

The 2007 USGS Model for South East Asia

The 2007 USGS seismic hazard model for South East Asia is described in the report by [Petersen et. al. 2007](#) (see also [the USGS Website](#)). Here we present a description of the OpenQuake-engine implementation of the model.

Earthquake catalogue

The earthquake catalogue was compiled using instrumentally recorded earthquakes from four global catalogues:

- The Centennial catalogue (Engdahl and Villaseñor, 2002) [link](#);
- The EHB catalogue (Engdahl et al., 1998) [link](#);
- The USGS/NEIC catalogue (<http://neic.usgs.gov>) and;
- The ISC catalogue (<http://www.isc.ac.uk>).

The Seismic Source Model

The seismic source model employs different seismic source typologies to model seismicity occurring in different tectonic settings. Gridded seismicity is used to model both spatially variable seismicity as well as zones of uniform seismicity. Fault sources are instead used to model shallow crustal faults and large subduction interface faults.

Gridded seismicity models are implemented as collections of point sources (following the NRML [pointSource](#) definition). Crustal and subduction interface faults are instead modeled as simple (NRML [simpleFaultSource](#)) and complex fault sources (NRML [complexFaultSource](#)) when associated to a Gutenberg-Richter magnitude-frequency distribution, while as characteristic fault sources (NRML [characteristicFaultSource](#)) when associated to a Characteristic model.

The entire source model can be divided into a number of sub-models:

- Active shallow crust gridded seismicity
- Subduction intraslab gridded seismicity
- Stable continental crust gridded seismicity (Sunda intraplate)
- Active shallow crust faults
- Subduction interface faults

The map below depicts the annual occurrence rate per source (between minimum and maximum magnitudes) for the different source models included in the hazard model. Click the *show map layers* icon to view different source models and base layer maps.

Total occurrence rate
(number of events / year)

