SSS35-01 Room:103 Time:May 23 11:03-11:27

The great Nankai-trough earthquake-how can we handle largest earthquake and tsunami-

Takashi Furumura[1*]

[1]CIDIR/ERI Univ. Tokyo

Following the lessons from the great 2011 off the Pacific coast of Tohoku earthquake, we need to realize the greatest earthquakes which may be occurred along the Nankai trough in future for practical disaster mitigation as well as for moderate scale earthquakes. However, our knowledge on the occurrence history and their linkage occurrence properties of the Nankai earthquake is limited due to restriction of the paleoseismology and geological data. Although the strong ground motion and tsunamis for the largest Nankai trough earthquake scenario have been examined recently, we should remember that the present estimations are based on the limited knowledge of the unknown earthquake. We need further scientific and opened discussions from various point of view to understand the occurrence probability and for treatment for social disaster mitigation plan.

SSS35-02 Room:103 Time:May 23 11:27-11:42

Re-Investigation of Disaster from the 1944 Tonankai Earthquake (Part 2): the Seismic Intensity Distribution

Masayuki Takemura[1*], Kenji Toraya[1]

[1]Disaster Mitigation Research Center, Nagoya University

Damage statistics for the 1944 Tonankai earthquake (M=7.9) have been re-evaluated by Takemura(2012), mainly from the reports by Miyamura(1946) and Iida(1985). The seismic intensity distribution in JMA scale (I) is estimated from the collapse rate of wooden houses from the new developed dataset by Takemura(2012). This covers almost the entire region of the affected area. The areas with I=7 was limited, because the focal region of this event was located under the ocean, while the area with I =6- is more extended than the 1923 Great Kanto earthquake (M=7.9). The areas with I=7 are as follows: (1) A part of the Kikukawa city in the Sizuoka prefecture, (2) A part of Fukuroi city in the Sizuoka prefecture, and (3) A part of Nishio city in the Aichi prefecture. 161 lives were lost in Fukuroi city, where is one of the most severe damage region from the 1944 event and some monuments for victims were surveyed in this area.

Keywords: 1944Tonankai Earthquake, Seismic Intensity

SSS35-03 Room:103 Time:May 23 11:42-11:57

Zenisu fault, south of Nankai trough and 1498 Meio earthquake

Takashi Nakata[1*], Hidekazu Tokuyama[2], Takashi Kumamoto[3], Mitsuhisa Watanabe[4], Yasuhiro Suzuki[5], Hideaki Goto[1], Azusa Nishizawa[6], Ritsuko S. Matsu'ura[7]

[1]Hiroshima Univ., [2]Kochi Univ., [3]Okayama Univ., [4]Toyo Univ., [5]Nagoya Univ., [6]Japan Coast Guard, [7]ADEP

Zenisu fault was first recognized as an extensive active fault extending for about 150km along the southern fringe of the Zenisu ridge to the south of the Sagami trough (Research Group for Tokai-oki Submarine Active Faults, 1999). We discuss the relation between submarine active faults and historical earthquakes based on location and geometry by interpretation of anaglyph image made from DEM obtained from detailed bathymetric survey data by Japan Coast Guard.

We clarified that the Zenisu fault is an over 250km-long active fault extending ENE-WSW south of the Nankai trough from off Hamana-ko to south of Kouzu-shima across the Izu bar. Distinctive fault scarps with a relative height of about 100m along the southern foot of the Zenisu ridge is good evidence for repeated faulting in the recent geological periods.

We estimated magnitude of earthquake as about Mw8.3-8.4 from a fault model with fault plane 275 km long and 50 km wide. The plane strikes N 60 degree E and dips 24 degree NW with pure slip of 8-10 m. Tsunami height along the coast from southeast Kii peninsula to Boso peninsula is also simulated based on the same fault model. Tsunami height is 8-10 m around Shima peninsula, 6-10 m along the Enshu coast, 5-6 m on Izu peninsula and southern Boso peninsula. The estimated magnitude of the earthquake and tsunami height agree well with 1498 Meio earthquake.

Keywords: 1498 Meio earthquake, submarine active fault, large earthquak, Zenisu fault, tsunami, Nakai trough

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SSS35-04 Room:103 Time:May 23 11:57-12:12

Geological evidence of the tsunami inundation area during the historical Tokai earthquakes in the Otagawa lowland, Japan

Osamu Fujiwara[1*], Eisuke Ono[2], Kiyoshi Ichikawa[3]

[1]AFERC GSJ AIST, [2]Faculty of Education, Niigata University, [3]Hanshin Consultants Co., Ltd.

Tokai area's earthquake and tsunami history is inspected by using coastal geology of the Otagawa lowland, central Shizuoka Prefecture. Four historical tsunami deposits corresponding to AD 684, 887, 1096 and 1498 earthquakes occurred along the Nankai Trough have been reported from the excavation sites of the lowland (Fujiwara et al., 2012). Here we made a coring campaign to reveal the landward extent of these tsunami deposits and reconstruct the inundation distance of the paleo-tsunamis. We used orient-controlled sediment core sampler named as Long face, as well as conventional drilling machine and obtained a total of 53 continuous sediment cores along three transects in shore normal direction, the longest transect reaches about 3.8km inland .Cores are 90-100 mm diameter and 2 to 25 m long (deep).

Here we introduce a preliminary result along a survey transect. Some sand beds showing a fining landward trend were found in the transect. These sand beds suggest the deposition by inundated tsunamis. According to radiocarbon ages, these sand beds formed after the 7th century and probably originated from the historical Tokai earthquake.

Keywords: Tokai earthquake, Tsunami, Tsunami deposit, Historical earthquake, Shizuoka

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SSS35-05 Room:103 Time:May 23 12:12-12:27

Study on the 1707 Hoei Tsunami on the basis of the descriptions in Kokuryoki along the coast of Kochi Prefecture

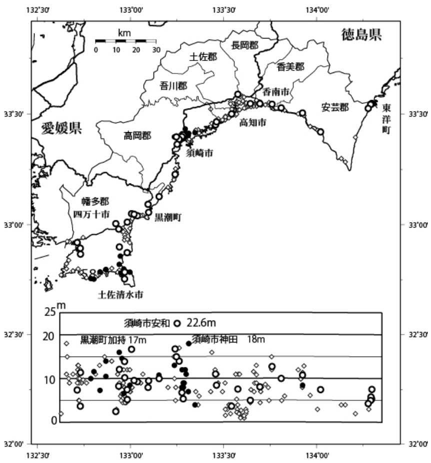
Yoshinobu Tsuji[1*], Kentaro Imai[2], Yoshikane Murakami[3], Fumihiko Imamura[2]

[1]Fukada Geolog. Inst., [2]IRIDeS, [3]KEPCO

The tsunami of the Hoei earthquake of October 28, 1707 hit the coasts between Kyushu Island and Kanto District. Studies on the distribution of the heights of this tsunami were conducted by Imamura(1941), Hatori(1978, 1981), Tsuji et al.(1994), and Murakami et al.(1994, 1996) on the basis of descriptions of old documents, stone monuments, and oral literatures. But none of those authors had never referred the official report book of this hazard called Kokuryoki, which was edited by Okumiya Masaaki. He was a teacher of the school of Tosa Clan. He edited and published Kokuryoki on the basis of official records of the clan within a few years after the tsunami. In this book damage of the tsunami for 211 towns and villages along the coast of Tosa province (Kochi prefecture at present) is described. Why the preceded researchers had not referred this book? It is because in this book the descriptions for most of the villages are simple; for example, perfectly went to ruin, rice fields were flooded, but hoses were only slightly damaged, or Sea water reach the foot of the hind hill and so on, and poor for the descriptions of the limit of submergences. In the present study, we made database of the description in this book, and found out that this book contains the records of inundation limit at 41 points in total. We conducted survey of the heights of those points. In addition that, we gathered about 300 copies of city planning maps in scale of 2,500 to 1 with contour intervals of 2 meters by visiting public work sections in city and town halls. We can estimate the heights of the limits of the submerged area at the village where such descriptions were given in this book that, sea water went to the foot of the hind hill or sea water flooded all rice fields, but no house damage took place. For such villages, we estimated the tsunami inundation height in the accuracy of one meter.

