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

SSS24-01 Room:A06 Time:May 27 09:00-09:15

Prediction of ground shaking from shaking itself: application of numerical shake prediction method for various frequency

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Many of the present Earthquake Early Warning (EEW) systems quickly determine the hypocenter and magnitude, and then predict strengths of ground motions. The Mw 9.0 Tohoku earthquake, however, revealed some technical issues with such methods: under-prediction at large distances due to the large extent of the fault rupture, and over-prediction because the system was confused by multiple aftershocks that occurred simultaneously. To address these issues, a new concept was proposed for EEW, in which the distribution of the present wavefield is estimated precisely in real time (real-time shake mapping) by applying a data assimilation technique, and then the future wavefield is predicted time-evolutionally by simulation of seismic wave propagation (Hoshiba and Aoki, 2014). Information on the hypocenter location and magnitude are not necessarily required in the method; instead physical processes are simulated from the precisely estimated present condition. The method is called "numerical shake prediction" by analogy to "numerical weather prediction" in meteorology. In this presentation, we will apply the numerical shake prediction method to the 2011 Tohoku Earthquake and the 2004 Mid-Niigata Earthquake (Mw 6.7) for not only frequency band of seismic intensity (that is, around 1 Hz (period of 1 s)) but also for various bands such as around 0.3 Hz (3 s) and 0.15 Hz (6 s). We will show that low frequency waves were trapped in the Kanto basin while high frequency waves passed by, and that the numerical shake prediction method is applicable even for low frequency of around 0.15 Hz in case of prediction of near future.

Keywords: Earthquake Early Warning, Real-time prediction of earthquake ground motion, Numerical shake prediction, long period ground motion

SSS24-02 Room:A06 Time:May 27 09:15-09:30

Consideration of site amplification and data stability of OBS for magnitude estimation of earthquake early warning

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[1]Meteolorogical Research Institute, [2]JAMSTEC

In Japan, large-scale ocean bottom seismographs (OBSs) network, such as DONET and DONET2 (JAMSTEC) and S-net (NIED), are now under construction to make use of those data for real-time monitoring, and it is expected to utilize those systems for Earthquake Early Warning (EEW). However, since OBSs are installed on unconsolidated sedimentary layer, the installation environment of OBSs may be different from that of land stations.

Site amplification of OBS is one of the important factors. Magnitude of EEW (M_{eew}) at Tonankai OBS estimated from maximum displacement amplitudes of three component vector waveforms was generally larger than M_j by about 0.6 because of site amplification of OBS (Hayashimoto and Hoshiba, 2013). Similar amplification is also found at DONET (JAMSTEC, Nakamura *et al*. (2014)). From the relative site amplification factor of OBS estimated from spectral ratio in frequency domain, it is found that amplification of horizontal component is remarkably larger than that of vertical component at less than 1 Hz.

Stability of OBS data exposed strong shaking is also essential factor. Yamamoto *et al*. (2004) pointed out that one of Off-Kushiro OBS (JAMSTEC) was rotated about 5 degree by strong ground motion during the 2003 Tokachi-oki earthquake of Mjma8.0. The inclination of OBS causes baseline offset change in acceleration waveform on the gravitational acceleration component. We investigate the characteristics of OBS data during strong shaking at the Off-Kushiro OBSs, and it is found that the acceleration offsets are larger on the horizontal component (perpendicular to the cable line) than the other horizontal component (along the cable line). Furthermore, it is found that the S-wave H/V ratio for strong motion at OBS has typical features of non-linear response, which is similar with that of land stations.

In this presentation, we discuss influence for EEW magnitude estimation. To avoid their influence, we will propose a new stable magnitude estimation method by using vertical component.

Acknowledgement: The strong ground motion acceleration waveform data used in this study were obtained from the Japan Meteorological Agency (JMA) network, DONET and Off-Kushiro OBS of the Japan Agency Marine-Earth Science and Technology (JAMSTEC), K-NET and KiK-net of the National Research Institute for Earth Science and Disaster (NIED).

