

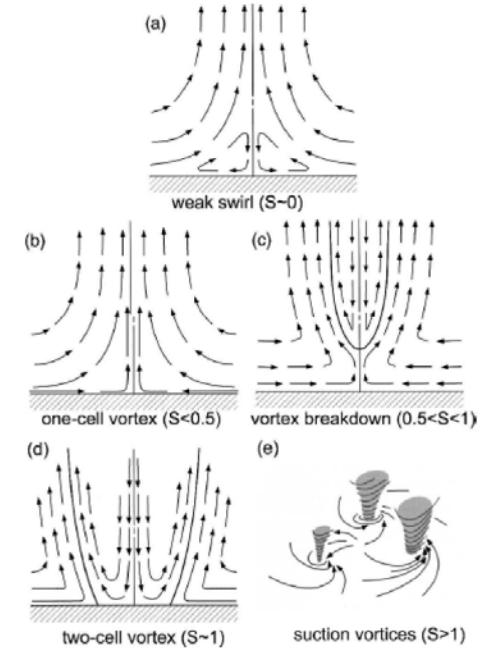
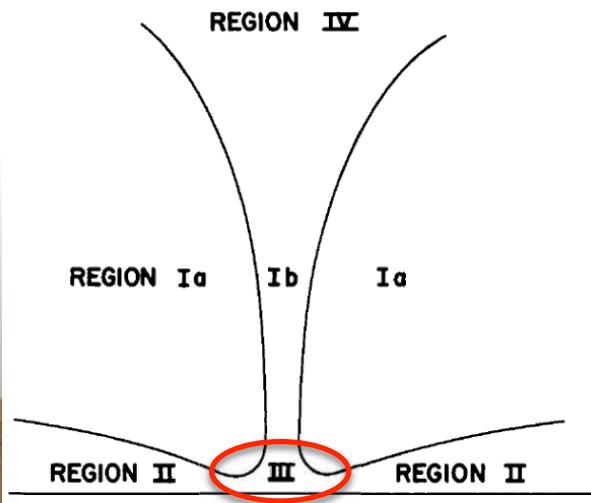
# Integrated In Situ, DOW and damage observations in tornadoes



**Karen A. Kosiba, Josh Wurman, Paul Robinson**  
*Center for Severe Weather Research*

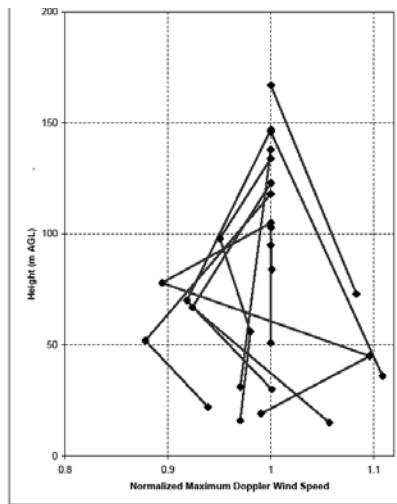
# Motivation.

- Wind speed below radar level
  - How do wind speeds change with height
  - Relation of wind to damage
- Tornado vortex structure
  - Boundary layer depth
  - Wind velocity distribution



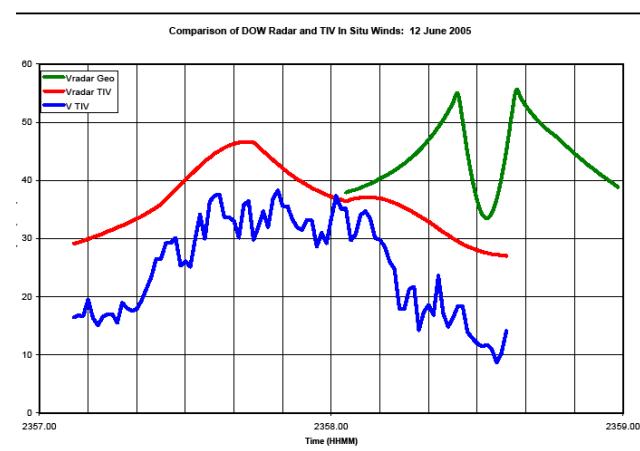
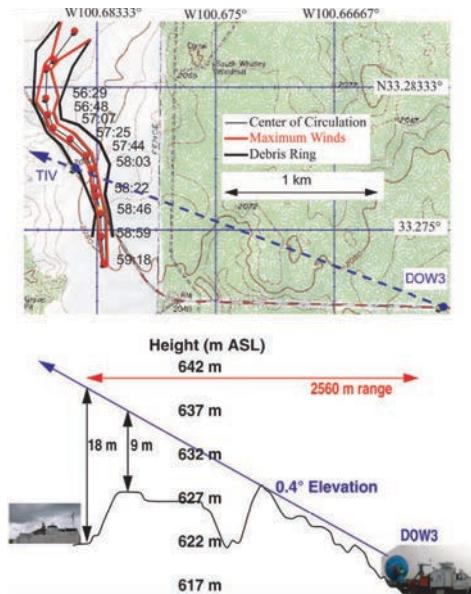
Limited in situ and near-surface radar observations

## Spencer, SD

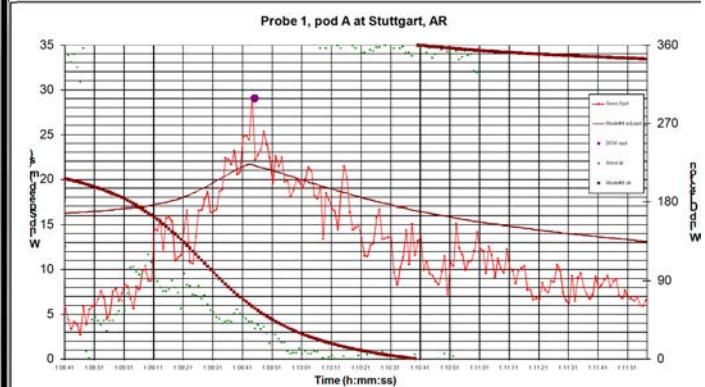
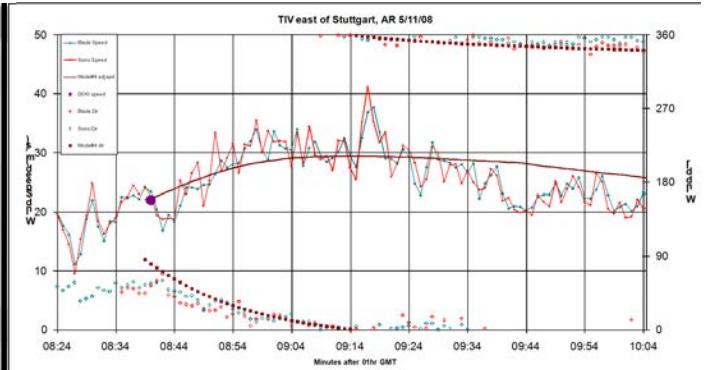


No clear dependency of wind speed with height

Similar wind speeds observed near surface as 18 m AGL



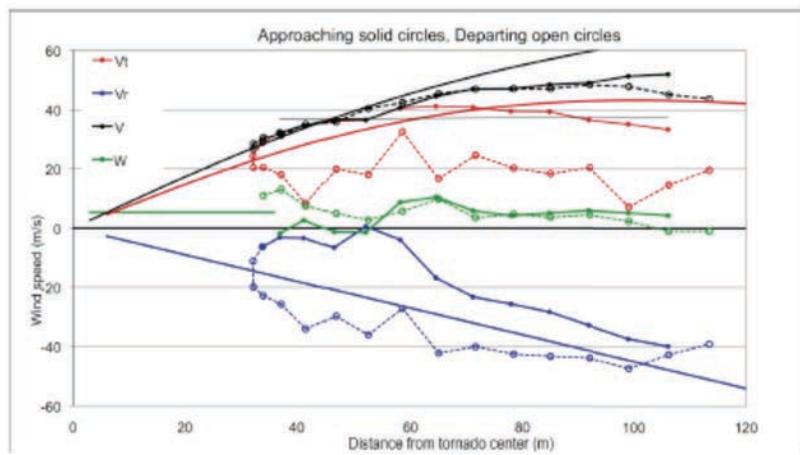
Wurman, J., C. Alexander, P. Robinson, and Y. Richardson, 2007c: Low Level Winds in Tornadoes and Potential Catastrophic Tornado Impacts in Urban Areas. *Bull. Amer. Meteor. Soc.* **88**, 31-46.



