

WEATHER HAZARDS & HAZARD CLIMATOLOGY

DR. MIKE LANGSTON

USGS DEPUTY DIRECTOR

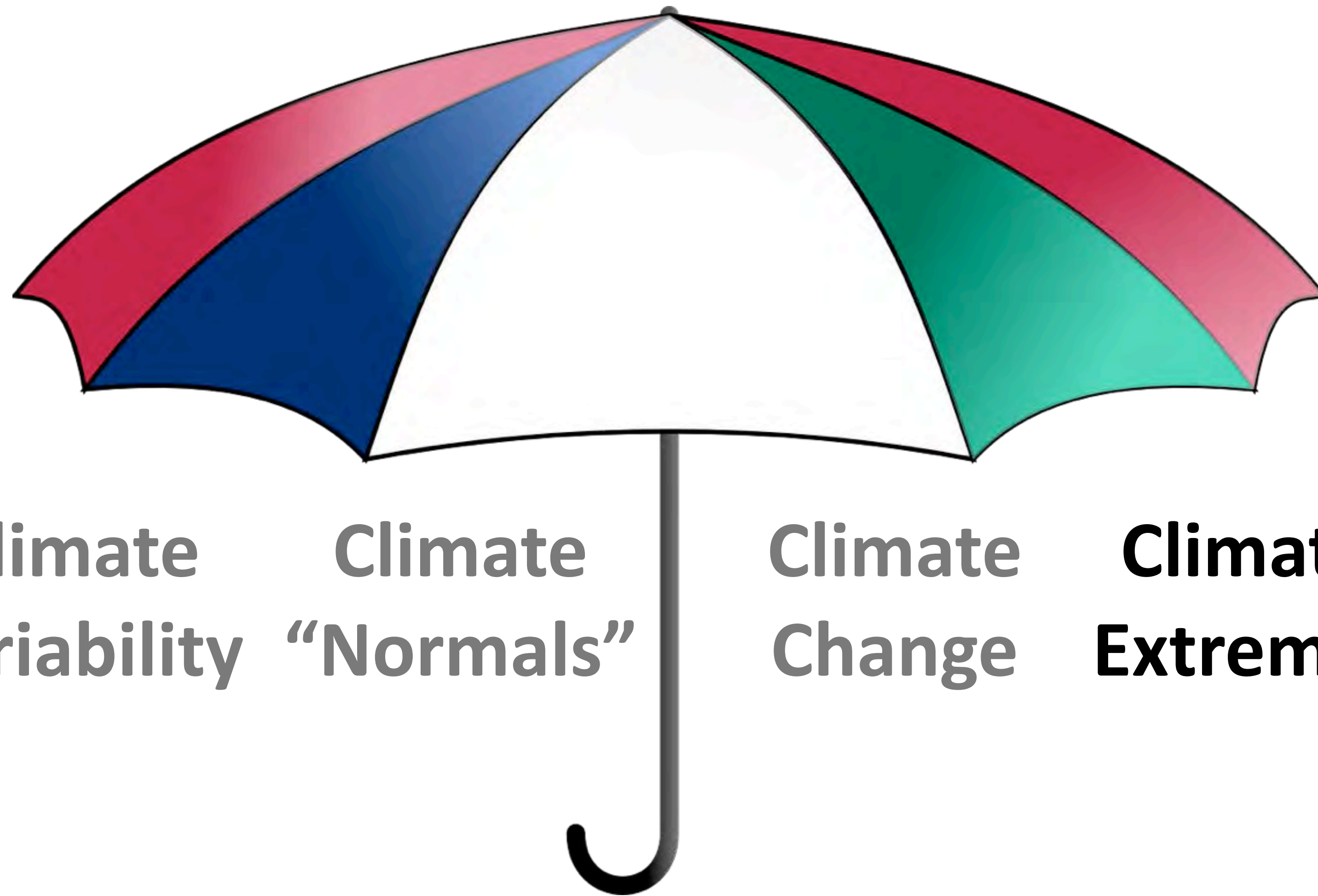
SOUTH CENTRAL CLIMATE ADAPTATION SCIENCE CENTER

U.S. GEOLOGICAL SURVEY



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

THE CLIMATE UMBRELLA



Climate
Variability

Climate
“Normals”

Climate
Change

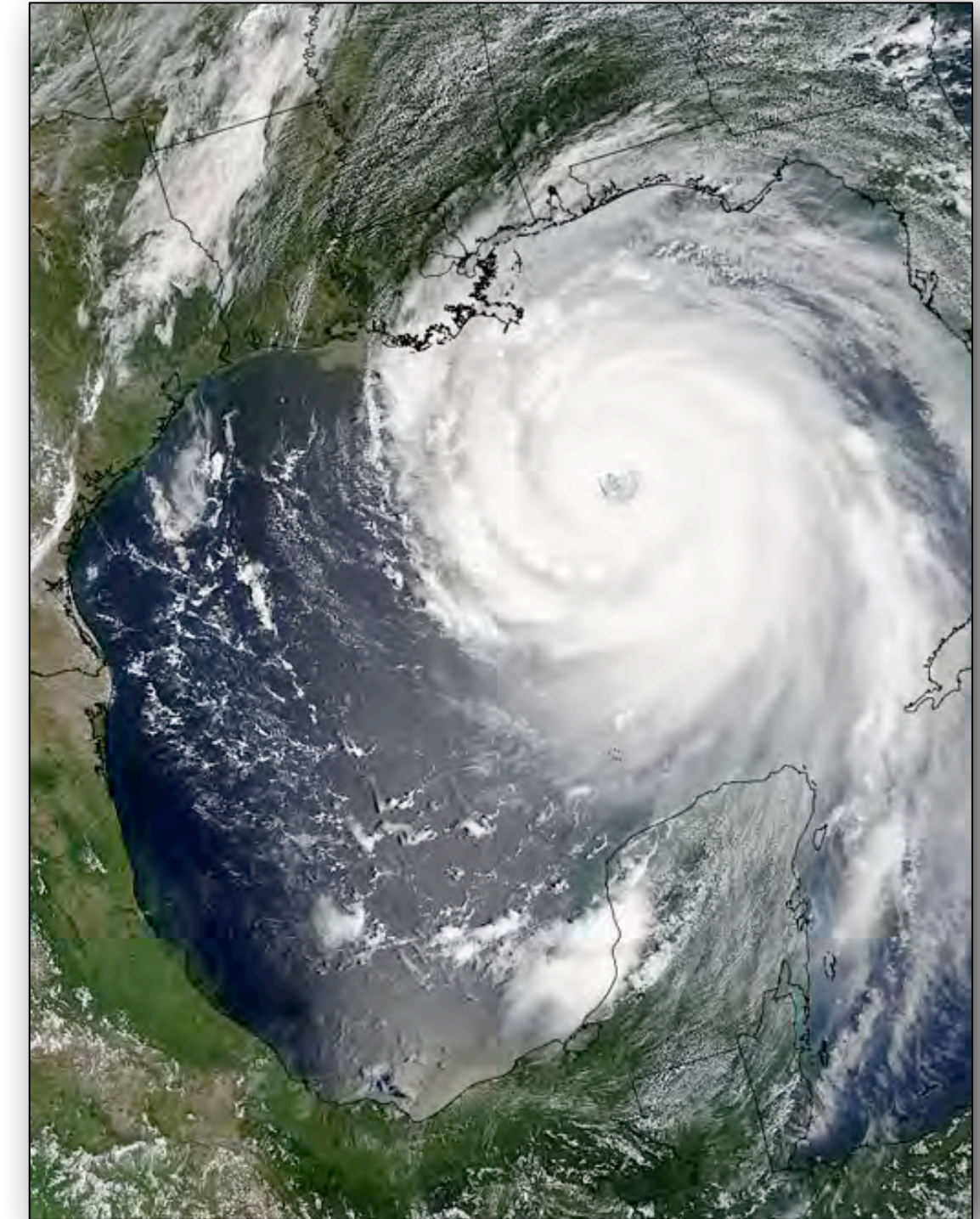
**Climate
Extremes**



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

CLIMATE EXTREMES (WEATHER HAZARDS)

- Severe Thunderstorms
- Tornadoes
- Drought
- Wildfires

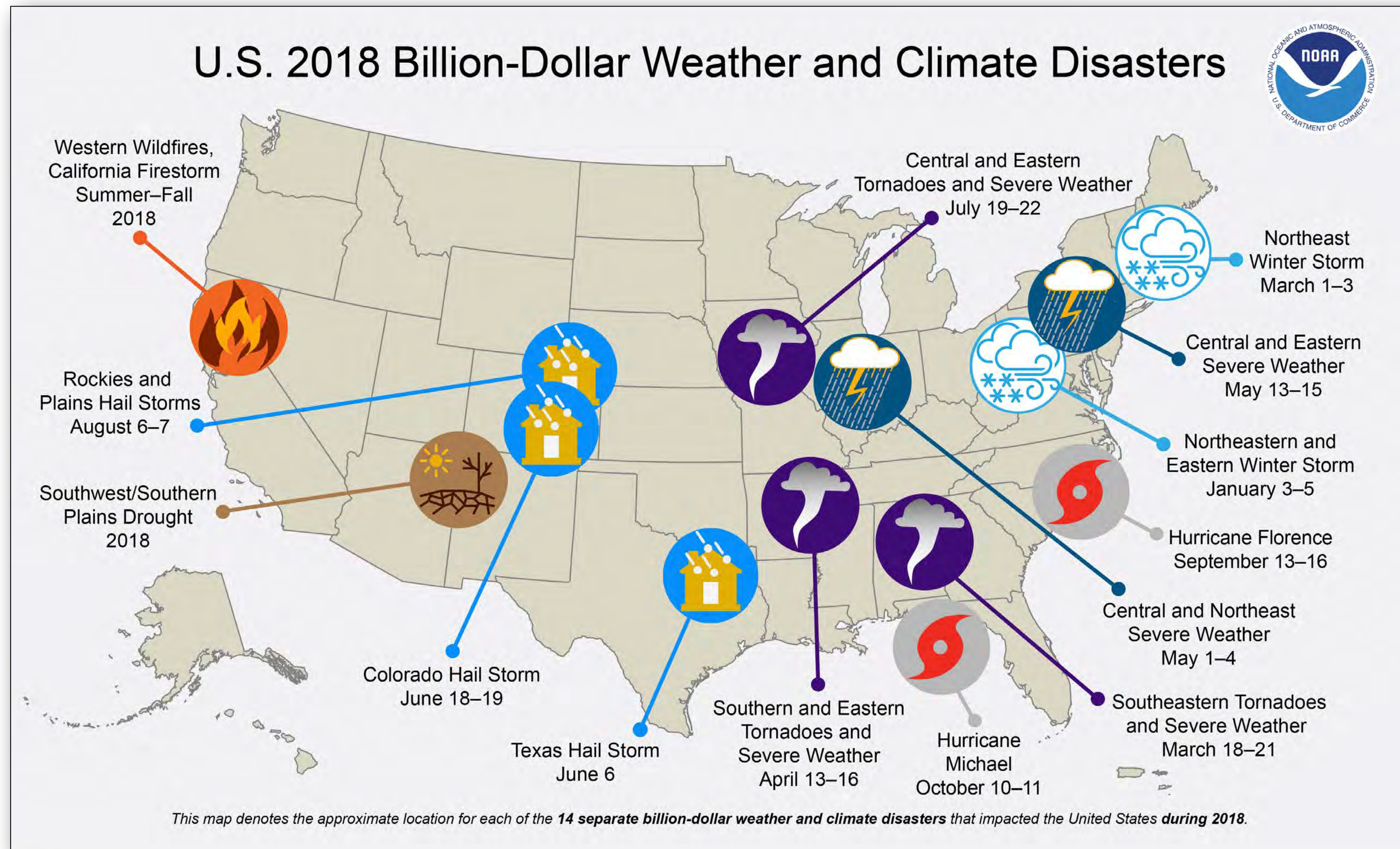


- Hurricanes
- Flooding
- Extreme Heat
- Winter Weather



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

BILLION-DOLLAR CLIMATE DISASTERS



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

**WHAT WEATHER EVENT WAS THE MOST
COSTLY IN THE U.S. SINCE 1980?**



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

HURRICANE KATRINA

- Made landfall on August 29, 2005
- Became the deadliest storm since 1928 (1,833 deaths)
- Costliest storm in U.S. (\$161.3 Billion)



NOAA BILLION-DOLLAR DISASTERS (1980–2018)

1) Hurricane Katrina (2005) – \$165 Billion

2) ?

3) ?

4) ?

5) ?

6) ?

7) ?

8) ?

9) ?

10) ?



NOAA BILLION-DOLLAR DISASTERS (1980–2018)

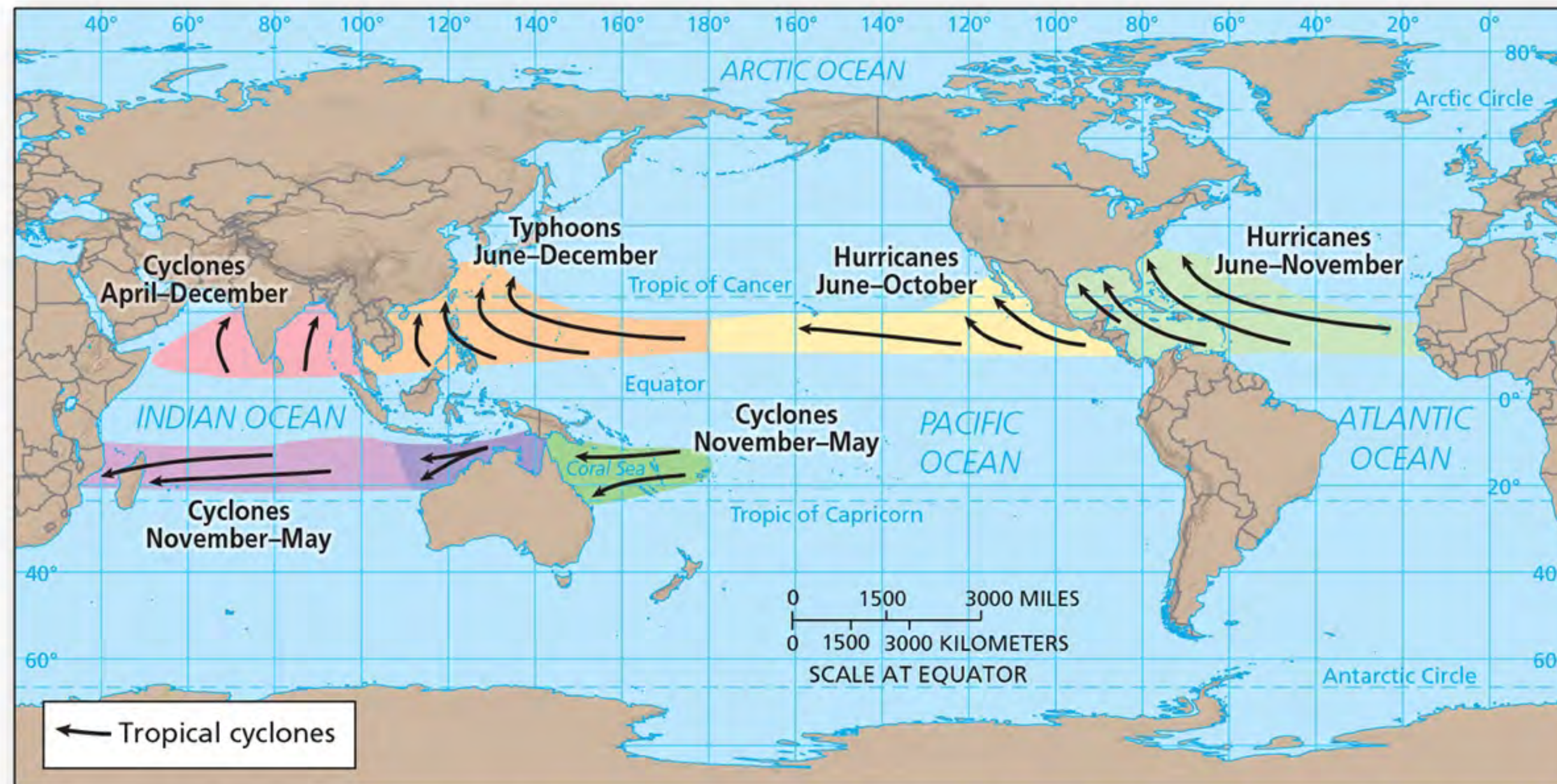
- 1) Hurricane Katrina (2005) – \$165 Billion**
- 2) Hurricane Harvey (2017) – \$127.5 Billion**
- 3) Hurricane Maria (2017) – \$91.8 Billion**
- 4) Hurricane Sandy (2012) – \$72.2 Billion**
- 5) Hurricane Irma (2017) – \$51.0 Billion**
- 6) Hurricane Andrew (1992) – \$49.4 Billion**
- 7) ?**
- 8) ?**
- 9) Hurricane Ike (2008) – \$35.7 Billion**
- 10)?**



HURRICANES & THEIR THREATS

- **Hurricane** – a **tropical cyclone** with winds exceeding 74 miles per hour (mph)
- **Storm surge** – moves ocean water against the coast; can raise water level by 15 feet or more
- **Winds** – sustained winds over 160 mph; gusts over 200 mph recorded in the most intense hurricanes
- **Inland flooding** – may drop several feet of rain in a few days; 60% of deaths related to inland flooding
- **Tornadoes** – often embedded in rainbands

