Tsunami alarm equipment (3)

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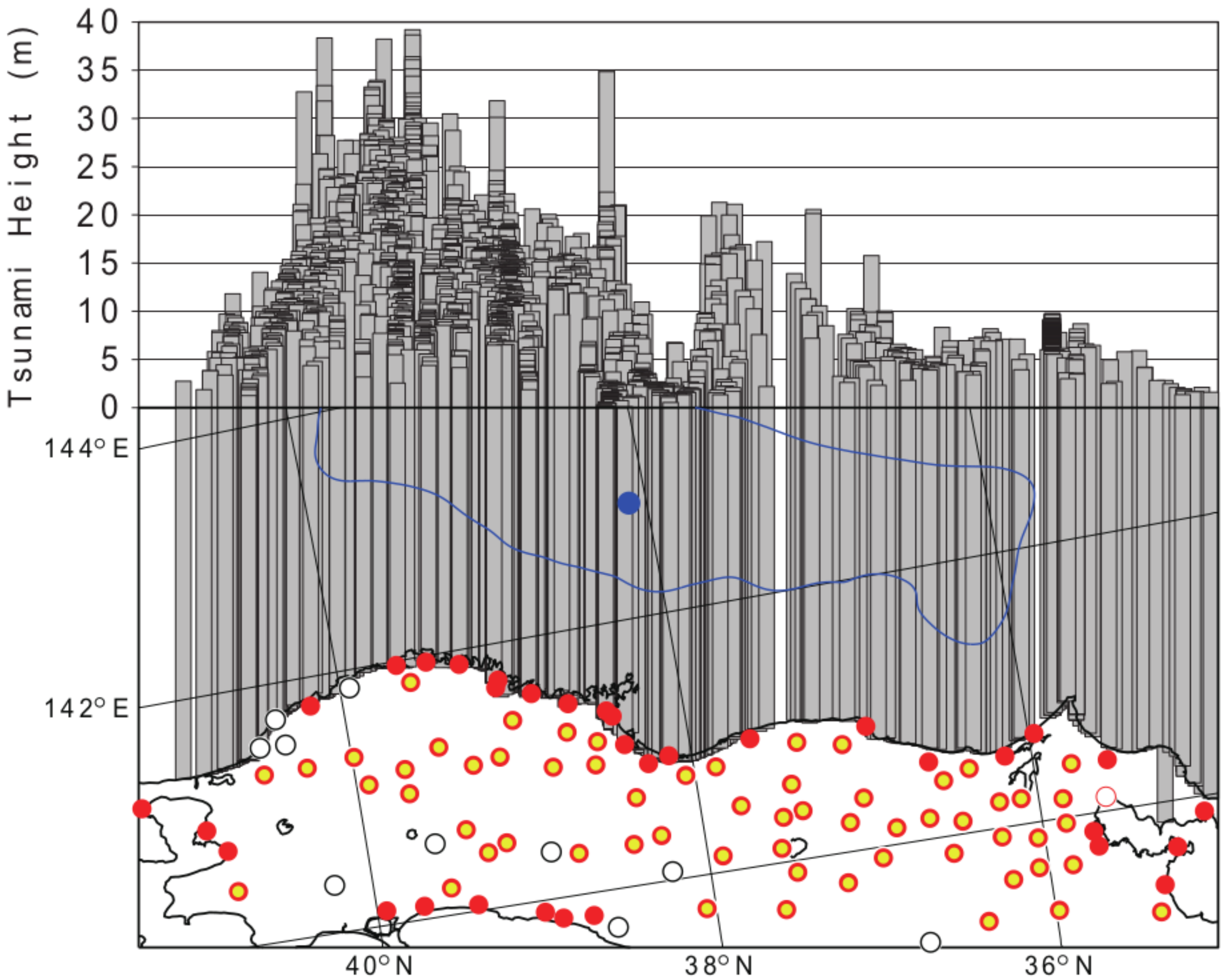
We investigated possibility of appliance to alarm tsunami hazard from single site ground motion observation. It is considered that one of the quickest ways of tsunami evacuation is transfer to higher place soon after a strong and long ground shaking. Strong ground motion means that the source area of the event would be close to the current location, and long ground shake or large displacement mean that the event magnitude would be large.
At the first, we limited epicentral distance by setting upper limit of the modified Mercalli seismic intensity of 5.5, which is obtained by converting peak ground velocity. The seismic intensity corresponds to epicentral distance of about 140 km for an earthquake of Mw 8.0. We tried to find a threshold instrumentally observable value which distinguishes earthquakes with tsunami potential from others. Thread score is used to obtain the optimal threshold value. It was found that a suitable value for single site tsunami alarm would be strong-motion duration of long-period peak displacement. Although two threshold magnitude of 7.8 and 8.5 were tried, clear difference was not recognized in the score.
Applying this method to recent major earthquakes, it was shown that this method is partly effective to inform possibility of disastrous tsunami. When the source area is away from the shoreline, such as northern area of the 2011 off the Pacific coast of Tohoku Earthquake, the observed values were lower than the threshold. We expect this method would work as complimentary alarm for evacuation from tsunami.

