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A Preliminary Look at the Ardmore, OK Tornado of 7 May 1995

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1. INTRODUCTION.

A supercell thunderstorm formed in northern Texas on the afternoon of 7 May 1995 and moved into southern Oklahoma. The storm produced a series of six tornadoes which killed five people, injured dozens of others, and caused tens of millions of dollars in property damage. The two most intense tornadoes (both F3) together produced a continuous damage track of 60 miles, beginning in Montague County, Texas and ending just north of Ardmore, Oklahoma. The Ardmore supercell was associated with a line of storms that formed early in the day, in advance of anticipated late-afternoon severe activity. A second round of thunderstorms was triggered along a dryline in western Texas later in the day. That activity quickly became a large squall line that produced multiple reports of strong winds and large hail, but no significant tornadoes.

This paper discusses results of preliminary analysis of several data types (including mesonetwork, upper air, satellite, and radar) in an attempt to unravel the series of complex events which resulted in the Ardmore event. Mesoscale features and interactions seem to have played a key role in the storm's history. Many of these mesoscale features could be identified through careful analysis of remote sensor data.

2. DATA SOURCES.

Satellite data used in this study are from the GOES-8 satellite which routinely provides imagery at 15-minute intervals from five different imaging channels at a higher spatial resolution than has previously been available from geostationary satellites. The channels are; Channel 1 - visible wavelength (0.52 to 0.72μm at a 0.57 x 1.00 km sub-point resolution), Channel 2 - shortwave infrared (3.78 to 4.03 μm at 2.3 x 4 km resolution), Channel 3 - upper level watervapor (6.47 to 7.02μm at 2.3 x 8 km resolution), Channel 4 - longwave infrared window (10.2 to 11.2μm at 2.3 x 4 km resolution), and Channel 5 - low level watervapor (11.5 to 12.5μm at 2.3 x 4 km resolution).

Radar data used in the study are from the National Weather Service, WSR-88D radars at Ft. Worth, TX (KFWS), Frederick, OK (KFDR), and Oklahoma City, OK (KTLX). These radars operate at a 10 cm wavelength with a 1° beamwidth. Range gates are at 250m for velocity, and 1 km for reflectivity. Data are collected in volume coverage patterns of 9-14 elevation angles in 5-6 minutes. All basic data (called Level II data) were archived at KFWS and KTLX, but only some of the derived-products (Level IV) were kept for KFDR.

Various standard charts and maps from the National Meteorological Center's compliment of facsimile weather maps were used to define the background synoptic situation during the evolution of the tornadic activity. Also available were maps of standard meteorological variables at 15 minute intervals from the Oklahoma Mesonetwork.

3. MAY 7, 1995

a. Synoptic Conditions.

The synoptic situation on 7 May was one that might be characterized as "synoptically evident" (Doswell, et al. 1993). The National Severe Storms Forecast Center's Severe Local Storms Unit (SELS) issued an early Convective Outlook calling for a moderate risk of severe convection over a substantial portion of the Kansas, Oklahoma, and northwest Texas (Figure 1). This was upgraded to a high risk by 1500 UTC.

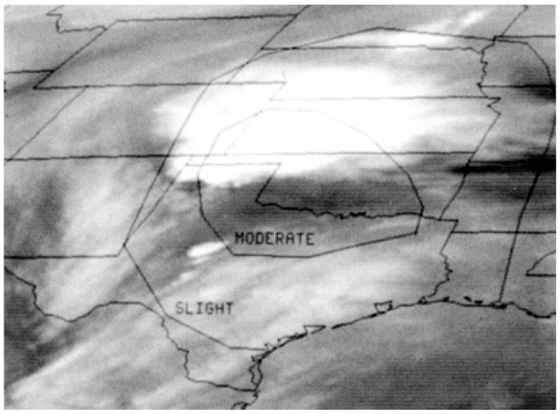

Figure 1. Outline of the severe thunderstorm outlook for 7 May 1995, as forecast by the National Severe Storms Forecast Center. Areas are overlayed on the 1130 UTC, GOES-8 6.7 μm upper-level water vapor image.

