

16 November Narrow Frontal Rain band Floods and severe weather

By

Richard H. Grumm
National Weather Service
State College, PA 16803

1. INTRODUCTION

southern Louisiana and a wide swath of

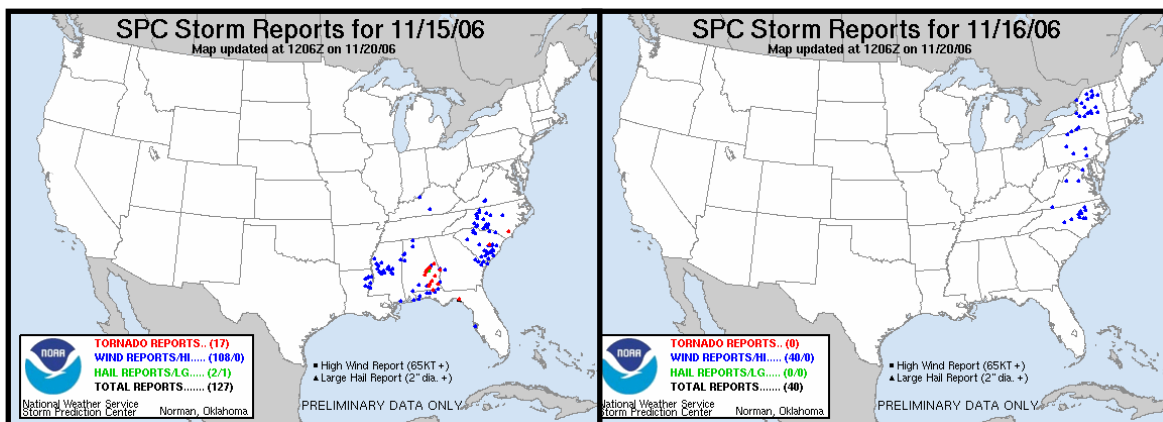


Figure 1 Storm reports for 15 and 16 November as reported by the Storm Prediction Center. Values are coded by color for the various types of severe weather.

A strong frontal system brought heavy rains and severe weather to the eastern United States on the 15th and 16th of November 2006. Ahead of the frontal system, a large swath of severe weather was reported (Fig. 1) with over 127 and 40 severe reports on the 15th and 16th respectively. The tornado outbreak in the southeastern United States included a deadly F3 tornado in North Carolina.

The rainfall over the northeast valid for the 24-hour period ending at 1200 UTC 17 November is shown in Figure 2. Though hard to see over 6 inches of rainfall was observed in some eastern Pennsylvania locations. Along the frontal zone, intense convection produced 1.5 to 5 inches of rain, mainly over eastern portions of Pennsylvania. Though not shown, heavy rains were observed in the Gulf States on the 15th. Over 8 inches of rain was observed in

2-6 inches of rain extended from Louisiana, Alabama, Georgia and into southwesternmost North Carolina.

The severe weather and rain was associated with a strong frontal system which had anomalous southerly flow along and ahead of the front. This produced strong shear and favored severe storm in the south. In addition to the strong winds, abnormally high precipitable water (PW) was observed in the warm sector. During the day, the high PW air was also the region of high CAPE. High CAPE is a relative term as CAPE values in the 200-400 JKG⁻¹ were observed in Pennsylvania, which does and did not support large updrafts but was well above the average CAPE for the year which is close to 0200-400 JKG⁻¹.

