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GEOLOGICAL SURVEY OF CANADA
OPEN FILE 8924

Sixth-generation seismic hazard model of Canada: final input files used to generate the 2020 National Building Code of Canada seismic hazard values

Version 1.0

M. Kolaj, S. Halchuk, and J. Adams

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Canada

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Publications in this series have not been edited; they are released as submitted by the author.

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1. ABSTRACT

The enclosed files provide OpenQuake compatible input files to reproduce the 6th Generation Seismic Hazard Model of Canada (CanadaSHM6) as used to produce the seismic hazard values for the 2020 edition of the National Building Code of Canada (NBCC 2020). Example hazard values at selected localities are included, in order for other users to verify that the model has been implemented as we intended. This report contains minimal technical information on CanadaSHM6; complete documentation will be released as a separate Open File. This report supersedes Open File 8630, and the values derived from the model and the online seismic hazard tool described herein supersede the trial values provided in Open File 8629.

2. INTRODUCTION

This Open File contains the necessary information required to reproduce seismic hazard values using the 6th Generation Seismic Hazard Model of Canada (CanadaSHM6) as implemented for the 2020 edition of the National Building Code of Canada[a] (NBCC 2020). This report supersedes Open File 8630 (Kolaj et al., 2020d), and the values derived from the model and the online seismic hazard tool described herein supersede the trial values provided in Open File 8629 (Kolaj et al., 2020a).

The CanadaSHM6 seismic hazard values were calculated with v3.3[b] of the OpenQuake engine (Pagani, et al., 2014; Global Earthquake Model, GEM, 2019). Although subsequent OpenQuake versions have been released (current version is v3.12 as of March 2022), the version used for NBCC 2020 was frozen to ensure consistency during the approval and release phases. The enclosed model files are thus provided largely in formats consistent with those required by OpenQuake. The files included in the electronic supplement to this Open File are the NBCC 2020 version of CanadaSHM6:

- source models in the 'Natural hazard' Risk Mark-up Language (NRML; GEM, 2019), a type of XML,
- summary of the seismic source models (SSMs) in comma separated values (CSV) file formats,
- lists of sites and a summary of selected hazard values in CSV format
- logic trees for the sources and Ground Motion Models (GMMs) in NRML-XML format, and
- example job-description initialization (INI) files consistent with OpenQuake v3.3.

An overview of the directory structure of the electronic supplement to this archive, noting relevant sections within this report, is shown in Figure 1. Files and folders in the supplement are referred to in sans-serif font, for example, the root folder is CanadaSHM6_NBCC2020. References to OpenQuake functions and classes use a `monospace` font.

This Open File contains minimal technical information on the scientific justifications of the model. Interested readers are referred to Adams et al. (2019), Kolaj et al. (2019), Halchuk et al. (2019) and Kolaj et al. (2020b) for further information.

Note that this Open File does not include the other, non-NBCC versions of the model (e.g., non-collapsed model) that will be released as a subsequent series of Open Files. In general, when referring

[a] The NBCC 2020 was officially released on March 28th 2022.

[b] Results in this Open File (and for CanadaSHM6 and NBCC 2020) were generated using v3.3.2 of OpenQuake. Hazard values generated using other versions of OpenQuake or using different hazard software may differ. In these cases, special attention should be taken to ensure that the model is both implemented correctly and produces values consistent with those included in the electronic appendix (additional sites for com`parison may also be required).

to CanadaSHM6, we are either referring to the 6th Generation national seismic hazard mapping project as a whole, or are referencing the version which forms the basis of NBCC 2020.

