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# CHARACTERISTICS OF THREE EXTREME MAXIMUM TEMPERATURE EPISODES IN MENDOZA, ARGENTINA

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## 1. INTRODUCTION

The Extreme Maximum Temperature Episodes (EMTE) in Argentina are generally associated with Heat Waves Events (HWE) which have a regular frequency especially during summer-time.
Over western Argentina there are three HWE with an important recurrence period: one observed at the end of December, known as "Christmas Heat Wave" (CHW), other during the second fortnight of January, generally after the 20th, and the third on February first fortnight .
A HWE is defined when the minimum temperature (mt) is greater than the Higher Monthly mean minimum temperature (HMmmt), and when the Maximum Temperature (MT) is greater than the Higher Monthly mean Maximum Temperature (HMmMT). This definition is valid for the central west of Argentina and must occur at least during two days.
During the CHW of 2000, the MT reached 40.1ºC at 18:15 local time (21:15 UTC) on December 25$^{th}$, in Mendoza Aero (SAME) located at 32.50ºS 68.47°W (EMTE-D). On February 9$^{th}$ 2001 the MT reached 39,6°C (EMTE-F) at 17:30 local time (20:30 UTC) was registered. The highest MT (44,4°C) in SAME since records exist was registered on January 30th 2003 at 17:15 local time (20:15 UTC) (EMTE-J).
The EMTE episodes impact on population health, especially on children and old aged people, augment dramatically the heart attack and dehydration risk, as well as higher demand of electrical energy.
The goal of this work is to analyze the prevailing meteorological conditions during the occurrence of three EMTE from the synoptic, thermodynamic and dynamic point of view in order to establish differences and similitude between them.
The study of EMTE is increasingly necessary because of the impact in social and economical activities caused by an excessive warming in a Global Climatic Change scenario..
Colombo et al (1999) shows the impact of warming in the EMTE frequency during summer obtaining high positive correlation with energy consumption for different areas in Canada.
Rusticucci and Vargas (1995) analyzed synoptic situations related to extreme temperatures. The warmest summer pulse (January 1972) occurred with a cold front advancing from the south, a low pressure and a north flow over central Argentina they named "type A"

In the second fortnight of March 1980 an intense heat wave affected north and central Argentina (Campetella and Rusticucci, 1998) with mt over 27ºC The MT reached 37.6°C in Buenos Aires city and it was máximum maximorum data for March since 1901. Two factors caused this heat wave: a persistent long wave ridge on 55º W in the middle and high troposphere with strong subsidence and sustained northerly winds in low levels bringing warm and humid advection from the Tropical Atlantic Ocean and west Amazonian.
The warming was helped by an intense solar radiation because of long duration of clear days in a large area of the country.
To understand other causes of EMTE, aspects related to Norwestern Argentinean Low (NAL), also known as "thermal orographic low" (Lichtenstein 1980) and (Seluchi et al, 2001) were considered. Norte, F. et al (2005) showed that an important factor causing the historical EMTE on January 30th 2003 was NAL shifting to higher latitudes.

## 2. DATA AND METHODOLOGY

Surface data were obtained from the Servicio Meteorológico Nacional (SMN) Argentina and Dirección Meteorológica de Chile (DMC); the aerological data reconstructed from NOAA Air Resources Laboratory Real Time Environmental Applications and Display System (ARL). Reanalysis from the National Center for Environmental Prediction and the National Center for Atmospheric Research (NCEP/NCAR).
All data were used for the characterization of synoptic scale circulation, dynamical and thermodynamic structure of troposphere and for analyze the temporal temperature (°C) and spatial specific humidity (kg/kg) distribution.
For the synoptic analysis was considered a 40° latitude X 40° longitude grid centered at 40°S 70°W, and for q analysis a 15° latitude X 15° longitude grid centered at 30°30'S 67°30'W
The 925 hPa level was selected because it represents the surface level of SAME.
The Skew-T of SAME and Quinteros (Chile), and several surface data for each EMTE episodes, were used for the initialization of the Mendoza Argentina Convection Statistical Model (MASCM) (Simonelli, 2000) to obtain the probability of convection occurrence. This model was used to see the competition between the descending air (subsidence) and ascending air (convection).

