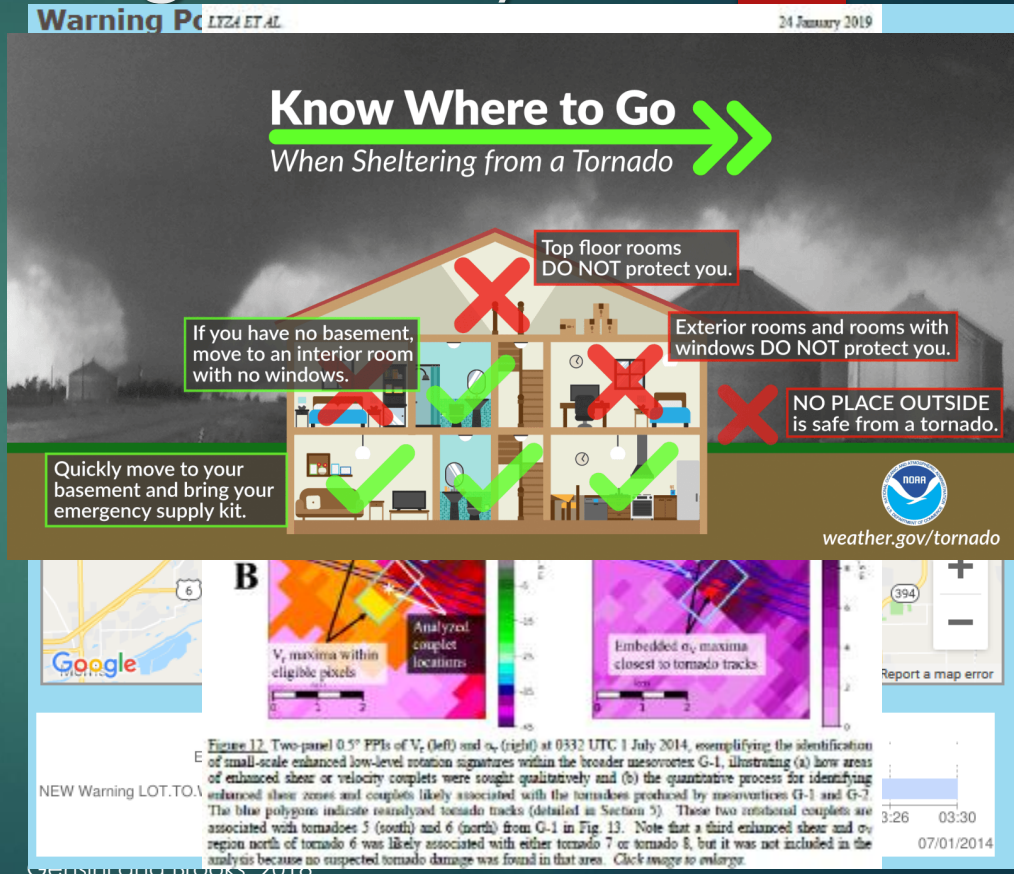
Post Storm Damage Assessment: Determining Tornado Strength

ERIC LENNING, SCIENCE AND OPERATIONS OFFICER

NATIONAL WEATHER SERVICE – CHICAGO/ROMEOVILLE

Purpose of NWS Damage Surveys

- Verify warning performance
- Advance the science
- Support climatology
- Promote public safety and preparedness



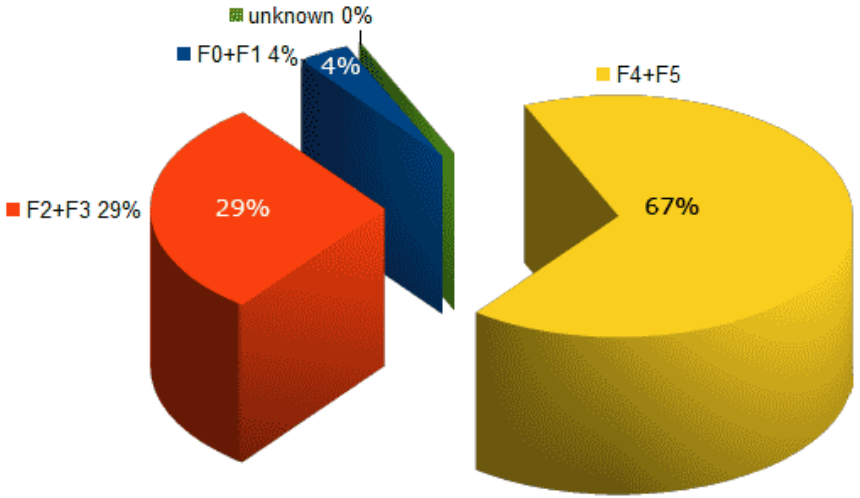
Gensini and Brooks, 2018

What prompts a damage survey?

- Tornado Warning issued:
  - Damage reported, or
  - Nothing reported, but strong suspicion
- *Reliable* report of tornado (warned or not)
- Sufficient time and resources
- Confidence that survey goals can be met:
  Verify warning, advance science, etc.

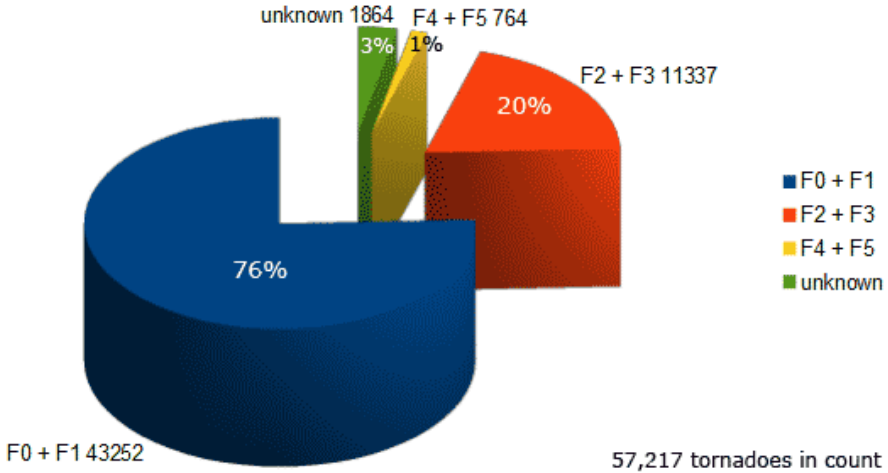
Weak Tornadoes (EF0-EF1): Most frequent, least dangerous

Tornado Deaths by F-Scale



F0
F1
F2
F3
F4
F5

Total Tornadoes by F-Scale



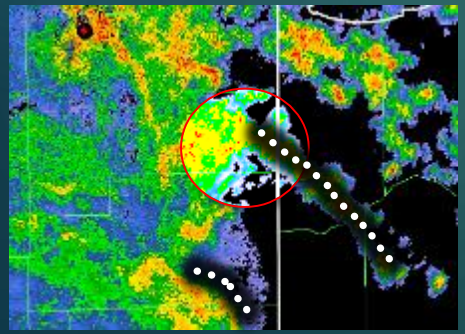
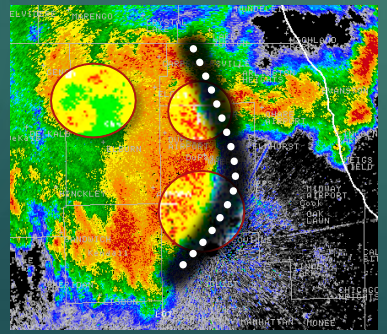
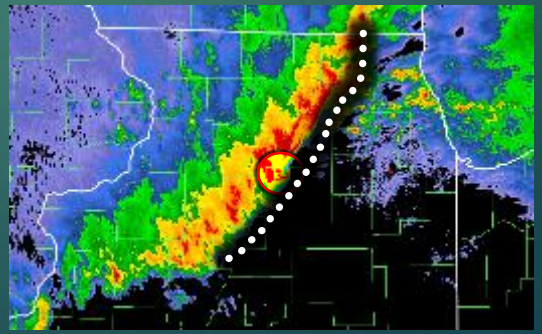
Tom Grazulis, The Tornado Project

Basic Damage Survey Process

- What are we looking for? Tornado vs "Wind"
- Assess length, max width, max EF rating
- Record and share results (ASAP)

