Climate Change and Health:

Concepts, Measures and Processes

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Training on Climate Change Related Health Impacts
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Overview

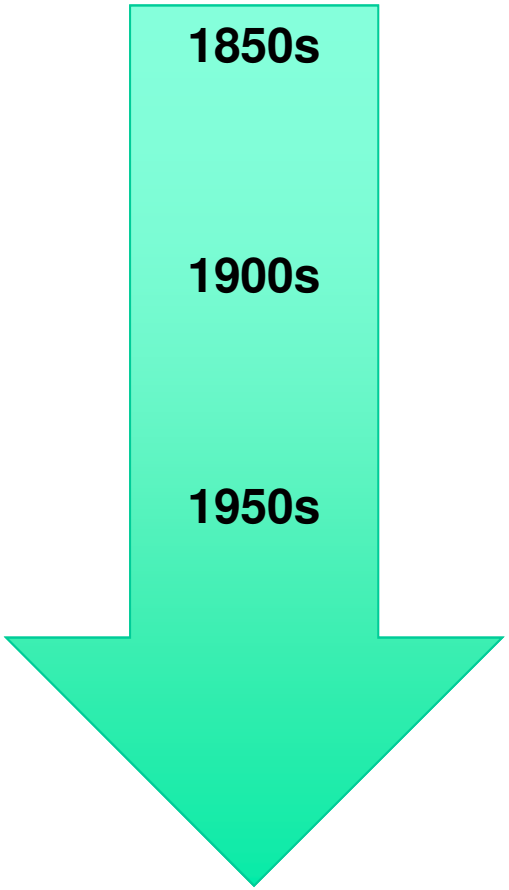
- Introduction to global environmental change
- Definitions: weather, climate, climate change
- Discuss evidence that humans are influencing the climate
- Characterize some changes that have occurred
- Explore likely climate change scenarios for future

Historical Perspective

- Over past 10,000 years, humans have altered their environment
  - Leading to increased population size, improved living conditions, and increased life expectancy
- Last 150+ years, gains in population health from increasing:
  - Access to safe water and sanitation
  - Food security
  - Access to simple medical care
  - Education and literacy

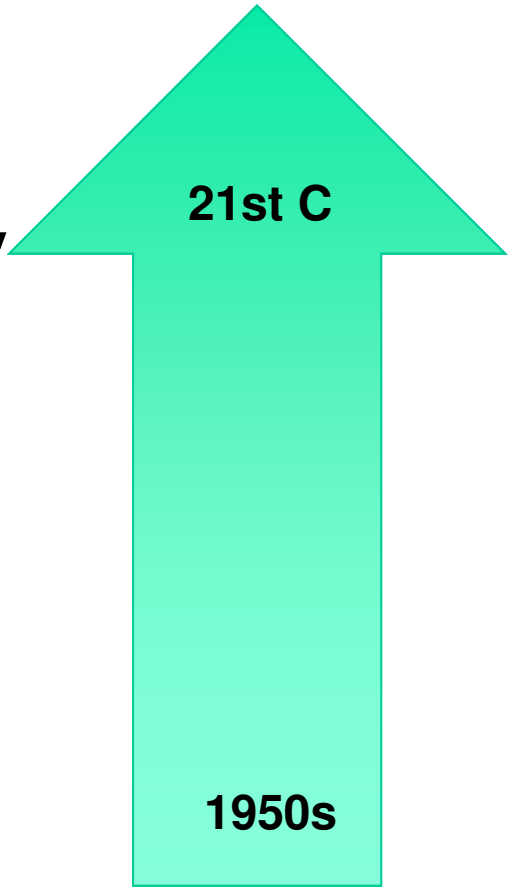
Epidemiology Since ~1850: Changes in Emphasis / Units of Analysis

- Population
  - Germ theory
  - Micronutrients
- Sub-groups
  - Occupational risks
- Individuals
  - Non-infectious diseases
  - Individual risk factors
  - Genetics and epigenetics



Epidemiology Since ~1950: Changes in Emphasis / Units of Analysis

- Social Epidemiology
  - Population patterns
  - Lifecourse, complex etiology
- Complex Regional Factors
  - Environment, land use
- Individuals
  - Non-infectious diseases
  - Individual risk factors
  - Genetics and epigenetics



21st Century

- Risks populations face have become more complex, larger scale, and potentially more devastating
- Global environmental changes require that environmental epidemiology consider current and future health risks due to changes in climate, food systems, water resources, and other factors

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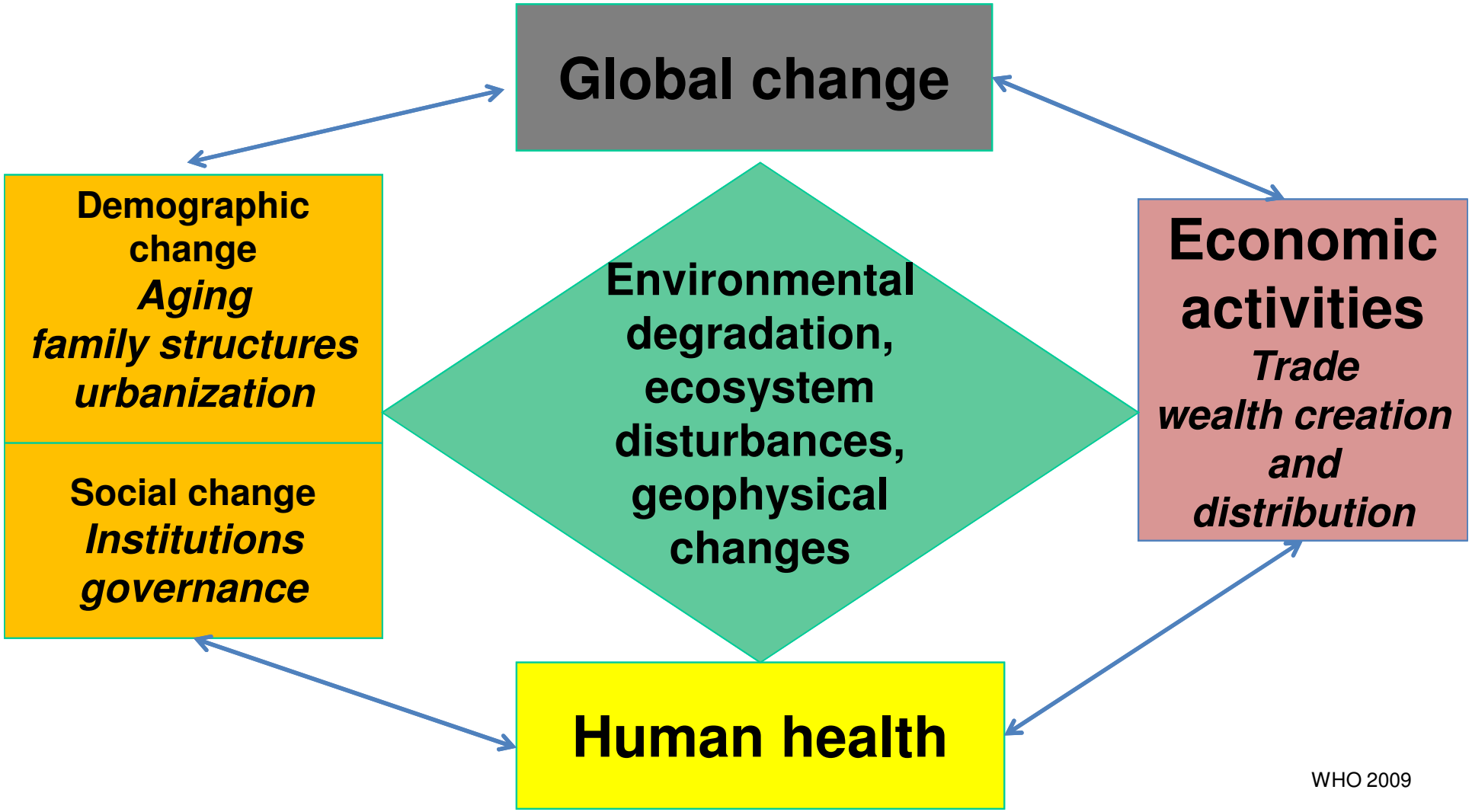
Global Change Involves Many Factors

