THUNDERSTORM AND LIGHTNING CHARACTERISTICS ASSOCIATED WITH SPRITES IN BRAZIL

O. Pinto, Jr., M. M.F. Saba, I. R. C. A. Pinto, K.P. Naccarato,
F.S.S. Tavares, N.N. Solorzano and E.C. Ferraz
National Institute of Space Research – INPE
São Jose dos Campos - Brazil

M.J. Taylor, P.D. Pautet and M. Bailey
Utah State University
Utah – United States

and

R.H. Holzworth, J. N. Thomas and M. P. McCarthy
University of Washington
Seattle - United States

INTRODUCTION

The lightning characteristics of sprite producing storms have been extensively studied by several authors (e.g., Lyons, 1996; Lyons et al., 2002; Tavares et al., 2003). In general, they found that most sprites are associated with positive cloud-to-ground (CG) flashes with peak current values from 10 kA to more than 100 kA. For a given storm, however, they found that the average intensity of the parent flashes tends to be larger than the average of all positive flashes of the storm.
In this paper, the lightning characteristics associated with 6 storms that produce a total of 18 transient optical events were analyzed. The 18 events were recorded at three different days in 2002 and 2003; 16 exhibited vertical structures typically associated with sprites, while the other two were disc-like events, characteristic of sprite halo or elves. Figure 1 shows an example of sprite recorded in 25 November 2002 at 02:49 UT. Table 1 summarizes all information related to the 18 events, including date, time in UT, peak current of the causative positive flash (14 cases), sprite type, location of the camera and storm identification number. The storms were relatively small ones that were induced primarily in association with the passage of strong cold fronts. These observations provide the first quantitative measurements of sprites over Brazil. The lightning data were obtained by a network of Impact and LPATS sensors located in the Southeast region of Brazil.

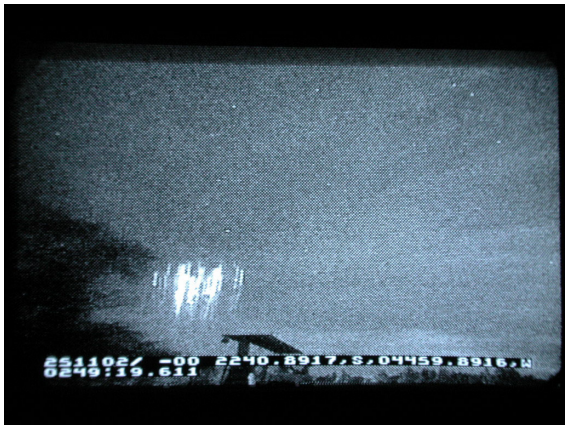


Figure 1 - An example of sprite recorded in 25 November 2002 at 02:49 UT in the Southeast of Brazil.

TABLE 1 - Summary of the sprite events.

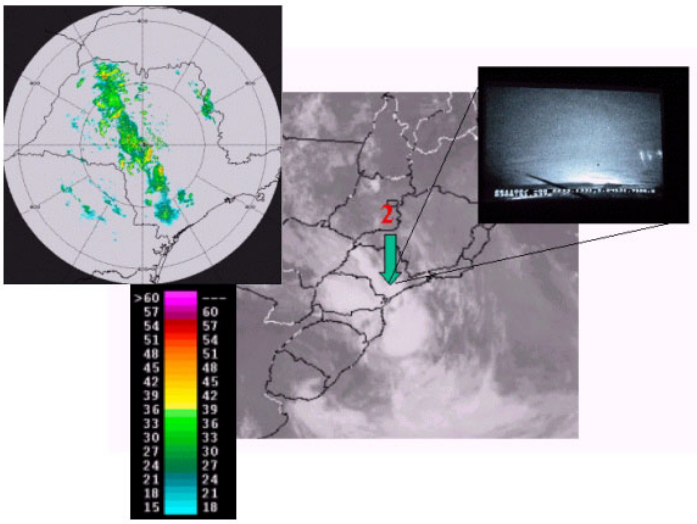
#	DATE (UT)	TIME (UT)	PEAK CURRENT (kA)	SPRITE TYPE	LOCATION OF THE CAMERA	STORM NO.
1	11/25/02	2:49.19.611	41	Column Sprite	CP	1
2	11/25/02	2:52.15.022	45	Unit Sprite	CP	1
3	11/26/02	3:00.11.947	33	Sprite	aircraft	2
4	11/26/02	3:03.07.524	44	Cluster Sprite	aircraft	2
5	11/26/02	3:08.51.471	122	Cluster Sprite	aircraft	2
6	11/26/02	3:09.50.63		Carrot Sprites	aircraft	2
7	3/21/03	0:41.11.374	29	Carrot Sprites	aircraft	3
8	3/21/03	2:04.01.397		Carrot Sprites	aircraft	3
9	3/21/03	5:52.19.449	150	Sprite (Fuzzy)	CP	4
10	3/21/03	6:06.54.79	93	Cluster Sprite	CP	4
11	3/21/03	6:10.45.13		Carrot Sprites	CP	4
12	3/21/03	6:22.19.74	101	Elve ?	CP	4
13	3/21/03	6:32.39.63	146	Elve ?	CP	5
14	3/21/03	6:36.15.93	28	Dancing Sprite	CP	4
15	3/21/03	6:38.03.22		Carrot Sprites	CP	4
16	3/21/03	7:07.25.652	30	Carrot Sprites	CP	4
17	3/21/03	7:12.15.011	28	Carrot Sprites	CP	6
18	3/21/03	7:14.41.592	26	Carrot Sprites	CP	6

