

# Topic 18b: Tornadoes

<http://geowiki.ucsd.edu/sio15>

HW7 online  
video/Gradescope submission portal also open

test #7  
topic 18, HW5, HWB (beachwalk) – practice quiz 28  
(see geowiki under 'tests' tab)



# Tornadoes



- near-vertical funnel cloud
- rotates extremely rapidly
- rel. small and short-lived
- in violent thunderstorms

- initially white
- dark after touchdown

tornadoes do odd things!





# What Makes Tornadoes Destructive?



Tornadoes are very destructive due to

- ❖ strong winds in the funnel
- ❖ low pressure at the center

however: blown out windows due to low pressure is an urban legend!

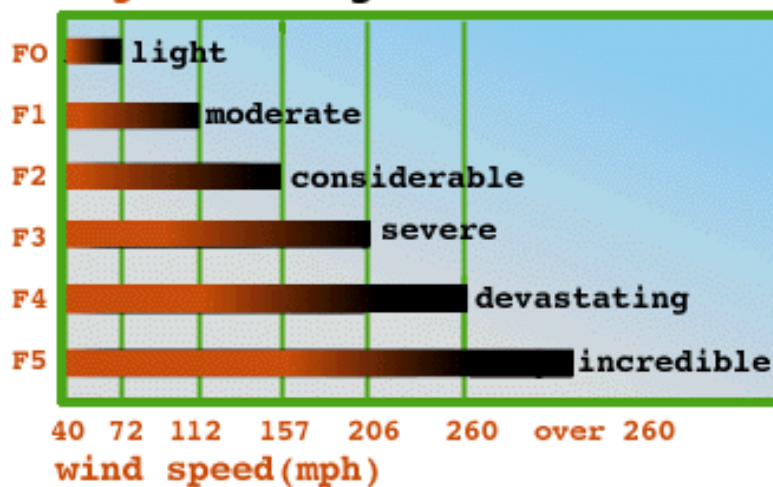
tornado rotation NOT controlled by Coriolis Effect!



# Tornadoes and the (enhanced) Fujita Scale

- relatively small/5-1500 m across
- path of destruction 1 - 500km long
- **travel speed**: 0-100km/h
- **wind speeds**: F0 to F5 (> 420 km/h)
- estimated from damage

**Fujita damage scale**



Tab. 14.3

- enhanced Fujita Scale to better estimate wind speeds
- higher at lower levels/lower at higher levels

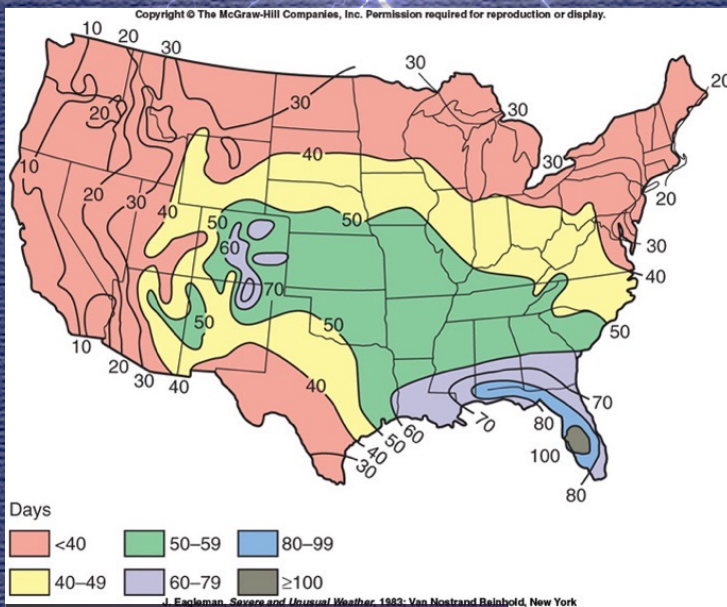


Fig. 14.8

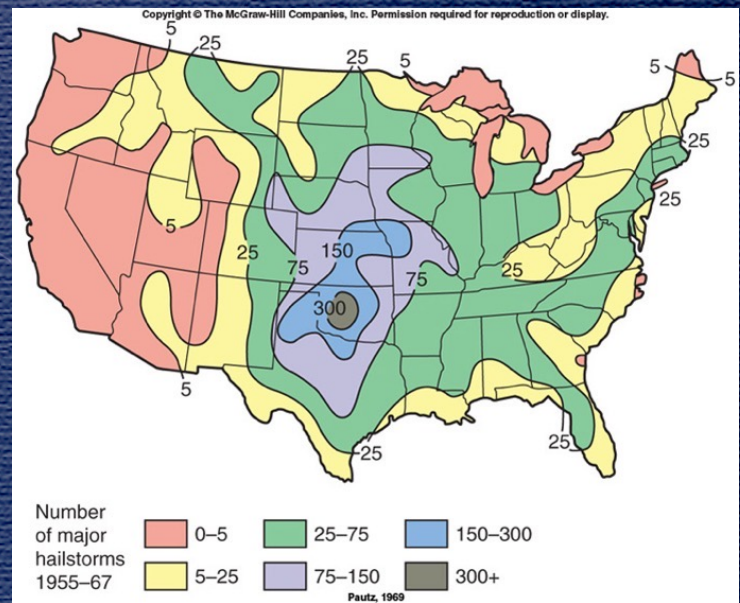
# Hail and Thunderstorms

Fig. 14.15

# thunderstorms/year



# hail storms 1955-67

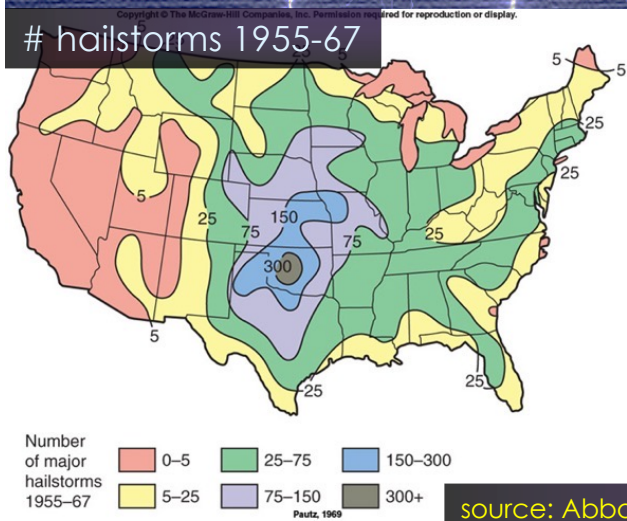
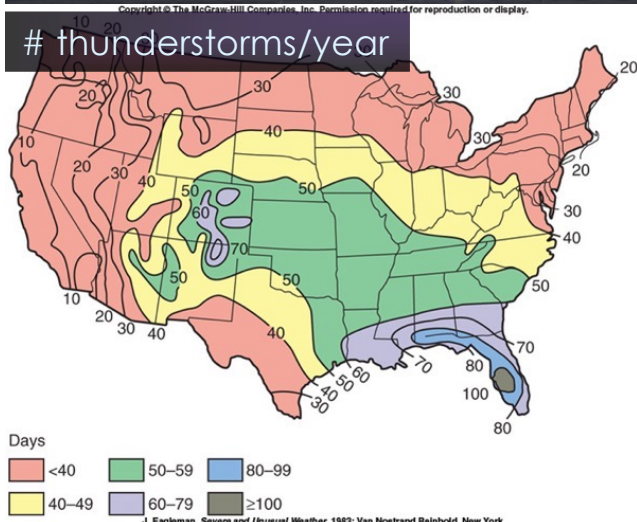


source: Abbott "Natural Disasters"

