

# EARTHQUAKE MODELS

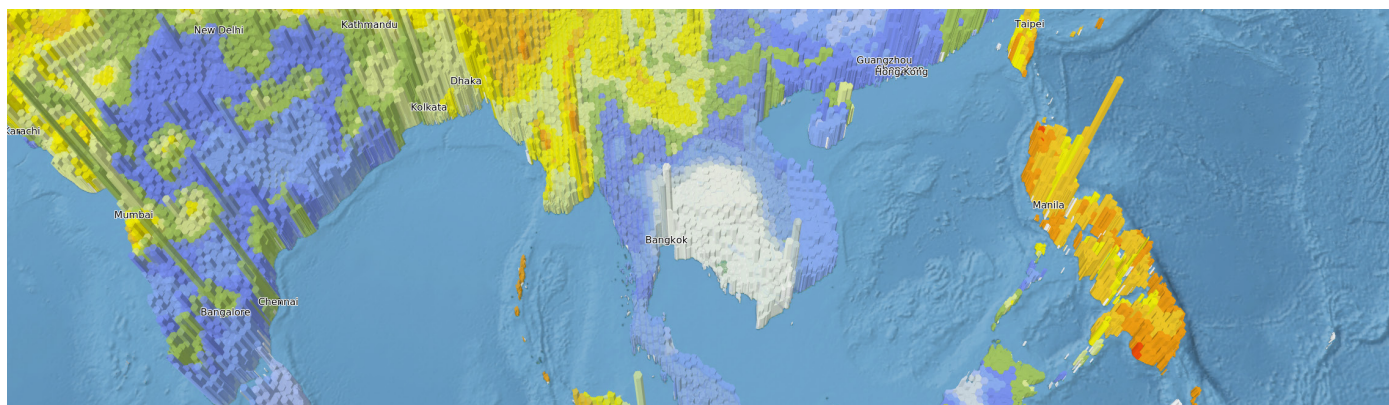
October 2020 Release

## Introduction

The GEM (Global Earthquake Model) Foundation develops hazard and risk models for the calculation of human and economic losses due to earthquakes. These models are important for a wide range of risk management applications, including standards for the design of buildings and infrastructure, insurance/risk transfer, national risk assessments, as well as public risk awareness and education.

In line with GEM's mission to support disaster risk reduction efforts toward a world that is safe from earthquakes, GEM is now releasing publicly hazard and risk models for Arabia, the Caribbean and Central America, South America, Indonesia, Continental Southeast Asia, Taiwan and South Africa. These models are released in a format compatible with the GEM's freely available OpenQuake Engine (<https://www.globalquakemodel.org/oq-get-started>). GEM is also releasing its global exposure database (to Administration Level 1) and global vulnerability database for residential, commercial and industrial buildings. The updated models and databases underpin GEM's Global Seismic Hazard and Risk maps launched in December 2018. All of these products may be downloaded from GEM's new Products page (<https://www.globalquakemodel.org/products>). In addition, a number of other products are being made available for non-commercial, public-good use by request, including the global hazard map digital dataset.

To date GEM and its partners have released a wide range of datasets and models that contributed to the 2018 global hazard and risk maps. By the end of the year, all models and databases developed for the global model will have been released openly or will be available for non-commercial, public-good use upon request.



## How we built the models

The newly released seismic hazard models include contributions from various national geological survey groups and academic institutions, local experts and scientists in Indonesia, Taiwan, South Africa, Southeast Asia, Arabia, South America and the Caribbean & Central America.

For the seismic risk models, GEM developed exposure and vulnerability models for human population and for residential, commercial and industrial buildings. Exposure and vulnerability were combined with the global hazard model to estimate economic and human losses. Collectively, the models and resulting hazard and risk maps represent the most comprehensive resource for risk assessment and loss estimation in the countries and regions included in this release.



## For what purpose and for whom

The earthquake hazard and risk models are based on the latest scientific data and represent a major step in understanding earthquake risk. The results can be used to understand earthquake risk at the sub-national, national and regional level, and as the basis for developing custom models and risk profiles at higher resolution, e.g., at city level. The results can be used by engineers and scientists for in-depth hazard and risk analysis, as well as by risk managers, urban planners, emergency responders and humanitarian agencies for input to a wide range of disaster risk reduction activities, including anticipatory actions, building codes, building retrofits, land-use planning, insurance/risk financing, and education.



## Overview of the models

### Hazard

Using the OpenQuake Engine, the seismic hazard models for the countries and regions included in this release can be used to calculate the hazard due to ground shaking for any given return period in terms of peak ground acceleration and a range of spectral acceleration periods. They can also be used to calculate future earthquake shaking scenarios or stochastic event sets (i.e., all possible scenarios). The seismic source models are constrained by historic and recorded seismicity, and fault kinematics when available.