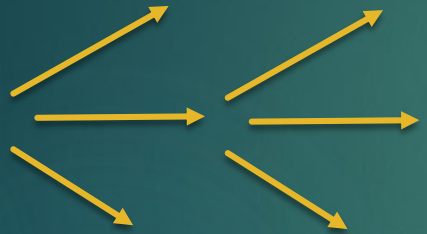
Damaging Wind Sources

	Storm Type	Downbursts	Tornados
Multicell Squall Lines	Gust Front	✓	Maybe
	Bow Echo	✓	✓
	Derecho	✓	✓
Single Cell	Ordinary Cell	✓	Maybe
	Supercell	✓	✓

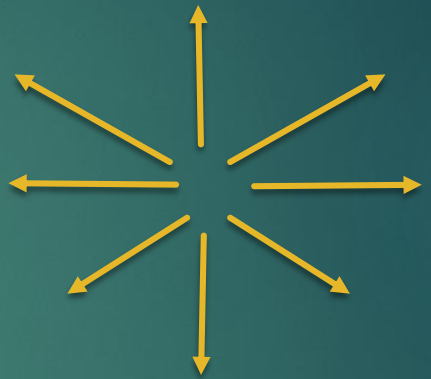





Damaging Wind Mechanisms

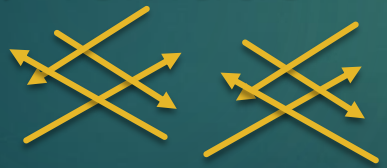
- Downburst – Divergent



OR



- Tornado – Convergent (usually)



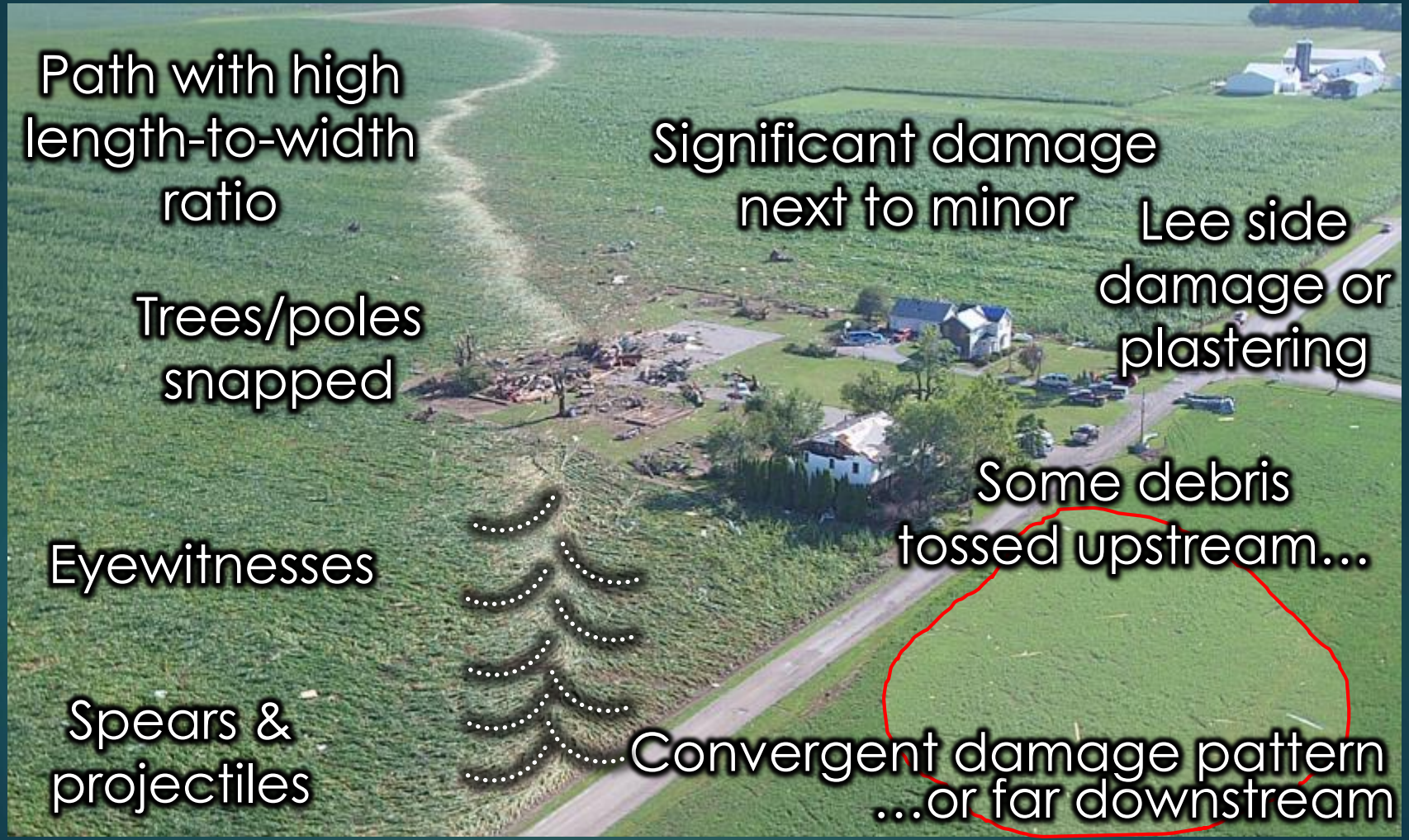
OR

Wind vs Tornado Damage*
What are we looking for?


