Mid-Atlantic Severe Event of 22 May 2013

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Abstract:

A strong low-level and a surge of high CAPE produced a severe weather event over Pennsylvania during the late afternoon and evening hours of 22 May 2013. Most of the reports of severe weather were due to strong and damaging winds. In central Pennsylvania a long-lived bow echo developed which accounted for a significant portion of the wind damage reports from Westmoreland County northeastward to Luzerne County, Pennsylvania.

This was the second event in May of 2013 where a strong bow echo developed out of a cluster of storms. The bow echo then went on to produce a significant number of the reported severe weather.

1. Overview

A quasi-linear convective systems (QLCS: Rotunno et al. 1998;Weisman et al. 1988; Coniglio et al 2004, Coniglio et al 2007) brought severe weather to portions of the Mid-Atlantic region (Fig. 1) during the late afternoon and evening hours of 22 May 2013. There were over 22 reports of wind damage and 1 report of large hail in Pennsylvania. A close inspection of the data in Figure 1 and Table 1 reveals a southwest to northeast series of severe winds or wind damage reports in central Pennsylvania. Most of these reports were from one bowing segement which formed Fayette County, Pennsylvania and moved to the northeast before turning slightly to the east.

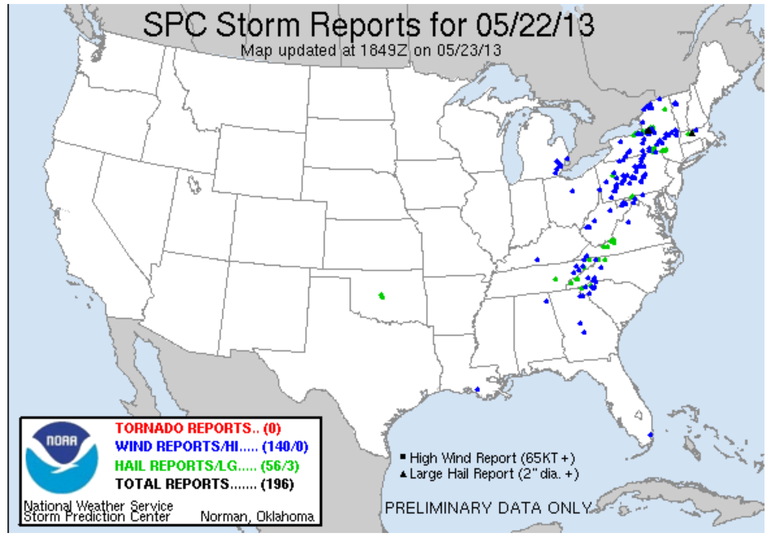

Figure 1. Storm reports from the Storm Prediction Center showing all reports over the United States color coded by report type. Courtesy of the Storm Prediction Center.

Clusters of cells developing cold pools and accelerating in the direction of the steering flow is a common storm evolution type associated with QLCS. In Pennsylvania there may be the added effect of channeled flow by the terrain. This mechanism as produced several events (Grumm 2013; Grumm and Colbert 2012) where a strong bow echo within an evolving QLCS system is the feature which often dominates the severe weather reports during a severe weather event. This creates a quasi-linear pattern in the severe report (Figs 1 & 2). The long-lived system on 8 September 2012 that produced damage from north Maryland, Pennsyvlania and Connecticut (Grumm, Cobert, Evanego 2012) is difficult to visualize among all the other severe reports.

Critical to all of these events is the evolution of a cold pool which can then sustain the system. The ability of low-level soundings to support the generation of a cold pool (Weisman et. al 1998) and down draft CAPE (DCAPE) may provide clues to the potential evolution of these systems. Larger scale severe weather events; large derechoes such as the 30 June 2013 derecho to impact the Washington, DC metropolitan region; have more significant swaths of damage with a linear appearance. These smaller events are often less obvious due to their compact nature and limit area impacted.

This paper will document the event of 22 May 2013 over the Mid-Atlantic regoin with an emphasis on the conditions and radar evolutions over central Pennsylvania.

2. Data and Methods

The larger scale pattern was reconstructed using the Climate Forecast System (Saha et. 2010). The means and standard deviations were used based on the method described by Hart and Grumm (2001) suing the NCEP/NCAR reanalysis data (Kalnay et al. 1996). Daily values of raw CFS data were compared to the 21-day centered means and standard deviations.

Storm reports were obtained from the Storm Prediction Center. Processed SPC data was used to overlay on the anomalies and the base SPC images were used.

3. Pattern over the region

The larger scale pattern over the United States (Fig. 3) shows the closed 500 hPa cyclone with a ridge along the East Coast (Fig. 3a), the confluence over the ridge produced a strong 250 hpa westerly jet in southern Canada (Fig. 3b). The low-level southerly flow (Fig. 3c) over the Mid-West was accelerating into the jet entrance region along with a plume of above normal precipitable water (PW:Fig. 3d).

Locally over the Mid-Atlantic region, the RAP analyzed strong low-level southerly flow at 850 hPa (Fig. 4) and relatively high CAPE over Pennsylvania (Fig. 5), though higher CAPE was present over eastern Pennsylvania, relative to western Pennsylvania where the convection developed and the severe weather was observed. The flow over Ohio was southerly but the flow west-central Pennsylvania became more southwesterly, which is the direction the bow echo moved and the direction of the arc of severe weather in Figure 1.

A model based skew-T taken at point in central Pennsylvania valid at 2100 UTC shows the linear shear, the inverted-V sounding supporting some drying below the cloud based and thus the potential for evaporative cooling the production of cold air beneath an evolving thunderstorm. The NAM estimated about 1200JKg-1 at this point and time. The CAPE peaked at this point in the NAM forecasts at 1747JKg-1 at 0000 UTC, after the actually convective line had moved through this location (not shown).

4. Radar

The initial cells which produced this long-lived bow echo were shown at 2037 UTC over the border of Fayette and Westmoreland Counties. By 2054 UTC the system had developed strong out bounds (red) northeast of Greensburg, Pennsylvania (Fig. 7 lower panel). The 0.5 degree winds quickly showed a mini-bow shape as it moved past Blairsville around 2111 UTC and south of Indiana around 2124 UTC (Fig. 8). The storm blew down trees and closed numerous roads as it blew into northwestern Cambria County after 2124 UTC. Winds on KBPZ were in the 40 to 52kts range during the peak evolution over Indiana and Cambria Counties.

Due to the location and viewing angle, the cold pool and mini-bow echo was better defined by the KCCX radar (Fig. 9) which showed stronger winds than KPBZ lower in the system. KCCX observed winds in the 50 to over 60kt range. The red bow in the image shows the bowing feature which was more pronounced than the reflectivity (Z often referred to as ZH due to dual-pol) signatures on radar. By 2217 UTC (Fig 10) the Z and V along with the CC and ZDR. These data were in all the other products shown but clipped out to focus on the Z and V products which in bow echo events are the best products upon which to base warning decisions. The CC product at times and the hydrometeor classification algorithm output (HCA not shown) at times suggested small hail which may have contributed to the generation of the cold pool, which the strong V winds are used as a proxy for.

Figure 11 shows the bow as it grew in size around 2234 UTC recently after it blew through the radar data acquisition site (RDA). The bow echo blew through the Lock Haven area around 2307 UTC. Viewing static images makes it difficult to realize that the same feature was tracked all of this time. ***It is also interesting to note that after passing through the RDA, the bow echo got larger in horizontal extent and it began to track along a more eastward path making turn to the right, similar to the orientation of the terrain***.

By 0000 UTC the bow echo had passed through Williamsport (Fig. 12 upper) and by leading edge of high winds had moved into Luzerne County (Fig. 12 lower).

