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

HDS26-01 Room:301B Time:May 20 16:15-16:30

Tsunami Warning Improvement

Tomoaki Ozaki[1*], Toshihiko Nagaoka[1], Tatsuo Kuwayama[1], Kenji Nakata[1], Yohko Igarashi[1], Masaaki Minami[1], Toshihiro Ueno[1]

[1]Japan Meteorological Agency

After the devastating tsunami caused by the 2011 off the Pacific coast of Tohoku Earthquake (the great Tohoku earthquake), the Japan Meteorological Agency (JMA) prepared a tsunami warning improvement plan in March 2012 based on advices of tsunami experts and relevant disaster management organs. JMA will start renewed tsunami warning operation in line with the plan from March 2013. Major improved points of renewed tsunami warning are as follows.

1) Measures to avoid underestimation of magnitude for huge earthquakes

JMA issued tsunami warning for the great Tohoku earthquake within three minutes with estimated maximum tsunami heights of 6m or 3m based on underestimated magnitude of 7.9, which were much lower than the real tsunami heights. JMA uses JMA magnitude (Mj) for tsunami warning, and Mj is, similar to Richter scale magnitude, calculated from maximum amplitude of short period displacement seismic wave, and has the property to saturate around 8.0. And there is no established method to estimate reliable huge magnitude value of much larger than 8.0 within several minutes. To deal with this matter, JMA will introduce tools with which validity of Mj estimation can be evaluated before the initial tsunami warning issuance. If the possibility of Mj saturation is detected with the tools, JMA will issue tsunami warning by replacing the magnitude by the maximum possible magnitude around the region close to the epicenter. In the oral session, these tools and maximum possible magnitude values will be introduced.

2) Change of tsunami warning messages

In relation to the tsunami warning for the great Tohoku earthquake, it was pointed out that the underestimated tsunami heights in numerical expression such as "3m" based on Mj7.9 might have led to the delay of evacuation. And the number of tsunami height estimation levels divided into eight (0.5, 1, 2, 3, 4, 6, 8, 10m or more) was required to be reduced taking into account realistic variety of responses to be taken in emergency. Considering these matters, in the renewed tsunami warning, tsunami height estimation for such a huge event as described in 1) will be issued qualitatively, e.g., "huge", aiming at conveying impending danger. And the number of tsunami height estimation levels expressed in numerical value will be reduced to five (1, 2, 5, 10, over 10m).

3) More precise update of tsunami warning

For the great Tohoku earthquake, JMA could not calculate moment magnitude (Mw) within 15 minutes as with JMA's normal operation, because of out-ranged large amplitude records observed with most of domestic broadband seismometers. In addition, cable-type sea-bottom pressure sensors' data, which indicated large offshore sea level change about 15 minutes after the quake, could not be applied to warning update because such procedure and relevant technique did not established at that time. To deal with these issues, JMA is deploying broadband strong motion seismometers to acquire full scale of broadband seismic wave data and to obtain Mw robustly, and started the operation of utilizing sea-bottom pressure sensors' data for warning update from March 2012. In addition, JMA deployed three buoy-type sea-bottom pressure sensors to detect tsunamis generated around Japan trench. Offshore observation results are planned to be reported in new information of "offshore tsunami observation information", together with existing GPS buoy data.

Along with the above mentioned tsunami warning improvement, JMA will promote education and awareness-raising activities on tsunami evacuation such as letting people to know the importance of immediate evacuation on feeling strong, or week but long-lasting ground shaking.

Keywords: The 2011 off the Pacific coast of Tohoku Earthquake, Tsunami warning improvement

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HDS26-02 Room:301B Time:May 20 16:30-16:45

Rapid magnitude determination from peak amplitudes for tsunami warning

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Rapidly determining the magnitude soon after a great earthquake is necessary for issuing effective tsunami warnings, as demonstrated in the great earthquake off Tohoku district in Japan on March 11, 2011. The earthquake magnitude for the first tsunami warning was underestimated due to magnitude saturation.

We present an empirical method to determine magnitude rapidly from peak velocity and displacement of long-period seismic waves up to 100 seconds at local stations. When waveform data at local stations are available, the magnitude from S-wave peaks is expected to be determined faster than that from only P-wave peaks. Velocity/displacement records are obtained from strong-motion acceleration records with numerical integration. Processing with recursive digital filters makes it possible to observe magnitude value change soon after the hypocenter determination.

It took about 140 second to estimate a magnitude of about 9 for the March 11, 2011, earthquake, which enables us to issue the first tsunami warning within three minutes after the same type of earthquakes. It was also possible to get a magnitude value of 8.8 for the 2010 Chile Maule earthquake within three minutes from the origin time.

