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First European Sprite Campaign: EuroSprite 2000 Summary Report

Thomas H. Allin and Torsten Neubert

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First European sprite campaign: EuroSprite 2000 Summary Report

Thomas H. Allin and Torsten Neubert,
Solar-Terrestrial Physics Division, Danish Meteorological Institute

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1 Introduction

The campaign EuroSprite 2000 was conducted during this summer from Observatoire Midi-Pyréenées (OMP), located at Pic du Midi de Bigorre ($42^o56'12.0''$N; $0^o0'34.16''$E), in the French high Pyrenees. The aim was, for the first time, to investigate the occurrence of sprites over European thunderstorms, which regularly forms over central Europe throughout the summer, as well as to compare sprite-producing thunderstorms with those found elsewhere in the world.

Sprite images were recorded by a low light level CCD video camera, while supporting information on lightning characteristics were available from both European lightning detection networks and Schumann resonance measurement stations in USA and Hungary. A total of 40 sprites were recorded during three evenings, where perfect local conditions and distant storm activity were coinciding.

The following presents a summary of the observations and a discussion of the electrical and meteorological properties of the sprite-producing thunderstorms. It is found that sprites are also common over European thunderstorms, although these are smaller and weaker than typical sprite producing storms in the US. The results suggest that sprites occur more commonly world-wide than previously thought.

2 The OMP campaign site

The astronomical observatory OMP at Pic du Midi de Bigorre served as the basis for the sprite image recordings. At an altitude of 2877 m, this location enabled a full 360 degrees view of the horizon and very clear skies when local weather conditions were favorable. The campaign site and a map showing central and western Europe are shown in figure 1. Within a range of 1000 km, storms could be observed over most of France, the Alps, northern Italy, the western Mediterrainian Sea, the Iberian peninsula and the Biscay.

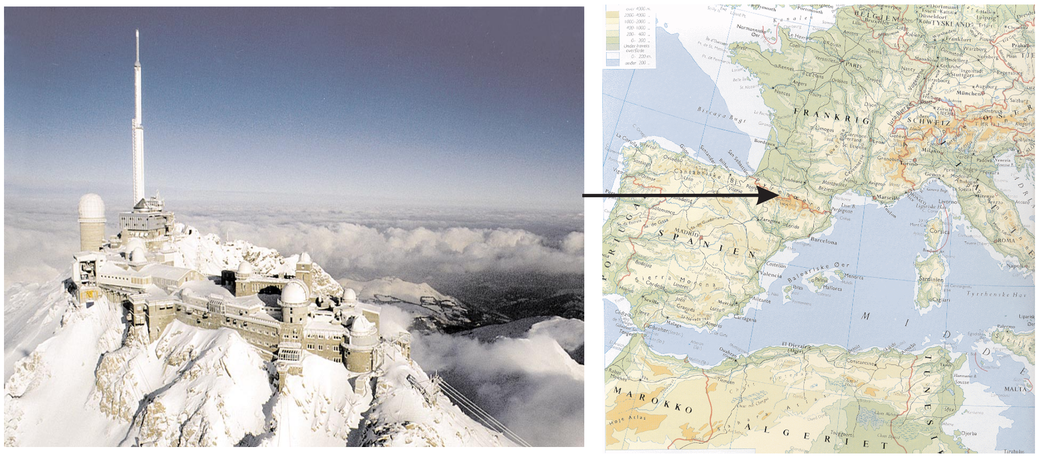

Figure 1: The OMP observatory and a map showing its location in southern France.

Sprite observation requirements were met locally approximately 50% of the evenings during the one-month period, and remote sprite-producing storms developed within the visible range of the observatory during 20% of these evenings. In all, sprites were observed, on the average, every tenth evening from the OMP. For comparison, observations from the Kitt Peak observatory, Arizona/USA, performed during a campaign last year, were possible locally only 25-30% of the evenings, half of which with sprite observations over remote storms, yielding approximately the same sprite observation probability for any given night for the two sites.

