P3.4 CONVECTIVE STORM INITIATION IN THE AMAZON

Maria Andrea Lima[1] and James W. Wilson[2]

[1]Instituto de Pesquisas Meteorológicas, Bauru SP BR
[2]National Center for Atmospheric Research, Boulder CO USA

1. INTRODUCTION

Most of the precipitation during the summer months in continental areas comes from deep convection. This is particularly true over tropical regions. The diurnal cycle represents an important element for determining where and when convective precipitation occurs. The occurrence of cumulus convection must be diagnosed and the processes that trigger or suppress it must be known for suitable representation of convection in numerical weather models. As the size of horizontal grid decreases, the processes that determine the location, timing and intensity of convection must be better resolved. The objective of this study is to investigate the causes determining convective storm initiation in the southwest Amazon region using radar and satellite data. The TRMM/LBA campaign over the Amazon provides a unique data set to study convection in tropical continental areas. Section (2) presents the data and the methodology and section (3) discusses the results.

2. DATA AND METHODOLOGY

2.a Overview of TRMM/LBA Experiment

The Tropical Rainfall Measuring Mission (TRMM)/Wet Season Amazon Mesoscale Campaign (WETAM) was conduct from January 1999 through February 1999. The goals and observing network were described by Silva Dias et al., 2001. During the first two weeks of January organized rain systems occurred associated with the penetration of the South Atlantic Convergence Zone (ZCAS) into South and Southeast Brazil. From mid-January to mid February large scale forcing was absent and the rain was primarily associated with isolated scattered convective storms. The last week of February brought several mesoscale convective systems (Silva Dias et al., 2001). From radar studies, it became quite clear that distinct convective regimes existed depending on whether the low-level flow was westerly or easterly. These lower tropospheric wind fields were related to the large scale synoptic situation (Marengo et al., 2001)

2.b Case Selection

To study convection initiation in the Amazon area, the case of 05 February 1999 was selected. On this day the winds were very light from the surface up to 400 mb. A moist surface layer was overlaid by a slightly drier layer up to 500 mb. This was typical from late January to early February when weak westerly winds extended to the mid-troposphere (Rickenbach et al., 2001).

2.c Satellite and Radar Data

During the LBA/TRMM experiment satellite images from GOES-8 were available every half hour. Visible images with a simultaneous overlay of radar data were used to identify which clouds were precipitating and to describe the characteristics of convection. As part of the observing network, the NCAR SPol radar has operated during the field experiment. The radar employed several different scanning strategies depending on where the convection was occurring in relation to the instrumentation (rain gage network, aircraft flight path and dual-Doppler lobes). The analysis was based on low-level reflectivity scans out to a range of 150 km, obtained from SPol every 10 minutes. The use of low-level scans was to explore the boundary layer features and their characteristics.

2.d Storm Initiation Location Algorithm

Storm initiation locations were obtained objectively using the NCAR SILoc (Storm

* *Corresponding author address*: Maria Andrea Lima, IPMet/UNESP, PO Box 281, 17015-970, Bauru, SP, Brasil; e-mail: andrea@ipmet.unesp.br

Initiation Location) algorithm. This software reads a data base composed of storms identified by the TITAN software algorithm (Dixon and Wiener, 1993). SILoc determines which storms are significant using longevity and storm area criteria and records the latitude and longitude of their initiation location. Storm initiation was defined when a convective cell first reached 35 dBZ covering an area of 8 km^2. The analysis was limited to a radar radius of 130 km. This helped to exclude storms that advected into radar range. All data where displayed on the NCAR CIDD (Configurable Interactive Data Display) system. Displayed data included high resolution topography, land use, radar, storm initiation location, storm contours and visible images from satellite.

