

# The Climate of the Southeast: Extremes, Impacts, and Future Impacts

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# Objective

- Provide an introduction to the climate of the Southeast through a description of weather and climate extremes.
- Examine weather and climate extremes in terms of the following:
  1. Geographic pattern of occurrence across the region.
  2. Variability and trends over last 50-100 yrs.
  3. Societal and public health impacts.
  4. Future projections

# Background

Many influences:

- Dry vs. very moist air
- Very cold vs. very hot air
- Extratropical cyclones (lows)
- Tropical cyclones

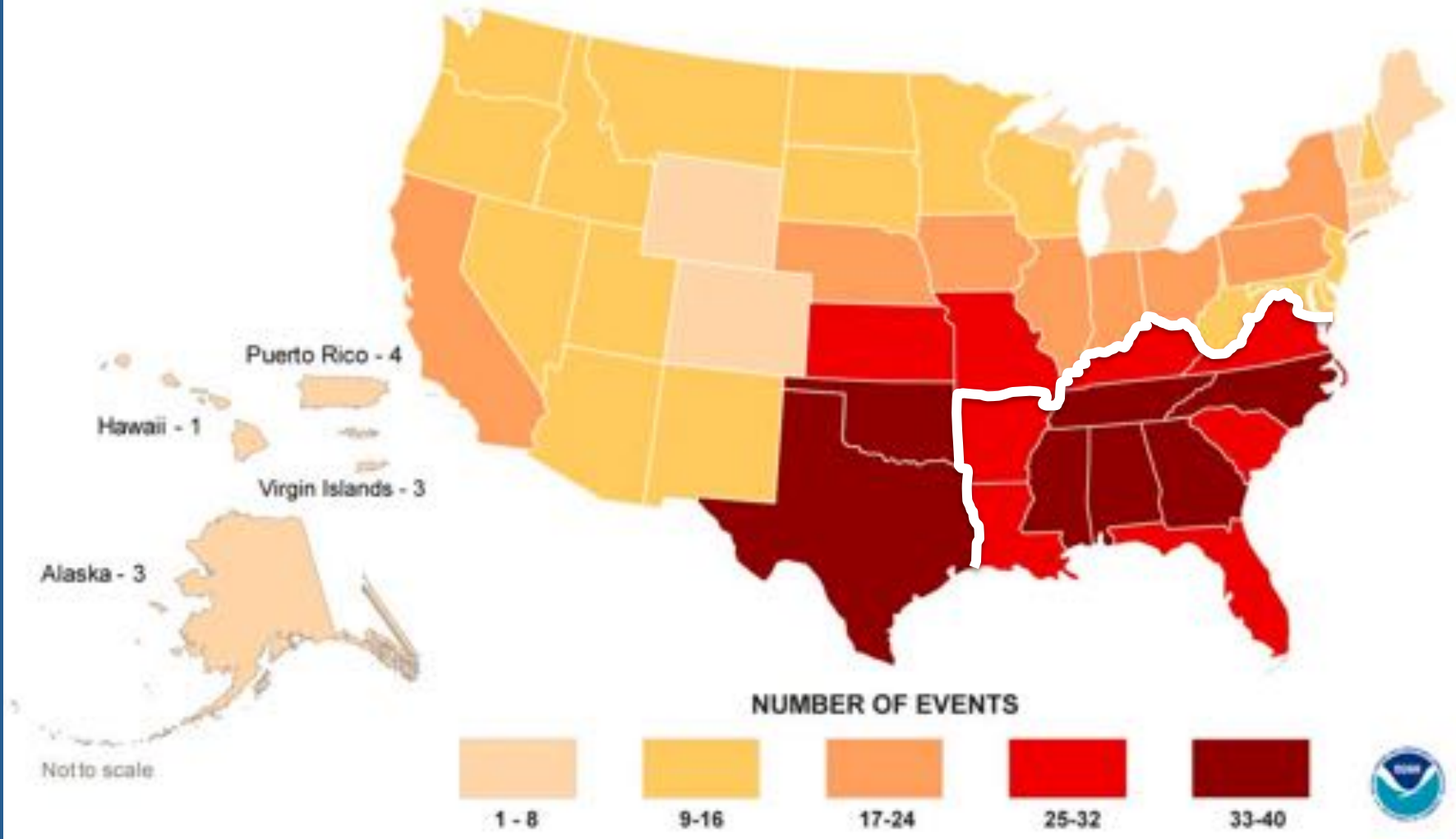


# Weather and climate extremes in the Southeast

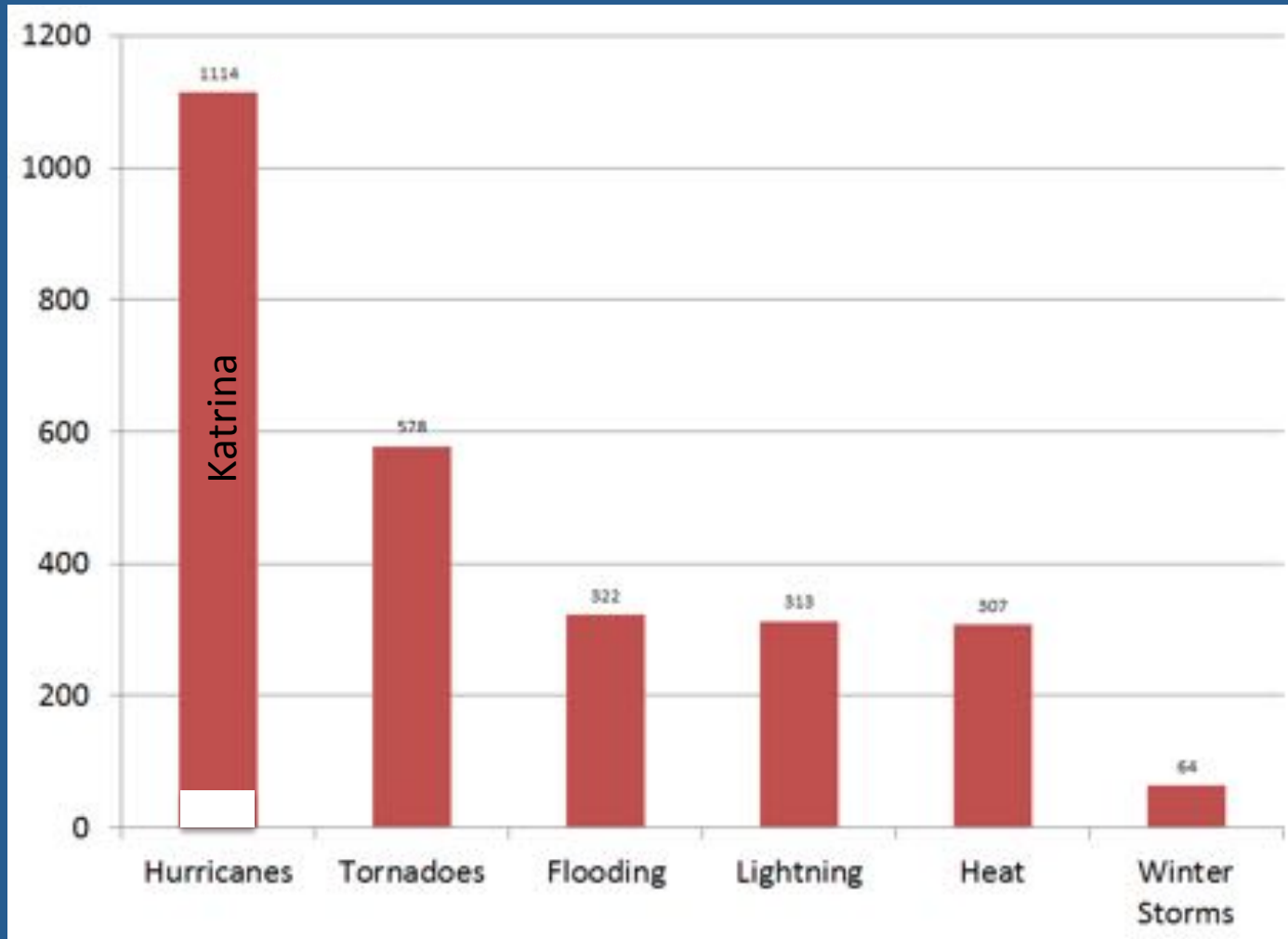
1. Flooding
2. Droughts
3. Extreme Cold
4. Heat waves
5. Heavy snow
6. Ice storms
7. Hurricanes
8. Tornadoes
9. Severe Thunderstorms
  - High winds
  - Large Hail
  - Cloud to ground lightning

