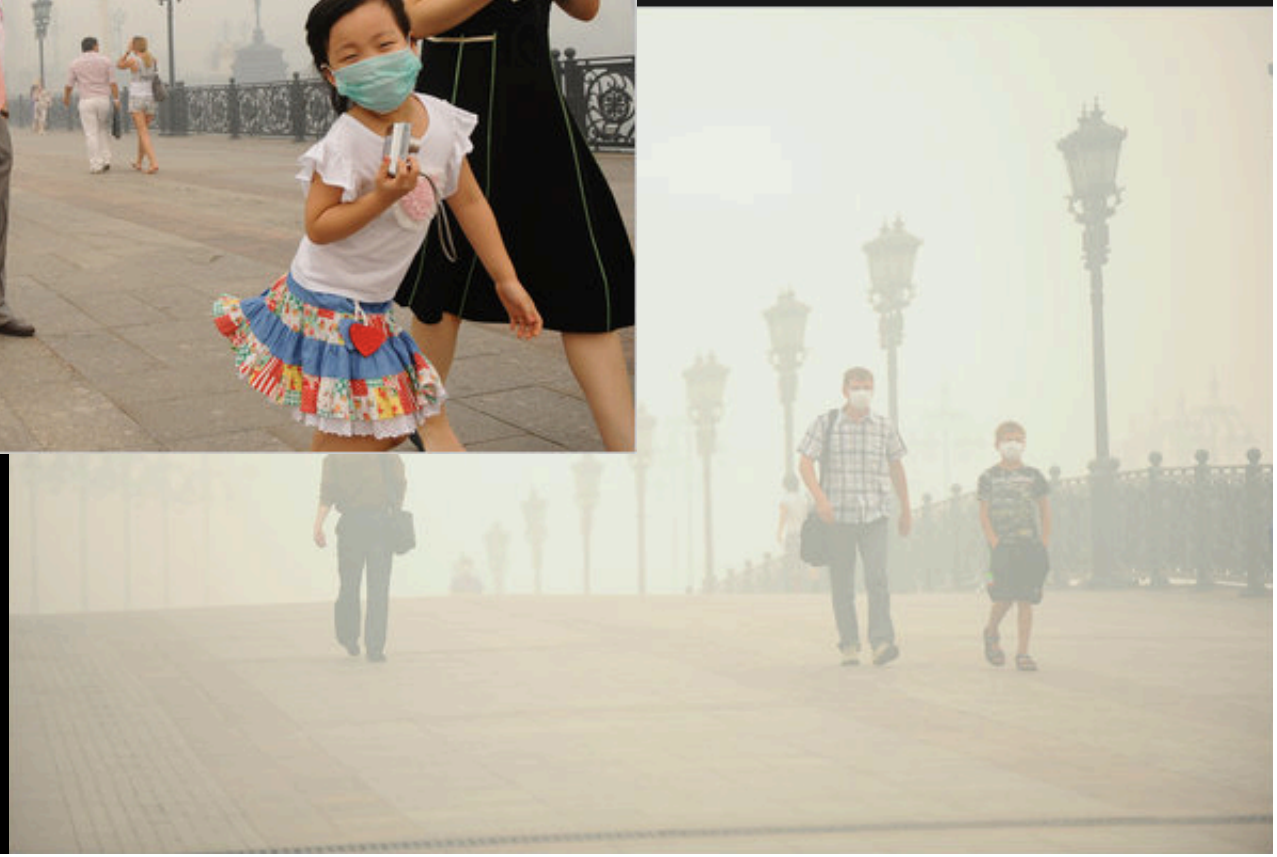
Quiz: Where Are We?



Source: NYTimes

Russia!

- Warmest July in 130 years
  - Heat -> Fires -> Air pollution -> Death (1000s)
  - Drought -> Reduced wheat harvest -> Ban on export of wheat (millions acres)

In Weather Chaos, a Case for Global Warming

By JUSTIN GILLIS

The floods battered New England, then Nashville, then Arkansas, then Oklahoma — and were followed by a deluge in Pakistan that has upended the lives of 20 million people.

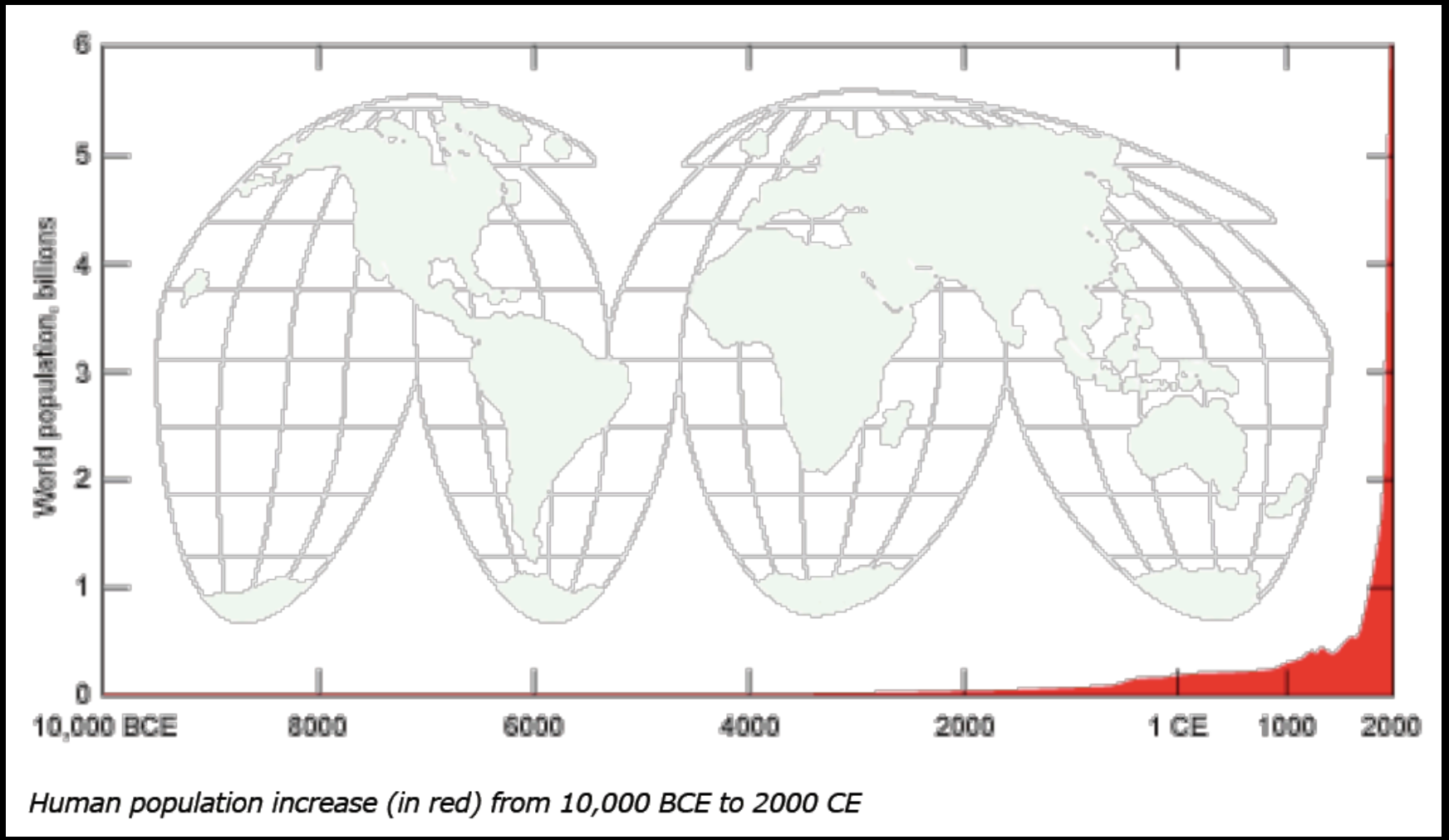
The summer's heat waves baked the eastern United States, parts of Africa and eastern Asia, and above all Russia, which lost millions of acres of wheat and thousands of lives in a drought worse than any other in the historical record.

- What makes our current era unique?
- What will we be remembered for 1,000 years from now?
- What are our ethical obligations to future generations?

What is driving change?

- Global population increase 6x since late 18th centry
  - 4x since 1880, 22% since 1990 to 6.7 billion
- Gross World Product (GWP) grew 80x since late 18th century, 40% since 1990
- Since 1950:
  - Population up 2.5x
  - GWP up 7x
  - CO_2 emissions up 7x

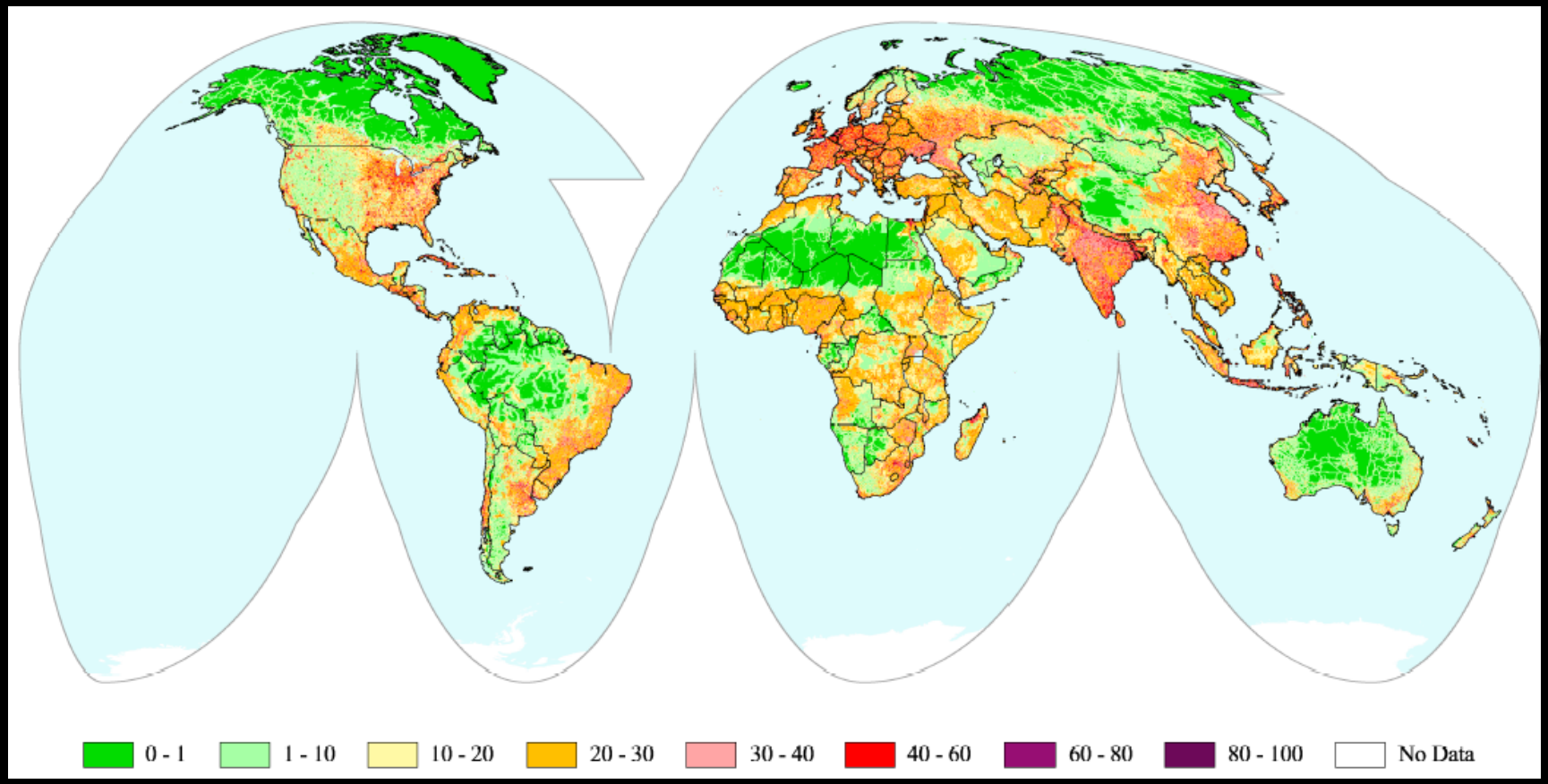
Population rise is not necessarily a bad thing!



Human population increase (in red) from 10,000 BCE to 2000 CE

- Source: UCAR Quarterly, Summer 2007

>85% of all land has been modified by human use

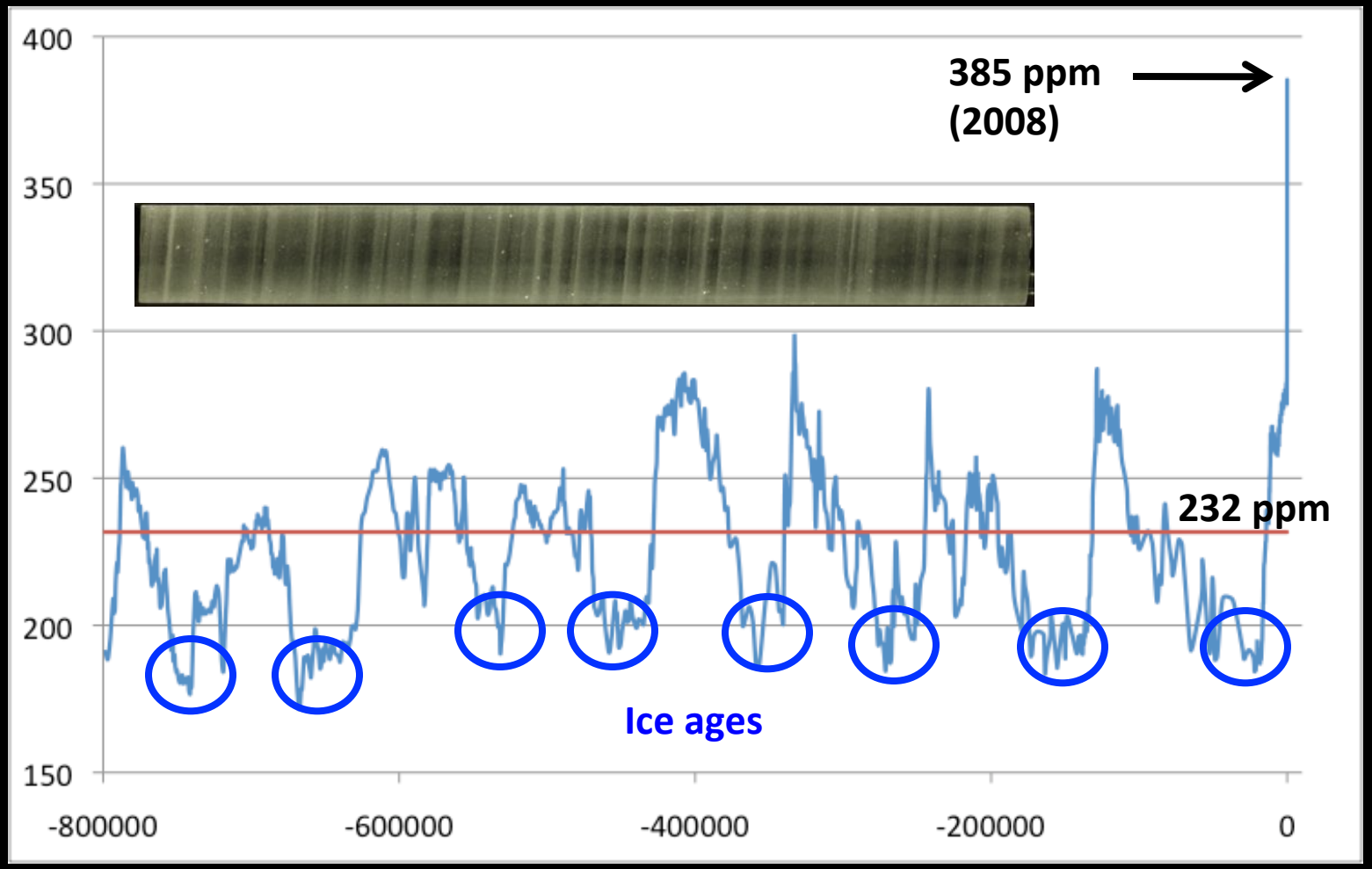


- Sanderson et al., 2002, Bioscience

CO_2 concentrations today exceed anything scientists have measured or estimated in at least the past

