A Widespread Severe Weather Outbreak on 1 July 2012

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1. Overview

Widespread severe thunderstorms developed across the Weather Forecast Office (WFO) Greenville-Spartanburg (GSP) County Warning Area (CWA) during the late afternoon and evening of 1 July 2012. The storms resulted in numerous reports of wind damage and large hail (quarter size to baseball size). The severe weather was part of a large outbreak that was responsible for more than a thousand reports of storm damage from the Ohio Valley to the southeastern United States (Fig. 1). The severe thunderstorms formed in an extremely unstable air mass that promoted strong updraft development and allowed the interaction of numerous convective outflow boundaries. The combination of very high surface temperatures and cooling aloft contributed to the development of extreme instability values.

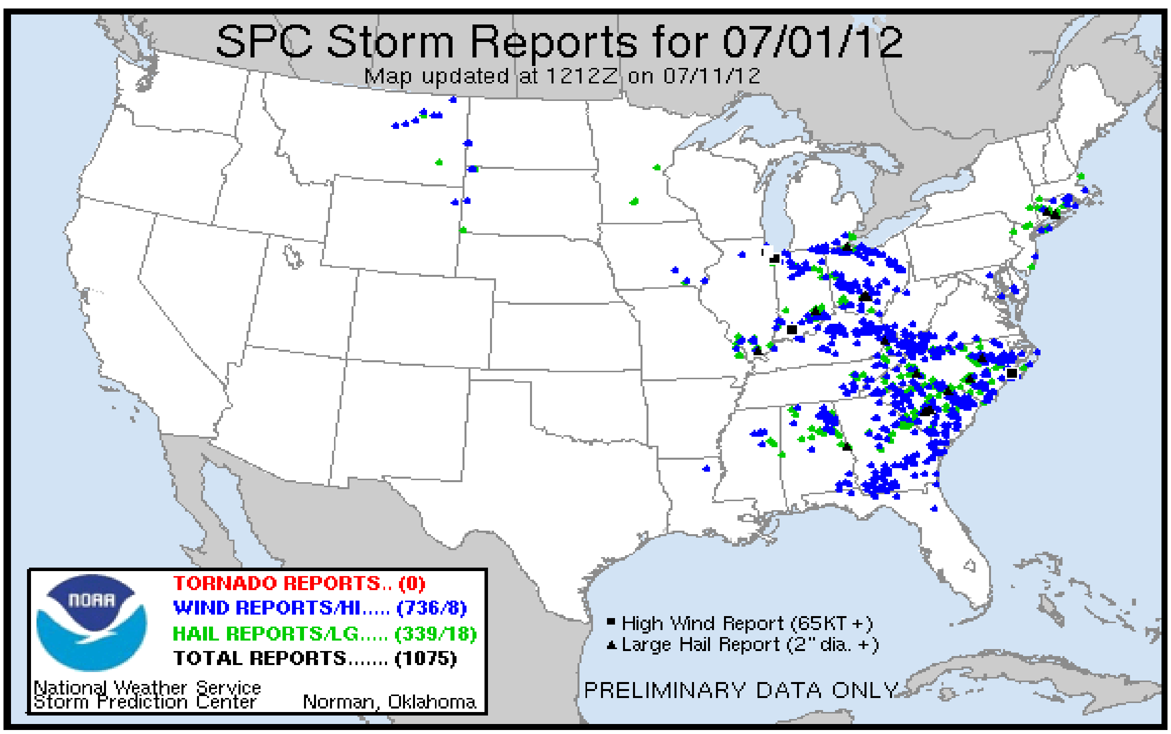


Fig.1. Storm Prediction Center (SPC) preliminary storm reports on 1 July 2012.

2. Synoptic Features and Pre-Storm Environment

A strong upper level ridge of high pressure existed across much of the United States at 1200 UTC on 30 June (Fig. 2), with the ridge axis over the Rockies. An upper level trough was developing across the Hudson Bay and New England regions. The persistent, strong upper level ridging was primarily responsible for record heat across much of the central and southeastern states from 30 Jun to 1 July. The 500 mb analysis at 1200 UTC on 1 July indicated that the upper ridge slightly weakened across the Southeast as the upper level low pressure trough over the northeastern states deepened south across the mid-Atlantic and into the southern Appalachians (Fig. 3). This development resulted in mid-level cooling across many of the eastern states on 1 July. The 700 mb temperatures were 13°C to 14°C across much of the Southeast on 30 June (Fig. 4), but they dropped a few degrees to 10°C to 13°C on 1200 UTC on 1 July (Fig. 5).

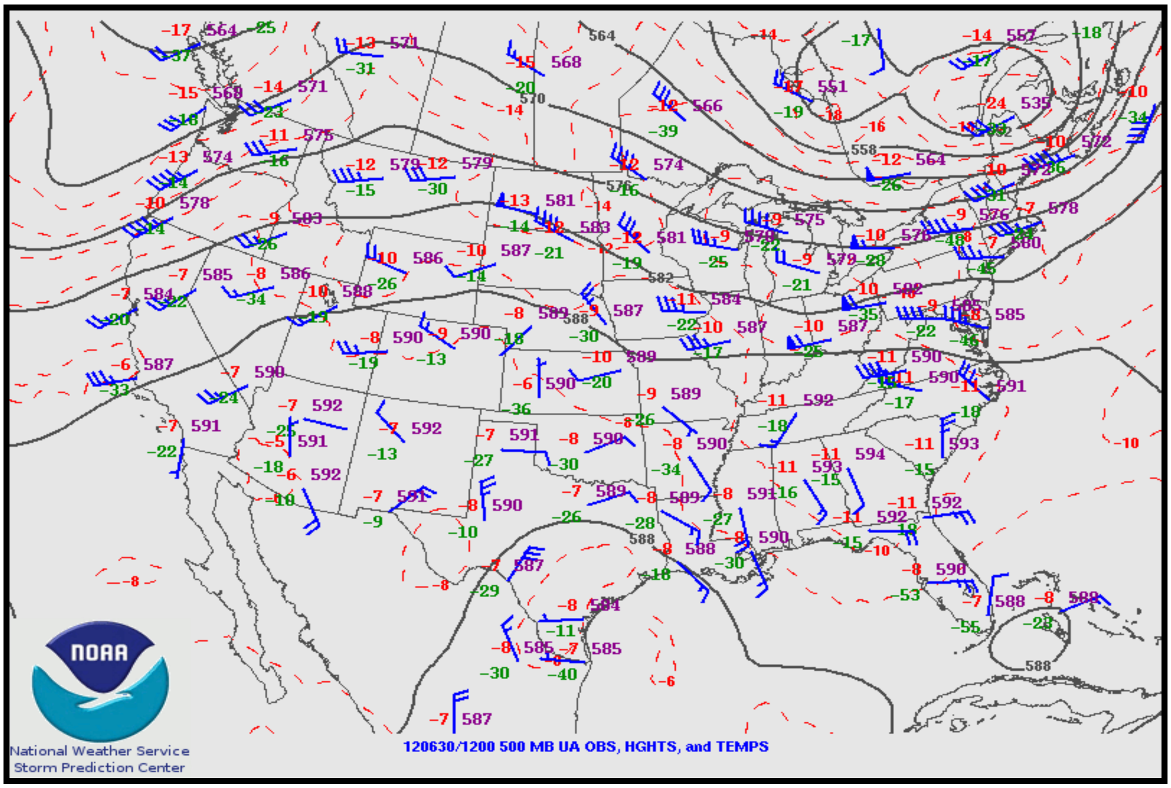


Fig. 2. SPC objective analysis of 500 mb geopotential height (dm; dark gray contours), wind (kt; barbs), and temperature (degrees C; dashed red contours) at 1200 UTC on 30 June 2012.

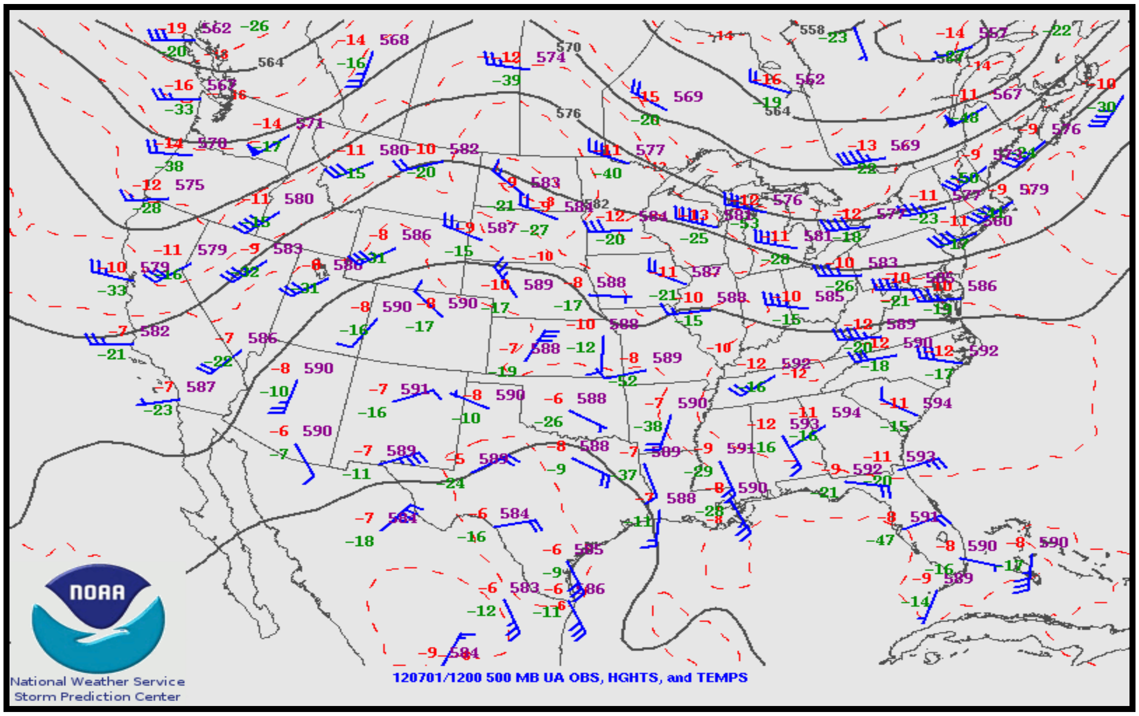


Fig. 3. Same as Fig. 2 except 1200 UTC on 1 July 2012.

