The 6 May 2010 Elevated Supercell During VORTEX2

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Introduction

- Convection over statically stable boundary layers (i.e., elevated convection) occurs over much of the United States, producing heavy rainfall, hail, and occasionally severe surface winds.
- Elevated supercells present an operational challenge because they look similar to surface-based storms on radar, which can lead forecasters to issue warnings for severe winds and tornadoes that are not likely to verify. However, both tornadoes and severe winds do seem to occur in a handful of supercells that are believed to be elevated, with the reasons behind their formation currently unknown.
- Observational analysis of an elevated supercell observed during the second Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX2) is performed here in conjunction with an idealized model simulation.

Methods

- Observations
  - Dual-Doppler wind syntheses (dual-pass Barnes scheme, 250 m horizontal and vertical grid)
  - Near-storm environmental soundings (Figs. 1, 2)
  - Surface observations from mobile mesonet and StickNet platforms
- Idealized simulation using CM1 (Bryan and Fritsch 2002), v16.
  - 250 m grid spacing in x, y
  - Stretched vertical grid ranging from 100 m up to 3 km to 500 m at 9+ km
  - Input sounding created by blending two observed near-inflow soundings (Figs. 1, 2)
  - Storm initialized with sustained convergence

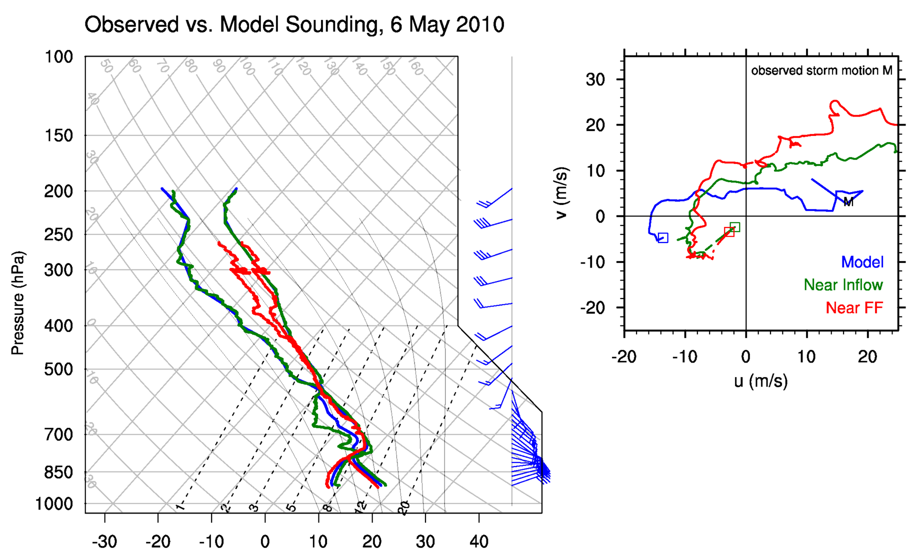

Fig. 1: Soundings and hodographs from the 6 May 2010 case (green – near inflow taken at 0039 UTC 7 May 2010, red – near forward-flank taken at 0117 UTC 7 May 2010) and used in modeling simulation (blue). Wind profile shown is the one used in the model and is from a far inflow sounding taken at 0106 UTC 7 May 2010.

