



The State of Climate Change and its Impacts: General Concepts and a Southeast US Perspective

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11 June 2014

Climate versus Weather

- “Weather is the mix of events that happen each day in our atmosphere including temperature, rainfall and humidity.”
- “Climate is the average weather pattern in a place over many years.”
- Climate controls weather

More information: www.eo.ucar.edu/basics

What is Climate Change?

- Significant and prolonged change in average weather (climate)
- Can occur at a range of spatial scales, e.g.
 - **Global:** Changes in the Earth's mean temperature
 - **Regional:** Changes in Southeast US average summer temperature
 - **Local:** Changes in Richmond's precipitation

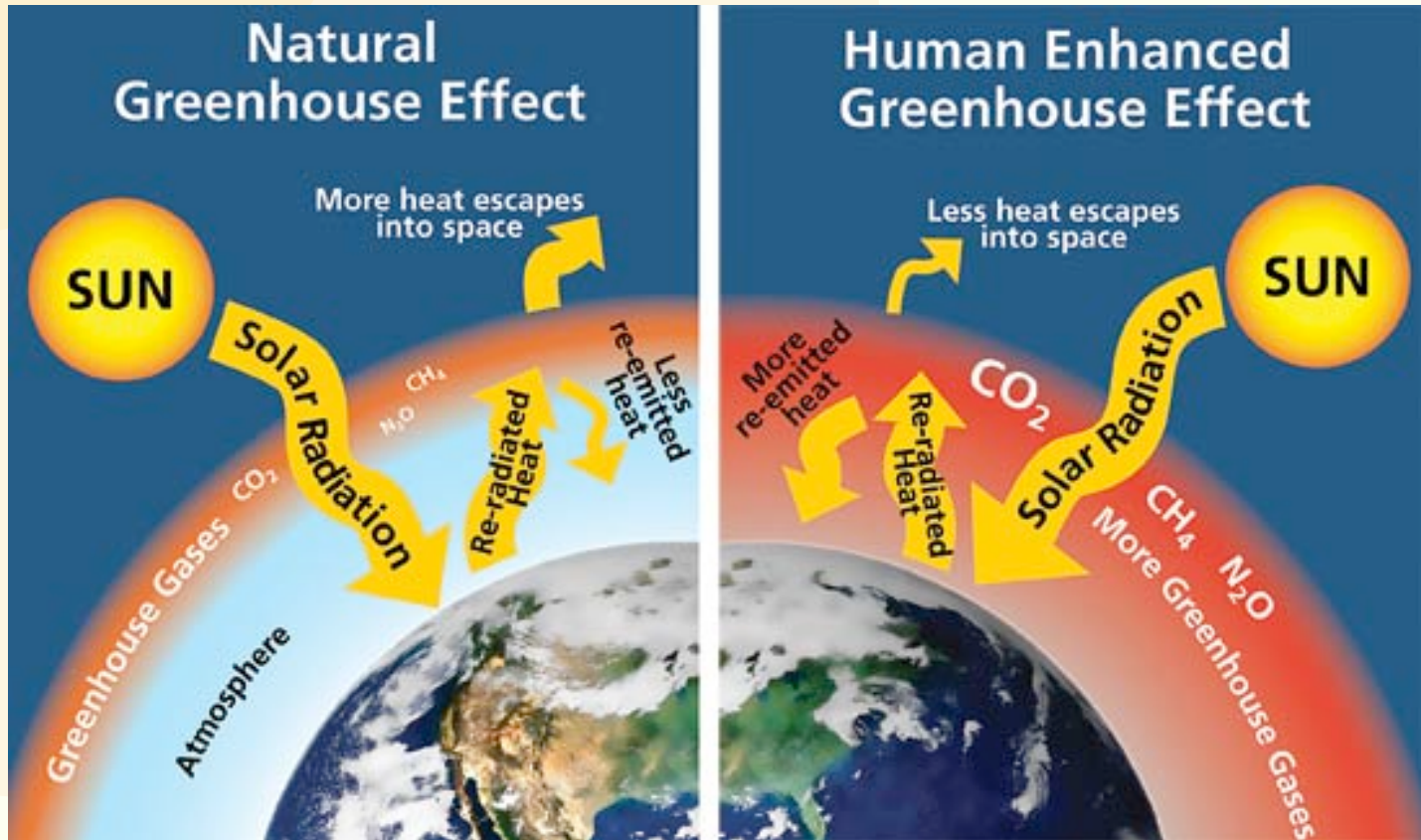
More information: www.eo.ucar.edu/basics

What Influences Climate?

- Natural factors, e.g.
 - Volcanoes
 - Solar output
- Human factors (anthropogenic)
 - Greenhouse gas emissions
 - Aerosols
 - Land use change

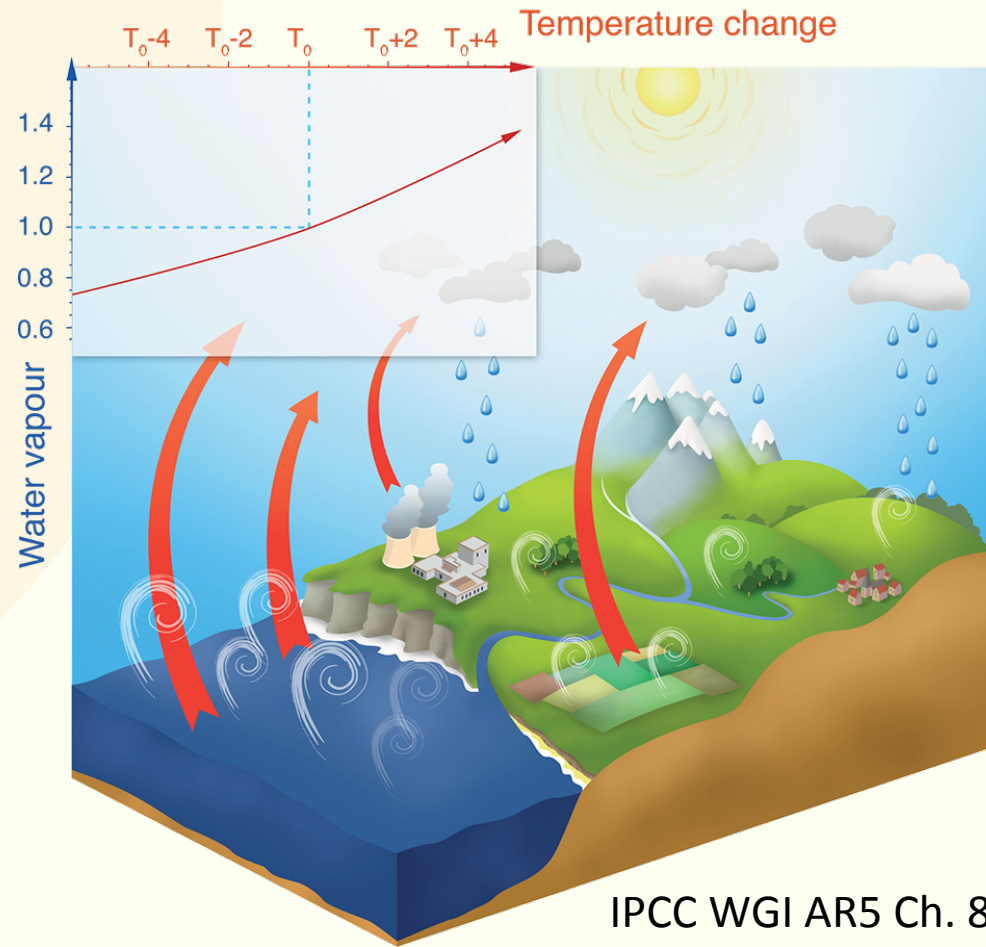
Anthropogenic Climate Change

- Greenhouse gas emissions (e.g. CO_2 , CH_4 , N_2O)
- Greenhouse Effect



Anthropogenic Climate Change

- CO₂ is the main anthropogenic driver of climate change
- But, water vapor: largest greenhouse effect
- Significant feedback