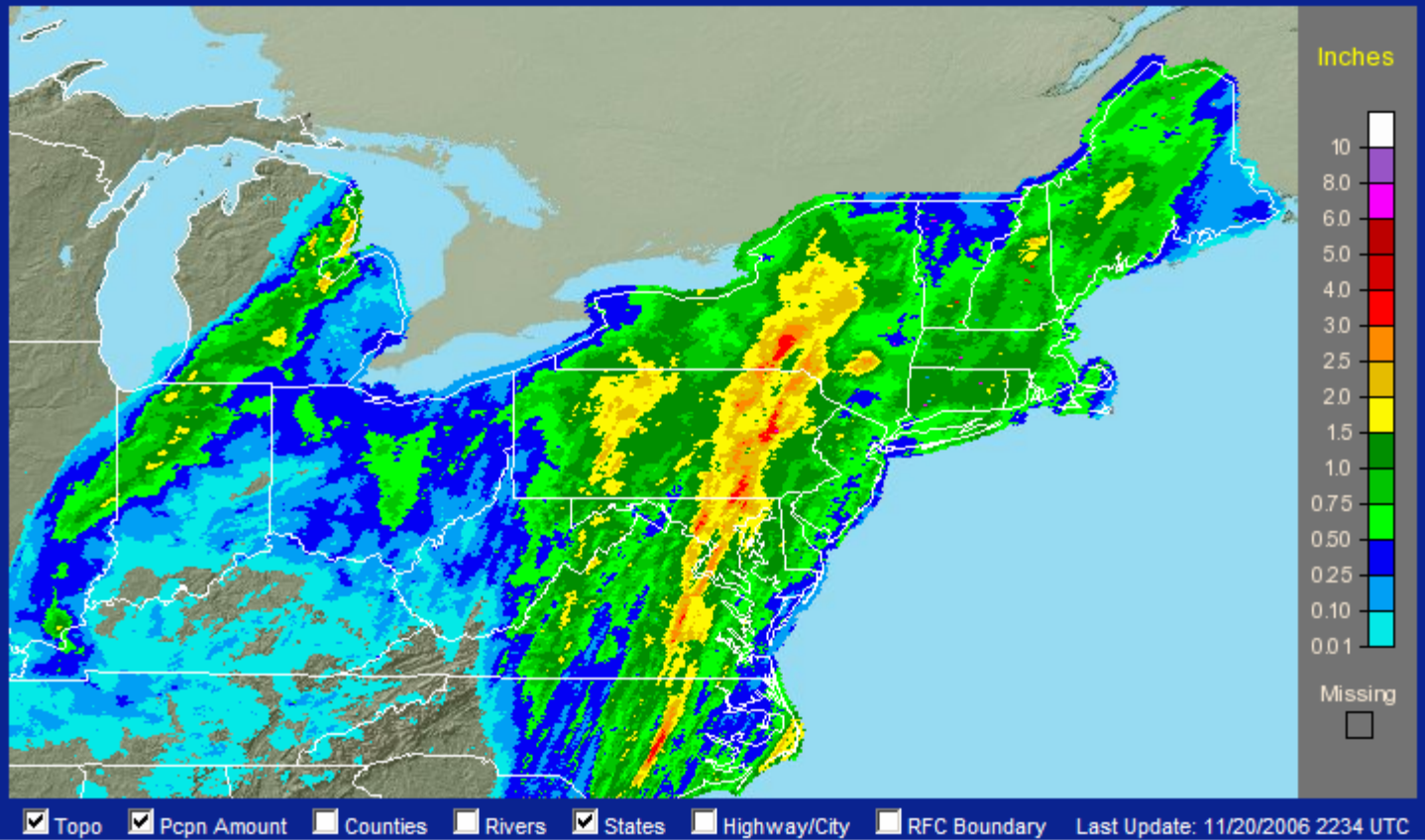


Figure 2. Analyzed precipitation from the Precipitation Analysis website. Values are color coded as shown to the right. Image is zoomed over the eastern United States.

This paper will examine the conditions associated with the frontal rainbands in the eastern United States. Normally, these would be considered narrow cold frontal rainbands, however from Pennsylvania northward, it was clear that the convection was with an occluded front and the cold front came in hours later with little or no significant weather.

2. METHODS

Severe weather reports were retrieved from the Storm Prediction Center (SPC) website. This site also includes descriptions of the severe weather. The plotted data was presented in Figure 1.

Precipitation data was retrieved from the southern Region precipitation analysis website. Wide views were provided

though the site allows for the examination of State Scales to see the local maximums. These data were shown in Figure 2.

Model and ensemble prediction system (EPS) data were taken from the real-time data archive the National Weather Service office website in State College.

3. RESULTS

Figure 2 shows the GEFS plume diagram of accumulated precipitation, by type, and the 6-hourly accumulated rainfall. This forecast shows the high probability of rain; and a period of intense rain; on the 16th with a very high probability of rain centered on 1800 UTC. The short duration of the rain and the chance of light snow behind the front

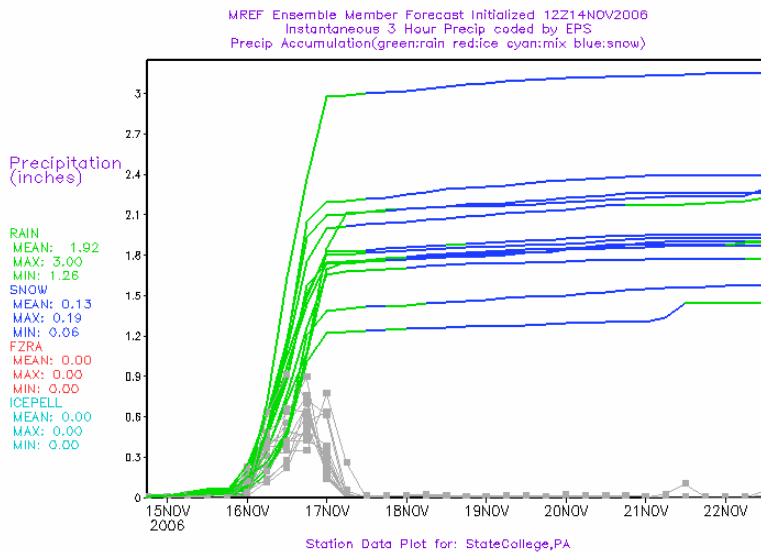


Figure 3. GEFS plume diagram initialized from forecast at 1200 UTC 14 November 2006. Color code lines show accumulated precipitation by type for each ensemble member. Gray lines show each member 6-hour instantaneous precipitation (inches).

illustrate the strength cold air behind the front. This point will be reinforced with shorter range forecasts, but a salient point will be the highly predictable nature of this event.

Figures 4 & 5 show GEFS forecast initialized at 0000 UTC 14 November 2006. These data show the strong north-south frontal boundary forecast to move across Pennsylvania. At 850 hPa, the isotherms show above normal 850 hPa temperatures in the warm air ahead of the front and below normal temperatures in the northern Gulf States. The PW field shows the surge of above normal to much above normal PW into the Mid-Atlantic region and New York. This overall signature shares many of the characteristics of the Maddox Synoptic type heavy rain event.

In addition to the front, with the anomalous PW values, a strong 850 hPa jet was present in the warm sector. Winds were forecast to be in excess of 60KTS with anomalies on the order of +4SD above normal in the low-level jet. Previous work has shown the close

association of strong low-level winds and severe weather, and the combination of anomalous southerlies with anomalous PW values with Maddox Synoptic type heavy rain fall events.

Figure 6 shows the 850 hPa winds and PW valid at 1800 UTC 16 November from forecasts initialized at 1200 UTC 15 November 2006. The forecasts were consistent with the forecast from 14 November.

Though not shown, this was true of all GEFS forecasts from around 1800 UTC 13 November through 1200 UTC 16 November 2006 (not shown). The overall character of the event was well forecast by the GEFS.