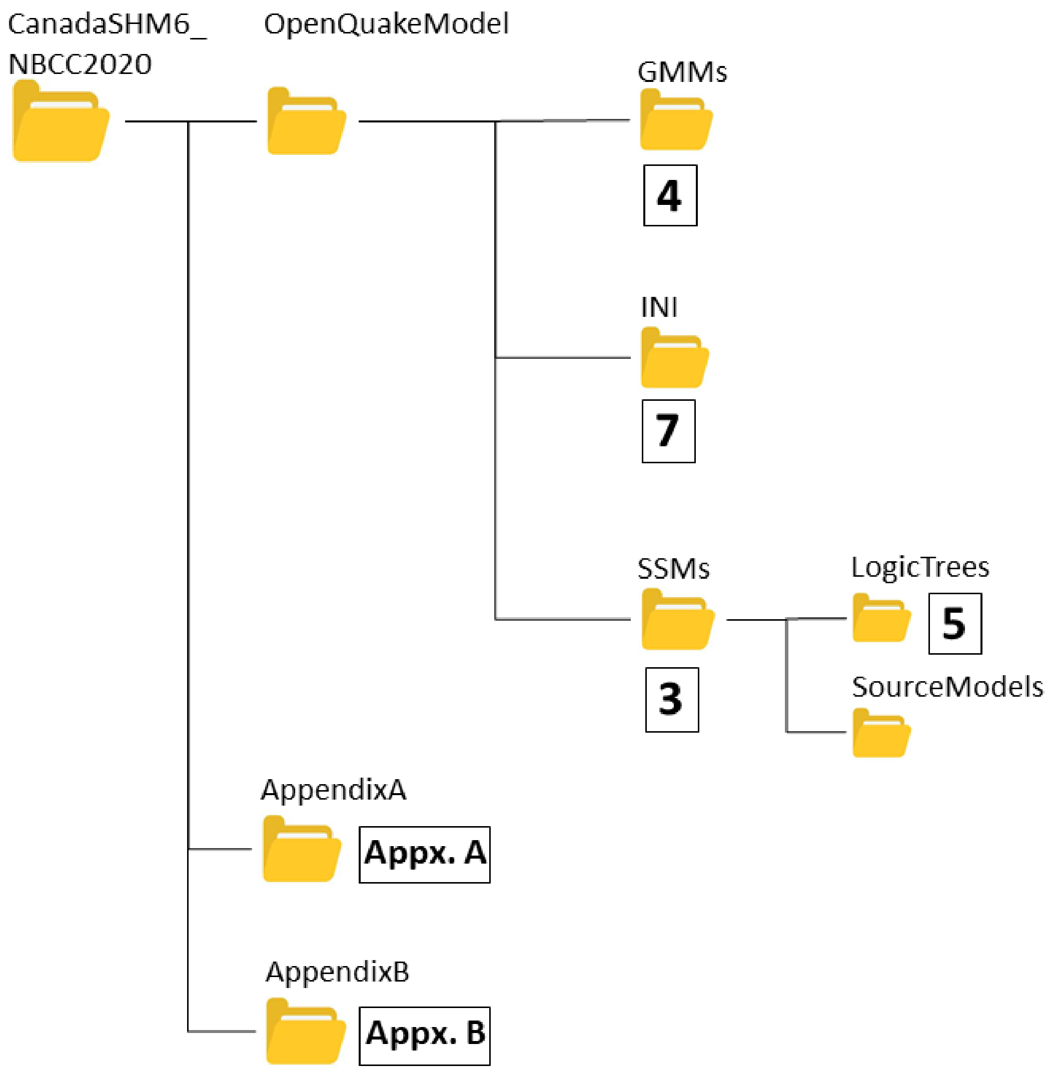

Figure 1. Directory structure of enclosed files. Numbers and letters refer to relevant sections in this Open File.

3. SOURCE MODELS

The NBCC 2020 - CanadaSHM6 model is comprised of three separate regional models (Figure 2). The subdivision of the national model into three components was necessary to account for different numbers of weighted sub-models in each region. Sub-models within each regional model are used to represent the epistemic uncertainty in the characterization of the sources. The three regional models and their individual sub-models are (see also Adams et al., 2019, Kolaj et al., 2020c):

- The western model comprised of a single sub-model, weighted at 1.0;
- The east arctic model comprised of two sub-models: Historical (H2) weighted at 0.6 and Regional (R2) weighted at 0.4;

- The eastern model comprised of three sub-models: H2 weighted at 0.4, Hybrid (HY) weighted at 0.4 and R2 weighted at 0.2.

In CanadaSHM6, the hazard for a site in the boundary region of the sub-models is taken as the larger hazard calculated from each of the two adjacent sub-models (overlap regions in Figure 2). For most sites, the boundaries have been placed in low-hazard regions and the difference in hazard values between the adjacent sub-models are not significant. A national version of the model without regional partitioning will be released in a subsequent publication.