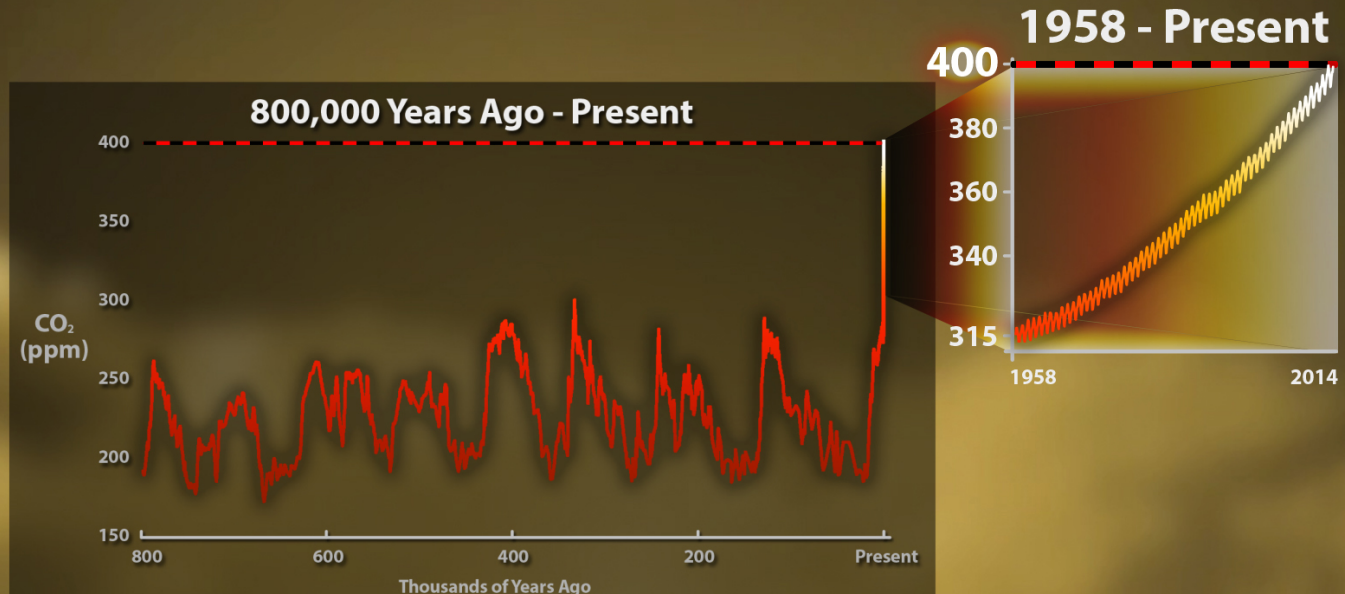


Global Observations

- Increase in greenhouse gases

CO₂ Hits Climate Milestone

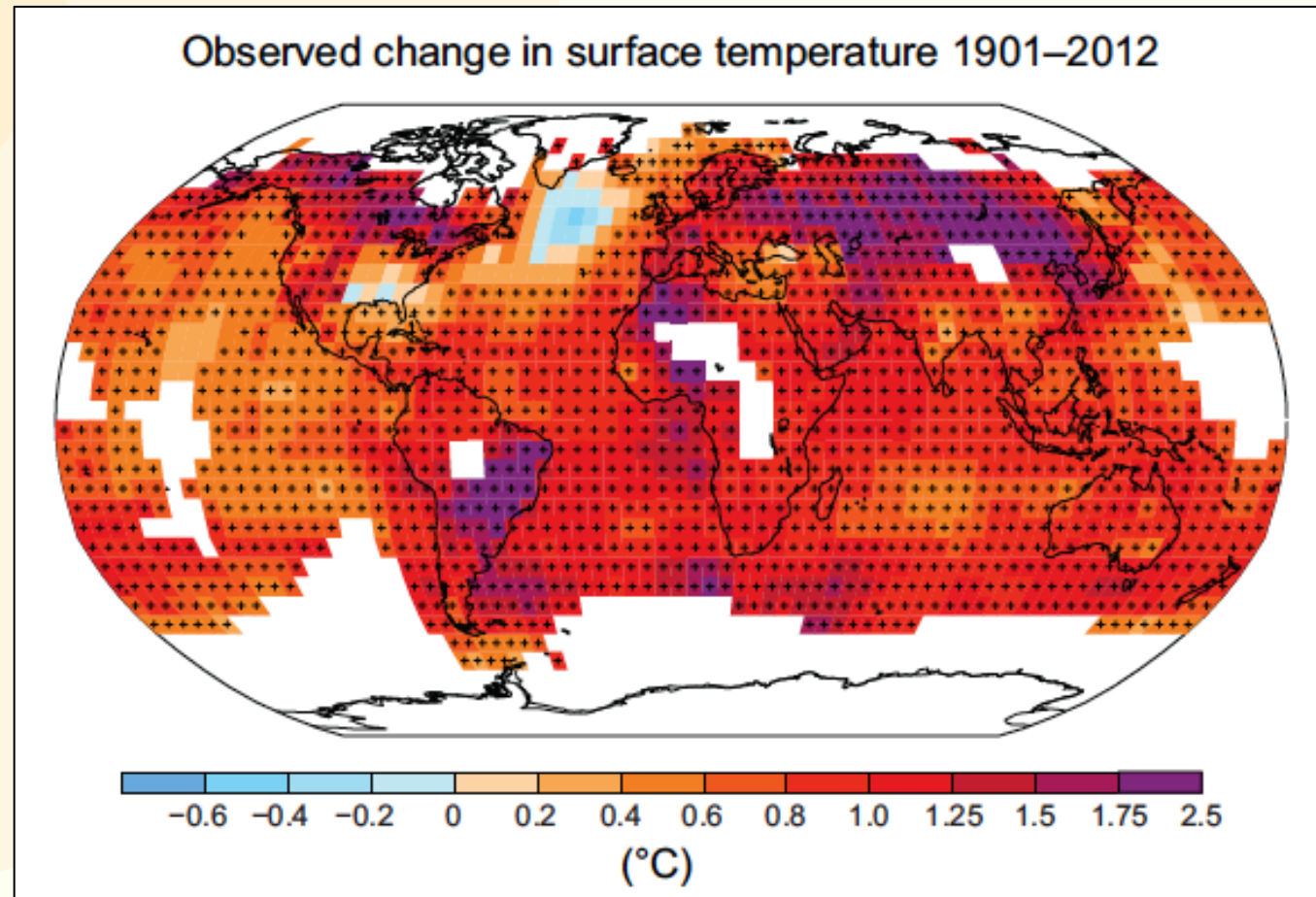
First Full Month with Levels Above 400 ppm



Global Observations

- Atmosphere and ocean have warmed

Change in
global mean
temperature:
1850-1900 to
present:
0.61°C (1.1°F)

