Modulation of Lightning Occurrence by the Solar Wind

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The connection between terrestrial and space weather phenomena is an emerging field of study with implications for different aspects of operational weather forecasting. This study investigates the influence of solar wind events on the frequency of lightning occurrence over North America. Empirical mode decomposition (EMD) is applied to National Lightning Detection Network (NLDN) data from 1996 to 2012 and correlated against various solar wind parameters. EMD performs operations that partition the lightning time series data into modes or Intrinsic Mode Functions (IMFs). Using composite analysis, we identified an IMF that corresponds to a 27-day co-rotating interaction region (CIR) that results in a statistically significant decrease in thunderstorm occurrence across the entire NLDN for approximately three to nine days. This finding is consistent with previous studies indicating that faster solar wind speeds are correlated with a decrease in galactic cosmic ray (GCR) flux and a reduction in lightning reports. However, the analysis also highlighted a latitudinal stratification in the thunderstorm response. In the mid-latitudes (30-38 deg N), faster solar wind speeds initially increased the number of lightning occurrences before decreasing significantly over the next 14 days. In the upper mid-latitudes (38-46 deg N), the response was reversed with an increase in thunderstorm events followed by a significant decrease. Additional “lightning response reversals” are noted at even higher latitudes. It is hypothesized that solar energetic particles associated with the CIRs are able to penetrate to tropospheric altitudes and increase lightning rates at higher latitudes, while at lower latitudes, the solar wind modulated GCR flux drives the decrease in lightning occurrence. Overall, understanding the electrodynamic connection between the lower and upper atmospheres has important implications for both space physics and atmospheric science communities.

Keywords: Lightning, Solar Wind, Empirical Mode Decomposition, National Lightning Detection Network

