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LARGE PEAK CURRENT CLOUD-TO-GROUND LIGHTNING FLASHES IN SOUTHEASTERN BRAZIL

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1. INTRODUCTION

Large peak current cloud-to-ground (LPCCG) lightning flashes have significant effects on different areas. Many studies have shown a clear association between LPCCG of positive polarity and sprites and elves in the stratosphere and mesosphere. For instance, Lyons et al. (1998) report on the first climatology of LPCCG lightning flashes compiled from the U.S. National Lightning Detection Network (NLDN), arbitrarily defined as flashes with peak currents >75 kA. Analysis of 1.46 million LPCCG flashes from 14 summer months (1991–95), corresponding to 2.4& of all flashes recorded, reveals distinct geographic differences in the distribution of positive and negative polarity. Positive LPCCG flashes were concentrated in the High Plains and upper Midwest, the region in which a large majority of optical sprite and elves observations have been obtained. By contrast, negative LPCCG preferentially occurred over the coastal waters of the Gulf of Mexico and the southeastern United States. From the total of LPCCG flashes, only 13.7% were positive. Almost 70% of the positive LPCCG flashes, however, occurred in the central United States (308–508N, 888–1108W). The percentage of all LPCCG flashes that were positive approached 30% in the central United States compared to 4.5% for the remainder of the country. Lyons et al. (1998) suggest that these results contribute to obtain a better understanding of the climatology of LPCCG flashes, which will greatly assist in the design of global radio frequency remote sensing systems to study these phenomena.

Lightning protection engineering guidelines generally assume mean peak current values, differentiating between mean values of positive and negative flashes. However if LPCCG have markedly differences in their concentration at different regions, there probably be a need to take these findings under consideration for engineering applications for utilities and other lightning sensitive installations. In addition, if NOx production by lightning were found to be non-linearly related to peak current, the regional differences in LPCCG flash densities may prove important.

Despite of the importance of to know the climatology of LPCCG, most studies have focused on the climatology of all CG flashes (Diendorfer et al., 1998; Orville and Huffines, 2001; Orville et al., 2002; Pinto et al., 2003; Schulz et al., 2005; Soriano et al., 2006; Zajac and Rutledge, 2001) and only a few studies have been carried out for LPCCG (Lyons et al., 1998). Besides the possible differences on the climatology of these two different peak current populations, both in terms of their geographical and time distributions, the climatology of all CG flashes is more sensible to changes in the detection efficiency of the lightning location networks.

The goal of this article is present for the first time the climatology of the LPCCG in the southeastern Brazil in terms of the geographical distribution based on data provided by the Brazilian Lightning Detection Network (recently renamed to BrasilDat) from 1999 to 2006. The results are compared the geographical distributions for all CG flashes in the same region and discussed in comparison with the observations made by Lyons et al. (1998) in the United States.

2. BRAZILIAN LIGHTNING DETECTION NETWORK

Data from the Brazilian Lightning Detection Network (BrasilDat) from 1999 to 2006 were used in this analysis. The data were not corrected by a detection efficiency model since for the peak current range considered in this study (> 75 kA) the detection efficiency in this region can be considered almost constant and very close to 100%. The network consists basically of several IMPACT and LPATS sensors, which determine the angle to the lightning stroke at the sensor location and/or the time of the lightning event, and a processing unit, which calculates stroke characteristics like the strike point location and time, peak current, and others. For a comprehensive description of lightning locating techniques, see for example, Cummins et al. (1998a, b) and Rakov and Uman (2003). Figure 1 shows the configuration of the BrasilDat network at the period of this analysis. More details about BrasilDat can be found in Pinto Jr. (2003, 2005), Pinto and Pinto Jr. (2003) and Pinto Jr. et al. (2003, 2006a,b, 2007).

3. RESULTS

Figures 2 and 3 shows the geographical distribution of negative and positive LPCCG flashes. The maps correspond to a spatial resolution of 48 km x 48 km (approximately 0.5 degrees x 0.5 degrees).

The negative LPCCG flash distribution is quite different from that for all negative flashes (Pinto et al., 2006b, 2007) suggesting that the peak current distribution is not the same in different regions. Considering the distribution of different type of thunderstorms in the region of study, no dependence on it was evident. In addition, it is quite interesting that large LPCCG flash densities seems to avoid regions where the altitude is larger than 1000 m, as indicated in Figure 4, suggesting that peak current are lower in very high altitude regions. Schulz and Diendorfer (1999) have found that up to about 2000m the mean peak current is almost constant, decreasing at altitudes above 2000m. They suggest that the mean peak current at very high altitudes is affected by fact that very often regions with high altitudes are inside or at least very close to the thunderstorm causing a decrease of peak currents at high altitudes. They also speculate that at very high altitudes either the field signatures of cloud to ground flashes are changed and therefore only some flashes are located. Our results reinforce the hypothesis that negative LPCCG flashes are low frequent at high altitude regions.

The positive LPCCG flash distribution is quite different from that for all positive CG flashes (Naccarato, 2005) and for the LPCCG negative flashes, as it can be concluded comparing Figures 3 and 4. It seems to have a northwest-southeast dependence typically of the frequency of cold fronts in this region, as indicated in Figure 5, not evident on the negative LPCCG flash distribution. Such dependence suggests that positive LPCCG are more frequent in thunderstorm associated with large mesoscale convective systems than in isolated thunderstorms, in agreement with the results obtained by Lyons et al. (1998) in the United States.

