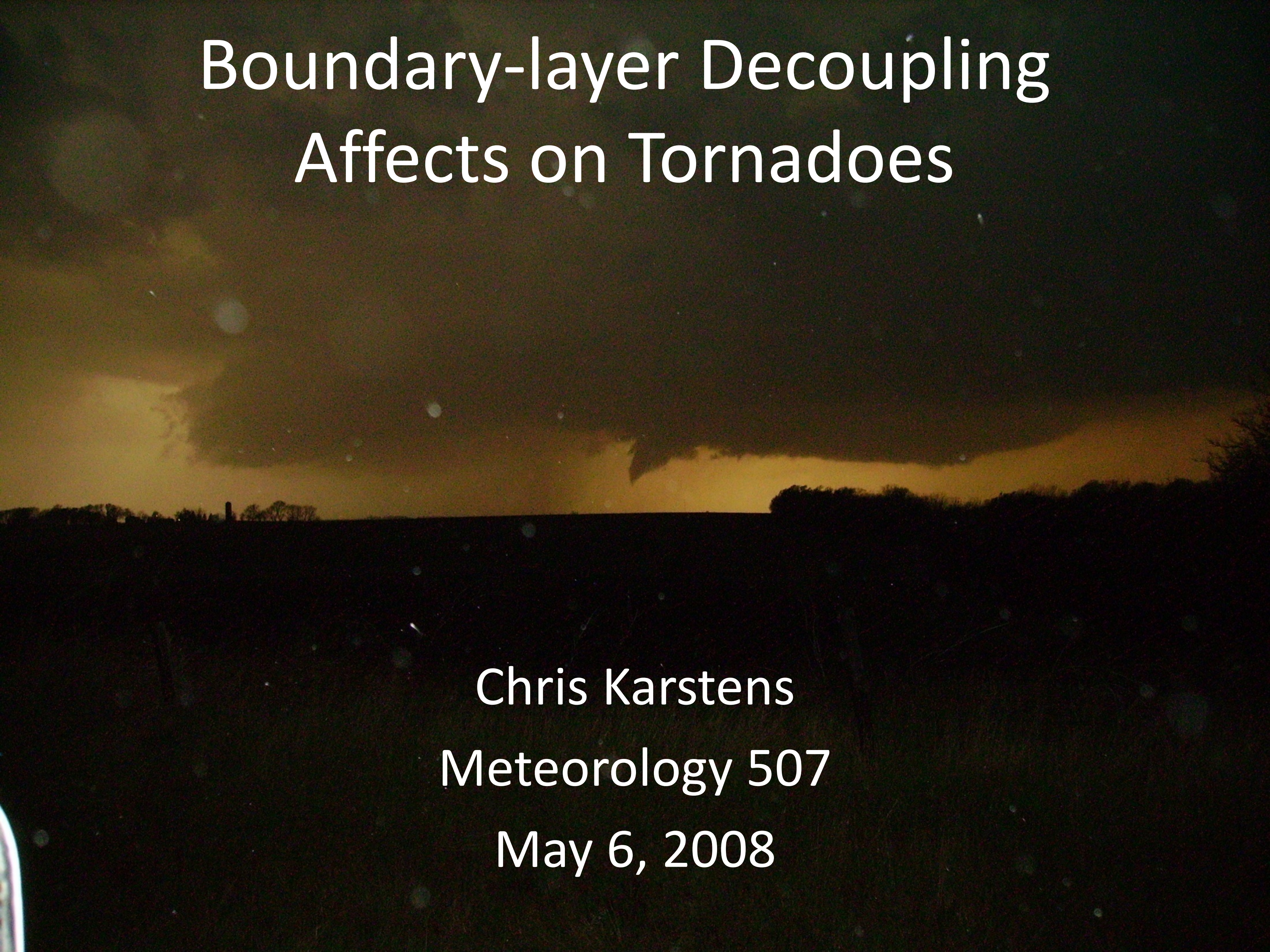

Boundary-layer Decoupling Affects on Tornadoes

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Meteorology 507

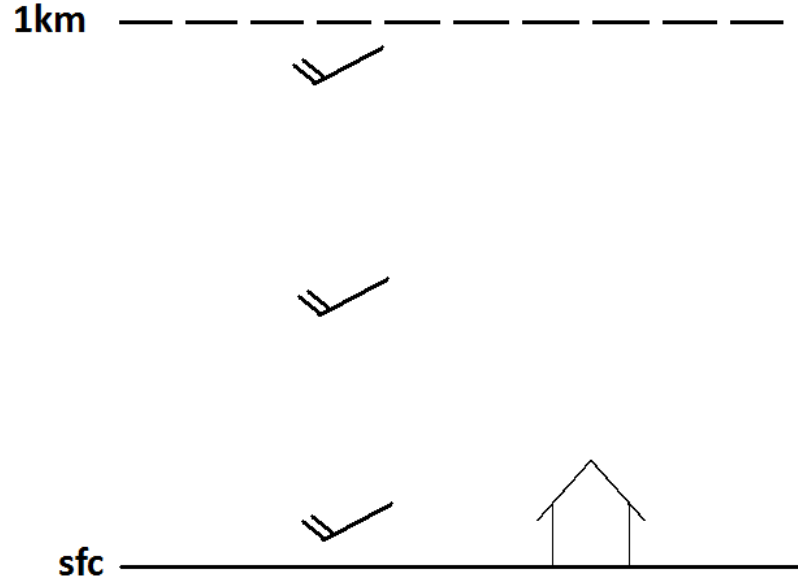
May 6, 2008

Outline

- Background
- Motivation
- Methodology
- Results
- Conclusions
- References
- Questions

