Dynamical Networks characterization of space weather events

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The plasma and magnetic field of earths near-space environment is highly dynamic, with its own space weather. Space weather impacts include power loss, aviation disruption, communication loss, and disturbance to or loss of satellite systems, on some of which a range of technologies depend for navigation or timing. Space weather observations are increasingly becoming a data analytics challenge. Constellations of satellites observe the solar corona, the upstream solar wind (the suns expanding atmosphere that drives space weather at earth) and throughout earths magnetosphere (earths near-space environment). Space weather effects on the ground are monitored by 100+ magnetometer stations in the auroral region. Ionospheric currents can be detected by magnetometers on (for example the 60+ Iridium) polar orbiting satellites in low earth orbit (LEO). These data are multipoint in space and extended in time, so in principle are ideal for study using dynamical networks. There are several challenges however. The spatial sampling points are not uniformly spatially distributed and are moving w.r.t. the plasma-current system under observation, and the plasma-current system itself is non-linear and highly dynamic. Whilst networks are in widespread use in the data analytics of societal and commercial data, there are also additional challenges in their application to physical timeseries. Determining whether two nodes (here, ground based magnetometer stations) are connected in a network (seeing the same dynamics) requires normalization w.r.t. the detailed sensitivities and dynamical responses of specific observing stations. We present the first dynamical network study of the auroral current system which is observed by the SuperMAG set of over a hundred ground based magnetometers. The dynamics of this current system reflect the dynamical response of the earths magnetosphere to solar wind driving where energy is stored and then released in a bursty manner (substorms). Spatio-temporal patterns of correlation between the magnetometer time series can be used to form a dynamical network [1], the properties of the network can then be captured by (time dependent) network parameters. This offers the possibility of characterizing detailed spatio-temporal pattern by a few parameters, so that many events can then be compared [2] with each other and with theoretical predictions.

[l] Dods et al, J. Geophys. Res **120**, doi:10.1002/2015JA02 (2015).

[2] Dods et al, J. Geophys. Res. **122**, doi:10.1002/2016JA02 (2017).