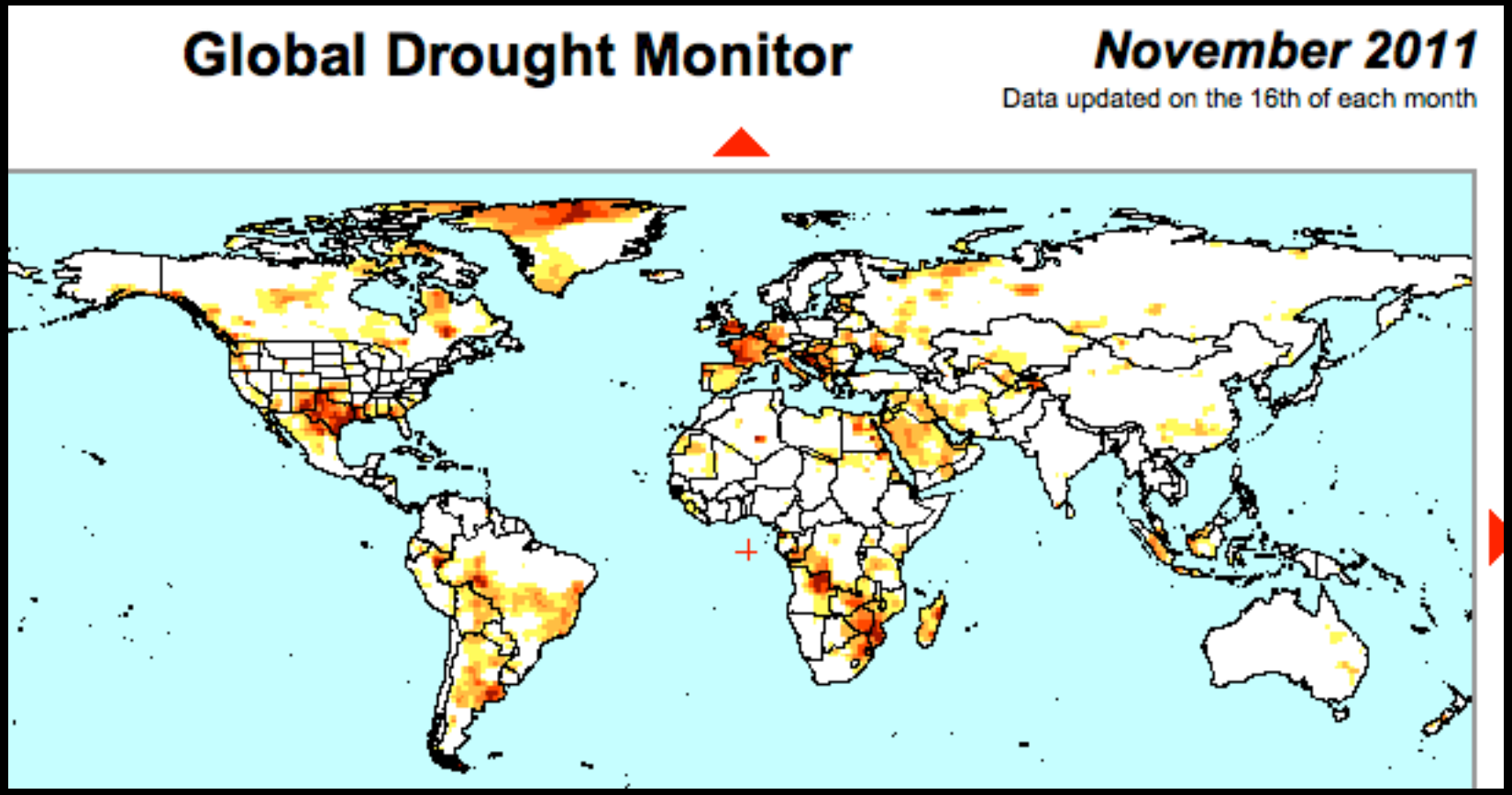
Quiz: Where are we?



Forget Irene: The Drought in Texas Is the Catastrophe That Could Really Hurt

Catastrophic Drought in Texas Causes Global Economic Ripples

By KATE GALBRAITH

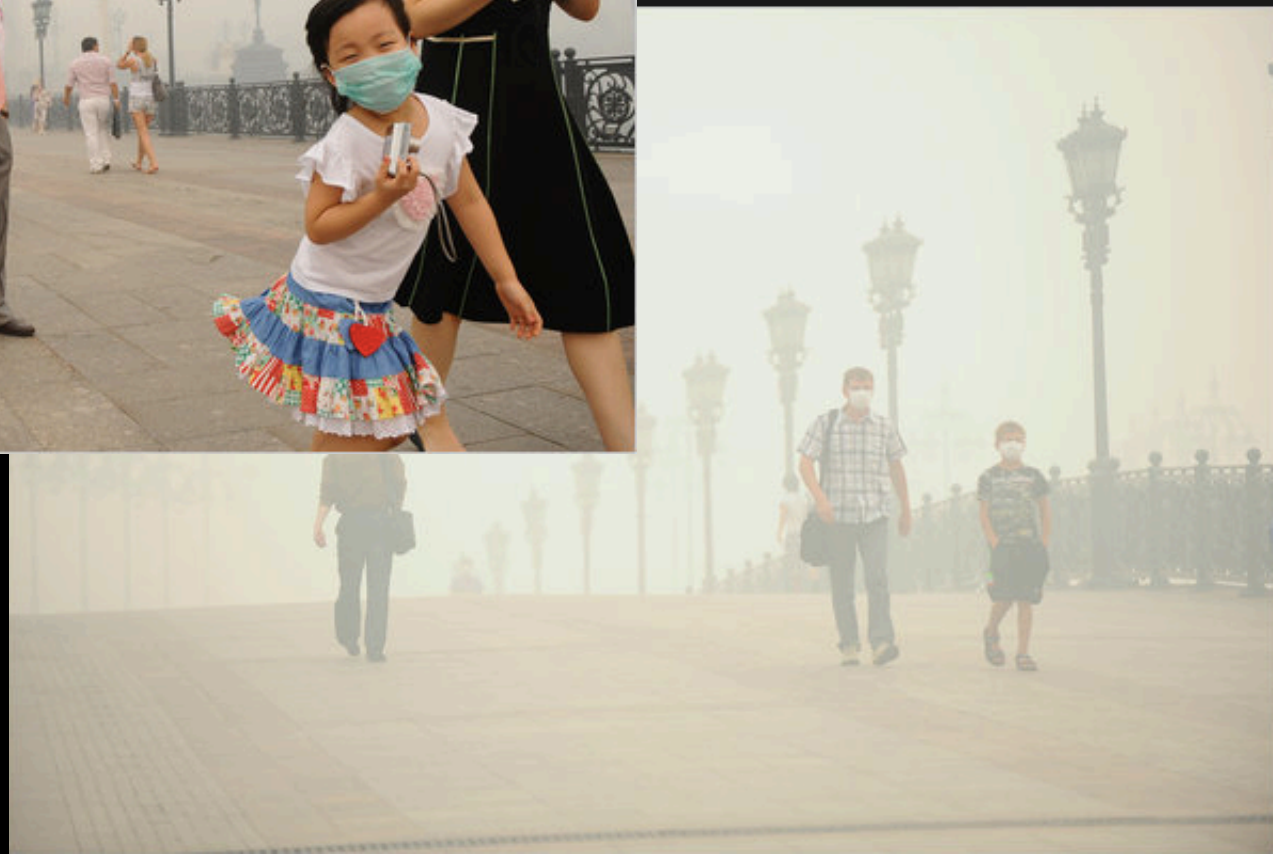
Texas Drought 2011: Depleted Lakes Expose Ghost Towns, Graves And Prehistoric Bones

Drought stumps Texas Christmas trees

Kaufman County farm will hurt for next five years

Texas fire officials predict more large blazes in winter as wildfire season hits 1-year mark

Quiz: Where Are We?



Source: NYTimes

Russia!

- Warmest July 2010 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.

IPCC report: Extreme weather is fuelled by climate change

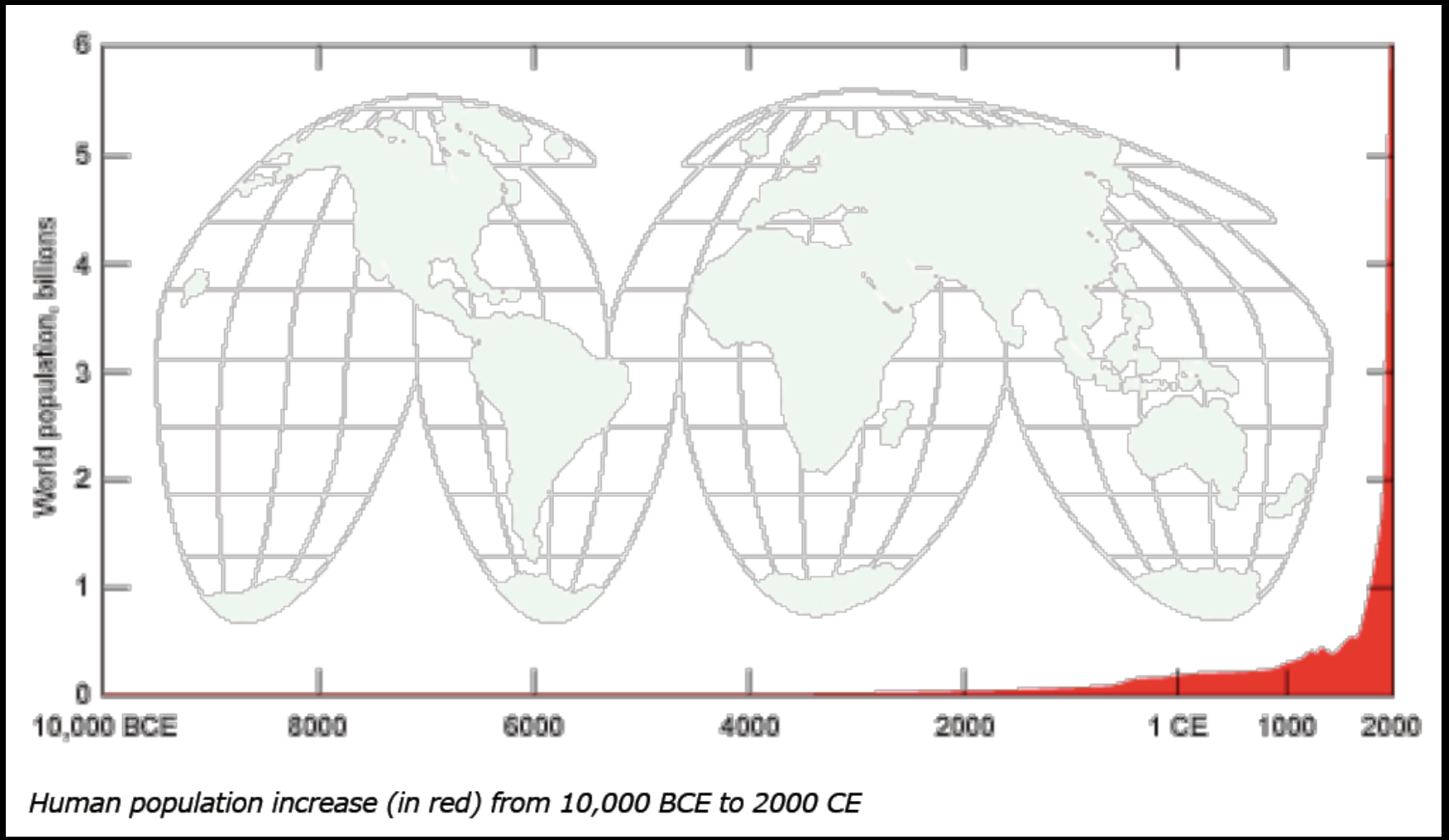
Blogpost by **Brian Blomme** - November 21, 2011 at 14:50

- What makes our current era unique?
- What will we be remembered for 1,000 years from now?
- What are our legal and ethical obligations to other nations and 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
- Current world population is…

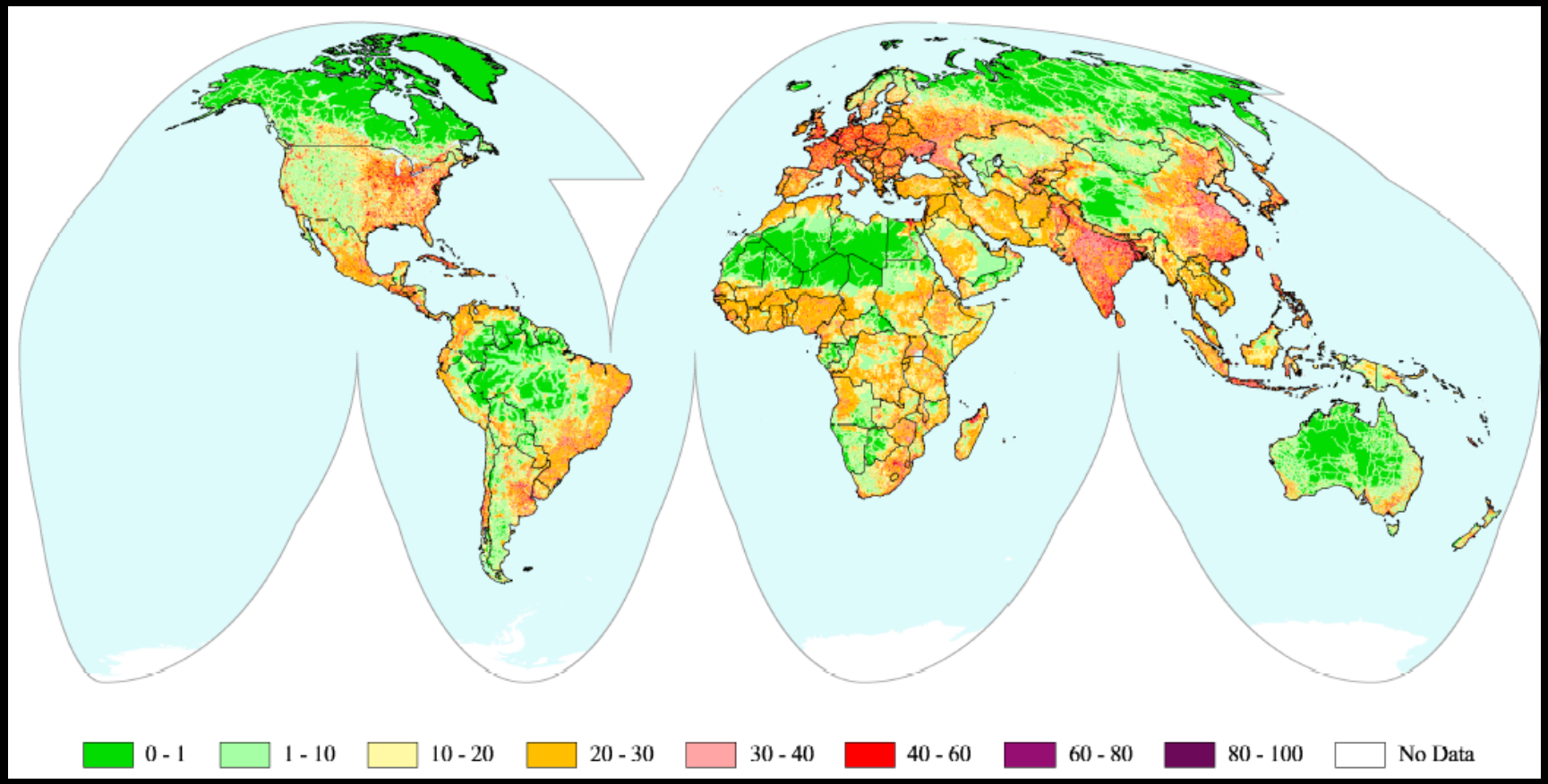
Population rise is not necessarily a bad thing!



