EGU2020-10098
https://doi.org/10.5194/egusphere-egu2020-10098
EGU General Assembly 2020

Variations in the temporal evolution of seismicity pointed out by non-extensive statistical physics approach

Renata Rotondi and Elisa Varini
Istituto Matematica Applicata Tecnologie Informatiche, CNR, Milano, Italy (reni@mi.imati.cnr.it)

Physics-based models focus on the generation process of individual earthquakes but the strong space-time interaction existing among the events of seismic sequences requires that the seismic activity be studied as a whole through statistics-based models in order to forecast its future trend. Properties such as long-range interactions, power law distributions, fractal geometries are common to all complex systems and are also shared by earthquakes and fault systems. Over recent years, on the one hand many studies have shown the inability of classical statistical mechanics to treat complex systems in exhaustive manner, and, on the other hand, the application of the Tsallis entropy S_q - a generalization of the classical Boltzmann-Gibbs entropy in non-extensive sense – has led to long-tailed power-law distributions typical of complex systems (Vallianatos *et al*. 2018); it seems hence that the non-extensive statistical physics can offer an appropriate framework of investigation for complex phenomena. In this work we follow this approach giving a detailed statistical treatment of its application to Italian earthquake sequences covering a period of some years; each data set was partitioned in moving time windows.

Given a continuous variable X with probability distribution *f(X)*, by maximizing the Tsallis entropy under appropriate constraints, such as the generalized expectation value and the normalization constant, it turns out that *f(X)* is a *q*-exponential distribution. The *q* entropic index can assume positive values less or larger than 1: in the former case the system is in a super-additive state and *f(X)* is defined on a finite domain depending on model parameters, in the latter case the system is in a sub-additive state and *f(X)* is defined on R^+. Through a variable transformation required by the fragment-asperity model for earthquake generation, one derives the probability distribution of the magnitude from the two versions of *f(X)*. Following the Bayesian approach we have estimated the parameters by generating random samples from the posterior distributions through the Metropolis-Hasting algorithm; moreover, in each time window, we have evaluated the Tsallis entropy and compared the performance of the two versions of the magnitude distribution in terms of marginal posterior likelihood. The temporal variations of the *q*-index and of the entropy $S_q$can be helpful in identifying in which dynamics regime the system is, and therefore in improving our ability to forecast seismicity evolution. Some of the results achieved partially disagree with those present in the literature (Vallianatos *et al.* 2018); what seems reasonable is to consider the change of one of these variables, rather than a specific trend, as index of a phase change of the physical system.

References

Vallianatos F., Michas G. and G. Papadakis (2018) *Nonextensive statistical seismology: An overview*, from: **Complexity and Seismic Time Series. Measurement and Application**, eds. Chelidze T., Vallianatos F., Telesca L., Elsevier, 25-59