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DRY TO WET SEASON CHANGES IN THE LIGHTNING ACTIVITY IN THE NORTH REGION OF BRAZIL

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1. INTRODUCTION

In the north region of Brazil the thunderstorm activity is larger from October to December. On the other hand, the concentration of aerosols is higher in August and September, decreasing from September to December. Therefore, the storms in October/September are formed in an atmosphere rich in smoke from forest fires, while those in November/December are formed in a much clean atmosphere. This work is focused on the lightning occurrence in the state of Rondônia, in the North region of Brazil, from 01 Aug. 2002 to 12 Feb. 2003 and 01 Aug. 2003 to 25 Dec. 2003. The goal of the study is analyze the characteristics of existing lightning in the very contrasting atmospheres.

2. DATA AND METHODS

The investigated region of north of Brazil is located between latitudes 8° S and 14°S and longitudes 59°W and 66°S, including the total area of Rondônia and parts of Bolivia, Mato Grosso and Amazon. This area is showed in Figure 1. The study started in the dry season and finished in the wet season for two years, from Aug/1/2002 to Feb/12/2003, and from Aug/1/2003 to Dec/25/2003. The lightning data were obtained by four Impact sensors (T-141 ES), as showed in Figure 1, and by the Lightning Imaging Sensor (LIS) on board of TRMM satellite. The sensors give the discharge location, the time and current peak, while LIS gives the lightning location and time, without to discriminate cloud-to-ground to intra-cloud lightning. The comparison between LIS and the sensors data allowed to calculate the ratio (IC:CG) for this region during the LIS satellite exposition.

Because the sensors located in Guajará-Mirim - RO was off in 2002 August, the efficiency of the network was considered about 40% during this period. In the remaining period, the efficiency was considered about 75%. (Blaskeslee, private communication). The efficiency of LIS was assumed about 73% for daytime and 93% for the nighttime (Boccipio et al., 2002). To prevent the lightning contamination by intra-cloud (IN) flashes in the data obtained by the sensors, positive flashes with peak current less than 20 kA were neglected, in opposite to the recommended value of 10 kA (Cummins et al 1998). Despite of this, the results are not significantly modified if it the 10 kA was adopted. To avoid local time bias in the LIS data 49 days windows were adopted in the analysis. Four windows were considered: 01 Aug. to 18 Set. (W1), 19 Set. to 06 Nov. (W2), 07 Nov. to 25 Dec. (W3), and 26 Dec. 2002 to 12 Feb. 2003.

The ratio (Z) between the intra-cloud (IC) and cloud-ground (CG) flashes is given by the following expression (1):

$$Z = \frac{\frac{R_{LIS}}{DE_{LIS}} - \frac{R_{net}}{DE_{net}}}{\frac{R_{net}}{DE_{net}}} \qquad (1)$$

where R_{LIS} is the LIS flash rate and $R_{NET,}$ the network flash rate, both with a of 1degree x 1degree resolution inside the region of study. The detection efficiency (DE) for LIS is: DE_{LIS} = 0,93, during nocturnal satellite observations and DE_{LIS} = 0.73, during the daily satellite observations. For the sensors, it was adopted DE_{NET} = 0,4 for August of 2002 and DE_{NET} = 0,75 for the remaining portion of the period.

The concentration of aerosols was obtained from the model of emission and transport "Coupled Aerosol and Tracer Transport model to Brazilian Regional Atmospheric Modelling System" - CATT-BRAMS. This model supplies the "Columnar Particulate Material (dp<2.5μm)" - PMINT2.5 (μg m^{-2}), in 9 daily times (UTC): 0, 3, 6, 9, 12, 15, 18, 21 and 24, for the regional 40 km X 40km grid. In order to associate the lightning parameters with the PMINT2.5, the formers were grouped in the same space resolution of the regional grid. So, for each grid of 40 km X 40 km, that contains a value of the PMINT2.5, also was added the number of positive and negatives lightning, the average peak current for both polarities and the percentage of positive lightning. The lightning data were grouped in intervals of 3 hours like the time supplied for the model. The grid was classified in function of the PMINT2.5 in three groups: Polluted (PMINT2.5>30000 μg m^{-2}); moderate (9000<PMINT2.5<30000 μgm^{-2}) and clean (PMINT2.5<9000 μgm^{-2}). To increase the confidence, it was adopted maximum value for the clean grid larger than the value of "background" (12000 μg m^{-2}), and the minimum value for the pollute grids approximately three times larger than this value.