### Risk

The impacts of ground shaking in the built environment in countries and regions included in this release are captured by the risk model's exposed population and assets and associated vulnerability functions. The exposure database contains population, dwelling and building counts, structural characteristics, and replacement values at the Administrative Level 1 for all the countries covered by the global model. The vulnerability model database comprises vulnerability and damage curves for over 600 building types globally for residential, commercial and residential buildings. Losses may be calculated for earthquake scenarios or probabilistically in terms of annualized loss or loss exceedance curves.

## List of National and Regional Models

### Arabia

The 2018 seismic hazard model of the Arabian Peninsula (ARB) was developed by the Saudi Geological Survey (SGS). The model covers Saudi Arabia, Yemen, Oman, Qatar, Bahrain, Jordan, Kuwait and the United Arab Emirates. Exposure data is available for Administration level 1 for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes.

### Caribbean and Central America (2018, 2019)

This model covering the Central America and the Caribbean region (CCA) was developed in the framework of the CCARA project - a GEM collaboration project funded by USAID from 2016-2018. Exposure data is available for Admin level 1 for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes.

### Indonesia

The 2017 seismic hazard model for Indonesia was developed by the Team for Updating Seismic Hazard Maps of Indonesia of the National Center for Earthquake Studies, Indonesia (Irsyam et al., 2017). Exposure data is available for Admin level 1 for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes.

### South Africa

The seismic hazard model for South Africa (ZAF) was developed by scientists from the Council for Geoscience, South Africa and the Indian Institute of Technology, Jammu, India. Exposure data is available for Admin level 1 for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes.

### South America (2016, 2020)

The first version of the South America Model (SAM) was developed in the framework of the SARA project (SARA project v1.0, Garcia et al., 2017) funded by Swiss Re Foundation and benefits from the contribution of an important group of South American Institutions. Exposure data is available for Admin level 1 for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes. The 2016 model has been available openly and continues to be. A later 2018 version was used for the global hazard and risk maps; while the 2020 version has additional important revisions.

### Southeast Asia

The seismic hazard model for Continental Southeast Asia (SEA) covers Myanmar, Thailand, Vietnam, Laos, Cambodia, Singapore, and West Malaysia. The model was developed by a group of scientists from Singapore, Thailand, Myanmar and Vietnam. Exposure data is available for Admin level 1 for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes.

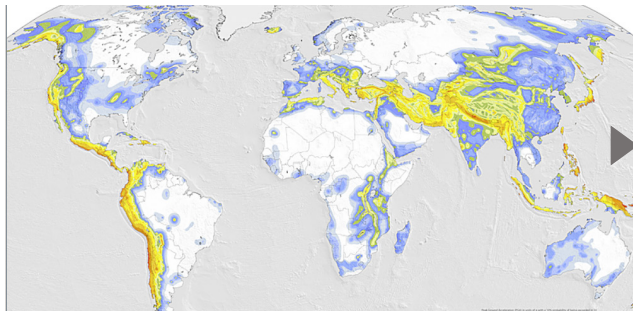
### Taiwan

Coverage of Taiwan is with the 2015 hazard model developed within the Taiwan Earthquake Model (TEM) initiative (Wang et al., 2016). The model was originally implemented for the OpenQuake Engine. Exposure data is available for Admin level 1 for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes.

### National and Regional Models License Information

Model	License Information
Arabia	All components are licensed under CC BY-SA <sup>1</sup> .
Caribbean and Central America	The 2018 hazard, vulnerability and exposure models are licensed under CC BY-SA <sup>1</sup> . The 2020 hazard model is presently available for public-good, non-commercial use under NDA <sup>3</sup> .
Indonesia	The hazard and exposure models are licensed under CC BY-NC-SA <sup>2</sup> , while the Vulnerability model is licensed under CC BY-SA <sup>1</sup> .
South Africa	All components are licensed under CC BY-SA <sup>1</sup> .
Southeast Asia	All components are licensed under CC BY-SA <sup>1</sup> .
South America	The hazard, vulnerability and exposure models for the 2016 model are licensed under CC BY-SA <sup>1</sup> . The 2020 model is presently available for public-good, non-commercial use under NDA <sup>3</sup> .
Taiwan	All components are licensed under are licensed under CC BY-SA <sup>1</sup> .

