Japan Geoscience Union Meeting 2013
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STT56-P01 Room:Convention Hall Time:May 19 18:15-19:30

Sea trials of new generation ocean bottom seismometer

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We developed a new generation of ocean bottom seismometer (OBS) for extensive seismic study, which designed to advance compactness, user-friendliness, and electrical/mechanical transmission response. The new OBS named OBS2G (2nd Generation OBS to Grid) is integrated in a 13-inch glass-sphere and its weight is just 35 kg in air including the sinker. Access to the stored data, parameter-setting, time-synchronization, and battery-charge are available without opening the glass-sphere by wireless transmission technique. The dynamic range of the seismic recorder is 135 dB at 100 Hz-sampling. OBS2G employs newly developed low-noise ($<$ 7ng/Hz^1/2 at 10Hz) and low-power-consumption accelerometers (15mW). The simple exterior of the OBS2G improves its mechanical transmission response compared to conventional short-period OBS that has some resonances. Observation period of OBS2G is over 4 weeks with the accelerometers.

Currently we have achieved four times of sea trials with OBS2Gs. The recent two trials were conducted at deep waters on JAMSTEC research cruise KR12-12 and KR13-01. The first experiment was held in August 2012 in a water depth of 4,000 meters, the Nankai Trough off Shizuoka. Recent one was held in January 2013 with two OBS2G in water depths of 7,000 meters, the Japan Trench off Miyagi. We have successfully obtained good quality seismic data on both experiments. In this paper, we will briefly introduce characteristics of new OBS and features of acquired data.

Keywords: OBS, seismic

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Ultra-deep ocean bottom seismographic observations just above the Japan Trench

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Recent giant earthquakes such as the 2011 Tohoku earthquake show large slip zones that generate huge tsunami can be located adjacent to trench. Observations in the vicinity are essential to resolve details of phenomena where the noticeable regions are. However, it is a challenging issue to observe earthquakes and their related phenomena just above the large slip zones because most trenches, which include the Japan Trench, are below ultra-deep sea, whose depth is over 6, 000 m. A number of ocean bottom seismometers (OBSs) have been used for marine seismic studies since last century, but most of them are available at less than 6,000 m water depth. Few seismometers equipped with special vessels have been to the deeper zones, but the specialties are barriers in order to make seismic array easily. It is one of the solutions if compact OBSs would be able to be set under ultra-deep sea. We have been developing several compact free-fall/pop-up type OBSs, which include a new type OBS, ultra-deep ocean bottom seismometer (UOBS). It is slightly improved for handling and safety, but basically designed just the same as conventional model for widespread utilization. The UOBS has already enabled to obtain seismic data from just above the Japan Trench since 2012. Each UOBS has a three-component seismometer, a data-logger with a precise clock and batteries inside a housing which is a single glass sphere (dia. 17 in.) with the transponder unit for acoustic communication to vessels, and radio beacon and flashing light for recovery. A prototype UOBS was installed to the sea bottom below more than 6,500 m from sea surface on May 2012. It was recovered after using acoustic transmission. A modified UOBS was deployed below over 7,500 m on August, and recovered on October 2012. We obtained the seismic data from both UOBSs.

Keywords: Ultra-deep ocean bottom seismometer (UOBS), Japan Trench

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Renewal of feed-back circuit in STS-1 broadband seismometer system

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STS-1 broadband seismometer is one of most popular broadband seismometers. The high performance with low instrument noise, high sensitivity and wide dynamic range supplied huge valuable data to seismologists. The production of STS-1 sensor and spare parts had been terminated, however many broadband networks are still using as main seismometer.

OHP seismic network also operates STS-1 sensor in the Western Pacific region. Usage period of the sensors have already been over 20 years. Mechanical body part that is kept in vacuumed and dry condition is still stable and intact status. However the characteristics of electric parts in feed-back and amplification circuit varied due to their life time. Practically some unstable and artificial signal is recorded in low background noise and stable stations.

Recently new feedback circuit box (STS1-E300) is developed and some seismic networks have started to use it. Our network is considering installation of new feed-back circuit to avoid problems by parts' aging. In this presentation, we will report the

New feed-back circuit box includes three components of outer electricity part in one body. It has serial communication port for command to the box for setting measurement mode (normal/maintenance), mass position control and calibration. In trial operation, all functions of the box are checked and operation procedure in our network is produced.

