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NUMERICAL SIMULATION OF A REAL CASE OF MULTICELL STORM OVER NORTHEASTERN ARGENTINA

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1. INTRODUCTION

In the late 1980s and early 1990s numerous observational and/or numerical studies (Rotunno et al. 1988, Weisman et al. 1988, Lee et. al. 1992, Johns 1993, Weisman 1993) were dedicated to describe and explain a long-lived mesoconvective structure that takes the form of a 60-200 km long bow-shaped segment of cells that evolves from a unique cell or as a part of a larger scale multicellular convective system (line or MCCs). This type of convective structure is resposible of inducing widespread damaging surface winds in its rear flank. It is worth to mention that the typical morphology of radar echoes associated with this bow structure was first depicted by Fujita (1978). This convective structure preferably evolves within an environment associated with elevated moisture (surface dew-point greater than 20C), moderate to strong CAPE values and with a moderate to strong vertical wind-shear in the lowest 2.5km AGL.

A mesoscale convective system, developed during the morning of 19 October, 2000 over the area of Resistencia (27°27'S, 59°03'W), Province of Chaco, Argentina. Satellite images displayed the evolution of this system with a pattern and time length similar to the expected for bow-echoes. Unfortunately, this suspicion could not be strictly confirmed as no radar is available in the Chaco area.

The synoptic environment of this event was studied using radiosoundings available at Resistencia, surface data provided by the National Weather Service of Argentina and the NCEP reanalysis data set. Some evidences of typical conditions leading to bow-echo development were present in the environment: a moderate to high CAPE and a vertical wind shear with a high magnitude in the first 2.5km above ground level.

Given the phenomena typically produced by these convective systems as severe winds, heavy precipitation and tornadoes, it is of interest to explore the possible formation and evolution of a bow-echo in this region. A simple approach to address this issue is to simulate this real storm case using a mesoscale numerical model.

2. METHODOLOGY

The numerical tool used for the numerical experiments is the Advanced Regional Prediction System (ARPS), a non-hydrostatic mesoscale model developed by the University of Oklahoma and completely described by Xue et al. (2000).

The following is a brief description of the configuration implemented in the model for this study. A bulk water, mixed-phase cloud microphysics, following Lin et al. (1983) is used. A 1.5 order prognostic turbulent kinetic energy equation option is used for subgrid scale turbulence parameterization. A Rayleigh friction absorption layer is activated near the top, and open lateral boundary conditions follow Klemp and Wilhemson (1987a).

A 1 km horizontal grid spacing and 0.5 km vertical grid spacing are used in a 71 km by 71 km horizontal domain and a 18.5 km high vertical domain. For the acoustic terms in the equations a "small" time step of 1 s is used and increased to 6 for the other terms.

The model is initialized with an horizontally homogeneous environment given by the Resistencia 12:00 UTC radiosounding (shown in Figure 1).

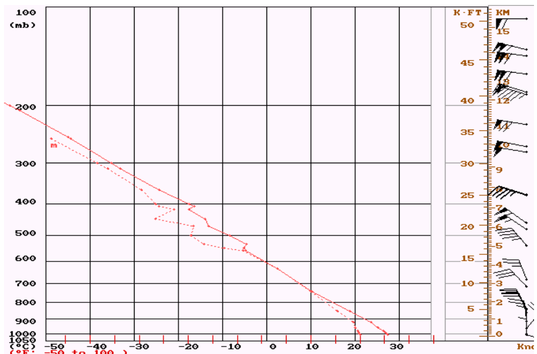

Figure 1: Radiosounding at Resistencia 12UTC

Two different numerical experiments have been performed aimed to understand the role of the enviromental wind profile in organizing convection in this particular event. The first one (**E1**) was run with a smoothed hodograph in order to simulate the evolution under a more idealized wind profile configuration (see Figure 2) while retaining the main features already

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discussed by previous research on deep convection dynamics. A second experiment with the real wind profile (**E2**) was conducted to compare the convective mode and evolution under real versus ideal conditions (Figure 2).

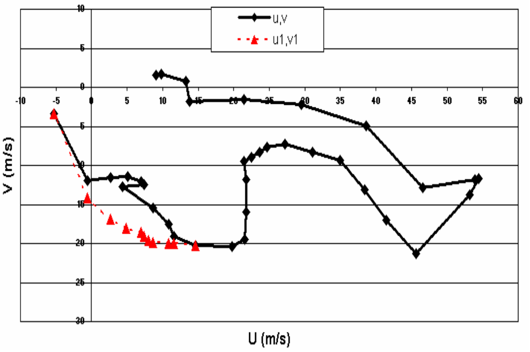

Figure 2: Wind hodograph used for experiments: **E1** (red line) and **E2** (blue line)

3. NUMERICAL RESULTS

The evolution in the experiment **E1** exhibits an explosive development with a complete cell splitting below 5km with a stronger intensification of the left flank updraft, coherent with the anticlockwise veering of the wind hodograph in the Southern Hemisphere.

