



PSHA input model documentation for India and surroundings (IND)

GEM Hazard Team

Version history

Table 1 summarises version history for the IND 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 IND input model.

Version	2018.1	2019.1	2022.1	2023.1	2026.1	Changelog
v2012.0.0	X					First version of the model implemented in OpenQuake.
v2012.1.0		X	X			Corrected to use GMPE Kanno et al. (2006) for shallow earthquakes instead of the version for deep earthquakes. On layer 3 the "subduction interface" TRT is replaced with "subduction intraslab".
v2012.2.0				X		gmmLT.xml updated with more recent GMPEs
v2012.3.0						Tailored version of the original model with work done for the FORCE and Bangladesh projects. In particular, the largest earthquakes admitted by the source model were moved from the distributed seismicity to fault sources; focal mechanisms for highly productive sources in the northeastern part of the model were checked and adjusted if needed; the tectonic region types were consolidated; and the gmmLT was changed based on more thorough reviews of the models originally included in consideration of the current model applications
v2012.4.0					X	The gmmLT has been updated according to more recent analyses.

The following text describes v2012.4.0.

Authors: N. Ackerley, K.K.S. Thingbaijam, S.K. Nath

1 Summary

Coverage of the Indian subcontinent is with the hazard model developed by Nath and Thingbaijam (2012). This model covers India, Bangladesh, Bhutan and Nepal. The model has been updated and translated from its original format into the [OpenQuake \(OQ\) engine](#) in collaboration with Natural Resources Canada. Additional information, material and documentation about the implementation of the model can be found at: <https://github.com/nackerley/indian-subcontinent-psha>.

Since the original OQ Engine implementation, GEM has made a number of updates to the model that reflect more recent data and modelling standards, and that improve the models utility for a wide range of applications. The most important changes are:

- The Main Himalayan Thrust and Indo-Burma Subduction Interface are now represented by finite faults instead of distributed seismicity
- For distributed seismicity sources producing the largest earthquakes, the nodal plane orientations were reviewed and (in cases) updated for consistency with observed focal mechanism in more recently compiled datasets
- the tectonic region types were consolidated
- ground motion models were reviewed and often updated nation wide
- one branch of the logic tree (the smoothed seismicity model with $M_{min}=4.5$) was eliminated due to its poor performance in statistical tests with a more recent catalogue

2 Tectonic overview

The Indian subcontinent moves northward with respect to Eurasia and is colliding with the southern Asian margin at 35-45 mm/yr; this collision has contributed greatly to the uplift of the great mountain ranges of central and eastern Asia, including the Himalaya, the Tien Shan, the Pamir, and the Tibetan plateau. The Indian subcontinent is much stronger than the Asian continental crust with which it collides, though, so most of the deformation and seismicity that results from the plate collision is located in and north of the Himalaya outside of India. Exceptions include in northwest and northeast India where the Himalaya are within the national borders, and the Shillong region of eastern India, where some component of the plate convergence is accommodated on intraplate faults. The faults in the Himalayan belt take up at least half of the total plate convergence and represent the greatest source of seismic hazard to India; earthquakes on the Himalayan thrusts may be large enough that those in Nepal, Bhutan and Pakistan may still produce dangerous seismic shaking in densely-populated northern India.

Nonetheless, the strong Indian crust is capable of transmitting compressive stresses over great distances, and large, damaging earthquakes have occurred well within the Indian borders as a result. A prime example of this is the 2001 *Mw* 7.6 Bhuj earthquake in Gujarat, which killed over 2000 people (*Bodin and Horton, 2004, Bulletin of the Seismological Society of America*)

3 Basic Datasets

See Nath and Thingbaijam (2012) for a description of the datasets used for developing the hazard model.

4 Hazard Model

4.1 Seismic Source Characterisation

Nath and Thingbaijam (2012) proposed three source models: a single set of areal seismicogenic source zones, and two smoothed-gridded point source models. Epistemic uncertainty is considered through alternative values of *b*- and *M*_{max} in each source zone which are collapsed (e.g. applied pre-calculation) within the three source models.

4.2 Ground Motion Characterisation

A wide range of tectonic regions are considered, and epistemic uncertainty is accounted for by using multiple GMPs per tectonic region; see Table 2. The table reflects the updated logic tree used in v2012.4.0.

active shallow crust	Weight
AbrahamsonEtAl2014	0.50
ChiouYoungs2014	0.50
Himalayan Thrust	Weight
AbrahamsonEtAl2014	0.50
ChiouYoungs2014	0.50
stable shallow crust	Weight
AtkinsonBoore2006Modified2011	0.33
YenierAtkinson2015BSSA	0.33
NRCan15SiteTerm	0.34
intraplate margin lower	Weight
AtkinsonBoore2006Modified2011	0.33
YenierAtkinson2015BSSA	0.33
NRCan15SiteTerm	0.34
intraplate margin upper	Weight
AtkinsonBoore2006Modified2011	0.33
YenierAtkinson2015BSSA	0.33
NRCan15SiteTerm	0.34
subduction intraslab	Weight
KuehnEtAl2020SSlab	0.50
ParkerEtAl2020SSlab	0.50
subduction interface	Weight
KuehnEtAl2020SInter	0.50
ParkerEtAl2020SInter	0.50
Oceanic Crust without Volcanism	Weight
AbrahamsonEtAl2014	0.25
BooreEtAl2014	0.25
CampbellBozorgnia2014	0.25
ChiouYoungs2014	0.25

Table 2 – GMM weights by tectonic region. Note that some GMMs include multiple branches with scaling terms, not listed here for brevity.

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 0.1s, 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: Dhaka, Kathmandu, Thimphu, New Delhi and Colombo. 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](#).

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 V_{s30} , Bulletin of the Seismological Society of America, 99, no. 2A, 935-943

Nath, S. K. and Thingbaijam, K. K. S. (2012). Probabilistic seismic hazard assessment of India. Seismological Research Letters, 83(1):135–149.

Last processed: Wednesday 7th October, 2026 @ 06:26

www.globalquakemodel.org

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