Figure shows the distribution of the inundation heights above the mean sea level for villages. White circles show the villages where heights were measured exactly, Diamonds shows the villages where tsunami heights were estimated by using city planning maps in the scale of 1:2500. Black circles show data given by the previous studies.

Keywords: the 1707 Hoei Earthquake, the Nankai gigantic earthquake, tsunami, old documents, inundation height of a tsunami, historical earthquakes



SSS35-06 Room:103 Time:May 23 12:30-12:45

Propagation of long-period ground motion in the Tokyo lowlands, Japan during the 2011 Tohoku Earthquake

Tomiichi Uetake[1*]

[1]Tokyo Electric Power Company

The studies about strong motion data obtained from past earthquakes in the Tokyo metropolitan area suggested that the long-period ground motions with period of about 8 s would be excited during the large earthquakes. Although, the response spectra calculated from the data of the 2011 Tohoku Earthquake had no significant peak at period of around 8 s. In this period range, the excellent peak of response spectra was assumed to be strongly affected by the excitation of the fundamental Love waves. UETAKE(2012) suggested that the higher mode surface waves were predominant over the fundamental mode in the long period ground motions of the Keihin area during the 2011 Tohoku Earthquake. In this article, the propagation characteristics of long-period ground motion in the Tokyo lowlands are studied using K-NET data during the 2011 Tohoku Earthquake.

Fifteen K-NET stations in the Tokyo lowlands were used for array analysis. The diameter of the array is about 10 km and minimum station distance is shorter than 1 km. The acceleration seismograms had spindle?shaped envelope and peak ground accelerations were recorded about 90 s after seismic wave on-set. The velocity response spectra with 5% damping showed flat feature in period of over 5 s, but response value was scattered between 30 and 80 cm/s at 5 s, and between 30 and 50 cm/s at 10 s. We performed semblance analysis using a narrow-band pass filtered waveforms in transverse component and evaluated the phase velocity for each time sections. The center periods of the filters are 5, 6, 7, 8, 9, 10, 12, 15, and 20 s. The length of time window for analysis was 40 s and the time windows were opened every 20 s in wave traces.

The peak values of semblance in first half part of waveforms are high but the values in the second half part are lower value in according with the period and in proportion to the start time of analytical windows. The semblance values of period 8 s in front part are over 0.8 but go down to 0.5 in later part. The phase velocities in first half part are over 3 km/s in every period. The Phase velocity in second half part shows the dispersion characteristics. The value at 10 s is 2.5km/s and the value in 7s is 1.4 km/s. The back azimuths of wave propagation in the first half part indicate that the seismic wave propagated from the epicenter direction. The back azimuths of several windows in second half part indicate the wave propagate from opposite direction of the epicenter. In second half part, the distribution of semblance value in the slowness plane has some peaks with low value.

To examine the relation between this dispersion characteristics and underground structure, we calculated phase velocities of the Love waves using the underground structure model for the center of array. The phase velocities evaluated in the first half part are faster than phase velocity of the fundamental mode and near to the velocities of higher modes. The phase velocities evaluated in the second half part coincide with the phase velocity of the fundamental mode.

Keywords: Long-period ground motion, the Tokyo lowlands, the 2011 Tohoku Earthquake, Array analysis

SSS35-07 Room:103 Time:May 23 14:15-14:30

A Study on the Long Period Ground Motions Observed in Osaka Bay Area

Takao Kagawa[1*]

[1]Tottori Univ. Graduate School of Eng.

The predominant period of ground motion in Osaka bay area is assumed about 6 seconds from deep sedimentary structure. The bedrock depth in the area is estimated around 1.6 km. Through the 2011 off the Pacific coast of Tohoku earthquake, large long period ground motion was observed and high rise building with natural period around 6 seconds suffered considerable damage. KiK-net observation site in Osaka bay area, OSKH02 observed the strong ground motion with accelerometers at ground surface and in bedrock, 2000m depth. The spectral amplitude ratio between the sensors at around 6 seconds was about 30 times. The same phenomena were observed in the site through the 2000 western Tottori earthquake and the 2004 off the Kii peninsula earthquake.

From the minute analysis of the data, it is found that the amplitude ratio is smaller in the beginning of the record, while the ratio grows larger with elapsed time. The ratio in the beginning is around ten times that can be explained from sedimentary response of vertical incident body waves. However, the ratio in the later part is around several tens and it might be caused by nodes and antinodes of surface waves at observed points. Further analyses and discussions will continue.

Keywords: long period ground motion, Osaka bay area, The 2011 off the Pacific coast of Tohoku earthquake, surface wave

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SSS35-08 Room:103 Time:May 23 14:30-14:45

Several issues revealed from benchmark tests for strong ground motion simulations (Part 1: Theoretical & Hybrid Methods)

Yoshiaki Hisada[1*], Kenichi Kato[2], Chiaki YOSHIMURA[3], Masayuki Nagano[4], Hidenori Kawabe[5], Arihide Nobata[6], Takashi Hayakawa[7], Yu Yamamoto[8]

[1]Kogakuin University, School of Architecture, [2]Kobori Research Complex, [3]Osaka University, [4]Tokyo University of Science, [5]Kyoto University, [6]Obayashi Co., [7]Shimizu Co., [8]Taisei Co.

In this presentation in (Part 1), we will talk about the following three topics.

1. Summary on the important results from the benchmark tests of the theoretical methods, which carried out in 2011-2013 (Hisada, 2011, 2012; Matsumoto, 2013)

2. Various issues on the problems and techniques for the hybrid methods between the theoretical and stochastic methods in the combining periods (about 0.5 - 3 s), which are the most important periods for engineering structures.

3. New benchmark tests for predicting strong ground motions from large earthquakes along the Nankai trough and under the Kanto basin.

In (Part 2) and (Part 3), we will present the summary and new benchmark tests for the numerical and stochastic methods, respectively.

Keywords: strong ground motion simulation, benchmark tests, theoretical method, hybrid method, Large Earthquake on the Nankai Trough, Large Earthquake under the Kanto Basin

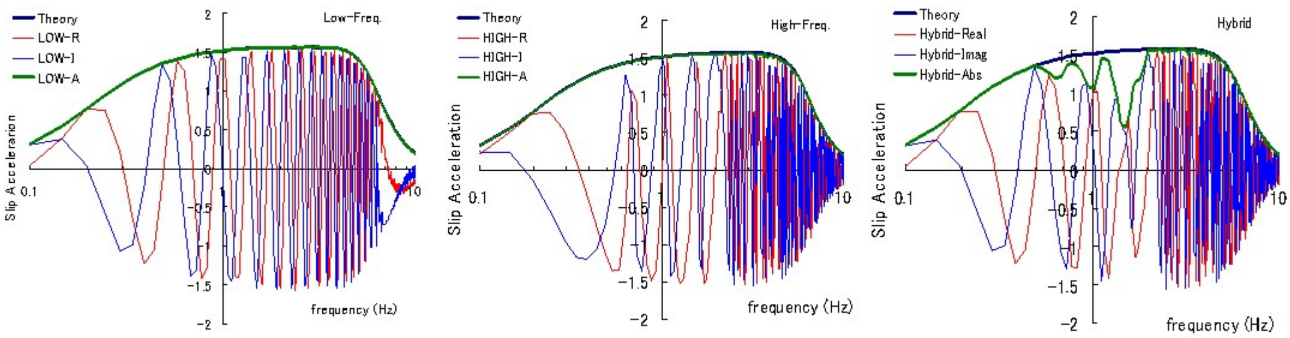

Figure 1: Fourier Amplitude Spectra of the omega-squared models using the three different phase spectra
Left: Zero Phases, Middle: Random Phases, Right: Hybrid using the two phases between 0.5 - 2 Hz

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SSS35-09 Room:103 Time:May 23 14:45-15:00

Several issues revealed from benchmark tests for strong ground motion simulations (Part 2: Numerical methods)

Chiaki YOSHIMURA[1*], Masayuki Nagano[2], Yoshiaki Hisada[3], Hidenori Kawabe[4], Takashi Hayakawa[5], Yu Yamamoto[6], Seckin Ozgur Citak[7], Shinichi Matsushima[8]

[1]Osaka University, [2]Tokyo University of Science, [3]Kogakuin University, [4]Kyoto University, [5]Shimizu Corporation, [6]Taisei Corporation, [7]JAMSTEC, [8]Kyoto University

1. Introduction

Numerical methods such as 3-dimensional finite difference method and 3-dimensional finite element method are often used to calculate long period earthquake ground motions in large sedimentary basins such as Kanto, Nobi and Osaka plains in Japan. These methods can consider complex source model and irregular subsurface ground model, however, the differences of modeling lead to differences of calculated ground motions. We have conducted a benchmark test for 3 years since 2009. In this presentation, we summarize the issues revealed from the benchmark study. We also show a newly proposed benchmark test targeting the source region along Nankai trough, in western Japan, where large subduction earthquakes are supposed to occur in near future.