A powerful extratropical cyclone was moving relatively slowly through the southern Rocky Mountains, with a vigorous trough at 500 mb over Arizona (Figure 2). At 850 mb (Figure 3), and below, southerly low-level flow through central Texas and Oklahoma was bringing considerable low-level moisture into a region of relatively steep lower- to mid-tropospheric lapse rates, yielding considerable convective instability. Furthermore, the air mass throughout central Texas was not strongly capped. Visible imagery from early in the morning shows that much of Texas and Oklahoma was characterized by low overcast in the warm sector east of the dryline, indicating abundant moisture. Wind fields associated with the system were strong through most of the troposphere, which led SELS to suggest supercells in their outlook.

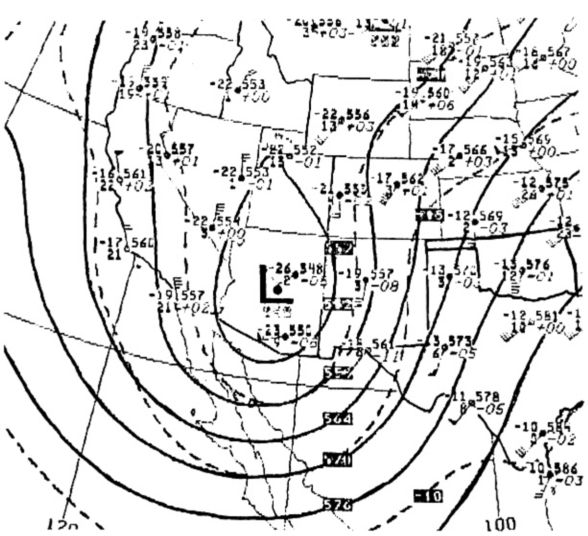

Figure 2. NMC, 500mb analysis chart from 1200 UTC on 7 May 1995. Oklahoma in bold.

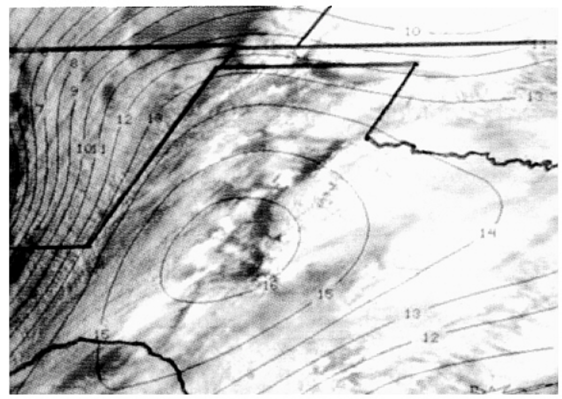

Figure 3. 850 mb dewpoint contours in degrees C, for 1200 UTC, 7 May 1995. Data are plotted on the 1315 UTC visible image.

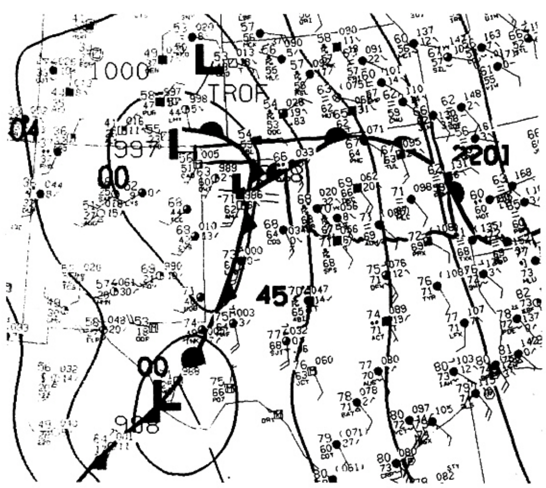

Figure 4. NMC, Surface analysis chart from 1200 UTC on 7 May 1995.

