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WSR-88D Observations of Mini-Supercells in Tropical Environments

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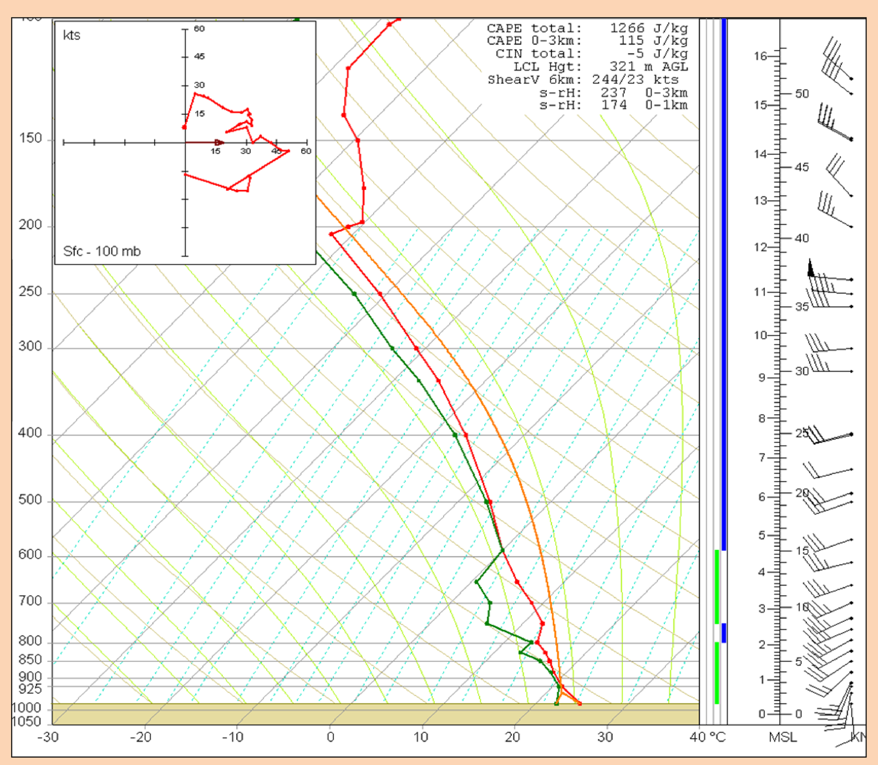
Introduction

Tornadic low-topped supercells, or mini-supercells, are a hazard to public safety and can pose significant challenges to the forecast and warning process. Tropical airmasses are a common environment for such storms especially in the vicinity of a tropical cyclone or its remnants. However, as described in Hawblitzel (2008), these environments can also occur in the middle latitudes without the presence of a tropical cyclone.

This preliminary radar study analyzes tornadic and non-tornadic mini-supercells in tropical environments using WSR-88D data. Because of the small horizontal and vertical extent of these storms, only storms within 60 nm of the radar were considered. This study focuses on small-scale signatures other than mesocyclone size and shape, which has been well sampled in other mini-supercell studies.

Seven cases were analyzed in this study. Two of these cases were near a tropical cyclone, and five were in the Midwest with no tropical cyclone or remnants present. A total of 34 storms were analyzed, 22 of which produced tornadoes. In all cases, mesocyclone depth was 4 km or less, a common characteristic of a mini-supercell.

Typical Tropical Environment



This observed sounding from Wilmington, OH was taken at 00Z 12 Jul 06, within one hour of tornadic mini-supercells developing nearby. It displays classic characteristics of a tropical mini-supercell environment such as:

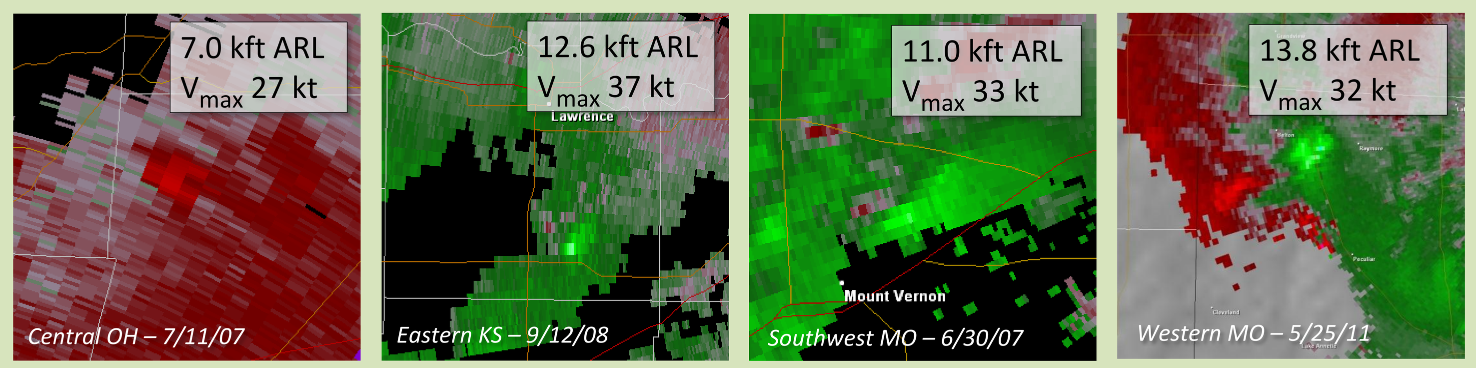
- Thin CAPE profile
- Deep moisture
- Horseshoe-shaped hodograph
- Low LCL heights

All environments in this study exhibited similar profiles.

Velocity Enhancement Signature

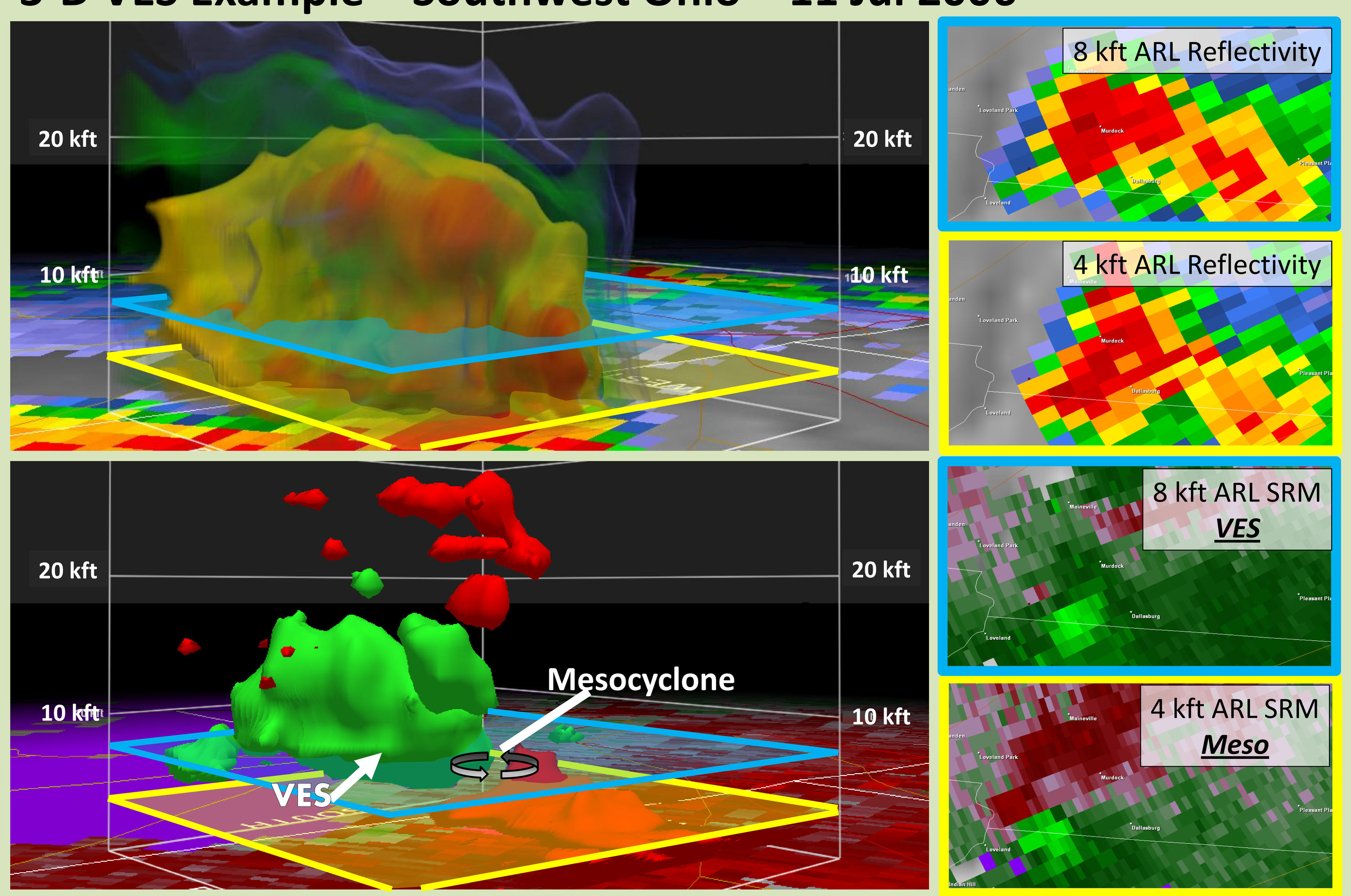
Schneider and Sharp (2007) documented a small area of radial velocity above the mesocyclones of several hurricane-spawned tornadic supercells over North Carolina, which they termed a velocity enhancement signature (VES). Similar signatures were found in almost all tornadic supercell cases analyzed in this study. In all cases the VES was located above the mesocyclone and within the mid-level precipitation core, typically between 2 and 4 km. The VES was directed toward the forward flank of each storm. The VES also appeared in many non-tornadic supercells in this study.

