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HAZE FORMATION ON THE NORTHERN COAST OF BRAZIL

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ABSTRACT

Two types of haze formation on the northern coast of Brazil were investigated. Comparisons of the thermodynamic and synoptic processes for haze associated with rain (HR) and without one (H) were elaborated. The hourly surface data at the Maceio International Airport were used for HR and H identification.

Thermodynamic processes were studied by temperature and humidity vertical profiles, elaborated by two methods: 1) NCEP reanalysis data for Maceio and 2) Air Parcels Trajectories of the HYSPLIT model at the 10 pattern levels. Vertical profile forecast, using the HYSPLIT model, was elaborated with 12, 24, 36 and 48h antecedence. High humidity of the superficial layer (up to 925hPa) and humidity convergence were confirmed by the both models and this layer was forecasted up to 48h antecedence. Weak ascendance motions at the superficial and high layers and subsidence in the middle layers have provoked a superficial humidity accumulation for H days. More intensive ascendance motions at the same levels were observed for HR days.

Synoptic situations before and during HR and H events were analyzed using different products of NCEP reanalysis, of high resolution (10km) ETA model results and infrared satellite images. All H and HR phenomena were accompanied by weak wave disturbances in the trade winds field.

HR was associated with one type of the synoptic scale systems and H events with other type at the middle levels. Different trough types were observed by both models for H days. An influence of the cyclonic circulation, which was identified only in the middle levels, was registered by NCEP data and was confirmed by satellite images for HR days.

Low visibility forecasting presented satisfactory results for H and HR days with 24h antecedence.

1. INTRODUCTION

Low visibility on the Northern Coast of Brazil (NEB) was not observed with high frequency (Fedorova et al, 2008) and therefore a few investigations were elaborated. At the same time, low visibility events caused different accidents. For example, intensive fog provoked fatal accident near Maceio Airport on 26 July 2007.

The first investigation about haze formation shown that the phenomena, with visibility of 1-2km, was observed on the northern coast of Brazil during 33 hours per year with the greatest frequency in June (Levit et al., 2007). The low visibility of 2–4km was detected during 236 hours per year with the highest frequency in a rainy season.

Processes formation analysis of haze associated with rain (HR) and without one (H) was the principal study goal. Also, the models (high resolution ETA and HYSPLIT) verification capacity for haze forecast was the second goal.

2. DATA SOURCE AND METHODOLOGY

The haze and rain occurrence was identified by hourly conventional meteorological data at the Maceio International Airport during 2004.

Synoptic analysis

Synoptic situations before and during phenomena was analyzed using different information:

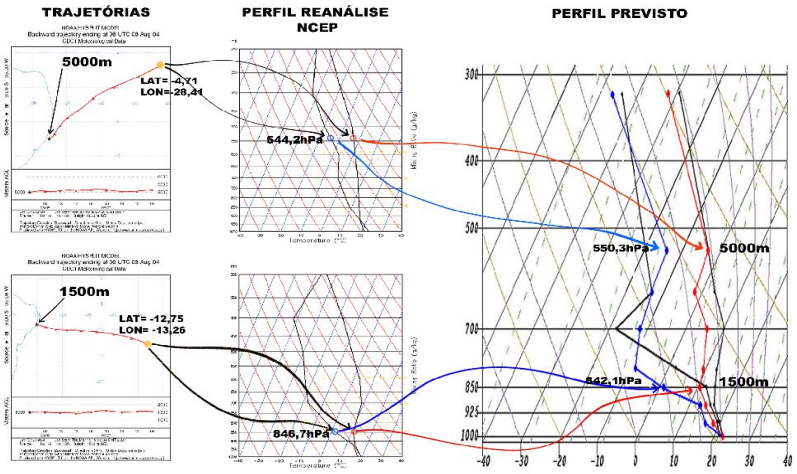
1. Satellite data (www.cptec.inpe.br/satelite) in the infrared channel;
2. Products of reanalysis data by National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR), each 6h: 1) streamlines at the low, middle and high levels, 2) omega vertical sections along 10ºS.
3. Products of high resolution (10km) ETA model each 3h: 1) streamlines at the low, middle and high levels and 2) humidity characters at the low levels (relative humidity, humidity advection, humidity confluence).

The WDTWs identification was elaborated by using streamline maps and vorticity at low levels (1000 and 925hP) and satellite images according to Molion and Bernardo (2002).

Thermodynamic analysis
Vertical profiles by NCEP reanalysis data in Maceio were used as *real profiles (Pr)* because of a radiosond data absence.

Forecast of vertical temperature and humidity profile (Pf) was elaborated with 12, 24, 36 and 48h antecedence (Figure 1). Firstly, air parcels trajectories of the HYSPLIT model at the 10 levels were constructed. Afterwards, the NCEP reanalysis of the vertical profile on the beginning trajectory points (latitude and longitude) were elaborated for each level trajectory. Then, forecast of vertical temperature and humidity profile was elaborated, using the temperature and humidity data at the beginning points (altitude) of each vertical profile.

