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: (please write either extended name or code)
Institute of Geophysical Researches of the Republic of Kazakhstan, Kazakhstan National Data Center (KNDC)

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**
mb	Short-period body-wave magnitude	P-waves
mpv	Regional short-period body-wave magnitude	P-waves
MLV (analogue of Ms)	Surface wave magnitude	Rayleigh surface wave
K	Energy class	P and S 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.

KNDC processes events within the Central Asia region only. The epicentral distances do not exceed 4000 km. The stations network and instruments are described on the Data Center web-site www.kndc.kz. For measurement of magnitudes and energy class, broad-band three-component instruments only are used. To measure the short-period magnitudes and energy class, first,

digital filtering is applied, the channel of SKM type for which calibration curves were obtained is emulated. To measure MLV magnitude, the broad-band channels like BB channels of IRIS stations are used.

1.1 mb

Measurement of body wave mb by P-wave. The magnitude is estimated by measured values of amplitude and shift period after digital filtering by emulating of short-period channel of SKM instrument type [3]. The calibration curve of Veith – Clawson [1] is used.

$$mb = \lg(A/T) + \sigma_1(\Delta), \quad (1)$$

Where

$\sigma_1(\Delta)$- calibration function of Veith – Clawson;

Δ - epicentral distance, km;

A – amplitude of ground movement in P-wave by Z-component in SKM channel, mkm;

T – period corresponding to maximum A/T, in seconds.

1.2 mpv

Calculation of regional magnitude mpv by P-wave is conducted using formula (2) for distances $\Delta<1000$ km. Amplitudes and periods are measured after digital filtering by emulating of short-period channel of SKM instrument type. The regional calibration curve of Mikhailova, Neverova [2] is used.

$$mpv = \lg(A/T) + \sigma_{peg}(\Delta), \quad (2)$$

$\sigma_{reg}(\Delta)$- calibration function;

Δ - epicentral distance, km, for $\Delta<1000$;

A – amplitude of ground movement in P-wave by Z-component in SKM channel, mkm;

T – period corresponding to maximum A/T, in seconds.

Values of regional calibration function $\sigma_{reg}(\Delta)$ are shown in Table 2.

Table 2.

Calibration function for determination of mpv (Δ - in kilometers).

$\sigma_{reg}(\Delta)$	Δ, km	$\sigma_{reg}(\Delta)$	Δ, km	$\sigma_{reg}(\Delta)$	Δ, km	$\sigma_{reg}(\Delta)$	Δ, km
3.8	10	4.6	100	5.25	350	5.87	700
3.8	20	4.85	150	5.36	400	6	800
4	30	4.85	200	5.46	450	6.1	900

4.15	40	4.95	250	5.55	500	6.22	1000

1.3 MLV (analogue of Ms)

MLV by surface waves is calculated using formula (3) for distances 220 km < Δ< 4000 km and source depth h<60 km.

$$MLV = \lg(A/T) + \sigma_2(\Delta), \quad (3)$$

where

σ_2 (Δ)-calibration function;

Δ - epicentral distance, km;

A – amplitude of ground movement in maximum phase of Rayleigh surface wave by Z-component in broadband instruments, for example, BB channels of IRIS stations.

T – period corresponding to maximum A/T, in seconds.

1.4. K

Measurement of energy class K[4] is conducted using formula for distances Δ< 3000 km

$$K = 1{,}8\lg(A_p + A_s) + \sigma_3(\Delta), \quad (4)$$

where,

σ_3(Δ)-calibration function for energy class calculation;

A_p –maximum amplitude in P-waves in channels of SKM type;

A_s –maximum amplitude in S-waves in channel of SKM type;

Δ - epicentral distance, km.

Values of calibration function to calculate the energy class by Rayutian [7] are shown in Table 3.

Table 3

Calibration function for energy class measurement (Δ - in kilometers).

$\sigma_2(\Delta)$	Δ, km	$\sigma_2(\Delta)$	Δ, km	$\sigma_2(\Delta)$	Δ, km	$\sigma_2(\Delta)$	Δ, km
6.4	10	10	150	11.8	650	13.25	1200
7.5	20	10.25	200	12	700	13.4	1300
8.1	30	10.4	250	12.2	750	13.5	1400
8.5	40	10.6	300	12.3	800	13.7	1500
8.9	50	10.8	350	12.5	850	13.8	1600
9.1	60	11	400	12.6	900	14	1700
9.3	70	11.2	450	12.75	950	14.1	1800
9.5	80	11.4	500	12.8	1000	14.2	1900

9.7	90	11.6	550	13	1050	14.25	2000
9.8	100	11.7	600	13.1	1100	14.8	3000

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.

Antelope, however, for magnitude computation the in-house developed program is used.

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?

Mw is not computed in KNDC practice.

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?

Class K is not calculated for large earthquakes K>15. K, also, has restrictions for Δ, it is calculated for Δ<3000 km.

MLV is not calculated for small and near earthquakes.

mpv – for Δ<1000 km only.

All magnitudes are computed for crust earthquakes only (h<60).

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?

Network magnitude and network energy class are arithmetic mean value of station magnitudes. The magnitudes from the stations located on rock ground are averaged. And magnitudes from the stations located on thick sedimentary cover having significant corrections to magnitudes overestimation are not averaged.

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

Amplitudes are reported in units of ground motion (in table CSS3.0 arrival considering instruments response).

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.

Measurements are made in maximum of P and S (Lg) wave-trains.

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?

For all magnitudes mb, mpv, MLV the measurements are made on vertical component. Class is computed by amplitude of P-wave in Z-component, for S-waves the maximum value of two horizontal components is selected.

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?

For mpv calculation, filter 0.6-1.9 Hz (channel of SKM type) is used,
For K, filter 0.6-1.9 Hz (channel of SKM type) is used [3].

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?

The amplitude 0.5*(peak-to-trough amplitude) corresponds to half difference between a maximum positive excursion and a maximum negative excursion of the 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?

The "peak" and "trough" are the adjacent peak and trough on the trace.

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)?

It is measured at the time of the maximum of the quotient (A/T), is selected on velocity record.

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?

It is the time between the neighboring peaks or neighboring troughs.

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?

It is the time of the zero-crossing associated with a peak-to-adjacent trough measurement.

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.

1 Veith, K.F. Magnitude from short-period P-wave data / K. F. Veith, G.E. Clawson // Bull. Seism. Soc. Am., 1972. – V 62. – P. 435 – 452.

2. Mikhailova N.N., Neverova N.P. Calibration function s(d) for MPVA measurement of Northern Tien Shan earthquakes//Integrated researches at Almaty prognosis site. Alma-Ata. Nauka, 1986. P.41-47.

3. Recommendations for determination of standard magnitudes of earthquakes at teleseismic distances by records of broad-band digital seismometers at Geophysical Survey RAS. GS RAS. 2005. 84 p.

4. Rayutian T.G. To measurement of earthquake energy at distances up to 3000 km //Proceedings of IPE AS USSR. #32 (199). 1964. P.72-98.

5. Rautian, T., Khalturin, V., Fujita, K., Mackey, K.G. and Kendall, A.D., (2007). Origins and methodology of the russian energy k-class system and its relationship to magnitude scales, Seismol. Res Lett., 78, 579–590.

In addition, it is worth to mention a paper on underestimated magnitudes and energy classes by data of borehole seismometers of seismic arrays in comparison with surface stations [6] noted by KNDC staff.

6. Mikhailova N.N., Ryabenko O.V. To the reasons of energy characteristics estimations discrepancy in different processing Centers. Vestnik NNC RK, #4, 2014. P. 102-110.