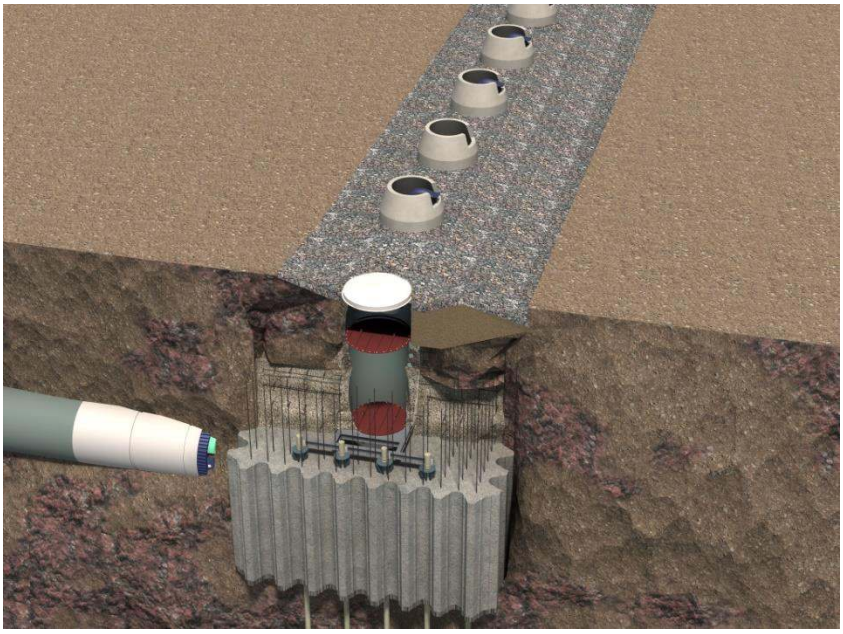
APPENDIX B
GEOTECHNICAL REPORTS

B.2: Seismic Design Criteria

Annacis Island WWTP New Outfall System

Vancouver Fraser Port Authority
Project and Environmental Review Application



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CDM Smith

Golder Associates

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TECHNICAL MEMORANDUM

DATE 8 July 2016 **REFERENCE No.** 1525010-010-TM-Rev0

TO John Newby
Project Manager, CDM Smith Canada ULC

FROM Viji Fernando/Upul Atukorala **EMAIL** vfernando@golder.com

SITE SEISMICITY, SEISMIC PERFORMANCE EXPECTATIONS, AND INPUT GROUND MOTIONS ANNACIS ISLAND WWTP TRANSIENT MITIGATION AND OUTFALL, DELTA, BC

This Technical Memorandum provides guidance on site seismicity, seismic performance expectations, and input ground motions for consideration for the transient mitigation and outfall system including a secondary bypass conduit. A feasibility study for twinning or replacing the existing South Surrey Interceptor (SSI) crossing the Fraser River is also being undertaken as part of the transient mitigation and the seismic performance objectives and requirements for the SSI are also provided.

The guidance provided herein draws from a number of sources, including the Metro Vancouver Seismic Design Criteria, the 2010 National Building Code of Canada (NBCC) that is currently in effect in the province's jurisdiction, the 2015 NBCC that is currently in effect at the national level, the design manual for AIWWTP Stage V Expansion project, and our understanding of some of the relevant content in the upcoming 2015 NBCC Commentary based on personal communications with select code committee members.

1.0 SITE SEISMICITY

The seismicity/seismic hazard at the project site results from the thrusting (subducting) of the offshore Juan de Fuca Plate beneath the continental North America Plate. The tectonic environment generates three distinct types of earthquakes in the region:

- Relatively shallow crustal earthquakes (depths in the order of 20 kilometres);
- Deeper inslab earthquakes (depths in the order of 60 kilometres) within the subducting plate; and,
- Very large interface earthquakes, often referred to as the "megathrust" or "subduction" earthquakes.

Earthquakes of the first two types (crustal and inslab) have occurred at regular intervals over the last several decades. The largest are those were near Campbell River in 1946 (M7.3), near Olympia in 1949 (M7.1), near Seattle/Tacoma in 1965 (M6.5), and in Nisqually in 2001 (M6.8). The duration of strong shaking of these two types of earthquakes is expected to be about 15 to 20 seconds. A very large earthquake apparently occurred near the USA/Canada border in 1872.

Large subduction earthquakes have not occurred in the region in historic time. However, there is geologic evidence that they have occurred in the past (possibly at 400 to 600 year intervals). The measured accumulation of strain between the tectonic plates suggests that these large earthquakes should be expected in the future.

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The current consensus is that the magnitude of a large subduction earthquake would be in the order of M8.5 to M9 occurring with the center of energy release located some 120 to 150 kilometres from the project site.

2.0 SEISMIC PERFORMANCE EXPECTATIONS

MV's seismic design criteria dated April 10, 2015 state that the seismic performance expectation for the Liquid Waste Collection Systems is *aspirational* except for occupied spaces, which are covered by the Building Code. The RFP requires the proposed transient mitigation and outfall system to be assessed for ground motions corresponding to return periods of 475 years, 975 years, and 2,475 years to allow for cost-benefit analyses. Following award of the project, MV confirmed that the outfall system should be designed for the post-disaster performance level, which requires the outfall system to be functional following design ground motions corresponding to a return period of 2,475 years.

A feasibility study for twinning or replacing the existing South Surrey Interceptor (SSI) crossing the Fraser River is also being undertaken as part of the outfall system and the MV's seismic design criteria indicate Class III or Class IV seismic performance requirements for the SSI in accordance with the American Lifelines Alliance (ALA) 2005.

2.1 Post-Disaster Objectives – Outfall System

The definition of post-disaster performance comes from Commentary A of 2010 NBCC and it states that "Buildings designed as post-disaster facilities should remain operational immediately after an emergency or disaster". It further states that "the mere application of an importance factor greater than 1.0 does not necessarily ensure the operational readiness of a facility following an emergency or disaster and this only can be determined by carrying out a detailed study of what equipment and services need to be in operation following an emergency or disaster and of the anticipated behaviour of the equipment and structural components". This includes, for example, establishing what equipment needs emergency power, what the reserves for emergency generator should be, fuel supply reliability, and requirements for potable water supply.

The project team will undertake a detailed study to establish the performance requirements of different process units as part of the detailed design.

2.2 Class III and Class IV Objectives – South Surrey Interceptor

According to MV's seismic design criteria, sewers crossing major water bodies are classified as either Class III or Class IV and designed for ground motions with a return period of 975 years or 2,475 years, respectively. Class III pipelines are described as critical pipelines serving large numbers of customers and presenting significant economic impact to the community or a substantial hazard to human life and property in the event of failure. Class IV pipelines are described as essential pipelines required for post-earthquake response and recovery and are intended to remain functional and operational during and following a design earthquake (i.e. 2,475-yr ground motions).

According to the criteria described above, the SSI can be classified as a Class III crossing and designed to meet the performance expectations considering ground motions with a return period of 975 years, provided that it is acceptable from environmental considerations to discharge untreated sewage into the river in the event of failure following the design seismic event. The project team can undertake a cost benefit analysis of designing and

constructing the SSI crossing to Class III and Class IV criteria described above to assess the incremental costs including potential environmental impacts. Designing the SSI to meet the performance expectation of Class IV pipelines considering the 2,475 year ground motions may be preferable from connectivity considerations of the crossing to the land-based facilities and increased seismic resilience.

2.3 Normal Performance Objectives – Other Non-Critical Structures/Pipelines

The transient mitigation and outfall system components, which are not critical for the post-disaster performance objectives can be designated with a normal performance level in accordance with the MV's seismic design criteria. These components may experience significant but repairable damage but should not be in a condition of potential collapse under the 2,475 year ground motions.

In accordance with the MV's seismic design criteria, the pipelines that are designated with a normal functional level (I.e., Class II) based on the ALA 2005 are required to be functional under the design ground motions corresponding to a return period of 475 years. However, the design criteria are not explicit in terms of their performance objectives under the 2,475 year ground motions. Consistent with the 2010 NBCC, it is expected that they should not be in a condition of potential collapse. Similar performance objectives are also expected for the pipelines that are designated as Class III.

3.0 FIRM-GROUND RESPONSE SPECTRA AND DE-AGGREGATION OF HAZARD

This section describes the seismic design criteria proposed for the subject project taking onto consideration the site seismicity and MVs performance expectations described above.

3.1 Firm-Ground Response Spectra

The MV's seismic design criteria refer to the 4th generation seismic hazard maps for seismic design considerations, which were developed as input to the seismic design provisions in the 2010 National Building Code of Canada (2010 NBCC) and refer to the 5th generation seismic hazard maps developed as input to the 2015 NBCC for future considerations.

The 4th generation seismic hazard maps consider the shallow crustal and deep inslab earthquake sources in the probabilistic assessment. The interface earthquake (subduction) is considered separately, following a deterministic approach using the earthquake magnitude and distance as noted previously. The response spectra extend from PGA to a maximum period of 2.0 seconds.

The 5th generation seismic hazard maps developed as input to the 2015 NBCC, incorporate several major changes:

a) The seismic hazard is defined in terms of the mean hazard parameters;

b) The "H" and "R" seismic zones used in predicting the hazard were replaced with a new seismic zoning model;

c) The subduction earthquake scenario was incorporated into the probabilistic calculation;

d) The Ground Motion Prediction Equations (GMPEs) now correspond to an average shear wave velocity of 450 m/s as opposed to the shear wave velocity varying between 360 m/s and 760 m/s;

e) The Uniform Hazard Response Spectra are now computed for periods ranging from 0.01 sec to 10.0 sec periods; and,

f) The short and long-period site amplification factors F_a and F_v have been replaced with a single site amplification factor F that is dependent on the level of shaking, Site Class, and period.

The site-specific hazard parameters based on both 4th and 5th generation seismic hazard models were obtained from Natural Resources Canada (NRCan) and they are summarized in Table 3-1 in terms of 5% damped spectral accelerations at a number of different structural periods. They correspond to the "reference ground condition" referred to as Site Class C and denoted by the shear wave velocity (V_s) noted above in the upper 30 m.

Table 3-1: Site-Specific Probabilistic Firm-Ground (Site Class C) Uniform Hazard Response Spectra

Return Period (2,475 Years)	PHGA	Sa (0.2s)	Sa (0.5s)	Sa (1.0s)	Sa (2.0s)
2010 NBCC [4th generation model]	0.51 g	1.03 g	0.68 g	0.34 g	0.17 g
2015 NBCC [5th generation model]	0.36 g	0.84 g	0.75 g	0.42 g	0.25 g
Return Period (975 Years)					
2010 NBCC [4th generation model]	0.37 g	0.74 g	0.49 g	0.24 g	0.12 g
2015 NBCC [5th generation model]	0.26 g	0.59 g	0.53 g	0.29 g	0.17 g
Return Period (475 Years)					
2010 NBCC [4th generation model]	0.27 g	0.54 g	0.35 g	0.17 g	0.09 g
2015 NBCC [5th generation model]	0.19 g	0.43 g	0.38 g	0.20 g	0.12 g

Note: In Table 3-1, PHGA refers to peak horizontal ground acceleration; Sa refers to spectral acceleration for a given period.

The interface (subduction) spectral accelerations obtained from NRCan are summarized in Table 3-2. The spectrum from the 4th generation seismic maps/models corresponds to the 84th percentile accelerations established based on a deterministic approach, whereas the spectrum from the 5th generation seismic maps/models corresponds to mean accelerations established based on a probabilistic approach.

Table 3-2: Site-Specific Firm-Ground (Site Class C) Spectrum for Subduction Earthquake

Subduction Earthquake Scenario	PHGA	Sa (0.2s)	Sa (0.5s)	Sa (1.0s)	Sa (2.0s)
2010 NBCC [4th generation model][1]	0.16 g	0.37 g	0.31 g	0.17 g	0.09 g
2015 NBCC [5th generation model][2]	0.14 g	0.29 g	0.34 g	0.27 g	0.19 g

Note: In Table 3-2, PHGA refers to peak horizontal ground acceleration; Sa refers to spectral acceleration for a given period.

[1] Open File 4456 published by NRCan

[2] Provided in an email by NRCan

The 2,475-yr UHRS spectra and the interface earthquake spectra provided by NRCan for the 4th and 5th generation seismic hazard models are shown in Figure 3-1.

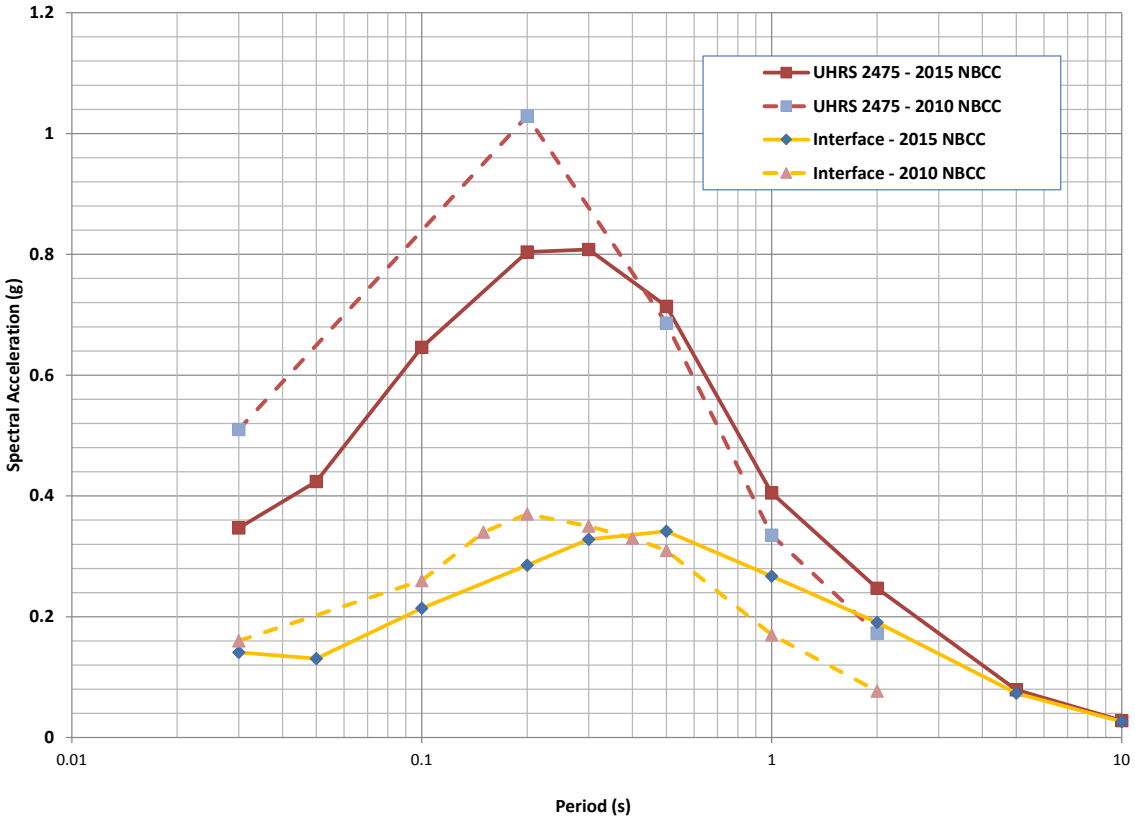


Figure 3-1: Comparison of 2475-yr UHRS and Interface Response Spectra

3.2 De-aggregation of Seismic Hazard – 4th Generation Hazard Model (2010 NBCC)

Figure 3-2 shows the de-aggregation matrix provided by NRCan for the 2,475-yr return period based on the 4th generation seismic hazard model, when the 1.0 second period de-aggregation is used as an example. The complete set of de-aggregation results are provided in Attachment 1.

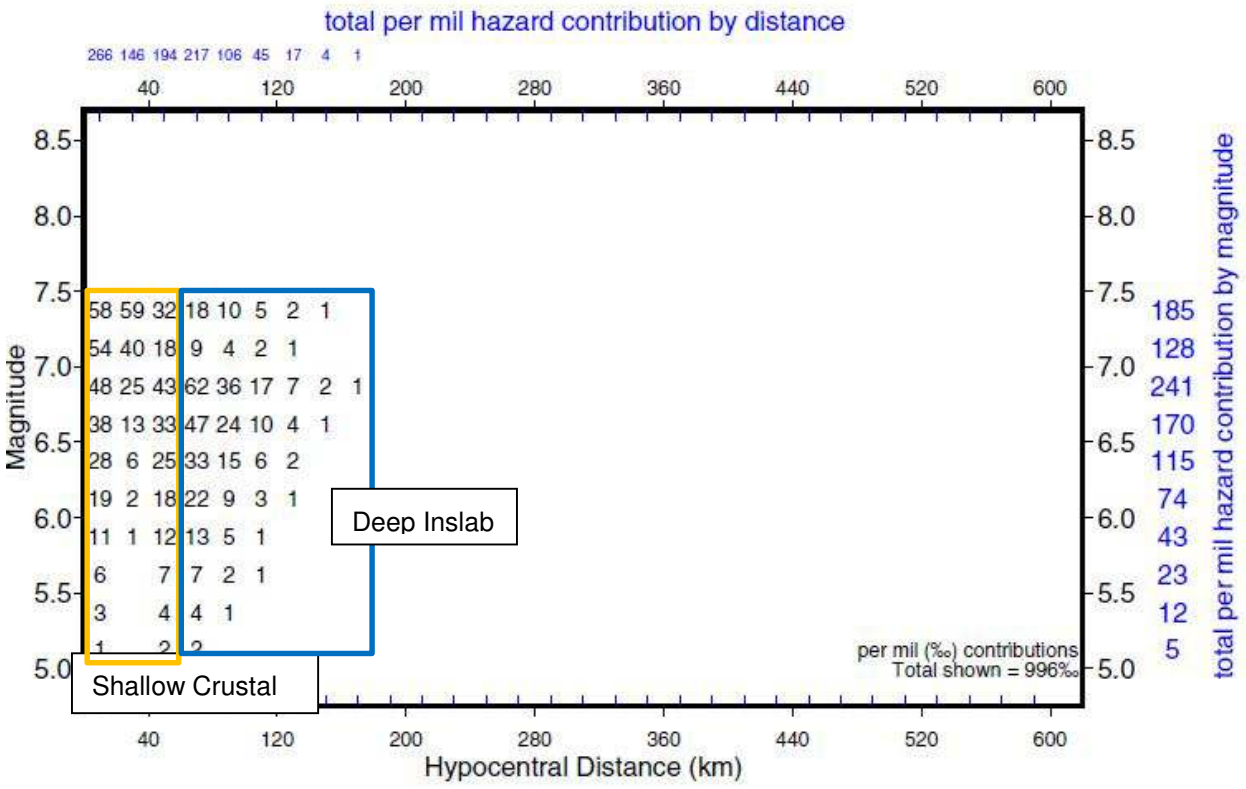


Figure 3-2: Example Distribution of Earthquake Magnitude and Distance Contributions for 1.0 Second Period [De-aggregation Results for 2,475-year Seismic Hazard]

The de-aggregation results of the seismic hazard for different return periods and at PHGA, 0.2 second, and 1.0 second are summarized in Table 3-3.

Table 3-3: De-aggregation Results for Different Return Periods (2010 NBCC)[1]

Return Period	PHGA			0.2 Second Period			1.0 Second Period		
	Shallow Crustal	Deep Inslab	Mean Magnitude	Shallow Crustal	Deep Inslab	Mean Magnitude	Shallow Crustal	Deep Inslab	Mean Magnitude
2,475 Year	~52%	~48%	M6.3	~51%	~48%	M6.4	~61%	~39%	M6.7
975 Year	~48%	~51%	M6.3	~48%	~52%	M6.4	~53%	~47%	M6.7
475 Year	~46%	~54%	M6.2	~45%	~55%	M6.3	~46%	~54%	M6.6

[1]*numbers are approximate and large distance sources have been ignored.*

The de-aggregation results indicate that the PHGA and 0.2 second spectral accelerations corresponding to the 2,475 year hazard are associated with M6.3 and M6.4 earthquakes and the 1.0 second spectral accelerations are associated with an M6.7 earthquake. These results do not reflect the contribution from the interface (subduction) earthquakes.

3.3 De-aggregation of Seismic Hazard – 5th Generation Hazard Model (2015 NBCC)

Figure 3-3 shows the de-aggregation matrix provided by NRCan for the 2,475-yr return period based on the 5th generation seismic hazard model, when the 1.0 second period de-aggregation is used as an example. The complete set of de-aggregation results are provided in Attachment 2.

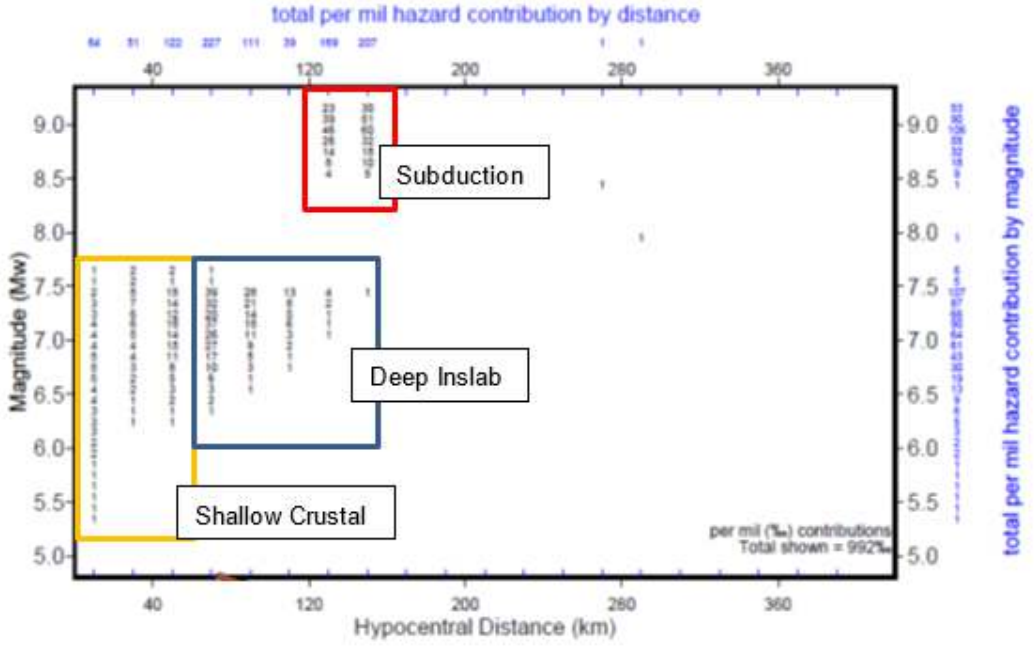


Figure 3-3: Example Distribution of Earthquake Magnitude and Distance Contributions for 1.0 Second Period [De-aggregation Results for 2,475-year Seismic Hazard]

The de-aggregation results of the seismic hazard for different return periods and at 0.2 second, 1.0 second, and 2.0 second periods are summarized in Table 3-4.

Table 3-4a: De-aggregation Results for Different Return Periods (2015 NBCC)[1]

Return Period	PHGA				0.2 Second Period			
	Shallow Crustal	Deep Inslab	Inter-plate	Mean Magnitude	Shallow Crustal	Deep Inslab	Inter-plate	Mean Magnitude
2,475 Year	~44%	~48%	~7%	M7	~40%	~54%	~4%	M7
975 Year	~38%	~51%	~`10%	M7	~35%	~56%	~6%	M7
475 Year	~33%	~53%	~11%	M7	~31%	~58%	~8%	M7

Table 3-4b: De-aggregation Results for Different Return Periods (2015 NBCC)[1]

Return Period	1.0 Second Period				2.0 Second Period			
	Shallow Crustal	Deep Inslab	Inter-plate	Mean Magnitude	Shallow Crustal	Deep Inslab	Inter-plate	Mean Magnitude
2,475 Year	~24%	~38%	~36%	M7.8	~15%	~30%	~52%	M8.1
975 Year	~21%	~42%	~32%	M7.7	~14%	~36%	~43%	M7.9
475 Year	~20%	~46%	~27%	M7.5	~14%	~41%	~34%	M7.7

[1]numbers are approximate and large distance sources have been ignored.

Based on the NRCan's 5th generation hazard model and de-aggregation plots, the main contributors to the seismic hazard at short periods are the shallow crustal and deep inslab earthquakes, whereas the main contributors at long periods are the deep inslab and interface earthquakes. For the subject site, the transition of seismic hazard from deep inslab to interface earthquakes occurs at a period ranging from 1.0 to 2.0 seconds. These results are useful when selecting earthquake scenarios and ground motion records for site response analysis and assessment of liquefaction potential of site soils.

4.0 INPUT FIRM-GROUND ACCELERATION TIME-HISTORIES

Non-linear site response analysis requires firm-ground response spectra and corresponding acceleration time-histories as input to the wave propagation models. The applicable input acceleration time-histories can either be developed using scaling or spectral matching techniques outlined in Commentary A of 2010 NBCC. However, since the firm-ground response spectra developed using the 4th and 5th generation seismic hazard models are different, as seen from the data presented in Tables 3-1 and 3-2, the corresponding acceleration time-histories will also be different.

4.1 Input Acceleration Time-Histories – 2010 NBCC

We understand that spectrally-matched acceleration time-histories have already been developed by Brown and Caldwell for the design and analysis of the Stage V Expansion of the AIWWTP. Site Class C ground motions have been developed using the 4th generation seismic hazard model and the corresponding UHRS. 3 sets of ground motions with each set comprising two orthogonal time-histories to represent the crustal and inslab earthquakes and 1 set ground motions comprising two orthogonal time-histories to represent the interface (subduction) earthquakes have been developed for site response and liquefaction analysis of soils.

We understand that vertical ground motions have not been developed as input to structural or soil-structure interaction analyses. Table 4-1 provides a summary of the seed motions selected for development of acceleration-time histories for analyses.

Table 4-1: Details of the Ground Motions - Stage V Expansion [2,475-Year Return Period]

Earthquake	Date of Earthquake	Magnitude	Station ID
Loma Prieta	October 18, 1989	M7.0	Capitola
Landers	June 28, 1992	M7.3	Joshua Tree
Chi Chi	September 20, 1999	M7.6	Taichung – TCU078
Mexico	September 19, 2985	M8.1	La Union

It would be prudent to use the same firm-ground input ground motions that have already been developed by Brown and Caldwell for the outfall system to be consistent with the designs being completed for the Stage 5 Expansion. We have proposed this as our preferred approach for seismic analysis of the subject facilities in our proposal submission.

Firm-ground motions for the Stage V expansion have only been developed for the 2,475 year return period plus subduction event. The firm-ground motions for the 475 year and 975 year return periods, if required, would still need to be developed.

4.2 Input Acceleration Time-Histories – 2015 NBCC

New ground motion time-histories consistent with the 2015 NBCC would need to be developed for the project. The 2015 NBCC Site Class C UHRS consists of contributions from crustal, inslab and interface earthquakes and extends to a period of 10 seconds. Spectrally matching time-histories over the full period range (from PGA to 10 seconds) is not recommended as this would result in "modified" earthquake records that are very different from those observed from past earthquakes and with increased displacement demand at long periods.

In order to be consistent with the seismic design standards already established for the Stage V Expansion that is currently underway and to account for the revised seismic demand resulting from the use of the 5th generation seismic hazard maps developed for 2015 NBCC, we propose the following approach to develop input firm-ground motions for engineering analyses:

- Develop spectrally-matched ground motions with seed motions obtained from past earthquakes that represent crustal and inslab seismicity. The motions will be spectrally-matched to the 2015 NBCC UHRS (Site Class C) over a period range extending from PGA to about 3.0 seconds. A total of eleven single-component acceleration time-histories will be developed. The seed input motions will be selected from past earthquakes with similar tectonic environment (i.e. Nisqually (2001), Northridge (1994), Loma Prieta (1989), etc.); and,
- Develop spectrally-matched ground motions with seed motions obtained from past interface earthquakes that represent the interface seismicity. The motions will be spectrally-matched to the 2015 Interface Spectrum summarized in Table 3-2 and shown in Figure 3-1 over the full period range varying from PGA to 10 seconds. A total of five single-component acceleration time-histories will be developed. The seed motions from past large-magnitude interface earthquakes such as Tohoku (2011), Maule (2010), Mexico City (1985), etc. will be selected to match the interface spectrum.

We do not propose to develop vertical ground motions and assume that site response analyses that will be carried out will be two-dimensional. We have retained Dr. Tuna Onur from Onur Seemann Consulting Inc. to develop the time-histories consistent with the approach described above.

In proposing the above, we recognize that the upcoming 2015 NBCC Commentary may contain different recommendations with regards to selection of ground motions for site response and liquefaction analyses as noted in Section 6.0. We understand that the Commentary for the 2015 NBCC is in its final stages of development and has not been released at the time of preparation of this Technical Memorandum.

5.0 SITE RESPONSE AND SOIL LIQUEFACTION ANALYSES

We propose that site response and soil liquefaction analyses be undertaken for the ground motions developed for the seismic hazard parameters established from both the 4th and 5th generation hazard models. We envisage that the ground motions that correspond to the 5th generation hazard model to have a higher impact on soil liquefaction and the associated consequences such as lateral spreading than the ground motions that correspond to the 4th generation hazard model. The results from these analyses should be compared and the impacts on the subject project assessed prior to selecting the design ground motion parameters.

6.0 UPCOMING 2015 NBCC COMMENTARY GUIDELINES

Based on our personal communications with select code committee members, we understand that the upcoming 2015 NBCC Commentary may include specific guidelines in terms of developing design spectra for the input acceleration time-histories, especially for the interface (subduction) event. The guidelines may recommend scaling the 2015 interface spectrum as summarized in Table 3-2 to match the UHRS at long periods, where the contribution from the interface sources to the seismic hazard is considered significant. Figure 6-1 shows a typical scaled interface spectrum to match the UHRS at long period along with the unscaled interface and UHRS spectra.

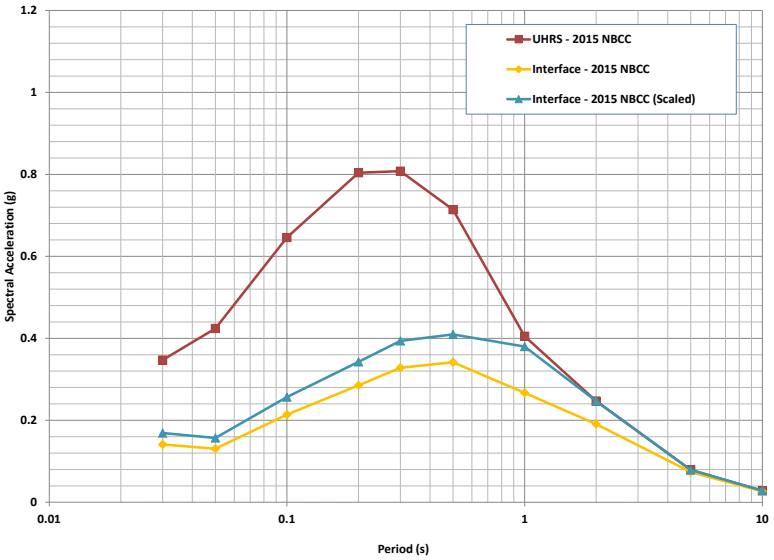


Figure 6-1: Interface and UHRS Spectra

Considering that the Commentary for the 2015 NBCC is not published yet and the guidelines noted above may well change based on peer review prior to publication, we consider that it is prudent to follow the approach consistent with the 2010 NBCC as noted in Section 4.0 for comparison purposes, which would help MV to understand the potential differences in making a decision on the appropriate seismic hazard parameters for the new outfall system.

Consideration may be given to the upcoming commentary guidelines if MV decides to consider the 2015 NBCC for the final design of the outfall system following the initial assessment based on the approach summarized in Section 4.0 above.

7.0 SITE CLASS (2010 NBCC)

We understand that the above and below grade structures associated with the outfall system will be designed based on the 2010 NBCC.

According to the 2010 NBCC, the site is classified as Site Class F due to the presence of potentially liquefiable overburden soils. However, the site can be classified as Site Class E without considering the effects of soil liquefaction for structures with a fundamental period equal to less than 0.5 second provided that structural measures are implemented to address the consequences of liquefaction, such as loss of foundation capacity and lateral soil displacements and settlements resulting from soil liquefaction. The F_a and F_v factors for Site Class E, as per Tables 4.1.8.4B and 4.1.8.4C, are 0.9 and 1.8, respectively.

It is noted that site-specific analyses incorporating the effects of soil liquefaction should be carried out in accordance with the 2010 NBCC for structures with a fundamental period higher than 0.5 second.

8.0 CLOSURE

We trust that the information contained in this Technical Memorandum is sufficient for your immediate requirements. Please contact the undersigned if you have any questions.

Yours very truly,

GOLDER ASSOCIATES LTD.