For the installation on site, stable power supply, re-structure of cable wires and interface to PC are required as accessory equipment. We designed and produced new control unit for new feed-back circuit box which is enables to be improved at OHP stations even in the case of unstable power condition.

Test measurement was performed with sensor mechanical part in room and at some our station to evaluate the control unit performance and stability. After test measurement, we installed new feed-back circuit box and control unit at OGS (Ogasawara) station officially this year. In early monitoring, artificial signal that was recorded in original configuration is erased and new system is recording stable signal. By common feed-back circuit, each sensitivity of output changes from original one, which is estimated by electric device constant. Evaluation of exact coefficient is required by other procedures.

Keywords: STS-1 seismometer, feed-back circuit, broadband seismometer, OHP network

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Performance of quartz nano-resolution accelerometer in tidal bands

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The quartz nano-resolution accelerometer developed by Quartz Seismic Sensors, Inc. detects acceleration in the range of +/-2g with high resolution through strain measurement of a quartz oscillator connected to a test mass. This makes use of the same technology of nano-counting as used in the nano-resolution barometer developed by Paroscientific, Inc. We made a parallel observation with this accelerometer and the superconducting gravimeter T011 at the Matsushiro Seismological Observatory, Japan Meteorological Agency, in order to examine the performance of the quartz accelerometer in the tidal frequency bands.

The accelerometer was installed in the vertical orientation about 2 m apart from the superconducting gravimeter. We prepared a simple platform with adjustable feet to level the accelerometer. The sensor and the counter were covered by a polystyrene foam box for reducing the effect of ambient temperature changes. The acceleration output as well as sensor temperature were logged at the rate of 20 Hz. In addition, a platinum thermometer was installed to monitor the temperature in the box. Changes in the room temperature are about 0.1 degrees p-p per day, whereas the changes in the sensor temperature are about 0.02 degrees p-p per day.

Although at first the acceleration value indicated irregular drift and steps, the drift became almost linear with respect to time after two weeks. A tidal analysis of the data with BAYTAP-G revealed that the accelerometer records the tidal gravity signals correctly, approximately consistent with those derived from the superconducting gravimeter. On the other hand, it was also found that barometric admittance is anomalously large, suggesting existence of some instrumental effect of atmospheric pressure on the accelerometer. In addition, effects of temperature changes, which are compensated internally, are still identified in the residual data. Results of a more detailed analysis will be given in the presentation.

Keywords: nano-resolution, quartz accelerometer, superconducting gravimeter, earth tides

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Portable multi-channel seismic reflection system for high-resolution structural imaging

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Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has been conducted seismic survey using multi-channel seismic reflection (MCS) system and ocean bottom seismometers (OBS) for understanding seismogenic and arc evolution processes. Existing seismic systems are large scale fixed-type on R/V Kairei and Kaiyo, which are research vessels of JAMSTEC, because targets are deep from crust to uppermost mantle. Recently, new demands for seismic surveys are increased as acquiring high-resolution data in shallow waters or arctic area for drilling and environmental researches. Therefore JAMSTEC has developed a new portable MCS system in 2011, which can easily be attached to or removed by vessels with cranes.

Four cruises have been conducted with newly developed portable MCS system. The first one was the first sea trial for the portable MCS system by R/V Kaiyo in the Sagami Bay, because sea condition is always calm and many previous seismic lines exist. We confirmed the high-resolution data from a comparison between the portable MCS data and previously acquired by R/V Kairei for deep imaging (Miura et al., 2013). Second cruise was dense 2D grid survey at the tow of the Japan Trench revealing deformation process at the tow of the trench (Kodaira et al., 2012), contributing for drill site selection (Mori et al., 2012) of Integrated Ocean Drilling Program (IODP). Third cruise was for high-resolution imaging of landward slope deformation and sedimentary sequences on oceanic crust around the Nankai Trough. And fourth one was the first cruise with R/V Mirai acquiring high-resolution images around the Nankai Trough partly overlapping the third cruise. In 2013, the portable MCS system will be used for seismic cruise of R/V Kairei. In this presentation, we will show the portable MCS system and examples of high resolution data comparing with existing data.

