# Enhancing tornado intensity estimates with Doppler radar

MALLIE TOTH
PURDUE UNIVERSITY
INDIANA, USA

WITH R.J. TRAPP, J. WURMAN, AND K.A. KOSIBA

# Motivation

- The tornado climatology is limited by:
  - Eyewitness reports
  - Post-event damage surveys
- The information is incorporated into the record as EF Scale ratings.
  - Relates damage to low-level wind speed.
  - Requires damage to occur to provide an estimate.
- There is currently no known way to objectively remove the effects of these biases from the record.

# An Alternate Approach

- Fixed Doppler radar (i.e. WSR-88D) data in isolation to approximate low-level tornadic winds.
- Use mobile radar (i.e. DOW) data for true low-level wind speeds.
- Previous work to relate WSR-88D data to:
  - Climatological purposes
  - F Scale rating
- Mobile radar velocity estimates have been used to augment EF Scale ratings in the United States.

# Data Selection and Methods

- Relating "numbers to numbers," the WSR-88D velocity signature to the DOW "ground truth."
- Restricted heights considered:
  - DOW data to <5° elevation.
  - WSR-88D data to 0.5° elevation.
- Event selection was limited by the velocity data and the operational status of the nearest WSR-88D.

| Date | Location | 88D range |
|---|---|---|
| 05/16/95 | Hanston, KS | 52 |
| 06/02/95 | Dimmitt, TX | 109 |
| 05/26/96 | Friona, TX | 90 |
| 05/31/96 | Rolla, KS | 170 |
| 04/10/97 | Tulia, TX | 81 |
| 05/26/97 | Kiefer, OK | 53 |
| 05/30/98 | Spencer, SD* | 75 |
| 05/01/99 | Tarzan, TX | 44 |
| 05/03/99 | Moore, OK* | 17 |
| 05/31/99 | Sitka, KS | 66 |
| 06/03/99 | Almena, KS* | 120 |
| 06/04/99 | Thedford, NE | 21 |
| 06/05/99 | Bassett, NE | 108 |
| 05/17/00 | Brady, NE | 112 |
| 05/26/00 | Throckmorton,TX | 197 |
| 05/06/01 | Marietta, OK | 139 |
| 05/24/04 | Hebron, NE* | 62 |
| 05/13/05 | Seymour, TX | 116 |
| 06/09/05 | Hill City, KS | 150 |
| 06/15/05 | Trego Center, KS | 115 |
| 04/21/07 | TX Panhandle | 45 |
| 04/23/07 | Protection, KS | 75 |
| 05/10/08 | Stuttgart, AR | 82 |
| 06/05/09 | Goshen County, WY | 64 |

# Events

- Range from ~20-200 km from the WSR-88D.
  - Eventually removed events >100 km away.
- F or EF Scale ratings from 0 to 5.
  - Retains relevance for countries with primarily weak tornadoes.
- Covers nearly 15 years of data collection.