Cross sections revealed a forward tilt to the Z field (not shown) as the strong mid-level southwesterly flow pushed the updraft cores to the northeast. Additionally, the bow echo showed ZDR columns which had a similar tilt to the ZH column.

5. Summary

A severe weather event affected Pennsylvania and much of the eastern United States on 22 May 2013. In Pennsylvania, high CAPE along with strong southwesterly flow and a linear shear profiled produced the convection. The soundings showed some drying potential in the lower levels of the atmosphere (Fig. 6) and an inverted-V profile. In central Pennsylvania a significant number of the severe wind reports were associated with a strong, persistent and long-lived bow echo.

The focus of the radar data shown here was on the cluster of storms which developed a cold pool and mini-bow echo which accelerated to the northwest then turned to the east. It accounted for the majority of wind reports in the State College WFO region and many of the reports in the Pittsburgh WFO area in southwestern Pennsylvania. This long-lived feature produced wind damage from WFO Pittsburg into WFO Binghamton county warning areas. Early in the bows life cycle it moved from southwest to northeast nearly down radial of the KCCX radar. The bow made a right turn as it passed through the RDA losing some of preferred down radial viewing of the radar data. As the system, moving nearly eastward, moved out the State College CWA it became difficult to view the true winds from KBGM or KCCX. KBGM viewed the storm from the north-northeast as they system moved to the east.

From a warning decision perspective, the bowing features (Figs. 8 &9) are often more apparent in base velocity data than in the reflectivity data. Experience suggest once the strong winds and bow show the organization, the winds become the best product to track and base warnings on. Often times the base reflectivity (ZH) does show a good bow shape and often, as in the case showed discrete cells which collectively have produced a cold pool and a strong rear-inflow jet. Following the winds and looking for wind in excess of 50kts is a good method to issue higher probability warnings. The mini-bow signature with strong winds, typically over 40kts is systems which can be relatively long-lived. *The Z and V products which in bow echo events are the best products upon which to base warning decisions*.

Though dual-pol products were examined in this event, they appeared to be of minimal supplemental value. Some of the dual-pol products implied wet hail and large drops, likely of recently melted hail during the early stages of the cold pool evolution. It would take many more cases to explore the value and role of hail and large drops aiding in the early initiation of the cold pool.

6. Acknowledgements

The staff at WFO State College for data collection and access. And all the spotter and 911 centers for access to damage reports and reports from local newspapers related to damage and the reports of customers who lost power during the storm in the State College region where over 2000 customers lost service.

7. References

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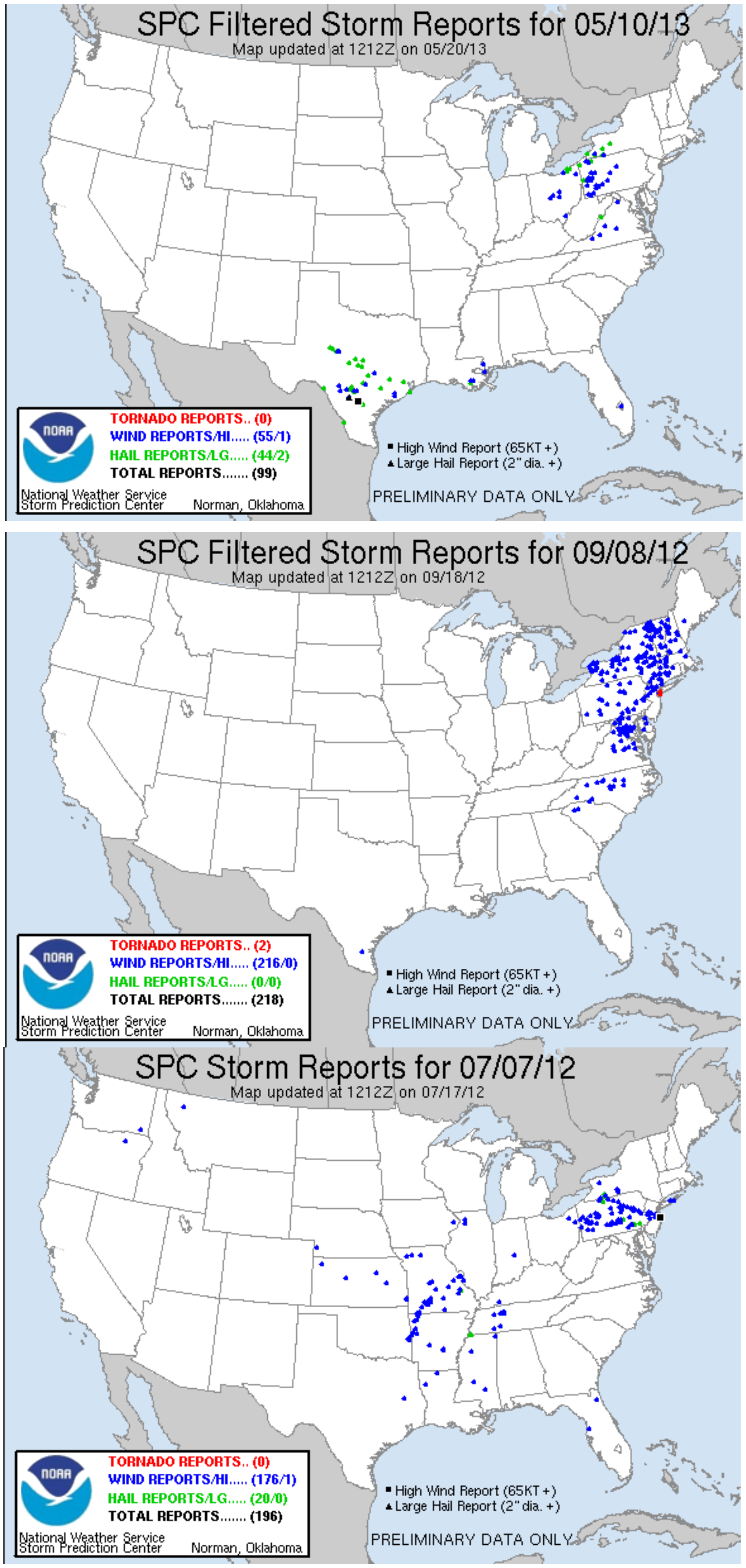

Figure 2. As in Figure 1 except for storm reports for (top) 10 May 2013 , (middle) 8 September 2012, and (bottom) 7 July 2012. **Return to text.**

