APPLICATION OF STEPP METHOD FOR ASSESSING THE COMPLETENESS OF INSTRUMENTAL AND PRE-INSTRUMENTAL EARTHQUAKE DATA IN DIFFERENT SEISMIC PROVINCES OF IRAN

Mona SALAMAT
Seismological Research Center, IIEES, Tehran, Iran
m.salamat@iiees.ac.ir

Mehdi ZARE
Seismological Research Center, IIEES, Tehran, Iran
mzare@iiees.ac.ir

Keywords: Magnitude of Completeness, Stepp Method, Seismic Provinces, Iran

Probabilistic Seismic Hazard analysis is challenged by large uncertainties of pre-instrumental data. One of the most important sources of uncertainties is incompleteness of historical seismic records. Thus, checking the completeness of indifferent magnitude levels and aftershock removal is a predominant step in a seismic hazard assessment (Massimiliano et al., 2004; Raghukanth, 2010). The assessment of completeness of historical earthquake data has usually been approached in seismology and especially in probabilistic seismic hazard assessment. By statistical procedures, we can determine time interval for which on the data set is considered as complete above a given magnitude. The part of the data set before this time is considered as incomplete and not suitable for statistical analysis. It is a general issue that statistical approach to completeness assessment started with the work by Stepp (1972).

In this article, we used this method for checking the completeness catalogues. The methodology which was proposed by Stepp (1972) is applied to determine the interval in a magnitude class over which the class is complete. For this purpose, data is grouped into three classes such as $4 \leq M_w \leq 5,\ 5 \leq M_w \leq 6,\ 6 \leq M_w \leq 7$. With a time interval of 10 years, the average number of events per year in each magnitude range is determined. If $x_1, x_2, \dots, x_n$ are the number of events per year in a magnitude range, then the mean rate for this sample is

$$X = \frac{1}{n}\sum_{i=1}^{n} x_i$$

Where n is the number of unit time intervals. The variance is given by: $\sigma_x^2 = \frac{X}{T}$, Where T is the duration of the sample. If X were to be constant, σ_X would vary as $\frac{1}{\sqrt{T}}$. As per Stepp (1972), the standard deviation of the mean rate for the three magnitude intervals as a function of sample length are plotted with nearly tangent lines with slope $\frac{1}{\sqrt{T}}$. The deviation of standard deviation of the estimate of the mean from the tangent line indicates the length up to which a particular magnitude range maybe taken as complete. (Nasir et al., 2013) figure (1), shows the achieved results in Azerbaijan using Stepp method. After dividing the seismicity data, the threshold magnitude (m_0), defined as the lowest above which 100% of the events in a given region are detected, is found from the complete part of the catalogue (Woessner and wiemer, 2005). We used The Maximum Curvature (MAXC) and the goodness of fit (GFT) methods for achieving magnitude of completeness (Mc).The maximum curvature (MAXC) method (Woessner and Wiemer, 2005), in which the completeness magnitude is defined as the point where the first derivative of the frequency magnitude curve assumes its maximum (being the maximum of the non-cumulative frequency magnitude distribution). The goodness of fit (GFT) method (Woessner and Wiemer, 2005) in which the observed frequency-magnitude distribution is compared with synthetic distribution and the GFT is calculated as the absolute difference of the number of earthquakes in the magnitude bins between observed and synthetic distribution.

Synthetic distributions are calculated using estimated a- and b-values of the Gutenberg-Richter law for the observed dataset increasing the cutoff magnitude; the completeness magnitude, thus, is given by that cutoff magnitude value, at which the 90% of the observed data is modelled by a straight line (Telesca et al., 2012).

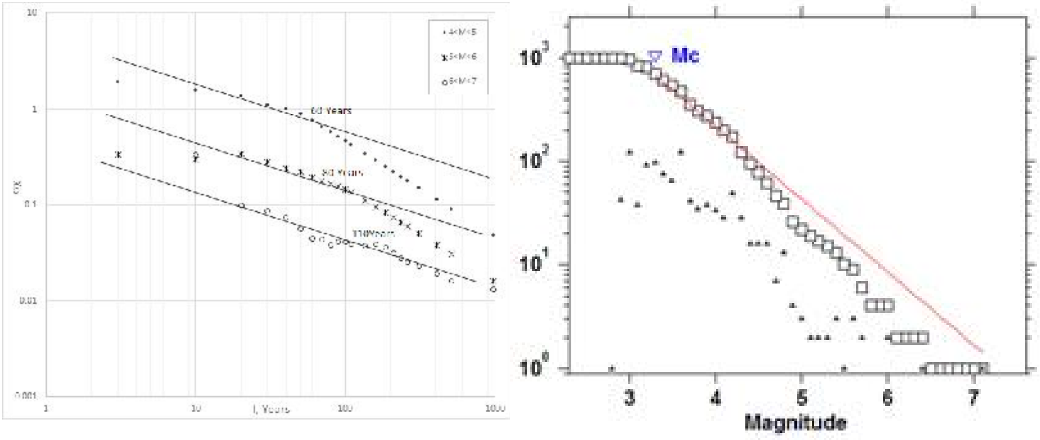

Figure 1. Time duration and value of magnitude of completeness in Azerbaijan seismic region

For this purpose, a composite catalogue for Iran was created and divided into 6 sub-catalogues in 6 seismotectonic provinces of Iran namely: Alborz, Azerbaijan, Zagros, Central Iran, Makran and Kopeh-dagh.

REFERENCES

Nasir A, Lenhardt W, Hintersberger E and Decker K (2013) Assessing the Completeness of Historical and Instrumental Earthquake Data in Austria and the Surrounding Areas, *Austrian Journal of Earth Science*, 106(1): 90-102

Raghukanth STG (2010) Estimation of Seismicity Parameters for India, *Seismological Research Letters*, 81(2): 207-217

Stepp JC (1972) Analysis of Completeness of Earthquake Sample in the Pugest Sound Area and Its Effect on Statistical Estimates of Earthquake Hazard, *National Oceanic and Atmospheric Administration Environmental Research Laboratories*, Boulder Colorado, 80302

Stucchi M, Albini P, Mitro C and Rebez A (2004) Assessing the Completeness of Italian Historical Earthquake, *Annals of Geophysics*, 47(2/3)

Telesca L, Aleaz V and Sandu I (2012) Analysis the 1978-2008 Crustal and Sub-Crustal Earthquake Catalog of Vrancea Region, *Natural Hazard and Earth System Science Journal*, (12): 1321-1325

Woessner J and Wiemer S (2005) Assessing the Quality of Earthquake Catalogues: Estimating the Magnitude of Completeness and Its Uncertainty, *Bulletin of the Seismological Society of America*, 95(2): 684-698