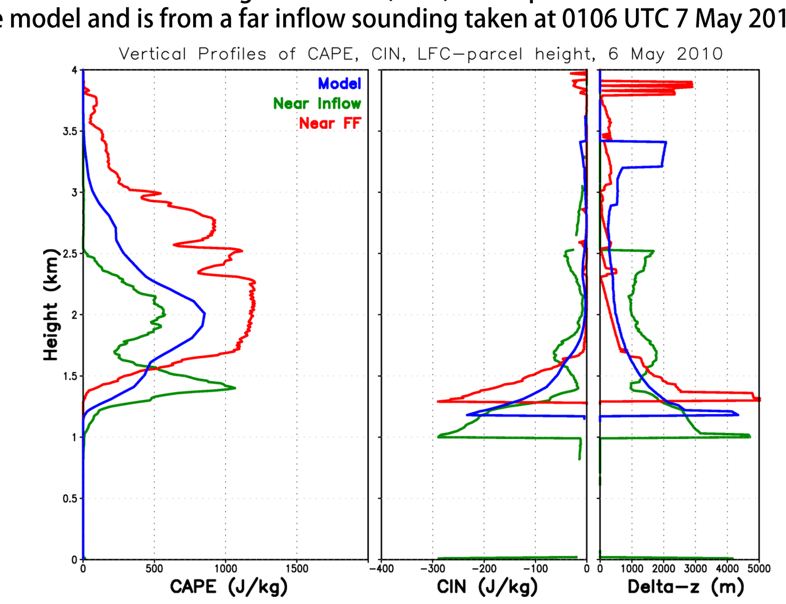

Fig. 2: Vertical profiles of CAPE, CIN, and delta-z (the distance between the parcel height and the level of free convection) for the soundings shown in Fig. 1.

Acknowledgments

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Observational Analysis

- Storm remains quasi-steady over much of sampling period (Fig. 3)
- Gravity waves appear to be present on the inversion, which may contribute to maintaining the supercell updraft (Fig. 4)
- Supercell is decoupled from the surface, evident from the relatively steady flow below the height of the inversion (Figs. 4, 5)
- Cooling exists underneath the storm at the surface from the evaporation of precipitation as shown by the deficit in θ without one in θ_e (Fig. 6)

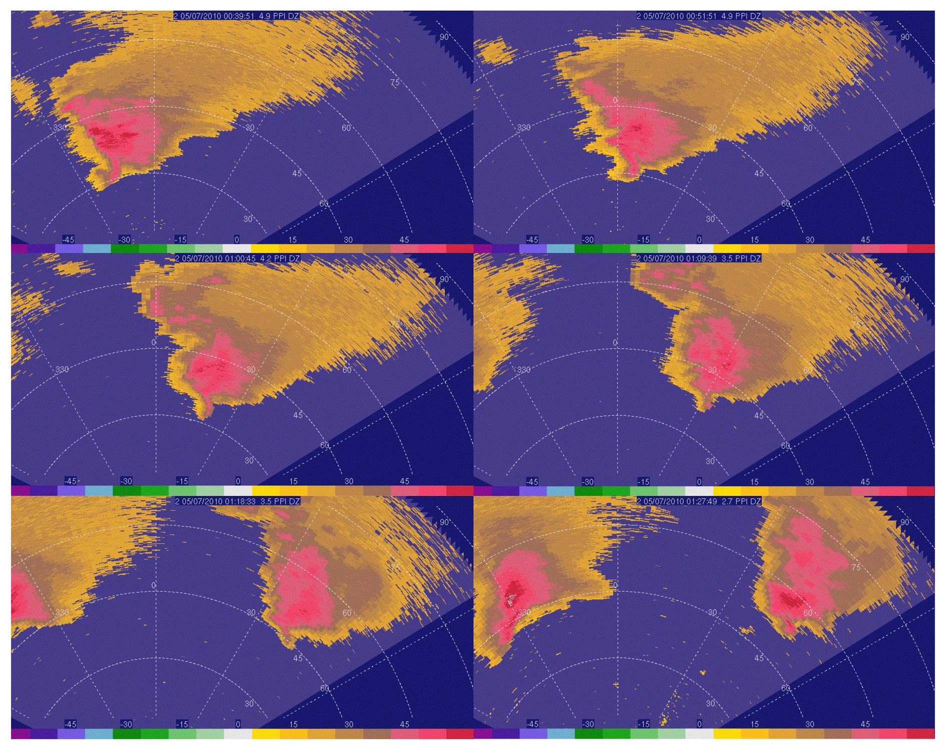


Fig. 3: Plan view of reflectivity from SMART-R2 mobile radar at (upper left to lower right) 0039, 0051, 0100, 0109, 0118, and 0127 UTC 7 May 2010. Snapshots were taken when hook echo was at a height of ~2.5 km.

