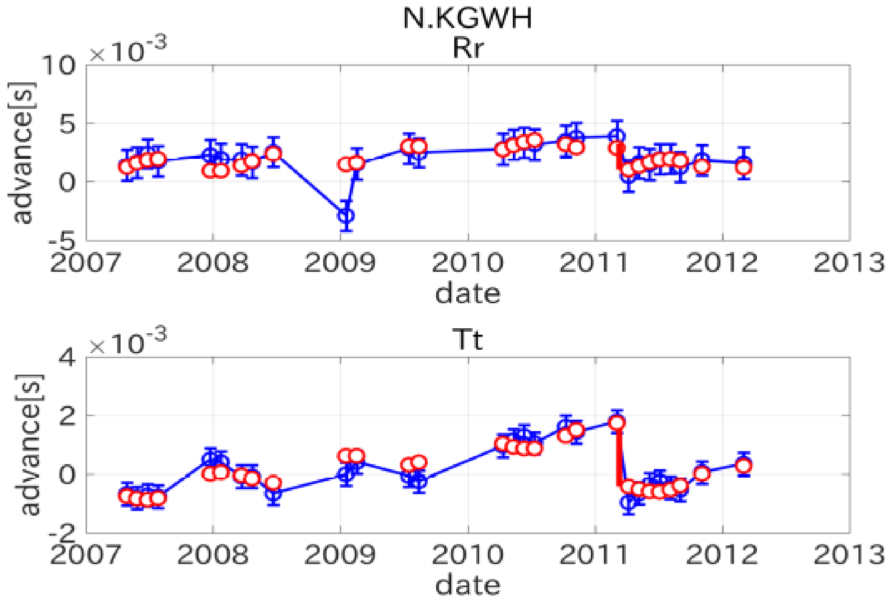


Fig.1 Travel time advances at Kakegawa Hi-net station

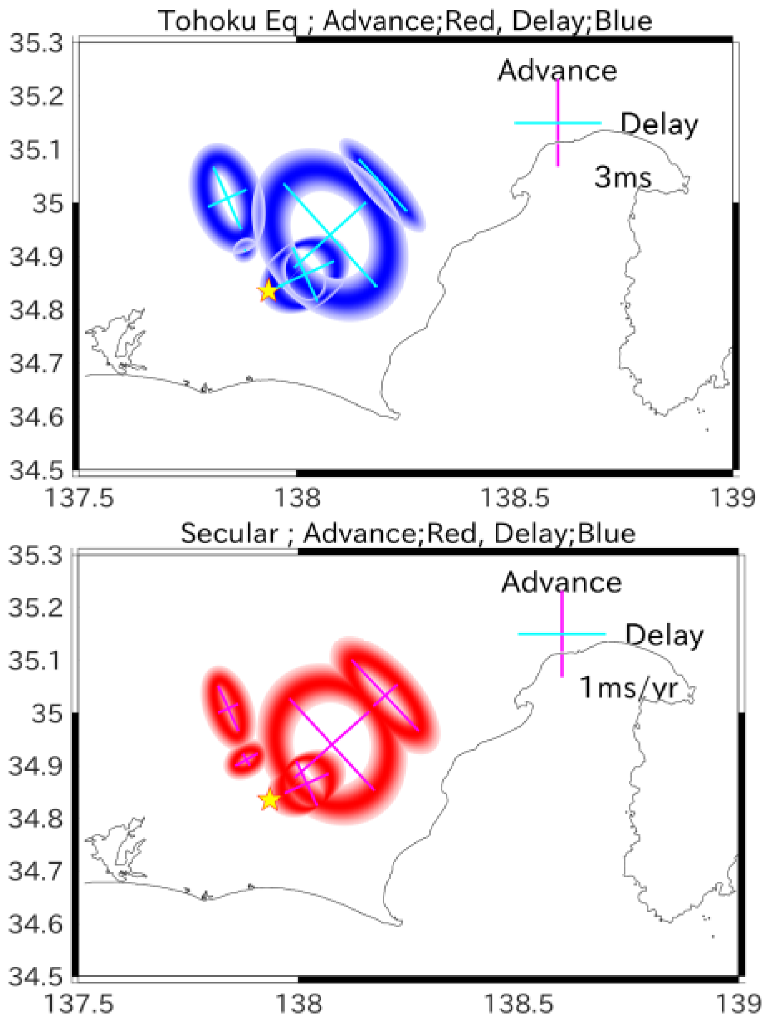


Fig.2 Co-seismic (top) and Secular (bottom)
travel time changes

Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) - Construction of subsea part of the S-net -

*Masashi Mochizuki[1], Toshihiko Kanazawa[1], Kenji Uehira[1], Hiromi Fujimoto[1], Shin-ichi Noguchi[1], Takashi Shimbo[1], Katsuhiko Shiomi[1], Takashi Kunugi[1], Shin Aoi[1], Takumi Matsumoto[1], Shoji Sekiguchi[1], Yoshimitsu Okada[1], Masanao Shinohara[2], Tomoaki Yamada[2]

1.National Research Institute for Earth Science and Disaster Prevention, 2.Earthquake Research Institute, University of Tokyo

NIED (National Research Institute for Earth Science and Disaster Prevention) has launched the project of constructing an observatory network for tsunami and earthquake on the seafloor, after the occurrence of the 2011 off the Pacific coast of Tohoku earthquake by the reflection that we could not monitor the expanse of the earthquake and the tsunami outbreak on site and in real time due to poor coverage of observation in ocean area. The project has been financially supported by MEXT (Ministry of Education, Culture, Sports, Science and Technology - Japan).

The observatory network was named “S-net”. S-net consists of 150 seafloor observatories which are connected in line with optical cables. The total length of submarine optical cable is about 5,700km. S-net system extends along Kuril and Japan trenches around Japan islands from north to south covering the area between southeast off island of Hokkaido and off the Boso Peninsula, Chiba Prefecture. Each observatory equips two sets of quartz type pressure gauge and four sets of three-component seismometers. Digitized data from those sensors are transmitted to land and used for early warning and precise measurement for earthquakes and tsunamis.

