A Review of the 10-11 November 2002 Severe Thunderstorm and Tornado Outbreak

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I. Introduction

A significant severe weather outbreak affected the eastern United States November 10th and 11th, 2002. Numerous reports of damaging winds and hail, and 91 tornadoes (tentative number) affected areas from the Gulf Coast to western Pennsylvania.

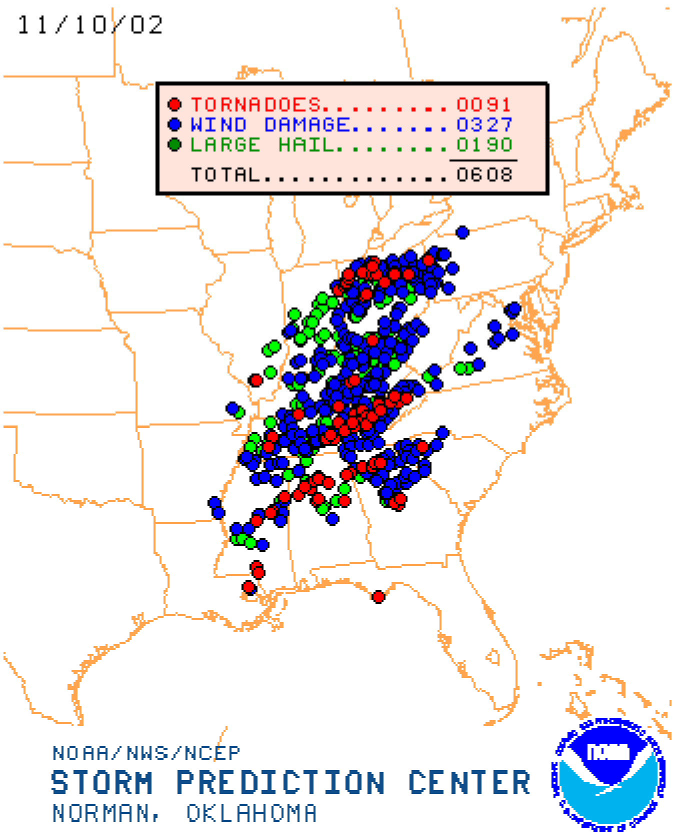

FIG. 1. SPC severe report log from 1200 UTC 10 Nov to 1200 UTC 11 Nov 2002. Several events occurred in the GSP CWA after the valid time of log.

In the GSP county warning and forecast area (CWFA), 31 warnings were issued, 29 for severe thunderstorms, and 2 for tornadoes. Despite the large number of warnings, we were comparatively lucky as there were only two confirmed tornadoes. One tornado produced F0 damage and the other produced F1 damage. Both tornadoes were associated with linear convection, not a supercell thunderstorm.

Section 2 of this case study will provide a synoptic scale review of the major features that drove the event, focusing on an anomalously strong 300 hPa jet and an unseasonably strong northward surge of low-level warm air and moisture. In Section 3, a review of stability and mesoscale features in and near the GSP CWFA will be presented. Section 4 will focus on the orientation and movement of convection across the region and the radar characteristics of the most damaging storms. Finally, there will be a brief discussion/conclusion section with some recommendations for future events.

II. Synoptic scale evolution

An unseasonably strong upper troposheric jet stream began to traverse the contiguous United States a few days prior to the event. Wind speeds in the core of the jet, as it crossed the West Coast, were as high as 200 mph. This anomalously strong jet went on to carve out a deep, broad long wave trough over the central part of the country. As a series of short waves lifted out of the east side of the slow moving trough, moisture and warm low level air spread unusually far to the north. One wave in particular helped to bring moisture much farther to the north than is typical for November. This short wave trough can be seen exiting northern New England in Fig. 2, the 300 hPa isotach, streamline and divergence analysis valid at 0000 UTC on the 11th. It was this trough, as it crossed the Ohio Valley during the early morning hours of the 10th, which helped advect 10 deg C 850 hPa dewpoints as far north as extreme southern Canada, as can be seen in Fig. 3.

