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A parameter for the solar cycle variation in geomagnetic activity as quantified by bursts in the AE and SMR indices

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Geomagnetic storms have the potential for significant impact on a wide range of technologies, including aviation, communications and power transmission grids. The likelihood of occurrence of geomagnetic storms varies with the solar cycle of level of activity, and each solar cycle has a unique amplitude and duration. The space weather response at earth then varies within and between successive solar cycles and can be characterized by the statistics of bursts, that is, time-series excursions above a threshold, in geomagnetic indices derived from ground based magnetometer observations. We consider non-overlapping 1 year samples of the minute-resolution auroral electrojet index (AE) and the minute-resolution SuperMAG-based ring current index (SMR), across the last four solar cycles. These indices respectively characterize high latitude and equatorial geomagnetic disturbances. We propose that average burst duration T and burst return period R (that is, the time between successive upcrossings of the threshold) form an activity parameter, T/R [1] which characterizes the fraction of time the magnetosphere spends, on average, in an active state for a given burst threshold. If the burst threshold takes a fixed value, T/R for SMR tracks sunspot number, while T/R for AE peaks in the solar cycle declining phase. Level crossing theory directly relates T/R to the observed index value cumulative distribution function (cdf). For burst thresholds at fixed quantiles, we find that the probability density functions of T and R each collapse onto single empirical curves for AE at solar cycle minimum, maximum, and declining phase and for -SMR at solar maximum. Moreover, underlying empirical cdf tails of observed index values collapse onto common functional forms specific to each index and cycle phase when normalized to their first two moments. Together, these results offer operational support to quantifying space weather risk which requires understanding how return periods of events of a given size vary with solar cycle strength.

[1] A. Bergin, S. C. Chapman, N. Moloney, N. W. Watkins, Variation of geomagnetic index empirical distribution and burst statistics across successive solar cycles, J. Geophys. Res, in press (2022)