

EAPS 10000 Y01

Online Course

Planet Earth

Prof. Lawrence Braile

Welcome to the EAPS 10000 Y01 online course
Planet Earth (also known as EAPS 100)!

Professor Lawrence Braile

Dept. of Earth, Atmospheric, and Planetary Sciences

2271 HAMP (CIVL), Purdue University

braile@purdue.edu, (765) 494-5979



PURDUE
UNIVERSITY™

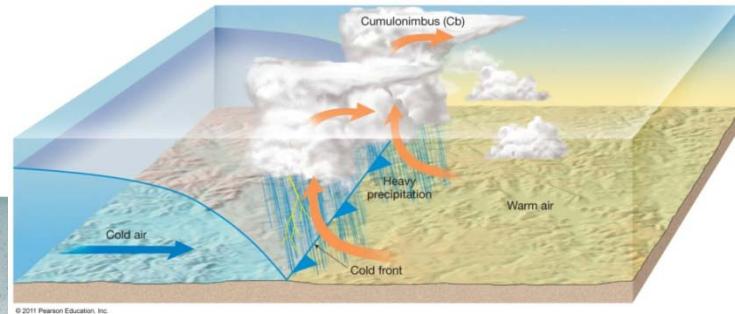
Earth
Atmospheric
Planetary
Sciences

A circular graphic containing a stylized representation of the Earth's globe. Overlaid on the right side of the globe is the text "Earth Atmospheric Planetary Sciences" in a serif font, with "Earth" in a larger size than the other words.

EAPS 10000 Y01 - *Planet Earth* (online course)

Week 7, Chapter 14 (pages 442-471)

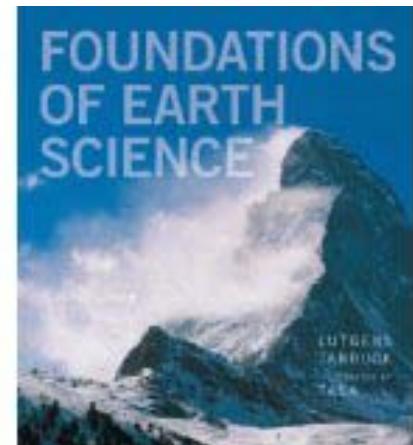
Week	Chapter	Assigned Pages	Major Concepts	Important Terms
7	14 – Weather Patterns and Severe Weather	442 – 471	Thunderstorms, tornadoes, hurricanes, tracking hurricanes	Air masses, fronts, Fujita scale, Saffir-Simpson scale



Hurricane Katrina



Cold front and tornado



*EAPS 10000 Y01 - **Planet Earth** (online course)*
Week 6, Chapter 14 (pages 442-471)

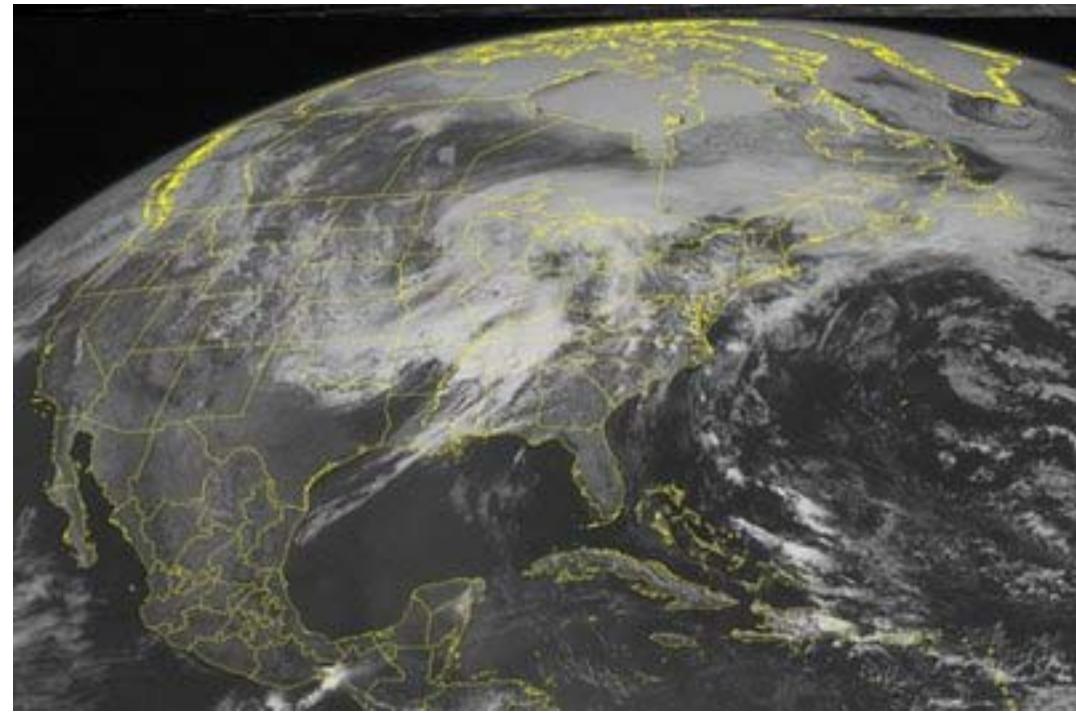
When you have finished reading Chapter 14 and viewing the weekly PowerPoint file for Chapter 14, take the quiz (Quiz12; be sure to read the Syllabus for more information on quizzes). You can use your book, notes, etc. during the quiz.

The PPT files (converted to PDF files) are best viewed with the Full Screen view in browsers.

The following slides illustrate some of the important concepts and topics of Chapter 14:

Tornadoes:

Tornadoes in SE US – April 27-28, 2011: At least 160 tornadoes in “outbreak”, at least 291 deaths, 10 states.

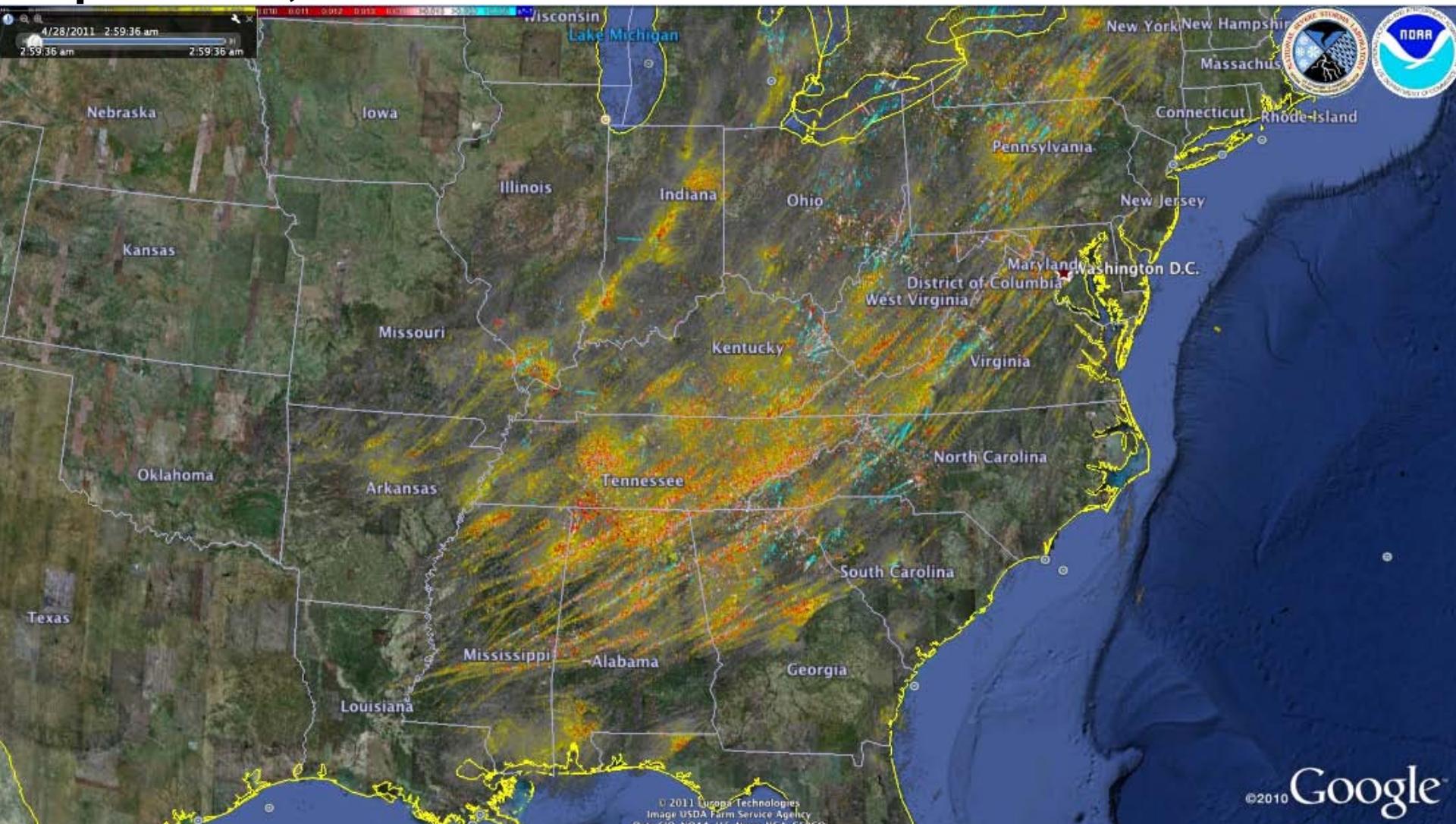


<http://www.nytimes.com/2011/04/29/us/29tornadoes.html>

<http://www.youtube.com/watch?v=vz8xiHpBGNM&feature=related>

<http://www.youtube.com/watch?v=6U1asLiDYB0&feature=related>

April 27-28, 2011 tornado outbreak storm rotation tracks



Bright reds, oranges and yellows show tracks of where rotation was strongest as detected by NWS Doppler radars during the April 27-28, 2011 tornado outbreak.
<http://www.norman.noaa.gov/2011/04/nssl-product-captures-april-27-tornado-outbreak-storm-rotation-tracks/>

From USA Today, April, 2011

By Oren Dorell
USA TODAY

Communities across the Southeast are preparing to bury the dead this weekend after the deadliest day of tornadoes in 37 years killed at least 291 people.

President Obama, who visits Alabama today, said Thursday the damage in six Southeast states is "nothing short of catastrophic." He called the region's first responders heroes and pledged that the federal government will do everything it can to help states recover and rebuild.

Obama issued a disaster declaration for Alabama. It frees federal funds to help state and local authorities.

Alabama Gov. Robert Bentley said his state had 204 confirmed deaths. There were 33 deaths in Mississippi, 33 in Tennessee, 15 in Georgia, five in Virginia and one in Kentucky. The tornadoes injured thousands of people — 600 alone in Tuscaloosa, Ala., home of the University of Alabama. As many as 1 million homes and businesses in Alabama were without power.

Several twisters that hit Wednesday were monsters more than a mile wide, stayed on the ground for tens of miles



By Amanda Sowards, Montgomery Advertiser, via AP

Home ravaged: Daniel Hinton looks through the remains of his house Thursday in Tuscaloosa, Ala.



