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Estimation of earthquake magnitudes using coda wave duration in Zagros zone and southwest in central Iran

Asadi, S.[1], Rahimi, H.[2*], Rezapour, M.[3]and Amirifard, R.[4]

1. M.Sc. Student, Institute of Geophysics, University of Tehran, Iran
2. Assistant Professor of Seismology, Institute of Geophysics, University of Tehran, Iran
3. Associate Professor of Seismology, Institute of Geophysics, University of Tehran, Iran
4. Ph.D. Student, International Institute of Earthquake Engineering and Seismology, University of Tehran, Iran

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Summary

Amplitude and duration of seismic signals depend on recording distance, propagation path of the wave through different media and geology at the recording site. In addition, amplitude of recorded signals varies according to the P- and S-wave radiation patterns. Influence of these factors on seismic signals has been considered for magnitude computation in many seismic regions (e.g., Michaelson, 1990 and Eaton, 1992). Estimation of earthquake magnitude is a routine task in all seismological observatories. Several magnitude scales are available, based on amplitude measurement of different seismic phases, and/or on total signal duration. Among them, the duration magnitude (M_D) is adopted in many regional networks because it provides a rapid and reliable estimate of the earthquake size through a fairly simple procedure based on the measure of the duration of recorded seismograms. Bisztricany (1958) first demonstrated the existence of a relationship between magnitude and duration, and several authors (e.g., Sole'vev, 1965; Vidal and Munguía, 2005; Hara, 2007; Colomblli et. al., 2014 and among many others) later discussed the use of duration of the recorded seismograms to measure the event size. proposed a duration magnitude procedure for the rapid determination of the moment magnitude, based on the P-wave recordings at teleseismic distances, which can be applied for tsunami early warning. In this study, the relationship for estimation of earthquake magnitude was derived using the duration of the coda-waves of recorded signals in the Zagros area. Determination of duration magnitude (M_D) is fast and reliable while in other methods it is difficult to read the correct amplitude. Another advantage in this method is that there no need to correct signals for instrumental effect. In this study more than 3890 records with magnitude in the range of 2 to 5 with epicentral distances less than 200 km were used. The mentioned data is recorded in IIEES seismic network in the period between 2006 and 2013. Locations of earthquakes were in the range of 23.59 to 37 degree latitude and 43.37 to 61.63 longitude. The aim of this study was to determine the relationship between the magnitudes of the duration using the following equation:

$M_D = a + b.\log_{10}\tau + c.R + S_c$

In which R is the hypocentral distance, $\boldsymbol{\tau}$ is the signal duration, S_c stands for the station correction, and coefficients of a, b, and c must be determined by analysis of regression. Duration was considered as the time elapsed since the first P-wave arrival to the moment when the noise level is reduced to the coda wave amplitude. By comparing the signal amplitude of the noise before the event, the signal end was determined, and our conditions were $\frac{A_{sign}-A_{noise}}{A_{noise}} < 0.05$, in which A_{sign} and A_{noise} represent the signal average amplitude in the coda window and noise amplitude before the P picking, respectively. After obtaining the duration parameter with the given distance and local magnitude, a three-dimensional regression of them, the coefficients a, b and c were obtained. In this research, we obtained the following equation for event less distances than 200 kilometers:

$M_D = -17.4 + 10.32 \times \log_{10}\tau - 0.0032 \times R$

In order to increase the accuracy of estimation of magnitude, a correction factor was estimated. After calculating the station correction factor, the final relation is made up as follow:

$M^*_{D,ij} = -17.4 + 10.32 \times \log_{10}\tau - 0.0032 \times R + S_{c_j}$

Finally, for each occurrence, magnitude duration was obtained as the mean values for all $M^*_{D,ij}$.

Keywords: Duration, Coda wave, Magnitude estimation, Estimation relationship magnitude.

*Corresponding author: rahimih@ut.ac.ir kmotaghi@iasbs.ac.ir

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