Common solar wind drivers behind magnetic storm – magnetospheric substorm dependency

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The storm-substorm relationship is one of the most controversial aspects of geospace magnetic storm dynamics and one of the unresolved topics of solar-terrestrial coupling. Here we investigate the statistical dependencies between storm and substorm indices in conjunction with multiple relevant solar wind variables with an information-theoretic causal inference approach. We find that the vertical component of the interplanetary magnetic field is the strongest driver of both storms and substorms. Importantly, this common driver explains the transfer entropy between substorms and storms found by a previous bivariate analysis. These results hold during both a year close to solar maximum (2001) and minimum (2008) and suggest that, at least based on the analyzed indices, there is no statistical evidence of a direct or indirect information transfer and, therefore, likely no physical mechanism by which substorms drive storms or vice versa.