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.

Table 1 – Version history for the CHN input model.

Version	2018.1	2019.1	2022.1	2023.1	Changelog
v2015.0.0	X				First version of the model by the 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). 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.

The following text describes v2021.1.0.

Authors: Thomas Chartier, Richard Styron, Marco Pagani (GEM Foundation)

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.

4.2 Ground Motion Characterisation

The ground motion logic tree was built using available published literature on GMPE selection for China. Unfortunately, due to unavailability of strong motion data, we were not able to test or add other GMPEs.

The table below shows the ground motion characterisation (GMC), which is comprised of a set of ground motion prediction equations (GMPEs). The GMM for China distinguishes among four main tectonic regions: *Active Shallow Crust*, *Stable Crust*, *Stable Crust Non-Cratonic*, and *Deep Crust*.

Craton	**Weight**
AtkinsonBoore2006	0.5
YenierAtkinson2015BSSA	0.5
Deep Crust 1	**Weight**
AbrahamsonEtAl2015SSlab	0.5
ParkerEtAl2020SSlab	0.5
Himalayan Thrust	**Weight**
AbrahamsonEtAl2014RegCHN	0.33
CauzziEtAl2014	0.33
ChiouYoungs2014	0.34
Active Shallow Crust	**Weight**
AbrahamsonEtAl2014RegCHN	0.33
CauzziEtAl2014	0.33
ChiouYoungs2014	0.34

Active-Stable Shallow Crust	Weight
AbrahamsonEtAl2014RegCHN	0.33
CauzziEtAl2014	0.33
ChiouYoungs2014	0.34

Table 2 *– GMPEs used in the CHN model.*

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 the inclusion of the fault as a 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 0.2s, 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 0.2s, 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.

7 References

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If you have any questions please contact the GEM Foundation Hazard Team at: hazard@globalquakemodel.org