THUNDERSTORMS FORECAST IN THE NORTHEASTERN BRAZIL

Vladimir Levit *[1], Natalia Fedorova [1], Bruno Miranda de Brito[1] ,Anatoly Peresetsky [2],
[1]Institute of Atmospheric Science, Federal University of Alagoas, Brazil,
[2]New Economic School, Moscow, Russia

1. INTRODUCTION

The thunderstorm formation study for Alagoas State in the northeastern Brazil (NEB) is very important because of absence of any information about the phenomena for this region, but the accidents occur frequently. For example, five mortal accidents on March and February 2008 were registered.

The principal goal of the paper is elaboration of thunderstorms forecast method on the base of regular existent information. Synoptic scale processes and thermodynamic atmosphere structure, associated with the phenomena were investigated to study of thunderstorms frequency. Another goal of the paper is to evaluate the atmosphere vertical structure forecast by the Air Parcels Trajectories of HYSPLIT model for Low thunderstorm days.

2. DATA SOURCE AND METHODOLOGY

Thunderstorms frequencies were studied for 10 years (1992-2007) by two data types: 1) the hourly surface data at the Maceio International Airport Zumbi dos Palmares, 2) TRMM *(Tropical Rainfall Measuring Mission)* satellite data. The frequencies were compared with sea surface temperature data (http://www.redemet.aer.mil.br/) and an influence of La Nina and El Nina years was investigated. The thunderstorms existence was confirmed by radar data (radar of Alagoas -SIRMAL) since 2002.

Synoptic processes before and during thunderstorms were analyzed using different products of NCEP reanalysis and infrared satellite images. Synoptic systems, responsible for atmospheric vertical structure formation during thunderstorms days, were analyzed. The regions of Jet Streams on NEB (***JSNEB***) and of Upper Tropospheric Cyclonic Vortex (***UTCV***), associated with thunderstorm development, were investigated.

Thermodynamic processes were studied by vertical profiles, elaborated by three data sources. 1) Vertical profiles for Maceio (latitude 9.7^{o}S, longitude 35,8^{o}W) were drawn by NCEP reanalysis data (Simulated profile - ***Ps***). These profiles were used as the real data because of the absence of any radiosonde data in Alagoas State. 2) Radiosonde data for the neighboring states (Real profile - ***Pr***); 3) Forecasted (with 12, 24, 36 and 48h antecedence) vertical temperature and humidity profiles (Forecasted profile - ***Pf***) were drawn up, using Air Parcels Trajectories of ***HYSPLIT*** (Hybrid Single-Particle Lagrangian Integrated Trajectory) model at the 10 levels. Differences and similarities of all profiles were analyzed. The strong convection was available using K, TT, LI indexes and positive CAPE (Convictive Available Potential Energy), calculated by *Ps*, *Pr* and *Pf* vertical profiles.

3. RESULTS

3.1 Thunderstorms frequencies

Thunderstorms were observed with more frequency from December to April, with the greatest frequency on March (2.8days) (Table 1). The frequency by TRMM data was more than by surface data.

The thunderstorm frequency was grown during study time period up to 19 evens per 2007 year. During Normal and La Niña years more thunderstorms events (up to 80%) were observed. The El Niño years decrease the number of events (up to 20%).

3.2 Synoptic processes of thunderstorms formation

One example of synoptic analysis is presented for intensive thunderstorm event on 29 January 2003. The thunderstorm identification was made by TRMM and radar data (figure 1a and 1b). This thunderstorm was localized on the west ***UTCV*** periphery and in the ***JSNEB*** exit region (figure 1c). The ***UTCV*** and **JSNEB** were associated with the northern periphery of frontal zone (figure 1a).

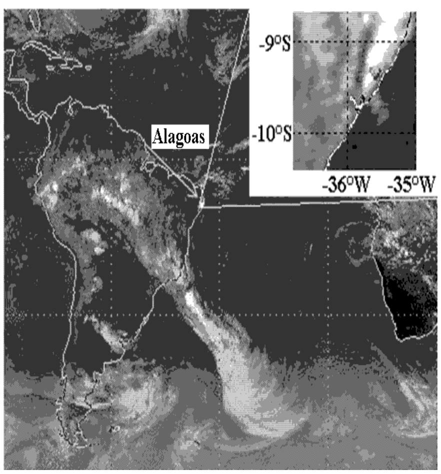
The synoptic analysis revealed the synoptic systems, which have effect on thunderstorms development:
1) ***UTCV*** and **JSNEB** were detected at the high levels; 2) no predominant systems were found at the middle levels; 3) troughs in the trade winds were detected at the low level.

The northwest UTCV region had more frequently thunderstorms evens. The phenomena were registered in typical jet stream regions with ascendant movements, in warm side of entrance and in cold side of JSNEB exit.