Keywords: Ocean Bottom Seismograph, Earthquake Early Warning, Site amplification, Inclination angle, Non-linear response, Magnitude estimation

SSS24-03 Room:A06 Time:May 27 09:30-09:45

A Method to Identify Multiple Concurrent Events and its Application

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[1] JMA

The extremely active seismicity after the 2011 off the Pacific Coast of Tohoku Earthquake caused serious issues for the automatic hypocenter determination such as the Earthquake Early Warning (EEW) system in Japan. Because multiple earthquakes shook distant seismometers within a short period of time, the system misidentified a large earthquake shook them.

To solve this problem, Liu and Yamada (2014) proposed a likelihood function suitable for classifying multiple concurrent earthquakes, which uses amplitude information. Tamaribuchi et al. (2014) developed the concept, named Integrated Particle Filter method (IPF), using maximum amplitudes together with P-wave arrival times, B-delta method, and principal component analysis. This method can avoid false alarms in the case of multiple concurrent events, including aftershocks of the 2011 off the Pacific coast of Tohoku Earthquake.

In this study, I applied this method to deep earthquakes such as occurred at Southern sea of Okhotsk (M7.3, 654km depth). The current system issued a warning because estimation of the earthquake was inland and shallow using only P-wave arrival times on the first alert. In this case, the IPF method can avoid the inaccurate warning taking into account the B-delta method as well as P-wave arrival times.

In addition, I developed the IPF method for smaller earthquakes such as JMA catalog. This method uses P- and S-wave arrival times and maximum amplitude integrally. I applied this method for some swarms and aftershocks activity, including the earthquake at Northern Nagano Prefecture on 22 October, 2014. In this case, this method can detect more than 1,700 events within 24 hours, although the current system could detect only 250 events.

I think it is useful to grasp seismic activities in real time. These methods, including for EEW and for JMA catalog, will deploy in the next our system.

References:
Liu and Yamada, 2014, BSSA, 104-3, 1111-1121.
Tamaribuchi et al., 2014, Zisin2, 67, 41-55.

Keywords: Automatic hypocenter determination, Earthquake Early Warning, JMA catalog

Japan Geoscience Union Meeting 2015
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SSS24-04 Room:A06 Time:May 27 09:45-10:00

P and S wave identification filter for the on-site seismic alarm

HORIUCHI, Shigeki[1*]

[1]Home Seismometer Corporation

1. Introduction

S wave average amplitude is about 5 times larger than that of P wave. Onsite warning system measures P wave amplitude or real-time shaking intensity and estimates that of S wave. In a case when an onsite warning system is not able to discriminate S wave arrivals and estimates S wave amplitude using observed S wave data instead of P wave, estimated S wave amplitude becomes five times larger in average than the observed value. Damaging earthquakes except for those in the subduction zones occur in areas within about 30km and their (S-P) times are less than 3 or 4 seconds. Therefore, it is important to develop a technique to discriminate S wave arrival within a short time from S wave onset. The present study propose a filter which makes possible to identify S wave arrival within a short time from its onset.

2. P and S wave identification filter

It is well known that 1) The amplitude of the vertical component is large at P wave arrival and horizontal component at S wave arrival, 2) The dominant frequency of the S wave is longer than that of P wave. We propose the following filters for identifying the P and S waves.

$$F(t) = \{bZ(t) - NS(t) - EW(t)\} - c\{V(t) - rA(t)\} \quad (1)$$

Where, Z (t), NS (t) and EW (t): running means of absolute value of vertical, NS and EW components, V (t) and A(t); running mean of the absolute value of the three component seismograms and their derivative by time, b, c , and r are constants. b, c and they are put to be 2.0, 0.3 and 0.0. In a case P wave onset is measured, b and r are re-defined using about one second of data after P wave arrival so that the first and the second terms in (1) become 0.

The first term of Equation (1) corresponds to the amplitude variation of the vertical and horizontal components. If the vertical component becomes dominant at P wave arrival, it becomes positive and becomes negative if the horizontal component dominants at S wave arrival. The second term corresponds to the change in the dominant frequency. The value becomes negative by the low frequency S wave arrival.