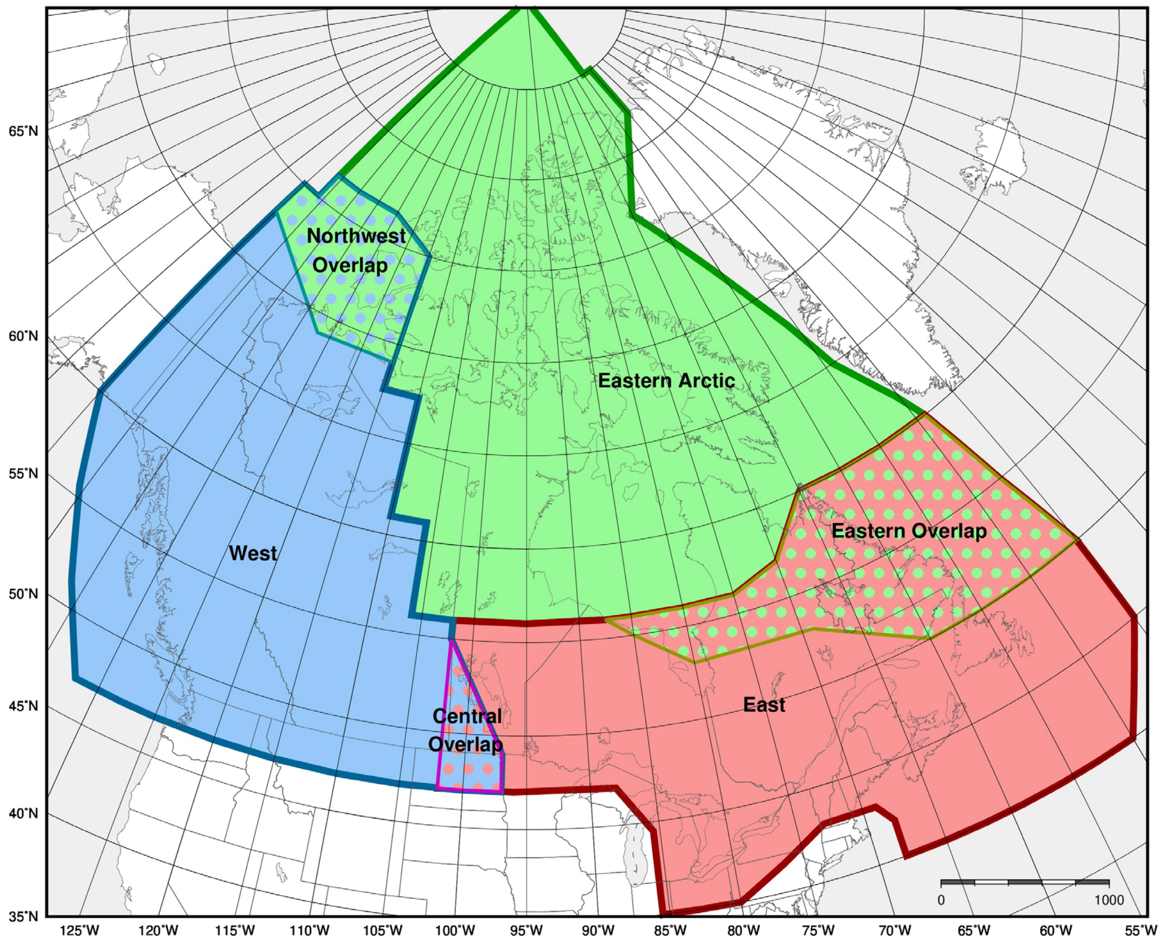

Figure 2. Three regional models used to calculate hazard in the final version of CanadaSHM6. In the central, eastern and northwest overlap zones, the larger hazard of the adjacent models is used.

The model parameters for all sources are provided in OpenQuake NRML-XML format in CanadaSHM6_NBCC2020\OpenQuakeModel\SSMs\SourceModels\ (note that these are the simplified source models, see Section 6), and summarized as tables in CanadaSHM6_NBCC2020\AppendixA (see Appendix A). The NRML-XML file should be taken as the authoritative document for the source information.

Earthquake rates are mostly described in terms of a truncated Gutenberg-Richter (GR) magnitude-frequency distribution. Prior to CanadaSHM6, the rates were described as cumulative rates according to Weichert (1980):

$$N(m) = N_0 e^{-\beta m}\left[1 - e^{-\beta(M_{\max}-m)}\right] \quad (1)$$

where N is the cumulative number of earthquakes greater than magnitude m, N_0 is the number of earthquakes per year with magnitude greater than or equal to 0, M_{max} is the maximum magnitude considered, and β is a constant that describes the relative number of small to large earthquakes. Herein, the magnitude values for m and M_{max} are measured on the moment magnitude scale, M_W.

In the enclosed OpenQuake files and for CanadaSHM6, the rates are implemented as discretized incremental frequency distributions. This is largely done in order to collapse the magnitude recurrence logic tree (see Section 6.1). The incremental rates were calculated using the `TruncatedGRMFD` OpenQuake class (effectively equivalent to equation 1 but defined in terms of incremental instead of cumulative rates, and using the Gutenberg-Richter *a*- and *b*-values where $N_0 = 10^a$, and $\beta = b \ln(10)$).

There are several exceptions to the implementation of `TruncatedGRMFD` in CanadaSHM6, namely:

- Cascadia interface source: incremental rates were derived directly from the paleoseismic record and implemented in OpenQuake using the `incrementalMFD` class (see Kolaj et al., 2020b),
- Western faults: pseudo-characteristic rates were estimated using a combination of $b = 0.8$ and $b \approx 0$ following Allen et al. (2015). Note that the near-zero *b*-value rate model uses a modification of equation 1 which normalizes the rates such that the $N(m = 0)$ rate is equal to N_0 (this modification was also used for the BMC source).
- Leech River Valley and Devil's Mountain Faults as described in Halchuk et al. (2019) using source-weights as listed in the source summary CSV files.
- The offshore (OFS) southwestern British Columbia source had the first 5 bins of the incremental rates removed to simulate a reduction in magnitude of 0.5 units. This accounts for the higher attenuation in the oceanic crust and accomplishes it in a different manner to the approach used in CanadaSHM5, where a variant of the active crustal GMMs was used in which the magnitudes were adjusted downwards by 0.5 units.

Additional source parameters (e.g., adopted magnitude scaling relations) are available in the NRML-XML and associated summary CSV files (Appendix A).

4. GROUND MOTION MODELS

A description of the Ground Motion Models (GMMs) used in CanadaSHM6 are provided in Kolaj et al. (2019) with further modifications as described in Kolaj et al. (2020a). The model includes GMMs for subduction interface, subduction inslab, active crust, and stable crust earthquakes.

Unlike earlier versions of CanadaSHM6, the GMMs are now implemented in OpenQuake as their own custom OpenQuake ground shaking intensity model (GSIM) classes. The GMMs have been contributed to the OpenQuake v3.11 repository and can be obtained directly from the OpenQuake GitHub repository[c][d].

[c] Available at https://github.com/gem/oq-engine/tree/engine-3.11 (last accessed March 24th 2022).

[d] Note that while the GMMs are made available through OpenQuake version 3.11, version 3.3.2 of the OpenQuake engine was used to generate the NBCC 2020 hazard values. Users of the GMMs may therefore wish to port the GMMs into the earlier version themselves.