SEASONS & LOCATIONS FOR TROPICAL CYCLONES



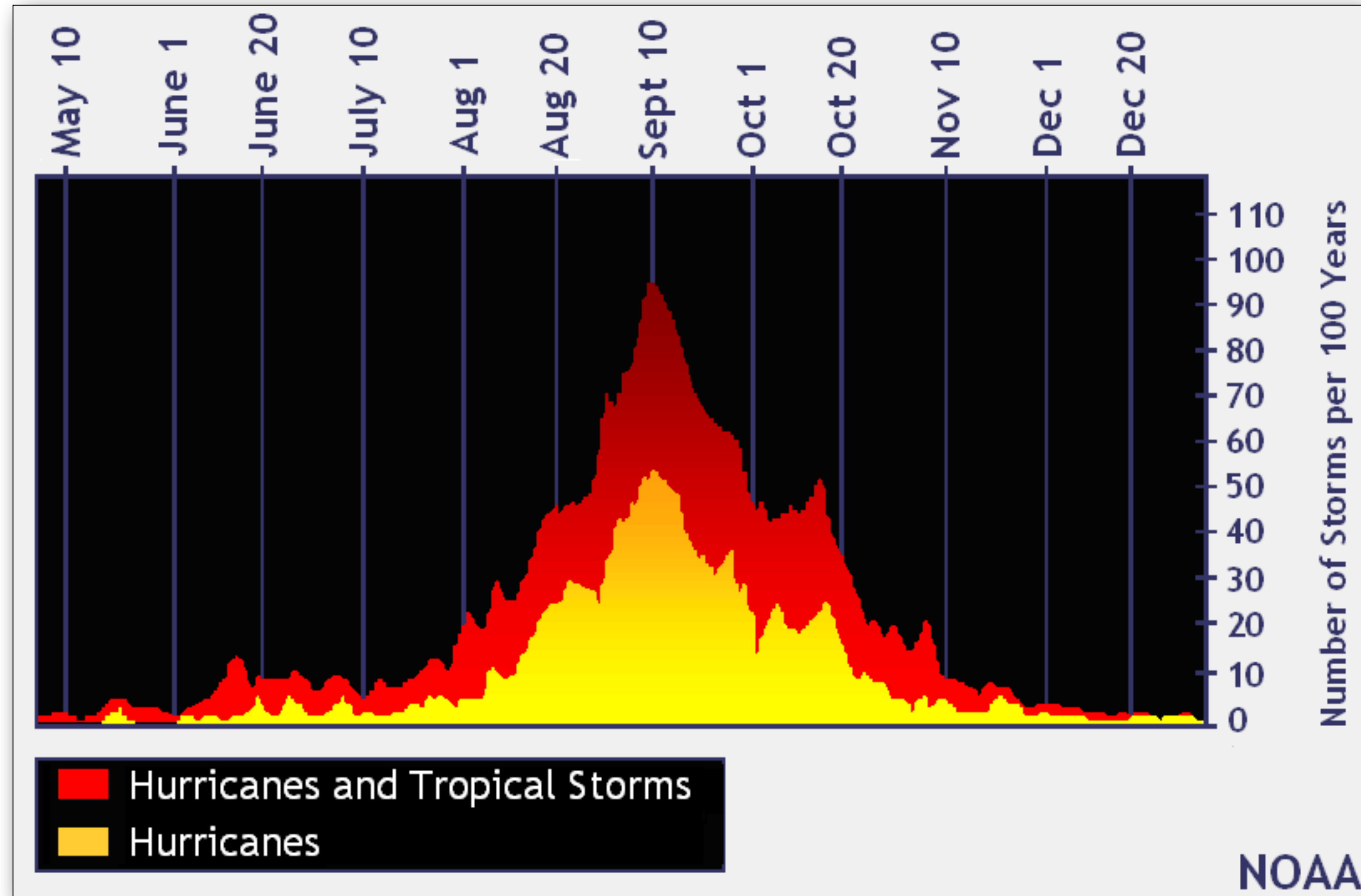
(a) Seven primary areas of tropical cyclone formation, with regional names and principal months of occurrence. Note that the general time period is the same for the Southern Hemisphere cyclones.

© 2017 Pearson Education, Inc.



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

ATLANTIC SEASON: JUNE 1ST TO NOVEMBER 30TH



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

SAFFIR-SIMPSON SCALE FOR HURRICANE DAMAGE

- Category 3-5 account for 83% of damages, but are only 21% of U.S. landfalling hurricanes



Table 4.3 Saffir–Simpson Hurricane Wind Scale		
Category	Wind Speed	Types of Damage
1	119–153 kmph (74–95 mph; 65–82 knots)	Some damage to homes
2	154–177 kmph (96–110 mph; 83–95 knots)	Extensive damage to homes; major roof and siding damage
3	178–208 kmph (111–129 mph; 96–112 knots)	Devastating damage; removal of roofs and gables
4	209–251 kmph (130–156 mph; 113–136 knots)	Catastrophic damage; severe damage to roofs and walls
5	> 252 kmph (> 157 mph; > 137 knots)	Catastrophic damage; total roof failure and wall collapse on high percentage of homes

© 2017 Pearson Education, Inc.



NOAA BILLION-DOLLAR DISASTERS (1980–2018)

- 1) Hurricane Katrina (2005) – \$165 Billion
- 2) Hurricane Harvey (2017) – \$127.5 Billion
- 3) Hurricane Maria (2017) – \$91.8 Billion
- 4) Hurricane Sandy (2012) – \$72.2 Billion
- 5) Hurricane Irma (2017) – \$51.0 Billion
- 6) Hurricane Andrew (1992) – \$49.4 Billion
- 7) ?**
- 8) ?**
- 9) Hurricane Ike (2008) – \$35.7 Billion
- 10)?**



NOAA BILLION-DOLLAR DISASTERS (1980–2018)

- 1) Hurricane Katrina (2005) – \$165 Billion
- 2) Hurricane Harvey (2017) – \$127.5 Billion
- 3) Hurricane Maria (2017) – \$91.8 Billion
- 4) Hurricane Sandy (2012) – \$72.2 Billion
- 5) Hurricane Irma (2017) – \$51.0 Billion
- 6) Hurricane Andrew (1992) – \$49.4 Billion
- 7) Drought/Heatwave (1988) – \$43.6 Billion**
- 8) ?
- 9) Hurricane Ike (2008) – \$35.7 Billion
- 10) Drought/Heatwave (2012) – \$33.3 Billion**

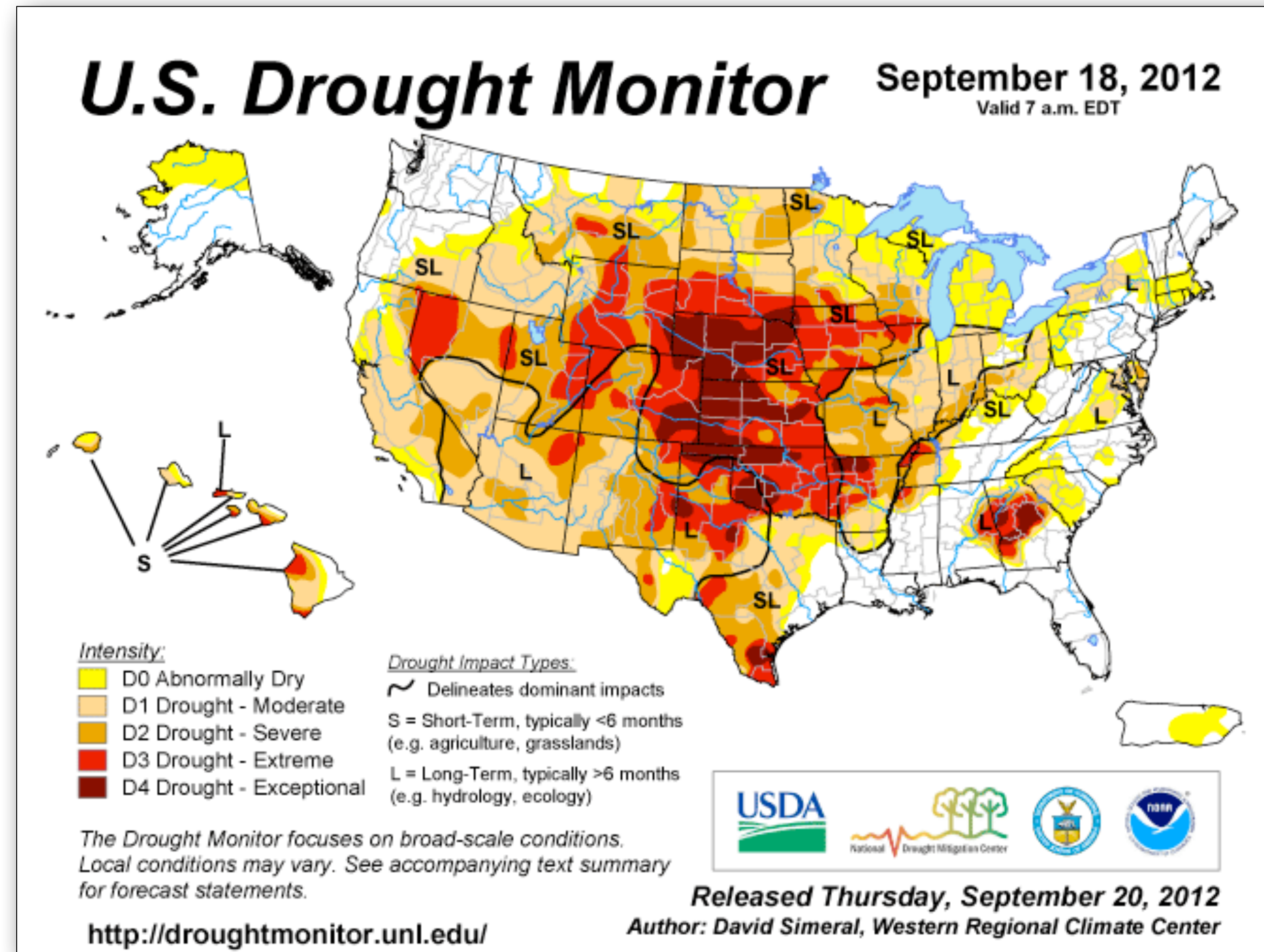


WHAT IS DROUGHT?

- **Drought** – the condition that occurs when water resources are insufficient to meet water needs
- **Meteorological drought** – below “normal” precipitation
- **Agricultural drought** – low soil moisture that affects vegetation health
- **Hydrologic drought** – deficiency of water in rivers, streams, groundwater, reservoirs, etc.
- **Ecological drought** – deficit in biologically available water that imposes multiple stresses in terrestrial & aquatic ecosystems



EXAMPLE OF DROUGHT EXTENT



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

SOME DROUGHT IMPACTS DURING 2011–2013

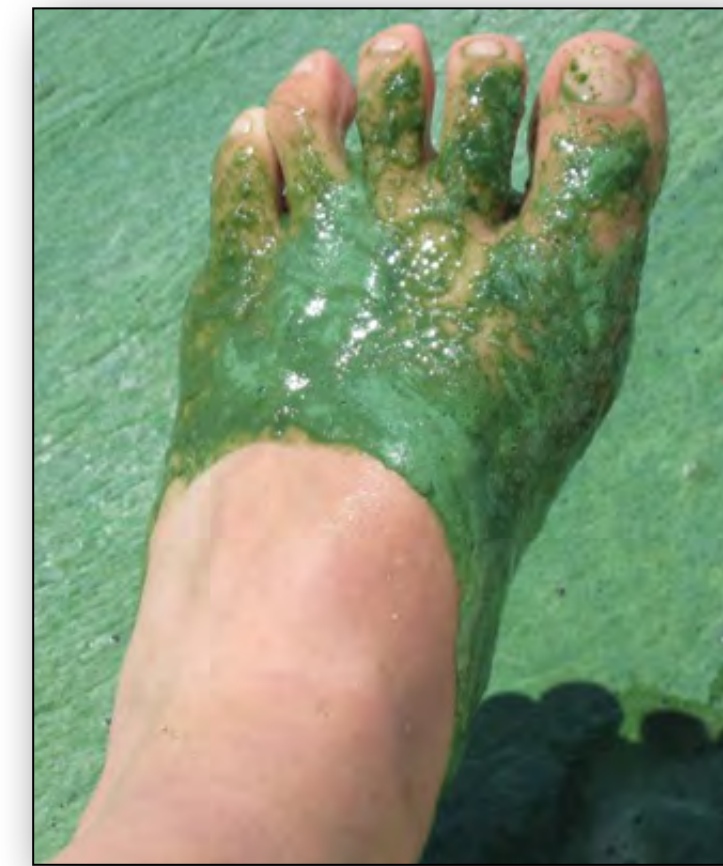
- **Reduced cattle herds** – poor grassland pasture conditions
- **Extreme heat** – OK summer 2011 hottest of any state on record
- In 2012, OK had 24 lakes with **harmful blue green algae** blooms
- In 2013, municipal **water quality and quantity threatened** in Canton Lake, Oklahoma City, Wichita Falls, and elsewhere



Wildfire near Noble, OK; Aug. 2012 (Reuters)



Cotton fields near Pocasset, OK; Aug. 2012 (AP)



NOAA BILLION-DOLLAR DISASTERS (1980–2018)

- 1) Hurricane Katrina (2005) – \$165 Billion
- 2) Hurricane Harvey (2017) – \$127.5 Billion
- 3) Hurricane Maria (2017) – \$91.8 Billion
- 4) Hurricane Sandy (2012) – \$72.2 Billion
- 5) Hurricane Irma (2017) – \$51.0 Billion
- 6) Hurricane Andrew (1992) – \$49.4 Billion
- 7) Drought/Heatwave (1988) – \$43.6 Billion
- 8) ?**
- 9) Hurricane Ike (2008) – \$35.7 Billion
- 10) Drought/Heatwave (2012) – \$33.3 Billion



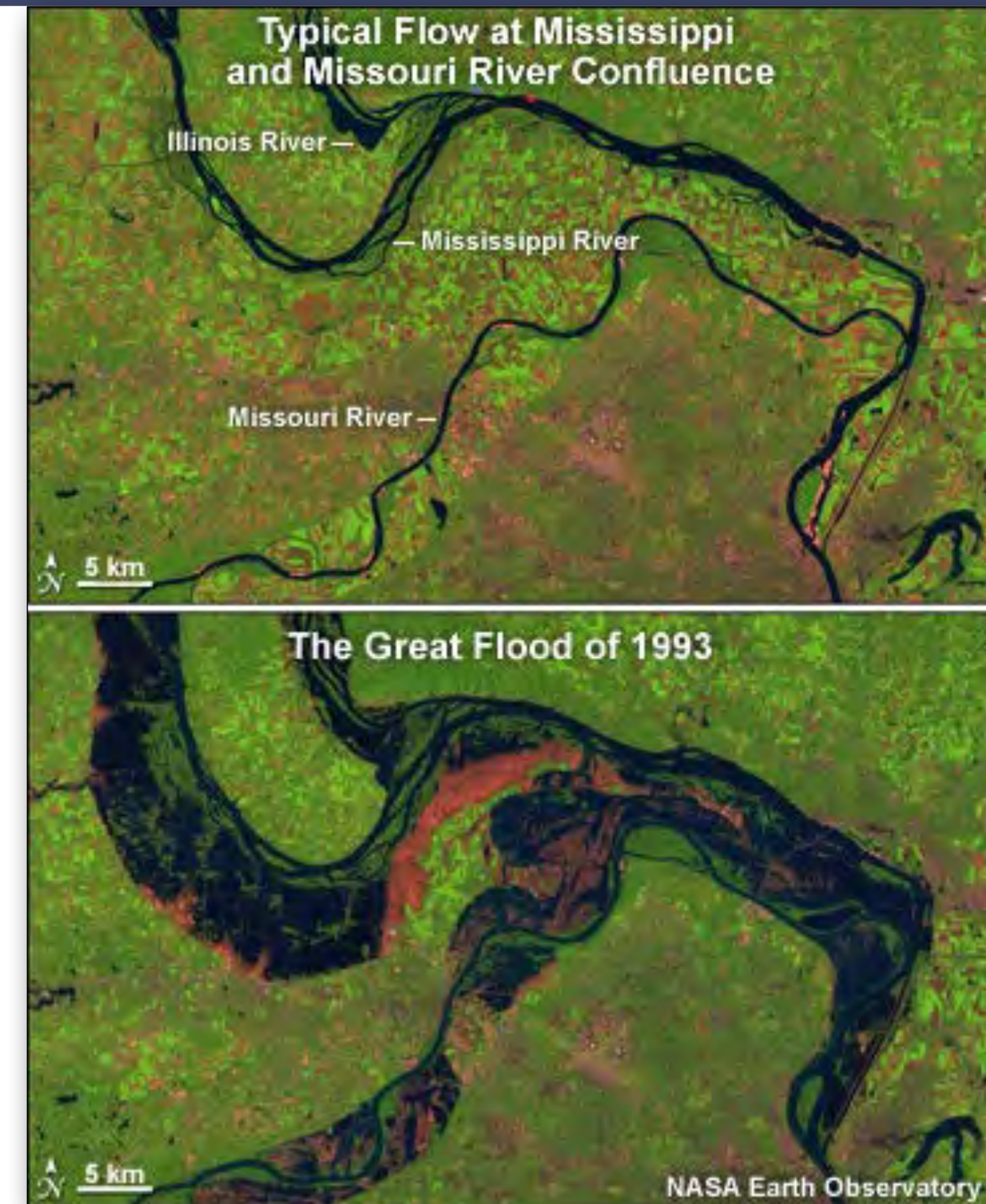
NOAA BILLION-DOLLAR DISASTERS (1980–2018)