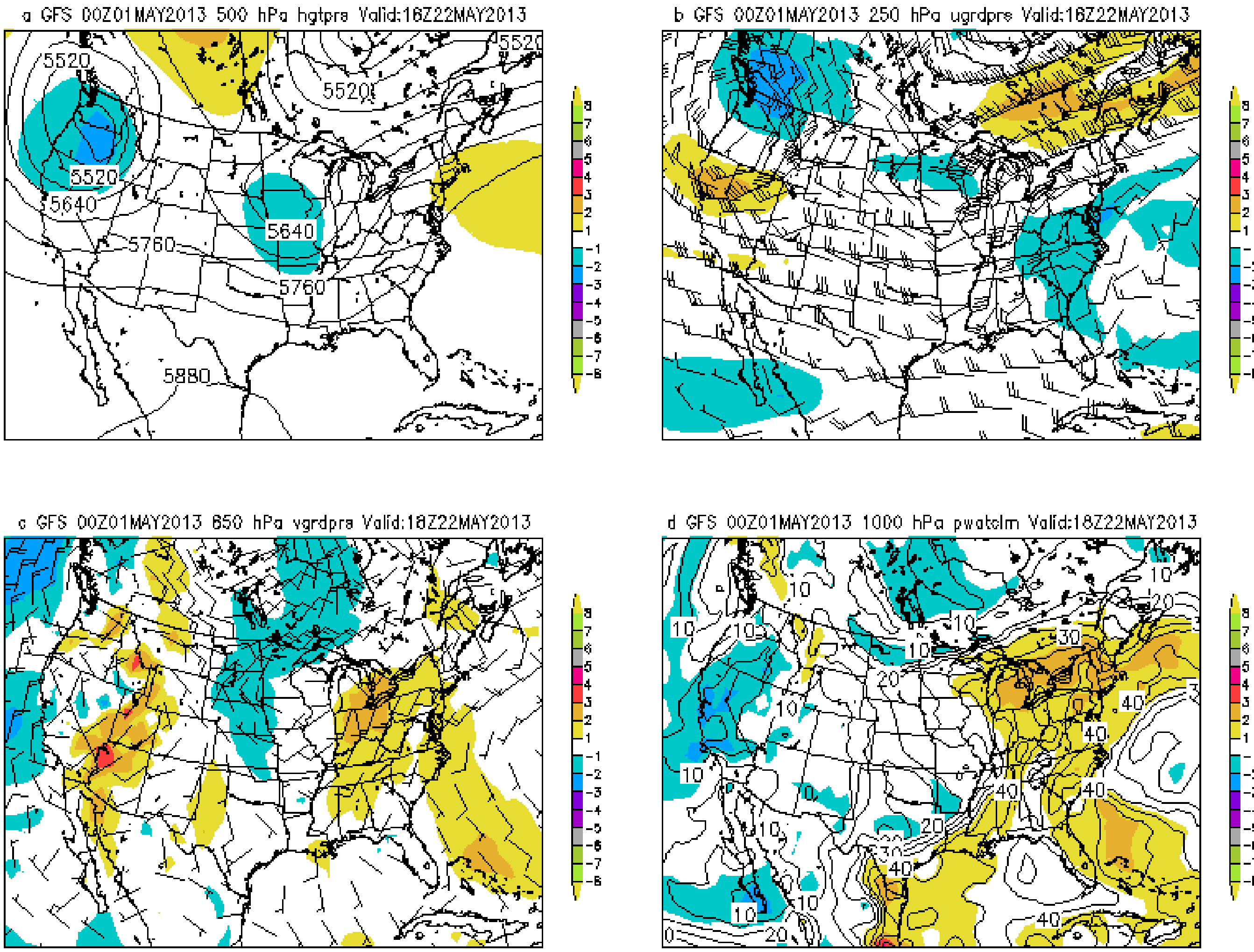

Figure 3. GFS 00-hour forecasts valid at 1800 UTC 22 May 2013 showing a) 500 hPa heights and anomalies, b) 250 hPa winds and u-wind anomalies, b) 850 hPa winds and v-wind anomalies, and d) precipitable water and precipitable water anomalies. **Return to text.**

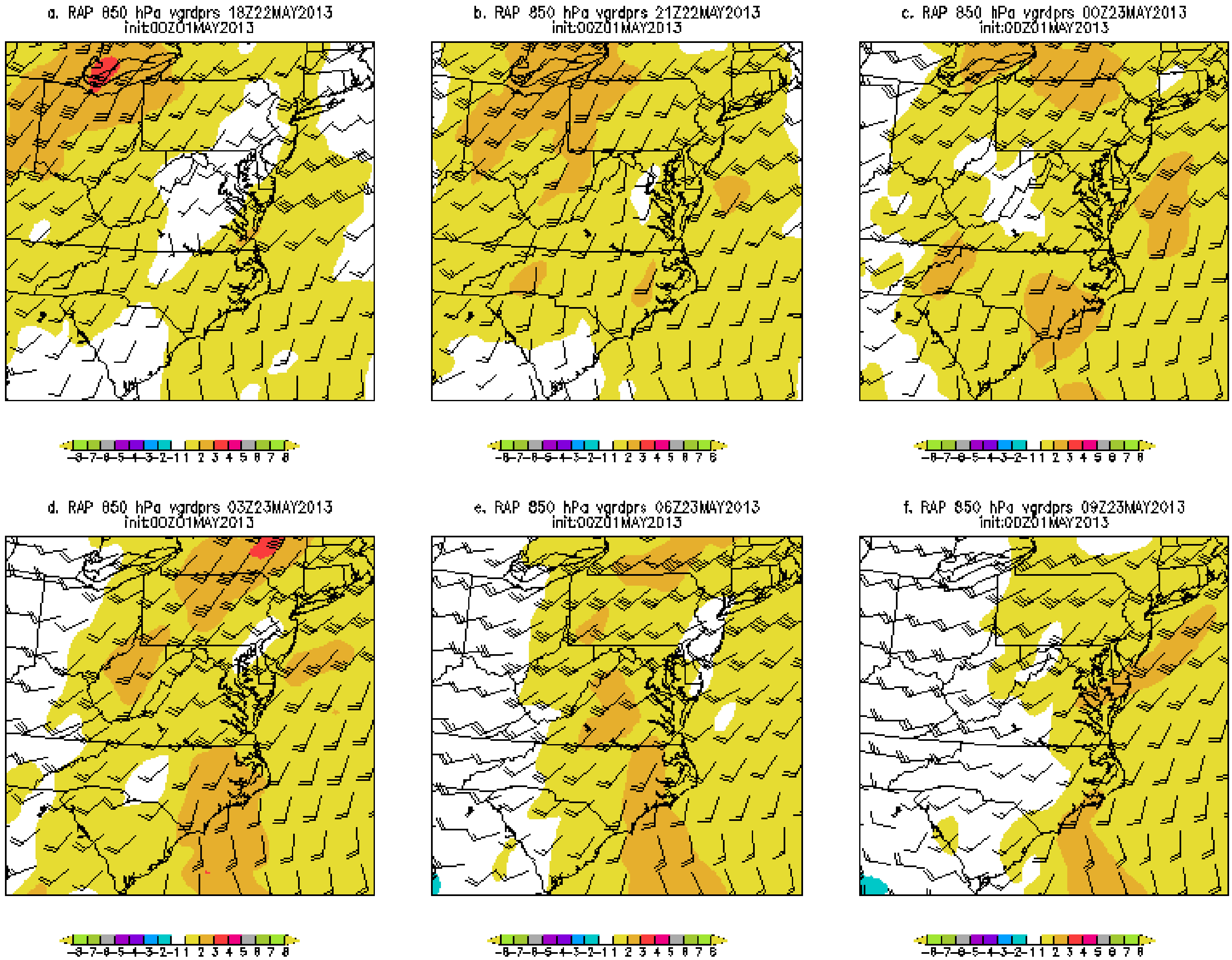

Figure 4. RAP 850 hPa winds and 850 hPa v-wind anomalies from a) 1800 UTC 22 May through f) 0900 UTC 23 May 2013 **Return to text.**