Viji Fernando, M.E.Sc., P.Eng.
Associate, Senior Geotechnical Engineer

Upul D Atukorala, Ph.D., P.Eng.
Principal, Senior Geotechnical Engineer

VF/UDA/kn

Attachments: Attachment 1 – Seismic Hazard De-aggregation (2010 NBCC)
Attachment 2 – Seismic Hazard De-aggregation (2015 NBCC)

ATTACHMENT 1 -
Seismic Hazard De-aggregation (2010 NBCC)

Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/17

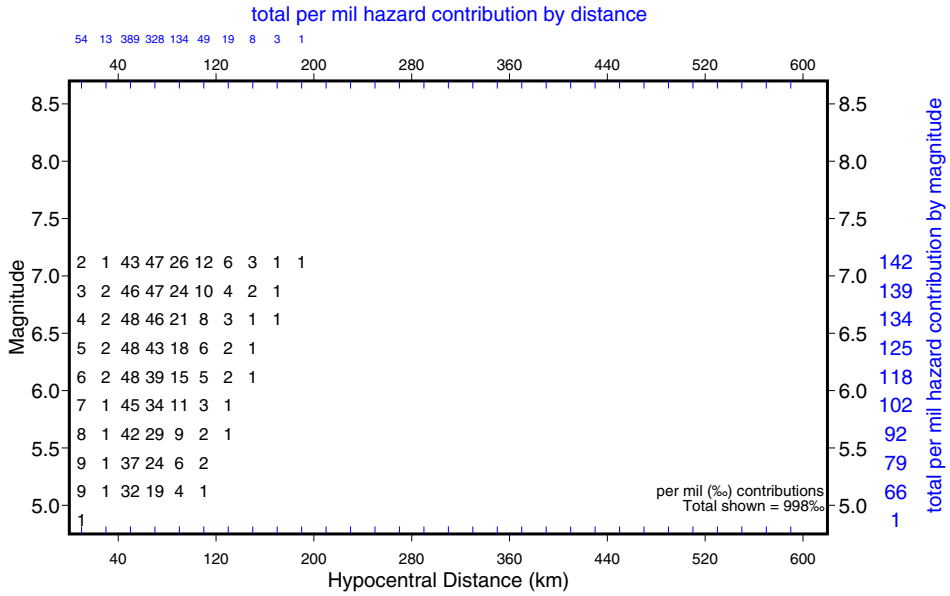
For site Vancouver, BC at 49.165 N 122.952 W

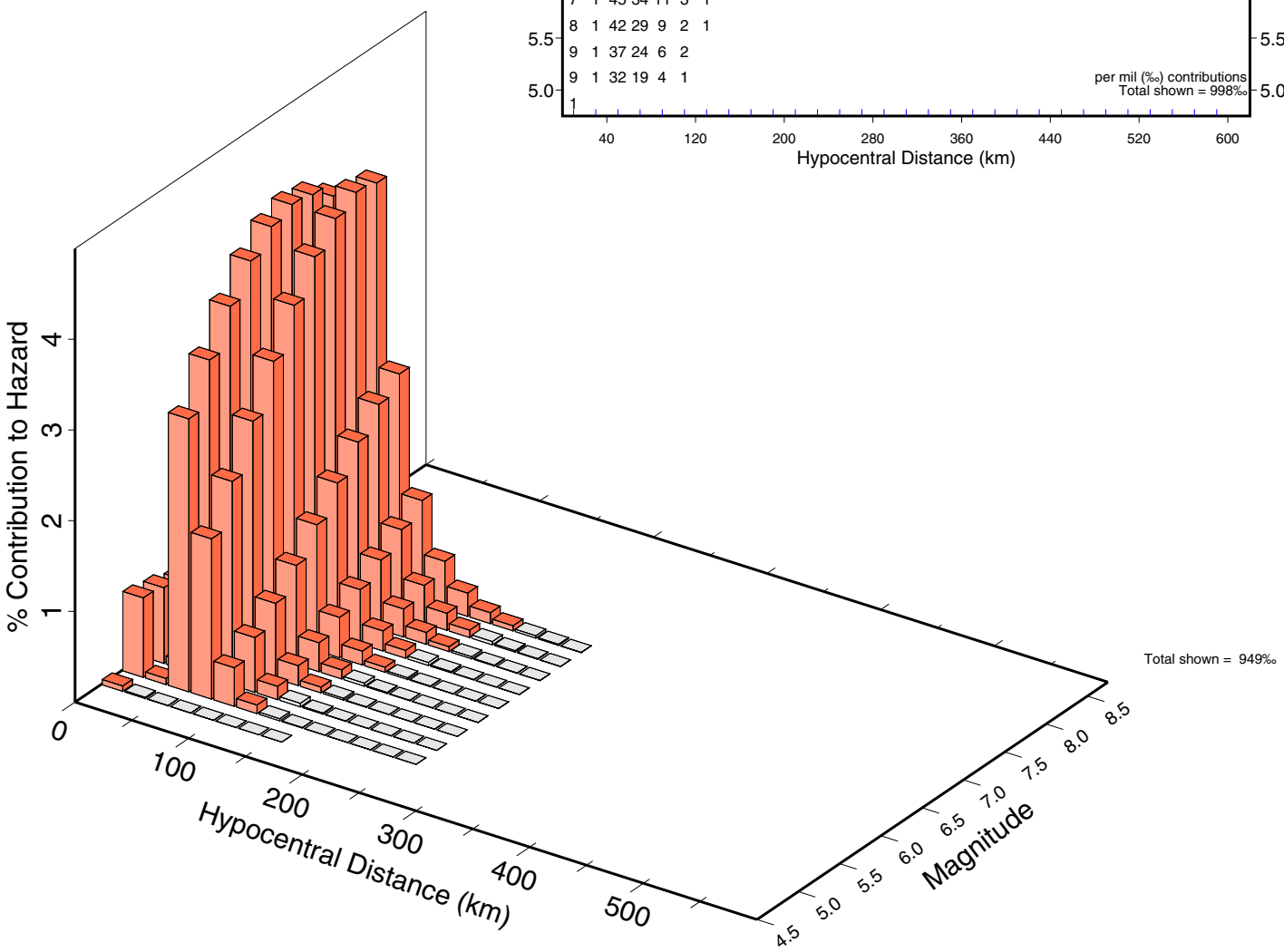
For ground motion parameter: PGA, Peak ground acceleration for 2005 NBCC site class C
at a probability of 0.002100 per annum, seismic hazard = 0.275 g

Mean magnitude 6.20 Mean distance 65 km
Modal magnitude 6.375 Modal distance 50 km

Deaggregation of median hazard
Model: wh2005_pga.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459
page 7 and 154.





Aussi disponible en français

Natural Resources Canada Ressources naturelles Canada

Canada

Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/17

For site Vancouver, BC at 49.165 N 122.952 W

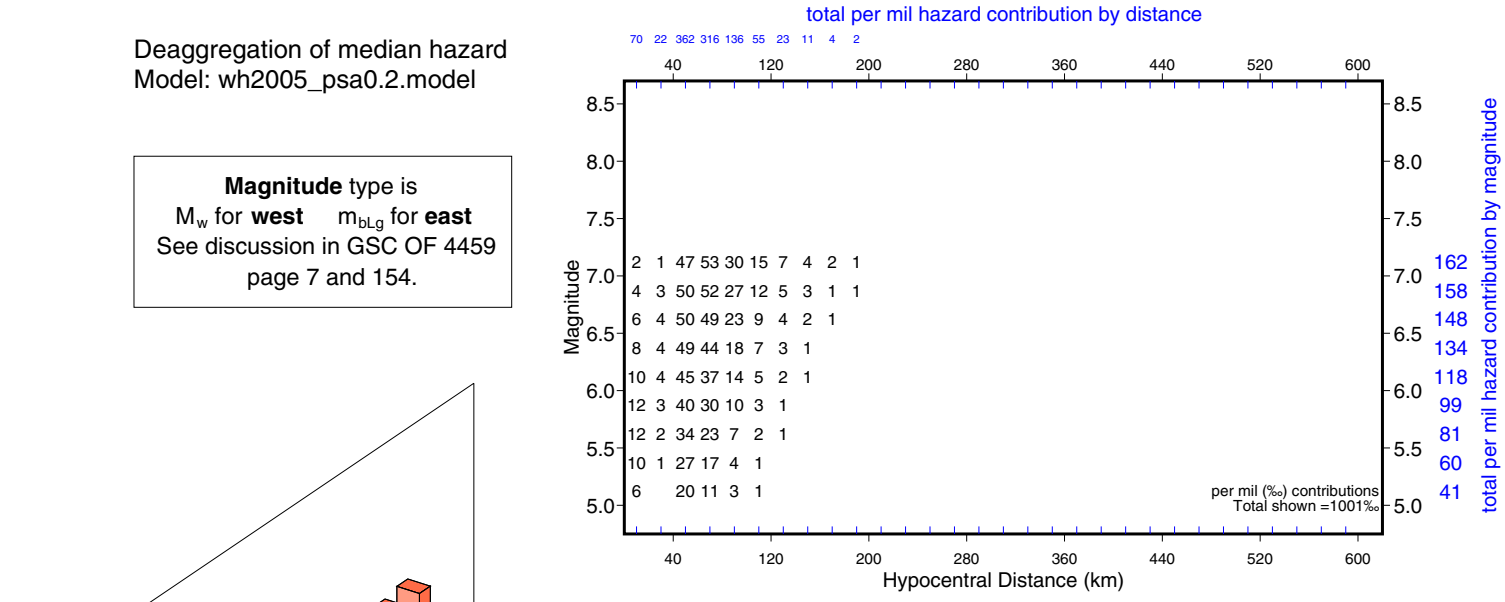
For ground motion parameter: Sa(0.2), spectral acceleration at a 0.2 second period for 2005 NBCC site class C at a probability of 0.002100 per annum, seismic hazard = 0.544 g

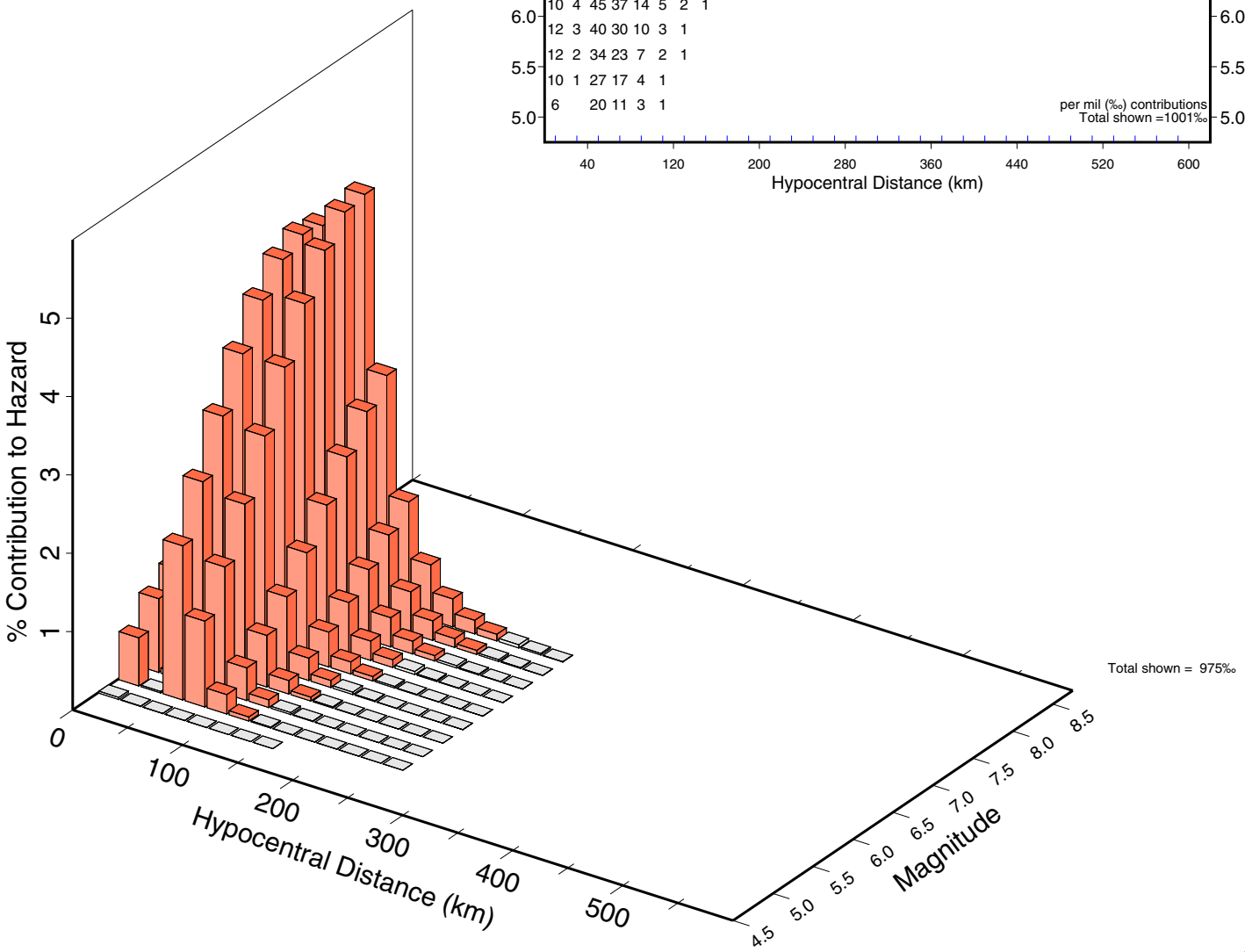
Mean magnitude 6.33 Mean distance 65 km

Modal magnitude 7.125 Modal distance 70 km

Deaggregation of median hazard
Model: wh2005_psa0.2.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459 page 7 and 154.





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Natural Resources Canada Ressources naturelles Canada

Canada

Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/17

For site Vancouver, BC at 49.165 N 122.952 W

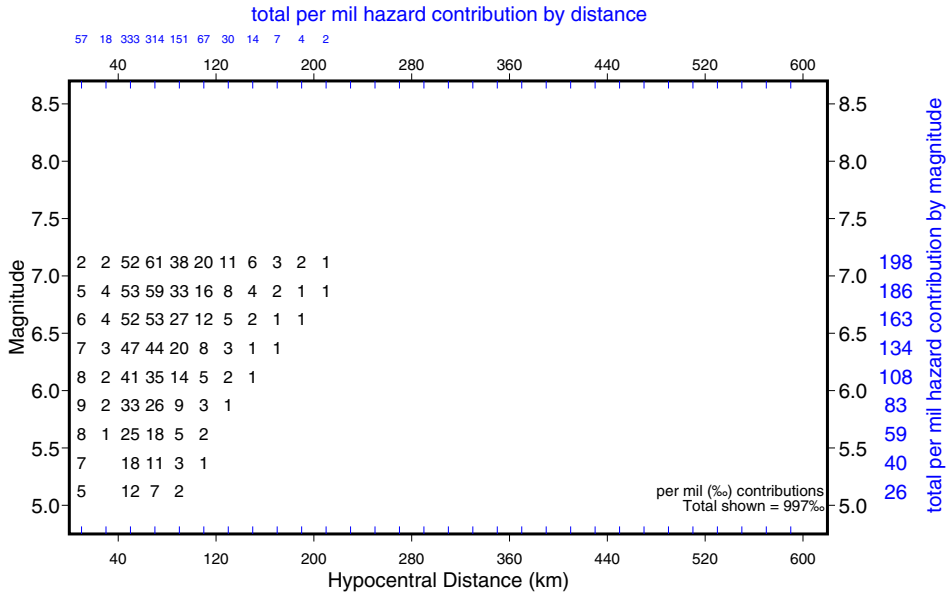
For ground motion parameter: Sa(0.5), spectral acceleration at a 0.5 second period for 2005 NBCC site class C at a probability of 0.002100 per annum, seismic hazard = 0.355 g

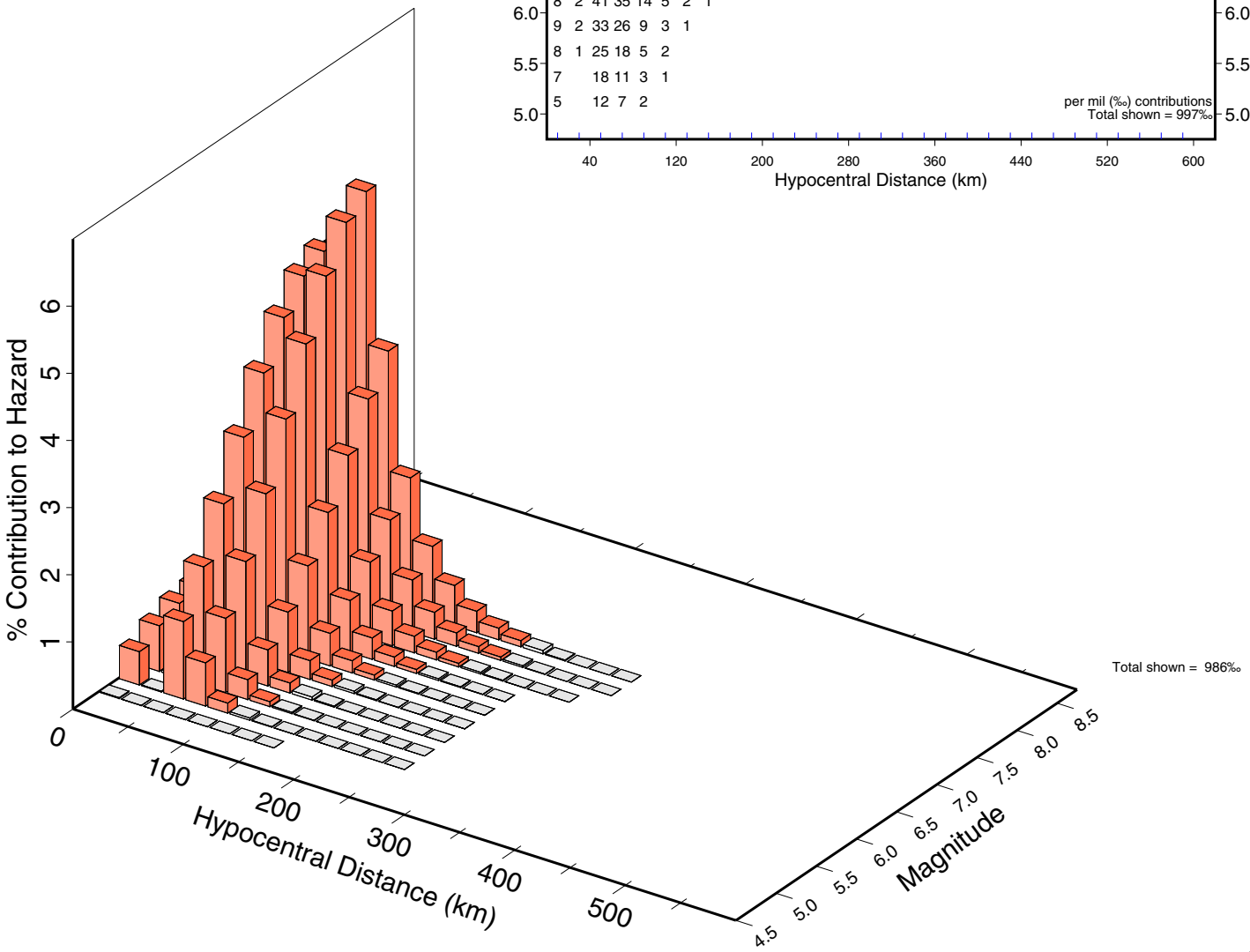
Mean magnitude 6.45 Mean distance 69 km

Modal magnitude 7.125 Modal distance 70 km

Deaggregation of median hazard
Model: wh2005_psa0.5.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459 page 7 and 154.





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/17

For site Vancouver, BC at 49.165 N 122.952 W

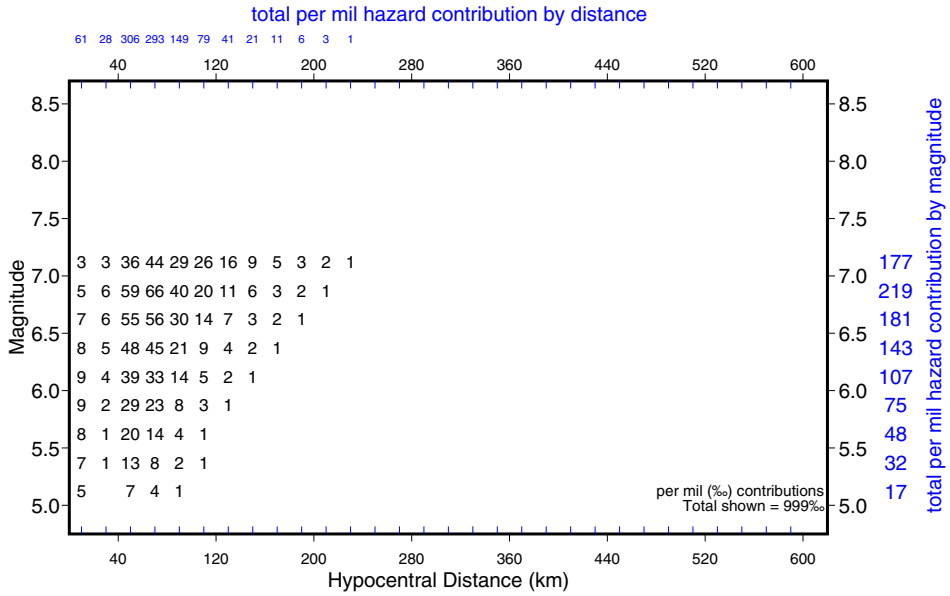
For ground motion parameter: Sa(1.0), spectral acceleration at a 1.0 second period for 2005 NBCC site class C at a probability of 0.002100 per annum, seismic hazard = 0.163 g

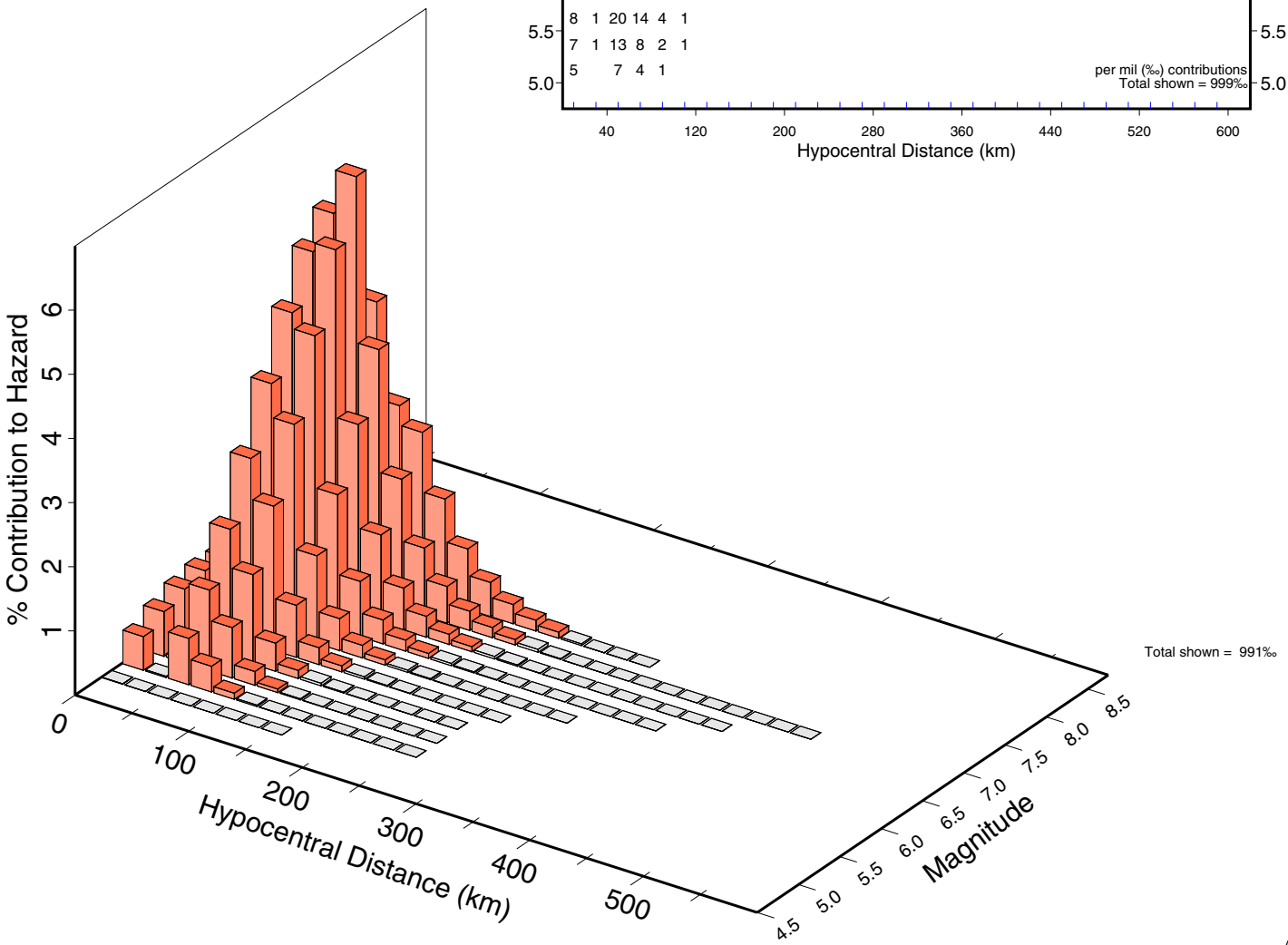
Mean magnitude 6.49 Mean distance 72 km

Modal magnitude 6.875 Modal distance 70 km

Deaggregation of median hazard
Model: wh2005_psa1.0.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459 page 7 and 154.





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/17

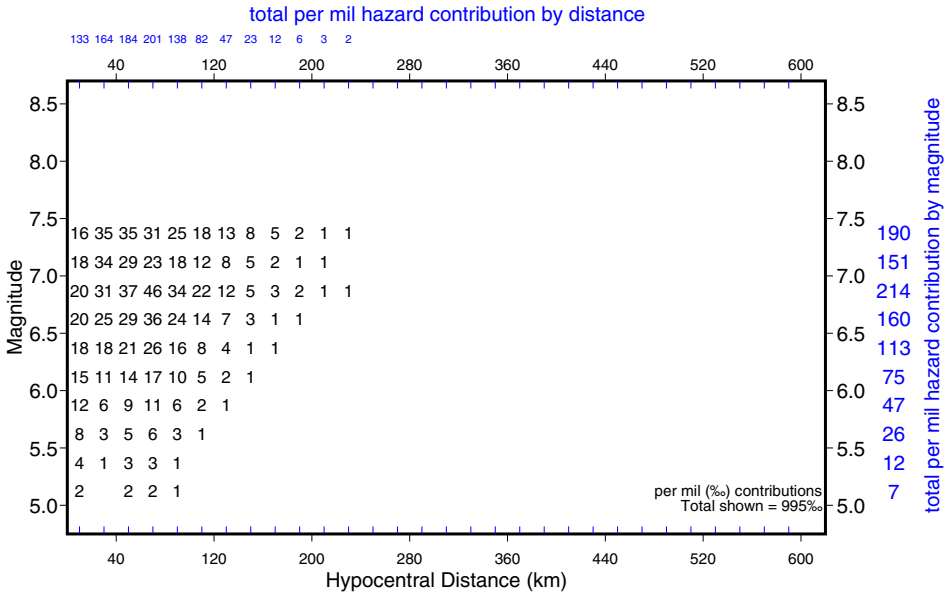
For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter: Sa(2.0), spectral acceleration at a 2.0 second period for 2005 NBCC site class C
at a probability of 0.002100 per annum, seismic hazard = 0.082 g

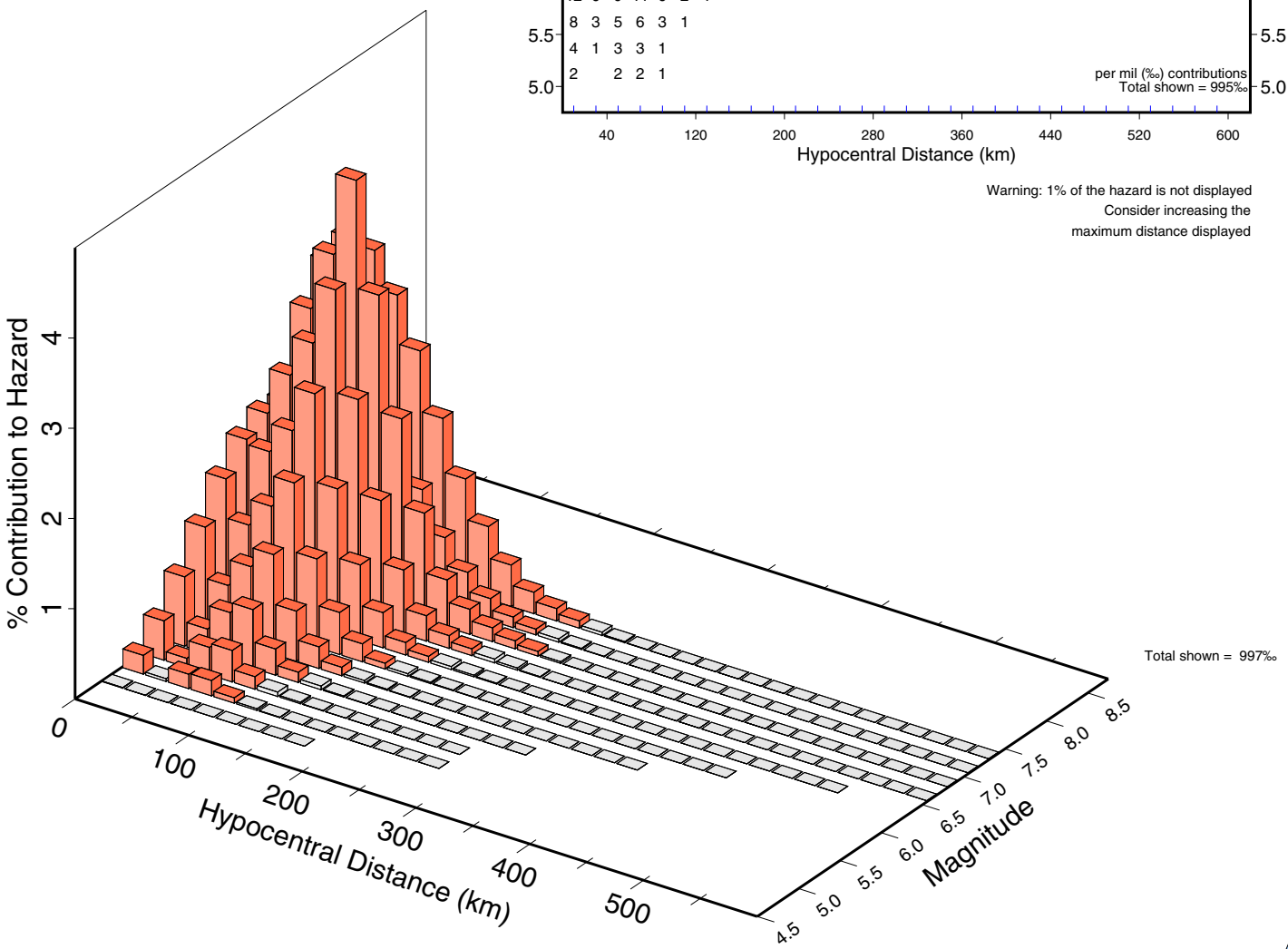
Mean magnitude 6.74 Mean distance 66 km
Modal magnitude 6.875 Modal distance 70 km

Deaggregation of median hazard
Model: wr2005_psa2.0.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459
page 7 and 154.



Warning: 1% of the hazard is not displayed
Consider increasing the
maximum distance displayed



Total shown = 997‰

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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/17

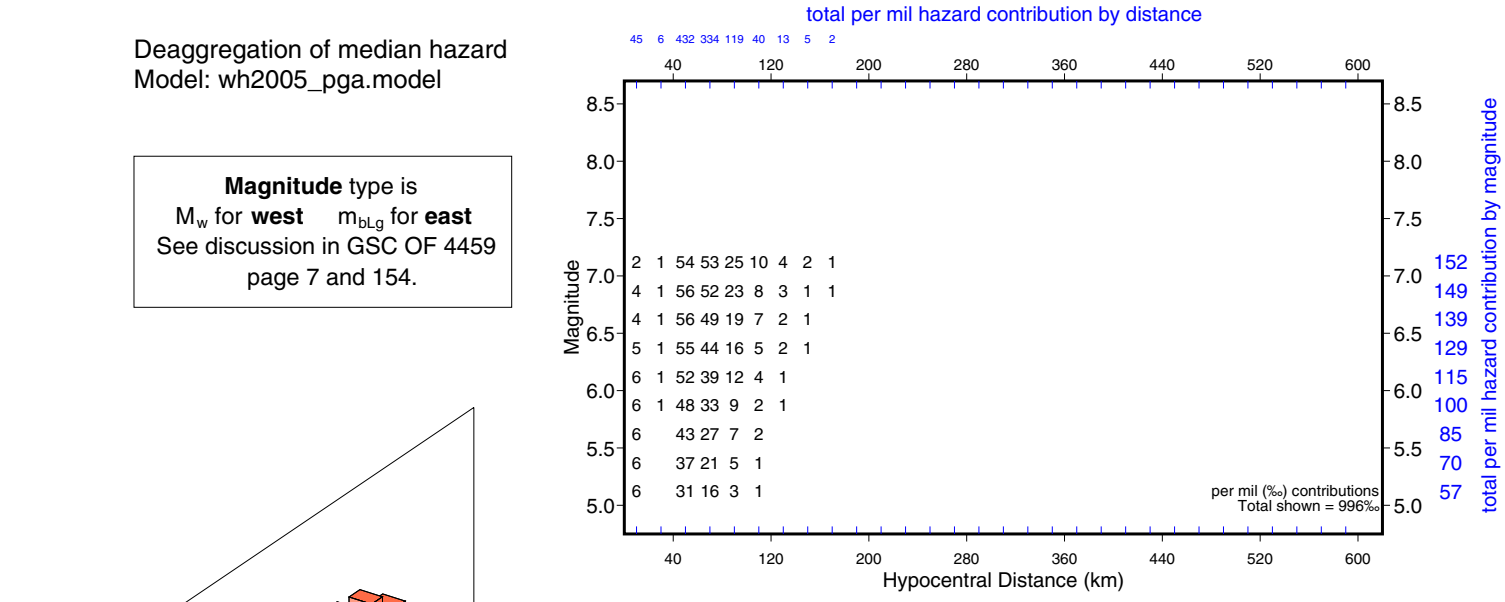
For site Vancouver, BC at 49.165 N 122.952 W

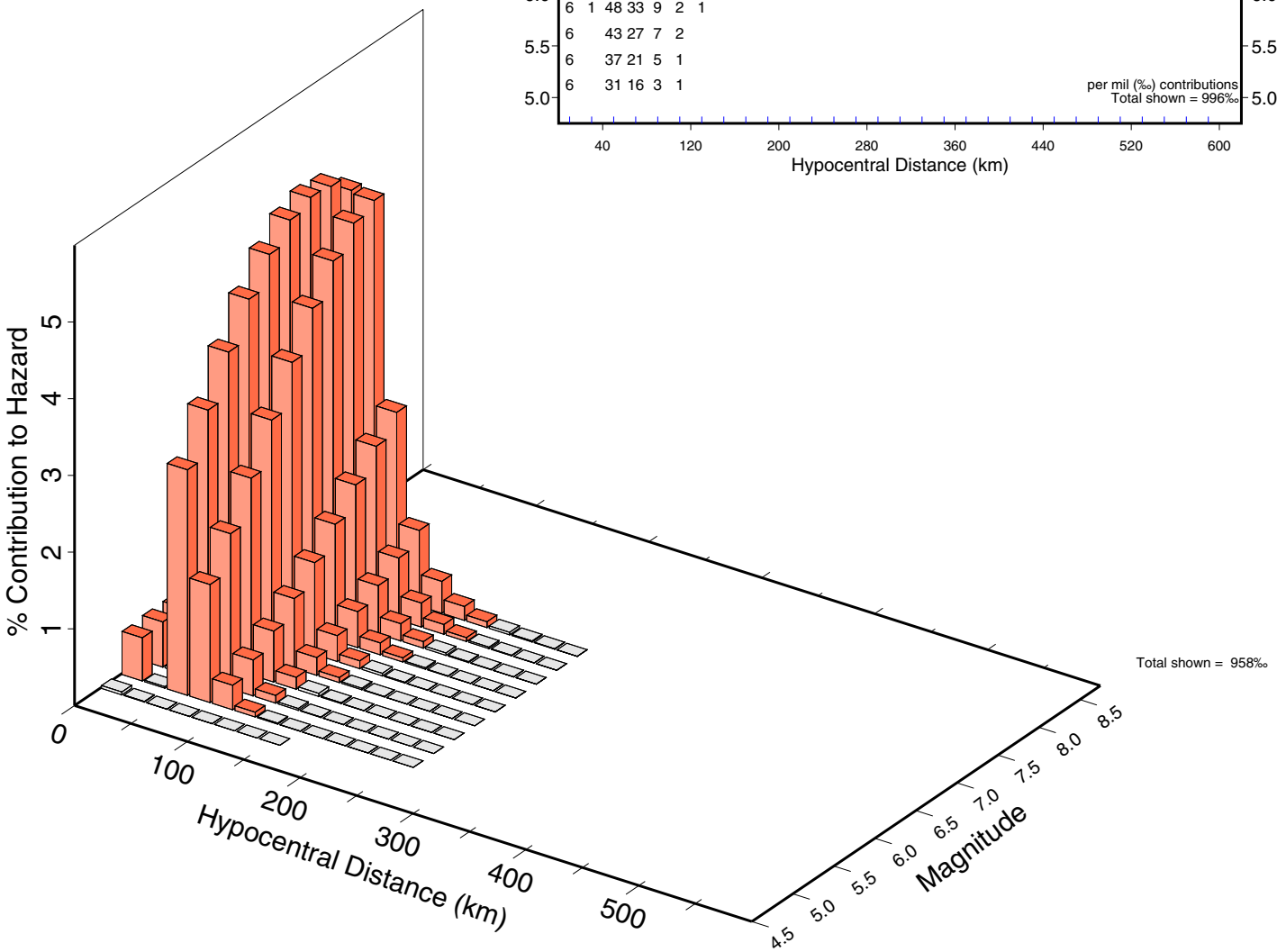
For ground motion parameter: PGA, Peak ground acceleration for 2005 NBCC site class C
at a probability of 0.001000 per annum, seismic hazard = 0.371 g

Mean magnitude 6.25 Mean distance 64 km
Modal magnitude 6.625 Modal distance 50 km

Deaggregation of median hazard
Model: wh2005_pga.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459
page 7 and 154.