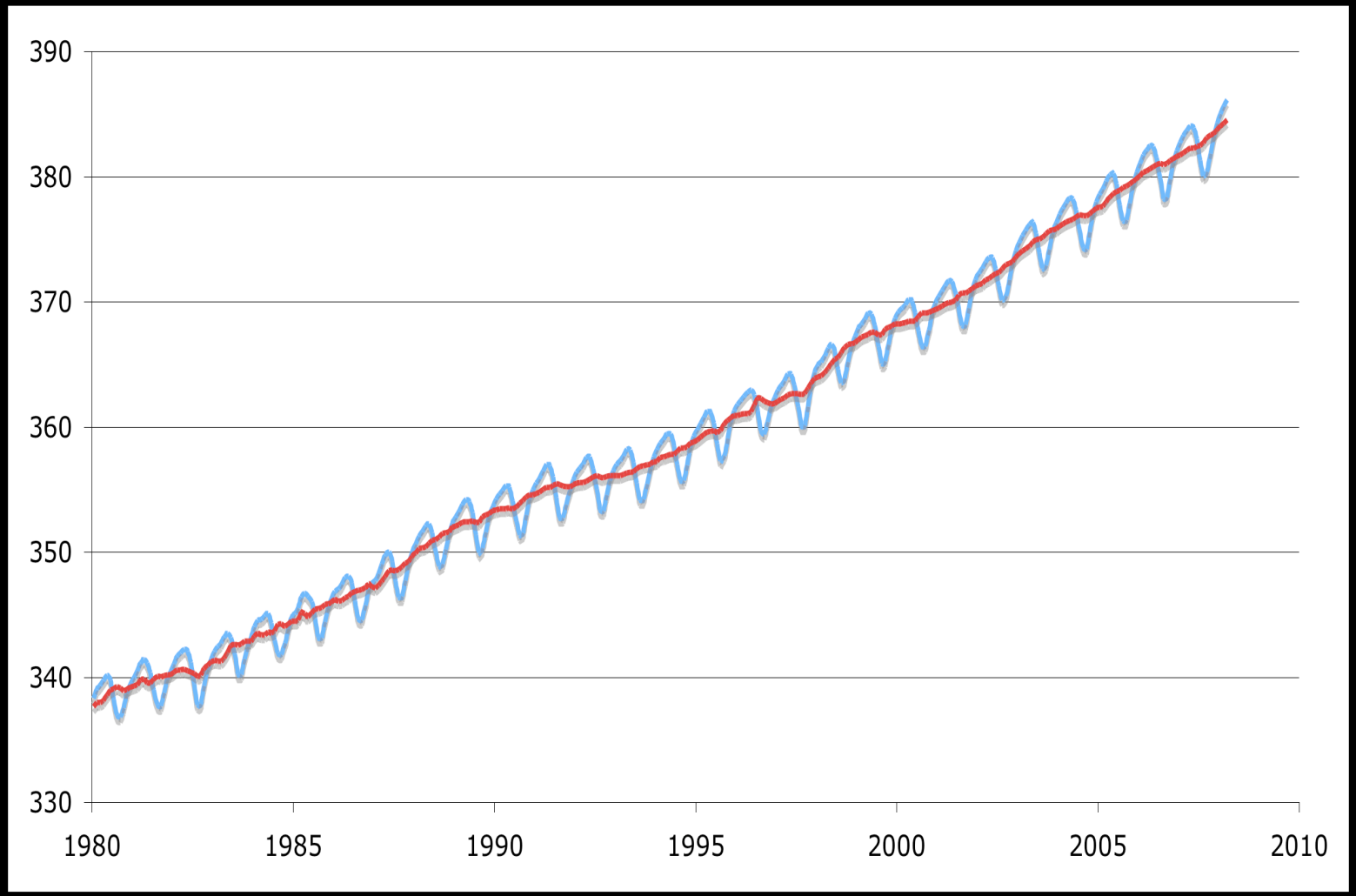
A. 200 years, but probably not longer
B. 400,000 years, but probably not longer
C. 800,000 years, but probably not longer
D. 3.2 million years, but probably not longer
E. All of Earth's history

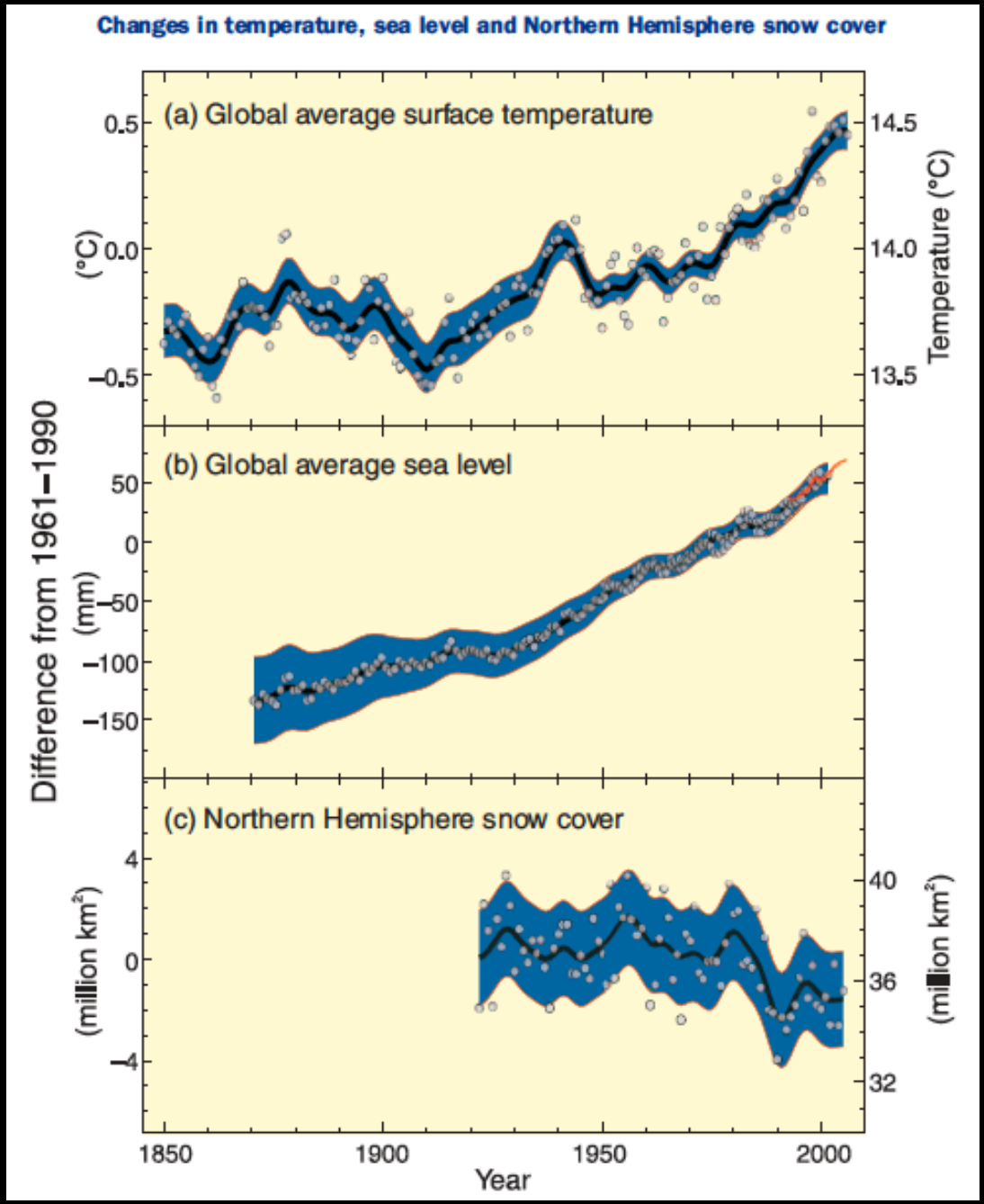
800,000!



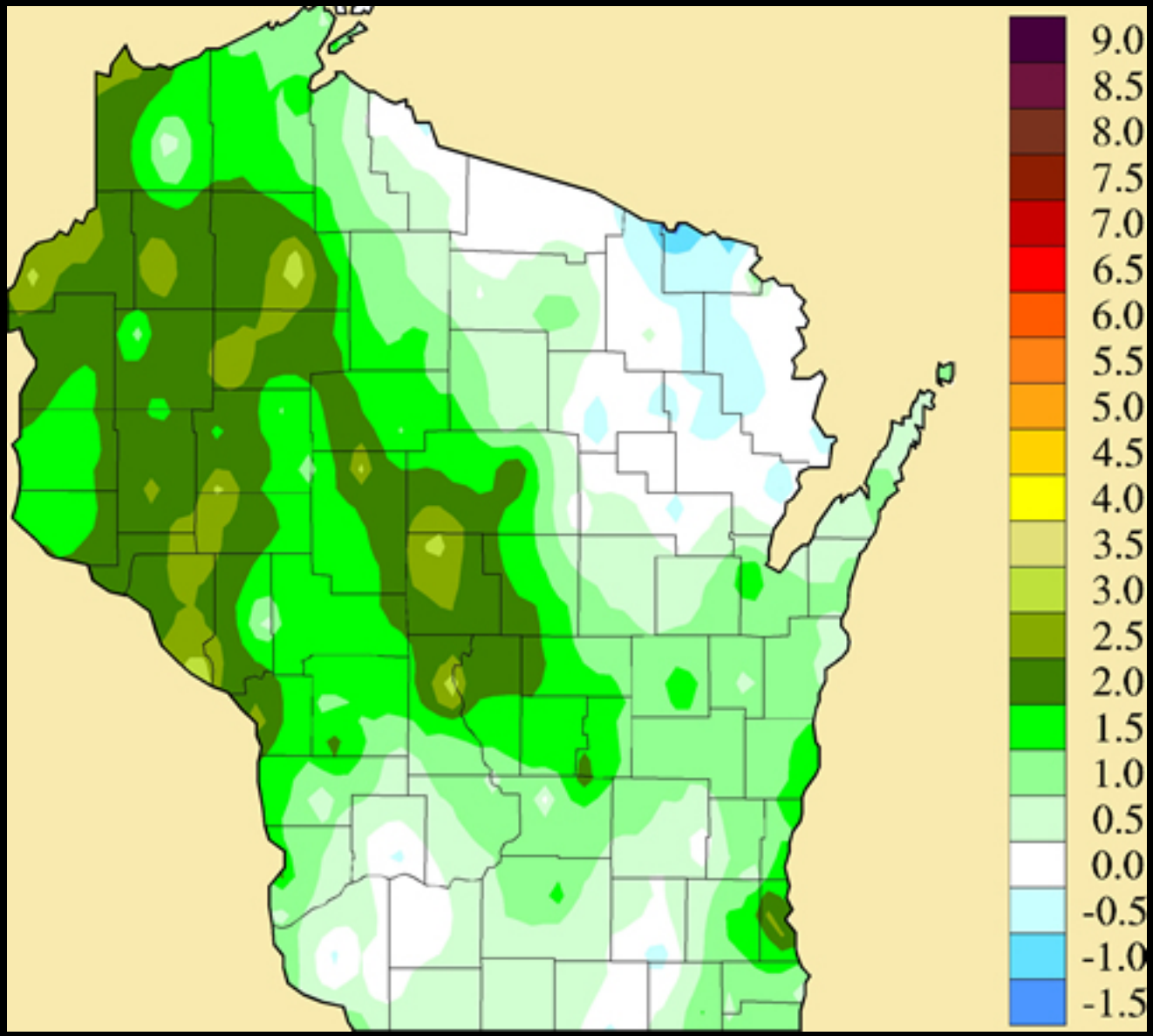
Source: Lüthi et al (2008), CDIAC, & Wikimedia Commons

