Let's look at National Seismic Hazard Maps

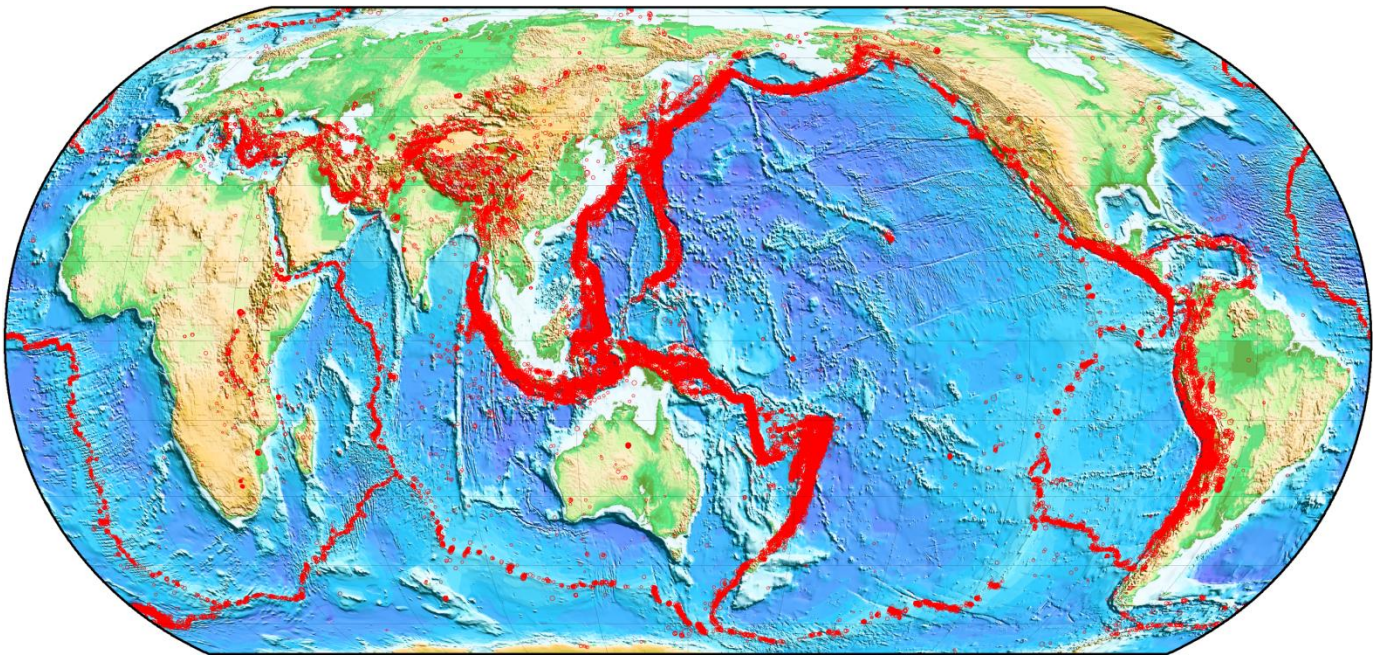
Introduction

The Headquarters for Earthquake Research Promotion, which was set up immediately after the Great Hanshin-Awaji Earthquake Disaster, seeks to mitigate seismic damage through promoting survey and research earthquakes and communicating these results to the public. The National Seismic Hazard Maps are part of these efforts. Herein, we describe the key features of the seismic hazard maps in the interest of enabling the public to understand and utilize them effectively.

Strong ground shaking likely throughout Japan

Earthquakes do not occur everywhere on our planet. Some regions experience frequent earthquakes while others do not. The red dots on the world map shown below denote earthquakes of magnitude 5 (M5) or larger that occurred between January 1977 and December 2012. The area of Japan is less than 1% of that of the world; however, approximately 10% of the earthquakes around the world occurred in and around Japan during this period. Japan has a much higher probability of experiencing earthquakes compared to other countries. Thus, all regions of Japan have a greater possibility of experiencing severe ground shaking due to earthquakes.

