J-SHIS - AN INTEGRATED SYSTEM FOR SHARING INFORMATION ON NATIONAL SEISMIC HAZARD MAPS FOR JAPAN

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Abstract

The National Seismic Hazard Maps for Japan （NSHMJ） are issued by a governmental organization, the headquarters for earthquake research promotion of Japan, to estimate strong motions caused by earthquakes that could occur in the future and show the estimated results on the maps. The NSHMJ consists of two types of maps that are different in nature: the probabilistic seismic hazard maps and the scenario earthquake-shaking maps for specified seismic source faults. The probabilistic seismic hazard maps are based on the PSHA that combines long-term evaluations of earthquake occurrence and strong motion evaluation.

An integrated system of Japan seismic hazard information station (J-SHIS) has been developed since 2005 for sharing NSHMJ information. The system manages various data in an integrated manner, including provide detail NSHMJ information and site amplification models with a 250m mesh resolution, and the deep subsurface velocity structure models. The system is also capable of providing these data in a user-friendly manner by showing them over background maps. This J-SHIS system is a web mapping system based on open source software that allows public users to easily view various data by Internet browsers.

Based on the lessons learned from the 2011 Great East Japan Earthquake disaster, the revised NSHMJ have been published. In order to meet increase of need to promote the understanding of seismic hazard assessment, we added a new function to the J-SHIS for viewing NSHMJ either in PC or a portal smartphone. Moreover, we provide a service of 'Seismic Hazard Karte', an integrated information system on seismic hazard for every 250m mesh.

In order to promote the utilization of J-SHIS data in interoperable system, development of J-SHIS Web application programming interface (API) has been progressed. Based on the API, several applications in smart phones that use J-SHIS data are newly published. Moreover we have been developing the J-SHIS functions as a basis for transmitting seismic hazard information for needs of earthquake disaster reduction in municipals and governments.

Keywords: Japan Seismic Hazard Information Station (J-SHIS), Seismic Hazard Assessment (SHA), Probabilistic Seismic Hazard Map (PSHM), Scenario Earthquake-Shaking Map (SESM)