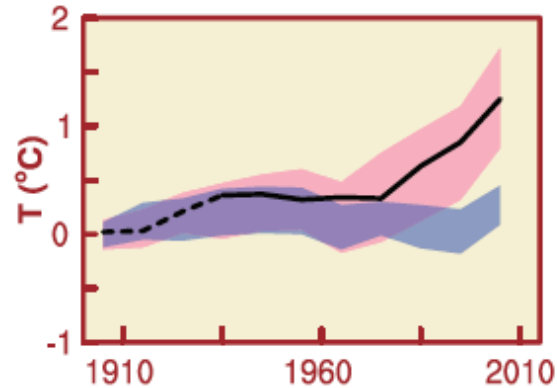


Anthropogenic Climate Change

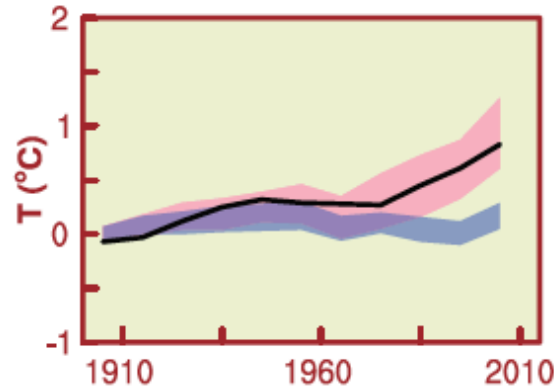
- Attribution of warming to humans

Global averages

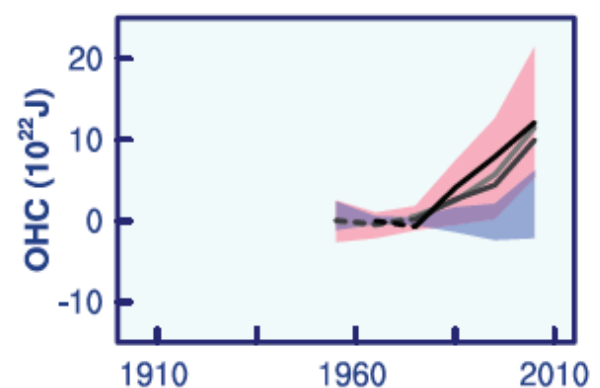
Land surface



Land and ocean surface



Ocean heat content



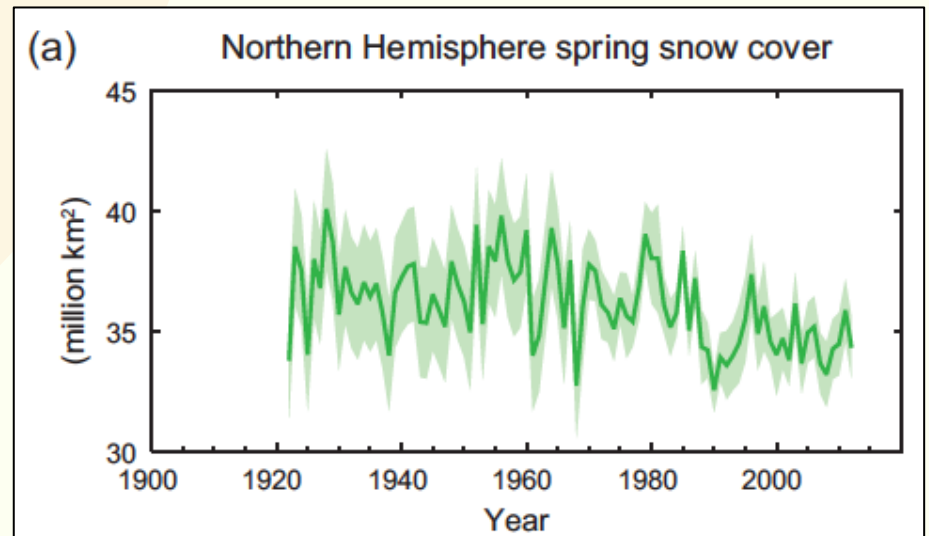
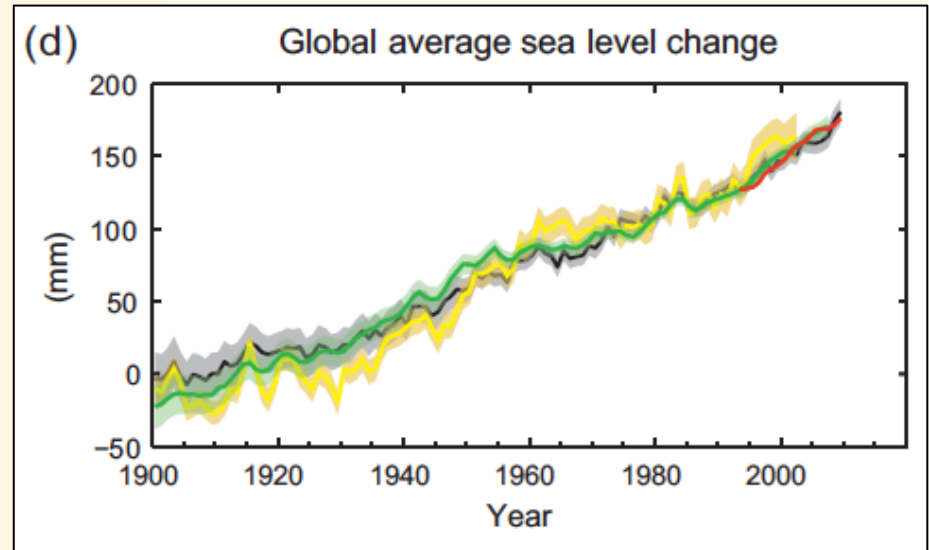
≡ Observations

■ Models using only natural forcings

■ Models using both natural and anthropogenic forcings

Global Observations

- Sea level has risen
- Amount of snow & ice has diminished

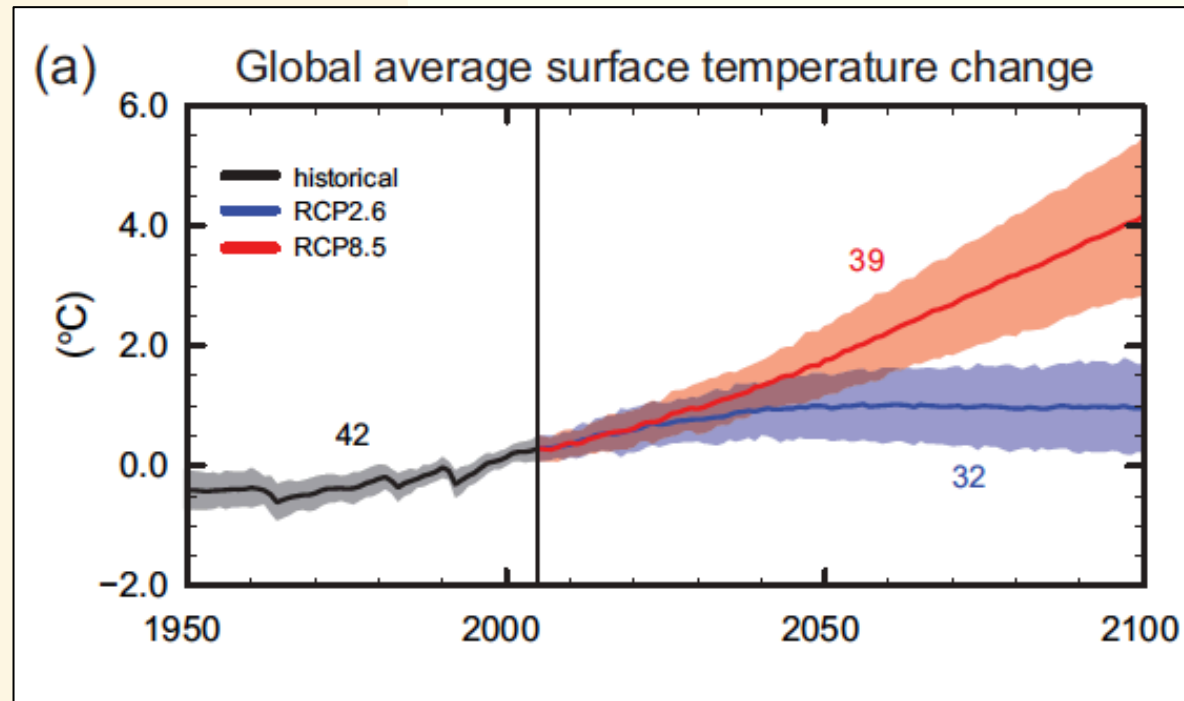


Global Projections

- Future warming depends on emission pathways

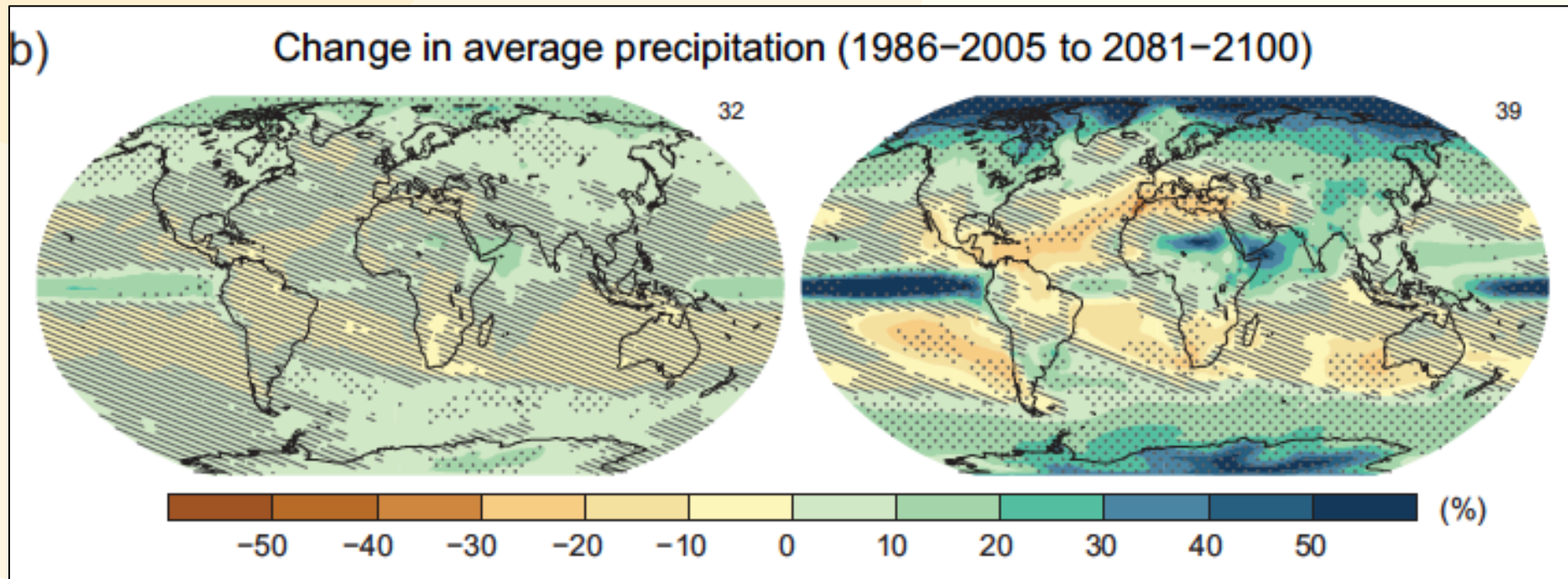
Next 2 decades:
Warming likely
 0.3° - 0.7°C over
present

