Ebro Lightning Mapping Array: Sprite-producing lightning

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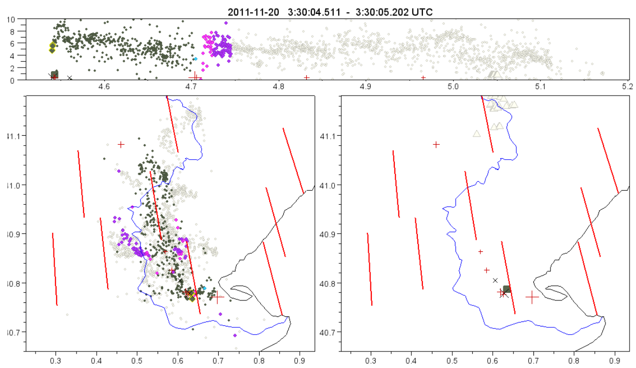
In the summer of 2011 a three-dimensional lightning mapping array (LMA) has been deployed in the Ebro delta and surrounding area in eastern Spain. This area profits from the proximity to summer storms over land and cold season thunderstorms over sea, which often produce transient luminous mesospheric events (mainly sprites and elves). In 2011, six of the twelve VHF band (60-66 MHz) sensors were operational. The area is also covered by LS8000 interferometer and LINET detection systems which provide complementary data. From July till December 2011 at least 33 sprites were recorded by cameras in southern France within 150 km range from the Ebro LMA.



1. General results

The initial data show the sprites to occur mainly over the sources emitted during the period between the triggering +CG (positive cloud-to-ground stroke) and the onset of the sprite, from ~6-8 km altitude (-15° to -30°C). This activity is often horizontally displaced up to 20 kilometers from the +CG stroke. In the cases of the short-delayed sprites (<30 ms), these sources tend to occur scattered along older channels which grew before the +CG occurred, indicating that the +CG most likely tapped charge directly from these channels. Column sprite elements tended to be grouped around the lightning branches which developed before the +CG. The farthest elements can be displaced horizontally up to 25 km from the LMA-detected sources. In the cases of the longer-delayed sprites, usually carrots, leaders started to expand from pre-existing channels into new regions, discharging the cloud more gradually. We speculate that very large sprites may involve both processes simultaneously. As in our previous study[1], SAFIR interferometer source bursts tended to be collocated well with sprite azimuths and timing, although they also occur at other times and during common flashes. They might be associated with continuing currents. LMA source power increases to a maximum during sprites, but can also be elevated at other moments during the flash.

2. Detailed analysis of flashes

During two nights, particularly 20 November 2011, nine sprite-producing +CG flashes occurred less than 25 km from the LMA sensors and were registered by the system in great detail. The thunderstorm consisted of stationary convective cells and an adjacent stratiform rain zone downwind. The sprite-producing flashes involved both regions. We developed a time-distance-altitude graph which provides a different perspective on negative and positive leader development and CG timing. The sprite-producing flashes can be characterized into at least three different development patterns: 1) direct convective-to-stratiform gradually descending negative leader, convective +CG; 2) low convective -CGs with strong mid-level positive leader followed by rapidly ascending and expanding negative leaders at high altitudes; 3) high altitude convective negative leaders, suddenly dropping to mid altitudes, propagating at high speed into stratiform region. It appears that type 2 is more conducive to long-delayed sprites, at least in our still small dataset.

3. References

[1] O. A. van der Velde, J. Montanyà, S. Soula, N. Pineda, and J. Bech, Spatial and temporal evolution of horizontally extensive lightning discharges associated with sprite-producing positive cloud-to-ground flashes in northeastern Spain, *J. Geophys. Res., 115*, A00E56 (2010)