P9.7 **A CASE STUDY OF THE FORT WORTH AND ARLINGTON TORNADIC SUPERCELLS OF 28 MARCH 2000**

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1. Introduction

On 28 March 2000, a series of tornadic supercells affected North Texas. Two tornadoes struck populated areas of Tarrant County (Fort Worth and Arlington), causing 2 deaths, 80 injuries, and nearly a half billion dollars in damage. The extensive damage came from tornadoes that were relatively small, and limited to producing damage mainly in the F2 and lower F3 categories. This paper deals with the meteorological and sociological challenges that severe storms present for large population centers. We concentrate on the synoptic and mesoscale forecasting, warning dissemination, and public response aspects of the integrated warning system (IWS). Some aspects of the warning decision process are discussed as well. Interested readers should consult Marshall and Foster (this volume) for a more thorough discussion of warning decisions and the damage survey of the tornadoes.

2. 1200 - 1800 UTC Meteorological Diagnosis

At 1200 UTC, a vigorous mid-level, quasi-geostrophic disturbance (QGD; Fig. 1) was approaching a conditionally unstable environment across North Texas. Numerical models and forecasters correctly assessed that synoptic vertical motions associated with the QGD would weaken the capping inversion and result in convective initiation late in the day. Further, the Storm Prediction Center had correctly addressed the potential threat by issuing a moderate risk of severe thunderstorms over this region. Nevertheless, the forecast was difficult in several respects. Despite the instability, the vertical wind shear was weak at 1200 UTC. Although the vertical wind profile exhibited substantial turning of the winds with height, wind speeds were weak at the Fort Worth upper-air site (Fig. 2) with storm relative environmental helicity well below 100 m^{2}s^{-2}.

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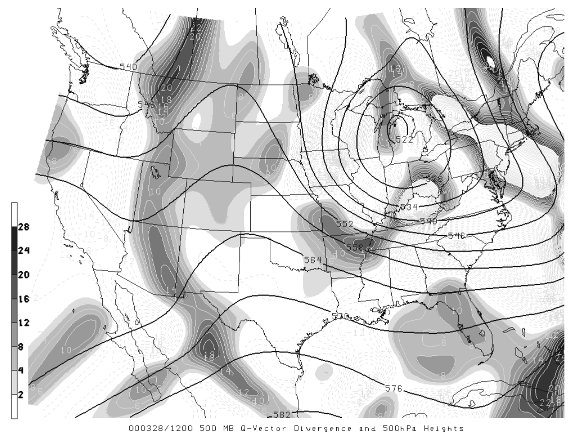

Figure 1. 28 March 2000 1200 UTC 500 hPa Heights and 300:700 hPa Q-Vector Divergence.

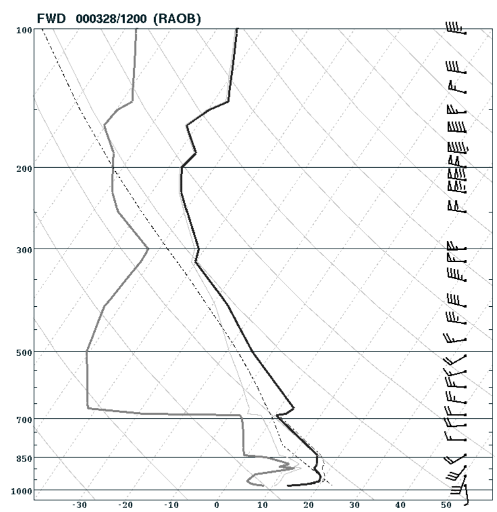

Figure 2. 28 March 2000 1200 UTC FWD Sounding.

Morning analysis revealed that a cold front in Oklahoma was decelerating, probably in response to the approaching QGD. The numerical models accurately forecasted the front to become stationary by 1800 UTC, with a triple point low pressure center at the intersection of the front and dry line. Manual analysis of surface data at 1800 UTC reflected these features well. (Fig. 3). The 1200 UTC Eta model's 12 hour forecast was for the best union of shear and instability to be along the front (Fig. 4). National Weather Service meteorologists at the Weather Forecast Office in Fort Worth (FWD) reasoned that any threat of tornadoes would be mainly near the front (Markowski et al. 1998), while assuming that the amount of daytime air mass modification north of the front would determine the degree of the tornado threat. It appeared that the tornado risk south of the front would be limited, given the lack of warm sector boundaries. The upper level winds were thought to be supportive of supercells, but the strength of the low- and mid-level wind fields south of the boundary did not appear to be sufficiently strong for tornadoes (Fig. 2), even with modest afternoon strengthening suggested by the models. Thus, the 1800 UTC FWD Hazardous Weather Outlook (HWO) called for a significant threat of damaging wind and hail within the moderate risk area, but only a minimal risk of tornadoes, mainly near the front.

