Courtesy of NOAA/NSSL Photo Library

Chapter 19
Tornadoes

Tornado – a violently rotating column of air
What is the typical size of a tornado?

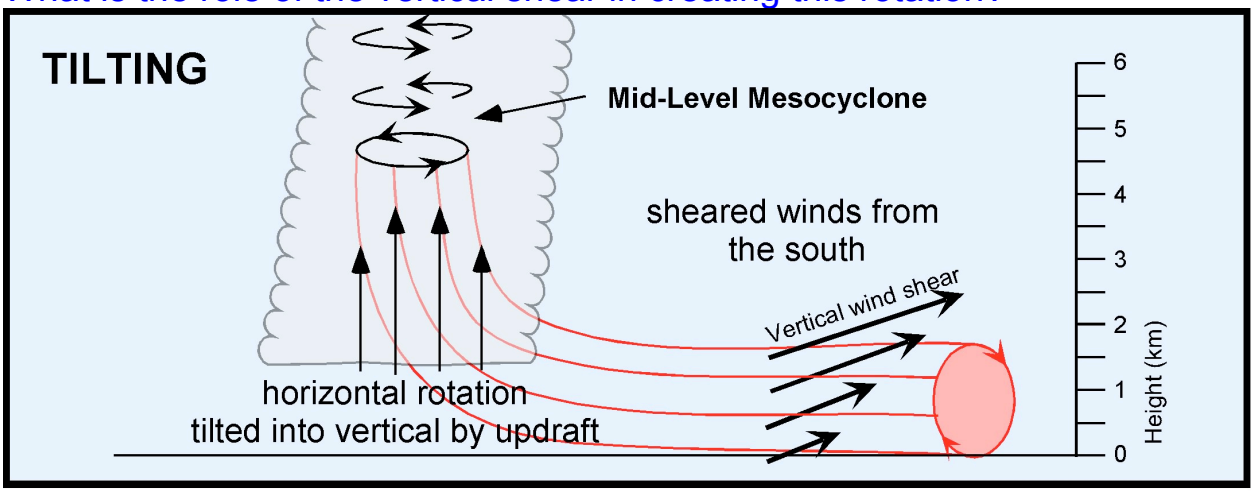
What range of wind speeds are present in a tornado?

What kinds of storms do tornadoes form in?

Tornado Formation in Supercells

What causes a supercell thunderstorm to rotate?

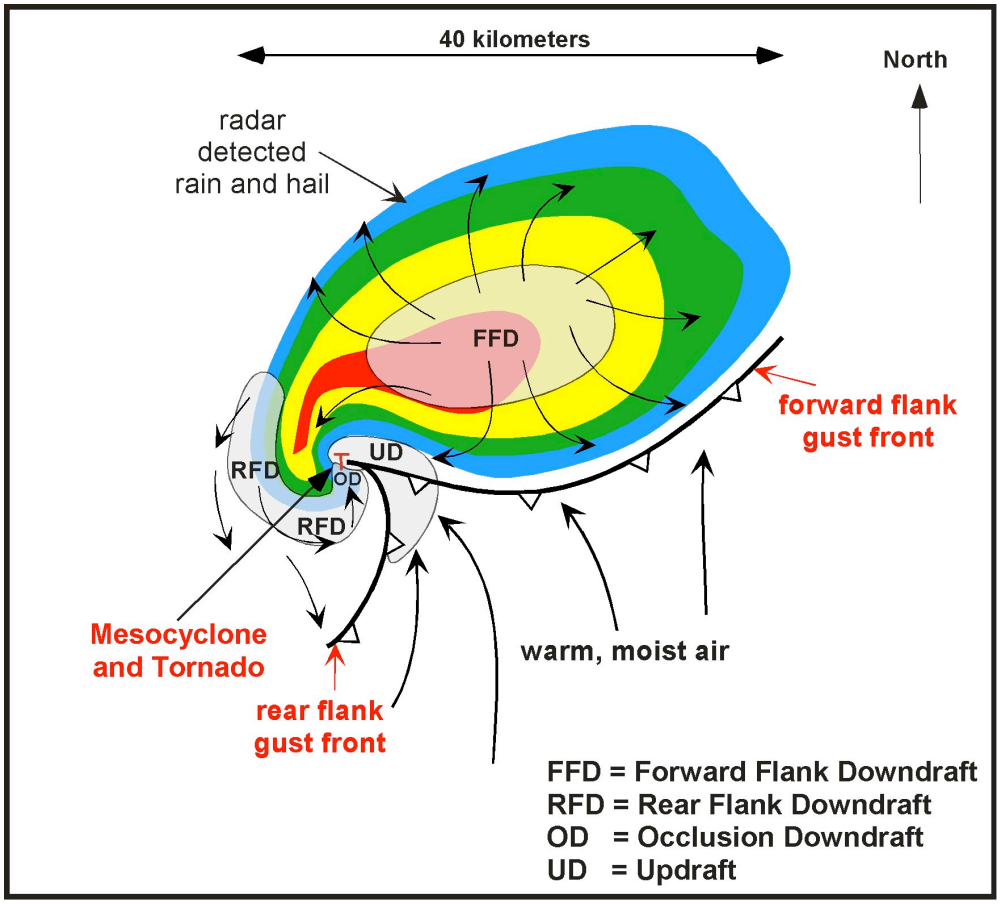
What is the role of the vertical shear in creating this rotation?