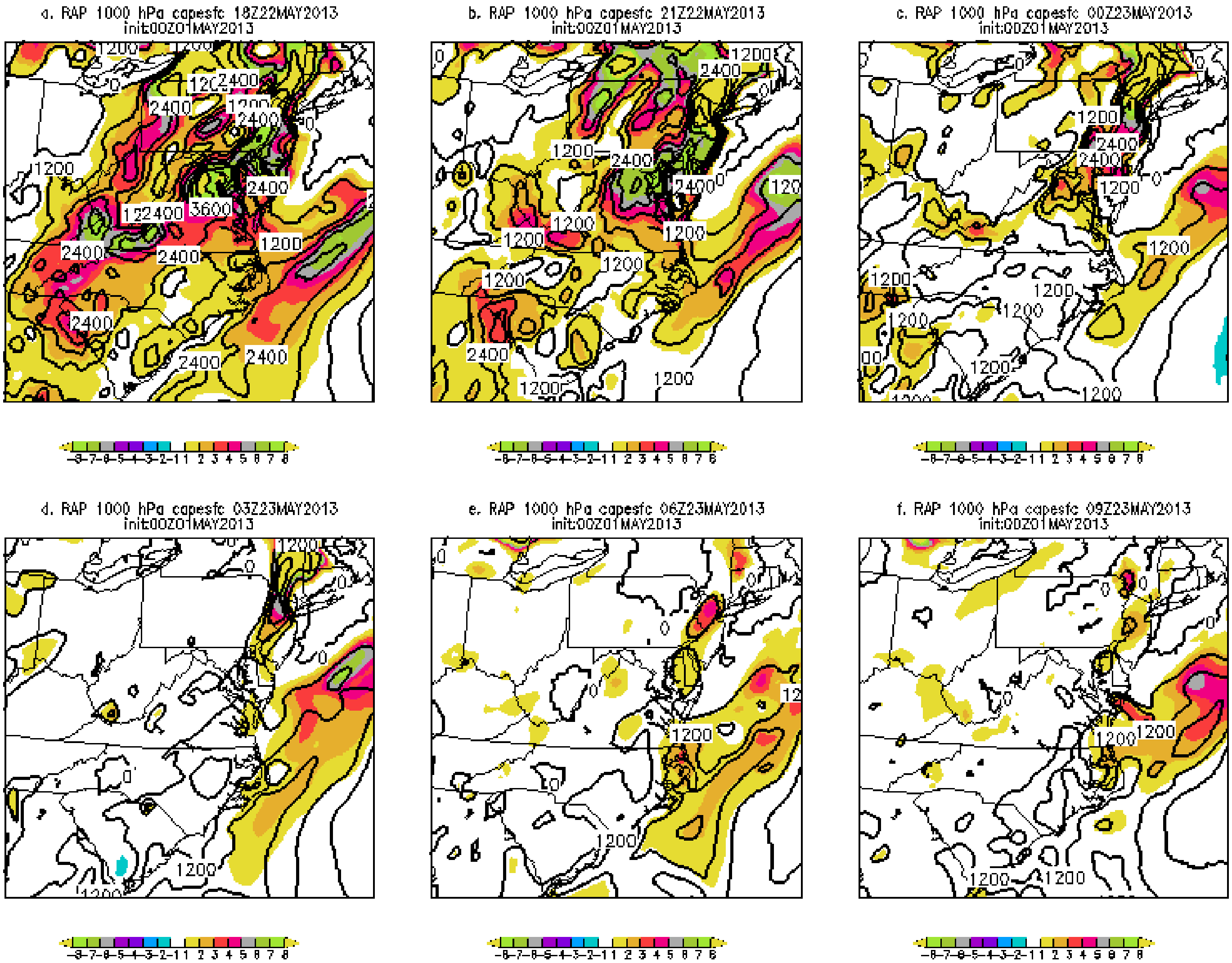

Figure 5. RAP 00-hour forecasts of surface based CAPE in 3-hourly increments from a) 1800 UTC 22 May through f) 0900 UTC 23 May 2013. **[Return to text.]**

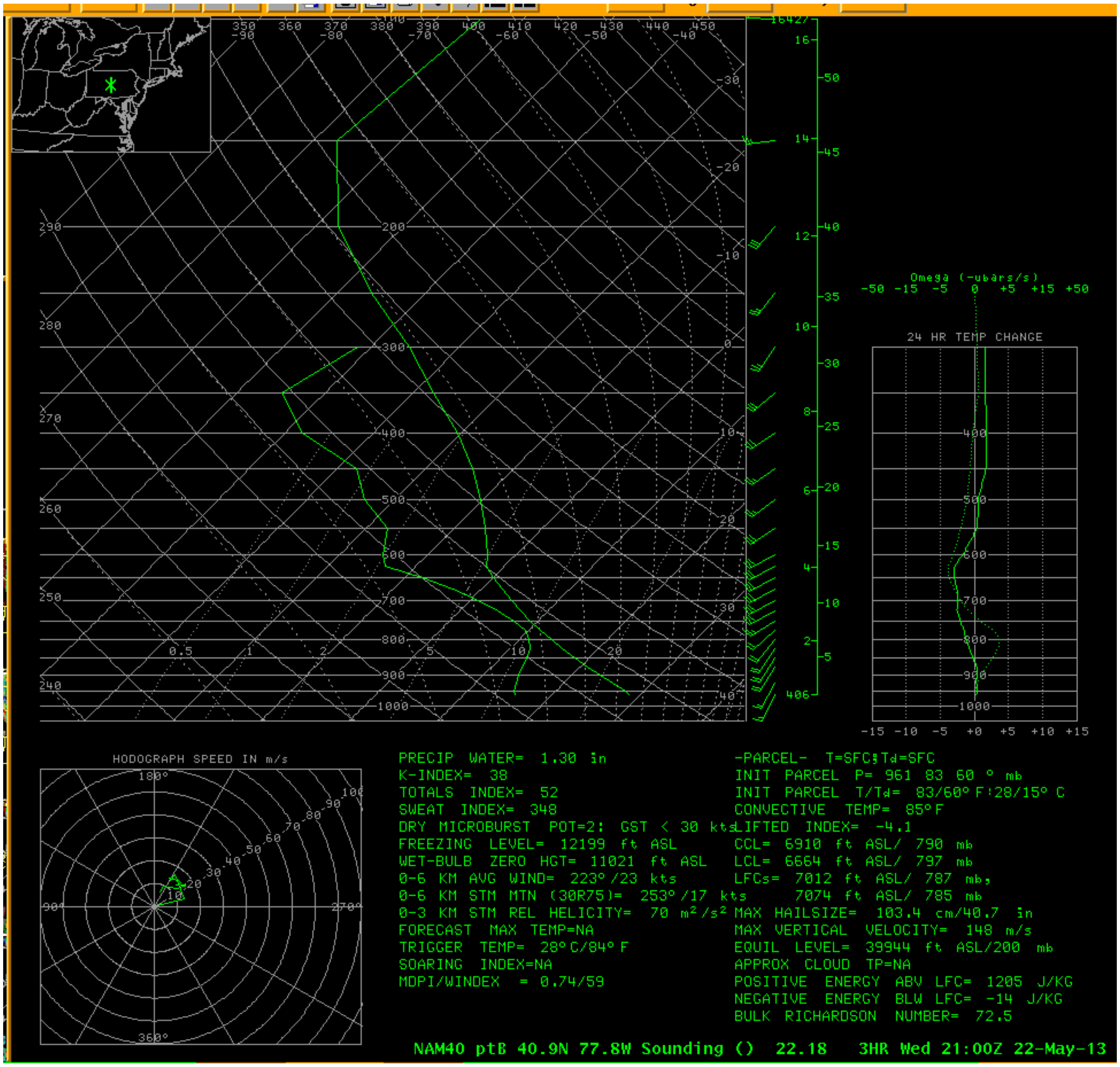

Figure 6. NAM sounding valid at 2100 UTC 22 May 2013 for a point in central Pennsylvania which was in the track of the bow echo which produced most of the wind damage reports. [Return to text.]