Keywords: high-resolution, multi-channel reflection seismic, seismic survey

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Evaluating performance of automatic earthquake detection and location system developed to the nationwide seismic network

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In addition to the nationwide dense Kiban seismic network, which is composed of about 1200 seismic stations, many temporary seismic networks with a variety of dimensions have been deployed in various areas in Japan. The number of seismic stations will increase even more. Ability of managing such a huge amount of seismic waveform data by manually picking P- and S-wave arrival times, P-wave polarities, S-wave maximum amplitudes etc. is limited, and therefore application of automatic earthquake detection and location system is anticipated.

Horiuchi et al. (2012) developed such an automatic processing system, and recently Horiuchi et al. (2013) have further developed the system for the application to the nationwide seismic network. This system was set up at Tohoku University, and automatic detection and location processing for the nationwide seismic network has started. It can detect and locate many earthquakes which are difficult to be located by the routine processing based on manual pickings of P- and S-wave arrivals. However, sometimes earthquakes cannot be correctly discriminated by the system: for example, when more than two earthquakes occur almost simultaneously.

In order to consider the application of automatic earthquake detection and location system to the actual seismic network, we need to know its performance. When earthquakes are detected and located by the system, how correctly P- and S-wave arrival times can be picked, and how accurately their hypocenters can be determined? How well is the detection capability of the system in region to region? In which case the system cannot detect or cannot correctly discriminate earthquakes?

To answer these questions, we have started to evaluate performance of the earthquake detection and location system presently developed for the application to the nationwide seismic network. Preliminary results obtained for 1 week period data show that the automatic system can detect and locate earthquakes about 1.5 times more than those in the JMA unified catalogue, which were located by manually picked P- and S-wave arrival times. Frequency distribution of magnitudes shows that the automatic system extends the lower limit of the detection capability to much smaller magnitude range than that by the JMA unified catalogue. Events with magnitudes greater than ~0.0 can be located in the inland areas of Japan by the presently developed automatic processing system. We will report evaluation results of performance of the system applying to much longer period data.

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Development of a system for old seismological records using ZOOMA technology

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We digitized the old seismological records that are stored in WAKAYAMA Observatory of Earthquake Research Institute, applying ZOOMA technology. The digitized data are published at http://wwweic.eri.u-tokyo.ac.jp/ZOOMA/WSO/.

Keywords: old seismological record, zooma

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Seismograms observed by a strong-motion seismograph at Matsushiro

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At Matsushiro Seismological Observatory, a strong-motion seismograph started from September, 1951 (Yamazaki and Kobayashi, 2006), and a strong motion seismograph has been working still now.Many of the earthquake records on strong-motion seismograph were recorded by the Matsushiro Earthquake Swarm. Matsushiro Earthquake Swarm started in August, 1965 at the Matsushiro town in the Nagano city. The greatest magnitude of Matsushiro Earthquake Swarm was 5.4 which occurred on April 5, 1966.Except the Matsushiro Earthquake Swarm, a few earthquake records on strong-motion seismograph were recorded by large earthquakes with serious damage in Japan, such as the 1995 Southern Hyogo Prefecture Earthquake, the 2004 Mid Niigata Prefecture Earthquake, and the 2011 Off the Pacific Coast of Tohoku Earthquake.In the foreign earthquake, very few earthquake records on strong-motion seismograph were recorded by very large foreign earthquake with serious damage, such as the Off of Sumatra Earthquake of Indonesia on December 26, 2004 and the Sichuan Earthquake of China on May 12, 2008.In order to use these analog records practically, we investigated seismic waveforms on the strong-motion seismograph.

(1)Magnitude

In domestic 628 earthquakes, the minimum magnitude of 346 earthquakes recorded by strong-motion seismograph in the Matsusiro Earthquake Swarm is about magnitude 3, that of 25 earthquakes recorded by strong-motion seismograph around Nagano Prefecture is about magnitude 4 and that of 257 earthquakes recorded by strong-motion seismograph outside of Nagano Prefecture is about magnitude 5.In foreign 52 earthquakes, the minimum magnitude is more than 7. The furthest earthquake recorded by strong-motion seismograph was near India on January 26, 2001(magnitude7.7).