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

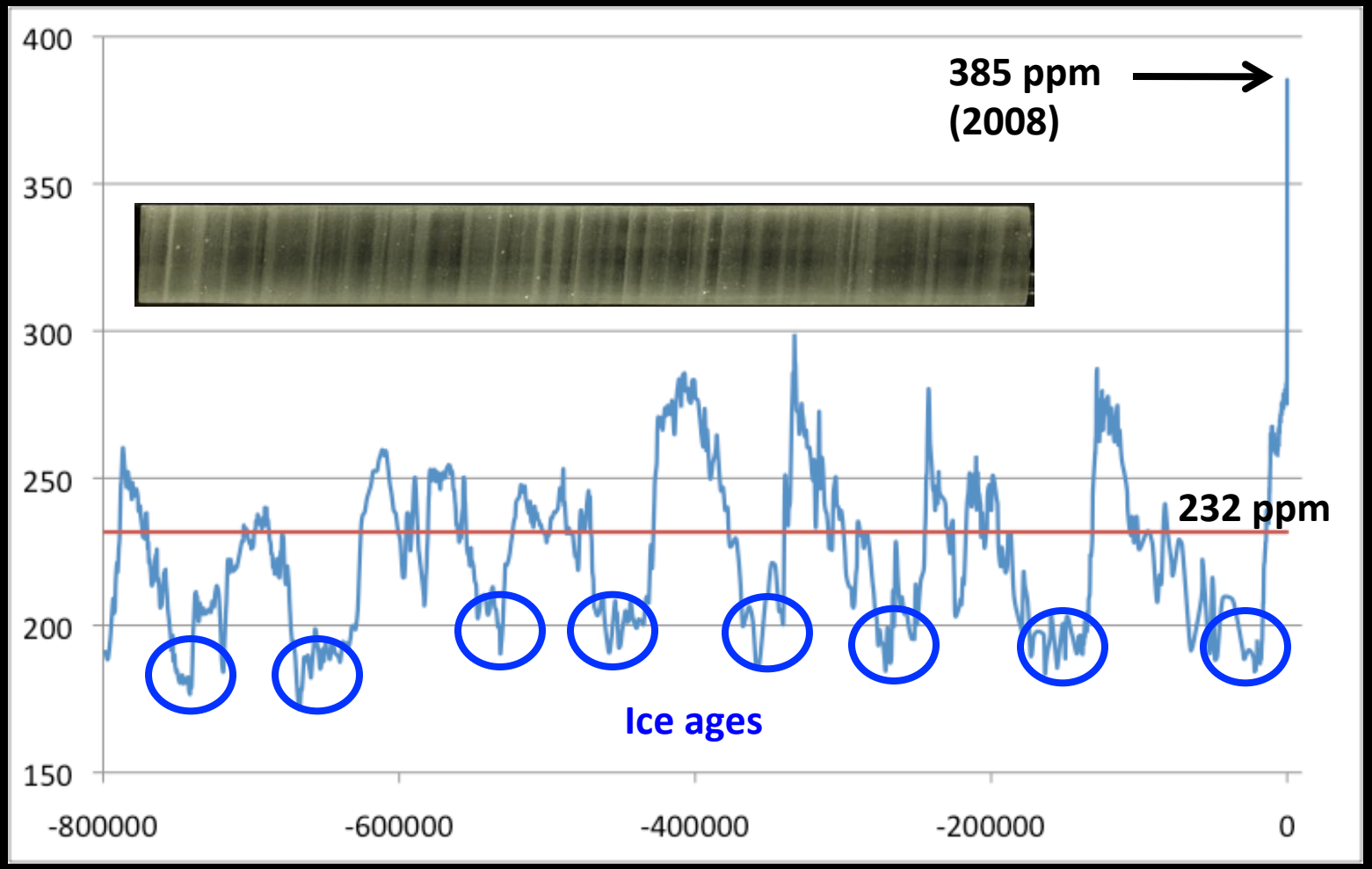


- Sanderson et al., 2002, Bioscience

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

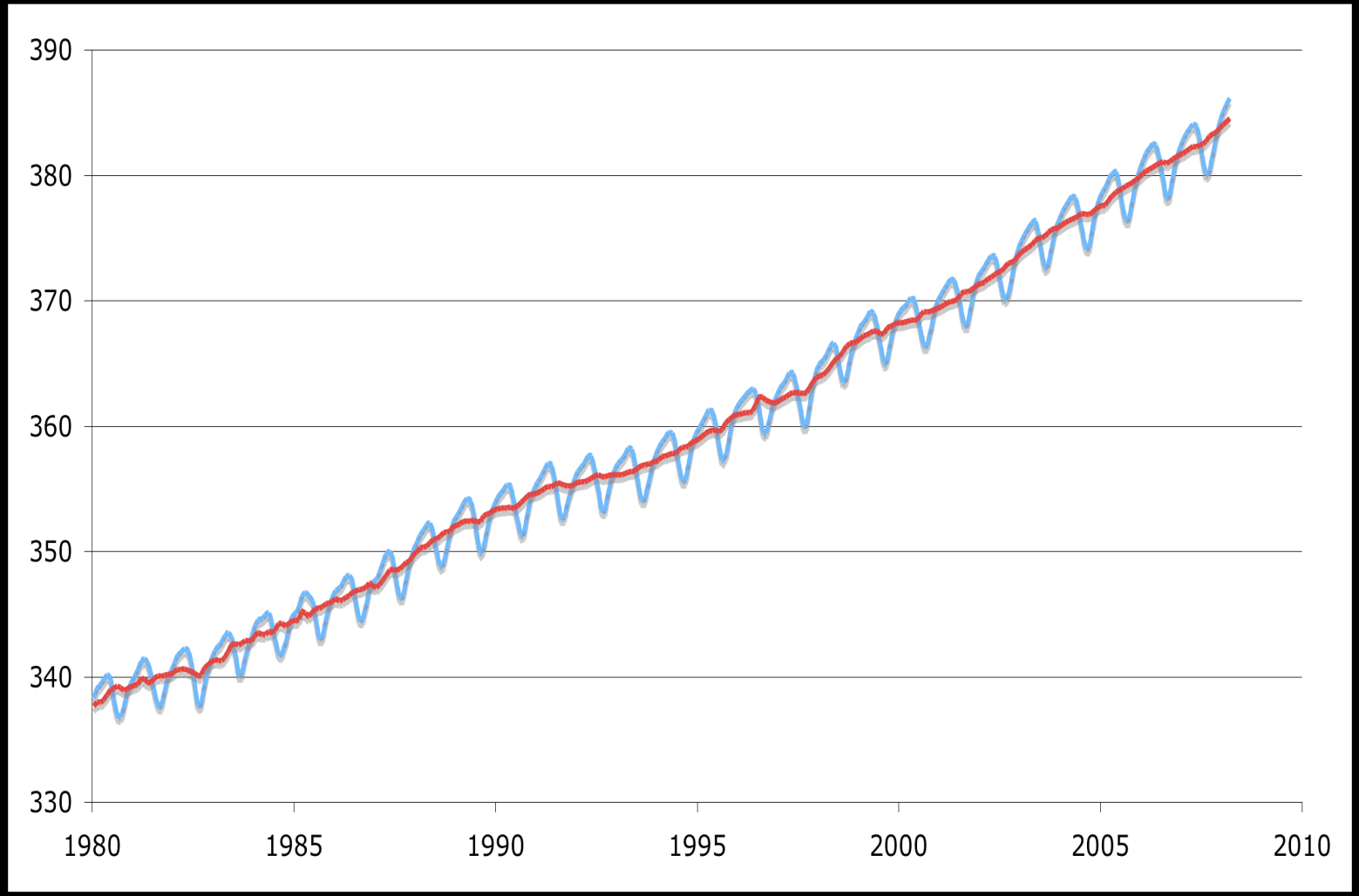
A. 200 years, but probably not longer
B. 400,000 years, but probably not longer
C. 800,000 years, but probably not longer
D. 3.2 million years, but probably not longer
E. All of Earth's history

800,000!

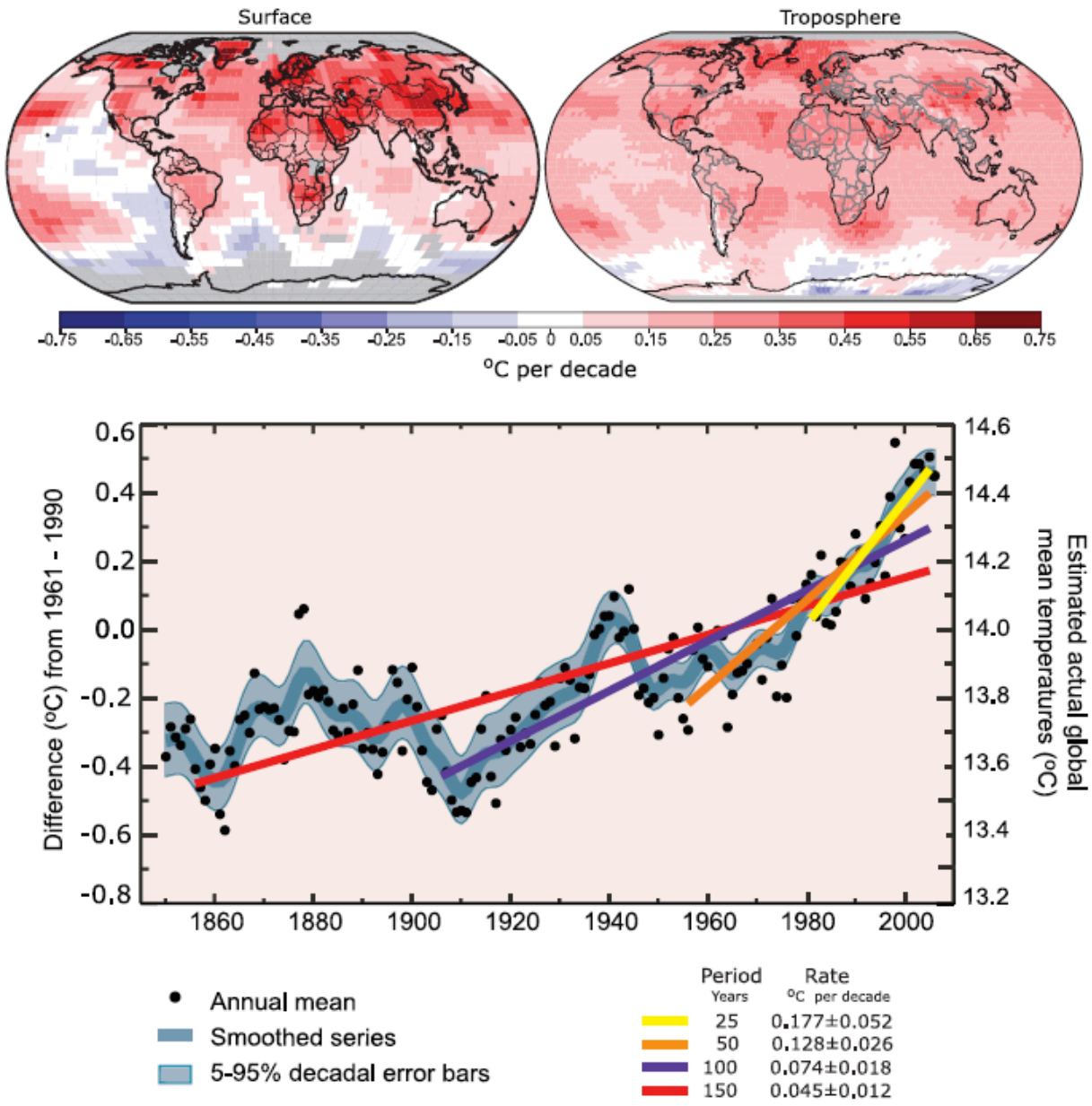


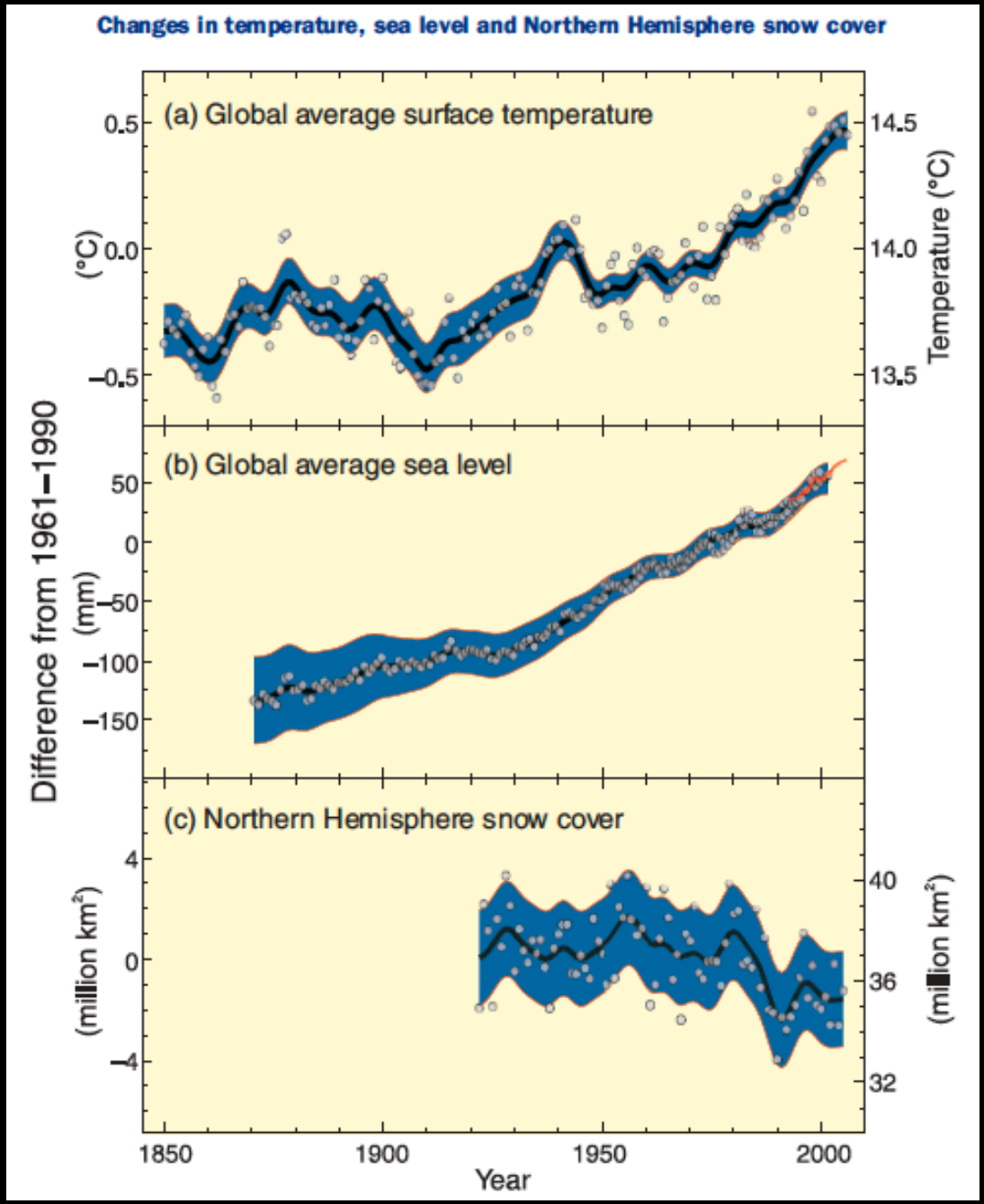
Source: Lüthi et al (2008), CDIAC, & Wikimedia Commons

