Title	Proposal for unique magnitude nomenclature
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Current practice at the international seismological data centers is to determine the following “generic” magnitudes (alternative names given in brackets) from amplitude and period or signal duration readings and reports of seismological stations or networks:

mb – (m_b, Mb) short-period teleseismic P-wave magnitude from vertical component records
Ms – (M_s, MS) surface-wave magnitude from vertical and/or horizontal component records
Ml – (M_L; ML) local magnitude from horizontal and/or vertical component records as derived from original or simulated Wood-Anderson seismograph records
Md – (M_D, MD) local duration magnitude using different types of records

Besides these classical magnitudes, which have been determined already for decades, mostly from analog records, others, such as the moment magnitude Mw and the energy magnitude Me, require digital broadband recordings and their spectral analysis or integration in the time-domain. Up to now they have been regularly determined only by a few specialized data centers. However, the broader use of these modern magnitude concepts is rapidly growing.

Short-comings of the current procedures to determine and annotate classical magnitudes are:

- body-wave magnitudes are determined from *vertical component* P-waves only although Gutenberg-Richter published body-wave calibration functions Q(Δ, h) for both vertical and horizontal component readings of P and PP as well as for horizontal component readings of S;
- mb is determined from *short-period* recordings only, although the body-wave Q-functions have been derived mainly from medium-period, more or less broadband recordings;
- earlier recommendations made by respective IASPEI Commissions and published in the old Manual of Seismological Practice (Willmore, 1979) have not been put into practice yet, namely to determine magnitudes for all seismic waves and from all components for which calibration functions are available and to indicate the type of instruments on which the parameter readings (amplitudes, periods and/or duration) for a given magnitude value were made;
- the currently used “generic” nomenclature does not describe unambiguously which type of seismic wave, response characteristic and record component has been used for deriving the magnitude values. This has resulted in averaging incompatible non-standard magnitude readings and sometimes uncontrolled shifts in baselines (see 1.1 and 3.2).

Data providers should be aware that earlier limitations in seismological parameter reporting to World Data Centers based on the old Telegraphic Format no longer exist. The IASPEI Seismic Format (ISF) adopted at the IASPEI meeting in 2001 (see Chapter 10, section 10.2.5) is much more flexible and permits detailed parameter reports with unambiguous flagging.

An IASPEI Working Group on magnitude measurements, established in 2001, is at present critically screening the procedures of amplitude measurement and magnitude determination practiced at seismic stations and various data centers. Its members are: J. Dewey (chairman), P. Bormann, P. Firbas, S. Gregersen, A. Gusev, K. Klinge, B. Presgrave, L. Ruifeng, K. Veith, and W.-Y. Kim. This group came to the following preliminary conclusions:

“Recently identified significant differences, e.g., in mb values determined by the IDC and NEIC, are due in part to differences in signal filtering and measurement procedures at the two centers. Therefore, the WG has been charged by IASPEI to propose by mid 2003 specific filter parameters and amplitude and period measurement procedures to be authorized by IASPEI as "standard." The WG is also to propose a unique standard nomenclature for parameter reporting. The group has agreed to elaborate such recommendation for the following "generic" magnitudes: Ml, Ms, mB, mb, Mw and Me. The first three magnitudes are based on band-limited recordings of typically 0.5 to 1, maximum of 2 decades bandwidth. They are in good agreement with the original definitions for local magnitudes by Richter (1935) and for teleseismic body-wave and surface-wave magnitudes by Gutenberg and Richter (1945a and b) and other authors. Deviating from this, the more recent mb is a short-period (1Hz) narrowband (about 0.3 decade) version of the body-wave magnitude mB for P-waves only. Its main advantage is related to the fact that this frequency band is nearly optimal for remote monitoring of even weak seismic events in any area of the Earth. Thus the number of earthquakes with known teleseismic mb is much larger than that for any other teleseismic magnitude. In contrast, Mw and Me are based on (very) broadband (typically 3 to 4 decade) digital displacement or velocity recordings and their computer-assisted analysis. These modern magnitude concepts have a clear physical basis and gain rapidly more and more importance with the current availability of low-noise high-resolution broadband sensors and digital recordings with large dynamic range. Nonetheless, both Mw and Me are scaled to Ms and the classical Gutenberg-Richter logEs-Ms relationship. Moreover, these classical magnitudes still form the majority of available magnitude data and have, besides their recognized limitations (such as saturation), well established merits, e.g. the relevance of Ml and mb, for engineering seismology, their reasonable scaling with seismic intensity and thus their relevance for seismic hazard assessment. Therefore, to assure the long-term continuity of classical standard magnitudes is a matter of high priority. This requires a proper scaling of modern magnitudes based on digital data with their forerunners that were based on analog data. Jumps in detection thresholds and catalog completeness due to unknown or not properly documented changes in measurement procedures may result in wrongly inferred changes of the relative frequency of occurrence of weaker and stronger earthquakes and be misinterpreted as changes in the seismic regime and the time-dependent seismic hazard. This is not acceptable. On the other hand one should also recognize, that no one of the above mentioned standard magnitudes can fully substitute for the others. None of them allows a comprehensive and unique quantification of the "size" of an earthquake. Rather, these scales complement each other, and - when used in combination - allow better to understand the specifics of the seismic source process. Therefore, the magnitude WG intends, after authorization by IASPEI, to publish before the end of 2003 recommended standard procedures to determine these basic magnitudes with modern data and procedures in a unique or equivalent way and assure proper scaling to their original definition. These recommendations will then become an Annex to this manual."

By May 2002, the WG had also reached the following general understanding that:

- the "generic" magnitudes Ml, mb and Ms (see 3.2) are most common, and related data for their determination are regularly reported by seismic stations and networks/arrays to international data centers;
- these "generic" magnitudes are widely accepted and applied by a diversity of user groups. Therefore, their names should be kept when reporting magnitude data to a broader public.
- this nomenclature is also considered to be adequate for many scientific communications, on the understanding that these magnitudes have been determined according to well established rules and procedures;
- the WG realized, however, that different data producers make their related measurements for determining these magnitudes on records with different response characteristics and bandwidths, on different components and types of seismic waves and sometimes also use different period and time windows. This increases data scatter, may produce baseline shifts and prevents long-term stable, unique and reproducible magnitude estimates that are in tune with original definitions and earlier practices;
- this situation is no longer acceptable, therefore, the WG felt a need to introduce an obligatory more "specific" nomenclature for reporting amplitude (and period) measurement data for databases and for use in scientific correspondence in which the ambiguity inherent in the "generic" nomenclature might cause misunderstanding;
- the WG notes that the recently accepted IASPEI Seismic Format (ISF, see 10.2.5) and the flexibility of internet data communication allow such specifications in nomenclature and even complementary remarks to be reported to international data centers, and to store and retrieve such data from modern relational databases.

In order to assure future IASPEI-authorized standards annotation and reporting of measurements for amplitude-based seismic magnitudes, the WG agreed therefore along these lines of understanding on the following preliminary recommendations pending future specification and approval by IASPEI:

"Amplitude measurements for identified seismic phases are to be specified and reported to data centers in the following general format:

AXY(F)

with	A	amplitude
	X	phase name according to the new IASPEI nomenclature (see IS 2.1)
	Y	component of measurement (Z = V – vertical; N – north-south; E – east-west; H – horizontal, i.e., vectorially-combined N and E; R – radial or T – transversal)
	F	one of several standard filter/seismograph responses

An IASPEI Working Group is currently elaborating standardized filter/seismograph responses (F) for making amplitude measurements for the estimation of standard generic magnitudes Ml, Ms, mb and mB."

