Observations of High Densities and Rates of Positive Flashes in Summertime Thunderstorms in Brazil

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Observations of summertime thunderstorms in Brazil in 1993 indicate periods with the predominance of positive cloud-to-ground lightning flashes. The periods present high density (average value of $0.66/\text{km}^2\text{h}$.) and high hourly rate (average value of 478/h) of positive flashes. In most cases, they occurred at or near the beginning of the storm's cloud-to-ground lightning activity and had duration of about 2.5h.

INTRODUCTION

The first evidence of thunderstorm with predominance of positive cloud-to-ground lightning flashes in Brazil, called positive storms, were obtained by simultaneous balloon and lightning ground system measurements in 1989 (Gin, 1992; Pinto et al., 1992). Afterwards, Gin et al. (1996), Gin (1997) and Pinto Jr. et al. (1997) have confirmed such an evidence analysing data obtained by the Lightning Positioning and Tracking System (LPATS) during the summer season of 1993 in the state of Minas Gerais.

In this paper it will be analysed the data obtained during 12 positive storms which occurred in the summer season of 1993 in terms of flash density and hourly rate. The synoptic meteorological conditions associated with the storms were identified (in most cases) through images of the Meteosat-3 satellite. The results are compared with similar observations made by Stolzenburg (1994) in the Great Plains of the United States.

OBSERVATIONS AND DISCUSSION

About 300,000 cloud-to-ground lightning flashes were measured by the LPATS during the summer season of 1993 in the state of Minas Gerais, in the southeastern region of Brazil. The main characteristics associated with the positive flashes (about 35%) were the low peak-current intensity (average of 21 kA) and the occurrence of 20 periods in which they were predominant (average of 64% during these periods). The average duration of these periods was 4 hours (Pinto et al., 1997). During these periods the positive flashes occurred at almost same region of the negative flashes, not showing any evidence of a bipolar pattern. A bipolar pattern in the thunderstorm lightning activity has observed by several authors (e.g. Orville et al., 1988).

12 out of 20 positive storms shown high density and high hourly rate of positive flashes. Table 1 summarizes the main characteristics of positive flashes during these storms. The average density ($0.66/\text{km}^2\text{h}$) and hourly rate (478/h) were higher than the values obtained by Stolzenburg (1994) in the Great Plains of the United States, $0.18/\text{km}^2\text{h}$ and 114/h, respectively. Most storms

were located at latitudes of $18-20^\circ\text{S}$ and longitudes of $44-48^\circ\text{W}$, and were associated with the presence of a cold front (SF). The periods of high density of positive flashes have average duration of 2.5 hours, and occurred at (6 cases) or near (6 cases) the beginning of the storm's cloud-to-ground lightning activity. During these periods, the storms presented a high percentage of positive flashes (average of 70%). The positive flashes have an average peak current of 18kA. These values is much lower than the average value of 70kA found by Stolzenburg for similar periods.

The maximum values of density and hourly rate of positive flashes were observed in March 11, 1993. These values, $2.53/\text{km}^2\text{h}$ and 1576/h, respectively, are about 4 times greater than the maximum values obtained by Stolzenburg (1994) of 393/h and $0.6/\text{km}^2\text{h}$. Figure 1 shows the location of positive and negative lightning flashes during the storm of March 11, 1993. About 2500 positive flashes occurred during a 2 hour period, with an average hourly percentage of 83%.

The duration of the period of high density of positive flashes showed variations from 1 to 5 hours. Figure 2 shows the duration of the high density period of positive flashes versus the number of positive flashes. Differently from Stolzenburg (1994), who found a weak correlation between these parameters, no correlation was found in this study. This fact seems to be a direct consequence of the large variation in the positive flash density (see Table 1).

CONCLUSIONS

As it has been identified by Stolzenburg (1994) in the Great Plains of the United States, the positive storms in Brazil also show high flash density and hourly rate. The values, however, are about 4 storms higher than found by Stolzenburg (1994). The number of positive flashes in a given storm is not correlated with the duration of the storm, reflecting the large variations in the positive flash density. The average peak-current intensity of the positive flashes was found to be 18kA.

These value is much lower than the average value of 70kA found by Stolzenburg (1944).

Although there are similarities between the positive storms presented in the paper and those reported by Stolzenburg (1994), some differences were found. In this sense, the suggestion given by Stolzenburg (1994) that the positive storms may be related to tall storms that exhibit a stage of early, rapid increase in radar echo-top

height and produce large hail may not be valid in this sense. More research is necessary in order to identify which mechanism or mechanisms are responsible for such storms.

Fig. 1 - The location of negative (a) and positive (b) cloud-to-ground lightning flashes during the storm of March 11, 1993.

Fig. 2 - Total number of positive flashes related to the duration (min) of high density lightning period for 12 storms in Table 1.

Table 1. Characteristics of positive CG lightning flashes in summertime thunderstorms in Brazil

Date 1993 (Pos.-Storm period -UT)	Location Lat.:°S Long:°W	High-pos. time-period (UT)	Average hourly percent pos.	Total number of pos flashes	Max. pos. rate (/h)	Max. pos. density (km ² /h)	Meteorolog. Condition
11/01-12/01 (2200-0300)	18-20 43-45	2200-0300	62	1135	459	0.13	Assoc. SF
16/01 (1400-1700)	20-21 43-44	1500-1700	82	479	258	0.65	Isolate
17/01 (0700-1000)	19-20 43-44	0700-1000	84	416	302	0.38	Assoc. SF
11/02-12/02 (0000-0200)	21-22 44-45	0000-0200	60	262	147	0.05	*--
13/02-14/02 (2300-0200)	19-20 47-49	2300-0200	51	527	272	0.46	*--
20/02 (0100-0500)	18-20 47-49	0200-0500	67	676	306	0.06	*--
(1200-1500)	20-21 46-47	1200-1500	75	422	292	0.19	*--
22/02 (0000-0300)	20-21 43-44	0200-0300	60	800	800	0.8	*--
22/02-23/02 (2300-0200)	17-19 47-48	0000-0100	52	199	199	0.22	*--
11/03 (1400-1800)	20-21 46-48	1600-1800	83	2209	1576	2.53	Assoc. SF
12/03 (1300-1600)	19-20 47-48	1500-1600	85	679	679	0.85	Assoc. SF
13/03 (1500-1900)	19-20 45-47	1500-1900	77	5700	675	2.25	Assoc. SF
Average		2.5 h	70	1038	478	0.66	

*No meteorological satellite data available.

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