Composite Analysis of Cool-Season Severe Weather Outbreaks in the Lower Ohio Valley

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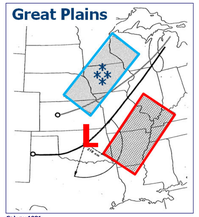
Introduction

- According to Brooks et al. (2000 & 2003), severe weather in the Ohio Valley is most frequent in the spring and summer months.
- However, cool-season severe weather events, while rare, are capable of posing a significant forecast challenge due to limited research on these events and their associated environments.
- One avenue of research is to examine the climatology of cool-season severe weather outbreaks and their attending environmental conditions to provide situational awareness and impact potential.
- Previous research such as Beebe (1956), Glass et al. (1995), Bierly and Winkler (2001), Moore et al. (2003), and Thomas and Martin (2007) have shown the effectiveness of a composite analysis approach to diagnose the synoptic and mesoscale phenomena associated with certain weather events.
- In this presentation, cool-season severe weather outbreaks that affected the Lower Ohio Valley over a 29-year period are analyzed using composite fields to illustrate the evolution of common features.



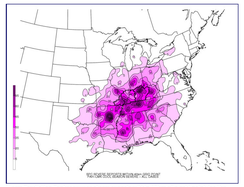
Galway 1981

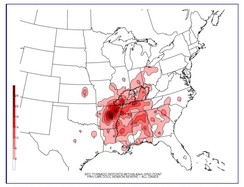
Methodology

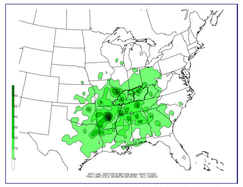
- An examination of Storm Prediction Center storm reports revealed 96 events containing at least 1 storm report (tornado, wind, or hail) for that day in the cool season (November-February) in the Paducah, KY (PAH) and Louisville, KY (LMK) NWS CWAs between 1980 and 2008.
- An outbreak was classified as an event containing 6 or more storm reports. Of the 96 events, 41 events were classified as outbreaks. Of the 41 outbreaks, 38 outbreaks contained at least 1 wind report, 29 outbreaks contained at least 1 hail report, and 24 outbreaks contained at least 1 tornado report.
- Using the General Meteorological Package (GEMPAK) with the North American Regional Reanalysis (NARR), system-relative composites were generated using software developed by Saint Louis University.
- An initial analysis time (t=0h) for each outbreak was defined as the time at which the cold front was on the western edge of the storm reports. It was assumed that the cold front was associated with the initiation of convection and resultant severe weather (Smith et al. 2008).
- The locations of the 925-mb lows for the 32 events (9 events were omitted because the 925-mb circulation was undefinable) were used as the center of the compositing grid.
- In order to track the progression of the system, the locations of the 925-mb lows were also used to generate system relative composites at t=-6h and t=+6h.

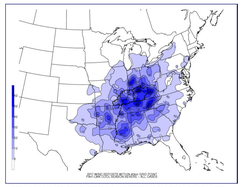
Characteristics of Cool-Season Severe Weather Events in PAH and LMK

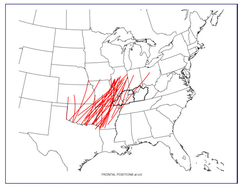

Storm Prediction Center severe storm reports for the 96 cool-season severe weather events impacting the PAH & LMK CWAs.


Storm Prediction Center severe storm reports within 40km of a grid point for the 96 cool-season severe weather events impacting the PAH & LMK CWAs.

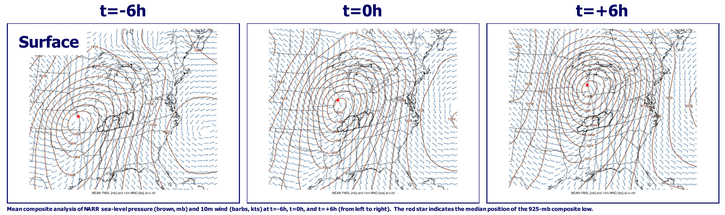

Storm Prediction Center tornado reports within 40km of a grid point for the 96 cool-season severe weather events impacting the PAH & LMK CWAs.


Storm Prediction Center hail reports within 40km of a grid point for the 96 cool-season severe weather events impacting the PAH & LMK CWAs.

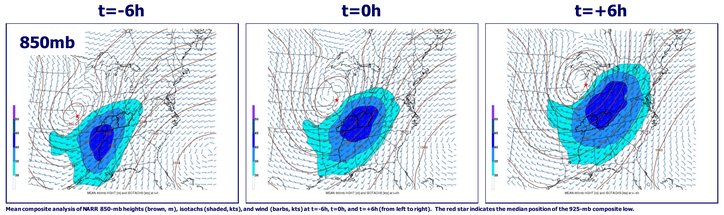

Storm Prediction Center wind reports within 40km of a grid point for the 96 cool-season severe weather events impacting the PAH & LMK CWAs.


Cold front positions at t=0h for the 32 outbreaks used in the compositing analysis.

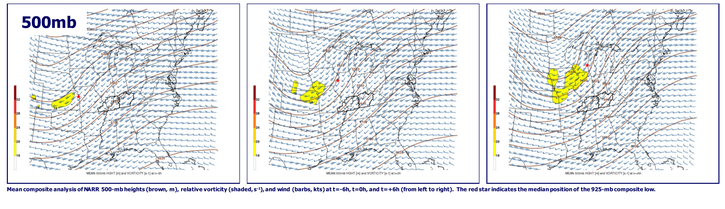
Synoptic-Scale Composites



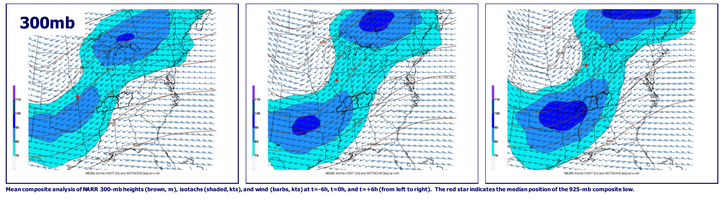
Mean composite analysis of NARR sea-level pressure (brown, mb) and 10m wind (barbs, kts) at t=-6h, t=0h, and t=+6h (from left to right). The red star indicates the median position of the 925-mb composite low.