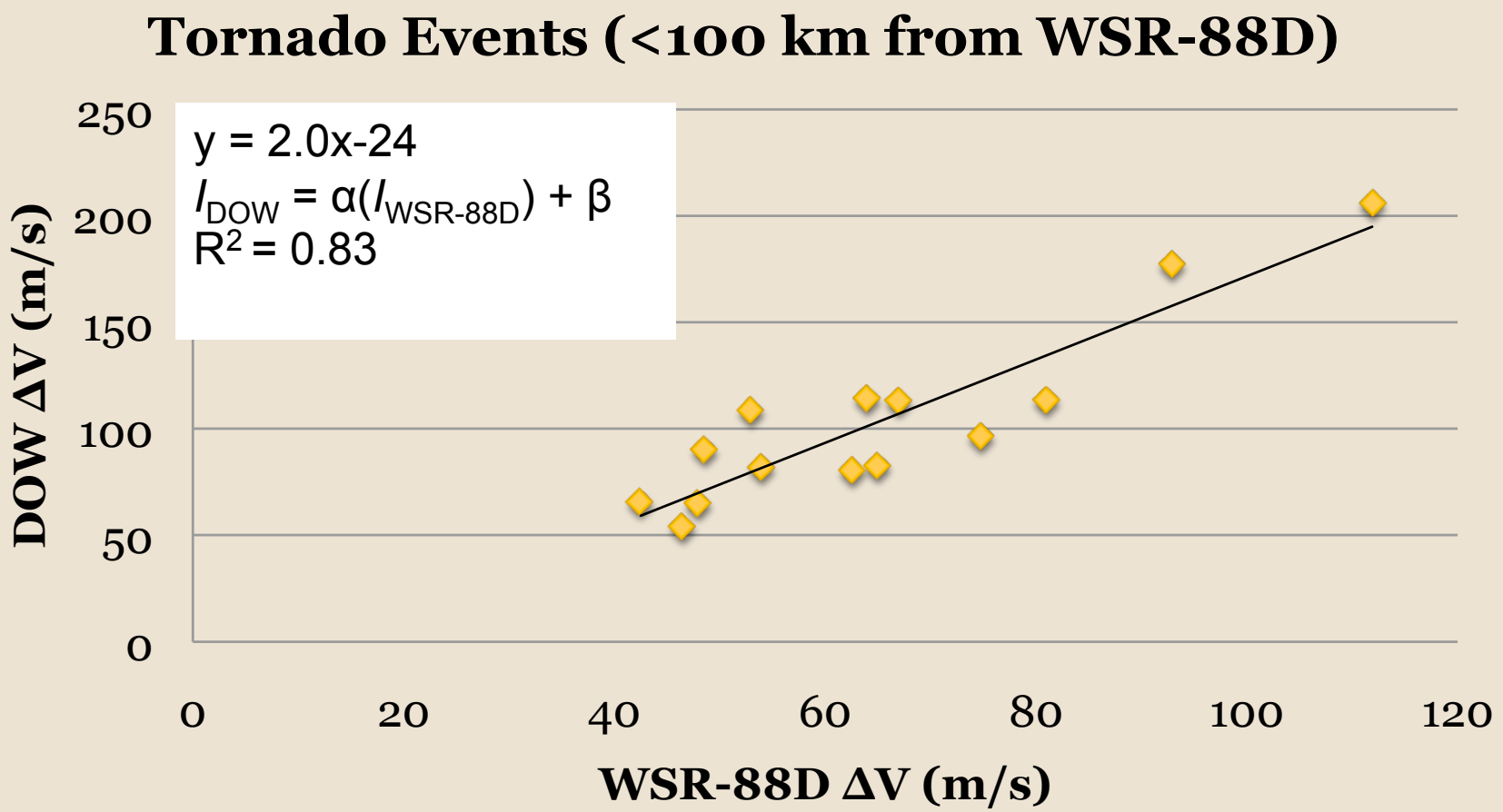
# Data Selection and Methods

- Statistical relationship between WSR-88D and the corresponding DOW data.
- Differential velocity:

$$\Delta V = (V_{max} - V_{min})$$

- DOW and WSR-88D $\Delta V$ maxima were determined for each event.
- Relate the intensity of the WSR-88D $\Delta V$ to that of the DOW for each event via linear regression.

