Enhanced Storm Investigation

National Weather Service
Milwaukee/Sullivan, WI

www.weather.gov/milwaukee

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“We’re going to die, we’re going to die” screaming heard on Oklahoma Highway Patrol radio before they were killed. Tim Samaras was found strapped in the car. Other victims were discovered 1/2 mile east and 1/2 mile west of the car.

http://geekslop.com/main/wp-content/uploads/2013/06/image9.png

Personal Safety

Video

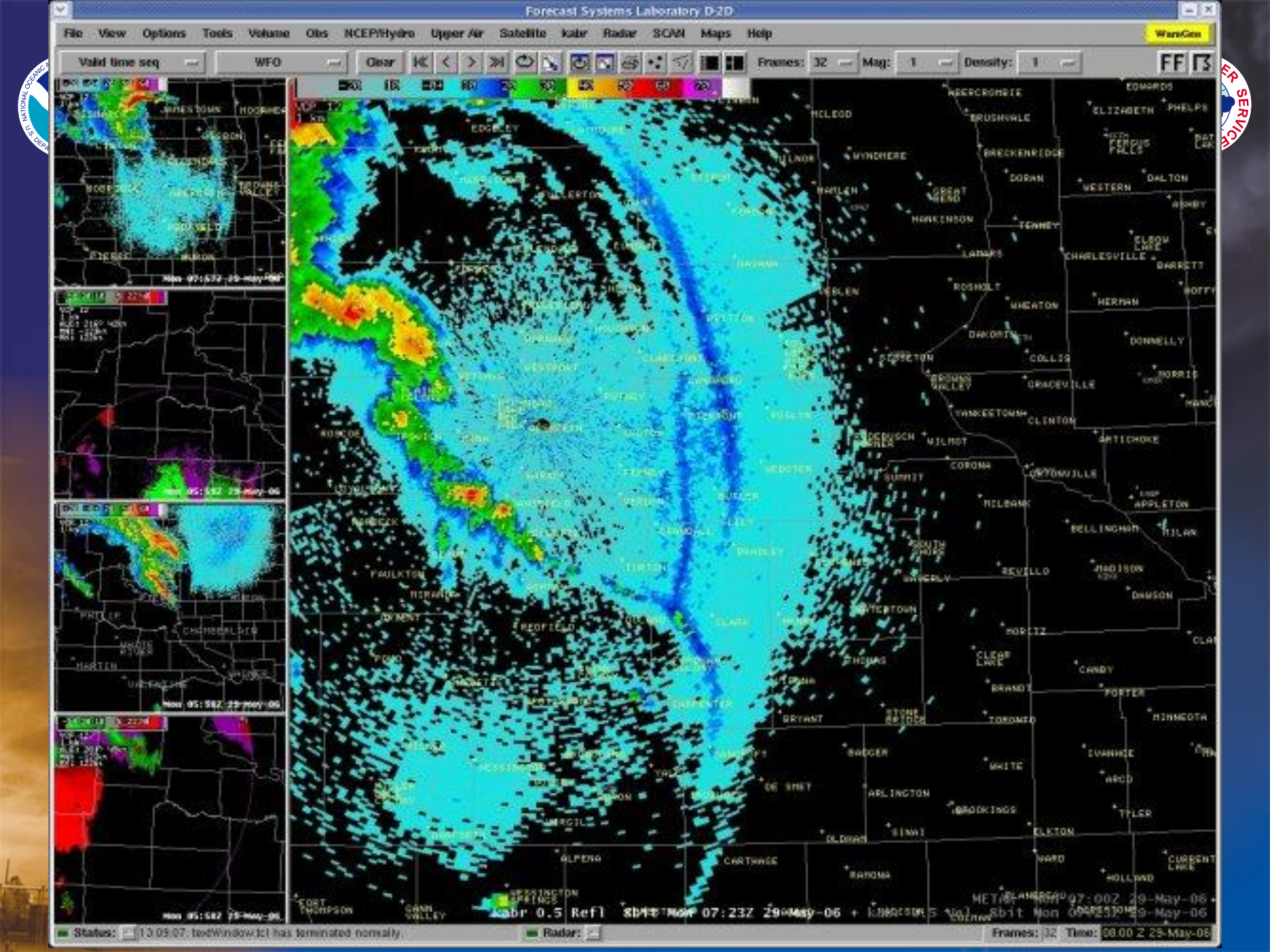
This was a weak tornado – what about a strong or violent tornado?

Convection Basics

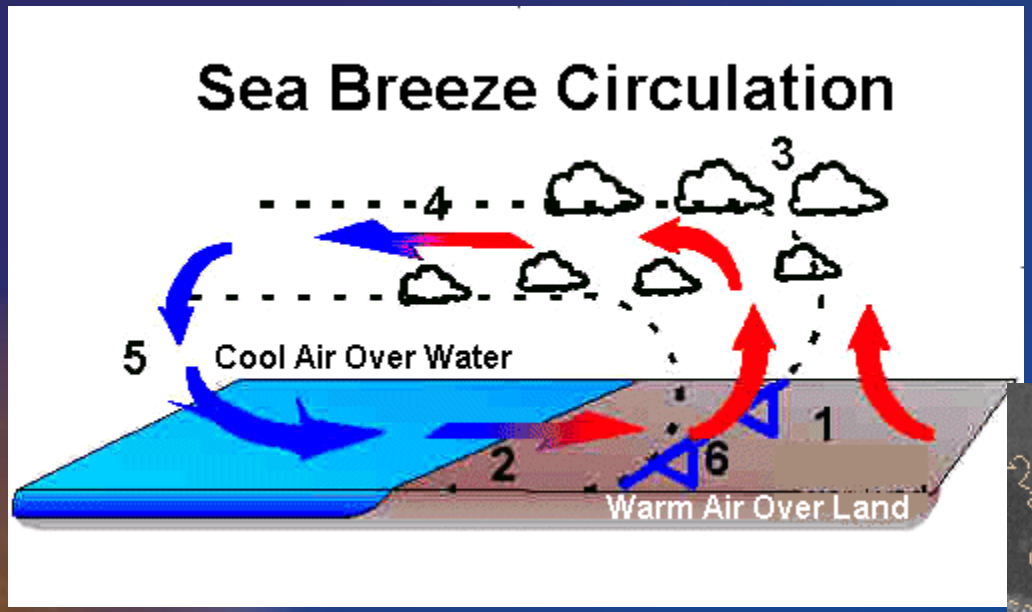
- Moisture
- Instability
- Lift
- Wind Shear (for severe storms)

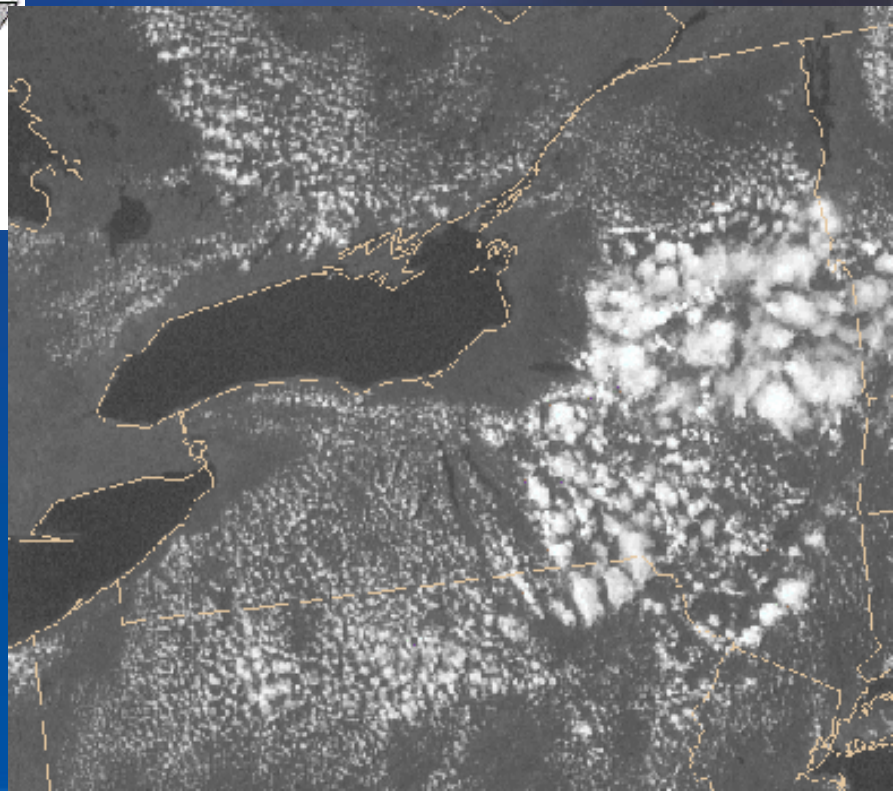
“Triggering” Mechanisms

- **Starts the convection**
  - *Low pressure systems/Jet ‘s*
  - *Air mass boundaries, Fronts*
  - *Sea/Lake Breeze*
  - *Thunderstorm ‘outflow boundaries’*
  - *Orographic lift*

