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)

UEHIRA, Kenji[1*] ; KANAZAWA, Toshihiko[1] ; MOCHIZUKI, Masashi[1] ; FUJIMOTO, Hiromi[1] ; NOGUCHI, Shin-ichi[1] ; SHIMBO, Takashi[1] ; SHIOMI, Katsuhiko[1] ; KUNUGI, Takashi[1] ; AOI, Shin[1] ; MATSUMOTO, Takumi[1] ; SEKIGUCHI, Shoji[1] ; OKADA, Yoshimitsu[1] ; SHINOHARA, Masanao[2] ; YAMADA, Tomoaki[2]

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

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.

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

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

KIMURA, Takeshi[1*] ; MURAKAMI, Hiroshi[2] ; MATSUMOTO, Takumi[1]

[1]National Research Institute for Earth Science and Disaster Prevention, [2]Association for the Development of Earthquake Prediction

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

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

HIRATA, Naoshi[1*] ; NAKAGAWA, Shigeki[1] ; SAKAI, Shin'ichi[1] ; URABE, Taku[1] ; IWASAKI, Takaya[1] ; YOKOI, Yasutaka[2]

[1]Earthquake Research Institute, the University of Tokyo, [2]OHTI

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

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

Improvement of the JMA's hypocenter determination program

MATSUOKA, Hidetoshi[1*] ; UEDA, Mitsuharu[1] ; MORIWAKI, Ken[1]

[1]Japan Meteorological Agency

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.

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

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

Development of a laser strain gradiometer: reduction in thermal noise

DEGUCHI, Takehiro[1*] ; ARAYA, Akito[1]

[1]Earthquake Research Institute, University of Tokyo

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

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

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

New sensors for improved disaster warning systems and geodetic measurements

KOBAYASHI, Taro[1*] ; PAROS, Jerome M.[2] ; OI, Takuma[3]

[1]Paroscientific, Inc., [2]Quartz Seismic Sensors, Inc., [3]Toho Mercantile Co., Ltd.

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