3. Result

We used waveform data with seismic intensity larger than 5 lower recorded by K-NET, NIED to examine the effectiveness of the present P and S wave discrimination filter. The plot of the outputs of the filter together with observed waveforms shows that filter outputs for almost all seismograms become negative at S wave arrivals and their absolute values are several times larger than amplitudes of P wave or P wave coda. We conclude that the present filter is effective for the development of accurate on-site alarm system. We also concluded that this filter is effective for the automatic P and S wave arrival time picking in periods just after a large earthquake when the aftershock activity is extremely high and difficult to distinguish between P and S wave.

Keywords: Onsite Alrm, P and S wave identification filter, H/V change, frequency change, intensity estimation, Automatic hypocenter location

Japan Geoscience Union Meeting 2015
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SSS24-05 Room:A06 Time:May 27 10:00-10:15

How to utilize the information acquired by home seismometers spread across Japan

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[1]National Research Institute for Earth Science and Disaster Prevention, [2]A2 Corporation

1. Introduction

The Japan Meteorological Agency has started the practical service of Earthquake Early Warining (EEW) system since 2007. But, because of limitations imposed by station spacing and the determination and transmission of earthquake source parameters in real-time, the automatic system cannot issue an EEW to areas within 30 km of the earthquake parameters [Horiuchi et.al (2009)]. So, Horiuchi et.al (2007) pointed out that by spread of home seismometer, the receiving unit of EEW equipped with a CPU and memory, the extra addition of cheap seismometer and A/D converter, we would have over 10 times of the number of the current seismic stations, also we can get more rapid warning information near focal areas.

Yamamoto et.al (2007) also issued about the development of the home seismometer, an inexpensive, compact and user-friendly EEW intelligent system based upon a MEMS accelerometer. Besides, Nakamura et.al (2008) reported about demonstration test in house to observe seismic signal and noise. Furthermore, Horiuchi et.al (2008) developed a function in the home seismometer to discriminate seismic signal from noise event. Moreover, A2 Corporation have been provided the EEW information service for a price by utilization of the home seismometer and these research achievements.

In this study, we issue about the number of the adoption of home seismometers, also consider how to utilize the information acquired by them.

2. Diffusion of home seismometers

At the point of 2014, 7 years have passed since the first release, there are approximately 4,000 home seismometers in Japan. The distribution of locations are heterogeneous. The urban areas located around Kanto, Osaka, and Noubi Plain are densely installed. On the other hand, there are many sparse installed areas in a thinly populated area such as island or mountain.

3. Utilize the information acquired by home seismometers

For the purpose of estimating seismic damages and delivering information with a high degree of accuracy, we have been provided data recorded when approximately 8,700 earthquakes happens from A2 Corp. Meanwhile, we have to take into account how to utilize these data because they have considerable variation factors, for example, soil conditions, building structures, settings, surrounding noises.

For an experiment, Figure 1 shows a plot of JMA intensity versus epicentral distance using a number of seismic waves recorded by home seismometers and K-NET / KiK-net stations. Each data have nearly consistent tilt, but home seismometers show higher dispersion.

In consideration of these dispersion, it will be possible to utilize data recorded by home seismometer by using of interpolate K-NET and KiK-net data. So, we are going to research about the way to decrease these dispersion, and think about the way to utilize data for the purpose of estimating detailed seismic damaged areas and delivering information in real time.

Reference

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Shigeki Horiuchi et.al: Development of a function in the home seismometer to discriminate seismic signal from noise event(2), JPGU, 2008.

Keywords: Home Seismometer, EEW, MEMS

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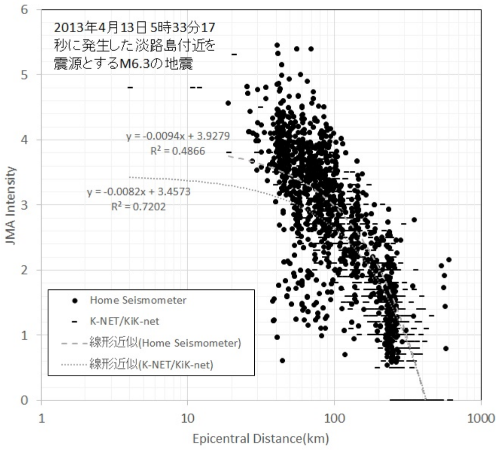

