NATS 101
Section 13: Lecture 27

Thunderstorms and Severe Weather
Part II: Tornadoes

Last time I ended with the picture of what happens when the “loaded gun” fires…

TORNADO: **A rapidly rotating column of air that blows around a small area of intense low pressure that reaches the ground.**

I'm focusing on supercell-generated tornadoes—because they produce the most powerful ones.

Tornadoes, though, can occur in all the various thunderstorm types…and in some places you wouldn't otherwise expect!

MORE POLICE/FIRE, A4

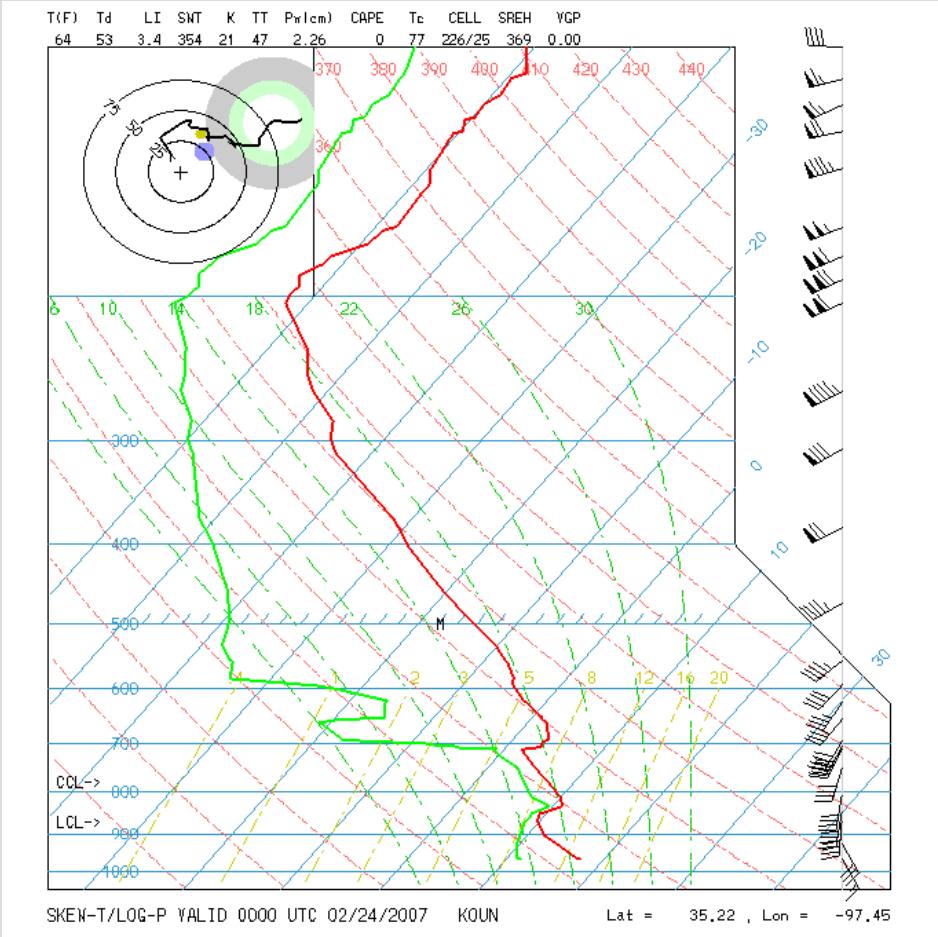
NEWSWATCH

JOHN KEONI WELCH / SPECIAL TO THE STAR-BULLETIN

ARE WE HAVING FUNNEL YET? Two funnel clouds formed above Oahu and another developed over Maui during unstable weather conditions yesterday, according to the National Weather Service. Funnel clouds, like this one photographed yesterday from Kapolei, are more likely to develop when conditions switch from wet to dry, the service said.

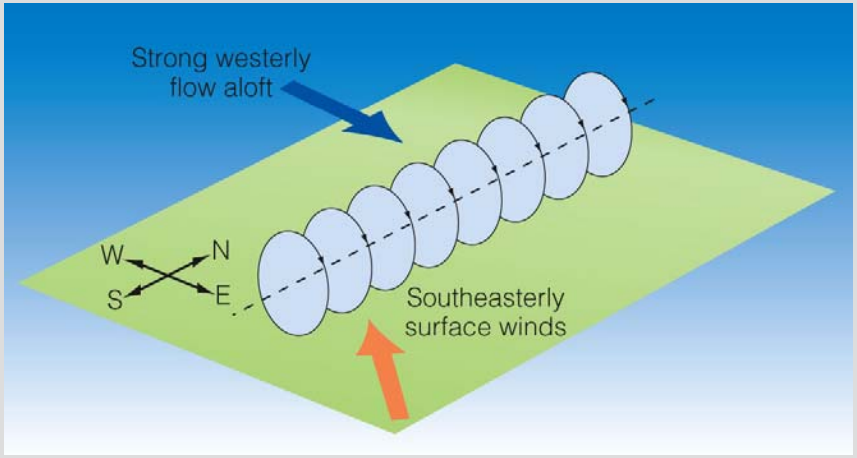
Honolulu Star-Bulletin
March 17, 2007
(courtesy of Ms. Alison Walshe)

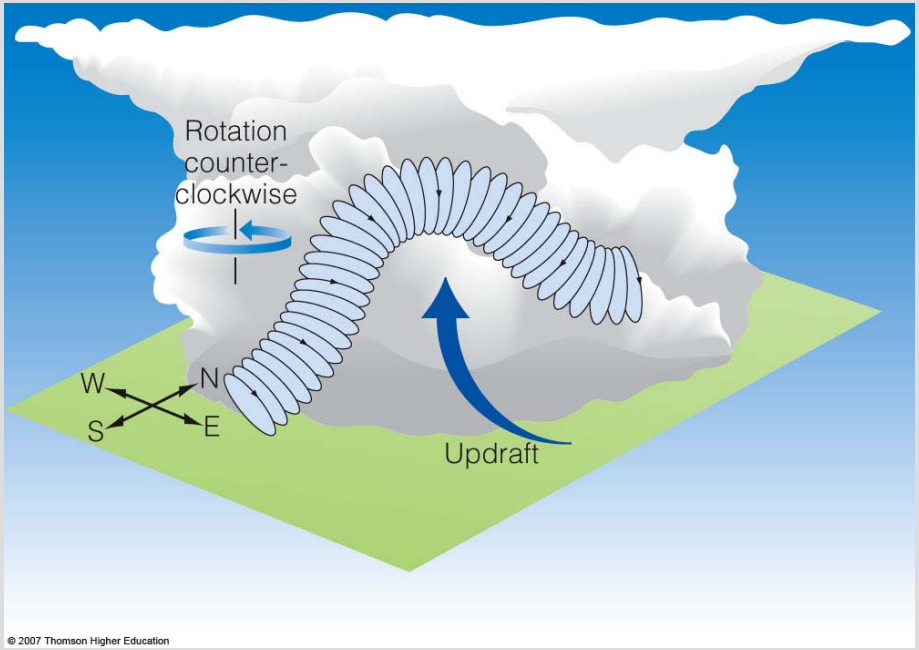
THE “LOADED GUN” SOUNDING
THE SIGNATURE FOR SUPERCELLS!



