GEM GLOBAL EARTHQUAKE MODEL

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Understanding Earthquake Risk

EARTHQUAKE MODELS

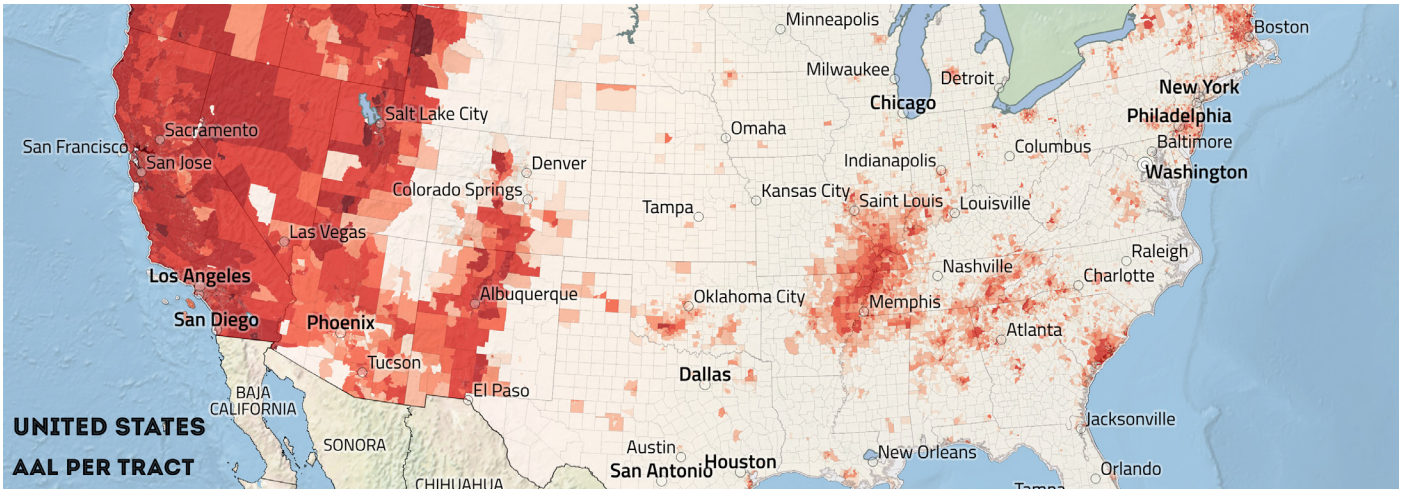
January 2021 Release

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 hazard and risk models for public-good, non-commercial use for Alaska, Canada, Hawaii, Japan, Korea, Mexico, Northeast Asia, Northwest Asia, South Pacific Islands, Philippines, California (based on UCERF3) and the rest of the conterminous United States. These models are released in a format compatible with the GEM's freely available OpenQuake Engine (https://www.globalquakemodel.org/oq-get-started). All of these products are available from GEM's Products page (https://www.globalquakemodel.org/products), with the majority of the models available by application for a free license for non-commercial, public-good use.

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. With the completion of this release, models and databases developed for the global model are now available openly or are available for non-commercial, public-good use upon request for all countries except Korea and China.



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 Canada, Japan, Mexico, New Zealand, Australia, the Philippines, and the United States.

For the seismic risk models, GEM developed the majority of the exposure and vulnerability models for the human population and for residential, commercial and industrial buildings in this release using only publicly available sources of information. 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 open 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.

