



## PSHA input model documentation for Canada (CAN)

GEM Hazard Team

## Version history

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

Version	2018.1	2019.1	2022.1	2023.1	Changelog
v2015.0.0	X				First version of the model implemented in OpenQuake.
v2015.0.1					Weights in the gmmLT were corrected to correspond with the original NBCC2015. The GMPE assigned to TRT="Subduction Intraslab50" was corrected (it was formerly using the interface GMPEs)
v2015.1.0					A source that was missing from the hybrid model of the south-east quadrant was added. The integration distance for subduction sources was changed to 800 km. The GMPEs were changed to use a new method provided by NRC, in which the GM table for vs30=450 m/s is corrected for the site condition using a site term. The weights of the gmmLT were again changed at the direction of NRC.
v2015.1.1		X	X		Additional geometries of the Cascadia interface were added.
v2023.0.0				X	Latest Seismic hazard model for Canada as will be released by NR-Can (CanadaSHM6-N)

The following text describes v2023.0.0.

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## 1 Summary

The Global Hazard Mosaic coverage of Canada uses Canada's 6th Generation Seismic Hazard Model (*Kolaj et al., 2019 and Kolaj et al., 2020*), produced by Natural Resources Canada (NRC), in order to develop the 2020 National Building Code of Canada. The model was originally for the [OpenQuake \(OQ\) engine](#).

## 2 Tectonic overview

Canada is, overall, tectonically stable, though tectonic activity does exist at the western margin. Here, the Pacific plate translates northward relative to the North American plate. This relative plate motion is, for the most part, parallel to the plate margin and the Queen Charlotte Transform, the major plate-boundary fault. The Queen Charlotte Transform produces quite a bit of seismicity, but the earthquakes are dominantly strike-slip and quite a ways offshore of the sparsely-populated mainland. The northwestern and southwestern margins are a bit different, however. In the north, the plate margin bends to the west, which induces a large convergent component to the relative plate motion, and deformation includes both strike-slip and reverse faults that are distributed throughout the western Yukon Territory. In the south, subduction of the Juan De Fuca plate occurs off Vancouver Island in the northern reaches of the Cascadia Trench. Very recently, paleoseismic evidence of sparse upper-plate seismicity has been found in southern British Columbia (e.g., *Morell et al., 2017, GSA Today*).

## 3 Basic Datasets

Please refer to *Halchuck et al. (2014)*, *Kolaj et al. (2019)* and *Kolaj et al., (2020)*.

## 4 Hazard Model

### 4.1 Seismic Source Characterisation

The input model includes three OpenQuake source typologies:

- seismicity modelled as **area sources** based on the historical distribution of earthquakes, regional seismotectonics, or a hybrid of these
- onshore **simple fault sources** in northwestern Canada and Alaska
- subduction thrusts and other faulting offshore Canada's west coast, modelled as **complex** and **simple fault sources**

The seismic source characterisation is mostly consistent with that of the 5th generation model, but with increased rates of seismicity on the Cascadia subduction interface, subdivision of the in-slab seismicity in X-Cascadia, and the addition of two fault sources in south-west British Columbia.

The source model is subdivided geographically to represent each quadrant of Canada. The western two quadrants use a single area source model and both typologies of faults. In the northeastern quadrant, historical and regional area source models are weighted at 0.6 and 0.4, respectively. In the southeastern quadrant, historical, regional, and hybrid models are weighted at 0.4, 0.4, and 0.2.

Epistemic uncertainty of the model parameters (downdip extent of the Cascadian subduction zone, maximum magnitude, etc.) is accounted for by a complex logic tree (see *Halchuck et al., 2015*), which has been collapsed into a single source model.

