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

HDS27-P01 Room:Poster Time:May 1 18:15-19:30

Large tsunami remote observations from high altitude using the induced magnetic field of tsunami.

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On The 2011 off the Pacific coast of Tohoku Earthquake, massive tsunamis more than 10m attacked it in the wide range of Ibaraki from Aomori coast area. The tsunami warnings were not only sufficient but also no observation result of the tsunami, it was a big problem. The other side, at the Chichijima geomagnetic observation point had observed the tsunami induced magnetic field

As a result of example analysis for a past tsunami on Chichijima islands, the signal of the induced magnetic field was able to detect almost more than 1m tsunamis. The observation of the tsunami by the tsunami induced field has a weak point that sensitivity and a point of S/N ratio, but has a characteristic of the remote observation unlike the observation by tide gauges. If a geomagnetism sensor was installed in the hill of the Sanriku coast as a huge tsunami meter, they endured a massive tsunami and might continue observation without being destroyed.

We introduce the wave pattern of the prospective induced field of the tsunami and some character, if a sort of electromagnetic huge tsunami meter had been installed in the Sanriku coast.

Keywords: tsunami, Huge tsunami meter, induced magnetic effect

HDS27-P02 Room:Poster Time:May 1 18:15-19:30

Tsunami spectral analysis in and around Tokyo Bay

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Coastal areas in the Kanto region have been damaged by large tsunamis in the past. The reported tsunami heights from the 1923 M7.9 Kanto earthquake show a great difference between in and around Tokyo Bay. Attenuation of tsunami heights was observed at the mouth of the bay. For example, tsunami heights were less than 1.0 m inside the bay at Shinagawa, Funabashi, and Chiba, although they were 3.0-10.0 m outside the bay (Hatori et al., 1973, ERI special publication).

On the other hand, the tsunams from the 2011 Mw 9.0 Tohoku earthquake did not experience such attenuation. For example, tsunami heights were 1.46 and 2.84 m inside the bay at Tokyo and Funabashi respectively, although they were 1.45 and 1.60 m outside the bay at Tateyama and Kyonan (Sasaki et al., 2012, CEJ).

It is important to know why this difference occurs, when estimating tsunami damage to the metropolitan area for future earthquakes. Therefore we conducted spectral analysis of tsunami waveform obtained by numerical simulations, and found that the dominant wave period in the bay is different for each earthquake. It is around 100 min for the Kanto earthquake tsunami and around 70 min for the Tohoku one. We inferred that the 100 min period may result from the normal mode of Tokyo bay (Aida, 1996, Zisin) and the 70 min period from the normal mode of Sagami Bay (Imai et al., 2011, SSJ meeting). In future, we will examine the relation between these different periods and tsunami behaviors.

Keywords: Tsunami, Spectral analysis, Tokyo Bay, 1923 Kanto earthquake, 2011 Tohoku earthquake

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HDS27-P03 Room:Poster Time:May 1 18:15-19:30

Wave period dependence of the tsunami energy decay based on observation: In the case of the 2011 Tohoku-oki Earthquake

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1. Introduction

2011 Tohoku-oki Earthquake caused serious damage. In the case of such a giant earthquake, transportation network suffer serious damage. Therefore ensuring sea route safety as the relief course is important for smooth relief and restoration activity. It is important that realize the decay process of tsunami to early ensure the security of the sea route. On the other hand, there is no clear and scientific standard to judge tsunami convergence (Hayashi et al., 2010).

In this study, we use the 2011 Tohoku-oki Earthquake tsunami wave form and show the characteristic of the tsunami decay process by the connection with time of the moving root mean square amplitude maximum onset and tsunami arrival time. And we paid attention to period, intended to clarify the characteristic of each decrement process.

2. Analysis

We targeted for analysis 20 points chose from observed tsunami wave form in the 2011 Tohoku-oki Earthquake that located in the Japanese Islands Pacific on shore and off shore station (observed by Japan Meteorological Agency, NOWPHAS, Geospatial Information Authority of Japan).

It is obvious that long sampling intervals can lead to a marked distortion of the wave properties (Rabinovich et al., 2011). We unified the sampling intervals for 30 sec and High-frequency filtering was used to remove sea level variations associated with synoptic atmospheric activity. We used the maximum of the moving root mean square amplitude to normalize the observed wave because of tsunami amplitude different from every observation point. After the Normalized process we analyzed that wave form.

Because the tsunami includes wave of various periods, and suggested decay process is different every period (Rabinovich et al., 2013). So we used band-pass 2-16 min, 16-32 min, 32-64 min, and 64-128 min filter to divide tsunami every periods. I calculated the moving root mean square amplitude and we analyzed it with a method of Hayashi et al. (2010) to define a decay coefficient.