From USA Today, April, 2011

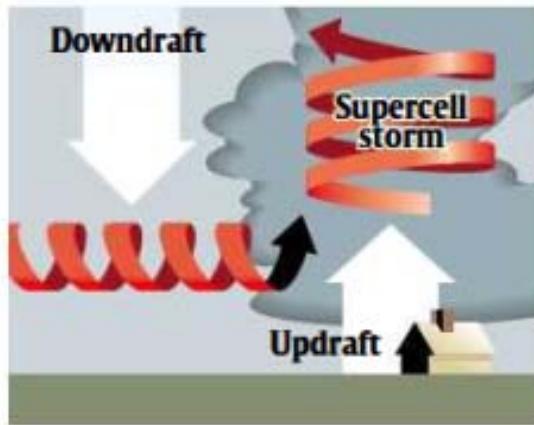
By Dusty Compton, The Tuscaloosa News, via AP

Community wiped out: Wednesday's tornado destroyed the Rosedale Court housing community in Tuscaloosa, Ala.

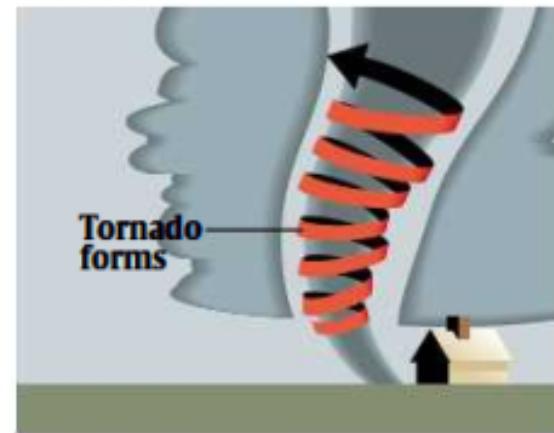
Formation of violent tornadoes

From USA Today, April, 2011

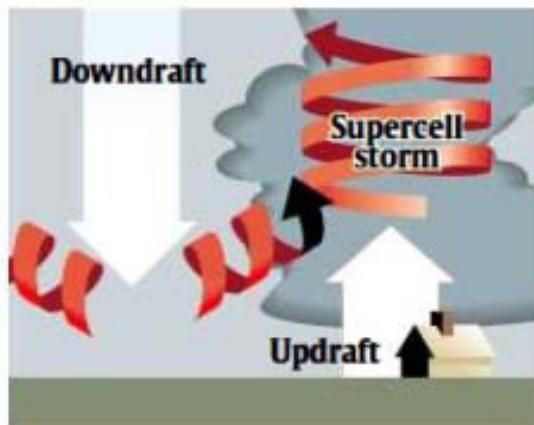
- 1** A spinning tube of air formed by low-level wind shear is lifted into the supercell thunderstorm, causing it to rotate.



- 3** The updraft stretches the counterclockwise spinning column into the rotating storm; when the storm and column connect, a tornado often is formed.

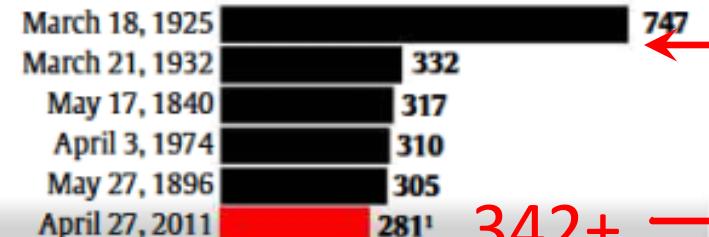


- 2** A downdraft splits the tail end of the tube into two columns – one spinning clockwise, the other spinning counterclockwise.



Tornado toll

Wednesday was the sixth-deadliest day in U.S. history.



1 – As of 7:41 p.m. ET April 28.

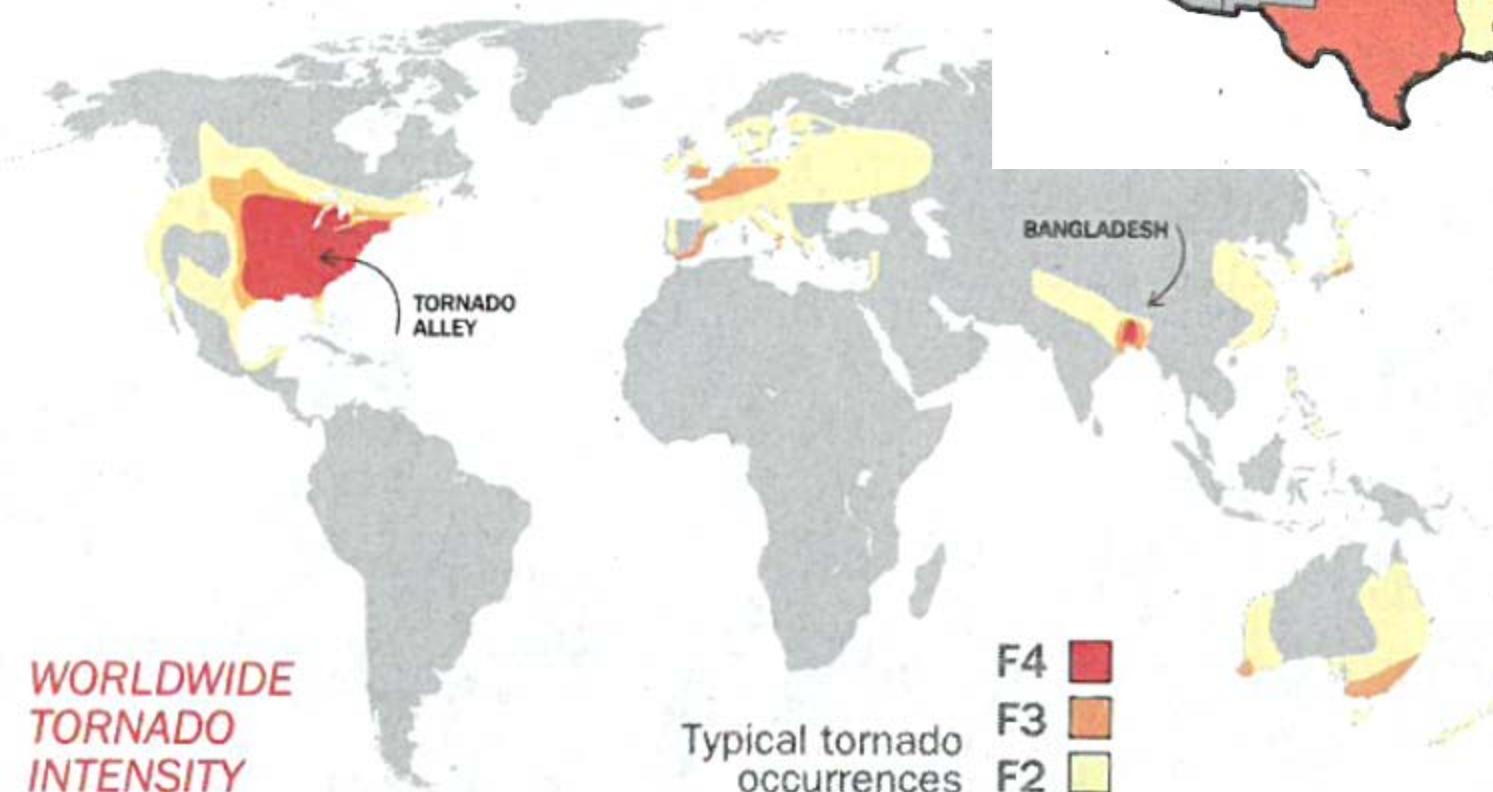
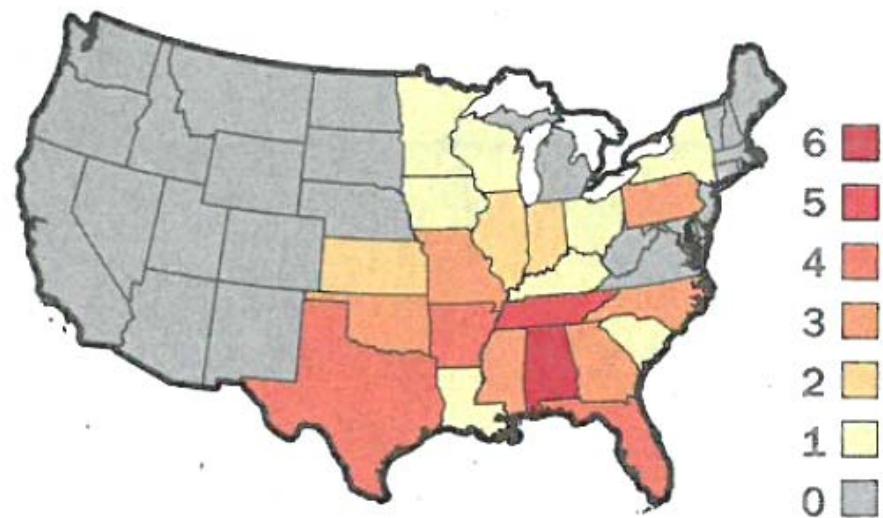
Sources: Harold Brooks, National Severe Storms Laboratory



May, 2013 Moore, Oklahoma tornado, EF 5
(From Time Magazine, May, 2013)

AVERAGE ANNUAL TORNADO FATALITIES
PER STATE, 1981-2010

From Time Magazine, May, 2013



Sources: NWS; NOAA

**AVERAGE U.S.
WARNING TIMES**

TORNADO

14 minutes

SEVERE
THUNDERSTORM

18 minutes

FLASH FLOOD

64 minutes

HURRICANE

36 hours

**NATIONWIDE
PERCENTAGE OF
TORNADO WARNINGS
THAT ARE
FALSE ALARMS**



76%

**TORNADOES
IN 2012**

46

Number of states that reported tornadoes

939

Total number of tornadoes reported

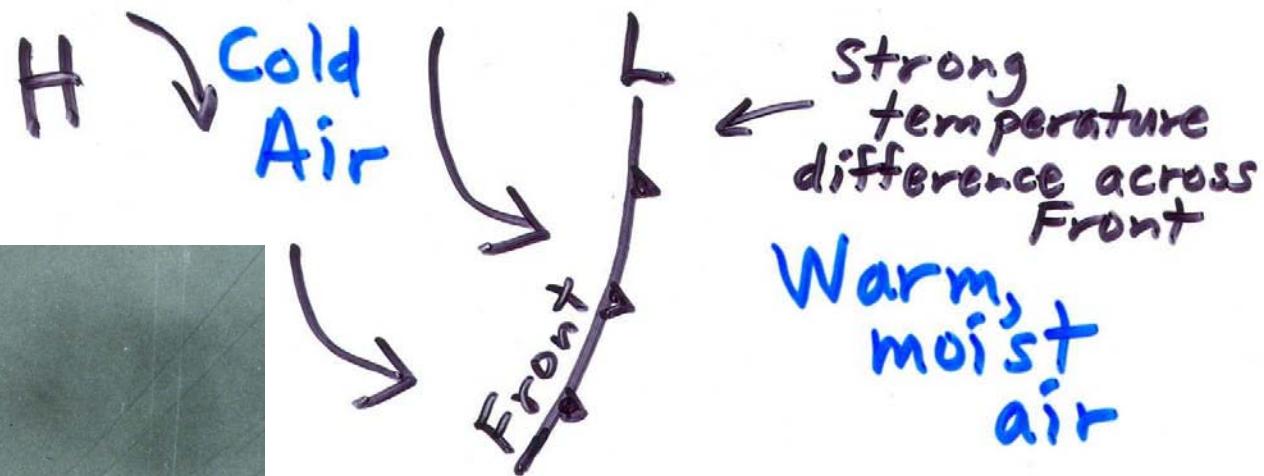
\$1.6 billion

Estimate of property and crop damage from tornadoes

From Time Magazine, May, 2013

Tornadoes:

1. Form in intense thunderstorms caused by collision of cold air and warm, moist air along a Front.



Elkhart, Indiana, 1965 April 11; note “twin funnels”.

