Heat wave ending severe events of 23-25 July 2010

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1. INTRODUCTION

A strong subtropical ridge (Fig. 1a) dominated the eastern United States from 17 to 25 July 2010. The heat in the eastern United States peaked on 24-25 July when the ridge reached its maximum extent in the eastern United States (Fig. 2). Short-waves moved over the top of the ridge and tapped the deep moisture which had moved over the ridge (Fig. 2d). This produced a series of severe weather events over the eastern United States on the 24th and 25th of July 2010.

During the period of 23-25 July there were 17, 20, and 33 reports of severe weather respectively over Pennsylvania. This included an EF1 tornado on the evening of 24 July. The initial severe weather was associated with the building ridge and the surge of deep moisture into the region. The culminating event on 25 July was the most widespread event producing 33 severe reports in Pennsylvania. This event involved the deep moist air over the region (Fig. 2d) around the subtropical ridge and heat episode ending frontal system.

Not all heat waves go out with a “convective bang” but this system, similar to the July 1995 (Galarneau, et al. 2006) this event was not quite as impressive as the 15 July 1995 “ridge-roller: derecho. Figure 3 shows the severe weather over the eastern United States from 23-25 July 2010. There was a clear focus on severe weather from Illinois to the Mid-Atlantic.

2. METHODS

Storm reports were retrieved from the Storm Prediction Center (SPC) website. These data are updated as they come in and are verified by National Weather Service offices and storm survey teams.

The SPC data were decoded for use in a relational database and for use in GrADS (Doty and Kinter 1995). The data for 10 May were plotted on several images, such as Figure 1 to show the types color coded by type. The data were plotted based on the latitude and longitude of the data point. No time issues were addressed here thus all observed severe weather has been plotted.

The pattern was reconstructed used the NCEP GFS and NAM and were possible the JMA 1.25x1.25 data (Onogi et al. 2007). All data were plotted in GrADS (Doty and Kinter 1995). The severe weather data was overlaid on the JRA data. The higher resolution NCEP NAM is used to show the conditions during the event.

The anomalies were computed from the NCEP/NCAR re-analysis data (Kalnay et al. 1996) as describe by Hart and Grumm 2001 and Grumm and Hart 2001. Unless otherwise stated, the base data was the NAM and the means and standard deviations were computed by
comparing the NAM to the NCEP/NCAR 30-year climatological values.

For brevity times are referred to in the format of 25/1800 for 25 July 2010 1800 UTC.

3. RESULTS

i. Large scale pattern

The larger scale pattern over the period of interest is displayed in Figures 1-3. These data show that a large subtropical ridge was positioned to the south and there was a flow of high PW air over the ridge. This ribbon of high PW air extended from the Midwest to the Mid-Atlantic region.

Most of the severe weather (Fig. 3) was focused in the height gradient and moisture surge along the northern...
Figure 2. As in Figure 1 except over the eastern United States and for the period of 0000 UTC 24 to 0000 UTC 26 July 2010. The 700 hPa temperatures are used in lieu of mean sea level pressures.

The periphery of the subtropical ridge (Figs. 1 & 2).

ii. **Regional features**

**Figure 4** shows the pattern at 25/0000 UTC and the observed severe weather on 24 July. The time 25/0000 UTC was chosen as it was near the time of maximum activity in the eastern United States. As in the composites, the severe weather was focused along the edges of the ridge and in the ribbon of high PW air. The synoptic scale importance of the ridge is understood. The focus of the convection however was associated with the low-level jet and PW anomalies.

Figures 5-8 show the total 850 hPa winds and anomalies, PW and PW anomalies and the severe weather for 22 through 25 July 2010. The earlier period
is shown to contrast the severe weather and flooding pattern of 22-23 July with the widespread faster moving severe events of 24-25 July. The inflow at 23/0000 UTC (Fig. 5) over the Midwest was near the apex of the ridge (not shown) and the upper-level flow was relatively weak.

Figure 5 shows the high PW air and strong LLJ focused in the Midwest at 23/0000 UTC. This region had some severe weather and flooding. By the 24/0000 UTC (Fig. 6) the pattern shifted with the LLJ extending to the east. The inflow and inflection of the LLJ over Iowa and Illinois produced another round of flooding. But the stronger band of westerly wind in the LLJ along the high PW channel produced a more widespread severe event (Fig. 6).

Figure 7 shows the severe weather on 24 July and the 25/0000 UTC LLJ and PW values. The LLJ was focused with big anomalies in western New York and

a. Mean 500 hPa from 00Z23JUL2010–00Z26JUL2010

Figure 3. Mean 500 hPa pattern and severe weather for the period of 0000 UTC 23 to 0000 UTC 26 July 2010.
western Pennsylvania. The severe weather aligned well with this feature. Though not shown, temperatures were near 20°C and 10°C at 850 hPa and 700 hPa respectively over central Pennsylvania southward which may have limited the southern extent of convection.