Two Japanese cable layer ships, which are specially designed for installation and repairing of submarine telecommunication cables, have been used for installation of the S-net submarine cable system. The S-net submarine cable system including the observatories is buried 1m beneath the seafloor to prevent from interference with fishing industry in the area shallower than 1,500m water depth. Those cable layer ships have capabilities of burying submarine cables. The S-net submarine cable system was originally designed to be deployed with the cable layer ships.

Three of authors are now board on C/S SUBARU, which is one of two cable layer ships described above, and in charge of installation of a subset of the S-net submarine observatory network which covers the area between east off Aomori Prefecture and south off island of Hokkaido. Installations of 23 observatories and about 800km length optical cable on the seafloor will be completed shortly after.

We will report the progress of the construction of S-net submarine cable system in this presentation.

Keywords: Seafloor Observatory Network, Tsunami, Submarine Earthquake

Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) - System of landing station part -

*Kenji Uehira[1], Toshihiko Kanazawa[1], Masashi Mochizuki[1], Hiromi Fujimoto[1], Shin-ichi Noguchi[1], Takashi Shimbo[1], Katsuhiko Shiomi[1], Takashi Kunugi[1], Shin Aoi[1], Takumi Matsumoto[1], Shoji Sekiguchi[1], Masanao Shinohara[2], Tomoaki Yamada[2]

1.National Research Institute for Earth Science and Disaster Prevention, 2.Earthquake Research Institute, University of Tokyo

Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) project to construct a large-scale seafloor network of cable-linked observatories is in progress around Japan Trench and Kuril Trench in Japan. The S-net consists of 150 ocean bottom earthquake and tsunami observation stations, ocean bottom fiber optic cables which are about 5,700 km in total length, landing stations, IP-VPN network which delivers data to data centers, and data centers. The ocean bottom fiber optic cables connect the observation stations to land, and they are drawn inside landing stations.