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## 3. RESULTS

### *3.1 EMTE-D*

Figure 1 shows the hourly temperature evolution (solid red line) at SAME from December 21th 00:00 UTC to December 26[th] 23:00 UTC, where the dashed blue line is the HMmmt ,(20.1°C) and the dashed red line is the HMmMT (34.6°C) for the 1985/1999 period.

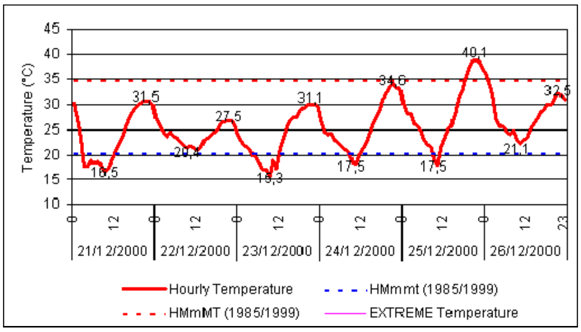


*Figure 1: Hourly temperature evolution at SAME for EMTE-D*

In this episode the MT is above the critical value only on December 24[th] and December 25[th]; and the mt is under Hmmt so this EMTE does not satisfy the HWE definition.

On December 25th at18:00UTC in 925 hPa level (Figure 2) the NAL is almost seven degrees latitude to the south from its mean position which is at 29ºS 66ºW.

The synoptic condition of this EMTE shows a baric configuration very similar to the mean baric field of Zonda wind days (Norte, F., 1988)

The Zonda is a warm, dry wind on the leeward of a mountain range (Andes Cordillera in this case) the warmth and dryness of the air being due to adiabatic compression upon descending the mountain slopes (Huschke, R., 1980).

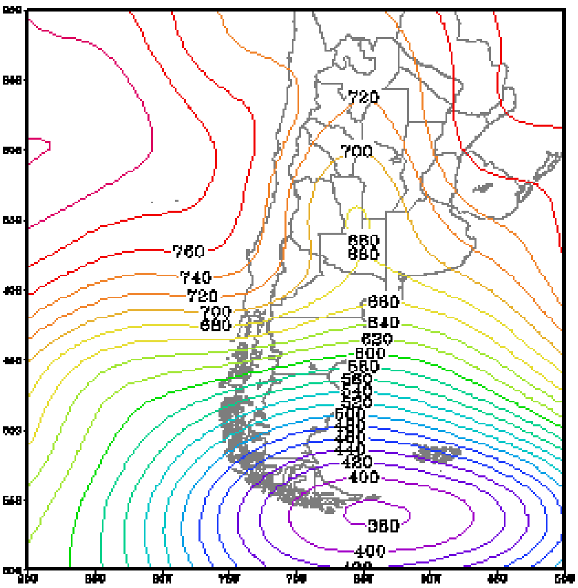

*Figure 2: 925hPa Geopotencial Height (m) – 18:00UTC 25 Dec 2000*

At the 850 hPa level (not shown) the synoptic configuration is similar to the 925 hPa level.

In general, the synoptic situation of this event obeys to Lichtenstein´s (1980) concept respect to the progressive disappearance of NAL with height

(At 850 hPa level is open to the south in a trough form, not so clear at 700 hPa and disappearing at high levels.)

The 600 hPa level (Figure 3) shows a trough associated to a surface frontal system located at approximately 1000 km south of SAME.