2. Several issues revealed from benchmark test (2009-2012)

In step 1 and 2 during 2009, we studied a uniform media and a two-layered media with a point source or a rectangular source. The waveforms calculated by 6 teams showed generally good agreement to each other. However, the results showed differences depending which properties are allocated at the grids just on the boundary between the surface layer and the basement layer.

In step 3 and 4 during 2010, we considered two simple sedimentary basin models: a symmetric trapezoidal basin and an asymmetric slant-basement basin. In the process of discritization of subsurface ground model, differences of properties allocation among teams appeared near the curved boundary or along the slant basement. It generated differences at the waveforms of surface waves.

In step 5 and 6 during 2011, we solved a realistic Kanto basin model considering 3 observed small or medium earthquakes and the 1923 Kanto earthquake. The waveforms of body waves showed good agreement among teams. However, those of surface waves showed differences among teams whose grid space are different. Choice of grid space makes differences regarding allocation of soil properties along depth near the surface. It affects the accuracy of surface waves that propagate long distance in horizontal direction.

As mentioned above, the modeling of soil structure near the surface is important because it affects the accuracy of surface waves that are dominant in long-period domain the numerical methods consider.

3. Outline of the newly proposed benchmark test

The benchmark test is to simulate the southeast off the Kii peninsula earthquake (Mj 7.1) that occurred in the source region along Nankai trough on September 5th, 2004.

Table 1 summarizes the calculation condition. Figure 1 shows the source location and output points. Calculation domain is to be chosen so that it includes any one of Kanto, Nobi and Osaka plain, or more than one plain. Source model is to be the one proposed by Yamamoto and Yoshimura (2012). The subsurface ground model of Kanto plain is to be build based on the model proposed by "Long period earthquake ground motion prediction project in 2012 (2012 model)". For Nobi and Osaka plain, the 2012 model is to be used for the lower crust and deeper, and the 2009 model for the upper crust and shallower. The calculation is to be valid up to 0.25 Hz for Kanto plain and up to 0.4 Hz for others. Five to 10 output points are selected for each plains and 5 points along propagation path to each plain as shown in fig.1.

The details of the benchmark test are available at http://kouzou.cc.kogakuin.ac.jp/test/home.htm.

Acknowledgements:

This study was supported by Grand-in-Aid for Scientific Research (B) of MEXT, the research subcommittees on Earthquake Ground motion of the Architectural Institute of Japan, and Research center of UDM of Kogakuin University.

1)Yoshimra et al.(2011), AIJ. Technol. Des. Vol.17, No.35, 67-72.
2) Yoshimra et al.(2012), , AIJ. Technol. Des. Vol.18, No.38, 95-100.
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Keywords: Fault Model, Finite Difference Method, Finite Element Method, Kanto Plain, Nobi Plain, Osaka Plain

Table 1 Calculation condition

	Step 7
Model name	N71
Target Eq.	Southeast off the Kii Peninsula Eq. (2004/9/5, 19:07, M7.1)
Source	Point Source
Soil model	Kanto plain: Long period earthquake ground motion prediction model 2012 Nobi and Osaka plain: 2009 model + 2012 model
Attenuation	Yes
Calculation frequency	Kanto plain : 0～0.25Hz (more than 4s) Nobi and Osaka plain : 0～0.4Hz (more than 2.5s)
Output	5～10 points in each plain、5 points on the path to each plain

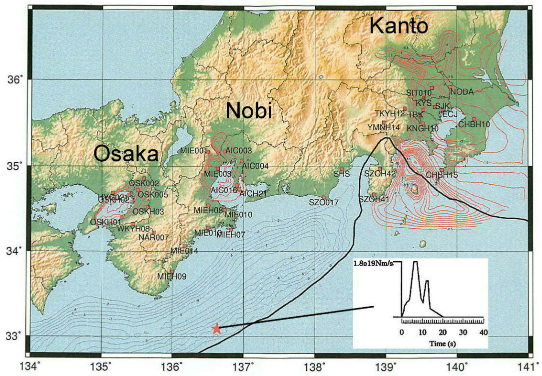

Figure 1 Source and output points

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SSS35-10 Room:103 Time:May 23 15:00-15:15

Several issues revealed from benchmark tests for strong ground motion simulations (Part 3: SGF)

Kenichi Kato[1*], Yoshiaki Hisada[2], Susumu Ohno[3], Arihide Nobata[4], Atsushi Morikawa[1], Yu Yamamoto[5]

[1]Kobori Research Complex, [2]Kogakuin Univ., [3]Tohoku Univ., [4]Obayashi Co., [5]Taisei Co.

1. Introduction

Stochastic Green's function method is widely used to generate strong ground motions in high frequency range, and applied to simulate the input ground motions for designing aseismic buildings/structures. Since random phases are used in generating time histories in this method, it is important to know the range of variation among synthesized results under the same source, path and site conditions. To quantitatively know the range of the variation, benchmark tests for the strong motion simulation methods have been performed as three years project since 2009 (Kato et al., 2011, 2012, 2013). The purpose of this paper is to reexamine the results of previous benchmark tests, and to reveal several issues and problems for strong ground motion simulations based on the stochastic Green's function method. We also show the plan of the new benchmark tests to resolve the issues through the simulation of observed strong ground motion records.

2. Outline of the results of previous benchmark tests and several issues to be resolved

The previous benchmark tests consist of 6 steps. Very simple point source models in homogeneous and two-layered subsurface structures are used in Step 1, and extended sources are used in Step 2. Radiation coefficient of the source is assumed to be frequency independent, and only SH wave is considered. Since random phases are used in generating time histories, synthesized amplitude shows variation in particular frequencies. We do not know how many random phases should be generated to obtain the average spectra. We also find the serious sags in the Fourier amplitudes in the middle frequency range, around 1Hz, as compared with the omega-squared model, which have to be improved (Kato et al., 2011).

In Steps 3 and 4, more complicated analytical conditions are considered. Frequency dependent radiation coefficient of the source is applied. Since oblique incidences of both SH and SV waves are considered, vertical component is also generated. We also apply the exact Green's function to the Step 4 based on the wavenumber integral method. There exist amplitude and phase differences in the period range longer than 1s. This differences stem from the excitation of surface wave, which can't be considered in Stochastic Green's function method (Kato et al., 2012).

In the Steps 5 and 6, the Kanto sedimentary basin for the 1923 Kanto earthquake (M7.9) is considered as an actual source and structure model. Strong ground motions from the asperity are synthesized in Step 5, and those from characterized source model are synthesized in Step 6. The spectra from Stochastic Green's function method are underestimated in the range longer than 0.5s. It is suggested that the assumption of oblique incidences of plane waves and frequency dependent radiation coefficient of the source may not be practical (Kato et al., 2013).

