

CLOUD-TO-GROUND LIGHTNING ACTIVITY IN MESOSCALE CONVECTIVE COMPLEXES IN SOUTHEASTERN BRAZIL IN 1993-94

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ABSTRACT: The characteristics of cloud-to-ground lightning flashes in association with Mesoscale Convective Complexes (MCC) which occurred in the southeastern Brazil in the years of 1993 and 1994 were investigated. During this period 4 MCCs were identified. However, only 1 of 4 MCCs occurring in 1993-94 spent their entire life cycle within the 50 % detection efficiency region. It had a duration of 15 hours and at time of maximum extent its area was approximately 110,000 km². The characteristics of cloud-to-ground flashes during their major life-cycle phases were studied in terms of the hourly flash rate, polarity, multiplicity and average peak current intensity.

INTRODUCTION

Mesoscale Convective Complexes (MCC) are large mesoscale convective systems defined in terms of their circular appearance, duration and size of the weather system cloud shield in GOES infrared satellite images (Maddox, 1980). In the United States, MCC generally occur over the central region in the spring and summer months (McAnelly and Cotton, 1989) and are associated with severe weather (Maddox, 1980). In South America, Velasco and Fritsch (1987) and Conforte (1997) have found that MCC occur in almost all months between September and May. Although more frequently in the north part of Argentina, south of Brazil, Paraguay and Bolivia, they occur in almost all regions of South America from the equator to 40 degrees south.

The cloud-to-ground lightning activity in MCC, in turn, has not been studied in details, in part due to the difficulties to detect all events in space and time. At present, the more complete study and the first to provide a characterization of the lightning activity throughout the MCC life cycle was reported by Goodman and MacGorman, 1986 (hereafter referred to as GM, 1986). They studied the lightning activity in 10 MCC, which occurred in Oklahoma between 1981 and 1983. However, only in three of the ten cases the entire MCC life cycle take place in the region covered by the local lightning detection network (NSSL). Nevertheless, their results were sufficient to infer some lightning activity properties of MCC: flash rates in excess of 1000 h⁻¹ can be sustained on average for more than nine consecutive hours; the development and mature phases constitute the most electrically active period; the most electrically active period also corresponds to the period of large flash multiplicity, while the fewest multiple flashes occur during the first hour of the MCC development. GM (1986) also found that the lightning flash activity appears to be independent of the size of the local storm system cloud shield at maximum extent and MCC life cycle duration. However, in their study, flash polarity discrimination as well as peak current intensity were not available.

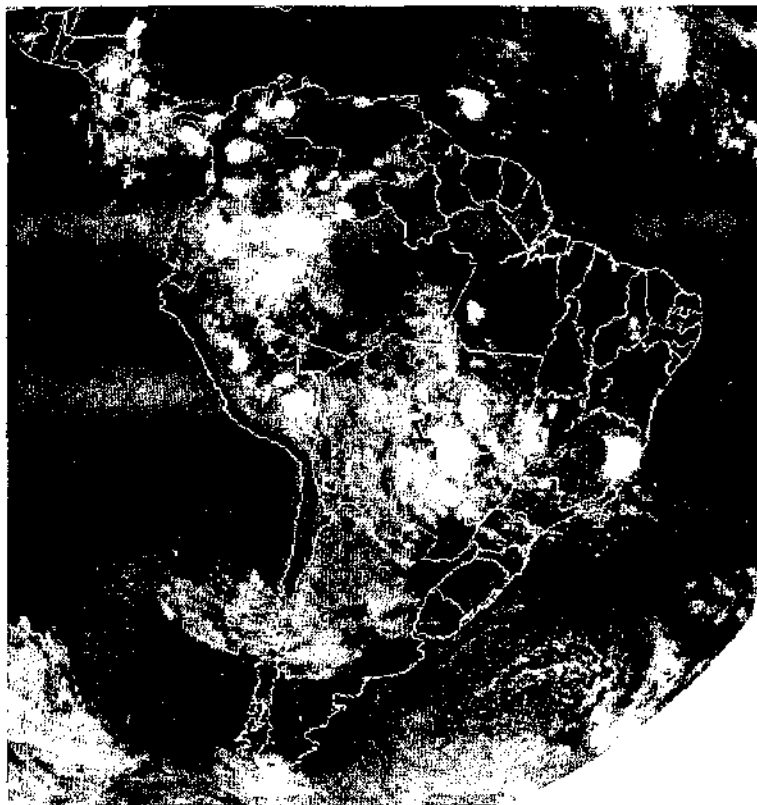
In this paper, the first results about the cloud-to-ground lightning activity in tropical MCC are reported. The characteristics of cloud-to-ground flashes during the major MCC life cycle

