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GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7724

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ABSTRACT

Canada's Fifth Generation seismic hazard model is the basis for the seismic design provisions in the 2015 National Building Code of Canada (NBCC). The SHEEF2010 version of the Seismic Hazard Earthquake Epicentre File (SHEEF) was compiled to be the authoritative catalogue for the Fifth Generation seismic hazard model. Canadian and American source catalogues were consulted, magnitudes and locations for important older earthquakes were re-evaluated, and moment magnitudes were assigned to the earthquakes based on appropriate conversion equations.

INTRODUCTION

The Geological Survey of Canada (GSC) has produced a new seismic hazard model (Halchuk et al., 2014) and from this, a suite of new seismic hazard maps for Canada (Adams et al., 2015, in preparation). Adams et al. (2015) will cover the development of (and rationale for) the hazard model and give the seismic hazard results for selected cities and localities across Canada. It is intended that Adams et al. (2015) will document the final version of the body of work that formed the basis for the Standing Committee on Earthquake Design's (SCED) final recommendations for the seismic design provisions in the 2015 edition of the National Building Code of Canada (NBCC). The final seismic hazard values for a 10-km-spaced grid covering all of Canada and surrounding coastal waters will be presented in Halchuk et al. (2015, in preparation), similar to the 2005 grid Open File (Halchuk and Adams, 2008) .

The present Open File is being issued to place on record and make available the Seismic Hazard Earthquake Epicentre File (SHEEF) that was used to develop the model and hence underpin the Fifth Generation Seismic Hazard Maps of Canada. This open file is an update of GSC Open File 6208 (Halchuk, 2009), which should be referred to for the prior history of discussions on the methodology and parameters of the catalogue. The earthquake epicentre solutions are provided in a simplified Canadian Earthquake Epicentre File (SHEEF) format. Sample solution lines are given in Table 1, with a detailed explanation of the format.

METHOD

The original SHEEF file in GSC Open File 6208, in CEEF format, contained data to the end of 1990 in eastern Canada and to the end of 1991 in western Canada. Details of the derivation of SHEEF are in Halchuk (2009), which also contains supplemental data files for earthquakes to the end of 2008.

The current SHEEF2010 file was initiated in early 2011 and intended to include all known events with a catalogue magnitude[a] of 2.5 or larger through to the end of 2010. Earthquake hypocentres for 2009 and 2010 were extracted from the Canadian National Earthquake Database (NEDB) *eqi* database and added to the original SHEEF file and its supplements. This interim catalogue of GSC-sourced epicentres was then supplemented from U. S. Geological Survey (USGS) and international sources, as described in the regional sections below. The extent of the earthquakes in SHEEF2010 is shown in Figure 1.

Catalogue sources for Eastern Canada

For eastern Canada (east of 95°W) it was decided to combine the catalogues by allowing the location to determine the preferred source (earthquakes in Canada used the solution provided by the GSC, earthquakes in the United States used the solution provided by the USGS). Events close to the border were examined for possible duplicates or missing events.

SHEEF2010 earthquake data for the neighbouring US was taken from the USGS' National Seismic Hazard Mapping Project (NHSMP), which in early 2011 was complete to the end of 2006. The USGS catalogue (Version 2) was obtained from the USGS website in April 2011. This non-declustered catalogue does not contain duplicates, but may contain man-made events. To update the US catalogue,

[a] The catalogue magnitude is the preferred magnitude chosen by the analyst at the time of locating the earthquake; in most cases it is M_L or m_N and is seldom M_W.

extracts were done from the online US PDE catalogue, for the time period 2007-2010 for the lower 48 states (20-50°N, 90-50°W).

As Halchuk (2009) and the NEDB already included the larger Greenland earthquakes, there was no merging of the latest Greenland catalog.

The cut-off boundary for eastern Canada was chosen so that earthquakes at distances of at least 100 km from the 5th Generation source zones were included. In eastern Canada (90°W to 45°W), events south of 38°N were discarded. At this stage the magnitudes in the original catalogs were retained.

Catalogue sources for South-Western Canada

Consistent with Halchuk (2009), U.S. solutions were not used for Washington, Idaho, and Montana because the NEDB already included the events needed for seismic hazard analysis.

Catalogue sources for North-Western Canada and Alaska

Preferred locations for earthquakes west of 141°W (the Canada-US border north of 61°N) were taken from the catalogue used to develop the USGS Seismic Hazard Maps of Alaska (Wesson *et al*., 2007; C. Mueller, pers. comm., 2013), while we retain the preferred SHEEF epicentres for earthquakes east of 141°W, including for the Alaska panhandle. The USGS Alaska catalogue was truncated at 160°W. This longitude was chosen to provide reliable source zone-statistics for earthquakes in Alaska subduction zone region that may pose a threat to Canadian territory.

