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DISTRIBUTION AND CHARACTERISTICS OF LIGHTNING PRODUCED BY MESOSCALE CONVECTIVE SYSTEMS WITHIN SIPAM'S LDN COVERAGE AREA

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Abstract – This work analyzes the spatial and monthly distribution of lightning produced by Mesoscale Convective Systems (MCSs) defined by the "Tropical Rainfall Measuring Mission (TRMM) satellite on the Eastern Amazonia and surroundings, which includes the area of coverage of the of Lightning Detection Network of the Amazonia Protection System (RDR / SIPAM) in the period 1998 to 2008. We selected nine regions of 5° × 5° between the latitudes of 10°S to 5°N and the longitudes of 60°W and 45°W; and grid boxes of 1° × 1° between the latitudes of 5° S to 0° and longitudes of 50°W to 45°W. The results showed that the MCSs more intense are found on latitudinal ranges of 5 ° S latitude to 10 ° S of the region studied, and in the least rainy period in most regions. In sub-regions of 1° by 1°, the largest number of lightning is located between the latitudes 1 to 2° S and longitudes 47 to 50°W and between latitudes of 2 a3° S and longitudes of 46 to 50° W and the largest number of MCSs during the rainy months and/or in the transition between the rainy and the least rainy season. There was also a trend of increase in the number of lightning between 11 years of data analyzed.

1 INTRODUCTION

A mesoscale convective system (MCS) is a cloud system that occurs in connection with a ensemble of storms and producing an area of precipitation of approximately 100 km or more in horizontal scale in at least one direction [1]. According to [2] the MCSs have great contribution in the production of lightning on the eastern Amazonia. Observations have established that the areas with the highest occurrence of lightning have also been the regions where there was a greater contribution of MCSs in the production of lightning. Brazil is known as one of the main areas of lightning activity in the world [3]. An estimated 100 million lightning reach the Brazilian territory per year, causing damage to the society. According to [4] approximately 100 to 200 deaths per year recorded in Brazil are caused by lightning, as well as being responsible for an annual loss of around 500 million dollars to the country. Because of various injuries caused by lightning in the present and the possible increase in the number of occurrences and intensity of this atmospheric phenomenon in the future [5] [6], many researchers have sought not only to understand the lightning, but also how to forecast them. Thus, this work uses data produced by lightning from the MCSs sampled by the "Tropical Rainfall Measuring Mission (TRMM) satellite in the period 1998 to 2008, aiming to analyze the monthly, annual, and spatial distribution of lightning over the area covered by the Lightning Detection Network of the Amazonia Protection System (RDR / SIPAM).

2 DATA AND METHODOLOGY

In this work we used lightning data (cloud to ground, intra-cloud and cloud-cloud types), sampled by the Lightning Imaging Sensor (LIS) aboard the TRMM satellite, in the period 1998 to 2008, in nine regions (Figure 1) of 5 × 5 degrees between the latitudes of 10°S to 5°N and longitudes 60°W and 45°W, located in the Eastern Amazonia and surroundings. The selected regions are included within the scope of the RDR / SIPAM. And, for greater detail on the area of higher efficiency of detection of the RDR / SIPAM (located, according to [7], around the latitude 4 ° S and longitude of 48 ° W) were selected 25 grids of 1° × 1° of latitude and longitude within the sub-region F (between latitudes 0° to 5°S south and longitudes 50° to 45°W. MCSs s All MCSs contain information relating to the brightness temperature in the microwave channel of 85 GHz frequency, radar reflectivity, lightning flashes and volumetric rain. The data were handled by the software Excel, which could generate graphs of the total number of MCSs, lightning, total monthly and total annual of lightning and MCSs

