1. INTRODUCTION

A building subtropical ridge over the eastern United States set up the classic “ring of fire” convective pattern on 2-4 June 2008. The produced several days of severe weather with 275, 284, and 410 severe reports on June 2, 3 and 4 respectively. The reports for 4 June 2008 are shown in Figure 1. The focus of this report is on the conditions in the eastern United States and the derecho that evolved during the afternoon of 4 June 2008.

The severe weather developed along the southern edge of the frontal zone associated with a building subtropical ridge. The ridge was pushing warm subtropical air northward which created the conditions conducive for convection to include Mesoscale convective complexes (MCC: Maddox 1980) and Mesoscale convective systems (MCS: Maddox 1980). These conditions include strong flow of warm moist air northward with into the baroclinic zone, the baroclinic zone itself serving as a boundary that the warm moist air must glide over, and inertial instability as short waves mover over the ridge.

MCS developing in these environments are quite common. The building heat episode pattern favors the development of clouds and mesoscale convective complexes in this zone. A building heat episode produced a series of MCS over Pennsylvania in July 2005. The MCS event of 24 July heralded in the warm episode of July 2005. Other heat episodes such have produced Derechoes as they developed including the events of mid-July 2006.

The MCS associated with building heat episode often develop into Derechoes which is a widespread and long lived windstorm associated with a band of rapidly advancing thunderstorms (Hinrichs 1888; Johns and Hirt 1987, Duke and Rogash 1992). Derechoes are typically grouped into the progressive and serial derecho categories as described by Johns and Hirt (1987). Progressive Derechoes “are often characterized by short curved squall
Figure 2. NAM 00-hour forecast valid at 1800 UTC 4 June 2008 showing a) 500 hPa heights and height anomalies, b) 700 hPa heights and height anomalies, c) 850 hPa temperatures and temperature anomalies, and d) 925 hPa temperatures and temperature anomalies.

*lines oriented nearly perpendicular to the mean wind direction with a bulge in the direction of the mean flow*. Derechoes often show a distinct line echo wave patterns (LEWP) and bow-echo structures on radar. The event of 4 June was produced the bow echo signatures and likely would be classified as a progressive derecho (see Fig 3 Johns and Hirt 1987).

MCS often produce distinct bow echoes on radar (*Przybylnski 1995*) which can produce clear mid-altitude radial convergence signatures (MARC) on radar. Schmocker et al. 1996 show the importance of monitoring features often associated with bow echoes such as the MARC signature. This signature often is associated with a widespread pattern of damaging winds. Atkins et. al (2005) showed the value of the MARC signature and cyclonic bookend vortices when monitoring bow echoes and derechoes on radar.

It should be noted that heat waves or “warm episodes” can also produce significant severe weather events when they develop and when the end. The cold
fronts of 3 August 2006 and 27 July 2005 events are good examples of heat wave ending severe weather events.

This note will examine the conditions associated with the progressive derecho of 4 June 2008.

2. METHOD

The SPC severe weather data base was used to determine the number of severe weather events. These data are subject to change as new report come in.

Radar imagery was retrieved from the State College AWIPS after the event. The imagery shown was from the Sterling WSR-88D (KLWX).

Large scale flow and anomalies were derived from NCEP model and ensemble data. The anomalies are as described by Grumm and Hart (2000). All images were produced using GrADS.

3. Results
The large scale pattern is shown in Figures 2 & 3. The data show the 500 hPa ridge over the region (Fig. 2), with the heights near normal. The 700 hPa heights showed subtle short-wave over the Ohio Valley (Fig. 2b) with some slightly below normal heights in that region. The low-level temperatures were above normal on the warm side of the baroclinic zone at both 850 and 925 hPa. The relatively cool air was present over the northeastern United States. The moisture was above normally high with precipitable water (PW: Fig 3d) anomalies on the order of 1-3 SDS above normal in the eastern United States. The PW anomalies were above normal north of the area were temperatures were above normal implying that the warm subtropical air was riding over the frontal boundary.

The 850 hPa winds showed a strong southwestern jet aimed into the panhandle of West Virginia and western Maryland. The 850 hPa v-wind anomalies were 2.5 to 3SDs above normal in that region. The u-winds were also anomalously strong showing 2SD above normal values in the Ohio Valley.
The screaming message was that a strong low-level jet was present into the warm moist boundary.

A surface pressure trough was present over the region and pressure anomalies were on the order of -1.5 SD below normal in the region where the derecho developed.

By 05/0000 UTC the strong low-level jet (LLJ) had moved off the Mid-Atlantic Coast (Fig. 4) but a stronger LLJ had developed over the western Ohio Valley setting up another round of MCS activity in the Midwest.