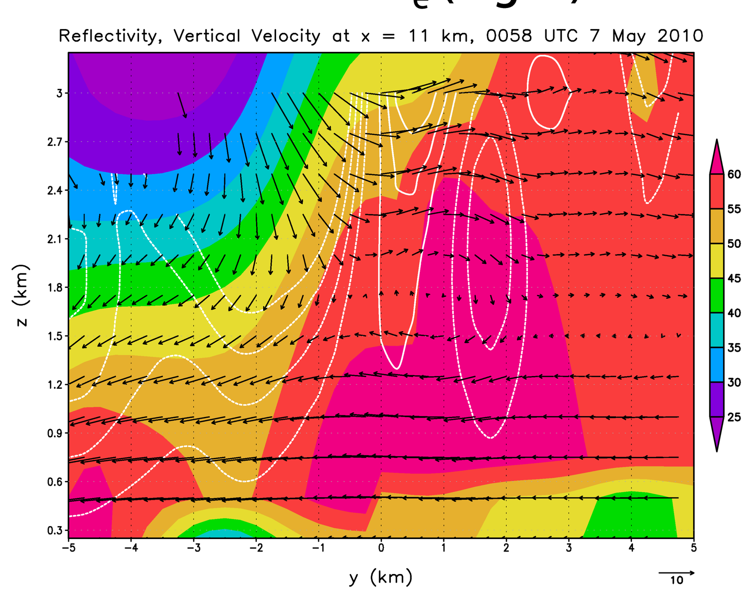


Fig. 4: Vertical cross-section at x = 11 km (see Fig. 5) of reflectivity (shaded), vertical velocity (white; contoured every 1 m/s, negative values dashed), and storm-relative wind vectors (derived from DOW6/SMART-R2 dual-Doppler synthesis) for 0058 UTC 7 May 2010.

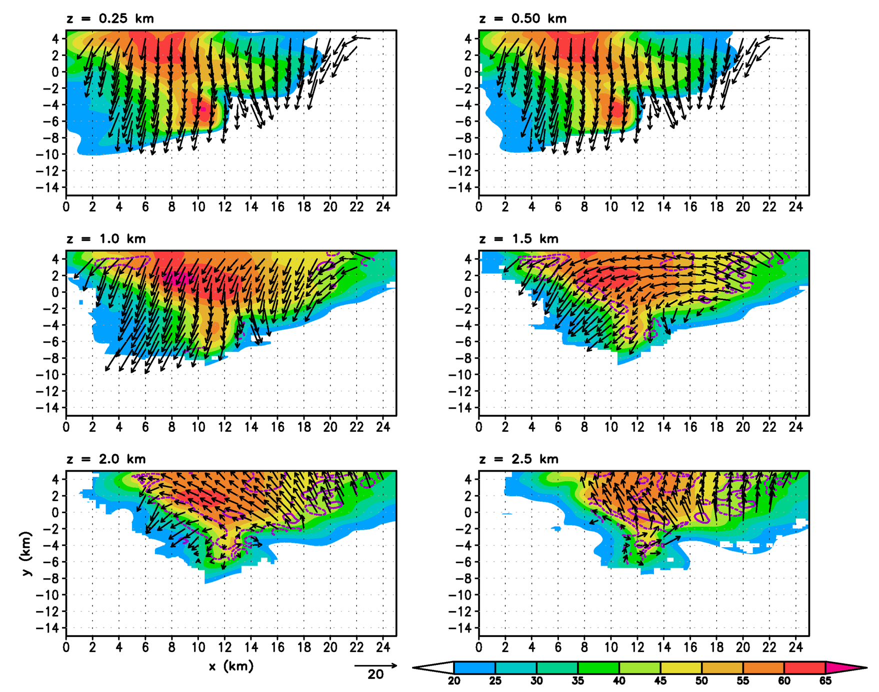
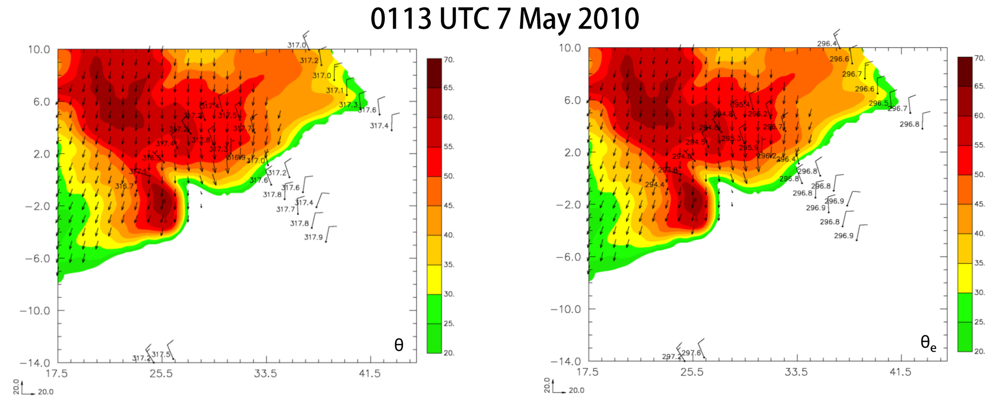


