

ATM S 103

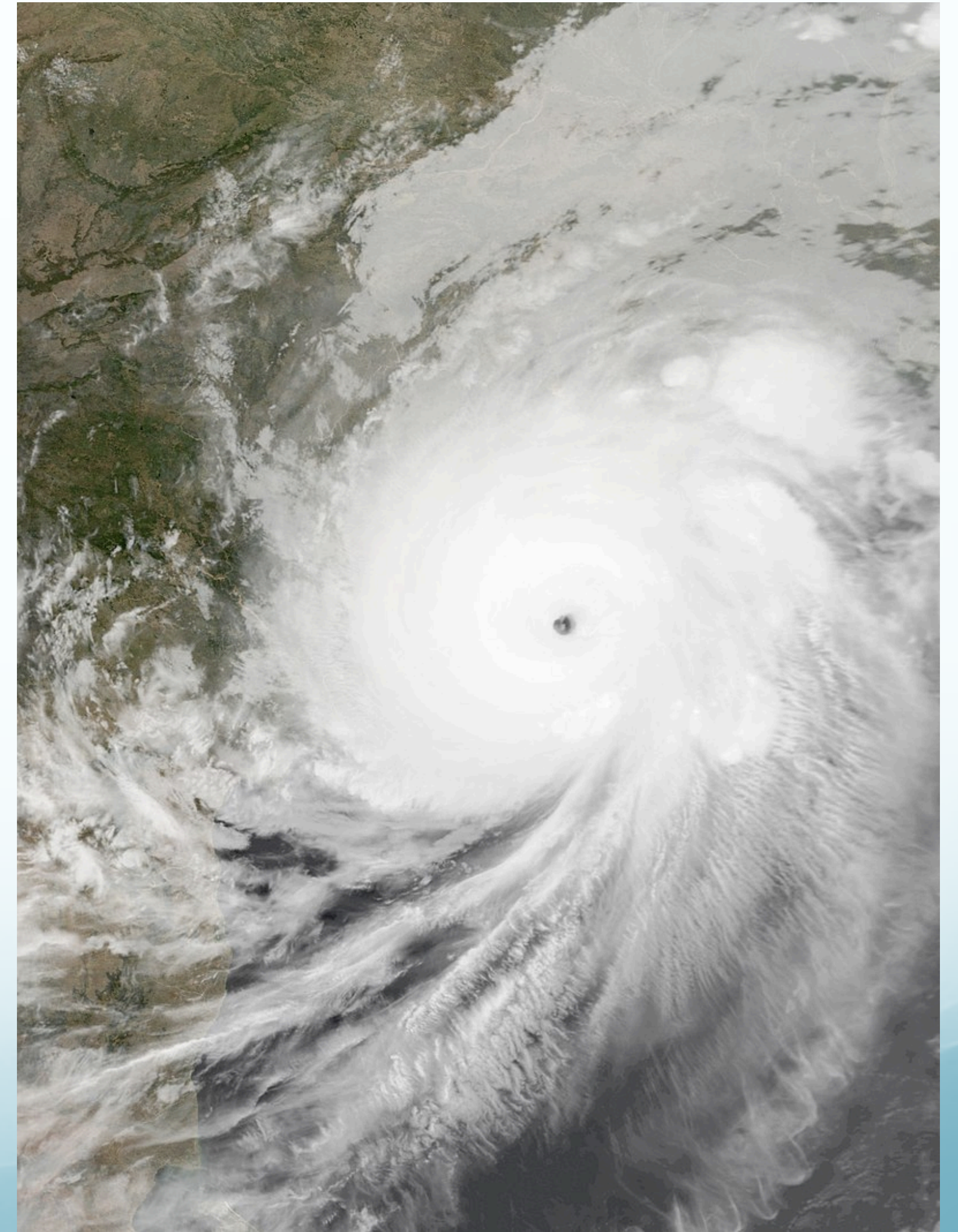
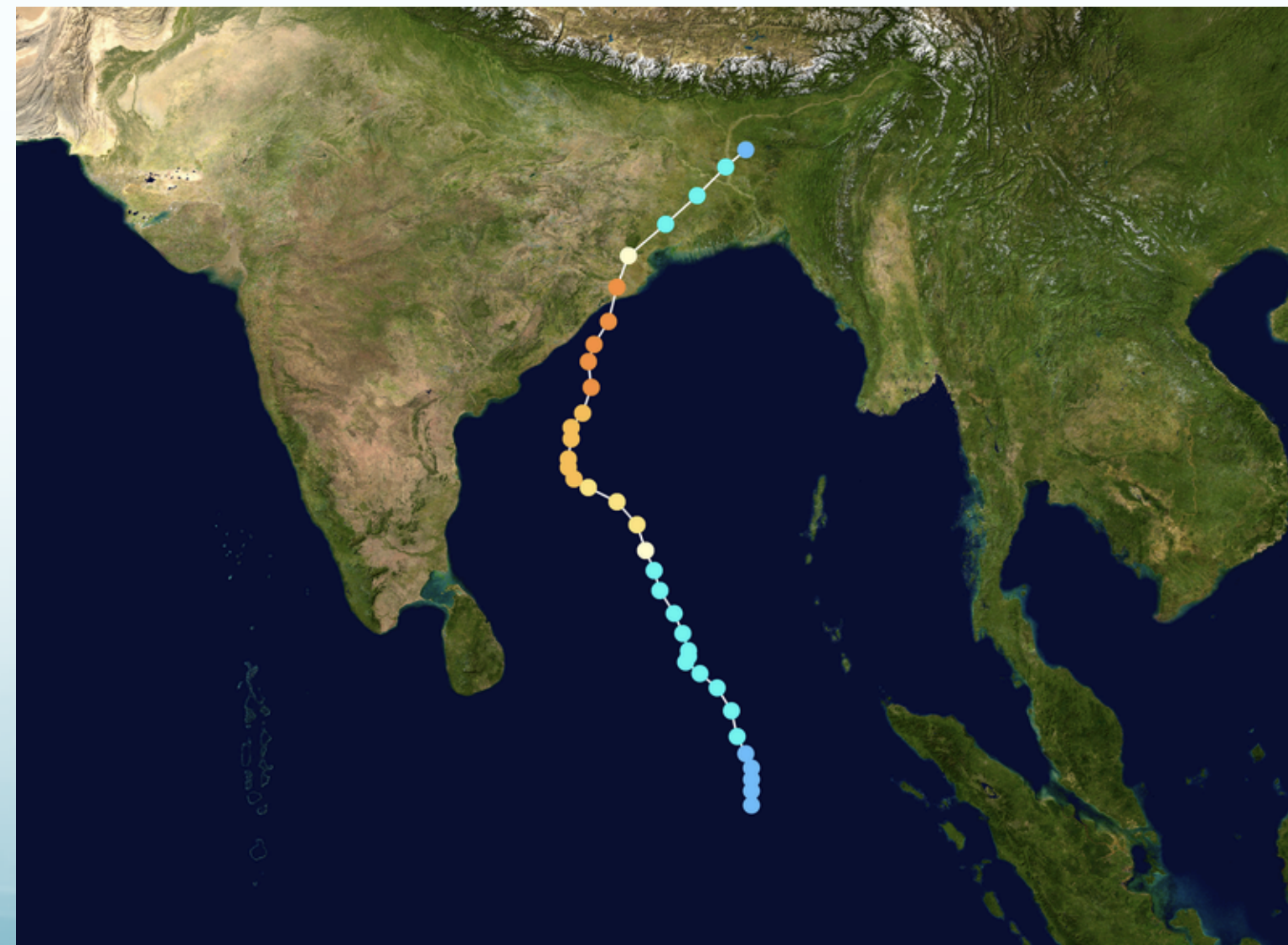
Hurricanes and Thunderstorms

