

PSHA input model documentation for China (CHN)

GEM Hazard Team

Version history

Table 1 summarises version history for the CHN 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.

The following text describes v2021.3.0.

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

Version	2018.1	2019.1	2022.1	2023.1	2026.1	Changelog
v2015.0.0	X					First version of the model by the China Earthquake Administration (CEA) implemented in OpenQuake.
v2015.1.0		X				Modified original version to be in terms of Mw instead of Ms.
v2021.0.0			X			A new hazard model developed by the GEM Secretariat
v2021.1.0				X		Sources were reorganized to more accurately reflect their tectonic region type (TRT). Source_id naming convention adjusted to follow the disagg_by_src requirements. Multi-fault ruptures were divided into multiple files by their TRT. Multi-fault ruptures M<6.0 were removed, significantly lowering hazard at sites very close to faults. The multi-fault ruptures representing the Himalayan Thrust were replaced with one simple fault, assigned the summed MFD of the replaced ruptures. gmmLT.xml was updated.
v2021.2.0						The Longquan fault has been refactored. Mapping file placing sections on faults added to the multi-fault sources so that it can be used with disagg by source. OQ Engine v3.23.2 is required.
v2021.3.0					X	The gmmLT has been updated according to more recent analyses

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1 Summary

The Global Hazard Mosaic coverage of China was developed by the GEM Secretariat. The model covers mainland China and is composed of smooth seismicity sources and fault sources, the latter of which are mostly located in the western half of the territory.

2 Tectonic overview

China sits at the western edge of Eurasia, and faulting and tectonics in China are determined by the interaction of Eurasia with the neighboring India and the plates and microplates of the western Pacific and Indochina areas. The most active regions are in the west, where the Indo-Asian collision causes faulting in the Tibetan plateau and Tien Shan ranges; this belt of deformation continues through Mongolia. Though the Tibetan plateau is very sparsely populated and the attenuation of seismic waves is great, the eastern margins of this deformation zone abut the densely populated Sichuan Basin and adjacent areas; seismic activity here is among the most deadly on earth. Slow faulting extends from eastern Tibet to the northeast into the Gulf of Bohai near Beijing, and possibly north to the border with Russia along the Tanlu Fault Zone. In the southeast, strike-slip faults radiate from Eastern Tibet through Yunnan, and rapid contractional deformation related to the collision of the Philippine Sea plate with China cuts through Taiwan.

3 Basic Datasets

For this model, a homogenous catalogue was developed from open source catalogues, including both instrumental and historical. The catalogue included records from the ISC-GEM extended catalogue (*Weatherill et al., 2016*), the GHEC (*Albini et al, 2014*), and a Chinese historical catalogue (*Min et al., 1995*). Before developing the SSC, extensive work on the completeness analysis of the catalog was performed. While the historical records for China extends very far in the past, many issues with the magnitude frequency distributions were observed, especially in the moderately active eastern part of the country. In order to minimize the impact of potential misestimation of the magnitude of historical earthquakes, the estimation of the earthquake rate is based on the more modern, better constrained, instrumental part of the catalog. The historical catalog was used to compare projected earthquake rates for large magnitudes to the recorded rates. Two manners of calculating the completeness and two smoothing kernels for the spatialization of the seismicity were used.

4 Hazard Model

4.1 Seismic Source Characterisation

The seismic source characteristion includes two parts: **fault sources** and smoothed seismicity composed of **point sources**.

The slip rates of the faults were inverted by GEM's Oiler code, which uses GPS deformation and local geological information to obtain the displacement along around 70,000 km of fault traces from the Global Active Faults Database (*Styron and Pagani, 2020*). These slip-rates were then converted into earthquake rates using the seismic hazard and earthquake rate in fault systems (SHERIFS) tool (Chartier et al., 2019), allowing for the occurrence of a large diversity of complex multi-fault ruptures. The rates modelled by SHERIFS were compared to the one observed in the catalog and adjustment of the estimation of the largest magnitude of the local magnitude frequency distribution (MFD) were performed if needed.

The smooth seismicity model and the faults were merged in order to avoid double counting of earthquakes, ensuring the compatibility between the observed rate and the modelled rate both at a local level and at a larger regional level.

Since the original model, several updates and bug fixes have been made to the seismic source characterisation; see the changelog.

4.2 Ground Motion Characterisation

The ground motion characterisation (GMC) was originally built using available published literature on ground motion prediction equation (GMPE) selection for China. The GMC has been updated in the most recent versions as shown in the table below.

Active Shallow Crust	**Weight**
AbrahamsonEtAl2014RegCHN	0.33
CauzziEtAl2014	0.33
ChiouYoungs2014	0.34
Himalayan Thrust	**Weight**
AbrahamsonEtAl2014RegCHN	0.33
CauzziEtAl2014	0.33
ChiouYoungs2014	0.34
Craton	**Weight**
AtkinsonBoore2006Modified2011	0.33
YenierAtkinson2015BSSA	0.33
NRCan15SiteTerm	0.34
Deep Crust 1	**Weight**
AbrahamsonEtAl2015SSlab	0.50
ParkerEtAl2020SSlab	0.50
Active-Stable Shallow Crust	**Weight**
AbrahamsonEtAl2014RegCHN	0.33
CauzziEtAl2014	0.33
ChiouYoungs2014	0.34

Table 2 *– GMM weights by tectonic region*

5 Comparison to former models

Depending on the region in China, the results can be different from past studies by *Rong et al., 2020* and the Chinese national model by the *China National Standardization Management Committee (2015)*. In the eastern part, it is mostly due to the choice of giving a strong weight to the instrumental part of the catalog where other studies rely strongly on the historical part. In the west, it is due to including the fault system where in the past they were often simplified as area sources.

6 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 0.1s, 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: Beijing. 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 0.1s, 0.2s, 0.3s, 0.6s, 1.0s and 2.0s
- Vs30=800 m/s

All calculations used a ground motion sigma truncation of 5. Onshore 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.

7 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

Albini P., Musson R.M.W., Rovida A., Locati M., Gomez Capera A.A., and Viganò D. (2014). The Global Earthquake History. Earthquake Spectra, May 2014, Vol.30, No.2, pp. 607-624. http://doi.org/10.1193/122013EQS297

Chartier, Thomas, Oona Scotti, and Hélène Lyon-Caen. "SHERIFS: Open-source code for computing earthquake rates in fault systems and constructing hazard models." Seismological Research Letters 90.4 (2019): 1678-1688. doi: 10.1785/0220180332

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