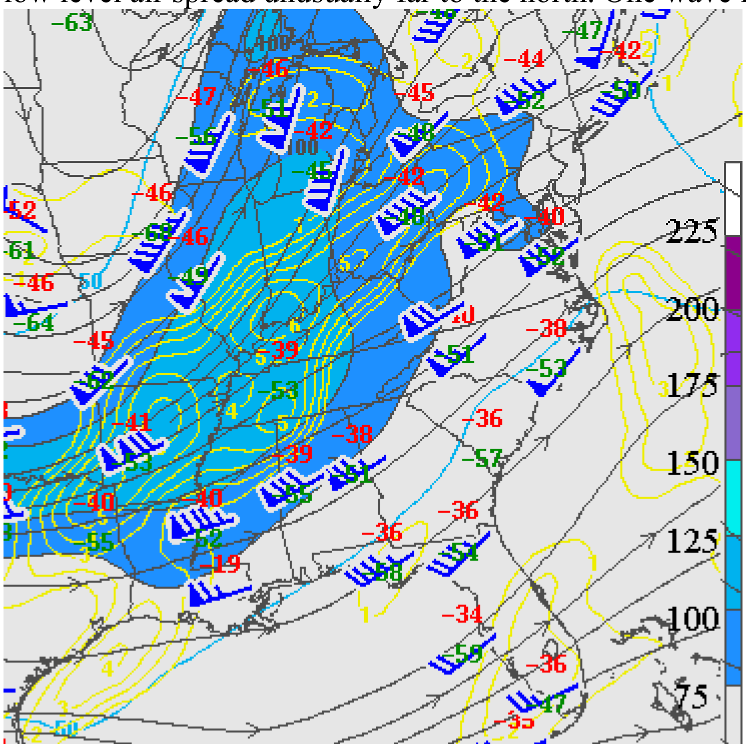

FIG. 2. 0000 UTC 11 Nov 2002 300 hPa isotachs, streamlines and divergence. Courtesy SPC.

Also of note in Fig. 3, a hand analysis of the 850 hPa upper air plot from 0000 UTC on the 11th, are the well-defined thermal and moisture axes. The 1200 UTC plot from the 10th was even more dramatic. By 1200 UTC on the 11th, the thermal ridge had moved to the coast, with the moisture axis across the foothills of the Carolinas. The strong upper divergence, and low-level warm advection, delimits quite well the location of the tornado outbreak (compare the reports in Fig. 1 with the fields in Fig. 2 and 3). While the longitudinal extent of the unstable air was extensive, the latitudinal extent was not as great. Therefore, as a linear MCS developed along the surface front and quickly moved east, supercell thunderstorms did not have as long a period of time to range the warm air ahead of the front as they did in other widespread tornado outbreaks, such as the super outbreak of 3-4 April, 1974.

A 700 hPa dry slot was evident on the 1200 UTC upper plots, with a dewpoint depression of 8 deg C at GSO and 23 deg C at BNA. While the main 500 hPa vorticity maximum was well west of the CWFA at 1200 UTC, a 700 hPa cold front aloft (CFA) was clearly in evidence on the hand analysis over the Appalachians. This is a good example of how the 700 hPa CFA is often a better indicator of forecast MCS development and location than the 500 hPa vorticity maximum.

III Mesoscale features

The initial severe convection over central and eastern Tennessee, which consisted of several discrete supercells, a few of which produced long track tornadoes, was absorbed by linear convection to its west. By the time the area of convection entered the North Carolina Mountains, it was mainly an area of stratiform rain with a few stronger segments on the leading edge of the line. It was one of these segments for which the first warnings were issued around 0500 UTC. Even weak convective segments often down numerous trees and power lines in our high mountain counties when the lower tropospheric winds are as strong as those on the morning of the 11th. After the first few warnings, the convective elements at the leading edge of the MCS completely dissipated over the higher terrain, leaving a large area of stratiform rain. While this is an interesting forecast challenge for our CWFA, especially when it comes to the decision to issue a High Wind Warning or handle the event with Severe Thunderstorm Warnings, this is not an unusual occurrence in our area, and no further attention will be paid to the northern part of the MCS.