NWS Birmingham, AL

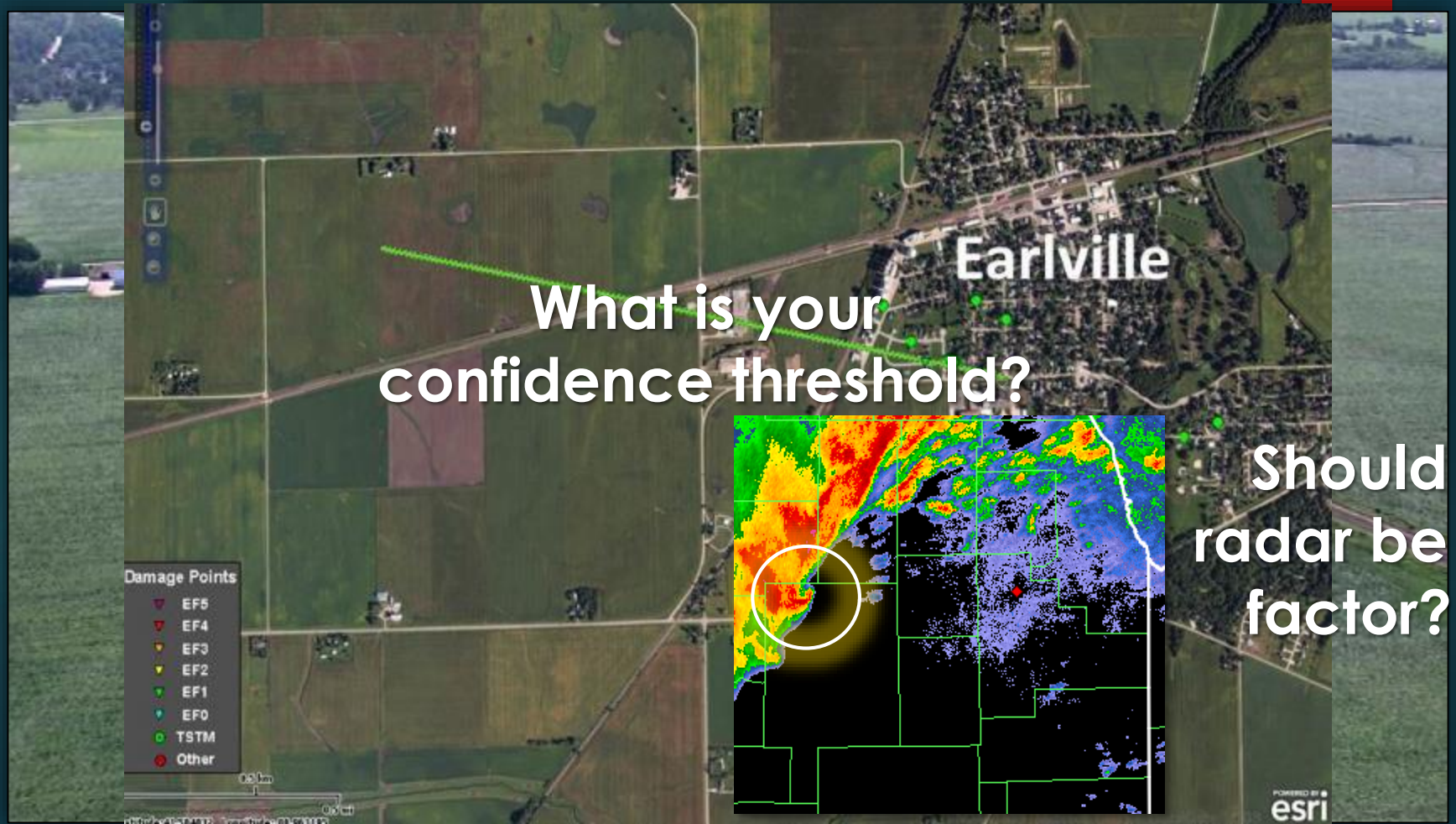

Kristofer Tuftedal

**Remember: It's all wind damage*



8/24/16 Damage near Roberts/Doty Roads-Woodburn, IN (Scott Jordan Drone Footage/NWS Storm Survey)

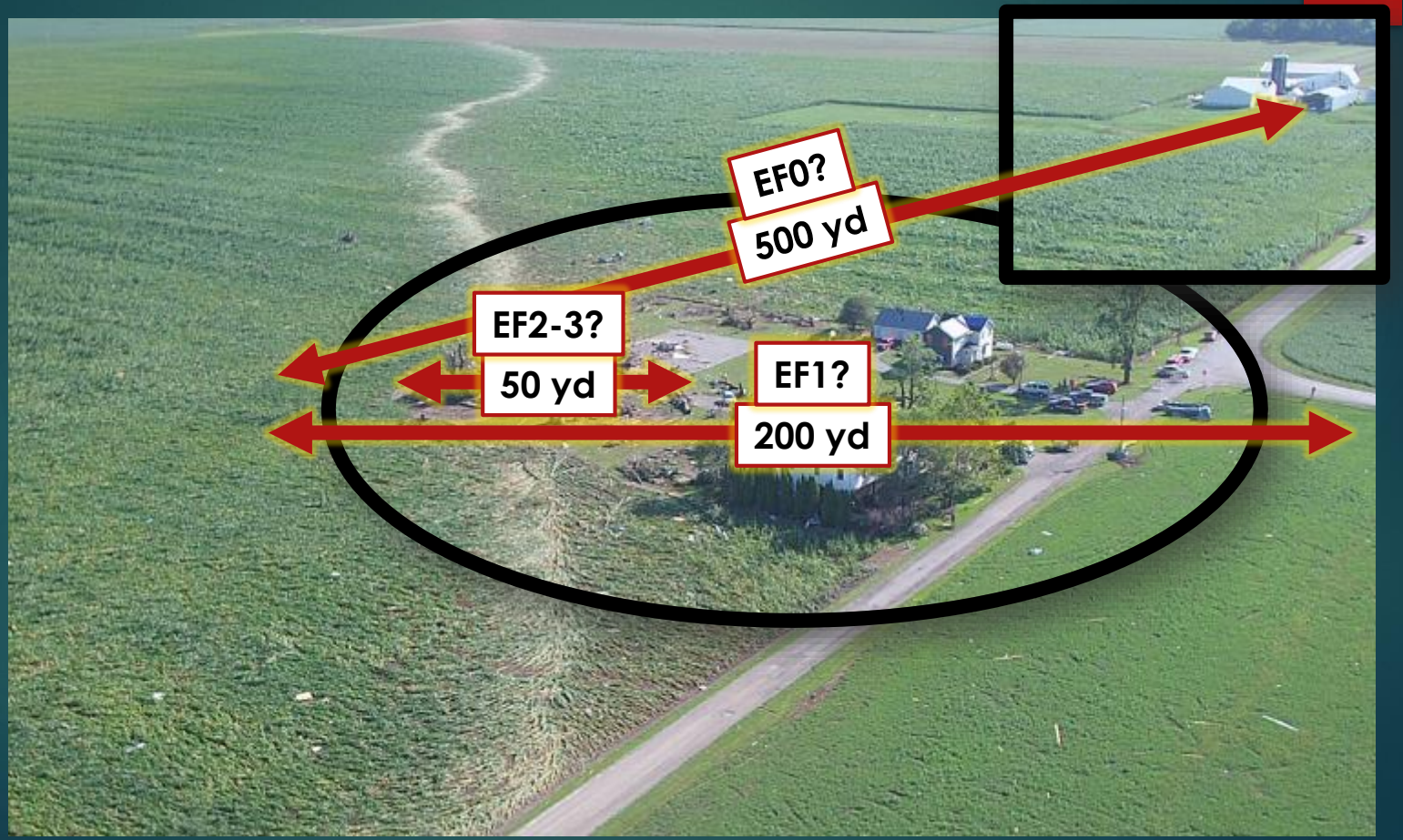
Practice time!



Assessing length, width, and intensity (EF-Scale)

TO THE BEST OF OUR ABILITY…

Path length and width



EF-Scale for tornado *damage*

SUBJECTIVE!

EF Rating	Wind Speeds	Expected Damage		
EF-0	65-85 mph	'Minor' damage: shingles blown off or parts of a roof peeled off, damage to gutters/siding, branches broken off trees, shallow rooted trees toppled.		
EF-1	86-110 mph	damage, windows broken, exterior doors damaged or lost, mobile homes overturned or badly damaged.		
EF-2	111-135 mph	'Considerable' damage: roofs torn off well constructed homes, homes shifted off their foundation, mobile homes completely destroyed, large trees snapped or uprooted, cars can be tossed.		
EF-3	136-165 mph	'Severe' damage: entire stories of well constructed homes destroyed, significant damage done to large buildings, homes with weak foundations can be blown away, trees begin to lose their bark.		
EF-4	166-200 mph	'Extreme' damage: Well constructed homes are leveled, cars are thrown significant distances, top story exterior walls of masonry buildings would likely collapse.		
EF-5	> 200 mph	'Massive/incredible' damage: Well constructed homes are swept away, steel-reinforced concrete structures are critically damaged, high-rise buildings sustain severe structural damage, trees are usually completely debarked,		

25

30

35

Using the EF-Scale

- Determine **Damage Indicator** (**DI**: house, barn, etc.)
- Determine **degree of damage** (**DOD**: 1-3…1-12, etc.)
  - Note "Expected" wind for given DI and DOD
  - Adjust toward Lower- or Upper-Bound (LB/UB) wind?
- Identify **EF-Rating** based on inferred wind speed

DI/DOD/EXP-UB-LB → Wind Speed → EF-Rating

28 February 2017
Naplate / Ottawa, IL

DOD for House/Duplex (DI 2)

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
3	Broken glass in doors and windows	96	79	114
4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney; garage doors collapse inward; failure of porch or carport	97	81	116
5	Entire house shifts off foundation	121	103	141
6	Large sections of roof structure removed; most walls remain standing	122	104	142
7	Exterior walls collapsed	132	113	153
8	Most walls collapsed, except small interior rooms	152	127	178
9	All walls	170	142	198
10	Destruction of engineered and/or well constructed residence; slab swept clean	200	165	220

* DOD is degree of damage

DOD for House/Duplex (DI 2)

DOD for House/Duplex (DI 2)

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
3	Broken glass in doors and windows	96	79	114
4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney; garage doors collapse inward; failure of porch or carport	97	81	116
5	Entire house shifts off foundation	121	103	141
6	Large sections of roof structure removed; most walls remain standing	122	104	142
7	Exterior walls collapsed	132	113	153
8	Most walls collapsed, except small interior rooms	152	127	178
9	All walls	170	142	198
10	Destruction of engineered and/or well constructed residence; slab swept clean	200	165	220

* DOD is degree of damage

DOD for House/Duplex (DI 2)

DOD for House/Duplex (DI 2)