NRCan and USGS independently locate the same earthquakes, and for several earthquakes the solutions were located on the foreign side of the international border by each authority. Consequently, the bulk inclusion of the Alaska data west of 141°W resulted in several individual events being duplicated in the resulting SHEEF. These duplicates were detected automatically and removed by hand, with the Geological Survey of Canada solutions (often in Canada) being taken as the preferred solution.

As the refinement of SHEEF epicentres was being conducted, the joint International Seismological Centre – Global Earthquake Model (ISC-GEM) catalogue of significant global earthquakes was released (Storchak *et al.*, 2013). The catalogue includes earthquakes from 1900 to 2009 and uses and modern location algorithms and, wherever possible, additional phase picks that were not available at the time the earthquakes were originally located. The hypocentres and magnitudes from the ISC-GEM catalogue were merged with the SHEEF using a semi-automated process, with human intervention only for earthquakes with similar epicentres and origin times. Figure 2 shows a comparison of epicentres from the respective catalogues. For earthquakes north of 58.5°N and west of 120°W, the ISC-GEM hypocentres and magnitudes are taken as the preferred solutions. Additionally, hypocentres from the ISC-GEM catalogue were adopted for all events west of 141°W rather than USGS hypocentres (see Figure 2).

Additional modifications were made to earthquake hypocentres based on special studies. These studies include:

- earthquake relocations from the Beaufort Sea region (Hasegawa *et al.*, 1979)
- relocations and magnitude assessment for the 1940 Richardson Mountains earthquakes, Yukon Territory (Cassidy and Bent, 1993)
- earthquake relocations from the Yakutat block and south-central Alaska (Doser *et al.*, 1997)

- earthquake relocations from southeastern Alaska (Doser and Lomas, 2000)
- earthquake relocations from the Denali-Totschunda Fault Zone in central Alaska (Doser, 2004)
- earthquake relocations from south-central Alaska (Doser, 2006)
- earthquake relocation and magnitude assessment from northwestern Canada (west of 120°W) by Malcolm White and Taimi Mulder (GSC) using historical phase picks with modern location procedures and velocity models (unpub. work 2012-2013)

Conversion to Moment Magnitude (M_W) for Eastern Canada

One of the primary goals for the SHEEF2010 update was the production of a uniform magnitude catalogue. Moment magnitude (M_W) is proportional to the total energy released by an earthquake and does not saturate for large events (Hanks and Kanamori, 1979). The current ground motion prediction equations (GMPEs) in use for Canada are described in terms of M_W. Furthermore, M_W is commonly used as the preferred magnitude scale in evaluating seismic hazard. Realizing that truncating the magnitude to 1 decimal may quantize the data for users other than the seismic hazard map, we have provided the M_W value to 2 decimal places at the end of each solution line.

Moment magnitude values determined by Bent (2009) for 150 of the largest earthquakes in eastern Canada were adopted as the preferred magnitude in the SHEEF2010 catalogue. Moment magnitude is not routinely determined for smaller ($M_W < 5$) earthquakes. Consequently, a set of magnitude conversion equations were applied to most of the catalogue. The rules applied to convert various eastern magnitudes to M_W were based on Bent (2011) and are given below:

- Canadian portion of the eastern SHEEF catalogue:
  - Pre-1995
    - $M_W = m_N - 0.4$ (note m_N is similar but not identical to m_{bLg})
    - $M_W = M_L - 0.4$ (value for M_W expected to be slightly high, that is, conservative for seismic hazard estimation. This estimation is based on older, onshore earthquakes with M_L magnitudes.)
    - Treat all other magnitudes as M_W
  - 1995-and-after (to the end of 2010)
    - $M_W = m_N - 0.5$ (where $M_L = m_N$ and all other magnitudes treated as M_W)

For the USGS-sourced events we used conversion relations adopted by the USGS:

- USGS main catalogue to the end of 2006

  All magnitudes in the catalogue are effectively m_{bLg}, converted using the two equations below (the adopted estimate for M_W is the average of the two results):
  - Atkinson and Boore (1995):
    - If $m_{bLg} \leq 5.5$, $M_W = 0.98\, m_{bLg} - 0.39$
    - If $m_{bLg} > 5.5$, $M_W = 2.715 - 0.277\, m_{bLg} + 0.127\, m_{bLg}^{\,2}$
  - Johnston (1996): $M_W = 2/3 \times (17.76 + 0.36\, m_{bLg} + 0.14\, m_{bLg}^{\,2}) - 10.7$

- USGS PDE catalogue (2007-2010)

- Treat M_W, M_S, and m_b as M_W
- Treat all other magnitude scales as m_{bLg} and apply the same equations as for the USGS main catalogue

Conversion to Moment Magnitude (MW) for Western Canada

The majority of earthquakes recorded in western Canada in recent times are have been assigned local magnitudes (M_L). Earthquake magnitudes earlier than 1955 are assumed to be equivalent to current local magnitudes. Ristau *et al*. (2003; 2005) evaluated moment tensor solutions for earthquakes in western Canada and earthquakes off the west coast. They developed the following conversions between M_W and M_L:

- $M_W = M_L$ for shallow crustal earthquakes within western Canada (Ristau *et al.*, 2005);
- $M_W = M_L + 0.6$ for inslab earthquakes in the Vancouver Island/Puget Sound region (Ristau *et al.*, 2005);
- For offshore earthquakes, two equations are used:
  - $M_W = M_L + 0.28$ for offshore earthquakes along the Queen Charlotte Fault that have travel paths mostly through continental crust (Zone 1 of Ristau *et al.*, 2003; see Appendix A);
  - $M_W = M_L + 0.55$ for earthquakes that have a significant travel path through oceanic crust (Zones 2 of Ristau *et al.*, 2003; see Appendix A)

Conversions from surface-wave magnitude M_S and body-wave magnitude m_b in western Canada follow the same approach as that adopted for the USGS National Seismic Hazard Maps (Petersen *et al.*, 2008; C. Mueller, pers. com., 2008). These conversions are:

- m_b to M_W:
  - If $5.3 \leq m_b \leq 7.3$, $M_W = 1.46\ m_b - 2.42$ (modified from Sipkin, 2003);
  - Otherwise $M_W = m_b$;
- M_S to M_W following Utsu (2002):
  - If $M_S < 5.8$, $M_W = 0.75 \times (M_S + 1.93)$;
  - If $M_S > 7.8$, $M_W = 1.50 \times (M_S - 2.60)$;
  - Otherwise $M_W = M_S$.

In compiling this report, the authors became aware that there are a small number (13) of earthquakes in the inslab Vancouver Island/Puget Sound region with an original magnitude type of M_L that do not appear to have been corrected as should be expected based on the logic above. These are mostly small-magnitude events $M_L (= M_W) \leq 2.5$. As their uncorrected magnitudes were used for the NBCC2015, we preserve them in the SHEEF2010 data file.

Catalogue Minimum Magnitude

As noted the SHEEF2010 catalogue was intended to include all known events with an original catalogue magnitude of 2.5 or larger. However, when converted to moment magnitude, the SHEEF2010 file has a variable minimum magnitude. This is because the minimum M_W varies depending on the conversion rules applied to the original magnitude. For example, eastern events of $m_N = 2.5$ become $M_W = 2.1$ or 2.0

depending on their date, and western events of M_L 2.5 become M_W 2.5. This ragged lower limit needs to be considered in the choices of completeness magnitudes. For the 5th Generation Seismic Hazard Model, the minimum magnitude considered for the evaluation of Gutenberg-Richter magnitude-frequency distributions varies with the region being considered. The completeness years used in the model will be provided in an upcoming open file.

Aftershocks, induced events

SHEEF2010 excludes earthquakes flagged in the Canadian National Earthquake Database (NEDB) as induced, but still includes induced events that were not flagged. It includes aftershocks and other dependent events. It has not been declustered.

SUMMARY

Herein, we have documented the 2010 Seismic Hazard Earthquake Epicentre File (SHEEF2010) that was used to develop the 5th Generation Seismic Hazard Model of Canada. The SHEEF2010 combines multiple catalogues from national and international sources to provide the highest quality epicentres and magnitudes for the assessment of earthquake hazard in Canada. For the first time, earthquake magnitudes have been harmonized to moment magnitude, M_W, using magnitude conversion equations appropriate for particular regions and specific to the original catalogue magnitude types. The magnitude harmonization represents a significant advance in our ability to represent earthquake hazard in a uniform manner throughout the country.

The SHEEF2010 is a snapshot of the earthquake catalogue at a given point in time. The file was built in stages as the 5th generation seismic hazard model was developed. SHEEF2010 was initiated for eastern Canada beginning in March 2011. The portions of the catalog covering southwestern and northwestern Canada and the neighbouring United States were compiled through 2012 and 2013. Note that earthquake epicentres are being constantly investigated and updated. The latest available epicentre file will differ from the SHEEF for some solutions.

SHEEF DATA AND SUPPLEMENTARY FILES THAT ACCOMPANY THIS REPORT

SHEEF2010.txt – SHEEF catalogue in ascii text format. For source, depth flag, and magnitude type explanations, see Table 1 and Appendix B.

SHEEF2010postermap.pdf – poster sized map displaying the epicentres in SHEEF2010.

SHEEF2010.shp – SHEEF catalogue shapefile for use with GIS applications. The shapefile is a grouping of several files to represent different aspects of geodata (OpenStreetMap, 2013):

- `.shp`: shape format; the feature geometry.
- `.shx`: shape index format; a positional index of the feature geometry to allow quick searching.
- `.dbf`: attribute format; columnar attributes for each shape, in dBase IV format.

The feature attributes can be examined in the GIS software, or through opening the `.dbf` file in Microsoft Excel, for example. A description of the attribute fields is provided in Appendix C. There

are also several optional files in the shapefile format. The most significant of these is the `.prj` file which describes the coordinate system and projection information used. The shapefiles generated for NBCC2015 hazard model are specified with the WGS84 projection.