The CanadaSHM6 GMMs are valid for the NBCC 2020 defined ground measures (PGA[e], PGV[f], Sa(0.2)[g], Sa(0.5), Sa(1.0), Sa(2.0), Sa(5.0), Sa(10.0)) and NBCC Commentary values (Sa(0.05), Sa(0.1), Sa(0.3)). While the GMMs have only been tested for the above specific values, they are expected to be appropriate for any period between 0.05 and 10 seconds. However, it should be noted that the stable crust NGA-East GMMs (Goulet et al., 2018) use a ground measure dependent weighting (i.e., the logic tree weights for the 13 branches of the CanadaSHM6 NGA-East GMMs vary as a function of period). As such, if ground measures other than those mentioned above are used (e.g., Sa(0.7)), the user should ensure that the GMM logic tree (see Section 5) contains the appropriate weights (as recommended in Goulet et al., 2018).

The CanadaSHM6 GMMs are able to provide ground motion values for any V_{s30} (time-averaged shear-wave velocity to a depth of 30 m) value between 140 and 3000 m/s. For NBCC 2020, seismic hazard was calculated for each location for a specified set of V_{s30} values: 140, 160, 180, 250, 300, 360, 450, 580, 760, 910, 1100, 1500, 1600, 2000 and 3000 m/s. The online hazard calculator (see Section 9) performs log-log interpolation of the seismic hazard values calculated from these values. Thus, to exactly match NBCC 2020 seismic hazard values at a desired V_{s30} requires two hazard calculations: at the specified V_{s30} immediately higher and lower, and then performing interpolation for the desired intermediate V_{s30} value. To obtain the hazard for Site Classes A-E, one must calculate the hazard for each of the V_{s30} values within the V_{s30} bounds of the Site Class (including both the bottom and top boundary) and take the largest hazard value for each ground motion parameter (e.g., Figure 3; Kolaj et al., 2020a; Kolaj et al., 2020b).

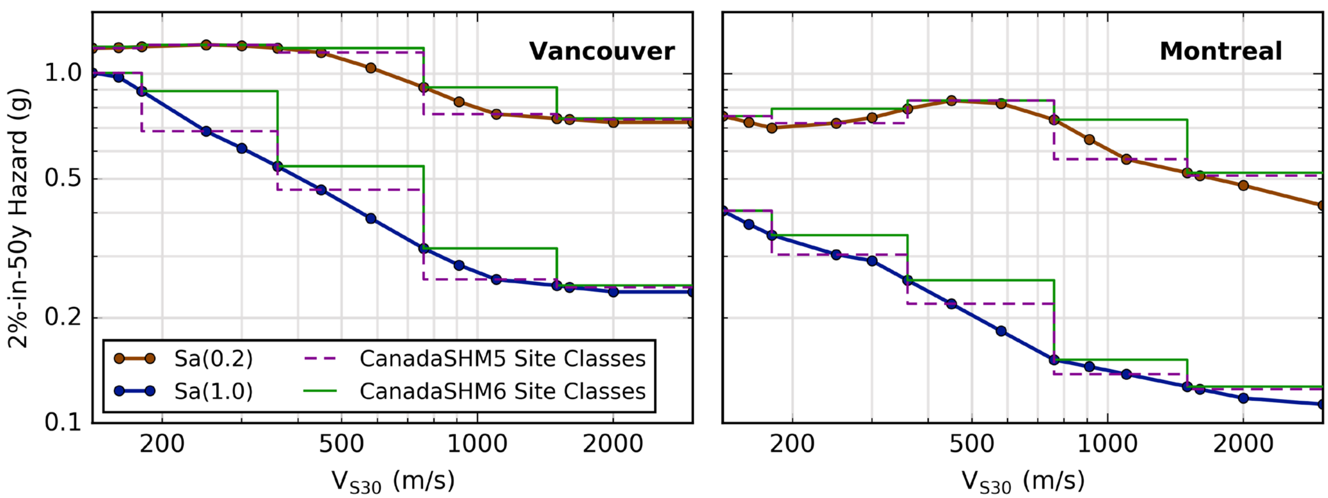

Figure 3. Hazard as a function of V_{s30} for Vancouver (left) and Montreal (right) for Sa(0.2) and Sa(1.0). Site Class definitions using the CanadaSHM6 approach (solid-green lines) are compared to the CanadaSHM5 approach (dashed-purple lines). Blue dots represent the hazard at the specified V_{s30} values and blue line represents the V_{s30} function used for interpolation. From Kolaj et al. (2020a).

Complete technical documentation for the GMMs will be released in subsequent CanadaSHM6 Open Files.

[e] Peak Ground Acceleration

[f] Peak Ground Velocity

[g] 5%-damped Spectral Acceleration

5. LOGIC TREES

Epistemic uncertainty in model parameters is incorporated using a logic tree. An example of the logic tree for the southeastern regional model is in Figure 4. Each source region has preferred values (central, *c*) for maximum magnitude and the recurrence parameters (N_0 and *b* pairs), and these are given the largest weights in the logic tree. Each of these parameters has an "upper" (*u*) and a "lower" (*l*) value, which are given lesser weights. The regional source models for eastern Arctic and western Canada are the same, with the exception of the number of source sub-models (Section 3) and the ground motion models (Section 4).