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

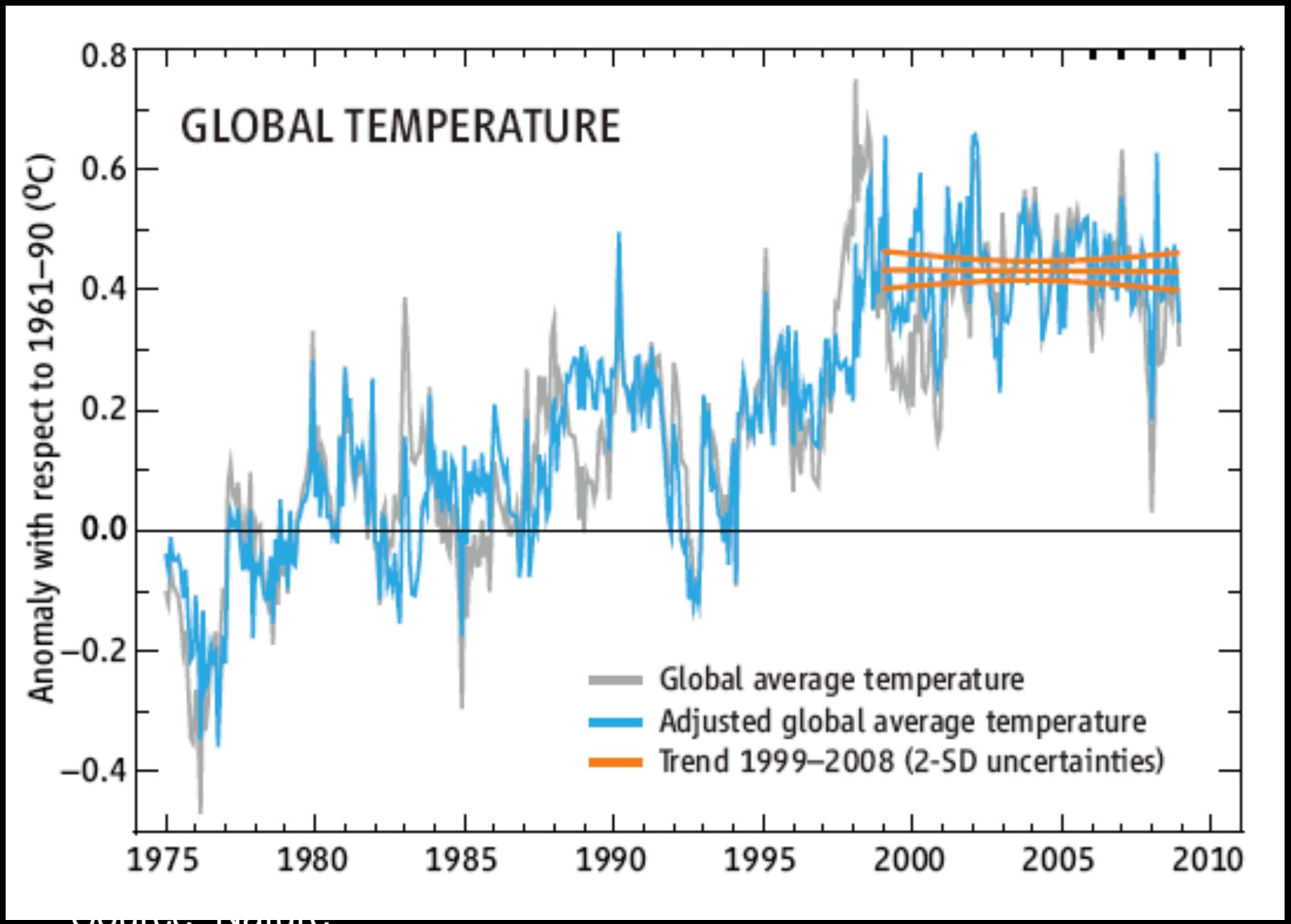


Global Temperature Trends




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

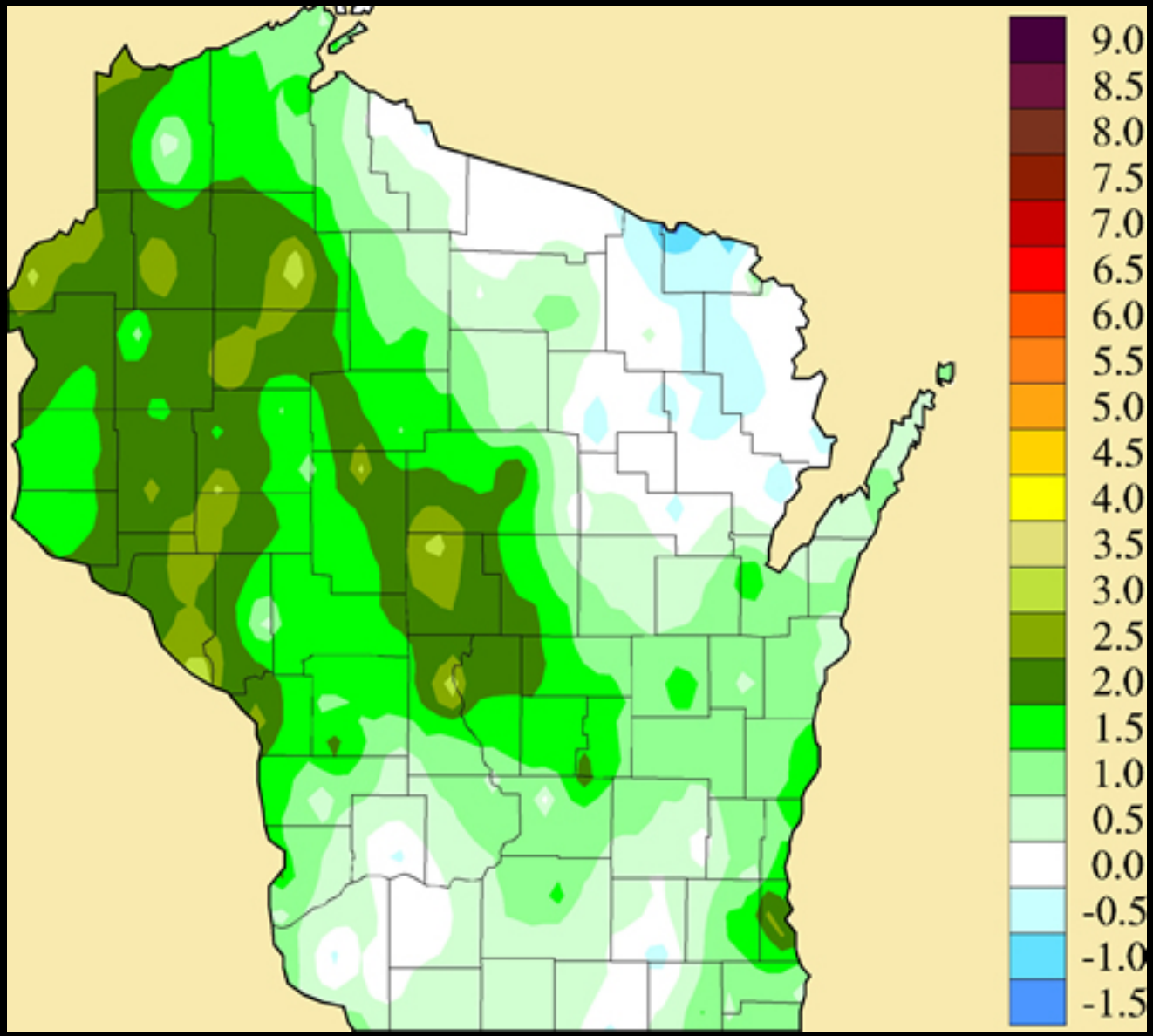
Short-term plateaus in climate trends are expected



Source: Nature

- Climate is not felt directly – it is the spatial and temporal statistics (averages, extremes) of weather (global heat transport)
- Ecosystems, industries, societies, probability of hazards, risk expectations are conditioned by a steady climate
  - How systems respond to changes, how much damage will society tolerate, and how willing are we to pay to mitigate those risks is what we seek to know!

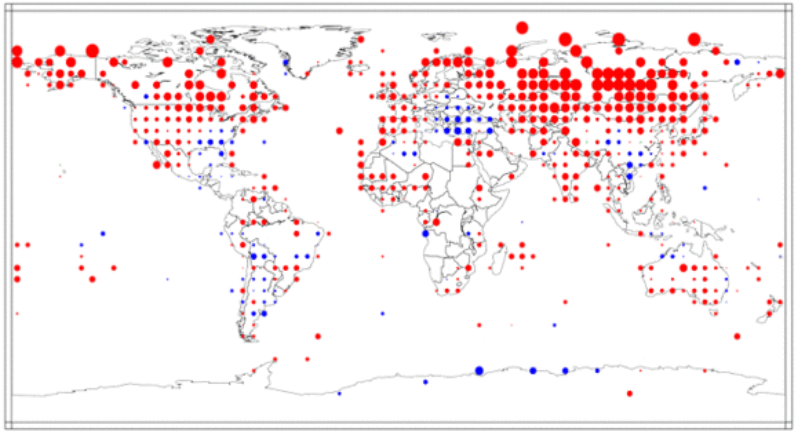
Wisconsin has warmed in 50 yrs



Temperature Anomalies October 2011

(with respect to a 1961-1990 base period)

National Climatic Data Center/NESDIS/NOAA



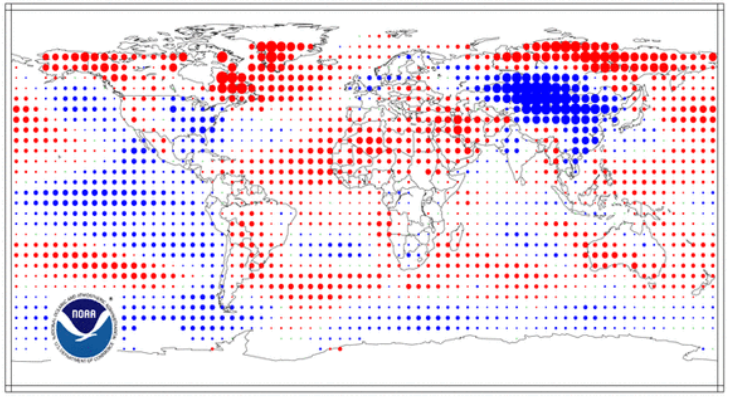
-5C -4C -3C -2C -1C 0C 1C 2C 3C 4C 5C

Degrees Celsius

Temperature Anomalies January 2011

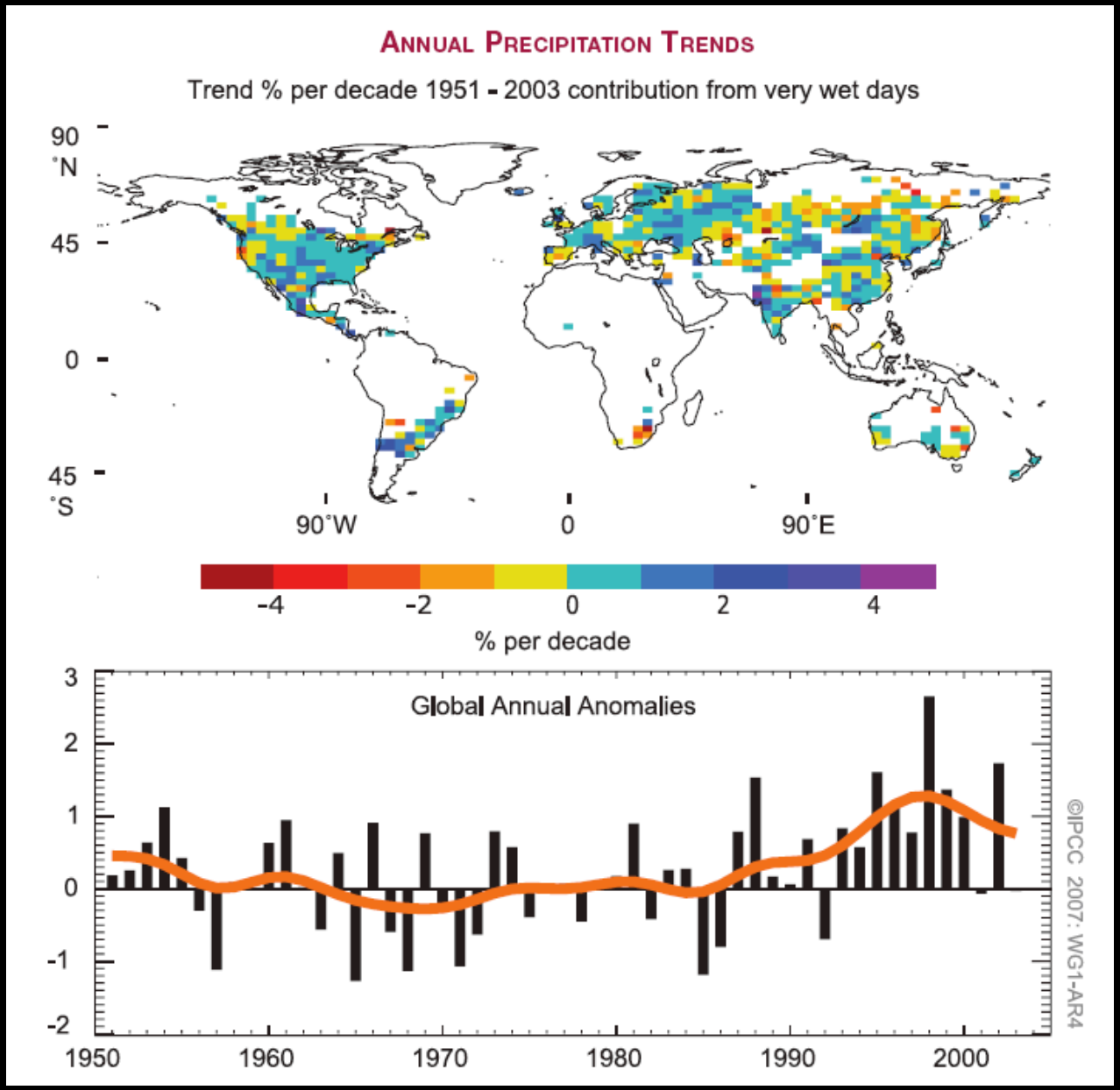
(with respect to a 1971-2000 base period)