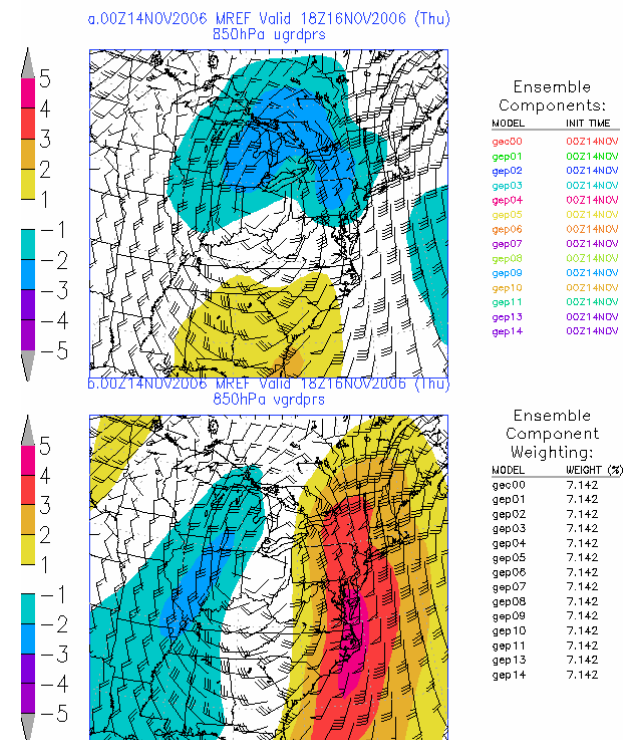


Figure 5. As in Figure 4 except 850 hPa winds (KTS) showing a) U-wind anomalies and b) V-wind anomalies in standard deviations from normal.

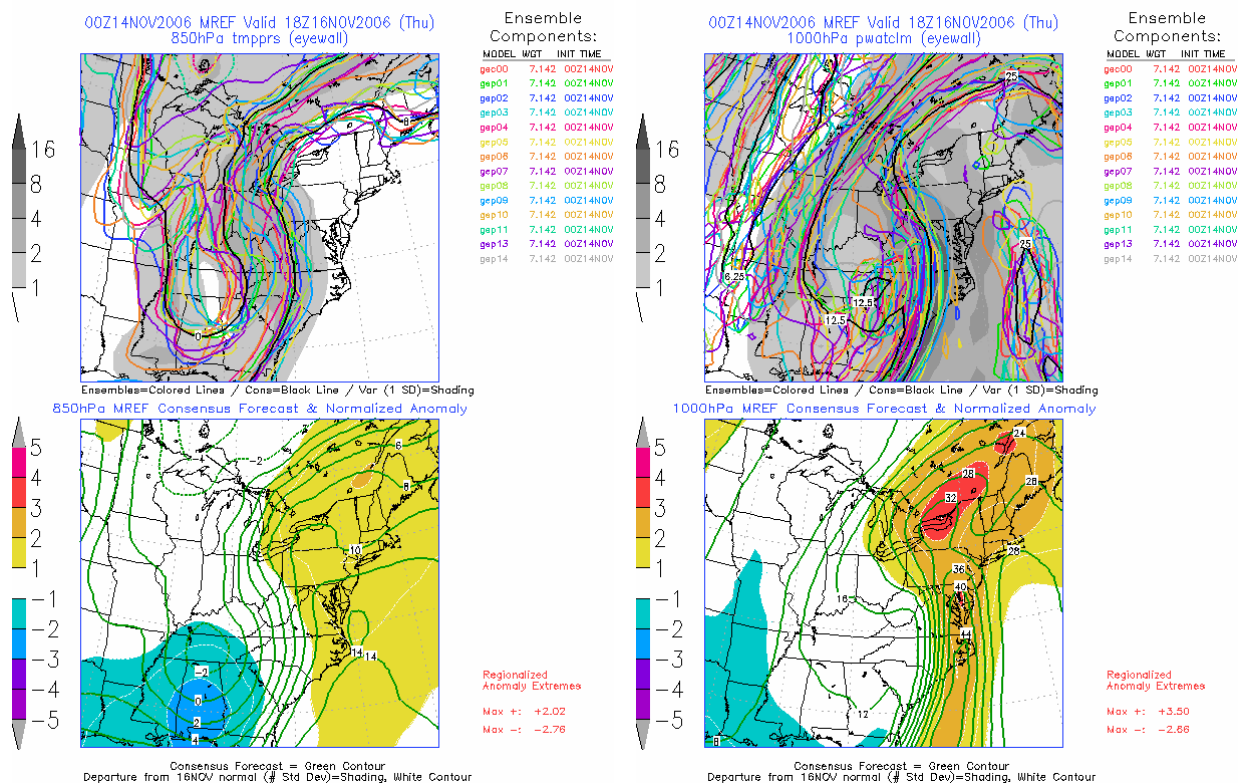


Figure 4 GEFS forecasts initialized at 0000 UTC 14 November valid at 1800 UTC 16 November 2006 showing (left) 850 hPa temperatures (C) a) each members 8,0, and -8C contour, the mean of each contour (Black) and the dispersion about the mean and b) the ensemble mean and the departure from normal in standard deviations from normal; (right) PW (mm) with a) each members 12.5 and 25 mm contour and the mean of each over the spread and b) the ensemble mean and the departure from normal in standard deviations from normal.

It is interesting to note the increased values of the PW and the increase in the anomalies. As the forecast range decreased and agreement among members converged, the overall values of the ensemble mean and the anomalies increased markedly in the PW fields (Fig. 4 relative to Fig 6).

Short-range forecasts from the SREF were similar to those provided by the GEFS and are not shown. The plume diagram of 2m temperatures from 1200 and 1500 UTC 15 November from the GEFS and SREF respectively are shown in Figure 7 to illustrate this point. Both EPS's forecast warm conditions ahead of the front then a rapid cool down as the frontal system passed through the region. Though not shown, precipitation plumes

also showed a period of heavy rain ahead of the front, similar to that shown in Figure 3. The steeper cooling curve in the GEFS is at least in part due to the 6-hour verse 3-hour resolution of the data.

Though not shown, the GEFS forecast a high probability of 1 inch of rain over most of central Pennsylvania with a north-south axis, aligned with the front between 1200 UTC 16 November and 0000 UTC 17 November 2006 (not shown). This was reflected in the GEFS (MREF) QPF forecasts shown in Figure 8 which show the 24-hour accumulated precipitation and POPS for 1 inch or more QPF. For comparison purposed, the 1500 UTC 15 November 2006 SREF forecasts are shown in the right side.

