LECTURE #16: Severe Weather: Tornadoes

Date: 17 March 2025

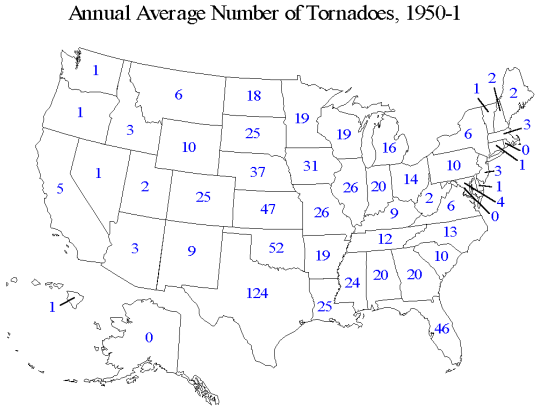
I. Exam 2

- please remember that exam 2 is this Wednesday *(next class)*
- **not** cumulative *(includes everything from the second tsunami lecture to today's lecture on tornadoes)*
- same format/length/style as exam 1
- be on time, bring a pencil, eraser, photo ID, and your PeopleSoft number
- if you did well on exam 1, you can skip this test *(or take it for practice)*
  - I will count the highest of your two midterm exams

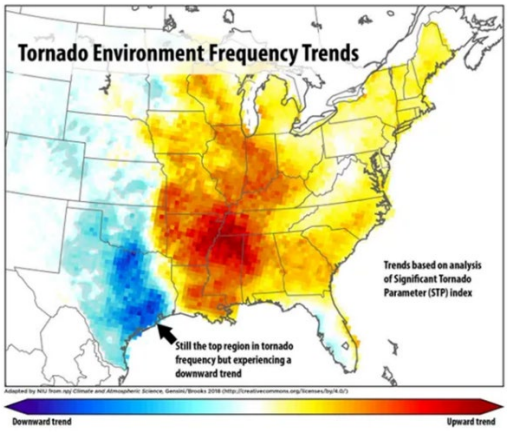
- *remember:* everyone must take the final exam on **April 30th @ 8:00am**

II. Tornado General Information

- generated in regions of already severe thunderstorms
- two prime factors for tornado initiation
  - the general topography
  - local climate
    - created over areas where air is undisturbed by mountains
      - very common in Midwest USA
      - "tornado alley" (TX, OK, KS, NB, IA, MO, IL)
      - Alaska has the rarest tornado touchdowns
      - Texas has the most



- *is tornado alley changing with the changing climate?* Notes:



III. Tornado Formation

- average dimensions
  - width: 75 yards
  - track length: 1-4 miles
  - time on ground: 5 minutes
  - forward speed: 25 mph

- timing
  - prime season for the combination of ideal conditions
    - spring to early summer
    - *although this appears to be shifting earlier*
  - prime time of day
    - late afternoon to late evening
    - time of maximum local ground and atmospheric heating

Tornado formation probabilities (white is the highest)

JAN

JUL

FEB

AUG

MAR

SEP

APR

OCT

MAY

NOV

JUN

DEC

- tornado structure
  - combination of opposing wind patterns
    - high level, relatively dry/cooler winds from the west
    - lower level, warm/wet winds from the southeast originating in the Gulf of Mexico/America
  - winds form cyclonic rotation parallel to the ground *(called 'rollers')*
  - large thunderstorms pull warmer air upward from lower levels
    - warm/wet air provides energy for the storm
  - large updrafts can cause a roller to tip into a vertical position
  - tornado is born upon touchdown with the ground
  - large storms can produce more than one tornado
    - called tornado "families" or "swarms"
    - <u>example:</u> large tornado swarm in 1974 caused damage in 13 states from AL to OH
      - 148 tornadoes touched down in about 16 hours
      - 307 killed, over 6,000 injured and $600 million in damage (in 1974$)

- severe pressure drops *(measured on a barometer)*
  - inside a twister can be as low as 3" mercury (Hg)
  - for comparison
    - average daily pressure here is ~ 31-32" Hg
    - a large thunderstorm can be as low as 27" Hg

- movement
  - track direction is generally SW to NE
  - combination of the prevailing wind direction from the west
  - the CCW rotation of the tornado

IV. Fujita Scale

- created in 1971 by Professor Theodore Fujita
- modified in 2007 to the "Enhanced Fujita Scale"
- varies from EF0 to EF5
  - EF0: weakest, winds of 65 - 85 m.p.h., minor damage to building/trees
  - EF5: strongest, winds of > 200 m.p.h., complete destruction
  - *precise wind speed numbers are actually estimates based on damage after the storm and not measured directly during it*

SCALE	WIND (mph)	TYPICAL DAMAGE	EXAMPLES
EF0	**65 – 85**	Light damage Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.	
EF1	**86 – 110**	Moderate damage Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.	
EF2	**111 – 135**	Considerable damage Roofs torn off frame houses; mobile homes demolished; train cars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.	

EF3 **136 – 165** <u>Severe damage</u>
Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.

EF4 **166 – 200** <u>Devastating damage</u>
Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown, and large missiles generated.

EF5 **> 200** <u>Incredible damage</u>
Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yds.); trees debarked.

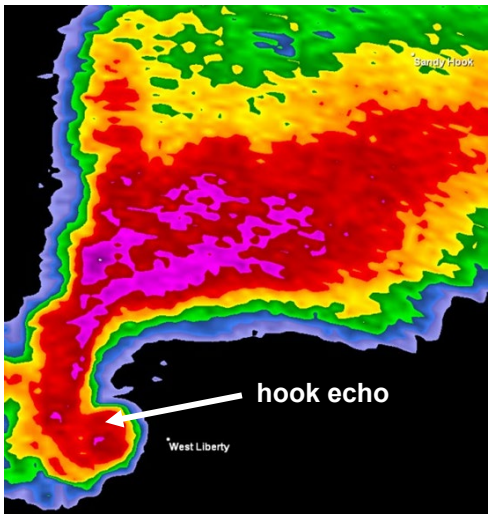
V. Monitoring

- early 1980s
  - with a device called TOTO *(Totable Tornado Observatory)*
    - designed to get swept up into a tornado and measure all the atmospheric parameters from the inside
    - scientists had to race to get ahead of a tornado and place the 400-pound cylinder squarely in its path
  - never truly successful (close in Apr. 1984)
    - problem of getting it safely into the path of an oncoming tornado
    - when they did, it usually tipped over
  - variation featured in the 1996 movie "Twister"

- Storm Prediction Center (SPC)
  - located in Norman, Oklahoma
  - monitors regional weather conditions every morning
  - issues a risk warning for severe weather later that day
  - interacts with National Weather Service (NWS)

- National Severe Storms Laboratory (NSSL)
  - use Doppler radar
    - measures the frequency change of objects moving away from the antenna
    - interpret the mesocyclones signatures (within a thunderstorm)
    - as well as the tornado vortex signatures
      - these have a very distinctive pattern in the Doppler radar called a "hook echo"

- Mobile Doppler Radar
  - operated on a mobile platform to image nearby tornadic activity
    - gets much closer to the tornado to image it more clearly
    - captures three-dimensional images of the tornado's structure



Mobile doppler radar

VI. Mitigation

- no practical efforts
  - most injuries/death occur from flying objects or being picked up and thrown great distances

- scientific instrumentation and early warning systems are being improved
  - detection lead times are only a matter of minutes to no more than an hour

- very localized tracking by nearby television station's weather centers
  - not all areas of the US have the money to install these systems

- build underground tornado bunkers
- build "safe rooms" above ground to withstand very strong winds
  - as great as 300 mph!