Fig. 5: Plan view of reflectivity (shaded), storm-relative wind vectors (derived from DOW6/SMART-R2 dual-Doppler synthesis), and vertical velocity (purple; contoured every 3 m/s, negative values dashed) at 0058 UTC 7 May 2010. Positions are relative to the location of DOW6 in km.

0113 UTC 7 May 2010



← Fig. 6: Plan view of reflectivity (shaded), storm-relative wind vectors (250 m above the surface; derived from DOW6/DOW7 dual-Doppler synthesis), and time-to-space converted mobile mesonet and StickNet observations (θ on left, θ_e on right) at 0113 UTC 7 May 2010. Tracks are 3 minutes in length. Positions are relative to the location of DOW6 in km.

Conclusions

- Air in the stable layer is relatively unaffected by the storm (decoupled) with much of the updraft air coming from above the inversion.
- Wave-like features near the inversion appear to play a role in maintaining the supercell updraft (i.e., lifting parcels to the LFC).
- Although outflow is not necessarily present at the surface, cooling does occur beneath the storm, likely from evaporation.
- Low-level wind perturbations might be the result of cooling or wave activity.

Model Simulation

- Supercell lacks typical features below the inversion; features locally accelerated flow that may cause bow-like shape of hook echo (Fig. 7)
- Storm is quasi-steady (Fig. 8)
- Very little stable layer air makes it into the tilted updraft (Fig. 9); downdraft air penetrates the stable layer, but does not reach surface (not shown)
- Ripples in the θ surfaces in association with vertical velocity perturbations suggest that gravity waves are present near the inversion height (Fig. 10)
- Significant vertical vorticity does not exist in the stable layer (Fig. 11)

