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RAINFALL SPACE VARIABILITY DURING THE LBA/TRMM EXPERIMENT IN AMAZONIA1999

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1. INTRODUCTION

The Amazon forest has a high level of rainfall (average annual precipitation ranging from 2,000 up to 2,200mm) associated with very strong convective activity, with long periods of intense rain during the year. The rainfall in the rainy season peaks usually exceeds 250mm/month. Convective rainfall is very frequent in equatorial regions. As the winds are weak the air movement is basically in the vertical direction (Tucci, 1997), producing convection, cloud and rain processes. This process is typically local (variation scale less than 1km) and has a short duration (less than 1 hour). Another important characteristic associated with convective rains is their intermittence. The main convective activity on the planet occurs in Amazonia and it may have a great influence on the climate in other places due to horizontal energy and vapor transport. Nowadays, for example, the way atmospheric transport in Amazonia may affect the behavior of the Prata River watershed pluviosity regimen, 3,000km from Amazonia (Vera et al. 2006) is studied.

Information about rainfall in Amazonia, despite being the climatic element with the largest amount of available records, is still scarce and concentrated in the villages and towns, or along the roads or rivers used as a transport system. Molion and Dallarosa (1990), for example, discuss some errors originating in studies of the Amazonian pluviosity regimen that are based in the main on rainfall data from sites along the rivers. More recently, Tota et al. (2000) and Marengo et al. (2004) analyzed the same data set used in this work so as to study point rainfall occurrence (Tota et al., 2000) or occurring all over the state area (Marengo et al. 2004). But, those authors did not study how convective rainfall varies spatially and its spatial-temporal interrelations. The spatial-temporal relations are important to extrapolate point measurements to represent large areas in hydrologic applications, such as estimating the total amount of water generated in a river basin during a storm.

This work intends to analyze rainfall data sets with high spatial resolution recorded during the LBA (Large Biosphere Atmosphere)/TRMM (Tropical Rainfall Measuring Mission) 1999 experiment (more details in Silva Dias et al., (2002), or in http://www.master.iag.usp/lba) and to determine the rain's spatial distribution, aiming to help in characterizing and understanding the rainfall events in the Amazon region.

2. DATA SETS AND METHODOLOGY

The study was based on the data sets recorded during the LBA/TRMM experiment 1999 (Tota et al., 2000 and Marengo et al., 2004). Thirty-seven tipping bucket gauges were installed, forming four networks. In network 1, there were 14 rain gauges, in network 2, 13, in network 3, 5 and in network 4, 5 rain gauges. The sites were located in different places in Rondonia state and centered in Ji-Parana village. Table 1 shows the geographical location of the gauges, with a maximum distance between them of around 50km. Figure 1 shows the layout of the experimental networks and also the other rainfall sample points operated during the LBA/TRMM, which were not analyzed in this work. A detailed analysis of the pluviosity regimen was presented by Dias (2000) and Marengo et al. (2004).

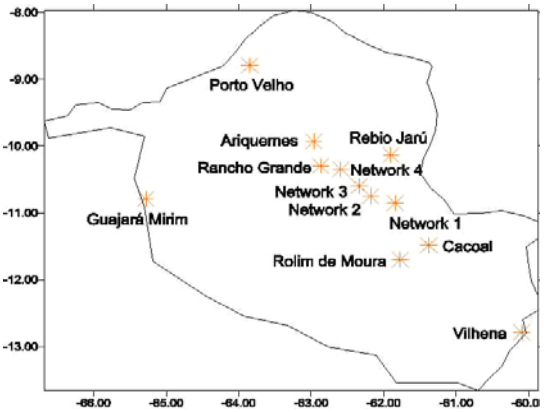

Figure 1- Rondonia state map showing the 4 networks geographical coordinates during the LBA/TRMM 1999 experiment.

The field campaign period lasted from December 23rd 1998 to February 28th 1999, which represents the rainy season. Although this two-month period can be considered a short period, the total rainfall amount recorded was high (more than 500mm), presenting many rainfall events (basically originating from convective processes). Anomalies related to rainfall and temperature were not recorded in that period in Rondonia state, so the period presented typical meteorological conditions for the region for the rainy season. The equipment was calibrated before the field campaigns and the gauges records were surveyed to perform quality control and to detect mechanical or electronic failures. Some

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rainfall gauges were eliminated from the analysis because they presented long and obvious failures. This happened to gauges 3, 5, 10 and 14 (network 2), gauge 24 (network 1) and gauge 33 (network 4).

The methodology of interstation correlation (based on conditional probability and assuming a bivariate mixed lognormal distribution) was applied to daily rainfall. The correlation takes into account the records on two gauges and the distance between them. The methodology was proposed by Habib and Krajewski (2001) departing from convective rainfall data collected in Florida during the Teflun_B summer 1998 experiment to perform the calibration of radar measurements and to validate the TRMM satellite TRMM data.