- < 1e-6
- 1e-6 - 1e-5
- 1e-5 - 1e-4
- 1e-4 - 1e-3
- 1e-3 - 1e-2
- 1e-2 - 1e-1
- 1e-1 - 1
- 1 - 10
- >= 10

```
.my-legend .legend-title { text-align: left; margin-bottom: 5px; font-weight: bold; font-size: 80%; }
.my-legend .legend-scale ul { margin: 0; margin-bottom: 5px; padding: 0; float: left; list-style: none; }
.my-legend .legend-scale ul li { font-size: 80%; list-style: none; margin-left: 0; line-height: 18px;
margin-bottom: 2px; } .my-legend ul.legend-labels li span { display: block; float: left; height: 16px;
width: 30px; margin-right: 5px; margin-left: 0; border: 1px solid #999; } .my-legend .legend-source {
font-size: 70%; color: #999; clear: both; } .my-legend a { color: #777; }
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The Ground Motion Model

The ground motion model distinguishes between four main tectonic regions:

- Active Shallow Crust
- Stable Continental Crust
- Subduction Interface
- Subduction Intraslab

For each tectonic region, various GMPEs are used to account for epistemic uncertainties.

Active Shallow Crust	Weight
Boore and Atkinson 2008	0.333
Campbell and Bozorgnia 2008	0.333
Chiou and Youngs 2008	0.333
Stable Continental Crust	Weight
Toro et. al. 1997	0.25
Frankel et. al. 1996	0.125
Campbell 2003	0.125
Atkinson and Boore 2006 (140 bar stress drop)	0.125
Atkinson and Boore 2006 (200 bar stress drop)	0.125
Tavakoli and Pezeshk 2005	0.125
Silva et. al. 2002	0.125
Subduction Interface	Weight
Zhao et. al. 2006	0.5
Atkinson and Boore 2003	0.25

Youngs et. al. 1997	0.25
Subduction Intraslab	Weight
Geomatrix 1993	0.5
Atkinson and Boore 2003 (Global model)	0.5

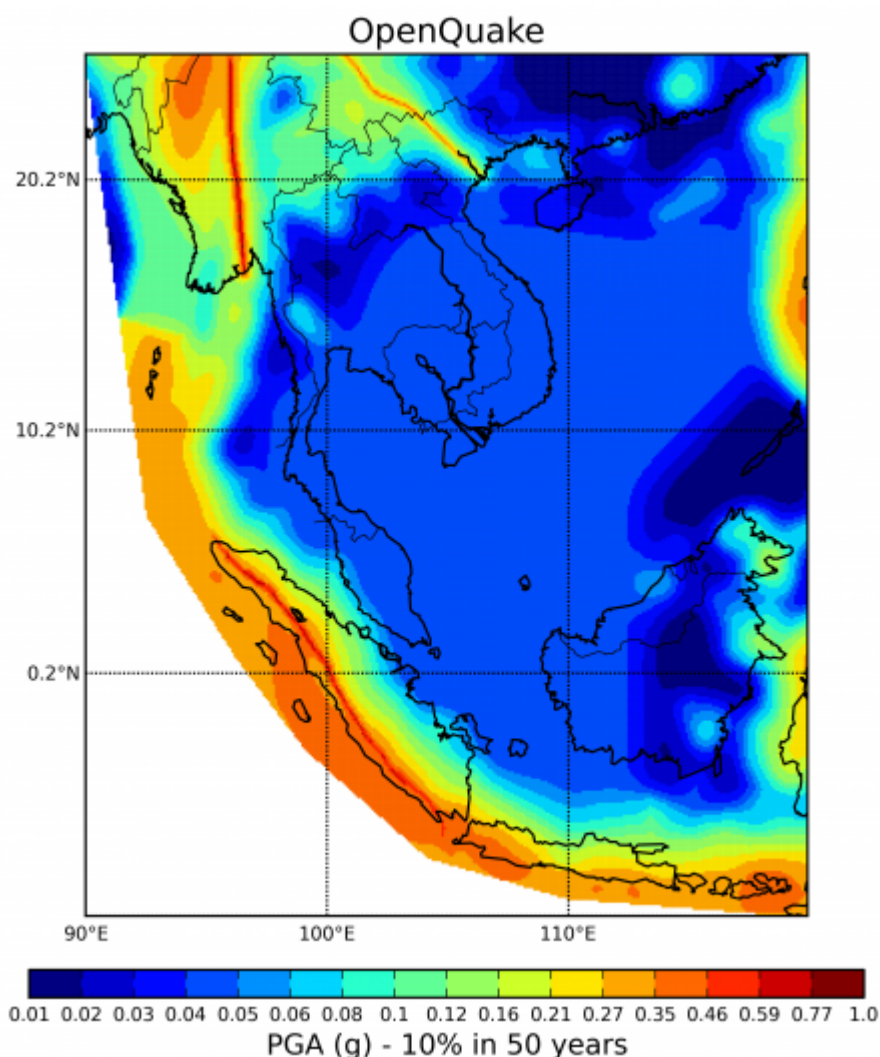
Reference site condition

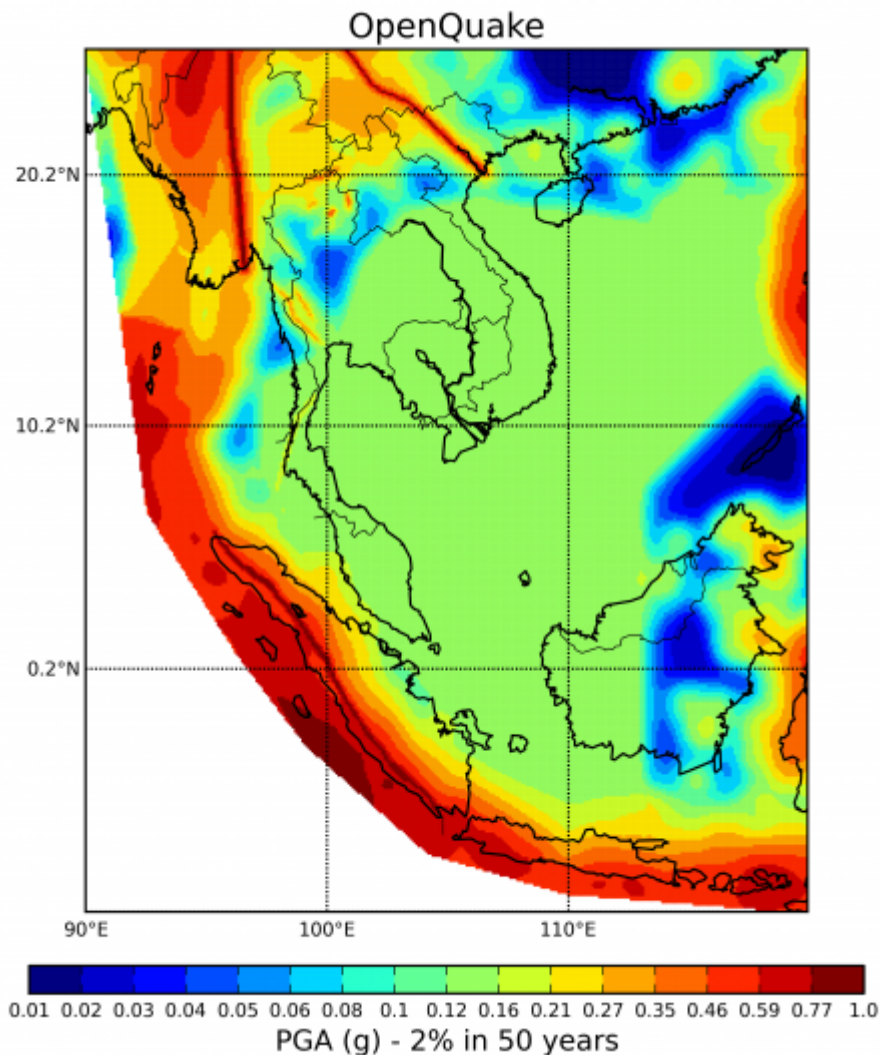
The NEHRP B/C site condition is assumed to be the reference site conditions for the hazard model. This is equivalent to a Vs30 (shear wave velocity in the uppermost 30 meters) = 760 m/s. Almost all GMPEs utilized for active shallow crust and subduction interface accept Vs30 as prediction variable. The remaining GMPEs are used with coefficients corrected for the B/C site conditions.

Hazard Results

Hazard Maps

The figures below represent hazard maps for peak ground acceleration, corresponding to 10% and 2% probabilities of exceedance in 50 years, computed with the OpenQuake-engine.





References

- Petersen, M., Harmsen, S., Mueller, C., Haller, K., Dewey, J., Luco, N., Crone, A., Lidke, D., and Rukstales, K., Documentation for the Southeast Asia Seismic HazardMaps, Administrative Report September 30, 2007, U.S. Geological Survey [Report](#)
