P6.8 NUMERICAL INVESTIGATION OF THE ORIGINS OF THE GRANITE FALLS, MN, TORNADO

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1. INTRODUCTION

On July 25, 2000 an F4 tornado occurred at Granite Falls, Minnesota around 23:20 UTC (6:20 PM CDT). Both WSR-88D radar imagery from MPX (Chanhassen, MN, located about 100 miles to the east), along with visible and IR GOES satellite imagery show that a storm interaction or merger occurred between a supercell on the south end of a squall line moving east and a second band of convection on the leading edge of a rapidly expanding MCS (Mesoscale Convective System) that first developed in extreme eastern South Dakota about 43 nautical miles due west of Granite Falls between 2210 UTC and 2225 UTC. The interaction occurred between 2247 UTC and 2302 UTC while the response to storm merger became evident between 2302 UTC and 2315 UTC on GOES IR data when a spike occurs in the overshooting storm top of the supercell near Montevideo at 2315 UTC. GOES IR data displays a rather dramatic collapse of the supercell top between 2315 UTC and 2325 UTC during the time of the Granite Falls tornado.

It appears that during the 20 minute time period leading up to the storm merger, storm-relative inflow for the supercell approaching near Montevideo, MN (about 20 miles northwest of Granite Falls) was greatly enhanced due to advancing thunderstorms along with their outflow on the leading edge of the MCS over the border between Yellow Medicine, Lincoln and Lyon Counties.

An accelerated influx of warm and moist air likely developed into the right rear flank of the supercell near MVE as the inflow wedge between the two convective systems was gradually pinched off. This in turn led to an updraft pulse into the supercell and the observed intensification of its overshooting top. As the inflow wedge pinched off, support for the updraft was rapidly cut off and the storm top collapsed suddenly between 2315 UTC and 2325 UTC leading to the Granite Falls tornado; note the warming of the storm top from a range of –55ºC to –60ºC to a range of –38ºC to –47ºC over this time span. In addition to the above, we also believe that enhanced mid-level flow (i.e. at 10K to 20K above ground level) from the MCS southwest of the supercell near MVE may have dynamically performed the same role of a supercell rear flank downdraft and may have been the catalyst for strong mesocyclogenesis in the boundary layer making a storm of the magnitude of Granite Falls possible.

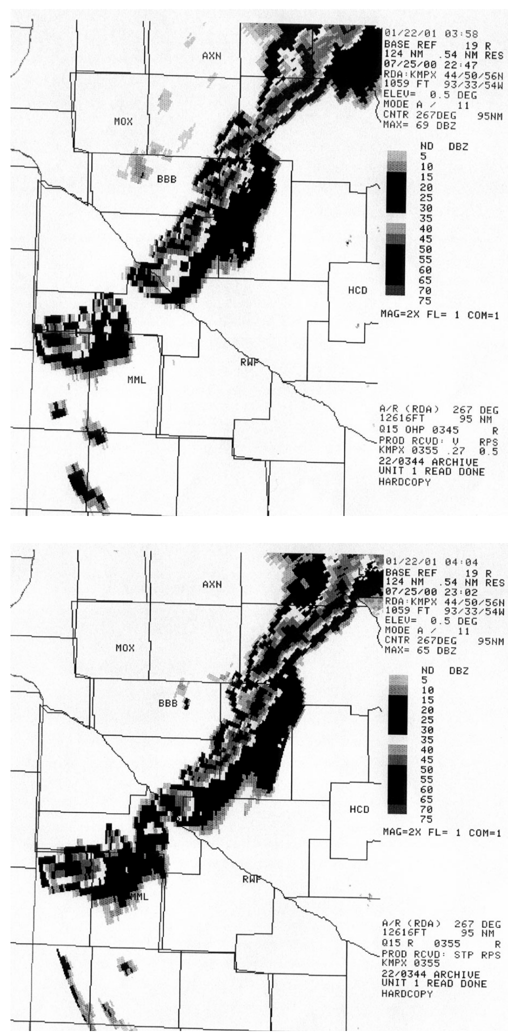

Figure 1: Radar images from MPX showing the merger of the two storms between 2247 UTC and 2302 UTC