Their Science and Impacts



Cyclone Fani

- Maximum intensity: 250 km/hr or 155 mph
- Made landfall on May 3
- More than 1 million people evacuated
- At least 56 people killed



W

Which of these develops as initially rotating air gets sucked into an updraft?

Tornado

Dust devil

Waterspout

All of the
above

Answer: All of the above: Tornadoes, Dust Devils, etc.

Common behavior: rotation speeds up as air is drawn in toward the centerline of an updraft (conserving angular momentum)



Topics for today

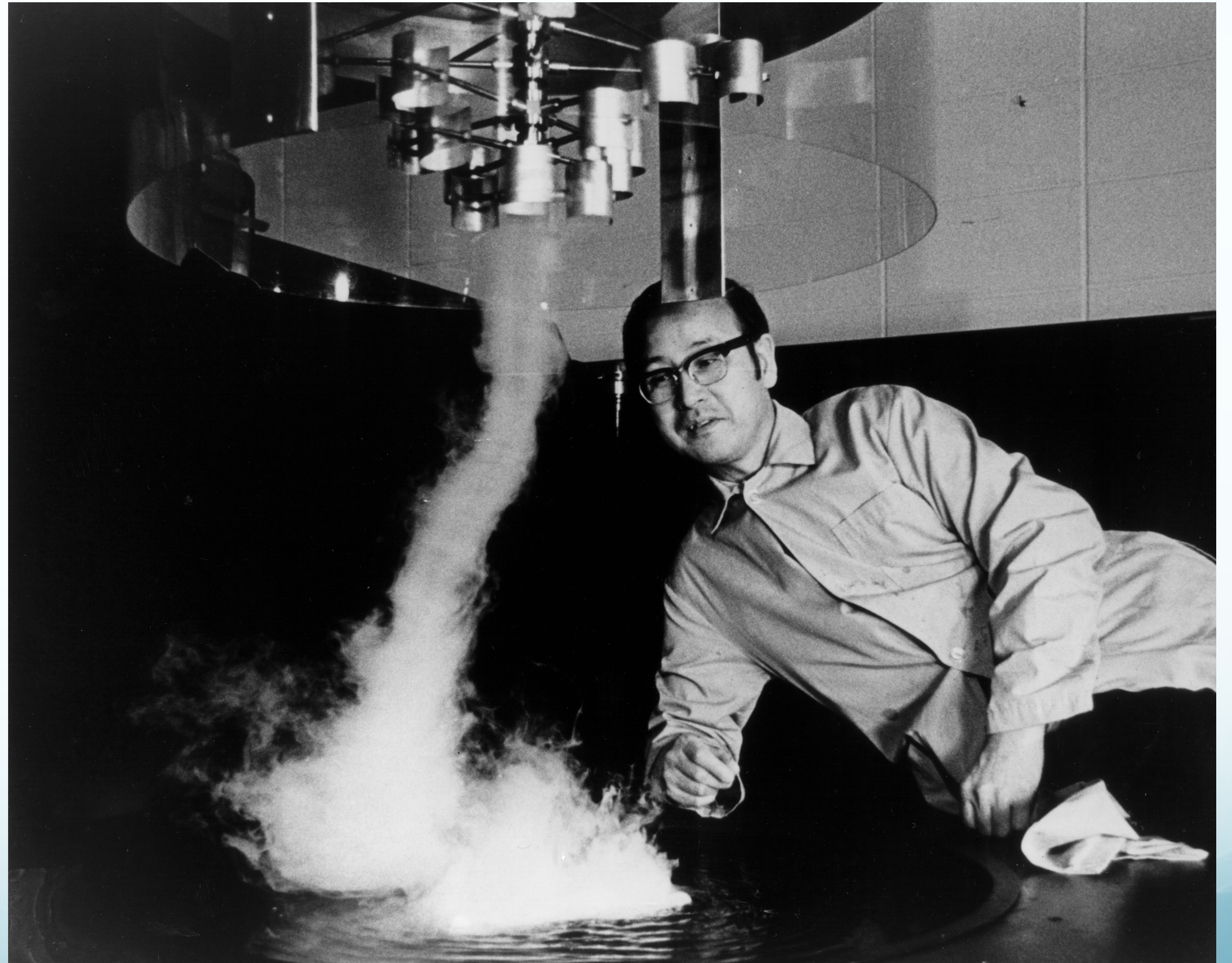
- Fujita tornado intensity scale
- Tornado safety
- Non-mesocyclonic tornadoes



When is it a tornado

- **Definition** of a tornado:
 - A violently rotating column of air
 - In contact with the ground
 - Connecting up to a cumulus cloud
 - Often (not always) visible as a funnel cloud
- Connection to a (vigorous) cumulus cloud:
 - Excludes dust devils and steam devils
 - Makes a stronger updraft and a more intense swirl

Tornado Intensity: Enhanced Fujita Scale

- Based on the damage
- Wind speeds are estimates
- EF-0 through EF-5



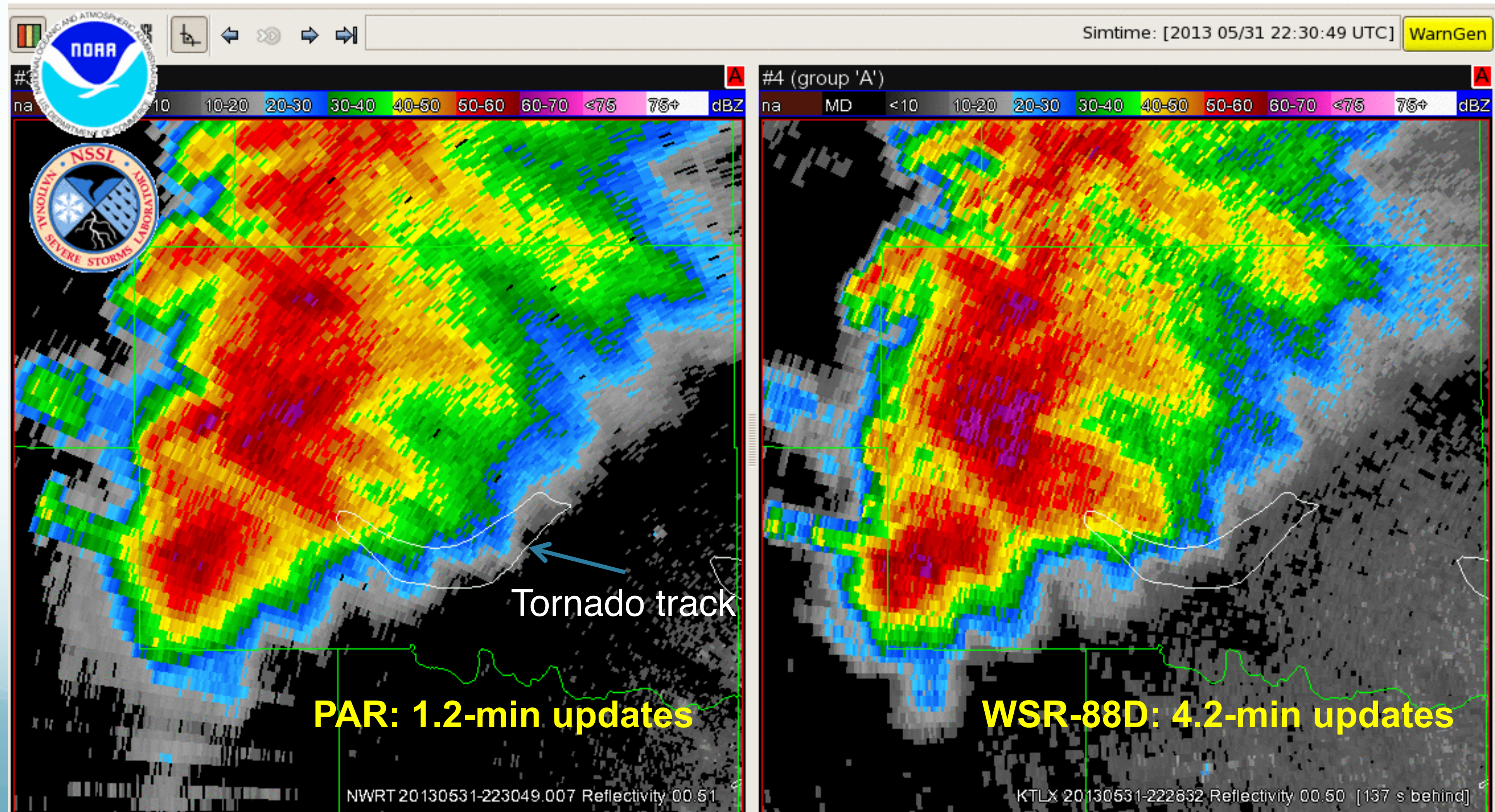
EF Rating	Wind Speeds	Expected Damage	
EF-0	65-85 mph	'Minor' damage: shingles blown off or parts of a roof peeled off, damage to gutters/siding, branches broken off trees, shallow rooted trees toppled.	 
EF-1	86-110 mph	'Moderate' damage: more significant roof damage, windows broken, exterior doors damaged or lost, mobile homes overturned or badly damaged.	 
EF-2	111-135 mph	'Considerable' damage: roofs torn off well constructed homes, homes shifted off their foundation, mobile homes completely destroyed, large trees snapped or uprooted, cars can be tossed.	 
EF-3	136-165 mph	'Severe' damage: entire stories of well constructed homes destroyed, significant damage done to large buildings, homes with weak foundations can be blown away, trees begin to lose their bark.	 
EF-4	166-200 mph	'Extreme' damage: Well constructed homes are leveled, cars are thrown significant distances, top story exterior walls of masonry buildings would likely collapse.	 
EF-5	> 200 mph	'Massive/incredible' damage: Well constructed homes are swept away, steel-reinforced concrete structures are critically damaged, high-rise buildings sustain severe structural damage, trees are usually completely debarked, stripped of branches and snapped.	 

