National Seismic Hazard Maps for Japan (2020)

Guide & Commentary

English version
Translated in January 2026
Earthquake Research Committee,
Headquarters for Earthquake Research Promotion

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Guide & Commentary

Table of Contents

*The "National Seismic Hazard Maps for Japan (2020) Guide & Commentary" is a document written by the Secretariat of the Headquarters for Earthquake Research Promotion, based on discussions in the Earthquake Research Committee of the Headquarters for Earthquake Research Promotion and related subcommittees.

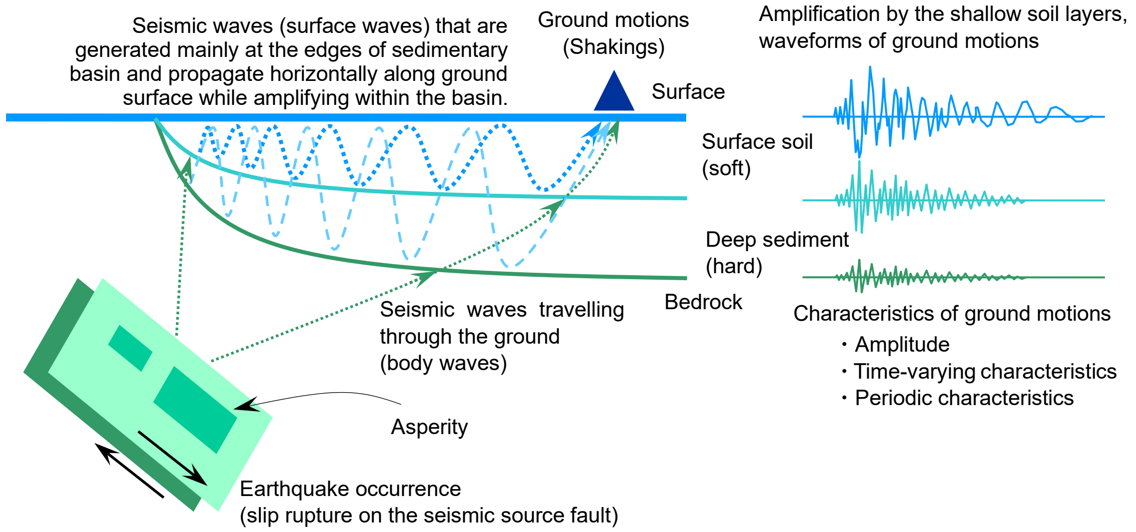
Guide to National Seismic Hazard Maps for Japan

National Seismic Hazard Maps for Japan – Introduction

What is “ground motion”?

When an earthquake occurs, the ground and buildings experience shaking. An earthquake is a natural phenomenon in which strain gradually accumulates in deep subsurface rocks, causing slip rupture in the rocks. When a slip rupture occurs, seismic waves propagate through the ground and along the ground surface. When seismic waves reach a site, the resulting shaking are called "ground motion."

Although ground motions are often termed earthquakes in everyday language, this book distinguishes between earthquakes, seismic waves, and ground motions.



Earthquake (slip rupture of fault) / Seismic waves (waves propagating through the ground or on the ground surface) / Ground motions (shakings)

★Characteristics of ground motions

The characteristics of ground motions depend on the features of slip rupture on the seismic source fault (the fault that causes the earthquake), the propagation of the seismic waves, and the local soil response to shaking. These characteristics are represented by three elements: amplitude (the intensity of shakings), time (the variation in shaking over time), and period (whether the shaking is rapid and abrupt or it is slow with longer oscillation periods).

★Attenuation of ground motions with distance

The intensity of ground motion is influenced by both the earthquake magnitude and the distance from the seismic source. A larger earthquake magnitude and a shorter distance to the source result in stronger ground shaking, affecting a broader area and extending farther from the source.

★Fault models and asperities

The hypocenter is a point on the fault plane where the rupture initiates, with the rupture propagating into the fault plane. Thus, the model representing this rupture process is called the "fault model." In reality, slip distribution across the seismic source fault plane is non-uniform. The main rupture region, where major parts of ground motions are generated, is known as the "asperity."

★Engineering bedrock and shallow soil layers

The geological layers in a region that possesses sufficient stiffness and strength to support high-rise structures are defined as "engineering bedrock." Ground motions on the top of engineering bedrock can be typically analyzed without considering the effect of the overlying layers. Since the amplification characteristics of seismic ground motion vary substantially across sites due to shallow soil layers above the engineering bedrock, site-specific response analyses are typically conducted.

Relevant descriptions → Commentaries on National Seismic Hazard Maps for Japan 33, 34, 51

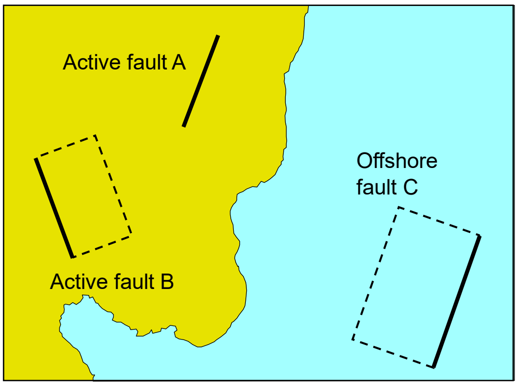
National Seismic Hazard Maps for Japan – Introduction

Basic concepts of the Seismic Hazard Map for a specified seismic source fault (Seismic Hazard Map for a scenario earthquake)

The National Seismic Hazard Maps include two types of maps: a "Seismic Hazard Map for a specified seismic source fault (Seismic Hazard Map for a scenario earthquake)" and a "Probabilistic Seismic Hazard Map."

A **Seismic Hazard Map for a Specific Seismic Source Fault (Seismic Hazard Map for a scenario earthquake)** illustrates the spatial distribution of estimated ground shakings at individual sites for a specific earthquake.

(1) The fault parameters of an earthquake occurring at a specific seismic source fault are determined using the strong ground motion prediction method ("Recipe"), based on the long-term evaluation (refer to “Commentaries on National Seismic Hazard Maps for Japan” for long-term evaluation and “Recipe”).



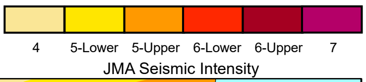
Macroscopic Fault Parameters:
- Location of the fault
- Magnitude
- Length and width of the fault plane
- Dip angle of the fault plane
- Depth of the fault top

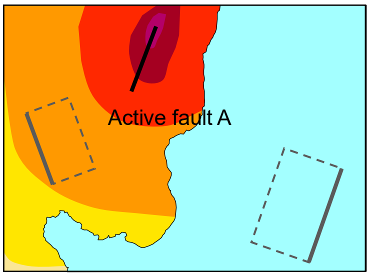
(2) The rupture initiation point, rupture process characteristics, and geological structure are taken into account:

- Slip direction
- Location of the asperities
- Slip, stress drop, etc. in the asperities and the surrounding background region

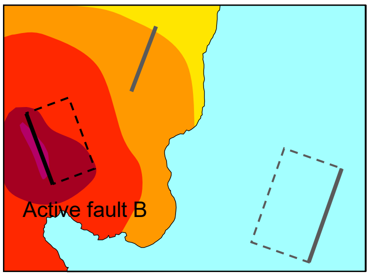
(3) Considering the distance from the seismic source fault and site amplification effects due to the local ground conditions, Ground motions are computed for each surface grid cell.

(4) The resulting hazard maps illustrate the distributions of ground shakings for scenario earthquakes. The results vary depending on the rupture processes and site conditions described in steps (2) and (3).

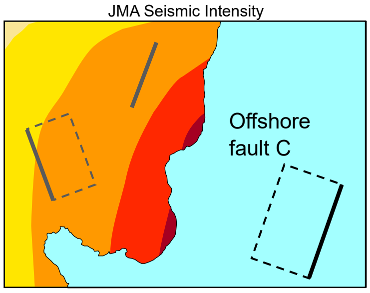




Seismic hazard map for an earthquake on active fault A



Seismic hazard map for an earthquake on active fault B



Seismic hazard map for an earthquake on offshore fault C

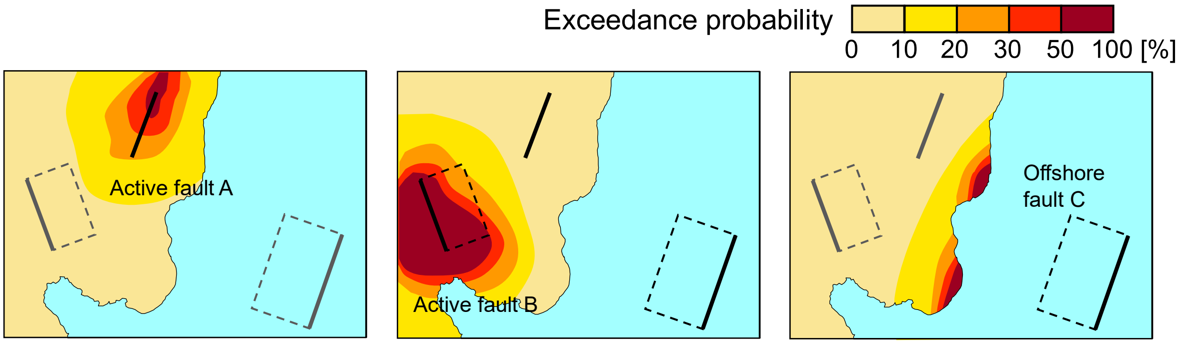
To Probabilistic Seismic Hazard Map (next page)

National Seismic Hazard Maps for Japan – Introduction

Basic concepts of a Probabilistic Seismic Hazard Map

A **Probabilistic Seismic Hazard Map** shows a distribution of calculated probabilities (of exceedance) and intensities of shakings at individual sites, based on the locations, magnitudes, and probabilities (of occurrence) for all earthquakes that can be considered at present.

(1) The distribution of the probabilities of shakings at individual sites exceeding a specific seismic intensity for an earthquake is computed. The result is multiplied by the probability of occurrence of the relevant earthquake based on a long-term evaluation.



Probability of the intensity of shaking due to earthquake on active fault A exceeding a certain level.

×

Probability of earthquake occurrence on active fault A:
Ex. 5% within the next 30 years

Probability of the intensity of shaking due to earthquake on active fault B exceeding a certain level.

×

Probability of earthquake occurrence on active fault B:
Ex. 0.05% within the next 30 years

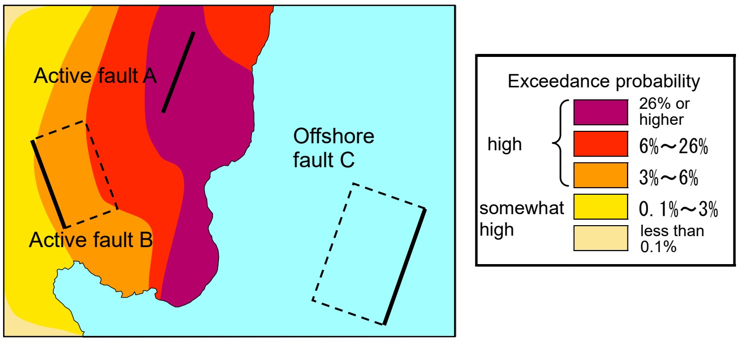
Probability of the intensity of shaking due to earthquake on offshore fault C exceeding a certain level.

×

Probability of earthquake occurrence on offshore fault C:
Ex. 50% within the next 30 years

↓

(2) All earthquakes in the peripheral area, including those difficult to be specified in advance, and the probabilities of shakings caused by them are used to produce a Probabilistic Seismic Hazard Map (a distribution map of probability) for the next 30 years. Conversely, a map can be generated to show the expected ground motion level corresponding to a fixed probability of exceedance.



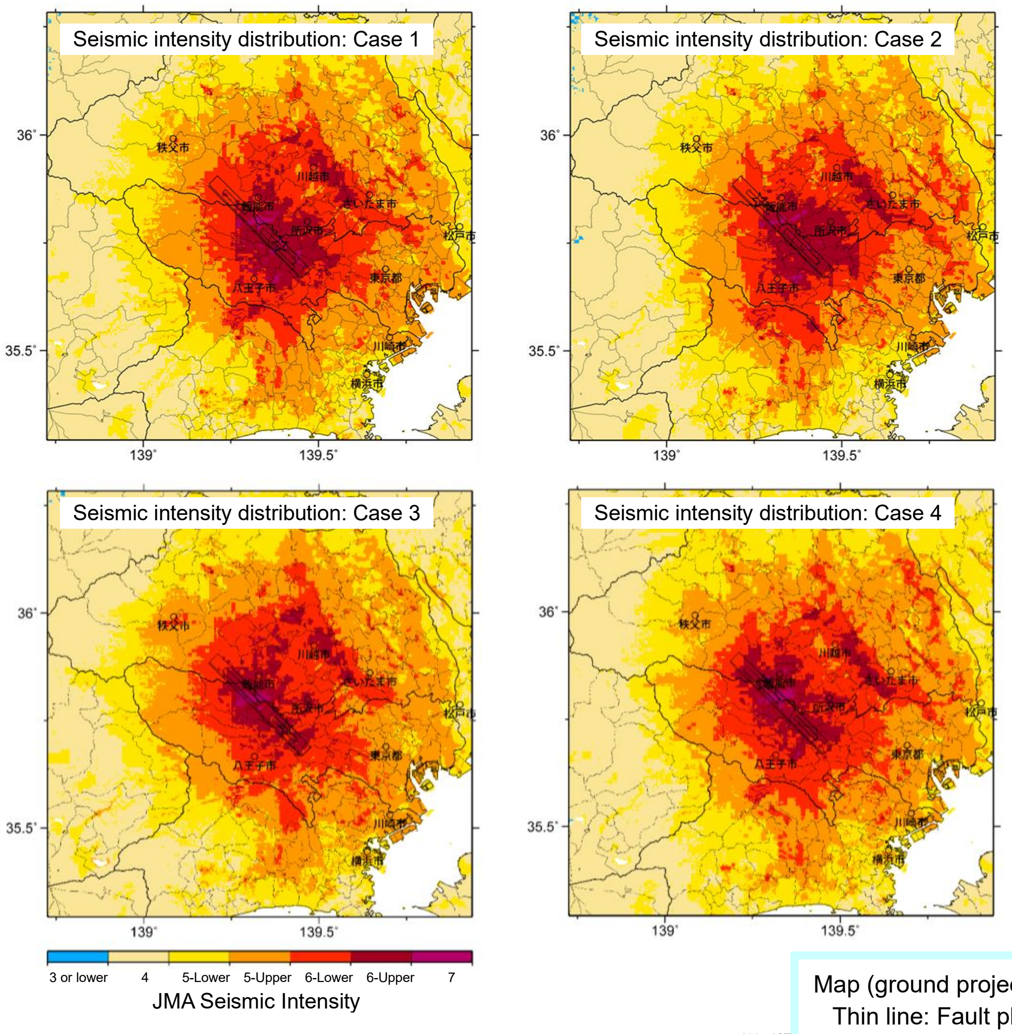
In this example, as the probability of earthquake occurrence on active fault B is only 0.05% in 30 years, the entire distribution in the Probabilistic Seismic Hazard Map is mainly dominated by the earthquakes on active fault A and offshore fault C, where the probabilities of occurrence are high.

The "National Seismic Hazard Maps (Probabilistic Seismic Hazard Maps)" published annually by the Earthquake Research Committee since 2005 were reproduced based on the above-described concepts.

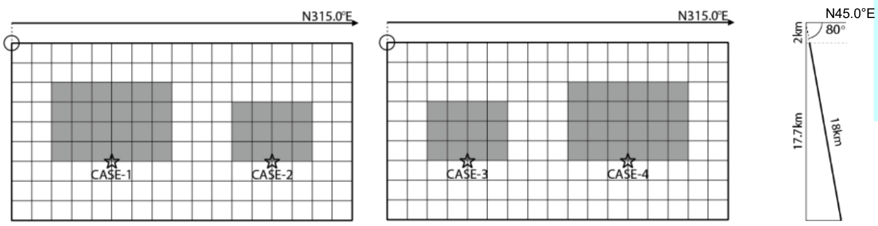
Relevant descriptions → Commentaries on National Seismic Hazard Maps for Japan 31, 32, 35, 36, 48, 49, 57

Seismic Hazard Maps for Specified Seismic Source Faults (Seismic Hazard Maps for Scenario Earthquakes)

Example of strong ground motion prediction based on the strong ground motion prediction method for earthquakes with specified source faults (“Recipe”) (example of the Tachikawa fault zone in the 2020 edition)



Map (ground projection) legend
Thin line: Fault plane
Thick line: Asperity
☆symbol: Rupture initiation point



Layout of asperities and rupture initiation points Cross-section

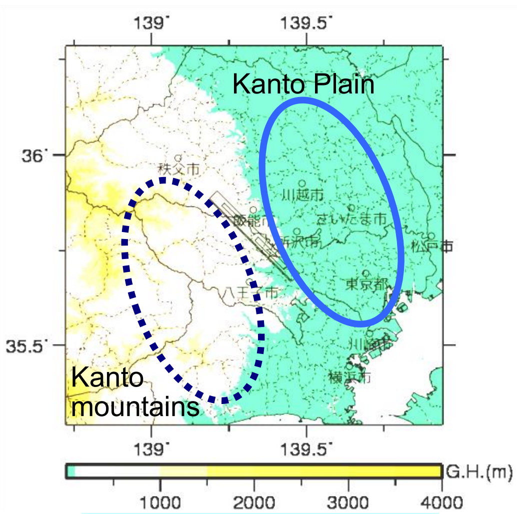
The Seismic Hazard Map for specified seismic source faults (Seismic Hazard Map for scenario earthquakes) illustrates **the regional distribution of shakings resulting from the fault ruptures, according to the assumed rupture mode (scenario)**. Since 2009, seismic intensity distributions on the ground surface from earthquakes along major active-fault zones across the country have been predicted based on a standardized nationwide strong ground motion prediction method (“Recipe”). In the Map, **several representative rupture scenarios** are assumed. The results of these scenarios demonstrate **the diversity and complexity** of the fault rupture phenomena, and the information can be leveraged for disaster prevention. In the above example, representative arrangements of two different sizes asperities (the main rupture areas on the fault plane) are considered. For these two examples of the asperities arrangement, In Cases 1 and 3, the rupture is assumed to initiate from the southeast asperity, while in Cases 2 and 4, it is assumed to initiate from the northwest asperity.

Interpreting Seismic Hazard Maps for Specified Seismic Source Faults

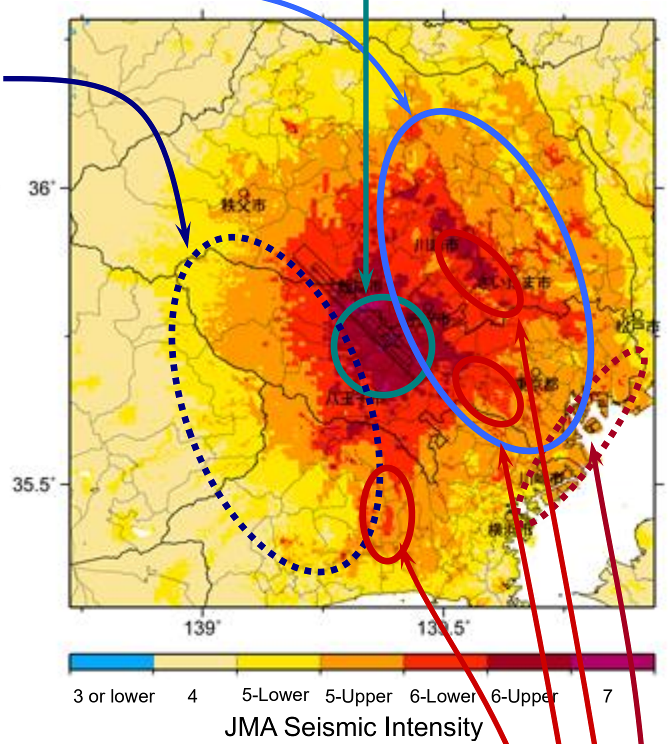
Example of strong ground motion prediction based on the strong ground motion prediction method for earthquakes with specified source faults (“Recipe”) (example of Case 1 of the Tachikawa fault zone in the 2020 edition)

In plains or basins with thick soft sedimentary strata, ground motions are significantly amplified and are greater than those in mountainous areas or plateaus. In this example, despite the symmetric positions with respect to the fault, the easter part of Kanto plain experiences larger ground motions compared to the western Kanto mountainous area.

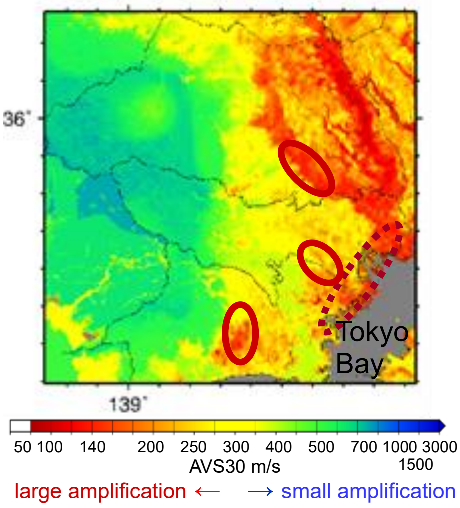
The areas immediately above or close to an asperity (the main rupture area on the fault plane from where seismic waves that dominate ground motion originate) experience strong ground motions.



Terrain around the seismic source fault



Distribution of seismic intensities on the ground surface



Surface AVS30 distribution in shallow soil layers

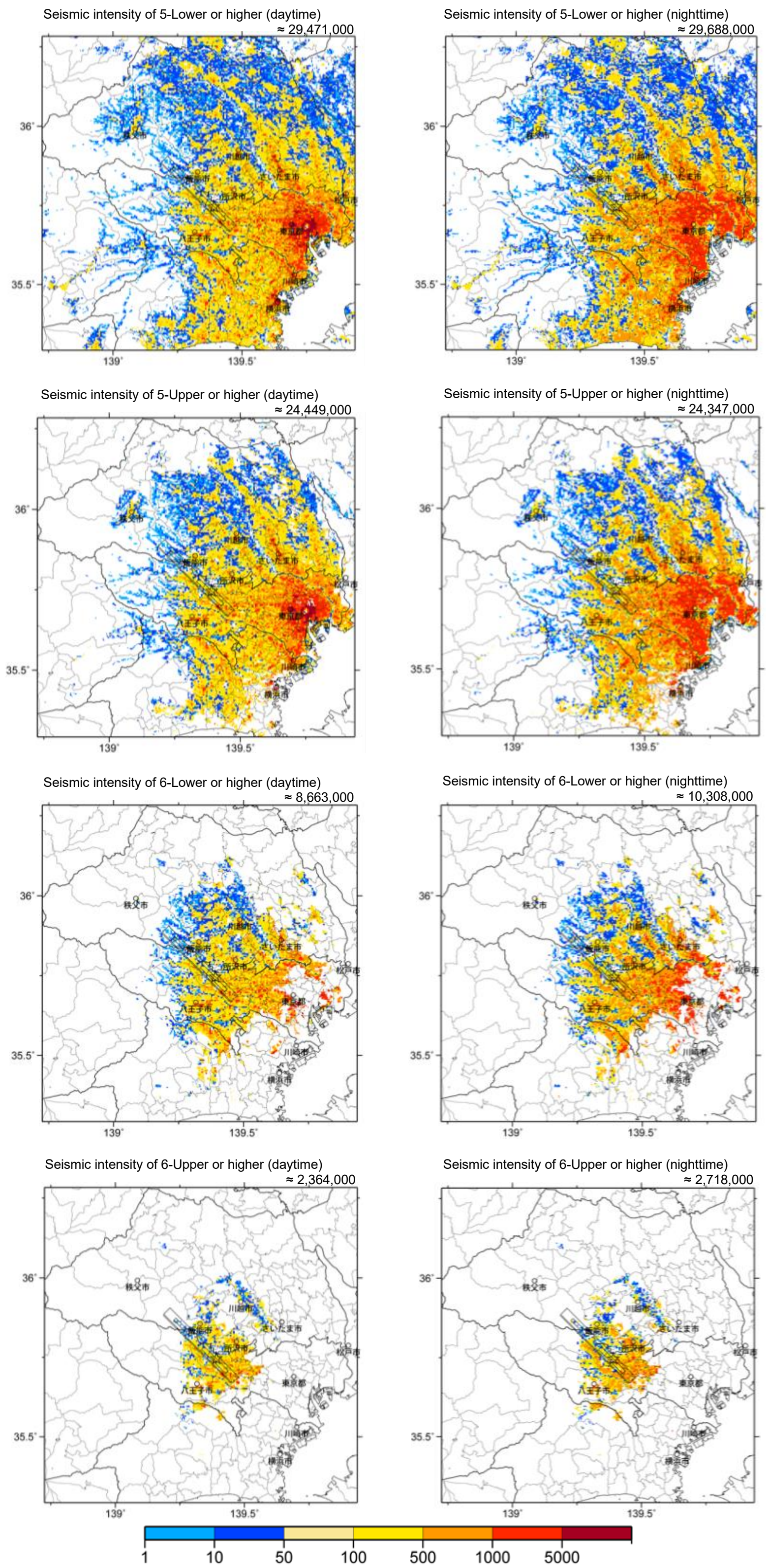
Areas with soft shallow soil layers experience large amplifications and strong ground motions.

In the example shown above, lowlands along the Sagami River, lowlands along the Tama River, lowlands along the Arakawa River, and lowlands around the Tokyo Bay experience strong ground motions compared to that in the neighboring areas.

Relevant descriptions → Commentaries on National Seismic Hazard Maps for Japan 49-56

Population Exposed to a Specified Seismic Intensity

Population exposed to shaking intensity greater than specified seismic intensity (example of Case 1 of the Tachikawa fault zone in the 2020 edition)



Population exposed to a specified seismic intensity
(number of people per grid cell)
(number in upper right corner of each figure is total population exposed to seismic intensity in the area)

To utilize the National Seismic Hazard Maps for earthquake disaster prevention and risk assessments, a new approach was developed to generate National Seismic Hazard Maps with specified source faults (National Seismic Hazard Maps for scenario earthquakes) by combining seismic intensity distribution with the latest population distribution data. Populations exposed to shaking intensity greater than a specified seismic intensity in an approximately 250-m grid cell was determined and color-coded according to population on a map.

This approach allows for an approximate estimation of the target population and its distribution according to the source fault, rupture scenario, seismic intensity level, and time zone (day or night). Additionally, estimations can be tabulated by prefecture and municipality. This information can be used to make preliminary assessments of damage distribution across a region.

*The population data used are as follows. The standard regional data were arranged in an approximately 500-m grid cell (1/2 regional grid cell), with equal division into approximately 250-m grid cells (1/4 regional grid cell).
[Daytime population]
Regional grid cell statistics with links to the 2010 National Census, 2009 Economic Census and Basic Survey, etc.
[Nighttime population]
Regional grid cell statistics for the 2010 National Census

*Representative examples of maps with seismic intensities of “6-Lower or higher” and “6-Upper or higher” were published in the Map edition, and all evaluation results that included these examples were published in J-SHIS.

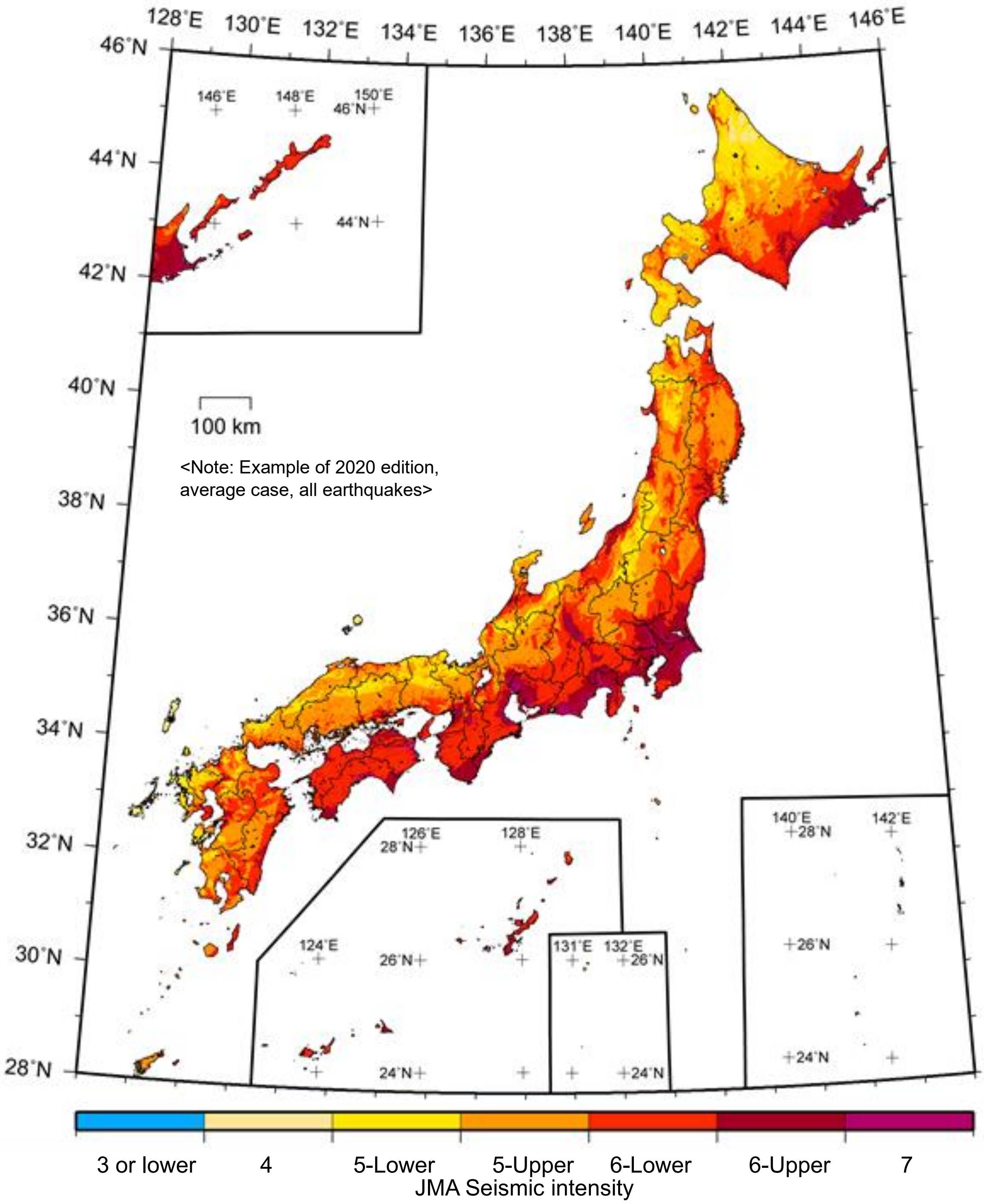
Relevant descriptions → Commentaries on National Seismic Hazard Maps for Japan 56

Probabilistic Seismic Hazard Map

Example of seismic intensities distribution map for 3% probability of exceedance within the next 30 years

The Probabilistic Seismic Hazard Map plots the "intensity", "period", and "probability" of ground motions experienced at each site in the country based on the locations, magnitudes, and probabilities of earthquakes that will occur in and around Japan. By fixing the "period" and either "intensity" or "probability", a map of the remaining parameter can be produced. The map below shows the distribution of seismic intensity, with "period" and "probability" fixed.

(Note: For Minami-Torishima Is. and Oki-no-Tori Shima Is., which are Japanese territories, are not included in the map due to the unavailability of input data required for the computation. Lakes and rivers are shown in white.)

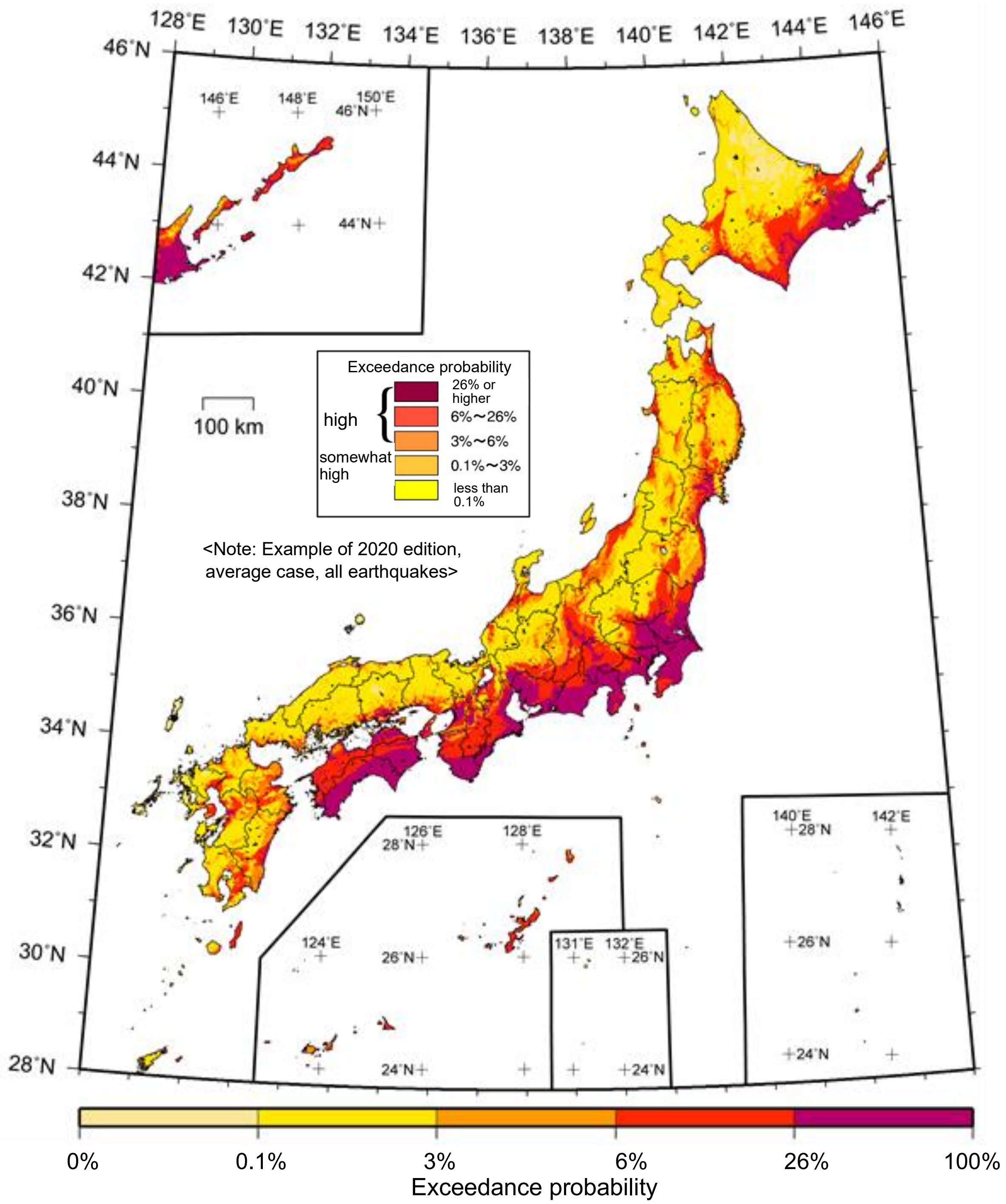


Probabilistic Seismic Hazard Map

Example of probability distribution map of ground shakings with a seismic intensity of 6-Lower or higher within the next 30 years

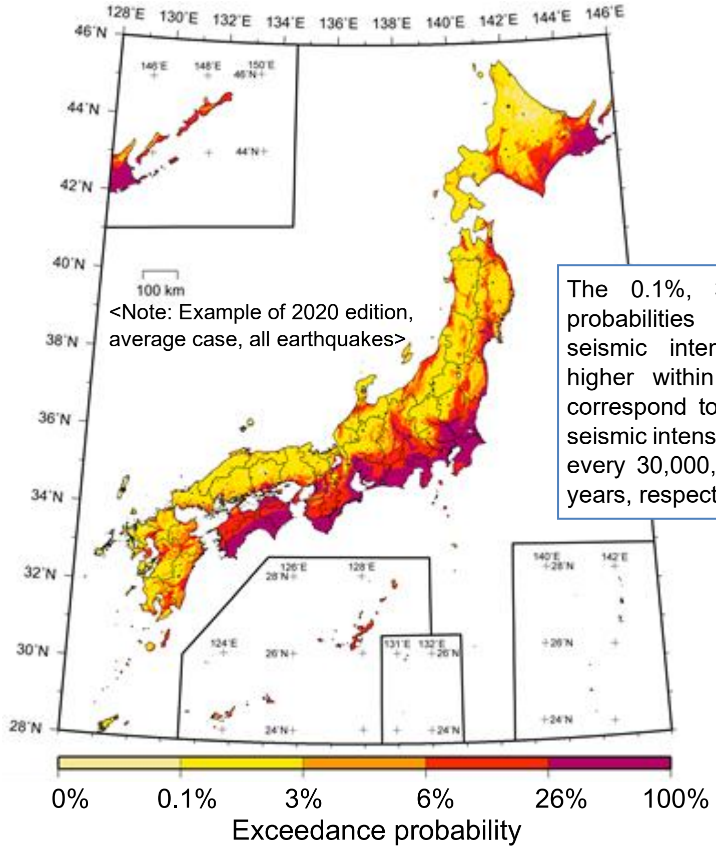
The Probabilistic Seismic Hazard Map shows the "intensity", "period", and "probability" of ground motions that each site in the country experiences, based on the locations, magnitudes, and probabilities of earthquakes that will occur in and around Japan. By fixing the "period" and either "intensity" or "probability", a map of the remaining parameter can be produced. The map shown below was created by fixing "period" and "intensity".

(Note: For Minami-Torishima Is. and Oki-no-Tori Shima Is., which are Japanese territories, are not included in the map due to the unavailability of input data required for the computation. Lakes and rivers are shown in white. The grid cells with zero probability owing to the conditions of the model computations are also shown in white.)