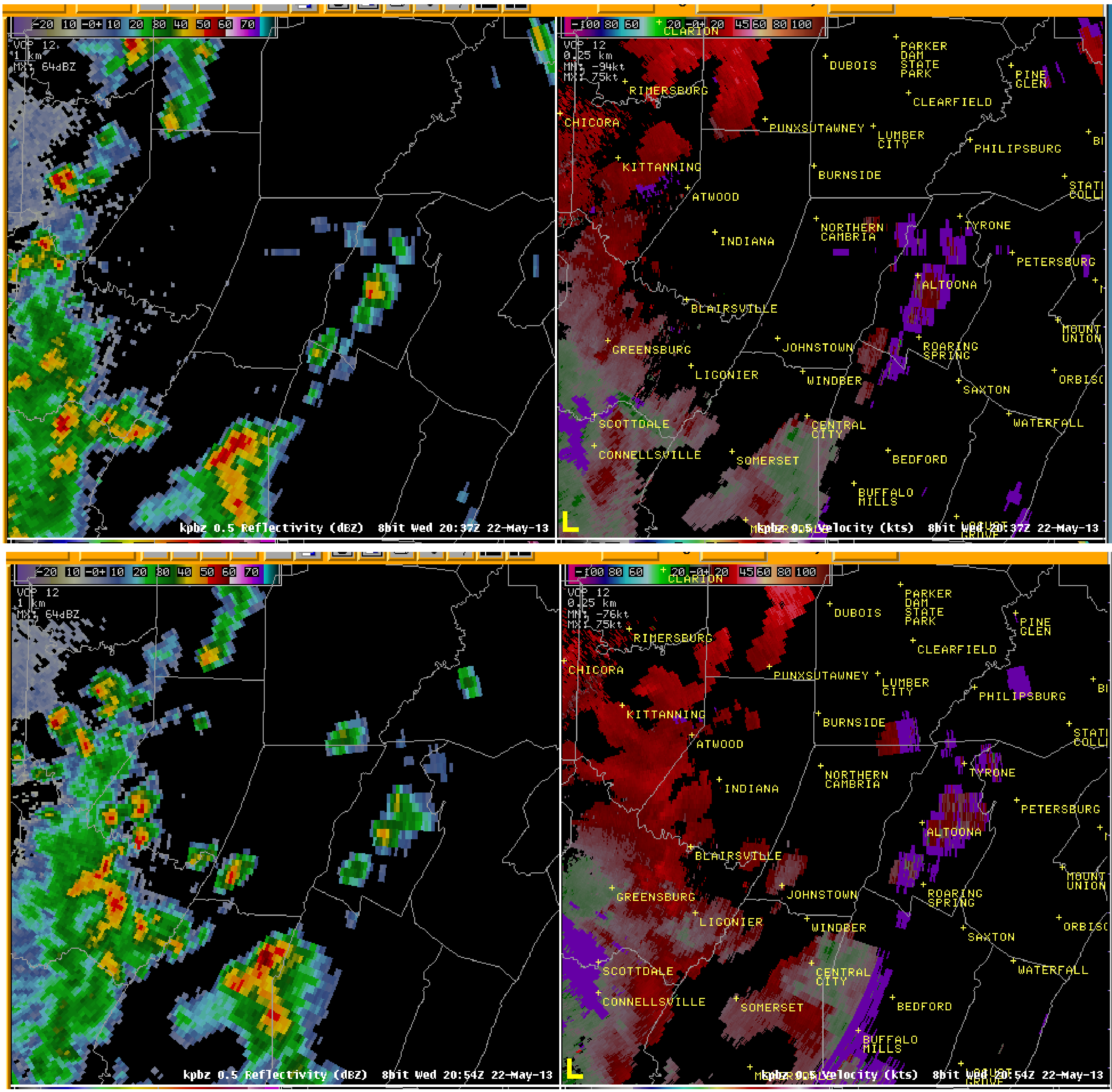

Figure 7. KPBZ radar at 0.5 degrees showing base reflectivity and velocity at 2037 and 2054 UTC. Return to text.

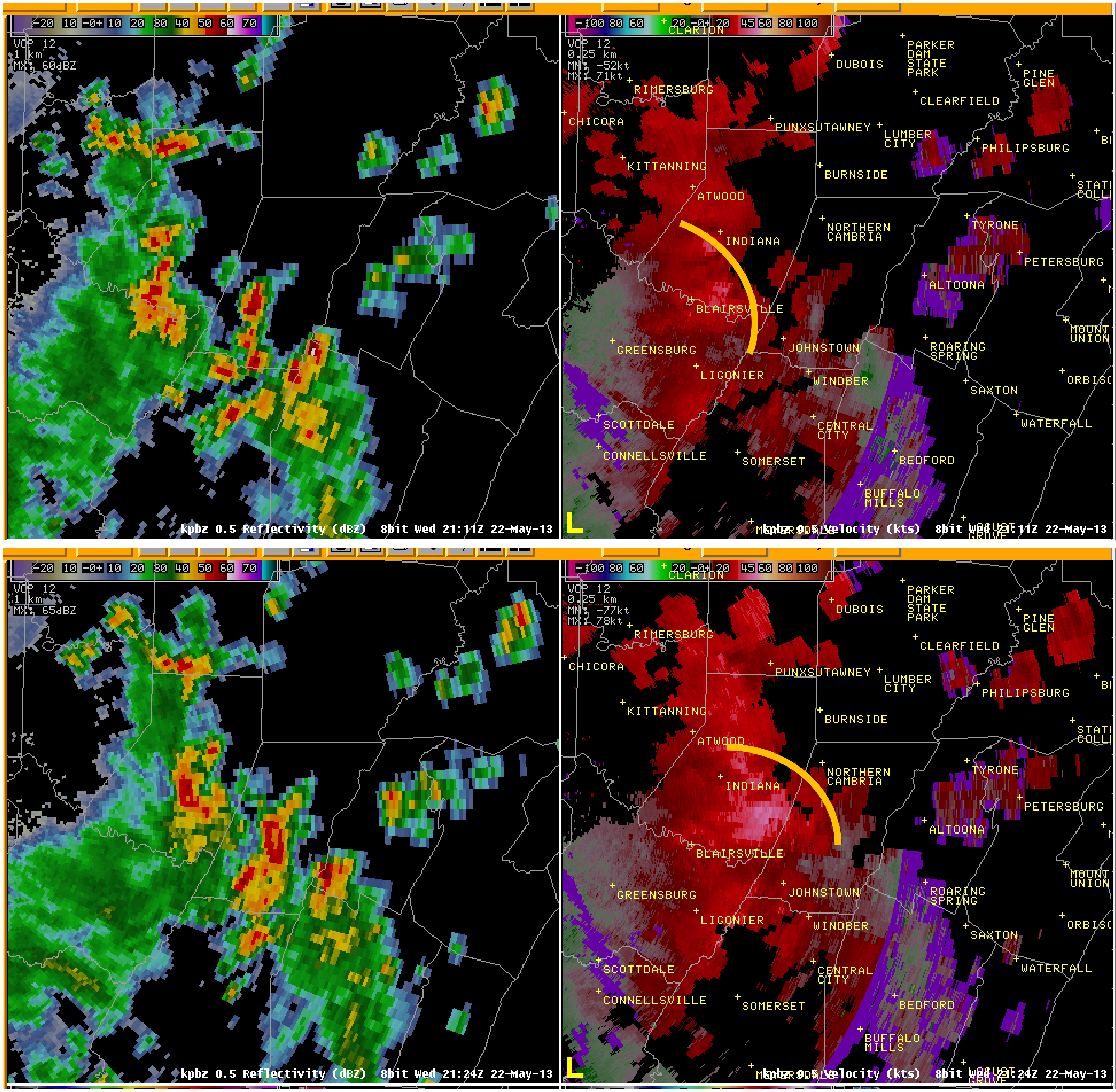

Figure 8. As in Figure 7 except at 2111 and 2124 UTC. The bow is outlined in the velocity data though skewed backward to avoid obscuring the town of Indiana, PA. Return to text.