End of century:
Warming likely
 0.3° - 4.8°C over
present



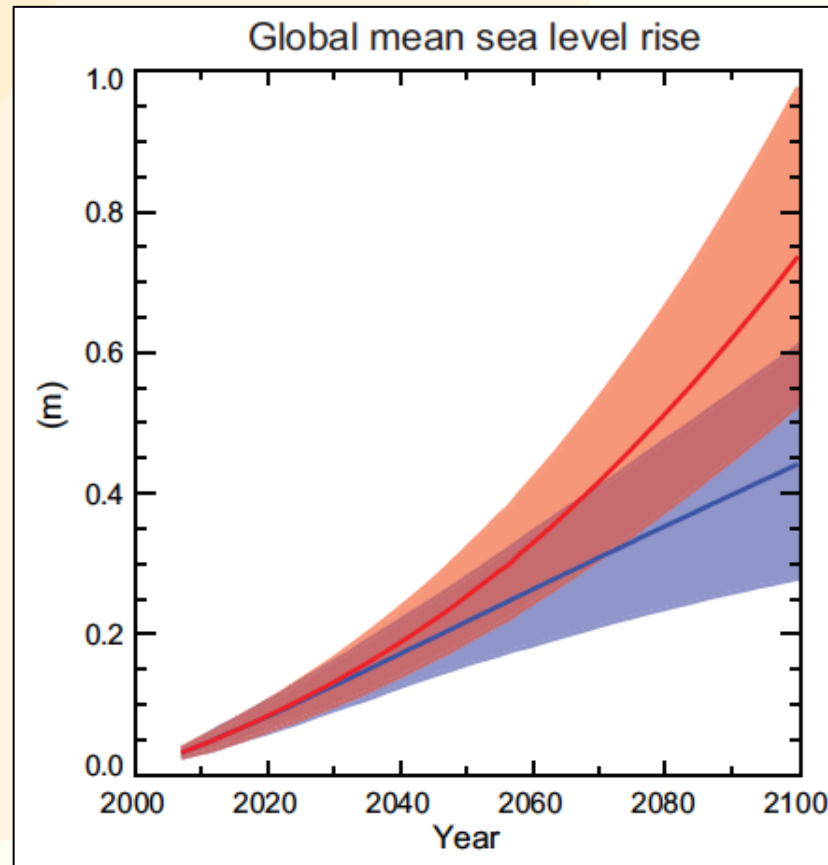
Global Projections

- Many other important changes, e.g.
Precipitation (average and extremes)



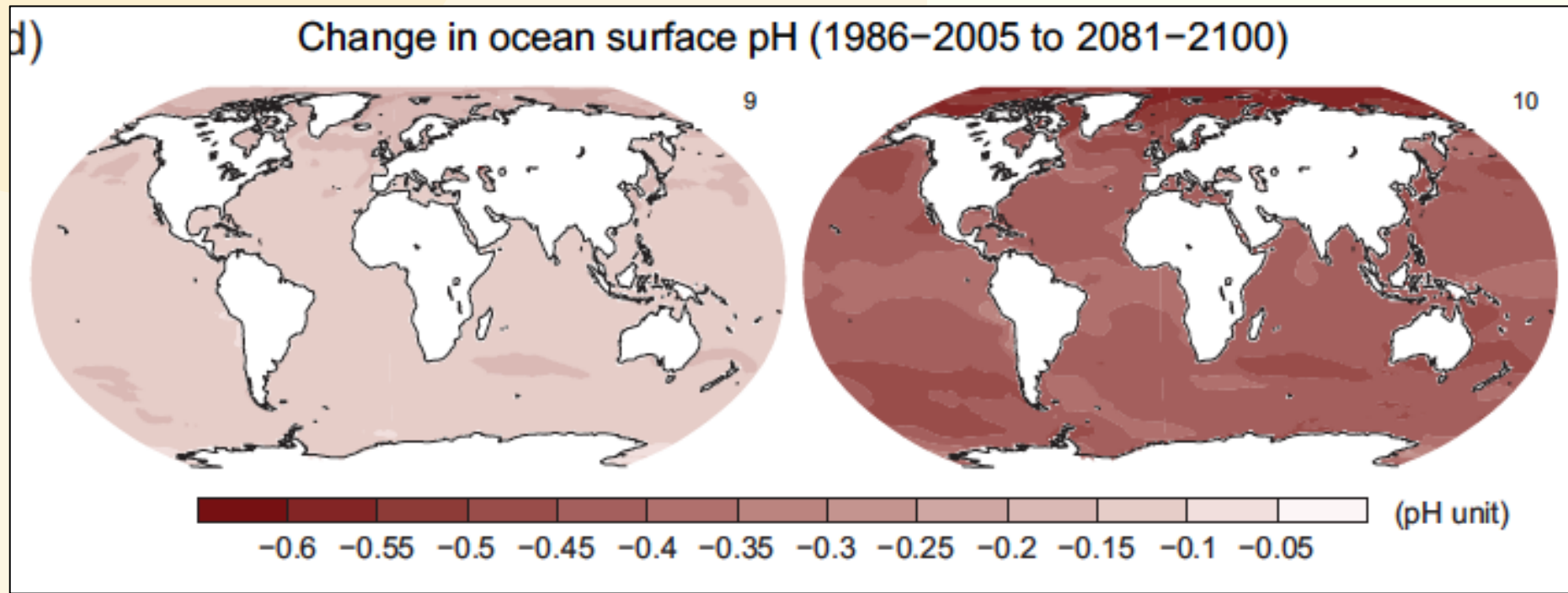
Global Projections

Increasing sea level



Global Projections

Decrease in ocean pH



Global Projections

Many other important changes, e.g.

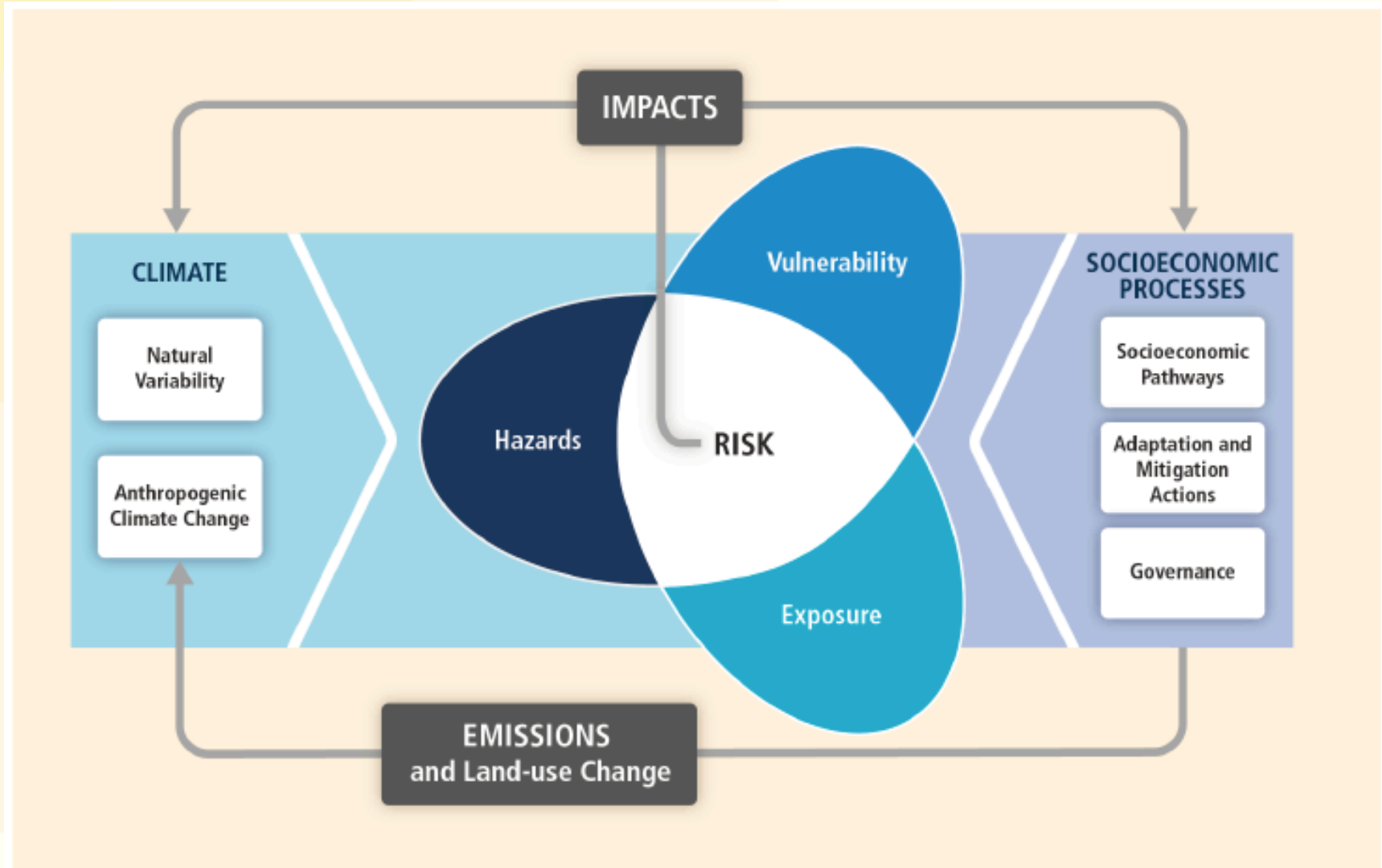
- More frequent and longer heatwaves
- Decrease sea ice extent
- Decrease snow & ice cover

Global Observed Impacts

What does this all mean?

