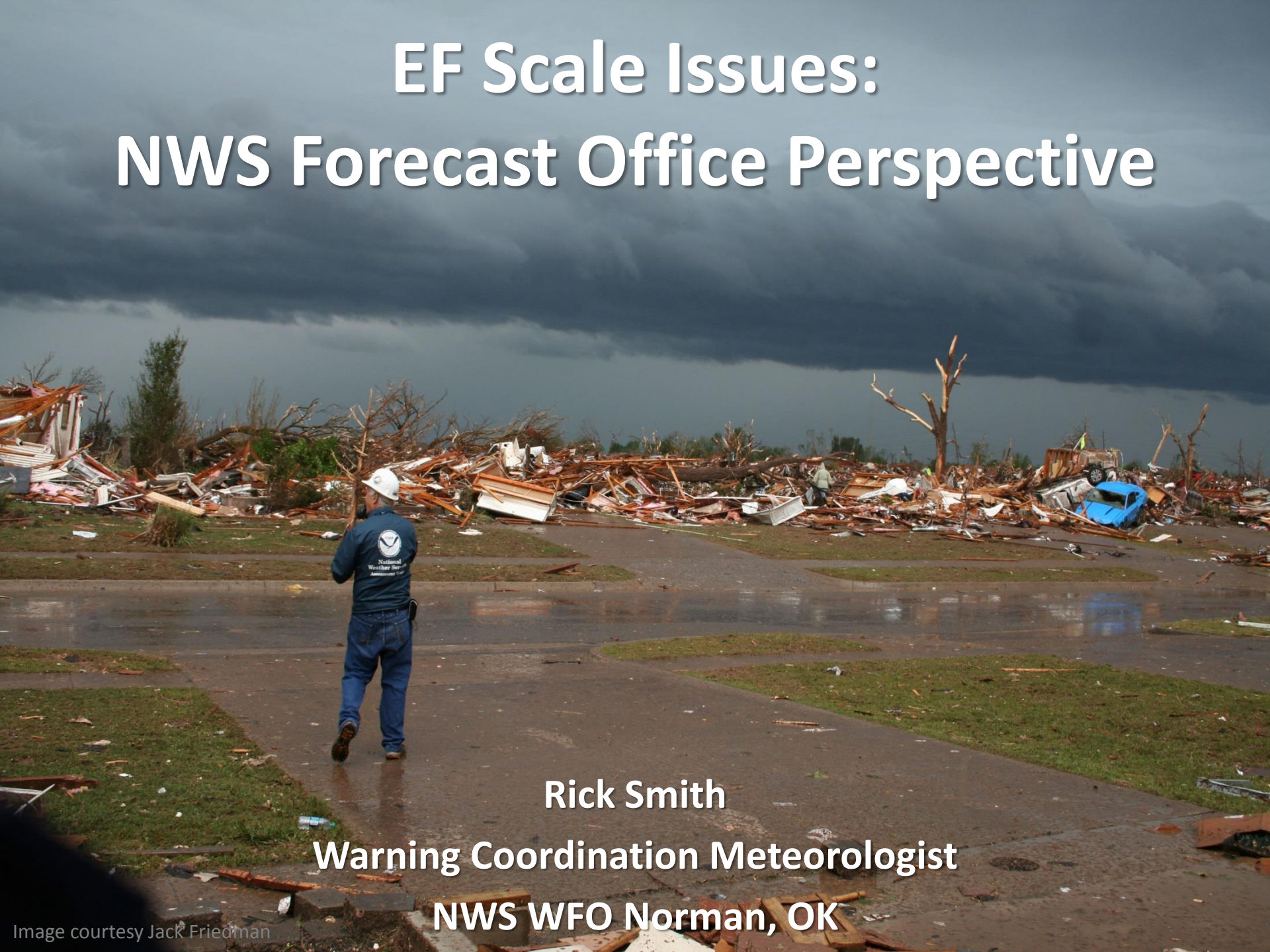
EF Scale Issues:
NWS Forecast Office Perspective