Tornado and flying debris, Chapter 14 , text



Tornadoes (cont.)

2. Midwest US is most prominent location (“tornado alley”)
 - moisture from Gulf of Mexico
 - Cold air from Canada moving south and east and “guided” by Rocky Mtns. and Appalachians
3. Mostly in Spring due to climatic conditions of warm air in Gulf of Mexico and SE U.S and occasional cold air and front moving south and east from cold Canadian air mass.

Tornadoes (cont.)

4. Conditions for formation:

- unstable air -- cold air over-riding warm (warm air below then rises due to lower density, cold air above descends due to higher density leading to strong vertical movements)
- rising, warm, moist air
- precipitation, evaporation (and cooling) cause down-drafts when warm air contacts cold air along the front
- Tornado occurs in updraft region

Circulation around Low pressure area often results in formation of a **cold front**. Collision of dry, cold air with warm, moist air results in precipitation and, possibly, thunderstorms and tornadoes.

Cold front moves from west to east due to **trade winds** (westerlies) and **counter-clockwise circulation** around the Low

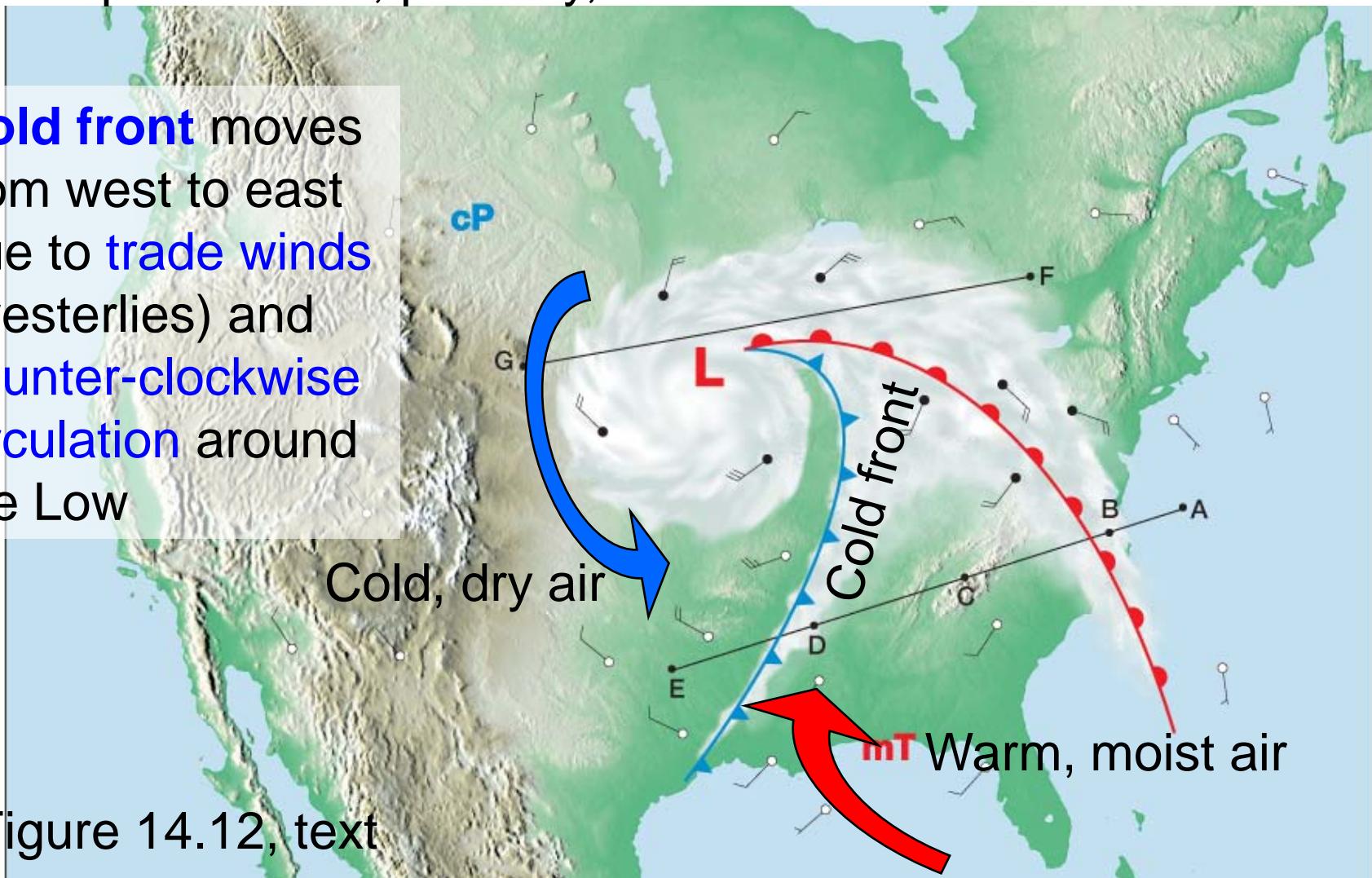
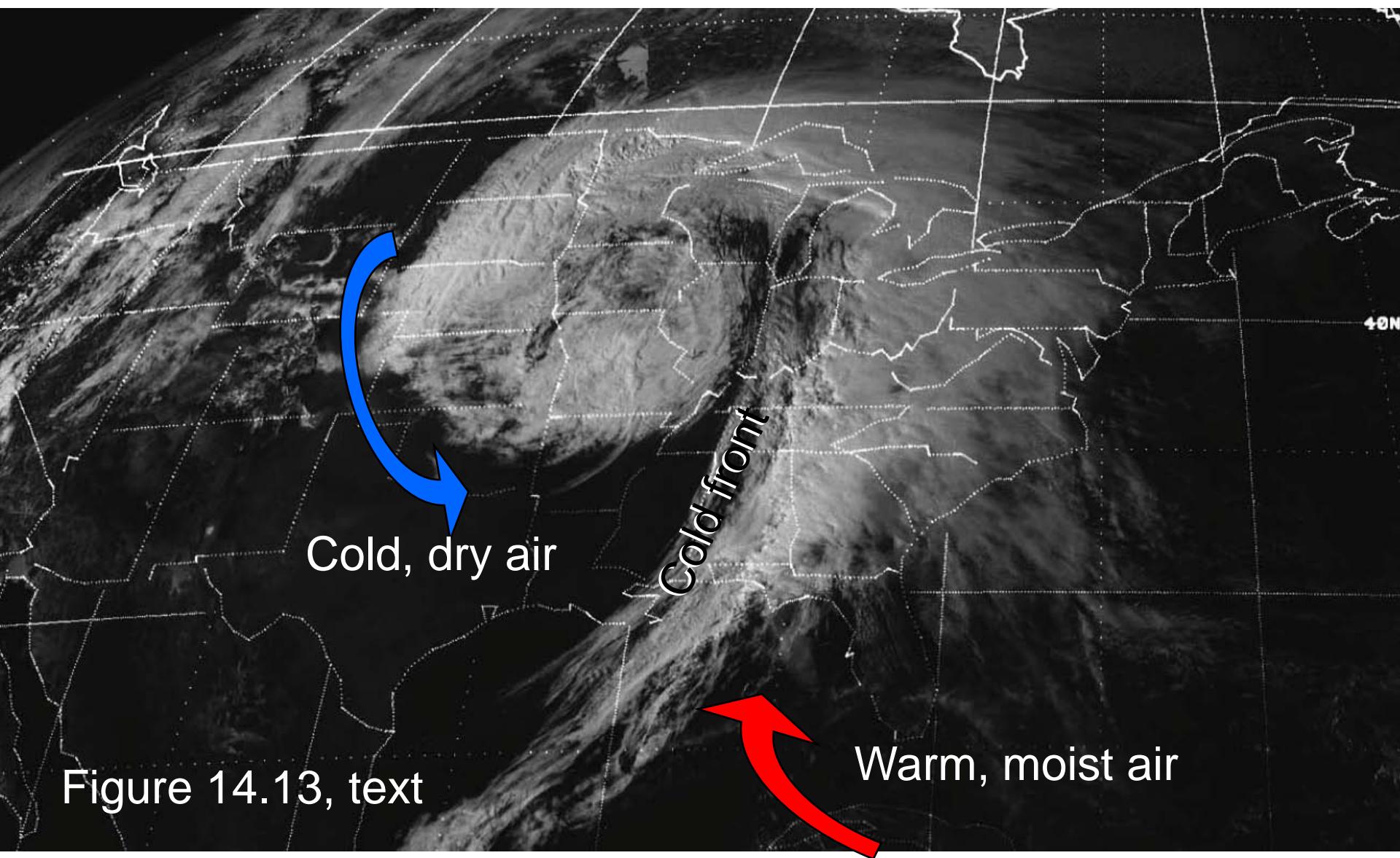
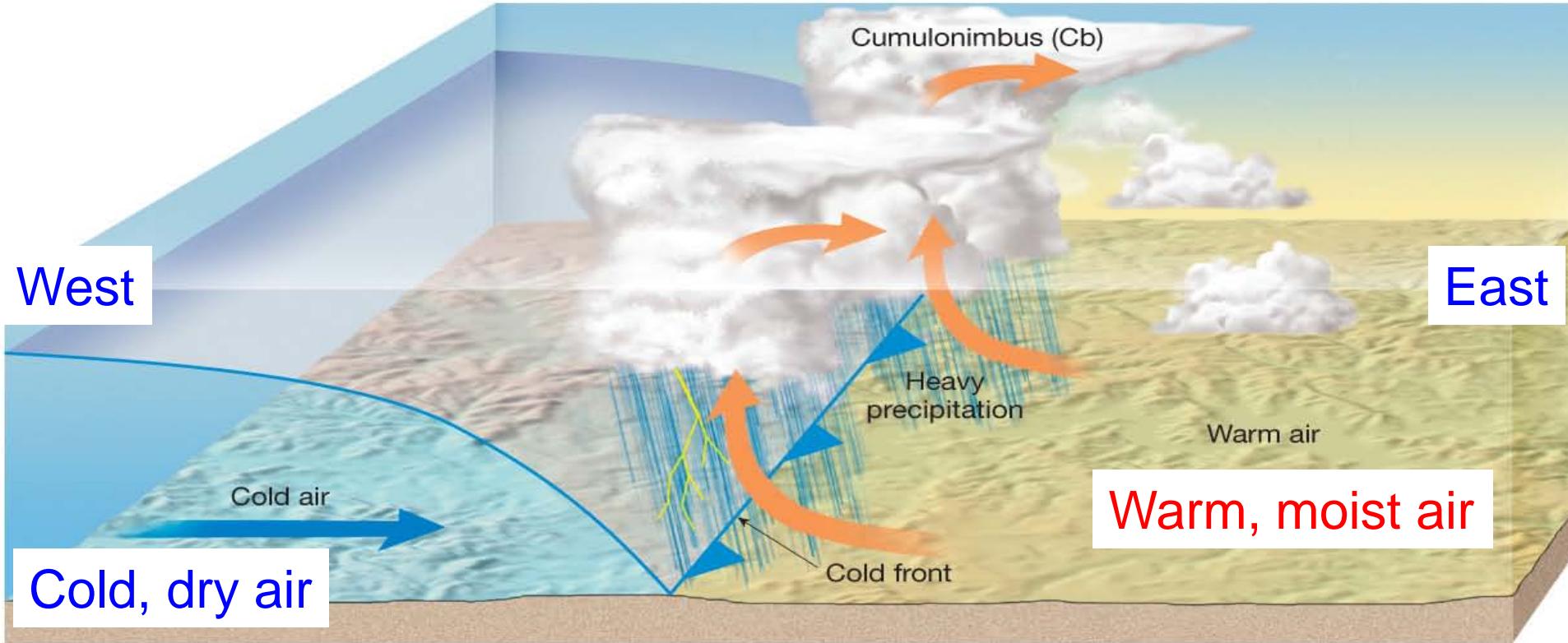


Figure 14.12, text

Clouds associated with a Low pressure area and cold front



Cold air is more dense so it stays near the Earth's surface and causes the adjacent warm moist air to rise along the front (shows cross section view equivalent to profile E to C of Figure 14.8, text)



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Figure 14.8, text

Tornadoes (cont.)