Mesocyclone – the rotating circulation in a supercell thunderstorm that is associated with the updraft

The mesocyclone is associated with an area of lower pressure.
What is the typical size of a mesocyclone?

Supercell features related to tornado formation:



How does a tornado form?

Tornadogenesis – the formation of a tornado

Vortex Stretching

The mesoscylone occlusion forms when the RFD gust front catches up to the FFD gust front.

When this occurs the updraft is weakened in the lower part of the supercell, but remains strong aloft.

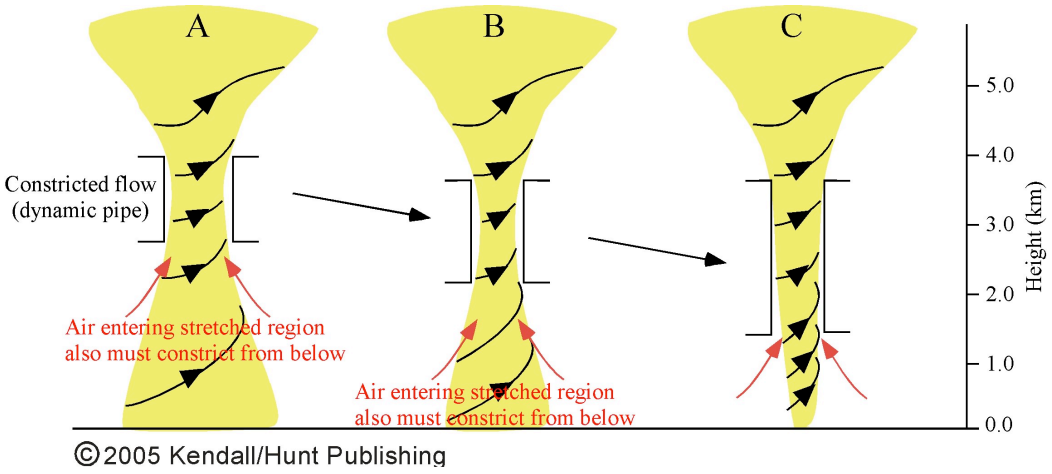
This leads to vertical stretching of the rotating updraft (vortex stretching), and a strengthening of the rotation.

Vortex stretching occurs in nearly all supercells, but is not sufficient to create a tornado (only 30% of supercells produce tornadoes).

What other processes must occur for a tornado to form?