3. RESULTS

3.a General Description

On 5 February with no large scale forcing present the convection over Rondônia (RO) initiated in response to diurnal heating. Shallow cumulus clouds showed a regular pattern in the morning which developed into deep convection during the afternoon. From 1000 LT to 2000 LT a total of 303 storms initiated in the area of analysis. The suspected cause of initiation was classified into 7 categories which are listed bellow:

3.b Classification of Storm Initiation

***Triggered by terrain* (TF)**

Starting at 1145 LT scattered storms began to initiate over relatively high terrain peaking between 1300 LT and 1500 LT. Storms that initiated at elevations over 300 m where placed in this category. The terrain elevation in the analysis area varies from 150 m to 500 m and is covered by tropical forests with numerous clear cut areas used for cattle raising and small scale farming.

***Triggered by terrain in sw/w RO* (TC)**

This is a sub classification of TF but referring to two specific regions in southwest RO where storms initiated at elevations > 300 m. The first occurred in the late morning in the SSW part of the area and the second in early afternoon in the W part of the area. Both these systems produced long lasting cold pools. These two areas were associated with a convective line that developed between Bolivia and Rondônia.

***Instability line* (LI)**

This is another sub classification of TF. An organized line of deep convection initiated over terrain >300 m and slowly moved west initiating storms as it moved. It dissipated hours later in the valley. Storms initiating with this line were placed in this category.

***Triggered by outflow* (OF)**

Numerous storms were triggered by outflows (gust fronts) from storms that initiated over the relatively high terrain. Storms initiated by these outflows were placed in this category.

***Triggered by gust front* (GF)**

A gust front associated with the above instability line (LI) moved away from the instability line initiating additional storms that were placed in this category.

***Triggered by colliding outflow boundary* (CB)**

New storms initiated by colliding gust fronts were placed in this category.

***Triggered by a combination process* (CP)**

Storms that were initiated over high terrain by outflows were placed in this category.

***Unclassified storms* (UK)**

In this case neither radar nor satellite images revealed clear evidence about the triggering mechanism.

Figure 1 shows the topography in the Spol radar range. Figure 2 is a histogram showing the time of initiation for all storms during the period of analysis. The histogram clearly illustrates the diurnal evolution with the storms initiating late morning, peaking in the middle of the afternoon and ending after sunset. The mid-afternoon rain peak is typical of westerly wind regimes for the Rondônia region (Marengo et al., 2001). To examine the effect of deforestation on storm initiation location, a surface vegetation cover map was overlaid on the radar data. No clear signal was found in this study. Silva Dias et al. (2001), have shown for a case of convective development in RO that the effect of deforestation was to enhance total rainfall. Clearly additional studies on are needed. Figure 3 shows the number of storm. initiation for each category. The most common initiation mechanisms were along gust fronts (27%), over high terrain (300 m) without any other triggering mechanism (20%) and colliding gust fronts (16%). An initiation cause could not be determined for 21% of 303 cases. The time evolution for each trigger mechanism (or classification) suggested that the convective pattern observed on 05 February was an interaction of many processes. Storms tended to first form over the higher terrain. Many of these storms generated cold pools with associated gust fronts. New storms were then initiated by the gust fronts typically on the downwind shear side. With time gust fronts would collide and initiate new storms which tended to be the more intense and longer lived storm. This study will be extended for the whole period of TRMM/LBA.

4. SUMMARY

We suspect that storm initiation and evolution over the Amazon under weak synoptic forcing conditions is very similar to what was observed during this study. Storm initiation would begin over the higher terrain near local noon. Many of these storms would generate cold pools with associated circular gust fronts. These gust fronts would then initiate additional storms particularly along the down wind steering level side. That is if the storm steering level winds were from the NE storm initiation would be along the southwest side of a ring gust front. Toward mid-afternoon gust fronts would collide initiating the strongest and longest lived storms. During the late afternoon as cooling increases the stability convection would rapidly decrease and end shortly after sunset.

