A study about the occurrence of days with high activity of cloud-to-ground lightning flashes in the southeastern Brazil in the years 1992 to 1994

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ABSTRACT

The occurrence of days with high activity of cloud-to-ground lightning flashes in the southeastern Brazil in the years 1992 to 1994 was investigated. The high activity days were arbitrarily defined as those with more than 20,000 cloud-to-ground flashes. The meteorological conditions and flash characteristics during these days were determined. The lightning data were obtained through a lightning location system (LPATS), and the flash characteristic studied were the polarity, the peak current intensity and the diurnal distribution.

INTRODUCTION

During the years from 1992 to 1994, 18 events were selected to obtain the characteristics of the cloud-to-ground lightning in days of high activity. The data were obtained by a storm location system (LPATS), that is located in the southeast of Brazil, in the state of Minas Gerais (14º -23º S, 39º - 52ºW). The days of high activity of cloud-to-ground lightning presented at least 20,000 discharges.

Of the 18 events selected for study, 11 occurred in the transition period between the warn and cold seasons, and were associated with the presence of cold front systems organizing tropical convection, and intensifying the lightning activity. Considering a possible contamination of the positive cloud-to-ground flashes by intracloud flashes, only positive flashes with peak current larger than 15 kA were considered. In this article we will present the results obtained for the occurrence of cloud-to-ground flashes in relation to the months of the year, the polarity of the flashes, the peak current intensity, and the diurnal distribution.

RESULTS AND DISCUSSIONS

The figure 1 presents the variation, month to month, of the occurrence of the 18 analyzed events. They occur predominantly during the austral spring (September, October and November), with a lower occurrence during the austral winter (June, July and August), (Faria, 1998). In austral spring, the front systems when they reach the Southeast region, organize the tropical convection, intensifying the activity of lightning.

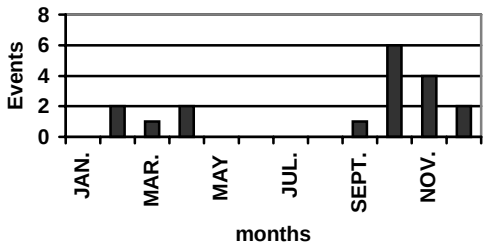

Figure 1 – Distribuition of the days wiht high activity of lightning flashes in terms of the months of the year.

In this study it can be observed that the average characteristics of positive and negative lightning flashes, for the days of high activity, didn't vary in the period of 1992-1994, table 1. The average percentage of positive lightning was of approximately 30% and for the negative lightning was of 70%, in agreement with studies made for the summer and winter in the same region (Gin, 1997; Rocha, 1997) and indicating that the polarity of the cloud-to-ground lightning doesn't vary sensibly with the season and with the activity of flashes (Faria, 1998). Figure 2 presents the percentages of positive and negative lightning flashes in terms of the months for each year. The percentage of positive lightning flashes is generally above the values presented in the literature, that are less than 30% (Fuquay, 1982; Beasley, 1985; Orville et al., 1987; Reap e MacGorman, 1989; Hojo et al., 1989; Orville, 1994; Orville e Silver, 1997).

Table 1 - Monthly and annual percentages of positive and negative lightning flashes for the days of high activity.

Months	Polarity					
	Positive			Negative		
	1992	1993	1994	1992	1993	1994
January	0	0	0	0	0	0
February	0	20,7	28,9	0	79,3	71,1
March	0	21,8	0	0	78,2	0
April	28,2	33,5	0	71,8	66,5	0
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	26,4	0	0	73,6	0
October	23,5	24,2	0	76,5	75,8	0
November	38,3	16,7	20,3	61,7	83,3	79,7
December	0	44,0	0	0	56,0	0
Average values	30	26,8	24,6	70	73,2	75,4

The average peak current intensities for positive and negative lightning flashes were 31 kA and 41 kA, respectively. The maximum peak current intensity for positive flashes was of 421 kA and for the negative 505 kA. The negative lightning flashes presented large variation of peak current intensity, from event to event, which may be associated to latitudinal variations (Orville, 1990).

