Climate change impacts and adaptation in the Carolinas

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Greater Piedmont Chapter of the Explorers Club

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cisa
carolinas integrated sciences & assessments

Climate is what you expect
Weather is what you get– Mark Twain

Today: 3 lines of evidence and adaptation options for the Carolinas

Climate Change Means Changing…

- Weather (Temp., Precip., storms, droughts)
- Water levels in rivers, oceans, and aquifers
- Melting snow, sea ice, permafrost, and glaciers
- Species ranges, communities, and life cycles
- Changes to human health, economy, security, natural hazards, agriculture, land use

3 lines of evidence
supporting the projections

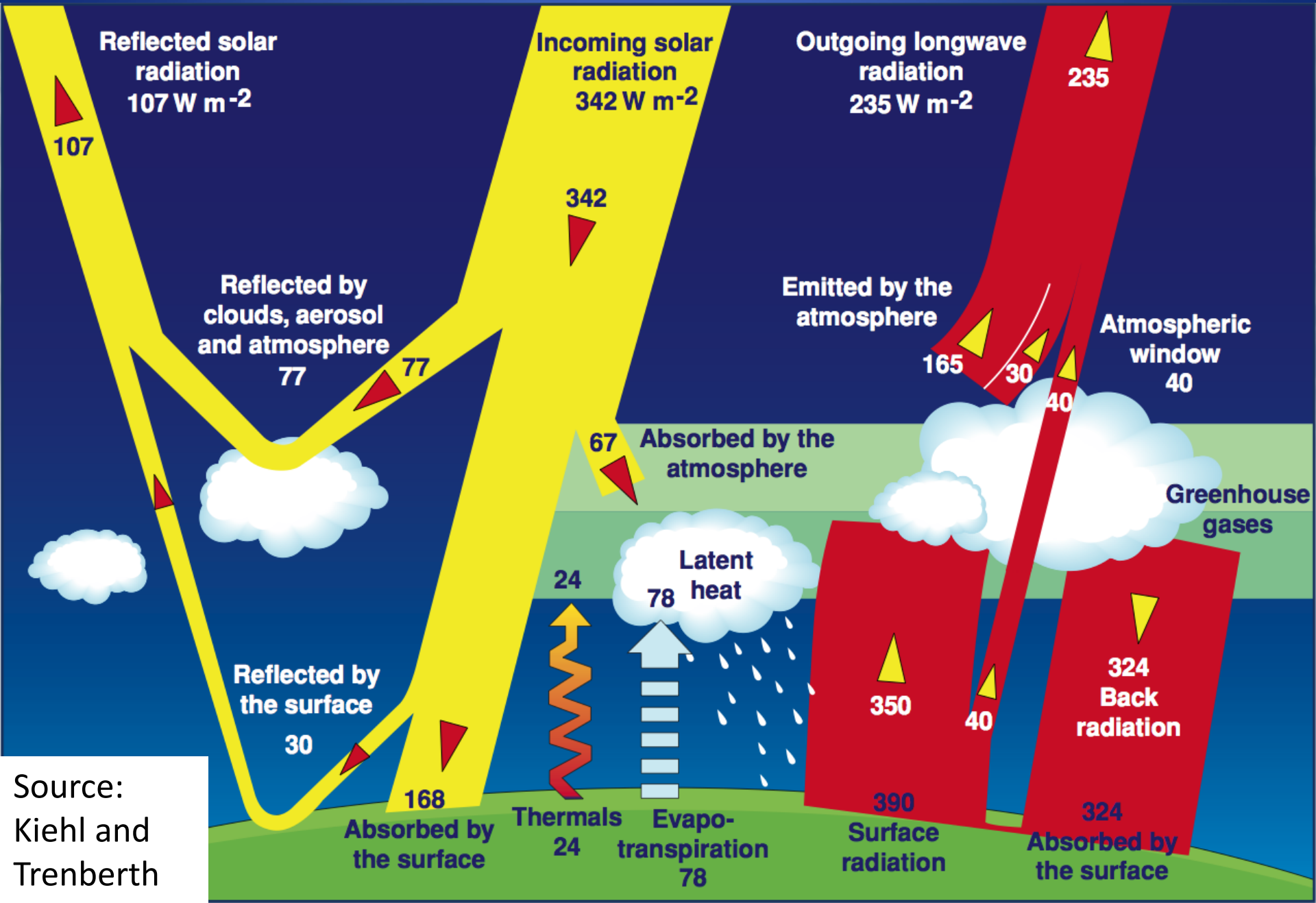
1. Established Theory and Process

Svante Arrhenius, Swedish scientist (1859-1927), in 1895 presented "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground."

Svante Arrhenius
Fotografi. 1893.

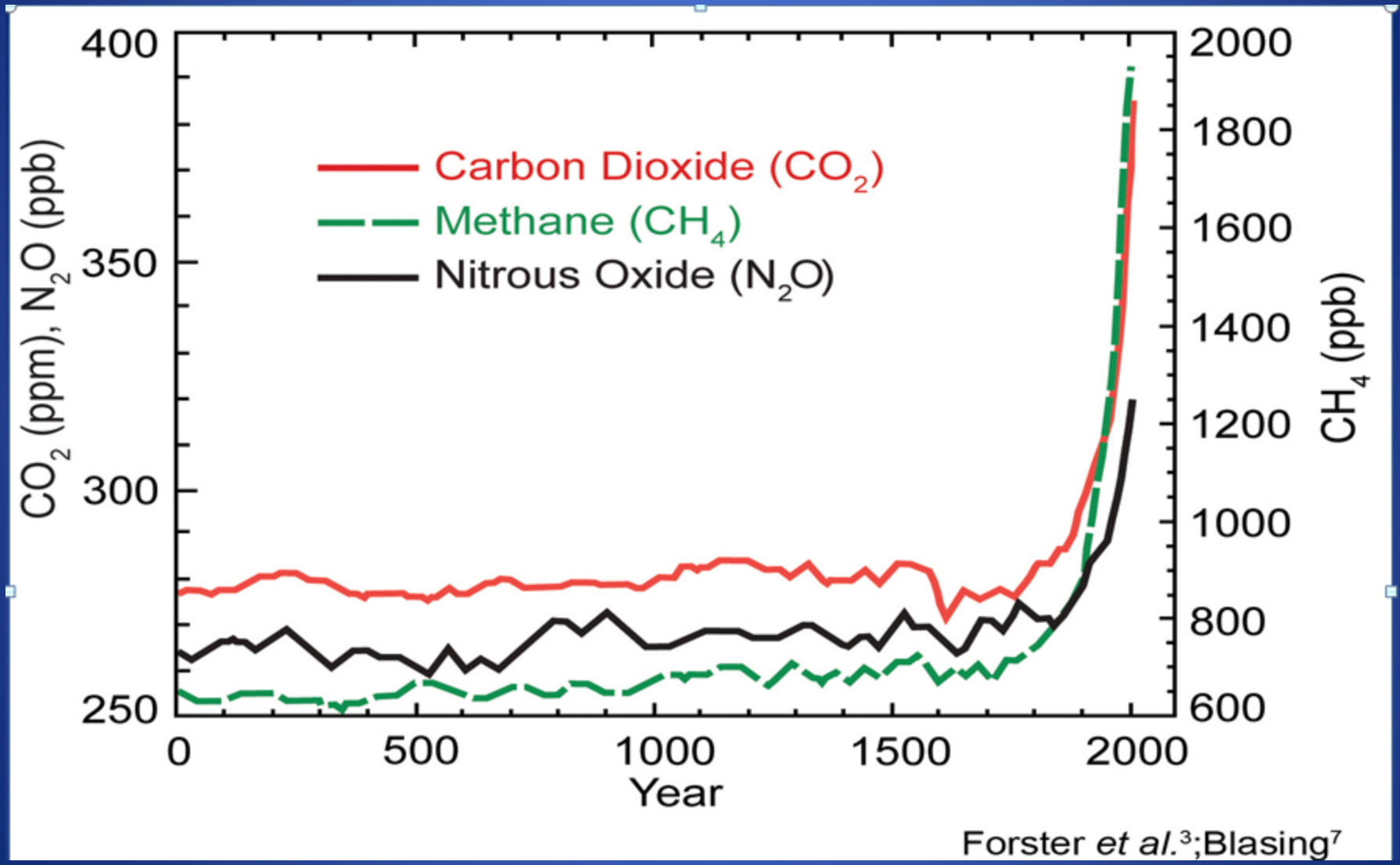
First presentation of the theory and calculations on the effect of carbon dioxide and other chemicals in the atmosphere on the heat budget of the Earth