Japan Geoscience Union Meeting 2015
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SSS24-06 Room:A06 Time:May 27 10:15-10:30

Improvement of the single-station EEW algorithms for railways

YAMAMOTO, Shunroku[1*] ; IWATA, Naoyasu[1] ; NODA, Shunta[1] ; KORENAGA, Masahiro[1]

[1]Railway Technical Research Institute

The present earthquake early warning system for railways adopts a single-station approach which has functions of a S-wave warning that is issued by threshold excess of acceleration and a P-wave warning that is issued by analyzing the P-wave initial phase, in order to control trains as rapid as possible during earthquakes. To improve accuracy and rapidity of the P-wave warning, here we proposed upgraded P-wave warning using the new algorithms developed recently.

Major upgraded points are as follows, 1) P-wave detection, 2) epicentral distance estimation, 3) back-azimuth estimation, 4) magnitude estimation and 5) noise discrimination. For improving P-wave detection, we re-determined the STA/LTA parameters so as to be able to detect seismic motions growing very slow, and we also introduced the level trigger logic which simply monitors threshold excess to make the trigger performance more reliable. For enhancing the performance of estimating epicentral distance and back-azimuth, we introduced the C-Δ method (Yamamoto et al., 2012) and the variable time window method (Noda et el., 2012) which improve the accuracy of estimation by 12% and 28% respectively. Further we re-defined the relation between the coefficient C and epicentral distance. For upgrading magnitude estimation, we introduced acceleration magnitude which is directly determined from observed acceleration. Since it is confirmed that the peak amplitude of seismic motions averagely appears faster in acceleration than in displacement, faster estimation can be possible by using acceleration for magnitude estimation. To improve the noise discrimination performance, we developed the new algorithm using frequency information of the input signal (Iwata et al., 2014).

Improvement of the P-wave warning is expected by using those upgraded algorithms. A prototype seismometer has been developed and tested in the field to evaluate its performance.

Keywords: Earthquake Early Warning, P-wave, Single-station method

Japan Geoscience Union Meeting 2015
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SSS24-07 Room:A06 Time:May 27 10:30-10:45

Improvement of the discrimination algorithm between train-induced vibrations from seismic motions for EEW

IWATA, Naoyasu[1*] ; YAMAMOTO, Shunroku[1] ; KORENAGA, Masahiro[1]

[1]Railway Technical Research Institute

When the safety of railway facilities and running vehicles are threatened by large shakings of ground motions during earthquakes, railway operators stop trains as soon as possible (Nakamura, 1996; Ashiya et al., 2007; Yamamoto and Tomori, 2013). To stop trains rapidly, it is effective to utilize the P-wave whose propagation velocity is faster than the S-wave. At present the warning systems which estimate the epicenter location and the seismic magnitude using the initial P-wave information in several seconds are in operation to stop the trains (Odaka et al., 2003; Iwahashi et al., 2004).

It is necessary to discriminate clearly between the seismic motions and the train-induced vibrations regarding seismographs installed along railways, because the feeble vibrations are used typically to estimate the seismic parameters from the initial P-wave. The seismographs now in use are implemented with the algorithm to discriminate the train-induced vibrations from the seismic motions using the component ratio of amplitudes (Sato and Nakamura, 2005). In this study, we proposed the new discrimination index taking account of frequency characteristics and evaluated the discrimination performance. Further, we developed the new discrimination algorithm using the combination of the current and the proposed indices (Iwata et al., 2014).

The improvement of the warning reliability during earthquakes is expected by using the proposed method.