- Natural system impacts include:
 - Shifts in geographic ranges of species (terrestrial, freshwater, and marine)
- Human system impacts include:
 - Negative effects on crop yields (some positive, largely in high latitudes)
 - Some increase in heat-related mortality

Climate-related Risks & Impacts



Global Projected Risks & Impacts

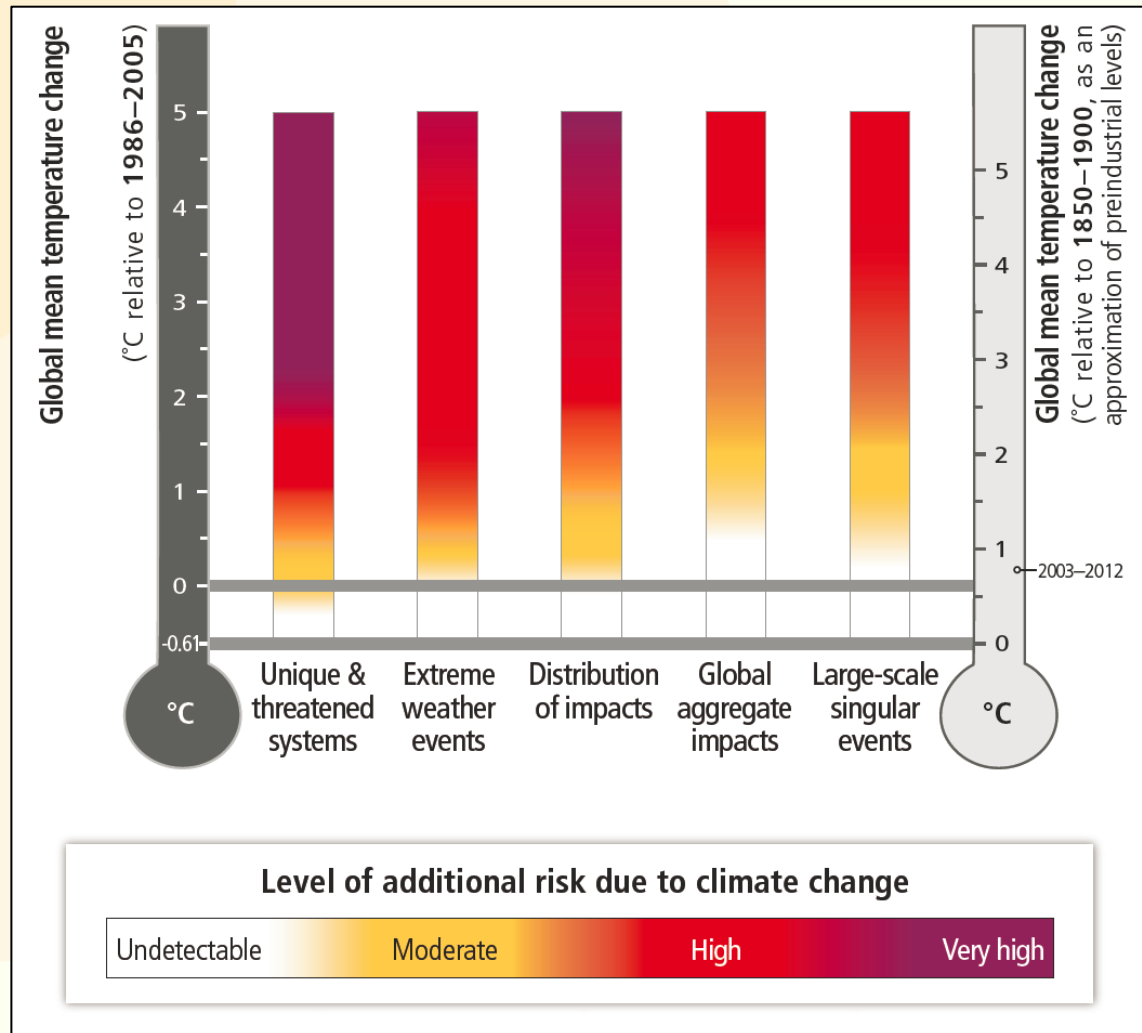
Examples of Key Risks:

- 1) Risk of food insecurity for poor urban & rural populations
- 2) Risk of loss of terrestrial, inland water, marine & coastal ecosystems, biodiversity & their ecosystem goods & services
- 3) Risk of increased mortality & morbidity as a result of exposure to extreme heat

(IPCC AR5 WGII SPM)

Global Projected Impacts

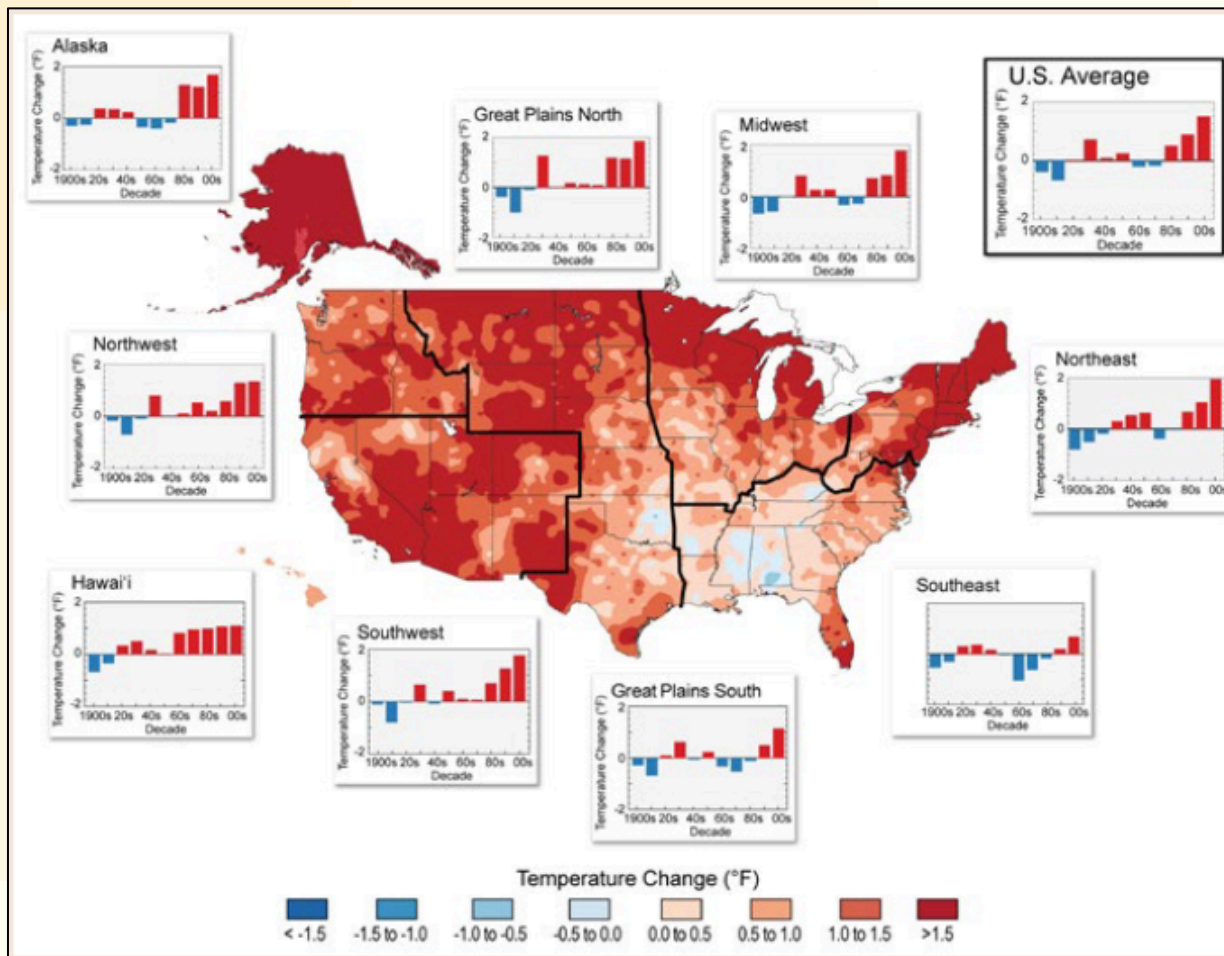
Risks due to climate change



U.S. - Observed Climate Change

Average Temperature

- Increased 1.3°-1.9°F (1985-present)