# Billion Dollar Weather/Climate Disasters

1980 - August 2011

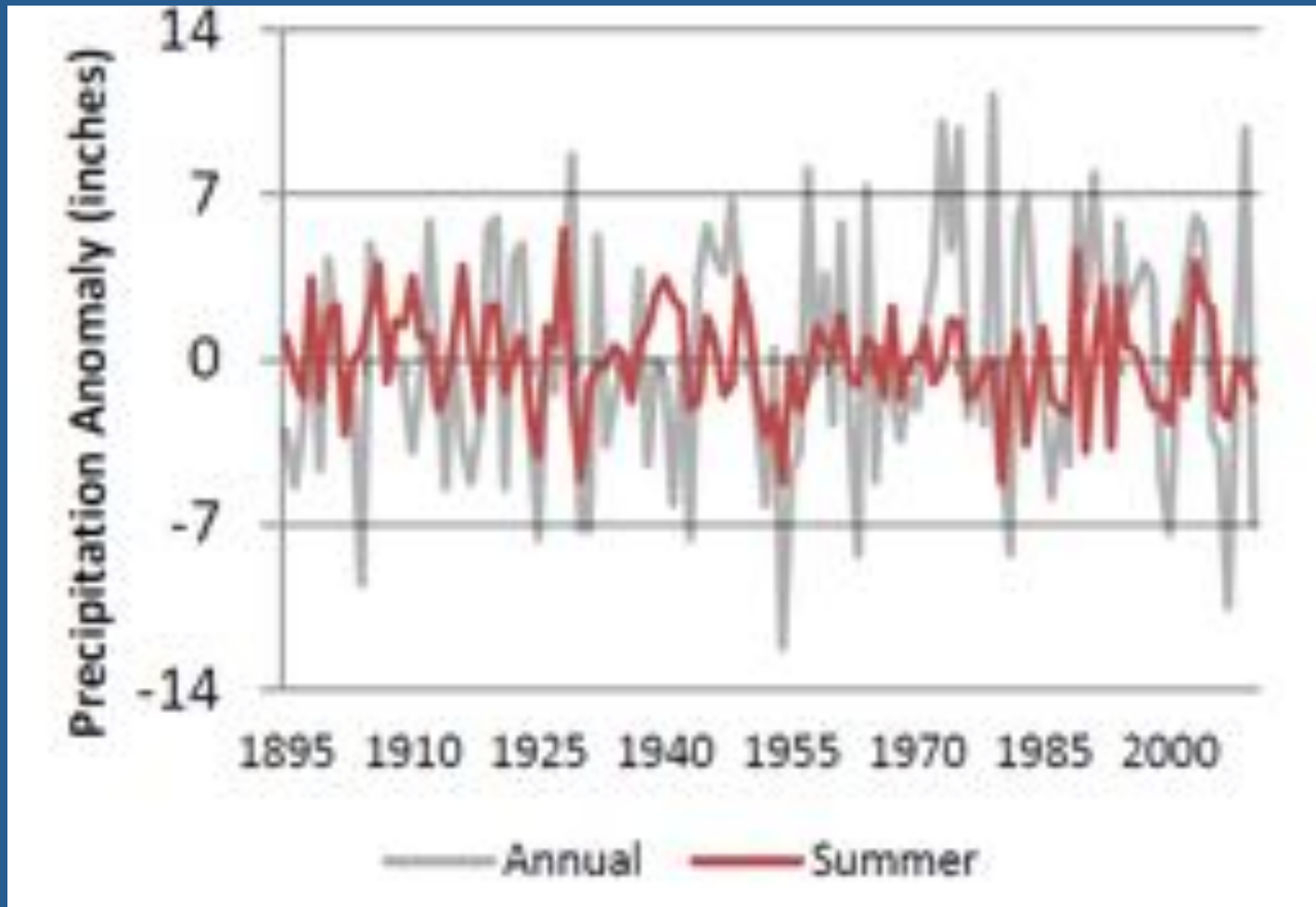


# Fatalities Due to Extreme Events in the Southeast (1995-2010)



Source: National Weather Service

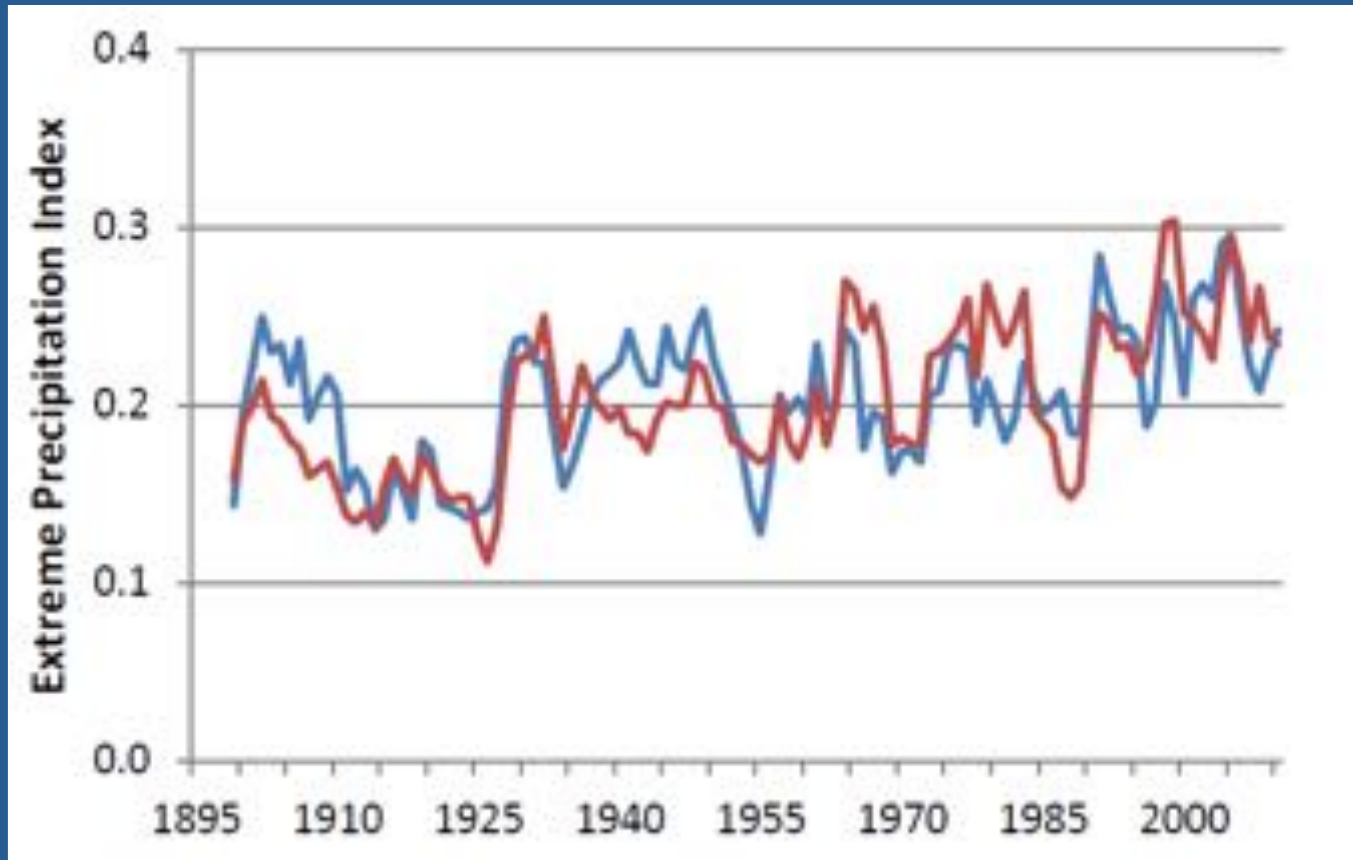
# Precipitation



## Precipitation Extremes

High rainfall rates → Flash flooding: Property damage and loss of life

Broad scale heavy rainfall → High surface runoff, river flooding: disease and poor water quality



5-yr running mean of extreme precipitation index for SE region.

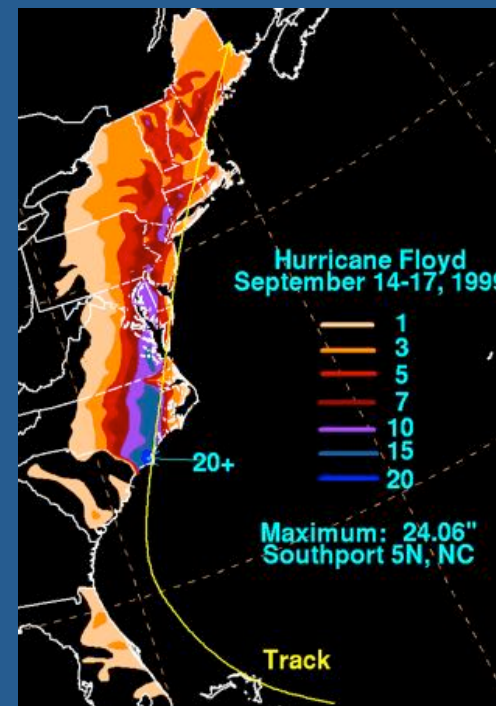
1 day 1 in 5-yr events. 5 day 1 in 5-yr events Constructed by K. Kunkel



Heavy rain in early May 2010 caused major flooding and over \$1.5 billion in damage in Nashville, TN and contributed to over 30 deaths across TN, KY, and MS.



Heavy rain with Hurricane Floyd in caused major flooding and over \$8 billion in damage across eastern NC, VA and portions of the NE U.S.

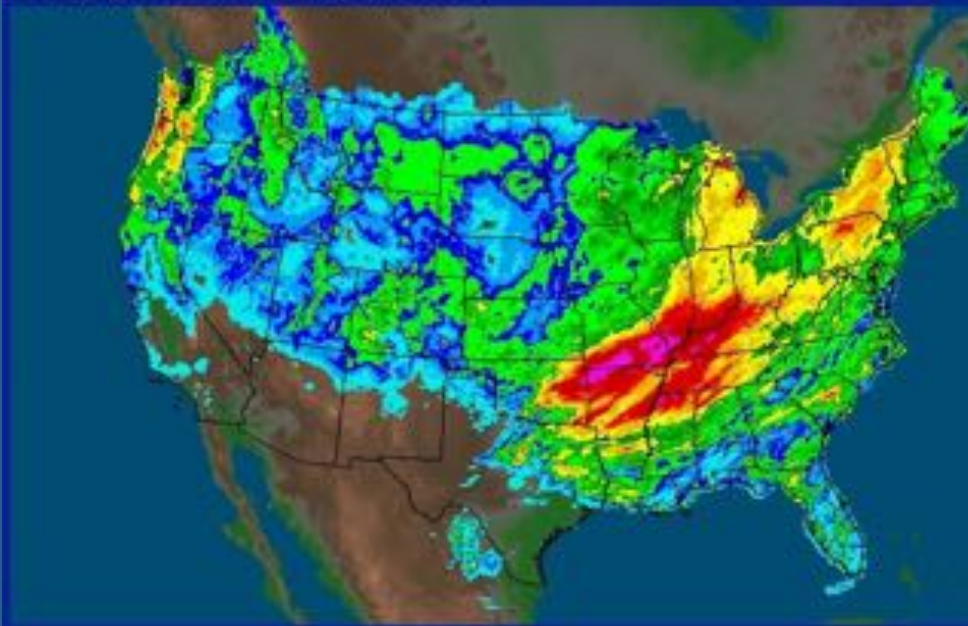




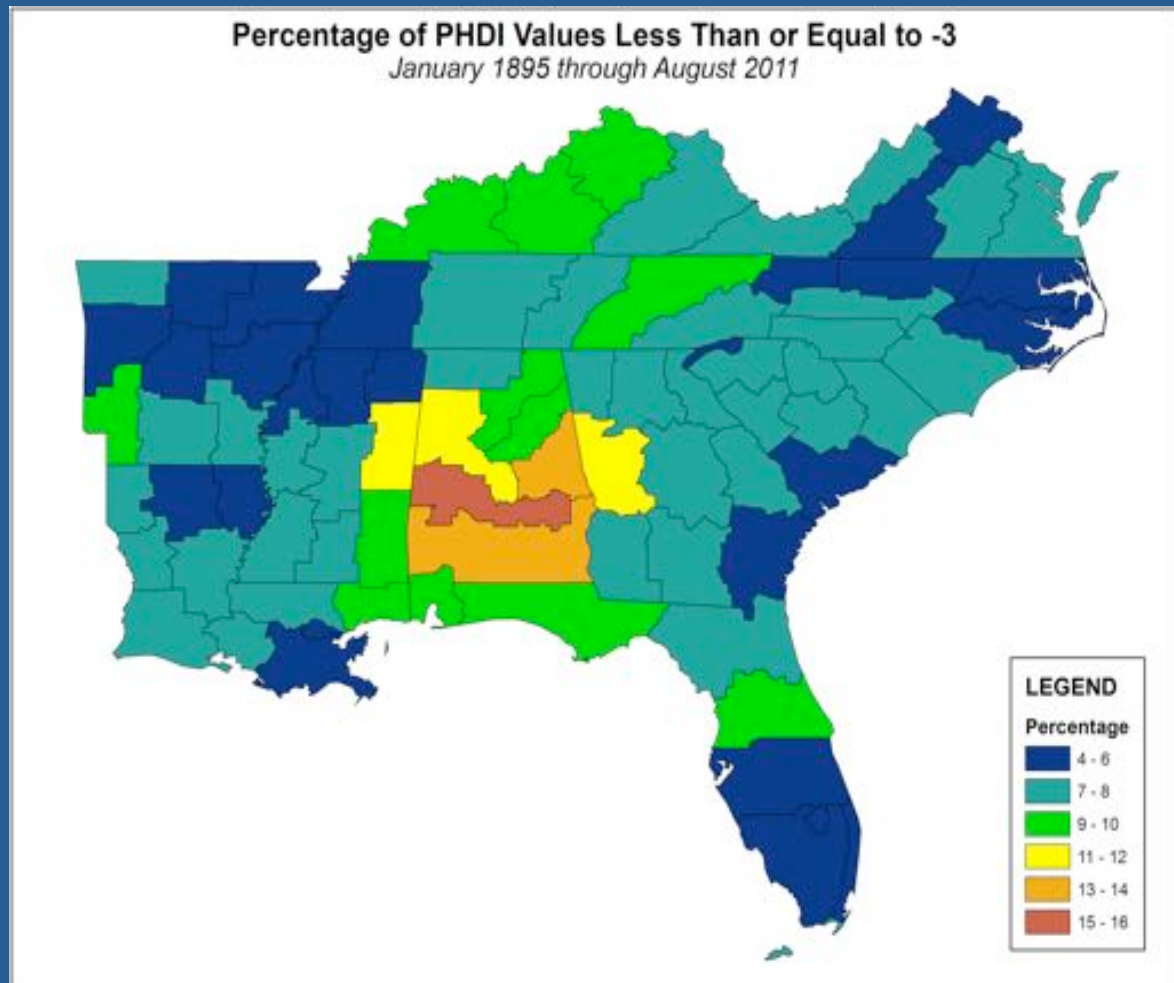
# Historic Flooding along the Mississippi River in April-May 2011

**\$2-4 billion in damage**

COMUS + Puerto Rico: Yesterday's 7-Day Observed Precipitation  
 Valid at 4/29/2011 1200 UTC - Created 4/29/11 23:38 UTC

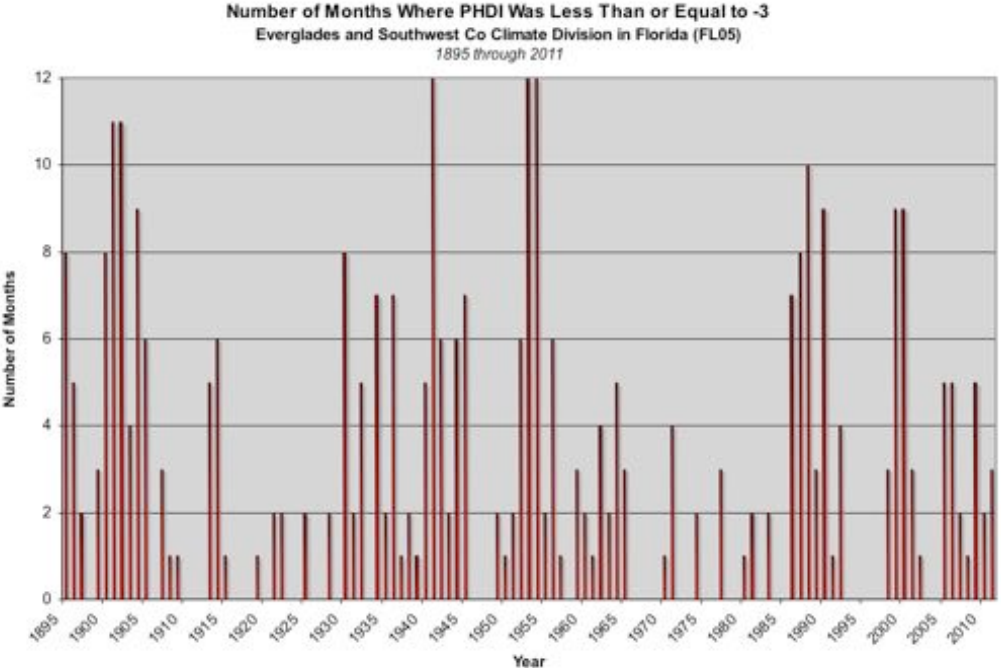
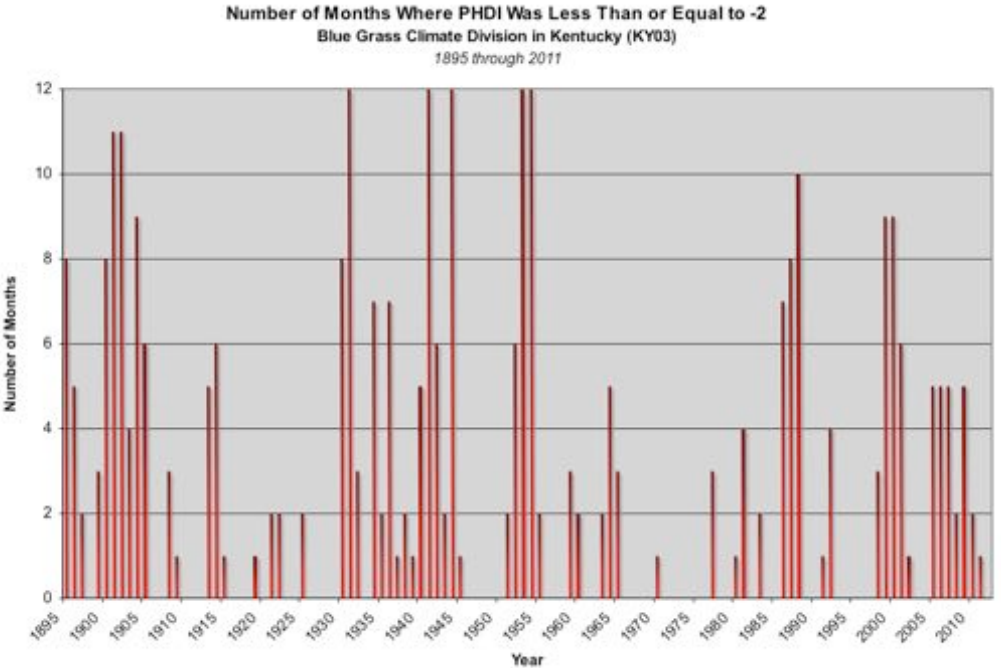