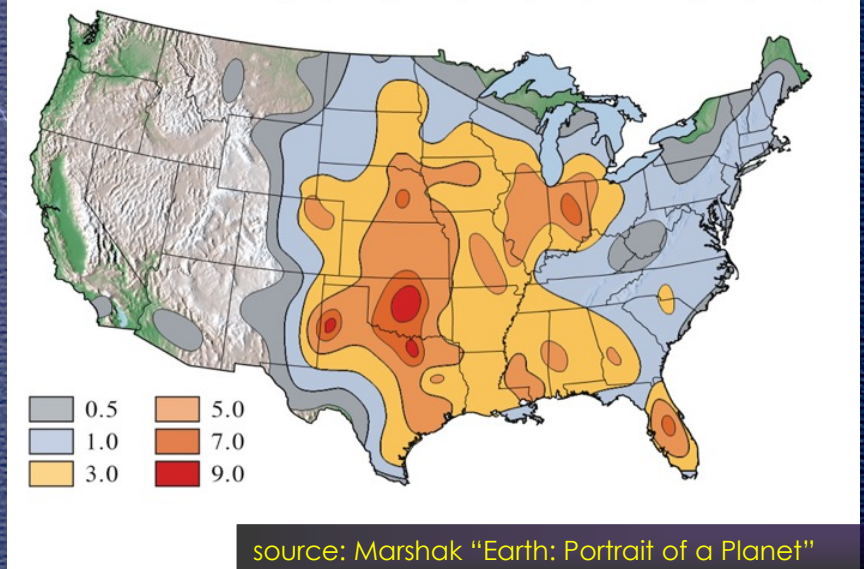
- most thunderstorms don't produce hail
- hail requires large tss/strong updraft



# Tornadoes and Thunderstorms



# tornadoes/year  
Number of tornadoes per year (per 26,000 sq. km, for a 27-year period)



- most t-storms don't spawn tornadoes
- hail-producing t-storms may spawn tornadoes
- need special conditions to spawn tornadoes
- often in supercell t-storms
- only 15% of these spawn tornadoes

source: Abbott "Natural Disasters"



# Formation of a Supercell Thunderstorm

Supercell thunderstorm over Chaparral, NM  
producing 2" diameter hail/widespread damage



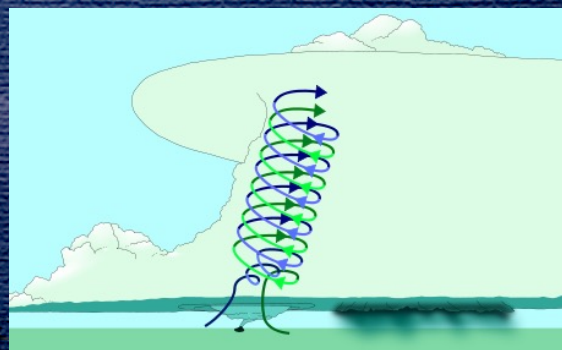
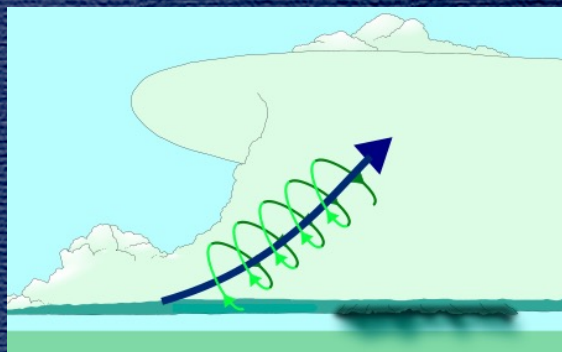
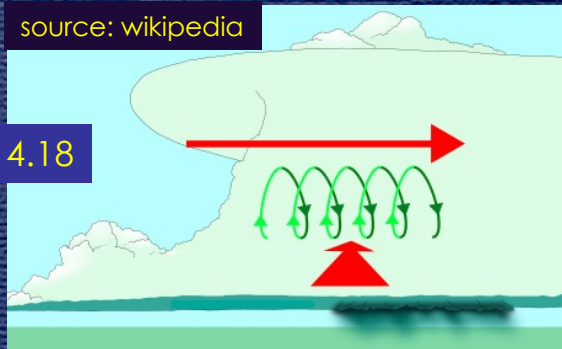
source: wikipedia

Fig. 14.17

- need strong wind shear within T-storm
- Mesocyclone: strong, rotating updraft
- only 15% of supercells produce tornadoes

source: wikipedia

Fig. 14.18

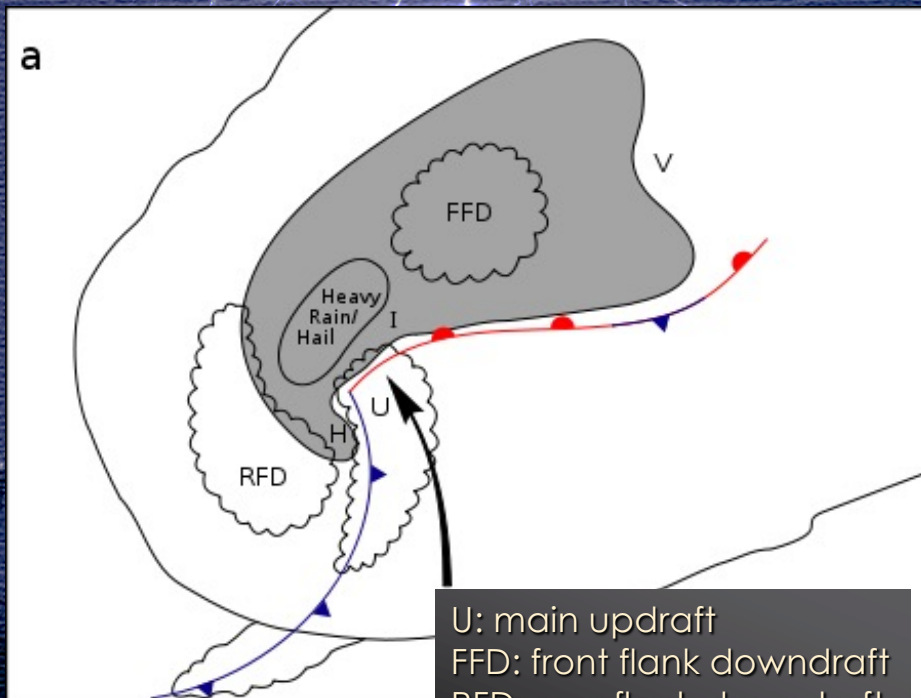




# Supercell Thunderstorm and Tornadoes

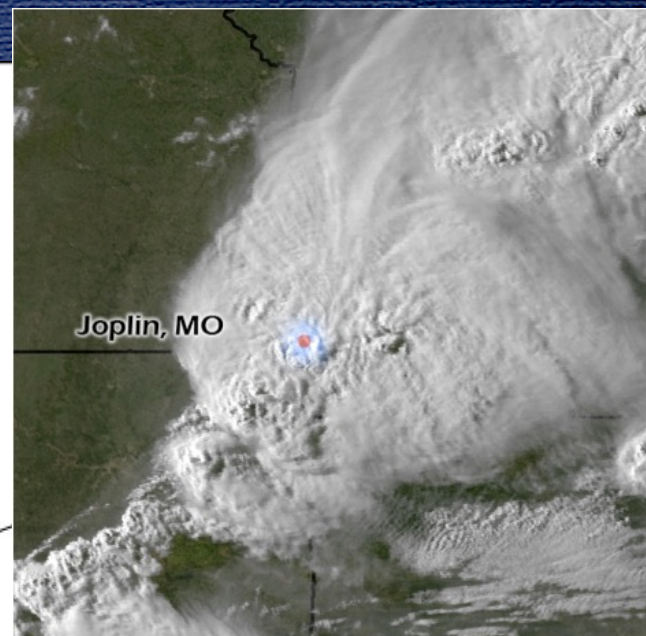
- strong tornadoes near right rear of thunderstorm
- land-/waterspouts near front end
- characteristic radar hook echo helps forecasting

