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ABOUT THE PEAK CURRENTS ABOVE 300 kA OBSERVED BY LIGHTNING LOCATION SYSTEMS

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1. INTRODUCTION

Even though the largest directly measured peak currents of either polarity of cloud-to-ground (CG) strokes do not exceed 300 kA, it is well known that lightning detection networks (LDN) have estimated from remotely measured electric and magnetic fields peak currents in excess of even 1000 kA. These values are estimated using an empirical formula assuming a linear relationship between the peak field and the peak current derived from the transmission line model applied to the return stroke and that the return stroke velocity is independent on the peak current. The validity of this assumption, however, has only been tested for negative subsequent strokes of triggered flashes with peak currents up to 60 kA (Rakov, 2007).

In order to investigate if the larger values (above 300 kA) of stroke peak current estimated by the LDN are real or artifacts of the network process algorithm, an analysis of the events observed in southeast Brazil from 1999 to 2005 by the Brazilian Lightning Detection Network (BrasilDat) was done, associating them to the type of meteorological system involved (frontal systems or local convection, the prevailing meteorological systems in this region) and to the region in the system where they are located (convective or stratiform). Figure 1 shows the BrasilDat sensor configuration at the time of this study. More than 200 strokes with peak currents above 300 kA were reported, being the largest value for negative strokes of 1265.8 kA and for positive strokes of 426.5 kA. More details about the BrasilDat can be obtained in Pinto Jr. et al. (2006, 2007).

In this paper the results of the analysis of the negative strokes with peak currents above 300 kA is presented. The analysis was done in terms of the geographical, monthly and diurnal distributions and it was restricted to negative strokes due to the low number of positive events. The same restriction was applied to the associated study between lightning data and meteorological aspects.

Figure 1. Map of the location of the sensors of the BrasilDat network at the time of the present study.

2. RESULTS

Figure 2 shows the spatial distribution of the negative CG strokes above 300 and 500 kA in the southeast region of Brazil from January 1999 to May 2005. Almost all of the high peak current strokes were concentrated in the states of Minas Gerais and São Paulo especially in the west portion. Negative CG strokes above 500 kA were predominant over the lowest state of the interest region according to the red stars in the map.

Figure 3 shows a map of the annual average CG lightning flash density for a spatial resolution of 10 km ×10 km observed in the tropical region of Brazil (Pinto Jr. et al., 2007). The regions in white correspond to densities larger than 7.5 flashes km^{-2} year^{-1}. The region of maximum CG lightning flash density in this figure, showed by a large white spot, is coincident with the urban area of the city of São Paulo. Evidences suggest that this maximum was caused by the heat island effect associated with the presence of the large urban area (Naccarato et al., 2003, Pinto et al., 2004). For the spatial resolution in Figure 3, the maximum CG lightning flash density in this region is 9-10 flashes km^{-2} year^{-1}. In comparison with Figure 2 the critical white area in the density map does not enclose the location of the strong negative strokes observed.

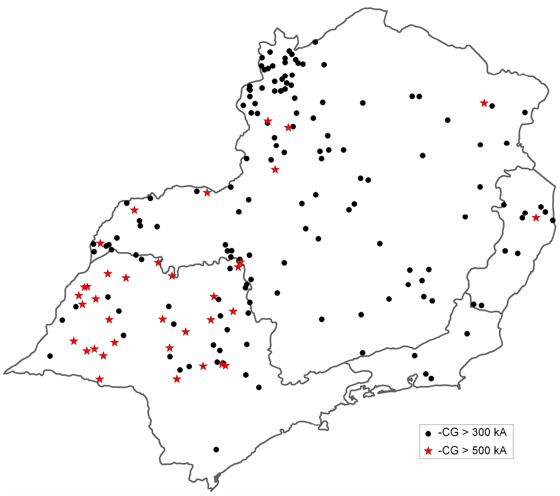

Figure 2. Map of the spatial distribution of the negative CG strokes above 300 kA (black dots) and 500 kA (red stars) in the region of interest for the 1999-2005 period.