Measurements of the Earth's Radiation Budget

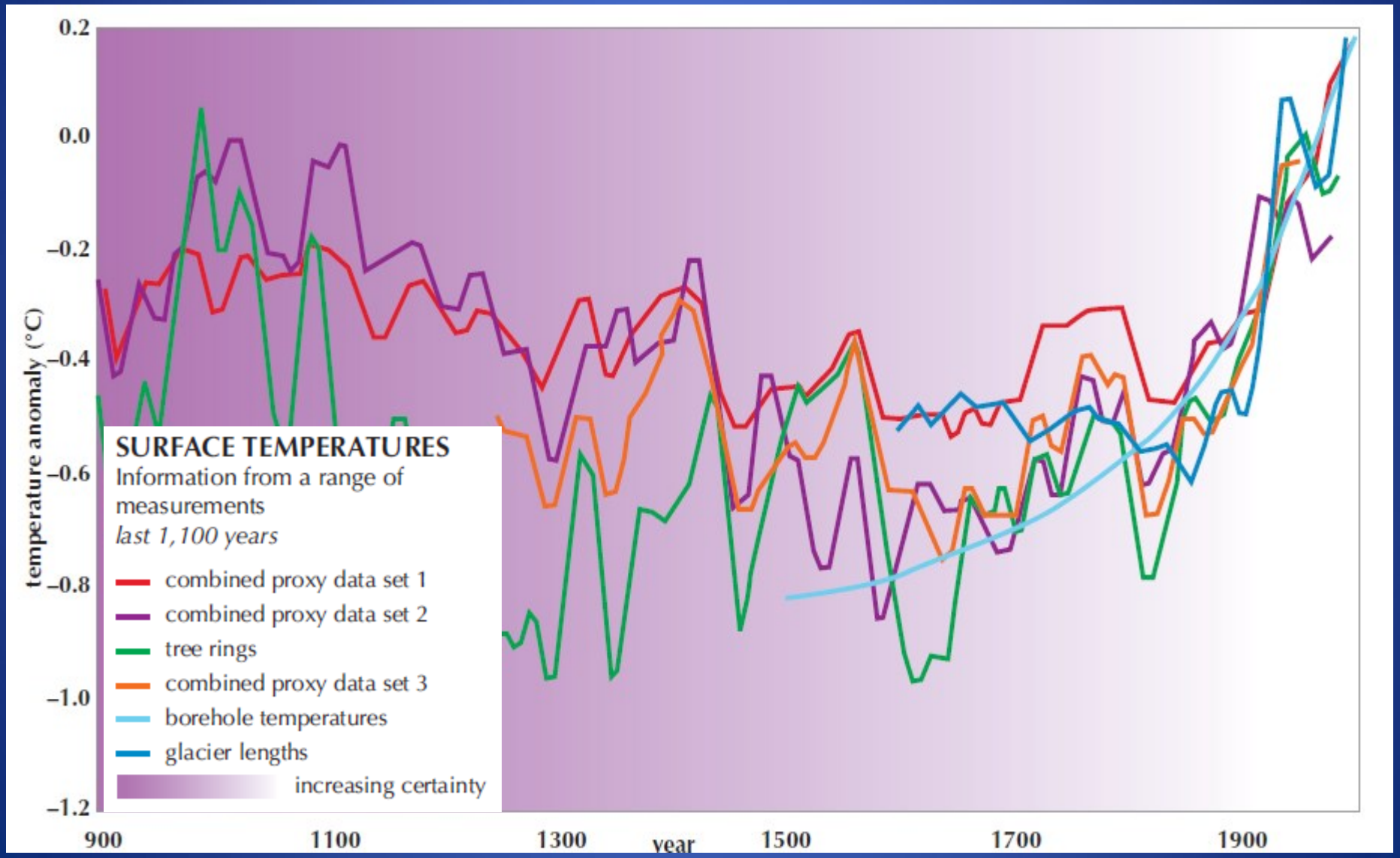


Source:
Kiehl and
Trenberth

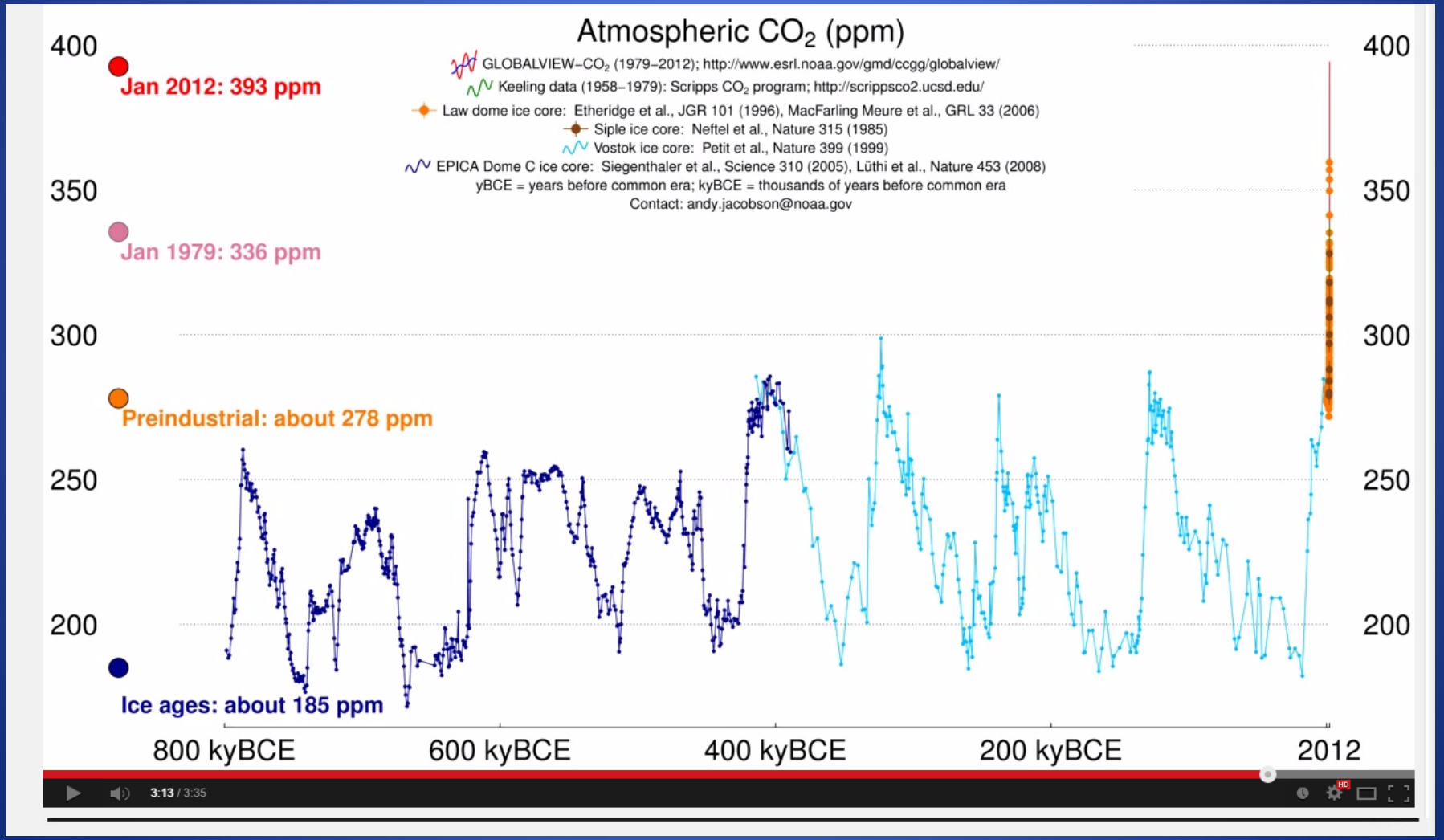
Measurements of Greenhouse Gases



Multiple sources of evidence on past temperatures



In the context of planetary and human history

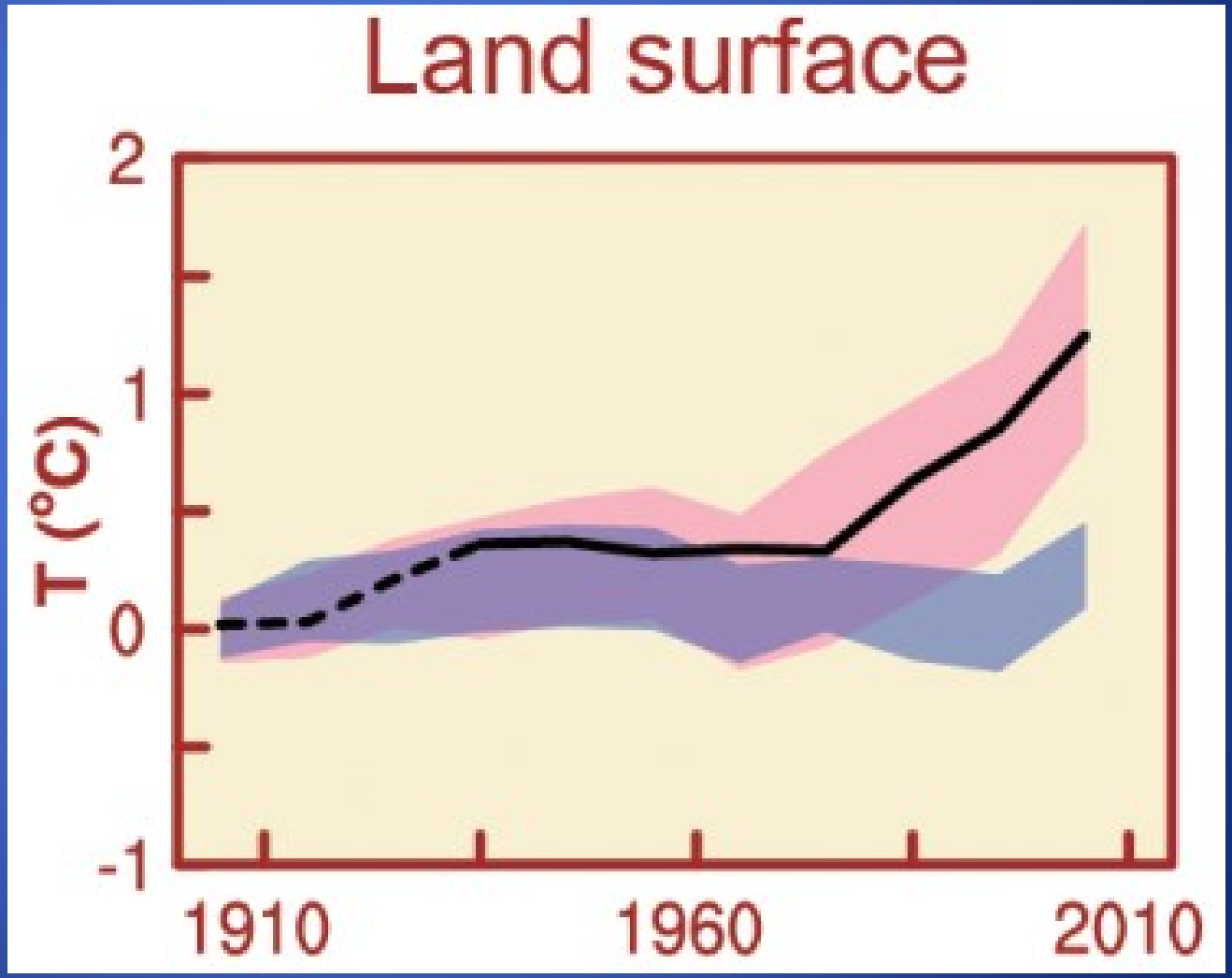


2. Models require greenhouse gas inputs to replicate observed changes

Temperature change relative to 1880-1919

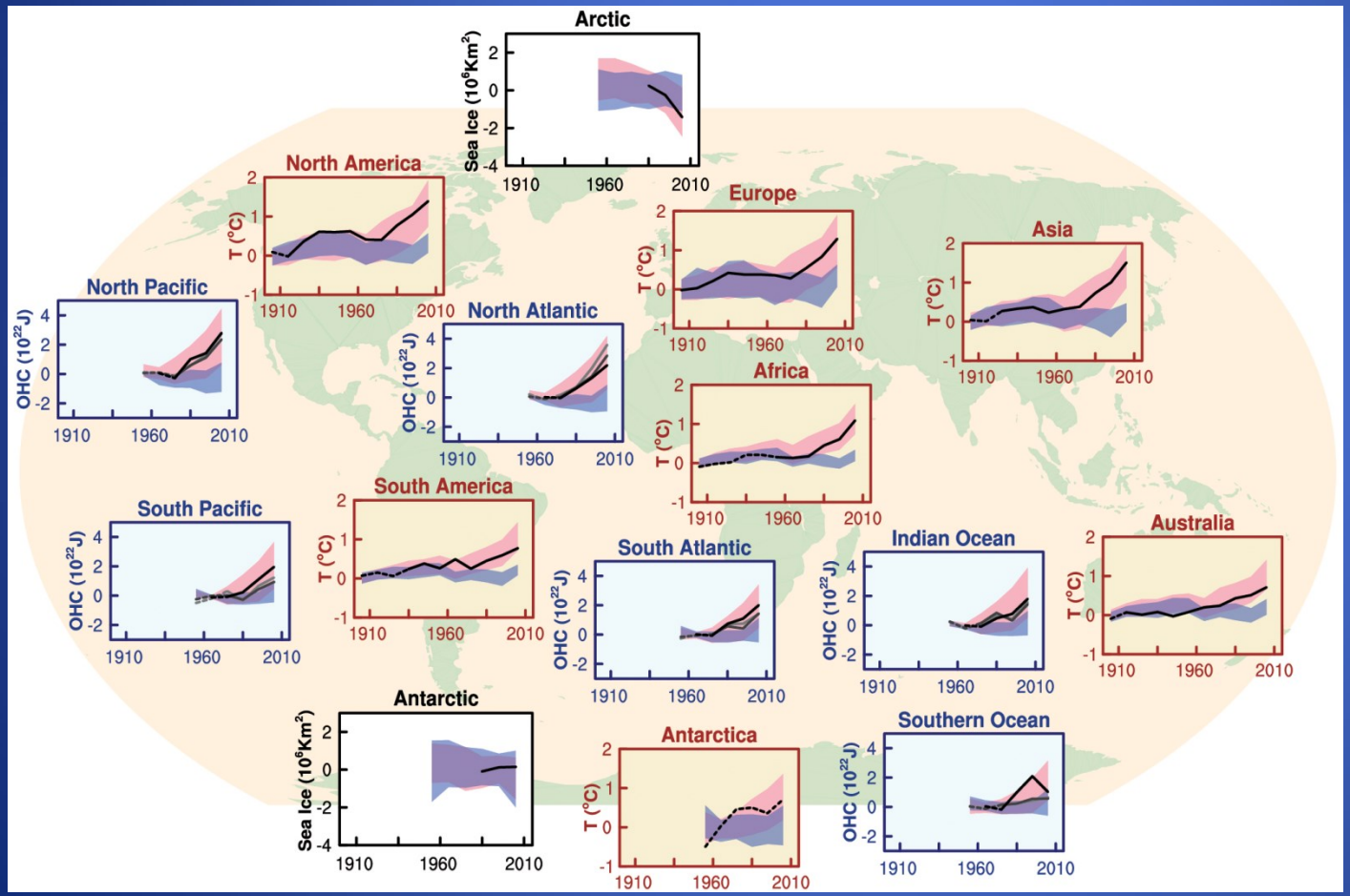
Models using Natural Forcings

Models using Natural & Human Forcings



IPCC 2013 SPM fig 6

Same relationship holds at the regional level
Gives some confidence in the models



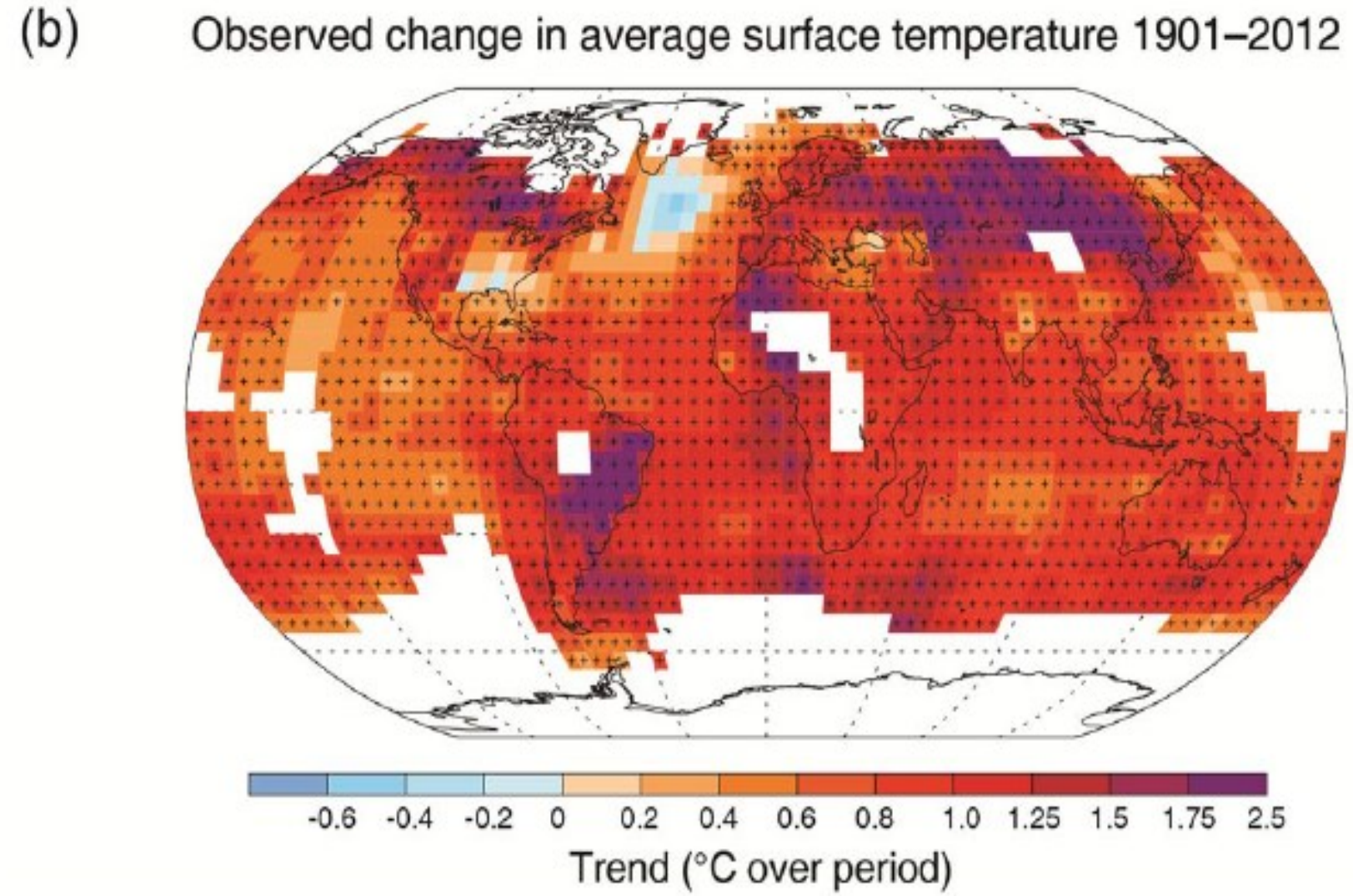
Temperature change
(Artic – sea ice area)