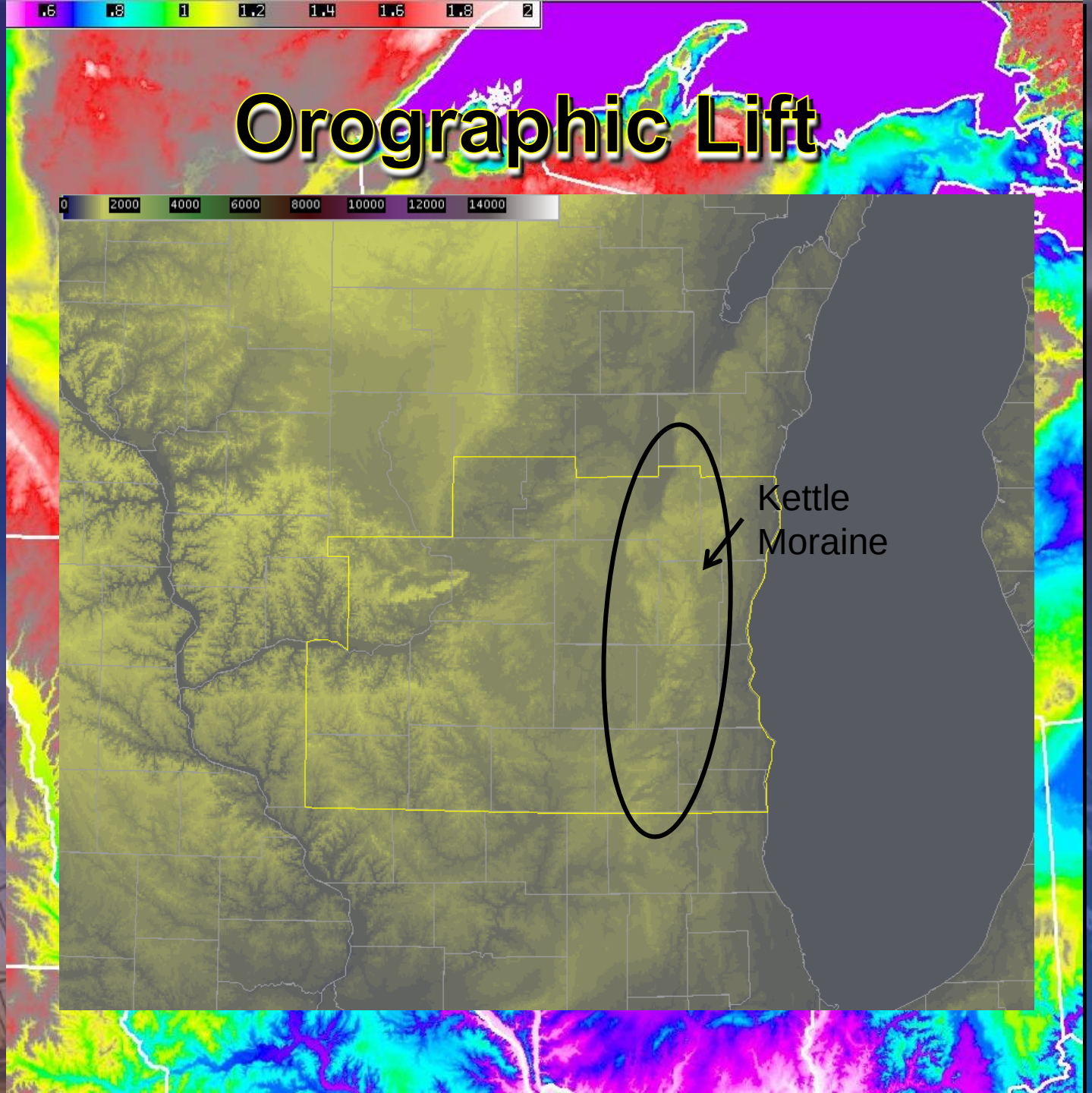

Forecast Systems Laboratory D-2D
File View Options Tools Volume Obs NCEP/Hydro Upper Air Satellite kabr Radar SCAN Maps Help
WarnGen
Valid time seq
WFO
Clear
Frames: 32
Mag: 1
Density: 1
kabr 0.5 Refl
Status:
Radar:
Frames: 32
Time: 00:00 Z 29-May-06

Lake Breeze


Sea Breeze Circulation
3
4
5
Cool Air Over Water
1
2
6
Warm Air Over Land



Orographic Lift



June 30, 2011

Video

Four Types of Thunderstorms

Single Cell	Multicell Cluster	Multicell Line	Supercell
Weak updraft (non-severe or severe)	**Moderate updraft (non-severe or severe)**	**Moderate updraft (non-severe or severe)**	**Intense updraft (Always severe)** **Mesocyclone - Rotating updraft**
Slight threat	***Moderate threat***	***Moderate threat***	***High threat***

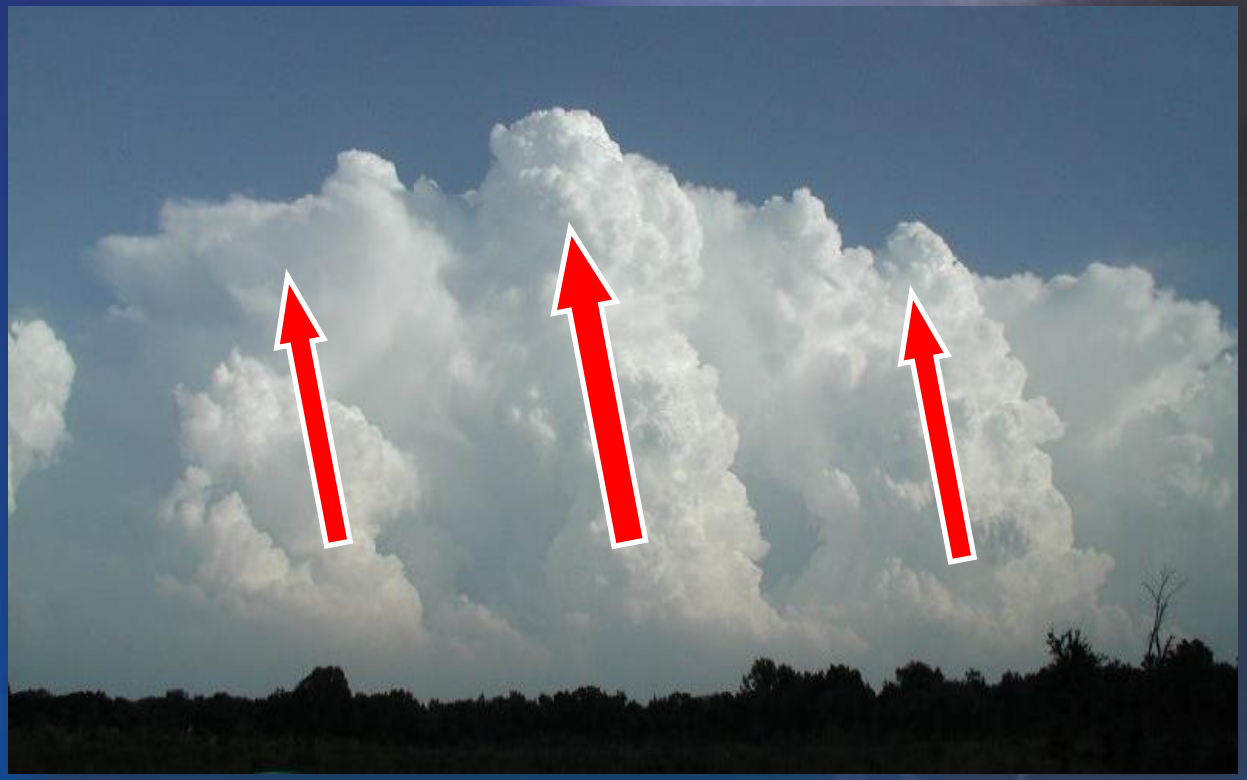
Single Cell Storms

May produce brief severe weather

Multi-Cell Thunderstorms

Ordinary, non-organized storms with low severe threat

Each cell lasts 20-30 minutes, but a cluster can last for hours



Heavy rain is the main problem

Strong winds, small hail and weak tornadoes are possible

Multi-Cell Thunderstorms

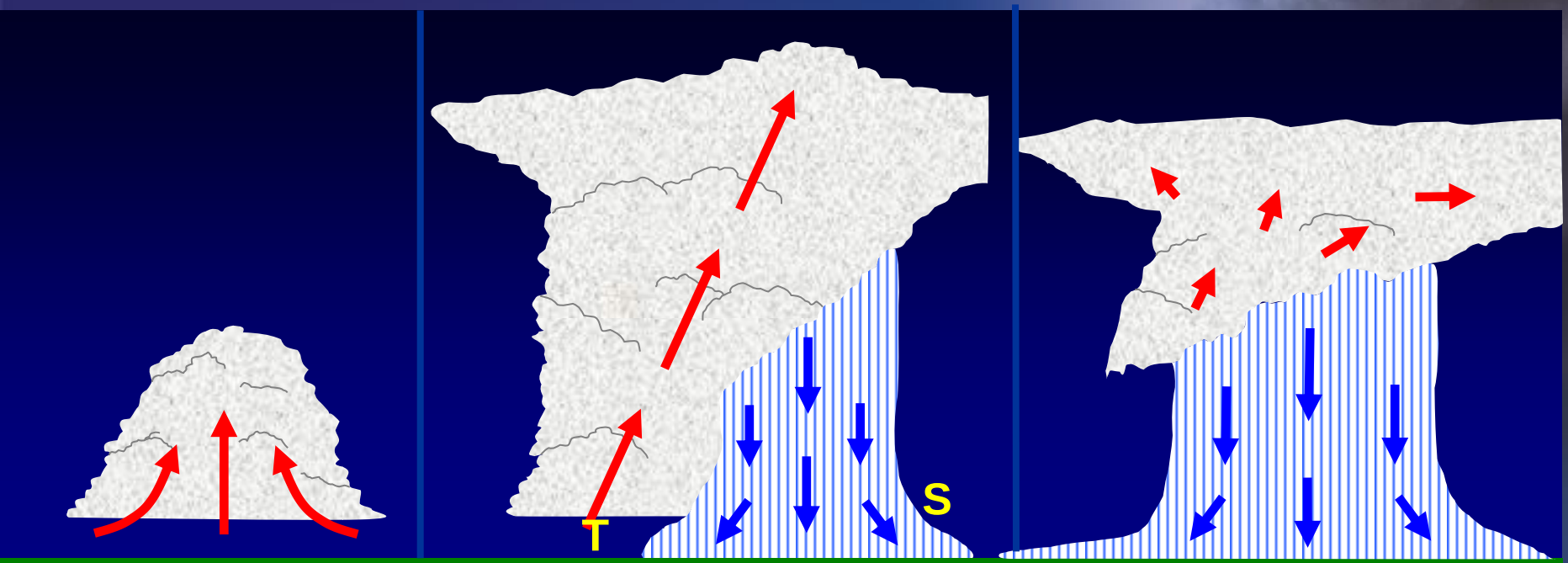
Ordinary, non-organized storms with low severe threat

