Changing Climate Evidence and Future Directions for the Southeast Region

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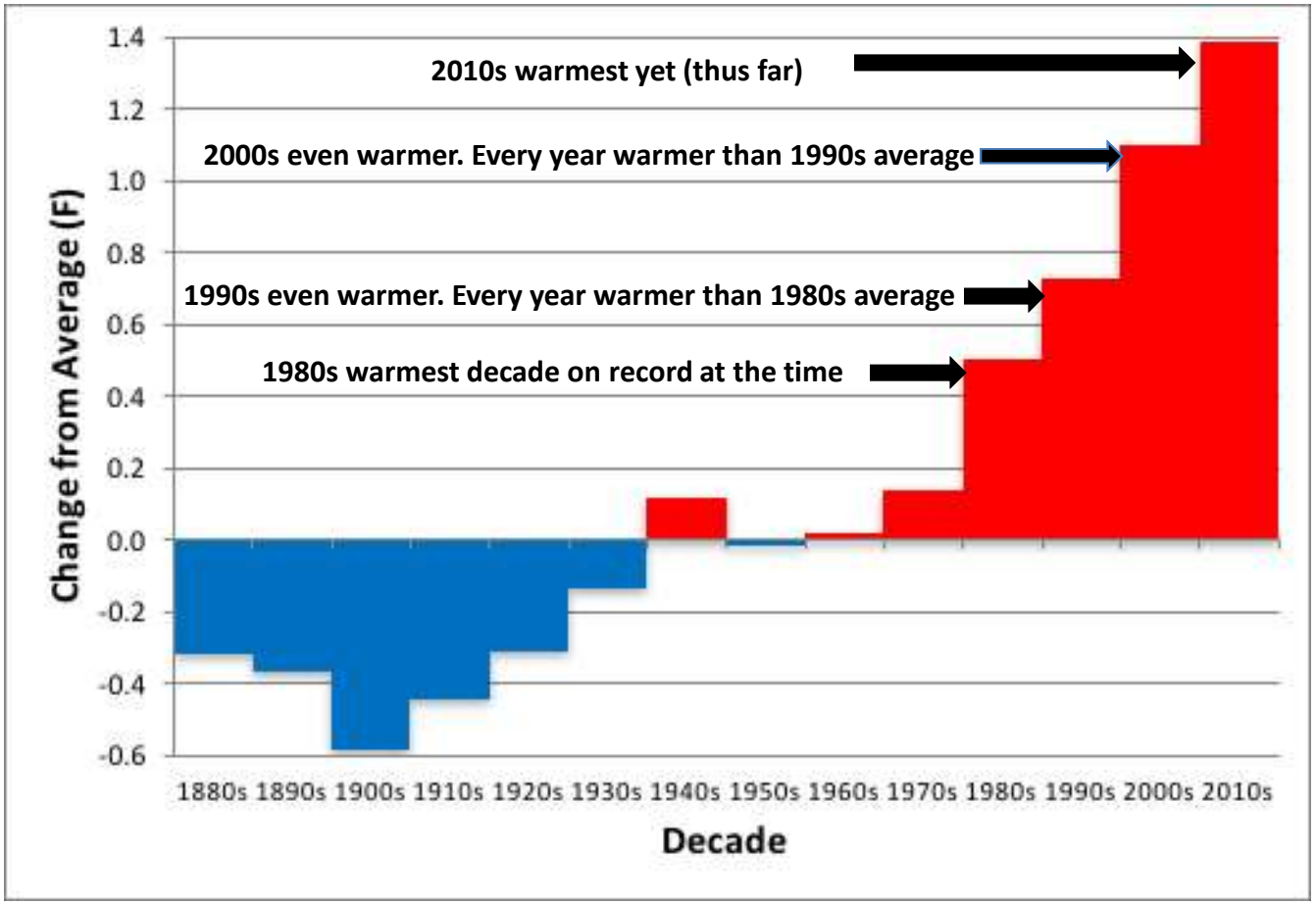
Global Temperature Changes/Causes

Global Temperature Change by Decade



2014 warmest year on record at time 2015 set new record 2016 set yet another record