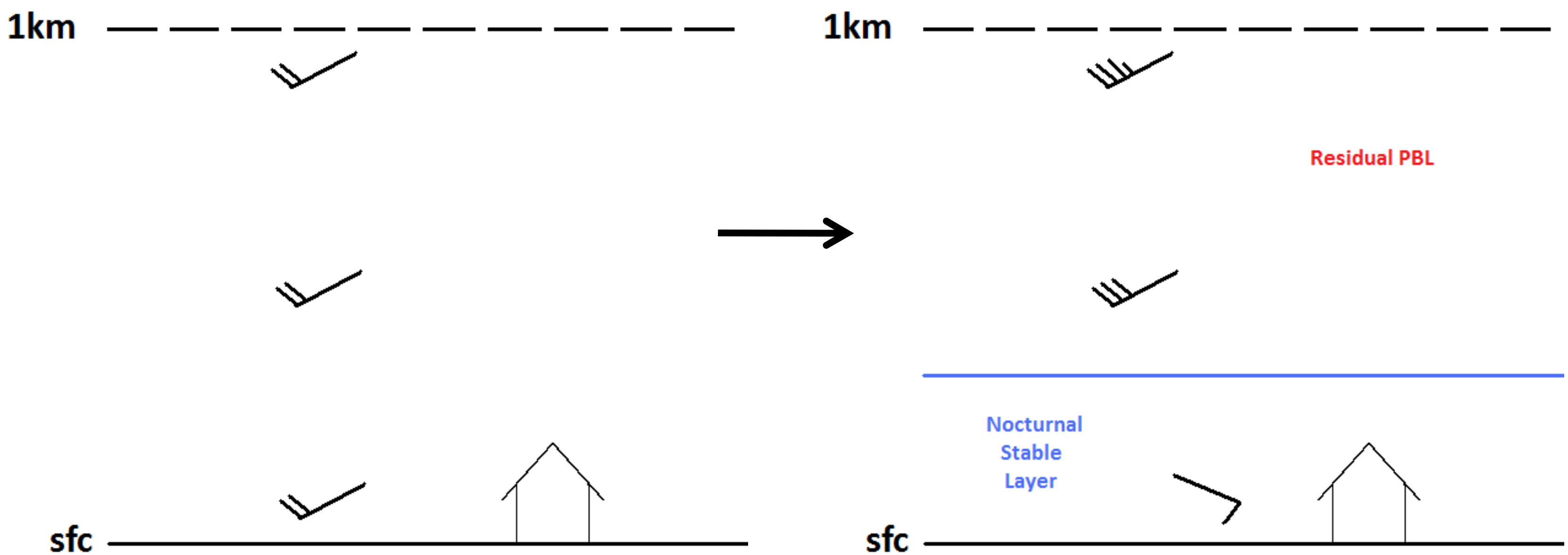
Background

- Blackadar (1957).
  - Solar heating causes the PBL to become well mixed.
  - Vertical transport of momentum, sub-geostrophic winds.
  - About 1 hour prior to sunset, net upward radiation flux reduces to zero.
  - Nocturnal stable layer forms, decoupling the residual PBL from the surface.



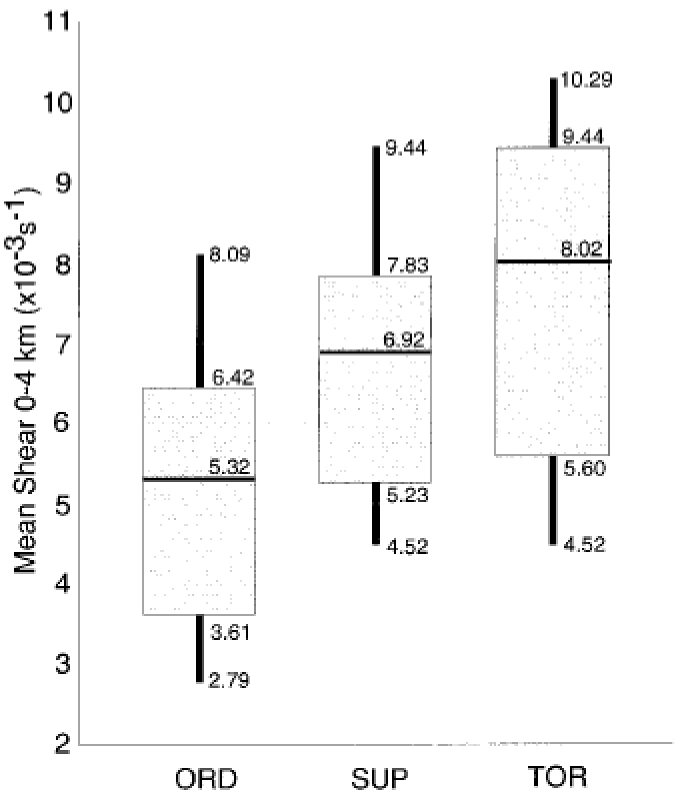
Background

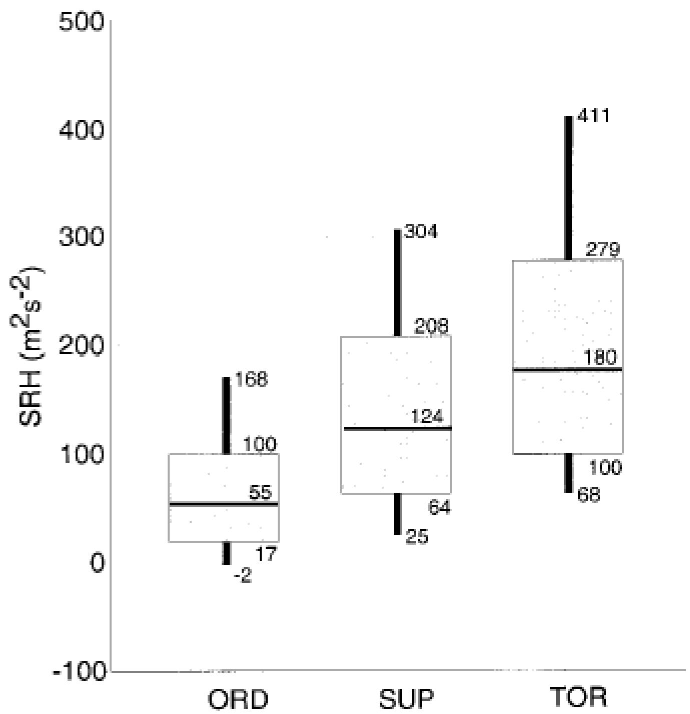
- The residual PBL is allowed to acceleration toward geostrophic balance through an inertial oscillation.
  - Forms the low-level jet.
- The effect of friction in the nocturnal stable layer is enhanced.
  - Increases the ageostrophic component of the wind.



Background

- Storms developing in environments with large low-level shear values have a higher probability for producing tornadoes (Rasmussen and Blanchard, 1998).

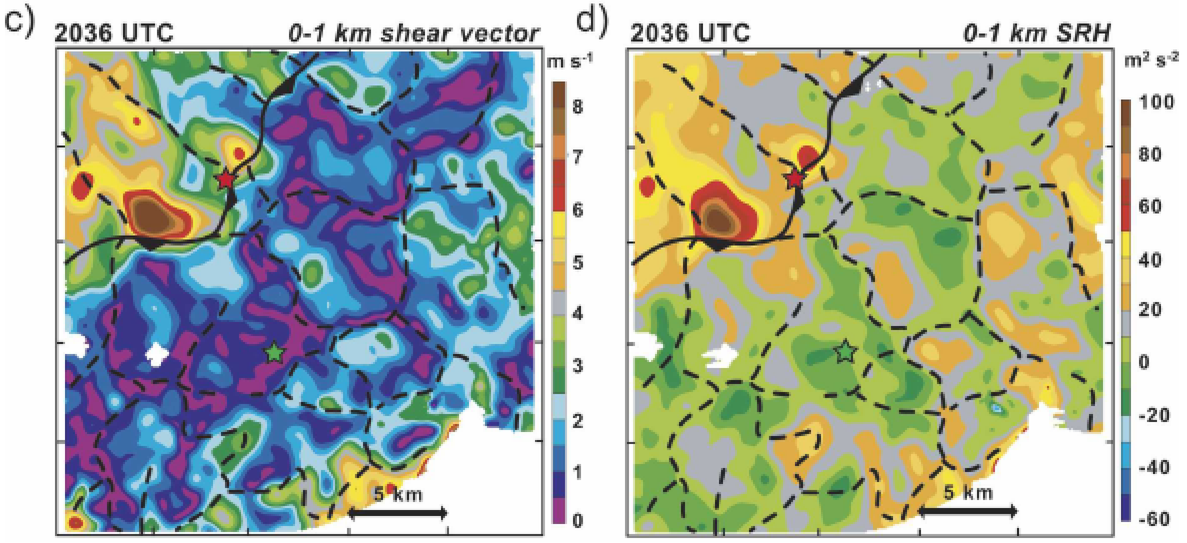




(Rasmussen and Blanchard, 1998)