We have constructed five landing stations; Minamiboso station in Minamiboso City, Chiba Pref., Kashima station in Kashima City, Ibaraki Pref., Watari station in Watari Town, Miyagi Pref., Miyako station in Miyako City, Iwate Pref., and Hachinohe station in Hachinohe City, Aomori Pref.. The Watari station is located on the third floor of reinforced concrete building, and other stations are container-type data centers.
In the landing station, there are a high voltage receiving transformer equipment, an emergency diesel generator with a tank which can store fuel for one week, uninterruptible power supplies (UPSs), a power feed equipment (PFE) that supplies constant DC current (1.1 A) to a submarine cable and observation units, optical receiver transmission equipment, optical wavelength division multiplexing equipment (WDM), GPS clocks, data conversion servers, data transmission servers, supervisory equipment, and so on.

In each earthquake and tsunami observatory under sea water, there installed two sets of three component servo accelerometers, a set of three component velocity seismometers (analog outputs), and two quartz type depth sensors and a set of three-component quartz type accelerometers (frequency outputs). These data are transmitted to the landing stations as the digital data which synchronized to a GPS clock signal supplied from the landing station. The data of frequency outputs are frequency count values at sampling frequency of 8 kHz, and these of analog outputs are digitized values by 24 bits AD converter at sampling frequency of 1 kHz. Data conversion servers at the landing station receive these data. The 8 kHz frequency count data are converted into physical value data of 100 Hz (acceleration) or 10 Hz (water pressure and temperature), and these physical data are delivered to data transmission servers. The 1 kHz digitized analog data are converted into 100 Hz data by decimation filter, and delivered to data transmission servers.

The data received by data transmission servers will be transmit to Tsukuba data center, Tokyo backup data center, Japan Metrological Agency (JMA), and related institutions via two control center using an IP-VPN network.

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

Installation of compact seafloor cabled seismic and tsunami observation system using ICT