Correction for epicentral distance is applied for the magnitude determination. Effect of the hypocenter location on magnitude value was estimated for the events on March 11, 2001. Magnitude values were calculated with assumed hypocenter locations within the source area, and the magnitude differences were no more than 0.1 in a large part of the source area. Focal mechanism also affects the observed peak amplitudes. Effect of focal mechanism is considered to be slight for local events, and it could be considerable for the case of observing events near Kuril Islands on Japanese islands.

We used data obtained by Japan Meteorological Agency, University of Chile, and National Research Institute for Earth Science and Disaster Prevention.

Keywords: rapid magnitude determination, peak amplitude, tsunami warning

Japan Geoscience Union Meeting 2013
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HDS26-03 Room:301B Time:May 20 16:45-17:00

Development of the system for high-precision prediction of coastal tsunami wave heights

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Meteorological Research Institute and Kokusai Kogyo Co. Ltd. developed the system for high-precision prediction of coastal tsunami wave heights by September, 2012. The integrated software for a series of tsunami numerical analysis of tsunami propagation and inundation was installed in this Windows 7 workstation-based system. Some functions were realized together with general-purpose software. Then, the system provides interactive operating environments to support following routine processes on tsunami numerical analysis.

1. Setting calculation regions and their nesting structure.
2. Setting the initial tsunami source by computing the crustal movement field from a fault model or a given sea-level distribution.
3. Preparing mesh data of bathymetry, elevation, coastal structures, and roughness parameters. This process includes datum transformations and merging two sets of mesh data.
4. Setting parameters and options, for examples, a normal tide level, presence or absence of tsunami run-up and non-linear effects, items to be output, locations of observation points.
5. The generation of program sources and executable files; then performing calculation.
6. Analyzing calculation result by visualizing various physical values, such as distribution and time-series of sea-levels or current velocity vectors, map of inundation area, moving images of them.

Basic data of bathymetry, elevation, coastal structures, and roughness parameters necessary to perform tsunami computing at along the Pacific coast facing Japan Trench or along the Pacific coast facing Nankai Trough were also prepared. This system has potential to improve research efficiency of tsunami numerical analysis. We will present some utilization examples at the meeting.

Keywords: integrated software, tsunami inundation computing, tsunami propagation computing, flow visualization

Japan Geoscience Union Meeting 2013
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HDS26-04 Room:301B Time:May 20 17:00-17:15

Ocean bottom seismic and tsunami network along the Japan Trench (2)

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[1]National Research Institute for Earth Science and Disaster Prevention, [2]Earthquake Research Institute, University of Tokyo

Huge tsunami, which was generated by the 2011 off the Pacific Coast of Tohoku Earthquake of M9 subduction zone earthquake, attacked the coastal areas in the north-eastern Japan and gave severe casualties (about 20,000 people) and property damages in the areas. The present tsunami warning system, based on land seismic observation data, did not work effectively in the case of the M9 earthquake. It is strongly acknowledged that marine observation data is necessary to make tsunami height estimation more accurately. Therefore, new ocean bottom observation project has started in 2011 that advances the countermeasures against earthquake and tsunami disaster related to subduction zone earthquake and outer rise earthquake around Japan Trench and Kuril Trench. A large scale ocean bottom cabled observation network is scheduled to be deployed around Japan Trench and Kuril Trench by 2015. Concepts of this network are: 1) Locate one station by each M7-7.5 class seismic source region (that is minimum size tsunami generation earthquake). 2) Incorporate the land and sea networks in on observation network. The network consists of about 150 ocean bottom observation stations. Ocean bottom fiber optic cables, about 5,700 km in total length, connect the stations to land. Observation stations with tsunami meters and seismometers will be placed on the seafloor off Hokkaido, off Tohoku and off Kanto, in a spacing of about 30 km almost in the direction of East-West (perpendicular to the trench axis) and in a spacing of about 50 - 60 km almost in the direction of North-South (parallel to the trench axis).

This cable system is divided into 6 subsystems. Both ends of each cable subsystem will be landed, and electric power will be fed from both sides. And also all data will be acquired from both sides in order to ensure operation in case of cable trouble. In addition, the neighboring cables will be brought into the same landing station, and 6 subsystems are going to be finally connected into one big loop. By do this, the minimum data necessary for the warning which is acquired the whole cable subsystems can be transmitted from one landing station of somewhere.

Two sets of JAE three component servo accelerometers, a Geospace Technologies three component velocity seismometers, and two Paroscientific quartz type depth sensors and a three-component quartz type accelerometers (frequency outputs) will be installed. Tsunami data and seismometer data will be digitized at sampling frequency of 10 Hz and 100 Hz, respectively, and will be added clock information at land stations. These digitized data will be transmitted to the data centers (main at NIED and backup at ERI), JMA (Japan Meteorological Agency), universities, and so on, using IP-VPN network.