## List of Global Digital Databases

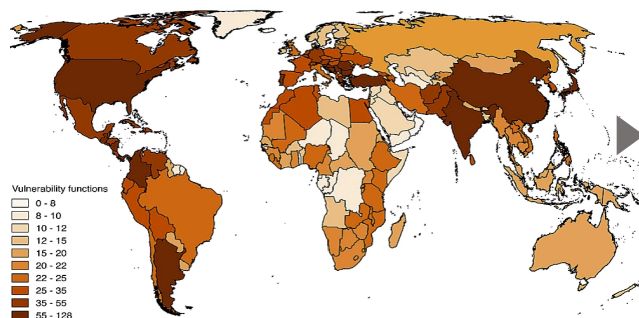
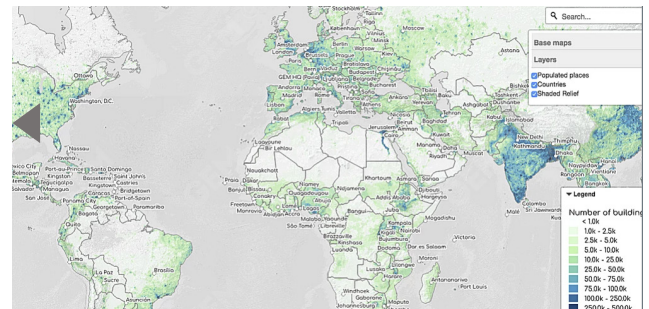


### Global Comprehensive Hazard

This is a global digital database product produced by GEM. The 2018 global hazard map is in terms of peak ground acceleration (PGA) with a 10% probability of exceedance in 50 years on rock. The new, comprehensive global hazard product is from the v2019.1 of the Global Seismic Hazard Model, and provides ground motion values for PGA and spectral accelerations (SA) at 0.2, 1.0, and 2.0 s, for 2% and 10% probability of exceedance in 50 years on rock and soil. Available for commercial license or for public good, non-commercial use under an NDA<sup>3</sup>.

### Global Exposure Model

This is a global digital database product produced by GEM. The Global Exposure Model includes data for Administration level 1 for commercial, industrial, residential buildings, and global population (except Australia, Canada, US and NZ). The product is licensed under CC BY-SA<sup>1</sup>.

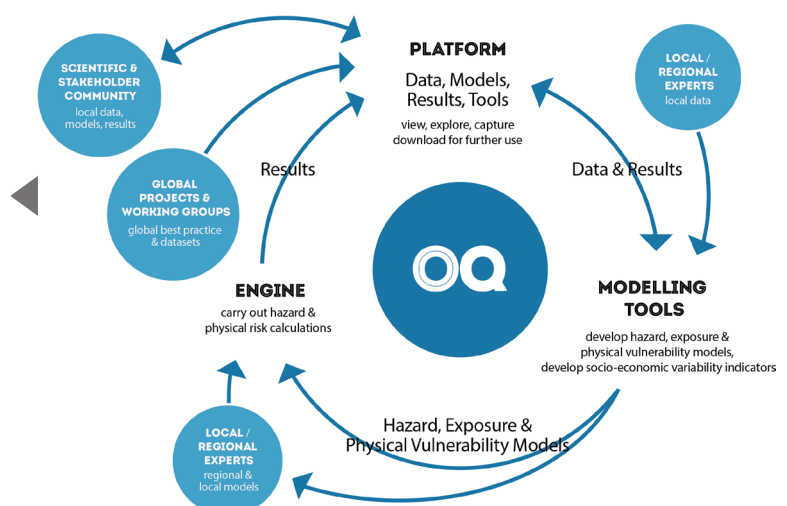


### Global Vulnerability (Buildings)

This is a global digital database produced by GEM. The Global Vulnerability digital database includes data for commercial, industrial, residential (including 600 curves funded by USAID). The product is licensed under CC BY-SA<sup>1</sup>.

### The OpenQuake Engine Environment

The [OpenQuake Engine](https://openquake.org/) is GEM's state-of-the-art software for seismic hazard and risk assessment at varying scales of resolution, from global to local. The OQ engine was used for the calculation of hazard and risk in the models included in this release. Freely available for public use with no commercial restrictions under [AGPL](https://creativecommons.org/licenses/by-sa/4.0/).



### License Description

<sup>1</sup> **CC BY-SA** – Creative Commons, Open By Attribution, Share-Alike and Commercial use provided the by-products are shared under the same conditions as the original license

<sup>2</sup> **CC BY-NC-SA** – Creative Commons, By Attribution, Non-Commercial, Share-Alike

<sup>3</sup> **NDA** – Available for public-good, non-commercial use under a non-disclosure agreement (NDA)

More information at: <https://creativecommons.org/licenses/by-sa/4.0/> and <https://creativecommons.org/licenses/by-nc-sa/4.0/>.





