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: former: University of São Paulo (ISC agency code **VAO**)
present: Brazilian Seismographic Network (**RSBR**)

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_R	**Regional magnitude**	**P-waves**
mb	**Short-period (1-sec) teleseismic body-wave**	**P-waves**
mB	**Broadband teleseismic body-wave**	**P-waves**
MLv	**Local Magnitude**	**Largest phase, Z comp.**

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

1. **The equation used for calculating the regional magnitude is (Assumpção, 1983):**

1.1 regional magnitude m_R

$$m_R = \log V(um/s) + 2.3 \log R(km) - 2.29$$

a) type of distance: m_R uses epicentral distance, R, in km.
b) distance range: $200 \leq R \leq 1500$ km
c) applications: m_R only applies to intraplate crustal earthquakes (shallow depths).
d) amplitude measurement: V = maximum peak ground velocity (microns/s) in the whole P-wave train (half of the largest peak-to-trough swing) measured within a moving window of 0.2s. Broadband records are band-pass filtered between 1 and 25 Hz (to simulate old short-period records)

1.2 1-sec teleseismic mb, broadband MB, and MLv: calculated by SeisComp3 (version Seattle 2014.023)

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

m_R : No.
mb, mB, MLv (SeisComp3 procedures)

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

m_R is calculated with SAC macros, or with a SeisComp3 plug-in developed locally.
mb and mB are calculated by the standard SeisComp3 implementation (version Seattle 2014.023).

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?

We are nor reporting Mw yet.

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?

The regional magnitude m_R is equivalent to the teleseismic 1-sec m_b in the range $3.5 \leq m \leq 5.5$ (Assumpção et al., 2014). However, we measure m_R magnitudes above ~ 1.0 provided there is good signal to noise ratio at distances larger than 200 km. Other scales, such as ML, tend to overestimate magnitudes in Brazil due to very low attenuation of the predominantly Precambrian lithosphere.

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?

Median value of network single station magnitudes.

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

We do no report amplitudes yet…

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.

Regional m_R: we measure the largest peak-to-trough of the ground velocity, that is (A/T)max, in units of um/s, (half of the largest peak-to-trough swing) measured within a moving window of 0.3s in the whole P-wave train, between the P onset and before the S arrival. We only use the vertical component. The measured phase can be Pg, Pn, PmP or any other. Broadband records are band-pass filtered between 1 and 25 Hz, 2nd order butterworth (to simulate old short-period records)

mb, mB, MLv: SC3 measurement criteria.

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?

Only vertical components are used for mb, mB and m_R. Also for MLv.

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?

Mb, and mB are calculated with SC3, presumably following all IASPEI standards.

m_R was developed in the 1980's using different types of short-period records. For this reason, we now band-pass filter all broadband traces between 1 and 25 Hz to roughly simulate old short-period records, before measuring (A/T)max. We do not measure periods directly, but most measurements correspond to swings of predominant period between 0.1 and 0.5 s.

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?

m_R: 0.5*(peak-to-trough amplitude)

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?

m_R: adjacent peak and trough (about the same "swing"). We use a moving window of 0.3s to ensure peak and trough are adjacent.

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)?

m_R: we measure maximum ground velocity in velocity records, so we do not measure periods directly.

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?

m_R: when estimates of periods are needed, it is the time between neighboring peaks (or trough).

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?

We are not reporting amplitudes and times of amplitudes, but it would be the zero-crossing (~average time of adjacent peak and trough)

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:

Assumpção, M., 1983. A regional magnitude scale for Brazil. *Bull. Seism. Soc. Am.*, 73, 237-246.

Assumpção, M., J. Ferreira, L. Barros, F.H. Bezerra, G.S. França, J.R. Barbosa, E. Menezes, L.C. Ribotta, M. Pirchiner, A. Nascimento, J.C. Dourado, 2014. Intraplate Seismicity in Brazil. In *Intraplate Earthquakes*, chapter 3, ed. P. Talwani, Cambridge U.P., ISBN 978-1-107-04038-0.