Interpreting Probabilistic Seismic Hazard Maps

Example and interpretation of probability distribution map of ground shakings with a seismic intensity of 6-Lower or higher within the next 30 years.



The 0.1%, 3%, 6%, and 26% probabilities of experiencing a seismic intensity of 6-Lower or higher within the next 30 years correspond to experiencing such a seismic intensity approximately once every 30,000, 1,000, 500, and 100 years, respectively.

What does the National Seismic Hazard Map show?

This is a National Seismic Hazard Map showing the probabilities of shakings with a seismic intensity of 6-Lower or higher within 30 years from 2020. They are not the probabilities of earthquake occurrences at the sites, but the probabilities at the sites experiencing ground shakings with a seismic intensity of 6-Lower or higher, caused by earthquakes that may occur in Japan and neighboring areas.

Difference in probability of exceedance among districts

Japan is one of the most earthquake-prone countries in the world, and the map shows that the probabilities of seismic hazards vary across the country.

Earthquakes include "**subduction-zone earthquakes**" that occur along a trench where an oceanic plate is subducting beneath a continental plate (e.g., the 2011 Tohoku Earthquake) and "**shallow crustal earthquakes**" that occur in shallow land and sea areas on active faults (e.g., the 1995 Hyogo-Ken-Nanbu earthquake). The recurrence intervals of the subduction-zone earthquakes are relatively short, typically ranging from several decades to a few hundred years; therefore, the probability of shaking is particularly high in coastal areas on the Pacific Ocean side, where there are offshore trenches. Meanwhile, the recurrence intervals of shallow crustal earthquakes are generally greater than 1,000 years (longer than those of the subduction-zone earthquakes); therefore, the probability of shaking is generally low, particularly in areas far from the trench. However, many active faults—including those not yet identified—are distributed in the Japanese Archipelago; the potential for strong ground shaking exists across the country.

Ground susceptibility to shaking and probability of exceedance

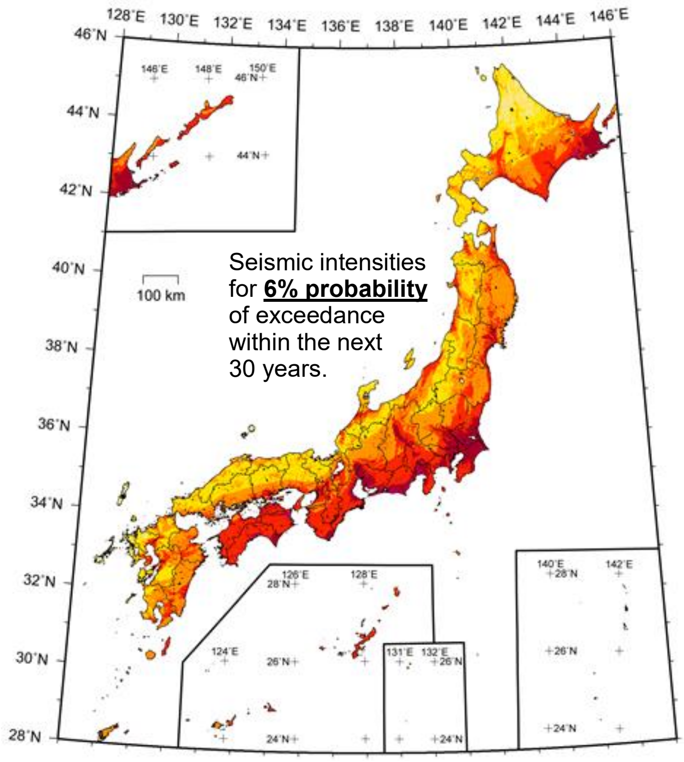
A closer look at the map shows that the probabilities of exceedance are high in plains, basins, and along rivers. This is because the ground conditions in such regions are soft and susceptible to shaking. The susceptibility of the ground to shaking, and consequently, its probability, varies significantly depending on the location.

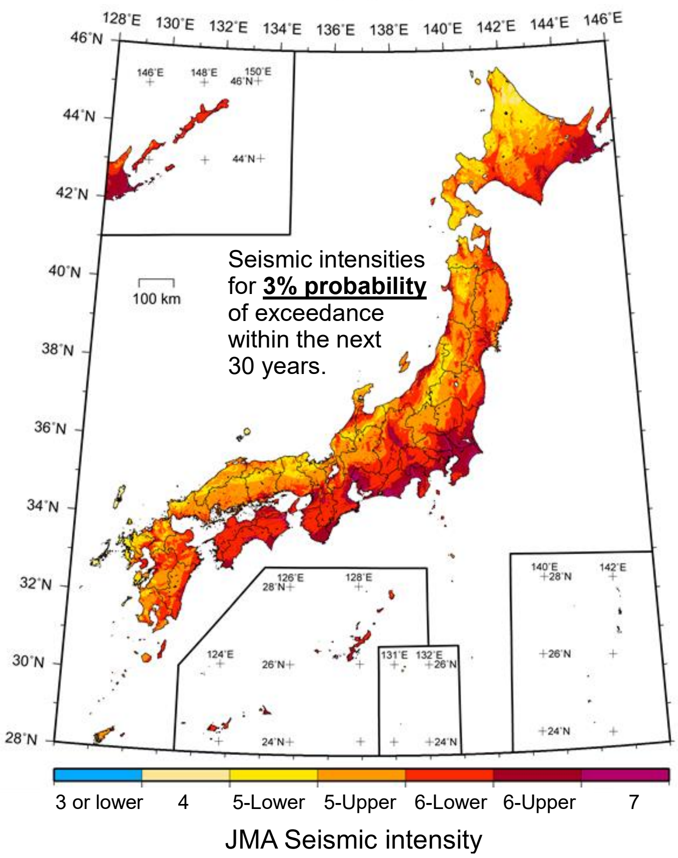
Relevant descriptions → "Let's look at National Seismic Hazard Maps"

Interpreting Probabilistic Seismic Hazard Maps

Comparative example of seismic intensity distributions for 6% and 3% probability of exceedance within the next 30 years

<Note: The two figures below are examples of the 2020 edition, average case, and all earthquakes>





The probability at which the intensity of ground shakings (seismic intensity) exceeds a specific value in a specific period is called the probability of exceedance (exceedance probability) of JMA seismic intensity.

These figures show variation in seismic intensities corresponding to exceedance probabilities of 6% (upper figure) and 3% (lower figure) over the next 30 years. For the same exceedance probability, there are regions with seismic intensities 5-Upper or higher as well as regions with seismic intensities 6-Upper or higher. For example, in the lower figure, regions in areas along the Itoigawa-Shizuoka Tectonic Line fault zone, which extends from northern Nagano to southern Yamanashi and along the Nankai Trough, are estimated to experience seismic intensity of 7.

For a given region, the lower the exceedance probability, the higher the expected ground motion (i.e., greater seismic intensity). Compared to the upper figure (6% probability of exceedance within 30 years), the lower figure (3% probability) presents larger seismic intensities.

The ground motions for exceedance probabilities of 3% or 6% within 30 years should not be disregarded (refer also to the Commentaries on National Seismic Hazard Maps for Japan).

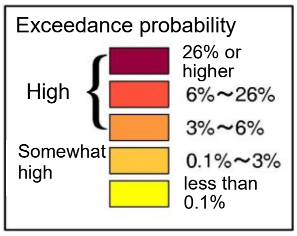
Relevant descriptions → Commentaries on National Seismic Hazard Maps for Japan 57-63

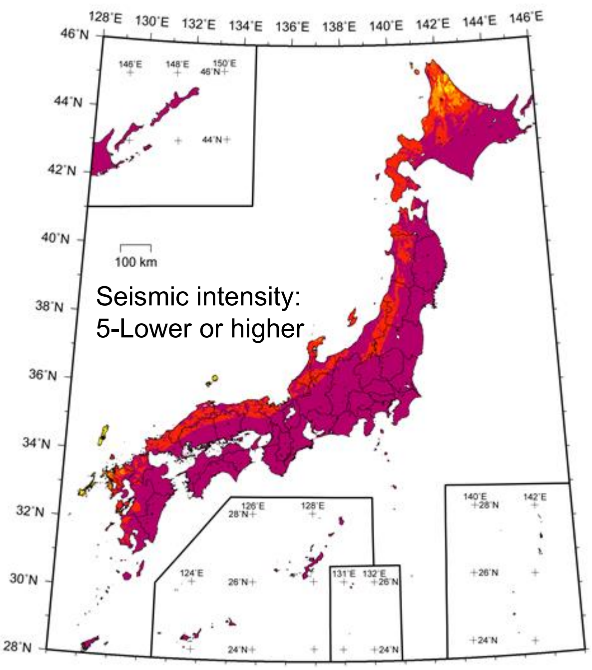
Interpreting Probabilistic Seismic Hazard Maps

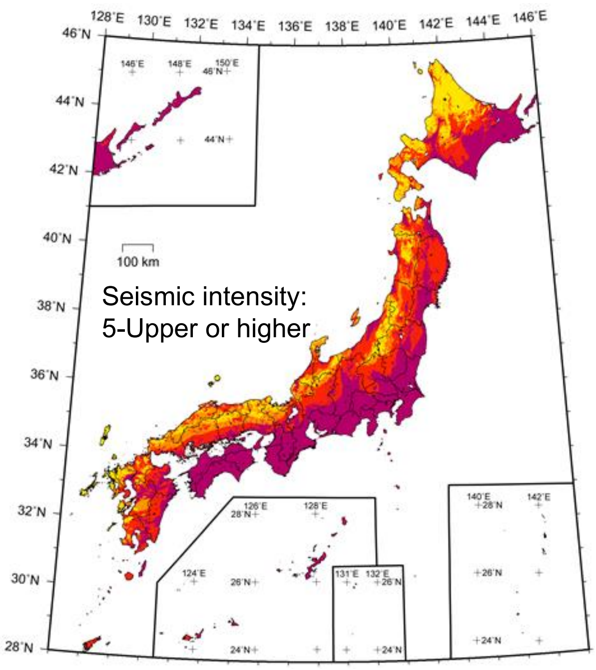
Comparative example of distribution map of probability of ground motions equal to or greater than a specific value of intensity (seismic intensity) within the next 30 years

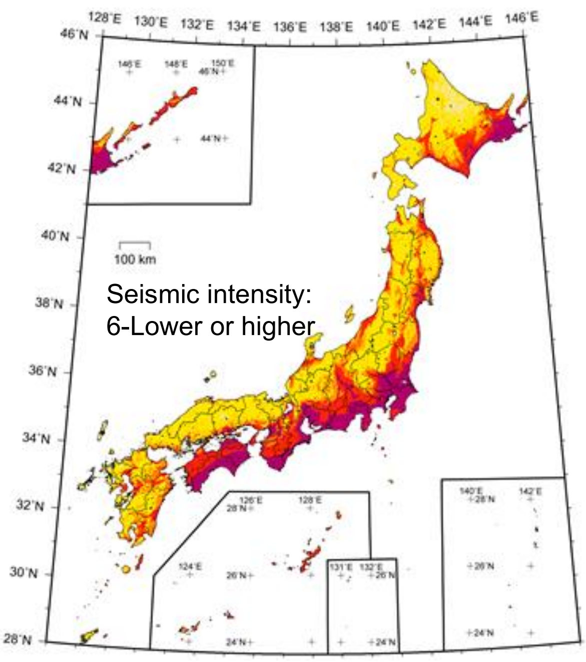
<Note: The four figures below are examples of the 2020 edition, average case, and all earthquakes>

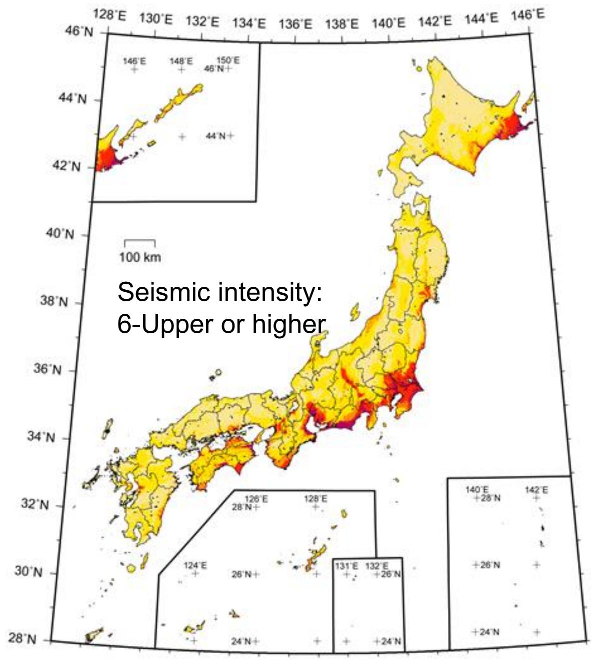
Within the same region, the higher the seismic intensity, the lower the possibility of experiencing such shaking. Furthermore, the regions where the ground is susceptible to shakings (plains or areas along rivers) or near seismic-source regions with a high probability of occurrence (for example, areas near the Nankai Trough, Sagami Trough, or Nemuro region in Hokkaido) show relatively high probabilities of exceedance.











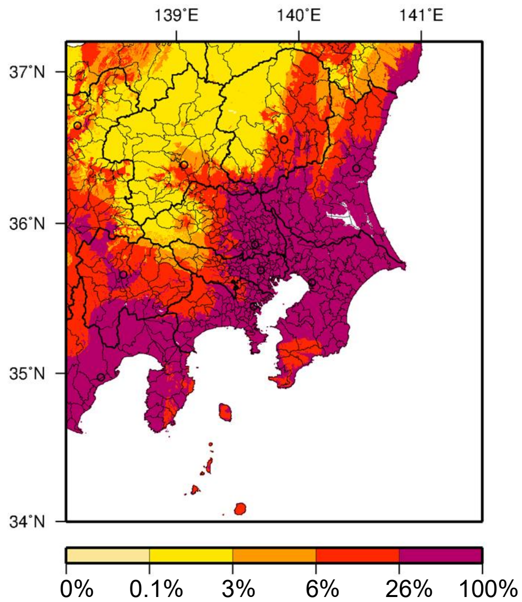
Relevant descriptions → Commentaries on National Seismic Hazard Maps for Japan 57-61

Interpreting Probabilistic Seismic Hazard Maps

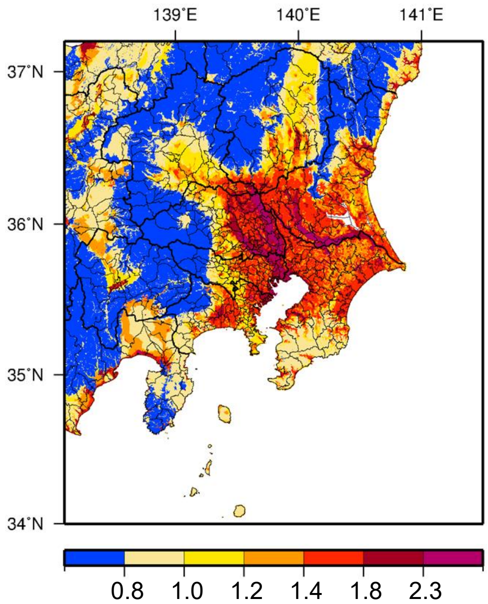
Seismic hazard maps by region and prefecture

Seismic hazard maps by region and by prefecture are specialized National Seismic Hazard Maps designed to present Probabilistic Seismic Hazard Maps on a localized scale for more accessible regional and prefectural analysis. Regional seismic hazard maps serve as reference materials for earthquake prevention measures spanning multiple prefectures, such as infrastructure planning, while prefectural seismic hazard maps support disaster prevention strategies at the prefectural level or across multiple municipalities. Additionally, the influence of shallow soil layers and scenario earthquakes in the National Seismic Hazard Maps can be assessed by comparing them with site amplification factors and active-fault distribution maps.

<Note: The five figures below are examples of the 2020 edition>

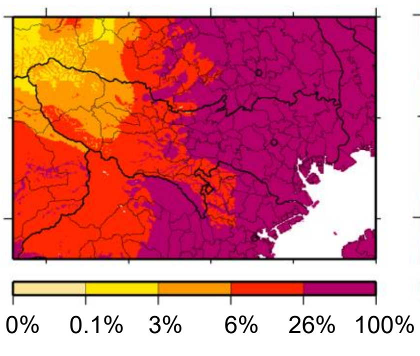


30-year probability of ground shakings with a seismic intensity of 6-Lower or higher

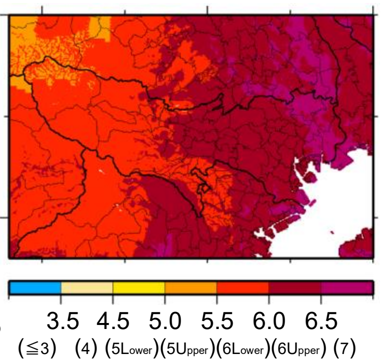


Peak ground velocity amplification factor of shallow soil layers

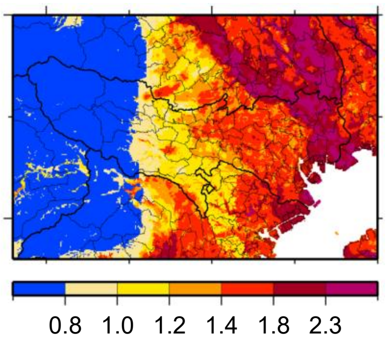
Example of seismic hazard map by region (Kanto region)



30-year probability of ground shakings with a seismic intensity of 6-Lower or higher



Instrumental seismic intensities (seismic intensity) with 3% exceedance probability within the next 30 years



Peak ground velocity amplification factor of shallow soil layers

Example of seismic hazard map by prefecture (Tokyo (excluding islands))

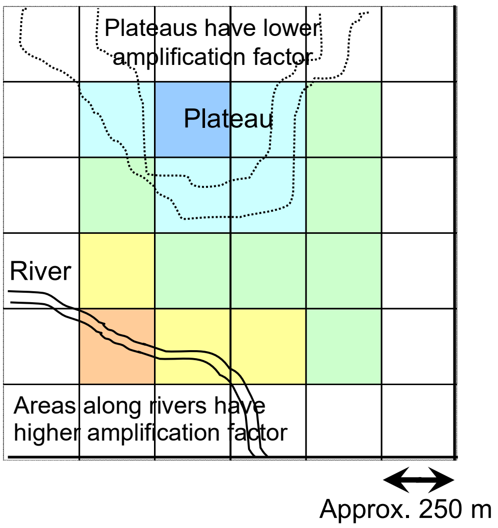
Interpreting Probabilistic Seismic Hazard Maps

Relationship between shallow ground conditions and Probabilistic Seismic Hazard Maps

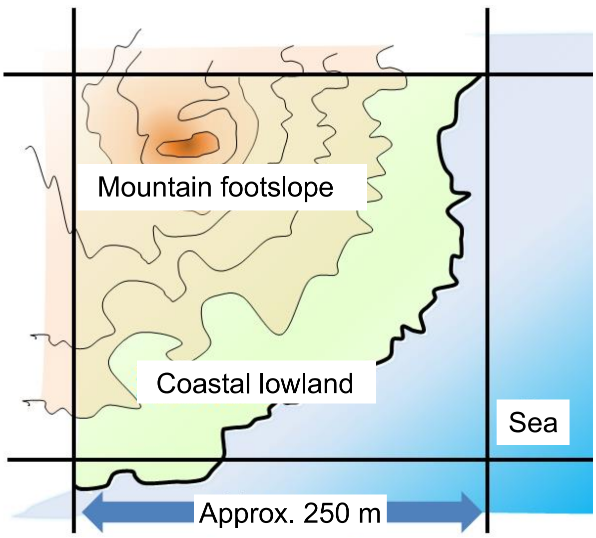
Shallow ground conditions significantly affect ground shaking

The intensity of ground shaking caused by an earthquake is significantly influenced by shallow soil layers characteristics. Probabilistic Seismic Hazard Maps account for the amplification effects of shallow soil layers, which vary considerably in space. The amplification tends to be lower in mountainous or hilly regions but higher in low-elevated regions such as deltas, reclaimed lands, or filled land. Thus, the probability of strong ground shaking can differ substantially at individual sites, even between locations just a few hundred meters apart. Shallow soil layers play a critical role in determining the intensity of ground shaking in a given area.

Probabilistic Seismic Hazard Maps consisting of 250-m square grid cells



The shallow soil layer data used in the Probabilistic Seismic Hazard Maps are created in units of approximately 250-m square grid cells, and the soil model in each cell is represented by the dominant one in that cell. Therefore, the site amplification factor of shaking due to the shallow soil layers and the probability of shaking calculated using the amplification factor are uniform within each 250-m cell. However, actual soil conditions may vary by location within a single 250-m cell; therefore, the calculated probabilities may differ from the actual probabilities at each point in the cell.



For example, in the 250-m square unit cell shown in the figure on the left, as the mountain footslope dominates the unit cell, the entire points in the cell belong to the same classification unit. Accordingly, the shaking amplification factor for the unit cell is calculated as that for the mountain footslope, resulting in the probability of exceedance being based on the mountain footslope at any point within the unit cell.

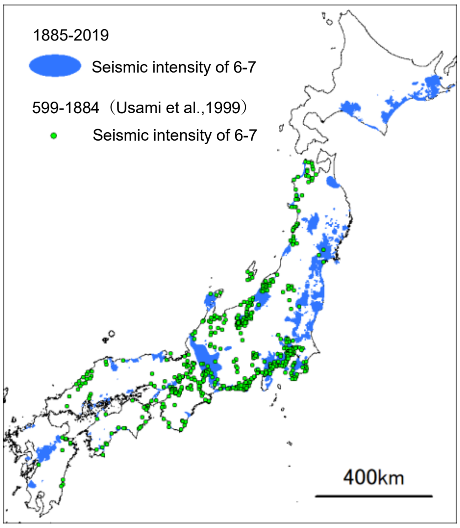
However, there also exists points in coastal lowland area within the unit cell, where shakings are typically more strongly amplified than on the mountain footslope. Thus, the actual probability in the coastal lowland area will be greater than the calculated probability from the Probabilistic Seismic Hazard Map, and this discrepancy should be carefully noted.

Relevant descriptions → Commentaries on National Seismic Hazard Maps for Japan 57-61

Comparison of Probabilistic Seismic Hazard Maps with Historically Recorded Shaking Information

Examination of appropriateness of Probabilistic Seismic Hazard Maps

The commonly used 30-year period in long-term earthquake evaluations and Probabilistic Seismic Hazard Maps is generally sufficient for individuals to plan their lives, experience earthquakes, and develop an intuitive understanding of seismic risk. However, the recurrence intervals of large earthquakes vary significantly, ranging from several decades to a few centuries for subduction-zone earthquakes and thousands to tens of thousands of years for earthquakes along active faults—far exceeding the 30-year timeframe. Consequently, directly comparing recent earthquakes and their ground motions with hazard maps projecting the next 30 years is not particularly meaningful. Instead, to assess correspondence, we compare long-term National Seismic Hazard Maps with historically recorded ground shaking data.

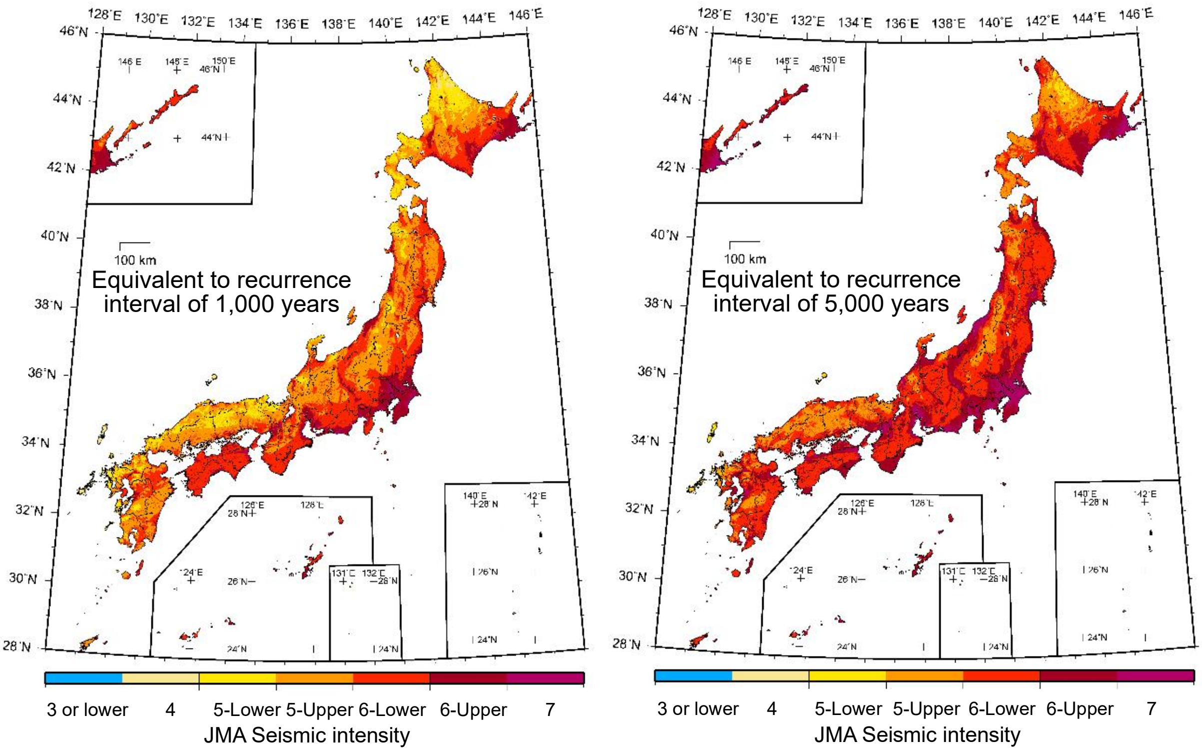


Regions estimated to have a seismic intensity of 6 or higher in previous earthquakes (599–2019) [added to Midorikawa and Miura (2016)]

The left figure shows the points and regions estimated to have been hit by shaking with a seismic intensity of 6 or higher in the past, based on historical records of earthquakes and seismic observation records in Japan spanning approximately 1000 years—from several centuries to over a millennium ago. The lower figures show the National Seismic Hazard Maps for recurrence intervals equivalent to 1,000 and 5,000 years, indicating the expected ground shaking intensity that would occur, on average, once every 1,000 or 5,000 years, respectively.

Comparing the record-based map and the long-term average seismic hazard map, the areas that show seismic intensity of 6-Lower or higher with a recurrence interval equivalent to 1,000 years (lower left figure) generally correspond well with the areas with seismic intensity of 6 or higher in the past record (left figure), although predicted seismic intensities are somewhat lower along parts of the Sea of Japan coast. Furthermore, when the recurrence interval is set to 5,000 years (lower right figure), the areas showing a seismic intensity of 6-Lower or higher generally include the areas where the seismic intensity was 6 or higher in the past record.

It is evident from these comparisons that the National Seismic Hazard Maps with sufficiently long recurrence intervals covered regions with strong shaking from previous earthquakes indicates that the Probabilistic Seismic Hazard Maps have a certain degree of validity.

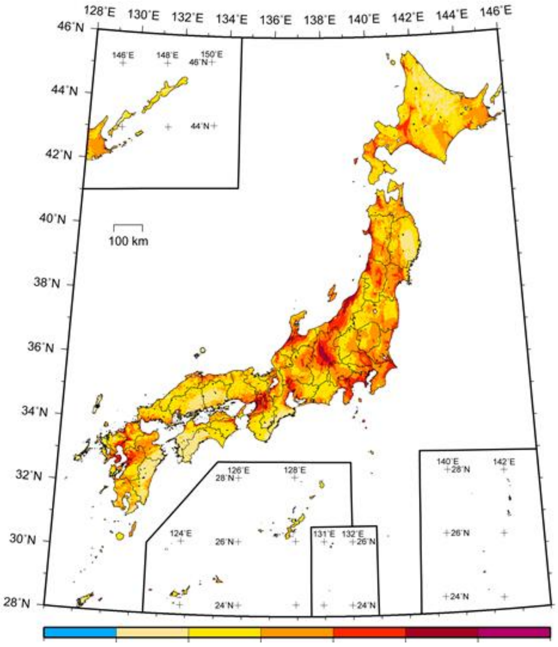


Seismic intensity distribution of Probabilistic Seismic Hazard Maps
<Long-term average seismic hazard maps, 2020 edition>

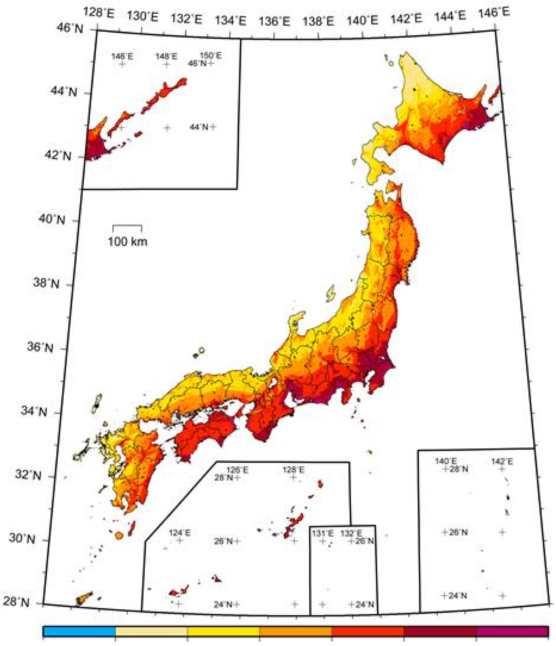
Earthquake Classifications

Preparing for earthquakes of varying magnitudes

In the National Seismic Hazard Maps, Probabilistic Seismic Hazard Maps are generated by categorizing potential earthquakes into shallow crustal earthquakes and subduction-zone earthquakes and calculating the probability of ground motion exceedance for each category. These maps illustrate which regions are primarily affected by shallow crustal or subduction-zone earthquakes, enabling region-specific preparedness. They serve as valuable tools for developing appropriate mitigation strategies based on the distinct characteristics of different earthquake types.



Shallow crustal earthquakes



Subduction-zone earthquakes

Note: The figures above are examples of the distribution of seismic intensities for a 3% probability of exceedance occurring within the next 30 years for the 2020 National Seismic Hazard Maps. This signifies a seismic intensity of shaking that occurs about once every 1,000 years.

Earthquake groups extracted and specified as probabilistic scenario earthquakes in each earthquake classification

Shallow crustal earthquakes

- Earthquakes on major active-fault zones and active faults under regional evaluation (including earthquakes where fault traces are difficult to identify from surface evidence)
- Earthquakes on other active faults
- Earthquakes offshore northwest of Hokkaido Pref.
- Earthquakes offshore west of Hokkaido Pref.
- Earthquakes offshore southwest of Hokkaido Pref.
- Earthquakes offshore west of Aomori Pref.
- Earthquakes offshore of Akita Pref.
- Earthquakes offshore of Yamagata Pref.
- Earthquakes offshore of northern Niigata Pref.
- Earthquakes offshore north of Sadoshima Is.
- Shallow crustal earthquakes in places where active faults are unspecified (including the eastern margin of the Sea of Japan, south of the Izu Islands, and the Yonagunijima Is.)
- Earthquakes without specified source faults offshore of Urakawa (including eastern Iburi)

Subduction-zone earthquakes

- Megathrust interplate earthquakes along the Kuril Trench (17th century-earthquake type)
- Large interplate earthquakes offshore of Tokachi
- Large interplate earthquakes offshore of Nemuro
- Interplate earthquakes near the trench offshore of Tokachi to Etorofu Is. (tsunami earthquakes)
- Megathrust earthquakes along the Japan Trench (the 2011 Tohoku Earthquake type)
- Large interplate earthquakes offshore east of Aomori Pref. and in the north region offshore of Iwate Pref.
- Large interplate earthquakes offshore of Miyagi Pref.
- Interplate earthquakes near the trench offshore east of Aomori Pref. to Boso (tsunami earthquakes)
- Earthquakes on the external side of the Japan Trench axis
- *M*8-class earthquakes along the Sagami Trough
- Large earthquakes along the Nankai Trough
- Interplate earthquakes of the Hyuganada Sea
- Smaller interplate earthquakes of the Hyuganada Sea
- Earthquakes around Yonagunijima Is.
- Pacific interplate and intraplate earthquakes without specified source faults (including those undergoing long-term evaluations not listed above)
- Philippine Sea interplate and intraplate earthquakes without specified source faults (including those undergoing long-term evaluations not listed above)

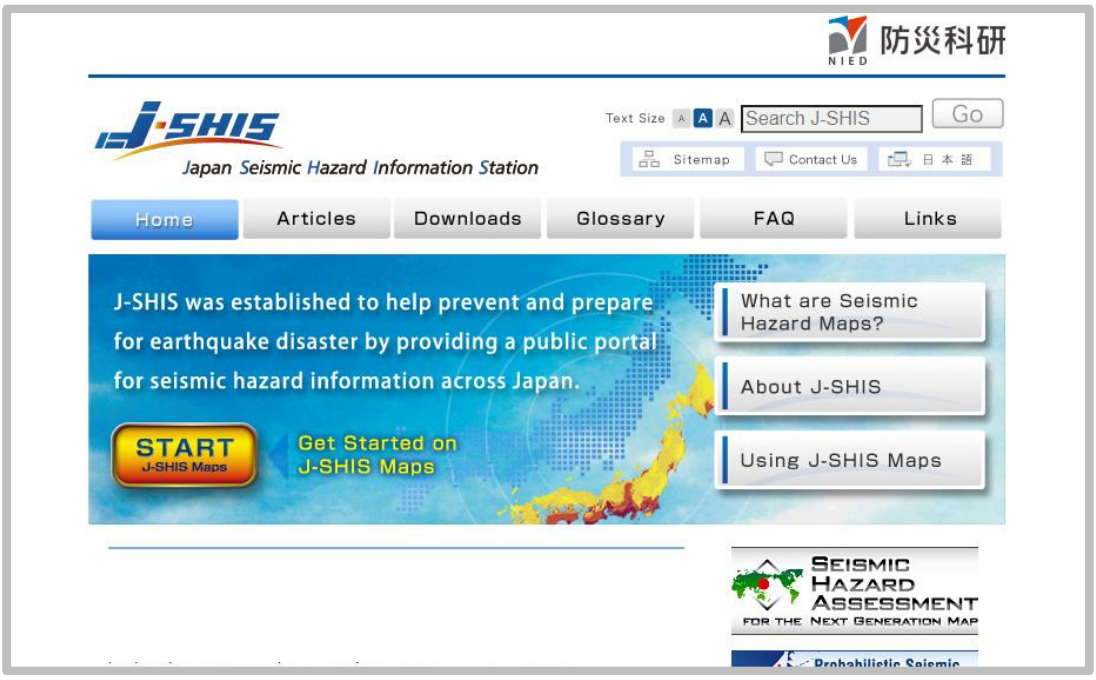
Relevant descriptions → Commentaries on National Seismic Hazard Maps for Japan 39-42, 64-66

Japan Seismic Hazard Information Station (J-SHIS)

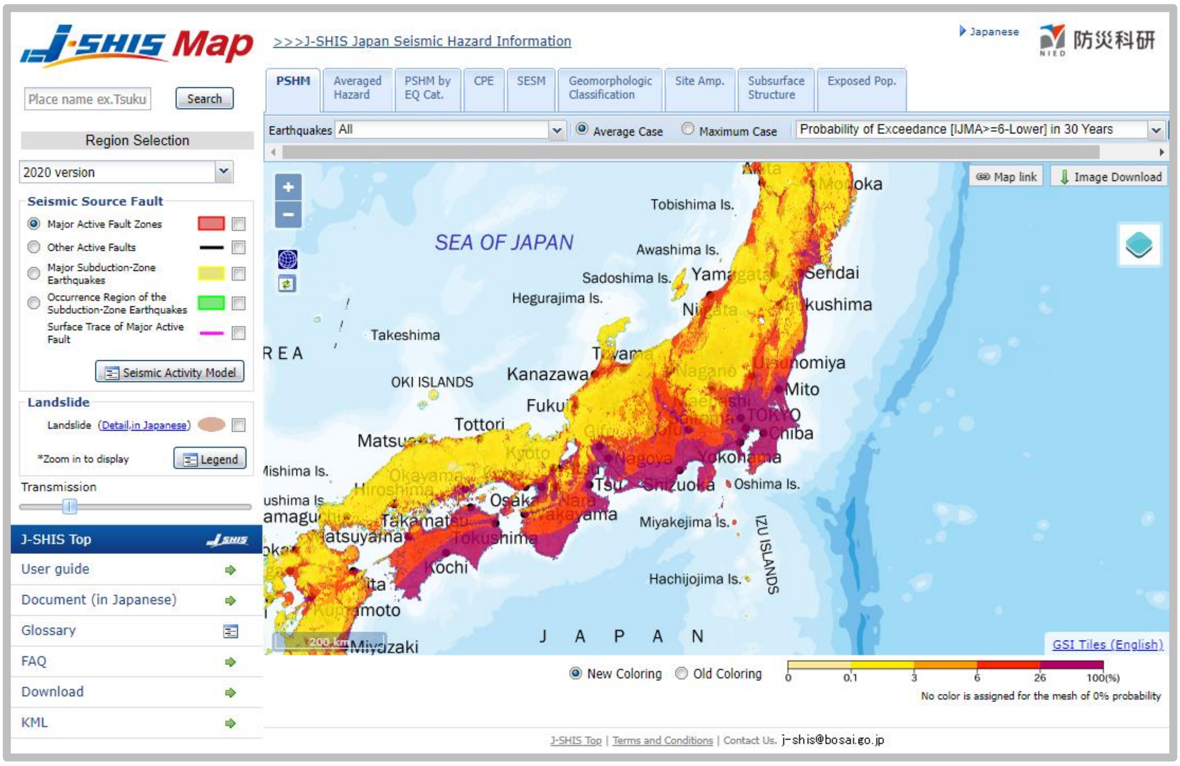
J-SHIS Map

Various National Seismic Hazard Maps created by the Headquarters for Earthquake Research Promotion are available on the J-SHIS Map in the Japan Seismic Hazard Information Station (J-SHIS) operated by the National Research Institute for Earth Science and Disaster Resilience. The National Seismic Hazard Maps can be displayed in 250-m grid cell units when enlarged, and the National Seismic Hazard Maps data can also be downloaded.