**Hydrological droughts** – reduced municipal water supplies, dried up wells in rural areas, poor water quality, algal blooms etc

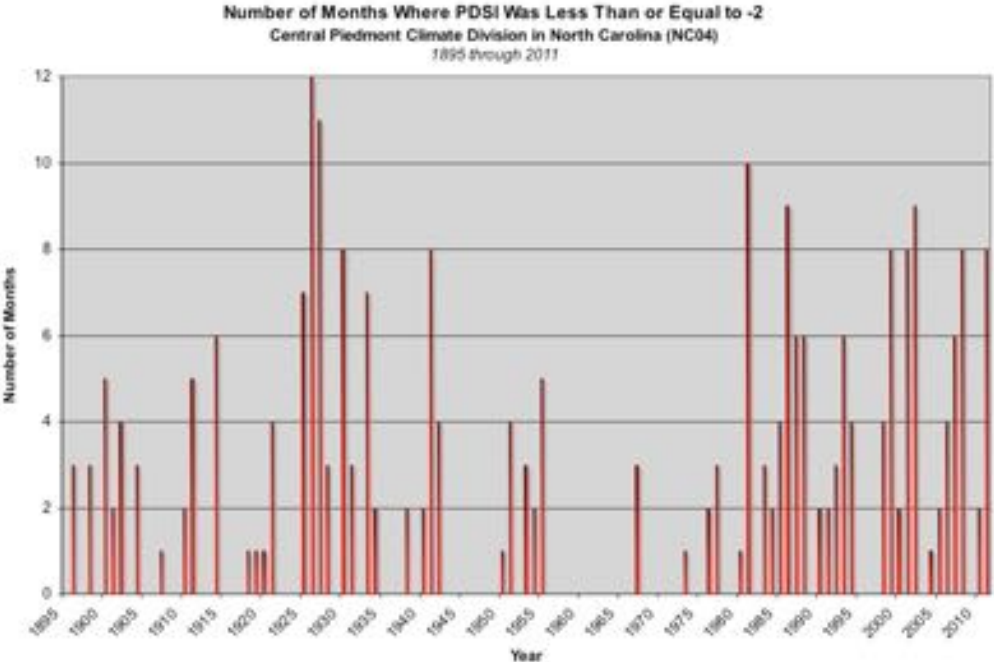


Kentucky CD 3

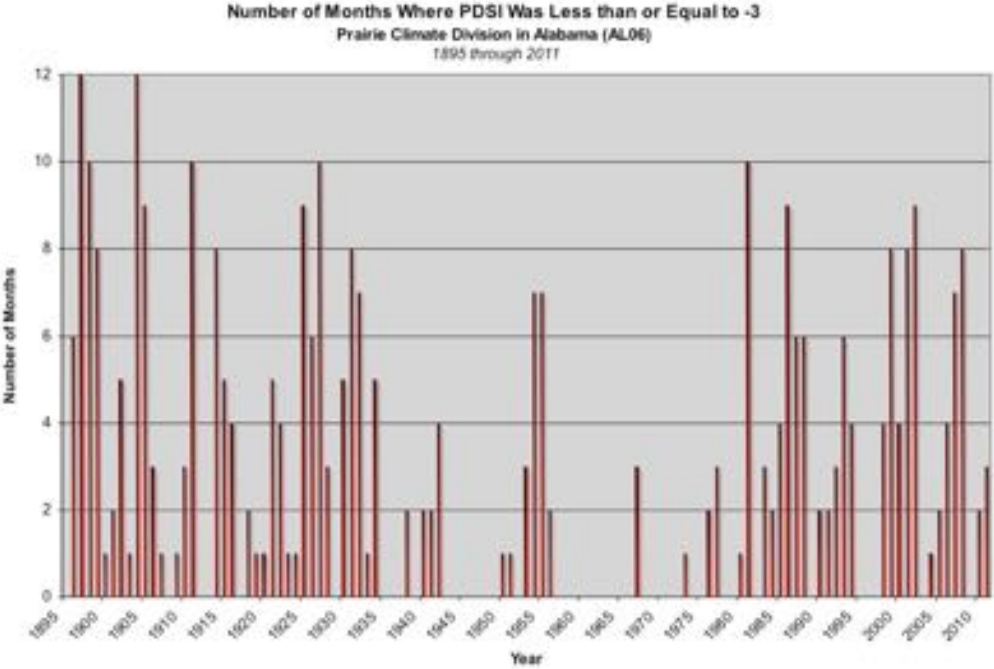
Florida CD 5

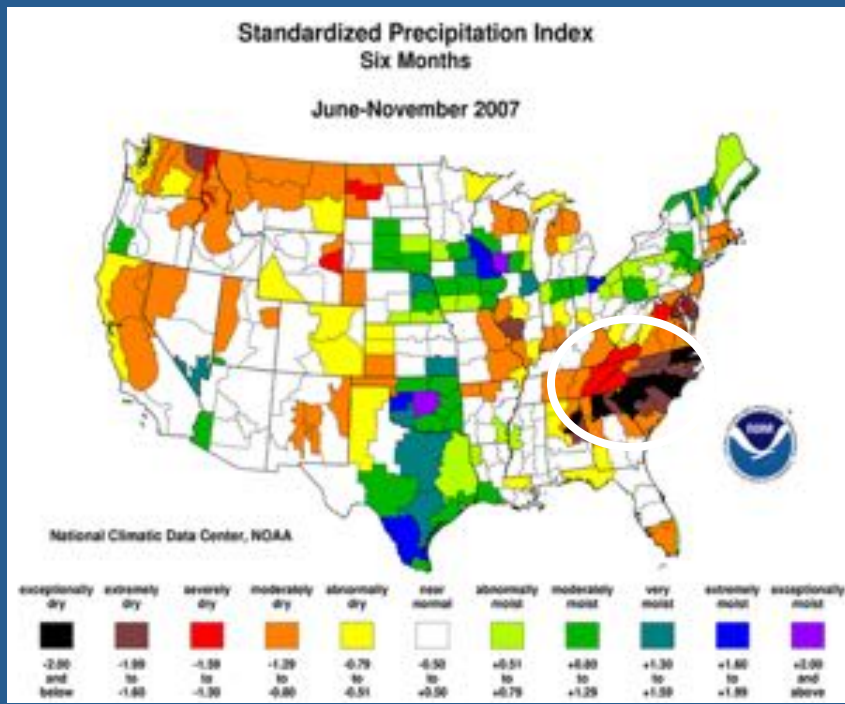


North Carolina CD 4

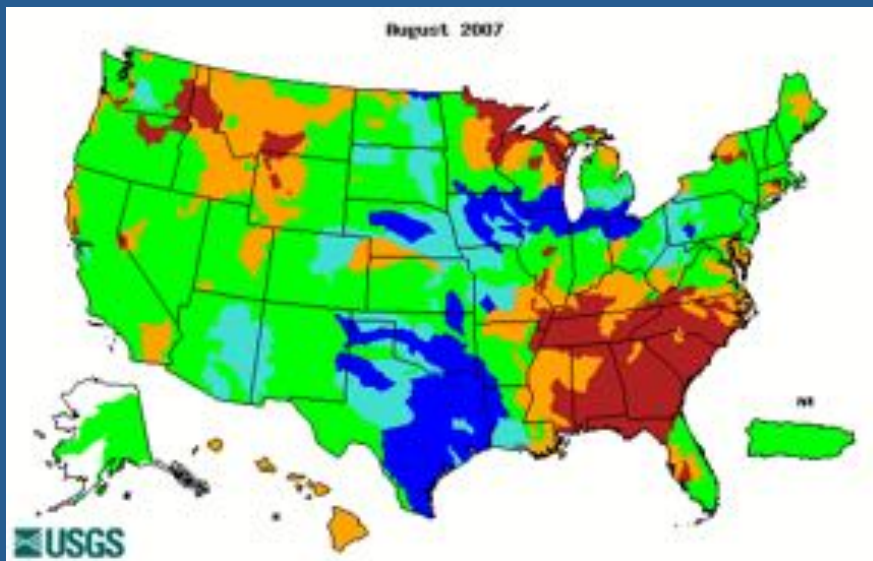


Alabama CD 6





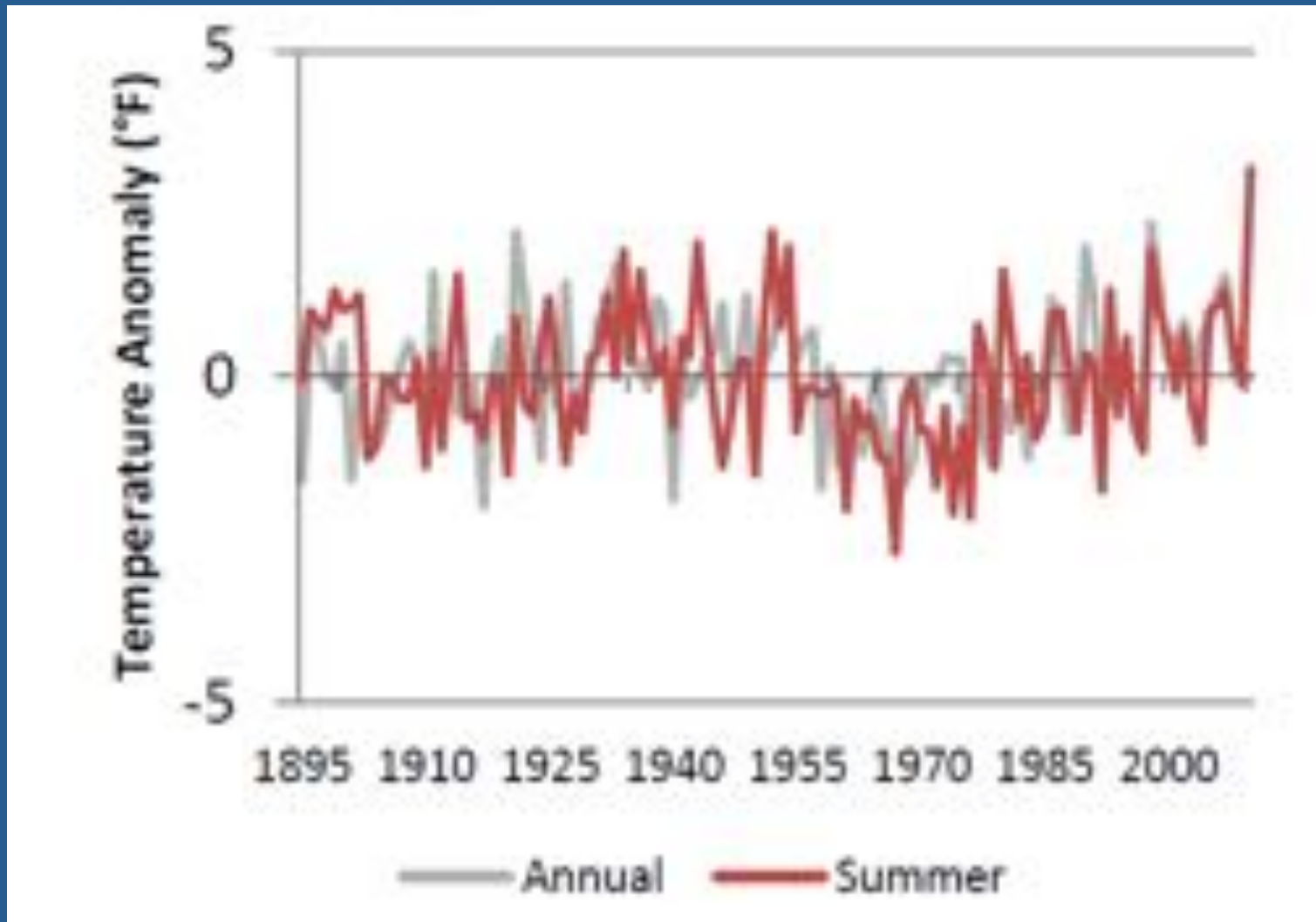
Stream flow (red = <10<sup>th</sup> percentile)



