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!_
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.
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 supercell

*Reflectivity*

WHAT HAPPENS HERE??

FORWARD FLANK

DOWNDRAFT

WHAT HAPPENS HERE??

HOOK

ECHO
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

<table>
<thead>
<tr>
<th>AIRMASS</th>
<th>WINDS</th>
<th>CHARACTER</th>
<th>WHAT IT DOES</th>
</tr>
</thead>
<tbody>
<tr>
<td>cP</td>
<td>Westerly above about 700 mb</td>
<td>Cold and dry.</td>
<td>CREATE INSTABILITY ALOFT</td>
</tr>
<tr>
<td>cT</td>
<td>Southwesterly at about 800 mb</td>
<td>Warm and dry.</td>
<td>PROVIDES CAPPING INVERSION</td>
</tr>
<tr>
<td>mT</td>
<td>Southerly to Southeasterly near surface</td>
<td>Warm and moist</td>
<td>CREATE INSTABILITY NEAR SURFACE AND PROVIDES FUEL FOR STORMS</td>
</tr>
</tbody>
</table>
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

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

Professor Ted Fujita
EF0: Very Weak

Winds: 65-85 mph

Damage: Broken tree branches and signs.
EF1: Weak

Winds: 86-110 mph

Damage: Small trees snapped and windows broken
EF2: Strong

Winds: 111-135 mph

Damage: Large trees uprooted, weak structures destroyed
EF3: Very Strong

Winds: 136-165 mph

Damage: Severe; trees leveled, cars overturned, walls removed
EF4: Violent

**Winds:** 166-200 mph

**Damage:** Major devastation of sturdy structures.
EF5: Catastrophic

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.
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)
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.
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.
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 MATTRESS 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.
We’ll finish Chapter 14 next time.

**Chapter 14 Questions (today + last lecture)**

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.)