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To b or not to b

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Since its introduction in the 90s, the spatial mapping of Gutenberg-Richter's b-value has become an increasingly popular method for the physical interpretation of various geological structures, faulting regimes and volcanoes. Many studies have correlated spatial b-value variations to differential stress. However, the main problem with these studies is that the input parameters (such as grid spacing, cylindrical mapping radius, and minimum number of events) are arbitrarily chosen without objective justifications, mostly in order to obtain interpretable results. Published b-value maps often feature extreme spatial variations at small scales, rarely observed in well-sampled large catalogs. The openly available b-value mapping software and an increasing coverage and quality of earthquake catalogs have also promoted those applications while little has been done to assess the sensitivity, validity and statistical significance of the results.

In this study we propose a fully automated, objective method which is driven by penalized likelihood and the wisdom of the crowd philosophy. The method incorporates a non-arbitrary partitioning scheme based on Voronoi tessellation which allows for the optimal partitioning of space with a minimum number of free parameters. By increasing the number of Voronoi cells and placing them randomly within the region of interest we are able to explore the whole solution space in terms of model complexity. We calculate an overall likelihood for each model by estimating the b-value in each Voronoi region and calculating its likelihood using Aki's formula. Accounting for the number of free parameters (given by the partitions and the Gutenberg-Richter laws used to fit the data) we then calculate the Bayesian Information Criterion (BIC) for each model. We obtain the ensemble mean and variance by BIC weighted averaging of all models which have a higher likelihood than the prior model (a single b-value for the whole catalog). We present results on synthetic catalogs, the Parkfield cross-section of the San Andreas Fault and whole California.

In contrast to the prevalent method, our method does not feature any adjustable input parameters and is thus fully objective. The validity of its results and its robustness are demonstrated by synthetic benchmark runs. In the lights of these facts, our results suggest that previously found spatial variations of the b-value are dominated by statistical artifacts rooted in the overfitting caused by arbitrary parameter choices.