Japan Seismic Hazard Information Station（J-SHIS）: https://www.j-shis.bosai.go.jp/en/



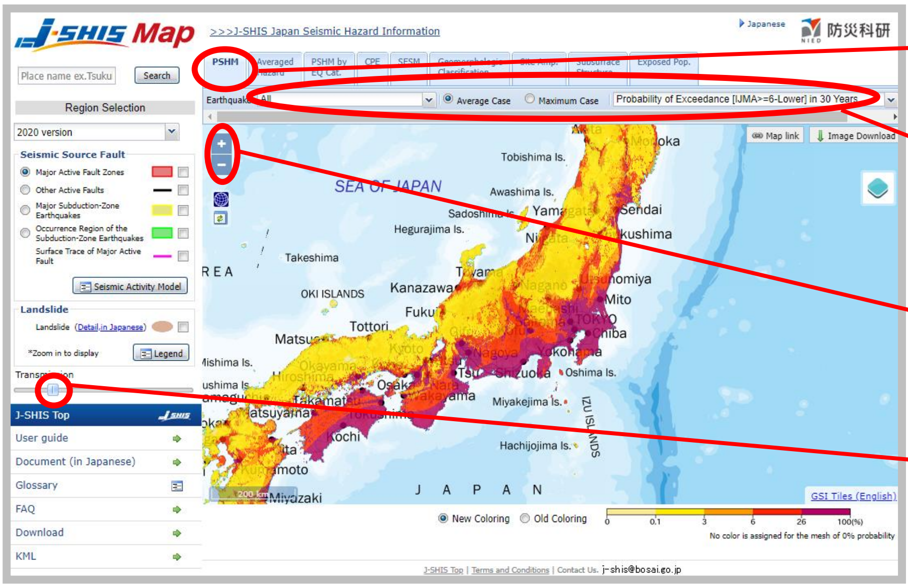
J-SHIS Map：https://www.j-shis.bosai.go.jp/map/?lang=en



Japan Seismic Hazard Information Station (J-SHIS)

Probabilistic Seismic Hazard Maps

On the J-SHIS Map, Probabilistic Seismic Hazard Maps can be viewed in greater detail. Additionally, numerical data from both the Probabilistic Seismic Hazard Maps and the Seismic Hazard Karte can be examined for each 250-m grid cell by performing the following operation.



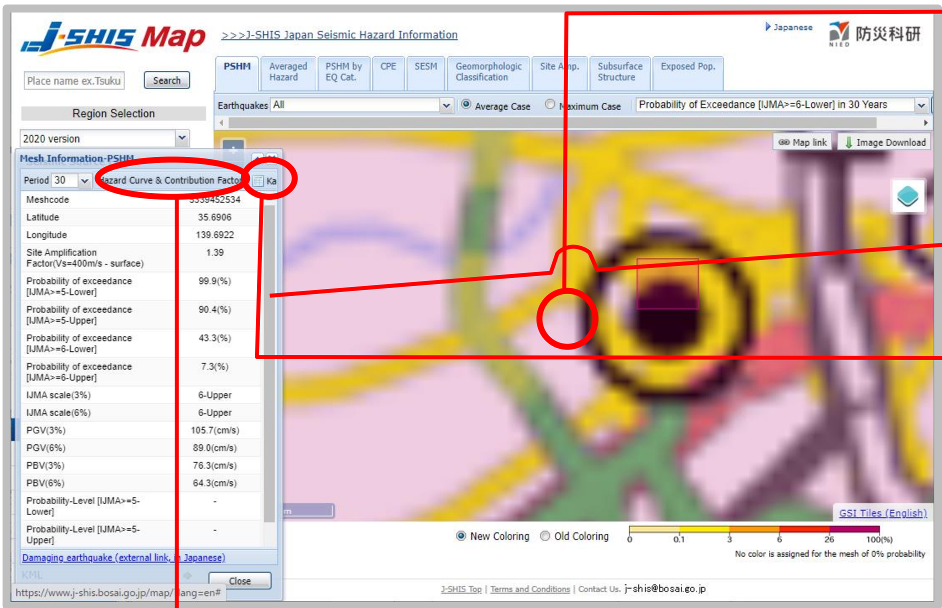
(1) Click on the "PSHM" (Probabilistic Seismic Hazard Maps) tab

(2) Select the National Seismic Hazard Maps to be displayed

(3) Use the "+" and "-" buttons to enlarge or reduce the map

(4) By clicking the transmission mark and sliding it to the right, the color of the National Seismic Hazards Maps will fade, and the standard map will be visible

Close-up of area near Tokyo Metropolitan Government Building



(5) When double-clicking a point on the map, the point information of the Probabilistic Seismic Hazards Maps will be displayed on the left

(6) Point information of the Probabilistic Seismic Hazard Maps

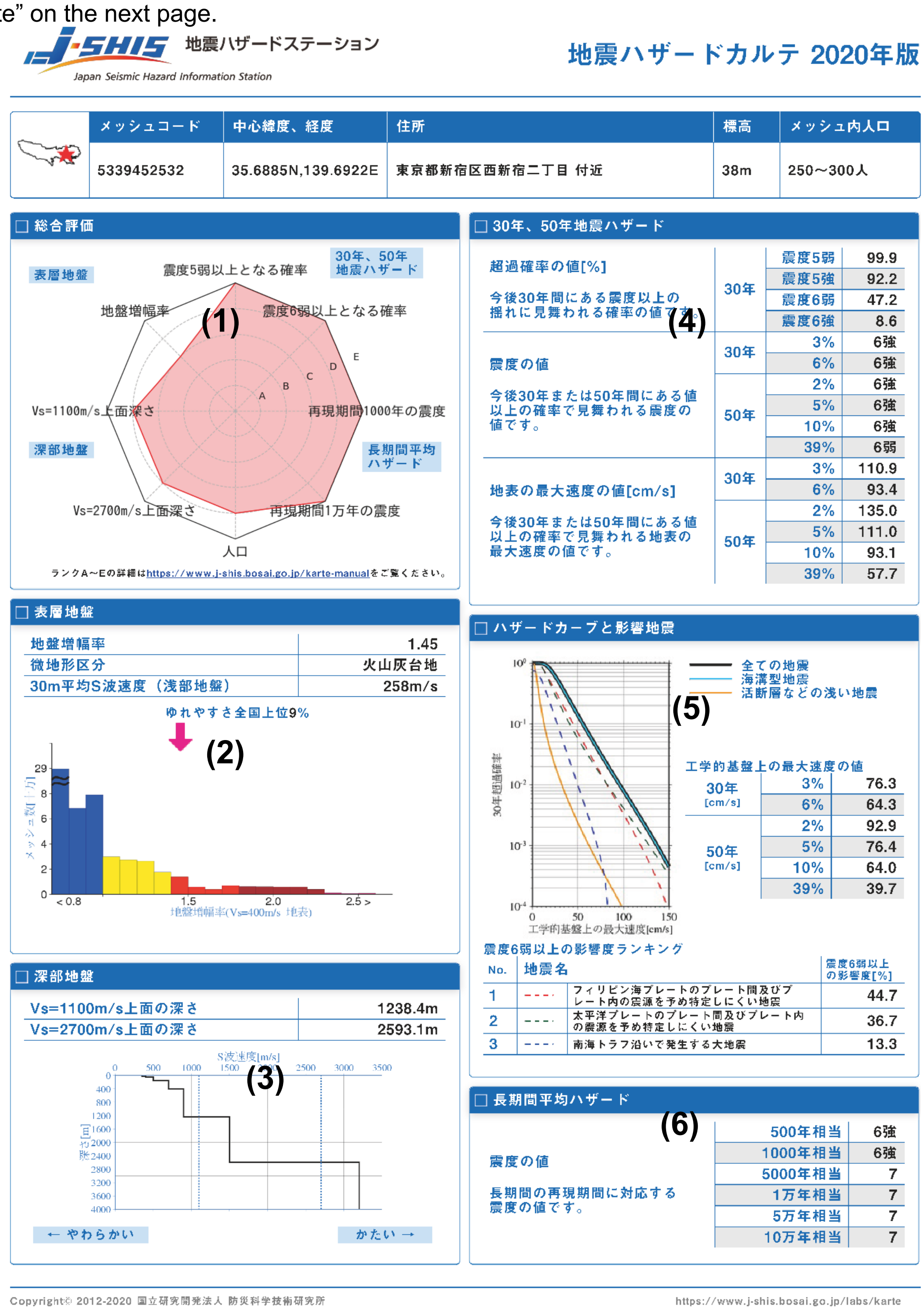
(7) When clicking on "Karte" on the top right of the location information, a Seismic Hazard Karte for the point will be available
→Next page

(8) When clicking on "Hazard Curve & Contribution Factor" on the upper left of the point information, a list of earthquake groups and their hazard curves up to the third largest contribution factor at the point will be created

Japan Seismic Hazard Information Station (J-SHIS)

Seismic Hazard Karte

J-SHIS creates and provides a Seismic Hazard Karte (summary of seismic hazard assessment) for every 250-m grid cell. The Seismic Hazard Karte is a compilation of earthquake hazard information based on data from Probabilistic Seismic Hazard Maps. The Seismic Hazard Karte near the Tokyo Metropolitan Government Building is shown below as an example. For explanations of each chart (1)–(6) in the Karte, please see the “Reading the Seismic Hazard Karte” on the next page.



For more information about the Seismic Hazard Karte, please go to the following.
URL: https://www.j-shis.bosai.go.jp/tag/karte
(In Japanese)

Japan Seismic Hazard Information Station (J-SHIS)

Reading the Seismic Hazard Karte

The following are descriptions of each item in the Seismic Hazard Karte. See the previous page for the positions (1)–(6) in the Karte. For more information about the Seismic Hazard Karte, please refer to the J-SHIS instruction page (https://www.j-shis.bosai.go.jp/tag/karte).

(1) 総合評価（Overall evaluation）

In the hazard evaluation radar chart, larger areas indicate higher hazards.

The rank of each item is presented in the table below.

Item name/rank	A	B	C	D	E
Probability of seismic intensity of 5-Lower/6 -Lower or higher	< 0.1%	≥ 0.1% & < 3%	≥ 3% & < 6%	≥ 6% & < 26%	≥ 26%
Seismic intensities with recurrence intervals of 1,000 and 10,000 years	< 5-Lower	≥ 5-Lower	≥ 5-Upper	≥ 6-Lower	≥ 6-Upper
Population	< 1	≥ 1 & < 10	≥ 10 & < 100	≥ 100 & < 1,000	≥ 1,000
Upper surface depth of Vs* = 2700 m/s layer	< 300m	≥ 300m & < 1000m	≥ 1000m & < 2000m	≥ 2000m & < 3000m	≥ 3000m
Upper surface depth of Vs = 1100 m/s layer	< 200m	≥ 200m & < 500m	≥ 500m & < 1000m	≥ 1000m & < 2000m	≥ 2000m
Amplification factor of shallow soil layers	< 1.0	≥ 1.0 & < 1.4	≥ 1.4 & < 1.8	≥ 1.8 & < 2.3	≥ 2.3

* Vs represents S-wave velocity.

(2) 表層地盤（Shallow soil layers）

This is information relating to shallow soil layers at each grid cell. “Shallow soil layers” are the soils above the engineering bedrock (see p. 3). The amplification factor of shallow soil layers is the magnification at which ground shaking is amplified in shallow soil layers. The larger the value, the stronger the ground shaking.

The geomorphologic classification is a classification of surface geological and topographical features at a grid cell using the standardized method for the entire area of Japan (Wakamatsu and Matsuoka(2020)).

The 30-m average S-wave velocity (AVS30) is the average S-wave velocity in the top 30 meters. S-wave, or shear waves, are a type of seismic wave that cause strong shaking; a smaller AVS30 results in a larger amplification. The term “浅部地盤(shallow soil layers)” or “微地形(geomorphologic unit)” is displayed in parentheses after the AVS30. The term “浅部地盤(shallow soil)” indicates that the AVS30 value is calculated based on the combined model of shallow and deep layers, and “微地形(geomorphologic)” indicates that the value is calculated based on geomorphologic classification.

The figure shows a histogram of the amplification factors for the entire area of Japan, and the arrow indicates the value at the grid cell.

(3) 深部地盤（Deep sedimentary layers）

This is information relating to deep sedimentary layers at each grid cell. The deep sedimentary layers are the geological layers from the upper surface of the seismic basement (hard rock at the top of the crust) to the upper surface of the engineering bedrock. The upper surface depth of the layers with Vs of 1,100 m/s corresponds to the lower limit of depth of the sedimentary layers that significantly contribute to the amplification of ground shaking, and the upper surface depth of the layer with Vs of 2,700 m/s corresponds to the depth equivalent to the seismic basement. If the upper surface depths of these layers are unavailable, the upper surface depths of the layers with the higher and nearest velocities are displayed. Deeper depths of these layers typically indicate thicker sedimentary layers that are more prone to shaking, and thus have high in hazards.

The figure is a staircase graph of the change in S-wave velocity.

(4) 30 年、50 年地震ハザード（30-year and 50-year seismic hazards）

This is information for Probabilistic Seismic Hazard Maps at the grid cell. Probabilistic Seismic Hazard Maps are created using these values.

The probability of exceedance represents the probability that a ground motion exceeding a certain level will occur within a given period.

In general, 30 years is the typically considered length of time for various decision-making in daily life planning, and 50 years is equivalent to the service life of a structure in the engineering field.

The seismic intensity and peak ground velocity in each period and probability of exceedance signify the following:

- 3% over 30 years: shaking strength that occurs once about every 1,000 years
- 6% over 30 years: shaking strength that occurs once about every 500 years
- 2% over 50 years: shaking strength that occurs once about every 2,500 years
- 5% over 50 years: shaking strength that occurs once about every 1,000 years
- 10% over 50 years: shaking strength that occurs once about every 500 years
- 39% over 50 years: shaking strength that occurs once about every 100 years

(5) ハザードカーブと影響地震（Hazard curve and contributing earthquakes）

These are the seismic hazard curves and representative values at the grid cell.

The hazard curve illustrates the relationship between ground shaking intensity (horizontal axis) and the probability of exceedance (vertical axis). As the curve extends higher to the upper right, the seismic hazard level increases. The accompanying figure presents the hazard curve for earthquake-induced ground motion, specifically peak ground velocity (PGV) on the engineering bedrock, over a 30-year period. The table to the right of the figure displays the probability of exceedance derived from the hazard curve, accounting for all potential earthquakes, along with the corresponding PGV values on the engineering bedrock. The table below the figure lists the top three earthquakes that contribute most significantly to the probability of experiencing a seismic intensity of 6-Lower or higher within the next 30 years. Additionally, it provides the contribution factor for each earthquake, representing the proportion of its seismic hazard relative to the total.

(6) 長期間平均ハザード（Long-term average hazard）

This is the information of long-term average hazards at the grid cell.

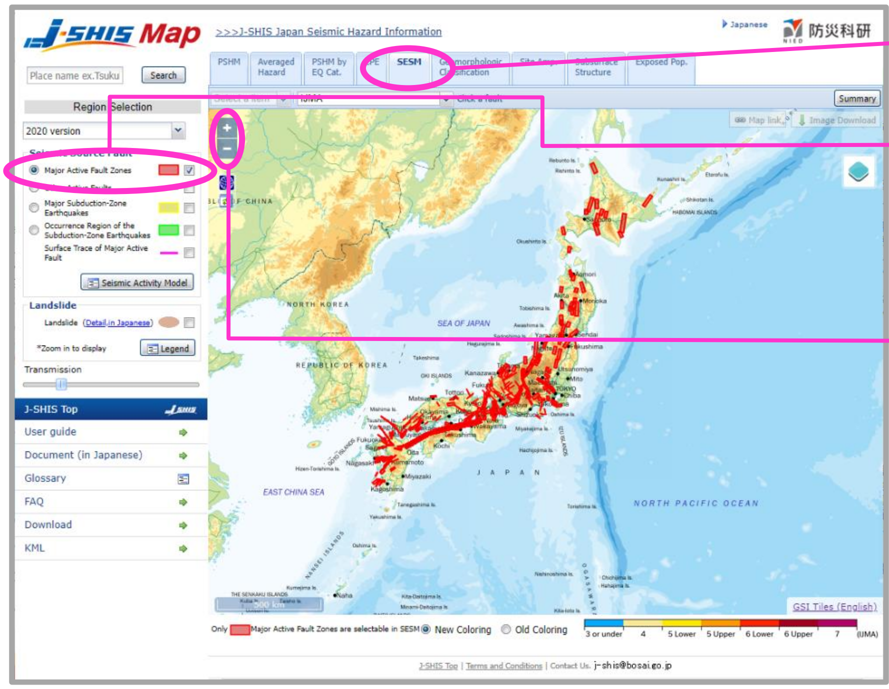
The recurrence interval is the mean recurrence interval of a given event. For example, the term “recurrence interval equivalent to 1,000 years” represents the shaking that occurs once approximately every 1,000 years at this grid cell.

For a better understanding, consider the following perspective: “How much shaking can occur at the evaluation point due to earthquakes such as active faults on land with low frequency of occurrence (generally occurring once every several thousand to tens of thousands of years) but causing massive damage?”.

Japan Seismic Hazard Information Station (J-SHIS)

Seismic Hazard Maps for scenario earthquakes

On the J-SHIS Map, results of the detailed method posted on the Seismic Hazard Maps for specified source faults (Seismic Hazard Maps for scenario earthquakes) can be enlarged to be depicted in 250-m grid cell units.

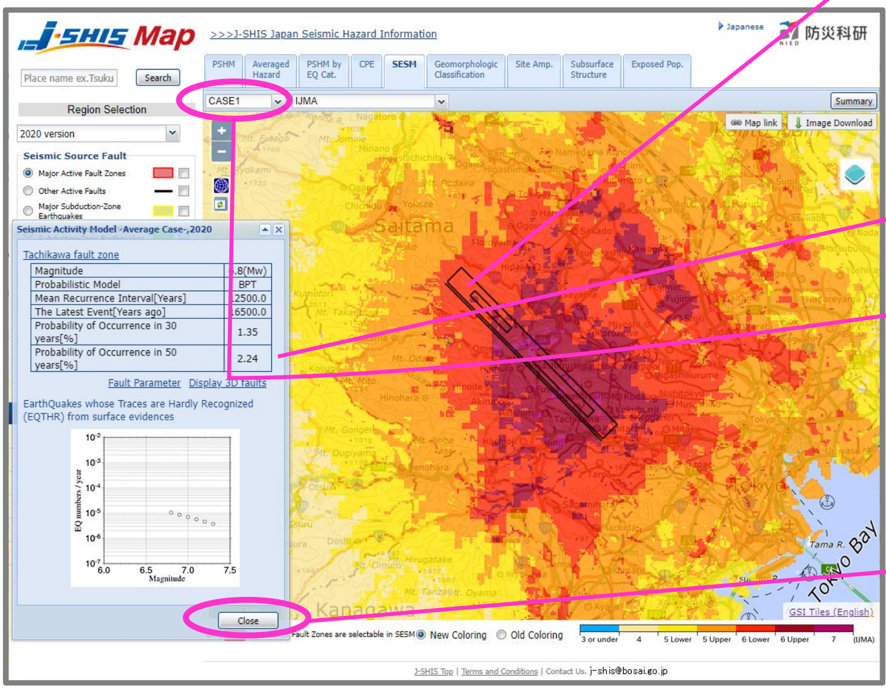


(1) Click on the “SESM” tab

(2) Click “Major active-fault zones” and click the right of the red rectangle to place a checkmark

(3) Use the “+” and “-” buttons to enlarge or reduce the map

Close-up of area near the Tachikawa fault zone



(4) Clicking on the source fault in red displays the JMA instrumental seismic intensity distribution map on the ground surface, and information of the fault zone is displayed on the left

(5) Information on the selected fault zone

(6) Selecting an assumed case (differences in the location where fault rupture begins) displays the instrumental seismic intensity distribution map of the selected case

(7) After clicking on the “Close” button, the instrumental seismic intensity distribution map and fault zone information disappear, and another source fault can be selected (clicked)

Japan Seismic Hazard Information Station (J-SHIS)

List of various types of maps published on J-SHIS Map

On the J-SHIS Map, various types of related maps are available, including maps published in “National Seismic Hazard Maps.”

List of National Seismic Hazard Maps on J-SHIS Map (tab name at top of J-SHIS Map is in [])
<Red letters indicate maps published in
“National Seismic Hazard Maps 2020 version: Map edition”>

[PSHM] (Probabilistic Seismic Hazard Maps)

Distribution map of Probability of Exceedance [I_{JMA}≥6-Upper] in 30 Years[※1]
(I_{JMA} : JMA instrumental seismic intensity)
Distribution map of Probability of Exceedance [I_{JMA} ≥6-Lower] in 30 Years
Distribution map of Probability of Exceedance [I_{JMA} ≥5-Upper] in 30 Years
Distribution map of Probability of Exceedance [I_{JMA} ≥5-Lower] in 30 Years[※1]
Map of I_{JMA} for a 3% Probability of Exceedance in 30 Years
Map of I_{JMA} for a 6% Probability of Exceedance in 30 Years
Map of I_{JMA} for a 2% Probability of Exceedance in 50 Years[※1]
Map of I_{JMA} for a 5% Probability of Exceedance in 50 Years[※1]
Map of I_{JMA} for a 10% Probability of Exceedance in 50 Years[※1]
Map of I_{JMA} for a 39% Probability of Exceedance in 50 Years[※1]

PGV for a 3% Probability of Exceedance in 30 Years
(PGV: Peak ground velocity at the ground surface)
PBV for a 3% Probability of Exceedance in 30 Years
(PBV: Peak ground velocity on the engineering bedrock)
PGV for a 6% Probability of Exceedance in 30 Years
PBV for a 6% Probability of Exceedance in 30 Years
PGV for a 2% Probability of Exceedance in 50 Years
PBV for a 2% Probability of Exceedance in 50 Years
PGV for a 5% Probability of Exceedance in 50 Years
PBV for a 5% Probability of Exceedance in 50 Years
PGV for a 10% Probability of Exceedance in 50 Years
PBV for a 10% Probability of Exceedance in 50 Years
PGV for a 39% Probability of Exceedance in 50 Years
PBV for a 39% Probability of Exceedance in 50 Years
(all earthquakes/shallow crustal earthquakes/subduction-zone earthquakes)
※1: Only “all earthquakes” are published in “National Seismic Hazard Maps 2020 version: Map edition”

[Averaged Hazard]

I_{JMA} with a Return Period of 100,000-year
(Return period : recurrence interval)
I_{JMA} with a Return Period of 50,000-year
I_{JMA} with a Return Period of 10,000-year
I_{JMA} with a Return Period of 5000-year
I_{JMA} with a Return Period of 1000-year
I_{JMA} with a Return Period of 500-year

[PSHM by EQ Cat.]

Shallow EQs in land area & in sea area (”shallow crustal earthquakes”)
(Quartile representation of 30-year probabilities of I_{JMA} ≥6-Upper, I_{JMA} ≥6-Lower, I_{JMA} ≥5-Upper, and I_{JMA} ≥5-Lower)

Subduction-zone EQs
(Quartile representation of 30-year probabilities of I_{JMA} ≥6-Upper, I_{JMA} ≥6-Lower, I_{JMA} ≥5-Upper, and I_{JMA} ≥5-Lower)

CF of PSHM (Degree of contribution factor of earthquake classification)
(30 years, I_{JMA} ≥6-Upper, I_{JMA} ≥6-Lower, I_{JMA} ≥5-Upper, and I_{JMA} ≥5-Lower)

[CPE]

probability of Exceedance [I_{JMA} ≥6-Upper]
probability of Exceedance [I_{JMA} ≥6-Lower]
probability of Exceedance [I_{JMA} ≥5-Upper]
probability of Exceedance [I_{JMA} ≥5-Lower]
Expected I_{JMA}

[SESM] (National Seismic Hazard Maps for scenario earthquakes)

I_{JMA}
PBV

[Geomorphologic Classification]

Engineering Geomorphologic Classification

[Site Amp.] (Shallow Soil Layers)

Site Amplification factor (Vs=400 m/s - surface)
Average Shear-Wave Velocity in the Upper 30m (AVS30)

[Subsurface Structure]

Depth/elevation of seismic bedrock
(seismic bedrock: seismic basement)
Depth/elevation of 28th (Vs=2900m/s) Layer’s Lower Surface
Depth/elevation of 27th (Vs=2700m/s) Layer’s Lower Surface
Depth/elevation of 26th (Vs=2100m/s) Layer’s Lower Surface
Depth/elevation of 25th (Vs=2100m/s) Layer’s Lower Surface
Depth/elevation of 24th (Vs=2000m/s) Layer’s Lower Surface
Depth/elevation of 23th (Vs=1900m/s) Layer’s Lower Surface
Depth/elevation of 22th (Vs=1800m/s) Layer’s Lower Surface
Depth/elevation of 21th (Vs=1700m/s) Layer’s Lower Surface
Depth/elevation of 20th (Vs=1600m/s) Layer’s Lower Surface
Depth/elevation of 19th (Vs=1500m/s) Layer’s Lower Surface
Depth/elevation of 18th (Vs=1400m/s) Layer’s Lower Surface
Depth/elevation of 17th (Vs=1300m/s) Layer’s Lower Surface
Depth/elevation of 16th (Vs=1200m/s) Layer’s Lower Surface
Depth/elevation of 15th (Vs=1100m/s) Layer’s Lower Surface
Depth/elevation of 14th (Vs=1000m/s) Layer’s Lower Surface
Depth/elevation of 13th (Vs=950m/s) Layer’s Lower Surface
Depth/elevation of 12th (Vs=900m/s) Layer’s Lower Surface
Depth/elevation of 11th (Vs=850m/s) Layer’s Lower Surface
Depth/elevation of 10th (Vs=800m/s) Layer’s Lower Surface
Depth/elevation of 9th (Vs=750m/s) Layer’s Lower Surface
Depth/elevation of 8th (Vs=700m/s) Layer’s Lower Surface
Depth/elevation of 7th (Vs=650m/s) Layer’s Lower Surface
Depth/elevation of 6th (Vs=600m/s) Layer’s Lower Surface
Depth/elevation of 5th (Vs=550m/s) Layer’s Lower Surface
Depth/elevation of 4th (Vs=500m/s) Layer’s Lower Surface
Depth/elevation of 3rd (Vs=450m/s) Layer’s Lower Surface
Depth/elevation of 2nd (Vs=400m/s) Layer’s Lower Surface
Depth/elevation of 1st (Vs=350m/s) Layer’s Lower Surface
Depth/elevation of 0th Layer’s Lower Surface
Elevation of Ground (Ground surface, elevation only)

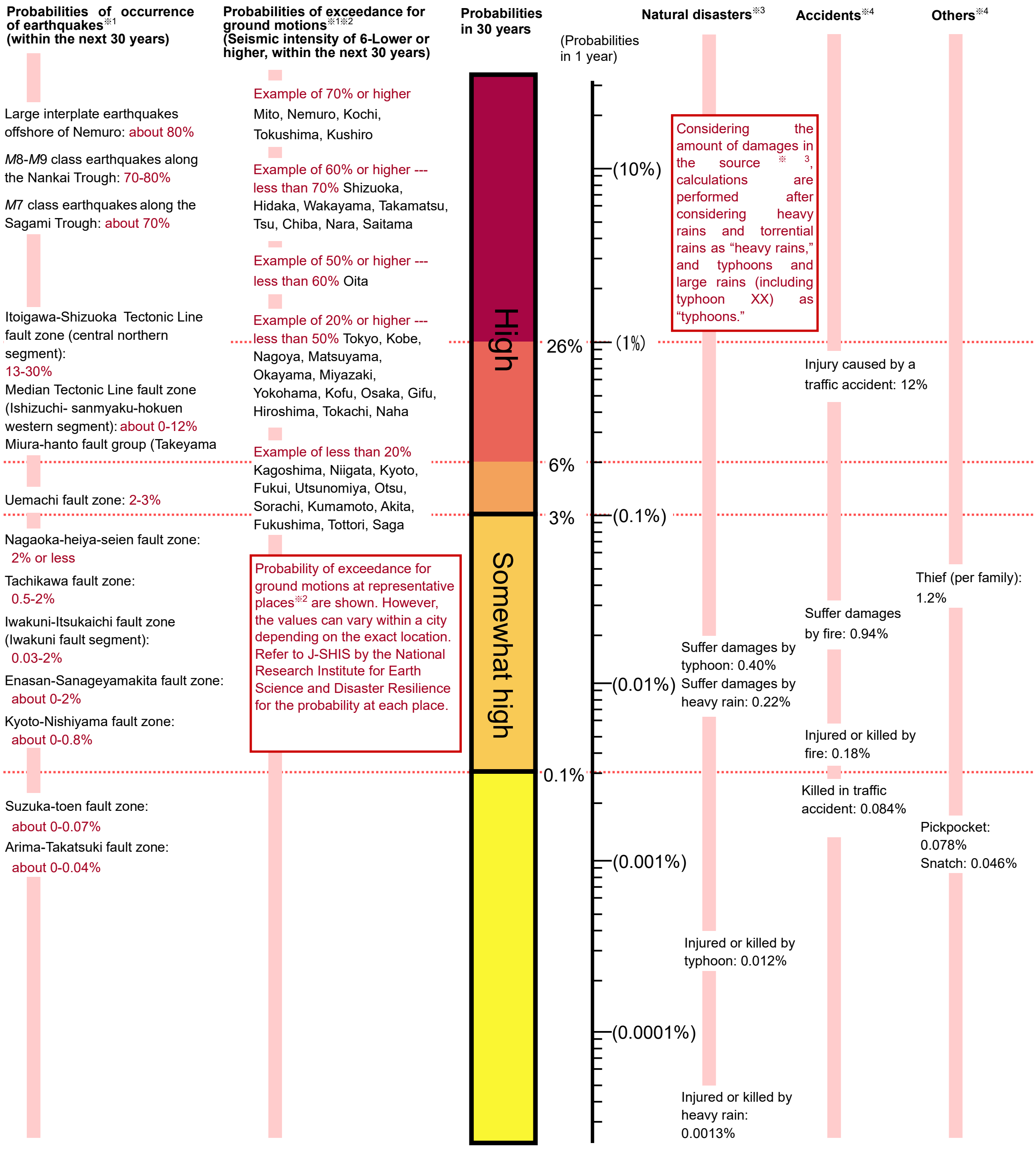
[Exposed Pop.] (National Seismic Hazard Maps for scenario earthquakes)

I_{JMA} ≥5-Lower (daytime population/nighttime population)
I_{JMA} ≥5-Upper (daytime population/nighttime population)
I_{JMA} ≥6-Lower (daytime population/nighttime population)
I_{JMA} ≥6-Upper (daytime population/nighttime population)

Reference Information for Understanding the Probability

Examples of probabilities of occurrence of earthquakes and probabilities of exceedance for ground motions versus probabilities of occurrence for natural disasters and accidents in Japan

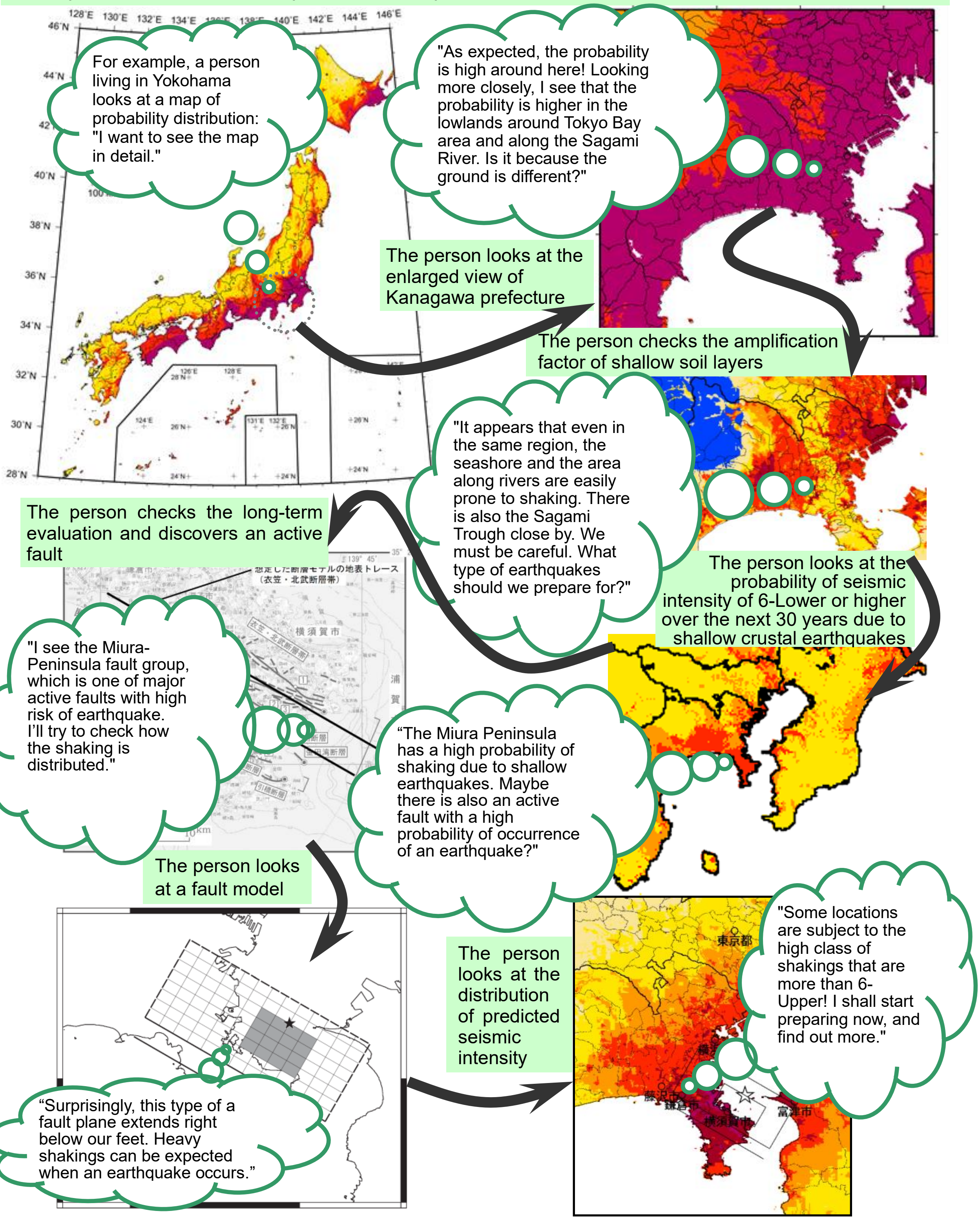
The figure below provides reference information to illustrate that probabilities such as "several percent within the next 30 years" are significant enough to warrant consideration in daily life. The "probability of shakings equal to or higher than a specific intensity (probability of exceedance) within a given future time period," as indicated in the Probabilistic Seismic Hazard Map, represents an evaluation of hazard. This measure may not be directly comparable, in the same sense, to the "probability of occurrence" or "risk" of the events shown in the figure. Nevertheless, the comparison serves as a reference to highlight the importance of the computed values.



※1 The probabilities of occurrence of earthquakes and probabilities of exceedance for seismic ground motions shown above are from the January 1, 2020 assessment. ※2 The probabilities are at city halls of prefectural capitals, Tokyo Metropolitan government office and Sub-prefectural Bureau offices in Hokkaido. Attention needs to be paid because the values can vary even within the same city. For details, refer to J-SHIS by the National Research Institute for Earth Science and Disaster Resilience (https://www.j-shis.bosai.go.jp/en/). ※3 The event probability of occurrence for natural disasters are calculated based on values from the Fire and Disaster Management Agency's Annual Report on Disasters for the period 1999-2018. ※4 The event probability of occurrence for accidents in Japan are calculated based on "The White Paper on Police 2019", "The 2019 White Paper on Fire Service" and "Statistical data on penal code offenses 2019".

Understanding Earthquakes using National Seismic Hazard Maps and Preparing for Earthquake Disaster Prevention

Efficiently using various types of maps to understand earthquakes and preparing for earthquakes based on earthquake disaster prevention



For further detail, refer to the Headquarters for Earthquake Research Promotion and Japan Seismic Hazard Information Station (J-SHIS) by the National Research Institute for Earth Science and Disaster Resilience. The National Seismic Hazard Maps for Japan in this page are as of 2020.

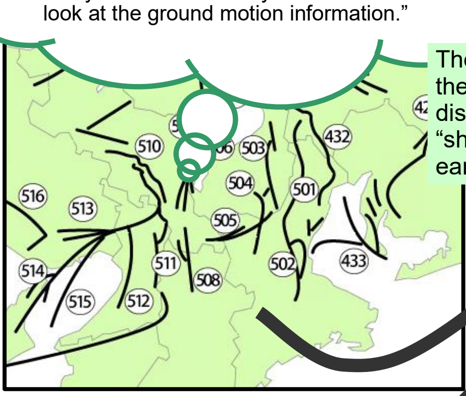
https://www.jishin.go.jp/main/index-e.html
https://www.j-shis.bosai.go.jp/en/

Relevant descriptions → Commentaries on National Seismic Hazard Maps for Japan 67-71

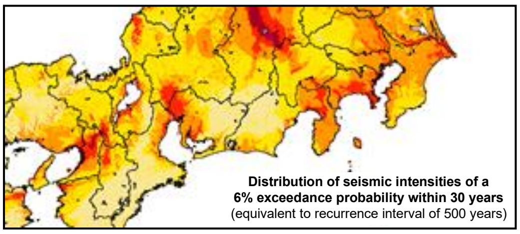
Understanding Earthquakes using National Seismic Hazard Maps and Preparing for Earthquake Disaster Prevention

Learning about earthquakes to prioritize preparations based on the numerous earthquakes of varying magnification and using it for earthquake disaster prevention

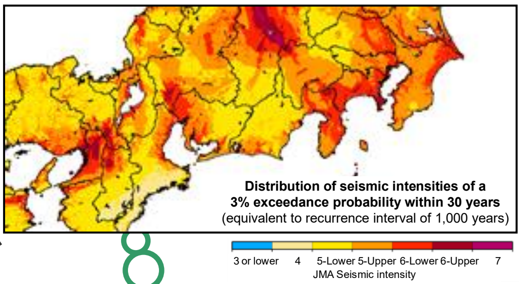
For example, a corporate manager about to expand into the Kinki/Chukyo Area is going through the Headquarters for Earthquake Research Promotion website for long-term evaluations for major active-fault zones.
"I thought there were fewer earthquakes here than in Tokyo; however, there are so many active faults. Maybe I should at least look at the ground motion information."



