Solar cycle variability in solar wind turbulence, magnetospheric currents, and ionospheric electric fields

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The solar wind, magnetosphere, and ionosphere form a vast multi-scale system. Continuity of observations in space and time is necessary to specify the past behaviour and current state of the system — understanding and predicting its subsequent behaviour is of paramount concern to advanced technological society. Although useful, observations limited both in space and time do not reveal the so-called "big picture"; they can even lead to miss-understandings. Here we use probability density functions (PDFs) and structure function analysis to attain a comprehensive overview of activity in the solar wind, magnetosphere, and ionosphere on time scales of 1 min to hours and greater throughout solar cycles 22–23. The OMNI 1-min interspersed IMF-solar wind bow shock data set of King and Papitashvili (GSFC/SPDF) (a merged ACE, Wind, IMP-8, and Geotail data set) were used to specify solar wind parameters and estimate the solar-wind-magnetosphere coupling function $d\Phi_{MP}/dt$ of Newell et al. (2007). The AL, AU, AE and SYM-H indices (WDC-C2 Kyoto) were used to measure magnetospheric current activity, and TIGER SuperDARN radar observations were used to infer changes in the variability of electric fields in the auroral ionosphere. A striking feature was the enhanced geomagnetic activity during the recurrent fast streams of 1994 and 2003. These enhancements were strongest in the AU index which is more directly linked to solar wind activity, but they were also prevalent in AL (~substorms) and SYM-H (~storms). The scaling exponents of the small-scale fluctuations in the corresponding parameters also exhibited distinct signatures; this raises the possibility that relatively short records of geomagnetic indices can be analysed to infer the likelihood of major storms.