Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS33-01 Room:302 Time:May 22 15:45-16:00

Detailed hypocentral distribution associated with the 2011 Boso Slow Slip Event

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The slow slip events (SSEs) recur every 5-7 years off the Boso Peninsula. The latest event occurred from October to November in 2011, with the shortest recurrence interval in the last 29 years. In association with this event, significant crustal deformations caused by the SSE were clearly observed by high-sensitivity accelerometer (tilt meter) operated by the NIED. The Boso SSE has a significant feature that it accompanies seismic swarms. During the 2011 SSE, numerous swarms also occurred and clear migration was observed. Its spatio-temporal distribution agrees well with slip migration estimated from crustal tilt data for each characteristic period. Focal mechanisms from the NIED Hi-net and AQUA catalogue for major earthquakes are thrust type with slip vectors consistent with the relative motion between the Japanese island arc and the Philippine Sea plate. Repeating earthquakes also occurred during the period of significant crustal deformation. Since repeating earthquakes at the plate subduction zone reflect interplate quasi-static slips (Kimura et al., 2006), these repeating earthquakes associated with the Boso SSE also can be regarded as interplate earthquakes triggered by the SSE slip. In this study, we determined high-precision hypocentral distribution to investigate the SSE activity in detail.

The Kanto plain is covered with thick sedimentary basin and this is a critical issue in the hypocenter determination. In other words, seismic wave velocities of the sediments are approximately Vp˜1.9km/s and Vs˜0.7km/s, and affect arrival time of seismic wave greatly, and surface ground noise is very large due to human activity. To avoid these issues, the NIED have constructed deep borehole stations. At the Boso peninsula, seven 1000m-class borehole stations have been constructed. In these stations, seismographs are installed at the bottom of the boreholes, where effect of low velocity sediments is small. We relocated hypocenters by using five 1000m-class or deeper borehole stations. When arrival time data is available for four or more stations, we determined hypocenter by using hypomh (Hirata and Matsu'ura, 1987). By using these results as initial hypocenters, we determined high-precision hypocenters by Double Difference (DD) method. For comparison, we also determined high-precision hypocenters by DD method by using the NIED Hi-net hypocenter.

Compared to the latter results, hypocentral depths in the former results are 2.0 km shallower on average below the eastern coast of the Boso peninsula and 2.1km deeper below the southeastern coast. As a result, the former results exhibit clear planar distribution gently dipping northward. Earthquakes along this plane have thrust type focal mechanisms. Repeating earthquakes are also distributed along this plane. These results indicate that this plane corresponds to the interface of the interplate shearing. In the 2007 SSE, more seismic swarms occurred off the eastern coast of the Boso peninsula and more swarms occurred below the southwestern coast in the 2011 SSE. The above results indicate that such difference of the swarm activity corresponds to difference of the SSE slip.

Keywords: Slow slip event, Boso Peninsula, high-precision hypocenter distribution, repeating earthquake

SSS33-02 Room:302 Time:May 22 16:00-16:15

Seismotectonics beneath Kanto: A review of recent seismological studies

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The Kanto region, surrounding the Tokyo metropolitan area, has been hit by disastrous M8-class earthquakes and numerous intensely damaging M7-class earthquakes throughout recorded history (e.g., Utsu, 1979, 1999; Usami, 2003). For example, the 1923 Kanto megathrust earthquake (M7.9), which occurred along the upper surface of the Philippine Sea slab (Figure 1b), was one of the most destructive earthquakes of the 20th century, causing severe damage to the Tokyo metropolitan area and resulting in 105,000 fatalities. Earthquake Research Committee (2004) evaluated the probability of the occurrence of an M7-class earthquake beneath southern Kanto, based on the assumption that the five most recent M7-class earthquakes since 1885 occurred randomly as a Poisson process. The evaluation revealed a 70% probability that such an earthquake will occur in the next 30 years.

Here we review our recent seismological observations in Kanto and present geometries of the Pacific and Philippine Sea plates, the lateral extent of a contact zone of the two plate, relationship between heterogeneous structure in the Philippine Sea plate and three of the five M7-class earthquakes (1921, 1922, and 1987 earthquakes) used in the evaluation of Earthquake Research Committee (2004).