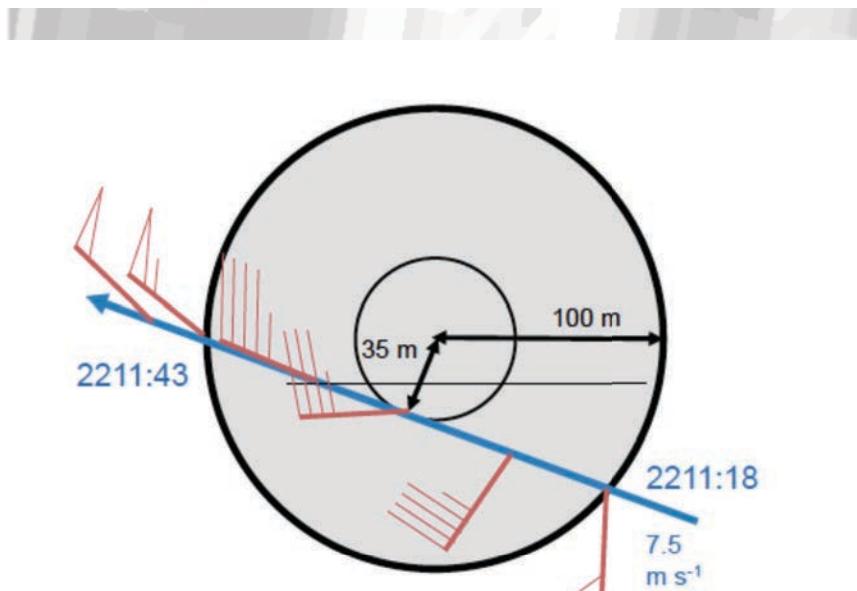
DOW, TIV, and Tornado Pod Measurements in Violent Tornado (Vmax = 102 m/s) East of Stuttgart, Arkansas, 2008

TIV 3-m winds 90% as intense as DOW 250 m winds. No apparent inward turning of winds in sector sampled by TIV.

Pod 1-m winds 50-60% as intense as DOW winds. 40-50 degree inward turning in this sector.



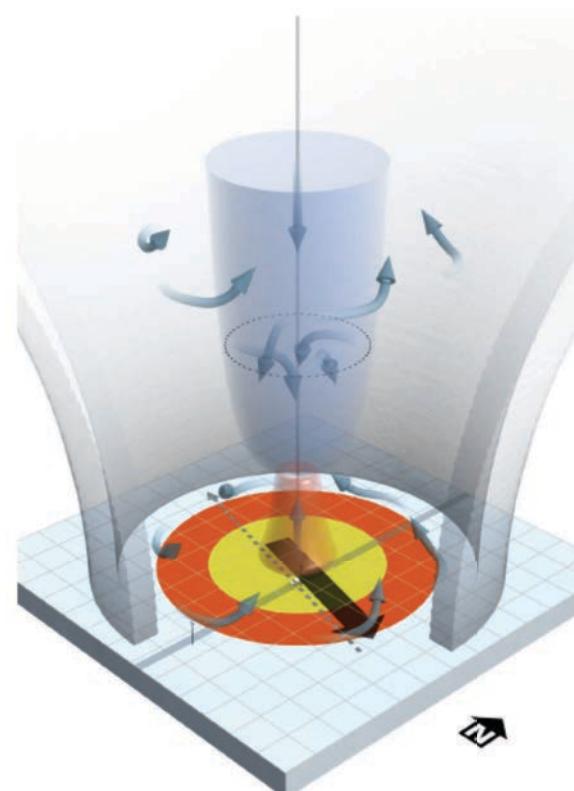
**Fig. 6.** Profiles from data (marked lines) and Burgers-Rott modeled (unmarked lines)  $V_t$ ,  $V_z$ ,  $V$ , and  $W$  versus  $R$ . Data collected during tornado approach (departure) indicated with solid (open) circles. Data Strong inward and upward motion is present from  $35\text{m} \leq R < 120\text{m}$ .



**Figure 4.** Schematic illustration of transect of tornado by Tornado Intercept Vehicle (TIV). The tornado, with a radius of maximum winds of 100 m, propagates toward 110 degrees at  $7.5 \text{ m s}^{-1}$ , with the center of circulation passing 35 m north northeast of the TIV, resulting in measurements through a chord of the tornado as shown. Wind barbs show measurements of  $V_g$  at 3.5 m AGL with pennants indicating  $50 \text{ m s}^{-1}$ , full bars  $10 \text{ m s}^{-1}$ , and half bars  $5 \text{ m s}^{-1}$ . Times are in UTC.

## 05 June 2009: Goshen County, WY

Wurman, J., K. A. Kosiba, P. Robinson, 2012: In-Situ, Doppler Radar and Video Observations of the Interior Structure of a Tornado and Wind-Damage Relationship. *Bull. Amer. Meteor. Soc.*



**Fig. 9.** Three-dimensional structure of the tornado constructed using TIV, DOW, and video data, revealing inward spiraling surface flow and axial downdraft aloft. RMV (orange), RMV, (yellow) and debris cloud (gray) indicated. Spirally inflowing air slowly rises (red isosurface) near the surface, and is met by an axial downdraft (blue isosurface) below 100 m AGL. TIV, Poles along road, and tornado motion/transect indicated.