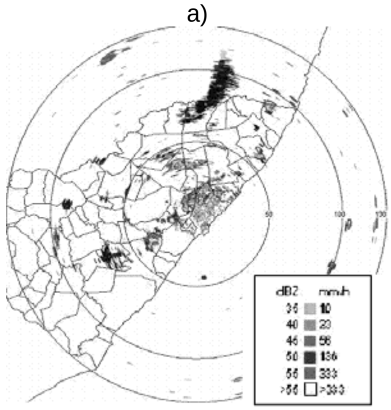
* *Corresponding author address:* Campus A.C. Simoes, Av., Lourival Melo Mota, UFAL, Cidade Universitaria, Maceio, Alagoas, Brazil, 57072-900; e-mail: vlevit@dimin.net

Y/M	98	99	00	01	02	03	04	05	06	07	Σ/A
January	3(0)	1(0)	5(1)	0(0)	4(0)	4(1)	4(1)	4(0)	0(0)	1(0)	27 / 2,7
February	0(0)	1(0)	3(0)	0(0)	4(1)	5(0)	1(1)	2(0)	1(1)	8(1)	27 / 2,7
March	2(0)	4(0)	0(0)	2(2)	2(1)	2(2)	2(0)	5(1)	5(1)	3(0)	28 / 2,8
April	1(0)	0(0)	0(2)	0(0)	2(0)	2(0)	0(0)	1(0)	5(0)	3(2)	18 / 1,8
Mayo	0(0)	2(0)	2(0)	0(0)	0(0)	0(0)	1(0)	1(0)	2(0)	1(0)	9 / 0,9
June	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1(0)	0(0)	0(0)	1 / 0,1
July	0(0)	0(0)	0(0)	1(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1 / 0,1
August	0(0)	0(0)	0(0)	0(0)	0(0)	2(0)	0(0)	0(0)	0(0)	0(0)	2 / 0,2
September	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	-
October	0(0)	0(0)	0(0)	2(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	2 / 0,2
November	0(0)	1(0)	1(0)	0(0)	2(0)	0(0)	1(0)	0(0)	0(0)	0(0)	5 / 0,5
December	0(0)	4(1)	0(0)	7(0)	2(0)	1(0)	1(0)	3(2)	2(0)	1(0)	21 / 2,1
Total	6	13	13	12	16	17	12	17	16	19	141 / 14,1
Average	0,5	1,1	1,1	1,0	1,3	1,4	1,0	1,4	1,3	1,6	-

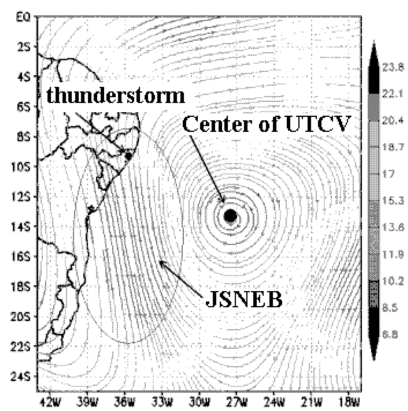
Table 1 **-** Thunderstorms frequency (in days) by TRMM and surface (in bracket) data in 1998-2007. White, grey and dark colors present Normal, La Niña and El Niño years respectively. Y –year; M – month; A – average. Source: CDC/NOAA



a)



b)

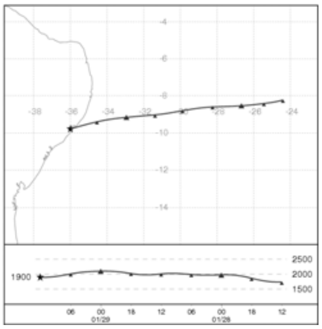


c)

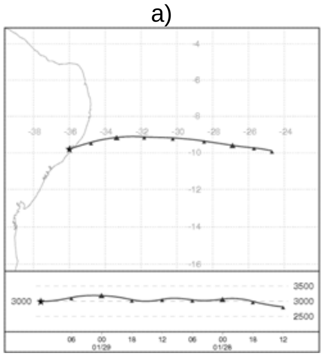
Figure 1 – Thunderstorm event on 29 January 2003, 12UTC: a) Infrared satellite image and TRMM data; b) radar data; c) 200hPa streamlines. Sources: CPTEC, TRMM, SIRMAL e NCEP.

3.3 HYSPLIT model test for forecasting of thermodynamic processes of the thunderstorms formation

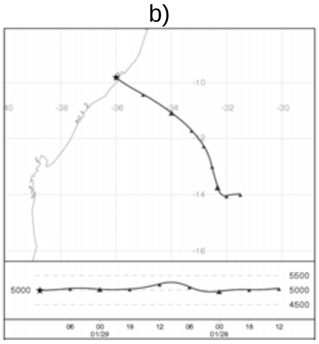
Air parcel trajectories have to depend on the synoptic systems. Therefore, the HYSPLIT model air parcel trajectories show an influence of the main synoptic systems over thunderstorms formation. For example, trajectories for the same thunderstorm event are presented in Figure 2. Trajectory at the low levels up to 700hPa from the east shows the WDTW influence for haze formation (Figure 2a, b). A high level trajectory from the northeast and the north is related to the UTCV and JSNEB position (Figure 2d).