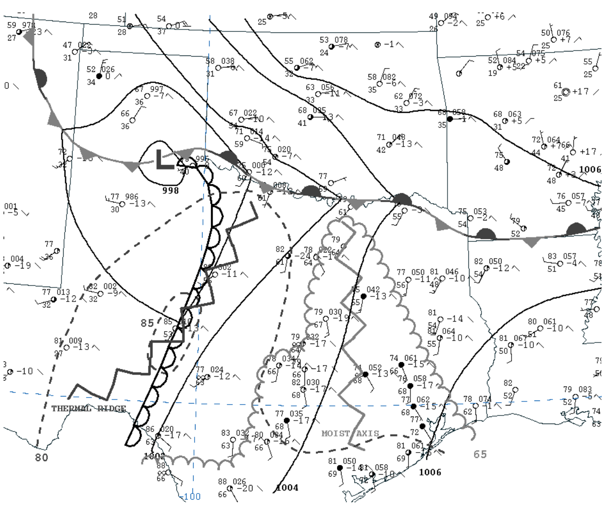

Figure 3. 28 March 2000 1800 UTC Surface Composite Chart.

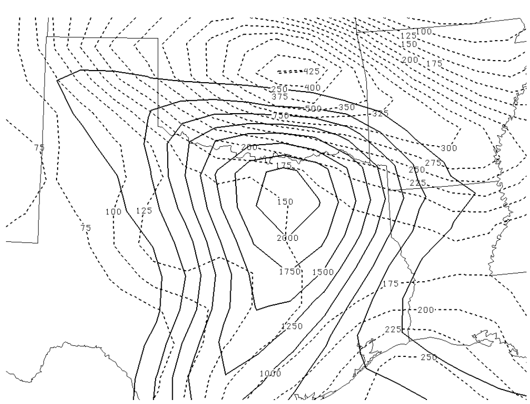

Figure 4. 12 hour forecast from the 28 March 2000 1200 UTC ETA model run. Solid black line is CAPE, dashed line is 0-3km Storm Relative Helicity.

3. 1800 - 0000 UTC Meteorological Diagnosis and Severe Storm Warnings

Diagnostic integration of surface data, satellite imagery, and the vertical wind shear continued throughout the afternoon. The Jayton TX profiler exhibited rapid mid-level wind accelerations by 2100 UTC (Fig. 5), with the winds stronger than forecasted by the numerical models. This led FWD forecasters to issue an updated HWO, describing a modest increase in the tornado risk, especially near the front, but also farther south into the Dallas Fort Worth area.

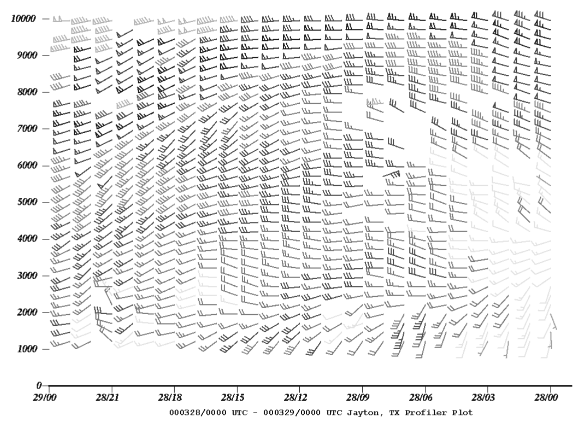

Figure 5. Jayton, TX Wind Profiler Plot. Horizontal axis represents 29 March 2000 0000UTC at left to 28 March 2000 0000UTC at right.

Widespread severe storm formation (not shown) resulted in a transition of work priorities, with all available WFO personal from both the day and evening shifts becoming engaged in either warning decision-making, warning dissemination, or communication duties. By necessity, the mesoscale diagnostic work efforts were reduced sharply. Fortunately, the warning program was largely successful, as warning forecasters had sufficient environmental situation awareness (SA, Bunting 1998) to make generally correct warning decisions through the evening hours.

