DIURNAL CYCLE IN CONVERGENCE PATTERNS IN THE BOUNDARY LAYER EAST OF THE ANDES AND CONVECTION

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I. INTRODUCTION

Different processes related to the Andes mountain range as well as west-east gradients in surface characteristics influence the generation of mesoscale circulations that may be influenced by surface friction and large-scale pressure gradients and may gradually force deep moist convection (Nicolini et al, 1987, Borque et al., 2006). These mesoscale circulations are associated with divergence/convergence patterns in the boundary layer (Segal and Arrit, 1992, Pan et al., 2004 and references therein).

This work has been done using an enriched analysis for the summer 2002-2003, during which the South American Low-Level Jet Experiment (SALLJEX) was performed in Southeastern South America (Vera et al., 2006). SALLJEX aimed to monitor, quantify and analyze the low-level circulation over this region and its related precipitation typically located southward the low-level jet (SALLJ, Nicolini et al., 2006), ahead of the maximum wind where convergence dominates. SALLJEX data set provides a quantitative improvement in both spatial and temporal resolution over that of the operational network. Enriched analyses were generated ingesting all available data with a higher spatial and temporal resolution than that available for the region, following a downscaling methodology (García Skabar and Nicolini, 2009), using the Brazilian Regional Atmospheric Modeling System (BRAMS, see Freitas et al ,2007).

With the purpose of progressing in the study of the mechanisms that control the diurnal cycle of precipitation and convection in subtropical latitudes east of the Andes during summer, this work focuses in exploring the diurnal cycle in mesoscale circulations in the boundary layer over northern and central Argentina not resolved by the low density observational network available in this region. A hypothesis is that convergence over the broad valleys east of the mountains may be efficient in triggering or intensifying deep moist convection that may have started earlier during the afternoon (Nicolini et al, 1987). Different authors as Nicolini and Saulo, 2006, Salio and Nicolini, 2006, Salio et al. 2007, have shown evidence of a strong nocturnal phase in heavy precipitation and convection over central and northern Argentina. Besides lifting related to boundary layer convergence, the simultaneous existence of the other two ingredients necessary to initiate deep convection, namely conditional instability and moisture availability, are also explored. A first question that arises is if the enriched analyses with SALLJEX data reproduce a diurnal cycle of convergence/divergence in the boundary layer (rising/subsiding motions at its top) that may be related to a northwestern mountains-central plain flow regime and if there is a relationship between the phases of convergence and of precipitation/convection in the area. We also inquire the extent to which these circulations are sufficient by themselves to control deep convection in different synoptic environments or else other circulation patterns are more effective. The present study is organized around a two weeks long period (since January 24 up to February 7/2003) during SALLJEX that followed a cold incursion and during which different environmental conditions prevailed. A heat wave occurred between 25 January and 2 February of 2003 that produced the highest February temperatures in the previous 35 years long period that was documented by Cerne et al, 2007. Also, Saulo et al., 2005 identified during the period 31 January to 6th February 2003 the presence of a thermal-orographic low pressure system (NOA) located over northwestern Argentina close to the eastern Andes slopes whose duration was atypically long. This system has an important influence in the poleward penetration of the SALLJ.

II. PRESENTATION OF RESEARCH

During the period of study the boundary layer mean divergence fields have been analyzed. The height of the boundary layer has been determined as the level where potential temperature gradient exceeds 1,7º/km and also a minimun value is set at 900m. Divergence is estimated at each grid point as a vertical average weighted at each level by the thickness of the layer that corresponds to the divergence value..