- Population
- Climate
- Economy
- Resource use
- Energy development
- Transportation
- Communication
- Land use / land cover
- Urbanization
- Globalization
- Atmospheric circulation
- Ocean circulation
- Carbon, nitrogen, water and other cycles
- Sea ice loss
- Sea-level rise
- Food webs
- Pollution
- Over fishing
- Biological diversity
- Health

Pathways from Global Change to Human Health



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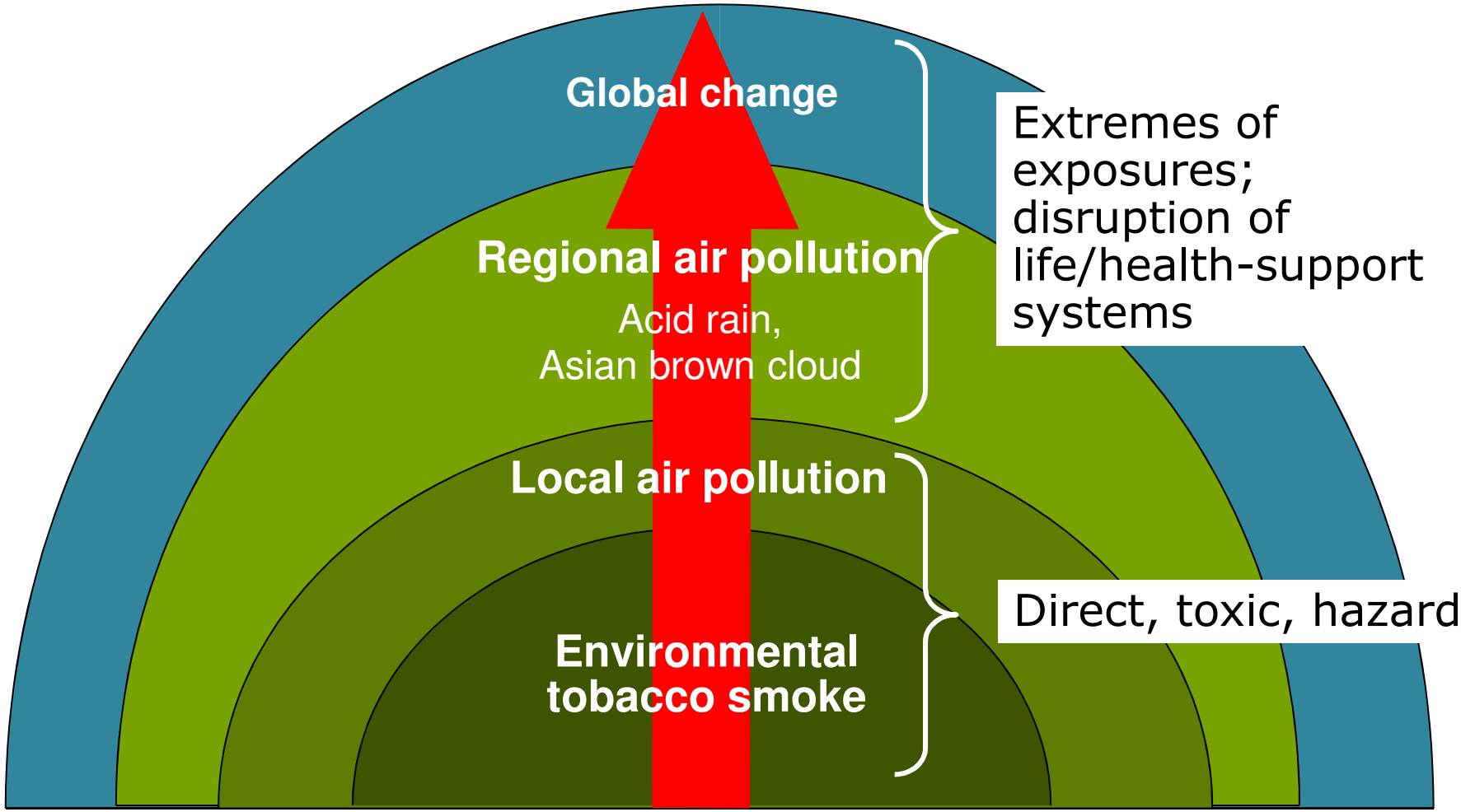
Ecosystem Services and Human Health

- Regeneration of fertile land → food
- Viable fisheries → food
- Wetlands: flood storage, cleansing of surface water
- Nutrient recycling (nitrogen, phosphorus, etc.)
- Intact ecosystems: control of infectious disease vectors (mosquitoes, ticks, rodents)
- Buffering against environmental stressors (protection by forests and reefs against cyclones, storm surges, and droughts)
- Source of medicinals
- Support/inspiration for aesthetic/spiritual values

What is Different About Studying the Health Impacts of Global Change?

- Temporal and spatial scale issues
- Not a discrete exposure
- Everyone is exposed – but not all equally
- Exposures will increase over coming decades
  - Risks will increase with increasing exposures
- Impacts operate through a wide range of pathways