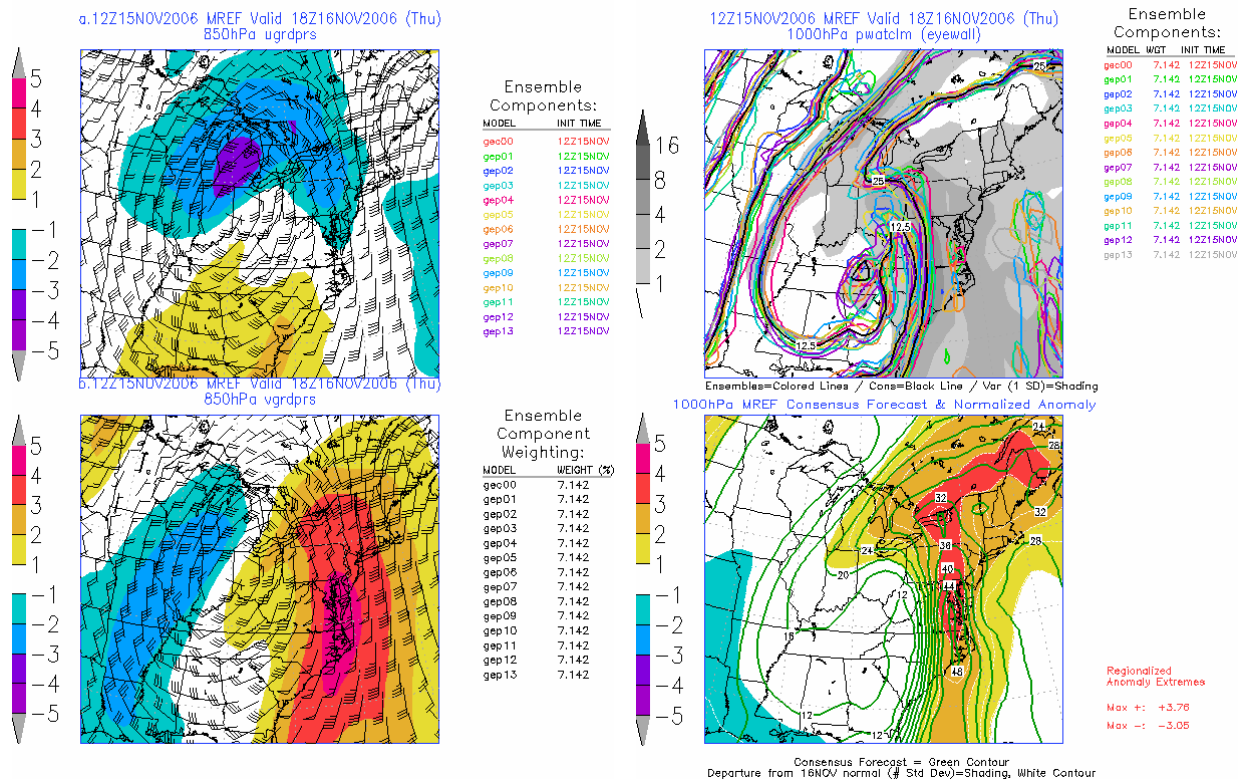


Figure 6 GEFS forecasts initialized at 1200 UTC 15 November valid at 1800 UTC 16 November 2006 showing (left) 850 hPa winds (KTS) and a) U-wind anomalies and b) V-wind anomalies; and (right) PW (mm) with a) each members 12.5 and 25 mm contour and the mean of each over the spread and b) the ensemble mean and the departure from normal in standard deviations from normal.

These data were used in real-time¹ to forecast the rainfall and flood potential for the 16th. Based on what was observed, the GEFS out performed the SREF system with the QPF. The similar character in the mass, thermal and moisture fields made it unclear why the SREF had so much QPF to the west and why it was so slow to bring the rain eastward.

The NAM is used to show condition over the Mid-Atlantic region at 1800 UTC 16 November and 0000 UTC 16 November 2006. The 850 hPa winds and PW fields from the 00-hour NAM initialized at 1800 UTC 16 November 2006 are shown in Figure 9. These data

¹ The author worked the event and used the GEFS as the basis of the more eastward rainfall based on the large scale features in each model and biased based the QPF on the GEFS. Though 0900 UTC SREF was used at that time.

show the anomalous low-level (850 hPa) jet as forecast by the GEFS, though a bit more intense than forecast. Southerly wind anomalies approached 5SDs above normal over the Delmarva. Strong easterly winds were present over New York State. The PW field shows the surge of high PW into the region with near 48 mm of PW in the Mid-Atlantic region with anomalies on the order of 3-4SDs above normal. Subjectively, a good GEFS forecast.

The NAM 00-hour forecasts valid at 0000 UTC 16 November 2006 are shown in Figure 10. These data show the strong jet to the south where the severe weather event of the 15th was near its peak. The strong southerly jet was over Alabama and Georgia. Though not shown, most of the severe weather in North Carolina was observed early on the 16th. In fact the F3 tornado occurred