As an exercise, try to identify all of the necessary ingredients for supercells from this sounding.

Formation of a rotating updraft in a supercell



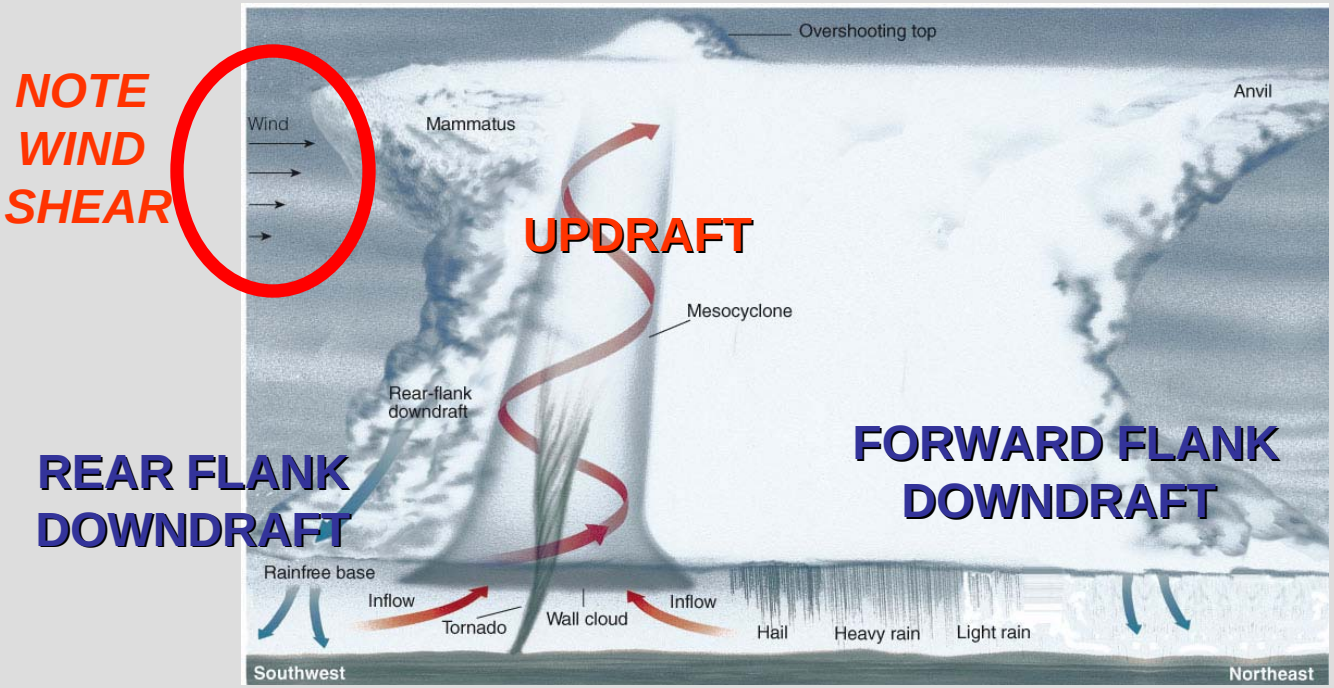


What causes the rotation in the horizontal?

Updraft in a thunderstorm tilts horizontal rotation into vertical rotation.

Net result is a relatively small, supercell rotating about a mesocyclone.

