The 2005 Canada National Seismic Hazard Model

The 2005 Canada national seismic hazard model is described in detail by Adams and Halchuck (2003) and Halchuck and Adams (2008). We report here a description of the OpenQuake-engine implementation of the model.

The Seismic Source Model

The full probabilistic seismic hazard model is intended to be used as a “robust” model, one in which the hazard at each site is taken as the greatest value of the ground motions defined by several different models. These models are:

- The **Historical** Model (H): Uses relatively small source zones drawn around historical seismicity clusters
- The **Regional** Model (R): Uses larger uniform regional zones, reflecting the wider seismotectonic units
- The **Cascadia (Deterministic)** Model (C): A deterministic model based on the expected ground motions from a M_w 8.2 earthquake on the Cascadia subduction interface. Due to the expected probabilities of recurrence of such an event (typically on the order of 400 to 600 years), the median ground motion from the scenario earthquake is assumed approximately equivalent to the 5 % probability of exceedance in 50 years, whilst the median plus 1 standard deviation is assumed notionall equivalent to the 2 % probability of exceedance in 50 years.
- The **Stable Floor** Model (F): A simple area source model intended to represent the lowest level of ground motion hazard for the stable intraplate regions of Canada.

The H and R models are themselves separated into two different models: East (covering the Eastern and Central Canada) and West (covering Western Canada and the Rocky Mountains). The “robust” model for each site is therefore constructed by taking, for each ground motion intensity measure, the maximum of the four (H, R, C and F) models within each of the two (Eastern and Western) regions. To ensure continuity at the frontier between East and West, the larger of the two respective models is preferred at the site. Both the **Historical** and **Regional** models are composed of area sources, with the only exception of the Queen Charlotte fault (in western Canada) treated as a fault source.

A more complete implementation of the stable floor model is currently in preparation, but in the meantime users of the model are advised to use those values of the stable floor model provivided by Geological Survey of Canada (Table 4 of OF4459):

All values are reported in (g)

	PGA	**Sa (0.1)**	**Sa (0.15)**	**Sa (0.2)**	**Sa (0.3)**	**Sa (0.4)**	**Sa(0.5)**	**Sa (1.0)**	**Sa (2.0)**
2 % PoE in 50 years	0.059	0.087	0.110	0.120	0.082	0.064	0.056	0.023	0.006
10 % PoE in 50 years	0.021	0.031	0.040	0.044	0.033	0.024	0.024	0.009	0.002

Earthquake ruptures associated with area sources are assumed to have no spatial extension (that is

point ruptures), while earthquakes on the fault follows a magnitude-length scaling relationship. Area sources are defined as NRML areaSource while the Queen Charlotte fault as NRML simpleFaultSource.

Occurrence rates in each source are defined through a double-truncated Gutenberg-Richter distribution, with minimum magnitude equal to 4.75. Epistemic uncertainties in the magnitude-frequency distribution are captured by the definition for each source of three possible (aGR, bGR) pairs and three possible maximum magnitudes. Each source is also associated to three possible hypocentral depths.

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

Total Occurrence Rate
(number of events > Mmin / 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

