

# THERMODYNAMIC CLASSIFICATION OF CAXIUANÃ DURING THE DRY SEASON

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## 1. Introduction

In the Amazonian, the characteristic of the cloudiness is of cumuliform cloud resulting mainly, of the liberation of latent heat, because exists great amount of humidity and heat being transported vertically in the atmosphere. Due to the turbulent state of the atmosphere, these cumulus clouds in the majority of time they grow reaching the tropopause forming the cumulonimbus clouds. The development, the movement and the decline of these clouds constitute an important link in the maintenance of the atmosphere general circulation (Riehl, 1979). In other words, the cumulus clouds supply the necessary heat to move the circulation of large scale and the disturbances of large scale produce the essential convergence to feed the cumulonimbus convection.

The thermodynamic structure of the atmosphere presents, usually, a diurnal cycle very defined with heating during the day and cooling during the night and the dawn, which it is associated to the transfer of energy originating from the solar radiation and of amount of water present water in the atmosphere (Betts, 1974). In the Amazonian, this structure is very influenced by the high humidity contained in the atmosphere so much that in rainy days the same is colder than in the dry days (Riehl et al, 1973).

The purpose of this paper is to do the thermodynamic classification of the soundings of Caxiuaná, during a dry season in the east region of Amazonian, using the proposal of Betts (1974).

## 2. Data and methodology

### 2.1 - Data

The data used in this study were collected during the Amazonian East Mesoscale Circulation Experiment (CiMeLA), accomplished in the period of 10/28/03 until 11/15/03 in the Pena Ferreira Scientific Station in Caxiuaná (01°42'30 " S, 051°31'45 " W), which is a forest reservation located in the east of the State of Para in the municipal district of Melgaço (Illustration 1).



Illustration 1 - Location of Caxiuaná - PA

During the period of the experiment were set afloat thrown four rawinsonde soundings daily, whenever possible, in the following synoptic schedules: 00, 06, 12 and 18 UTC, using the system VÄISÄLA RS 80-15 G, what totaled 65 soundings. It was also collected the happened rainfalls during the experiment.

### 2.2 - Methodology

The methodology used in this study was developed by Betts (1974) and after it was adapted for Belém by Ribeiro and Mota (1994), where the soundings are classified according to the thermodynamic characteristics of the atmosphere accordingly in association with the rainfall happened.

To do the classification of the soundings it was calculated the thermodynamic parameters like the equivalent potential temperature ( $\theta_e$ ) and saturation equivalent potential temperature ( $\theta_{es}$ ), using the equations proposed by Betts (1973), and after modified by Bolton (1980).

$$\theta_e = \theta \exp \left[ \left( \frac{3,376}{T_L} - 0,00254 \right) r (1 + 0,81 \times 10^{-3} r) \right] \quad (1)$$

$$\theta_{es} = \theta \exp(2,64 r_s / T_K) \quad (2)$$

Where,

$T_L$  - Absolute temperature in the level condensation for rising.

$T_K$  - Temperature of the air in (K).

$r$  - Mixing ratio.

$r_s$  - Saturation mixing ratio.

## 3. Results

The illustration 2 presents the variation of the happened rainfall in Caxiuaná during the dry season which can be verified, that in most of the days of the experiment it did not happen rainfall, except in the days 02, 04 and 06 of November. The observed rainfalls were weak, with the larger value of 1,8 mm, happening in the end of the night and in the beginning of the dawn (between 23:00 and 01:00 HL), what characterizes the dry season in the region.

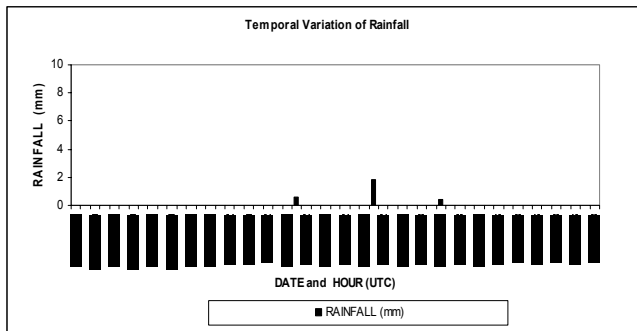


Illustration 2 - Variation of happened rainfall in Caxiuana during the experiment.

The Table I presents the classification of the convective regime and rain during the dry season. In the analysis of the series of 55 soundings were observed that 80% of the soundings are classified in the Convective Regime I (Dry), 15% in the Convective Regime II (Diurnal Convection), 5% in the Convective Regime III (Enhanced Convection) and there was not any sounding classified in the Convective Regime IV (Disturbed). The climate of the area is tropical (hot and humid) and the period of the experiment was the dry season (October and November), what justifies 80% of the soundings be classified in the regime I (dry). The rain of the regime II was due to the altostratus clouds resulting of present cumulonimbus clouds next to the region of the experiment, according to the observers' report. Only one day was classified in the Regime III, on this day cumulonimbus clouds was observed in the southeast quadrant of the experiment, what characterizes Enhanced Convection.

