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

HOSHIBA, Mitsuyuki[1*] ; AOKI, Shigeki[2]

[1]Meteorological Res. Inst., JMA, [2]Japan Meteorological Agency

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

HAYASHIMOTO, Naoki[1*] ; HOSHIBA, Mitsuyuki[1] ; NAKAMURA, Takeshi[2]

[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

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

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

A Method to Identify Multiple Concurrent Events and its Application

TAMARIBUCHI, Koji[1*]

[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
(May 24th - 28th at Makuhari, Chiba, Japan)

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
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS24-05 Room:A06 Time:May 27 10:00-10:15

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

NAITO, Shohei[1*] ; NAKAMURA, Hiromitsu[1] ; AZUMA, Hiroki[1] ; FUJIWARA, Hiroyuki[1] ; FUJIMAKI, Shizuko[2] ; KAWANO, Tsubasa[2] ; KACHI, Masaaki[2]

[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

Shigeki Horiuchi et.al: Home Seismometer Spread Plan, JPGU, 2007.

Shigeki Horiuchi et.al: Home seismometer for earthquake early warning, Geophysical Research Letters, Vol.36 No.5. L00B04, 2009.

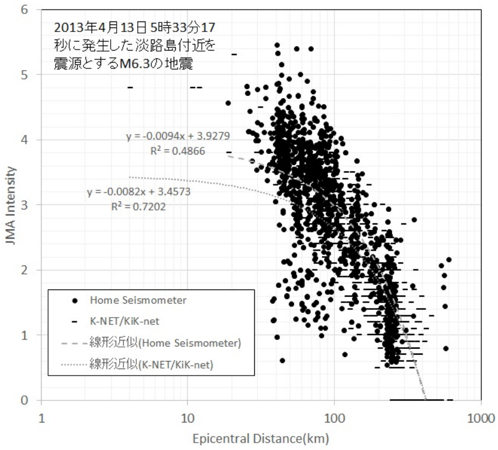
Shunroku Yamamoto et.al: Making of home-seismometer and its performance, JPGU, 2007.

Hiromitsu Nakamura et.al: Measurement performance of Home-seismometer and its demonstration test in house, JPGU, 2008.

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

SSS24-05 Room:A06 Time:May 27 10:00-10:15



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

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

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
(May 24th - 28th at Makuhari, Chiba, Japan)

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

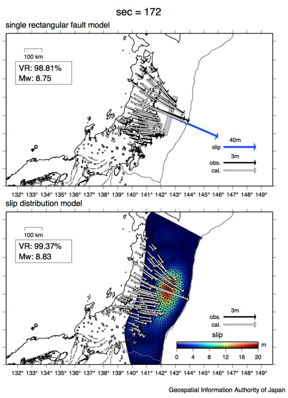
The recent development of Global Navigation Satellite Systems (GNSS) and communication infrastructures provides real-time displacement data. The data enables the real-time estimation of coseismic fault model for large earthquake, which is free from the saturation problem found for seismic data. The obtained 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
(May 24th - 28th at Makuhari, Chiba, Japan)

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