NC STATE UNIVERSITY

Extreme Rainfall and Future Flooding A Growing Risk? Why?

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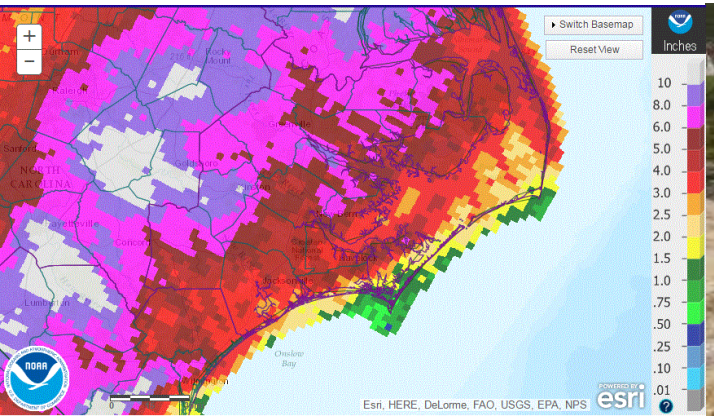
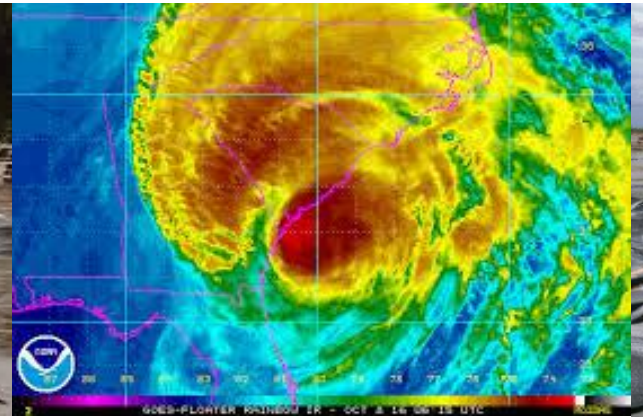
Coastal Resilience Workshop