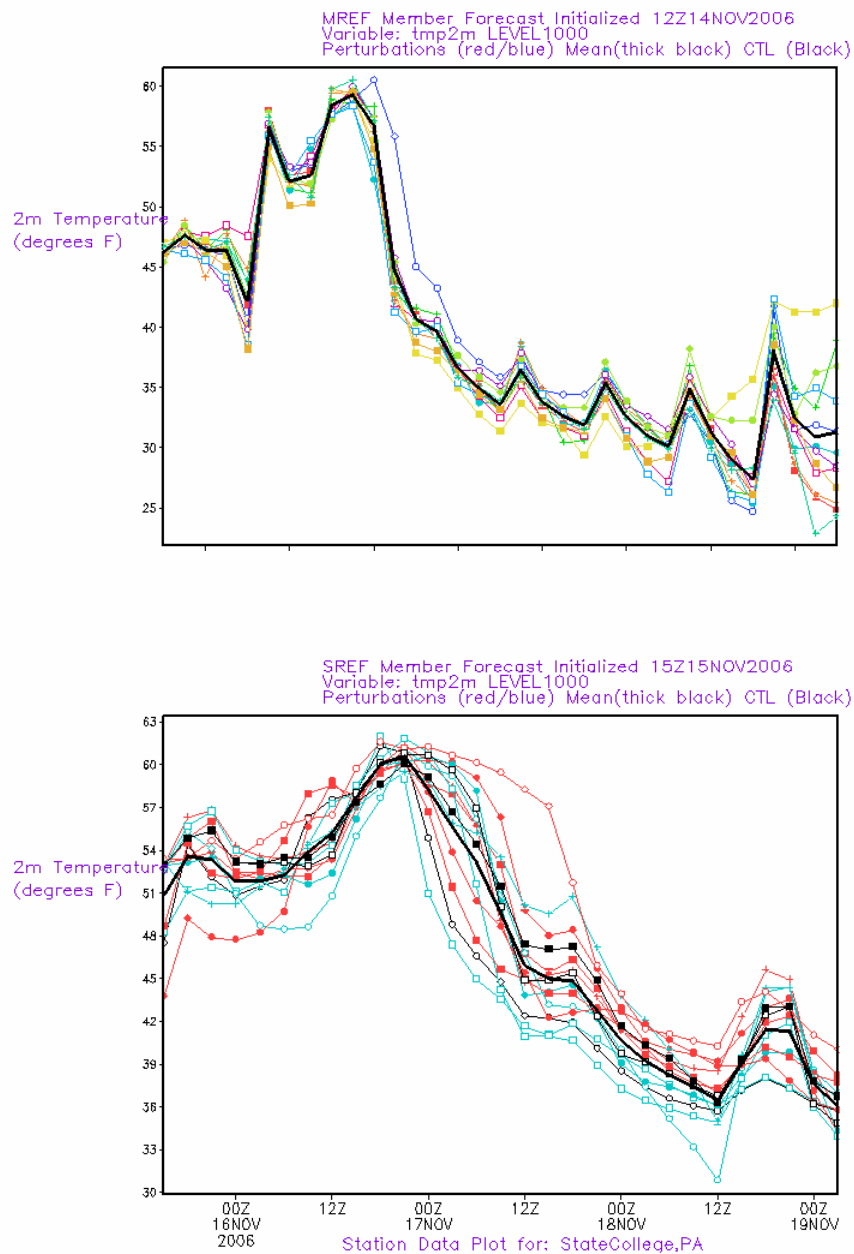
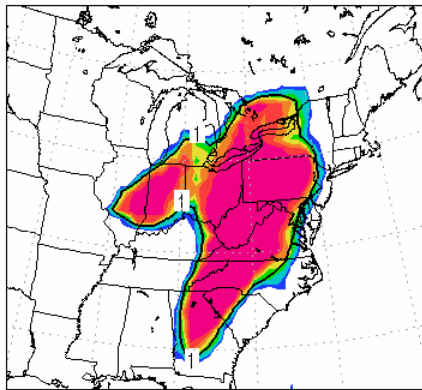


Figure 7 Plumes of 2m temperature for a point near State College, Pennsylvania. The upper panels shows the GEFS forecasts initialized at 1200 UTC and the lower panel shows the 1500 UTC SREF forecasts. Thick black lines in each figure are the ensemble mean value. Colored lines show each members forecast.

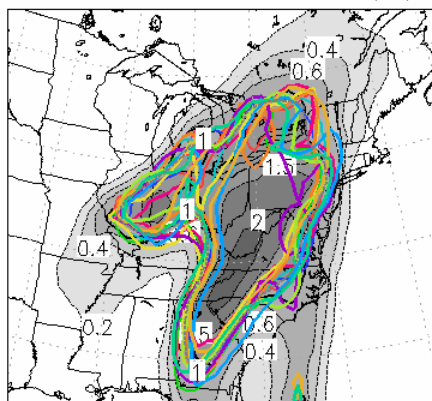
shortly before 1200 UTC so it was recorded as an event for the 15th. But the strong jet that moved northward from Alabama on late afternoon of the 15th moved into the Carolinas between 0600 and 1200 UTC on the 16th. The intense jet at 1200 UTC is shown in Figure 11. Along with the high PW and thus

relatively high CAPE, this anomalously strong jet produced the shear and instability associated with that tragic event. Note that the V-wind anomalies were over +5SDs above normal in North Carolina at 1200 UTC 16 November as analyzed by the NAM.

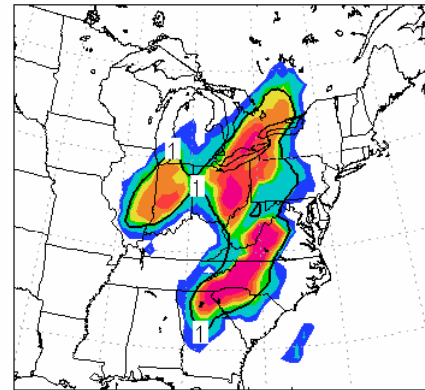
a. 12Z15NOV2006 MREF Prob of 1.00 apcpsfc in 24-hr
Valid 00Z16NOV2006 to 00Z17NOV2006 Fri



b. 24-hr 1.00 apcpsfc MREF (RED) and MREF (Blue)
Valid 00Z16NOV2006 to 00Z17NOV2006(ens)



15Z15NOV2006 SREFETA Prob of 1.00 apcpsfc in 24-hr
Valid 00Z16NOV2006 to 00Z17NOV2006 Fri



24-hr 1.00 apcpsfc SREFETA (RED) and SREFRSM (Blue)
Valid 00Z16NOV2006 to 00Z17NOV2006

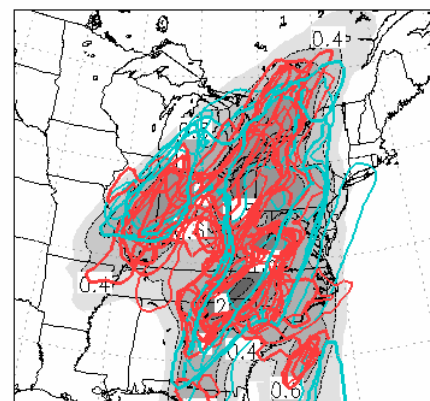


Figure 8 GEFS and SREF forecast of 1.00 inches of QPF from forecasts initialized at 1200 and 1500 UTC 15 November 2006 valid for the 24 hour period ending at 0000 UTC 17 November 2006. The left side show GEFS forecasts and the right side shows the SREF. In each side a) shows the probability (shaded) of 1.00 or more QPF in 24-hours and the ensemble mean (black) and b) the ensemble mean QPF and each member 1.00 inch.

