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Long-term Trends and Occurrence Distributions of Geomagnetic Fluctuations as Revealed by 35 Years of CARISMA Observations at 5s Cadence

Stavros Dimitrakoudis, Ian R. Mann, Andy Kale, and David K. Milling
University of Alberta, Faculty of Science, Department of Physics, Edmonton, Canada (dimitrak@ualberta.ca)

The rate of change of the horizontal component of the geomagnetic field is a useful proxy for determining the severity of geomagnetically induced currents (GIC). While contemporary measurements for geomagnetic disturbances (GMD) are available from a number of arrays, short timescale datasets are not ideal for the characterisation of extreme events since their data sets are rarely indicative of the most extreme geomagnetic conditions. In the absence of long duration data sets, statistical methods have to be employed to assess the overall longer timescale historical power occurrence distributions, so as to extrapolate the behaviour of their high-end tail and which is required for the assessment of extreme events. Conversely, the CANOPUS array, subsequently expanded and operated as the CARISMA magnetometer array (www.carisma.ca), has been in continuous operation in Canada since 1986, first with a 5-second and then more recently with a 1-second cadence. Using that long timebase dataset we are able to evaluate the occurrence distributions of 5-second cadence measurements for over 10,000 operational days for each of several stations. Of particular significance for the expected magnitude of extreme events is an assessment of whether the disturbances follow a power law or log-normal distribution. Such indications can inform risk assessments on the potential for extremely hazardous GICs, for example in the estimation of a 1-in-100-year event. The CANOPUS/CARISMA GMD occurrence distributions, overall, appear to be well-approximated by log-normal rather than power law distributions. However, for extreme events, the local time at which the largest GMD typically occurs rotates away from the midnight sector, such that the largest events in the tail of the distribution most often occur instead at dawn. This has significant implications for assessing the size of expected extreme GMD events, and indeed the local time of the largest vulnerability, with clear applications for assessing extreme space weather impacts on the electric power grid.