Global CO_2 is rising in concert (at half the rate) with fossil fuel emissions

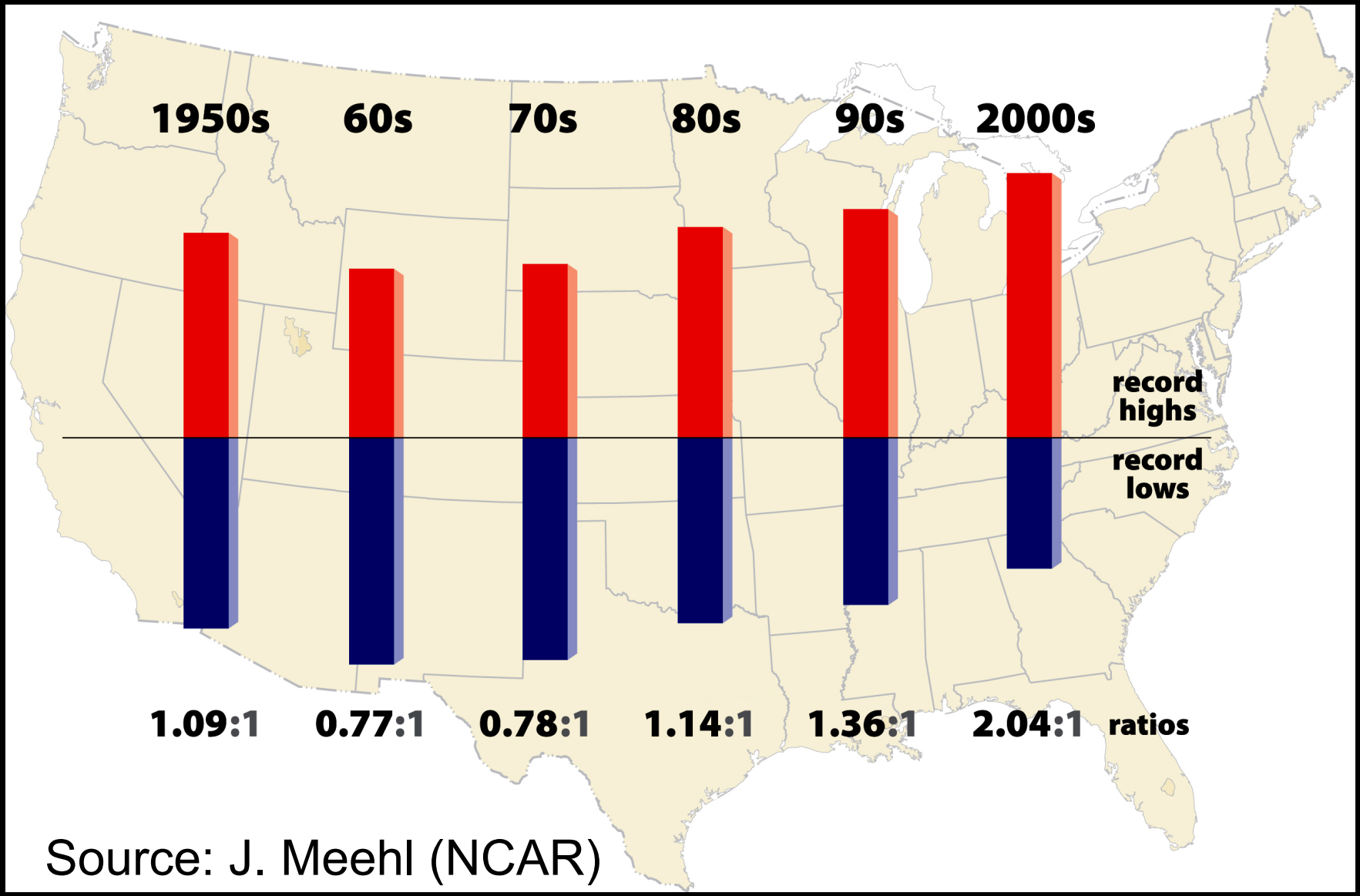



Changes in temperature, sea level and Northern Hemisphere snow cover
(a) Global average surface temperature
(b) Global average sea level
(c) Northern Hemisphere snow cover
Difference from 1961–1990
(°C)
(mm)
(million km²)
Temperature (°C)
(million km²)
0.5
0.0
–0.5
14.5
14.0
13.5
50
0
–50
–100
–150
4
0
–4
40
36
32
1850
1900
1950
2000
Year

Wisconsin has warmed in 50 yrs

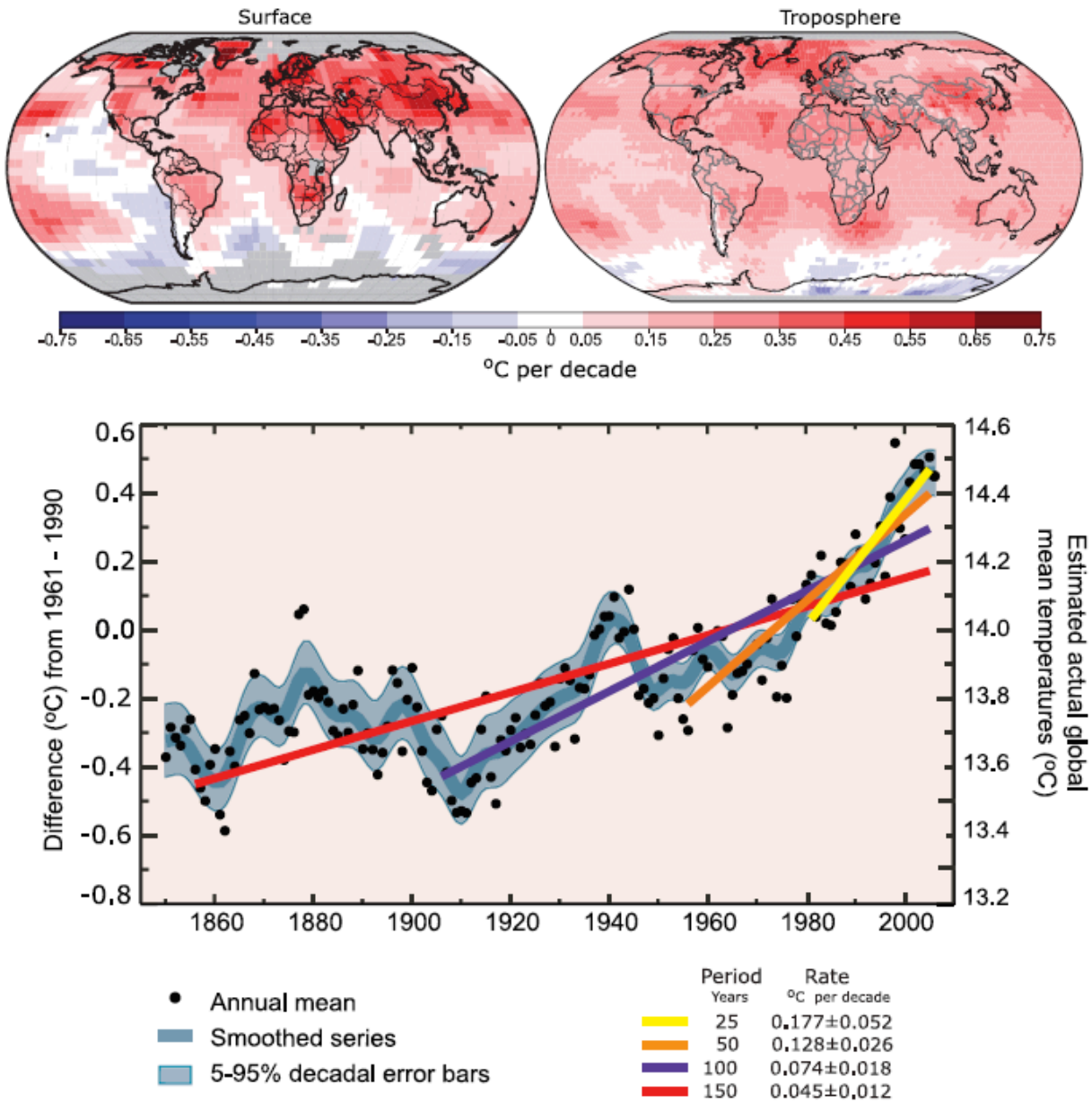


Ratio of record highs to lows now 2:1

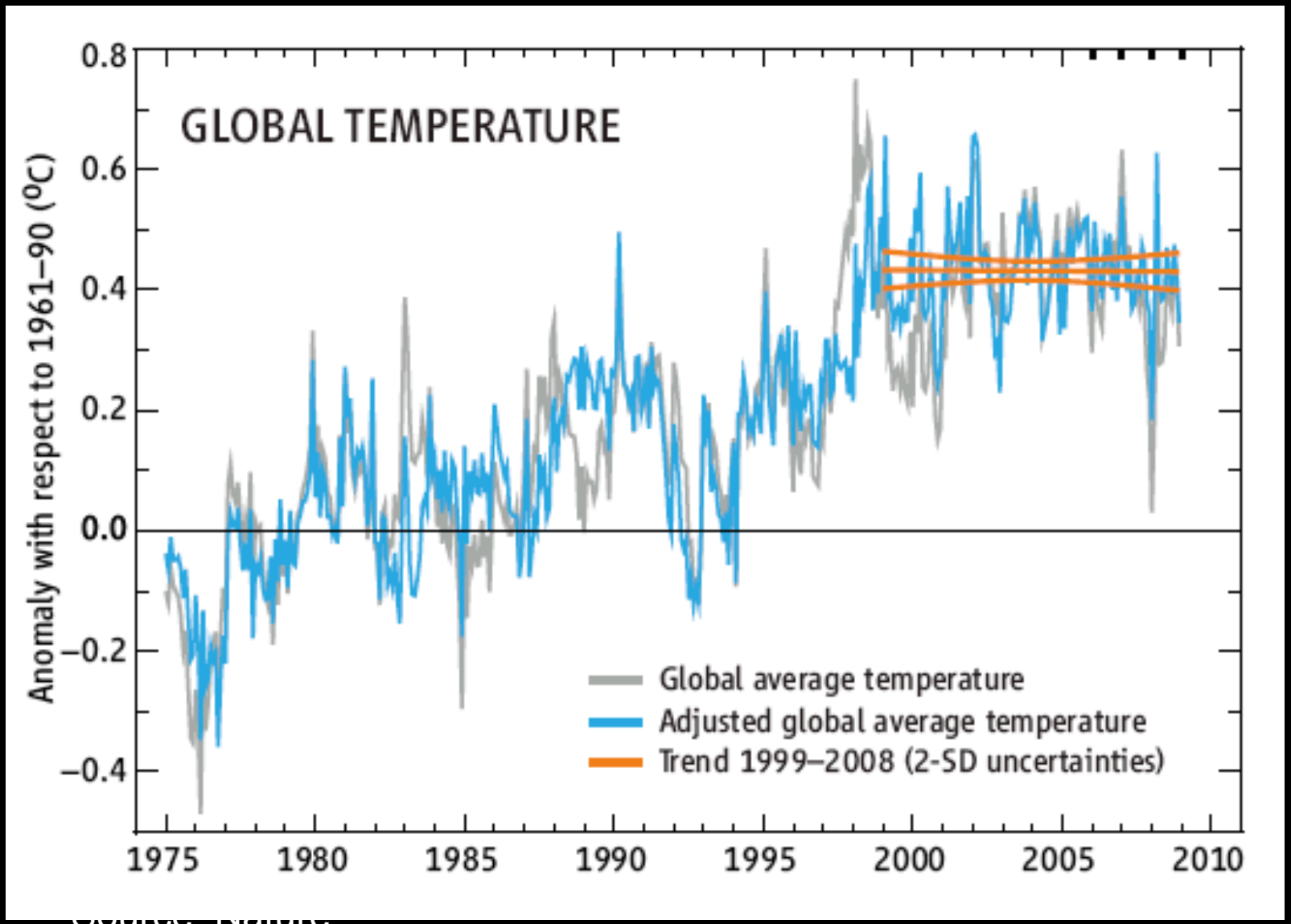


Source: J. Meehl (NCAR)