Figure 12 shows the radar reflectivity valid at 1829 UTC 16 November 2006 over central Pennsylvania. The narrow frontal rainband produced the heavy rains during the afternoon hours. In many areas over 70% of the total rainfall was associated with this rainband. This band also produced wind damage, along with flooding. Despite the wind damage little lightning was observed long the band.

4. CONCLUSIONS

A strong frontal system brought heavy rain and some high winds to the Mid-Atlantic region on 16 November 2006.

The strong frontal system was well forecast by the NCEP GEFS and the SREF. The GEFS QPF forecasts appeared to be superior to those produced by the SREF in this case.

The strong frontal system had anomalously warm air ahead of the cold front. In addition to the warm air, there were anomalous PW values and low-level southerly winds. The PW anomalies and southerly wind anomalies often accompany Maddox Synoptic heavy rain events. With intense winds narrow (cold) frontal rain bands often develop and focus the period of heavy rain. This case was not a classic narrow

cold frontal rain band example as the cold front lagged the band by over 6 hours. The rain appeared to be associated with the PW gradient and possibly a weak occlusion, though a rigorous analysis has not been accomplished to conclusively state that an occluded front moved through the region.

Though not shown, a wide frontal rain band developed behind the main system and contributed to the overall rainfall. Though heavy rain, with 1 to 3 inches of rainfall were observed during the event in central Pennsylvania and New York. In the State College area 1-2 inches fell in the early afternoon hours with about 80% of the rain falling in about 30 minutes. The intense heavy rain produced rapid flooding in urban areas. This pattern was repeated as the intense band moved eastward. The maximum rainfall in Pennsylvania was observed in Luzerne County where a report of 4.45 inches was recorded. That county was particularly hard hit by flooding. Current NWP models and EPS's do not depict the short duration heavy rain often observed in these events.

The anomalous 850 hPa winds were responsible for the widespread reports of wind damage in Pennsylvania and New York. The intense and anomalous low-level jet, at +5SDs above normal at 1200 UTC 850 hPa was in close proximity to the deadly tornado in North Carolina shortly before 1200 UTC on 16 November 2006. *The value in anomalous 850 hPa V-wind anomalies in forecasting and refining high threats of severe weather continues to be validated by repeated cases over the past 7 years of observations.*

The EPS QPFs *demonstrate the value and skill of the GEFS at short-range forecasting.* Comparison of SREF and GEFS forecasts continues to show that the low resolution GEFS is comparable in skill to the SREF. *The value of 3-hour GEFS data in the 0-60 hour forecast period could help improve forecasts of a wide range of problems to include QPFs.*

5. Acknowledgements

Ron Holmes (ITO) State College for radar, rainfall, and storm damage imagery and summaries of the event.

6. References

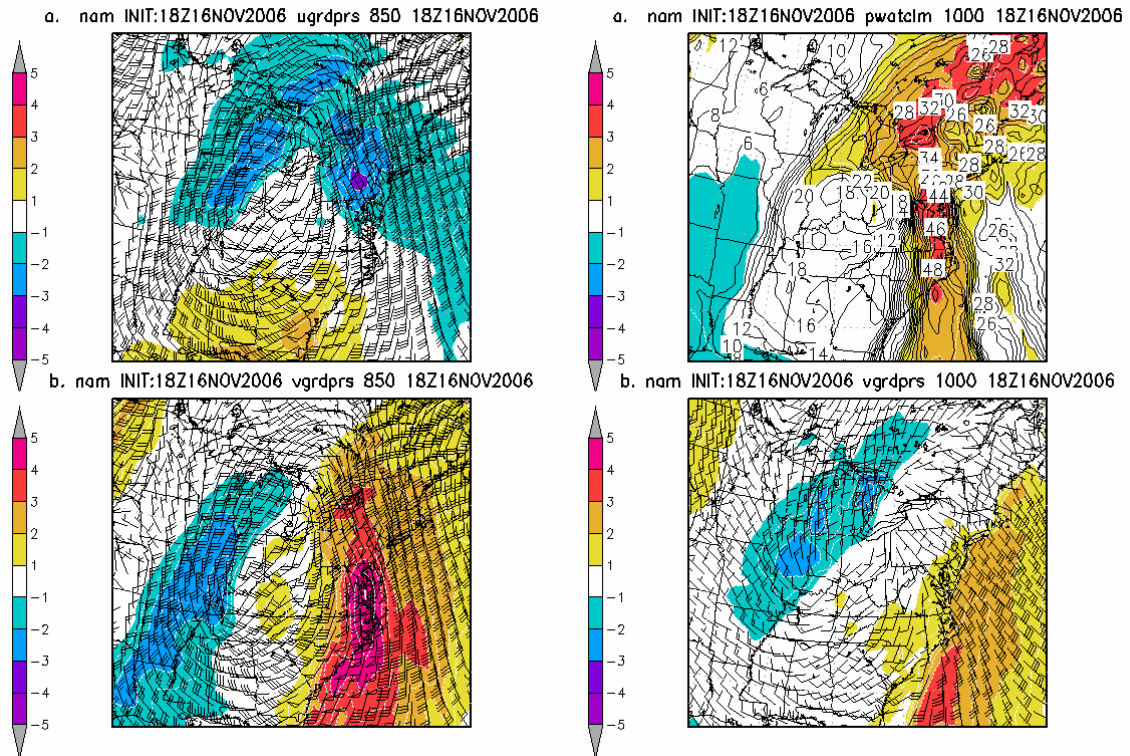


Figure 9 NAM 00-hour forecast initialized at 1800 UTC 16 November showing (left) 850 hPa winds and a) U-wind anomalies and b) 850 hPa winds and V-wind anomalies; and (right) a) PW and anomalies and 1000 hPa winds and V-wind anomalies.