National Climatic Data Center/NESDIS/NOAA

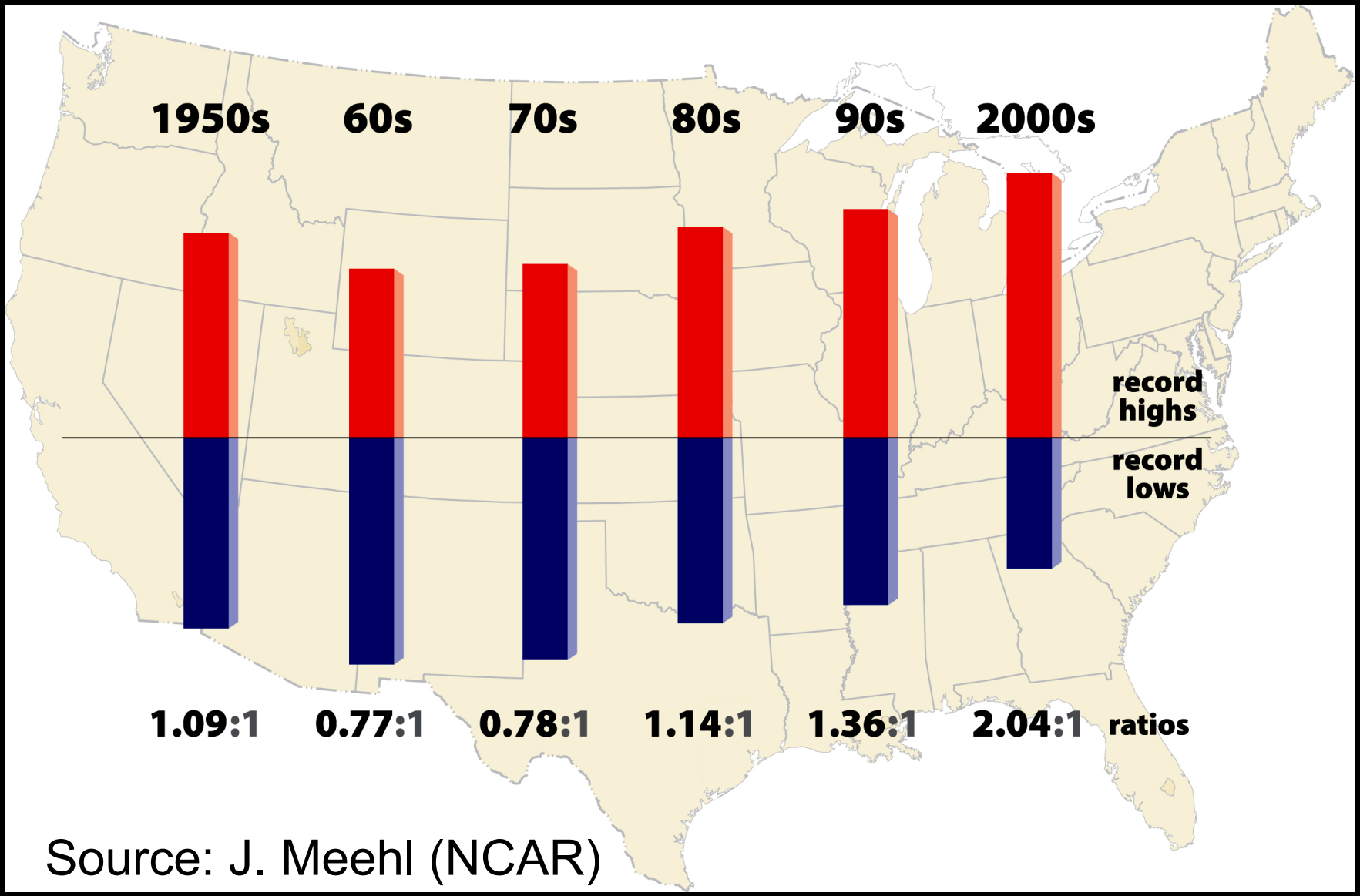


-5C -4C -3C -2C -1C 0C 1C 2C 3C 4C 5C

Degrees Celsius


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

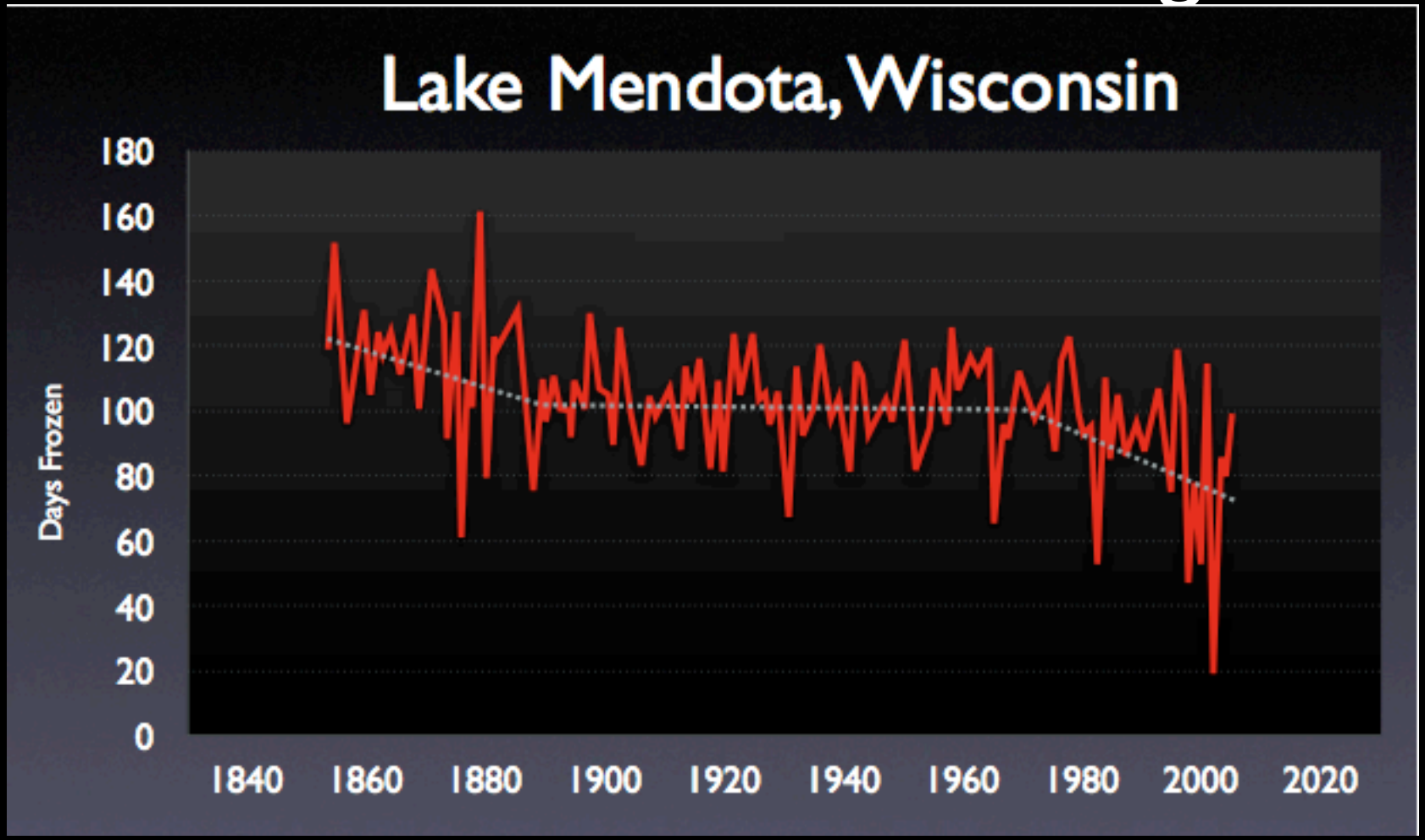
Ratio of record highs to lows now 2:1



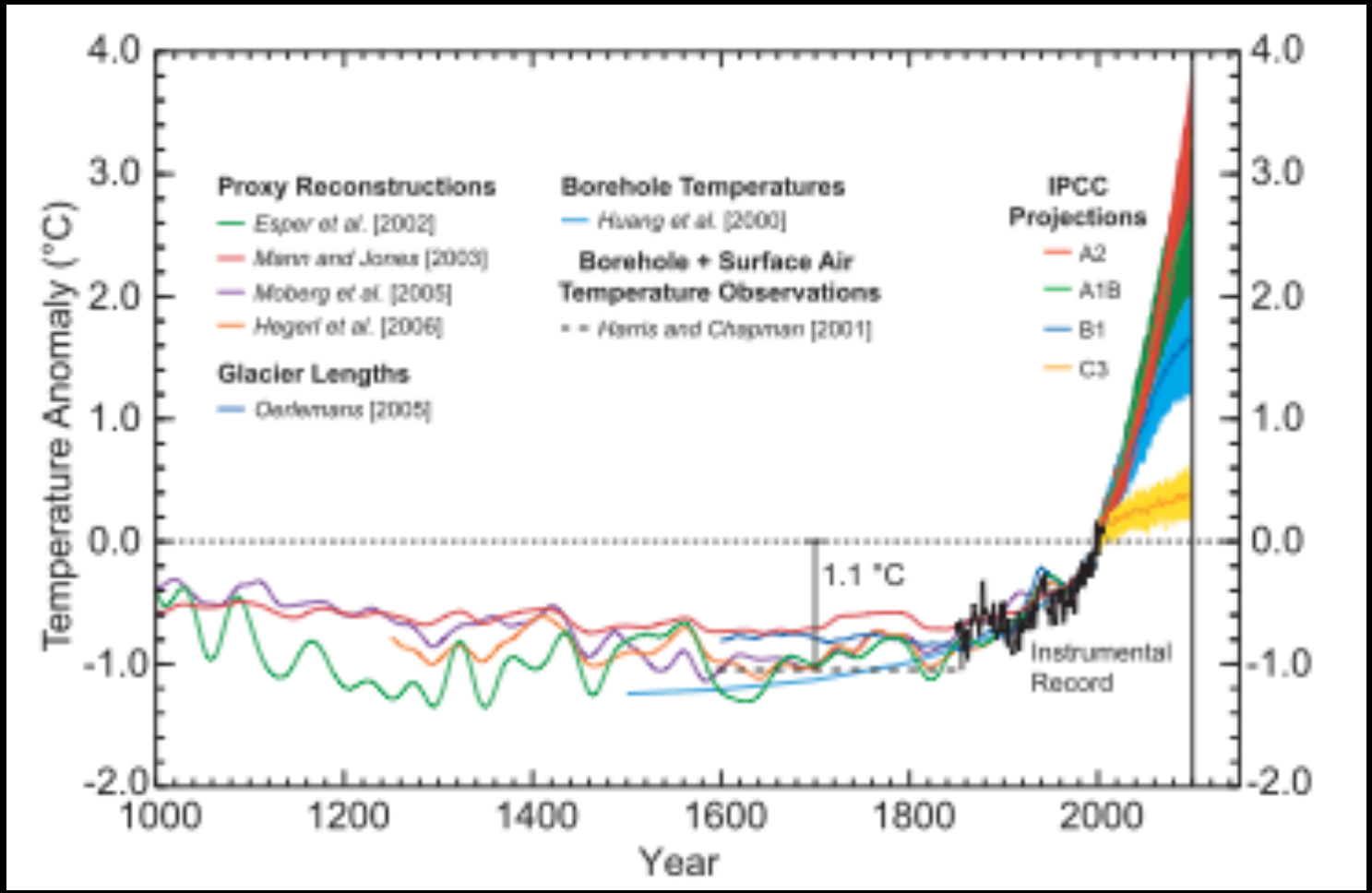
Source: J. Meehl (NCAR)

Where are we?

Lake Ice Is Retreating



Human civilization flourished in an era of stable climate



Climate destabilization has international policy implications

August 9, 2009

Climate Change Seen as Threat to U.S. Security

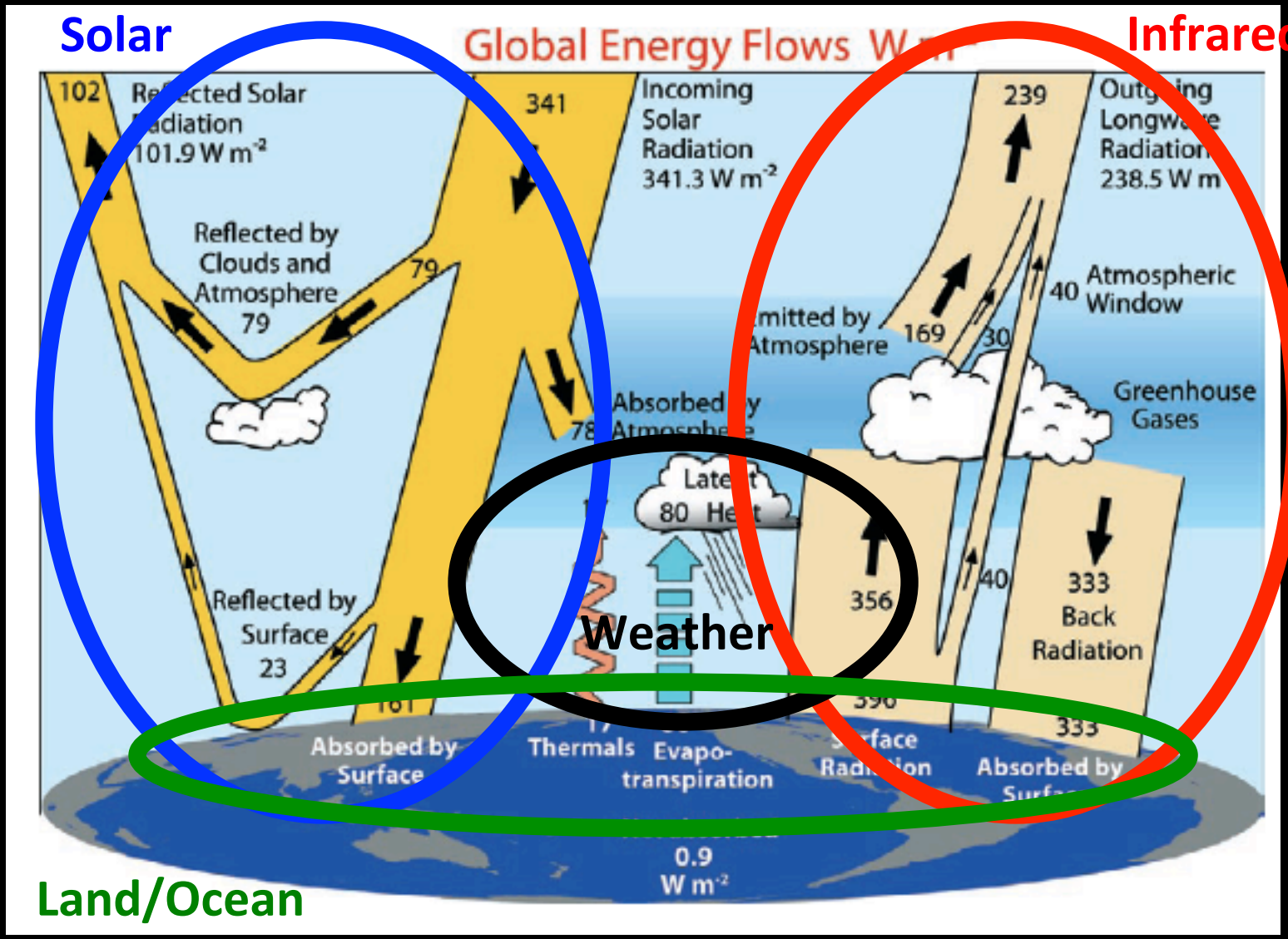
By JOHN M. BRODER

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

Canada will announce next month that it will formally withdraw from the Kyoto Protocol

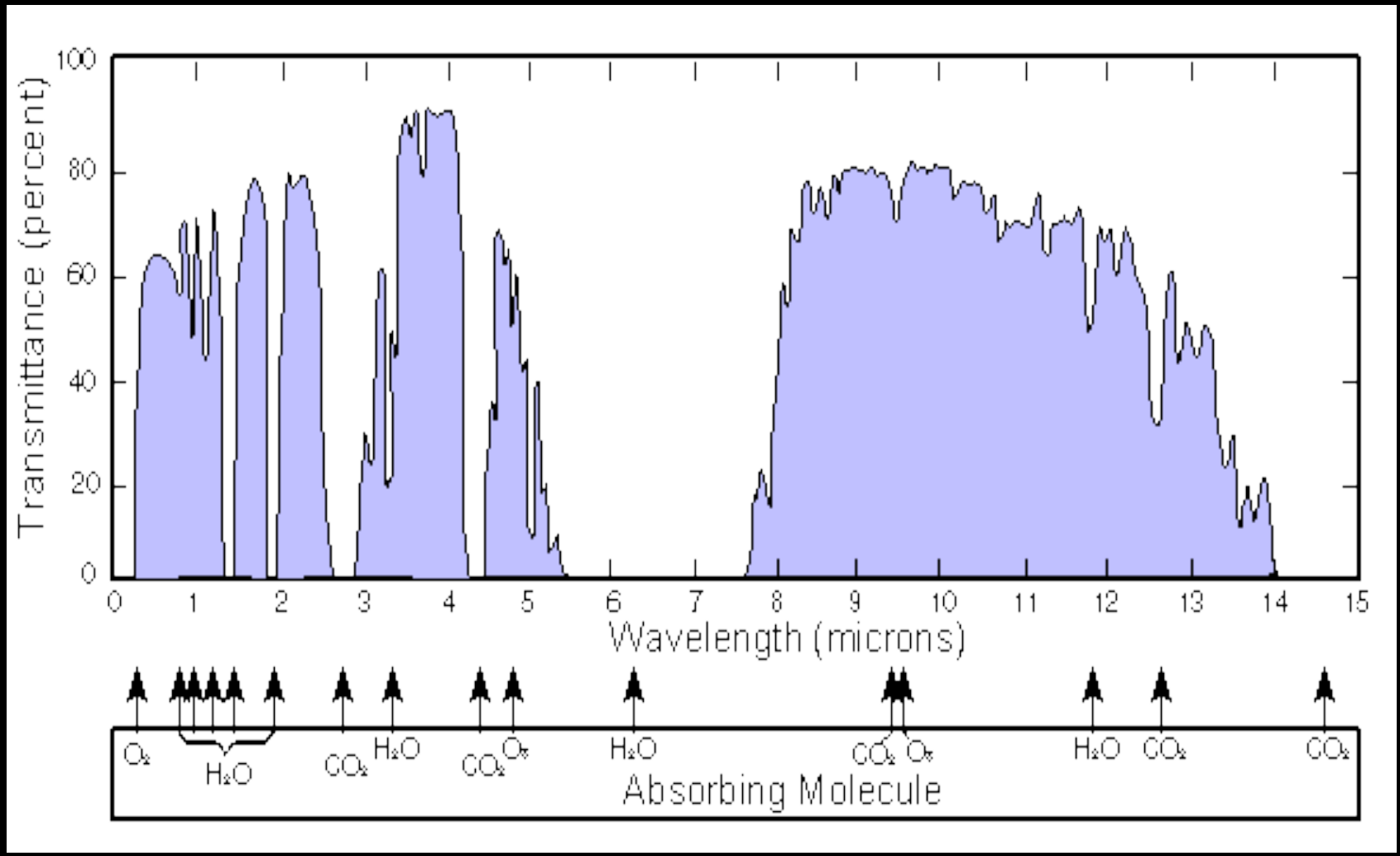
Durban: Europe Finally Abandons Unilateral Climate Policy

