

# Plan of activities of the new IASPEI Working Group on Magnitude Measurements

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August 2019

## 1. Background

The Working Group (WG) on Magnitude Measurements of the IASPEI Commission on Seismological Observation and Interpretation (CoSOI) was established in 2001. It began as an outgrowth of the CoSOI meeting in Hanoi. The first chair was K. Shedlock of the U.S. Geological Survey (USGS). J. Dewey took over as chair in 2002 with P. Bormann joining as co-chair in 2009. In 2013, both announced that they would be resigning. The CoSOI suggested that the Magnitude WG continue and asked the former chairs to help with the transition to a restructured Magnitude WG. In 2014, Domenico Di Giacomo (International Seismological Centre, ISC) became the new chair and was tasked with re-organizing the WG so that it could continue and also expand its activities. In 2018, he announced that he would be stepping down as chair following the 2019 IUGG meeting in Montreal but would remain a member of the working group. The current chair of the Magnitude WG is Allison Bent (Natural Resources Canada, NRCan).

The mission of the Magnitude WG is to develop IASPEI standards for magnitude measurements that should be implemented by regional and global networks as part of their routine operations. The WG proposed such standards in a 2005 preliminary report to the CoSOI ([ftp://ftp.iaspei.org/pub/commissions/CSOI/summary\\_of\\_WG\\_recommendations\\_2005.pdf](ftp://ftp.iaspei.org/pub/commissions/CSOI/summary_of_WG_recommendations_2005.pdf)). The standards were accepted by the CoSOI pending testing of these standards in operational mode. The current and more detailed 2013 formulation of the IASPEI standards may be accessed at [http://isc-mirror.iris.washington.edu/docs/papers/download/Summary\\_WG\\_recommendations\\_20130327.pdf](http://isc-mirror.iris.washington.edu/docs/papers/download/Summary_WG_recommendations_20130327.pdf)

Functionally, the 2013 standards are not significantly different from the 2005 standards but they specify the standard filter responses to be applied, address ambiguities recognized after 2005, agree on the nomenclature for reporting standard magnitudes and their period and amplitude data, provide reasons for agency-specific modifications to the recommended standard procedures, hint at several slightly adjusted procedures to be more easily implemented with current analysis software or to extend the domain over which a given magnitude can be determined and provide a questionnaire for the detailed and unambiguous Documentation of Agency/Station Magnitude Procedures. Additional details and data were published by Bormann and Dewey (2012, in the New Manual of Seismological Observatory Practice).

During the 2013 Gothenburg meeting of the CoSOI, the WG and CoSOI recognized the need to continue the WG to see the IASPEI standards fully implemented at several data centres and/or in software packages, such as SeisComp and Antelope and to achieve goals that had recently become recognized as important. By unanimously adopting IASPEI Resolution No. 1, the IASPEI General Assembly at Gothenburg recognized the importance of the magnitude standards proposed by the Magnitude WG and the CoSOI. These standards are also published in the second edition of the New Manual of Seismological Observatory Practice, NMSOP2, available at <http://gfzpublic.gfz-potsdam.de/pubman/faces/viewItemOverviewPage.jsp?itemId=escidoc:245421>, which recommends that station operators adopt these standards in their day to day operations and encourages the developers of waveform processing programs to incorporate these standards within their software packages.

## **2. Membership from 2019**

The current WG consists of Allison Bent (chair; Canada), Domenico Di Giacomo (UK), Aleksey Emanov (Russia), Gavin Hayes (USA), Alberto Michelini (Italy), Lars Ottemöller (Norway), Liu Ruifeng (China), Joachim Saul (Germany), Anna Skorkina (Russia) and Siegfried Wendt (Germany). The members of the WG are selected as representatives of communities and agencies involved in magnitude measurements and/or software developments. New members may join the WG in the future. Colleagues of WG members are encouraged to cooperate and collaborate with the WG to achieve the best possible results within the plans of the WG.

## **3. Goals of the WG**

The new, restructured WG aims at achieving several goals in the coming years. These are divided into two groups. The first consists of activities to be undertaken by the WG to improve standards in magnitude measurements and to identify areas in which improvements are needed. The second group consists of research activities that would enable the WG to make better recommendations for standardization of magnitude measurements and practices. The research activities may be carried out by members of the WG, by members of the broader seismological community or both.

### 3a. Activities to be carried out by the WG

i. continue to gather relevant documentation on the procedures used by seismological agencies in magnitude computation: seismological agencies operating at all scales, from local to regional to global, often use procedures that are not well documented to compute various magnitudes, which are reported in the ISC Bulletin ([www.isc.ac.uk/iscbulletin](http://www.isc.ac.uk/iscbulletin)). A goal of the ISC and WG is to engage as many agencies as possible to make the most important aspects of these agencies' magnitude procedures available online. The ISC has taken and will continue to take a leading role toward this end as it is the most comprehensive and final repository of seismological parameter data. Progress toward this goal was made by the previous WG but many agencies have not yet completed the documentation. The current WG intends to explore ways by which to increase the number of reporting agencies, such as providing explanatory text and making the form available online (e.g. IASPEI website/newsletter)

ii. Development of more detailed standard nomenclature for Moment Magnitude: the proliferation of different types of moment magnitude ( $M_w$ ) continues; these magnitudes may have significant differences from each other yet most are labeled as  $M_w$ . These variations result from different procedures, such as frequency range and velocity model, used to calculate moment magnitude as well as the introduction and increased use of moment tensor inversions at regional distances. A goal of the WG is to establish clear nomenclature for the various moment magnitudes currently calculated to allow the user to better understand the procedure used to calculate a given moment magnitude. Additionally, comparisons between the various moment magnitude scales need to be undertaken. The WG believes there might be some benefit derived from consulting and/or collaborating with the IASPEI Commission on Earthquake Source Mechanics on this issue. At the 2019 IUGG meeting, the possibility was raised with Satoshi Ide, who agreed to provide advice to the Magnitude WG.

