SBGf37799

# Meteorological Aspects Related to Cloud-to-Ground Lightning Occurrence in Minas Gerais During the Summer of 1995/96

Natália N. Solorzano,Osmar Pinto Jr. and Nelson J. Ferreira

Instituto Nacional de Pesquisas Espaciais - INPE

ABSTRACT

**Lightning strokes recorded in Southeast Brazil during the summer of 1995/96 in a period of aproximately one month were studied. The main parameters of the discharges (position, date, time, polarity, peak current) were determined and analyzed. Using these data, the mean number of strokes per hour and per day, as well as the mean values of the peak current were calculated. Within the period considered it was possible to distinguish days of high electrical activities from periods of low activities. Those bursts and breaks were characterized meteorologicaly by means of infrared immagery from the GOES satellite and reanalisys data from NCEP. The later were used to calculate the wind fields, the moisture flux convergence, the specific humidity and the equivalent potential temperature. The meteorological systems were identified, and a relashionship was observed between the diurnal cycle of the negative strokes and the meteorological conditions. The correlations between positive and negative discharges and the equivalent potential temperature were determined. It was concluded that the negative strokes, as well as positive strokes with peak currents above 15 kA show good correlations with the equivalent potential temperature. Such a variable seems to be a good parameter for evaluating the electrical activity, as it is for evaluating the depth and vigor of convection.**

---

## INTRODUCTION

The southeast region of Brazil has one of the greatest lightning activities in the world. Considerable interest has focused on the study of atmospheric electrical discharges in Brazil during the last years, owing to the damage, monetary loss and security hazards these discharges may cause.

Lightning activity is directly linked to meteorological conditions and characteristics. In the southeast region, thunderstorms are brought up by systems such as fronts, the Bolivian High, the SACZ (South Atlantic Convergence Zone), the South Atlantic Subtropical High, squall lines and others, which may perform a combined action and are predominant during summer. Also, the number of strokes increases with the depth and vigor of convection, which is expressed in terms of thermodynamic instability indexes such as CAPE (Convective Available Potential Energy), the wet bulb temperature, the potential equivalent temperature, etc. The later has been used successfully in comparison with lightning activity (Watson et al., 1994).

Lightning flashes can be classified according to the position of initiation and end of the discharge. The cloud-to-ground lightning (CG) is the most damaging type, although not the most common The most usual type of discharge is the intracloud, which, however, has lower values of peak currents, and consequently lower energies, being less hazardous. CG flashes can be distinguished by their polarities. The negative CG flashes deliver negative charge to earth and are the most frequent. The positive lightning lower positive charges, and are usually more energetic, therefore more dangerous.

Since 1988 a ground-based lightning detection network has been implanted in Minas Gerais State, by the local energetic company CEMIG (Companhia Energética de Minas Gerais). The LPATS (Lightning Position and Tracking System) is the detection system employed,using the "time-of-arrival" technique. In 1996 there were six sensors spread over that State.

In this work, electrical discharges that occurred in the brazilian southeast during the summer of 1995/1996 in a period of aproximately one month were studied. Their main physical parameters (polarity, peak current, time, latitude and longitude) were determined by means of the LPATS network. Using those data, the mean values of the number of strokes and peak current per hour and per month were calculated for negative and positive discharges. A comparative study was made using these results and meteorological data.

## LIGHTNING DATA

**The stroke data set during the period of interest (January 28 to February 29) was provided by the LPATS network. In 1996, the LPATS network had 6 sensors spread over the State, covering the area comprehended by the coordinates 16S and 23S, and 48W and 42W. By using a software called VIS, provided by Global Atmospheric, and a computer program in FORTRAN language, the data were processed and analyzed.**

**There were two bursts of lightning activity, with days of relatively low numbers of discharges before, in between and after those bursts. The high activity days occurred for both negative and positive strokes. The burst and break periods were labelled as in Table 1 and can be visualized in Figure 1.**

Table 1 - Bursts and breaks

| Event | Type | Period | Number Of strokes per day |
|---|---|---|---|
| **A** | **Break** | **28/1/96 - 30/1/96** | **4000 - 9000** |
| **1** | **Burst** | **31/1/96 - 14/2/96** | **10.000 - 33.400** |
| **B** | **Break** | **15/2/96 - 19/2/96** | **2.600 - 10.000** |
| **2** | **Burst** | **20/2/96 - 27/2/96** | **12.000 - 30.000** |
| **C** | **Break** | **28/2/96 - 29/2/96** | **3.000 - 5.000** |