An EF-5 tornado

Philadelphia, Mississippi (April 27, 2011)

31 May 2013: El Reno Tornado

Transition to tornadic storm seen 5 minutes earlier and more clearly by Phased Array
Radar
Record 2.6 mile wide tornado.



Tornado's sudden turn kills 3 veteran chasers: May 31, 2013: El Reno, Oklahoma



Fujita scale rating is based on damage surveys

- Damage from the El Reno tornado gave an EF3 rating
 - Tornado occurred in a very sparsely populated area
- Mobile Doppler radars measured winds of 295 mph
 - “EF5 strength”
 - 2nd highest ever observed
 - Record is 301 mph from the 1999 Bridge Creek---Moore tornado
 - Wind speed observations are very rare

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The Fujita scale assesses tornado intensity by estimating damage instead of wind speeds because

There is no practical alternative

To be consistent with historical observations (before Doppler radar)

Answer

There is no practical way to measure the wind speed in most tornadoes, so damage is used to estimate the wind speeds.

Tornadogenesis

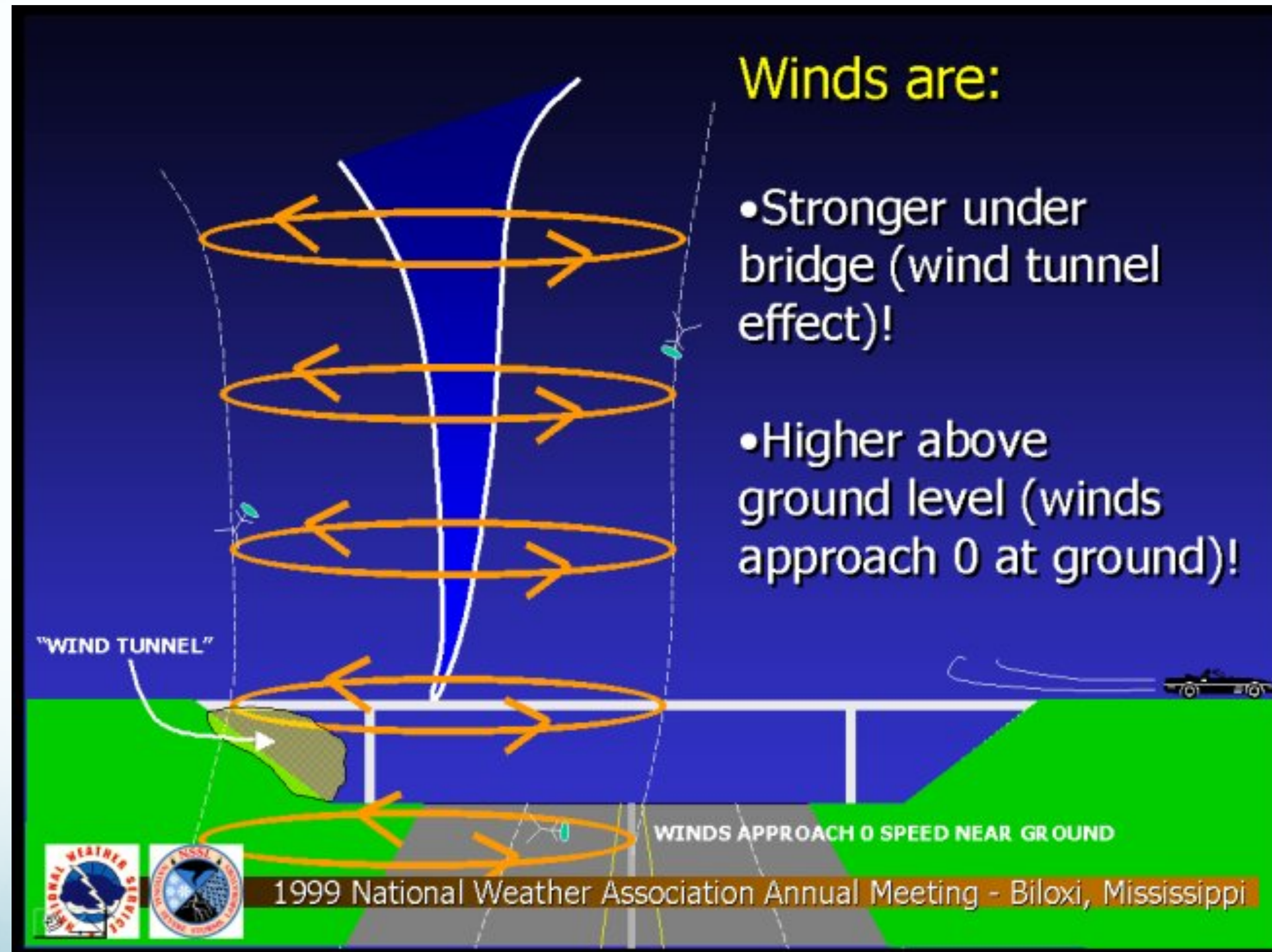
First a bit about tornado safety

Tornado and TV Crew

Chase gets too close

Version with captions

Don't Shelter Under an Overpass



Watches versus Warnings

[NOAA explains](#)

NOAA = National Oceanic and Atmospheric Administration

Contains the National Weather Service (NWS)

W Which is the greatest danger in tornados?