Figs. 14.35/14.46



Source: Wikipedia

U: main updraft  
FFD: front flank downdraft  
RFD: rear flank downdraft  
H: hook echo

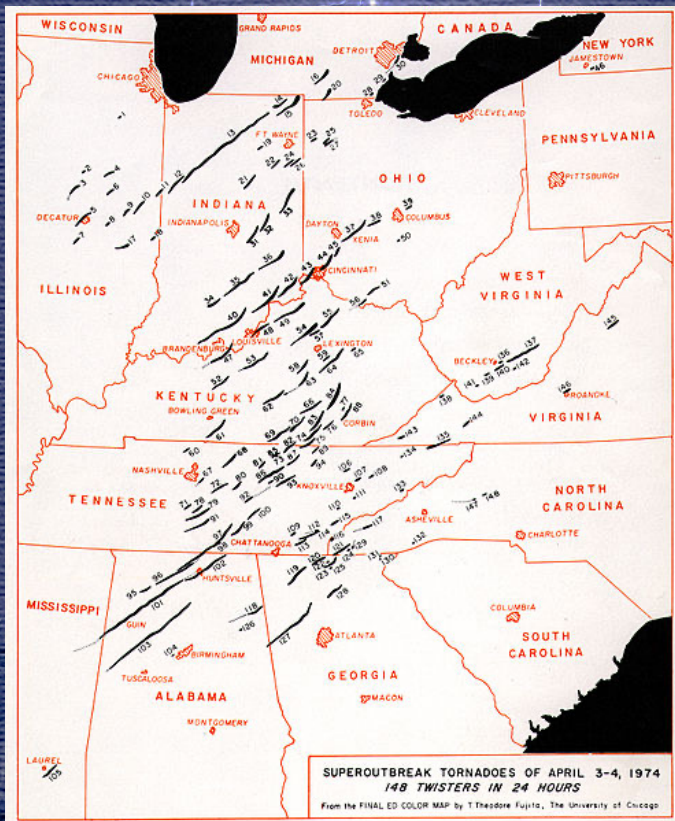


22 May 2011 Joplin, MO  
minutes before EF5



# U.S. Tornadoes - Paths

## 3-4 April 1974 Super Outbreak



- tornadoes tend to travel NE-ward
- can travel 100s km

source: wikipedia/NWS

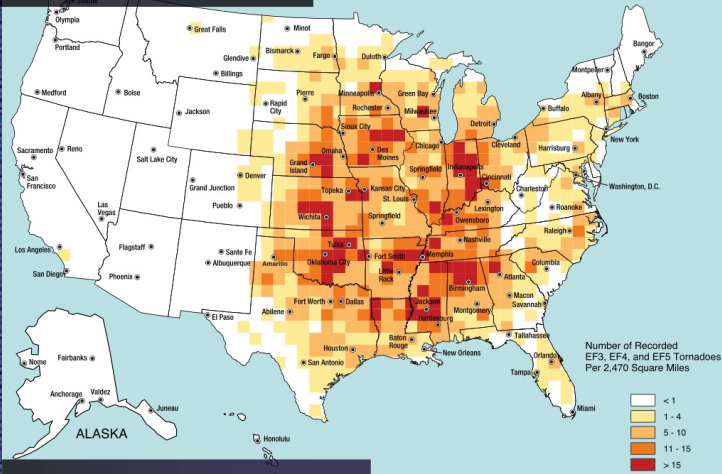


Figs. 14.30/14.37

# Tornado Alley

# EF3+ 1950-2006

**TORNADO ACTIVITY IN THE UNITED STATES\***  
Summary of Recorded EF3, EF4, and EF5 Tornadoes  
Per 2,470 Square Miles (1950-2006)



source: FEMA/wikimedia

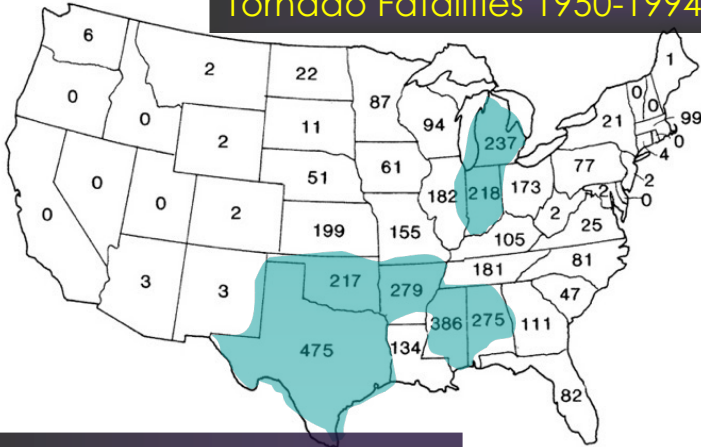
\* Based on NOAA, Storm Prediction Center Statistics

- Tornadoes:  
Oklahoma, Texas

- Tornado deaths:  
Texas, Mississippi,  
Arkansas, Michigan

Kansas is not near the top

## Tornado Fatalities 1950-1994



source: Abbott "Natural Disasters"





# Tornado Alley

need strong wind shear

change in wind direction  
with altitude may cause  
rotating updraft

## GENERAL

- unstable atmosphere (cold above warm)
- intense thunderstorm (strong wind shear)
- strong, rotating updraft (mesocyclone)

supercell thunderstorm

## Tornado Alley

- big excursion in polar jet stream
- very cold polar air meets warm GoM air
- strong cold front chases warm front

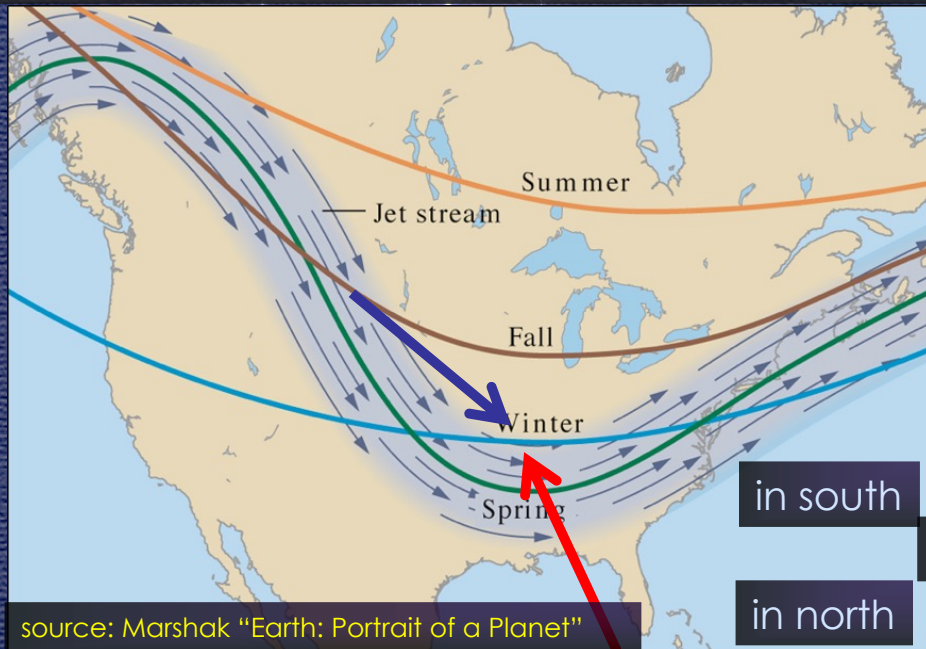


source: wikipedia

Fig. 14.17



# Tornado Alley - The Polar Jet Stream



- provides "favorable" conditions in Tornado Alley
- early spring: large excursions southward
- allows cold Polar air mass to travel far south
- warm tropical marine air from GoM
- jet stream provides high-altitude windshear