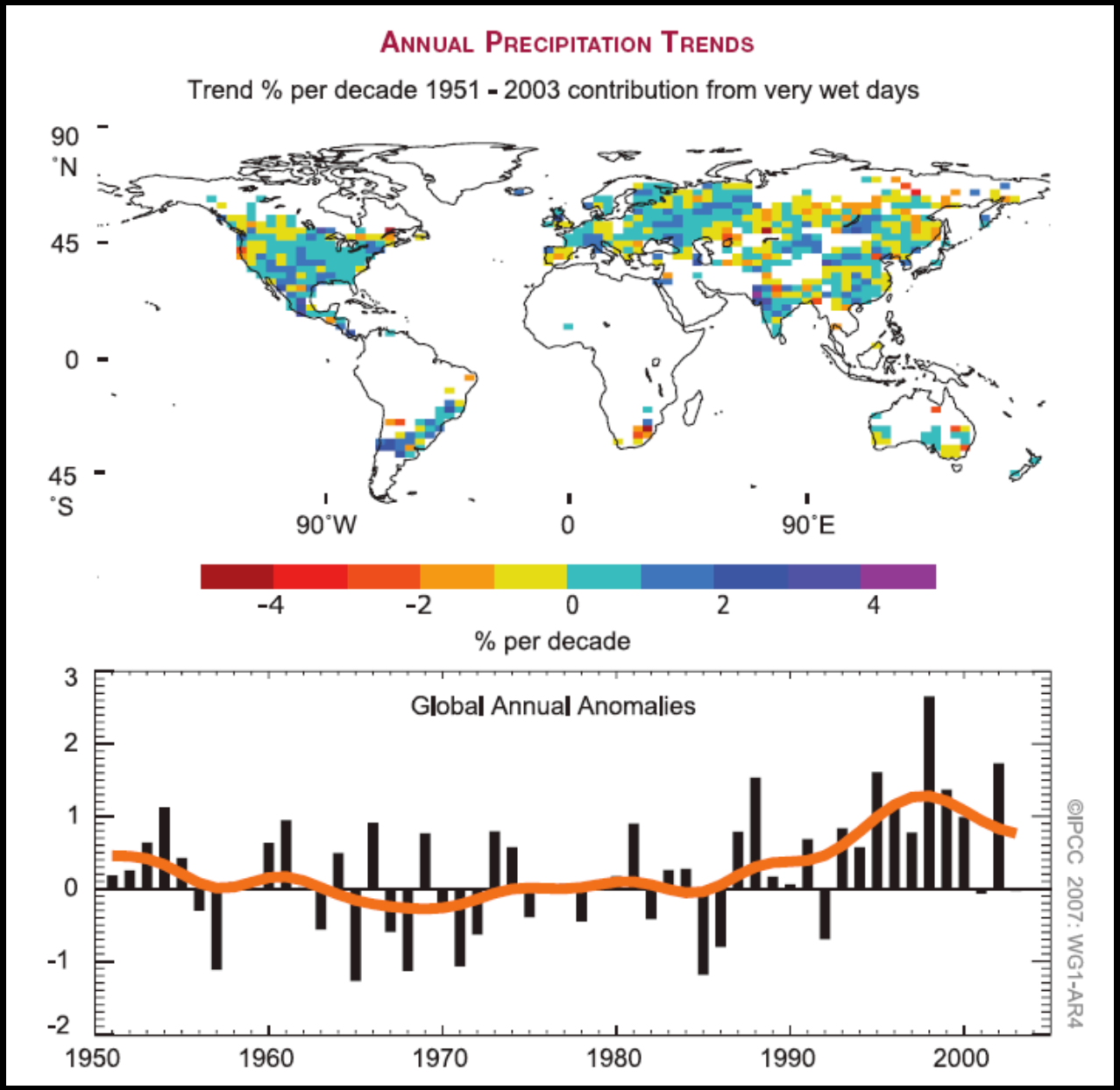
Global Temperature Trends



Short-term plateaus in climate trends are expected

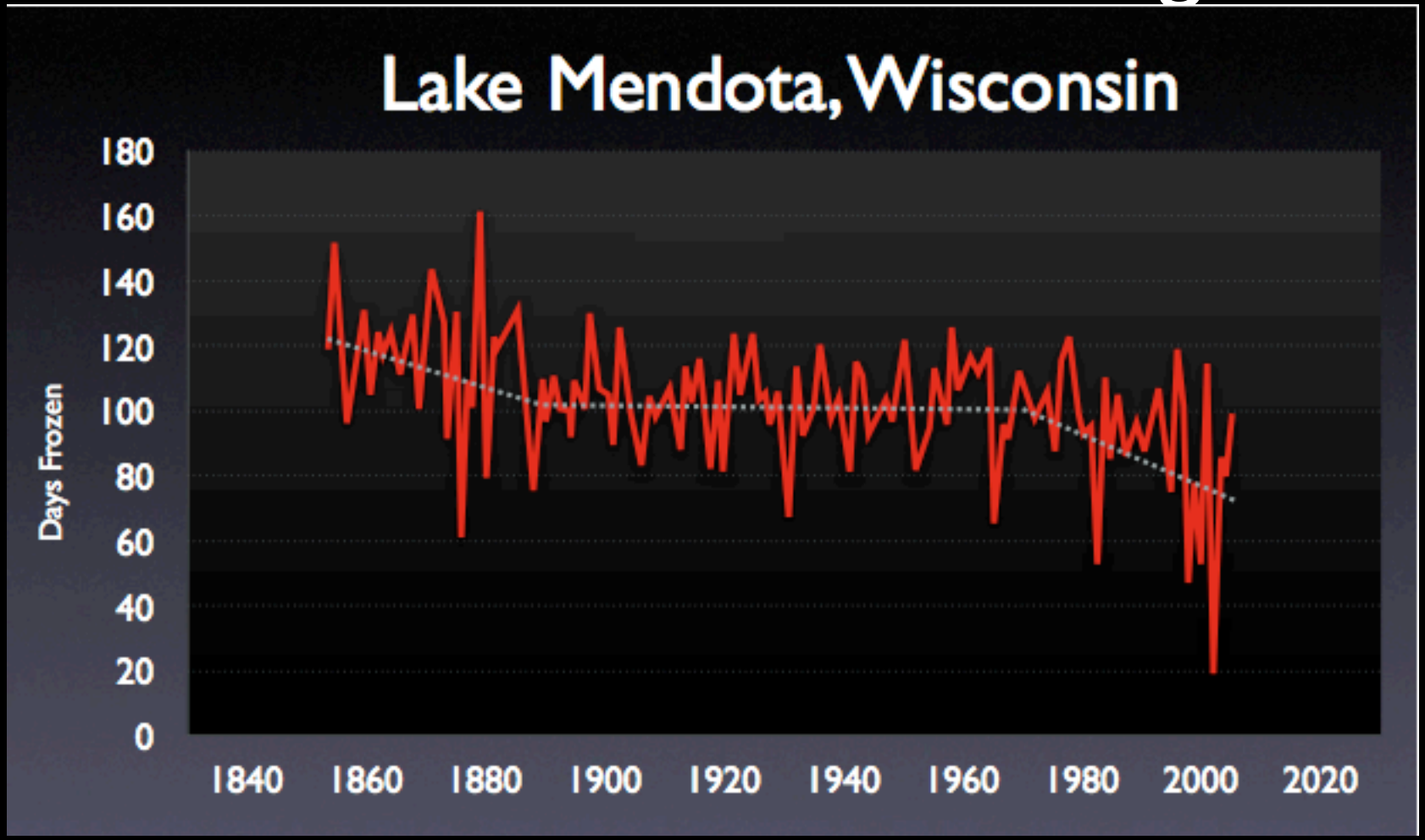


Source: Nature

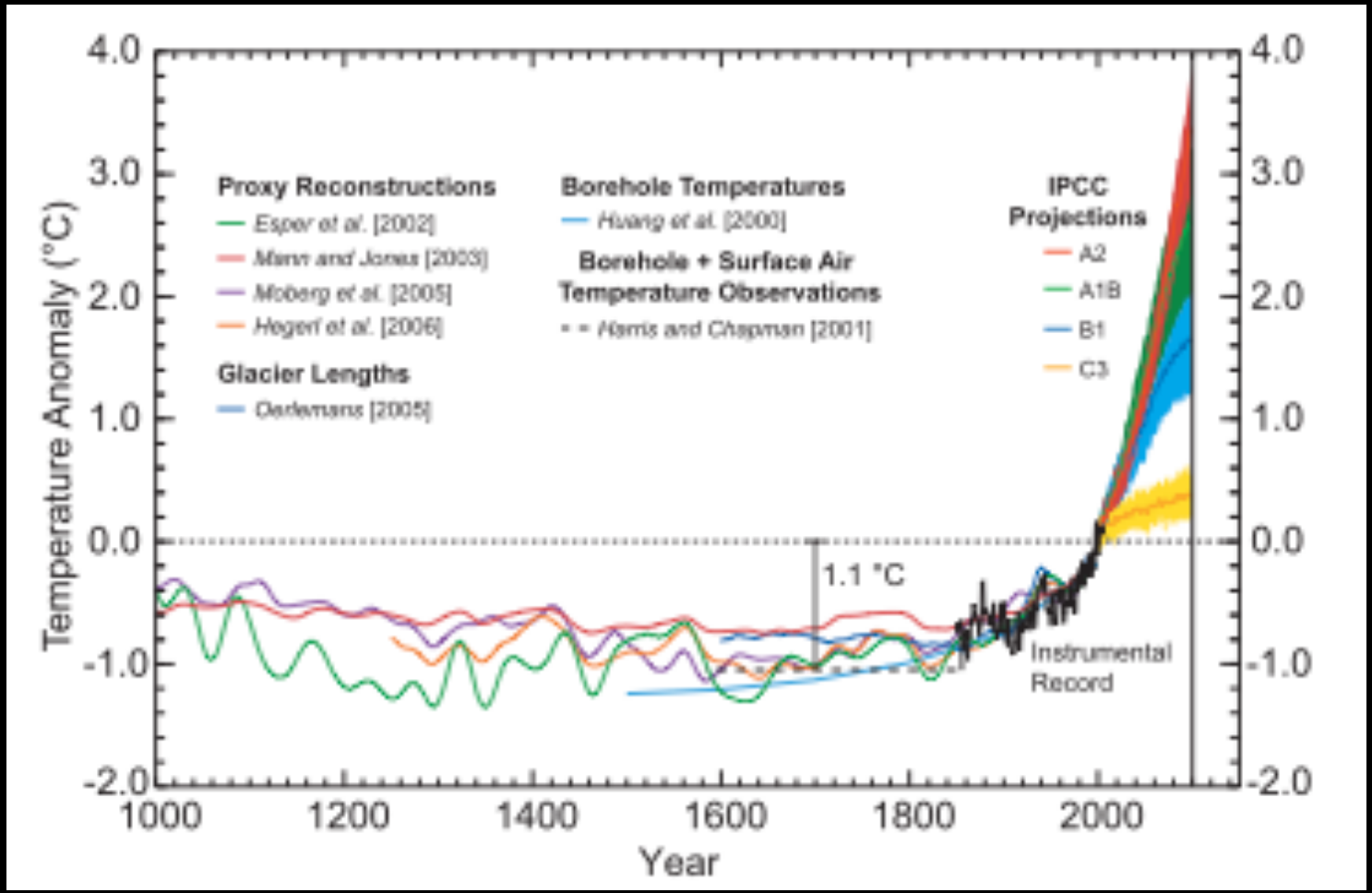

Annual Precipitation Trends
Trend % per decade 1951 - 2003 contribution from very wet days
90 °N
45
0
45 °S
90°W
0
90°E
-4
-2
0
2
4
% per decade
Global Annual Anomalies
3
2
1
0
-1
-2
1950
1960
1970
1980
1990
2000
©IPCC 2007: WG1-AR4

Where are we?

Lake Ice Is Retreating



Human civilization flourished in an era of stable climate



Climate destabilization has policy implications, even for the US Military

August 9, 2009

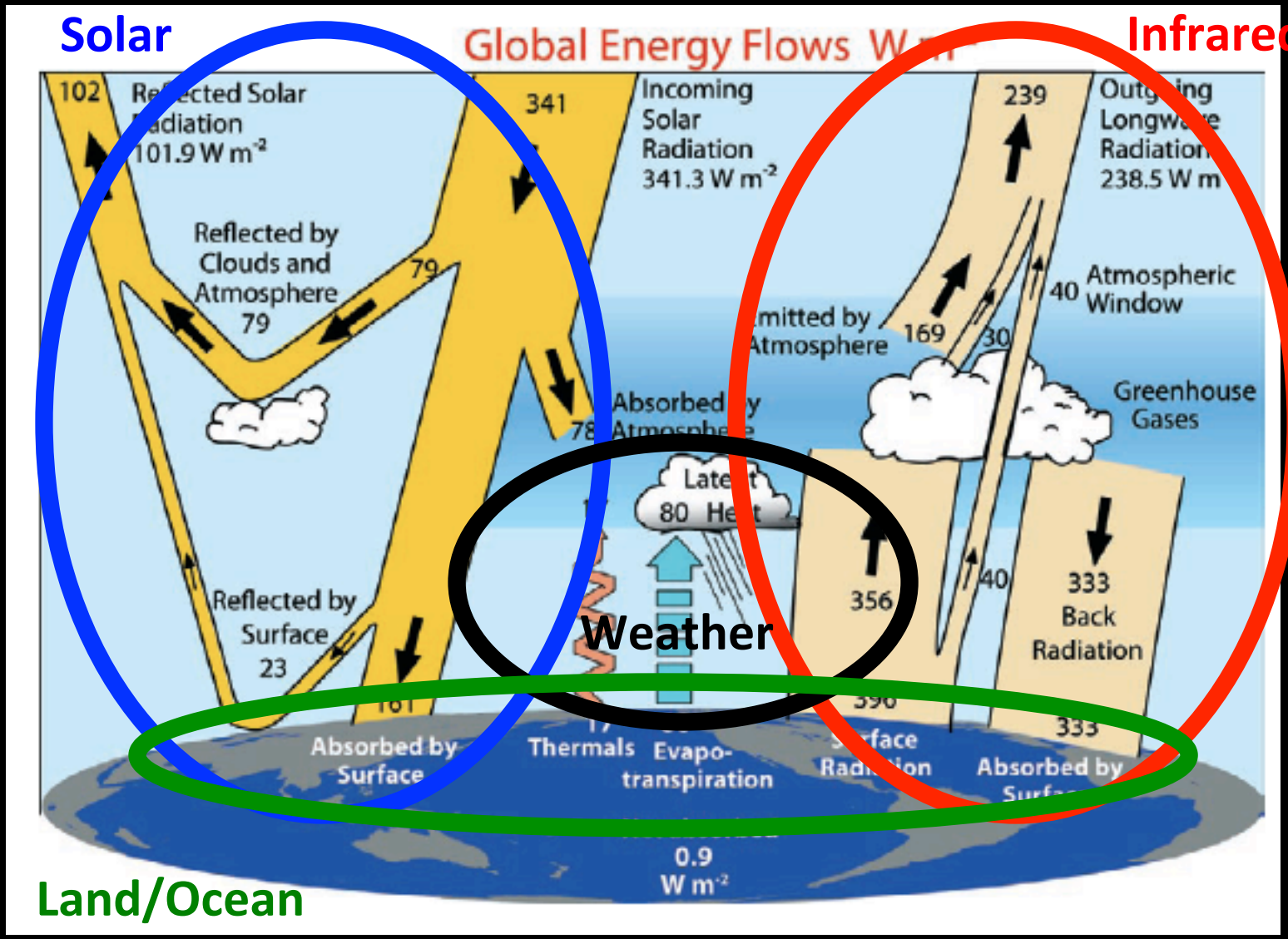
Climate Change Seen as Threat to U.S. Security

By JOHN M. BRODER

WASHINGTON — The changing global climate will pose profound strategic challenges to the United States in coming decades, raising the prospect of military intervention to deal with the effects of violent storms, drought, mass migration and pandemics, military and intelligence analysts say.