3. RESULTS AND DISCUSSION

The original information stored in the installed gauges was the beginning and the end of each rainfall, besides the amount of precipitated water. The recorded information was converted to daily precipitation integer values in mm, to follow the premises recommended by Habib et al. (2001) and Shimizu (1993). Although total daily rainfall was employed, the rain events were independent as the rain occurred once a day, characterizing convective processes. Moreover, although the two-month period can be considered a short observation period, the cumulative rainfall observed was very high when compared to the regional climatology.

Applying the methodology proposed by Shimizu (1993) it was possible to obtain the correlation coefficient between all the gauges considered. The distance between gauges was estimated with the aid of geographical coordinates (Table 1).

Figure 2 shows the correlation coefficient on the vertical axis and the distance between gauges on the horizontal axis for all pairs of gauges analyzed.

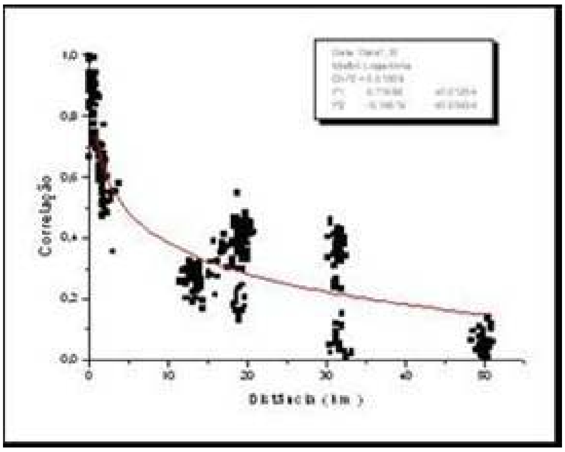

Figure 2. Correlation coefficient versus between all pairs of gauges analysed.

A least squares method was used to fit the correlation coefficient variation with distance, assuming a logarithmic model. The best curve fitted to the data was:

$$\rho = 0.7169 - 0.1452 \ln(\mathbf{d}) \qquad \mathbf{(1)}$$

where ρ is the correlation (dimensionless) and **d** is the distance (km) between two gauges. Applying the equation 1 it is possible to estimate ρ which varies from 0.86 for convective cells very close to each other (0.5km distance) up to 0.75 for 1km distances. If the distance is 2km the correlation coefficient is 0.48, 0.38 and 0.15 for 5, 10 and 50km distances.

4. CONCLUSIONS

The rainfall in Amazonia is predominantly local and convective. However, the intermittent behavior of the precipitation process leads to large spatial variability, which causes uncertainties when a point value is used to extrapolate the value on the area (Ali et al. 2003). This sort of problem will certainly be minimized in the coming years when the SIVAM/SIPAM project will be operating ten meteorological radars in the Amazon region.

The results obtained show that for gauges separated by up to 1km the correlation coefficient is high, varying from 0.7 up to 0.9. For gauges separated by 5km, the correlation was 0.2 to 0.4. These low values are usual in local rainfall of short duration and intense cells that are characteristic of convective rainfall events. Therefore it is possible to conclude that the convective rainfall events during the LBA/TRMM were representative in a 1km radius. The results obtained can help to improve the understanding of rainfall modeling and its inclusion in Climatic Model Forecasting.

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Table 1 . Rain gauge´s geographical coordinates.

Raingage	Latitude S	Longitude W	Raingage	Latitude S	Longitude W
1	10º 46' 11"	62º 7' 48"	19	10º 52' 48"	61º 51' 0"
2	10º 45' 35"	62º 9' 35"	20	10º 52' 48"	61º 51' 0"
3	10º 45' 35"	62º 9' 35"	21	10º 52' 48"	61º 51' 0"
4	10º 44' 24"	62º 11' 23"	22	10º 52' 48"	61º 51' 0"
5	10º 46' 47"	62º 11' 23"	23	10º 52' 48"	61º 49' 47"
6	10º 45' 0"	62º 10' 47"	24	10º 52' 48"	61º 57' 36"
7	10º 45' 0"	62º 10' 47"	25	10º 52' 48"	61º 51' 35"
8	10º 45' 0"	62º 10' 47"	26	10º 51' 0"	61º 51' 35"
9	10º 45' 0"	62º 10' 47"	27	10º 52' 48"	61º 51' 0"
10	10º 46' 11"	62º 11' 23"	28	10º 35' 23"	62º 21' 0"
11	10º 46' 47"	62º 10' 47"	29	10º 35' 23"	62º 20' 24"
12	10º 46' 47"	62º 10' 47"	30	10º 36' 0"	62º 20' 24"
13	10º 46' 47"	62º 10' 47"	31	10º 35' 23"	62º 20' 24"
14	10º 51' 35"	61º 50' 24"	32	10º 36' 0"	62º 20' 24"
15	10º 52' 11"	61º 51' 0"	33	10º 21' 0"	62º 34' 12"
16	10º 52' 11"	61º 50' 24"	34	10º 20' 23"	62º 33' 36"
17	10º 52' 11"	61º 50' 24"	35	10º 21' 0"	62º 34' 47"
18	10º 52' 11"	61º 51' 0"	36	10º 21' 0"	62º 35' 24"