(2) The number of events with each area

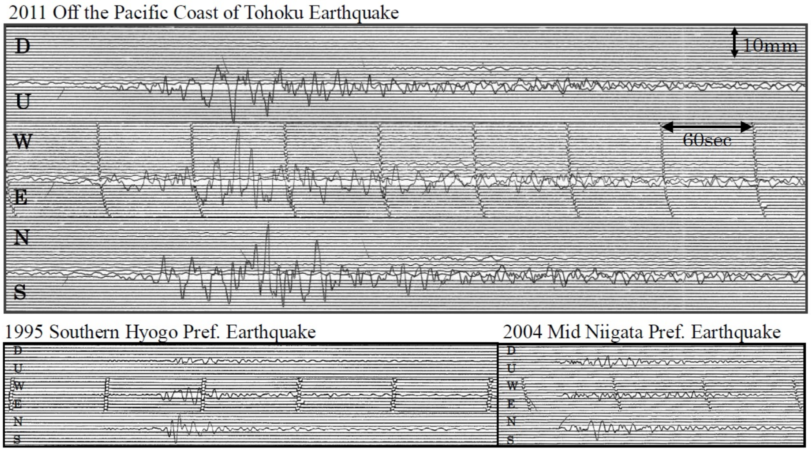
When we divided Japan into East Japan and West Japan with the boundary of Nagano Prefecture except the outskirts of Nagano Prefecture, 221 events are in the East Japan and 36 events are in the West Japan.In the foreign earthquakes, 16 events are around the Kuril Islands, 3 events are around the Vladivostok, 4 events are around the Aleutian Islands, 4 events are around the Micronesia, 7 events are around the Philippine Islands, 10 events are around the Indonesia Islands, 6 events are in the China and 2 events are around the India. Frequency of events is biased in each area.

(3) The waveform feature of strong-motion seismogram

In Japan earthquakes, the maximum amplitude and the period of strong-motion seismograph by Matsushiro Earthquake Swarm on April 5, 1966 were about 5 mm and 1-2 seconds, these of strong-motion seismograph by the Southern Hyogo Prefecture Earthquake on January 17, 1995 were about 9 mm and 4-5 seconds, these of strong- motion seismograph by the Mid Niigata Prefecture Earthquake on October 23, 2004 were about 6 mm and 2-4 seconds and these of strong-motion seismograph by the Off the Pacific Coast of Tohoku Earthquake on March 11, 2011 were about 20 mm and 4-7 seconds.In foreign earthquakes, the maximum amplitude and the period of strong-motion seismograph by the Off of Sumatra Earthquake on December 26, 2004 were about 2 mm and 15-20 seconds, these of strong-motion seismograph by the Sichuan Earthquake on May 12, 2008 were 1 mm and 10-15 seconds.In Japan and foreign earthquakes, we have no over-scale strong-motion seismograph. When magnitude of earthquake was larger than 8, the period of strong-motion seismograph was longer than 35 seconds.

For this reason, the strong-motion seismograph were recorded by large earthquakes with serious damage in domestic and foreign earthquakes, and the earthquake with the largest amplitude was the Off of the Pacific Coast Tohoku Earthquake on March 11, 2011.

Keywords: strong-motion seismograph, magnitude, maximum amplitude, period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2004 Mid Niigata Pref. Earthquake

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The accuracy evaluation of sampling clock of Hi-net and data correction for precise measurement of travel time

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Recently, attempts have been made to detect of seismic travel time change with the use of Hi-net data by various approaches. For example, one to tens of msec of delay in seismic travel time associated with the 2011 M9.0 Tohoku-Oki earthquake were detected by the methods of ACROSS, seismic interferometry, repeating earthquake and so on. For precise measurement of slight change of seismic travel time, synchronization of clock between sources and receivers or receivers and receivers is absolutely essential, but accuracy estimation of sampling clock of Hi-net is not always sufficient so far.