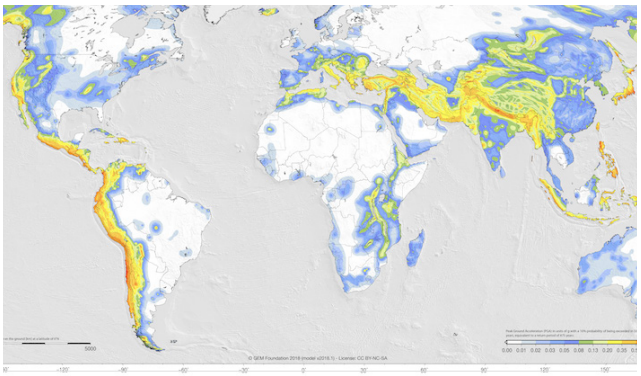
Overview of the models

Hazard

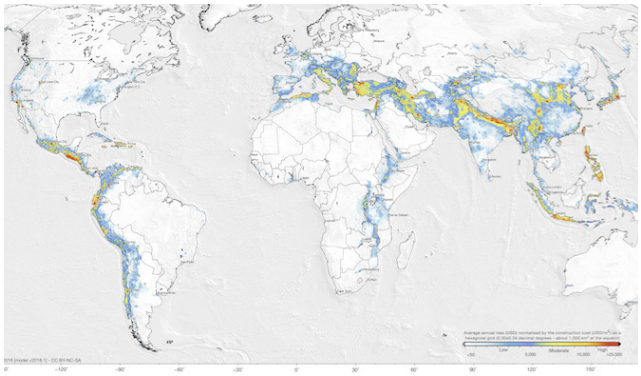
Using the OpenQuake Engine, the seismic hazard models for the countries and regions included in this release can be used to calculate the hazard due to ground shaking for any given return period in terms of peak ground acceleration and a range of spectral acceleration periods. They can also be used to 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.



Global Seismic Hazard map v.2018



Global Seismic Risk map v.2018

Local, National and Regional Models License Information

Model	License Information		
	Hazard	Exposure	Vulnerability
Alaska v2007.0.0	CC BY-SA[1]	***	CC BY-SA[1]
Canada v2015.1.1	CC BY-NC-SA[2]	Exposure data and license information to be available on NRCan's Federal Geospatial Platform soon for population, commercial, industrial and residential buildings.	Fragility and vulnerability functions developed by GEM and UBC Civil Engineering, to be published in an upcoming validation paper by NRCan.
Hawaii v1998.0.1	NDA[3] for public-good, non-commercial use	***	CC BY-SA[1]
Japan v2014.0.0	NDA[3] for public-good, non-commercial use	NDA[3] for public-good, non-commercial use	CC BY-SA[1]
Mexico v2018.0.0	NDA[3] for public-good, non-commercial use	NDA[3] for public-good, non-commercial use	CC BY-SA[1]
Northeast Asia v2018.0.0	NDA[3] for public-good, non-commercial use	NDA[3] for public-good, non-commercial use	CC BY-SA[1]
Northwest Asia v2018.0.0	NDA[3] for public-good, non-commercial use	NDA[3] for public-good, non-commercial use	CC BY-SA[1]
South Pacific Islands v2018.2.0	NDA[3] for public-good, non-commercial use	NDA[3] for public-good, non-commercial use	CC BY-SA[1]
Philippines v2018.1.1	CC BY-NC-SA[2]	CC BY-NC-SA[2]	CC BY-NC-SA[2]
California (UCERF3) v2014.0.0	NDA[3] for public-good, non-commercial use	***	CC BY-SA[1]
United States (Conterminous U.S.) v2014.1.0	NDA[3] for public-good, non-commercial use	***	CC BY-SA[1]

***The exposure data for Alaska, Hawaii, California and the United States can be found on the FEMA Hazus download page. Please note that the exposure data is not in the OpenQuake format and GEM will not provide support for its conversion. To obtain a license for the exposure data, please contact hazus-support@riskmapcds.com.

License Description

[1] **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; [2] **CC BY-NC-SA** – Creative Commons, By Attribution, Non-Commercial, Share-Alike; More information at: https://creativecommons.org/licenses/by-sa/4.0/ and https://creativecommons.org/licenses/by-nc-sa/4.0/. and [3] **NDA** – Available by application to GEM for public-good, non-commercial use under a license including non-disclosure agreement (NDA). For more information, go to https://www.globalquakemodel.org/products.