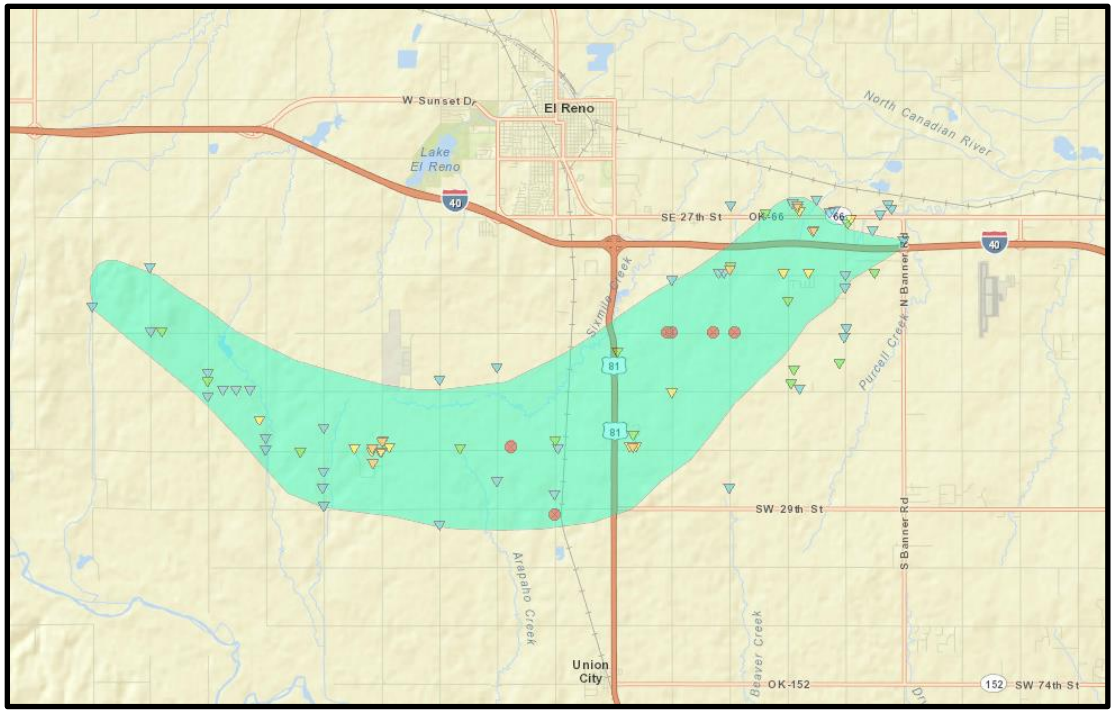
Rick Smith

Warning Coordination Meteorologist

NWS WFO Norman, OK

Image courtesy Jack Friedman

El Reno Tornado (II) – 5/31/13



How to account for wind measurements

Storm Data and Unusual Weather Phenomena - May 2013

Location	Date/Time	Deaths & Injuries	Property & Crop Dmg	Event Type and Details
OKLAHOMA, Western, Central and Southeast				
CANADIAN COUNTY --- 8.1 S CALUMET [35.48, -98.10], 6.0 SSW RICHLAND [35.50, -97.85]				
	05/31/13 17:03 CST	8	0.30M	Tornado (EF3, L: 16.20 mi , W: 4576 yd)
	05/31/13 17:44 CST		0	Source: NWS Storm Survey

On 31 May, an intense, long-track tornado formed southwest of El Reno. This exceptionally wide tornado took a complex path, rapidly changing in both speed and direction. The tornado spared El Reno and its airport from a direct hit, tracking just south of those locations. The tornado damaged numerous homes along with a few businesses near El Reno. Additionally, intense sub-vortices destroyed crops in numerous fields in the area.

The monetary damages were estimated. This tornado was well sampled by two separate mobile research radar teams – the University of Oklahoma RaXPol radar, and the Center for Severe Weather Research's Doppler on Wheels. Both radars captured high temporal and spatial resolution data relatively close to the large tornado. Both radars measured winds in the tornado of more than 200 mph. The RaXPol radar data shows winds of at least 295 mph very close to the surface. These intense winds were present in very small sub-vortices within the larger tornado circulation. An analysis of the high resolution radar data combined with the results of the ground damage survey indicates that none of these intense sub-vortices impacted any structures in rural Canadian County. So despite the measured wind speeds, surveyors could not find any damage that would support a rating higher than EF3 based solely on the damage indicators used with the EF scale.

Eight people were killed in the tornado, all in vehicles. This included three severe storm researchers who were killed east of US-81 as the tornado overtook their position. Additionally, several other people were killed while attempting to escape the tornado near Highway 81. Finally, two people were killed along I-40 while waiting for the storm to pass.