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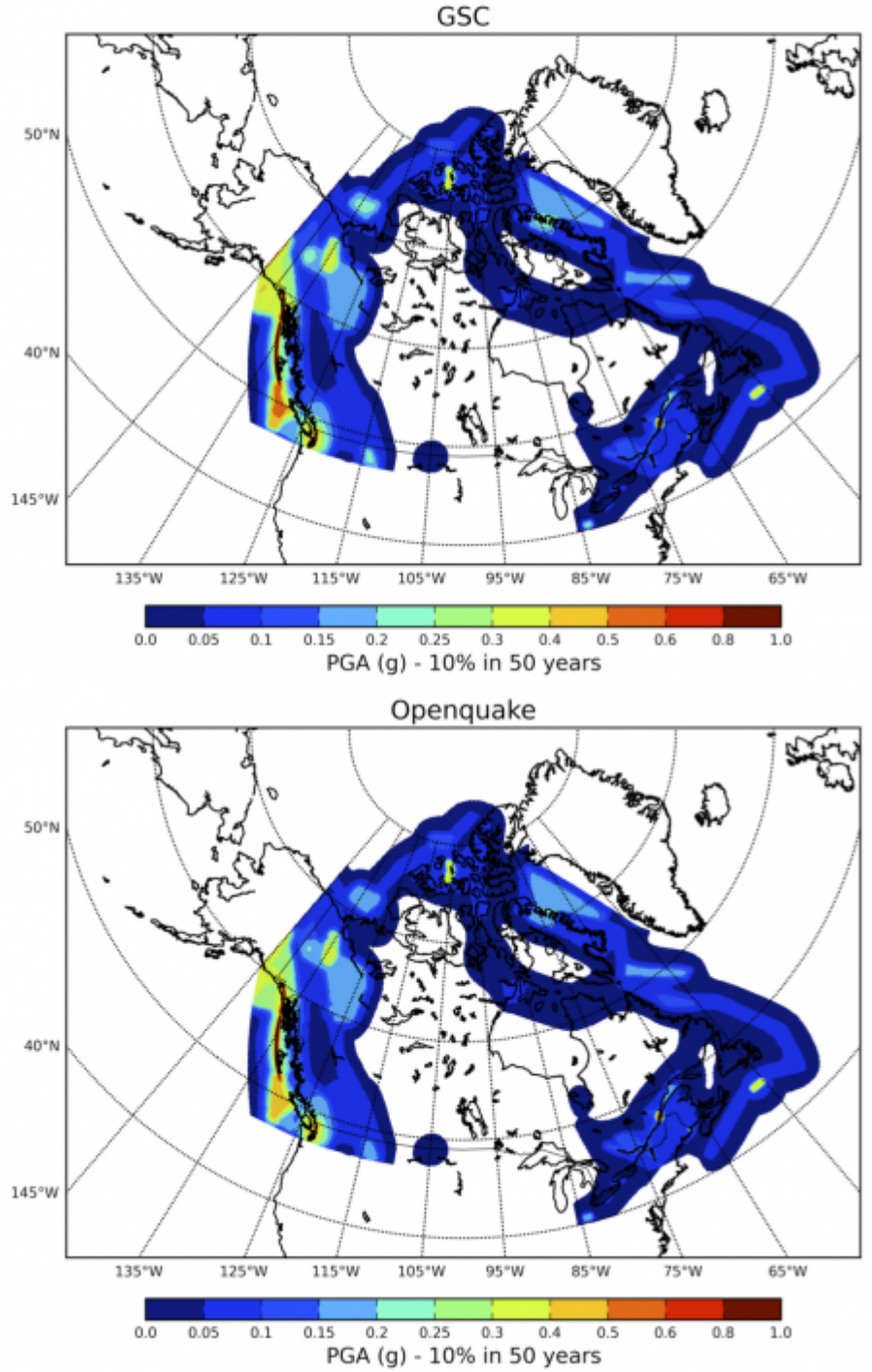
The Ground Motion Model

The ground motion model distinguishes between eastern and western Canada because of the different properties in the crust. For eastern and central Canada the GMPE model of Atkinson and Boore 1995 is used. For western Canada the model of Boore et. al. 1993 is used for shallow crustal sources, while for deep intraslab sources the model of Youngs et. al. 1997 is adopted. Epistemic uncertainties are included by defining, for each GMPE, a pair of parallel alternative relations, with higher and lower mean values.