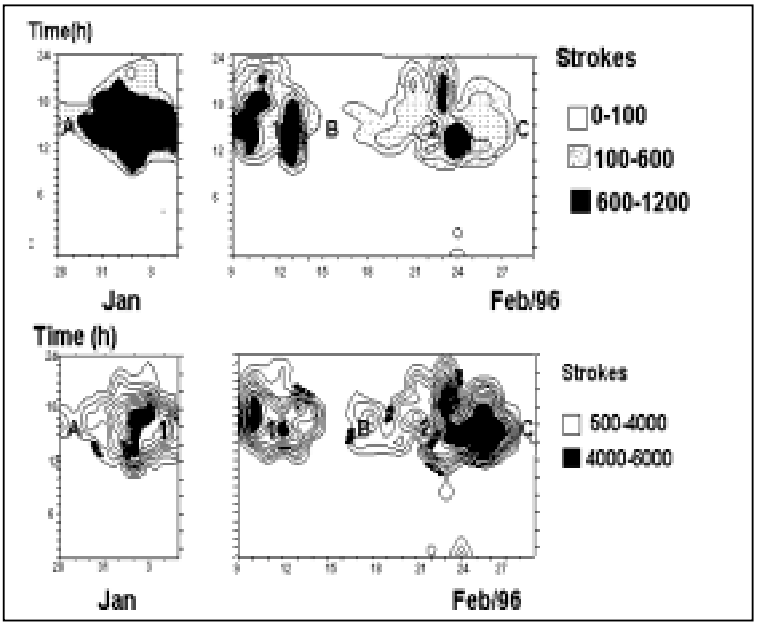



Figure 1 - Positive and negative strokes occurred during the period of interest.

**Figure 2 shows the mean monthly distribution of the number of positive and negative flashes. The negative strokes present a single peak centered at aproximately 16 LT, corrobarating previous results (Pinto Jr. et al., 1996). The positive discharges show a double peak centered at aproximately 14 LT and 18 LT. This double peak tends to disappear when the lower limit of peak current is raised (here shown only for 25 kA). It is not known if the pattern expected for positive strokes in the brazilian southeast is actually a double peak, but considering the results of Zaima et al. (1997) in Japan, concluding that the positive lightning results were contaminated by intracloud flashes, it was assumed in this work that the lowest acceptable limit to eliminate the parasite discharges would be 15 kA.**

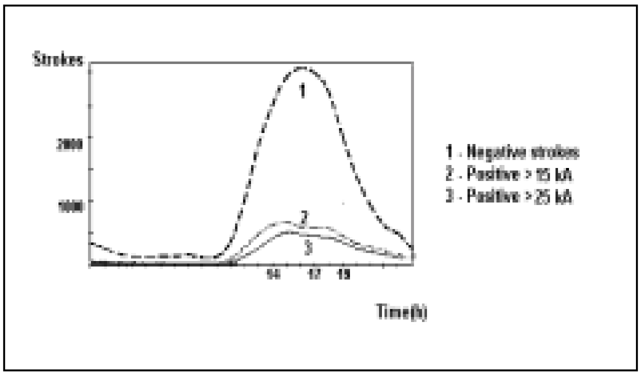



**Figure 2 - Mean diurnal distribution of negative and positive strokes.**

METEOROLOGICAL ASPECTS

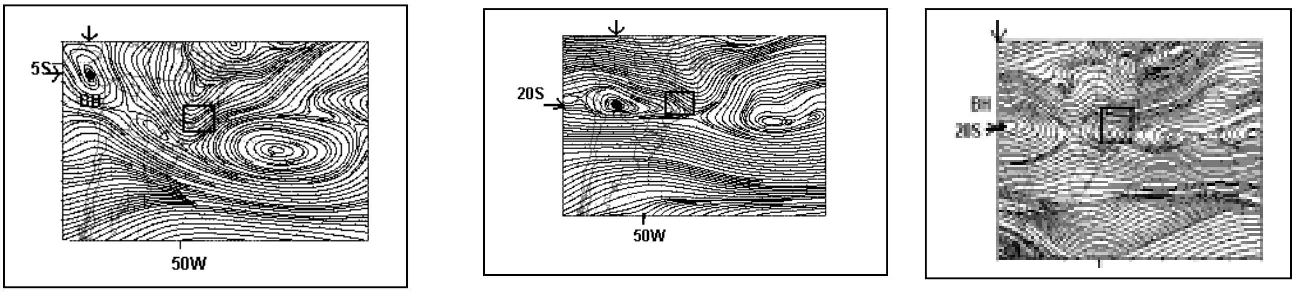
The meteorological data were obtained from the NCEP (National Center for Environmental Prediction) reanalysis and processed and analyzed by means of the software GRADs (Grid Analysis and Display System). Also, infrared images from the geostationary satellite GOES were used.The principal results obtained are discussed below.