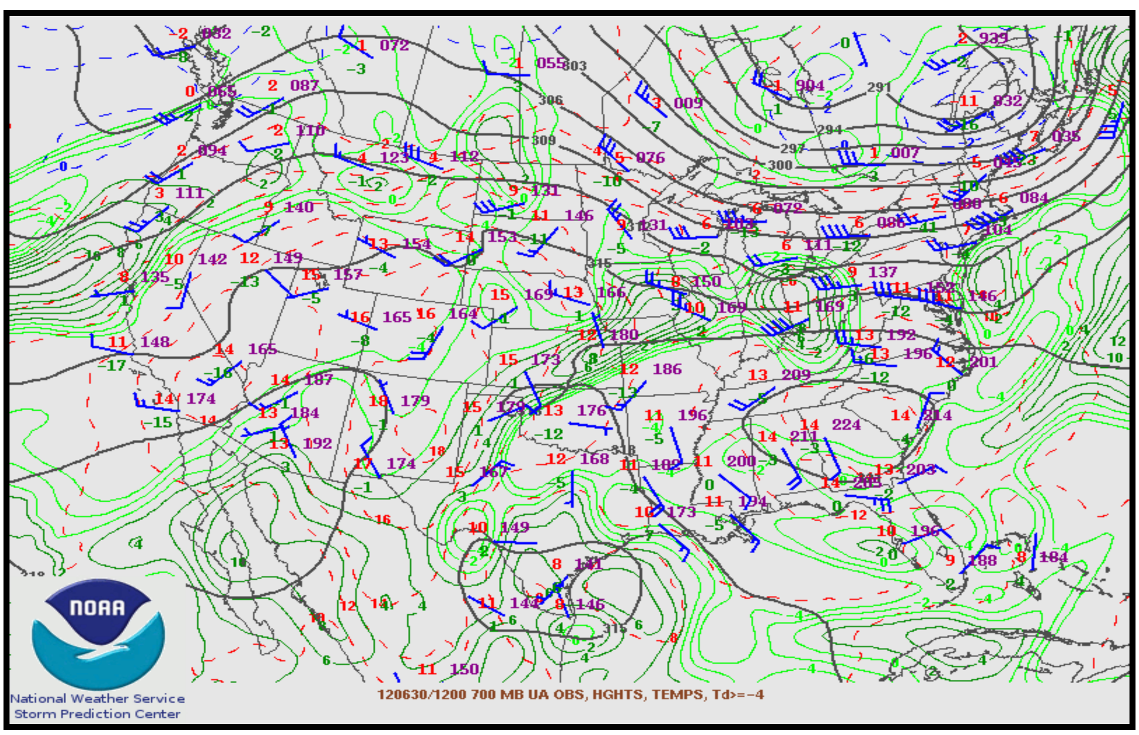


Fig. 4. SPC objective analysis of 700 mb geopotential height (dm; dark gray contours), wind (kt; barbs), temperature (degrees C; red dashed contours), and dewpoint (degrees C; green contours) at 1200 UTC on 30 June 2012.

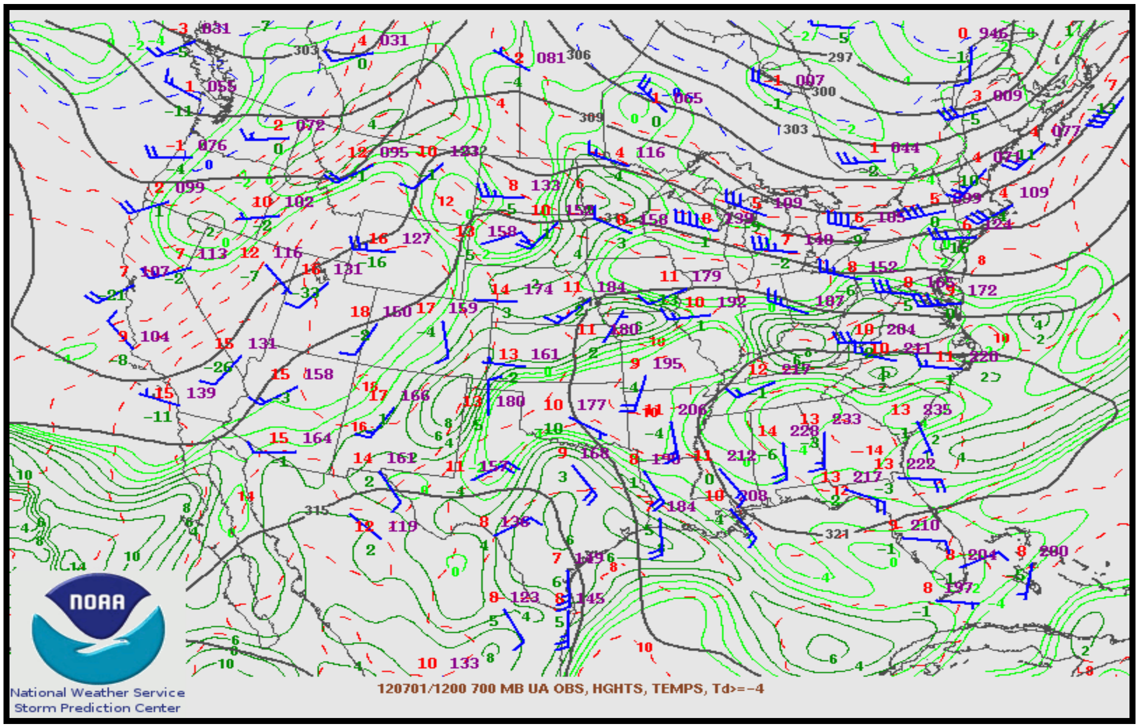


Fig. 5. Same as Fig. 4 except 1200 UTC on 1 July 2012.

A broad surface high pressure covered much of the United States at 1200 UTC on 1 July 2012 (Fig. 6). A nearly stationary front stretched from northern California through the Great Plains and Ohio Valley to the mid-Atlantic and southern New England coasts. A cold front extended from northern Maine to the upper Great Lakes.

The 2100 UTC regional surface analysis revealed a surface boundary stretching from the North Carolina coastal plain to southern Georgia (Fig. 7). Surface temperatures ranged from 95° to 105°F across Georgia, the foothills and Piedmont of western North Carolina, and Upstate South Carolina. The combination of very high surface temperatures and mid-level cooling caused a steep 850-500mb lapse rate of 8.0° to 8.5°C km^{-1} to become established over the Piedmont during the afternoon (Fig. 8).

Local Analysis and Prediction System (LAPS) surface based convective available potential energy (CAPE) at 1600 UTC revealed extremely high values ranging from 5000 J kg^{-1} to 6000 J kg^{-1} (Fig. 9). Surface based Downdraft Convective Available Potential Energy (DCAPE) exceeded 1300 J kg^{-1} across portions of the Carolinas Piedmont, which resulted in a very high potential for strong thunderstorm downdrafts (Fig. 10).

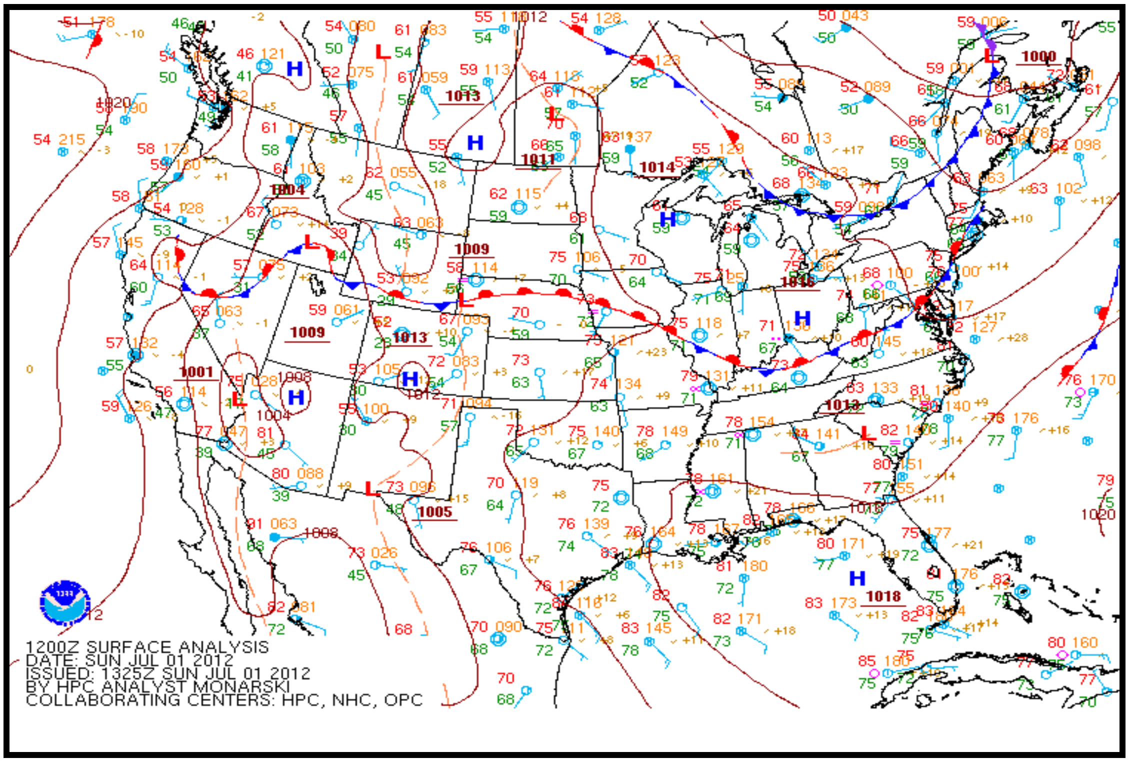


Fig. 6. Hydrometeorological Prediction Center (HPC) surface front and pressure analysis at 1200 UTC on 1 July 2012.

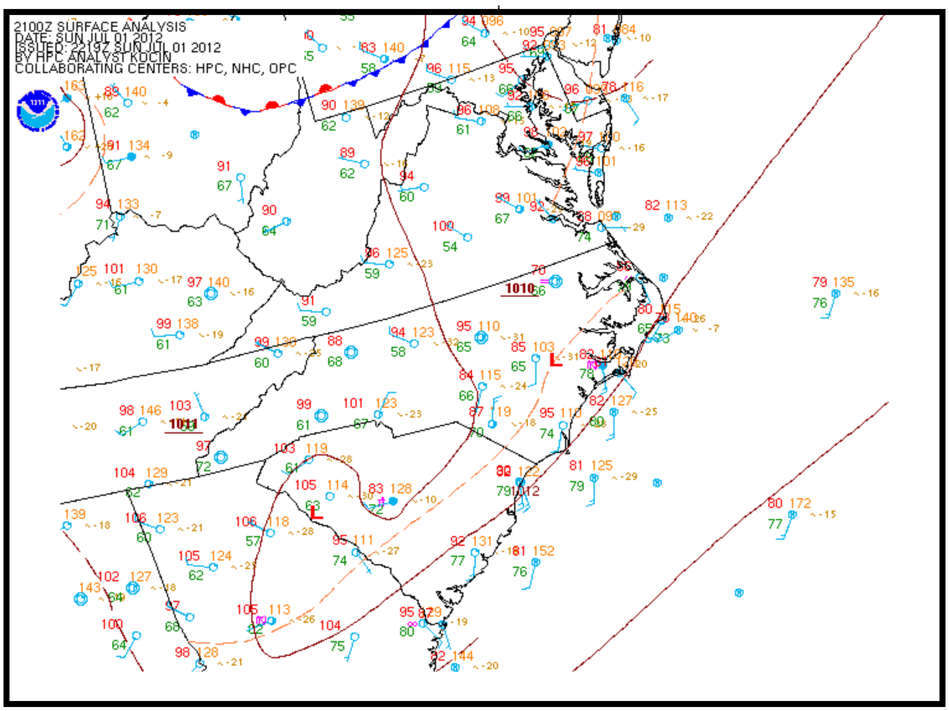


Fig. 7. Regional HPC surface front and pressure analysis at 2100 UTC on 1 July 2012.