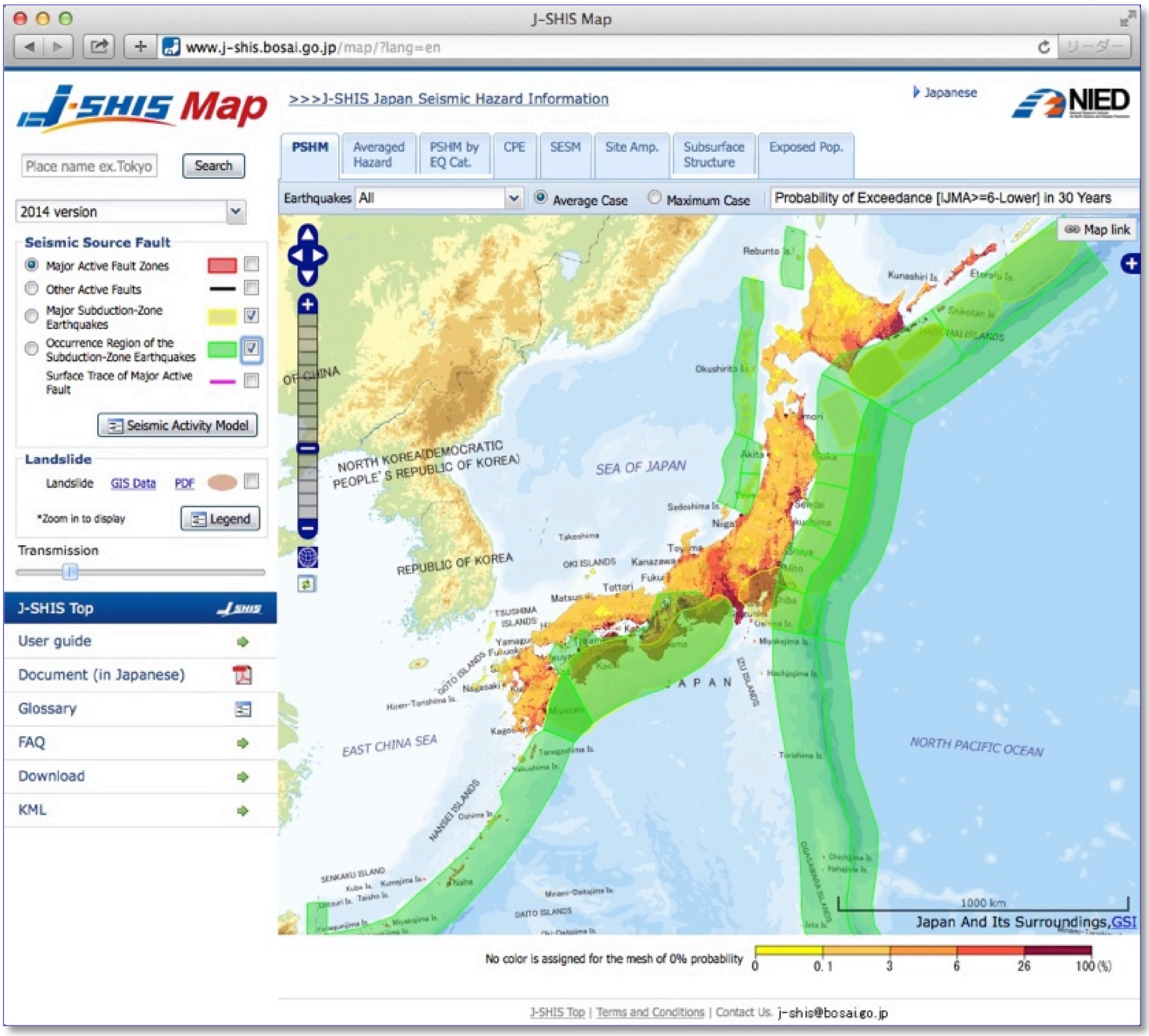
1. Introduction

Aimed contributing to a national fundamental policy of earthquake disaster prevention, a national seismic hazard map (NSHM) for Japan is issued by a governmental organization of the headquarters for earthquake research promotion (HERP) of Japan. HERP evaluates the scale and probability of future earthquakes based on the results from studies of the past earthquakes in the major active fault zones and subduction-zones, and publishes the evaluation results.

The NSHM consists of two types of natural different maps: the probabilistic seismic hazard assessment (SHA) map and the scenario earthquake-shaking map (SESM) for specified seismic source faults. In order to share NSHM information and communicate not only with the decision makers but also with the public and societies, Japan seismic hazard information station (J-SHIS) has been developed since 2005 [1,2]. This J-SHIS system provides a web mapping system based on open source software that allows public users to easily view various data by Internet browsers.

Along with the seismic hazard map displayed as much as detail to about 250m meshes, an integrated system with the new Web GIS technology, the J-SHIS was operated since July 2009. The system manages various data in an integrated manner, including provide detail NSHM information and site amplification models with a 250m mesh resolution, and the deep subsurface velocity structure models. The system is also capable of providing these data in a user-friendly manner by showing them over background maps.

Based on the lessons learned from the 2011 Great East Japan Earthquake disaster, the revised NSHM for Japan have been published [3,4,5,6,7,8]. In order to meet increase of need to promote the understanding of



seismic

Fig. 1 Top page of J-SHIS map.

hazard assessment, we added new functions to the J-SHIS for viewing NSHM maps either in PC or a portal smartphone.

Moreover, we provide a J-SHIS API service for application developers. The 'Seismic Hazard Karte' is one of examples for public to know seismic hazard information for an interested location as much detail as to about 250m resolutions. In this paper, we mainly introduce the features of J-SHIS map (Fig. 1).

2. Concept of J-SHIS Map

In the J-SHIS map, it is possible to display a variety of information about the earthquake hazard on Geospatial Information Authority of Japan (GIAJ) map or Google map. Since June 2014, the GIAJ map has been used as the formal background map (Fig.1a), however, it is possible to switch to Google background map to be displayed. Once enlarged map to identify a mesh, it is possible to display information about the mesh. Furthermore, J-SHIS provides effective ability to download the data used in the calculation results or calculation.

J-SHIS map can display both of natural different maps: the probabilistic seismic hazard assessment (PSHA) map and the scenario earthquake-shaking map (SESM) for specified seismic source faults. The PSHA map has been updated every year since 2005, the current system can be traced back to those created in 2008 in what the map as a reference date of January 1, 2014 is up to date. Further, after the 2011 Great East Japan Earthquake, the studied models in 2012 and 2013 on the basis of plurality of seismic activity model can be displayed respectively.

In order to aid in understanding of the various types of hazard information in the J-SHIS map, we opened a J-SHIS Portal to describe how to use J-SHIS Portal and technical terminologies, such as clarify a difference of magnitude and intensity, a difference of earthquake and ground motion, a difference in the exceedance probability of occurrence probability and the ground motion of the earthquake. Furthermore, terms and concepts have been described for properly understand the information in the map.

