CONSTRUCTING A SYSTEM TO EXPLORE VELOCITY STRUCTURES USING A MICROTREMOR OBSERVATION

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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

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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

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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)

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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

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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

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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

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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

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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