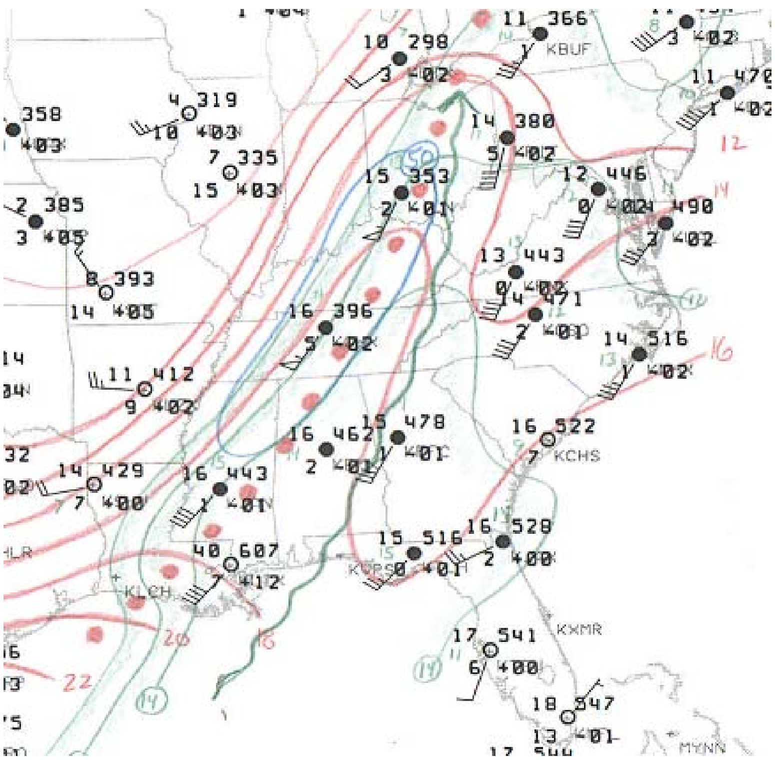

FIG. 3. 0000 UTC 11 Nov 2002 850 hPa hand analysis. Red dotted line is a thermal ridge, and green, wavy line is a dewpoint axis.

Farther to the south, and later that night, supercells across northern Mississippi, northern Alabama and northwest Georgia, were again caught by the rapidly advancing MCS. This MCS remained in a more unstable air mass than did the system farther to the north. As a result, it maintained a consistent character as it crossed north-central and northeast Georgia and the South Carolina Upstate. The MCS consisted of several small, bowing segments, often separated by some distance. While this mode of convection is sometimes favorable for supercell development, in this case of the 10-11 Nov event, the segments appeared to be more a series of small but intense bow echoes rather than supercells. This MCS was responsible for most of the severe reports across the GSP CWFA.

The third, and final area of convection to affect the GSP CWA started as several weak convective cells over south central Georgia, well ahead of the MCS. These cells slowly organized during the early morning hours on the 11th. By 0900 UTC, at least three discrete supercell thunderstorms had developed. These storms did not produce any documented tornadoes in Georgia, though they did produce large hail and damaging winds. A tornado warning was issued for one of these cells as it merged with the MCS over Greenwood County. No tornadoes were reported, but the cell did go on to produce a tornado in Newberry County, over WFO Columbia, SC's CWFA.