ACKNOWLEDGEMENTS

The creation of an earthquake catalogue is a complex undertaking, and has involved many of our colleagues at Natural Resources Canada. We thank them. Additionally, we would like to thank Chuck Mueller for provision of the 2007 Alaska and 2008 conterminous US earthquake catalogues as used by the USGS Earthquake Hazards Program. Discussions with Dmitry Storchak on the ISC-GEM earthquake catalogue in advance of its public release were also very helpful. Most of the figures were generated using the freely available GMT (Generic Mapping Tools) software package, developed by P. Wessel and W.H.F Smith. Our sincere thanks for their development and maintenance of this versatile product.

REFERENCES

Abe, K., and S. Noguchi (1983). Revision of magnitudes of large shallow earthquakes, 1897-1912 *Phys. Earth Planet. In.* **33,** 1-11 doi: 10.1016/0031-9201(83)90002-X.

Adams, J., Halchuk, S., Allen, T.I., Rogers, G.C. (2015). Fifth Generation seismic hazard model and values for the 2015 National Building Code of Canada. Geological Survey of Canada Open File (*in preparation*).

Atkinson, G.M. and Boore D.M. (1995). New ground motion relations for eastern North America. Bull. Seism. Soc. Am., v. 85, p. 17-30.

Bent, A. L. (2009). A moment magnitude catalog for the 150 largest eastern Canadian earthquakes. Geological Survey of Canada, Open File 6080, 2009; 23 pages, doi:10.4095/247618

Bent, A. L. (2011). Moment magnitude (Mw) conversion relations for use in hazard assessment in eastern Canada. Seismological Research Letters vol. 82, no. 6; p. 984-990, doi:10.1785/gssrl.82.6.984

Cassidy, J. F. and A. L. Bent (1993). Source parameters of the 29 May and 5 June, 1940 Richardson Mountains, Yukon Territory, earthquakes, *Bull. Seism. Soc. Am.* **83,** 636-659.

Cassidy, J. F., R. M. Ellis, and G. C. Rogers (1988). The 1918 and 1957 Vancouver Island earthquakes, *Bull. Seism. Soc. Am.* **78,** 617-635.

Doser, D. I. (2004). Seismicity of the Denali-Totschunda Fault Zone in central Alaska (1912–1988) and its relation to the 2002 Denali Fault earthquake sequence, *Bull. Seism. Soc. Am.* **94,** S132–S144.

Doser, D. I. (2006). Relocations of earthquakes (1899–1917) in south-central Alaska, *Pure appl. geophys.* **163,** 1461–1476.

Doser, D. I., and R. Lomas (2000). The transition from strike–slip to oblique subduction in southeastern Alaska from seismological studies, *Tectonophys.* **316,** 45–65.

Doser, D. I., J. R. Pelton, and A. M. Veilleux (1997). Earthquakes in the Pamplona zone, Yakutat block, south central Alaska, *J. Geophys. Res.* **102,** 24,499-24,511.

Halchuk, S. (2009). Seismic Hazard Earthquake Epicentre File (SHEEF) used in the fourth generation seismic hazard maps of Canada; Geological Survey of Canada, Open File 6208; 16 pages (1 sheet); 1 CD-ROM, doi:10.4095/261333.

Halchuk, S and Adams, J. (2008). Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2005 National Building Code of Canada; Geological Survey of Canada, Open File 5813, 2008; 32 pages; 1 CD-ROM, doi:10.4095/225402

Halchuk, S., Allen, T.I., Adams, J., and Rogers, G.C., (2015). Fifth Generation Seismic Hazard Model Input Files as Proposed to Produce Values for the 2015 National Building Code of Canada; Geological Survey of Canada, Open File 7576. (*in preparation*)

Hanks, T. C., and H. Kanamori (1979). A moment magnitude scale, *J. Geophys. Res.* **84,** 2348–2350.

Hasegawa, H. S., C. W. Chou, and P. W. Basham (1979). Seismotectonics of the Beaufort Sea, *Can. J. Earth Sci.* **16,** 816-830.

Horner, R. B. (1983). Seismicity in the St. Elias region of northwestern Canada and southeastern Alaska, *Bull. Seism. Soc. Am.* **73,** 1117-1137.

Johnston, A.C. (1996). Seismic moment assessment of earthquakes in stable continental regions—I. Instrumental seismicity. Geophysical Journal International vol. 124 (2): p. 381-414. doi: 10.1111/j.1365-246X.1996.tb07028.x

Kelleher J. and Savino, J. (1975). Distribution of seismicity before large strike-slip and thrust type earthquakes. Journal of Geophysical Research, **80**, 260-271.

National Earthquake Database (NEDB) http://www.earthquakescanada.nrcan.gc.ca/stndon/NEDB-BNDS/index-eng.php, verified in June, 2015

National Seismic Hazard Mapping Project catalogs, downloaded in 2011 on April 20, 2011 from: http://earthquake.usgs.gov/hazards/products/conterminous/2008/catalogs/, verified in June, 2015

OpenStreetMap. (2013). *Shapefiles*, Retrieved 3 January 2014, from http://wiki.openstreetmap.org/wiki/Shapefiles.

