GLOBAL EARTHQUAKE MODEL
working together to assess risk

# PSHA input model documentation for Japan (JPN)

GEM Hazard Team

## Version history

Table 1 summarises version history for the JPN input model, named according to the versioning system described here, and indicating which version was used in each of the global maps produced since 2018. Refer to the GEM Products Page for information on which model versions are available for various use cases. The changelog describes the changes between consecutive versions and are additive for all versions with the same model year.

***Table 1** – Version history for the JPN input model.*

| Version | 2018.1 | 2019.1 | 2022.1 | 2023.1 | Changelog |
|---|---|---|---|---|---|
| v2014.0.0 | X | X | X | | First version of the model implemented in OpenQuake. |
| v2021.0.0 | | | | X | The 2021 version of the national model by NIED. Translated into OQ by GEM. |

The following text describes v2021.0.0.

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# 1 Summary

The Global Hazard Mosaic coverage of Japan is based on the 2021 seismic hazard model issued by the Headquarters for Earthquake Research Promotion (HERP). The model is described by Fujiwara et al. (2009), Fujiwara et al. (2015), and Fujiwara et al. (2023). The model has been translated from its original format into the OpenQuake (OQ) engine within a collaboration between the National Research Institute for Earth Science and Disaster Resilience (NIED), Japan, and GEM.

# 2 Tectonic overview

Japan is located on the upper plates of several subduction zones, where oceanic plates of the western Pacific system subduct under crust of eastern Asia (primarily the Amur plate). At the latitude of central Honshu and farther north, the Pacific plate suducts under Japan at the Japan and Kuril trenches, which are continuous along strike. South of this latitude, the Pacific plate subducts under the Philippine Sea plate along the Izu-Bonin-Marianas trench, while the Philippine Sea plate subducts under Japanese crust in the Nankai Trough and, farther south, the Ryukyu Trench, which continues south to Taiwan (e.g., Loveless and Meade, 2010). Suduction of the Philippine Sea Plate under southern Japan is oblique, with a large right-lateral component, which is expressed in the right-lateral Median Tectonic Line dextral fault system through Shikoku and Kyushu. Stepovers in this system as well as additional slip partitioning and other second-order tectonic complexities result in distributed reverse, normal and strike-slip faults throughout the islands, which generate shallow, moderate-magnitude earthquakes that pose substantial hazard and risk for local populations.

# 3 Basic Datasets

See Fujiwara et al. (2009), Fujiwara et al. (2015), and Fujiwara et al. (2023) for a description of the datasets used for developing the hazard model.

# 4 Hazard Model

## 4.1 Seismic Source Characterisation

The seismic source characterisation (SSC) consists of various seismic source typologies to describe earthquake occurrence in different tectonic settings. They are classified according to three categories: the first includes subduction-zone earthquakes modelled on well-constrained faults; the second includes subduction interplate and intraplate earthquakes which lack well-defined source faults (i.e. modelled in the background); and the third comprises all other shallow crustal earthquakes sources occurring onshore, offshore, on well-constrained faults, and in the background.

The SSM for Japan considers the time-dependent earthquake occurrence on some crustal and subduction faults. For mega-subduction interface ruptures, a number of possible mutually exclusive and collectively exhaustive sets of ruptures are defined in a finite period of time and each assigned a corresponding probability of occurrence.

The OQ implementation uses three OQ source typologies. The background (gridded) seismicity is implemented as collections of **Point Sources**. Crustal and Subduction faults with a time-independent model are modelled using **Characteristic Fault Sources** with planar surfaces, and those with a time-dependent behavior are modeled as **Nonparametric Sources**.

## 4.2 Ground Motion Characterisation

The table below shows the ground motion characterisation (GMC), which is comprised of a set of ground motion prediction equations (GMPEs).

The origial seismic hazard maps for Japan provide estimates of JMA seismic intensity and peak ground velocity. To compute hazard in terms of peak ground acceleration (PGA), an update to the GMPE Si and Midorikawa (1999) GMPE was added to OQ and used for the hazard computation. This was used to calculate PGA values on rock. A second logic tree (Table 3) was used for other intensity measure types (IMTs) and for all results computed for spatially varying vs30.