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/17

For site Vancouver, BC at 49.165 N 122.952 W

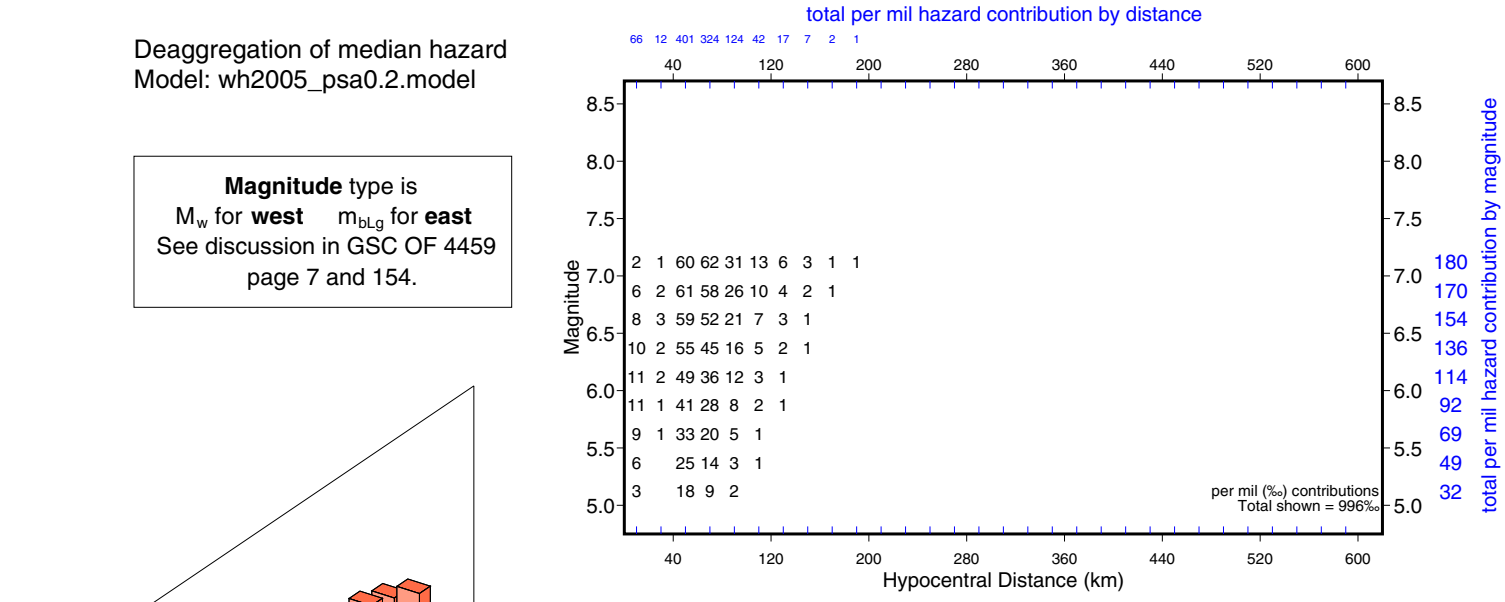
For ground motion parameter: Sa(0.2), spectral acceleration at a 0.2 second period for 2005 NBCC site class C at a probability of 0.001000 per annum, seismic hazard = 0.741 g

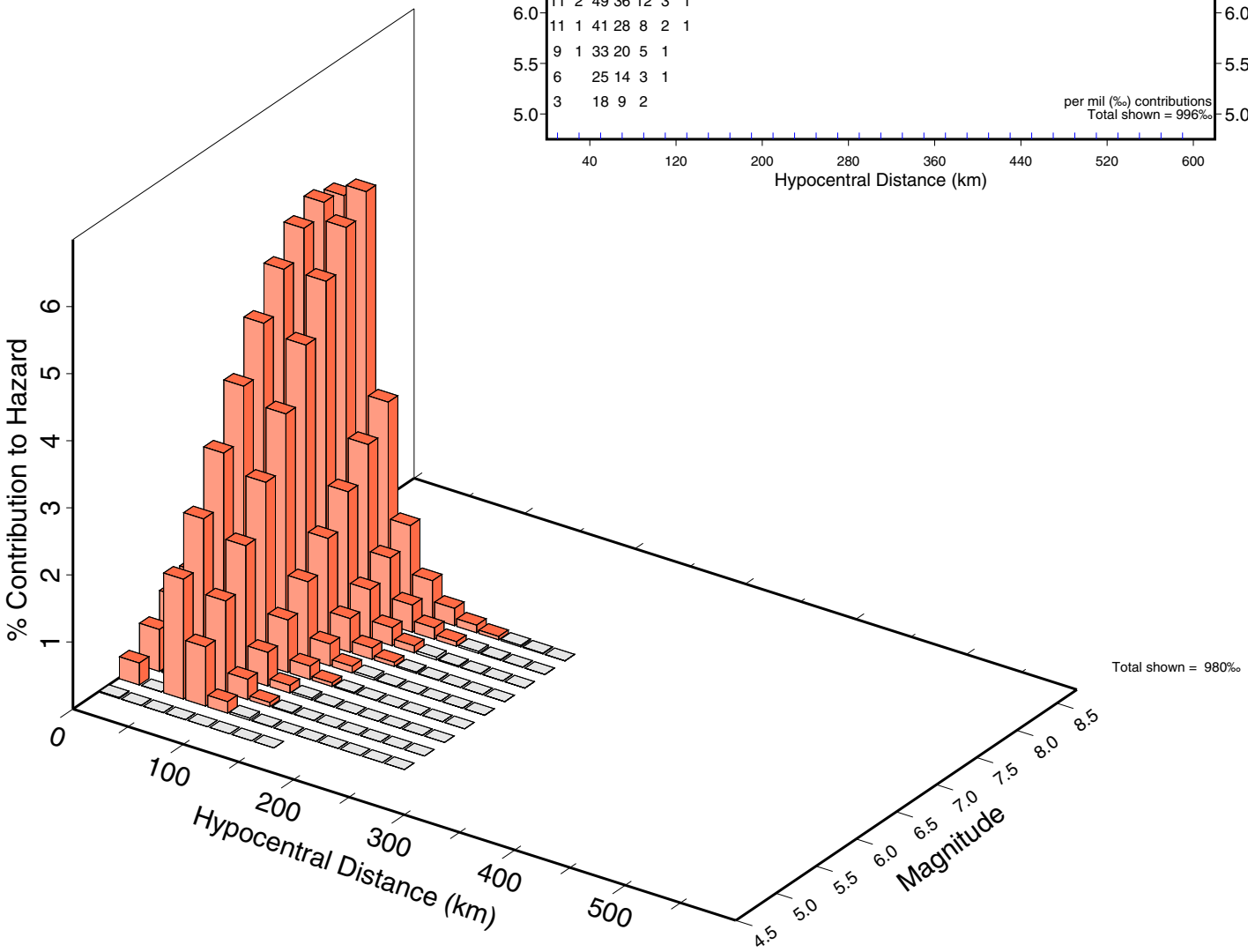
Mean magnitude 6.39 Mean distance 64 km

Modal magnitude 7.125 Modal distance 70 km

Deaggregation of median hazard
Model: wh2005_psa0.2.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459 page 7 and 154.





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/17

For site Vancouver, BC at 49.165 N 122.952 W

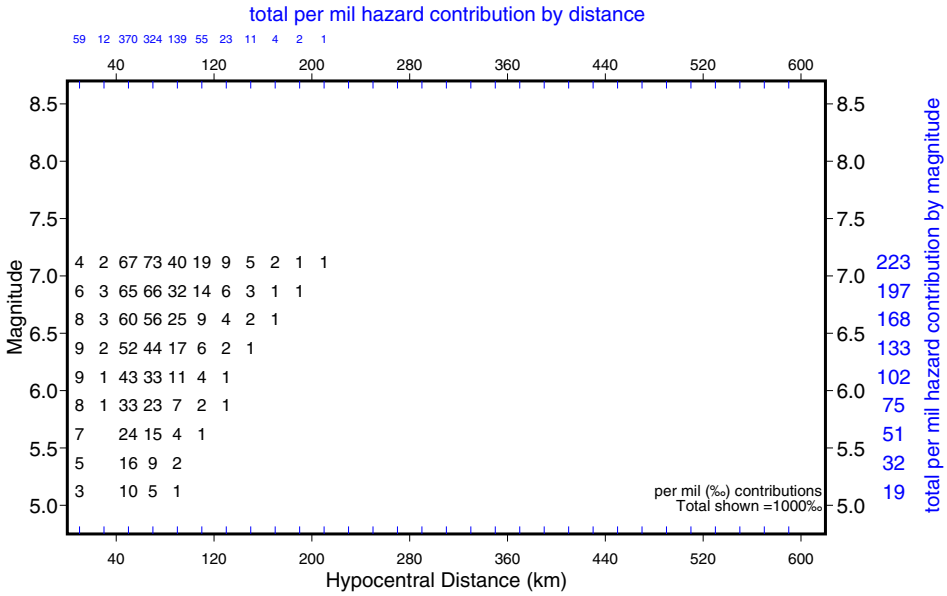
For ground motion parameter: Sa(0.5), spectral acceleration at a 0.5 second period for 2005 NBCC site class C at a probability of 0.001000 per annum, seismic hazard = 0.488 g

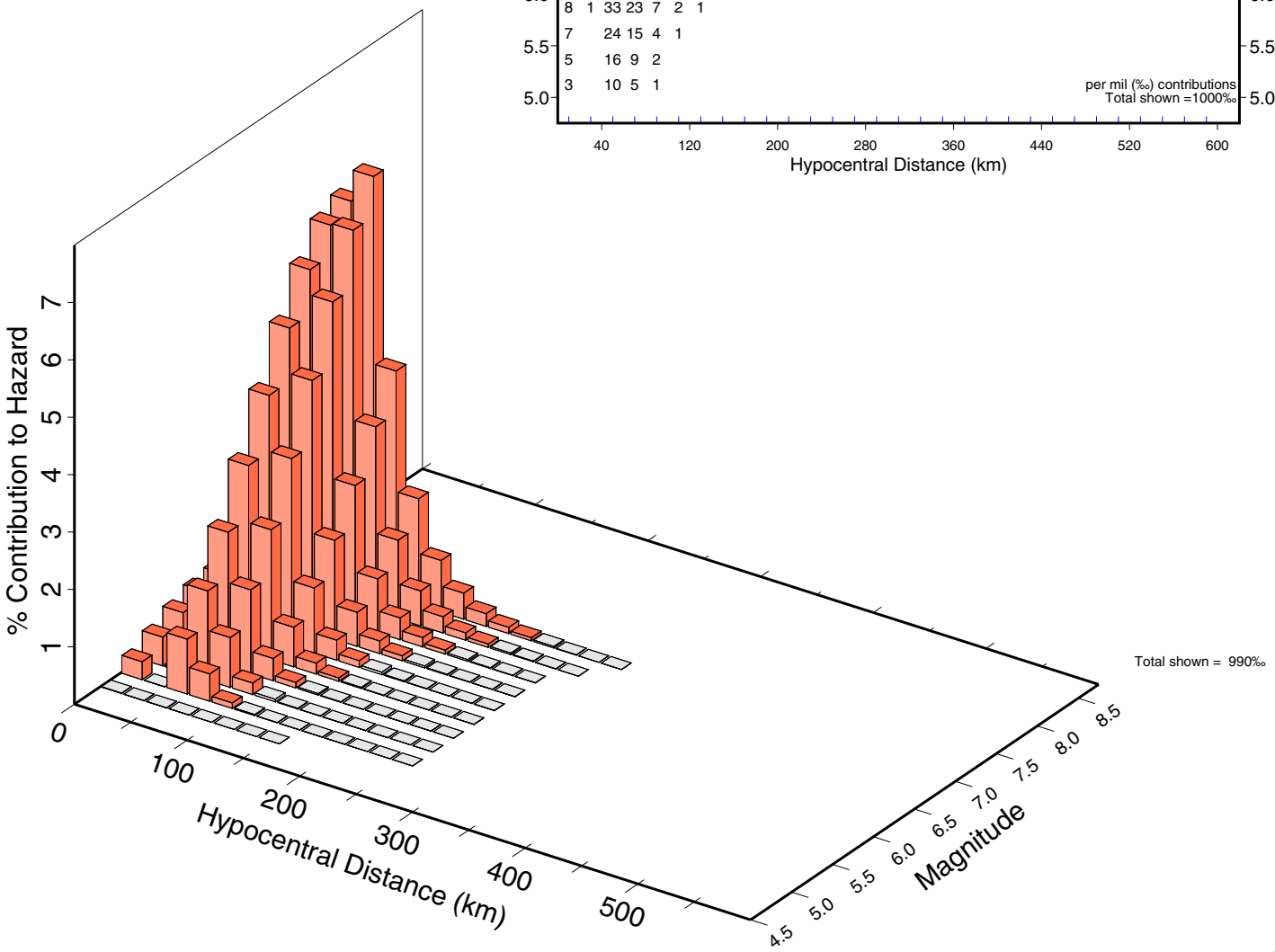
Mean magnitude 6.51 Mean distance 67 km

Modal magnitude 7.125 Modal distance 70 km

Deaggregation of median hazard
Model: wh2005_psa0.5.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459 page 7 and 154.





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/17

For site Vancouver, BC at 49.165 N 122.952 W

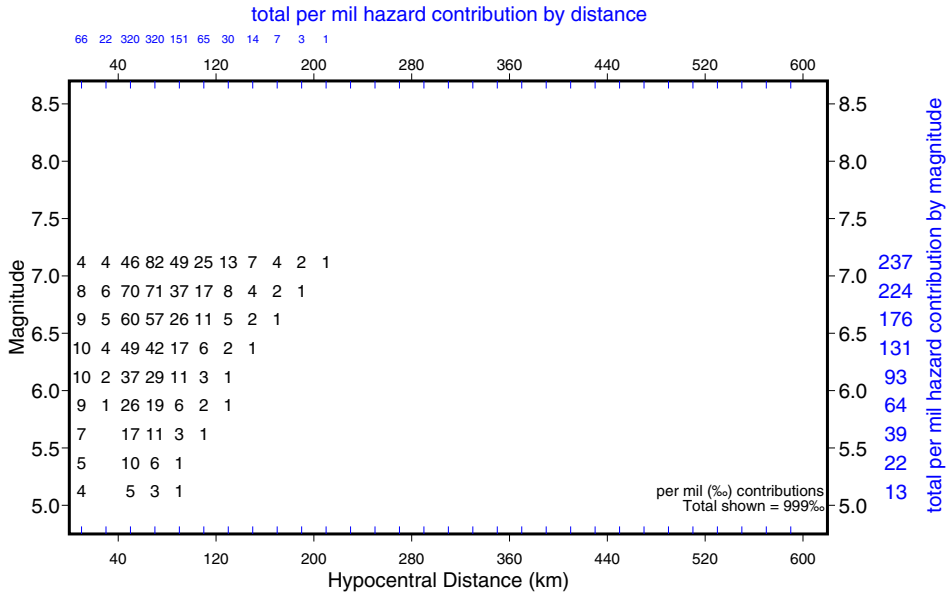
For ground motion parameter: Sa(1.0), spectral acceleration at a 1.0 second period for 2005 NBCC site class C at a probability of 0.001000 per annum, seismic hazard = 0.224 g

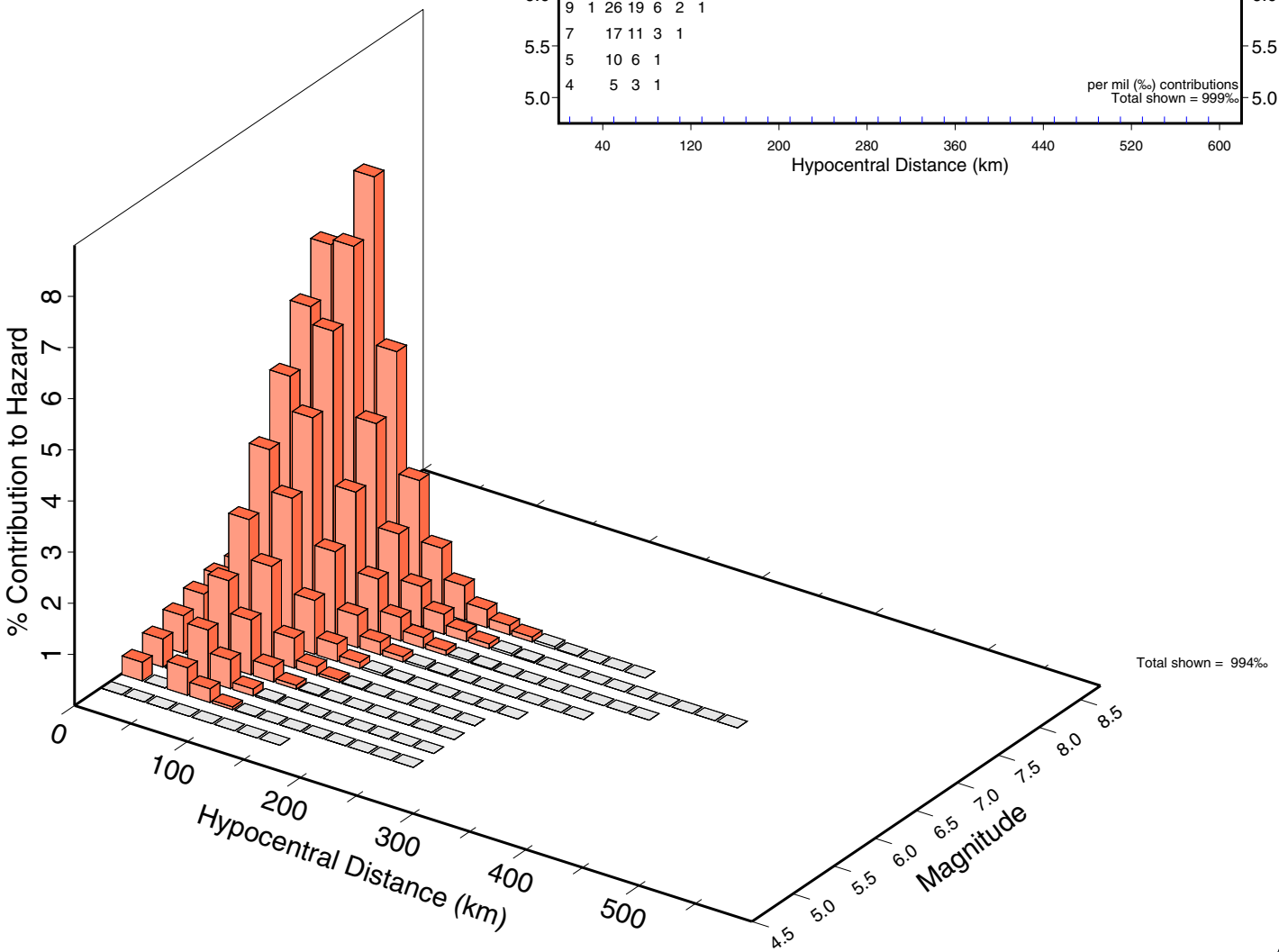
Mean magnitude 6.57 Mean distance 69 km

Modal magnitude 7.125 Modal distance 70 km

Deaggregation of median hazard
Model: wh2005_psa1.0.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459 page 7 and 154.





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/17

For site Vancouver, BC at 49.165 N 122.952 W

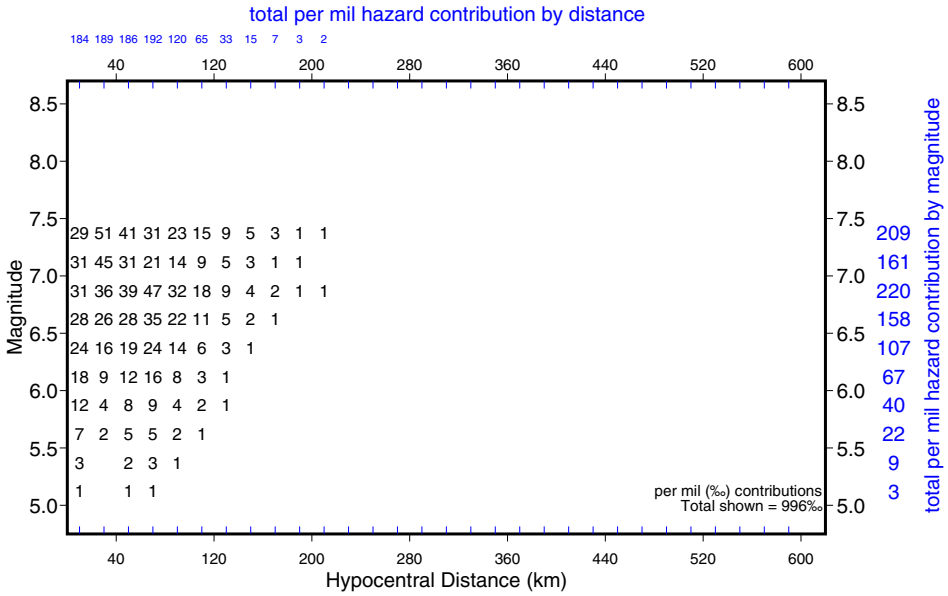
For ground motion parameter: Sa(2.0), spectral acceleration at a 2.0 second period for 2005 NBCC site class C at a probability of 0.001000 per annum, seismic hazard = 0.113 g

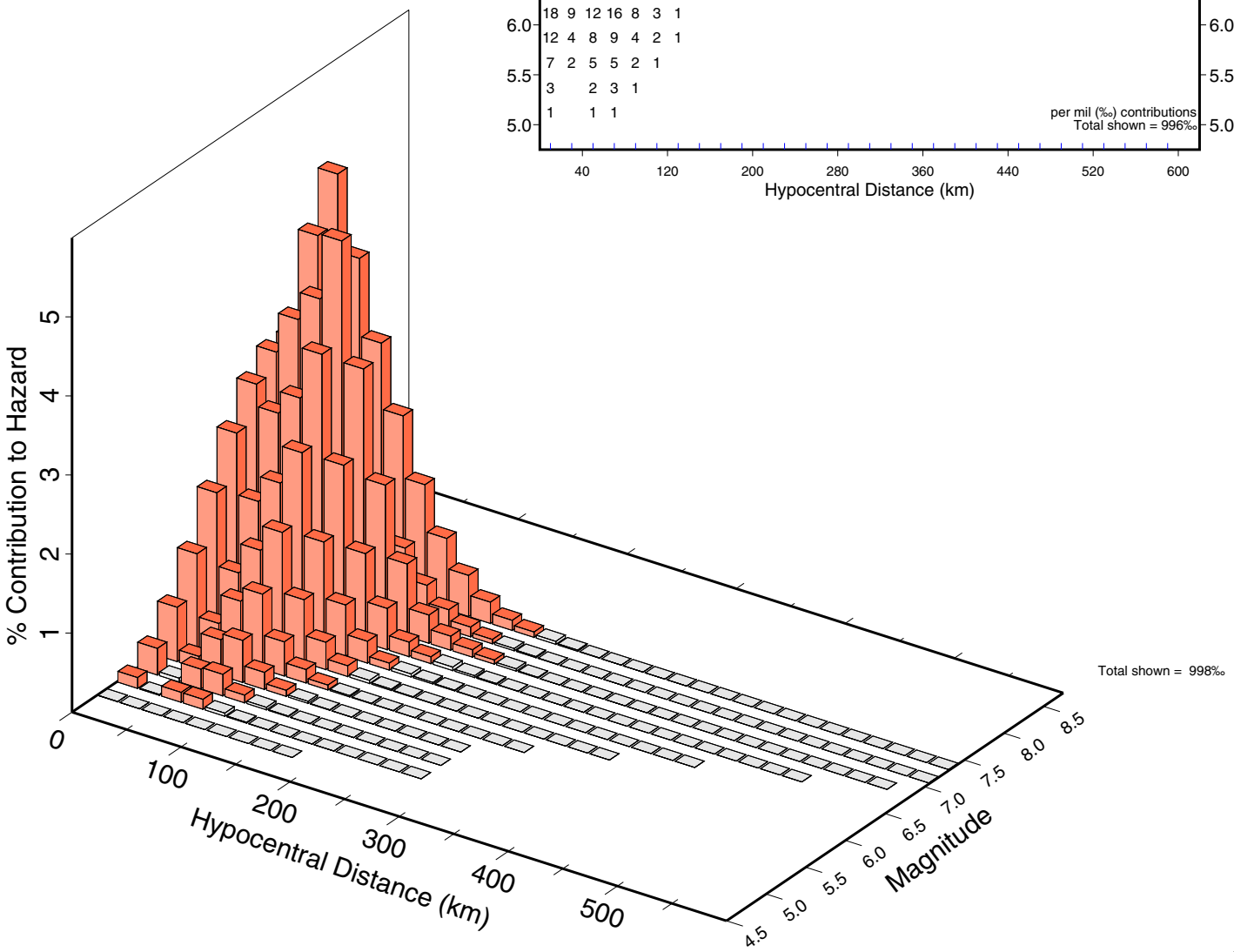
Mean magnitude 6.78 Mean distance 58 km

Modal magnitude 7.375 Modal distance 30 km

Deaggregation of median hazard
Model: wr2005_psa2.0.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459 page 7 and 154.





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/16

For site Vancouver, BC at 49.165 N 122.952 W

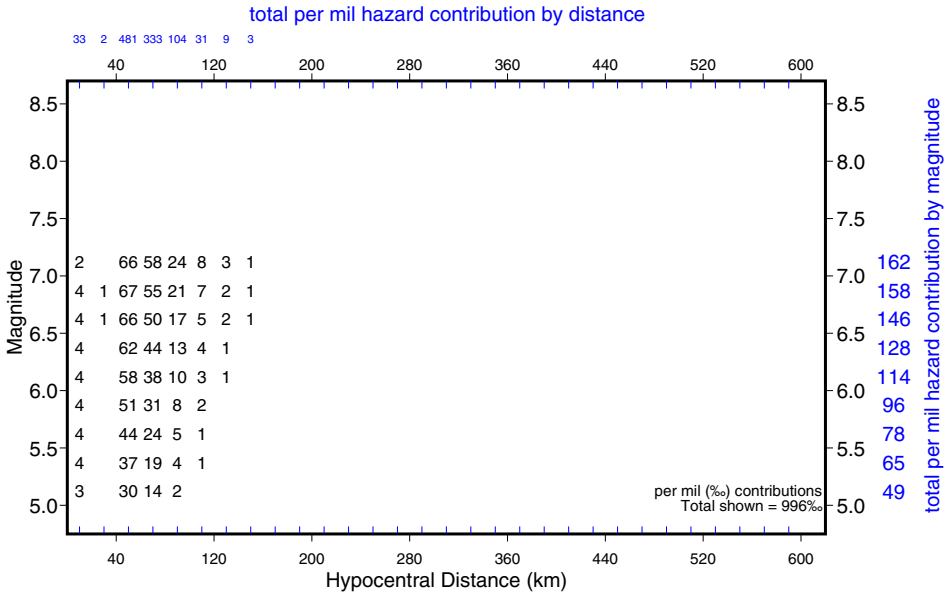
For ground motion parameter: PGA, Peak ground acceleration for 2005 NBCC site class C
at a probability of 0.000404 per annum, seismic hazard = 0.515 g

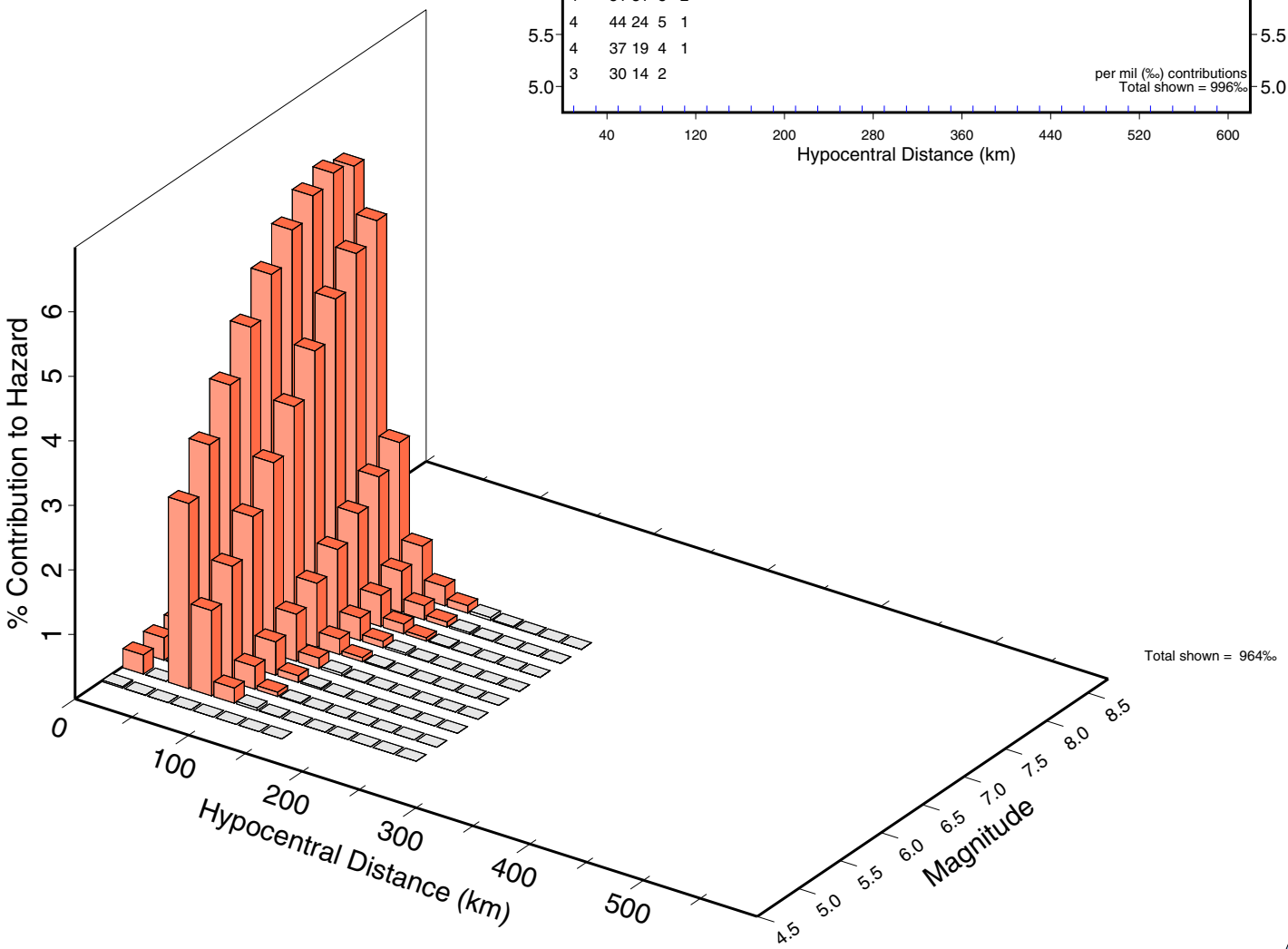
Mean magnitude 6.30 Mean distance 62 km

Modal magnitude 6.875 Modal distance 50 km

Deaggregation of median hazard
Model: wh2005_pga.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459
page 7 and 154.