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HDS26-05 Room:301B Time:May 20 17:15-17:30

A development of GPS tsunami meter —-A data communications experiment using ETS-VIII—-

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On 11th March 2011, Tohoku-Oki earthquake tsunami clarified two problems to be solved about the function of GPS tsunami meter. One is the technical development of the further offshore deployment of a GPS tsunami meter, and another is the avoidance of a risk of locating the tsunami information base station in an earthquake disaster area. The result of having examined these two subjects is reported.

In the former investigation, the GPS-FIX solution is obtained by the performed appropriate troposphere compensation for the 100 km baseline RTK-GPS method. Moreover, the positioning methods without reference data, the point precise variance detection method (PVD) and precise point positioning with ambiguity resolution method (PPP-AR), are effective tsunami observation without distance limitation for offshore deployment. These are proved by continuous experiment from April 2012 using the GPS tsunami meter at Muroto cape offshore.

In the latter investigation, communications satellite is useful for this subject. The data measured on GPS buoy is sent to the satellite, and is transported to the area without the earthquake disaster. The subject in satellite communication is how keep the gain for electric wave intensity on the condition of the GPS buoy, which moves with the sea level displacement and restrict the power supply. The communications satellite ETS-VIII (Kiku VIII) gives the solution which is proved by the experiment using the Muroto GPS buoy at Oct. 2012.

This work was supported by JSPS KAKENHI Scientific Research (S) 212210007.

Keywords: GPS tsunami meter, ETS-VIII, PVD, PPP-AR

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HDS26-06 Room:301B Time:May 21 09:00-09:15

Simulation of distant tsunami propagation with a loading deformation effect

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Recent studies have revealed that observed leading waves of great tsunamis propagate slower by about 1% than those simulated by usual tsunami propagation models. We simply implement a seafloor deformation effect into a traditional long-wave model, and show that trans-oceanic tsunami propagation is realistically simulated in terms of travel time and waveform as well, in cases of the 2010 Chilean and 2011 Tohoku tsunamis. The loading deformation rates of seafloor are about 2% of the tsunami heights for both the giant tsunamis.

Keywords: tsunami propagation, travel time, loading deformation

HDS26-07 Room:301B Time:May 21 09:15-09:30

Cause of travel-time difference between observed and synthetic waveforms of distant tsunami

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It has been reported that the observed tsunami waveforms from distant tsunami are delayed by several to a few tens of minutes from synthetic waveforms based on linear long-wave theory. Tsunami waveforms recorded on pressure gauges in deep oceans from the 2011 Tohoku-Oki earthquake and the 2010 Chilean earthquake. The cause of this delay may include the effect of bathymetry data and parameters for numerical computation (e.g., Kusumoto et al., 2011) or the effects of elasticity of the earth, compressibility of seawater and gravity potential change that are not included in the present numerical computation (e.g., Watada et al., 2011). The contributions of these effects to travel-time delay of the observed tsunami waveforms are studied.

The travel-time delay increases as a function of travel time. Travel-time delay for the Tohoku-Oki earthquake monotonically increases with travel time, and becomes near 15 minutes at travel time of 1200 minutes. Travel-time delay for the Chilean earthquake is almost zero up to travel time of 600 minutes, then rapidly increases with travel time, and reaches more than 10 minutes at travel time of 1200 minutes.

Three different kinds of bathymetry data, ETOPO5, ETOPO1 and GEBCO are examined. They all produce similar travel-time differences, but the travel-time differences for ETOPO5 are 1-3 minutes larger than the others.

The gravity and the earth's radius are usually assumed as constant for present numerical computation. However, these should be treated as variables because the real earth is spheroid. When these are treated as variables that depend on only colatitude, travel-time difference hardly changes until travel time of 400 minutes, but decreases by 1-2 minutes over the travel time of 600 minutes.

Phase velocity of the observed waveforms are measured, and normalized for a constant (4 km) deep ocean. The normalized phase velocity is compared with theoretical dispersion curves of linear gravity wave and of the PREM model, which includes the effects of the elasticity of the earth, compressibility of seawater and gravity potential change. Phase velocity of the normalized observed waveforms is slower by more than 1 % than that of the linear gravity wave at a period range more than 2,000 seconds, and these match with the dispersion curve of PREM.

The main cause of the travel-time difference is thus inferred as wave dispersion of longer period due to the effect of elasticity of the earth, compressibility of seawater and gravity potential change. Moreover, gravity and the earth's radius should be treated as variables when tsunami propagates for a long time in equatorial regions.

Finally, to include the effects of the above main causes, i.e., elasticity of the earth, compressibility of seawater and gravity potential change, into the current simulation method, phase delay of the theoretical dispersion curves was applied to the simulated waveforms. Comparison with the observed tsunami waveforms shows that the travel-time difference became less than 5 minutes for both earthquakes.

