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ANTICIPATING PULSE SEVERE THUNDERSTORMS USING THE WSR-88D ALL-TILTS DISPLAY: A CASE STUDY

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Abstract

Rapidly developing severe pulse thunderstorms are common in the Southeastern United States during the summer months. Traditionally, National Weather Service warning meteorologists have used WSR-88D volume products such as Vertically Integrated Liquid (VIL), Reflectivity Cross Sections (RCS), and Layer Reflectivity Maximum (LRM) to make warning decisions for pulse severe thunderstorms. The All-Tilts display in AWIPS provides forecasters with reflectivity and velocity products as the volume scan progresses and forecasters can assess this information before the volume products are available. This paper illustrates how the WSR-88D All-Tilts Display was used to make a Severe Thunderstorm Warning decision for a pulse thunderstorm over Edgefield County, South Carolina on 25 June 2007. In this case, information in the All-Tilts display allowed the forecasters to issue a warning nearly 15 minutes before severe characteristics were noted in the volume products, such as the VIL. Had the forecasters waited until the VIL reached the "VIL of the Day" (2222 UTC) to issue the warning, lead time for this event would have been zero.

1. Introduction

Severe pulse thunderstorms are common in the Southeastern United States during the summer months. Pulse severe thunderstorms were defined by Lemon (1977) as short-lived, slow moving storms with elevated cores of high reflectivity that often develop in weak-flow environments. Traditionally, National Weather Service (NWS) warning meteorologists have used Weather Surveillance Radar-1988 Doppler (WSR-88D) volume products such as Vertically Integrated Liquid (VIL), Reflectivity Cross Sections (RCS), and Layer Reflectivity Maximum (LRM) to make warning decisions for pulse severe thunderstorms (Cerniglia and Snyder 2002). The All-Tilts display in the Advanced Weather Interactive Processing System (AWIPS) provides forecasters with reflectivity and velocity products *as the volume scan progresses* and forecasters can assess this information before the volume products are available (Earth System Research Laboratory 2004).

This paper illustrates how the WSR-88D All-Tilts Display was used to make a Severe Thunderstorm Warning (SVR) decision for a pulse thunderstorm over Edgefield County, South Carolina on 25 June 2007. In this case, if the forecasters had waited until the VIL reached or exceeded the "VIL of the day" to issue the SVR, the SVR would not have been issued until approximately 15 minutes later, which would have resulted in zero lead time.

Section 2 describes the commonly used "VIL of the day" concept, and other radar product details. Section 3 describes the event and warning decision process. Section 4 presents verification of the event, and section 5 concludes the paper.

2. Radar Products

The WSR-88D VIL product is described by NOAA (1991). Due to the large reflectivity associated with hail, VIL will be larger for storms with hail than storms without hail. However, threshold severe hail/sub-severe hail VIL thresholds may vary considerably based on the environment (Edwards and Thompson 1998). The VIL-of-the-day value as applied in this paper is based on a logistic regression equation, developed locally to predict the probability of large hail for the Columbia, South Carolina (CAE) County Warning Area (CWA) (DeLisi 1998). An AWIPS-based local computer program allows the user to input the following independent variables: the current (or expected) 500mb temp, storm echo top, and Total Totals Index. The output from the application calculates the probability of large hail for given values of VIL. Operationally, forecasters at CAE regard the value associated with 80% as the "VIL-of-the-day".

WSR-88D products are labeled by the time in which its corresponding volume scan commenced. A volume scan takes anywhere from 4 1/2-10 minutes to complete, depending on the Volume Coverage Pattern (VCP) that is utilized. In this case, the WSR-88D was in VCP-12, which takes approximately 4 ½ minutes to complete a volume scan. Therefore, volume products such as the VIL, are available approximately 4 ½ minutes after the start time of the volume scan, and the time stamp of the product itself. Reflectivity Cross Sections (RCS) take even longer to produce since they have to be manually created after a volume scan has completed. As mentioned above, the All-Tilts display in the Advanced Weather Interactive Processing System (AWIPS) provides forecasters with reflectivity and velocity products *as the volume scan progresses*.

In practice, when viewing real-time reflectivity data via the All Tilts display, one would use a single panel layout. Each frame will automatically update with the most recent data. For convenient display in this paper, however, relevant base reflectivity slices were placed in four-panel layouts.

3. Event description

A pulse severe thunderstorm developed rapidly over central Edgefield County, South Carolina during the evening of 25 June 2007 in an area of enhanced low level convergence and moderate instability. The Local Analysis and Prediction System (LAPS) sounding for Edgefield County valid at 2200 UTC indicated the air mass was moderately unstable with Convectively Available Potential Energy (CAPE) around 1200 J/kg and a Total Totals index of 49 (Fig.1). Although the freezing level was 14,600 ft, the Wet-Bulb Zero (WBZ) height was lower (10,566 ft) due to a dry layer evident in the 700mb-500mb layer (Fig. 1). This convective analysis suggested there was potential for large hail.