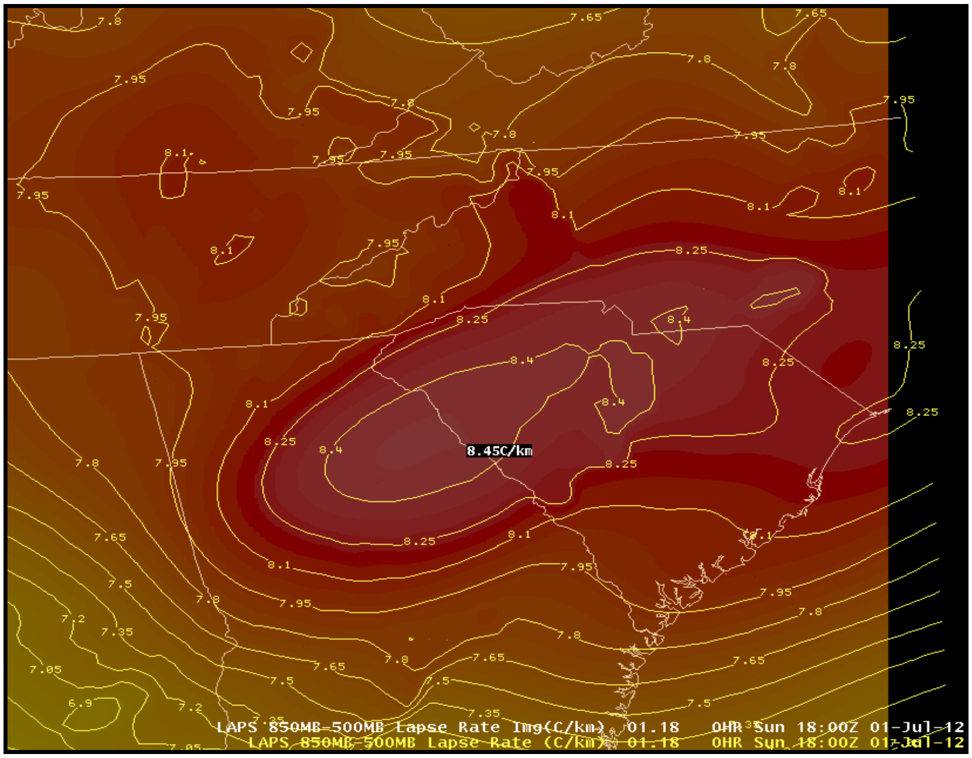


Fig. 8. LAPS 850-500mb layer lapse rate (yellow contours) at 1800 UTC on 1 July 2012.

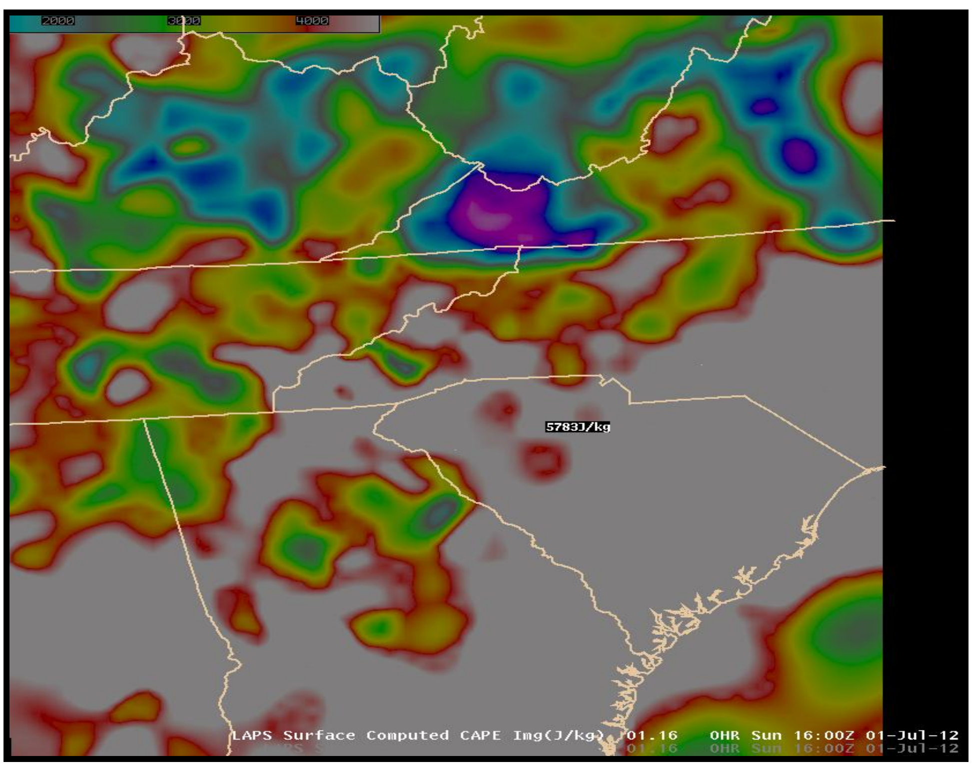


Fig. 9. LAPS surface-based computed CAPE at 1600 UTC on 1 July 2012. Gray shade represents CAPE values greater than 5000 J kg^{-1}.

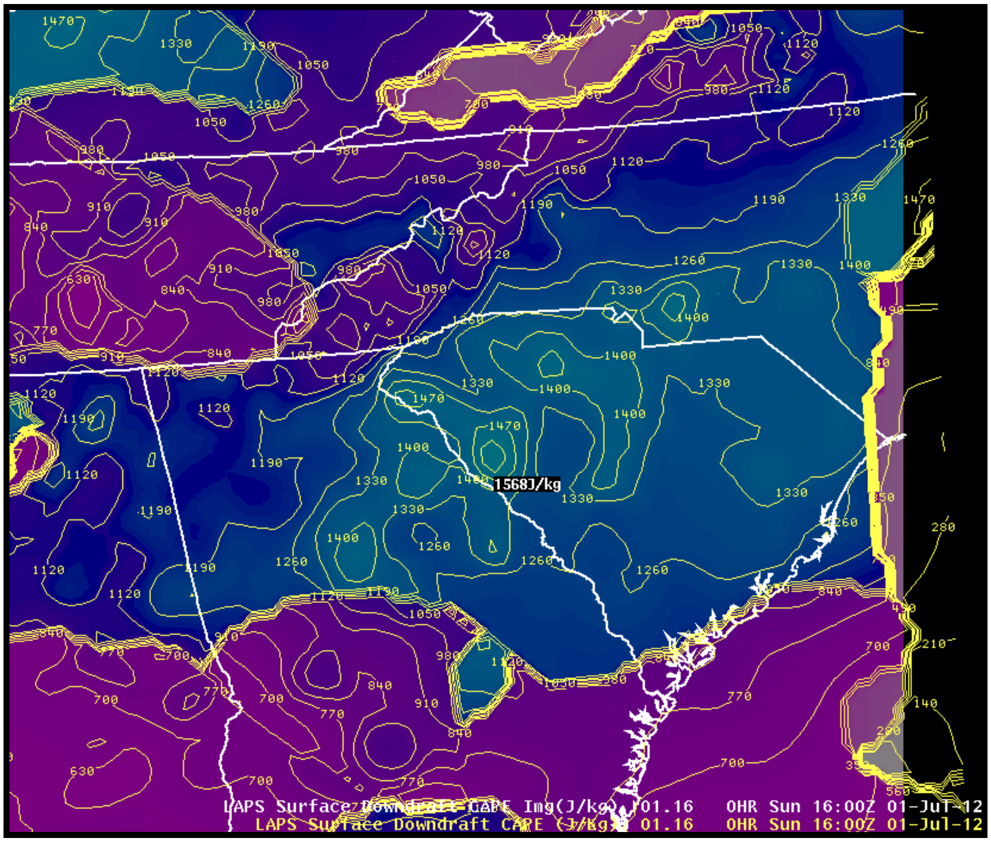


Fig. 10. LAPS surface downdraft CAPE (yellow contours) at 1600 UTC on 1 July 2012. Bright blue shades over the Piedmont of South Carolina denote DCAPE values greater than 1300 J kg^{-1}.

The 1200 UTC 1 July observed sounding at Peachtree City, Georgia, depicted most unstable CAPE of 3959 J kg^{-1} and precipitable water (PW) of 1.53 inches (Figs. 11). The skew-T/log P diagram indicated very large and tall CAPE that would support the development of very deep convection. The maximum computed vertical velocity of 87 m s^{-1} (195 mph) driven by the extremely large CAPE indicated that any thunderstorm initiated in this environment would tend to grow very fast. The equilibrium level was near 50,000 ft which also indicated thunderstorms would be very tall. The presence of a drier air mass in the mid-level layer above 700 mb represented high potential for severe thunderstorms producing large hail and strong downburst winds (Fig. 11).

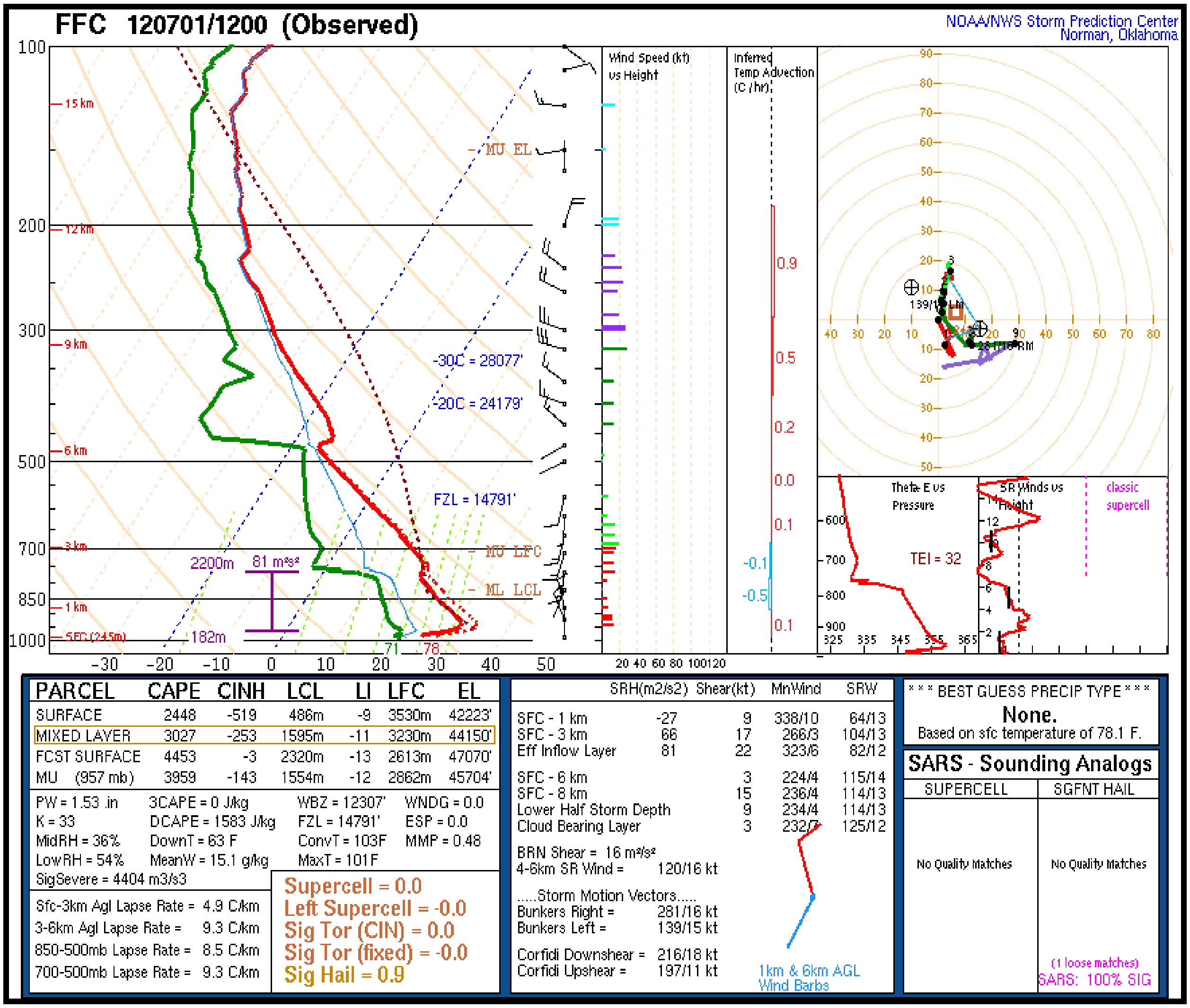


Fig. 11. Observed sounding at Peachtree City, Georgia (FCC) at 1200 UTC on 1 July 2012. The temperature profile is shown by the green line, and the hypothetical path of a parcel lifted from the most unstable layer is shown by the brown dashed line. A table of convective parameters is given at the bottom.