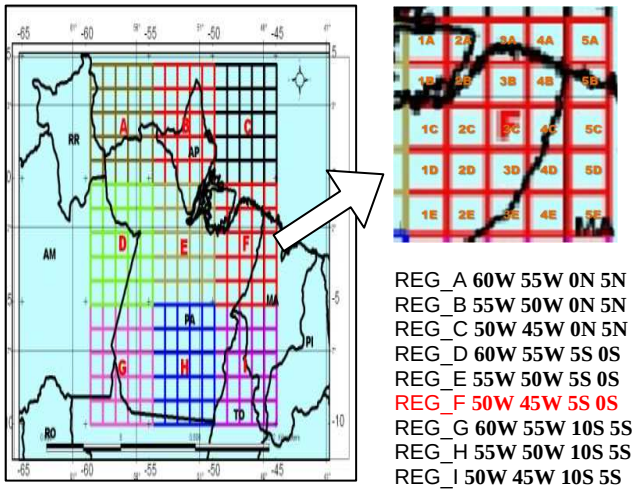

Figure 1. Map of 9 regions used for the analysis of the distribution of MCS's and lightning, with a depth of 1° by 1° in the region F.

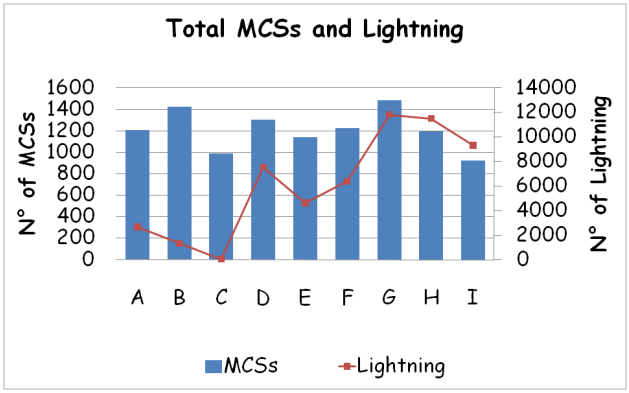

Figure 2. Total number of MCSs and Lightning sampled by the TRMM satellite on the region of study in the period 1998 to 2008.

3 RESULTS

3.1. Distribution of Total MCSs and Lightning in the Nine sub-areas of Study.

We sampled 10,894 MCSs, which were responsible for the production of more than 55,000 lightning flashes in the area from 60°W to 45°W and 10°S to 5° N. The analysis of the distribution of total MCSs and lightning in the area selected (Figure 2) shows that the regions B and G were the ones that had the largest sample of MCSs along the 11 years studied, with values of 1,426 MCSs and 1,485 samples, respectively. Regarding the total number of lightning produced by the MCSs, we observed that the regions located further south of the area studied (regions G, H and I) were those that had the largest number of lightning, with values exceeding 11,800 lightning. While the regions further north of the area studied (regions A, B and C) showed a peak of 2,661 lightning sampled in the sub-region B, a difference of over more than 9,000 lightning flashes. We also noticed that that the total number of MCSs sampled by TRMM showed no large variations between regions when compared to the total sampled lightning flashes, this usually occurs because the MCSs formed in coastal (regions A and B) or oceanic (region C) areas are less intense and less deep, and therefore producing lesser electrified clouds than in continental regions. The region C covers much of the North Atlantic Ocean, and the number of lightning sampled is significantly low, with values much smaller than in the other regions studied. The study by [8], analyzed the frequency of lightning and their hourly and monthly distributions, in the locations of Belém, Paragominas, Tucuruí and São Luís, in the period November 2006 to March 2007. They found that coastal locations tend to have a smaller number of lightning flashes.

The monthly variation of the total lightning and MCSs (Figure 3) shows that the largest samples of MCSs concentrated in the months within the rainy season in eastern Amazonia, which starts in December to May in all regions studied. Regarding the variation of the monthly total of lightning, we can see that the highest values of lightning concentrated in the months belonging to the less rainy period, which begins in the middle of May and runs to mid-November, except in regions E, F region, which covers the area of higher efficiency of detection of lightning RDR / SIPAM) and the region I. As the greater occurrence of lightning occurred in the month of August in the area in July in the area B and C, in September in the areas D, E areas in December and I, in January in F and in October in the G and H. Through the Figure 3 it is evident the large variability in the number of MCSs and lightning existing in the area studied (60°W to 45°W longitude, 0°N to 10°S latitude), in addition, the results observed in the sub-region F, confirms the observations performed by RDR / SIPAM and studied by [9], which have shown higher incidence of lightning in the rainy season. With respect to the annual change of total MCSs and lightning were unable to verify through the graph of deviation (Figure 4), that there was considerable variation in the amount of MCSs in the period 1998 to 2008. However, there is a slight tendency to increase in number of MCSs sampled in 11 years. This may indicate an increase in the intensity of MCSs because, despite the amount of lightning have shown a significant trend of increase, the total number of MCS sampled has undergone major changes annually.

