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.

Agency Name: Council for Geoscience (Agency code: PRE)

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**
M_L	Local Magnitude	Surface waves (vertical channel)
M_b	Body Wave Magnitude	*P*-wave on vertical channel
M_s	Surface Wave Magnitude	Surface waves (vertical channel)

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.

Local Magnitude:

$$M_L = log_{10}(A) + 1.149\ log_{10}(R) + 0.00063R - 2.04$$

where *A* is the maximum amplitude in nanometers and *D* is the hypocentral distance in kilometers.

a) Hypocentral distance
b) Up to 10°

c) Explosions restricted to surface, mining related fixed to 2km (Guzman, 1978) and tectonic 5 to 10 km (Brandt, 2014).

Body Wave Mangitude

$$M_b = log_{10}(A/T) + Q(h,\Delta)$$

where A is the maximum amplitude in nanometers and T is the corresponding period in seconds. Correction for distance and depth $Q(h,\Delta)$ is determined empirically.

a) Hypocentral distance
b) >20°
c) Fixed to the hypocentral depth reported by NEIC, GEOFON, EMSC.

Surface Wave Magnitude

$$M_S = log_{10}(A/T) + 1.66(D) + 3.3$$

where A is the amplitude in nanometers, T is the corresponding period in seconds and D is the distance in kilometers.

a) Hypocentral distance
b) 20° to 60° (hypocentral deph <60km)
c) Fixed to the hypocentral depth reported by NEIC, GEOFON, EMSC.

2. Is any signal-to-noise ratio criterion applied to the analyzed signal?

No.

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

SEISAN

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?

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?

M_L ~<7.0.

M_b ~<7.0

M_s ~<7

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?

Arithmetic mean.

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

Nanometers. Ground motion.

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 or is always the maximum velocity amplitude, respectively (A/T)max in the whole surface-wave train in a wide range of periods be measured? If so, give the range of periods.

M_L: Flexible time window after identified (picked *S*-phase) to coda (envelop over surface waves).

M_b: Flexible time window over *P*-wave prior to *PP*.

M_s : Flexible time window over surface waves.

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?

M_L: Maximum amplitude of surface waves on the vertical channel.

M_b: Maximum amplitude of *P*-phase on the vertical channel.

M_s : Maximum amplitude of surface waves on the vertical channel.

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 IASPEI recommended standard Wood-Anderson seismometer simulation filter with the parameters according to Uhrhammer and Collins (1990) used to compute ML?

Seisan response filters (Ottemöller et al., 2012)

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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?

Automatic amplitude picker of Seisan (Ottemöller et al., 2012)

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?

Automatic amplitude picker of Seisan (Ottemöller et al., 2012)

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)?

Automatic amplitude picker of Seisan (Ottemöller et al., 2012)

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?

Automatic amplitude picker of Seisan (Ottemöller et al., 2012)

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?

Automatic amplitude picker of Seisan (Ottemöller et al., 2012)

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.

References

Brandt, M.B.C. (2014). Focal depths of South African Earthquakes and Mine Events. *The Journal of the Southern African Institute of Mining and Metallurgy*, 114, 855 – 862.

Guzman, J.A. (1978). A package of computer programs for the evaluation of local earthquakes and the publication of the seismological bulletin. *Geological Survey of south Africa*, Report No.GH2446.

Karnik, V., Kondorskaya, N.V., Riznitchenko, Y.V., Savarensky, E.F., Solov'ev, S.L., Shebalin, N.V., Vanek, J. and Zatopek , A. (1962) Standardization of the earthquake magnitude scale. Studia Geophysica et Geodetica 6, pp. 41–47.

Ottemöller, L, P. Voss and J. Havskov (2012). The SEISAN Earthquake Analysis Software for the Windows, Solaris, Linux and MACOSX. University of Bergen, Bergen, Norway. 372pp

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