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
3	Broken glass in doors and windows	96	79	114
4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney; garage doors collapse inward; failure of porch or carport	97	81	116
5	Entire house shifts off foundation	121	103	141
6	Large sections of roof structure removed; most walls remain standing	122	104	142
7	Exterior walls collapsed	132	113	153
8	Most walls collapsed, except small interior rooms	152	127	178
9	All walls	170	142	198
10	Destruction of engineered and/or well constructed residence; slab swept clean	200	165	220

* DOD is degree of damage

DOD for House/Duplex

Schmidlin et al.
(BAMS, 2002)

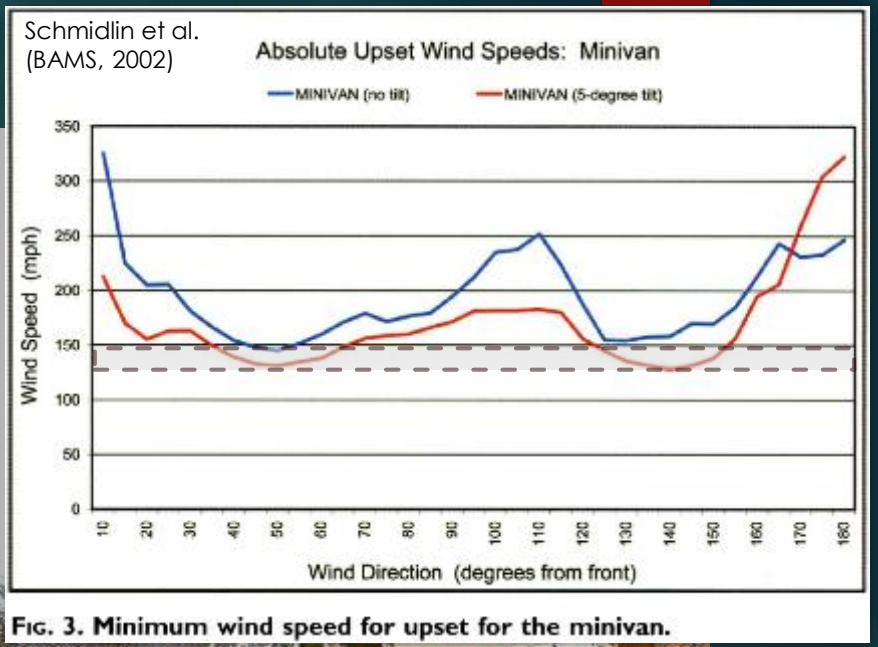
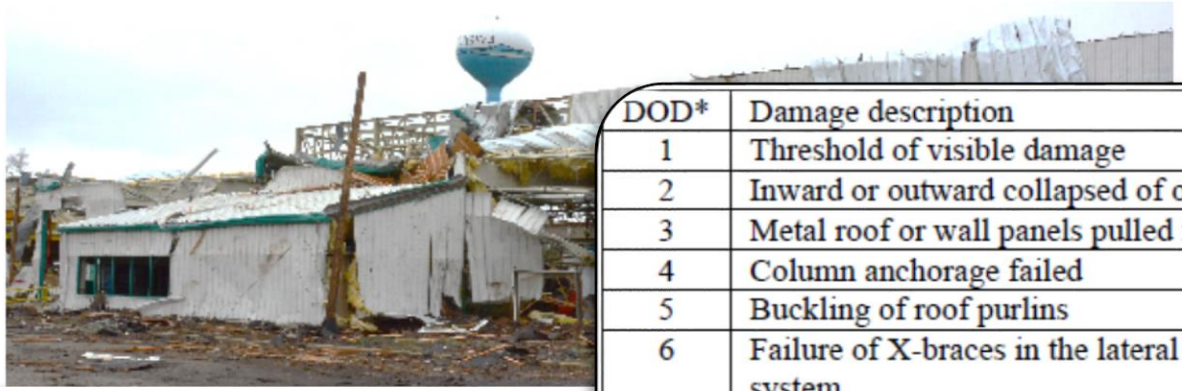


FIG. 3. Minimum wind speed for upset for the minivan.

- Vehicle moved laterally: EF1 or higher
- Several cars moved, none or few tipped: EF2
- More than half moved, several tipped: EF3

"In the absence of other damage, observation of vehicles tipped over probably indicates EF3 or stronger"
Paulikas et al. (WCS 2016)

Naplate: EF3 (DI 21. METAL BUILDING SYSTEMS)



DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	67	54	83
2	Inward or outward collapsed of overhead doors	89	75	108
3	Metal roof or wall panels pulled from the building	95	78	120
4	Column anchorage failed	117	96	135
5	Buckling of roof purlins	118	95	138
6	Failure of X-braces in the lateral load resisting system	138	118	158
7	Progressive collapse of rigid frames	143	120	168
8	Total destruction of building	155	132	178

Facility got the warning, sheltered all employees…
no injuries reported!

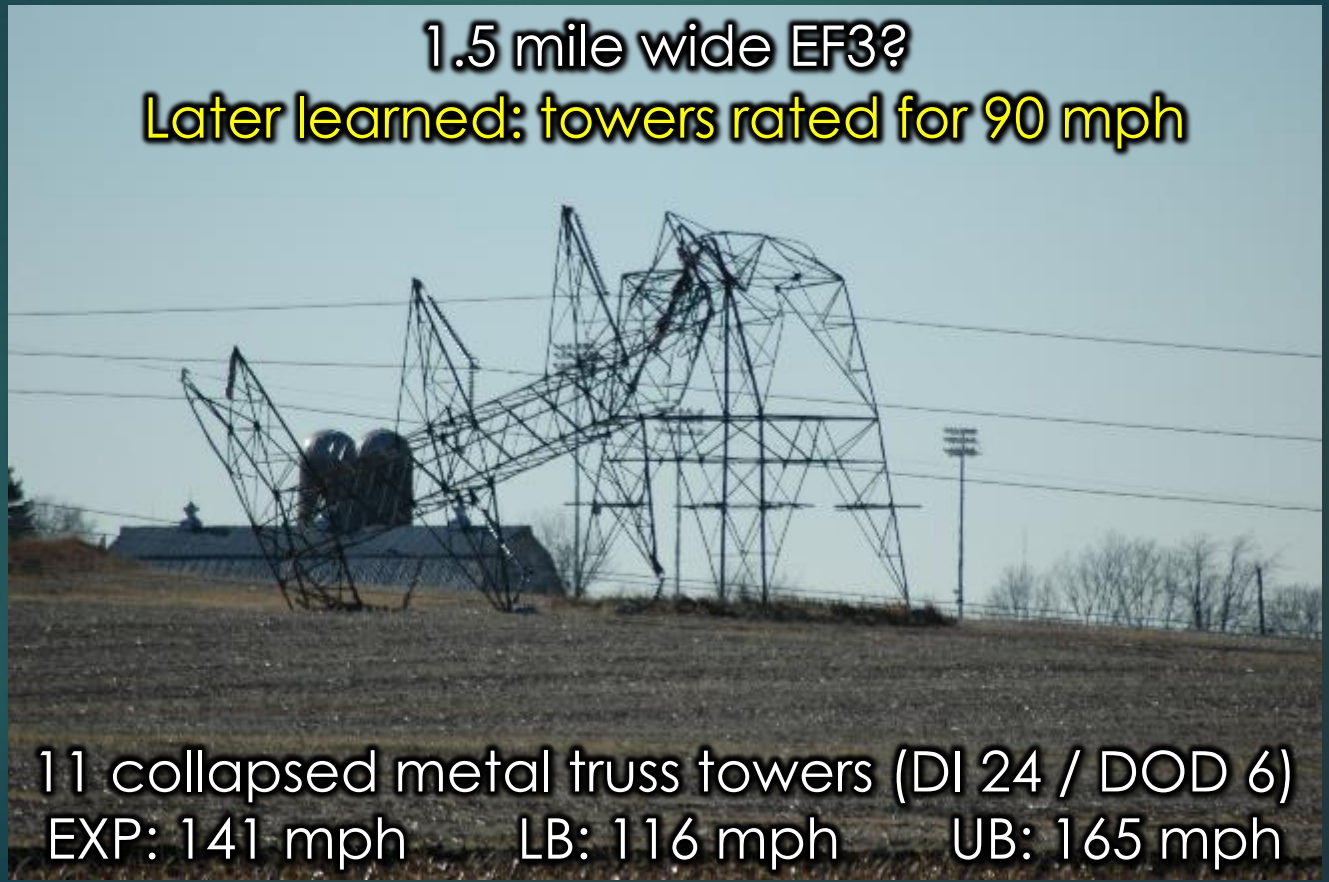
Naplate: More Safety Lessons

Two people were home, got the warning, sheltered in the bathroom …and lived

9 April 2015
Rochelle/Fairdale, IL

22 November 2010
Loves Park / Caledonia, IL

Loves Park / Caledonia
22 November 2010



12-13 March 2006
Monroe County, MO

DOD for House/Duplex (DI 2)