3 Measurements

Sprites were recorded with an intensified Pulnix CCD video camera using an NTSC S-VHS Panasonic VCR, and frames were time stamped using a Horita FP-50 GPS time code inserter. The times of sprite occurrences were thus established to an accuracy of 33 ms, and the parent lightning strikes could be sought in the EUCLID[1] lightning database. Schumann resonance recording stations in Hollister, California and in Hungary were operating during the period, detecting horizontal magnetic field and vertical electric field variations due to powerful cloud-to-ground (CG) lightning discharges, propagating in the earth-ionosphere waveguide [2].

[1]EUropean Corporation for LIghtning Detection. Data was merged from the national networks BLIDS (Germany), the SIRF (Italy) and ALDIS (Austria).

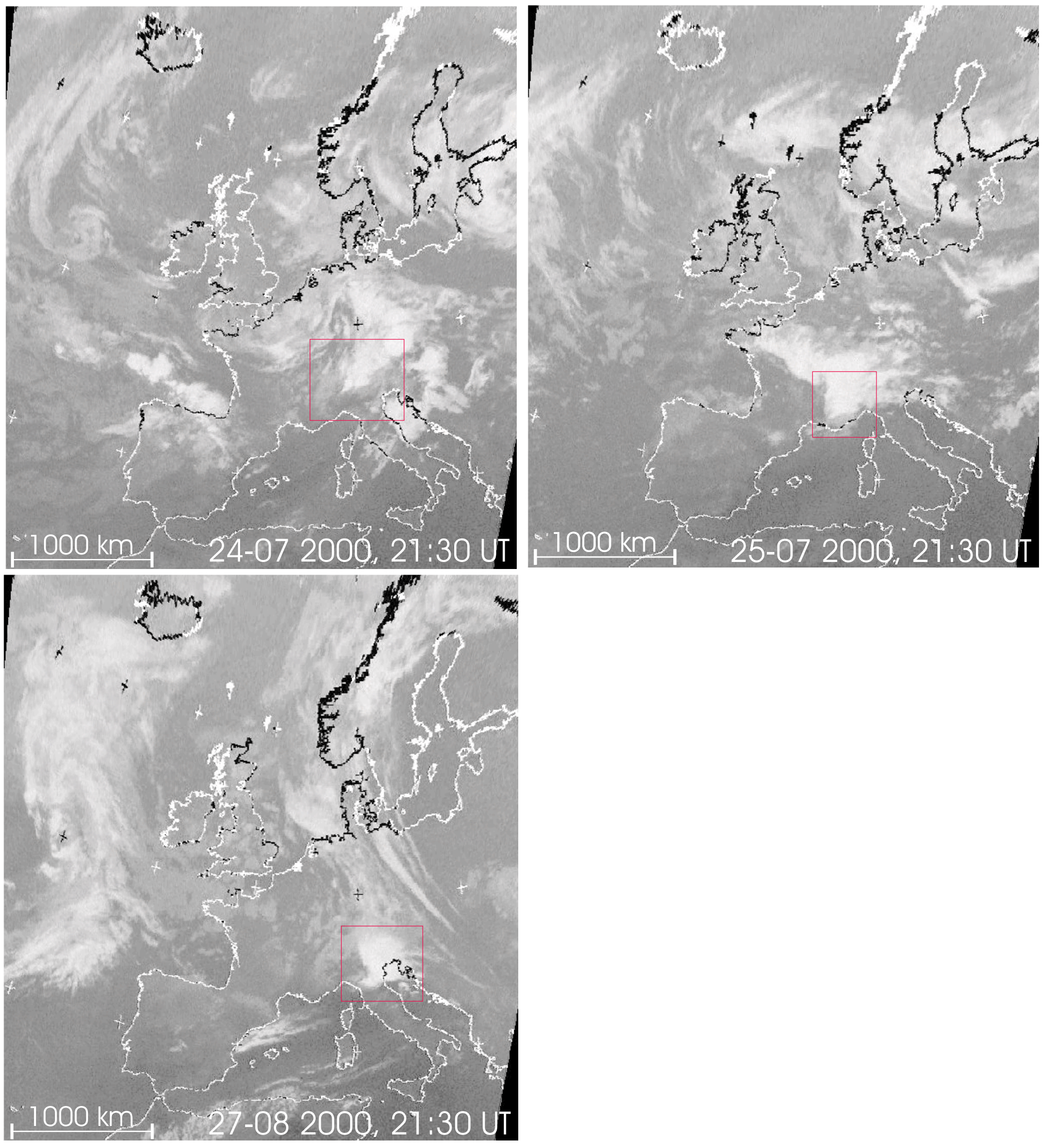

Figure 2: Cloud cover, the nights of July 24,25 and August 27, at 21:30 UT, corresponding to the time of sprite activity.

4 Meteorological conditions