Keywords: earthquake early warning, seismic motion, train-induced vibration, noise discrimination, algorithm

Japan Geoscience Union Meeting 2015
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SSS24-08 Room:A06 Time:May 27 11:00-11:15

Real-time Earthquake Magnitude Estimation by the GEONET real-time processing system: REGARD

KAWAMOTO, Satoshi[1*] ; MIYAGAWA, Kohei[1] ; SATO, Yudai[1] ; NISHIMURA, Takuya[2] ; OHTA, Yusaku[3] ; HINO, Ryota[3] ; MIURA, Satoshi[3] ; TODORIKI, Masaru[4]

[1]Geospatial Information Authority of Japan, [2]Disaster Prevention Research Institute Kyoto University, [3]Graduate School of Science, Tohoku University, [4]The University of Tokyo Interfaculty Initiative in Information Studies

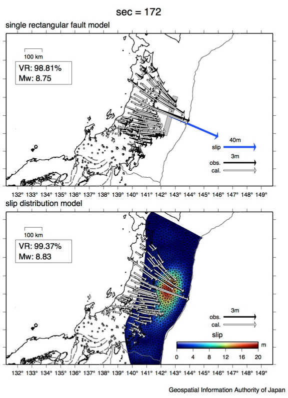
The recent development of Global Navigation Satellite Systems (GNSS) and communication infrastructures provides real-time displacement data. The data enables the real-time estimation of coseismic fault model for large earthquake, which is free from the saturation problem found for seismic data. The obtained moment magnitude (Mw) constrains the size of a subsequent tsunami, thus it potentially improves tsunami warning systems that rely only on the seismic data.

Geospatial Information Authority of Japan (GSI) and Tohoku University have jointly developed a real-time analysis system in the Japan's national GNSS network, GEONET: the Real-time GEONET Analysis system for Rapid Deformation monitoring (REGARD). The goal is to estimate the magnitude and finite fault models for large earthquake in real-time. Currently the system involves about 1300 GNSS stations, RAPiD algorithm (Ohta et al., 2012) for automatic event detections, and two real-time fault modeling routines: a single rectangular fault modeling routine and a slip distribution fault modeling routine.

We evaluate the two fault modeling procedures for the 2003 Tokachi-oki earthquake, the 2011 Tohoku earthquake and the 1707 Hoei type Nankai trough earthquake in the real-time situations. The real-time waveform data for the Nankai trough earthquake are based on the simulation (Todoriki et al., 2013). Furthermore, we also evaluate the past large earthquakes using the published finite fault models (Sato et al., 1989) and the maximum class tsunamigenic earthquake models used to predict the potential tsunami inundation area in each prefecture.

Both routines gave magnitudes with high variance reduction for the 2003 Tokachi-oki earthquake and the 2011 Tohoku earthquake within 3 minutes. However, only the slip distribution model provided reasonable magnitude for the simulated Nankai trough earthquake. On the other hand, the single rectangular fault modeling routine was unstable to model the Nankai trough earthquakes. This implies the fault rupture is too heterogenic to approximate with a single rectangular fault for the future Nankai trough earthquake, and should adopt the slip distribution for the robustness.

Keywords: GEONET, Real-time analysis, RTK-GPS, Fault model inversion



Japan Geoscience Union Meeting 2015
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SSS24-09 Room:A06 Time:May 27 11:15-11:30

An Attempt of Using of Earthquake Prompt Reports for Dispatching Health and Medical Support Team

ISHIMINE, Yasuhiro[1*]

[1]National Institute of Public Health

I will talk about an attempt to develop an information tool for supporting the activities of health and medical assistant teams during earthquake disasters by using the damage estimation based on the earthquake prompt reports. Japan has built up a framework for dispatching assistant teams such as DMATs to rescue victims as soon as large scale disaster occurs on the basis of the lessons learned from previous devastating disasters due to earthquakes and some other natural hazards. However, rescue in mostly affected areas might be delayed because of the absence of information. The rapid estimation of the numbers of damaged buildings and injured people based on the real-time information such as earthquake prompt reports has a potential to provide the indication for the effective support with efficient usage of limited resources. I will present a fundamental design of an information tool for the above purpose.

Keywords: Earthquake Prompt Report, Rescue, Health and Medical Support, DMAT

Japan Geoscience Union Meeting 2015
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SSS24-P01 Room:Convention Hall Time:May 27 18:15-19:30

Application to display Earthquake Information using Mobile Terminal

FURUDATE, Tomomichi[1*]

[1]Japan Meteorological Agency, Meteorological Research Institute

Recently, the users utilize emergency earthquake information using mobile terminals. The mobile terminals run on multiple OS as Android or iOS etc. and have been developed using multiple programming language as C++, Java or Objective-C etc. It is difficult to execute these programs on multiple platforms. But it is easy to execute these program on web browser with standard as HTML5.