5. Characteristics:

- Weak F0 to F1 (winds <180 km/hr)
- Strong F2 to F3 (winds 181- 332 km/hr)
- Violent F4 to F5 (winds >333 km/hr)
(about 20/yr violent; peak in April; most deaths and damage result from the small number of violent [F4 to F5] tornadoes each year)
- Intensity of tornado is ~ proportional to the amount of water vapor in air

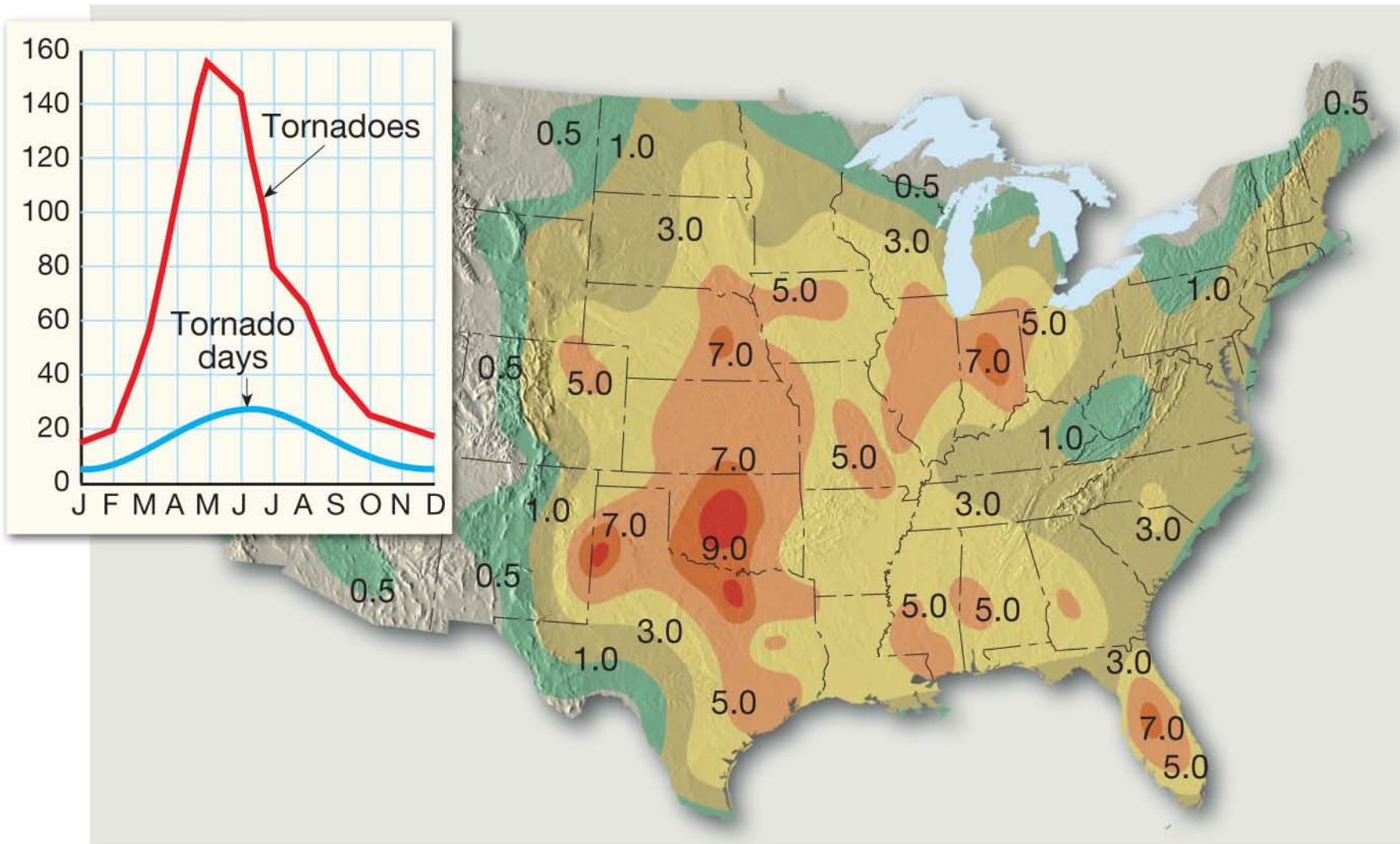
Table 14.1 Enhanced Fujita Intensity Scale*

Scale	Wind Speed		Damage
	Km/Hr	Mi/Hr	
EF-0	105–137	65–85	<i>Light.</i> Some damage to siding and shingles.
EF-1	138–177	86–110	<i>Moderate.</i> Considerable roof damage. Winds can uproot trees and overturn single-wide mobile homes. Flagpoles bend.
EF-2	178–217	111–135	<i>Considerable.</i> Most single-wide homes destroyed. Permanent homes can shift off foundations. Flagpoles collapse. Softwood trees debarked.
EF-3	218–265	136–165	<i>Severe.</i> Hardwood trees debarked. All but small portions of houses destroyed.
EF-4	266–322	166–200	<i>Devastating.</i> Complete destruction of well-built residences, large sections of school buildings.
EF-5	>322	>200	<i>Incredible.</i> Significant structural deformation of mid- and high-rise buildings.

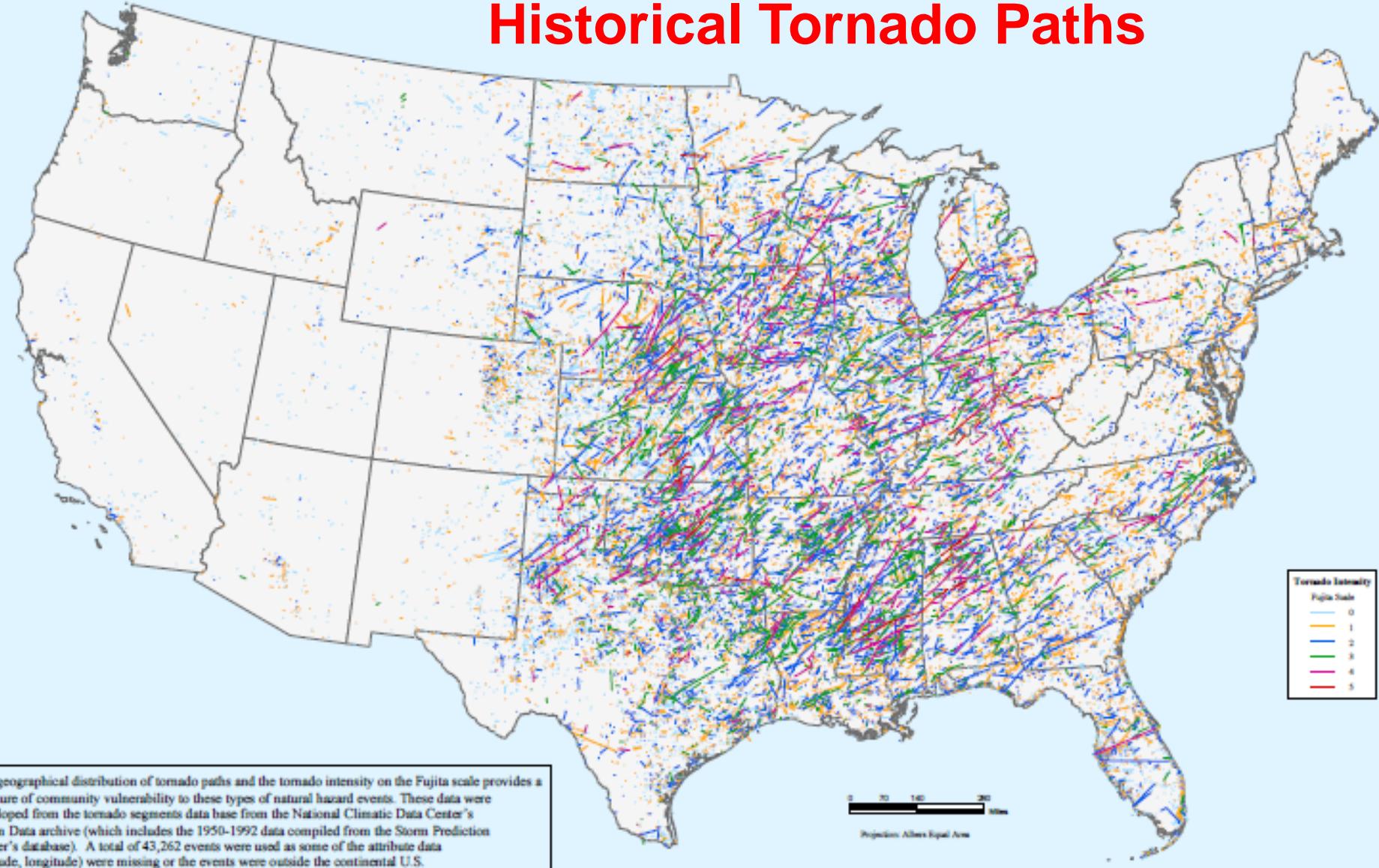
*The original Fujita scale was developed by T. Theodore Fujita in 1971 and put into use in 1973. The Enhanced Fujita Scale is a revision that was put into use in February 2007. Winds speeds are estimates (not measurements) based on damage, and represent 3-second gusts at the point of damage. More information about the criteria used to evaluate tornado intensity can be found at <http://www.spc.noaa.gov/efscale/> and at <http://www.spc.noaa.gov/faq/tornado/ef-scale.html>.