2015 and 2016 data influenced by strong El Nino

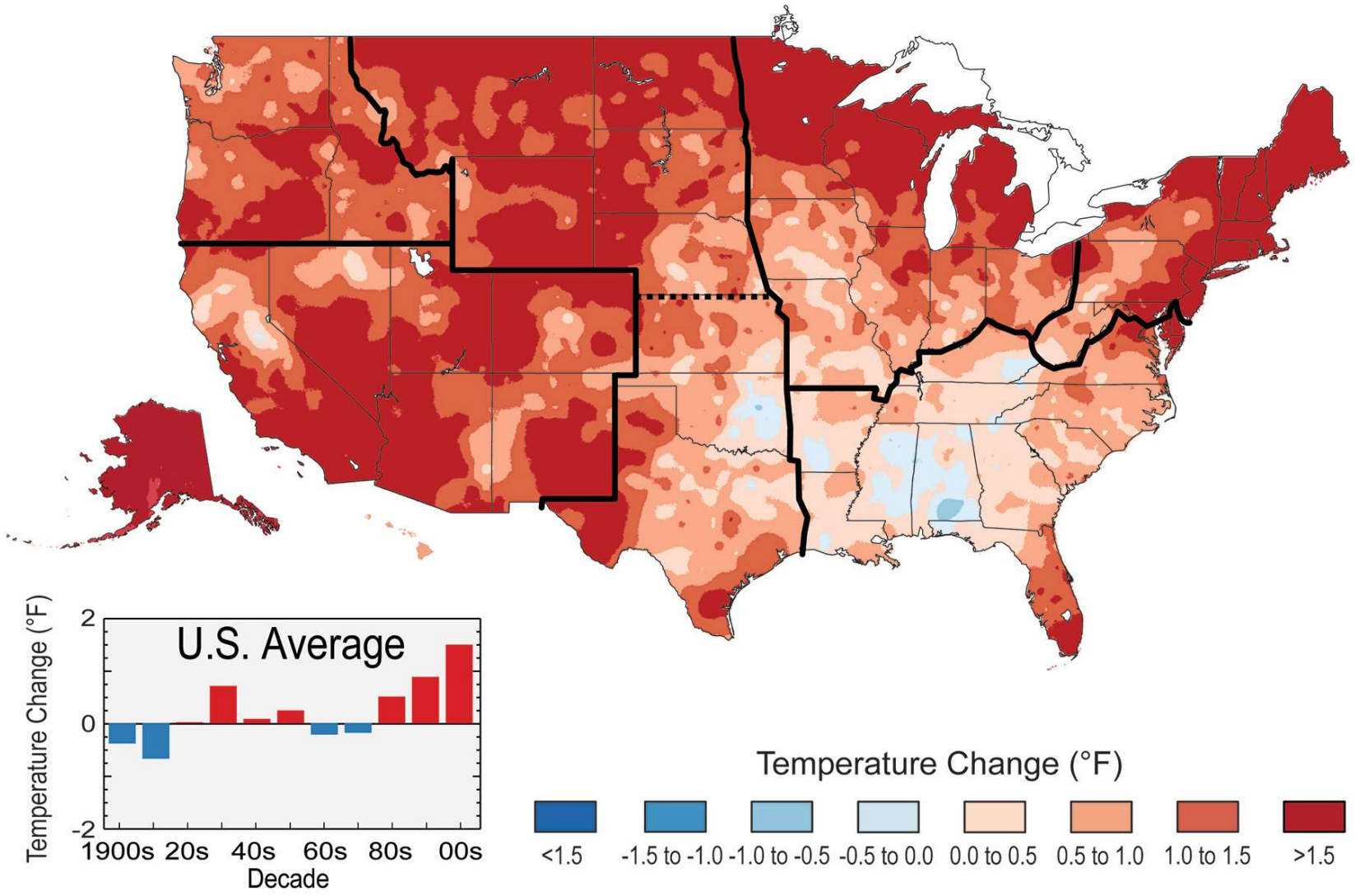
2017 3rd warmest

SUMMARY OF CLIMATE SCIENCE

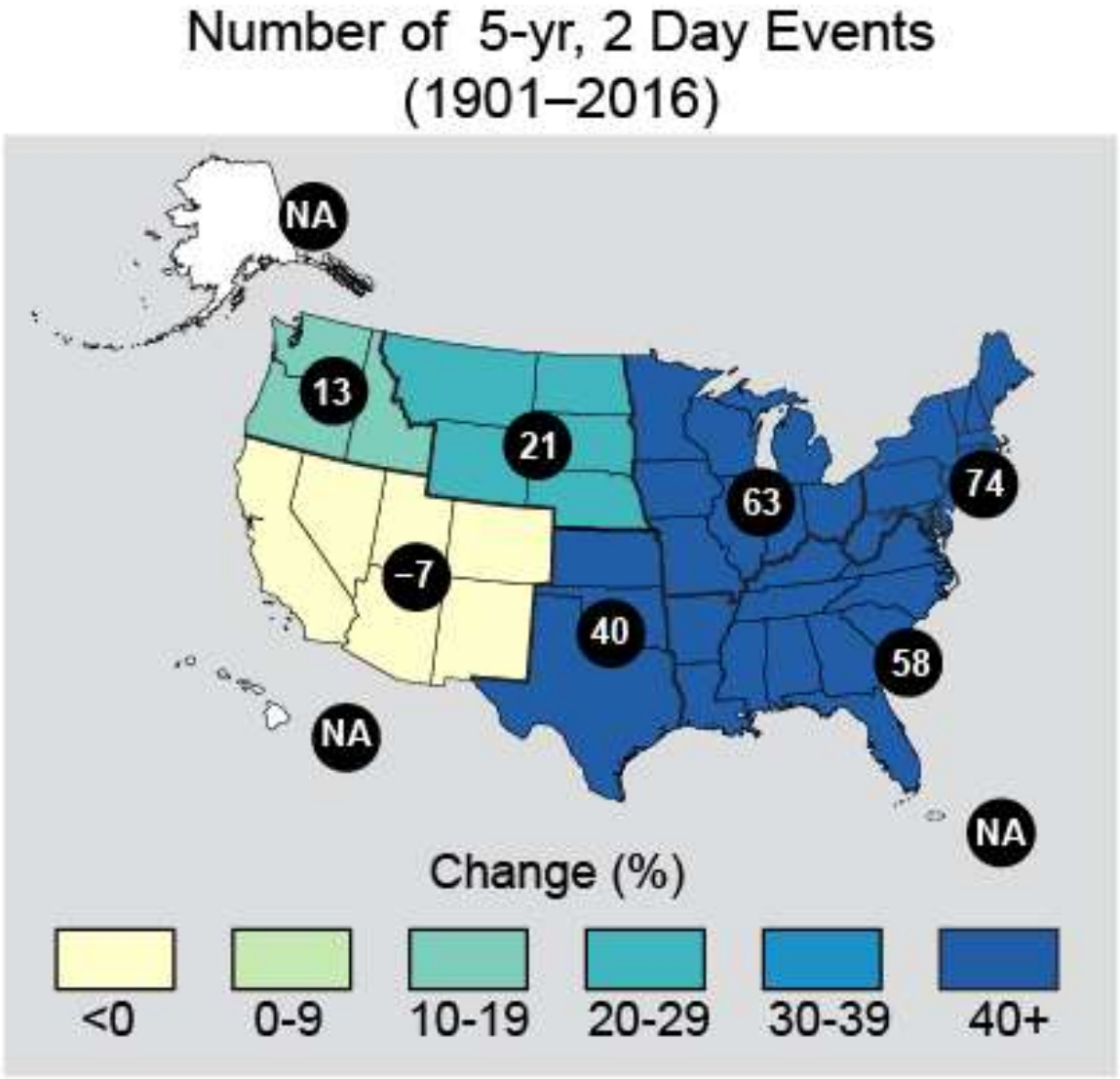
- **Consensus** of the large majority of **climate scientists**
  - **CO_2 concentrations are increasing rapidly**
  - **The primary cause is burning of fossil fuels**
  - **CO_2 is a greenhouse gas and is having a warming influence on the earth**
  - **The earth is warming**
  - **Increasing concentrations of CO_2 and other greenhouse gases are most likely causing much, if not all, of the warming**
  - **All other explanations of warming are speculative at this point and not supported by strong scientific evidence**