Surface features (Figure 4) included a broad region of low pressure that covered southeastern Colorado, northeastern New Mexico, and the Texas panhandle. A dryline stretched southward through western Texas and a confluence line ran through central Texas -- apparently a surface reflection of the low-level jet stream axis. Rain-stabilized air covered much of southwest Kansas, as well as parts of western and central Oklahoma. However, there was no apparent effect from this activity on the storms that would develop further to the south or west. The anticipated scenario by both SELS and VORTEX forecasters was that the most important convection would develop in association with the dryline. Actual events were not entirely consistent with this expectation. The convection that was to develop into the Ardmore, Oklahoma (ADM in figure 4) tornadic storm began in association with the low-level jet stream axis in north-central Texas.

b. Evolution on radar and satellite.

Pre-dawn infrared satellite imagery, together with observations from morning charts, found a region of strong upper diffluence over western Texas associated with the eastern edge of the large synoptic trough. A line of fairly intense convection had formed (around 1000 UTC) on a line from about 60 NM south-southwest of San Angelo, Texas (SJT) to just west of Abilene, TX (ABI). Overlaying 850mb data on satellite imagery confirms that this early squall line had formed along the eastern edge of a low-level jet. Note the 16°C moisture maximum (Figure 3) in the west-central Texas region described, and also notice the position of the squall line with respect to this moist tongue.

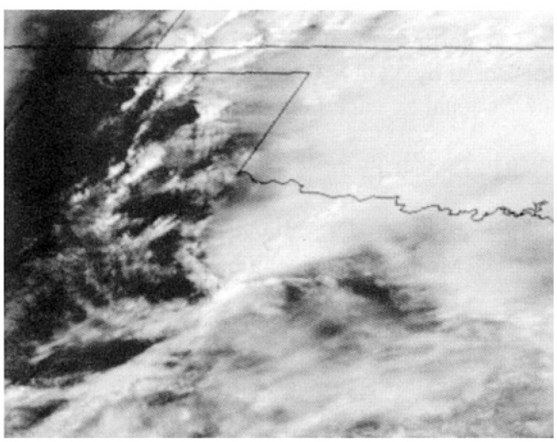

Figure 5. 1km visible wavelength image from GOES-8 taken on 7 May 1995 at 1615 UTC.

During the mid-morning hours, the northern end of the central-Texas squall line moved into Oklahoma and was located near Anadarko at about 1600 UTC. A very intense storm just south of ABI marked the southern end of the line, and outflow from this activity was stablizing the region to its west (Figure 5). At this time, we first note the appearance of transverse waves in the low-level Cu field in western Texas. These broad lines of supressed looking Cu stay stationary throughout the morning and into the early afternoon.

By midday, a large region of freshly stabilized air had formed throughout much of the High Plains region of west Texas. By then, the southern end of the early line was situated about 60 NM south of Wichita Falls, Texas (SPS) with a clearly defined arc cloud line trailing south-southwestward from there (Figure 5). That line marked the eastern edge of the rain-stabilized air. A new, isolated storm formed and intensified quickly at the intersection point of this arc cloud line and one of the transverse waves. The new storm moved north-northeastward along the arc cloud line.

Satellite and radar data throughout the remainder of the afternoon showed that the early Texas activity continued to move across eastern Oklahoma, leaving behind a very well-defined outflow boundary. The isolated, Ardmore storm continued to travel along the boundary, growing larger and more intense as it did so (Figure 6).

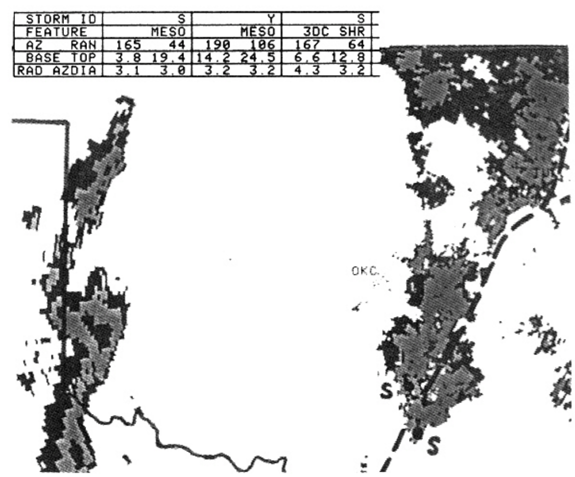

Figure 6. Base reflectivity from KTLX at 0.5° elevation angle for 2103 UTC. Eastern and western storm lines are visible with Ardmore storm (Y) at south end of eastern line. Mesocyclone algorithm locations and attributes are overlaid; circulations are at S and Y. Dashed line is radar/mesonet estimated location of outflow boundary.