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
3	Broken glass in doors and windows	96	79	114
4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney; garage doors collapse inward; failure of porch or carport	97	81	116
5	Entire house shifts off foundation	121	103	141
6	Large sections of roof structure removed; most walls remain standing	122	104	142
7	Exterior walls collapsed	132	113	153
8	Most walls collapsed, except small interior rooms	152	127	178
9	All walls	170	142	198
10	Destruction of engineered and/or well constructed residence; slab swept clean	200	165	220

* DOD is degree of damage

Across the road from this house


TRUCK
CAR?
CAR
CAR

DOD for House/Duplex (DI 2)

DOD*	Damage description	EXP	LB	UB
1	Threshold of visible damage	65	53	80
2	Loss of roof covering material (<20%), gutters and/or awning; loss of vinyl or metal siding	79	63	97
3	Broken glass in doors and windows	96	79	114
4	Uplift of roof deck and loss of significant roof covering material (>20%); collapse of chimney; garage doors collapse inward; failure of porch or carport	97	81	116
5	Entire house shifts off foundation	121	103	141
6	Large sections of roof structure removed; most walls remain standing	122	104	142
7	Exterior walls collapsed	132	113	153
8	Most walls collapsed, except small interior rooms	152	127	178
9	All walls	170	142	198
10	Destruction of engineered and/or well constructed residence; slab swept clean	200	165	220

* DOD is degree of damage

In the absence of other damage, observation of vehicles tipped over probably indicates EF3 or stronger. **If most vehicles are tipped then an EF4 rating may be appropriate.** *Paulikas et al. (WCS 2016)*

Additions for bigger events

- Quick Response Team (QRT)
- Aerial surveys – manned and unmanned
- Satellite Imagery

Quick Response Teams (QRTs)
Wind Damage Experts

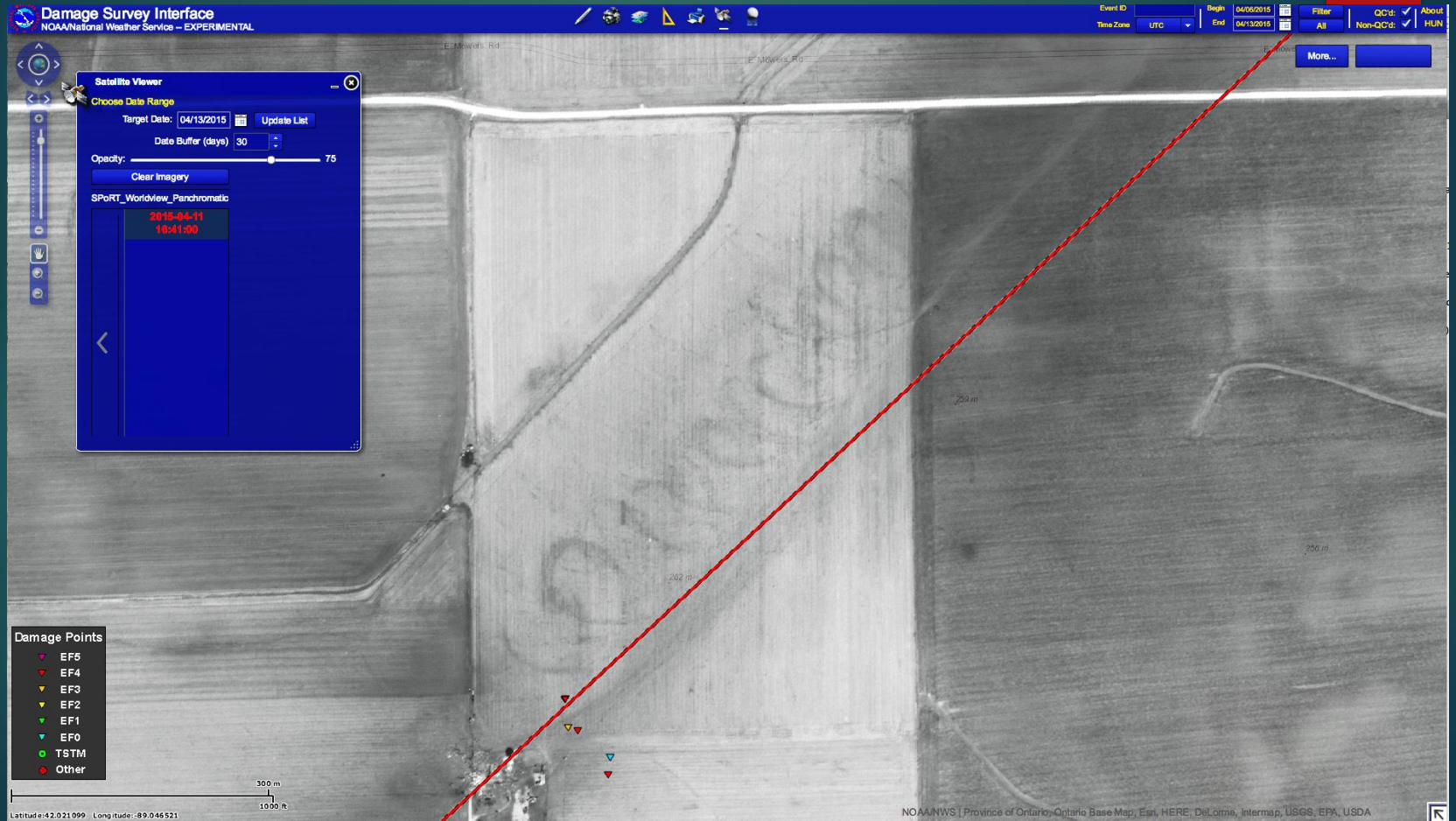
Consideration for fielding a QRT includes:

- damage "possibly greater than EF3"
- large number of casualties
- significant scientific interest

Aerial Surveys: Manned & Unmanned

- Manned
  - Civil Air Patrol
  - NOS/National Geodetic Survey
  - State/Local EM or law enforcement
  - Local media (TV helicopters)
- Unmanned – Drones
  - NWS offices do not own or operate
  - Happy to accept volunteer footage