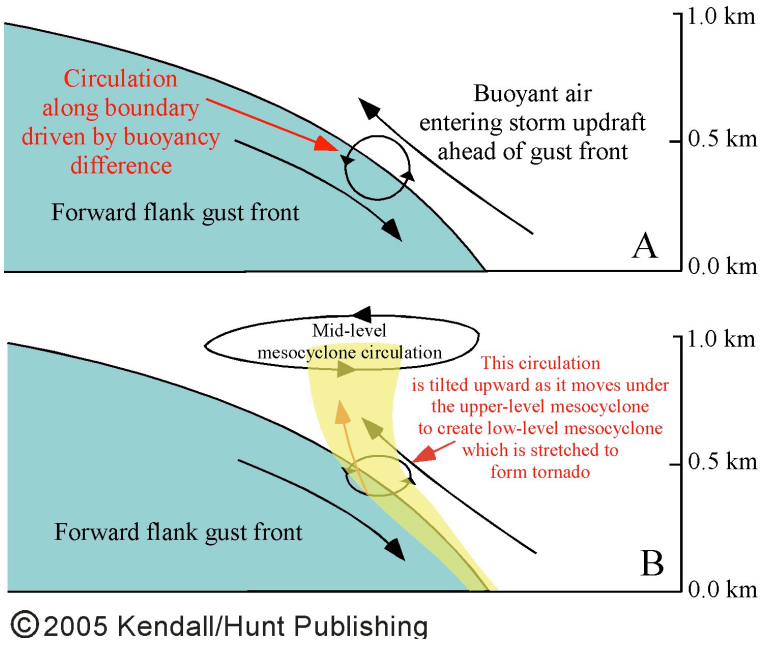
Scientists have identified three possible methods for tornadoes to form in supercell thunderstorms.

1. Dynamic pipe effect



Constricted flow at mid-levels can result from vortex stretching.

2. Bottom-up Approach

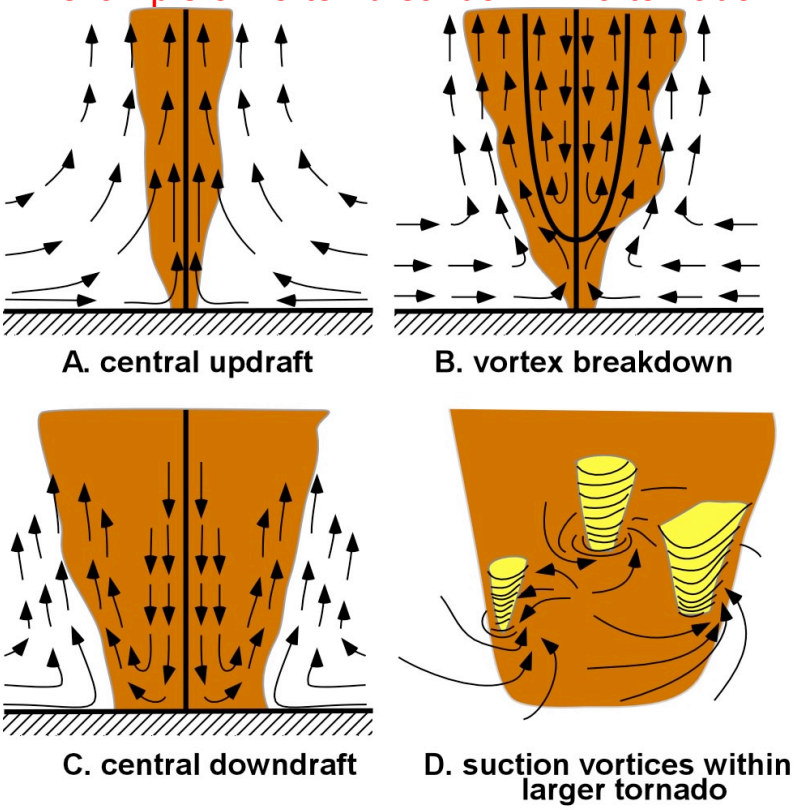


The generation of rotation in a tornado, in the bottom-up approach, is similar to how the rotation of a mesocyclone is created due to tilting.

3. Vortex Breakdown

Vortex breakdown can occur in many types of vortices such as mesocyclones and tornadoes.