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Average number of tornadoes, tornado days, and annual tornado incidence each month in the U.S. (Figure 14.24, text)

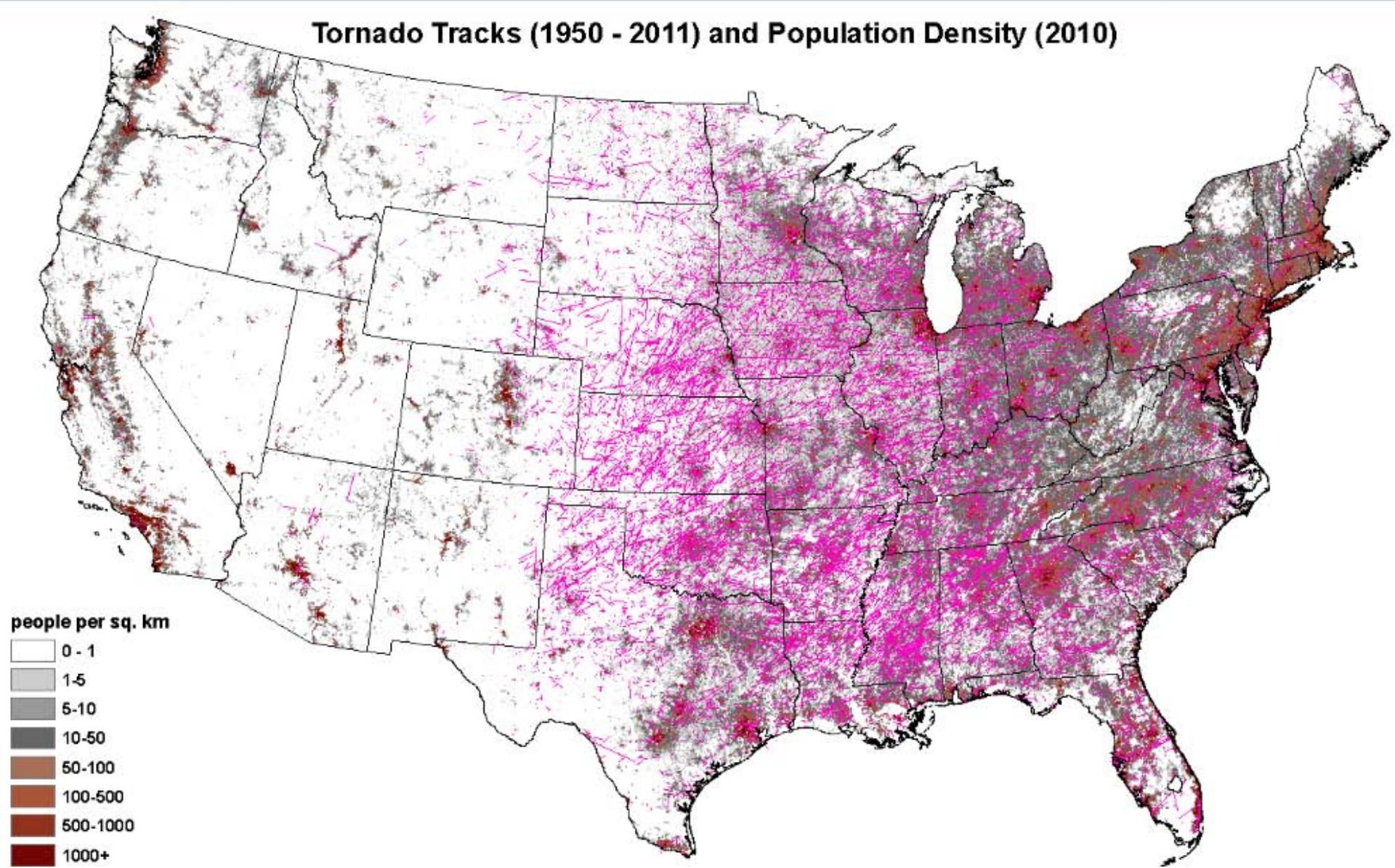


Historical Tornado Paths

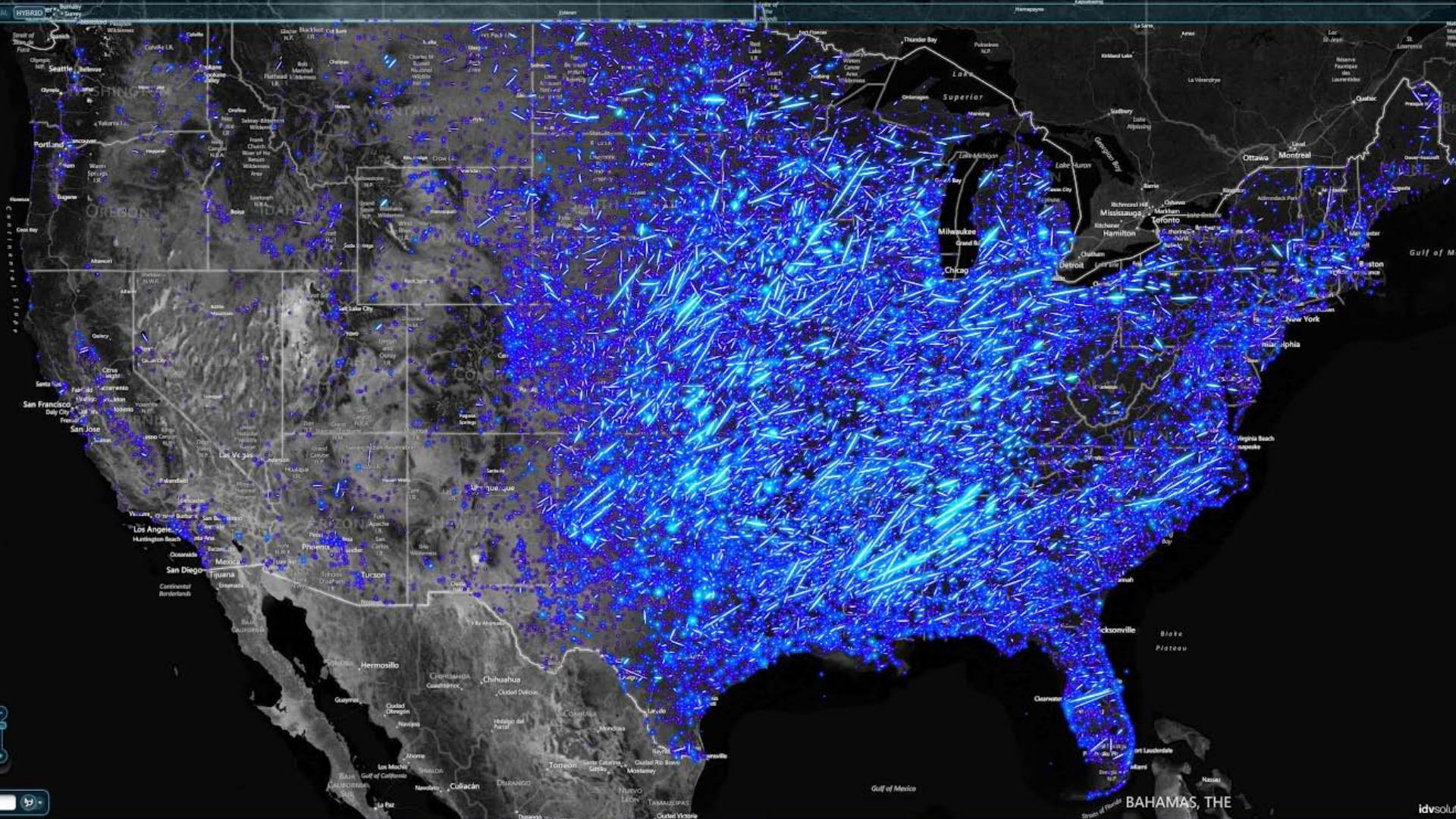


U.S. Tornado Paths 1953-2001, Hazards Research Laboratory, U. South Carolina

Tornado Tracks (1950 - 2011) and Population Density (2010)

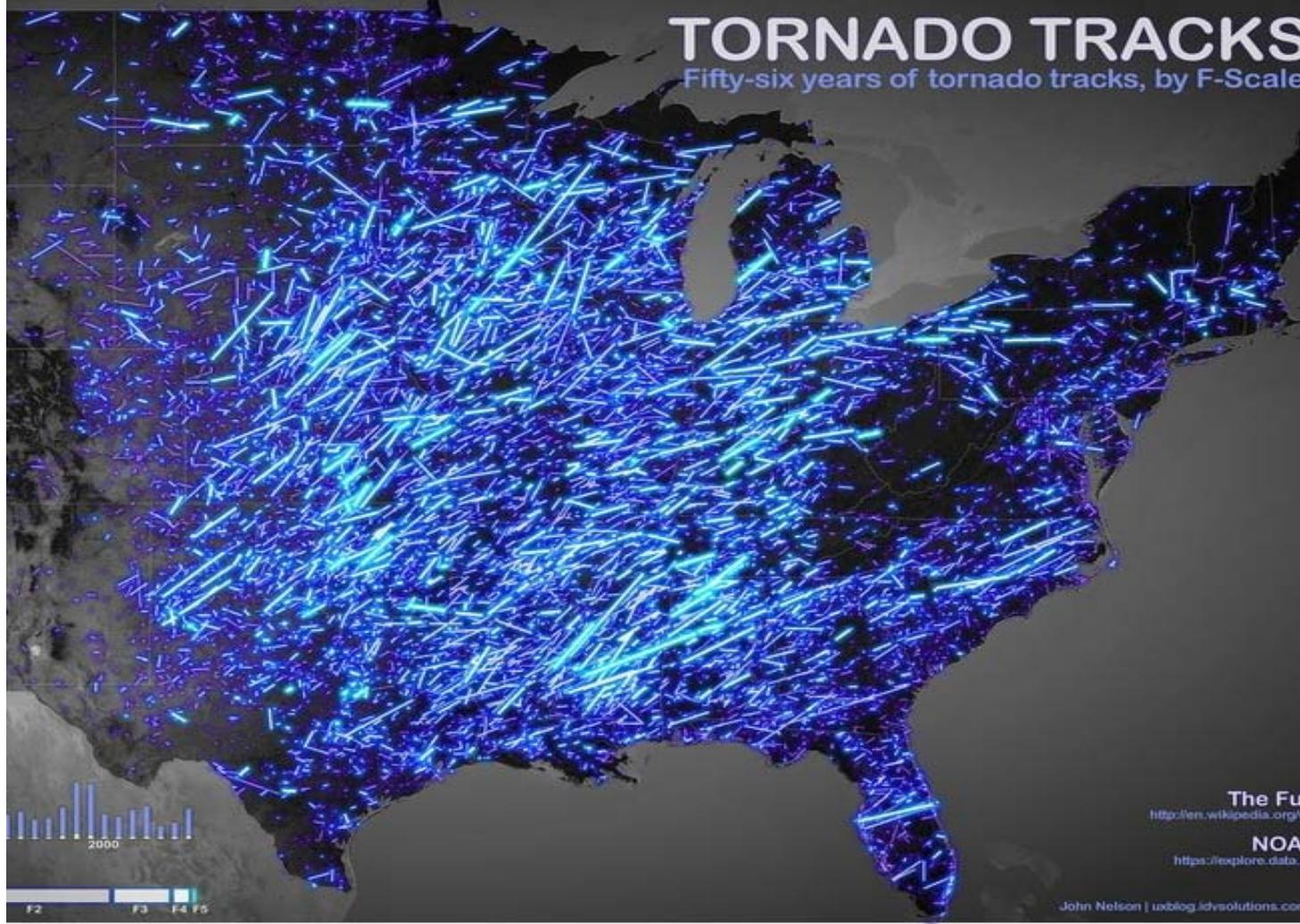


http://www.spc.noaa.gov/gis/svrgis/images/tornadoes_population.png
<http://www.spc.noaa.gov/gis/svrgis/>



<http://uxblog.idvsolutions.com/2012/07/interactive-tornado-tracks-map-is-live.html>

Watch the YouTube video to see the tornado tracks (1950-2011) by year: <http://www.youtube.com/watch?v=1d8OVf829kw>
note the 1974 and 2011 outbreaks.



You can also see the tornado tracks by month (<http://www.youtube.com/watch?v=eRDke7vreK8&feature=youtu.be>) which better illustrates the seasonal cycle of tornadoes but also shows that tornadoes can happen in any month of the year.

