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CLOUD-TO-GROUND FLASHES IN SEVERE STORMS: A CASE STUDY IN THE CITY OF SÃO PAULO

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Abstract – Severe storms are characterized by the occurrence of large hail (> 2cm in diameter), winds of 100km/h or higher or tornadoes. Although the number of flashes is not used to define a severe storm, most severe storms produce high number of flashes. Severe storms are of great concern due to their power to cause damage. Unfortunately, however, there is no sufficient knowledge to predict them in most cases. In this paper, it will described a comparative study between two storms that occurred in the city of São Paulo in 25 February of 2005 between: a local storm in the period from 15:10 and 16:05 UT and a severe storm in the period from 17:30 and 19:30 UT. In this preliminary study, some ideas will be presented of how to distinguish local and severe storms in the Southeast Brazil based on lightning data. The analysis of the two storms indicated that the severe storm presented higher flash rate and peak current of negative and positive flashes than the local storm.

1 INTRODUCTION

Severe storms, for its propensity to kill, and to cause material damages, are of great concern not only of the researchers, but also of great part of the people. The necessity to know more aspects of this type of storm is inherent to the pretension to forecast it and to adopt ways to prevent its damages. One of the aspects associate with severe storms is the great lightning production. However, the details about the characteristics of this electric activity are unknown. Still it seems obscure the differences between cloud-to-ground (CG) lightning activity of severe storms and non severe ones. An article series [1, 2, 3, 4] has reported general annual CG lightning properties in the United States. Orville and Huffines [4] had observed in a period of ten years significant regional differences in lightning characteristics. For example, the annual average percentage of positive flashes that is normally of 2% to 10% on the majority of the United States, in the region center-north of the United States is much higher (10% - 20%). More recently, Orville and Huffines [5] had analyzed 3 years (1998 the 2000) of NALDN (North American Lightning Detection Network) data that covered Canada and United States. They showed that the highest percentage of positive occurs in the central region of the United States including the regions of Manitoba and Ontário in Canada.

Carey and Rutledge [6] had carried through the study most complete until the moment of the characteristics of CG lightning in severe and not severe storms, in different regions. They had analyzed the region of the Kansas/Colorado until Minesota in the United States, region that it is previously associated with positive anomalies in the percentage and average intensity of positive CG lightning. They describe significant differences between CG lightning associate with severe and not severe storms. The percentage of positive CG flashes was substantially higher (more than three times bigger) and the negative peak current was higher in severe storms than in no severe storms. In their study, they had arrived at the result that, in this region, 30% - 70% of the positive discharges are associated with severe storms, while only 2%-30% of the negative discharges are associated with them. However, they pointed out that this increase of positive lightning seems to have a regional variation. When other regions had been analyzed, for example Oklahoma, the CG lightning properties associated with severe storms was substantially different from the region of Kansas until Minesota. The authors had concluded that the differences between CG lightning characteristics in severe and not severe storms depend basically on the region of study. The authors also concluded that for US the best criterion to identify a severe storm would be the high flash rate.

Based on the above results, it is evident the importance to make a similar analysis for Brazil, in order to identify these regional aspects. It is important to note that no such a study was made in Brazil. For that, we intend to analyze what are the aspects of the lightning activity can be used to identify severe storms in Southeast Brazil using RINDAT. In Brazil, many

studies using information of the RINDAT have been published [7, 8, 9, 10, 11, 12, 13, 14], but most not related to severe storms.

2 OBJETIVE

The general objective of this article is try to establish differences between the lightning activity of a particular case of a severe storm and a non severe storm, looking for to quantify them. For this we will use the data of the Brazilian Integrated Lightning Detection Network (RINDAT), that provides the spatial and time localization of the CG flashes and the following characteristics: estimate value of the return peak current, polarity, number of return discharges (multiplicity), if the discharge will be of multiple nature. To identify the severe storm we used local observations of at least one of the cited characteristics (hail, strong or high winds).