Table 1 shows the timeline of events for the Edgefield event. During the course of the

2200 UTC volume scan, WSR-88D all-tilts display imagery showed that a thunderstorm developing over Edgefield County was beginning to display severe characteristics in the mid level reflectivity slices (Fig.2). A three body scatter spike (TBSS) was indicated on the 4.0^o and 5.1^o slices and reflectivity values of 65 dBZ were indicated on the 5.1^o slice at an elevation of 23,110 ft AGL. This information was available to the forecasters around 2203 UTC (Table 1). The WBZ height, as indicated by the LAPS sounding was 10,556 ft (Fig. 1). Local warning guidance indicates that reflectivity values of 65 dBZ or greater above the WBZ height are likely associated with severe sized hail. Based on this information, the forecasters decided to compose a SVR, and have it ready for quick release, if additional information still warranted a SVR. At that time (2203 UTC), the most recent VIL product that was available was the 2156 UTC product which indicated a value of 35 to 40 kg/m^2 with that storm (Table 1). Earlier in the shift, the "VIL of the day" was calculated to be 57 kg/m^2.

Severe characteristics continued to be indicated during the 2205 UTC volume scan (Fig. 3). A TBSS was indicated on the 3.1, 4.0, and 5.1^o reflectivity slices, which became available around 2207 UTC (Table 1). On the 5.1^o slice, reflectivity values of 66 dBZ were indicated at a height of 23,099 ft AGL. Based on this information, the forecasters issued the SVR at 2207 UTC. At that time (2207 UTC), the most recent VIL product was the 2200 UTC product (Table 1) indicating a VIL of 40 to 45 kg/m^2 , still well below the "VIL of the Day" threshold.

During the 2209 UTC and 2213 UTC volume scans, the storm maintained a steady state. The composite reflectivity product (CR) indicated an area of 65-70dBZ still contained in the storm (not shown) and a VIL of 45 to 50 kg/m^2 (Fig. 4).

During the 2218 UTC volume scan, the radar imagery showed some further intensification of the storm with strong TBSS signatures at the 3.1 through 6.4^o reflectivity slices, and reflectivity values of 67 dBZ were indicated on the 6.4^o slice at an elevation of 29,213 ft AGL (Fig. 5). The 3.1 through 6.4^o slices became available by 2221 UTC (Table 1). The corresponding 2218 UTC VIL product, which became available around 2222 UTC, indicated the VIL increased to 70 kg/m^2 (Fig. 6). This was the first time that the VIL product indicated a value exceeding the "VIL-of-the-day", approximately 15 minutes after the SVR was issued using information from the All-Tilts display (Table 1). Reflectivity cross sections (RCS) were created after the 2218 UTC and 2222 UTC scans (Fig. 7a,b). The 2218 UTC volume scan RCS product, which was available around 2223 UTC (Table 1), showed a 65-70 dBZ core extending up to 29,000 ft and a60-65 dBZ core extending up to 38,000 ft (Fig. 7a). These are characteristics of a storm producing large hail (Cerniglia and Snyder 2002).

4. Verification

The SVR for Edgefield County, South Carolina was issued at 2207 UTC and was in effect until 2245 UTC. At approximately 2230 UTC, a phone call was placed to a National Weather Service Cooperative (Coop) Observer located 3 miles north-northeast of Edgefield, close to where the storm had been indicated by radar. The observer reported "nickel sized" (.88 in.) hail had fallen approximately 10 minutes earlier. A local storm report (LSR) was issued indicating the time of the event at 2220 UTC, resulting in a warning lead time of 13 minutes. Had the forecasters waited until the VIL reached the "VIL of the Day" (2222 UTC) to issue the SVR, lead time for this event would have been zero. The WSR-88D indicated that larger hail potentially fell later over northern Edgefield County, north of the Coop observer's location. This is a sparsely populated region and severe weather reports were not obtained from that area.

5. Conclusion

To make Severe Thunderstorm Warning decisions for pulse thunderstorms, forecasters often utilize WSR-88D volume products, such as the VIL, RCS, and LRM (Cerniglia and Snyder 2002). The All-Tilts display of reflectivity and velocity products can be used to identify severe characteristics in a thunderstorm before the volume products indicate the presence of a severe thunderstorm. In this case study, information in the All-Tilts display allowed the forecasters to issue a warning nearly 15 minutes before severe characteristics were noted in the volume products, such as the VIL. Had the forecasters waited until the VIL reached the "VIL of the Day" (2222 UTC) to issue the warning, lead time for this event would have been zero. This case study illustrates the usefulness of using the WSR-88D All-Tilts Display to interrogate thunderstorms in the warning decision process.