Keywords: Kanto asperity, serpentine, slab contact zone

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SSS33-04 Room:302 Time:May 22 16:30-16:45

Classification of Magnitude 7 Earthquakes in Tokyo Metropolitan Area since 1885

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We estimated the source regions of five earthquakes which occurred in southern Kanto region since 1885 (i.e., the 1894 Meiji Tokyo, 1895 and 1921 Ibaraki-Ken Nambu, 1922 Uraga channel and 1987 Chiba-Ken Toho-Oki earthquakes) and classified them into intraplate or interplate earthquakes by analyzing collected data (Ishibe et al., 2009a, 2009b; Murotani et al., 2011) and comparing with seismic velocity model (Nakagawa et al., 2011). The 1894 Meiji Tokyo Earthquake was a slab earthquake within the Philippine Sea plate (PHS) or an interslab earthquake between PHS and Pacific plate (PAC). The 1895 Ibaraki-Ken Nambu Earthquake was a slab earthquake within PAC. The 1921 Ibaraki-Ken Nambu, 1922 Uraga Channel and 1987 Chiba-Ken Toho-Oki Earthquakes were slab earthquakes within PHS with strike-slip fault mechanisms.

Significant changes in both hypocentral locations and focal mechanisms have been observed after the 2011 off the Pacific coast of Tohoku earthquake (e.g., Hirose et al., 2011; Kato et al., 2011). The same situation would be expected for the Kanto earthquakes and understanding the spatio-temporal changes in stress field during a seismic cycle might be a key to time-dependent evaluation of earthquake occurrence probability. For example, the association between the 1923 Kanto Earthquake and two preceding slab earthquakes within PHS is interesting (e.g., Nakajima et al., 2011).

Probability of large earthquakes with magnitude (M)˜7 during the next 30 years was estimated to be 70 % based on the above five earthquakes by the Earthquake Research Committee (2004). However, types of these earthquakes are not well known due to low quality of data. We tried to classify these earthquakes into intraplate or interplate earthquakes.

The focal depths of the 1894 Meiji Tokyo earthquake (M7.0; Utsu, 1979) from previous studies are variable due to the differences of s-p times. Our study also shows similar variation (7-10 s) obtained from waveforms at Hongo, the University of Tokyo. Seismic intensity map based on the Central Meteorological Observatory (1895) and Hagiwara (1972) indicates circular pattern. However, the seismic intensity distribution of the earthquake of October, 7, 1894 occurred in southern Kanto indicates isoseismals extended along the PAC. In Hongo, the s-p times of the Meiji Tokyo earthquake and earthquake of October, 7 are about 7.0 s and 17.0 s, respectively. This suggests that the discussion on the focal depth is possible based on seismic intensity distribution and that the Meiji Tokyo earthquake was not a slab earthquake within PAC.

The focal depth of the 1895 Ibaraki-Ken Nambu earthquake (M7.2) was estimated to be ˜80 km using s-p time at Tokyo (11.3 s) assuming epicenter by Utsu (1979). The s-p times read in this study are about 11 s and are consistent with the report of Omori (1899) although they show some variations.

The focal depth of the 1921 Ibaraki-Ken Nambu earthquake (M7.0) was estimated to be around 53 km using s-p times of seismograms or JMA reports. Seismic intensity distribution supports this result; anomalous seismic intensity distribution characterizing the PAC slab earthquakes is not recognized. Furthermore, initial motion focal mechanisms using modified HASH algorithm (Hardebeck and Shearer, 2002) are strike-slip types, even if the uncertainty of hypocenter locations is taken into account.

The hypocenter of the 1922 Uraga Channel earthquake was estimated in the southwestern Chiba at a depth of around 53 km from s-p times obtained from seismograms or JMA reports. The initial motions indicate either strike-slip or normal fault type focal mechanism if the hypocenter uncertainty is taken into consideration. The circular isoseismals suggests that this earthquake was not a slab earthquake within PAC.