Multi-Cell (Squall) Line

- <u>Leading edge</u> of squall line usually marked by shelf cloud
- Do not report shelf clouds

- <u>What to expect</u>
  - ***Strong and possibly damaging wind***
  - ***Heavy rain/hail***

Thunderstorm Life Cycle



Cumulus Stage | **Mature Stage** | **Dissipation Stage**

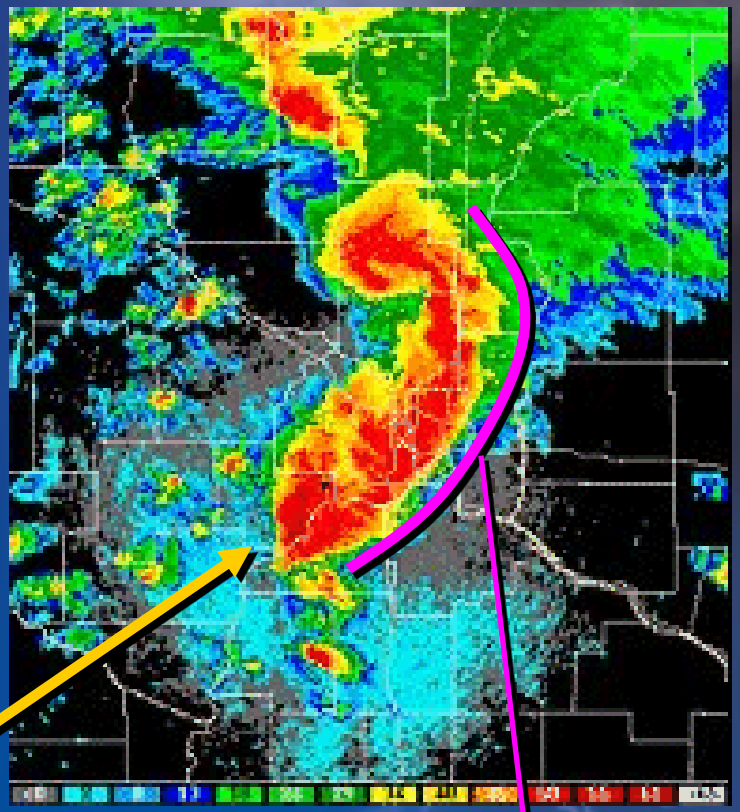
Downburst Winds!

shelf cloud

Downburst Winds!

Squall Line - Bow Echo

This shelf cloud is ahead of bow echo on right



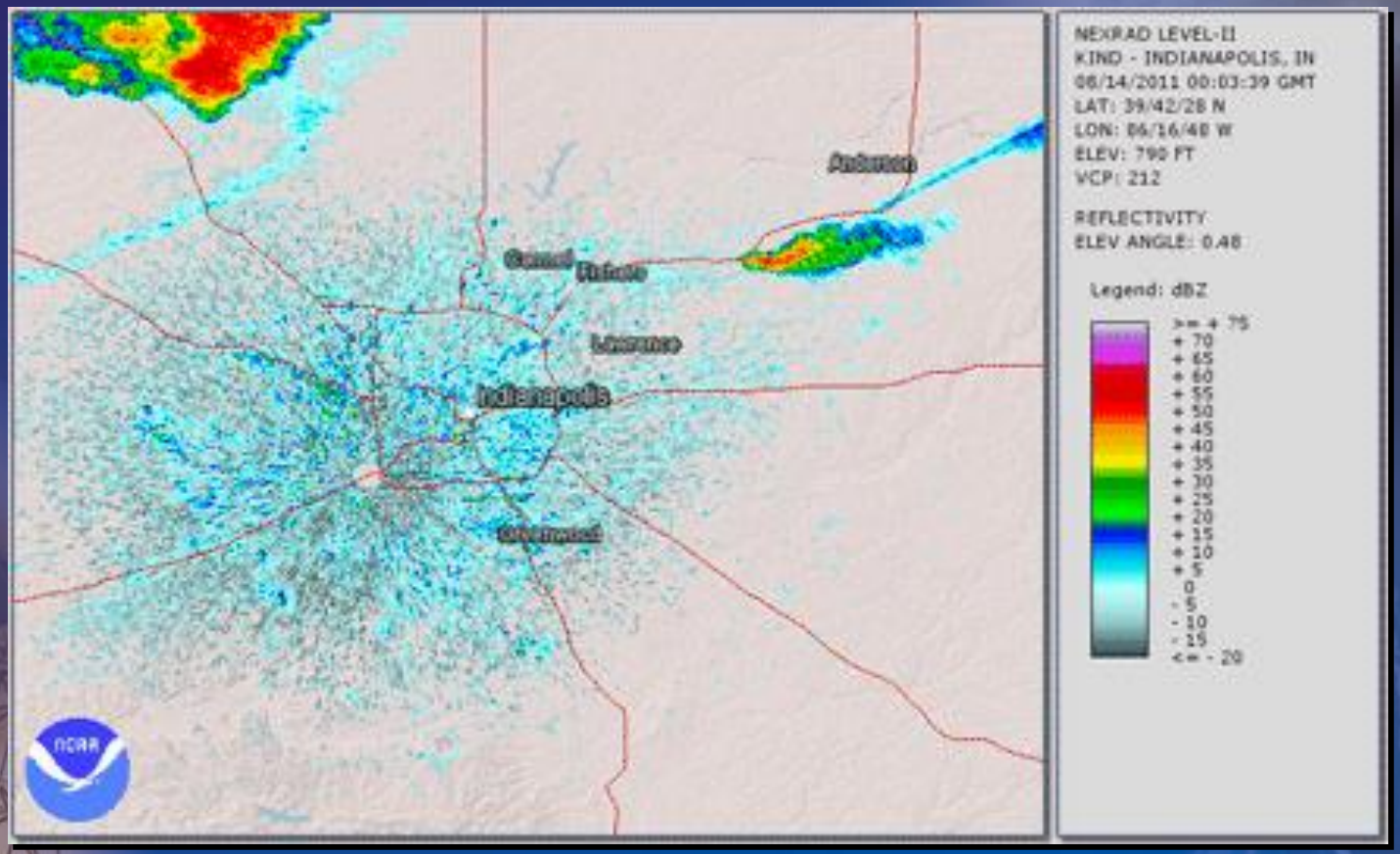
Storm moving left to right (W-E)