Scale and Type of Environmental Health Risks



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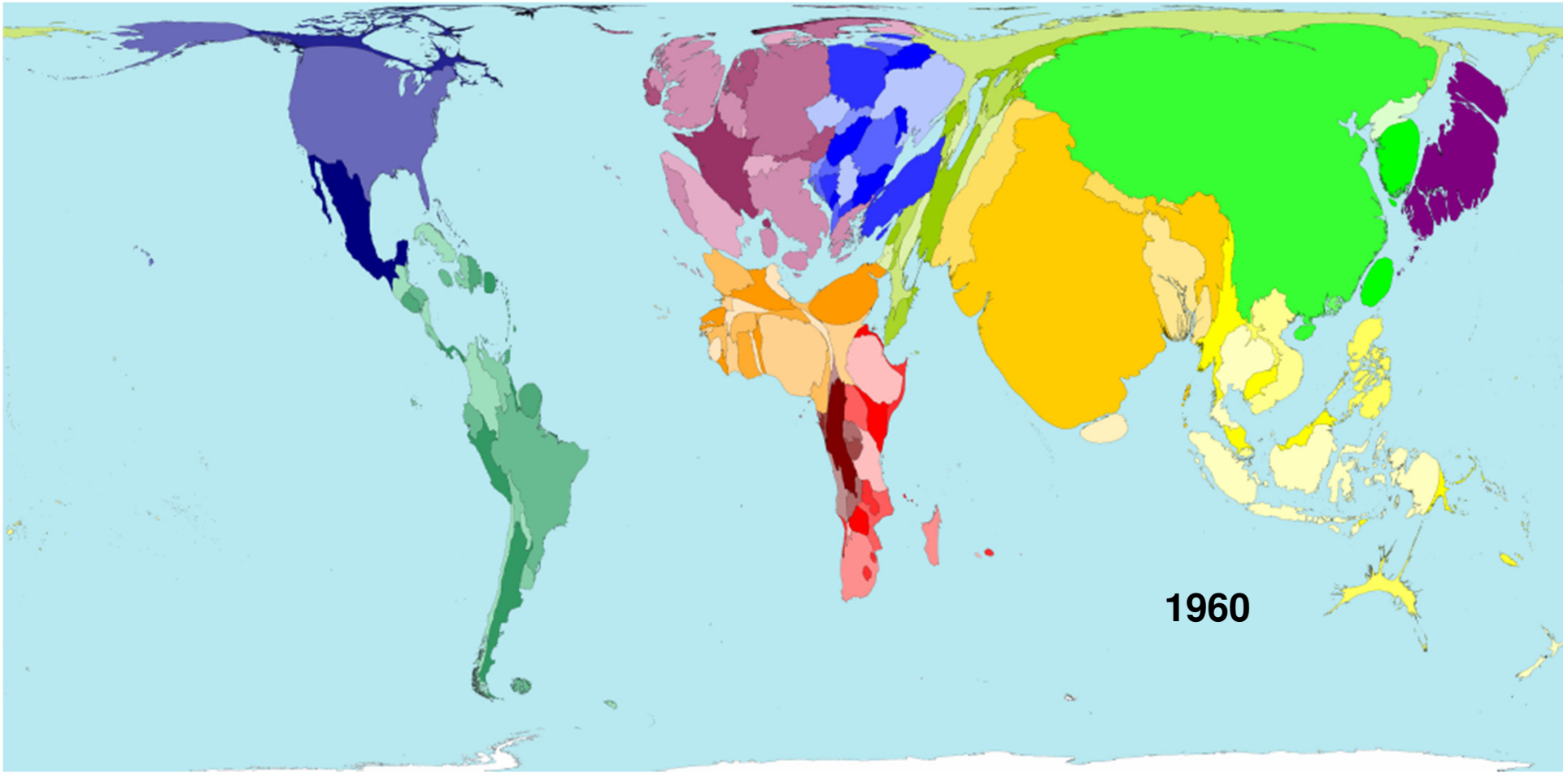
Not Only is Environment Changing

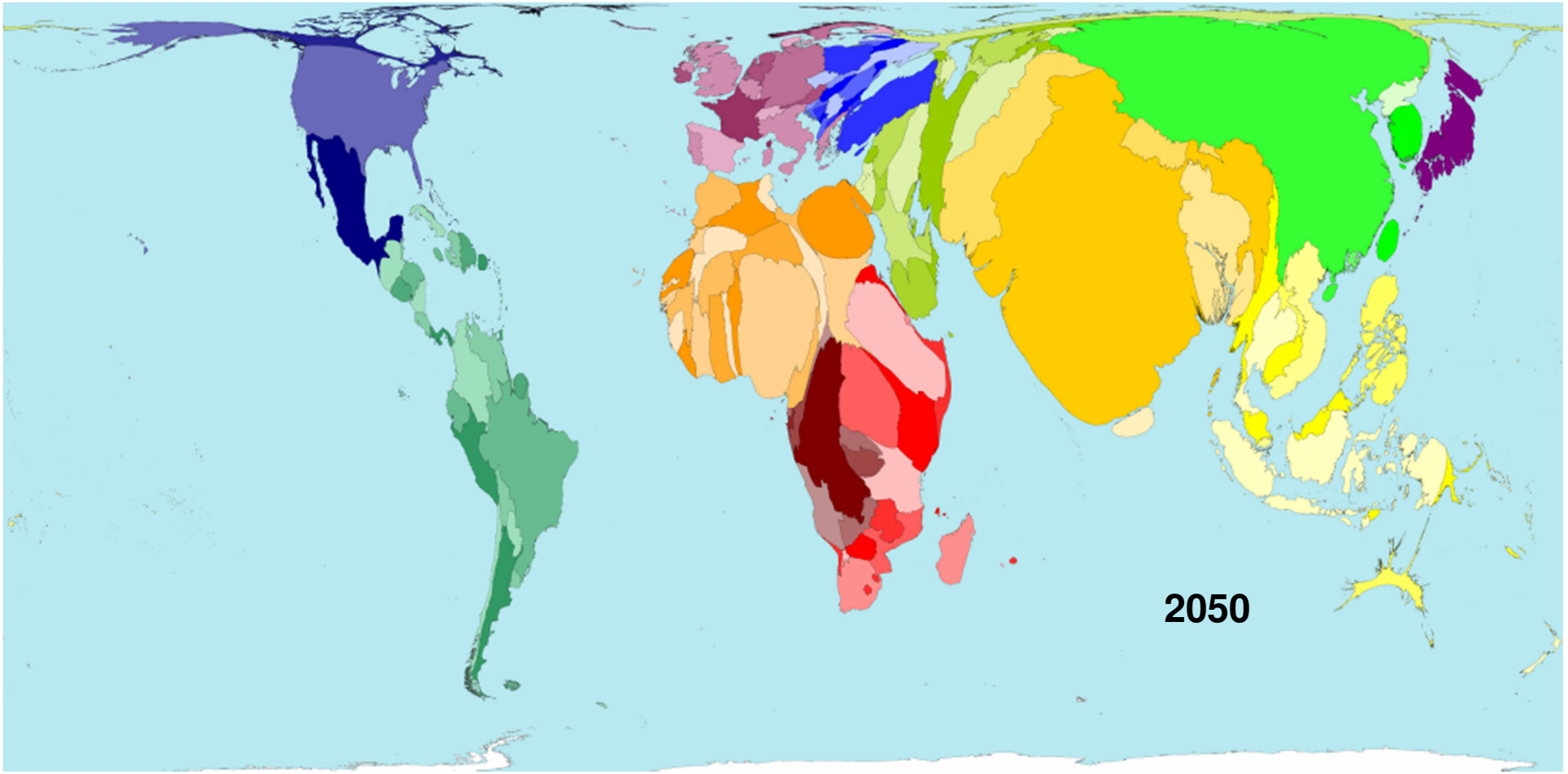
- Worldwide emergence and re-emergence of infectious diseases since 1970s
- Increase in obesity and diabetes
- Trade and travel increasing transport of lifestyles, infectious people, hazardous materials, ….
- Export of occupational hazards to low-income countries
- Increasing income inequalities