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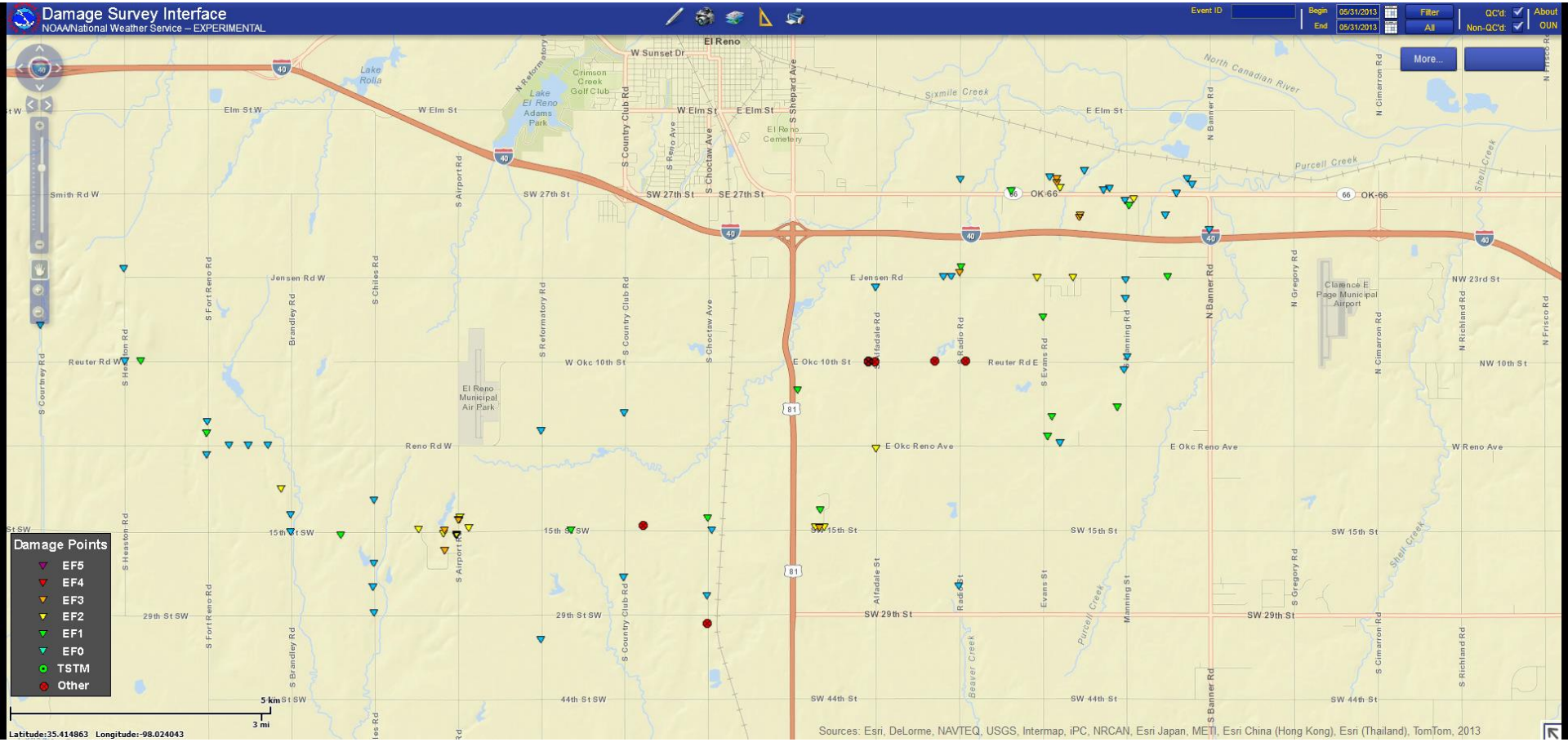
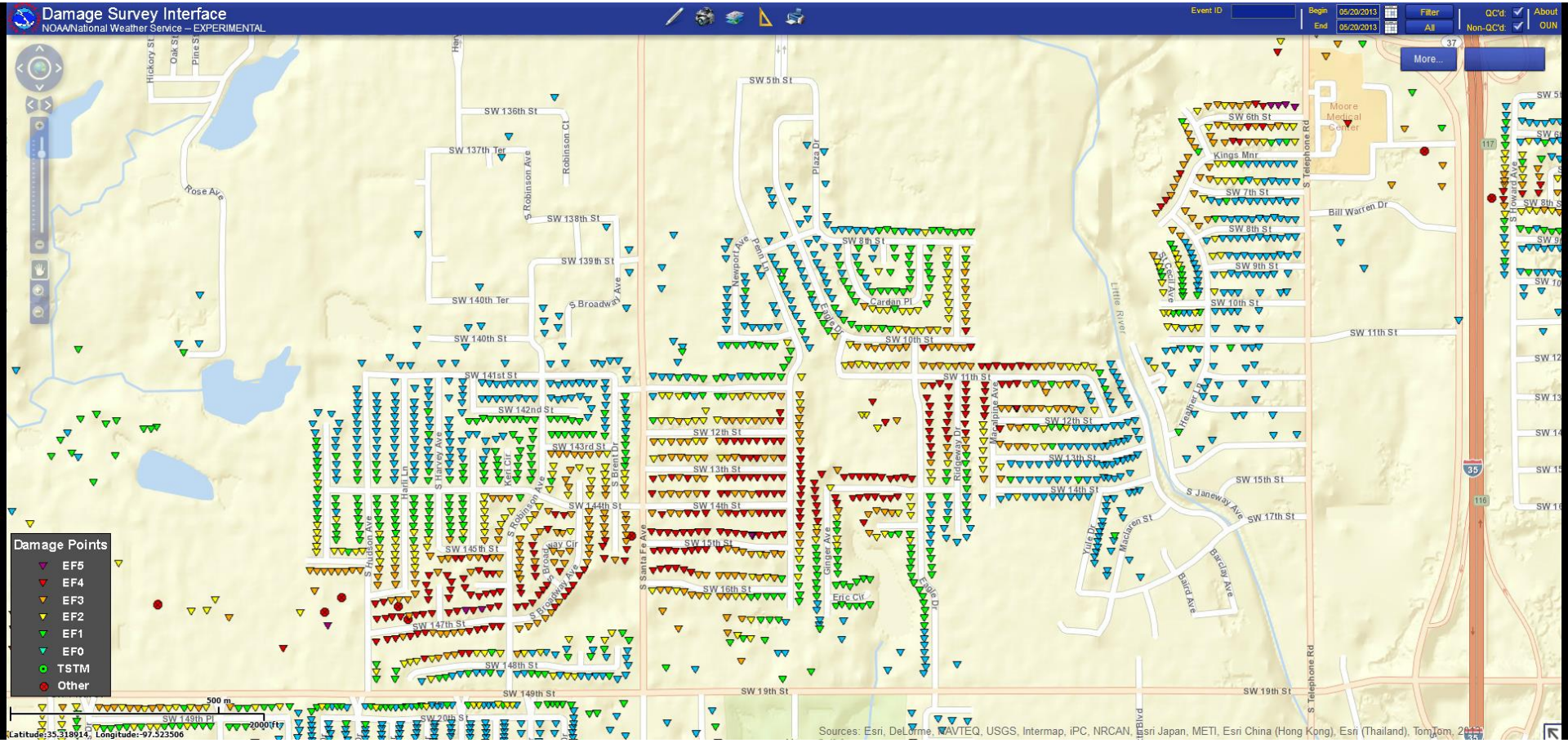
The maximum tornado width was 2.6 miles. However, the damaging wind swath was much larger, as non-tornadic downdraft winds extended for at least a mile south of the tornado. Given the difficulty of separating this damage from tornadic damage, the OU RaXPol radar was used to help determine the width.