Petersen, M. D., A. D. Frankel, S. C. Harmsen, C. S. Mueller, K. M. Haller, R. L. Wheeler, R. L. Wesson, Y. Zeng, O. S. Boyd, D. M. Perkins, N. Luco, E. H. Field, C. J. Wills, and K. S. Rukstales (2008). Documentation for the 2008 update of the United States National Seismic Hazard Maps, U.S. Geological Survey Open-File Report 2008–1128 128.

PDE (Preliminary Determination of Epicenters) catalog, accessed in 2011, now available from: http://earthquake.usgs.gov/earthquakes/search/, verified in June, 2015

Ristau, J., G. C. Rogers, and J. F. Cassidy (2003). Moment magnitude–local magnitude calibration for earthquakes off Canada's west coast, *Bull. Seism. Soc. Am.* **93,** 2296–2300.

Ristau, J., G. C. Rogers, and J. F. Cassidy (2005). Moment magnitude–local magnitude calibration for earthquakes in western Canada, *Bull. Seism. Soc. Am.* **95,** 1994–2000.

Rogers, G. C. (1983). Some comments on seismicity of the northern Puget Sound-southern Vancouver Island region, *in* Yount, J. C. and R. S. Crosson (eds), *Proceedings of Workshop XIV: Earthquake hazards of the Puget Sound region, Washington*. U.S. Geological Survey Open File Report 83-19, 19-39.

Sipkin, S. A. (2003). A correction to body-wave magnitude m_b based on moment magnitude M_W, *Seism. Res. Lett.* **74,** 739-742.

Storchak, D. A., D. Di Giacomo, I. Bondár, E. R. Engdahl, J. Harris, W. H. K. Lee, A. Villaseñor, and P. Bormann (2013). Public release of the ISC–GEM global instrumental earthquake catalogue (1900–2009), *Seism. Res. Lett.* **84,** 810-815.

Tobin, D.G. and Sykes, L.R. (1968). Seismicity and tectonics of the northeast Pacific Ocean. Journal of Geophysical Research, **73**, 3821-3846.

Utsu, T. (2002). Relationships between magnitude scales, *International handbook of earthquake engineering and seismology*. *ed.* W. K. Lee, H. Kanamori, P. C. Jennings, and C. Kisslinger. Amsterdam, Academic Press. **81A,** 733-746.

Wesson, R. L., O. S. Boyd, C. S. Mueller, C. G. Bufe, A. D. Frankel, and M. D. Petersen (2007). Revision of time-independent probabilistic seismic hazard maps for Alaska, *U.S. Geological Survey Open-File Report 2007-1043*, 33 pp.

TABLES AND FIGURES

Table 1 – SHEEF2010 sample solution lines and explanation of SHEEF format.

Date	MW	Longitude	Latitude	Source	Depth	DF	OM	OMT	MW2
201012290510	2.2	-92.330	35.290	PDE	5.00		2.5	MD	2.19
201012291415	2.7	-114.560	79.362	GSC	18.00	F	3.2	ML	2.67
201012300038	2.0	-72.724	49.482	GSC	18.00	F	2.5	MN	1.97
201012300149	4.0	-133.442	65.218	PGC	5.00	F	4.0	Mw	4.00
201012300622	3.0	-130.282	50.599	PGC	10.00	F	3.0	Mw	3.00

Date in the format YYYYMMDDHHMM (YearMonthDayHourMinute)

MW – Preferred Magnitude (Mw or estimated Mw)

Longitude – in decimal degrees

Latitude – in decimal degrees

Source – agency providing the location and magnitude. A list of source agencies is provided in Appendix B. A map of the most common agencies contributing to SHEEF2010 is plotted in Figure 3. Depth in kilometres. Note that older earthquakes typically do not have a depth determined. Modern earthquakes (from the late 1950s onwards) with no depth flag generally indicates that the depth has been freely determined.

Depth – in km

DF – Depth Flag (generally applies to earthquakes within Canada and its territorial waters).

- F or G indicates the depth has been assigned.
- H indicates assigned hypocentre but calculated origin time.
- N indicates assigned hypocentre and time.
- V indicates depth determined by regional depth phase modelling method.

OM – Original magnitude

OMT – Original magnitude type

- MB/mb Body wave magnitude
- mBAB (D06 source)
- mblSC (EVCEHB source)
- MbLg Short period body wave magnitude
- MC Coda duration magnitude
- MD Duration magnitude

- ML Local magnitude
- MN Nuttli magnitude
- Mq (M? unknown original magnitude type)
- MS Surface wave magnitude
- Mw Moment magnitude
- MwHRV/MwP&S, UKBRK, UKPAL, UKPAS
- OT Other magnitude type (usually intensity magnitude)

MW2 – Preferred magnitude with two decimal places.