tornadoes most likely in

in south

in north

winter

summer

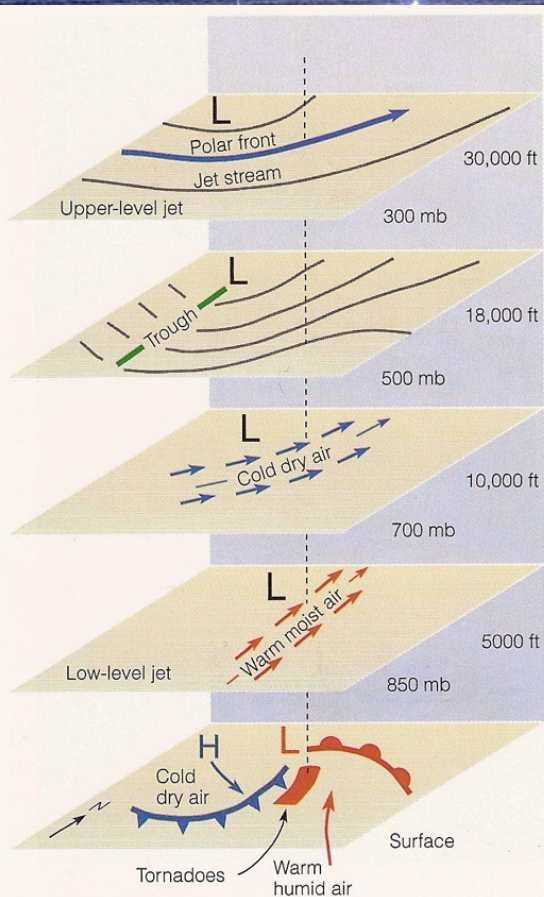
most dangerous:  
spring



# Tornado Alley through the Year

Fig. 14.34

Source: "Meteorology Today"



**FIGURE 15.36**

Conditions leading to the formation of severe thunderstorms that can spawn tornadoes.

## GENERAL

- unstable atmosphere (cold above warm)
- intense thunderstorm (strong wind shear)
- strong, rotating updraft (mesocyclone)

## TORNADO ALLEY:

- TOP: jet stream (strong updraft)
- cold polar air from Canada
- warm humid air from Gulf of Mexico
- BOTTOM: spring wave cyclone

change in wind speed may cause rotating updraft

in south

winter

tornadoes most likely in

in north

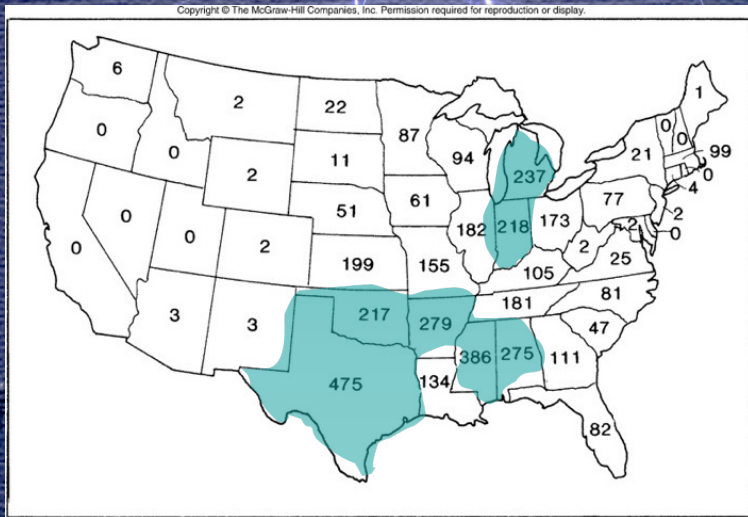
summer



# Topic 1: 2025 St Louis Tornado

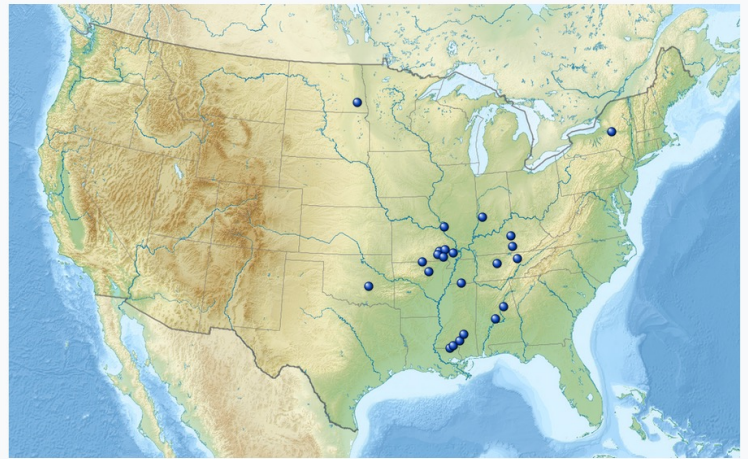
student question: Is Tornado Alley moving east?  
– not sure

## Tornado Fatalities 1950-1994



source: Abbott "Natural Disasters"

## Fatal United States tornadoes in 2025



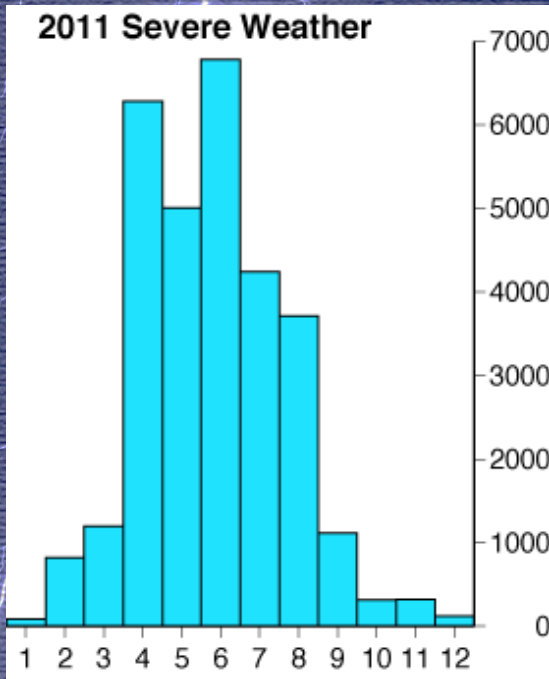
Approximate touchdown location of deadly tornadoes in 2025

source: Wikipedia

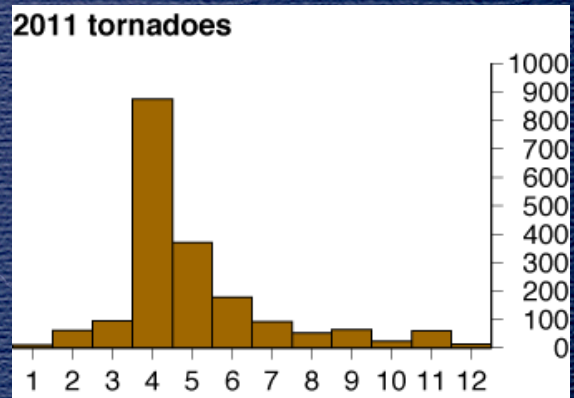


# U.S. Tornadoes Throughout the Year

Fig. 14.39



tornadoes peak in April!



derechos

- severe weather (T-storms) Apr – Jul
- 62% wind, 31.5% hail, 6.5 % tornadoes
- but tornado fatalities early winter and late spring !

early and late fatalities!