Earthquakes distribution in the world

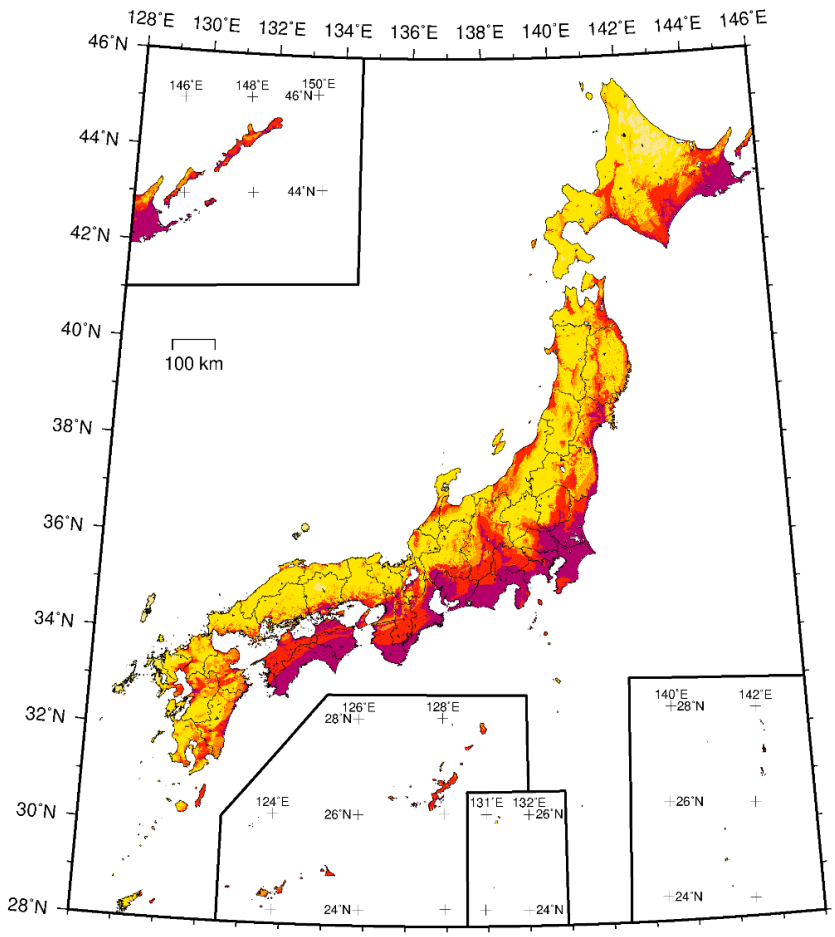


*Hypocenter data were provided by the USGS (U.S. Geological Survey). Topographic data were obtained from the ETOPO5 model developed by NOAA (National Oceanic and Atmospheric Administration). This map was created using Generic Mapping Tools (GMT).

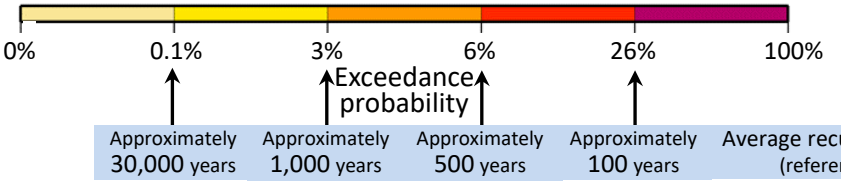
The probability of strong ground shaking in Japan

The figure below is a seismic hazard map that depicts the “probability of ground shaking of Japan Meteorological Agency (JMA) seismic intensity 6-Lower or higher within the next 30 years from 2020”. Herein, we use the original Japanese scale of the seismic intensity (JMA seismic intensity) as shown on page 5. The probability shown on the map is not the probability of occurrence of earthquakes at a particular site, but it is the probability of experiencing ground shaking with seismic intensity 6-Lower or higher at that site as a consequence of expected earthquakes in and around Japan.

Seismic hazard maps and the data used to produce them are utilized in regional disaster prevention strategies, seismic design, and ratings for property insurance. Furthermore, this information is used by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) to promote the efficient implementation of seismic reinforcements for school facilities and assess the urgency of earthquake-resistant projects for infrastructure, respectively.



Probability of ground shaking of JMA seismic intensity 6-Lower or higher within the next 30 years from 2020



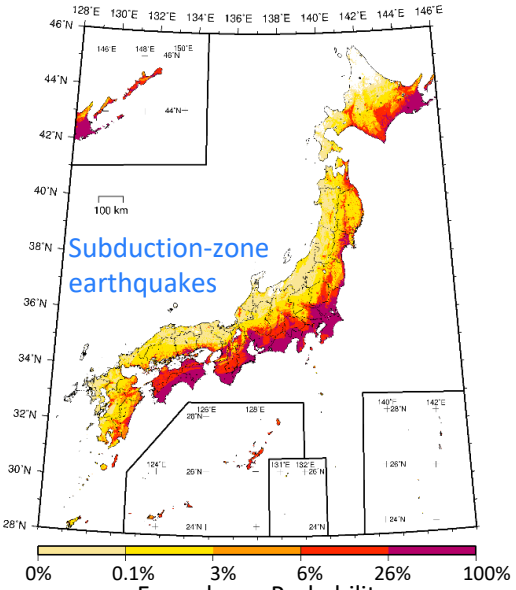
While Japan faces high seismic risk from a global perspective, the map presented on the left shows that the probability of a ground shaking exceeding a certain level of seismic intensity at a site is relatively high in only some regions (red-purple) and low in the others (light yellow). Furthermore, the probability tends to be higher toward the Pacific side of Japan. We must still point out that the entirety of Japan has the potential to experience strong shaking, as seen on the map on page 1.