phases were studied in terms of the hourly flash rate, polarity, multiplicity and average peak current intensity. The results are compared with those obtained by GM (1986) for middle latitudes MCC in the United States.

RESULTS

The characteristics of cloud-to-ground lightning flashes in association with Mesoscale Convective Complexes (MCC) which occurred in the southeastern Brazil in the years of 1993 and 1994 were investigated using a LPATS lightning detection network. During this period 4 MCCs were identified. However, only one of these cases spent their entire life cycle within the 50 % detection efficiency region. The first storms began to develop on 28 October 1994 at 21:00 UT (cloud top area with temperatures $< -52^{\circ}\text{C}$ equal to $10,000\text{ km}^2$). The MCC initiated (cloud top area with temperatures $< -52^{\circ}\text{C}$ equal to $50,000\text{ km}^2$) on 29 October 1994 at 02:00 UT, had its maximum extent at 06:00 UT, and terminated (cloud top area with temperatures $< -52^{\circ}\text{C}$ equal to $10,000\text{ km}^2$) on the same day at 12:30 UT. It had a duration of 15.5 hours and at time of maximum extent its area was approximately $110,000\text{ km}^2$. Fig. 1 shows an infrared GOES image of the MCC on October 28-29, 1994 at the instant of maximum extent. Near its center, the cloud top reached the tropopause at about 16 km. During its life time about 5500 cloud-to-ground lightning flashes were recorded, assuming an average lightning detection efficiency of about 50 % in the region of the MCC and considering only positive flashes above 15 kA.

About 12.2 % of the flashes were positive. The average peak current along the whole life cycle was 33.2 kA for negative flashes and 33.5 kA for positive flashes. It was found that the peak currents of both polarities tended to increase after the MCC initiation. Table 1 shows a comparison between the lightning flash characteristics of the MCC on October 28-29, 1994 with the average values obtained by GM (1986). The instants of first storm development, initiation, maximum extent and termination are represented, respectively, by the letters F, I, M and T.



	Duration (h)	Cloud top area <52°C at maximum extent (km ²)	Peak flash rate (h ⁻¹)	Characteristics at different phases			
				F-I	I-M	M-T	
Goodman and MacGorman (1986)	14.3	160	2679	Total Flashes	7538 33.8%	16878 41.9%	5438 24.4%
1994 MCC	15.5	110	1020	Total Flashes	2860 51.9%	1980 36%	666 12.1%
				Neg.	2480	1780	574
				Pos.	380	200	92
				% Pos.	13.3	10.1	13.8
				% Neg. S.	66	67	53
				% Pos. S	100	100	100

Table 1

DISCUSSION AND CONCLUSIONS

From the analysis of Table 1, several interesting points are worth mentioning:

- most lightning activity in the 1994 MCC occurred in the same periods as reported by GM, that is, between the F and M;
- the lightning activity in the 1994 MCC was very low compared with the middle latitude MCCs reported by GM.
- the percentage of positive flashes presented only small variations along the life cycle of the 1994 MCC.
- the percentage of negative single flashes decreased in the M-T period of the 1994 MCC, in agreement with the results of GM (1986).
- the percentage of positive single flashes was constant along the life cycle of the 1994 MCC.

The lower activity of the 1994 MCC may indicate that tropical MCCs produced less flashes than middle latitude MCCs or, perhaps, less cloud-to-ground flashes. The MCC with lower activity in the ten cases reported by GM (1986) had two times the number of flashes of the 1994 MCC. More data, however, is necessary to confirm such a difference.

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