Keywords: Tokyo metropolitan earthquake, Classification, intraplate earthquake

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SSS33-05 Room:302 Time:May 22 16:45-17:00

Tsunami Deposits obtained from Long Geoslicer Survey in Koajiro Bay on the Miura Peninsula, Kanagawa, Japan

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We have conducted single channel acoustic reflection survey and Geoslicer survey at the Koajiro Bay, which locates in the southwestern part of the Miura Peninsula, in order to reveal preceding histories to the Genroku event in the great Kanto earthquake sequence. As a result, five event layers are identified at 0-2 m depth which deposited during past 1500 years. Among these, the upper three event layers can be correlated with tsunami deposits obtained at the head of Koajiro Bay. The result in this survey is consistent with Shimazaki et al. (2011), who suggested that the 1293 earthquake which caused destructive damage in Kamakura, the capital in those days, was the antepenultimate Kanto earthquake.

The great Kanto earthquakes (M~8) occurred in 1703 and 1923 between the continental plate and Philippine Sea plate. However, the occurrence time of the antepenultimate Kanto earthquake have not been revealed although some candidates are proposed based on geological or geomorphological surveys and/or historical documents (e.g., Ishibashi, 1991, 1994; Shishikura, 2003). Shimazaki et al. (2011) conducted handy Geoslicer survey at the head of Koajiro Bay and identified three tsunami deposit layers, probably due to the 1923, 1703 and antepenultimate Kanto earthquakes (1060-1400 AD). Single channel acoustic reflection profiling identified many continuously-distributed reflective layers, which suggests that tsunami deposits due to the previous Kanto earthquakes are probably preserved. Thus, we conducted long Geoslicer survey at the inner Koajiro Bay and obtained 6 cores (2 cores x 3 locations) with a length of 4-6 m.

From the observation, coarse layers, which consist of mixture of materials such as shell fragments, mud clasts, gravels, and coarse sandy sediments, are identified at 0-2 m depth. These coarse layers are significantly distinguishable from inner bay deposits which consist of fine sand, silt and clay. Five possible event layers were identified from the grain size analysis with an interval of 2 cm.

The uppermost event deposit locates at just below the seafloor. Palmer-sized gravel flatly deposited at the other core with the depth corresponding to the second event deposit. The radiocarbon (14C) age of 1560-1820 AD (2sigma, including calendar year calibration and marine reservoir correction) was obtained from barnacle attached at the upper part of the gravel. This is consistent with 14C ages of marine shells uplifted by the 1703 Kanto earthquake (Shishikura et al., 2007) and thus, barnacle possibly attached after the gravel has been conveyed by the 1703 Kanto earthquake tsunami. The 14C age of 1230-1400 AD and 1210-1280 AD were obtained from gamopetalous clam and wood within the third event deposit. These 14C ages indicate that the upper three layers can be correlated with tsunami deposits which were identified from handy Geoslicer survey in the head of Koajiro Bay. The occurrence time of antepenultimate Kanto earthquake estimated from this survey is after 1210 AD and it supports that the 1293 earthquake was the antepenultimate Kanto event.

The fourth event layer deposited 720-1280 AD based on 14C ages. It is difficult to identify corresponding historical earthquakes because of large uncertainty although some damaging earthquakes (e.g., the 818 and 878 earthquakes) are documented. The fifth event layer deposited 560-690 AD.

Acknowledgement: This research is a product of Special Project of Earthquake Disaster Mitigation in Tokyo Metropolitan Area from the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan.

Keywords: Kanto earthquake, Miura Peninsula, Koajiro Bay, Tsunami deposit, The 1293 Kamakura earthquake

SSS33-P01 Room:Convention Hall Time:May 22 17:30-18:30

Seismic activity of the metropolitan area and Philippine Sea plate obtained by MeSO-net

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The Japanese government has estimated the probability of earthquake occurrence with magnitude 7-class during the next 30 years as 70 %. This estimation is based on five earthquakes that occurred in this area in the late 120 years. However, it has been revealed that this region is lying on more complicated tectonic condition due to the two subducted plates and the various types of earthquakes which have been caused by. Therefore, it is necessary to classify these earthquakes into inter-plate earthquakes and intra-plate ones. Then, we have been constructing a seismic observation network since 5 years ago. Tokyo Metropolitan area is a densely populated region of about 40 million people. It is the center of Japan both in politics and in economy. So that human activities have been conducting quite busily, this region is unsuitable for seismic observation. Then, we have decided to make an ultra high dense seismic observation network. We named it the Metropolitan Seismometer Observation Network; MeSO-net. MeSO-net consists of 296 seismic stations. Minimum interval is about 2km and average interval is about 5km.

