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

SSS27-P01 Room:Poster Time:April 29 18:15-19:30

Nonlinear radiation of hypocenter and prevision of earthquakes

KIKUCHI, Toshiaki[1*]

[1]National defence Academy

Hypocenter vibrations have been analyzed using the analysis method based on time reversal. The dynamic model of the hypocenter vibrations based on the results was advocated. In addition, the effectiveness of the dynamic model was confirmed. The activity regions in the hypocenter are presumed using the dynamic model here.

First, the outline of the dynamic model is described. The time-reversal process was executed to the P wave signals received at the observation stations for the earthquake that occurred in the central part of Suruga Bay in August, 2009, and the pulses formed at the position of the hypocenter, that is, time reversal pulse (TRP) was obtained. The TRP corresponds to an equivalent source to which the hypocenter emits. The obtained TRP provided clear orientation dependency. To clarify the origin of the azimuthal dependence, the frequency spectrum of the TRP to azimuth was obtained. The frequency spectrum was greatly changed by the azimuth. Then, the distribution of the maximum amplitude frequency to azimuth was obtained. As a result, the maximum amplitude frequency rises greatly as azimuth moves from west to east and it has descended afterwards. This frequency rise shows the local movement of sources by high speed. The moving direction converged in the direction of Nishiizunishi, Kawazu, and Ito.

The P waves received at these observation stations exhibited a unique behavior. The head part of the wave received in Nishiizunishi was expanded. However, there was no expansion in the head part in the waves received in Ito and Kawazu near Nishiizunishi.

The head's growing in this manner occurs when the progression rate of cracks in an active fault becomes near the velocity of propagation. The pressure that occurs due to the crack is added cumulatively by moving by high speed. That is, the parametric effect occurs in the active fault. Nishiizunishi is a specific point that reflects the feature of this earthquake.

As for the waveform of the aftershock that received at the specific observation station, the head part of the P waves expanded more than that of main shock. Similarly, the expansion of the head part was observed for the precursor earthquake that occurred before the main shock. The dynamic model of hypocenter vibrations has advocated from these results. The point where the narrow beam emitted from an active fault reaches the surface of the earth is called a parametric spot. The head of the pulse to which the head expands is called a parametric head. This model was verified about four earthquakes larger than M5 that occurred from 2012 to 2009 near Mt. Fuji. The effectiveness of the dynamic model was confirmed.

The dynamic model is consistently approved for precursors, a main shock, and aftershocks. Therefore, the dynamic model may be used for the prevision of earthquake.

The precursor earthquakes of the earthquake that occurred in the central part of Suruga Bay in August, 2009 are examined. The receiving waves that accompanied the parametric head in that were observed seven times. These represent evidence that the progress of the crack began to become a high speed in the active fault. Therefore, observing the seismic waves of a slight earthquake at the peculiar parametric spot and examining the change, may foresee a big earthquake afterwards.

Keywords: hypocenter vibrations, dynamic model, time reversal, prevision of earthquakes

SSS27-P02 Room:Poster Time:April 29 18:15-19:30

Frequency domain calculation of the seismic wavefield propagating along an ocean trench, with a constant Q attenuation

MITSUHASHI, Yuta[1*] ; FURUMURA, Mitsuko[2] ; MATSU'URA, Ritsuko S.[2] ; SHOJI, Masahiro[1]

[1]KKE, [2]ADEP

For shallow interplate earthquakes, large long-period later phases are frequently observed at long distance. Simulations using the finite difference, which we have performed, revealed an important effect of seawater on those later phases (e.g. Furumura et al., 2011).

However, attenuation exp(-πft/Q) in the finite difference calculation is set to exp(-πft/(Q_of/f_o)), meaning Q/f=Q_o/f_o is set as a constant, where f_o is a target frequency of the calculation purpose, and Q_o is its corresponding attenuation factor, so it causes some problems especially for waves propagating for a long distance.

Then we calculated waves propagating in a 2.5D structure in the frequency domain with FEM to realize Q as a constant instead of Q/f, for both cases with and without seawater. We could confirm the important effect of seawater on later phases as well as the finite difference calculations. Calculated later phases have relative large amplitude for frequencies lower than f_o in the Q-constant model compared with the Q/f-constant model. It indicates necessity of estimation of difference between realistic Q and modeled one, when we use the finite difference method. In addition, the results reveal large later phases in the case with seawater, which are rarely seen in the calculated waveforms without seawater. It implies overestimation of magnitude of ocean earthquakes obtained from analysis of waves propagating through a long distance along and across an ocean trench, such as the 1911 off Kikai Island earthquake and the 1933 off Sanriku earthquake observed in Honshu.

