Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

STT57-P01 Room:Poster Time:April 30 18:15-19:30

The annual variation in the teleseismic detection capability at Syowa Station, Antarctica

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Kanao et al. [2012a, 2012b] have pointed out the annual variation in the teleseismic detection capability at Syowa Station located in Antarctica. The main cause of the variation is considered to be the increase in area and/or thickness of sea ice in winter, which restrains the generation of sea waves around Antarctica; consequently the noise level in seismic records changes annually [Grob et al., 2011; Kanao et al. 2012c].

This implies that environmental parameters relevant to climate, sea ice, and so forth affect the teleseismic detection capability. To investigate the relationship in detail, a quantitative evaluation of the annual variation in the detection capability is dispensable because the aforementioned studies have revealed the annual variation only qualitatively on the basis of the time history of the minimum magnitude of detected teleseismic events at the station. Therefore, we conducted the following analysis in this study.

The dataset analyzed in this study is the same as the examined one in Kanao [2010] and Kanao et al. [2012]. The data period ranges from 1987 to 2007 and the magnitudes of the events are measured with the body-wave magnitude (Mb) scale. The number of analyzed earthquakes of which magnitudes are determined is 19,044. Because the main interest of this study is to quantify the annual variation, the earthquake sequence is divided into periods of one year and these one-year sequences were stacked.

For the quantification of the detection capability, the model representing a magnitude-frequency distribution of earthquake covering the entire range [Ogata & Katsura, 1993] is used with a small modification. In this model, the distribution is assumed to be the product of the Gutenberg-Richter (GR) law [Gutenberg and Richter, 1946] and the detection probability of earthquakes at magnitude M. As mentioned above, the magnitudes in the examined dataset are given as Mb, which saturates at its large value. Therefore, instead of the original GR law, we introduced a modified type of the GR law, which is suggested by Utsu [1974], that contains the maximum magnitude of earthquake potentials as a parameter. The detection probability was represented by the cumulative distribution of a normal distribution, following the suggestion of Ringdal [1975] and its accompanied studies [e.g., Ogata & Katsura, 1993; Iwata, 2008, 2012, 2013a, 2013b, 2013c]. This formulation results in the introduction of a parameter μ, which corresponds to the magnitude at which 50% of earthquakes are expected to be detected, and this parameter quantifies the quality of the earthquake detection capability.

Then, the annual variation in μ was estimated by adopting a Bayesian approach used in Iwata [2013a, 2013b]. In this approach, the annual variation is represented by a piecewise linear approximation of which breaking points were taken at each of the occurrence times of each events. We determined the variation in μ with a smoothness constraint.

The result of the estimation is summarized as follows. The significance of the existence of the annual variation was evaluated with ABIC [Akaike, 1980]; the value of ABIC in the case with the annual variation is 54.9 smaller than that in the case without the annual variation, suggesting high significance of the variation. The maximum (i.e., the worst detection capability) and minimum (i.e., the best) values of μ appear around the end of December and the middle of August, respectively. The difference between the maximum and minimum values is 0.13. Because the maximum and minimum of the average temperature at Syowa Station also appear in those periods, this result reinforces the relationship between the environmental parameter and teleseismic detection capability.

(The references are listed in the abstract written in Japanese.)

Keywords: earthquake detection capability, annual variation, Antarctica, Syowa Station, Bayesian statistics, statistical seismology

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STT57-P02 Room:Poster Time:April 30 18:15-19:30

Towards Detection of Hydraulic Fracturing Induced Earthquakes Using Neural Network

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Detection, location and determination of focal mechanism of low frequency and hybrid events such as volcanic and non-volcanic events have been extensively studied. Recently, Das and Zoback (2011) found unusual events which has relatively low frequency in the seismic activity induced during hydraulic fracturing in a gas shale reservoir. Those events were observed in limited frequency band similar to tectonic tremor sequences. It is important to understand the mechanisms of those events for clarifying the fracturing process during the hydraulic stimulation. In this study, we introduce a method to detect the band-limited waveform using neural network. The results of the initial numerical test indicate that the harmonic function waveforms could be identified when they have clear features in shape. As the next step, we will add realistic noise to the synthetic data and perform the synthetic analyses. After we verify the applicability of our method, we will apply the method to real seismic data observed during fluid injection.