The manager looks at the seismic intensity distribution of "shallow crustal earthquakes."



Distribution of seismic intensities of a 6% exceedance probability within 30 years (equivalent to recurrence interval of 500 years)



Distribution of seismic intensities of a 3% exceedance probability within 30 years (equivalent to recurrence interval of 1,000 years)

"The contribution factors of active faults on the Osaka Plain and Nobi Plain are greater than in Tokyo; therefore, the largest-class shaking is expected. So, specifically, what kind of active-fault earthquake should I prepare for?"

The manager investigates "shallow crustal earthquakes" that will cause seismic intensity of 6-Upper or higher within the next 30 years on the grid cell of the Osaka City Hall location.

<Example of 2020 version, 30-year seismic intensity of 6-Upper or higher, average case >

The first largest	CF*	The second largest	CF*	The third largest	CF*
Uemachi fault zone	48.1%	Shallow crustal earthquakes without specified source faults	6.1%	Rokko/Awajishima fault zone (Rokko-sanchi nan'en-Awajishima-togan segment)	2.7%

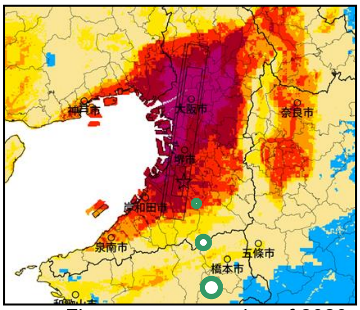
*Contribution Factor

"I see…I wonder what type of shaking this will be?"

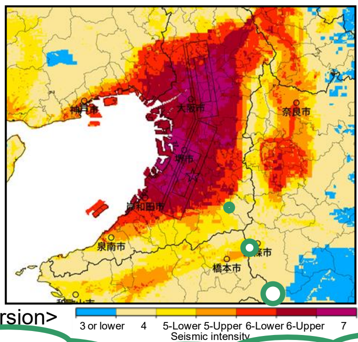
"I keep looking at the many active faults; however, I should also focus on earthquakes that occur where no active faults have been found."

The manager goes through the predicted seismic intensity distribution

Straight fault model



Bending fault model



<Figures are examples of 2020 version>

"I want to set up important business bases away from active faults; however, I should consider the seismic resistance of the facilities, as there is possibility of an unexpected earthquake occurring directly below."

"An earthquake directly below Osaka! A maximum-class shaking with a seismic intensity of 6-Upper to 7."

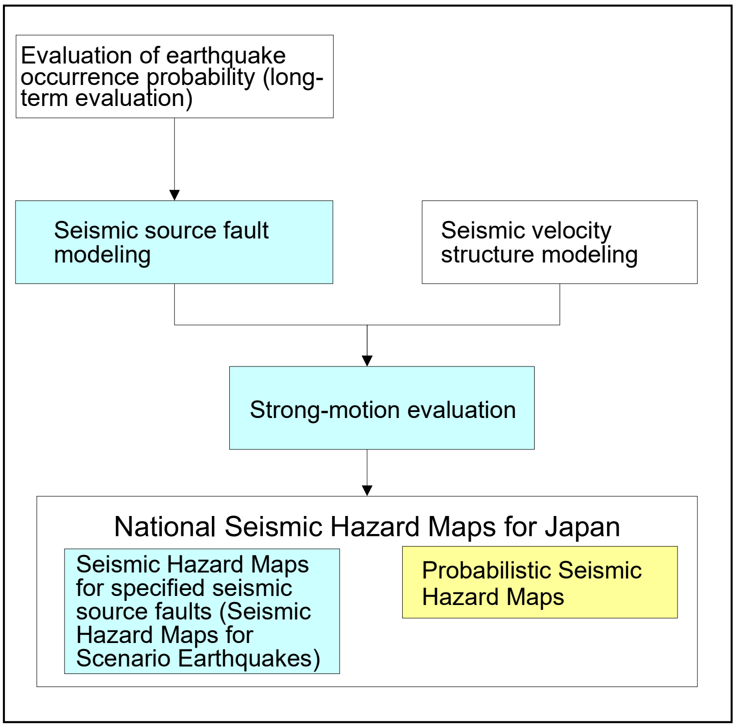
"This is another really strong quake! The shaking is especially intense in the southern part of the plains."

For further detail, refer to the Headquarters for Earthquake Research Promotion and Japan Seismic Hazard Information Station (J-SHIS) by the National Research Institute for Earth Science and Disaster Resilience.
The National Seismic Hazard Maps for Japan in this page are as of 2020.
https://www.jishin.go.jp/main/index-e.html
https://www.j-shis.bosai.go.jp/en/

Relevant descriptions → Commentaries on National Seismic Hazard Maps for Japan 67-71

Commentary on National Seismic Hazard Maps for Japan

Commentary: Additional Information (Overview of Commentaries)

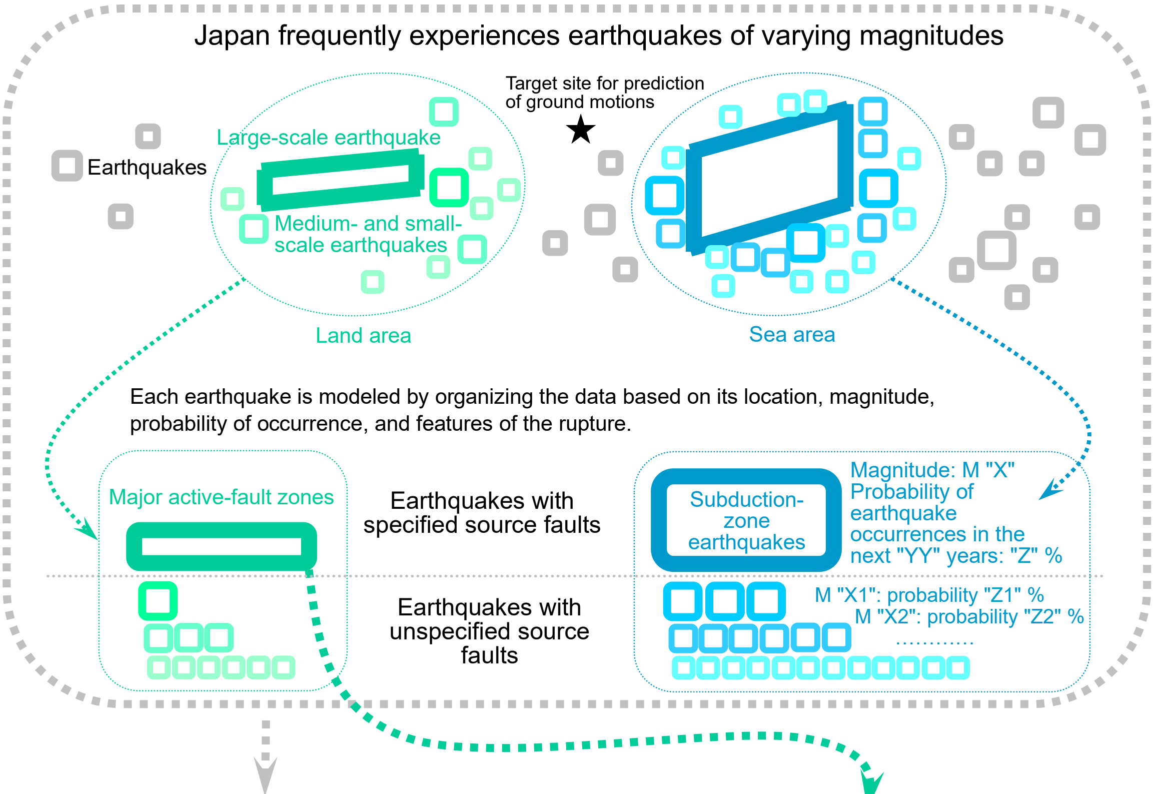


Overview of seismic hazard mapping

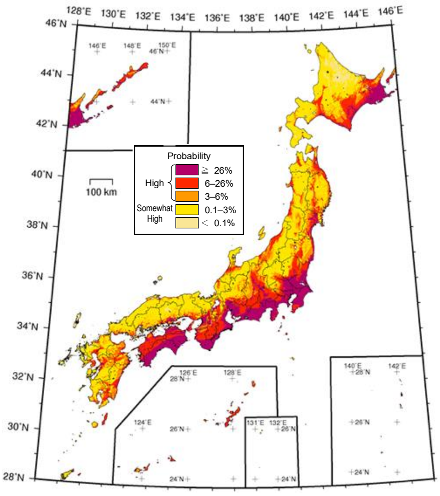
Commentary: National Seismic Hazard Maps for Japan

Creating “Seismic Hazard Maps for specified seismic source faults” and “Probabilistic Seismic Hazard Maps”

The Seismic Hazard Maps for Japan released by the Headquarters for Earthquake Research Promotion are divided into two types: the “Seismic Hazard Maps for specified seismic source faults (Seismic Hazard Maps for Scenario Earthquakes)” and the “Probabilistic Seismic Hazard Maps.”

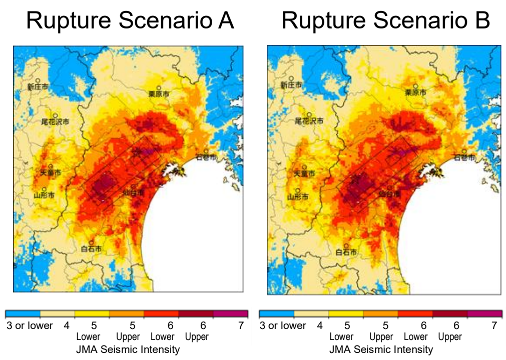


The intensity and probability of ground motions at each site are calculated simultaneously based on the locations, magnitudes, and probabilities of occurrence of all earthquakes that can be considered at present. The distribution of the calculated intensities or probabilities is plotted on a map.



Probabilistic Seismic Hazard Map

The ground motion intensity at each site for a given fault rupture scenario is calculated, and the results are plotted on a map.



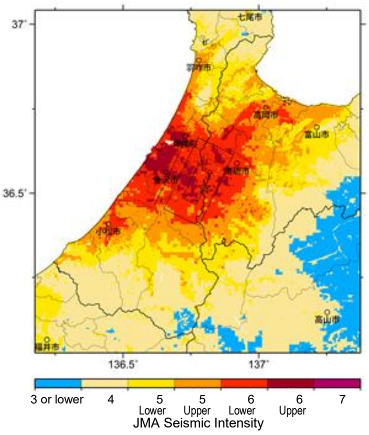
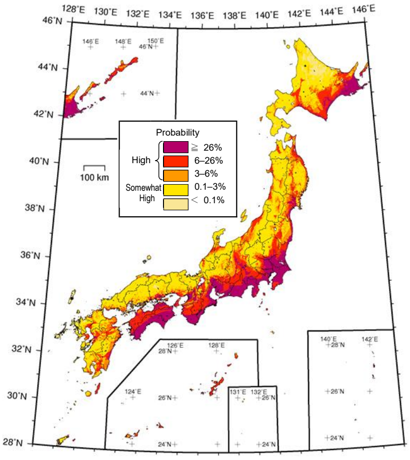
Seismic Hazard Maps for specified seismic source faults (Seismic Hazard Maps for Scenario Earthquakes)

Commentary: National Seismic Hazard Maps for Japan

Comparison of “Seismic Hazard Map for a specified seismic source fault” and “Probabilistic Seismic Hazard Map”

★ A “Seismic Hazard Map for a specified seismic source fault (Seismic Hazard Maps for Scenario Earthquakes)” is a National Seismic Hazard Map that shows, for a selected fault, the distribution of the ground motion intensity at all sites, as calculated based on a certain fault rupture scenario (for details, see pp. 51–56).

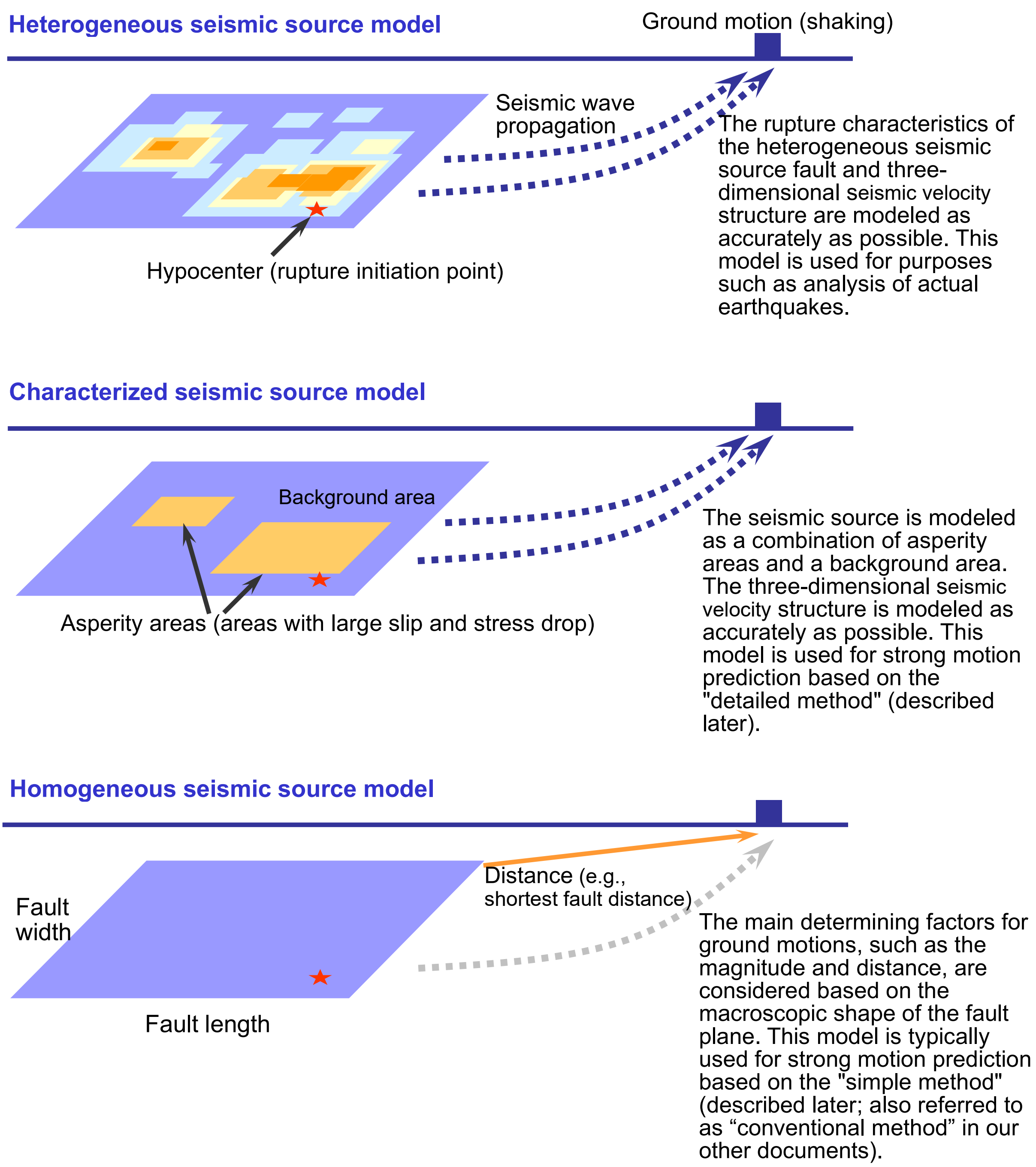
★ A “Probabilistic Seismic Hazard Map” is a National Seismic Hazard Map that shows the distribution of the probability of ground shaking at all sites, as calculated and summed up based on the locations, magnitudes, and probabilities of occurrence of all earthquakes that can be considered at present (for details, see pp. 57–65).

	Seismic Hazard Map for a specified seismic source fault	Probabilistic Seismic Hazard Map
Definition	A map showing the distribution of the ground motion intensity that occurs simultaneously in a region for a specific rupture pattern of a scenario earthquake.	A map showing relationships between the ground motion intensity, period, and probability at each site, which is taken from a hazard curve constructed through probabilistic processing of data on the occurrence of earthquakes of varying magnitudes and their ground motion intensity.
Type	A map showing the distribution of ground motion intensity.	A map showing the distribution of the probability of exceedance (exceedance probability). A map showing the distribution of ground motion intensity.
Example	Instrumental seismic intensity of ground surface shaking for one of the scenario earthquakes, Case 1, in the Morimoto/Togashi fault zone. 	The probabilities of ground motions equal to or greater than seismic intensity of 6-Lower occurring within the next 30 years from various earthquakes. 
Key features	● Before the mapping, a specific earthquake or a specific rupture scenario is assumed. ● Different results are obtained for different earthquakes or rupture scenarios. ● Advanced ground-motion evaluation is possible by utilizing detailed information relating to the characteristics of the seismic source, propagation path, and site. ● The time history of ground motions (waveform) is evaluated.	● Areal distribution of either ground motion intensity or probability, under the condition that the period is fixed and one of the remaining parameters is held constant ● The distribution is not of the ground motion intensity of a single earthquake. ● All earthquakes are modeled probabilistically on a type-by-type basis. ● Currently, the map is based on ground motion evaluation by empirical equations (attenuation equations).
Examples of main applications	● Developing countermeasures, response action plans, and stockpiling plans for assumed specific earthquakes ● Aseismic design, earthquake resistance evaluation, and reinforcement of various structures and related research using time history of ground motions (waveform) that reflect characteristics unique to the region and area ● The detailed information on the local area is useful information in itself	● Legislation ● Design load setting, design guidelines ● Large-area disaster prevention planning ● City planning, selection of locations for developing new facilities ● Public education ● Calculation of earthquake insurance premium rates

Commentary: Basic Concepts of Ground Motion Prediction

Modeling of complex source fault rupture and seismic wave propagation

Earthquakes, as natural phenomena, are highly complex, with ground motion characteristics influenced by the three-dimensional shape and rupture dynamics of the seismic source fault, the three-dimensional propagation characteristics of the seismic waves, and amplification due to the local seismic velocity structures that are three-dimensionally non-uniform. In practice, the seismic source characteristics, and propagation characteristics are modeled according to the quality and quantity of the available information on these characteristics and the purpose of utilization of the ground motion prediction results.

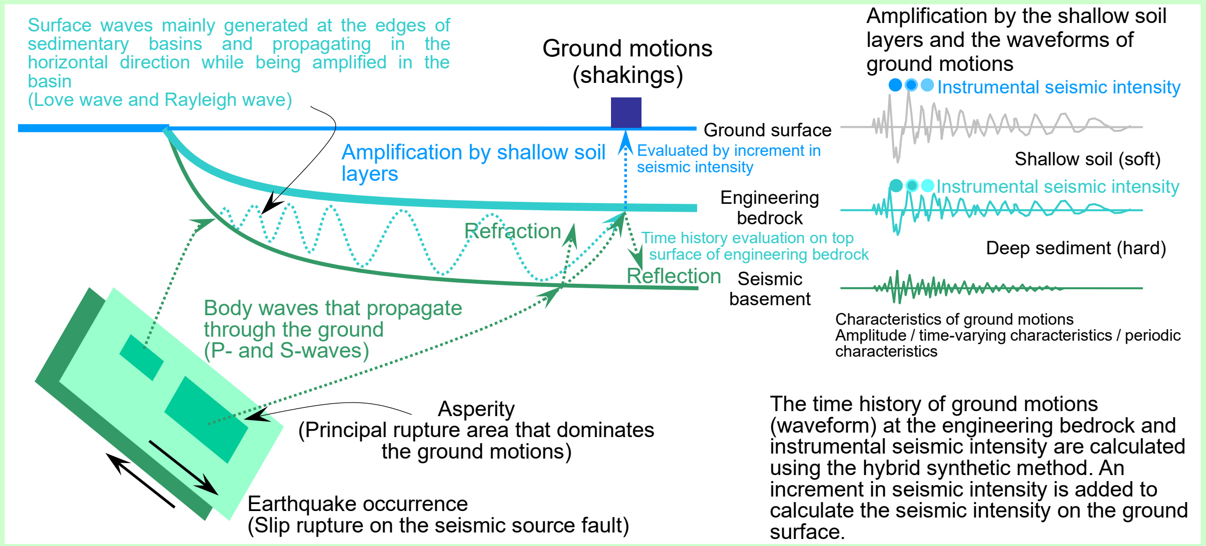


Commentary: Basic Concepts of Ground Motion Prediction

"Detailed method" based on the hybrid synthetic method and "simple method" based on ground motion prediction equations (GMPEs)

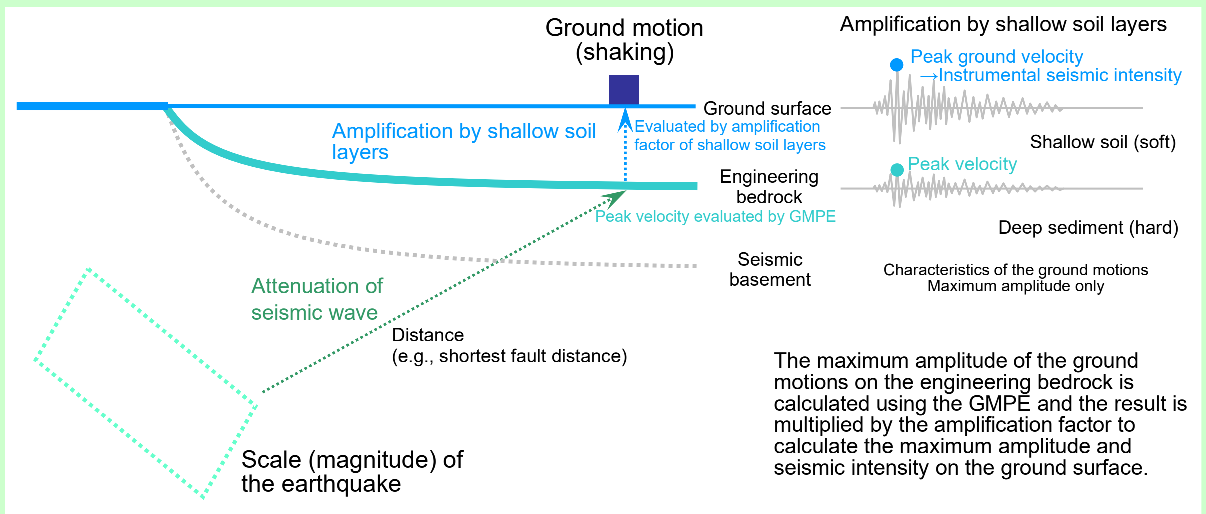
The National Seismic Hazard Maps for Japan are generated using two ground motion prediction methods: a "detailed method" based on the hybrid synthetic approach and a "simple method" based on the ground motion prediction equation (GMPE).

The detailed method, a type of physics-based ground motion modeling, predicts the time history of broadband ground motions (waveform) by (1) calculating the long-period ground motions from a seismic source fault model with three-dimensional structure and rupture propagation using the finite difference method; (2) calculating the short-period ground motions using the stochastic Green's function method; and (3) combining the results of the two calculations using a matching filter. The finite difference method accounts for wave propagation within a three-dimensional seismic velocity structure model, while the stochastic Green's function method assumes a horizontally stratified, one-dimensional seismic velocity structure.



Overview of ground motion prediction using the detailed method based on the hybrid synthetic method

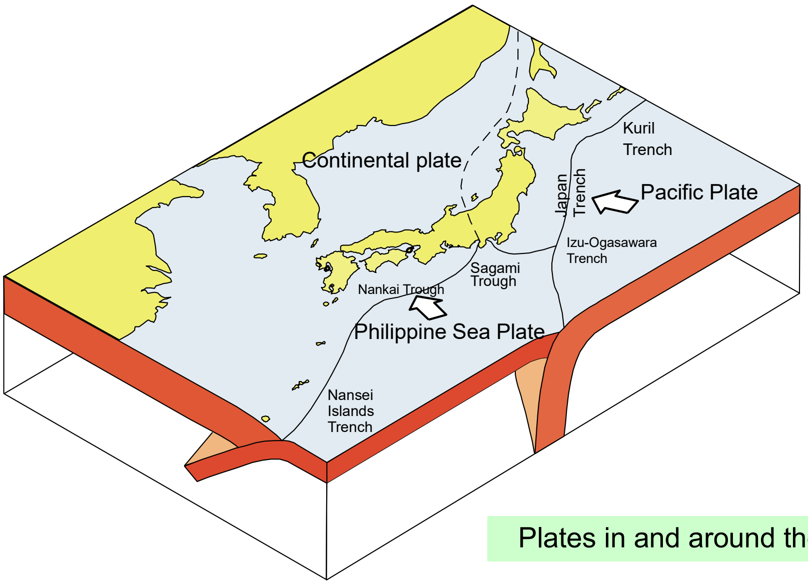
The simple method, or the conventional method, is a type of empirical ground motion modeling that predicts the maximum amplitude of the ground motions by employing the GMPE for the given scale (magnitude) of the earthquake and given distance (e.g., the shortest distance from the fault).



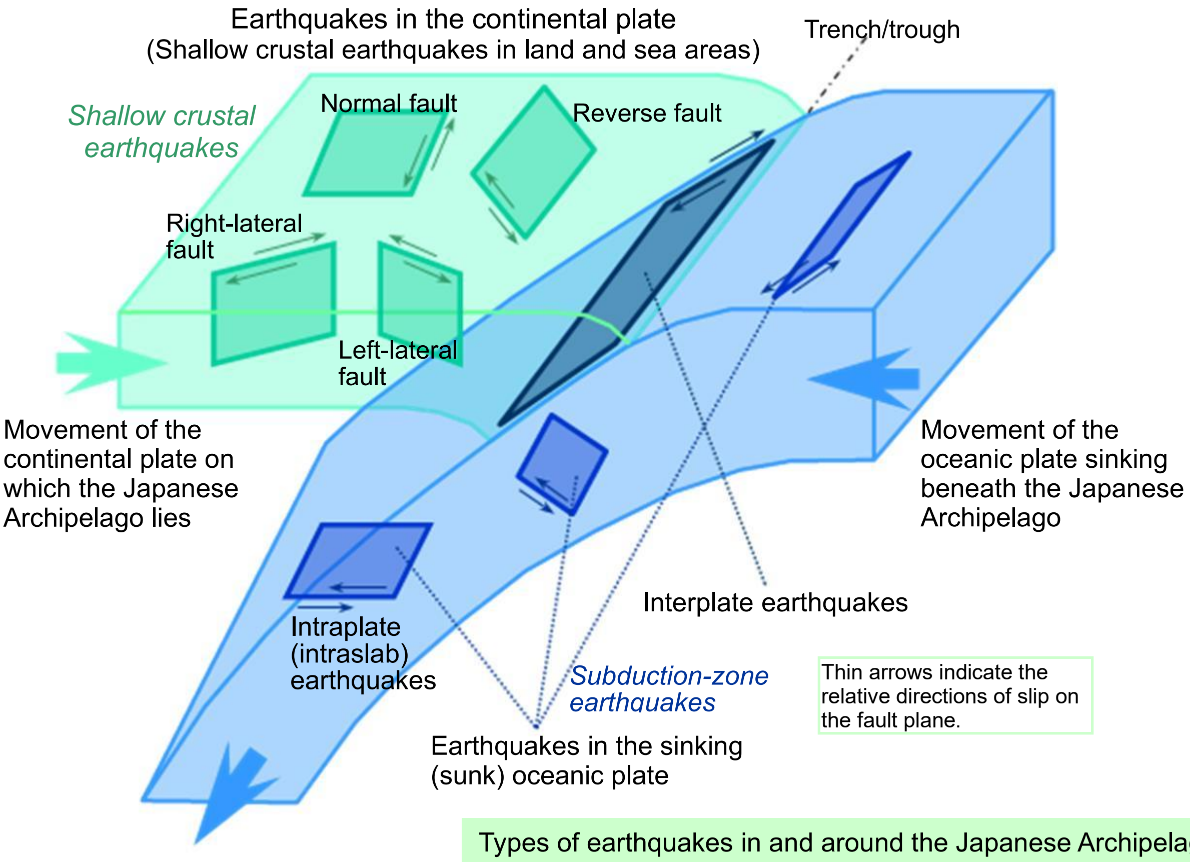
Overview of ground motion prediction by the simple method based on GMPE

Commentary: Types of Earthquakes In and Around the Japanese Archipelago
Structures of the plates surrounding the Japanese Archipelago and various types of earthquakes

Plates are masses of bedrock, with thicknesses of several tens of kilometers to 100 km, covering the surface of the earth. The Japanese Archipelago and its surroundings comprise the continental plate on which the Japanese Archipelago lies and two oceanic plates (Pacific Plate and Philippine Sea Plate). Earthquakes that occur in these areas can be broadly classified as shallow crustal earthquakes and subduction-zone earthquakes.



Plates in and around the Japanese Archipelago

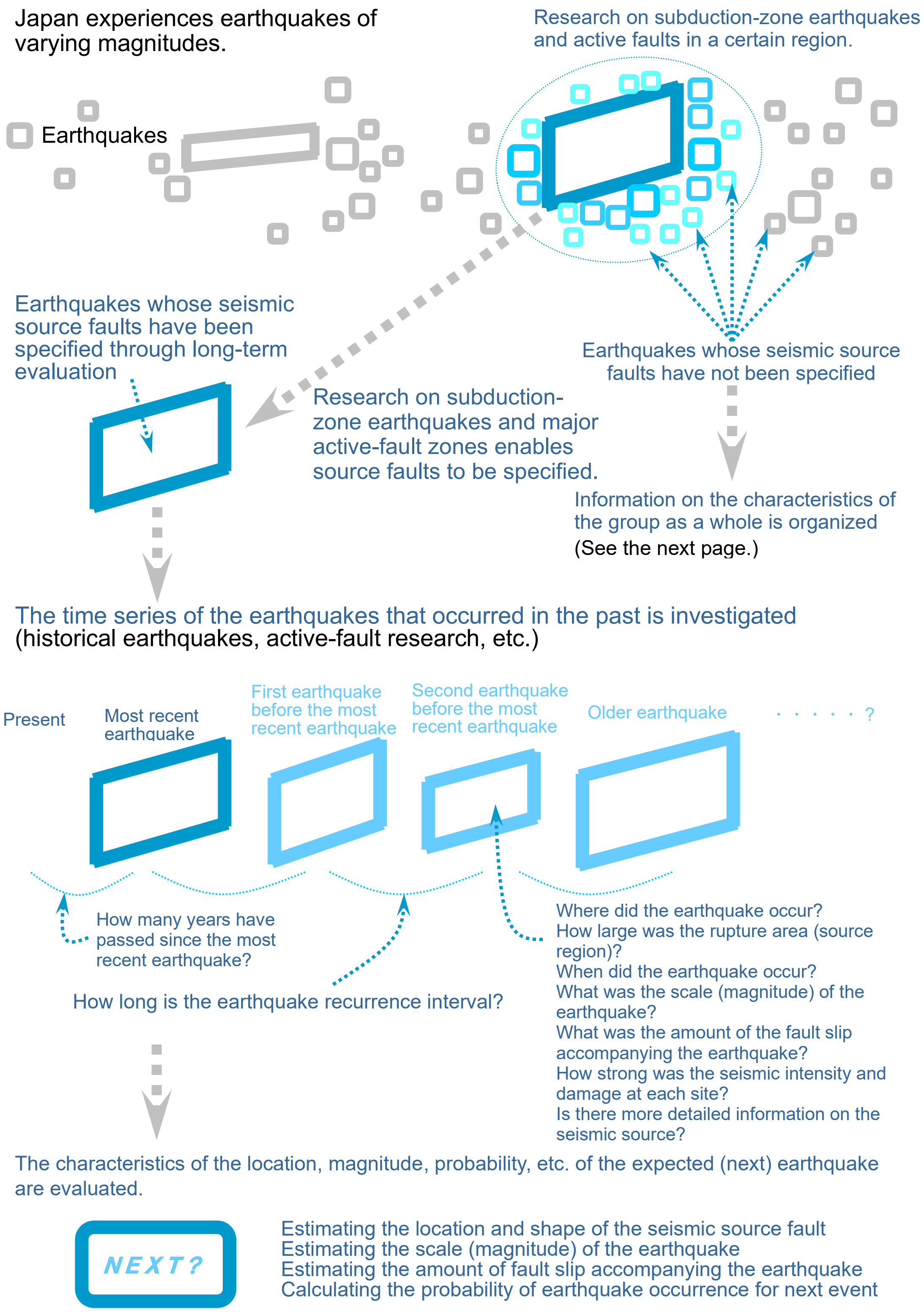


Types of earthquakes in and around the Japanese Archipelago

Commentary: Scenario Earthquakes and Their Long-Term Evaluation

Overview of long-term evaluation by the Headquarters for Earthquake Research Promotion

The Headquarters for Earthquake Research Promotion estimates the locations and shapes of the faults expected to generate future earthquakes, along with their magnitudes, fault slip amounts, and probabilities of occurrence for the next event, as illustrated in the diagram below.



Commentary: Earthquakes For Unspecified Source Faults

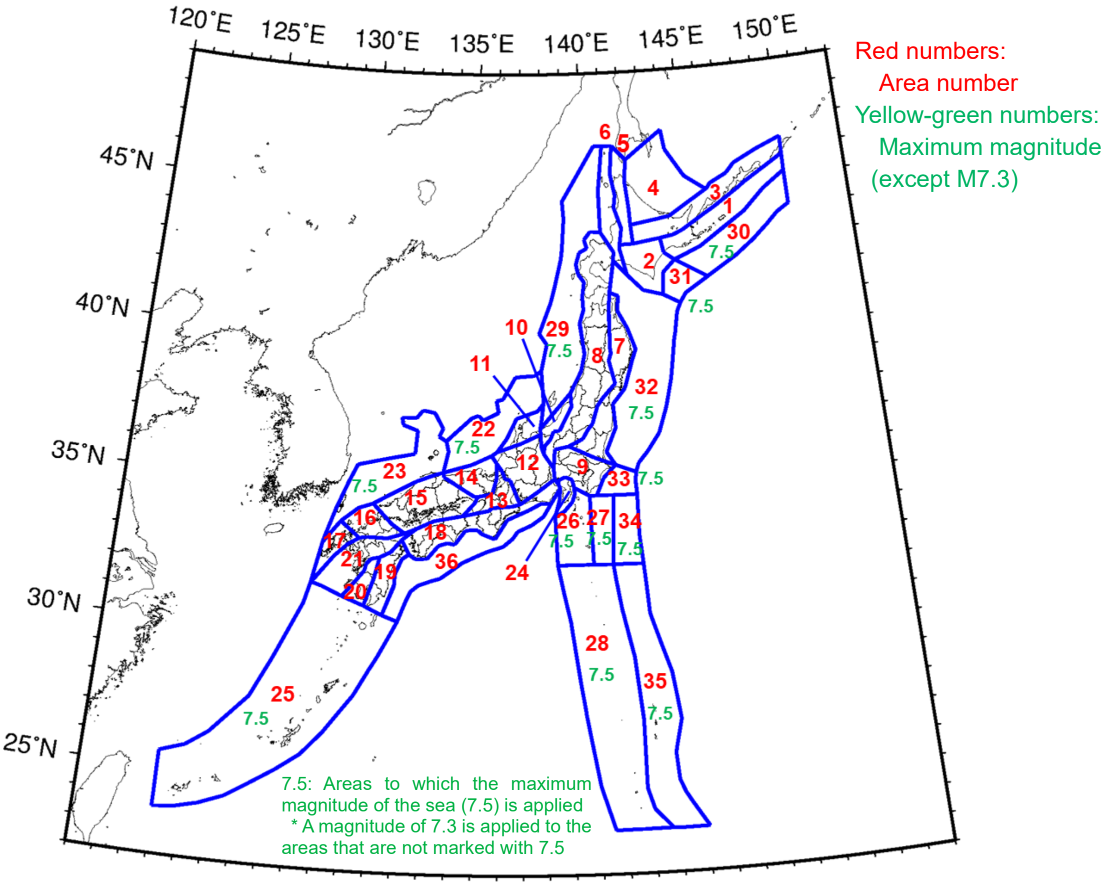
Earthquake modeling area and maximum magnitude of earthquakes for unspecified source faults

Earthquakes, different from those on major active-fault zones and subduction-zone ones, with seismic source faults specified through the long-term evaluation conducted by the Headquarters for Earthquake Research Promotion exist. These include shallow inland earthquakes in areas where no active faults have been identified, earthquakes on the plate boundary, and others. The Headquarters for Earthquake Research Promotion terms these earthquakes “earthquakes for unspecified source faults” and considers their effects during its production of Probabilistic Seismic Hazard Maps. As specifying the locations, magnitudes, and probabilities of earthquake occurrences for unspecified source faults on individual earthquake basis is challenging, the characteristics of groups are analyzed using probabilistic models.

Earthquakes that fall under the following definitions are considered to be earthquakes for unspecified source faults.

* Shallow crustal earthquakes in places where active faults are unidentified
* Earthquakes for unspecified source faults in the eastern margin of the Sea of Japan (East Sea)
* Earthquakes for unspecified source faults offshore of Urakawa (including eastern Iburi), in Izu Islands (and southern regions), and around Yonagunijima Is. (and surroundings)
* Pacific interplate and intraplate earthquakes for unspecified source faults
* Philippine Sea interplate and intraplate earthquakes for unspecified source faults

The maximum magnitude of earthquakes for unspecified source faults to be considered (setting the maximum magnitude) varies between areas. The figure below shows the maximum magnitude settings for shallow crustal earthquakes.