SSS27-P03 Room:Poster Time:April 29 18:15-19:30

Development and extinction of long-period ground motion in thick sediments

TAKEMURA, Shunsuke[1*] ; YOSHIMOTO, Kazuo[1]

[1]Yokohama City University

To obtain better insights of long-period ground motion in thick sediments, which often cause severe damage of large-scale man-made structures, we analyzed horizontal seismograms recorded by dense strong motion networks in the complex large Kanto basin. We found distinct large amplitude long-period ground motion around northern Kanto, which is caused by Love wave excited at the northwestern edge of Kanto basin. Amplitude of Love wave significantly developed during propagation in thick (>3 km) sediments and then suddenly weakened at region where significant change of basin structure exists.

To clarify causes of such observations, we conducted 3D finite difference method (FDM) simulation of seismic wave propagation. In simulation, we assumed plane SH-wave incident into a realistic basin structure model embedded in a homogeneous half-space background structure, to focus characteristics of Love wave excited at the basin edge. Simulation result in a realistic basin model referred from JIVSM (Koketsu et al., 2008) well reproduced observed Love wave development around the northern Kanto. Another simulation in the model, which is limited to maximum bedrock depth of 3 km, shows no significant difference of simulated waveforms compared with the previous model. Thus, development of surface waves in thick sediments is mainly caused by the deepening of shallower low-velocity layers, rather than the depth variation of bedrock.

Acknowledgement

We acknowledge the National Research Institute for Earth Science and Disaster Prevention, Japan (NIED) for providing the K-NET/KiK-net waveform data. We also use strong motion data from SK-net.

Keywords: long-period ground motion, surface wave, kantou basin, basin structure, numerical simulation

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

SSS27-P04 Room:Poster Time:April 29 18:15-19:30

Receiver function travel time tomography

HIRAHARA, Kazuro[1*] ; YAMASAKI, Tomona[1] ; ABE, Yuki[1] ; SHIBUTANI, Takuo[2]

[1]Graduate School of Science, Kyoto University, [2]Disaster Prevention Research Institute, Kyoto University

Hirahara et al. (2006) proposed a method of Receiver Function (RF) Tomography which combines travel time tomography using travel times from local and teleseismic events with receiver function analyses. In the method, a 3-D P and S wave velocity structure is estimated together with the velocity discontinuity interfaces, where we add both data of the amplitudes and differential travel times of Ps converted phases in RFs employing Gaussian beam RF synthetics. We found, however, that it is difficult to match the amplitudes of Ps phases to estimate the velocity contrasts between velocity discontinuity interfaces with 2-D undulations.

.

Here, as a step toward RF Tomography, we are developing a method of RF Travel Time Tomography using only travel times of P and S waves from local and teleseismic events and P-Ps times of Ps converted phases obtained with the receiver function analyses. Abe et al. (2011) developed a method to estimate iteratively geometries of dipping seismic velocity discontinuities with high dipping angles of 30 to 70 degrees from common conversion point stacking of receiver functions, in which the multistage fast-marching method (de Kool et al., 2006) is applied to the ray tracing with refraction at dipping interfaces. The large amplitudes of RFs stacked in 3-D cells are interpreted to the Ps phases converted at the velocity discontinuity interfaces and the differential travel times P-Ps of the corresponding phases are additionally used for the travel time tomography of P and S waves from local and teleseismic events.

In this paper, we do not analyze the actual data but aim at developing the code of RF Travel Time Tomography based on the code of FMTOMO (Fast Marching Tomography) by Rawlinson (2007). First, for a 3-D heterogeneous structure with interfaces of a Moho and a subduction slab, we synthesize travel times of P and S waves from local and teleseismic events, and also Ps times converted at the Moho and the slab top and the oceanic Moho interfaces. Then we investigate the ability of retrieving the 3-D velocities and the undulation of the Moho and the dipping slab interfaces.

Keywords: Receiver function, Tomography, Ps convered wave, Travel time, Seismic velocity discontinuity interface

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

SSS27-P05 Room:Poster Time:April 29 18:15-19:30

Ocean acoustic Rayleigh wave persistently excited by earthquake signals

TONEGAWA, Takashi[1*] ; FUKAO, Yoshio[1] ; TAKAHASHI, Tsutomu[1] ; OBANA, Koichiro[1] ; KODAIRA, Shuichi[1] ; KANEDA, Yoshiyuki[1]

[1]JAMSTEC

In the interferometry, the wavefield propagating between two positions can be retrieved by correlating ambient noise recorded on the two positions. This approach is useful for applying to various kinds of wavefield, such as ultrasonic, acoustic (ocean acoustic), and also seismology. Off the Kii Peninsula, Japan, more than 150 short period (4.5 Hz) seismometers, in which hydrophone is also cosited, had been deployed for 2 months on 2012 by Japan Agency for Marine-Earth Science and Technology (JAMSTEC) as a part of " Research concerning Interaction Between the Tokai, Tonankai and Nankai Earthquakes " funded by Ministry of Education, Culture, Sports, Science and Technology, Japan. In this study, correlating ambient noise recorded on the hydrophones, we attempt to investigate characteristics of wavefield observed at seafloor.