At 500 hPa the first signs of anomalous 500 hPa heights with the building warm episode were present over Georgia. In the Mid-Atlantic region, a weak trough was present over Pennsylvania. The feature was more noticeable in the 700 hPa height field (Fig. 5b). The derecho had cooled the 925 and 850 hPa temperatures over Pennsylvania and Maryland. However, anomalously warm air was present over the southeastern US with some +2.5SD temperature anomalies at 850 hPa from Georgia to southeastern Virginia.
Figures 6 & 7 show the KLWX 0.5 degree reflectivity and the storm relative velocity (SRM) data at 1837 and 1851 UTC respectively. These data show the intense inbounds along the line of convection and the outbounds ahead of
the line. Though not shown, the convergent signature at times extended to over 32000 ft (9.8km) in the line of storms. There were several distinct areas along the line where the inbounds were punching through the convergence line and there were visible circulations.

Figures 8a-e show the progressive MCS activity over the eastern United States form 3 to 5 June 2008. Figure 8a shows the MCS activity at 1101 UTC 3 June. A large active MCS’s were present over Iowa and Illinois. A weaker convective area was present over Kentucky with flanking convection on the southwest side of the Iowa MCS.

The MCS activity at 0631 UTC 4 June showed a “ring of fire” of MCS’s of varying sizes. No lightning data was plotted, but the colder tops showed 4 to 6 activity areas. The largest MCS’s were over Missouri and Illinois.

Figures 8c-d show the activity during the afternoon hours of 4 June 2008. The 1855 UTC image shows the three primary convective regions over Illinois, southern Ohio, and western Maryland (Fig. 8c). The intense lightning activity at 1902 UTC (Fig. 8d) shows the intense line of convection in the MCS from Maryland into northern Virginia. This data was not plotted on Fig. 8c as not to obfuscate the data.

Figure 8d shows the MCS activity at 04/2225 UTC. The MCS which produced the derecho over Maryland and Virginia is off the coast; a second MCS was over western Virginia, and a third MCS was located over the central Ohio Valley. Finally, another area of organized convection was developing over Illinois.

4.Conclusions

A building subtropical ridge over the eastern United States set up the classic “ring of fire” convective pattern on 2-4 June 2008. These patterns have become known signals for existing strong subtropical ridges or building subtropical ridges associated with warm season heat episodes.

This strengthening subtropical ridge produced several days of severe weather with 275, 284, and 410 severe reports on June 2, 3 and 4 respectively. Most of these reports were associated with large MCS and some large MCC’s which developed in the moisture plumes moving up the west side of the ridge.

The severe weather reports for 4 June 2008 are shown in Figure 1. With 410 reports, this was the most active day and as shown in Figures 8a-8e it was a time of active production of MCS, several of which clearly developed in Derechos. This reports focused on the conditions associated with the derecho that affected the Mid Atlantic region during the afternoon hours of 4 June 2008.

The series of MCS and the resulting destructive severe weather was at times well aligned with the strong and anomalous LLJ. In this report the 850 hPa u- and v-wind anomalies appeared to be good predictors as to the general area favoring the development of convective systems. The high PW air and the strong LLJ, with some 2-3 SD above normal u – and v-winds were clearly associated with the derecho that impacted the Mid Atlantic region on 4 June 2008.
Figure 8a. 1101 UTC 3 June 2008 IR imagery and 1-minute lightning flashes.

Figure 8b. 0631 UTC 4 June 2008. IR image cropped over the eastern US.

In addition to the LLJ and PW
anomalies, the NAM 00-hour forecasts indicated the presence of a weak short wave moving over the ridge and a strong baroclinic zone, with above normal temperatures on the warm side of this boundary.

The strong signals on the KLWX radar were the result of this unusually strong LLJ and high moisture values, The latter likely produced high CAPE values (not shown) and deep instability favoring deep convection. This combined to produce a significant severe weather event and also likely signaled the beginning of a string of unseasonably warm weather over much of the eastern United States.

5. Acknowledgements

6. REFERENCES


Schmocker G. K., R. W. Przybylinski, and Y. J. Lin, 1996: Forecasting the initial onset of damaging downburst winds associated with a mesoscale
convective system (MCS) using the midlatitude radial convergence (MARC) signature. Preprints, 15th Conf. on Weather Analysis and Forecasting, Norfolk, VA, Amer. Meteor. Soc., 306–311.

Figure 8c 1855 UTC 4 June IR imagery over the eastern US.

Figure 8d. 1902 UTC 4 June 2008 IR imagery and lightning over the Mid Atlantic region..
Figure 8e 2245 UTC 4 June 2008. Showing three MCS in a row over eastern US.