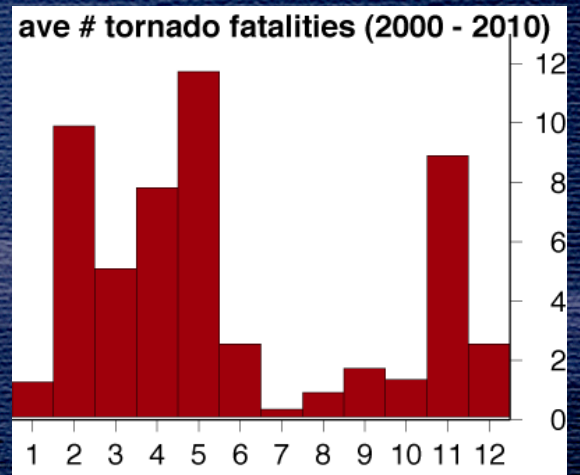




Fig. 14.44

# 2011 Tornadoes

Fig. 14.47

Study guide/  
Case studies

25-28 April 2011 Super Outbreak  
third-worst outbreak (1974; 1965)  
300 tornadoes (15 EF4/EF5)  
322 fatalities

It's been  
~ 40 years!!



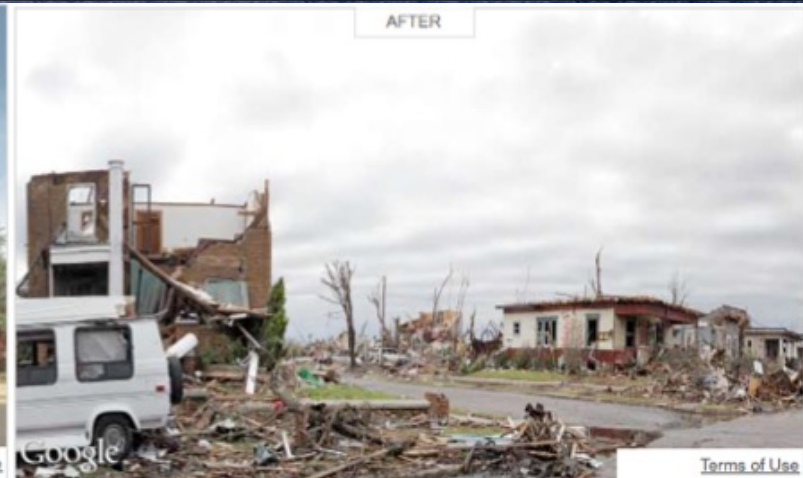
damage in Tuscaloosa, AL (source: wikipedia)



Fig. 14.28

## 2011 Tornadoes

Fig. 14.47



EF5 22 May 2011 Joplin, MO

- 160 fatalities; 1/3 Joplin destroyed
- Irving Elementary School destroyed





# 10-11 Dec 2021 Kentucky Tornado

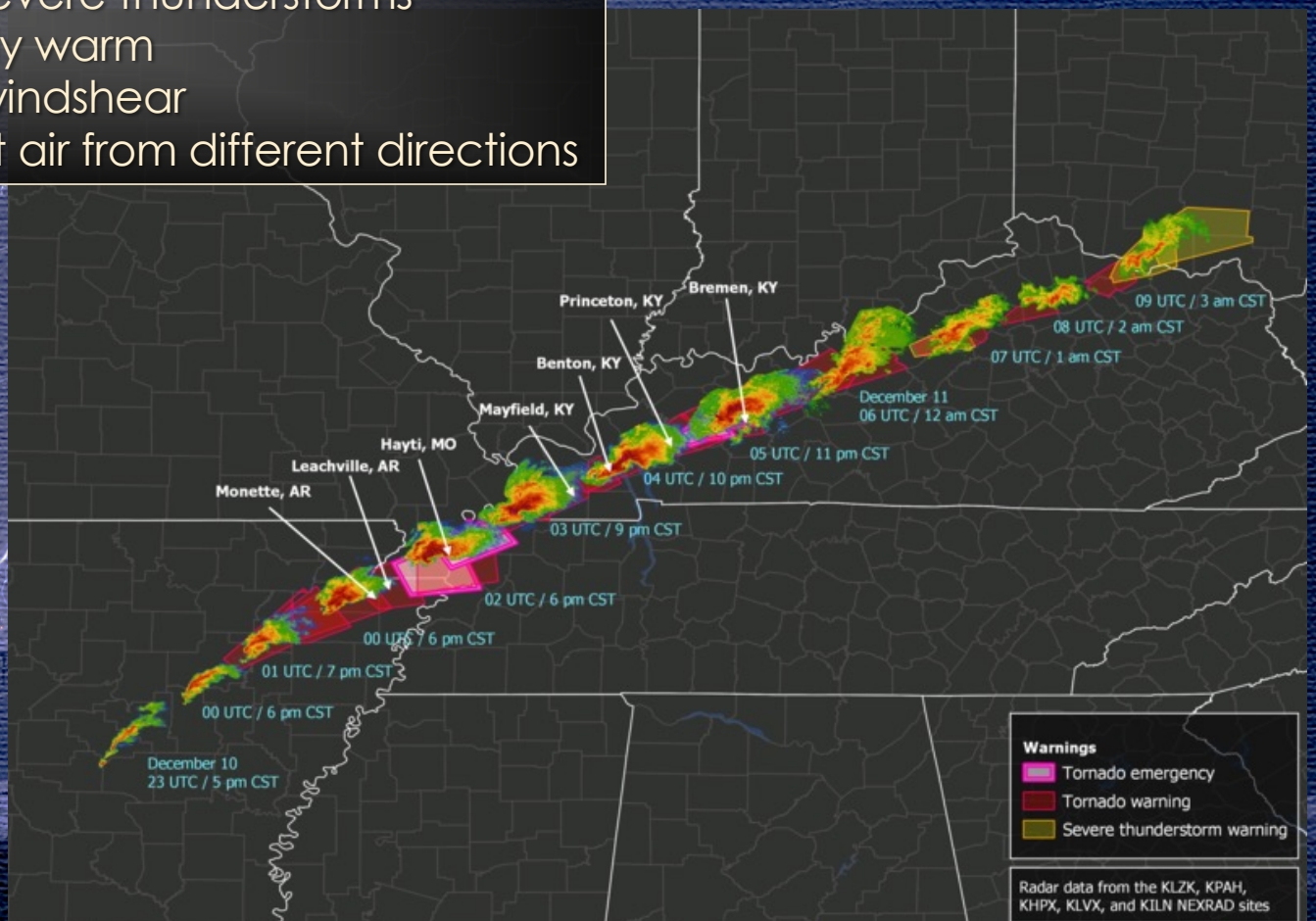
- long-tracked (267 km)
- EF 4
- 58 fatalities
- unusually late (Apr-Jun normal)