3. Notable occurrences during the severe weather event

a. Damaging convective outflow boundaries

The regional composite radar at 2106 UTC depicted an organized line of multi-cell clusters near the surface boundary that stretched from central Georgia to the coastal plain of North Carolina (Fig. 12). Meanwhile, other thunderstorms developed across portions of western North Carolina.

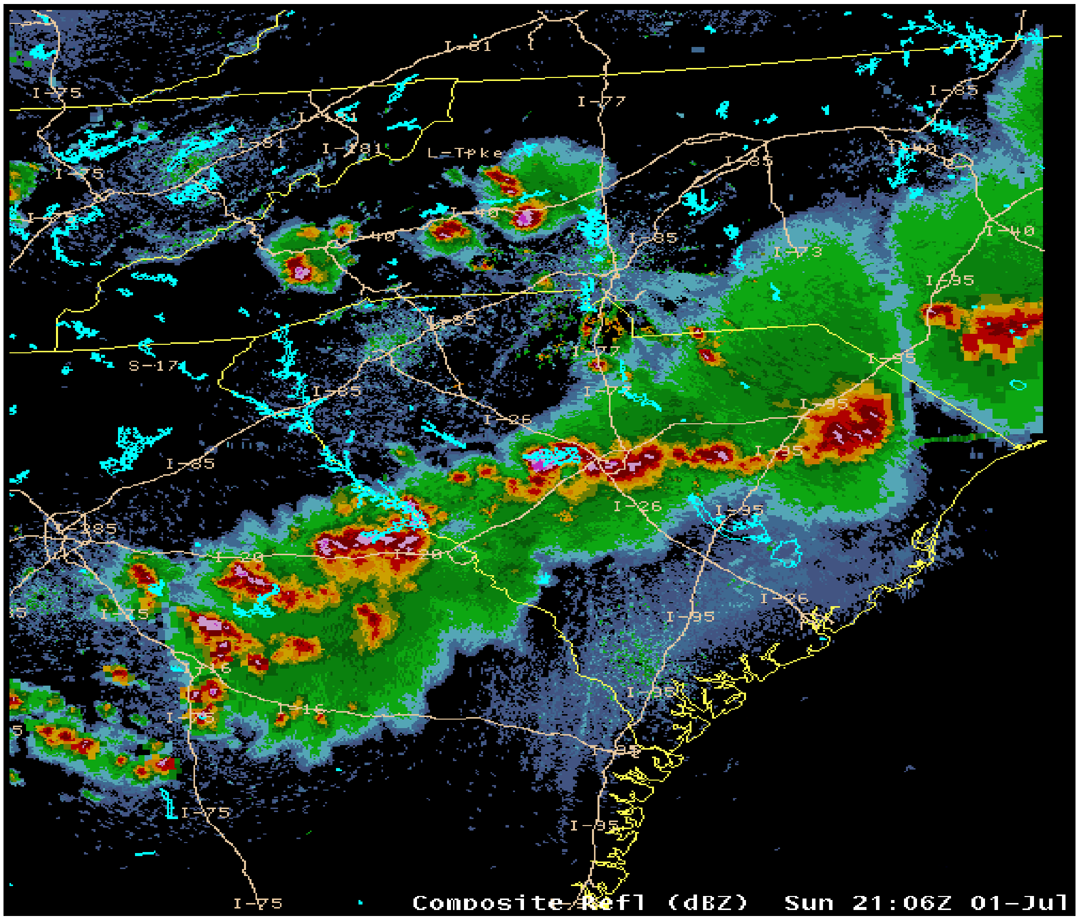


Fig. 12. Regional WSR-88D composite reflectivity (dBZ) at 2106 UTC on 1 July 2012.

The line of multi-cell clusters south of the GSP CWA produced a series of convective outflow boundaries that propagated northward into Upstate South Carolina at 2207 UTC (Fig.13). Another outflow boundary that originated from a convective cell over the Piedmont of North Carolina moved southwestward into the Upstate. A stronger convective outflow boundary that moved north across Elbert, Franklin, Greenwood, Laurens, Abbeville, and Anderson counties knocked down numerous trees and power lines between 2154 and 2245 UTC (Fig. 15). This occurrence prompted WFO GSP to issue a Severe Thunderstorm Warning even though there were no thunderstorms in the warned area at the time of the issuance. The GSP WSR-88D 0.5° scan detected a 40 kt inbound base velocity along the leading edge of the approaching convective outflow boundary 10 miles south of GSP at 2239 UTC (Fig. 14).

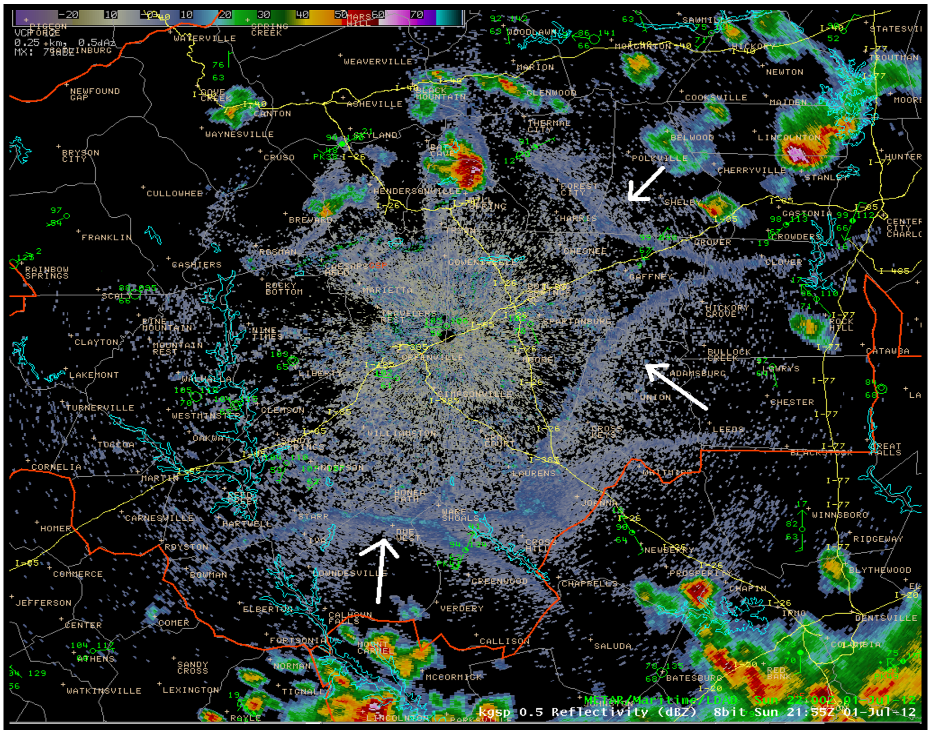


Fig. 13. Greenville Spartanburg (KGSP) WSR-88D 0.5 degree reflectivity at 2207 UTC on 1 July 2012. White arrows indicate convective outflow boundaries and direction of movement.

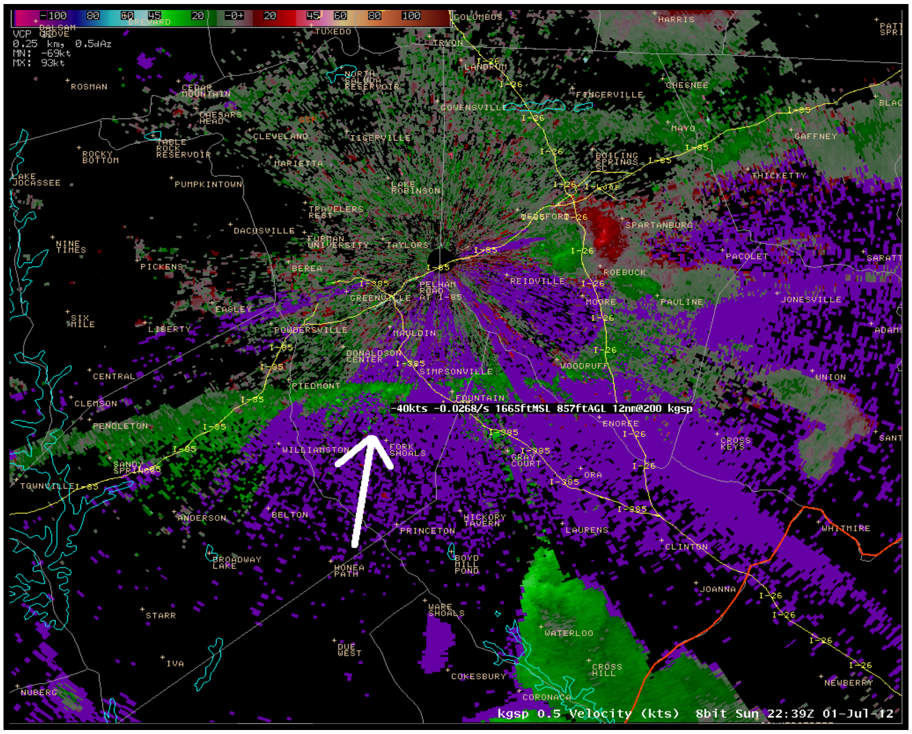


Fig. 14. KGSP WSR-88D 0.5 degree velocity (kts; green, inbound; red, outbound) at 2239 UTC on 1 July 2012.

