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Is the Occurrence of Superbolts Influenced by Solar Weather?

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Abstract

In their recently published paper, Holtzworth et al. (2019) discussed the global distribution of lightning strokes with very high energies (above 1 MJ far-field radiated electromagnetic energy in the frequency band from 5 to 18 kHz), which they called superbolts. For some of the events used by Holtzworth et al. (2019), not only WWLLN data but also ENTLN data are available which provide peak current estimates. The lowest amplitude stroke that corresponded to a superbolt in Holtzworth's study had a peak current of 162 kA and the average superbolt had a peak current of 267 kA. In the present study, we use NLDN and GLD 360 data to test both the 150 kA and 250 kA threshold levels for superbolts. Holtzworth et al. (2019) showed that both the temporal and spatial distributions of these superbolts are very different from those of average-energy lightning strokes. Specifically, superbolts are most common during the winter months and tend to occur over the oceans and at higher latitudes, such as the North Atlantic region. These results have prompted the authors (Holtzworth et al., 2019) to discuss possible explanations for these phenomena, and they hypothesized that there may be a link between superbolts and solar activity or cosmic rays. A number of previous studies have investigated the general connection between lightning rates and the incident flux of galactic cosmic rays (GCR) and solar energetic particles (SEP) by analyzing lightning during the time of solar space weather phenomena (e.g. Forbush decreases or Heliospheric current sheet crossings). Previously, Owens et al. [2014] and Scott et al. [2014] have found that the Heliospheric magnetic field (HMF) polarity appears to have an important effect on lightning rates over the UK. They have shown that, on average, days when the HMF was pointing towards the Sun had approximately 50% more lightning events than those when the HMF was pointing away from the Sun.

The present study focuses on superbolts and aims to address some of the questions raised by Holtzworth et al. (2019). First, we analyze the spatial and temporal distribution of superbolts based on

Vaisala's NLDN data (see, for example, overviews by Cummins and Murphy [2009] and Rakov and Uman [2003, Ch 17]) for the State of Florida and for a narrow strip stretching from Louisiana to southern Canada, as well as Vaisala's GLD 360 data for the UK and portions of Brazil. The use of these lightning datasets allowed us to independently compare our spatial and temporal distributions to those obtained by Holtzworth et al. (2019) who used WWLLN data.

Furthermore, we obtained solar weather parameters using NASA's OMNI datasets and looked at how solar activity may influence the frequency, location, and magnitude of superbolts. The HMF interacts with Earth's own magnetosphere and HMF polarity is an important factor in magnetic reconnection at the magnetosphere as discussed by Thomas [2015], which can affect the local energetic particle fluxes that can potentially influence lightning activity (Owens et al., 2014). Holtzworth et al. (2019)

mentioned the apparent connection between sunspot numbers and superbolts, however in order to gain a more systematic understanding we study if HMF polarity and sudden HMF polarity reversals (i.e. Heliospheric Current Sheet crossings) are correlated with lightning rates. Through this process, we examine the degree to which the occurrence of superbolts is influenced by solar weather.

Topic Areas

Lightning Physics, Characteristics and Measurements, Lightning Climatology

Submission Format

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