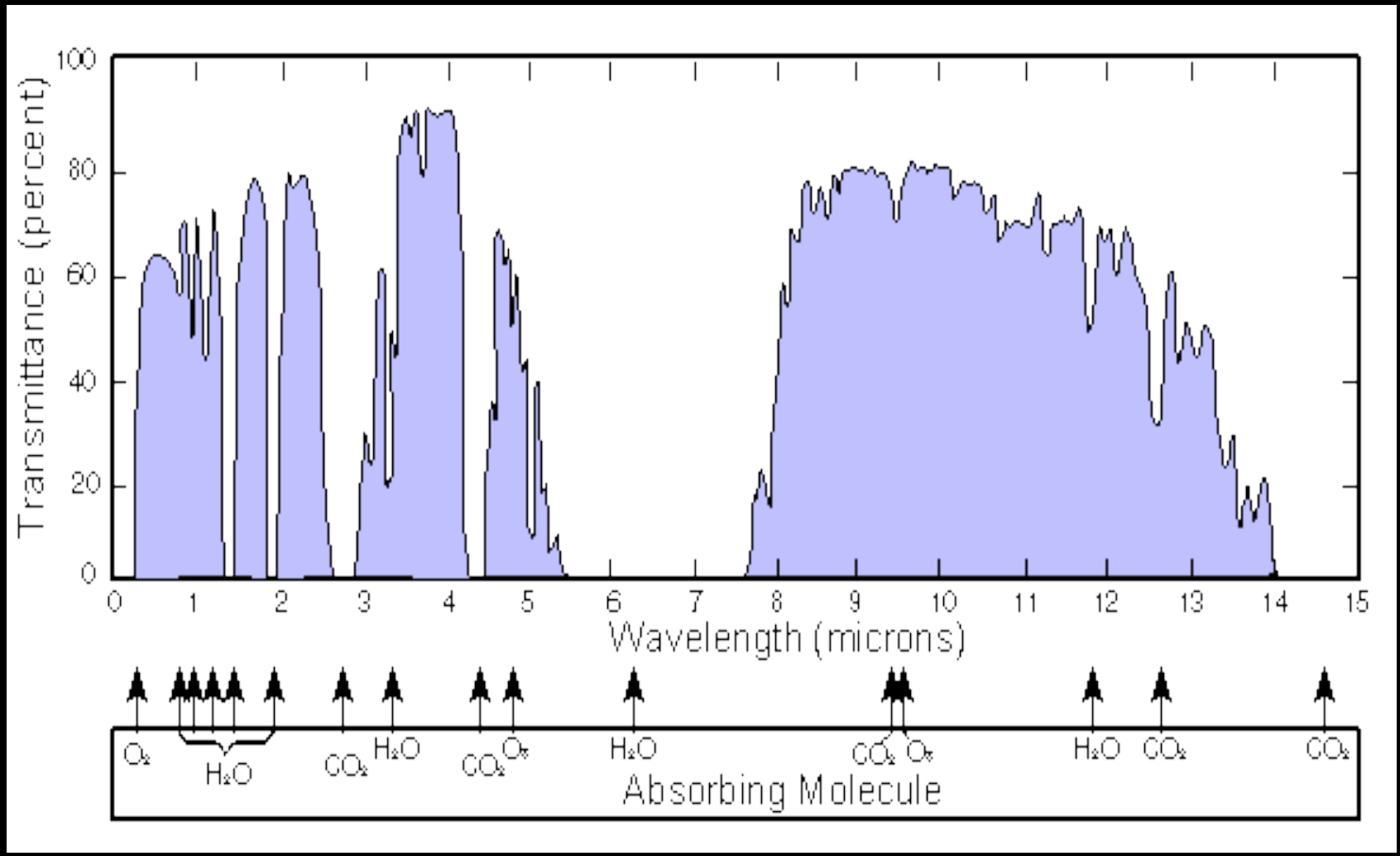
- Source: NYTimes

Greenhouse gases change Earth's radiation balance

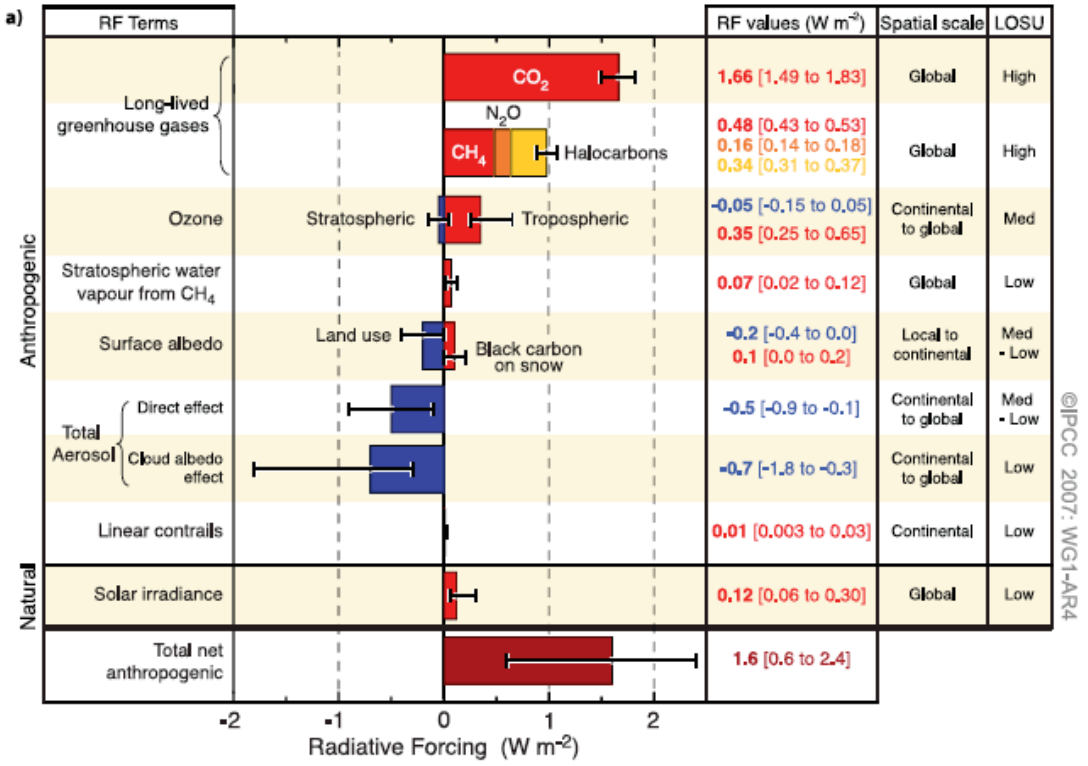


Trenberth et al. (2009)

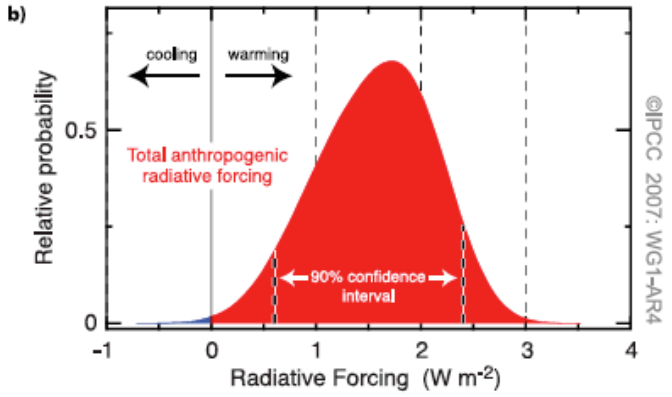
Greenhouse gases “smudge” the “window”