Keywords: tsunami propagation, travel-time differences, Deep-Ocean Assessment and Reporting of Tsunamis, the 2011 Tohoku-Oki earthquake, 2010 Chilean earthquake

HDS26-08 Room:301B Time:May 21 09:30-09:45

Magnitude of the Western Canada Earthquake Tsunami of October 27,2012

Tokutaro Hatori[1]*

[1]Nnne

The major earthquake occurred on October 27,2012 near the Queen Charlotte Is., B.C., Canada (52.788N, 132.101W, 14km depth, M7.7, USGS) .Moderate tsunami was widely observed in the Pacific zone (WC/ATWC, NOAA,JMA).The estimated tsunami source lies along the west side of Moresby Is. ,extending 120km length. The maximum semi-amplitudes are 3-25cm in B.C. Canada ,44cm at Crescent City,CA,43-79cm at Hawaii, 10-14cm in New Zealand and 10-24cn in Japan (large amplitude: Kuji,Ayukswa and Kagoshima-Nakanoshima). Judging from the attenuation of tsunami height with distance, tsunami magnitude is determined to be m=1.5 that the grade is relatively small for earthquake magnitude. Amplitudes at Hawaii, Japan and New Zealand were conspicuously large, suggesting the effective energy is projected toward the SW and E directions. It should be considered for the seismic gaps in Cascade and Yakutat regions.

Keywords: Western Canada Earthquake, Earthquake Tsunami, Magnitude, October 27,2012

HDS26-09 Room:301B Time:May 21 09:45-10:00

Dispersive tsunami generated by the 2013 off the Santa Cruz Islands earthquake (M8.0)

Takayuki Miyoshi[1*], Tatsuhiko Saito[1], Daisuke Inazu[1], Sachiko Tanaka[1]

[1]NIED

On February 6, 2013, great earthquake (M8.0) occurred off the Santa Cruz Islands in Solomon Islands. We have simulated the tsunami generated by this earthquake using linear long wave theory and dispersive theory. The assumed tsunami source is located off the Santa Cruz Island (10.7^{o}S, 165.1^{o}E, depth 28.7 km). We assumed the following source parameters: strike 309^o, dip 17^o, rake 61^o, length 119km, width 59km, and slip 5.9 m based on the moment tensor solution by USGS and scaling laws.

Based on the two types of the numerical simulations and the comparison with the simulation results and the observed tsunami data, we obtained the results as follows: (1) the difference between the simulation of long wave theory and dispersive theory is appeared clearly in the direction of the minor axis of the tsunami source, (2) dispersive tsunami observed at DART station 55012 located in the southwest direction of the source, and (3) dispersive tsunami observed on the second tsunami phase at DART station 55023 located in the west-southwest direction of the source. Our results shows dispersion effects cannot be neglected on the modeling of the 2013 off the Santa Crus Islands tsunami.

Acknowledgements: We used the DART record provided by the NOAA in this study.

Keywords: the 2013 off the Santa Cruz Islands earthquake, tsunami, dispersive wave, simulation

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HDS26-10 Room:301B Time:May 21 10:00-10:15

Analysis of Tsunami Generated by the 1994 East Java Tsunami Earthquake

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[1]ISV-Hokkaido University

A tsunami earthquake (Mw7.8) occurred off the south coast of Java Island, Indonesia on June, 1994. This earthquake generated a large tsunami. Average tsunami height of around 4-6 meter along the south coast of East Java and maximum tsunami height of 13 meter were measured by a field survey (Tsuji et al., 1995). Tsunami waveforms of this event were also recorded at two tide gauges in Cilacap, Central Java and Banyuwangi, East Java.

To simulate the tsunami propagation and inundation, Geoclaw model is used. Bathymetry dataset used for the simulation is assimilated from Indonesian Navy-chart, GEBCO 30 arc second, and topography data of Indonesian Geospatial Information Agency base-map with scale of 1:25.000.

The propagation and inundation is simulated using source model estimated by seismic data analysis of a previous study (Bilek and Engdahl, 2006). The simulation results were compared with the measured tsunami heights, inundation extents, and tsunami waveforms at the two stations. The seismic source model produced tsunami heights of only about 12% of the measurements. This mean that source model from seismic data could not explained tsunami heights along the coast.

Therefore, we try to add an additional source model which can explain tsunami heights and tsunami waveforms data. The additional fault model is located near the trench in the shallowest segment of subduction zone. The estimated source model produced tsunami heights of about 70% of the measured data.