Throughout the campaign, the weather situation was, as is typical for the European summer, dominated by a high pressure over the easternmost parts of Europe, while moist and colder air from the atlantic was moving in from the west. Upon the arrival of frontal systems, which occurred approximately every 4-5 days, thunderstorms developed in the eastern warm air mass.

Figure 2 presents the cloud cover as derived from the METEOSAT infrared im-

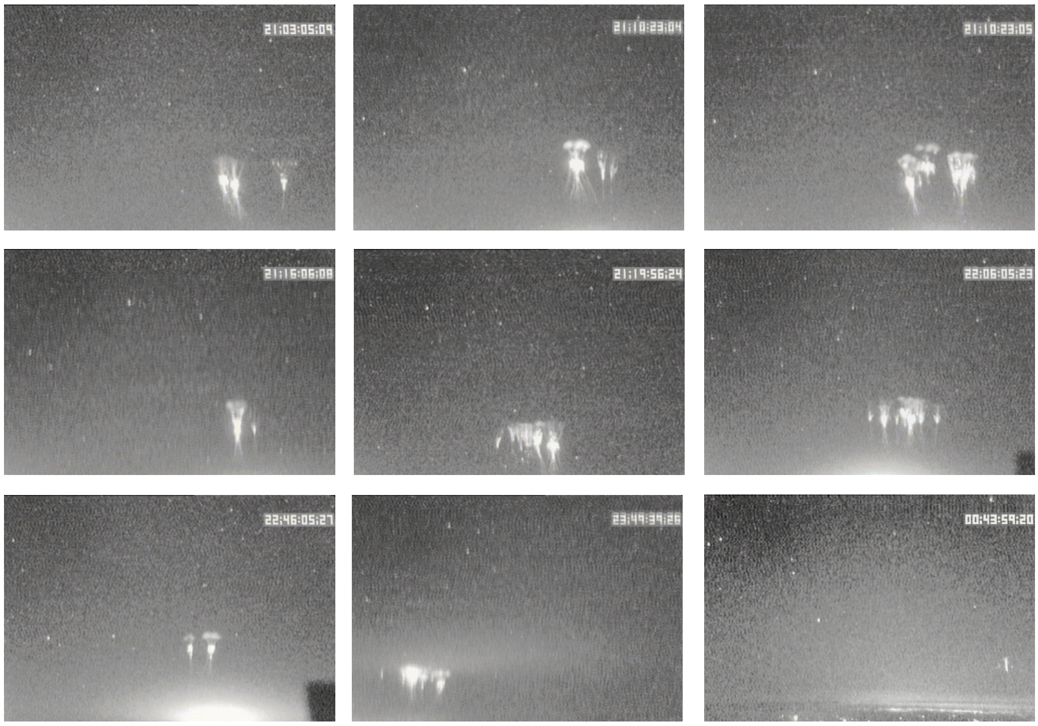

Figure 3: 9 sprites from the night of July 25.

ager. It is noteworthy that the cloud structure was not that of isolated convective storm systems seen typically over the US plains, but seems organized somehow in a frontal zone. During the one month period, what appeared to be very large and isolated thunderstorms frequently formed over the easternmost Europe, unfortunately out of range for our observations. It is possible that these storms are more similar to mesoscale convective systems (MCS) in the US than the storms over which sprites were observed from the OMP. The thunder clouds observed from OMP have less deep convection and smaller cloud top heights than those typically reported over the US plains.