In this study, t is the elapsed time from shock, M(t) is moving root mean square amplitude at t, Mmax is maximum of the M(t), Tm is time of onset Mmax, Tt is time of the first wave′s maximum observed, TL is differences between Tm and Tt, k is proportional constant every observation point, e is Napier's constant, τ is decay time. τ mean time required for the average amplitude being decay to 1/e .

As a result of analyzed, the tsunami decrement process of each observation point is characterized by the longer period wave that attenuate later and shorter period wave that maximum wave late for arrival.

3. Conclusion

In this study, we used the tsunami wave pattern at the 2011 Tohoku-oki Earthquake and analyzed it. I discussion a factor to characterize a decay process of the tsunami energy, and get the following result.

(1)Regardless of on shore or off shore, equilateral correlation has τ and Tt, and on shore points tends to get longer than τ.

(2)For a wider tendency, tsunamis indicates that shorter period waves attenuate much faster than longer period waves in a short period.

(3)Some observation point have a long TL about less than 32 min period.

Acknowledgments

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And I gratefully acknowledge the following organizations for providing with records for the 2011 tsunami: observed by Japan Meteorological Agency, NOWPHAS, Geospatial Information Authority of Japan

Keywords: tsunami, decay, decay time, period

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Oscillations starting immediately after the 2011 Tohoku earthquake in Japan Sea

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The tsunamis from the March 11, 2011 Tohoku earthquake were recorded in the Japan Sea. At some tide gauge stations along the Japan Sea coast of Honshu and the Russian coast, sea surface disturbances were observed immediately after the earthquake, followed by tsunami propagated through the Tsugaru Strait between Honshu and Hokkaido. Using tsunami numerical computations from seafloor displacements including the effect of the horizontal displacement and seafloor slope, the oscillations starting immediately after the origin time were reproduced. We interpret that these tsunami forerunners were generated from horizontal motion of seafloor slopes in the Japan Sea.

The tsunami forerunners were particularly remarkable at Awashima (JCG), Sado, Noto Toyama and Fukaura (JMA) tide gauge stations along the Japan Sea coast of Honshu and at Rudnaya Pristan, Preobrazhenie, and Nakhodka stations along the Russian coast of Primorye (Shevchenko et al., 2013: Pageoph). The 2011 tsunami originated in the Pacific Ocean would pass the Tsugaru Strait 1.5 hours after the earthquake. It indicates that these forerunners were different from the tsunami originated in the Pacific Ocean.

We made the tsunami numerical computation to reproduce these forerunners from seafloor displacements in the Pacific Ocean and Japan Sea. We used the source model of Satake et al. (2013, BSSA). According to Tanioka and Satake (1996, GRL), if the ocean bottom contains steep slopes or steps, the effect of the horizontal displacement of ocean bottom cannot be neglected. Computation including this effect showed the oscillations starting immediately after the origin time. However, the short-period components about a few minutes are not well reproduced. Use of finer bathymetry grid than we used (30' and 5') may better reproduce the short-period components of the Japanese tide gauge stations. Seismograms at nearby stations suggest that some of the short-period components may be the seismic ground motion. When we applied low-pass filter to the observed waveforms, the agreement between the observed and synthetic waveforms on tide gauges became better.

Because the Russian stations are about 500 km away from the source area, we also computed the synthetic tsunami waveforms from seafloor displacements computed on the spherical Earth model (Sun et al., 2009: Geophys. J. Int.). However, the computed waveforms from the spherical models are not very different from those computed on Cartesian coordinate system. It is necessary to compute the tsunami waveforms using the finer grid including the shape of the bay.

Keywords: the 2011 Tohoku earthquake, the 2011 Tohoku tsunami, Japan Sea, seafloor displacement

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The 24 September 2013 tsunami in the Makran region, northwestern Indian Ocean

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Tsunami waves were observed in the northwestern Indian Ocean following the Mw 7.7 Pakistan inland earthquake on 24 September 2013. We analyze eleven tide gauge records as well as one DART record of this tsunami and perform numerical modeling of tsunami. The tsunami registered a maximum wave height of 109 cm in Qurayat tide gauge station (Oman). Spectral analysis showed that the most governing period of the tsunami waves was around 12 min though wavelet analysis showed that parts of the tsunami energy were partitioned into other period bands of 7 and 16 min. Distribution of aftershocks in the region showed that all of them were located inland indicating that the tsunami was generated by submarine geological phenomena triggered by the earthquake. Tsunami backward ray tracing showed that the tsunami source was possibly located at offshore Jiwani (Pakistan) and the tsunami was most likely generated immediately after the main shock. Tsunami modeling assuming a pile-up structure at the location of the new island was not successful in reproducing the observed sea level records. A landslide source with a length of about 15-20 km, a thickness of 100-150 m located at 61.72^{o}E and 24.60^{o}N seems capable of fairly reproducing the observed sea level records. This event was the second tsunami recorded in the Makran region since 1945, and may be evidence for hazards from landslide-generated waves following seismic activities.