3. Outline of the new benchmark tests

We plan the new benchmark tests, Step 7, focusing on the validity of oblique incidences of plane waves and frequency dependent radiation coefficient. Target event is the 2004 Kii-hanto-nantou-oki earthquake (fore shock), and strong ground motions recorded at K-NET and KiK-net stations are simulated. Fig. 1 shows the epicenter and the location of stations, and Table 1 shows analytical conditions. Preliminary results from several models will be presented at the conference. Please check the following web site for more details. http://kouzou.cc.kogakuin.ac.jp/test/home.htm

Acknowledgments:

This work was supported by Grant-in-Aid for Scientific Research (B) of MEXT, the Research Subcommittees on the Earthquake Ground Motion of the Architectural Institute of Japan, and the Research Center of UDM of Kogakuin University.

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Kato et al., AIJ J. Technol. Des. Vol. 18, No.38, 67-72, 2012.
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Keywords: Strong motion prediction methods, Benchmark tests, Stochastic Green's function method, Random numbers, the 2004 Kii-hanto-nantou-oki earthquake

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Table 1 Benchmark tests for stochastic green's function method

	ステップ7：2004年紀伊半島南東沖の地震(前震)			
モデル名	S71	S72	S73	S74
地盤	多層地盤（岩盤、平野内）			経験的地盤増幅率(野津・長尾、2005)
入射角	斜め入射		鉛直入射	
Q値	振動数依存のQ値（岩盤、平野内）			
震源	点震源			
ﾗﾃﾞｨｴｰｼｮﾝ (SH & SV)	振動数(f)依存	振動数(f)一定		
破壊開始時間				
有効振動数	0～20 Hz			
出力点	関東、濃尾、大阪平野内のK-NET、KiK-net地点(図1)			
出力成分	NS, EW, UDの3成分		NS, EWの2成分	
乱数の設定	各自の乱数３パターン			

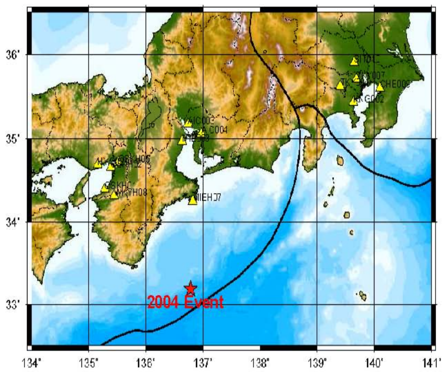

Fig.1 Epicenter of the 2004 Kii-hanto-nantou-oki earthquake and stations for calculation

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Long-period ground motion for megathrust earthquakes at the Sagami Trough: Effects of source variety on ground motion

Asako Iwaki[1*], Nobuyuki Morikawa[1], Takahiro Maeda[1], Shin Aoi[1], Hiroyuki Fujiwara[1]

[1]NIED

Two types of earthquakes, the 1923 Taisho- and the 1703 Genroku-type Kanto earthquakes, have been well known as the historical megathrust earthquakes at the Sagami Trough and considered as future scenario earthquakes. However, a new long-term evaluation for Sagami Trough megathrust earthquake currently under discussion by the Headquarters for Earthquake Research Promotion (HERP) considers the earthquake source region which extends to the outside the source areas of the two types where no historical megathrust event is known to have taken place.

In this study, we perform long-period ground motion simulations by 3D finite-difference method for Sagami Trough earthquakes based on the source region proposed by HERP. As for Sagami Trough, lack of accumulated historical earthquake records prevents us from obtaining knowledge of the source model for the next anticipated event. Therefor it is important to consider as many choices as possible of the unknown outer and inner source parameters.

To construct our source models, the maximum source region is divided into six segments, each of which composes a number of scenario cases by itself or in combination with other segment(s). We compared ground motions for several scenario cases with different magnitudes, including Taisho-type (M_W7.9), Genroku-type (M_W8.3), and the largest case (M_W8.6). Peak ground velocity (PGV) within the Kanto area, including Tokyo metropolitan area, differs by several to several to several ten times depending on the choice of the scenario case.

We also studied the effects of variety in inner fault parameters, such as rupture starting points and asperity patterns. They can greatly vary the ground motion within Kanto area, especially in the direction of rupture propagation, suggesting the sever impact of directivity.

Then we studied heterogeneous models by introducing multi-scale spatial heterogeneity (e.g. Sekiguchi and Yoshimi, 2006) to rupture velocity and rake angle distribution. PGV for the heterogeneous models are reduced by up to 1/5 compared to that for the homogeneous models, indicating that the heterogeneity in rupture propagation reduces the directivity effects.

Keywords: megathrust earthquake, long-period ground motion, Sagami Trough

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Long-period ground motion evaluation for the Nankai Trough megathrust earthquakes

Takahiro Maeda[1*], Nobuyuki Morikawa[1], Asako Iwaki[1], Shin Aoi[1], Hiroyuki Fujiwara[1]

[1]NIED

The megathrust earthquakes in Nankai Trough have been occurring with an interval of 100-200 years. The past earthquakes show various occurrence patterns and we have no exact idea for the occurrence pattern of next earthquake. Thus it is important to understand a possible range of long-period ground motion by considering the uncertainty of source model. In this study, we evaluate long-period ground motions for the Nankai Trough megathrust earthquake, especially for the anticipated largest earthquake, using many scenarios with various possible source parameters including asperity distribution and hypocenter. We also assumed a variation of rupture velocity and source time function for the shallower part of source area. The long-period ground motions were simulated by the finite difference method using characterized source model and 3D velocity structure model of Japan. We used the GMS (ground motion simulator) for the 3D finite difference simulation.

The simulation results at selected sites show that deeper part of source area has larger contribution to long-period ground motions for the anticipated largest earthquake than shallower part of source area. The asperity distribution on the deeper part of the source area and hypocenter location cause variation of the peak ground velocity (PGV) by a factor of two and a factor of up to five, respectively. The simulated PGV values show a large scattering compared to those for smaller earthquakes in the Nankai Trough which we have already simulated.

Keywords: Nankai Trough, long-period ground motion, megathrust earthquake, GMS

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Strong motion evaluation for a scenario earthquake along the Nankai Trough based on the SPGA model

Atsushi Nozu[1*]

[1]Port and Airport Research Institute

The occurrence of the 2011 Tohoku earthquake (Mw9.0) along the Japan Trench motivated us to hypothesize an equally gigantic earthquake along the Nankai Trough, which is another plate boundary close to the coast of Japan. The evaluation of strong ground motions for such an earthquake should be based on a source model whose applicability for gigantic earthquakes has been demonstrated using existing strong motion records including those from the Tohoku earthquake.

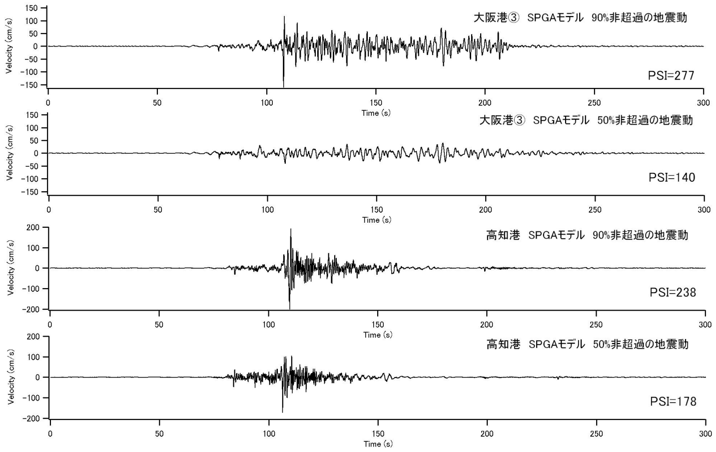
In this respect, the authors proposed a source model called the 'SPGA model', which can reproduce strong ground motions from gigantic earthquakes quite accurately including strong motion pulses observed during the Tohoku earthquake.

In this article, the SPGA model was applied to a scenario earthquake with Mw9.0 along the Nankai Trough. Because it is difficult to predict the locations of SPGAs, quite a large number of cases are considered with different distributions of the SPGAs and strong ground motions with a given percentile were calculated. Numerical elaborations were made to carry out this process efficiently so that it can be done on an ordinary desktop PC.