In this survey, I evaluate processing performance and compatibility of HTML5 programs

and make applications to display earthquake information. I tested smart phones, tablets, laptop PCs. First I evaluated performance and compatibility using programs for numerical calculation, 2D display, 3D display. The results show that programs using HTML5 have compatibility for terminals with Windows, Android, iOS. The performances of latest mobile terminals are about 1/2 to 1/3 compared with PC. Next, I made applications to display earthquake information and evaluate the compatibility. The programs are for information display on local map and global map, real-time seismic wave data display, semblance processing display. The programs have compatibility for multiple mobile terminals.

I conclude that the programs using standard HTML5 have compatibility for multiple mobile terminals with Windows, Android, iOS. The performances have been catch up to PC.

I plan to more survey and revamp the applications.

Keywords: mobile terminal, earthquake information, HTML5, WebGL

SSS24-P02 Room:Convention Hall Time:May 27 18:15-19:30

Array observation of strong motion for the precise estimation of current wavefield

OGISO, Masashi[1*] ; HAYASHIMOTO, Naoki[1] ; HOSHIBA, Mitsuyuki[1]

[1]Meteorological Research Institute

We conduct a research for the next generation of earthquake early warning based on the concept of Hoshiba (2013), where we will predict ground motion without estimating hypocentral information. Recently, Hoshiba and Aoki (2015) presented examples of ground motion prediction with observed records based on this concept.

For estimating current wavefield, Hoshiba and Aoki (2015) uses only amplitude at each station. It is expected that some more information about current wavefield such as propagation direction and apparent velocity leads to more accurate estimation of current wavefield. Array observation is one of the powerful tools to observe propagation direction and apparent velocity, so that we started array observation at the premises of our institute.

Our array network are consisted by six CV-374 type strong motion seismometers. Sampling frequency is 500 Hz. Except one station buried under the ground, five stations are fastened to the floor of each building. The size of array network is about 300 m.

We applied semblance analysis (Neidell and Tarner, 1971) to the records of the earthquake at Northern Nagano Pref. (2014/11/22, M6.7) using 1 s time window in several frequency ranges. At the time ranges of direct P wave arrival and P coda waves, semblance value of UD component is high even in a high frequency range. Backazimuth, however, is slightly southward than the expected arrival direction. Apparent velocity is also higher than the expected velocity, which means that the low velocity layer under the array may affect the backazimuth and apparent velocity. At the time range of direct S wave arrival, semblance value is relatively high for frequency under 4 Hz of horizontal component, although the backazimuth and apparent velocity at that time is not stable compared with those of direct P waves. Backazimuth and apparent velocity becomes unstable at the time range of S coda waves in spite of high semblance value.

To estimate the velocity structure under the array, we conducted seismic interferometry (e.g. Nagaoka et al., 2012) using continuous records. Dispersion relation of phase velocity of Rayleigh waves from 400 to 300 m/s for 1 to 4.5 Hz, which means the existence of low velocity layer under the array. We will further estimate the velocity structure under the array with other information.

Rapid calculation is needed in semblance analysis for the purpose of earthquake early warning. We will work on the development of effective calculation considering the velocity structure, as well as the parallel computation.

Keywords: Array observation, Earthquake early warning, efficient calculation

Japan Geoscience Union Meeting 2015
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SSS24-P03 Room:Convention Hall Time:May 27 18:15-19:30

Fast Estimate of Rupture Process of Large Earthquakes via Real Time Hi-net Data

WANG, Dun[1*] ; KAWAKATSU, Hitoshi[1] ; MORI, James[2]

[1]Earthquake Research Institute, The University of Tokyo, [2]Disaster Prevention Research Institute, Kyoto University

We developed a real time/automated system based on Hi-net seismic array that can offer fast and reliable source information, for example, source extent and rupture velocity, for earthquakes that occur at distance of roughly 30- 85 degrees with respect to the array center (Figure 1).?