Keywords: tsunami alarm, instrumental seismic intensity, single station processing


Tsunami Height (m)
40
35
30
25
20
15
10
5
0
144° E
142° E
40° N
38° N
36° N

Was the submarine landslide which caused the 1998 Papua New Guinea tsunami detectable by a seismograph?

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The 1988 Papua New Guinea tsunami caused casualties over 2,200(Tappin 2008). The tsunami higher than 10 m followed an earthquakes of Mw 7.0. It is considered that the tsunami was caused by a submarine landslide because the tsunami was higher than that expected for an earthquake of magnitude 7, the tsunami generation was estimated about 10 minutes after the earthquake, and submarine topography which seemed to have been related to the landslide was identified (e.g., Tappin et al., 1999). Tsunami caused by an ordinary earthquake can be aware of before its arrival by seismic analysis. In the case of the 1988 Papua New Guinea tsunami, it was impossible to prepare for the tsunami only by the ordinary seismic analysis. Here we discuss possibility of detecting landslides with seismic method.
Watts et al. (2003) estimated the landslide which could caused the 1998 tsunami at the length of 4.5km, the width of 5km, and the thickness of 760m. The mass was considered to have slumped on a slope of 12 degree dip with characteristic time of 32 seconds. The force causing the landslide was gravity. The friction and drag of water decelerated the mass. It is considered that the mass was being held with the static friction, and it dropped to dynamic friction when the mass started to slide. The ground was considered to be subject to the force change between the static and dynamic frictions.
The force is estimated at
(ρ1-ρ2)Va,
where ρ1 is the density of the ground mass (2.15X10^3kg/m^3), ρ2 the density of the water (1.0X10^3kg/m^3), V volume of the mass (4,500mX5,000mX760m), a the initial acceleration (0.36m/s^2). It turn out to be 7X10^12N. The force by the collapse of Mt. Saint Helens in 1980 was estimated at 2.6X10^12N (Kanamori et al., 1984). The force by the drain-back at Mt. Mihara in Izu-Oshima in 1987 was estimated at 4X10^11N (Takeo, 1990). For the case of the Papua New Guinea event, similar order of force could act on the ground. If a single force of 7X10^12N and source time duration of 30 seconds was applied, it is expected that some seismic records would have been recognized at PMG station (900 km from the event) under a condition of no other seismic source. However the seismic wave by the earthquake was larger than the expected amplitude, and no clear long-period trace was recognized on the seismic record.

Keywords: tsunami by landslide, seismic record, 1998 Papua New Guinea tsunami

Landslide model of the 1741 Oshima-Oshima eruption

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The 1741 tsunami occurred near Oshima-Oshima in Hokkaido caused great damage along the coast of Japan Sea in Oshima and Tsugaru peninsula. Assuming that the tsunami was generated by flowing a landslide into the sea with a sector collapse in Oshima-Oshima, the landslide was simulated. Distribution of debris deposits, topography before the sector collapse, and landslide volume were re-calculated from a bathymetry survey data (Satake and Kato, 2001) in the north part of Oshima-Oshima. Based on these data, the landslide was simulated using the integrated model of landslide and tsunami (Yanagisawa et al., 2014). As a result, distribution of computed debris deposits agree relatively well with the distribution of debris deposits made out from bathymetry. However, the computed debris deposits spread to north part than debris deposits made out from bathymetry and not reach to the east and west part compared to debris deposits made out from bathymetry in detail. The thickness of computed debris deposits was thicker to the north part than debris deposits made out from bathymetry. Further, model parameters and topography before the sector collapse are needed to be improved for more realistic tsunami simulation.