<http://uxblog.idvsolutions.com/2012/05/tornado-tracks.html>

Hurricanes:

1. Form in Tropical marine areas (\approx 5 - 20° latitude; not right at the equator because of small Coriolis Effect)
2. Energy for storm (Energy for one day of a hurricane \approx Electricity produced in US in one year)
 - Solar radiation -- Heated air rises forming low pressure region, also provides moisture in atmosphere by evaporation from ocean

Hurricanes (cont.)

- Exchange of heat from warm ($\geq 28^{\circ}\text{C}$) ocean **to** atmosphere; therefore, storms form in late summer in tropical oceanic areas
- Latent heat of condensation **further drives** storm by heating air when moisture in air condenses to form rain (heating $1 \text{ cm}^3 = 1 \text{ g}$ of water to evaporation takes 1 calorie [adding energy to the water to make it water vapor], so when the water vapor condenses [precipitation], it releases this energy).

Hurricanes (cont.)

3. Circulation

- Hurricanes move according to the trade winds ($\approx 10 - 50$ km/hr)
- Circulation in hurricane is around low pressure (counter-clockwise in N. Hemisphere); higher velocity near center because of conservation of angular momentum (like spinning figure skater)

Hurricane

4. Damage from hurricane



- High winds ($> 122 \text{ km/hr [75 mph]}$)
- Torrential rains (up to 25 cm in a few hours)
- Salt water flooding of fresh water region

Table 14.3 Saffir-Simpson Hurricane Scale

Scale Number (category)	Central Pressure (millibars)	Winds (km/hr)	Storm Surge (meters)	Damage
1	≥980	119–153	1.2–1.5	Minimal
2	965–979	154–177	1.6–2.4	Moderate
3	945–964	178–209	2.5–3.6	Extensive
4	920–944	210–250	3.7–5.4	Extreme
5	<920	>250	>5.4	Catastrophic

Hurricanes (cont.)

- Storm surge (up to 7 m of local, temporary sea level rise; most significant cause of damage and loss of life)
 - Low pressure (as low as 900mb produces 1 m of surge)
 - Storm buildup (especially for “bay-like” coastlines, “focusing”)
 - Wave action
 - High tides can compound the storm surge

Hurricanes (cont.)

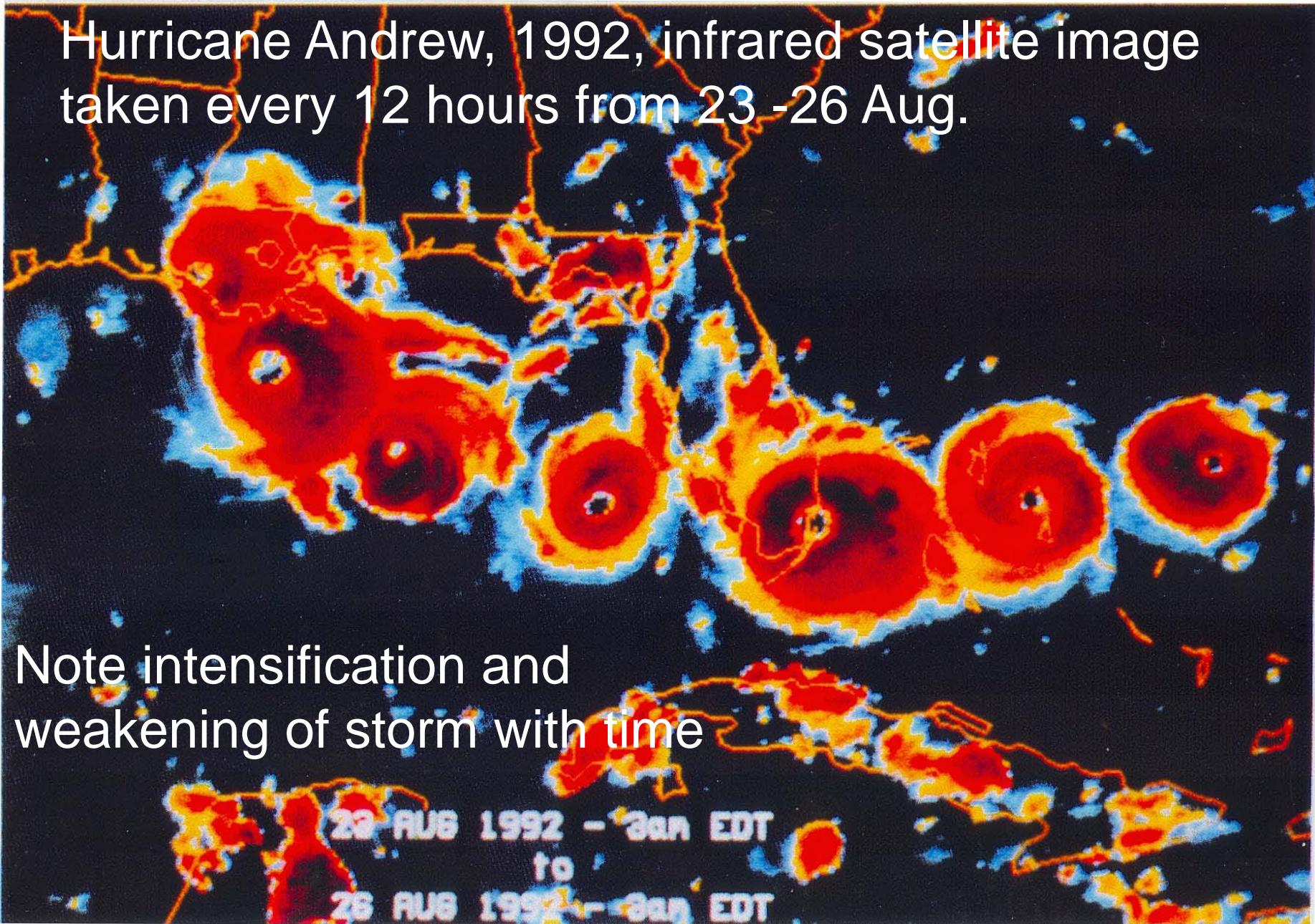
5. Names for Hurricanes (“just for interest”):

- Atlantic Ocean: Hurricanes
- W. Pacific Ocean: Typhoons
- Indian Ocean: Cyclones
- Australia: Willy-Willys

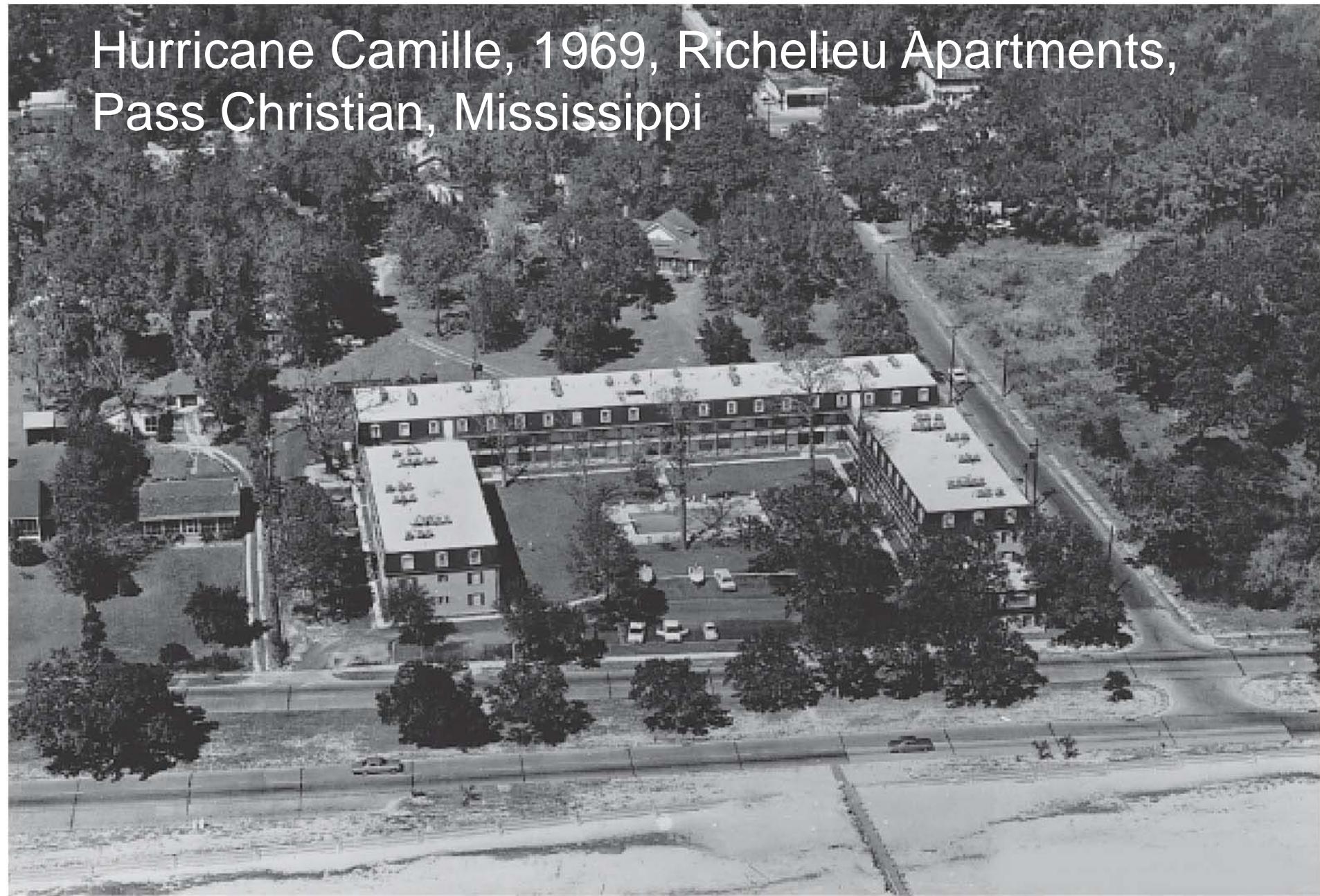


Some images and information on Typhoon (Hurricane) Haiyan (Philippines, November, 2013) is contained in the Week 13 folder.