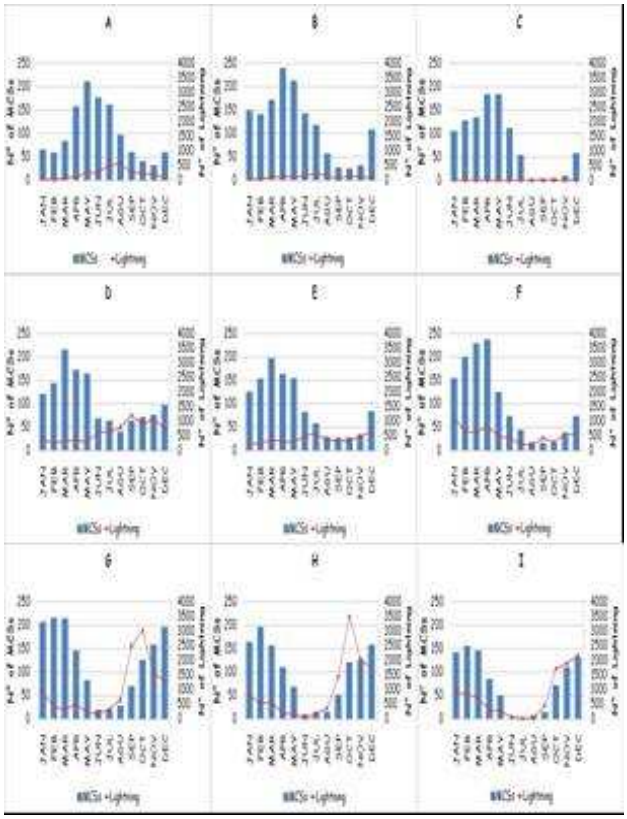

Figure 3. Graph of monthly total of MCSs and Lightning sampled by TRMM satellite on the study region in the period 1998 to 2008.

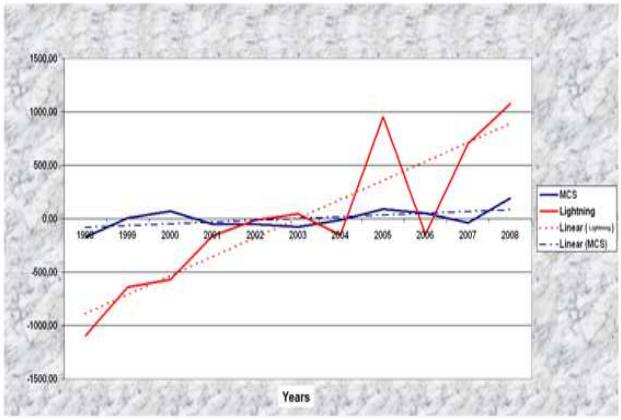

Figure 4. Deviation of Total Annual MCSs Lightning and sampled by TRMM for the period 1998 to 2008 in the 60ºW to 45°W longitude and 5ºN to 10°S latitude.