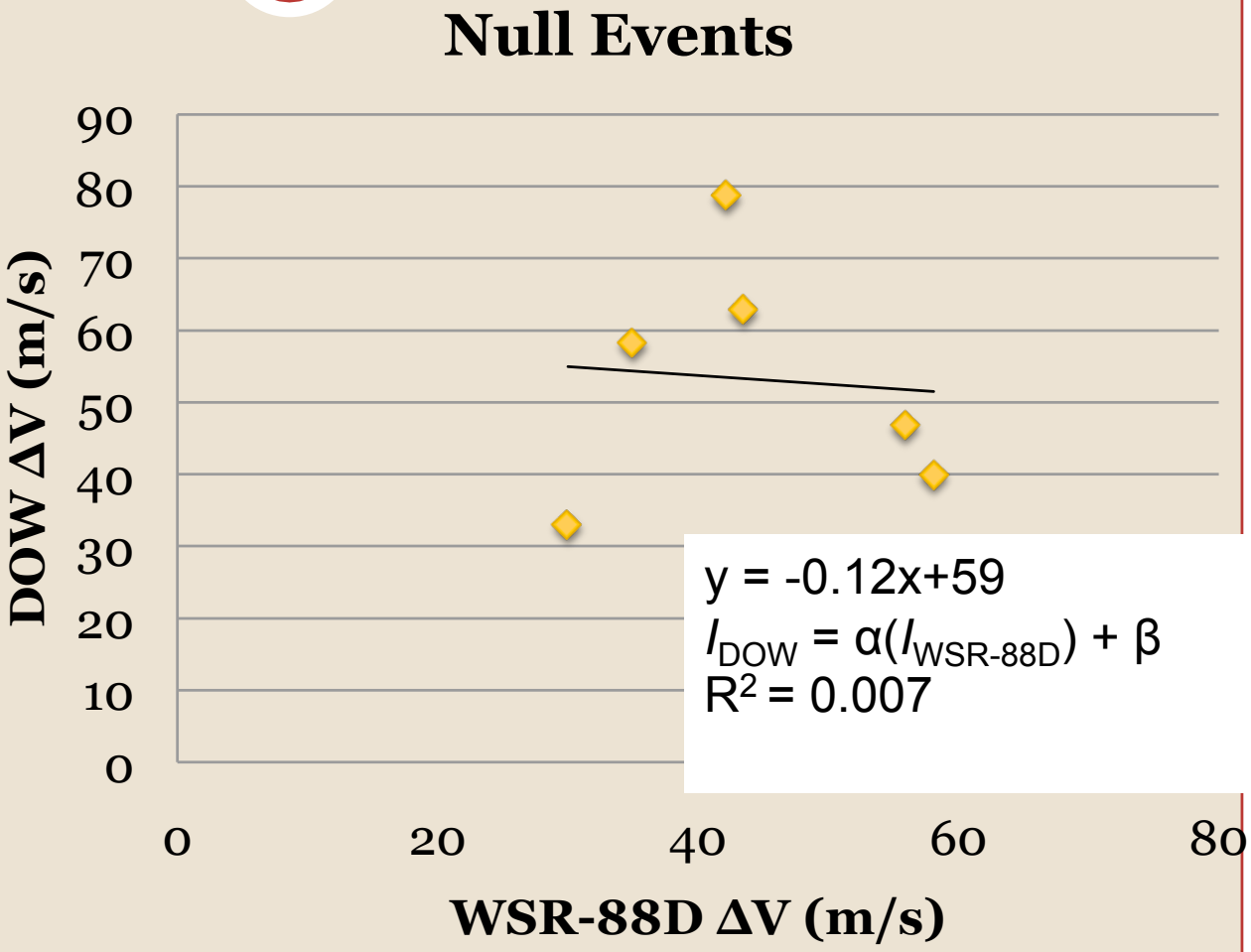
# Regression Model



# Null events

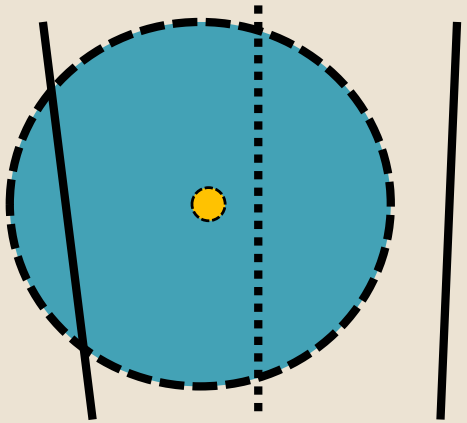
| Date | 88D range |
|---|---|
| 05/31/05 | 42 |
| 06/07/05 | 157 |
| 05/26/09 | 100 |
| 06/07/09 | 119 |
| 06/09/09 | 37 |
| 06/13/09 | 33 |

| Location |
|---|
| Levelland, TX |
| Okaton, SD |
| Sanger, TX |
| Maysville, MO |
| Mullinville, KS |
| Panhandle, TX |