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/16

For site Vancouver, BC at 49.165 N 122.952 W

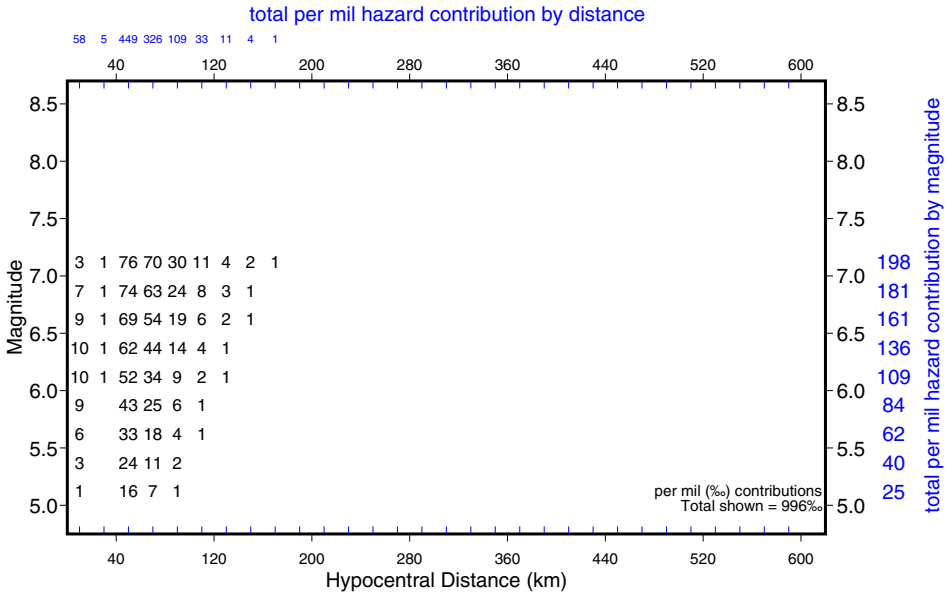
For ground motion parameter: Sa(0.2), spectral acceleration at a 0.2 second period for 2005 NBCC site class C at a probability of 0.000404 per annum, seismic hazard = 1.033 g

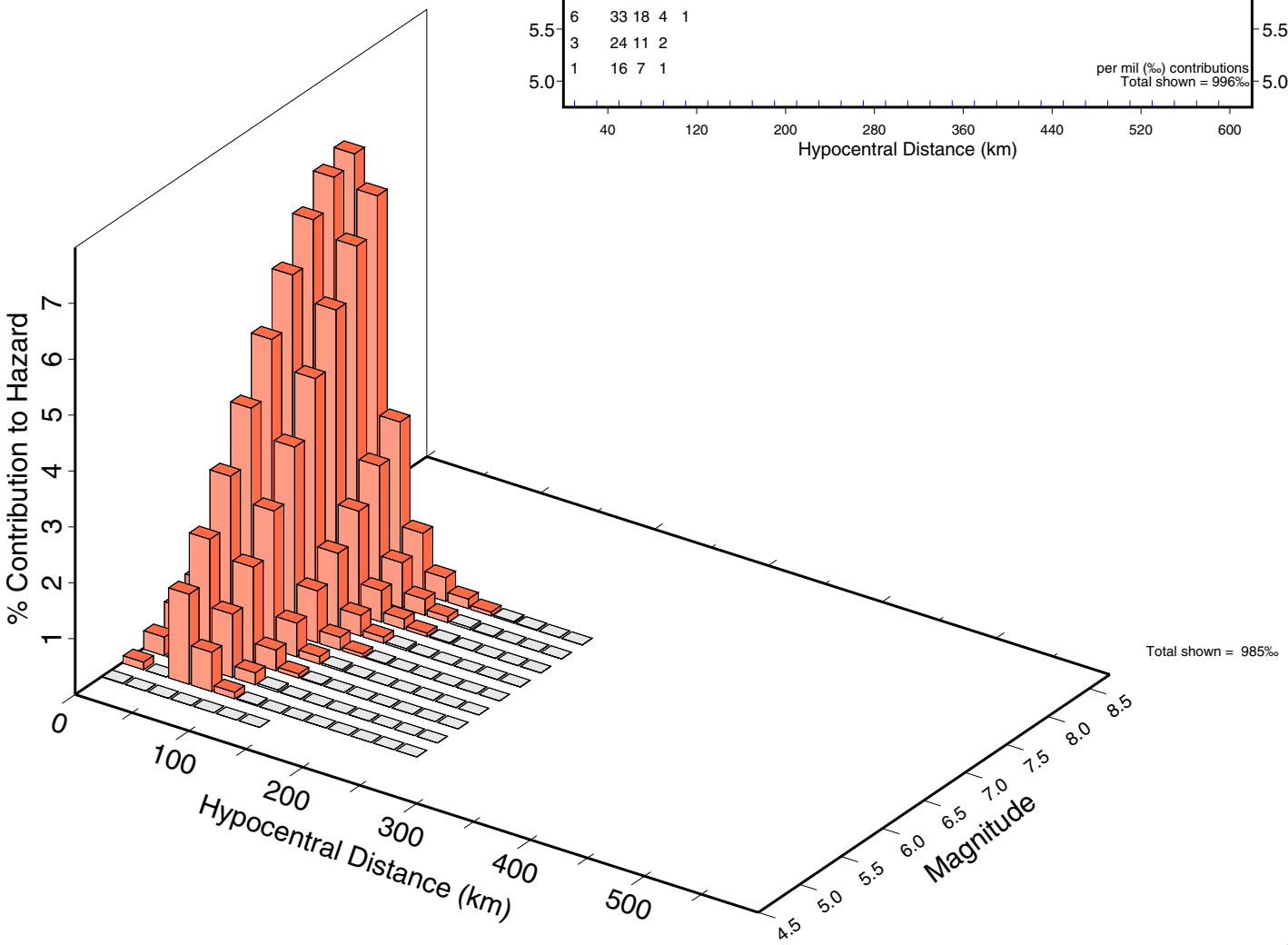
Mean magnitude 6.44 Mean distance 62 km

Modal magnitude 7.125 Modal distance 50 km

Deaggregation of median hazard
Model: wh2005_psa0.2.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459 page 7 and 154.





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/16

For site Vancouver, BC at 49.165 N 122.952 W

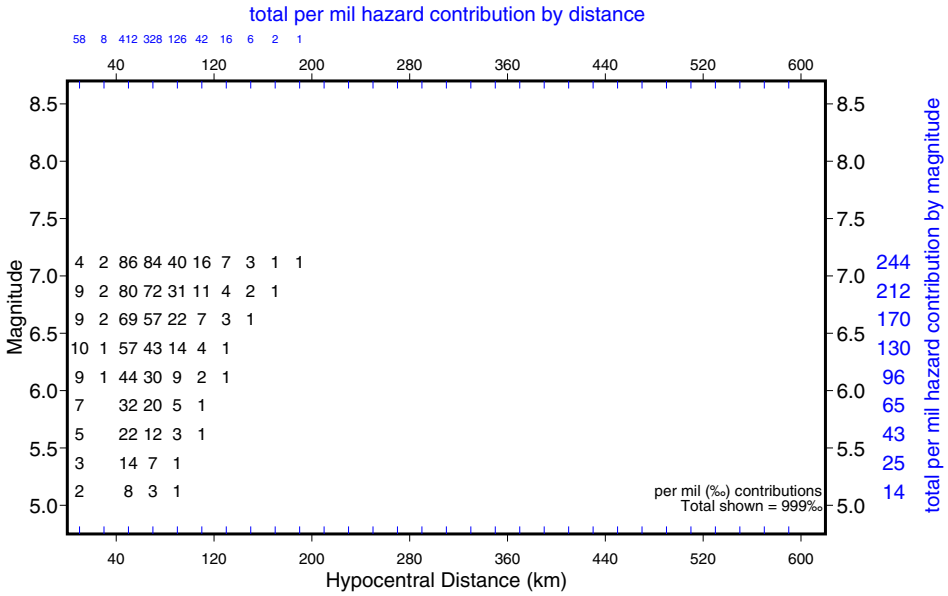
For ground motion parameter: Sa(0.5), spectral acceleration at a 0.5 second period for 2005 NBCC site class C at a probability of 0.000404 per annum, seismic hazard = 0.687 g

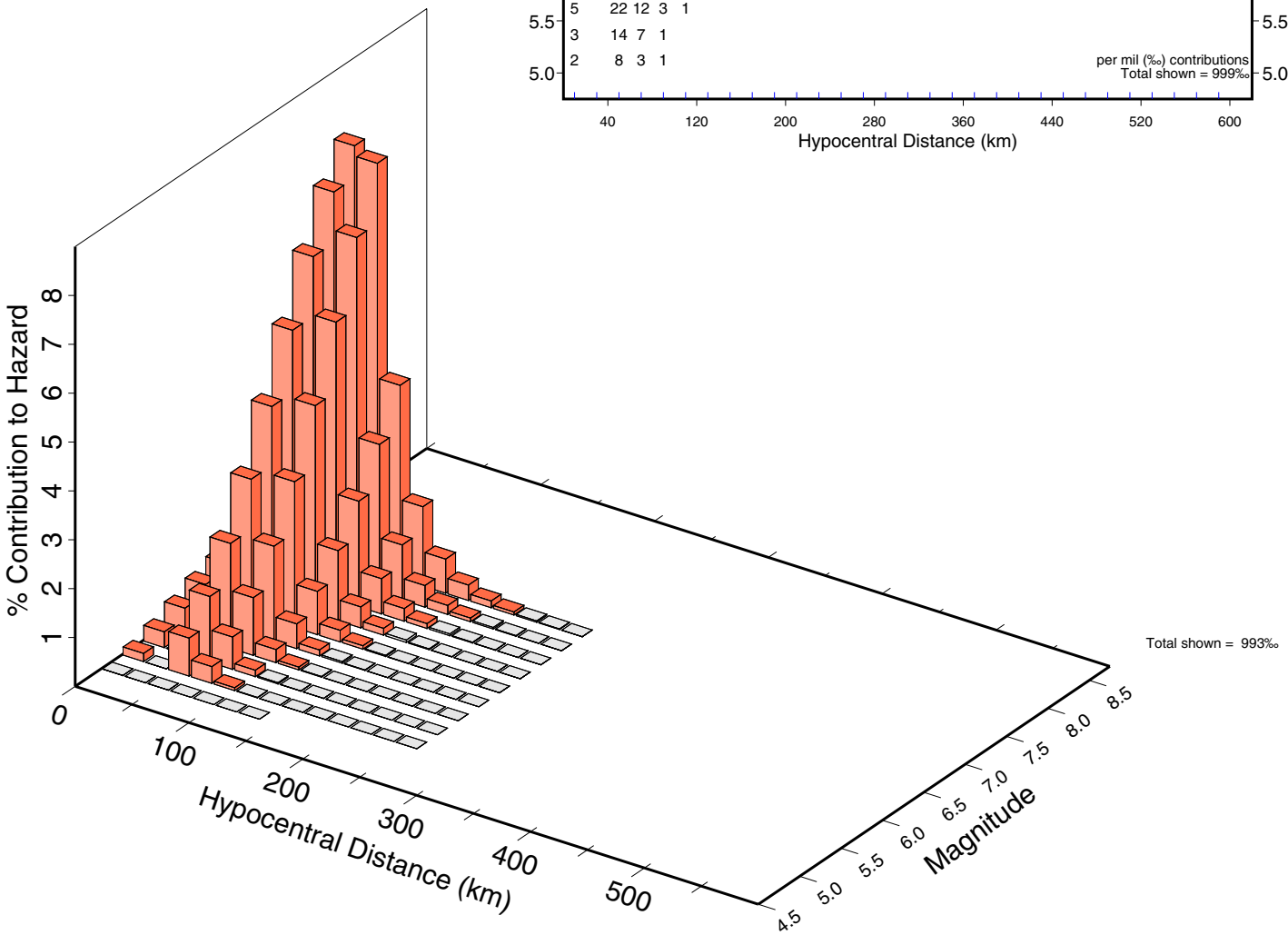
Mean magnitude 6.57 Mean distance 64 km

Modal magnitude 7.125 Modal distance 50 km

Deaggregation of median hazard
Model: wh2005_psa0.5.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459 page 7 and 154.





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/16

For site Vancouver, BC at 49.165 N 122.952 W

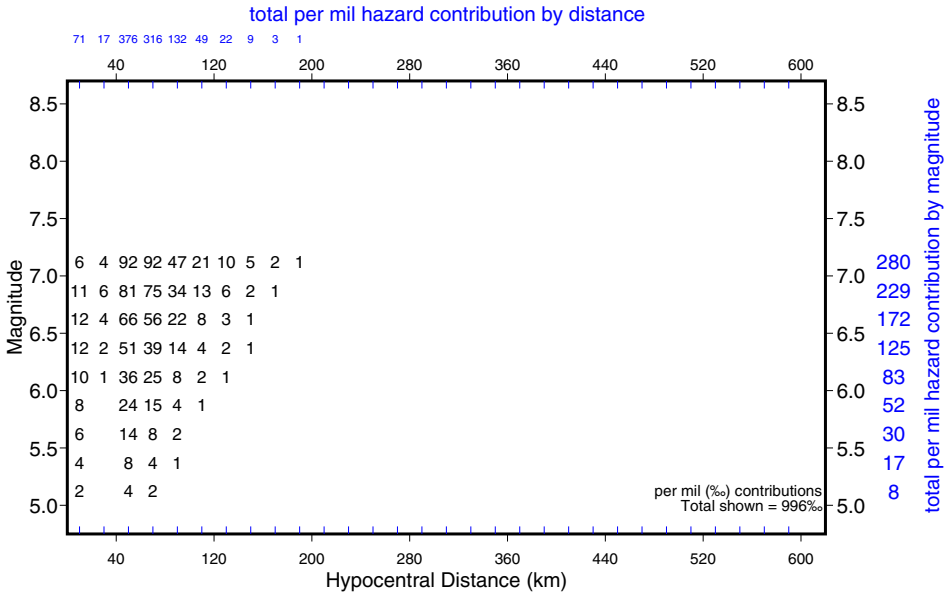
For ground motion parameter: Sa(1.0), spectral acceleration at a 1.0 second period for 2005 NBCC site class C at a probability of 0.000404 per annum, seismic hazard = 0.318 g

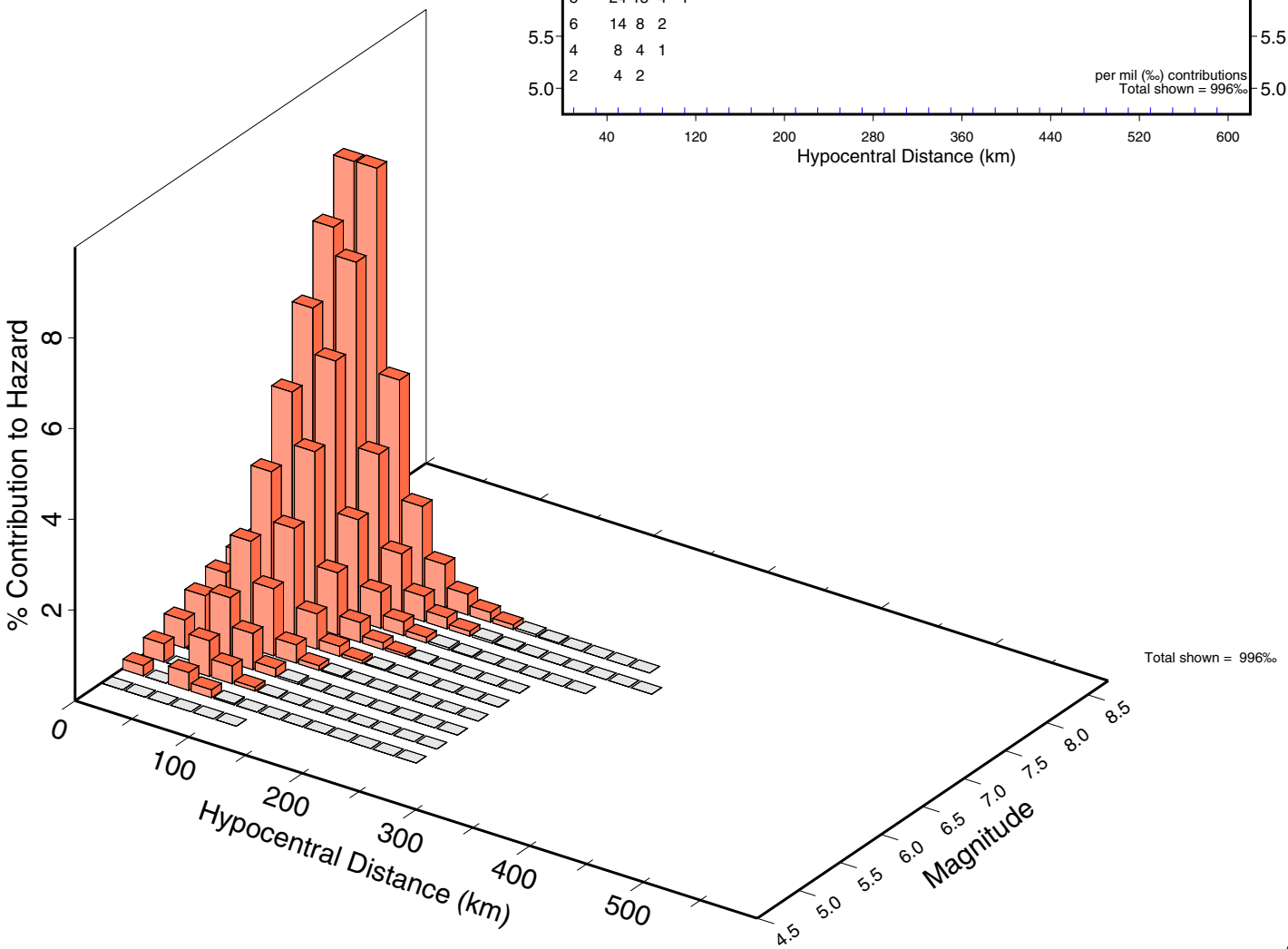
Mean magnitude 6.64 Mean distance 65 km

Modal magnitude 7.125 Modal distance 70 km

Deaggregation of median hazard
Model: wh2005_psa1.0.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459 page 7 and 154.





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Deaggregation requested by: Viji Fernando, Golder Associates 2015/11/16

For site Vancouver, BC at 49.165 N 122.952 W

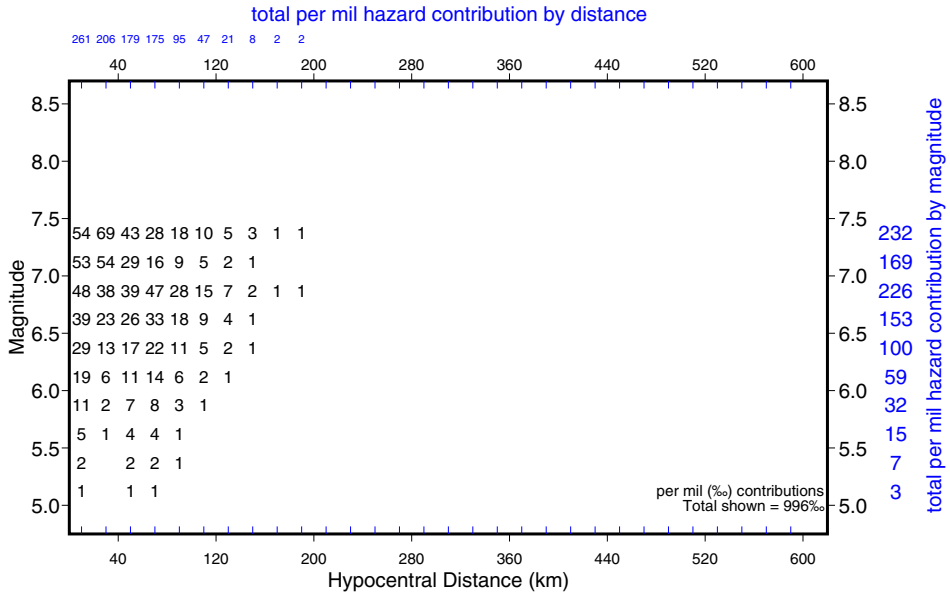
For ground motion parameter: Sa(2.0), spectral acceleration at a 2.0 second period for 2005 NBCC site class C at a probability of 0.000404 per annum, seismic hazard = 0.161 g

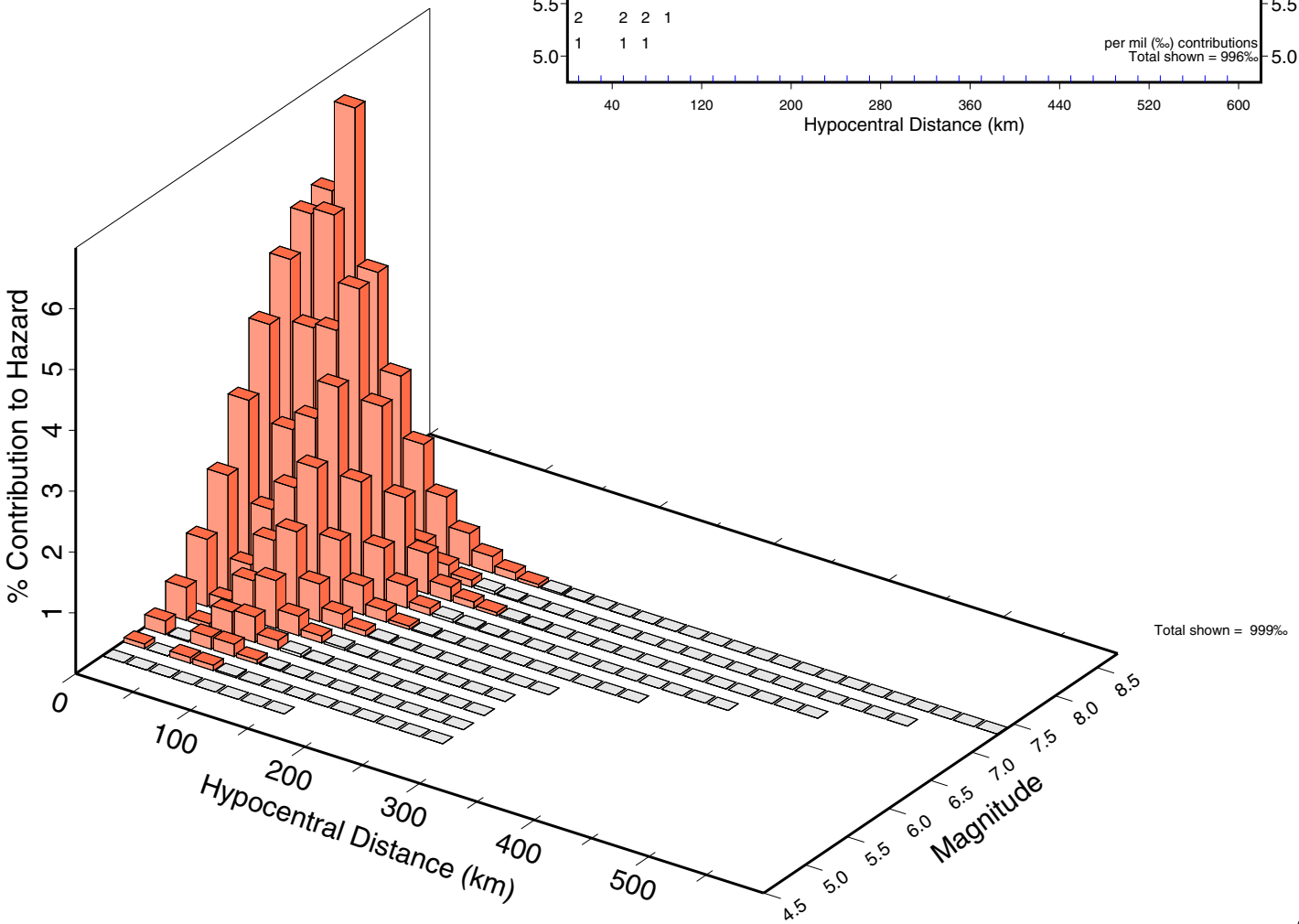
Mean magnitude 6.83 Mean distance 49 km

Modal magnitude 7.375 Modal distance 30 km

Deaggregation of median hazard
Model: wr2005_psa2.0.model

Magnitude type is
M_w for **west** m_{bLg} for **east**
See discussion in GSC OF 4459 page 7 and 154.





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Natural Resources Canada Ressources naturelles Canada

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ATTACHMENT 2 -
Seismic Hazard De-aggregation (2015 NBCC)

Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter peak ground acceleration (PGA)

at a probability of 0.002100 per annum, seismic hazard = 0.187 g

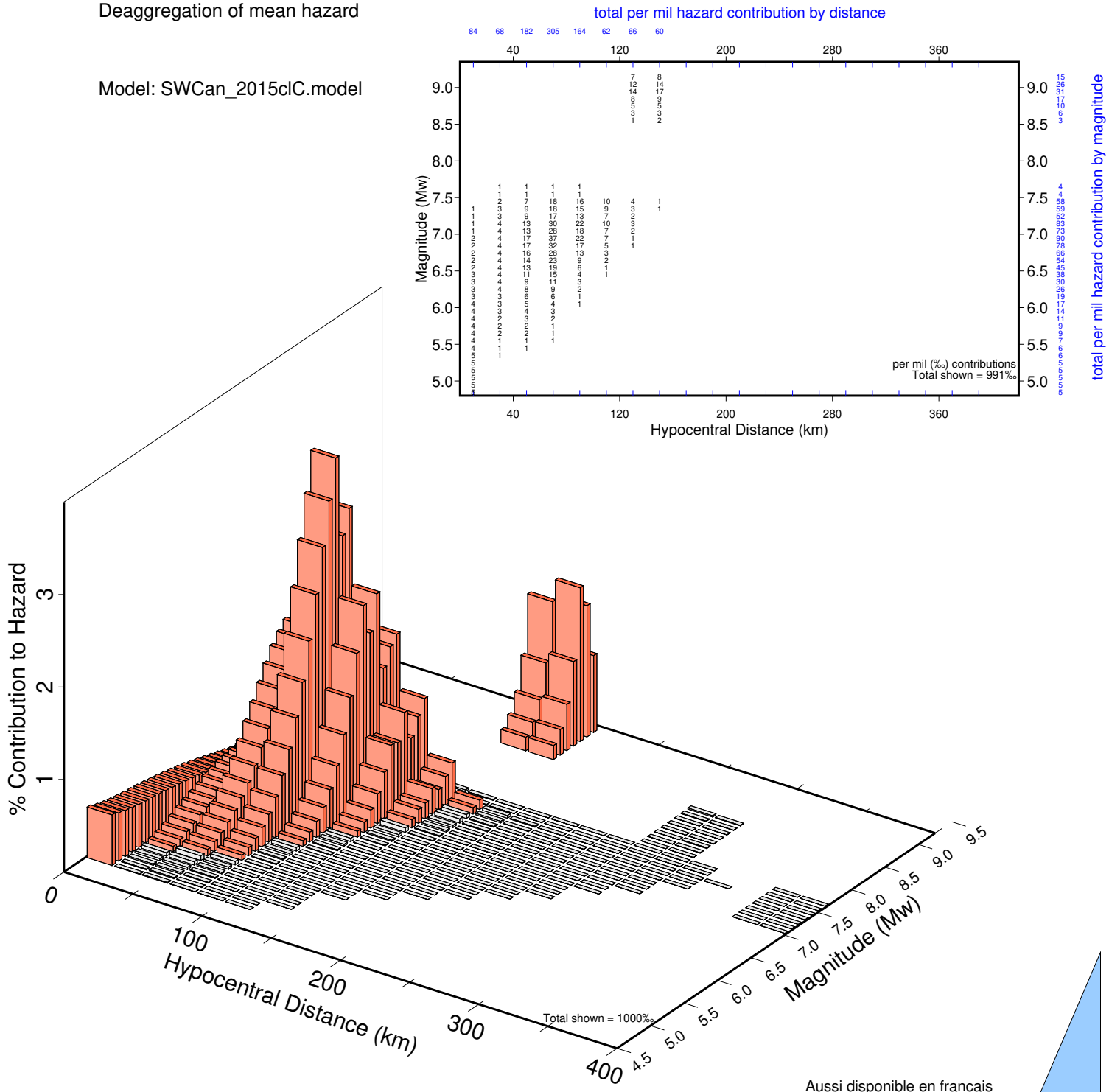
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 6.99 Mean distance 73 km

Mode magnitude (Mw) 6.950 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.05 seconds

at a probability of 0.002100 per annum, seismic hazard = 0.224 g

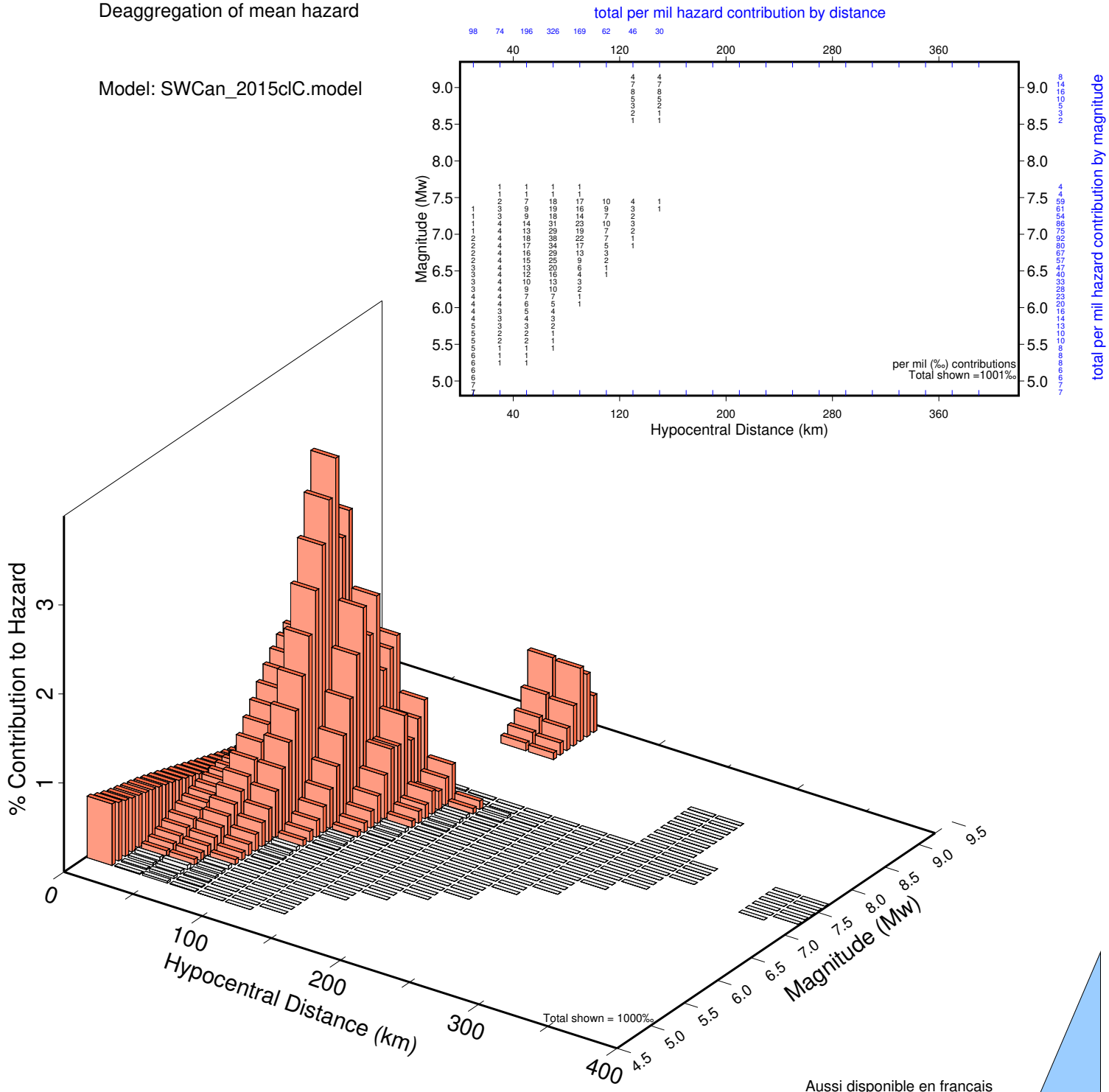
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 6.85 Mean distance 69 km

Mode magnitude (Mw) 6.950 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Natural Resources Canada Ressources naturelles Canada

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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*

Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.10 seconds

at a probability of 0.002100 per annum, seismic hazard = 0.343 g

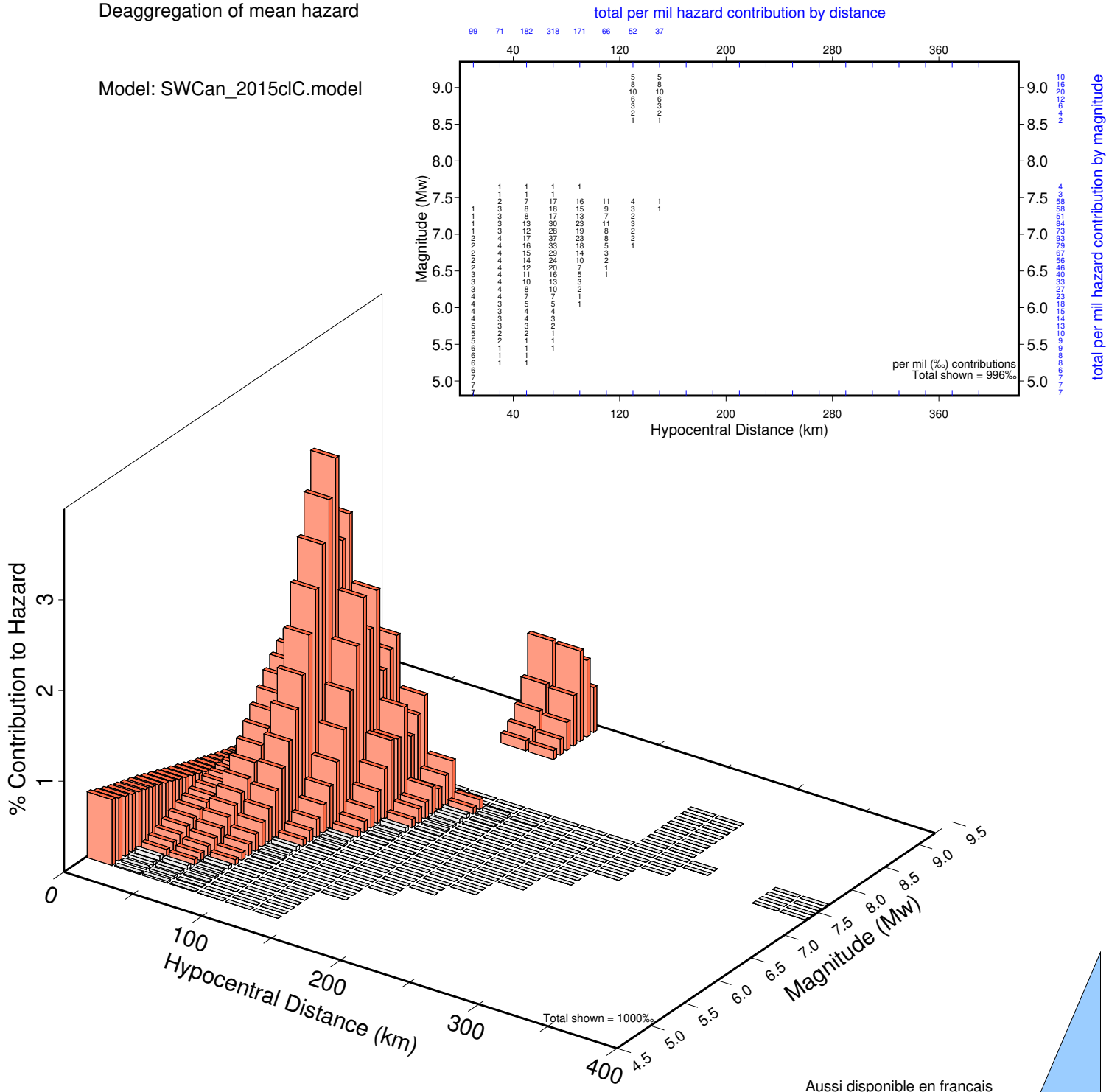
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 6.87 Mean distance 70 km

Mode magnitude (Mw) 6.950 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*

Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.20 seconds

at a probability of 0.002100 per annum, seismic hazard = 0.434 g

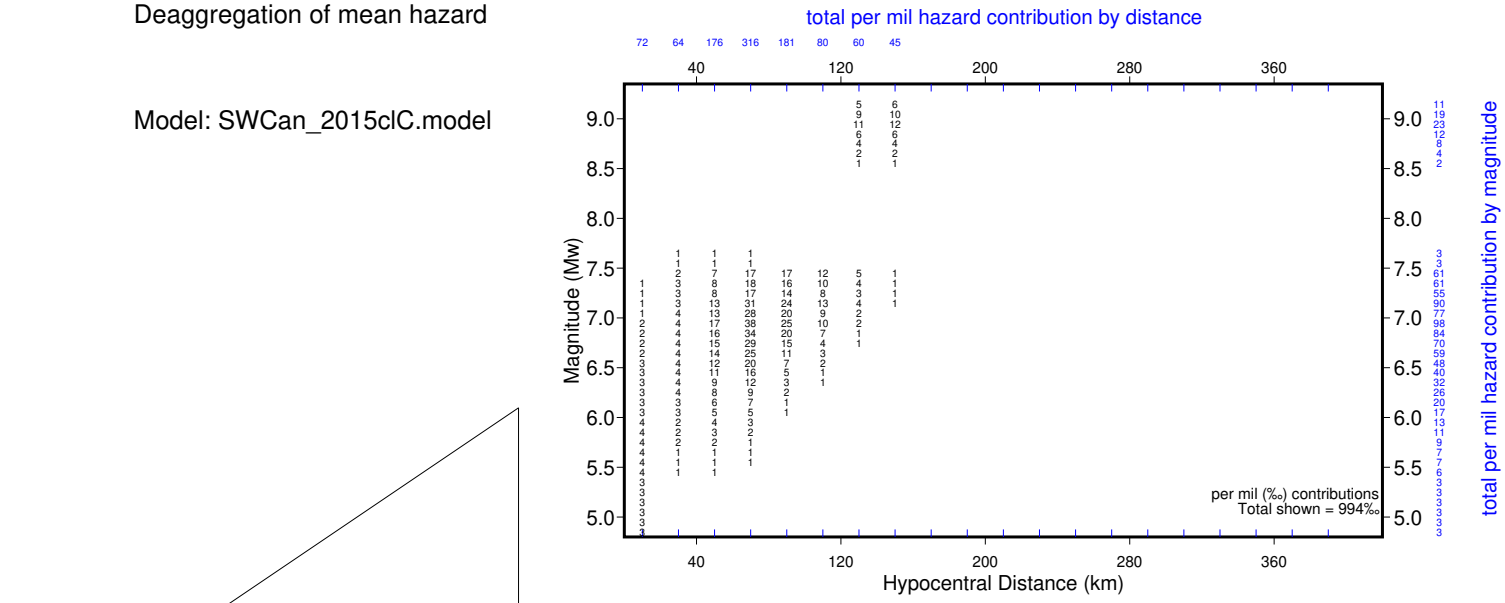
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

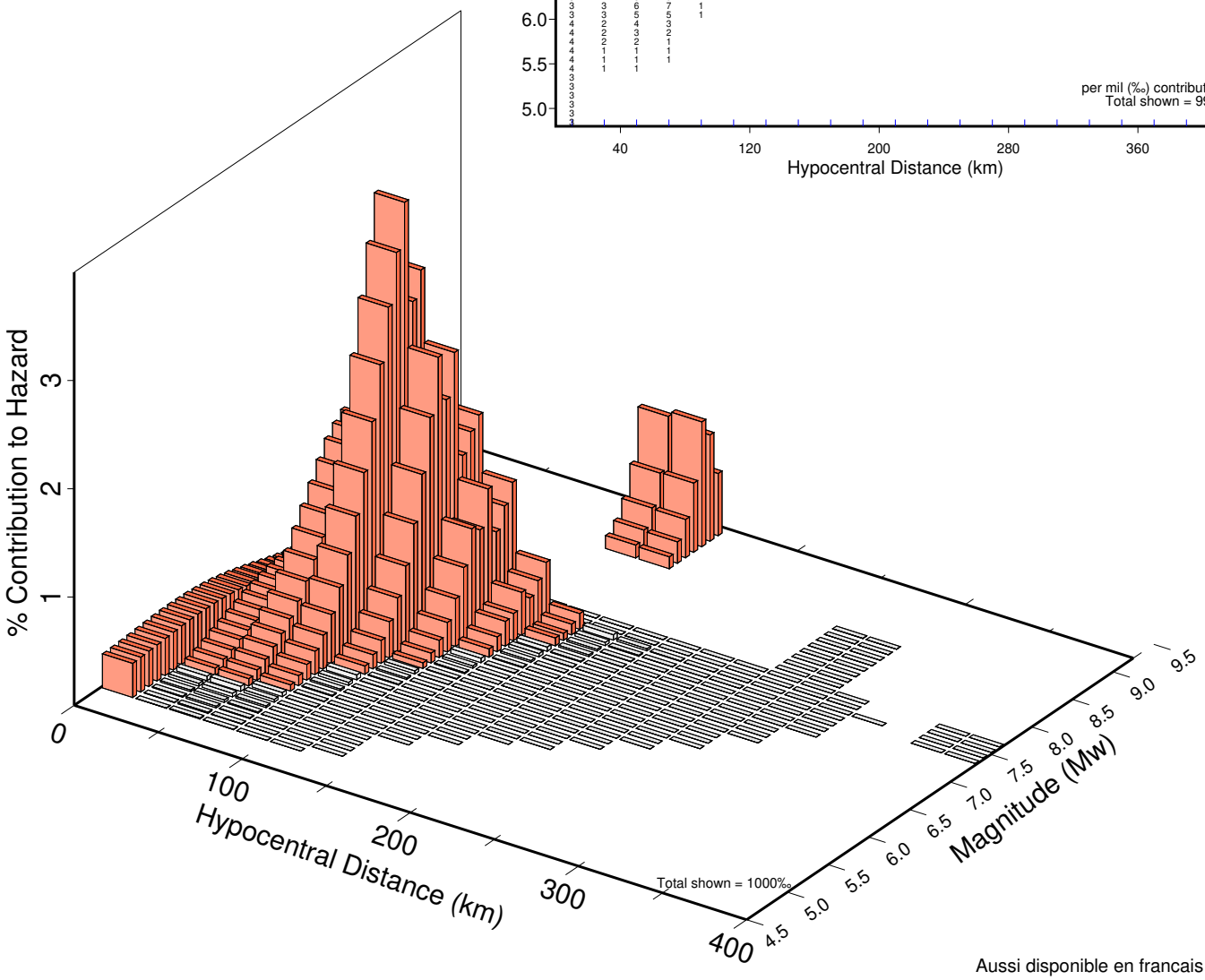
Mean magnitude (Mw) 6.96 Mean distance 74 km

Mode magnitude (Mw) 6.950 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model





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INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.30 seconds

at a probability of 0.002100 per annum, seismic hazard = 0.439 g

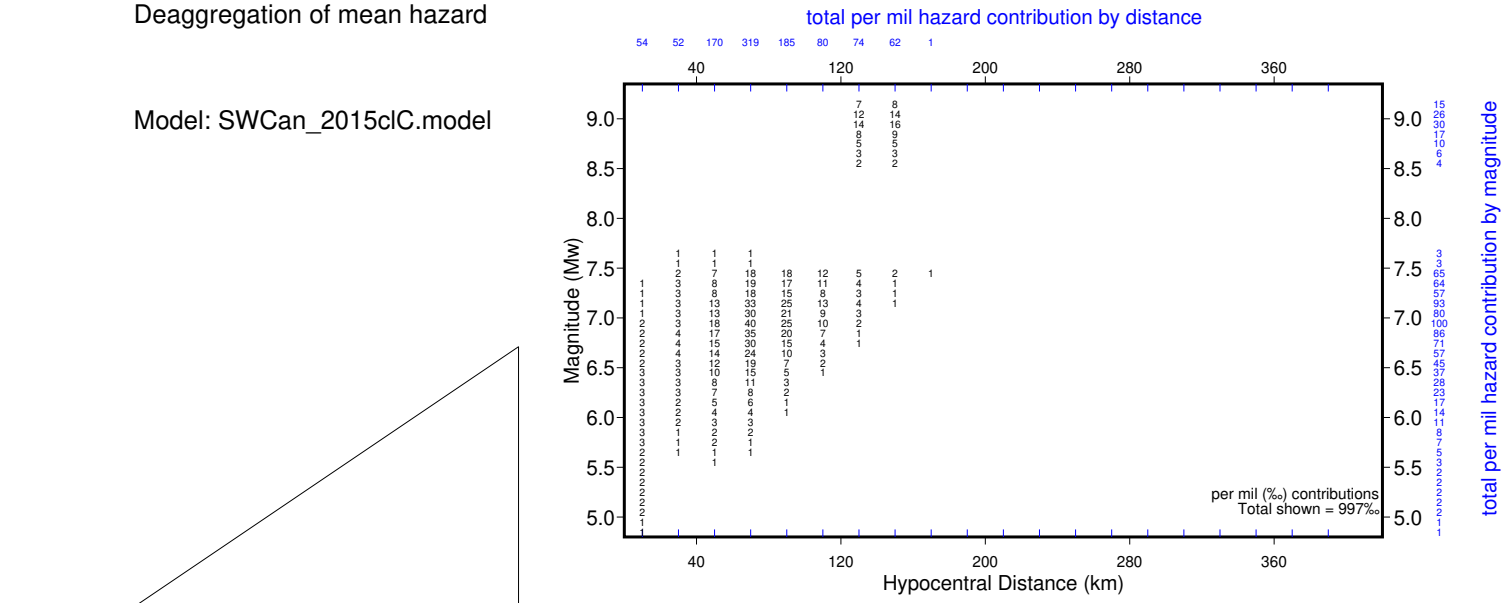
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

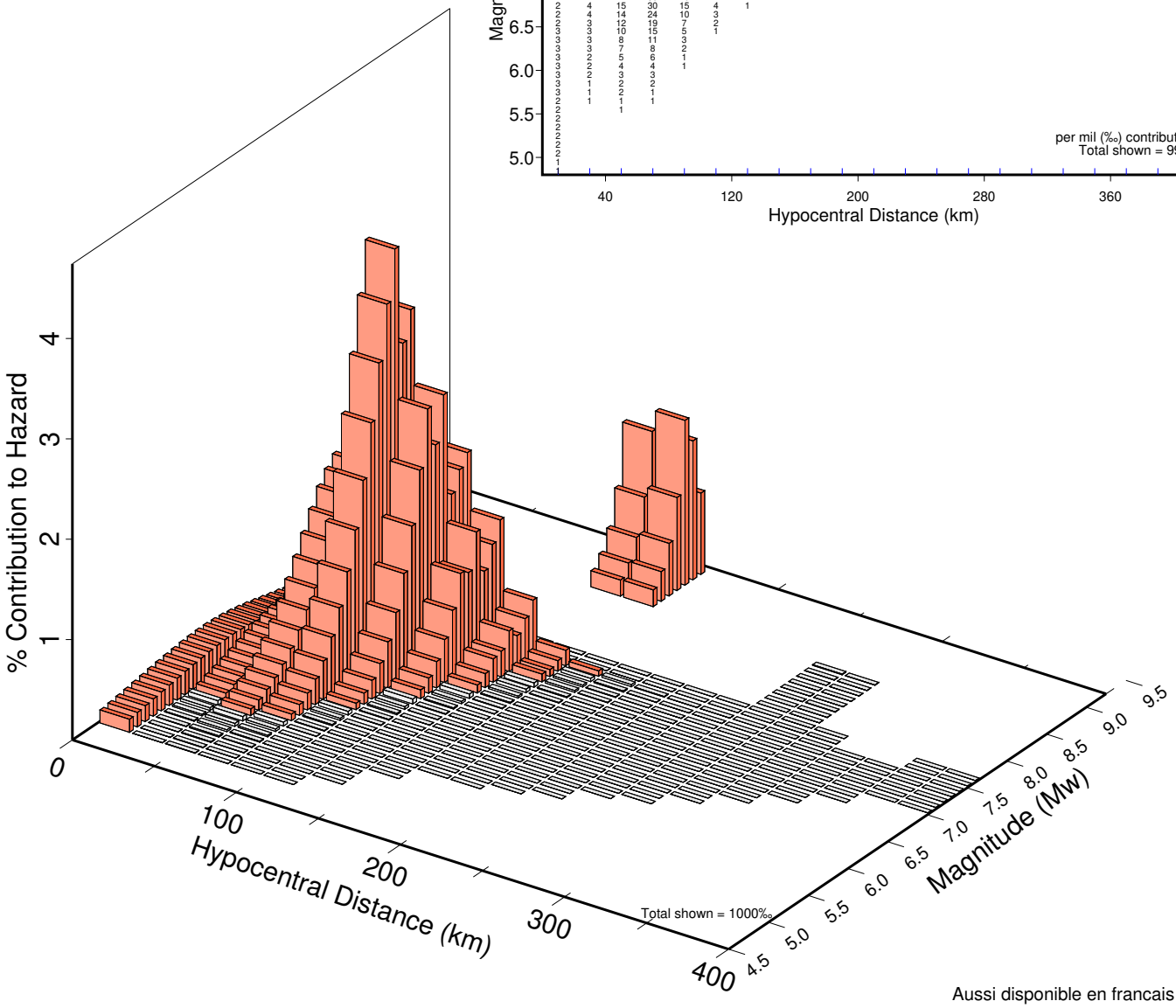
Mean magnitude (Mw) 7.07 Mean distance 78 km

Mode magnitude (Mw) 6.950 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.50 seconds

at a probability of 0.002100 per annum, seismic hazard = 0.381 g

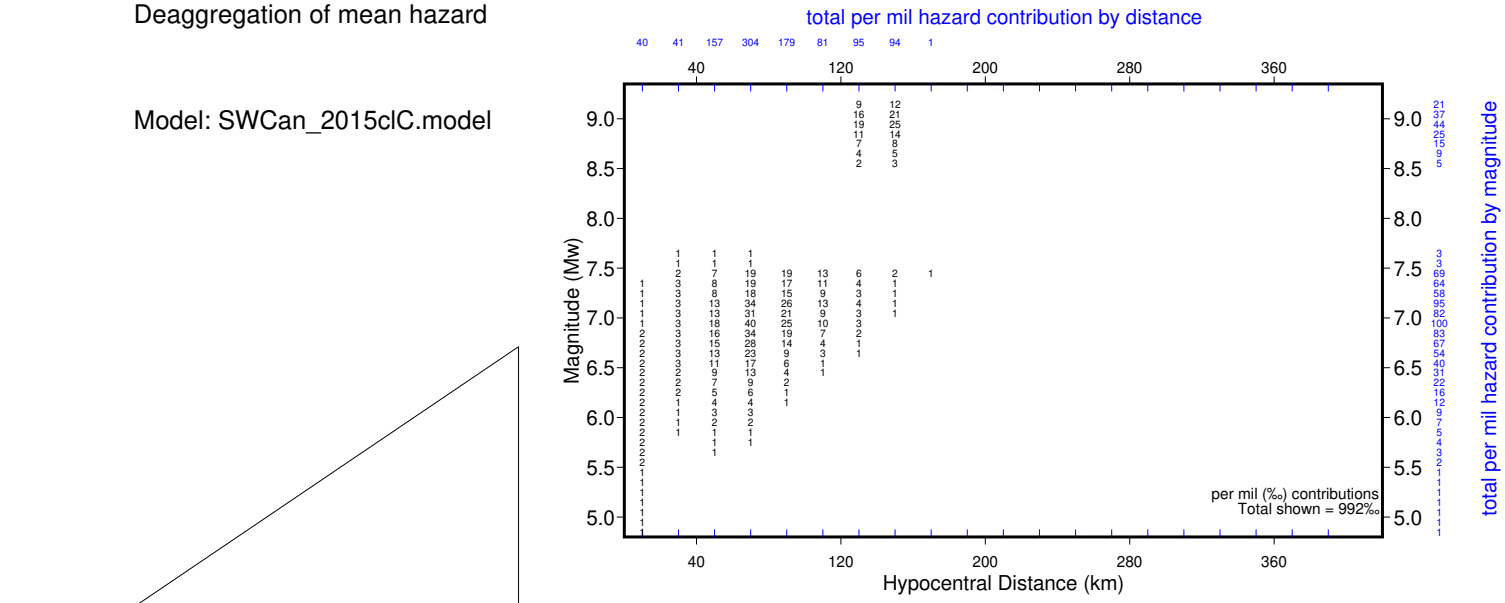
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

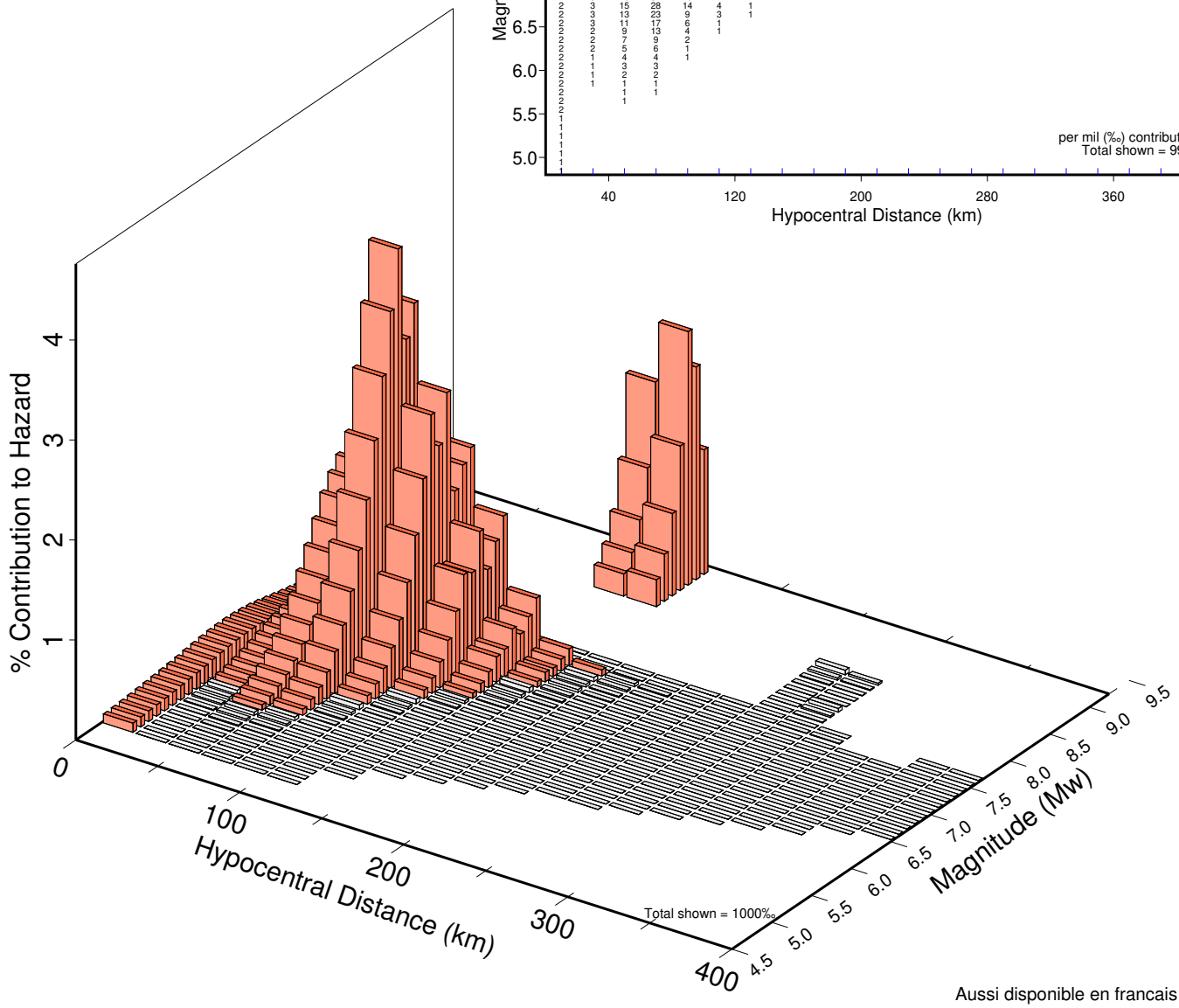
Mean magnitude (Mw) 7.22 Mean distance 84 km

Mode magnitude (Mw) 6.950 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 1.0 seconds

at a probability of 0.002100 per annum, seismic hazard = 0.204 g

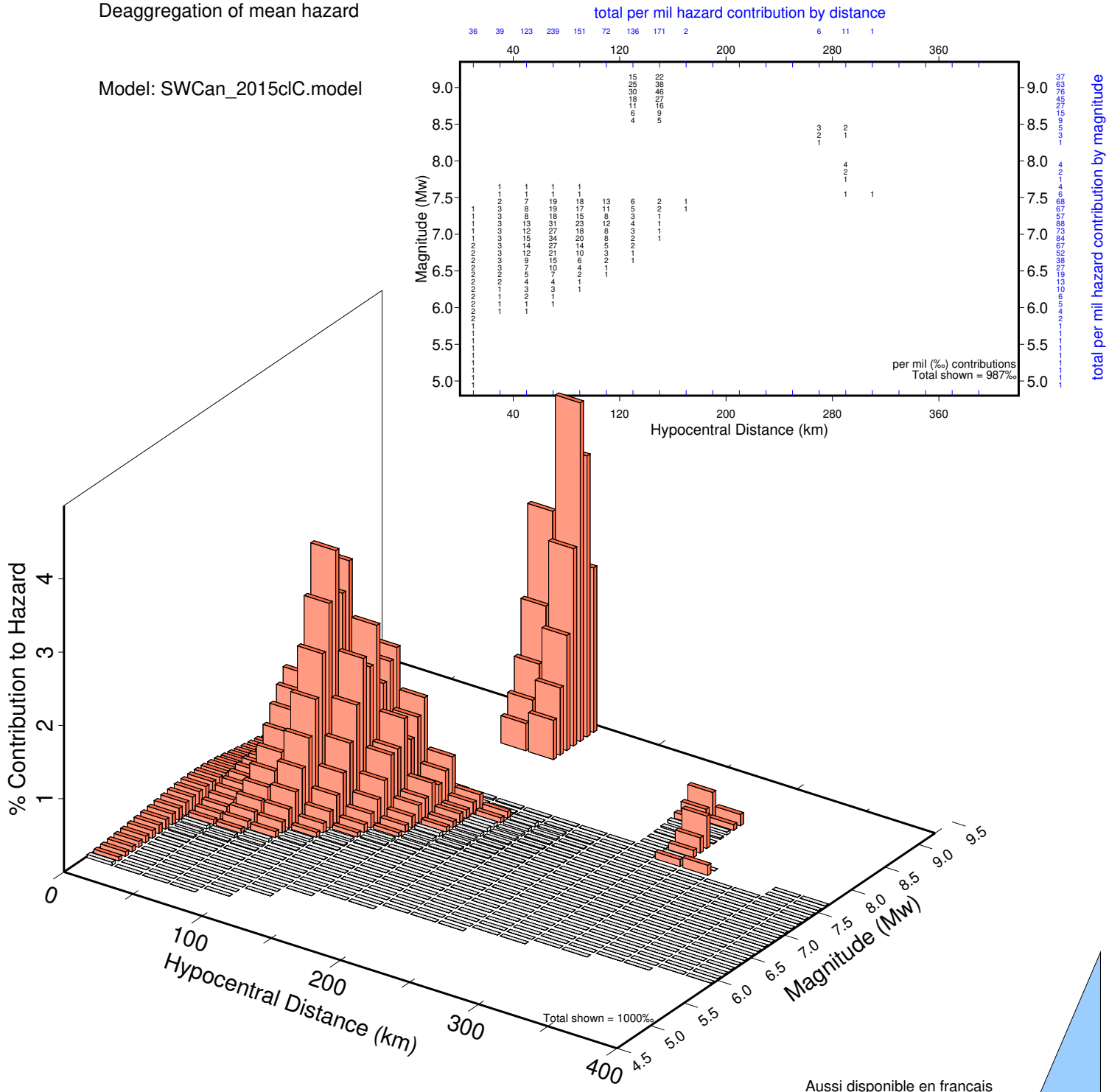
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 7.53 Mean distance 97 km

Mode magnitude (Mw) 8.950 Mode distance 150 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 2.0 seconds

at a probability of 0.002100 per annum, seismic hazard = 0.117 g

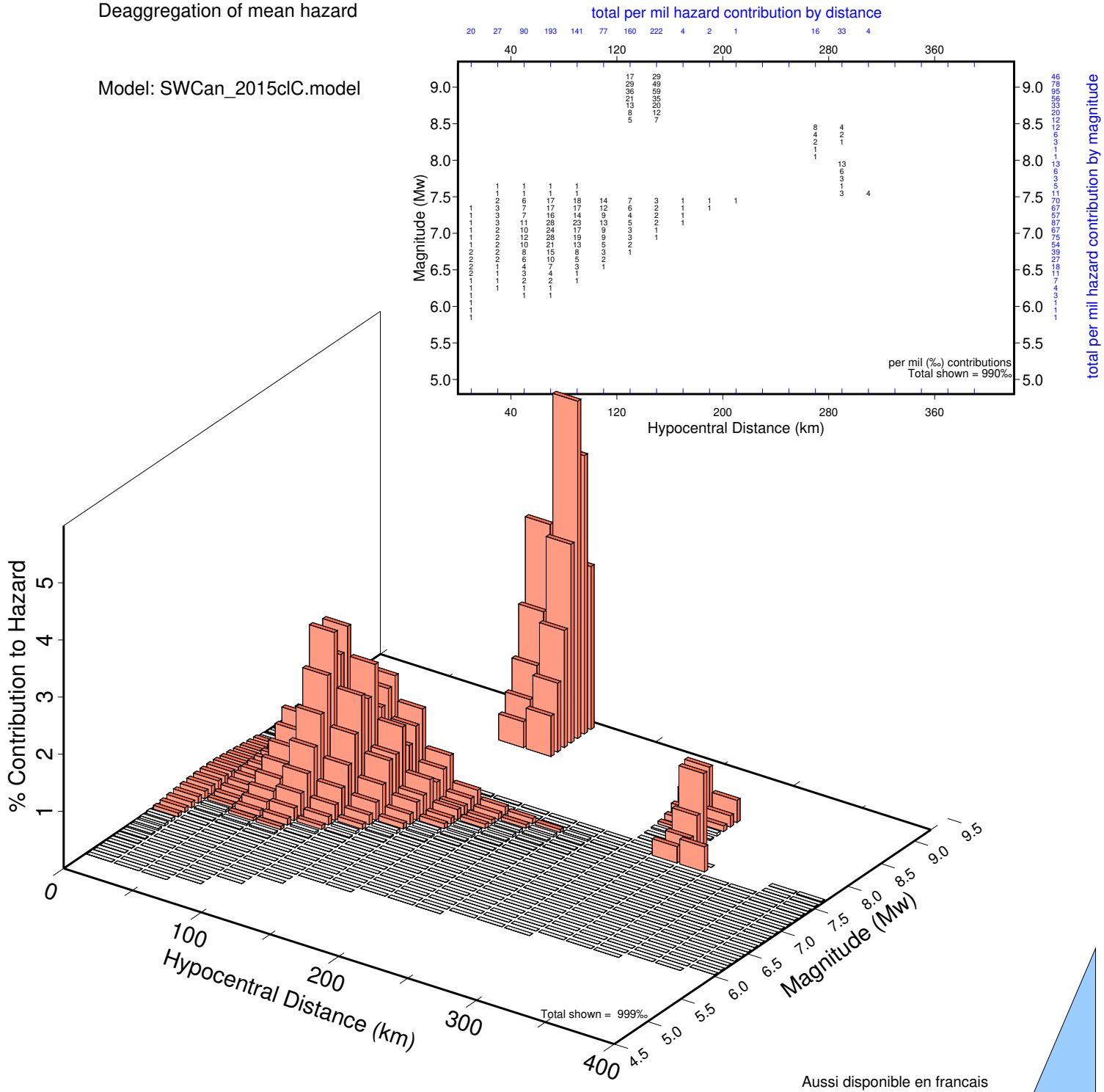
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 7.74 Mean distance 113 km

Mode magnitude (Mw) 8.950 Mode distance 150 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Seismic Hazard Deaggregation

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Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 5.0 seconds

at a probability of 0.002100 per annum, seismic hazard = 0.028 g

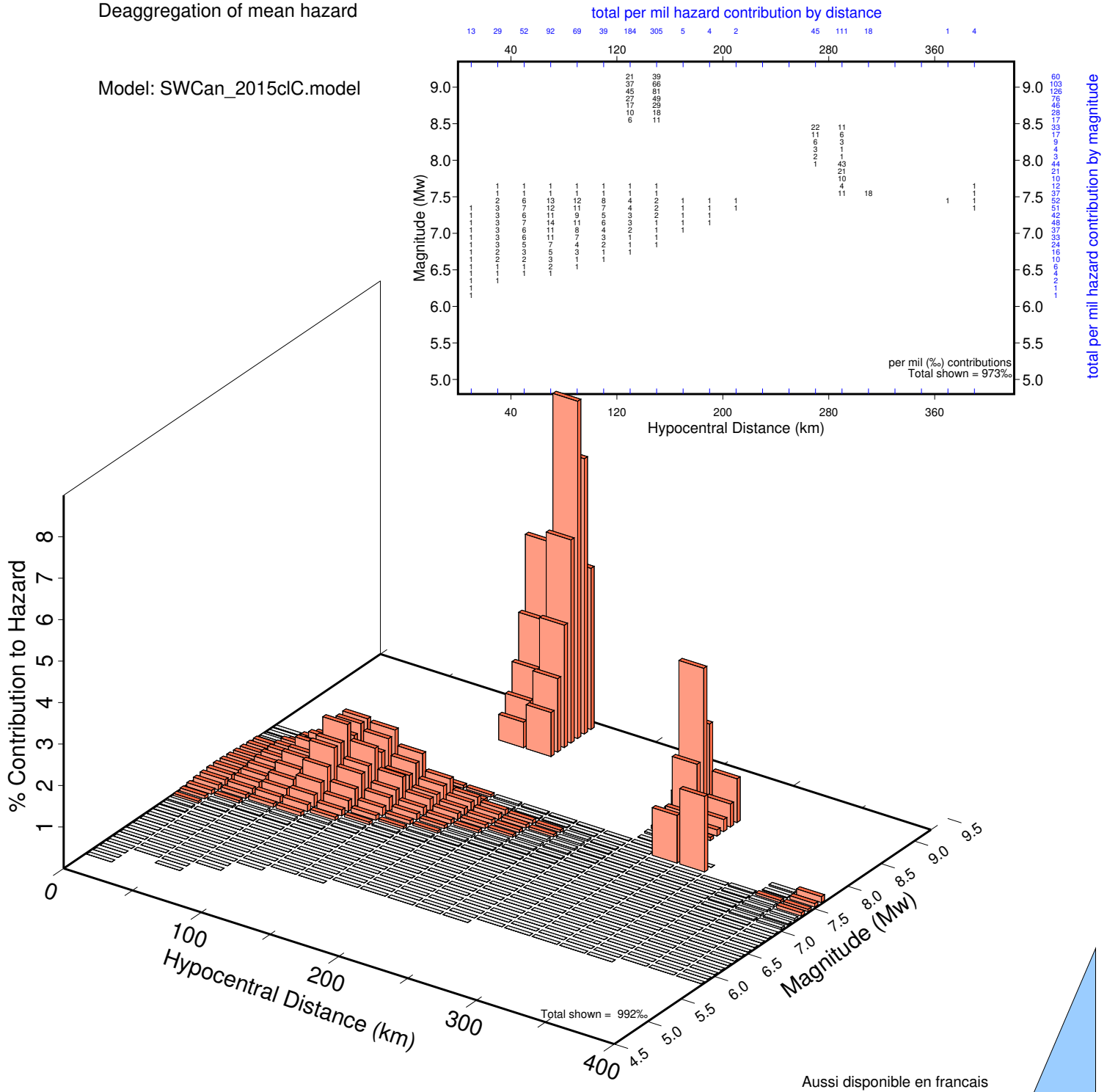
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 8.11 Mean distance 151 km