Models using Natural Forcings

Models using Natural & Human Forcings

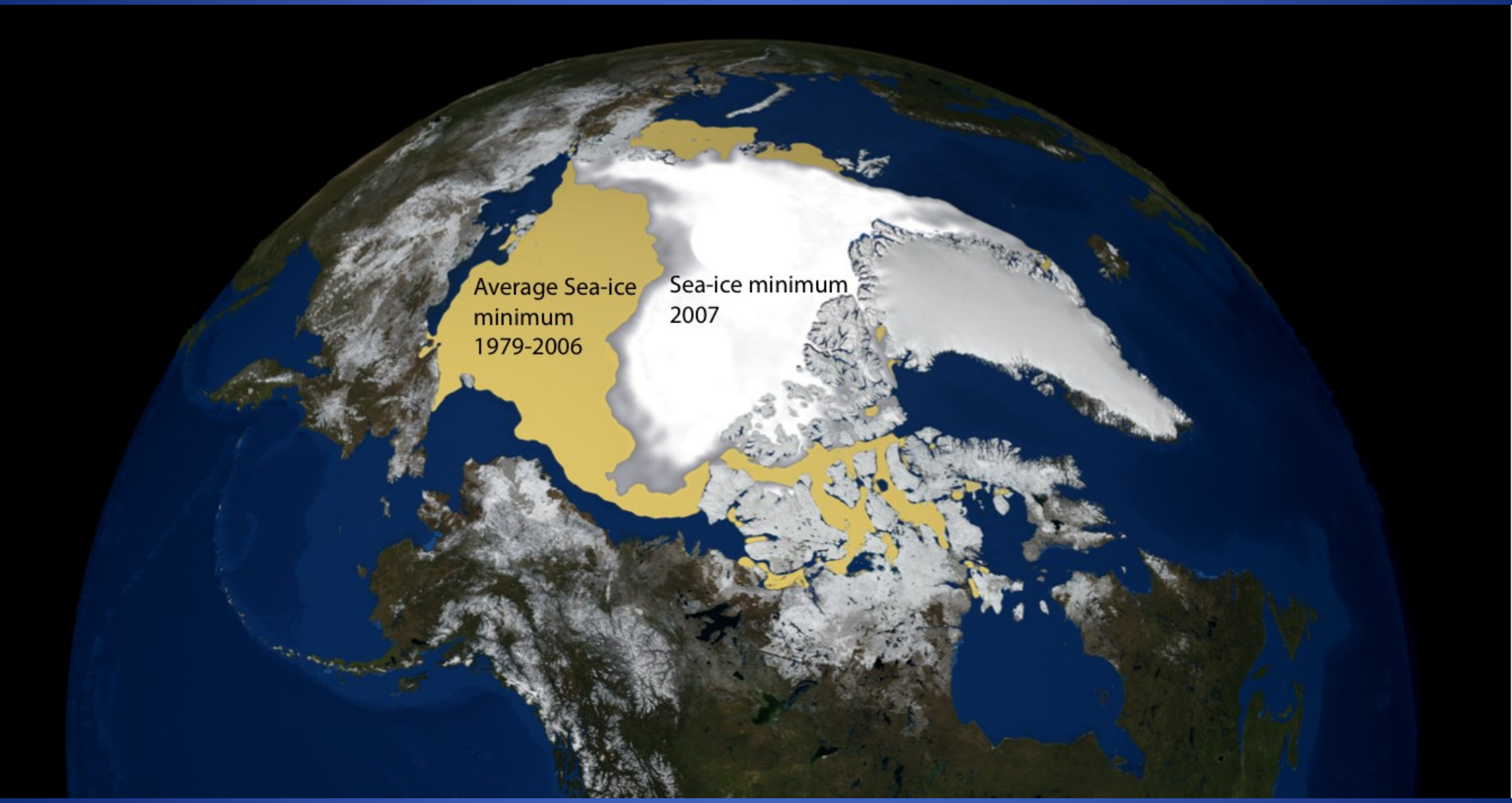
IPCC 2013 SPM fig 6

3. Observations are consistent with theory



IPCC, 2013; Working Group 1, Figure 3.9 Summary for Policy Makers

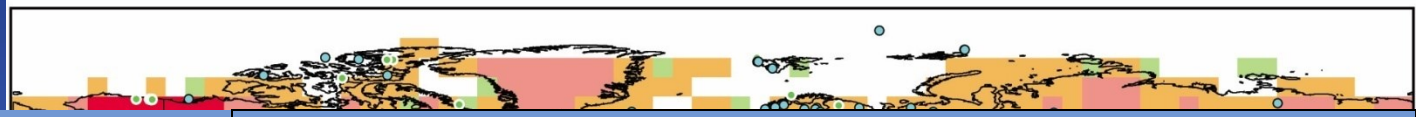
Arctic Sea Ice



Climate chang being obser

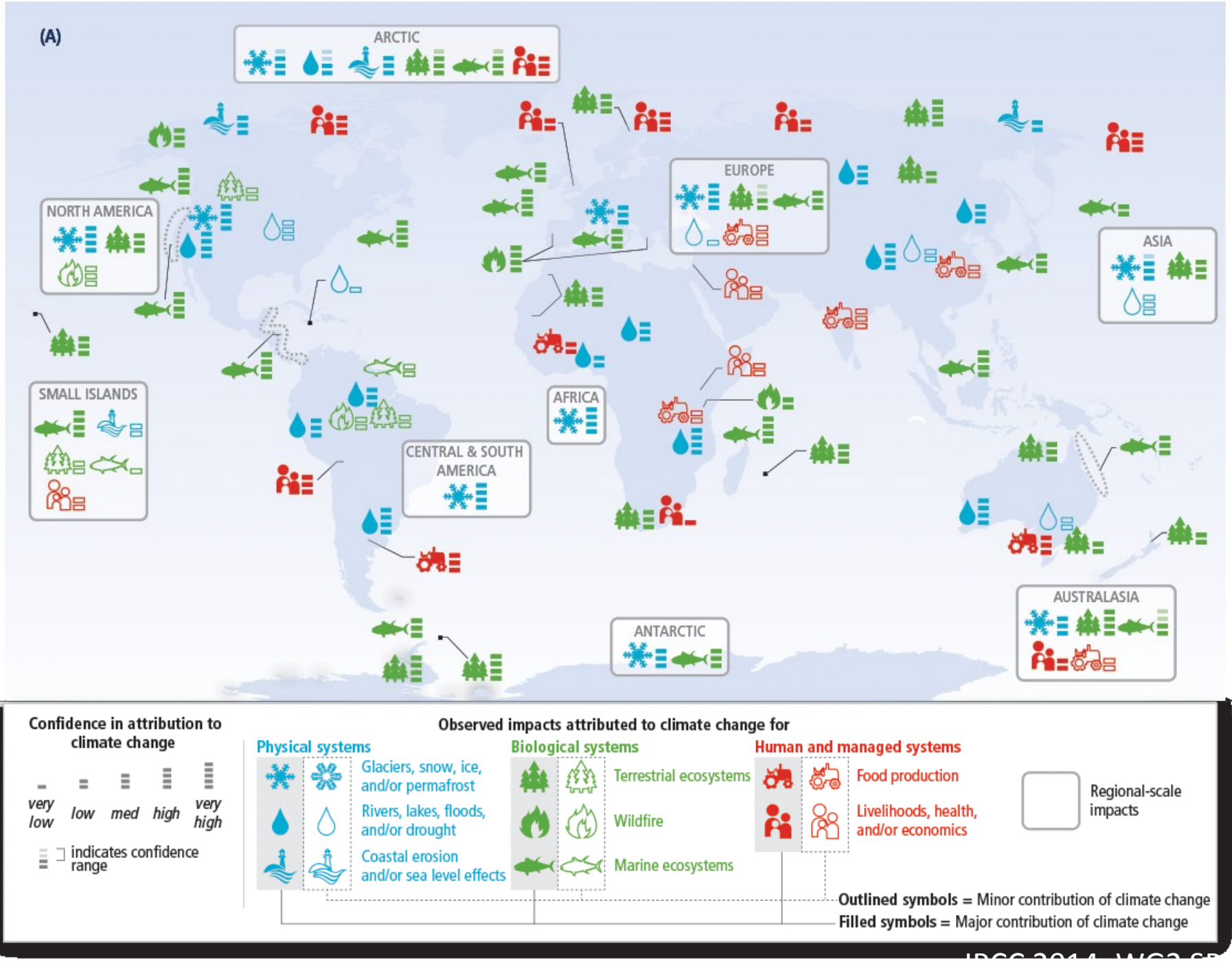
- Temp
- Phys syster
- Biolo syster

•Source: I Working G Summary Makers



	Globally	
	Physical	Biological
# of signif. observed changes	765	28,671
% consistent with warming	94%	90%
% consistent with warming	94%	92%

epresent 1 to 7,500 data series.


(A)
ARCTIC
NORTH AMERICA
EUROPE
ASIA
SMALL ISLANDS
AFRICA
CENTRAL & SOUTH AMERICA
AUSTRALASIA
ANTARCTIC
Confidence in attribution to climate change
very low
low
med
high
very high
indicates confidence range
Observed impacts attributed to climate change for
Physical systems
Glaciers, snow, ice, and/or permafrost
Rivers, lakes, floods, and/or drought
Coastal erosion and/or sea level effects
Biological systems
Terrestrial ecosystems
Wildfire
Marine ecosystems
Human and managed systems
Food production
Livelihoods, health, and/or economics
Regional-scale impacts
Outlined symbols = Minor contribution of climate change
Filled symbols = Major contribution of climate change

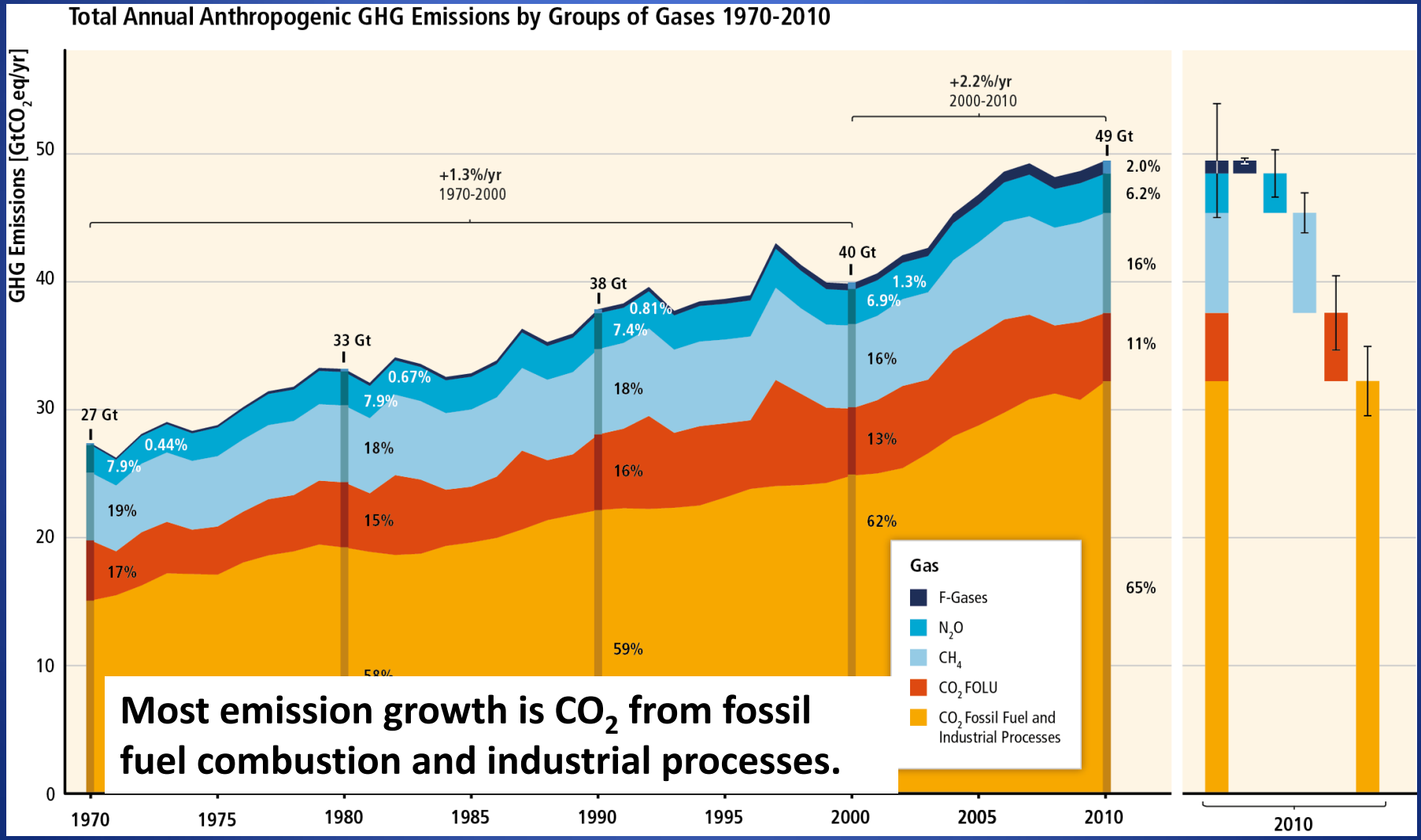
Increased flooding: $200 million in flood control underway in C'ton