An example of vortex breakdown in a tornado



Courtesy of the American Meteorological Society

A. Initially the tornado consists of only an updraft, with low pressure at the center near the surface.

B. If the low pressure at the surface becomes strong enough a downdraft forms in the center of the tornado.

C. As the downdraft descends the tornado widens.

D. Smaller vortices can form on the edge of the original tornado (these are called suction vortices).

How does vortex breakdown lead to tornado formation in a supercell?

A process similar to vortex breakdown in a tornado can occur in the mesocyclone updraft of a supercell thunderstorm.

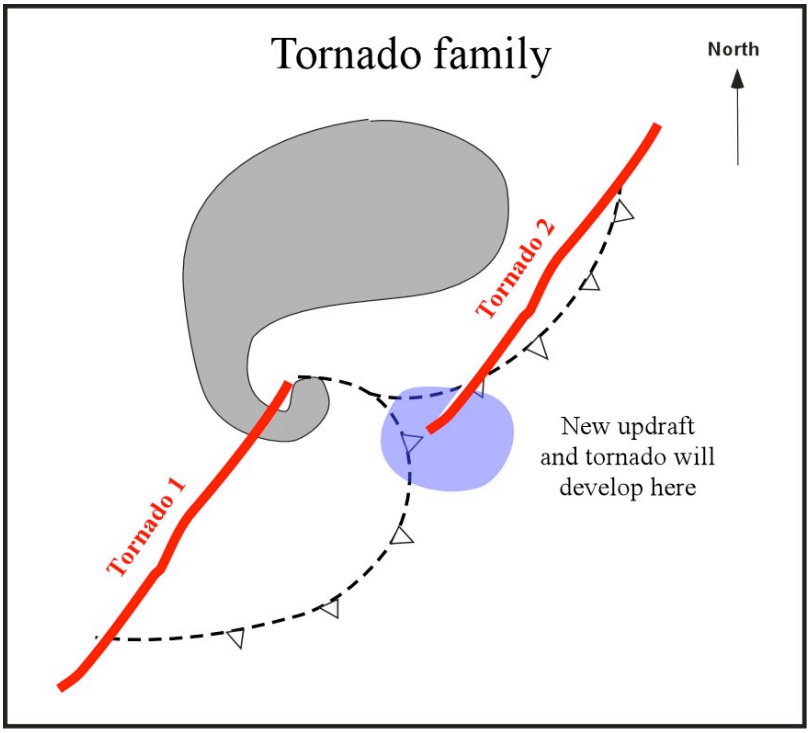
Occlusion downdraft (OD) – the central downdraft that can form in the mesocyclone

Tornadoes can form in the region between the occlusion downdraft and the mesocyclone updraft, similar to suction vortices forming in a tornado.

This is one way that tornadoes may form in a supercell thunderstorm, but other processes may also cause tornadoes to form in supercells.

What causes the tornado to dissipate?