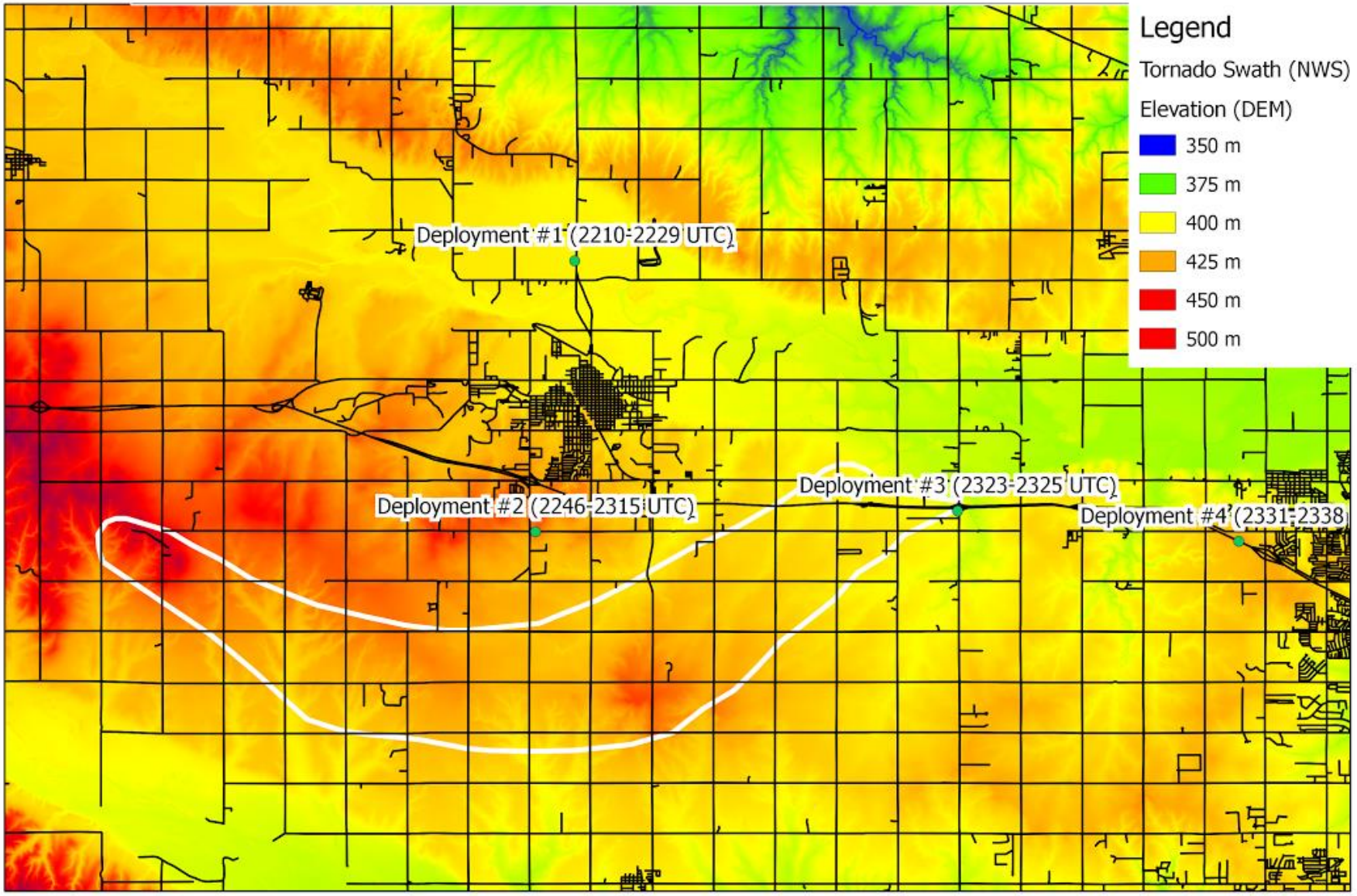


Damage Indicators
El Reno – 5/31/13



Damage Indicators
OKC-Moore - 5/31/13

5/31/2013 RaXPol Deployments



Map Created 6/6/2013 by Jeff Snyder - jsnyder@ou.edu
Tornado path from NWSFO OUN (6/6/13)
Road shapefile and DEM data from USGS

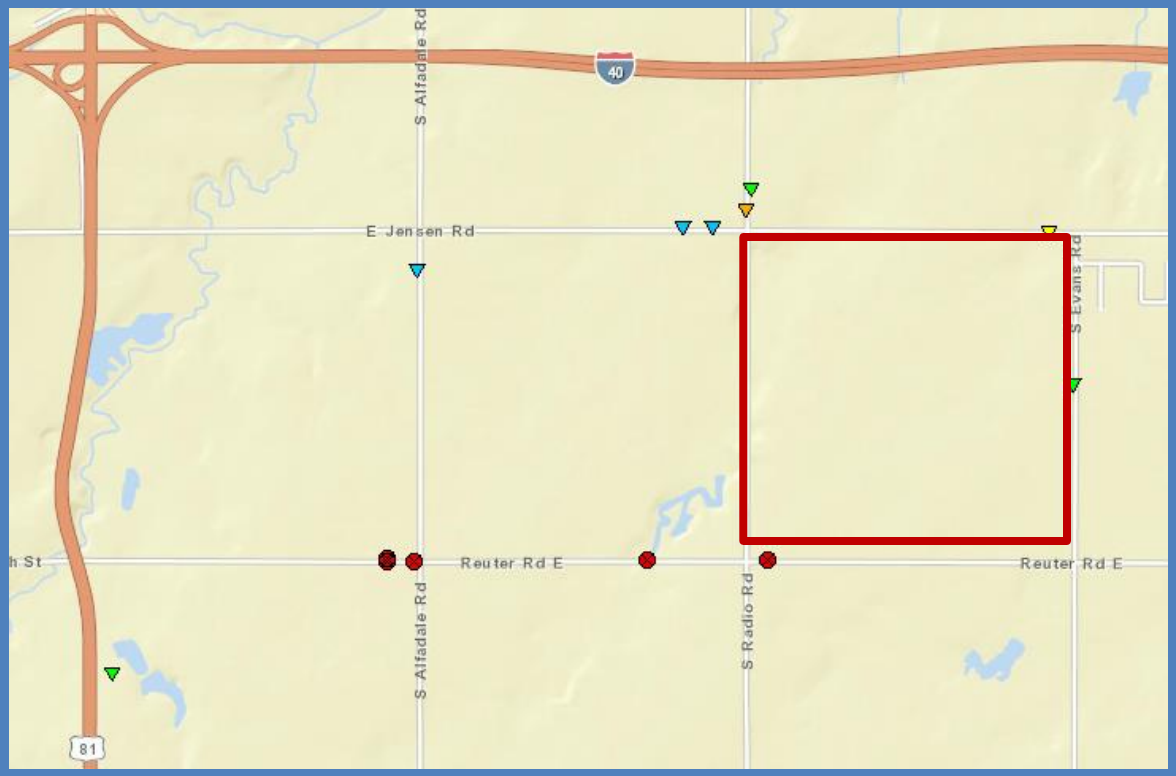
N

0.0015 0 0.0015 0.003 0.0045 0.006

Data courtesy Bluestein and Snyder

Approx 2325 UTC

AGL	
250m (820ft)	256 mph
125m (410ft)	290 mph
94m (308ft)	292 mph
57m (187ft)	287 mph
10m (32ft)	292 mph