Greenhouse gases change Earth's radiation balance

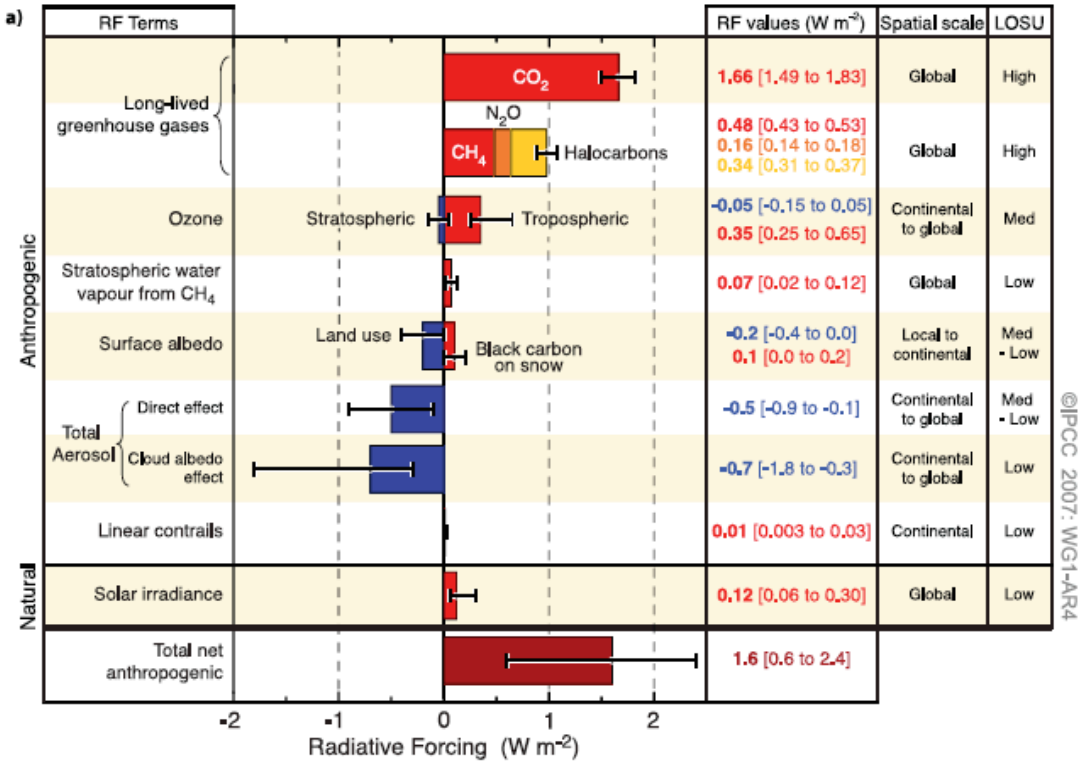


Trenberth et al. (2009)

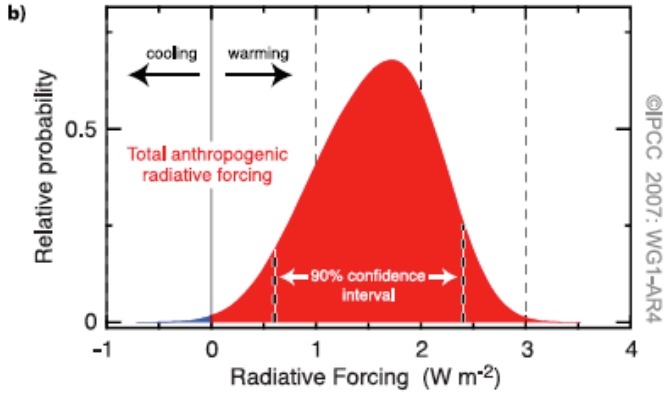
Greenhouse gases “smudge” the “window”



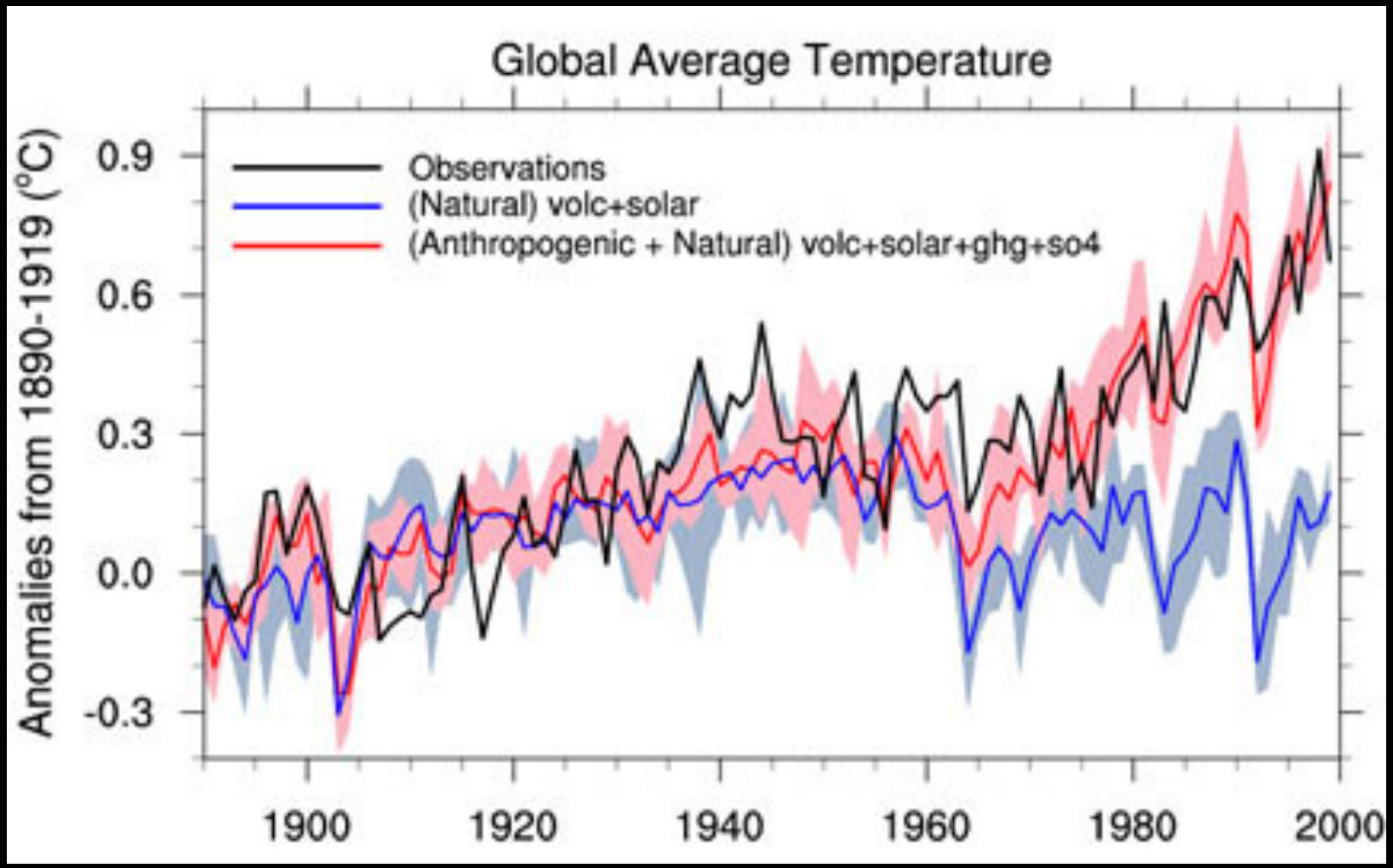
Global Mean Radiative Forcings



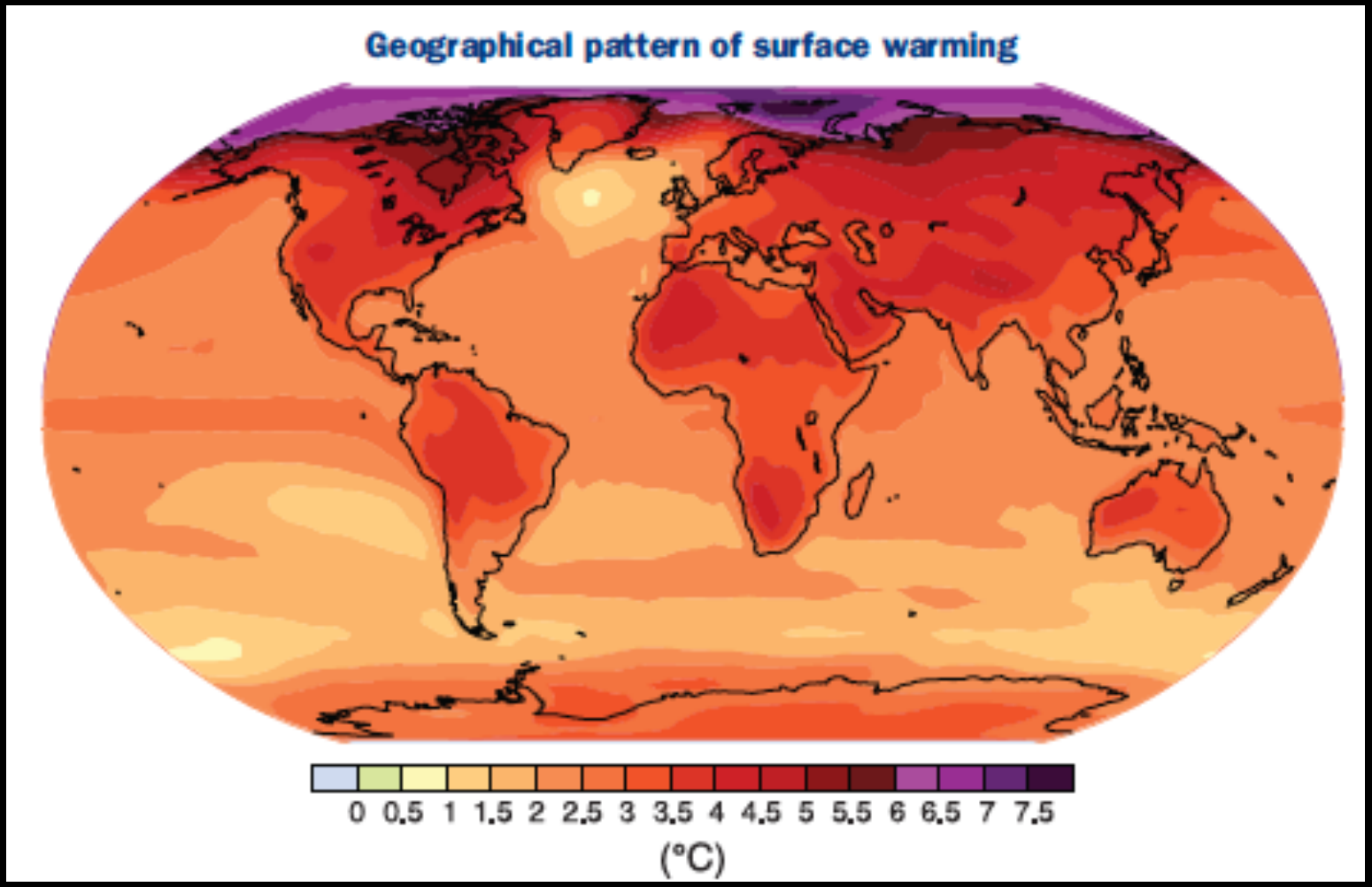
Probability Distribution



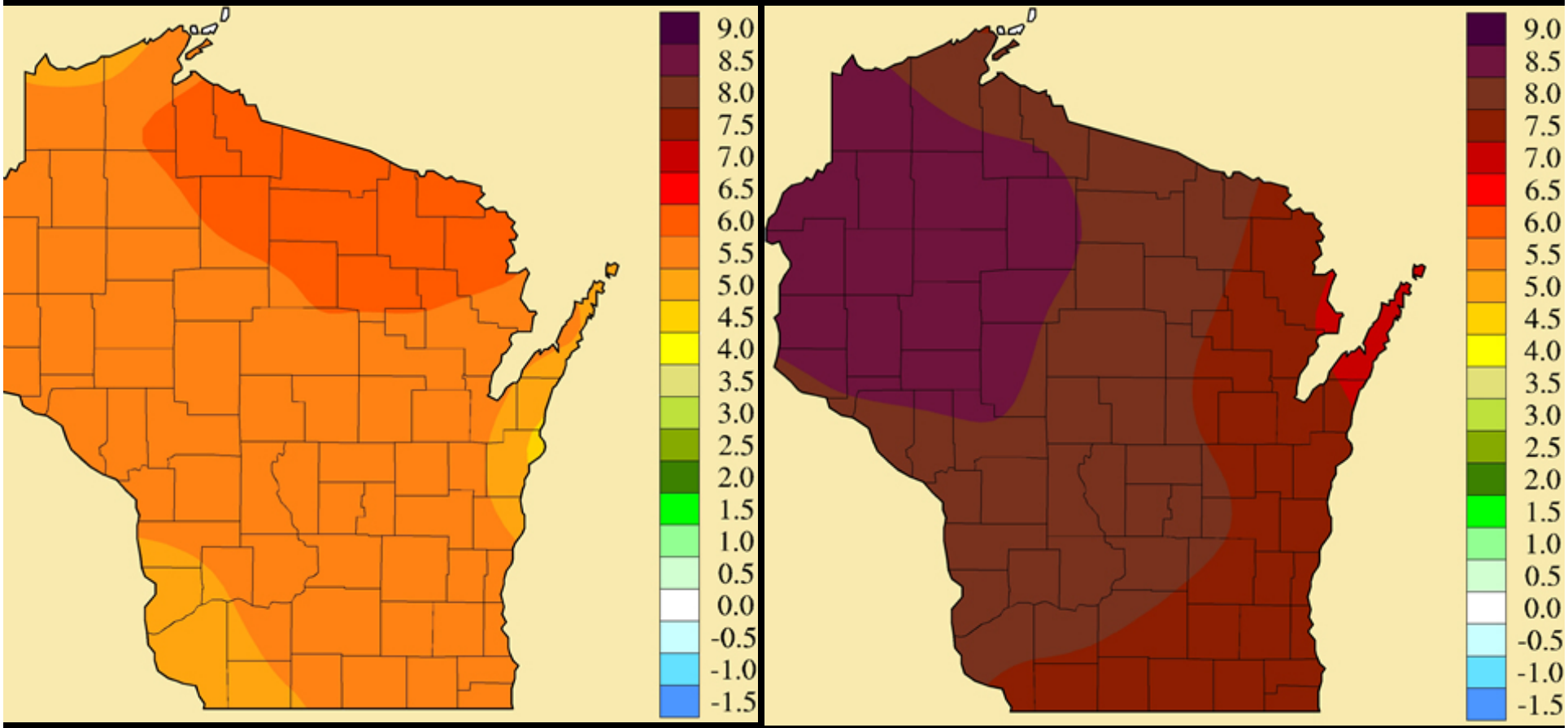
Models require anthropogenic climate change to replicate modern climate



Warming is not equal in all areas

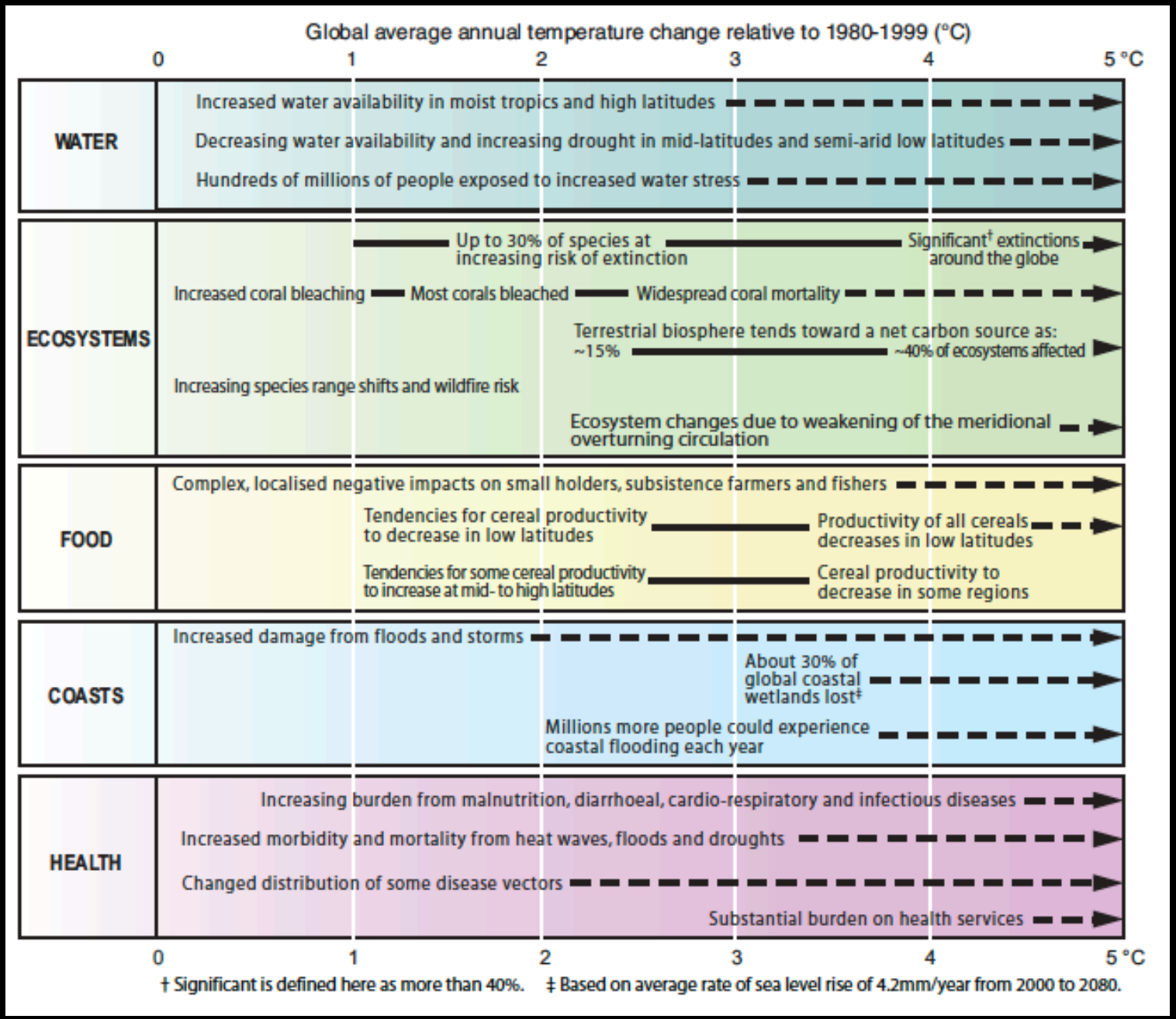


Or in all seasons!