3.2. Total Distribution of MCSs and Lightning in the 1 x 1 grid boxes

In Figure 4 we can observe with greater detail the distribution of MCSs and lightning on the region F. We found that in areas further north of the selected area (1A, 2A, 3A, 4A and 5A) the number of MCSs shows a decrease in their total to east. The MCSs sampled in the sub-regions of the B sector showed large variability in their total value. And the sectors C, D and E also showed the total sample of MCSs decreasing to east of the area selected. With regard to lightning, we observed that the sector A has the smallest number of occurrences of lightning. In sector B we see a peak in the number of lightning, with a value of 660 lightning in the sub-region 2B, was also found a decrease in the number of lightning to the east. In sector C was observed two peaks of occurrence of lightning in sub-regions 2C and 4C, with values of 680 and 514 respectively lightning. Already in sectors D and E was observed little variation in the total number of lightning, and was found only one peak in the sub-region 1E, which showed a value of 289 lightning. Regarding the monthly variation of the total MCSs and Lightning, we see that all sectors had a higher sampling of MCSs in the rainy season, when the Intertropical convergence zone (ITCZ) is present favoring the formation of cloudiness and precipitation on the Northern Region of Brazil. The total monthly number of lightning present large variation between the sectors studied. In sector A, we observed two peaks in August and November, with values of 85 and 159 of flashes, respectively, while in other sub-regions of the sector there was considerable variation in the total number. In sector B, the monthly lightning number quite varied in the sub-regions studied and was found the highest value in January in the sub-region 2B, in the sub-region 5B there was considerable variation in the monthly total of lightning. In sector C, also the total number of lightning showed large monthly variation and was found a peak in the number of lightning in September in the sub-region 1C, in January and December in the sub-region 2C, in February 3C in the sub-region, in January, March and October in the sub-region 4C and two less significant peaks in April and September in the sub-region 5C. In sector D, the largest total of lightning is concentrated in the months within the rainy season, except in the sub-region 1D, in which two peaks: one in April and another in November. Sector and also the largest total of lightning is concentrated in the months within the rainy season, except in the sub-region 5E where the peak of lightning occurred in October. A general analysis on the area F shows that the sub-regions located further northeast of the studied area (2A, 3A, 4A, 5A, 4B, 5B and 5C) did not show large variations in the monthly total of lightning. Sub-regions in the center-north (2B, 3B, 2C, 3C and 4C) and located in the northwest (1A, 1B and 1C) of the selected area show more variation in monthly total of lightning.

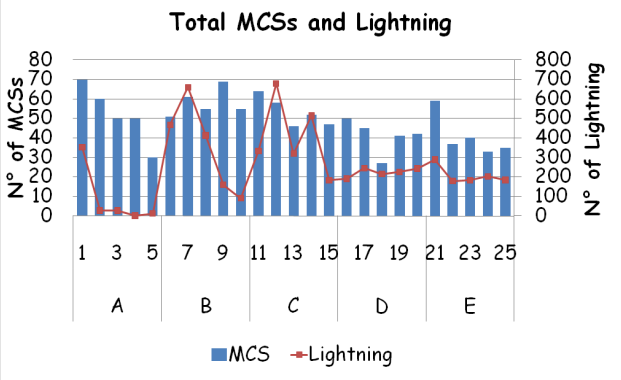

Figure 5. Total number of MCS's and Lightning sampled by TRMM satellite on the sectors A (1A, 2A, 3A, 4A and 5A), B (1B, 2B, 3B, 4B and 5B) C (1C, 2C, 3C, 4C and 5C) D (1D, 2D, 3D, 4D and 5D) and E (1E, 2E, 3E, 4E and 5E) in the period 1998 to 2000.

4 CONCLUSIONS

This work showed that the most intense and electrified MCSs are in the southern regions of the area studied (regions G, H and I), with production exceeding 8,000 lightning flashes in each region. It was also observed that the MCSs have large contribution to the rainy season in eastern Amazonia. However, the most intense and electrified MCSs are found in months belonging to the less rainy period, except in sub-regions E, F and I. The annual analysis showed that there was a tendency to increase the number of lightning in the 11 years studied, having been established in the year of 2008 a million cases more than the annual average of 10 years. This indicates a possible increase in the intensity of the MCSs in the Eastern Amazon, although the deviation in the annual amount of MCSs showed no significant increase in recent years.