RaXpol Radar Observations

Max Radial Velocities

Preliminary Results from the ROTATE-2013 Season

Joshua Wurman, Karen Kosiba, Paul Robinson
Center for Severe Weather Research, Boulder, CO

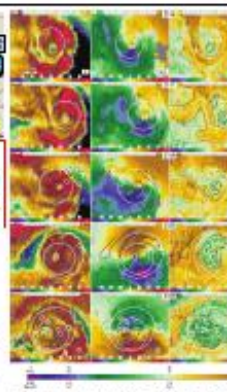
Center for Severe Weather Research

During the spring of 2013, attempts were made to deploy DOWs and in-situ Tornado Pod instrumentation near and in several violent tornadoes during a reduced experimental season consisting of only a few IOPs. These include the EF-3 El Reno tornado, the EF-4 Rozel, Kansas tornado, the EF-4 Bennington, Kansas tornado, and the EF-2 Wichita, Kansas tornado. Very fine-scale radar observations, including rapid-scan (7-second volumes) and quick-scan (7-second sweeps) radar data reveal quickly-evolving structures, low level winds, and relationships with damage.

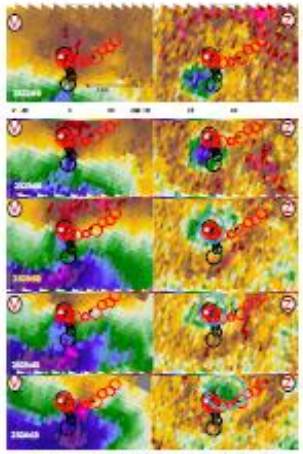
El Reno, OK:

A large and violent tornado/multiple vortex mesocyclone (MVMC) tracked south and east of El Reno, Oklahoma on 31 May 2013, causing 8 fatalities, including storm-chaser/researchers attempting to deploy in-situ instrumentation. Transient and persistent sub-vortices moving within and near the MVMC were documented, some moving in trochoidal-like patterns inside the tornado/MVMC, with ground-relative translational velocities ranging from near zero to 79 m/s, the fastest ever documented. Winds measured by a DOW radar in one of these sub-vortices exceeded 115 m/s at 114 m AGL. If assumptions concerning radar-unobserved components of the velocity vector are made, peak wind speeds of 130-150 m/s are implied, comparable to the strongest ever measured. However only Enhanced Fujita Scale 3 (EF-3) damage was documented, likely due to a paucity of well-built structures in the path of the small, most-intense portions of sub-vortices and because the regions of most intense winds were very small, and translating extremely rapidly, resulting in 100 m AGL winds exceeding 120 m/s occurring for perhaps < 1 s over particular locations. The region enclosing the maximum winds of the MVMC extended ~2 km. DOW-measured winds >50 m/s (>30 m/s) extended outward from the radius of maximum winds (RMW) to cover a cross-track region extending > 5km (7km), comparable to the widest ever documented.

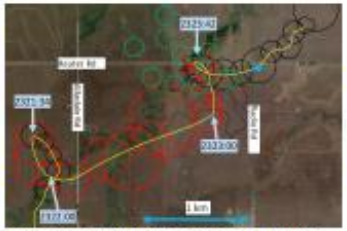
Above. (top) Track of tornado/MVMC, internal sub-vortex impacting research team, and other vortices near El Reno, Oklahoma on 31 May 2013. Very wide path and complex and intense multiple vortex structure combined to make this tornado particularly hazardous. (bottom) Reflectivity in the supercell thunderstorm as measured by DOW6 at 3 degrees, approximately 1 km AGL at 2316 UTC.



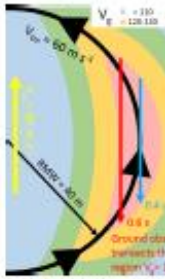
Above. El Reno tornado as observed by DO from left to right: Reflectivity (Z), Doppler Differential Reflectivity (ZDR), and the cros coefficient (ρ_{hv}). Stippled (Solid) lines indic interest in the ZDR (ρ_{hv}) field(s).