2007 “Flash Drought”  
in the Southeast

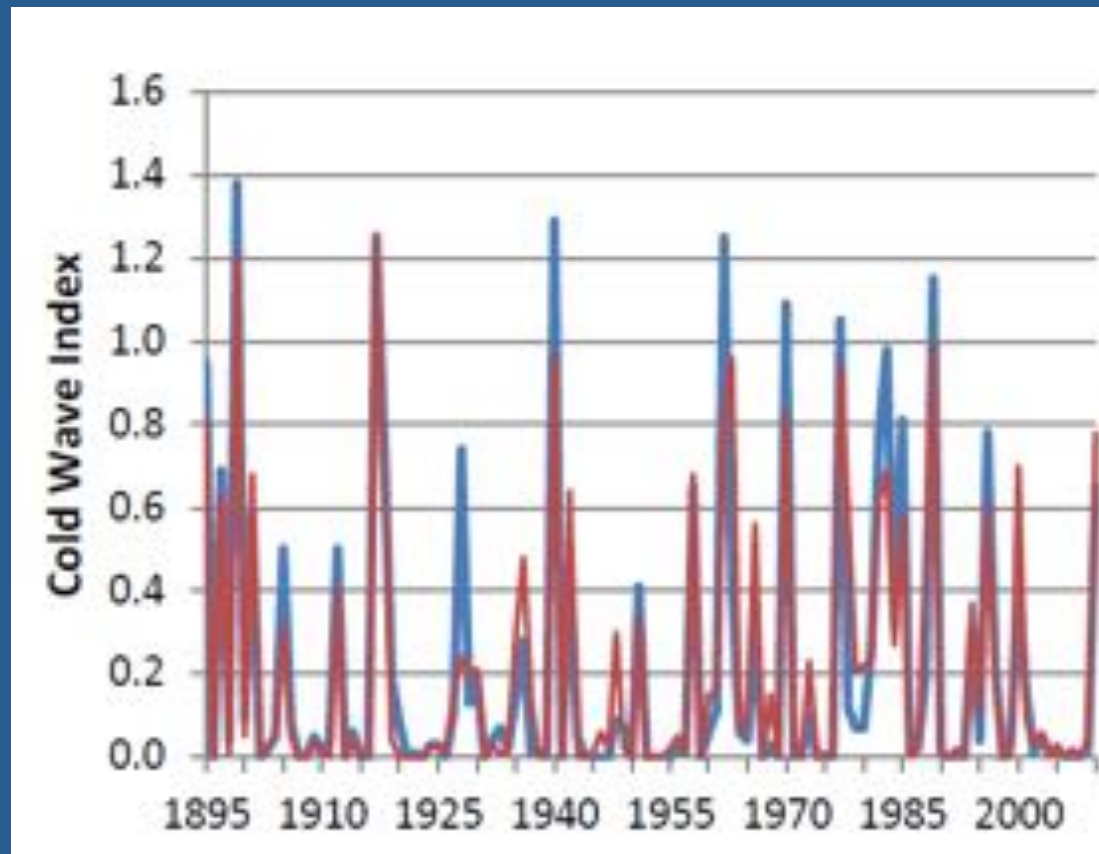
# Temperature

Temperature anomalies across the SE region



## Extreme Cold Air Outbreaks

→ hypothermia, morbidity/mortality

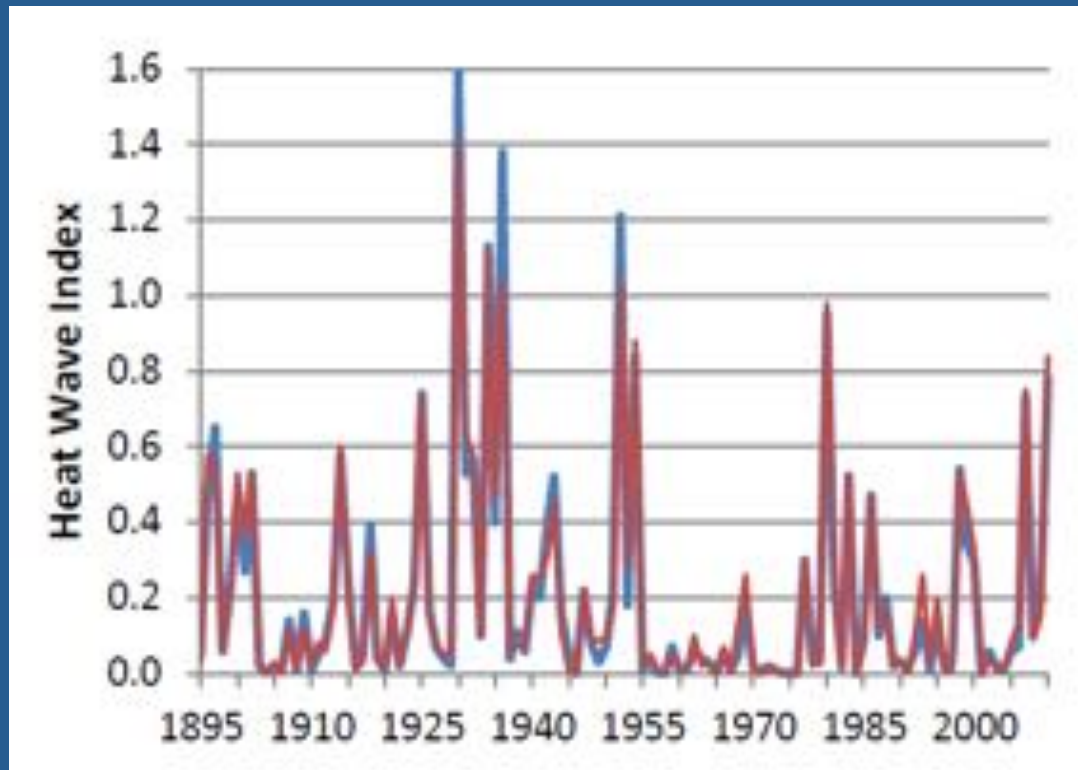


Time series of an index for the occurrence of cold waves defined as **4-day periods** and **7-day periods** that are colder than the threshold for a 1-in-5 year recurrence. Constructed by K. Kunkel



# Heat Waves

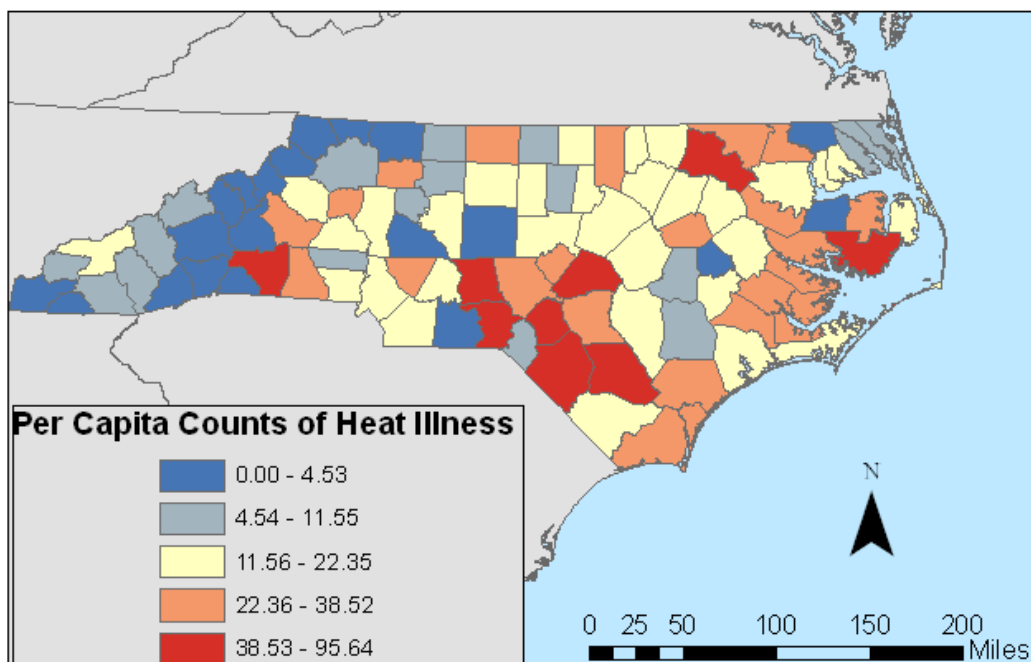
## Especially urban areas at night



Time series of an index for the occurrence of heat waves defined as **4-day periods** (blue) and **7-day periods** (red) that are hotter than the threshold for a 1-in-5 year recurrence. Constructed by K. Kunkel

## Heat Waves

- Heat morbidity and mortality
- High energy cost → morbidity/mortality



### Rate of ED visits (per capita) for HRI by county from 2007 to 2008

#### Total Visits:

<b>Urban</b>	<b>1186</b>
<b>Rural</b>	<b>1404 (+218)</b>

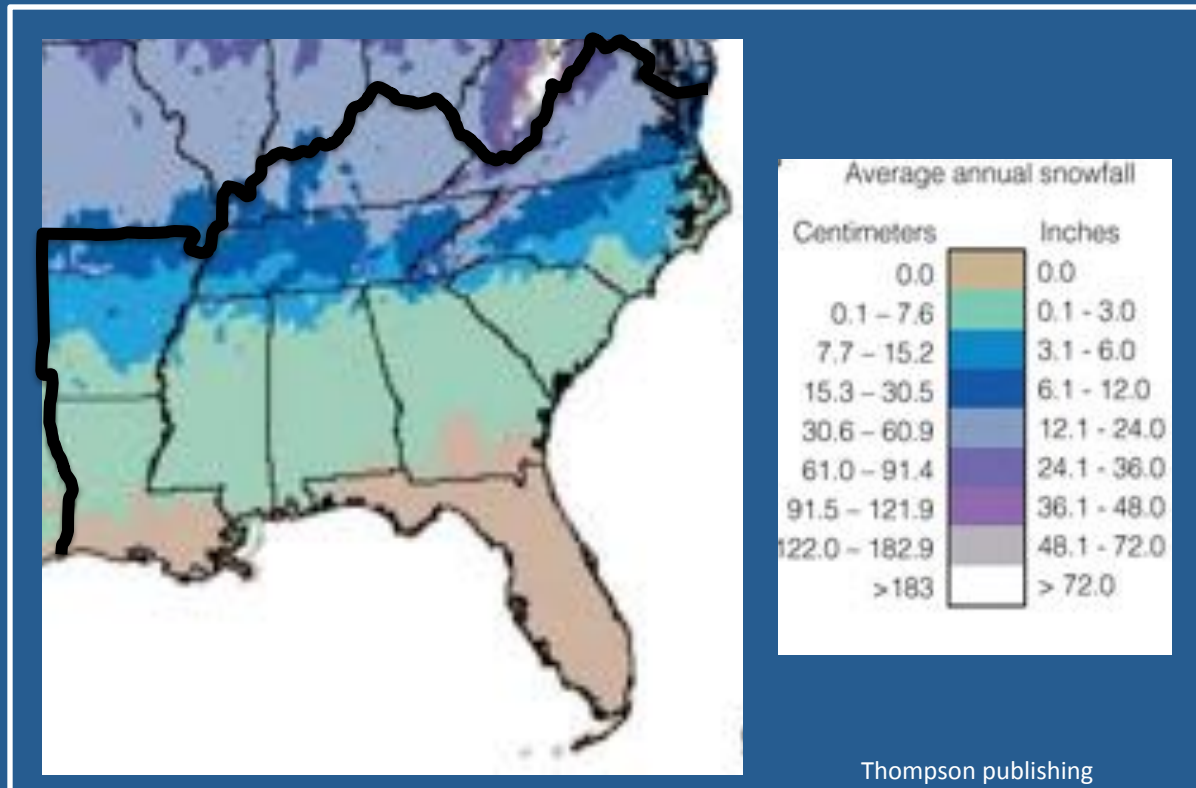
#### Annual Visit Rate (per 100,000):