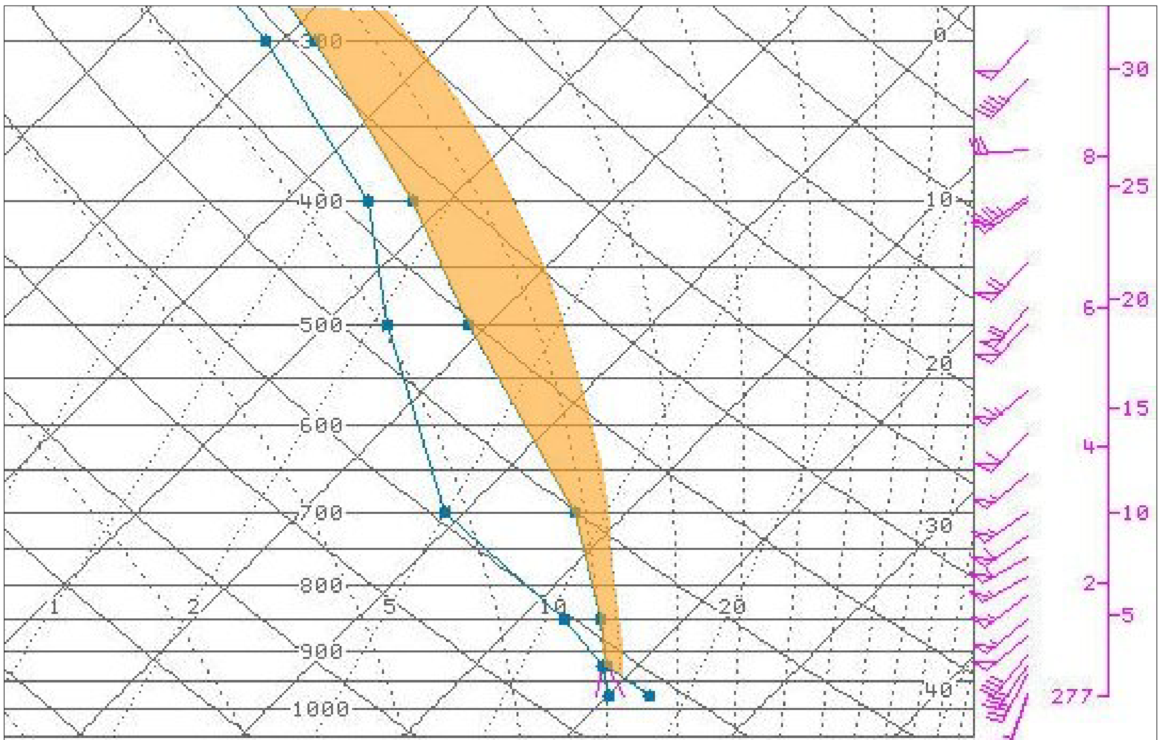

FIG. 4. 1200 UTC 11 Nov 2002 modified GSO sounding. CAPE shaded in orange.

Hereafter this case study will concentrate on the northeast Georgia and Upstate South Carolina MCS. The 1200 UTC GSO sounding from the morning of the 11th was modified in Fig. 4 to reflect the surface conditions at roughly the time of the first tornado in eastern Anderson County. With a surface temperature of 72 deg F, and a dewpoint of 69 deg F, the CAPE from this sounding (non-virtual temperature) was 2107 j/kg. Even unmodified, the GSO sounding's numbers were impressive. The LI was –5, the Sweat Index was 344, the Total Totals 50, the EHI 2.67 and the 0-3 km SRH was 258. It should also be noted that the winds on the GSO sounding appear to be bad above 450 hPa. This appears to have been a side lobe, though we do not know the cause for certain. The 1800 UTC run of the Eta from the 10th had surface based (SB)-CAPE values of only around 500 j/kg for 0900 UTC on the 11th.

The GSO sounding also had an LCL under 1000 meters, and a small area of CAPE, and no CIN, below 700 hPa. Both of these are considered parameters conducive to supercell tornado formation. The fact that the supercells that clipped the southernmost part of the CWFA did not produce tornadoes is a very fortuitous aspect of this event. Several of the severe weather indices from the SPC experimental products page also indicated a high supercell and tornado potential across the southeast part of the CWFA that morning.