National Changes

Observed U.S. Temperature Change



Observed U.S. Trends in Heavy Precipitation

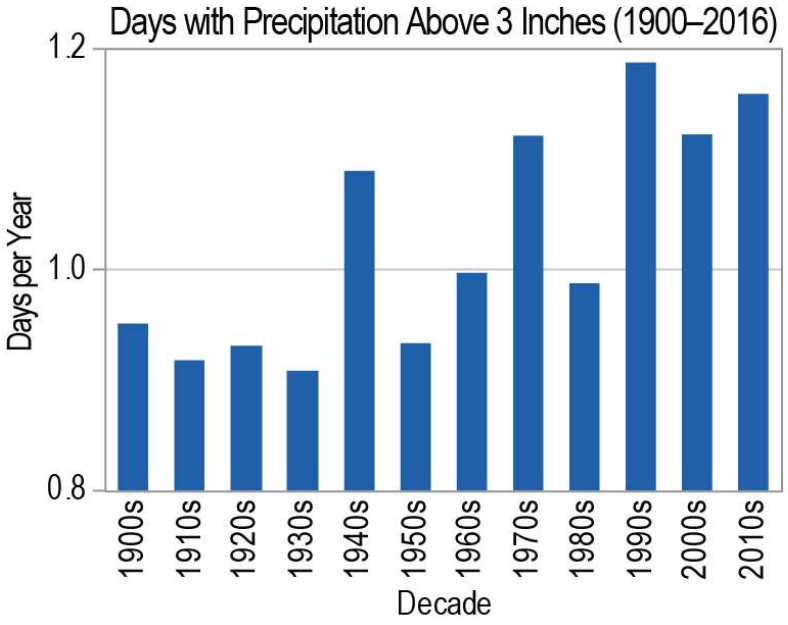


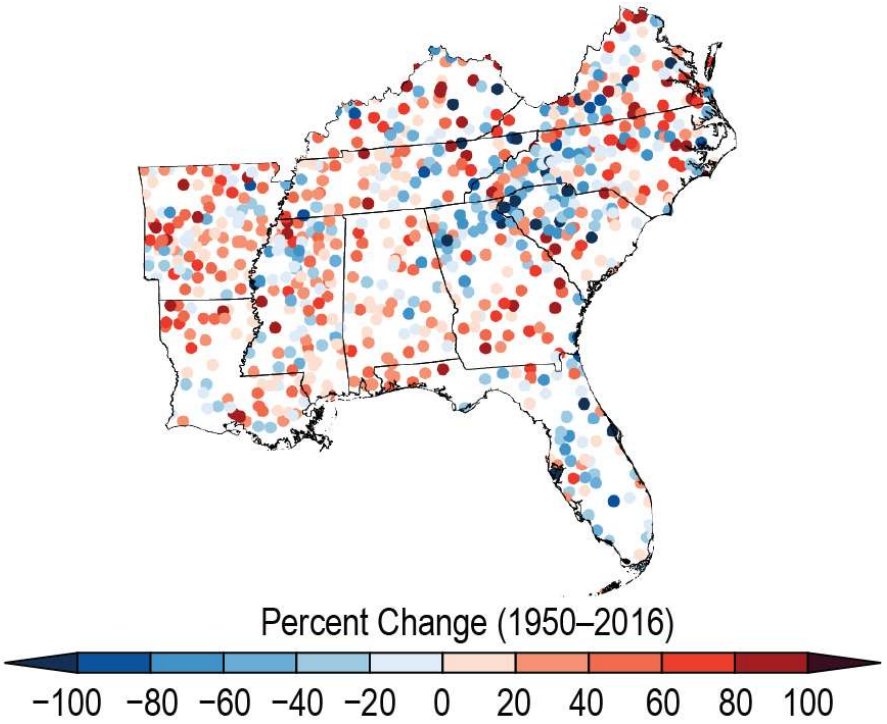
National Changes

- Most regions have warmed
  - Exception is a small area of the southeast U.S.
- Most regions have experienced an increase in heavy rainfall

Southeast Changes

Trend in 3 inch days: Southeast



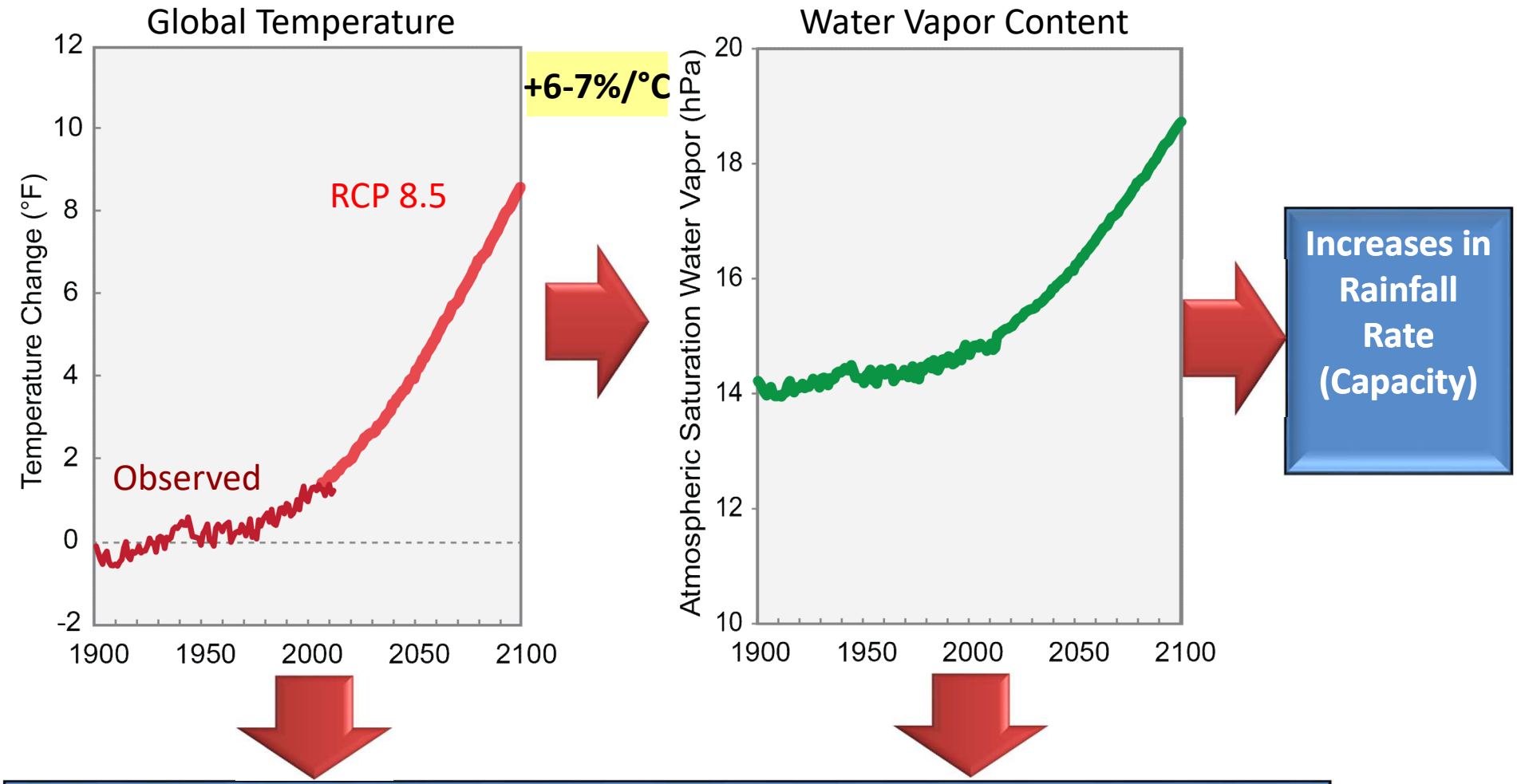


Trend in 3 inch days

- Most stations have experienced an upward trend
- There is substantial spatial variability, for example, a station with an upward trend near a station with a downward trend
  - This is due to the natural high spatial variability of heavy rainfall
  - Conclusions about systematic (non-random) changes require an examination of relatively large spatial areas