Acknowledgements

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References

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Time	Event
2200 UTC	2156 UTC Volume Scan is completed. 2156 UTC VIL product becomes available. 2200 UTC Volume Scan commences.
2203 UTC	2200 UTC volume scan All-Tilts imagery beginning to display severe characteristics. Forecasters began to compose a SVR
2205 UTC	2200 UTC Volume Scan is completed. 2200 UTC VIL product becomes available. 2205 UTC Volume Scan commences.
2207 UTC	2205 UTC volume scan All-Tilts imagery continued to indicate severe characteristics. Decision to issue the SVR was made, and SVR transmitted.
2222 UTC	2218 UTC volume scan VIL product indicates value exceeding "VIL-of-the-day" for the first time.

Table 1. Timeline of events for Edgefield County pulse severe thunderstorm 25 June 2007.

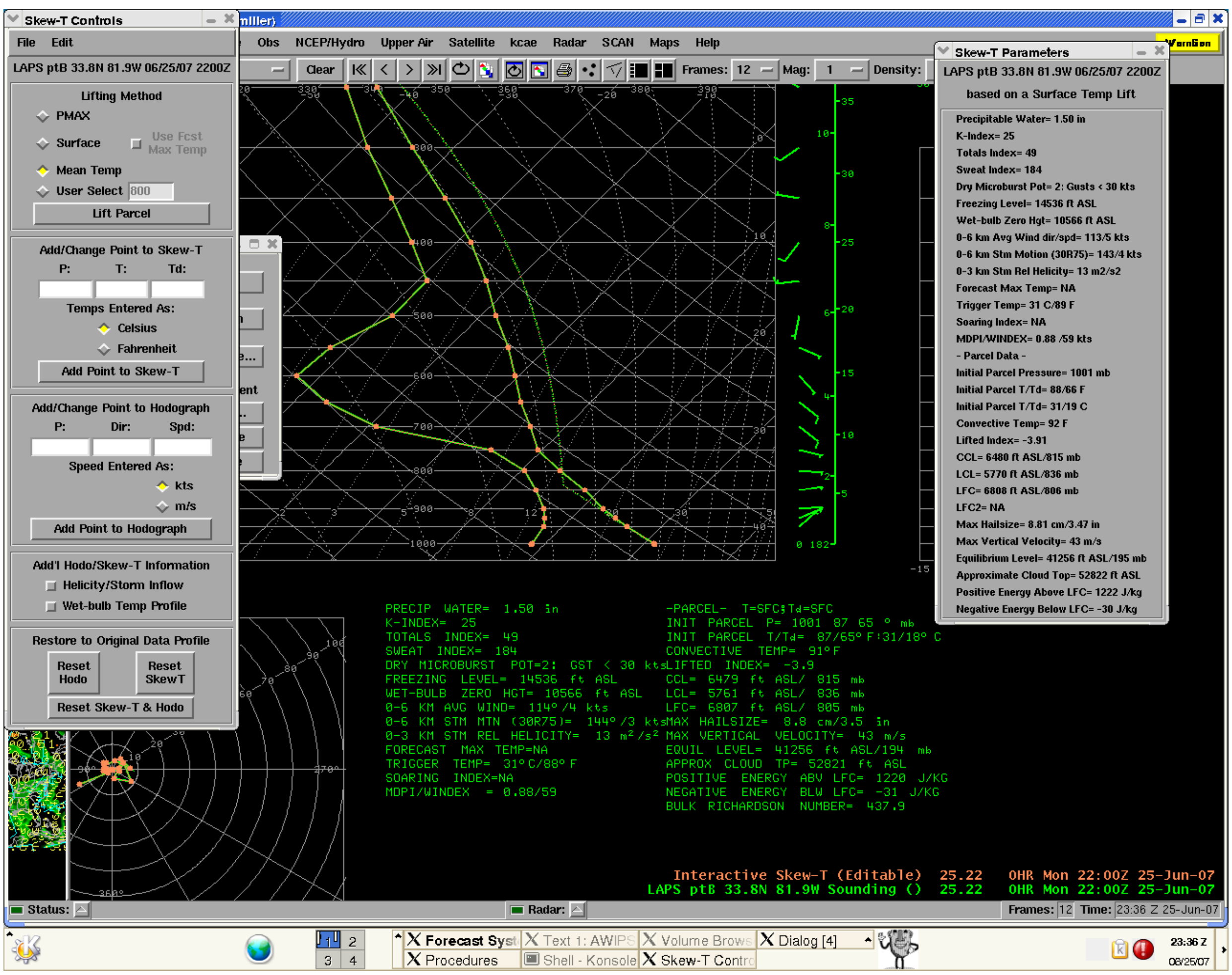

Fig. 1. LAPS sounding for Edgefield County valid at 2100 UTC 25 June 2007.

