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

To capture epistemic uncertainties in the seismic source definiton, two complete seismic source models are defined: the historical (H) and regional (R) models. The historical model uses relatively small source zones drawn around historical seismicity clusters, while the regional model defines larger, regional zones reflecting seismotectonic units. Both models are composed of area sources, with the only exception of the Queen Charlotte fault (in western Canada) treated as a fault source. The model also prescribes a floor model (F) for the relatively aseismic central part of Canada and a deterministic model for the Cascadia subdution zone (C). Currently, only the H and R models are implemented in the OpenQuake-engine.

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

.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; }

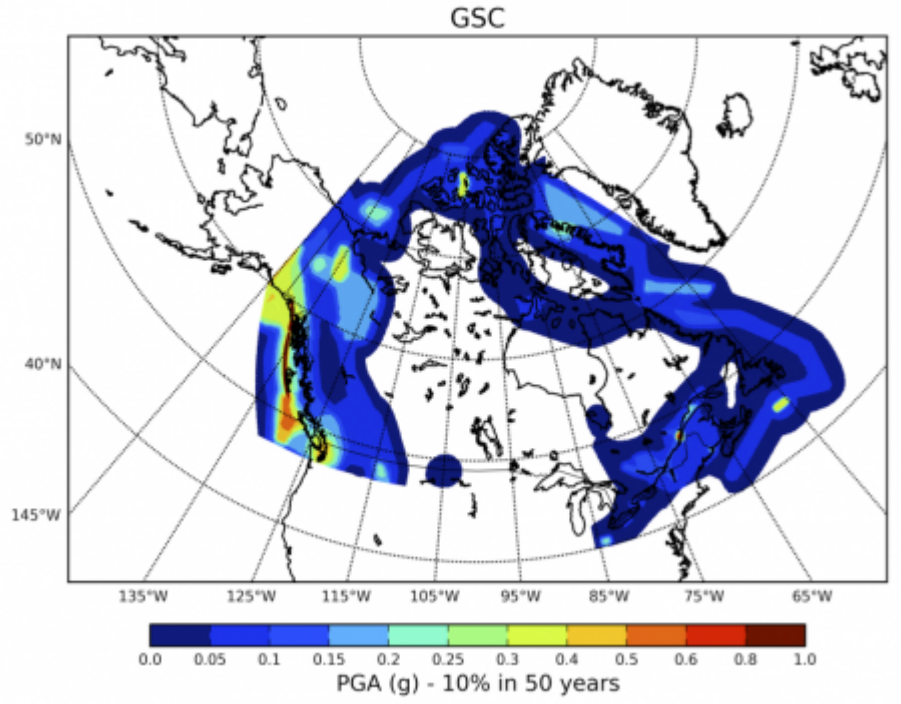
The ground motion model

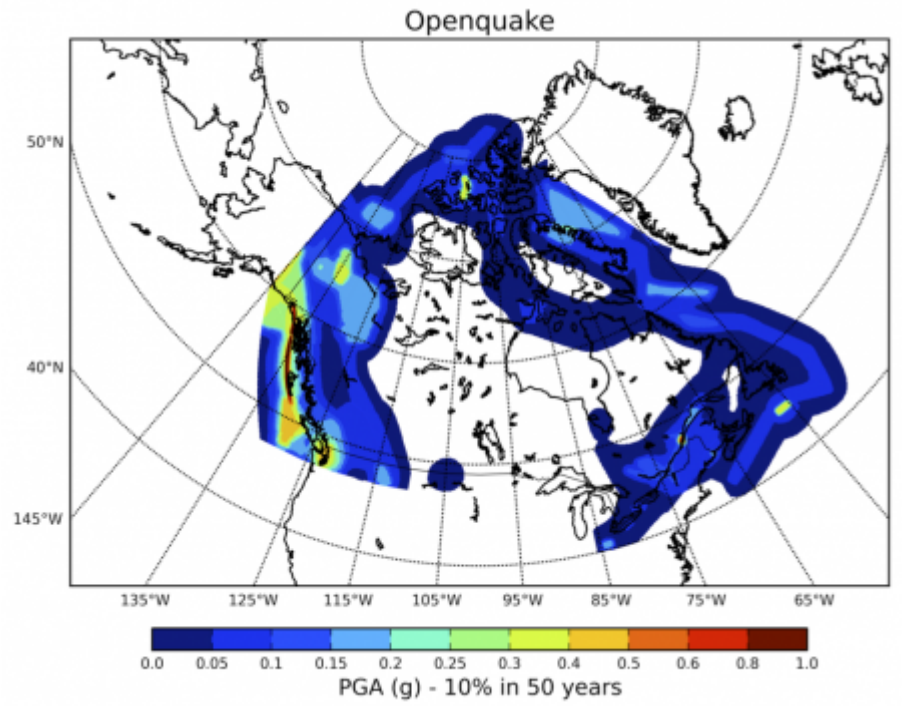
The ground motion model distinguishes between eastern and western Canada because of the different properties in the crust. For eastern and central Canada the GMPE model of Atkinson and Boore 1995 is used. For western Canada the model of Boore et. al. 1993 is used for shallow crustal sources, while for 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

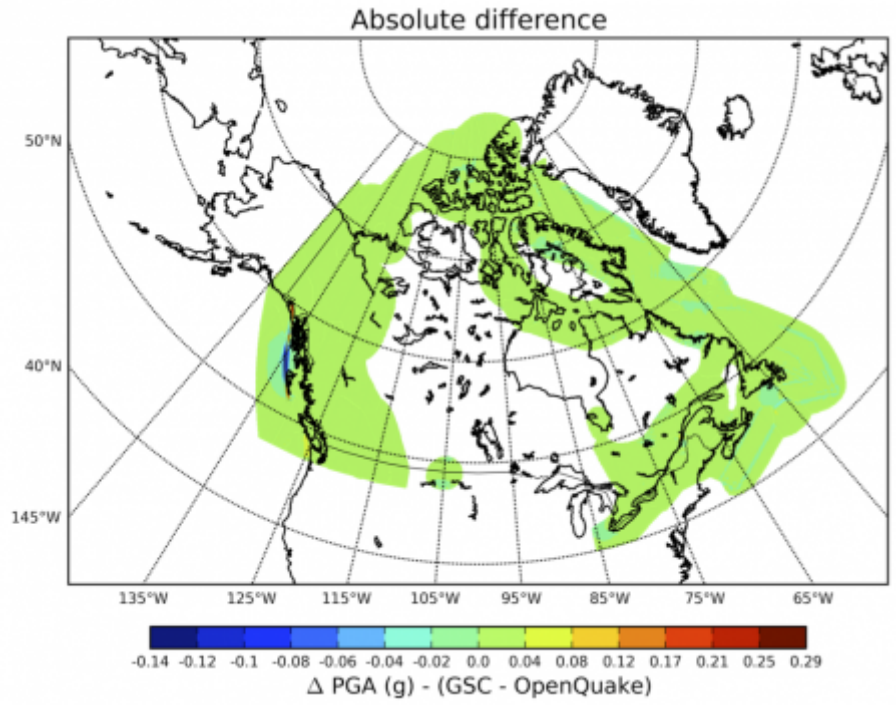
Comparison against GSC Canada hazard maps

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	