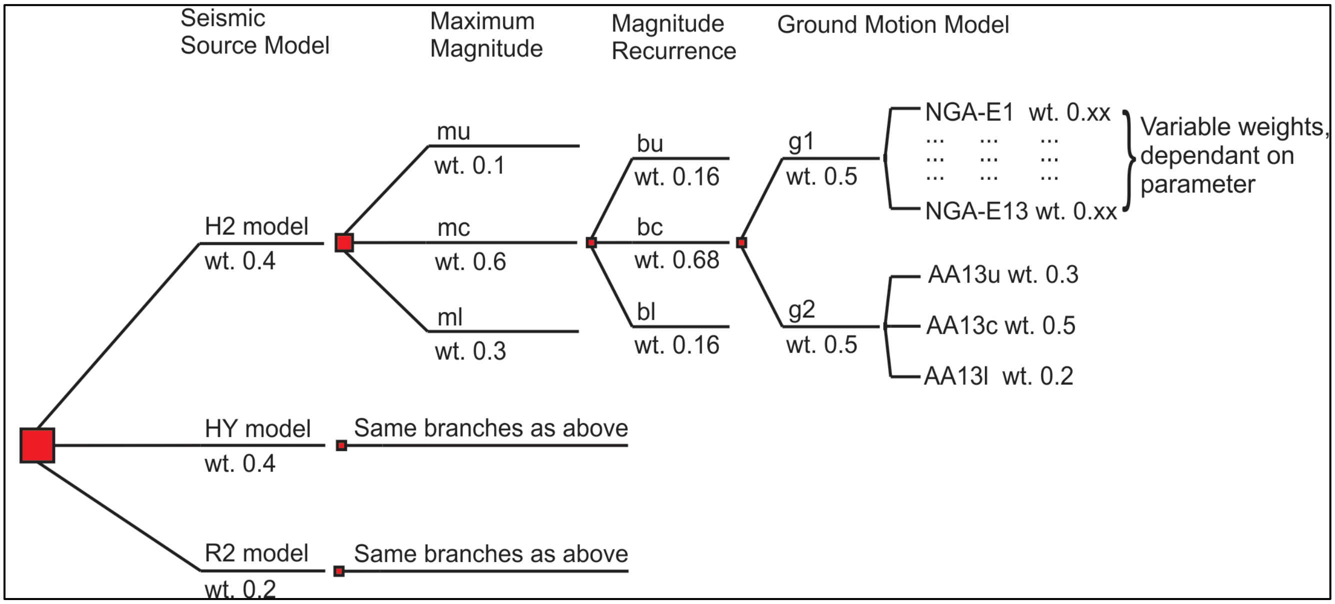

Figure 4. Source logic tree for southeastern Canada (from Kolaj et al. 2020c). The symbols mu, mc, ml and bu, bc and bl refer to the upper, central (preferred) and lower values for M_{max} and magnitude recurrence parameters, respectively. Note that the b-branches are composed of N_0 and b value pairs (e.g., "bc" refers to N_0c and bc). The logic-tree weights for the NGA-East GMMs depends on the ground motion parameter (Goulet et al., 2018).

With OpenQuake, the logic trees for sources and ground motion models are encoded in two sets of NRML-XML files. The source-model logic trees for each region are located in CanadaSHM6_NBCC2020\OpenQuakeModel\SSMs\LogicTrees\. The GMM logic tree is located in CanadaSHM6_NBCC2020\OpenQuakeModel\GMMs\. Details on the file format are provided in the OpenQuake manual (GEM, 2019).

6. MODEL SIMPLIFICATIONS FOR NBCC 2020

The complexity of the model was reduced in order to reduce the time required to compute hazard values for NBCC 2020 on a national grid. The two simplifications were:

a) collapsing of magnitude recurrence branches (see 6.1), and
b) reduction in the number of rupture planes and hypocentral depths (see 6.2).

For the NBCC 2020 version of CanadaSHM6, only this simplified model was used. The simplified models produce mean hazard values very close to those from the full model, but cannot accurately produce quantile (e.g. median, 84th percentile) values. For site-specific hazard studies, the model simplifications may not be appropriate. The non-simplified model will be released in a subsequent CanadaSHM6 publication.

6.1 COLLAPSING OF MAGNITUDE RECURRENCE BRANCHES

The 6th Generation model includes nine branches for the epistemic uncertainty in magnitude recurrence statistics (three M_{max} and three activity rate (N_0) / b-value pairs). For mean hazard, the recurrence statistics can be collapsed by finding the mean of the nine incremental rates weighted by the probabilities assigned in the logic tree. This reduces the logic tree by a factor of nine. This simplified version of the model is referred to as the "collapsed" model. An example of the nine branches and the collapsed equivalent magnitude recurrence for the Gatineau (GAT) source is provided in Figure 5.

While the collapsed magnitude recurrence accurately represents the mean activity and thus gives the mean hazard, it is not appropriate for any other hazard quantile/percentile (e.g., median) or for the computation of hazard uncertainty (e.g., Kolaj et al., 2020c).