We picked the P- and S-wave arrival times manually. We applied double-difference tomography method to the data set and estimated the velocity structure. We depicted the plate boundaries from the newly developed velocity model. And, we referred to the locations of the repeating earthquakes, the distributions of normal hypocenters and the focal mechanisms. Our plate model became relatively flat and a little shallower than previous one.

Seismicity of Metropolitan area after the M9 event was compared to the one before M9 event. The seismic activity is about 6 times as high as before the M9 event occurred. We examined spatial distribution of the activated seismicity with respect to the newly developed plate configuration. The activated events are located on upper boundaries and they have almost thrust type mechanisms. Recently, a slow slip event has occurred on October. This observation suggests that shear stresses on the plate boundaries have increased due to eastwards movement of the eastern Japan driven by post-seismic slip of the M9.0 Tohoku-oki event.

The present study is supported by Special Project for Earthquake Disaster Mitigation in Tokyo Metropolitan Area from the Ministry of Education, Culture, Sports, Science, and Technology of Japan.

Keywords: MeSO-net, ultra-dense seismic network, seismicity, plate structure

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SSS33-P02 Room:Convention Hall Time:May 22 17:30-18:30

Clarification of Large or Great Historical Earthquakes in Tokyo Metropolitan Area

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The Tokyo Metropolitan area is located in a tectonically complex region associated with the subduction of the Philippine Sea (PHS) and Pacific (PAC) Plates, and various types of large or great earthquakes have occurred. We have studied past large or great earthquakes in order to estimate their recurrence intervals and to evaluate the future probability of occurrence by using geological and geomorphological data such as tsunami deposits and marine terraces, historical documents, and seismological data.

The great Kanto earthquakes (M˜8) occurred in 1703 and 1923 between the continental plate and PHS. However, the occurrence time of the antepenultimate Kanto earthquake have not been revealed although some candidates are proposed based on geological or geomorphological surveys and/or historical documents (e.g., Ishibashi, 1991, 1994; Shishikura, 2003). We have studied tsunami deposits obtained from geoslicer survey at Koajiro Bay, Miura Peninsula, Kanagawa Prefecture and revealed that the antepenultimate Kanto earthquake occurred between 1060 and 1400 (Shimazaki et al., 2011). This may correspond to the 1293 earthquake which caused extensive damage at Kamakura, the capital in those days. We have also conducted geoslicer survey at Ena Bay, southern tip of the Miura Peninsula and obtained tsunami deposits during the past 4000 years (Chiba et al., 2011). Furthermore, detailed distribution of uplifts due to the 1923 Kanto earthquake was revealed by the LIDAR data, air photos and topography maps (Kim et al., 2011).

There are historical documents describing detailed damage due to the historical earthquakes since 1600, hence we obtained a detailed distribution map of seismic intensity using historical documents for the large earthquake which occurred at Kanagawa post town, in Yokohama city on 7th December, 1812 (Tsuji, 2009). The seismic intensity in the main area of Yokohama city was estimated to be 6 in Japan Meteorological Agency (JMA) scale, and the magnitude was estimated to be 6.4 based on the area of seismic intensity 5. We have also revealed the detailed distribution of damage in residential area, at temples, and old samurai residences due to the 1855 Ansei Edo earthquake. Furthermore, we established a database which compiles historical documents for these damaging earthquakes.

The occurrence probability of M˜7 earthquakes during the next 30 years was estimated to be about 70 % by the Earthquake Research Commiittee in 2004, based on five damaging earthquakes since 1885 (i.e., 1894 Meiji Tokyo, 1895 and 1921 Ibaraki-Ken Nambu, 1922 Uraga Channel, and 1987 Chiba-Ken Toho-Oki earthquakes). We reviewed previous studies on these five earthquakes, collected seismic waveform records and pick data (Ishibe et al., 2009a, 2009b; Murotani et al., 2011), and classified these earthquakes into intraplate or interplate earthquakes by analyzing collected data and comparing with seismic velocity model (Nakagawa et al., 2011) obtained from the newly developed seismic observation network (MeSO-net; Kasahara et al., 2009). The 1894 Meiji Tokyo Earthquake was a slab earthquake within PHS or an interslab earthquake between PHS and PAC. The 1895 Ibaraki-Ken Nambu Earthquake was a slab earthquake within PAC. The 1921 Ibaraki-Ken Nambu, 1922 Uraga Channel and 1987 Chiba-Ken Toho-Oki Earthquakes were slab earthquakes within PHS with strike-slip fault mechanisms.

