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Scaling and Mutual Information as Measures of Solar Wind-Magnetospheric Coupling

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Scaling and a departure from Gaussian statistics has been identified as a key property of magnetospheric energy release in the form of bursty bulk flows in the magnetotail, "blobs" in the aurora, non-Gaussian fluctuations in geomagnetic indices and in single station magnetometer data. Scaling is also an intrinsic property of the turbulent solar wind driver.

We study scaling in fluctuations of the AU and AL geomagnetic indices that provide a measure of magnetospheric activity, and of the epsilon parameter which is a measure of the solar wind driver. We perform analyses that provide quantitative measures within the framework of models for turbulence and for critical phenomena; that is, we find the exponent that captures the self-similarity in the time series, and the functional form of the non- Gaussian Probability Density Function (PDF) that expresses its intermittency. Generalized structure function analysis is accompanied by PDF rescaling. Fluctuations in all quantities are found to exhibit self-similar statistics for up to 1-2 hours for fluctuation size up to 10 standard deviations. This leads straightforwardly to a Fokker- Planck model for these fluctuation timeseries. We divide the data into intervals of solar maximum and minimum and find that whereas fluctuations in epsilon and AU change their properties with the solar cycle, fluctuations in AL do not. This suggests statistical constraints on the propagation of information from these below- substorm scale fluctuations from the solar wind to the magnetosphere as seen by the indices. We investigate this further by calculating the mutual information- a quantitative and fully nonlinear measure of correlation- between the indices and the solar wind driver.

Keywords: geomagnetic indices; turbulence; intermittency; mutual information; statistical complexity