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Dynamical complexity in the magnetosphere - A recurrence perspective

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Magnetic storms are the most prominent global phenomena of nonlinear magnetospheric dynamics. Studying the associated dynamical complexity can provide a window to identifying the relevant processes and scales associated with this phenomenon. In this work, multiple characteristics from recurrence quantification analysis (RQA) and recurrence network analysis (RNA) are applied to studying the nonlinear features of the hourly disturbance storm-time (Dst) index during magnetic storms and periods of normal variability. Both types of analysis have been developed over the last two decades and provide versatile tools for studying nonlinear dynamical systems from various fields. Our results reveal that recurrence-based measures provide excellent tracers for changes in the dynamical complexity along non-stationary records of geomagnetic activity. In particular, trapping time (characterizing the typical length of "laminar phases" in the observed dynamics) and recurrence network transitivity (associated with the number of the system's effective dynamical degrees of freedom) allow a very good discrimination between activity (magnetic storms) and quiescence phases. Specifically, we find that the discriminatory skills of some RQA and RNA characteristics are equal or even superior to those of previously considered characteristics like Hurst exponent or symbolic dynamics based entropy concepts. Our results point to great potentials of recurrence characteristics for unveiling temporal changes in the dynamical complexity of the magnetosphere.