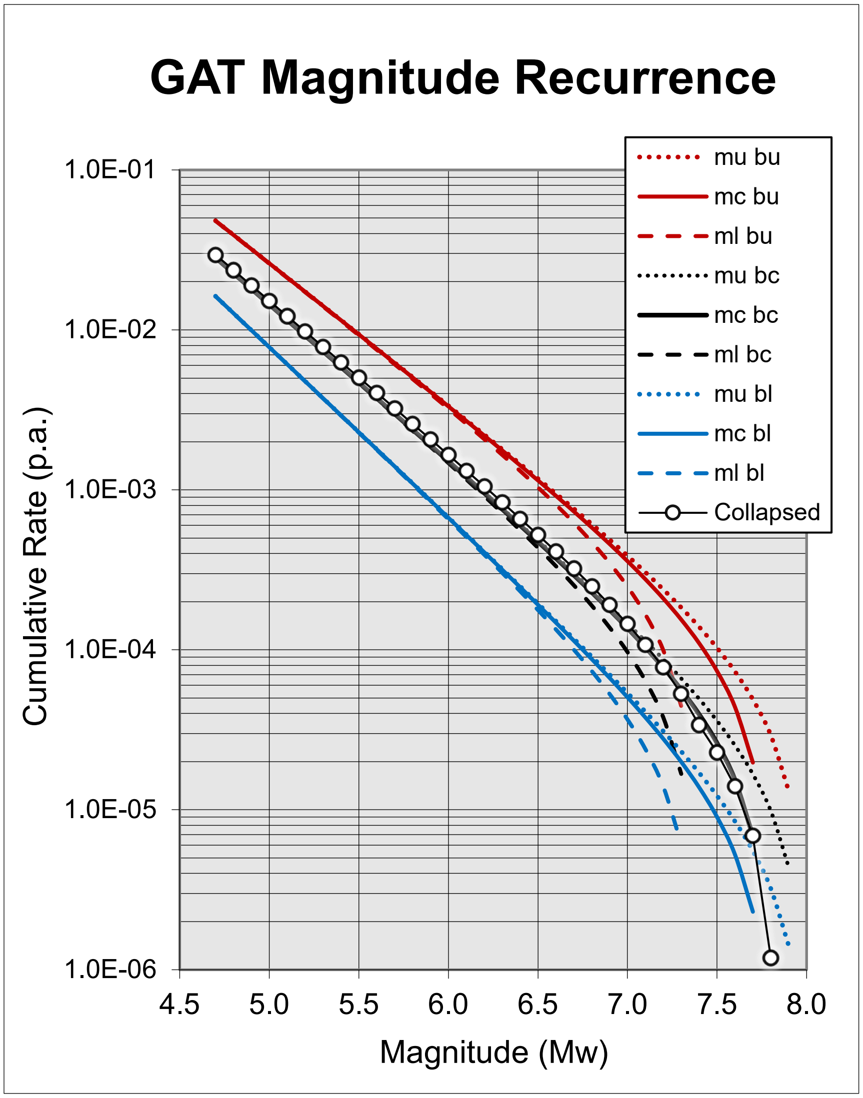

Figure 5. Example of the nine-branch and collapsed magnitude recurrence rates for the Gatineau Source (GAT). mu, mc, ml and bu, bc and bl refer to the upper, central and lower values for M_{max} and magnitude recurrence parameters (N_0 and b value pairs), respectively.

6.2 FURTHER SIMPLIFICATIONS

Further simplifications were made to reduce the runtime of the model. The model simplifications include:

- East and east-Arctic regional models:
  - Reduction in the number of rupture planes from twelve to two.
  - Reduction in the number of hypocentral depths from three to one.
- Western regional model:
  - Reduction in the number of rupture planes from twelve to six.
- Stable cratonic core (SCC) sources:
  - Reduction in the number of rupture planes from twelve to one.

Testing with an early version of CanadaSHM6 indicated that these simplifications resulted in mean hazard values that were within a few percent of the base model (i.e., well within the inherent epistemic uncertainty in mean hazard which is on the order of a factor of 2; Kolaj et al. 2020c). For some sources, the full hypocentral and rupture plane distributions were retained (e.g., Charlevoix).

The non-simplified model will be released in subsequent CanadaSHM6 publications.

7. OPENQUAKE JOB DESCRIPTION FILES

Example OpenQuake job description "INI" files for the three regional zones (i.e., Figure 2) are located in the CanadaSHM6_NBCC2020\OpenQuakeModel\INI directory. Please see the OpenQuake manual (GEM, 2019) for more information on the required fields within the INI file.

The example INI files reference the collapsed simplified model (Section 6) and the CanadaSHM6 GMM logic tree (Section 4). The INI files use relative file paths (as shown in the Figure 1) such that if the file structure in the electronic supplement is maintained, the files should not need any modification.

Example hazard outputs for a selection Canadian locations using the example INI files are included in the electronic supplement and described in Appendix B. New implementations should verify that those hazard values are adequately reproduced. Minor discrepancies of less than 1% may occur, and will likely be considered acceptable (note the special treatment for the overlap zones, as discussed in Section 3).

8. MODEL CONSIDERATIONS

The enclosed NBCC 2020 version of CanadaSHM6 has the following limitations:

- The regional/national scope model used for NBCC 2020 may not be appropriate for site-specific studies.
- The model is valid for PGA, PGV and for spectral accelerations with periods between 0.05 and 10s. Note the requirements for ground motion parameter specific logic tree weights for the NGA-East GMMs (see Section 4).
- The chosen $M_{\min}$ (minimum magnitude of earthquakes contributing to hazard) of 4.8 can have a significant effect on the calculated hazard values, especially for high return probabilities and in regions of low-seismicity (Halchuk and Adams, 2010).

- The model is of unknown reliability at probabilities below 2%-in-50 years (0.000404 p.a.) and above 40%-in-50 years (0.01 p.a.).

9. 2020 NATIONAL BUILDING CODE OF CANADA SEISMIC HAZARD TOOL

The enclosed model was used to generate the NBCC 2020 seismic hazard values. The seismic hazard values are made available using the 2020 National Building Code of Canada Seismic Hazard Tool (https://doi.org/10.23687/b1bd3cf0-0672-47f4-8bfa-290ae75fde9b). The webtool provides seismic values for the design of buildings in Canada under Part 4 of the National Building Code of Canada 2020 as prescribed in Article 1.1.3.1. of Division B of the NBCC 2020.