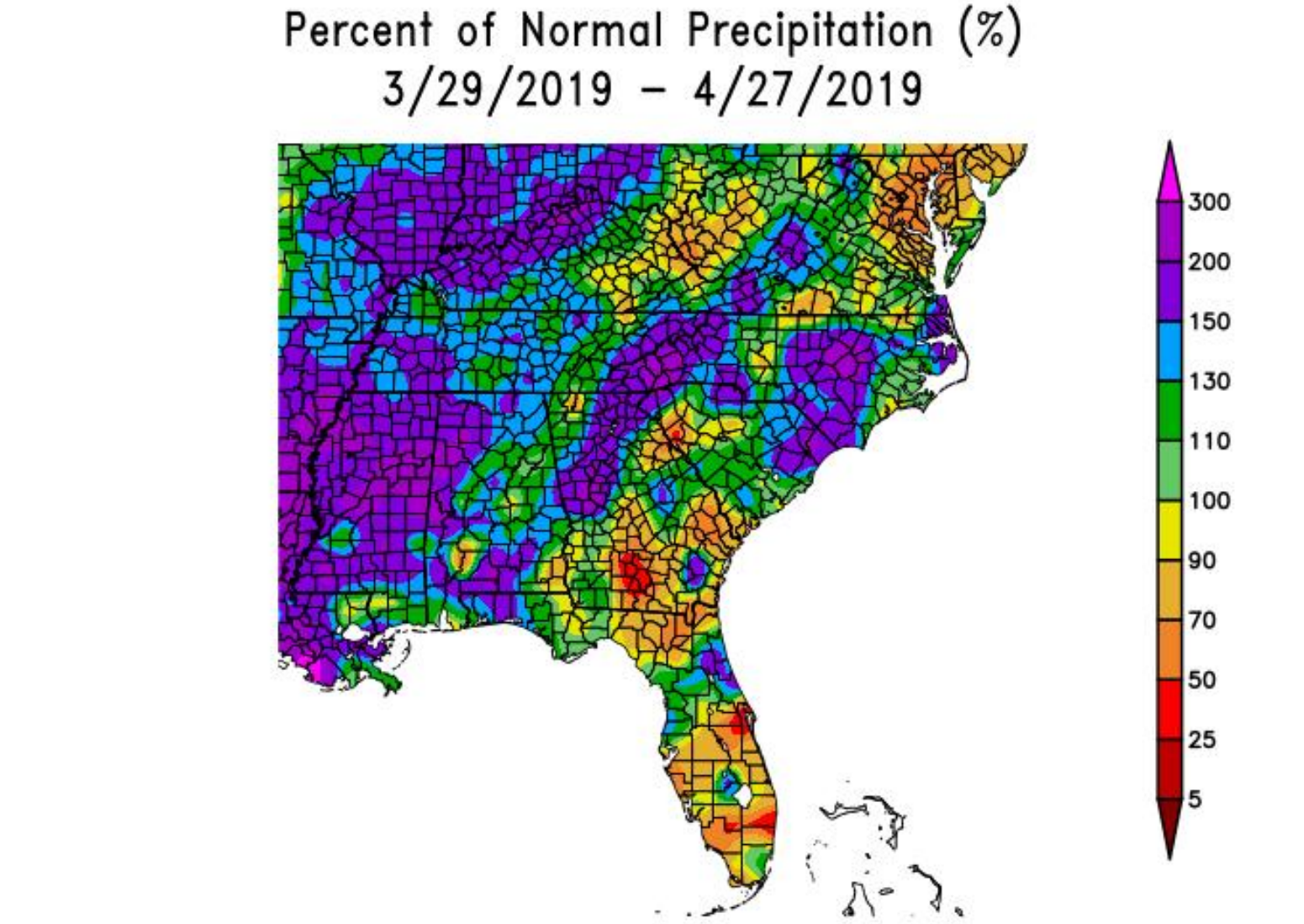
Wilmington, NC

May 14, 2019

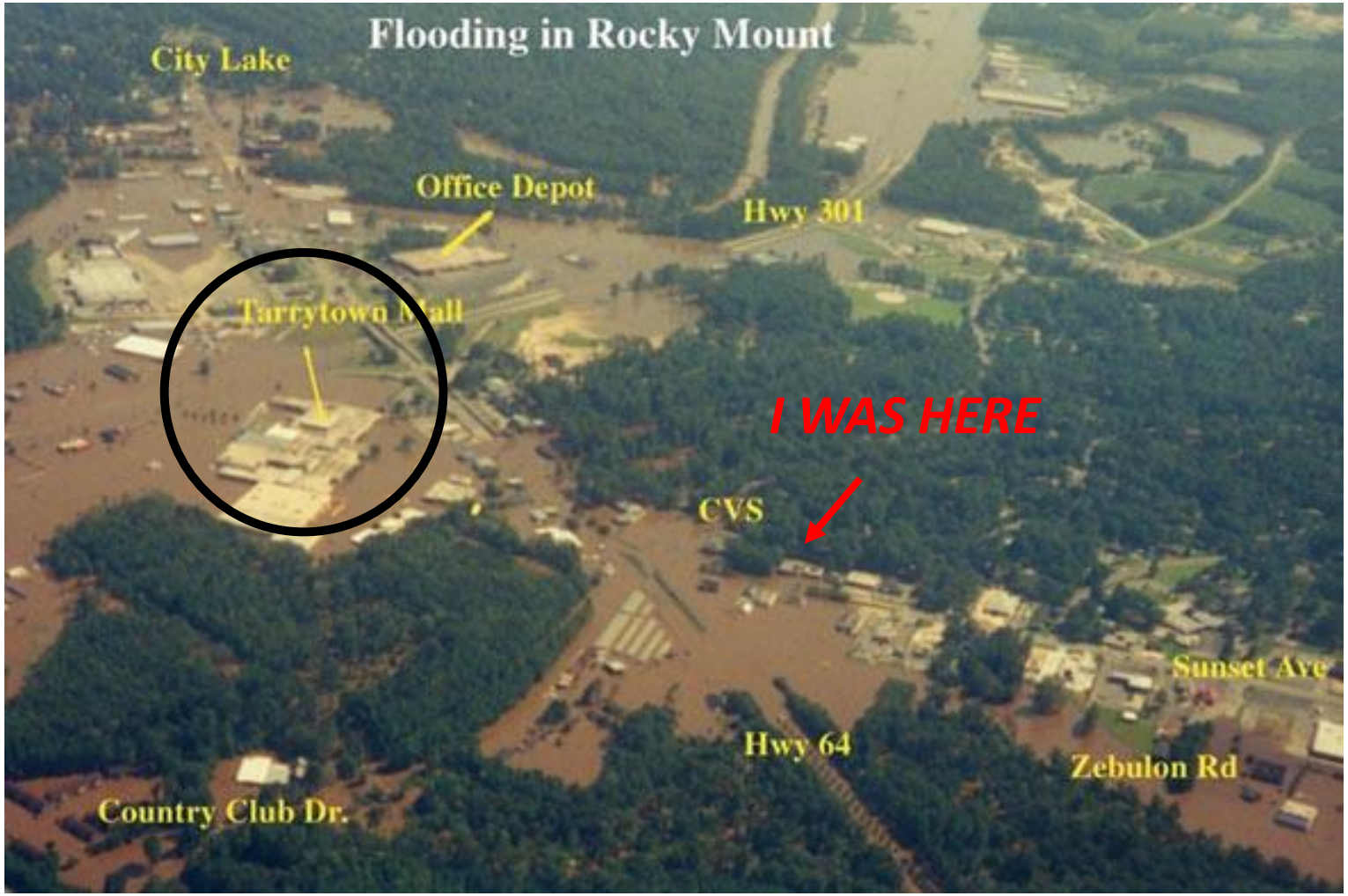




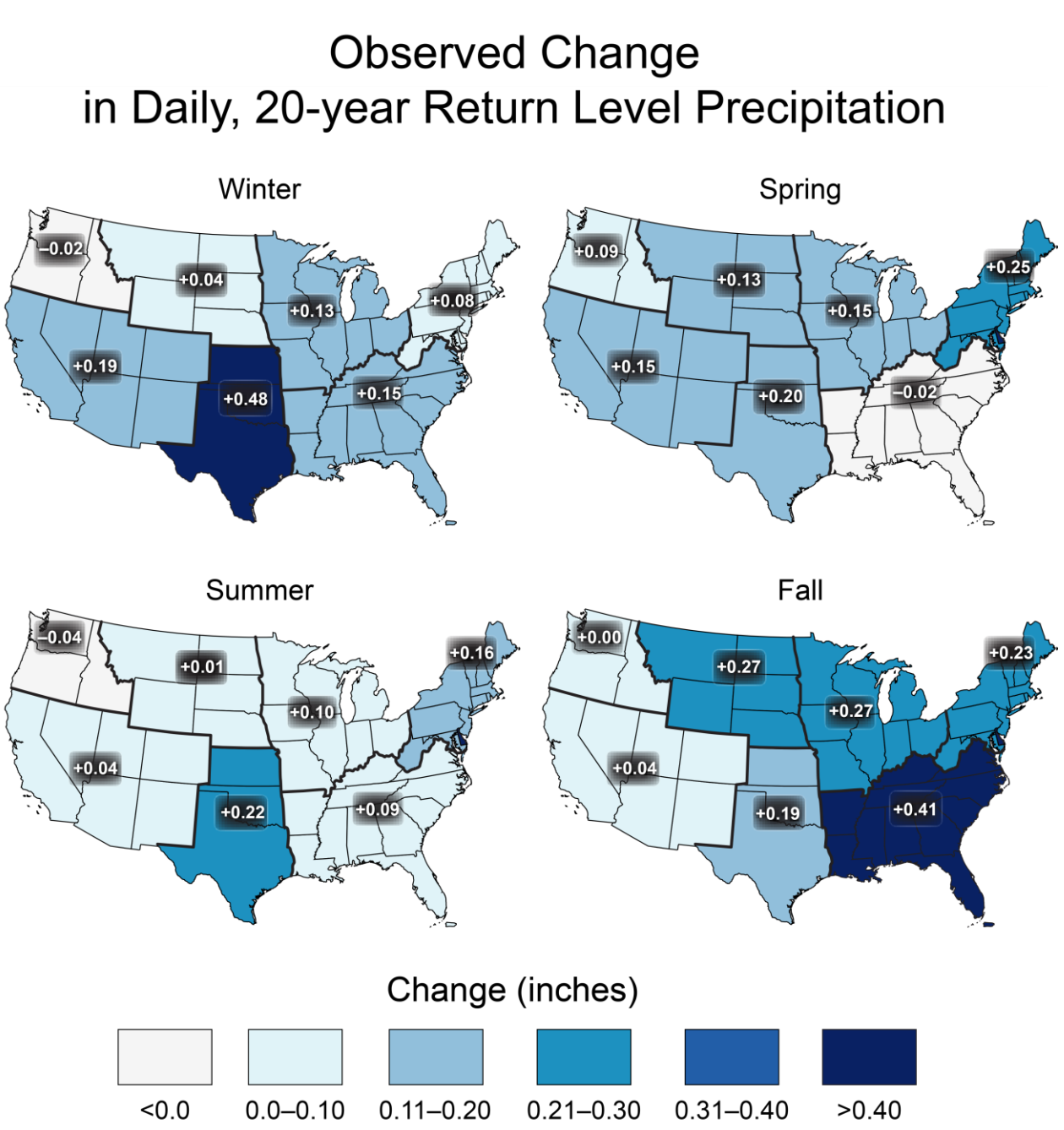
Wet April for much of NC
Antecedent Conditions A Concern



Hurricane Dennis
Then Floyd



Took 6 years to remove
Tarrytown Mall



Easterling, D.R., et al., 2017. U.S. Global Change Research Program

What We Know:

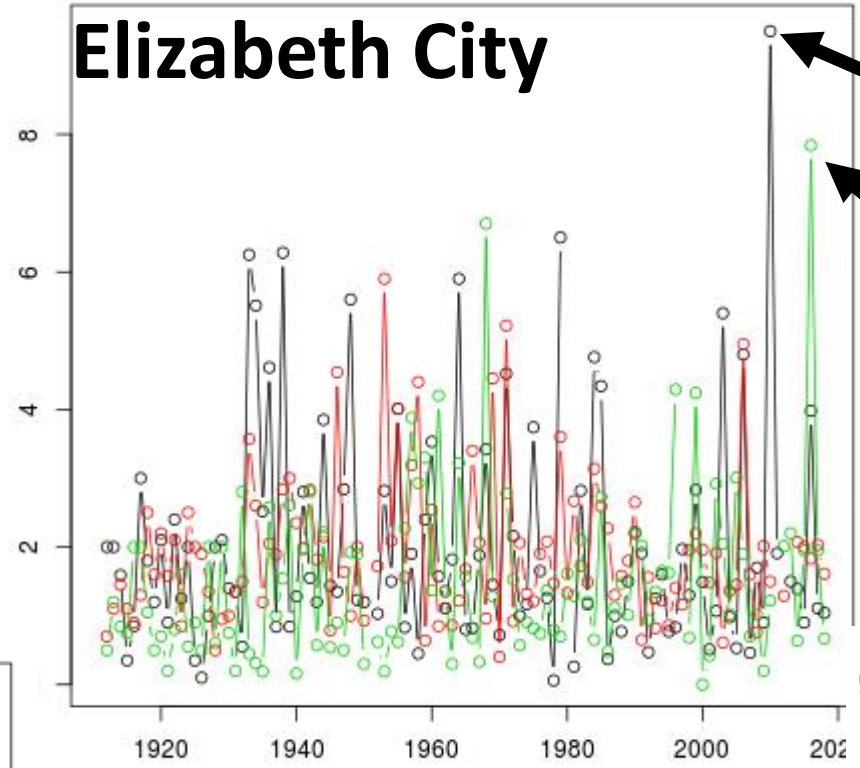
Detectable Changes in Extreme Precipitation

- Precipitation intensity and frequency are increasing, especially east of the Rockies,
- Seasonality is important for Southeast US.
  - Fall (Sept., Oct., Nov.)
  - Winter (Dec., Jan. Feb.)

What we Know: Rainfall Intensity Increases (max. daily precip.)

