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Solar Wind magnetosphere coupling during the 2024 Geomagnetic storms

Geomagnetic storms pose a threat to both technological systems and human health, making them a crucial area of research. In this study, we analyze the interaction between the solar wind and the magnetosphere during the strong geomagnetic storms of 2024 (March 3, March 24, and May 11). The research is based on the horizontal component of Earth's magnetic field (H) from the Dusheti Geomagnetic Observatory, alongside solar wind parameters such as pressure (P), plasma beta (βp), also the interplanetary magnetic field (Bimf) and its components (Bx,By,Bz). Special attention is given to the May 11, 2024 storm, the most powerful in over two decades. Cross-correlation and wavelet coherence analyses revealed significant correlations and distinct coupling structures for each storm. Notably, plasma beta (βp) was observed to rise sharply approximately 12 hours before a storm's commencement. By applying a 12-hour time shift to this parameter, we identified significant coherence in the 10 to 30-hour period range, suggesting its potential as a predictive tool. Detrended Fluctuation Analysis (DFA) captured shifts in the system's dynamics, showing drops in the Hurst exponent (indicating more noise like behaviour) during the storms of March 23 and May 11. In this work, we also investigate the multifractal nature of the global SYM – H and AL indices to better characterize their complexity and compare them to local geomagnetic field fluctuations. This study validates the reliability of local geomagnetic data for understanding the local response during the global space weather events in Georgia. The findings can aid in the improvement of geomagnetic storm forecasting models.

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