The result indicates that the ground motions are strongly dependent on the locations of the SPGAs. The ground motions with the 90th percentile can be much more intense than those conventionally assumed for the design of structures. The ground motions with the 50th percentile are close to conventionally assumed ground motions in terms of PSI values. The calculated ground motions are often characterized by a pulse-like waveform.

Acknowledgment: I would like to thank the National Institute for Earth Science and Disaster Prevention for K-NET and KiK-net data.

Keywords: Strong ground motion, Nankai Trough, Strong motion pulse generation area, the 2011 Tohoku earthquake



Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS35-14 Room:103 Time:May 23 16:15-16:30

Towards tsunami hazard assessment for Japan

Hiroyuki Fujiwara[1*], Hiromitsu Nakamura[1], Nobuyuki Morikawa[1], Shin Aoi[1], Shinichi Kawai[1], HIRATA, Kenji[1], OSADA, Masaki[1], Hisanori Matsuyama[2], Yoichi Murashima[3], Shinichi Akiyama[4]

[1]NIED, [2]OYO, [3]KKC, [4]CTC

We have started a research project in NIED for tsunami hazard assessment for the whole of Japan, based on the lessons learned from the Great Tohoku earthquake. In this project, we are planning to carry out probabilistic tsunami hazard assessment in which we consider all earthquakes that could be tsunami sources and also we will study detailed tsunami analysis of scenario type for specified earthquakes.

For probabilistic tsunami hazard assessment for the whole of Japan, we will make tsunami source model for all possible earthquakes based on the long-term evaluation of earthquakes by the Headquarters for Earthquake Research Promotion, taking into account of the various types of uncertainty. Based on the model, using probabilistic assessment methods, we evaluate the height of tsunami at the coast. In the calculation for the nationwide tsunami hazard assessment, the minimum mesh size for the land side is 50m and set larger mesh size as 150m, 450m, 1350m for the ocean side. We conducted test calculation of probabilistic tsunami hazard assessment for earthquakes in the Japan Trench. In addition, by limiting the area, we calculate tsunami hazard by using the fine mesh (10m as minimum mesh size). We propose a new method to express probabilistic tsunami hazard information in a form of chart like medical records. By indicating probability of tsunami height, inundation depth, and the arrival time, we will consider how representation can show the regional tsunami risk in the form of chart for tsunami hazard.

In the tsunami analysis of scenario type, we will evaluate the height of the tsunami, inundation area and the inundation depth, for specified earthquakes that are assumed in each region. By comparison with the previous record, we are planning to examine the validity of the calculation results and tsunami source parameters.

In order to implement the tsunami hazard assessment, we make terrain model for sea area and coastal terrain model needed to calculate the tsunami for the whole of Japan. Summarized the concept of source model for tsunami hazard assessment, we organize materials on various surveys used in modeling into database. To strengthen regional cooperation and improving the reliability of the hazard assessment, we will collect and organize information about the tsunami hazard maps of local governments and we will reflect them into the model for calculation.

Based on these efforts on tsunami hazard assessment, we will summarize typical tsunami hazard assessment methods. We will consider the utilization of the information on tsunami hazard.

This study has been prepared as contributing to the consideration by the Tsunami Evaluation Subcommittee of Headquarters for Earthquake Research Promotion of Japan.

Keywords: Tsunami, Hazard Assessment, Probability

SSS35-15 Room:103 Time:May 23 16:30-16:45

Tsunami simulation using fault model from strong motion records of the 2011 off the Pacific coast of Tohoku Earthquake

Shinichi Akiyama[1*], Kaoru Kawaji[1]

[1]ITOCHU Techno-Solutions Corporation

Many source models for the 2011 off the Pacific coast of Tohoku Earthquake are proposed from the inversion analyses of seismic observations or from those of tsunami observations. Most of these models show similar features, which large amount of slip is located at the shallower part of fault area near the Japan Trench. That indicates that seismic wave propagation and tsunami can be evaluated by the single source model.

We have been examining the possibility of the tsunami prediction, using the fault model estimated from seismic observation record. In the previous study, we have carried out the tsunami simulation for the 2011 off the Pacific coast of Tohoku Earthquake, using the displacement of oceanic movements calculated from the ground motion simulation due to the fault model based on the teleseismic body wave by Yoshida et al.(2011). Comparisons of synthetic waveform and observation of the GPS wave gauge showed that the tsunami simulation underestimates the maximum tsunami height in most observing stations. This was because the tsunami due to the large slip in the shallower part of the fault plane near the Japan trench was not calculated in the last simulation.

On the other hand, the fault model estimated from the regional strong motion record by Yoshida et al.(2011) has a large slip in the shallower part of the fault plane near the Japan trench. Therefore it is suggested that the maximum wave height of the tsunami which was not able to be reproduced in the last simulation can be evaluated by the tsunami simulation using this fault model. In this paper, the tsunami simulation using the fault model due to the regional strong motion data is performed. First, the large-scale ground motion simulation based on the voxel finite element method is performed for the whole eastern Japan. Next, the tsunami simulation is performed by the finite difference calculation based on the shallow water theory. The initial wave height for tsunami generation is estimated from the vertical displacement of ocean bottom due to the crustal movements, which is obtained from the ground motion simulation mentioned above.

Acknowledgement : We thank Yasuhiro Yoshida of Meteorological Research Institute for offering the fault model from the strong motion records.

Keywords: the 2011 off the Pacific coast of Tohoku Earthquake, tsunami, strong motion record, fault model, simulation

SSS35-16 Room:103 Time:May 23 16:45-17:00

Large-scale tsunami modeling in the Nankai trough implemented on the K computer

Toshitaka Baba[1*], Kazuto Ando[1], Morifumi Takaesu[1], Narumi Takahashi[1], Yoshiyuki Kaneda[1], Toshihiro Kato[2]

[1]Japan Agency for Marine-Earth Science and Technology, [2]NEC Corporation

The recent great tsunamis caused horrible wide-spread disasters along the coast. It reminds us the importance of high-speed and accurate tsunami inundation modeling which should be useful in residential evacuations, rescue operations, and following measurements. Therefore in this study, we implemented large-scale tsunami calculations looking enviously at a real-time tsunami predicting for a large area with high spatial resolution by using the K computer in Japan. We used our new parallelized tsunami code, JAGURS (Baba et al, 2013), which solves either the linear or nonlinear shallow water equations by a finite difference method with a variable nesting algorism. The three nesting grid layers were used in this study to efficiently increase spatial resolution in the target region. The dimension of the finest layer gridded by each 2/9 arcsec (about 5m) spacing is about 140 km by 100 km that includes Tosa Bay on the Pacific coast of Southwestern Japan, where the great subduction zone earthquake is anticipated to occur. In this case, the total number of the grids needed was going to be about 670 million. By a test run on the 5184 nodes of the K computer, it took 7.5 hours to calculate tsunami propagation of 5 hours in the Nankai trough with time step of 0.01 sec. But any performance tuning for the K computer was still not made on the present code. Especially reduction of communications between the nesting grids would be needed. We are going to continue to improve the code making for the best use of the K computer.

Keywords: Tsunami, Large-scale computation, Nankai Trough, K computer

SSS35-17 Room:103 Time:May 23 17:00-17:15

Integrated simulation of strong ground motion and tsunami for large earthquakes in Hyuga-nada, Japan

Toshihiro Kuramoto[1], Akira Fujioka[1*], Hiroshi Takenaka[1], Takeshi Nakamura[2], Taro Okamoto[3]

[1]Department of Earth and Planetary Sciences, Graduate School of Sciences, [2]Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University, [3]Earthquakes and Tsunami Research Project for Disaster Prevention, Japan Agency for Marine-Earth Scie, [4]Department of Earth and Planetary Sciences, Graduate School of Science and Engineering, Tokyo Instit

Hyuga-nada is located at the southern extension of the Nankai trough, Japan. In Hyuga-nada, the Philippine Sea Plate subducts northwest beneath the Eurasian Plate at a rate of about 40-70 mm/year. This plate motion causes earthquakes which generate strong ground motion and tsunami. In this study we perform integrated simulations of seismic-propagation and tsunami in Hyuga-nada region. We apply the scheme proposed by Takenaka et al. (2012, ACES) to Hyuga-nada area for calculating of seismic motion and near-field tsunami based on a three-dimensional earth model with a sea layer. This scheme can simultaneously model all of the seismic waves and static deformation in the solid earth and acoustic and tsunamis waves in sea from sub-oceanic earthquakes. We then simulate seismic wave propagation for a sub-oceanic earthquake, including both land and ocean-bottom topographies and a seawater layer with gravity. We use the structure data of Kishimoto (1999) for land and ocean-bottom topography and the Japan Integrated Velocity Structure Model (2012, Headquarters for Earthquake Research Promotion, Japan) for subsurface structure. In the presentation we show numerical simulations for some events such as the 1996 Oct. 19 Hyuga-nada earthquake (M6.9).

