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An analysis of Greek seismicity based on Non Extensive Statistical Physics: The interdependence of magnitude, interevent time and interevent distance.

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The context of Non Extensive Statistical Physics (NESP) has recently been suggested to comprise an appropriate tool for the analysis of complex dynamic systems with scale invariance, long-range interactions, long-range memory and systems that evolve in a fractal-like space-time. This is because the active tectonic grain is thought to comprise a (self-organizing) complex system; therefore, its expression (seismicity) should be manifested in the temporal and spatial statistics of energy release rates. In addition to energy release rates expressed by the magnitude M, measures of the temporal and spatial interactions are the time (Δt) and hypocentral distance (Δd) between consecutive events. Recent work indicated that if the distributions of M, Δt and Δd are independent so that the joint probability p(M,Δt,Δd) factorizes into the probabilities of M, Δt and Δd, i.e. p(M,Δt,Δd)= p(M)p(Δt)p(Δd), then the frequency of earthquake occurrence is multiply related, not only to magnitude as the celebrated Gutenberg – Richter law predicts, but also to interevent time and distance by means of well-defined power-laws consistent with NESP.
The present work applies these concepts to investigate the self-organization and temporal/spatial dynamics of seismicity in Greece and western Turkey, for the period 1964-2011. The analysis was based on the ISC earthquake catalogue which is homogenous by construction with consistently determined hypocenters and magnitude.
The presentation focuses on the analysis of bivariate Frequency-Magnitude-Time distributions, while using the interevent distances as spatial constraints (or spatial filters) for studying the spatial dependence of the energy and time dynamics of the seismicity. It is demonstrated that the frequency of earthquake occurrence is multiply related to the magnitude and the interevent time by means of well-defined multi-dimensional power-laws consistent with NESP and has attributes of universality,as its holds for a broad range of spatial, temporal and magnitude scales. Provided that the multivariate empirical frequency distributions are based on a sufficient number of observations as an empirical lower limit, the results are stable and consistent with the established ken, irrespective of the magnitude and spatio-temporal range of the earthquake catalogue, or operations pertaining to re-sampling, bootstrapping or re-arrangement of the catalogue. It is also demonstrated that that the expression of the regional active tectonic grain may comprise a mixture of processes significantly dependent on Δd.
The analysis of the size (energy) distribution of earthquakes yielded results consistent with a correlated sub-extensive system; the results are also consistent with conventional determinations of Frequency-Magnitude distributions. The analysis of interevent times, has determined the existence of sub-extensivity and near-field interaction (correlation) in the complete catalogue of Greek and western Turkish seismicity (mixed background earthquake activity and aftershock processes),as well as in the pure background process (declustered catalogue).This could be attributed to the joint effect of near-field interaction between neighbouring earthquakes or seismic areas and interaction within aftershock sequences. The background process appears to be moderately – weakly correlated at the far field. Formal random temporal processes have not been detected.
A general syllogism affordable by the above observations is that aftershock sequences may be an integral part of the seismogenetic process, as they appear to partake in long-range interaction. A formal explanation of such an effect is pending, but may nevertheless involve delayed remote triggering of seismic activity by (transient or static) stress transfer from the main shocks and large aftershocks and/or cascading effects already discussed by Marsan and Lengliné (2008). In this view, the effect weakens when aftershocks are removed because aftershocks are the link between the main shocks and their remote offshoot.
Overall, the above results compare well to the results of North Californian seismicity which have shown that the expression of seismicity at Northern California is generally consistent with non-extensive (sub-extensive) thermodynamics.

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References:

Tzanis A., Vallianatos F., Efstathiou A., Multidimensional earthquake frequency distributions consistent with Non-Extensive Statistical Physics: the interdependence of magnitude, interevent time and interevent distance in North California. Bulletin of the Geological Society of Greece, vol. XLVII 2013. Proceedings of the 13th International Congress, Chania, Sept. 2013

Tzanis A., Vallianatos F., Efstathiou A., Generalized multidimensional earthquake frequency distributions consistent with Non-Extensive Statistical Physics: An appraisal of the universality in the interdependence of magnitude, interevent time and interevent distance

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Marsan, D. and Lengliné, O., 2008. Extending earthquakes's reach through cascading, Science, 319, 1076; doi: 10.1126/science.1148783

On-line Bulletin, http://www.isc.ac.uk, Internatl. Seis. Cent., Thatcham, United Kingdom, 2011.