Proceedings of the 18th Iranian Geophysical Conference, May 2018, pages 846-849

An empirical magnitude estimation for 7.3 Mw Kermanshah earthquake of 11th December 2017 using Period and Amplitude parameters

Tara Evaz zadeh[1], Zaher Hossein Shomali[2]

[1]*M.Sc Student, Institute of Geophysics, University of Tehran, Iran, taraevazzadeh@ut.ac.ir*
[2]*Associate Professor, Institute of Geophysics, University of Tehran, Iran, shomali@ut.ac.ir*

ABSTRACT

The deadliest earthquake of 2017, the Mw 7.3 Kermanshah earthquake, proves the need of an earthquake early warning system for Iran. The ability of rapidly estimating an earthquake magnitude from first part of the P phase is a factor than can help building an earthquake early warning system, as in many countries. In this paper, magnitude of the 7.3 Mw earthquake which occurred on the border of Iran and Iraq on 11th November of 2017 is estimated using the period (Tc, Tpmax, Tlog) and amplitude (Pd) regressions extracted for northwest of Iran. They could successfully estimate the magnitude of this earthquake with the values, 6.9, 6.9, 8.3 and 6.6 from the parameters Tc, Tpmax, Tlog and Pd respectively using only the first 2.5 seconds of initial part of P-wave (3 seconds in case of using Tlog and Tpmax). The largest magnitude error using these parameters is 0.6 which is normal for earthquake early warning purposes.

Keywords: Earthquake Early Warning, Northwest of Iran, Kermanshah earthquake, Tc, Tpmax, Pd.

INTRODUCTION

Science and technology have been developed as a response to the needs. Saving our lives and properties has made human to find a way to minimize the destruction caused by different natural phenomena such as earthquakes. This need is felt much more in earthquake-prone countries such as Iran. The next step after reinforcing building codes is to set up an Earthquake Early Warning System since earthquake prediction has remained impossible based on the current knowledge of human.

Iran is a seismically active zone and has lately experienced earthquakes with a diverse range of magnitudes. The 7.3 Mw earthquake which occurred on the border of Iran and Iraq on 11th November of 2017 is mentioned to be the deadliest earthquake of 2017. Thus, existence of an Earthquake early warning system is essential. Seismic hazard assessment and earthquake early warning systems are complementary. Strong and reliable building codes prevent building collapses and serious damages and the earthquake early warning systems reduce the secondary hazards introduced by the destructions, if any. These systems can automatically detect arrival of the P-waves excited by the earthquakes, calculate a parameter that can be a measurement of the damage, such as magnitude, and then alarm in case needed.

The magnitude scaling relationships used in this study, are extracted for northwest of Iran, which is of high importance. Dense population, experiencing large magnitude earthquakes during the history, occurrence of the double Ahar-Varzaghan quakes with magnitude of 6.3 and 6.5 Mn in 11th of august 2012 and lately, The 7.3 Mw Kermanshah earthquake in the southwest corner reveals the necessity of this study. All this has made us extract empirical magnitude scaling relationships that can rapidly estimate magnitude of earthquakes for the area in order to make an earthquake early warning system possible.

There are different parameters based on which magnitude of an earthquake can be rapidly estimated. These parameters are divided into two main groups: period parameters and amplitude parameters. The former is an estimation of the period of first part of the signal (usually 3 seconds) and can help in rapid assessment of the magnitude since the larger the magnitude of an earthquake, the lower the frequency of the waves emitted by the rupture process (Tc, Tpmax, Tlog, etc). The latter is obtained from the first part of the displacement, velocity or acceleration signal and is defined to be the largest amplitude observed; called Pd, Pv and Pa respectively.

In this paper magnitude of the 7.3 Mw Kermanshah is estimated using strong motion records which was not included in the database from Tc, Tpmax, Tlog and Pd regressions achieved for northwest of Iran.

Methodology & Data

Following the methods introduced by different researchers (Kanamori, 2005)(Nakamura, 1988)(Ziv, 2014)(Wu & Kanamori, 2005), 4 different magnitude scaling relationships were extracted. To extract each regression, the respective parameter was calculated for each record and a regression was then fitted to all the values. These regressions can relate magnitude with each parameter mentioned above. Using these scaling relationships, magnitude can be rapidly estimated using first few seconds after P-wave arrival. Period parameters and the amplitude parameter used in this paper are Tc, Tpmax, Tlog and Pd respectively. Table1shows the parameters, the time window in seconds (initial part of the arrival of the P-wave), using which these parameters are decided and also the resulting regression obtained for northwest of Iran.

Table1. Parameters, their time window and the regressions obtained (Evazzadeh, 2018).

Regression	Time window(s)	Parameter
Log Tc = 0.15 Mw - 1.18	2.5	Tc
Log Tpmax = 0.17 Mw - 1.52	3.0 (0.2 transition time is included)	Tpmax
Log Tlog = 0.16 Mw - 1.30	3.0	Tlog
Log Pd = 0.66 Mw - 1.12 Log (R/10) - 4.75	2.5	Pd

The regressions are extracted using 422 Strong motion signals from BHRC network for northwest of Iran.