Extreme low pressure
makes your house explode

Being sucked up and
thrown long distances

Flying debris

Being hit by a large hail
stone

Answer: Biggest danger is flying debris



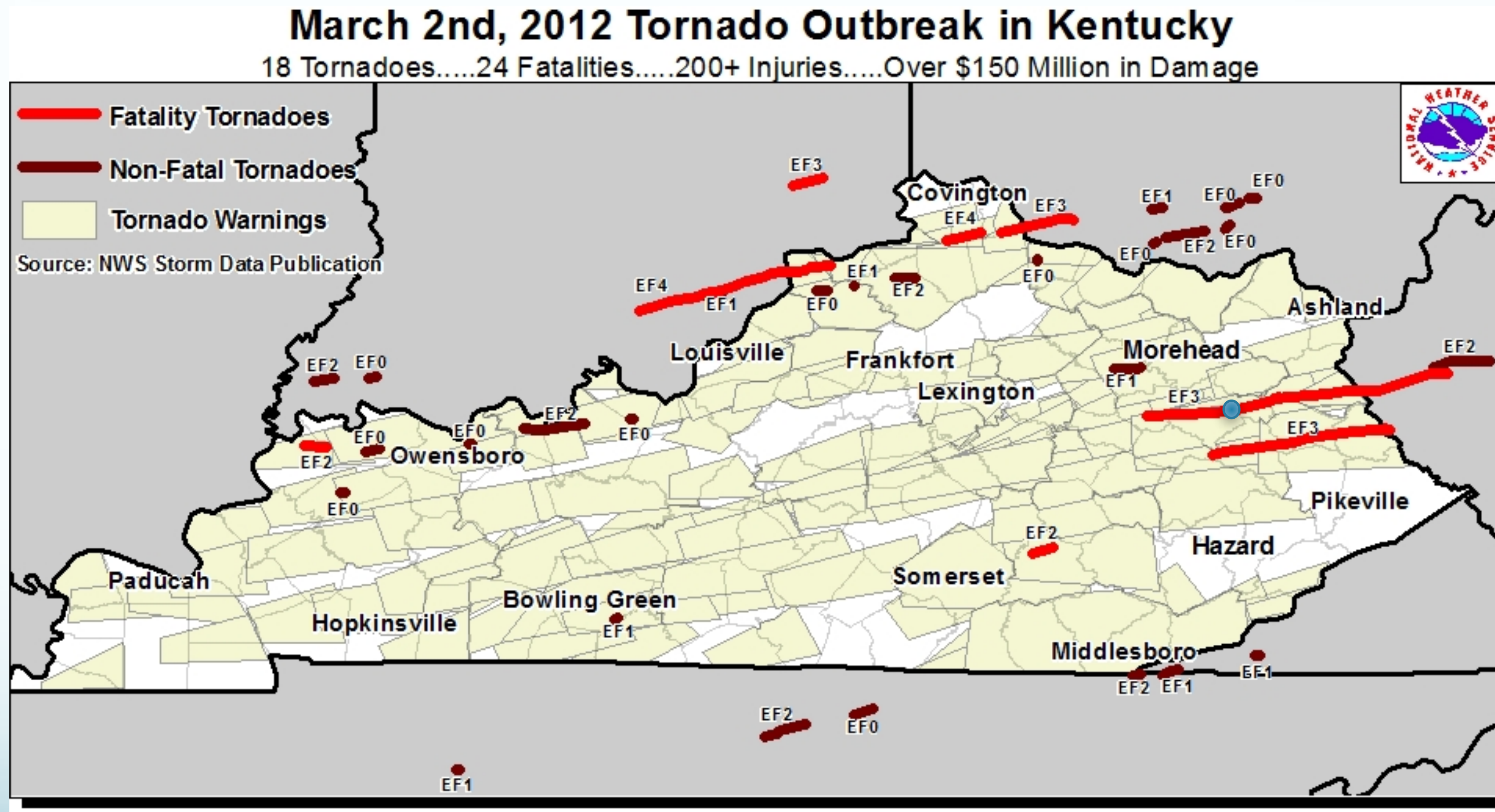
Flying Debris



Flying Debris

March 2, 2012 West Liberty

West Liberty, KY



Flying I-Beams



Avoiding Flying Debris

- Stay away from windows.
 - Go to a windowless interior room
- Cover yourself with a mattress or similar protection
 - Get in the bathtub (too bad the top is open)
 - Get under protection (sturdy table or workbench)
- Go to the basement, if there is one
 - Get under protection (sturdy table or workbench)
 - Don't pick the spot in the basement beneath your 1st-floor piano.

Encountering a tornado when in your car (bad).