Keywords: Kanto earthquake, Historical earthquake, M7-class earthquake, Tsunami deposit, Classification

SSS33-P03 Room:Convention Hall Time:May 22 17:30-18:30

Rupture process of March 11, 2011 Ibaraki oki earthquake obtained from back-projection approach using MeSO-net data

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Introduction

The largest aftershock (M7.6) of the giant M9.0 Tohoku-oki earthquake occurred near the coast of Ibaraki prefecture about thirty minutes after the main shock. We report here results of back-projection analysis that makes an image of the rupture process of the M7.6 earthquake.

Data and method of the analysis

In investigating the rupture process of the M7.6 earthquake by the back-projection analysis, we used waveforms observed by the MeSO-net. We integrated the original acceleration seismograms, then, band-pass filtered the seismograms in a frequency range of 0.1 ? 1.0Hz. In this study, we adopted the plate boundary model obtained from source mechanism analysis (Nakajima and Hasegawa, 2006) as the fault model. A fault plane with a length of 100 km and a width of 100 km was taken and it was divided into 112 sub faults. Travel times from subfaults to observation sites are calculated by using 3-D velocity structure model (Matsubara and Obara, 2011). As constraints, we assumed that the rupture velocity is smaller than 4 km/s, and rupture duration on each sub fault is less than 100 sec. By projecting the power of the stacked waveforms onto the assumed fault plane, rupture propagation image was successfully obtained.

Result and discussion

The estimated asperity is located down dip extension of the M7.0 earthquake that occurred on May 2008. The rupture seems to have propagated westward or south-westward avoiding the asperity of the 2008 event as well as the area where pretty large seismic energy was radiated during the main shock.

In the region off the coast of Ibaraki prefecture, M 7 class earthquakes have occurred repeatedly in the past. Such a recurrence of large earthquakes is considered to be caused by high frictional strength due to existence of subducted seamounts. Around the region the Philippine Sea plate contacts with the Pacific plate as well. We think our results will be of help to understand stress accumulation process in the tectonically complex region.

Keywords: The 2011 off the Pacific coast of Tohoku Earthquake, Back-projection, The largest aftershock, MeSO-net

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SSS33-P04 Room:Convention Hall Time:May 22 17:30-18:30

Stress accumulation pattern in the Kanto region, Japan, computed with the collision model of the Izu-Bonin arc obtained

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The Kanto region of Japan is in a highly complex tectonic setting with four plates interacting with each other: beneath Kanto, situated on the Eurasian and North American plates, the Philippine sea plate subducts and the Pacific plate further descends beneath the North American and Philippine sea plates, forming the unique trench-trench-trench triple junction on the earth. In addition, the Izu-Bonin (Ogasawara) arc on the Philippine sea plate is colliding with the Japan islands due to the buoyancy of the arc crust. In this study, we construct the model of the collision of the Izu-Bonin arc from the constraint of the long-term deformation data in Kanto, and using this model we estimate the stress accumulation pattern in the Kanto region.

In Kanto, we can observe one of the most active crustal deformations on the earth. In the southern part of the Boso peninsula to the south, the uplift rate is estimated to be 5 mm/yr from the height of marine terraces. From geological evidence, the Kanto mountains to the west are considered to uplift at 1mm/yr. In contrast, the center part of the Kanto region is stable or subsiding, covered by the Holocene sediments. The depth of the basement reaches 3 km at the deepest. Vertical deformation in the timescale of 1 Myr is being revealed by the analysis of the recent seismic reflection experiments compared with the heights of the dated sediment layers exposed on land.

To reveal the crustal deformation under these plate-to-plate interactions, we use the kinematic plate subduction model based on the elastic dislocation theory. This model is based on the idea that mechanical interaction between plates can rationally be represented by the increase of the displacement discontinuity (dislocation) across plate interfaces. Given the 3-D geometry of plate interfaces, the distribution of slip rate vectors for simple plate subduction can be obtained directly from relative plate velocities. In collision zones, the plate with arc crust cannot easily descend because of its buoyancy. This can be represented by giving slip-rate deficit.

