Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

STT56-01 Room:102B Time:May 19 11:00-11:15

Development of ocean bottom cabled seismic and tsunami observation system using ICT

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The Pacific plate is subducting below the northeastern Japan islands arc. The 2011 Tohoku earthquake occurred at the plate boundary between the Pacific plate and the landward plate below landward slope of the Japan trench. In 1996, Earthquake Research Institute, University of Tokyo had installed seismic and tsunami observation system using seafloor optical fiber in the off-Sanriku area. The cabled system observed seismic waves and tsunamis generated by the 2011 Tohoku earthquake, and the data from the system are indispensable to estimate the source process of the 2011 event. However, the landing station of the system was damaged by huge tsunami 30 minutes after the mainshock. Therefore we decide to install newly developed Ocean Bottom Cabled Seismic and Tsunami (OBCST) observation system off Sanriku to continue the sea floor observation.

Until 2010, we had already developed and installed the new compact Ocean Bottom Cabled Seismometer system near Awashima-island in the Japan Sea. After the installation, data are being collected continuously and we have continuous seismic data for approximately 2.5 years at the present. The new system for off-Sanriku area is based on this system. The new OBCST has three accelerometers as a seismic sensor. Signals from accelerometers are 24-bit digitized with a sampling rate of 1 kHz and sent to a landing station using standard TCP/IP data transmission. A precise pressure gauge is equipped as a tsunami sensor. The tsunami data are also transmitted by TCP/IP protocol. In addition, we have a plan that an observation node has an external port for additional observation sensor which will install on seafloor using Power over Ethernet technology. The data will be stored on the landing station and sent to Earthquake Research Institute in the real-time. At the present, we are producing a proto-type of the new OBCST. In this paper, we will present a system of the new OBCST in detail, and installation plan.

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STT56-02 Room:102B Time:May 19 11:15-11:30

Modeling of time series structure of seismic waveforms based on hidden Markov models

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Modeling of time series structure of seismic waveforms allows to quantitatively evaluate time-series characteristics of waveforms or obtain clues about physical processes of earthquake generation. Modeled time series structure leads to phase detection, event classification, analysis of frequency structure, analysis of rupture process, and waveform synthesis. Hidden Markov model (HMM) is one of the typical methods for modeling time series structure statistically from observation data. In this study, we focus on phase detection and develop a new automatic detection method for first arrivals of P and S wave based on time series structure modeled by HMM. The new method is expected to demonstrate higher detection capability than conventional methods because information about time series of seismic events is incorporated directly in the new method.

Seismic events which occur in Ashio area (the western part of Tochigi Prefecture) at depths of 0 to 15 km are modeled in this study. Energy, polarity and higher order statistics are extracted as features from about 1,000 clear event waveforms observed from 2009 to 2011 at E.ASO, which is one of the observation points in Ashio. Three HMMs which represent noise, P wave and S wave are constructed from time series of the extracted features. A HMM which represents time series structure of event waveform is obtained by connecting the three HMMs. Detecting first arrivals of P and S wave of given seismic waveform is performed by inferring hidden states of the HMM from the waveform.

The automatic detection method based on HMM is compared with another method based on changes of amplitude and frequency (STA/LTA-AR method) using about 1,000 clear event waveforms observed in 2012 at E.ASO. For P wave, phase picking accuracy of the HMM-based method is equivalent to that of STA/LTA-AR method. For S wave, phase picking accuracy of the HMM-based method is higher than that of STA/LTA-AR method. It is thought that this high detection capability for S wave results from the process of detecting S wave arrival after recognizing subsequent waveforms of P and S wave.