The severe weather and pattern on 25 July are shown in Figure 8. The event in Pennsylvania occurred early in the day and thus the 1800 UTC time was selected. These data again show the focus of the severe weather in the high PW channel and near the nose of an enhanced LLJ at 850 hPa. This event had the additional push of a cold front with cooler and drier air behind it. Note the slightly below normal PW anomalies over the Great Lakes behind the frontal system. Figure 9 shows the 250 hPa jet and 850 hPa jet at 26/0000 UTC. This was the only event from 22-25 July in the eastern United States in close proximity to a strong 250 hPa jet.

v. Observational data-satellite

Figure 10 shows the GOES-IR image at 23/0045 UTC and the GFS 500 hPa heights. A developing MCS is evident over Wisconsin on the periphery of the subtropical ridge. Approximately 24 hours later there a series of MCS’s were present from northern Illinois to New York (Fig. 11). The next day, at 24/2255 UTC there were at least 3 organized MCS’ along the periphery of the ridge. The westernmost produced flooding over Iowa and Illinois (Fig. 12). Finally, at 25/1800 UTC (Fig.13) another MCS’ was present over the Mid-Atlantic region. This system was the severe weather event which ended the heat wave over most of the eastern United States.

vi. Observational data-radar

1 A massive severe event on 21 July in the northeastern United States had a very strong 250 hPa jet associated with it.
Two radar images over the Mid-Atlantic are shown in Figures 14 & 15. The first image (Fig. 14) shows the line of storms over northern Pennsylvania on Saturday night at 25/2334 UTC. One storm had a completely bounded weak echo region and a strong rotating mesocyclone (storm relative data right side). Earlier, this storm produced a short-lived EF1 tornado. This storm produced know wind damage in at least 4 counties and an EF1 tornado. There were several rotating storms in northern Pennsylvania during this event.

Figure 15 shows the radar returns at 25/1654 when a line of storms along and ahead of a cold front was moving across Pennsylvania. The largest storm, which produced a mesocyclone (not shown) and most damaging storm in Pennsylvania, was ahead of the main line near point A. The lower panel shows the line of storms moving through the Washington-Baltimore region. This organized squall line produced widespread damage and downed power lines. At the peak 300000 customers lost power due to these storms.

4. CONCLUSIONS

A large subtropical ridge dominated the weather over eastern United States from 17 to 25 July 2010. Flow around this feature created several severe weather events. The focus here was on the severe weather events of 23-25 July 2010. Initially the severe weather occurred well south of the stronger 250 hPa jet in the channel of high PW air flowing over the subtropical ridge. The final event on 25 July 2010 was associated with a strong 250 hPa jet entrance region as well as the strong LLJ and high PW air moving over the ridge.

This case clearly illustrated the importance of subtropical ridges in modulating convection. A few key points:

- Near the apex of the ridge with weak mid-level flow flooding is a serious forecast issue.
- The high PW channel when aligned with the strong low-level jet is a good feature to focus the region of convection.
The stronger flow over the top of the ridge allows the storms to progress limiting flooding.

The interaction of the high PW plume and LLJ with a frontal system (25 July) produced more widespread and damaging winds.

5. Acknowledgements

Satellite images (not used) provided by Dave Ondrejik. Radar images provided by Jason Krekeler.

6. References


Figure 6. As in Figure 5 except valid at 0000 UTC 24 July and severe weather on 23 July. Return to text.
Figure 8. As in Figure 5 except for 0000 UTC 25 July 2010 and severe weather on 24 July. Return to text.

Figure 7. As in Figure 5 except valid at 1800 UT 25 July and severe weather on 25 July 2010. Return to text.
Figure 9. As in Figure 8 except valid at 0000 UTC 26 July 2010 showing a) 250 hPa winds and b) 850 hPa winds. Return to text.
Figure 10. GOES-IR valid at 0045 UTC 23 July 2010 and GFS 500 hPa heights valid at 0000 UTC 23 July 2010.  

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Figure 11. As in Figure 10 except for IR valid 2255 UTC 23 July and GFS 500 hPa valid at 0000 UTC 24 July 2010. Return to text.
Figure 12. As in Figure 10 except for GOES valid 2255 UTC 24 July and GFS valid at 0000 UTC 25 July 2010. Return to text.
Figure 13. GOES IR valid at 1831 UTC 25 July 2010. Return to text.
Figure 14. KCCX radar with 0.50 degree reflectivity (left) and storm relative motion (right) at 2334 UTC 24 July 2010. The strong mesocyclone is A and the weaker one is B. Return to text.
Figure 15. Composite reflectivity from top) KCCX at 1654 UTC and b) KLWX at 1937 UTC. 
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