## 4.2 Ground Motion Characterisation

<b>Subduction IntraSlab55</b>	<b>Weight</b>
<a href="#">CanadaSHM6_InSlab_AbrahamsonEtAl2015SSlab55</a>	0.25
<a href="#">CanadaSHM6_InSlab_AtkinsonBoore2003SSlabCascadia55</a>	0.25
<a href="#">CanadaSHM6_InSlab_GarciaEtAl2005SSlab55</a>	0.25
<a href="#">CanadaSHM6_InSlab_ZhaoEtAl2006SSlabCascadia55</a>	0.25
<b>Subduction IntraSlab30</b>	<b>Weight</b>
<a href="#">CanadaSHM6_InSlab_AbrahamsonEtAl2015SSlab30</a>	0.25
<a href="#">CanadaSHM6_InSlab_AtkinsonBoore2003SSlabCascadia30</a>	0.25
<a href="#">CanadaSHM6_InSlab_GarciaEtAl2005SSlab30</a>	0.25
<a href="#">CanadaSHM6_InSlab_ZhaoEtAl2006SSlabCascadia30</a>	0.25
<b>Subduction Interface</b>	<b>Weight</b>
<a href="#">CanadaSHM6_Interface_AbrahamsonEtAl2015SInter</a>	0.25
<a href="#">CanadaSHM6_Interface_AtkinsonMacias2009</a>	0.25
<a href="#">CanadaSHM6_Interface_GhofraniAtkinson2014Cascadia</a>	0.25
<a href="#">CanadaSHM6_Interface_ZhaoEtAl2006SInterCascadia</a>	0.25
<b>Active Shallow Crust</b>	<b>Weight</b>
<a href="#">CanadaSHM6_ActiveCrust_AbrahamsonEtAl2014</a>	0.25
<a href="#">CanadaSHM6_ActiveCrust_BooreEtAl2014</a>	0.25
<a href="#">CanadaSHM6_ActiveCrust_CampbellBozorgnia2014</a>	0.25
<a href="#">CanadaSHM6_ActiveCrust_ChiouYoungs2014</a>	0.25
<b>Stable Shallow Crust</b>	<b>Weight</b>
<a href="#">CanadaSHM6_StableCrust_NGAEast</a>	0.0757
<a href="#">CanadaSHM6_StableCrust_NGAEast</a>	0.0757
<a href="#">CanadaSHM6_StableCrust_NGAEast</a>	0.0757
<a href="#">CanadaSHM6_StableCrust_NGAEast</a>	0.0757
<a href="#">CanadaSHM6_StableCrust_NGAEast</a>	0.0757
<a href="#">CanadaSHM6_StableCrust_NGAEast</a>	0.0757

CanadaSHM6_StableCrust_NGAEast	0.0757
CanadaSHM6_StableCrust_NGAEast	0.0757
CanadaSHM6_StableCrust_NGAEast	0.0757
CanadaSHM6_StableCrust_NGAEast	0.0757
CanadaSHM6_StableCrust_NGAEast	0.0757
CanadaSHM6_StableCrust_NGAEast	0.0757
CanadaSHM6_StableCrust_NGAEast	0.0757
CanadaSHM6_StableCrust_AA13	0.0646
CanadaSHM6_StableCrust_AA13	0.0646
CanadaSHM6_StableCrust_AA13	0.0646

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

## 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 0.2s, 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: Ottawa, Edmonton, Victoria, Winnipeg and Saint-Pierre. 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](#).

## 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

Halchuk S, Allen T.I., Adams J, and Rogers G.C. (2014). Fifth generation seismic hazard model input files as proposed to produce values for the 2015 National Building Code of Canada. Geological Survey of Canada, Open File 7576. Natural Resources Canada, Ottawa, Ont.

Kolaj M, Allen T, Mayfield R, Adams J and Halchuk S (2019). Ground-motion models for the 6th Generation Seismic Hazard Model of Canada. In 12th Canadian Conference on Earthquake Engineering.

Kolaj M, Halchuk S and Adams J (2020) Sixth generation seismic hazard model of Canada: Final input files used to generate the 2020 National Building Code of Canada seismic hazard values. Geol. Surv. Canada Open-File 8630.

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