<b>Urban</b>	<b>13.0</b>
<b>Rural</b>	<b>15.6 (+2.6)</b>

## Heavy Snowfall – largely restricted to the northern third of the region

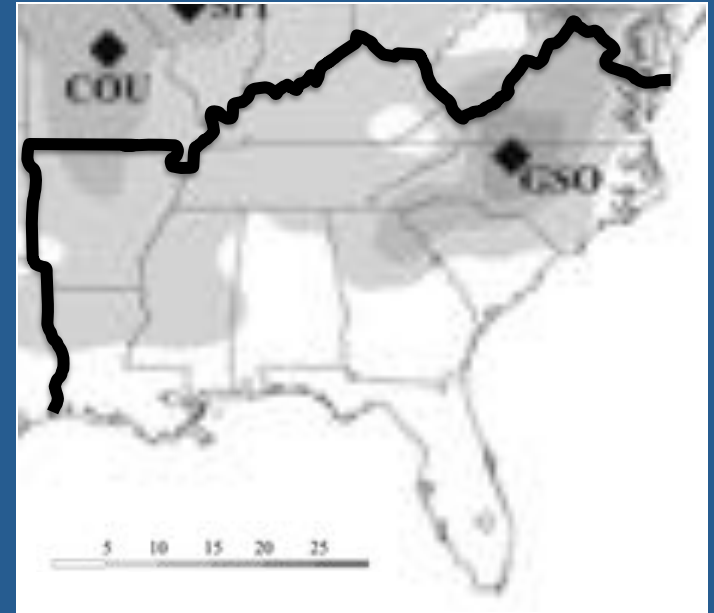
→ Increased automobile accidents, plus slips/falls → injuries and deaths

### Average annual snowfall



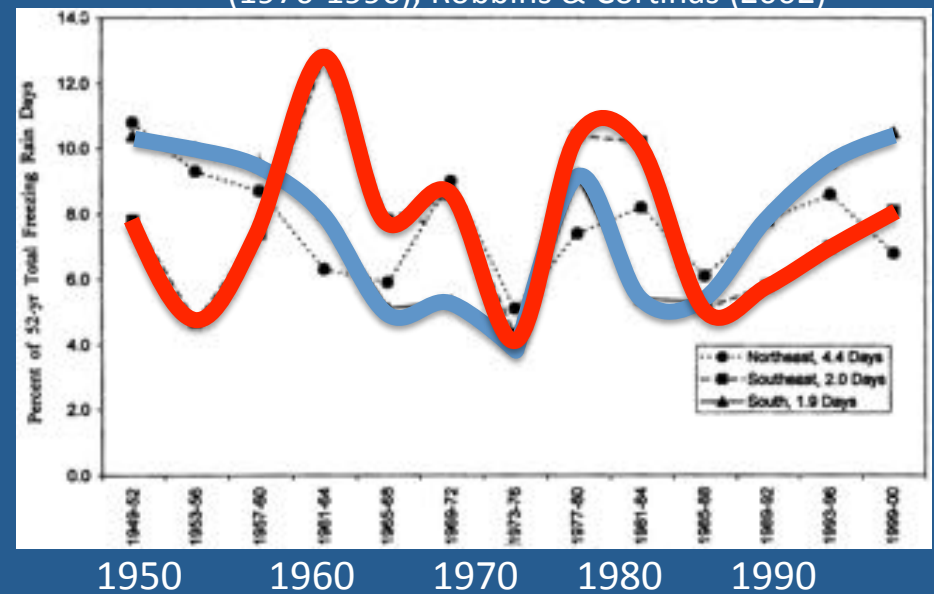
**Ice storms**— largely restricted to the northern half of the region

- Ice accretion on tree limbs and power lines → power outages
- Deaths from carbon monoxide poisoning



Average annual number of freezing rain hours (1976-1990), Robbins & Cortinas (2002)

Temporal fluctuations in frequencies of freezing-rain days in **Southeast**, and **South** climate regions. Values for each 4-yr period are percent of the 1949–2000 total number of freezing-rain days for each region. From Changnon and Karl (2003)



# North Carolina Ice Storm December 2002

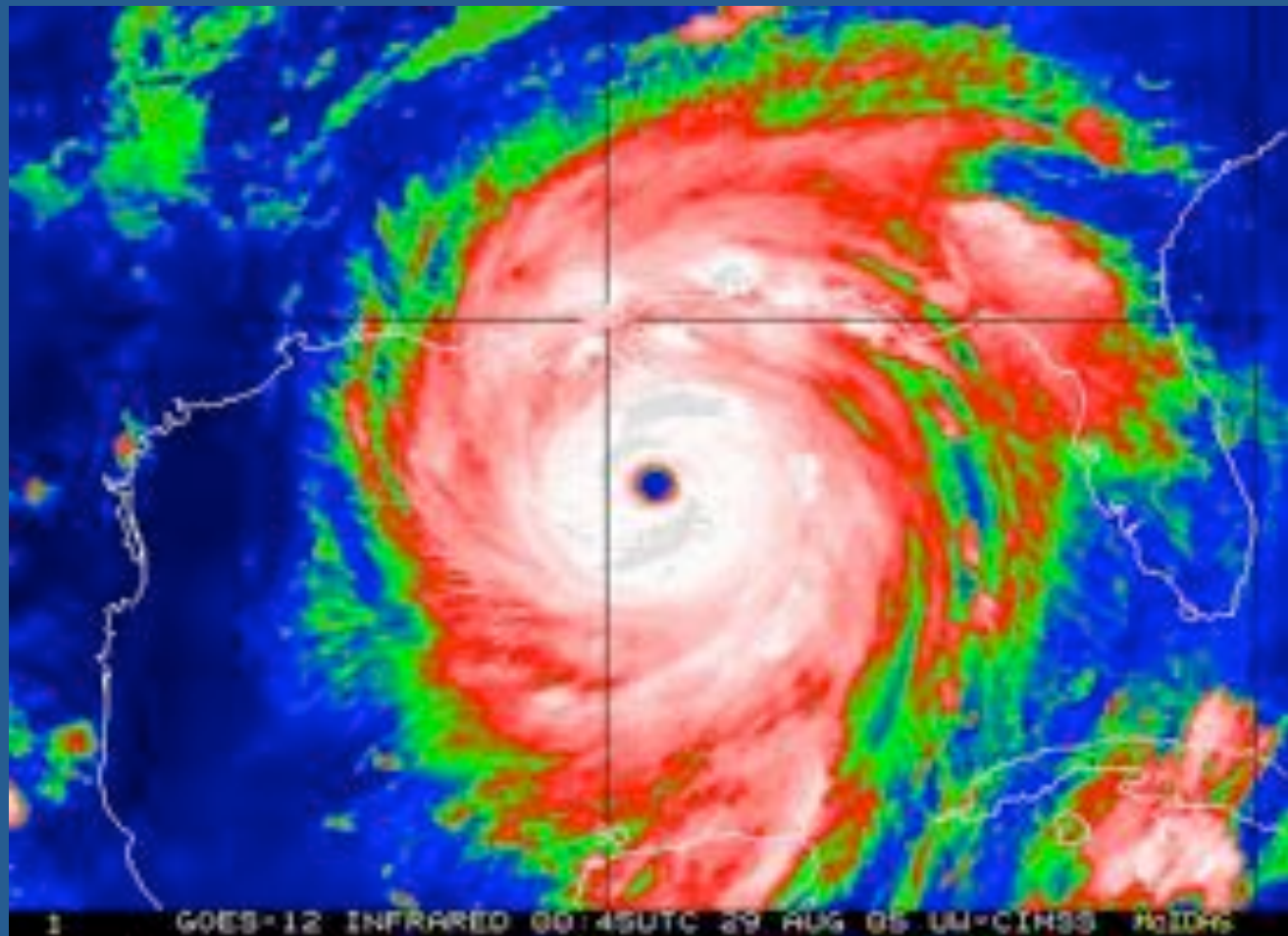


# Hurricanes

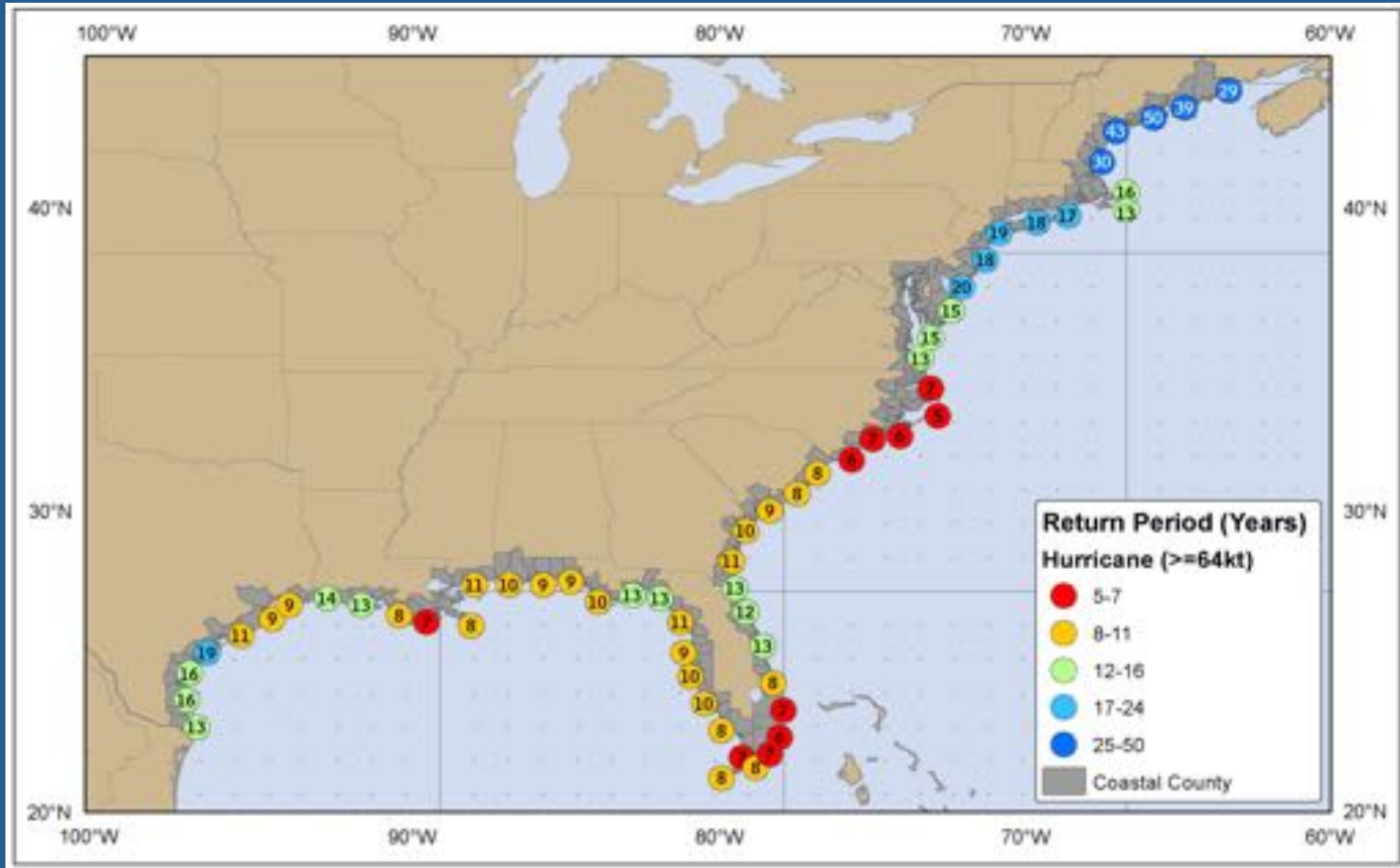
Storm surge → coastal flooding

Strong winds → structural damage, downed trees, power outages, especially inland

Heavy rainfall → Inland flooding → structural damage and drowning fatalities



# Hurricanes



Estimated return period in years for hurricanes passing within 50 nautical miles of various locations on the U.S. Coast in the last 100 years (from the National Hurricane Center)