List of Local, National and Regional Models

Alaska
The 2007 seismic hazard model for Alaska (USA) was developed by the United States Geological Survey (USGS; Wesson et al., 2007). The model covers the state of Alaska including the Aleutian Islands. The model has been translated from its original format into the OpenQuake engine by GEM. The exposure data was originally developed by the U.S. Federal Emergency Management Agency's HAZUS program and has been translated to the OpenQuake engine format by GEM. The exposure model uses the 2010 U.S. Census for residential buildings (U.S. Bureau of the Census, 2010), Dun & Bradstreet (2006) for nonresidential buildings, and R.S. Means (2014) for all building replacement costs. Exposure data is available through FEMA's Hazus program at the census tract level for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes.

Canada
The Global Hazard Mosaic coverage of Canada uses Canada's 5th Generation Seismic Hazard Model (Halchuk et al., 2015), produced by Natural Resources Canada (NRCan), in order to develop the 2015 National Building Code of Canada. The model was originally developed for GSCFRISK software, and was subsequently converted into the OpenQuake engine format by NRCan. Small, additional adjustments were made by the GEM Secretariat in order to fit the mosaic criteria. The exposure data was developed by NRCan. Exposure data to be available on NRCan's Federal Geospatial Platform soon for population, commercial, industrial and residential buildings. Fragility and vulnerability functions developed by GEM and UBC Civil Engineering, to be published in an upcoming validation paper by NRCan.

Hawaii
The Global Hazard Mosaic coverage of Hawaii is based on the 1998 USGS model by Klein et al., (2001). The GEM implementation relies on the best judgement of the Secretariat in converting the documented model into the OpenQuake engine format from the NSHMP input files provided by the USGS. The exposure data was originally developed by the U.S. Federal Emergency Management Agency's HAZUS program and has been translated to the OpenQuake engine format by GEM. The exposure model uses the 2010 U.S. Census for residential buildings (U.S. Bureau of the Census, 2010), Dun & Bradstreet (2006) for nonresidential buildings, and R.S. Means (2014) for all building replacement costs. Exposure data is available through FEMA's Hazus program at the census tract level for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes.

Japan
The Global Hazard Mosaic coverage of Japan is based on the 2014 seismic hazard model issued by the Headquarters for Earthquake Research Promotion (HERP). The model is described by Fujiwara et al. (2009) and Fujiwara et al. (2015). The model has been translated from its original format into the OpenQuake engine within a collaboration between the National Research Institute for Earth Science and Disaster Resilience (NIED), Japan, and GEM. Exposure data is available for Admin level 1 for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes.

Mexico
The model covering Mexico (MEX) was developed by the GEM hazard team within a project funded by Suramericana (Sura). The model was originally implemented in 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.

Northeast Asia
The Northeast Asia (NEA) hazard model was developed internally by GEM. The active shallow part of the model is based on the combination of distributed sources and active faults, the latter obtained from the Global Active Fault Database of GEM, applying rate redistribution to better represent the spatial variability of seismicity. Exposure data is available for Admin level 1 for population and residential buildings. Vulnerability curves are available for all building classes.

Northwest Asia
The Northwest Asia (NWA) hazard model was developed internally by GEM in collaboration with the Swiss Seismological Service (SED), Swiss Federal Institute of Technology (ETH), Switzerland. The model is based on a distributed seismicity approach, using rate redistribution to better represent the spatial variability of seismicity. Exposure data is available for Admin level 1 for population and residential buildings. Vulnerability curves are available for all building classes.

South Pacific Islands
The South Pacific Islands model covers islands in the area of ~30-0° S and 150-200° E, including the Solomon Islands, Vanuatu, New Caledonia, Fiji, Samoa, American Samoa, and Tonga. The model was built for the OpenQuake engine by the GEM Secretariat. Exposure data is available for Admin level 1 for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes.

Philippines
The model covering the Philippines was developed jointly by the Philippine Institute of Volcanology and Seismology (PHIVOLCS) and GEM in the OpenQuake engine format. Exposure data is available for Admin level 1 for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes.