Keywords: landslide, tsunami, Oshima-Oshima

Re-estimation of damages in the Miyako District Okinawa by 1771 Great Meiwa Tsunami

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Precise description of damages by devastating 1771 Great Meiwa Tsunami (Yaeyama Earthquake Tsunami) is recorded in “Kyuyo”, the chronicle of the Ryukyu Dynasty and “Otoiai-gaki”, local manuscript in Miyako district. Run-up heights at several villages in Miyako District recorded in this manuscript were compared with the result of the recent Tsunami Height Assessment in Okinawa Prefecture (released in 2015). Most of the recorded run-up heights were smaller than the recent assessment assumed by 8m slip of the three major faults along the southwestern Ryukyu Trench off Yaeyama and Miyako districts. The difference may cause the difference in slip rate along the faults and the slip rate might be smaller off Miyako than that off Yaeyama. Another possibility may be that a rupture along the fault plane was generated off Yaeyama and propagated towards Miyako where it terminated.

Keywords: Great Meiwa Tsunami, run-up height, Miyako District

Accurate measurement of the tsunami heights of the Kanpo Tsunami of 1741 caused by the volcanic eruption of Oshima-Ooshima Island on the coasts of Esashi and Matsumae districts, Hokkaido

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In the early morning of August 28th, 1741, Oshima-Ooshima volcanic island, off the coast of SW Hokkaido became active, and a huge tsunami was generated. The tsunami hit the coasts of Matsumae and Esashi districts, Hokkaido. Height distribution of this tsunami had been studied by Harori(1984), Imamura et al(1998), and Tsuji et al(2002). In the present study, tsunami height estimation was made by several newly developed ways. We checked the numbers of damaged houses, casualties, and wrecked ships for each coastal village. On the other hand we researced total numbers of houses and population for each coastal village. We calculated the percentage of damaged houses to total number, and of casualties to the population. We decided the point of ground height measurement with considering the percentage of damage. For the case of villages where almost all houses were swept away, we measure the ground height at the highest point of the residential area of the village. In each village on the coast of Matsumae and Esashi districts of Hokkaido, a shrine had been generally situated behind the highest point of the residential area of the village. Some villages has such historical record that "Whole the houses in this villages were entirely swept away, but only shrine was safe". For such villages, we measured the ground height between the house on the highest ground and the shrine.
Our field surveys were made during 14th to 16th December, 2015 on Hokkaido coast. Fig. 1 shows the result of tsunami height distribution. White circles on the coast show the measured points with high reliability , and black circles show that with less accuracy or reliability.
Acknowledgement: The present study was achieved as a part of the commissioned research named "Study on the historical tsunamis in Japan Sea (2015)" on disaster prevention for nuclear facilities proposed by the Nuclear Reglation Authority, Japan.

Keywords: tsunami caused by a volcanic eraption, accurate measurement of height of a tsunami, the tsunami generated by the 1741 Oshima-Ooshama volcanic eraption