Keywords: Hyuga-nada, seismic wave, tsunami, numerical simulation, strong motion

SSS35-18 Room:103 Time:May 23 17:15-17:30

Real-time tsunami inundation forecast which works for a recurrence of 17 century great Hokkaido earthquake (M8.8)

Yuichiro Tanioka[1*], Aditya Gusman[1], Kei Ioki[1]

[1]Institute of Seismology and Volcanology, Hokkaido University

Along the Pacific coast of Hokkaido, great recent interplate earthquakes such as the 2003 Tokachi-oki earthquake, generated large tsunamis and caused large disasters along the coast historically. Also, paleotsunami studies revealed that much larger tsunamis attacked the Pacific coast than tsunamis from historical great earthquakes. The most recent tsunami of those great paleotsunamis occurred in 17 century, and many tsunami deposit data were available for this 17 century large tsunami. First, we estimate the fault model for the 17 century great earthquake which can explain the most of tsunami deposit data. The result indicates that the large slip, about 25m, along the plate interface near the trench is necessary in addition to the fault models found by the previous study (Satake et al., 2003). The seismic moment of this 17 century great earthquake is estimated to be 1.7×10^{22} Nm (Mw 8.8). For the 2011 Tohoku-oki great earthquake (Mw9.0), the largest slip of more than 40 m was also estimated at the plate interface near the Japan Trench in addition to the large slip at the deeper plate interface. This suggests that the 17 century great earthquake off Hokkaido had the same source process as the 2011 Tohoku great earthquake. If a great earthquake like the 17 century earthquake occurs off the Pacific coast of Hokkaido, the devastating disaster along the coast is expected. To minimize the tsunami disaster, the research on a development of the real-time forecast of a tsunami inundation area is necessary.

To estimate a tsunami inundation area, it is necessary to carry out a tsunami numerical simulation with a very fine grid system of less than 10 m. Because a computation time is much longer than the available time for a tsunami forecast, we do not have a time to compute the tsunami inundation area after a large earthquake occurs. In this study, we develop a real-time tsunami inundation forecast method using a database where many tsunami inundation areas previously computed using various fault models are saved.

After a great earthquake occurs, a fault model of the earthquake will be estimated from a magnitude and a hypocenter of the earthquake using a scaling relationship of earthquakes. The mechanism of the earthquake is assumed to be an interplate earthquake. From that fault model, a tsunami is computed using the linear long-wave equations. That tsunami simulation takes only 1-3 minutes using a typical PC, so it can be used for a tsunami forecast. Using that result, we develop a method to choose the best tsunami inundation area from the database.

In a database, tsunami inundation areas computed numerically using various fault models and tsunami waveforms at several locations near the inundation area at the ocean depth of about 50 m. The locations are chosen that tsunami propagation with a linear long-wave approximation is good enough for the first wave of tsunami. Those computed tsunami waveforms are used to compare the tsunami waveforms computed from the fault model of an actual earthquake using the linear long-wave equations we describe above. Therefore, the best tsunami inundation area will be chosen by comparison of tsunami waveforms in the database with the tsunami waveforms computed from the fault model of the earthquake.

This method is tested at Kushiro city in Hokkaido. The tsunami inundation areas in Kushiro city from various fault models are numerically computed and saved into a database. The great earthquake which is the same as the 17 century great earthquake occurs as an example. First, the tsunami inundation area in Kushiro city is computed from the source models estimated in this study as an answer. The tsunami waveforms computed using the linear long-wave equations are compared with the tsunami waveforms in the database, and the best inundation area are chosen to be a forecast inundation area at Kushiro. We found that the method worked well enough to forecast the tsunami inundation area at Kushiro.

Keywords: tsunami inundation forecast, 17 century Hokkaido earthquake, Tsunami numerical simulation

SSS35-19 Room:103 Time:May 23 17:30-17:45

Tsunami wave estimation using GPS-TEC back projection

Takeo Ito[1*]

[1]Nagoya Univ

1. Introduction

Large tsunami generates an acoustic wave and shakes the atmosphere layer around a focal region. The generated acoustic wave propagates to ionosphere layer which is located at about 300km hight and causes a ionospheric disturbance. So, a generated acoustic wave causes the density of total electron content (TEC) inside ionospheric layer to be change. The changing TEC inside ionospheric layer can be measured by dense GPS network, such as GEONET. TEC can be easily measured as the phase differences of the L band carrier waves in two frequencies from GPS satellites. A kind of TEC disturbance widely appear in relating with solar activities, acoustic wave, gravity wave and so on. For example, Heki (2006) estimates an explosion energy of the 2004 eruption of the Asama volcano from changing of TEC, which is measured by GPS observation.

We focus on a large tsunami such as the 2011 March 11 Tohoku-Oki earthquake (Mw 9.0) , which caused vast damages to the country. Large events beneath dense observation networks could bring breakthroughs to seismology and geodynamics. Tsunami wave due to the 2011 Tohoku-Oki earthquake generates acoustic wave which propagates to ionospheric layer. The Japanese dense network of GPS detected clear anomaly of ionospheric TEC due to Tsunami wave around the focal region. We assume that acoustic wave cause the ionospheric disturbance and estimate tsunami wave propagation using Back Projection (BP) method of ionospheric disturbance.

2. GPS-TEC data

The Japanese dense array of GPS recorded ionospheric disturbances as changes in TEC due to the 2011 Tohoku-Oki earthquake. In this study, we try to reveal the detail of generating tsunami propagation using changing TEC from GPS observation network. At first, we process GPS-TEC above focal region by 1 sec sampling of GEONET. We remove slant GPS-TEC effects using filter out second degrees polynomial fitting. After this, for noise reduction, we adapt a band pass filter from 5 sec to 300 sec. We try to process for all combination between GEONET sites and GPS satellites. The number of combination is over 10,000. In particular, GPS-TEC is measured over 1,000 points above the focal region.

3. GPS-TEC Back Projection

We assume tsunami wave due to the event cause the anomaly of GPS-TEC. The large tsunami waves generate acoustic waves above focal region. It is propagating to ionosphere as compressional wave. In order to estimate Tsunami wave propagation, we adapt the BP method to the observed anomaly of TEC time series. The BP method has the experience of seismic wave analysis (e.g., Ishii *et al.* (2005)). We make image of spatio-temporal source distribution of acoustics wave using the BP method based on acoustic wave velocity.

We try to adapt back projection (BP) method for GPS-TEC time series. The BP product shows the beam formed time history and location of coherent acoustic-wave energy generated by large tsunami observed at ionospheric layer regional arrays and across the GPS Network. BPs are performed by beam forming (stacking) energy to a flat grid around the source region with variable spatial resolution scaled by the magnitude of generating tsunami velocity for each second.

4. Results

In result, we can obtain the generating tsunami wave due to a large earthquake. The method is perfectly new and provide detail of tsunami propagating wave distribution from huge GPS-TEC data. We can obtain in-direct measurement Tsunami wave generation from ionospheric disturbances. So, this result will bring a revolution of tsunami study.