## Application of Models and Global Datasets

The above models, maps and datasets may be used directly for a wide range of disaster risk reduction applications:

- hazard or risk identification and screening using the global and national hazard and risk maps;
- general insurance or building portfolio risk analysis using national risk models;
- calculation of losses at the country and provincial (Admin 1) levels using national risk models;
- "what if?" scenarios for anticipatory disaster planning using national risk models;
- scenario impact modelling for post-disaster response using national risk models; and
- baseline national risk assessment and benchmark against other risk models.

Models may also be used for a wide range of analyses by introducing modifications or improvements based on additional local information or DRR plans:

- cost-benefit of risk reduction activities such as building retrofit or land-use planning actions; and
- future risk trends based on population growth or planning scenarios.



## Application to the Sendai Seven indicators

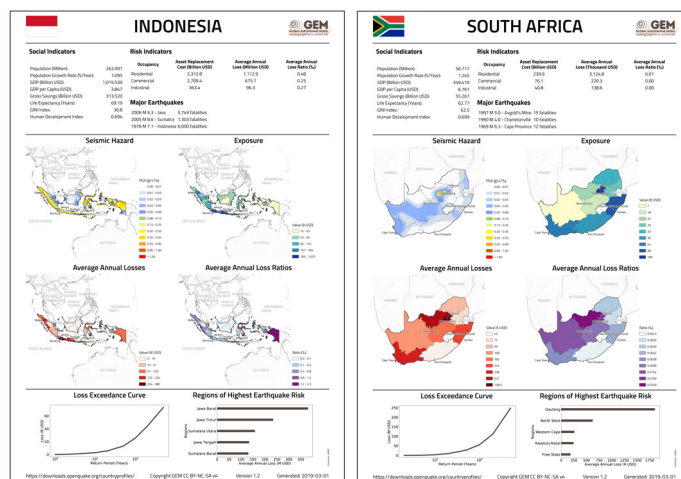
Below are some examples of how our resources can be utilized to address the Sendai Seven indicators.

### GLOBAL TARGETS A-E:

Reduced global disaster mortality, number of affected people, direct economic loss and disaster damage to critical infrastructure and disruption of basic services.

The GEM hazard and risk models included in this release can be used directly in the assessment of economic and human losses due to earthquakes. An additional set of hazard and risk models will be released in December 2020.

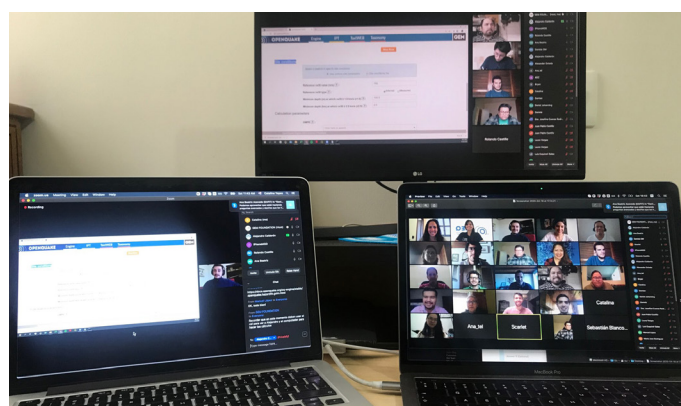
**Right:** Examples of country risk profile for Indonesia and South Africa developed by GEM. The profile consists of social and risk indicators including average annual losses and regions of highest seismic risk.



### APPLICATION TO OTHER GLOBAL TARGETS (F & G):

GEM offers training in the use of OpenQuake engine and the application of its products across academic, public and private sectors; and provides a wide variety of [other risk information products such as global hazard and risk maps and national risk profiles](#) to support sound disaster risk-reduction planning at various levels.

For more information, visit:  
<https://www.globalquakemodel.org> and  
<https://platform.openquake.org>



**Above:** In 2020, due to the pandemic, GEM has started to organize online training workshops in the use of OpenQuake engine. Under the [TREQ project](#), more than 100 individuals have been trained since May 2020.



## Let's work together

Partner with us and experience the benefits of GEM's comprehensive approach to seismic hazard and risk assessment including vulnerability, fragility and exposure modeling and pioneering efforts in social vulnerability and recovery. Download our brochure at: <https://bit.ly/33CdSsi>

For more detailed information on partnership options, visit: <https://www.globalquakemodel.org/get-involved> or contact [join@globalquakemodel.org](mailto:join@globalquakemodel.org).