5 Results

Figure 3 shows samples of sprites seen on the night of July 25, where sprite occurrence was closest to the observatory. The sprites seen throughout the campaign were similar to sprites observed in the US, the dominant form being carrot or column sprites or clusters of these. Also, sprites were frequently dancing over the horizon, following lightning activity in the clouds beneath (figure 4).

With information on the distance from the observatory to the parent +CG discharge, the vertical size of the sprites can be measured. The 9 sprites of figure 3 had vertical extents of approximately 40 km, measured by counting pixels and

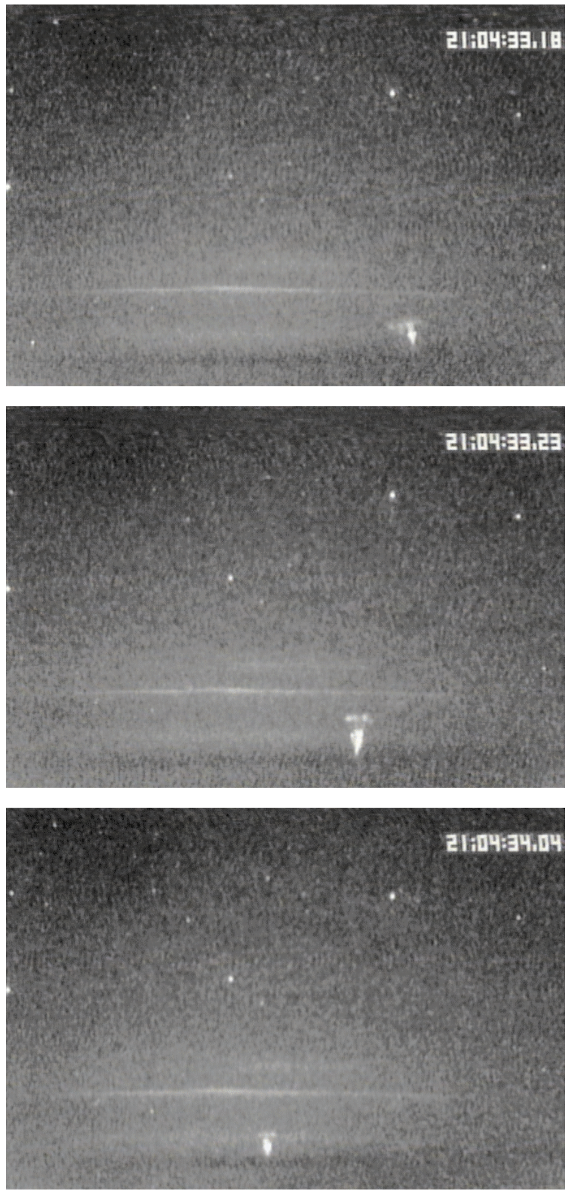

Figure 4: Dancing sprites from the night of July 24. The GPS-derived UT time stamp (upper right) is $hh : mm : ss.nn$, where nn designates the video frame number since second ss. With 30 frames per second, the frames shown are separated by 165 ms and 363 ms, respectively.

using the vertical FOV size of 15 degrees. We take these sprites to be representative for the sprites observed and find that these sizes are similar to sprites observed in the US.

Table 1 summarizes the times of sprite observation, along with their type, lightning correlation, and for August 27, the presence of a Schumann resonance excitation detected in Hollister, California. In total, 38 out of 40 sprites occurred immediately after (within less than 100 ms) a +CG stroke, in accordance with Sprites observed in the US [1]. However, the peak current of the sprite-causing +CGs averaged to only 33.5 kA, whereas sprites in the U.S. are accompanied by +CGs with a peak current average of 81 kA [1]. Since peak currents average to roughly the same for one day of lightning in the US and in Europe, there is no evidence that the peak current average cited above should be in error due to differing detection techniques.