The following pages explain the information provided by seismic hazard maps and the important points to consider when observing these maps.

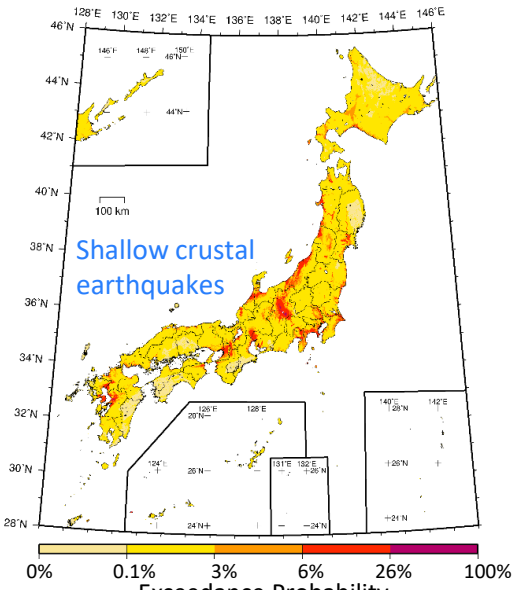
Note that 3% and 26% probabilities of seismic intensity 6-Lower or higher within the next 30 years are roughly equivalent to occurrences of such seismic intensity levels once every 1,000 years and 100 years, respectively.

What Seismic Hazard Maps tell us

Probability of ground shaking of JMA seismic intensity 6-Lower or higher within the next 30 years from 2020



The probability of ground shaking due to subduction-zone earthquakes



The probability of ground shaking due to shallow crustal earthquakes

●Why is the probability higher along the Pacific Ocean coast of Japan?

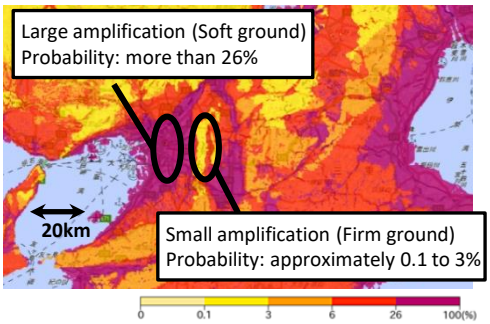
Two types of earthquakes occur in and around Japan. One is subduction-zone earthquakes, which occur near trenches (e.g., 2011 off the Pacific Coast; the Tohoku Earthquake). The other is shallow crustal earthquakes, which occur inland on active faults (e.g., the 1995 Hyogoken Nanbu Earthquake) or in sea areas near the coast. The map on the top left shows the probability of ground shaking equal to or higher than seismic intensity 6-Lower due to subduction-zone earthquakes, while the top-right map shows the probability of ground shaking due to shallow crustal earthquakes. Both probabilities are included in the probabilistic seismic hazard map on page 2.

Just off the Pacific Ocean coast of Japan, there are boundaries between the continental and oceanic plates, such as the Kuril Trench, the Japan Trench, and the Nankai Trough, where subduction-zone earthquakes occur. These earthquakes have short recurrence intervals spanning a few decades to 100 years. Therefore, the probability of experiencing shaking due to such earthquakes is higher in the Pacific coast region, as illustrated in the top-left map. In particular, the probability of earthquakes on the Pacific coast region of western Japan is quite high, because large earthquakes have occurred on the Nankai Trough at approximately 100-year intervals, the last of which occurred more than 70 years ago.

In contrast, the recurrence interval of shallow crustal earthquakes, e.g., active fault earthquakes, is generally around 1000 years or more. As the top-right map shows, the probabilities of experiencing shaking due to such earthquakes are generally less than those of subduction-zone earthquakes. However, many active faults, including unverified faults, are distributed throughout Japan, indicating the imminent possibility of an earthquake anywhere in Japan.