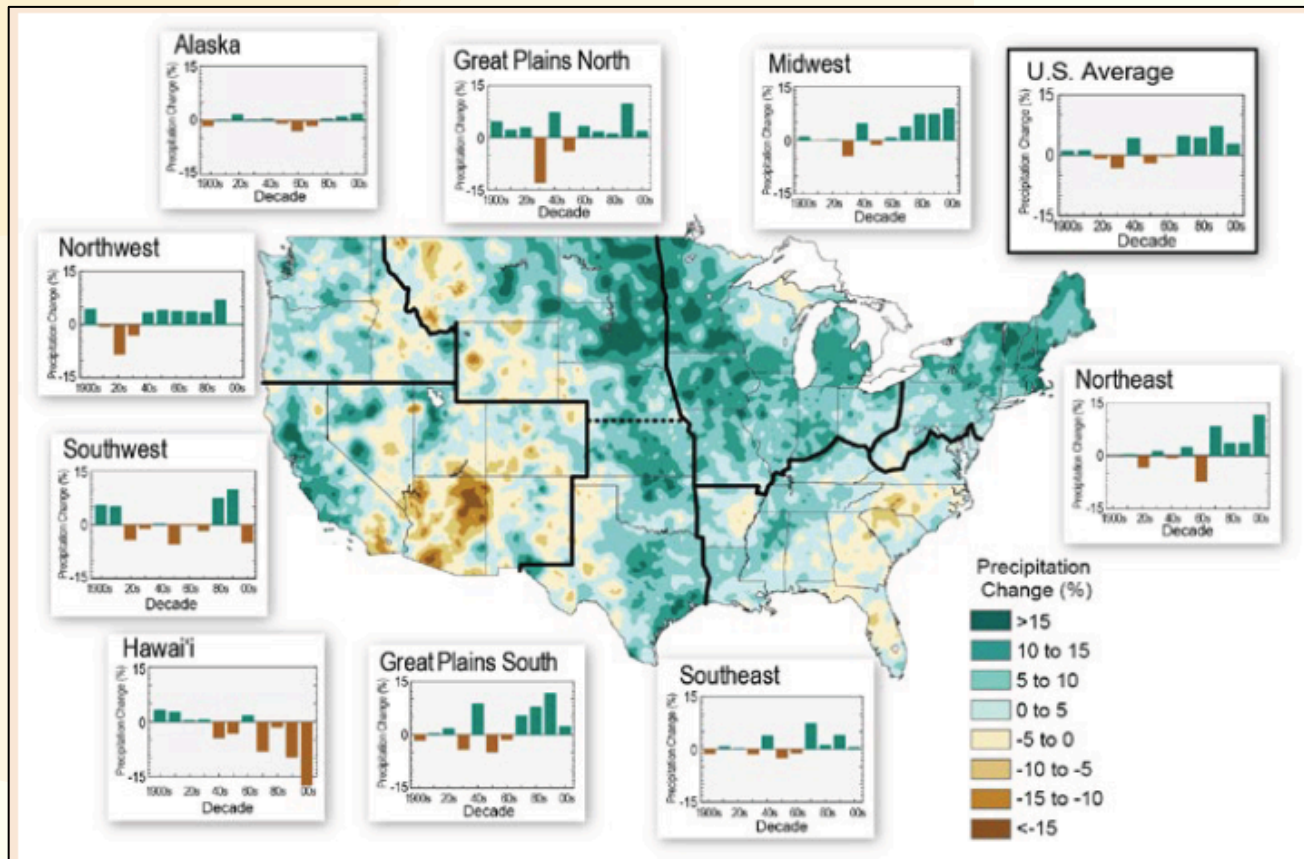


(1991-2012)
compared to
(1901-1960)

U.S. - Observed Climate Change

Average Precipitation

- Increased overall
- Some regions more than average, some drier



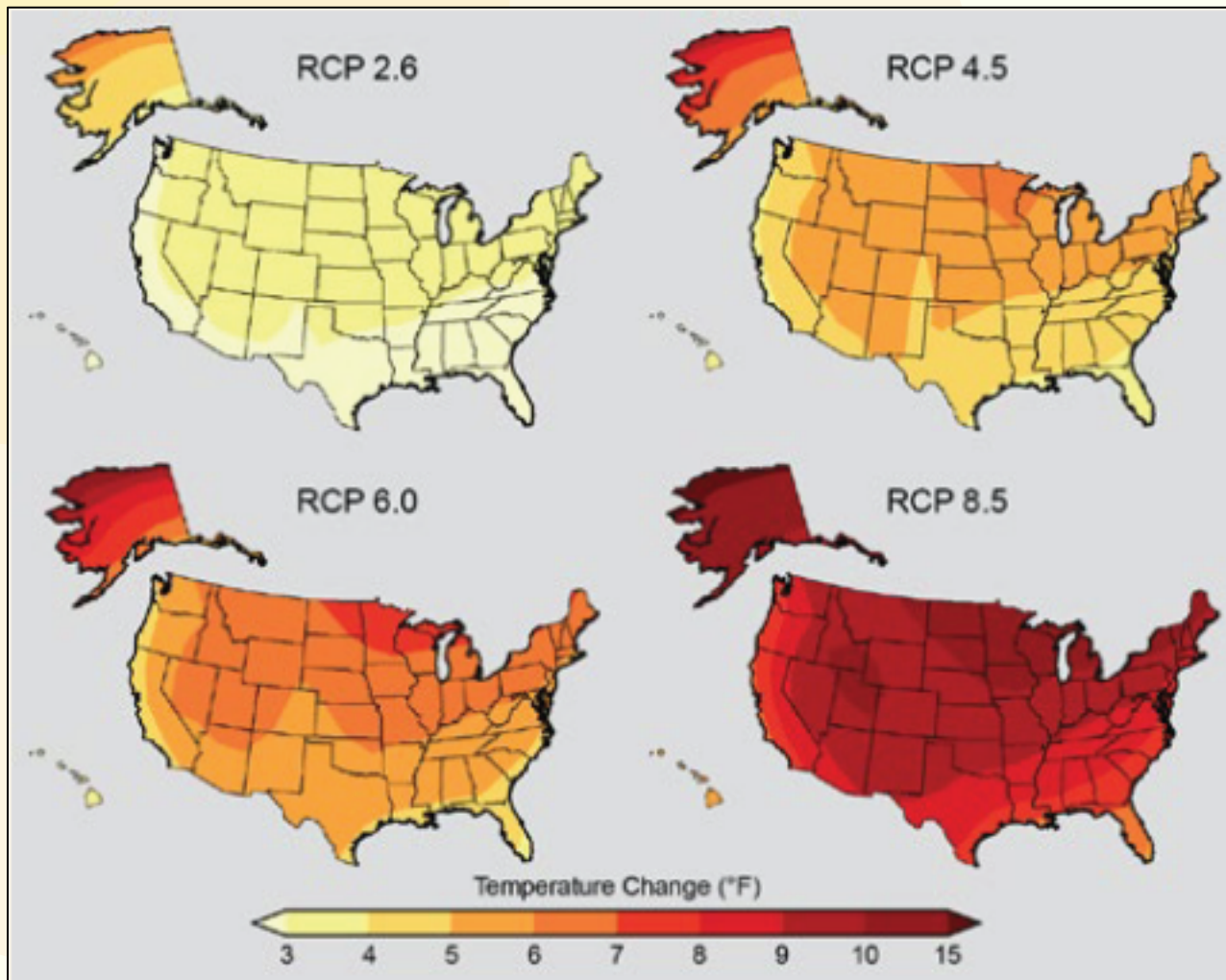
(1991-2012)
compared to
(1901-1960)

U.S. - Observed Climate Change

Other important changes, e.g.

- Heavy precipitation events: increase
- Heat waves: more frequent & intense
- North Atlantic hurricanes: increase in intensity, frequency & duration (human contribution still uncertain)
- Winter storms: increase in frequency & intensity since 1950s
- Sea level rise: 8 inches since 1880

US: Projected Climate Change



Average
temperature
change:

Late 20th
century
(1970-1999)
to
Late 21st
century
(2071-2099)

US: Projected Climate Change

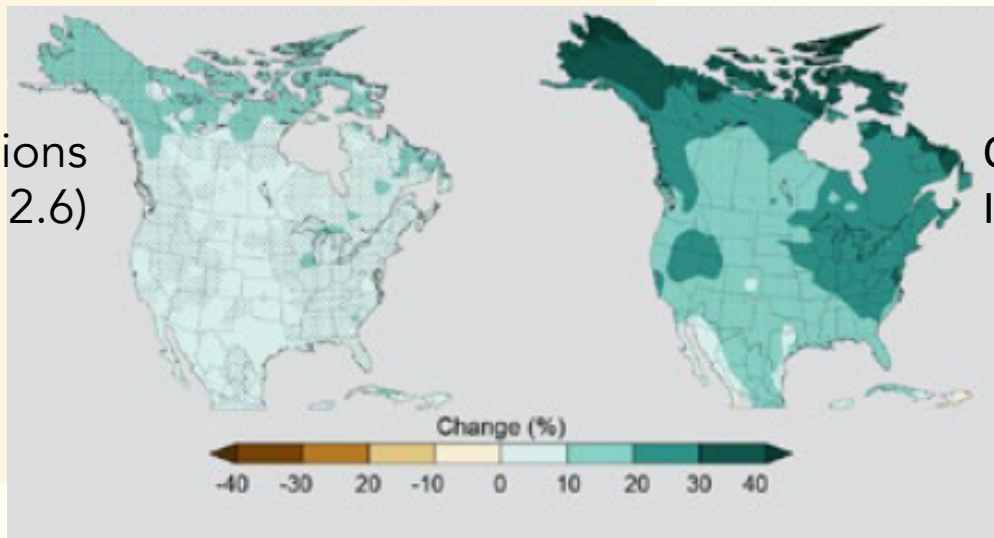
Changes in overall precipitation – some uncertainty