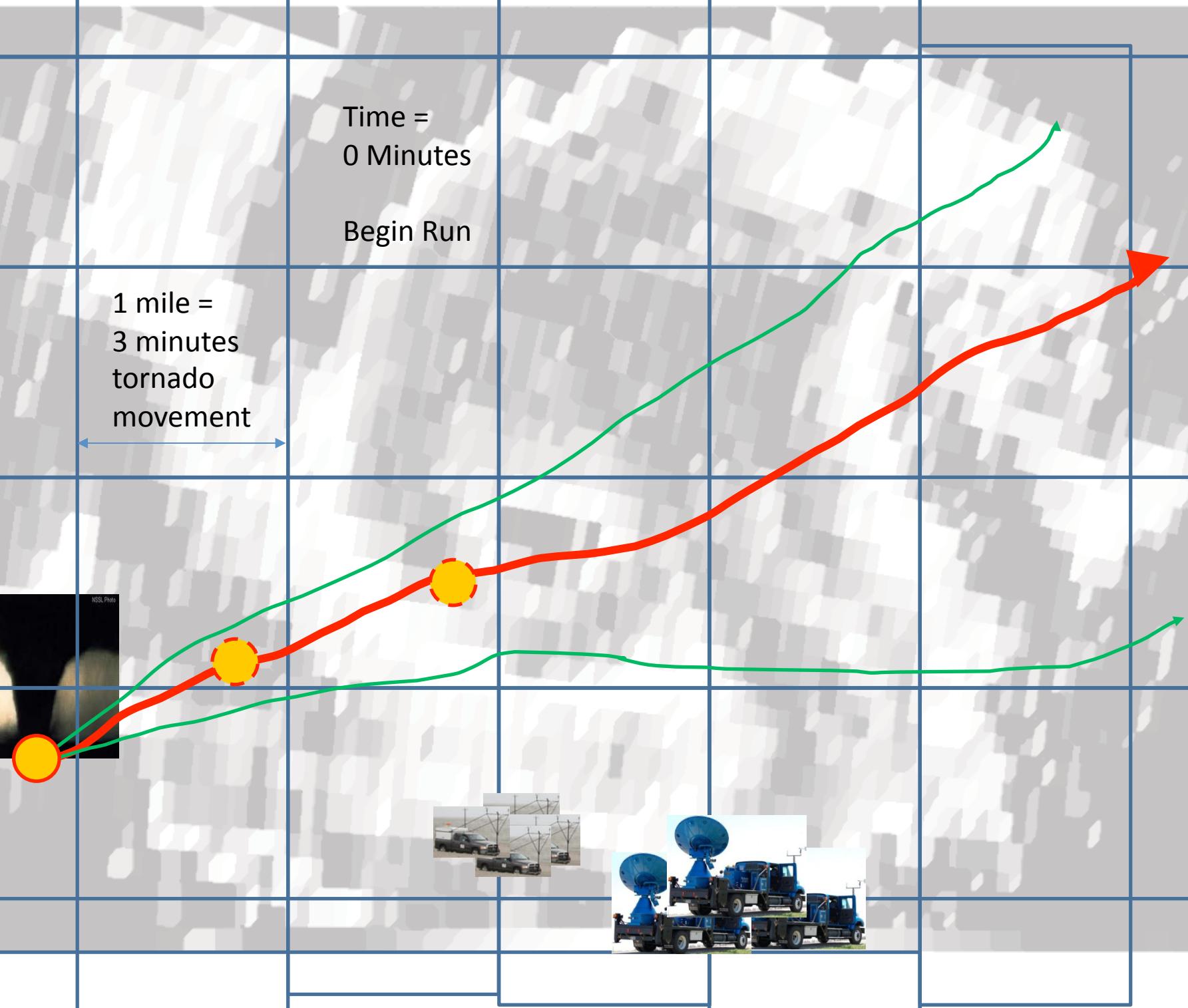
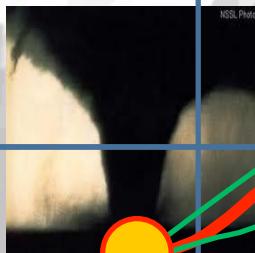
No vertical profile of the winds

**ROTATE 2012: Low-level Winds**  
**3 May – 23 June**  
**3 DOWs**  
**5 Mobile Mesonets**  
**22 Pods**  
**1 mobile office**  
**24+ Participants**



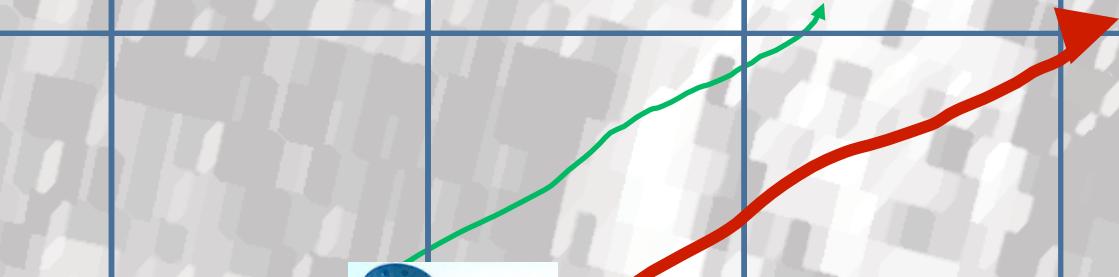
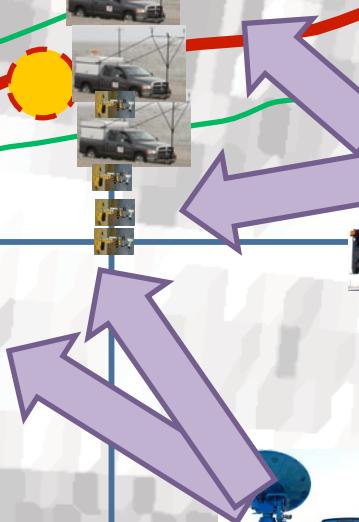
1 mile =  
3 minutes  
tornado  
movement

Time =  
0 Minutes  
Begin Run



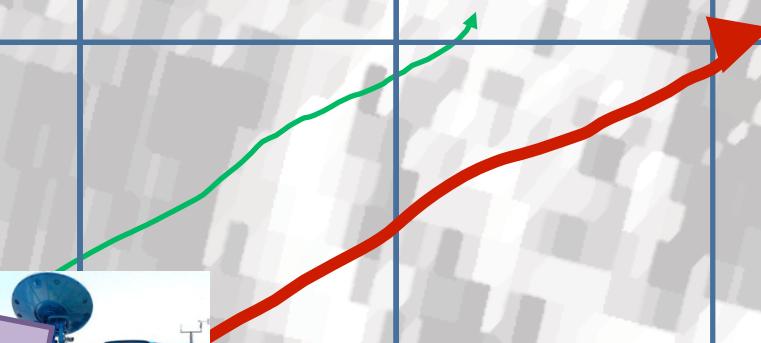
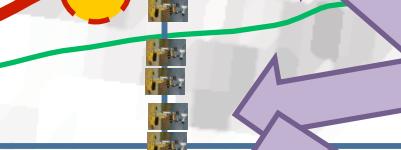
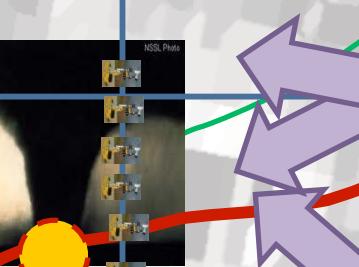
Time =  
3 Minutes  
Mid Run