3 RESULTS

In 25 February of 2005, two storms occurred in the city of São Paulo: a non severe between 15:10 and 16:05 UT and severe one between 17:30 and 19:30 UT. Figures 1 and 2 show the total of lightning of each one of these storms. The non severe storm produced 78 flashes, while the severe storm produced 477 flashes.

3.1 Maximum flash rate in 5 minutes

The first parameter of comparison was the number of lightning in five minutes intervals. In the non severe storm, the maximum rate was of 19 lightning in five minutes, while the severe one reached a maximum rate of 76 lightning in 5 min. In both storms we can observe that the rate grows until reaching a maximum, characterizing a period of larger activity. From there, it decreases until the total dissipation of the cloud. The histogram of figure 3 shows these aspects. As expected, the flash rate per five minutes seems to be in principle a good parameter to distinguish severe and non severe storms in most cases.

3.2 Negative flashes with multiplicity larger than 5

Another parameter that we can study is the multiplicity of lightning, i.e. the number of return strokes in each flash. To analyze this, we observe the lightning occurrence with the multiplicity equal or greater than five. In the non severe storm we had 3 occurrences (4%) and in severe storm 22 (5%). Figure 4 shows the histogram of the number of flashes with multiplicity larger or equal to 5, the number of positive lightning and negatives to each five minutes. This histogram was made in the hope to find some correlation between these three parameters. As we can see in the figure, in principle there are no indicative of severity associated with lightning with great multiplicity. Perhaps, in a more deepened study, with more cases, we can find a relation. We can also see that the severe storm does not present a larger number of positive lightning. In non severe storm, 3% of lightning was positive, while in the severe one, only 2%.

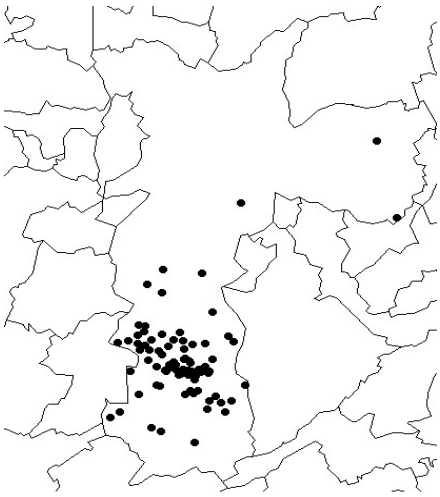

Figure 1: Map of the lightning occurrence in the region of the city of São Paulo in February 25 of 2005, 15:10 to 16:05 UT. This storm was identified as a non severe storm that produced 78 lightning in this period.

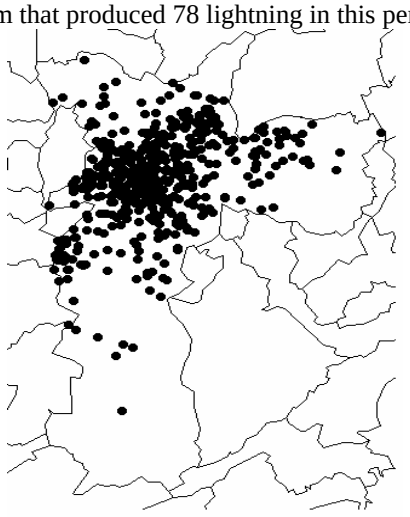

Figure 2: Map of the lightning occurrence in the region of the city of São Paulo in the same day of figure 1 for 17:30 to 19:30 TU. This storm was identified as severe producing 477 lightning in this period.