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

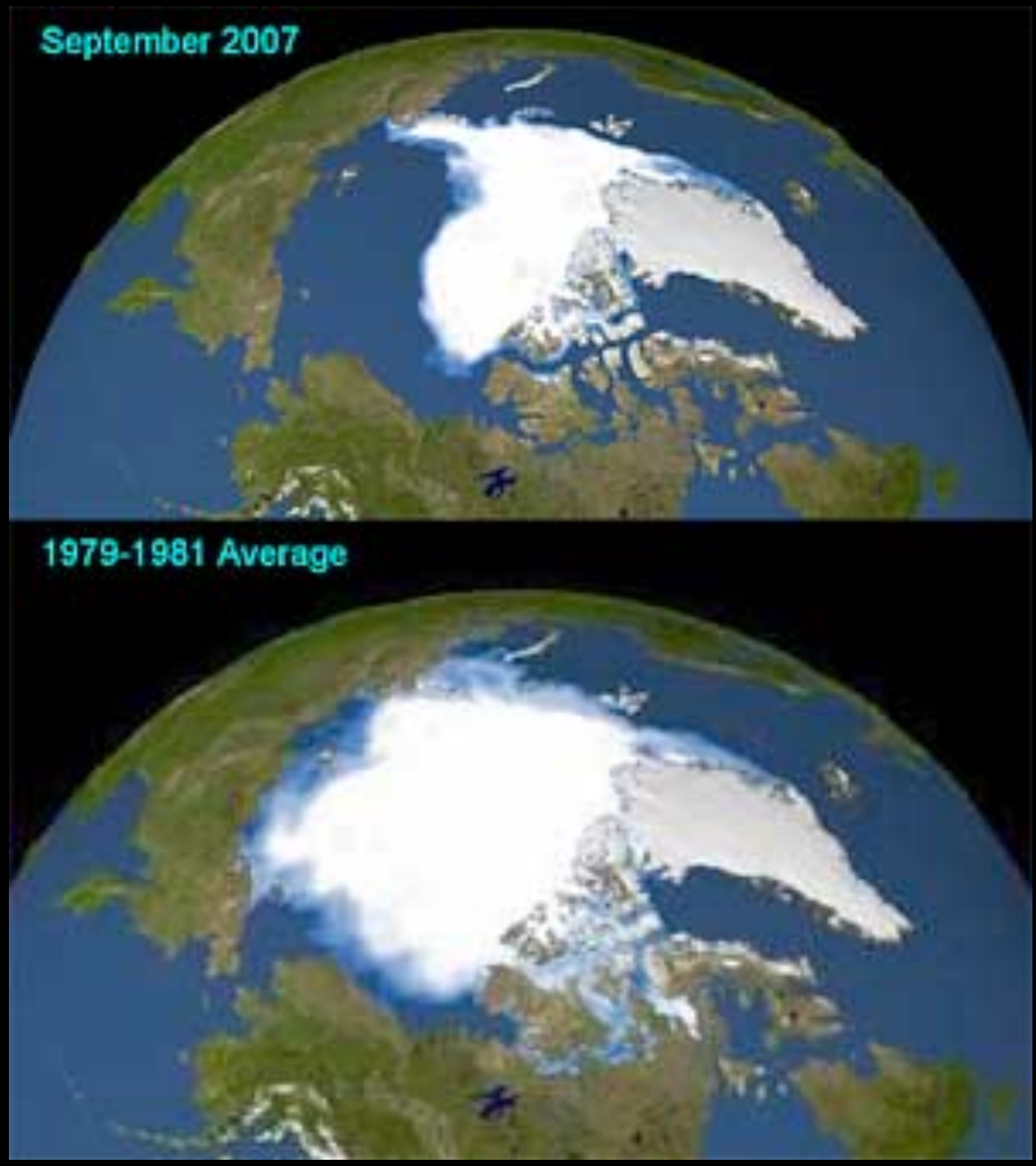
Where are we?

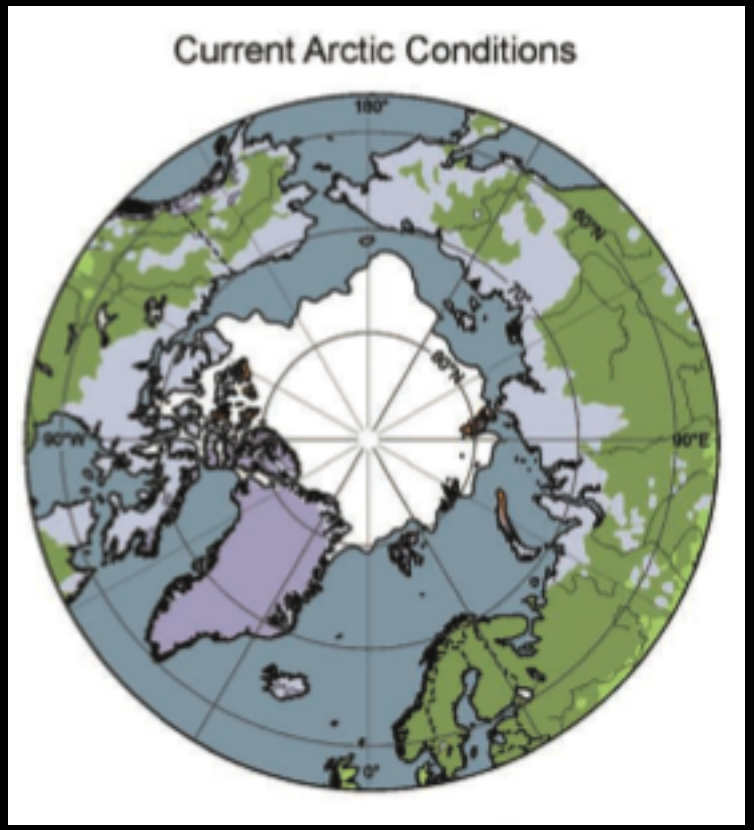
Source: NYTimes

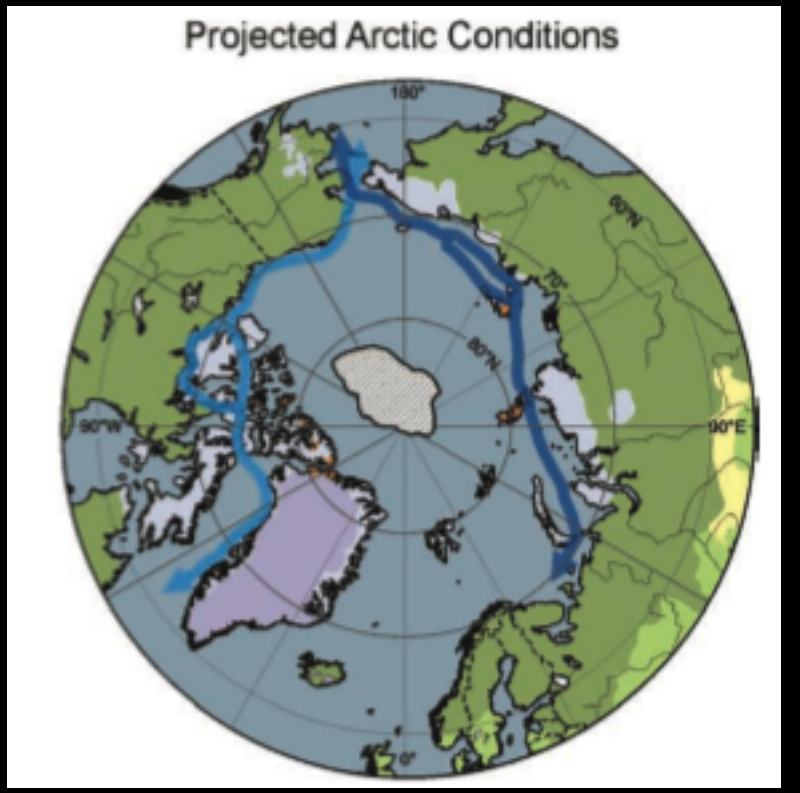
Holgate Glacier, Alaska

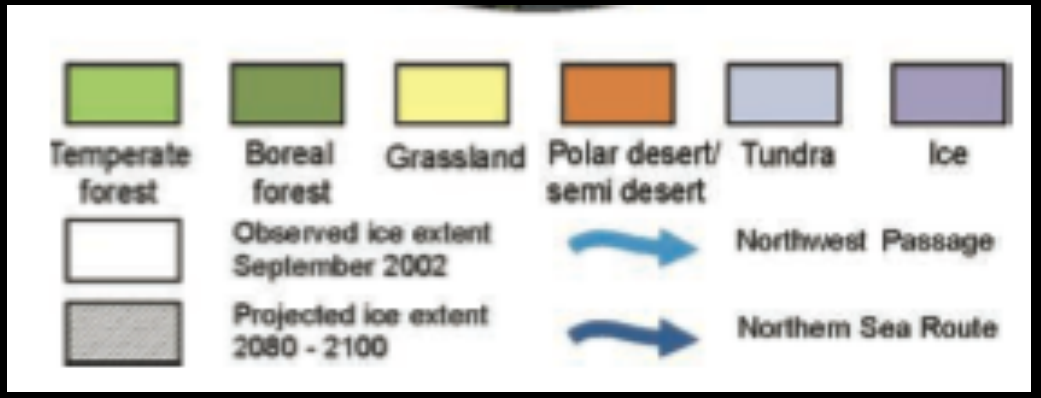
Online glacier photograph database. Boulder, CO: National Snow and Ice Data Center/World Data Center for Glaciology. Digital media.