# 10-11 Dec 2021 Kentucky Tornado

- line of severe thunderstorms
- unusually warm
- strong windshear
- different air from different directions





# 10-11 Dec 2021 Kentucky Tornado

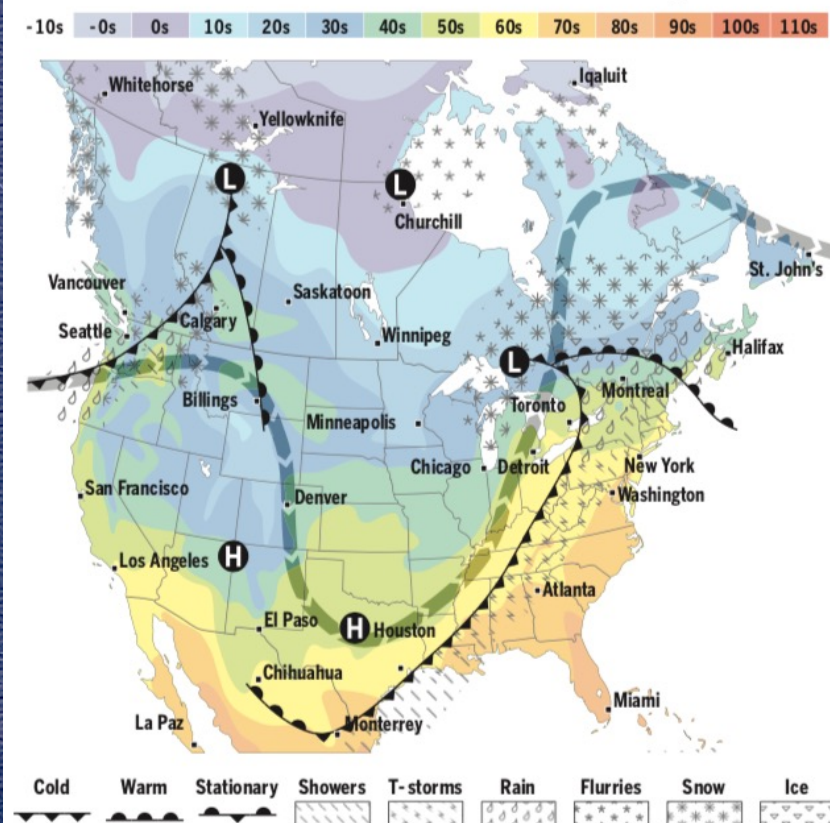
- jet stream loops
- usually in spring
- allowed Arctic air far south

Source: SD Union Tribune

## Across the nation and world

NATIONAL WEATHER SYSTEMS

Forecast for noon today



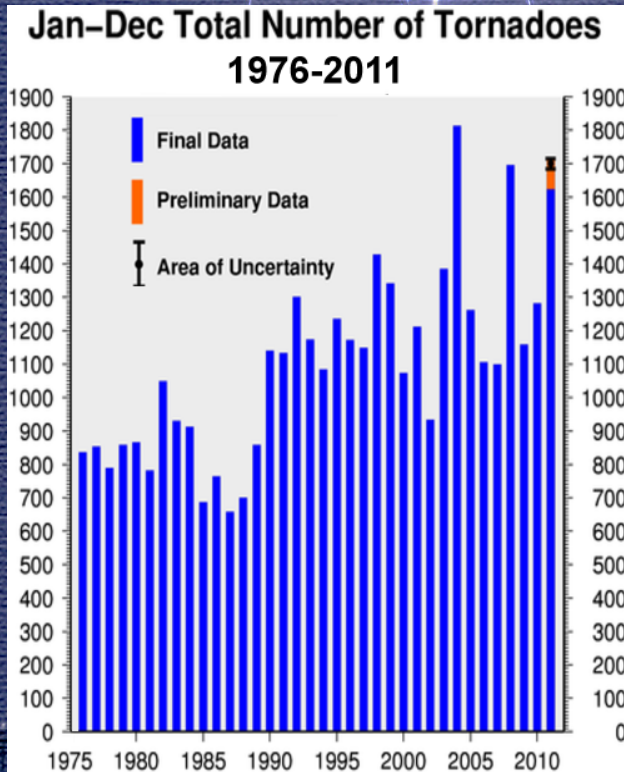
Forecasts and graphics provided by AccuWeather, Inc. ©2021

Warmth will surge in the East ahead of a strong cold front with showers and severe thunderstorms today. As snow ends around the Great Lakes, winds will howl. Rain and snow will begin in the Northwest.



# U.S. Tornadoes Last Few Decades

Fig. 14.40



source: NOAA/wikipedia

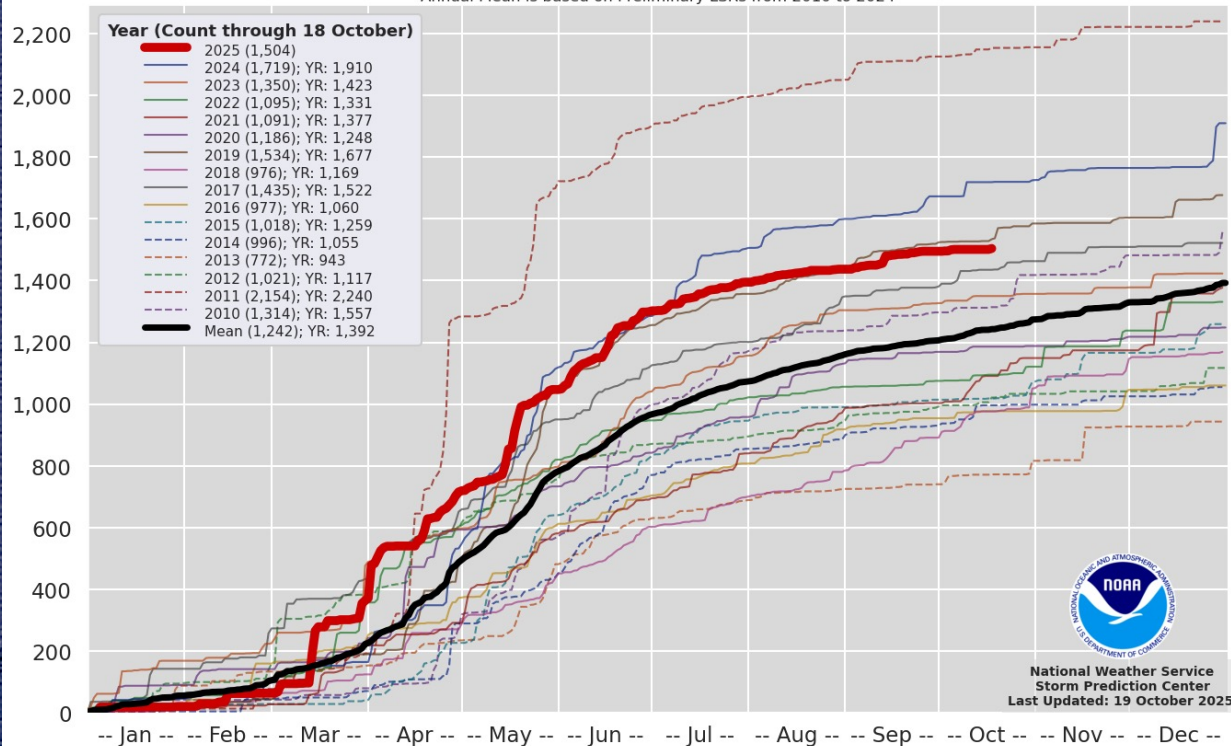
- number of tornadoes increasing due to:
  - \* related to climate change???
  - \* shift in jet stream ???
  - \* El Niño/La Niña???