Well-developed shelf cloud is found on front side of line

Shelf Cloud

Video

August 13, 2011
Indiana State Fair

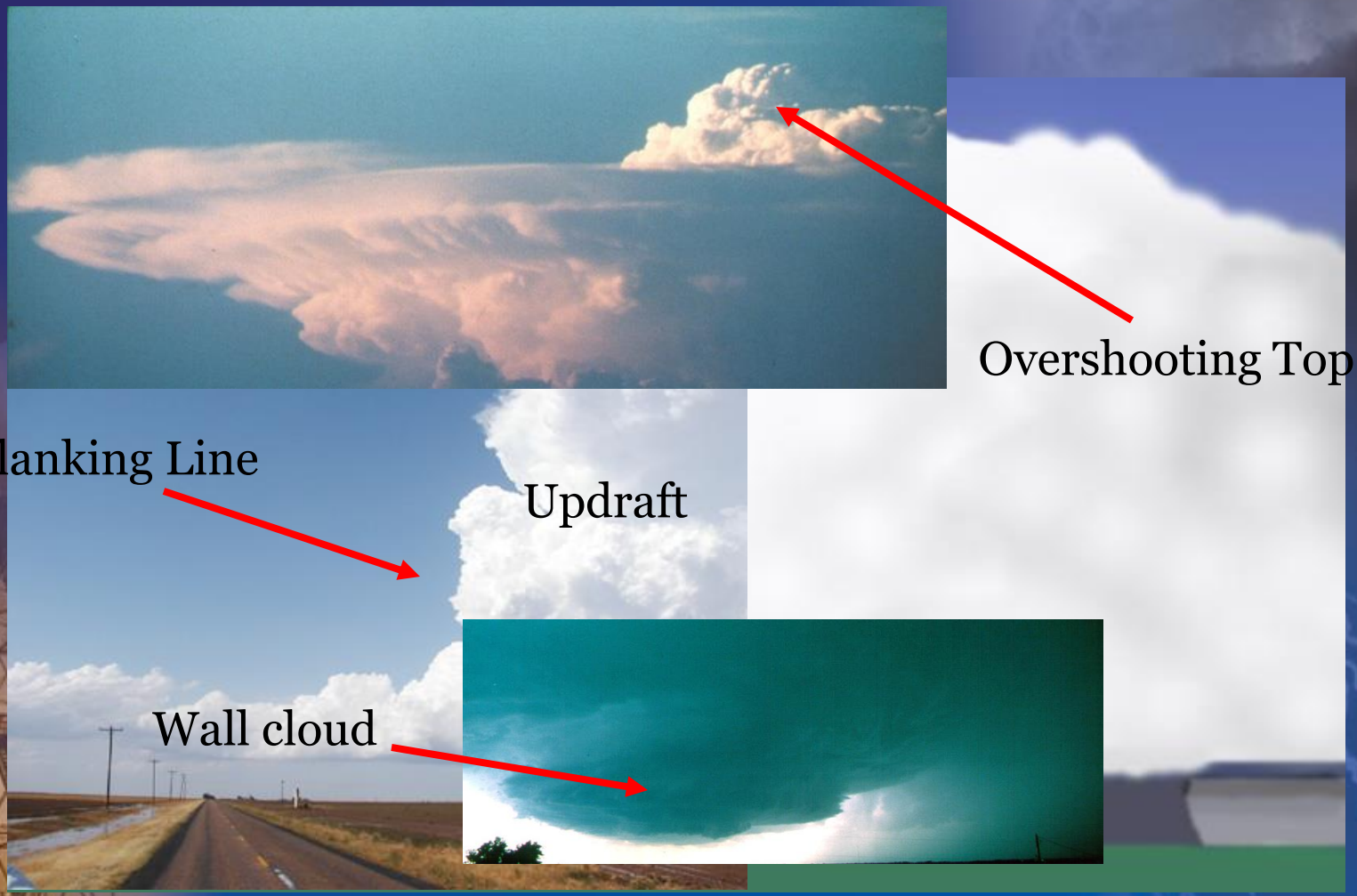


Stage collapsed at an outdoor concert

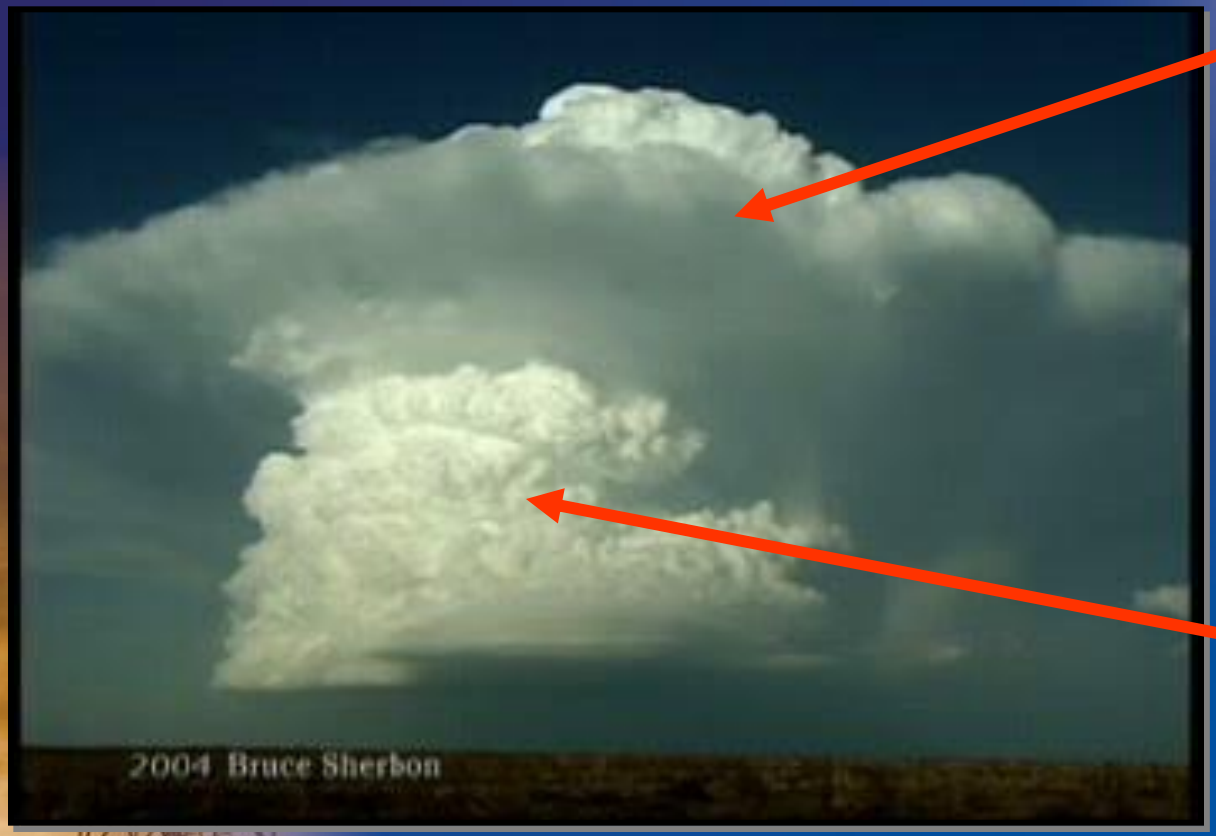
7 Fatalities, 43 injured, Estimated Wind Gusts 70 mph

Hail Shaft

Storm Strength Clues



Evaluating the Surroundings



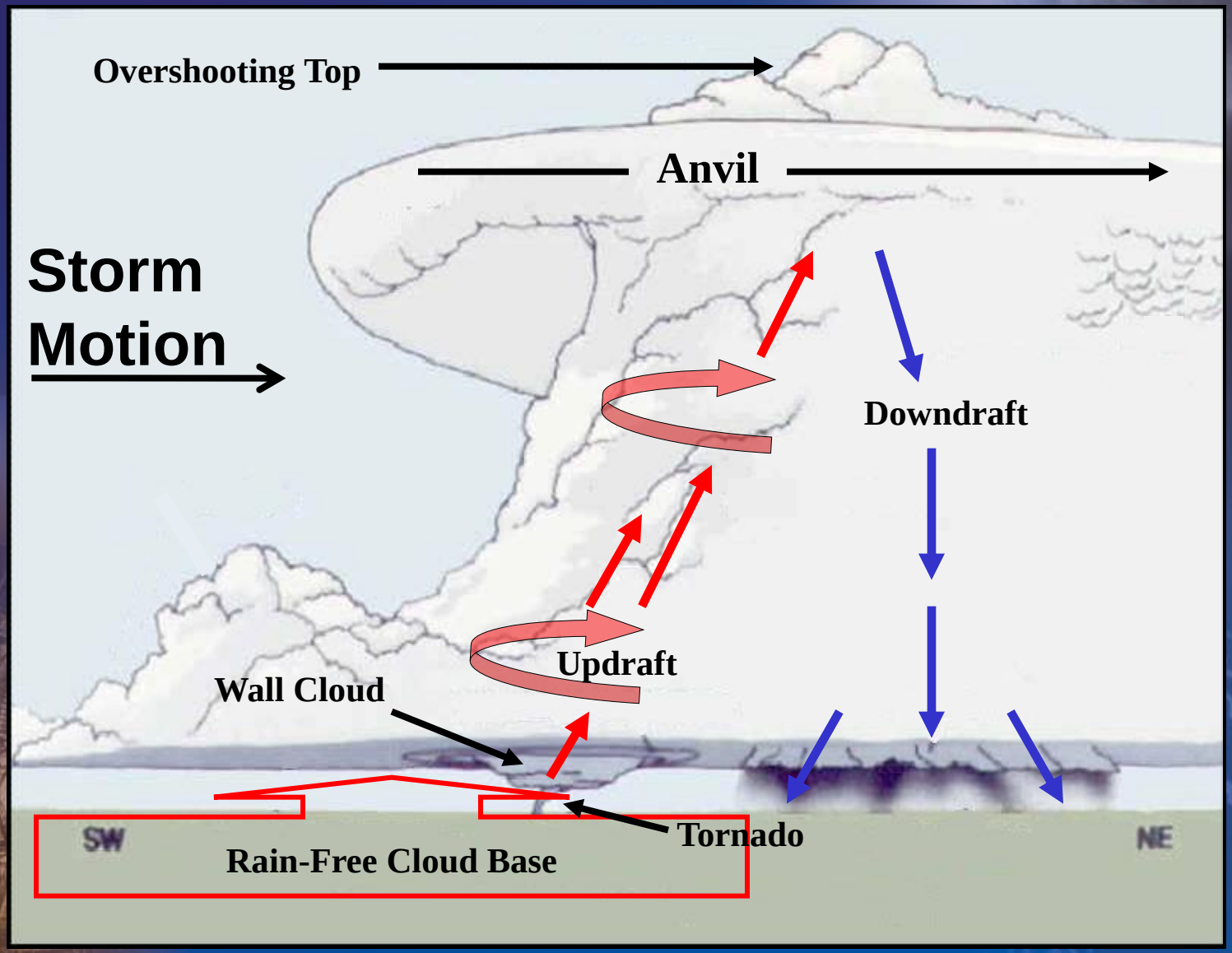
A thick, crisp anvil (knuckles) is another sign of a strong updraft

Hard-crisp appearance is indication of a rapidly, intensifying storm!