World Population: 1960



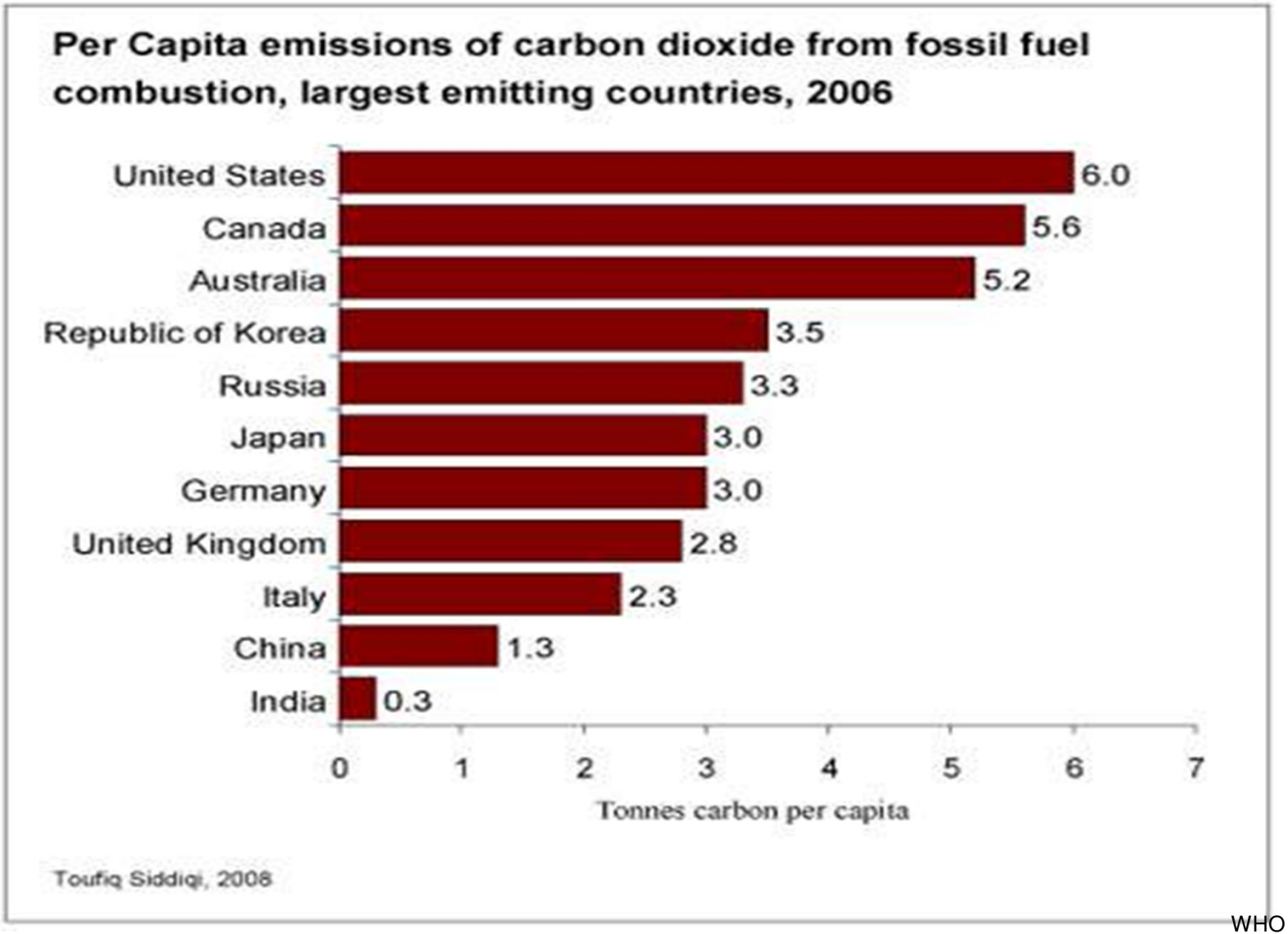
Worldmapper, 2008b, e

World Population: 2050



Worldmapper, 2008b, e

National Carbon Dioxide Emissions



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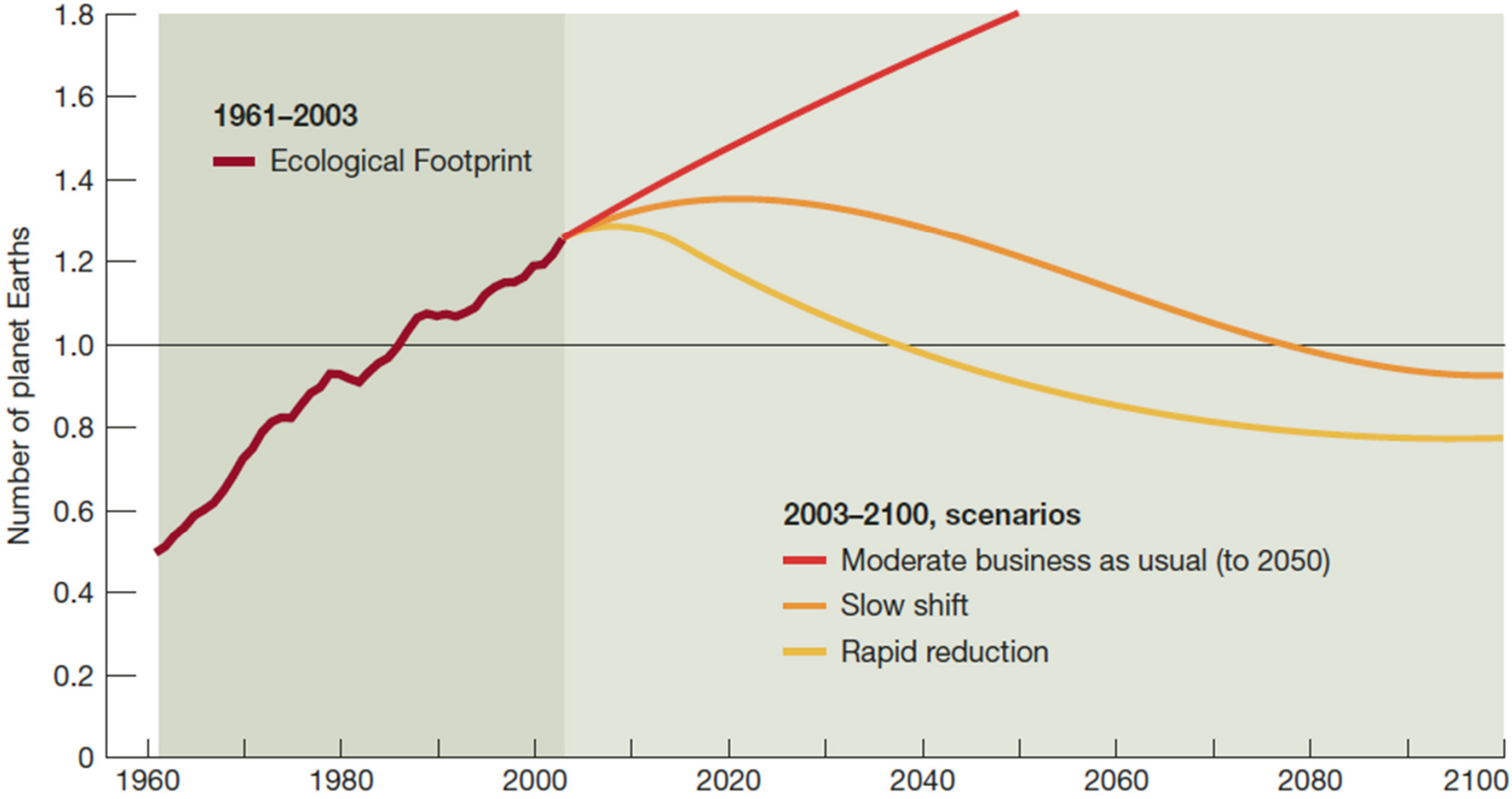
THREE ECOLOGICAL FOOTPRINT SCENARIOS 1961–2100