Figs. 6 and 7 show a plan view of RUC SB-CAPE, and 0-3 km EHI respectively across the region (taken from the SPC web page). CAPE values of between 1500 and 2000 j/kg were evident across this area at 0800 UTC. No image was available for 0900 UTC, but the 0-3 km EHI for 0900 UTC showed values around 4 over much of the CWA. The author seldom recalls seeing EHI values this high over the CWFA during the past 4 years.

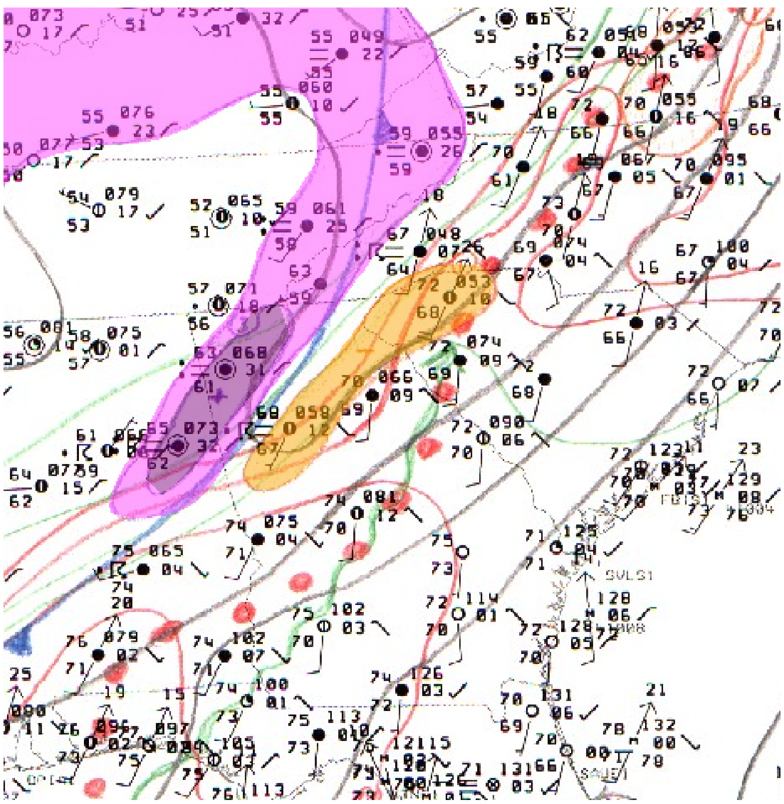

FIG. 5. 0900 UTC surface analysis. Pressure rise/fall couplet shaded purple/orange.

III. Radar characteristics of the MCS over northeast Georgia and the Upstate

Figure 8 shows a regional perspective of the MCS at 1002 UTC on the 11th. This was about 20 minutes prior to the first tornado. Considering the amount of instability and shear it is not surprising that the MCS exhibited a high degree of organization. Fig. 9 is a set of five images running from 1004 UTC to 1027 UTC, centered on the most organized cell to affect the CWFA that morning. Numerous trees and power lines were downed by this segment as it moved out of northeast Georgia, and there was straight line wind damage to some homes. The 4th frame in Fig. 9 is coincidental with the time of the 1st tornado. A second tornado developed shortly after the time of the last frame. Due to a bug in the AWIPS Archive Manager, the data for the