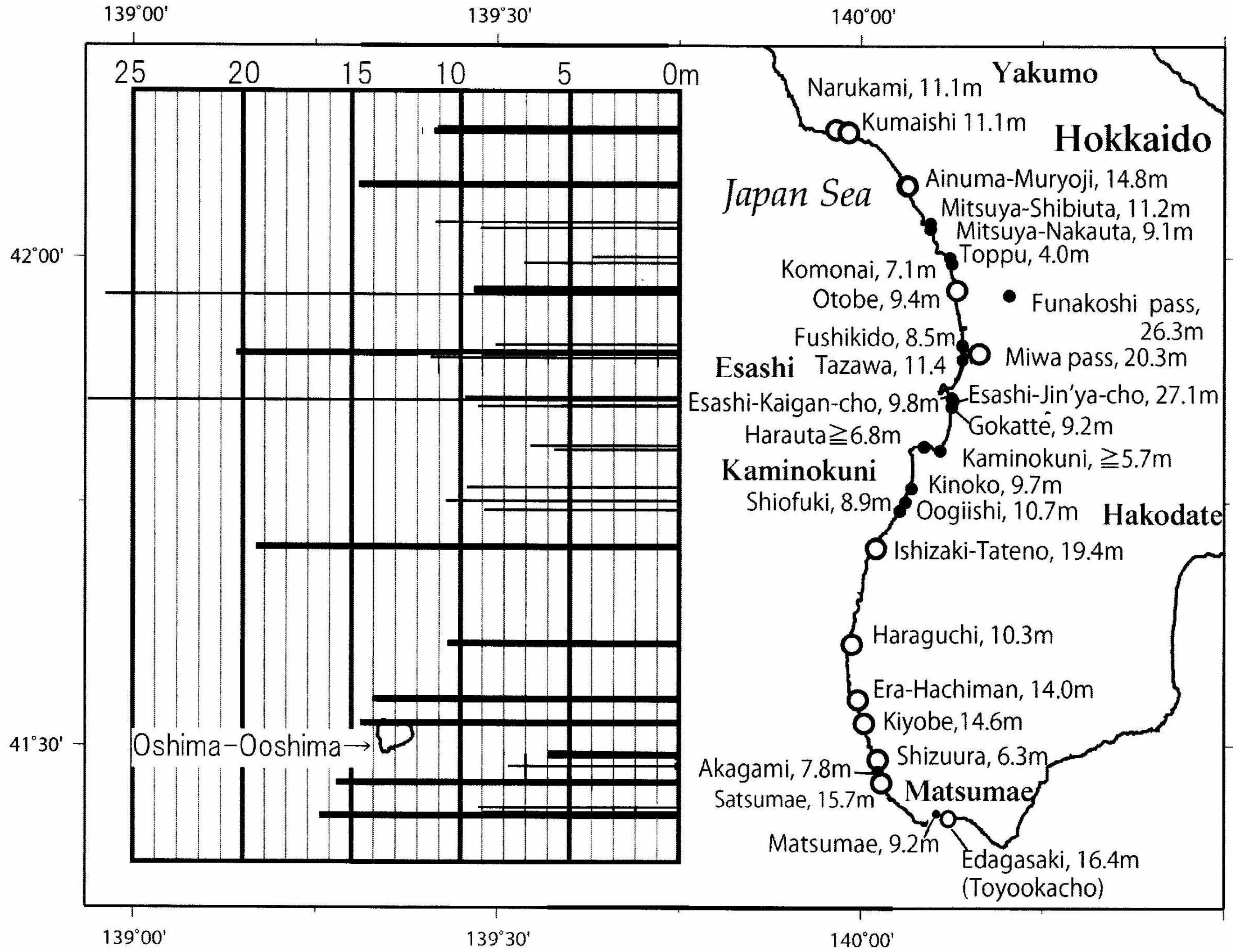

Fig. 1 Height Distribution of the tsunami caused by the volcanic eruption of Oshima-Ooshima in 1741.

Tsunami heights of historical tsunamis based on the “Japan Tsunami Trace database” and other tsunami trace data along the Pacific Coast of Iwate Prefecture

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Iwate Prefecture is advancing examination for future tsunami hazard based on scientific knowledge such as historical records and tsunami deposits. We referred to the “Japan Tsunami Trace database” and previous studies about tsunami heights and arranged them to compare with each other. First, we arranged tsunami heights of five major tsunamis which occurred after the modern times (2011 Tohoku-oki, 1896 Meiji Sanriku, 1933 Showa Sanriku, 1968 Tokachi-oki, 1960 Chile). Then we compared these major tsunamis with historical tsunamis that recorded damages along the Iwate coast.
According to comparison between major tsunamis, 2011 Tohoku-oki is highest in most part of the coast of Iwate Prefecture. However, 1896 Meiji Sanriku is almost the same as 2011 Tohoku-oki along the northern coast, and higher than 2011 Tohoku-oki at several sites.
1896 Meiji Sanriku and 1933 Showa Sanriku recorded large tsunami at the Yoshihama Bay, the Ryori Bay and the Hirota Point. These records might mean exaggeration or suggest conditions that amplified tsunami.
Although tsunami heights that documented in the “Yamana Reports” is almost matching with other records, unusual heights are shown at several sites. These records might include exaggeration based on folklore.
1968 Tokachi-oki and 1960 Chile tsunami are almost lower than 5m throughout the coast of Iwate Prefecture. These tsunamis show a trend which heights are a little higher at inside than the mouth of the bay.
1611 Keicho Oushu (Sanriku) tsunami recorded large tsunami at the Tanohata, Iwaizumi, Taro Coast and the Funakoshi, Yoshihama, Okirai Bay. Because large tsunami was recorded along southern coast of Iwate, the trend of tsunami heights distribution is similar to 2011 Tohoku-oki.
Although there are no records of definite damage by 869 Jogan tsunami in ancient documents along the Iwate coast, the distribution of tsunami deposits suggest that this tsunami might be large as 2011 Tohoku-oki.
Tsunami heights of 1856 Ansei, 1763 Hohreki, 1677 Enpoh tsunami which source located in northern part of Japan Trench show similar trend to 1968 Tokachi-oki. The effect of these tsunamis seems small along the Iwate coast. However, Tsunami height might be over 10m high on the coastal condition because 1677 Enpoh tsunami recorded 13m at Settai site. 1793 Kansei tsunami is also small relatively along the Iwate coast except for 9m at Ryoishi site.