- If traffic is light and the road heads the right direction, drive away at right angles to its path.
 - Don't count on out-running it.
- Seek shelter in sturdy building or even a low lying ditch
- If trapped in the car, take cover there.
 - Leave your seat belt on – the car will be moving



Your Car Will Be Moving



Your Car Will Be Moving



Flying Truck Trailers

Dallas April 4, 2012

Houses destroyed by a tornado

Katie Oklahoma, May 9, 2016

Tornadogenesis

How are tornados generated?

What is the source of the intense rotation?

Two Types of Tornadoes

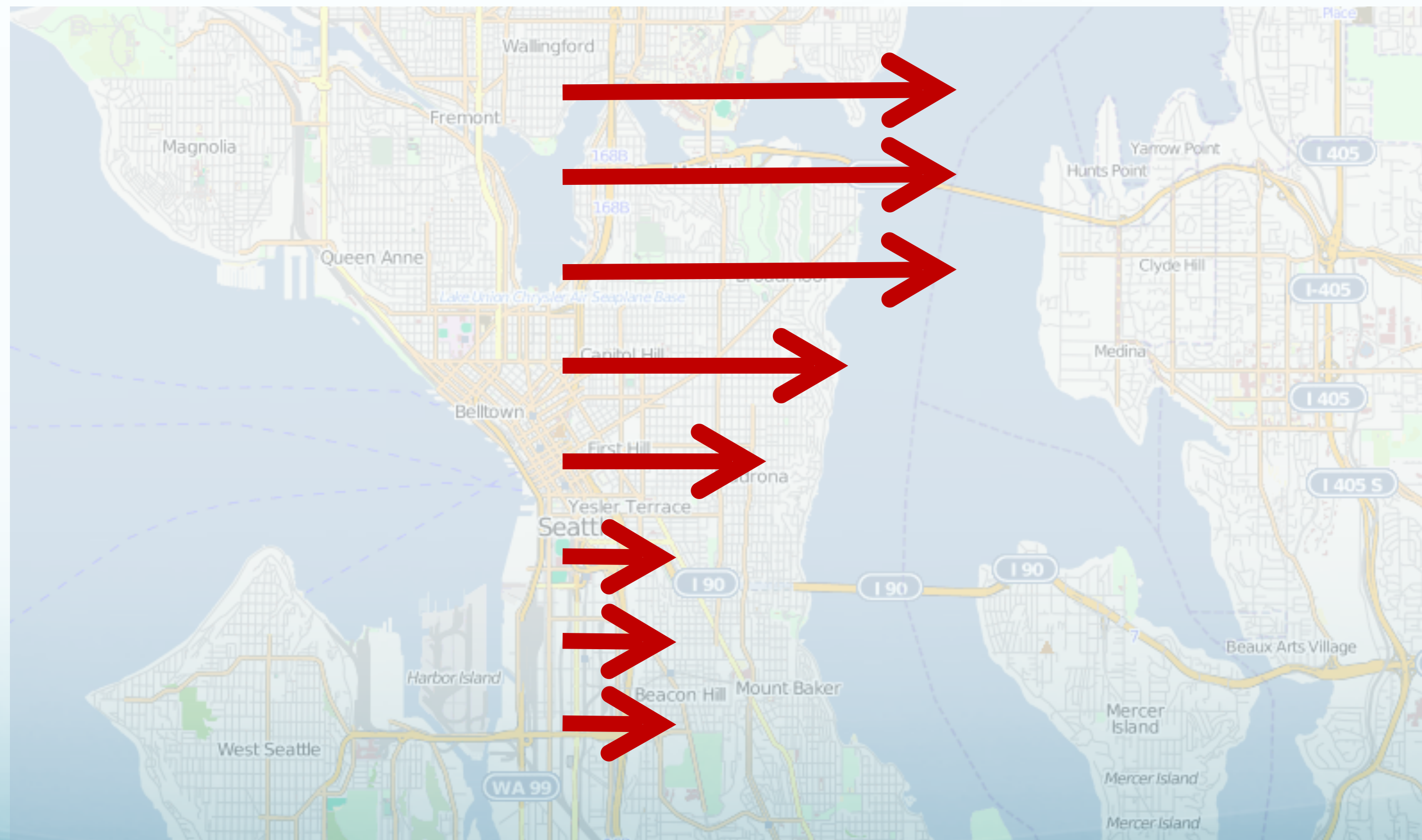
- Those associated with a **mesocyclone** (most strong and all violent tornadoes, > EF2),
 - Requires a supercell
- **Non-mesocyclonic** tornadoes
 - Any thunderstorm or even deep cumulus cloud may generate these.
 - Includes waterspouts and landspouts