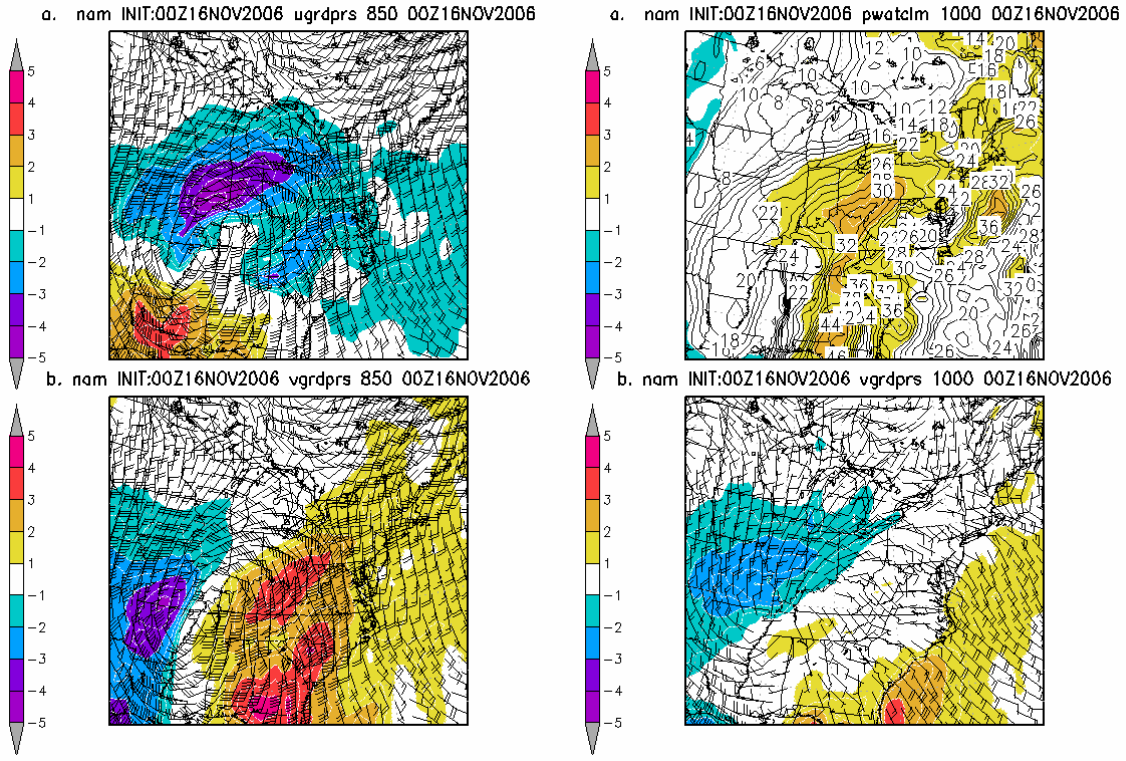
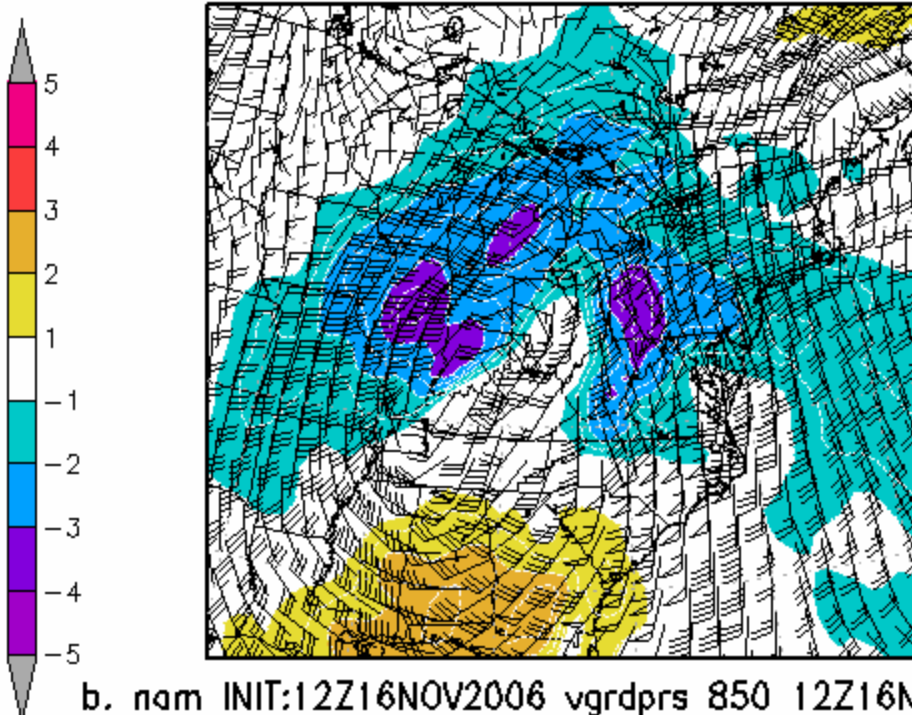


Figure 10 As in Figure 9 except NAM 00-hour forecast valid at 0000 UTC 16 November 2006.