3. Display function of Probabilistic Seismic Hazard Assessment (PSHA) map

To display the probabilistic seismic hazard map (PSHM) in the J-SHIS map, the left four shortcut keys for PSHA maps (Fig. 1) have been settled on the top line of 1) [PSHM]: Probabilistic seismic hazard map; 2) [Averaged Hazard]: Long period of time average hazard, 3) [PSHM by EQ Cat.]: Earthquake category PSHM map; 4) [CPE]: Conditional Probability of Exceedance [1,2,8]. The shortcut key functions are described in detail as below paragraph 3.1 ~ 3.4. Both of PSHA map either [Average Case] or [Maximum Case] can be selectable on PSHM in the shortcut key 1 and 3 due to different logical theories of calculating the earthquake occurrence probability. The former is applied to by using a central value of the average recurrence interval and the latter by the estimated maximum value of earthquake occurrence probability.

3.1 Probabilistic Seismic Hazard Map

In the shortcut key [PSHM], a PSHA map with probability of exceedance [a given Intensity JMA (IJMA) >= 5-Lower, 5-Upper, 6-Lower and 6-Upper or more] in 30 years can be selectable displayed. And alternatively, an IJMA map for 3%, 6% probability of exceedance in 30 years, or an IJMA map for 2%, 5%, 10%, and 39% probability of exceedance in 50 years can also be selectable displayed. More alternatively selectable PSHMs are extendable for Peak Ground Motion (PGV) and Peak Bedrock Motion (PBV) maps. More detail, people can zoom in to a particular mesh size to possibly display the detail hazard curves. In addition to displaying by considering all the earthquakes, people can also by choosing different seismic category as described in section 3.3.

3.2 Long-term evaluation

In the shortcut key [Average Hazard], the expected intensities (IJMA) maps of earthquake ground motions can be selectable at the given probability of exceedance, with long-term return period from 500 up to 100,000 years [8]. This kind of evaluation is called long-term evaluation because it handles at least next several decades. The probabilistic seismic hazard maps (PSHM) are prepared based on these evaluation results.

The map is created to represent an effect of earthquake that has relatively low probability but could cause strong motion, which is added after the lessons learnt from the 2011 Great East Japan Earthquake. The conventional PSHM have difficult to capture the low frequency effects of ground motion hazard caused by subduction-zone earthquake. The long-term average hazard map can be considered as one of alternative solutions to capture the earthquake ground motion hazard with a low frequency. All of earthquakes in the map are evaluated as Poisson process in seismic activity model. For example, a map of "Return Period of 1,000-year", which is equivalent to "3% Probability of Exceedance in 30 Years" in PSHM shows distribution of intensities that will possibly experience once in 1,000 years. Earthquakes around Japan can be cataloged by the return periods as:

- 1,000-year: Major subduction-zone earthquakes
- 10,000-year: Almost all of subduction-zone earthquakes and earthquakes on major active fault zones
- 100,000-year: Almost all of earthquakes including those of without specified source faults

3.3 Earthquake Category map

In the shortcut key [PSHM by EQ Cat.] that stand for the PSHM by Earthquake Category, all of the earthquake sources are classified as three types of earthquake category I, II, and III in terms of its properties to make the seismic hazard information usable well [1].

Category I is the subduction-zone earthquakes with specified seismic source faults. The Mega earthquakes in subduction zones with a recurrence interval of several hundred years are belongs this category, such as so-called Nankai Trough earthquakes (Nankai Earthquake/Tonankai Earthquake/Assumed Tokai Earthquake), the Great East Japan Earthquake (2011 type) [8].

Category II is subduction-zone earthquakes without specified seismic source faults. The Interplate / Intraplate earthquakes without specified source faults are belongs this category with relatively high frequency of occurrence, such as so-called the large interplate earthquakes in Northern Sanriku-Oki, the Miyagi-ken-Oki Earthquake.

Category III is shallow earthquakes in land area and in sea area. The earthquakes with a recurrence interval of several thousands of years, the earthquakes without specified source faults in land area and in the surrounding sea area are belongs this category, such as characteristic earthquakes occurring in major active fault zones, earthquakes occurring on active faults other than major active fault zones, earthquakes occurring at onshore locations where active faults have not been specified. Since the low epicenter of this category, the seismic intensity can possibly reach to IJMA 6-Upper.

To show a relative influence in whole of Japan, the PSHM by Earthquake Category I, II and III indicate probability distribution in quartiles on the given intensity 5-Lower, 5-Upper, 6-Lower, and 6-Upper. The four level darkness colors are allocated to represent the four equivalent-quantities of datasets where the whole meshes are sorted based on its exceedance probability with a descending order.

The PSHM Contribution Factor maps display distributions of the most contributive earthquake category, which are based on the exceedance probabilities of each category. The Contribution Factor at each site varies dependent on the ground motion level. Therefore, local communities may make countermeasure to the most contributive earthquake category based on the contribution factor.

