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DECLUSTERING ZAGROS EARTHQUAKE CATALOGUE USING THE EPIDEMIC TYPE AFTERSHOCK SEQUENCE (ETAS) MODEL

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The main goal of this article is to decluster the earthquake catalogue of Zagros seismotectonic zone in the Iranian plateau by the epidemic type aftershock sequence (ETAS) model and compare the results with some older methods. Declustering is the process of separating an earthquake catalogue into independent earthquakes (main shocks) and dependent earthquakes (foreshocks and aftershocks). Declustering also is very important in seismological studies. Basic assumption in most probabilistic seismic hazard analysis is that: in a declustered catalogue, earthquakes follow the homogenous Poisson process. There are several declustering approaches that have been proposed over the years (Van Stiphout et al., 2012) which are including deterministic approaches such as: window-based method (Gardner and Knopoff, 1974; Uhrhammer, 1986; Gruenthal, pers.comm), linking to spatial interaction zones (Reasenberg, 1985) and probabilistic approaches such as: stochastic model (Zhuang et al., 2002, 2004, 2006). Zagros is one of the largest seismic regions of Iran's earthquake-prone plateau. This large seismic zone extends from northwest to southern Iran and undergoes several earthquakes annually. The extracted earthquake catalogue for Zagros zone, had a total of 3741 earthquakes (Mw>4) that occurred in the time span 1983-2017.

The Epidemic Type aftershock sequence (ETAS) model is a statistical approach based on a space-time branching process model that explains how each earthquake epidemically can generate its aftershocks (Van Stiphout et.al, 2012). Despite the great potential of the ETAS model, mainly due to the simplicity of traditional methods, generally, researchers have used traditional deterministic approaches to decluster Iran earthquake catalogue. In this paper, the results of declustering by the ETAS model are compared with result of Gardner and Knopoff (1974), Uhrhammer (1986), Gruenthal (pers.comm) and Reasenberg (1985) declustering methods. In the ETAS model, any triggered earthquake (aftershock) can also have its aftershocks. As expected, we have a catalogue with a maximum number of independent earthquakes considering the least threshold (0.5). Uhrhammer and Reasenberg's methods compared to ETAS model, estimate more main shocks in the declustered catalogue. There is a great difference that roughly we can say that the Uhrhammer and Reasenberg's methods overestimate the main shocks number. The maximum number of clusters and therefore a maximum number of dependent earthquakes is estimated using the Gruenthal windowing method. On the other hand, the Reasenberg's method estimates a catalogue with the least number of clusters. For a better comparison in Figure 1, the ETAS model results are presented with respect to different threshold values of probability.

In this study, the hypothesis that declustered catalogues follow the homogenous Poisson process has been evaluated. If the P-value estimated by the Kolmogorov-Smirnov test or the chi-square method is greater than 0.05, then the result is

positive and the declustered catalogue is Poissonian. In Table 1, the results of the Kolmogorov-Smirnov and chi-square tests on declustered catalogue are presented for the Zagros major seismotectonic zone.

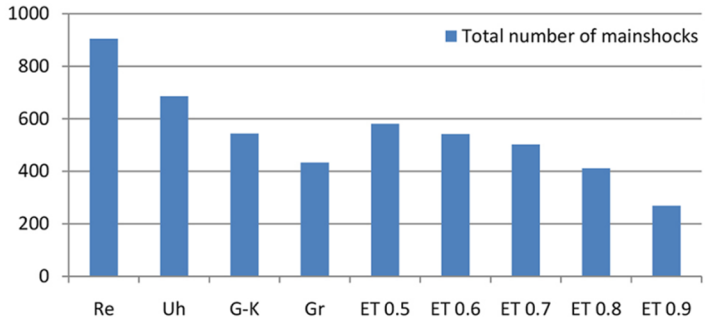

Figure 1. Results of different declustering methods. Re: Reasenberg method, Uh: Uhrhammer method, G-K: Gardner and Knopoff method, Gr: Gruenthal method, ET: ETAS model with different thresholds.

Table 1. Result of some statistical tests on the declustered catalogue of Zagros zone.

Declustering Method	Number of Independent Earthquakes	Annual Frequency	Mean of Magnitudes	Standard Deviation	Chi-Square Test	K-S test
					Asymp. sig. (P- value)	Asymp. sig. (P- value)
Primary Catalogue	1196	34.17	4.38	0.4378	0.0	0.02
Reasenberg	974	27.82	4.42	0.4322	0.05	0.01
Uhrhammer	764	21.82	4.41	0.4344	0.52	0.05
Gardner and Knopoff	638	18.22	4.44	0.4519	1.0	0.76
Gruenthal	521	14.88	4.48	0.4739	1.0	1.0
ETAS-0.5	671	19.17	4.41	0.4321	1.0	0.1
ETAS-0.6	640	18.28	4.41	0.4370	0.66	1.0
ETAS-0.7	612	17.48	4.42	0.4403	1.0	0.88
ETAS-0.8	559	15,97	4.44	0.4569	1.0	1.0
ETAS-0.9	427	12.2	4.44	0.4802	1.0	1.0

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