**METEOROLOGICAL SYSTEMS**

Within the period of study, two meteorological systems had remarkable influence on the weather conditions. The first one is known as the Bolivian High (BH). The BH is a summer system characterized by an anti-cyclonic circulation in high pressure levels (tipically 300 hPa) climatologically positioned over 17S and 65W, over Bolivia.The second one is the SACZ (South Atlantic Convergence Zone), tipically seen as a cloud band at least four-days enduring in satellite imagery, extending from Amazonia to the South Atlantic. The SACZ is also a summer system and is acompained by intense precipitation. Other meteorological systems were present, but their influence was less noticeable.
The BH was present during the whole period and when the discharges bursts took place, especially event 2, the BH was very noticably displaced to the Southeast from its climatological position, as shown in Figure 3. The stream lines field (wind field) taken for 300 hPa, with the aid of the software GRADs, allow the positioning of the BH. The displacement of

Sixth International Congress of the Brazilian Geophysical Society

the BH caused a great increase in precipitation and electrical activity. During the break events, the BH tends to withdraw from the area of study, as can be seen in Figure 3.



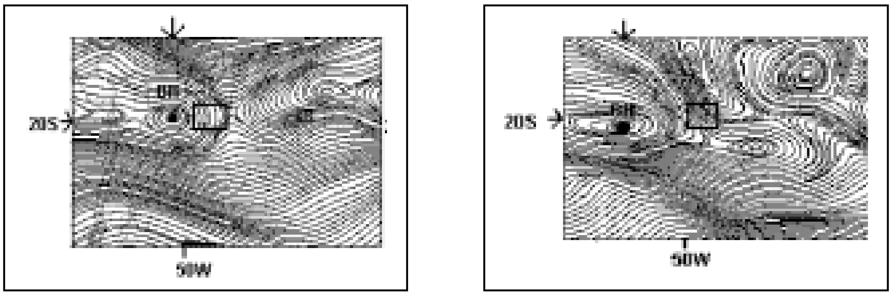
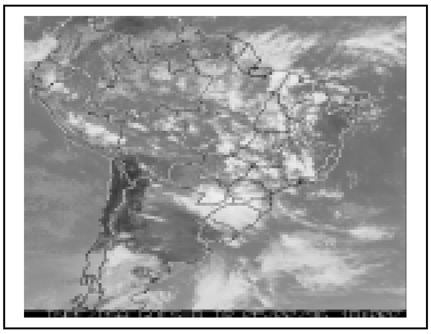




Figure 3 - The displacement of the BH:mean positions in events A, 1, B, 2 and C, from left to right. The square indicates the area of study and the displacement is shown by the arrows and the black spot. The BH is dramatically displaced towards Minas Gerais during event 2.



The SACZ was present only during event 1, and acting together with the BH caused the electrical activity to raise in this event. The SACZ started to stablish at the very beginnig of the event. Figure 4 contains a satellite picture of the SACZ in event 1, with its nebulosity band easily observable.

Figure 4 - The SACZ in Feb 2, 1996, at 18 UT (15 LT), from the GOES satellite. The nebulosity band persisted during the whole event 1, associated to an increase of the electrical activity.