- Wells, D.L., and Coppersmith, K.J., 1994, New empirical relationships among magnitude, rupture length, rupture width, and surface displacements: Bulletin of the Seismological Society of America, v. 84, p. 974-1002. [Journal Article](#)

Model summary table

This table summarises the main characteristics of the original implementation of this model

1	Datasets availability	
1.1	Earthquake catalogue	Not available. Developed or modified existing catalogs (see pg 17 in Petersen, 2007)
1.2	Geological database	Fault and fold database for Indonesia given in Appendix C of Petersen, 2007)

1.3	Strong-motion database	Not available
1.4	Site characterization database	Not available
Notes		
2	Methodology for model development	
2.1	Scientific participation (SSHAC levels) and review process	Level 2
2.2	Documentation describing model preparation	Petersen, 2007
2.3	Codes used for model preparation	Not available
Notes		
3	PSHA input model	
3.1	Seismic Source Model	
3.1.1	Area sources	Included (background seismicity)
3.1.2	Grid sources	Included (background seismicity)
3.1.3	Crustal faults	Included (e.g. Sumatran transform fault)
3.1.4	Subduction faults	Included (Sumatran subduction zone)
3.1.5	Non-parametric ruptures	Not included
3.1.6	Magnitude-area scaling relationships	Wells and Coppersmith, 1994
3.2	Ground Motion Model	
3.2.0	Tectonic regionalisation	Included
3.2.1	Models for active shallow seismicity	Included
3.2.2	Models for subduction interface	Included (Sumatran subduction zone)
3.2.3	Models for subduction intraslab	Included (Sumatran subduction zone)
3.2.4	Models for stable continental regions	Included (Sunda plate)
3.2.5	Models for deep non-subduction sources	Not included
3.2.6	Models for volcanic areas	Not included
3.3	Site Response Model	
3.3.1	Based on GMPEs	Yes, hazard is computed for a reference soil condition corresponding to NEHRP B/C boundary ($V_{s30}=760$ m/s)
3.3.2	Based on site-response analysis	No
3.4	Epistemic uncertainties	
3.4.1	Seismic Source Model	Included
3.4.2	Ground Motion Model	Included using a logic tree (see the ground motion model section)
3.4.3	Site Response Model	Not included
Notes		
4	Hazard Input Description	
4.1	Hazard input document	Not available
4.2	Input files	Not available
Notes		
5	Calculation	
5.1	Software	Suite of Fortran and C codes
5.2	Results	
5.2.1	Hazard curves	Available for Jakarta and Bangkok (see Petersen, 2007)

5.2.2	Hazard maps	Available (created for Sumatra and Java Indonesia, Malaysia, and Thailand see Appendix C of Petersen, 2007)
5.2.3	Uniform hazard spectra	Not available
5.2.4	Disaggregation	Not available
5.2.5	Stochastic event sets	Not available
5.2.6	Ground motion fields	Not available
<i>Notes</i>		

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