Keywords: Neural Network, Waveform detection, Hydraulic fracturing, Low frequency earthquake, Seismic Waveform

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STT57-P03 Room:Poster Time:April 30 18:15-19:30

Background noise characteristics of F-net broadband seismograms

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National Research Institute for Earth Science and Disaster Prevention (NIED) has operated a broadband seismometer network, F-net. F-net consists of 73 stations in Japan and a broadband seismometer, STS-1/2/2.5 or CMG-1T/3T, has been installed at each station. The seismometers are installed in 30-50 m vault to prevent effects of the temperature and air pressure changes. All the data are openly available on the web, and rapid automated data processing systems, such as AQUA system [Matsumura et al., 2006], have used these data. To evaluate the data quality continually is important for the operation of the observation network, the earthquake monitoring, and the automated analyses. In order to assess the F-net data quality, we investigated the characteristics of their background noise.

To quantify the background noise of F-net waveform data, we used probability density functions (PDFs) of power spectral densities (PSDs) [McNamara & Buland, 2004]. For 1996-2013 continuous waveform data with the interval of 1 sec, PSDs of ground acceleration were computed from overlapping (50 %) 1-day time-windows. Each time-window was divided into 13 time segments (6 hours) overlapping by 75 %, and the 1-day PSD estimate was calculated as the average of the 13 segment PSDs. These 1-day PSDs were gathered by binning periods in 1/8 octave intervals and binning power in one-dB intervals.

We calculated a new noise model for F-net, based on the statistical mode of the obtained PDFs for vertical component of all the F-net stations [McNamara & Buland, 2004]. The noise model was constructed from the minimum PDF mode value among all the stations at each period. The values of the F-net model is ˜5 dB higher than ones of the mode noise model of the continental United States [McNamara & Buland, 2004] around periods of 4 sec and 40 sec. The F-net noise model is mainly defined by the STS-1 mode values. The STS-2 values are ˜5 dB larger than STS-1 ones at the periods of 200-800 sec, and the CMG-1T/3T are ˜15 and ˜10 dB larger than STS-1 at 30-2000 sec and 100-2000 sec, respectively.

Recently, we have equipped a styrofoam cover on the broadband sensor for temperature shielding. This cover has reduced the PDF mode values for vertical component of STS-2 by ˜5 dB at the periods longer than 500 sec, and is useful to obtain such long-period signals with a good signal/noise ratio.

Keywords: background noise, broadband seismometer, F-net

STT57-P04 Room:Poster Time:April 30 18:15-19:30

Long-term ocean-bottom seismometers in MRI/JMA and some related problems

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In 2011 to 2012, seismology and volcanology research department/MRI introduced eight long-term ocean-bottom seismometers (OBSs) by converting existing short-term ones so that we were able to conduct one-year-long, three-component seismographic observation. The conversion was made by changing the control circuit, the AD convert, and the data storage device into low-power consumption ones.

In November 2011, four long-term OBSs were deployed off Boso Peninsula, about 40 km east of Tokyo, to test them and to investigate seismicity in this region that adjoins the southern end of the mainshock rupture area of the March 11, 2011 Tohoku earthquake (Mw9.0). In September 2012, we tried to recover the four long-term OBSs that were deployed in 2011 and re-deploy other four long-term OBSs. However, all transponder units of four long-term OBSs to be newly deployed got out of order soon after the vessel left the port. So we declined to newly deploy other four long-term OBSs. Also, we could not recover two long-term OBSs among four that were deployed. We confirmed that two recovered long-term OBSs recorded ultra-micro earthquake activity successfully.

After the cruise, the OBS transponder units that became out of order were tested in manufacturer's laboratory so that the cause of the trouble was inferred to be (1) possible opening within the housing of transducer unit of OBS transponder due to thermal expansion/contraction thorough high temperature in summer and low temperature in winter, and (2) cavitation in silicon-oil within the housing of transducer unit of OBS transponder due to hull vibration. Countermeasures were devised as follows; (a) overhaul of electric circuits and transducer unit housing filled with silicon oil, (b) use of base-isolation floor-mat on which OBSs should be placed. Both of manufacturer's laboratory tests and actual onboard tests suggest that these countermeasures are effective.