Mean composite analysis of NARR 850-mb heights (brown, m), isotachs (shaded, kts), and wind (barbs, kts) at t=-6h, t=0h, and t=+6h (from left to right). The red star indicates the median position of the 925-mb composite low.

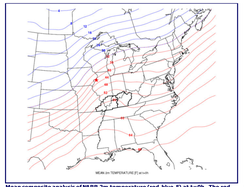


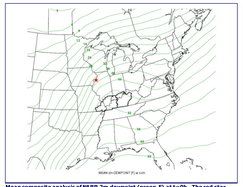
Mean composite analysis of NARR 500-mb heights (brown, m), relative vorticity (shaded, s^{-1}), and wind (barbs, kts) at t=-6h, t=0h, and t=+6h (from left to right). The red star indicates the median position of the 925-mb composite low.

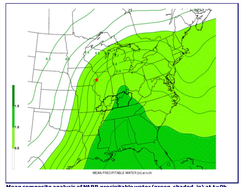


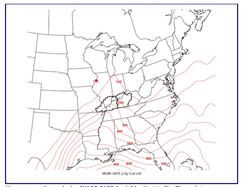
Mean composite analysis of NARR 300-mb heights (brown, m), isotachs (shaded, kts), and wind (barbs, kts) at t=-6h, t=0h, and t=+6h (from left to right). The red star indicates the median position of the 925-mb composite low.

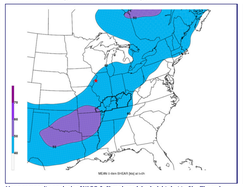
Severe Weather Composite Fields at t=0h

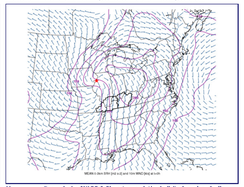

Mean composite analysis of NARR 2m temperature (red, blue, F) at t=0h. The red star indicates the median position of the 925-mb composite low.


Mean composite analysis of NARR 2m dewpoint (green, F) at t=0h. The red star indicates the median position of the 925-mb composite low.

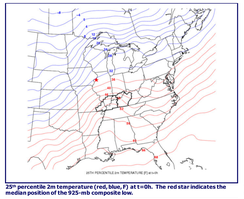

Mean composite analysis of NARR precipitable water (green, shaded, in) at t=0h. The red star indicates the median position of the 925-mb composite low.

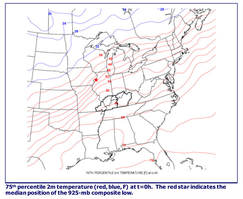

Mean composite analysis of NARR CAPE (red, J kg^{-1}) at t=0h. The red star indicates the median position of the 925-mb composite low.

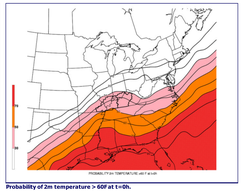

Mean composite analysis of NARR 0-6km shear (shaded, kts) at t=0h. The red star indicates the median position of the 925-mb composite low.

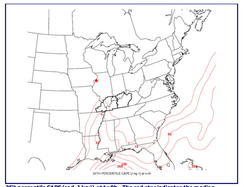

Mean composite analysis of NARR 0-3km storm relative helicity (purple, m^2 s^{-2}) and 10m wind (barbs, kts) at t=0h. The red star indicates the median position of the 925-mb composite low.

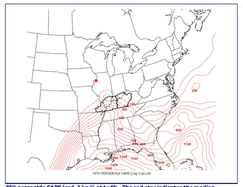
Temperature and Instability Statistics at t=0h

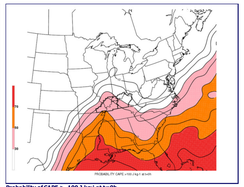

25th percentile 2m temperature (red, blue, F) at t=0h. The red star indicates the median position of the 925-mb composite low.


75th percentile 2m temperature (red, blue, F) at t=0h. The red star indicates the median position of the 925-mb composite low.


Probability of 2m temperature > 60F at t=0h.


25th percentile CAPE (red, J kg^{-1}) at t=0h. The red star indicates the median position of the 925-mb composite low.


75th percentile CAPE (red, J kg^{-1}) at t=0h. The red star indicates the median position of the 925-mb composite low.


Probability of CAPE > 100 J kg^{-1} at t=0h.

Conclusions

- The composite analysis depicts features and their evolution that are representative of a typical event.
- A classic developing mid-latitude cyclone moves through the Upper Mississippi River Valley accompanied by mid-level and upper-level support.
- Abundant mid-level and low-level shear is present.
  - 50 to 60 kts mid-level jet streak (500mb).
  - 0-6km shear magnitude of approximately 50 kts.
  - 850-mb low-level jet of approximately 40 kts.
  - 0-3km storm relative helicity greater than 250 m^2 s^{-2}.
  - 0-1km shear magnitude of approximately 30 kts.
  - Surface winds suggest strong 0-1km storm relative helicity (SSE at t=-6h to S at t=0h; currently unavailable).
- Marginal CAPE nosing into the area of interest (300 J kg^{-1}).
- Anomalous moisture present at the surface (dewpoints ~50F) and through the troposphere (PWs exceeding 200% of normal).