Mode magnitude (Mw) 8.950 Mode distance 150 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 10.0 seconds

at a probability of 0.002100 per annum, seismic hazard = 0.010 g

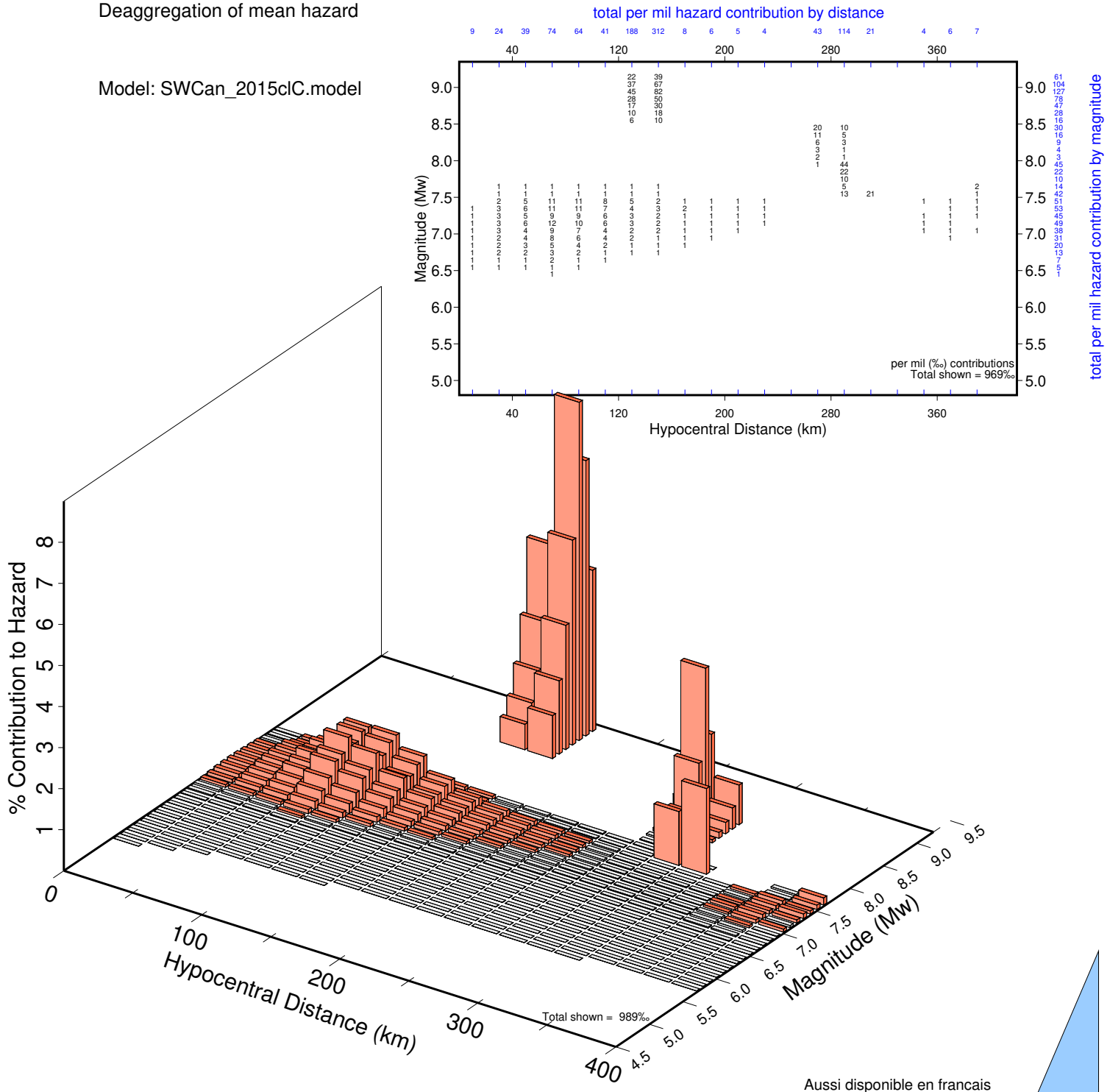
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 8.13 Mean distance 160 km

Mode magnitude (Mw) 8.950 Mode distance 150 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*

Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter peak ground acceleration (PGA)

at a probability of 0.001000 per annum, seismic hazard = 0.257 g

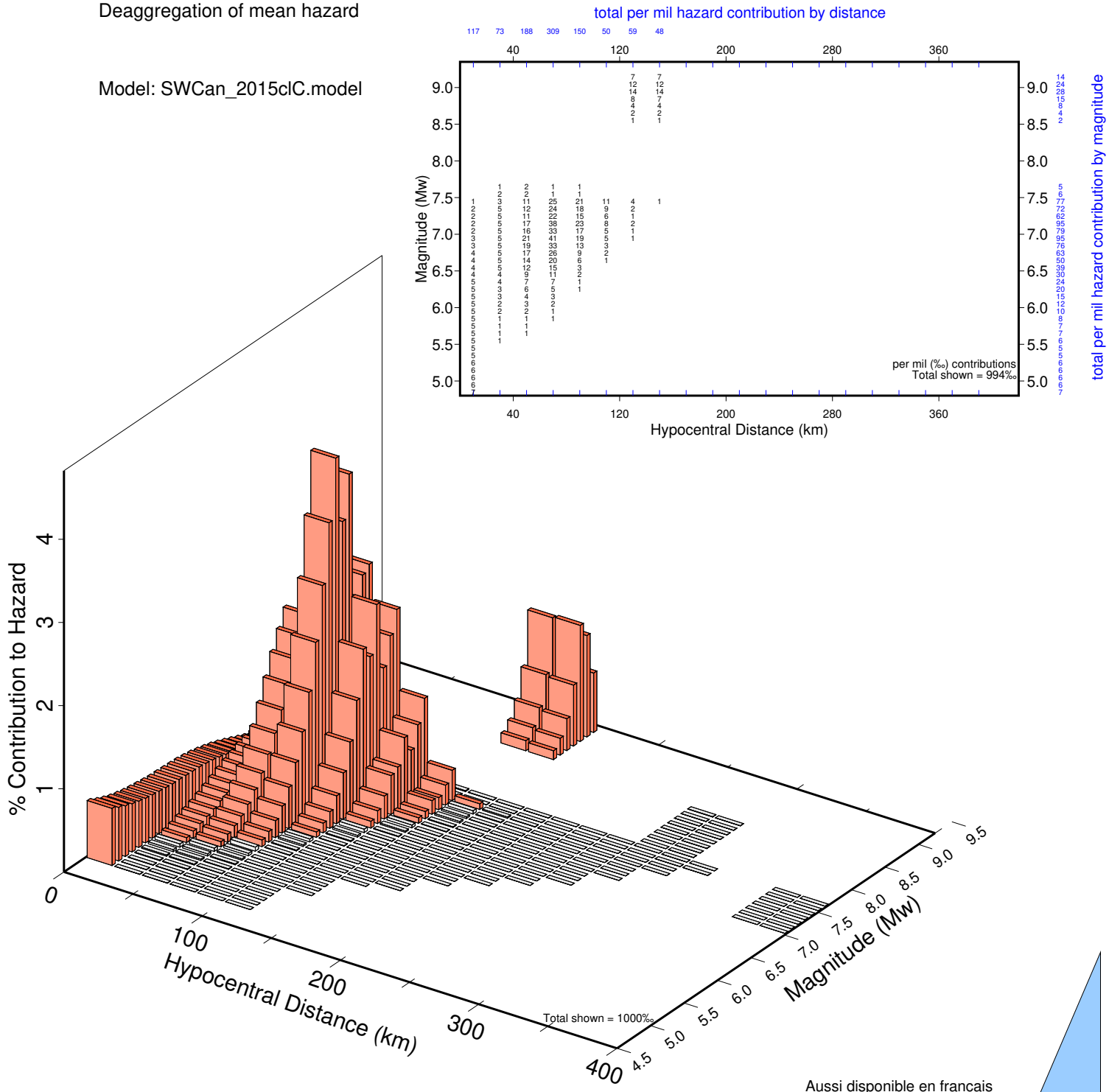
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 7.02 Mean distance 69 km

Mode magnitude (Mw) 6.950 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*

Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.05 seconds

at a probability of 0.001000 per annum, seismic hazard = 0.309 g

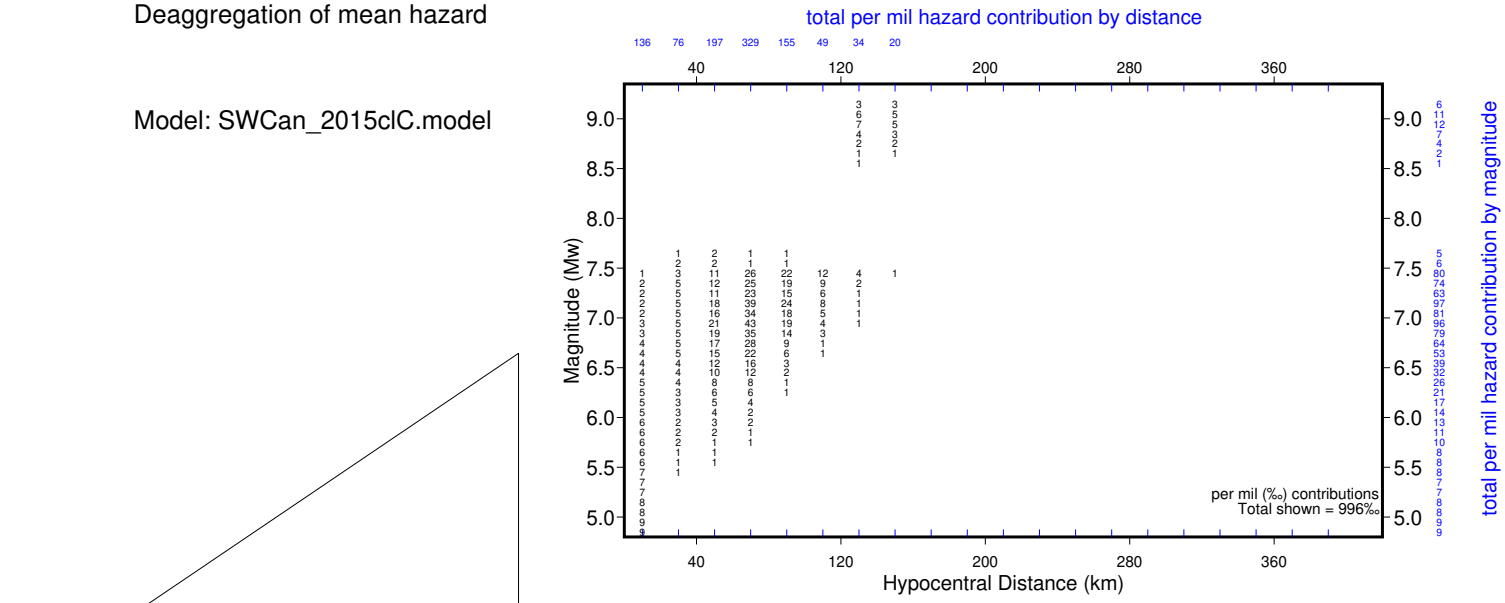
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

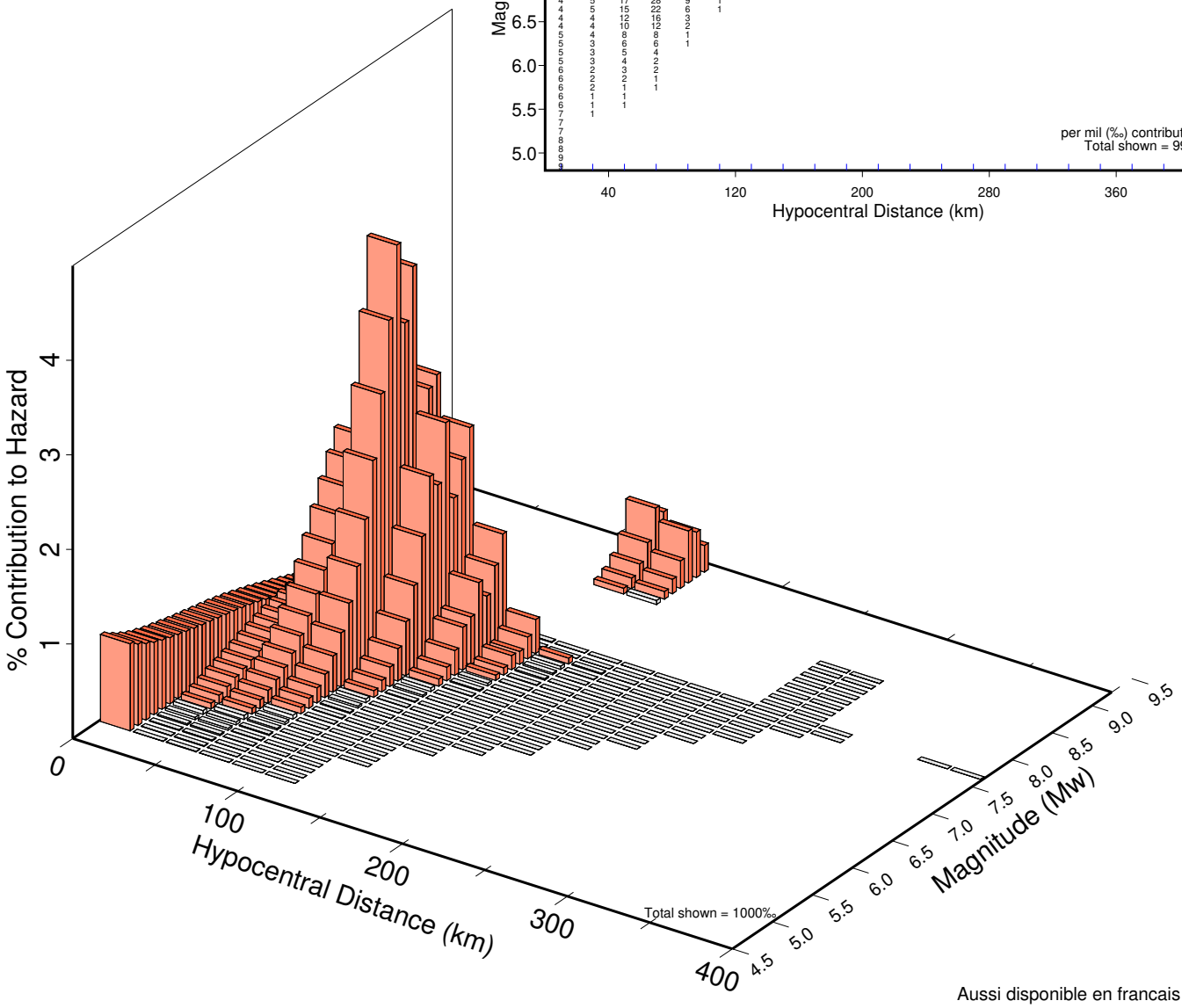
Mean magnitude (Mw) 6.87 Mean distance 63 km

Mode magnitude (Mw) 6.950 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*

Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.10 seconds

at a probability of 0.001000 per annum, seismic hazard = 0.472 g

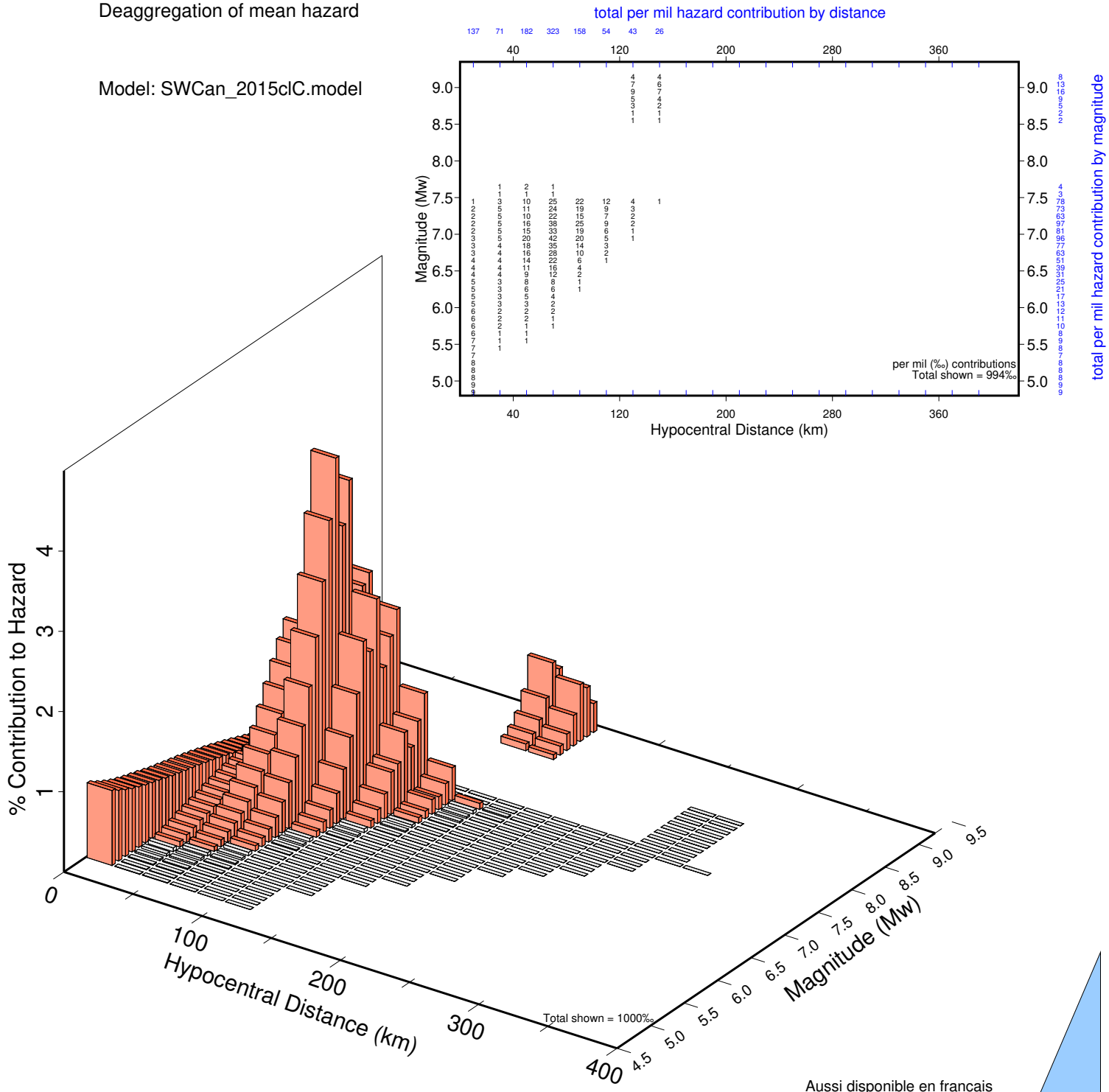
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 6.89 Mean distance 65 km

Mode magnitude (Mw) 6.950 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.20 seconds

at a probability of 0.001000 per annum, seismic hazard = 0.594 g

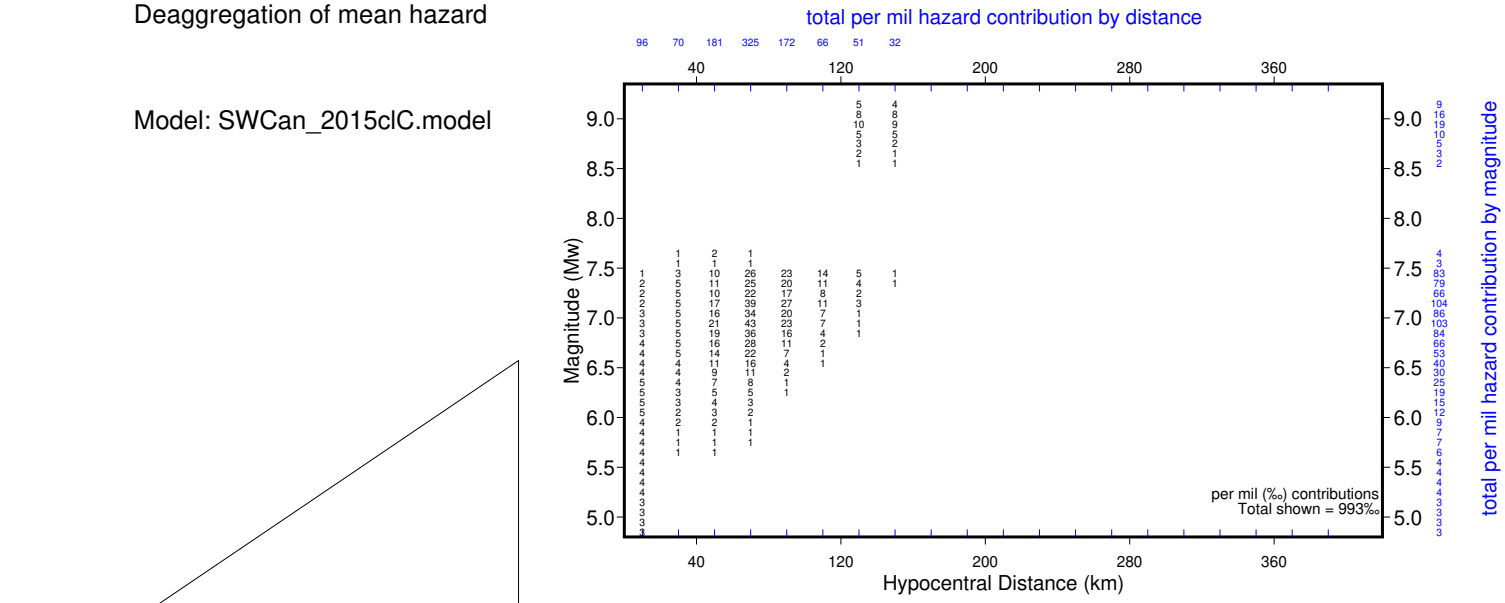
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

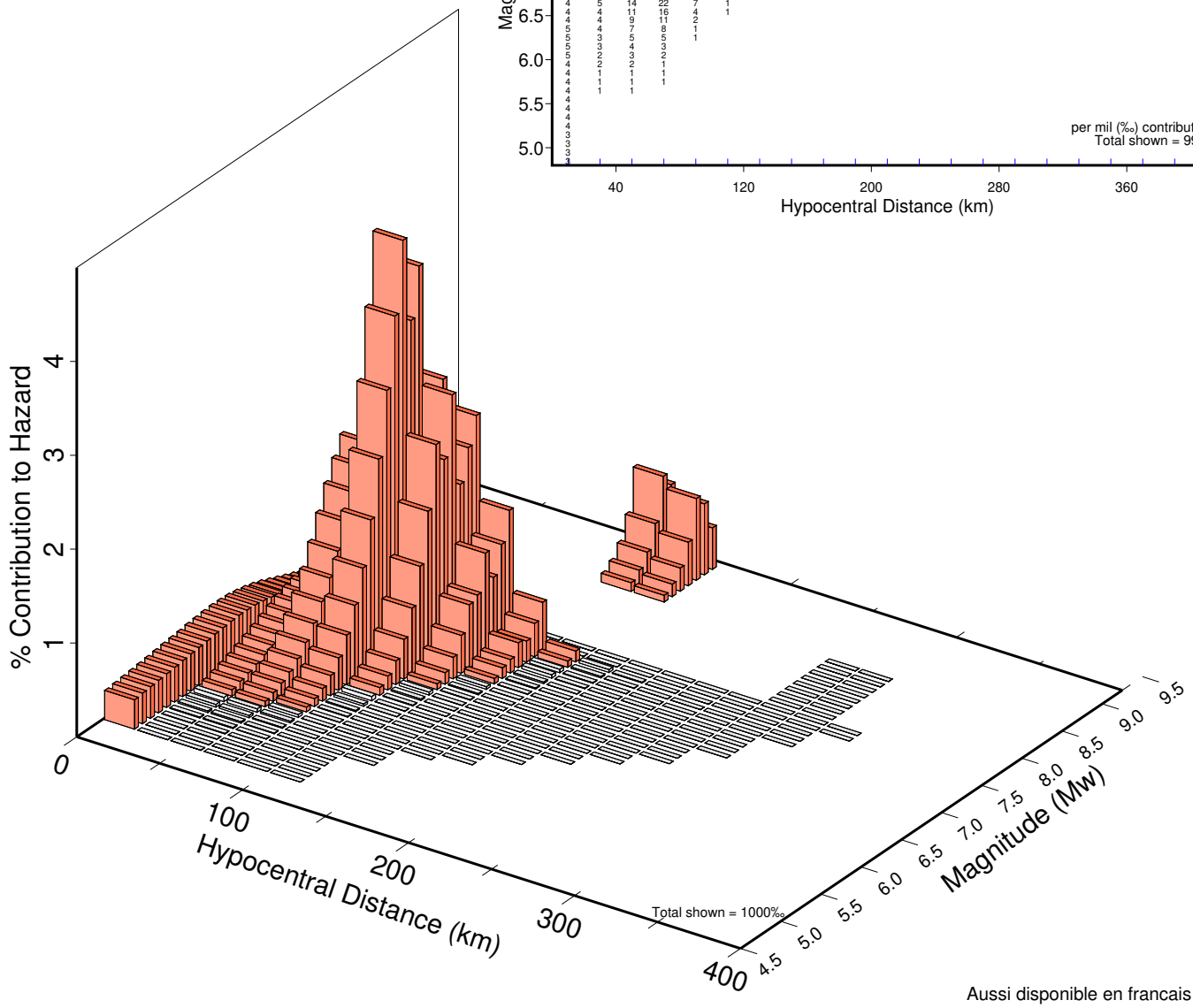
Mean magnitude (Mw) 7.00 Mean distance 70 km

Mode magnitude (Mw) 6.950 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model





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INFORMATION: *EarthquakesCanada.nrcan.gc.ca*

Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.30 seconds

at a probability of 0.001000 per annum, seismic hazard = 0.601 g

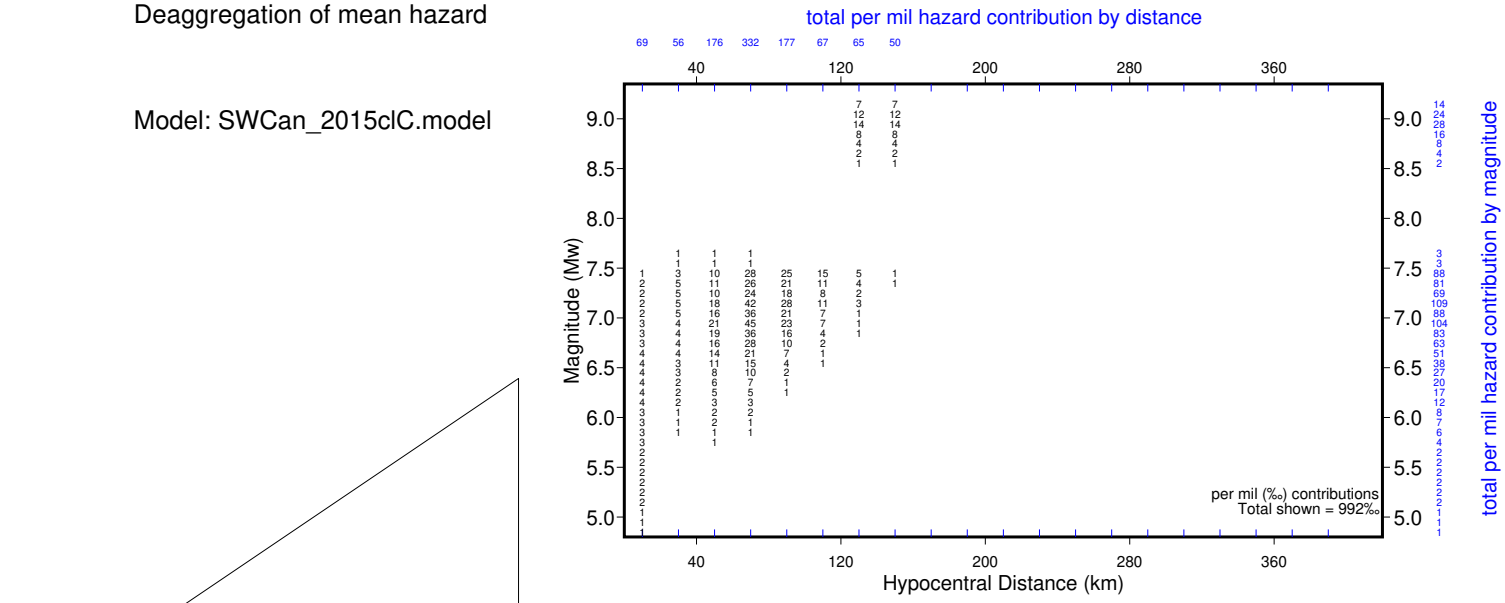
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

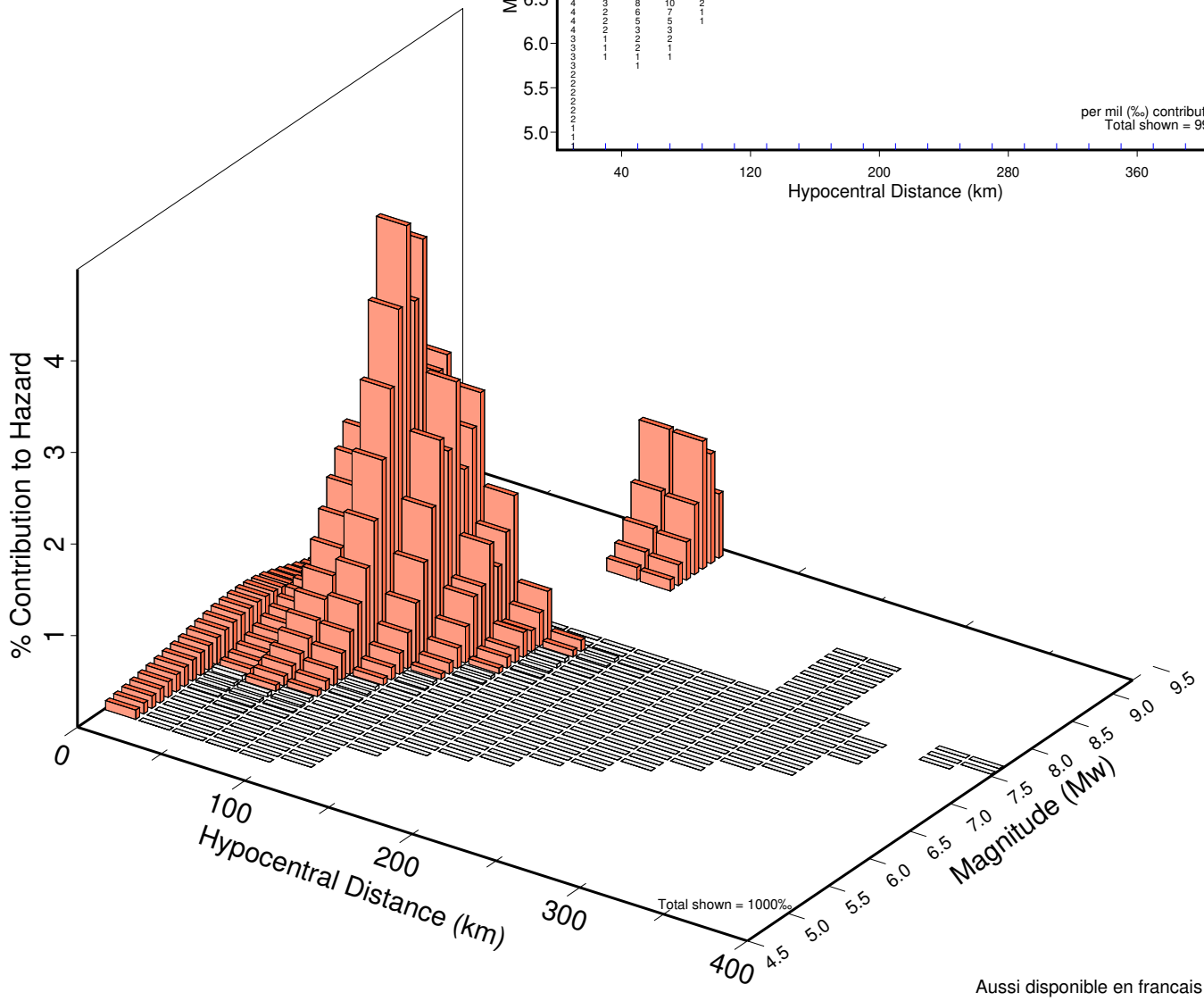
Mean magnitude (Mw) 7.13 Mean distance 74 km

Mode magnitude (Mw) 6.950 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model