Velocity Enhancement Signatures - *Storm-Relative Velocity Images*

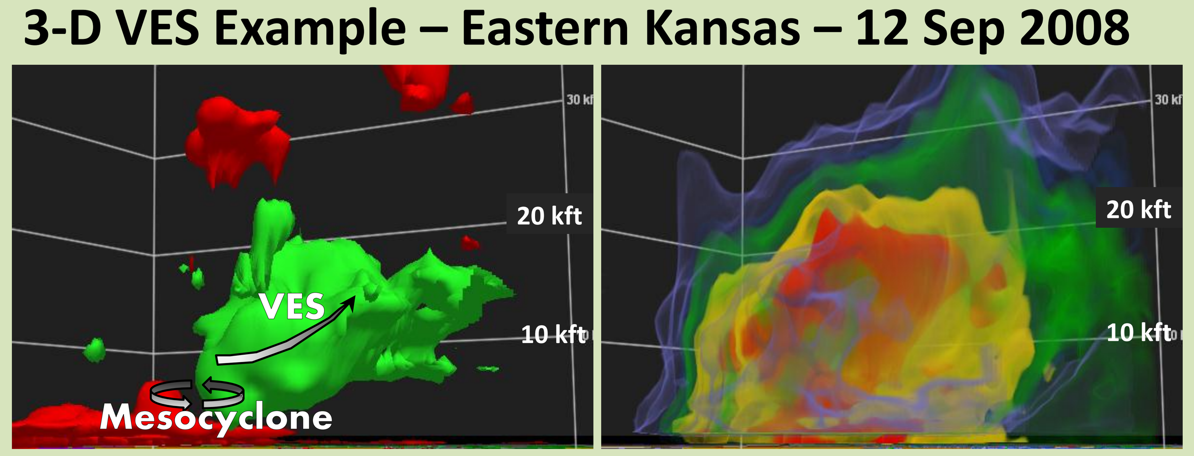


3-D views of reflectivity and the ±20-kt isostach of storm-relative velocity (below) show the VES as a forward-facing jet above the mesocyclone, directed into the precipitation core. The radar is located out of the board in the upper image and into the board in the lower image. Corresponding horizontal slices are shown on the right.