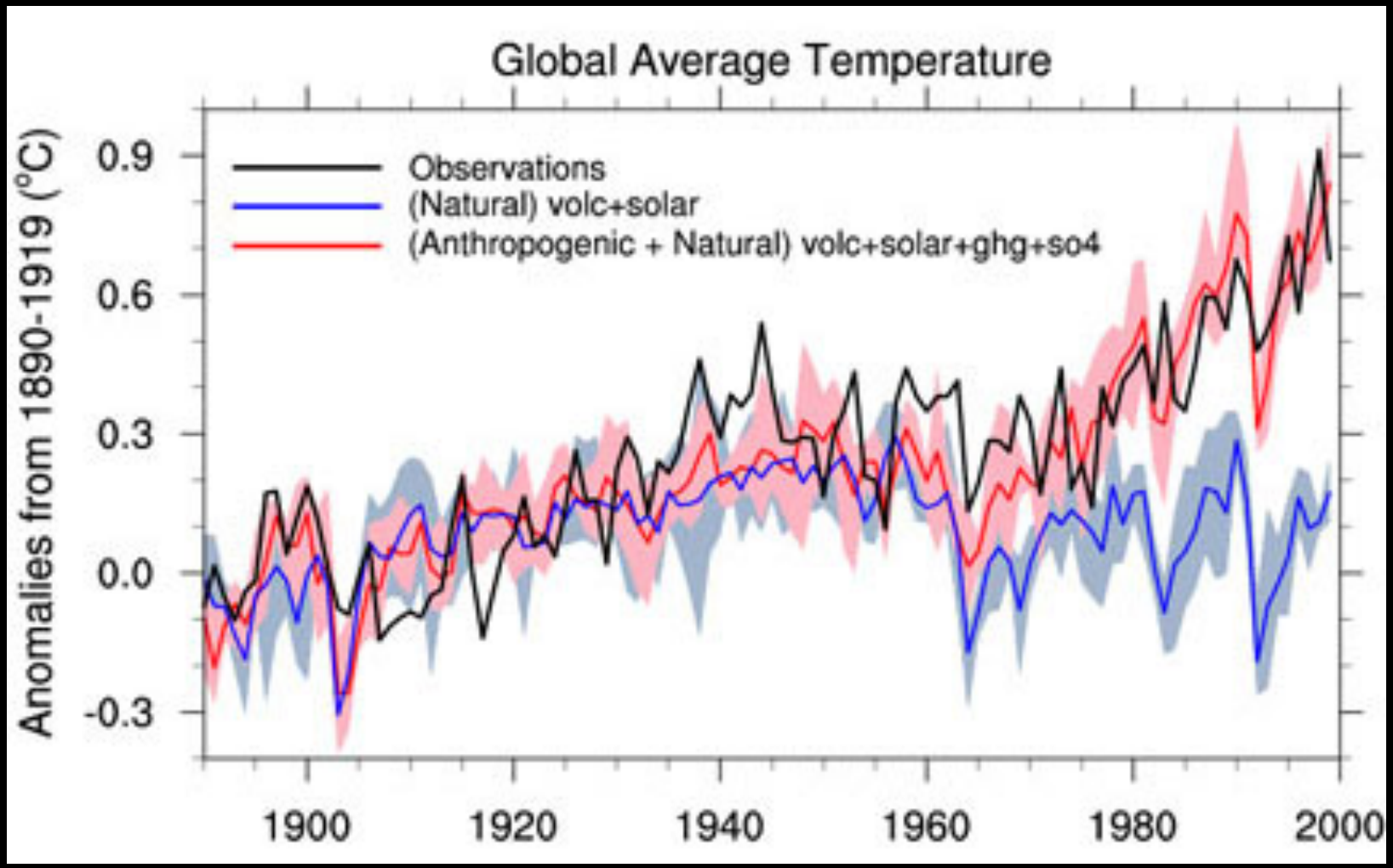
Global Mean Radiative Forcings



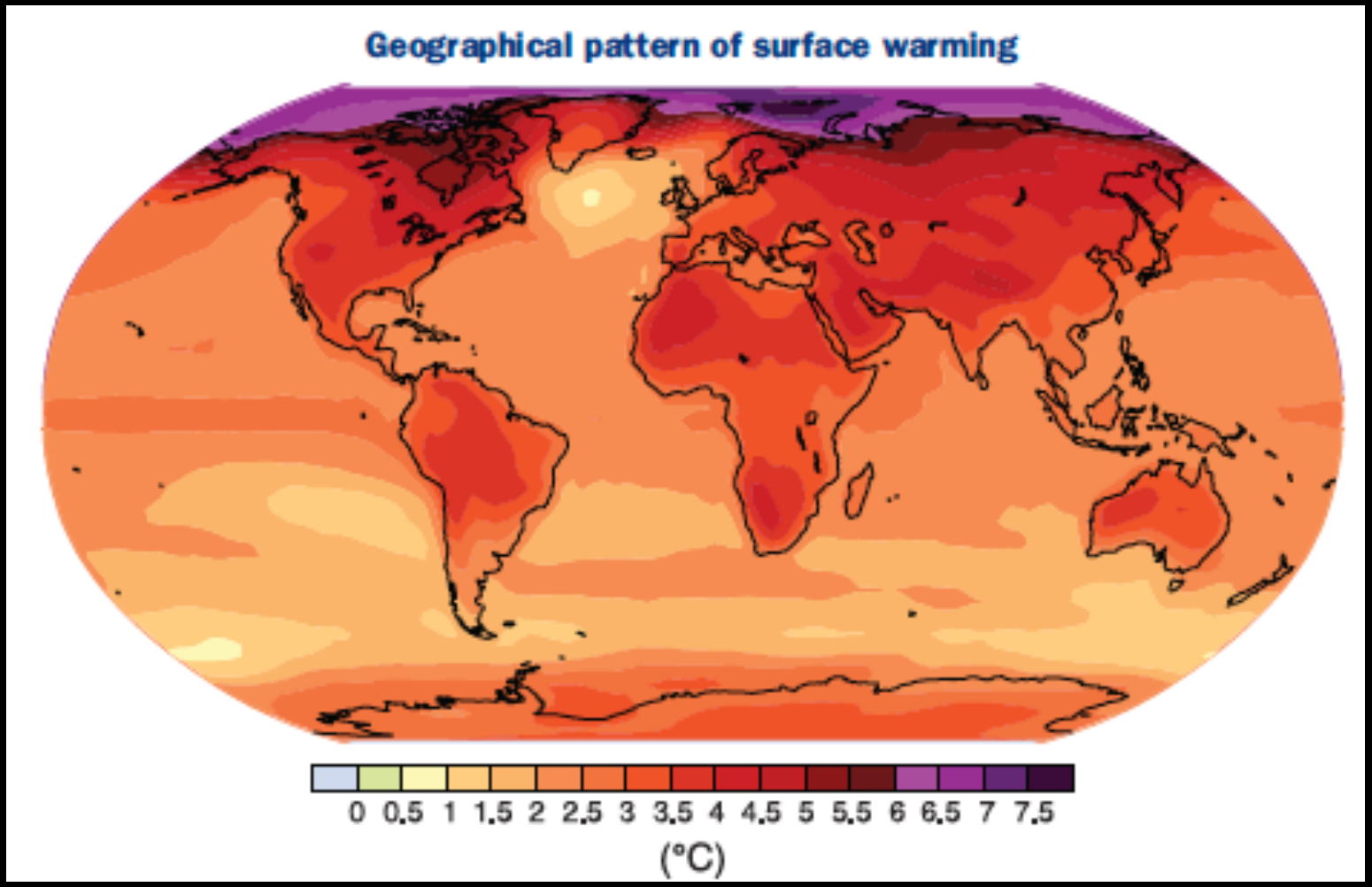
Probability Distribution



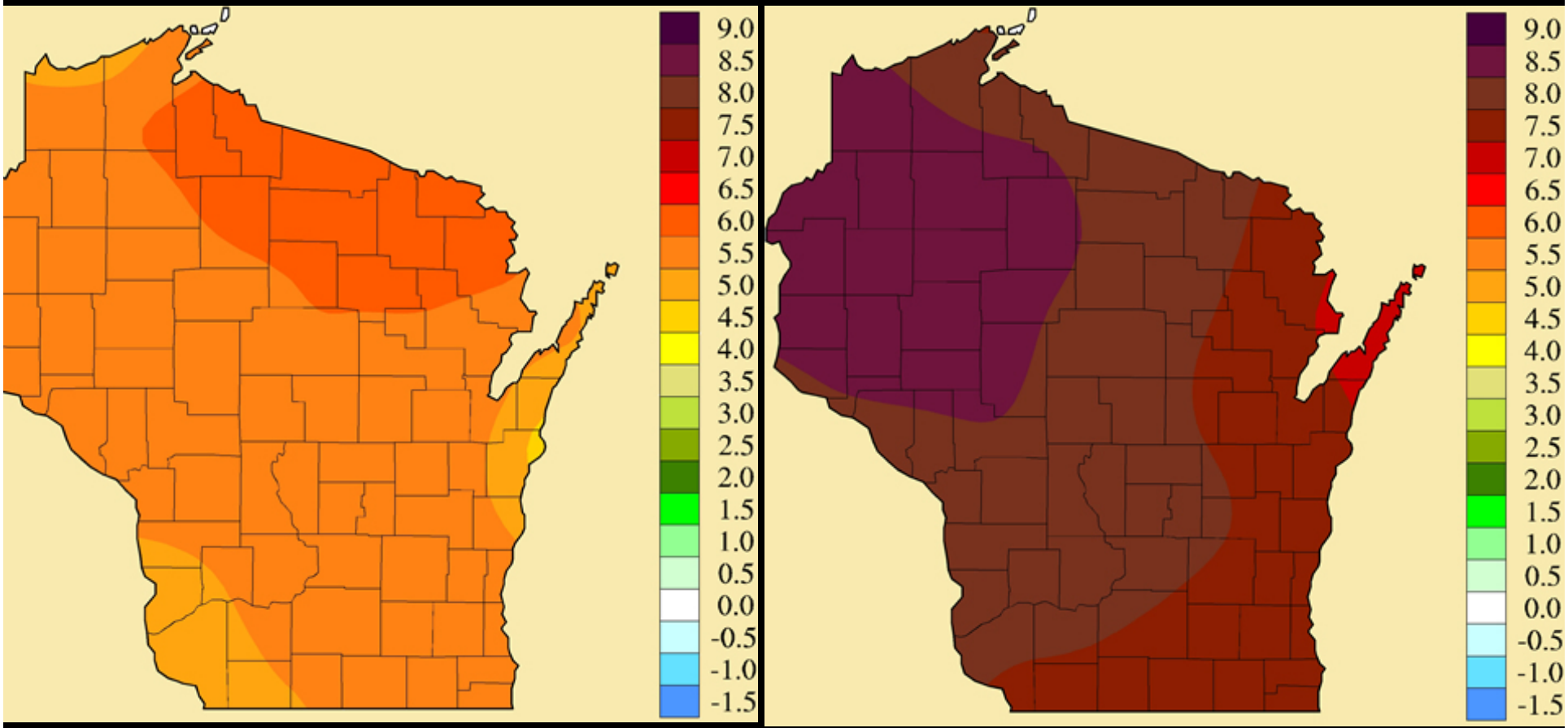
Models require anthropogenic climate change to replicate modern climate



Warming is not equal in all areas

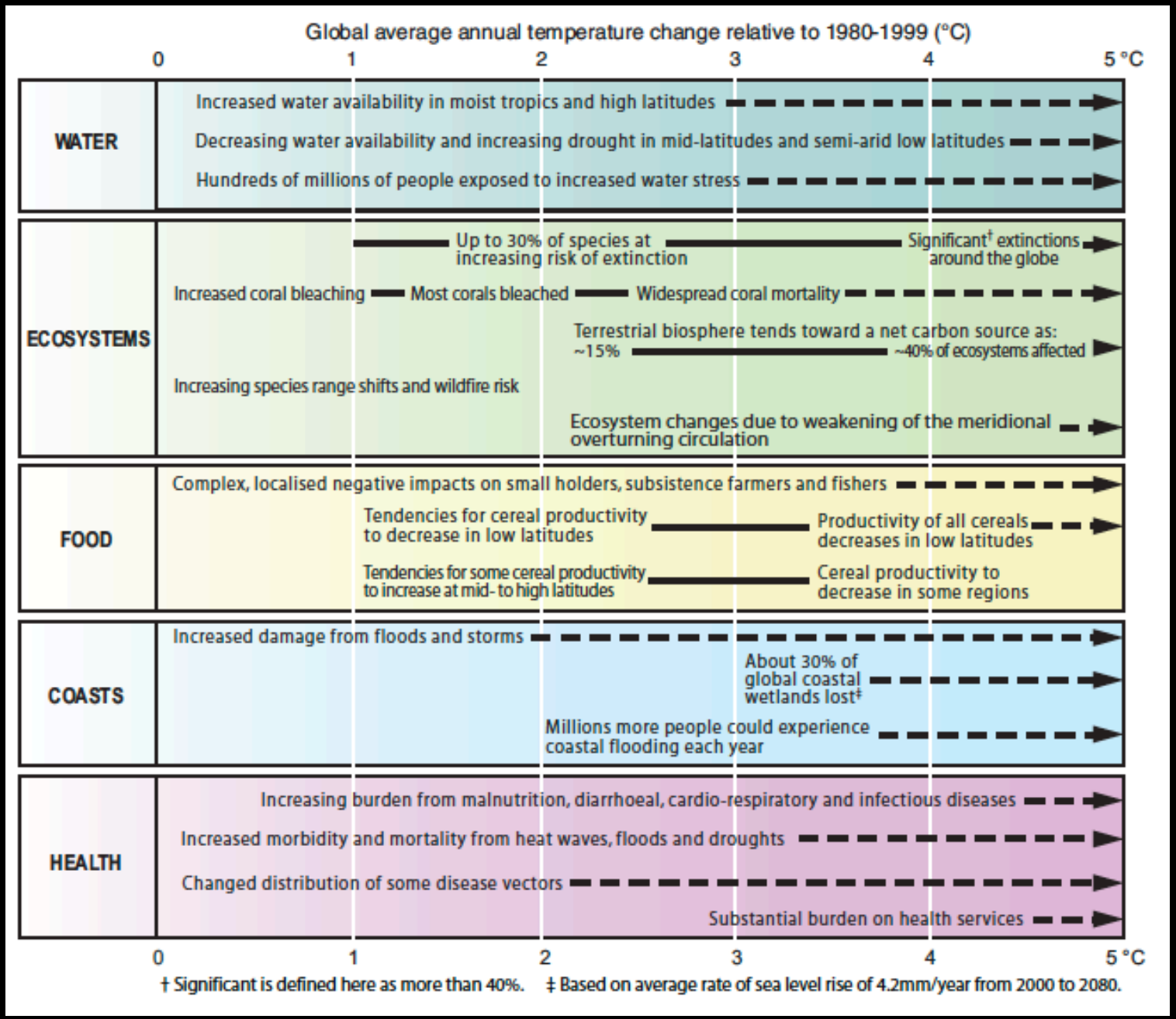


Or in all seasons!



Impacts are broad

- Freshwater supply
- Ecosystems
  - Biodiversity / migration / extinction (e.g., polar bear)
  - Fisheries and ocean shell-building organisms (pH)
- Agricultural production, food, fiber
- Coastal lands and small islands
  - Population migration
- Human health
  - Vector-borne diseases, health, malnutrition
  - Heatwaves
- Industry and society
  - Extreme weather (trop. cyclones, storms)
  - Unstable infrastructure (permafrost)


Global average annual temperature change relative to 1980-1999 (°C)
0
1
2
3
4
5 °C
WATER
Increased water availability in moist tropics and high latitudes
Decreasing water availability and increasing drought in mid-latitudes and semi-arid low latitudes
Hundreds of millions of people exposed to increased water stress
ECOSYSTEMS
Up to 30% of species at increasing risk of extinction
Significant† extinctions around the globe
Increased coral bleaching
Most corals bleached
Widespread coral mortality
Terrestrial biosphere tends toward a net carbon source as:
~15%
~40% of ecosystems affected
Increasing species range shifts and wildfire risk
Ecosystem changes due to weakening of the meridional overturning circulation
FOOD
Complex, localised negative impacts on small holders, subsistence farmers and fishers
Tendencies for cereal productivity to decrease in low latitudes
Productivity of all cereals decreases in low latitudes
Tendencies for some cereal productivity to increase at mid- to high latitudes
Cereal productivity to decrease in some regions
COASTS
Increased damage from floods and storms
About 30% of global coastal wetlands lost‡
Millions more people could experience coastal flooding each year
HEALTH
Increasing burden from malnutrition, diarrhoeal, cardio-respiratory and infectious diseases
Increased morbidity and mortality from heat waves, floods and droughts
Changed distribution of some disease vectors
Substantial burden on health services
0
1
2
3
4
5 °C
† Significant is defined here as more than 40%.
‡ Based on average rate of sea level rise of 4.2mm/year from 2000 to 2080.

Where are we?

http://www.nytimes.com/2010/10/19/science/19aspen.html

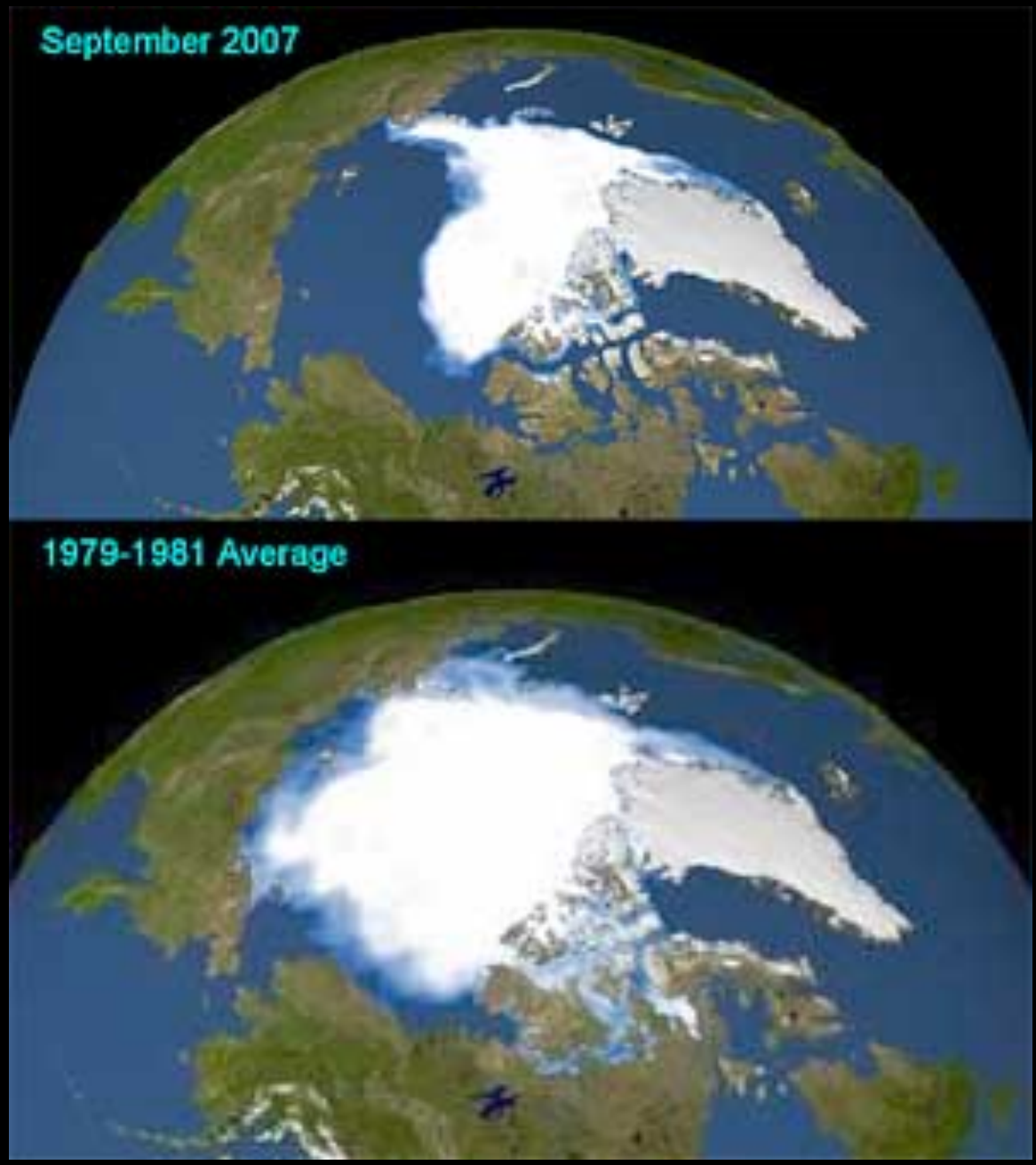
Where are we?