More confidence in extreme event projections:

- Heaviest precipitation events increase everywhere
- Most regions: dry spells lengthen

Annual Maximum Precipitation

Rapid Emissions
Reductions (RCP 2.6)



Continued Emissions
Increases (RCP 8.5)

US: Projected Climate Change

Many other important changes projected, including:

- Increase in heatwaves
- Greater rainfall rates in hurricanes
- Increase in sea level rise (1-4 feet above present by 2100)
- Decrease in ice volume & spatial extent (land, lakes, & sea)

Southeast US: Observed Climate

Warm and cool periods

- Trend in average temperature not as clear as other regions

Clearer trend in extremes

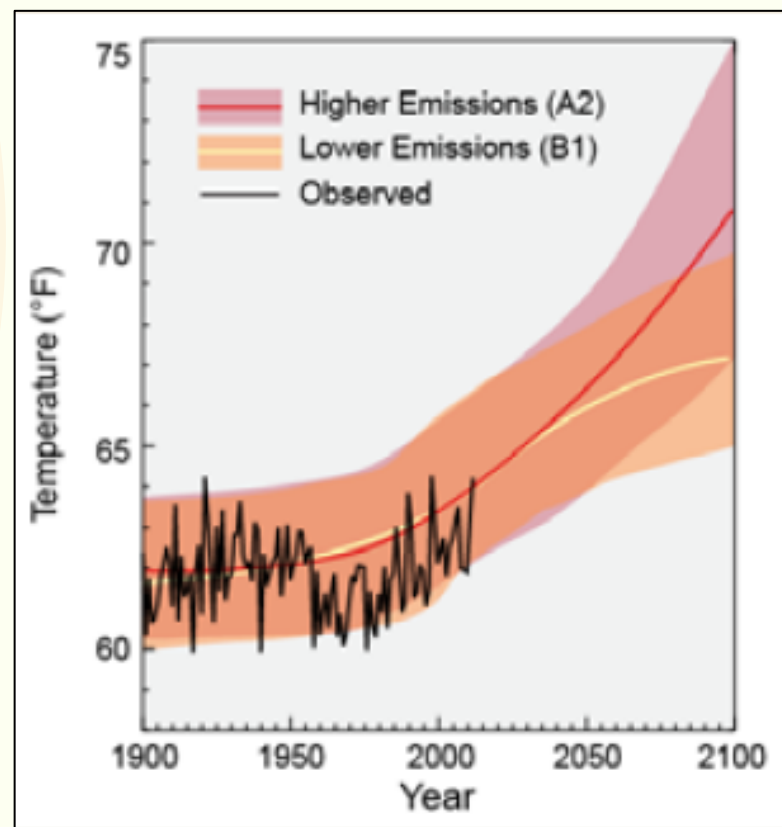
- Days above 95°F: increase
- Nighttime temperature: increase

Precipitation extremes

- Summers: some regions becoming drier, some wetter

Category 4 & 5 Atlantic hurricanes

- Increase in number – both human & natural causes



NCA, 2014 – Chapter 17

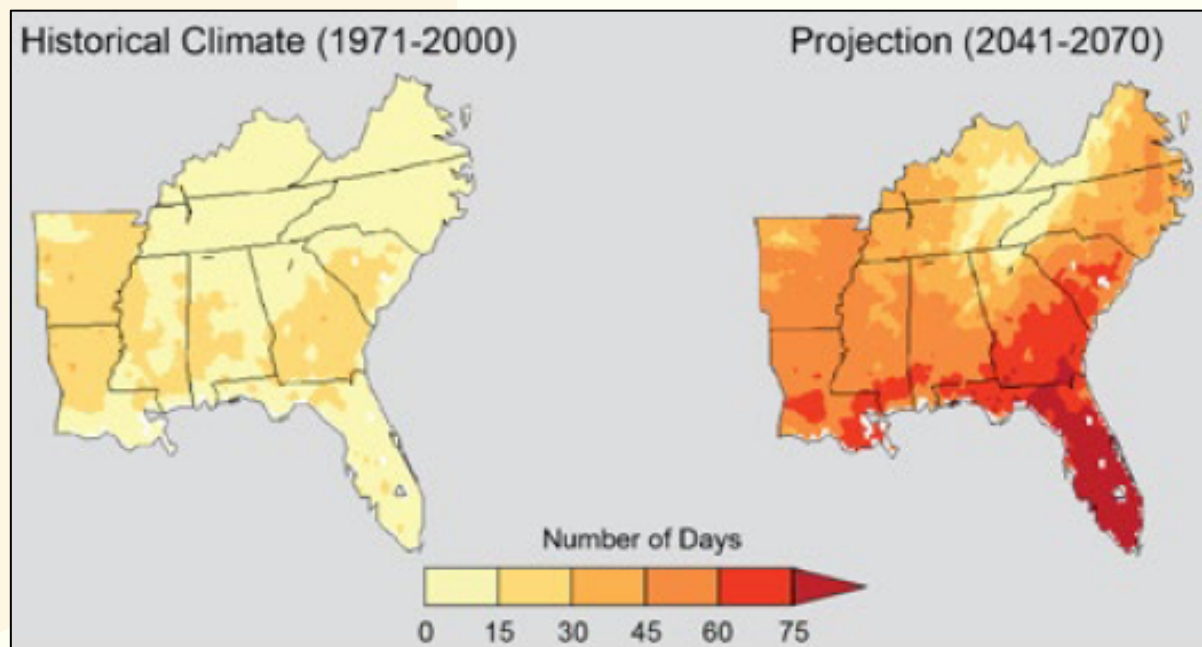
Southeast US: Projected Climate

Projected increase in average temperature (4-8°F)

- Often not as severe as other regions of US
- Interior warming most severe

- Increase: Days per year with maximum temperature above 95°F

- Decrease: Nights below freezing



Southeast US: Projected Climate

Average precipitation projections: less certain

- Southeast at transition between drier SW & wetter N

Extreme precipitation: continue to increase

Potentially fewer tropical storms, but:

- Those that occur will be greater in force
- More category 4 & 5 hurricanes

Southeast US: Projected Impacts

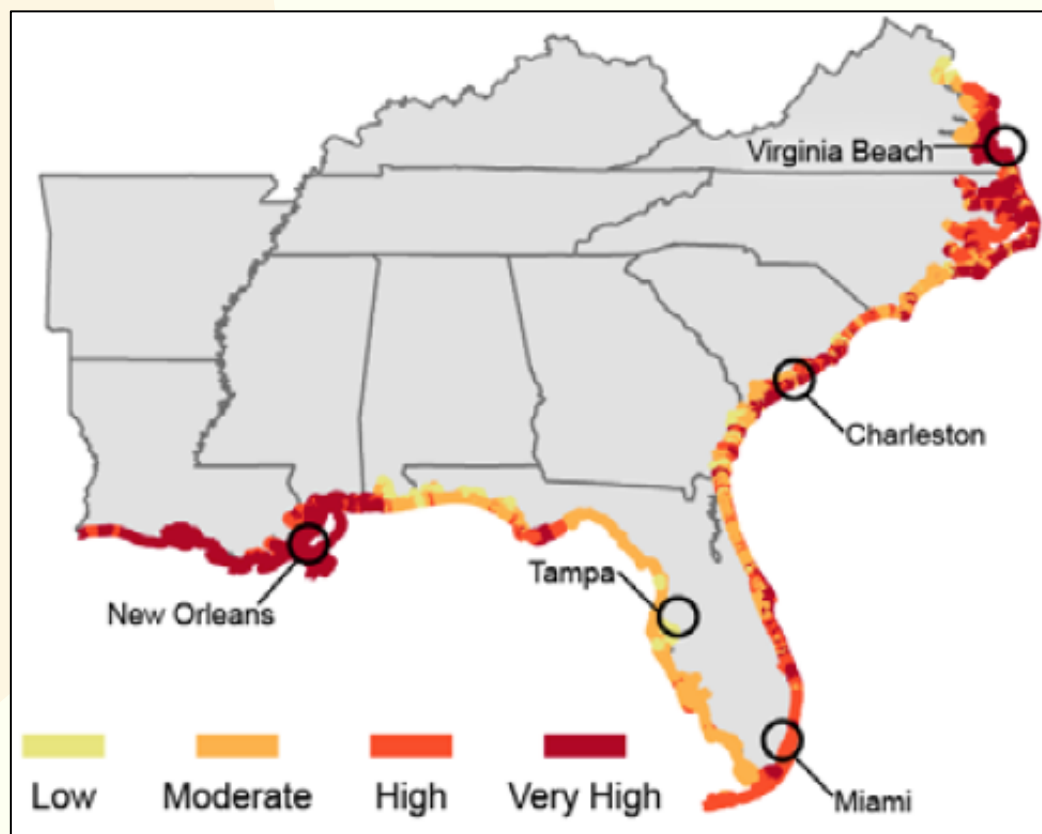
Many risks due to sea level rise

- Natural & built environments
- Regional economy

Intrusion of saltwater into freshwater resources,
Problem for utilities

Inundation of coastal wetlands, loss of protection

Vulnerability to Sea Level Rise



Southeast US: Projected Impacts

Many risks due to sea level rise (continued)

- Risk of species and ecosystems not tracking increasing water & salinity
- Saltwater intrusion – reduced water suitability for irrigation

Southeast US: Projected Impacts

Risks due to increasing temperature & extreme heat

Health effects, e.g.