Kayaking through the Charleston City Market, August 28, 2012

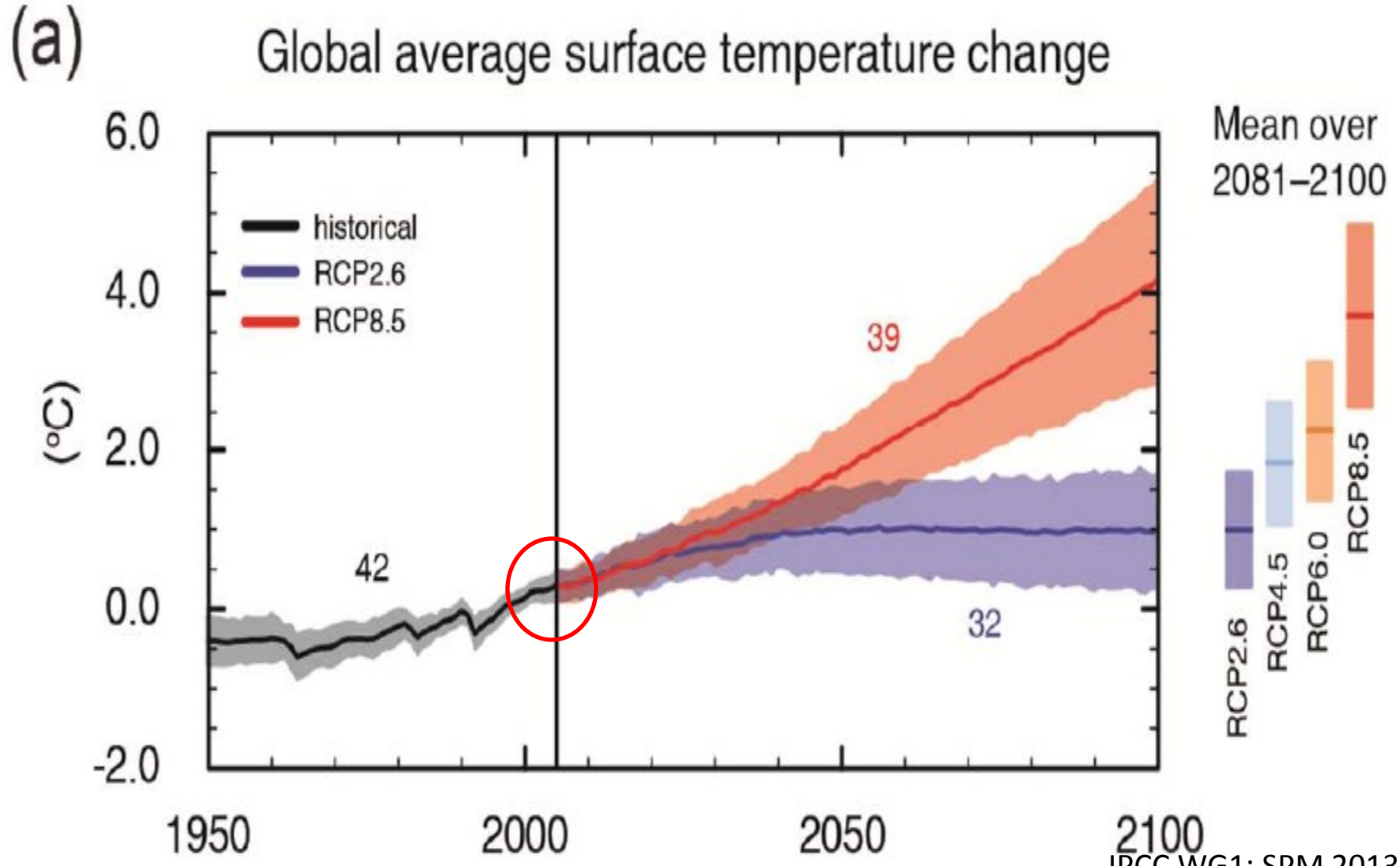
3 Lines of Evidence

1. **The fundamental process is well established**
2. **Climate models show some ability to replicate observations indicating they are capable of representing some processes**
3. **Current observations consistent with theory**

Currently, GHG emissions accelerate despite reduction efforts.