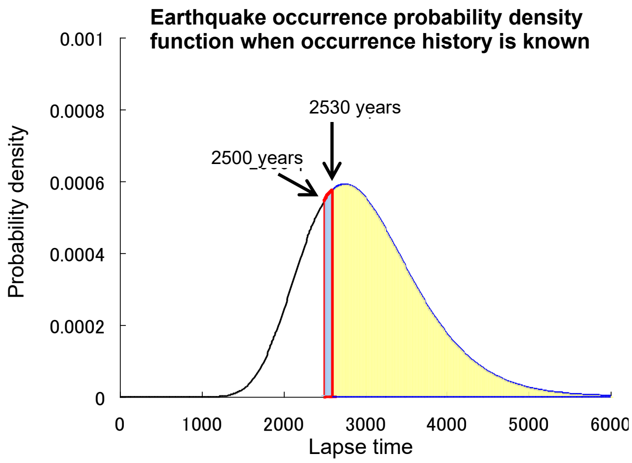


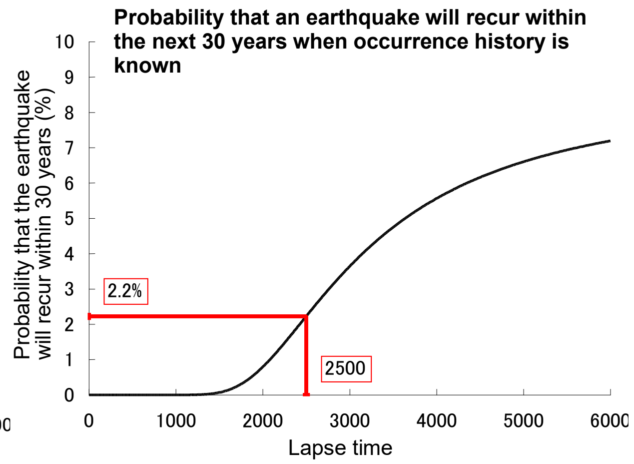
Areas and maximum magnitudes of shallow crustal earthquakes in places where active faults are unidentified

Commentary: Methods of Calculating Probabilities of Earthquake Occurrence

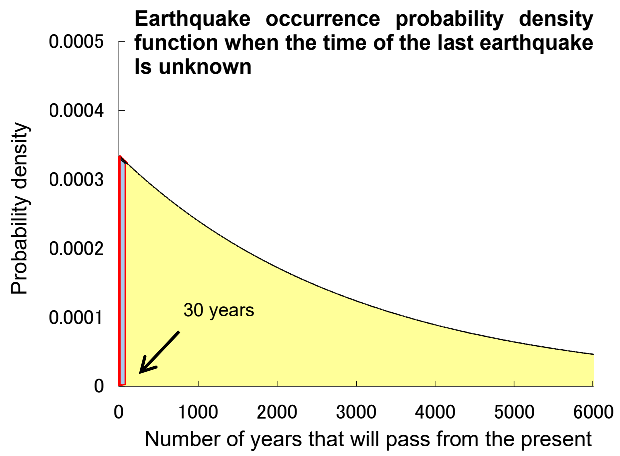
Brownian Passage Time (BPT) distribution-based method and Poisson process-based method

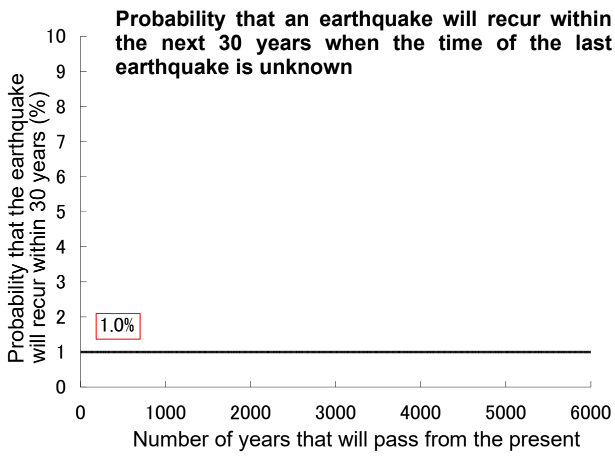
Earthquakes on major active-fault zones and subduction-zone earthquakes are considered to recur, and their activity intervals follow BPT distributions. A BPT distribution is represented by the probability density function shown in the left graph below. In this case, the probability according to the BPT distribution that an earthquake will recur in 2500–2530 years after the last event is represented by the light blue portion of the left graph. If assuming that 2500 years have passed since the last earthquake, the probability that the earthquake will recur within the next 30 years can be calculated by dividing the area of the light blue portion by the area of the light blue portion + the area of the yellow portion. The relationship between the probability that an earthquake will recur within the next 30 years and the number of years that have passed since the last earthquake (lapse time) is plotted in the right graph below.





In the case in which the time of the last event is unknown, earthquake occurrence is assumed to follow the Poisson distribution, and the probability of occurrence of earthquake is calculated based only on the information on its mean recurrence interval (number of years). In the left graph below, the probability that the earthquake will recur within the next 30 years can be calculated by dividing the area of the light blue portion by the area of the light blue portion + the area of the yellow portion. The relationship between the probability that an earthquake will recur within the next 30 years and the number of years that will pass from the present is plotted in the right graph below. In this case, the probability that an earthquake will recur within 30 years from an evaluation reference date will be the same regardless of the evaluation reference date.





Because the results of actual evaluations of the mean recurrence interval and the time of the last earthquake have a wide range in many cases, two cases are considered for earthquakes on active faults. One is the average case, in which the probability of earthquake occurrence is calculated using the medians of the evaluation results as representative values. The other is the maximum case, in which the maximum value of the evaluated probability is used.

Commentary: Earthquake Classification

Earthquake classifications for seismic hazard maps by the Headquarters for Earthquake Research Promotion and their utilization

In Probabilistic Seismic Hazard Maps, earthquakes are classified into two groups for clarity and ease of analysis. Preparing for earthquakes that have the most significant impact on each region is possible by examining the probabilistic seismic hazard map for each earthquake classification and contribution factor.

Classification of earthquakes in Probabilistic Seismic Hazards Maps

Shallow crustal earthquakes (mean recurrence interval is between several thousands and several tens of thousands of years)

Shallow inland and coastal earthquakes on active faults

- Earthquakes on major active-fault zones and active faults under regional analysis (including earthquakes where fault traces are difficult to identify from surface evidence)
- Earthquakes on other active faults
- Earthquakes offshore northwest of Hokkaido Prefecture
- Earthquakes offshore west of Hokkaido Prefecture
- Earthquakes offshore southwest of Hokkaido Prefecture
- Earthquakes offshore west of Aomori Prefecture
- Earthquakes offshore of Akita Prefecture
- Earthquakes offshore of Yamagata Prefecture
- Earthquakes offshore of northern Niigata Prefecture
- Earthquakes offshore north of Sadoshima Is.

Shallow crustal earthquakes for unspecified source faults

- Shallow crustal earthquakes in places where active faults are unidentified
- Earthquakes for unspecified source faults offshore of Urakawa (including eastern Iburi)
- Earthquakes for unspecified source faults in the eastern margin of the Sea of Japan
- Earthquakes for unspecified source faults in the Izu Islands (and southern regions)
- Earthquakes for unspecified source faults around Yonagunijima Is. (and surroundings)

Subduction-zone earthquakes (mean recurrence interval is between several decades and several hundred years)

Subduction-zone earthquakes whose source faults are individually modeled

- Megathrust interplate earthquakes along the Kuril Trench (17^{th} century-earthquake type)
- Large interplate earthquakes offshore of Tokachi
- Large interplate earthquakes offshore of Nemuro
- Interplate earthquakes near the trench offshore of Tokachi to Etorofu Is. (tsunami earthquakes)
- Megathrust earthquakes along the Japan Trench (the 2011 Tohoku Earthquake-type)
- Large interplate earthquakes offshore east of Aomori Prefecture and in the north region offshore of Iwate Prefecture
- Large interplate earthquakes offshore of Miyagi Prefecture
- Interplate earthquakes near the trench offshore east of Aomori Prefecture to Boso (tsunami earthquakes)
- Earthquakes on the external side of the Japan Trench axis
- M8-class earthquakes along the Sagami Trough
- Large earthquakes along the Nankai Trough
- Interplate earthquakes of the Hyuganada Sea
- Smaller interplate earthquakes of the Hyuganada Sea
- Earthquakes around Yonagunijima Is.

Subduction-zone earthquakes for unspecified source faults

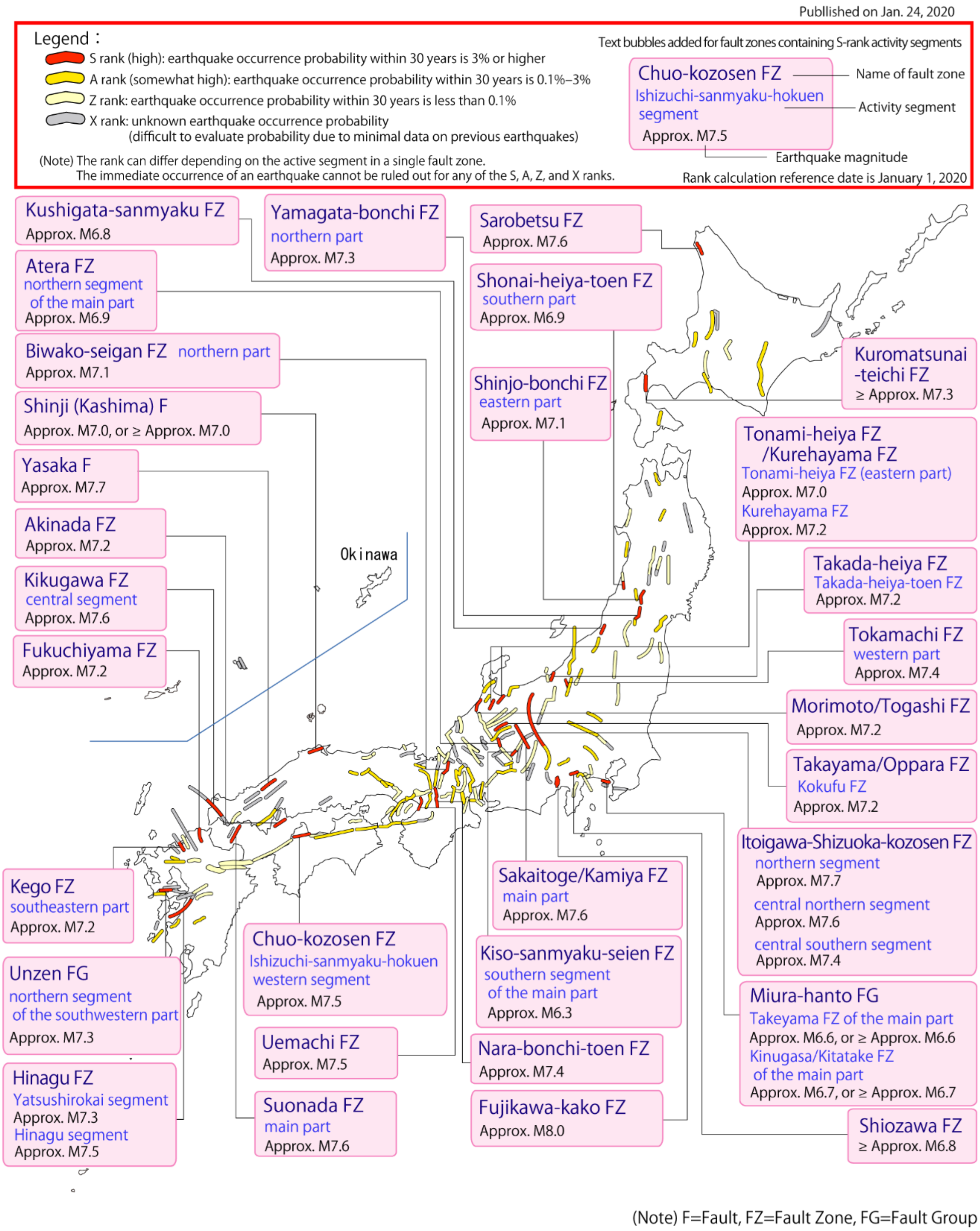
- Pacific interplate and intraplate earthquakes for unspecified source faults
- Philippine Sea interplate and intraplate earthquakes for unspecified source faults

Note: Earthquake classifications are devised and set mainly to improve the explanations of probability and contribution factor maps (Probabilistic Seismic Hazard Maps); there are cases in which these classifications may not be followed when selecting a strong ground motion prediction method or creation method for seismic hazard maps for specified seismic source faults. For example, earthquakes on the eastern margin of the Sea of Japan (East Sea), which are expected to have high recurrence intervals, are classified as shallow crustal earthquakes.

Commentary: Earthquake Classification

Overview of results of long-term evaluations of shallow inland earthquakes on active faults

In Probabilistic Seismic Hazard Maps, shallow inland and shallow coastal earthquakes occurring on active faults—whether from specified source faults with long-term evaluations or unspecified source faults— are collectively categorized as shallow crustal earthquakes. The following provides an overview of long-term evaluation results for shallow inland earthquakes within this category.

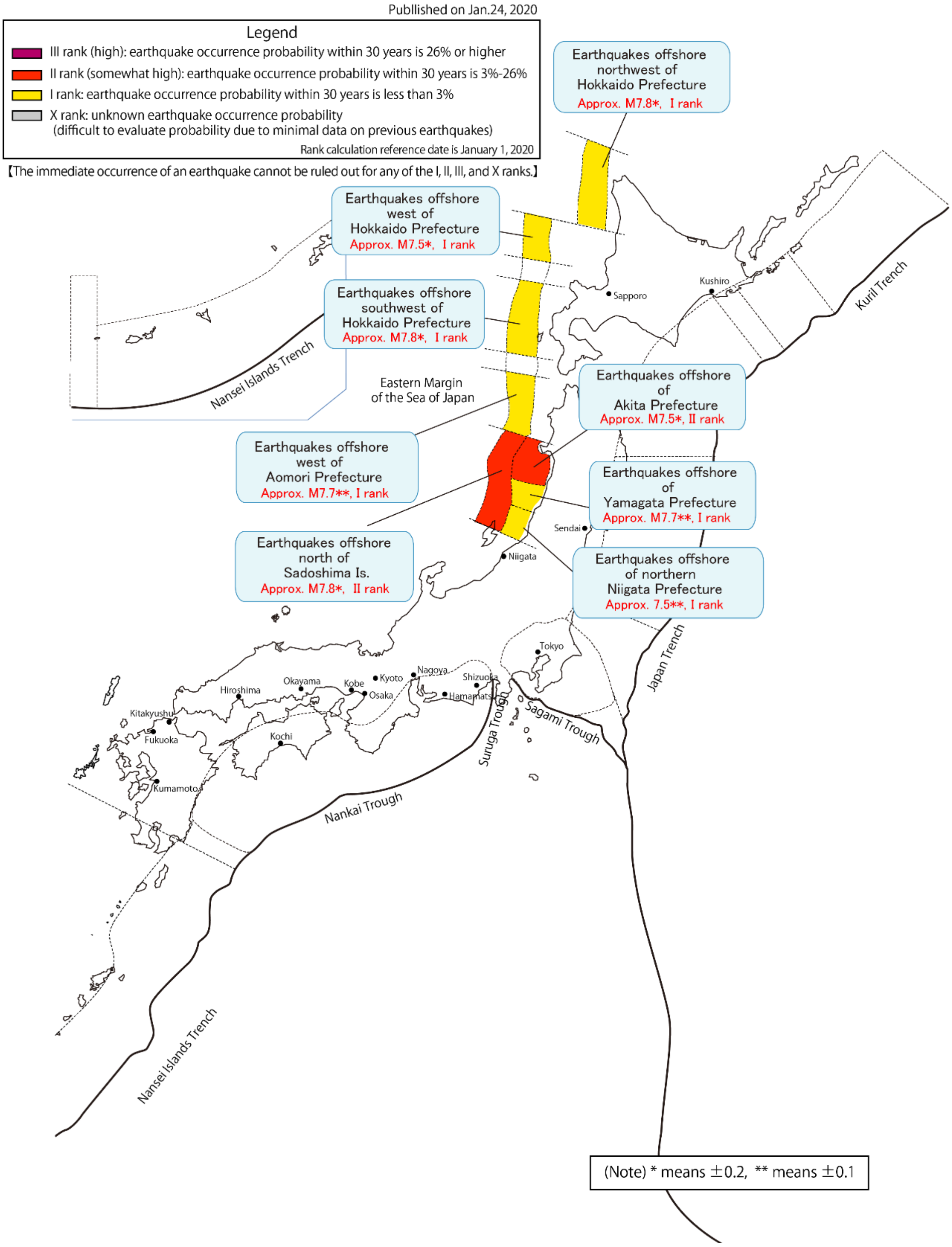


<Evaluation values as of January 1, 2020>

Commentary: Earthquake Classification

Overview of results of long-term evaluations of shallow coastal earthquakes on active faults

In Probabilistic Seismic Hazard Maps, shallow inland and coastal earthquakes on active faults (earthquakes with a mean recurrence interval of several thousand to several tens of thousands of years) for specified source faults for which long-term evaluations are conducted and for unspecified source faults are combined and collectively categorized as shallow crustal earthquakes. An overview of the results of long-term evaluations of shallow coastal earthquakes among these is shown below.

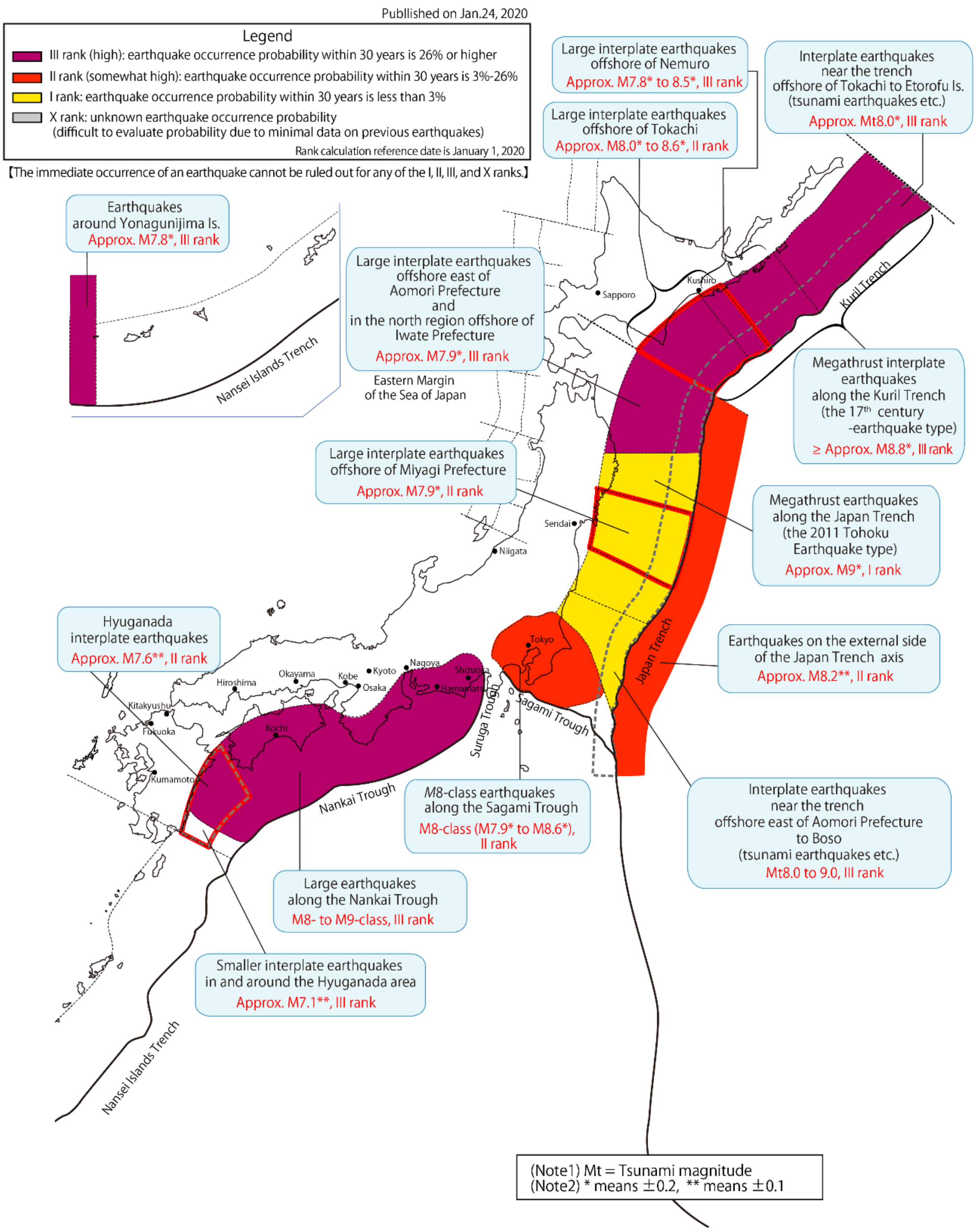


<Evaluation values as of January 1, 2020>

Commentary: Earthquake Classification

Overview of results of long-term evaluations of subduction-zone earthquakes whose source faults are individually modeled

An overview of long-term evaluation results for subduction-zone earthquakes, where source faults could be individually modeled and have mean recurrence intervals ranging from several decades to several hundred years is provided below.

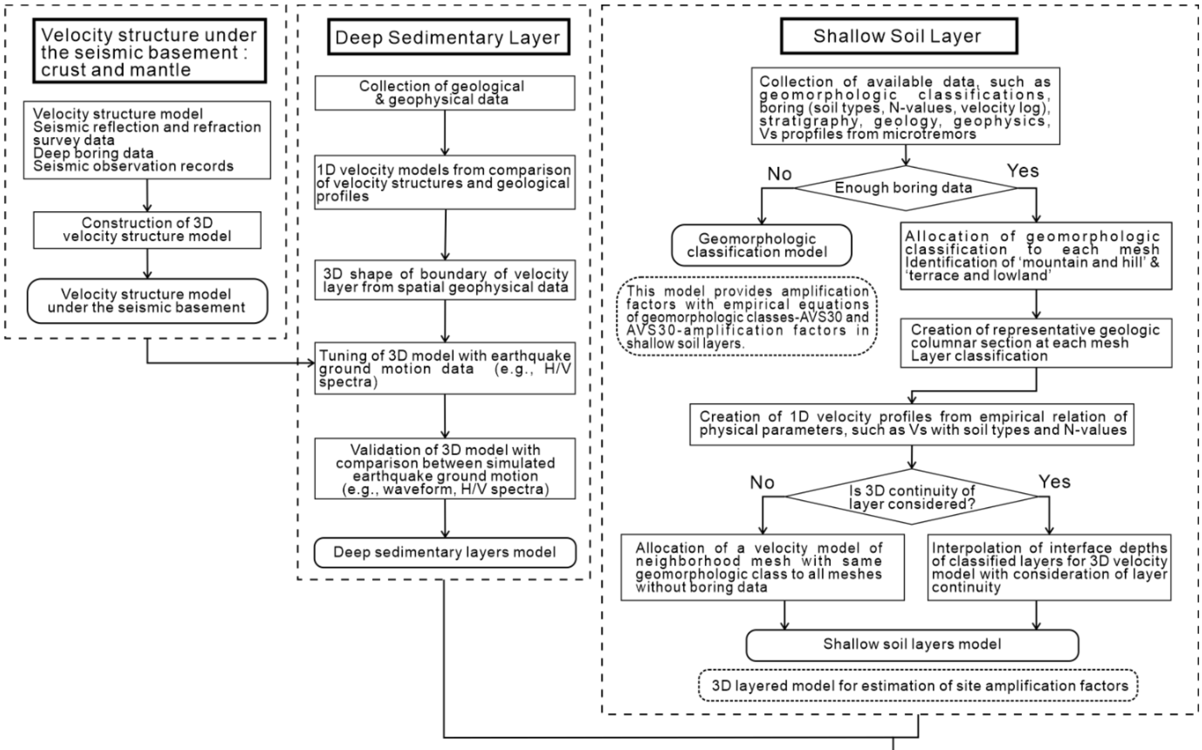


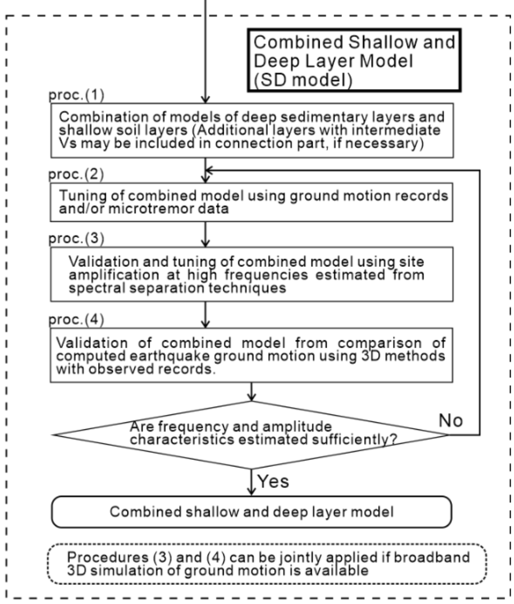
<Evaluation values as of January 1, 2020>

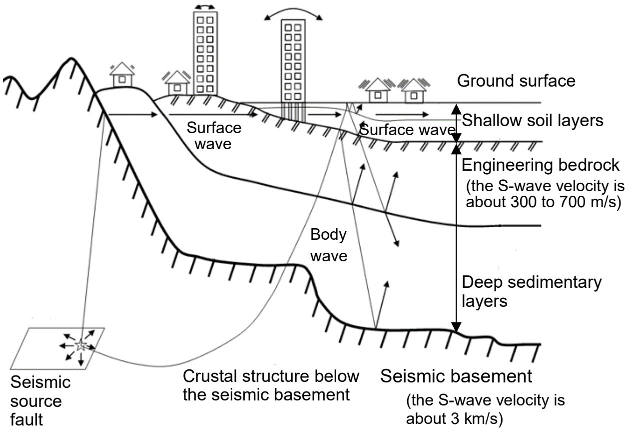
Commentary: Seismic Velocity Structure Models

Modeling of the Shallow Soil Layers, Deep Sedimentary Layers, and Crustal Structure below the seismic basement

Three-dimensional seismic velocity structure models for strong motion prediction are constructed by combining the results of various surveys.





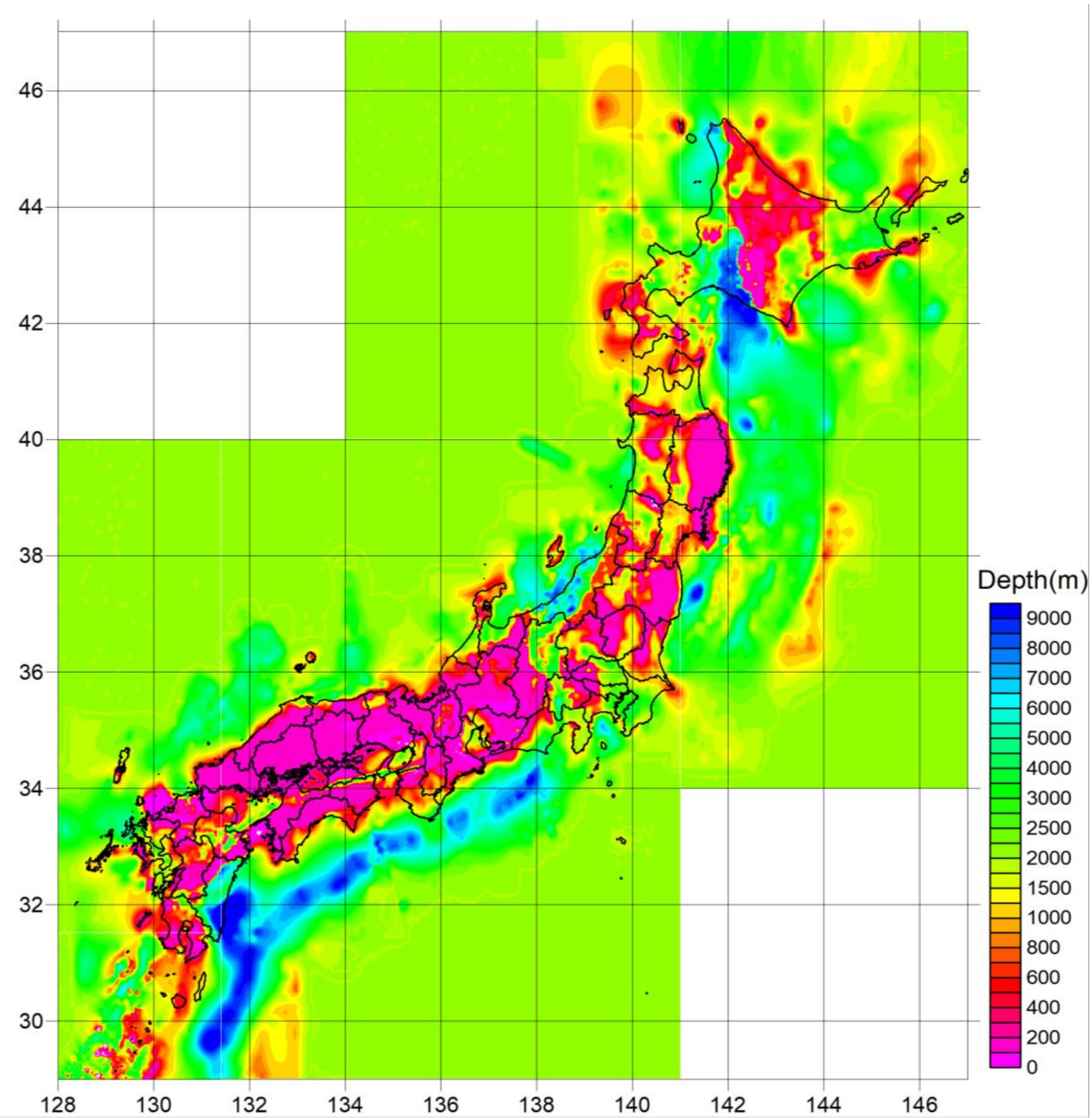


Overview of seismic velocity structure and seismic wave propagation

Procedure for seismic velocity structure model

Commentary: Deep Sedimentary Layers
Three-dimensional deep sedimentary layers model from the seismic basement to the engineering bedrock

The three-dimensional models of deep sedimentary layers of the entire area of Japan from the seismic basement to the engineering bedrock were constructed for strong motion prediction. The figure below illustrates the distribution of the depths of the seismic basement surfaces in the models. The reliability and accuracy of the seismic velocity structure models are not uniform throughout the area. For example, the reliability and accuracy for the areas that were revised to explain the observed seismograms are different from those for the unrevised areas. In addition, the reliability and accuracy may differ across the boundary of two neighboring models constructed using different data. While these models integrate the latest knowledge and research findings, continuous efforts will be made to refine them further in the future.

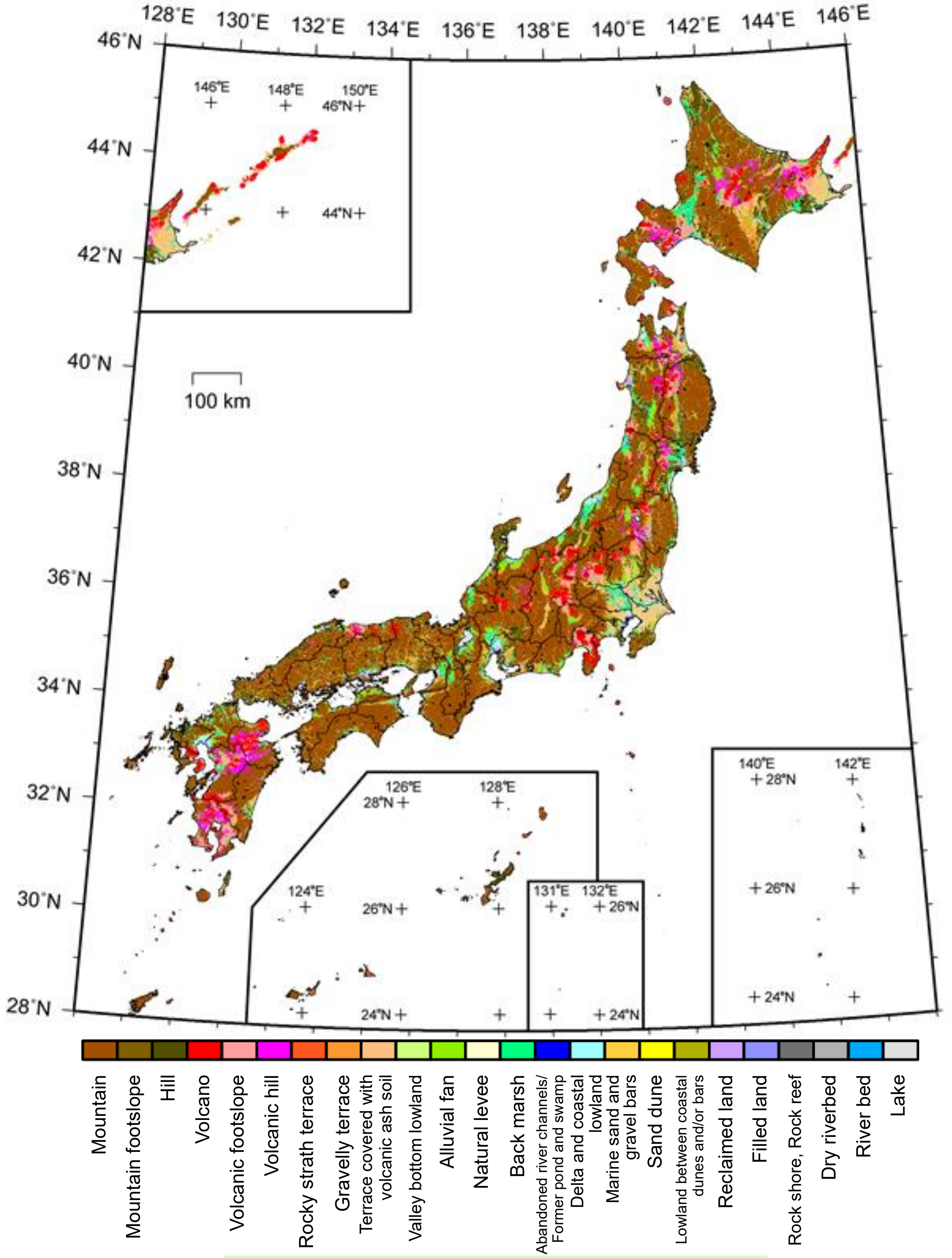


Distribution of the depths of the seismic basement surfaces in the models
(used in the National Seismic Hazard Map for Japan (2020))

Commentary: Shallow Soil Layers

the Shallow Soil Layers based on the latest geomorphologic classifications

In Seismic Hazard Maps for Japan, except for that of the Kanto region where the Combined Shallow and Deep Layers Model (2021) is employed, an approximately 250-m grid cell geomorphologic classification is used to evaluate the peak ground velocity amplification factor owing to the surface soil layers. The geomorphologic classification (Wakamatsu and Matsuoka, 2020) used in the 2020 edition onwards is shown below.



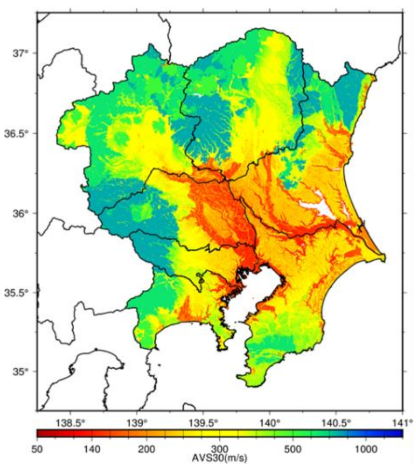
Distribution of the geomorphologic classification

Commentary: Combined Model of Shallow and Deep Layers

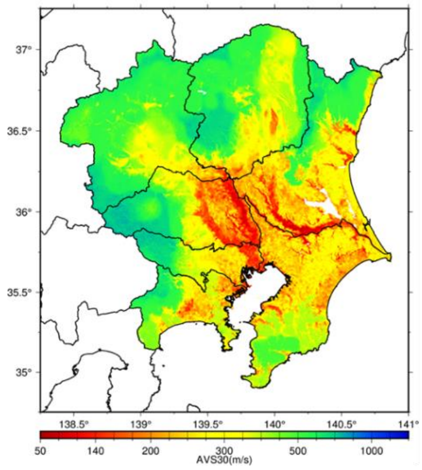
the Combined Shallow and Deep Layers Model of Kanto region (2021)

A combined model of shallow and deep layers was constructed to further enhance strong motion prediction in the Kanto region. This model is a revision of an initial model that combines the Shallow Soil Layer model from the ground surface to the engineering bedrock created from boring data and the existing Deep Sedimentary Layer model from the engineering bedrock to seismic basement; revisions were made using seismic records obtained from seismic stations such as the National Research Institute for Earth Science and Disaster Resilience, the Japan Meteorological Agency, and local governments, as well as microtremor array observation results.

Since the 2017 edition of the National Seismic Hazard Maps for Japan, the Deep Sedimentary Layers of the Combined Shallow and Deep Layers Model have been employed to calculate the seismic waveform on the engineering bedrock using the detailed method (refer to page 34). Furthermore, in the National Seismic Hazard Maps for Japan (2020), the Shallow Soil Layers of the Combined Shallow and Deep Layers Model (2021) were used to calculate the site amplification factor of shallow soil layers. The following is a comparison of the AVS30 in the Shallow Soil Layers and seismic basement depth distribution used in the previous edition (left figures) with those in the National Seismic Hazards Maps for Japan (2020) (right figures).