3. RESULTS

As showed in Figures 2 and 3, the most significantly lightning activity occurs in windows 02 and 03, but this distribution does not affect the peak current behavior. In the two analyzed periods, the daily average of the negative current peak presented an interesting systematic growth during the days (Figures 4 and 5), while the daily average of the positive current peak presented significantly fluctuation (Figures 6 and 7). In windows 01 and 02 practically there are no daily averages peak currents up than 30kA, while in windows 03 and 04 there are no values below of 20 kA. Inside of window 01 it was noticed that the percentage of strong lightning above 50 kA corresponded to 5% of all negative lightning in both periods (Figure 8 and 9). This percentage increases from window 01 to window 04.The same analysis for positive lightning showed opposite behavior. The highest percentage of positive flashes with peak current up to 50 kA was observed in window 01 and it decrease toward window 04. The percentage of positive CG lightning presented a distribution opposite to that for the flash rate of the CG lightning. The highest percentage was found inside of window 01 (Figures 10 and 11). The average of the intracloud to cloud-to-ground ratio and the flash rate for each window presented in Figure 12 show that in window 01 the ratio is higher than the ones observed in the other windows. Rutledge et al (1992) found that IC/CG ratio tends in general to increase with the lightning rate per minutes what it was not observed in this work. The lowest intensity of the negative peak current exactly in window 01, where the highest IC/CG ratio occurs (Figures 4 and 5), could lead to believe that perhaps the contamination of the IC on the CG also occurs in the negative lightning. However, Table 1 indicates that it is not the case, since even excluding the negative lightning with peak current below 20 kA in the analysis, the average still is lower in window 01. In reality, the reason for this fact is lack of negative lightning with high intensity current peak, for example, up of 50 kA.

The averages for each window indicated in Table 1 are also showed in Figure 13 as a function of the PMINT2.5. It can be noted that the positive peak current and the percentage of positive lightning increase as PMINT2.5 increases, while the negative peak current decreases.

4. CONCLUSION

The main differences between the polluted and clean periods observed in this work was a decreases in the intensity of the negative peak current, while the percentage of positive CG lightning and the positive peak current increase with the aerosol concentration, in agreement with was observed by Lyons et al, 1998 and Murray et al, 2000. In the polluted period, it was also observed high percentages of intra-cloud lightning. The high percentages of positive lightning were found in windows 01 and 02, where the higher values of the IN/CG ratio were also found. Boccippio et al. (2000) e Pinto et al. (2003) found a correlation between Z and the percentage of positive lightning. Boccippio et al. showed that high values of Z only occur in regions with high percentages of positive lightning, although the reciprocal is not true.

In the comparative analysis with the data from the transport and emission of aerosols model, the polluted grids presented higher percentages of positive lightning and higher average positive peak current in comparison with the values of the clean grids, while the opposite occurs with the average negative peak current. This behavior suggests that the electrical structure of polluted clouds is modified due the high aerosol concentration.

5. REFERENCES

Boccippio, D., K. Cummins, H. Christian and S. Goodman, Combined satellite- and surface based estimation of the intracloud-cloud-to-ground lightning ratio over the continental United States, Mon. Wea. Rev., 129, 108-122, 2000.

Boccippio, D.J., Koshak, W.J., e Blaskeslee, R.J.,Performance Assessment of the Optical Transient Detector and Lightning Imaging Sensor. Part I: Predicted Diurnal Variability . *J. Atmos. Oceanic Technol.,* 19, 1318–1332. 2002.

Cummins, K. L.; Murphy, M. J.; Bardo, E. A.; Hiscox, W. L., Pyle, R. B.; Pifer, A. E. A combined TOA/MDF technology upgrade of the U.S. National Lightning Detection Network. J. Geophysical Research. v.103, D8, p. 9035-9044, Apr. 1998.

Lyons, W.A., T.E. Nelson, E.R. Williams, J. Cramer, and T. Turner, Enhanced positive cloud-to-ground lightning in thunderstorms ingesting smoke, Science, 282, 77-81, 1998.

Murray, N., R. Orville and G. Huffines, Effect of pollution from Central American fires on cloud-to-ground lightning in May 1998, Geophys. Res. Lett., 28, 2597-2600, 2000.

Pinto, O., Jr., I.R.C.A. Pinto, and H.H. Faria., A comparative analysis of lightning data from lightning networks and LIS sensor in the North and Southeast of Brazil, Gephys. Res. Lett., 30(02), 1073 -1076, 2003.

Rutledge, S.A., E.R. Williams, and T.D. Keenan, The Down Under Doppler and Electriccity Experiment (DUNDEE): Overview and preliminary results. Bull. Amer. Meteor. Soc., 73, 3-16, 1992.

