19990636666

P12.4

A LOW PRECIPITATION SUPERCELL OVER THE SOUTHEAST US; A CASE STUDY

Barry C. Roberts*
NASA, Marshall Space Flight Center, Huntsville Alabama

Kevin R. Knupp and Dennis Buechler
University of Alabama in Huntsville, Huntsville, Alabama

1. INTRODUCTION

On 28 March 1997 a low precipitation supercell storm was observed 125 km east of Memphis, TN. The storm exhibited a visual appearance similar to that of Great Plains low precipitation (LP) supercells (Doswell, et al., 1990) while it was being video taped for 35 min. beginning at 2335 UTC. While the storm produced hailstones up to 4.5 cm in diameter, and had a 4 hour lifetime, tornadoes were absent. However, over 20 tornadoes were produced in Kentucky and Tennessee (TN) by other thunderstorms during that afternoon and evening.

The purpose of this paper is to document this LP supercell that occurred in the Southeastern US. To the authors' knowledge an LP storm has not yet been documented in the Southeastern US. This paper presents a detailed overview of the LP supercell, including synoptic conditions, radar observations, lightning data and visual observations of the storm.

2. SYNOPTIC CONDITIONS

At mid-levels, a positively tilted trough was moving from the mid Mississippi Valley into the Tennessee Valley. A surface cold front extended from a surface low near the Great Lakes, through west TN, and into central Texas. A plot of the 00 Z surface observations are shown in Figure 1. Temperatures fell gradually across the front from 22.8°C in Nashville, TN to 21.1°C in Little Rock Arkansas. However, dew points fell drastically behind the front, varying from 15.5°C in Nashville, to 2.8°C in Little Rock. It is interesting to note that an area of drier air at the surface was located in northeast Mississippi (MS), ahead of the cold front. The dew points in Tupelo and Columbus, MS were 5°C lower than surrounding reporting stations in Alabama, middle TN, and western MS throughout the afternoon and evening.

* *Corresponding author address:* Barry C. Roberts, NASA, Marshall Space Flight Center, Mail Code EL23, Huntsville, AL 35812;
e-mail: barry.roberts@msfc.nasa.gov

The closest sounding station was Nashville, 220 km NE of the storm at 00 UTC. A special sounding was also made at 18 UTC. Between the 18 UTC and 00 UTC soundings, the lift indices had decreased from -2 to -7, and the 0 - 3 km storm relative helicity had increased from 63 m^2/s^2 to 452 m^2/s^2. The Convective Available Potential Energy (CAPE) at 18 UTC was 422 J/kg, however due to an incomplete sounding, it could not be calculated at 00 UTC. The 500mb temperatures in the region were approximately -15°C.

3. STORM STRUCTURE

The storm had several radar characteristics similar to a Great Plains LP supercell. The storm's first echo (>30 dbz) formed about 40 km east of Memphis, TN at approximately 2230 UTC and moved east-northeast at 18 m/s. As shown in Figure 2, at 2344 UTC the storm was located between a broken line of thunderstorms near the front, and another line of the same orientation 180 km ahead of the front, trailing from Kentucky down to 130 km northeast of the LP supercell. During this time the storm was the southern-most of the event. The Memphis WSR 88-D (KNQA) indicated the storm had a persistent mesocyclone at mid levels, extending from 3 km up to 7 km (personal communication, Rick Smith, radar operator at the National Weather Service Forecast Office in Memphis during the event.). At 2344 UTC the KNQA storm relative velocities were -5 m/s inbound and 21 m/s outbound at a height of 3 km. However, during this time, the storm showed no appendage or hook often associated with classic supercells. These radar characteristics are similar to those mentioned by Bluestein and Woodall (1990), and continued in the storm until 00 UTC 29 March 1998.

At 00 UTC the storm rapidly weakened for 20 minutes. As shown in Figure 3, the vertically integrated liquid water content (VIL) of the storm droped from 45 kg^2/m^2 to 8 kg^2/m^2, and the maximum reflectivity decreased from 63 dBZ to 45 dBZ. When the storm reorganized, the base reflectivity echo pattern from the Nashville WSR 88-D (KOHX) became slightly elongated in the east-west direction, often showed a V-notch pattern, and sometimes took on a "C" shape during the next 2 hours. Also at 00 UTC strong (eventually tornadic) storms began developing and strengthening 65 km southwest of the storm, near the cold front. The storm began to weaken at 0200 UTC until at 0245 UTC the lightning and radar echo of the storm from KOHX became indistinguishable from nearby precipitation and strong storms just to the west and southwest.