August, September, October

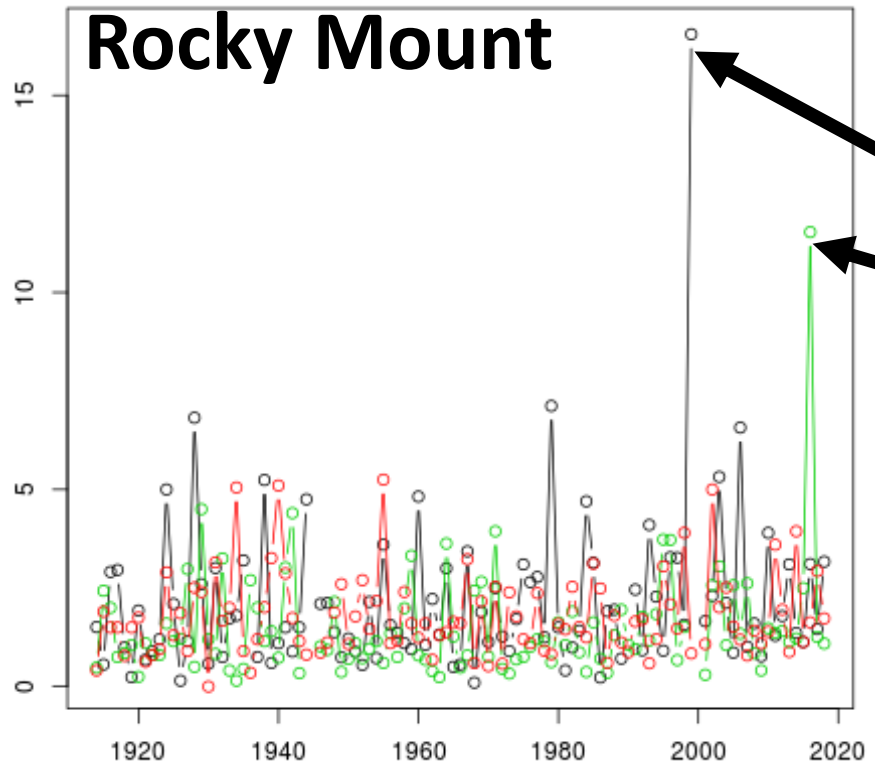
Elizabeth City



Sept. 2010 – Remnants of Tropical Storm Nicole moisture w/ frontal system

Oct. 2016 - Matthew

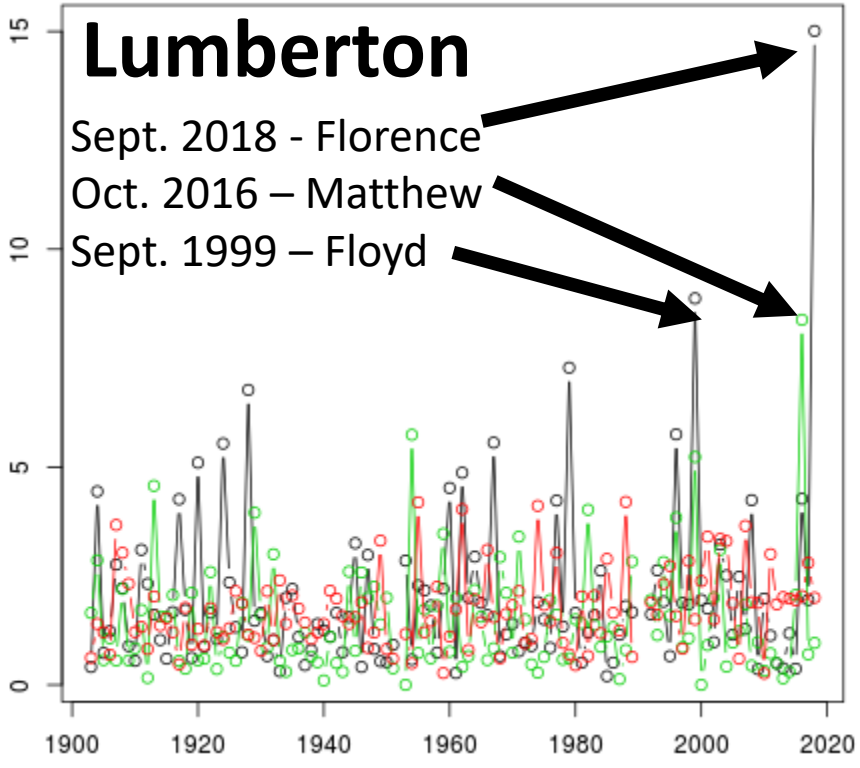
Rocky Mount



Sept. 1999 - Floyd

Oct. 2016 - Matthew

Lumberton

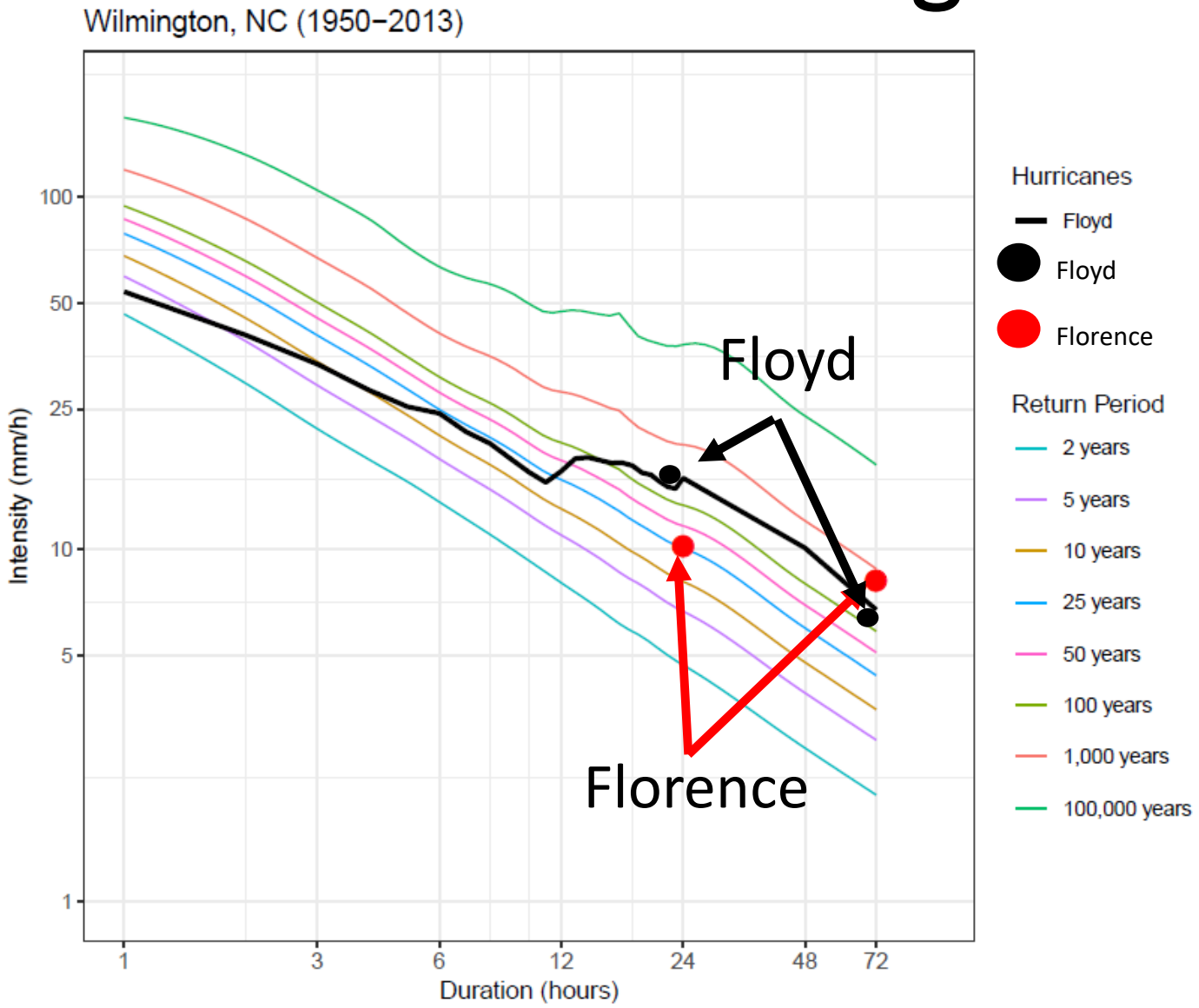


Sept. 2018 - Florence

Oct. 2016 – Matthew

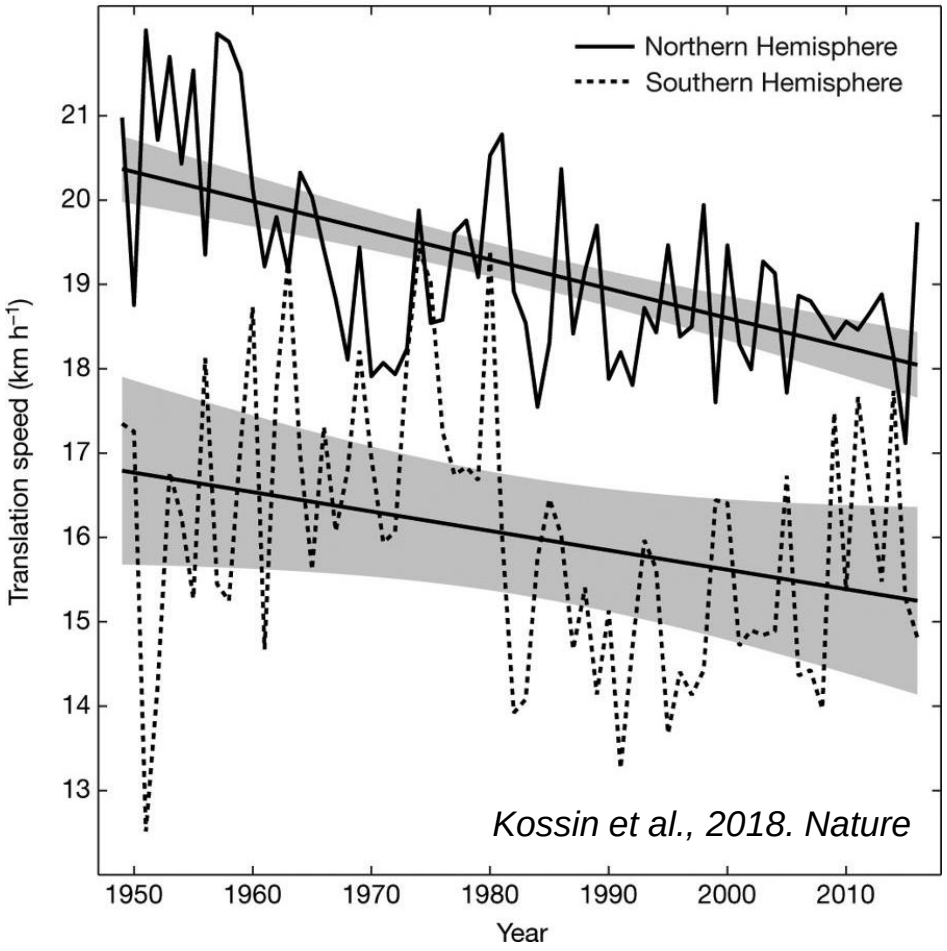
Sept. 1999 – Floyd

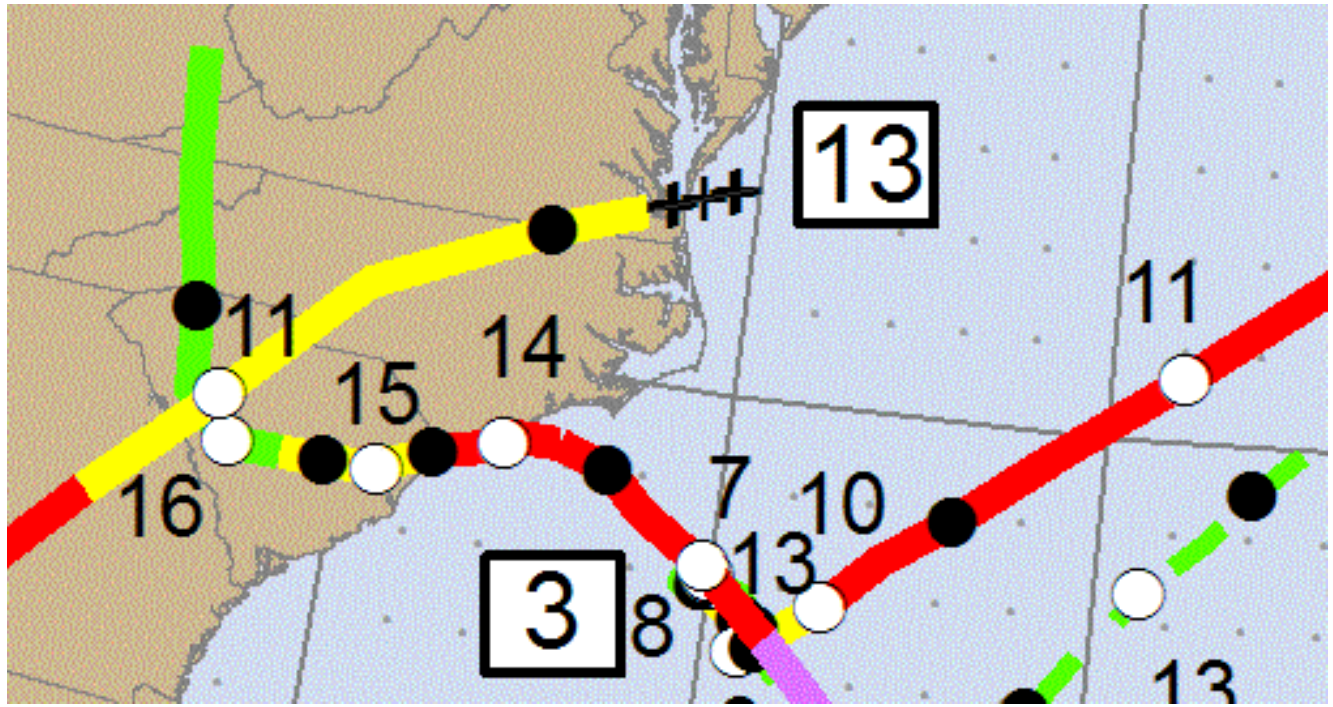
What We Know:
100-year storms are becoming more frequent



What We Know:

Storm Characteristics are Changing



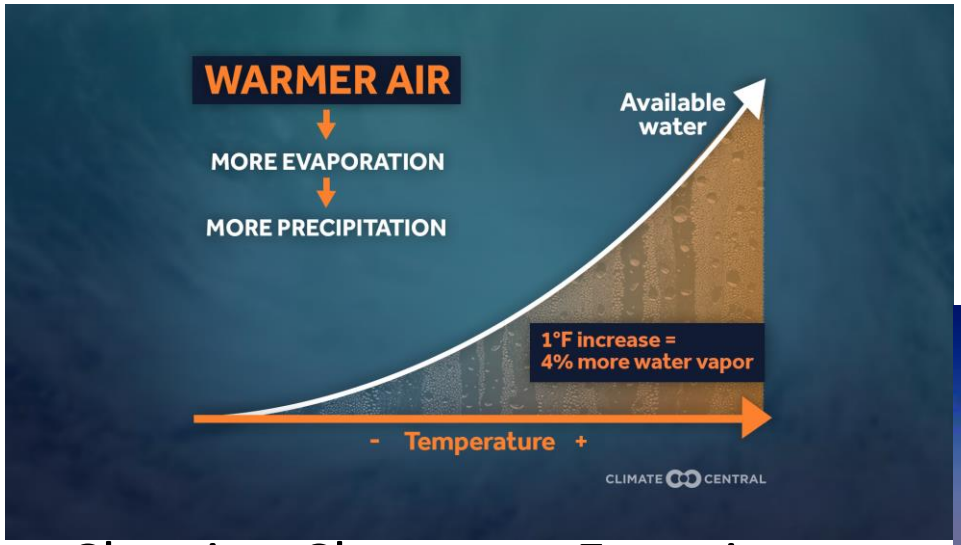


Hurricane Florence stalled
3 day event
https://www.nhc.noaa.gov/

- Slower moving tropical storms (hurricanes)

What We Know:

Extreme rainfall scales with atmospheric temperature

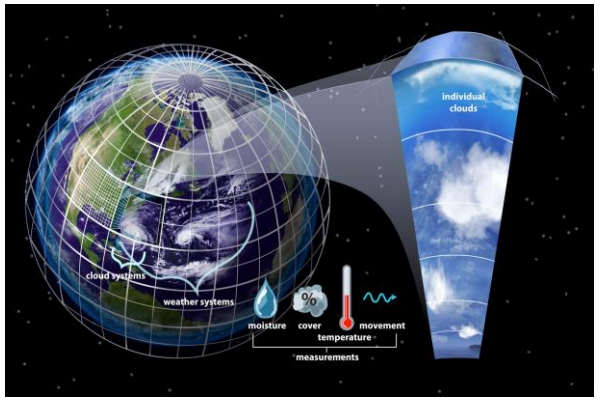


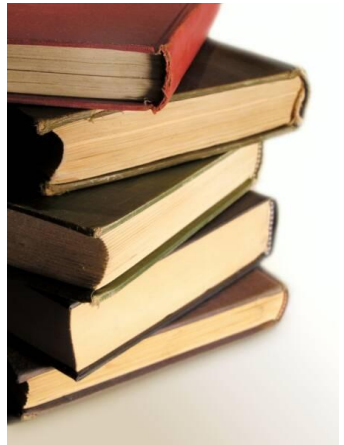
Clausius-Clapeyron Equation

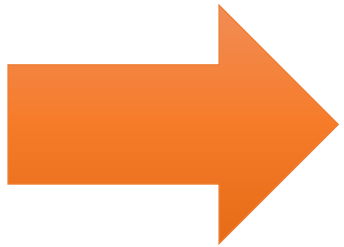
$$\frac{1}{e_s}\frac{de_s}{dT} = \frac{L_v}{R_v T^2}$$

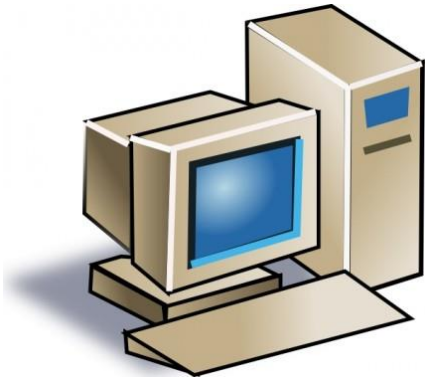
What might we anticipate in the future (30-100 years)?