**THE POTENTIAL EQUIVALENT TEMPERATURE**

The potential equivalent temperature (PET) is a thermodynamical property which depends both upon humidity and temperature. High values of the PET correspond to a great convective development, therefore to a probable increase in the number of atmospheric discharges. PET has already been compared to electrical activity (Watson et al., 1994).
In this work the pressure level of 700 hPa was considered suitable for PET calcutations. The mean daily values of this variable were compared to the number of strokes. In Figure 5 (left hand side) the results obtained are shown. The left axis contains the number of strokes and the right axis contains the daily mean of the PET. The x-axis stands for the date.These results suggested that the correlation between the running average of the number of stokes for five elements and the PET should be calculated. The running average was taken because the number of strokes fluctuates more rapidly than the PET, which is has a smooth fluctuation.The resulting graphic is in the right hand side of Figure 5. The correlation coefficient for both the total number of strokes and the negative strokes (not shown here) is of aproximately 0.80. For positive discharges with peak currents over 15 kA this coefficient is 0.60. For positive discharges with peak currents under this value, the correlation coefficient is only 0.35, which corroborates the evidence that the positive lightning data are contaminated.

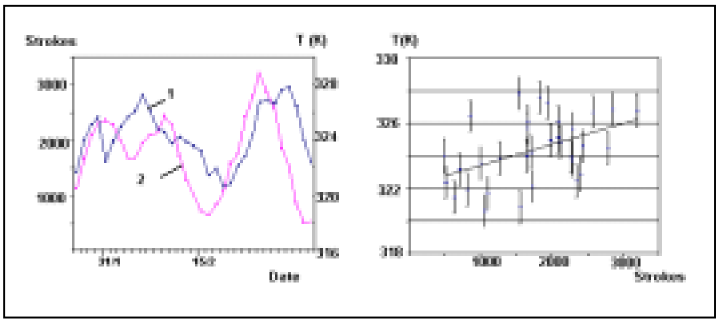



**Figure 5 - Left: total number of CG flashes (1) and PET (2) during the period analyzed. Right: PET against the running average of five elements of the total number of strokes and the correlation best fit line obtained.**

## CONCLUSIONS

Alternating periods of low and high electrical activities were detected. The bursts of CG strokes were associated to the presence of meteorological systems and to favorable conditions to potential instability. There were two periods of bursts: (a) from 31/01/1996 to 14/02/1996, when it was observed a ridge in the equivalent potential temperature field, high values of specific humidity and strong vertical movements in high and low levels of pressure. The SACZ was present during the whole process. (b) From 20 to 27/02/1996, when basically the same features of the meteorological parameters described in (a) were observed. The Bolivian High was displaced to the Southeast from its climatological position in the days of highest electrical activity, being over the Minas Gerais state. The intense nocturnal convection occurred on 23 and 24/2 caused the unusually high electrical activity at night.

The mean distribution of the number of strokes per hour taken for the whole period studied (bursts and breaks) showed a single peak for negative discharges, centered at 16 LT, which corroborates previous results.

The diurnal and monthly distributions of negative and positive discharges indicate that the stroke data set may be contaminated by intracloud discharges for positive strokes with peak currents inferior to 15 kA. There was no evidence that discharges with higher peak currents might be also contaminated.

The diurnal cycle of the mean distribution of the number of negative strokes of the two bursts events was different. The event labelled as 1 showed a single peak near 16 LT, whereas event 2 showed a double peak at 14 and 18 LT This happened because event 2 had a greater thermodynamical instability at night, and nocturnal convection took place.

The number of negative and positive strokes with peak current over 15 kA presented a good correlation with the daily mean values of potential equivalent temperature. Therefore the activity of CG lightning, both negative and positive, is a good indicator of convection, and vice-versa.

*REFERENCES*

*Pinto Jr., O; Pinto, I.R.C.A; Mendes Jr.,O; Diniz, J.H.; Carvalho, A.M., 1996, Cloud-to-Ground Lightning Flash Characteristics in Southeastern Brazil for the 1992-1993 Summer Season, Journal of Geophysical Research 101 (D23), 29.627-29.635.*

*Watson, A.I.; Holle, R.L.; López, R.E., 1994, Cloud-to-Ground Lightning During Bursts and Breaks in the Southwest Monsoon, Monthly Weather Review 122 (8), 1726-1739.*

*Zaima, E.; Mochizuki,A.; Fukiama, N.; Hojo, J.; Ishii, M., 1997, Observation of Lightning by Means of Time-of-Arrival Type Lightning Location Systems, Electrical Engineering in Japan 120 (1), 9-15.*

## ACKNOWLEDGMENTS

The authors would like to thank CAPES (Fundação Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) for the scolarship that made this work possible. Also we would like to thank J. H. Diniz, A. Cazetta Filho and A.M. Carvalho for providing the lightning data.