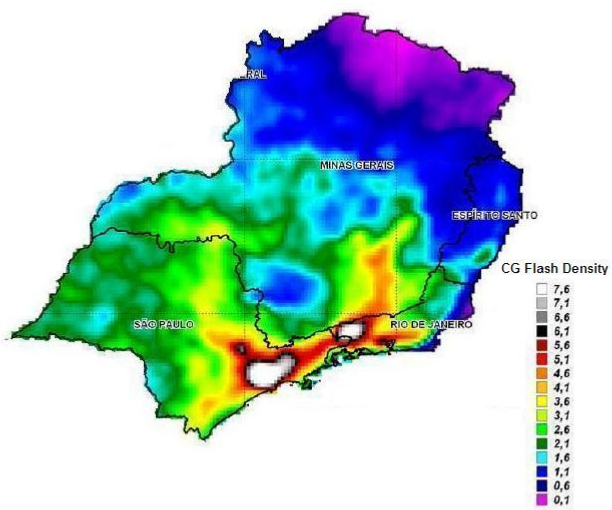

Figure 3. Map of the annual average CG lightning flash density in the southeastern Brazil from 1999 to 2004 for a spatial resolution of 10 km ×10 km.

Figure 4 shows a map of the location of all fires recorded by satellite from 1999 to 2004 in the southeastern Brazil. It is interesting to note that the location of negative strokes above 300 kA in the northwest of the state of Minas Gerais in Figure 2 is coincident with the regions with large number of fires, suggesting that there could be a relationship between these strokes and the presence of fires.

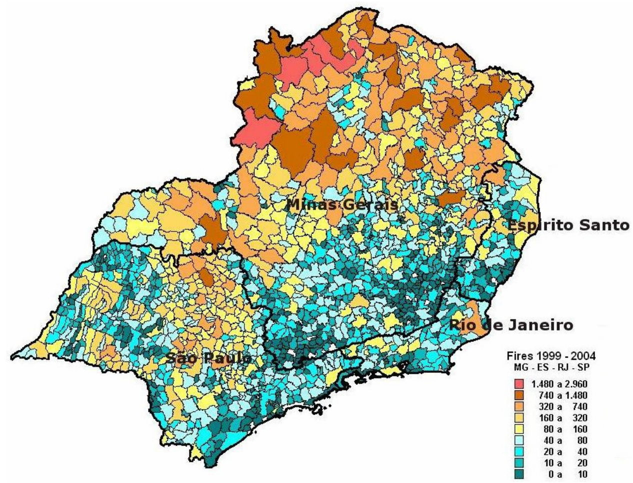

Figure 4. Map of the location of all fires recorded by satellite from 1999 to 2004 in the southeastern Brazil.

Figures 5 and 6 show the monthly and diurnal (local time) variation of the strokes above 300 kA, respectively. Both distributions are coincident with the distributions for all flashes in the same region and for the same period (Naccarato, 2005).

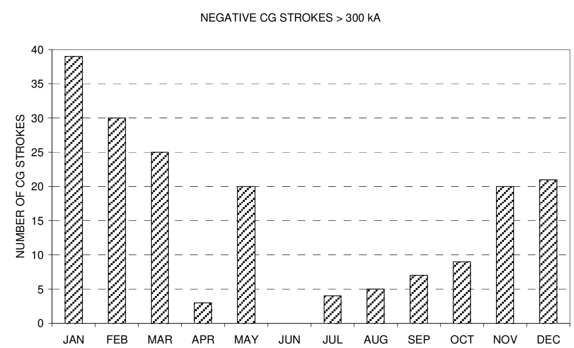

Figure 5. Monthly variation of the number of negative CG strokes above 300 kA in the region of interest for the 1999-2005 period.

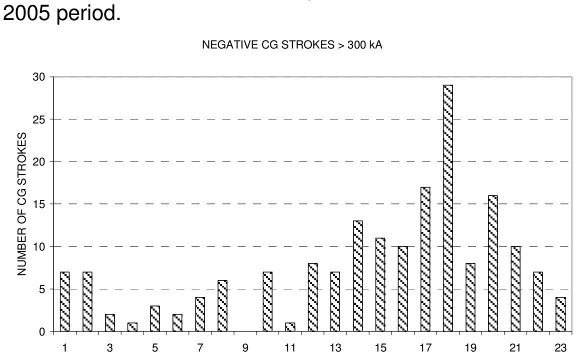

Figure 6. Local time variation of the number of negative CG strokes above 300 kA in the region of interest for the 1999-2005 period.

The southeastern region of Brazil is known to have a high lightning activity level associated with local and large-scale meteorological conditions. Among the large-scale conditions, lightning in the southeastern Brazil has been found to be related specially to the occurrence of fronts. At the same time, the number of flashes increases with local conditions associated with deep convection, as expressed by the wet-bulb temperature, the equivalent potential temperature and the convective available potential energy (CAPE) (Pinto Jr. et al., 2003).