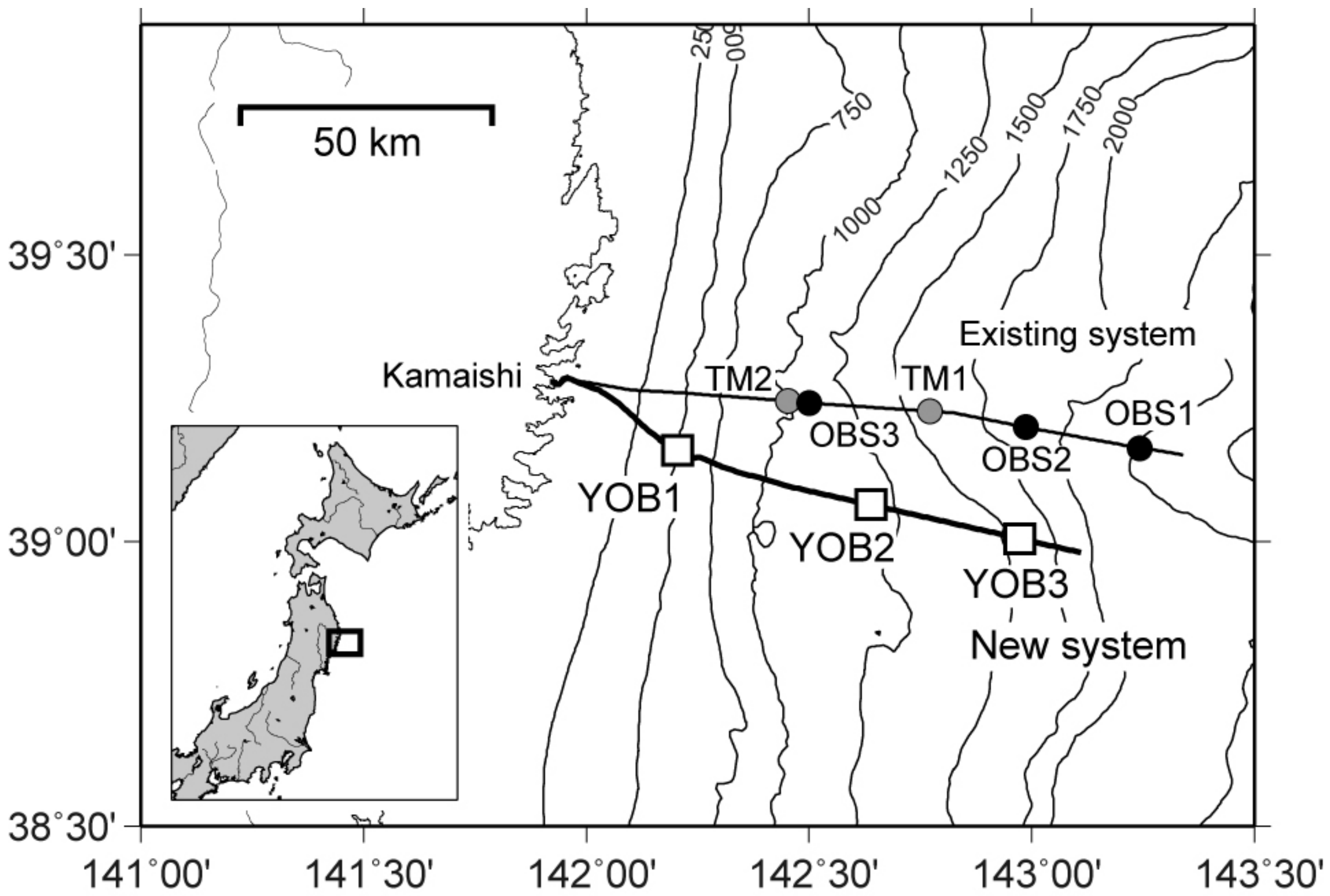
*Masanao Shinohara[1], Tomoaki Yamada[1], Shin'ichi Sakai[1], Hajime Shiobara[1], Toshihiko Kanazawa[2]

1.Earthquake Research Institute, the University of Tokyo, 2.National Research Institute for Earth Science and Disaster Prevention

A seismic and tsunami observation system using seafloor optical fiber had been installed off Sanriku, northeastern Japan in 1996 to obtain exact seismic activity and to observe tsunami on seafloor. This system is based on the tele-communication technology, and observation was performed continuously in real-time. In March 2011, the Tohoku-oki earthquake occurred at the plate boundary, and the system recorded seismic waves and tsunamis by the mainshock. These data are useful to obtain accurate position of the source faults and source region of tsunami. However, the landing station of the system was damaged by huge tsunami, and the observation was suspended. Because the real-time seafloor observation by cabled system is important in this region, we decide to reconstruct a landing station and install newly developed Ocean Bottom Cabled Seismic and Tsunami (OBCST) observation system for additional observation and/or replacement of the existing system. From 2005, we have been developed the new compact Ocean Bottom Cabled Seismometer (OBCS) system using Information and Communication Technology (ICT). Our system is characterized by securement of reliability by using TCP/IP technology and down-sizing of an observation node using up-to-date electronics technology. In 2010, the first OBCS was installed in the Japan Sea. The new OBCST system is placed as the second generation of our system, and uses standard TCP/IP protocol with a speed of 1 Gbps for data transmission, system control and system monitoring. The Wavelength Division Multiplexing (WDM) is also introduced to reduce number of optical fibers. There are two types of observation nodes. Both types have accelerometers as seismic sensors. One type of observation nodes equips a crystal oscillator type pressure gauge as tsunami sensor. Another type has an external port for additional observation sensor by using Power over Ethernet technology. Clock is delivered to all observation nodes from the GPS receiver on a landing station using simple dedicated lines. In addition, clock can be synchronized through TCP/IP protocol with an accuracy of 300 ns (IEEE 1588). A simple canister for tele-communication seafloor cable is adopted for the observation node, and has diameter of 26 cm and length of about 1.3 m.
A route for the new OBCST was selected in consideration of those of the existing cable and plans for another new cable system, and results form a route survey in 2013. According to the route plan, the system has a total cable length of 105 km and 3 observation nodes with 30 or 40 km spacing. Two observation nodes have a built-in tsunami meter, and the furthest observation node has the PoE port. At the deployment of the cable system, we attached a precise pressure gauge with digital output to the PoE port.
Deployment of the OBCST system was carried out in September 2015 by using a commercial telecommunication cable ship. First, the cable ship swept the seafloor along the cable route to remove obstacles on the seafloor. An end of cable was landed to the landing station and the cable ship started deployment of the cable system offshore. In the region where the water depth is less than 1,000 meters, the submarine cable and the observation node closest to the coast were simultaneously buried with using a plough-type burial machine. Burial depth is 1 meter below the seafloor. Finally, a remote operated vehicle buried the submarine cable around the landing point. After finishing of the deployment, data recording was immediately started.
From the seismic data from the new system, it is found that the noise levels are comparable to those at the existing cabled system off Sanriku. In addition, it is confirmed that burial of the sensor package is effective noise reduction. For water pressure data, pressure gauges have a

