

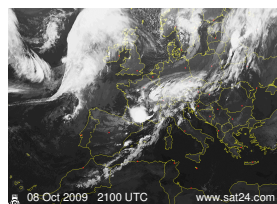


Lightning Activity of a Sprite Producing Storm over South East France

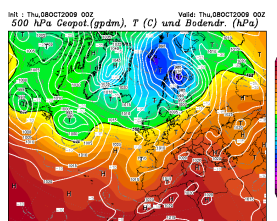
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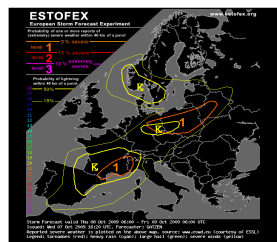
INTRODUCTION



Satellite image of the meteorological weather over the European continent for the night of 8 October 2009 (source: sat24.com)



Map of 500hPa geopotential and ground pressure (source: wetterzentrale.de)



Storm forecast for 8-9 October 2009. A level 1 (5% severe weather) was issued for the southern France region mainly for excessive rain (source: estofex.org)

Examples of sprites observed during the night of 8 October 2009



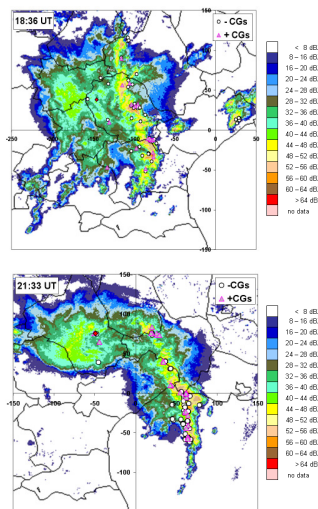
What are sprites?

Sprites are luminous spots of red light with short duration (0.01–0.1 s) appearing over mesoscale convective systems (MCSs) due to a quasi-static electric field resulting from a positive cloud-to-ground (+CG) flash which generates a strong charge moment change (CMC) (Boccippio et al., 1995; van der Velde et al., 2006). Usually, the initiation occurs at 70–75 km altitude, with tendrils propagating downwards to almost 40 km and upward expanding diffuse glow (Pasko et al., 2002). Many similar discharges can be generated simultaneously over a horizontal distance of over 50–100 km. The lower portion of the sprites sometimes has a distinct blue coloration.

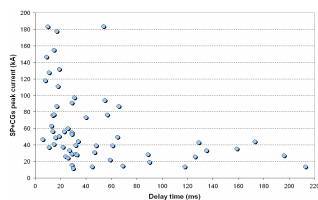
Case study

On the night of 8 October 2009, a warm frontal wave passing over Western Europe caused the development of a thunderstorm over South West France. In ten hours it produced excessive rain, very high flash rate and eventually 77 lightning luminous events (TLEs). The sprites were detected with Watec video camera for remote observations from Sent Vicenç de Castellet, Spain.

The work is directed to investigate the characteristics in lightning activity, radar reflectivity and their various relationships for the whole life period of the thunderstorms as well as in the moment of the sprite appearance.



Two samples of lightning activity (separate CG strokes) overlaid on radar reflectivity for period of one minute before sprite occurrence (circles: -CG strokes; triangles: +CG strokes; red diamonds: P+CGs).

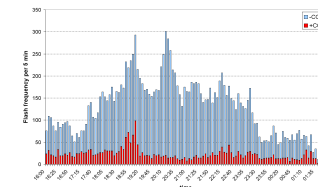


Delay time of sprite appearance after parent +CG flashes in relation to peak current of the P+CGs.

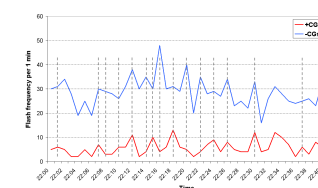
RESULTS & CONCLUSIONS

- Six of the sprites were accompanied by a halo and in total 74 of the 77 TLEs could be associated with a positive “parent” cloud-to-ground lightning (P+CG) flash.
- In the beginning of the sprite production period the events were mostly carrot shaped while at the dissipating stage of the storm sprites were predominantly column shaped.
- The average value of the P+CG peak current was ~60 kA (with average values of 64 kA and 56 kA respectively for carrot and column sprites) and the maximum value was 183 kA.
- The average delay time of the sprites after the P+CG flashes was around 60 ms for the carrot shaped and around 50 ms for the column shaped sprites. The TLEs with short delay times (less than 40 ms) were characterized by high P+CG peak currents (above 100 kA) while those with long delay times (above 60 ms) had predominantly low P+CG peak currents (less than 50 kA). For the sprites with too large delay times, the parent flash was probably missed.
- The P+CGs were located mostly in the stratiform region of the storm with reflectivity values below 45 dBZ and cloud top temperatures between -55° C and -60° C.
- The analysis of the flash rate for the whole lifetime of the storm showed that there was almost no correlation between the frequency of negative and positive CG flashes. The +CG flash rate remained almost stable during the whole life of the storm with around 4 flashes per minute, while the -CG flash rate had their maximum (60/min) during the mature stage of the convective region of the storm and decreased gradually during the dissipation stage.
- The average -CG/+CG ratio for the whole lifetime of the storm was around 5.
- The average peak current values for -CGs and +CGs were respectively -22.5 kA and 24.6 kA, when excluding the lightning flashes with peak current values below -10 kA and 10 kA, assuming they were intra-cloud (IC) flashes. The maximum peak current value for negative and positive CG flashes was respectively -232 kA and 183 kA.

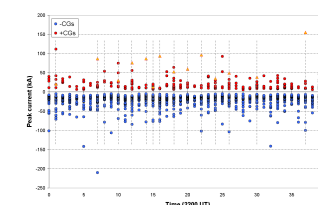
- Most of the P+CG flashes were preceded by a short increase in the +CG activity around a minute before the sprite production and an overall tendency could be observed that the sprite production periods are co-appearing with the local maxima in the -CG rates.
- The analysis revealed that in overall the characteristics of the P+CG flashes in this study were according to the already established general picture of sprites and their parent lightning.



Rates of the negative and positive lightning flashes per five minutes for the whole lifetime of the storm.



Detailed plot of the lightning activity rates per one minute for the period 2200-2240 UTC, approximate sprite moments are marked with dotted lines.



Time series of peak current for CG flashes and for SP+CG flashes (orange triangles) for the period 2200-2240 UTC, sprite moments are marked with dotted lines.

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