Keywords: long-term, seismographic observation, ocean-bottom seismometer, measure for a glitch

STT57-P05 Room:Poster Time:April 30 18:15-19:30

Value change of ocean bottom pressure gauge (Paroscientific depth sensor) by inclination of the sensor

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Introduction

Ocean bottom pressure gauges (OBP) using depth sensor of Paroscientific Inc. are used for observation of up-down crustal movement at ocean bottom (e.g. Inazu et al., 2012). Observation error of this sensor is about 0.5 hPa (about 5mm in water) (e.g. Kono et al., 2012). So, this sensor is expected to detect coseismic movements and movements with large slow slip events such as the Boso slow slip events. But , it is known that this sensor shows incorrect values when the sensor is inclined. This suggests the possibility that this sensor can not obtain correct value because OBP itself may be inclined by coseismic crustal deformation. This presentation shows measurements of value change by inclination of the sensor, and discusses limits of inclination based on the observation error.

Measurements and results

We used an intelligent depth sensor 8CB2000-I, Paroscientific Inc. We set the sensor upright, then incline it, hold it for some time, then return it upright. We measured differences of the values between upright position and inclined position. We found that if we incline the sensor very fast, it shows very large transient values after inclined. So, we need slow inclination (a few ten seconds par 10 degree inclination) of the sensor. After the measurements, we fit the data using a spherical harmonic function.

The observed data show 2 hPa at 10 degree inclination, 6 hPa at 20 degree, and 12 hPa at 30 degree. The data is not symmetrically with respect to the upright position, but symmetrically at a point which is inclined about 15 degree from the upright position. The reproducibility of the values for inclination is within about 0.3 hPa (STD). From this result, inclination limit of OBP is about 5 degree if OBP sits on the ocean bottom flat. If OBP touches down at steeper inclined bottom, the limit become narrower. If OBP is inclined at 20 degree, the limit is about 2 degree.

Keywords: Pressure gauge, inclination correction, Paroscientific Depth Sensor

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Evaluating performance of automatic earthquake detection and location system for the nationwide seismic network(2)

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The number of seismic stations has tremendously increased by many temporary seismic networks recently deployed in various areas, in addition to dense routine seismic networks such as the nationwide Kiban seismic network. Effective automatic earthquake detection and location system is anticipated, because the ability of data processing is limited. Manually picking P- and S-wave arrival times etc. from a huge amount of seismic waveform data observed by such many seismic stations is considerably time consuming work.

Horiuchi et al. (2012, 2013) have developed such an automatic seismic waveform processing system. This system was set up at Tohoku University on December 2012, and automatic detection and location processing of the nationwide seismic network data has been operating since then. The system can detect and locate many earthquakes which are difficult to be located by the routine processing based on manual pickings. 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.

Nakayama et al. (2013) tried to evaluate performance of this earthquake detection and location system for the application to the nationwide seismic network. Results showed that the automatic system could detect and locate earthquakes about 1.5 times more than those in the JMA unified catalogue. The automatic system extended the lower limit of the detection capability to much smaller magnitude range than that by the JMA unified catalogue. The evaluation also showed that S-wave arrival times picked by the automatic system were systematically delayed by ˜0.05-0.1 sec compared with those by the manual pickings of the unified catalogue. Based on this performance evaluation, Horiuchi et al. (2014 this meeting) have tried to improve the system by developing a new algorithm to better pick S-wave arrivals.

We have evaluated performance of this presently improved automatic processing system by using the waveform data for the same period as those in the previous evaluation. Results show that the systematic delay of S-wave arrivals by the automatic pickings is considerably improved and the difference in S-wave arrivals between the new automatic system and the unified catalogue has become nearly the same as that between the manual pickings by Tohoku University and those in the unified catalogue. This indicates that the S-wave arrival times, as well as P-wave arrival times, picked by the automatic system almost stand comparison with those by the manual picking. Moreover, the evaluation shows that the new system also improved the rate of correct discrimination of earthquakes: the percentage of events that were missed to be correctly located decreased from 19% to 14% (most of these events are those located in and around the Izu-Bonin Islands and the Ryukyu Islands), and the percentage of events that were incorrectly defined as earthquakes decreased from 3.1% to 2.5%. This is because of the improvement of algorithm to correctly discriminate more than two earthquakes that occurred nearly simultaneously.

