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A robust, flexible and automatic framework for joint estimation of magnitude of completeness, b-value, magnitude binning and their time variation

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The magnitude of completeness (Mc) of earthquake catalogues is an indispensable parameter that has critical implications for probabilistic seismic hazard assessment, primarily because the estimate of the exponent (b-value) of Gutenberg Richter (GR) law hinges on the reliable estimate of Mc. The stability of Mc estimation, in turn, depends on the correct specification of bin sizes (dm) at which magnitudes of earthquakes in the catalogue are discretized as well as the time partitions, which correspond to the changes in the Mc due to changes in the network properties.

We propose a framework to jointly estimate the Mc, b-value and dm given only the magnitude of earthquakes in the catalogue. The framework relies on measuring the consistency between an assumed magnitude distribution above Mc and empirical magnitude distribution that is observed and is flexible enough to allow for following constraint switches: (1) Specification of time partitions based on expert judgement or jointly invert them (2) b-value is constant/variable in time (3) Mc and/or dm decreases as function of time or it does not (4) assumed magnitude distribution follows GR law or any other exotic magnitude distribution. Furthermore, we reduce the expert judgements from non-trivial tasks such as visual assessment of the quality of fit to trivial tasks such as the minimum number of events to be used to estimate these parameters, thus, striving for reproducibility and transparency in the estimation of these parameters.

We demonstrate the reliability and robustness of this framework to correctly estimate Mc, b-value, dm and time partitions using rigorous synthetic tests. Furthermore, we compare the performance of this framework to two most popular Mc estimation methods on the synthetic data. Finally, we apply the method to European and Californian earthquake catalogues.