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A novel approach to the dynamical complexity of the Earth's magnetosphere at geomagnetic storm time-scales based on recurrences

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Magnetic storms are the most prominent global manifestations of out-of-equilibrium magnetospheric dynamics. Investigating the dynamical complexity exhibited by geomagnetic observables can provide valuable insights into relevant physical processes as well as temporal scales associated with this phenomenon. In this work, we introduce several innovative data analysis techniques enabling a quantitative analysis of the Dst index non-stationary behavior. Using recurrence quantification analysis (RQA) and recurrence network analysis (RNA), we obtain a variety of complexity measures serving as markers of quiet- and storm-time magnetospheric dynamics. We additionally apply these techniques to the main driver of Dst index variations, the VB_{South} coupling function and interplanetary medium parameters B_z and P_{dyn} in order to discriminate internal processes from the magnetosphere's response directly induced by the external forcing by the solar wind. The derived recurrence-based measures allow us to improve the accuracy with which magnetospheric storms can be classified based on ground-based observations. The new methodology presented here could be of significant interest for the space weather research community working on time series analysis for magnetic storm forecasts.