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


September 2007
1979-1981 Average

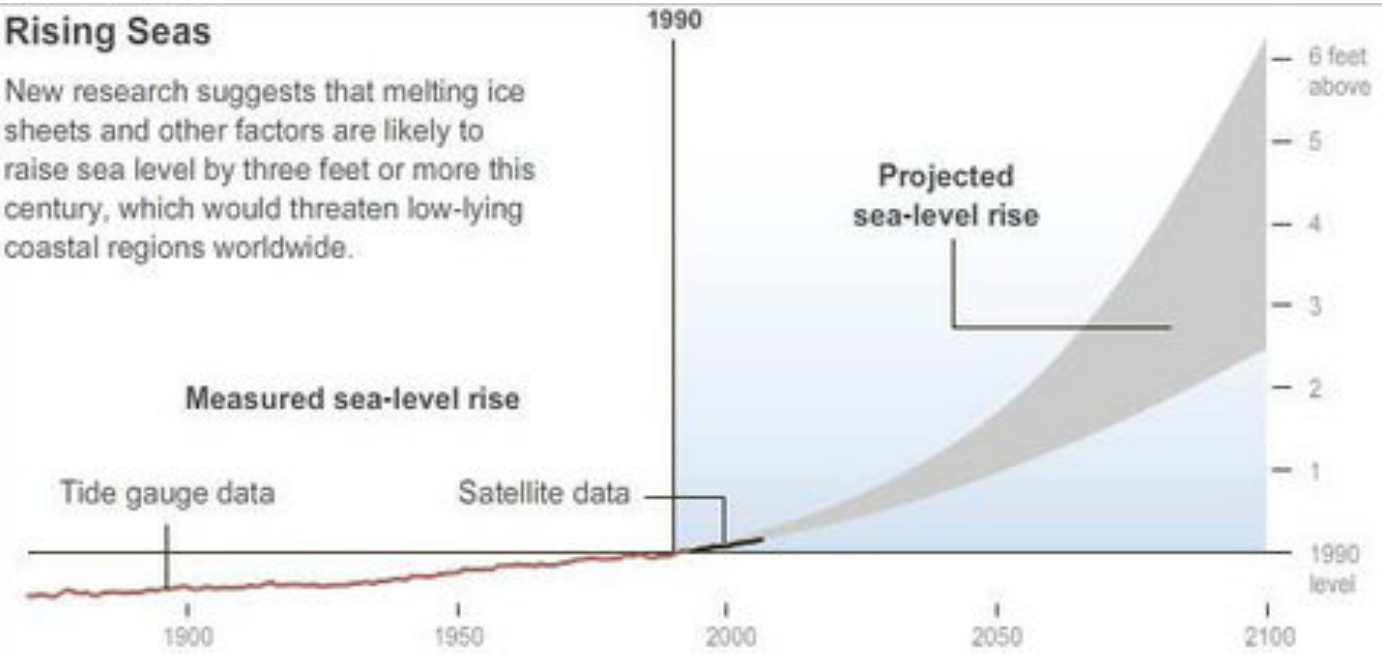

Current Arctic Conditions
180°
60°N
70°
80°N
90°W
90°E
0°


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

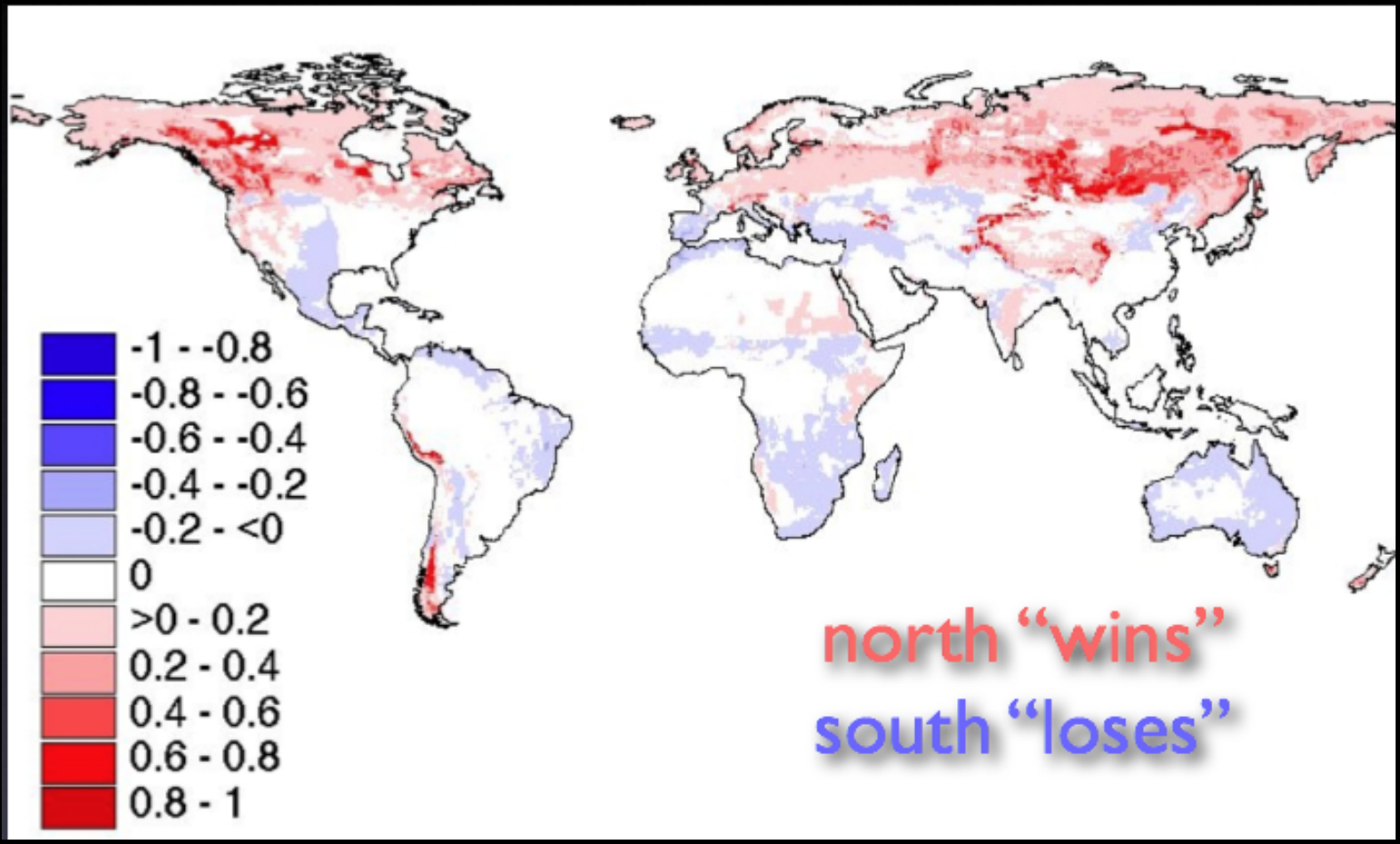


Vulnerable Areas

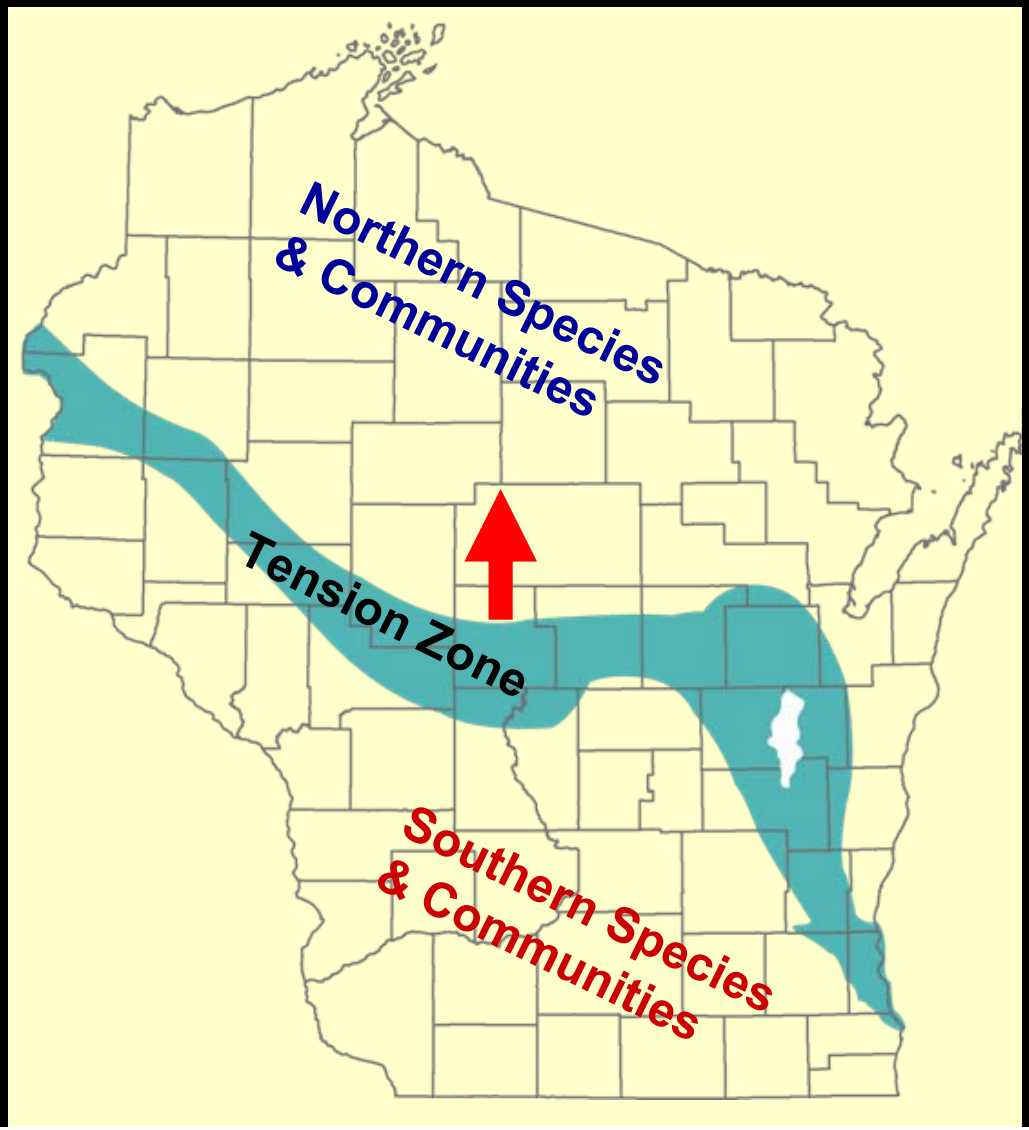
Low-lying areas in Louisiana, Florida and southern Asia are especially vulnerable, and some coastal cities like New York and San Francisco also face threats along their shorelines.

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

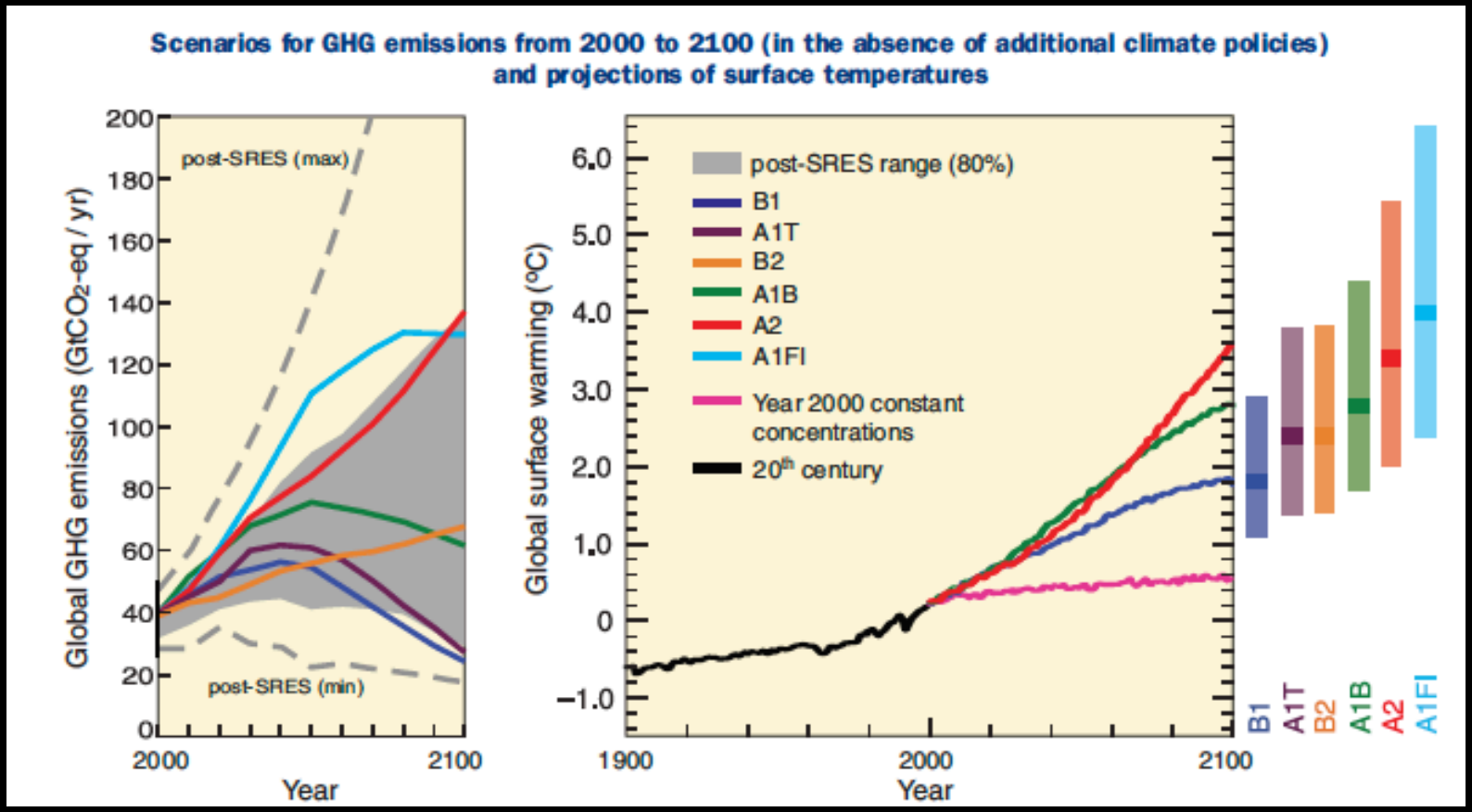


Wisconsin's tension zone moves north

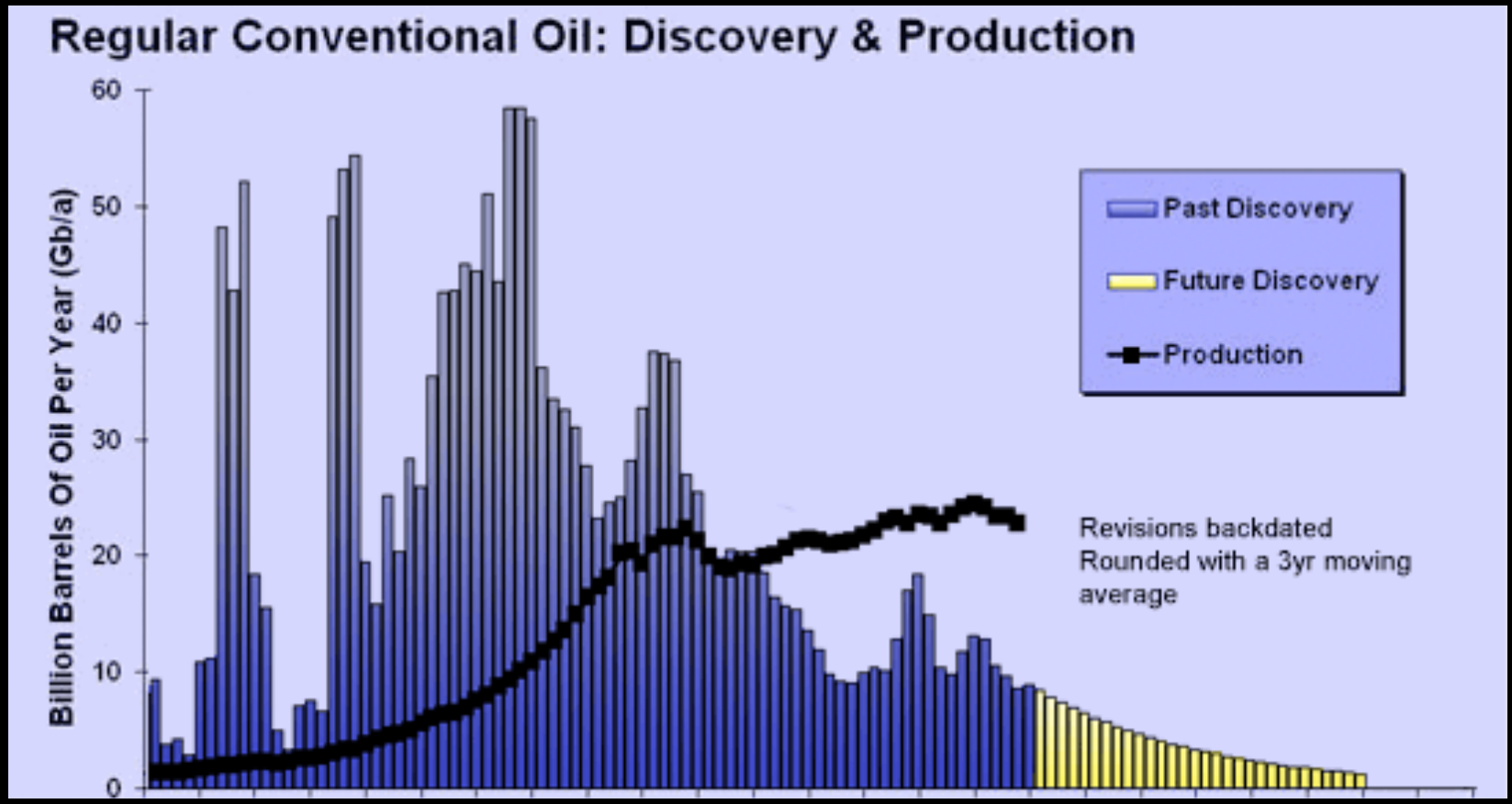


Coastal areas have to adapt

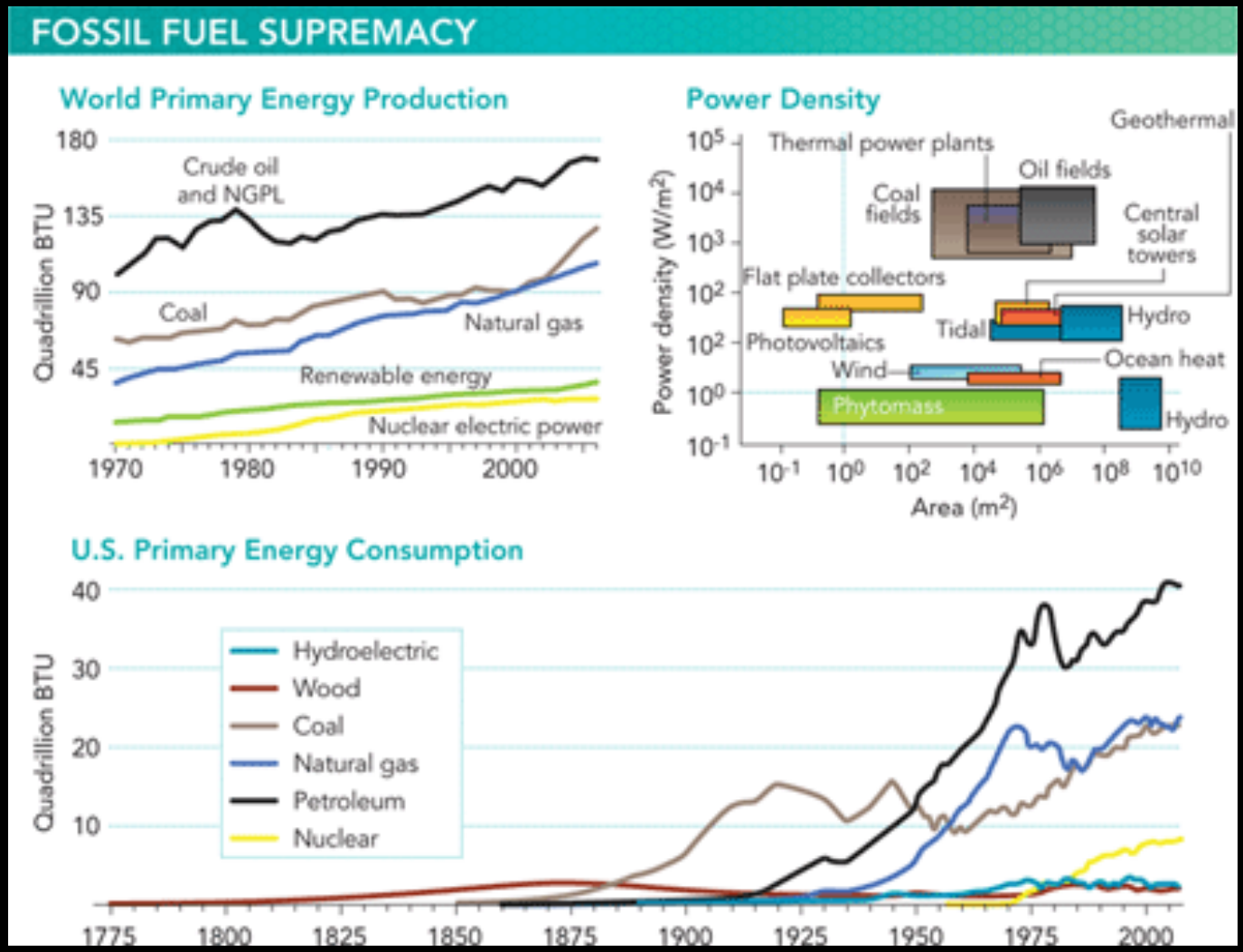
Human behavior is the largest uncertainty in climate projections



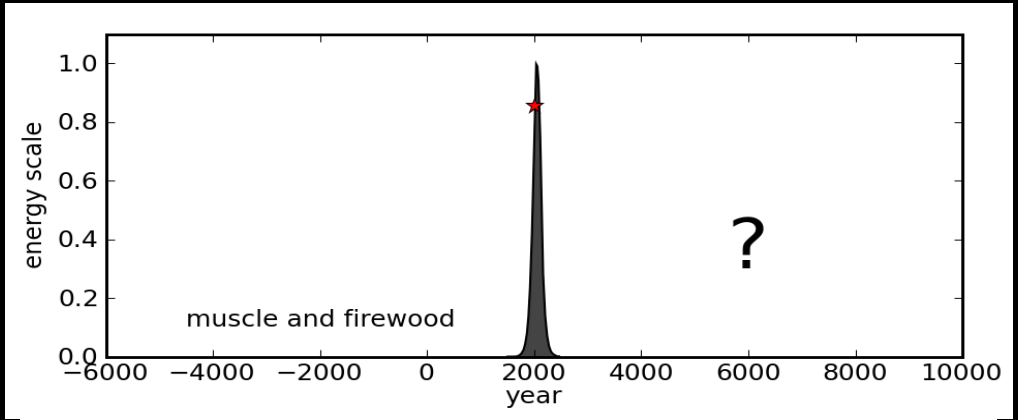
Are we running out of oil?