The GMM for the 2021 Japan model distinguishes between five main tectonic regions: *Active Shallow Crust*, *Subduction Interface*, *Subduction Interface - North East Correction*, *Subduction IntraSlab - North East Correction*,and *Subduction IntraSlab - South West Correction*.

| **Active Shallow Crust** | **Weight** |
|---|---|
| SiMidorikawa1999Asc | 1.0 |
| **Subduction Interface** | **Weight** |
| SiMidorikawa1999SInter | 1.0 |
| **Subduction Interface - North East Correction** | **Weight** |
| SiMidorikawa1999SInterNorthEastCorrection | 1.0 |
| **Subduction IntraSlab - North East Correction** | **Weight** |
| SiMidorikawa1999SSlabNorthEastCorrection | 1.0 |
| **Subduction IntraSlab - South West Correction** | **Weight** |
| SiMidorikawa1999SSlabSouthWestCorrection | 1.0 |

***Table 2*** *– GMPEs used in the Japan model for calculating PGA on rock.*

| **Subduction Interface - South West Correction** | **Weight** |
|---|---|
| AbrahamsonEtAl2015SInter | 0.5 |
| ParkerEtAl2020SInter | 0.25 |

| | |
|---|---|
| ZhaoEtAl2016SInter | 0.25 |
| **Subduction IntraSlab** | **Weight** |
| AbrahamsonEtAl2015SSlab | 0.5 |
| ParkerEtAl2020SSlab | 0.25 |
| ZhaoEtAl2016SSlab | 0.25 |
| **Subduction Interface - North East Correction** | **Weight** |
| AbrahamsonEtAl2015SInter | 0.5 |
| ParkerEtAl2020SInter | 0.25 |
| ZhaoEtAl2016SInter | 0.25 |
| **Subduction IntraSlab - South West Correction** | **Weight** |
| AbrahamsonEtAl2015SSlab | 0.5 |
| ParkerEtAl2020SSlab | 0.25 |
| ZhaoEtAl2016SSlab | 0.25 |
| **Subduction Interface** | **Weight** |
| AbrahamsonEtAl2015SInter | 0.5 |
| ParkerEtAl2020SInter | 0.25 |
| ZhaoEtAl2016SInter | 0.25 |
| **Active Shallow Crust** | **Weight** |
| ChiouYoungs2014 | 0.35 |
| BooreEtAl2014 | 0.35 |
| ZhaoEtAl2016Asc | 0.3 |
| **Subduction IntraSlab - North East Correction** | **Weight** |
| AbrahamsonEtAl2015SSlab | 0.5 |
| ParkerEtAl2020SSlab | 0.25 |
| ZhaoEtAl2016SSlab | 0.25 |

***Table 3*** *– GMPEs used in the JPN model for calculating results on spatially varying vs30 and for intensity measure types other than PGA.*

## 5 Results

Hazard curves were computed with the OQ engine for the following:

- Intensity measure types (IMTs): peak ground acceleration (PGA) and spectral acceleration (SA) at 0.2s, 0.3s, 0.6s, 1.0s, and 2s
- reference site conditions with shear wave velocity in the upper 30 meters (Vs30) of 760-800 m/s, as well as for Vs30 derived from a topography proxy (Allen and Wald, 2009)

Hazard maps were generated for each reference site condition-IMT pair for 10% and 2% probabilities of exceedance (POEs) in 50 yrs. Additionally, disaggregation by magnitude, distance, and epsilon was computed for the following cities: Tokyo. The results were produced as csv files and bar plots for each of the following combinations:

- hazard levels for 10% and 2% POE in 50 yrs
- PGA and SA at 0.2s, 0.3s, 0.6s, and 1.0s
- Vs30=800 m/s

All calculations used a ground motion sigma truncation of 5. Results were computed for sites with 6 km spacing

Visit the GEM Interactive Viewer to explore the Global Seismic Hazard Map values (PGA for Vs30=800 m/s, 10% poe in 50 years). For a comprehensive set of hazard and risk results, see the GEM Products Page.

## 6 References


Allen, T. I., and Wald, D. J., 2009, On the use of high-resolution topographic data as a proxy for seismic site conditions $Vs30$, Bulletin of the Seismological Society of America, 99, no. 2A, 935-943

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