- 1) Hurricane Katrina (2005) – \$165 Billion
- 2) Hurricane Harvey (2017) – \$127.5 Billion
- 3) Hurricane Maria (2017) – \$91.8 Billion
- 4) Hurricane Sandy (2012) – \$72.2 Billion
- 5) Hurricane Irma (2017) – \$51.0 Billion
- 6) Hurricane Andrew (1992) – \$49.4 Billion
- 7) Drought/Heatwave (1988) – \$43.6 Billion
- 8) Midwest Flooding (1993) – \$37 Billion**
- 9) Hurricane Ike (2008) – \$35.7 Billion
- 10) Drought/Heatwave (2012) – \$33.3 Billion



THE GREAT FLOOD OF 1993

- Transportation interruption
- Displacement of low income residents
- Average flood statistics (1986-2015)
 - \$7.96 Billion damage per year
 - 82 deaths per year
 - 40-50% of deaths are vehicle related



SOME OKLAHOMA FLOOD EVENTS

- **Summer of 2007**
 - OK's wettest June on record
 - River flooding in July
 - Lake Texoma overtopped spillway
 - Remnants of Tropical Storm Erin alone caused 6 deaths & \$4M in damage



Rooster Creek Bridge,
Lake Texoma, July 2007
(The Oklahoman)



Oklahoma City on
May 31, 2013 (AP)

- **Oklahoma City Flash Flood May 31–June 1, 2013**
 - Parts of OKC had over 7 inches of rain
 - Deadliest flash flood in city history (13 people died; 12 in Oklahoma City)



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

TYPES OF FLOODING

- **River Flooding**

- When river spills over its banks; excess water from upstream or persistent rainfall or snowmelt
- Slow onset & widespread
- Primary threats: Economic & property damage

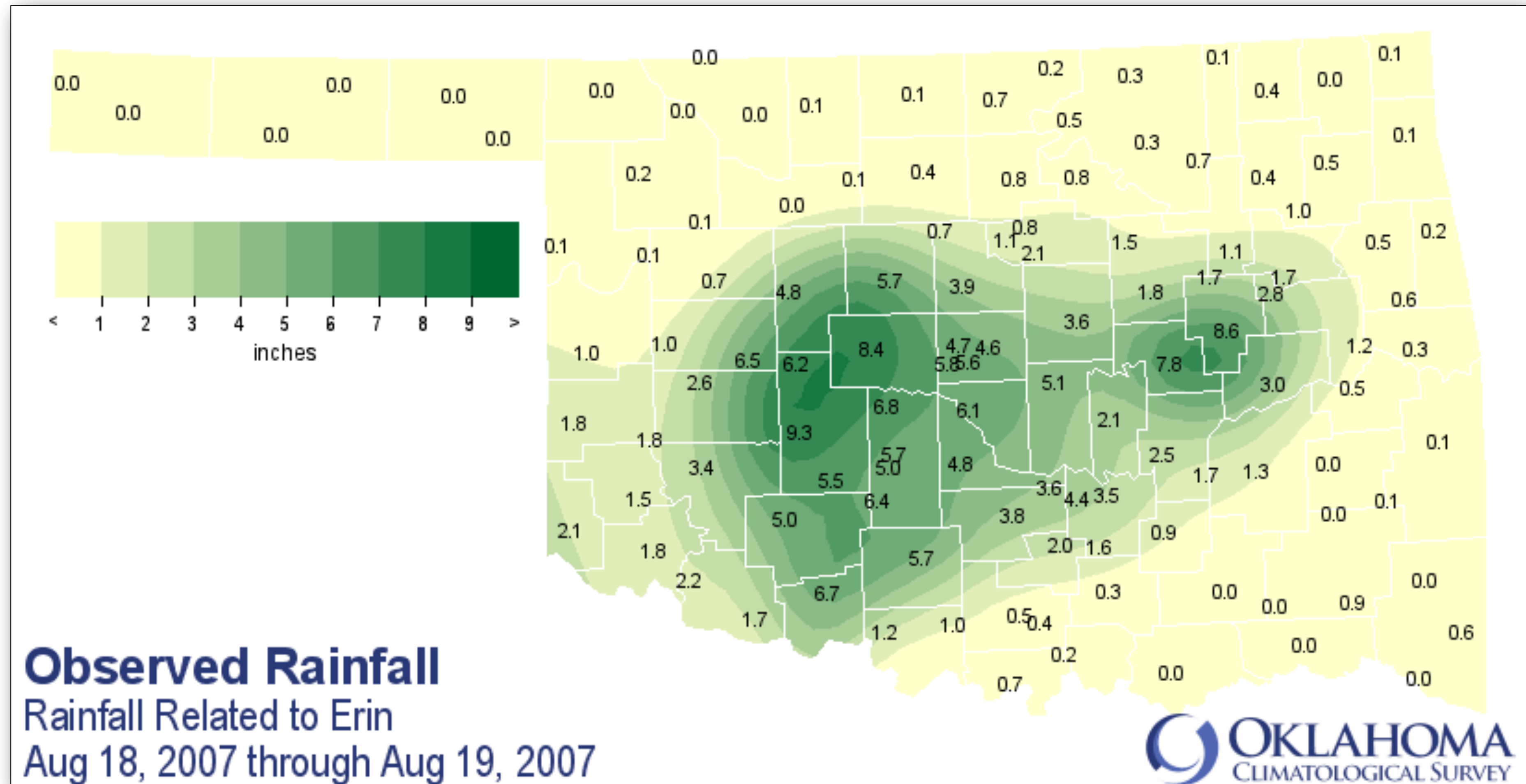


- **Flash Flooding**

- When rain falls too quickly for runoff to drain
- Fast onset
- Primary threat: human safety

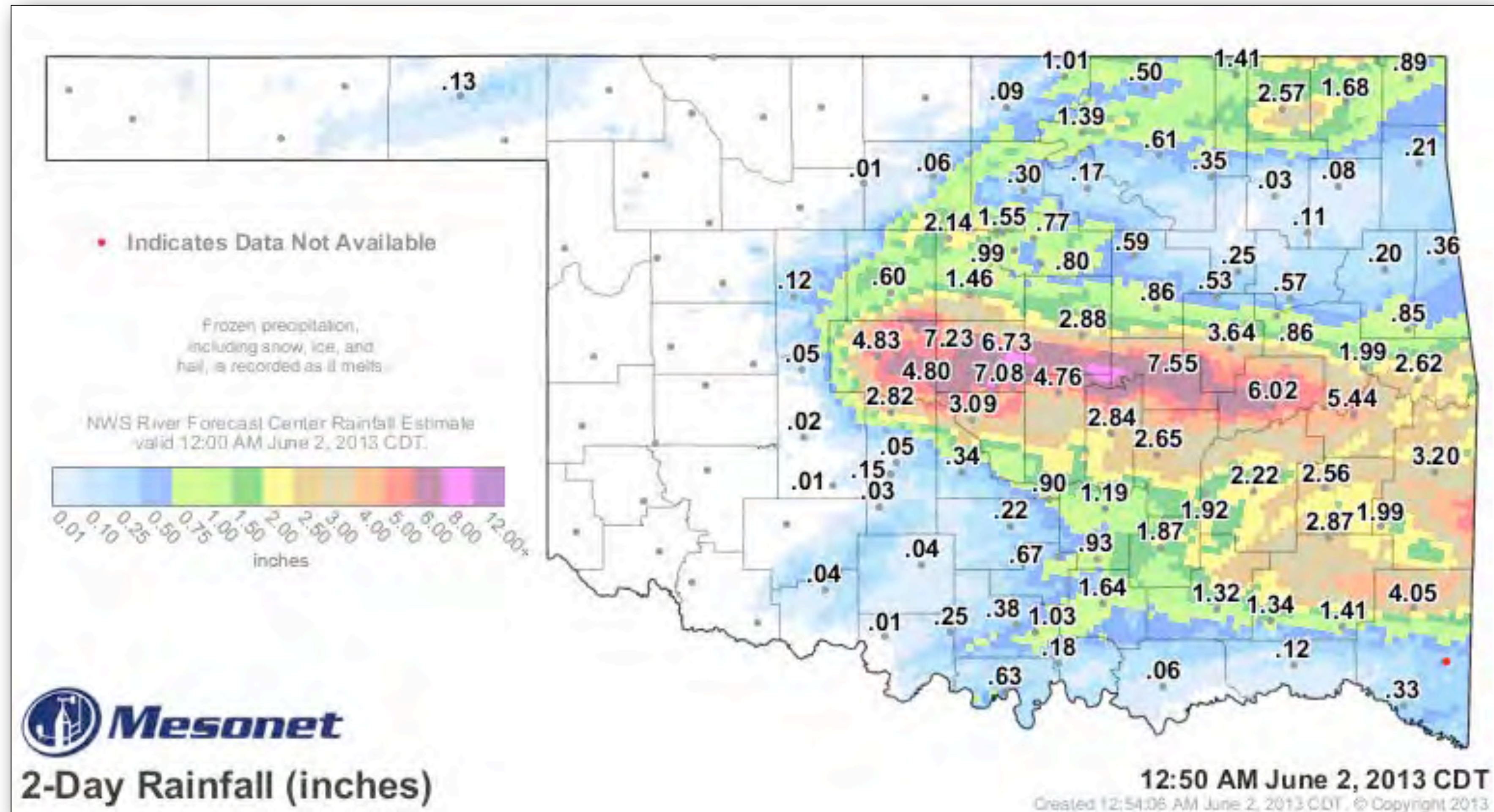


EXAMPLE OF SPATIAL DIFFERENCES



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

EXAMPLE OF SPATIAL DIFFERENCES

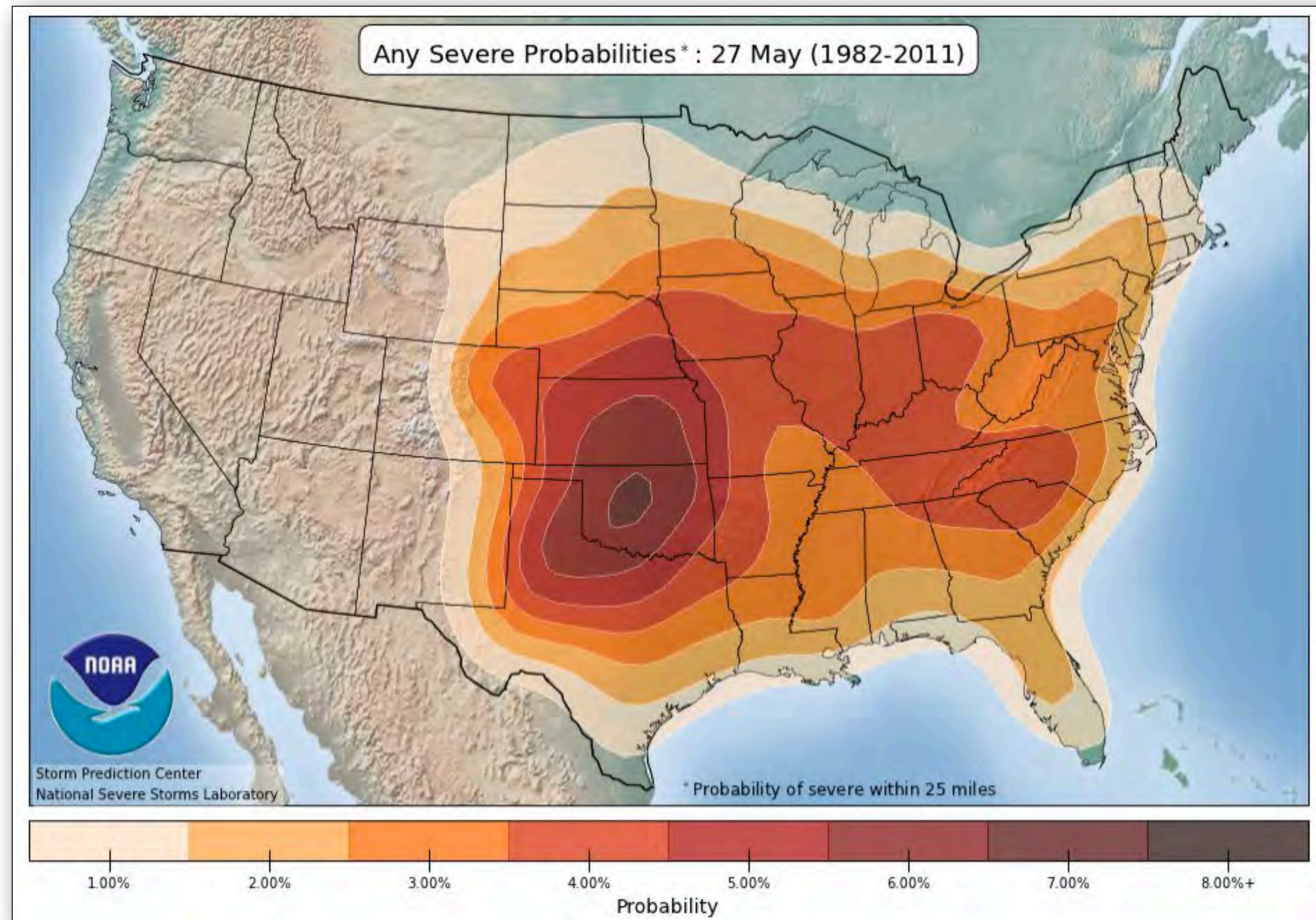


SEVERE THUNDERSTORMS

- Defined by the U.S. National Weather Service as a thunderstorm that has **one or more of the following attributes**:
 - Tornado
 - Wind speeds greater than **57 mph**
 - Hail greater than **1-inch diameter**
- Nearly 100,000 thunderstorms occur around the United States annually
 - Of these, about **10% are severe**