Keywords: GPS, TEC, Back Projection, Tsunami

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SSS35-P01 Room:Convention Hall Time:May 23 18:15-19:30

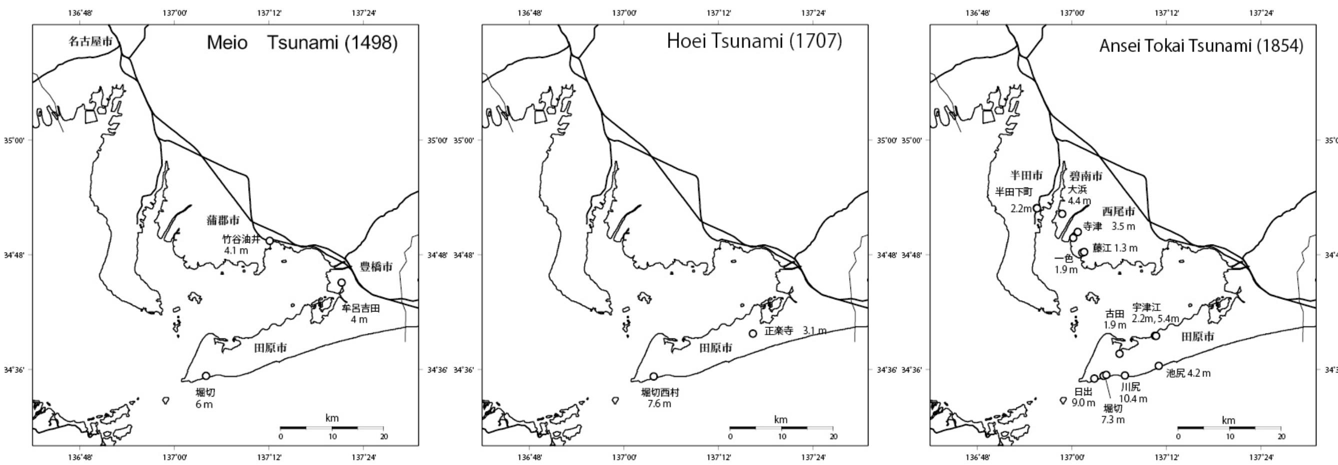
Tsunami heights distributions of the 1498 Meio, the 1707 Hoei, and the 1854 Ansei-Tokai earthquakes in Aichi prefecture

Yoshinobu Tsuji[1*], Takashi Yanuma[2], Takenori Hirahata[2], Fumihiko Imamura[3]

[1]Fukada Geolog. Inst., [2]PASCO, [3]IRIDeS

Aichi prefecture is situated in the central part of Tokai District, Central Japan, and was hit by the tsunamis accompanied with the series of the gigantic Tokai earthquakes, the 1498 Meio, the 1707 Hoei, and the 1854 Ansei Tokai earthquakes. But the tsunami heights of those gigantic Tokai earthquakes had not been discussed in past while that they had been discussed in detail by Hatori(1977, 1978) and Namegaya and Tsuji(2005). In the present study, we gathered the descriptions of those tsunamis in old documents data books published as ”Revised volumes of Collected Materials of Historical Earthquakes in Japan, vols.1, 3 additional, 5 additional vol.5-1, ERI, 1981, 1983,1987). We made field surveys at the points where there are descriptions on those tsunamis. Before the survey we checked the features of those villages on the map in the scale of 50,000 to one published in the end of 19-th centuries. We also checked historical chronologies of villages by ”Encyclopedia of place names in Aichi prefecture” published by Heibonsha Press. We visited the places of recorded points, and conducted survey of the heights and position by VRS-GPS. In the present study we did not estimate tsunami height only by descriptions on the damage. We assumed that the height of floor in a house is 70 centimeters above than ground level. Ws also assumed the thickness of water covering on the ground as 2 meters for the case that a group of houses were washed away in a village. Of course, actual tsunami heights was possible to exceeded two meters. Figure shows the distribution of the tsunami heights for the 1498 Meio, the 1707 Hoei, and the 1854 Ansei Tokai earthquakes in Aichi prefecture. The present authors wish to express their thanks to JNES for its financial support.

Keywords: the 1498 Meio Earthquake, the 1707 Hoei Earthquake, the 1854 Ansei Tokai Earthquake, Tsunami, Historical earthquakes



SSS35-P02 Room:Convention Hall Time:May 23 18:15-19:30

H/V spectral analysis based on high density micro-tremor observations in Kochi Plain

Yusuke Oishi[1*], Hirokazu Takahashi[1], Tadashi Yamashina[2], Atsuki Kubo[2]

[1]Faculty of Science, Kochi Univ, [2]Kochi Earthq. Obs., Fac. of Sci., Kochi Univ

Kochi Plain is located around source region of the great Nankai Earthquake. Strong ground motion is expected in this area, because soft subsoil is widely deposited in Kochi Plain. In this study, we investigate H/V spectra of micro-tremor in the Kochi Plain. Micro-tremor study with single station is cheaper, quick and easier way than sampling boring core. It is convenient to reveal horizontal variation of soil/basement structure. We append 320 measurements in addition to previous reported 380 measurements (JpGU 2012, SSS26-P12). In total 700 measurements are used to H/V spectral analysis. In perspective, dominant periods of H/V spectra around Urado-Bay region are longer than other regions. According to soil/basement model using boring data, the bedrock depth at this region is especially deep but boring which reaches the bedrock is limited. In contrast, H/V spectral analysis is useful to grasp the extent of region with deep soil/basement boundary. Dominant periods of H/V spectra around western part of Kochi Plain are relatively shorter than Urado regions. High density observations in this region show clear local variations. These are not reflected on current hazard maps or seismic intensity estimation maps. Using H/V spectral analysis based on high density micro-tremor observation, we are detecting patterns of soil/basement structure which has not be grasped using only boring core data.

We planned micro-tremor observation with 200m interval and also array observation to construct soil/basement structure model to improve estimation of strong ground motion.

Acknowledgement
We thank to Prof Tadashi Hara, Nobuaki Kitamura and NEWJEC Inc for providing their data.

Keywords: Soil/Basement Structure, H/V spectra, Strong Motion, Kochi Plain, Dominant period

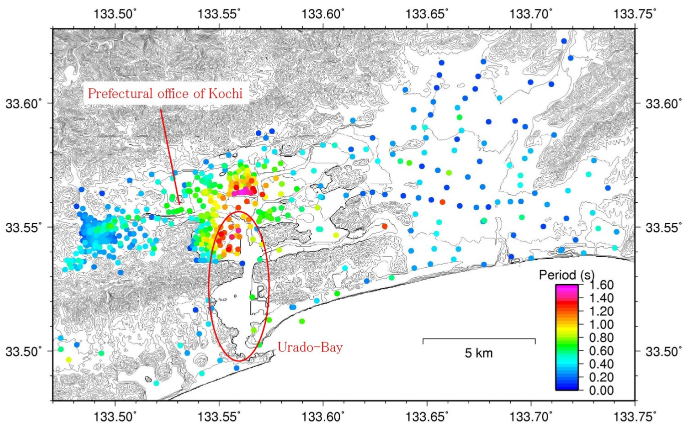


Figure 1 distribution map of H/V spectral analysis based on micro-tremor observations in Kochi Plain

SSS35-P03 Room:Convention Hall Time:May 23 18:15-19:30

Characterized source model for the 2011 Tohoku earthquake based on peak moment rate distribution

Kunikazu Yoshida[1*], Ken Miyakoshi[1]

[1]Geo-Research Institute

We proposed a characterized source model based on peak moment rate distribution of the 2011 Tohoku earthquake. The asperities estimated from the total slip distribution inverted from the long-period ground motion (e.g., Yoshida et al., 2011, EPS) do not coincide with the strong motion generation areas (SMGAs) estimated using the empirical Green's function method (e.g., Kurahashi and Irikura, 2011, EPS) for the M9 Tohoku earthquake. Yoshida et al. (2011, SSJ) proposed a characterizing procedure of the source model using peak moment rate distribution. We developed a characterized source model for the M9 Tohoku earthquake for simulating the long-period (a period of 10-100 s) strong-ground motion records.

We, firstly, characterized the source model from the total slip distribution following the procedure of Somerville et al. (1999). One asperity area is extracted on the shallow margin of the fault. We used a smoothed ramp function as a slip rate function. Pulse width of the smoothed ramp function is determined with 2 Mo/M, where Mo and M are an average moment and average maximum moment rate on the asperity and background, respectively. We determined the pulse width of 57.2 s and 39.8 s for the asperity and the background. The shot-period (about 20 seconds) components of the calculated velocity waveforms do not agree with the observed ones.