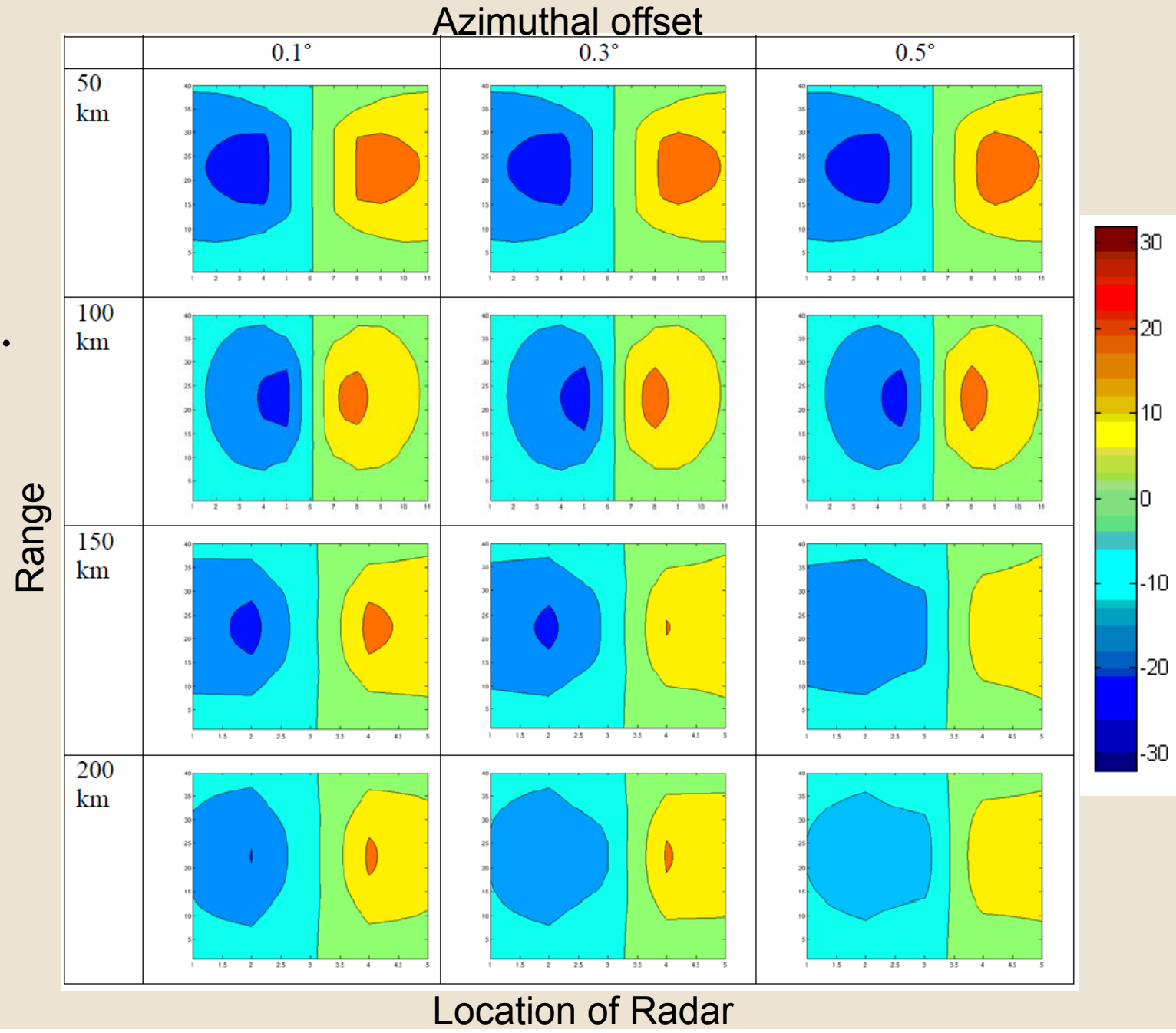
# Acknowledging Limitations

- WSR-88D (and similar platforms) have inherent limitations:
  - Beam broadening
  - Increasing height sampling with increasing range
  - Chance positioning of the vortex relative to the radar beam
    - "Azimuthal offsets"