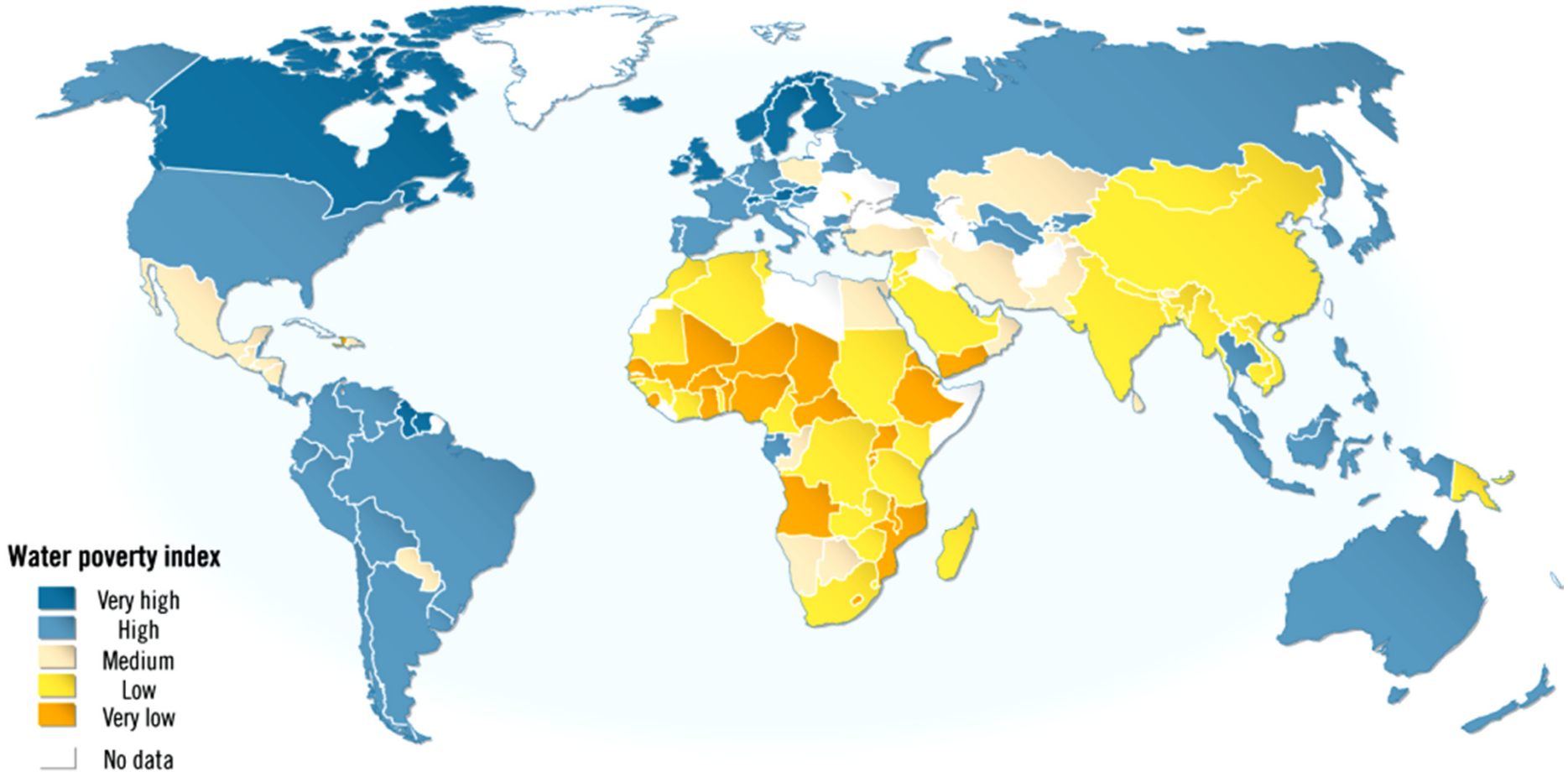


World Wildlife Fund, 2006

Millennium Ecosystem Assessment (2005): Ecosystems and Human Wellbeing

The structure and functioning of the world's ecosystems changed more rapidly in the second half of the twentieth century than over any comparable period in human history. Humans are fundamentally, and to a significant extent irreversibly, changing the diversity of life on Earth and most of these changes represent a loss of biodiversity. Most changes to ecosystems have been made to meet a dramatic growth in the demand for food, water, timber, fibre and fuel.