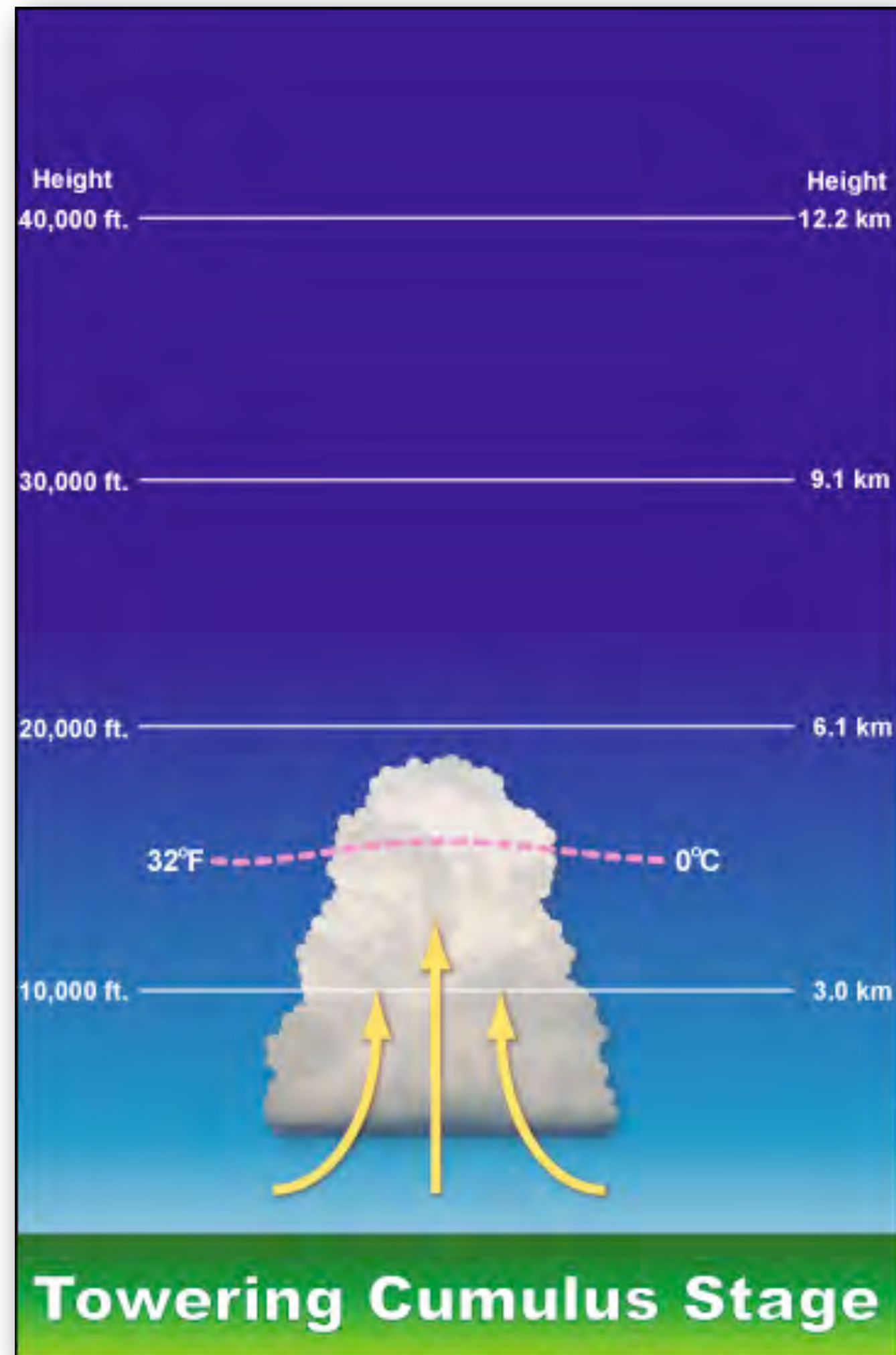


SEVERE WEATHER CLIMATOLOGY



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

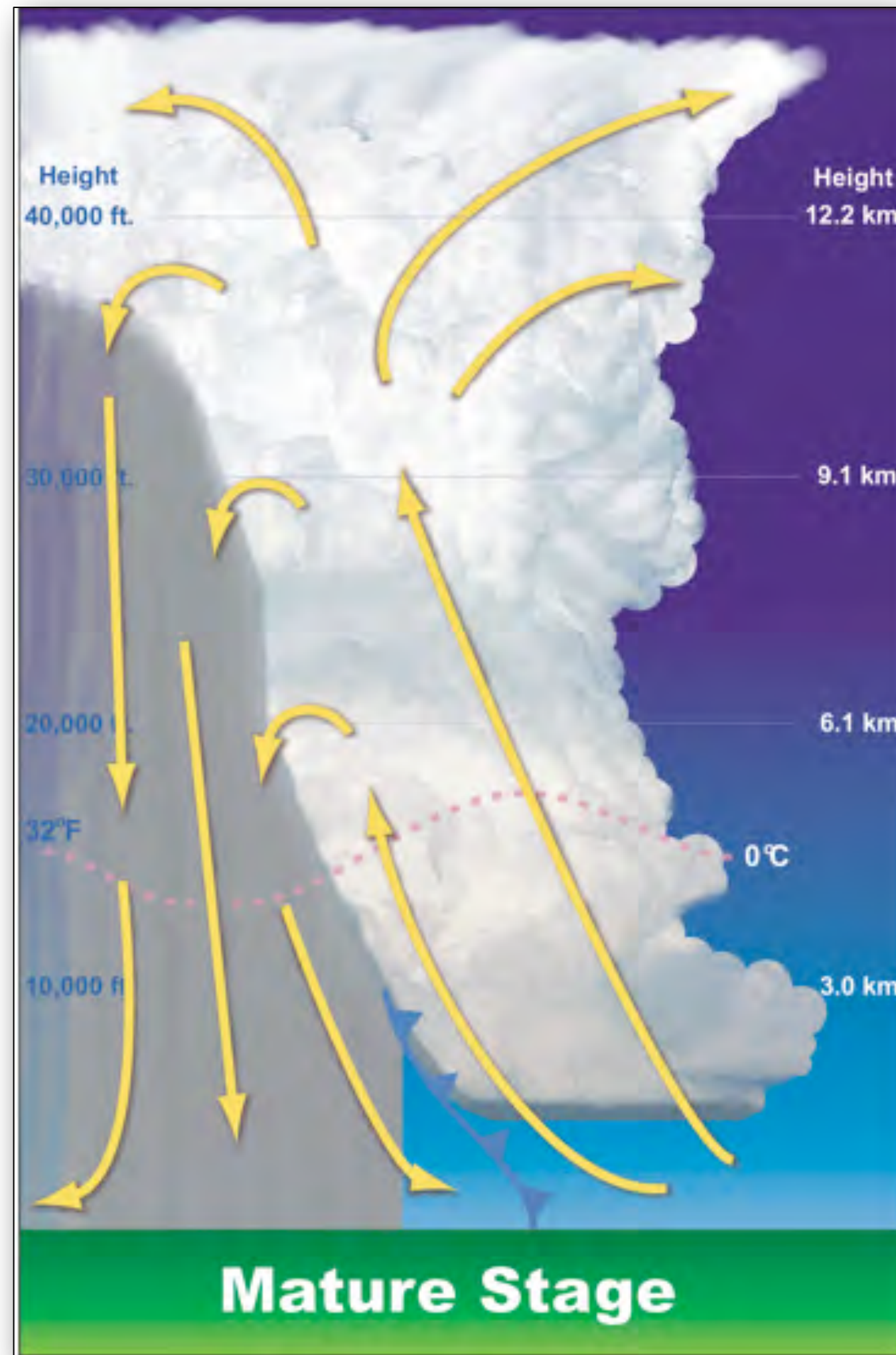
CUMULUS STAGE OF THUNDERSTORM



- Usually little, if any, rain during this stage
- Lasts about 10 minutes
- Occasional lightning



MATURE STAGE OF THUNDERSTORM

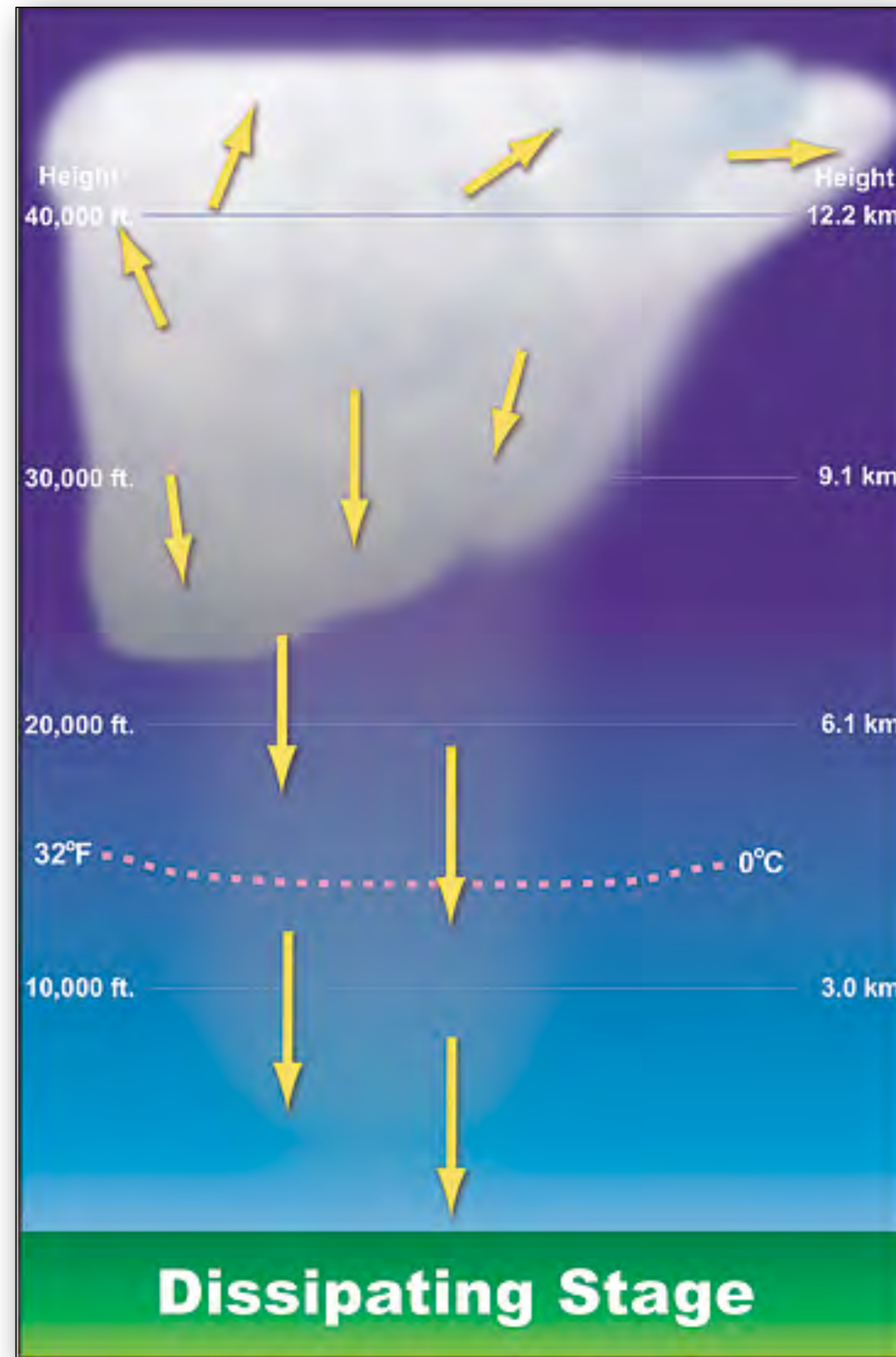


- Most likely time for hail, heavy rain, lightning, strong winds, & tornadoes
- Lasts 10-20 min. but may last much longer in some storms



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

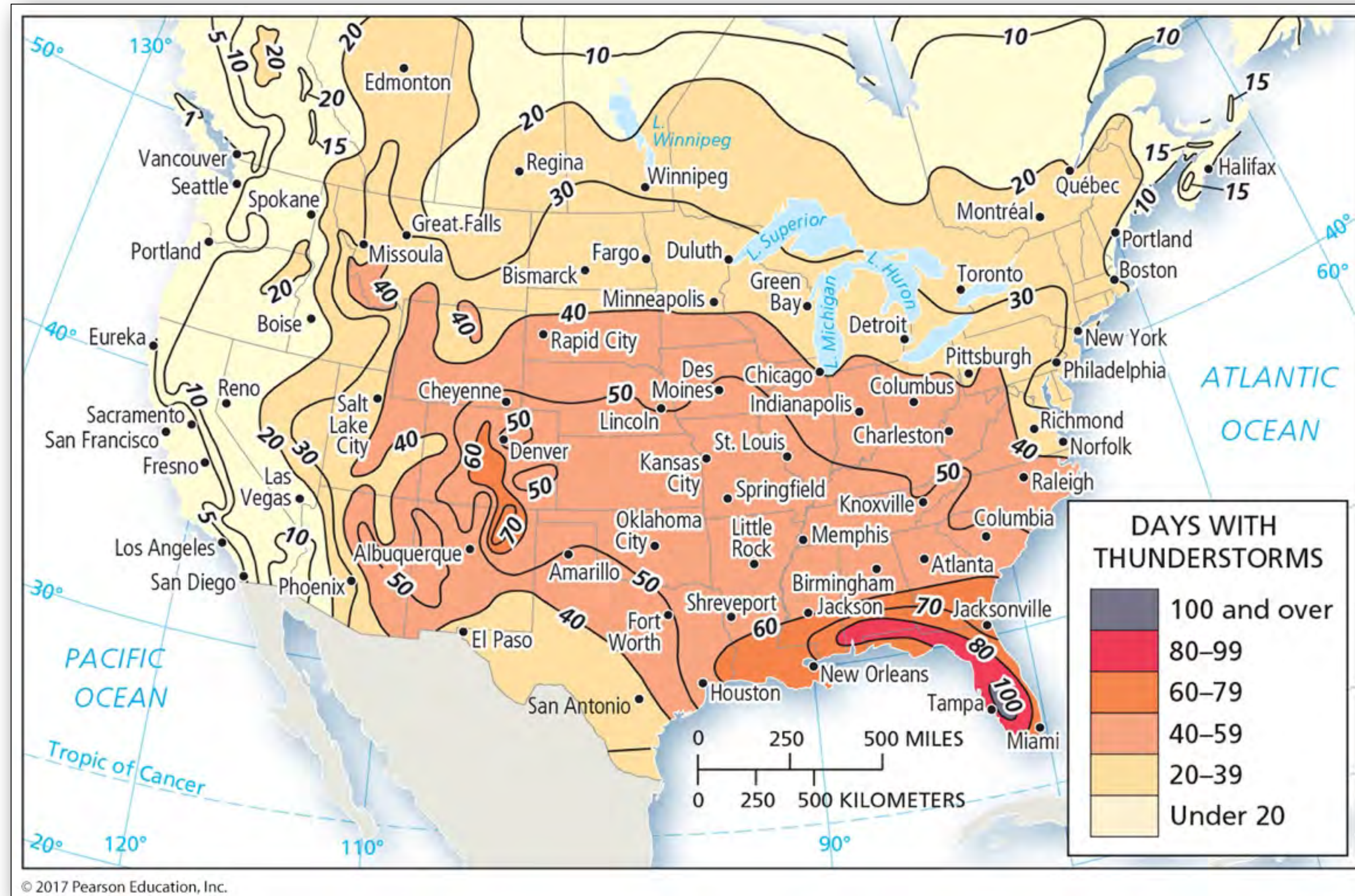
DISSIPATING STAGE OF THUNDERSTORM



- Rainfall decreases in intensity
- Some storms produce a burst of strong winds during this stage
- Lightning remains a danger



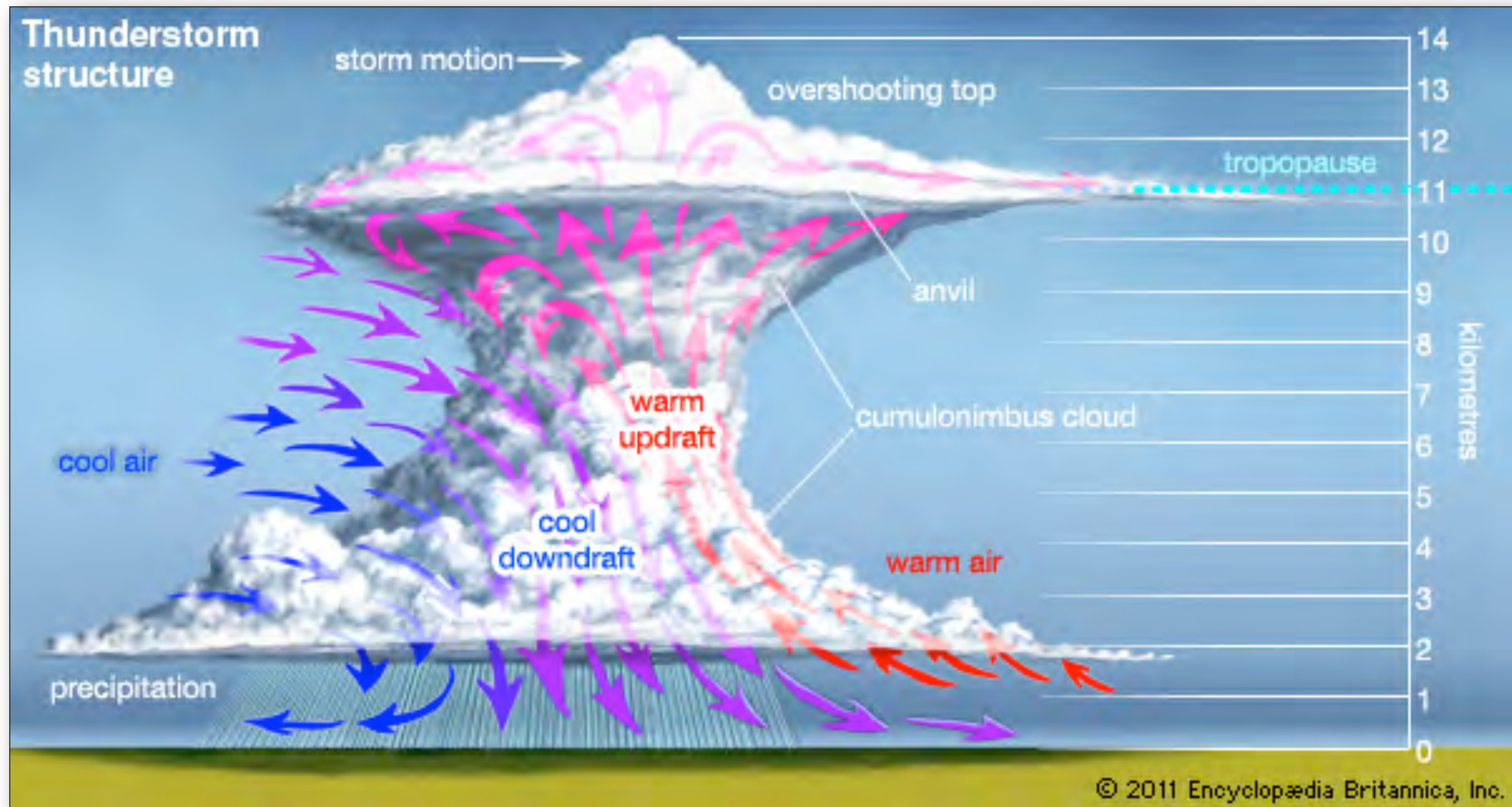
AVERAGE THUNDERSTORM DAYS IN U.S.