Using the tool, the user can choose to query results for any location in Canada based on a specified V_{s30} value (in the range of 140 to 3000 m/s) or Site Class (A, B, C, D or E). Spectral acceleration, peak ground acceleration and peak ground velocity values are provided for the probabilities of 2%, 5% and 10% in 50 years, as prescribed in the NBCC. Other probabilities between 2% in 50 years and 40% in 50 years are also provided as additional information. The results are shown as tables, and can be downloaded as comma separated (CSV) files, or viewed as plots to aid in the interpretation of the data.

The values provided by the 2020 National Building Code of Canada Seismic Hazard Tool supersede the trial hazard values provided in Open File 8629.

10. UPDATES FROM OPEN FILE 8630

Since the release of Open File 8630, CanadaSHM6 was accepted as the basis for the seismic hazard values for NBCC 2020. This Open File includes the final model that was used to generate those hazard values. The major difference between the trial model files in Open File 8630 and those contained herein is the move from table-based GMMs to the use of OpenQuake GSIM classes. In general, each GMM used is now implemented as its own OpenQuake GMM which can be called via the OpenQuake engine. As such, the model is now applicable for any V_{s30} values between 140 and 3000 m/s. The desired V_{s30} value(s) should be set within the OpenQuake INI file or the site file (see OpenQuake manual for further details).

11. UPCOMING CANADASHM6 RELEASES

Several Open Files describing various aspects of CanadaSHM6 are planned for 2023-2024. The following are currently planned (subject to change):

1. National grid of values for NBCC 2020 which are the ones interpolated by the online hazard calculator.
2. CanadaSHM6 maps for select probabilities, site designations and ground motion intensity measures.
3. National version of CanadaSHM6, which merges the sub regions.
4. A revised (non-NBCC) version of CanadaSHM6 that addresses an issue arising from the simplified way in which the areal Alaska interface source (AKC) was modelled. This change

removes inappropriate deaggregation results in parts of northwestern Canada, and slightly decreases mean-hazard estimates for these localities.
5. Summary of the CanadaSHM6 GMMs and site amplification modifications.
6. Seismic hazard values contributed separately from crustal, in-slab and interface earthquakes in southwestern Canada.
7. Comprehensive scientific description and rationale for CanadaSHM6 model elements.

12. SUMMARY

This Open File contains the model files required to calculate hazard using the CanadaSHM6 model which is the basis for the seismic hazard values for NBCC 2020. A subsequent Open File will be released to document the scientific and technical background for CanadaSHM6. Further details on the required input files and on the definition of model parameters in OpenQuake can be found in GEM (2019).

Questions and comments can be directed to Michal.Kolaj@NRCan-RNCan.gc.ca.

11. ACKNOWLEDGEMENTS

We would like to thank Trevor Allen and members of Standing Committee on Earthquake Design (SC-ED) and various NBCC task groups for their contributions to CanadaSHM6. We also thank Hadi Ghofrani and Nicholas Ackerley for their review of this Open File, which improved the document.

12. REFERENCES

Note that the references published by the authors of this Open File are available in the hazard section of the Earthquakes Canada website https://earthquakescanada.nrcan.gc.ca/hazard-alea/recpubs-en.php (website address correct as of March 2022).

Adams J, Allen T, Halchuk S, Kolaj M (2019): Canada's 6th Generation Seismic Hazard Model as Prepared for the 2020 National Building Code of Canada. *12th Canadian Conference on Earthquake Engineering*, Quebec City, Canada.

Allen T, Adams J, Halchuk S, Rogers, G (2015): 5th Generation seismic hazard model for north-western Canada. *11th Canadian Conference on Earthquake Engineering*, Victoria, Canada.

GEM (2019): The OpenQuake-engine User Manual. Global Earthquake Model (GEM) OpenQuake Manual for Engine version 3.3.2. doi: 10.13117/GEM.OPENQUAKE.MAN.ENGINE.3.3.2, 189 pages. Last accessed February 27 2020.

Goulet CA, Bozorgnia Y, Abrahamson NA, Kuehn N, Al Atik L, Youngs RR, Graves RW (2018): Central and Eastern North America Ground-Motion Characterization – NGA-East Final Report, PEER Report 2018/08.

Halchuk S, and Adams J (2010). Mmin - Implications of Its Choice for Canadian Seismic Hazard and Seismic Risk Applications Paper 439, *10th Canadian and 9th US National Conference on Earthquake Engineering*, Toronto, Canada.

Halchuk S, Allen T, Adams J, Onur T (2019): Contribution of the Leech River Valley - Devil's Mountain fault system to seismic hazard for Victoria B.C. *12th Canadian Conference on Earthquake Engineering,* Quebec City, Canada.

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

Kolaj, M, Halchuk S, Adams J, Allen TI, (2020a): Trial Sixth Generation seismic hazard model of Canada: seismic hazard values for selected localities; Geological Survey of Canada, Open File 8629, 1 .zip file. https://doi.org/10.4095/321473

Kolaj M, Adams J, Halchuk S (2020b): The 6th Generation seismic hazard model of Canada. *17th World Conference on Earthquake Engineering*, Sendai, Japan. Paper 1c-0028

Kolaj M, Adams J, Halchuk S (2020c): Seismic hazard in southeastern Canada: uncertainty and controls on seismic hazard in a region of low-to-moderate seismicity. *17th World Conference on Earthquake Engineering*, Sendai, Japan. Paper 1c-0029.