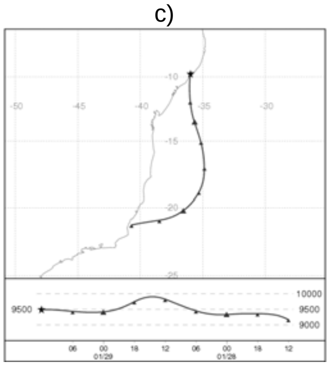
a)



b)



c)



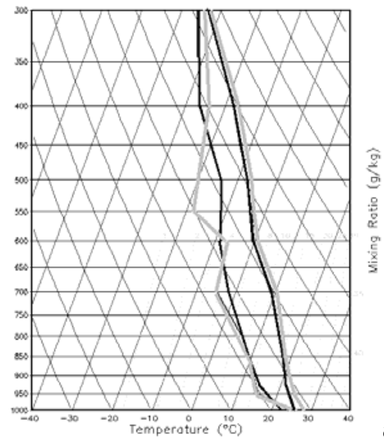
d)

Figure 2 – Air Parcels Trajectories of HYSPLIT model in vertical and horizontal outline at the low (a, 800hPa), middle (b, 700hPa and c, 550hPa) and high levels (d, 300hPa) with 48h antecedence for thunderstorm event on 29 January 2003, 12 UTC.

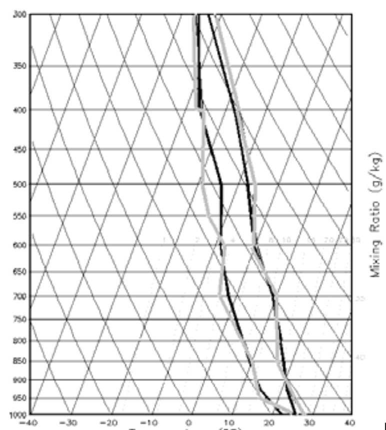
Source: NOAA/ARL.

The simulated temperature and humidity profiles revealed approximately real profiles in Maceio and adjacent regions. For example, the simulated and forecasted vertical profiles are presented for Maceio on 29 January 2003 (Figure 3). The forecasted profiles were very similar to the real ones with 24h antecedence in all studied cases.

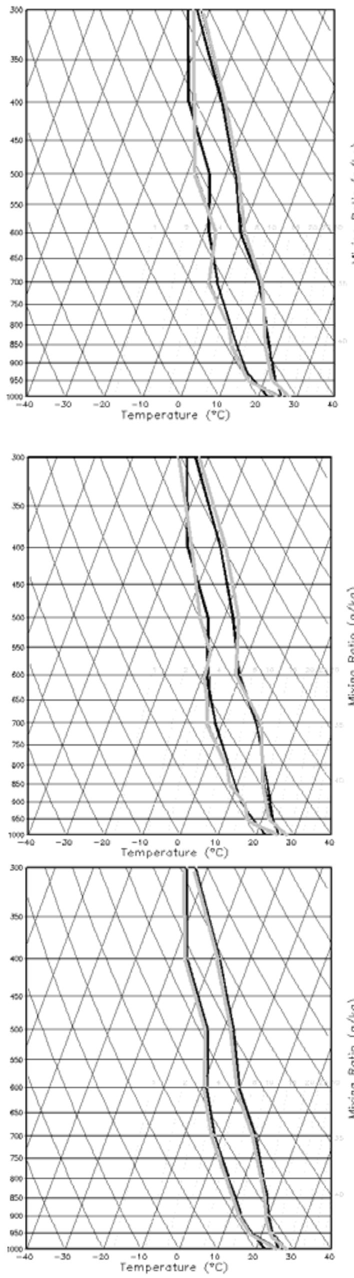
The forecasted temperature profiles were identical with real profiles (***Pr*** and ***Ps***) up to 48h antecedence, but the Td forecasted profiles were good only up to 24h antecedence (table is not presented). The K and TT indexes did not show the satisfactory results for the forecast. The CAPE values, calculated by ***Pr*** were less than ***Pf*** in all events. The thunderstorm were observed with LI<2.5 and CAPE+> 1500J/Kg. It is mean than the thunderstorms were developed with the less instability than were presented in the manuals (for example, in Djuric, 1994)



a)



b)



c)

d)

e)

Figure 3 - Simulated (black line) and forecasted (grey line) profiles for Maceio with 48h(a), 36h(b), 24h(c) and 12h(d) antecedence and 12 UTC (e) on 29 January 2003. Source: NCEP, NOAA/ARL

3.4 Thunderstorms forecasting

Three steps for thunderstorms forecast in Alagoas State are presented in Figure 4. *The first Step* exhibits the preferential season for the phenomenon development. *The second Step* determine the typical synoptic systems at high and low levels and also the preferential thunderstorms localization inside UTCV and JSNEB. *The third Step* presents the thermodynamic characters of the thunderstorms forecast.