During the time of visual observation (2335 - 0010 UTC) little lightning was noted (Figure 3). The National Lightning Detection Network (NLDN) also detected a low rate of cloud-to-ground (CG) lightning associated with the storm during this period (<1flash/min). All the CG's detected from 2250 - 2340 UTC were negative, which is in contrast to previous studies of Great Plains LP storms (i.e., Branick and Doswell, 1992; Curran and Rust, 1992), which produced predominately positive flashes during their LP phases.

During the time that the storm weakened, little CG lightning was observed. The lightning that was detected between 2340 UTC and 0030 UTC was of positive polarity. Shortly after 0030 UTC, the storm began producing CG lightning of both polarities, although the rates were still low (generally less than l flash/min). The CG lightning activity within Great Plains storms frequently show a shift from one polarity to another, coinciding with a change in storm structure (LP to classic, or classic to high precipitation (HP)) and often with tornado production (MacGorman and Burgess, 1994). However, in this case it is unclear if this storm underwent a change in structure associated with the polarity shift. Even though there are changes in the radar echo structure mentioned above, no visual observations are available since these changes occurred after sunset.

In addition, the positive polarity lightning periods of Great Plains storms are often associated with large hail. This storm was similar with reports of larger hail, up to golfball size (4.5 cm) around 0000 UTC, coinciding with the period of positive polarity CG lightning. Nickel size hail (2.2 cm) was reported at 2330 UTC, during the time of negative polarity CG lightning. There were no hail reports from the storm after 0000 UTC, possibly because the storm passed over no major populated areas, and across counties without well developed spotter networks.

Two frames from the video recording of the storm are shown in Figures 4 and 5. As the principal author approached the storm from the southeast, a large anvil, back sheared to the southwest was noted. This can be seen in Figure 4. After getting close enough to see the storm's base, it was surprisingly small. As can be seen in Figure 5, the cumulus tower is clearly visible along with the translucent regions under the base and just northeast of the cumulus tower, and extending under the anvil. At the time of this picture, 2.5 cm diameter hail was falling out of the storm. Mid-level striations could be seen wrapping around into the storm tower on the southeastern flank, and a funnel was also noted at mid levels passing around the southern flank of the cumulus tower. As the storm passed just north of this location, winds turned from south to southwest. As the storm passed northeast of our location, it was noted that the structure looked less organized, with the circular striations not as noticeable. Driving across the path of the storm minutes after it had passed, it was noted that very little rainfall had occurred. These observations are consistent to those mentioned by Bluestein and Parks (1983), and Bluestein and Woodall (1990) for an LP supercell.

4. SUMMARY

On 28 March 1998 a supercell storm was observed in TN that had a structure consistent with a Great Plains LP supercell. Radar observations of the storm also had characteristics consist with those found in Great Plains LP supercells. However, though the storm produced very little lightning, the polarity was opposite to that observed in Great Plains LP storms.

Great Plains LP storms are usually associated with the dry line. In this case, an area of slightly drier air in northeast Mississippi (possible caused by the mixing of drier air aloft down to the surface) may have created a "dry line" type boundary in southwest TN along which the storm developed and moved. The storm weakened and reorganized after 00 UTC 29 March. Radar and lightning characteristics also changed at that time. However, because these changes occurred after sunset, no visual observation could be made to determine if the storm had changed structure to a classic or HP supercell. The storm dissipated at 0245 UTC.

Acknowledgments. We thank Simon Paech, Eugene W. McCaul, Scott Sharp, Rick Smith, and Shelton Barnett for their help in gathering data, helpful discussions and constructive criticisms of our findings.

Bluestein, H. B., and C. R. Parks, 1983: A synoptic and photographic climatology of low-precipitation severe thunderstorms in the southern plains. *Mon. Wea. Rev.*, **111**, 2034-2046

Bluestein, H. B., and G. R. Woodall, 1990: Doppler-radar analysis of a low-precipitation severe storm. *Mon. Wea. Rev.*, **118**, 1640-1664

Branick, M. L. and C. A. III Doswell, 1992: An observation of the relationship between supercell structure and lightning ground-strike probability. Weather and Forecasting, 7, 143-149

Curran E. B. and W. D. Rust, 1992: Positive flashes produced by low-precipitation thunderstorms in Oklahoma on 26 April 1984. Mon. Wea. Rev., 120, 544-553

Doswell, C. A. III, A. R. Moller, and R. Przybylinski, 1990: A unified set of conceptual models for variations on a supercell theme. Preprints, *16th Conf. On Severe Local Storms*, Kananaskis Park, Alberta, Canada, Amer. Meteor. Soc., 40-45