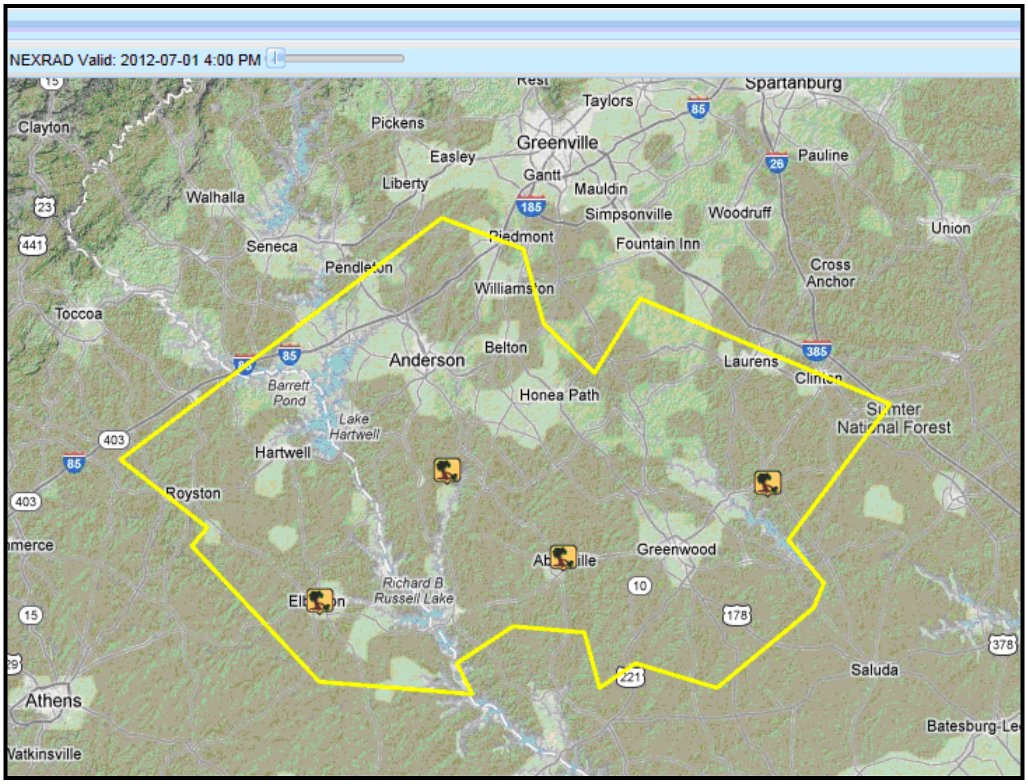


Fig. 15. Severe Thunderstorm Warning polygon (valid 2154utc to 2245 utc; solid yellow line) and thunderstorm wind damage reports (symbols).

b. Hail Storm in Spartanburg, South Carolina

Between 2227 and 2252 UTC, scattered thunderstorms developed over portions of Spartanburg, Cherokee, and York counties in South Carolina as the series of strong convective outflow boundaries pushed through the region (Fig.16). A thunderstorm that quickly developed just south of Spartanburg became severe by 2247 UTC. The reflectivity core greater than 60 dBZ detected by the WFO Columbia WSR-88D (KCAE) extended from 12,928 ft above ground level (AGL) to 26,700 ft AGL (Fig. 17B,D). The presence of very high reflectivity echoes and three-body scatter spike (TBSS) on both the 1.3° and 2.4° reflectivity scans was indicative of a high potential for large hail (Figs. 17B,C). In fact, WFO GSP received numerous large hail reports ranging from quarter size to golf ball size near the core of the storm south of Spartanburg (Fig. 19). This storm also produced frequent lightning flashes (Fig.18).

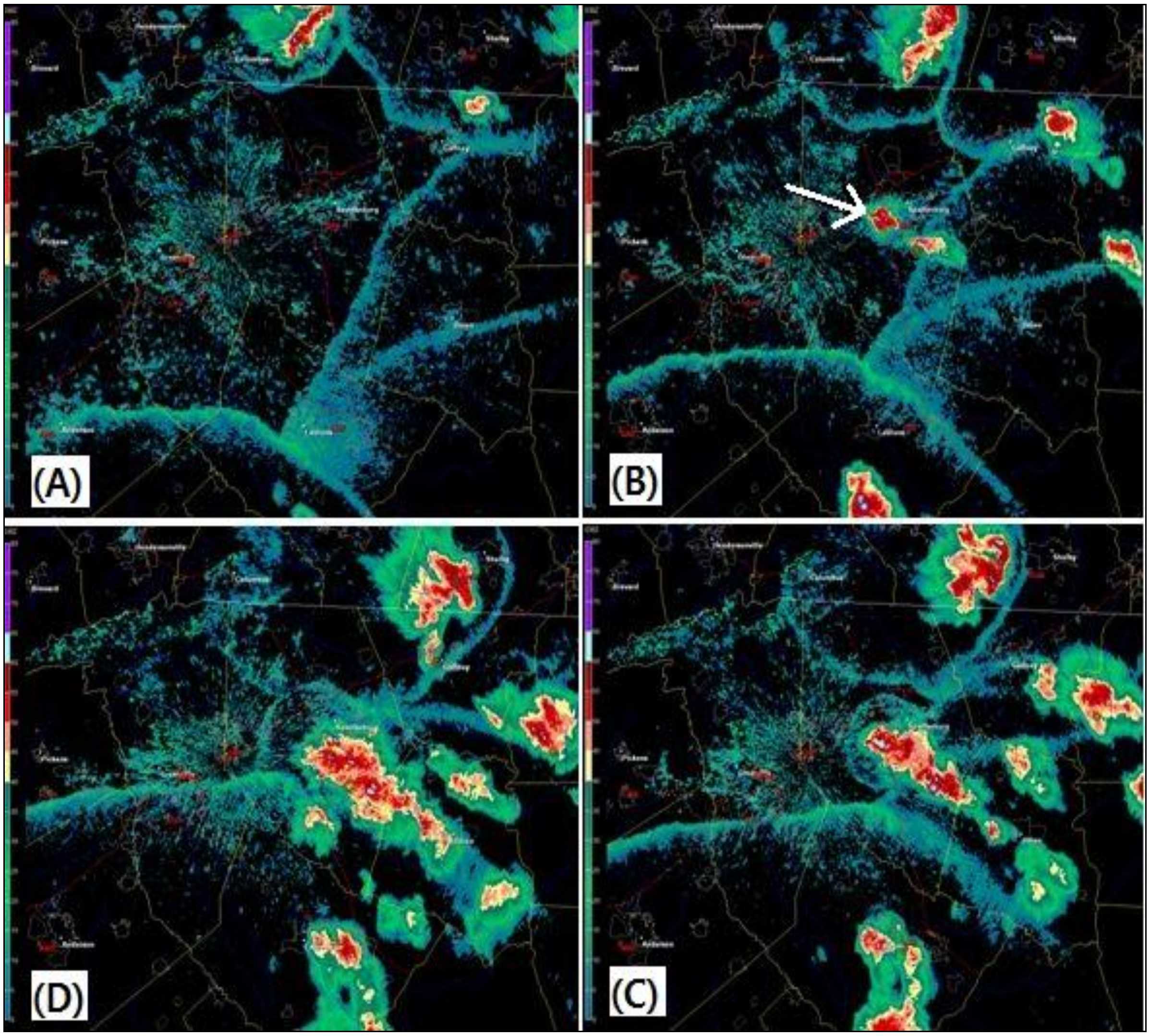


Fig. 16. KGSP WSR-88D 0.5° reflectivity at (A) 2216 UTC , (B) 2232 UTC , (C) 2248 UTC, and (D) 2300 UTC on 1 July 2012. A strong thunderstom that produced golf ball size hail south of Spartanburg is indicated by the white arrow.

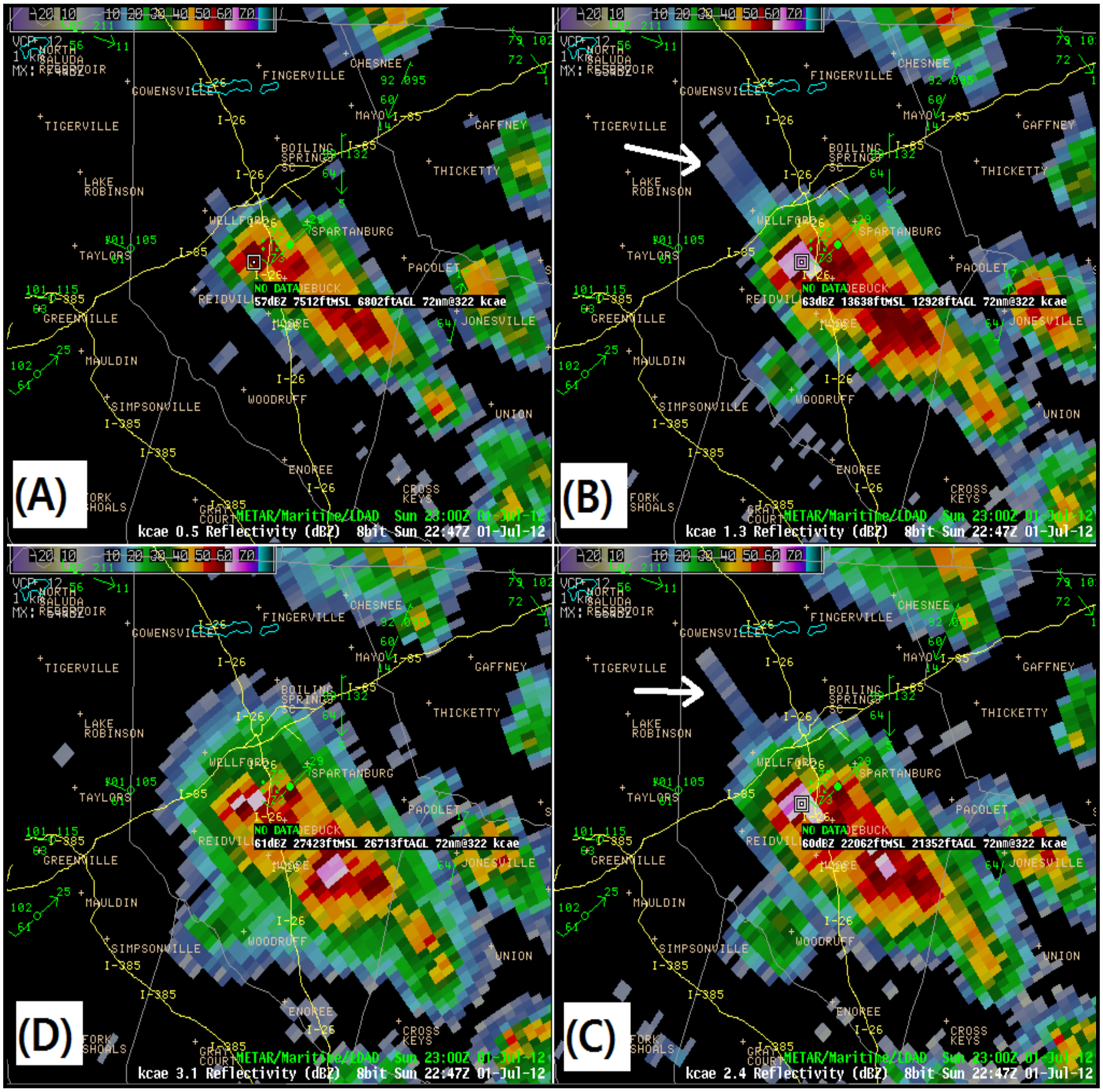


Fig. 17. Columbia (KCAE) WSR-88D base reflectivity on the (A) 0.5°, (B) 1.3°, (C) 2.4°, and (D) 3.1° scans at 2247 UTC on 1 July 2012 near Spartanburg. White arrows indicate TBSS.