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Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.50 seconds

at a probability of 0.001000 per annum, seismic hazard = 0.527 g

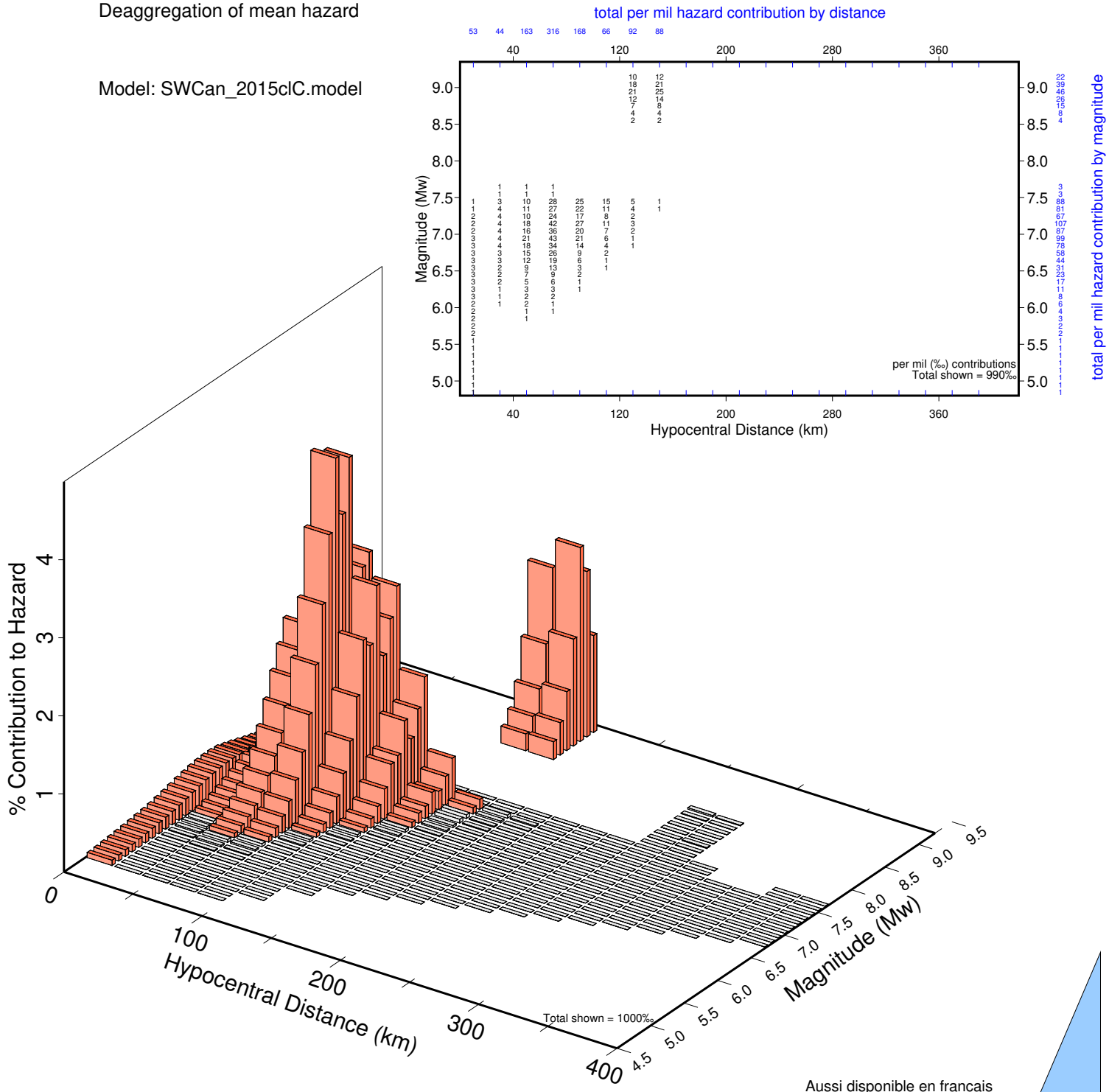
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 7.29 Mean distance 81 km

Mode magnitude (Mw) 6.950 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 1.0 seconds

at a probability of 0.001000 per annum, seismic hazard = 0.290 g

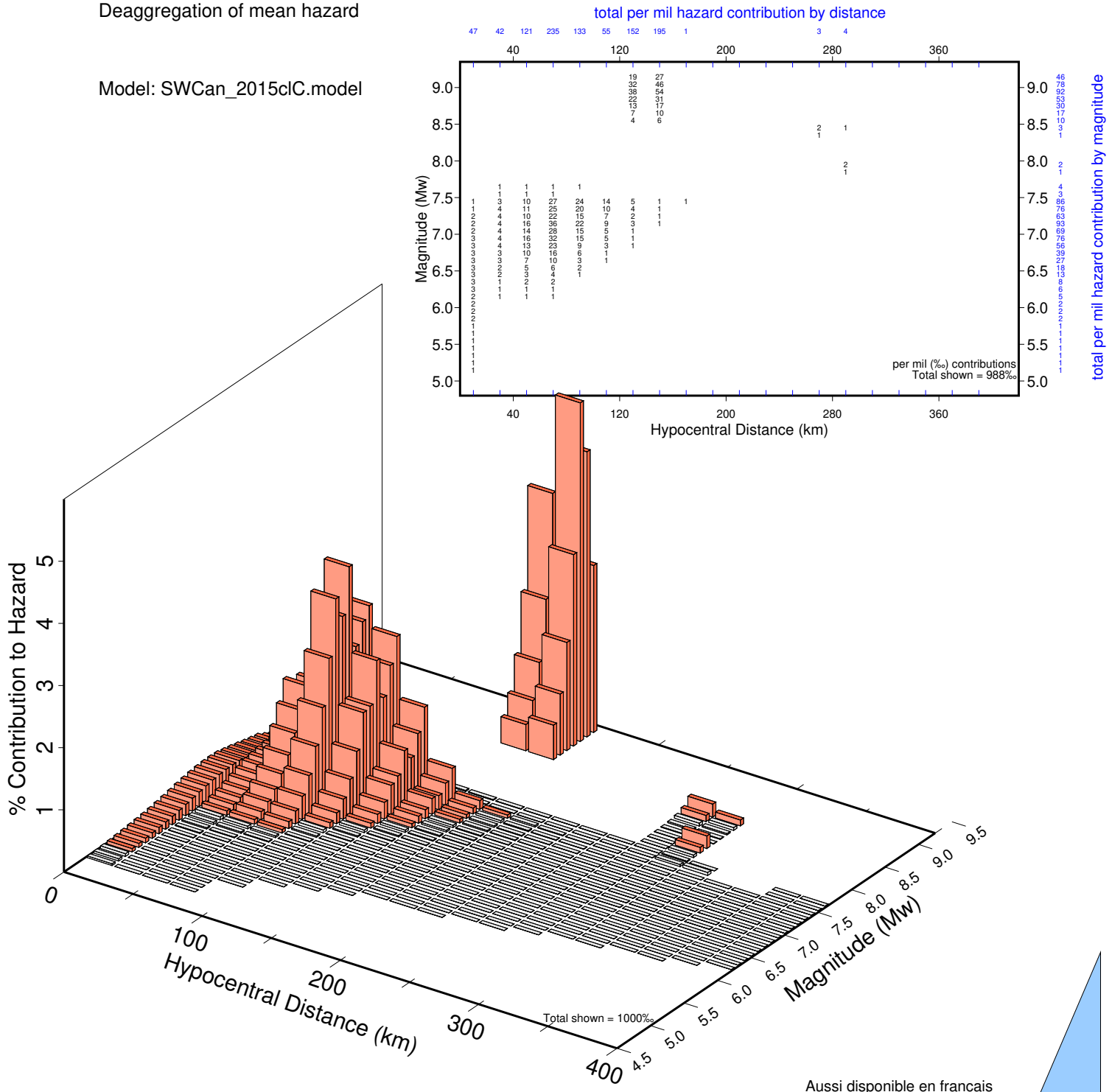
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 7.67 Mean distance 95 km

Mode magnitude (Mw) 8.950 Mode distance 150 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 2.0 seconds

at a probability of 0.001000 per annum, seismic hazard = 0.171 g

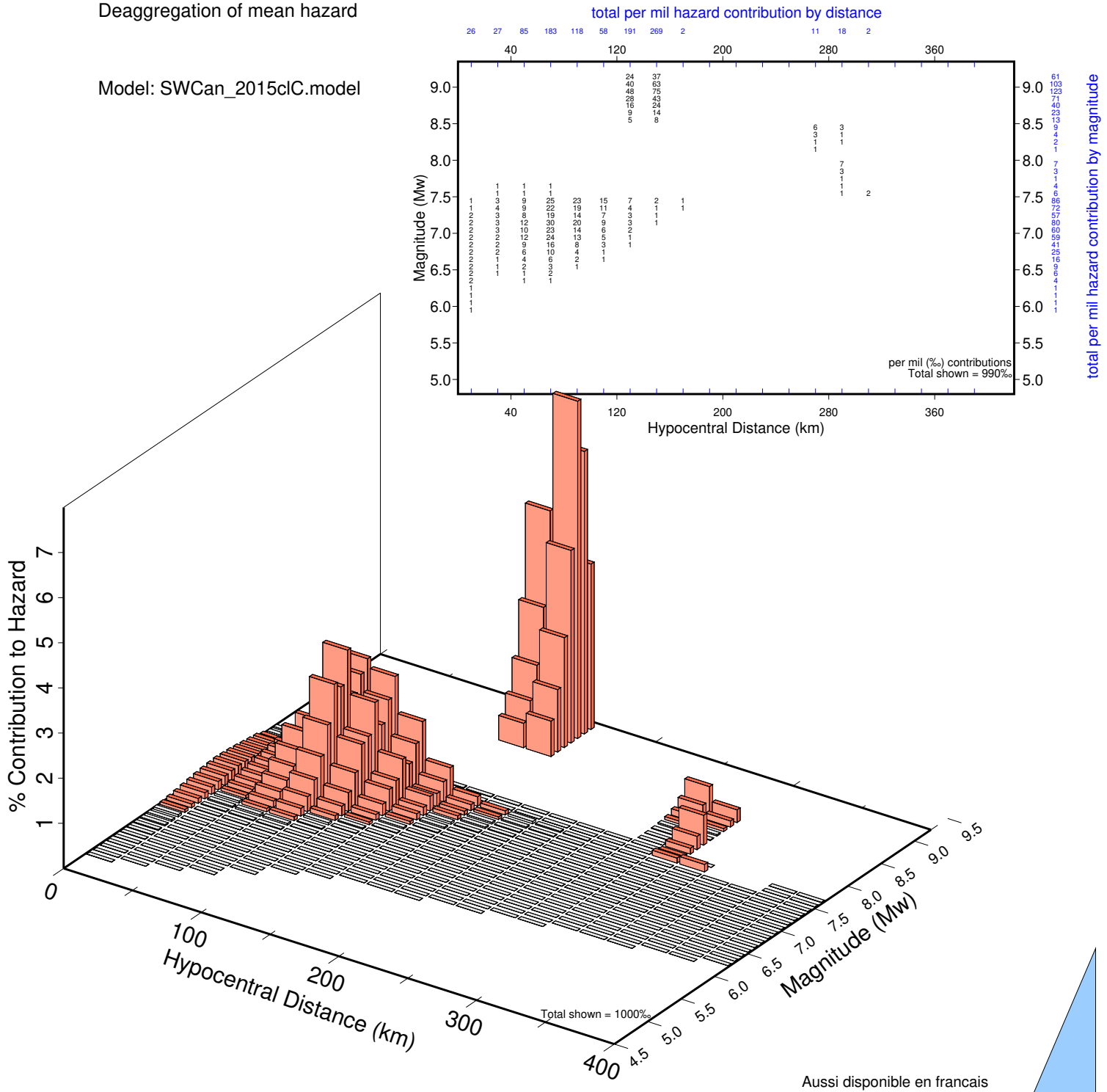
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 7.94 Mean distance 111 km

Mode magnitude (Mw) 8.950 Mode distance 150 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Seismic Hazard Deaggregation

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Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 5.0 seconds

at a probability of 0.001000 per annum, seismic hazard = 0.047 g

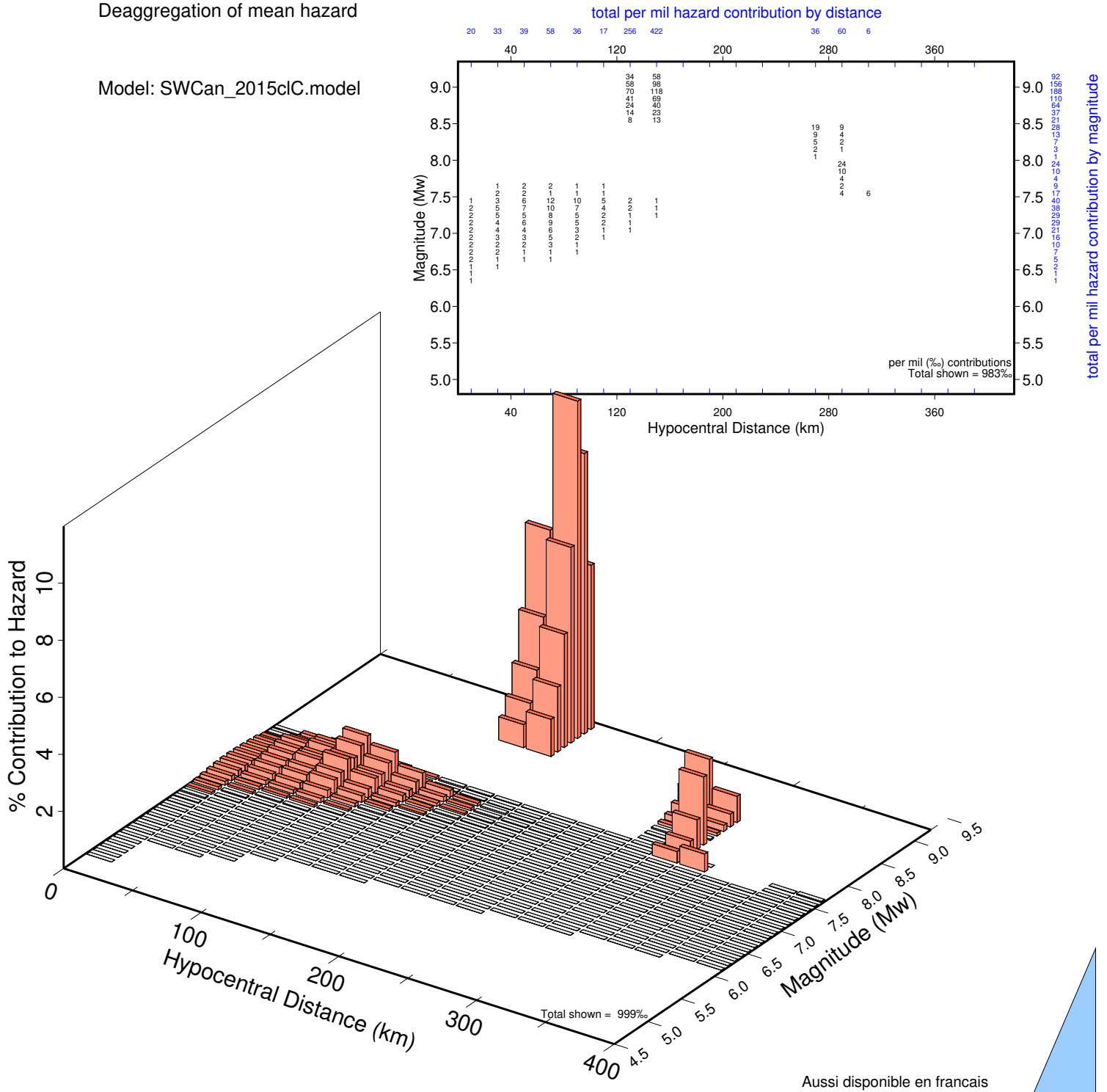
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 8.45 Mean distance 141 km

Mode magnitude (Mw) 8.950 Mode distance 150 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 10.0 seconds

at a probability of 0.001000 per annum, seismic hazard = 0.017 g

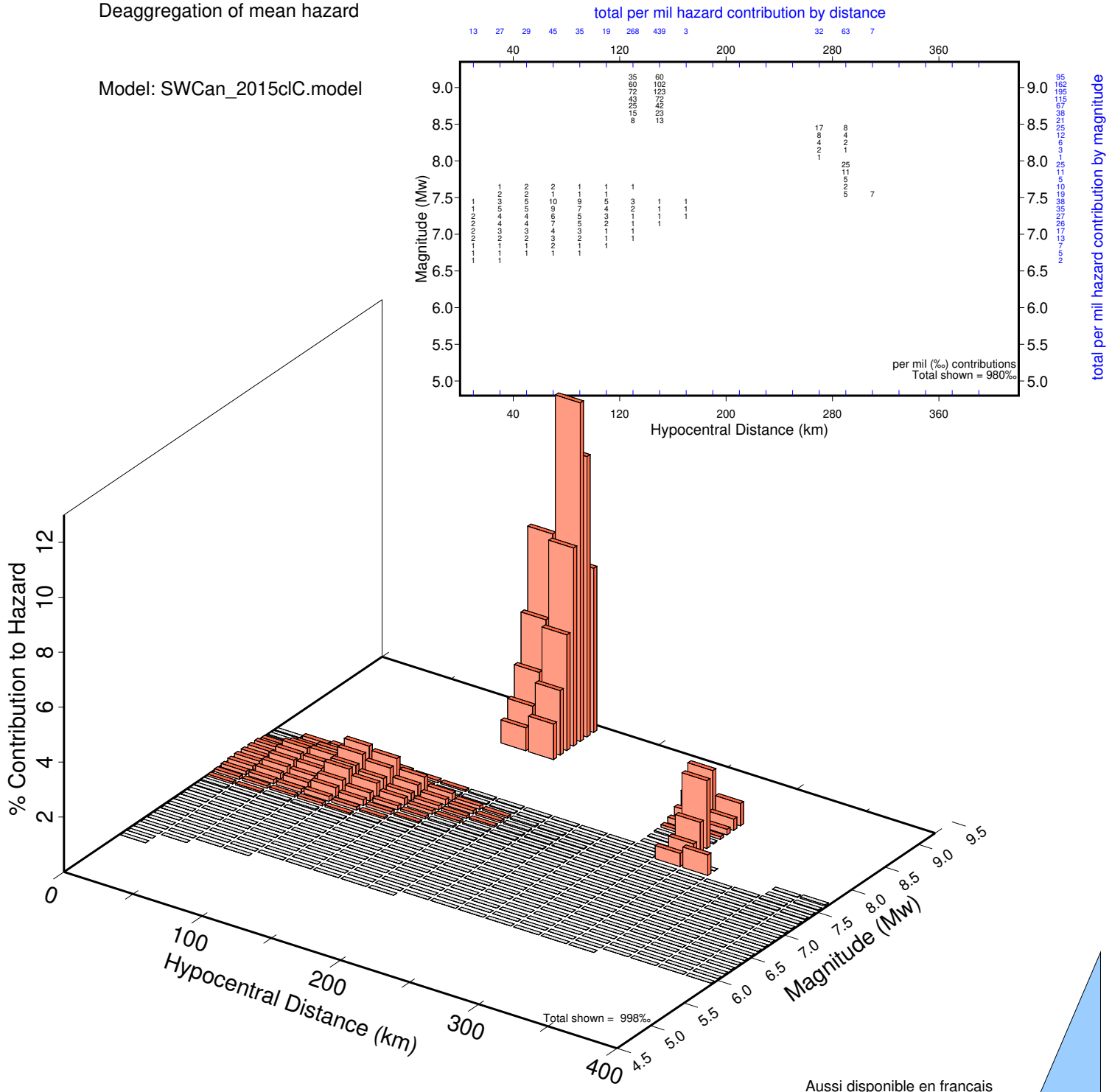
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 8.50 Mean distance 146 km

Mode magnitude (Mw) 8.950 Mode distance 150 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter peak ground acceleration (PGA)

at a probability of 0.000404 per annum, seismic hazard = 0.363 g

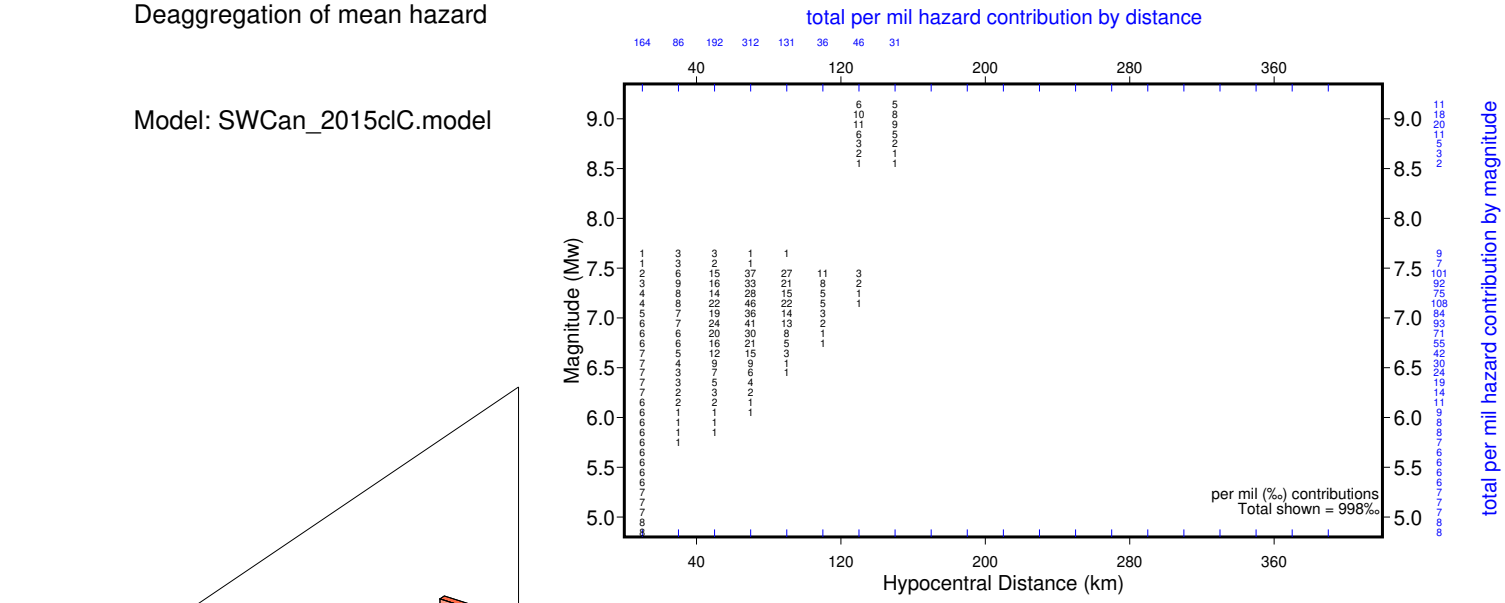
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

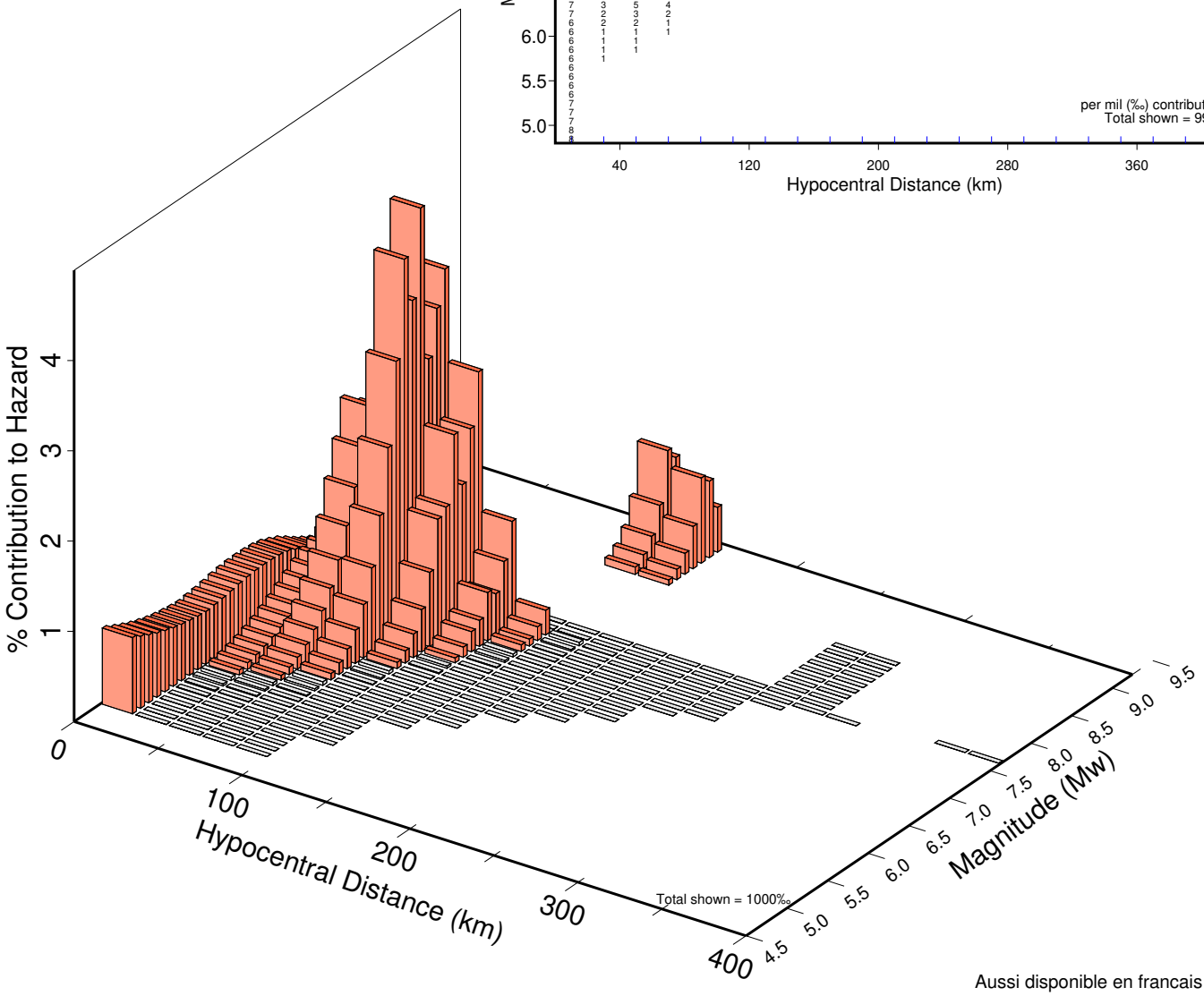
Mean magnitude (Mw) 7.01 Mean distance 62 km

Mode magnitude (Mw) 7.150 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model





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INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.05 seconds

at a probability of 0.000404 per annum, seismic hazard = 0.442 g

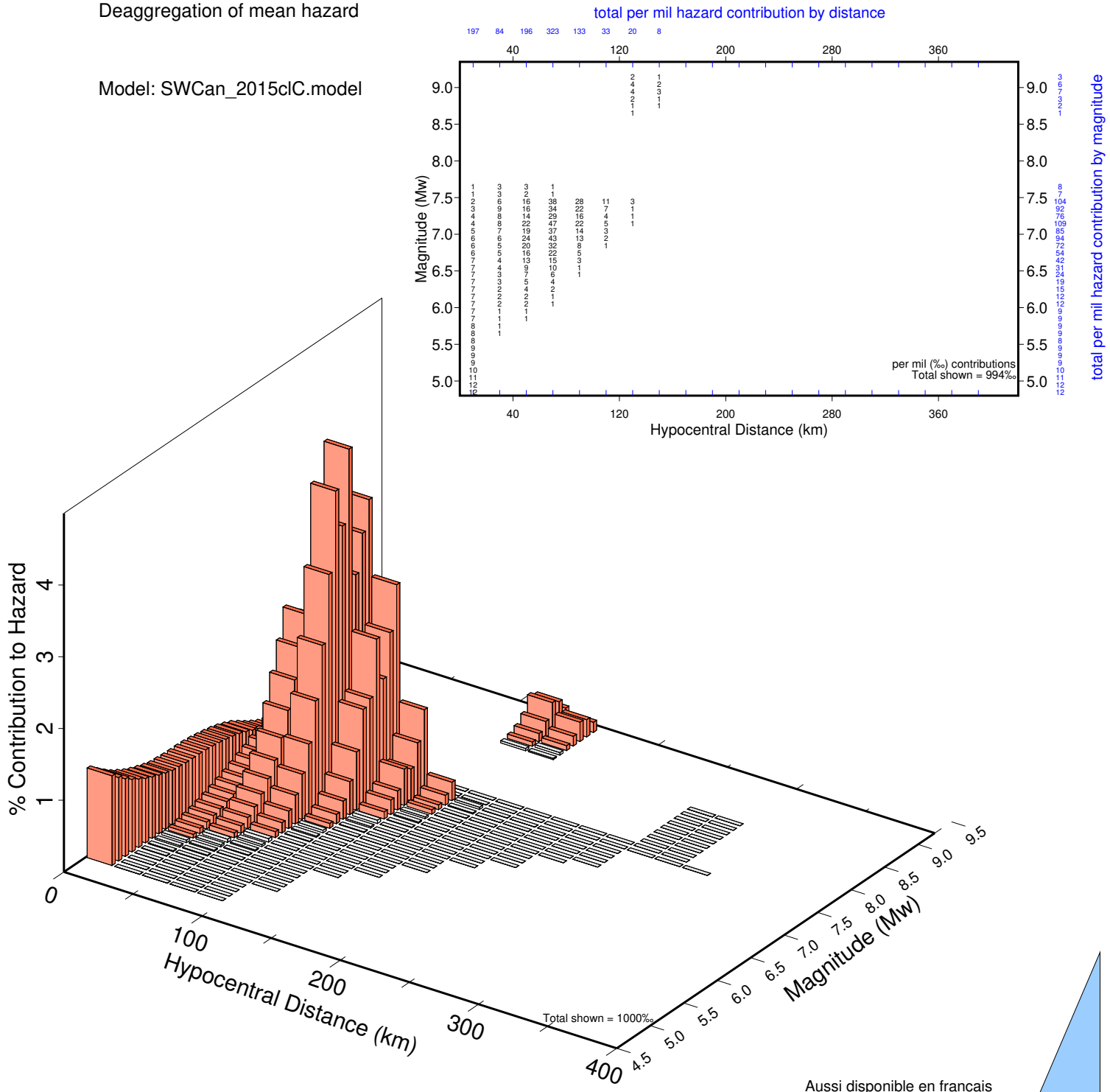
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 6.86 Mean distance 57 km

Mode magnitude (Mw) 7.150 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.10 seconds

at a probability of 0.000404 per annum, seismic hazard = 0.673 g

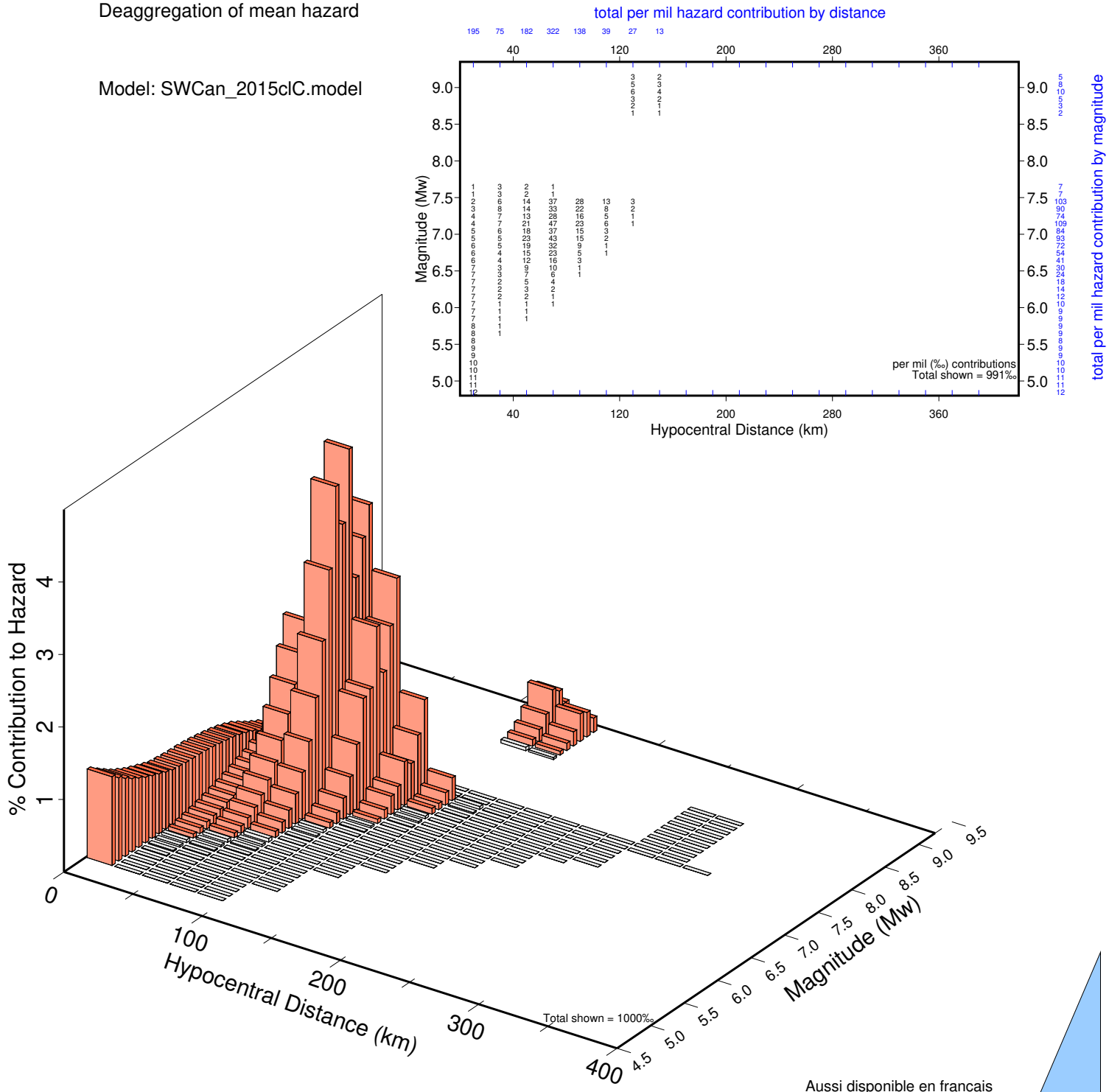
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 6.88 Mean distance 59 km