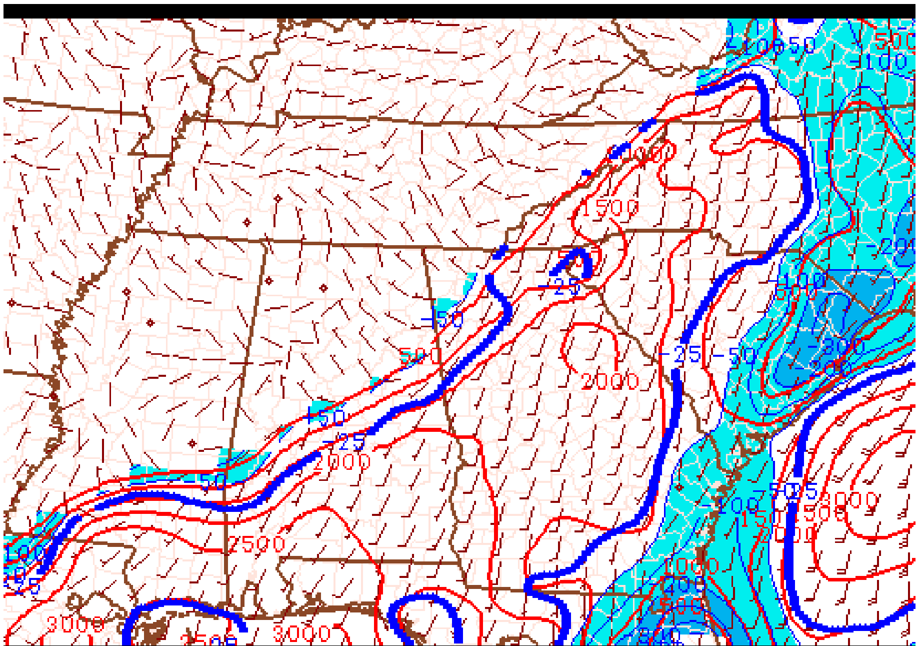

FIG. 6. 0800 UTC SB-CAPE and CIN.

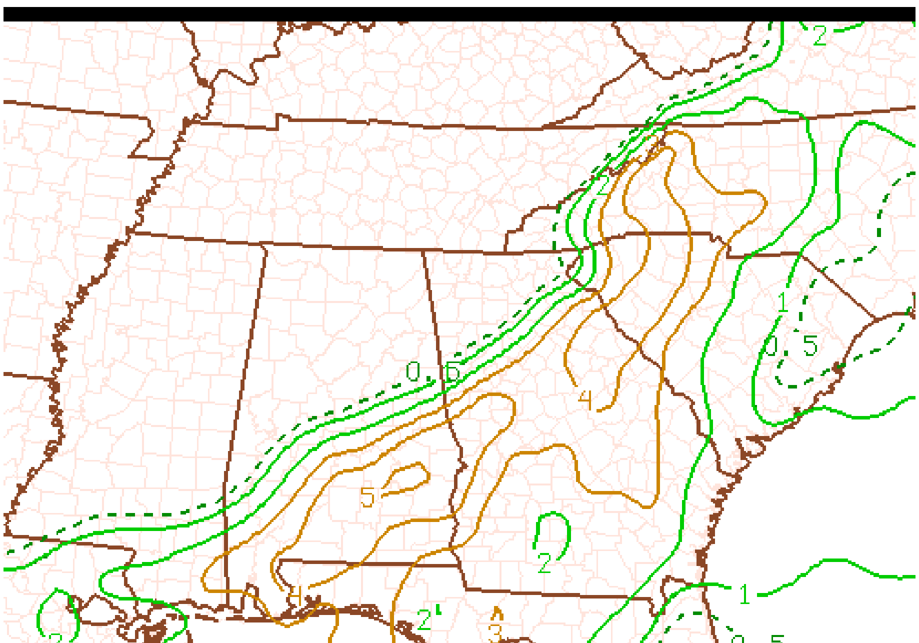

FIG. 7. 0900 UTC 0-3 km EHI.

second tornado, which produced F1 damage in Simpsonville in Greenville County, cannot be recovered.

Despite producing two tornadoes, there was only weak rotation with this storm, as can be seen in Figure 10. While only the 0.5 deg tilts are shown, higher tilts did not reveal any increase in rotation in the SRM data. There was a broad area of out-bound velocity north of the LEWP like segment, fairly typical of mesolows embedded in an MCS, and an area of weak cyclonic convergence that is nearly coincident with the small bow-head. A pronounced rear inflow notch (RIN) is evident in all the reflectivity images. In fact, the RIN was in evidence 45 minutes earlier as the segment first moved into the GSP CWA in Franklin County, GA.

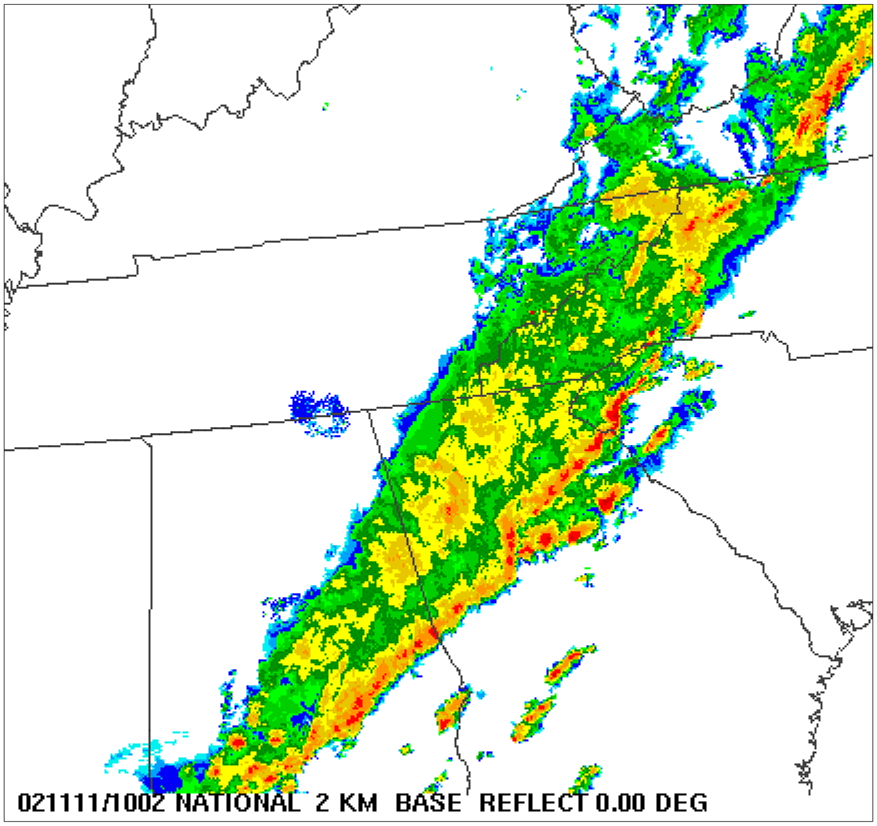

FIG. 8. 1002 UTC 11 Nov 2002 regional radar summary.

Weak tornadoes at the head of a bowing MCS are a fairly common occurrence. We have even documented weak tornadoes along breaks in a linear MCS. These events tend to be associated with little rotation. In this case, the two surveyed tornadoes from the morning of the 11th appear to have been a hybrid of these two mechanisms for non-supercell tornado development.