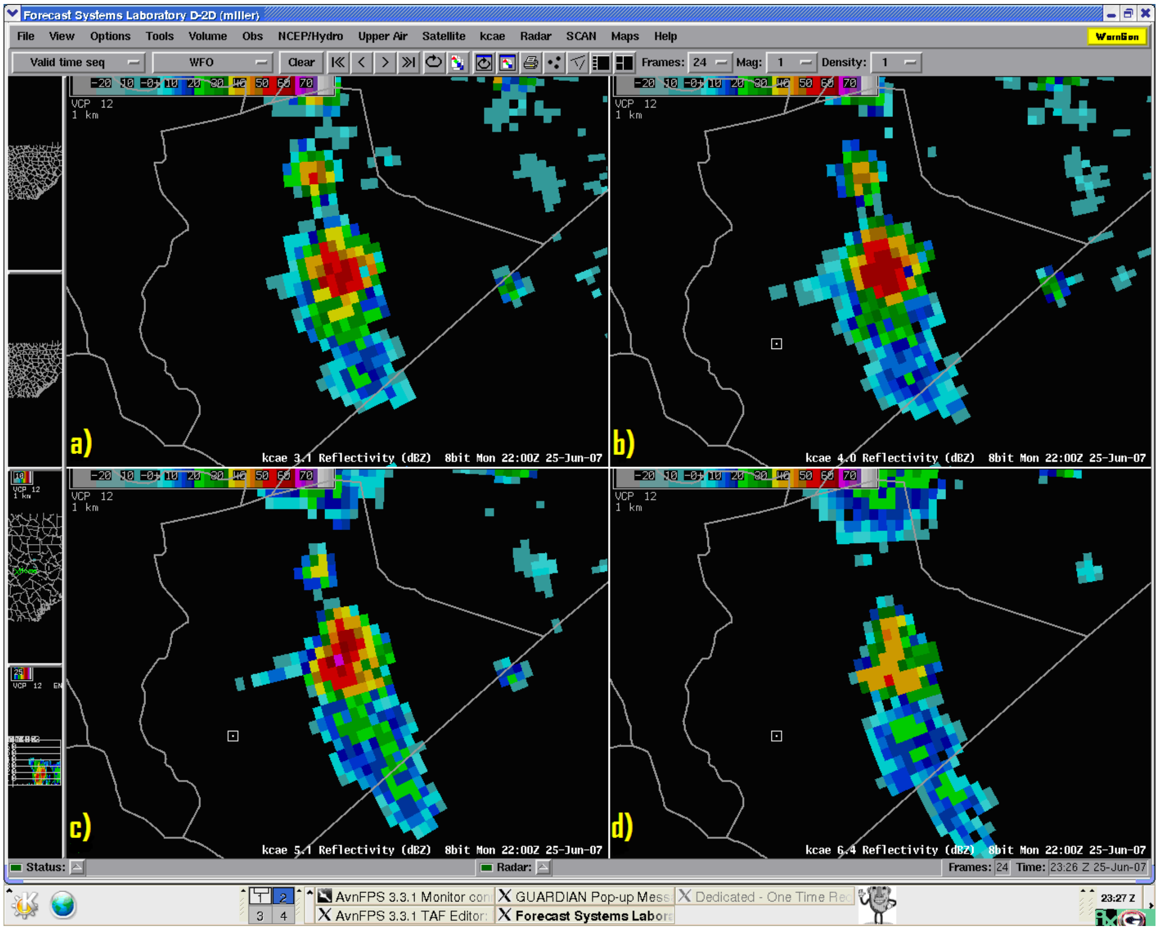

Fig. 2. Four-panel reflectivity valid at 2200 UTC 25 June 2007 for the (a) 3.1° (b) 4.0° (c) 5.1° and (d) 6.4° elevation angles.