Vertical structure of tornadic supercell

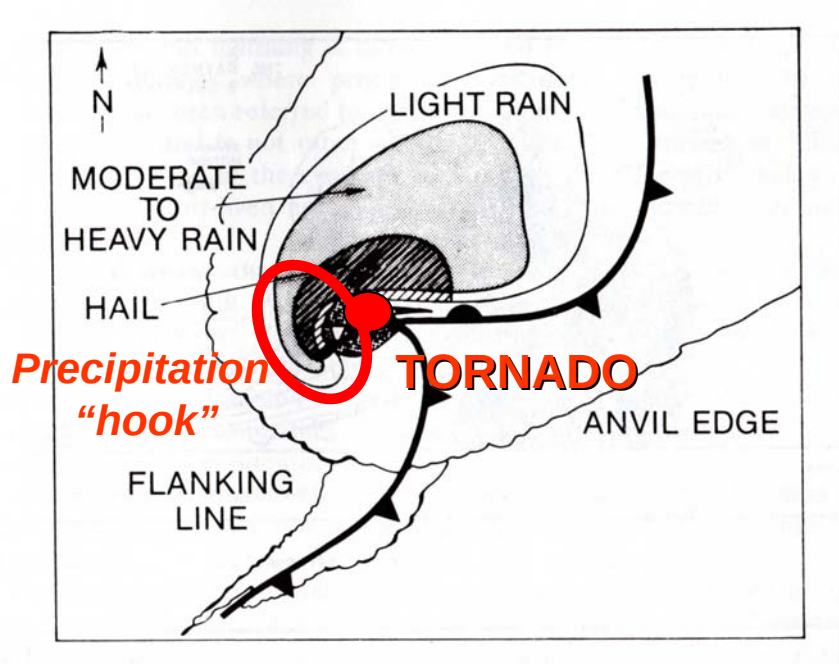


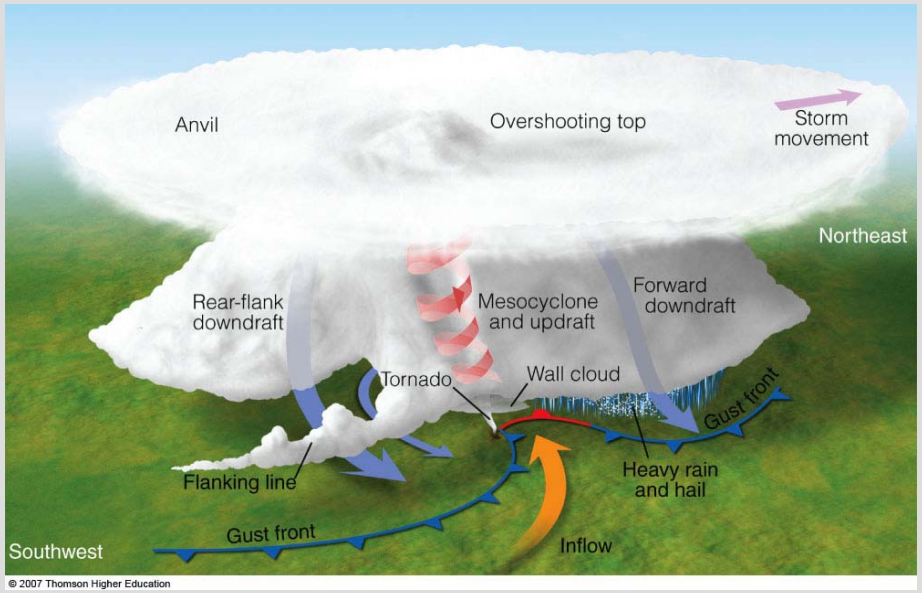
REAR FLANK DOWNDRAFT: Downdraft at the base of the supercell, right before the wall cloud.

UPDRAFT: Tornado forms at the base of the updraft is the extension of the mesocyclone, defined by a *wall cloud*.

FORWARD FLANK DOWNDRAFT: Precipitation falls in the form of (possibly large) hail and heavy rain.

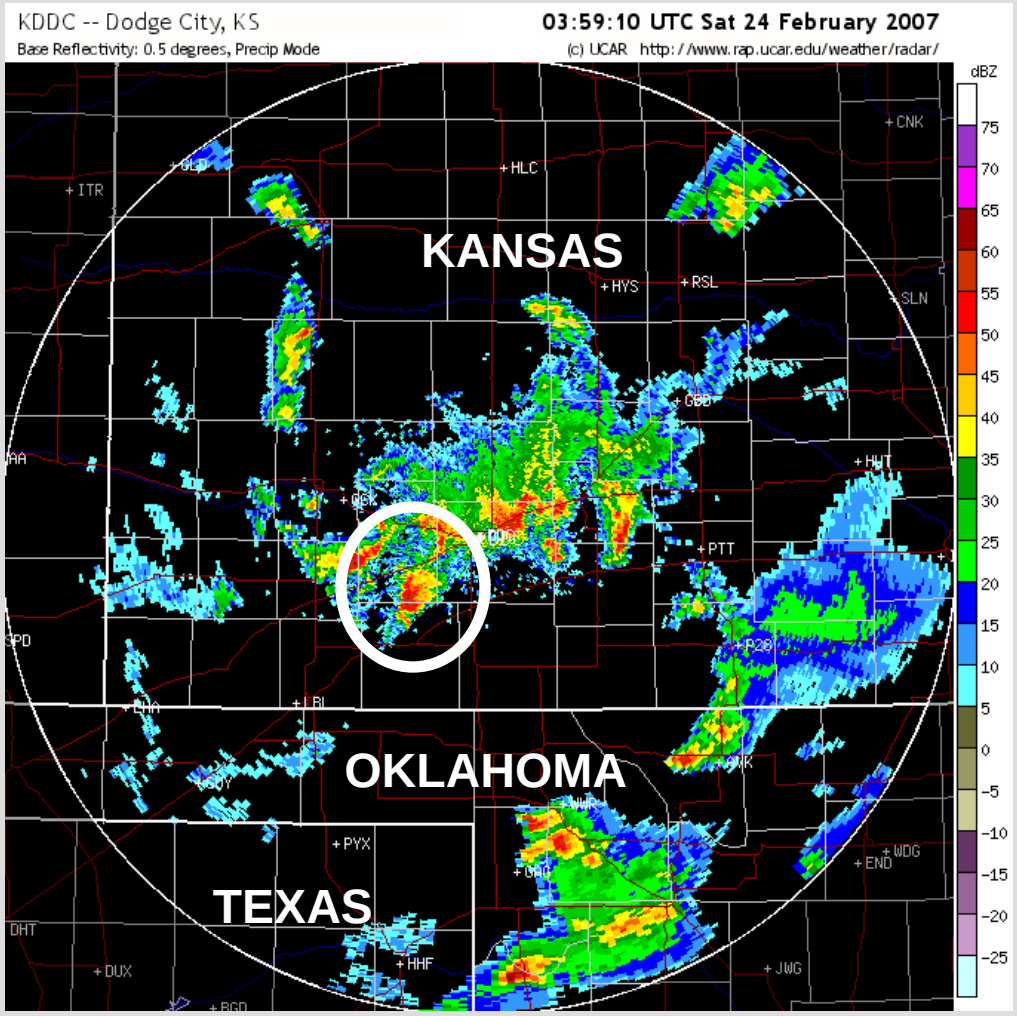
Horizontal structure of a tornadic supercell





The tornado is located in front of the precipitation "hook" which defines the area of hail and rain curving around the mesocyclone.

