Enhanced Storm Investigation.

National Weather Service Milwaukee/Sullivan, WI

www.weather.gov/milwaukee


twitter.com/NWSMKX
“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.
Personal Safety

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
Lake Breeze

Sea Breeze Circulation

1. Warm Air Over Land
2. Cool Air Over Water
3. Cloud Formation
4. Cloud Movement
5. Air Mixing
6. Weather Pattern
June 30, 2011

Video
Four Types of Thunderstorms

- **Single Cell**
  - Weak updraft (non-severe or severe)
  - *Slight threat*

- **Multicell Cluster**
  - Moderate updraft (non-severe or severe)
  - *Moderate threat*

- **Multicell Line**
  - Moderate updraft (non-severe or severe)
  - *Moderate threat*

- **Supercell**
  - Intense updraft (Always severe)
  - Mesocyclone - Rotating updraft
  - *High threat*

"Squall Line"
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

- Leading edge of squall line usually marked by shelf cloud
- Do not report shelf clouds

What to expect
- Strong and possibly damaging wind
- Heavy rain/hail
Thunderstorm Life Cycle

Cumulus Stage

Mature Stage

Dissipation Stage

NOAA
National Weather Service

©2001 Chris Kridler
SkyDiary.com
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.
August 13, 2011
Indiana State Fair

Stage collapsed at an outdoor concert
7 Fatalities, 43 injured, Estimated Wind Gusts 70 mph
Storm Strength Clues

- Wall cloud
- Updraft
- Overshooting Top
- Flanking Line
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

Overshooting Top

Anvil

Storm Motion

Downdraft

Wall Cloud

Updraft

Rain-Free Cloud Base

Tornado
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.
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

<table>
<thead>
<tr>
<th>Rating</th>
<th>Tornadoes</th>
<th>Relative Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF 0</td>
<td>65-85 mph</td>
<td>53.5% (weak)</td>
</tr>
<tr>
<td>EF 1</td>
<td>86-110 mph</td>
<td>31.6% (weak)</td>
</tr>
<tr>
<td>EF 2</td>
<td>111-135 mph</td>
<td>10.7% (strong)</td>
</tr>
<tr>
<td>EF 3</td>
<td>136-165 mph</td>
<td>3.4% (strong)</td>
</tr>
<tr>
<td>EF 4</td>
<td>166-200 mph</td>
<td>0.75% (violent)</td>
</tr>
<tr>
<td>EF 5</td>
<td>Over 200 mph</td>
<td>&lt;0.1% (violent)</td>
</tr>
</tbody>
</table>
“Classic” Tornado

Near Central City, IA, Apr 26, 2009
Wedge Tornado

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

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

April 27, 1984 near Wales (Waukesha 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

# of Events
- ≤ 9
- 10-19
- 20-29
- 30-39
- 40-49
- ≥50
New Technology on Horizon

- Phased Array Radar
- Warn-on-Forecasts
Phased Array Radar

• National Weather Radar Testbed (NWRT)

– Military technology used by Navy ships to protect naval battle groups from missile threats

– 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
El Reno Tornado

National Weather Radar Testbed (NWRT)

Phased Array Radar – May 31, 2013 – 1-minute resolution depicts the fluid motion of supercell development – Path along the Interstate

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

An ensemble of storm-scale NWP models predict the path of a potentially tornadic supercell during the next 1 hour. The ensemble is used to create probabilistic tornado guidance.

Probabilistic tornado guidance: Forecast looks on track, storm circulation (hook echo) is tracking along centerline of highest tornadic probabilities.
The End

Questions?