Using the above model, we estimate the long-term slip-rate distribution due to plate subduction/collision to explain the crustal deformation in Kanto obtained from geological and geomorphological studies. The basic deformation pattern of the basin-forming movement in the Kanto plain and uplifts in the southern Boso peninsula and in the Kanto and Akaishi mountains cannot be explained by the collision restricted to the Izu peninsula only. It is necessary to assume wider collision extended to the neighboring Sagami and Suruga trough, which is consistent to the width of the arc crust of the Izu-Bonin arc.

Using this model, we estimated the stress accumulation pattern in the interior of the plate. The result shows the NW compression under the Kanto rage, collided by the Izu-Bonin arc, and NW tension in the north Tokyo Bay and strike slip in the seaside of Philippine sea plate, which is consistent with the f-net mechanisms.

Keywords: Stress field, Simulation of tectonic evolution, Crustal deformation, Kanto, Izu-Bonin arc, Collision

SSS33-P05 Room:Convention Hall Time:May 22 17:30-18:30

Search for evidences from the Great Kanto earthquake in the 23 wards of Tokyo

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More than 88 years have passed since the Great Kanto Earthquake in 1923. Memories for the earthquake have faded away in people's mind. However, many matters related to the earthquake can be still found in the city of Tokyo, if we search for them carefully. Tokyo is the biggest damage city with 69,000 dead due to the Great Kanto Earthquake. 260 matters were surveyed at 170 places in the 23 wards, for example, the monuments for victims, evacuation, and restoration. We believe that the results of this survey are useful as the basic data for encouraging the mind of people for the preparations for the disastrous earthquakes in the future.

SSS33-P06 Room:Convention Hall Time:May 22 17:30-18:30

Investigation of azimuthal dependence of site responses in the Kanto Basin, using earthquake observation data

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Recently, several seismic observation networks have been installed in the Kanto Basin, such as K-net, KiK-net, SK-net and MeSO-net. Especially, MeSO-net (Sakai and Hirata, 2009) installed with an interval distance of about 5 km has high densely covered the Tokyo Metropolitan Area with more than about 250 stations. Large ground motions of the Kanto Basin for long periods were observed by these networks, during the 2011 off the Pacific coast of Tohoku Earthquake, Japan (Mw 9.0). Tsuno et al. (2011) reported complex distributions of earthquake ground motions observed in the Tokyo Metropolitan Area. However the observed ground motions for long periods seem to be small in contrast with those prospected by the scale of the main shock (Mw 9.0). Since the main shock occurred in the Tohoku Region on March 11, 2011, a lot of aftershocks including those with the small scale of magnitude occurred mainly in the East Japan due to the huge scale of the main shock. Also, earthquake ground motions induced by several aftershocks of more than Mj 6 were observed in the Kanto Basin. To investigate azimuthal dependence of site responses excited in the Kanto Basin, therefore, we evaluated the characteristics of ground motions in the Kanto Basin for different moderate aftershocks of the 2011 off the Pacific coast of Tohoku Earthquake.

We selected 5 aftershocks of the same scale (Mj 6.4 to 6.7) occurred in the different azimuth for the Kanto Basin. Also, the epicentral distances from the Kanto Basin for these events were around 200 km. The aftershock events used in this study were as follows: the Northern Nagano Prefecture Earthquake (March 12, 2011, Mj 6.7), the off Ibaraki Prefecture Earthquake (March 13, 2011, Mj 6.4), the Eastern Shizuoka Prefecture Earthquake (March 15, 2011, Mj 6.4), the Fukushima Prefecture Earthquake (April 12, 2011, Mj 6.4) and the off Fukushima Earthquake (July 31, 2011, Mj 6.5). At first, we confirmed the stability of ground motions observed in the seismic bed rock at Shimosa (CHBH04), Iwatuki (SITH01) and Koto (TKYH11) where the borehole stations by KiK-net were installed. To remove the effects of source and pass for different earthquakes, we obtained spectral ratios of underground motions on surface to the averaged ground motions by three stations in the bed rock. The site responses estimated by 5 different events were similar for periods of 1 and 0.5 seconds at the central stations in the Tokyo Metropolitan Area. However, the site responses were clearly different for periods of 5 and 8 seconds. The site responses obtained by the Northern Nagano Prefecture Earthquake and the Eastern Shizuoka Prefecture Earthquake were larger than those obtained by other earthquakes, in spite of the largest ground motions in the bed rock observed by the off Ibaraki Prefecture Earthquake. For example, site response for all the periods at TKY007 (Shinjyuku by K-NET) was almost same for the off Ibaraki Prefecture Earthquake, the Fukushima Prefecture Earthquake and the off Fukushima Earthquake. On the other hand, the site response for a period of 5 seconds obtained by the Northern Nagano Prefecture Earthquake and the Eastern Shizuoka Prefecture Earthquake were extremely larger than those obtained by other earthquakes by around 4 times.