MacGorman, D. R. and D. W. Burgess, 1994: Positive cloud-to-ground lightning in tornadic storms. Mon. Wea. Rev., 122, 1671-1697

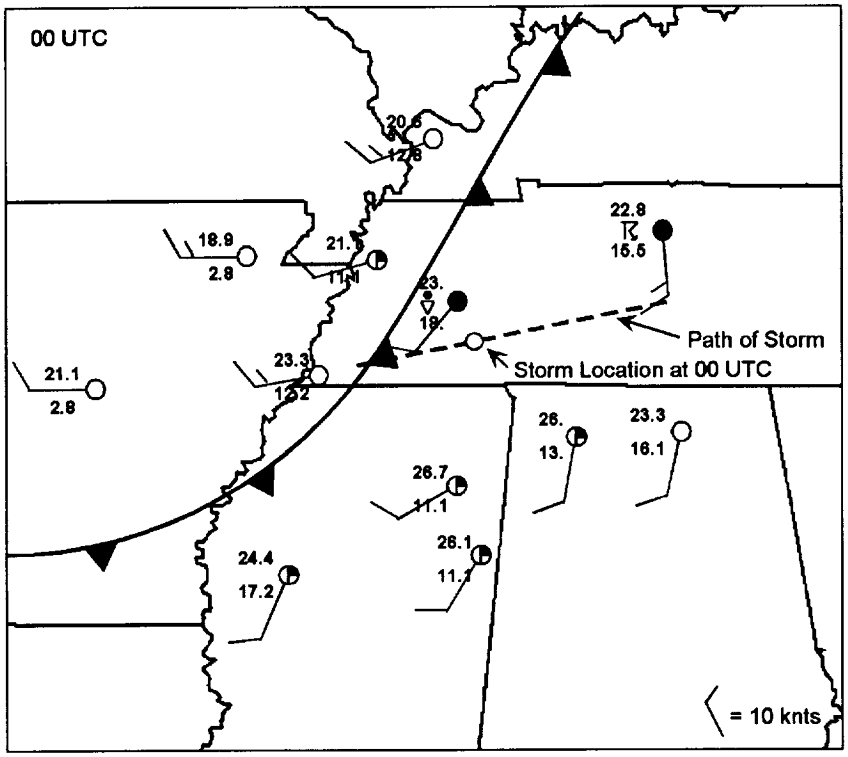

Figure 1. Surface features at 00 UTC. (Temperatures and dew points are in °C.)

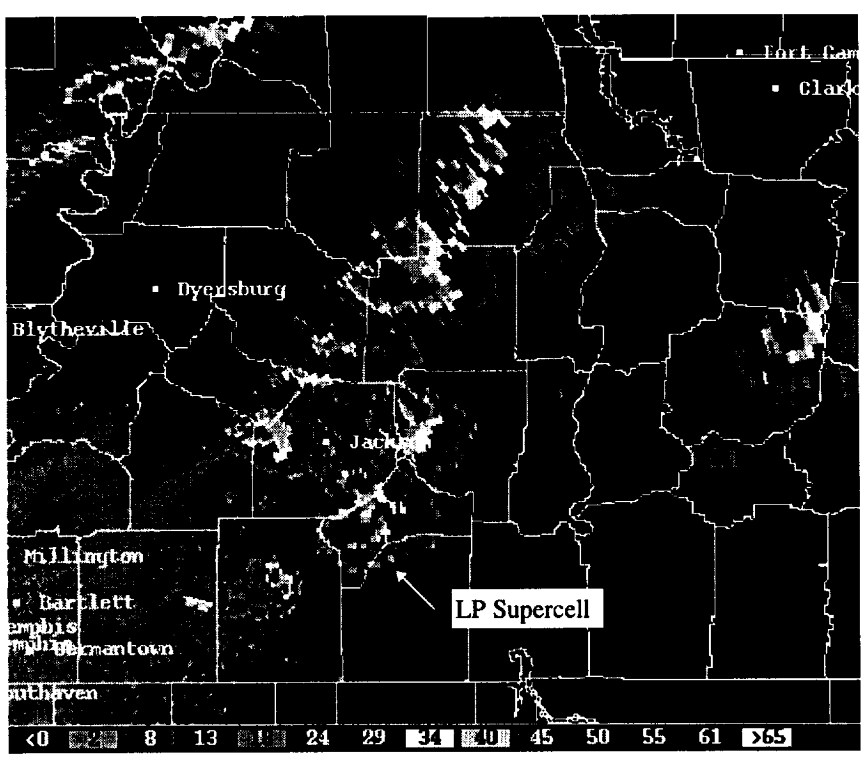

Figure 2. A base reflectivity image from the Memphis WSR 88-D (KNQA) at 2345 UTC generated using the WSR-88D Algorithm Testing and Display System (WATADS 8.0).