Keywords: East Java Tsunami, tsunami earthquake, tsunami waveforms, tsunami heights

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HDS26-11 Room:301B Time:May 21 10:15-10:30

Analysis of the doublet outer-rise earthquake and tsunami in Off-Miyagi coast occurred in 7 December 2012

Abdul Muhari[1*], Kentaro Imai[1], Anawat Suppasri[1], Fumihiko Imamura[1]

[1]International Research Institute of Disaster Science, Tohoku University

An earthquake with M7.3 occurred in Off-Miyagi coast, Japan in 7 December 2013. This earthquake was reviewed differently from seismological point of view. The US Geological Survey (USGS, 2012), for instance, concluded this event as reverse faulting in oceanic lithosphere. In contrary, the Geofon program (GFZ, 2012) and Aqua project (NIED, 2012) suggested the event as the normal faulting in the subducted slab. Global moment tensor (Harvard, 2012), however, examined this event as doublet earthquake consists of two different fault mechanisms as described by the previous sources. We carried out numerical analysis to determine the appropriate source and reconstruct the tsunami by verifying the simulated waves with the observed tsunami in 4 tide gauges and one GPS buoy (central Miyagi) in off-Miyagi coast. We conclude that tsunami were generated by two earthquakes where the reverse fault occurred much deeper than the normal faulting yield a lower through followed by high amplitude peak of the first tsunami wave.

Keywords: normal fault, outer-rise earthquake, tsunami simulation

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HDS26-12 Room:301B Time:May 21 10:30-10:45

Tsunami Vulnerability Assessment of the Southern Boso Peninsula

Gerasimos Voulgaris[1*]

[1]University of Tsukuba, Spatial Information Science

The Southern Boso Peninsula has been affected by tsunamis during historic years and during the Holocene. This study attempted to assess the tsunami hazard in the southern Boso Peninsula city of Tateyama, and assess the vulnerability in two of Tateyamas districts of Aihama and Mera. By using GIS it was possible to establish an inundation scenario for Tateyama, as well as to roughly approach some of its potential threat to the locals. Utilizing GIS and the Papathoma Tsunami Vulnerability Assessment model allowed for the vulnerability assessment of buildings in the scenario floodzone of Aihama and Mera. Applying a building population estimation model in both the hazard assessment of Tateyama and the vulnerability assessment of Aihama and Mera, allowed the estimation of the population distribution in dangerous zones and buildings in different vulnerability classes. Results show that almost half of the buildings in Tateyama and more than half of its population would be affected by the tsunami of the considered worst-case scenario. For the coast of Aihama and Mera, almost half of the buildings show high or very high vulnerability to tsunamis, with the population in these buildings distributed in similar fashion.

Keywords: Tsunami, Vulnerability, Boso Peninsula, GIS, PTVA Model, Tateyama

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HDS26-13 Room:301B Time:May 21 11:00-11:15

Tsunamis reflected from Hawaiian Islands and observed at south-west Pacific coast of Japan

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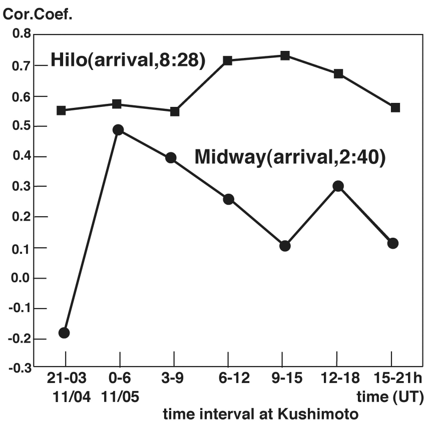
[1]Amigawara tsunami study room, [2]Meteorological Research Institute, [3]Meteorological Research Institute

Formerly week decay of tsunamis obliquely invading to the Pacific coast of Japan was noticed and reflected wave from Hawaiian Islands was suggested as one of the reasons. Therefore,we carried out wave analyses for 1952 Kamchatka,2006 Kuril and 2011 Tohoku-chiho tsunamis observed at Kushimoto tide station. The analyses consist of making diagrams of amplitude-time, period-time and calculating the spectra for 24-hour time histories. At the same time the same tsunami spectra observed at Midway Island and Hawaiian Island were calculated for the first 6 hours. Correlation coefficients were calculated for all the spectral components between Kushimoto and one of Hawaiian Islands in the 6 hour spectra. Time variations of the correlation were estimated for every 3 hour from the initial arrival time of Kushimoto. Arrival times of the reflected waves from Hawaiian Islands were estimated from refraction and inverse refraction diagrams. As the results we concluded that amplitude increases and period change were found approximately corresponding to the predicted arrival times in the diagrams and increases of spectral correlation between Kushimoto and tide stations in Midway, Hawaiian Island after the predicted arrival times. These facts strongly suggest that the reflected waves from Hawaiian Islands arrived at Kushimoto tide station and the reflected waves consist of characteristic radiation of the reflectors.