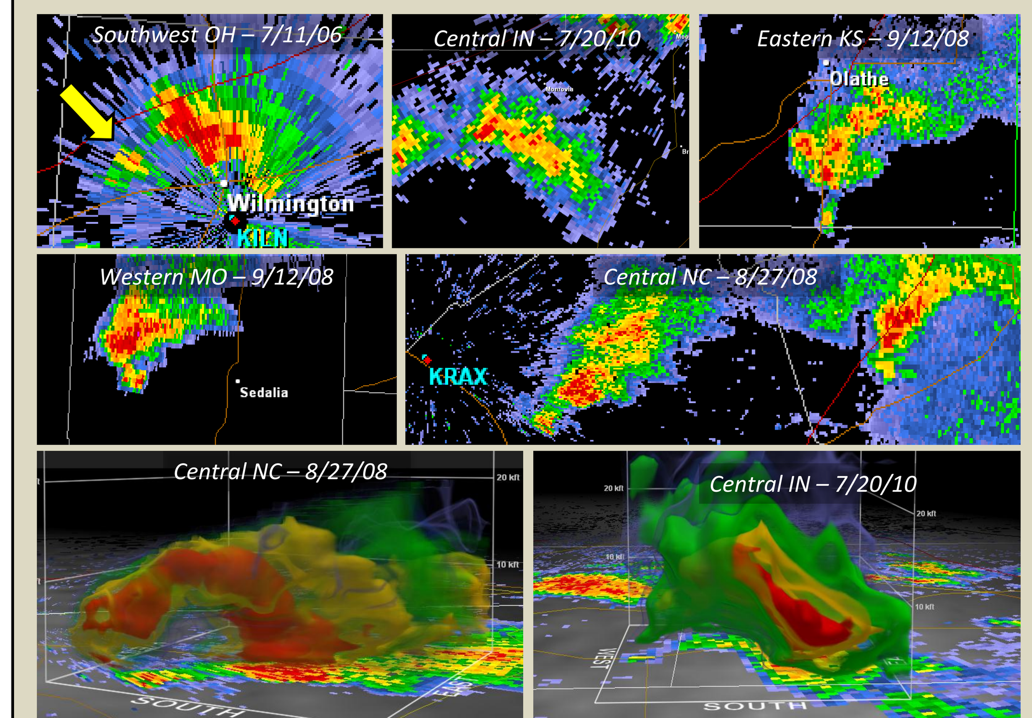
3-D VES Example – Southwest Ohio – 11 Jul 2006



3-D VES Example – Eastern Kansas – 12 Sep 2008



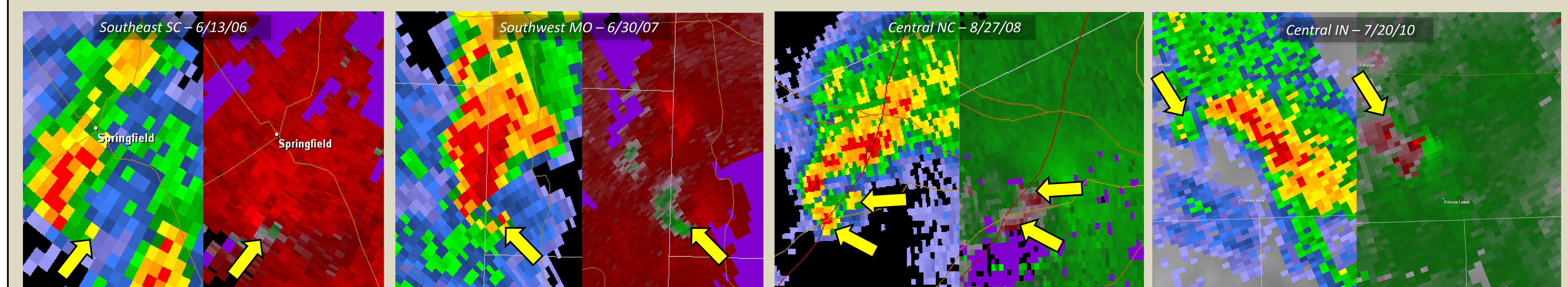
Detached Hook Echoes



Small hook echoes, often detached from the main precipitation cores, were commonly observed with tornadic mini-supercells particularly when very near the radar. 3-D views of these features show similarities to descending reflectivity cores (DRCs, Rasmussen et al. 2006) as a reflectivity maximum pendant to the echo overhang above the weak echo region.

Weak cyclonic circulations were observed inside the hook echo of many tornadic mini-supercells near the time of tornadogenesis. Sometimes these hook echo circulations appeared separately and simultaneously with the mesocyclone circulation. Many non-tornado producing storms never acquired this circulation inside the hook echo, making it a strong discriminator between tornadic storms and non-tornado producers.