Keywords: Northwestern Indian Ocean, Tsunami, Makran subduction zone, Landslide, Spectral analysis, Numerical modeling

HDS27-P06 Room:Poster Time:May 1 18:15-19:30

Pre-computed Tsunami Database with Additional Slip Near to the Trench for Tsunami Early Warning in Southern Java

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We build tsunami database based on simple fault model scenarios for the Java trench subduction zone. We have 480 points along the subduction zone with distance between each other of 20 arc-min. This points are used as the center of simple fault model scenarios. Each point is the center of several fault models with different moment magnitudes.We used a magnitude to fault length and width scaling relationship for the fault model scenario. The moment magnitudes for the fault model scenarios are from Mw 6.3 to Mw 9.0 with interval of 0.3. The fault depth parameter is also a variable for the fault model scenario. We used depth between 10 km to 60 km with interval of 10 km.

From each fault model scenario we simulate tsunami propagation by solving the linear shallow water equations. We used bathymetry data based on Indonesian navy chart and GEBCO bathymetric dataset. The grid size for the tsunami simulation is 1 arc-min. The pre-computed maximum tsunami heights and tsunami arrival time at every point along the coast are stored in a database.

If a real earthquake occur at any location in the forecasting domain then the pre-computed tsunami heights from 16 scenarios are retrieved from the database. Theses 16 scenarios are those that are surrounding the actual hypocenter and each of the scenario has the closest higher or closest lower magnitude to the actual one. Then the tsunami heights from these scenarios are used in interpolation methods to get the tsunami height forecast. The tsunami heights from two scenarios with a same hypocenter and different moment magnitudes are interpolated by logarithmic interpolation. Then the tsunami heights with different depths and different epicenters are interpolated using linear interpolation and bilinear interpolation, respectively. The the interpolated tsunami heights is group into district administrative regions, then the maximum height for each administrative region is selected. The selected tsunami heights are categorized into three different warning levels. These levels are tsunami smaller than 0.5 m, between 0.5 m to 3 m, and larger than 3 m.

We apply this method to forecast the tsunami generated by the 1994 East Java earthquake. The 1994 earthquake is classify as a tsunami earthquake (Newman and Okal, 1998; Pollet and Kanamori, 2000). The earthquake moment magnitude was estimated to be Mw 7.6 (Abercrombie et al., 2001), Mw 7.8 (Bilek et al., 2006; USGS), Mw 7.9 (Pollet and Kanamori, 2000). Our result shows that the forecasted tsunami heights underestimate the actual tsunami heights. One of the main cause could be the fact that we used simple fault model scenarios which sizes were estimated from scaling relationship of magnitude to fault dimension of regular earthquake but not tsunami earthquake. Previous studies shows tsunami earthquake may generate large slip near the trench (Tanioka and Satake, 1996; Satake et al., 2013). Therefore to obtain a more accurate forecast, the fault model scenarios near the trench should represent fault model for tsunami earthquake event.

Keywords: pre-computed tsunami database, tsunami earthquake, tsunami early warning

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Simulation of tsunami inundation from future megathrust earthquake scenarios of Central Peru

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Great tsunami events like the 2011 Great East Japan Earthquake and Tsunami might occur around the world in the future. In particular at areas of the Pacific Rim or the Andaman Sea as history has confirmed. In this study we will focus on the central coast of Peru on the western Pacific. The earthquake history of Peru accounts for many devastating tsunami disasters in the past (1555, 1586, 1609, 1630, 1655, 1678, 1687, 1746). The potential damage to national infrastructure exposed in Callao and Lima could yield to a heavy economical breakdown in Peru. It is of great importance to assess and estimate the future tsunami inundation scenarios in order to grasp the extent of possible damage and the severity of it. Consequently, this study evaluates the tsunami hazard and the related features of inundation at the central coast areas of Peru based on possible megathrust earthquakes.

The source model we used in this study (Mw = 8.90) was obtained from results of the interseismic coupling distribution in subduction areas using GPS monitoring data as well as historical earthquake recurrence information (Pulido et al., 2011). This slip model was used to generate twelve additional slip scenarios for strong ground motion simulation, by adding spatially correlated short-wavelength slip heterogeneities (Pulido et al., 2012).