Water Poverty Index



The Centre for Ecology & Hydrology of the United Kingdom, 2005

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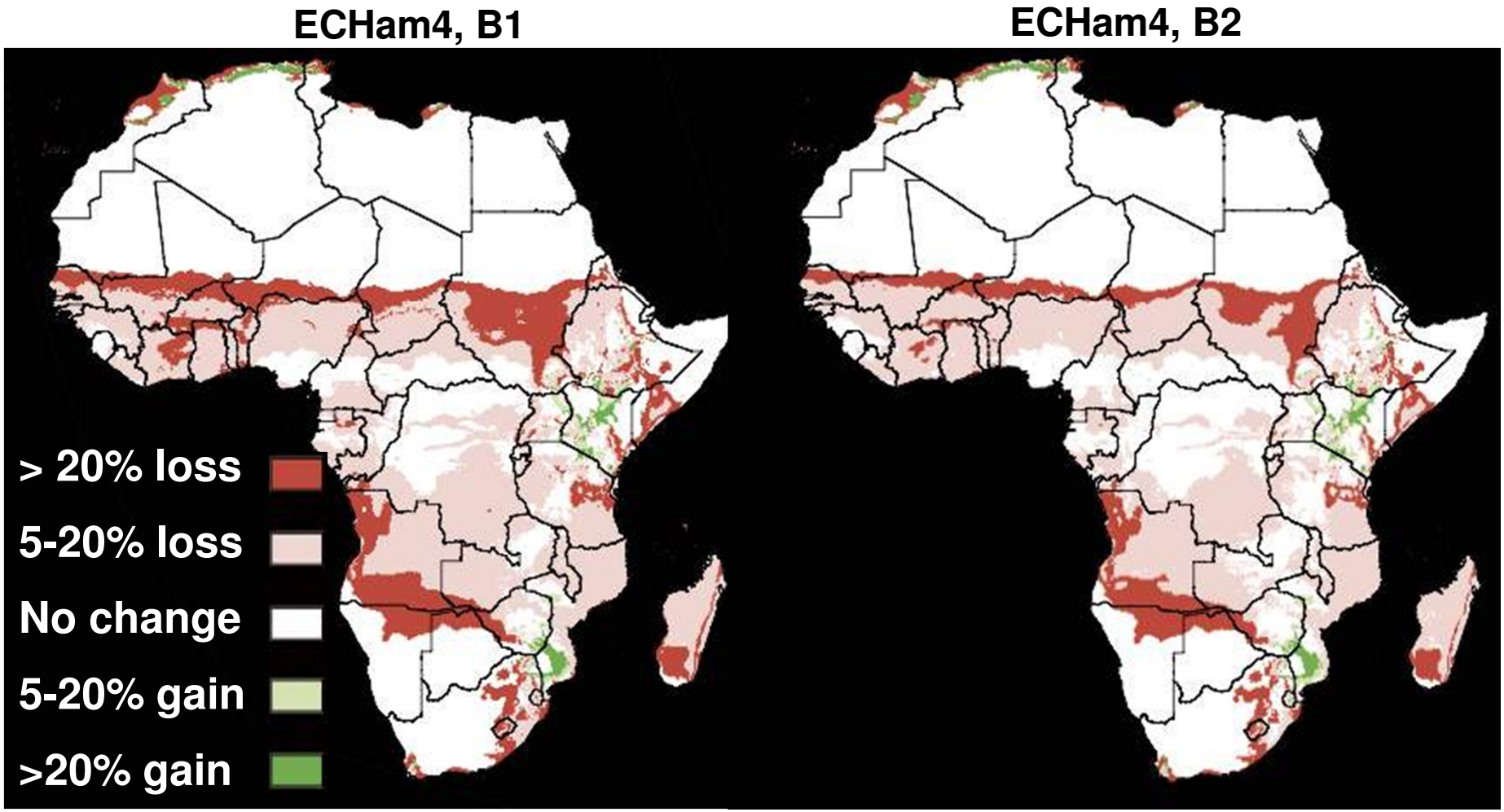
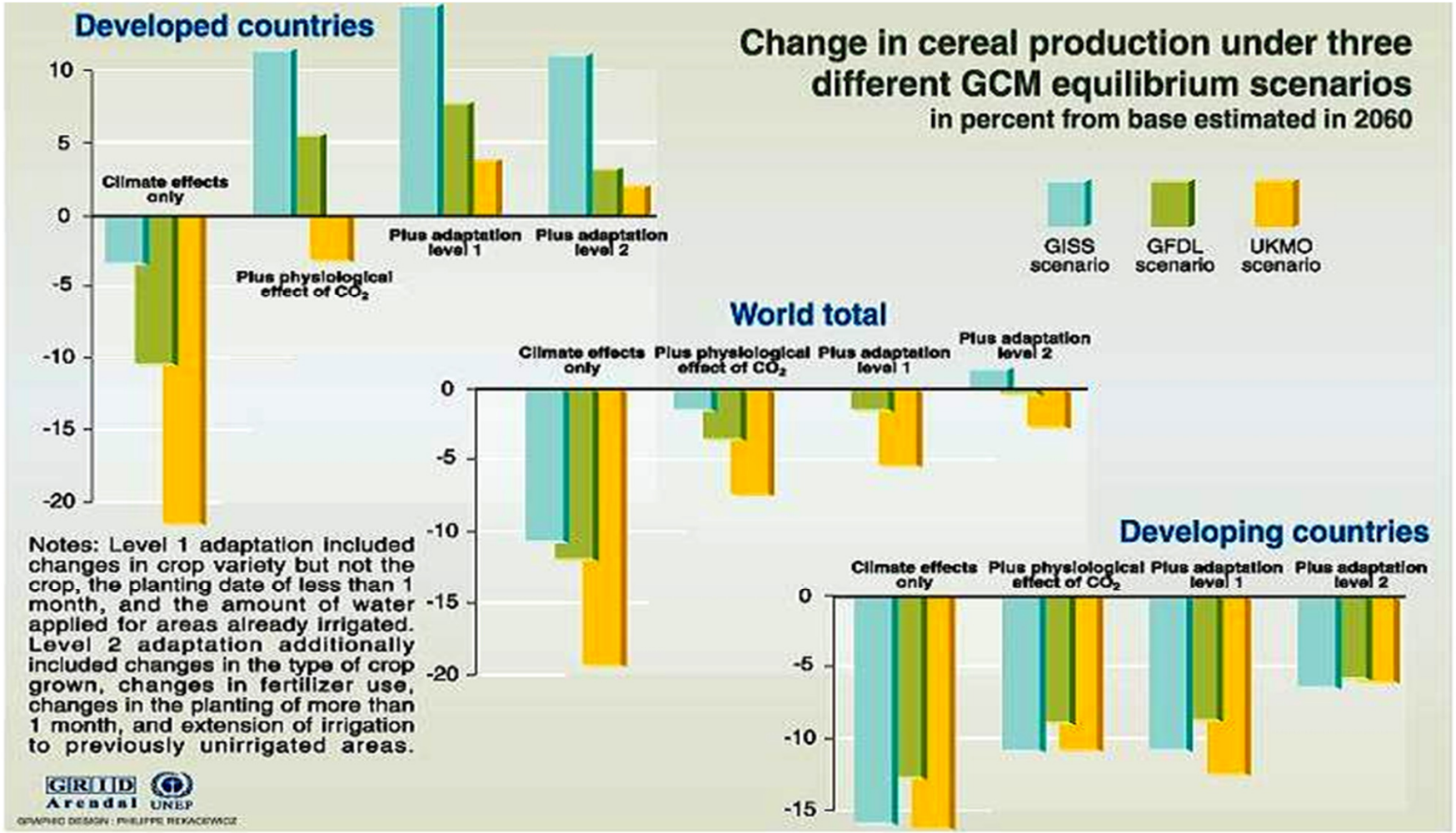
Projected Changes in Length of Growing Season, 2050