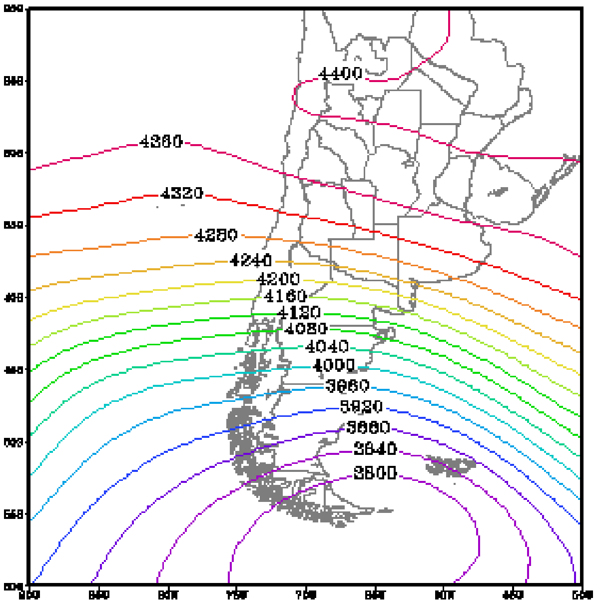

*Figure 3: 600hPa Geopotencial Height (m) - 18:00UTC 25 Dec 2000*

Areas of specific humidity (q) at 18.00 UTC (Figure 4) and at 00:00 UTC (not shown) indicate a minimum value (dryness area) close to SAME.

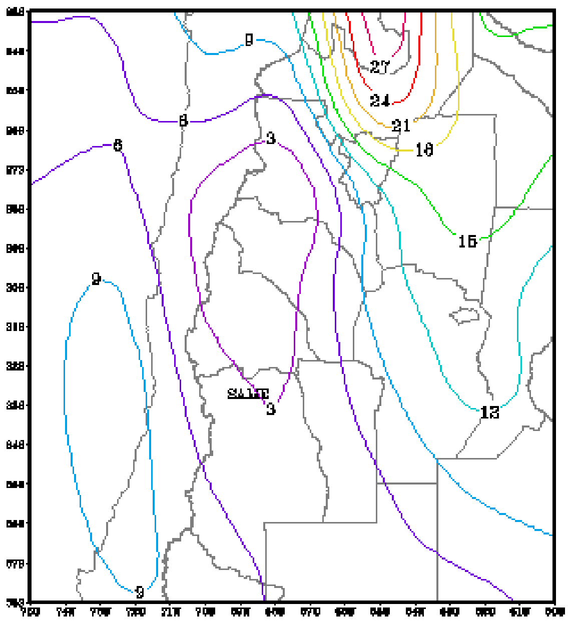


*Figure 4: 925hPa Specific humidity ($10^{-3}$ Kg/Kg) areas - 18:00UTC 25 Dec. 2000*

The Skew-T of SAME on December 25th. (Figure 5) indicates a temperature, humidity, and wind vertical profile of a classic winter zonda wind episodes. (Norte, F., 1988).

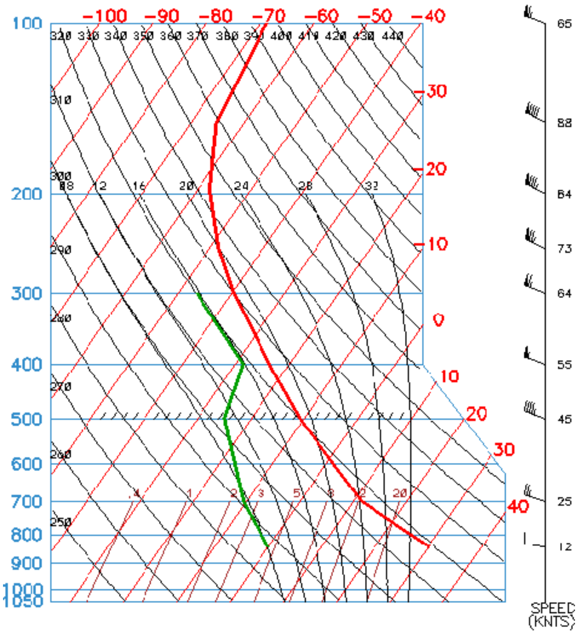


*Figure 5: SAME Skew-T - 18:00 UTC 25 Dic. 2000*

The MASCM outputs for December 25th 12:00 UTC show an 8% convection probability for the12:00 UTC to 18:00 UTC period; 89% for the 18:00 UTC to 00:00 UTC December 26th period and 90% for the 00:00.UTC to 06:00 UTC period on December 26th.