Below a starting proposal is made for further discussion on unambiguous nomenclature for "specific" magnitude names to be used in international data reporting and exchange with databases as well as in more specific scientific literature and communications. It is based on the following established procedures, reference data such as calibration functions, earlier recommendations by former IASPEI WGs and standard seismograph response classes (A, B, C and D) as presented in Fig. 1.1 of the old Manual of Seismological Observatory Practice (Willmore, 1979).

The following abbreviations are used in Table 1 below:

A records of type A (short-period and more or less narrowband, centered between about 1 and 2 Hz such as the WWSSN-SP);

B records of type B (long-period band-limited as WWSSN-LP with peak magnification around 15 s);

C displacement-proportional broadband in the period range 0.1 s to 20 s such as the Kirnos SKD seismographs;

D velocity-proportional broadband seismographs in the period range of about 1s to 100s

WA displacement-proportional Wood-Anderson horizontal seismographs in the period range 0.1 to 0.8 s;

IDC response characteristic used at the International Data Center of the CTBO in Vienna, and formerly used at the Prototype International Data Center in the U.S., for filtering beam data prior to magnitude determination. The response is velocity-proportional between about 1 and 5 Hz; i.e., its displacement magnification peaks at 5 Hz;

Note 1: These symbols for standard responses might be replaced in the final recommendations by specified filters (F) for simulated responses of either classical or specific modern seismographs.

M general symbol for magnitude. When used alone, M stands for the unified Magnitude according to Gutenberg and Richter (1956a and b). When followed by a phase symbol, the magnitude has been determined from amplitude/period readings of this phase;

Δ epicentral distance as commonly used in calibration functions;

h hypocentral depth;

$Q(\Delta, h)$ body-wave calibration functions according to Gutenberg and Richter (1956a and b). They are available for PZ, PH, PPZ, PPH, SH (see Figures 1a-c and Table 6 in DS 3.1). The use of $Q(\Delta, h)_{PZ}$ for mb determination is the current practice at the NEIC and the ISC although this is not fully correct (see 3.2.5.2);

$\sigma(\Delta)$ Prague-Moscow (Karnik et al., 1962) calibration function for surface-wave readings of both LZ and LH; recommended as standard by IASPEI and used at both the NEIC and the ISC (see Table 4 in DS 3.1)

$P(\Delta, h)$ body-wave calibration functions according to Veith and Clawson (1972) for vertical component displacement records with peak magnification centered around 1 Hz (see Figure 2 in DS 3.1). $P(\Delta, h)$ is currently used at the IDC for mb determination although the IDC response is centered around 5 Hz. This results in an underestimation of attenuation and thus systematically lowers mb values.

CF Stands for any other specific calibration function.

Note 2: For magnitudes that have been determined from records of seismographs with other response characteristics than the standards A to D or WA and/or by using calibration functions other than $\sigma(\Delta)$, $Q(\Delta, h)$ or local scales properly linked to the original Richter Ml (ML) scale, this has to be specified by giving F and CF in brackets, i.e., M(F; CF), or by adding a complementary comment line with the name of the relevant author/institution or with a link to proper reference and documentation.

Table 1 Preliminary proposal for "specific" and "generic" magnitude names and related descriptions.