# The costliest hurricanes to affect the United States (1900-2010)

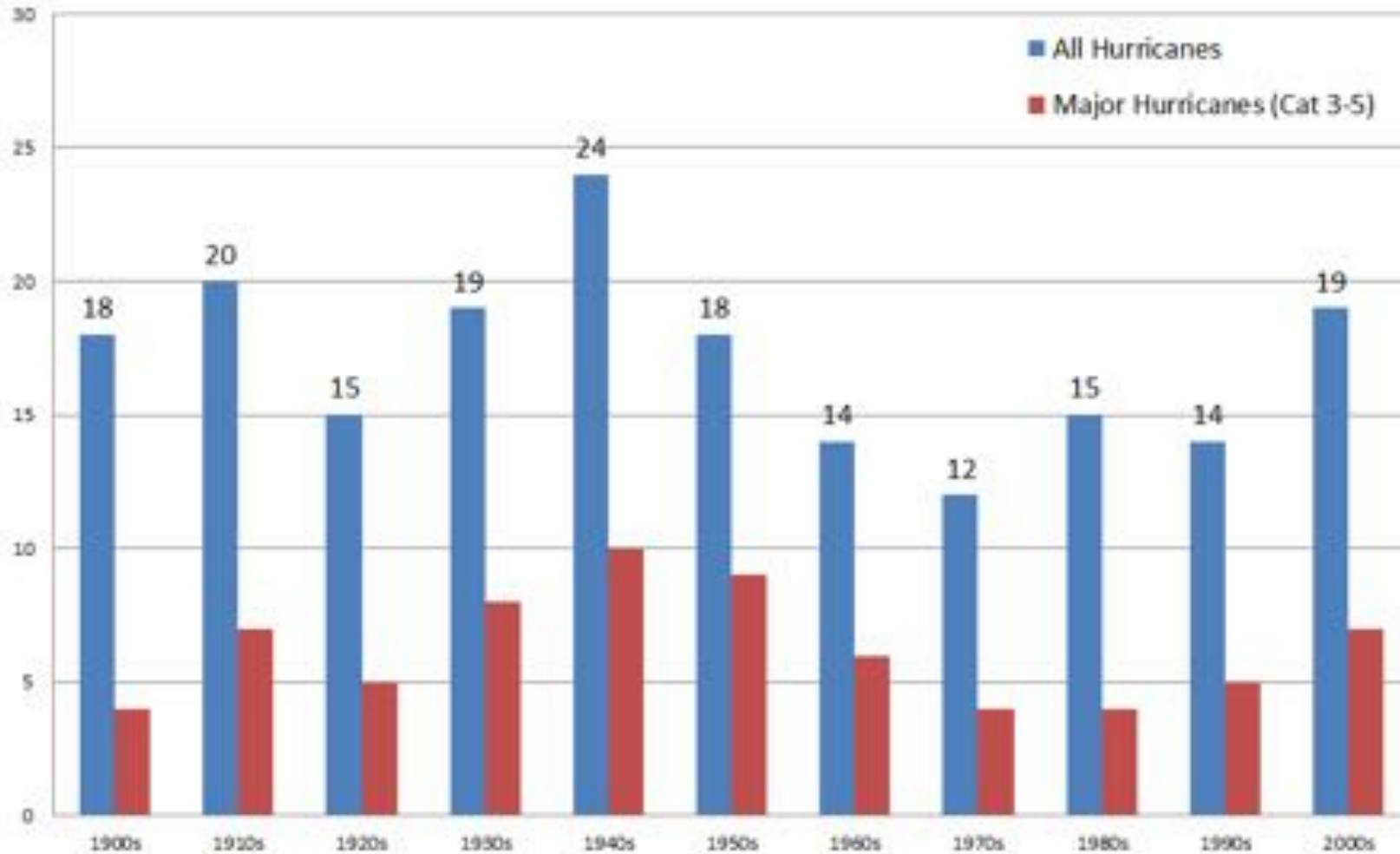
*6 of the 7 \$10 billion+ hurricanes have occurred in the past 7 years, all impacting the Southeast region*

RANK	TROPICAL CYCLONE	YEAR	CATEGORY	DAMAGE (U.S.)
1	KATRINA (SE FL, LA, MS)	2005	3	\$108,000,000,000
2	IKE (TX, LA)	2008	2	29,520,000,000
3	ANDREW (SE FL/LA)	1992	5	26,500,000,000
4	WILMA (S FL)	2005	3	21,007,000,000
5	IVAN (AL/NW FL)	2004	3	18,820,000,000
6	CHARLEY (SW FL)	2004	4	15,113,000,000
7	RITA (SW LA, N TX)	2005	3	12,037,000,000
8	FRANCES (FL)	2004	2	9,507,000,000
9	ALLISON (N TX)	2001	TS	9,000,000,000
10	JEANNE (FL)	2004	3	7,660,000,000
11	HUGO (SC)	1989	4	7,000,000,000
12	FLOYD (Mid-Atlantic & NE U.S.)	1999	2	6,900,000,000
13	ISABEL (Mid-Atlantic)	2003	2	5,370,000,000
14	OPAL (NW FL/AL)	1995	3	5,142,000,000
15	GUSTAV (LA)	2008	2	4,618,000,000
16	FRAN (NC)	1996	3	4,160,000,000
17	GEORGES (FL Keys, MS, AL)	1998	2	2,765,000,000
18	DENNIS (NW FL)	2005	3	2,545,000,000
19	FREDERIC (AL/MS)	1979	3	2,300,000,000
20	AGNES (FL/NE U.S.)	1972	1	2,100,000,000

Data from Blake et al. 2011



## Number of U.S. Hurricane Strikes by Decade (1900-2010)



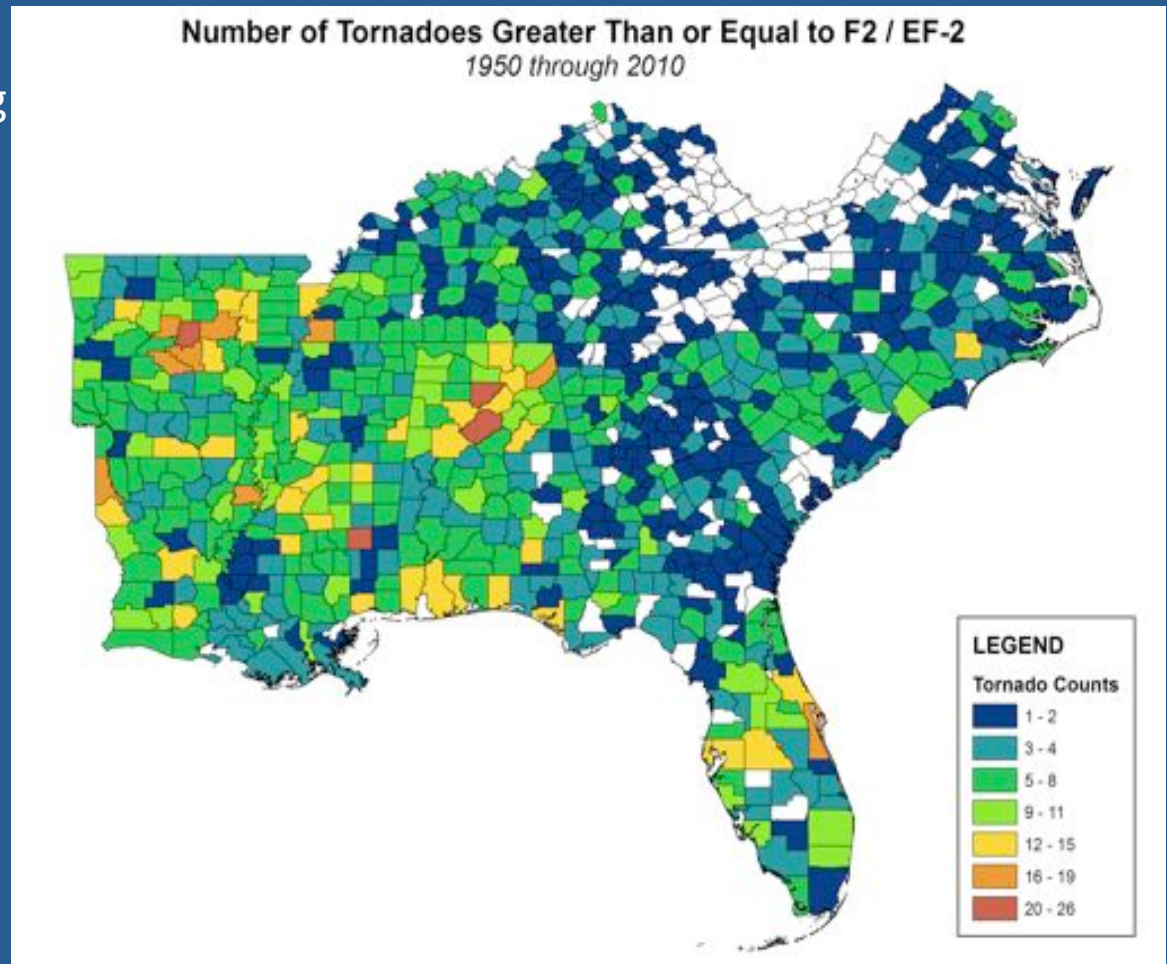
Data from Blake et al. 2011

# Tornadoes

– property damage, injuries, loss of life

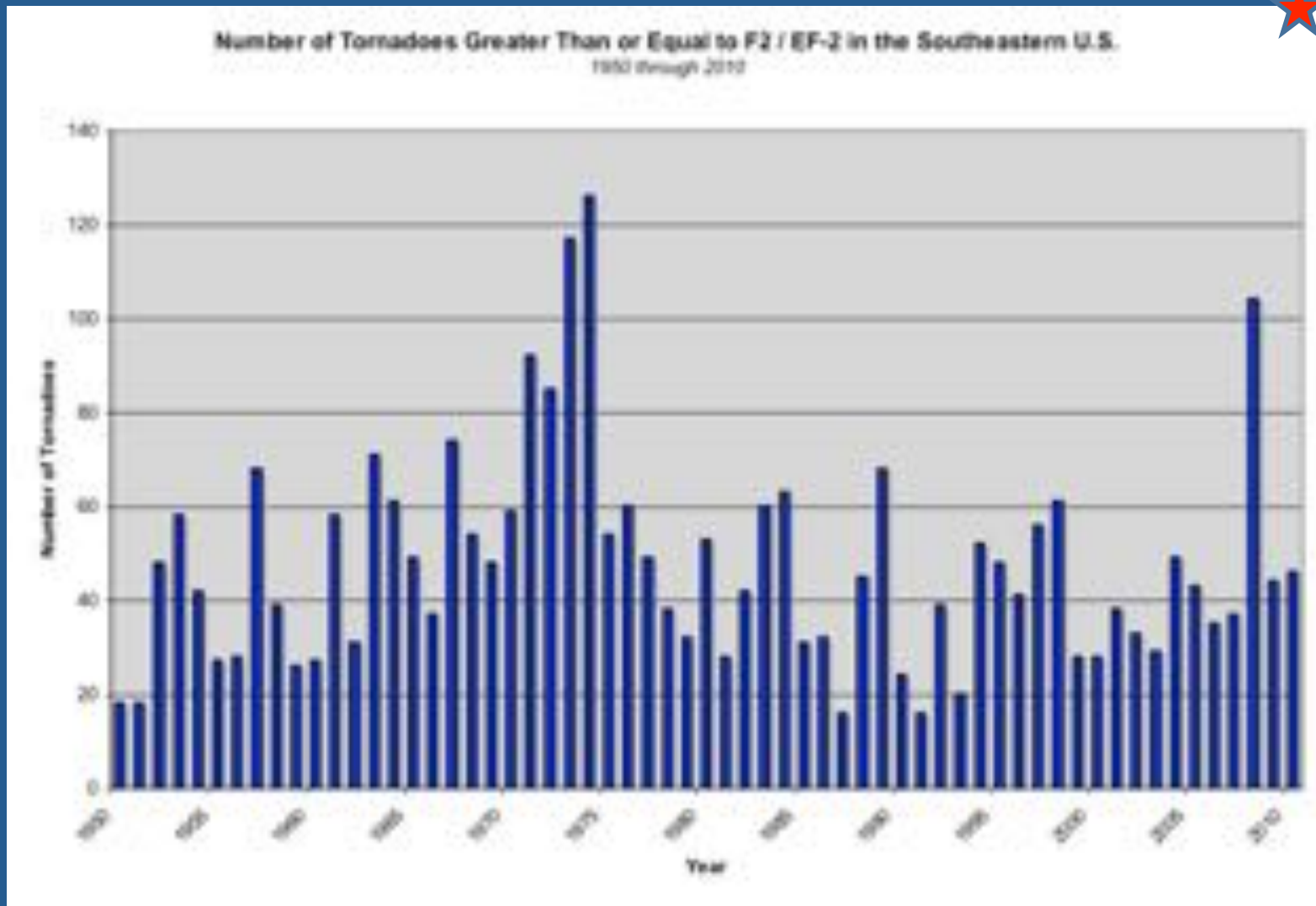
High vulnerability in the SE:

1. Much sub-standard housing (mobile homes).
2. Many trees and other materials that are hurled through the air
3. Poor visibility – many trees, low clouds, and precipitation.