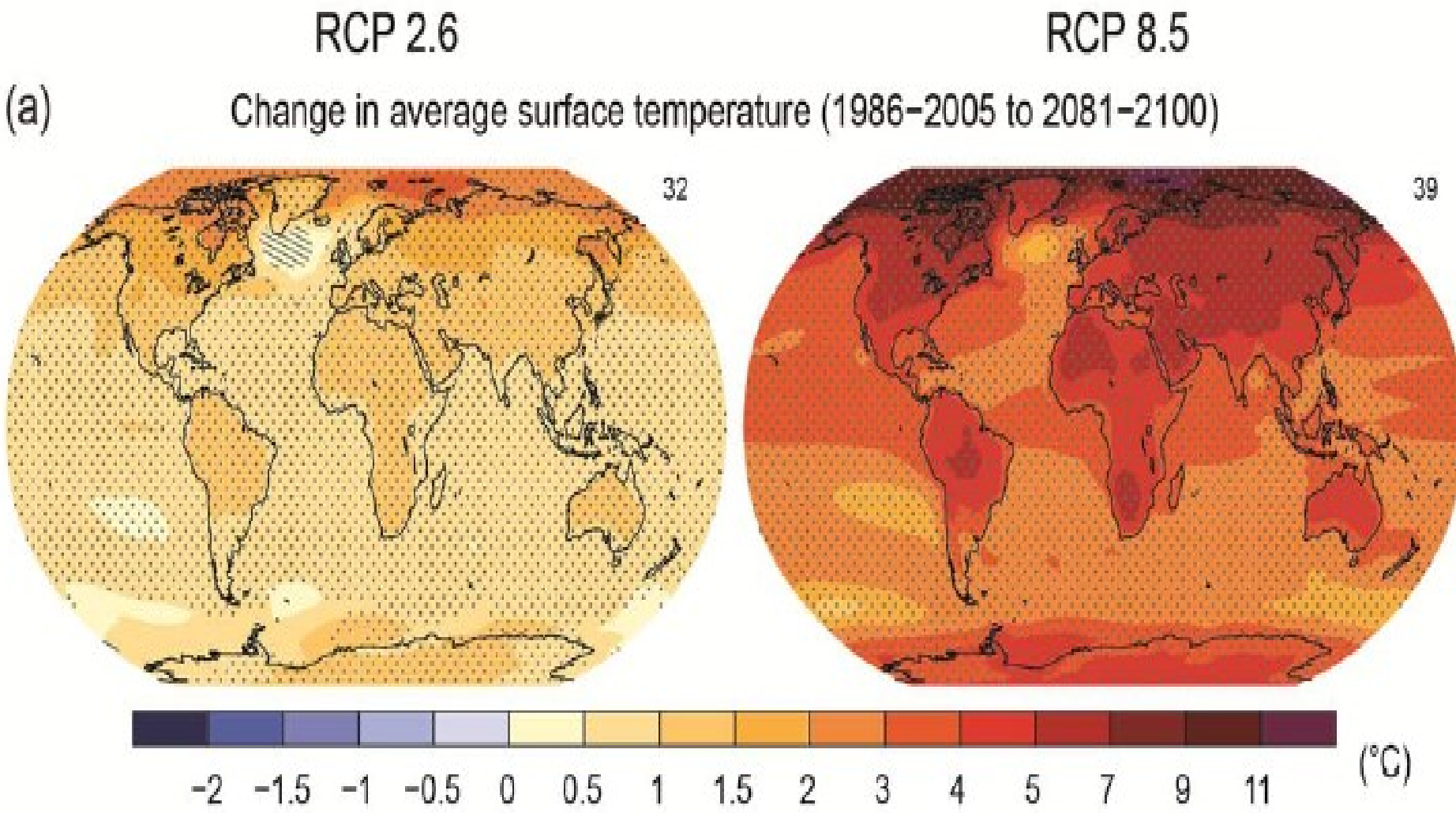


The choice of paths

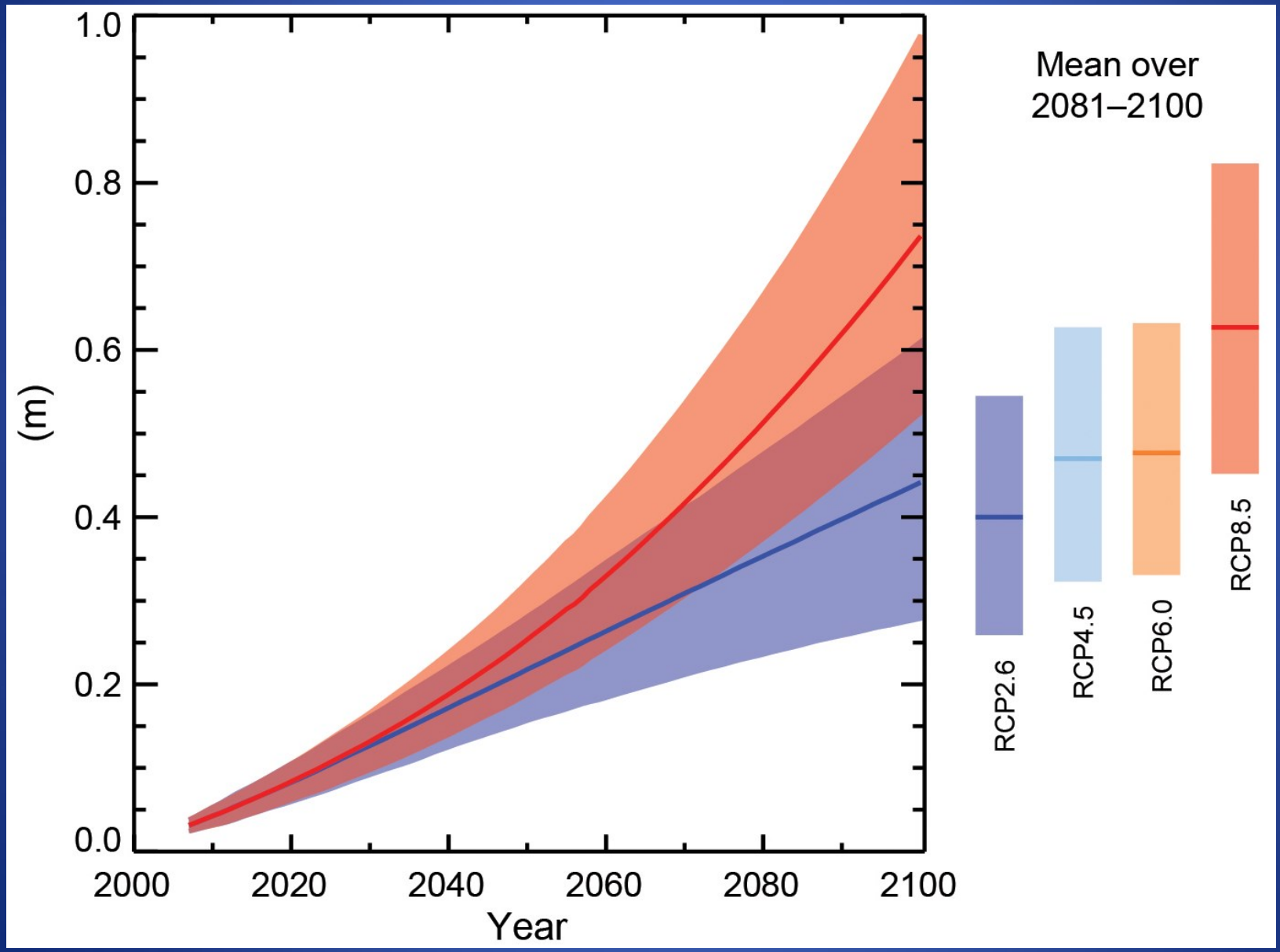


IPCC WG1: SPM 2013

High and low projections for 2081-2100

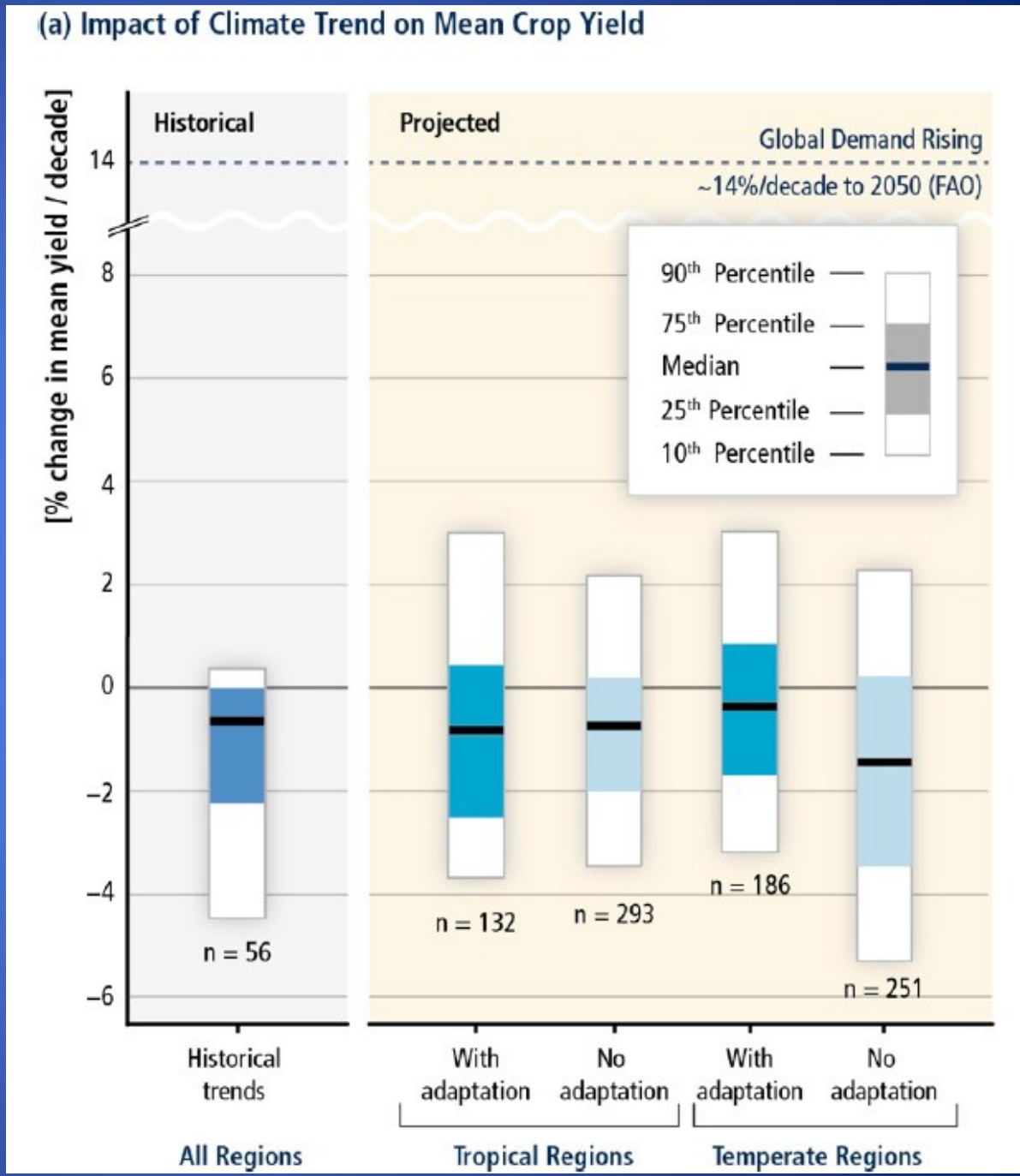


Projected Global Mean Sea Level Rise



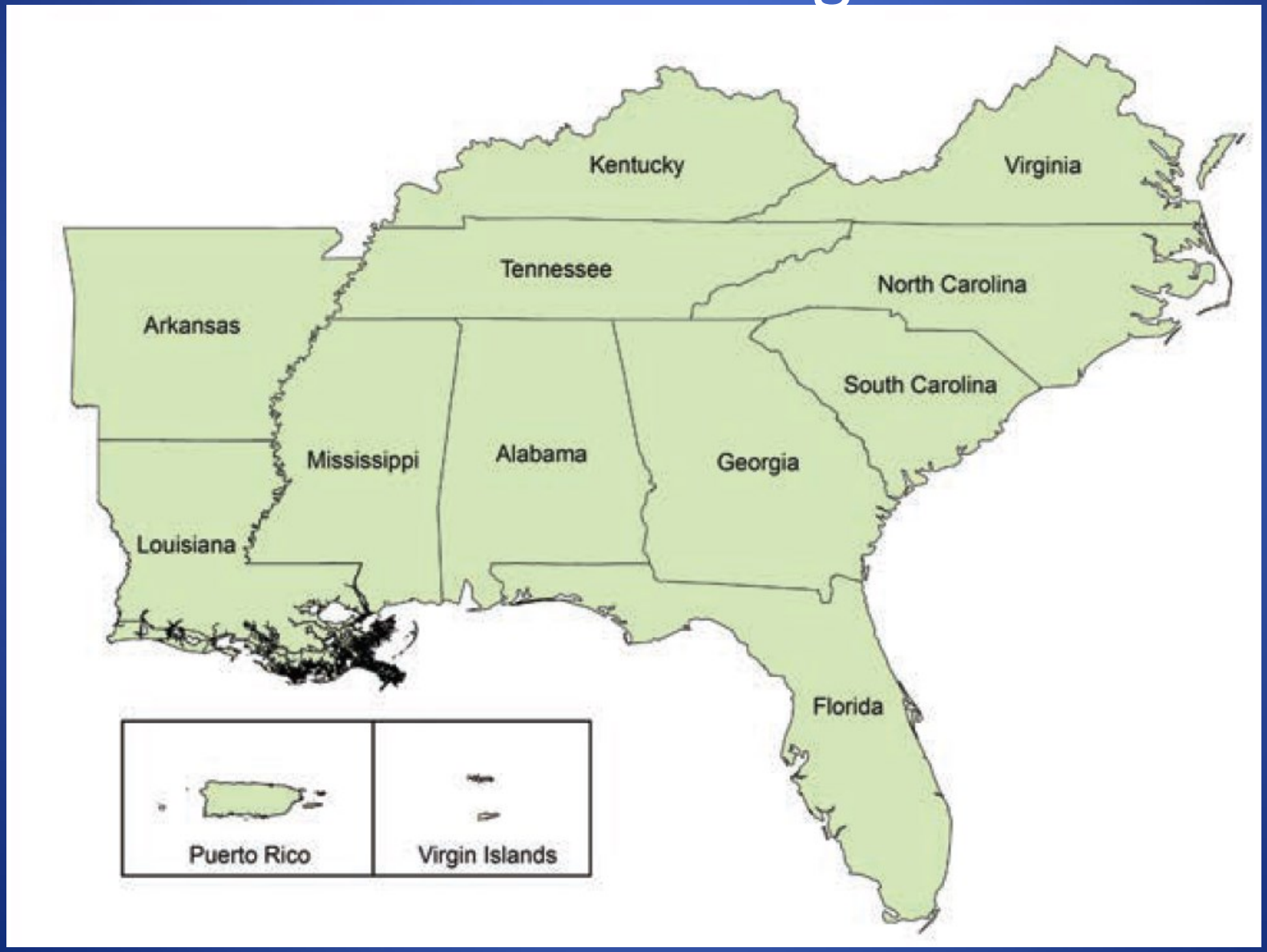
Impact on Crop Yields

- Projected +1 to -3.5 % decrease in yield/decade
- In the context of +14% growth in demand/ decade
- For 5 decades