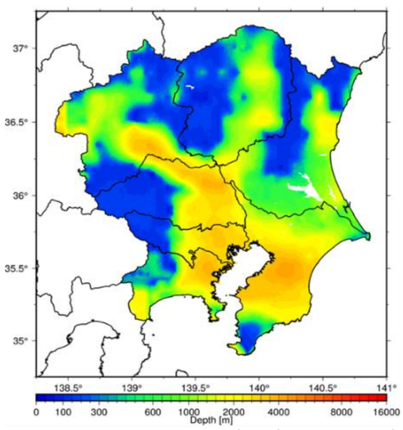


Previous edition (before 2017)
Geomorphologic classification
(Wakamatsu and Matsuoka, 2013)

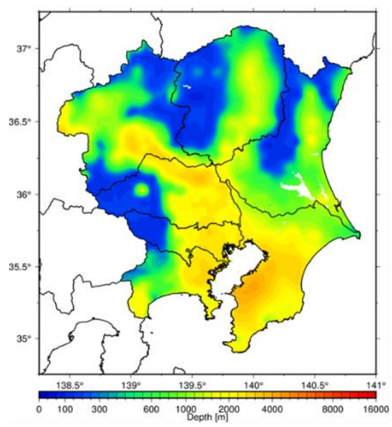


2020 edition
the Combined Shallow and Deep Layers Model (2021 edition)

Comparison of AVS30 in the Shallow Soil Layers of Kanto region



Previous edition (before 2017)
J-SHIS (V2) model



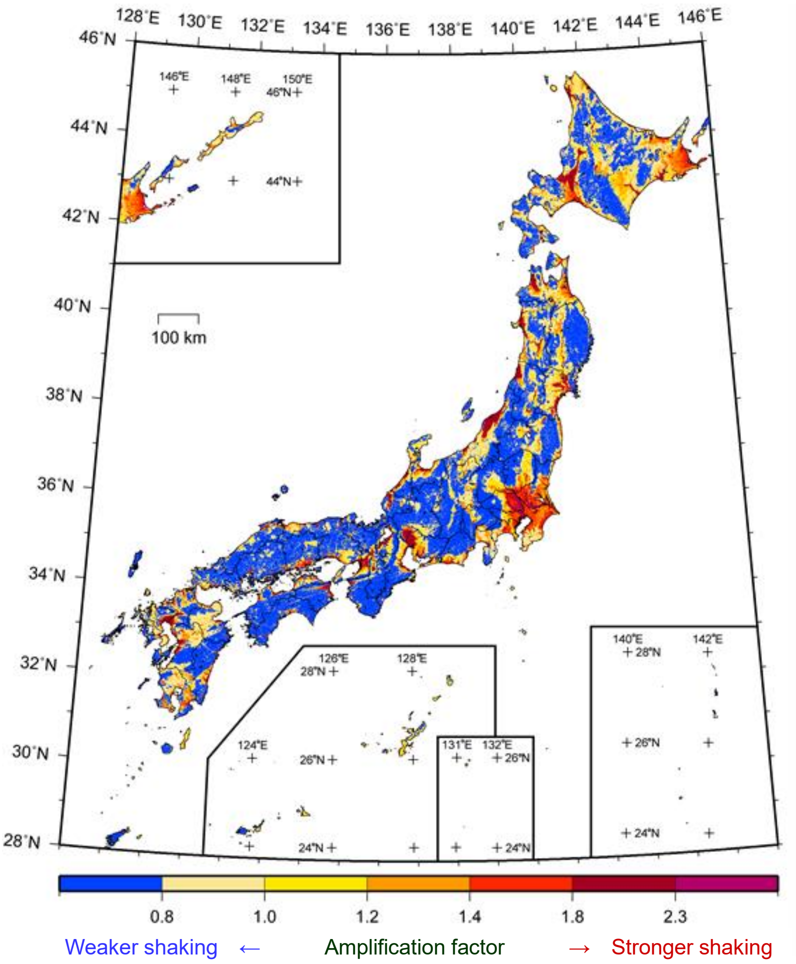
2020 edition
the Combined Shallow and Deep Layers Model (2021 edition)

Comparison of depth distributions of seismic basement (Vs3200 m/s layer top depth) of Kanto region

Commentary: Effect of Shallow Soil Layers on Ground Motion

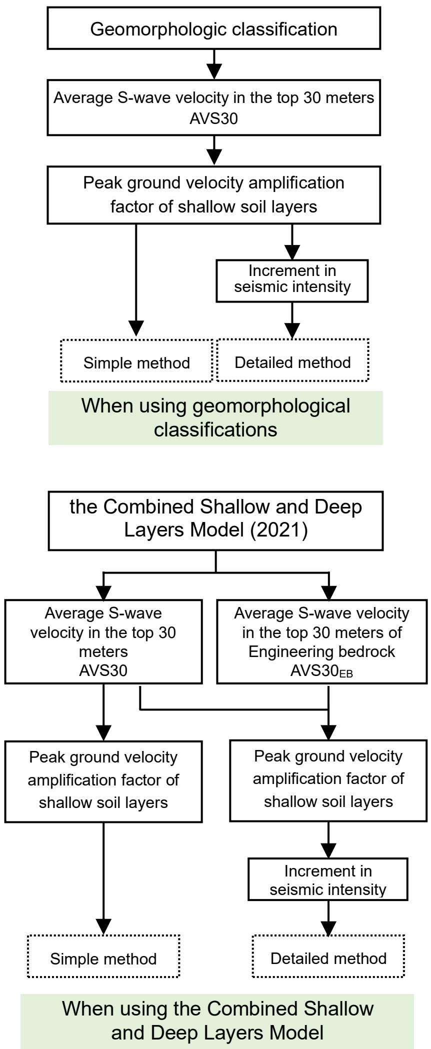
Peak ground velocity amplification factor for soil layers from the engineering bedrock to the surface

In Probabilistic Seismic Hazard Maps, the peak ground velocity of the ground surface is calculated using the peak ground velocity amplification factor from the engineering bedrock to the ground surface. For the Kanto region, the peak ground velocity amplification factor is calculated based on the Shallow Soil Layers of the Combined Shallow and Deep Layers Model (2021). By contrast, for other areas, it is calculated based on the average S-wave velocity in the top 30 meters (AVS30) obtained from an empirical formula (Matsuoka et al., 2006) using geomorphological classifications (Wakamatsu and Matsuoka, 2020), ground elevation, slope angle, and distance from mountains/hills. The calculation of the peak ground velocity amplification factor using shallow soil layers is shown below.



(The Combined Shallow and Deep Layers Model (2021) used for Kanto region, geomorphological classifications used for regions other than Kanto)

Peak ground velocity amplification factor of shallow soil layers from the engineering bedrock (corresponding S wave velocity (Vs) = 400 m/s) to the ground surface



Calculation procedure for peak ground velocity amplification factor of shallow soil layers

Commentary: Recipe for Strong Motion Prediction

Steps of the strong motion prediction method for scenario earthquakes

The "Recipe" is a standardized method to perform similar predictive calculations and is designed to model seismic sources and predict strong motions for earthquakes with specified source faults that occur in major active-fault zones and subduction zones. In this method, we obtain intensity measures such as peak ground acceleration, peak ground velocity, and seismic intensity, as well as the time history of ground motions to assess how structures will behave and sustain damage during earthquakes.

The steps of the Recipe for strong motion prediction are as follows:

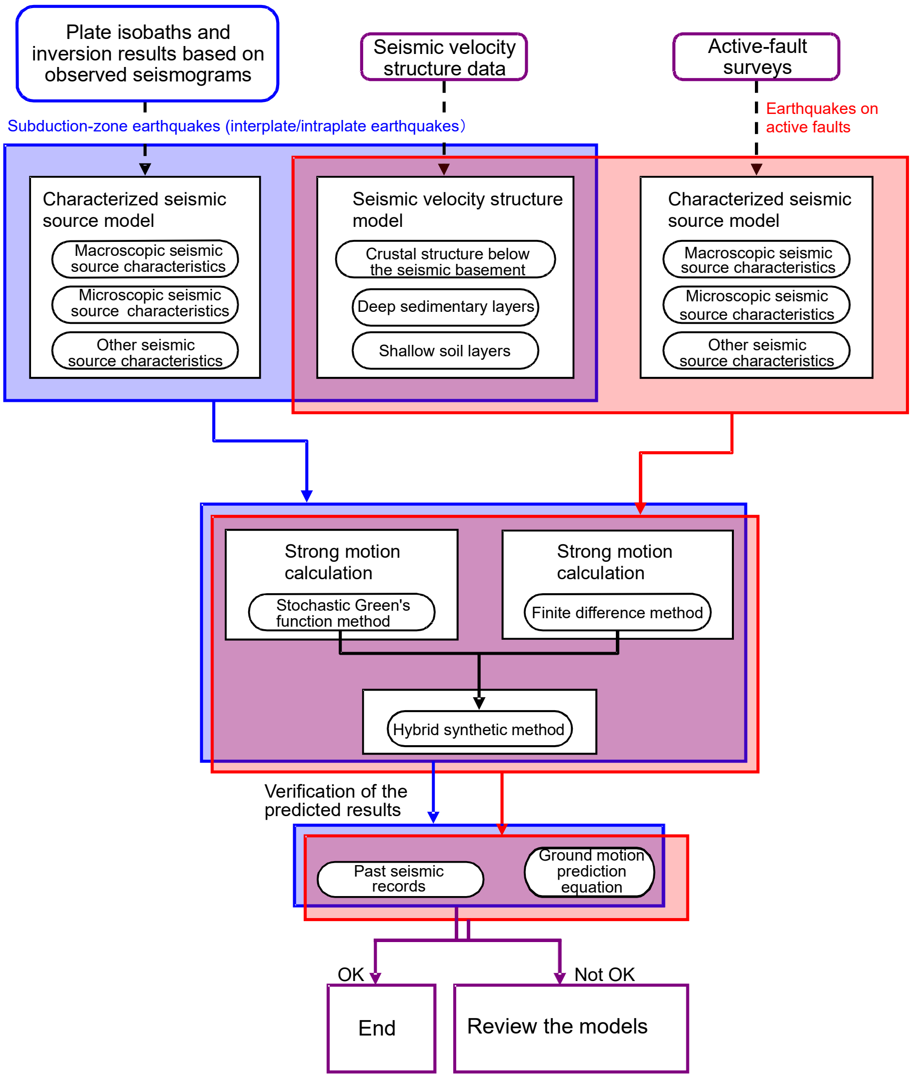
(1) Characterization of the seismic source of the scenario earthquake

(2) Modeling of the seismic velocity structure on which the seismic source and the area under consideration are located

(3) Simulation of ground motions

(4) Verification of the predicted result

The Recipe enables accurate strong motion predictions within the 0.1–10 s period range, which is crucial for assessing seismic damage to structures. These precise predictions contribute to the development of advanced measures for reducing seismic damage. The Recipe is continuously refined and improved using high-accuracy observational data and updated seismic source information from recent earthquakes.



Commentary: Fault Models for Scenario Earthquakes

Example of the source fault models for earthquakes on major active-fault zones and subduction-zone earthquakes (an example of the Tachikawa fault zone)

The fault models for scenario earthquakes have been constructed such that the following requirements are met:

★ All earthquake source fault models for strong motion prediction are defined based on the long-term evaluation results.

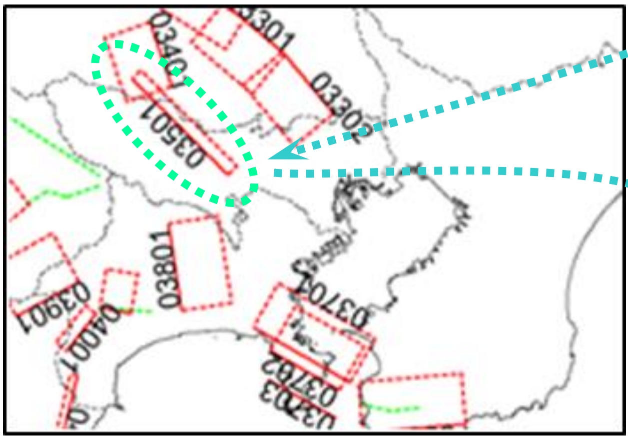
★ If detailed information on the area under consideration is available, such information must be considered first.

★ If the values of some parameters are unknown, the values are set in accordance with the Recipe that has been defined as the standardized procedure for all areas of Japan.

The example presented below is the seismic source fault model constructed for the Tachikawa fault zone.

Example of the seismic parameters in the Tachikawa fault zone

Fault name	Direction of displacement in the fault plane		M_J	Fault length	Fault width	Dip angle of the fault plane	Depth of the seismogenic layer
Tachikawa fault zone	Uplifting of the northeast side, accompanied by a left lateral slip component in the northwest part	Long-term evaluation	Approx. 7.4	Approx. 33 km	Unknown	Very large	unknown
		Modeling	M_W6.8	34 km	18 km	80°	2–20 km



Fault planes of earthquakes on active faults as projected onto the ground surface

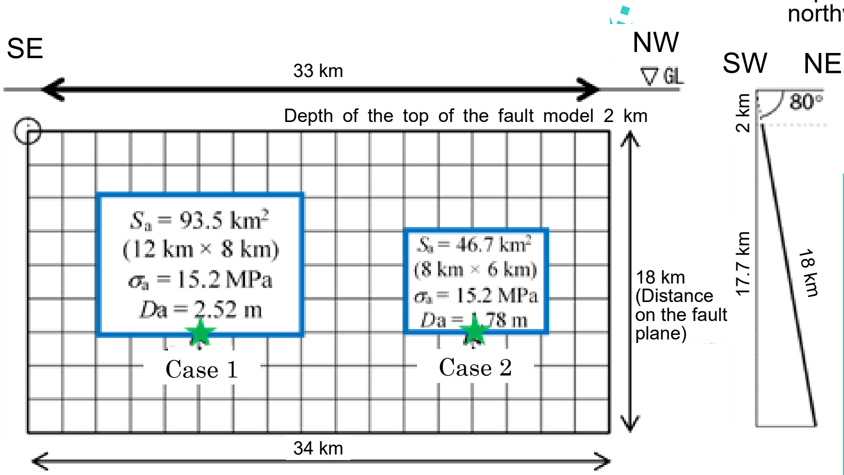
Macroscopic fault parameters
Parameters that describe the general characteristics of the seismic source fault, including the location and magnitude

Microscopic fault parameters
Parameters that describe the detailed characteristics of the seismic source fault, including the asperities

Blue frames in the figure below are asperity areas
(Main rupture areas)

★ marks in the figure below are rupture initiation points

In this model, 2 scenarios were defined:
Case 1: Rupture initiates at the bottom of the southeast asperity.
Case 2: Rupture initiates at the bottom of the northwest asperity.



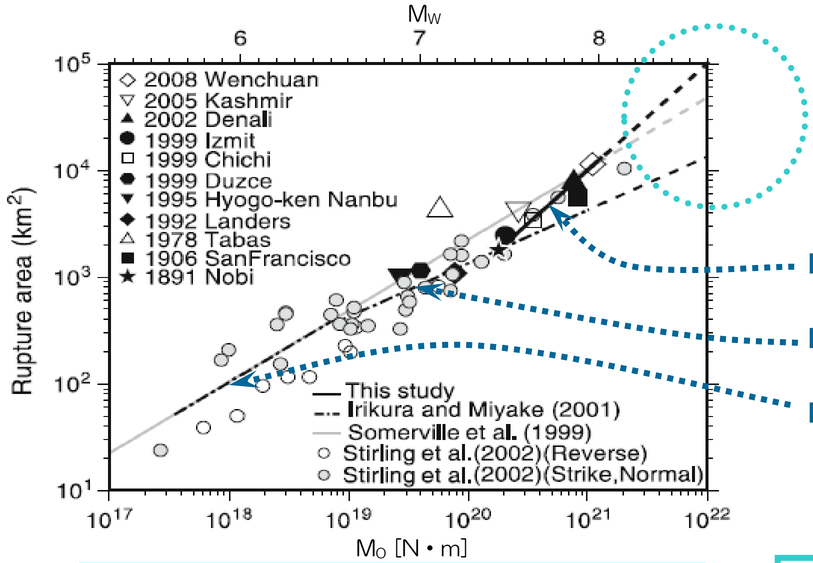
Microscopic fault model of an earthquake that will occur in the Tachikawa fault zone (left) and its orthogonal cross-section (right)

Basic rules for setting the number of asperities based on the Recipe

Unless there is any specific basis information:
* When the fault length is equal to or shorter than 25 km:
  one asperity at the center of the fault
* When the fault length is longer than 25 km and shorter than 30 km:
  Two cases; one or two asperities
* When the fault length is equal to or greater than 30 km:
  two asperities

Commentary: Fault Models for Scenario Earthquakes
Uncertainty of parameter relational expressions used in the Recipe and the variability of its underlying data

The Recipe developed by the Headquarters for Earthquake Research Promotion is used to predict the most likely ground motion, and the adopted expressions of the relationships among parameters explain the data of natural phenomena well on an average level. However, the data of natural phenomena exhibit variability, and uncertainties exist in these relationships, which may be reviewed as new findings emerge. Therefore, when considering the variation of natural phenomena and model uncertainty, it is particularly ideal to set fault models with sufficient consideration of these aspects.



There are no data in this range; therefore, the equation is an extrapolation here

Eq. (4) of Recipe (Murotani et al., 2015)

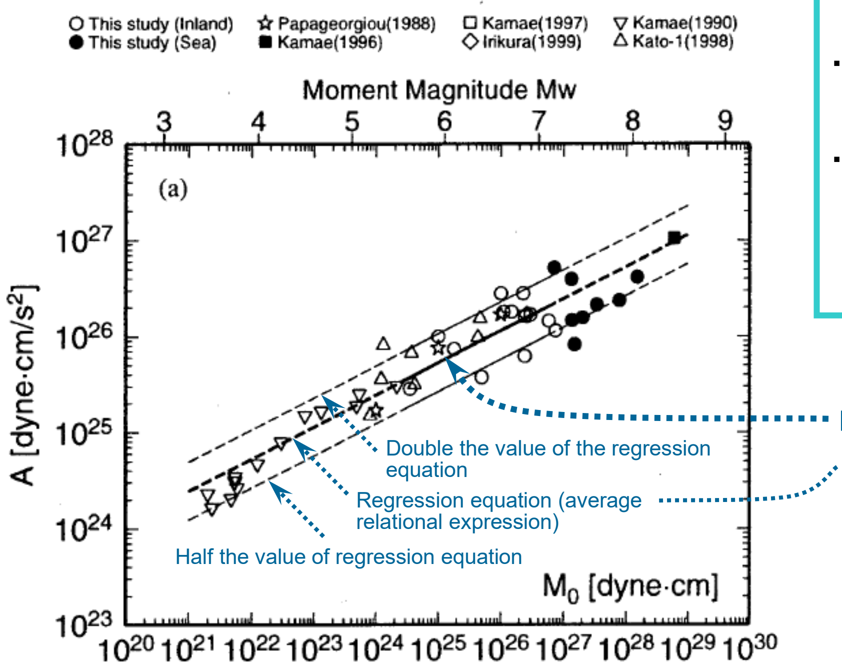
Eq. (3) of Recipe (Irikura and Miyake, 2001)

Eq. (2) of Recipe (Somerville et al., 1999)

Relationship between seismic moment M_0 and rupture area S
(added to Murotani et al., 2015)

Key points

- Equation is an empirical relationship that **provides an average explanation** of the natural phenomenon data.
- Natural phenomena (data) have some **deviation** from the equation.
- The relational expression (model) contains some **uncertainties**; if new data or findings are obtained in the future, this expression will be verified and revised as needed.



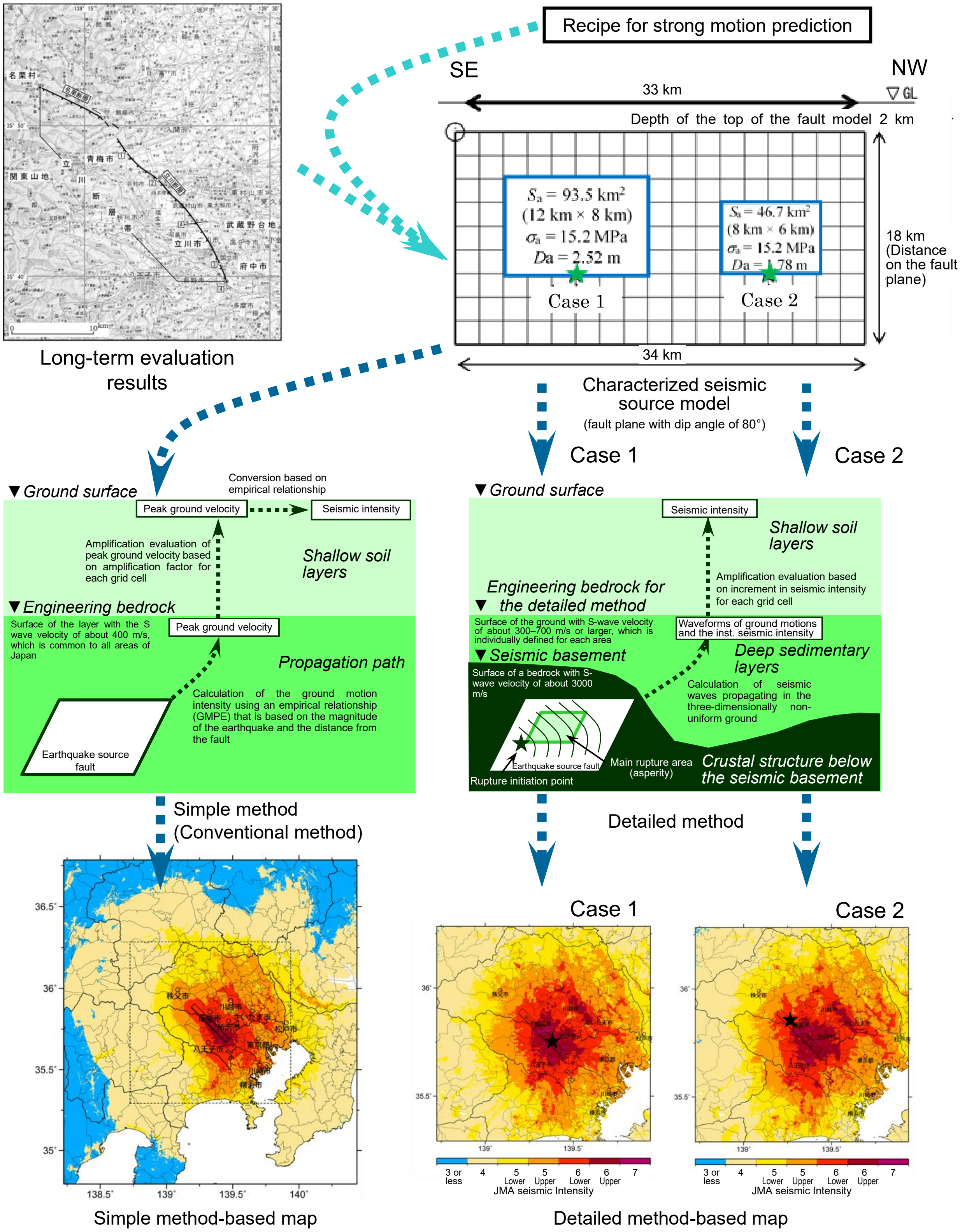
Eq. (12) of Recipe (Dan et al., 2001)

Relationship between seismic moment M_0 and short period level A
(added to Dan et al.,2001)

Commentary: Seismic Hazard Maps for Specified Seismic Source Faults (Seismic Hazard Maps for Scenario Earthquakes)

Procedure for strong motion predictions on the engineering bedrock and ground surface (an example of the Tachikawa fault zone)

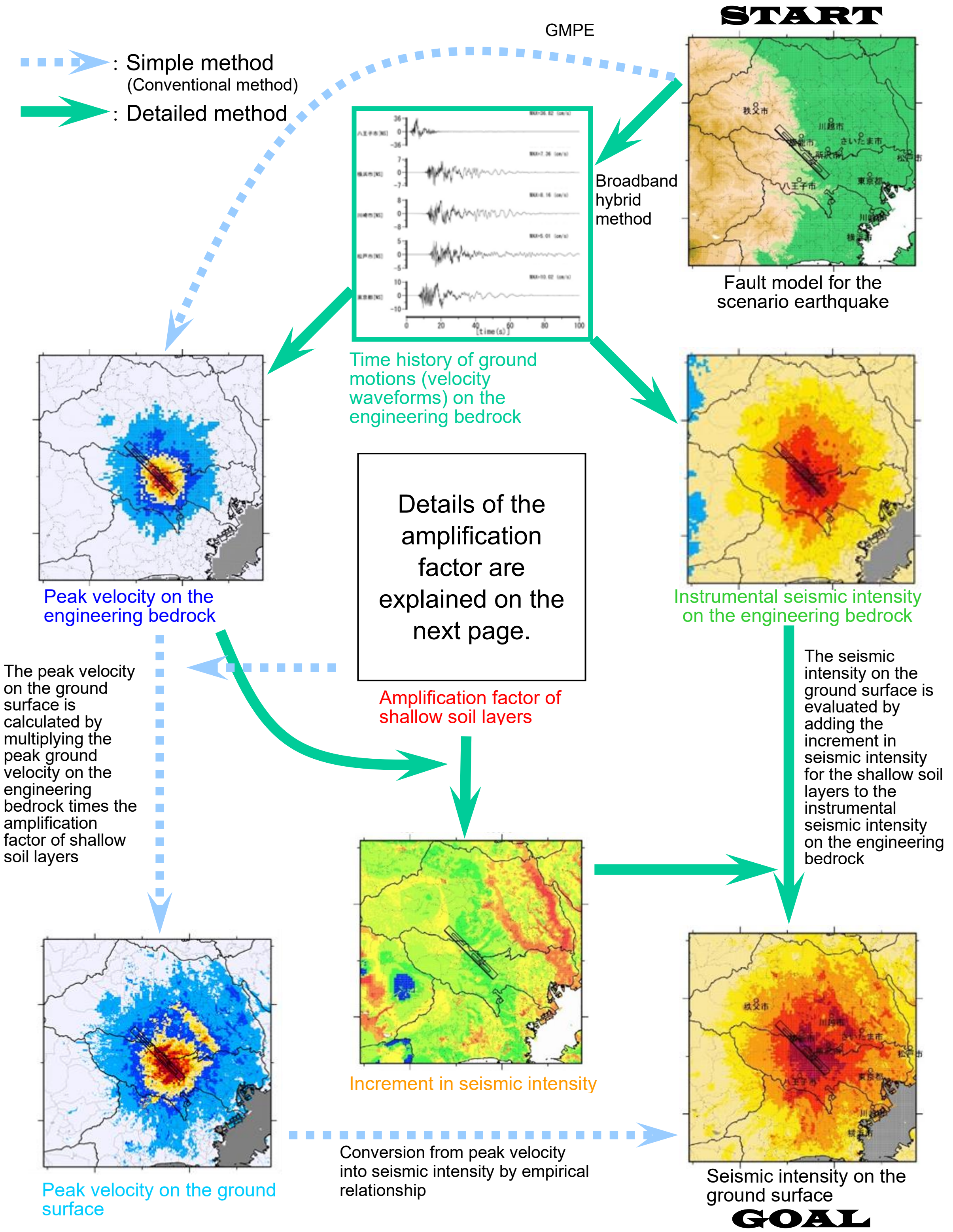
Seismic Hazard Maps for specified seismic source faults (Seismic Hazard Maps for Scenario Earthquakes) show the distributions of the calculated ground motion intensity that are expected to occur in individual areas under the rupture scenario for an anticipated earthquake.



Commentary: Seismic Hazard Maps for Specified Seismic Source Faults (Seismic Hazard Maps for Scenario Earthquakes)

Calculation procedure for ground motion (seismic intensity) shallower than that in engineering bedrock (an example of the Tachikawa fault zone)

Seismic Hazard Maps for specified seismic source faults (Seismic Hazard Maps for Scenario Earthquakes) include maps showing the peak velocity distributions of ground motions on the engineering bedrock and ground surface as well as seismic intensity distributions on the ground surface.



Commentary: Seismic Hazard Maps for Specified Seismic Source Faults (Seismic Hazard Maps for Scenario Earthquakes)

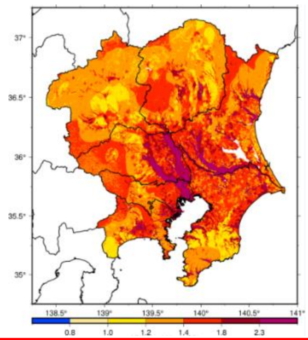
Calculation method of peak ground velocity amplification factor relative to engineering bedrock

The peak velocity amplification factor relative to the engineering bedrock is calculated using the average S-wave velocity in the top 30 meters (ground surface AVS30), S-wave velocity of the engineering bedrock (engineering bedrock Vs), and an empirical relationship. These differ depending on the Shallow Soil Layers used (combined model of shallow and deep layers [SD model] or geomorphologic classification model) and strong ground motion calculation method (detailed or simple method). The following shows the methods of calculating and setting the ground surface AVS30 and engineering bedrock Vs depending on the Shallow Soil Layers and strong ground motion calculation method, as well as the peak ground velocity amplification factor in the surface layers shallower than the engineering bedrock. The Combined Shallow and Deep Layers Model (2021) of the Kanto region and geomorphological classification (Wakamatsu and Matsuoka, 2020) were used.

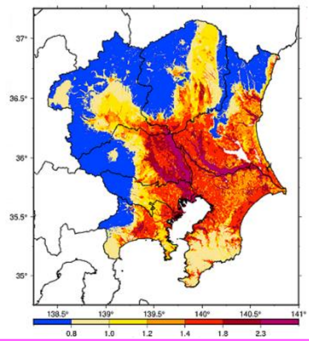
Calculation method of ground surface AVS30 and engineering bedrock Vs; their set values

Method	Detailed method		Simple (Conventional) method	
Vs	Ground surface AVS30	Engineering bedrock Vs	Ground surface AVS30	Engineering bedrock Vs
SD model	Calculated from SD model	Calculated from SD model AVS30EB *	Calculated from SD model	400 m/s
Geo-morphologic classification model	Calculated from geomorphologic classifications and empirical relationship	600 m/s	Calculated from geomorphologic classifications and empirical relationship	400 m/s

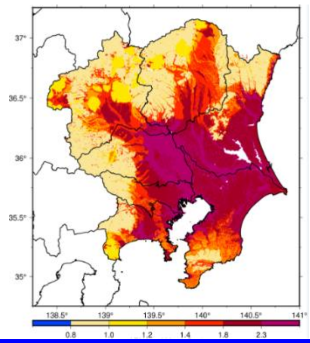
* Average S-wave velocity from the top of the stratum with an S-wave velocity of 350 m/s or grater to a depth of 30 m



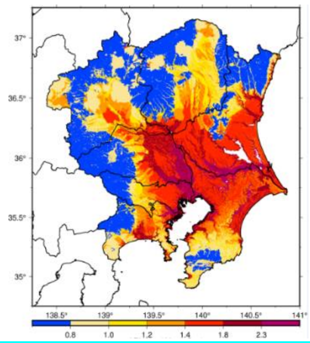
(a) SD model + detailed method



(b) SD model + simple method



(c) Geomorphologic classification model + detailed method

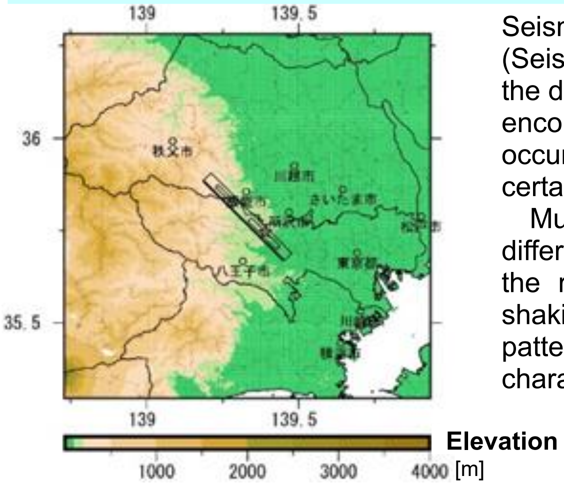


(d) Geomorphologic classification model + simple method

Peak ground velocity amplification factor relative to engineering bedrock for each model of the Shallow Soil Layers and calculation method (Kanto region)

Commentary: Seismic Hazard Maps for Specified Seismic Source Faults (Seismic Hazard Maps for Scenario Earthquakes)

Results of strong ground motion prediction based on the strong ground motion prediction method for earthquakes with specified source faults (“Recipe”) (an example of the Tachikawa fault zone)

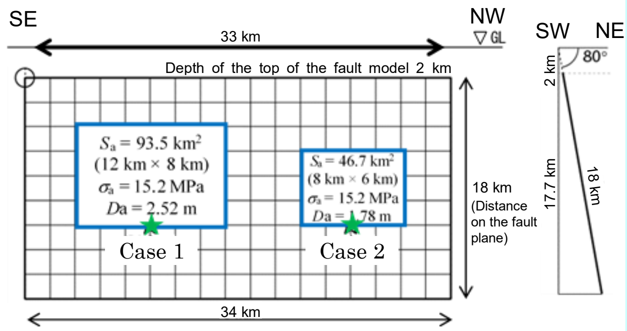


Seismic source fault model projected onto the ground surface

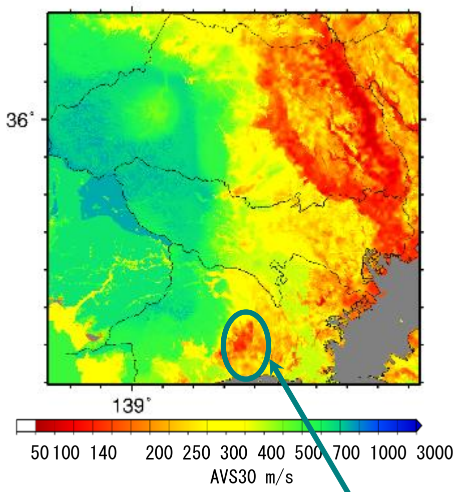
Seismic Hazard Maps for specified seismic source faults (Seismic Hazard Maps for Scenario Earthquakes) show the distributions of ground motion intensity that would be encountered in individual areas if an earthquake were to occur with a certain rupture scenario assumed for a certain fault (that is, in an assumed rupture model).

Multiple rupture scenarios (rupture cases) with different conditions have been considered. By comparing the results, regional characteristics, such as ground shaking susceptibility and differences in the shaking patterns between different rupture scenarios, can be characterized.

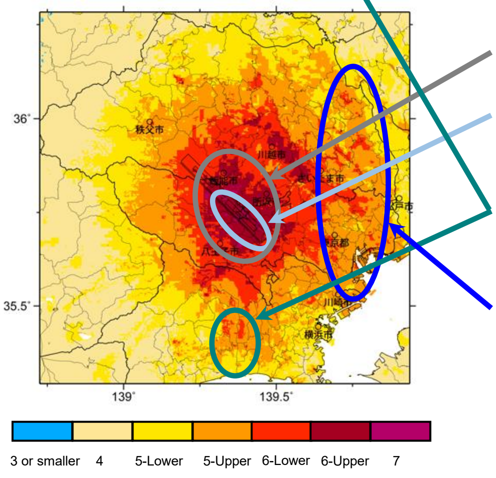
For each scenario, the main rupture areas, called "asperities" (the rectangles with blue edges in the figure below), and the rupture initiation points (the ★ marks in the figure) are set on the fault plane.



Microscopic fault model (left) and its orthogonal cross-section (right)



Distribution of ground surface AVS30



Distribution of seismic intensity on the ground surface

★ The ground surface just above or close to the asperity will be subjected to strong ground motions.

★ The area located ahead of the rupture propagation (along the rupture propagation path) will be subjected to strong ground motions.

★ The area with soft shallow soil layers will be subjected to strong ground motions because of the large amplification factor.

★ The plains, basins, and others, with a thick sedimentary stratum of soft soil, will be subjected to strong ground motions because of the large amplification factor.

★ If some of the conditions listed above exist in an area, then that area may be subjected to highest level of seismic intensity (6-Upper or 7).