Comparison of *Pf* and *Pr* was made by instability indexes K-Index (K), Total Totals (TT), Lifted Index (LI) and also by three parameters:
1. $|Tf - Tr| \leq 2^oC$; *Tf* and *Tr* are temperatures by *Pf* and *Pr* at the low and middle levels.
2. Humidity ($(T - Td) \leq 3^oC$) layer occurrence at the low levels.
3. Stability layer existence at the low levels.



a) b) c)

Figure 1 – Forecast vertical profile elaboration (c), using Air Parcels Trajectories of the HYSPLIT model at the 10 levels (a; figure show only 2 levels) and NCEP reanalysis vertical profile for Maceió on the beginning points of each trajectories (b)

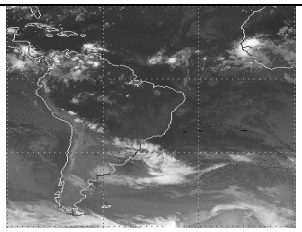
3. RESULTS

3.1 Synoptic processes of haze formation

Synoptic scale events analysis on the NEB shown the absence of principal systems, such as Intertropical Convergence Zone and Frontal zones of extrotropical baroclinic cyclones for the H and HR events (Figures 2 and 3). At the same time, any influence of Cyclonic Vortex, which is localized only at the Middle Levels (CVML), was detected for HR event (Figures 2b and 3d). The CVML cloudiness was identified by satellite images: it was up to high levels near CVML center and only at low levels on the cyclonic periphery over NEB (Figure 2b). The CVML occurrence was confirmed by cyclonic center existents at the middle levels (Figure 3d) and the center absence at the low and high levels (Figures 3b and 3f).

Weak Wave Disturbance in the Trade Winds field (WDTW) was accompanied the haze formation in all H and HR events and was identified by NCEP reanalysis data and by high resolution ETA model (Figures 3a and 3b). But WDTW was more intensive for HR event. By Rodrigues et all. (2010), 87% of the troughs near surface are associated with WDTW. At the same time, High center was localized nearest to the Southern America continent for H events, than for HR event.

Streamlines at the middle level present different trough types (Figures 3c and 3d). The trough in the HR event was associated with the CVML in the Southern Hemisphere and trough in the H event was linked with North Hemisphere Low. The east region of high level trough was identified in the HR and H events (Figures 3e and 3f). But the streamlines hade anticyclonic curvature for H events and cyclonic curvature for HR event.



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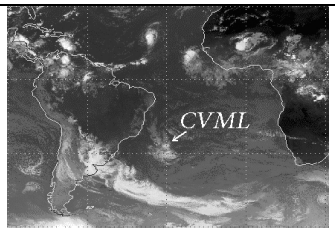

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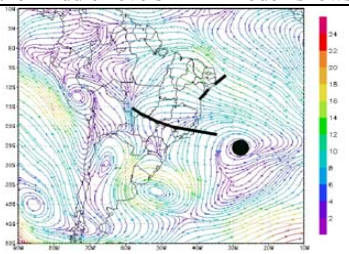
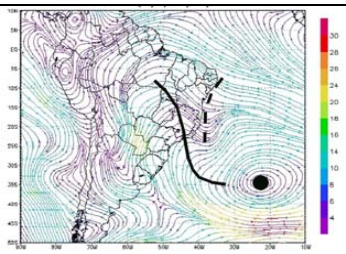
Figure 2 – Satellite infrared imageries for H (a) and HR (b) events

The ETA model and NCEP reanalisys shows similarly air currents at the low and high levels. But at the middle levels ETA model shows a High above the event region for the HR event and trough axis for the H event.



a) 21 08 2004, 06:00UTC



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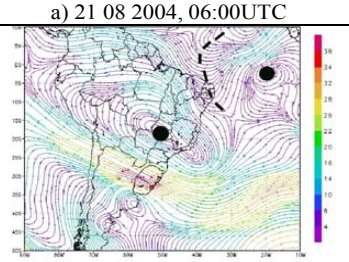

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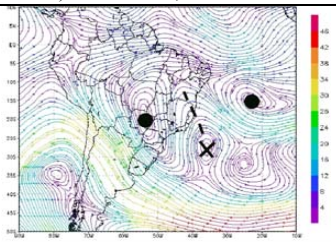

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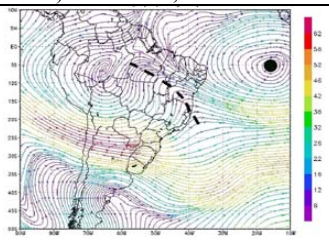