### 3.2 *EMTE-F*

Figure 6 shows the hourly temperature evolution (solid red line) at SAME from February 5th 00UTC to February 10th 23UTC, where the dashed blue line is the HMmmt (20.1°C) and the dashed red line is the HMmMT (33.6°C) for the 1986/2000 period.

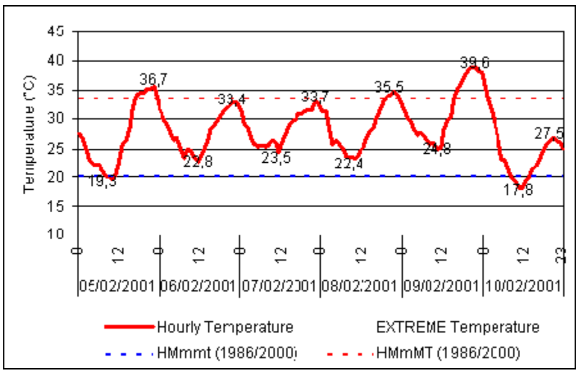


*Figure 6: Same as in Fig.1 but for EMTE-F*

This Figure shows that the evolution of temperature satisfied the two conditions of HWE definition.

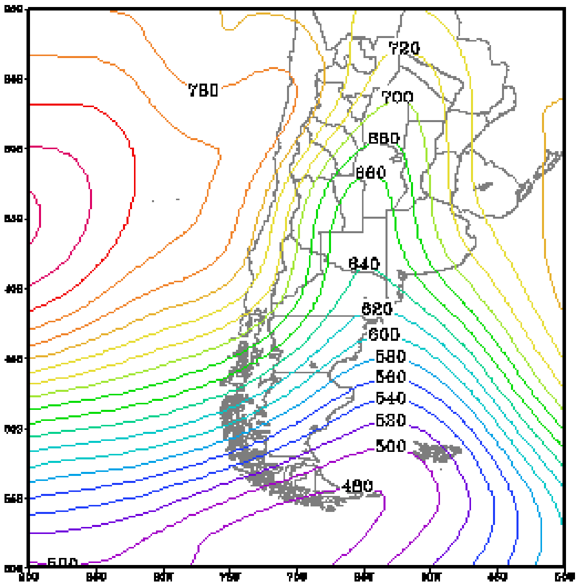

*Figure 7: Same as in Fig. 2 but at 1800UTC 9 Feb. 2001*

Figures 7 and 8 show similar structure for EMTE-D but the NAL does not reach higher latitudes and there is a cold front at 600 km south of SAME.

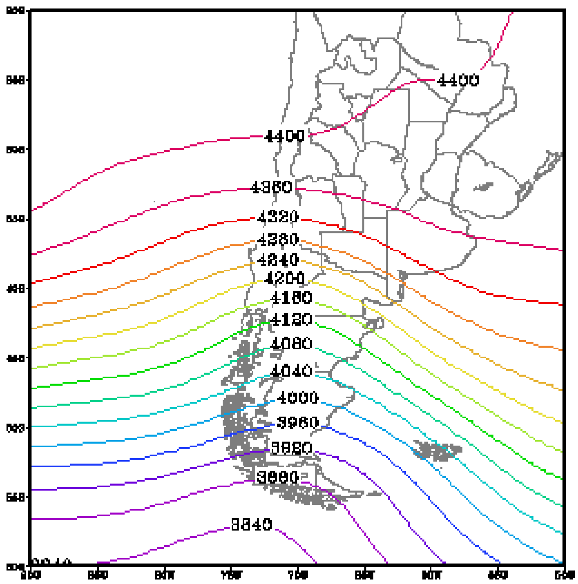

*Figure 8: Same as in Fig.3 but at 1800UTC 9 Feb. 2001*

The q analysis (Figure 9) is quite relevant .A minimum value over SAME can be seen and immediately to the east, a rapid increase because of a strong humid and warm advection coming from the northeast of the country.