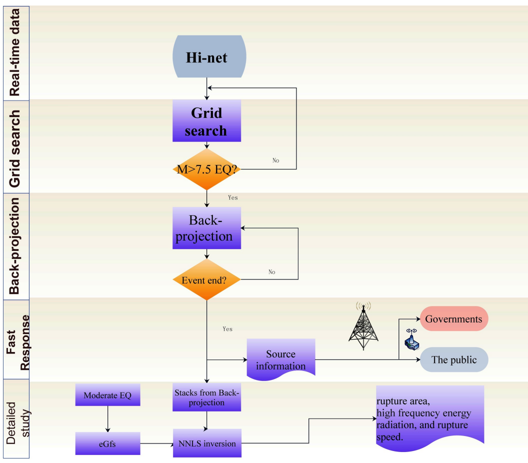
We perform continuous grid search on a Hi-net real time data stream to identify possible source locations (following?Nishida, Kawakatsu, and Obara, 2008, JGR). Earthquakes that occurred off the bright area of the array (30- 85 degrees with respect to the array center) will be ignored. Similarity of the waveforms, and location variations of the local maxima from neighboring windows are used to verify the occurrence of large earthquakes. Once a large seismic event is identified successfully, back-projection will be implemented to trace the source propagation and energy radiation using pre-calculated station corrections derived from nearby earthquakes that occurred previously. An inversion will be then applied to get the detailed high frequency energy distribution.

The time required is mainly due to the travel time from the epicenter to the array stations, so we can get the results between 6 to 13 min depending on the epicentral distances. This system can offer fast and robust estimates of source information for large earthquakes, which may be useful for disaster mitigation, such as tsunami evacuation, emergency rescue, and aftershock hazard evaluation.

Figure caption

Figure 1 Framework of the Real Time Back-Projection

Keywords: real time seismology, rupture process, Hi-net, disaster mitigation



SSS24-P04 Room:Convention Hall Time:May 27 18:15-19:30

REGARD - Real-time GEONET Analysis System for Rapid Deformation Monitoring -

SATO, Yudai[1*] ; MIYAGAWA, Kohei[1] ; KAWAMOTO, Satoshi[1] ; OSHIMA, Kennichi[1] ; MURAMATSU, Hiroki[1] ; INUKAI, Takaaki[1] ; OHTA, Yusaku[2] ; DEMACHI, Tomotsugu[2] ; MIURA, Satoshi[2] ; HINO, Ryota[2] ; NAKAMURA, Yasuhiro[3] ; NISHIYAMA, Mai[3] ; DOUKE, Yuki[3]

[1]GSI of Japan, [2]Graduate School of Science, Tohoku University, [3]Hitachi Zosen Corporation

Geospatial Information Authority of Japan (GSI) has been operating a continuous GNSS observation network system since 1994. This system is known as GEONET (GNSS Earth Observation Network) and consists of approximately 1300 nationwide GNSS stations (GEONET station) and the analysis center. Most stations collect GNSS data with 1-Hz sampling and transfer them to the analysis center in real time. Those data are available for surveying or research using real-time kinematic positioning technique. This technique is expected for describing cataclysmic earthquake from crustal displacement in short time especially after the 2011 off the Pacific Coast of Tohoku Earthquake in March 2011.

GSI and Tohoku University have developed the Real-time GEONET Analysis System for Rapid Deformation Monitoring (REGARD) since September 2011 to estimate moment magnitudes (Mw) soon after large earthquakes struck. This system consists of three subsystems. First subsystem does real-time kinematic positioning using RTKLIB (Takasu, 2011) and GSILIB (GSI, 2015). Second one detects seismogenic behavior using the RAPiD algorithm (Ohta et al. 2012) or the Earthquake Early Warning (Kamigaichi et al. 2009) and immediately run the third subsystem. This subsystem estimates Mw within three minutes using displacement vectors of GEONET stations (Kawamoto, 2014). Finally, results are mailed to persons involved.

