Boundary-layer Decoupling Affects on Tornadoes

Chris Karstens
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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

Legend
Percent of Tornadoes
- **Blue**: 0% - 5%
- **Dark Blue**: 5% - 10%
- **Light Blue**: 10% - 15%
- **Lighter Blue**: 15% - 20%
- **Green**: 20% - 25%
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

23 UTC

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


Miller, D. J., 2006: Observations of low level thermodynamics and wind shear profiles on significant tornado days, Preprints, *23rd Conference on Severe Local Storms*, Saint Louis, MO.

