Quantifying variation of geomagnetic index empirical distribution and burst statistics across successive solar cycles.

Aisling Bergin¹, Sandra Chapman¹, Nicholas Moloney², and Nicholas Watkins¹,³,⁴

¹Centre for Fusion, Space and Astrophysics, Physics Department, University of Warwick, Coventry, UK
²Department of Physics, Imperial College London, London, UK
³Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, London, UK
⁴Faculty of Science, Technology, Engineering and Mathematics, The Open University, Milton Keynes, UK

Impacts of space weather include possible disruption to electrical power systems, aviation, communication systems, and satellite systems. The climate of space weather is modulated by the solar cycle. The overall level of solar activity, and the response at earth, varies within and between successive solar cycles. Quantifying space weather risk requires understanding how the occurrence frequency of events of a given size varies with the strength of each solar cycle.

The auroral electrojet index (AE) is a geomagnetic index which parameterises high latitude geomagnetic response at earth. We consider non-overlapping 1 year samples of AE at different solar cycle phases. We use data-data quantile-quantile plots to identify the 75th quantile as the threshold between two physical components in the cumulative distribution function. The bulk of the distribution lies below the threshold, while above it is the long tail. The magnitude of 75th quantile threshold scales with overall solar cycle activity level. At solar maximum, the 75th quantile relates to events which exceed 160 - 350 nT. We find that above the 75th quantile of observed data records, there exists an underlying functional form for the tail of the cumulative distribution function which does not change from one solar maximum to the next.

Bursts, or excursions above a fixed threshold in the AE index time series, characterise space weather events. We perform the first study of variation in AE burst statistics within and between the last four solar cycles. We will discuss burst statistics for solar cycle maximum, minimum and declining phases. We find that, for bursts above 75th quantile thresholds, the functional form of the burst return period distribution is stable over successive solar maxima. A key result of crossing theory is that time series-averaged burst return period and duration are related to each other via the cumulative distribution function of raw observations. If the overall amplitude of the upcoming solar maximum can be predicted, our results may be used to provide constraints on the upcoming distribution of event return times.