Keywords: tsunami height, “Japan Tsunami Trace database”, historical tsunami, Jogan tsunami, Jogan tsunami, Keicho Oushu (Sanriku) tsunami, Iwate Prefecture

The effective PML absorbing boundary condition for linear long-wave and linear dispersive wave tsunami simulations

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Tsunami simulations in regional scale usually performed in the bounded domain with appropriate absorbing boundary condition surrounding the computational area, for avoiding fictitious reflections from the model boundary contaminates the simulated tsunami wavefield. For such purpose, the Sommerfeld or the sponge boundary conditions are widely used. In the present study, we report that the new Perfectly Matched Layer condition, originally proposed in electromagnetics and being used widely in earthquake seismology, applied to the tsunami numerical simulation problem gives significant improvement on the quality of the boundary condition.
The PML is a sort of the sponge boundary condition, which damps outgoing tsunami waves by absorbing layer placed surrounding the numerical model with a finite thickness. In this PML region, physical variables were decomposed into directions according to the directions of their derivatives. Then, only a wave propagating perpendicular to the model boundary is absorbed so as to avoid artificial reflection from the boundary. A wave propagating parallel to the boundary is unchanged. This decomposition is a key to provide high-quality on absorbing outgoing waves without fictitious reflection. The linear-long wave tsunami perfectly suite the PML condition. In the case of the linear dispersive tsunami, however, the decomposition is not straightforward because the momentum equation contains a term of higher-order derivatives along the mixed directions. Therefore, we introduced a weighting factor in the PML absorber region, so that the effect of tsunami dispersion is gradually decreased as the tsunami penetrates towards the absorber region. Under this assumption, tsunami equation approaches to the linear long-wave equation, which enable us to utilize the PML equation.
To examine the efficiency of the proposed PML absorbing boundary conditions for numerical simulation of a tsunami, we performed a finite difference simulation tests under smooth and realistic bathymetry models using the PML condition. For comparison, we also simulated the tsunami with the use of the Sommerfeld radiation condition and a traditional sponge condition. In addition, we performed a simulation with a larger, boundary-free model for the reference. In both cases, the tsunami simulation with PML boundary condition shows significantly improved results having little fictitious reflection from boundaries. The Sommerfeld radiation condition in particular shows degraded performance for strongly dispersive waves. This is due to the mismatch between the dispersed various tsunami velocity and long-wave tsunami velocity assumed in the condition. The sponge boundary shows moderate performance, however it tends to have strong fictitious reflection for near-parallel angle incidence to the boundary. The PML boundary was always superior, even for the approximate implementation used in the linear dispersive waves.
In the regional tsunami modeling, the absorbing boundary is usually set at offshore where the water is deep. Therefore, the fictitious reflection at the boundary quickly come back to the model area with increasing amplitude as the water gets shallower, and it easily contaminate the model area. Because the computational loads for linear long-wave tsunami simulation is not so heavy for recent computers, one might extend the model area to avoid such reflection. However, the same procedure for the linear dispersive waves is not realistic, because its computational cost is 50-100 times as high as that for the linear long wave tsunami. The proposed PML boundary condition significantly improve the quality of tsunami numerical modeling without increasing computational cost.

Keywords: Tsunami, Numerical simulation, Finite difference method, Absorbing boundary condition, PML

Simulation of the 2011 Tohoku earthquake including rupture process of seafloor motion and wave dispersion

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The 2011 Tohoku earthquake tsunami gave us a lot of physical data to study the generation process of mega-tsunami. After this event, tsunami scientists tried to make an initial tsunami source model by using tsunami waveform inversion analysis, so that some of models are used for the tsunami damage estimation in practice. Although a number of seismic source models also have been derived by seismologists by using geodetic data, teleseismic data and strong motion data, few studies used their models for the tsunami simulation. It is generally believed that fault models, which are determined by the tsunami inversion analysis and by the seismic inversion analysis, do not correspond with each other, however a series of phenomena such as earthquakes and tsunamis should be expressed as a single model. In this study, we conducted a numerical simulation of the 2011 Tohoku tsunami using the seismic source model, and discuss an importance of considering rupture processes of seafloor motion and wave dispersion effects of tsunami propagation.
In order to describe tsunami generation from detailed seafloor deformation, we adopted the seismic source model by Yagi and Fukahata (2011), which is estimated the rupture process from teleseismic P-wave data using the newly inverse method that takes into account the uncertainty of the Green’s function. This model provides rupture velocity and rise time to prescribe kinematic seafloor deformation with the planar fault model of Mansinha and Smylie (1971). Tsunami waves are computed using the dispersion potential model (Shigihara and Fujima, 2014), which is based on the staggered leap-frog implicit scheme; dispersive terms in the equation of motion is solved separately. The grid nesting method that we newly developed for the dispersion potential model are used for the bathymetry dataset with three levels of grid resolution (1350m, 450m and 150 m). The computed results were compared to the time history of the sea surface elevation observed at GPS buoys where are located along off the Sanriku coast. Considering the rupture velocity and the rise time makes the tsunami generation process slowly, and contributes the reproducibility of overall wave profiles. In addition, the wave dispersion effects on decrease of the leading wave height. The computed results agree well with observation, we found that both of the physical processes, that is the rupture process of the seafloor and the dispersion effect, must be considered if we want to simulate tsunami propagation using the seismic source model precisely.