High average peak current intensities occurred when the storms were located more to the north, lower latitudes, and low average peak current intensities occurred when the storms were located more to the south, higher latitudes, figure 3. For positive lightning flashes the variation of the current intensity with the latitude is not significant (Pinto Jr. et al., 1997). In this study it was verified that the average peak current of positive and negative lightning flashes are correlated. The storms with larger greater peak current intensity for positive flashes, also presented larger peak current intensity for negative flashes (figure 4), indicating a tendency of neutrality of the cloud in macroscopic terms (Faria, 1998).

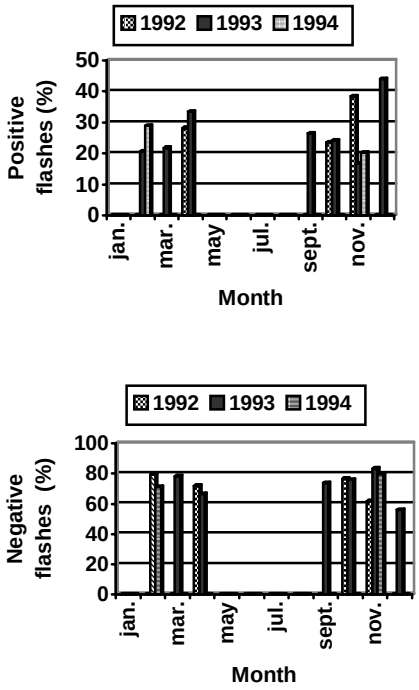

Figure 2 - Percentage of positive and negative lightning flashes month to month.

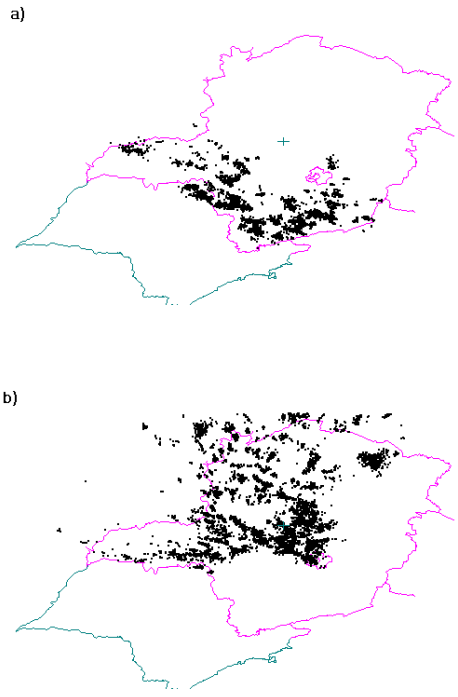

Figure 3 - Geographical location of the, cloud-to-ground lightning for storms with: a) low average peak current intensity, b) high average peak current intensity.

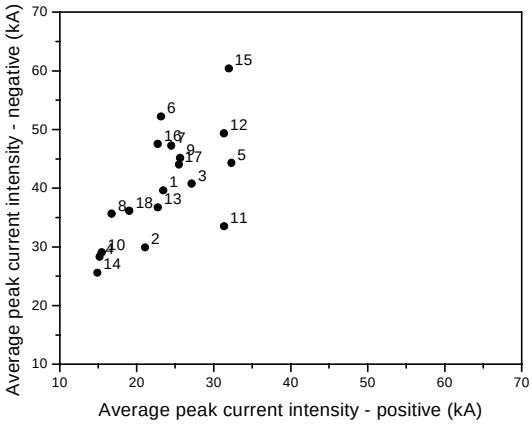

Figure 4 - Variation of the average peak current intensity of negative and positive lightning flashes, the numbers represent the event.