Role of the RFD in tornado dissipation



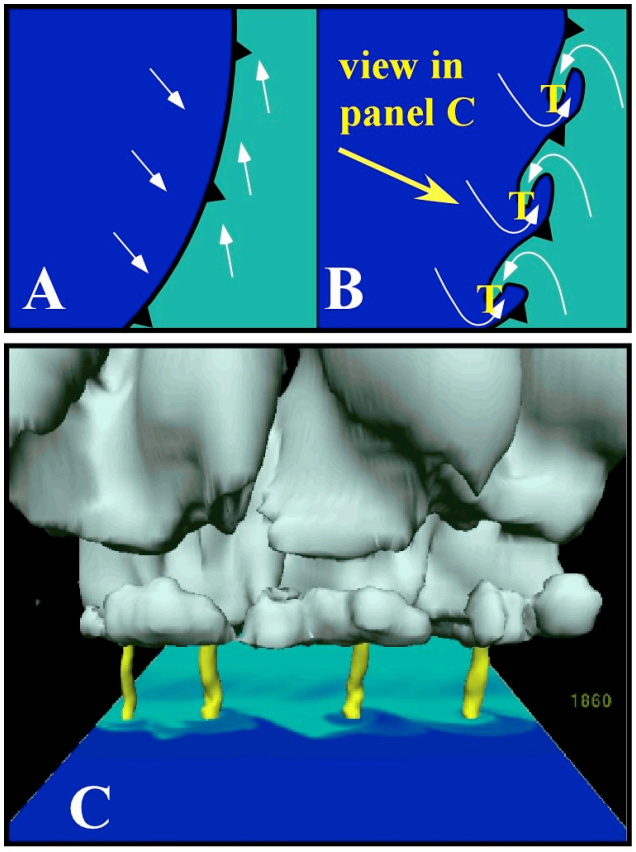
Tornado Families

Can multiple tornadoes form from the same mesocyclone?

Where will a new tornado form in relation to the features of a supercell?

Tornado Formation Within Non-supercell Thunderstorms

Landspout – a tornado that forms in a non-supercell thunderstorm



A, B ©2002 Kendall/Hunt Publishing
C. Courtesy of Bruce Lee

What causes a landspout tornado to form?

Large horizontal shear across a front can result in the formation of small vortices.

These vortices can be stretched, and intensify, if they form underneath a thunderstorm updraft.

How does the lifetime and strength of a landspout compare to that of a supercell created tornado?

Waterspout – a weak tornado (similar to a landspout) that occurs over water

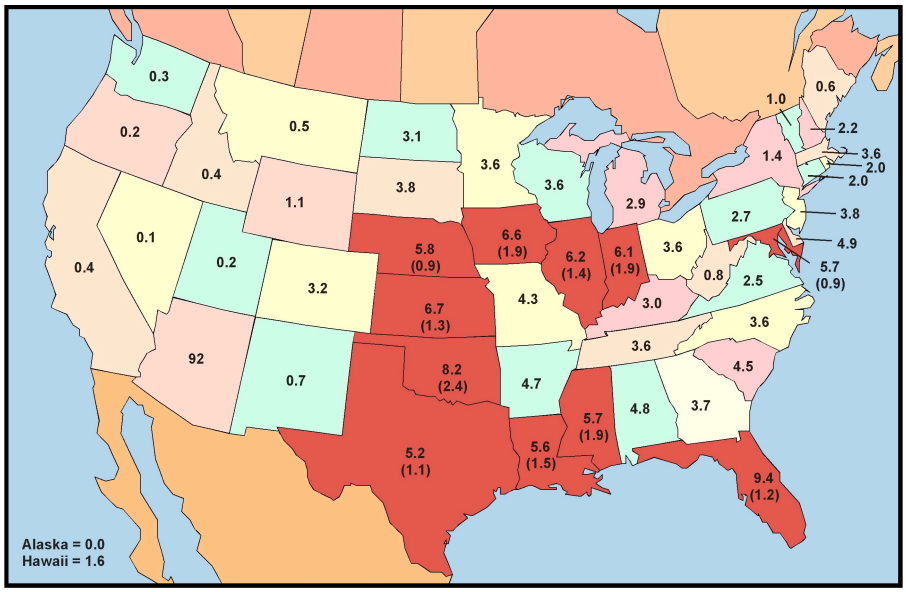
Waterspouts form when cold air moves over warm water.

Gustnadoes – a weak tornado that forms in a manner similar to a landspout, except the formation is associated with shear across a gust front

Non-supercell tornadoes also form in the NE quadrant of landfalling hurricances, but the mechanisms responsible for the formation of these tornadoes is still unknown.