In the evenings of July 24 and 25, the sprite-producing thunderstorms are clearly associated with frontal systems, and sprites occurred in several periods during each evening. July 24 was special in the sense that a relatively small storm (based on cloud cover and lightning concentration) produced 16 sprites, while the more extensive system on July 25 was less productive. For August 27, the storm over northern Italy seems more isolated, and the total time span for sprite observations were only 30 minutes, after which lightning activity ceased.

In figure 5, the overall lightning activity in time and space is shown for the three evenings of observation. Data is limited to the regions in which sprites caused by the lightning would be seen by the camera at the time of lightning,

July 24		July 25		August 27	
Sprite time	I (kA)	Sprite time	I (kA)	Sprite time	I (kA)
20:35:23* (M,CT)	+25.4	21:03:05 (M,CT)	+35.7	21:37:51*	+31.9
20:41:15 (CL)	+8.1	21:10:23 (M,CT)	+29.8	21:39:50	+12.3
20:45:43 (CL)	+7.7	21:16:06 (M,CT,CL)	+66.7	21:42:50*	+17.5
20:59:38 (CT)	+33.2	21:19:56 (M, CT)	+26.4	21:42:50*	+61.4
21:02:16 (CT)	+7.5	21:22:18 (M, CT)	+28.5	21:45:57*	+25.4
21:04:33 (CT)	+29.5	22:06:05 (M,CT)	?	21:49:02*	+40.8
21:07:59 (CT)	+12.3	22:33:37 (M, CT)	+14.4	21:51:09*	?
21:11:24 (CT)	+12.7	22:35:44 (M, CL)	+13.2	21:55:46*	+48.7
21:17:34 (M,CT)	+13.4	22:46:05 (M,CT)	+35.5	21:58:42*	+22.7
22:37:48 (M,CL)	?	23:49:39 (M,CT)	+89.4	22:02:26*	+38.9
22:50:37 (M,CL,CT)	+11.5	23:52:13 (M,CT)	+39.7	22:02:26*	+38.7
22:54:34 (CT)	+39.4	00:43:59 (CL)	+13.2	22:06:17*	+26.2
23:02:51 (M, CT)	+37.0				
23:11:57 (CT)	+14.6				
23:20:03 (CT)	+17.6				
23:25:46 (M,CT,CL)	+35.8				

Table 1: Sprite event occurrence in the evenings of July 24,25 and August 27, 2000. All times are in UT. Sprite types are M: Multiple, CT: Carrot and CL: Column, or combinations thereof. Sprites associated with a detectable Schumann resonance waveform has been marked by an asterisk.