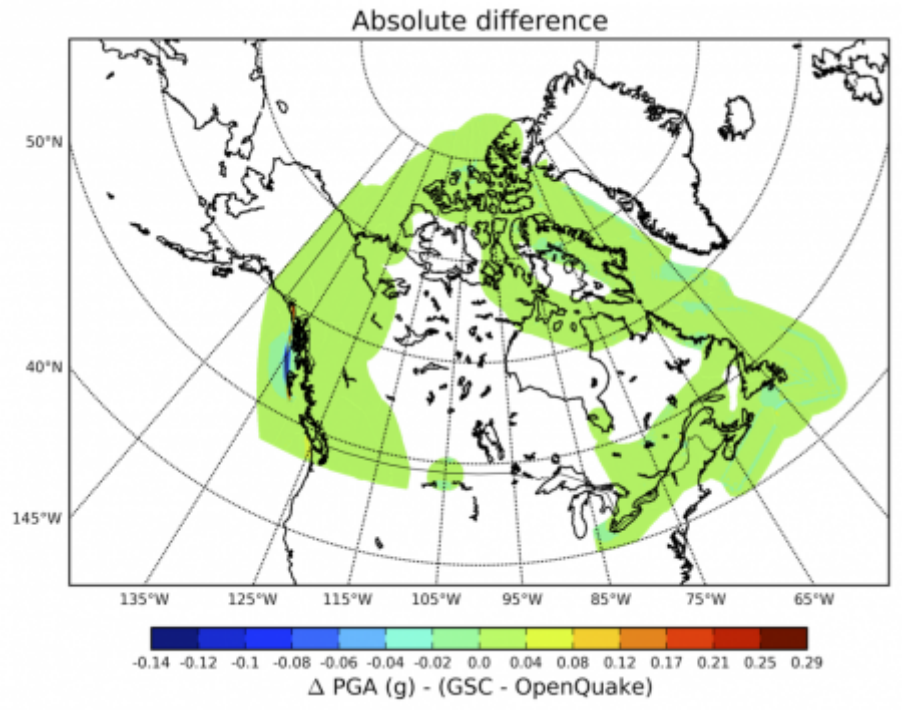
Hazard Results

Comparison against GSC Canada hazard maps

The figures below show hazard map values for peak ground acceleration (for 10% in 50 years probability of exceedance) as computed by GSC and by the OpenQuake-engine.



The absolute difference map is shown in the figure below. The largest differences are associated with the Queen Charlotte fault. This is due to the different scaling relationship used in the OpenQuake-engine implementation with respect to the one used by GSC.



References

- Adams, J. and Halchuck, S. (2003) Fourth generation seismic hazard maps of Canada: Values for over 650 Canadian localities intended for the 2005 National Building Code of Canada. Canada Geological Survey. Open File 4459. Report
- Dragert, H., R. D. Hyndman, G. C. Rogers, and K. Wang, Current deformation and the width of the seismogenic zone of the northern Cascadia subduction thrust, J. Geophys. Res., 99, 653–668, 1994 Journal Article
- Halchuk, S. and Adams, J. (2008) Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2005 National Building Code of Canada. Canada Geological Survey. Open File 5813 Report
- Hyndman, R.D., and K. Wang, Thermal constraints on the zone of possible major thrust earthquake failure on the Cascadia margin, J. Geophys. Res., 98, 2039–2060, 1993. 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	2005 model used SHEEF catalogue up to 1991
1.2	Geological database	Not available. Information for Cascadia comes from Hyndman and Wang (1993) and Dragert et al. (1994)
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	Adams and Halchuk (2003)
2.3	Codes used for model preparation	Not available
Notes		
3	**PSHA input model**	
3.1	**Seismic Source Model**	
3.1.1	Area sources	historical (H), regional (R), floor (F) & Cascadia (C)
3.1.2	Grid sources	Not included
3.1.3	Crustal faults	Queen Charlotte fault
3.1.4	Subduction faults	Cascadia (modelled deterministically)
3.1.5	Non-parametric ruptures	Not included
3.1.6	Magnitude-area scaling relationships	Not explicitly defined in defined in Adams and Halchuk (2003)
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
3.2.3	Models for subduction intraslab	Included
3.2.4	Models for stable continental regions	Included
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, The class C site condition (Vs30 between 360-750m/s) is assumed to be the reference site conditions for the hazard model.
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 by defining parallel alternative relations, with higher and lower mean values. See page 13 of Adams and Halchuk (2003)
3.4.3	Site Response Model	Not included
Notes		
4	**Hazard Input Description**	
4.1	Hazard input document	Not available
4.2	Input files	Examples in Appendix D of Adams and Halchuk (2003)
Notes		
5	**Calculation**	
5.1	Software	GSCFRISK (a customized version of FRISK88)
5.2	**Results**	

5.2.1	Hazard curves	Not available (hazard values included in supplement files of Halchuk, S. and Adams, J., 2008)
5.2.2	Hazard maps	Available
5.2.3	Uniform hazard spectra	Available
5.2.4	Disaggregation	Not available
5.2.5	Stochastic event sets	Not available
5.2.6	Ground motion fields	Not available
Notes	Results can be accessed interactively from the hazard section of the Earthquakes Canada website	

Download The OpenQuake-engine Input Model

The OpenQuake-engine input model (NRML format) can be downloaded at the link provided below - Please read the license and disclaimer attached to the model.

N.B. This is a model adapted by GEM Hazard team to the OpenQuake-engine from the original model developed by the Geological Survey of Canada. This explains minor differences you might encounter between the results presented in the OpenQuake platform and those disseminated by the original Organisation.

The model will be available in the first semester of 2015.