Keywords: 2011 Tohoku Tsunami, tsunami simulation

Database construction of Tsunami inundation zone for large subduction-zone earthquakes: A case of Ishinomaki City

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Real-time prediction of Tsunami in a coastal zone (Tsushima et al., 2009) is quite effective for an early warning, in terms of lead time to be evacuated from the coastal zone and to understand the tsunami water level; however, this information is not accessible to the citizens and various companies. To issue the better Tsunami early warning, Tsunami inundation zones should be visualized by database of Tsunami inundation zones for large subduction-zone earthquakes (Honma and Katada, 2009), in which Tsunami inundation zones are related to tsunami water levels in the coastal zones. In this report, for an example of Ishinomaki City, Miyagi Pref., we constructed database of Tsunami inundation zone for large subduction-zone earthquakes along Japan Trench. We simulated Tsunami inundation in Ishinomaki City for 27 models of scenario Tsunami sources (the Headquarters for Earthquake Research Promotion, 2011), which set on large subduction-zone earthquakes (M8-9) in Tohoku-Oki. In the simulation, we applied the non-linear long-wave theory, with a grid size of 1215m / time interval 0.9s in the sea and a grid size of 15m / time interval 0.1s in the land. We applied crustal deformations after Okada (1992) to initial water levels, in the boundary conditions of the perfect transmission in the sea and runup in the land (Kotani, 1998). In the future, we will investigate real-time prediction of Tsunami inundation zone by the matching method for the database of Tsunami inundation zones and tsunami water levels in the coastal zones.

Keywords: Tsunami inundation zone, Database, Ishinomaki City

A prototype of database-driven system for tsunami inundation prediction using the JMA’s disaster information XML

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The Nankai earthquakes are anticipated to occur accompanied by large tsunamis. Emergency disaster operations should be started rapidly and properly to save lives after the great tsunami disasters happen. In order to enhance the emergency disaster operation, we need to provide a possible tsunami inundation area as soon as possible. Although a site survey will be conducted after a half day or a day by using a helicopter for example, numerical tsunami predictions using the real-time seismic and tsunami observation are solely available until the first 12 hours to draw a big picture of the disaster. This study developed a prototype predicting tsunami inundation to the coastal area in Tokushima prefecture. The basic algorithm of prototype is similar with that of the national tsunami early warning system in Japan that selects an appropriate earthquake scenario from pre-computed tsunami database based on the epicentral location and magnitude. A difference between the JMA’s system and this study can be seen in prediction target. They predict tsunami height at the coast line, but our system will predict tsunami inundation on land. We applied an open source platform, JoruriDms, to carry out the prototype. JoruriDms is a disaster management system equipped with GIS and various functions to support operations of the local government during disaster, which has been already used in the Tokushima prefecture. We defined about 220 earthquake scenarios possibly occurred in the Nankai subduction zone with a range of magnitude from 6.5 to 9.0. We here assumed heterogeneous slips on the fault planes. We repeatedly calculated tsunamis by changing the earthquake scenarios to evaluate tsunami inundation on land with spatial resolution of 5 m interval. All data were stored in a tsunami database. A logic tree was constructed to select only one scenario from the tsunami database based on the epicentral location and magnitude provided by the JMA’s disaster information XML. However, this algorithm doesn’t take into account earthquake rupture extent. It is also not good at tsunami earthquake which generates a large tsunami with weak seismic shaking. We accordingly added a function to upgrade (re-select) scenario based on tsunami height observations off shore and at the coast, which are provided by follow-up information of the JMA’s XML. We will also discuss further plans in the presentation to improve the prediction accuracy by increasing number of the earthquake scenarios and adopting real-time data provided by the ocean bottom pressure array (DONET) in the Nankai trough.