SUPERCCELL THUNDERSTORM

- **Thunderstorm ingredients: sufficient moisture** (humid air), **instability** (warm air near surface & cold, dry air aloft), **and lift** (upward motion)
- **One additional ingredient for supercell: wind shear** (change in direction and speed of the wind with height); **produces rotation within the storm**
- Single-cell thunderstorm that may **persist for hours**
- **Main threats: large & long-lived tornadoes, large hail, strong winds, flash flooding**

SUPERCCELL THUNDERSTORM STRUCTURE



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

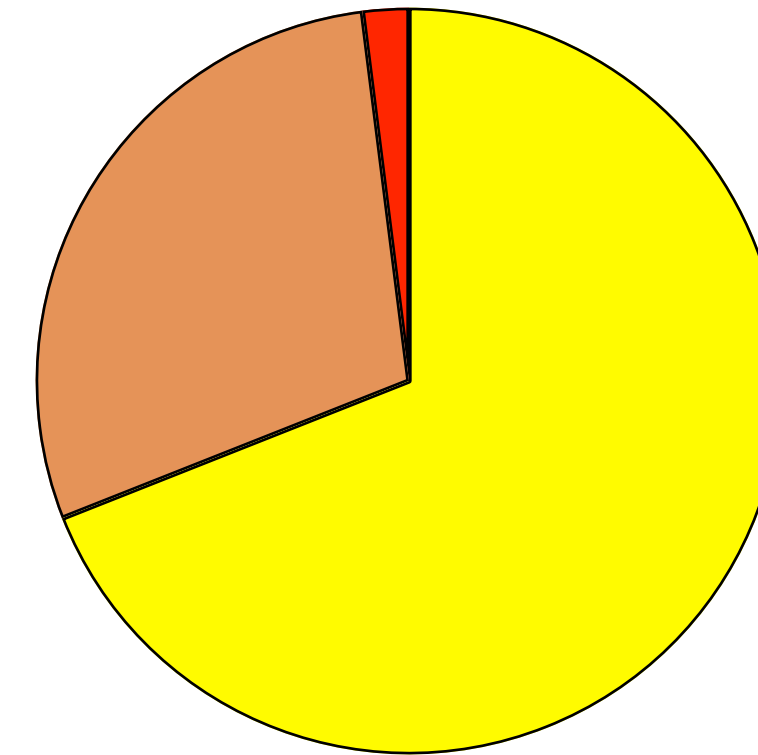
TORNADO

- Violently rotating column of air descending from thunderstorm in contact with the ground
 - May have wind speeds over 300 mph
- ~1,000 tornadoes occur in U.S. annually; average of 62 deaths
- Usually brief, but may last more than an hour & travel for tens of miles
- Rated on Enhanced Fujita scale

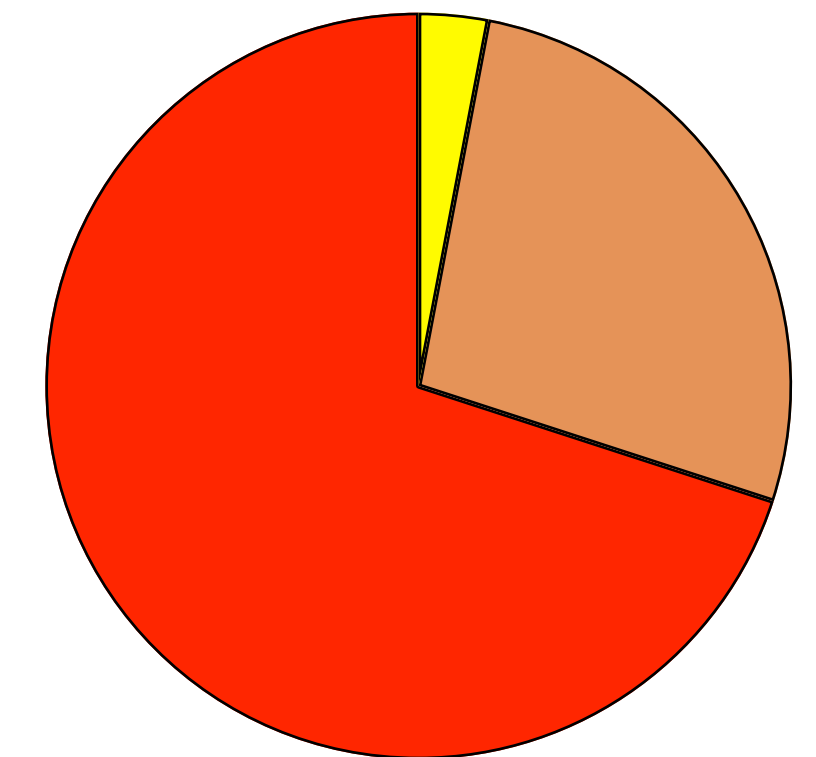
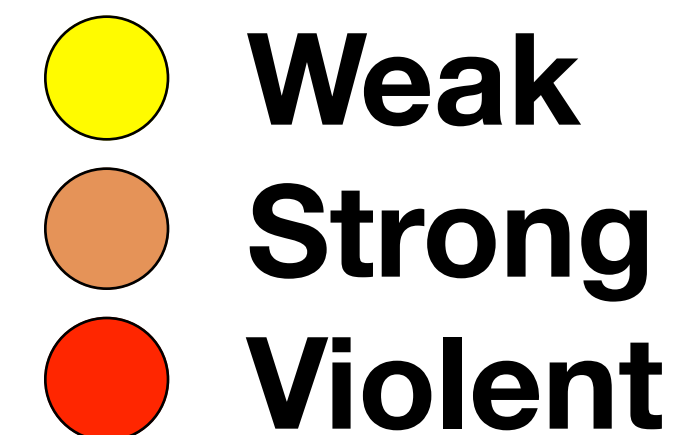


ENHANCED FUJITA (EF) SCALE

EF Number		Wind Speed (mph)
EF0	Weak	65-85
EF1	Weak	86-109
EF2	Significant/ Strong	110-137
EF3	Significant/ Strong	138-167
EF4	Significant/ Violent	168-199
EF5	Significant/ Violent	200-234



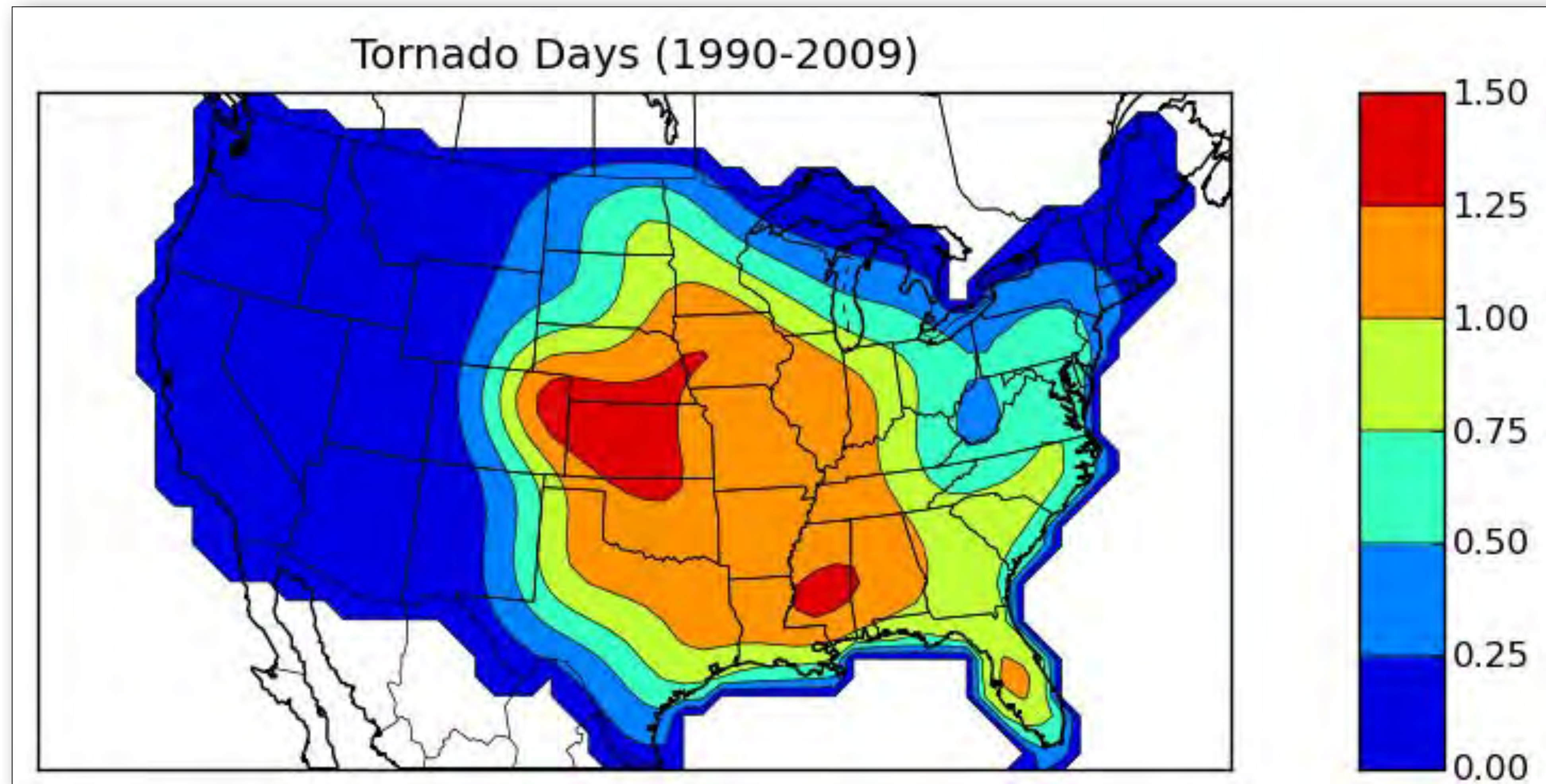
Number of tornadoes by strength



Tornadoes deaths by strength

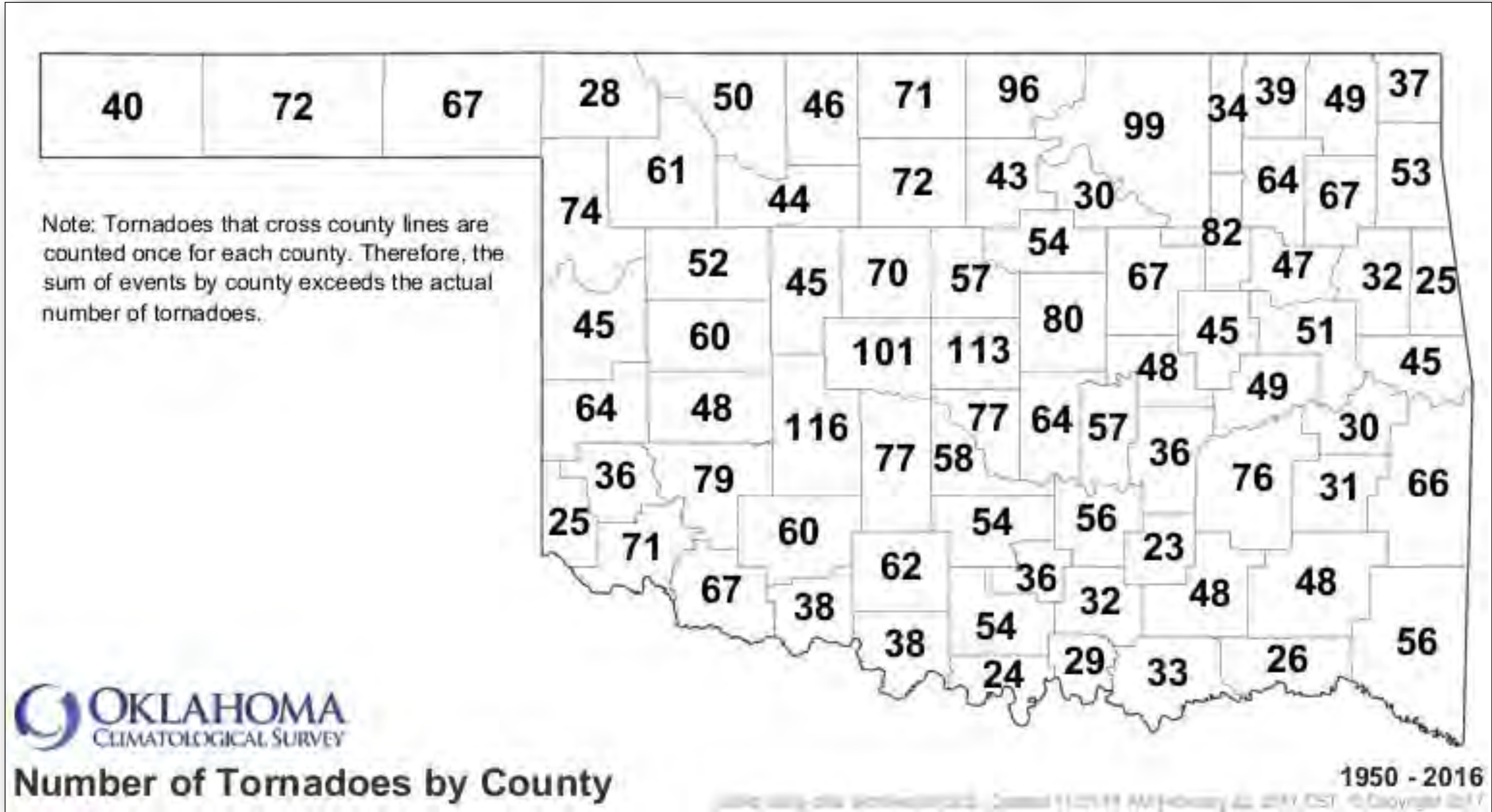


TORNADO DAYS IN THE U.S.