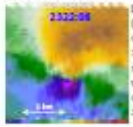
Above. Doppler Velocity (left) and Reflectivity (right). DOW sweeps at selected times illustrating path of sub-vortex which impacted Samaras research team. Red and black rings are schematic indications of region enclosing maximum winds. Times are HHMMSS UTC. Blue ring (right panels) annotates widening debris ring echo (DRE). White/Black dots are start/end location of vehicle. Beginning at ~2323:32, vehicle was transported south, then east about southern side of the sub-vortex.



Above. Smoothed track of interior sub-vortex as measured by the Rapid-Scan DOW. Yellow line is approximate center of circulation. Red and black circles delineate, at selected times, the approximate region enclosing the maximum tangential velocity, V_{tan}. Blue boxes label selected times along the track in HHMMSS UTC. Red (blue) dots represent start (end) locations of the Samaras team's vehicle. Green circles delineate vortices impacting the same area shortly afterwards. The vortex loops at 2321:34, moves rapidly east-northeastward from 2322:00 until 2323:00, then more slowly north-northwestward, becoming stationary over Reuters road and the vehicle, then moves east-northeastward again.



Above. Schematic of strong V_g s rapidly moving sub-vortex. Very m s^{-1}, adds to peak tangential w 60 m s^{-1}, at and near the radius winds resulting in peak V_g = 140 However, due to very fast V_{tr}, th of V_g > 130 m s^{-1} over a stationa observer is ≤ 0.6 s.



Left. Doppler velocity (RSDOW) 120m AGL during time of peak area >90 m s^{-1} (darkest blue to magenta) not in a sub vortex. Some points could have experienced >90 m s^{-1} for >15s.

(right). (top) strong vortices, exterior vortex, with LRE and DS/DRE signatures (blue rings). (middle) Large along-track width of 30 m s^{-1} and 50 m s^{-1} radar winds, ~ 2km diameter circulation and strong interior vortex. (bottom) several sub-vortices. Blue rings schematically illustrate debris ring echoes (DRE). Black rings denote velocity signatures of sub-vortices.

Wurman, J., K. A. Kosiba, P. Robinson, and T. Marshall, 2013: The Role of Multiple Vortex Tornado Structure in Causing Storm Researcher Fatalities. Accepted to *Wea. and Forecasting*.

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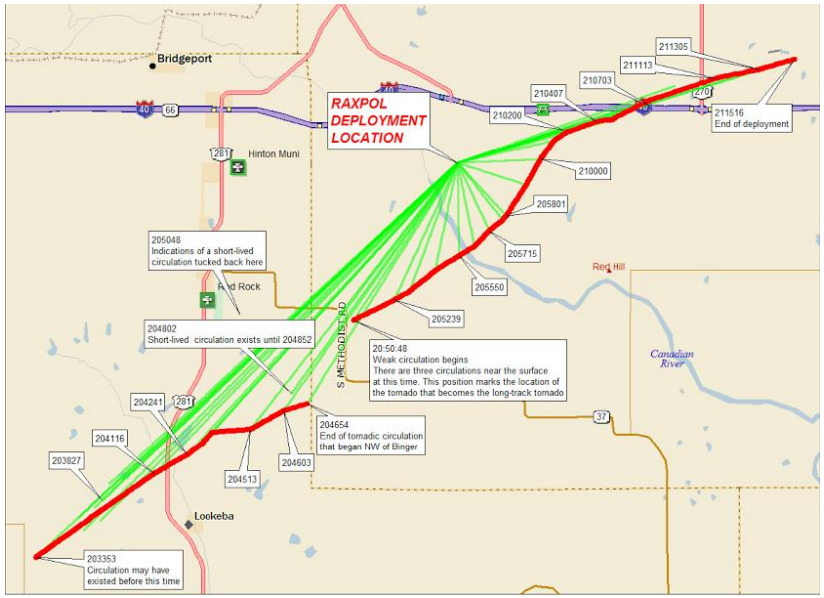
How to account for wind measurements

May 24, 2011 – El Reno I



Non-DI

Radar

PRELIMINARY DATA...

