DOCUMENTATION OF STATION/AGENCY MAGNITUDE PROCEDURES

(Modified from the SUMMARY OF IASPEI MAGNITUDE WORKING GROUP RECOMMENDATIONS ON DETERMINING EARTHQUAKE MAGNITUDES FROM DIGITAL DATA, updated version 2011; see http://www.iaspei.org/commissions/CSOI/Summary_WG-Recommendations_20110909.pdf)

This document is to outline the procedures adopted by seismological agencies to compute magnitudes of seismic events.

Please list the magnitudes computed and corresponding phase type analyzed in the table below (example provided). Add as many rows as required.

Magnitude type (nomenclature used at the agency)	Full name	Wave type analyzed
Mw	Moment magnitude	Regional body and surface waves

For each magnitude type computed at the agency, please specify:

1. The equations that are used for calculating each magnitude type and
a: specify if distance is measured as epicentral distance or hypocentral distance;
b: specify the distance range for which the equation is applied;
c: specify restrictions on hypocentral focal-depth, if any.
(see question 4 for method)

a. epicentral distance
b. maximum distance 1500 km; no strict minimum but distances of less than 100 km rarely used
c. maximum depth 70 km

2. Is any signal-to-noise ratio criterion applied to the analyzed signal?
Yes- user defined but typically S/N > 2 in frequency range of interest; noise measured in the 5 minute window preceding the first arrival

3. Specify the software used (such as SeisComp, Antelope, Seismic Handler, in-house developed programs) to perform the analyses for magnitude computation.

MTINV- details in paper referenced at end of questionnaire and references therein

4. If the agency is computing magnitudes not based on some amplitude/period measurement (e.g., moment magnitude Mw) please summarize the details of the technique used. For example, is Mw obtained with a centroid moment tensor, W-phase and/or spectral fitting technique?

Regional centroid moment tensor inversion (see question 5 for exceptions)

5. Other restrictions on the calculation of a specific magnitude. For example, is the magnitude measured only for earthquakes of a certain size, as defined by an independent measure of earthquake size? Also, are specific magnitudes computed only for seismic events occurring in specific areas?

Used for all of Canada; generally inversion is run only if earthquake is expected to have reasonable long-period energy based on another magnitude; typical values are MN 4.0 or greater in eastern Canada and ML 3.5 or greater in western Canada; both correspond roughly to Mw 3.5

Note: our current CMT database contains no earthquakes of Mw < 3.4; however, we do supply the ISC with some Mw's for smaller earthquakes; these are almost exclusively from the offshore southern British Columbia region; these Mw's are converted from ML (see ML documentation for details on how ML is calculated) by adding 0.62 to the ML value; in this region ML tends to underestimate the size of the earthquake (see Ristau et al paper below); in most other regions of western Canada ML and Mw are roughly comparable

Detailed questions on the magnitudes based on amplitude/period measurements:

6. How the network (event) magnitude and corresponding uncertainty is obtained? For example, is the network magnitude an arithmetic/trimmed mean, median value of the single station magnitudes?

Usually arithmetic mean but program allows for complex weighting schemes (option rarely employed in practice)

7. Units of the reported amplitudes. Specify if amplitudes are reported in units of trace-amplitude motion instead of ground motion.

Amplitudes not provided to ISC

8. Time-window in which the amplitude measurement is made for the phase type analyzed. For example, for body wave magnitudes, is the time window

a flexible time-interval between the P onset and the PP onset or a fixed time window after the first P onset (e.g. 5 s, 10 s or other)? Similarly, for the surface wave magnitudes, is the time window considered a time-interval spanned by waves having group-velocities between, e.g., 3.2 and 4.0 km/s?

Varies but distance related; windows start at first arrival; 100 sec window for distances of less than 100 km to 500 sec for 1500 km

9. Orientation of seismograph (horizontal or vertical) from which the measurement is made. For example, is Ms computed using both horizontal and vertical components? Specify also if, as for example might be the case for ML, data from each of the two horizontal components at a single station are used, are data from each component treated as a separate observation in the network magnitude computation, or are the two components first averaged into a station magnitude, which is then treated as a single observation in the network magnitude computation?

Vertical, radial and tangential; rotation angle based on back azimuth; each component treated as a separate measurement; note that not all components will be used from every station as signal quality may vary from one component to another

10. Describe the amplitude-response, filter characteristics, or transfer-function of the seismograph or simulated seismograph through which the amplitude measurement is made. For example, is the standard Wood-Anderson seismometer simulation filter used to compute ML?

Long-period bandpass filter; program allows for flexibility depending on S/N and frequency content of data but generally somewhere in the 0.01-0.03 Hz range for low corner frequency and 0.04-0.06 for Hz for high corner frequency

11. Details of measuring amplitude:

a: For example, does the amplitude correspond to 0.5*(peak-to-trough amplitude), where “peak-to-trough amplitude” corresponds to difference between a maximum positive excursion and a maximum negative excursion of the trace, or is the amplitude instead measured as the maximum absolute excursion from the “zero” position of the seismograph trace?

b: for example, if the amplitude corresponds to 0.5*(peak-to-trough amplitude), are the “peak” and “trough” respectively the absolute maximum and absolute minimum values of the entire wave-group, or

are they the adjacent peak and trough corresponding to the maximum trace excursion that is associated with a single zero-crossing?

c: for example, are displacement amplitude(A) and period(T) measured at the time of maximum A or at the time of the maximum of the quotient (A/T)?

Not applicable- magnitude based on fitting waveform

12. Details of measuring period. For example, is it the time between the neighboring peaks, respectively troughs or twice the time span measured between the largest peak and adjacent trough at which the double amplitude has been measured?

Not applicable

13. To what part of a phase the amplitude-measurement time refers. For example, is the amplitude-measurement time the time of the zero-crossing associated with a peak-to-adjacent trough measurement or is it the time of an absolute maximum or absolute minimum?

Not applicable

Finally, please add publications as well as internal reports or web links that can be quoted to describe the magnitude procedures adopted at the agency and/or any other relevant information which may not have been included in the questions above.

Kao, H., S.-J. Shan, A. Bent, C. Woodgold, G. Rogers, J. F. Cassidy and J. Ristau (2012). Regional Centroid-Moment Tensor analysis for Earthquakes in Canada and Adjacent Regions: An Update, *Seismological Research Letters*, **83**, 505-515, doi:10.1785/gssrl.83.3.505.

And references therein

For more on Mw-ML conversion for western offshore earthquakes

Ristau, J, G. Rogers and J. F. Cassidy (2003). Moment magnitude-local magnitude calibration for earthquakes off Canada's west coast, *Bulletin of the Seismological Society of America*, **93**, 2296-2300.