Keywords: tsunami, reflected wave, Kushimoto, Hawaian Islands, spectra



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Japan Geoscience Union Meeting 2013
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HDS26-14 Room:301B Time:May 21 11:15-11:30

Field Survey of the Beppu Bay Tsunami accompanied by the 1596 Keicho Bungo Earthquake

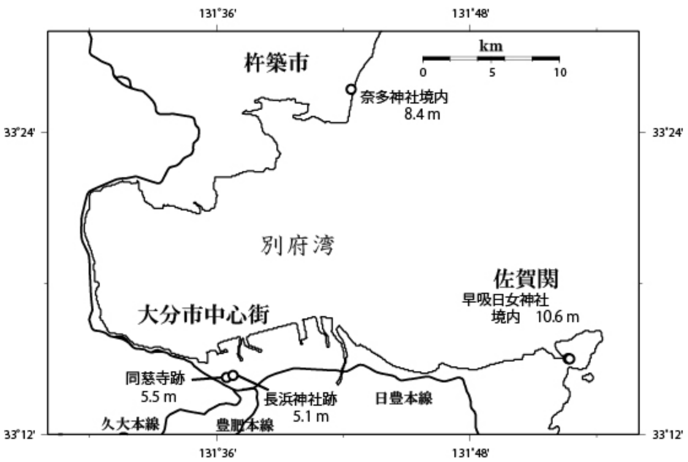
Yoshinobu Tsuji[1*], Yuya Matsuoka[2], Yuichi Namegaya[3], Kentaro Imai[4], Hiroyuki Iwase[5], Nobuhiko Hara[5], Fumihiko Imamura[4]

[1]Fukada Geolog. Inst., [2]Sendai City Museum, [3]AIST, [4]IRIDeS, [5]Echo Co. Ltd.

The Keicho Bungo earthquake (M6.9) broke out on 4th September, 1596 in the sea area of Beppu Bay, Ooita Prefecture, north east Kyushu. This earthquake was accompanied with a large tsunami, and severe damage occurred on the coast of Beppu Bay. We conducted survey at four points where submergence limits were clearly recorded. The Chronicle of Saganoseki town mentions that at Saganoseki, Ooita city at present, the stone gate of Seki Shrine was collapsed due to the tsunami and the main building was flooded above the floor. The master of the shrine testified that the location of the main building is not changed since the foundation of the shrine. The height of the ground was measured at 8.61 meter, and the floor surface is 2 meter higher above the ground, so it is estimated that sea water rose up to 10.6 meters above the mean sea level. In Funai 3 street in Oita city, where Ooita central post office stands at present, there was a temple called Doji-ji and several buildings were swept away due to the tsunami. The ground height was measured at 3.53 meters, and the thickness of covered water was estimated 2 meters or more, so the tsunami inundation height is estimated at 5.5 meters above MSL there. There was a shrine called Nagahama Shrine on the Ooita central police station, the 3rd street of Ootemachi square, and was carried to Kasuga Hill due to the

tsunami. The ground height is 3.13 meters, so tsunami inundation height is estimated at 5.1 meters above MSL. On the north coast of Beppu Bay, there is a shrine called Nata Hachiman Jinja in Kitsuki City. The Chronicle of Kitsuki city mentions that all buildings and stone gates were swept away due to the tsunami in 1596. The ground height of the shrine was surveyed at 6.4 meters, and so the tsunami inundation height was 8.4 meters or more there. The present authors wish to express their thanks to JNES for its financial support.

Keywords: the 1596 Keicho Bungo Earthquake, Tsunami, Beppu Bay, tsunami inundation height, Oita



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Maps and speeds of Tsunami measured by oblique mono photogrammetry with video image in Asahi City,Chiba Prefecture

Mitsuo Harukawa[1]*

[1]The Group of Recording for Tsunami Damage of Asahi City in 2011

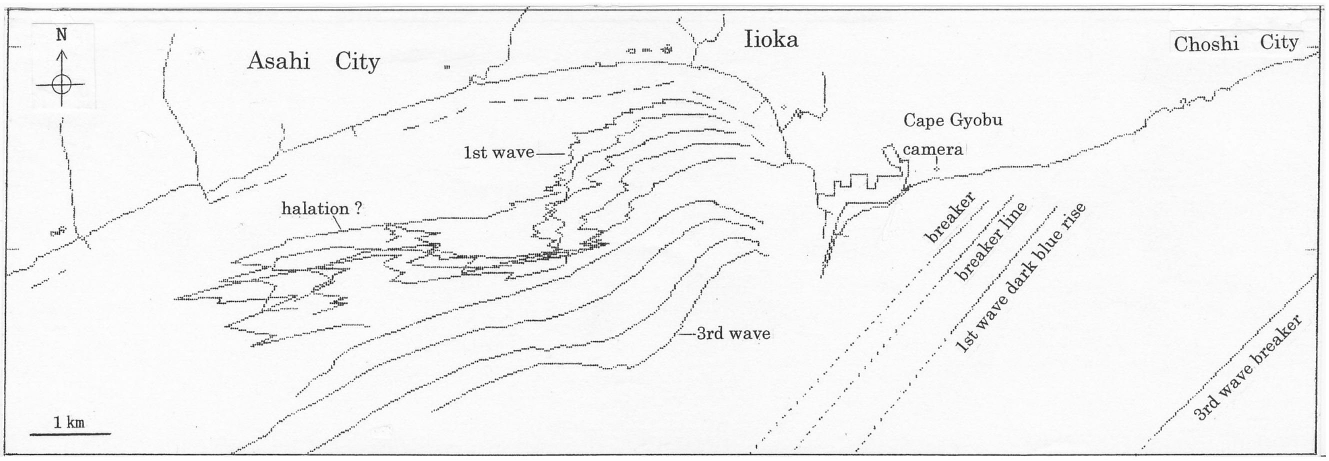
With captured pictures from video image, I made maps of tsunami waves and measured tsunami speeds by oblique mono picture photogrammetry.