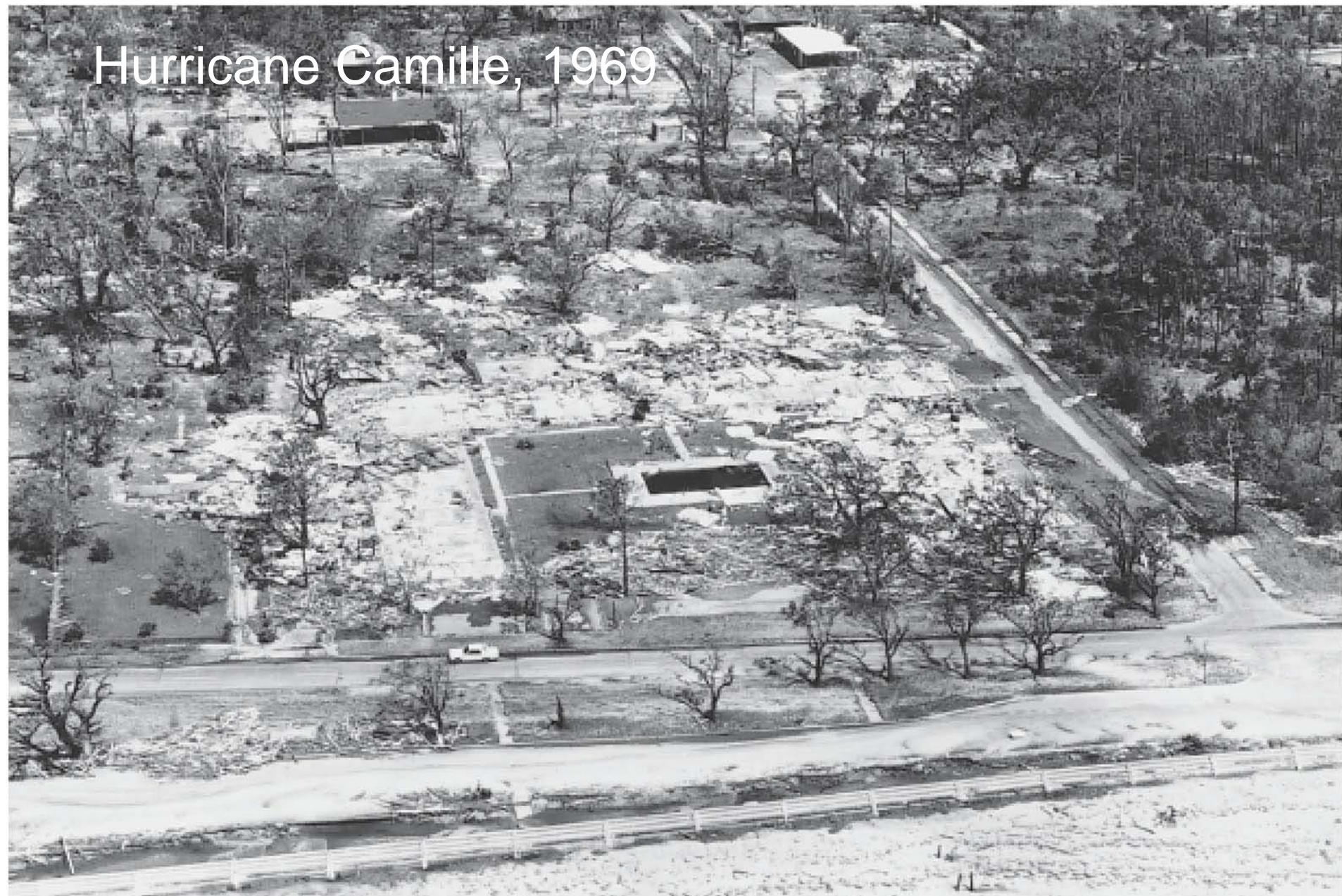
Hurricane Andrew, 1992, infrared satellite image taken every 12 hours from 23 -26 Aug.



Hurricane Camille, 1969, Richelieu Apartments, Pass Christian, Mississippi



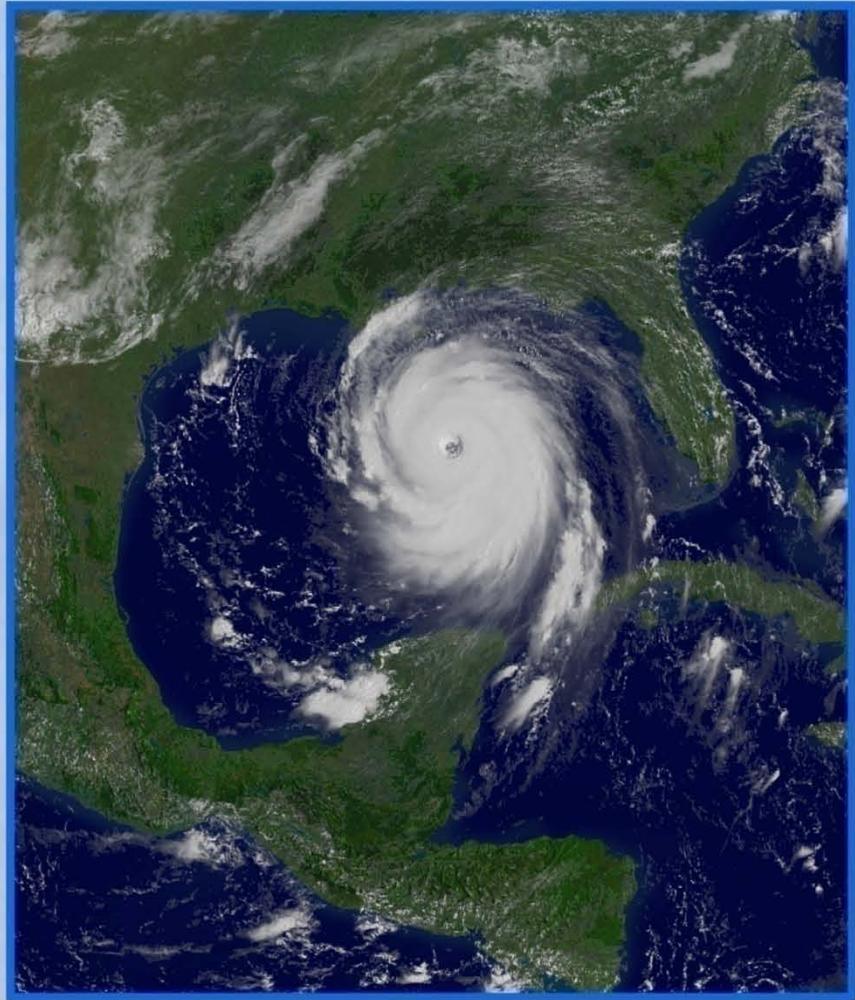
Hurricane Camille, 1969



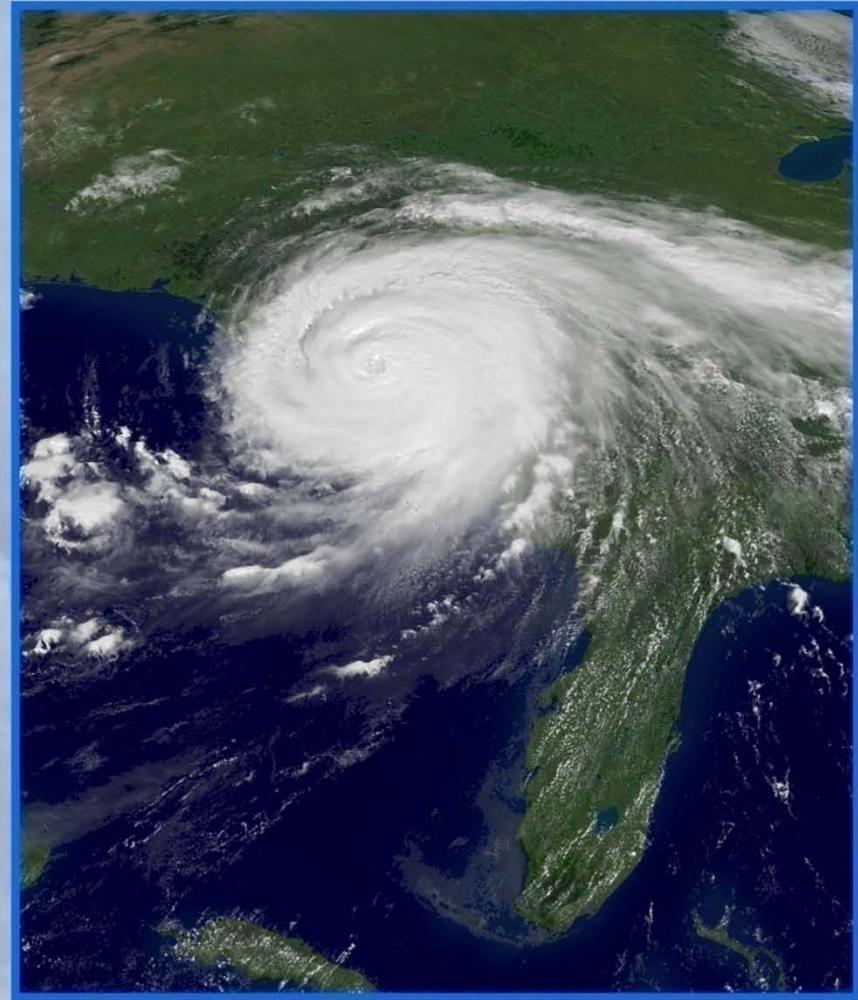
Hurricane Katrina, 2005



Hurricane Katrina, 2005 (not 2006)



AUGUST 28, 2006 at 1515Z



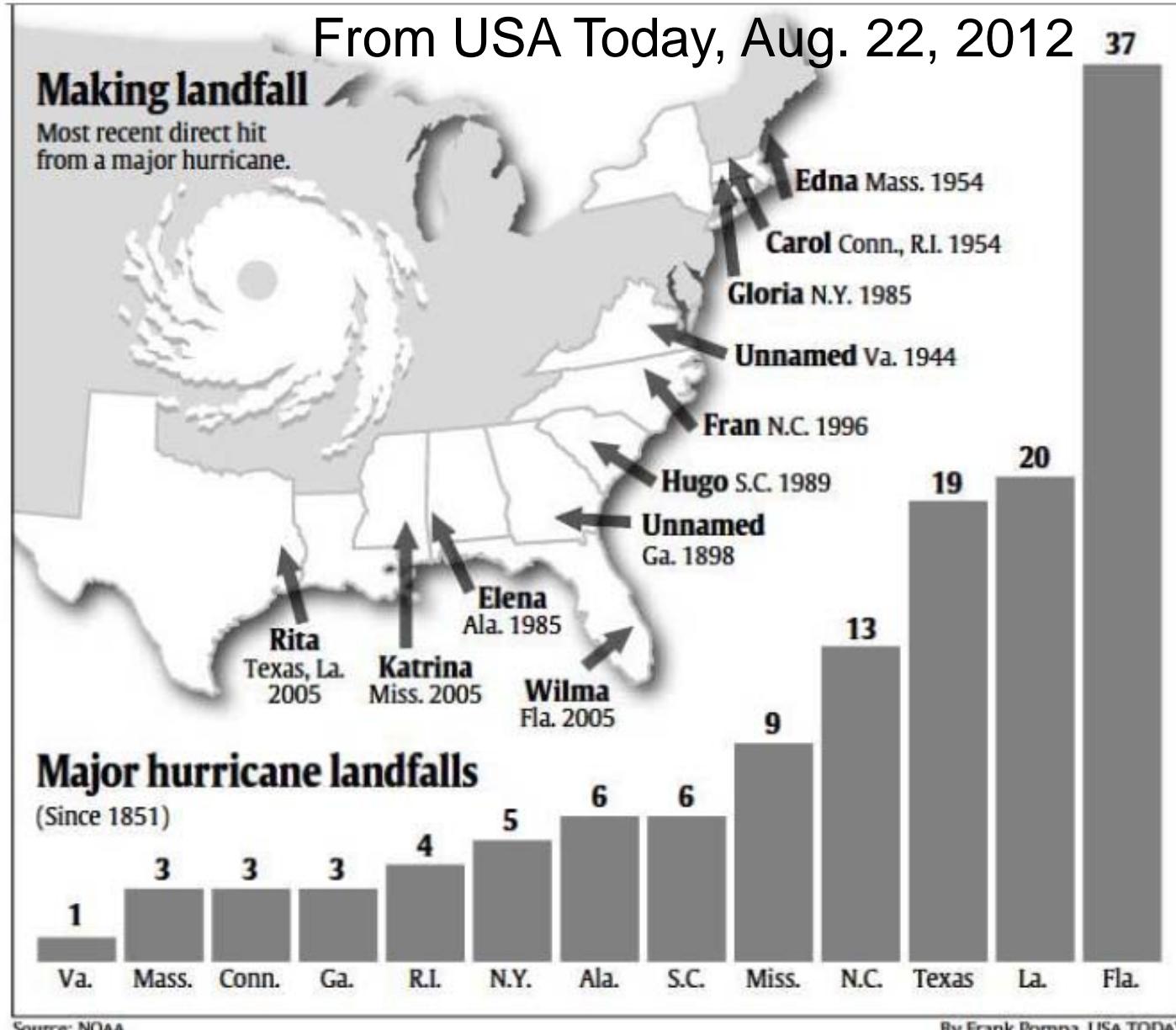
AUGUST 29, 2006 at 1615Z

From USA Today, Aug. 22, 2012

37

Making landfall

Most recent direct hit
from a major hurricane.