Secondly, we characterized the source model based on the peak moment rate distribution. The characterized procedure bases the peak moment rate distribution, instead of the total slip distribution. The other part of the procedure is same as the one of the slip-distribution based model. The 4 areas extracted based on the peak moment distribution (High moment/slip Rate Area, hereafter HRA) are identified. The largest HRA is similar to the asperity which is identified based on the total slip, but the other 3 HRAs are located on the deeper part of the fault. Slip rate functions of HRAs and background are determined by the same procedure for the slip distribution based model.

Assuming the circular rupture propagation (Vr=2.5km/s), we calculated velocity waveforms using the peak moment rate based source model (HRA model). However, the arrival times of the largest waves of the calculated waveforms do not agree with the ones of the observed records.

We made a complex rupture pattern for the HRA model. The rupture velocity inside each HRA is given to be 0.8Vs and the rupture velocity on the background is 2.5 km/s. The calculated waveforms using the HRA model with the complex rupture pattern agree with the observed ones. The short-period components of the calculated waves are emerged from the deeper and small HRAs.

Acknowledgements: We thank NIED and Hokkaido university for providing the data. This work is supported by JNES (Japan Nuclear Energy Safety Organization).

Keywords: characterized source model, peak moment rate, strong ground motion, megathrust earthquake

SSS35-P04 Room:Convention Hall Time:May 23 18:15-19:30

Constraining the extent of an earthquake source fault with seismic intensity distribution

Hisashi Nakahara[1]*, Katsuhisa KANDA[2]

[1]Graduate School of Science, Tohoku Univ., [2]Kobori Research Complex

The 2011 Tohoku-Oki earthquake has provided us with important lessons. One of them is that we should pay more attention to knowledge in the fields of paleoseismology in considering giant earthquakes. Concerning prediction of strong ground motion, finite fault models are usually considered. However, such finite fault models have been estimated mainly for recent earthquakes for which seismic, geodetic, and tsunami data are available. Studies to estimate finite fault models for historical earthquakes began recently [e.g. Kanda et al. (2003), Tokumitsu et al. (2006), and Sugawara and Uetake (2009)]. In this study, we try to image finite fault models from spatial distribution of seismic intensity using a backprojection-like method. Our final target is historical earthquakes. But in this study, we try to validate a method using two modern earthquakes: The 1944 Tonankai earthquake (M7.9) and the 1946 Nankai earthquake (M8.0).

An attenuation relation of seismic intensity on the Japan Meteorological Agency scale used in this study is the same as one used in 'the national seismic hazard maps for Japan'. Given the magnitude, depth, and fault type of an earthquake, the nearest distance to a finite source fault is estimated at a site from intensity there using the attenuation relation. The crossing points between the plate boundary and spheres with the nearest distances to the fault from the sites are candidate points of the fault edges. The intensity distributions for the two earthquakes estimated by Kanda et al. (2003) are used. Concerning the fault geometry, we follow the source models estimated by Ando (1975) mainly using geodetic data. Node points are set on the fault planes with a spacing of 1km x 1km. In using the attenuation relation, we set depths of the two earthquakes to be 20km. So far, Vs30 is assumed to be 600m/s without making correction of site conditions. For the two earthquakes, the number of data for intensity 6 is too small to image the extent of source faults. Data of intensity 4 cannot constrain the fault extent. Using data of intensity 5, the extent of source faults can be estimated. However, the shallow end and horizontal ends of the faults are not imaged, because data are limited on land. Only the deep end of the faults can be estimated, which are roughly consistent with the fault models of Ando (1975). However, estimation error in this study is probably at least 10km. This may suggest that we need to incorporate the site correction and more realistic shape of the plate boundary in the analysis.

In conclusion, we have tried to image the extent of finite source faults for the 1944 Tonankai and the 1946 Nankai earthquakes from the spatial distributions of seismic intensity data using a backprojection-like method. Data of intensity 5 can constrain the deep end of the source faults. But the shallow end and horizontal ends are not well constrained because data are limited on land. The deep end of a source fault is important for seismic hazard estimates. We plan to apply the method to historical earthquakes.

Keywords: Seismic intensity distribution, finite fault, historical earthquakes

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SSS35-P05 Room:Convention Hall Time:May 23 18:15-19:30

Evaluation of difference in tsunami response , among tsunami source models

Satoru Fujihara[1*], Takahiro Tamiya[1], Mariko Korenaga[1], Shinichi Akiyama[1], Haruo Kunishi[1]

[1]ITOCHU Techno-Solutions Corp

After the 2011 Tohoku-Oki earthquake (hereafter 3.11 earthquake) evaluating based on tsunami simulation approach becomes very important role for promoting tsunami disaster prevention measures against mega-thrust earthquakes. In considering tsunami disaster prevention measures based on the knowledge from tsunami simulation, it is important for us to carefully examine what kind of tsunami source model we use. In the current scheme of tsunami simulation, there exist several ways to set the tsunami-genic source model, such as (1) rather simplified model assuming an average slip for an entire fault zone, (2) static model assuming inhomogeneous slip distribution over finite fault zone, (3) another inhomogeneous slip model further assuming the effect of rupture propagation, and so on. Since each tsunami source model has each own feature, a fair amount of difference in tsunami behavior can be possibly expected.

Thus, in this report, we do tsunami simulation analysis using several tsunami source models and evaluate how different tsunami response could be in the tsunami runup process, among tsunami source models. Specifically in the present analysis, we do tsunami simulation of 3.11 earthquake around Soma Port in Fukushima Prefecture in Japan by using several tsunami source models ([1],[2], etc), and evaluate relative differences in things such as tsunami wave height, wave pressure, and so on. For evaluating tsunami wave pressure, we assume the method of Tanimoto et al.(1984)[4], which has been used in the past research of tsunami simulation of 3.11 earthquake around Soma Port [3]. As the result, we observed a fair amount of relative differences in maximum wave height and wave pressure for incoming tsunami onto inland region.

Basically, phenomena of tsunami runup are very complex and in this study we ended up evaluating the relative differences of things like wave pressure, based on the shallow water theory. For more details of tsunami runup, evaluation has to be done by three-dimensional method of tsunami simulation.

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Keywords: Tsunami simulation, The 2011 Tohoku-Oki earthquake, Tsunami wave force

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The uncertainties in the probabilistic tsunami hazard evaluation

Mariko Korenaga[1*], Yuta Abe[1], Norihiko Hashimoto[1], Shinichi Akiyama[1], Hiroyuki Fujiwara[2]

[1]ITOCHU Techno-Solutions Corporation, [2]NIED

In this study, we discuss the approach to several types of uncertainties in the probabilistic tsunami hazard for the whole of Japan.

We estimate peak of coastal tsunami heights by numerical simulations, and integrate for probabilistic model considering many kinds of uncertainties. In the numerical calculations for coastal tsunami heights, the initial sea surface displacements are set to be the same as vertical crustal deformations associated with earthquakes, and then a series of numerical simulations of tsunami propagation are carried out. The calculated peak tsunami height allows for a certain margin of uncertainties, in the value of the applied tsunami source model setting parameters, seafloor topography data, discrete topography of the grid-map and two-dimensional methodology of tsunami simulation scheme. Our goal is to treat these uncertainties during calculating hazard curve, so we quantitatively examine the probabilistic variability.

It is also essential to consider the variability associated with the uncertainty depend on an observation point and on tsunami source. In order to examine the uncertainty quantification, we need records of historical tsunami heights observed at same points by equivalent repeating earthquakes, but amount of high reliability observations is not enough.

In this study, we attempt to adopt the difference between the residual error from the numerical model and the observed data in the historical tsunamis, with concerning the ergodic hypothesis, as an acceptable spatial variability for analysis. Because of amount of observation data and its quality, we select 2011 off the pacific coast of Tohoku earthquake event, and decide the variability in ratio of historical data to computational value from estimated source model by previous study.

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