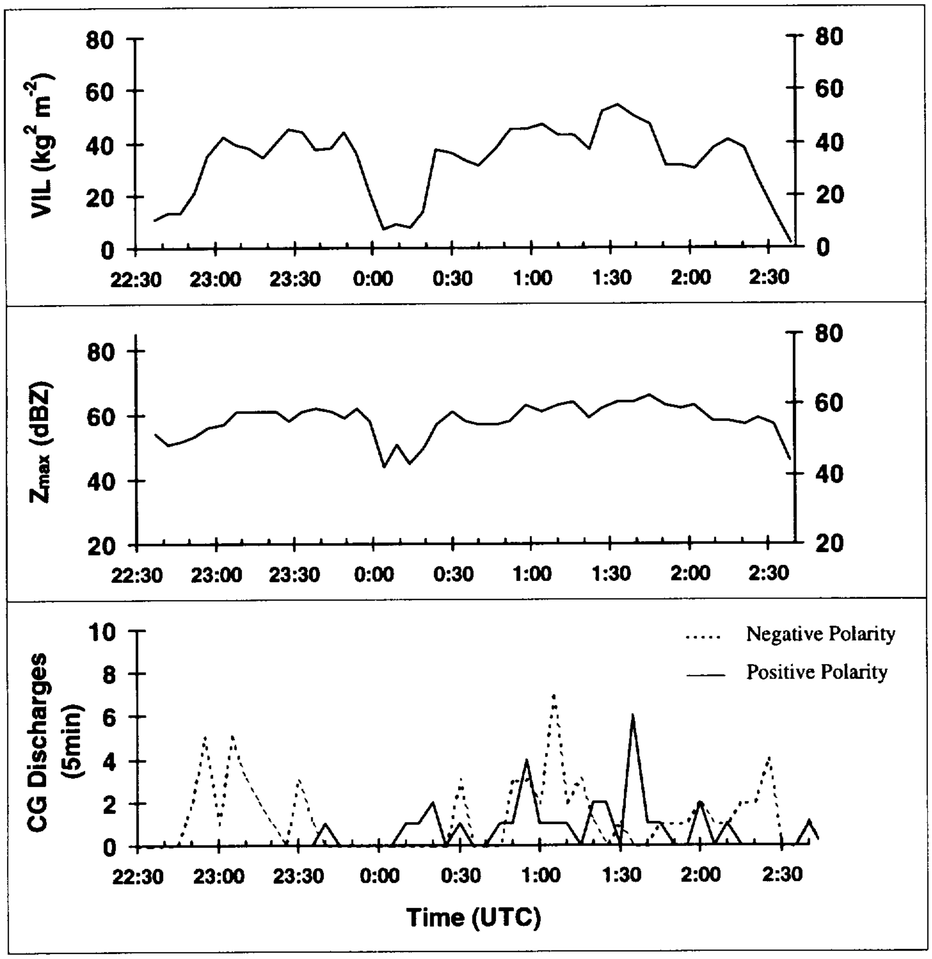

Figure 3. A time series of radar derived parameters output from WATADS 8.0 using data from KNQA and KOHX, and the NLDN cloud-to ground lightning strikes.

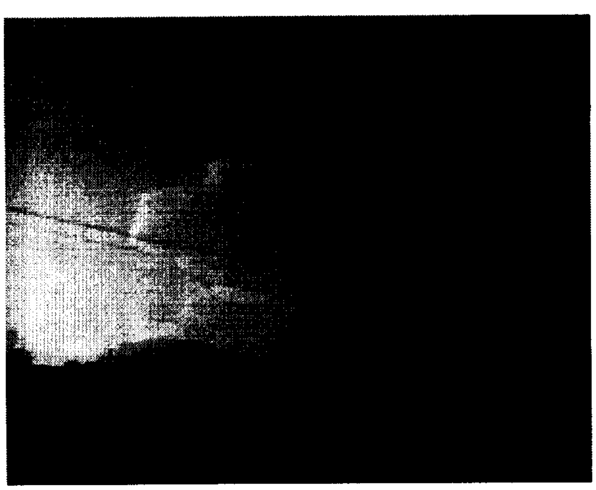

Figure 4. A picture of the LP supercell anvil looking toward the northwest at 2315 UTC.

Figure 5. A picture of the LP supercell base taken from video at 2345 UTC, looking WNW as the storm was producing 2.5 cm diameter hail in Chester County, Tennessee.