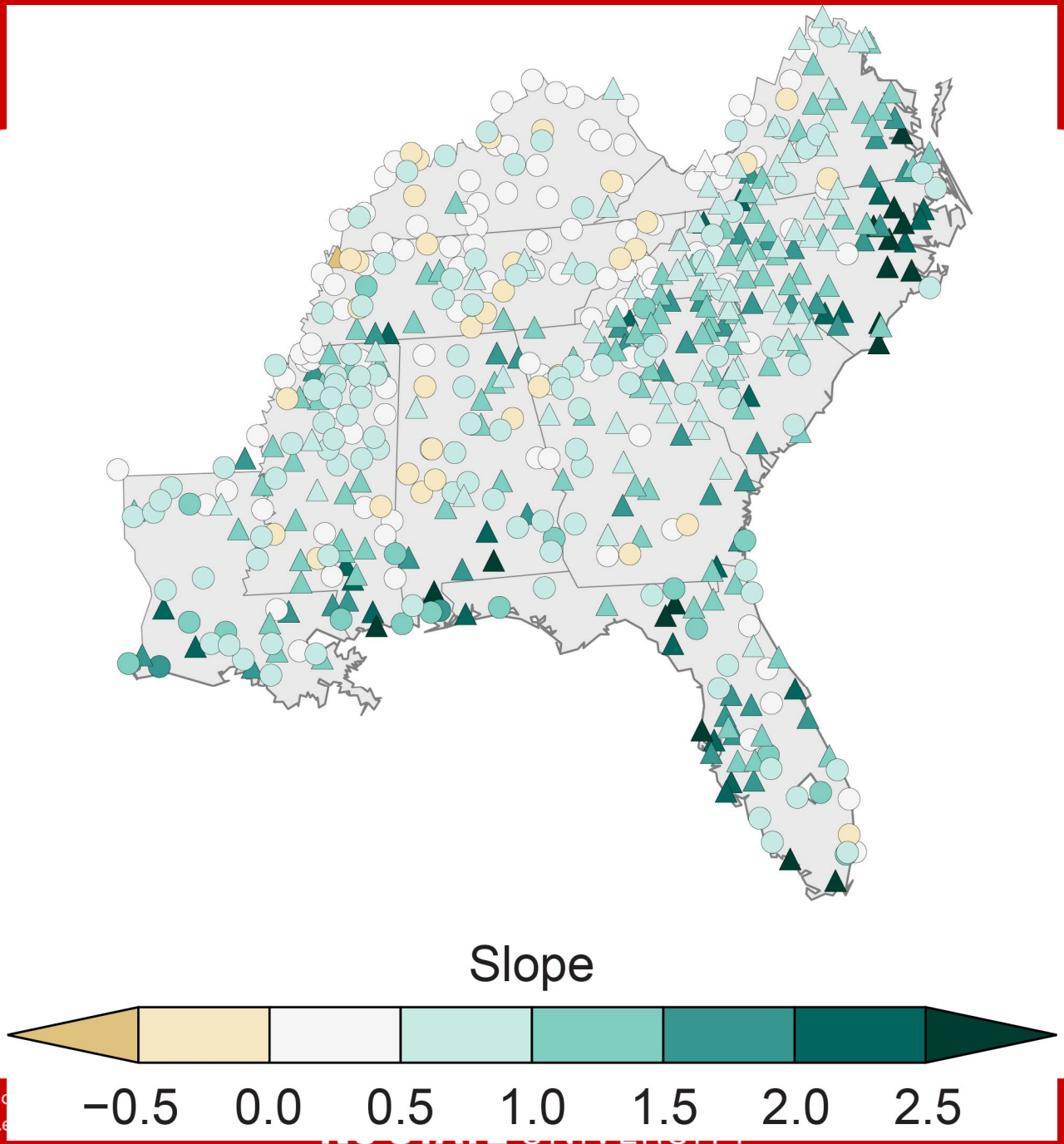
Future Changes

Global Warming->Saturation Water Vapor Increases



Water Vapor and Annual Max Precip

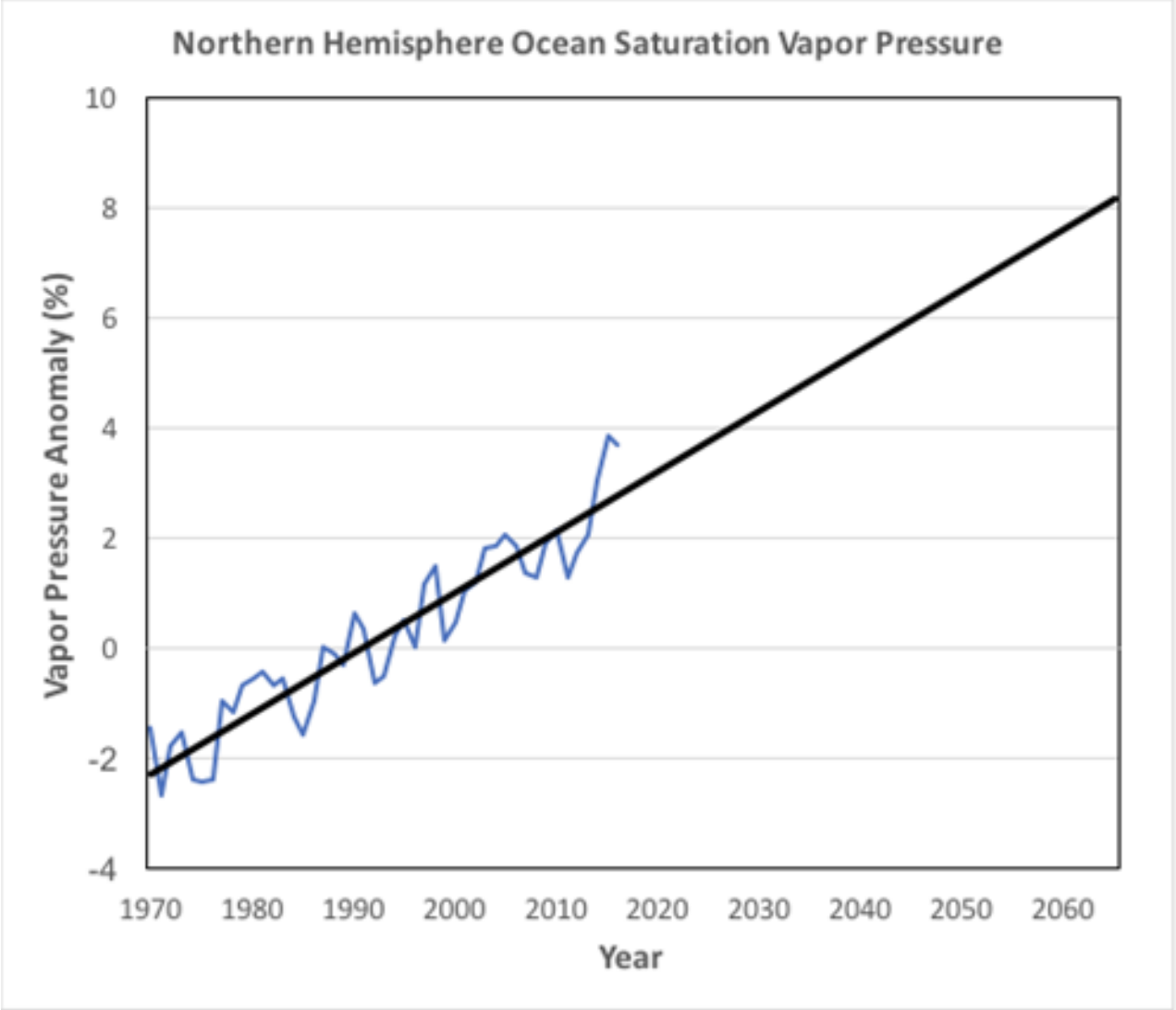
- For the southern U.S., we examined the historical relationship between extreme rainfall amounts and atmospheric water vapor content


