PARAMETRIC AND NON-PARAMETRIC PROCEDURES FOR ESTIMATING MAXIMUM MAGNITUDE OF EARTHQUAKES IN DIFFERENT SEISMOTECTONIC PROVINCES OF IRAN

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Locating in Alp Himalayas border and poor quality of structures, presents Iran as one of the most hazardous country of earthquake casualties in the world. Coherency of earthquake hazard maps and maximum magnitude of occurred earthquakes, show the importance of precise estimation of this factor. Thus, estimating maximum earthquake magnitude for any site of interest plays a crucial role in seismic hazard and risk analysis. This calculation can be assessed deterministically (where earthquake magnitude is associated with length of the fault) or probabilistically (using earthquake catalogues and statistical procedures). In this study, we apply probabilistic procedures using different statistical methods for calculating Mmax. These procedures, by the nature are statistical and derived by seismicity.

Nowadays, there are different statistical procedures for accurate estimation of maximum possible earthquake magnitude, Mmax. There are weak and strong points for each procedure based on its derivation, bias and condition for validity (Kijko and Singh, 2012)

In this methodology, the largest observed magnitude in each region and magnitude threshold of completeness, denoted as m_{max}^{obs} and m_{min} respectively. The next assumption is that magnitudes are independent, random values with probability density function (PDF), $f_M(m)$, and the cumulative distribution function (CDF), $F_M(m)$. The unknown parameter m_{max} is the upper limit of the range of magnitudes and termed the maximum regional earthquake magnitude, $\hat{m}_{max}$, that is to be estimated. The estimation procedures are divided into three sections, parametric, non-parametric estimators and fit of CDF of earthquake magnitudes.

When the parametric models of the frequency-magnitude distributions are known, parametric estimators can be used. Five procedures, such as Tate-Pisarenko (Pisarenko et al., 1996), Kijko-Sellevoll (Cramer's approximation), Kijko-Sellevoll (exact solution), Tate-Pisarenko-Bayes and Kijko-Sellevoll-Bayes (Kijko and Sellevoll, 1989; Kijko and Graham, 1998) can be categorized in this part.

When the empirical distribution of earthquake magnitudes are bi- or multi-modal character, non-parametric counterpart should be replaced. Non-parametric with Gaussian Kernel, based on order statistics and based on a few largest earthquakes are categorized in this part.

Procedures based on L_1 and L_2 norm used for fitting CDF of earthquake magnitudes. When the data are unreliable, contain significant outliers, come from different sources, L_1 norm regression is superior to L_2 norm which is equivalent to the classic least squares procedures.

Table 1. Achieved maximum magnitude in different seismic provinces by some statistical procedures

Mmax	Alborz	Azerbaijan	Markazi	Zagros	Makran	Kopeh-Dagh
Tate-Pisarenko	7.52 ± 0.33	7.63 ± 0.25	7.79 ± 0.27	7.65 ± 0.25		7.54 ± 0.29
Kijko-Sellevoll	7.48 ± 0.31	7.63 ± 0.25	7.78 ± 0.26	7.43 ± 0.25	8.87 ± 0.9	7.53 ± 0.28
Kijko-Sellevoll-Bayes	7.8 ± 0.48	8.2 ± 0.27	8.2 ± 0.32	7.65 ± 0.26	8.5	7.85 ± 0.27
Non-parametric withGaussian Kernel	7.52 ± 0.33	7.86 ± 0.36	7.84 ± 0.29	7.7 ± 0.39	8.91 ± 0.4	7.74 ± 0.42
Order statistics	7.39 ± 0.36	7.77 ± 0.36	7.79 ± 0.36	7.59 ± 0.4	8.61 ± 0.3	7.59 ± 0.39

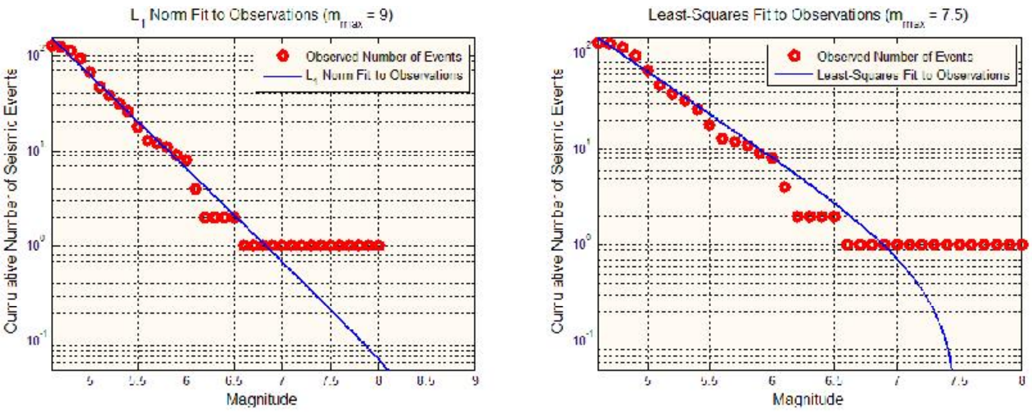

Figure 1. L_1 and L_2 norm methods for calculating maximum magnitude

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