Nonmesocyclonic Tornadoes

- Typically get their source of initial vertical rotation from **horizontal wind shear**
- Also true for
 - Waterspouts (tornado over water): [Penang, Malaysia \(April 1, 2019\)](#)
 - Landspouts: [Drajna, Calarasi Romania \(April 30, 2019\)](#)

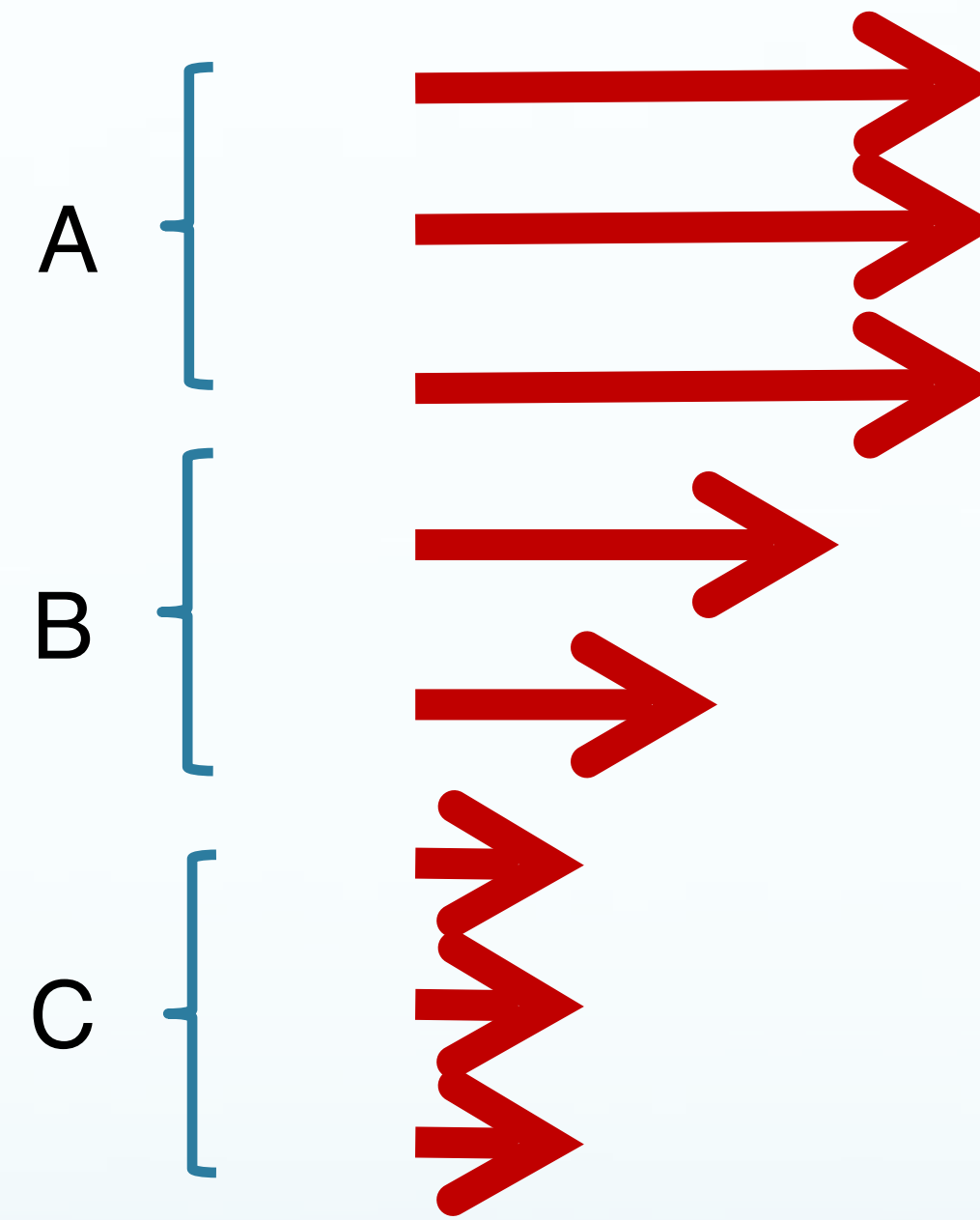
Horizontal wind shear

Horizontal wind shear: is present when the wind speed varies with horizontal position in the direction perpendicular to the wind itself.