●Effects of ground shaking amplification by the subsurface layers

If we look at an enlarged view of the map (obtained from the National Research Institute for Earth Science and Disaster Resilience's Japan Seismic Hazard Information Station (J-SHIS), see page 5) showing the probability of ground shaking equal to or higher than seismic intensity 6-Lower, occurring within 30 years from 2020, the probabilities vary considerably from area to area, as shown in the map on the right. The reason for this difference is that the amplification of ground shaking varies considerably from area to area. Therefore, as shown in the map on the right, the probabilities will vary considerably in space depending on how the ground shaking is amplified by the subsurface layers at each site.



※Figure above is from the 2020 edition.

Points to keep in mind when looking at Seismic Hazard Maps

● "Low probability" does not always mean that it is safe

Japan is highly exposed to strong ground shaking caused by earthquakes compared to other countries around the world. Considering the earthquakes that have caused significant damage in Japan over the last 200 years, on average, subduction-zone earthquakes have occurred approximately once every 20 years, and shallow crustal earthquakes have occurred approximately once every 10 years. Even if there have been no recent earthquakes in your region, it does not necessarily mean your region is safe. Even in areas where the probability of ground shaking is relatively low, we must prepare ourselves for earthquakes. Large earthquakes, such as the 1983 Japan Sea Earthquake (M7.7), the 2005 Offshore West of Fukuoka Prefecture Earthquake (M7.0), and the 2007 Noto Peninsula Earthquake (M6.9) caused severe damage due to strong shaking in such low-probability areas. It can be said that the 1995 Hyogoken Nanbu Earthquake (M7.3) and the 2016 Kumamoto Earthquake (M7.3) caused extremely strong shaking in areas with a relatively high probability. Nevertheless, these earthquakes occurred in places where large earthquakes had not been documented recently.

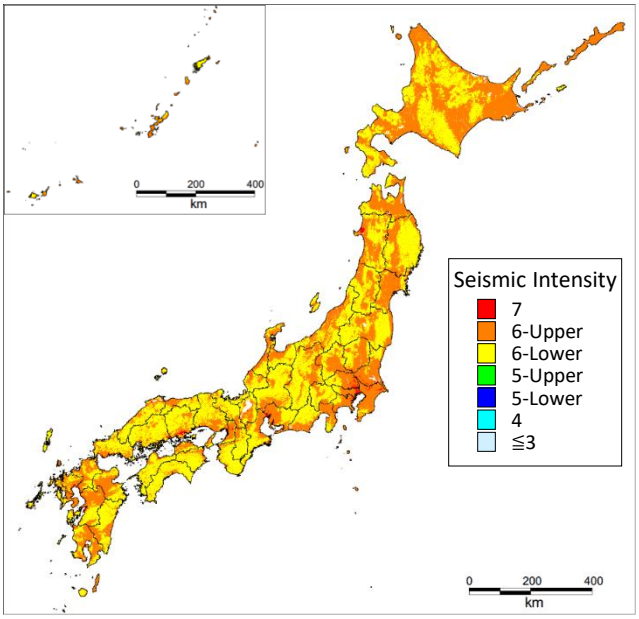
● Seismic Hazard Maps contain uncertainties

Seismic hazard maps are created based on data from the latest findings; however, the available information is limited. Therefore, the results involve uncertainties. For example, seismographs have only been installed for just over 100 years since the Meiji era (1868-1912); thus, modern observations cover a very short period in the long history of earthquakes. In addition, there are areas in Japan where investigations of active faults are still insufficient. For these reasons, seismic hazard maps contain uncertainties and even if the probability is low at present, future investigations may reveal the existence of previously unknown past large earthquakes or active faults, which may increase the probabilities of earthquake occurrences.

● What would happen if an M7 earthquake occurred directly below you?

For M7 earthquakes (comparable to the magnitude of the 1995 Hyogoken Nanbu Earthquake), we cannot necessarily find fault traces at the ground surface. This means that we cannot rule out the possibility of an M7 earthquake occurring in an area where fault traces due to past large earthquakes have not yet been discovered.

If an M7 earthquake strikes immediately below your house, how strong will the ground shaking be? We can observe the intensity level from the map on the right (this map is different from the seismic hazard maps we have discussed), which shows a distribution of seismic intensities from an M7 earthquake occurring directly under each area in Japan. We can observe that a seismic intensity of 6-Lower is possible anywhere in Japan, moreover, strong shaking is experienced in the plains and basins with soft ground and the shaking could reach a seismic intensity of 6-Upper or higher.