3.4 Exceedance probability map with conditions

In the shortcut key [CPE] that stands for conditional exceedance probability, the possible probability of exceedance map with expected seismic intensity (IJMA >=5-Lower, 5-Upper, 6-Lower, and 6-Upper) can be shown once a fault is specified and in case the scenario earthquake occurred at assumed fault. And in the same time, the expected average intensities (IJMA) map of earthquake ground motions can be displayed.

4. Display function of Scenario earthquake map

In the shortcut key [SESM] that stands for "scenario earthquake shaking map", the strong motion simulation results in terms of different cases can be selectable once a fault is specified and in case the scenario earthquake occurred at assumed fault. The shaking intensity of IJMA and peak ground velocity (PBV) can be shown on SESM map. To zoom the map to particular meshes, it is possible to display the velocity waveforms in the engineering bedrock of the mesh. In addition, there is also the ability to download the waveform data.

5. Display function of underground structure model

5.1 Site amplification

In the shortcut key [Site Amp.] that stands for "Site amplification factor", three kinds of surface geologic maps can be selectable as 1) Site amplification factor, 2) Average shear-wave velocity in the upper 30m depth and 3) Engineering geomorphologic classification. These three kinds of maps have been used in both of PSHA map and SESM map.

1) Site amplification factor
   This map shows distribution of amplification factors that obtained from the upper 30m average S-wave velocity (AVS30). The amplification factor means amplified ratio calculated from the engineering bedrock (Vs=400m/s) up to ground surface.
2) Average shear-wave velocity in the upper 30m depth
   This map shows distribution of the average S-wave velocity down to 30m in depth.
3) Engineering geomorphologic classification
   This map offers the geomorphologic classification map for the whole of Japan, divided by a standard way in the mesh of approximately 1km and 250m. By upgrade spatial resolution of the classifying the geomorphologic attribute, accuracy of the mesh 250m has improved in the 2009 (and later) version [10].

5.2 Subsurface Structure

In the shortcut key [Subsurface Structure], the 3D deep subsurface structure models have been databased for carrying out the strong motion simulation in the whole of country. The 28 layers of sedmentary or geological structure can be selectable from subsafce with a shear wave velocity of 350m/sec down to engineering bedrock of 400-600m/sec, and to the seismic bedrock of 2700-2900m/sec. The color gradation of the map may also be selectable either distribution of elevation or depth of the upper boundary of the each layer. To zoom the map to particular mesh area, it is possible to display the velocity structures in the area [9].

6. Web API develop for the J-SHIS promotion

In order to promote the utilization of J-SHIS data in interoperable system, development of J-SHIS Web application programming interface (API) has been progressed [11]. Based on the integrated system of http://www.j-shis.bosai.go.jp/ map/?lang=en, we have developed a J-SHIS Web API in machine-readable data format to provide powerfully function to promote J-SHIS information. This development environmental made possible for professional to develop various applications of seismic hazard information, such as smartphone application and Web system development [11,12]. Therefore, several applications in smart phones that use J-SHIS data are newly published. One of examples is the J-SHIS smartphone version. “Smartphone tells hazard” that was realized on a smartphone, a tablet and/or PC. At a given spot, the comprehensive information of SHA map can be easily obtained as indicated figures. Another examples is based on Web site, “Seismic Hazard Karte tells more” that was try to help end user and public have a better understanding of seismic environmental around.

7. Summary

In this paper, we have mainly introduced the integrated Japan Seismic Hazard Information Station (J-SHIS), a map browsing system. J-SHIS was developed for sharing seismic hazard assessment information started since May 2005. The J-SHIS system provides a display map function with four shortcut keys of 1) Probabilistic seismic hazard map (PSHM), 2) Long-term average hazard, 3) Earthquake category PSHM map and 4) Conditional Probability of Exceedance. The system also manages various database in an integrated manner, including provide detail downloadable NSHM information, site amplification models with a 250m mesh resolution, and the deep subsurface velocity structure models.

The most of J-SHIS data displayed on screen is available to download for professional, such as calculation of earthquake insurance rate, consulting services for local communities, earthquake resistance assessment and safety for the facility, basic database of damage estimation for local municipals and governments, real estate-related business, house maker and construction company.

We also provided population exposure to seismic intensity to show distribution of population exposed to a certain level of seismic intensity during a scenario earthquake. The landslide distribution occurred in the past have been provided.

In addition to transfer the updated earthquake hazard information to experts, decision makers, we also want to strive to get more public to use SHA information. We provided the J-SHIS Portal side for guide the seismic hazard assessment information, and provided J-SHIS API service for application developer. The Karte is available example APP for public.

J-SHIS becomes know by more and more people, we continuously provide and update the authorized NSHMs. In order to further transmission of our efforts to the world, it has promoted the internationalization of the J-SHIS [13].

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