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Unveiling the solar wind – Earth's magnetic field coupling and storm/substorm relationship by information-theoretic multivariate causality measures

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The identification of directed interdependencies between variables related to causal relationships in various geoscientific processes is necessary for an improved process-based understanding of the coupling between different variables or even systems. Especially in geomagnetism, the time-dependent coupling between solar wind and the Earth's magnetic field as well as the relationship between magnetic storms and magnetospheric substorms are of paramount importance for the development of appropriate numerical simulation models of space weather. Here we utilize an information-theoretic method of directional, multivariate causality measures using graphical models that goes beyond bivariate transfer entropy approaches and allows for the identification and statistical evaluation of linear as well as nonlinear causality between variables. In this study, we present and discuss results from an application of this method to the time series of various solar wind parameters as well as the AE and SYM-H geomagnetic activity indices.