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# Information flow within the magnetosphere-ionosphere system: insights from ensemble-based transfer entropy

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When the interplanetary magnetic field is characterized by nearly-southward conditions, the near-Earth magnetospheric environment and, specifically, the plasma circulation and the magnetospheric-ionospheric current systems undergo to some dynamical changes to dissipate the excess of energy-momentum and mass transfer from interplanetary medium to the magnetosphere. Geomagnetic storms and magnetospheric substorms are the macroscopic manifestation of such a response and their relation is one of the critical issues of the magnetospheric dynamics. In this framework, a very old and widely debated topic is the storm-substorm relations, such as for instance the role of substorms in developing a storms. In recent years, some novel methods developed in the ambit of the information theory, such us the transfer entropy, have been applied to unveil the directionality of the information flow between storms and substorms (De Michelis et al., 2011, Stumpo et al, 2020). However, these results have been partially criticised suggesting that there is not a clear net transfer of information between substorms to storms. However, the use of information theory methods which relies on time averages could hide the dynamics of the information flow. Indeed, the absence of a net information exchange between storms and substorms may be due to the fact that it is enhanced only during activity periods, so that it may be canceled out if transfer entropy is computed by averaging together quiet and activity periods.Here, we attempt an instantaneous estimation of the magnetospheric internal transfer of information during the occurrence of geomagnetic storms using an ensemble-based transfer entropy analysis. In detail using some geomagnetic indices as proxies of magnetospheric-ionosphere dynamics during geomagnetic storms, we investigate the directionality of the information flow within the magnetosphere-ionosphere system during the occurrence of periods of magnetic storms and substorms.

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