Convective Regime	Rainfall index range (mm)	Number of days	Number of Soundings
I - Dry	<0,3	12	44
II - Diurnal Convection	0,3 - 1,2	2	8
III - Enhanced Convection	1,2 - 5,0	1	3
IV - Disturbed	> 5,0	0	0

Table I - Classification of the soundings of Caxiuana in agreement with the regimes convectivos during the experiment CiMeLa

In the analysis of the vertical profile of equivalent potential temperature and saturation equivalent potential temperature (Illustration 3), it can be observed that the profile of Regime I (Dry) it is very dry and stable, where the level of condensation for rising (NCL) it is around 640 hPa (base of the cloud) and the balance level (NE) in 340 hPa (top of the cloud). To the regime II (Diurnal Convection), the atmospheric profile presents small instability starting from NCL in approximately 610 hPa and NE in 280 hPa. Finally, for the Regime III (Enhanced Convection) the NCL is around 730 hPa and the NE in 390 hPa, with instability where the area of the thermodynamic diagram suggests possibility of formation of convective clouds and stratiform clouds. The

observations done during the soundings confirm the analysis done, therefore they were observed in most of the days of the experiment presences of cumulus clouds, stratocumulus clouds, altostratus clouds, cirrus clouds and only on the 04 when it happened the largest rainfall close cumulonimbus clouds was observed next to the region of the experiment.

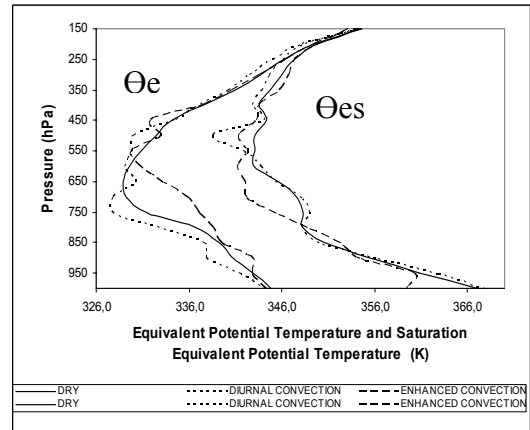


Illustration 3 - Vertical profile of equivalent potential temperature and saturation equivalent potential temperature of Caxiuana for the three regimes convectivos: Dry, Diurnal convection and Enhanced convection.

#### 4. Conclusion

During the experiment it was verified that in most of the days it didn't happen rainfall, presenting only three days with precipitation with very low values totaling 2,8 mm. In the analysis of the thermodynamic parameters  $\Theta_e$  and  $\Theta_{es}$  for Caxiuana- PA during experiment CiMeLa was observed that in most of the period of the experiment the atmosphere was stable and dry. With 80% of the soundings classified in the Convective Regime I (Dry), 15% in the Convective Regime II (Diurnal Convection), 5% in the Convective Regime III (Enhanced Convection) and there was not any sounding classified in the Convective Regime IV (Disturbed), what is justifiable because the studied period is the time dries in the studied area. The observations done during the soundings confirm the analysis done, therefore they were observed in most of the days of the experiment presences of cumulus clouds, stratocumulus clouds, altostratus clouds, cirrus clouds and only on the 04 when it happened the largest rainfall close cumulonimbus clouds was observed to the area of the experiment.

#### References

- Betts, A.K, 1974: Thermodynamic classification of tropical convective soundings, Mon. Wea. Rev., v. **102**, p. 760-764.
- BETTS, A.K., 1973: Non-precipitating cumulus convection and its parameterization, Quart. J. R. Met. Soc., v. **99**, p. 178-196.
- Bolton, D., 1980: The computation of equivalent potential temperature, Mon. Wea. Rev., v. **108**, p. 1046-1053.
- Ribeiro, J.B.M., e Mota, M.A.S., 1994: Classificação termodinâmica para atmosfera de Belém-PA para o ano de 1987. Anais do VIII Congresso Brasileiro de

Meteorologia e Il Congresso Latino-Americano e Ibérico de Meteorologia, p. 272-275.

Riehl, H, L. Cruz, M. Mata, e C. Muster, 1973: Precipitation Characteristics during the Venezuelan Rainy Season; Quart. J. Roy. Meteor. Soc., 746 – 757.

Riehl, H., 1979: Climate and weather in the tropics. Academic Press Inc., New York.