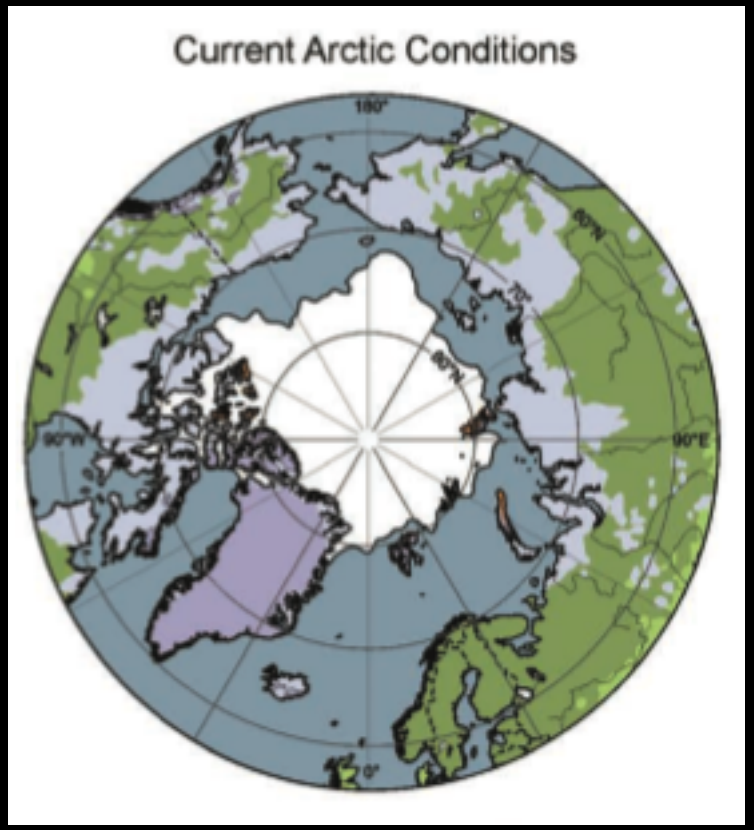
Source: NYTimes

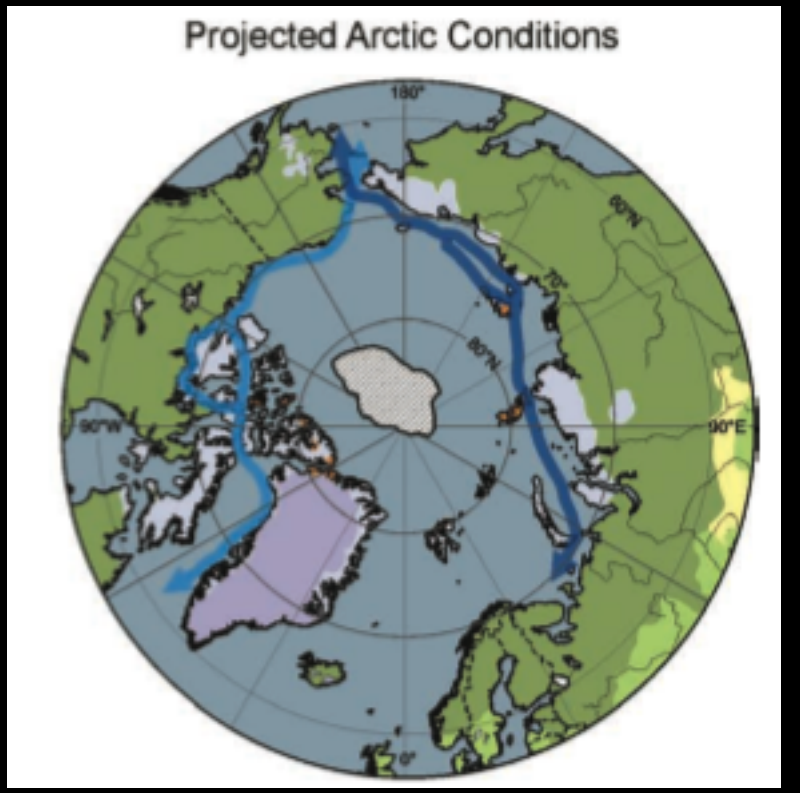
Holgate Glacier, Alaska

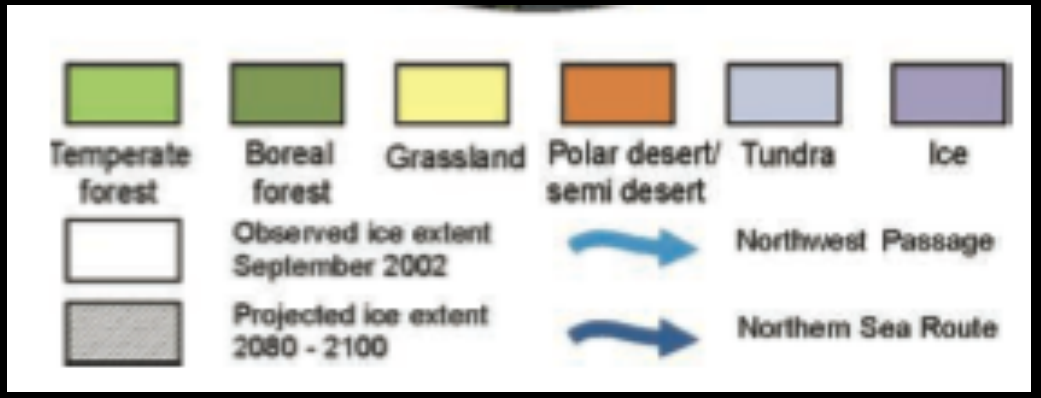
Online glacier photograph database. Boulder, CO: National Snow and Ice Data Center/World Data Center for Glaciology. Digital media.

1. Navy in Montana
2. A scientific way, sampling error?


September 2007
1979-1981 Average

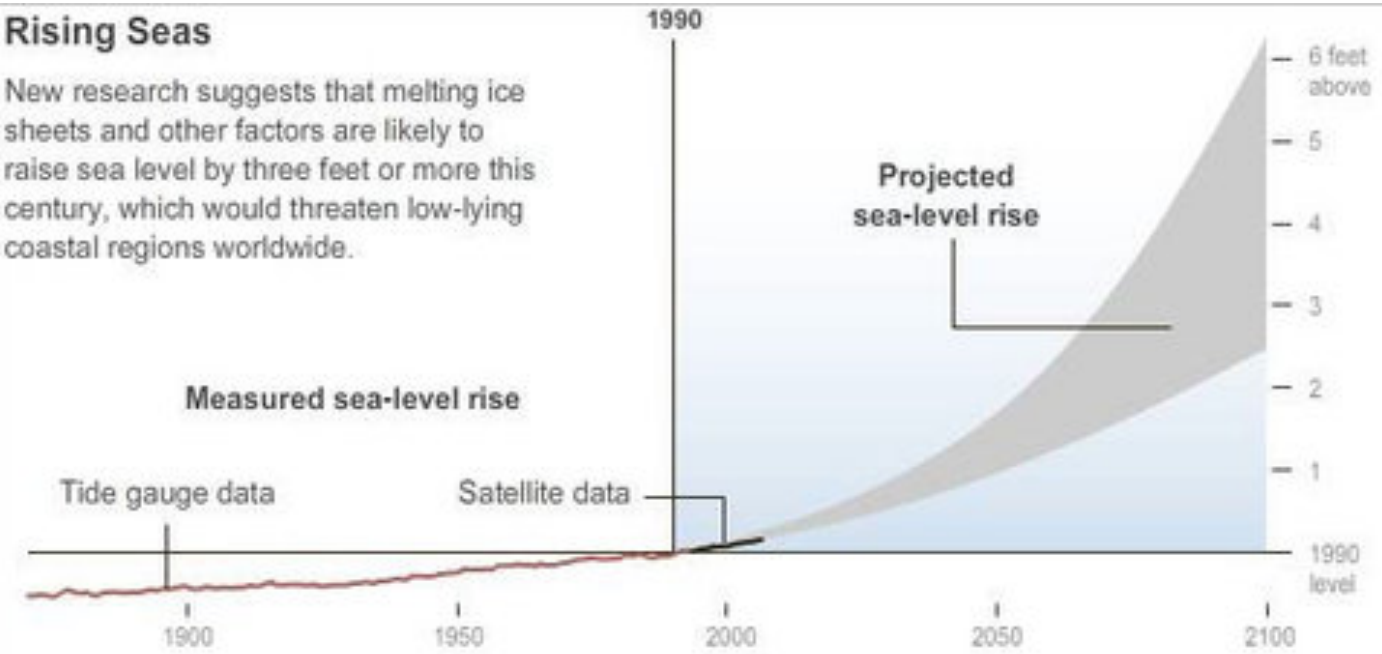

Current Arctic Conditions
180°
90°W
90°E
80°N
70°
60°N
0°


Projected Arctic Conditions
180°
90°W
90°E
80°N
70°
60°N
0°


Temperate forest
Boreal forest
Grassland
Polar desert/ semi desert
Tundra
Ice
Observed ice extent September 2002
Projected ice extent 2080 - 2100
Northwest Passage
Northern Sea Route

Rising Seas

New research suggests that melting ice sheets and other factors are likely to raise sea level by three feet or more this century, which would threaten low-lying coastal regions worldwide.

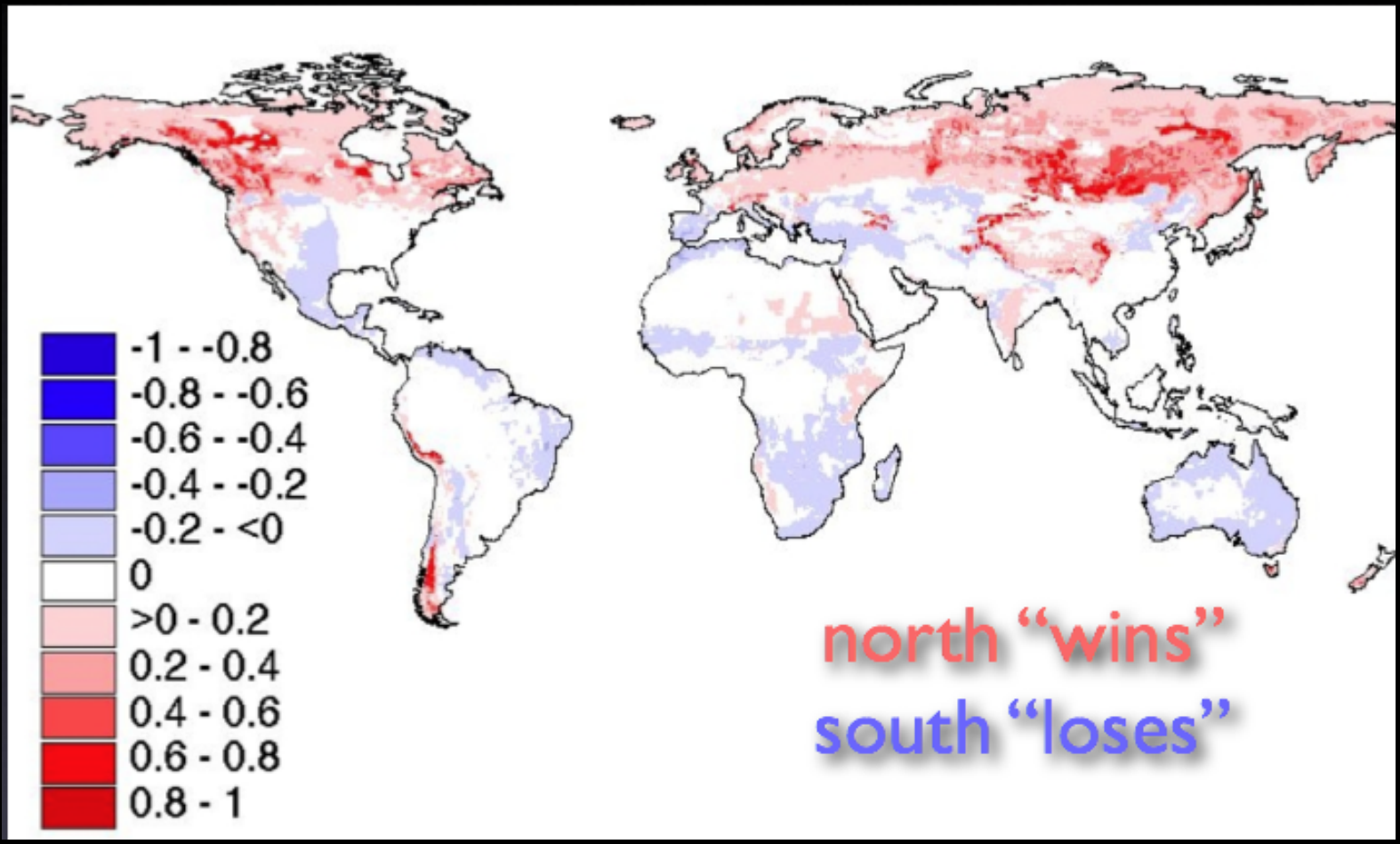


Vulnerable Areas

Low-lying areas in Louisiana, Florida and southern Asia are especially vulnerable, and some coastal cities like New York and San Francisco also face threats along their shorelines.

Sources: PNAS; Martin Vermeer, Aalto University; Stefan Rahmstorf, Potsdam Institute for Climate Impact Research; NASA; CNES; Center for Remote Sensing of Ice Sheets, University of Kansas

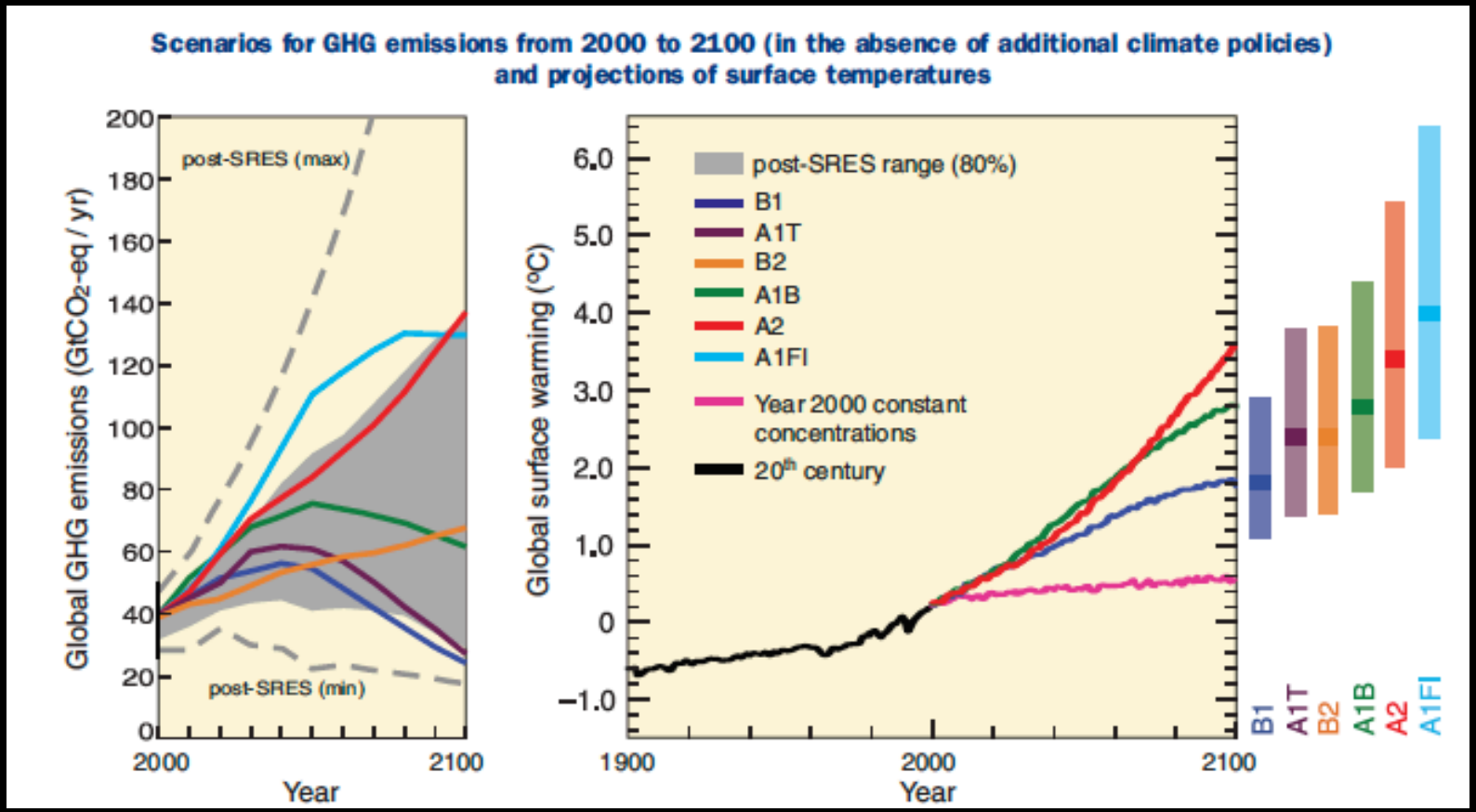
Ag. Yields increase in some areas with small warming, decrease in others