Tornado Statistics

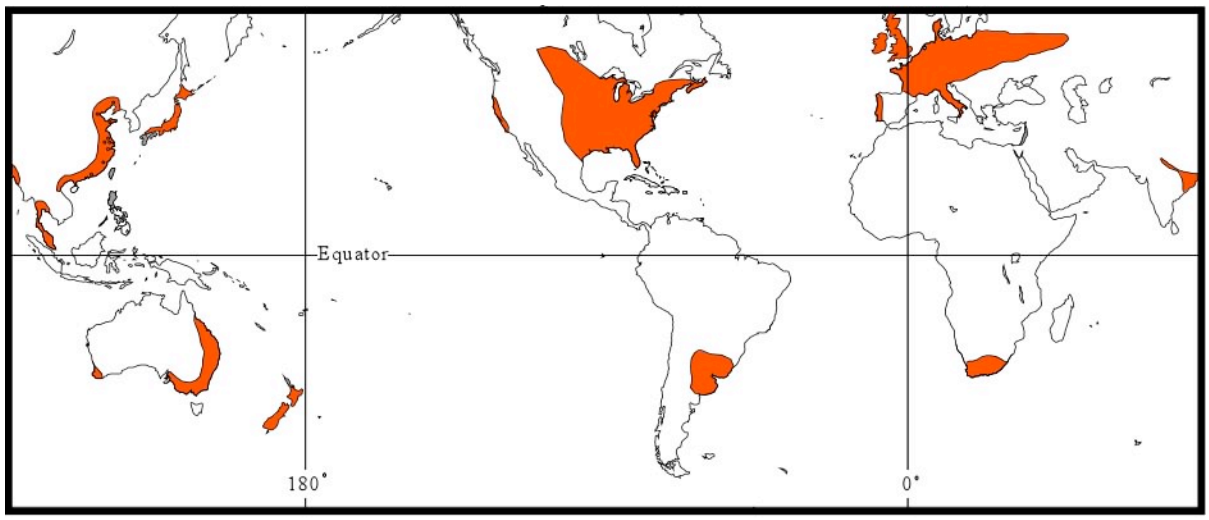
Where are tornadoes most common?



Tornado alley – the area of most frequent tornado occurrence in the United States

Extends from Texas to Illinois

Tornadoes Worldwide



75% of all tornadoes worldwide occur in the United States.

Tornado Intensity

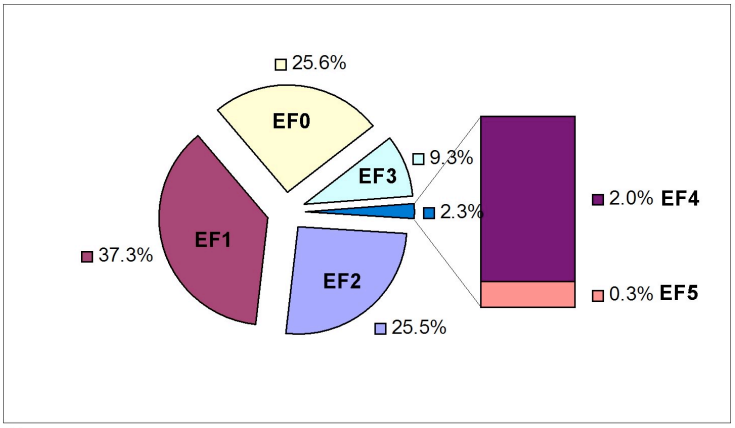
Fujita Scale (F-scale) of tornado intensity – based on the estimated maximum wind speed in a tornado

The Fujita scale was used from 1971 until 2007.

The Fujita scale has now been replaced by the enhanced Fujita scale (EF-scale).

Both the F-scale and EF-scale rating of a tornado is based on the damage done by the tornado since it is difficult to measure the wind speed in a tornado.

Fujita Scale	Wind Speed (mph)	Enhanced Fujita Scale	Wind Speed (mph)
F0	45 – 78	EF0	65 – 85
F1	79 - 117	EF1	86 – 110
F2	118 - 161	EF2	111 – 135
F3	162 - 209	EF3	136 – 165
F4	210 - 261	EF4	166 – 200
F5	262 - 317	EF5	> 200