UNDERSTANDING CLIMATE CHANGE
USING CLIMATE MODELS

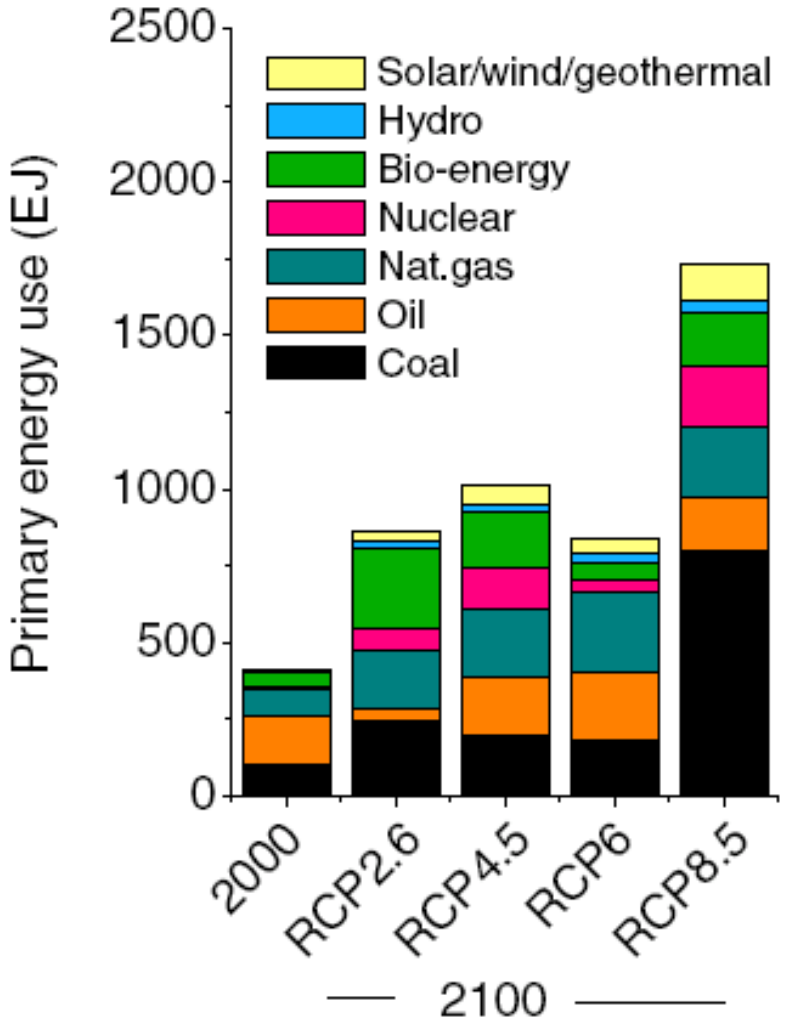








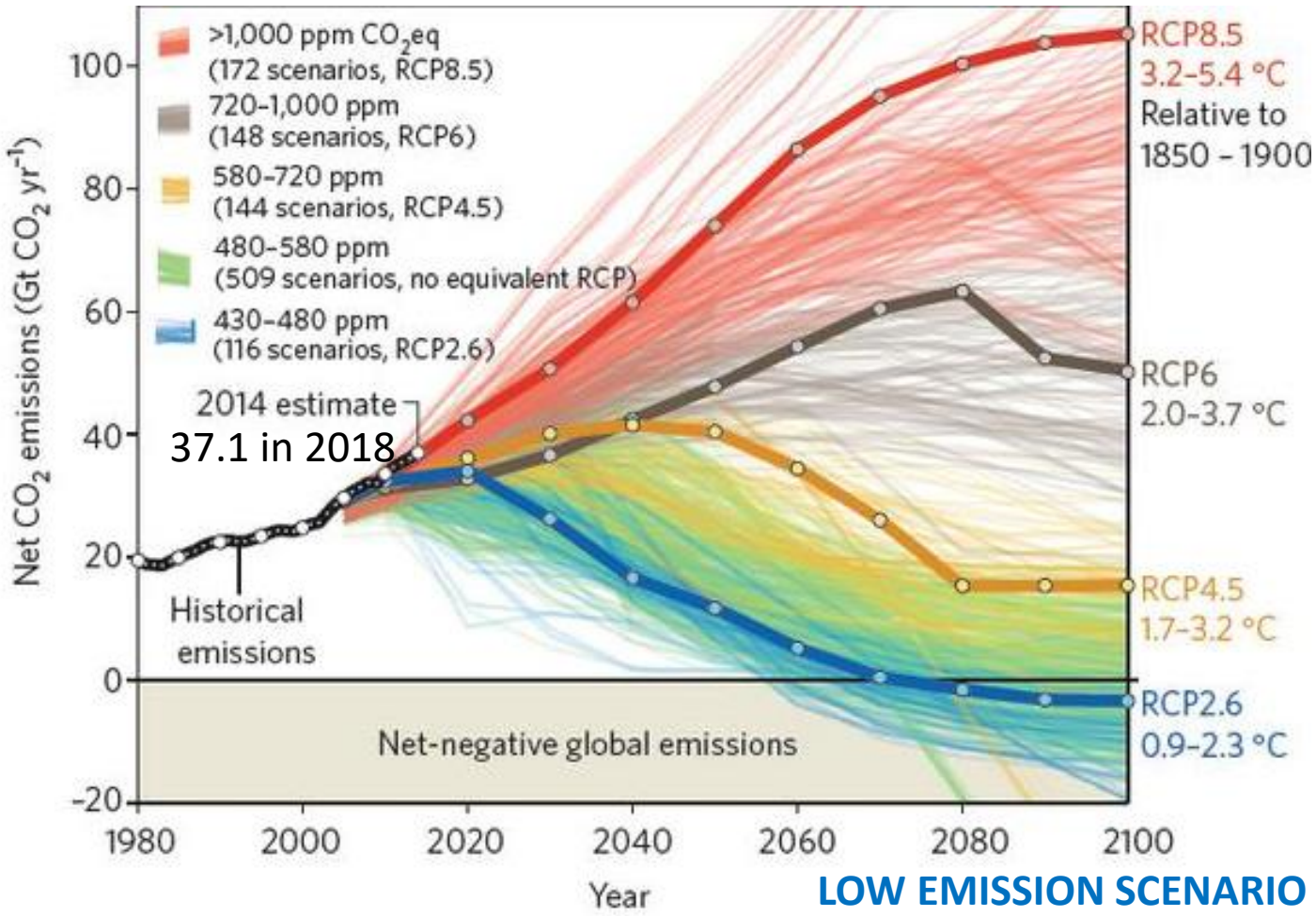
What will our energy mix look like in the future?
The modeling experiment