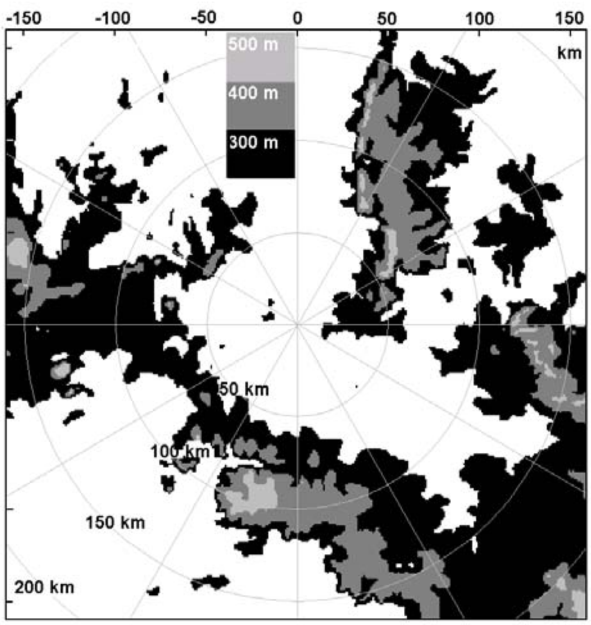

Figure 1. Topography within the Spol radar range in Rondônia (BR).

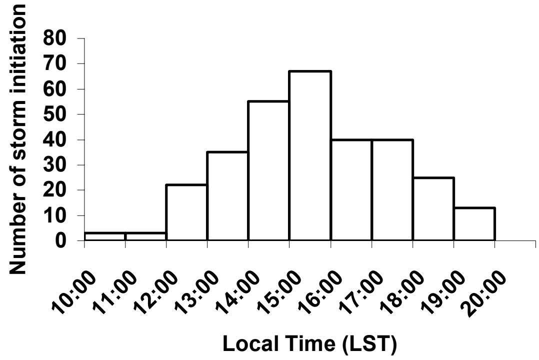

Figure 2. Number of cases of storm initiation by daily interval.

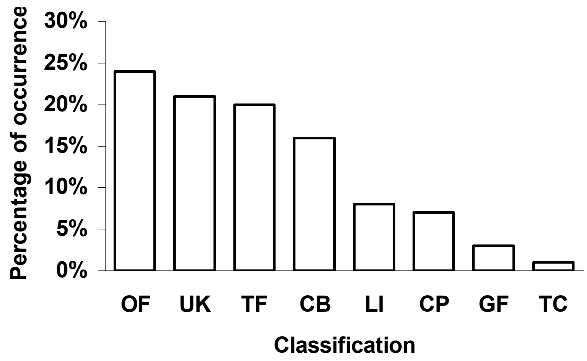

Figure 3. Number of cases of storm initiation by categories of possible trigger mechanism.

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4. REFERENCES

Dixon, M. and G. Wiener, 1993: TITAN: Thunderstorm Identification, Tracking Analysis and Nowcasting – A radar-based methodology, *J. Atmos. Ocea. Tech.*, 10, 785-797.

Marengo, J.A., G.F. Fish, I. Vendrame, P. Cervantes, C.A. Morales, 2002: On the diurnal and day-to-day variability of rainfall in Southwest Amazonia during the TRMM-BA and LBA-WET AMC campaign of the summer of 1999, *J. Geophys. Res.*, vol 107 .

Silva Dias, M.A.F., S. Rutledge, P. Kabat, P.L. Silva Dias, C. Nobre, G. Fish, A.J. Dolman, E. Zipser, M. Garstang, A. Manzi, J.D. Fuentes, H. Rocha, J. Marengo, A. Plana-Fattori, L.Sá, R. Alvalá, M.O. Andreae, P. Artaxo, R. Gielow, and L. Gatti, 2002: Clouds and rain processes in a biosphere atmosphere interaction context in the Amazon Region, *J. Geophys. Res.*, vol 107.