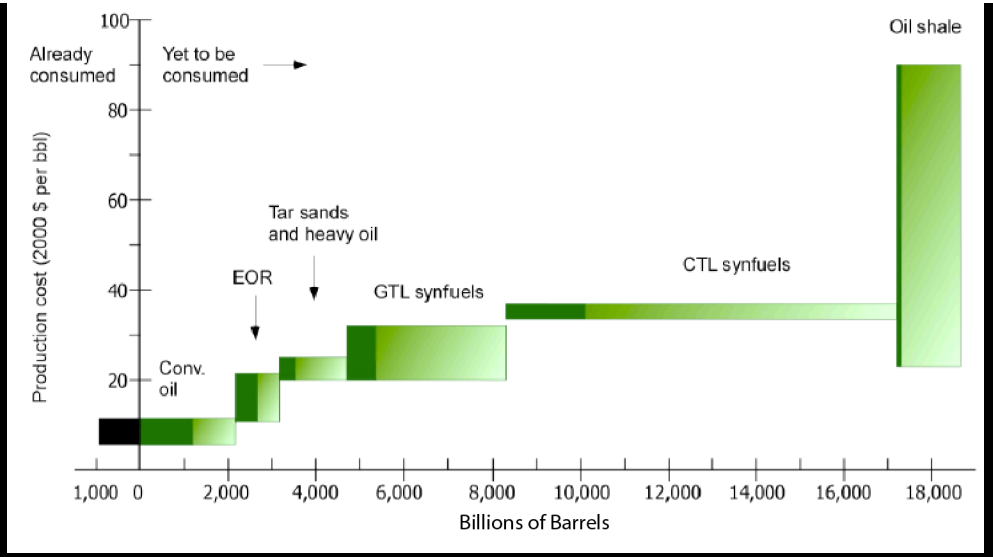


We Are Not Running Out of Fossil Fuels



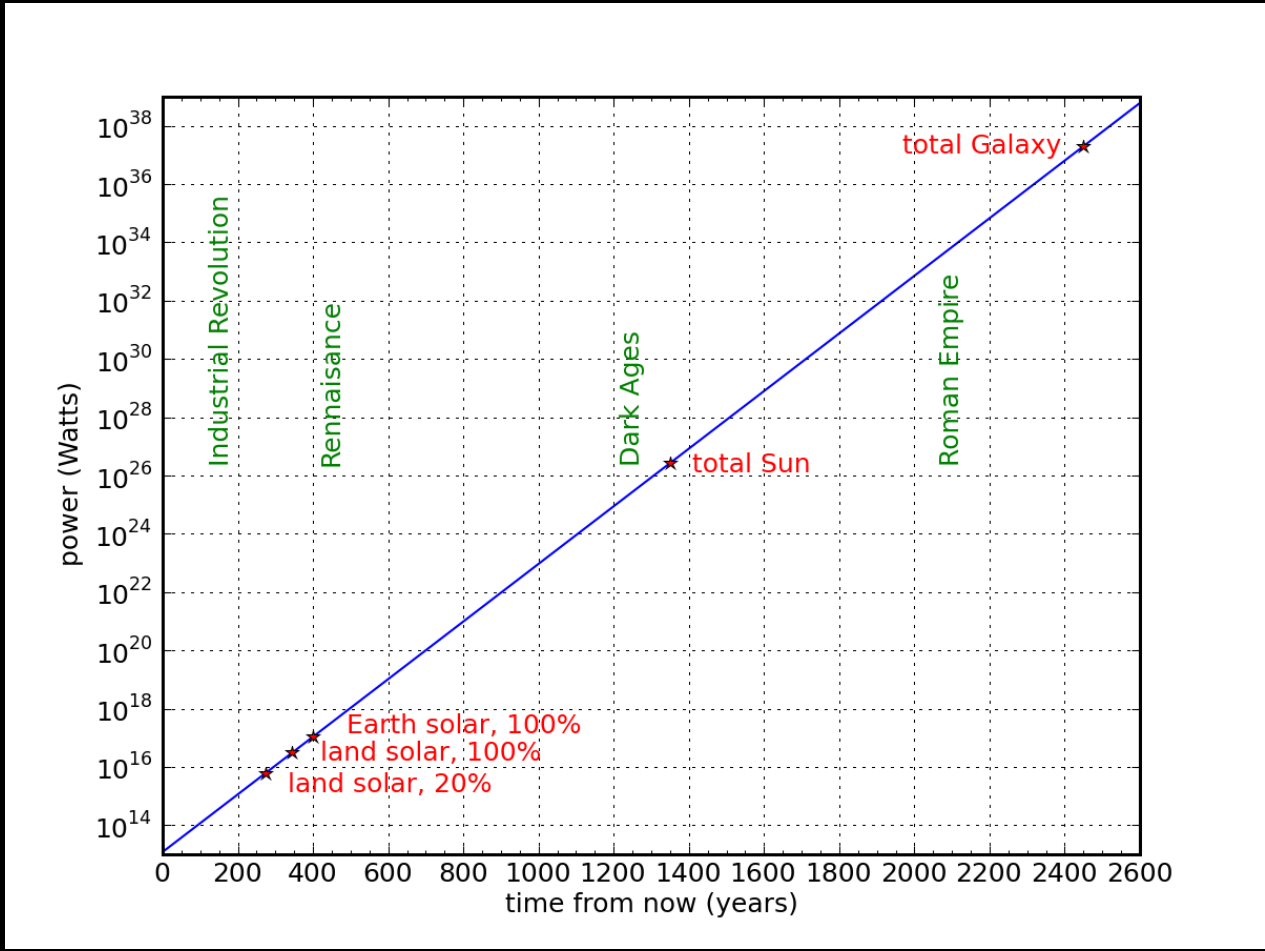
Not immediately anyway





Souce: http://physics.ucsd.edu/do-the-math/

But we can't continue on an energy growth path forever



Souce: http://physics.ucsd.edu/do-the-math/

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)

Psst…

10 billion tons C = 18,000 Gulf Oil spills per day

Embargoed to 6pm GMT (1pm US Eastern) on Sunday December 4 2011

Global carbon emissions reach record 10 billion tonnes - threatening two degree target

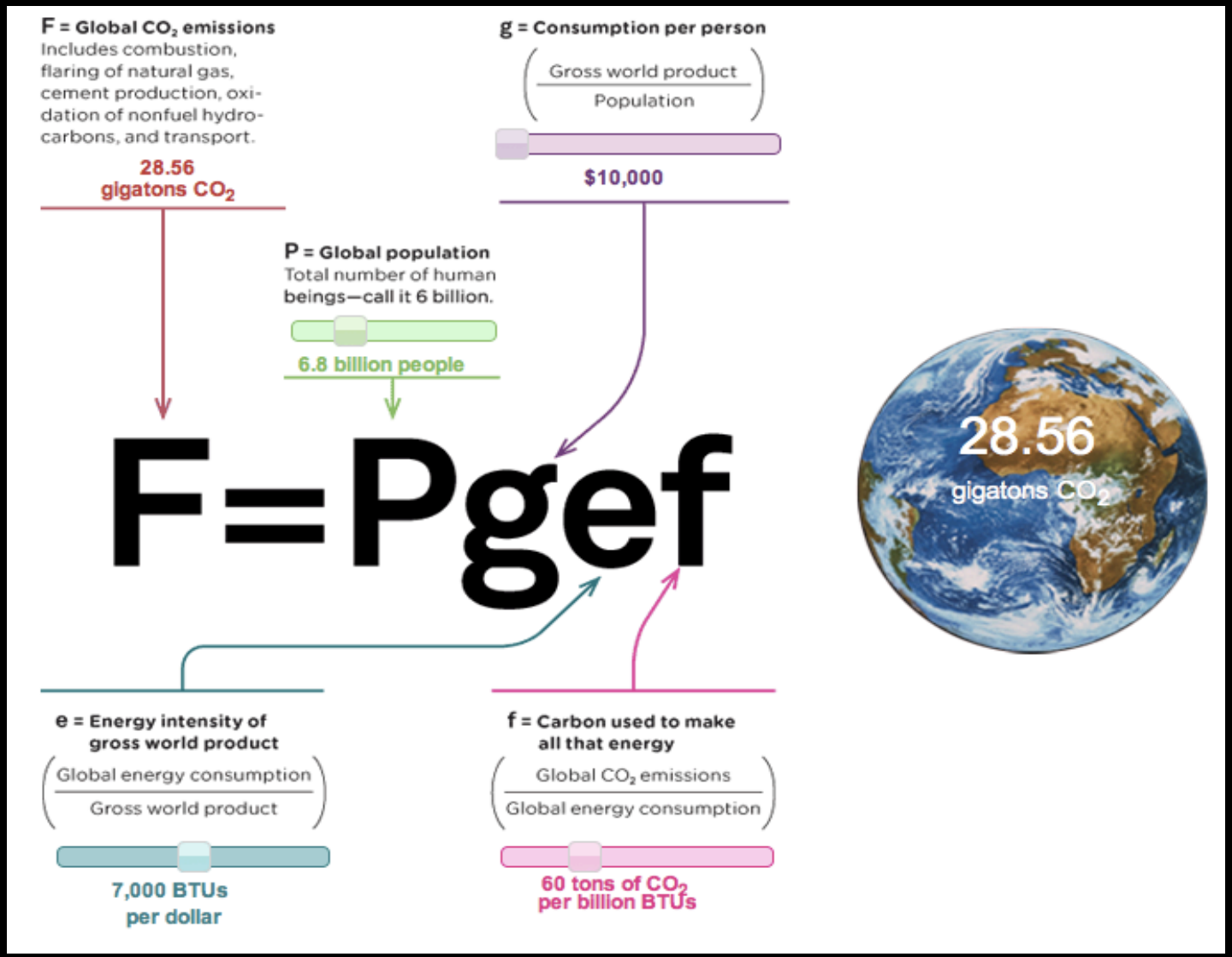
Global carbon dioxide emissions from burning fossil fuels have increased by 49 per cent in the last two decades, according to the latest figures by an international team, including researchers at the Tyndall Centre for Climate Change Research, University of East Anglia (UEA).

Total emissions - which combine fossil fuel combustion, cement production, deforestation and other land use emissions - reached 10 billion tonnes of carbon1 in 2010 for the first time. Half of the emissions remained in the atmosphere, where CO2 concentration reached 389.6 parts per million. The remaining emissions were taken up by the ocean and land reservoirs, in approximately equal proportions.

Rebounding from the global financial crisis of 2008-09 when emissions temporarily decreased, last year's high growth was caused by both emerging and developed economies. Rich countries continued to outsource part of their emissions to emerging economies through international trade.

Contributions to global emissions growth in 2010 were largest from China, the United States, India, the Russian Federation and the European Union. Emissions from the trade of goods and services produced in emerging economies but consumed in the West increased from 2.5 per cent of the share of rich countries in 1990 to 16 per cent in 2010.

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

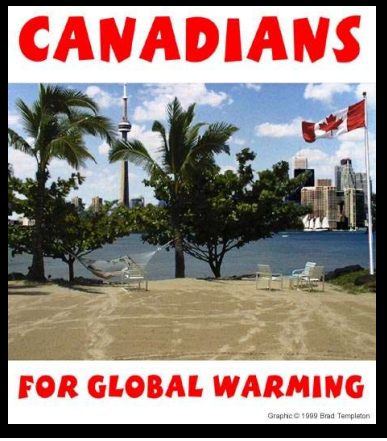


Which country has:

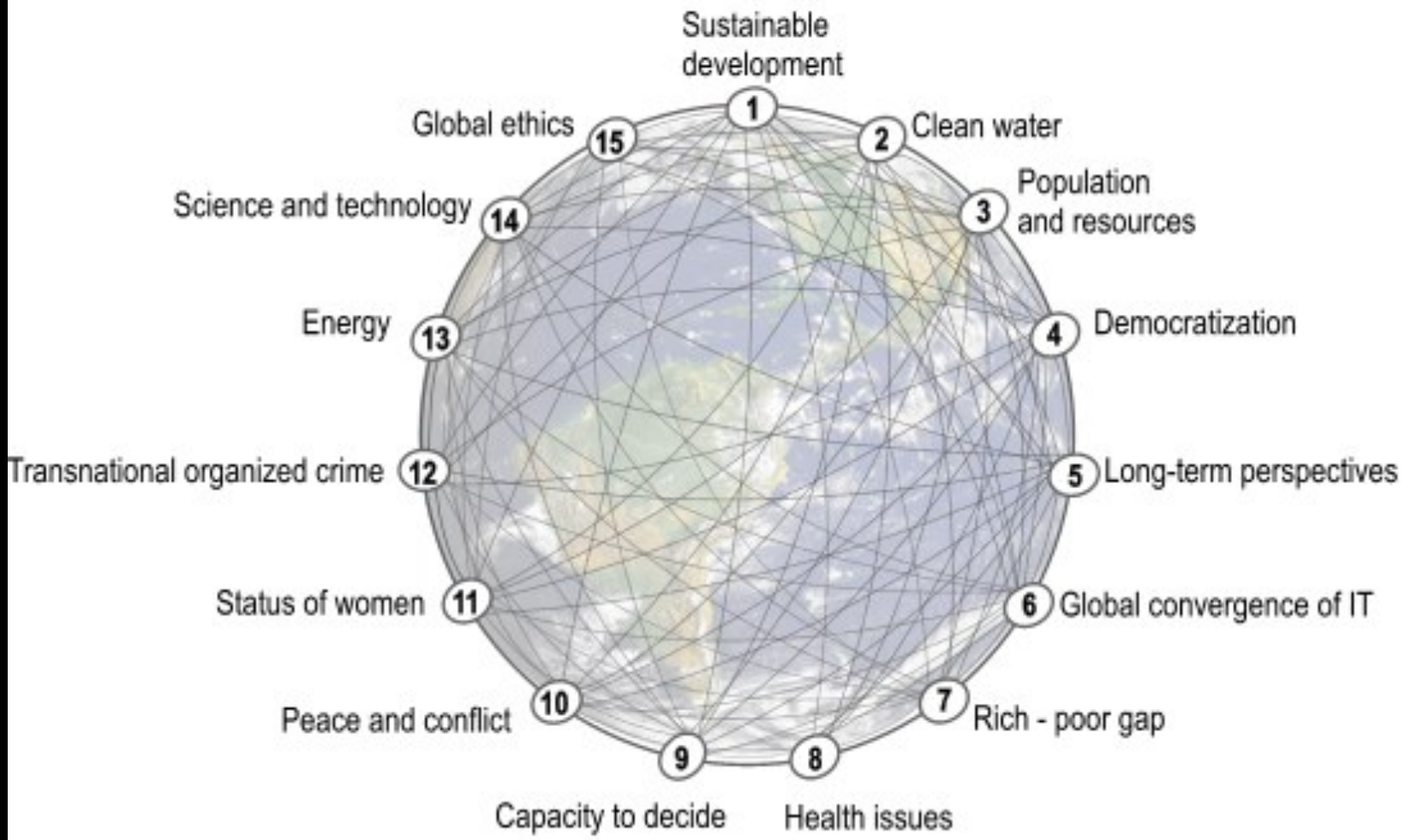
- The world's largest high speed rail network, soon to eclipse in mileage the total of the rest of world's?
- The highest efficiency coal plants?
- 30 nuclear power plants under construction?
- Current production of 5 million alternative energy vehicles?
- The fastest rate of wind power installation and home of 3 of the 10 largest wind turbine manufacturers?
- Manufacturing capacity of 40% of world's solar PV systems?
- 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



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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?