resolution of less than 1 hPa. Data from all the sensors both the new system and the existing system are consistent.

Keywords: Cabled seafloor observation system, Ocean bottom seismometer and tsunami meter, Real-time observation



CONSTRUCTING A SYSTEM TO EXPLORE VELOCITY STRUCTURES USING A MICROTREMOR OBSERVATION

*Shigeki Senna[1], Hiroki Azuma[1], Yuta Asaka[2], Hiroyuki Fujiwara[1]

1.National Research Institute for Earth Science and Disaster Prevention, 2.MSS Corp

Our final goal is to provide quantitative information on subsurface S-wave velocity structures in response to a variety of social needs regarding geological and soil matters. Since S-wave velocity is a physical property directly related to site amplification and ground stiffness, it is expected to contribute to, for example, improving accuracy of seismic zoning for the mitigation of earthquake disasters. Currently, we are constructing a system for observation and analysis of microtremors to explore S-wave velocities within the depth range from several to tens of meters on the basis of 15-minute observations with a miniature seismic array having a radius of 0.6 m. The simplicity and objectivity of our system affords automization and quality control, with an expected capacity to acquire large amounts of microtremor data.
We have ever collected bore-hole data and soil physical properties data, and then, by using them, have constructed initial geological models of subsurface structure from seismic bedrocks to ground surfaces in some areas of Japan, which have thicker sedimentary layers.
At present, we are constructing models of subsurface structure in wide area for Kanto and Tokai region of Japan as part of the national project, “Reinforcement of resilient function for disaster prevention and mitigation.”
In this study, at first, we collected as many records as possible obtained by microtremor and earthquake observation in the whole Kanto area, including Tokyo. And then, using geological models based on the results of boring surveys as reference, subsurface structure model from seismic bedrock to ground surface was improved based on records of microtremor array and earthquake observation in those areas.

Keywords: microtremor observation system, underground structure models, miniature array

Automated hypocenter detection system using both Hi-net and online temporal observation data

*Tatsuhiko Saito[1], Tomotake Ueno[1], Yohei Yukutake[2], Yoshikatsu Haryu[3], Youichi Asano[1], Katsuhiko Shiomi[1]

1.National Research Institute for Earth Science and Disaster Prevention, 2.Hot Springs Research Institute of Kanagawa Prefecture, 3.Association for The Development of Earthquake Prediction