Finally, Figure 6 shows the geographical distribution of the percentage of positive LPCCG flashes. The map corresponds to a spatial resolution of 48 km x 48 km (approximately 0.5 degrees x 0.5 degrees). The positive percentage of LPCCG flashes varies from approximately 10% to 40%, with a mean value of 18,9%, slightly higher than the value obtained in the United States by Lyons et al. (13.7%). The distribution does not shown any significant feature, perhaps due to the distinct dependence of negative and positive LPCCG flash distribution.

4. CONCLUSIONS

This paper presents the results of the first climatological study of LPCCG flashes in the Southeastern region of Brazil. While the negative LPCCG flashes seem to avoid regions of altitudes above about 1000 m, the positive LPCCG flash distribution has a dependence apparently related to the occurrence of mesoscale convective systems. All distributions do not show any effect related to large urban areas, as observed for the distributions for all CG flashes [Naccarato et al., 2003; Pinto et al., 2004). From the lightning protection point of view, the results suggest that observations of negative flashes far away of large mountains and of positive flashes in regions where most flashes are related to mesoscale convective systems instead of isolated thunderstorms should be adopted as standard for lightning protection codes.

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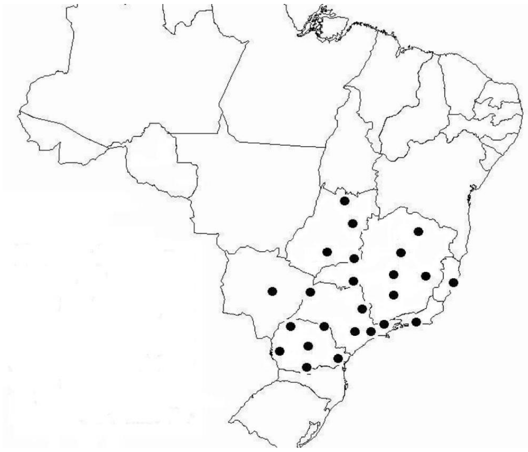

Figure 1. Map of the Southeastern region of Brazil indicating the configuration of the BrasilDat network at the period of this analysis.

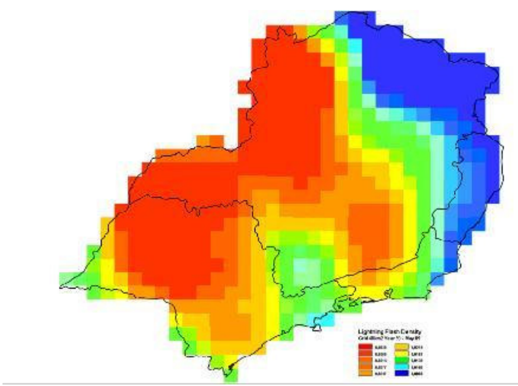

Figure 2. Map of the negative LPCCG flash density in the Southeastern Brazil.

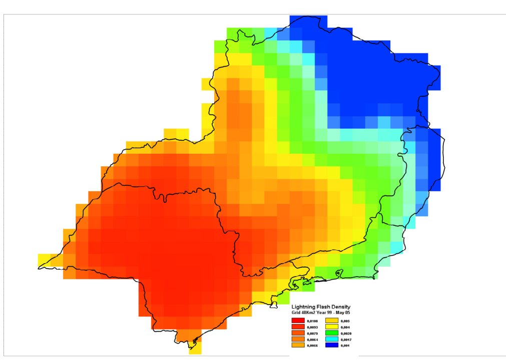

Figure 3. Map of the positive LPCCG flash density in the Southeastern Brazil.

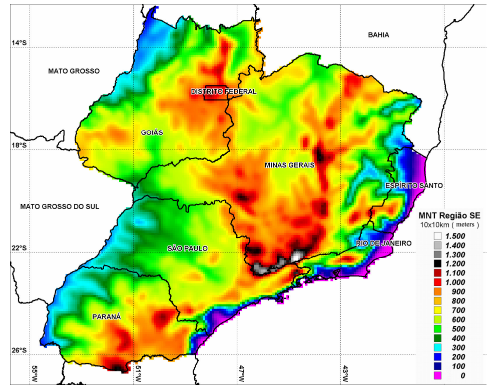

Figure 4. Map of the altitude for the Southeastern Brazil and surrounds (in meters).

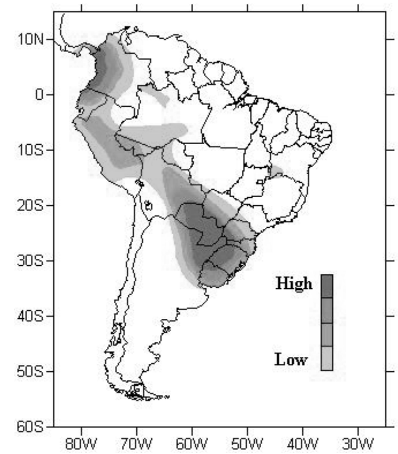

Figure 5. The relative occurrence of large mesoscale convective systems in the South America.

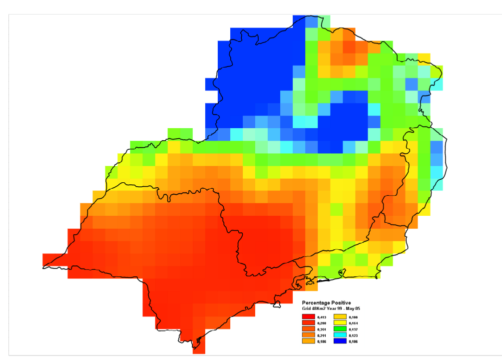

Figure 6. Map of the percentage of positive flashes in the Southeastern Brazil.