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Innovative techniques to analyze time series of geomagnetic activity indices

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Magnetic storms are undoubtedly among the most important phenomena in space physics and also a central subject of space weather. The non-extensive Tsallis entropy has been recently introduced, as an effective complexity measure for the analysis of the geomagnetic activity Dst index. The Tsallis entropy sensitively shows the complexity dissimilarity among different "physiological" (normal) and "pathological" states (intense magnetic storms). More precisely, the Tsallis entropy implies the emergence of two distinct patterns: (i) a pattern associated with the intense magnetic storms, which is characterized by a higher degree of organization, and (ii) a pattern associated with normal periods, which is characterized by a lower degree of organization. Other entropy measures such as Block Entropy, T-Complexity, Approximate Entropy, Sample Entropy and Fuzzy Entropy verify the above mentioned result. Importantly, the wavelet spectral analysis in terms of Hurst exponent, H, also shows the existence of two different patterns: (i) a pattern associated with the intense magnetic storms, which is characterized by a fractional Brownian persistent behavior (ii) a pattern associated with normal periods, which is characterized by a fractional Brownian anti-persistent behavior. Finally, we observe universality in the magnetic storm and earthquake dynamics, on a basis of a modified form of the Gutenberg-Richter law for the Tsallis statistics. This finding suggests a common approach to the interpretation of both phenomena in terms of the same driving physical mechanism. Signatures of discrete scale invariance in Dst time series further supports the aforementioned proposal.