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A CASE STUDY OF A WINDSTORM IN THE BRAZILIAN AMAZON

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1. ABSTRACT

On the morning of November 14, 2000, a Mesoscale Convective System (MCS) was observed over the center of the state of Amazonas, Brazil. This MCS moved eastward, and at around 1:00 PM local time reached the state capital, Manaus. The MCS was characterized by severe weather, with torrential rain, widespread flooding, and strong wind gusts. Rotational movement was identified at cloud base, characterizing this as a tornadic thunderstorm.

2. INTRODUCTION

The city of Manaus is located in the heart of the Brazilian Amazon, at a latitude of 3^{o} S and a longitude of 60^{o} W. Manaus is known by its extreme rainfall: 2286.2 mm per year, and therefore its inhabitants are used to storms that are big rainfall producers. However, the storm that reached the city at 1:00 PM local time (17:00 UTC) on November 14, 2000, had more severe weather than the locals are used to. Unfortunately, no reliable wind reports could be obtained. However, the storm caused an accumulated precipitation upwards of 74.2 mm accumulated in three hours, left many home without roofs, destroyed trees. electric lines, and many boats that are used for transport in the rivers. A 1500 ton boat was reported to be completely destroyed. The storm also caused widespread flooding in the city. The most interesting characteristic of this storm was its tornadic nature. A meteorologist of INFRAERO observed a funnel at cloud base. Although no register was made of such funnel, one layman recorded a video of debris flying at the base of the cloud, indicating clearly the presence of clockwise rotation at cloud base, extending all the way to the ground. The tornadic characteristics of this storm are remarkable because tornadic storms are rare in equatorial regions, and are seldom documented.

In this paper we present a brief discussion of the meteorological situation that was active on that day, and describe some details of the development of the MCS. The data used in this study comprises infrared (IR) and visible satellite images, rawindsonde data, surface data, model initialization data (from the Brazilian National Weather Service MBAR model), local and national newspaper clippings, national television news recorded on videotape, and personal reports.

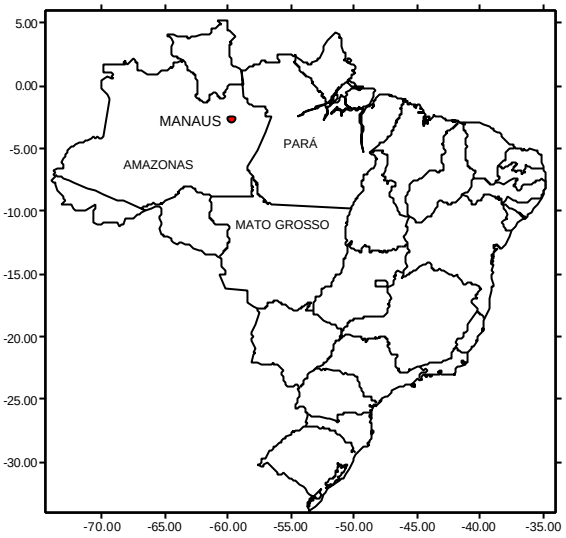

Figura 1. Map of Brazil, depicting the states of Amazonas, Pará, and Mato Grosso, and the city of Manaus.

3. METEOROLOGICAL SITUATION

The large scale, as observed in the satellite images and in the surface and upper air charts at 12:00 UTC on November 14, 2000 was:

a) Bolivian High Pressure System. An upper air (200 hPa) anticyclonic (counterclockwise) circulation centered on the border of the states of Pará and Mato Grosso. This system is usually associated with convection in central South America, and caused westerly upper level winds over Manaus.
b) South American Convergence Zone (SACZ). This zone is characterized by a wide band of convective and stratiform clouds that extends in the northwest-southeast direction, from the western Amazon to the Atlantic Ocean. Usually, as happened in this case, the SACZ forms when a polar front reaches southeast Brazil. The front is weak, and slowly moves to the Atlantic Ocean, but leaves this organized cloud region over the continent. The NW-SE pattern of cloud organization can be seen in Figures 2 and 3, which show the IR satellite image at 12:00 and 15:00 UTC. The SACZ is a region of low-level (850 hPa) wind

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convergence, where westerlies are observed. But since the SACZ was located to the south of Manaus, climatological easterlies prevailed over the city.

c) At mid-levels, 500 hPa, a small cyclonic (clockwise) circulation was observed centered at the border of the states of Pará, Amazonas and Mato Grosso. Due to this circulation, the mid-level winds over Manaus were westerlies. It is interesting to note that this was the only level at which westerlies were found.