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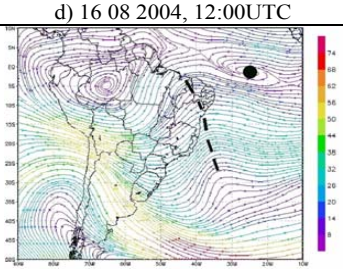


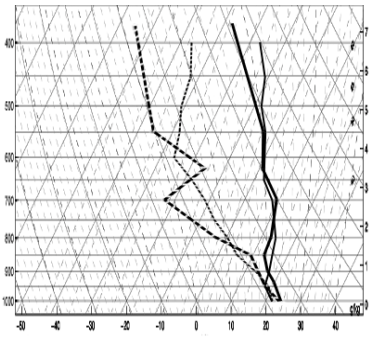
f) 16 08 2004, 12:00UTC

Figure 3 Streamlines at the low (925hPa, a and b), middle (500hPa, c and d) and high (200hPa, e and f) levels for H (a, c, e) and HR (b, d, f) events. CVML- cruz, High – circle, ridge- line, trough- dotted line.

3.2 Thermodynamic processes of haze formation

The *Pf* and *Pr* comparison presented the satisfactory results for temperature at the low and middle levels and for humidity only at the low levels.

High humidity of the superficial layer (up to 925hPa) was registered for H and HR events by *Pr* and ETA model and was forecasted with success by *Pf* up to 48h antecedence (figure 4). Humidity convergence, also, was identified and forecasted by the same model up to 48h antecedence (figure 5).



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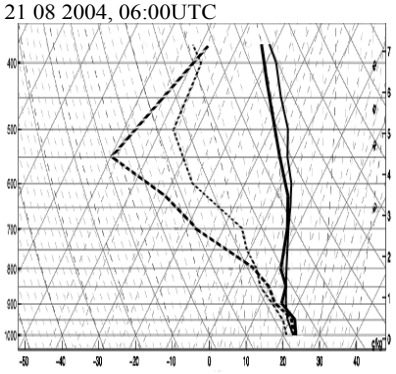

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Figure 4- Comparison of *Pr* (thin lines) *with Pf* (thick lines) with the 24h antecedence for H (a) and HR (b) events.

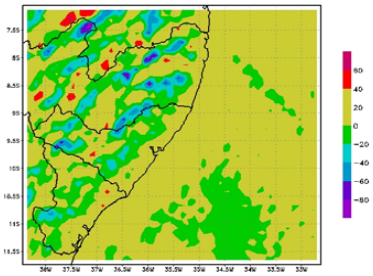
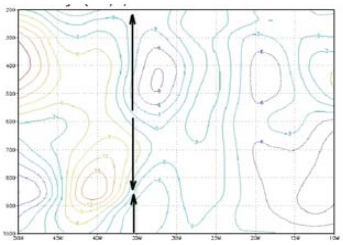


Figure 5 Humidity convergence by ETA model at the 1000hPa for H event, 21 08 2004, 06:00UTC

Weak ascendance motions at the low layers up to 850hPa and subsidence in the middle layers provoked a superficial humidity accumulation for H days (Figure 6a).

More intensive ascendance motions at the low (up to 820hPa) and high levels with thin subsidence motion layer nearly 700hPa were observed for HR day (Figure 6b).



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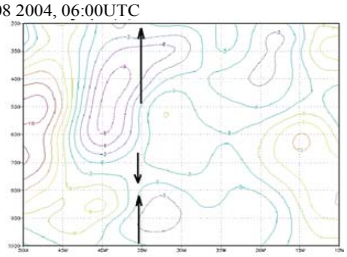

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Figure 6 – Omega vertical sections ($*10^{-2}$ $Pa.s^{-1}$) along 10ºS for H (a) and HR (b) events

4. CONCLUSION

Weak Wave Disturbance in the Trade Winds field was associated with the haze formation in all H and HR events.

Satisfactory results of the HYSPLIT and ETA models used for the low visibility forecasting with 24h antecedence were obtained for H and HR days.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

Fedorova, N., Levit, V. and D. Fedorov (2008) Fog and Stratus Formation on the Coast of Brazil, *Atmos. Res.*, **87**, 268-278.

Levit, V., Fedorova, N., Santos, D.M.B., Rodrigues, L. R. L., Costa, S. B., Santos, A.S. (2007) Visibility in Stratus Cloud days on the northern coast of Brazil. In: *Fourth International Conference On Fog, Fog Collection And Dew*, La Serena, Chile, 81-84.

Molion, Bernardo (2002) Uma revisão da dinâmica das chuvas no Nordeste Brasileiro. *Revista Brasileira de Meteorologia*, v **17**(1), 1-10.

Rodrigues L.R.L., Fedorova N., Levit V., (2010) Adverse meteorological phenomena associated with low level baric troughs in the Alagoas State in 2003. *Atmospheric Science Letters***,** DOI: 10.1002/asl.**273.**