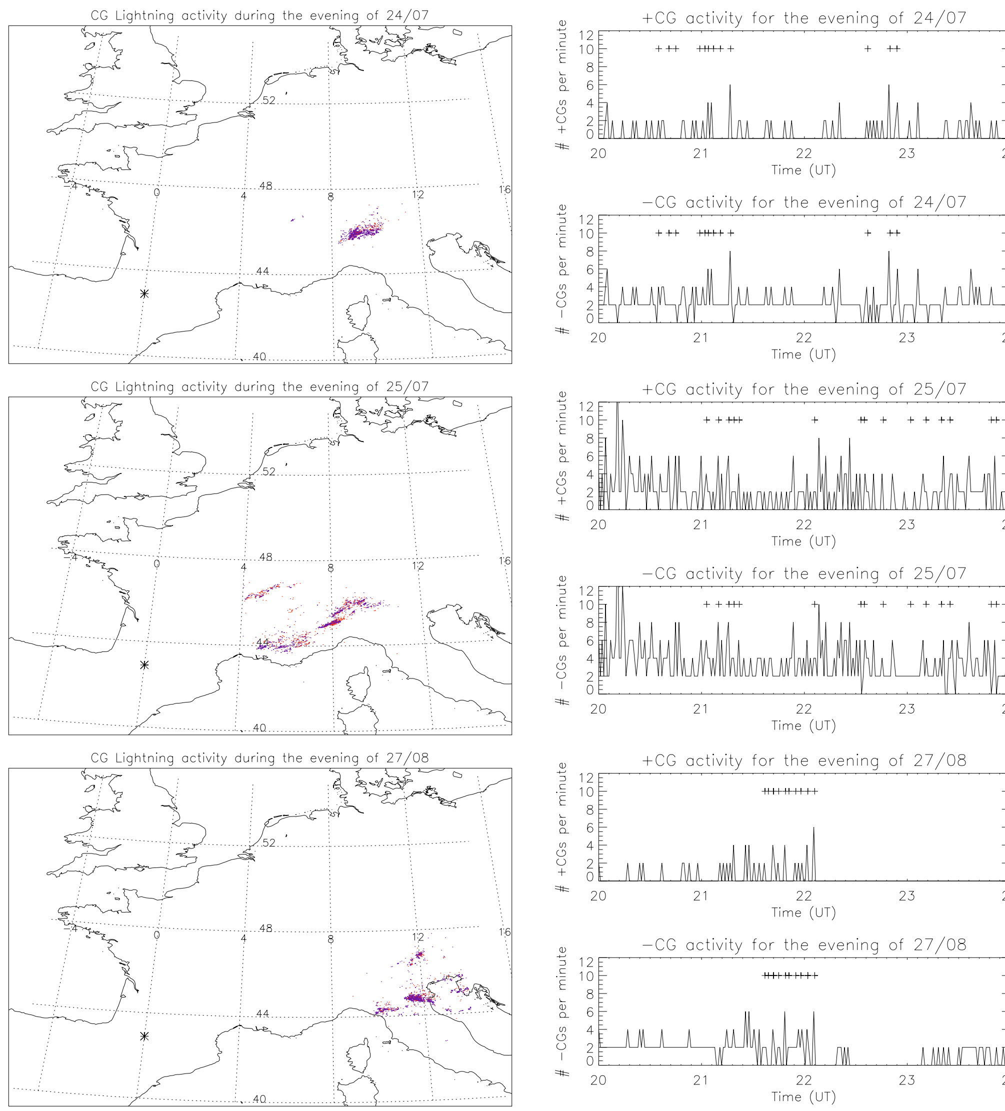

Figure 5: Geographical and temporal distribution of +CG (red) and -CG (blue) activity during the three evenings with sprite observations. The times of sprite occurrence is marked by +, the OMP site with an asterisk. Only strokes consistent with the camera FOV direction is included. Data from EUCLID, the European corporation for lightning detection.

so figure 5 does not reflect the total lightning activity in Europe on the three evenings. During the periods of high sprite activity (defined as the time interval between first and last sprite in a period where sprites occurred at a frequency above 1 per 10 minutes), on the average, 28% of the +CGs were accompanied by a sprite. This number is slightly higher than the same for MCS systems in the