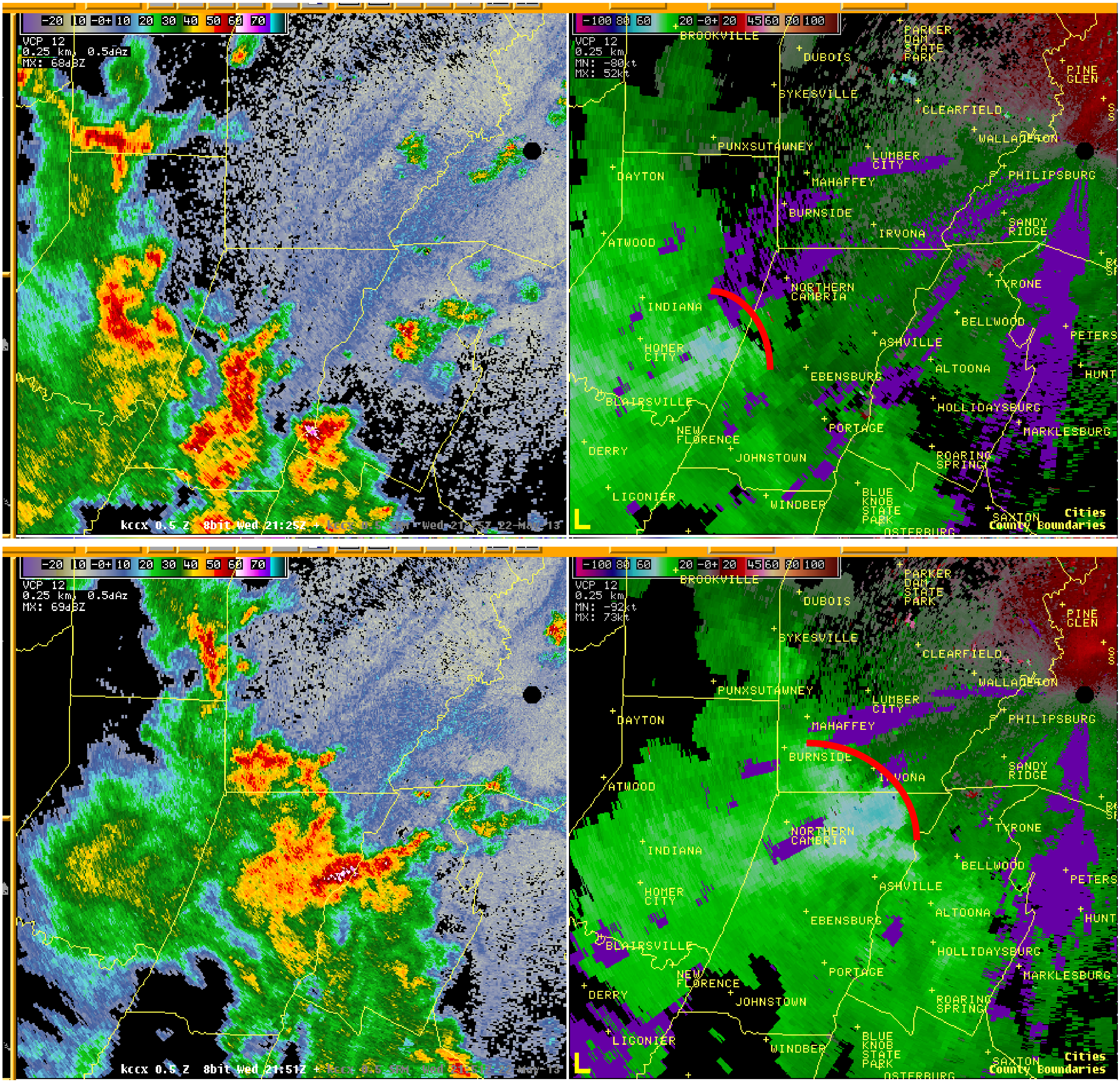

Figure 9. As in Figure 7 except for KCCX radar valid at 2125 and 2151 UTC 22 May 2013. Red arc shows the well define mini-bow described in the text. [Return text.](#)

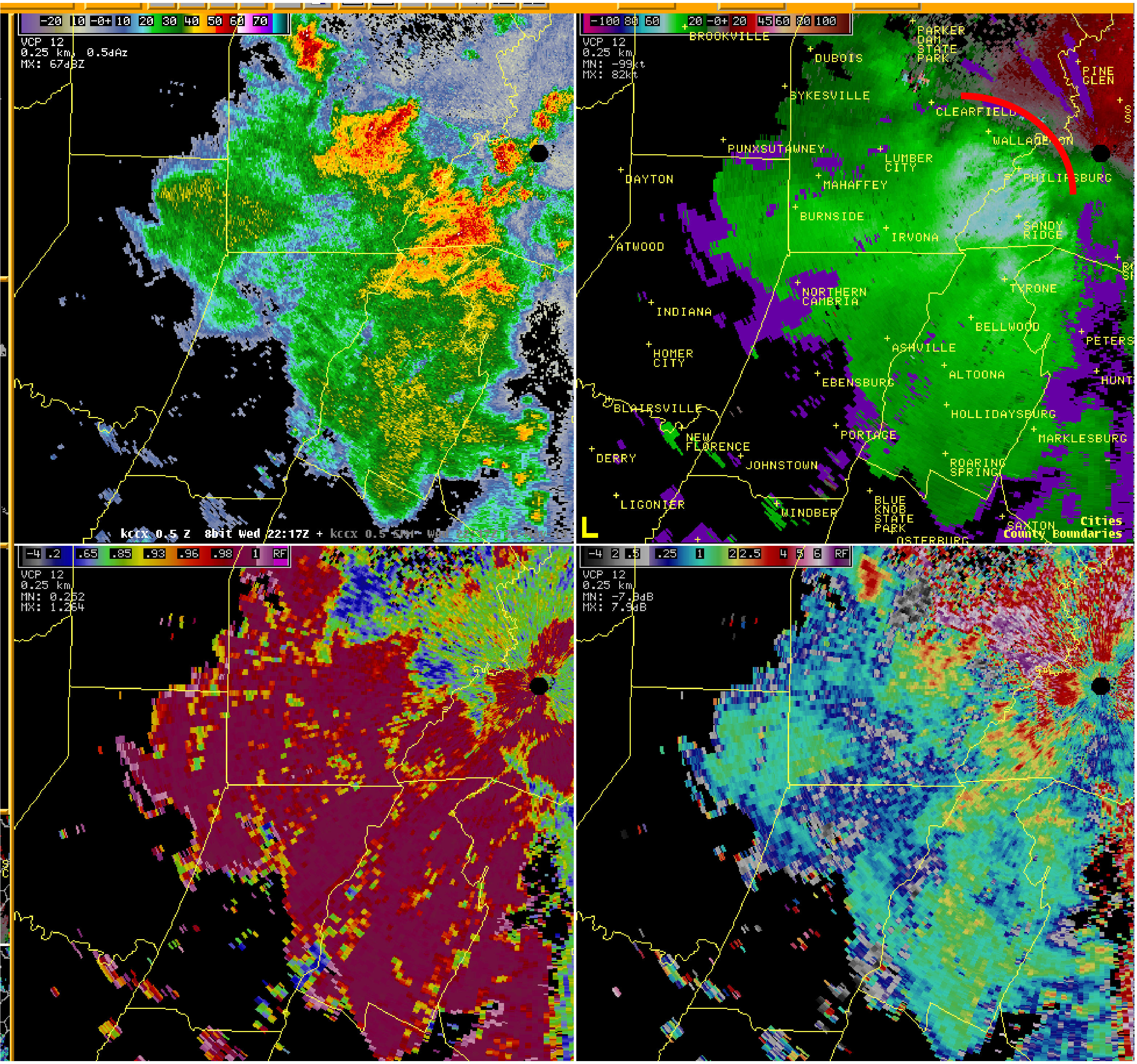

Figure 10. As in Figure 9 except valid at 2217 UTC but also showing CC and ZDR in the lower left and right respectively. **Return to text.**