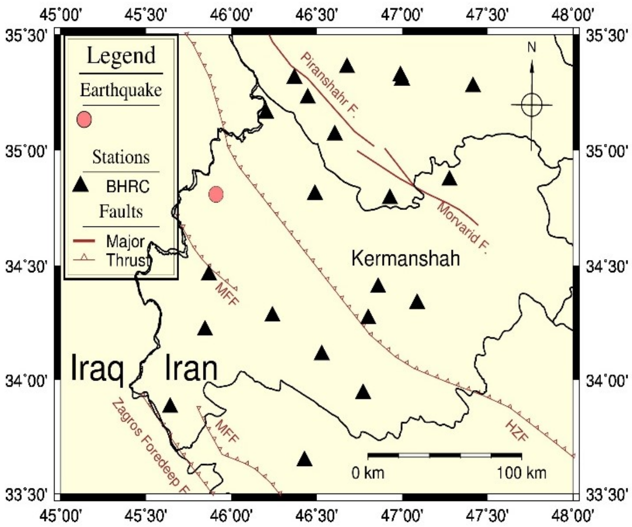

Figure1. Map of the Mw 7.3 Kermanshah earthquake which occurred on 11th November 2017. The black triangles show the strong motion stations which recorded the earthquake with an epicentral distance of less than 150 kms. The red circle represents the location of the earthquake.

The stations with available signals from the 7.3 Mw Kermanshah earthquake with an epicentral distance of less than 150 Km are shown in Figure 1 and also mentioned in the Table2 below with their epicentral distances. The black triangles show the strong motion stations and the red circle represents location of the earthquake.

Using the records, values of Tc, Tpmax, Tlog and Pd are calculated for each record and then, using the regressions, the respective magnitudes obtained from each record is achieved. The estimated magnitudes along with the stations and their epicentral distances are shown in Table2.

As it can be seen in the Table 2, there are 22 stations available with distances less than 150 kms from the 7.3Mw Kermanshah earthquake. We have estimated the magnitude for each record using different parameters. Please note the time required for each parameter in Table 1. For example, the magnitude estimation for the signal recorded by Sarpolezahab station using Tc, Tpmax, Tlog and Pd are 6.9, 6.9, 8.3 and 6.6 respectively. But due to the time window each parameter needs, the first estimations would be announced at the same time by Tc and Pd (6.9 and 6.6), 2.5 seconds after the P-wave arrival; then, after 0.5 seconds, estimations from Tpmax and Tlog will be available (6.9 and 8.3).

If we use mean of the available estimated magnitudes (for each single parameter) and name it averaged real-time magnitude, we can say that using Tc parameter, the averaged real-time magnitude was estimated to be 6.9 at the second 9.5 And 6.7=((6.9+6.4)/2) at the second 10.9 as shown in Figure2. The first P-wave arrival is received at second 7. Figure2 shows averaged real-time magnitude versus time for each parameter and zero represent the origin time.

As it can be seen in Figure2, the first estimation was made at the second 9.5 by Tc and Pd (6.9 And 6.6 respectively. the first grey and green estimations respectively). Half a second later, at the second 10, we have 2 more estimations using Tlog and Tpmax (8.3 and 6.9, the first yellow and blue estimations respectively). Following Tpmax trend (the blue line), for example, its second estimation is 7.9 and the second blue value in Figure2 shows 7.6 which is mean of the first and the second single estimations made by Tpmax. The dashed black line shows the observed magnitude (7.3 Mw). It can be observed that the final estimations of the parameters differ very slightly from the observed magnitude.

Table2. Stations, their epicentral distances, time of P-wave arrival to each and the estimated magnitude for each record using different period and amplitude parameters.

Magnitude estimated by Pd	Magnitude estimated by Tlog	Magnitude estimated by Tpmax	Magnitude estimated by Tc	Epicentral Distance in km	Station
6.6	8.3	6.9	6.9	39.1	Sarpolezahab
7.6	7.8	7.9	6.4	47.2	Nosood
6.3	6.7	6.6	5.6	53.0	Javanrood
7.1	6.2	6.1	5.8	66.0	Goorsefid
6.7	6.8	6.7	6.2	66.2	Kerend
7.2	7.9	8.1	7.0	67.3	Degaga
7.2	8.5	8.5	7.8	69.6	Palangan
6.6	7.8	7.9	7.5	69.6	SarvAbad
7.3	6.4	6.7	6.4	82.4	Marivan
7.2	7.6	7.9	7.3	92.7	Shoeisheh
6.3	7.9	7.1	7.3	93.2	Kamyaran
6.0	7.3	7.5	5.7	96.3	Eslamabadqarb
6.2	7.1	7.2	6.2	98.6	Sarabniloofar
5.6	6.6	6.1	6.1	101.5	Mahidasht
6.8	7.8	8.3	6.2	107	Soomar
7.2	8.1	8.4	7.6	113.5	Sanandaj2
7.1	7.0	7.1	7.0	113.7	Sanandaj1
6.3	5.8	6.8	6.7	120.3	Kermanshah1
6.8	7.3	6.9	6.4	124.8	Homail
6.4	7.7	7.8	7.5	125.2	Lenjab
6.7	7.8	7.7	6.3	137.8	Ilam1
7.5	6.8	7.9	6.6	146.7	Dehgolan