We tested this system in 2012, using 143 GEONET stations located in the Tohoku region. Last year, we expanded its function by using all the stations receiving 1-Hz streaming data covering almost all lands of Japan and enhanced its redundancy by carrying out two independent processing in parallel. In this year, we enhance real-time kinematic positioning by using QZSS and GLONASS as well as GPS. We also improve the browser used in the agency to search for previous results and visually recognize results of the real-time kinematic positioning.

In this presentation, we report the brief overview and the current situation of REGARD, including the accuracy enhancement and the browsing software.

Keywords: GEONET, RTK-GNSS, real-time

SSS24-P05 Room:Convention Hall Time:May 27 18:15-19:30

Real-time Damage Estimation for the 2014 Nagano Kamishiro Fault Earthquake by J-RISQ

NAKAMURA, Hiromitsu[1*] ; KUNUGI, Takashi[1] ; SUZUKI, Wataru[1] ; AOI, Shin[1] ; FUJIWARA, Hiroyuki[1]

[1]NIED

It is extremely important to quickly assess the damage immediately after an earthquake for providing suitable disaster response. We has constructed prototype of a Real-time Information System for earthQuake (J-RISQ) for appropriate decision-making regarding the initial response at an earlier stage immediately after an earthquake by combining amplification characteristic data for subsurface ground as well as basic data such as population and building information accumulated in J-SHIS development and observation data including real-time strong-motion data observed by K-NET and KiK-net (Aoi *et al.*, 2013, Nakamura *et al.*, 2013). A part of J-RISQ information (including the estimated distribution of seismic intensity and the population exposed to each seismic intensity level) is published as a "J-RISQ Report" on http://www.j-risq.bosai.go.jp/ immediately after the occurrence of an earthquake. In this study, we describe the estimations by J-RISQ for the 2014 Nagano Kamishiro Fault Earthquake.

J-RISQ issued five reports for this event. The first report was issued by using information from 12 observations approximately 27 seconds after the earthquake. J-RISQ estimated the population exposed to the seismic intensity of 5 lower or greater to be 20,000, one buildings were completely destroyed and 10 buildings partly destroyed. Eventually, the fifth report was made by using the information from 1567 observations approximately 11 minutes after the earthquake. J-RISQ estimated the population exposed to a seismic intensity of 5 lower or greater to be 200,000, the population exposed to a seismic intensity of 6 lower or greater to be 20,000, 46 buildings were completely destroyed and 186 buildings partly destroyed.

Keywords: J-RISQ, real-time, Damage Estimation, 2014 Nagano Kamishiro Fault Earthquake, K-NET, KiK-net

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A numerical study of real-time source mechanism inversion (GRiD-MT) considering 3D heterogeneous subsurface structure

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Abstract
One of the main objectives in this study is upgrading the GRiD-MT system (Tsuruoka et al., 2009), which performs a moment tensor inversion in real time basis by using both observed waveforms and correlation coefficients of Green's function. To achieve the goal, we firstly simulated seismic wave propagation using the finite difference method (FDM) which takes into account the heterogeneous underground structure, frequency dependence and so on.

GRiD-MT, considering 3D horizontally stratified structure model, is good for rather long period seismic waves (20-50s) and can determine MT solutions of Mw4 class earthquakes. We would like to apply GRiD-MT much smaller magnitude and more accurate determination for MT solution, we have to take into account using more shorter period seismic waves (less than 20s). We initially investigated effects of number of observation stations and frequency ranges for MT inversion. We used 2D model to know the features of MT inversion under the heterogeneous structure. Because, in the future, we would like to use Green's function under 3D heterogeneous structure model for the calculation.

We performed 2D simulation of seismic wave propagation and estimated hypocenter locations using the FDM method. We beforehand set 96 virtual sources in the model and computed 96 Green's functions for each observation point at the surface. So, we determine real hypocenter by comparing actual waveforms and Green's functions and using cross correlation coefficients. We adopt the highest point of cross correlation coefficient as a real hypocenter. In this study, we used maximum 5 stations to compare them.

In the future, we would like to compute 3D Green's function for 3D heterogeneous subsurface structure. Furthermore, we have a plan to use reciprocal theorem in the GRiD-MT.

Keywords: GRiD-MT, hypocenter location, correlation coefficient