International Livestock Research Institute, 2006

Cereal Production under GCM Scenarios



Source: Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

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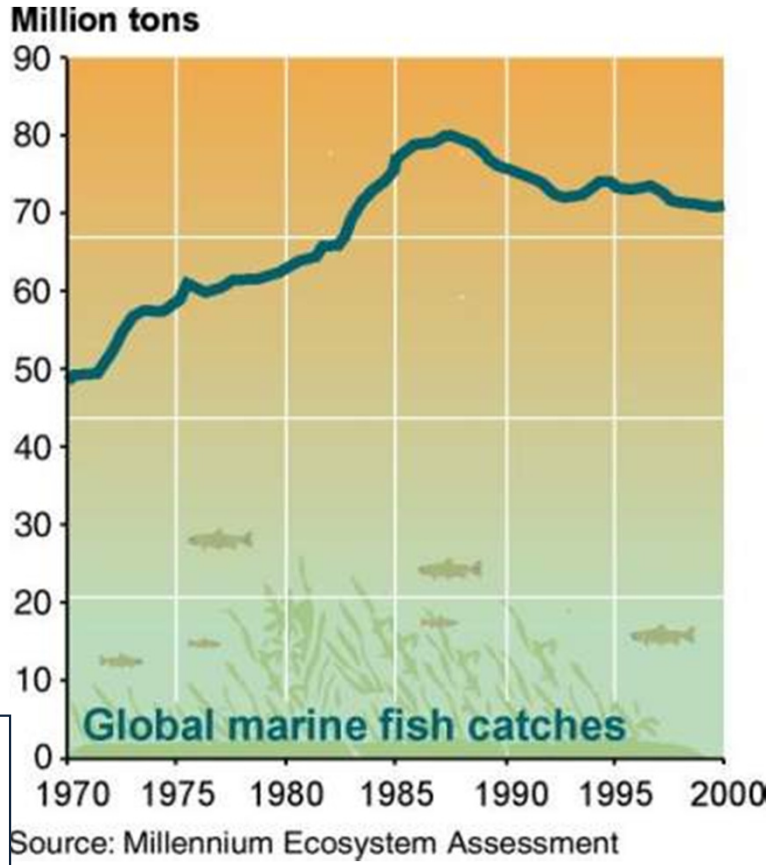
Food Web and Future Productivity of Ocean Fisheries Affected by

- Increasing ocean temperatures
- Ocean acidification
  - Zooplankton, crustaceans, shellfish sensitive to pH
- Over-fishing

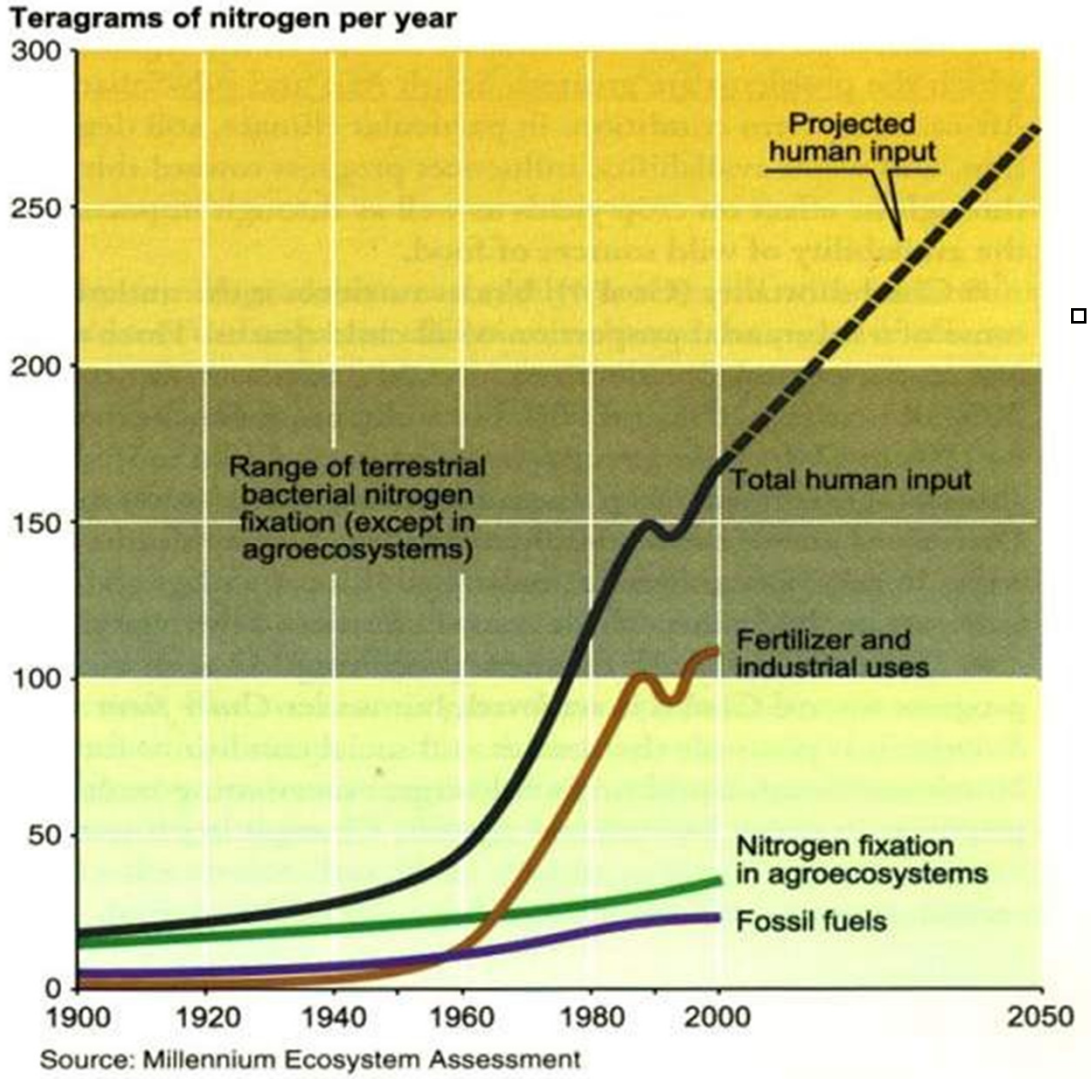
25% of commercially exploited marine fish stocks are now seriously over-harvested

(***Millennium Ecosystem Assessment, 2005)***



Source: Millennium Ecosystem Assessment

Human Changes to Global Activated Nitrogen Cycle, 1900-2050



- **Human health risks include:**
  - **Decreased crop yields**
  - **Nitrogen oxides (air pollution)**