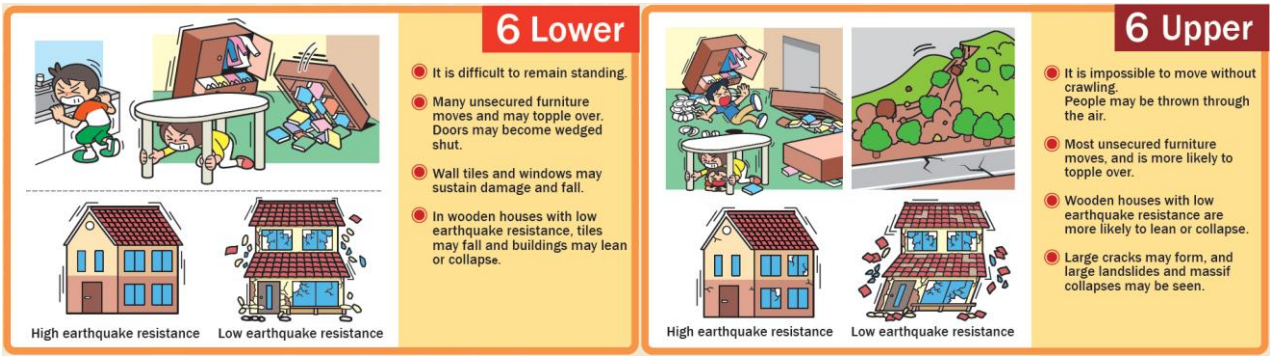


Seismic intensity map due to nearby M7 earthquakes * (Cabinet Office, 2013)

* This map was published by the Cabinet Office and shows the distribution of seismic intensities of Mw 6.8 earthquakes occurring directly under each area across Japan (assuming the depth of the upper edge of the fault is 4 km from the surface).
See http://www.bousai.go.jp/jishin/syuto/taisaku_wg/pdf/syuto_wg_siryo04.pdf (in Japanese).

● What would happen when shaking with a JMA seismic intensity of 6-Lower or 6-Upper occurred?

We have seen the maps of probability of ground shaking of JMA seismic intensity 6-Lower or higher within the next 30 years from 2020" on pages 2 and 3. What happens when severe ground shaking with seismic intensity 6-Lower occur? As shown in the figures below, wooden houses with low earthquake resistance may lean or collapse at seismic intensity 6-Lower, and such houses will increase in number and severity at a seismic intensity of 6-Upper or higher (see tables explaining the Japan Meteorological Agency, JMA, seismic intensity scale).



By Japan Meteorological Agency website (https://www.jma.go.jp/jma/en/Activities/intsummary.pdf)

● Available information on the Internet

You can view seismic hazard maps on the "Japan Seismic Hazard Information Station (J-SHIS)" website of the National Research Institute for Earth Science and Disaster Resilience website. This site allows you to zoom in and out of a map of Japan to investigate the "Probability of ground shaking of JMA seismic intensity 6-Lower or higher within the next 30 years" and the "severity of ground shaking". You can also check major active faults throughout Japan and the focal regions of subduction-zone earthquakes.

If you want to know the seismic intensity of the shaking for the occurrence of an earthquake at a particular active fault, you can refer to two different collections of maps; "the J-SHIS scenario earthquake shaking maps", and "Seismic Hazard Maps for Specified Seismic Source Faults" in "National Seismic Hazard Maps". Seismic hazard maps are updated to reflect the most recent data. Moreover, there are studies that are being conducted to make these maps easier to understand. Please refer to the homepage of the Headquarters for Earthquake Research Promotion for further information.

◆Japan Seismic Hazard Information Station (J-SHIS) https://www.j-shis.bosai.go.jp/en/
◆J-SHIS's Scenario Earthquake Shaking Map https://www.j-shis.bosai.go.jp/map/?lang=en
◆National Seismic Hazard Maps (in Japanese) https://www.jishin.go.jp/evaluation/seismic_hazard_map/shm_report/
◆The Headquarters for Earthquake Research Promotion https://www.jishin.go.jp/main/index-e.html
(in Japanese) https://www.jishin.go.jp/

● Steps to protect yourself during an earthquake

In the Great Hanshin–Awaji Earthquake Disaster, many people died due to the collapsing of buildings. We can reduce this type of disaster by construction and retrofitting of earthquake-resistant buildings. Grant subsidies may be available to evaluate the earthquake resistance performance of your house or to retrofit it. Furthermore, a house that has been retrofitted for earthquake resistance may be eligible for a tax reduction or an exemption. Therefore, please check with your local government office in the area where you live. Furniture toppling over during an earthquake also poses a danger; however, it is relatively easy to make furniture safe. Let's prepare for earthquakes by first doing what we can.

※This brochure, "Let's look at National Seismic Hazard Maps", was edited by Secretariat of the Headquarters for Earthquake Research Promotion, based on the discussion at the Earthquake Research Committee of the Headquarters for Earthquake Research Promotion and at related subcommittees.