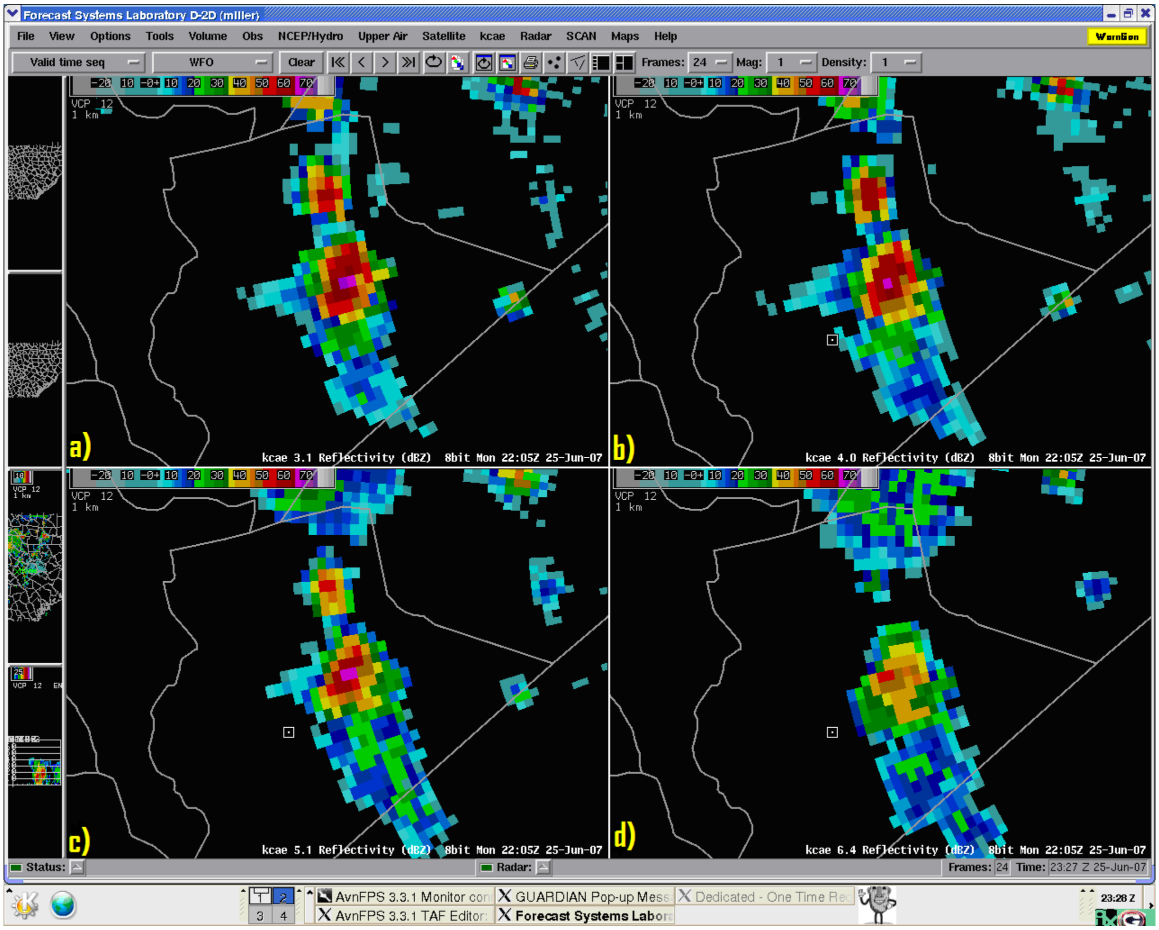

Fig. 3. Four-panel reflectivity valid at 2205 UTC 25 June 2007 for the (a) 3.1° (b) 4.0° (c) 5.1° and (d) 6.4° elevation angles.