Supercell Thunderstorm

- Contains a rotating updraft called a meso-cyclone
- Only about 10% of radar-detected meso's are associated with a tornado
- Produce large hail, high winds, and strong to violent tornadoes
- Can last for several hours

Supercell Structure

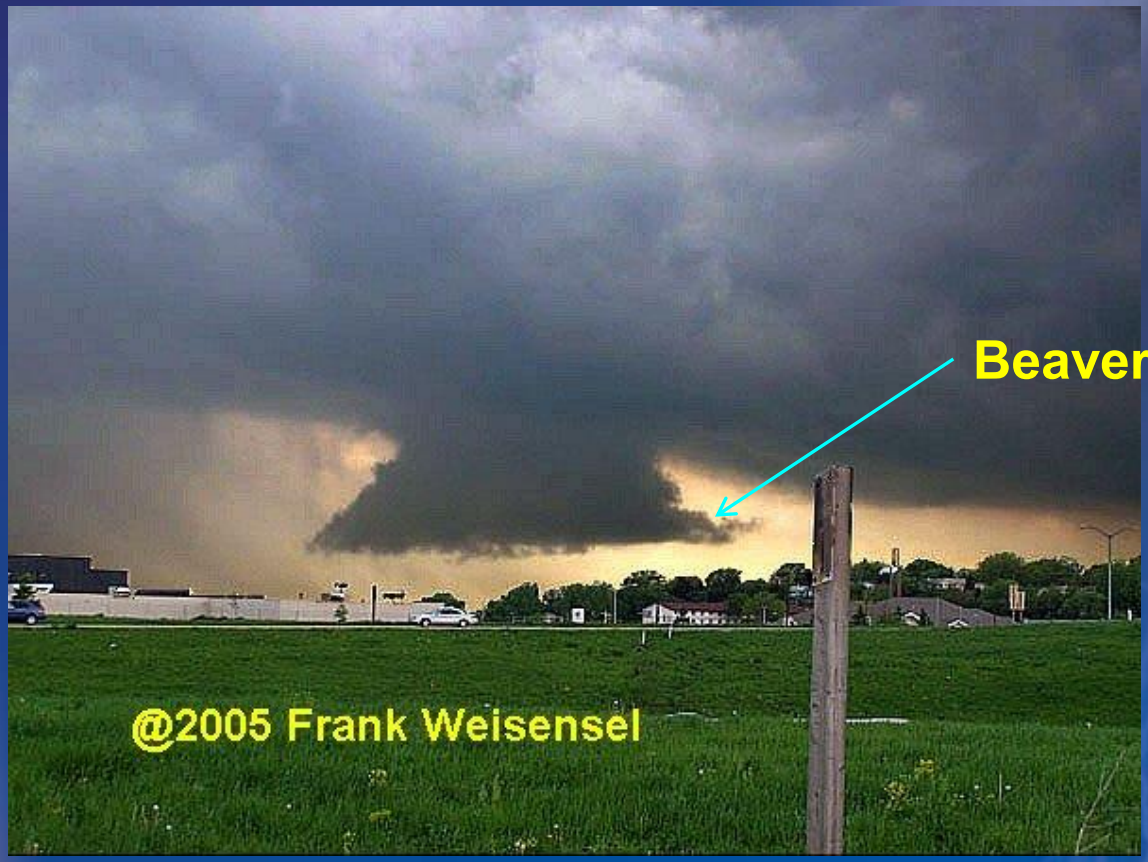


Rotation in Updraft Tower

Spiral bands and cork-screw look

Rotating Wall Clouds

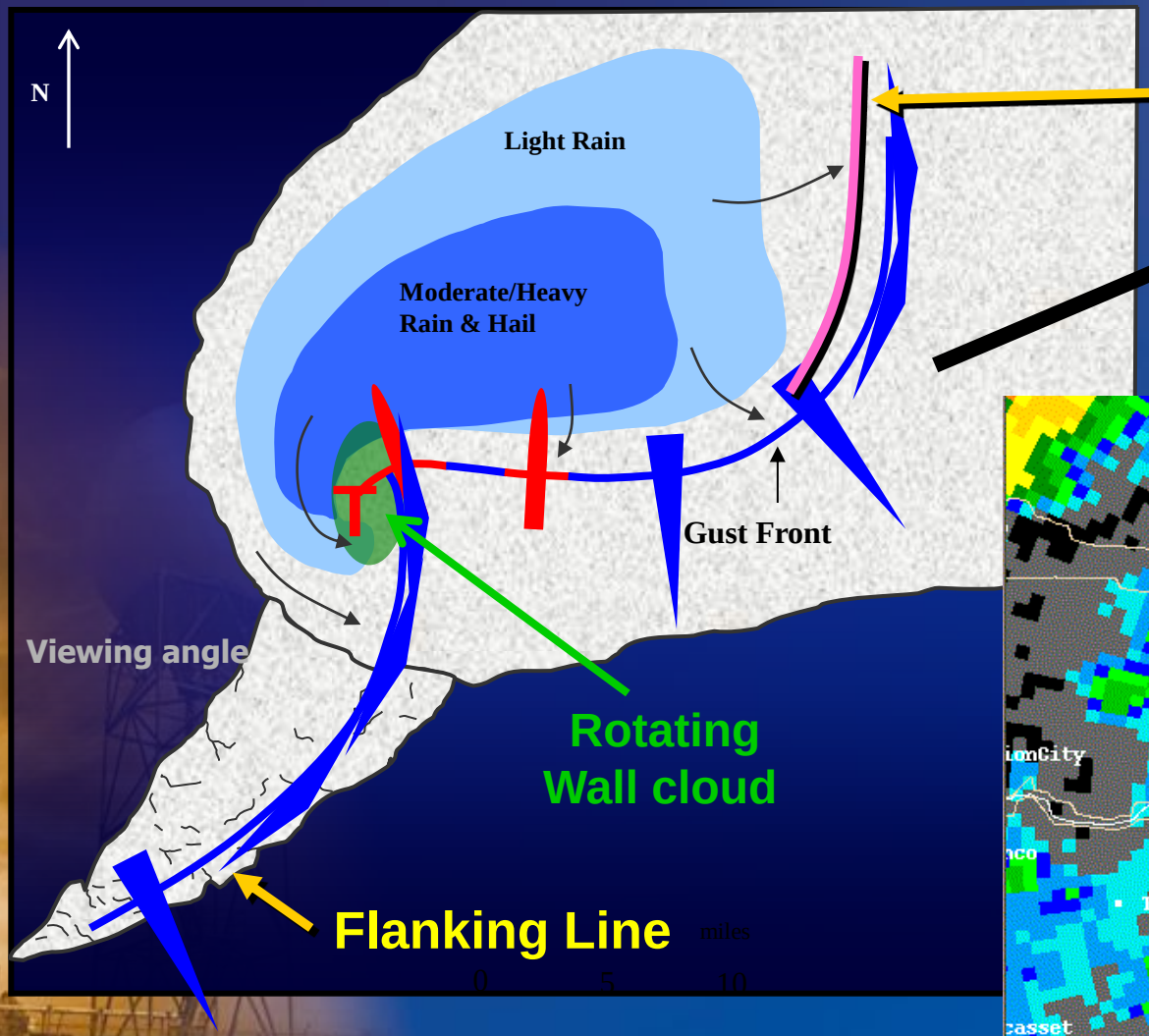
An isolated lowering of the rain-free base, rotating on a vertical axis



A good number of, but not all, tornadoes develop underneath or near a rotating wall cloud