Keywords: hidden Markov model, time series structure, automatic detection, seismicity

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Development of a laser strain gradiometer for the observation of slow earthquakes

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New schemes of observing crustal deformation were considered to detect slow earthquakes with duration of about 200 s to 1 day, which have not been easily observed. Displacement caused by slow earthquakes was analyzed in terms of point dislocation in an infinite homogeneous medium. The amplitude and the spatial scale of the background motion were also calculated by the model known as the New Low Noise Model and the observations by laser strainmeters. Comparing the expected deformation by slow earthquakes with the calculated background motion, we found that the current observation systems do not have potential to observe them but we can observe them by measuring strain gradient of deformation. We developed a prototype instrument for directly measuring the strain gradient. Its temperature dependence and the noises of photodetectors were measured in our laboratory. Then the noise of the interferometer was measured at Nokogiriyama Observatory, ERI. Its noise was composed of the unknown noise which have $1/f^2$ spectrum and the noise caused by convection of the air. $1/f^2$ noise was coupled with the asymmetry of the interferometer. These noises were compared with the spectra of slow earthquakes and the background motion. It was suggested that with less asymmetry and a vacuum chamber, lengths of baselines should be more than 300m. Reduction of the $1/f^2$ noise will be required to detect slow earthquakes with realistic instruments. We present the current situation in reducing the noises and the prospect about observing strain gradient at one place.

Keywords: strainmeter, laser interferometer, slow earthquake

STT56-04 Room:102B Time:May 19 11:45-12:00

Automatic arrival time picking compared to manual picking (4)

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1.Introduction.

Recent installation of many ocean bottom seismometers and inexpensive seismic equipments increases the number of P and S wave arrival time data to be measured. The recent increases make the number beyond the limits in which we can conduct manual picking. The increase require the development of an automatic system which can measure accurate P and S wave arrival times compatible with manual picking. We are developing an intelligent automatic system by introducing the knowledge of seismic experts.

The automatic system was installed to Tohoku University and it locates hypocenters using real-time waveform data from entire stations in Japan. The automatic system is also applied to seismic data of swarm events in Fukushima-Ibaragi prefectures. This paper presents the results of above application.

2. A new method of hypocenter location

Previously developed automatic systems could not locate accurate hypocenters at a time when two events occur simultaneously. We proposed a new technique of hypocenter location for the automatic system. The method introduces an observed function similar with synthetic seismograms. The function becomes positive values in time periods near P and S arrival times and becomes zero except for these periods. We also introduce same function computed from theoretical travel times. Hypocenter is located by the grid search method so that theoretically computed function satisfies the observed functions for all stations.

3. result

(1) We copied continuous seismic waveform data for all available stations in Japan for a period of one day on September 03, 2011 from Hi-net web site. Our automatic system locates 1,316 events. There are 588 events in the JAM catalogue of the same day. The result shows that our system can locate 2.4 times of hypocenters compared to that in JMA catalogue. There are many events with magnitude larger than two which are not located by JMA. It is found from the check of computed result by the automatic system that there are 1-2% of incorrectly located events.

(2) The present system was installed at Tohoku University in December, 2012. It started to locate hypocenters by using entire real-time waveform data in Japan. It locates almost twice of hypocenters compared to JMA, who locates hypocenter by conducting manually picking. Detail of this result is presented by Nakayama et al. in this meeting.

(3) Earthquake Research Institute, University of Tokyo installed 60 sets of temporary seismic stations in area of Fukushima-Ibaragi prefectures, where earthquake swarm occur after the Off Tohoku Earthquake with magnitude M9.0. The observed continuous waveform data are applied to the present automatic system. About 140,000 events are accurately located. The detailed result is presented by Kato et al. in the present meeting. We computed RMS residuals of P and S wave for arrival times of all stations and all events. The computed RMS for P and S wave are 0.075 and 0.098 sec respectively. RMS values computed by using manually picked data are 0.065 and 0.137 sec. The comparison of these values shows that automatic system can pick more accurate S wave arrival times than manually picking.

Keywords: Automatic picking, automatic hypocenter location, high accuracy, compared to manual, JMA hypocenter, picking accuracy