Slope
−0.5
0.0
0.5
1.0
1.5
2.0
2.5

Water Vapor and Extreme Precipitation

- Nearly all stations in the Southeast U.S. show a positive relationship between the amount of rainfall in big storms and the water vapor in the atmosphere

Historical SST changes – Northern Hemisphere



Water Vapor and Extreme Precipitation

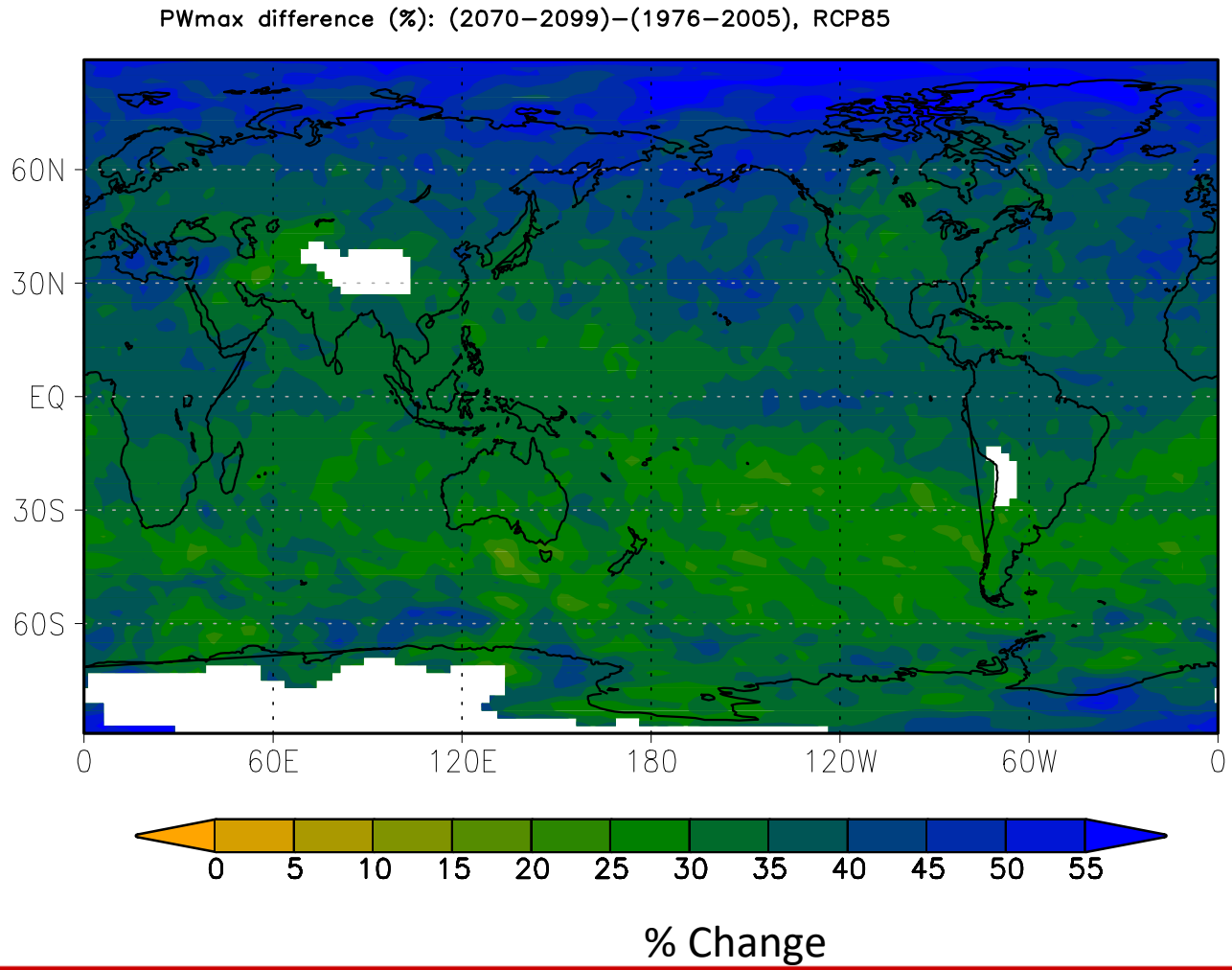
- Nearly all stations in the Southeast U.S. show a positive relationship between the amount of rainfall in big storms and the water vapor in the atmosphere
- Sea surface temperatures have been inexorably rising, leading to general increases in atmospheric water vapor
- This trend will continue if greenhouse gases increase in the future

Future Water Vapor Change (2085)