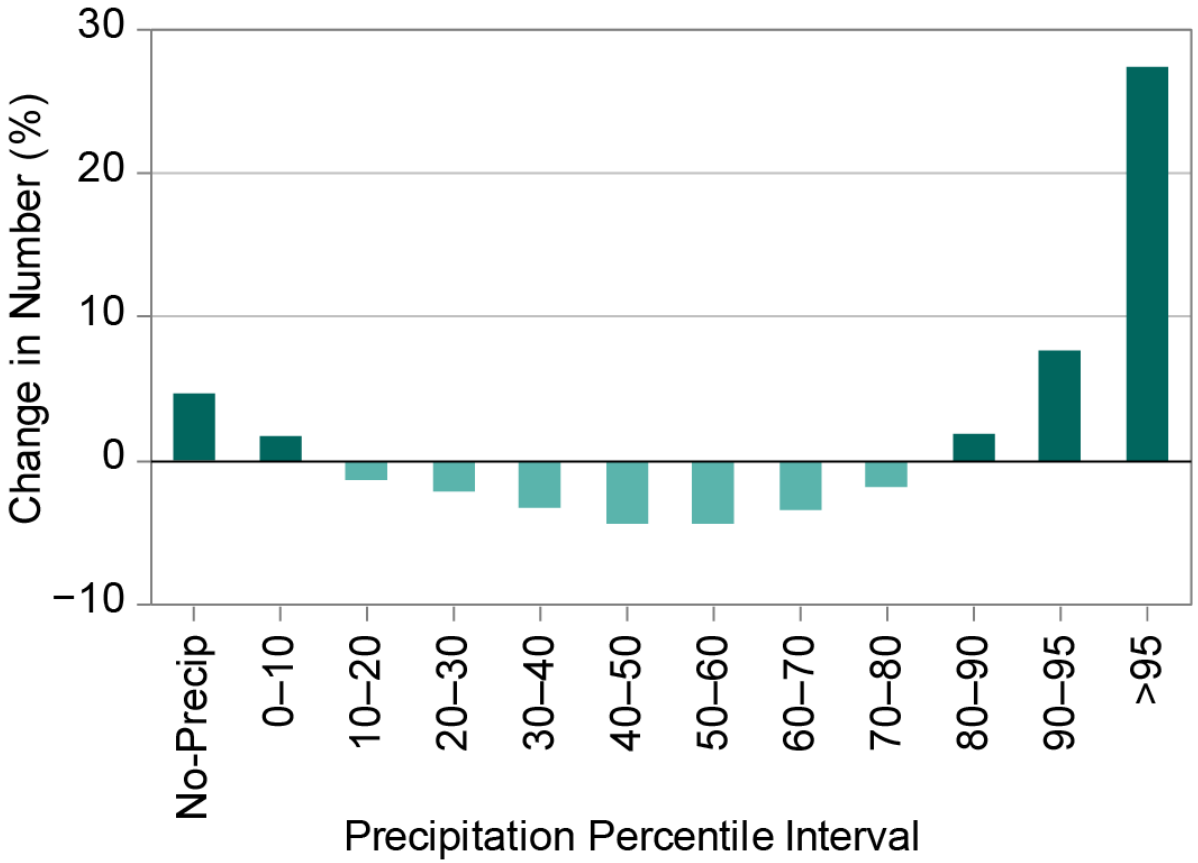
LOW EMISSION

HIGH EMISSION

HIGH EMISSION SCENARIO

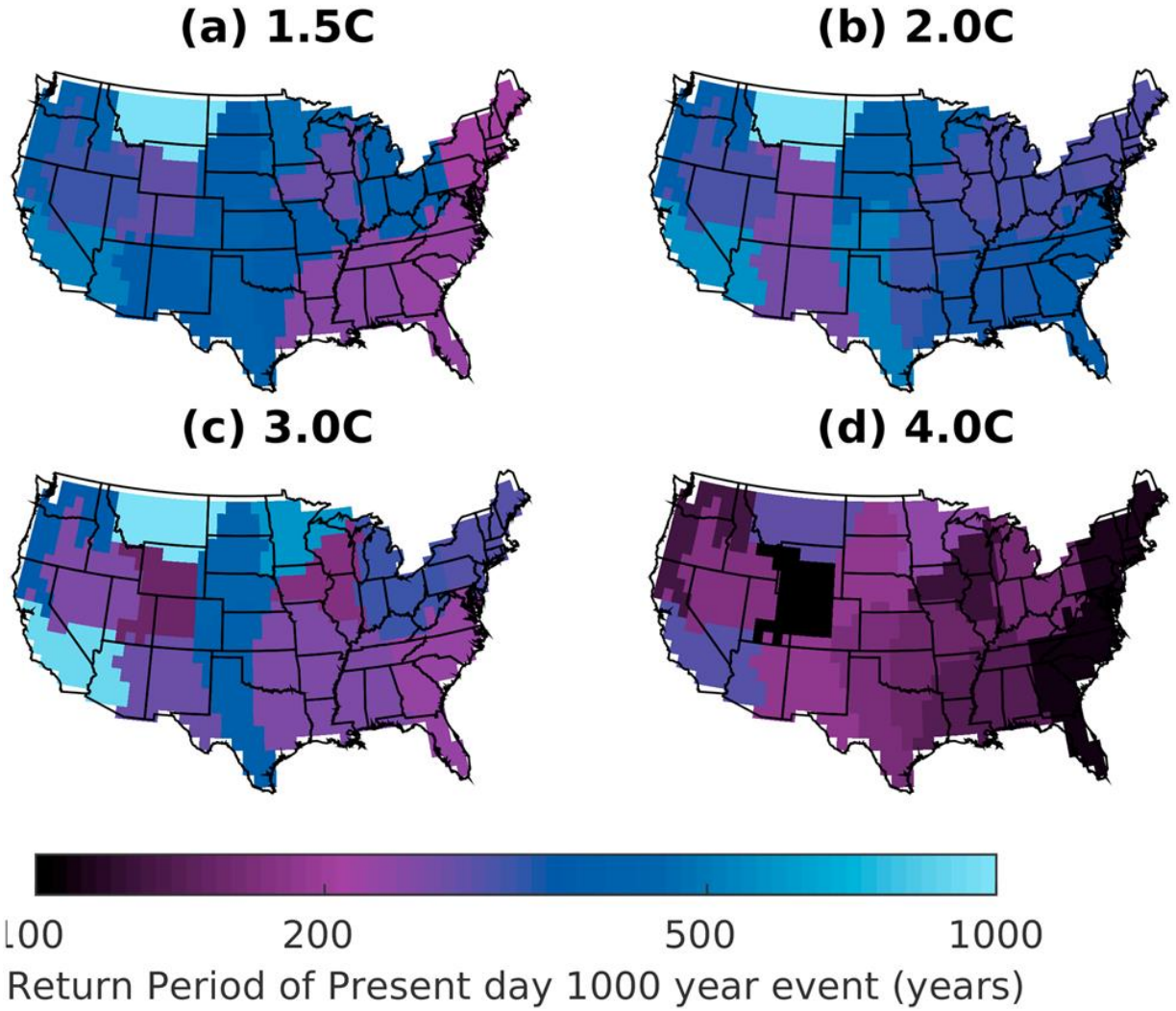


LOW EMISSION SCENARIO



Model changes to the rainfall frequency by end of century under a high scenario

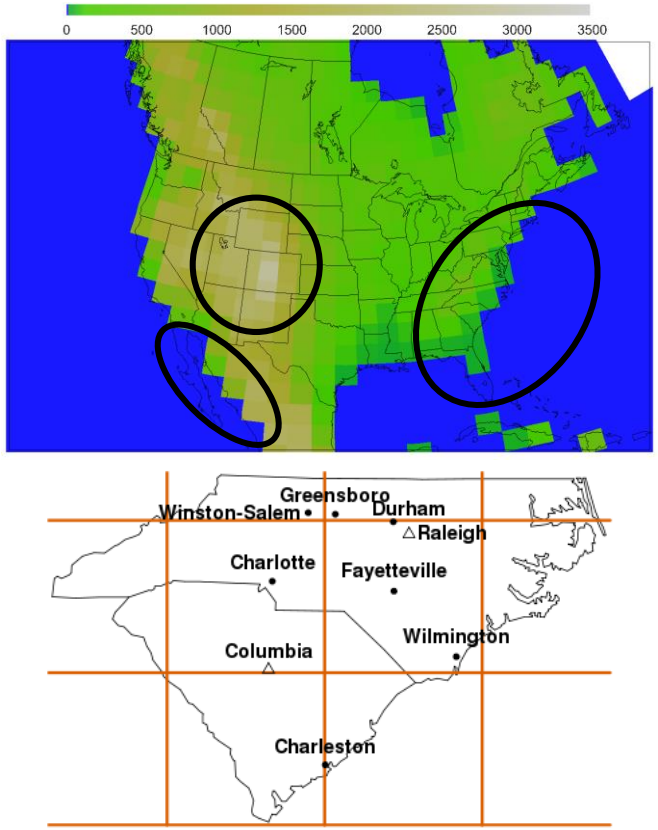
USCRP, 2017: Climate Science Special Report

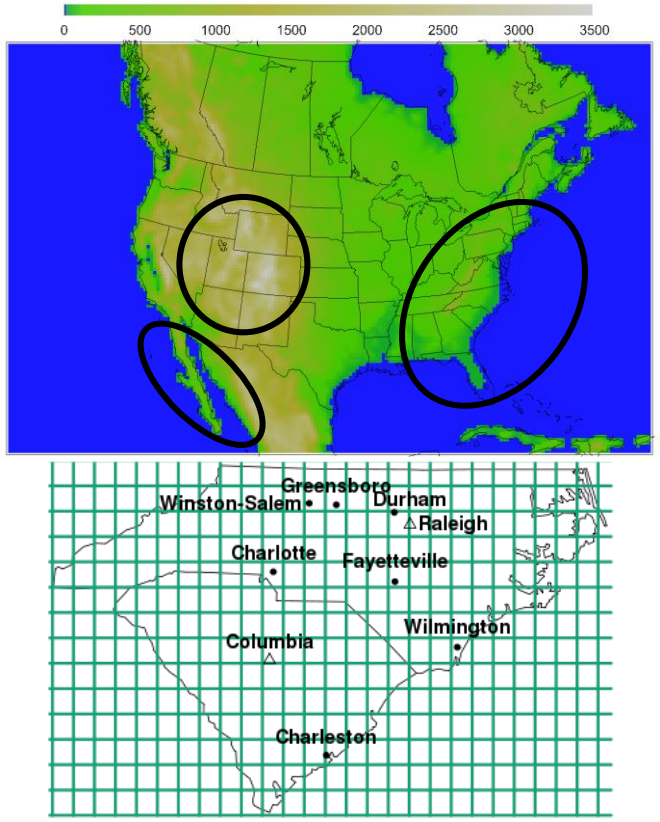


Model changes to the 1000 year event as global temperatures increase

Sanderson et al. 2019: Geophysical Research Letters

Future flooding : An engineering perspective from high-resolution climate change models (Ongoing Research)





Ongoing research with EPA-USGS

Tanya Spero, Anna Jalowska, Adam Terando

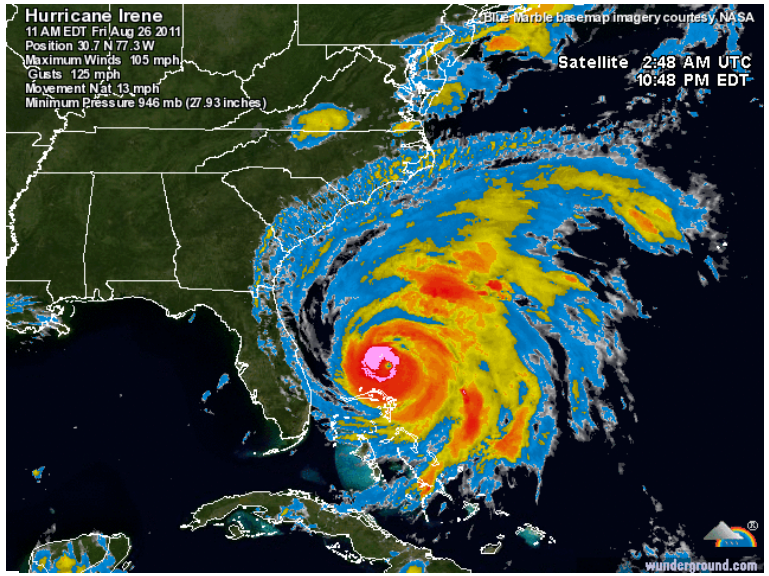
IDF curves for Wilmington, NC

	Value for 24h 25 year rain (mm)
NOAA	
Atlas 2008	240
Our Study	
1952-2013	241
1994-2013	346