Mode magnitude (Mw) 7.150 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.20 seconds

at a probability of 0.000404 per annum, seismic hazard = 0.838 g

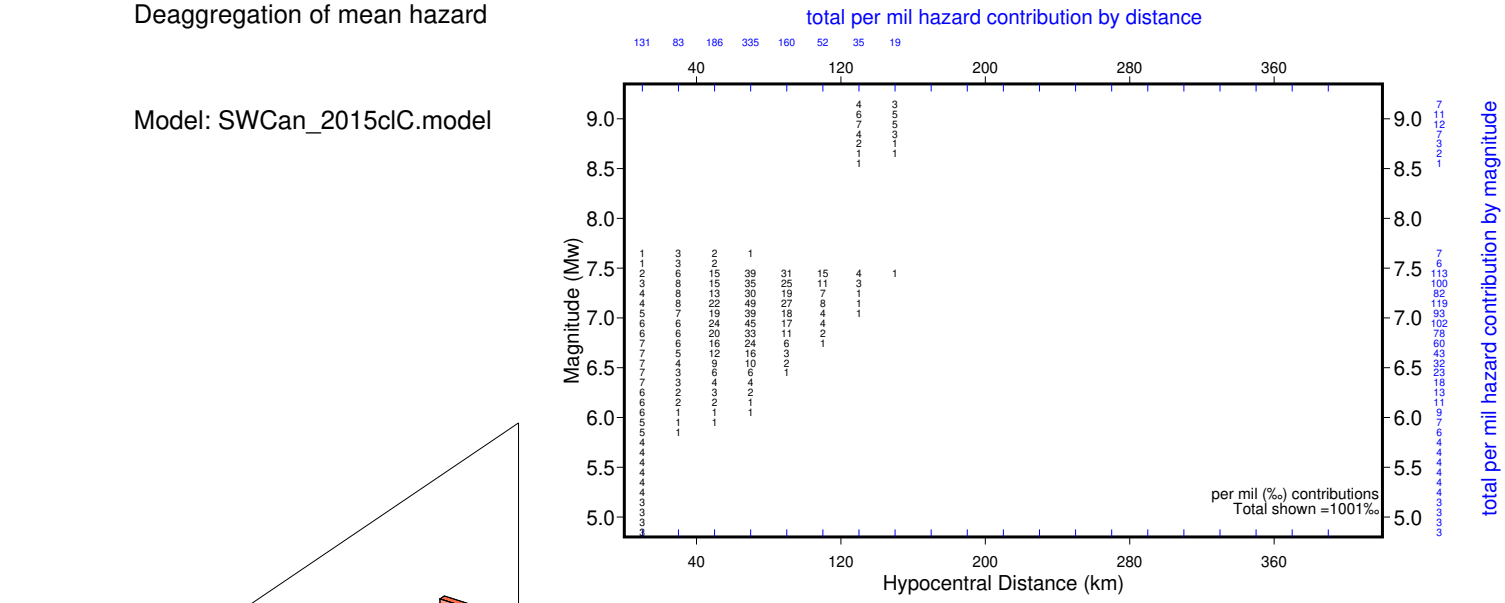
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

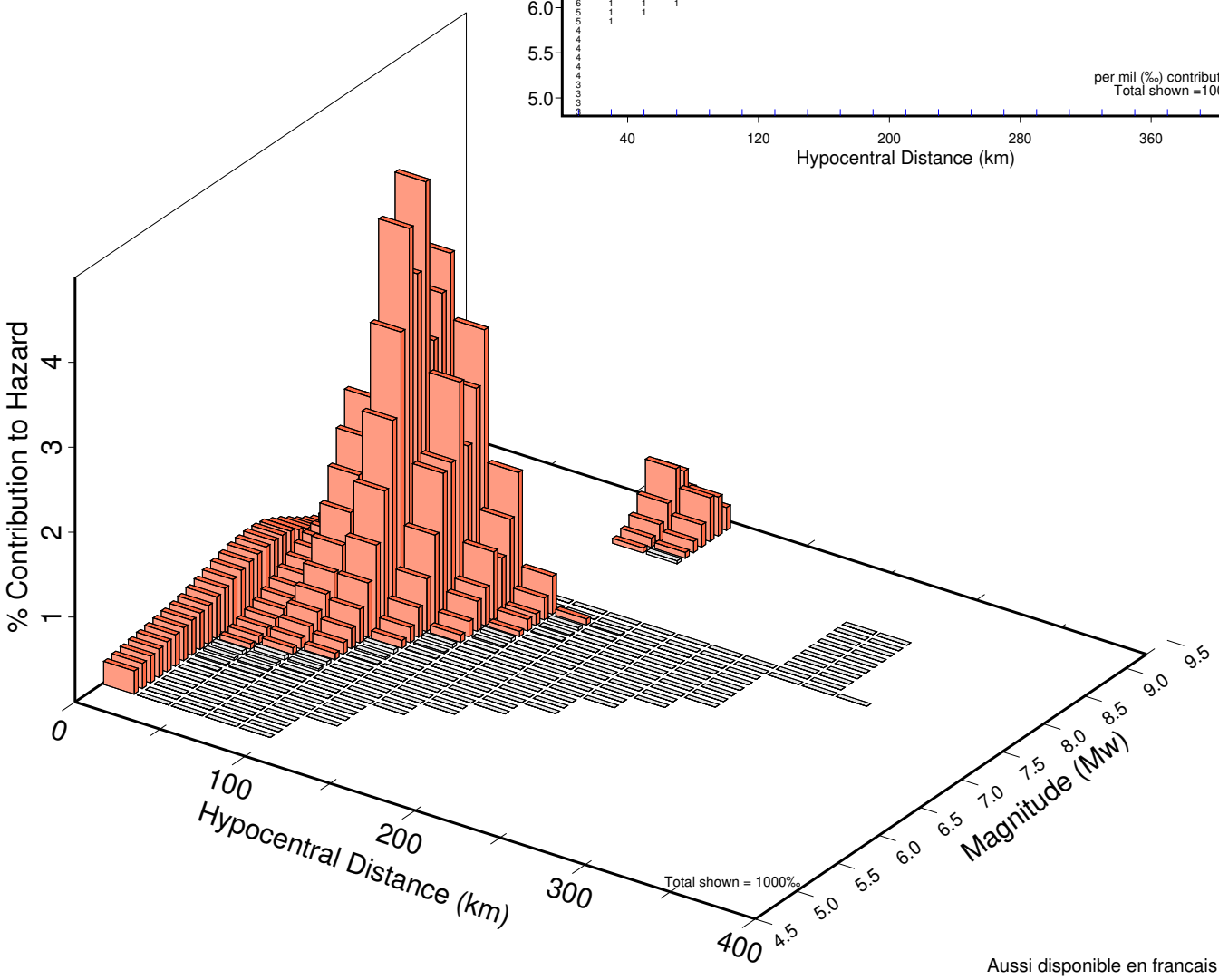
Mean magnitude (Mw) 7.03 Mean distance 64 km

Mode magnitude (Mw) 7.150 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model





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calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.30 seconds

at a probability of 0.000404 per annum, seismic hazard = 0.843 g

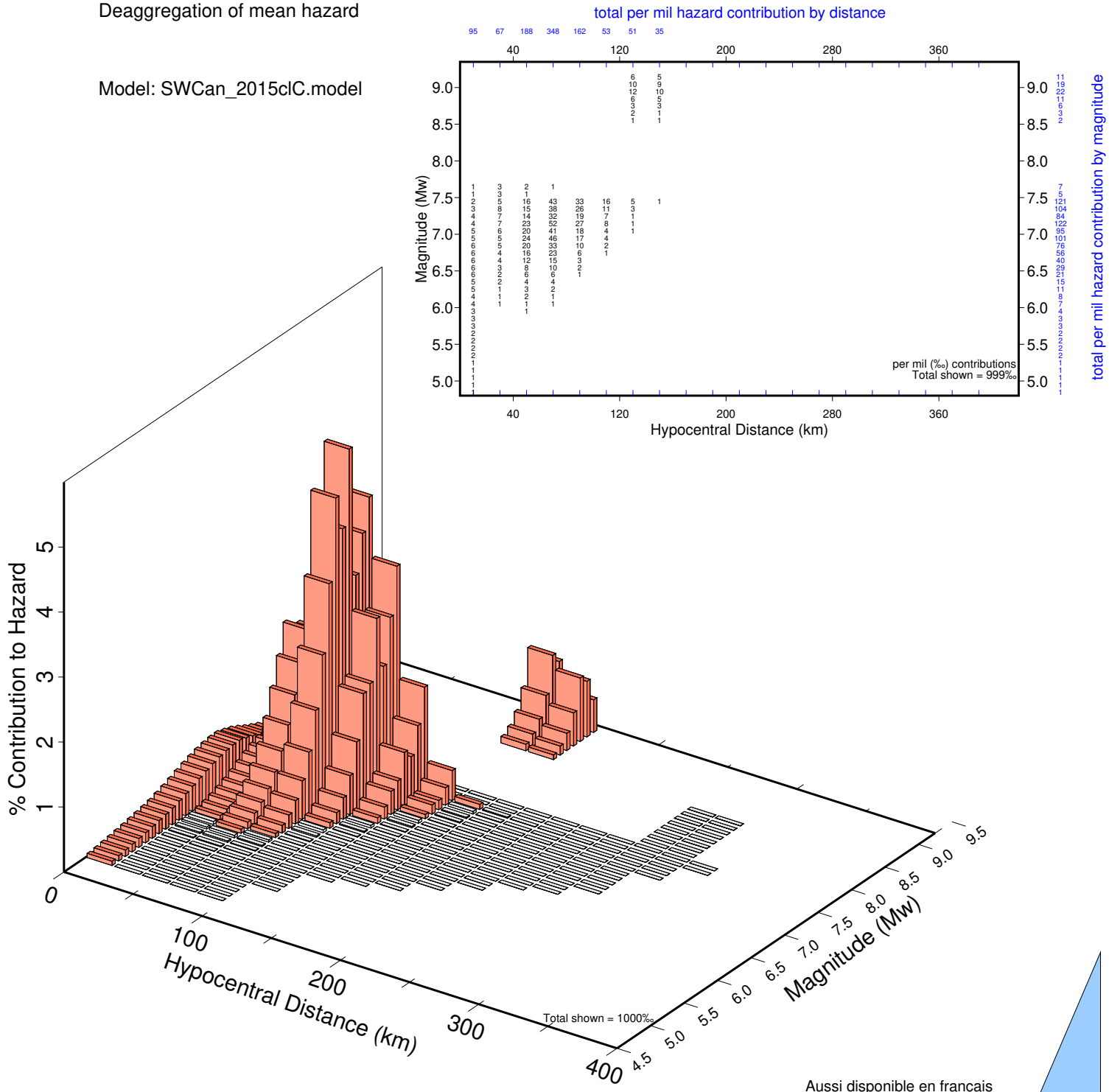
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 7.15 Mean distance 69 km

Mode magnitude (Mw) 7.150 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Canada

Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 0.50 seconds

at a probability of 0.000404 per annum, seismic hazard = 0.745 g

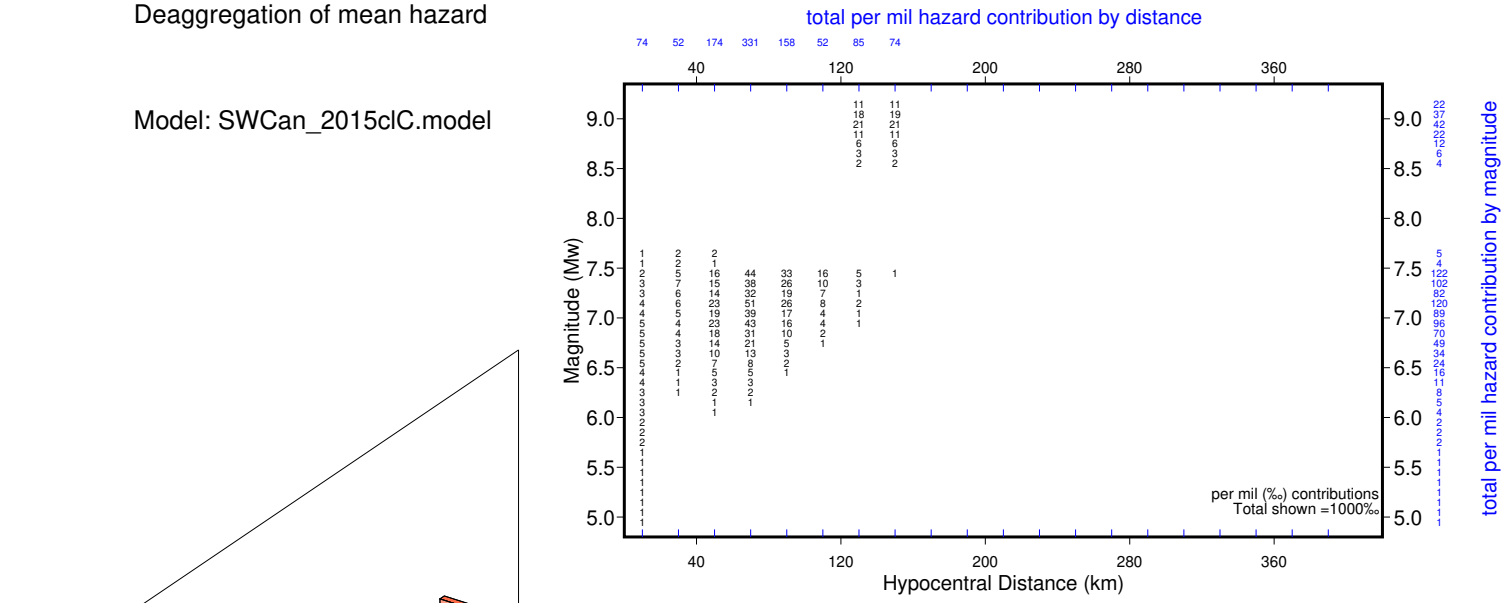
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

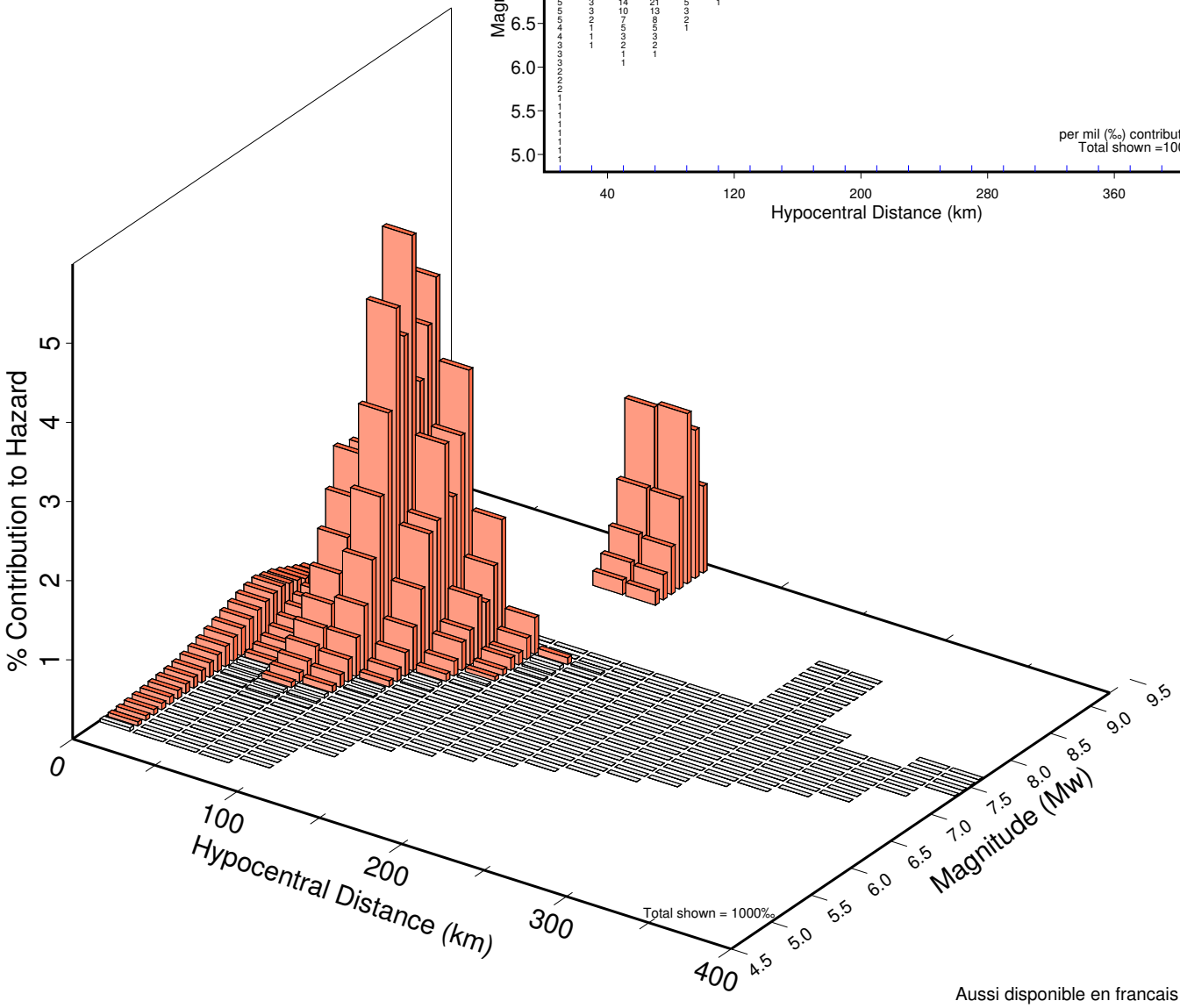
Mean magnitude (Mw) 7.32 Mean distance 76 km

Mode magnitude (Mw) 7.150 Mode distance 70 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model





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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
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Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 1.0 seconds

at a probability of 0.000404 per annum, seismic hazard = 0.420 g

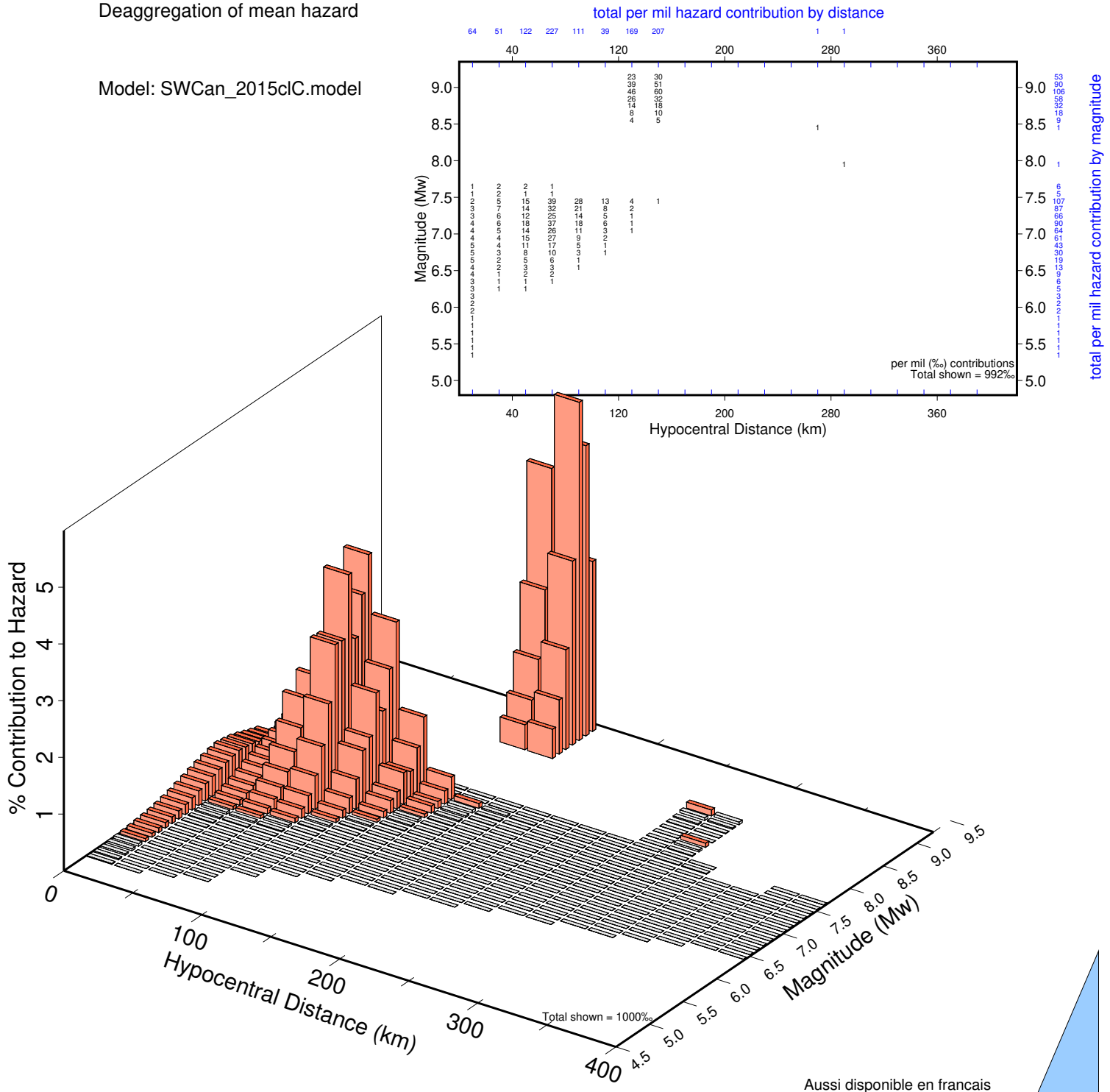
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 7.78 Mean distance 93 km

Mode magnitude (Mw) 8.950 Mode distance 150 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*

Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 2.0 seconds

at a probability of 0.000404 per annum, seismic hazard = 0.254 g

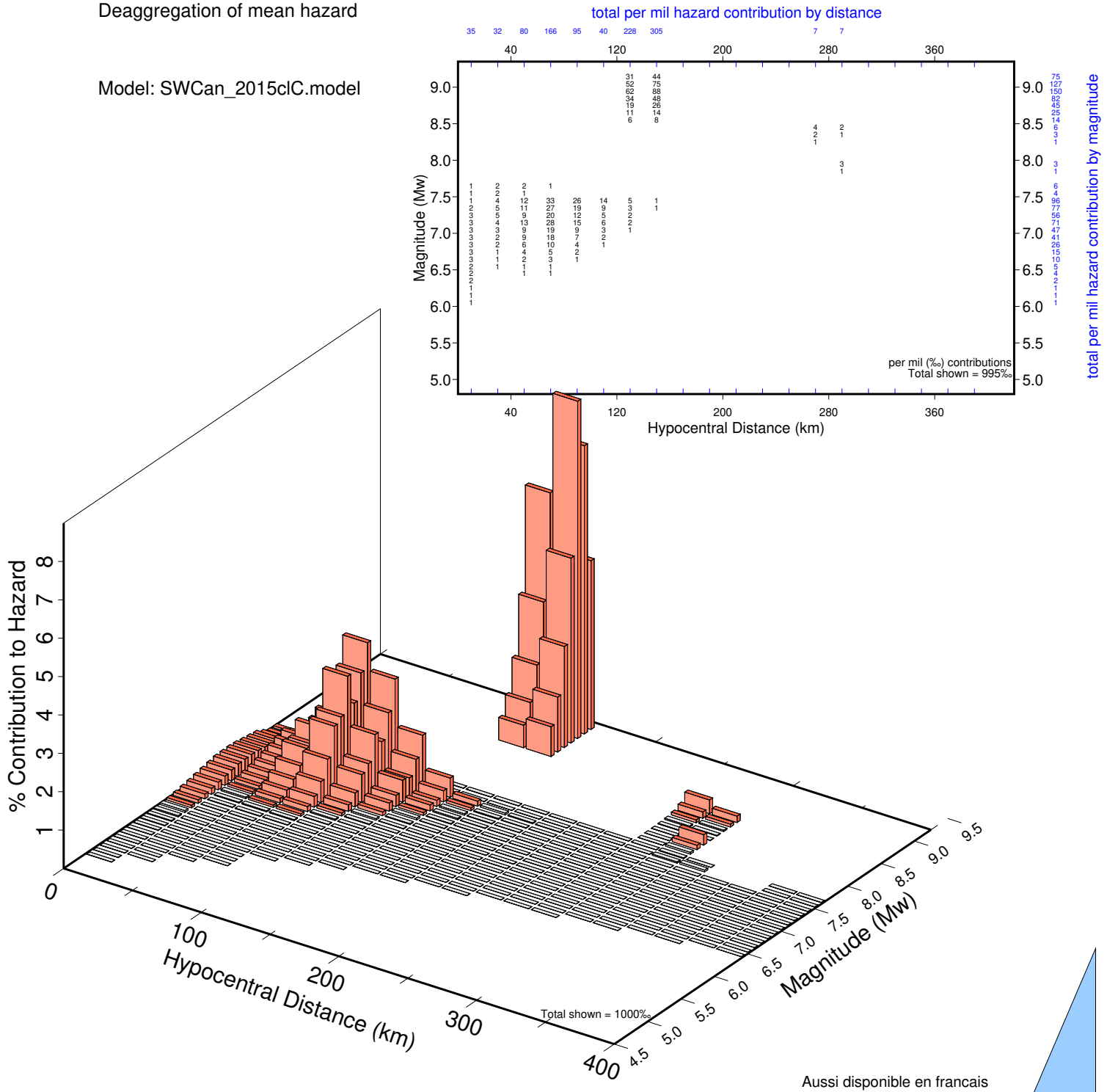
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 8.11 Mean distance 110 km

Mode magnitude (Mw) 8.950 Mode distance 150 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 5.0 seconds

at a probability of 0.000404 per annum, seismic hazard = 0.080 g

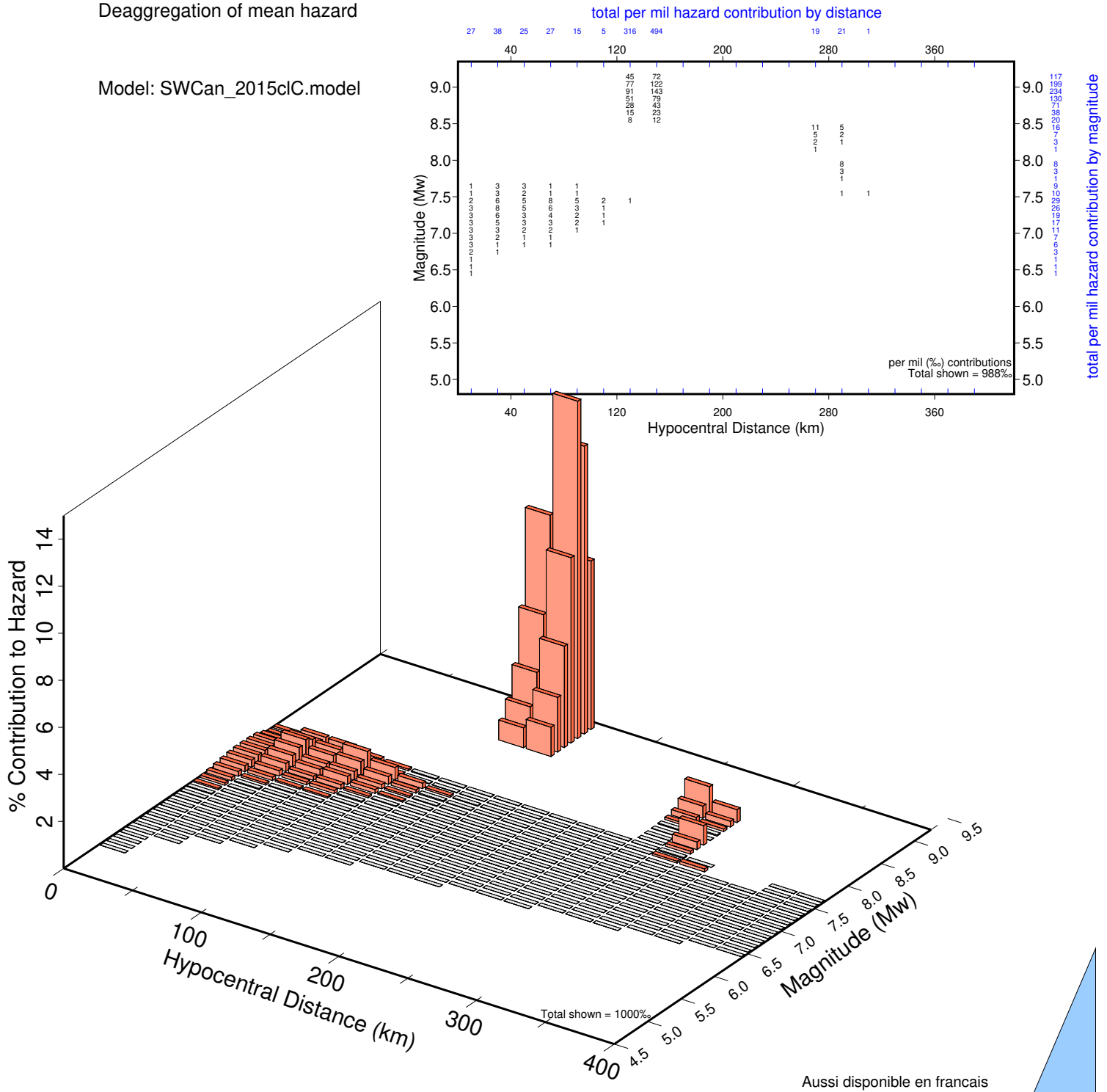
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 8.67 Mean distance 135 km

Mode magnitude (Mw) 8.950 Mode distance 150 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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Seismic Hazard Deaggregation

calculated by the Canadian Hazards Information Service

INFORMATION: *EarthquakesCanada.nrcan.gc.ca*
Eastern Canada (613) 995-5548 Western Canada (250) 363-6500

Requested by: Natural Resources Canada 2015/10/22

For site Vancouver, BC at 49.165 N 122.952 W

For ground motion parameter spectral acceleration with a period of 10.0 seconds

at a probability of 0.000404 per annum, seismic hazard = 0.028 g

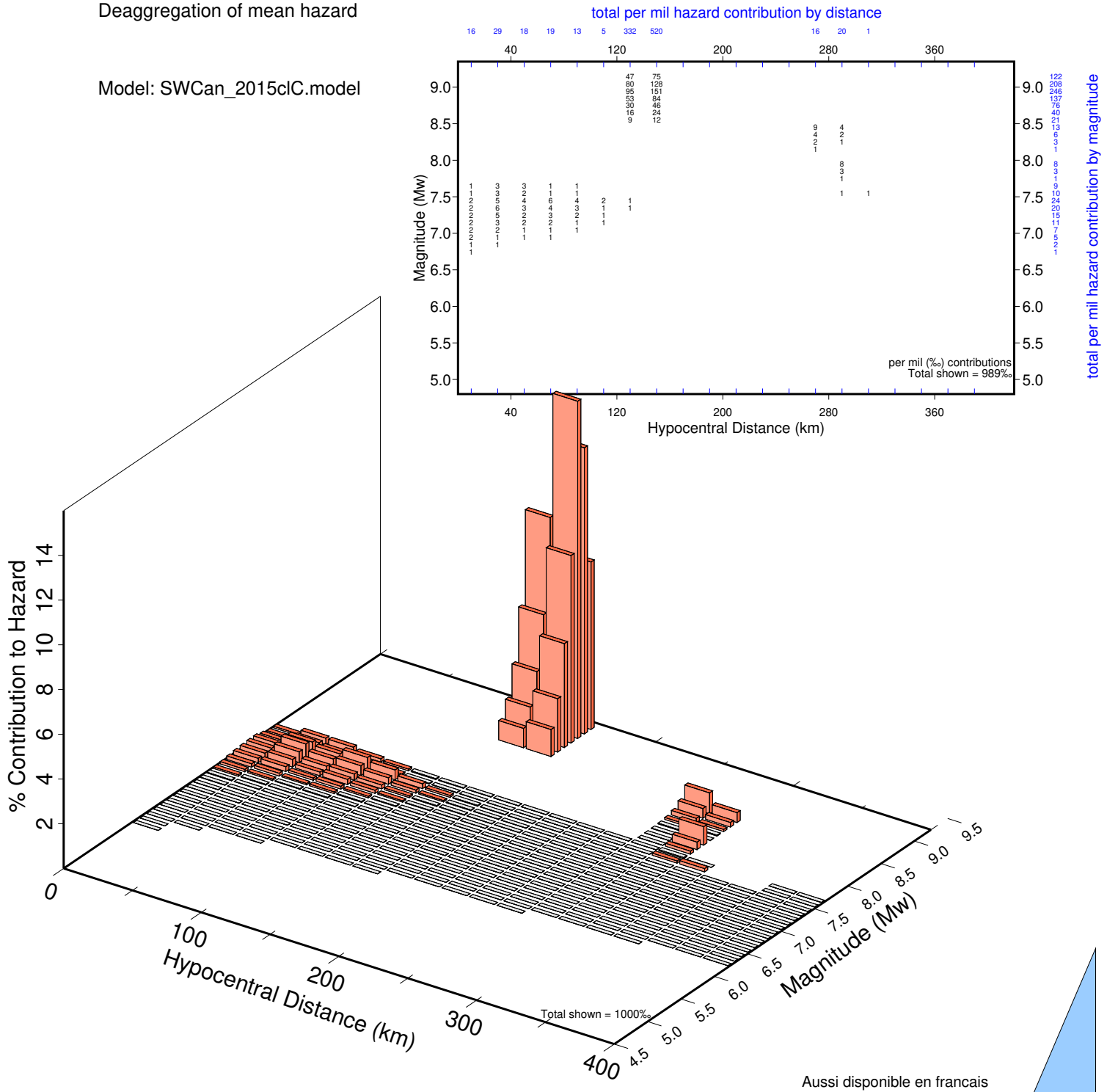
Soil Class C, 2015 Geological Survey of Canada 5th Generation model as prepared for NBCC2015

Mean magnitude (Mw) 8.73 Mean distance 139 km

Mode magnitude (Mw) 8.950 Mode distance 150 km

Deaggregation of mean hazard

Model: SWCan_2015clC.model



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