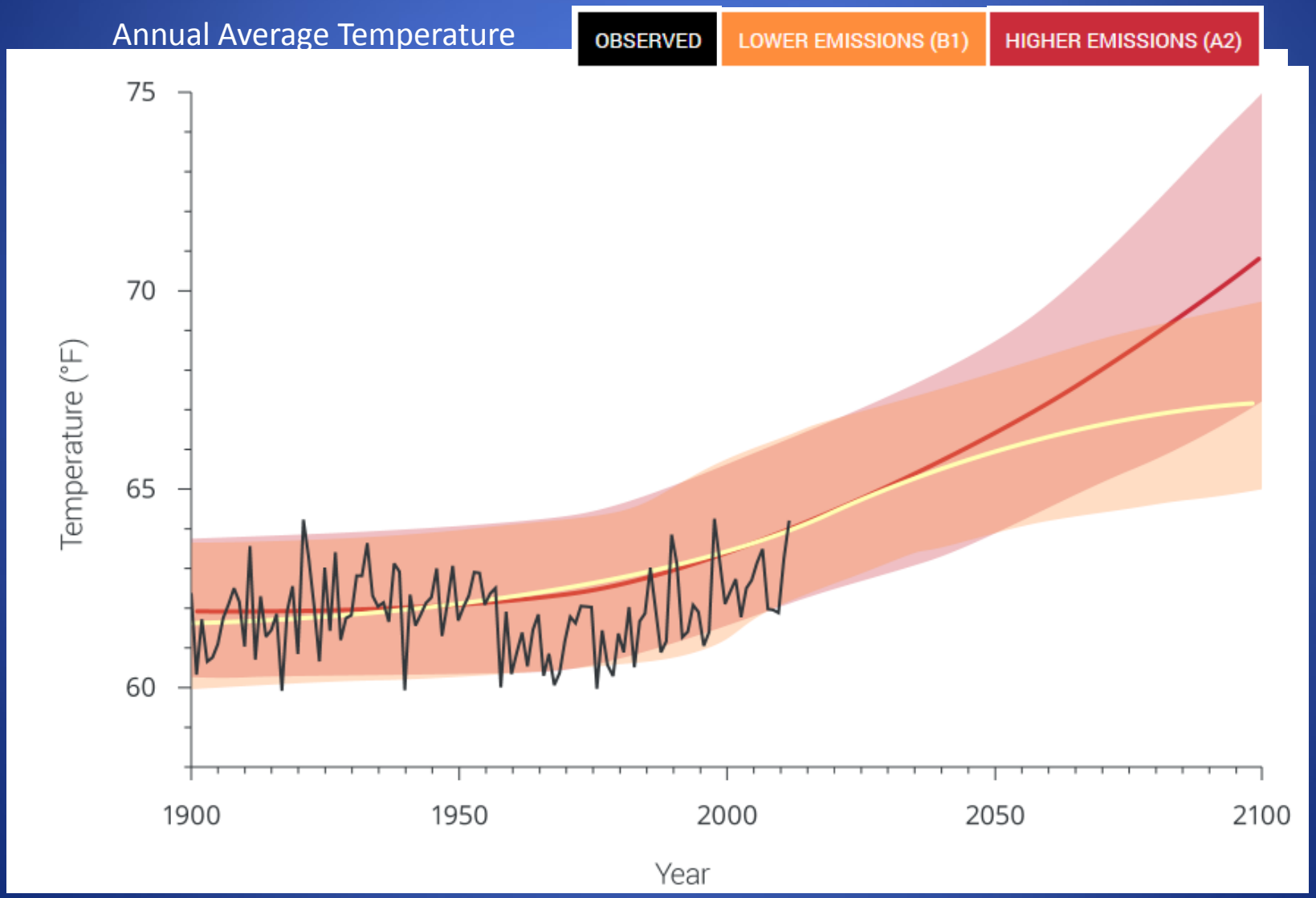
IPCC AR5 WG2 Chap. 7

US National Climate Assessment Southeast Region



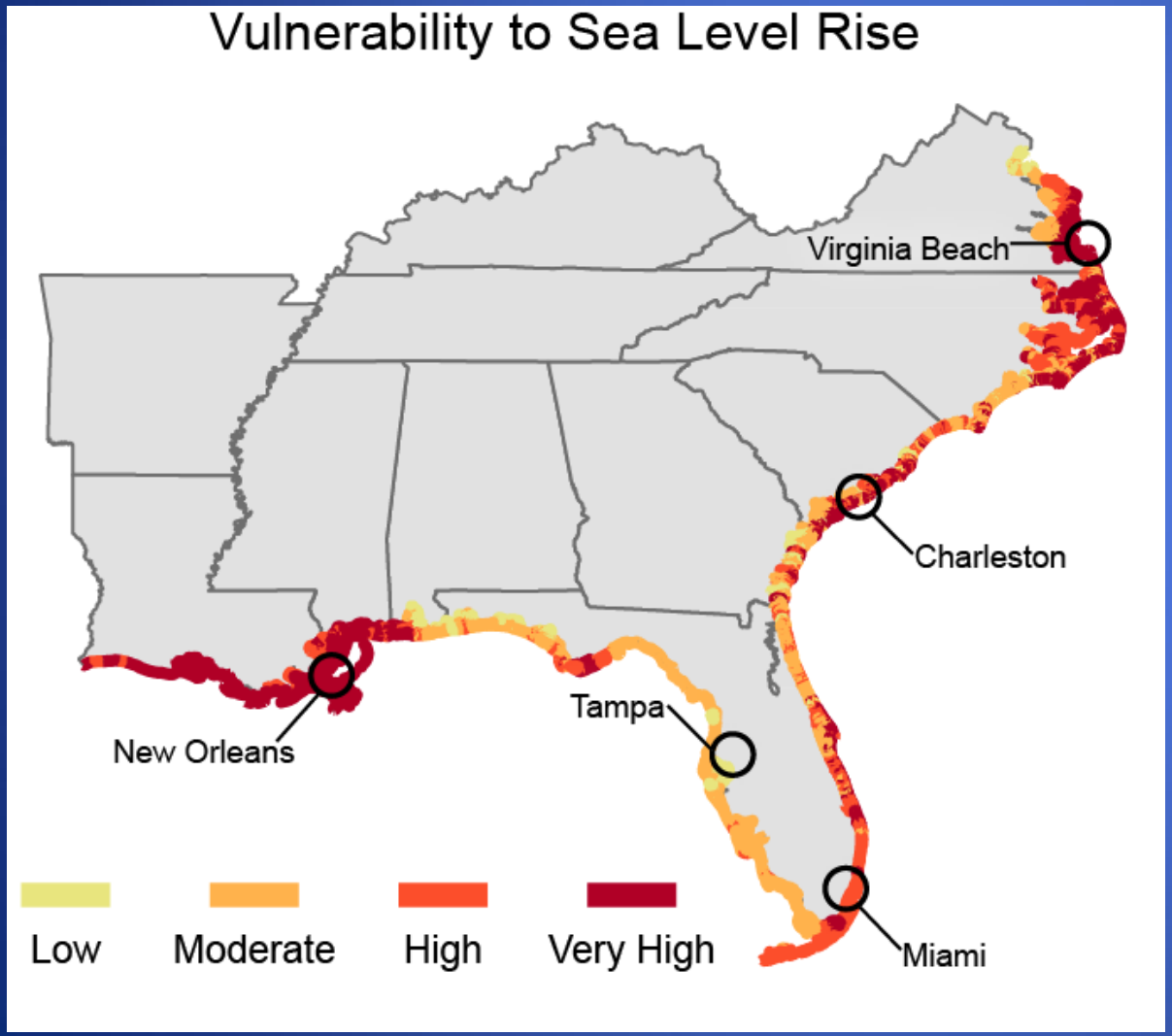
Southeast U.S. Temperature

Annual Average Temperature



Source: 3rd NCA, adapted from Kunkel et al. 2013

Sea Level Rise: Differences in Vulnerability



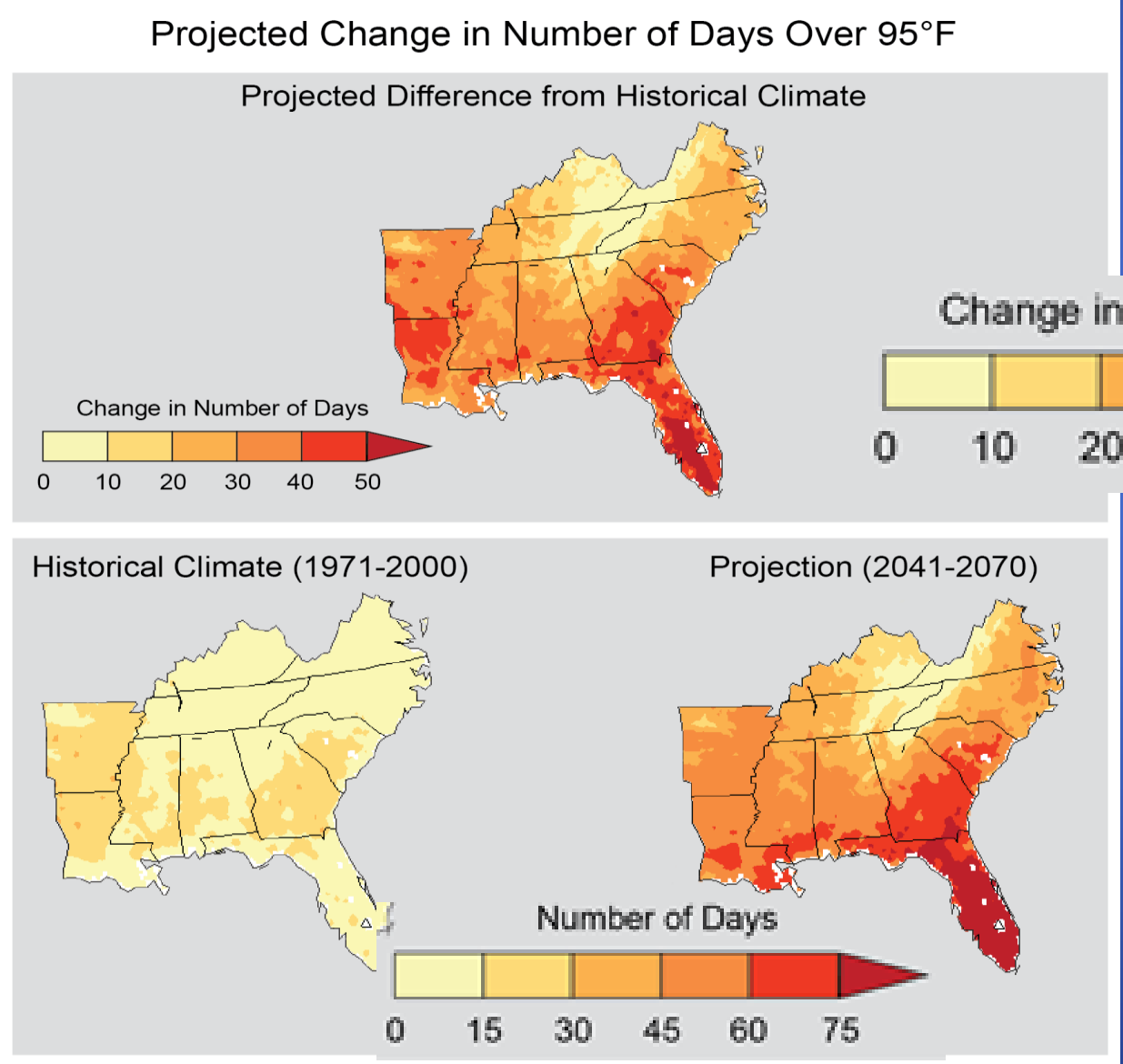
Causes of differences

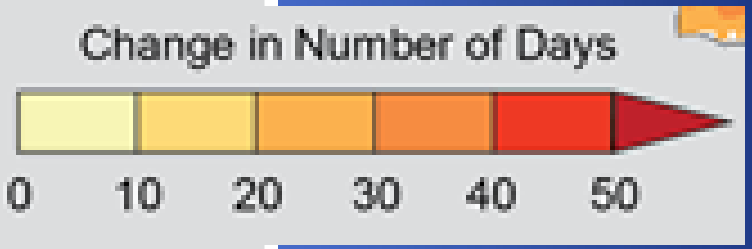
- Tidal range
- Wave height
- Coastal slope
- Shoreline change, landforms, and processes
- Historical rate of sea level rise

Source: Third NCA, Data from Hammar-Klose and Thieler 2001)

Hurricanes: Fewer overall, but more Cat 4 and 5

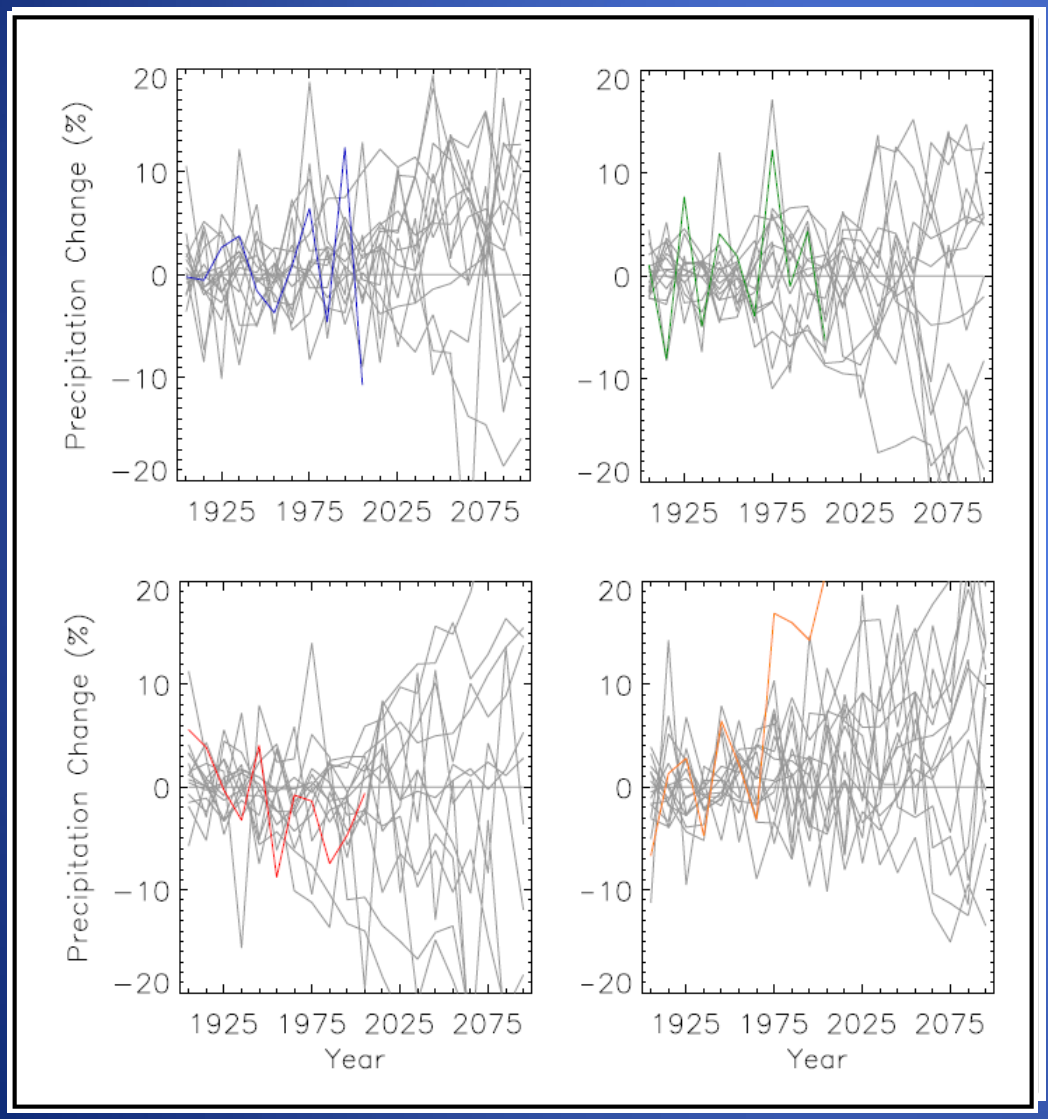
Southeast U.S. Days over 95F





Source: NOAA NCDC / CICS-NC

Southeast U.S. Total Precipitation Projections



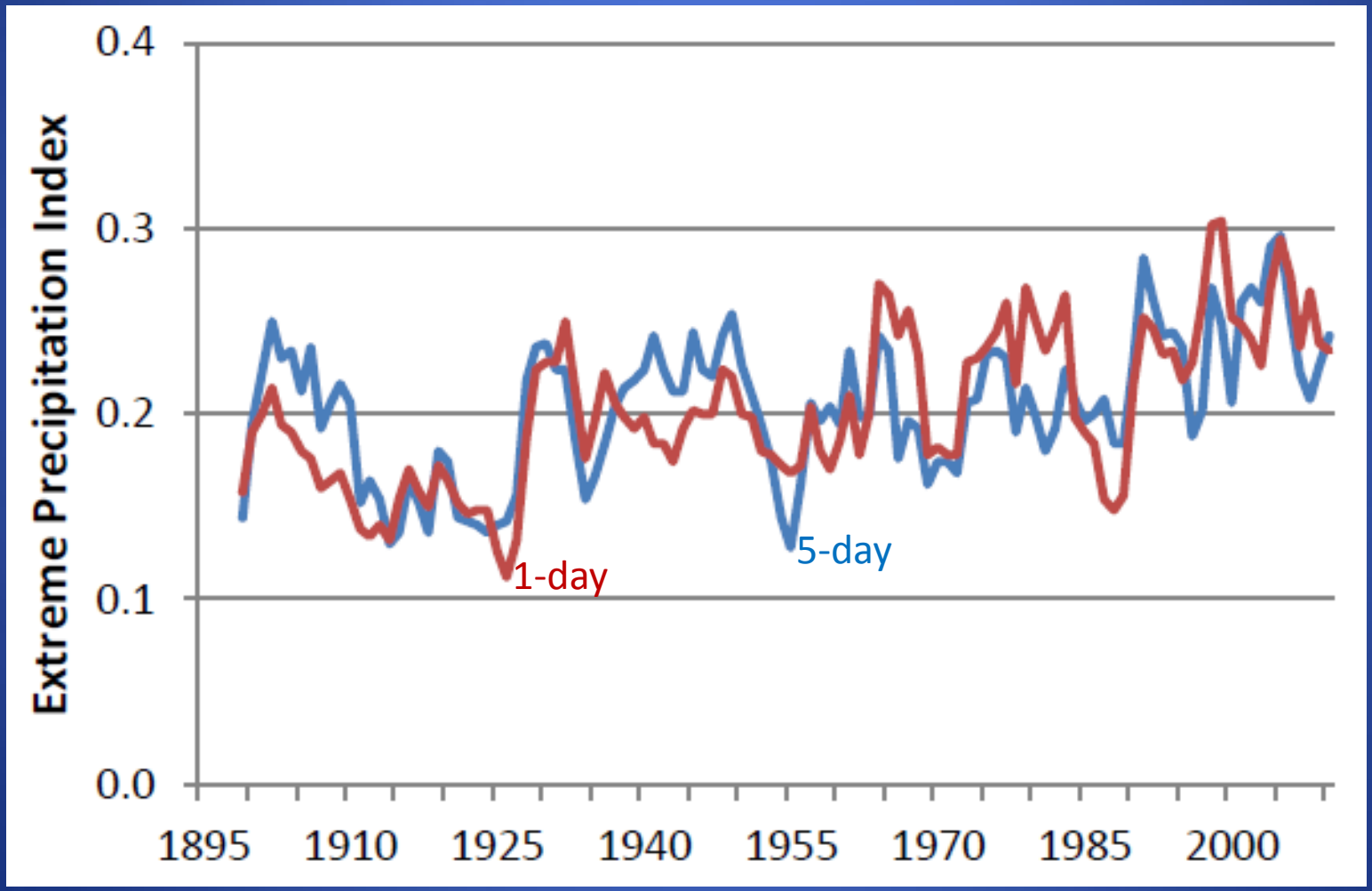
Black line – Observed decadal mean annual precipitation change

Colored lines – Observed decadal mean annual precipitation change

Gray lines – Model simulations from 15 CMIP3 models for the high (A2) emissions scenario.

Source: Kunkel et al. 2013

Heavy Precipitation



Source: Konrad/Kunkel

Indirect Connections

Protecting the Capital Lincoln Reflection Pond

estimated approximately $7 million to build a berm

$ millions more requested for work in DC

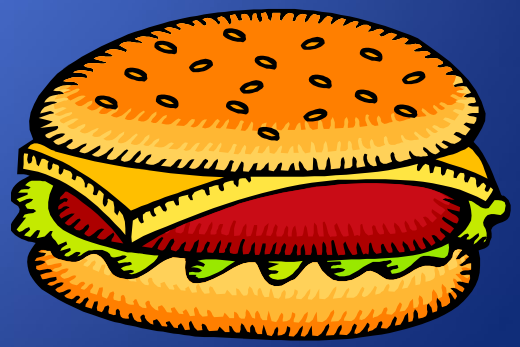
Source:blog.recovery.gov

Western Drought and Beef Prices

"Beef prices hit all-time high in U.S."