# Tornadoes

Year 2011 = 166



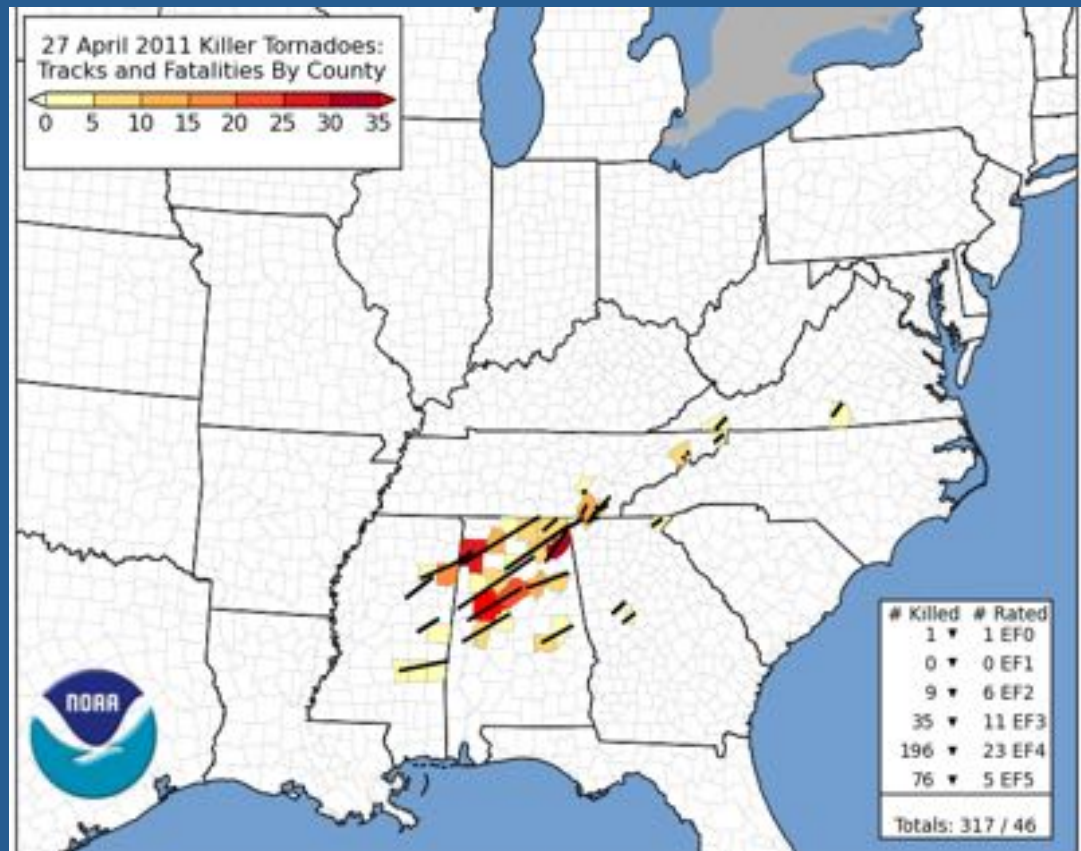
# Tracks of Killer Tornadoes from the April 2011 Southeast Super Outbreak

Number of Tornadoes: **190+** (~10 EF-4, ~4 EF-5)

U.S. States Affected: **14**

Fatalities: **317** (237 in Alabama)

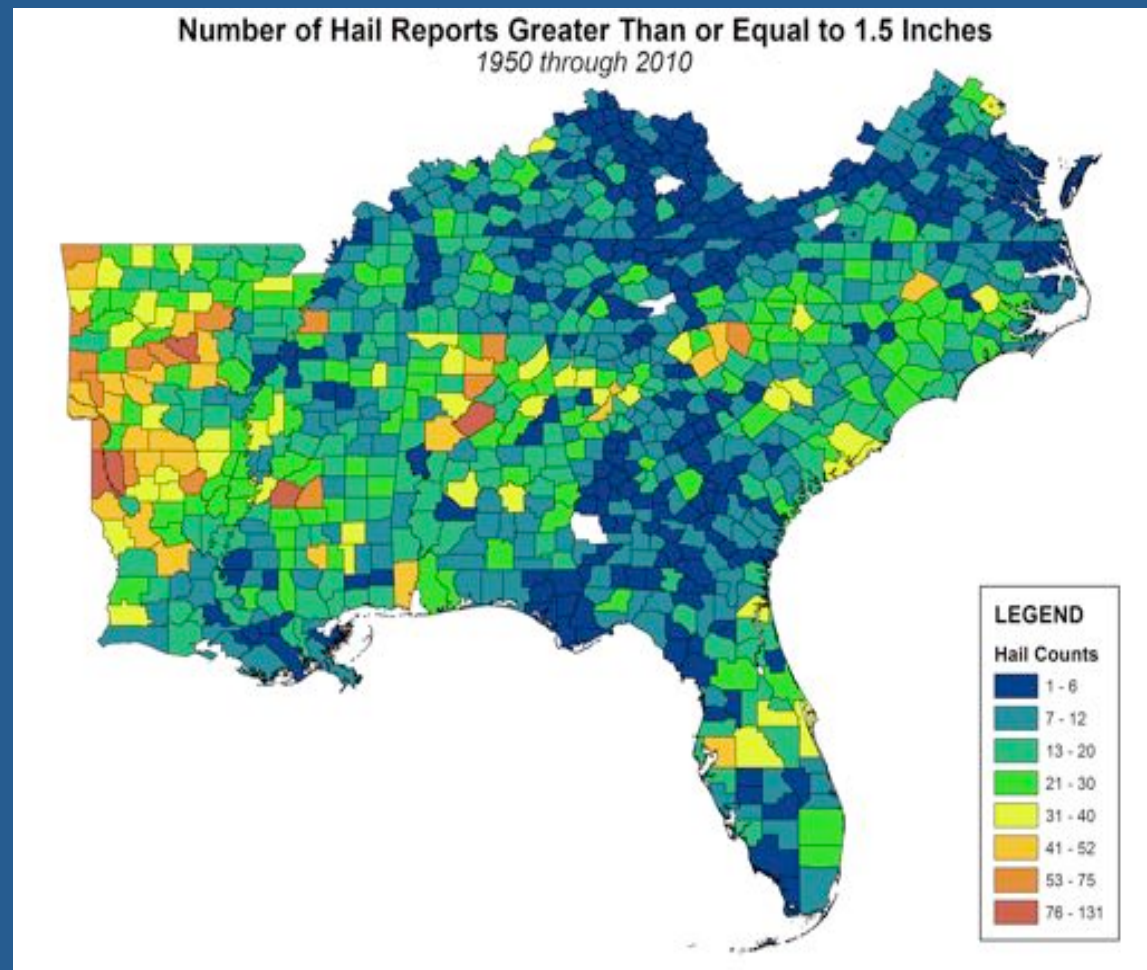
Economic losses: > \$4.8 billion



## Severe Thunderstorms

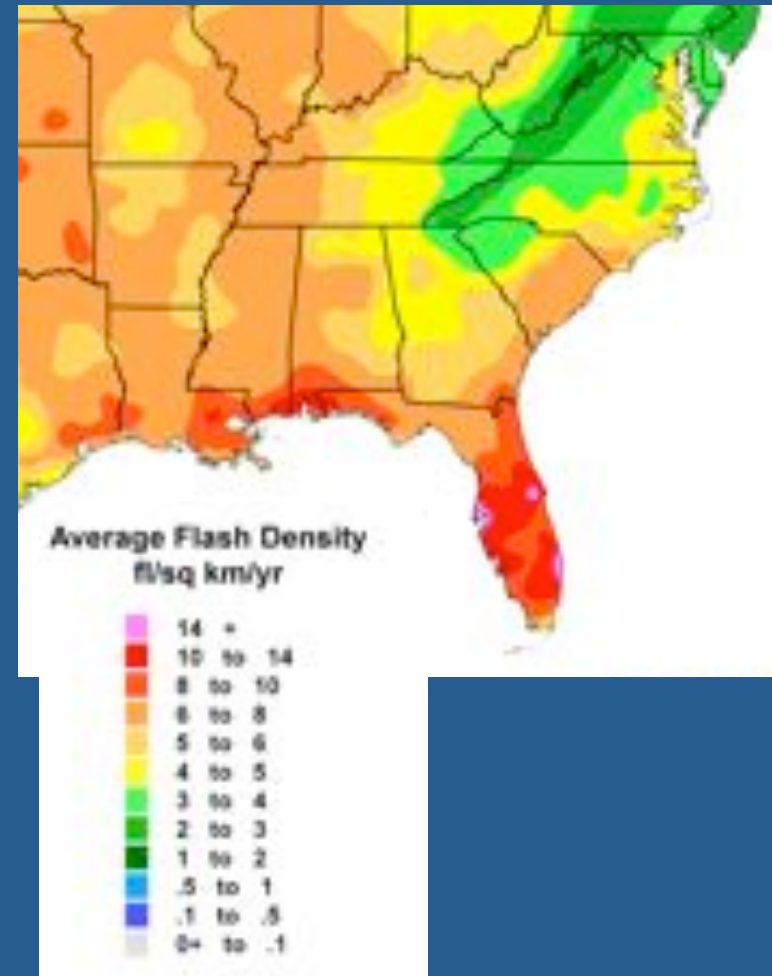
Damaging winds → downed trees/power lines → injuries, loss of life, and power outages

Lightning → power outages and loss of life



# Severe Thunderstorms: Lightning → property damage and loss of life

Rank	State	Death rate per million people 1994-2003
1	New Mexico	1.48
2	Wyoming	1.44
3	Arkansas	1.18
4	Colorado	0.88
5	Texas	0.88
6	Mississippi	0.87
7	Alabama	0.79
7	Oklahoma	0.79
9	Louisiana	0.74
10	South Dakota	0.73
11	Idaho	0.71
11	North Carolina	0.61
13	Tennessee	0.61
16	Maryland	0.60
15	Kentucky	0.60
15	South Carolina	0.60
17	Utah	0.60
17	Minnesota	0.60
18	Arizona	0.58



Source: Vasila

8/11 states in Southeast region are in the top 20

## Future Projections of Climate in the Southeast

- Projected changes are not as great as those observed in other parts of the world.
  - Past climate variability and weather extremes therefore serve as a good analog (i.e. what has happened before will happen again)
- There is much uncertainty in the model projections.

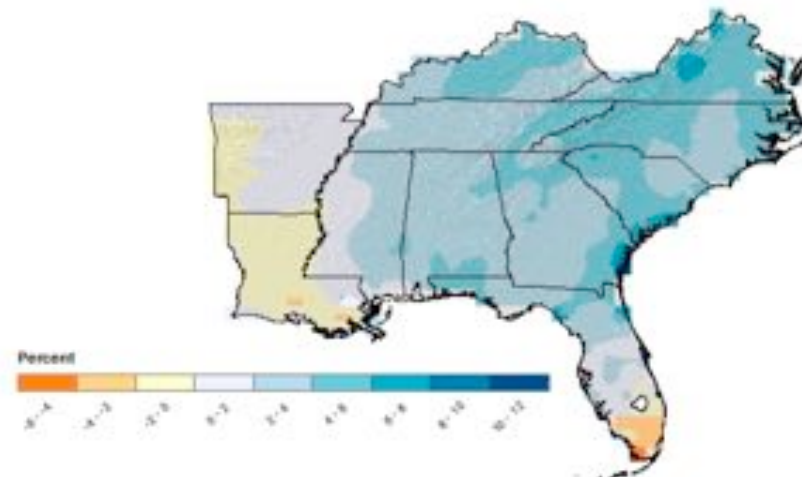
Focus will be on the scenarios that most models agree on.

However we must acknowledge the possibility that big changes may happen.

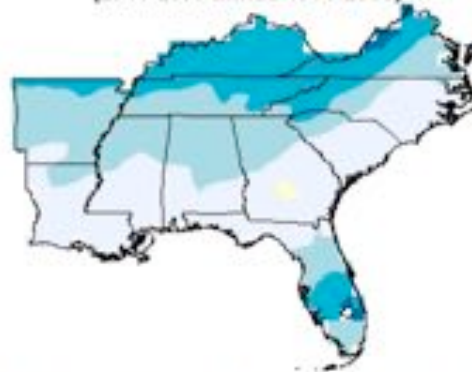
# Precipitation Projections

- Increases in precipitation, except for Arkansas and Louisiana.
- Little change in summer, which coupled with temperature increases → more drought

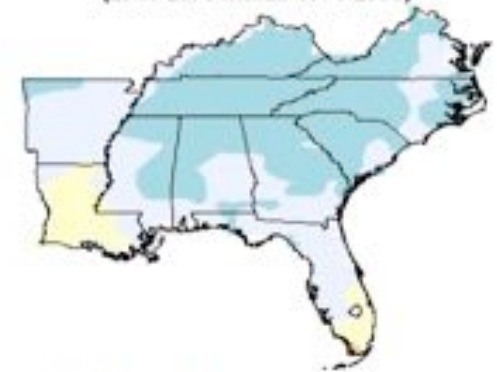
NARCCAP, PRECIPITATION CHANGE, ANNUAL  
(2041-2070 minus 1971-2000)



NARCCAP, Precipitation Change, Winter  
(2041-2070 minus 1971-2000)



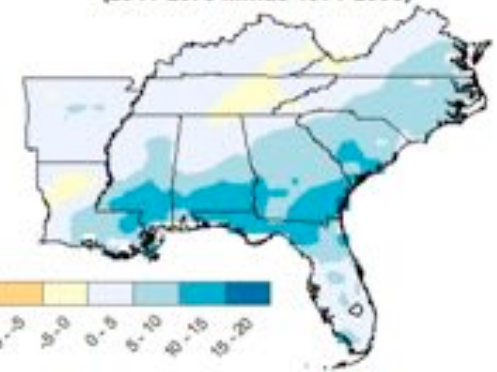
NARCCAP, Precipitation Change, Spring  
(2041-2070 minus 1971-2000)



NARCCAP, Precipitation Change, Summer  
(2041-2070 minus 1971-2000)