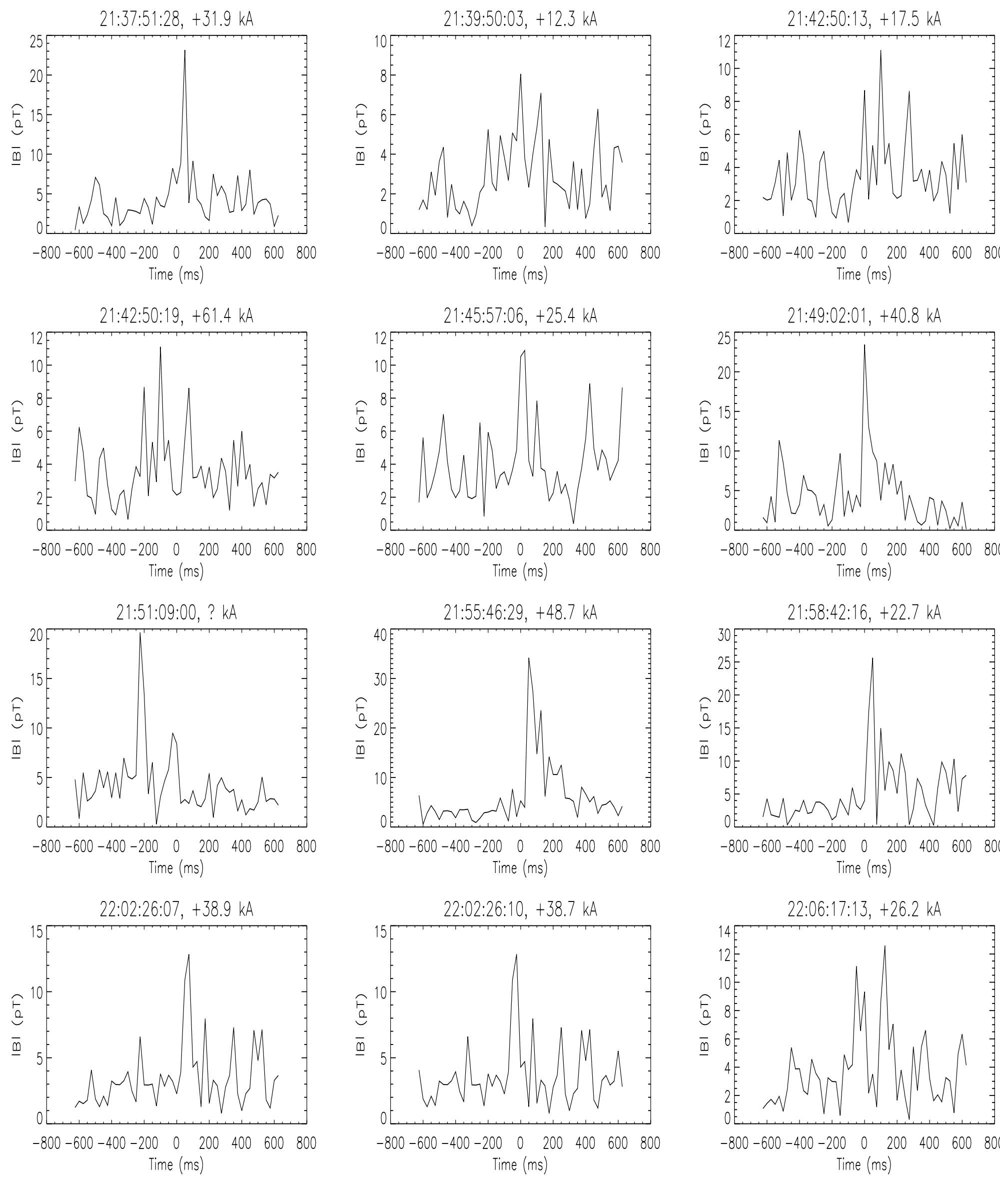

Figure 6: Horizontal magnetic field variations in 1.6 seconds time intervals, approximately centered on the time of sprite occurence in Europe, as measured by loop antennas in Hollister, California.

US (22%, [1]), and probably it reflects the tendency of smaller storms to produce sprites in bursts in the decaying phase of individual thunderstorm cells. We note also that the total CG lightning rate during the periods of sprite production were significantly lower than that of storms in the U.S. producing a similar number of sprites.