The first tornadic storm moved east through the Red River Valley, producing several brief tornadoes in rural areas. By 2230 UTC, the supercell threat quickly shifted south into the Dallas-Fort Worth area, as several right- and left-moving supercells traversed the area. Post-analysis of surface data showed that the surface low near Childress, Texas weakened, with a mesolow developing by 2000 UTC, just north of the bulging dry line (Fig. 6). For the remainder of the afternoon and evening, the greatest pressure falls were concentrated east of the bulging dry line and surface low (Fig. 6, grey shading). In response, surface winds backed to the southeast; increasing the storm relative helicity of supercells moving from 290° at 15 kt to approximately 200 m^2s^{-2} (not shown). Nevertheless, the evening FWD sounding (Fig. 7) still exhibited significant mid-level wind velocity weaknesses, especially below 500 hPa. It is not known if the mid-level wind accelerations that occurred at Jayton (Fig. 4), or farther east in the evening at the Palestine profiler (not shown) occurred shortly after the 2300 UTC sounding release time at FWD.

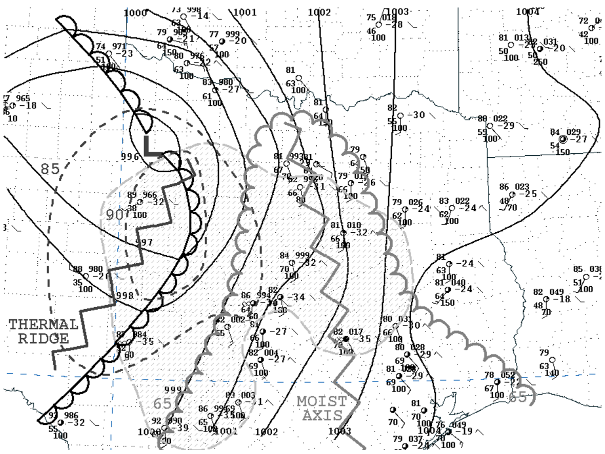

Figure 6. 28 March 2000 2100 UTC Surface Composite Chart.

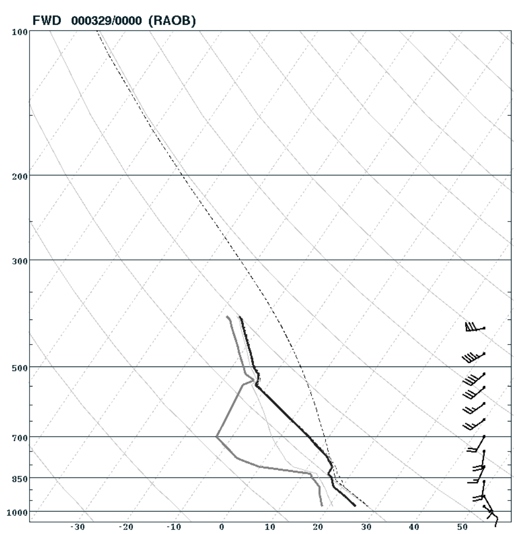

Figure 7. 29 March 2000 0000 UTC FWD Sounding.

Post analysis of surface observations revealed rather dramatic changes in the warm inflow field as the tornadic storm moved across the Naval Aviation base in west Fort Worth (NFW), which was close to the mesocyclone's path, and Meacham Field (FTW) in north Fort Worth, 5 miles north of the path. The altimeter fell almost 3 mb at NFW within an hour of the storm's arrival, with winds accelerating from 15012 kt to 11015G20 KT. At FTW, the altimeter fell 2 mb, and the winds accelerated from 15011 KT to 08018G25 KT in one hour. The pressure fell 1 mb in 8 minutes prior to the last observation. Such accelerations in winds and pressure falls often occur within the near environment of tornadic supercell storms (Moller 1979). Furthermore, a radar-detected boundary that was oriented parallel to the pre-tornadic supercell's inflow field (Figs. 8 and 9) was detected on the WSR-88D shortly after 2300 UTC. An off-duty NWS meteorologist reported a west-east oriented roll cloud, with the appearance of a supercell inflow band near this location. One possible origin for this radar (and visually) detected feature is that of an outflow boundary emerging from a left-moving cell over the WSR-88D site (Figs. 8 and 9). This external boundary may have played a pivotal role in the rapid spin up of the Fort Worth tornado (see Marshall and Foster, this volume). The left mover later merged with the weakening Fort Worth tornadic storm west of Arlington, with the resulting storm complex rapidly gaining strength and producing a damaging F3 tornado in Arlington. After a final, brief tornado south of Dallas, the storm weakened. Another supercell produced a series of 4 tornadoes in rural areas 30 to 40 miles south and southeast of Dallas during the mid-evening.