Background

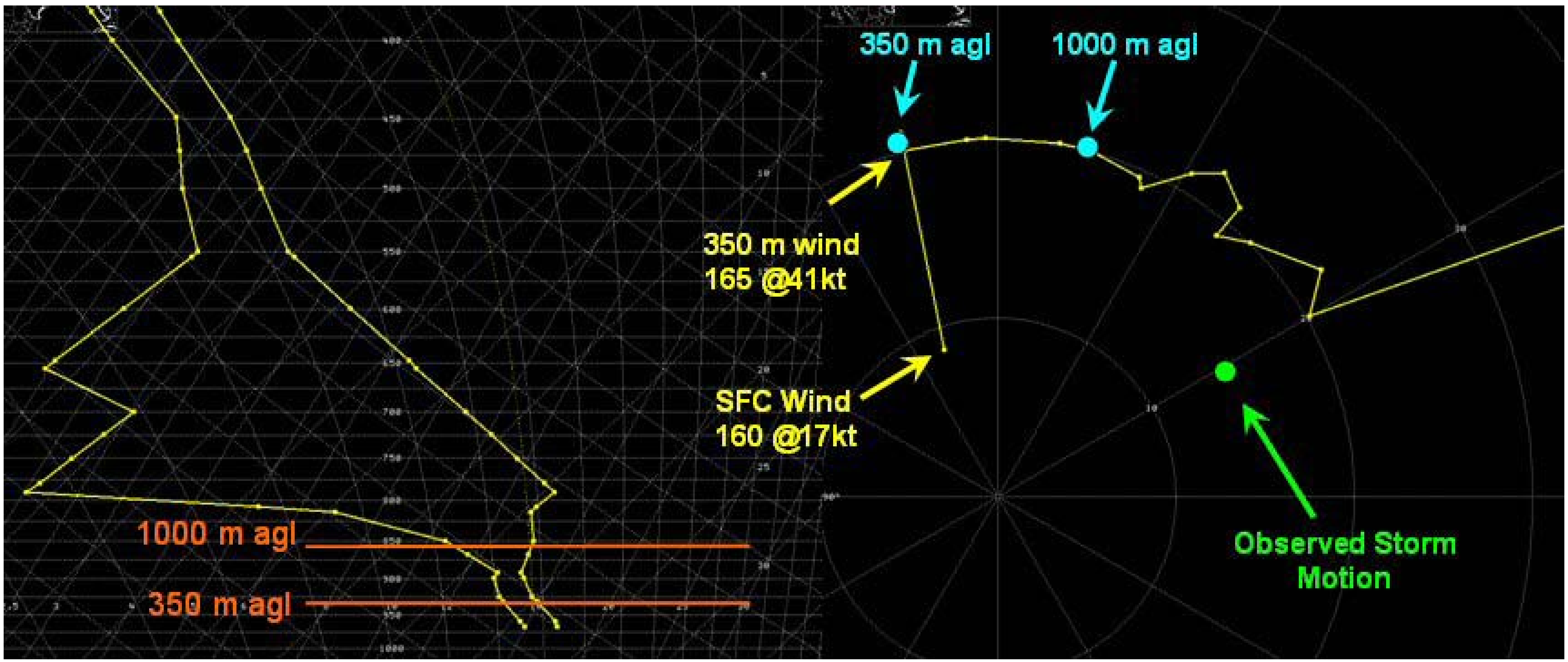
- Large spatial and temporal fluctuations in SRH can exist in the near-storm environment (Markowski et al., 1998).
  - Might offer an explanation as to why some storms produce tornadoes and why other do not.



(Markowski and Richardson, 2007)

Background

- Hodograph structures from proximity soundings near significant tornadoes show similarities (Thompson and Edwards, 2000)(Miller, 2006).
  - Kink in the hodograph, giving it a “sickle shape”.



(Miller, 2006)

Motivation

- The onset of the low level jet could rapidly alter an environment toward becoming more favorable for producing tornadoes.
- Is there any evidence of this phenomena?
  - Historical tornado reports.
  - Observed and model soundings.