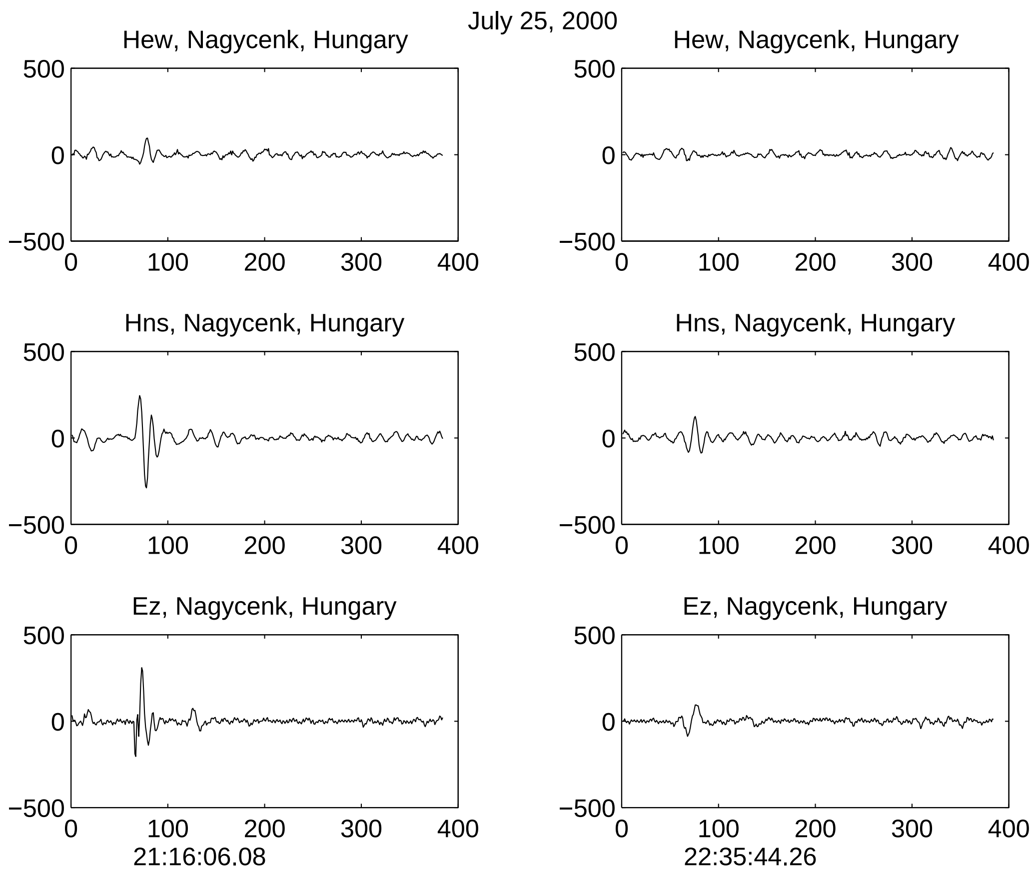

Figure 7: The components of the horizontal magnetic field and vertical electric field variations, as measured in Nagycenk, Hungary, for two sprites from the evening of July 25.

During the evening of August 27, all but one sprite exhibited a pronounced Schumann resonance excitation, as measured in Hollister, California, approximately 9000 km from Pic du Midi. In figure 6, the square of the magnitude of the horizontal magnetic field variations is shown for the 12 sprites of August 27. The sampling frequency is 40 Hz, giving a temporal resolution of 25 ms, or roughly the same as that of the video recordings. Figure 7 shows the individual components of the horizontal magnetic and vertical electric field variations, measured in Nagycenk, Hungary, for two sprites recorded during the evening of July 25.

6 Discussion

The occurrence of sprites over European thunderstorm systems have been confirmed for the first time by observations performed from the Observatoire Midi

Pyrénées. The sprites observed were found to fall into the categories of sprites observed in the US, and 95% of the sprites could be associated to a +CG lightning discharge, the remaining parent lightning strikes being undetected. We found a substantionally lower peak current average (33.5 kA) for sprite-producing +CG discharges compared to that of U.S. storms (81 kA), and significantly lower lightning rates than for storms in the U.S. producing similar numbers of sprites. This may reflect the different storm structure and nature of the positive charge reservoir within the storms. We note also that the occurrence rate of sprites during active periods was roughly the same as that for American storms [3].

Although exhibiting lower peak current, all but one of the sprite-causing +CGs also excited the Earth-Ionosphere waveguide, for the evening of August 27. Data for the other evenings remains to be analyzed, but we expect a similar pattern.

While the number of sprites did not compare to the numbers seen over storms in the U.S., it is evident, however, that sprites are common also over smaller European thunderstorms. The actual number of sprites over the large-scale weather systems of July 24, 25 and August 27 may be a factor of 3-4 higher than the numbers seen from our single camera at Pic du Midi.

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