INVESTIGATING DYNAMICAL COMPLEXITY IN THE MAGNETOSPHERE USING VARIOUS ENTROPY MEASURES

GEORGIOS BALASIS 1, Ioannis A. Daglis 1, Constantinos Papadimitriou 2, Maria Kalimeri 2, Anastasios Anastasiadis 1, Konstantinos Eftaxias 2

1. Institute for Space Applications and Remote Sensing, National Observatory of Athens, Greece, e-mail: gbalasis@space.noa.gr
2. Solid State Section, Physics Department, University of Athens, Greece

The complex system of the Earth's magnetosphere corresponds to an open spatially extended nonequilibrium (input - output) dynamical system. The non-extensive Tsallis entropy has been recently introduced (Balasis et al., 2008) as an appropriate information measure to investigate dynamical complexity in the magnetosphere. The method has been employed for analyzing Dst time series and gave promissing results, detecting the complexity dissimilarity among different physiological and pathological magnetospheric states (i.e., pre-storm activity and intense magnetic storms, respectively). This paper explores the applicability and effectiveness of a variety of computable entropy measures (e.g. Block entropy, Kolmogorov entropy, T complexity and Approximate entropy) to the investigation of dynamical complexity in the magnetosphere. We show that as the magnetic storm approaches there is clear evidence of significant lower complexity in the magnetosphere. The observed higher degree of organization of the system agrees with that inferred previously (Balasis et al., 2006), from an independent linear fractal spectral analysis based on wavelet transforms. This convergence between nonlinear and linear analyses provides a more reliable detection of the transition from the quiet-time to the storm-time magnetosphere, thus showing evidence that the occurrence of an intense magnetic storm is imminent. More precisely, we claim that our results suggest an important principle: significant complexity decrease and accession of persistency in Dst time series can be confirmed as the magnetic storm approaches, which can be used as diagnostic tools for the magnetospheric injury (global instability). Overall, Approximate entropy and Tsallis entropy yield superior results for detecting dynamical complexity changes in the magnetosphere in comparison to the other entropy measures presented herein. Ultimately, the analysis tools developed in the course of this study for the treatment of Dst index can provide convenience for space weather applications.

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Georgios Balasis, Institute for Space Applications and Remote Sensing, National Observatory of Athens, Metaxa and Vas. Pavlou, Penteli, 15236 Athens, Greece