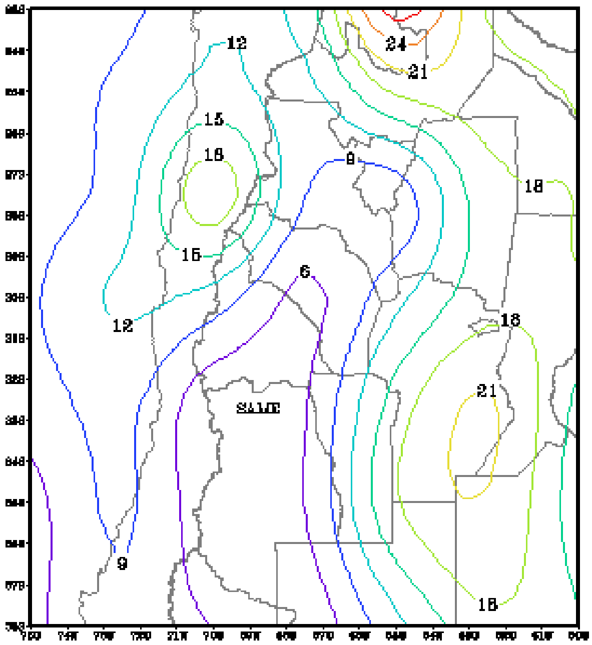


*Figure 9: Same as in Fig. 4 but at 1800UTC 9 Feb. 2001*

In Figure 10, the Skew-T of SAME on February 9th at 18:00 UTC, indicates a vertical profile quite similar to "high Zonda" situations (Norte, F., 1988) (Huschke, R., 1980).

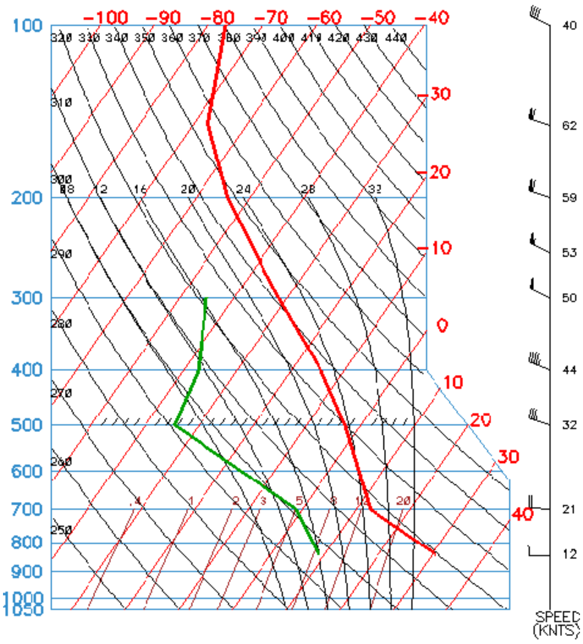


*Figure 10: Same as in Fig. 5 but at 1800UTC 9 Feb. 2001*

The MASCM outputs for February 9th 12:00 UTC show an 4% convection probability for the 12:00 UTC to 18:00 UTC period; 33% for the 18:00 UTC to 00:00 UTC February 10th period and 90% for the 00:00 UTC to 06:00 UTC period on February 10th.

### 3.3 *EMTE-J*

Figure 11 shows the hourly temperature evolution (solid red line) at SAME from January 26th 00UTC to January 31$^{th}$ 23 UTC, where the dashed blue line is the HMmmt (20.1°C) and the dashed red line is the HMmMT (33.1°C) for the 1988/2002 period.