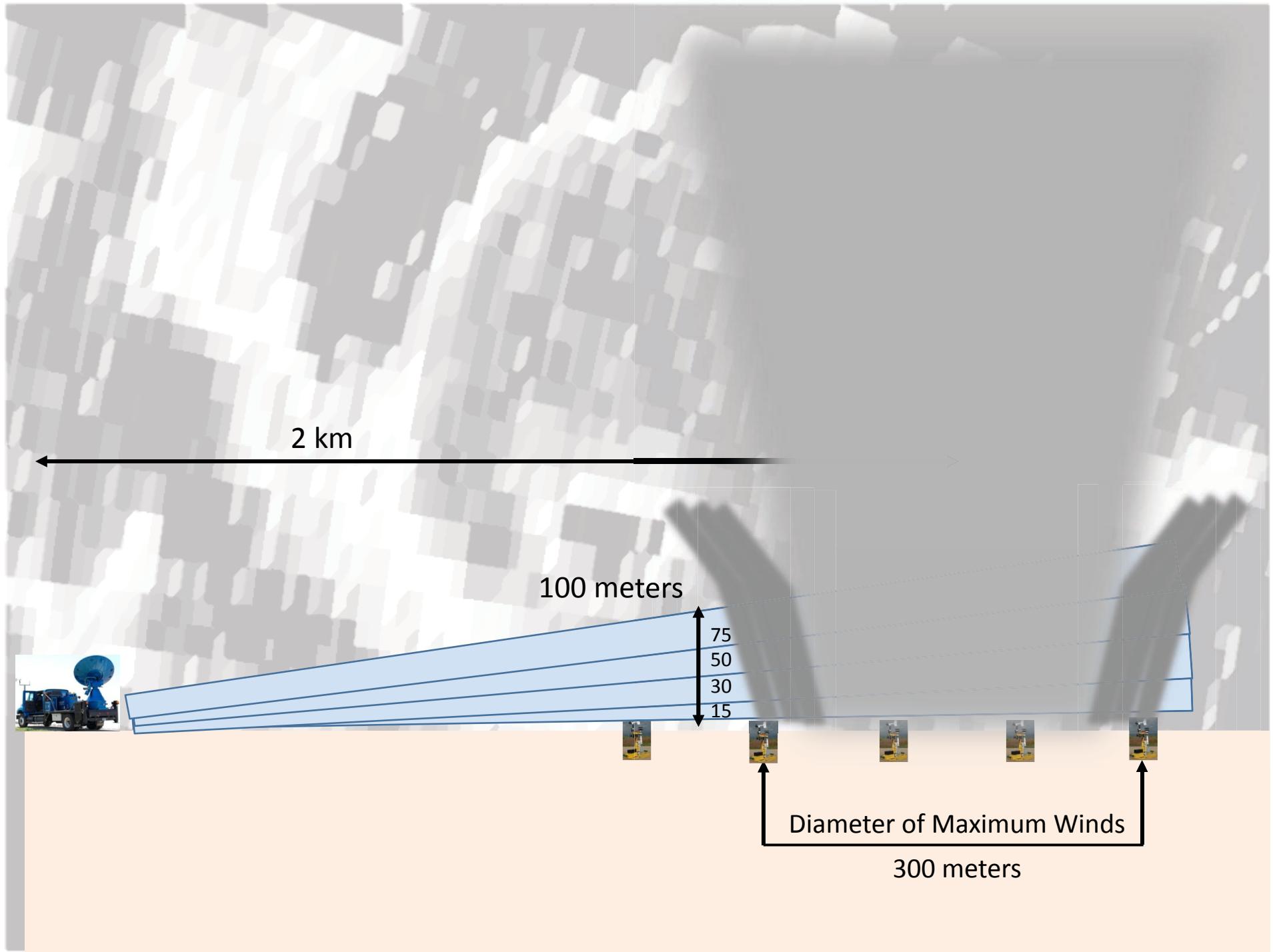
1 mile  
3 minutes

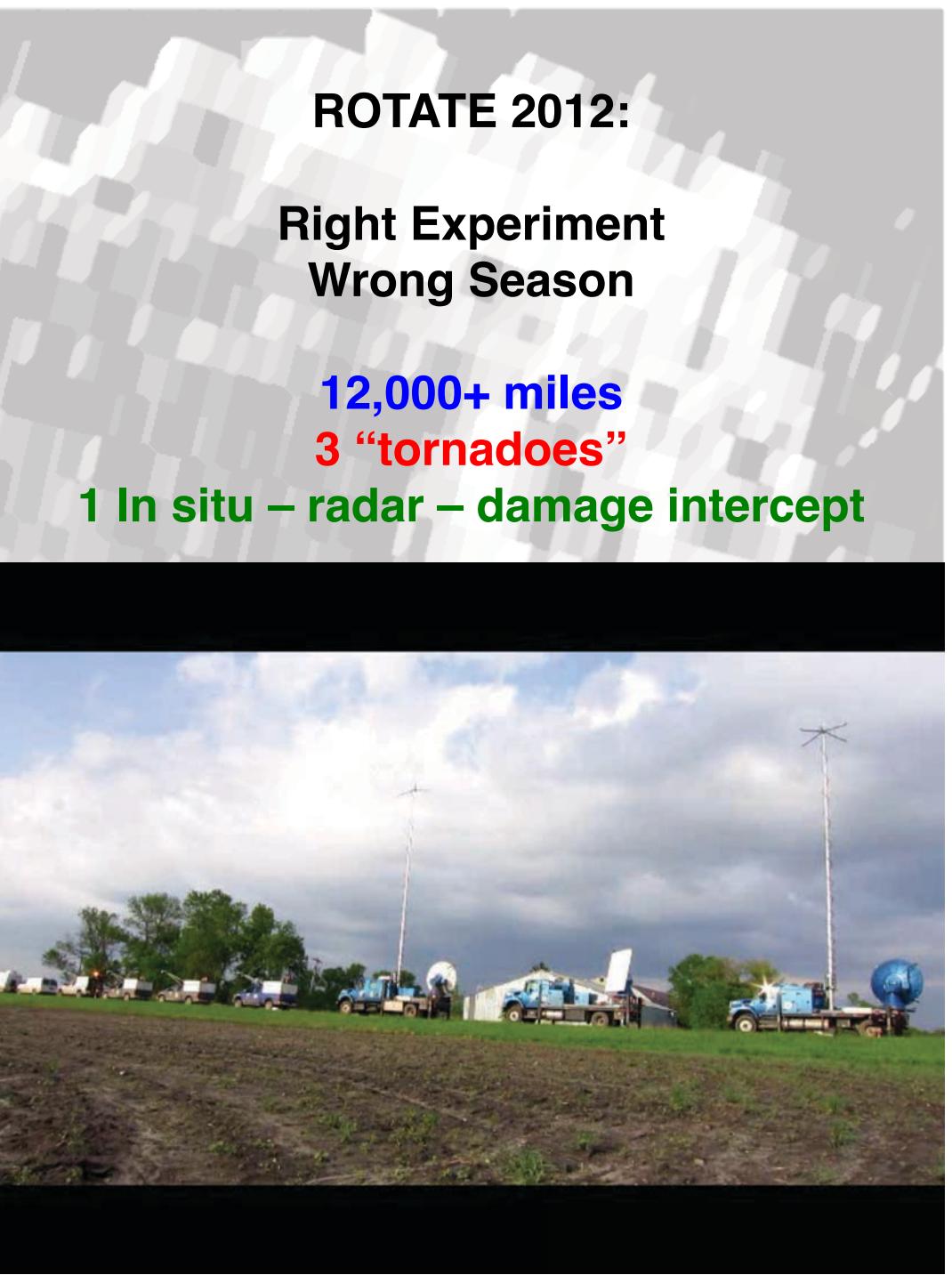
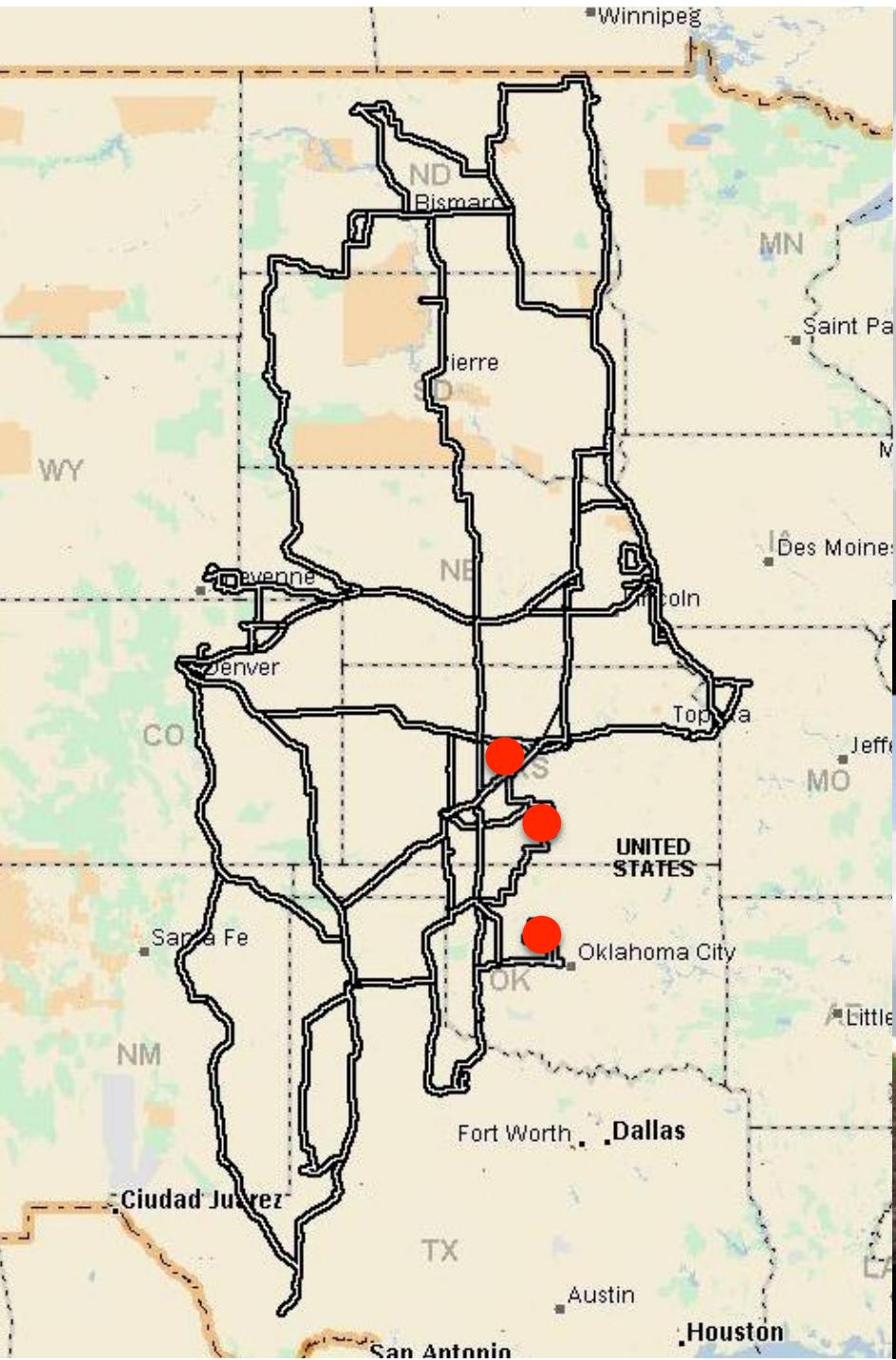