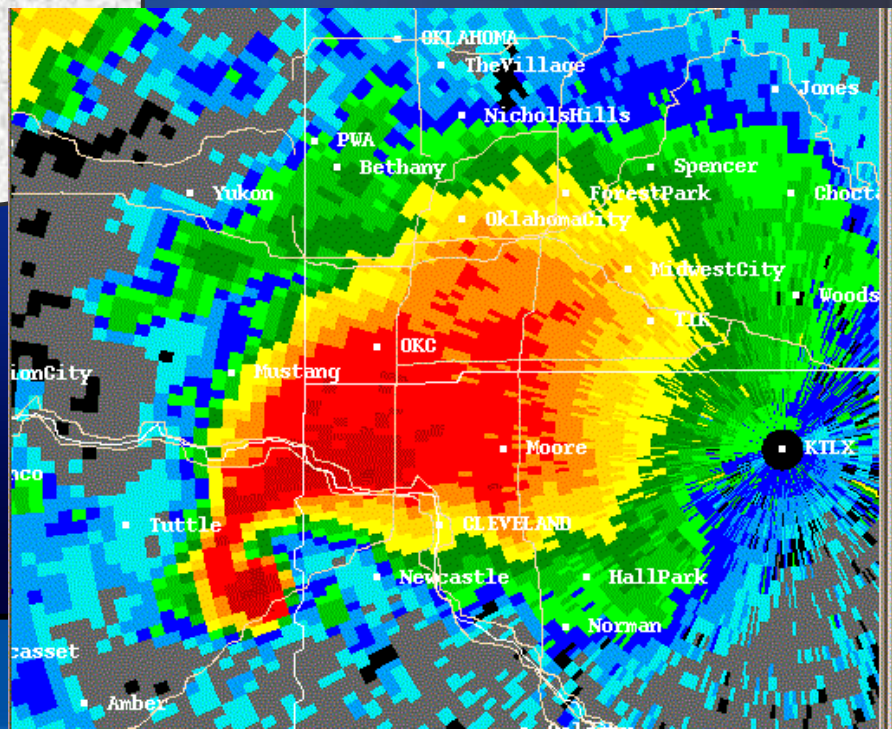
Tornadic Supercell Thunderstorm

top-down view



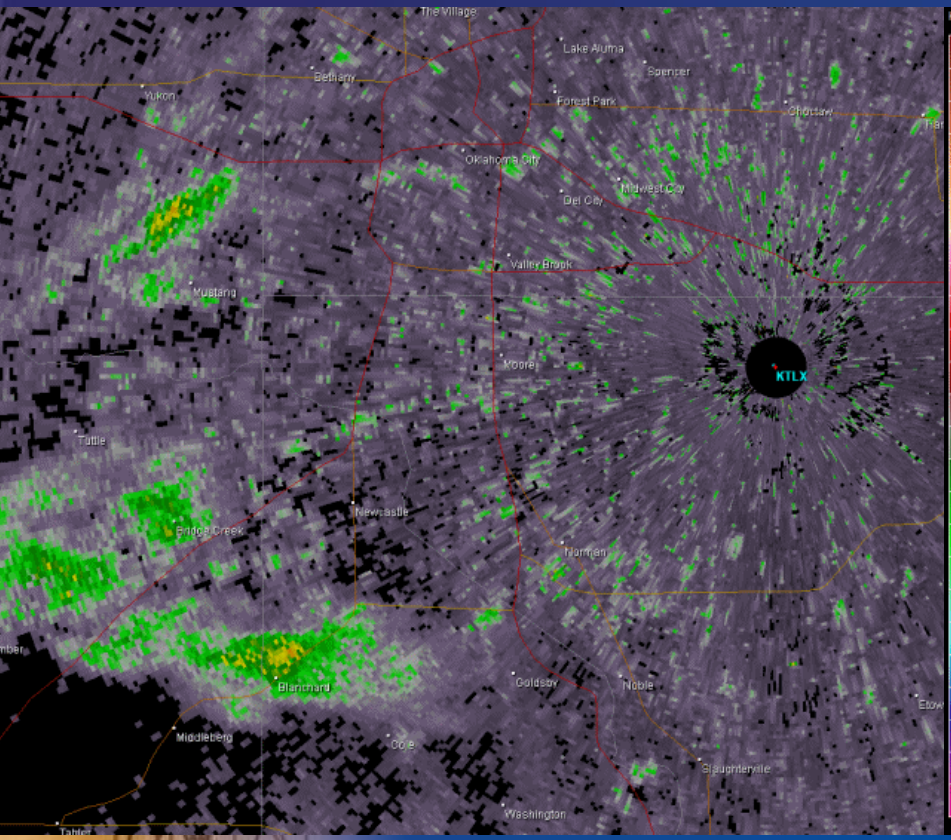
Shelf Cloud

Storm motion

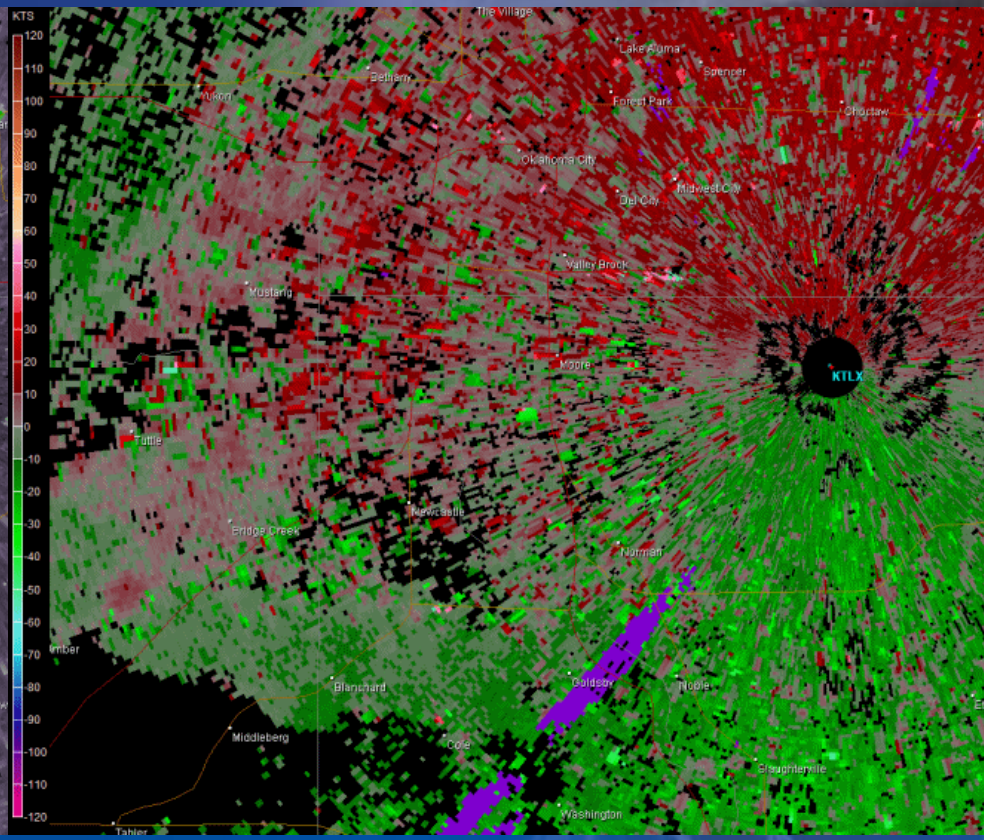


Radar Loops

Base Reflectivity



Storm Relative Velocity



May 20, 2013 Moore, OK

Tornado

Ratings & Types of Tornadoes

- Enhanced Fujita Scale (EF 0 to EF 5)
- Classic, Wedge, and Rope
- Injuries & fatalities can occur with each type.
- NWS does NOT need to know what type of tornado you are observing.

Enhanced Fujita Scale

Rating	Tornadoes	Relative Frequency
EF 0	65-85 mph	53.5% (weak)
EF 1	86-110 mph	31.6% (weak)
EF 2	111-135 mph	10.7% (strong)
EF 3	136-165 mph	3.4% (strong)
EF 4	166-200 mph	0.75% (violent)
EF 5	Over 200 mph	<0.1% (violent)

