The Detection of Optical Lightning Superbolts by the FORTE Satellite

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Abstract

In 1977, Turman identified lightning pulses that were 100 times brighter than normal lightning in the Vela satellite data. These “unusually intense lightning” pulses radiated between 100 GW and multiple terawatts of optical power at the source. This observation sparked a debate as to whether these so-called “superbolts” were caused by a certain type of powerful lightning, or were merely the result of measurement biases. Clouds dilute the optical signals generated by lightning pulses, and reduce the optical powers recorded from space. If lightning occurs at the edge of the storm or in a break in the clouds, then the light can travel to the space-based sensor at its full power. In this way, any lightning event could produce a superbolt if the satellite happened to be in a favorable position to see it, while sensors elsewhere might not classify it as such.

We use 12 years of photodiode detector (PDD) measurements from the Fast On-orbit Detection of Transient Events (FORTE) satellite to identify superbolts using the same approach as Turman (1977). Combined optical and radio-frequency (RF) measurements are then used to comment on the origins of these radiant pulses and the influences of the cloud scene on the peak optical powers recorded from orbit. We find that weaker superbolts (~100 GW) may result from normal lightning processes – particularly in flashes that occur near the edge of the thunderstorm. However, the most powerful cases (> 350 GW) occur with strong (> 80 kA)

positive Cloud-to-Ground (CG) return strokes (where ground-network coincidence exists), wintertime oceanic convection (particularly in the Mediterranean and off the coast of Japan), and in stratiform regions of large Mesoscale Convective Systems (MCSs). We suggest that both interpretations of optical superbolt origins from previous studies are correct: that some result from favorable viewing geometries while others are associated with a unique set of meteorological conditions that might merit distinction.

Topic Areas

Lightning Physics, Characteristics and Measurements

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