Fundamental seismic observation networks such as NIED Hi-net and F-net enable us to monitor moderate size seismic activity uniformly for whole Japan. Once a large earthquake occurs, its hypocenter location, magnitude, and mechanism are automatically determined. The earthquake information and the seismograms are opened to the public through the web site. It is also important to correctly monitor the spatial and temporal distribution of its aftershocks in order to assess and prepare for the events that possibly occurs after the large earthquake. However, the fundamental seismic observation networks are not suitable for correctly monitoring the aftershock and swarm activities because the station distribution is too sparse for the detail hypocenter determination. We, hence, constructed an online analysis system and examined its performance. We incorporated mobile observation records into continuous Hi-net records for automated hypocenter determination. We first developed a system in which the seismograms obtained by a mobile observation are transmitted to the NIED Data Management Center in Tsukuba and are compiled with the continuous Hi-net records for the automated analyses. The observed data were continuously stored in the integrated system within a few minutes. We investigated the performance of the automated hypocenter determination by taking the 2015 swarm activity of Hokone volcanic area, Japan as example. The records of a mobile station installed adjacent to the swarm activity increased the number of the automatically determined hypocenters. Also, the hypocenter locations were improved, in particular, the depths of the earthquakes were well constrained and became a few km shallower than those without using a mobile station.

Keywords: fundamental seismic observation network, mobile observation, automated hypocenter detection

Simulation of hypocenter determination of assumed hypocenters by using S-net stations

*Takashi Shimbo[1], Kenji Uehira[1], Toshihiko Kanazawa[1], Masashi Mochizuki[1], Hiromi Fujimoto[1], Shin-ichi Noguchi[1], Takashi Kunugi[1], Katsuhiko Shiomi[1], Shin Aoi[1], Shoji Sekiguchi[1], Takumi Matsumoto[1], Yoshimitsu Okada[1], Masanao Shinohara[2], Tomoaki Yamada[2]

1.National Research Institute for Earth Science and Disaster Prevention, 2.ERI

To observe earthquakes occurring under seafloor and tsunami, project to construct Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) is started in 2011. The S-net consists of 150 seismic and tsunami observation stations. These stations are arrayed from off Hokkaido to off Boso at intervals of about 30km in the direction North-South (parallel to the trench axis) and at interval of about 50-60km in the direction East-West (perpendicular to the trench axis). S-net makes it possible to forecast earthquake warning and tsunami warning much earlier than presence. To understand occurrence of earthquake occurring under seafloor, we must research hypocenters distribution, focal mechanism, velocity structure, and stress field under seafloor accurately. Then we need to research relationship between subducting plate and occurrence of earthquake and process of strain accumulation at interplate. To research these in detail, we need to locate hypocenters under seafloor precisely. In our previous study, travel times from aftershocks of 2011 off the Pacific coast of Tohoku Earthquake located by an ocean bottom seismic network [Shinohara et al. (2011, 2012)] to S-net stations were calculated and hypocenters were located. We researched resolution of hypocenter determination from the result. To estimate resolution of hypocenter determination, it is importance to analyze similarly in more large area than source area of 2011 earthquake.
To understand accuracy of hypocenters determined by S-net, we simulated of hypocenter determination by using travel times from assumed hypocenters to stations of S-net. These hypocenters are assumed in range between 35.5°N and 40.0°N latitude (grid spacing: 0.25°) and 140.5°E and 143.0°E longitude (grid spacing: 0.25°), depth between 5 and 50km (grid spacing: 2.5km). A number of earthquakes are 3971. We calculated travel times from these hypocenters to seismic stations and estimated arrival times of every station. Hypocenters were determined by using the arrival times. Then hypomh program [Hirata and Matu'ura (1987)] was used. Velocity structure of S-net used calculation of travel times and determination of hypocenters was modeled by introducing result of seismic survey for installation of S-net. As the result, 3914 hypocenters were located. We compared located hypocenters with assumed hypocenters. 196 of the hypocenters were difference than assumed hypocenters. Difference in the epicenters and/or in the depth is more than 3km. Hypocenters assumed in land of more than 100km from coast line were not located precisely. It is importance to research range of precise location of hypocenters by S-net because hypocenters far from a seismic network are not located precisely.