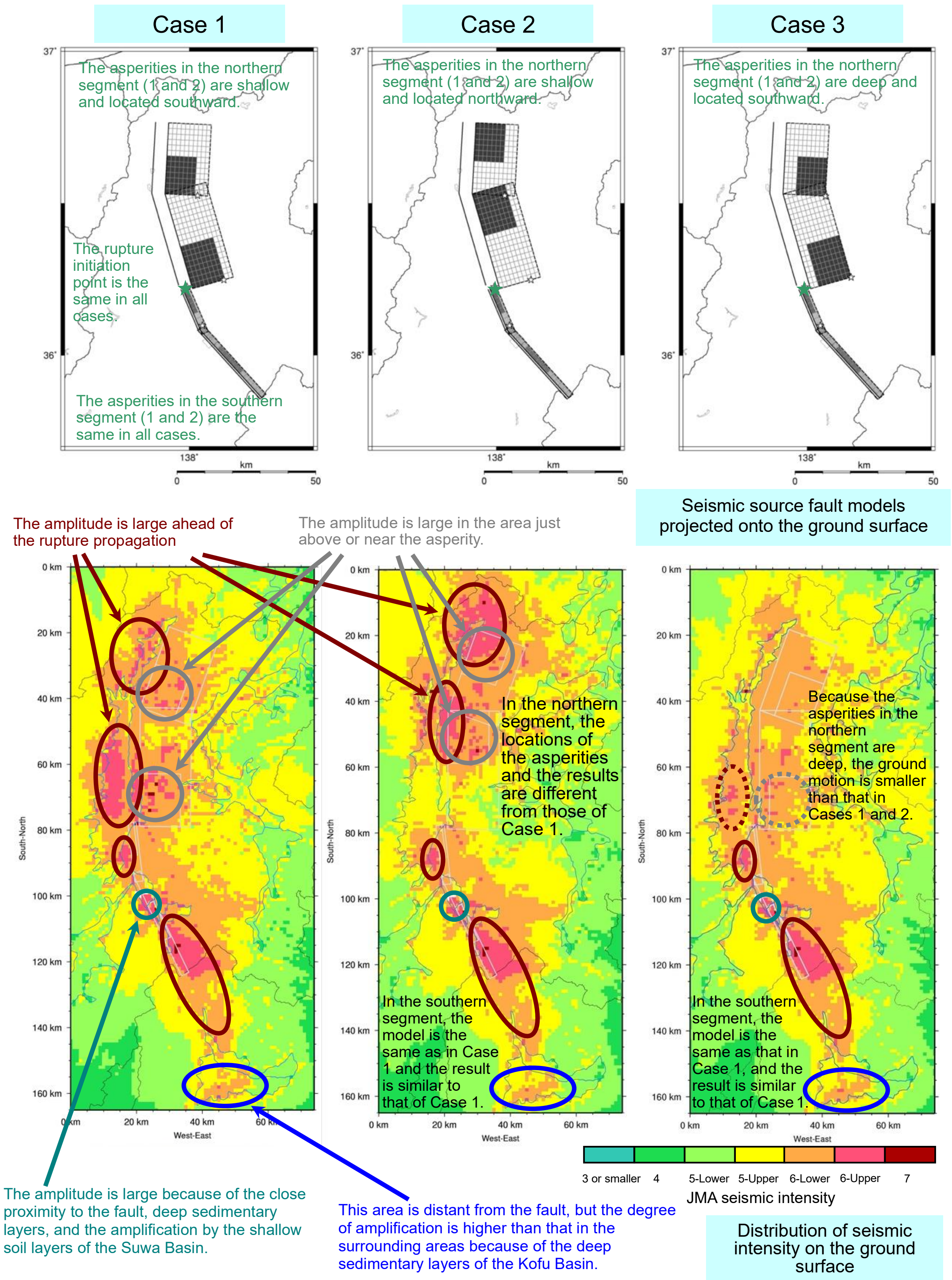
Commentary: Seismic Hazard Maps for Specified Seismic Source Faults (Seismic Hazard Maps for Scenario Earthquakes)

Several rupture scenarios (rupture cases) and their effects (an example of the Itoigawa–Shizuoka Tectonic Line fault zone, published in 2002)

Seismic Hazard Maps for specified seismic source faults (Seismic Hazard Maps for Scenario Earthquakes) helps identify the differences in the intensity, pattern, etc. of the ground motions owing to (1) the rupture scenario and (2) the susceptibility to shaking between areas:

★ The area just above the asperity; areas located ahead of the rupture propagation (along the rupture propagation path); areas with soft shallow soil layers; and plains, basins, and others, with thick sedimentary strata will be subjected to strong ground motions.

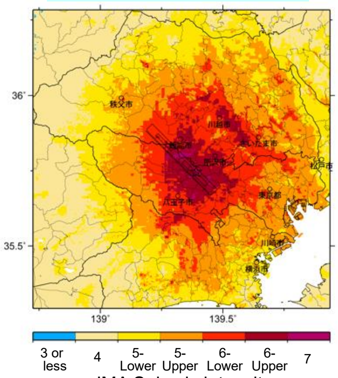
★If some of the conditions listed above exist in an area, then that area may be subjected to the highest level of seismic intensity (6-Upper or 7).



Commentary: Population Exposed to a Specified Seismic Intensity

Population exposed to ground motion greater than a given seismic intensity (an example of the Tachikawa fault zone, the rupture scenario of Case 1)

Seismic intensity distribution × Population distribution



Population exposed to a Specified seismic intensity

Daytime **Nighttime**

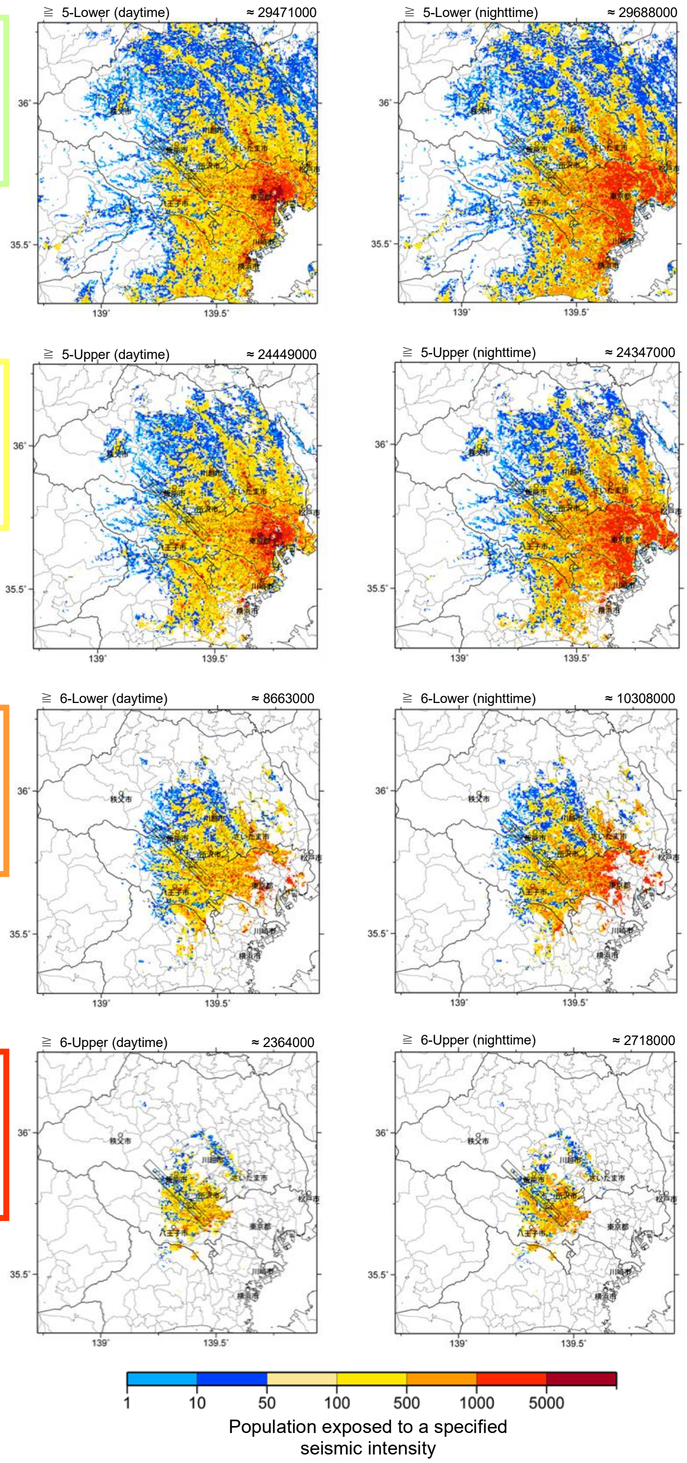
(The number on the upper right corner of each figure is the total population exposed to seismic intensity in the map area)

Seismic intensity 5-Lower or higher

Seismic intensity 5-Upper or higher

Seismic intensity 6-Lower or higher

Seismic intensity 6-Upper or higher



When determining the population exposed to seismic intensity, the approximate number of people exposed to a given seismic intensity or higher and its distribution can be estimated.

When further applying existing knowledge* to this information, the damage distribution situation in the area can be approximately evaluated. This information is expected to aid local governments in formulating wide-area disaster prevention measures based on the situations in their own region as well as in neighboring areas.

* For example, Japan Meteorological Agency commentary table relating to seismic intensity classes (https://www.jma.go.jp/jma/en/Activities/inttable.html)

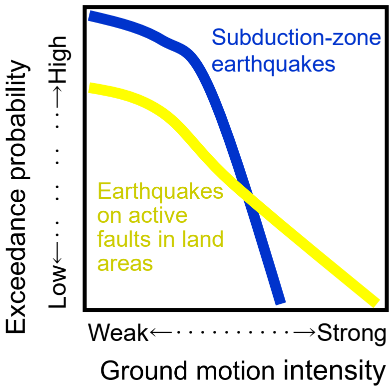
Commentary: Probabilistic Seismic Hazard Map

Combining information about time period, ground motion intensity, and probability

The term "seismic hazard" refers to the evaluated intensity and probability of ground motion (shaking), a natural phenomenon, induced by earthquakes. The potential damage caused by shaking is called the "seismic risk." As these two terms have different meanings, they must not be interchangeably used.

The Probabilistic Seismic Hazard Map shows the seismic hazard levels at sites throughout Japan. Specifically, it shows the ground motion intensity and probability constructed from "hazard curves" for all sites. The hazard curve for a site shows the relationship between the intensity of shaking and probability of exceedance obtained, for all considered earthquakes, as the product of the probability of occurrence of each earthquake and the probability that the intensity of the shaking caused by that earthquake exceeds a specific level. The terms "probability of occurrence of an earthquake" and "probability of exceedance (exceedance probability)" (which describes ground motion) must not be confused.

The probabilities of earthquake occurrence on active faults in land areas are generally smaller than those of subduction-zone earthquakes. However, areas near seismic source faults are subjected to very strong ground motions, as shown in the schematic hazard curve (on the right) depicting the relationship between ground motion intensity and the probability of exceedance. The actual shape of the hazard curve (that is, the probability of exceedance and the ground motion intensity) varies depending on the location, magnitude, and probability of earthquake occurrence.



The Probabilistic Seismic Hazard Map is constructed by calculating the earthquake occurrence probability for each of the earthquakes considered and the ground motion intensity for each site considered. Probabilistic Seismic Hazard Maps with various characteristics can be obtained by varying the period, ground motion intensity, and probability (of exceedance for the ground motions).

(1) A map showing the probability distribution with the period and ground motion intensity fixed
Example: The probability of ground motions equal to or greater than seismic intensity of 6-Lower (= instrumental seismic intensity of 5.5 or higher) occurring within the next 30 years

(2) A map showing the ground motion intensity distribution with the period and probability fixed
Example: The seismic intensity for a 3% exceedance probability occurring within the next 30 years (to be exact, the ground motion intensity is greater than the seismic intensity shown on the map)

Probability that a site will be subjected to a seismic intensity of 6-Lower or higher – Summation of ground motions caused by various earthquakes –

The probability that a site will be subjected to a seismic intensity of 6-Lower or higher within the next 30 years is determined by combining the products for all earthquakes considered, the product being the probability of occurrence of each earthquake multiplied by the probability that ground motion intensity becomes seismic intensity of 6-Lower or higher.

For example, if

(1) there are two earthquakes, Earthquakes A and B, to be considered for site S;
(2) the probabilities of occurrence of Earthquakes A and B within the next 30 years are 40% and 30%, respectively; and
(3) the probabilities that the ground motions will be equal to or exceed seismic intensity of 6-Lower at site S by Earthquakes A and B are 60% and 40%, respectively,

the probabilities that the ground motions will be equal to or exceed seismic intensity of 6-Lower at site S within the next 30 years due to Earthquakes A and B are as follows:

Earthquakes A: 24% (0.4×0.6 = 0.24)
Earthquakes B: 12% (0.3×0.4 = 0.12)

And the probabilities that the ground motions will be equal to or exceed a seismic intensity of 6-Lower at site S within the next 30 years due to Earthquake A or B is calculated as follows:

1 – {(1 – 0.24) ×(1 – 0.12)} = 0.3312 (approximately 33%)

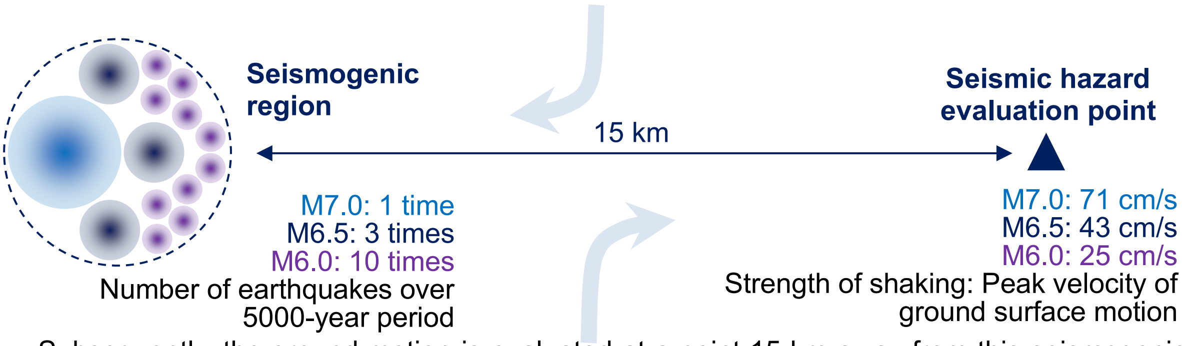
Note that this probability is not calculated by adding the two probability values (i.e., "24% + 12% = 36%").

Commentary: Probabilistic Seismic Hazard Map

Obtaining hazard curve (commentary using a simple example)

Smaller earthquakes occur more frequently. Moreover, the number of earthquakes N and magnitude M (Gutenberg-Richter law) exhibit a statistical relationship of $\log N = a - bM$; there is some regional variability in the constant a and coefficient b, but assuming $b \approx 1$ in general, N increases by approximately 3 and 10 times when M decreases by 0.5 and 1.0, respectively.

As a simple example, we first consider the case where one earthquake of M7.0, three earthquakes of M6.5, and ten earthquakes of M6.0 occur over a 5,000-year period in a single seismogenic region (lower figure, left).



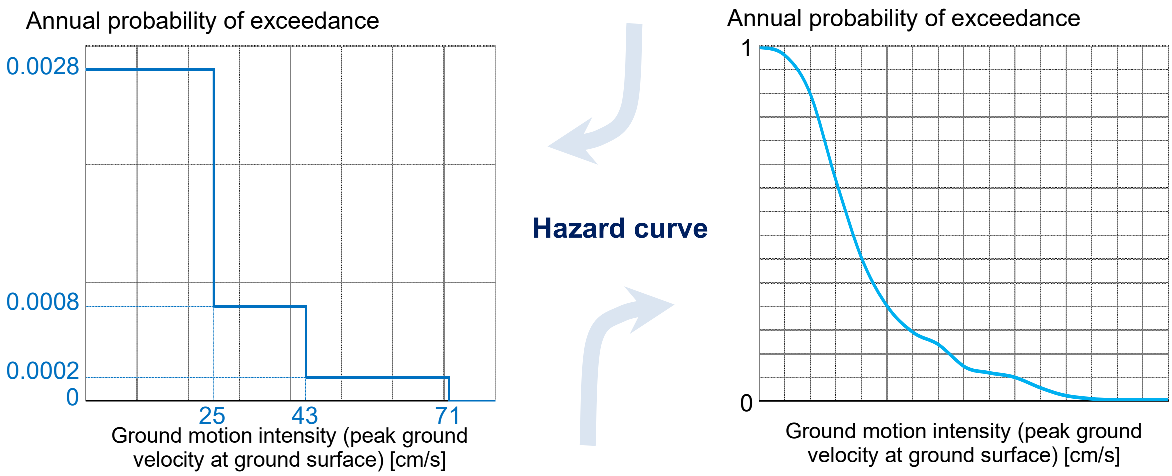
Subsequently, the ground motion is evaluated at a point 15 km away from this seismogenic region (upper figure, right).

Generally, as the earthquake magnitude increases and the hypocenter becomes closer, the ground motions (shakings) tend to become stronger. This relationship is mathematically expressed by "Ground Motion Prediction equations (GMPEs)." Using the GMPE that is used to calculate the Probabilistic Seismic Hazard Map and assuming that the amplification factor of shallow soil layers at the evaluated site is 2, the peak ground velocities of the ground surface motion at the evaluated site when each earthquake in the above figure are: 71 cm/s for M7.0 (seismic intensity of 6-Upper), 43 cm/s for M6.5 (seismic intensity of 6-Lower), and 25 cm/s for M6.0 (Seismic intensity of 5-Upper).

In this case, the ground motion intensity at the evaluation point over a 5000-year period is as follows.

71 cm/s exceeded zero times
43 cm/s exceeded one time (71 cm/s one time)
25 cm/s exceeded four times (71 cm/s one time, 43 cm/s three times)
0 cm/s exceeded 14 times (71 cm/s one time, 43 cm/s three times, 25 cm/s 10 times)

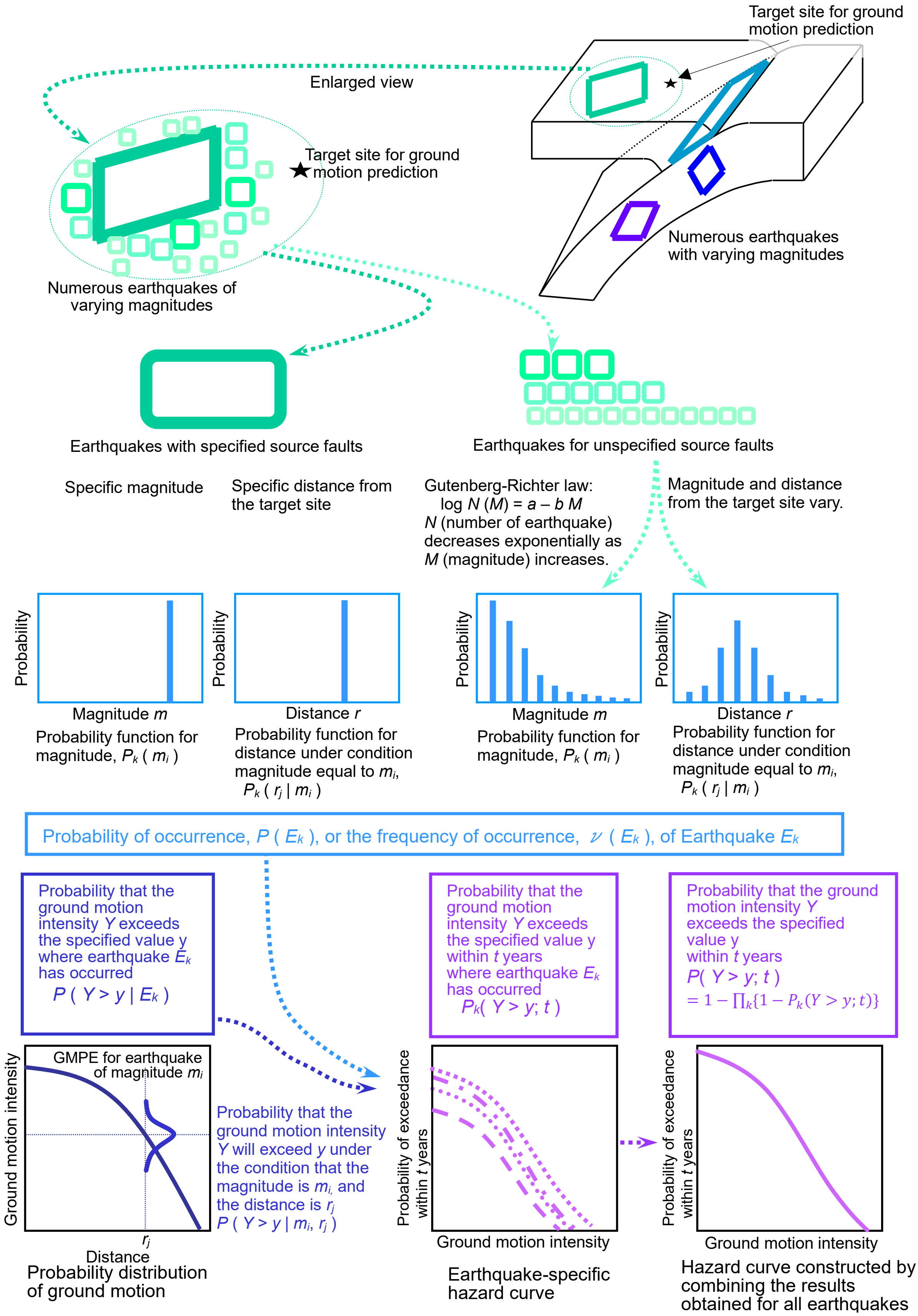
These are the number of times the ground motion intensity exceeds a given value over a 5000-year period. Dividing each number by 5000 results in the number of times that this intensity is exceeded in one year. Next, by adopting a Poisson distribution, annual probability of exceedance is calculated. Plotting this value on the vertical axis with the ground motion intensity on the horizontal axis yields the hazard curve for the 14 earthquakes in this example (lower figure, left).



In reality, earthquakes of various magnitudes occur at various distances from the evaluation point. If the annual probability of exceedance is calculated for all earthquakes using the same method, the hazard curve forms a smooth curve as shown in the upper right figure.

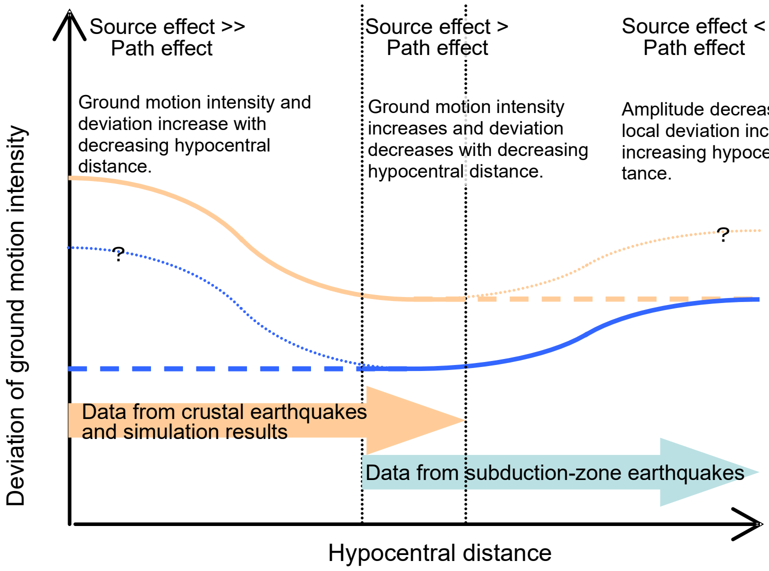
Commentary: Probabilistic Seismic Hazard Map

Steps of hazard curve calculation for producing a Probabilistic Seismic Hazard Map

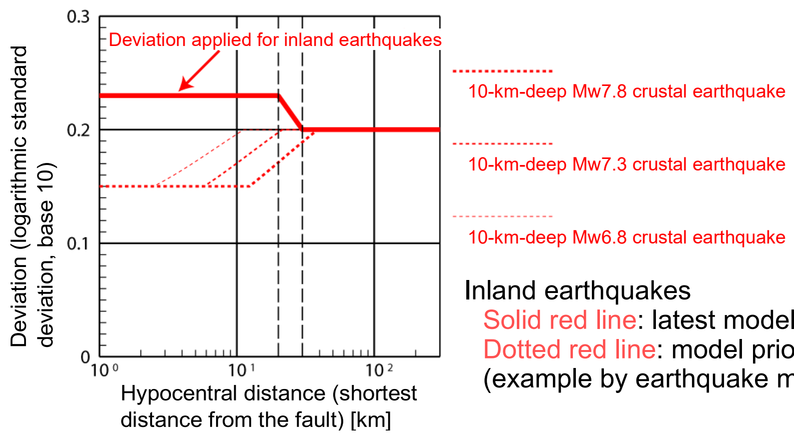


Commentary: Probabilistic Seismic Hazard Map

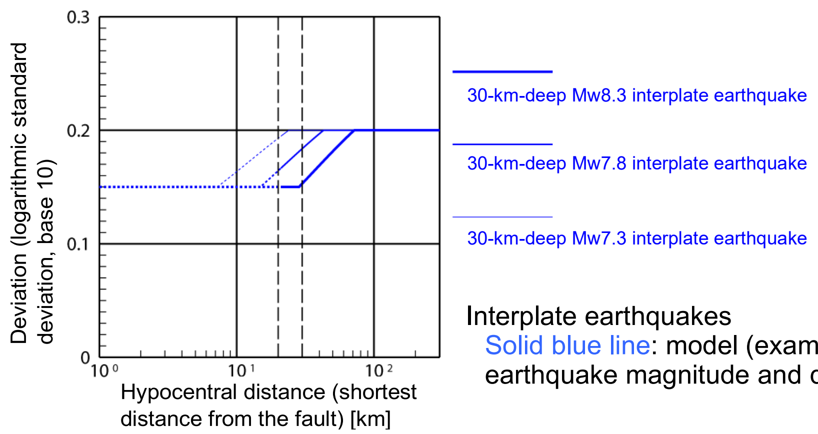
Deviation from the GMPE in the calculation of ground motion intensity



Dependence of deviation of ground motion intensity on hypocentral distance



Inland earthquakes
Solid red line: latest model
Dotted red line: model prior to 2008 edition
(example by earthquake magnitude and depth)



Interplate earthquakes
Solid blue line: model (example by earthquake magnitude and depth)

Models of the dependence of deviation of ground motion intensity on hypocentral distance

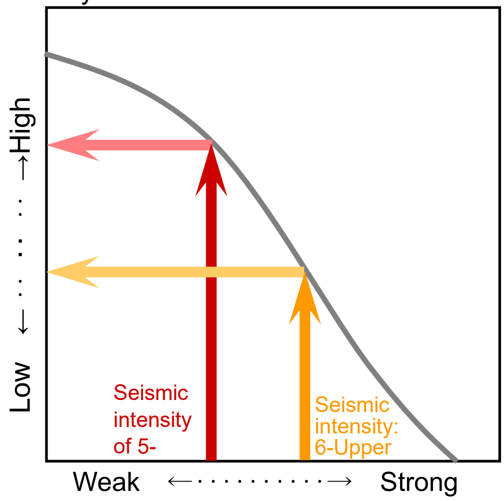
The models assume that the deviation of the ground motion intensity from the GMPE follows a lognormal distribution. To avoid unrealistic values at the tail of the distribution, the models were designed with the probability of appearance of values exceeding $\pm 3\sigma$ (where σ represents the standard deviation of the distribution) to be zero.

Commentary: Probabilistic Seismic Hazard Map

Combining information about time period, ground motion intensity, and probability

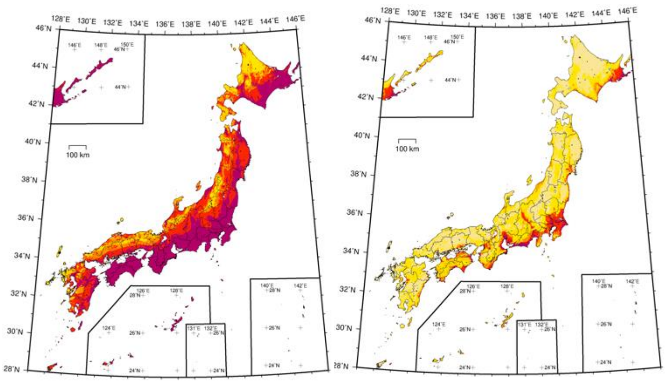
★The probability (probability of exceedance) that the ground motion intensity (seismic intensity) exceeds a specific value at any given site varies; the smaller the value of intensity, the larger the probability.

Probability of exceedance within *t* years



Hazard curve

<Note: The following figures show an example map of the average case for all earthquakes from the 2020 edition.>



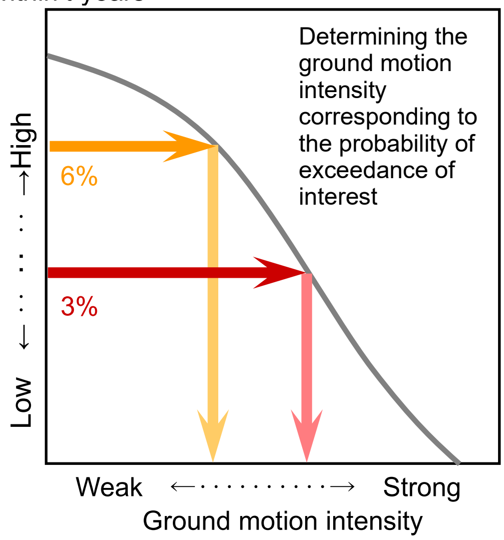
Probability of ground motions equal to or greater than Seismic intensity of 5-Upper occurring within the next 30 years (exceedance probability)

Probability of ground motions equal to or greater than seismic intensity of 6-Upper occurring within the next 30 years (exceedance probability)

Interpreting a hazard curve and maps of probability of exceedance

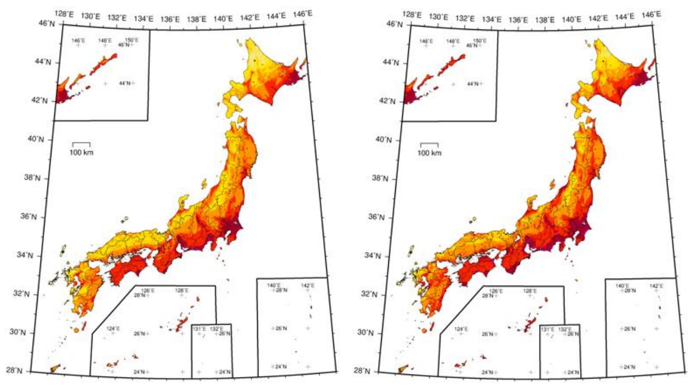
★The ground motion intensity (seismic intensity) at any given site varies; the smaller the probability of exceedance, the larger the ground motion intensity (seismic intensity).

Probability of exceedance within *t* years



Hazard curve

<Note: The following figures show an example map of the average case for all earthquakes from the 2020 edition. >



Seismic intensity for a 6% exceedance probability within the next 30 years

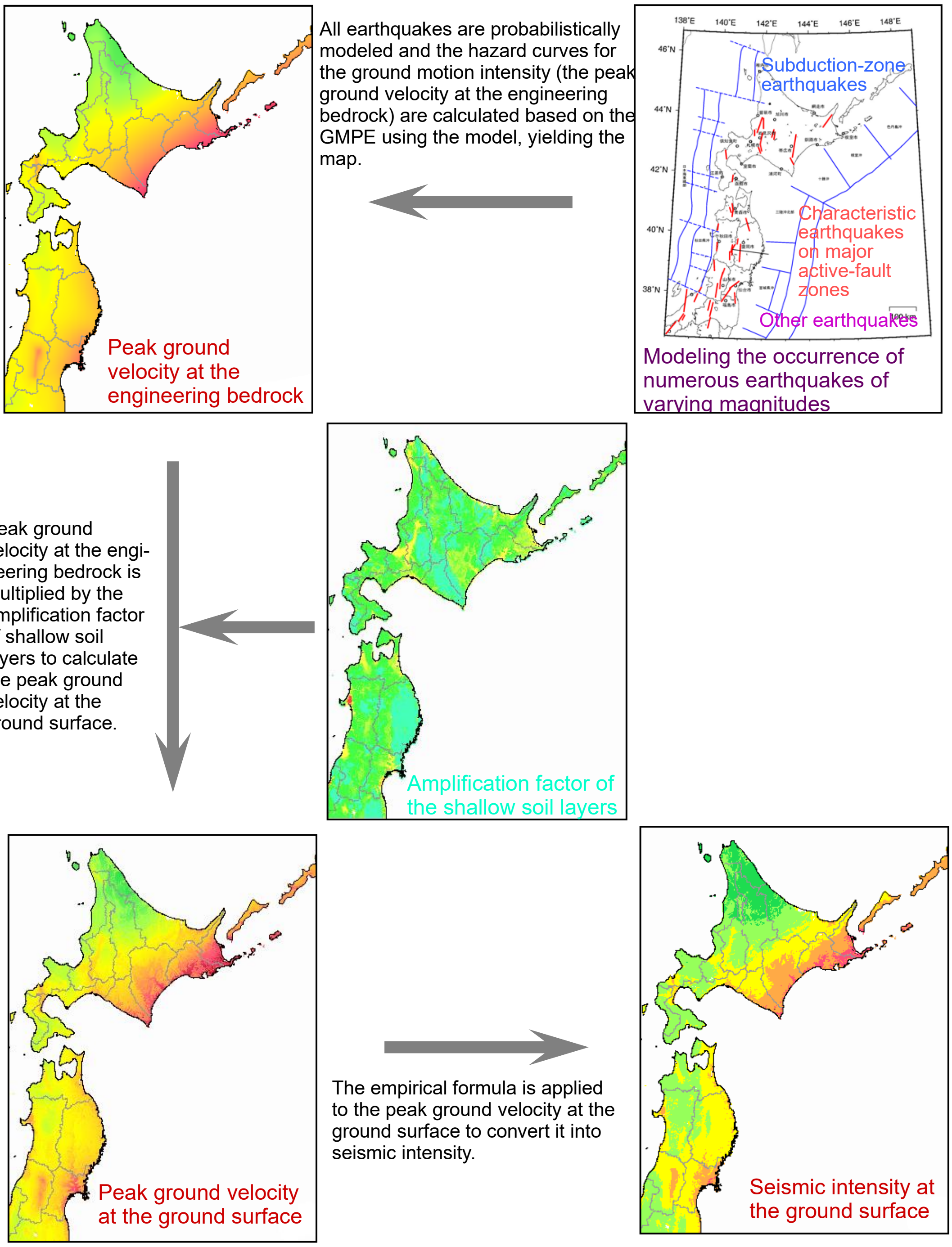
Seismic intensity for a 3% exceedance probability within the next 30 years

Interpreting a hazard curve and maps of ground motion intensity

Commentary: Probabilistic Seismic Hazard Map

Procedure for producing a map showing the ground motion intensity

(1) The occurrence of numerous earthquakes of varying magnitudes is modeled, (2) the peak ground velocity of ground motions on the engineering bedrock is calculated using the GMPE, (3) the peak ground velocity of ground motions on the ground surface is calculated by multiplying the peak velocity at the engineering bedrock by the amplification factor of the shallow soil layers, and (4) the seismic intensity at the ground surface is determined through conversion using an empirical formula. For seismic hazard maps for specified seismic source faults obtained by the simple method, steps (3) and (4) are also used for predicting ground motions (seismic intensities) on the ground surface from ground motions on the engineering bedrock.



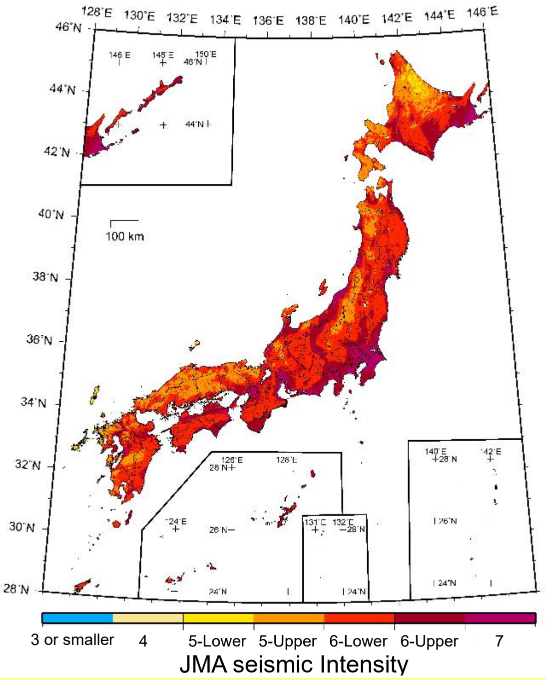
* The figure above illustrates the concept of the procedure, and the map samples were taken from the limited prototype version for the North Japan Region (March 2003).

Commentary: Probabilistic Seismic Hazard Map

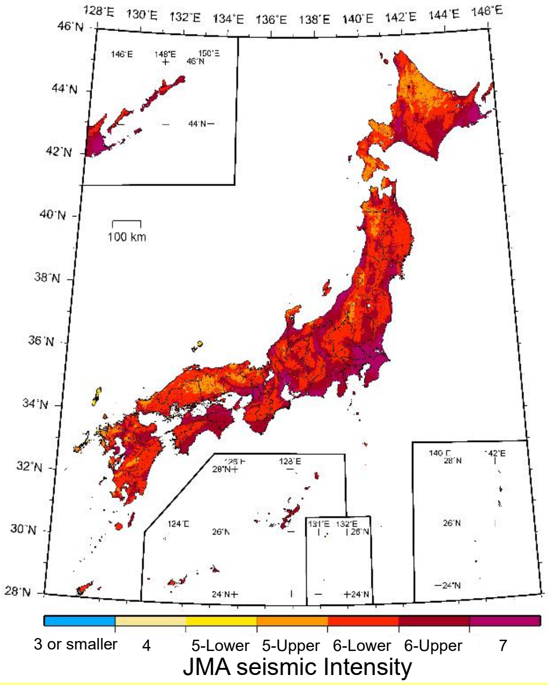
Long-term average seismic hazard (seismic intensity distribution)

The long-term average seismic intensity distributions shown below signify shaking that occurs once approximately every 5,000, 10,000, 50,000, and 100,000 years. The possibility that a given region experiences strong shaking is high when considering long period of time, particularly in areas along an active fault. Such maps have various applications—as basic materials for regional evaluations of ground motion intensity according to the probability level as well as design loads and earthquake disaster prevention.