Two F0 tornadoes were reported in Jack and Wise County Texas at 2017 and 2025, respectively. The first F3 tornado formed in Montague County Texas at 2100, producing two fatalities in rural areas. That tornado dissipated at 2120 as a second F3 tornado formed in close proximity -- so close that the damage track appeared continuous. (Note that this evolution is similar to the case of the Hesston, Kansas storm which also tracked along a lengthy outflow boundary -- Davies, et al, 1994). The second F3 tornado crossed into Oklahoma about 2125, causing three fatalities in rural areas before heavily damaging the western section of Ardmore about 2210. After its dissipation, ending 60 continuous miles of damage, two shorter-lived F1 tornadoes occurred northeast of Ardmore in Carter and Murray counties of Oklahoma about 2230 and 2250. The storms at the south end of the line (northeast of the Ardmore storm in Figure 6) were also tornadic, producing an additional series of six F0-F2 tornadoes during approximately the same time interval as the tornadic stage of the Ardmore storm.

An examination of radar data revealed that the Ardmore storm continuously displayed supercell characteristics for over three hours (Figure 7). A mid-level mesocyclone was first detected about an hour after first radar echo and continued until near the

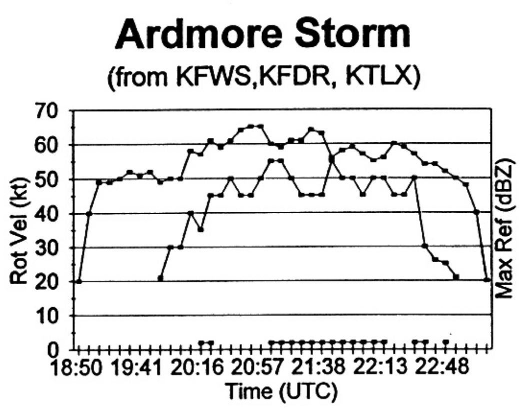

Figure 7. Summary of radar parameters for the Ardmore storm from KFWS, KFDR, and KTLX. Top curve is storm maximum reflectivity (dBZ), bottom curve is mesocyclone rotational velocity (kt). Bottom horizontal line marks time of tornado occurrence.

time of storm dissipation. The circulation was quite strong (rotational velocity greater than 40 kt) for most of that period. Although continuous, the mesocyclone appeared to undergo two classic core evolutions (Burgess *et al*, 1982); one about 2030 and the other about 2215. Both of the F3 tornadoes with their 60 mile track appeared to be associated with the same core circulation. It is interesting to note that the storm abruptly weakened about 2245 and completely dissipated shortly after 2300. Existing data do not give any indication as to the reason for the sudden demise.

4. CONCLUDING REMARKS.

There were many forecasting challenges associated with the Ardmore tornado event. The lack of much convective inhibition meant that thunderstorms re-developed relatively early in the day. Of course, the standard problems with anticipating the structure and evolution of convective outflow boundaries and their interaction with new convection were present. However, the question remains: could one have anticipated that the most significant storms would be the ones developing in north central Texas rather than those associated with the dryline boundary to the west? It is difficult to understand this evolution, even retrospectively, which suggests that the answer is "not likely."

Many past studies have shown that storms which interact with mesoscale boundaries left behind by earlier activity are often the most severe. This case was no exception in that respect. The Ardmore storm clearly tracked along a convergence line which had formed as rain-stabilized air was deposited behind an earlier squall line. Once formed, the storm displayed classical supercellular characteristics on Doppler radar. The favorable conditions along the boundary may have contributed to the steady, long-lived nature of the mesocyclone, and contributed to the production of the six tornadoes.

5. ACKNOWLEDGEMENTS.

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