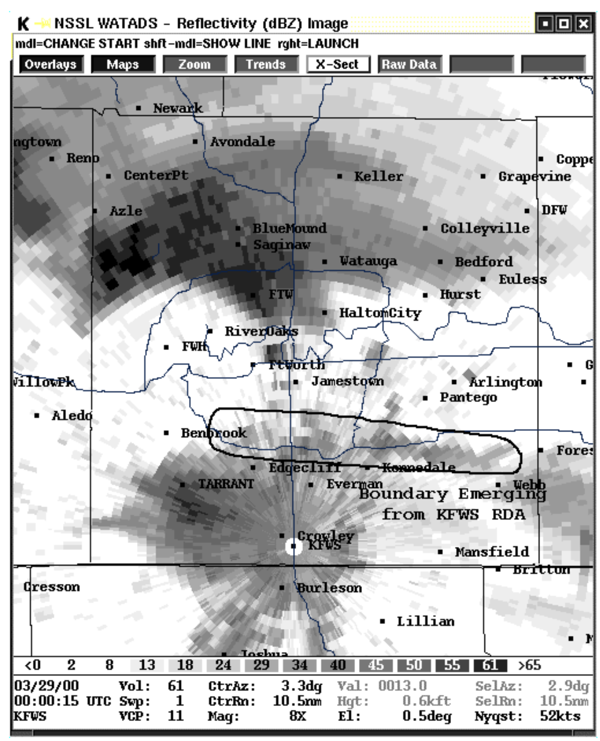

Figure 8. 29 March 2000 0000 UTC radar image.

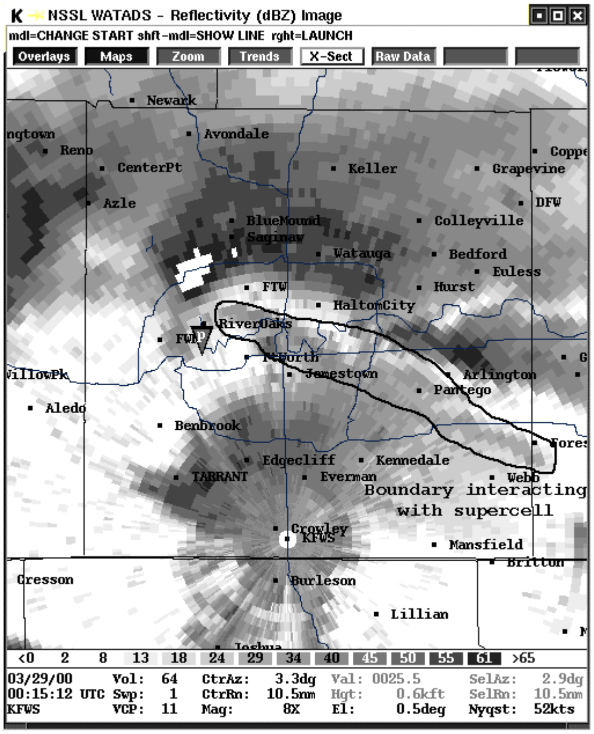

Figure 9. 29 March 2000 0015 UTC radar image

4. Discussion

Meteorological diagnosis was critical to the success of North Texas HWO's and warnings on 28 March 2000. Meteorological SA, and radar detection of strong sub-cloud base convergence, minutes before the Fort Worth tornado formed (Marshall and Foster, this volume), led to a life-saving tornado warning. Successful warning dissemination included an immediate response from the Fort Worth Emergency Preparedness Office, where the duty officer triggered the city's siren system a few minutes before the tornado struck a crowded neighborhood. Several families commented that the siren warning prevented injury or death. The electronic media also responded quickly, with one TV station showing live tower cam video of debris swirling around a high rise building as the tornado moved through the downtown area. The dramatic and timely media warnings may be why Arlington residents responded quickly to warnings for the second tornado, also preventing injuries.

One problem was that no amateur radio storm spotters were near the developing Fort Worth tornado, likely because it formed in an area where few spotters live. Spotter net officials might consider deploying spotters equidistant across grid sectors of a community, such that a developing tornado does not evade quick visual detection. Similarly, when widespread severe storms affect a forecast office's area, 2 or 3 warning forecasters may be needed for sectored radar detection duties. The two fatalities, and a number of the injured, were people who were caught outside during the Fort Worth tornado. It is fortunate that the tornado occurred after 600 PM; if it had moved through the downtown area an hour earlier, far more people would have been outside and directly in harm's way. The need for seeking indoor shelter from tornadoes cannot be overemphasized. Finally, there were two flash flood fatalities and a very rare hail fatality in northwest Fort Worth. These unfortunate events are reminders of the great vulnerability of densely populated areas to the multiple threats of severe storms such as supercells.

5. References

Available upon request