We confirmed the azimuthal dependence of local site responses in the Kanto Basin, using the different moderate earthquakes of Mj 6.4 to 6.7. The ground motions for periods of 5 to 8 seconds in the Tokyo Metropolitan Area were largely excited by the Northern Nagano Prefecture Earthquake and the Eastern Shizuoka Prefecture Earthquake. To evaluate and/or predict ground motions for long periods in the Kanto Basin induced by the Tokai Earthquake, which is supposed to occur in the Southern Shizuoka for the near future, we need to understand more clearly the azimuthal dependence of local site responses in the Kanto Basin.

Keywords: Ground motions, Azimuthal dependence, Site response, Kanto Basin, aftershock recordings, 2011 off the Pacific coast of Tohoku Earthquake

SSS33-P07 Room:Convention Hall Time:May 22 17:30-18:30

Examination of the creation technique of integrated model of shallow and deep structure

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In this study, basic data required for the foundation model creation of Chiba and Ibaraki Prefecture was collected.
in order to inspect the created model in detail Shallow and deep integrated structure model (model of first geology) creation was carried out, and the method was inspected.
Creation of Sallow and Deep integrated structure model evaluated by an order shown below.

(1) Creation of initial Sallow and Deep integrated model (geological model)
(2) Joint inversion processing by microtremor data + seismic observation data
(3) Examination of the extended method to field structure
(4) Evaluation of the S wave amplification characteristic and the periodic characteristic (SH and finite difference method)
(5) Inversion processing by single point microtremor data(H/V spectral ratio)

Finally, Shallow and Deep foundation structural models of the Chiba and Ibaraki whole region were created by a 250m mesh unit. The foundation structure model tuned up by this examination became the accuracy of the whole broadband, and a thing which the neighboring periodic characteristic and S wave amplification characteristic improve sharply for 2 to 0.5 second especially.

Keywords: integrated model of shallow and deep structure, Strong-motion, Microtremor measurements, Geology stratigraphy, S-wave velocity

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An evaluation of 3-D velocity models of the Kanto basin for long-period ground motion simulations

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Many institutes are involved in constructing and updating the 3-D velocity structure model of the deep sedimentary basins for the seismic disaster mitigation planning in Japan. The 2009 J-SHIS model for the deep sedimentary layers of the Kanto basin was reconstructed using diverse suite of data: the geological data, seismic reflection and refraction surveys, gravity surveys, H/V inversions, deep borehole profiles, and layer boundaries estimated by microtremor exploration method (e.g., Fujiwara et al., 2006). On the other hand, Yamada and Yamanaka (2011) introduced a new model (hereafter YY model) for the deep sedimentary layers of the Kanto basin based on the Rayleigh wave phase velocities at periods from 0.5 to 5 s deduced from the microtremor array observations at more than 250 sites in the area. There exist also other velocity models of the Kanto basin based on refraction data and geological data.

In this paper, we select the 2009 J-SHIS model and the 2011 YY model to evaluate their performance for the long-period ground motion simulation. We simulate waveforms in the period range of 2 to 10 s (0.1 ~ 0.5 Hz) for two moderate magnitude intermediate depth earthquakes: Mw 5.9, depth 68km (2005/07/23, 16:35, JST); and Mw 5.8, depth 80km (2011/04/16, 11:19, JST), which occurred beneath the Kanto basin, using a 3-D finite difference method. We used strong-motion records at about 600 and 450 sites to evaluate the models for the 2005 and 2011 events, respectively, recorded by the K-NET, KiK-net, and SK-net. For details about the earthquake source parameters, velocity models, waveform simulations, and goodness-of-fit measure, we refer readers to our previous paper (Dhakal and Yamanaka, 2012) and references therein.