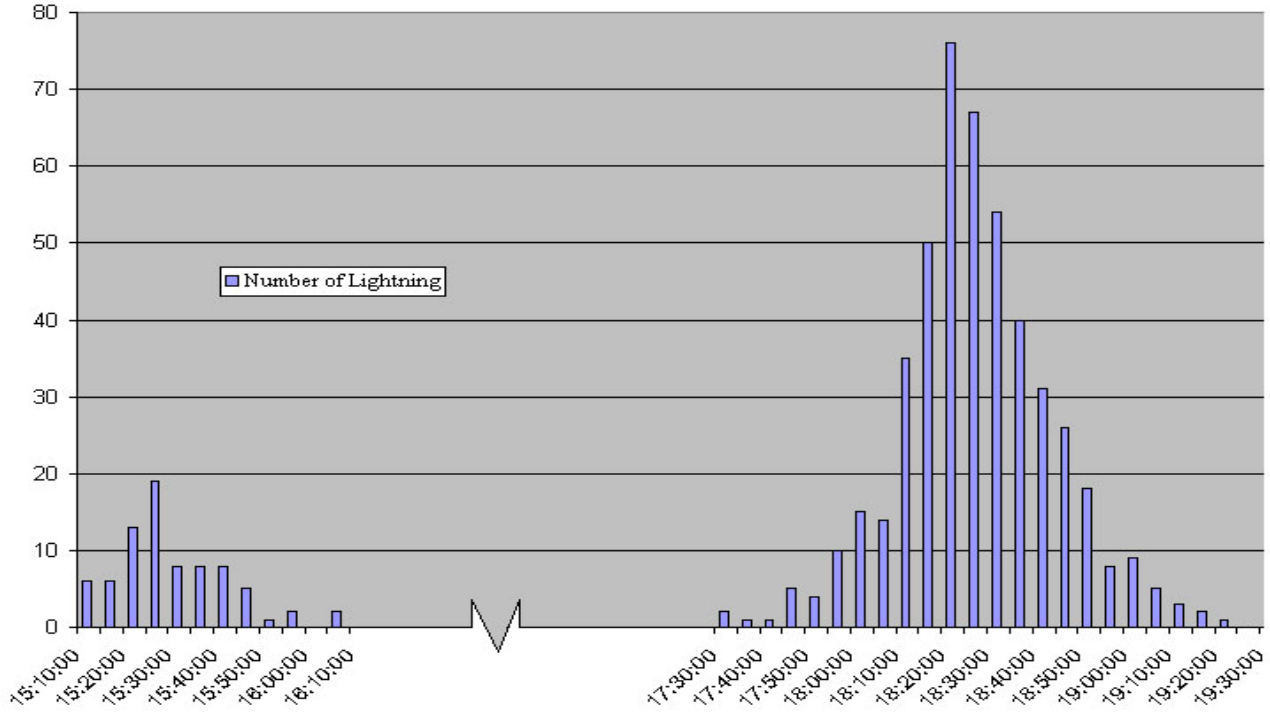

Figure 3: Histogram of the number of lightning to each five minutes of the two storms that occurred in the 25 February of 2005 in the city of São Paulo. From 15h10min to 16h05min occurred the non severe storm, with a peak of 19 lightning between 15h25min and 15h30min. From 17h30min to 19h30min occurred the severe storm, with a peak of 76 lightning between 18h20min and 18h25min.