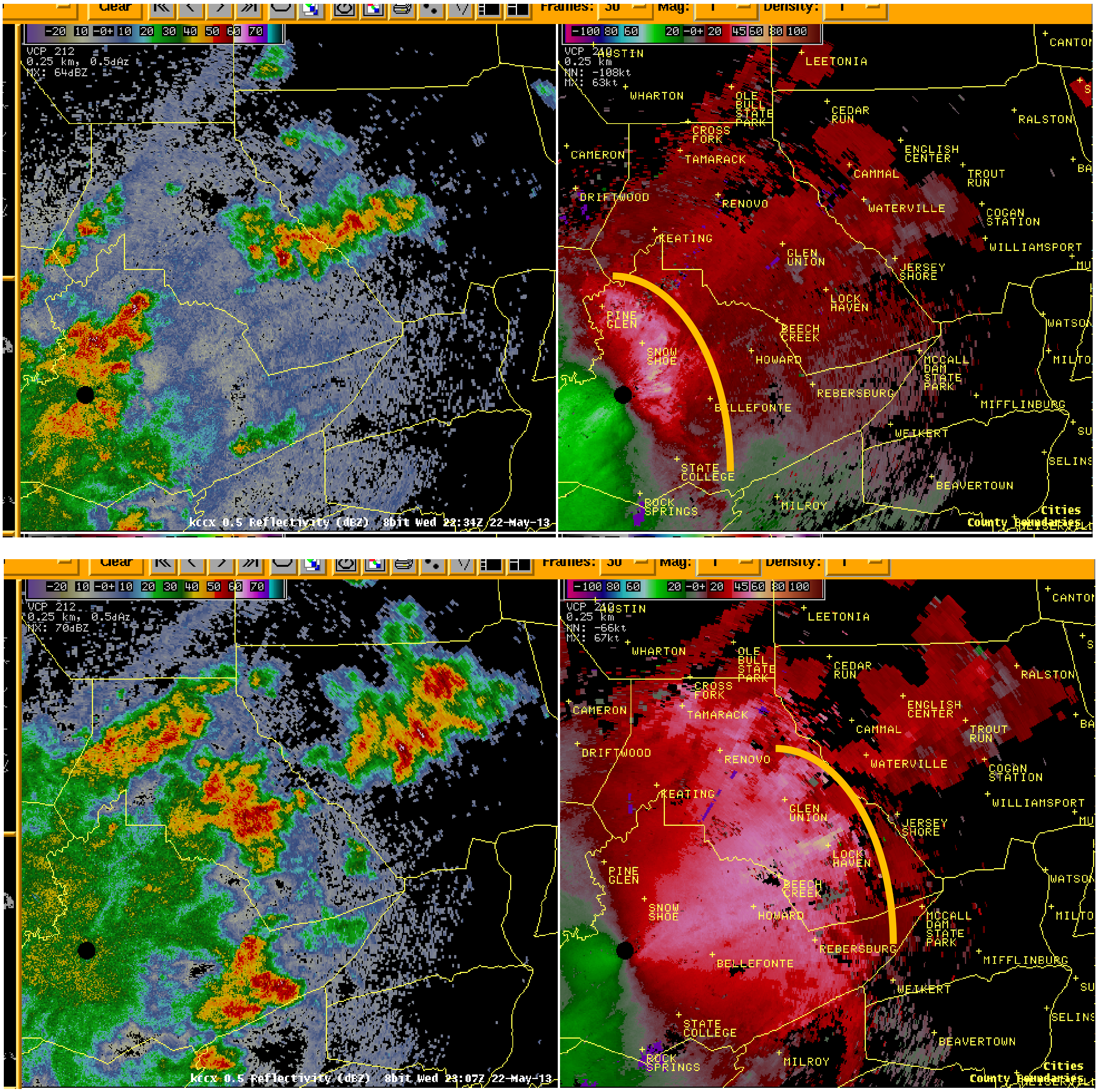

Figure 11. As in Figure 9 except valid at 2234 and 2307 UTC. [Return to text.](#)

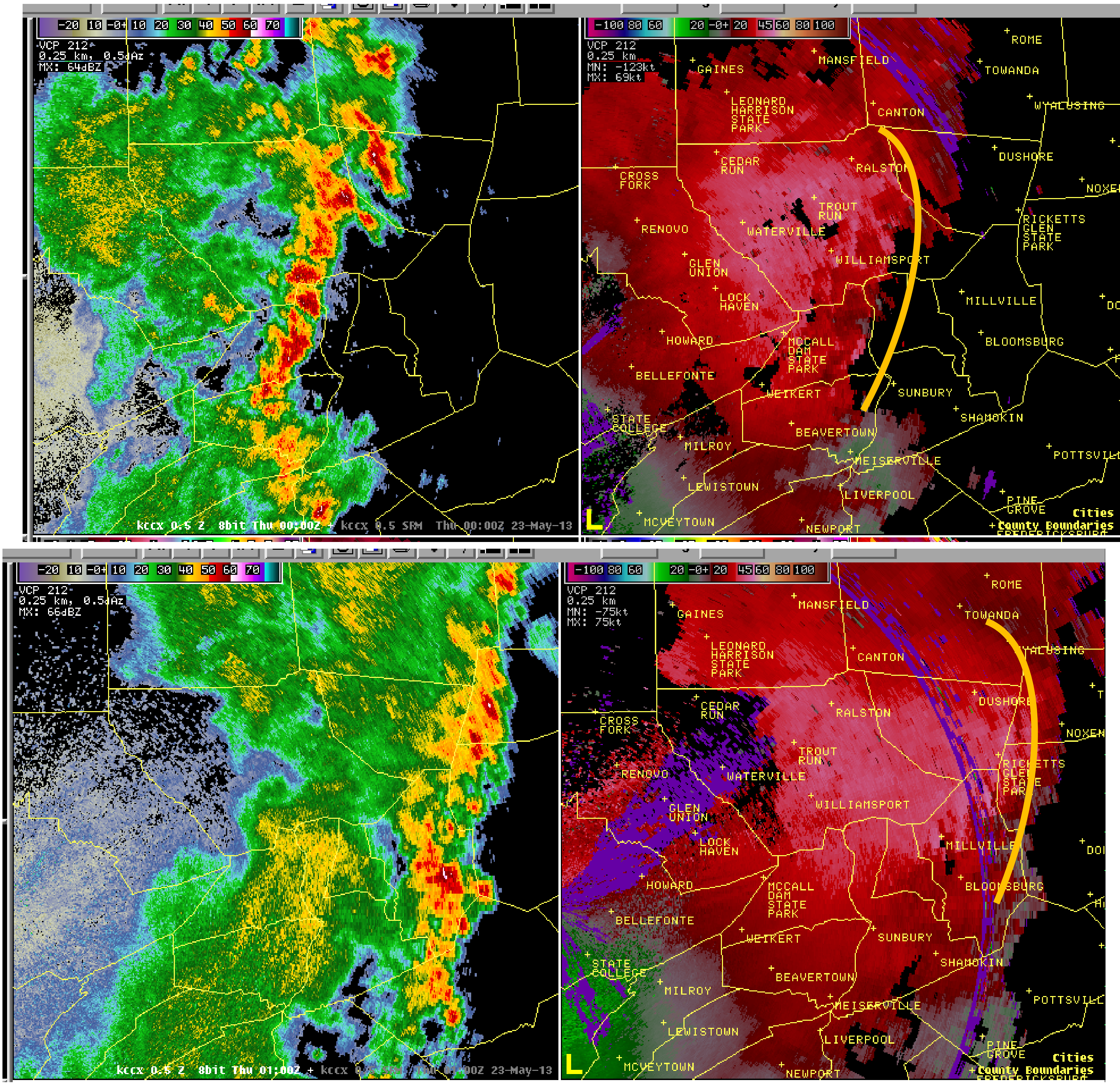

Figure 12. As in Figure 11 except valid at 0000 and 0100 UTC 23 May 2013. [Return to text.]