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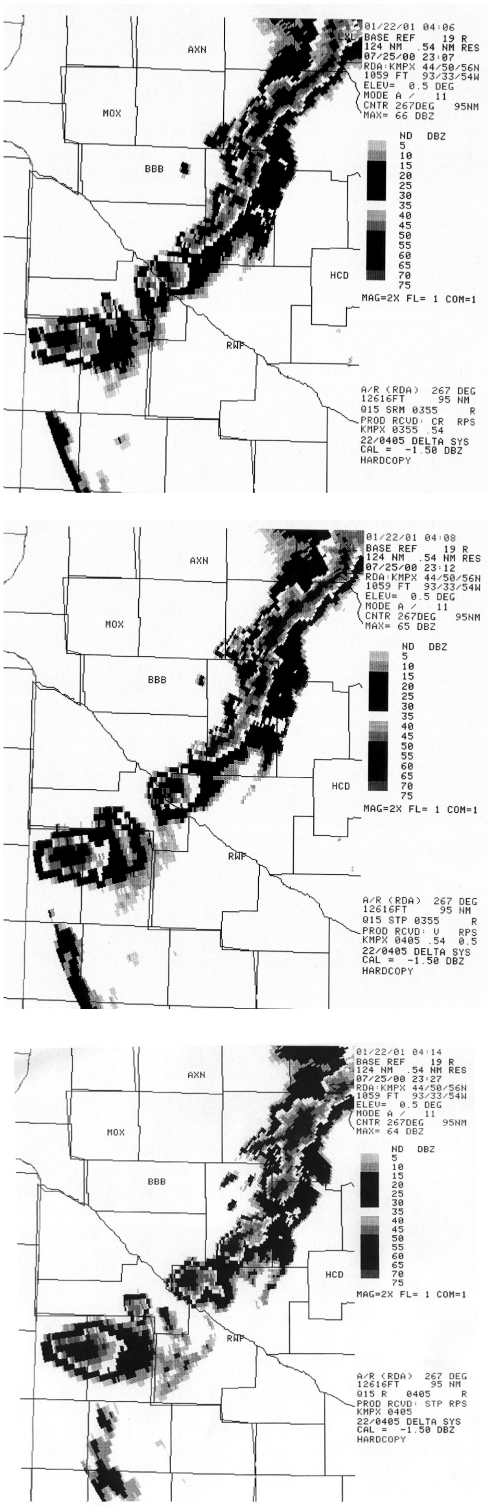

Figure 2: The response to storm merger becomes evident between 2302 UTC and 2327 UTC

It is difficult to gain a good mesoscale prospective on the meteorology leading up to the Granite Falls Tornado on 25 July 2000 by reviewing only WSR-88D radar data. GOES visible and infrared satellite imagery provide great detail on the evolution of convection leading up to this event and can be viewed at http://cimss.ssec.wisc.edu/goes/misc/000725.html.

2. ADDITIONAL DATA

Using 0.5º elevation WSR-88D (MPX) radar data,

(A) the mean speed (22 kts) and direction (290º)* for the supercell over Lac Qui Parle County was estimated between 2232 UTC and 2302 UTC by following the area of tightest reflectivity gradient on the southwest flank of the storm cell (i.e. near the probable location of the storm updraft) and

(B) the mean speed (42 kts)** and direction (260º)** of cell movement, on the east side of the MCS described above was estimated between 2242 UTC and 2257 UTC up to the approximate time of cell merger.

* an areal survey of storm motion out of Lao Que Parle county Minnesota was from 295º.

** reflectivity returns for 0.5º and 1.5º elevation averaged between 25 and 35 dbz and were 35 to 45 dbz for 20 minutes leading up to storm merger (representing a layer between 5 kft above ground level and 27 kft above ground level).

