# EVOLUTION OF DOWNDRAFT THERMODYNAMICS AND LOW-LEVEL ROTATION IN THE TORNADIC 29 MAY 2004 GEARY, OK, USA SUPERCELL STORM

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## I. INTRODUCTION

Markowski et al (2002) employed mobile mesonet and radar observations to show that tornadogenesis likelihood increases with decreasing magnitude of the temperature deficit of the rear flank downdraft (RFD). Their finding suggests that greater understanding of the origins and range of temperature and related airflow forcings will help improve the diagnosis and warning of tornadoes and their parent low-level mesocyclonic circulations. Examining the broader, storm-scale precipitation-filled boundary layer (BL), modeling studies have revealed a zone of intense convergence and baroclinicity on the storm-scale RFD's east flank of some supercells (i.e., "RFD boundary") that undercuts the classical forward flank downdraft (FFD) outflow (e.g., Wicker and Wilhelmson 1995), although this RFD boundary feature was not the focus of those earlier studies. The storm-scale RFD is typically located within the classic supercell's precipitation core to the north of the developing low-level mesocyclone (LLM).

The primary objective of the present study is to use dual-Doppler radar analysis and single-Doppler EnKF data assimilations of the 29 May 2004 Geary, Oklahoma, USA tornadic supercell to explore the origins of the storm's cold pool and the formation of the (baroclinic) RFD boundary. Initial LLM development is understood to occur via the solenoidal generation of streamwise horizontal vorticity in the storm's baroclinic forward-flank inflow region (e.g., Rotunno and Klemp 1985), with intense stretching within the main updraft base dominating the LLM intensification (e.g., Ziegler et al. 2001). Thus, a secondary objective is to explore the hypothesis that the subsequent storm-scale RFD boundary may contribute to the intensification of the near-ground LLM via additional baroclinic generation of streamwise horizontal vorticity behind the shallow storm-scale RFD boundary followed by tilting-stretching.

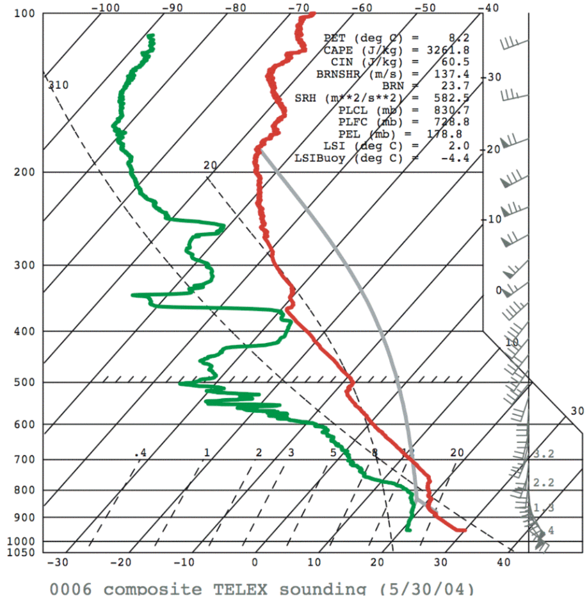

FIG. 1: Mobile environmental GAUS sounding obtained at 0006 UTC on 30 May 2004. The sounding was obtained in the inflow of the Geary storm about 75 km SE of the main updraft.

## II. RESULTS AND CONCLUSIONS

Two mobile C-band Doppler Shared Mobile Atmospheric Research and Teaching (SMART) radars were located south of the 29 May 2004 Geary supercell and sampled the storm's severe, right-moving phase. Details of the storm's evolution are described by Betten et al. (2009, this conference). Bulk parameters of the storm's near-environment were obtained from approximately hourly, storm-following mobile GPS advanced upper-air sounding system (MGAUS) profiles obtained within the storm's inflow extending from its initiation stage through the time of maximum low-level rotation in central Oklahoma. The environmental inflow sounding was strongly sheared and convectively unstable, although the BL contained a pronounced inversion during the most intense storm phase (Fig. 1). The storm had formed farther west in an unstable airmass capped by a weak inversion (not shown) and had subsequently intensified while moving eastward into the stronger inversion region.

A series of time-spaced, high-resolution 3-D dual-Doppler airflow analyses have been combined to determine the trajectories of air feeding the cold pool in the Geary storm. Air parcels that descend to the surface within the rear-flank downdraft (RFD) of the storm originate mainly within and below the capping inversion that overlies the moist BL (Fig. 2), suggesting that ambient stability may influence cold pool intensity by regulating the mass fractions of downdraft air originating in the moist BL and the dry elevated residual layer (ERL).