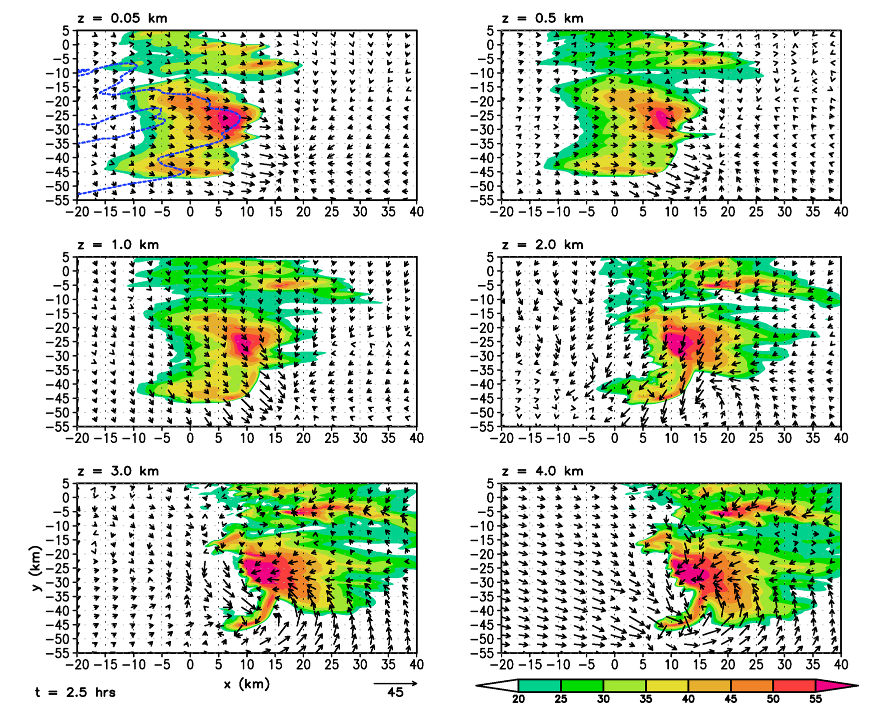


Fig. 7: Plan view of simulated reflectivity (shaded), perturbation wind vectors, and θ deficit (blue; only shown at lowest model level, contoured at -1 and -3 K) at t = 2.5 hours.

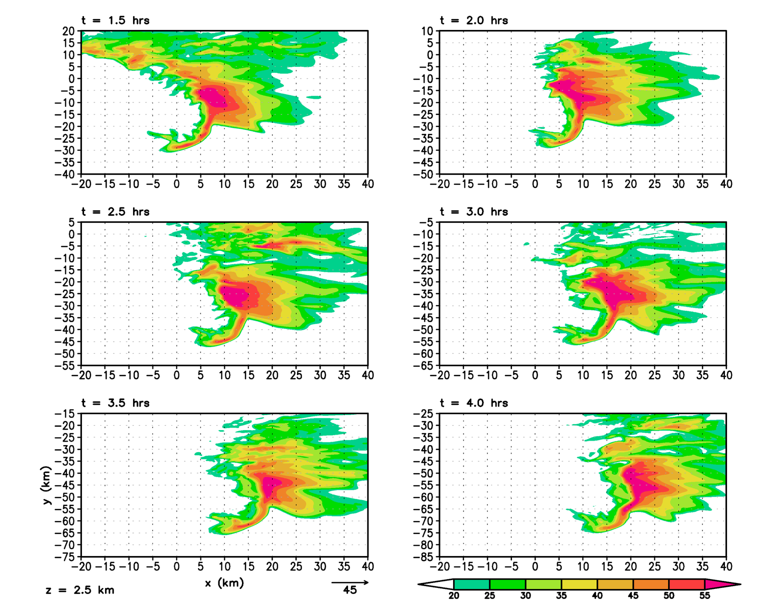


Fig. 8: Plan view of reflectivity at a height of 2.5 km at various hours during the simulation. Box moved to keep storm centered vertically.