We derived the goodness-of-fit (gof) values from the PGVs and Fourier spectra using the algorithm proposed by Olsen and Mayhew (2010). We found that more than 95% of sites belong to the fair fit and above for both the models for the 2005 event, and 85% for the 2011. The J-SHIS and YY models give one class high gof values at about 20%, and 15%, respectively, of about 600 sites used in this study, suggesting that one model performs better than the other at those sites.

In this paper, we extended the goodness-of-fit analysis in our previous paper to the cross correlation measure. We obtained cross correlation at 105 K-NET and KiK-net sites, which are located in the basin, for the 2005 event. The waveforms are shifted to match the S-wave arrivals. We found that, for a time window of 20s, starting from 10s before the S-wave, 76% and 79% of sites belong to the class of fair fit and above for the EW component, which had dominant amplitude over other components, for the J-SHIS and YY models, respectively. On the other hand, for a time window of 70s, starting from 10s before the S-wave, 62% and 51% of sites belong to the class of fair fit and above for the J-SHIS and YY models, respectively.

The above results suggest that the two models perform somewhat differently and need further revision. Also, an improved model can be obtained by integrating the two models.

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Reference

Dhakal, Y. P. and Yamanaka, H., 3-D Finite Difference Simulation of Long period Ground Motions for the Performance Analysis of two Subsurface Velocity Models of the Kanto Basin Using Moderate Magnitude Earthquakes,Joint Conference Proceedings, 9th International Conference on Urban Earthquake Engineering/ 4th Asia Conference on Earthquake Engineering, March 6-8, 2012, Tokyo Institute of Technology, Tokyo, Japan.

Keywords: Kanto basin, J-SHIS, Subsurface structure, Long-period ground motion, Goodness of fit

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Simulation of the Green's function estimated from seismic interferometry in the Kanto basin

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The correlation of long time series of microtremors makes possible to reconstruct the Green's function between two stations. The authors have validated the appropriateness of the surface wave group velocity by comparing between the Green's functions estimated from seismic interferometry and the theoretical ones in the last meeting. Although it is possible to reconstruct the Green's function theoretically, a lot of previous studies have used it only for the estimation on arrival times. Recently, Prieto and Beroza (2008) and Yamanaka et al. (2010) showed the similarity of the waveforms between the estimated Green's function and seismic event. Prieto et al. (2009) tried to infer a one dimensional model of the depth dependent Q structure in southern California. Ma et al. (2008) showed significant similarity between the estimated Green's function and the theoretical Green's function using finite element method in greater Los Angeles area. However as realistic wavefield is very complicated, numerical calculation is one of the most proper ways for investigation on the amplitudes of cross correlations. Here we calculated the theoretical Green's functions and made a comparison with the estimated Green's functions in the Kanto basin.

We estimated the Green's functions in a similar way we used in the last meeting based on more than half year microtremor data. Cross correlations are calculated after 1-bit normalization [Campillo and Paul, (2003)] and bandpass filtered between 2.0 to 6.0 seconds. The theoretical Green's functions are calculated by using three dimensional finite difference method at each observation sits. We referred Yamanaka and Yamada (2006) as subsurface structure model of the sedimentary layers and we used Ricker wavelet which has central frequency at the period of 6.0 seconds as the vertical point source. Comparison between theoretical and estimated Green's functions made it clear that the most of arrival times are similar from those of two waveforms and that there is a great possibility to estimate the velocity in the realistic wavefiled. Moreover not only arrival times but also amplitudes are similar with each other when the two observation sites locate close each other and the variation of subsurface structure is not big. On the other hand, there is a significant difference between the two waveforms when the observation sites are located in the marginal part of the basin and inter station distances are large. This result may come from the difference of the model from the actual basin structure because the theoretical Green's functions have significant later phases and the waveforms are very complex. In such a case, because of the complexity of the waveform, we need to take care for even estimation on velocity.

Keywords: seismic interferometry, Green's function, simulation, microtremors, Kanto basin