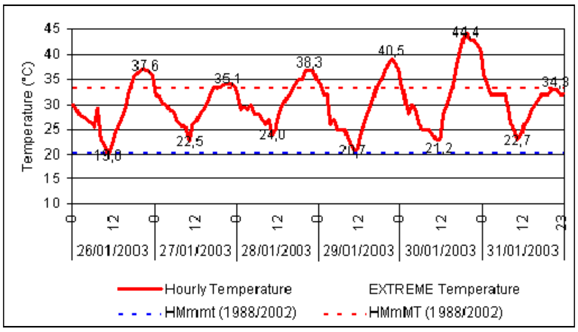


*Figure 11 Same as in Fig.1 but for EMTE-J*

Like in EMTE-D the hourly temperature evolution (Figure 11) satisfied the HWE conditions but for a longer period, more than a week, before the historical maximum temperature day.
The Figure 12 shows the intensification and translation of the NAL to the south, reaching 33°S latitude on January 30th afternoon, with a similar configuration to EMTE-D and EMTE-F.

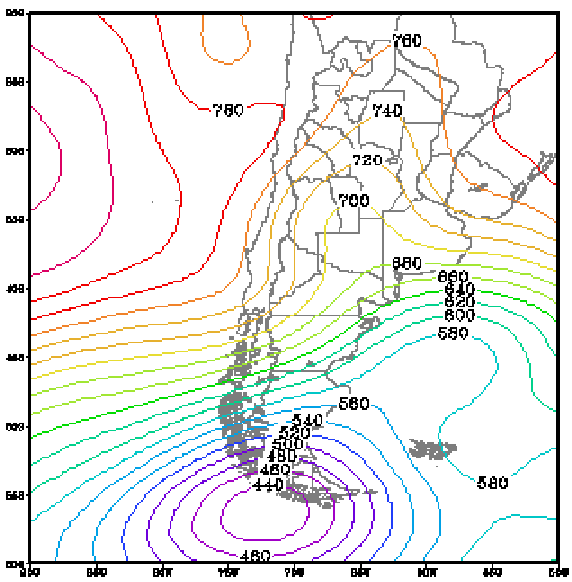

*Figure 12: Same as in Fig. 2 but at 1800UTC 30 Jan. 2003*

A ridge coming from the west (Pacific Ocean) can be seen since January 29th at 12:00 UTC (not shown) in 600 hPa level until January 30$^{th}$ at 18 UTC This configuration differs from the EMTE-D and EMTE-F because of a cut-off high centered at 600 hPa level (Figure 13) and a trough axis associated to a cold front that passed across the research area at dawn.

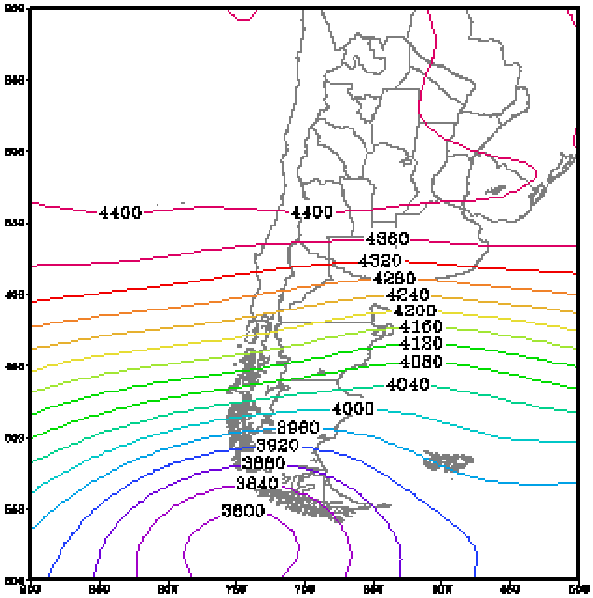


*Figure 13: Same as in Fig. 3 but at 1800UTC 30 Jan. 2003*

Q minimum values are also over the SAME area like in the other cases (Figure 14).