Keywords: Tsunami, Early prediction

Feature extraction from result of tsunami simulation by applying image analysis

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In this report, some interpretation methods of tsunami height distribution obtained by tsunami propagation simulation are tested. A wave crest, which is a typical feature of tsunami height distribution, is equivalent to a ridge in landform, so the methods used in landform analysis or image analysis are expected to be utilized to extract wave crest. In the case that Laplacian operator is applied, extracted region is broad in rise while disconnect in col, which is depend on selection of threshold. Application of median filter extracts wave crest successfully, including secondary wave crest formed by refraction effect. However, grids on which tsunami heights aren't local maxima are also extracted, so it needs to examine other type of filters.

Validation for tsunami source model of large earthquakes occurred in the Sea of Japan

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For the 1964 off Oga Peninsula (Mjma 6.9), 1971 West off Sakhalin (Mjma 6.9), 1983 West off Aomori (Mjma 7.1) earthquakes occurred in the Sea of Japan, tsunami waveforms are computed and compared with the recorded ones on tide gauges for the heterogeneous slip models obtained by the teleseismic waveform inversion and tsunami source models compiled by MLIT (Ministry of Land, Infrastructure, Transport and Tourism), CAO (Cabinet Office), and MEXT (Ministry of Education, Culture, Sports, Science and Technology) (hereinafter referred to as "MLIT model") (Murotani et al., 2015, JpGU; 2015, SSJ). As the results, the calculated tsunami waveforms were almost the same whether the dispersion term is included or not in the simulation, and whether the slip on faults is heterogeneous or uniform. In this study, we quantitatively compare the observed tsunami waveforms with the calculated tsunami waveforms to examine the validity of those fault models. It is difficult to compare the entire waveforms of M7 class tsunami, because the later part of waveforms may have an influence due to a bay or a shelf where tide gauge stations locate. In this study, we used factors K and k by Aida (1978, JPE). K is the geometrical mean value of K_i, where K_i is the ratio of the observed and the calculated amplitudes for the first wave and the second one of *i* th stations, and log k is the logarithmic standard deviation of K_i.
For the 1964 earthquake, we estimated K and k for six fault models which are the teleseismic waveform inversion model and some modified MLIT models, etc. k was the smallest (1.65) for a rectangular fault with uniform slip of 0.4 m, that is larger than the average slip 0.2 m of the heterogeneous slip distribution (fault size: 50 km x 40 km, M_0: 1.5 x 10^{19} Nm, maximum slip: 1.4 m) obtained by the teleseismic waveform inversion. This uniform slip 0.4 m best reproduced the amplitudes of the observations (K = 1.11). For the 1971 earthquake, we estimated K and k for five fault models which are the teleseismic waveform inversion model and modified uniform slip models. k was relatively small (2.42) for both the first and the second waves from the heterogeneous slip distribution (fault size: 50 km x 30 km, M_0: 1.3 x 10^{19} Nm, maximum slip: 1.2 m, average slip: 0.2 m) obtained by the teleseismic waveform inversion. However, the amplitudes of the calculated waveforms was so small (K = 2.41). The amplitudes of the observations were reproduced (K = 1.13) when we assumed the rectangular fault with uniform slip 0.5m, although k was a little larger (2.80). If only the first wave is used, k was the smallest (2.01) from two rectangular faults (fault size: 30 km x20 km and 30 km x20 km) with uniform slip 0.2 m and 1.5 m, respectively. The strike 21° of this model was changed from the strike 329° obtained by the teleseismic waveform inversion. However, k values of this earthquake are still large, hence further examination is necessary. For the 1983 earthquake, we estimated K and k for six fault models which are the teleseismic waveform inversion model and some modified MLIT models, etc. k was the smallest (1.64) from the heterogeneous slip distribution (fault size: 50 km x 30 km, M_0: 3.1 x 10^{19} Nm, maximum slip: 2.2 m, average slip: 0.5 m) obtained by the teleseismic waveform inversion. This model best reproduced the amplitudes of the observations (K = 1.33) as well.