An Ensemble Kalman Filter (EnKF) analysis that assimilates single-Doppler observations into a 3-D cloud model is used to determine the Lagrangian diabatic cooling/moistening rates that force the FFD and RFD. During the storm's most severe phase, a strong, storm-scale rear-flank downdraft boundary (RFDB) intersects a rather diffuse conventional forward flank downdraft boundary (FFDB) within the wrapping inflow to the intensifying low-level mesocyclone (Fig. 3). It is hypothesized that the LLM

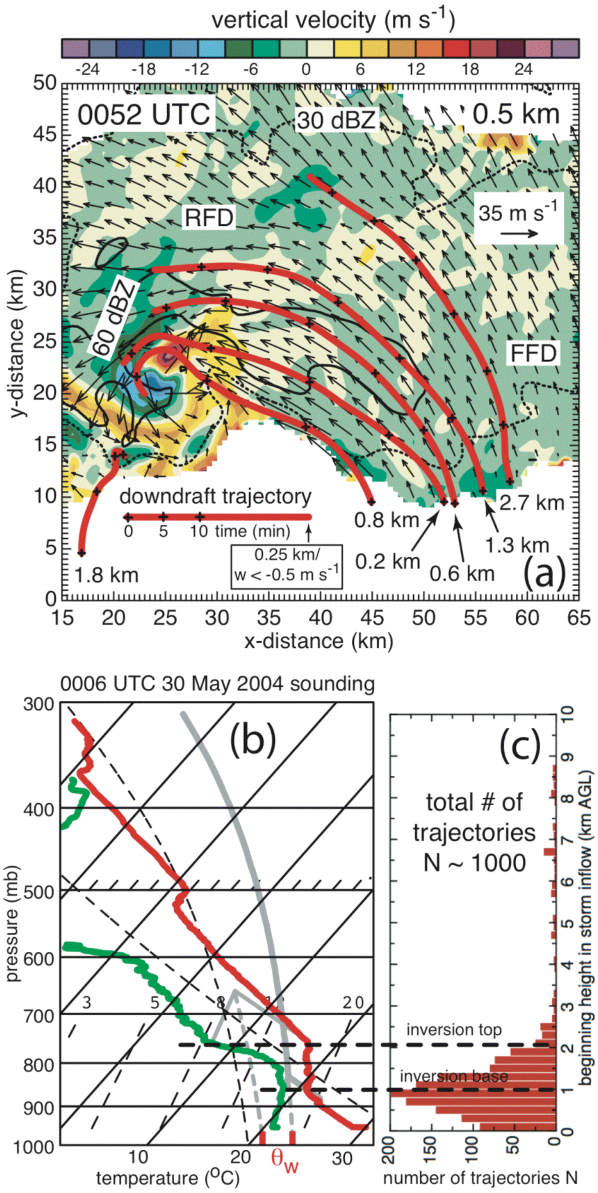

FIG. 2: Backward air trajectories from time-spaced dual-Doppler analyses beginning at 0052 UTC on 30 May 2004 in low-level downdrafts. (a) horizontal projection of backward trajectories from RFD beginning at 0.25 km and $w < -0.5$ m s$^{-1}$; (b) expanded view of inflow sounding (Fig. 1); (c) histogram of ending heights of backward trajectories in the inflow storm environment. Values of $\theta_W$ of the inflow BL and the overlying relatively warm, dry inversion layer are indicated in panel (b).

is intensified via the classical mechanism of solenoidal (horizontal streamwise) vorticity generation followed by tilting and stretching with contributions from both the RFDB and FFDB. Preliminary results of EnKF-based analyses of downdraft source regions and vorticity dynamics of the LLM will be presented at the conference.

# III. Acknowledgments

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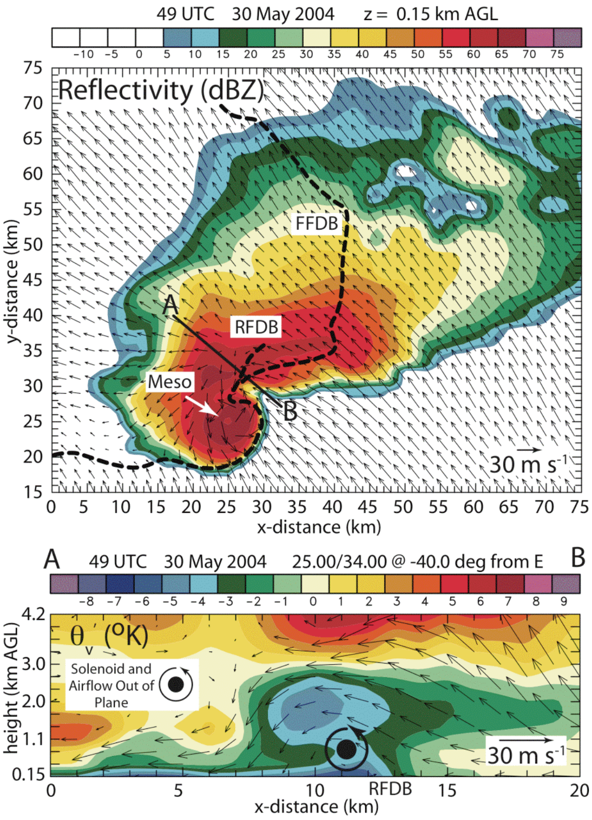

FIG. 3: Ensemble-mean output from an EnKF analysis of the Geary storm at 0049 UTC on 30 May 2004. The EnKF uses 30 members and a base state from the sounding in Fig. 1, inserts data from one SMART radar, and assumes an LFO one-moment, bulk microphysics parameterization scheme. (Top) reflectivity and horizontal airflow; (bottom) perturbation virtual potential temperature ($\theta'_v$) and airflow in cross-section A-B located in the top panel. Dashed curves locate the RFDB and FFDB while "Meso" is the LLM, as discussed in the text.

# IV. References

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