iii. evaluate usage of magnitude scales not covered in the IASPEI (2013) guidelines and variability in current practice to determine whether there is a need to develop standards for additional magnitude scales; develop standards as appropriate: these magnitude scales include, but are not limited to, short-period  $m_b$  from  $V_{max}$ ,  $MLg(f)$ ,  $M_E$ ,  $M_C$ ,  $M_D$ ,  $m_b$  ( $P_n$ ,  $S_n$ ),  $m_{PKP}$ . Data collected under goal 3a-i will contribute to the evaluation and follow up

iv. set up an advisory forum: this would be a platform on the IASPEI website that could be used for various purposes. It could be important for individuals or groups who are computing new versions of magnitudes who would like these magnitudes to be consistent with magnitudes computed worldwide. The establishment of a repository of examples for magnitude measurements and a library of approved code are under consideration as a way to enable more consistency in magnitude measurements. The forum could also be used for exchanging information with the WG and for discussions on magnitude related topics.

v. increase the visibility of the WG with the intent of encouraging research that would help further the goals of the WG and promoting the use of the IASPEI standards; strategies for achieving this goal include posting short descriptions of the WG activities in online newsletters, conference presentations by WG members, proposals for magnitude related sessions at key conferences, journal articles or a journal focus section

**3b. research activities to support WG goals; may be carried out by WG members and/or by the broader seismological community**

i. development of regional calibration curves for  $m_b$ ,  $m_B$  BB and  $M_s$  BB, documentation on how to develop calibration curves and improved calibration curves for other phases: body-wave magnitudes are typically calculated for distances of  $> 20^\circ$  because the complexity of the Earth's structure at shorter distances makes it difficult to apply a simple calibration curve on a global scale. Regional calibration curves can be developed and applied for rapid magnitude calculations in realtime procedures. For  $M_s$  BB more data covering a range of geodynamic settings need to be collected and evaluated to determine whether the current global calibration curve is adequate or whether there is a need for regional calibration curves; documentation on how to properly develop calibration curves would be a valuable asset to the magnitude community; reconstructed calibration curves for phases, such as PKP, using improved data sets may also be beneficial

ii. investigation on the effects of unbalanced geometry of the global seismic network and regional networks on magnitude determination: with the large number of digital seismograph stations worldwide, it is not uncommon for agencies, such as NEIC or the ISC, to have several thousand amplitude/period observations for a single earthquake. At NEIC, this situation has led to the consideration of computing magnitudes only for a preferred subset of the complete station set, with the preferred stations being selected on the basis of criteria, such as geographic location, station sensitivity and reliability or the continuation of a long-running data set. Before implementation, these considerations require systematic studies on the effects of station coverage on magnitude computation. The Magnitude WG will evaluate the possibility of creating and maintaining a list of recommended stations. Many regional networks face a related issue where station coverage may be highly variable with respect to azimuth or distance and studies to evaluate the effects of possible biases based on station coverage are needed.

iii. provide recommendations that will lead to the establishment of IASPEI standards on signal-to-noise ratio (SNR) computation: there is no consensus on how SNR should be calculated for amplitude

measurements within the procedures designed for magnitude computation. SNR should be a parameter systematically provided with amplitude and period. Because magnitudes are computed over different frequency ranges, spectral SNR offers the possibility of providing the SNR within the relevant frequency limits for a specific magnitude type. The WG will also explore ways to encourage authors to include and reviewers to request better documentation on the calculation of SNR in research articles.

iv. research into magnitudes at close distances to aid in the development of standards: most magnitude scales including those developed for regional distances are not calibrated for use at very close distances (a few km); in recent years there has been a significant increase in the volume of data recorded at very close distances; much of this comes from dense arrays designed to record induced seismicity or aftershock sequences; potential areas of research include ground motion prediction equations, evaluation of various magnitude scales at close distances, use of hypocentral vs epicentral distance bearing in mind that it may not be possible to determine depths for small earthquakes recorded by sparse regional networks

v. development/adaptation of IASPEI standards for earthquakes for which the current standards cannot be applied: the IASPEI (2013) standards provide detailed and specific instructions for the calculation of several standard magnitude types; however, it has become apparent that some agencies have chosen not to use the IASPEI standards because the filters or frequency limits when applied to small earthquakes result in a signal below the noise level;  $M_L$  and  $m_{blg}$  were noted as magnitude scales of particular concern as they are often applied to small earthquakes at regional distances; it has also been noted that some of these issues are exacerbated when used with automatic systems; recommendations on how to adapt these magnitude scales to smaller earthquakes (higher frequencies, poorer SNR) while ensuring consistency of each magnitude scale across the full range of magnitudes and recommendations on quality control for automatic solutions are needed

All links verified 13 August 2019.