High Emissions Scenario

Most of CONUS shows increases of 25-40%

Globally, increases are >20% everywhere



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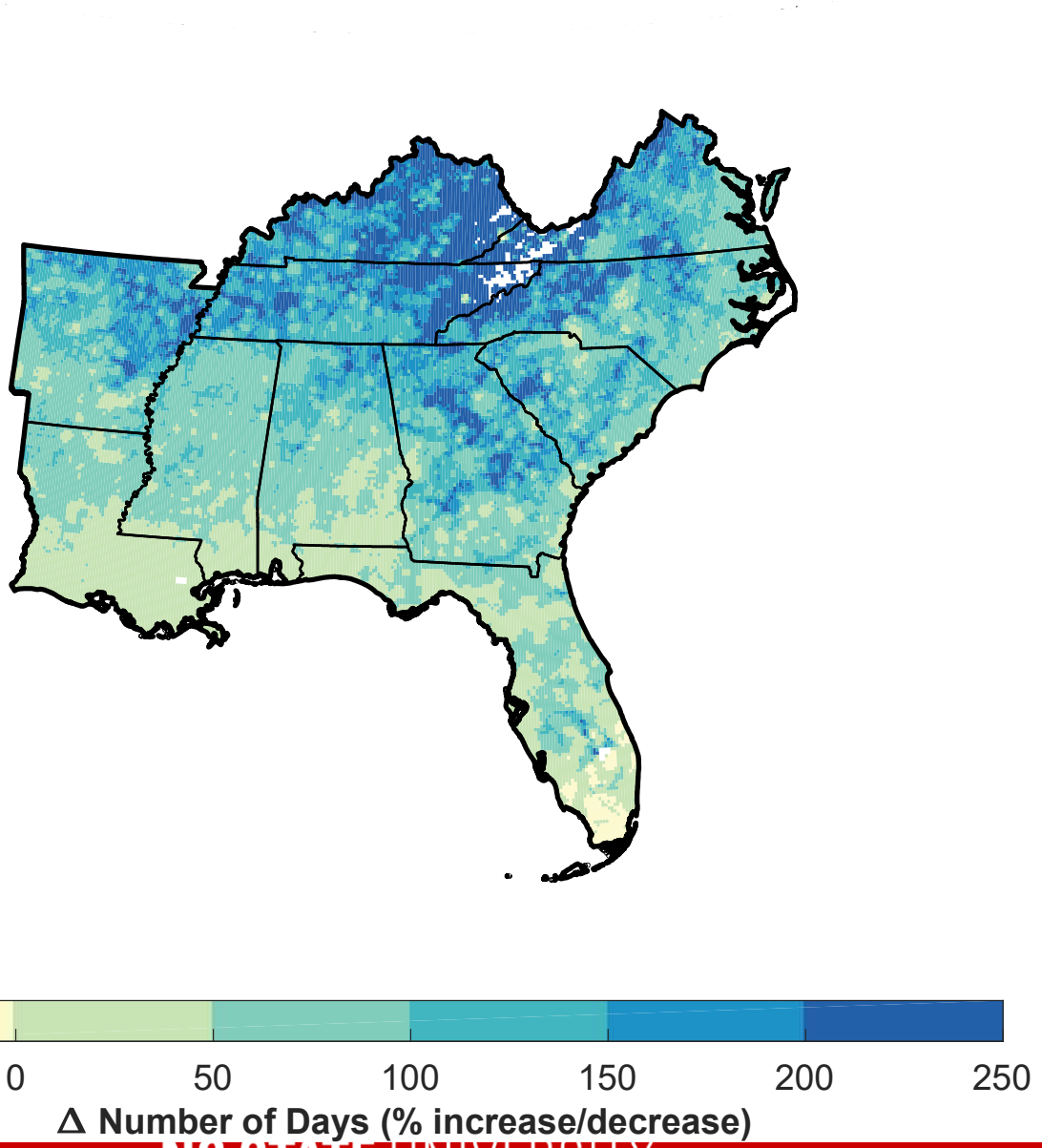
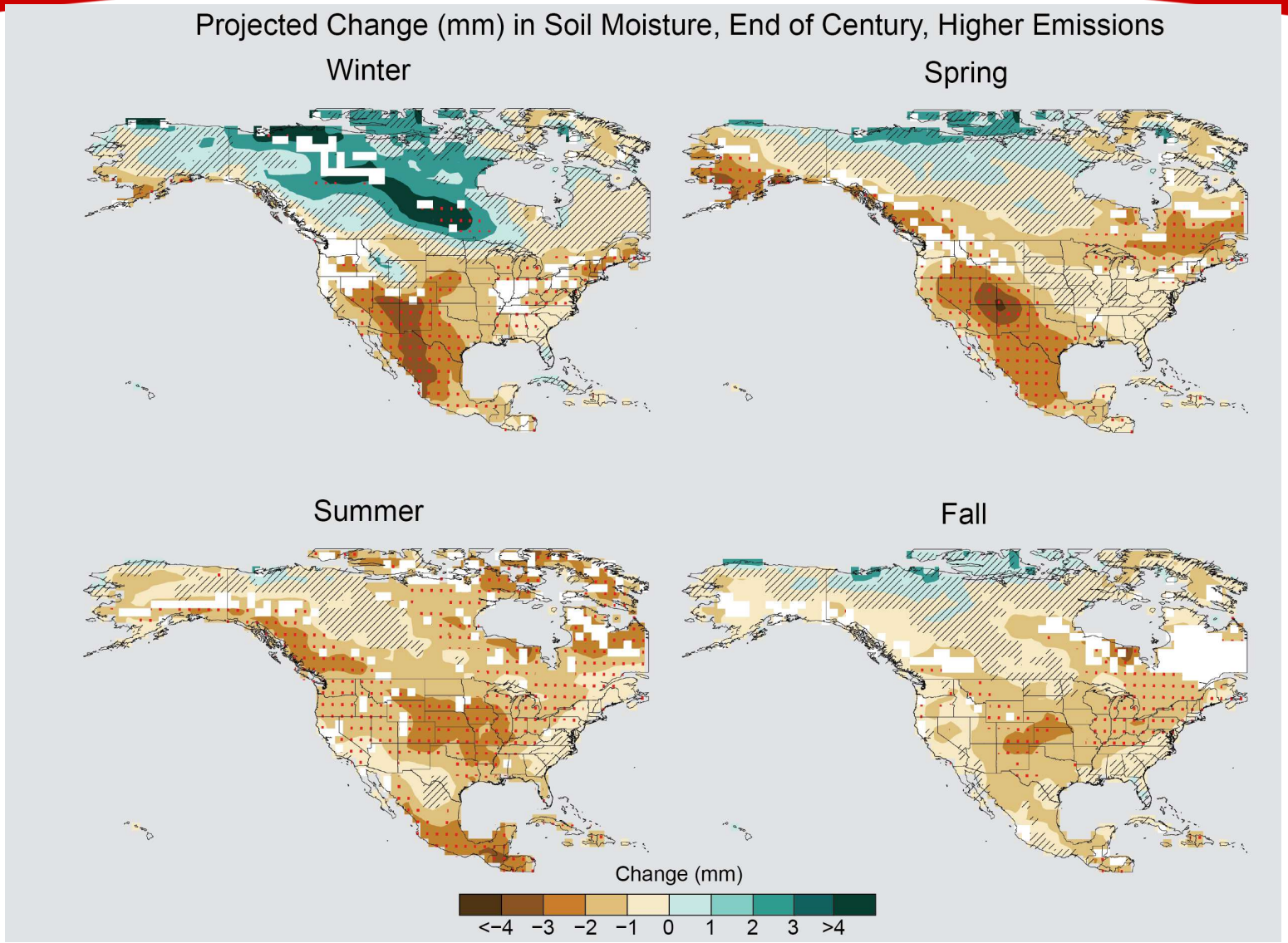
Change in Average Annual Number of Days with Precipitation > 3 Inches
(1976 - 2005 to 2070 - 2099)



Low Flow

- Low flow is governed by the severity and frequency of droughts
- Precipitation projections are quite uncertain, particularly for the Southeast U.S.
- It is likely that severe droughts will be more intense because of increases in temperature (evaporation rates)
- This could reduce low flow magnitudes