Here, we used these thirteen scenarios to evaluate the tsunami hazard of Callao area in Peru. From results of strong ground motion simulations Pulido et al. (2012) reported that the slip scenario with the deepest along strike slip average (Mw = 8.86) was the worst case scenario for strong ground motion in Lima-Callao area. On the other hand, in this study the slip model with the largest peak slip (Mw = 8.87) yielded the highest tsunami inundation and maximum velocity near shore. Such differences on maximum scenarios for peak ground acceleration and tsunami height reveals the importance of a comprehensive assessment of earthquake and tsunami hazard in order to provide plausible worst case scenarios of strong ground motion and tsunami inundation.

Acknowledgments

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Pulido, N., Tavera, H., Perfettini, H., Chlieh, M., Aguilar, Z., Aoi, S., Nakai, S., and Yamazaki, F. (2011). Estimation of Slip Scenarios for Megathrust Earthquakes: A Case Study for Peru. In *4th IASPEI/IAEE International Symposium*, pages 1?6, Santa Barbara, CA, USA.

Keywords: megathrust earthquake, megatsunami, numerical simulation, tsunami Peru, scenarios

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Identification of submarine landslide tsunami sources: A probabilistic approach for the Gulf of Mexico

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The devastating consequences of recent tsunami events in Indonesia (2004), Japan (2011) have changed the perception about tsunami potential and have prompted a scientific response in assessing the tsunami hazard in regions even though an apparent low-risk or/and lack of complete historical tsunami record exists. Although a great uncertainty exists regarding the return period of large-scale tsunami events in the Gulf of Mexico (GOM), geological and historical evidences indicate that the most likely tsunami hazard could come from a submarine landslide triggered by a moderate earthquake. Under these circumstances, the assessment of the tsunami hazard in the region could be better accomplished by means of a probabilistic approach to include the uncertainty in the hazard analysis and thus to identify tsunami sources.

This study aims to customize for the GOM an existing probabilistic methodology to determine landslide-tsunami sources associated with return periods. The Monte Carlo Simulation (MCS) technique is employed to determine the uncertainty related to location/water-depth and landslide dimension based on normal/lognormal distributions obtained from observed data. Along fixed transects over the continental slope of the GOM, slide angle of failure, soil properties and seismic peak horizontal accelerations (PHA) are determined by publicly available data. These parameter values are used to perform slope stability analyses in randomly generated translational submarine mass failure (SMF) obtained from the MCS technique. Once the translational SMF is identified as tsunamigenic for a given recurrence rate, a preliminary tsunami amplitude can be estimated by using empirical formulations. Thus, the annual probability of a tsunamigenic SMF is determined by the joint probability with the annual PHA.

By using the probabilistic approach we identified tsunami sources associated with return periods from few thousands to 10,000 years for each fixed transects defined over the continental slope of the GOM.

Keywords: tsunami, submarine landslide, the Monte Carlo Simulation

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A stochastic analysis and an uncertainty assessment of tsunami wave height using a random source parameter model

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In this paper, we conducted a stochastic tsunami hazard assessment including various uncertainties using a logic tree with targeting a region of the 3.11 Tohoku earthquake and investigated how heterogeneous slip faults generated by CRSP (Correlated Random Source Parameter) model influence the stochastic tsunami hazard assessment. In the assessment, observed tsunami wave height 6.7m in the 3.11 Tohoku Earthquake corresponded to 1112 year (0.50 fractile point), 1129 year (simple average) and 490 year (0.95 fractile point) for return period. Next, we investigated an influence that the number of slip patterns has on the results of the assessment. While the number of slip patterns had little impact on the results of the stochastic assessment in cases which a target wave height was comparatively low (2.0m), the return period at each fractile point was overestimated in case of 3 slip patterns and 5 patterns than 1 pattern when a target wave height was comparatively high (6.7m or 10.0m). We can conclude that the number of slip patterns had a great impact on the stochastic assessment depending on the target wave height. To clarify the uncertainties of tsunami wave height, we defined a 90 percent confidence interval and a coefficient of variation as indexes which can quantify the uncertainties of tsunami wave height. Basically, the 90 percent confidence interval had high value where the wave height at each fractile point was high. In addition, we confirmed that changing of maximum wave height due to changing of the asperity location in the assuming fault had a great impact on the coefficient of variations in the offshore point of the Ibaraki coast. The coefficient of variation in the offshore point of peninsula located in ria shoreline of the Iwate coast was comparatively higher than a result in closed-off section of bay located in ria coast. This result indicates an effect due to a characteristic topography in ria coast.

Keywords: probabilistic tsunami hazard assessment, uncertainty analysis, rogic tree, CRSP model