Tornadic supercells on radar

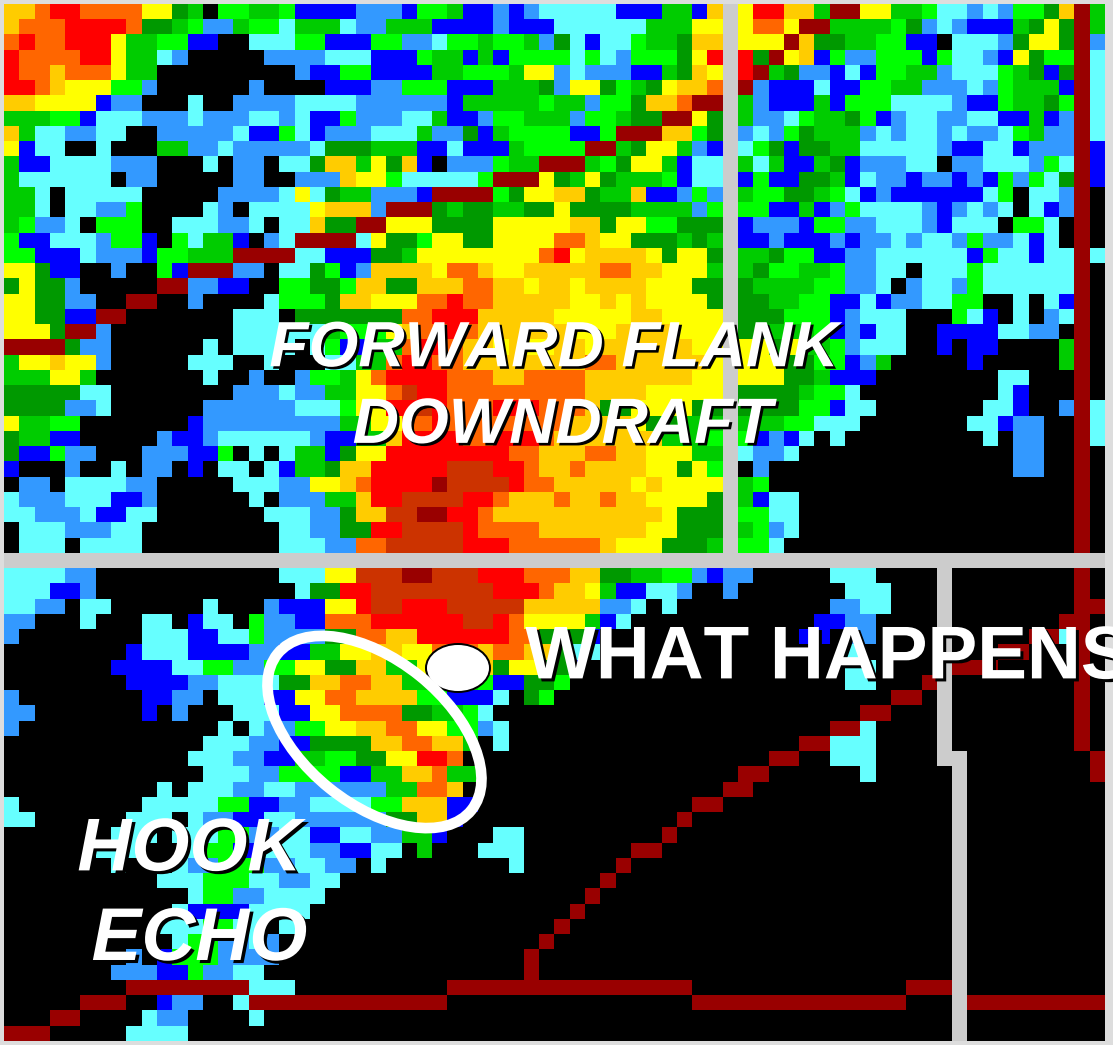


NOT big long squall lines!

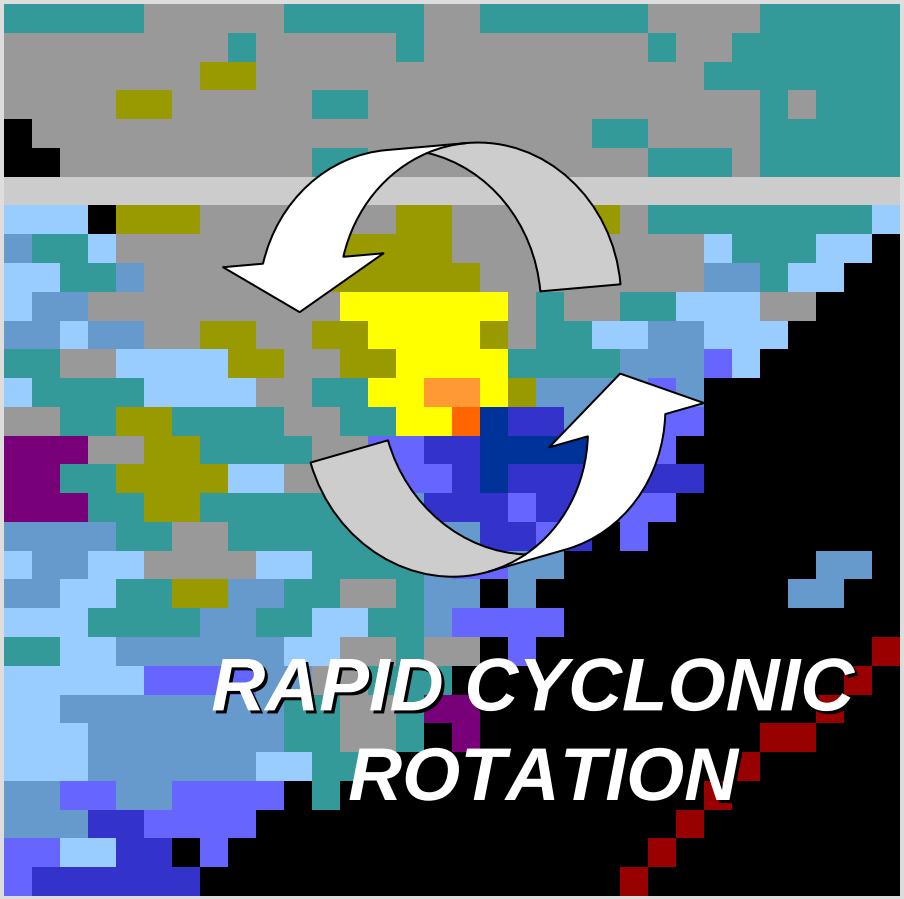
Get compact and isolated rotating cells!