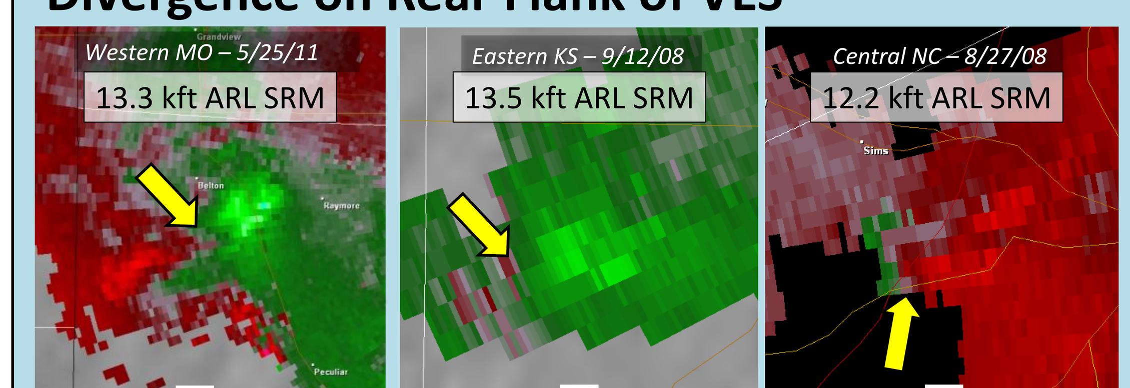
Weak vertical circulations within hook echoes *(0.5° tilt, all taken at or a few minutes before time of tornado)*



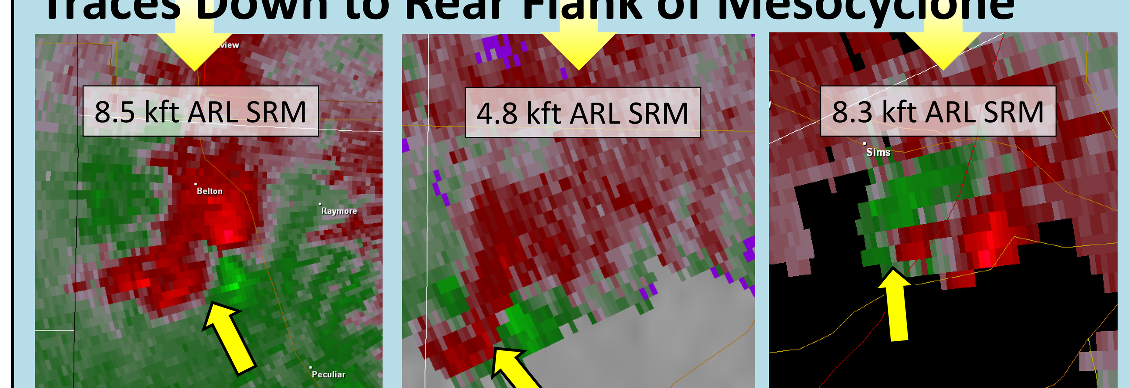
Rear-Flank Divergence

In many cases divergent radial flow was evident on the rear flank of the VES (within the precipitation core, thus not storm-top divergence). This divergent pattern could sometimes be traced downward to the rear flank of the mesocyclone and close to the hook echo. This could possibly be an indicator of the RFD and its relation to the VES and hook echo.

Divergence on Rear Flank of VES



Traces Down to Rear Flank of Mesocyclone



Summary

- Velocity Enhancement Signature:
  - Appeared in every tornadic storm but one. POD 95%
  - Average tornado lead time: 17 minutes
  - Average false alarm rate: 35% (varied case to case)
- Hook Echo:
  - Appeared in every tornadic storm but one. POD 95%
  - Average tornado lead time: 28 minutes
  - Average false alarm rate: 33% (varied case to case)
  - Detached hook echoes had a lower false alarm rate
  - Rotation within hook echo (usually only apparent close to the radar) is a strong indicator of a tornadic mini-supercell
- Rear-Flank Divergence:
  - Often evident on rear flank of VES, sometimes traceable to rear flank of mesocyclone
  - Could this be a sign of the RFD? If so, is the VES somehow related to its formation?

Future work will expand to more cases, and look closer into the potential relationship between rear flank divergence, RFD formation and the acquisition of vertical vorticity in the hook.

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