# Radar Model

- 2D based on Wood and Brown (1997).
- Rankine combined vortex
- Max velocity 25 m/s at 2.5 km from center.
- 1°x 250m beams



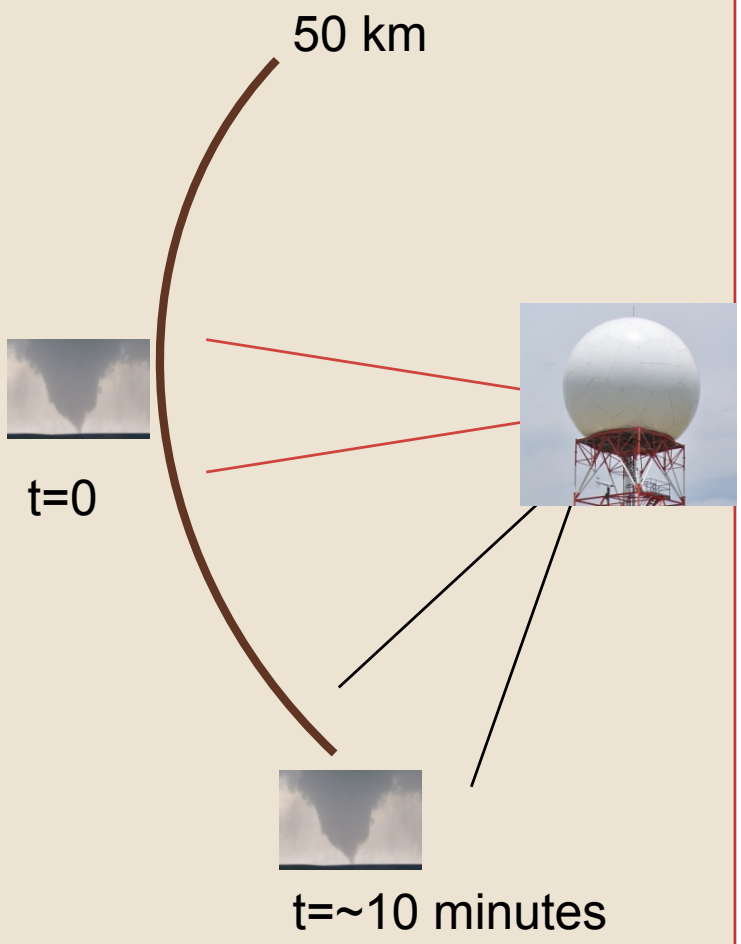
# Radar Model

| Range/ Offset | ΔV 0.0° | ΔV 0.1° | ΔV 0.3° | ΔV 0.5° | ΔV 0.9° |
|---|---|---|---|---|---|
| 50 km | 49.2 | 44.78 | 43.78 | 42.12 | 39.15 |
| 100 km | 36.36 | 36.75 | 39.34 | 39.64 | 34.06 |
| 150 km | 36.88 | 36.5 | 33.74 | 31.23 | 28.11 |
| 200 km | 33.42 | 33.13 | 30.95 | 27.17 | 21.09 |

*$\Delta V$ in m/s

# Radar Model

- Thought exercise:
  - In ~6 volume scans, for a tornado traveling consistently 50km away from the radar, what would have to occur for the tornado to be sampled at the same azimuthal offset in all 6 scans?
- Answer:
  - A specific, consistent translational speed *(e.g. 5 m/s for 30 minutes)*



# Conclusions and Future Work

- Results suggest that use of WSR-88D data may provide a more objective method of estimating low-level tornado wind speeds.
  - Dependent on the known existence of a tornado.
  - Dismissal of the platform as a tool for velocity estimates may be premature.
  - Applicable internationally for countries with sufficient radar coverage (e.g. Romania WSR-98D?)
- Future work will involve more complicated velocity profiles, including multiple vortex modeled output in a 3D radar model.

# *Thank you!*


Mallie Toth

Purdue University

Department of Earth and Atmospheric Sciences

Severe Weather Research Group

toth2@purdue.edu