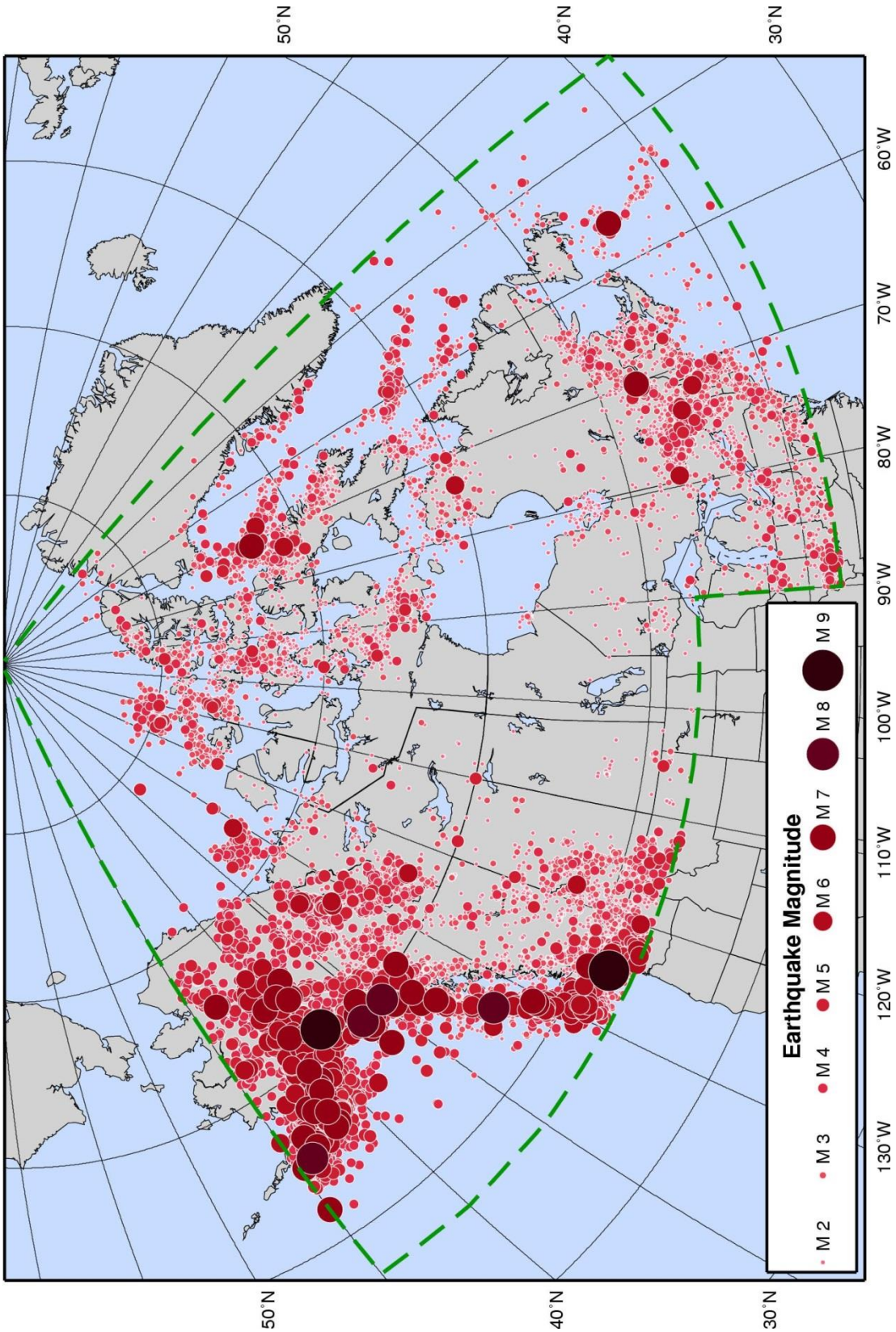

Figure 1. SHEEF2010 catalogue with its extent indicated by the dashed green line.