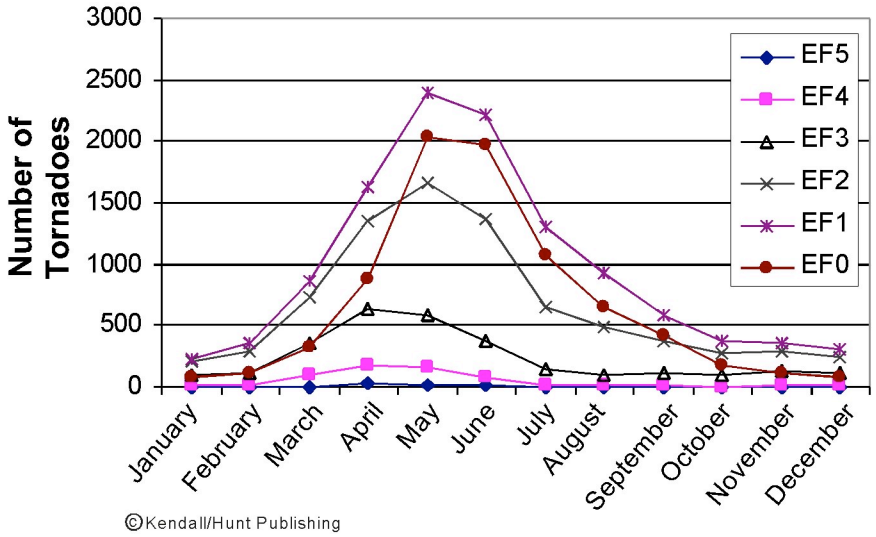


What intensity tornadoes are most common?

Which are least common?

EF5 tornadoes account for only 0.3% of all tornadoes in the United States.

What time of year are tornadoes most common?

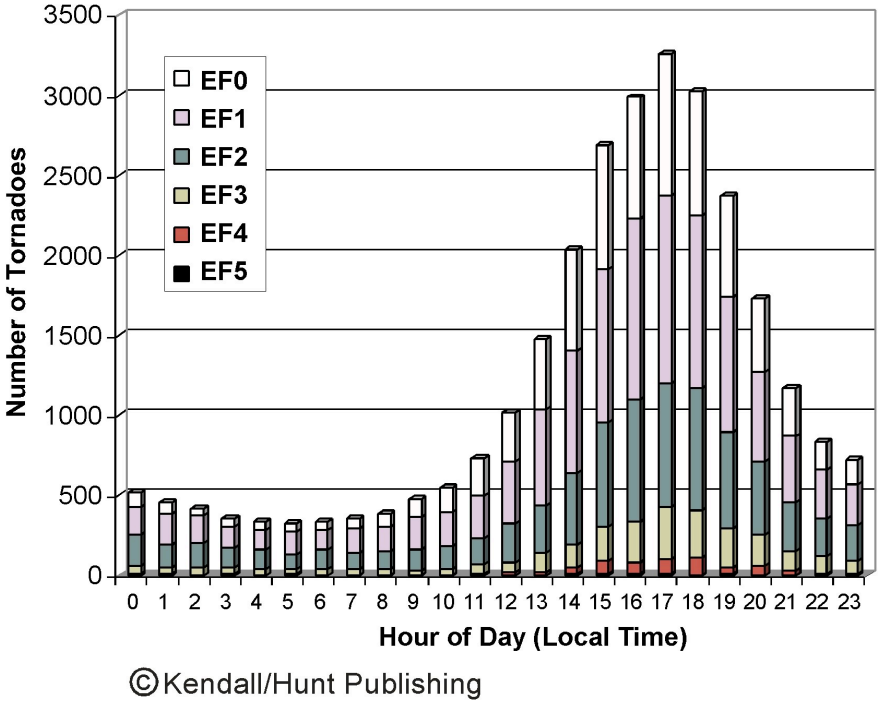


Tornadoes occur year-round, but are most common from April through June.

Why are tornadoes most common at this time of year?

See On-line 19.3 for an animation of the location of tornado occurrence for each month of the year.

What time of day are tornadoes most common?