# U.S. Tornadoes Last 15 Years

## United States Annual Counts of Tornado LSRs\*

\*Preliminary sightings/events from NWS Local Storm Reports (LSRs)  
Annual Mean is based on Preliminary LSRs from 2010 to 2024



source: NOAA/wikipedia

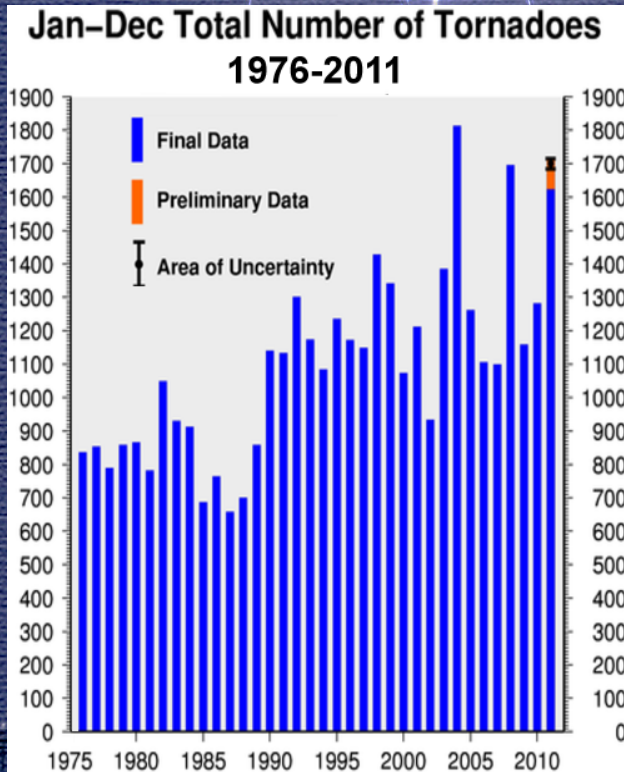
2025: 4<sup>th</sup> most tornadoes?

SIO15 2025: Topic 18b - Tornadoes

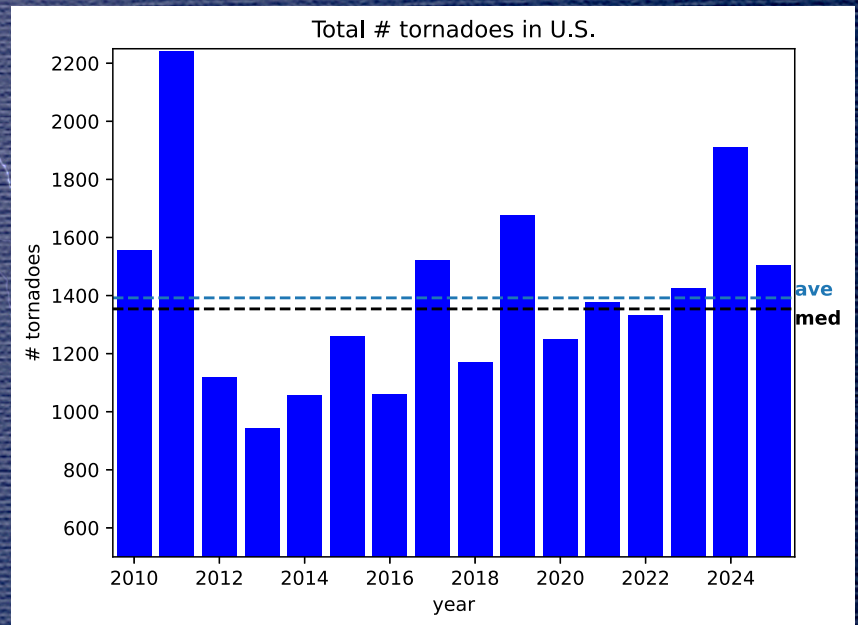


# U.S. Tornadoes Since 1975

Fig. 14.40



source: NOAA/wikipedia

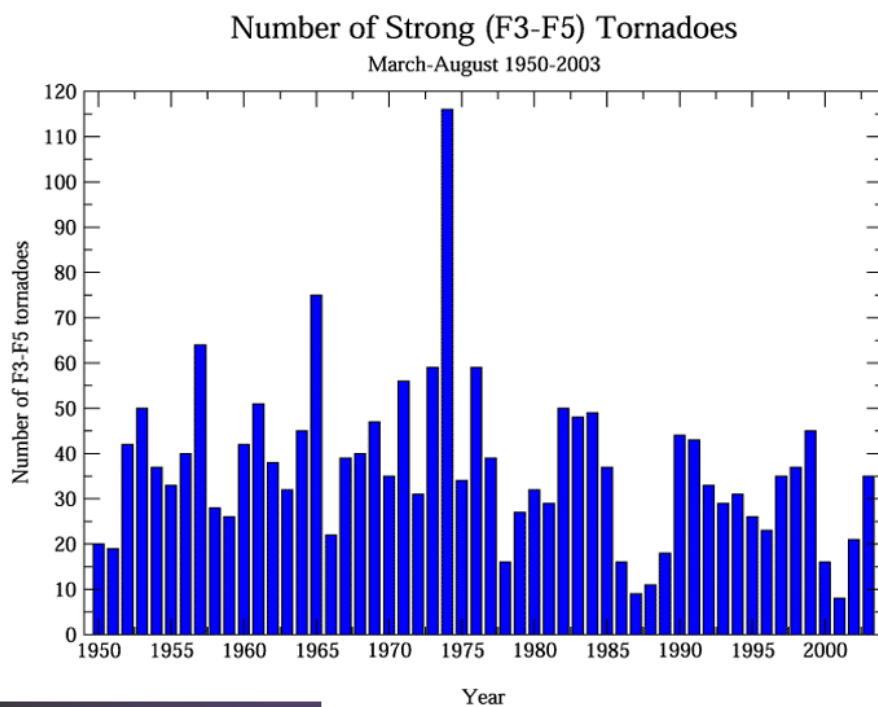


increase in tornadoes not clear-cut



# U.S. Tornadoes Throughout Century

Fig. 14.40



source: NOAA/wikipedia

number of STRONG tornadoes NOT increasing

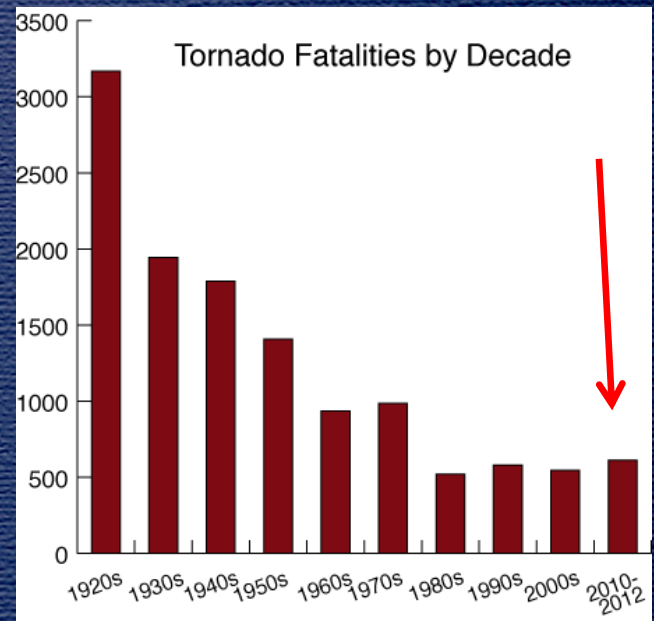


# U.S. Tornado Fatalities Throughout Century

Fig. 14.40 Tab. 14.5

- top 10 deadliest U.S. tornadoes were prior to 1953
- 18 March 1925 deadliest (695 fatalities) (Tri-State Tornado)
- tornado warning since 1950s
- tornado shelters had helped!

fatalities decrease  
-> warning system  
seems effective ...  
.... but ...  
... not improving!