4. CONCLUSION

The HYSPLIT model for the thunderstorms forecast was tested. Satisfactory results were obtained for forecast with 12 and 24h antecedence. The instability indices (CAPE, LI) can be used for the thunderstorms forecasting with 48h antecedence.

5. ACKNOWLEDGEMENTS

Partial financial support was provided by FAPEAL (Research Support Foundation of the Alagoas State), CNPq (National Council of Scientific and Technological Development) and CAPES (Coordination of the Level Superior Personal Improvement).

6. REFERENCES

Draxler, R. R. and Rolph, G. D. (2003) *HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) Model*. (http://www.arl.noaa.gov/ready/hysplit4.html). NOAA Air Resources Laboratory, Silver Spring, MD,.

Djuric, D., 1994. Weather Analysis. Prentice Hall, New Jersey.

Fedorova N., Levit V., Fedorov D. (2006) Fog and Stratus Formation on the Coast of Brazil, *Atmospheric Research*,2008.

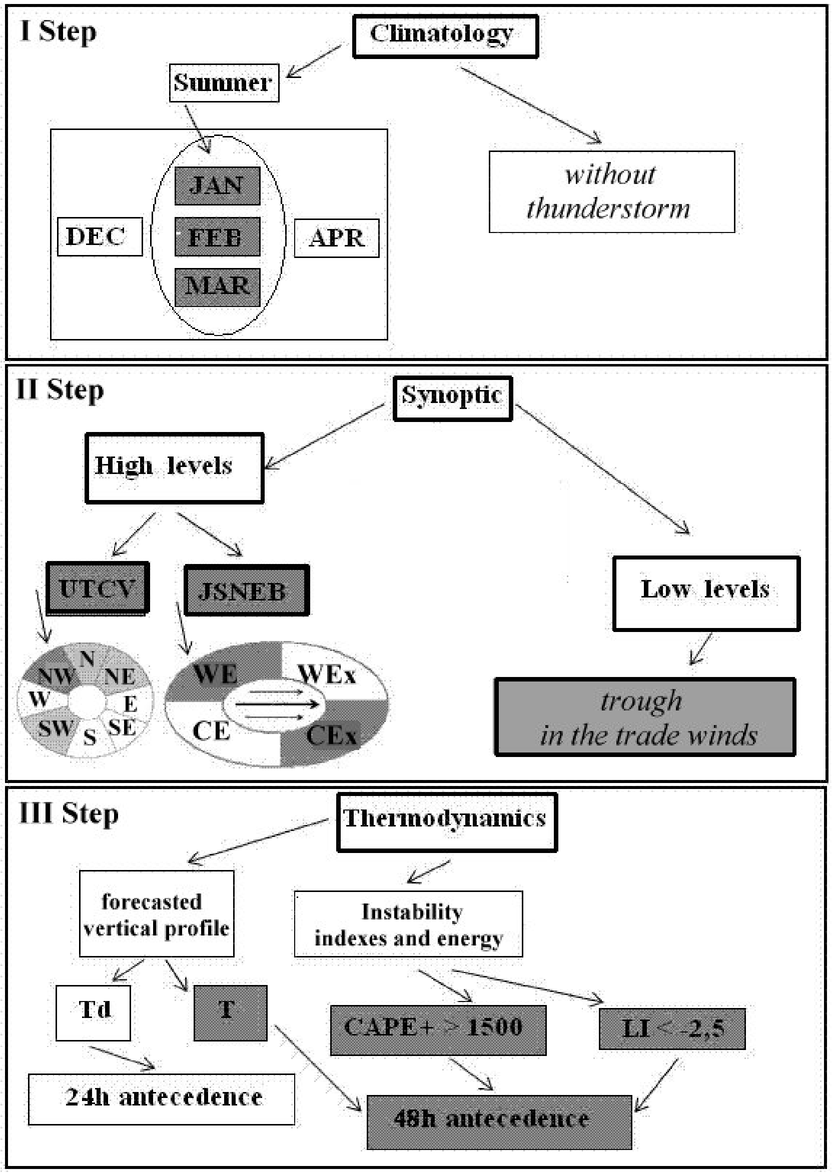


Figure 4 – Steps for thunderstorms forecast in Alagoas State, Brazil
JSNEB regions:
WE - warm side of entrance; CE - cold side of entrance; WEx - warm side of exit; CEx - cold side of exit