Time =  
6 Minutes  
Mid Run

1 mile  
3 minutes







**ROTATE 2012:**

**Right Experiment  
Wrong Season**

**12,000+ miles  
3 “tornadoes”**

**1 In situ – radar – damage intercept**

# 2012 May 25 Russell, Kansas

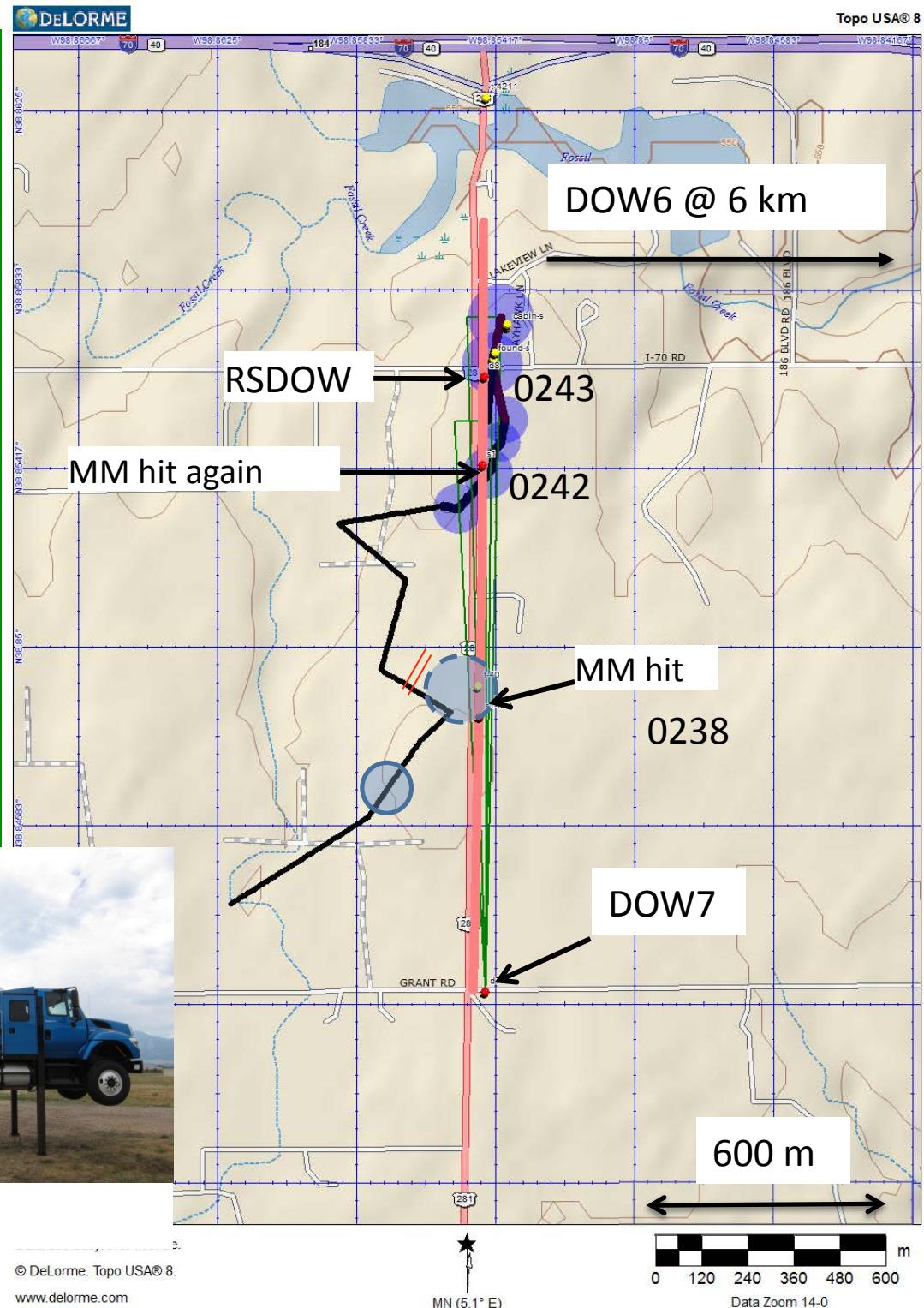
## Tornado Hits DOW and Mobile Mesonet

### Results:

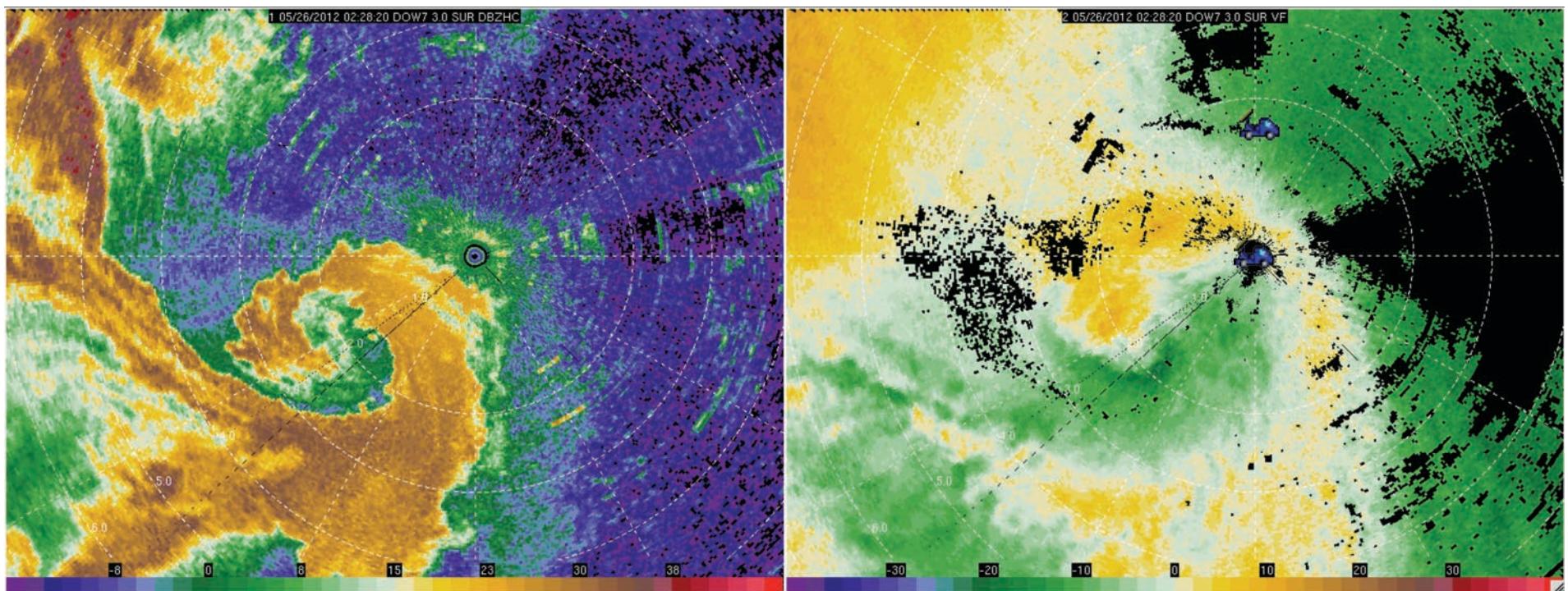
- We are all okay
- Ultra-fine-scale observations
- In-Situ obs @ 3.5 m AGL  
Several RSDOW slices 5-40 m AGL  
Every 7 seconds