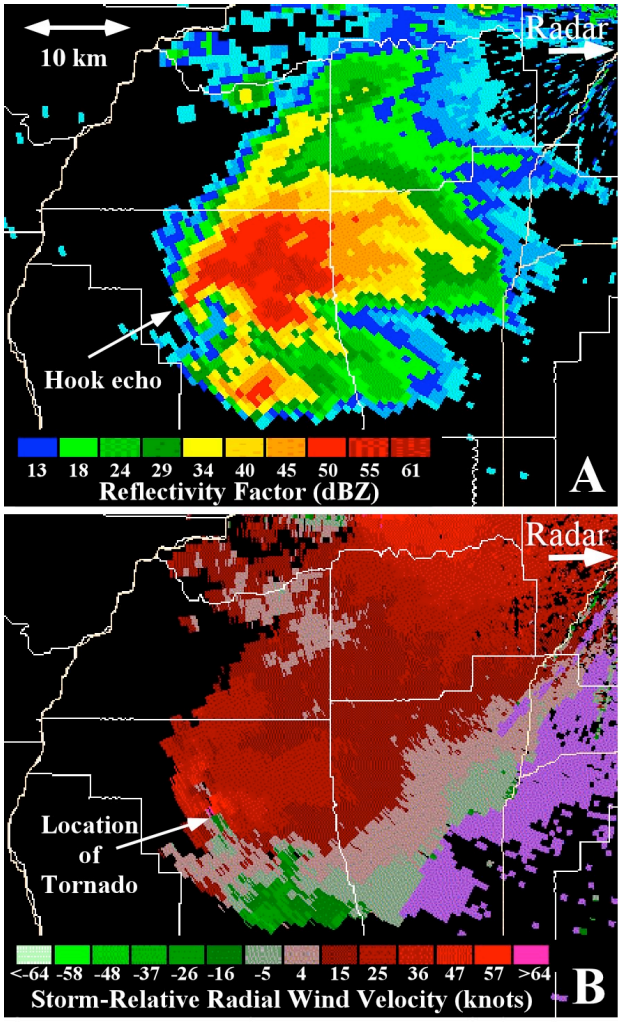


Why do tornadoes form most often during the late afternoon or early evening?

Tornado Detection

How do we know when a tornado is occurring?

Storm spotters, police reports, reports from the public
Doppler radar



Doppler Radar reflectivity

Hook echo – area of weaker reflectivity near mesocyclone updraft (top figure)

Doppler Radar Radial Velocity

Mesocyclone signature – small area where radial winds rapidly switch from outbound to inbound (bottom figure)

This is an indication of the circulation associated with the mesocyclone

Tornado vortex signature (TVS) – one pulse of a radar radial velocity image that has an unusually large velocity

On-line 19.4 – Doppler radar images of the May 3, 1999 tornado outbreak in Oklahoma City

This tornado outbreak killed 44 people and injured over 800 people, and damaged or destroyed 11,000 structures.

Severe Weather Watches and Warnings

Severe weather watches are issued by the Storm Prediction Center, and typically cover large portions of one or more states

Severe thunderstorm watch – conditions are favorable for the development of thunderstorms that contain strong winds, hail, frequent lightning, heavy rain, and possible tornadoes in and near the watch area

Tornado watch – conditions are favorable for the formation of tornadoes in and near the watch area

Severe weather warnings are issued by local National Weather Service offices and cover one or more counties

When a warning is issued for your area seek shelter immediately!

Severe thunderstorm warning – a severe thunderstorm is occurring or is imminent in or near the warning area

Tornado warning – a tornado is present or imminent in or near the warning area

Severe thunderstorm and tornado warnings are issued based on:

- Doppler radar indications of a severe thunderstorm or tornado
- Police or storm spotter reports
- Reports from the public

Information on watches and warnings are broadcast by TV and radio stations and on NOAA Weather radio.

Tornado Safety

If a watch is issued for your area, stay tuned to radio and TV throughout the day to get updates on the situation

In the event of a tornado:

- Seek shelter in a basement or underground shelter

- If no basement is available go to an interior room or hallway (stay away from windows and abandon mobile homes)

- If caught outside move as far away as possible from potential airborne objects and lie in the lowest spot available

- Do not try to outrun a tornado in a car. Instead abandon the car and seek shelter in a low-lying area.

- Do not seek shelter under highway overpasses, as wind speeds can be increased underneath the overpass