Value for 25 year rain (mm)	CESM RCP4.5 (mm)	CESM RCP8.5 (mm)
2025-2099	410	391

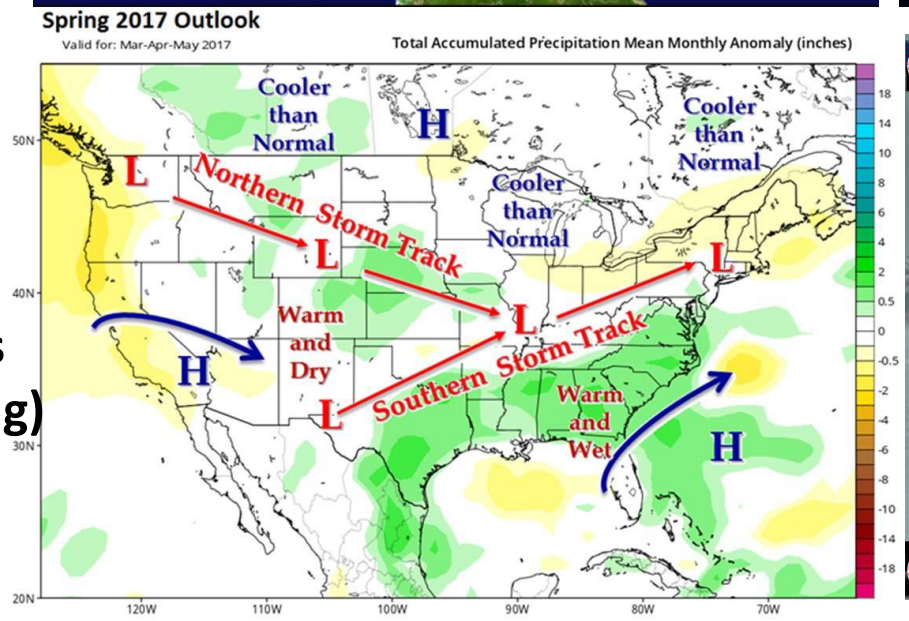
What are some of the underlying changes in the atmosphere that would favor an increase extreme precipitation and flooding for eastern NC?

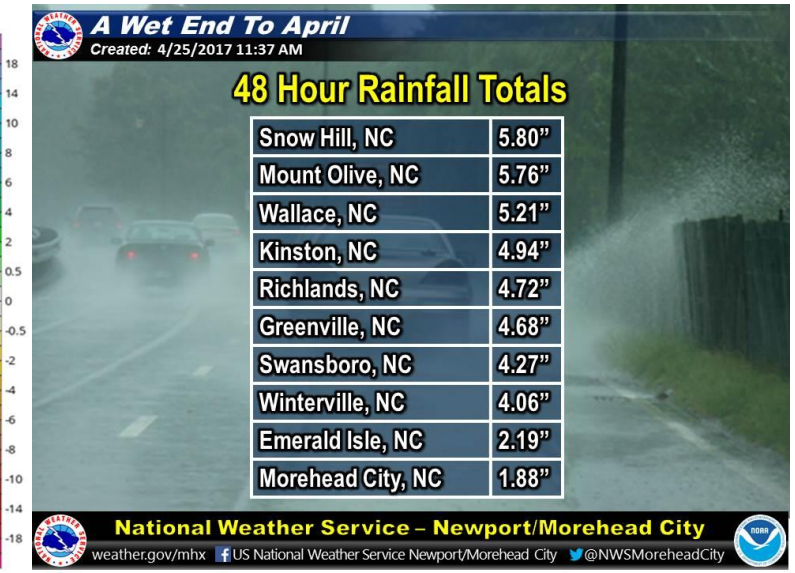
Bermuda High (Summer/Fall)



Tropical Storms (Hurricanes)

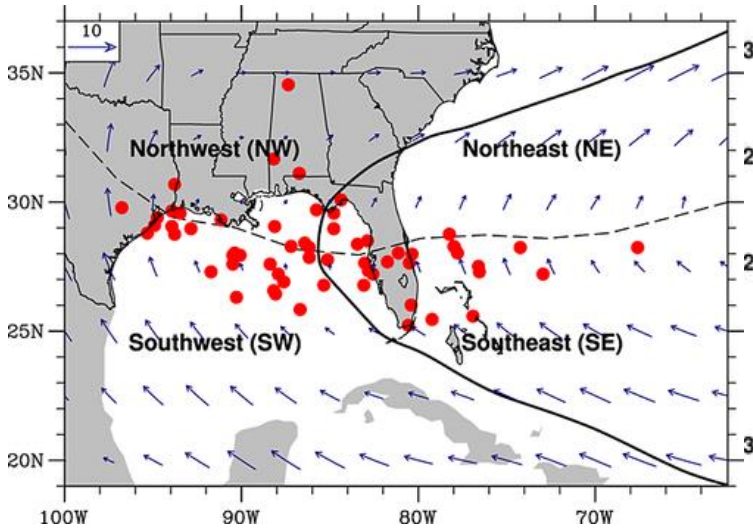
Weather Patterns Warm/Cold Fronts (Fall/Winter/Spring)



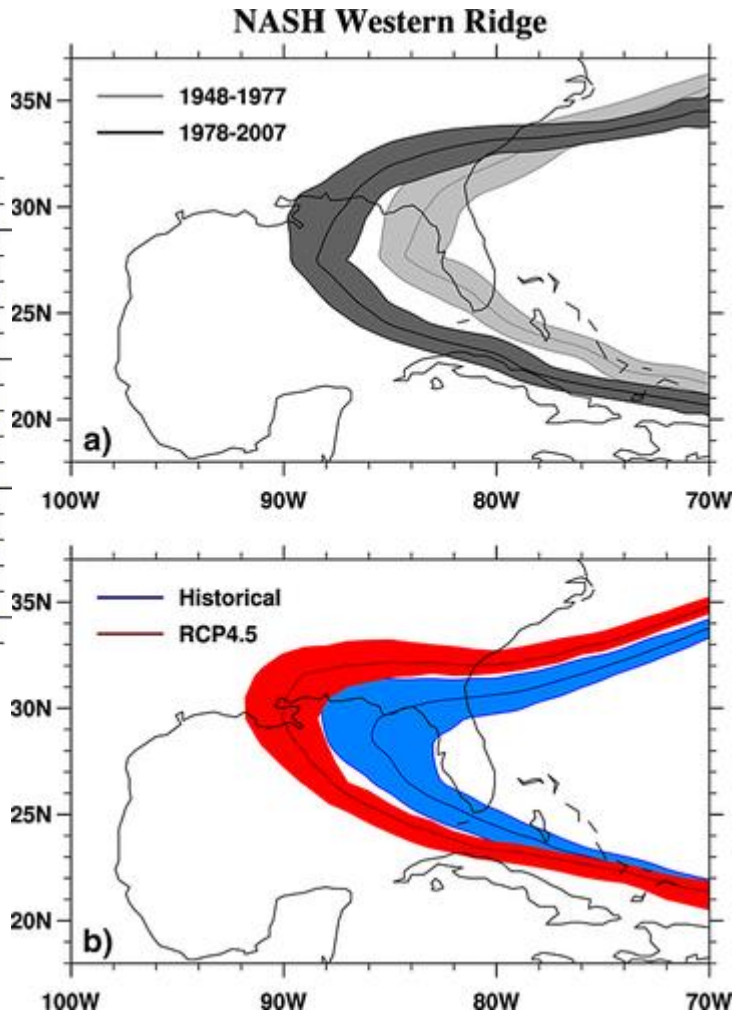


Spring Storm and flooding on April 25, 2017

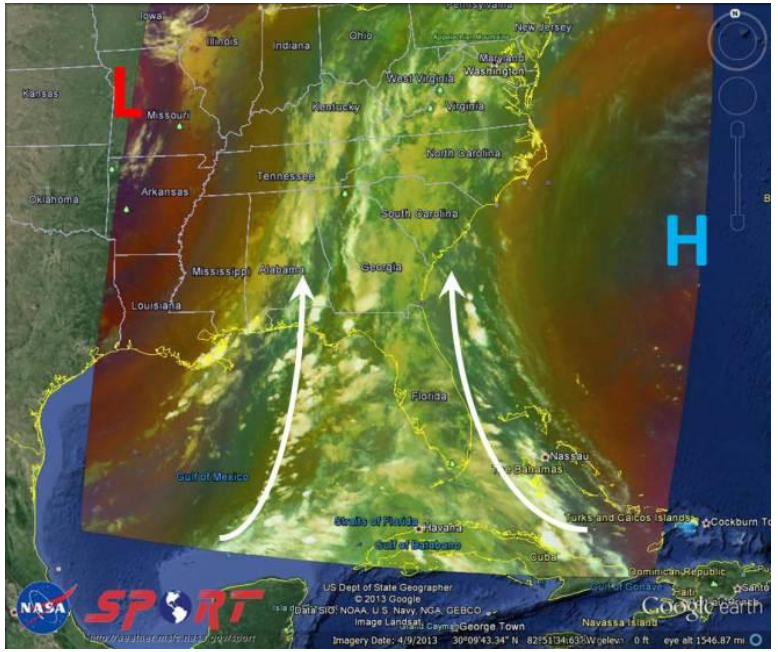
Bermuda High:
models show intensity to increase and westward shift
more variable precipitation in a warmer climate (wet and dry)
SPRING AND SUMMER SEASONS