Eastern area,Tsunami were plane waves. 1st wave emerged as a dark blue rise, and after 45 seconds it turned into breaker. 3rd wave emerged as a breaker, and after 10 minutes it reached Cape Gyobu. Strikes and speeds, 1st wave N40E 8.6-9.4m/s, 3rd wave N44E 4.9m/s. 3rd wave had little water depth in front.

Western area, For 1st wave, 5 lines were drawn in every about 17 seconds, and for 3rd wave, 4 lines in every about 60 seconds. Tsunami speeds,1st wave 10-12m/s, 3rd wave 4-6m/s. The disorder of 1st wave lines in the west part may be due to halation of the Sun, but it needs further examination. 3rd wave had no water depth in front.

I used DVD made by Reflect Image Channel. Our group is going to issue the report this year.

Keywords: maps of tsunami, tsunami speed, photogrammetry, video image, Asahi City, Iioka



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HDS26-16 Room:301B Time:May 21 11:45-12:00

High resolution tsunami inundation simulation using an unstructured mesh finite volume method and the K computer

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Simulations play an important role in tsunami hazard mitigation. For example, tsunami hazard maps are based on tsunami inundation simulations. In such simulations, a Leap-Frog finite difference method is usually applied to the shallow water equations and meshes with different resolutions are nested to have high resolution in the coastal region and lower resolution in the off shore region that covers the tsunami source region. The mesh resolutions are usually increased stepwise by keeping the ratio of the resolutions of the connected meshes at one third. Such simulations are usually performed on a relatively small computation system such as a workstation.

This study looks at future trends and discusses how high-speed computers can improve tsunami simulation technologies. For example, high-speed computers may make it possible to conduct tsunami inundation simulation much faster than real-time. Recently research on the instant analysis of high-resolution tsunami source distribution are being advanced, which use off-shore tsunami observations based on ocean bottom pressure gauges and GPS buoys. When almost-instant tsunami source data is used in the high-speed tsunami inundation simulations, accurate information on the inundated district can be obtained before the arrival of tsunamis. Another benefit of high-speed computation is that higher-resolution simulations can be conducted in a practical time scale. By applying a higher resolution at the coastline in a wider area, it becomes possible to accurately evaluate the waves that are reflected at the coastline and attack the coastline repeatedly, as observed in the 2011 Tohoku tsunami. Furthermore, the high-resolution simulations with high-resolution topography data (e.g., 2 - 5 km mesh spacing) provides accurate evaluations on urban inundation processes.

To efficiently conduct such high-speed and high-accuracy simulations using high-speed computers, an unstructured-mesh finite volume method is employed. We use the ANUGA software developed by the Australian National University and Geoscience Australia. In conventional tsunami simulations, the nested meshes basically have a rectangular shape. Therefore, deep ocean that does not need high resolution may be covered with a high-resolution mesh causing an unnecessary limitation on the time-step. And locations which are high above sea-level and never reached by the tsunami may be covered with a high-resolution mesh causing unnecessary calculations. Unstructured meshes can avoid such inefficiency by flexibly changing the mesh resolution depending on the topography. In addition, it is sometimes pointed out that artificial reflection may occur at the boundaries of higher and lower resolution nested meshes. Such problem can be avoided by using unstructured mesh that can change the mesh resolution more gradually.

In this presentation, we will explain the details of our tsunami model and the simulation results of the 2011 Tohoku tsunami. These results will be compared to the results from a conventional tsunami model based on the Leap-Frog finite difference method. These are followed by a report on the parallel computation performance on the K computer.

