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Clustering analysis of seismicity and aftershock identification

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Formation of extreme events in complex systems is often associated with break of self-similarity and abnormal clustering. This calls for developing problem-specific statistical tools for analysis of clustering and scaling in spatially distributed, time-dependent observations.

We present here a general technique for clustering and scaling analyses of marked point fields and apply it to the observed seismicity in the time-space-energy domain. Notably, we demonstrate that the clustering part of Southern California seismicity, mainly comprised of aftershocks, is statistically different from the homogeneous part, mainly comprised of mainshocks. This provides a basis for an objectve aftershock identification procedure that requires no apriori parameters.

The proposed approach expands the analysis of Baiesi and Paczuski [PRE, 69, 066106 (2004)] based on the space-time-magnitude nearest-neighbor distance η between earthquakes. We show, in particular, that for a homogeneous Poisson marked point field with independent exponential marks, the distance η has the Weibull distribution, which bridges our results with classical correlation analysis for unmarked point fields. We introduce a 2D distribution of spatial and temporal components of η, which allows us to identify the clustered part of a point field. The proposed technique is applied to several synthetic seismicity models and to the observed seismicity of Southern California.