Construction of the seismic observation network around Shimokita Peninsula (4)

*Shinako Noguchi[1], Yoshihiro Sawada[1], Keiji Kasahara[1], Shutaro Sekine[1], Yoshihiro Tazawa[1], Hiroshi Yajima[1], Shunji Sasaki[1]

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. Although, these networks were relatively thin around northern Tohoku and southeastern Hokkaido. It decreased the earthquake detection capability in this region compared to other regions. 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) and other). We report the result of manual hypocenter relocation using data derived by AS-net, in addition to the analysis using manual pick data.
The hypocenter location is conducted at the region from Aomori prefecture to southwestern Hokkaido using data from 134 seismic stations including 36 stations of AS-net in addition to networks operated by JMA, NIED, Hirosaki University, Tohoku University, Hokkaido University and Aomori Prefecture. We intend the events occurring during 16 months from September 2014, just after we finish the installation of AS-net, to the end of 2015. 5726 events are detected automatically in the region during the period. Then we check and relocate these events by means of manual pick. 2880 natural earthquakes are determined by manual pick. 40 % or more of events determined automatically are natural earthquakes, ~40 % are artificial events like a blast and the other are false detection. 10 % or less of natural earthquakes determined manually are determined based on JMA catalogue, because they have not detected automatically. JMA catalog has 1404 events in this region during the period. It means that the earthquake detection capability increased 2 times or more by using AS-net in terms of the number of events. Especially, around 5 times number of events are determined around Wakinosawa, almost the center of the region AS-net installed.
Then we calculate the average of O-C time, the average of the difference between manual pick for P- and S-wave arrival time and theoretical arrival based on 1D structure, to estimate the station correction of travel time at each AS-net station. The averaged O-Cs for each station show various tendency at sub-regions. The averaged O-C for P and S phase arrival show the same tendency. The stations which show lower noise-level estimated by ambient noise record tend to show smaller and negative O-C. Low noise level indicate that the basement of the site is shallower and the site amplification is weaker. Small O-C indicates that the delay of P and S arrival due to soft surface layer is smaller at the station. Thus, the relationship between O-C and noise level confirms that the averaged O-C reflects the site characteristic around the station. It shows the adequacy to estimate the station collection of travel time based on these averaged O-C.

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.

Acknowledgement
In this research, we use the seismic observation data which are observed and distributed by JMA, NIED, Hokkaido University, Tohoku University, Hirosaki University and Aomori Prefecture. We use the hypocentral data by JMA catalogue.

Keywords: Seismic observation network, Shimokita peninsula, Earthquake detection

Development of the seismic signal detection method under low SNR condition using an artificial neural network

*Kahoko Takahashi[1], Yuya Matsumoto[1], Zhe Sun[1], Kazuyuki Koizumi[1], Tatsuya Takeuchi[2], Hiroki Uematsu[3], Ahyi KIM[1]

1.Yokohama City University, 2.Yokohama National University, 3.Senshu University

We have developed a community based MEMS sensor network, Citizen Seismic Network (CSN) to obtain the detailed strong motion data which closely linked to community's life. In this project, we developed a sensor unit which detects strong motion and process the data. The unit is composed of 12 bit MEMS sensor and Raspberry pi. Since we expect the unit is set under the high noise environment (e.g. inside of house), it is important to discriminate between the earthquake signal and the others. However, under the such environment, the conventional method, ratio of short time average and long time average (STA/LTA) which depends on the amplitude of the signal often mislead to pick noise as the signal. To overcome this problem, we developed a method to detect and identify a seismic signal using an artificial neural network (ANN) which utilize a pattern recognition. In the initial test, we used waveform data recorded at our sensor network as the training data to detect the other observed data. We found the discrimination was successful. However, at the moment, since we only have five earthquakes detected in our network, the amount of training data is not enough. So as the next step, we use the seismic data obtained at the Yokohama strong motion network and loaded noise obtained by our sensor to the seismic waves. Using the waveforms as training data we will show the synthetic test to check the ability of our ANN detection algorithm.