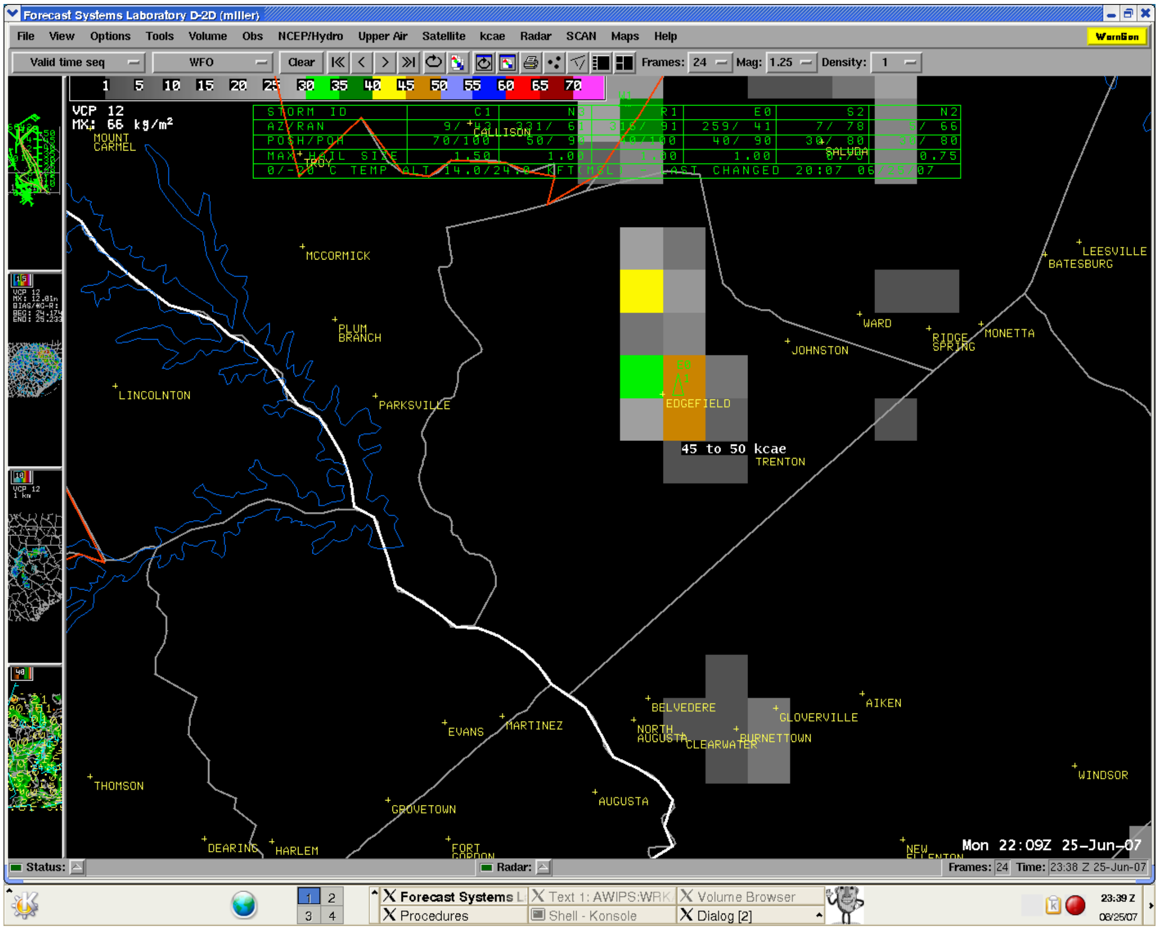

Fig. 4. VIL valid at 2209 UTC 25 June 2007.