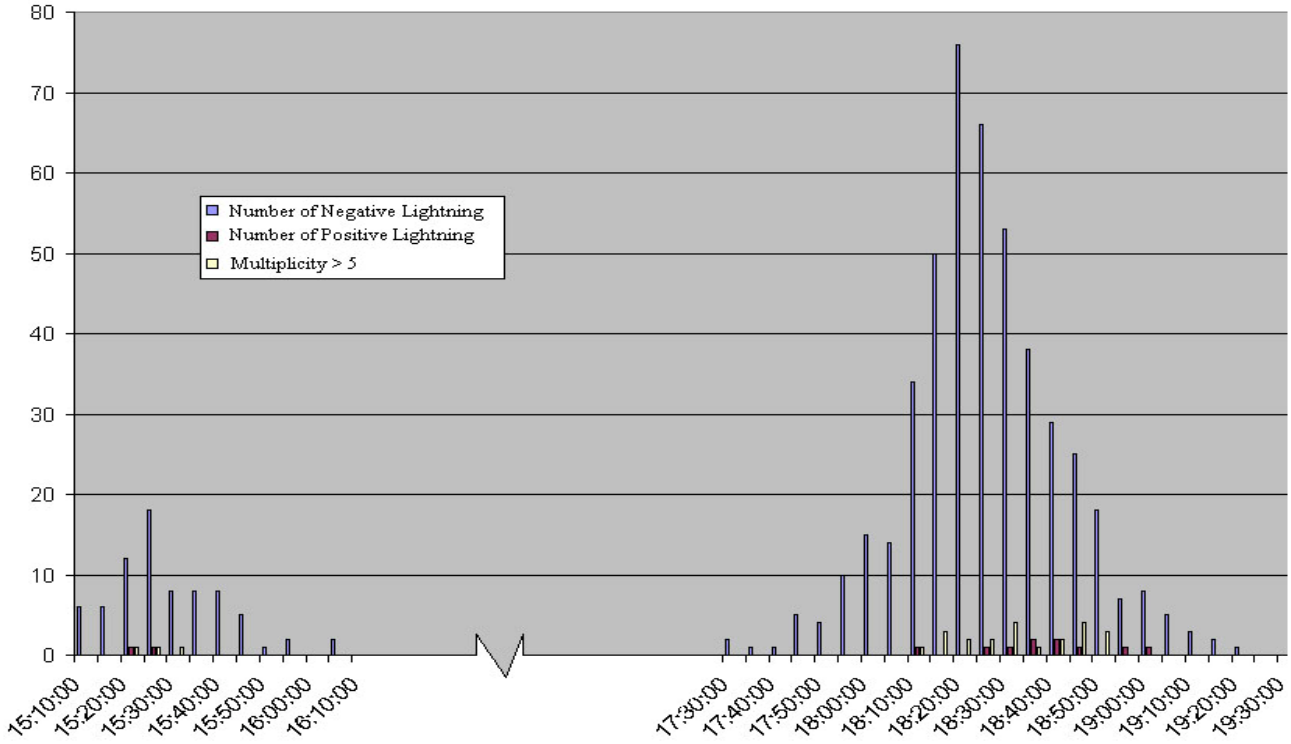

Figure 4: Histogram of the number of lightning with multiplicity bigger or equal than 5, the number of positive lightning and the number of negative lightning, in periods of 5 minutes, for the two storms in figure 3. It was observed that the number of positive flashes and negative (>5) multiple flashes increase proportionally from one storm to the other.

3.3 Peak current

Now we can analyze the peak current of negative and positive flashes for both storms. In figure 5 we can see the average intensities of lightning to each five minutes in both storms. In this histogram we can observe two things: the average intensity of negative lightning increases visibly from the non severe to severe storm. While in the non severe storm the average is around 15 kA, in the severe storm the average goes up to 20 kA. However, the change of intensity most significant is in the positive lightning in which the average of 5kA jumps to an average of 15kA from the non severe to severe storm. Therefore this parameter seems to an indicative of severity of a storm.