Wanna Be TIVs, No Armor



# DOW7: 0228:20 - 0244:45



## Data provide VERTICAL profiles

DOW7 beam

$$3 + 1360\sin(3.0) = 74 \text{ m}$$

DOW7 beam

$$3 + 1360\sin(1.0) = 27 \text{ m}$$

$$3 + 231\sin(6) = 27 \text{ m}$$

6

$$3 + 231\sin(5) = 23 \text{ m}$$

5

$$3 + 231\sin(4) = 19 \text{ m}$$

4

$$3 + 231\sin(3) = 15 \text{ m}$$

3

$$3 + 231\sin(1.2) = 9 \text{ m}$$

1.2

$$3 + 231\sin(0.5) = 5 \text{ m}$$

0.5

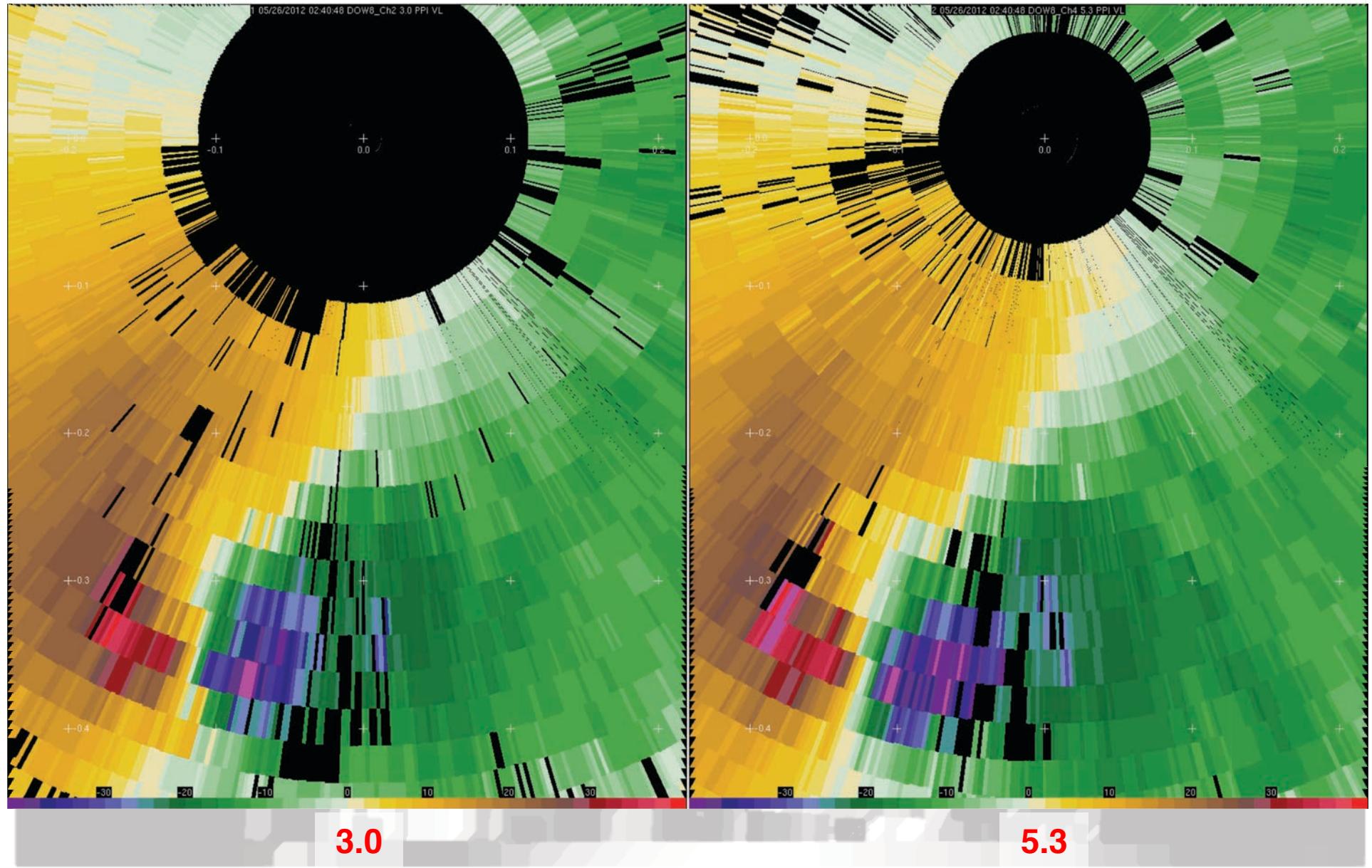
$$3.5 \text{ m}$$



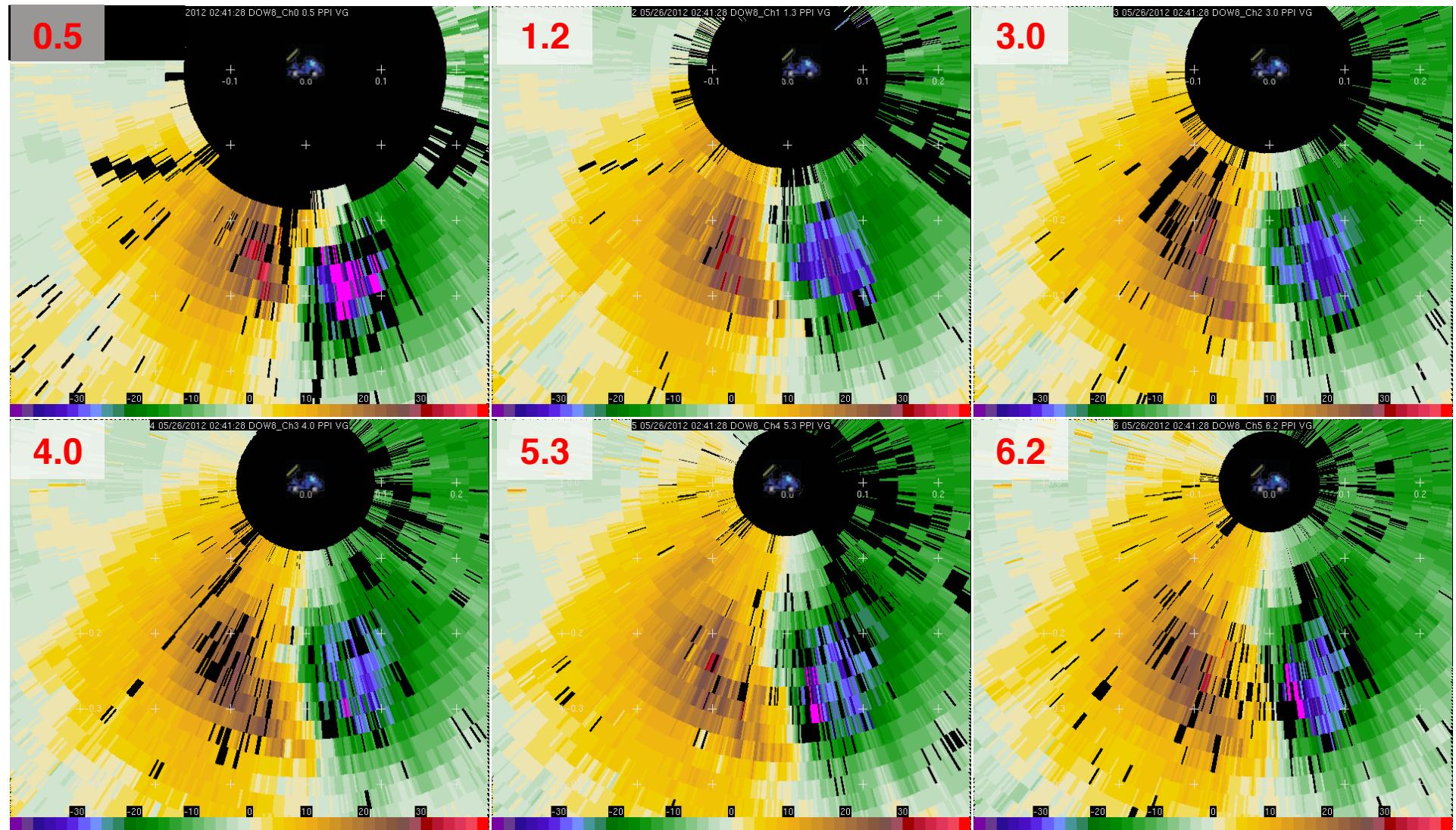
↔ 231 meters ↔

231 meters

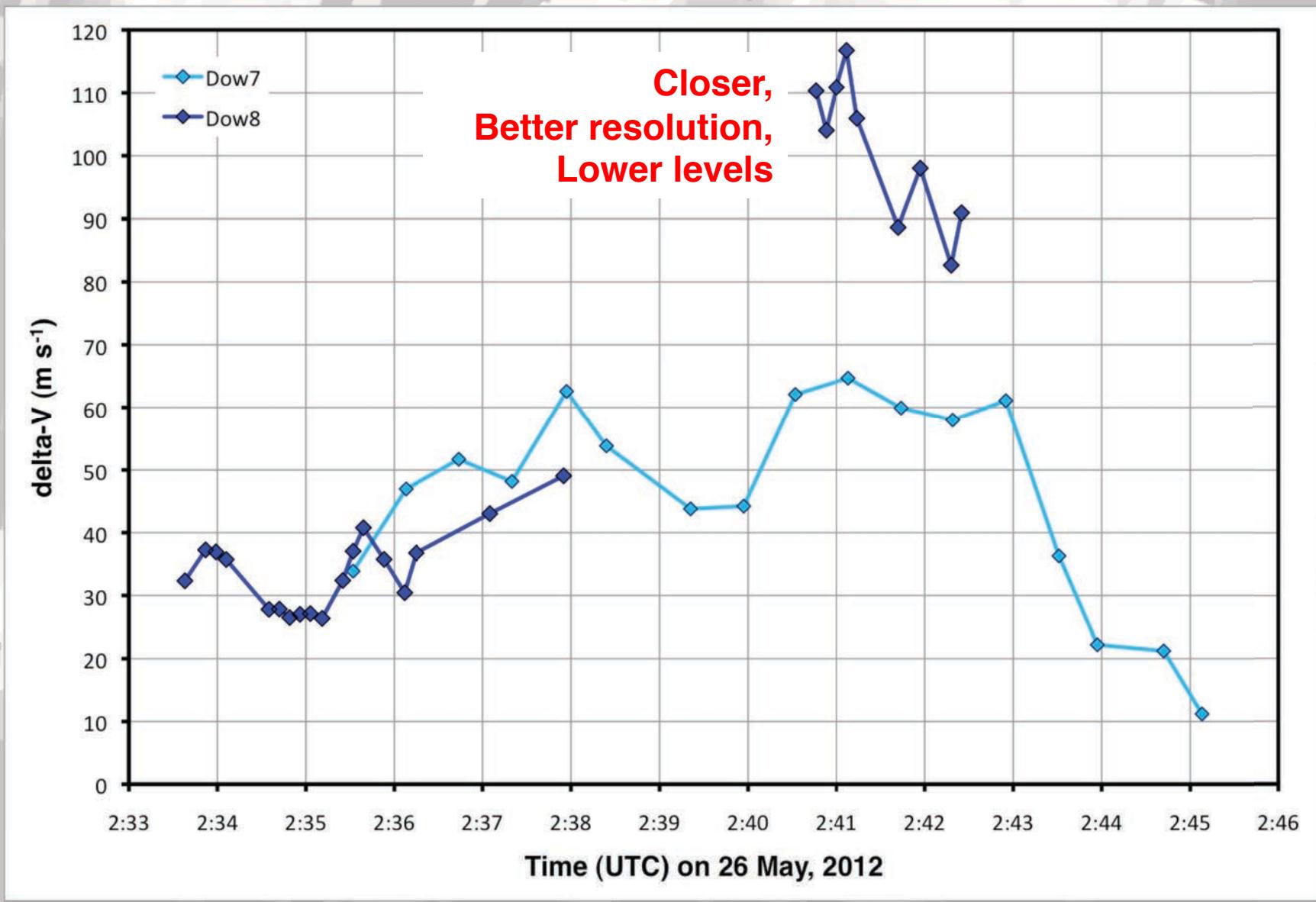
## DOW8 data every 7 seconds from 0240:48 – 0242:35 UTC



## DOW8 data at 6 vertical levels at 0241:28



# Radar Summary of the Russell Tornado



Instantaneous wind of  $43 \text{ m s}^{-1}$  (96 mph) when MM is stationary (3.5 m AGL)