California (UCERF3)
The Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3) is a model of earthquake occurrence for California developed by the USGS and the Working Group on California Earthquake Probabilities (WGCEP). The time-independent version of UCERF3 (Field et al., 2013; 2014) has been used for the 2014 update of the USGS National Seismic Hazard Maps (Petersen et al., 2014). The model has been translated from its original format into the OpenQuake engine by GEM. The exposure data was originally developed by the U.S. Federal Emergency Management Agency's HAZUS program and has been translated to the OpenQuake engine format by GEM. The exposure model uses the 2010 U.S. Census for residential buildings (U.S. Bureau of the Census, 2010), Dun & Bradstreet (2006) for nonresidential buildings, and R.S. Means (2014) for all building replacement costs. Exposure data is available through FEMA's Hazus program at the census tract level for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes.

United States (Conterminous U.S.)
The 2014 United States National Seismic Hazard Model (Petersen et al., 2014), covers the conterminous United States and was developed by the USGS within the National Seismic Hazard Model Project (NSHMP). The model has been translated from its original format into the OpenQuake engine by GEM. The exposure data was originally developed by the U.S. Federal Emergency Management Agency's HAZUS program and has been translated to the OpenQuake engine format by GEM. The exposure model uses the 2010 U.S. Census for residential buildings (U.S. Bureau of the Census, 2010), Dun & Bradstreet (2006) for nonresidential buildings, and R.S. Means (2014) for all building replacement costs. Exposure data is available through FEMA's Hazus program at the census tract level for population, commercial, industrial and residential buildings. Vulnerability curves are available for all building classes.

The OpenQuake Engine Environment
The OpenQuake Engine 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. It is freely available for public use with no commercial restrictions under AGPL.

Application of Models and Global Datasets

The above models 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

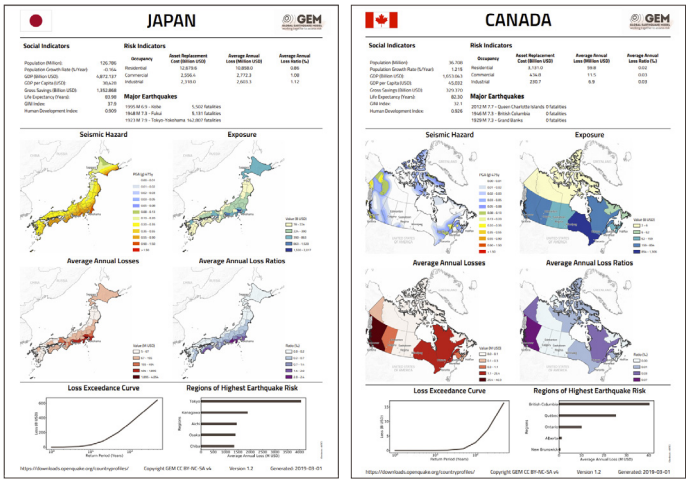
Below are some examples of how our resources can be utilized to address the Sendai Seven indicators.

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.

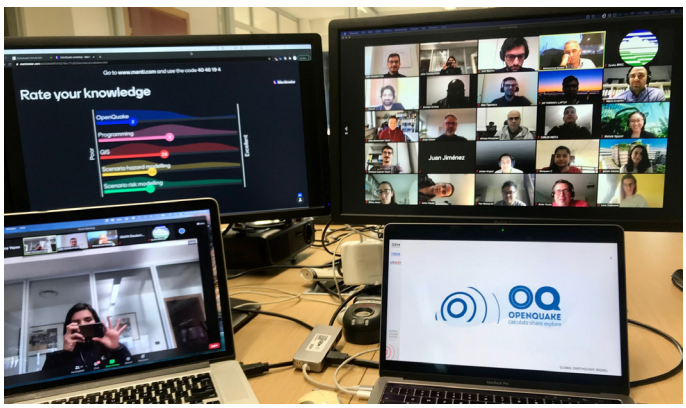
Right: Examples of country risk profile for Japan and Canada developed by GEM. The profile consists of social and risk indicators including average annual losses and regions of highest seismic risk.



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 300 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 the GEM 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.