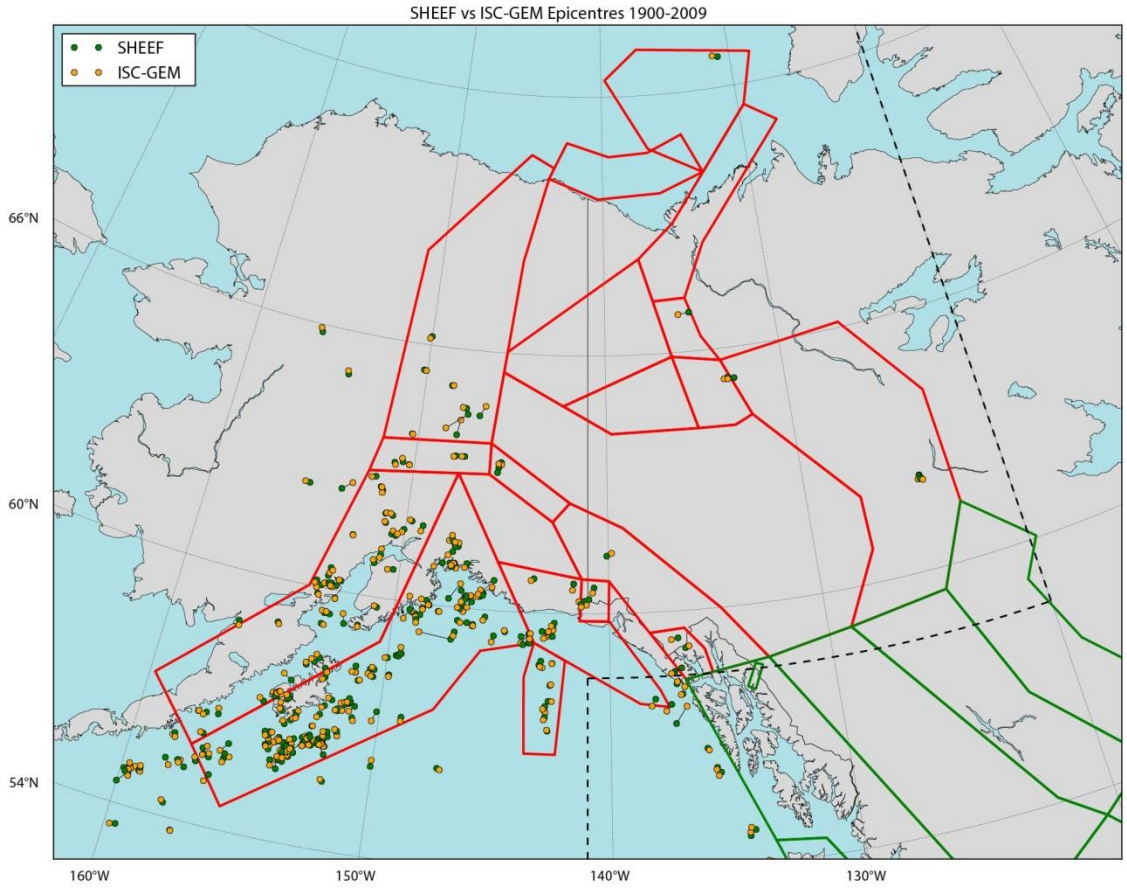

Figure 2: *Comparison of epicentres from the SHEEF2010 and ISC-GEM (Storchak et al., 2013) earthquake catalogues. Solid black lines link respective epicentres for the same earthquake. Preferred locations are taken from the ISC-GEM catalogue for earthquakes located to the west of the black dashed line. Epicentres are shown relative to the source zones (red and green polygons) for the 5th Generation Seismic Hazard Maps of Canada.*