Radar signature of a tornadic supecell

Reflectivity



Radar signature of a tornadic supercell
Wind velocity



YELLOW = ECHOES TRAVELING AWAY FROM RADAR

BLUE = ECHOES TRAVELING TOWARD RADAR

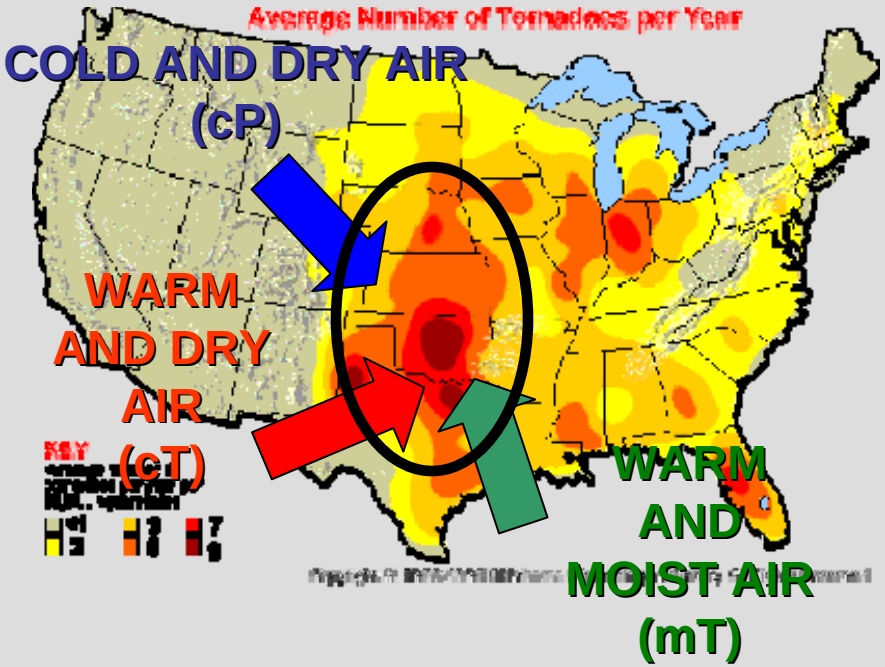
NOTE: In Northern Hemisphere, tornadic supercells typically rotate counterclockwise due to the typical wind shear profile.

They can also rotate clockwise on rare occasions—since the vortex is in _____ balance.

Tornadoes occur on all continents on Earth (except Antarctica)

BUT BY FAR THE PLACE WHERE THE MOST TORNADOES OCCUR IS IN TORNADO ALLEY…

Tornadoes occur where three different air masses clash



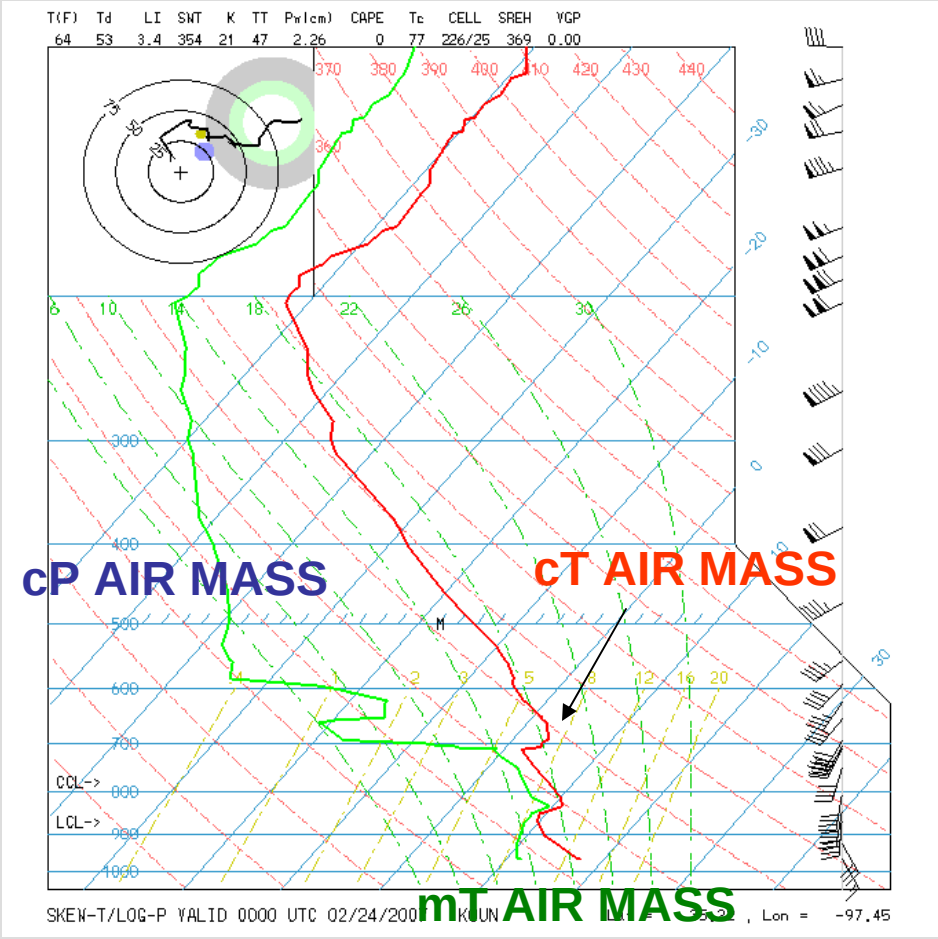
Tornadoes (and the supercell thunderstorms that spawn them) are most prevalent in “tornado alley” in the central U.S.

Some of the most severe weather on Earth!

Tornado Alley: A unique clash of air masses like no where else on Earth

AIRMASS	WINDS	CHARACTER	WHAT IT DOES
cP	Westerly above about 700 mb	Cold and dry.	CREATES INSTABILITY ALOFT
cT	Southwesterly at about 800 mb	Warm and dry.	PROVIDES CAPPING INVERSION
mT	Southerly to Southeasterly near surface	Warm and moist	CREATES INSTABILITY NEAR SURFACE AND PROVIDES FUEL FOR STORMS

THE “LOADED GUN” SOUNDING
THE SIGNATURE FOR SUPERCELLS!