- Increased exposure to air pollutants (e.g. ozone)
- Increase in allergens
- Potentially more favorable conditions for malaria-carrying mosquitoes

Ecosystem effects, e.g.

- Spread of non-native plants
- Disturbance of forests by insects & pathogens

Southeast US: Projected Impacts

Risks due to increasing temperature & extreme heat

Agriculture effects

- Heat & drought stress on crops & livestock
- Resulting economic impacts

A variety of other risks

- Increased wildfires & adverse health effects
- Harmful algal blooms & adverse health effects
- Harm to coral reef systems
- Stress on energy demand for air conditioning

Southeast US: Projected Impacts

Risks due to reduced water availability

- Confounded by population growth & land-use change

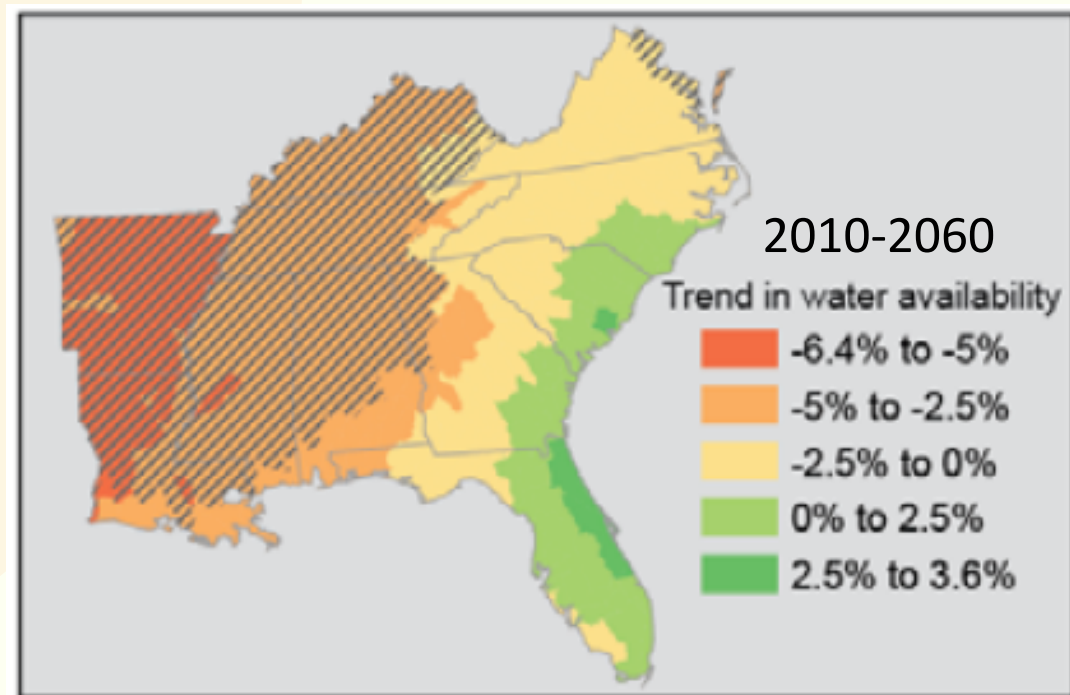
Examples of risks:

Saltwater intrusion

- Adverse effects on freshwater resources
- Risks to aquaculture

Saltwater intrusion + Land use change

- Risks to sensitive peri-urban wetlands



Reducing Climate Change Impacts

Adaptation – actions to reduce impacts
(e.g. building sea walls)

Mitigation – actual reduction of global warming
(e.g. reduction of greenhouse gas emissions)

Information Resources

Global and regional information: Intergovernmental Panel on Climate Change (IPCC)

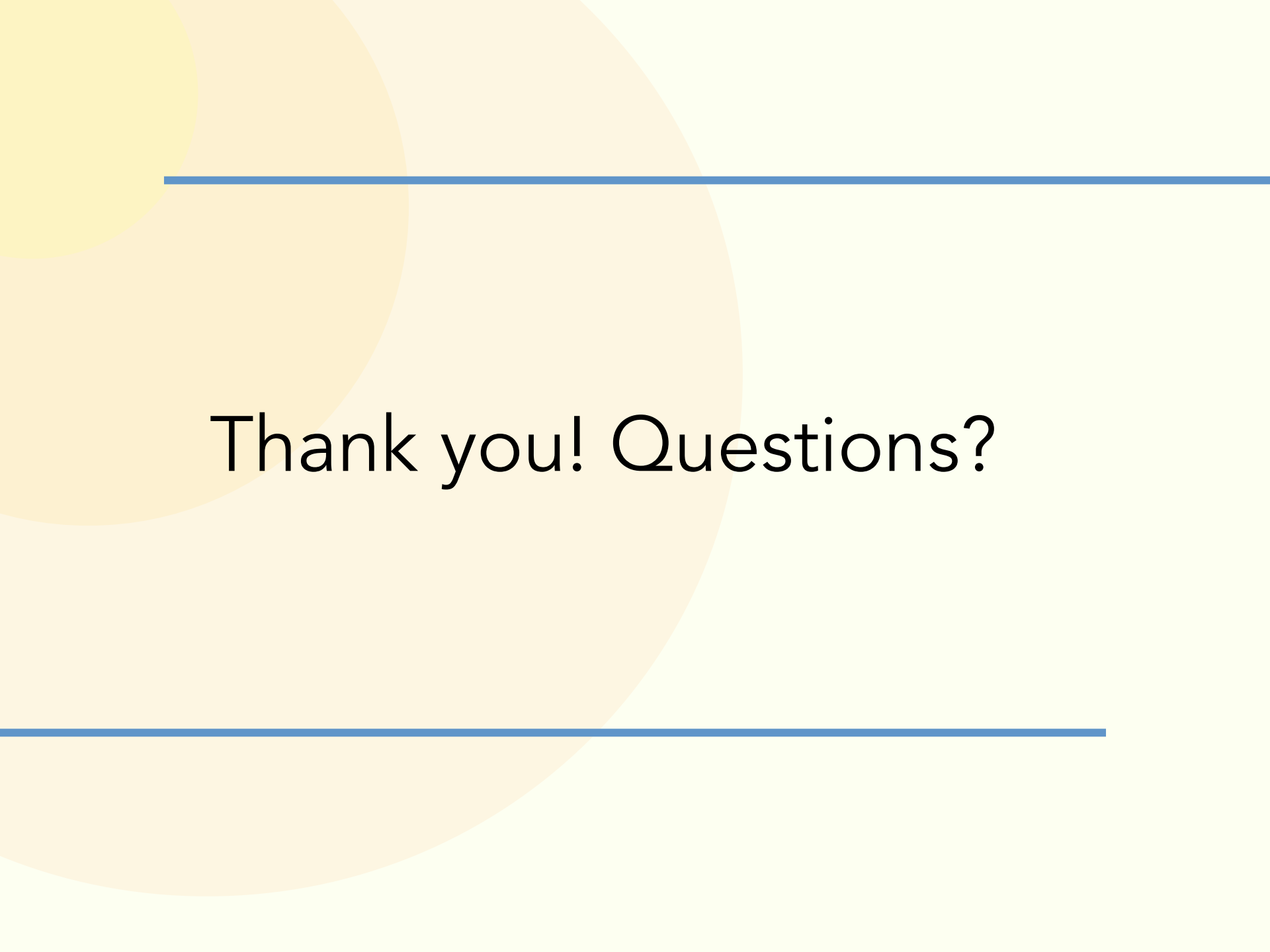
- Physical aspects: www.climatechange2013.org
- Impacts, adaptation, vulnerability: www.climatechange2014.org
- Mitigation: <http://mitigation2014.org/>

U.S.: Country and sub-national information:

National Climate Assessment: www.globalchange.gov

Up-to-date facts on climate change & impacts on American public: Climate Central: www.climatecentral.org

“Climate science from climate scientists”: RealClimate:
www.realclimate.org

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Thank you! Questions?

Emission Projections

