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Quantifying the spatio-temporal pattern of the ground impact of space weather events using dynamical networks formed from the SuperMAG database of ground based magnetometer stations.

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Quantitative understanding of the full spatial-temporal pattern of space weather is important in order to estimate the ground impact. Geomagnetic indices such as AE track the peak of a geomagnetic storm or substorm, but cannot capture the full spatial-temporal pattern. Observations by the $\sim$100 ground based magnetometers in the northern hemisphere have the potential to capture the detailed evolution of a given space weather event. We present the first analysis of the full available set of ground based magnetometer observations of substorms using dynamical networks. SuperMAG offers a database containing ground station magnetometer data at a cadence of 1min from 100s stations situated across the globe. We use this data to form dynamic networks which capture spatial dynamics on timescales from the fast reconfiguration seen in the aurora, to that of the substorm cycle. Windowed linear cross-correlation between pairs of magnetometer time series along with a threshold is used to determine which stations are correlated and hence connected in the network. Variations in ground conductivity and differences in the response functions of magnetometers at individual stations are overcome by normalizing to long term averages of the cross-correlation. These results are tested against surrogate data in which phases have been randomised. The network is then a collection of connected points (ground stations); the structure of the network and its variation as a function of time quantify the detailed dynamical processes of the substorm. The network properties can be captured quantitatively in time dependent dimensionless network parameters and we will discuss their behaviour for examples of ‘typical’ substorms and storms. The network parameters provide a detailed benchmark to compare data with models of substorm dynamics, and can provide new insights on the similarities and differences between substorms and how they correlate with external driving and the internal state of the magnetosphere.

We can also investigate the solar wind control of the magnetospheric-ionospheric convection system using dynamical networks. The dynamical networks are first interpolated onto a regular grid. Statistically averaged network responses are then formed for a variety of solar wind conditions, including investigating the network response to southward turnings.

[1] Dods, J., S. C. Chapman, and J. W. Gjerloev (2015), Network analysis of geomagnetic substorms using the SuperMAG database of ground-based magnetometer stations, J. Geophys. Res. Space Physics, 120, 7774–7784, doi:10.1002/2015JA021456