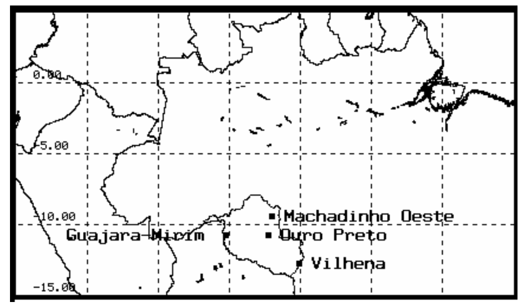

Figure 1 – Locations of the lightning sensors in the North region of Brazil.

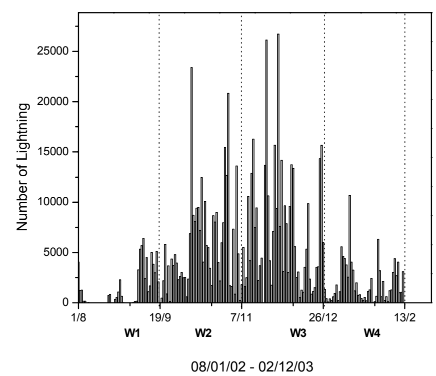

Figure 2 - Daily distribution of the CG lightning from August, 01 of 2002 to February, 12 of 2003.

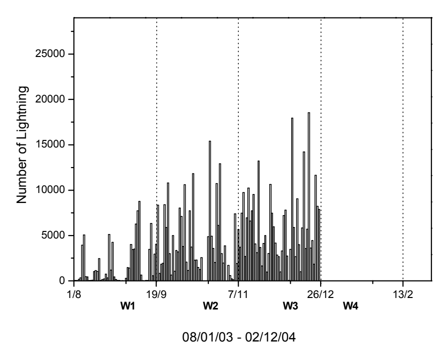

Figure 3 - Daily distribution of the CG lightning from August, 01 to December, 25 of 2003.

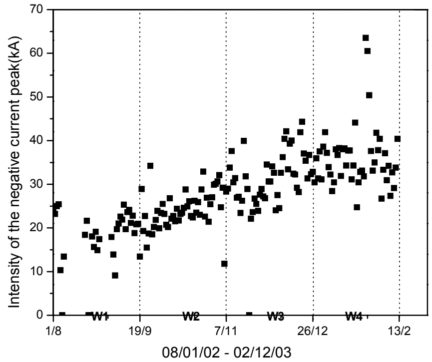

Figure 4 - Daily distribution of the negative peak current from August, 01 of 2002 to February, 12 of 2003.

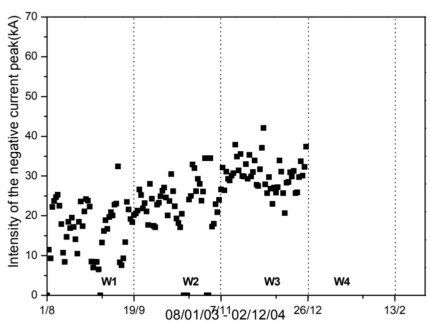

Figure 5 - Daily distribution of the negative peak current from August, 01 to December, 25 of 2003.

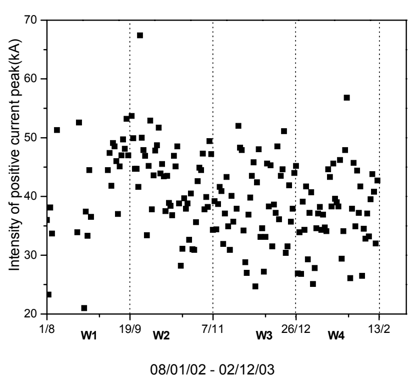

Figure 6 - Daily distribution of the positive peak current from August, 01 of 2002 to February, 12 of 2003.

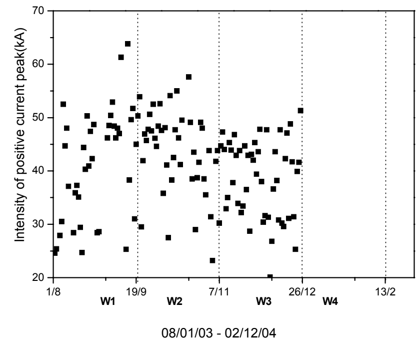

Figure 7 - Daily distribution of the positive peak current from August, 01 to December, 25 of 2003.

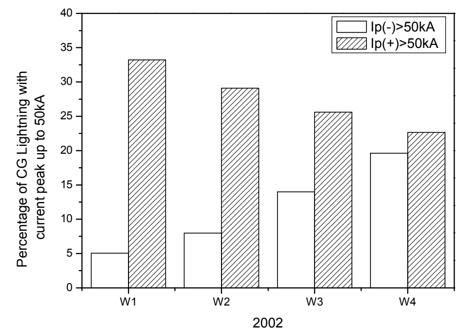

Figure 8 - Percentage of flashes with peak current higher than 50kA, for both polarities in the 2002 windows.