Later in the simulation the convective arrangement acquires a typical bow-echo configuration with strong rotational downdrafts in the apex of the convective line associated with a strong vertical vorticity field (book-end vortex) and a slight intensification of the wind in the rear part of the convective system at low-levels (≈ 2km). These dynamical features are depicted in Figure 3.

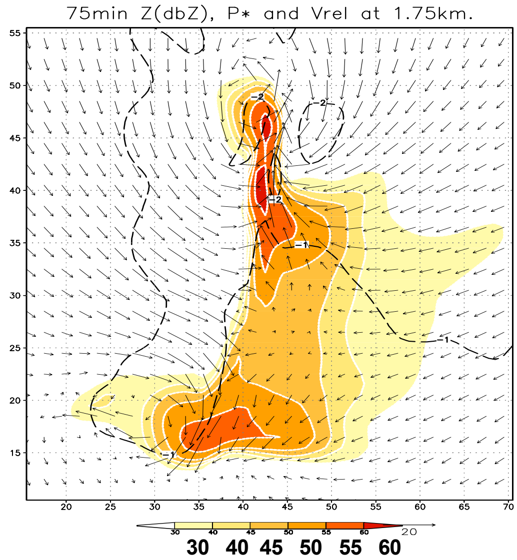

Figure 3: Horizontal field of reflectivity field (dBZ, shaded) and P* (hPa, dashed line. Contours every 1 Pa) for **E1** at 75 min

This pattern intensifies till the end of simulation time. However, at this time the convective system has not yet completed the development of all the features which define a bow-echo such as the typical deep gust-front and the intensification of the rear inflow (jet) behind the convective line.

The analysis of the real experiment (**E2**) displayed similar features to **E1** but with an evident reinforcement of the right updraft instead (see Fig. 4), besides the persistent character of the left cell. This persistence was explained by the merging of new developments at the gust-front in the eastern sector.

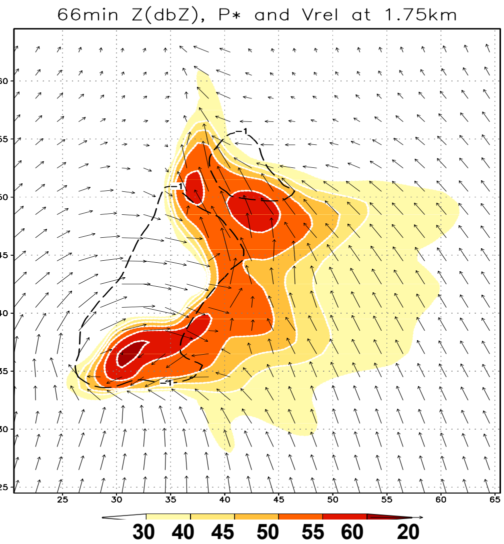

Figure 4: Horizontal field of reflectivity field (dBZ, shaded) and P* (hPa, dashed line. Contours every 1 Pa) for **E2** at 66 min

The right updraft mantains its dynamic prevalence through the whole simulation and as it was previously explained, the left cell persists. It is also evident in Fig 4, that the reinforcement of the rear inflow is stronger in **E2** (compare arrow sizes between Fig. 3 and 4)

A remarkable difference between both experiments is that vertical vorticities associated with the descending motion at 2 and 3km height level within the apex of the convective line are stronger in the real one (**E2**) (see Figure 5).

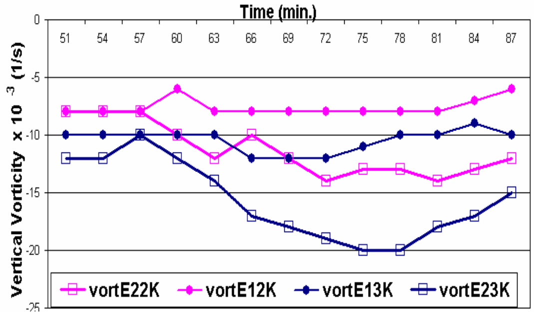

Figure 5: Vertical vorticity minimum related to descending motion in the right cell for both experiments. Vorticity at 2km (pink lines) and at 3km (blue lines) for both experiments

4. SUMMARY AND CONCLUSSIONS

The significant features characteristic of a bow-echo come up more clearly in the real hodograph experiment (**E2**) compared to the idealized case (**E1**). This is evident in the stronger reinforcement of the rear inflow behind the convective line. Both experiments exhibit extremely cold tops and negative temperature anomalies respect to the environment in these high levels ($\Delta\theta^* \approx -20K$), in agreement with the extreme cold temperatures that have been observed in the infrared satellite images. These differences between experiments is consistent with the well known high sensitivity of convection and particularly of its internal dynamics to initial conditions given in this case by slightly different environmental wind shear profiles.

Some of the bow-echo features (system persistence and deep cold pool) could not be completely developed in any of the simulations before the system reached the domain boundaries (about 2 hours of integration time). Due to the limitations in computational resources at the time of the runs this domain could not be enlarged and the simulation extended in time to assure a complete life system simulation.

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