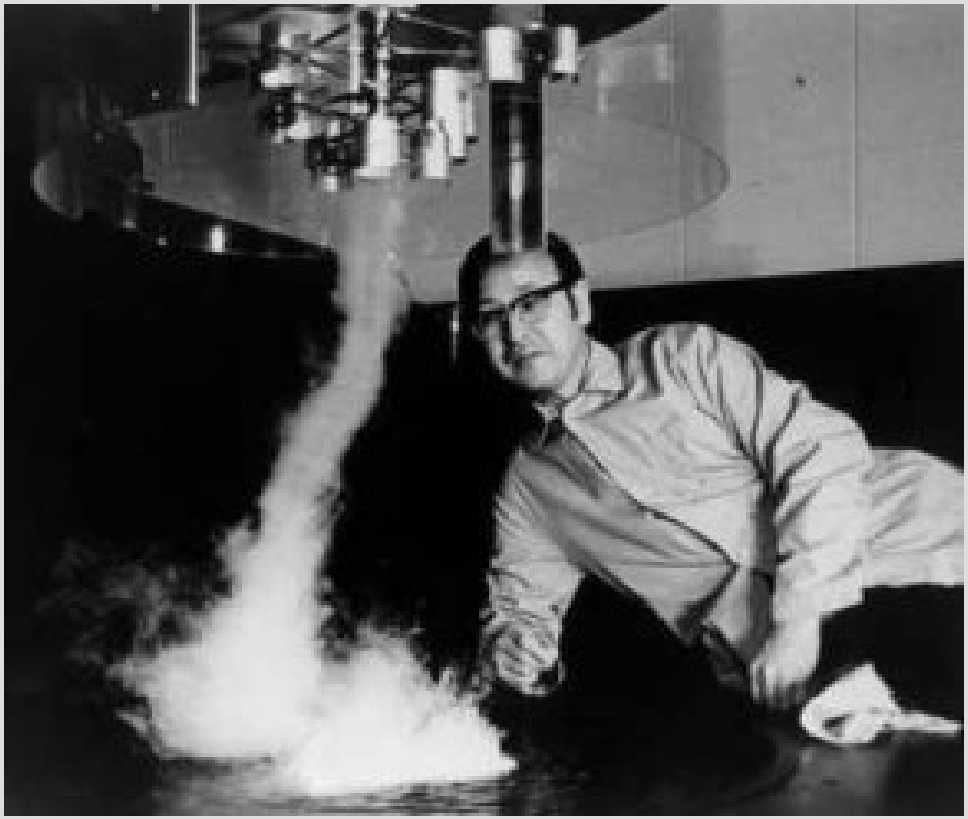
What do each of these air masses do to make this an environment conducive for tornadoes?

If a tornado starts to form, what happens next?

Depends on what type of tornado your talking about…

Fujita Scale:

Gives a scale for tornado damage



Professor Ted Fujita

Now we use the Enhanced Fujita (EF) scale, which has slightly lower wind speed thresholds for the higher numbers than the original scale.

EF0: Very Weak

<u>Winds</u>: 65-85 mph

<u>Damage</u>: Broken tree branches and signs.

EF1: Weak

Miami, FL

<u>Winds</u>: 86-110 mph

<u>Damage</u>: Small trees snapped and windows broken

EF2: Strong

<u>Winds</u>: 111-135 mph

<u>Damage</u>: Large trees uprooted, weak structures destroyed

EF3: Very Strong

<u>Winds</u>: 136-165 mph

<u>Damage</u>: Severe; trees leveled, cars overturned, walls removed

EF4: Violent

Winds: 166-200 mph

Damage: Major devastation of sturdy structures.

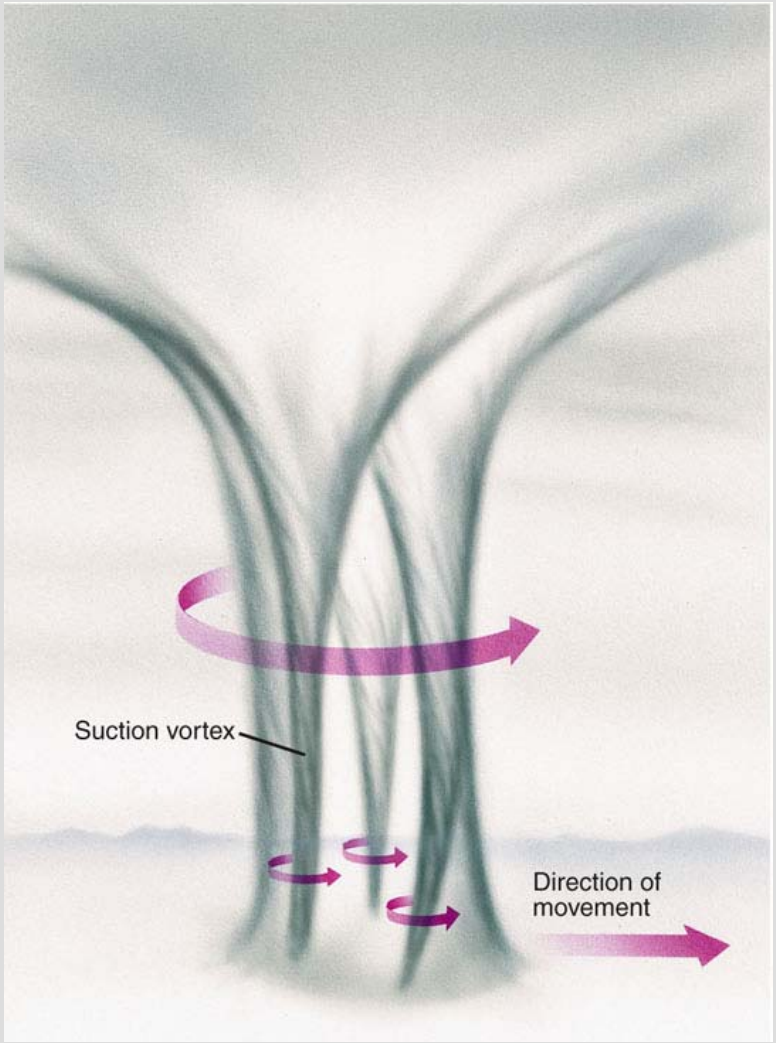
EF5: Catastrophic

Moore, OK
May 3, 1999

Winds: Over 200 mph

Damage: Ability to move major structures large distances (like houses, trucks, and cars). Total devastation!