Specific	**Generic**	**Description**
MPV(A)	mb	P-wave magnitude from short-period narrowband vertical component recordings of type A calibrated with Q(Δ, h) for PZ.
MPV(IDC)	mb	P-wave magnitude from short-period vertical component recordings with the IDC narrowband velocity band-pass filter and calibrated with P(Δ, h).
MPV(C)	mB	P-wave magnitude from medium-period (more broadband) recordings calibrated with Q(Δ, h) for PZ (= PV).
MPH(C)	mB	P-wave magnitude from medium-period (more broadband) recordings calibrated with Q(Δ, h) for PH.
MPPV(C)	mB	PP-wave magnitude from medium-period (more broadband) recordings calibrated with Q(Δ, h) for PPZ (= PPV).
MPPH(C)	mB	PP-wave magnitude from medium-period (more broadband) recordings calibrated with Q(Δ, h) for PPH.
MSH(C)	mB	S-wave magnitude from medium-period (more broadband) recordings calibrated with Q(Δ, h) for SH.
MLV(B or C)	Ms	Surface-wave magnitude from L readings in vertical component records of type B or C, respectively, calibrated with the IASPEI standard "Prague-Moscow" function σ(Δ) (cf. Eq. 3.10 in Chapter 3).
MLH(B or C)	Ms	Surface-wave magnitude from L readings in horizontal component records of type B or C, respectively, calibrated with σ(Δ).
MLRV(B or C)	Ms	Surface-wave magnitude from the maximum of the Rayleigh-wave train, vertical component in records of type B or C, respectively. MLRV is identical with MLV when calibrated with σ(Δ). If special calibration functions are used this has to be flagged accordingly.
MLRH(B,C)	Ms	Surface-wave magnitude from the maximum of the Rayleigh-wave train in the horizontal components of records of type B or C, respectively. MLRH may be identical with MLH when calibrated with σ(Δ). If special calibration functions are used this has to be flagged accordingly.
MLQH(B or C)	Ms	Surface-wave magnitude from the maximum of the Love-wave train in the horizontal component only of records of type B or C. MLQH may be identical with MLH when calibrated with σ(Δ). If special calibration functions Love waves are used this has to be flagged accordingly.
MH(WA; CF)	Ml=ML	Local magnitude from Wood-Anderson seismographs (or synthesized WA response; here for horizontal components only), as defined by Richter (1935). For M(WA) magnitudes in other regions local/regional calibration functions CF may be used which should, however, be calibrated according to the original Richter scale.

MV(WA; CF)	Ml=ML	Local magnitude from Wood-Anderson seismographs (or synthesized WA response; here for vertical component records), as defined by Richter (1935). For M(WA) magnitudes in other regions local/regional calibration function may be used which should, however, be calibrated according to the original Richter scale.
MLgH(Author)	Ml=ML	Magnitude from Lg horizontal-component amplitude or spectral readings based on records, filters, procedures/methodology and calibration functions as defined/derived by specified author(s) or institutions.
MLgV(Author; Ml)	Ml=ML	Magnitude from Lg vertical-component amplitude or spectral readings based on records, filters, procedures/methodology and calibration functions as defined/derived by specified author(s) or institutions and calibrated with respect to Ml.
MLgV(Author; mb)	mbLg = Mn	Magnitude from Lg vertical-component amplitude or spectral readings based on records, filters, procedures/methodology and calibration functions as defined/derived by specified author(s) or institutions and calibrated with respect to mb.
MPnZ(Author)	mb or Ml	Magnitude from Pn vertical-component amplitude or spectral readings based on records, filters, procedures/methodology and calibration functions as defined/derived by specified author(s) or institutions.
Md(Author)	Md	Magnitude from readings of signal duration based on records, filters, procedures/methodology and calibration functions as defined/derived by specified author(s) or institutions.
Mw(Author; Year)	Mw	Non-saturating moment magnitude based on the zero-frequency plateau of the displacement spectrum or other related estimates such as signal-moment in the time domain from digital broadband records as defined/derived by specified author(s) or institutions.
Me(Author; Year)		Energy magnitude as defined/derived by specific author(s) or institutions.
Mt(Author)	Mt	Tsunami magnitude as defined/derived by specific author(s) or institutions.

Note 3: Sometimes, even the same authors or institutions change their procedures or input parameters for magnitude computation. It is then recommended, to additionally specify the year of publication of documentation for a particular procedure.

Note 4: Amplitude readings on which magnitude determinations are based have to be flagged accordingly, e.g.: APV(A), APV(PIDC), ALgV(A), ASH(C), ALH(B), APn(PIDC) etc.

When comparing the first and second column in Table 1 one recognizes immediately the ambiguity of generic magnitudes. The differences between related specific magnitudes may be larger than 0.5 magnitude units. Such systematic differences would not be acceptable in many seismological studies.

References (see References under Miscellaneous in Volume 2)