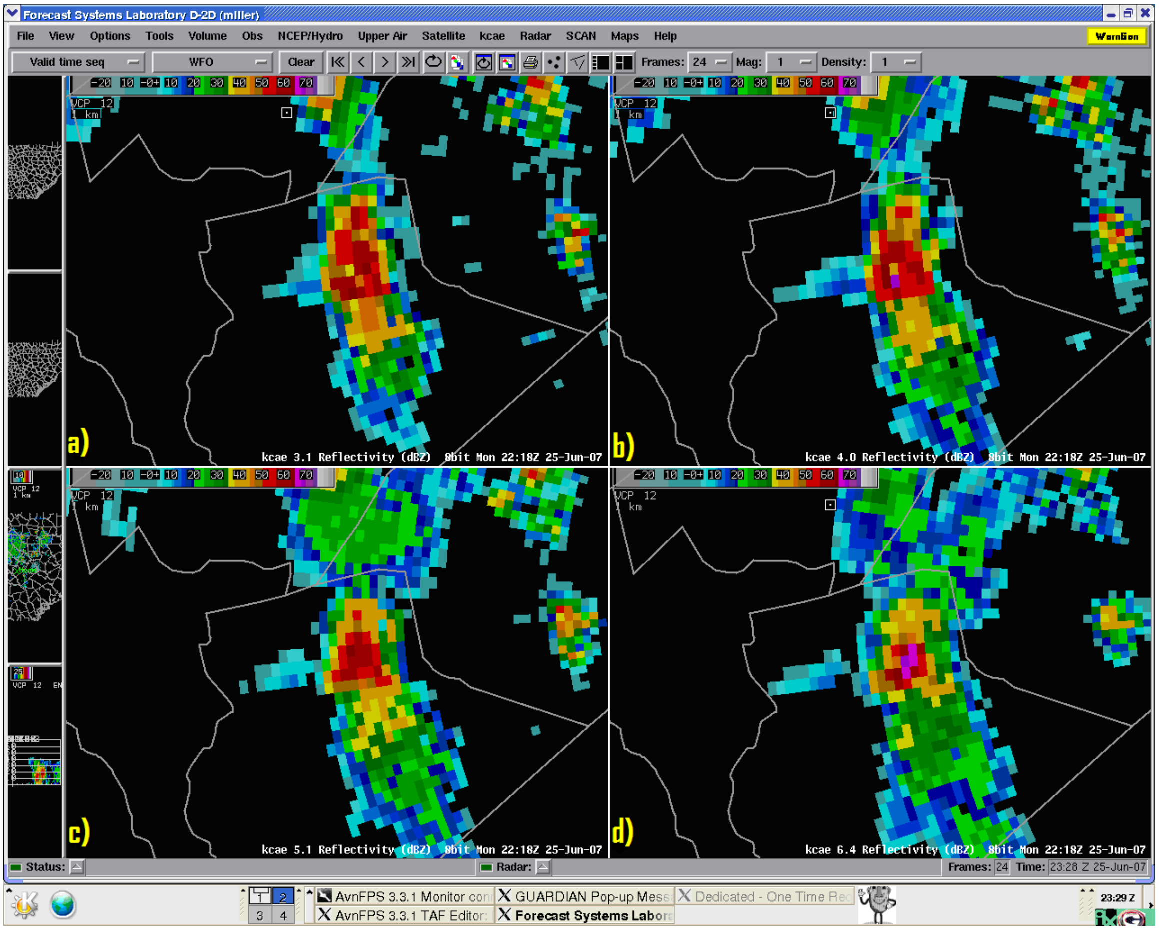

Fig. 5. Four-panel reflectivity valid at 2218 UTC 25 June 2007 for the (a) 3.1^o (b) 4.0^o (c) 5.1^o and (d) 6.4^o elevation angles.

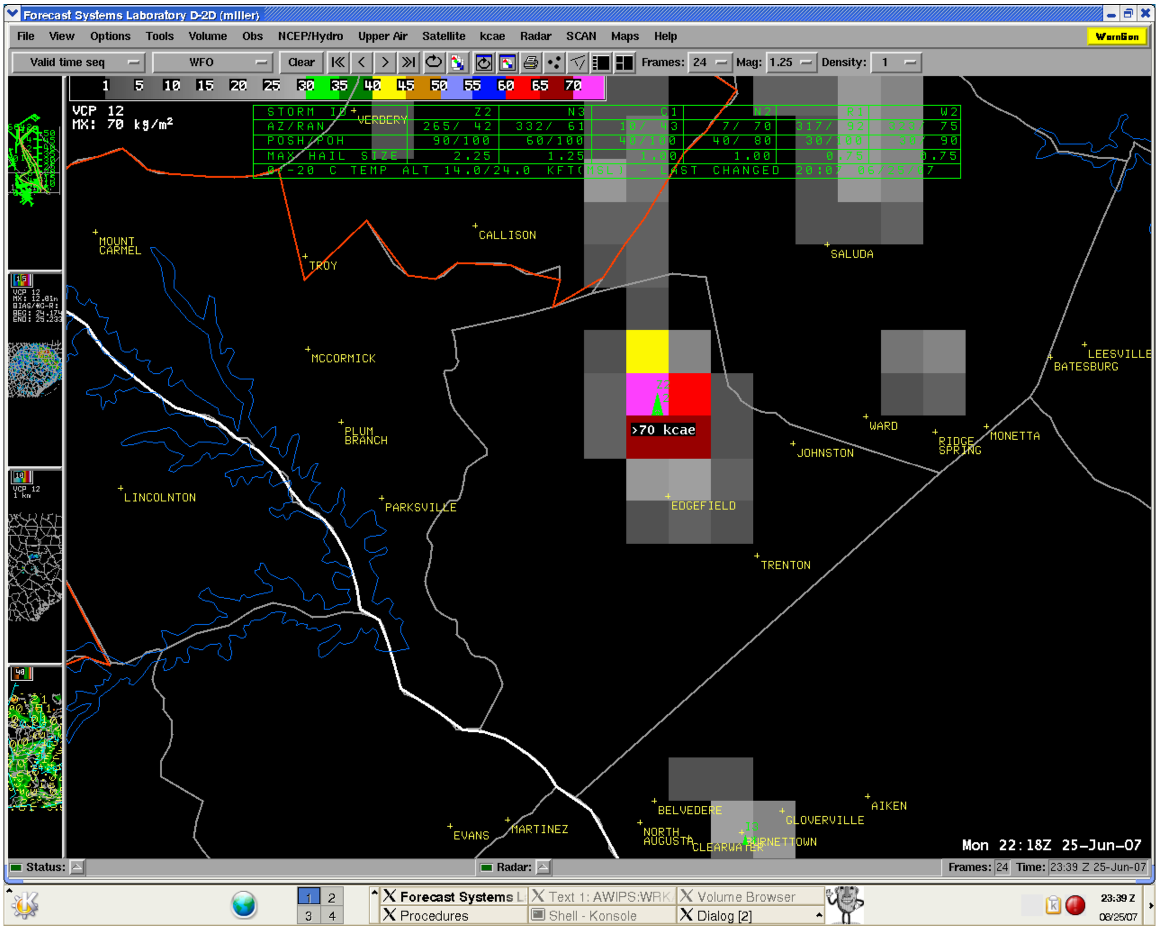

Fig. 6. VIL valid at 2218 UTC 25 June 2007.