EVENT DATE: MAY 24, 2011

EVENT TYPE: TORNADO

EF RATING: EF-5

ESTIMATED PEAK WINDS (MPH): GREATER THAN 210 MPH

INJURIES/FATALITIES: UNKNOWN/9

EVENT START LOCATION AND TIME: 8 WNW BINGER 3:30 PM CDT

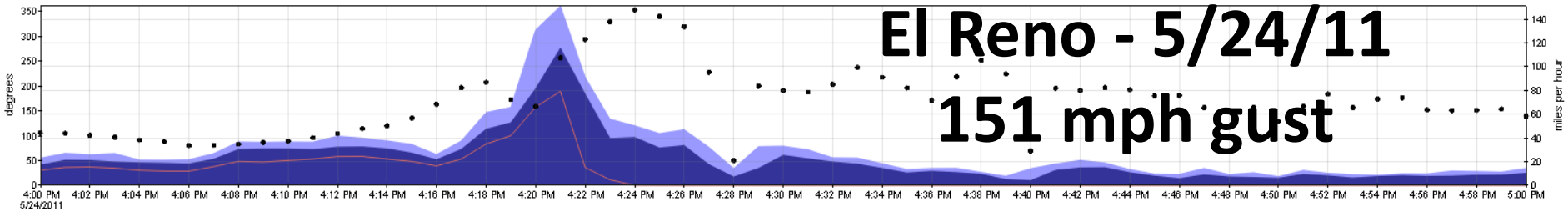
EVENT END LOCATION AND TIME: 4 NE GUTHRIE 5:35 PM CDT

DAMAGE PATH LENGTH (IN MILES): 75 MILES

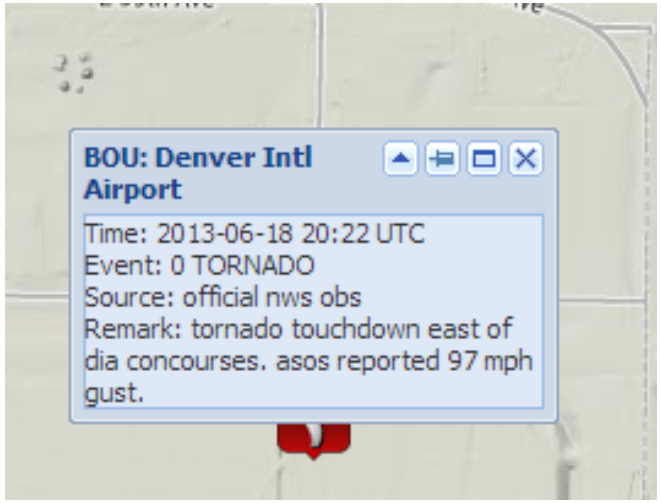
DAMAGE WIDTH: UNKNOWN

NOTE: RATING BASED ON UNIVERSITY OF OKLAHOMA MOBILE DOPPLER RADAR MEASUREMENTS.

How to account for wind measurements
(and not just radar!)



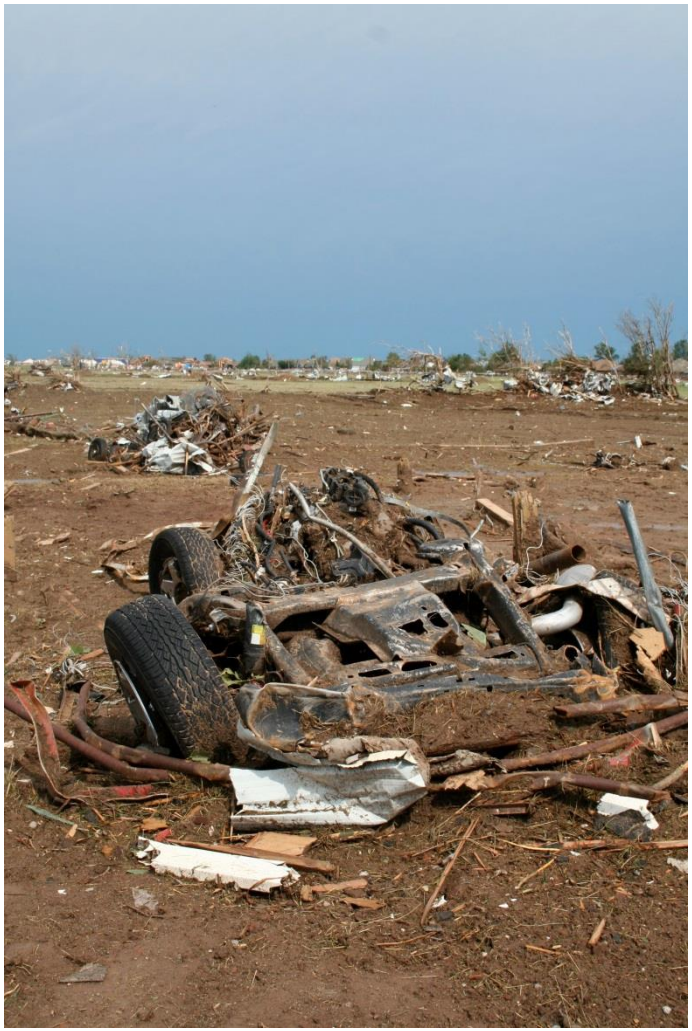
El Reno - 5/24/11
151 mph gust



Denver - 6/18/13
97 mph gust

Other Issues

Other Issues



Need more DI's

Other Issues

Sometimes, you just need to say…

EF U!

We need an EF Unknown option