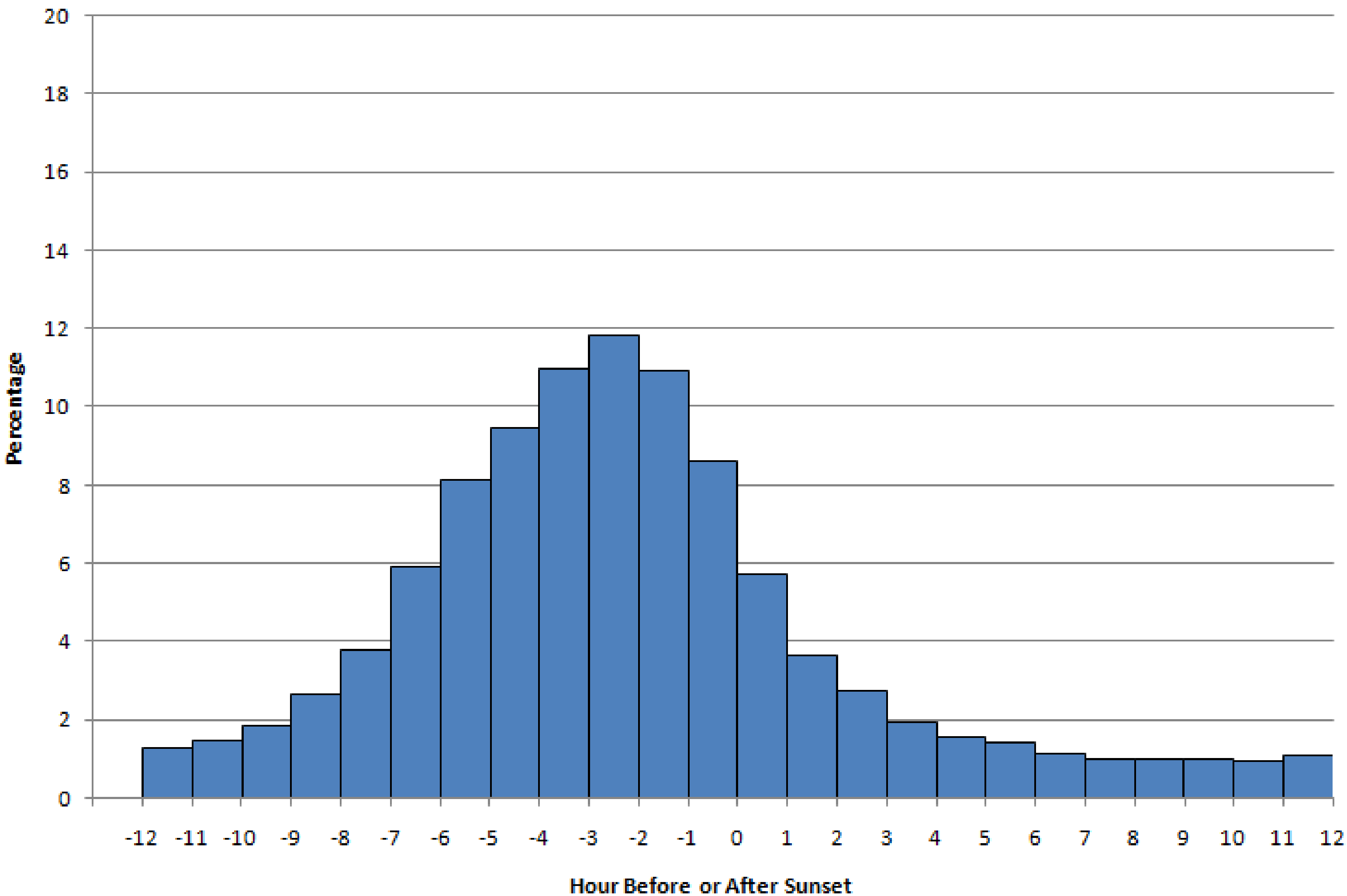
Methodology

- Analysis of the historical tornado records.
  - Each report has the location, latitude and longitude, the date, and the time (CDT) recorded.
  - Using the lat, lon, & the date, the sunset for each location could be determined.
  - This was used to normalized the reports.
    - 0 = sunset
    - -12 to 0 = before sunset
    - 0 to 12 = after sunset
  - Distributions were then constructed.
  - Represented in ArcGIS, by CWA's.

Methodology

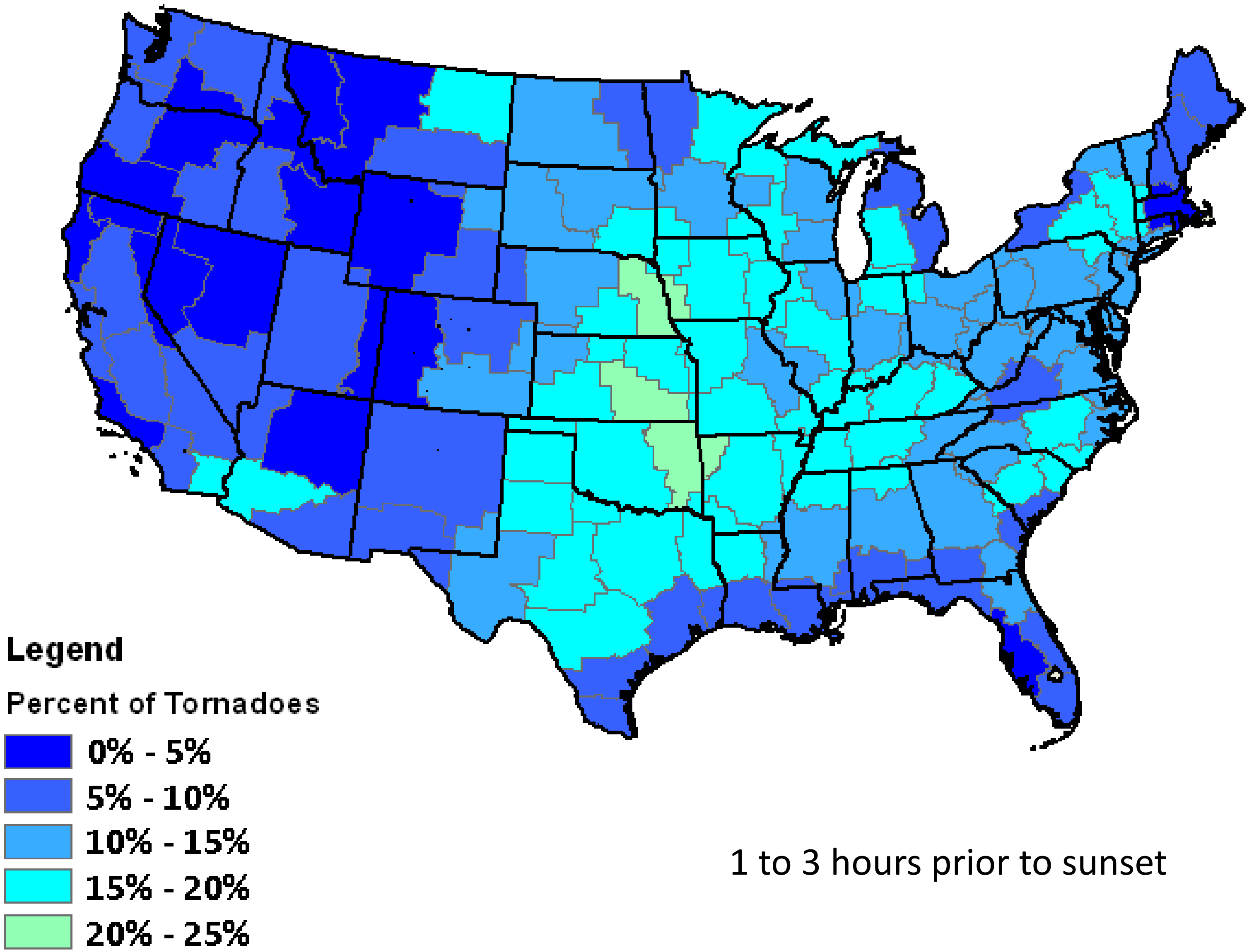
- Analysis of proximity soundings.
  - February 5, 2008 outbreak.
  - Analysis of 18 UTC and 00 UTC radiosondes.
    - How the environment changed leading up to the event.
  - Analysis of RUC and NAM model soundings.
    - The model's depiction of how the environment changed.
  - Hodographs from each sounding type are used to analyzed the low-level shear.