(Arrows showing the wind, longer=stronger)



Where is the wind shear

- A. Region A
- B. Region B
- C. Region C



W Where is the wind shear?

Region
A

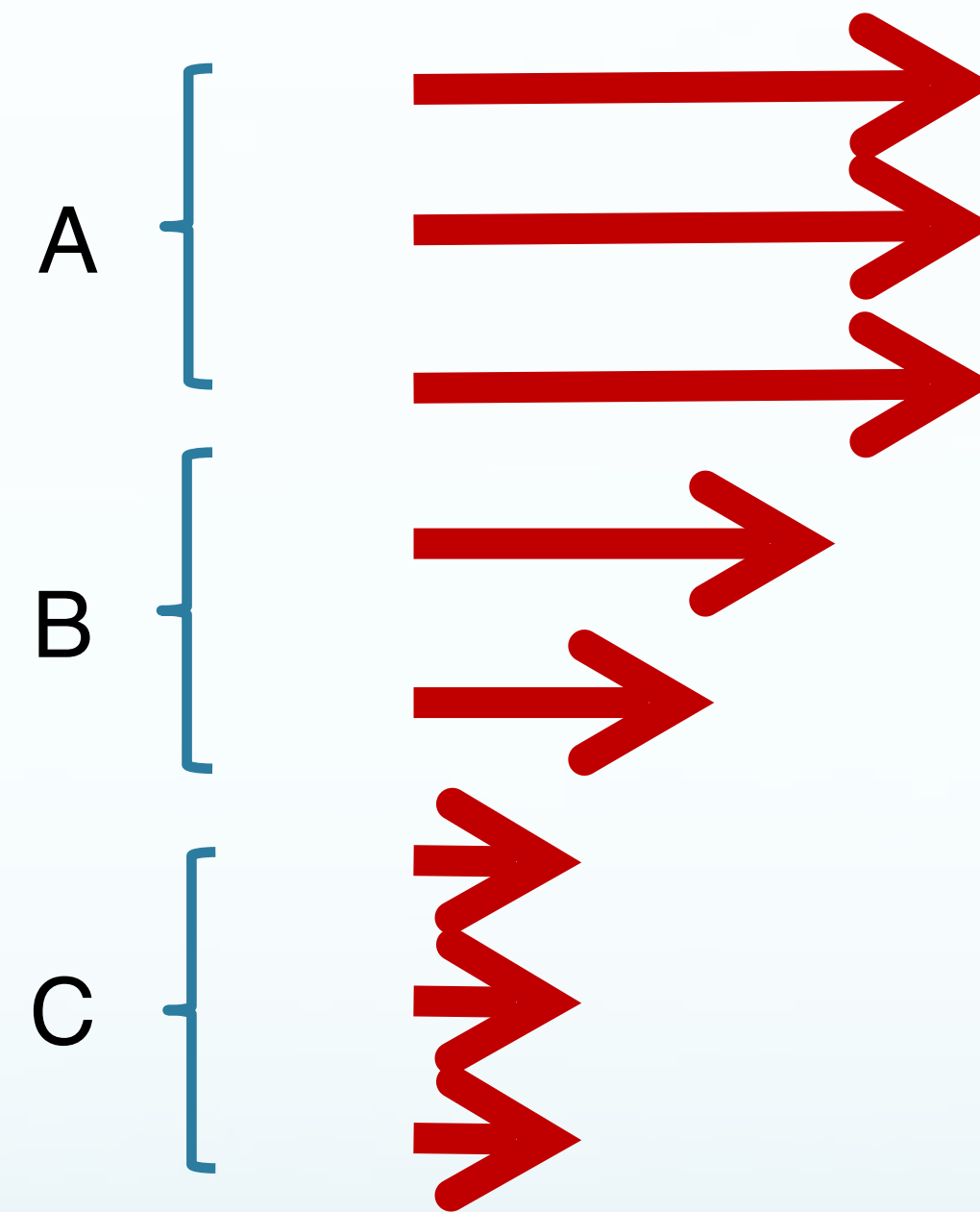
Region
B

Region
C

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Total Results

Answer: B



Shear instability

- Kelvin-Helmholtz instability (from **vertical** shear)