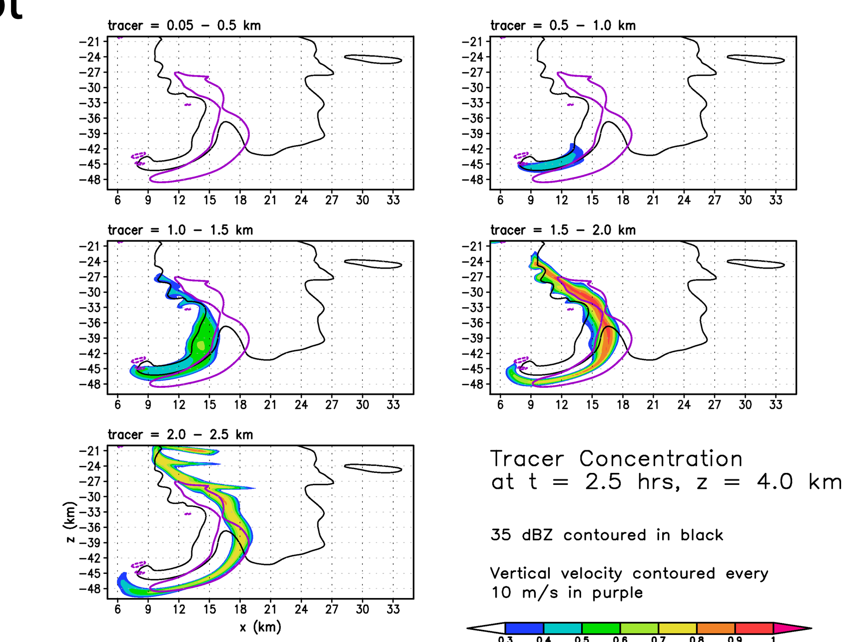


Fig. 9: Plan view of concentration of a passive tracer (shaded), vertical velocity (purple; contoured every 10 m/s, negative values dashed), and the outline of the supercell (black; 35 dBZ contour) at a height of 4 km, t = 2.5 hours.

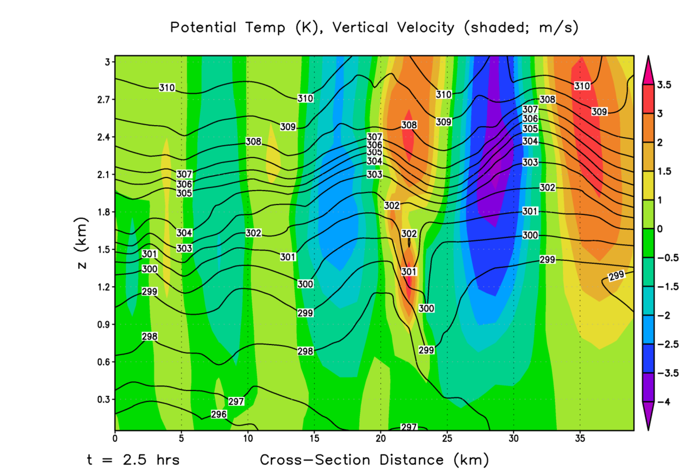


Fig. 10: Vertical cross-section of potential temperature (contoured) and vertical velocity (shaded) from (-20, -30; left edge) to (10, -55; right edge) based on axes in Fig. 7 at t = 2.5 hours.

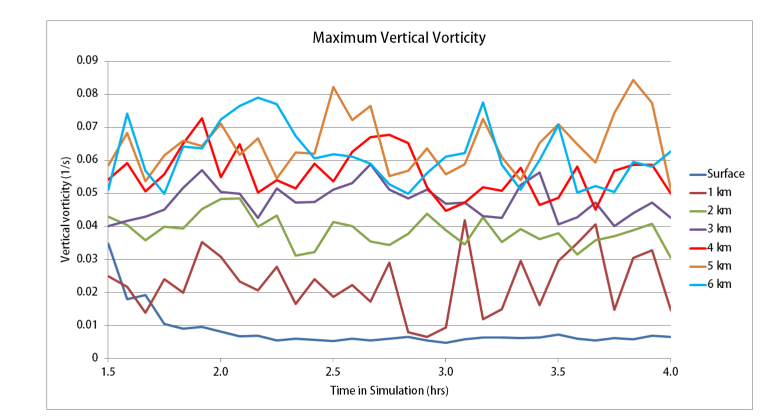


Fig. 11: Maximum vertical vorticity in the simulated supercell for various levels at t =1.5–4 hours.

Future Work

- Incorporate additional radar data (more times, triple-Doppler syntheses)
- Implement trajectories into the model simulation to further understand the origins of updraft and downdraft parcels
- Investigate dynamics contributing to storm structure and maintenance
- Attempt to understand origins of modeled low-level wind perturbations and possible linkages to severe