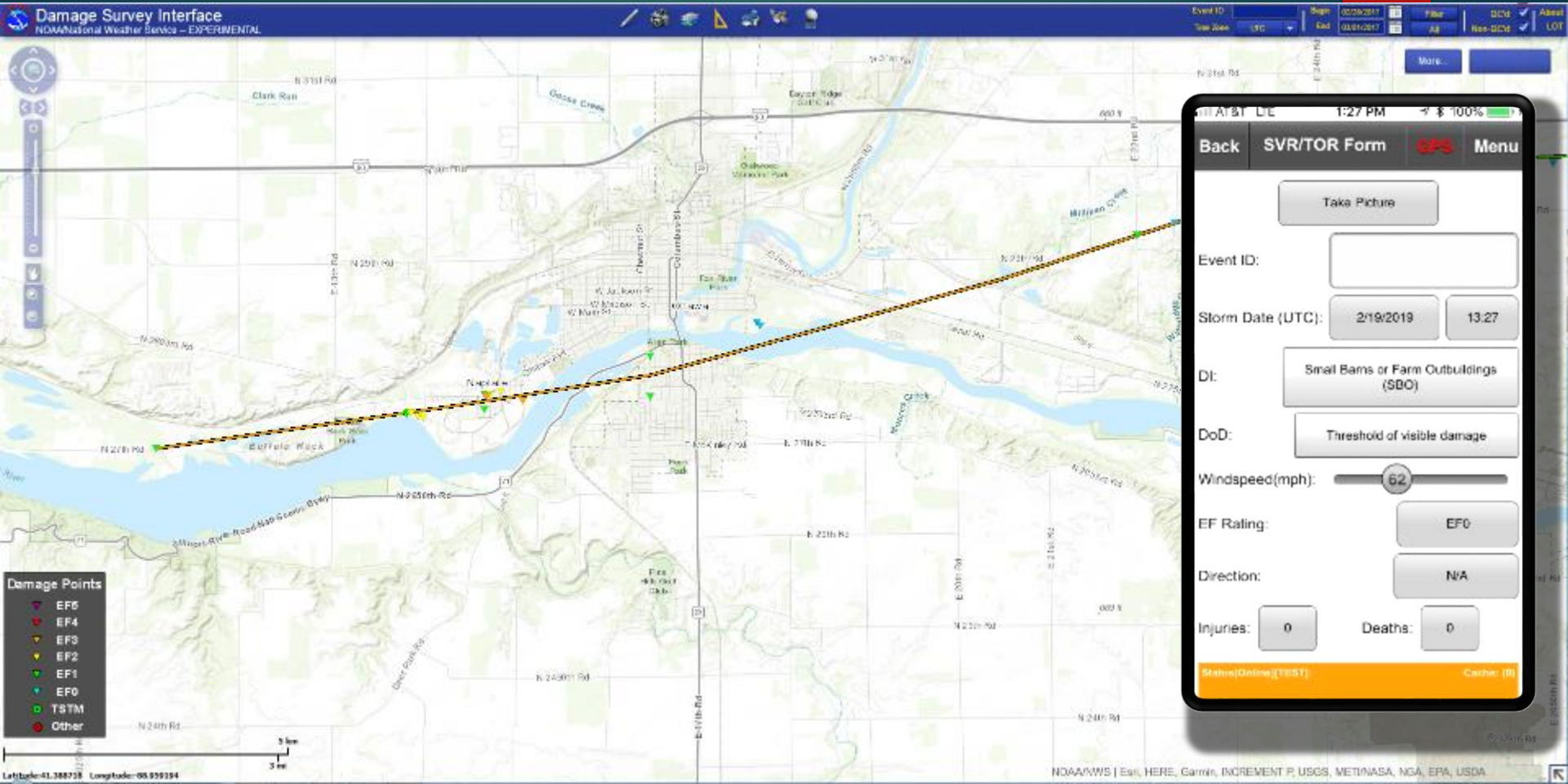
NASA/SPoRT Satellite Imagery



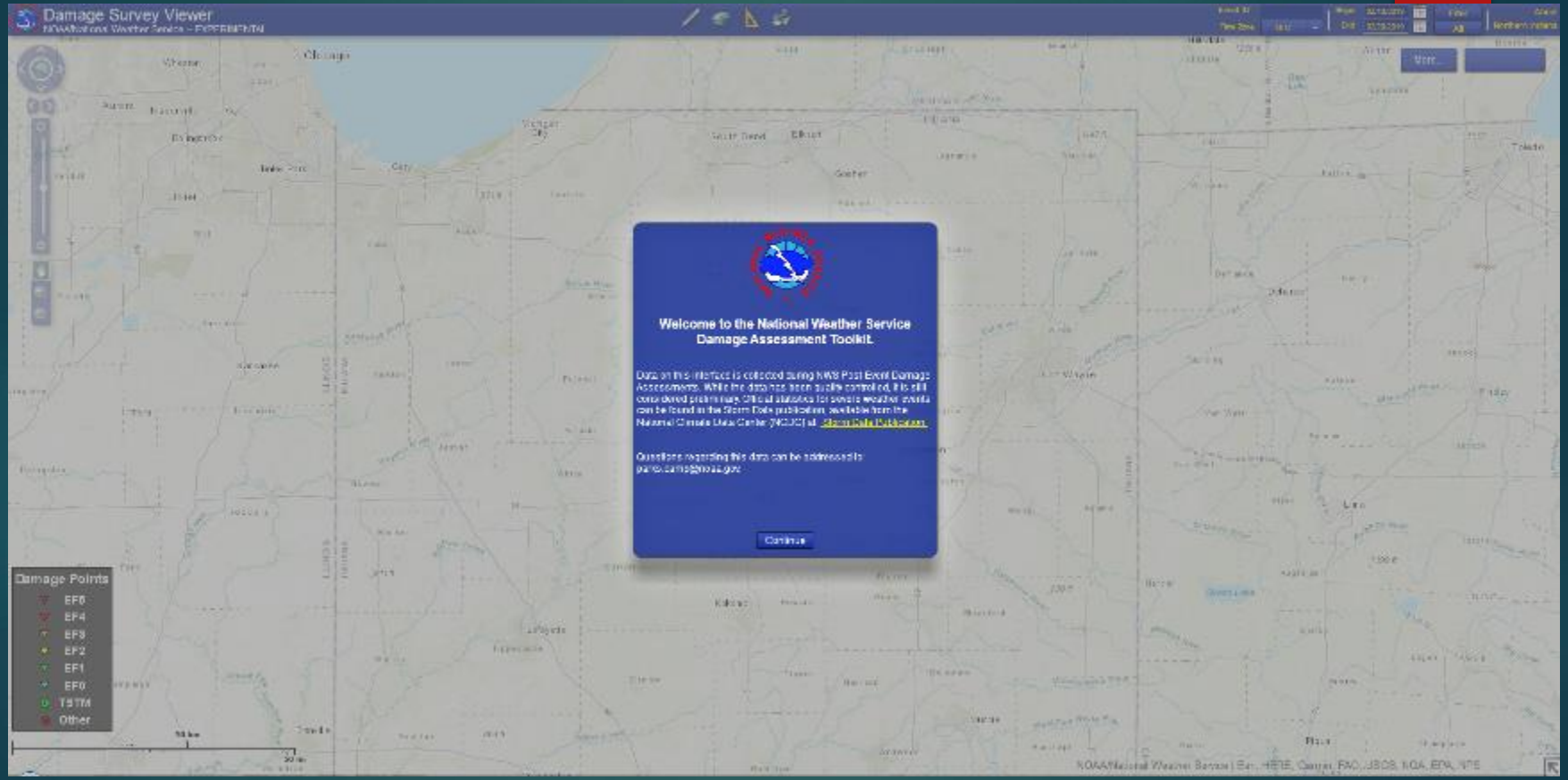
Sharing Results

1. Damage Assessment Toolkit
2. Public Information Statement
3. Website Events Summary
4. Storm Data

NWS Damage Assessment Toolkit (DAT)



NWS Damage Survey Viewer (Public)



https://apps.dat.noaa.gov/stormdamage/damageviewer/

Public Information Statement (PNS)

```
Public Information Statement
National Weather Service Chicago IL
502 PM CST Wed Mar 1 2017 /602 PM EST Wed Mar 1 2017/

...NWS DAMAGE SURVEY FOR 02/28/17 TORNADO EVENT...


.Naplate-Ottawa Tornado...

Rating:                  EF-3
Estimated peak wind:     155 mph
Path length /Statute/:   11.5 miles
Path width /Maximum/:    800 yards
Fatalities:              1
Injuries:                14

Start date:              Feb 28 2017
Start time:              4:41 PM CST
Start location:          3.5 miles south-southwest of Naplate
Start Lat/Lon:           41.3239 / -88.9504

End date:                Feb 28 2017
End time:                4:59 PM CST
End location:            2.5 miles northwest of Marseilles
End_lat/lon:             41.3597 / -88.7352

SURVEY_SUMMARY: The first area of significant damage in the EF2
range was in the area around the La Salle County Nursing Home and
La Salle County Highway Department, with lighter damage upstream
from this location. The tornado continued into Naplate and
produced widespread EF2 damage to numerous homes. EF3 damage also
was identified in two locations, the first where a home was
lifted off its foundation and left with only its interior walls
intact, and the second at the Pilkington Glass plant where one
section of the factory was completely destroyed. The tornado then
crossed the Illinois River and moved through the south side of
Ottawa, producing an 800 yard wide path of EF1 damage to trees
and homes. The tornado then crossed the Illinois River again and
continued to produce EF1 and EF0 damage as it exited Ottawa,
finally dissipating in the area northwest of Marseilles.

EF Scale: The Enhanced Fujita Scale Classifies
Tornadoes into the following categories.

EF0...Weak.....65 to 85 mph
EF1...Weak.....86 to 110 mph
EF2...Strong....111 to 135 mph
EF3...Strong....136 to 165 mph
```