Results



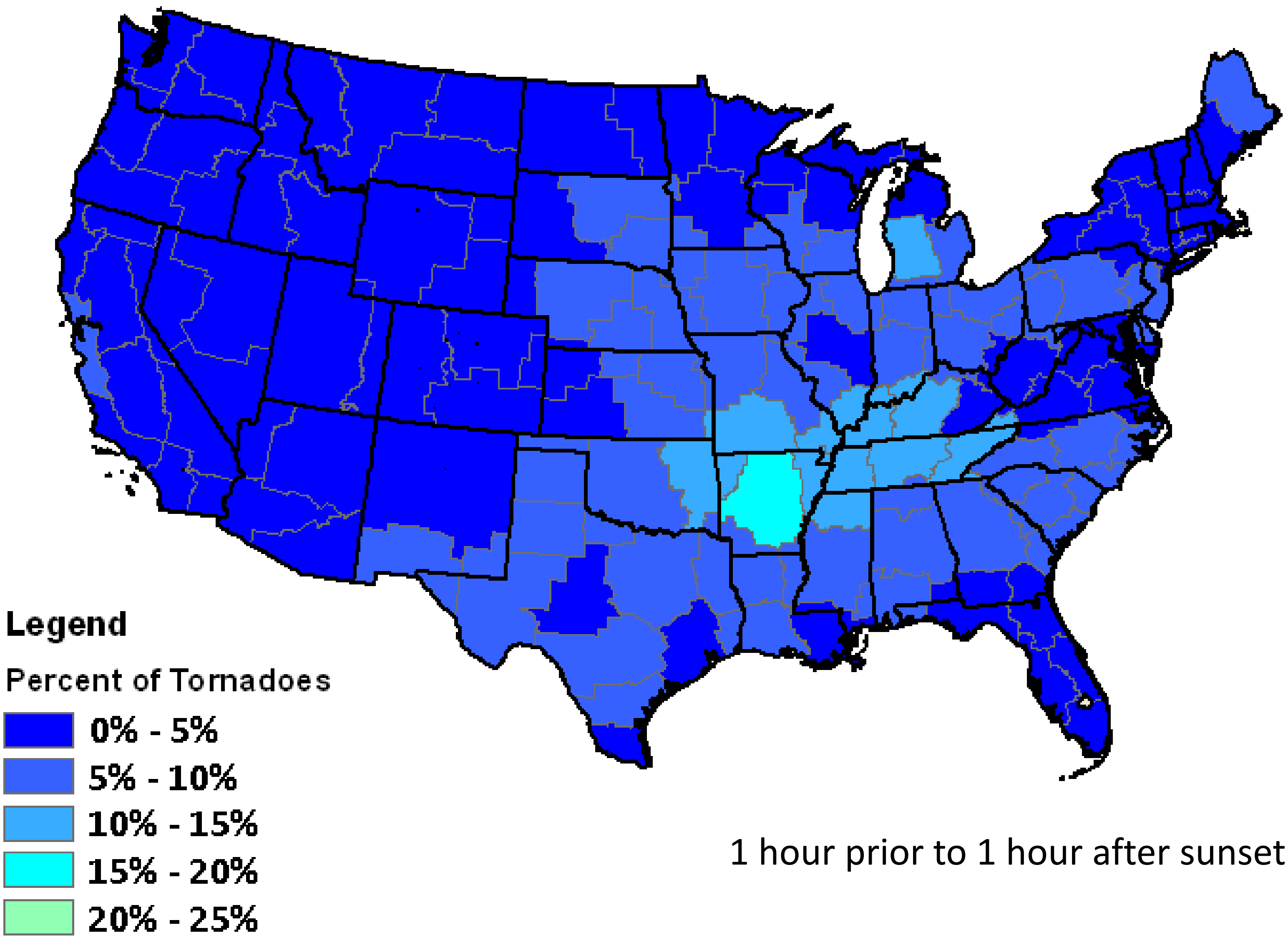
Distribution of all tornado reports, normalized to sunset

