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Robust estimation of magnitude–frequency relationship parameters

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Abstract

The precise estimation of the *a* and *b* parameters of Richter's magnitude–frequency relationship is of primary importance, since the evaluation of seismicity and assessment of seismic hazard depend on these two parameters. In the literature two popular methods of estimation are available for the estimation of these parameters, namely: least squares and maximum likelihood. However, in implementing these statistical methods, engineers very seldom check the validity of the underlying assumptions with respect to the available data and this may lead to serious problems. Under non-normality least squares estimators (LSEs) are neither efficient nor robust and maximum likelihood estimators (MLEs) are elusive due to numerous complexities. A robust estimation procedure, the modified maximum likelihood method (MML), can be utilized to estimate the unknown parameters *a* and *b* in such situations. The resulting estimators are explicit functions of sample observations and are shown to be considerably more efficient than the commonly used least squares estimators. In addition, we demonstrate that the MML estimators are more appropriate to estimate the parameters of Richter's magnitude–frequency relationship based on the comparison of their performance with those of the least squares estimators by using the seismic database on earthquakes recorded in Turkey.

Highlights

► Modified maximum likelihood method (MMLM) is introduced and described. ► MMLM is a robust estimation procedure. ► The resulting estimators are explicit functions of sample observations. ► MML estimators are shown to be more efficient than the least squares estimators. ► Parameters of the Richter's magnitude–frequency relationship are estimated by using MMLM.

Keywords

Modified maximum likelihood; Magnitude–frequency relationship; Seismic hazard; North Anatolian fault zone

Figures and tables from this article:

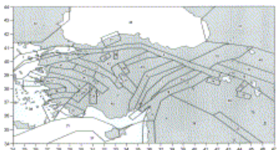

Fig. 1. Location of the North Anatolian fault zone and its four segments.

Figure options

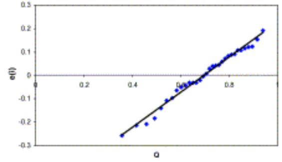

Fig. 2. $Q - Q$ plot of the estimated residuals (NAFZ as a whole).

Figure options

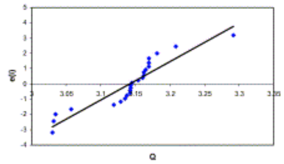

Fig. 3. $Q - Q$ plot of the estimated residuals (NAFZ − segment 2).

Figure options

Table 1. Values of (1) skewness $\mu_3/\mu_2^{3/2}$ and (2) kurtosis μ_4/μ_2^2 corresponding to different u and v values of the Beta distribution; μ_i represents ith central moment.

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Table 2. Values of the relative efficiency of the LSE.

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Table 3. Values of MML and LS estimates of a, b and σ and their standard errors (NAFZ as a whole).

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Table 4. Variation of $(1/n)\ln \hat{L}$ with respect to $b1$.

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Table 5. Values of MML and LS estimates of a, b and σ and their standard errors (NAFZ − segment 2).

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