Website Event Summary

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HOME | FORECAST | PAST WEATHER | SAFETY | INFORMATION | EDUCATION | NEWS | SEARCH | ABOUT

Local forecast by "City, St" or ZIP code
Enter location ... Go
Location Help

News Headlines
- Snow and Ice Event to End by Late Afternoon
- 2019 Spotter Class Calendar - A few additional classes to be added soon
- Changes coming to flood impact categories for Illinois River at Ottawa effective April 1st
- Changes coming to forecast services for the Rock River effective April 1st
- 28th Annual DuPage Advanced Severe Weather Seminar March 16th

MY FORECAST
Chicago O'Hare International Airport IL

Light Drizzle Fog/Mist

34°F
1°C Get Detailed Info

This Afternoon

Drizzle and Areas Fog
High: 35°F

Tonight

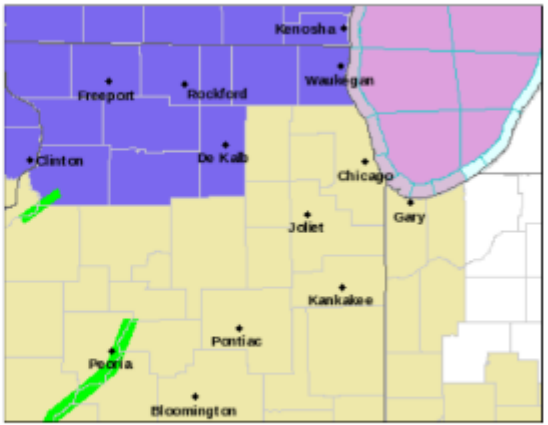
NWS Forecast Office Chicago, IL

Weather.gov > Chicago, IL

Chicago, IL
Weather Forecast Office

Current Hazards | Current Conditions | Radar | Forecasts | Rivers and Lakes | Climate and Past Weather | Local Programs

Click a location below for detailed forecast.



Last Map Update: Wed, Feb. 20, 2019 at 1:46:26 pm CST

Watches, Warnings & Advisories
- Flood Warning
- Gale Warning
- Winter Weather Advisory
- Small Craft Advisory
- Hazardous Weather Outlook

Drought
NOAA Climate Service
Event Summaries
Local

Website Event Summary

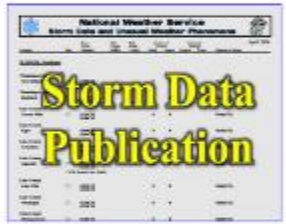
Event Summaries

Weather.gov > Chicago, IL > Event Summaries

Chicago, IL
Weather Forecast Office

This page serves as a location to find past weather event information for northern Illinois and northwest Indiana.

To the right is a link to *Storm Data*, a monthly publication by the NWS's National Centers for Environmental Information (NCEI). *Storm Data* will list all of the finalized, quality controlled severe weather reports and damage survey assessments within the **NWS Chicago County Warning Area** broken down by month. To the lower right there is a thumbnail link to an interactive map archive of preliminary Local Storm Reports that are issued by an NWS office when a severe weather event is reported.



Further below on this page are individual event reviews for the local area sorted by event type. Many of these are archived stories from web top news headlines on our home page in the hours to days after the events occurred. Click on the date to jump to the full archived event review. Each story contains data and records from the event, and often meteorological insight and photos. To quickly search for an event that you may not recall the date of, click the "All" tab, hit Ctrl + F to search your browser, and enter the event and/or city or county impacted.

If you cannot find what you are looking for here, try our **Local Climate Page**, or for visualizing various datasets also try the **NOAA Weather and Climate Toolkit.**

All | Historic | **Tornadoes** | Wind/Hail | Flood | Winter | Heat/Cold | Winds | Marine | Studies

Website Event Summary

All | Historic | **Tornadoes** | Wind/Hail | Flood | Winter | Heat/Cold | Winds | Marine | Studies

Tornadoes

- **September 3, 2018:** Brief EF-0 on the west side of Chicago
- **August 20, 2018:** Brief EF-0 tornado near Manhattan, IL in Will County
- **June 26, 2018:** Three brief tornadoes, including an EF-1 in Manhattan, IL
- **June 28, 2017:** Significant flash flooding in Rockford and Belvidere, with two EF-1 tornadoes in Boone County
- **May 20, 2017:** EF-0 in rural Benton County
- **May 17-18, 2017:** Severe storms bring scattered intense damage & EF-1 tornado in Capron in Boone County
- **February 28, 2017:** First February significant tornadoes in northern IL on record; EF-3 in Naplate & Ottawa, IL
- **August 9, 2016:** Weak landspout tornado on the southwest side of Chicago
- **July 17, 2016:** EF-1 near Cabery, IL in Ford County and 2 to 6" of rain
- **June 22, 2016:** Over a dozen tornadoes in northern IL, including an EF-2 near Marseilles to Seneca, IL & in Pontiac, IL
- **September 18, 2015:** Heavy rain and a brief EF-1 in the Frankfort-Monee area
- **August 18, 2015:** Severe thunderstorms and heavy rainfall; four confirmed brief EF-0 tornadoes
- **August 2, 2015:** EF-1 in Round Lake & Grayslake, IL in Lake County
- **June 22, 2015:** Dozen tornadoes in northern IL including EF-3 in Coal City & EF-2 near Sublette, IL
- **June 15, 2015:** Widespread flooding across the western Chicago metro; EF-1 near Symerton, IL in Will County
- **June 7, 2015:** Two brief tornadoes in Jasper County, IN
- **May 26, 2015:** Brief EF-0 in Summit, IL in Cook County
- **April 9, 2015:** Violent EF-4 strikes Rochelle area and Fairdale, IL
- **June 30, 2014:** 30 total tornadoes across northern IL & northern IN within the second of two derechoes

Website Event Summary

February 28, 2017: Tornado Event

Weathersavvy > Chicago, IL > February 28, 2017: Tornado Event

Chicago, IL
Weather Forecast Office

Current Hazards | Current Conditions | Radar | Forecasts | Rivers and Lakes | Climate and Past Weather | Local Programs

Overview

The late afternoon into the evening of Tuesday February 28 brought a favorable setup for severe weather, including strong tornadoes across much of the Mid-Mississippi Valley and Lower Great Lakes regions.

Fast Facts:

- There were **seven tornadoes confirmed in the NWS Chicago County Warning Area (CWA)**, including one that started in the NWS Lincoln CWA (Washburn to Rutland). Public Information Statement
- **In total, there were ten tornadoes confirmed across all of northern Illinois** that includes three in the NWS Quad Cities CWA.
- The strongest were **two tornadoes rated EF-3** on the Enhanced Fujita Scale -- one impacting the communities of Naplate and Ottawa, and the other Washburn, both causing significant damage.
- The Naplate to Ottawa tornado killed two persons and injured 14.
- The largest hail reported in the area was in Ottawa, to the size of baseballs.
- Tornadoes also impacted southern IL, MO, IA, IN, KY and MI. See this regional map for more.

Storm Event Map

Naplate-Ottawa Storm	Washburn-Rutland Storm	Oregon Storm
Tornado #1 (EF-0)	*Tornado #5 (EF-3):* ▪ Washburn (Woodford); ▪ Rutland (LaSalle)	*Tornado #7 (EF-1):* ▪ Oregon (Ogle)
Tornado #2 (EF-3): ▪ Naplate (LaSalle) ▪ Ottawa (LaSalle)	*Tornado #6 (EF-2):* ▪ Near Long Point (LaSalle/Livingston)	
Tornado #3 (EF-1) ▪ Marseilles Area (LaSalle)	For more on the Washburn area, please visit NWS Lincoln	
?*Tornado #4 (EF-0)*		

Tornadoes | Storm Reports | Rainfall | Photos | Radar | Environment | Climatology | Service | Other Links

Tornadoes:

A summary text listing of details can be found in this Public Information Statement.