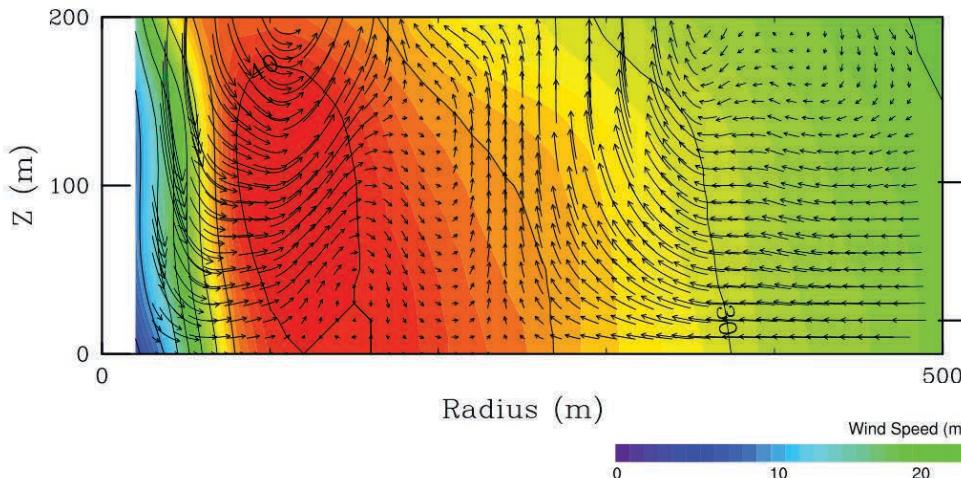
## EF2 Rating based in damage to house (located ~30 m from RSDOW)



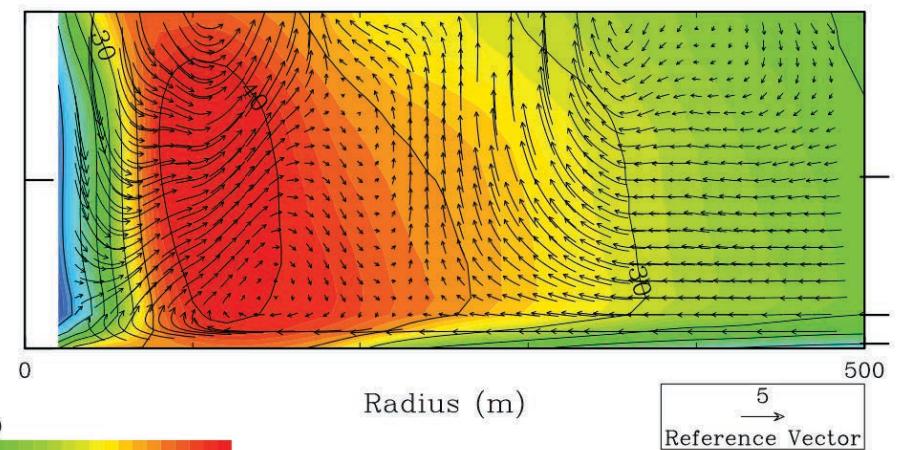
# Want to incorporate surface data (+ debris) in structure models

Integrating surface observations with radar data: Goshen, WY (05 June 2009)  
(Preliminary)

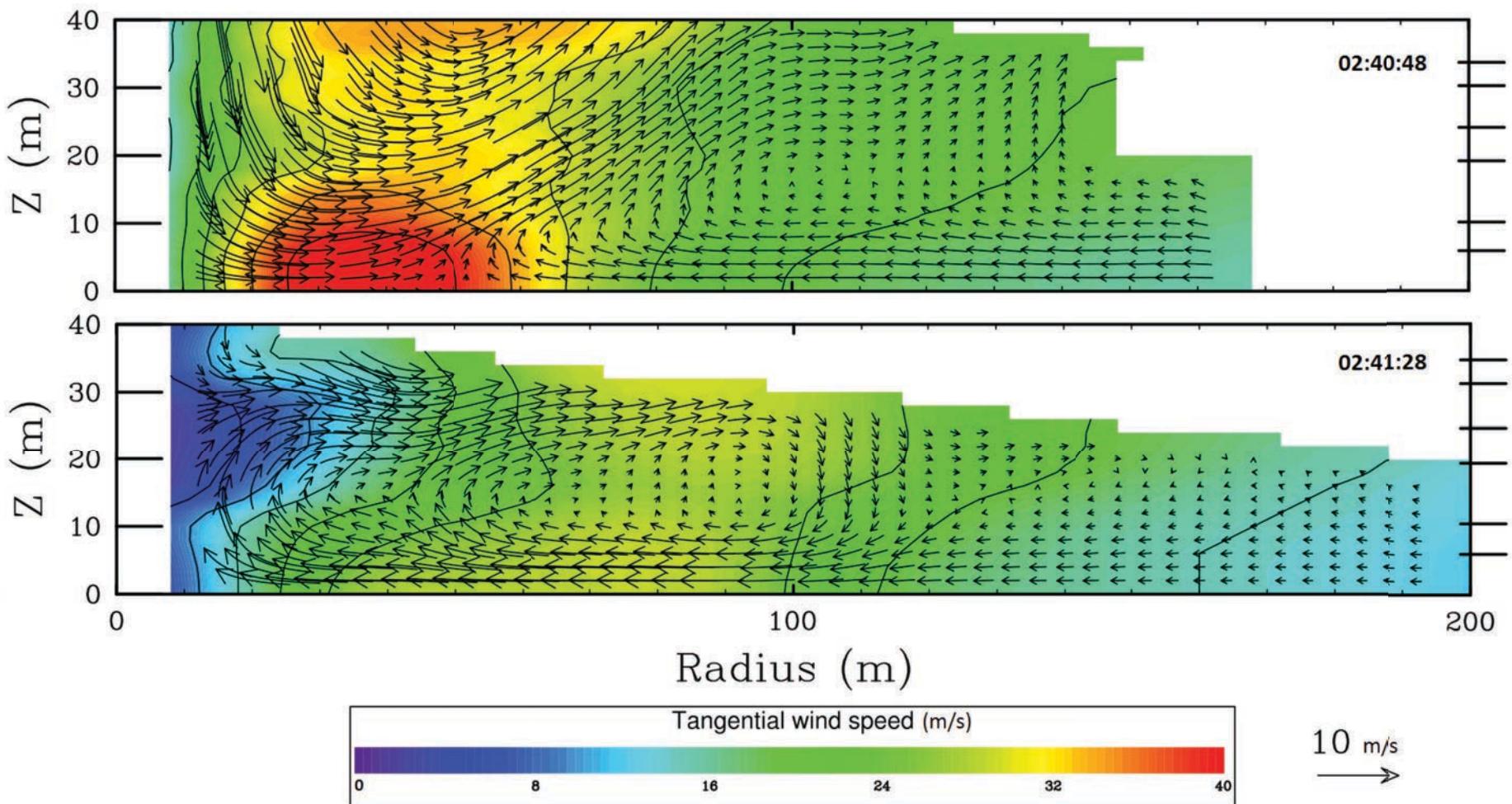
Goshen GBVTD from DOW7 only



Goshen GBVTD from DOW7 + Burgers-Rott



# Preliminary Rapid-Scan DOW GBVTD (no surface data)



Rapid-scan observations 5 m AGL: Capturing inflow?



**Analysis supported by NSF-ATM -0801041**

**DOWs supported by NSF-ATM-0734001 and -0966095 and -0946926**

**Data collection funded partially by the Merage Foundation**