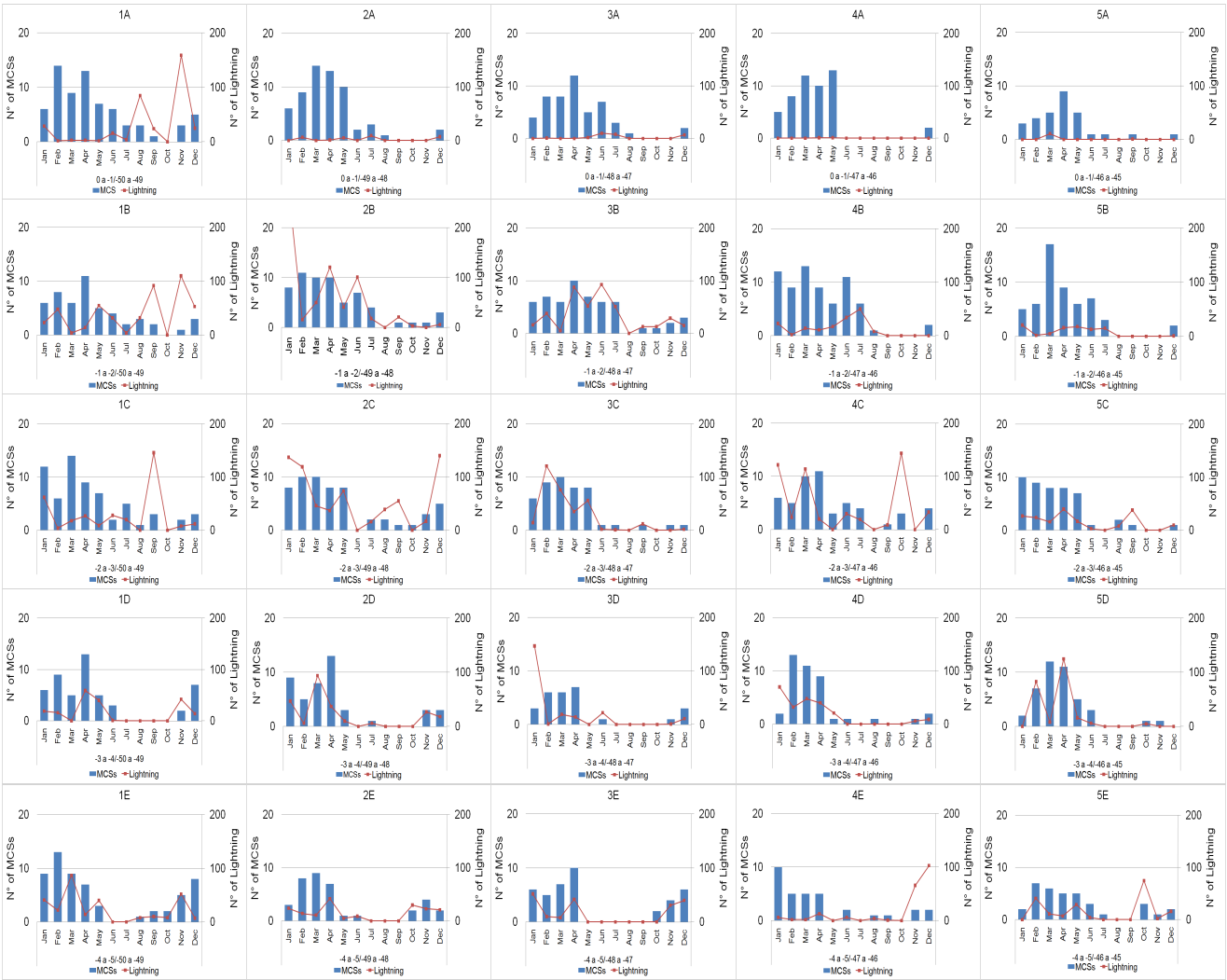

Figure 6. Graph of monthly total MCSs Lightning and sampled by the TRMM satellite on the sectors A (1A, 2A, 3A, 4A and 5A), B (1B, 2B, 3B, 4B and 5B) C (1C, 2C, 3C, 4C and 5C), D (1D, 2D, 3D, 4D and 5D) and E (1E, 2E, 3E, 4E and 5E) in the period 1998 to 2000.

As regards the distribution of lightning over the area F, there is great variability in total lightning in this region, has been found that the sectors B and C (respectively the latitude ranges from 1 to 2°S and 2 to 3°S) are the most varied, while the sectors D and E show little longitudinal variation in total lightning on those sub-regions. Having been observed a peak of occurrence of lightning in the sub-region 2B, 2C and 3C .

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