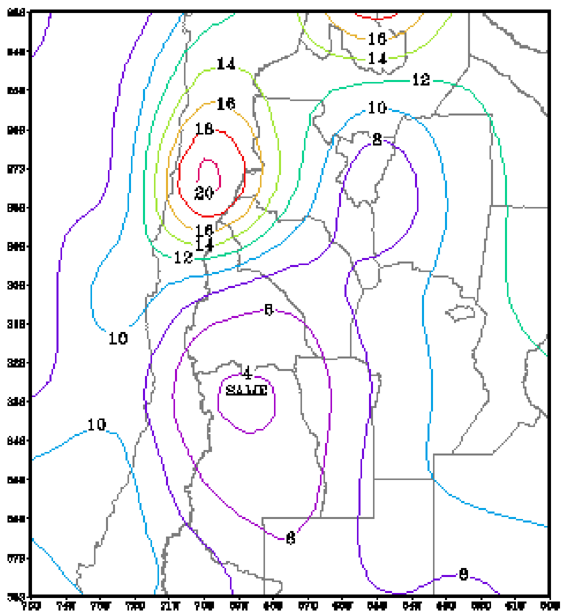


*Figure 14: Same as in Fig. 4 but at 1800UTC 30 Jan. 2003*

In Figure 15 the Skew-T of SAME on January 30th at 18:00 UTC indicates a vertical profile quite similar to "high Zonda" situations (Norte, F., 1988), (Huschke, R., 1980).

There is a remarkable dryness at all levels; the information is quite similar to the mean Skew-T associated to typical winter Zonda wind episodes. (Norte .F 1988) like in EMTE-D

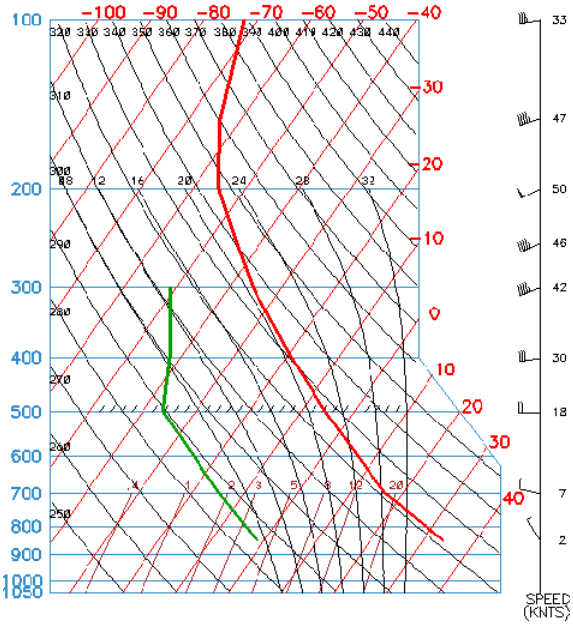


*Figure 15: Same as in Fig. 5 but at 1800UTC 30 Jan. 2003*

MASCM outputs for January 30th 12:00 UTC show an 7% convection probability for the 12:00 UTC to 18:00 UTC period, 67% for 18:00 UTC to 00:00 UTC January 31th period, and 90% for 00:00 UTC to 06:00 UTC period on January 31th.

## 4. CONCLUSIONS

In all EMTE analyzed at the 925 hPa level the baric configuration is very similar to Zonda wind conditions

Moreover the NAL is displaced to the south of it habitual position helping the occurrence of Zonda wind that contend with convection.

At the SAME latitude the height pattern at 600 hPa level shows a downward trough during EMTE-D and EMTE-F, and the presence of a height wedge with a cut off high in EMTE-J

The q analysis always shows a minimum value over the area and during EMTE-F there was a strong increment to the east of SAME.

In all EMTE analyzed zonda wind episodes of different intensity were present.

Another common element is the presence of a cold front. In all cases the extreme maximum temperature was registered some hours before the cold front arrived to SAME.

The EMTE occurrence is not a heat wave synonymous.

For example EMTE-D was associated to a Zonda wind event on the surface like in winter, characterized by a cold front approaching and a deep trough associated over the Pacific Ocean close to the continent.

The MASCM output for each EMTE showed the inhibition of convection because of Zonda wind effect before the occurrence of the MT.

To improve EMTE´S prediction in the growing global warming scenario it would be necessary to adjust regional mesoscale models and use satellite imagery.

***Acknowledgments:***

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