“Classic” Tornado

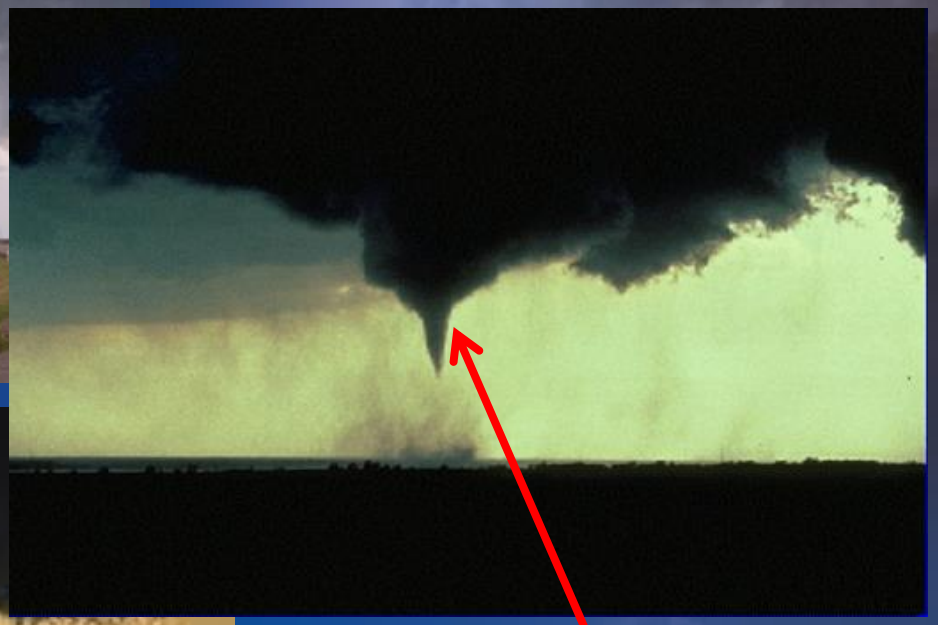
Near Central City, IA, Apr 26, 2009

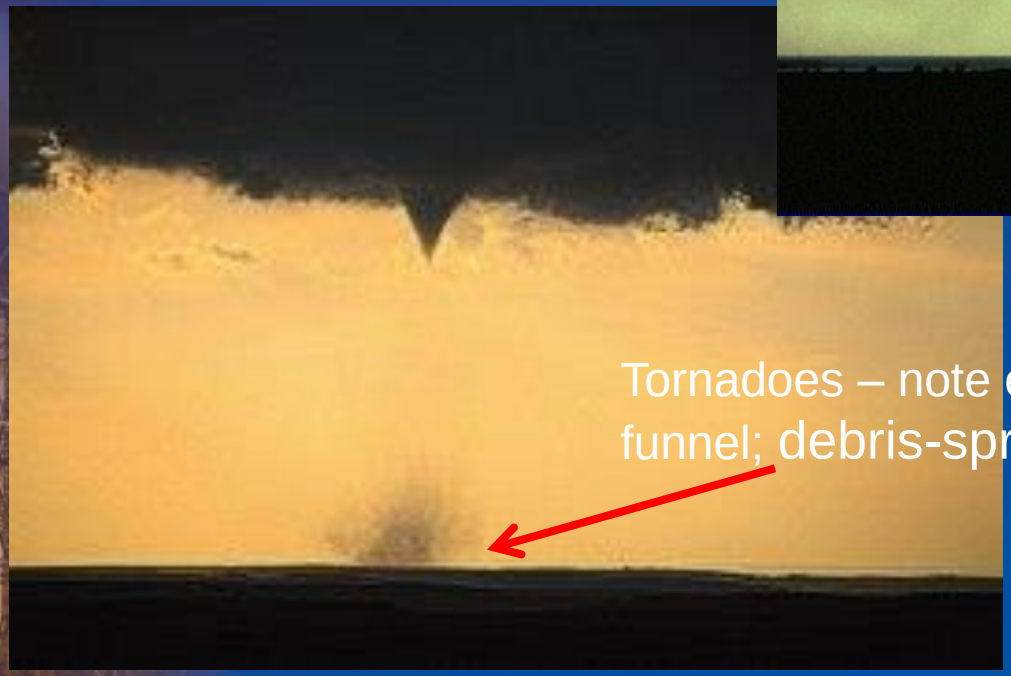
Wedge Tornado

They look wider than the distance from the ground to the cloud base

Rope Tornado

Tornado – note extent of condensation funnel; debris-spray at ground





Tornadoes – note extent of condensation funnel; debris-spray at ground

Tornado

Note – condensation funnel not touching ground

Video

Wisconsin Tornadoes

April 21, 1974 near Oshkosh

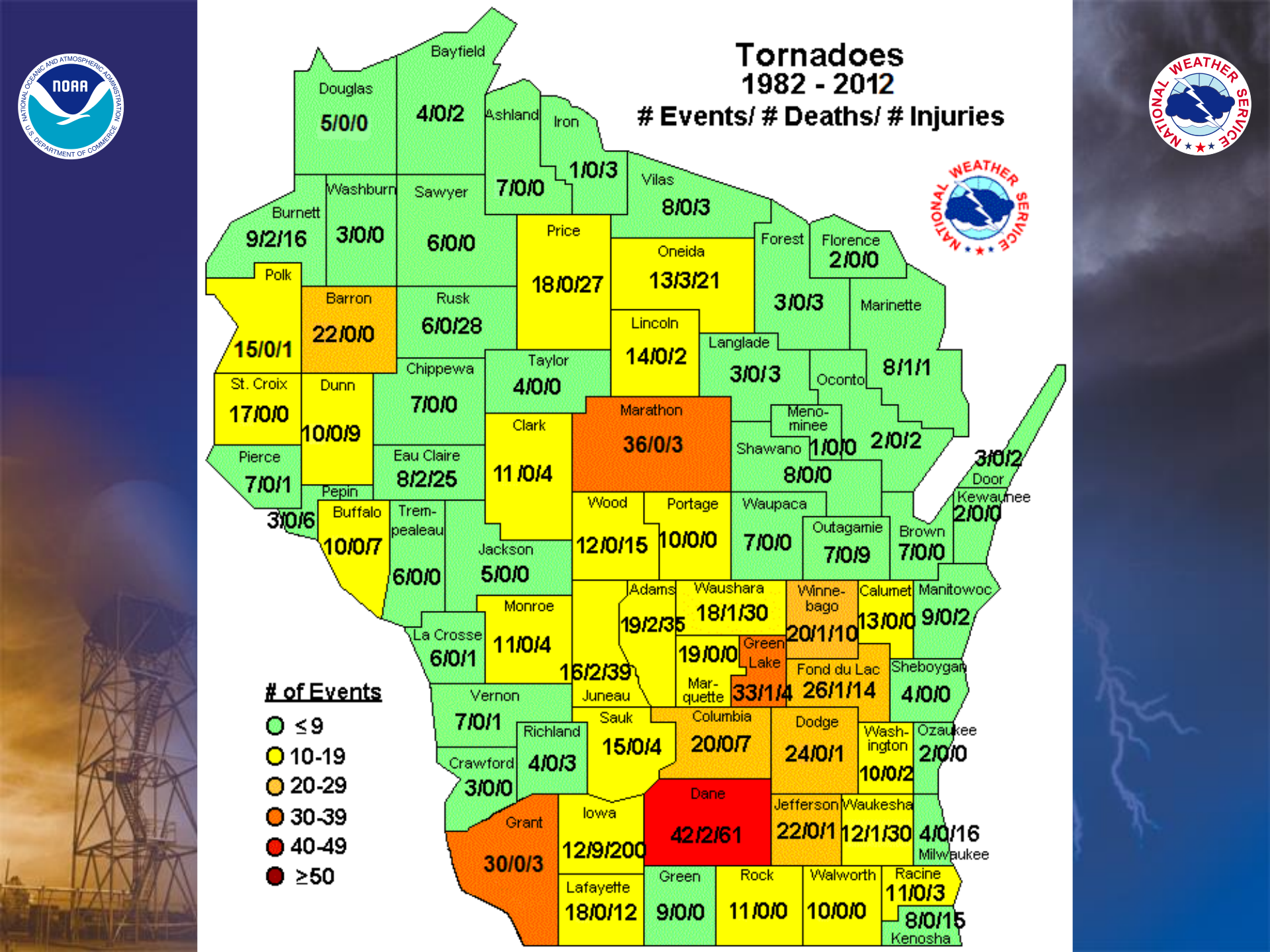
April 27, 1984 near Wales (Waukesha Co.)

July 18, 1996 approaching Oakfield (Fond du Lac Co.)

August 18, 2005 in Stoughton (Dane Co.)

Wisconsin Tornado Stats

- Most tornadoes spin up between 3 pm and 9 pm, with 6-7 pm being the busiest.
- Most tornadoes occur between April and September, with June being the peak month.
- Tornadoes generally move southwest to northeast, but west to east, and northwest to southeast movements are quite possible.


Tornadoes
1982 - 2012
Events/ # Deaths/ # Injuries
Bayfield
Douglas
5/0/0
4/0/2
Ashland
7/0/0
Iron
1/0/3
Vilas
8/0/3
Burnett
9/2/16
Washburn
3/0/0
Sawyer
6/0/0
Price
18/0/27
Oneida
13/3/21
Forest
3/0/3
Florence
2/0/0
Marinette
8/1/1
Polk
15/0/1
Barron
22/0/0
Rusk
6/0/28
Lincoln
14/0/2
Langlade
3/0/3
Oconto
2/0/2
St. Croix
17/0/0
Dunn
10/0/9
Chippewa
7/0/0
Taylor
4/0/0
Clark
11/0/4
Marathon
36/0/3
Meno-minee
1/0/0
Shawano
8/0/0
Pierce
7/0/1
Eau Claire
8/2/25
Pepin
3/0/6
Buffalo
10/0/7
Trem-pealeau
6/0/0
Jackson
5/0/0
Wood
12/0/15
Portage
10/0/0
Waupaca
7/0/0
Outagamie
7/0/9
Brown
7/0/0
Door
3/0/2
Kewaunee
2/0/0
Manitowoc
9/0/2
Calumet
13/0/0
Winne-bago
20/1/10
Waushara
18/1/30
Adams
19/2/35
Monroe
11/0/4
La Crosse
6/0/1
Green Lake
19/0/0
Mar-quette
16/2/39
Fond du Lac
26/1/14
Sheboygan
4/0/0
Vernon
7/0/1
Juneau
33/1/4
Sauk
15/0/4
Columbia
20/0/7
Dodge
24/0/1
Wash-ington
10/0/2
Ozaukee
2/0/0
Richland
4/0/3
Crawford
3/0/0
Dane
42/2/61
Jefferson
22/0/1
Waukesha
12/1/30
Milwaukee
4/0/16
Grant
30/0/3
Iowa
12/9/200
Lafayette
18/0/12
Green
9/0/0
Rock
11/0/0
Walworth
10/0/0
Racine
11/0/3
Kenosha
8/0/15
# of Events
≤9
10-19
20-29
30-39
40-49
≥50

Wisconsin Tornadoes 1950-2011

Credit: Doug Norgord, Geographic Techniques

New Technology on Horizon

- Phased Array Radar
- Warn-on-Forecasts

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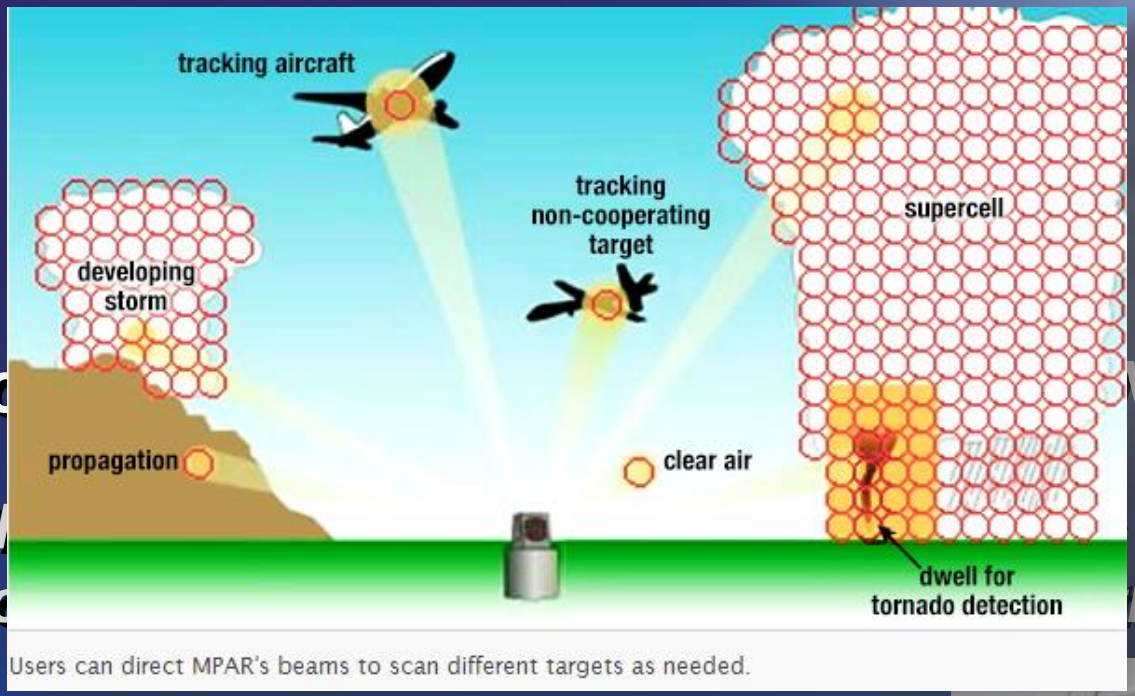
  - *Mil … to pro … hreats*