SOIL MOISTURE PROJECTIONS

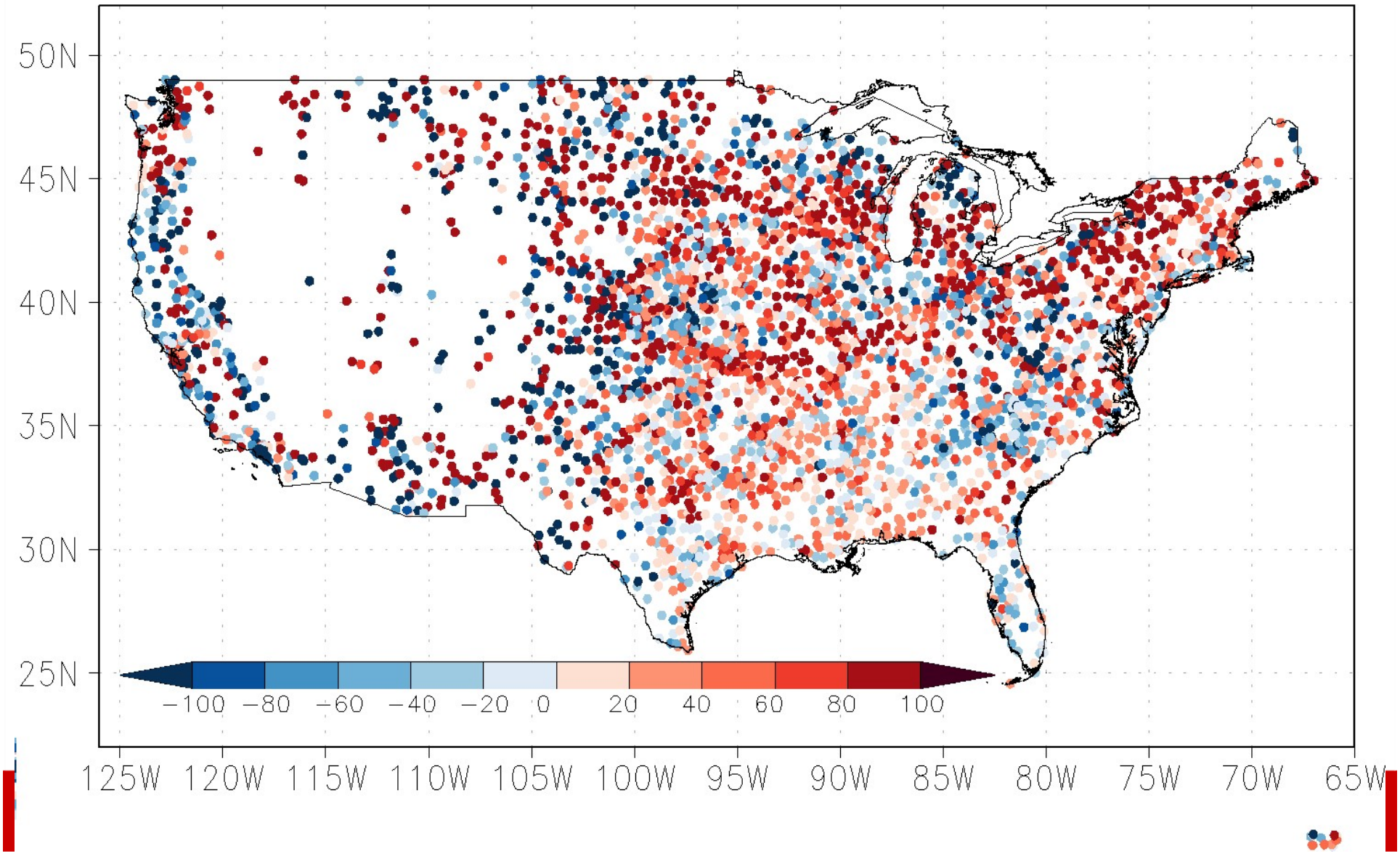


Conclusions

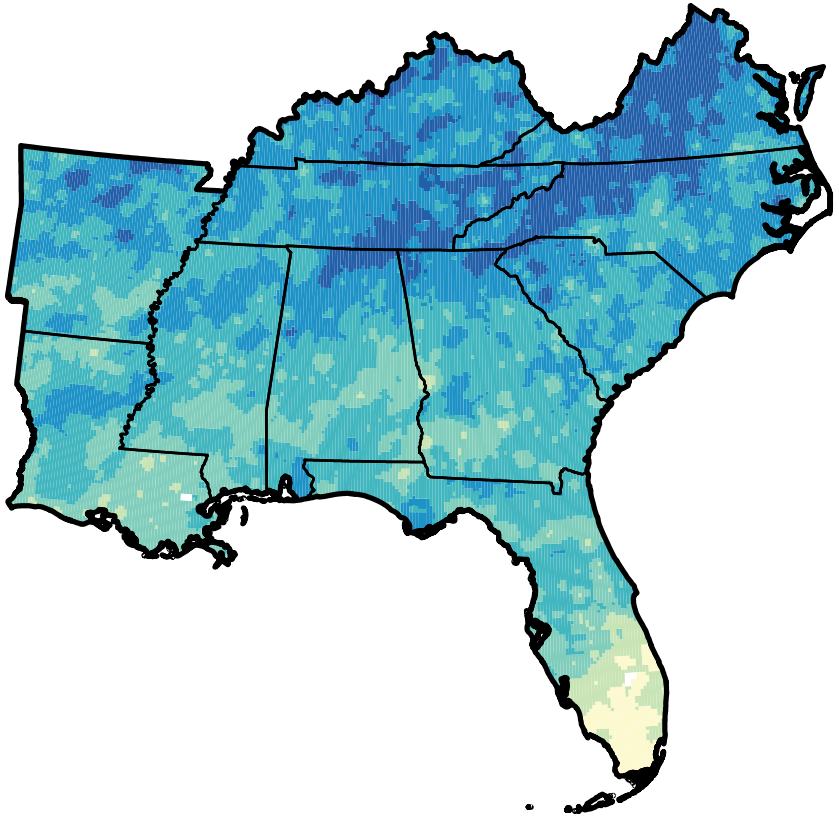
- Future increases in greenhouse gas concentrations will lead to increases in extreme precipitation because
  - Sea surface temperature increases will increase atmospheric water vapor content
  - Heavy rainfall magnitude is directly linked to atmospheric water vapor
- Low Flow magnitudes may decrease because of temperature-induced increases in drought intensity

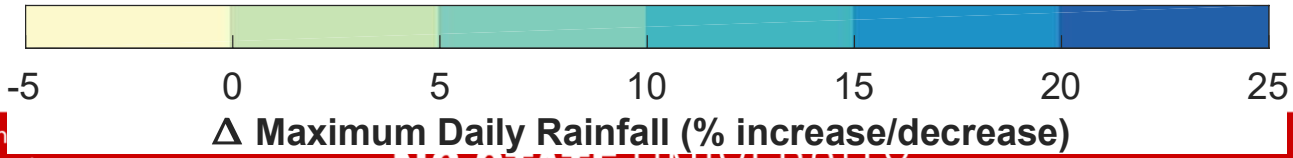
EXTRA SLIDES

Trend in 3 inch days (1951-2016)



Change in Average Annual Maximum Daily Rainfall
(1976 - 2005 to 2070 - 2099)