For the Washburn-Rutland area tornado, please see the NWS Lincoln web page

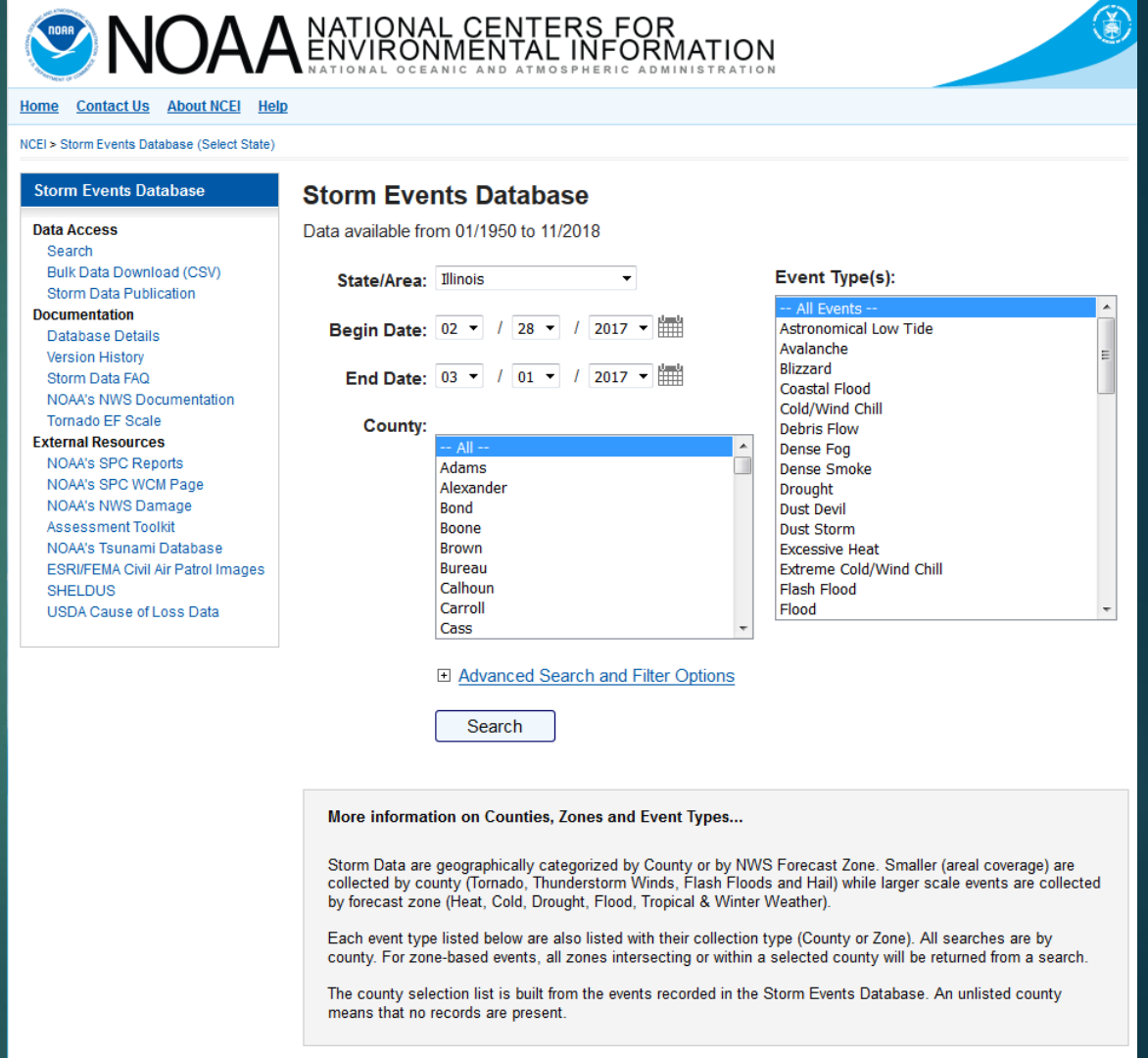
Tornado - Cedar Point Area
LA SALLE COUNTY

Date	2/28/2017
Time (Local)	4:22-4:30 PM CST

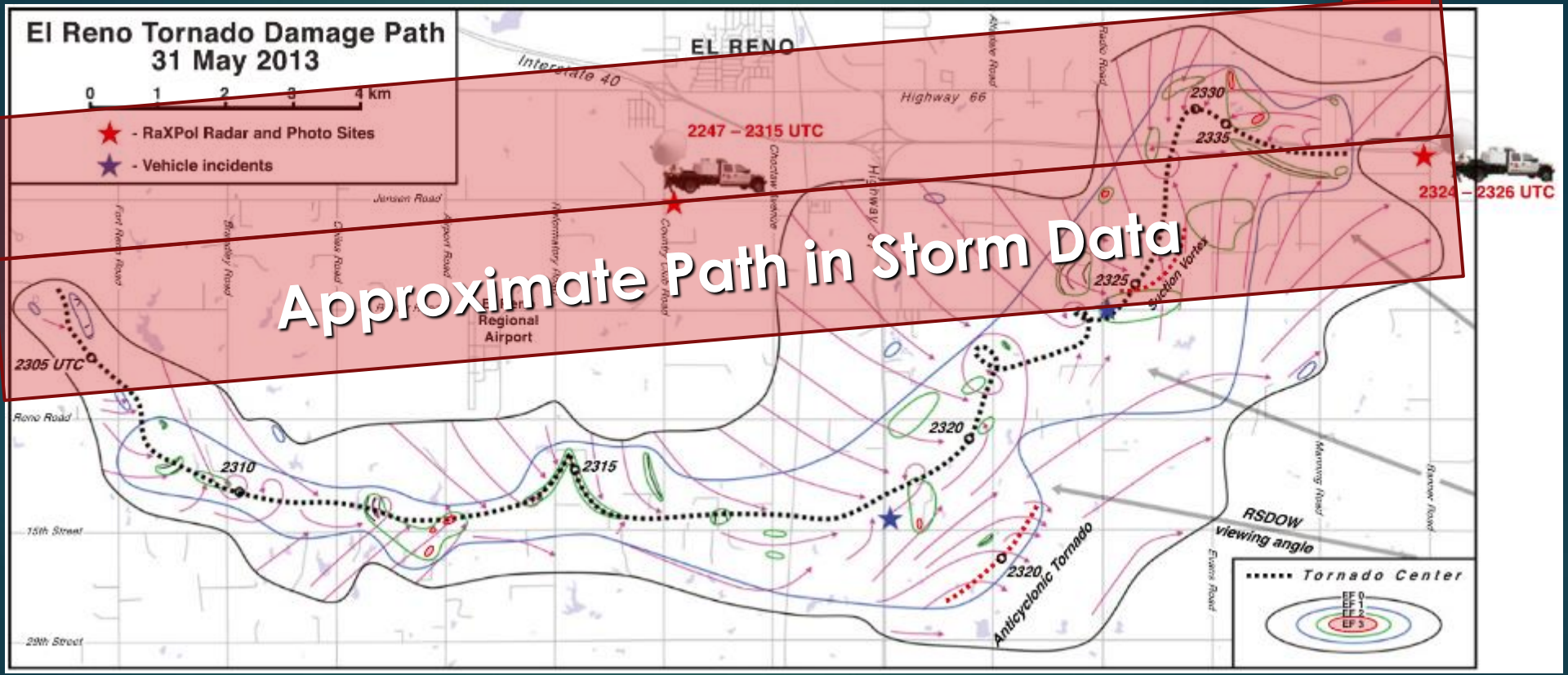
Track Map

NCEI Storm Data

- Start/end points
- Two decimal places
- Segments
  - County
  - State



Storm Data vs Reality



Wakimoto, R. M., and Coauthors, 2016: Aerial damage survey of the 2013 El Reno tornado combined with mobile radar data. Mon. Wea. Rev., 144, 1749–1776

Random Lessons Learned

- Get there early – but not too early
- Don't go alone
- EMA escorts are invaluable
- Take binoculars
- You **can't** document every detail
- You will freeze surveying winter tornadoes
- Get as much information beforehand as possible
- EF0/EF1 can be *really* hard to distinguish as tornadic

In memory of Ron Przybylinski

Born: September 15, 1953
South Bend, IN
Died: March 12, 2015
Chicago, IL