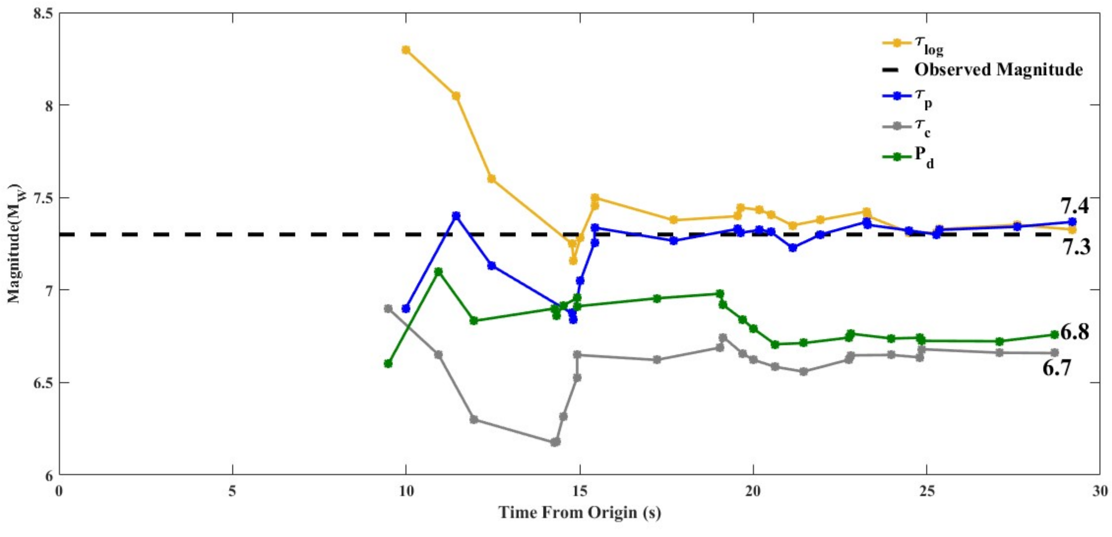

Figure2. Averaged real-time magnitude versus time. Here, averaged real-time magnitude is mean of the available magnitudes at any time. Yellow, blue, green and grey line show averaged real-time magnitude versus time for Tlog, Tpmax, Tc and Pd respectively. Final magnitude for Tlog,Tpmax,Tc and Pd are 7.4, 7.3, 6.8 and 6.7 respectively. Please note that the final magnitude or the final averaged real-time magnitude is mean of all the estimated magnituds by each parameter.The dashed black line shows the observed magnitude (7.3 Mw).

CONCLUSION

The results obtained from the current research show the ability of the magnitude scaling relationships extracted for the northwest of Iran. Four different earthquake early warning parameters, Tc, Tpmax, Tpmean and Pd could rapidly give a reliable magnitude estimation for the Mw 7.3 Kermanshah earthquake. The first estimation was made by Tc and Pd parameters, both at the same time (2.5 seconds after the first P-wave arrival) and equal to 6.6 and 6.9 respectively. The averaged real-time magnitudes estimated by Tc, Tpmax, Tlog and Pd parameters using 22 strong motion records, was 6.7, 7.4, 7.3, and 6.8 respectively. All the estimations show an error of less than 0.6 which is completely acceptable and demonstrates success of the regressions.

REFERENCES

Kanamori, H. (2005). Real-time seismology and earthquake damage mitigation. Annu. Rev. Earth Planet. Sci., 33, 195–214.

Nakamura, Y. (1988). On the urgent earthquake detection and alarm system (UrEDAS). In Proc. of the 9th World Conference on Earthquake Engineering (Vol. 7, pp. 673–678).

Wu, Y.-M., & Kanamori, H. (2005). Rapid assessment of damage potential of earthquakes in Taiwan from the beginning of P waves. Bulletin of the Seismological Society of America, 95(3), 1181–1185.

Ziv, A. (2014). New frequency-based real-time magnitude proxy for earthquake early warning. Geophysical Research Letters, 41(20), 7035–7040.

Evazzadeh, T.(2018). A network based earthquake early warning algorithm for northwest of Iran using Tpmax, Tc period parameters and amplitude parameter Pd. Ms. thesis, Institute of Geophysics of University of Tehran.