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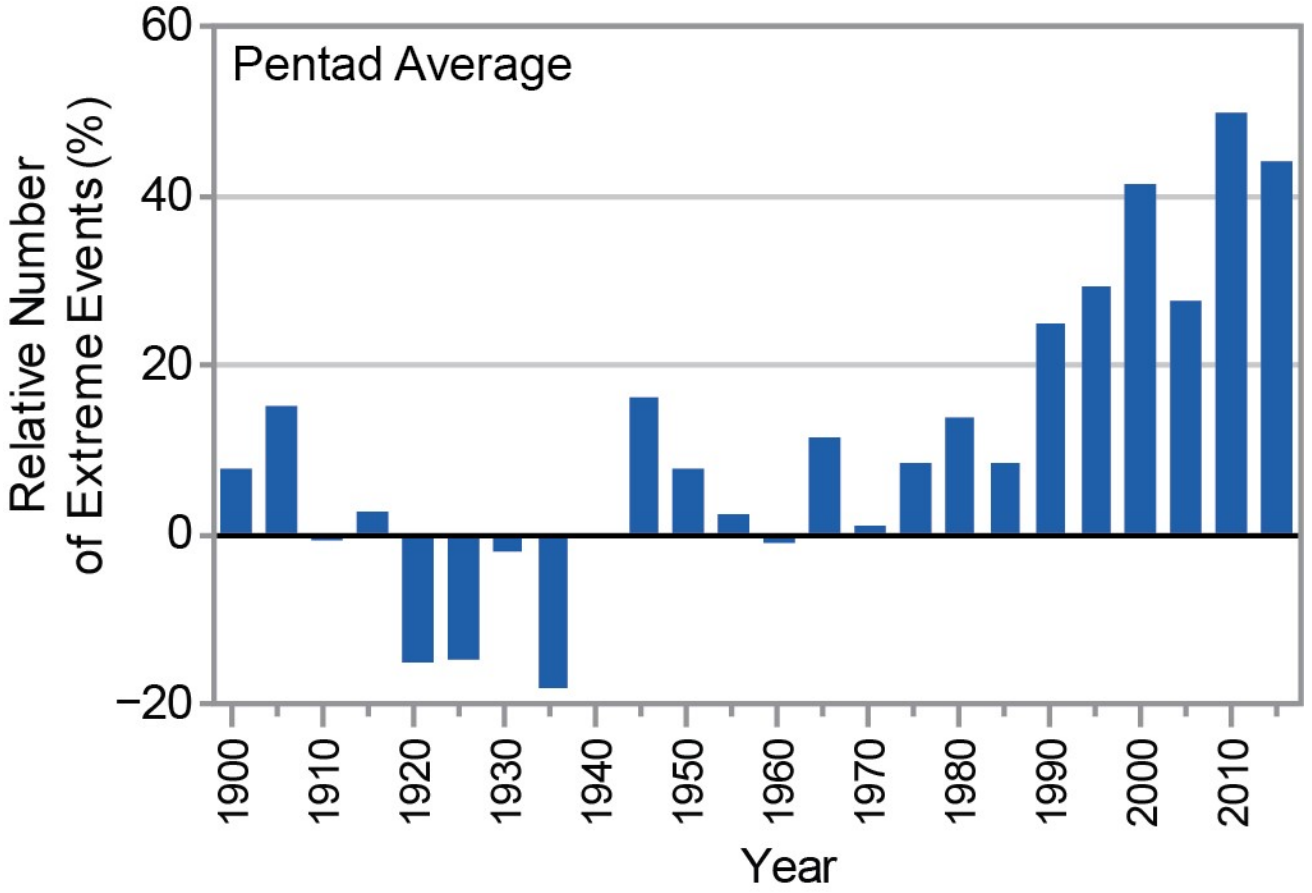

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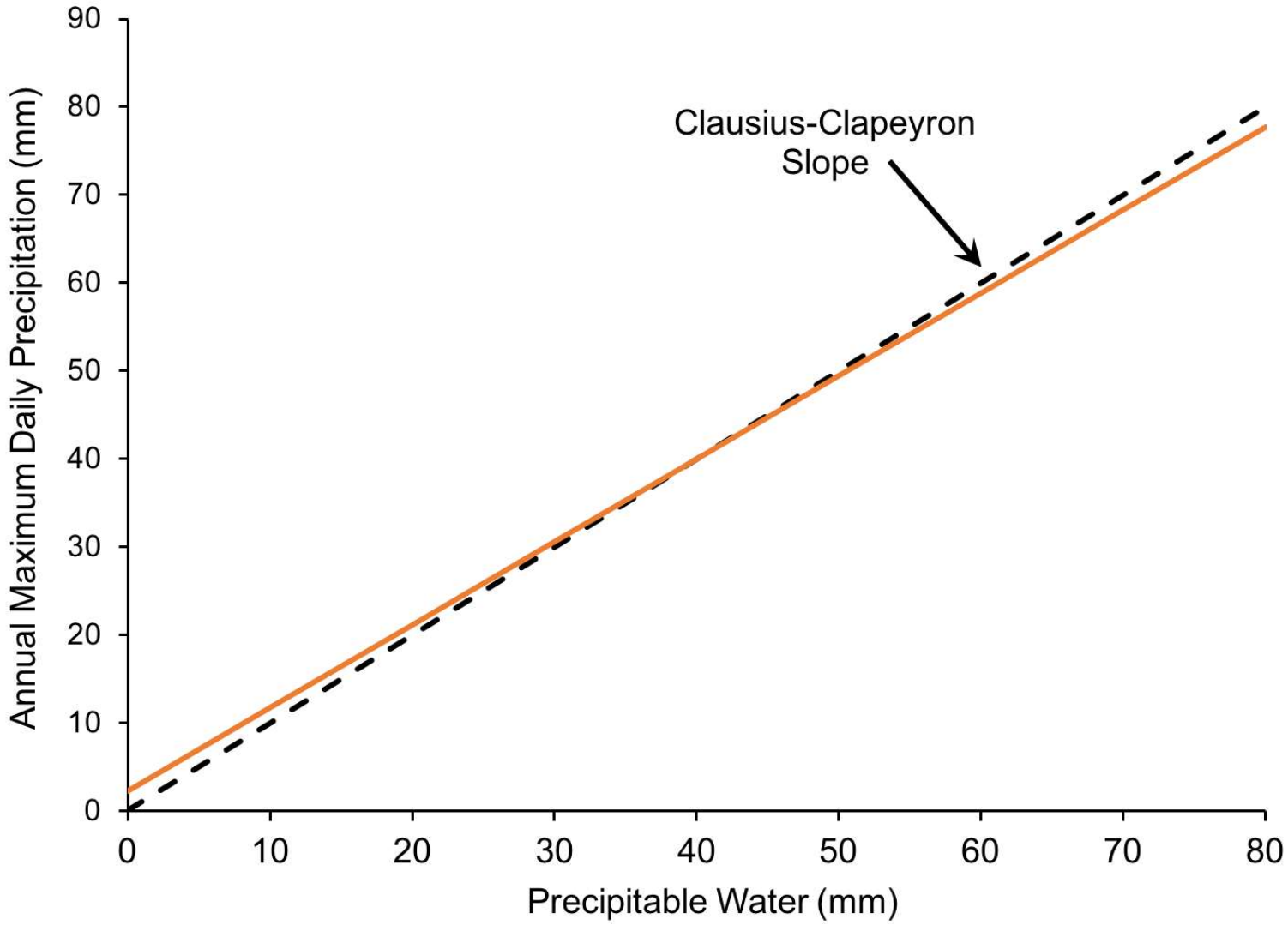

Water Vapor and Annual Max Precip

- For the southern U.S., we examined the historical relationship between extreme rainfall amounts and atmospheric water vapor content
- There is a direct relationship indicating that water vapor content is the primary determinant of the magnitude of extreme precipitation events