Keywords: Seismic signal detection, Neural network, ANN, MEMS

Fundamental improvement of precise and longterm monitoring system of seismic wave with giant magnetostrictive seismic source

*Takahiro Kunitomo[1], Hiroshi Ishii[1], Yasuhiro Asai[1], Osam Sano[1], Makoto OKUBO[2]

1.Tono Research Institute of Earthquake Science, ADEP, 2.Natural Science Cluster, Kochi University

An actuator using a giant magnetostrictive element is characterized by large generative stress and simplicity of use, but disadvantaged by small displacement relative to actuators such as electrodynamic shaker and hydraulic vibrator. Therefore, it is expected to be applied to the high frequency seismic source. In Tono Research Institute of Earthquake Science, the giant magnetostrictive seismic sources (GMSS) have been developed [Ishii et al. (2011), Sano et al. (2011), Okubo & Sano (2011)]. Boxcar signal of 500Hz with GPS time synchronization has been tested, in order to detect not only within the Mizunami observation tunnel but also in the borehole array observation system of TRIES far from the GMSS. However, detailed investigation in 2015 revealed that electrical noises, derived from the data logger or electrical signal such as trigger signal, have been mistakenly perceived as elastic wave signals from GMSS so far. The GMSS system, especially control instruments and signal design, was thoroughly renewed. As the result, P-wave arrival from the GMSS was clearly observed at the 350m borehole seismometer by ten days data stacking. We prepare to remake the GMSS into a single-force seismic source for power upgrade for the realization of practical subsurface monitoring.

Keywords: giant magnetostrictive actuator, GPS time synchronization, single force

Development of JAMSTEC Ocean-bottom Seismology Database (J-SEIS) to download DONET Event Data and Borehole Continuous Data

*HIROKI HORIKAWA[1], Morifumi Takaesu[2], Kentaro Sueki[1], Eiichiro Araki[1], Akira Sonoda[1], Narumi Takahashi[1], Seiji Tsuboi[1]

1.Japan Agency for Marine-Earth Science and Technology, 2.Nippon Marine Enterprises, Ltd.

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) have developed a database of seismic data observed in the Nankai Trough in southwest Japan. We have operated DONET Seismic Waveform Data Site and Long-Term Borehole Monitoring Data Site, these data site are download systems of seismic data.
DONET Seismic Waveform Data Site is a web application system to download seismic data of DONET1, we have operated the system since November 2014. This system allows researchers to download strong motion (EH type) and broadband (BH type) seismograph data as seismic event data of SEED format. Seismic event data is produced referring to event catalogues from USGS and JMA (Japan Meteorological Agency), Magnitude greater than 6 for far-filed and greater than 4 for local seismicity, respectively.
Long-Term Borehole Monitoring Data Site is a web application system to download seismic data of Long-Term Borehole Monitoring System, we have operated the system since July 2015. During IODP Exp. 332 in December 2010, the first Long-Term Borehole Monitoring System was installed into the borehole site located 80 km off the Kii Peninsula, 1938 m water depth in the Nankai Trough. It consists of various sensors in the borehole such as a broadband seismometer, a tiltmeter, a strainmeter, geophones and accelerometer, thermometer array as well as pressure ports for pore-fluid pressure monitoring. The signal from sensors is transmitted to DONET in real time. Long-Term Borehole Monitoring Data Site allows researchers to download seismic data as continuous data of SEED format.
DONET Seismic Waveform Data Site and Long-Term Borehole Monitoring Data Site are similar systems, we have integrated those systems. Integrated system is called JAMSTEC Ocean-bottom Seismology Database, J-SEIS.
J-SEIS allows researchers to download event data of DONET1 and continuous data of borehole. In addition, new system has additional futures (e.g. data download page like “Web Service” of IRIS). Operation of J-SEIS is scheduled for FY2016. In the future, it will be possible to download seismic data of DONET2 and new borehole site.

Keywords: Seismic Waveform Data, Long-Term Borehole Monitoring System, DONET, D/V Chikyu

