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In the United States, access to geomagnetically induced current (GIC) measurements historically has been limited. In 2014, the Federal Energy Regulatory Commission (FERC) directed the development of a set of reliability standards to address geomagnetic disturbances caused by severe space weather. A publicly accessible GIC monitor database provided by the North American Electric Reliability Corporation (NERC) now provides operational observations from the power grid during such events. This study analyzes 29 geomagnetic storms from 2015 to 2024 at a NERC mid-latitude station in Virginia, USA. Because the operational data is of mixed quality, the identification of research-quality measurements required the development of quality-assessment algorithms. The study presents a first climatological survey of GIC waveforms - Large-Amplitude Short-Duration (LASD) and Moderate-Amplitude Long-Duration (MALD) – occurrence extracted from the 29 assessed time series. Understanding these patterns is critical for power grid risk and resilience, as impulsive GIC spikes (LASD disturbances) can cause voltage instability and hotspots, while sustained currents (MALD disturbances) may lead to transformer core saturation and overheating.

LASD and MALD waveforms are quantified using frequency-band integrated wavelet power from the continuous wavelet transform (CWT). Three frequency bands - Pi2 (periods<150 s), Pc5 (periods<10min), and Ps6 (periods>10 min) - are selected to draw associations with magnetospheric drivers. Local time occurrence is evaluated by calculating the average GIC amplitude and spectral power for every local-time hour. Storm-phase dependence is examined with superposed epoch analysis referenced to interplanetary shock arrival time based on upstream monitor data and storm peak based on ground measurements. Results show that GIC amplitudes exceeding 20 A occur predominantly on the dayside and dusk sectors. The CWTs show dominant oscillations occur at timescales shorter than ~60 minutes; it is speculated that this observation indicates skin depth of the corresponding period. The local time and storm-time distributions show distinct differences: spikes and high frequency fluctuations appear on the dayside with a peak near 09–10 MLT and throughout storm intervals, whereas long-duration disturbances peak near midnight and are concentrated roughly 18–24 hours after shock arrival and around the most intense part of the storm. These findings are consistent with other statistical studies from high- and low-latitude magnetometers as well as from the inner magnetosphere.

Understanding when and where different GIC waveforms occur near a region hosting critical national infrastructure and the world's largest concentration of data centers is important and timely. The methodology introduced here provides a scalable framework for characterizing GIC waveform properties in ways directly relevant for power-system operators and space weather forecasters.

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