  - *Flat panel antenna*
  - *Scans sky in less than 1 minute*
  - *Possible cost-effective replacement for aging weather and aircraft tracking radars*

www.nssl.noaa.gov/tools/radar/mpar

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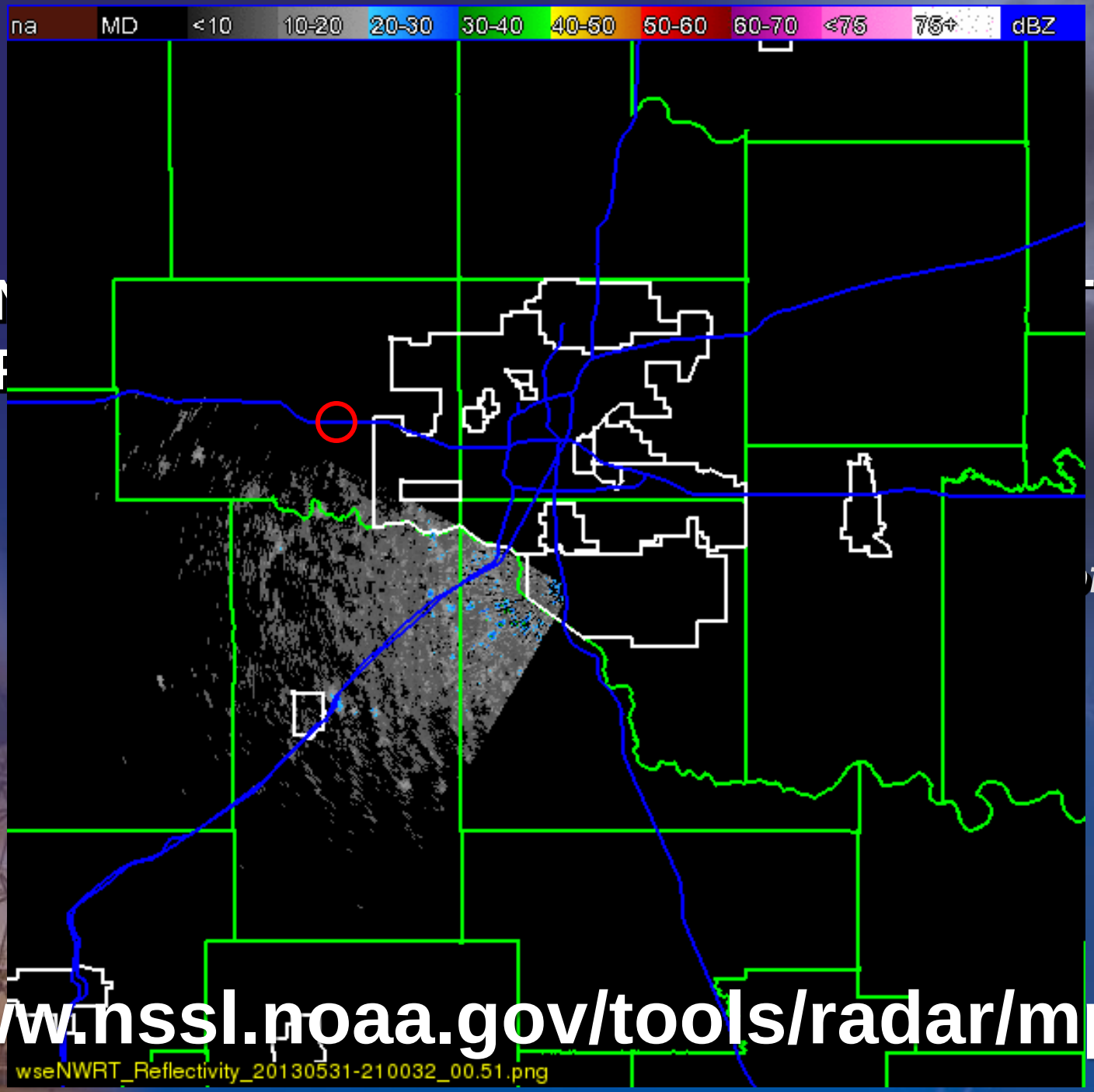


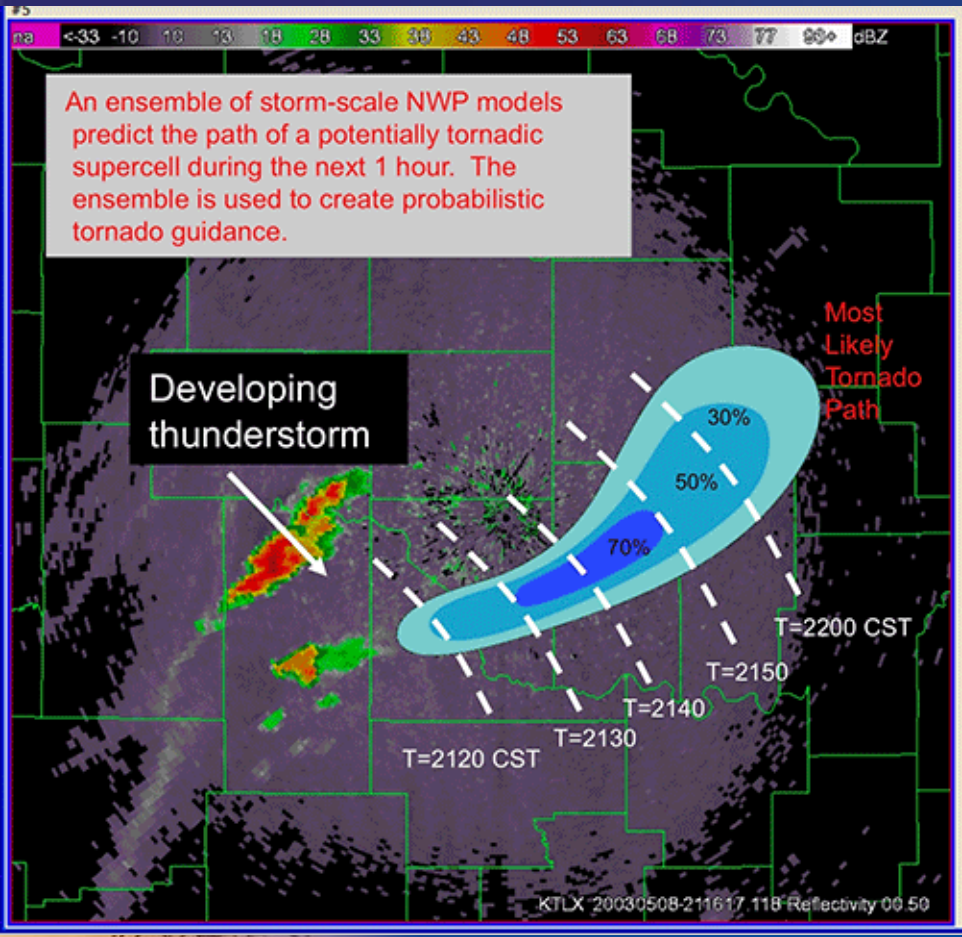
www.nssl.noaa.gov/tools/radar/mpar

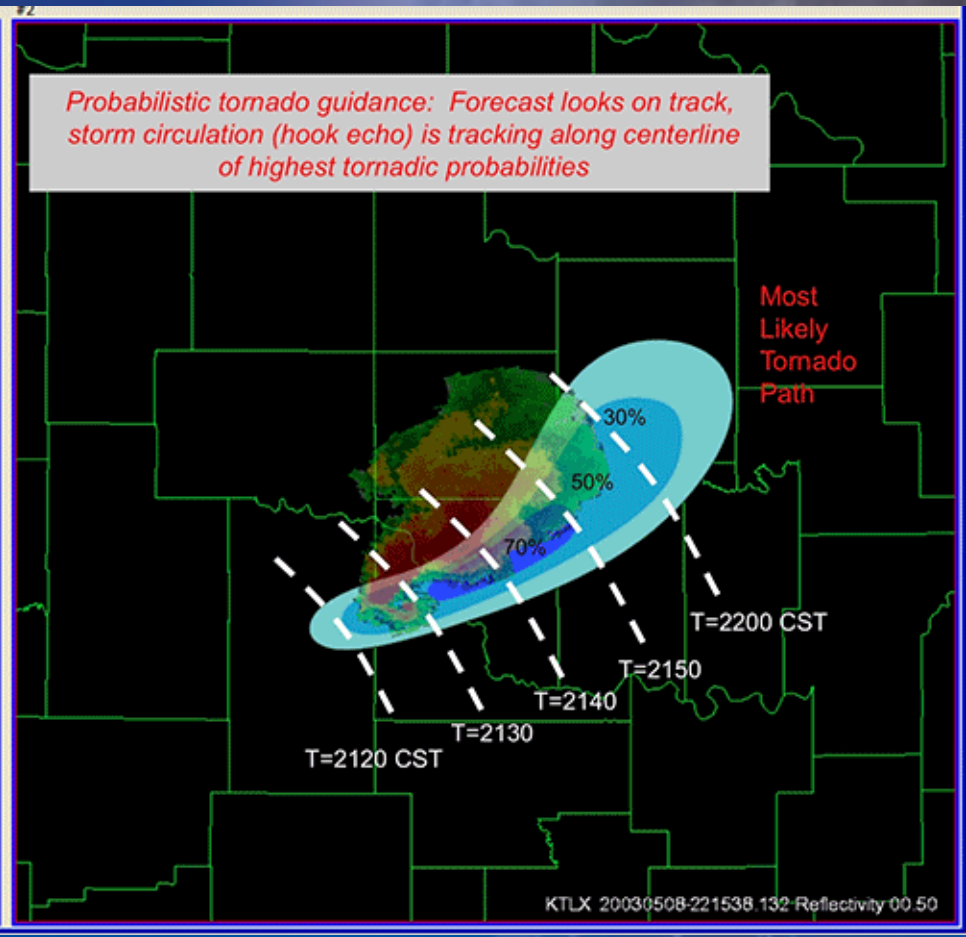
Warn-on-Forecast

- Currently, warning process based upon warn-on-detection approach
- Reaching a plateau in lead time
- Ensemble of storm-scale numerical weather prediction models
- Probabilistic hazard guidance

www.nssl.noaa.gov/projects/wof

Warn-on-Forecast





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The End

Questions?