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A non-extensive statistical physics view in Earth Physics: Geodynamic properties in terms of Complexity theory .

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Boltzmann-Gibbs (BG) statistical physics is one of the cornerstones of contemporary physics. It establishes a remarkably useful bridge between the mechanical microscopic laws and macroscopic description using classical thermodynamics. If long-range interactions, non-markovian microscopic memory, multifractal boundary conditions and multifractal structures are present then another type of statistical mechanics, than BG, seems appropriate to describe nature (Tsallis, 2001).

To overcome at least some of these anomalies that seem to violate BG statistical mechanics, non-extensive statistical physics (NESP) was proposed by Tsallis (Tsallis, 1988) that recovers the extensive BG as a particular case. The associated generalized entropic form controlled by the entropic index q that represents a measure of non-additivity of a system. S_q recovers S_{BG} in the limit q->1. For a variable X with a probability distribution p(X), as that of seismic moment , inter-event times or distances between the successive earthquakes or the length of faults in a given region, using terms of NESP, we obtain the physical probability which expressed by a q-exponential function as defined in Tsallis, (2009). Another type of distributions that are deeply connected to statistical physics is that of the squared variable X^2. In BG statistical physics, the distribution of X^2 corresponds to the well-known Gaussian distribution. If we optimize S_q for X^2, we obtain a generalization of the normal Gaussian that is known as q-Gaussian distribution (Tsallis, 2009). In the limit q->1, the normal Gaussian distribution, recovered. For q> 1, the q-Gaussian distribution has power-law tails with slope -2/(q-1), thus enhancing the probability of the extreme values.

In the present work we review a collection of Earth physics problems such as a) NESP pathways in earthquake size distribution, b) The effect of mega-earthquakes, c) Spatiotemporal description of Seismicity, d) the plate tectonics as a case of non-extensive thermodynamics e) laboratory seismology and fracture, f) the non-extensive nature of earth's ambient noise, and g) evidence of non-extensivity in eartquakes' coda wave. The aforementioned cases cover the most of the problems in Earth Physics indicated that non extensive statistical physics could be the underline interpretation tool to understand earth's evolution and dynamics.

We can state that the study of the non-extensive statistical physics of earth dynamics remains wide-open with many significant discoveries to be made. The results of the analysis in the cases described previously indicate that the ideas of NESP can be used to express the non-linear dynamics that control the evolution of the earth dynamics at different scales. The key scientific challenge is to understand in a unified way, using NESP principles, the physical mechanisms that drive the evolution of fractures ensembles in laboratory and global scale and how we can use measures of evolution that will forecast the extreme fracture event rigorously and with consistency.

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