Information on Hurricane Sandy:

<http://web.ics.purdue.edu/~braile/EAS100online/NE.Hurricanes.pdf>

FIERCE FORECAST

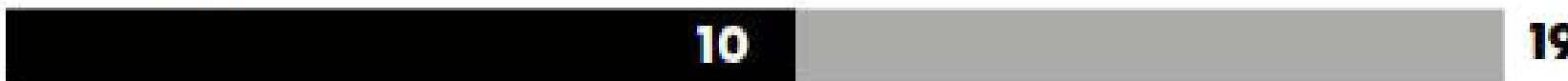
Forecasting Hurricanes

Forecasters from Colorado State University on Wednesday predicted an above-average 2013 Atlantic hurricane season:

2012 forecast



2012 actual



Long-term average



2013 forecast



● Named storms

● Hurricanes

Source Colorado State University
DOYLE RICE AND JULIE SNIDER, USA TODAY

**CSU Atlantic Hurricanes forecasts
for 2012 and 2013 seasons (USA
Today, April 11, 2013)**



NOAA 2013 Atlantic Hurricane Forecast

Storm Category	2013 Forecast	Long-term Average	2013 Actual
Named Storms	13 – 20	12	14
Hurricanes	7 – 11	6	2
Major Hurricanes (Category 3, 4, 5)	3 – 6	3	0

As you can see for the results of the 2013 hurricane season, hurricane forecasting is not always easy or accurate!

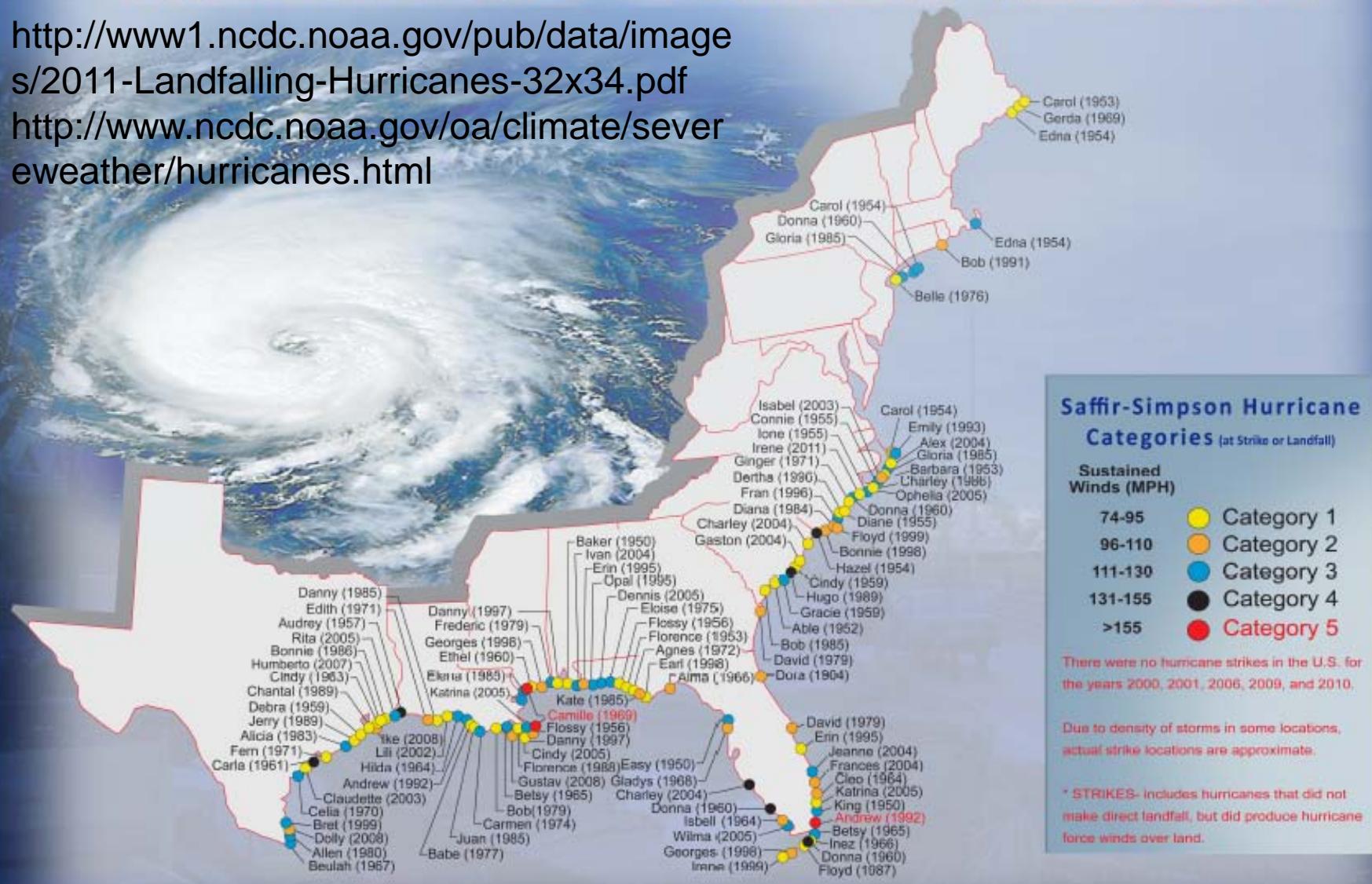
NOAA 2013 Atlantic Hurricane Forecast, May 24, 2013

http://www.noaanews.noaa.gov/stories2013/20130523_hurricaneoutlook_atlantic.html

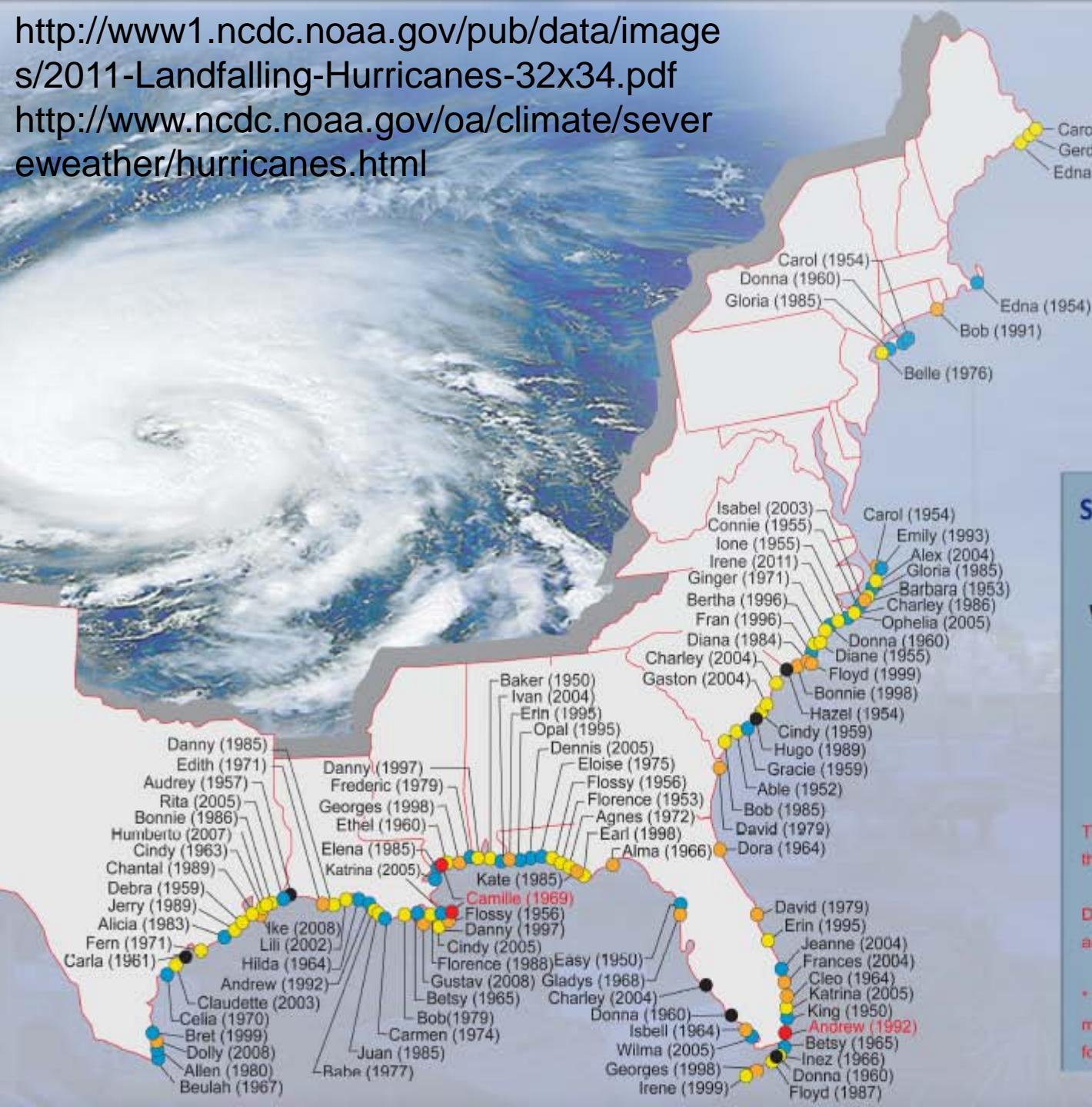
CONTINENTAL UNITED STATES HURRICANE STRIKES 1950-2011*

<http://www1.ncdc.noaa.gov/pub/data/images/2011-Landfalling-Hurricanes-32x34.pdf>

<http://www.ncdc.noaa.gov/oa/climate/severeweather/hurricanes.html>



<http://www1.ncdc.noaa.gov/pub/data/images/2011-Landfalling-Hurricanes-32x34.pdf>
<http://www.ncdc.noaa.gov/oa/climate/severeweather/hurricanes.html>



Note that over a long period of time, almost all of the gulf coast and the east coast of the U.S. is affected by hurricanes!

Saffir-Simpson Hurricane Categories (at Strike or Landfall)

Sustained Winds (MPH)

- | | |
|---------|------------|
| 74-95 | Category 1 |
| 96-110 | Category 2 |
| 111-130 | Category 3 |
| 131-155 | Category 4 |
| >155 | Category 5 |

There were no hurricane strikes in the U.S. for the years 2000, 2001, 2006, 2009, and 2010.

Due to density of storms in some locations, actual strike locations are approximate.

* STRIKES- includes hurricanes that did not make direct landfall, but did produce hurricane force winds over land.