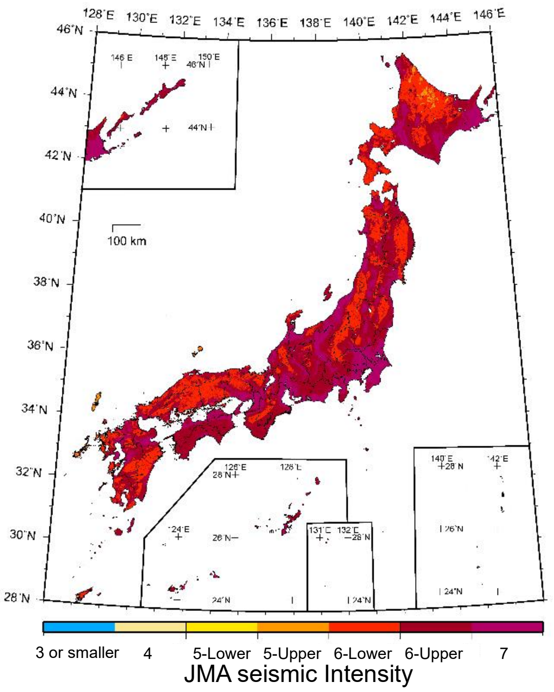
<Note: The following figures show an example of a long-term average hazard map from the 2020 edition>



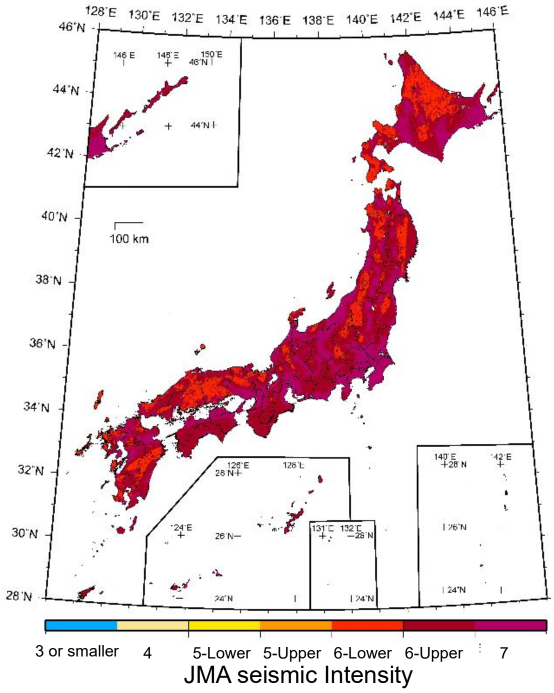
Recurrence period equivalent to 5,000 years (30-year exceedance probability of 0.6%)



Recurrence period equivalent to 10,000 years (30-year exceedance probability of 0.3%)



Recurrence period equivalent to 50,000 years (30-year exceedance probability of 0.06%)

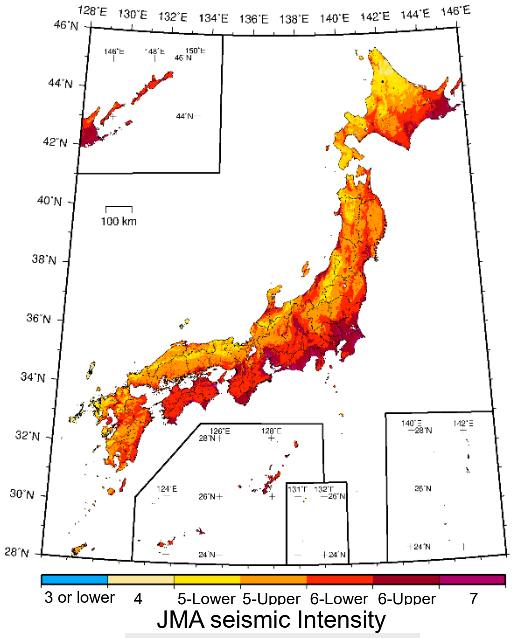


Recurrence period equivalent to 100,000 years (30-year exceedance probability of 0.03%)

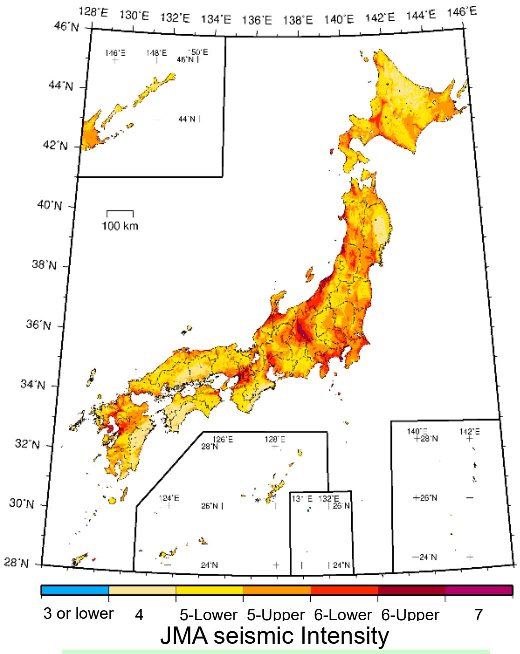
Commentary: Earthquake Classification and Contribution Factor

Comparative example of seismic intensity distribution for each earthquake classification

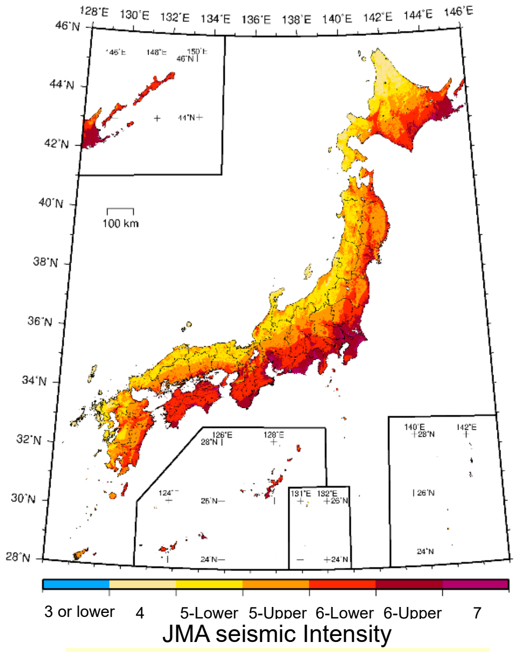
Even with the same period or probability, there is variability in the earthquakes that have the greatest impact on a region and in the resulting ground motion intensity (seismic intensity). Therefore, it is advisable to consider earthquake disaster prevention measures by examining the seismic intensity distribution for each earthquake classification and incorporating these characteristics. For instance, when comparing the seismic intensity distributions of shallow crustal earthquakes and subduction-zone earthquakes from Probabilistic Seismic Hazard Maps, the former has a significant influence on the Sea of Japan (East Sea) side, while the latter exerts a greater influence on the Pacific side.



All earthquakes



Shallow crustal earthquakes



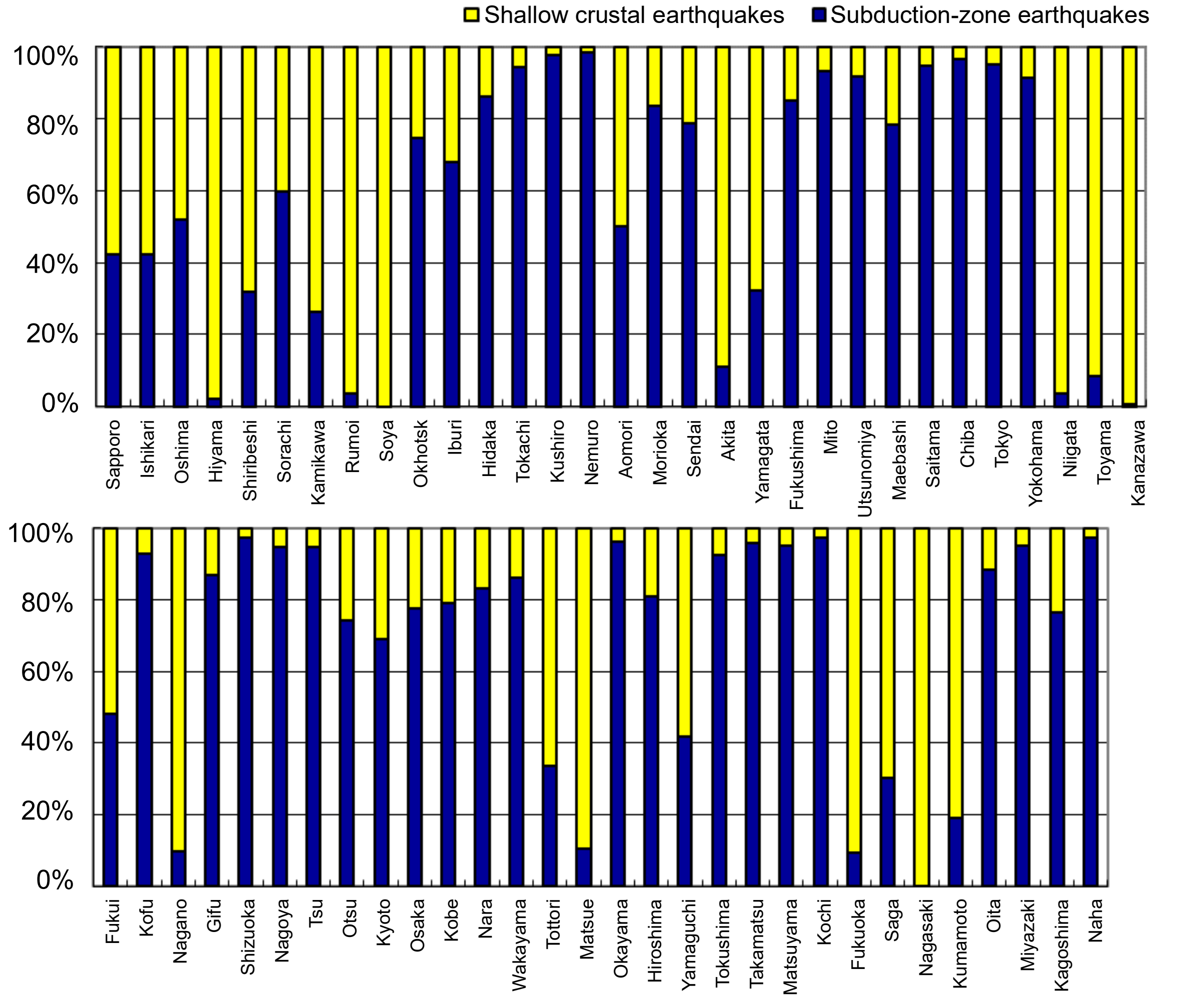
Subduction-zone earthquakes

Note: The figures provide an example of seismic intensity distribution where the probability of ground motion exceeding a given value within the next 30 years in the National Seismic Hazards Map for Japan (2020) is 3% (average case). A 30-year probability of 3% signifies the seismic intensity of shaking that occurs once approximately every 1000 years.

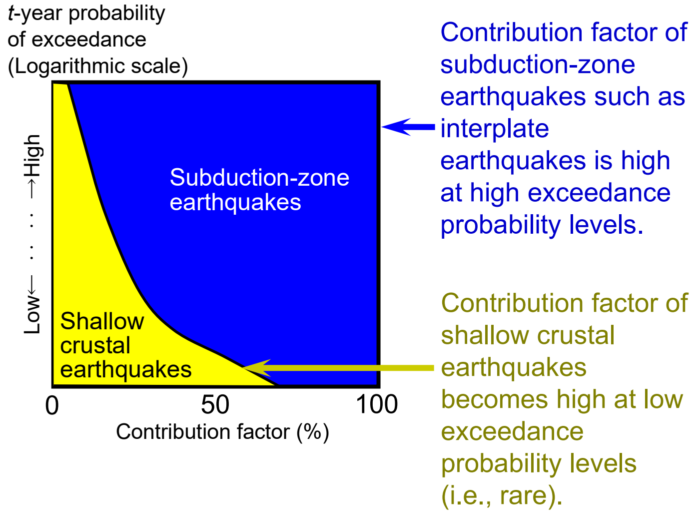
Commentary: Earthquake Classification and Contribution Factor
Contribution factor of 30-year probability of exceedance of seismic intensity of 6-Lower or higher at city halls in the prefectural capitals (Tokyo Metropolitan Government Office for Tokyo, Subprefectural Bureaus for Hokkaido)

The most contributive earthquake as well as the contribution factor characteristics for each earthquake differ by region.

<Note: The figure is an example with the 2020 edition data.>



The hazard curve shows the relationship between the ground motion intensity and the probability that this intensity is exceeded in a specified period (exceedance probability). The contribution factor expresses the relative probability of the effect of each earthquake class on the ground motion intensity corresponding to each probability level of exceedance. The contribution factor can be used as a basis for determining the type of precautionary measures to be adopted for different types of earthquakes.



Commentary: Probabilistic Scenario Earthquake

Earthquakes that have relatively large contribution factors with respect to seismic hazards at each location

The probability of exceedance obtained with respect to each ground motion intensity at each grid cell of a Probabilistic Seismic Hazard Map is obtained as the sum of the probabilities of exceedance of the ground motions due to numerous earthquakes for varying magnitudes. Therefore, in order to identify earthquakes that have relatively large contribution factors with respect to the probability of exceedance of ground motion for each grid cell (i.e., earthquakes with high contributions to the exceedance probability), Japan Seismic Hazard Information Station (J-SHIS) has been enhanced to allow users to check, for each grid cell, the contribution factors at each earthquake class and earthquakes with high contribution factors at each earthquake class.

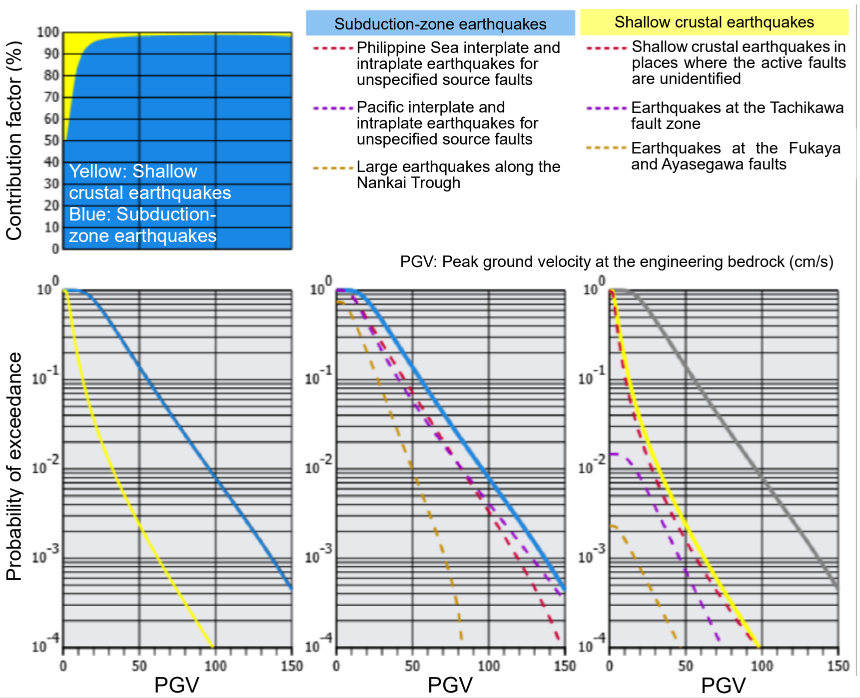
Shallow crustal earthquakes

- Earthquakes on major active-fault zones and active faults under regional analysis (including earthquakes where fault traces are difficult to identify from surface evidence)
- Earthquakes on other active faults
- Earthquakes offshore northwest of Hokkaido Pref.
- Earthquakes offshore west of Hokkaido Pref.
- Earthquakes offshore southwest of Hokkaido Pref.
- Earthquakes offshore west of Aomori Pref.
- Earthquakes offshore of Akita Pref.
- Earthquakes offshore of Yamagata Pref.
- Earthquakes offshore of northern Niigata Pref.
- Earthquakes offshore north of Sadoshima Is.
- Shallow crustal earthquakes in places where active faults are unidentified (including the eastern margin of the Sea of Japan, south of the Izu Islands, and the Yonagunijima Is.)
- Earthquakes for unspecified source faults offshore Urakawa (including eastern Iburi)

Subduction-zone earthquakes

- Megathrust interplate earthquakes along the Kuril Trench (17th century-quake type)
- Large interplate earthquakes offshore of Tokachi
- Large interplate earthquakes offshore of Nemuro
- Interplate earthquakes near the trench offshore of Tokachi to Etorofu Is. (tsunami earthquakes)
- Megathrust earthquakes along the Japan Trench (the 2011 Tohoku Earthquake-type)
- Large interplate earthquakes offshore of east of Aomori Pref. and in the north region offshore of Iwate Pref.
- Large interplate earthquakes offshore of Miyagi Pref.
- Interplate earthquakes near the trench offshore east of Aomori Pref. to Boso (tsunami earthquakes)
- Earthquakes on the external side of the Japan Trench axis
- *M*8-class earthquakes along the Sagami Trough
- Large earthquakes along the Nankai Trough
- Interplate earthquakes of the Hyuganada Sea
- Smaller interplate earthquakes of the Hyuganada Sea
- Earthquakes around Yonagunijima Is.
- Pacific interplate and intraplate earthquakes for unspecified source faults (including those undergoing long-term evaluations not listed above)
- Philippine Sea interplate and intraplate earthquakes for unspecified source faults (including those undergoing long-term evaluations not listed above)

Earthquake groups extracted and specified as probabilistic scenario earthquakes in each earthquake class

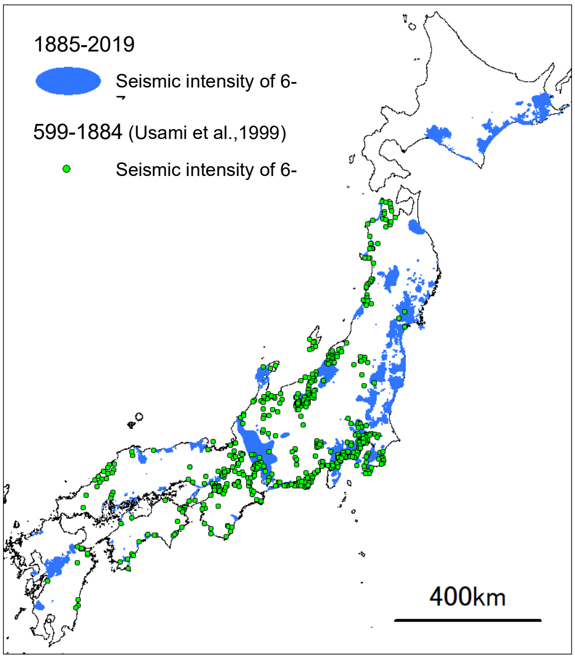


Example of contribution factor of each earthquake class with respect to the peak ground velocity at the engineering bedrock and the hazard curves of the top three earthquake groups with high contribution factors in each earthquake classification (the 30-year average case at Tokyo Metropolitan Government Office is used as an example)

Commentary: Understanding Earthquakes using National Seismic Hazard Maps and Preparing for Earthquake Disaster Prevention

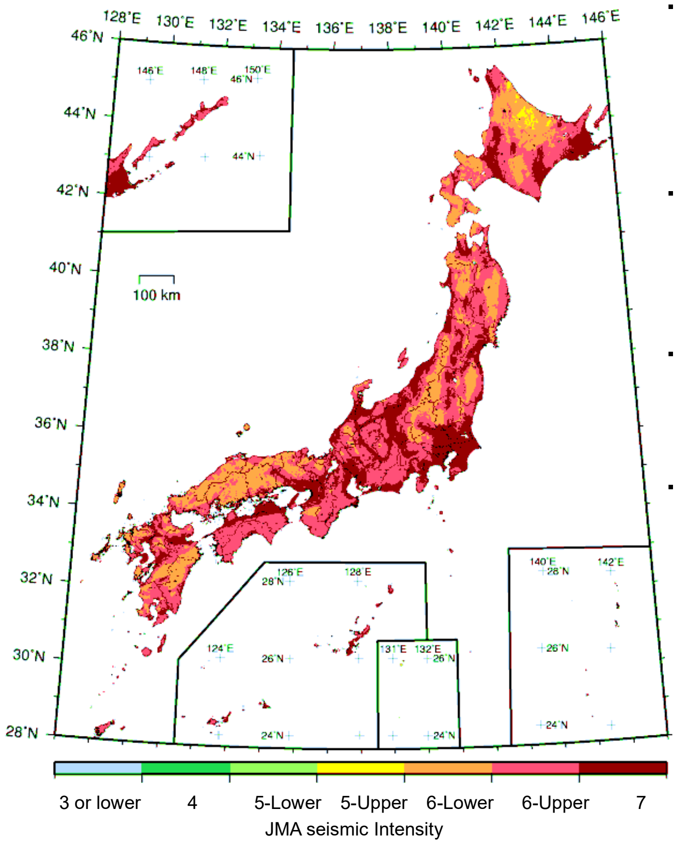
Using seismic hazard maps to consider past and possible future earthquakes

Information about earthquakes that occurred in the past and active faults that remain as traces of those earthquakes is valuable for understanding earthquakes and ground motion; however, simply collating this information is not useful for sufficient preparation for the future. The National Seismic Hazard Maps for Japan are the results of various surveys and research that include this information, predicting the possibility of the occurrence of shaking during future earthquakes through long-term evaluations and strong ground motion evaluations and depicting them as maps.



- The top left figure shows the locations and regions affected by earthquakes with seismic intensities of 6 or higher based on historical earthquake data in Japan and seismic observation records on the order of 1,000 years.
- There are limitations on earthquake information during a period less than approximately 1,500 years for crustal earthquakes along active-faults with long recurrence intervals.
- Information about Hokkaido, which has almost no historical materials prior to the Edo period, is generally limited to records on the Pacific coast since the modern era.
- Information about earthquakes that occurred in the past is limited to certain locations and is insufficient as information for a spatiotemporal distribution.
- Therefore, there exists a possibility of oversights when predicting and estimating regions that will be affected by strong shaking using only information of earthquakes that occurred in the past, as shown in the top left figure.

Regions where the estimated seismic intensity of past earthquakes (599–2019) was 6 or higher. [added to Midorikawa and Miura (2016)]



- The bottom left figure is a map of the seismic intensity distribution with the probability of shaking exceeding a given value occurring within the next 30 years at 0.03% (equivalent to a recurrence period of 100,000 years) and predicting the intensity of shaking that occurs approximately once every 100,000 years.
- This map shows regions that may be affected by strong shaking, including not only areas that experienced strong shaking in past earthquakes but also those that have not previously experienced such shaking. This allows for better preparedness in advance.
- This map considers the effects of active-fault zones and subduction-zone earthquakes with specified source faults based on long-term evaluation and those of earthquakes for unspecified source faults.
- The bottom left figure was created in 2014, prior to the 2016 Kumamoto earthquake. The map indicates that strong shaking has been predicted/estimated in the region where intense shaking occurred during the Kumamoto earthquake (see the top left figure); this suggests that advance preparations could have been possible.

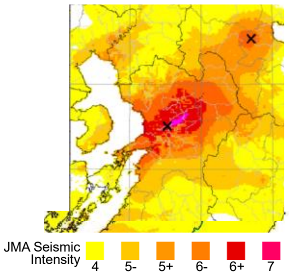
Long-term average probabilistic seismic hazard maps with recurrence period equivalent to 100,000 years (30-year exceedance probability of 0.03%)
(National Seismic Hazard Maps for Japan 2014 edition, Appendix 1[in Japanese])

Commentary: Understanding Earthquakes using National Seismic Hazard Maps and Preparing for Earthquake Disaster Prevention

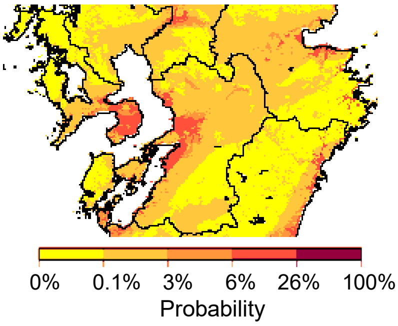
Using seismic hazard maps to investigate the 2016 Kumamoto earthquake and its seismic environment

The Headquarters for Earthquake Research Promotion has published various maps and related information. The 2016 Kumamoto earthquake is an earthquake that has already occurred, but the National Seismic Hazard Maps for Japan that were published prior to the earthquake are shown as an example here with commentary to demonstrate how the various maps and related information should have been viewed in advance to prepare against an earthquake in a nearby region.

Natural phenomena are characterized by variation and uncertainty; therefore, there are discrepancies between predictions and reality. However, preparations must be made for disasters in advance by reading maps and related information. These commentaries can serve as references to investigate nearby regions and help advance preparations that are feasible, such as making buildings earthquake-resistant and preventing furniture from toppling over.

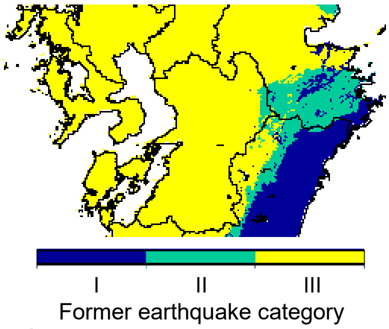


Estimated seismic intensity distribution map of main shock of the Kumamoto earthquake (M7.3) (Japan Meteorological Agency)



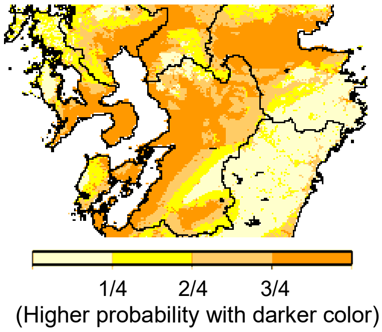
A. The probability of ground motions equal to or greater than seismic intensity of 6-Upper occurring within the next 30 years, taking into account all earthquakes

The seismic hazard varies even within Kumamoto Prefecture, and the area around Kumamoto has a high probability of being subjected to the largest ground motion.



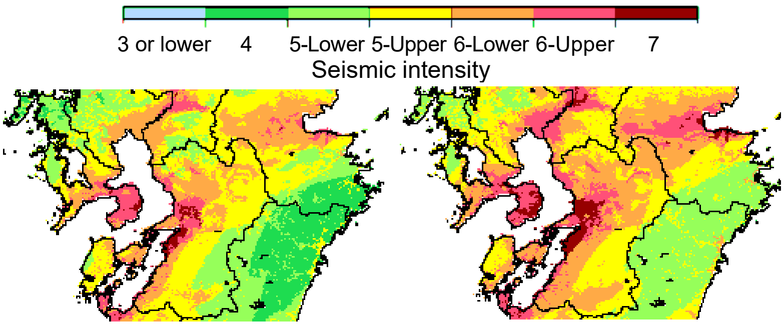
B. Most contributive former earthquake category for the probability of being struck by a seismic intensity of 6-Upper or higher within the next 30 years

Attention should be paid to shallow earthquakes on active faults (former earthquake category III) that cause infrequent catastrophic disasters around Kumamoto.



C. Quartile probability of being affected by seismic intensity of 6-Upper or higher within the next 30 years by former earthquake category III

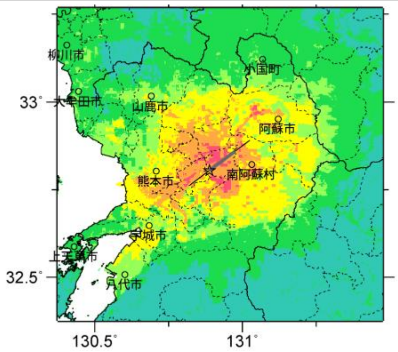
The area between Kumamoto and Oita has many active faults, plains, and basins that are prone to shaking, and the possibility of the largest ground motion occurring with inland earthquakes.



D. Seismic intensity with 30-years probability of exceedance of 3% due to shallow earthquakes on active faults

E. Seismic intensity with 50-years probability of exceedance of 2% due to shallow earthquakes on active faults

The area from Kumamoto to Oita has a high probability of being affected by the largest ground motion due to inland earthquakes, and it can be seen that this shaking could reach a seismic intensity up to 6-Lower–6-Upper–7.



F. Seismic intensity when rupture progresses from southwest to northeast from the Futagawa segment of the Futagawa fault zone evaluated by the detailed method

The scenario earthquakes show the possibility of the largest ground motion occurring in the area from Kumamoto to Aso.

(A.–E. are from the Probabilistic Seismic Hazard Maps, 2016 edition (maximum case), and F. is from the Seismic Hazard Maps for specified seismic source faults, 2014 edition)

Commentary: Understanding Earthquakes using National Seismic Hazard Maps and Preparing for Earthquake Disaster Prevention
Application example 1 of seismic hazard maps

Prioritizing seismic retrofitting of emergency transportation roads: Ministry of Land, Infrastructure, Transport, and Tourism

○Accelerating seismic retrofitting of emergency transportation roads

Based on the probability of occurrence of major earthquakes, the Ministry of Land, Infrastructure, Transport, and Tourism is implementing measures to prevent bridge collapse and to reinforce and replace bearings to prevent occurrence of large steps on the road surface for expressways and directly controlled national roads (*1). The Ministry is also promoting measures for locally managed emergency transportation roads. The target years of completion for these measures are as follows (*2).

- Aim for the completion of measures in, at a minimum, regions in which the probability of ground motions of seismic intensity of 6-Lower or higher occurring within the next 30 years is at least 26% by FY2021 (lower figure).
- Aim for completion of seismic retrofitting nationwide by FY2026.

Thus, seismic hazard maps can be utilized with the objective of implementing rational measures that prioritize areas that are likely to be affected by strong ground motions.

*1) Aim to restore bridge functions quickly through bearing reinforcement, etc. When the bearings cannot be reinforced, other measures should be implemented.

*2) Ministry of Land, Infrastructure, Transport and Tourism website: https://www.mlit.go.jp/road/bosai/measures/index1.html (last referenced December 10, 2020)

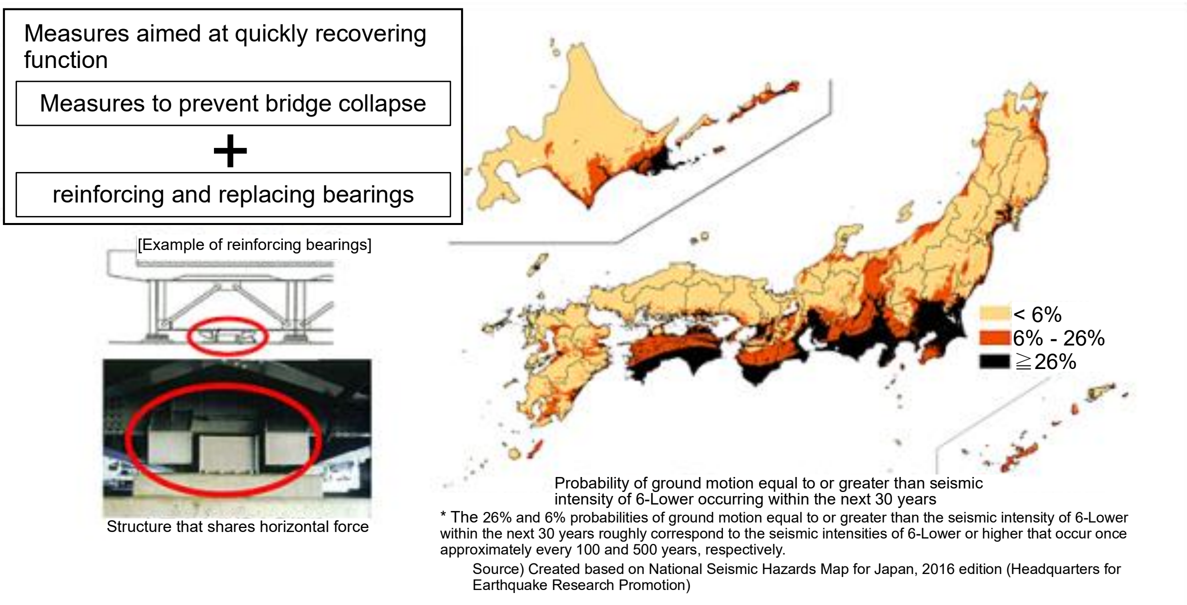


Figure: Example of bridge bearing reinforcement (left figure) and distribution map of probability of ground motions of seismic intensity of 6-Lower or higher occurring within 30 years (right figure). Excerpt from the material *2).

Commentary: Understanding Earthquakes using National Seismic Hazard Maps and Preparing for Earthquake Disaster Prevention
Application example 2 of seismic hazards map

Used as data for calculating earthquake insurance premium rates: General Insurance Rating Organization of Japan

○Calculating an appropriate standard rate using a rational method

Earthquake insurance premium rates are calculated by utilizing objective and highly accurate earthquake occurrence data (source model) to create Probabilistic Seismic Hazard Maps published by the Headquarters for Earthquake Research Promotion, predicting future insurance payments from damage prediction simulations, and calculating insurance premium rates (lower figure). In this example, the source model used to calculate seismic hazard maps was utilized as data, and the prediction of ground motion or tsunamis was conducted in a way that suited the user's purposes.

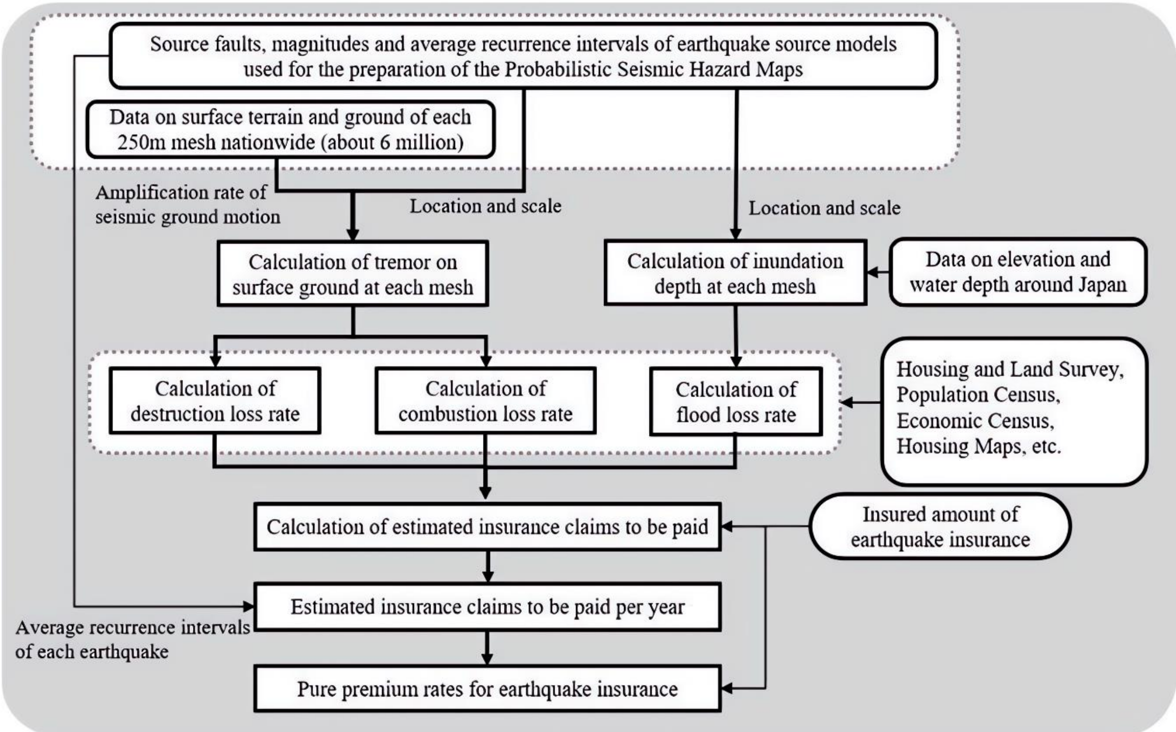


Figure: Flow of pure premium rate calculations in earthquake insurance.
Excerpt from " Earthquake Insurance in Japan (October 2022)"
by the General Insurance Rating Organization of Japan
(https://www.giroj.or.jp/english/pdf/Earthquake.pdf, referenced August 10, 2025).

Commentary: Understanding Earthquakes using National Seismic Hazard Maps and Preparing for Earthquake Disaster Prevention
Application example 3 of seismic hazard maps

Promoting earthquake resistance in school facilities: Ministry of Education, Culture, Sports, Science, and Technology

○ Earthquake-resistant priority surveys relating to the formulation of earthquake-resistance promotion plans for school facilities

Earthquake-resistant priority surveys were conducted by local governments with jurisdiction over many school facilities that need to undergo earthquake resistance diagnoses, with the primary objective of investigating the prioritization of earthquake resistance diagnosis. The assumed seismic intensity is one of the priority index items in the survey (table below). In “the collection of materials relating to active-fault and subduction-zone earthquakes,” which is one of the basic surveys conducted in advance of priority surveys, the use of seismic hazard maps is as follows(*):

- Materials are collected related to the locations of active faults around the applicable area, source regions of assumed subduction-zone earthquakes, intensity of ground motion predicted in the applicable area, and the results of assessment of damage due to ground motion.
- At that time, it is also effective to utilize seismic hazard maps for a national overview and for scenario earthquakes by the Headquarters for Earthquake Research Promotion.

Thus, seismic hazard maps can help promote earthquake resistance in school facilities ruled by local governments.

*Ministry of Education, Culture, Sports, Science and Technology website: https://www.mext.go.jp/a_menu/shisetu/bousai/taishin/03071501/004.htm
(In Japanese, referenced December 10, 2020)

Summary table of seismic reinforcement prioritization scheme (Example of steel-framed indoor athletic field)

Classification	Evaluation rank
Seismic performance of steel frame brace	A, B or C
:	:
Structural safety	A or C
Safety against falling objects	A or C
Estimated seismic intensity	A, B or C

Priority index
(calculated from the evaluation rank of each classification):
Number of B rank + 5 × number of C rank

Assumed seismic intensity of region where building is located.
Evaluation rank A: seismic intensity of 5-Upper or lower
Evaluation rank B: seismic intensity of 6-Lower
Evaluation rank C: seismic intensity of 6-Upper or higher

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Note: For other reports on long-term evaluation, strong-motion evaluation, and seismic hazard maps for specified seismic source faults (seismic hazard maps for scenario earthquakes), please refer to the following website.

★ Websites

(All pages are primarily in Japanese. English versions are noted where available.)

The Headquarters for Earthquake Research Promotion
https://www.jishin.go.jp/
https://www.jishin.go.jp/main/index-e.html *(English version available)*

The Headquarters for Earthquake Research Promotion: Long-term Evaluations
https://www.jishin.go.jp/evaluation/long_term_evaluation/

The Headquarters for Earthquake Research Promotion: Evaluations of Strong Ground Motion
https://www.jishin.go.jp/evaluation/strong_motion/

The Headquarters for Earthquake Research Promotion: National Seismic Hazard Maps for Japan
https://www.jishin.go.jp/evaluation/seismic_hazard_map/shm_report/

National Research Institute for Earth Science and Disaster Resilience: Japan Seismic Hazard Information Station J-SHIS
https://www.j-shis.bosai.go.jp/
https://www.j-shis.bosai.go.jp/en/ *(English version available)*