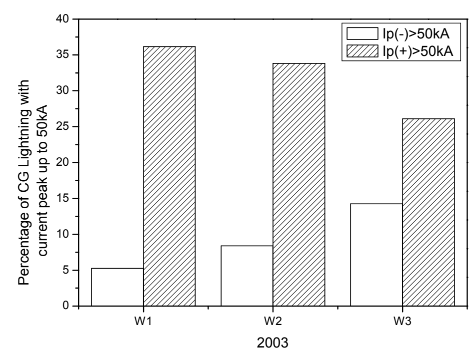

Figure 9 - Percentage of flashes with peak current higher than 50kA, for both polarities in the 2003 windows.

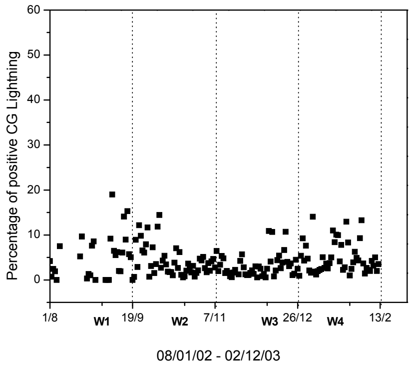

Figure 10 - Daily distribution of the percentage of positive CG lightning from August, 01 of 2002 to February, 12 of 2003.

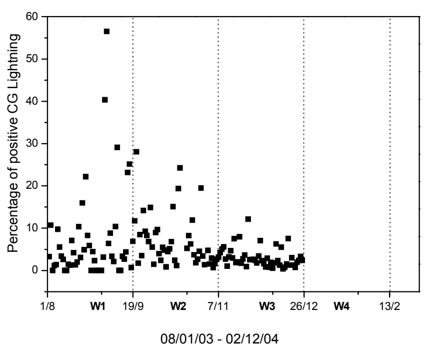

Figure 11 - Daily distribution of the percentage of positive CG lightning from August, 01 to December, 25 of 2003.

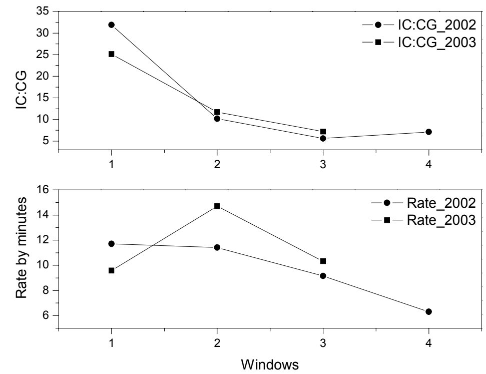

Figure 12 - Ratio the lightning IC/CG and flash rate per minute for each window.

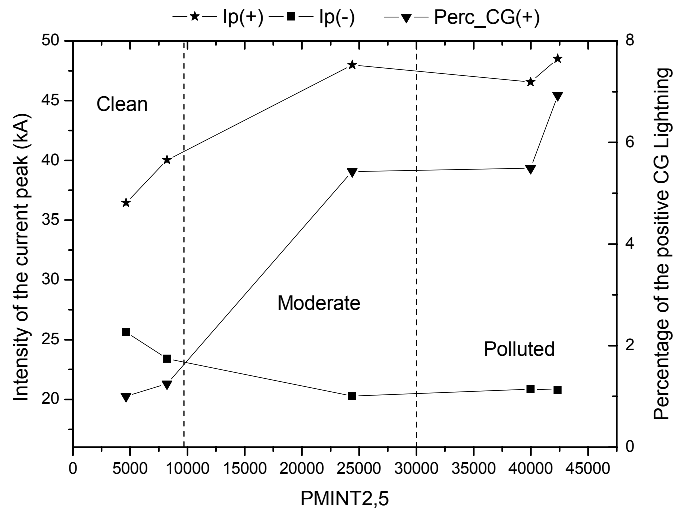

Figure 13 - Average values for different windows of the negative and positive peak current and the percentage of positive CG lightning as a function of the average PMINT2.5.

		Number CG(-)	Number CG(+)	% CG(+)	Ip(-) kA	Ip(+) >20kA	Ip(-) >20kA
2002	W_01	58103	5007	7.9	21	47	33
	W_02	276562	10351	3.6	24	43	36
	W_03	344646	10063	2.8	29	42	41
	W_04	94885	3414	3.5	34	39	46
2003	W_01	71909	8488	10.6	21	48	34
	W_02	191753	13975	6.8	25	47	37
	W_03	285545	9150	3.1	30	43	41

Table 1 - Number of positive and negative CG lightning, percentage of positive CG lightning and the average of positive and negative peak current of CG lightning for the different windows.