Suction Vortices

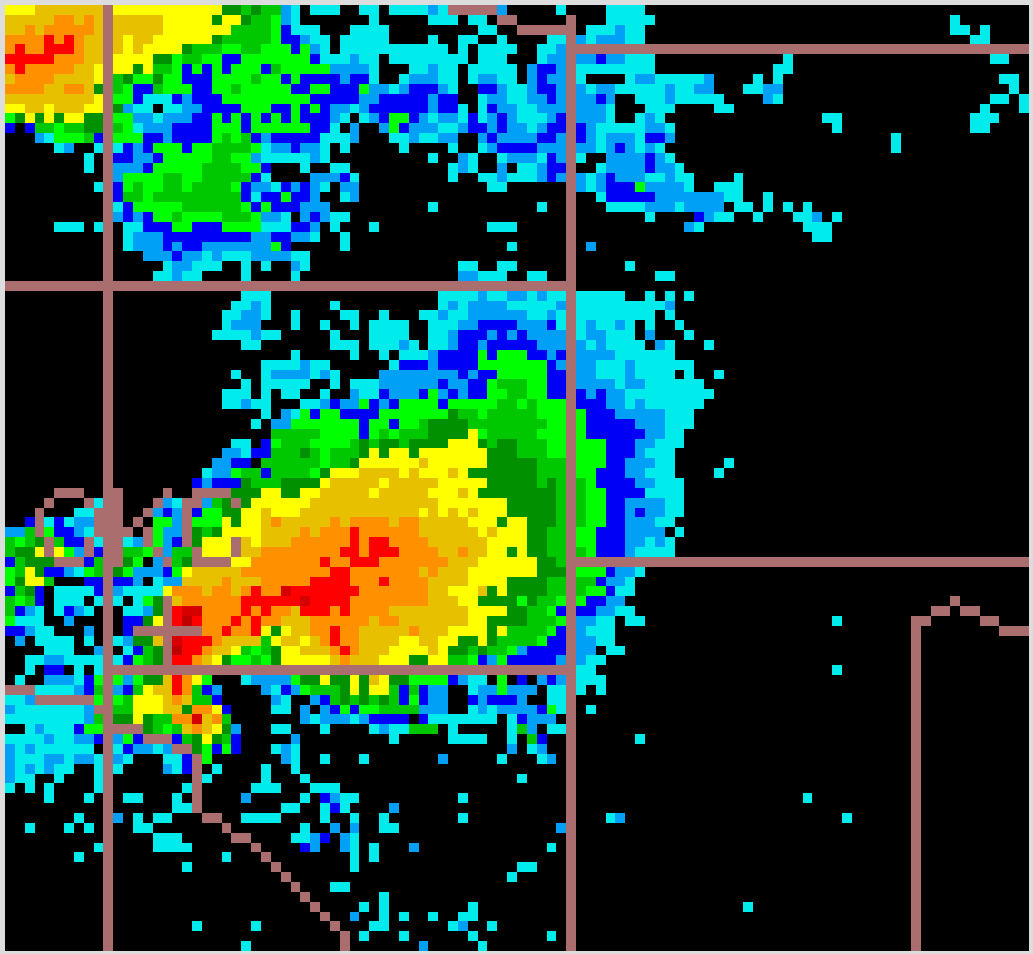


In the strongest tornadoes, small vortices within the main funnel with even higher wind speeds!

Moore, Oklahoma May 3, 1999

This is the case described in the textbook.

RADAR REFLECTIVITY



One of the more recent deadliest tornadoes in the U.S. after Moore, Oklahoma, occurred on this date and hour:

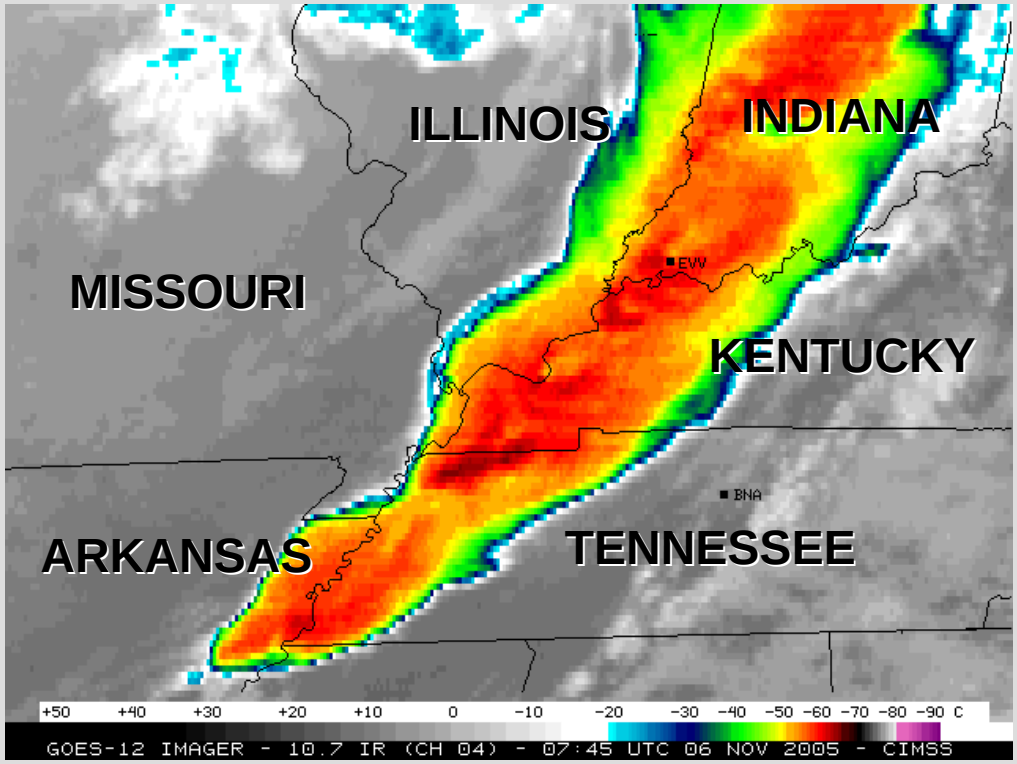
SUNDAY

NOVEMBER 6, 2005

(AT APPROXIMATELY 2 AM)

Meteorological Analysis
Sunday, Nov. 6, 2005

IR SATELLITE IMAGERY



(CIMMS, U. Wisc.)

A severe squall line along a cold front was moving through the lower Ohio River Valley.

National Weather Service in Paducah, KY, issued a severe thunderstorm watch.

Squall line broke down into supercell thunderstorms in the early morning hours after midnight.