BRAZILIAN LIGHTNING NETWORK IN THE SOUTHEAST REGION

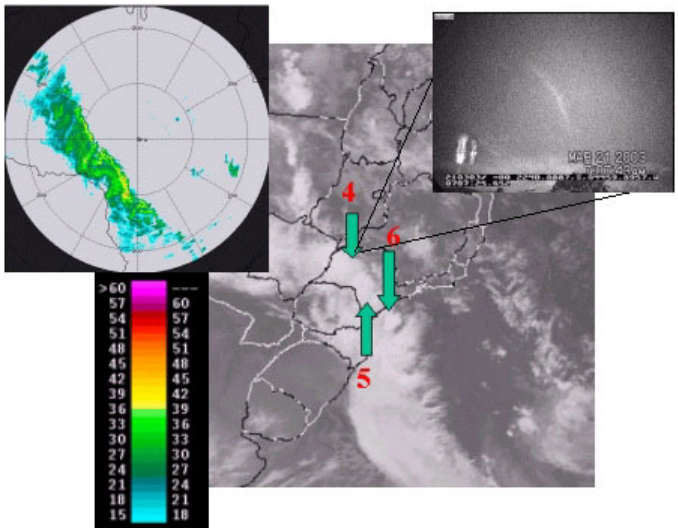
The lightning network in the Southeast Brazil at the time of the observations was composed by 23 sensors (7 Impact and 16 LPATS sensors), covering all the Southeast region and part of the South and Center regions (for more details, see Pinto et al., 1999a, b, 2003). Considering that this type of network is subject to contamination by intra-cloud flashes, mainly in the case of positive CG flashes, in this work we have only considered positive CG flashes with peak current larger than 10 kA. The data were analyzed in terms of strokes, no considering any algorithm to combine them into flashes. The location accuracy (LA) and the detection efficiency (DE) of the system for the region and period of this study are assumed to be in average 1 km and 80%, respectively, although no corrections for these values were applied to the data.

RESULTS AND DISCUSSION

Figure 2 shows examples of infrared satellite images and radar data for some of the events reported in Table 1. The numbers in red identify the storm; the sprite images are also shown.



(a)



(b)

Figure 2 - Infrared satellite images of storms 2, 4, 5 and 6, all of them associated with cold fronts. The sprite images are shown for case 2, taken from an airplane, and for case 4, on the ground. The radar PPI data are also shown for all storms at same time of the satellite images.

While storms 2, 4, 5 and 6 (shown in Figure 2) are related to cold fronts, storm 1 was produced by a tropical Mesoscale Convective System (MCS) and storm 3 was a local air mass thunderstorm. For all cases studied, the characteristics of the thunderstorms associated with

sprites (diameter, reflectivity, cloud top and duration) were not significant different from the typical values for these kind of thunderstorms in this region, that is, diameters from tens to a hundred of kilometers, reflectivities marginally above 40 dBz, cloud tops below 12 km and duration of individually storms approximately 1-2 hours.

Table 2 shows for the different storms the average peak current of all positive flashes in 20-min. time intervals centered in the sprite events, compared with the peak current of the sprite-associated flashes. Sprite-associated positive flashes have substantially larger average peak currents than the average of the the remaining positive population around the events, in agreement with the results reported by Lyons (1996).

TABLE 2 - Summary of the positive CG flashes.

STORM NO.	TOTAL NO. +CG (in a 20 min. interval centered in the sprite event)	AVERAGE PEAK CURRENT (kA) (all +CG)	AVERAGE PEAK CURRENT (kA) (sprite-associated +CG)
1	25	28	43
2	11	48	66
3	5	21	29
4, 5 e 6	69	41	73

CONCLUSIONS

Observations of sprites associated with five different storms were conducted for the first time in the Southeast Brazil during the end of 2002 and early 2003. The results indicated that sprites are apparently very common in this region in association with all types of convective storms (local thunderstorms and MCS). All events are associated with positive CG flashes with average peak current larger than the average peak current of the positive CG population in the same storms.

ACKNOWLEDGEMENTS

The authors would like to thanks the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) for supporting this research through the project 02/01329-1.

REFERENCES

Lyons, W.A., Sprite observations above the U.S. High Plains in relation to their parent thunderstorm systems, J. Geophys. Res., 101(D23): 29,641-29,652, 1996.
Lyons, W.A., E.R. Williams, S.A. Cummer, and M.A. Stanley, 3-D lightning characteristics of High Plains sprite-producing storms, Proceedings of the ILDC, Tucson, AZ, 2002.
Pinto, O., Jr., I.R.C.A. Pinto, M.A.S.S. Gomes, A.L. Padilha, I. Vitorello, J.H. Diniz, A.M. Carvalho, and A. Cazetta Filho, Cloud-to-ground lightning in the southeastern Brazil in 1993, 1, Geographical distribution, J. Geophys. Res., 104(D24), 31,369-31,379, 1999a.
Pinto, I.R.C.A., O. Pinto Jr., R.M.L. Rocha, J.H. Diniz, A.M. Carvalho, and A. Cazetta Filho, Cloud-to-ground lightning flashes in the southeastern Brazil in 1993, 2, Time variations and flash characteristics, J. Geophys. Res., 104(D24), 31,381-31,387, 1999b.

Pinto, O., Jr., I.R.C.A., Pinto, J.H. Diniz, A. Cazetta Filho, A.M. Carvalho, L.C.L. Chechiglia, and G.E. Amorin, A long-term study of the lightning flash characteristics in the southeastern Brazil, J. Atmos. Solar-Terr. Physics, 65(6): 739-748, 2003.
Tavares, F.S.S., D.D. Sentman, E.M. Wescott, O. Pinto Jr., O. Mendes Jr., M.J. Taylor, Statistical analysis of space-time relationships between sprites and lightning", J. Atmos. Solar-Terr. Physics, in press, 2003.