Cerne et al. (2007) have already found an intraseasonal oscillation with an intensified South Atlantic Convergence Zone during the week previous to the extreme heat wave conditions that prevailed from January 31, 2003. They identified subsidence and diabatic warming in the subtropical boundary layer as the main processes related to the strong SACZ presence that favored relatively dry conditions over central Argentina. In the synoptic scale an anticyclonic circulation prevailed during the first week preventing convection whereas warm horizontal temperature advection dominated since January 31 associated with an intensification of a more defined poleward orientation of the SALLJ and a weakening of SACZ. This warm and moist horizontal advection preconditioned the environment and drove to the development of mesoscale convective systems since February 3 that ended on severe convection at the end of the period of study (February 7).

No convection developed over the subtropics before January 27. Convection initiated during the afternoon in the following days over the Andes and southward 35ºS due to convergence related to a stationary frontal zone present during the whole period and horizontal warm advection just east of the Andes that reached 35ºS and triggered convection that evolved and dissipated during night. Even if boundary layer divergence pattern shows convergence at night (see Fig. 1) convection was not favored over the plains before given the prevalent dry conditions (not shown). This synoptic situation was followed from January 31 by the dominance of a low-level jet (with its maximum oscillating around 25S) strongly dominated by the evolving NOA circulation pattern. The warm and moist advection that starts to prevail creates the environmental conditions that gradually allow organized convection to develop. MCSs first develop southward 33S over the plains with a line structure during the 00TC to 12 UTC nocturnal times to reach lower latitudes once the NAL shifted to the NW and the maximum in the LLJ becomes located in the typical position that characterizes the intense SALLJ events. Convection over the mountains starting in the afternoon and propagating and intensifying over the plains at night prevails from February 3. An intensification of the stationary front at 35S and a strengthening of the NOA during February 6 enhance convergence generating by merging a stronger and more severe MCS. The propagation of the cold front together with a change in the orientation of the SALLJ dominate at the end of the period.

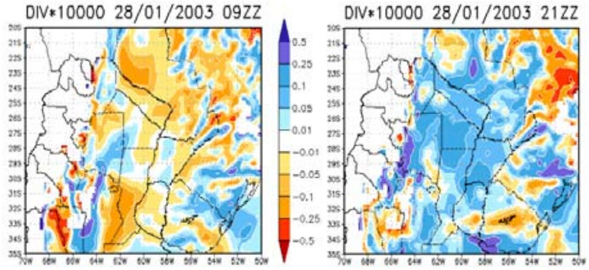

FIG.1: Boundary layer mean divergence fields.

A diurnal oscillation on the mean boundary layer divergence averaged also over the study area prevails from January 31. Figure 2 evidences this behavior as well as the weakening of the anticyclonic circulation dominated by divergence. Both the convergence pattern related to the mountains-central plain flow regime and the one related to the low-level jet are in phase with the time of maximum intensity of convection that prevails during the night.

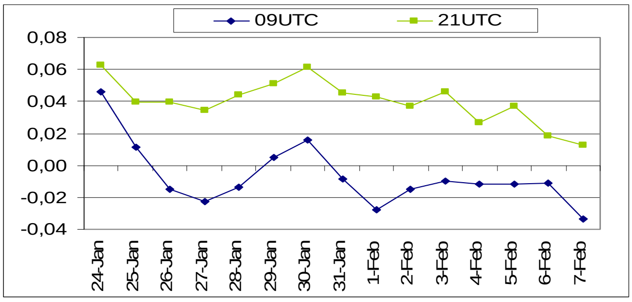

FIG.2:Evolution of divergence averaged (10^{-4}*1/s) over the study area .

III. RESULTS AND CONCLUSIONS

During weakly forced environment northward 35S a regime characterized by nocturnal drainage flow and convergence and daytime upslope flow and divergence over the plains dominates when the low-level circulation is not dominated by an anticyclone. However, once more cyclonic conditions prevail, a more defined cold front starts to propagate and more humid air is advected over the area favoring convection, the convergence downstream the nocturnal maximum in the low-level jet above the nocturnal boundary layer alters these mesoscale circulations and makes more difficult to differentiate the different contributions that eventually control convection.

IV. AKNOWLEDGMENTS

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