8 April 2014 LA Times

- October 2013 McDonald's Dollar Menu becomes a "Dollar Menu & More"
- January 2013 Wendy's "Dollar Menu" be came the "right price, right size"

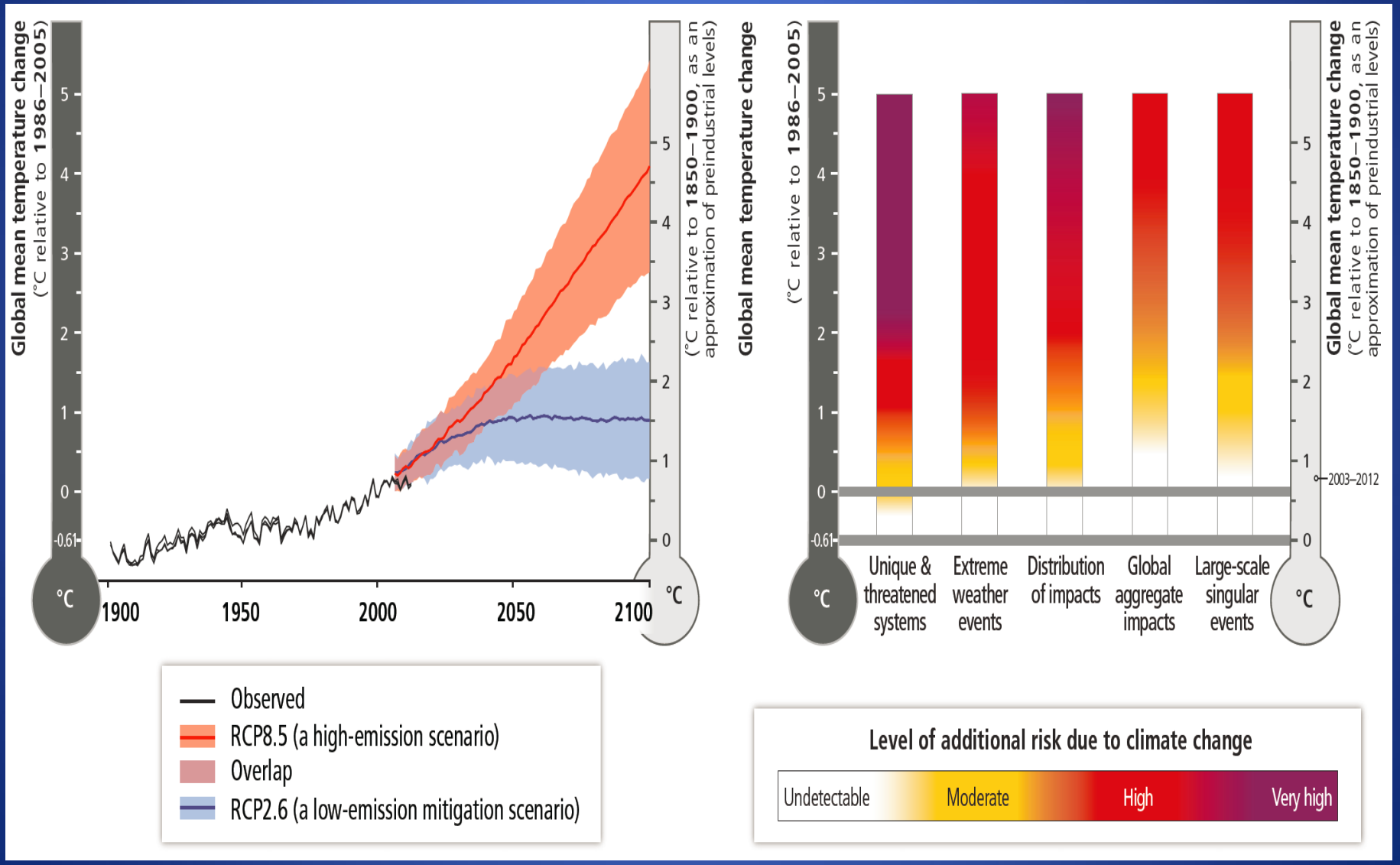


Vulnerability of global supply chains

“Thailand Flooding Cripples Hard-Drive Suppliers”
***New York Times*; 6 November 2011**

Approx. 10% increase in consumer prices
Slow down in Honda and Toyota car production

Climate Choices



Need to pursue both GHG reductions and adaptation strategies

Source: NPS

Two Adaptation Issues

- Increased temperatures and longer duration of warm periods – heat threats
- Changing timing and distribution of public health issues

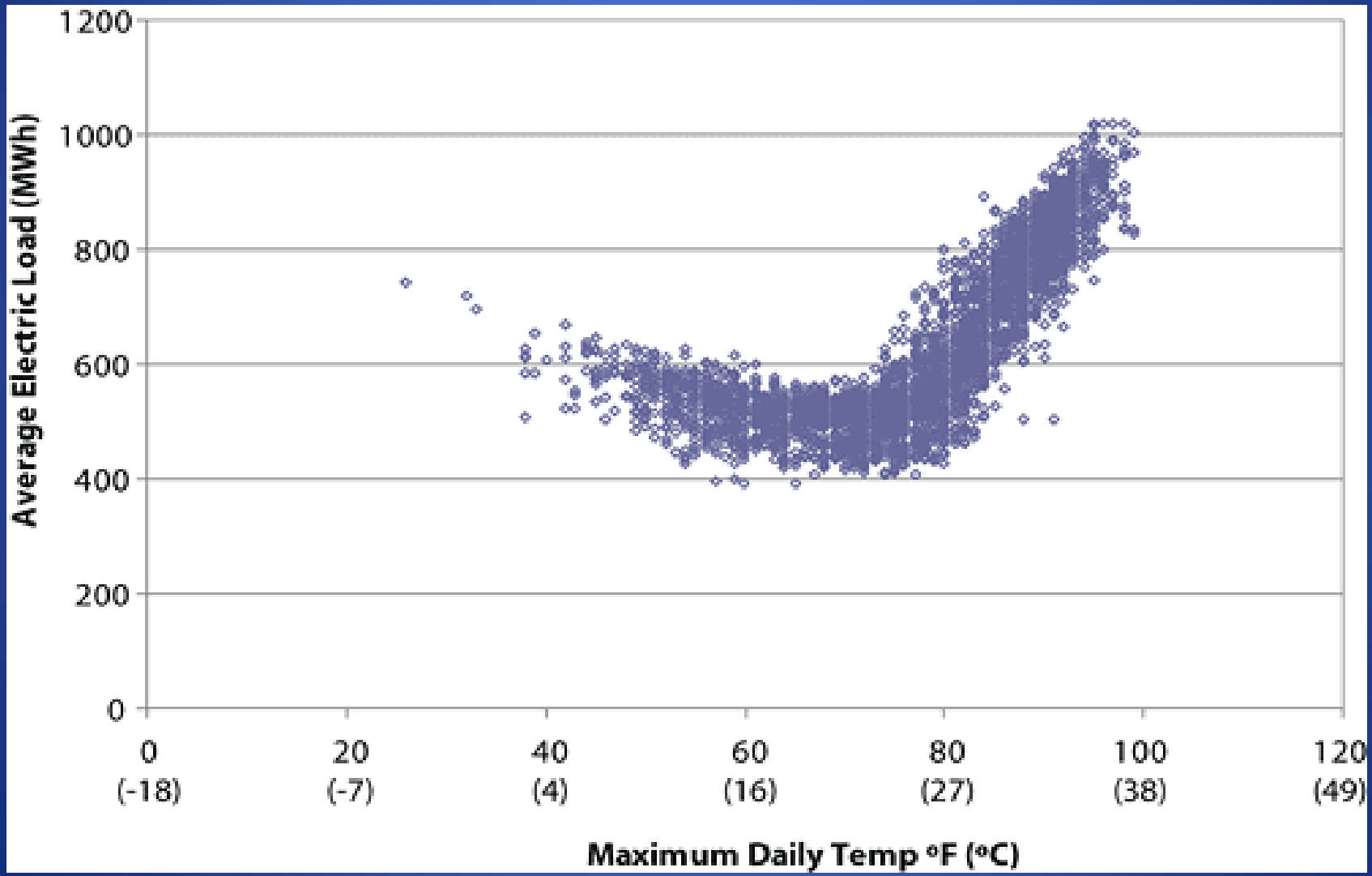
Adaptation Strategies and Considerations

- No Regrets Strategies – will provide benefits under existing conditions as well as potential future conditions
- Low Regrets Strategies
- Lock-in – making investments that will commit us to a pathway that may address a current problem but not future conditions
- Multiple Stresses – not just climate
- Timing of investments
  - Building adaptive capacity – preparing to act effectively

Increased Temperatures and Longer Duration of Warm Periods

- Health threats to those with limited access to cooling
  - Poor, elderly, socially isolated
  - People working outdoors
  - Athletes
- Budget expense
- Particular issue in urban areas due to the urban heat island effect

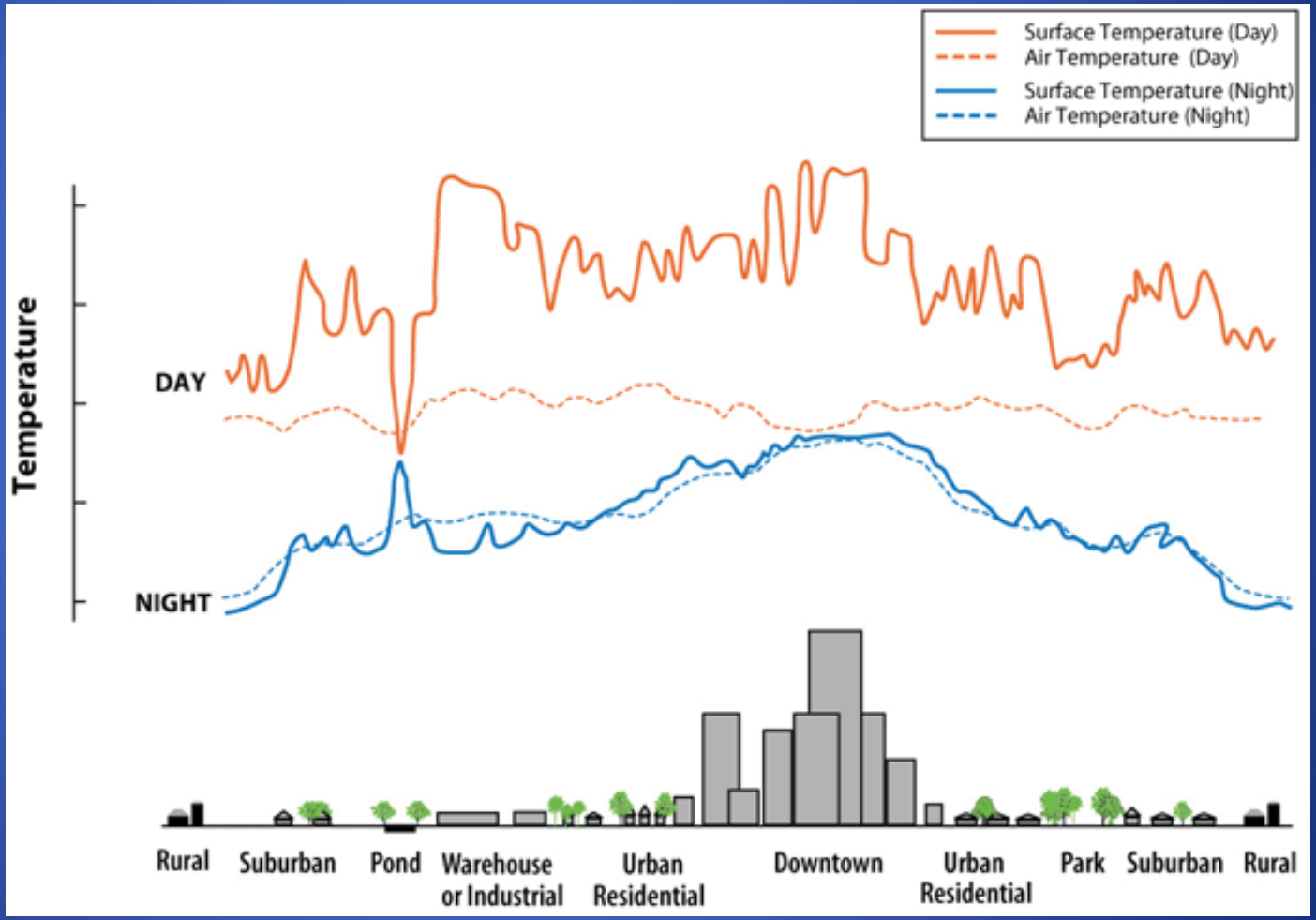
Energy demand increases with daily temperature



Urban Heat Island

Can raise temperature from 2-10^{o}F

Many cities in South Carolina will also have aging populations



Source: US EPA

Ozone Impacts

- Ground-level ozone is formed when Nitrous oxides (often fossil fuel emissions) and volatile organic compounds (VOCs) react in the presence of sunlight and hot weather.

- Hotter, sunnier conditions will result in greater levels of ground-level ozone production

- Increased Asthma incidences

Water Quality Impacts

- Pavement and rooftops at over 100 ^{o}F can raise rainfall temperature from 70^{o}F to 95 ^{o}F .

- This drains to storm sewers and then to water bodies where it can result in fast increases in water temperatures and harm to aquatic life
  - metabolism
  - reproduction

Adaptation Options

- Green spaces
- Planting trees
- Green roofs

Adaptation Option

- Urban tree planting
  - Lower summer temperatures by shading concrete and returning humidity to the air through evaporative cooling
  - ALSO
    - Improved air quality
      - Removing dust and pollutants
    - Capture carbon dioxide
    - Protect water quality
      - Capturing and retaining stormwater

Million Tree Programs

- New York City
- Baltimore
- Chicago
- Los Angeles
- Others

Green Roofs

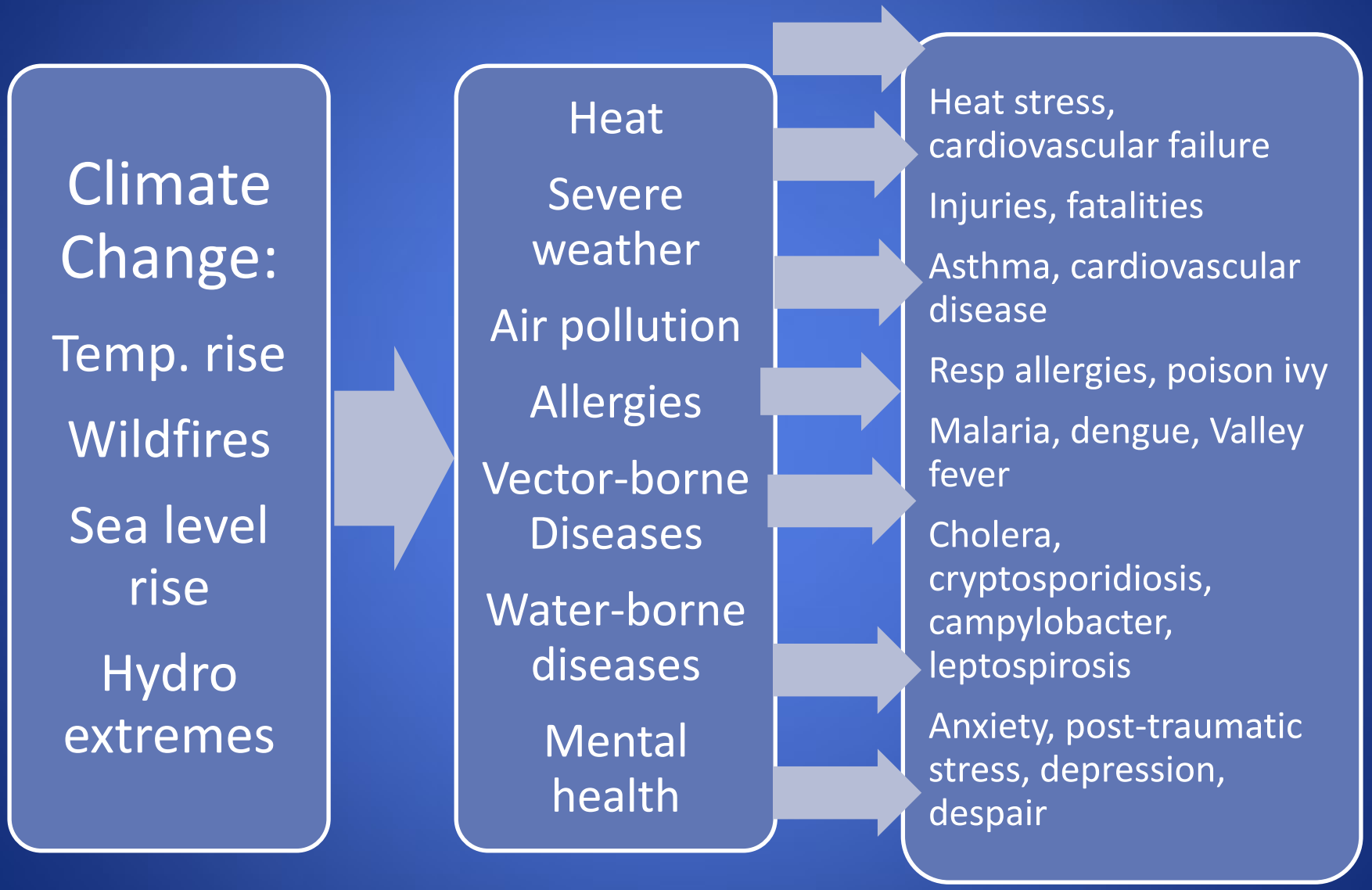
- Heat sensing pictures illustrate the major temperature difference between green roofing on

Chicago's City Hall (left) and traditional roofing (right)

USC West Quad

- See Greenroofs.org

Public Health and Climate Change



Source: Frumpkin, CDC

Local Specifics

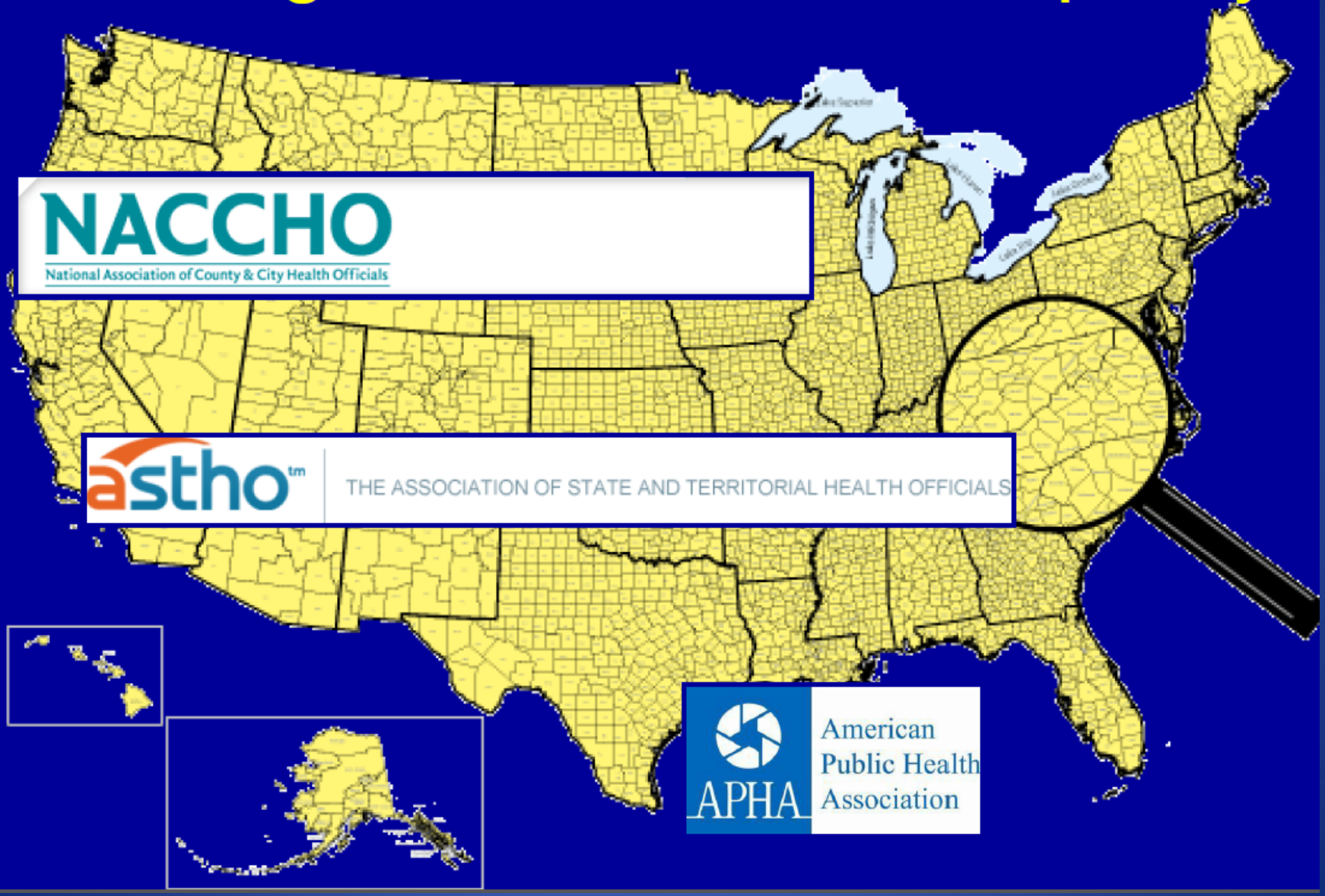
- Earlier springs, longer pollen seasons
- Warmer conditions favoring pathogens
  - Observations of *Vibrio* in Gulf Coast show cases earlier and later than usual

- Harmful Algae Blooms
  - Favored by warmer temperatures and changes in lake warming
  - Some can become air-borne and cause respiratory problems
  - Other spread into new areas as habitat conditions change
    - Red tide
    - *Aedes aegypti*

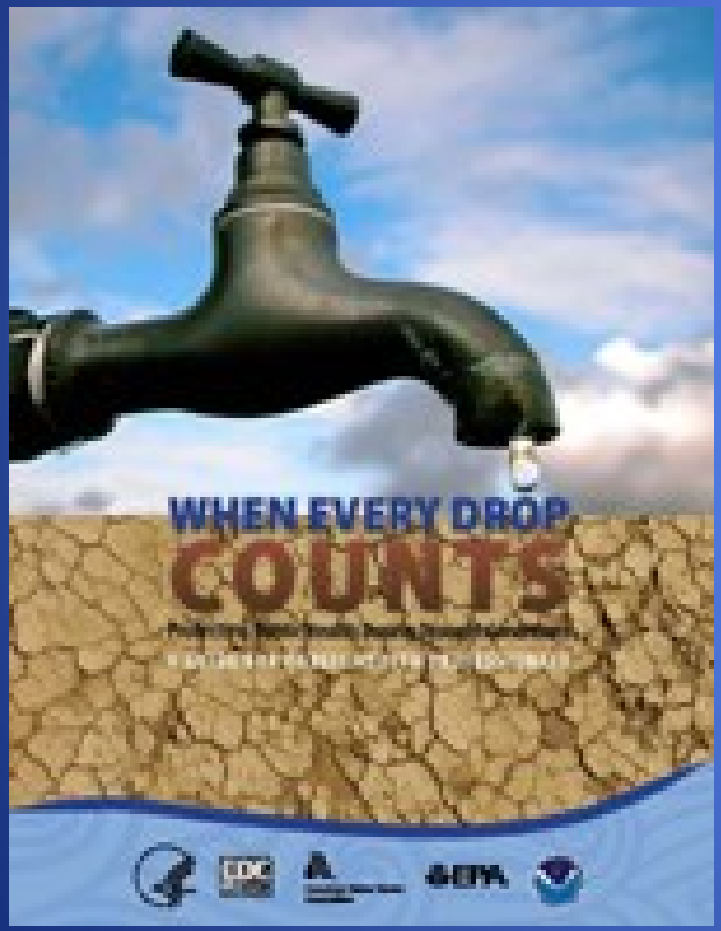
Vector-Borne and Zoonotic Disease

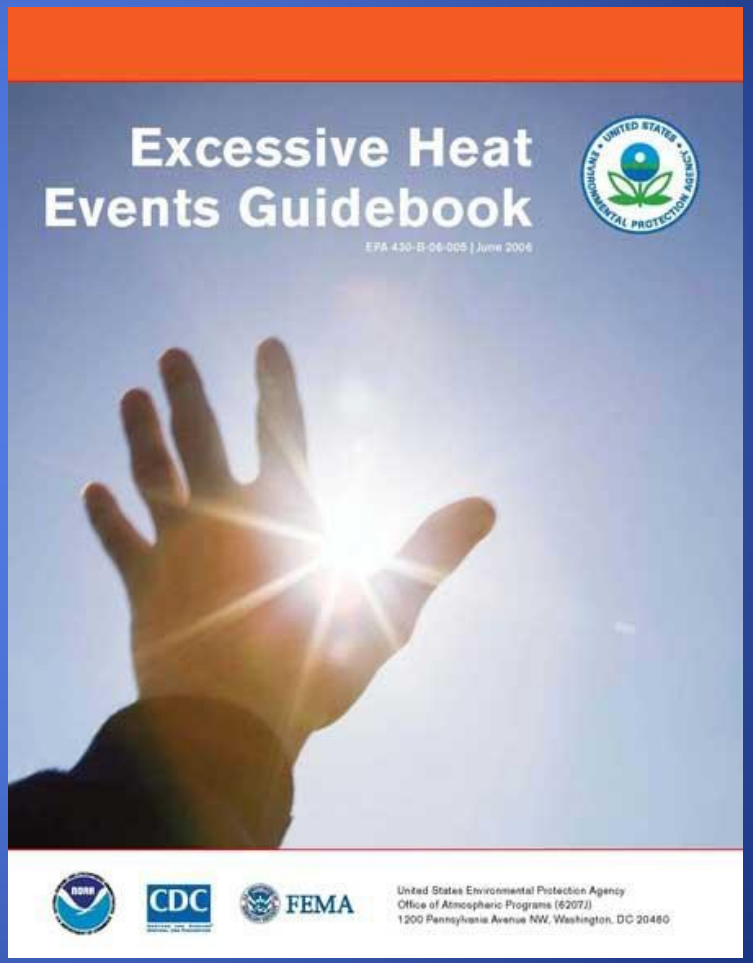
- Very Uncertain
- Spread is dependent on many factors, not just climate
- Mosquito, *Aedes aegypti* and *A. albopictus*
  - very adaptable to urban conditions
  - can transmit dengue and malaria
  - Chikungunya – 1st case in SC identified July 2014 – travel relate

Building State and Local Capacity



More resources are becoming available





General Resources

- In addition to federal agencies mentioned,

- CAKE – Community Adaptation Knowledge Exchange
- ICLEI – Local Governments for Sustainability
- Georgetown Climate Center Adaptation Clearinghouse

Thank You