Kolaj, M., Halchuk, S., Adams, J., and Allen, T.I., (2020d). Sixth Generation seismic hazard model of Canada: Input files to produce values proposed for the 2020 National Building Code of Canada; Geological Survey of Canada, Open File 8630, 1 .zip file. https://doi.org/10.4095/327322

NBCC (2020): National Building Code of Canada: 2020. Canadian Commission On Building And Fire Codes. National Research Council of Canada, 28 mars 2022. https://doi.org/10.4224/w324-hv93

Pagani M, Monelli D, Weatherill G, Danciu L, Crowley H, Silva V, Henshaw P, Butler L, Nastasi M, Panzeri L, Simionato M, Vigano D (2014): OpenQuake Engine: An Open Hazard (and Risk) Software for the Global Earthquake Model. Seismological Research Letters, 85 (3), 692-702.

Weichert DH (1980): Estimation of the earthquake recurrence parameters for unequal observation periods for different magnitudes. *Bulletin of the Seismological Society of America*, **70**, 1337-1346.

Appendix A: Description of source model summary CSV files

The NRML-XML version of the files should be considered the authoritative source. However, source summaries are also providing in individual CSV files for each regional model in CanadaSHM6_NBCC2020\AppendixA\. A description of the fields is available below. Note that the Leech River Valley and Devil's Mountain Faults and Cascadia Interface sources, have separate CSV files because their rates are calculated differently (characteristic rates and directly estimated incremental rates, respectively). See also the OpenQuake manual (GEM, 2019) for a description of the required source fields.

Area and faults:

srcCode	Unique source identifier/acronym
srcName	Name of source following convention of: "full source name (comments)"
srcType	OpenQuake source type (typically `areaSource`, `simpleFaultSource` or `complexFaultSource`)
tectReg	Tectonic region (determines which branch of the GMM logic tree is used)
srcWt	Source weight, value between 0 and 1
minMag	Minimum magnitude of truncated GR distribution (MFD)
maxMagCentral	Preferred maximum magnitude of truncated GR distribution (see Figure 4)
maxMagUpper	Upper maximum magnitude of truncated GR distribution (see Figure 4)
maxMagLower	Lower maximum magnitude of truncated GR distribution (see Figure 4)
N0Central	Preferred activity rate of truncated GR distribution (see Figure 4)
N0Upper	Upper activity rate of truncated GR distribution (see Figure 4)
N0Lower	Lower activity rate of truncated GR distribution (see Figure 4)
bCentral	Preferred b-value of truncated GR distribution (see Figure 4)
bUpper	Upper b-value of truncated GR distribution (see Figure 4)
bLower	Lower b-value of truncated GR distribution (see Figure 4)
seismogenicDepth (upper, lower)	Minimum and maximum seismogenic depths
hypoCentralDist (weight, depth)	List of hypocentral depths and associated weights (only for `areaSource`)
magScaleRel	Scaling relation between magnitude and the area of the rupture (e.g. `WC1994`, `CEUS2011`, `GSCOffshore`, etc.). See OpenQuake class descriptions for additional details.
ruptAspectRatio	Aspect ratio of the rupture (length / width)
NodalPlaneDistribution (weight, strike, dip, rake)	List of rupture orientations and associated weights (only for `areaSource`)
rake	Rake of fault (`simpleFaultSource` and `complexFaultSource` only)
faultDip	Dip of fault (`simpleFaultSource` only)
shape	Well-known text (WKT) format string describing geometry
areaGeometry discretization	Spacing (km) of mesh used to determine contributions from area sources (only for `areaSource`)

Additional or revised fields for fitted incremental rates (Cascadia Interface sources):

rates	List of lists of incremental magnitude frequency distributions (MFD, annual rates), one for each branch of the logic tree
binWidth	Width of the bin used for all MFDs
uncertaintyWeight	List of logic tree weights for each MFD

Additional or revised fields for characteristic rate faults (Leech River and Devil's Mountain Faults):

maxMag	List of characteristic magnitudes for each branch of the logic tree (note: Mmax is 0.25 units larger)
N0	List of activity rates for each branch of the logic tree
b_val	List of b-values for each branch of the logic tree
char_rate	List of characteristic rates of each of the characteristic magnitudes
uncertaintyWeight	List of logic tree weights for each characteristic rate

Appendix B: Example Hazard Values

Example hazard outputs of CanadaSHM6 are provided in: CanadaSHM6_NBCC2020\AppendixB\

The spreadsheet, *OF8924_CanadaSHM6_SampleHazardValues.xlsx*, provides a selection of seismic hazard values derived from the NBCC 2020 6th Generation Seismic Hazard Model of Canada (CanadaSHM6) model. Mean, 2%/50 year probability values are provided for five V_{s30} values: 140, 450, 1100, 2000 and 3000 m/s. The hazard values for a V_{s30} of 450 m/s were generated with the sample INI files described in Section 7 and located in the CanadaSHM6_NBCC2020\OpenQuakeModel\INI\ directory (other V_{s30} results could be generated by modifying the `reference_vs30_value` field).

Seismic hazard values should be reported to two significant figures (in our view, an appropriate level of precision). However, we have provided three significant figures to aid with verification of future implementations of CanadaSHM6.