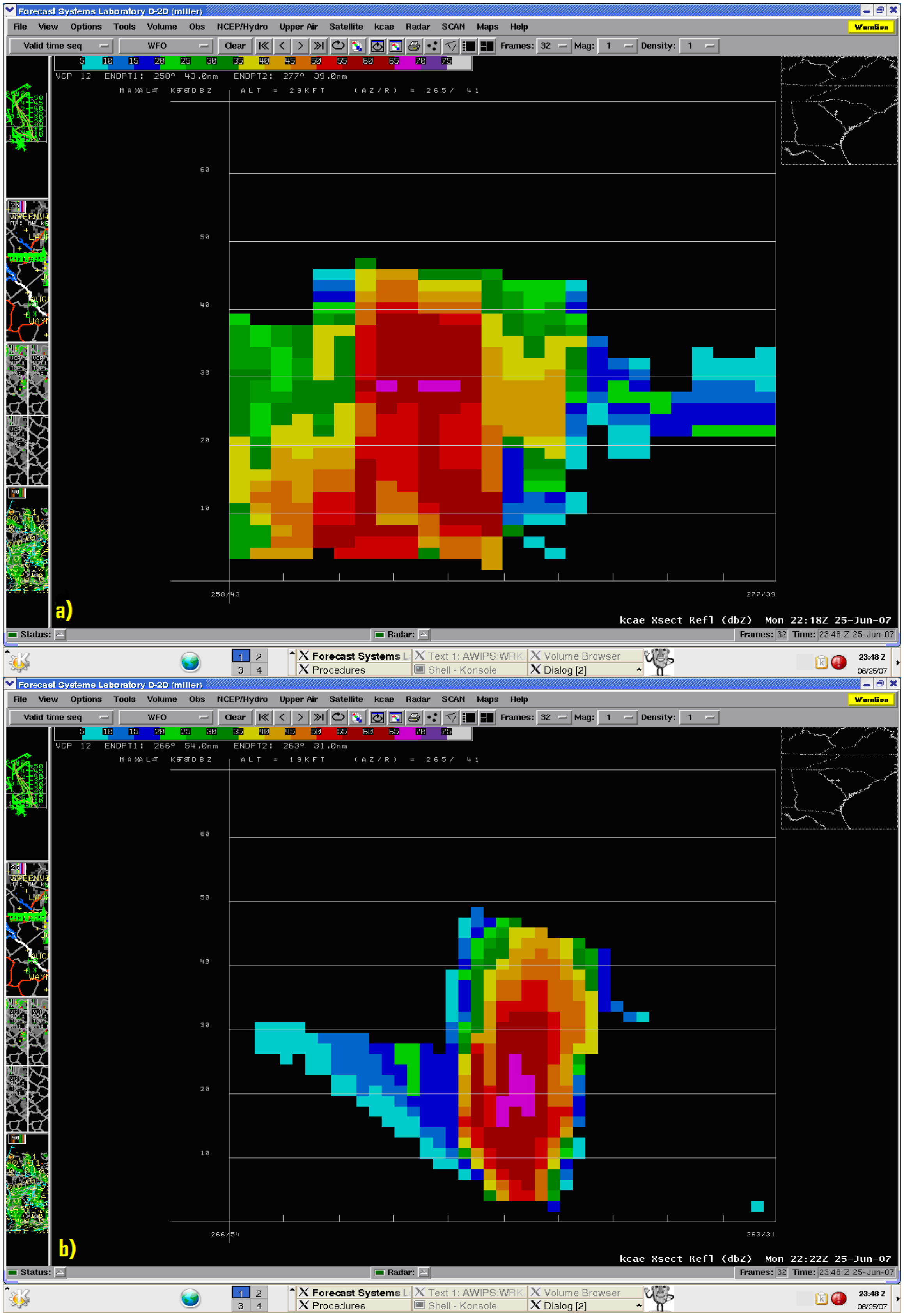

Fig. 7. RCS valid at (a) 2218 UTC 25 June 2007 and (b) 2222 UTC 25 June 2007.