Figure 7 shows respectively the percentage of strokes above 300 and 500 kA for thunderstorms associated with frontal systems and local convection. The identification of the meteorological system related to each negative CG stroke above 300 kA was established using infrared images of the geostationary satellite GOES-8 and severe weather information available in Climanálise Bulletin in the site of CPTEC (Weather Prediction and Climate Studies Center). It can be observed that most of the strokes are associated with thunderstorms related to frontal systems and that the percentage of these strokes increases with the increase in the peak current minimum threshold.

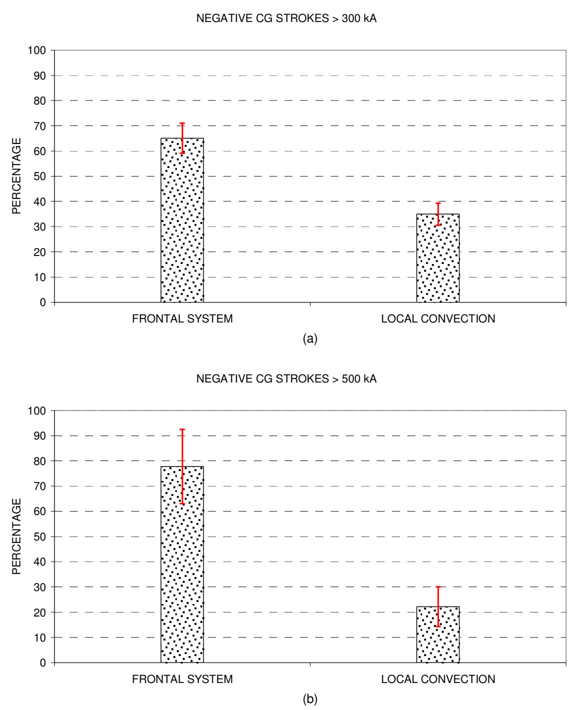

Figure 7. Percentage of negative CG strokes above (a) 300 kA and (b) 500 kA for thunderstorms associated with frontal systems or local convection.

Finally Figure 8 shows respectively the percentage of strokes above 300 and 500 kA located in the stratiform and convective thunderstorm regions. In this case the distinction between stratiform and convective region of a system was done only through visual analysis of satellite images. It can be observed that most of the strokes are located in the convective region of the thunderstorms and that the percentage of these strokes increases with the increase in the peak current minimum threshold.

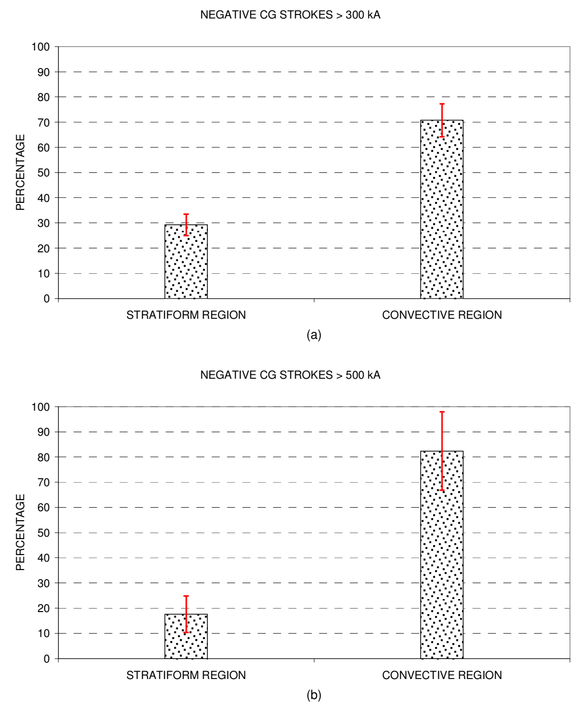

Figure 8. Percentage of negative CG strokes above (a) 300 kA and (b) 500 kA located in the stratiform or convective regions of thunderstorms associated with meteorological systems.

3. CONCLUSIONS

In this paper an analysis of the negative strokes with peak currents above 300 kA observed by the BrasilDat network in the southeastern Brazil from 1999 to 2005 was presented. The geographical distribution of the strokes above 300 kA showed a different distribution as compared with the all flashes detected by the network. The location of most of the negative strokes above 300 kA is coincident with the region of larger number of fires. In terms of the monthly and diurnal distributions, negative strokes show the same distribution of all negative flashes. The results indicate that negative strokes occur predominantly in the convective region of frontal systems, being this behavior still more evident for strokes with peak current above 500 kA. For positive strokes, the low number of events avoided any conclusion.

4. REFERENCES

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