... and then there was  
2011 (614 fatalities)

are we letting our  
guards down?



# U.S. Tornadoes and where People Die

tornado fatalities  
41% mobile homes  
30% permanent homes  
10% vehicles

vehicles are not safe! Seek shelters!



- some shelters in public buildings, e.g. ORD, DEN



source: wikipedia

... but are classical private shelters a thing of the past???

... new homes often have no tornado shelter to keep building costs down ....



# Tornadoes in SoCal

Sep 22, 2007

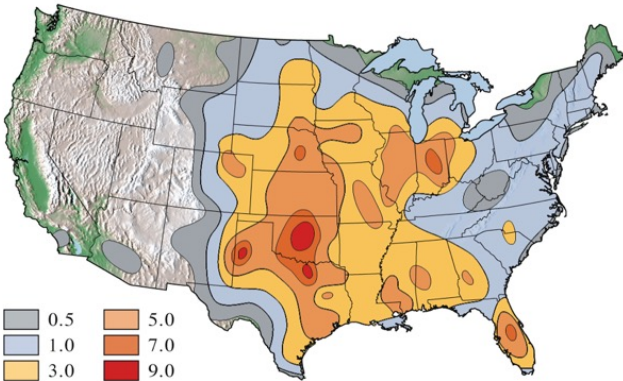
dang, I missed them!





# Tornadoes in SoCal

Number of tornadoes per year (per 26,000 sq. km, for a 27-year period)



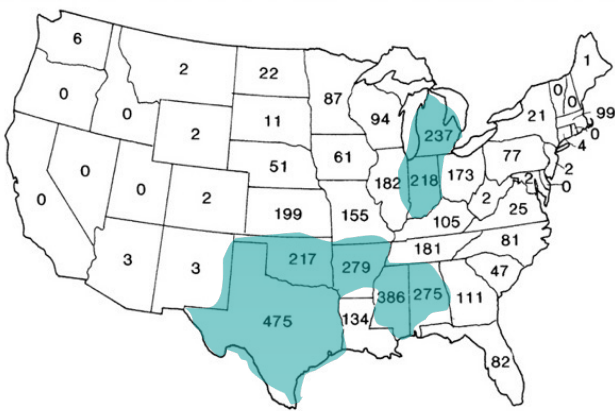
only in  
"The Day after Tomorrow?"

on the order of 1/year in  
Riverside

but one storm in N-Cal  
spawned 5 tornadoes on 23 Oct 2012  
(10/24/12 news clip)

12/12/2014 Pineapple Express brings  
tornado to Los Angeles

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display



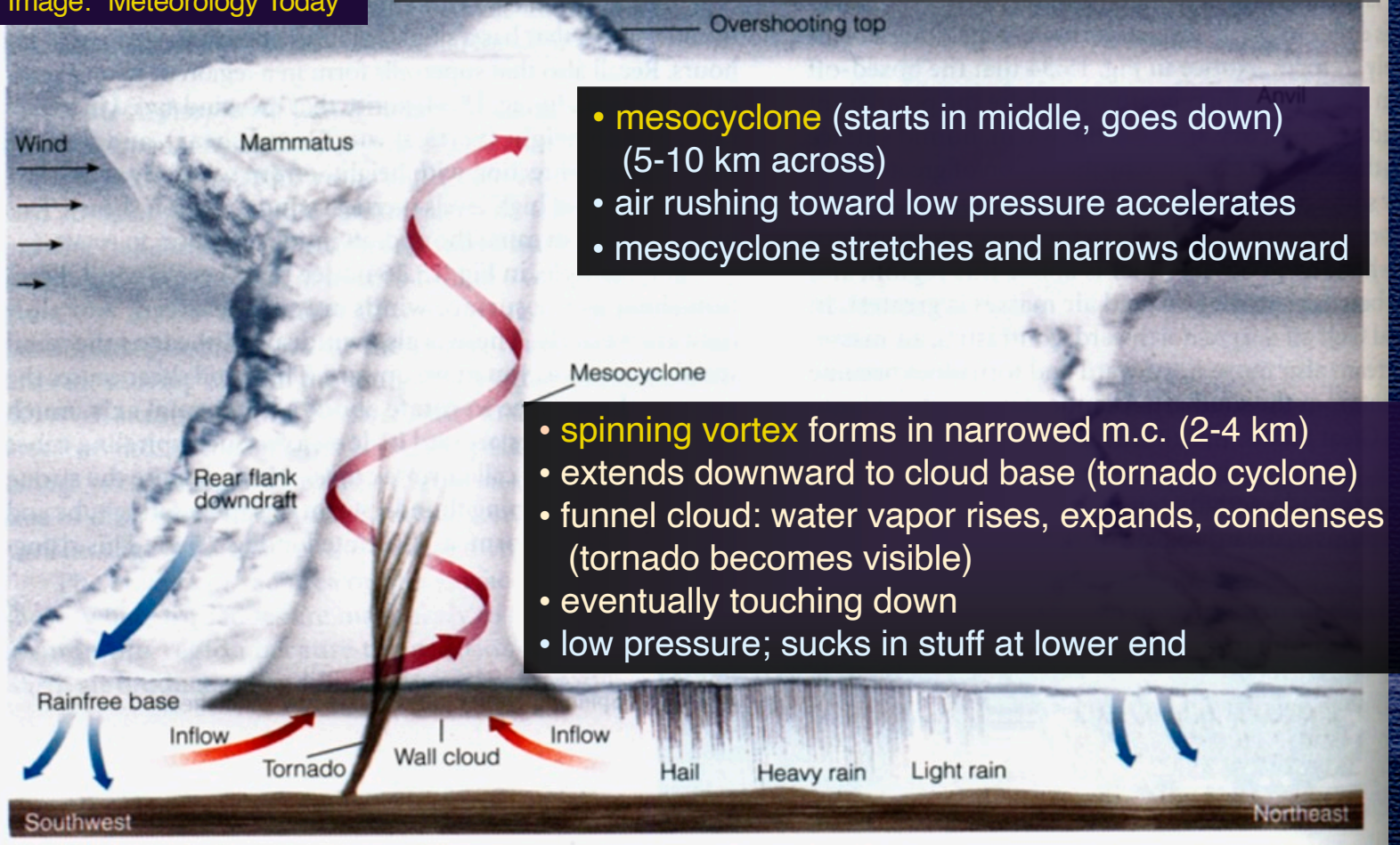


# How and Where Do Tornadoes Form?

Fig. 14.31

- strong tornadoes near right rear of thunderstorm
- land-/waterspouts near front end

Image: "Meteorology Today"





# How Do Tornadoes Form?



a funnel cloud touching down



looking for a good explanation on tornadoes?  
don't go to wikipedia/expert literature!