Keywords: automatic arrival time picking, automatic event detection and location system, performance evaluation

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W-phase analysis with 1Hz GNSS data

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The Japan Meteorological Agency analyze W-phase inversion solution and CMT solution when big earthquakes occur. Now we can analyze W-phase solution with broadband seismograms in Japan after 6 minutes of earthquake occurrence. These W-phase solution are one of information for performing grade changes or cancel of TSUNAMI warning.

Broadband seismic records is used by integrating for W-phase analysis. Because when big earthquake occur, the waveform data recorded at near site from source area may be unstable, it might be difficult for analyzing W-phase solution. On the other hand, the GNSS data to be recorded directly displacement, it can be used as a stable displacement.

In this study, using 1Hz GNSS data of Geospatial Information Authority of Japan(GSI), we analyzed W-phase solutions of Great Tohoku earthquake in 2011, its aftershock, and Tokachi-oki earthquake in 2003.

Keywords: W-phase analysis, 1Hz GNSS data, Great Tohoku earthquake

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Automated event identification of aftershocks(2)

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We are developing a seismic event identification technique for a quick grasp of aftershock activities of great earthquakes. For the case of the 2011 off the Pacific coast of Tohoku Earthquake, a number of onsets of aftershocks were not clear due to successive occurrence of aftershocks. Envelops of seismic waves are used to make it possible to estimate source locations of events without clear onsets.

The method is based on peak amplitudes and their times as

(1)A band pass filter is applied to the seismic waves.

(2)Envelop of seismic wave is obtained.

(3)Peak amplitudes and times are checked.

(4)Possible events are searched for the data of envelop amplitudes and times.

Formerly we tried to estimate source parameters by searching a solution in five-dimensional space of (origin time, latitude, longitude, depth, magnitude) by the shuffled complex evolution (SCE-UA) method. However, good solutions were seldom obtained because a combination of noise data often show a high score.

We changed the source estimation method. At the first, a group with high S/N data is searched for. We select a key data with highest S/N from the group. Then we estimate the best source parameter which is consistent to the selected data. While searching for the source location, the focal depth is fixed and epicentral distance and azimuth are changed. The origin time is obtained from the time of the envelop peak and epicentral distance, and the magnitude is estimated from the peak amplitude and epicentral distance.

Noise is often selected as the key data. Noises are usually rejected because they do not form a group of consistent data. Data of noise and identified events are removed from dataset to be checked. Data search is continued until no candidate is left.

Events are successfully identified and source locations are properly estimated for the events with a number of data. However source locations are not properly estimated for events with a small number of data.

We used seismic data from the National Research Institute for Earth Science and Disaster Prevention, Hokkaido University, Hirosaki University, Tohoku University, University of Tokyo, Nagoya University, Kyoto University, Kochi University, Kyushu University, Kagoshima University, the National Institute of Advanced Industrial Science and Technology, Aomori prefectural government, Tokyo metropolitan government, Shizuoka prefectural government, Kanagawa prefectural government, the City of Yokohama, the Japan Marine Science and Technology Center, and the Japan Meteorological Agency.

Keywords: automated seismic event identification, envelop of seismic wave

STT57-P09 Room:Poster Time:April 30 18:15-19:30

Construction of the seismic observation network around Shimokita Peninsula

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Introduction

Seismic activity in the Shimokita region is not well grasped, because the distribution of the seismic stations is not dense compared with that of Southern Tohoku region. So, it is not enough to estimate the depth of the seismogenic zone. Accordingly, the Association for the Development of Earthquake Prediction (ADEP), determined to newly construct a high-density seismic observation network (AS-net) in the region in question, as a part of its investigation and research into seismic activity in the Shimokita Peninsula. An outline of the observation network is presented below.

Outline of the network

The AS-net consist 36 seismic observation stations. 20 stations were made before the end of 2013. And the other stations will make in 2014.

The sensors of each station are installed in boreholes at a depth of about 20m. We set the short period three dimensional velocity sensors by Lennartz, and accelerometers by Japan Aviation Electronics Industry ltd. And A/D converter is LS-7000XT made by Hakusan Co.

The data of the each station send to ADEP using with Internet, and relay to other facility for research.

Future works

It is anticipated that useful data will be obtained regarding detailed velocity and attenuation structures in the area surrounding the seismic observation network, as well as micro earthquake activity in the regions. The number of the earthquakes we estimate in January, is twice as that of JMA.

Keywords: seismic observation network, Shimokita Peninsula