Keywords: eastern margin of the Sea of Japan, tsunami waveform analysis, fault parameters

Tsunami simulations toward probabilistic tsunami hazard assessment in the Nankai Trough

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NIED began a research project regarding probabilistic tsunami hazard assessment (PTHA) for Japan since 2012 (Fujiwara et al., 2013, JpGU). Hirata et al. (2014, JpGU) reported the concept of this study that a nation-wide PTHA is to obtained by aggregating evaluations performed for each region-wide PTHA such as shorelines along the Nankai Trough, the Japan Trench, etc. A region-wide PTHA is to analyze coastal hazard caused by tsunami wave heights estimated with a numerical simulation. Here, we show preliminary datasets of coastal tsunami wave heights in the shorelines between Kagoshima and Ibaraki prefectures computed by thousands of fault models on assumption of possible scenarios for Nankai Trough earthquakes.
We focus on Nankai Trough earthquakes which there are a concern that tsunami may arrive at coastal regions in future. Our research target includes not only the subduction earthquakes that are mainly considered by the possible tsunami-genic earthquake derived from a seismic slip on a plate boundary in subduction zone but also unspecified fault sources such as small and medium scale earthquakes.Toyama et al. (2015, JpGU) and Hirata et al. (2015, SSJ Fall Meeting) introduced how to build up a set of characterized earthquake fault models (CEFMs) on hypothesized earthquakes along the Nankai Trough, referring to the “Long-term Evaluation of earthquakes in the Nankai Trough region (2nd edition)” by the Headquarters for Earthquake Research Promotion (HERP, 2013), where we constructed a set of the 1442 simplified fault models in the 15 types of source regions described in the long-term evaluation, i.e. 1) the 24 basic fault models, in which we put a large slip area (LSA) on the basis of the configuration of the previous studies for the historical large earthquakes along the Nankai Trough, 2) the 1411 extended fault models, in which we put LSAs for variety of fault models, and 3) the 7 recurrence fault models, in which we put the source area corresponding to the historical tsunami-genic earthquakes evaluated by HERP. Additionally, a set of the other 2455 extended fault models in the other 70 types of source regions are newly constructed in this study. Then, the total number of the CEFMs reaches a little less than 4000.
With the around 4000 fault modes, initial wave heights are calculated from surface deformation via Okada’s equation (Okada, 1992). A tsunami run-up simulation estimates tsunami wave heights along pacific coast from Kagosima to Ibaraki prefectures, solved by the non-linear shallow-water equation using a leap-frog scheme. These simulations are configured by a nested grid system consisting of four sub-regions from outer 1350 m to inner 50 m in a horizontal, landward inundation keeping, and transparent at the seaward edges.
The preliminary datasets of coastal tsunami wave heights contributes to implementing uncertainty into coastal probabilistic tsunami hazard (Abe et al., 2015, JpGU) and to constructing a database.
This study was done as a part of the research project on probabilistic tsunami hazard assessment (PTHA) for Japan area by NIED.

Keywords: Probabilistic tsunami hazard assessment (PTHA), Tsunami simulation, the Nankai Trough, Database

Probabilistic Tsunami Hazard Assessment along the Nankai Trough considering the diversity of earthquake fault models

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We have conducted a probabilistic tsunami hazard assessment along the Nankai trough on the baseis of The Earthquake Research Committee(ERC)/HERP, Government of Japan (2013). From the experience of 2011 Tohoku earthquake, ERC(2013) revised their long-term evaluation of the forthcoming large earthquake along the Nankai Trough from specifying earthquake sources and magnitudes to considering the diversity of earthquake source. ERC(2013) exemplified 15 hypothetical source areas which were thought as source areas of historical earthquakes. We constructed characterized earthquake fault models on each of the hypothetical source areas (Toyama et al., 2015) and calculated tsunami hazard curves at every evaluation points on coasts (Hirata et al., 2015; Korenaga et al., 2015).

In this study, we extend the hypothetical source areas from those exemplified by ERC(2013) to every possible source areas including those where eathquake occurrence yet to be identified and update a probabilistic tsunami hazard assessment along the Nankai trough. The total number of the hypothetical source areas is 85 and the number of the characterized earthquake fault models is 3928. We set probabilistic weights for each characterized earthquake fault models as follows:

i) For the 15 hypothetical source areas exemplified by ERC(2013), weights are calculated by following a probability re-distribution concept (ERC,2014).

ii) For the other hypothetical source areas larger than 3 segments, we classify them 15 groups which are recognized as parts of hypothetical source areas exemplified by ERC(2013), and divide the weights.

iii) For the hypothetical source areas smaller than 2 segments, we assume that their occurrence obeys a Gutenberg–Richter model calculated by the past seismic activity around the Nankai trough.

Keywords: tsunami hazard assessment, probability, Nankai trough, long-term evaluation, tsunami simulation