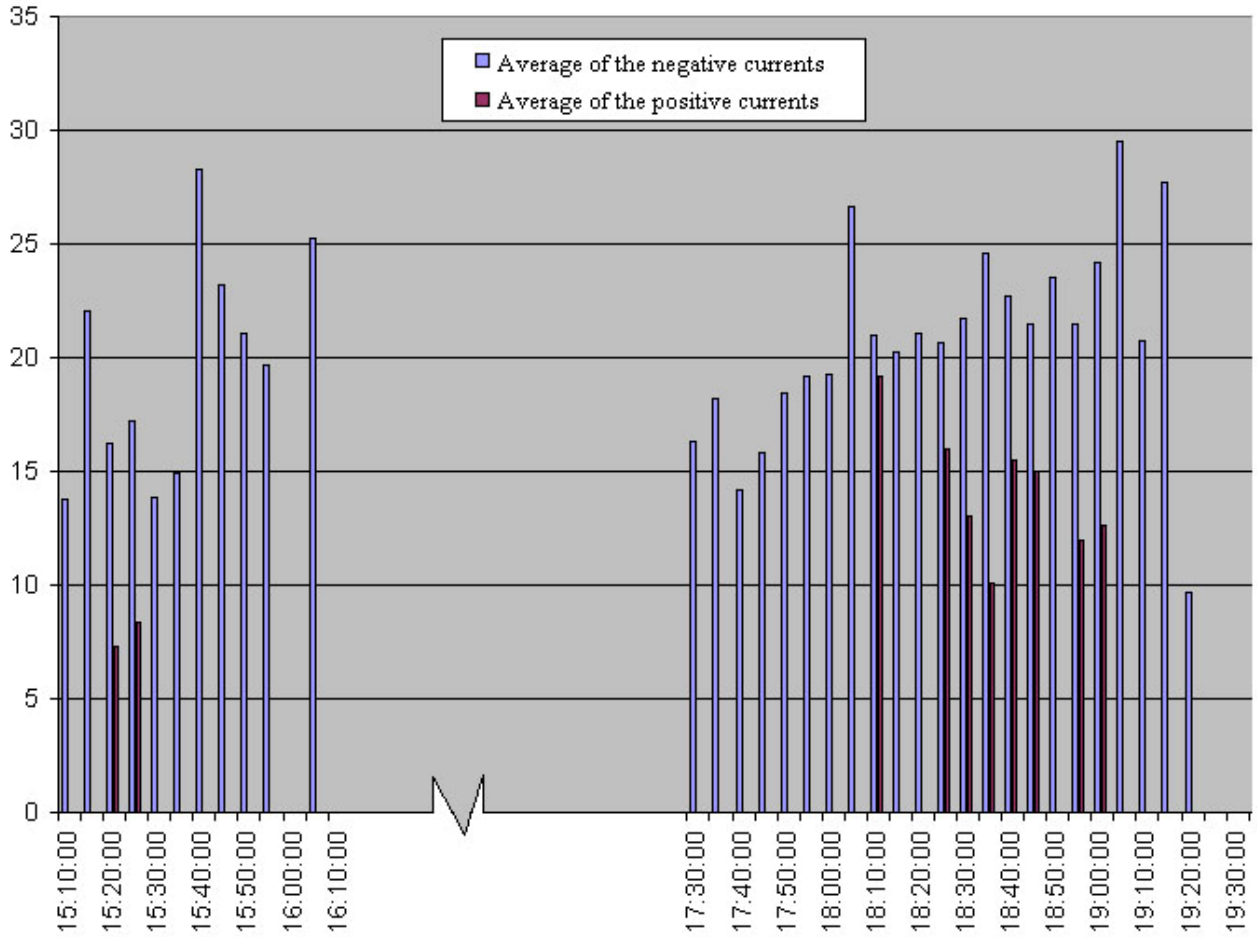

Figure 5: Histogram of the average peak current in kA to each 5 minutes. In the non severe storm on the left we can see that the current intensity of the negative lightning is smaller than the one in the severe storm on the right. However, it was for positive lightning that we found a larger difference of values, indicating that this can be a good parameter of comparison between these two types of storms.

4 CONCLUSION

The analysis of lightning data provided by RINDAT of two storms, one local and one severe, which occurred in the city of São Paulo in 25 February of 2005 was presented. Some lightning parameters were suggested. The data suggest that severe storms have higher flash rate and peak current of negative and positive flashes than the local storms in this region, althought just one case was investigated. It is necessary to study more events in order to have a more complete view about the differences between the lightning characteristics of local and severe storms in this region.

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