In this study, sensor check signal is used to evaluation and correction of sampling clock of Hi-net data acquisition system. The sensor check signal is a response waveform of seismometer for applied square-wave voltage with 5 seconds in duration to calibration coil. The square-wave voltage is generated by ON/OFF action of DC voltage source by a mechanical relay with 1pps timing of a GPS clock. That's timing is independent of sampling clock, therefore we can potentially check accuracy of the sampling clock on the basis of the GPS clock by using the sensor check signal. The important things here are stability of mechanical relay action and seismometer phase characteristics. The timing of sensor check signal was researched by cross-spectral method at 24 Hi-net stations for the eight years from 2004 to 2012.

Consequently it was revealed that OFF timing of mechanical relay is stable at all stations and there is little variation of temporal change of phase characteristics for high frequency band at a distant from natural frequency ~ 1Hz. Delay time of sensor check signal, starting at 5 seconds past 9 a.m. every day, was analyzed by cross-spectral method. Reference waveform is a month stacked data, Dec. 2012. Delay time of sensor check signal, that is to say sampling clock timing, changes like a stepwise function overlapped with random fluctuate related to data noise level. These results applied to travel time change data Hi-net Yaotsu (11.3km) and Hi-net Hourai(56.9km). Stepwise travel time change disappeared without change in the event of large earthquake, and annual and secular travel time change became clear.

The precision of clock is a foundation of modern science. For seismic measurement to be modern science, explicit information of precision of sampling clock is absolutely needed at a very least. Hereafter, I hope to get and circulate the information of clock correction of all Hi-net stations, and replaced data logger with accurate sampling clock.

Acknowledgement: Hi-net data are provided by National Research Institute for Earth Science and Disaster Prevention, Japan (NIED). Toki ACROSS transmitting station is managed by Japan Atomic Energy Agency (JAEA). I got any information of mechanical relay from Keisokugiken corporation.

Keywords: seismic velocity change, sensor check signal, cross-spectrum, seismic ACROSS

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Comparison of instrumental Mercalli seismic intensities

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The Mercalli intensity scale is widely used in the world. There have been many reports about relationships among the seismic intensity and instrumental measurements such as PGV. We compared several methods to calculate instrumental seismic intensity as one of collaborative works with Chile.

We used regression relationships of the modified Mercalli seismic intensity with PGA, PGV (Wald et al., 1999 : MMI(PGA), MMI(PGV)) and with amplitude used for the JMA instrumental seismic intensity (Shabestari and Yamazaki, 2001: MMI(JMA)). The regression relationships by Wald et al.(1999) are valid in 5-8 for MMI(PGA) , and 5-9 for MMI(PGV). We used acceleration records obtain by University of Chile for the 2010 Chili earthquakes. The number of stations are nine. The JMA instrumental seismic intensity were calculated also, and they range from 4.8 to 5.6.

The differences among MMI(PGA), MMI(PGV), and MMI(JMA) reached 1.6, the the difference is not negligible. The rms of MMI(PGA)-MMI(PGV) is 0.5, 0.7 for MMI(PGA)-MMI(JMA), and 0.4 for MMI(PGV)-MMI(JMA). MMI(PGA)-MMI(PGV) clearly has positive correlation with intensity. Whereas MMI(JMA) is a little smaller than MMI(PGV), the difference does not show clear correlation with the instrumental seismic intensity.

We will increase number of data, and investigate the instrumental seismic intensities with felt seismic intensity.

Keywords: instrumental seismic intensity, modified Mercalli seismic intensity, the 2010 Chile earthquake

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Efforts for the manpower training in JMA, for system development of earthquake and tsunami monitoring

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The Japan Meteorological Agency (JMA) has been developing and operating systems to issue disaster prevention information such as Tsunami Warnings and Earthquake Early Warnings. The systems are composed by various equipments including seismographs, telemeter systems and servers with many software components installed, for handling observation data and issuing information. The units need to be rapid, accurate and reliable for our purpose. To develop such systems, we need wide range of knowledge and technologies such as geophysics and computer science. However, we have had few opportunities to acquire knowledge from these extensive fields for our purpose. The development of our systems has been depended on small number of experienced staffs. To cope with this issue, JMA has been operating "the training course of technologies for seismological service management" for three years in cooperation with Dr. Urabe and Dr. Tsuruoka, from Earthquake Research Institute, University of Tokyo. We introduce the overview of this course, and suggest a path for raising system developers of earthquake and tsunami monitoring systems.

Keywords: automatic processing system, development of human resources, disaster prevention information