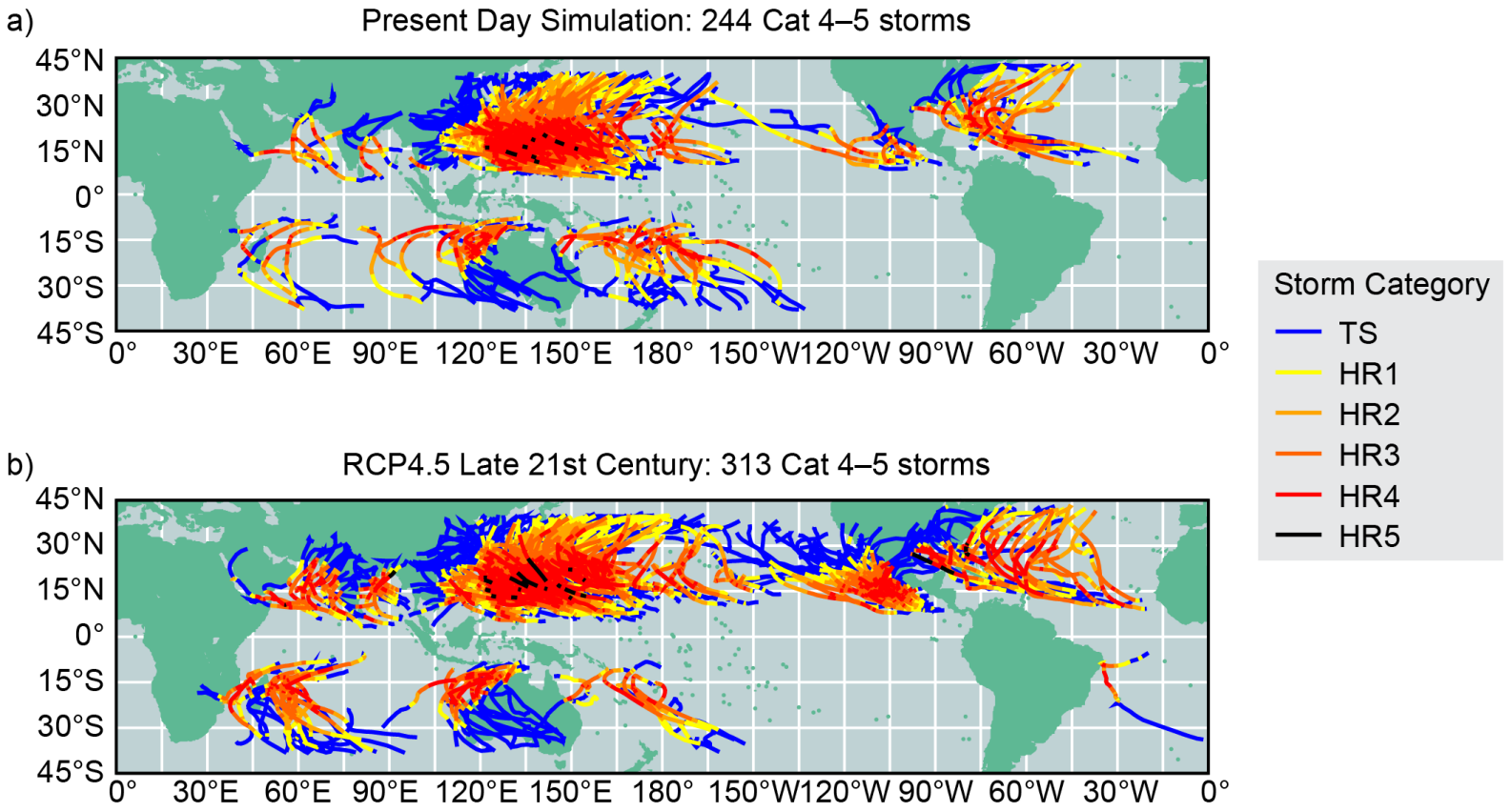
Li et al. 2013, JGR Atmospheres



Changes to deep moisture from the Gulf of Mexico Can support: "Stronger thunderstorms"



Tropical Cyclones (Hurricanes): models show frequency of high intensity storms to increase (Cat. 4 & 5); more rainfall associated with a future storm

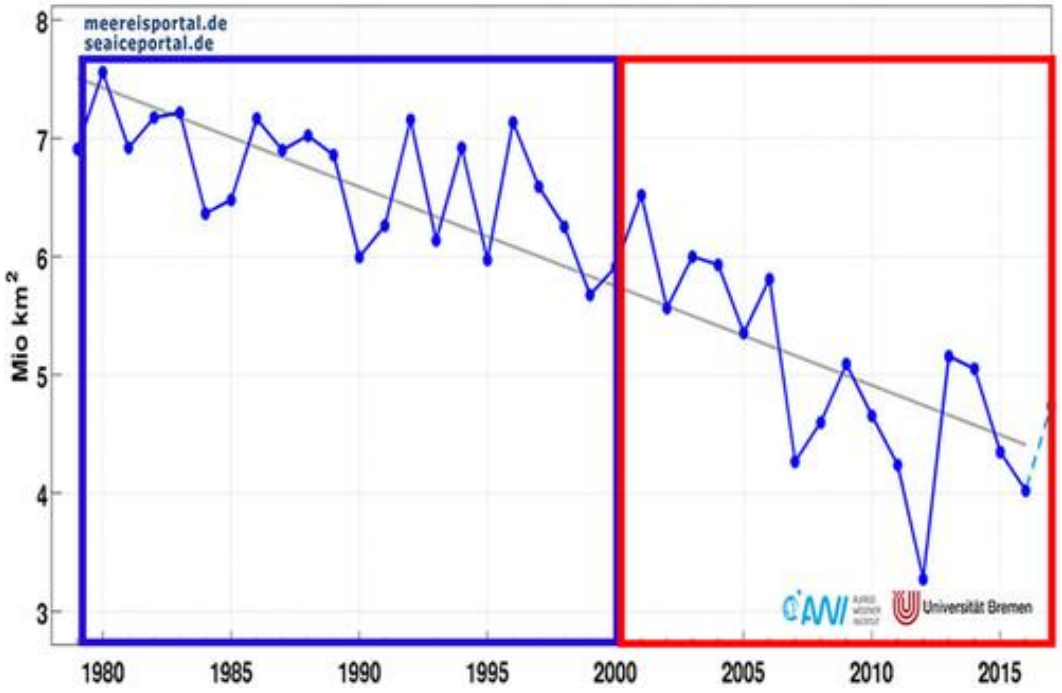


USCRP, 2017: Climate Science Special Report

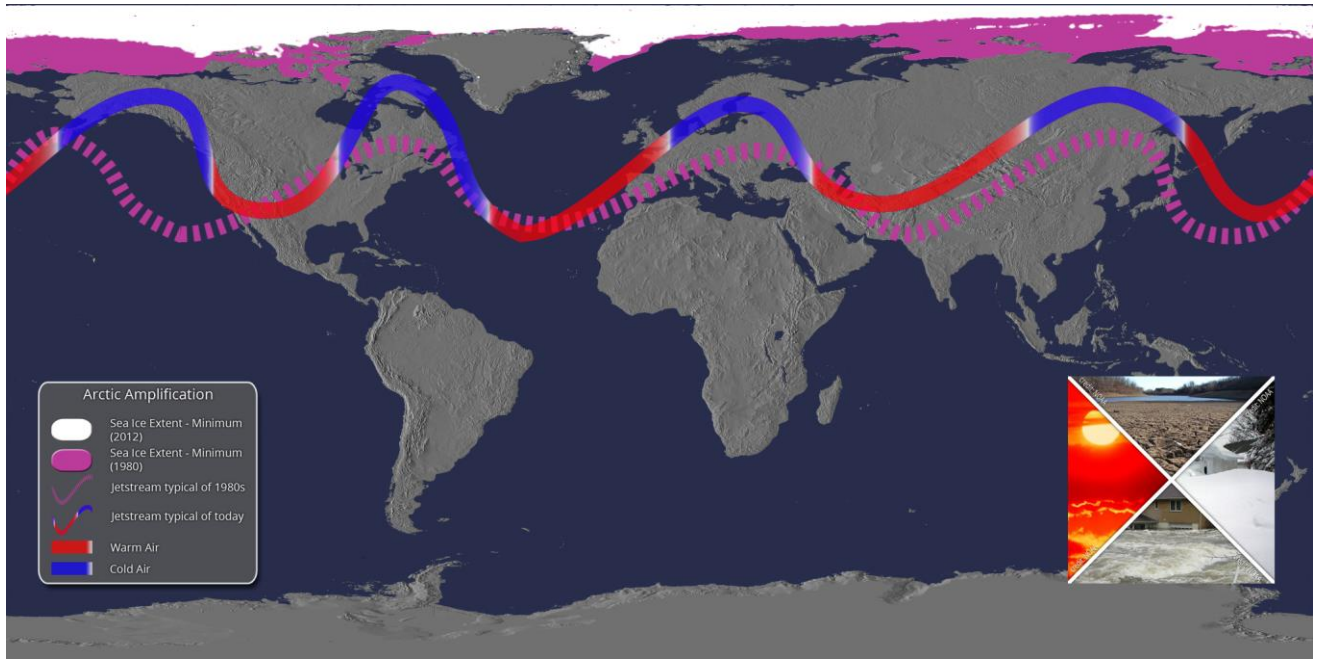
Arctic amplification

Changing weather extremes

with loss of arctic sea ice and surface air temperature warming in the Arctic



Sea ice extent in September (million km2)



Wavier weather pattern favors more extreme weather

Dethloff et al, 2019; NY Academy of Sciences

Take-Away: Our climate is not stationary and is changing as we continue to increase greenhouse gases. Scientific studies depict a future with more extreme weather events that increases the risk of flooding.