The observation period is from Sep. 2012 to Dec. 2012. Station spacing is around 5 km. For 5 lines off the Kii Peninsula, the 30 - 40 seismometers are distributed at each line. Sampling interval is 200 Hz for both seismometer and hydrophone. The instruments are located at 100 - 4800 m in water depth. In the processing for the both records, we applied a bandpass filter of 1 - 3 Hz, replaced the amplitude to zero if it exceeds a value that was set in this study. We calculated cross correlation function (CCF) by using continuous records with a time length of 600 s, stacked the CCFs over the whole observation period.

We first aligned only CCFs using two stations with a separation distance of 5 km along lines off Kii Peninsula. As a result, we could detect strong signals in the CCFs that clearly show travel time variation as a function of water depth. The group velocity of the signal gradually changes from 1.3 km/s to 0.7 km/s at water depths from 2000 to 4000 m. In addition to the wave, a relatively weak signal with a group velocity of 1.4 - 1.5 km/s can be seen in the region at water depth of 4,000 m.

We investigated the wavefield by using a numerical simulation with finite difference technique. As a result, all of these signals can be explained by acoustic Rayleigh wave, which has the energy within not only the ocean but also sediment. A case in which vertical forces are located at subseafloor generated the acoustic Rayleigh wave well, and the CCFs using synthetic waveforms match well with the observed ones. However, another one in which vertical forces are located at sea surface failed to describe the observation. This means that the observed acoustic Rayleigh wave in background wavefield would be generated by earthquake signal, not signals due to microseisms. Moreover, we will show that the amplitude of the signals possibly correlates with seismicity distribution, which also supports that the signals are excited by earthquake signals.

Keywords: acoustic Rayleigh wave, ambient noise, correlation analysis

SSS27-P06 Room:Poster Time:April 29 18:15-19:30

Modeling inclined cracks in a 2-D finite difference grid

NASUNO, Arata[1] ; KAWAHARA, Jun[1*] ; SHIINA, Takahiro[2] ; OKAMOTO, Taro[3]

[1]Ibaraki University, [2]Tohoku University, [3]Tokyo Institute of Technology

Seismic scattering due to cracks are often numerically simulated using a boundary integral equation method (BIEM), a finite element method, or a finite difference method (FDM). Among others, the FDM has a great advantage in tractability, though having a limitation that it can treat rectangular grids only. Using the rotated staggered grid that they developed, Saenger et al. (2000, Wave Motion) modeled a crack or cavity as a gather of grid points with zero elastic constants. In contrast, Suzuki et al. (2006, 2013, Earth Planets Space) modeled a 2-D empty crack as a linear array of grid points with zero traction on the basis of a standard staggered grid (Virieux, 1984, 1986, Geophysics). Using this method, these authors successfully simulated seismic wave scattering due to cracks. However, they only treated cracks parallel to grid lines.

Here we extended the method of Suzuki et al. (2006) for modeling cracks with zero antiplane shear traction to the case of cracks inclined with respect to grid lines. Using the idea of the staircase approximation to irregular free surface (Ohminato and Chouet, 1997, Bull. Seis. Soc. Am.), we modeled an inclined crack as staircase-like arrayed grid points with zero antiplane shear traction within a staggered grid. We then simulated a plane harmonic SH wave obliquely incident on the crack until the resultant oscillation of the crack became stationary. We then measured the amplitude of displacement discontinuity along the crack. We also calculated the same displacement discontinuity using a frequency-domain BIEM (Murai et al., 1995, Geophys. J. Int.). It was confirmed that the both results were consistent, irrespective of the crack inclination angle, if the grid spacing was much smaller than the crack length and hence the staircase-shaped crack plane was sufficiently smooth. This implies the validity of the present method of modeling inclined cracks.

Acknowledgments: For the BIEM calculations, we used a code of Dr. Yoshio Murai (Hokkaido University), and used the computer systems of the Earthquake and Volcano Information Center of the Earthquake Research Institute, the University of Tokyo.

Keywords: finite difference method, crack, SH wave