Operational Use of Spectrum Width to Improve Warnings for Quasi-Linear Convection in the Western Great Lakes

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Introduction & Background

Mesovortices: Predominantly cyclonic meso-gamma scale (2-20km) circulations along leading edge of quasi-linear convection

- Production of intense swaths of damaging winds and tornadoes
- Operational challenges of differentiating damaging vs. non-damaging circulations (when to issue a Severe Thunderstorm or Tornado Warning?)

Spectrum Width (SW): The standard deviation of velocity within a radar range gate

- Ability to locate circulations along leading edge of quasi-linear convection using Spectrum Width (Spoden et al 2012)
  - Defined maximum >20 knots collected with circulation

Objective: *Analyze mesovortex characteristics by using spectrum width as a differentiation factor.*

Methodology

- Within a Western Great Lakes domain (Fig 1), 11 different QLCS events that included widespread damaging winds and tornadoes between the years of 2008-2014 were identified by using the Storm Prediction Center (SPC) Severe Weather Events Archive.
- Radar data was downloaded and loaded into GRLevelX software
- "*Damage-Based Cataloging*" of local storm reports associated with circulations (or "mock" points created for circulations with no damage reported) lead to a sample size of 119 data points to analyze from 78 different mesovortices.
  - 30 tornadoes, 59 wind damage points, and 30 no damage points
  - Collectively, 89 "*Damage*" points; 30 "*No Damage*" points

Fig 1: The domain (orange) and 11 different events (black outlines) that were used in the study.

Terminology

- **Rotational Velocity: V_r** The average of the maximum inbound and outbound velocities within a couplet, or:

$$V_r = \frac{|V_{in}| + |V_{out}|}{2}$$

- **Circulation (V_r) Depth:** The maximum height at which the circulation is still clearly present

Spectrum Width Signature

Definition: Area of SW maximum ≥20 knots that is collocated with a circulation and has an element of depth

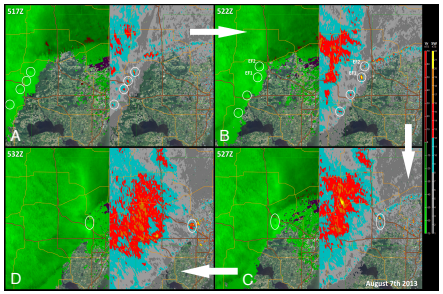
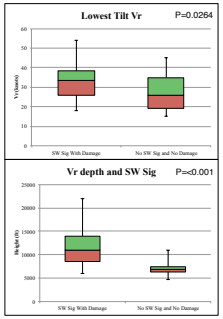


Fig 2 (left): Four maximums in SW collocated with circulations on the 0.5° tilt KGRB WSR-88D during the early morning hours of 7 Aug 2013. The bottom two circulations did not have any reported damage, while the top two produced multiple tornadoes.



- The SW signature was noted with…
  - 81% of all "Damage" points
  - 93% of all "Tornado" points
  - 57% of "No Damage" points
- Damage points that were collocated with the SW signature tended to have a **stronger V_r** and **deeper circulation depth** than points with no damage reported or SW signature (Fig 3).
- The SW signature did not perform well in regions further then 55 miles from the radar site (due to beam broadening) or very close to the radar.

Fig 3 (left): Statistical analysis for the lowest tilt Vr and Vr depth for circulations with and without the SW signature.

Conclusions and Future Work

SW Signature

- Indicative of stronger or deeper circulation compared to mesovortices without signature
- Higher potential to produce at least wind damage → Higher confidence in Severe Thunderstorm Warning?

SW Ring Signature

- Indicative of much stronger and deeper circulation with possible embedded microcirculations
- Very high potential for widespread wind damage and tornadoes→ High confidence for Tornado Warning?

Future Work: *Is there a correlation between the value of the SW maximum and the potential to produce a specific type of damage?*

Spectrum Width Ring Signature

Definition: Area of SW maximum ≥20 knots within a "ring" or "C" shape that is collocated with a circulation and has an element of depth

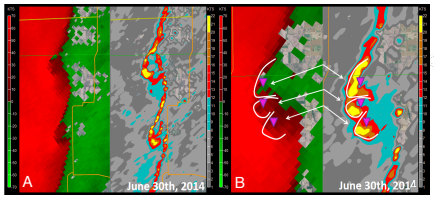


Fig 4A: Two clear rings in SW that were collocated with broad mesovortices on the 0.5° tilt KLOT WSR-88D during the evening hours of 30 June 2014.

Fig 4B: A close up of the northern mesovortex a few scans later showing three distinct microvortices. Each produced a tornado.

- 20 points were collocated with an obvious "ring" or "C" shape. Wide swaths of 80mph+ winds and multiple tornadoes were common with the SW Ring Signature.
- Damage points collocated with the SW Ring Signature had a **stronger V_r** and **deeper circulation depth** than all other considered points (Fig 6).

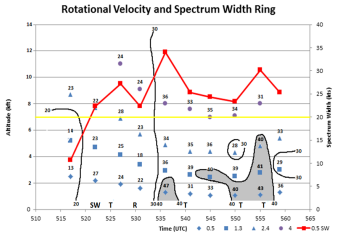


Fig 5 (above): Inspired by a plot by Spoden at al. (2012), the red line is the 0.5° tilt SW and the numbers above the points represent the V_r at each time step (also contoured) for a mesovortex on 7 Aug 2013. "SW" indicates when the SW Sig began; "R" for Ring Sig; and "T" are NWS-survey or radar confirmed tornadoes.

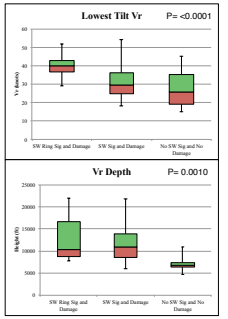


Fig 6 (above): Statistical analysis for the lowest tilt Vr and Vr depth for circulations with the different SW signatures.

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Spoden, P. J., R. A. Wolf, and L. R. Lemon, 2012: Operational uses of spectrum width. *Electronic J. Severe Storms Meteor.*, **7** (2), 1-28.