3. MODEL DESCRIPTION

The Advanced Regional Prediction System (ARPS), a non-hydrostatic, mesoscale prediction model, was used for the simulation. To facilitate computations and to minimize boundary effects, in several runs we reoriented the storms and soundings by subtracting 45º so that the storms were now oriented in a north-south direction. The domain used in the reoriented simulation was 100 km by 200 km with a 1 km grid spacing while the domains were 150 by 150 km and 100 by 100 km in the remaining runs. Radial (open) east/west lateral boundary conditions and periodic boundary conditions on the north and south ends of the domain were used. A vertical stretched grid was used with a grid spacing of 100 m at the surface to resolve finer low level details. To begin our analysis, a horizontal tube was used, with a 1.5 km vertical radius and 60 km long, with 2.5ºC and 3ºC perturbation, (Weisman, Klemp and Rotunno, 1988) oriented 45º from southwest to northeast (or north/south in the reoriented case) to model and initial segment of the squall line. We used both actual sounding files and several ETA/RUC "proximity" soundings. Additionally, wind data was obtained taken at 2300 UTC from the nearby Woodlake profiler which was then incorporated into one of the soundings. We measured the low-level vorticity of the cell at southern tip of the segment. Other runs, with an additional thermal bubble, again with a 2.5ºC or 3ºC perturbation, representing the mesoconvective system were made. Measurements were also made of the low-level vorticity at the southern end of the segment to determine the effect of the storm-storm interaction.

Using Vis5D, we created animations of the model runs. This gave us an additional tool to analyze the results.

4. RESULTS

Initial results of the various runs, including wind data from the profiler (taken at the time the storm came through), produced the expected new cell generation along the intersection of the outflow boundaries. Comparing the two-storm runs with the control runs usually showed slightly more rapid development of a stronger low-level rotation at the southern tip of the squall line segment. This, however, was usually short-lived. Using a RUC sounding (July 26 at 00 UTC, 46.28º Latitude, -95.57º Longitude) behind the front produced a storm with extremely strong low-level vorticity (.03 - .04 rad s^{-1}) in the first 500 m above the surface. This intensity was not present in runs with other soundings. This RUC sounding was the only one with west by northwesterly surface level winds (which might have produced an effect as seen in the last picture in fig. 2). We used a 3º C perturbation to initiate this storm. The cleanest results, minimizing boundary effects, were obtained from the 100 by 200 km model with the periodic north/south boundary conditions.

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5. FUTURE PLANS

The above results suggest that additional insight may be obtained by use nonhomogeneous soundings (as suggested in Markowski et al). To minimize boundary effects and to model a greater length of the squall line, a larger domain would be useful.

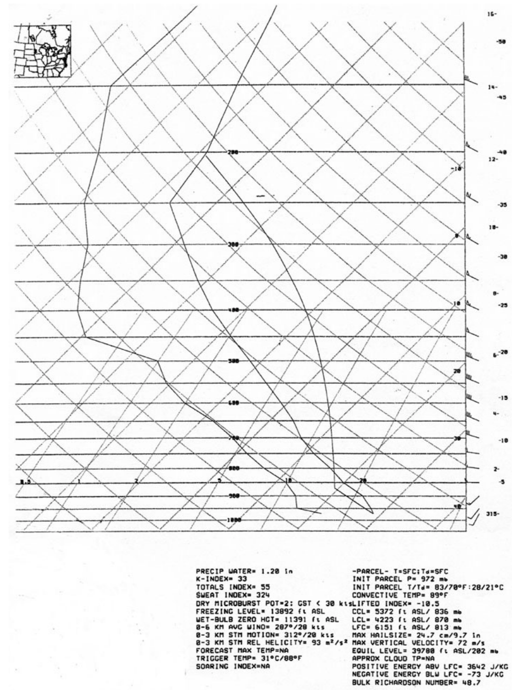

Figure 3: LAPS point-B sounding taken at 2200Z, 44.81º Latitude, -95.58º Longitude

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