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b. nam INIT:12Z16NOV2006 vgrdprs 850 12Z16NOV2006

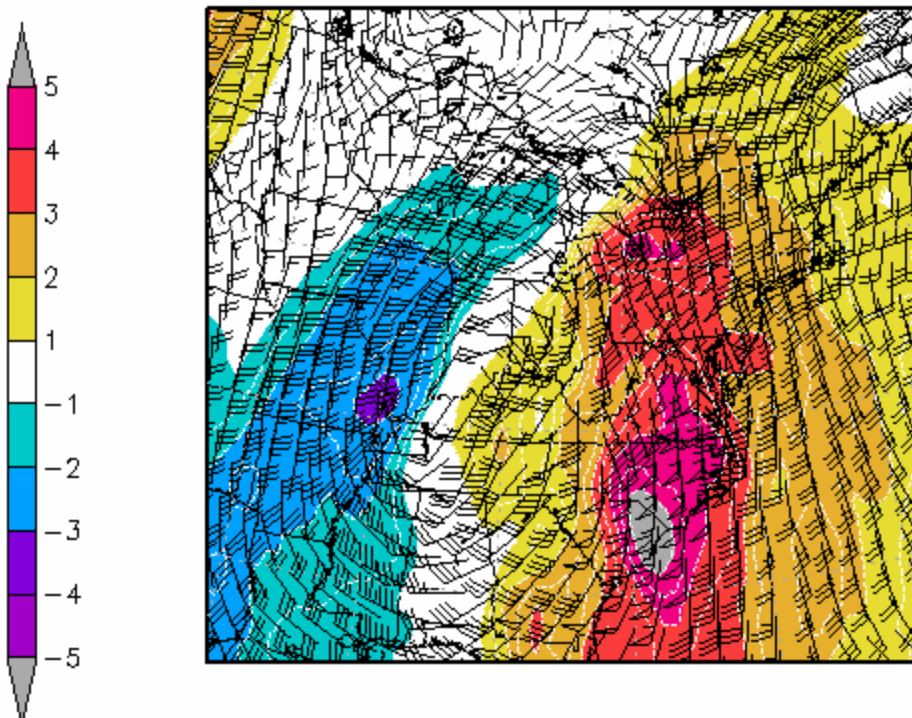


Figure 11 NAM 00-hour forecasts of 850 hPa winds at 1200 UTC 16 November 2006 showing a) 850 hPa winds and U-wind anomalies and b) 850 hPa winds and V-wind anomalies.

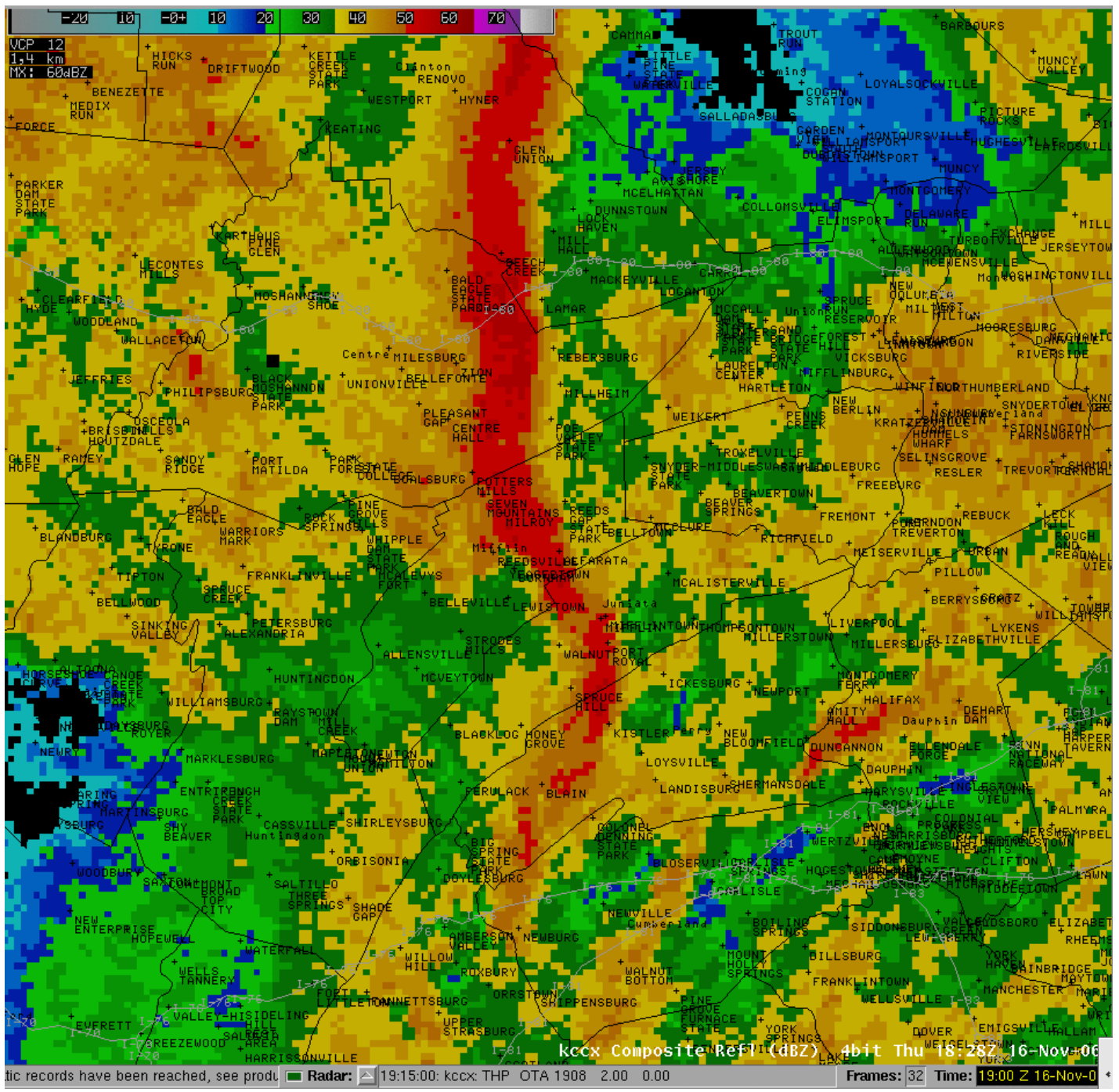


Figure 12 Radar image from KCCX radar at 1828 UTC 16 November 2006 showing the intense rainband that moved across the State. The line had bow like structures in it at times. Courtesy Ron Holmes (ITO-KCTP).

Precipitation Total (inches)
past 24 hours ending 7:00 AM Fri Nov 17 2006