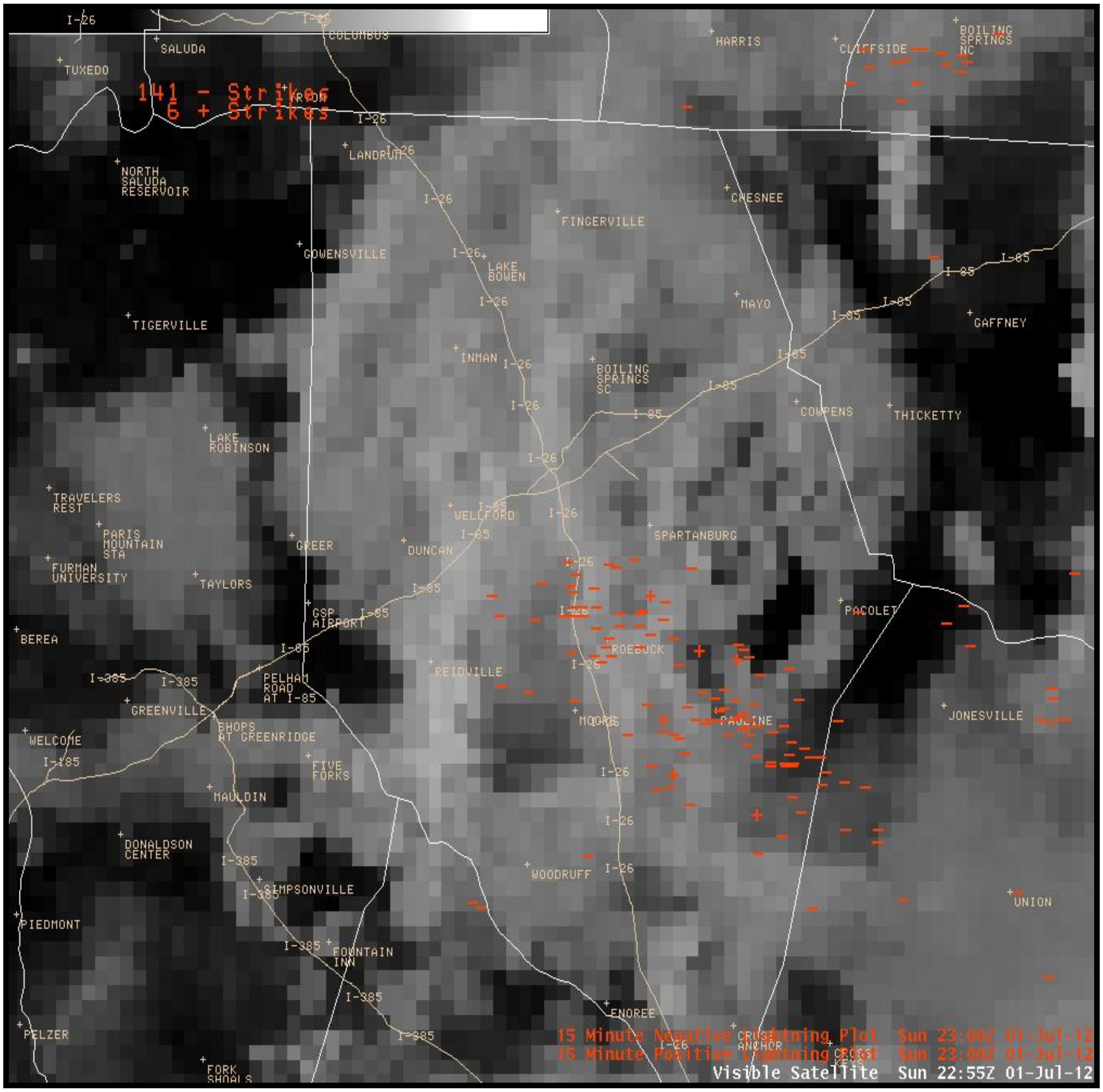
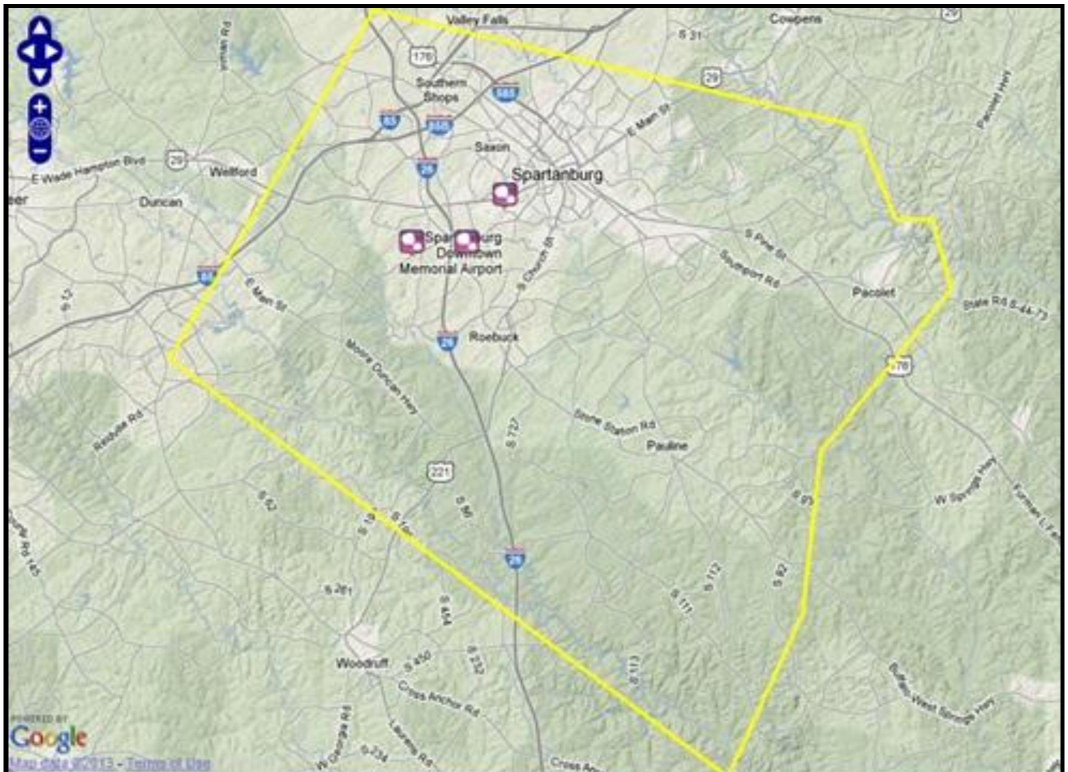


Fig. 18. GOES visible satellite imagery at 2255 UTC centered near Spartanburg, South Carolina. Red pluses and minuses indicate positive and negative lightning flashes.



Help | Local Storm Report Information | Storm Based Warnings

Print Data Grid | Export to Excel... | Save Shapefile | Expand All

Office	Report Time	County	Location	ST	Event Type	Mag
GSP	2012-07-01 6:30 PM	Spartanburg	2 W Spartanburg	SC	HAIL	1
GSP	2012-07-01 6:35 PM	Spartanburg	5 WSW Spartanburg	SC	HAIL	1.5
GSP	2012-07-01 6:42 PM	Spartanburg	3 WSW Spartanburg	SC	HAIL	1.75

Fig. 19. Severe Thunderstorm Warning polygon (valid from 2228 UTC to 2315 UTC; solid yellow line) and hail reports (symbols and table).

c. Hail storm near Hickory, North Carolina

At 2247 UTC, the KGSP WSR-88D radar 5.1° base reflectivity scan detected a severe thunderstorm near Hickory, North Carolina, with a 60 dBZ core top at 37,212 ft AGL (Fig. 20C). This storm originated north of Lenoir, North Carolina at 1945 UTC and became severe as it moved southeastward into Hickory, by 2247 UTC.

The storm marked the highest echo top of the day with a 50 dBZ core top at 45,883 ft AGL(Fig. 20D). A cross section display revealed an extremely tall echo top reaching a maximum height of 50,000ft AGL (Fig. 21). This storm produced hail ranging from golf ball size to baseball size south of Hickory (Fig. 22).

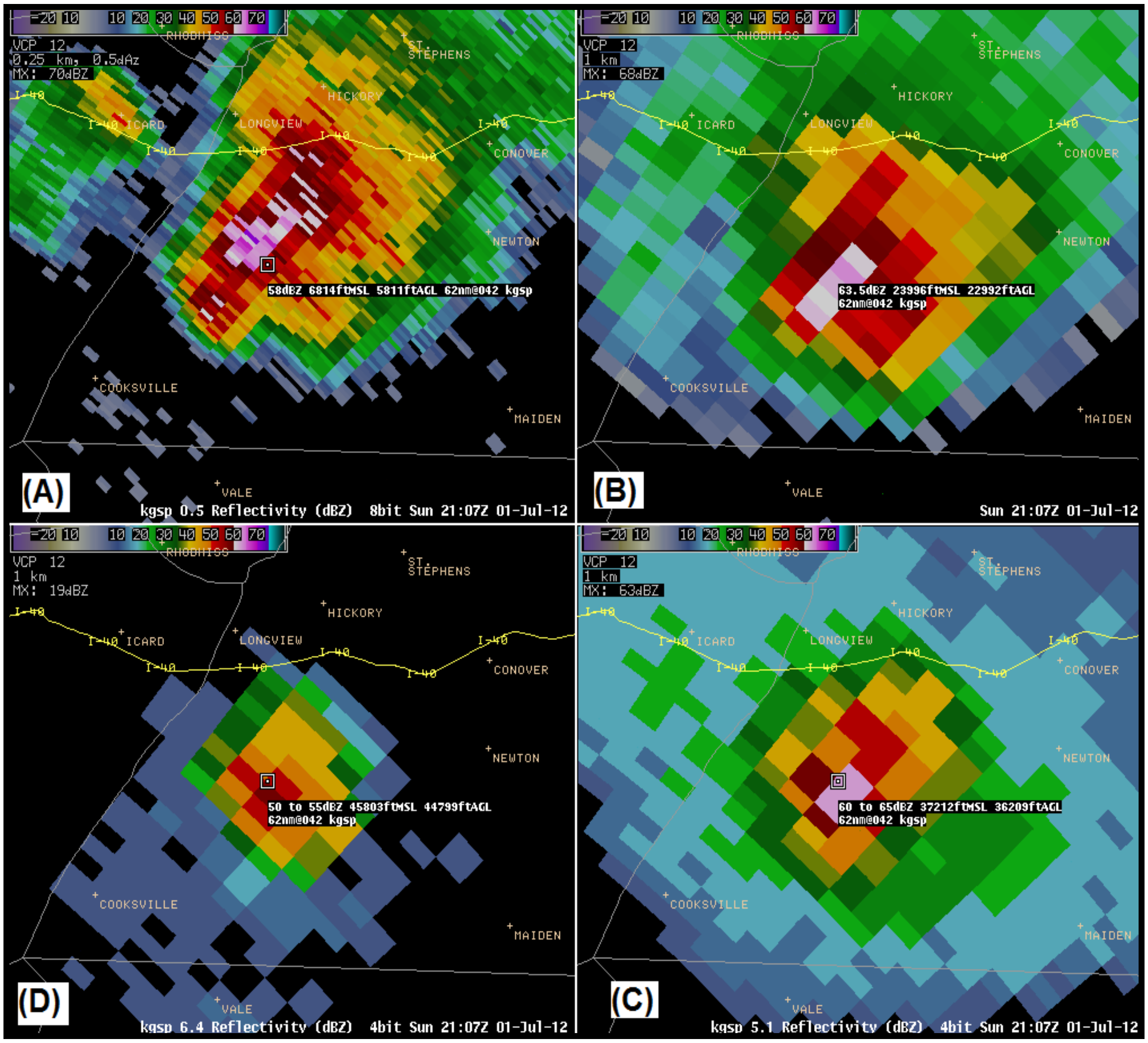


Fig. 20. KGSP WSR-88D base reflectivity on the (A) 0.5°, (B) 4.3°, (C) 5.1°, and (D) 6.4° scans at 2247 UTC on 1 July 2012 near Hickory, North Carolina.