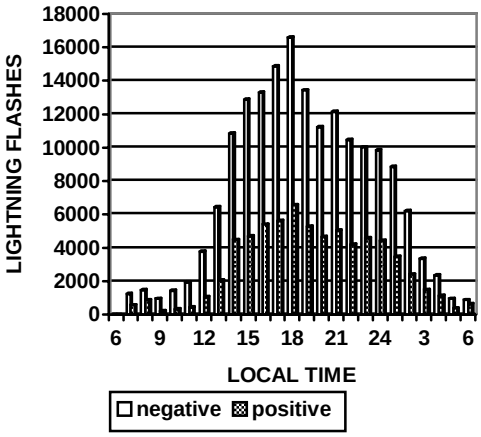

Figure 5 - Diurnal distribution of positive and negative lightning flashes.

Figure 5 presents the diurnal distribution of positive and negative lightning flashes, in which it can be verified that both polarities presented the same temporary behavior, with a peak around 18:00LT. The activity of cloud-to-ground lightning in the events remained above 1000 flashes per hour, for a mean period of 4 hours.

CONCLUSION

The largest occurrence of days of high activity of cloud-to-ground lightning for the studied period was in the month of October, being a total of 6 events. Due to cloud front organization of tropical convection, that occur between the warn and cold seasons, the activity of lightning intensifies.

The average percentage of positive and negative flashes were of approximately 30% and 70%, respectively. It was not found any dependence on the periods of the year. The average peak current intensity for positive and negative flashes was 30 kA and 40 kA, respectively. The peak current intensity of negative lightning flashes varied according to the location of the storm. The storms located more to the north, lower latitudes, presented peak current intensity larger, and those located more to the south, larger latitudes, the peak current intensities lower. The same was not found for positive cloud-to-ground lightning. No dependence on the period of the year was found as well.

The diurnal distribution of positive and negative cloud-to-ground lightning presented the same behavior, with a maximum activity around 18:00 LT. The average duration of the lightning activity during the events (considering 1000 or more flashes per hour) was 4 hours.

REFERENCES

Beasley, W. , 1985, Positive cloud-to-ground lightning observations, Journal of Geophysical Research, 90 , D4 , 6131-6138.

Faria, H. H., 1998, Estudo das características dos relâmpagos nuvem-solo durante dias de grande atividade no Estado de Minas Gerais nos anos de 1992-1994, Dissertação, Instituto Nacional de Pesquisas Espaciais.

Fuquay, D.M.,1982, Positive cloud-to-ground lightning in summer thunderstorms, Journal of Geophysical Research, 87, C9, 7131-7140.

Gin, R.B.B. , 1997, Estudo das características dos Relâmpagos nuvem-solo em Minas Gerais no verão de 1993, PhD Thesis, Instituto Nacional de Pesquisas Espaciais.

Hojo, J. et al., 1989, Seasonal variation of cloud-to-ground lightning flash characteristics in the coastal area of the sea of Japan, Journal of Geophysical Research, 94 , D11, 13207-13212.

Orville, R.E. et al., 1987, Cloud-to-ground lightning flash characteristics from June 1984 through May 1985, Journal of Geophysical Research, 92, D5, 5640-5644.

Orville, R. E., 1990, Peak-current variations of lightning return strokes as a function of latitude, Nature, 343, 149-151.

Orville, R. E., 1994, Cloud-to-ground lightning flash characteristics in the contiguous United States: 1989-1991, Journal of Geophysical Research, 99, D5, 10833-10841.

Orville, R. E.; Silver, A .C., 1997, Lightning ground flash density in the contiguous United States: 1992-1995, Bulletin American Meteorological Society, 125, 4, 631-638.

Pinto Jr., O.; Pinto. I. R. C. A.; Lacerda, M.; Carvalho, A. M.; Diniz, J. H.; Cherchiglia, L. C. L., 1997, Are equatorial negative lightning flashes more intense than those at higher latitude?, Journal of Atmospheric and Solar-Terrestrial Physics, 59, 15, 1881-1883.

Reap, R. M. ; MacGorman, D.R.,1989, Cloud-to-ground lightning: climatological characteristics and relationships to modelfields, radar observations, and severe local storms, Monthly Weather Review, 117, 3, 518-535.

Rocha, R.M.L., 1997, Análise de relâmpagos nuvem-solo durante o inverno de 1993, no estado de Minas Gerais, Dissertação , Instituto Nacional de Pesquisas Espaciais.