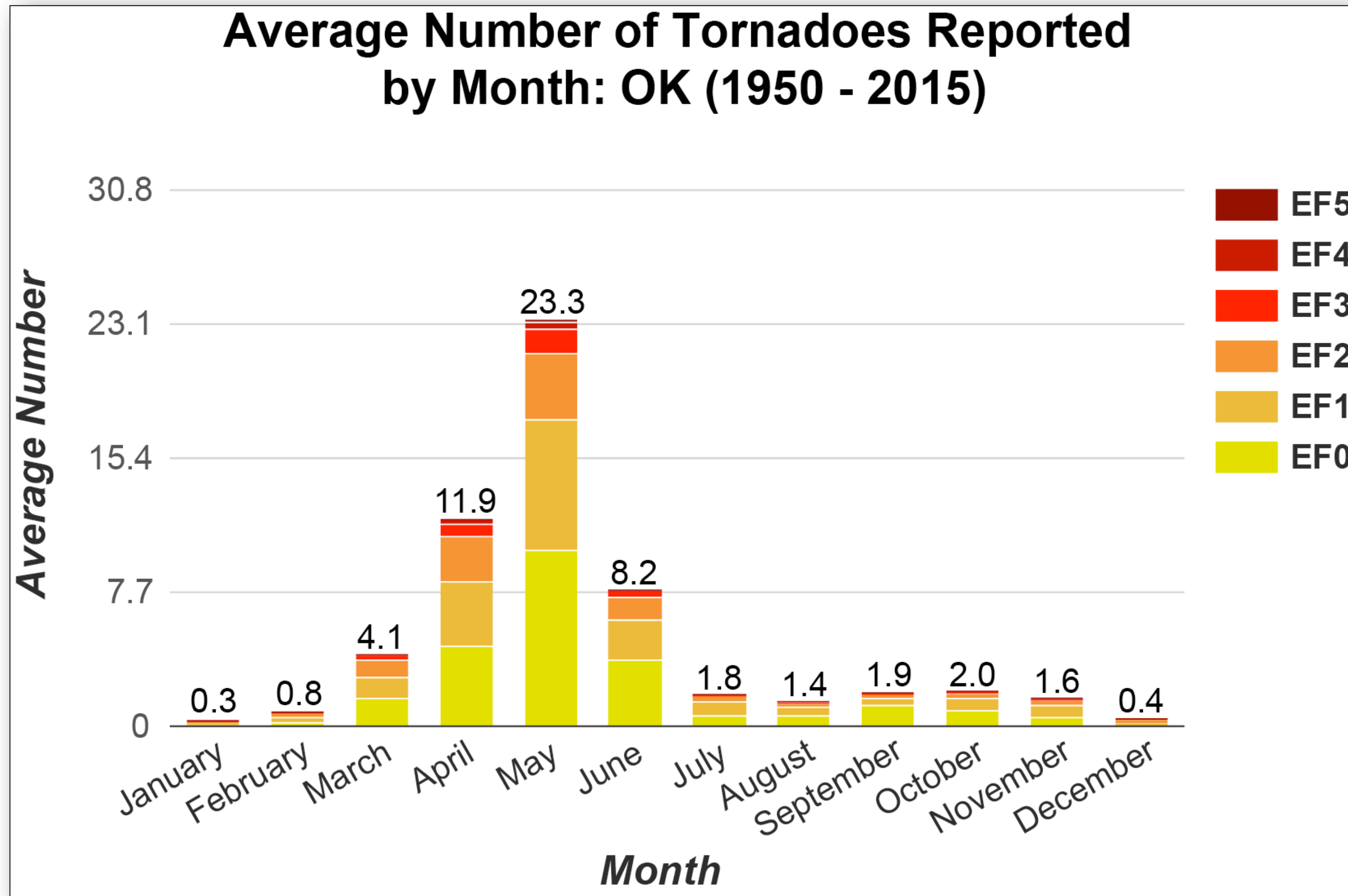


SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

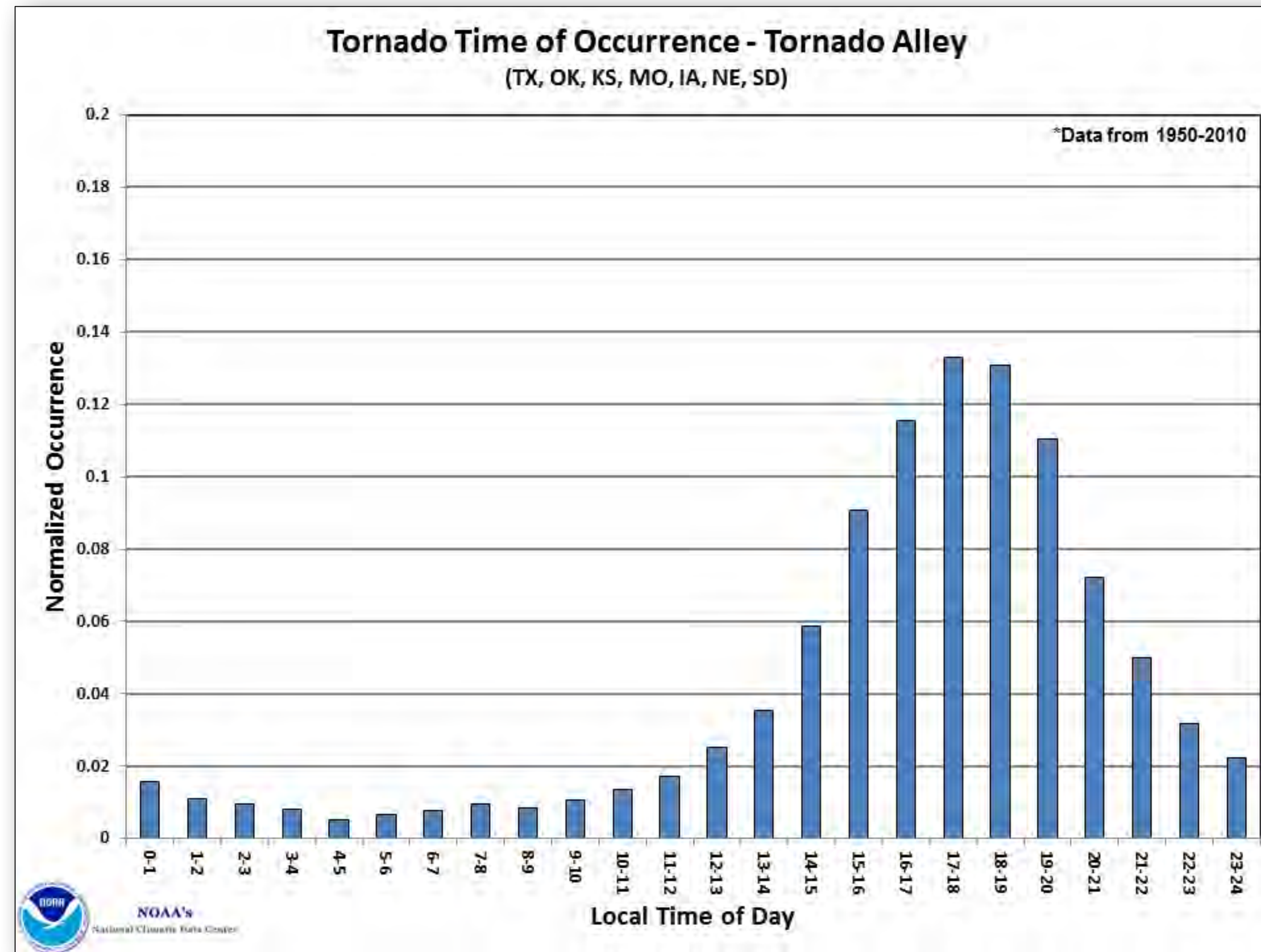
TORNADO CLIMATOLOGY



TORNADO CLIMATOLOGY



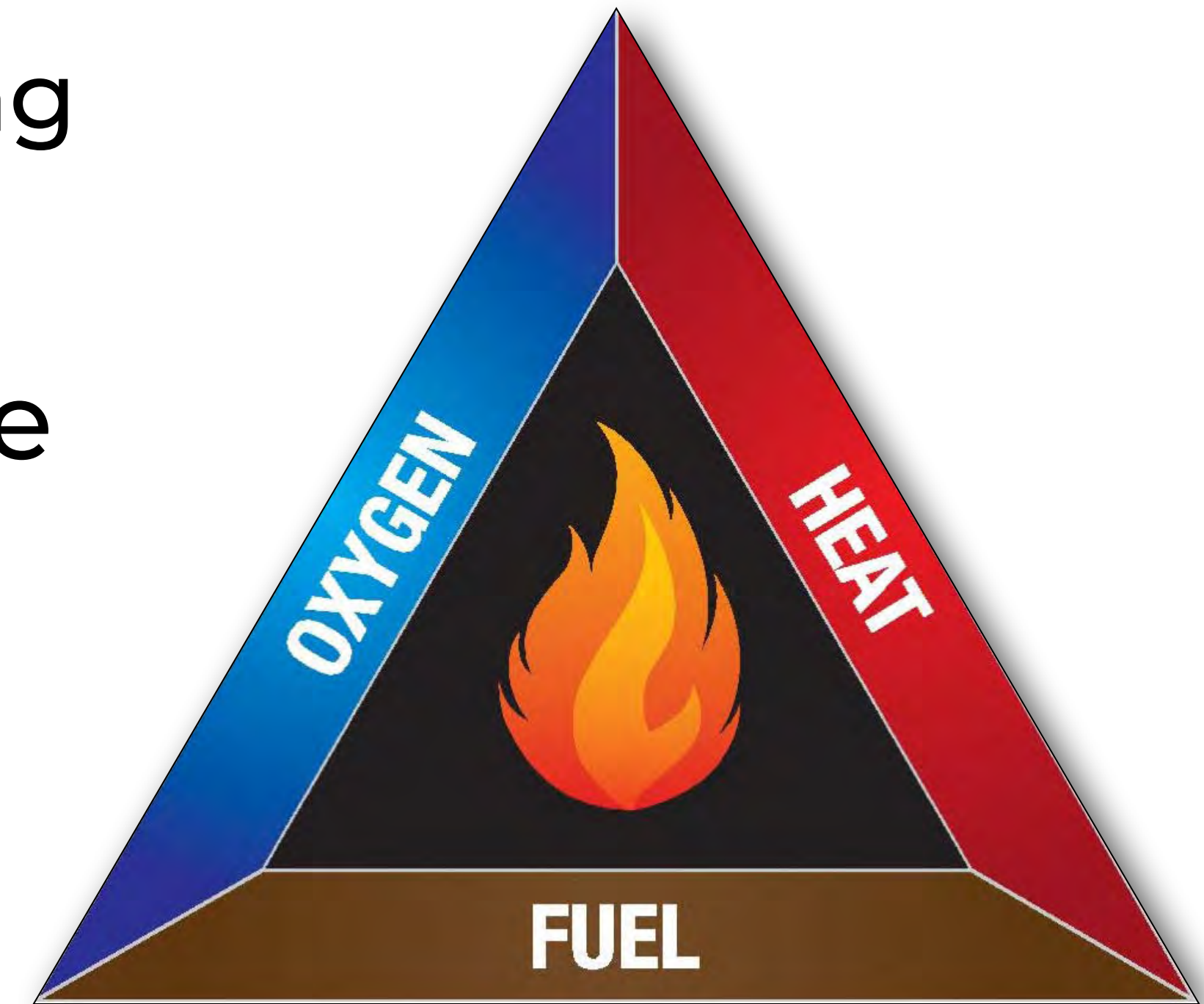
TORNADO CLIMATOLOGY



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

WILDFIRES

- **Fire triangle** – fire requires: oxygen, fuel, and heat
- Wildfires can develop quickly any time of the year
 - most are late fall through early spring
 - dormant vegetation & dry season
- **Urban-wildland interface** – where developed areas mingle with undeveloped areas
 - particularly susceptible to wildfires



MARCH 2017 WILDFIRES IN OKLAHOMA

- March 4-7, 2017
 - 400,000 acres burned in Oklahoma, 400,000 acres in Kansas, & 325,000 in Texas Panhandle
 - drought combined with strong winds & low humidities to create conditions for wildfires



climatesignals.org



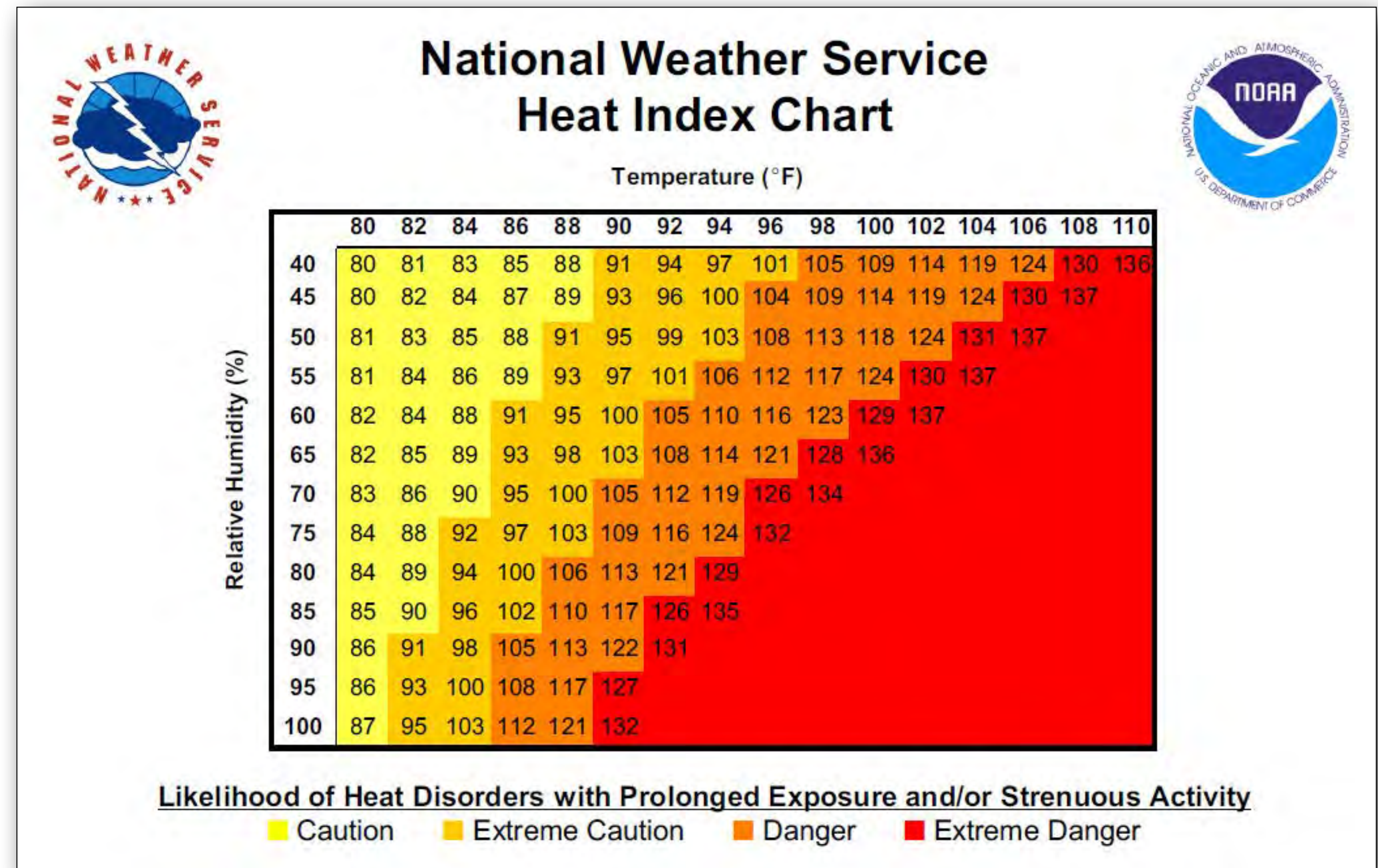
Bo Rader/The
Wichita Eagle via AP



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

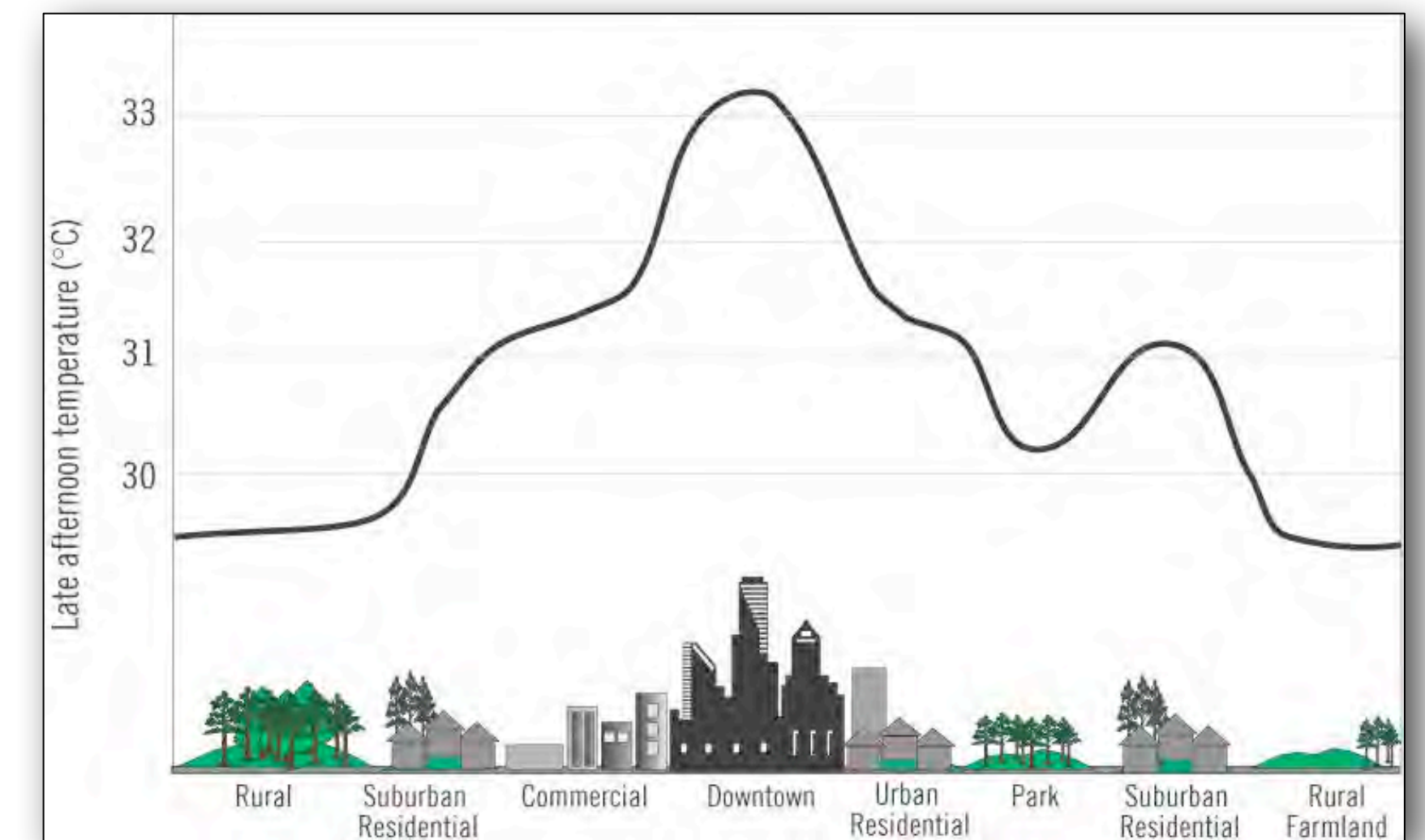
EXTREME HEAT

- **Heat index** – how hot it “feels” on exposed skin; due to high humidity & lack of evaporative cooling



EXTREME HEAT

- The Centers for Disease Control (CDC) report average of over **600 deaths per year from excessive heat**
 - Those at highest risk include people without access to air conditioning, chronically ill, elderly, very young, socially isolated, and disabled
- Effects are **enhanced in urban areas** due to heat island effect
 - Asphalt and concrete absorb & retain more heat, not allowing area to cool as much overnight