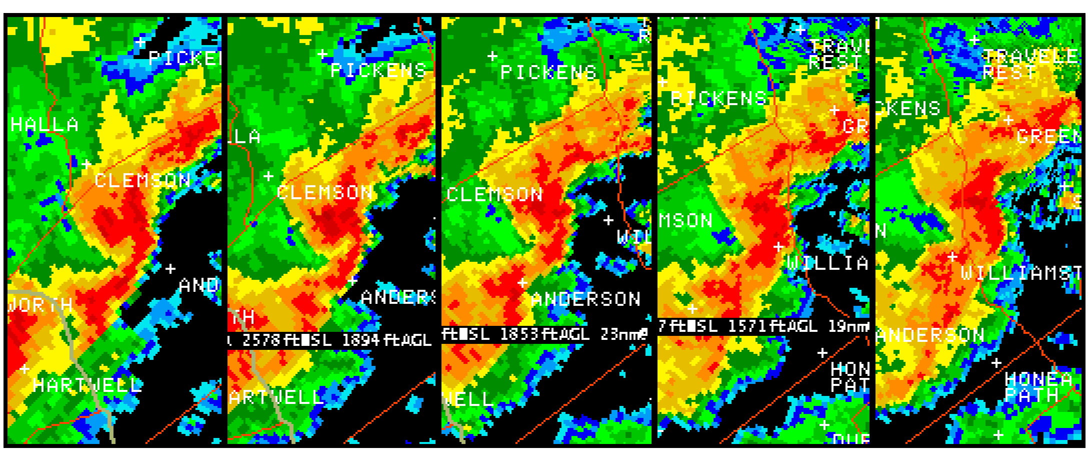

FIG. 9. 0.5 degree base reflectivity images from 1004 UTC, 1009 UTC, 1014 UTC, 1022 UTC and 1027 UTC.

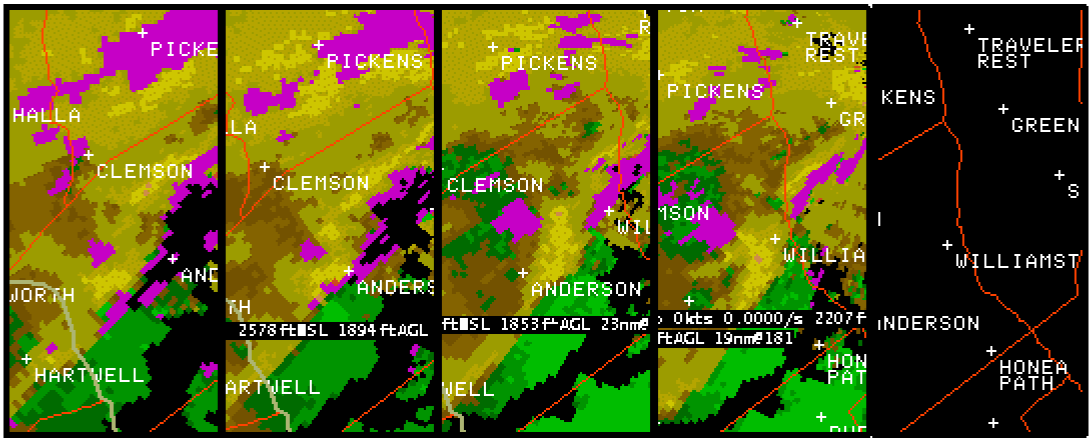

FIG. 10. Same as Fig 10, but with SRM data.

This degree of organization is not particularly rare in the Upstate. In fact, stronger features, similar in form to this one, have occurred in recent years over the region. Links to local case studies about such events are provided at the end of this review.

IV. Discussion/Conclusion

The environment over the GSP CWA the morning of Nov 11th was very favorable for the development of supercell thunderstorms and tornadoes. While we were fortunate not to have had this mode of convection, a strong MCS crossed northeast Georgia, the Upstate and a small part of the North Carolina Piedmont. Numerous reports of severe weather, and at least two weak, non-supercell tornadoes occurred.

For the most part, warnings were issued in a timely manner, with good average lead times, a high POD and a low FAR. A warning preceded the tornado in Anderson County, as the radar operator was familiar with modes of non-supercell tornado production. No tornado warning was issued for the Greenville County event. However, the storm structure was not as good when the storm entered Greenville County, and issuing a warning for this cell would have been very difficult.

The Eta model greatly under estimated the instability during the early morning hours of the 11th. However, the office was more than adequately staffed due to the severity of the upstream weather, and due to strongly worded Day 1 and Day 2 convective outlooks from SPC.

V. Notes

For information about an earlier tornadic storm associated with a mesolow crossing the GSP CWA, follow this link:

http://www.erh.noaa.gov/gsp/localdat/headline/3April00tornado/index.htm

And, for information about tornadoes along broken line segments in an MCS, go here:
http://www.erh.noaa.gov/gsp/localdat/Broken-S.pdf