At 12:00 UTC the MCS was already present west of Manaus (Figure 2). During the morning, the MCS moved eastward (Figure 3). This was remarkable, since as discussed above, the prevailing winds at most levels were easterlies. The movement of the MCS indicates that it followed some strong internal dynamics, and was not simply advected by the upper-level winds. It was also noticeable in the satellite images that the area northeast of Manaus was characterized by strong subsidence and absence of clouds.

One interesting system that appeared in the regional scale was a region of extremely hot near-surface temperatures located east of Manaus. A contrast of 7^{o} C over 400 km was noticed, which is extreme for this equatorial region. The center of high near-surface temperatures was located at the border of the states of Amazonas and Pará (Figure 4). A region of very strong wind convergence was located to the west of the temperature maximum, with northeast winds to the east of the maximum, and weak southerlies to its west. Significant surface relative vorticity was also noted in this region ($-1x10^{-5}$ s^{-1}).

When the MCS reached Manaus, and encountered this region of temperature contrast, convergence and vorticity, the system intensified abruptly and the devastating storm took place.

4. CONCLUDING REMARKS

Considering the characteristics of this storm, the rotation and funnel observed on cloud base (hopefully the video will be shown at the Conference), it can be characterized as a weak tornado, although no wind reports were obtained.

The mechanism of development of this tornado probably followed the classic non-supercell tornado conceptual model (Houze,1993), according to which high vorticity values can be concentrated in a column when a storm, and its associated low-level convergence, go over a region of pre-existing surface vorticity.

Acknowledgements

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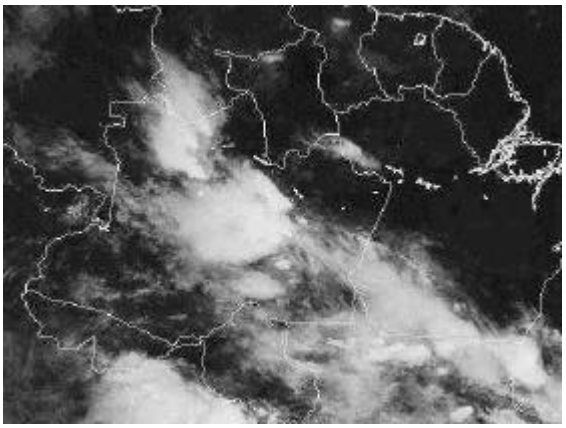

Fig. 2 - Infrared satellite image at 12:00 UTC on November 14, 2000.

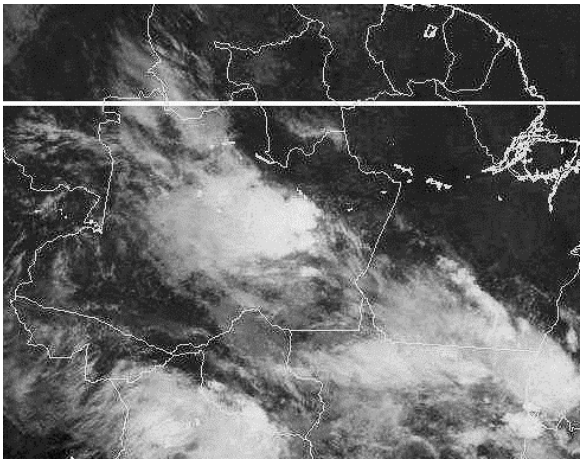

Fig. 3 - Same as Figure 2, except at 15:00 UTC

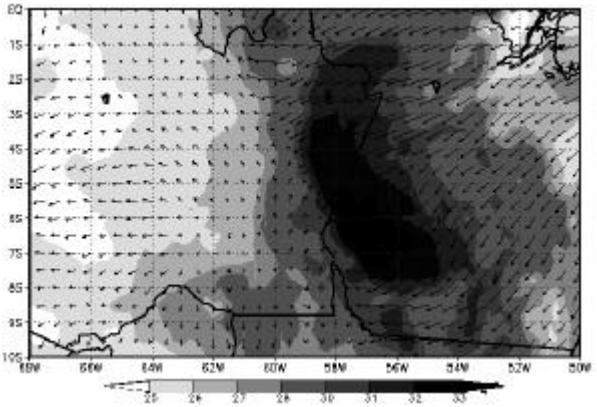

Fig. 4 – Surface temperature and winds from the November 14, 2000 – 12:00 UTC – MBAR intialization.

References

Houze Jr.,R.A ., 1993. Cloud Dynamics. Academic Press, Sandiego, 570 pp

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