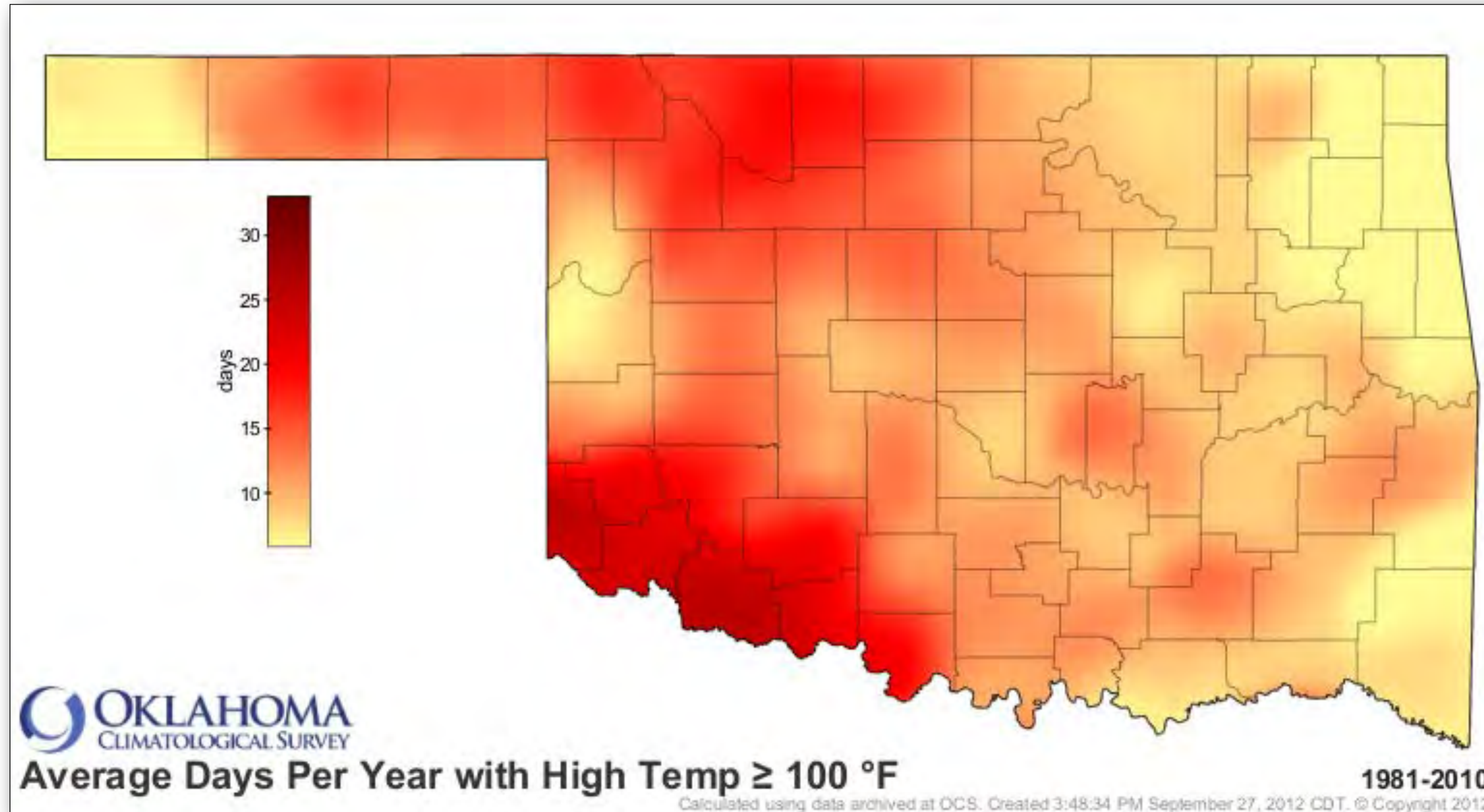
HEAT-RELATED MORTALITY

- 2003 European Heat Wave from June to August
 - Over 70,000 deaths attributed to heat, with over 15,000 in France alone
- 2010 Russian Heatwave in July & August
 - Over 55,000 deaths attributed to heat

HEAT EXHAUSTION	OR	HEAT STROKE
Faint or dizzy		Throbbing headache
Excessive sweating		No sweating
Cool, pale, clammy skin		Body temperature above 103° Red, hot, dry skin
Nausea or vomiting		Nausea or vomiting
Rapid, weak pulse		Rapid, strong pulse
Muscle cramps		May lose consciousness
• Get to a cooler, air conditioned place • Drink water if fully conscious • Take a cool shower or use cold compresses		CALL 9-1-1 • Take immediate action to cool the person until help arrives
Weather.gov/socialmedia Weather.gov/heat		@SacramentoOES SacramentoReady.org



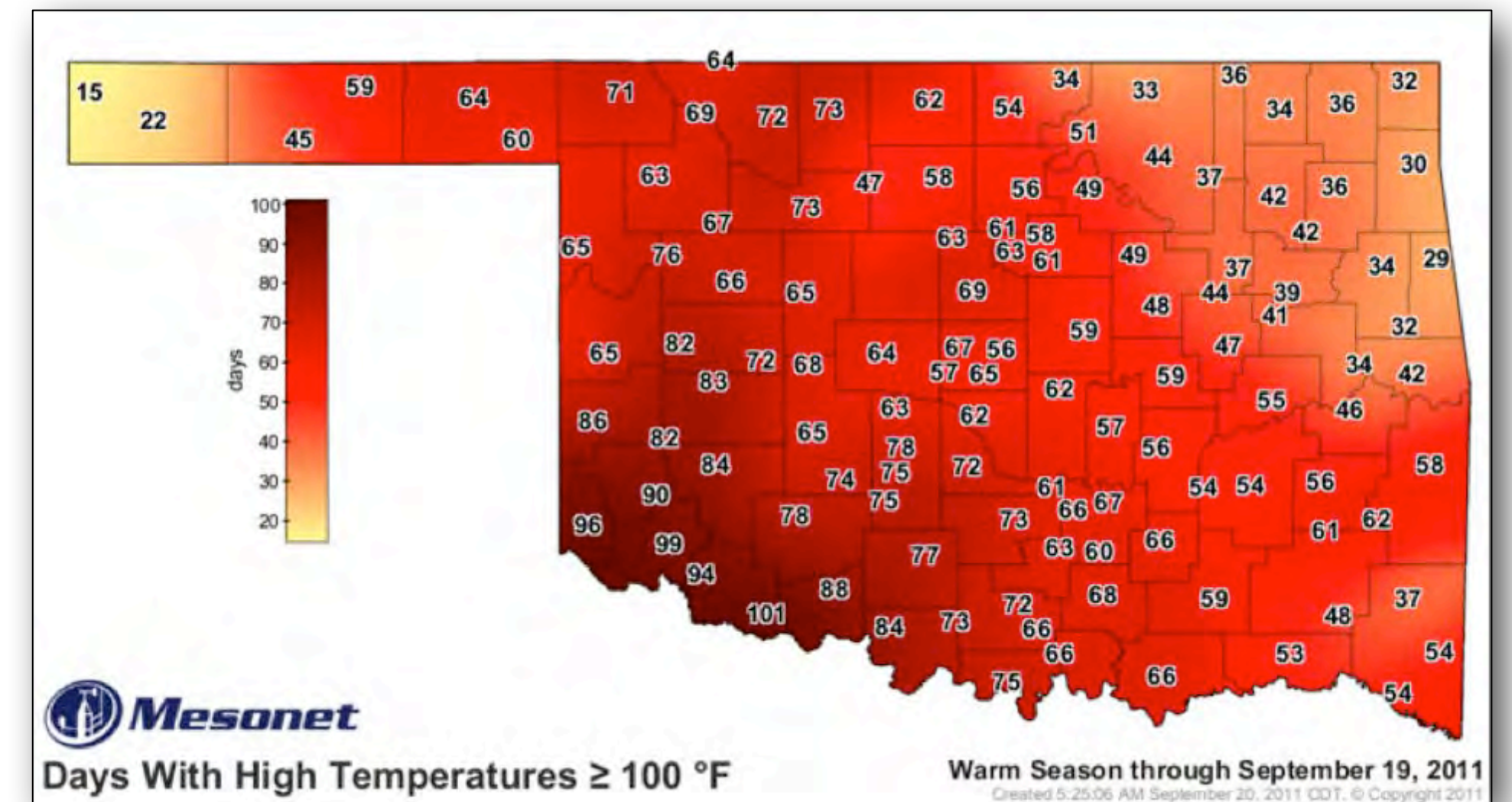
EXTREME HEAT



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

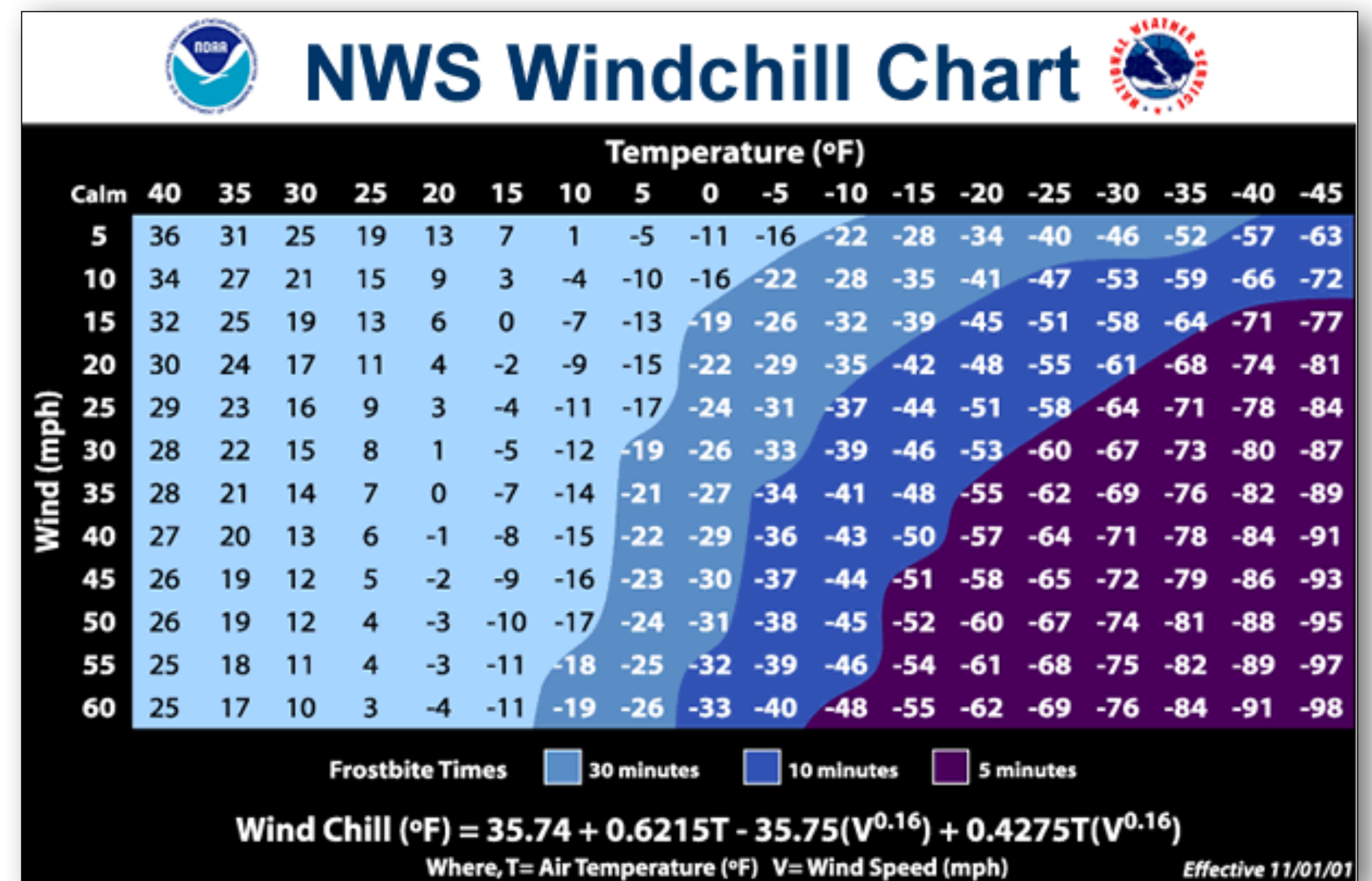
EXTREME HEAT OF 2011

- In 2011, Oklahoma had hottest month on record for any state (since record-keeping began in 1895)
 - July 2011 (statewide average 89.1° F)
 - Hot summers with long durations above 100° F often occur during droughts
- Oklahoma's hottest summer on record
 - 2011 (statewide average of 86.8° F)
 - 100 days of $\geq 100^{\circ}\text{F}$ in southwest Oklahoma

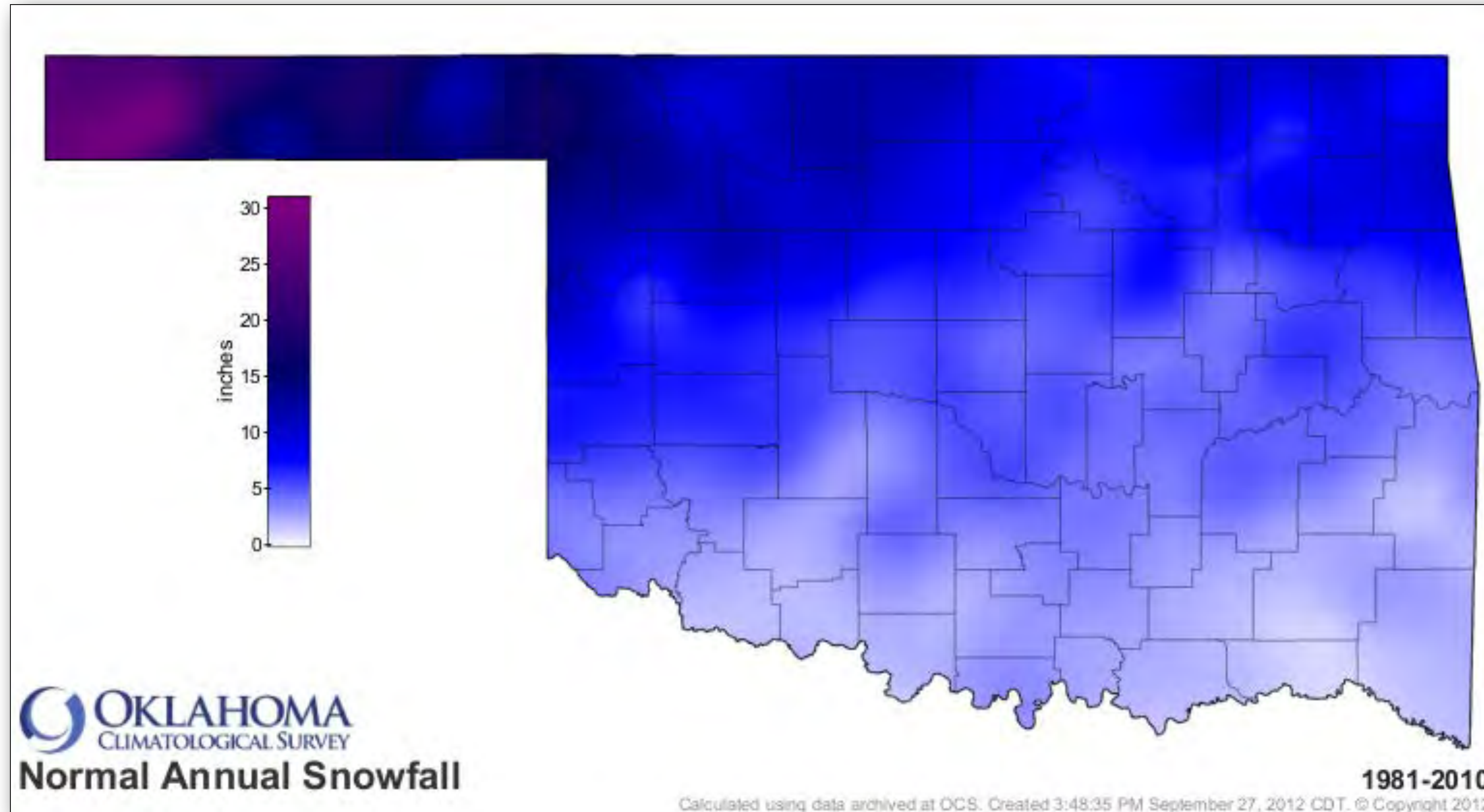


WINTER WEATHER

- **Winter precipitation** – snow, sleet, & freezing rain
- **Winter storms** – blizzards, ice storms
- **Extreme cold temperatures** – wind chill (how cold it “feels” on exposed skin)