Results



1 to 3 hours prior to sunset

Results

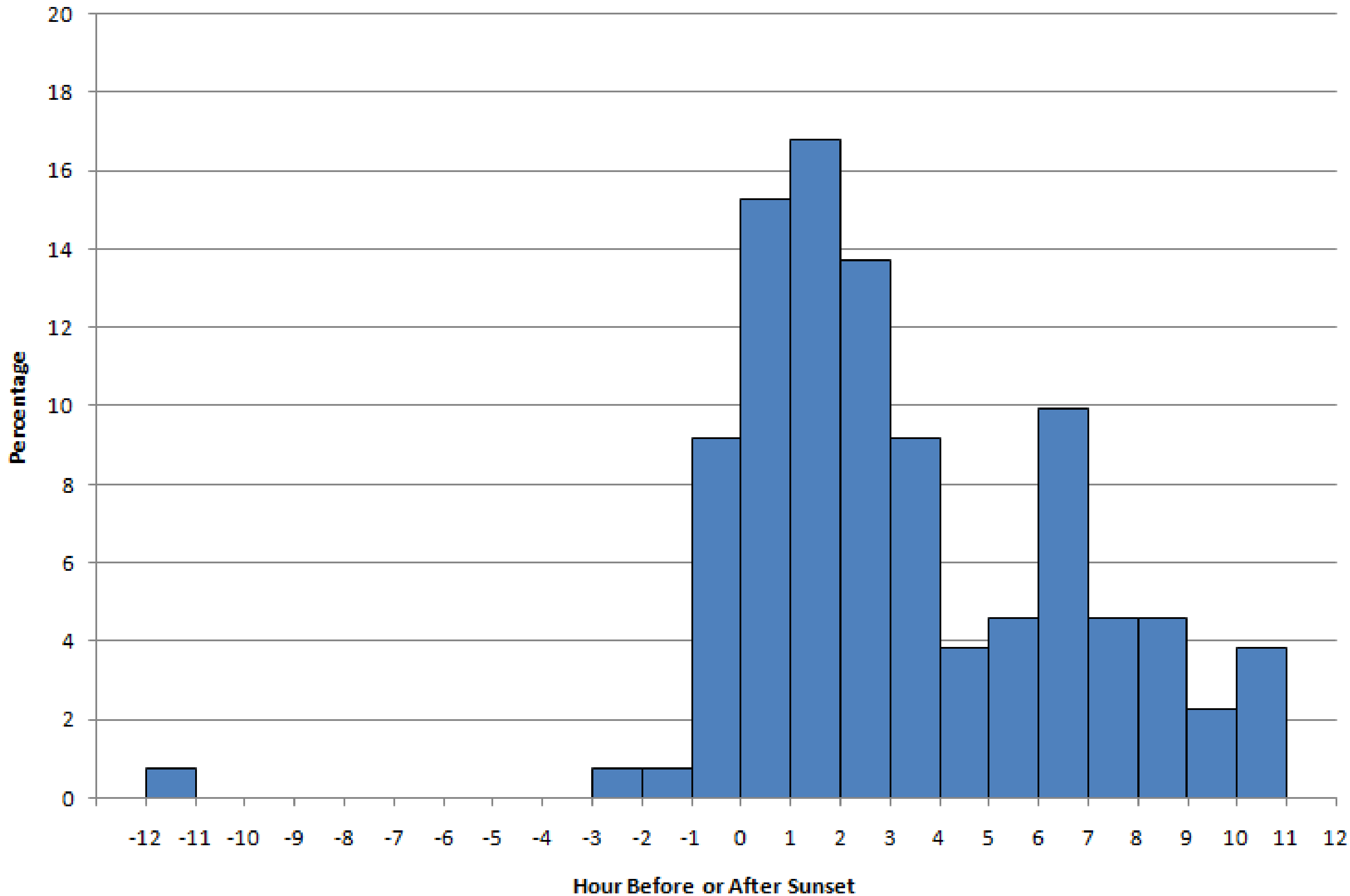


1 hour prior to 1 hour after sunset

Conclusions

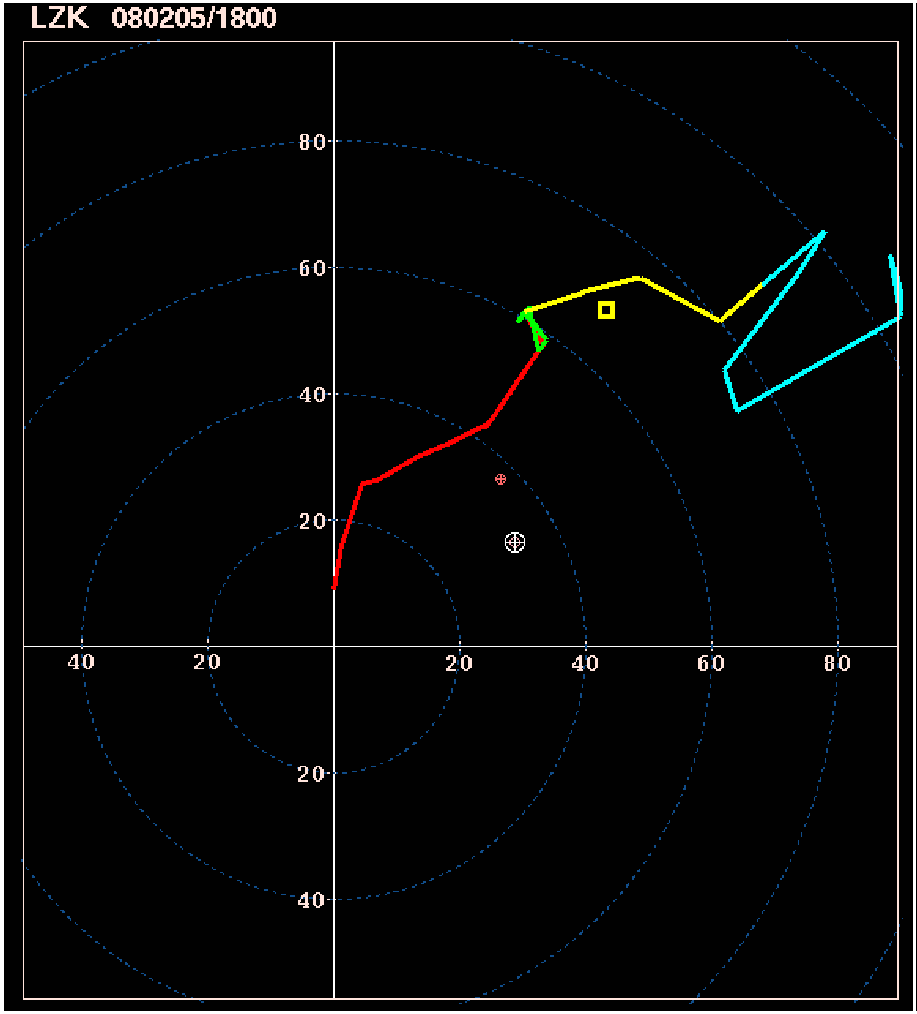
- No apparent increase in the number of reports coincides with the time when the boundary layer decouples from the surface.
  - Opposite trend is apparent.
  - Coincides with peak solar heating.
- A significant number of reports occur after peak solar heat.
  - Further investigation.

Results

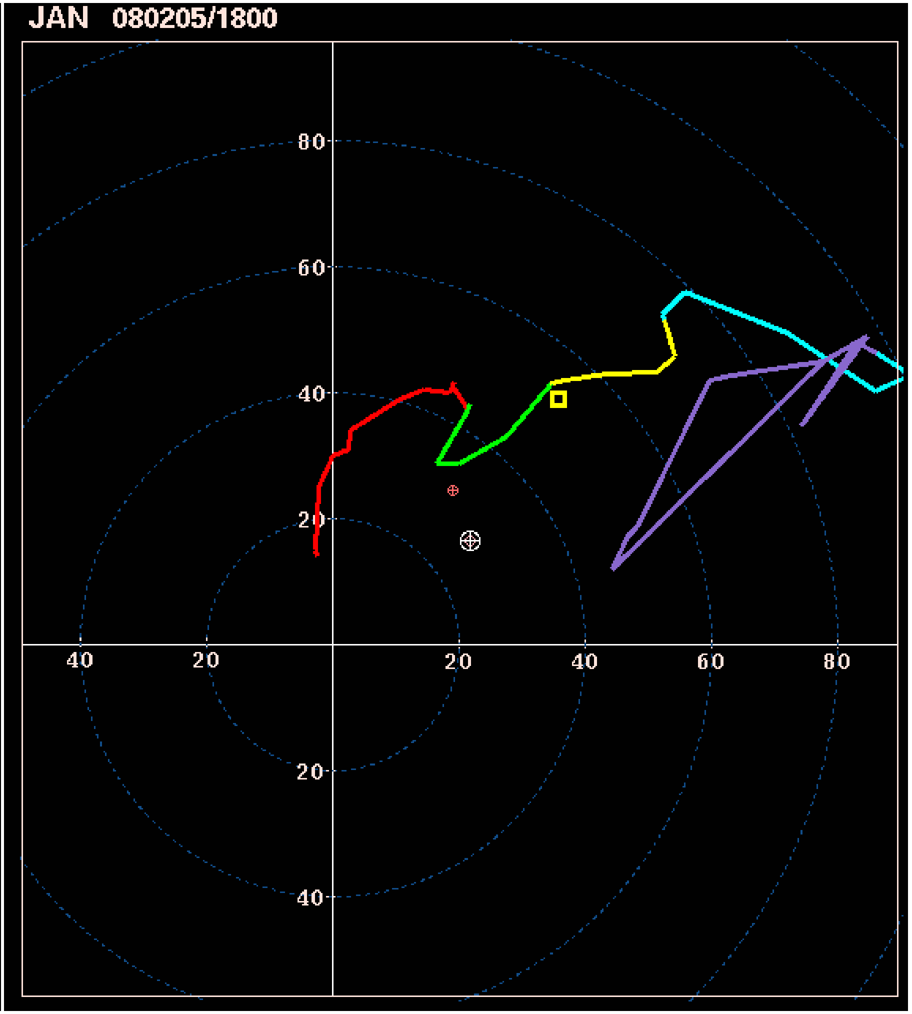


Distribution of Feb. 5, 2008 tornado reports, normalized to sunset

Results

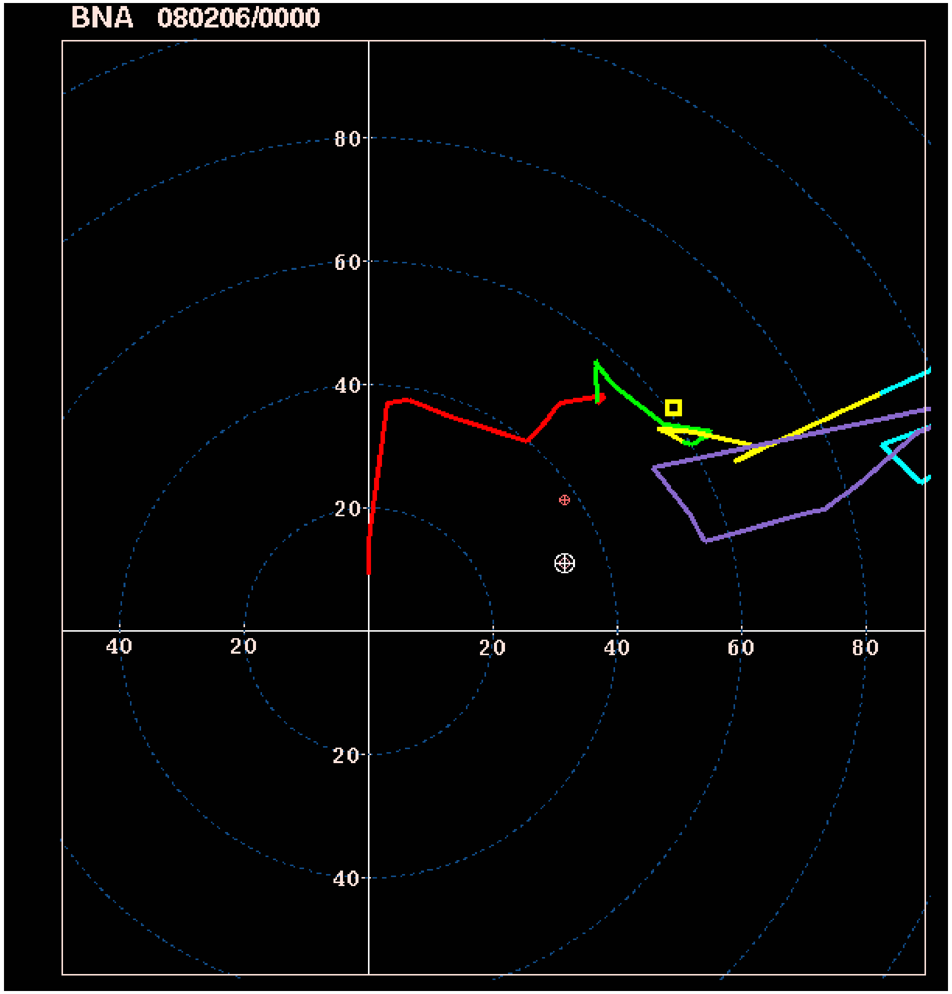


Little Rock, AR – 18 Z



Jackson, MS – 18 Z

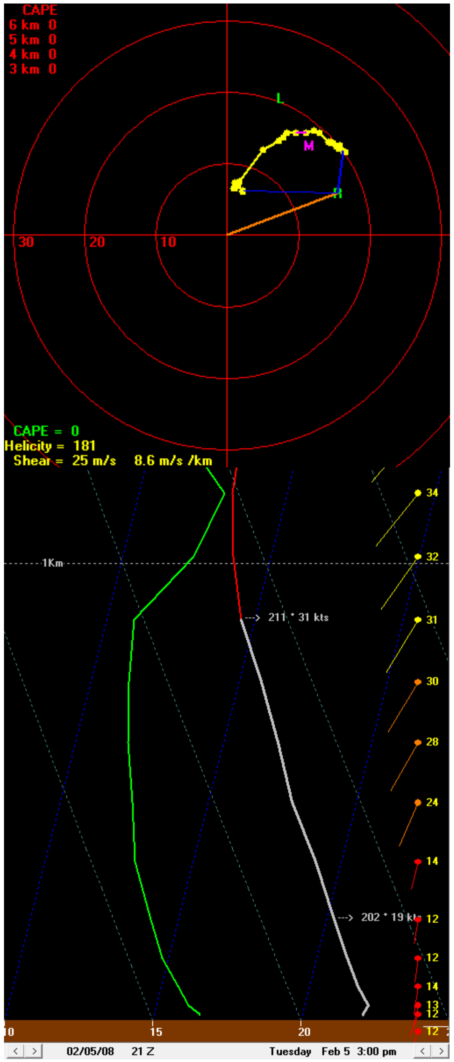
Results



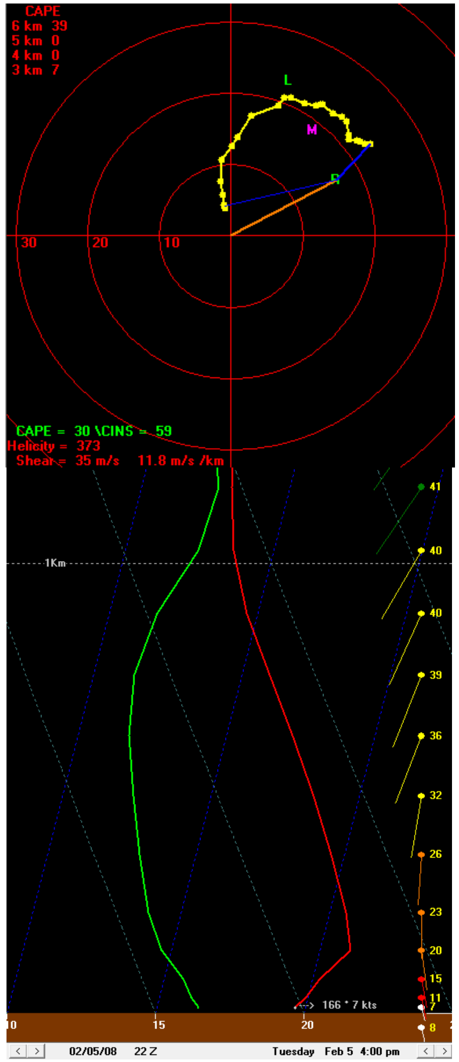
Nashville, TN – 00 Z

Results

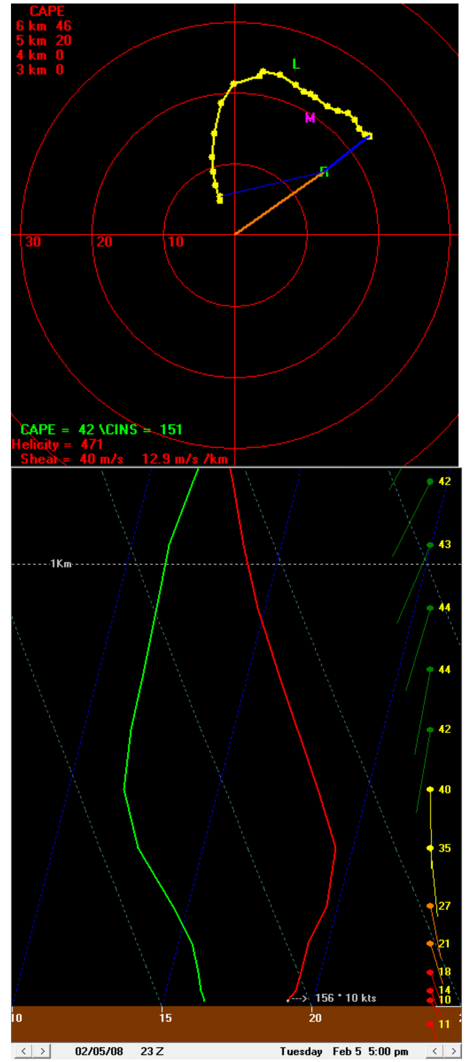
Nashville, TN – 21 Z RUC



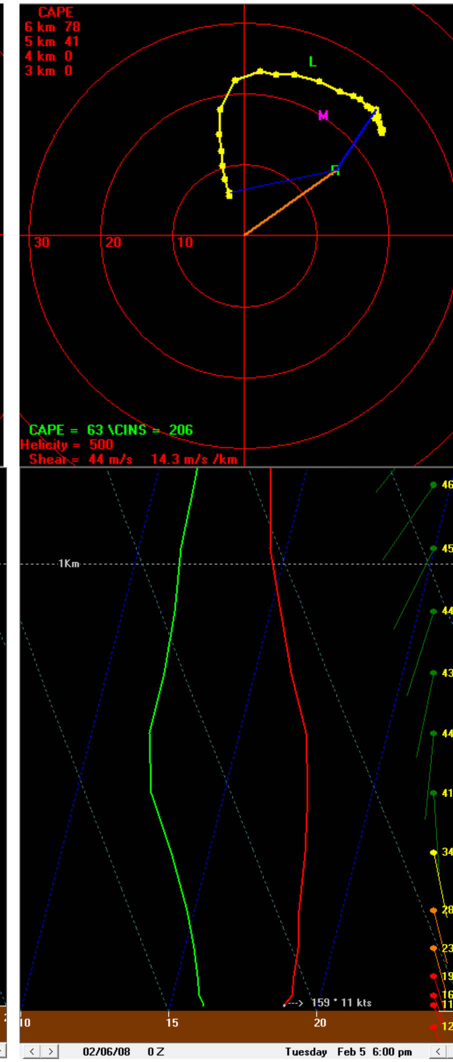
21 UTC



22 UTC



23UTC



00 UTC

Conclusions

- Analysis of proximity soundings show supporting evidence that boundary layer decoupling could be rapidly enhancing low-level shear.
  - Could offer a possible explanation as to why the environment suddenly changes in favor of producing tornadoes.
  - Might be particularly true for storms residing in the warm sector, where the Blackadar (1957) analytical solution of the low-level jet is valid.
- A sickle-shape hodograph is noted, but could be completely coincidental.

References