Meteorological Analysis
Sunday, Nov. 6, 2005

EVANSVILLE, INDIANA

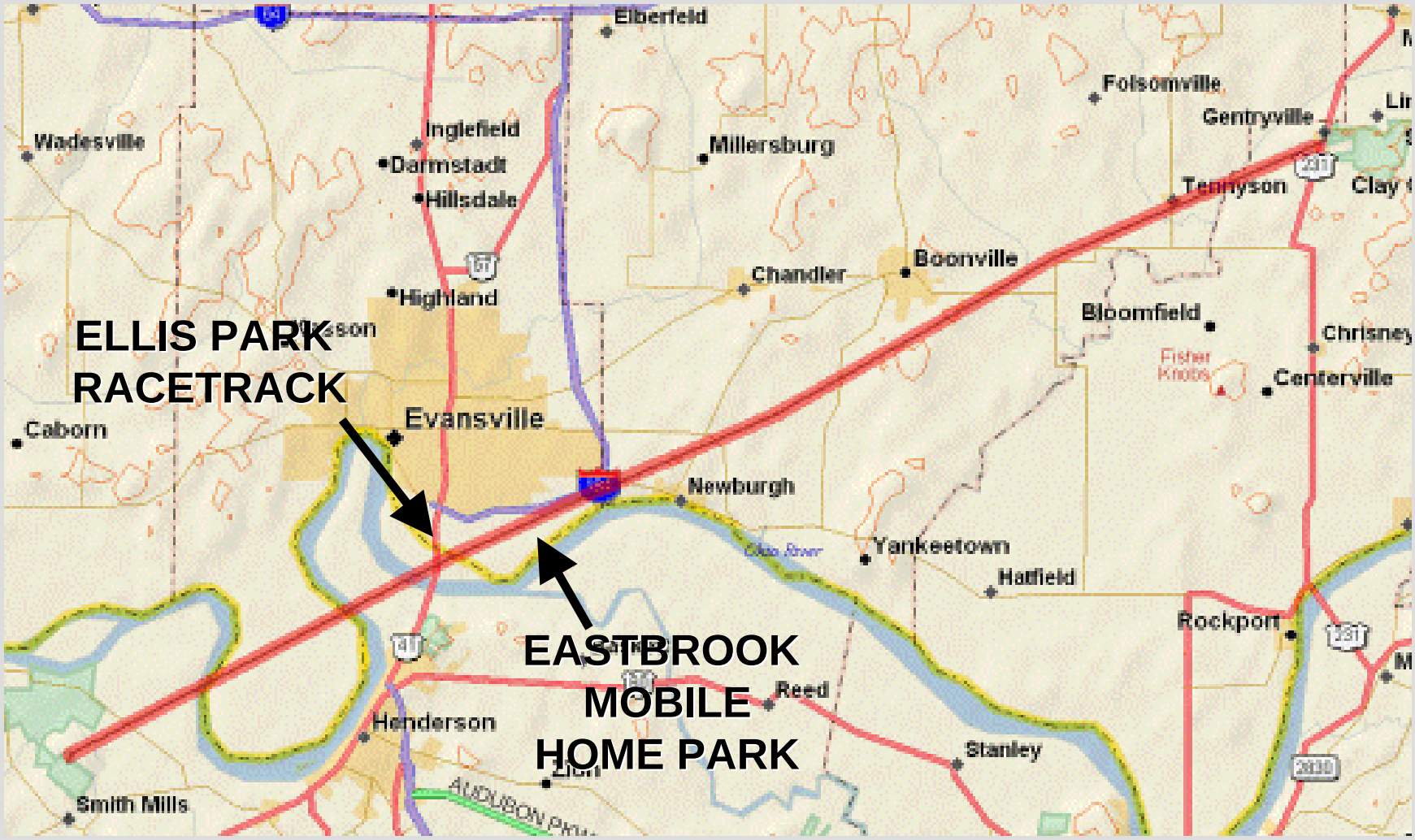
RADAR REFLECTIVITY

VIEW FROM DEACONESS HOSPITAL
DOWNTOWN EVANSVILLE

Before 2 AM, F3 tornado touched down near Smith Mills, Kentucky.

Several minutes later, the storm crossed the Ohio River and headed toward the east side of Evansville, Indiana.

Evansville Tornado Path



Ellis Park Racetrack

Tornado path after Ellis Park

Note the irregular pattern of torn up. What does this indicate?

Eastbrook Mobile Home Park

About 20 people died here because of inadequate shelter and the fact the storm hit at 2 AM.

Eastbrook: Arial View of Tornado Path

These residents of this house lived to tell the tale…

Residents of this house in Warrick County, Indiana, survived by seeking shelter in the interior bathroom.

That was the only room left standing!

Greensburg, Kansas
Wiped off the map May 4, 2007.

HOW TO SURVIVE A TORNADO

SEEK SHELTER IMMEDIATELY IN A BASEMENT OR INTERIOR ROOM OF A STURDY STRUCTURE

STAY AWAY FROM WINDOWS

PUT SOMETHING TO COVER YOURSELF—LIKE A MATRESS OR UNDER A DESK.

STAY IN A CROUCHED POSITION.

IF OUTSIDE, FIND THE LOWEST PLACE, LIKE A RAVINE OR DITCH.

IF IN A CAR, DON'T SEEK SHELTER UNDER AN OVERPASS AND DON'T TRY TO "OUTRUN" THE STORM.

Summary of Lecture 27

A tornado is a rapidly rotating column of air that blows around a small area of intense low pressure that reaches the ground.

Though tornadoes can occur with any type of thunderstorm, the strongest ones are those that occur in supercells.

Supercells arise in a very unstable, sheared environment

- **Three parts: Rear flank downdraft, updraft, and forward downdraft**
- **Tornado forms in mesocyclone updraft**

Radar signature of tornado

- **Hook echo in the reflectivity**
- **Rapid rotation in the wind velocity**

Most tornadoes occur in the central U.S. because of the unique combination of air masses there.

Tornado strength is given by the Enhanced Fujita scale (EF0-EF5).

If a tornado warning is issued, know the necessary actions to take to save your life.

Reading Assignment and Review Questions

We'll finish Chapter 14 next time.

<u>Chapter 14 Questions (today + last lecture)</u>

Questions for Review: 22,26,27,28 (8th ed.)
26,31,32,33,36 (9th ed.)

Questions for Thought: 7 (8th ed.)
7,9 (9th ed.)