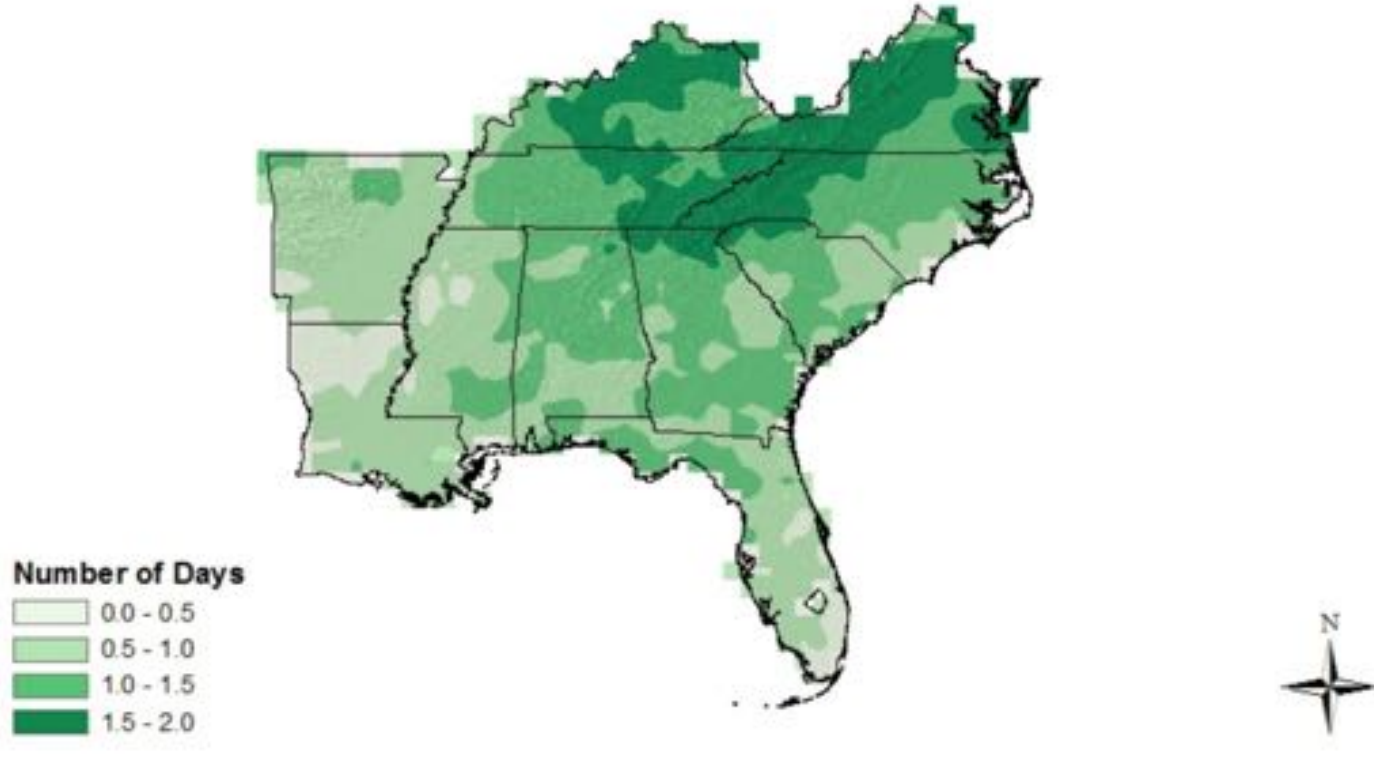
NARCCAP, Precipitation Change, Fall  
(2041-2070 minus 1971-2000)





More heavy rainfall, especially the Southern Appalachians.

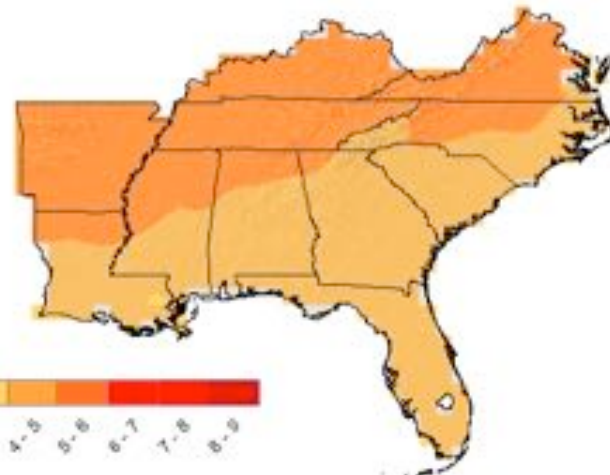
**NARCCAP, Annual # of Days Precipitation > 1 inch,  
Difference (2041-2070 minus 1971-2000)**



# Temperature Projections

Increases temperature, especially during the summer.

NARCCAP, TEMPERATURE CHANGE, ANNUAL  
(2041-2070 minus 1971-2000)



NARCCAP, Temperature Change, Winter  
(2041-2070 minus 1971-2000)



NARCCAP, Temperature Change, Spring  
(2041-2070 minus 1971-2000)



NARCCAP, Temperature Change, Summer  
(2041-2070 minus 1971-2000)

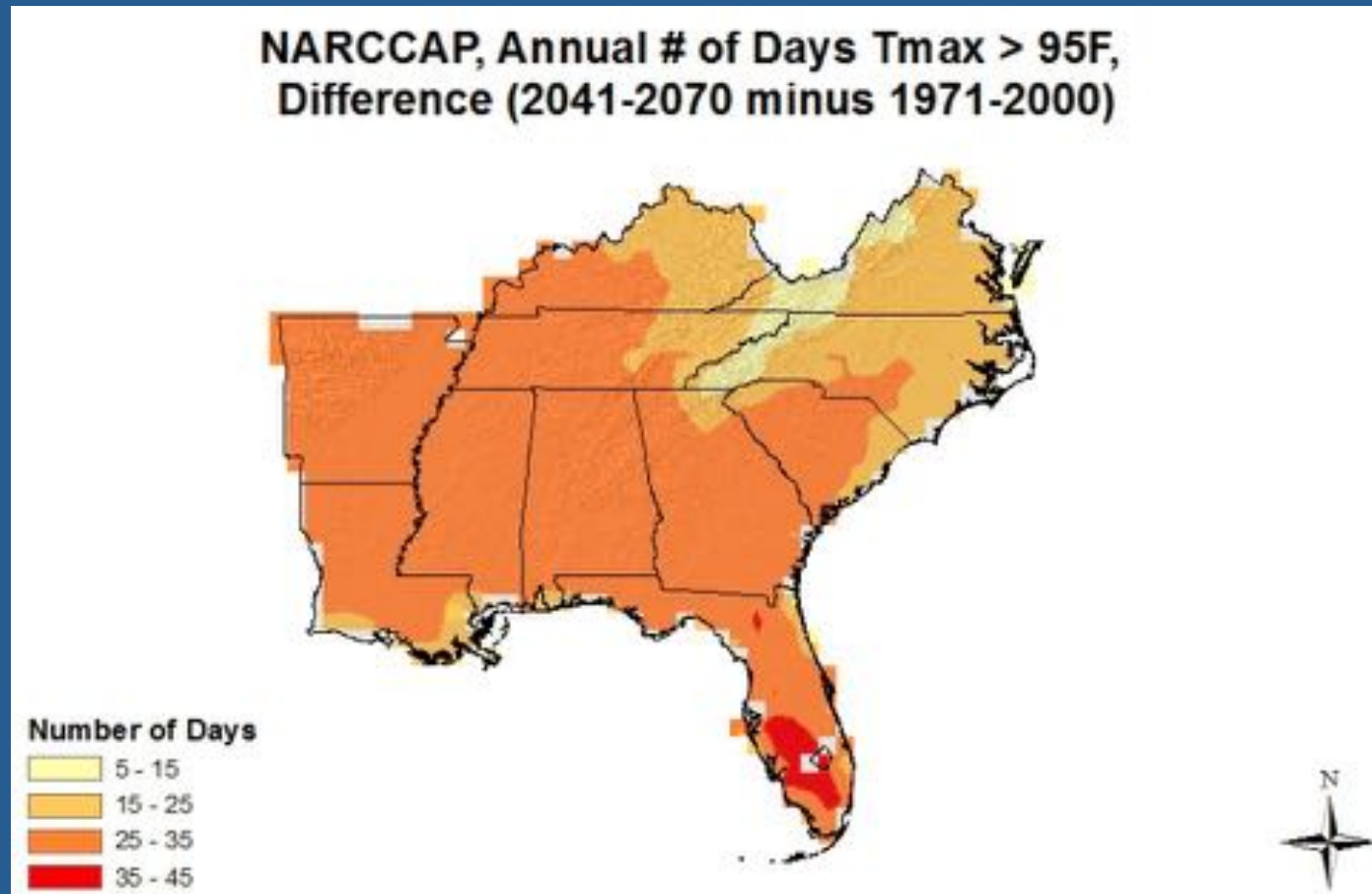


NARCCAP, Temperature Change, Fall  
(2041-2070 minus 1971-2000)



# Temperature Projections

→ More heat waves



## Droughts

- No clear trend; however vulnerability is increasing due to population growth, among other things.

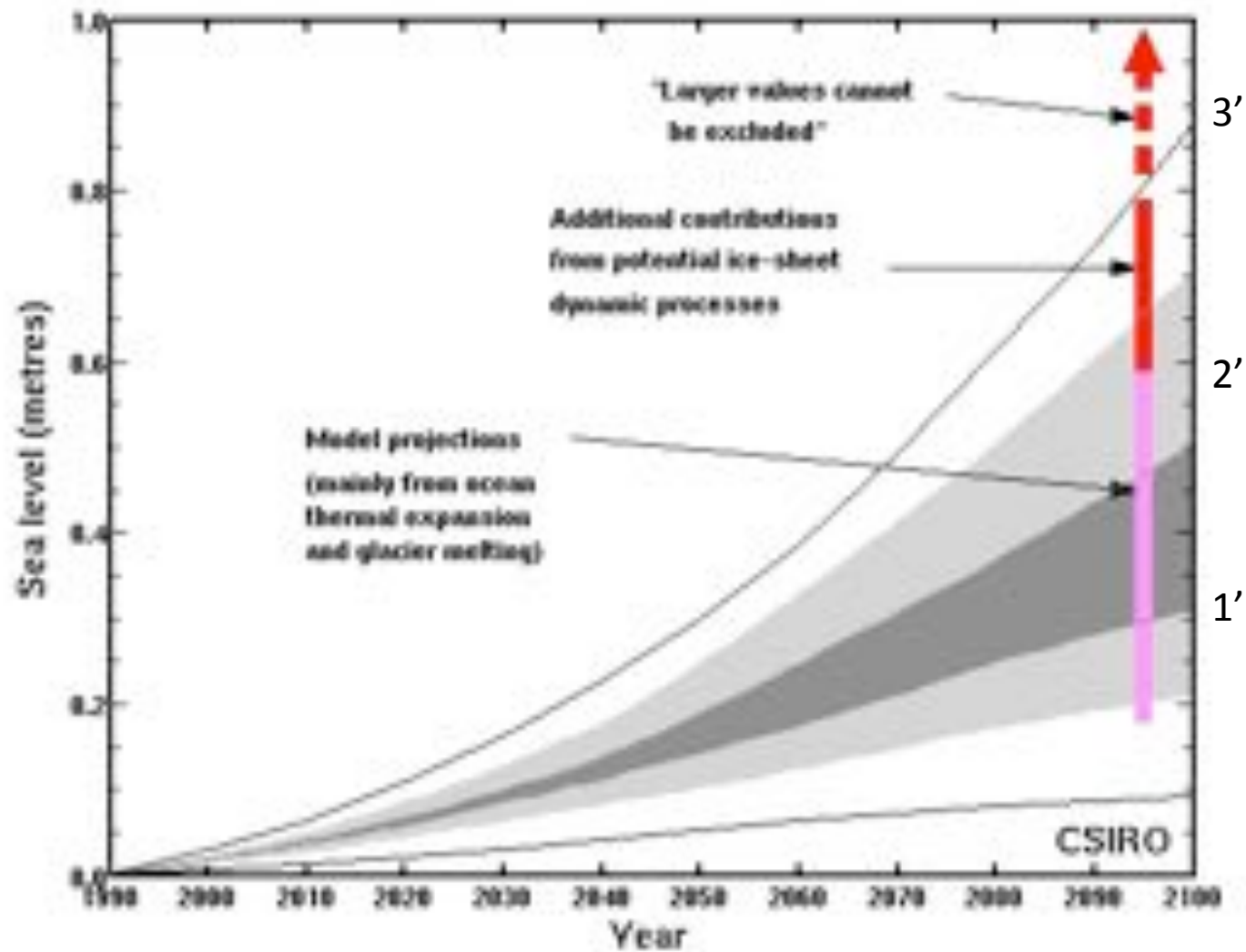
## Air Quality

- Increases in ground-level ozone, especially in urban/industrial areas (e.g. Atlanta and Ohio River Valley)

## Hurricanes

- Slightly fewer tropical storms and hurricanes overall, but more strong hurricanes (CAT3-CAT5).

# Sea Level Rise



## Acknowledgements:

- Chris Fuhrmann and Maggie Kovach from the Southeast Regional Climate Center
- Ryan Boyles and Ashley Fraser from the NC State Climate Office

**Thank You!**

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