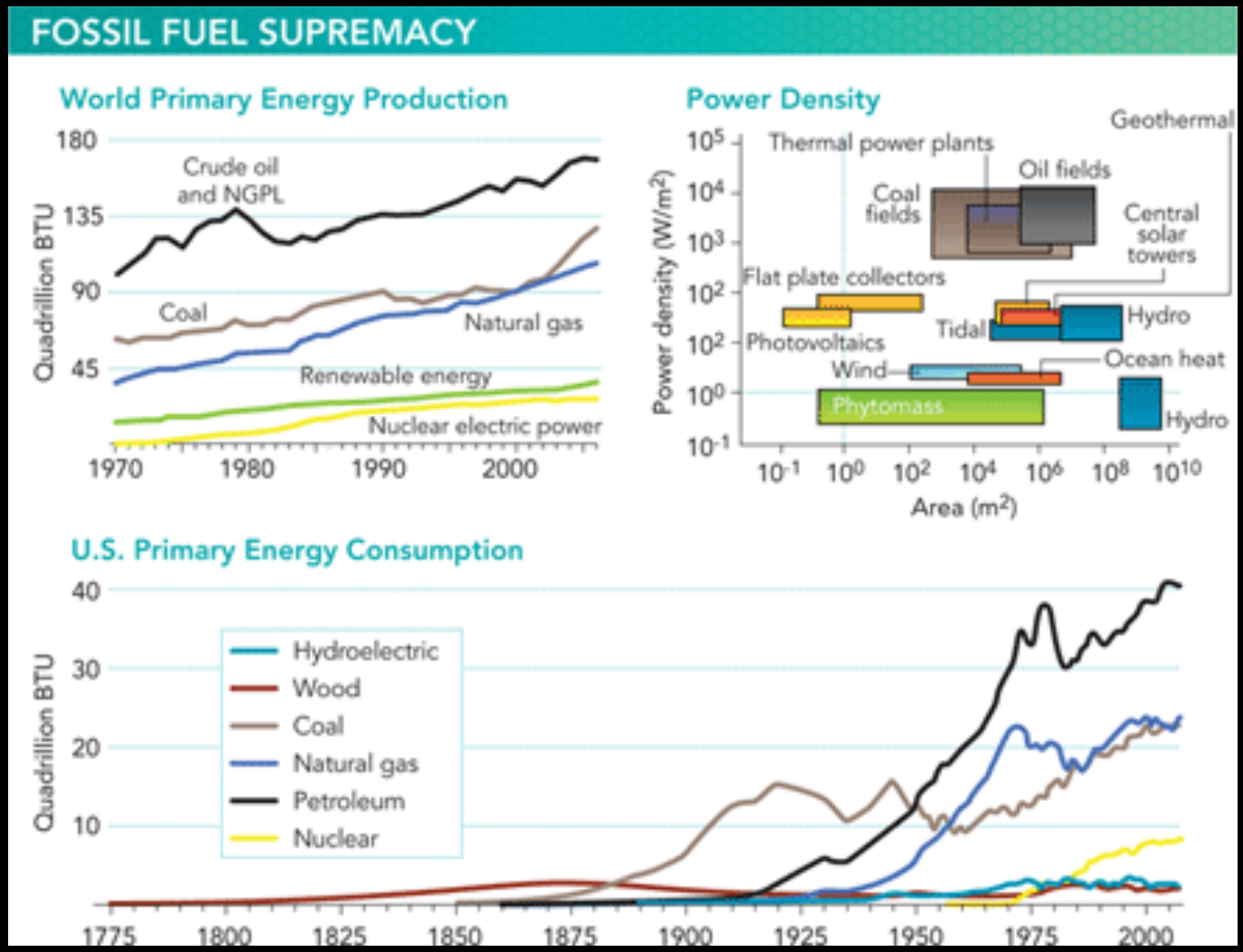
Wisconsin's tension zone moves north

Coastal areas have to adapt

Human behavior is the largest uncertainty in climate projections



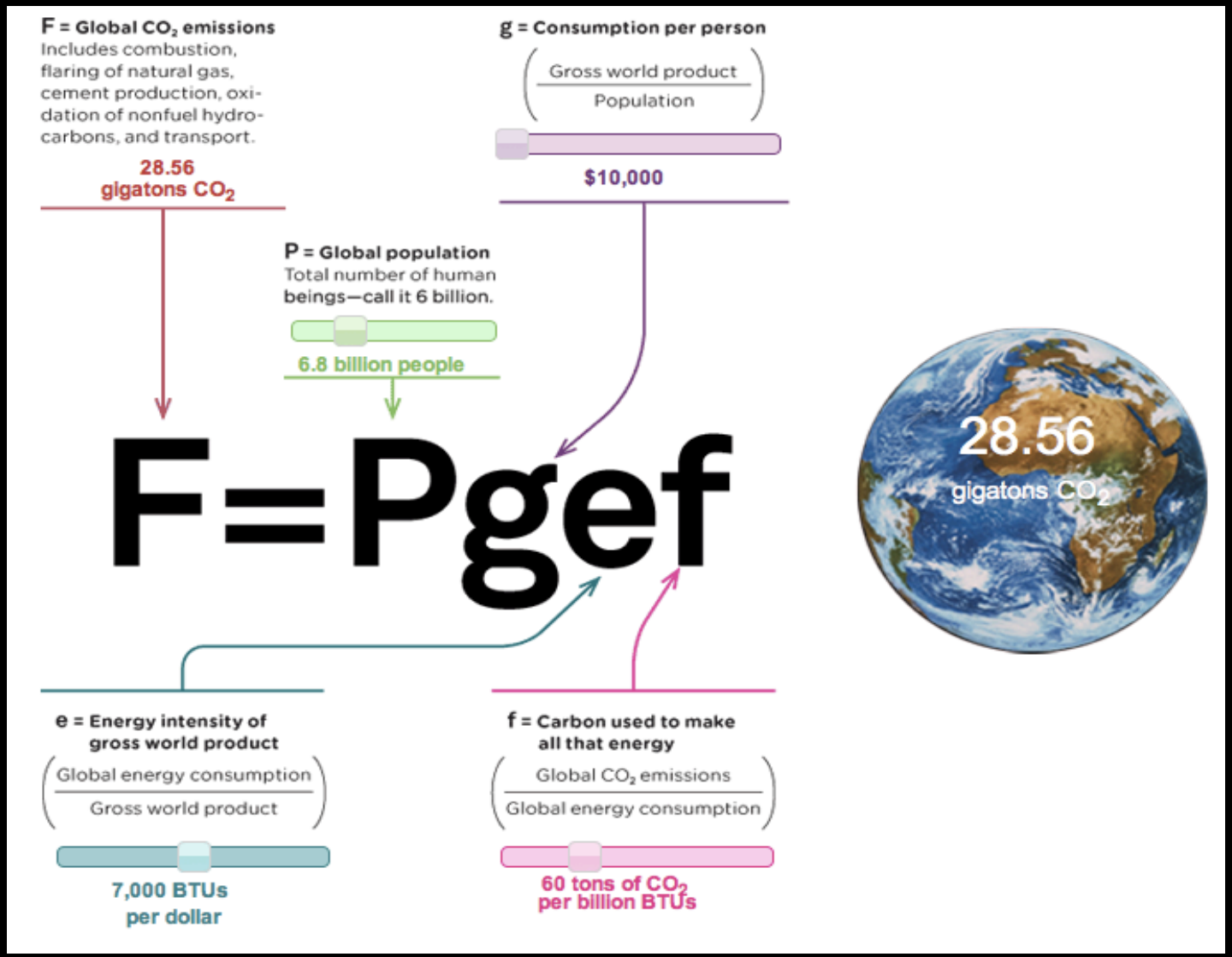
We Are Not Running Out of Fossil Fuels



What are the options?

- Adaptation
  - Economic/political (relocation, tech transfer, payments for damages, reduce poverty, educate)
  - Technological (resilient tech, seawalls, genetic hybrids, cure malaria, colonize new planet)
- Mitigation
  - Economic (taxes, cap and trade, R&D)
  - Political (treaties, bans, compacts, fuel/energy standards, public transit, voluntary agreements)
  - Societal (sustainable development)
  - Technological (CO2 capture, geoengineering, green tech, alternative energy, energy efficiency)

Kaya Identity is a way to conceptualize “levers” of change



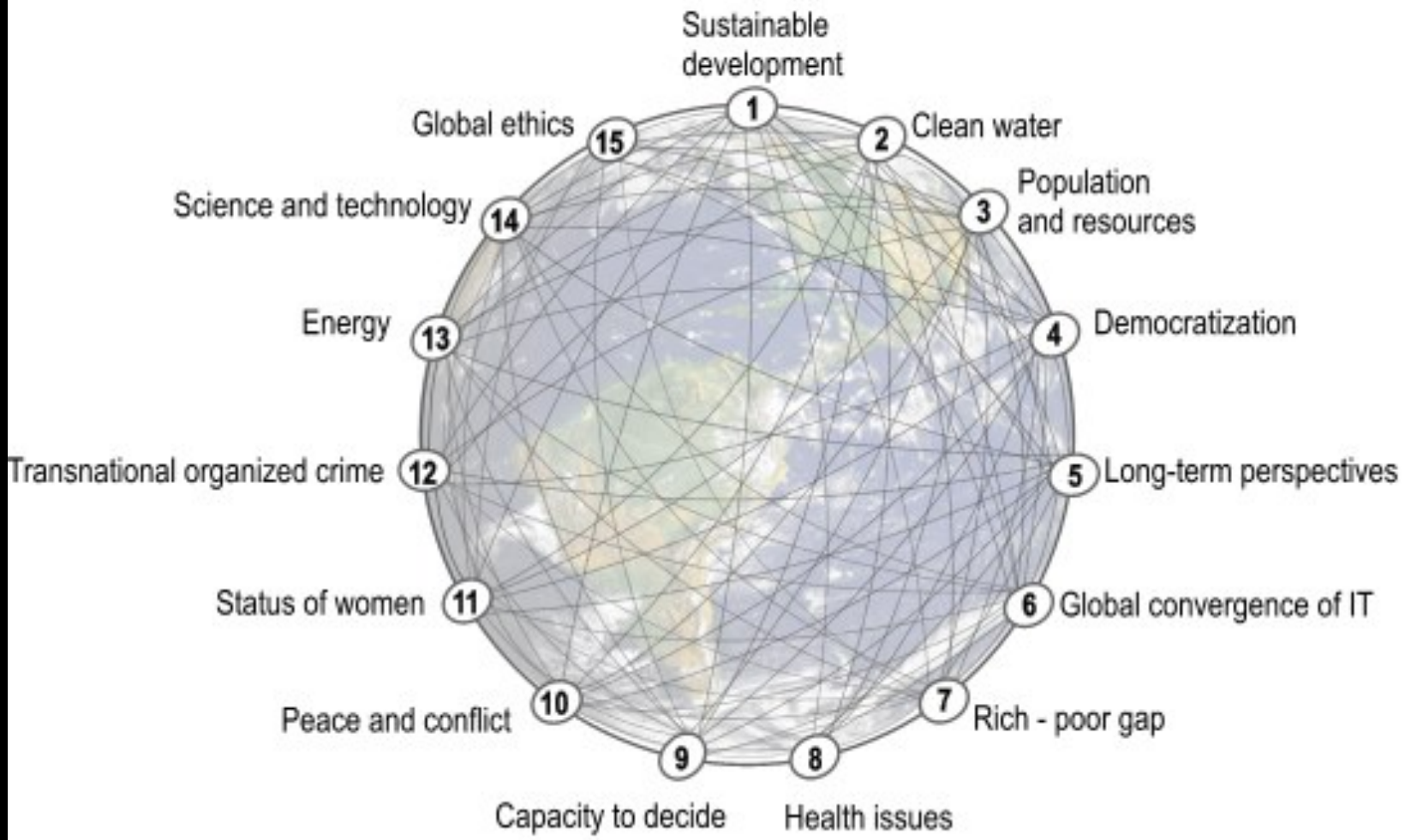
Which country has:

- Built the world's first ultra high voltage power line (6.4 GW)?
- The world's largest high speed rail network, soon to eclipse in mileage the total of the rest of world's?
- The highest efficiency coal plants at 48%, with carbon capture?
- 30 nuclear power plants under construction?
- Production of 5 million alternative energy vehicles?
- The fastest rate of wind power installation and home of 3 of the 10 largest wind turbine manufacturers?
- Manufacturing of 40% of world's solar PV systems?
- The world's fastest supercomputer?
- The largest number of people who got Ph.Ds in the US?
- Plans to reach 18% renewable energy by 2020?
  - Source: US DOE Secretary Steven Chu

Global treaties are not simple

- There is no international rules making body!
- Treaties are a game of incentives and disincentives to sign and to comply
- Individual countries weigh costs and benefits
- Compliance and monitoring are contentious issues

15 Global Challenges
facing humanity



by the Millennium Project of WFUNA
www.millennium-project.org

Ethics of Climate Change

- Is there a moral obligation to future generations? If so, how many?
- Is this merely a “tragedy of the commons” or the lack of a “social discount factor” or something else?
- Why have other global environmental treaties (e.g., ozone) been successful?

Are the “unconvinced” deliberately being misled?

- Prof. Naomi Oreskes
- Professor of History and Science Studies, University of California - San Diego
- Adjunct Professor of Geosciences, Institution of Oceanography
- "Merchants of Doubt"
- When: Tuesday, March 8, 2011, 4:00 - 5:00
- tea/cookies from 3:45 - 4:00
- Where: 1106 Mechanical Engineering