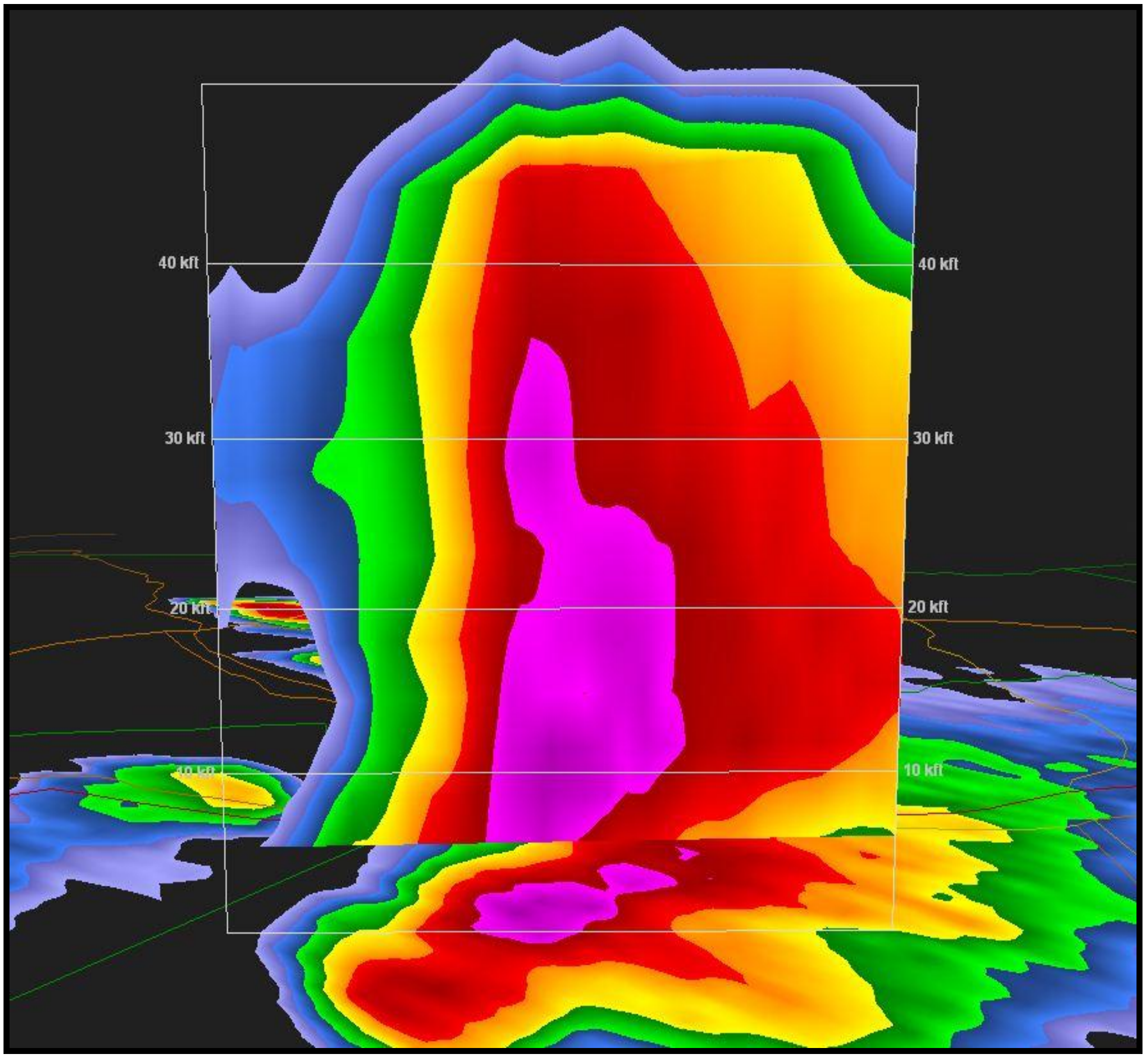
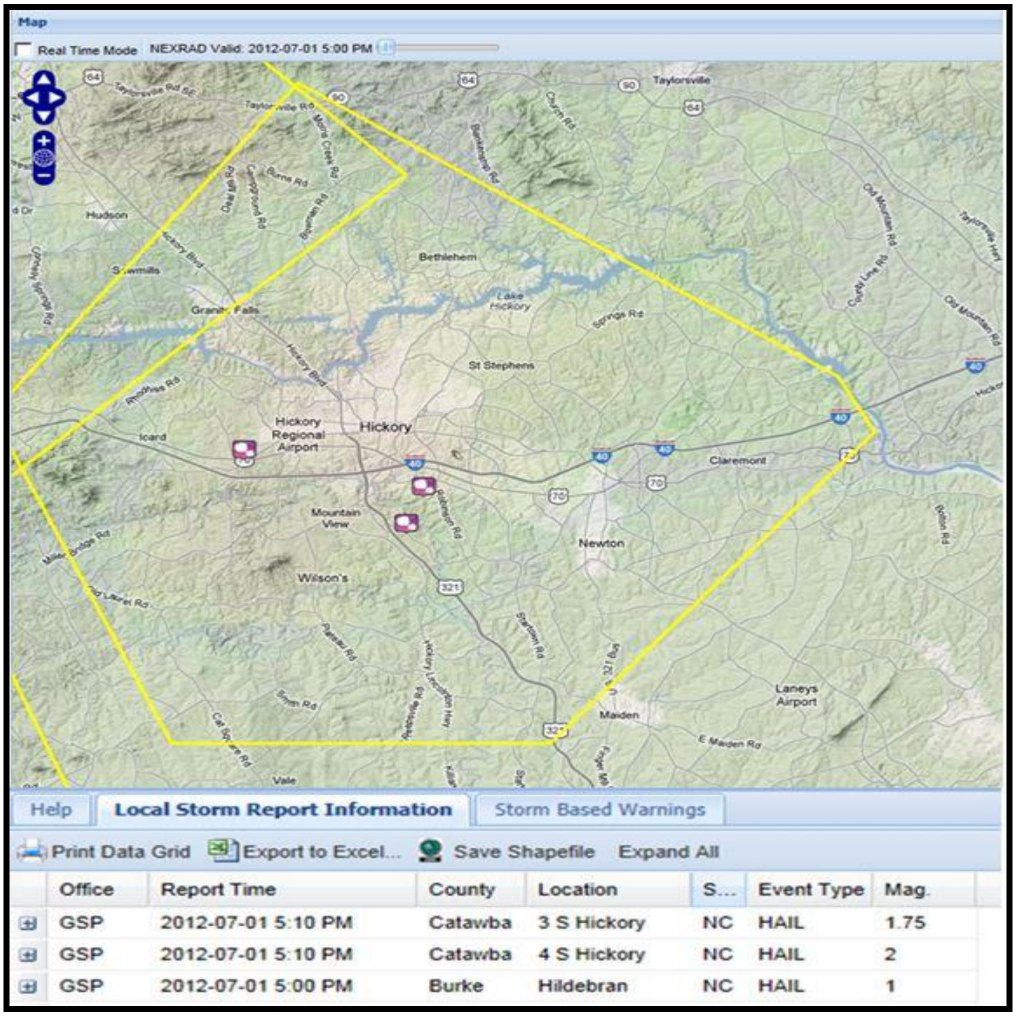


Fig. 21. GR2Analyst cross section display at 2247 UTC on 1 July 2012. Purple shades denote reflectivity values greater than 60 dBZ. Red shades represent reflectivity values between 50 and 59 dBZ south of Hickory, North Carolina.



Office	Report Time	County	Location	S...	Event Type	Mag.
GSP	2012-07-01 5:10 PM	Catawba	3 S Hickory	NC	HAIL	1.75
GSP	2012-07-01 5:10 PM	Catawba	4 S Hickory	NC	HAIL	2
GSP	2012-07-01 5:00 PM	Burke	Hildebran	NC	HAIL	1

Fig. 22. Severe Thunderstorm Warning polygon (valid from 2041 UTC to 2145 UTC; solid yellow line) and hail reports (symbols and table).

d. Damaging downburst winds near Mauldin, South Carolina

At 0124 UTC, the KCAE WSR-88D radar 3.1° base reflectivity scan detected a severe thunderstorm with a 60 dBZ core top at 27,318 ft AGL (Fig. 23D). Close examination of the radar imagery identified a small area of low reflectivity that was surrounded and capped by higher reflectivity (Fig. 23). This bounded weak eacho region (BWER) was a signature of a very strong updraft near the core of the severe thunderstorm. In addition, a downburst signature was detected at 0124 UTC on the KGSP WSR-88D 0.5° scan base velocity where an outbound velocity of 64 kts at 520 ft AGL maximum adjacent to a strong inbound velocity was sampled 7 miles south of GSP (Fig. 24). The winds associated with the downburst signature knocked down numerous trees just east of Mauldin, South Carolina (Fig. 25).

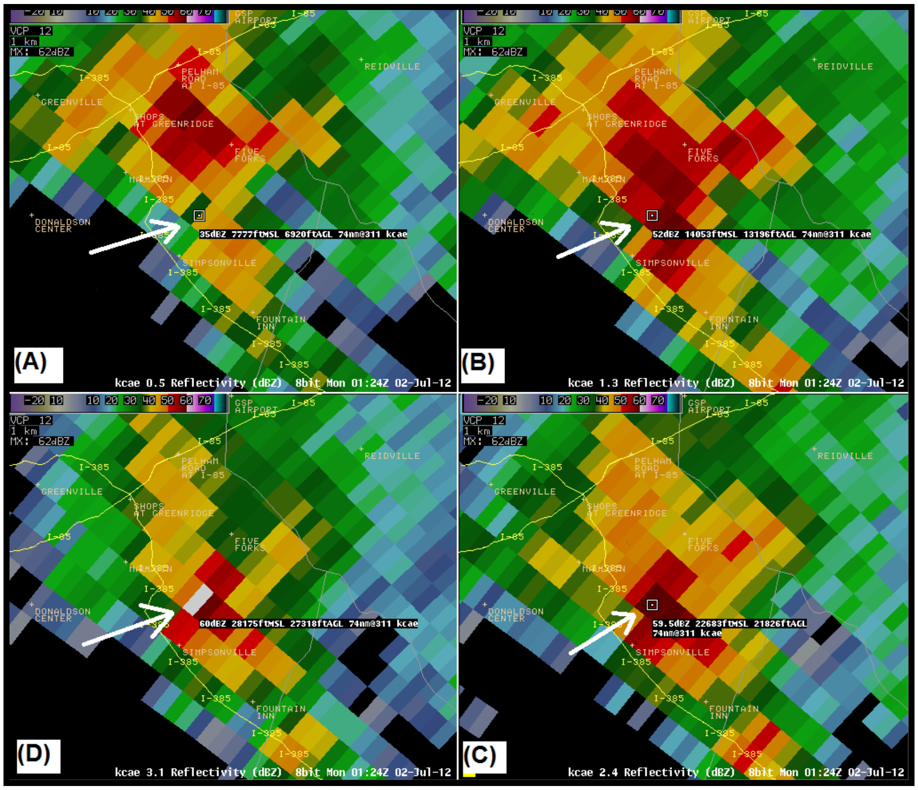


Fig. 23. KCAE WSR-88D base reflectivity scans at (A) 0.5°, (B) 1.3°, (C) 2.4°, and (D) 3.1° at 0124 UTC on 2 July 2012 near Mauldin, South Carolina.