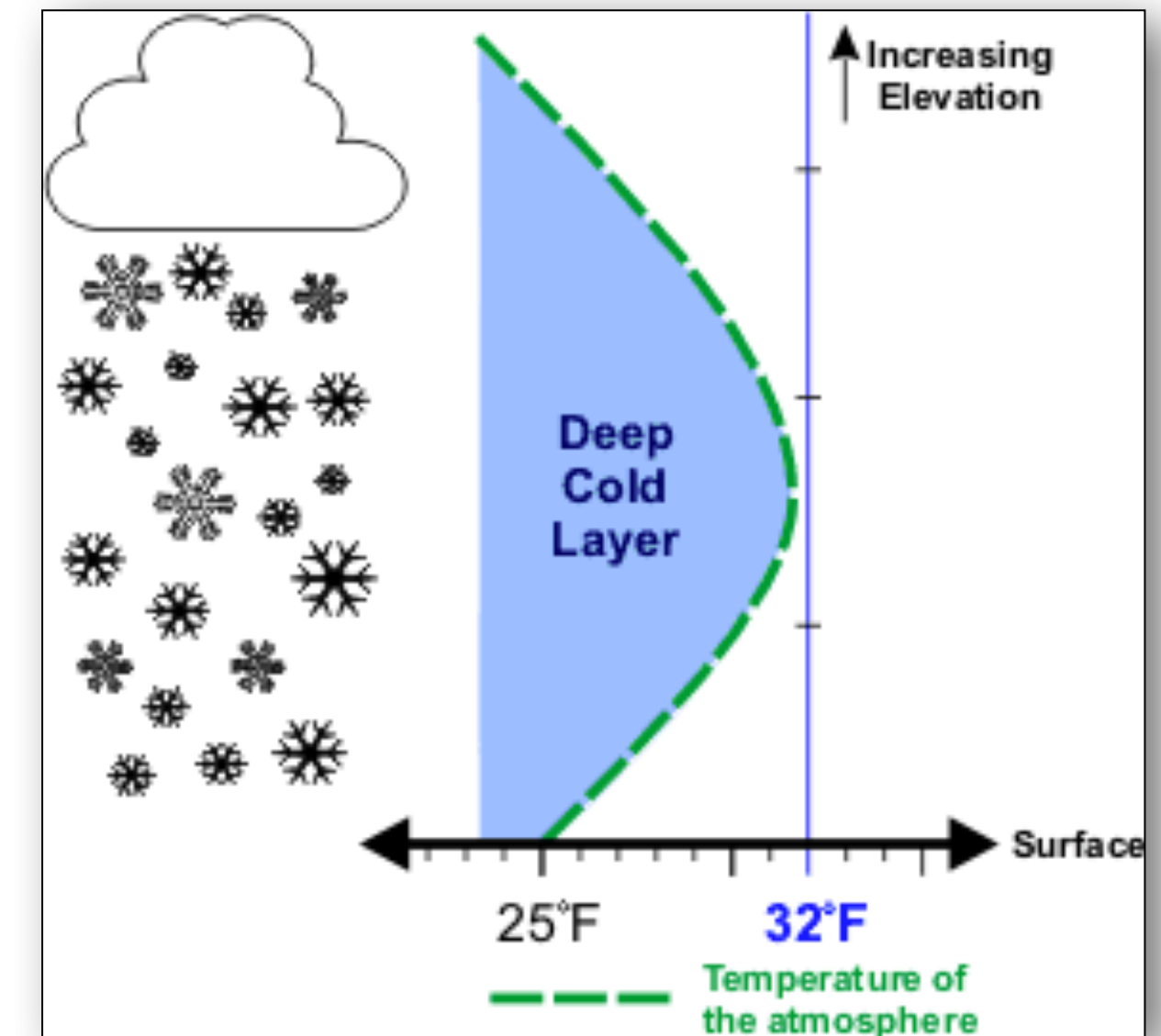
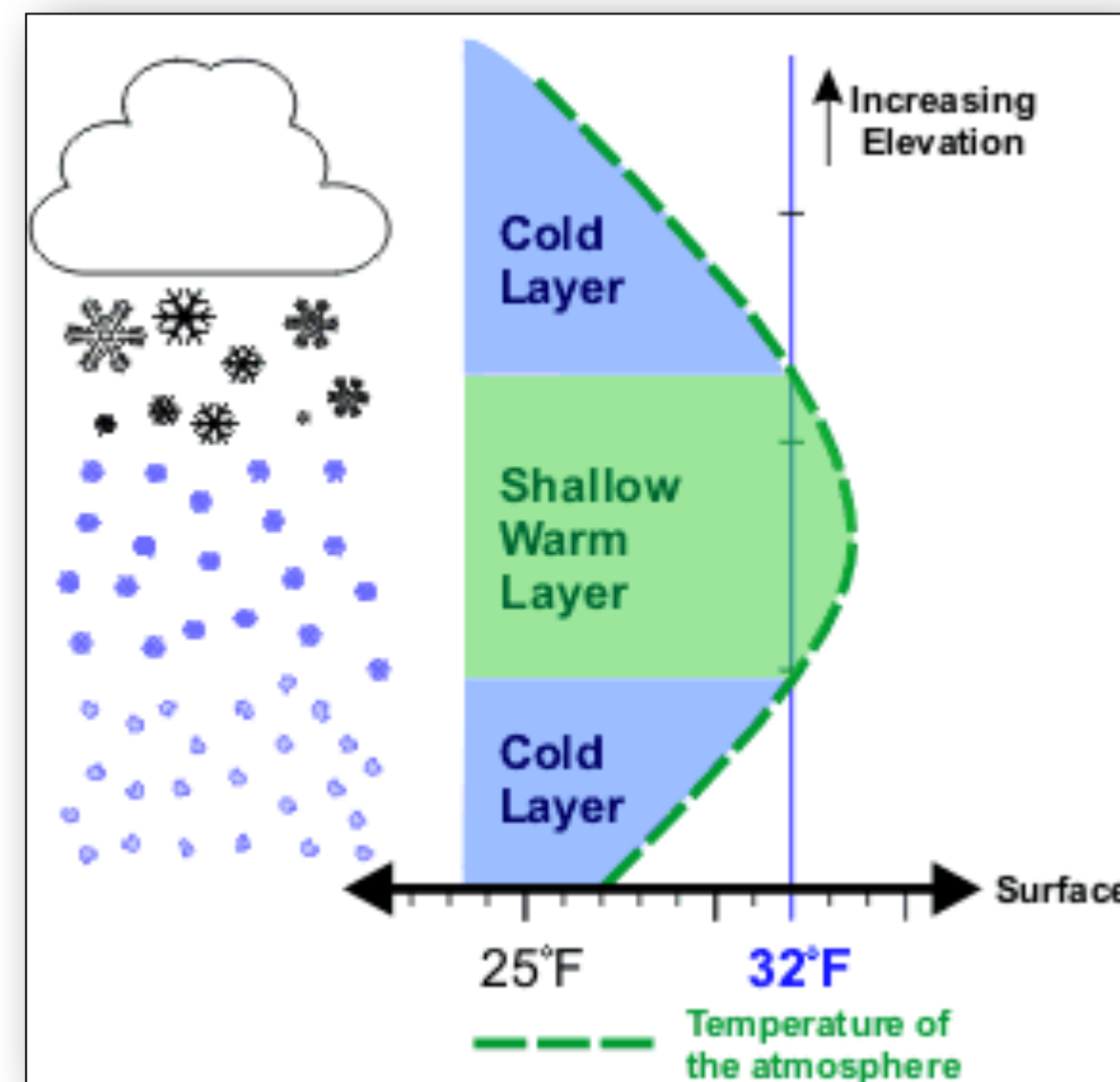
WINTER WEATHER



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

WINTER PRECIPITATION

- **Snow** – ice crystals form in cloud, stick together, & make **snowflakes**
 - Requires it to be below freezing from cloud to ground (right)

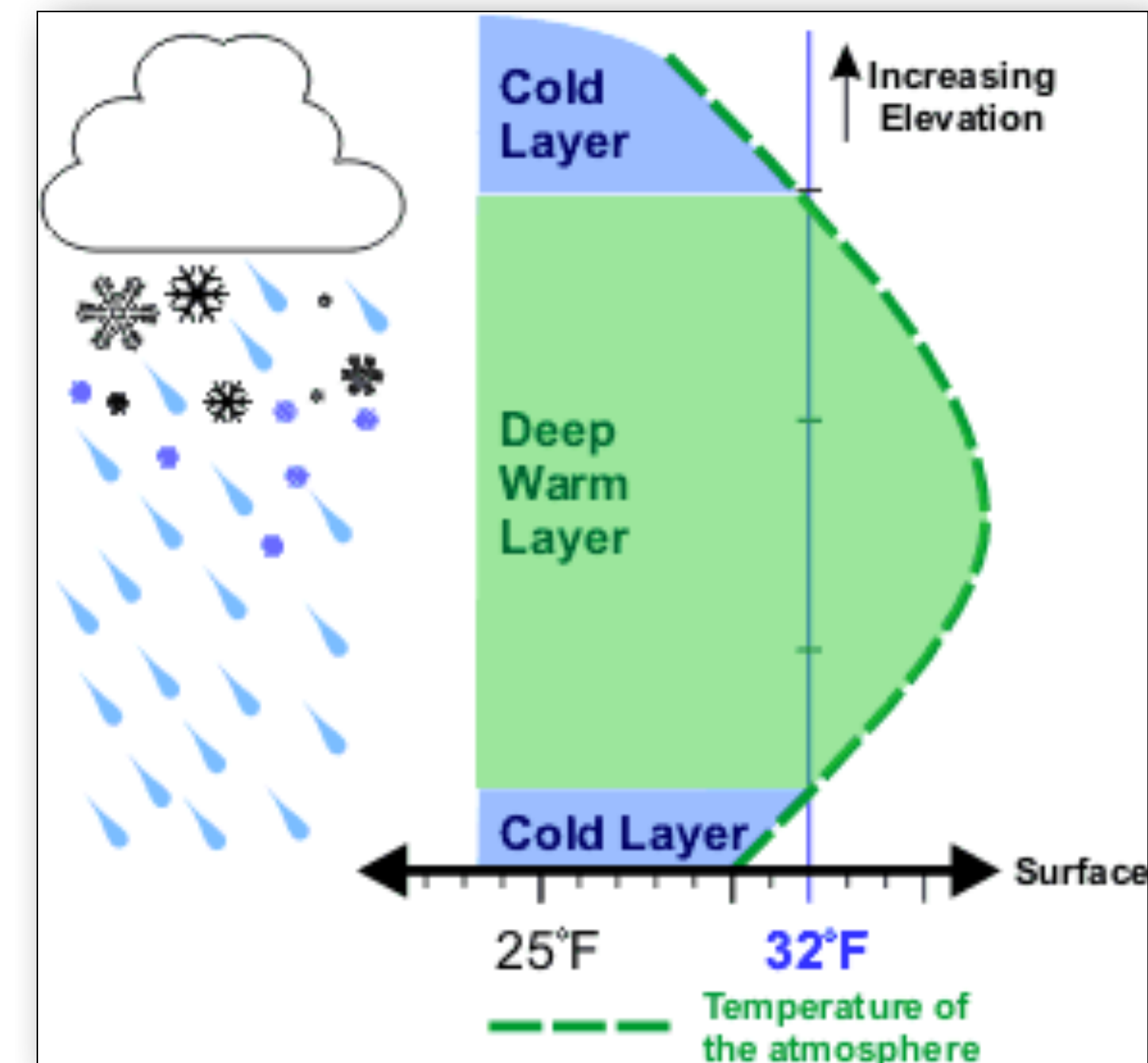


- **Sleet** – combination of snow and **ice pellets**
 - Needs intervening layer of warm air between cloud & ground (left); snow melts & re-freezes before reaching ground



WINTER PRECIPITATION

- **Freezing rain – liquid rain freezes on contact** with below-freezing surfaces (roads, trees, cars, ...)
 - **Deeper warm layer**; snow melts completely
 - Falls into shallow cold layer at surface where it becomes supercooled
 - Does not have time to re-freeze (like sleet)



DECEMBER 9-10, 2007 ICE STORM (OKLAHOMA)

- Up to 4 inches of freezing rain from OKC to Tulsa areas
- About 700,000 customers without power



ICE DAMAGE INDEX FOR ICE STORMS

The Sperry-Piltz Ice Accumulation Index, or "SPIA Index" – Copyright, February, 2009

ICE DAMAGE INDEX	* AVERAGE NWS ICE AMOUNT (in inches) *Revised-October, 2011	WIND (mph)	DAMAGE AND IMPACT DESCRIPTIONS
0	< 0.25	< 15	Minimal risk of damage to exposed utility systems; no alerts or advisories needed for crews, few outages.
1	0.10 – 0.25	15 - 25	Some isolated or localized utility interruptions are possible, typically lasting only a few hours. Roads and bridges may become slick and hazardous.
	0.25 – 0.50	> 15	
2	0.10 – 0.25	25 - 35	Scattered utility interruptions expected, typically lasting 12 to 24 hours. Roads and travel conditions may be extremely hazardous due to ice accumulation.
	0.25 – 0.50	15 - 25	
	0.50 – 0.75	< 15	
3	0.10 – 0.25	> = 35	Numerous utility interruptions with some damage to main feeder lines and equipment expected. Tree limb damage is excessive. Outages lasting 1 – 5 days.
	0.25 – 0.50	25 - 35	
	0.50 – 0.75	15 - 25	
	0.75 – 1.00	< 15	
4	0.25 – 0.50	> = 35	Prolonged & widespread utility interruptions with extensive damage to main distribution feeder lines & some high voltage transmission lines/structures. Outages lasting 5 – 10 days.
	0.50 – 0.75	25 - 35	
	0.75 – 1.00	15 - 25	
	1.00 – 1.50	< 15	
5	0.50 – 0.75	> = 35	Catastrophic damage to entire exposed utility systems, including both distribution and transmission networks. Outages could last several weeks in some areas. Shelters needed.
	0.75 – 1.00	> = 25	
	1.00 – 1.50	> = 15	
	> 1.50	Any	

(Categories of damage are based upon combinations of precipitation totals, temperatures and wind speeds/directions.)

Weather Conditions and SPIA Index Levels at a Glance:

Ice and Wind: *Average NWS Ice in Inches; Wind in MPH.	< 15 mph	15-25 mph	25-35 mph	> = 35 mph
0.10 – 0.25 inches	0	1	2	3
0.25 – 0.50 inches	1	2	3	4
0.50 – 0.75 inches	2	3	4	5
0.75 – 1.00 inches	3	4	5	5
1.00 – 1.50 inches	4	5	5	5
> 1.50 inches	5	5	5	5

SPIA Index © 2009, Sidney K. Sperry. Registration Number TX 7-027-591. *Graphics revised – October, 2011



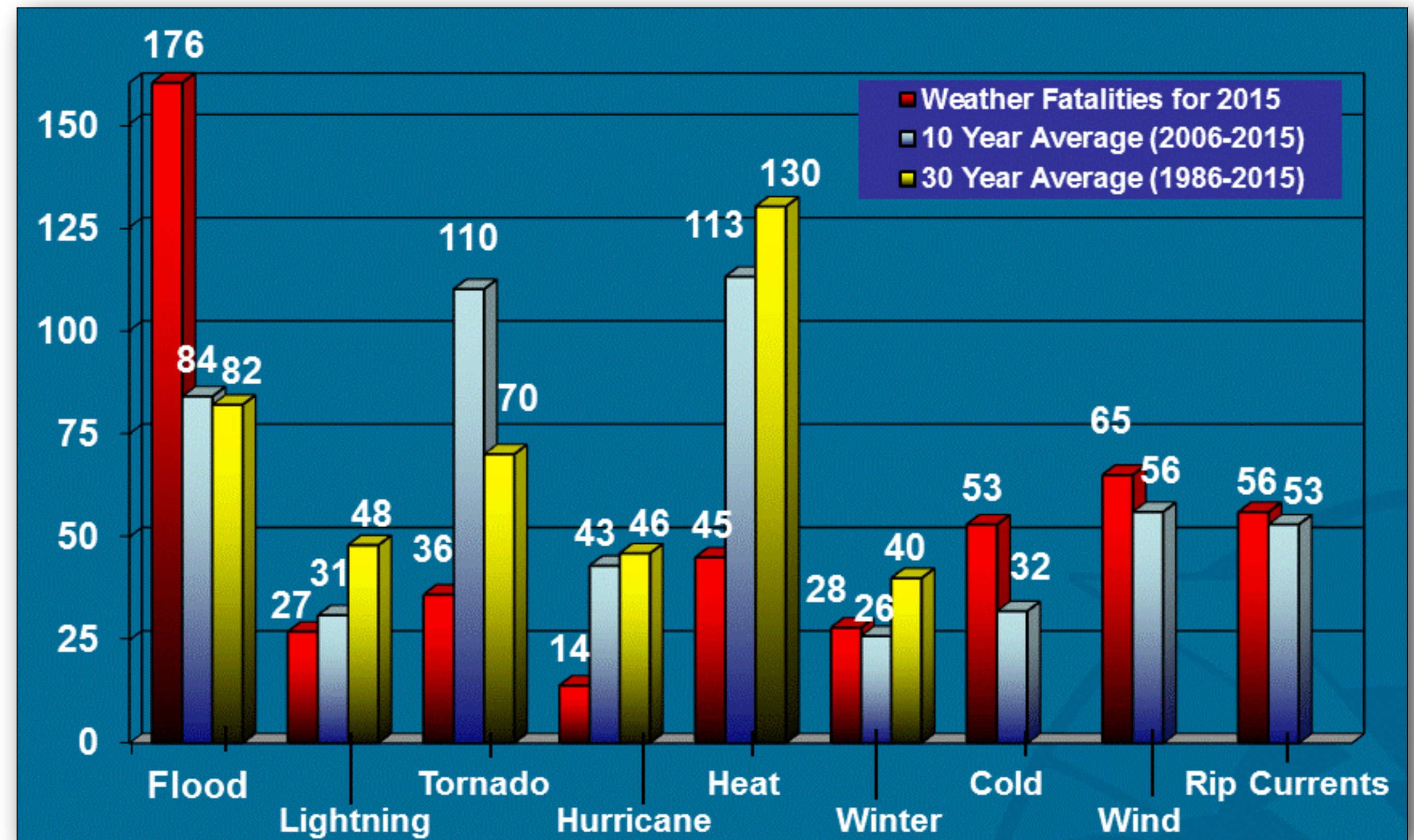
SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER

CLIMATE EXTREMES

- Each extreme event is a single event & part of the location's **weather**
- The frequency & average intensity of extreme events are statistics over a long period of time & part of the location's **climate**
- If the climate changes, then the frequency & average intensity of the location's extremes will change also

WEATHER FATALITIES

- Weather does not have to be extreme to kill; light rain & wet roads kill more people (over 6,000 per year) in the U.S. than extreme weather



QUESTIONS?



SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER