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Analysis of the Relationship Between Diverse Sprite Events and Lightning Activity Produced by a Single Storm

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Transient luminous events (TLEs) are relatively recently discovered phenomena that occur well above the clouds, in the upper atmosphere, shortly after lightning activity. Sprites are TLEs that occur a few milliseconds after cloud to ground (CG) lightning strokes (almost always positive) at altitudes ranging approximately between 40 to 90 km. On July 5th 2017 there was a large thunderstorm over north-eastern Spain, near Zaragoza, which was recorded from a low-light camera mounted in the *Pic du Midi* observatory in the French Pyrenees at an altitude of 2877 meters. A total of 13 sprite events were recorded and carrot, jellyfish and column types were identified. These events are analyzed in this work as well as their causing strokes and overall thunderstorm development. Also, the atmospheric characteristics leading up to these events are studied including cloud top temperatures and flash rates. The CG strokes associated with each sprite event are identified along with their peak currents, locations, charge moment changes, and the overall flash density is mapped over the area of the storm. The highest peak current of the underlying +CG strokes identified was $111.42kA$. Several rare phenomena were detected, including an ascending luminous bead that preceded carrot sprites which occurred between 37 and 57 milliseconds after a positive CG stroke. This sprite sequence lasted up to 120 milliseconds, however the current moment waveform shows that the current did not settle until 250 ms after the +CG stroke. The average ascending velocity of the bead was calculated to be $12.88\ deg/s$. In addition, converging column sprites were detected which occurred 1 ms after a +CG stroke and lasted up to 99 ms. The physical interpretation of these events will be discussed.