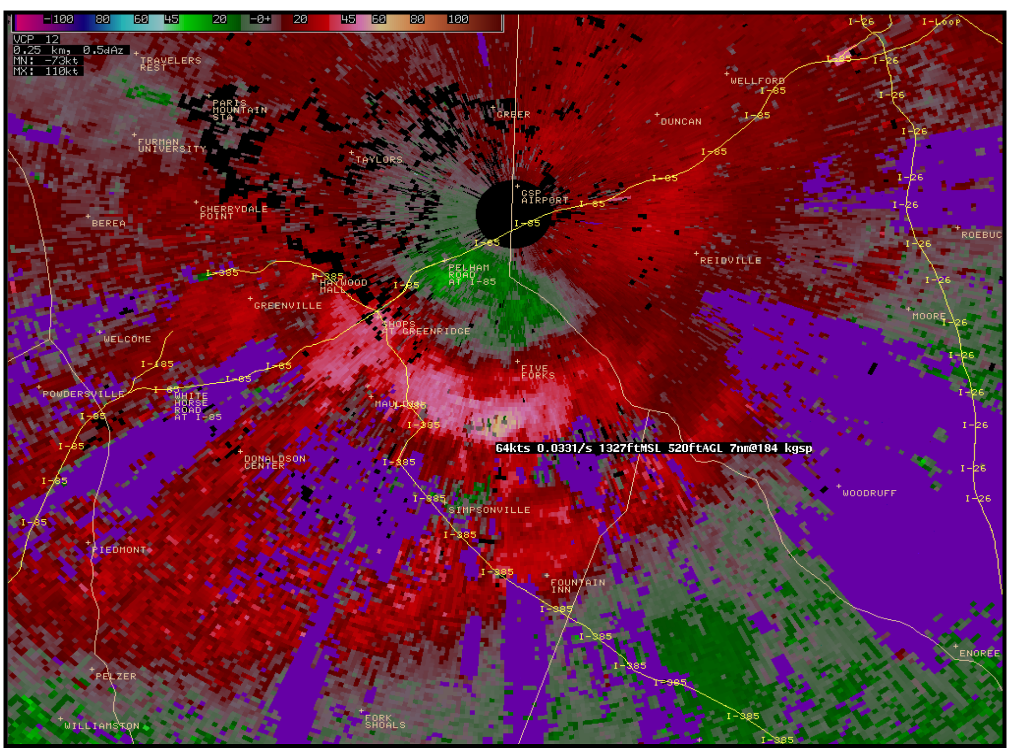


Fig. 24. KGSP WSR-88D 0.5° base velocity (kts; green, inbound; red, outbound) at 0124 UTC on 2 July 2012.

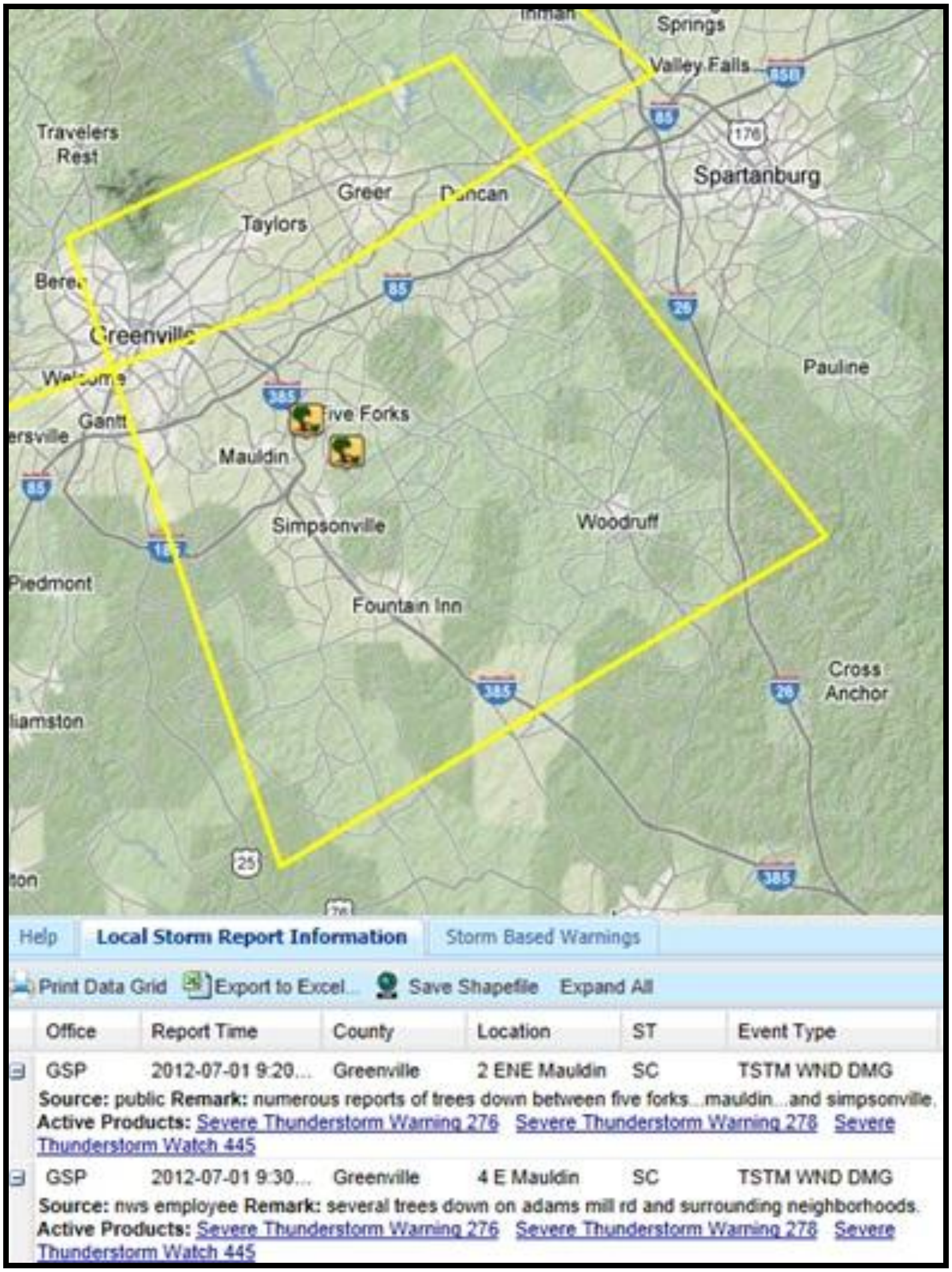


Fig. 25. Severe Thunderstorm Warning polygon (valid from 0110 UTC to 0215 UTC; solid yellow line) and wind damage reports (symbols and table).

4. Summary

A widespread severe weather outbreak occurred across the GSP CWA during the late afternoon and evening of 1 July 2012. Record-setting high surface temperatures and mid-level drying and cooling combined to create an extremely unstable atmosphere. Surface-based CAPE as high as 6000 J kg^{-1} promoted rapid updraft development and subsequent strong downburst winds and hail. In addition, strong convective outflow boundaries from the initial thunderstorms acted as catalysts to trigger ongoing development of severe thunderstorms. The widespread severe thunderstorms prompted WFO GSP to issue 49 Severe Thunderstorm Warnings and one urban Flood Advisory on 1 July. The severe weather outbreak produced 30 reports of large hail greater than one inch diameter, and 35 reports of thunderstorm wind damage across the GSP CWA (Fig. 26).

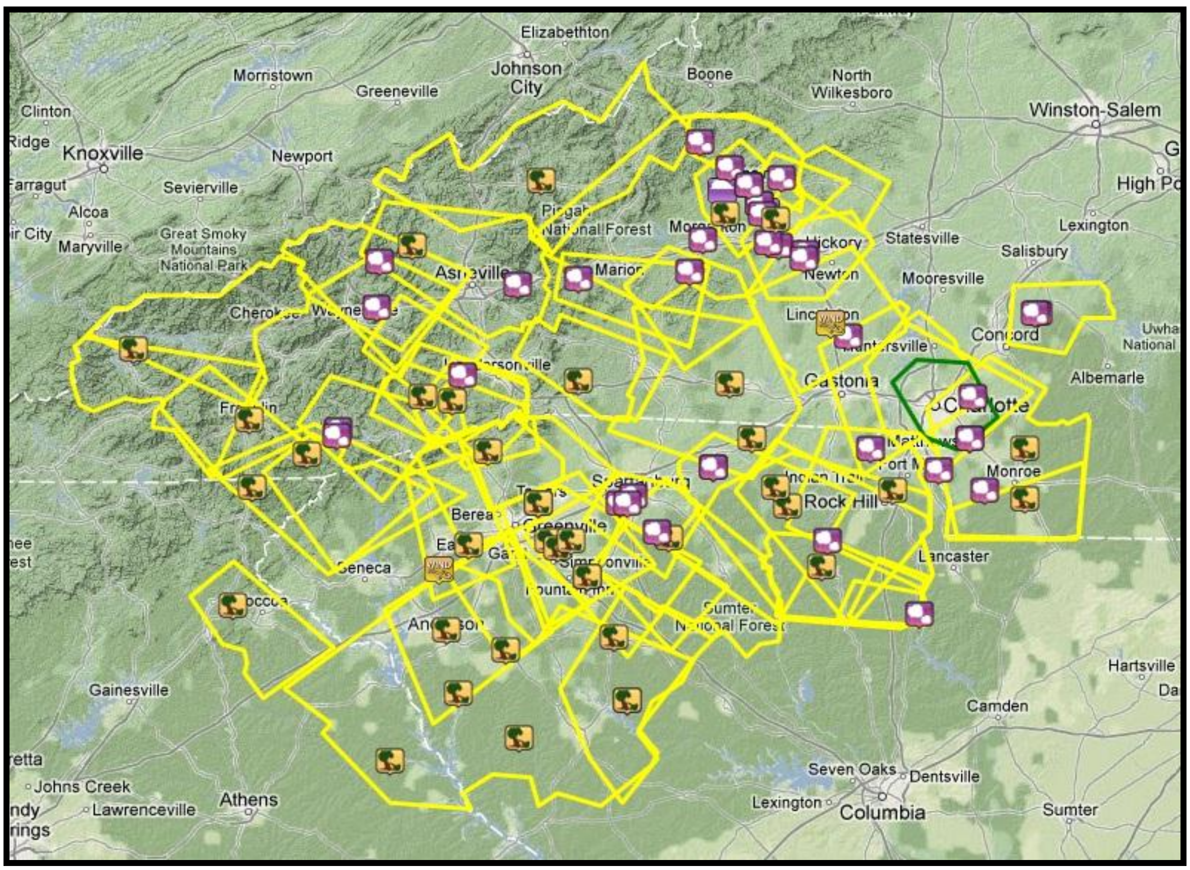


Fig. 26. Severe Thunderstorm Warning polygons (solid yellow line), Flood Advisory (solid green line), and hail and wind damage reports (symbols) on 1 July 2012.

Acknowledgements, The local storm report map and upper air analyses were obtained from the Storm Prediction Center. The surface fronts and pressure analyses were obtained from the Hydrometeorological Prediction Center. Justin Lane (NWS Greenville-Spartanburg) provided GR2Analyst radar imageries that were being used to create Fig. 16. The Severe Thunderstorm Warning polygon and storm report graphics and table were supplied by NWSChat. The cross section display (Fig. 21) was obtained from the GR2Analyst. Larry Lee, Pat Moore and Neil Dixon (NWS Greenville-Spartanburg) provided helpful comments and quality control of this document.

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