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

HDS26-17 Room:301B Time:May 21 12:00-12:15

Electric field variations induced by the tsunamis of the 2011 Tohoku-oki earthquake

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An ocean-bottom electromagnetometer (OBEM) emplaced 20 km west of the Japan Trench, 39.1 degrees north recorded the electric field variations around the March 11, 2011 Tohoku earthquake (M9.0). Two phases of the electrical field variation were recognized: 1) a large variation (8mV/km) between 14:47 and 14:51 in NNW direction and 2) a small variation (2mV/km) between 14:48 and 15:00 in ESE direction. These variations were possibly the first example of tsunami induced electric field variation because a former study that observed the tsunami-induced magnetic signal at the 50 km east of the trench did not record electric field due to instrumental problem (Ichihara et al., in rev). On the assumption that the electric signal are caused by tsunami, the variation 1) and 2) indicates short period wave (wave height: 5.0m) from ESE and long period wave (wave height: 1.4m) from SSW, respectively. The possible tsunami 1) is consistent to the impulsive wave from the narrow source along the trench in 39 degrees north (Fujii and Satake, 2013; Ichihara et al., in rev). The possible tsunami 2) is also consist to the long period tsunami by the wide source around 38 degrees north (e.g. Fujii and Satake, 2013).

Keywords: OBEM, tsunami, 2011 Tohoku-oki earthquake

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Uncertainties of tsunami wave height in the tsunami simulation due to dynamic fault rupture effects

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In 2011, the Great East Japan Earthquake generated tsunami that exceeded their expectations and caused massive damage in the Northeast coast of Japan. One of the methods to avoid such unexpected event is to understand cyclopaedically the uncertainties of tsunami wave height as an output of a tsunami simulation. There are two categories of fault parameters in a tsunami simulation: static parameters and dynamic parameters. Static parameters are such as dip, slip, strike angle. Dynamic parameters are risetime and rupture velocity. So far, uncertainties of tsunami wave height due to static parameters has been studying by many previous studies. However, the effect of dynamic parameters are still unclear. In this study, we focused on the dynamic parameters. We quantitatively assessed how dynamic parameters in the tsunami simulation effect on tsunami height. In case of such a great earthquake in 2011 Great East Japan Earthquake, it seemed that the effect of dynamic parameters on uncertainties of tsunami wave height is not negligible.

Firstly, five unit faults were set. Risetime was given and generated for 100 cases using monte-carlo simulation based on probabilistic distribution (log normal distribution) gatherd from past seismic data. The generated risetime applied to each small faults and tsunami simulation was perfomed. Tsunami wave height data was collected at 12 fixed virtual observation points and calculated the variability (standard deviation) from median value of tsunami wave heights. Rupture velocity was also generated for 100 cases using monte-carlo simulation. Rupture starting point applied to each unit fault (5 cases). In a way that rupture spread radially, tsunami simulation was performed. Tsunami wave height data was collected at the same 12 fixed points and calculated the variability from median value of tsunami wave heights.

Throughout the statistical analysis of the above simulation cases, we found that the effect of risetime and rupture velocity on uncertainties of tsunami wave height is not negligible compared with the effect of static parameters. Standard deviation of tsunami wave heights due to risetime and rupture velocity is about 0.01-0.14 and 0.001-0.01 respectively. In the future, we will also investigate the standard deviation change depending on strike angle and distance from fault center.

These results are supposed to be taken into account in the probabilistic tsunami hazard analysis (PTHA) as the aleatory uncertainty. the PTHA might be improved for the future work.

Keywords: tsunami hazard assessment, probabilistic approach, rupture velocity

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Numerical simulation of tsunami in Suruga Bay by debris avalanche of Mt. Fuji

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After the 2011 Tohoku tsunami, the risk of the tsunami with mega-earthquake along the Nankai trough is examined. After a mega-earthquake occurs, it is said that volcanic activity becomes active near the plate boundary. The tsunami by a debris avalanche can be considered as influence of volcanic activity and mega-earthquake. When considering the disaster measures of the local area, it is necessary to also consider the danger of the tsunami by a debris avalanche.

In this study, the numerical simulation of tsunami is conducted by debris avalanche from Mt. Fuji. The inflow of debris avalanche is set around Port of Tagonoura and Kano River. The inflow length of debris avalanche is set 3.6 and 7.2km along shoreline. The total volume of debris avalanche is set 0.1 and 1.0 km3. The tsunami height in Suruga Bay is calculated based on these settings of debris avalanche. From the results of simulation, tsunami by debris avalanche is spread and goes toward the outside of Suruga Bay. This feature is the effect by Suruga trough with 2,500m depth. And the tsunami height becomes high 3m more over in Yaizu and Omaezaki. A shoal is located in the offing in Yaizu or Omaezaki and it is affected to propagation of tsunami. On the Izu Peninsula west side, it did not become high tsunami. There is no shoal in the bottom topography of Izu Peninsula of the Suruga Bay. It is thought that tsunami near Izu Peninsula was spread out of Suruga Bay.

Keywords: Tsunami simulation, debris avalanche, Suruga Bay, Mt. Fuji