Blackadar, A. K., 1957: Boundary layer wind maxima and their significance for the growth of nocturnal inversions, *Bull. Amer. Meteor. Soc.,* **38,** 282-290.

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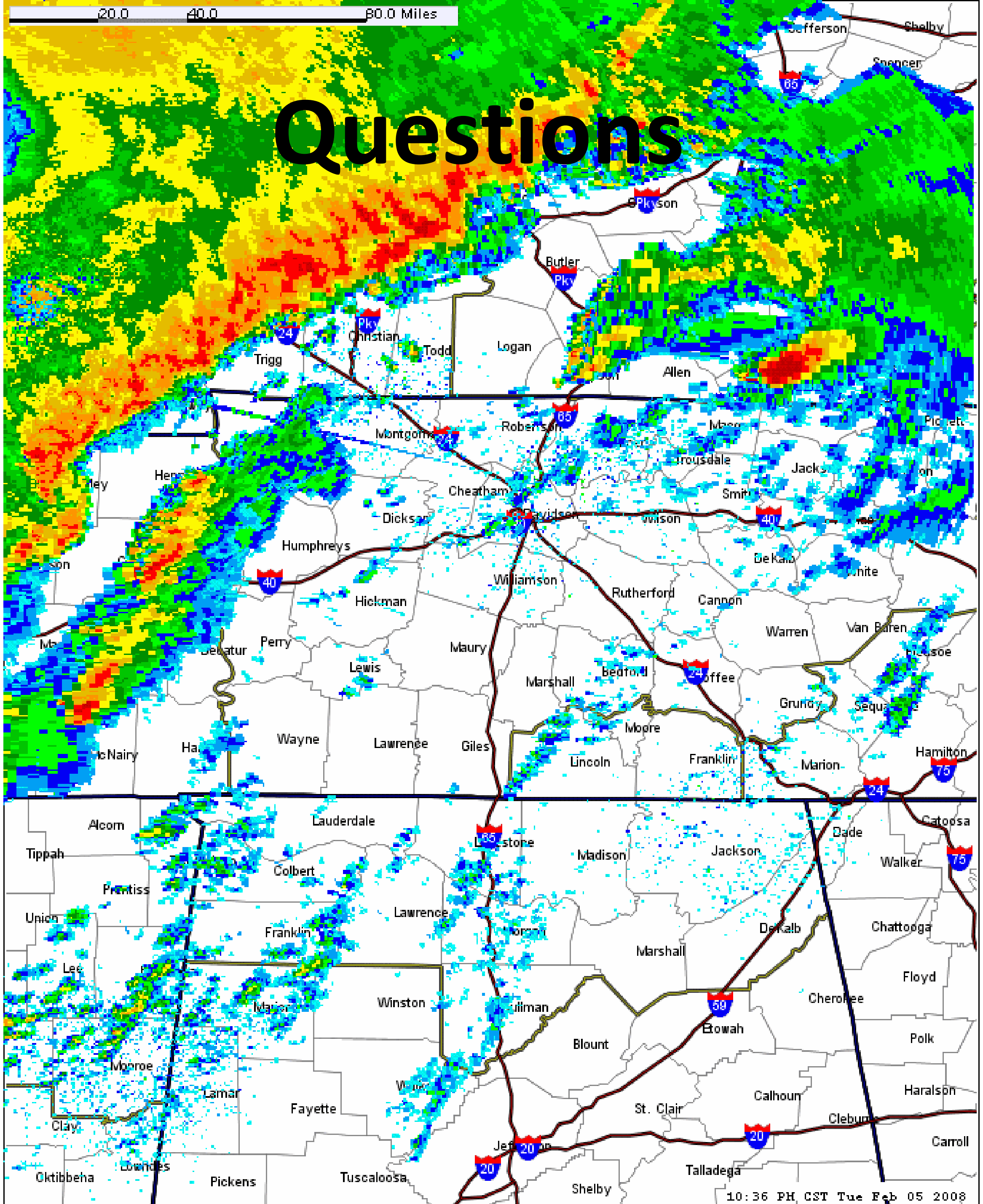
Rasmussen, E. N. and D. O. Blanchard, 1998: A baseline climatology of sounding-derived supercell and tornado forecast parameters. *Wea. Forecasting,* ***13,*** *1148–1164.*

Thompson, R.L., and R. Edwards, 2000: An overview of environmental conditions and forecast implications of the 3 May 1999 tornado outbreak. *Wea. Forecasting,* **15**, 682-699.

Questions



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Humphreys
DeKalb
Williamson
Rutherford
Cannon
Hickman
Warren
Van Buren
Perry
Maury
Lewis
Marshall
Bedford
Grundy
Moore
Wayne
Lawrence
Giles
Lincoln
Franklin
Marion
Hamilton
Alcorn
Lauderdale
Tippah
Madison
Jackson
Dade
Catoosa
Walker
Colbert
Prentiss
Union
Lawrence
Franklin
Dekalb
Chattooga
Marshall
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Floyd
Cherokee
Winston
Etowah
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