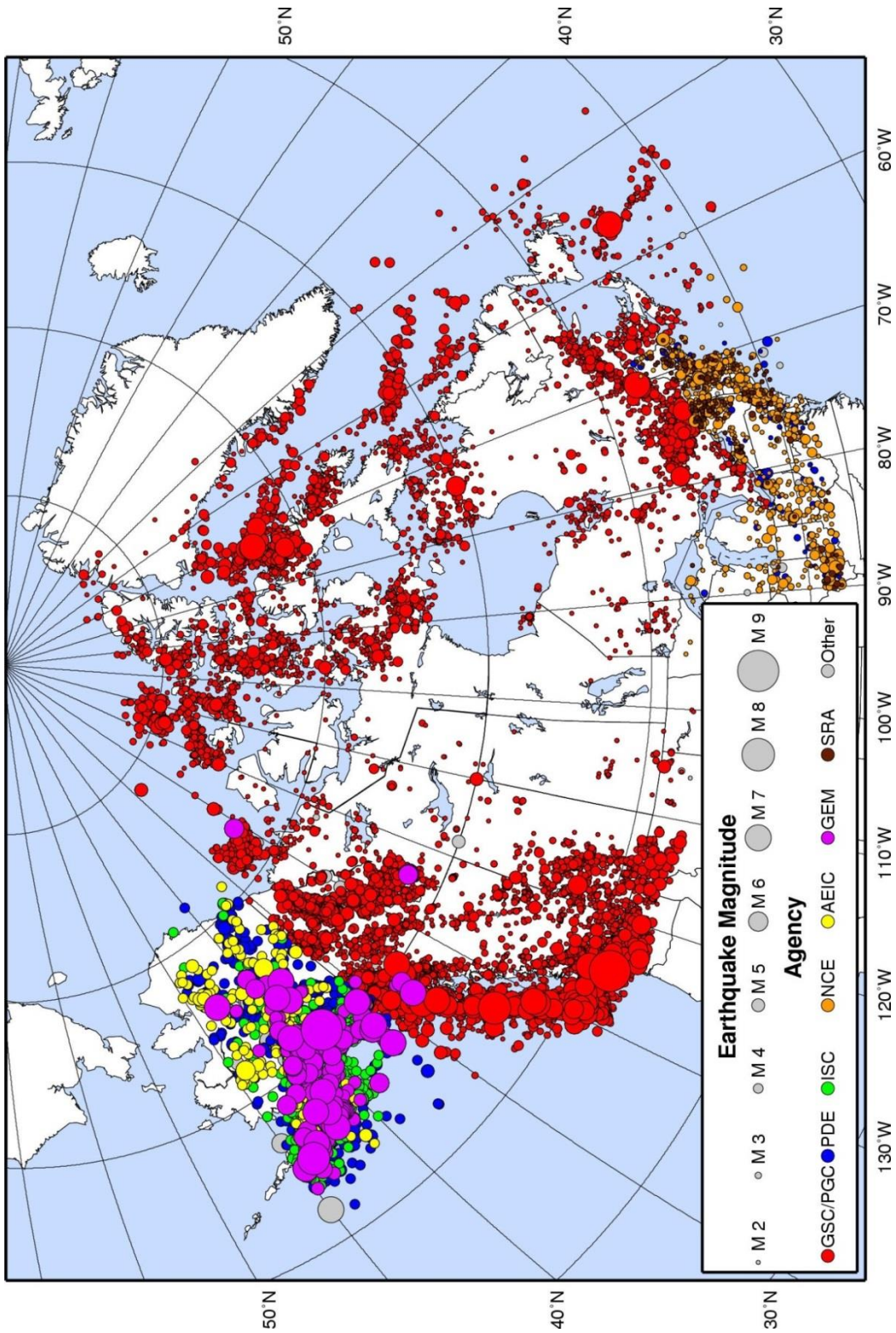

Figure 3. Selected agency sources for the SHEEF2010 catalogue. There are about 30 agencies in total. The seven agencies plotted as distinct colours encompass 98% of the total earthquakes. Events are plotted from smallest to largest magnitude for each agency. A full list of contributing agencies is given in Appendix A.

APPENDIX A

Polygons used for correction of M_L to M_W for shallow offshore events based on the conversions of Ristau *et al*. (2003).

```
region:  Ristau offshore Zone 1
    54.0   -135.5
    54.7   -134.0
    51.3   -132.0
    51.8   -130.5
    correction: Mw = ML+0.28;

region:  Ristau offshore Zone 2
    51.3   -132.0
    51.8   -130.5
    49.4   -127.4
    48.0   -129.0
    49.0   -131.0
    correction: Mw = ML+0.55;
```

APPENDIX B

List of agency sources in the SHEEF2010 catalogue

*MK, *MO, *PD	USGS catalogue
AEIC	Alaska Earthquake Information Center
AN83	Yukon/Alaska region (Abe and Noguchi, 1983)
C88	Cassidy *et al.* (1988)
CB93	Cassidy and Bent, 1993
D04	Doser (2004)
D06	Doser (2006)
D97	Doser *et al*. (1997)
DNA	USGS catalogue
Ebe	Weston parent catalogue (Ebel)
EPR	EPRI catalogue
EVCEHB, EVCG&R, EVCISS	Yukon/Alaska region
GEM	International Seismological Centre – Global Earthquake Model (ISC-GEM) catalogue
GS	Yukon/Alaska region (all from 1979)
GSC	Geological Survey of Canada Eastern Office
K&S	Kelleher and Savino (1975)
H79	Hasegawa *et al.* (1979)
H83	Horner (1983)
ISC	International Seismological Centre
ISS	International Seismological Summary
LDO	Lamont-Doherty Geophysical Observatory
NCE	National Centre for Earthquake Engineering Research 1991 catalogue
OTT	Ottawa (Dominion Observatory, now GSC eastern office)
PDE	United States Geological Survey Preliminary Determination of Epicenters catalogue
PGC	Geological Survey of Canada Western Office
R83	Rogers (1983)
SMI	Yukon event, 1961, M 5.3
SRA	Stover, Reagor, Algermissen (USGS)
T&S	Tobin and Sykes (1968)
UBC	University of British Columbia
USC	Yukon/Alaska region
USH	USGS catalogue

USHIS	Significant U.S. earthquakes (USGS)
WES	Weston Geophysical Observatory
WHI	Malcolm White and Taimi Mulder, unpublished

APPENDIX C

Description of the attribute fields in the SHEEF2010 shapefile (SHEEF2010.shp).

Field	Description
LOC_SRC	Source agency providing the solution
YEAR	Year of earthquake
MONTH	Month of earthquake
DAY	Day of earthquake
HOUR	Hour of earthquake
MIN	Minute of earthquake
LAT	Latitude in decimal degrees
LON	Longitude in decimal degrees
DEP	Earthquake depth in km
FIX_DEP	Depth flag (see Table 1 for description)
PREF_MW	Preferred moment magnitude (Mw or estimated Mw)
ORIG_MAG	Original magnitude
ORIG_MAG_TY	Original magnitude type (see Table 1 for description)
PREF_MW2	Preferred moment magnitude with two decimal places