Date	Time	Type	State	Lat	Lon
5/22/2013	0:00:00	WIND	PA	41.39	-77.04
5/22/2013	0:18:00	WIND	PA	40.86	-76.79
5/22/2013	0:18:00	WIND	PA	41.99	-76.52
5/22/2013	0:22:00	WIND	PA	41.3	-76.74
5/22/2013	0:24:00	WIND	PA	40.71	-76.89
5/22/2013	0:42:00	WIND	PA	40.8	-76.87
5/22/2013	1:40:00	WIND	PA	41.96	-75.58
5/22/2013	20:20:00	WIND	PA	39.9	-79.72
5/22/2013	20:42:00	HAIL	PA	41.2	-79.24
5/22/2013	20:45:00	WIND	PA	40.27	-79.37
5/22/2013	20:55:00	WIND	PA	41.31	-79.18
5/22/2013	21:16:00	WIND	PA	40.62	-79.16
5/22/2013	21:30:00	WIND	PA	40.94	-78.98
5/22/2013	21:45:00	WIND	PA	40.63	-78.65
5/22/2013	22:00:00	WIND	PA	40.83	-78.44
5/22/2013	22:01:00	WIND	PA	40.46	-80.49
5/22/2013	22:04:00	WIND	PA	41.93	-78.49
5/22/2013	22:12:00	WIND	PA	40.51	-78.07
5/22/2013	22:21:00	WIND	PA	41.02	-78.44
5/22/2013	22:25:00	WIND	PA	41.97	-78.19
5/22/2013	22:28:00	WIND	PA	40.86	-79.9
5/22/2013	22:30:00	WIND	PA	40.79	-77.86
5/22/2013	22:30:00	WIND	PA	40.99	-78.17
5/22/2013	22:39:00	WIND	PA	40.88	-77.81
5/22/2013	22:48:00	WIND	PA	40.71	-77.59
5/22/2013	23:05:00	WIND	PA	41.14	-77.45
5/22/2013	23:20:00	WIND	PA	40.42	-77.19
5/22/2013	23:25:00	WIND	PA	41.4	-76.97
5/22/2013	23:35:00	WIND	PA	41.66	-76.85
5/22/2013	23:41:00	WIND	PA	41.34	-77.35
5/22/2013	23:45:00	WIND	PA	40.49	-77.13
5/22/2013	23:53:00	WIND	PA	41.78	-76.79

Table 1 Listing of severe weather in Pennsylvania by date, time, type, state, latitude and longitude. Return to text.

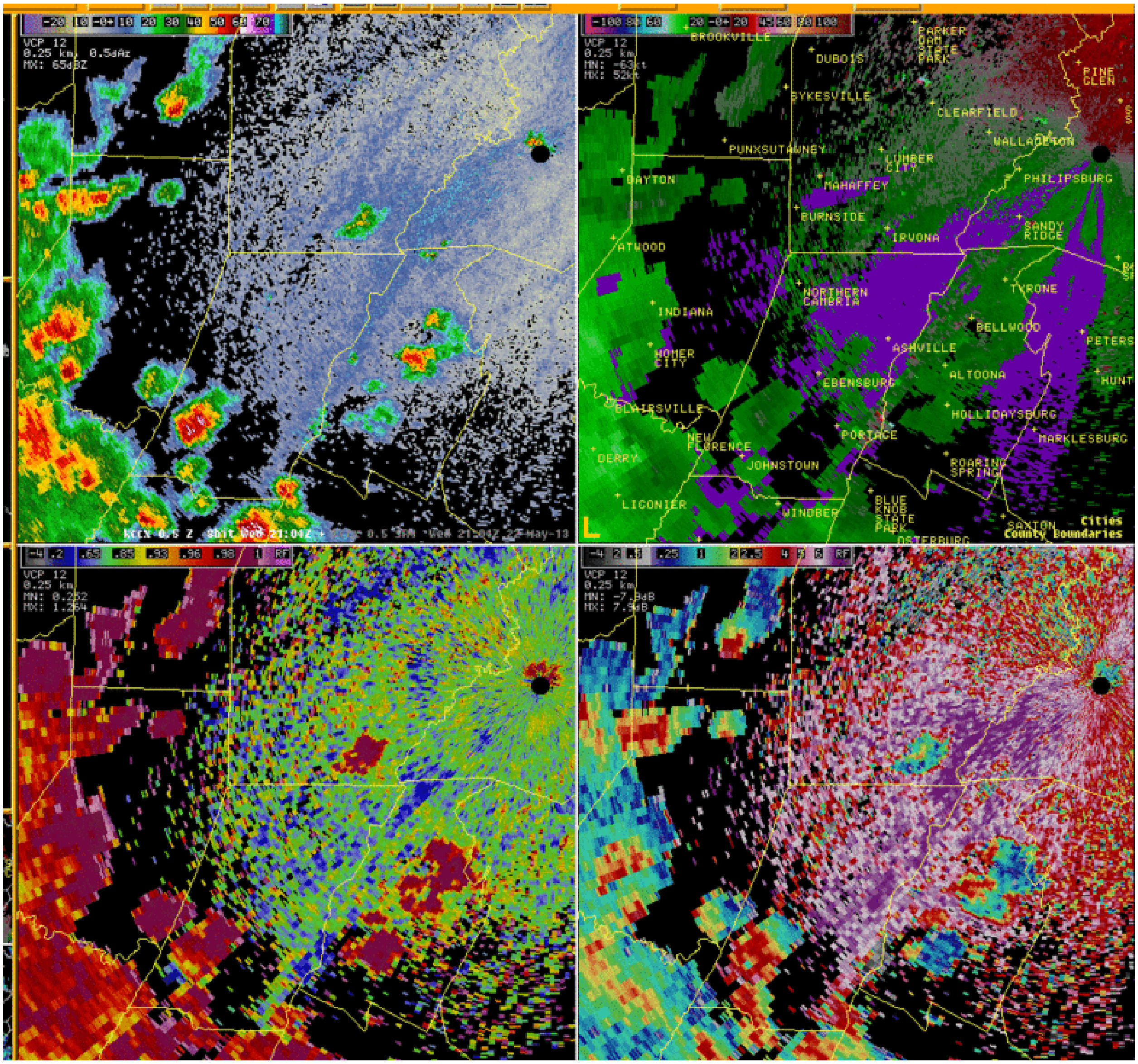

Figure 13 Loop of self contained data.

Speculative: not in text: The long-lived nature of this system may relate to the flow. As shown in Figure 4, the 850 hPa flows and the direction of the bow echo movement may have produced an ideal balance between the shear and the cold, thus cold pool aiding in maintaining the cold pool for over 4 hours. The strong southwest flow and northeastward movement of the bow suggest a balance may have been achieved in this case. Rotunno et al. (1988) developed the concept of the balance of the wind shear and the cold pool, referred to as RKW theory. The balance of the shear if sufficiently large and produce a balance allowing for a strengthening cold pool. A strong cold pool helps maintain upright convection along the leading edge of the cold pool and the generation of strong rear inflow jet (RIJ). In this case the 0-1.5 km shear was over 30 kts from the southwest and there was deep southwesterly shear in the 0-3km layer (Fig. 6).