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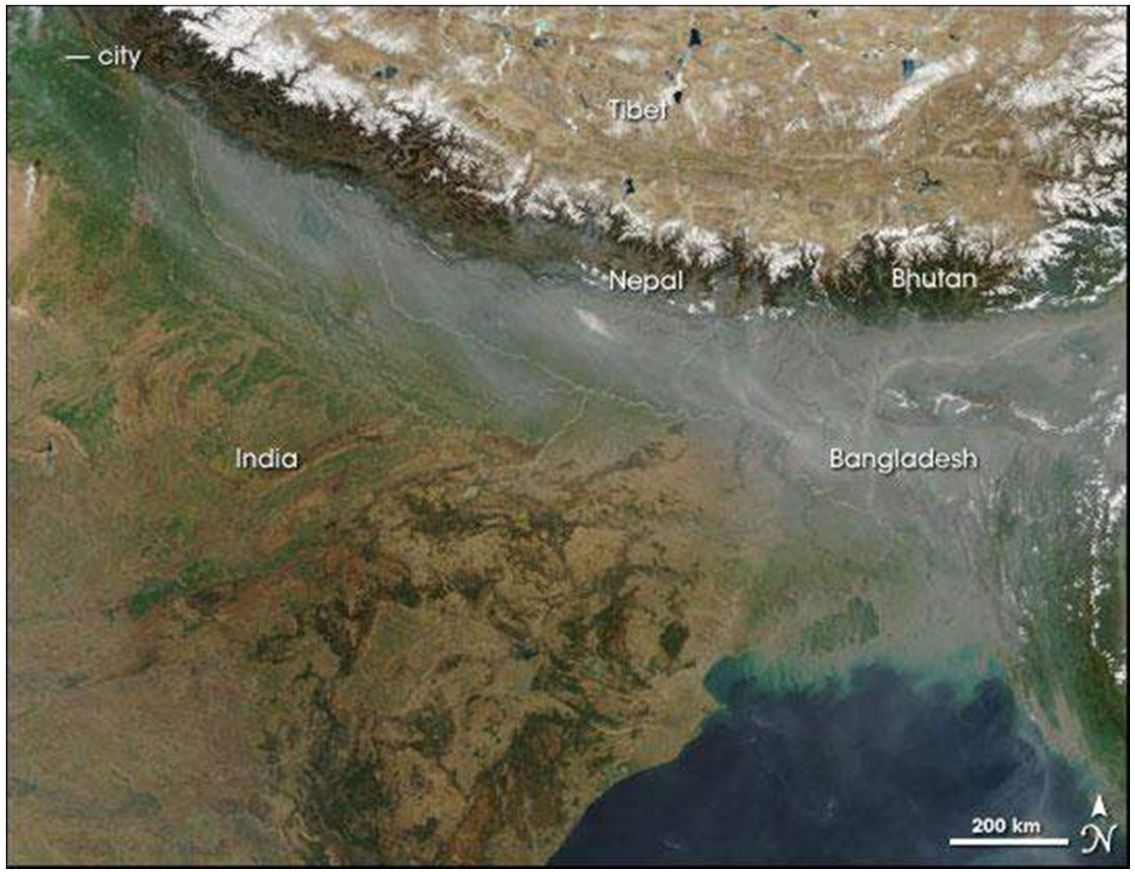
Asian Brown Cloud



United Nations Environment Program (UNEP) estimates 1-2 million deaths in India annually from atmospheric pollution

Asia's brown haze is also altering regional weather, creating acid rain, and (perhaps) affecting forest and crop yields

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Whose Research Task?

- Epidemiology is the study of the distribution and determinants of diseases in populations, and of ways to reduce the burden of disease
- Some say that global environmental change is too big/too complex for epidemiologists to study
  - Then who will ensure that population health is protected from expected impacts?
  - Epidemiology has a responsibility to address societal needs

Definitions

Weather, Climate, Climate Variability, and Climate Change

Definitions

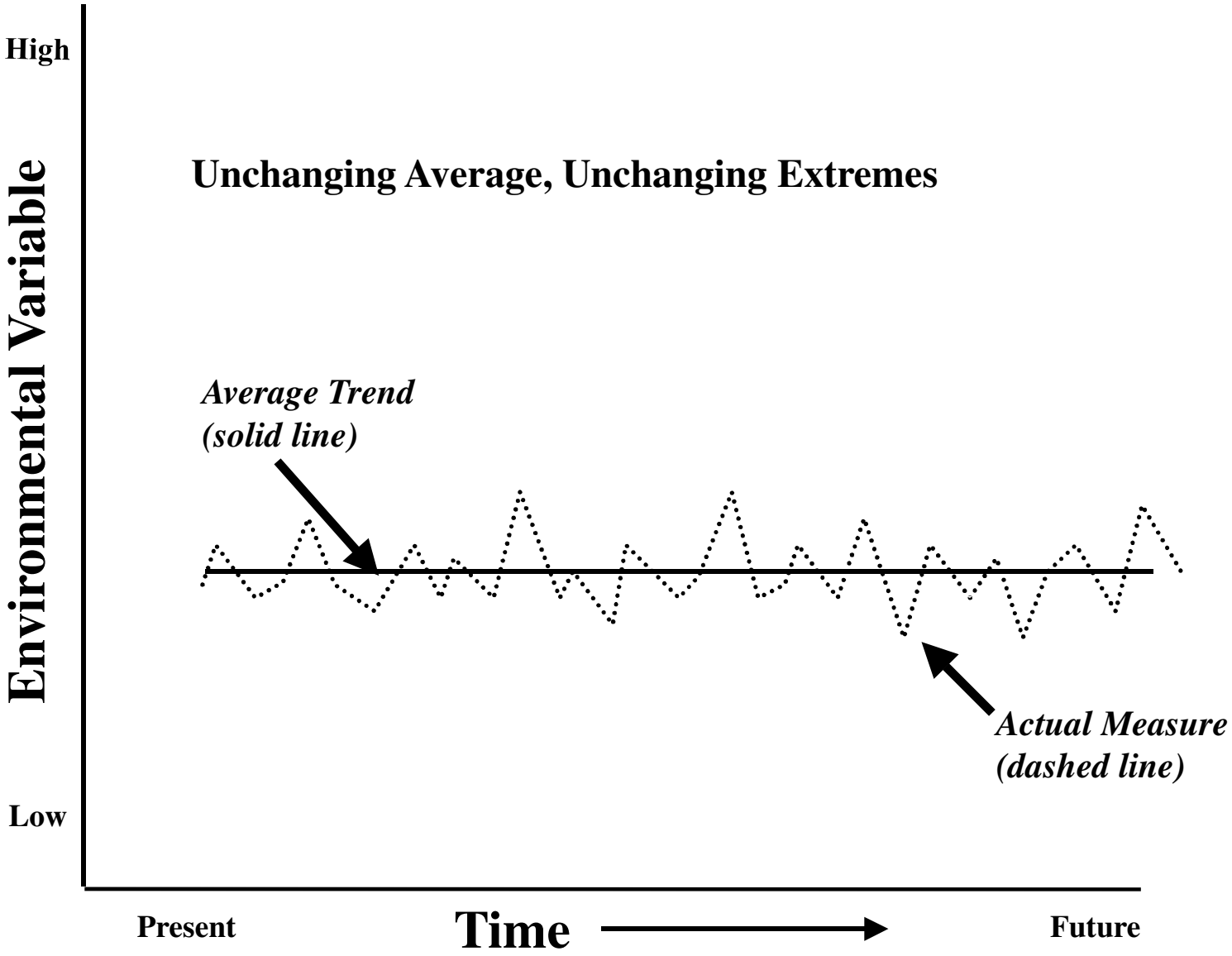
- **Climate** - expected atmospheric conditions
  - Based on 30-plus-year averages
- **Weather** - experienced day-to-day
- **Climate variability**
  - Short-term fluctuations (weeks-to-months) around avg. weather
  - Includes ENSO (El Nino-Southern Oscillation)
- **Climate change**
  - Operates over decades or longer
  - General circulation models (GCMs)
  - Scenarios, not predictions

More Definitions

- **Global climate change** - series of changes in Earth's weather patterns driven by temperature resulting in changes in precipitation, winds, ocean currents, and storms
- **Global warming** - emphasizes only rising temperature
- **Global environmental change** - includes global climate change along with all the other major changes that are occurring in our global environment
- **Global Change -** Multiple factors in many domains

  More than just climate and environment, involving populations, economies, food production, etc.

What is climate change? Climate variability?



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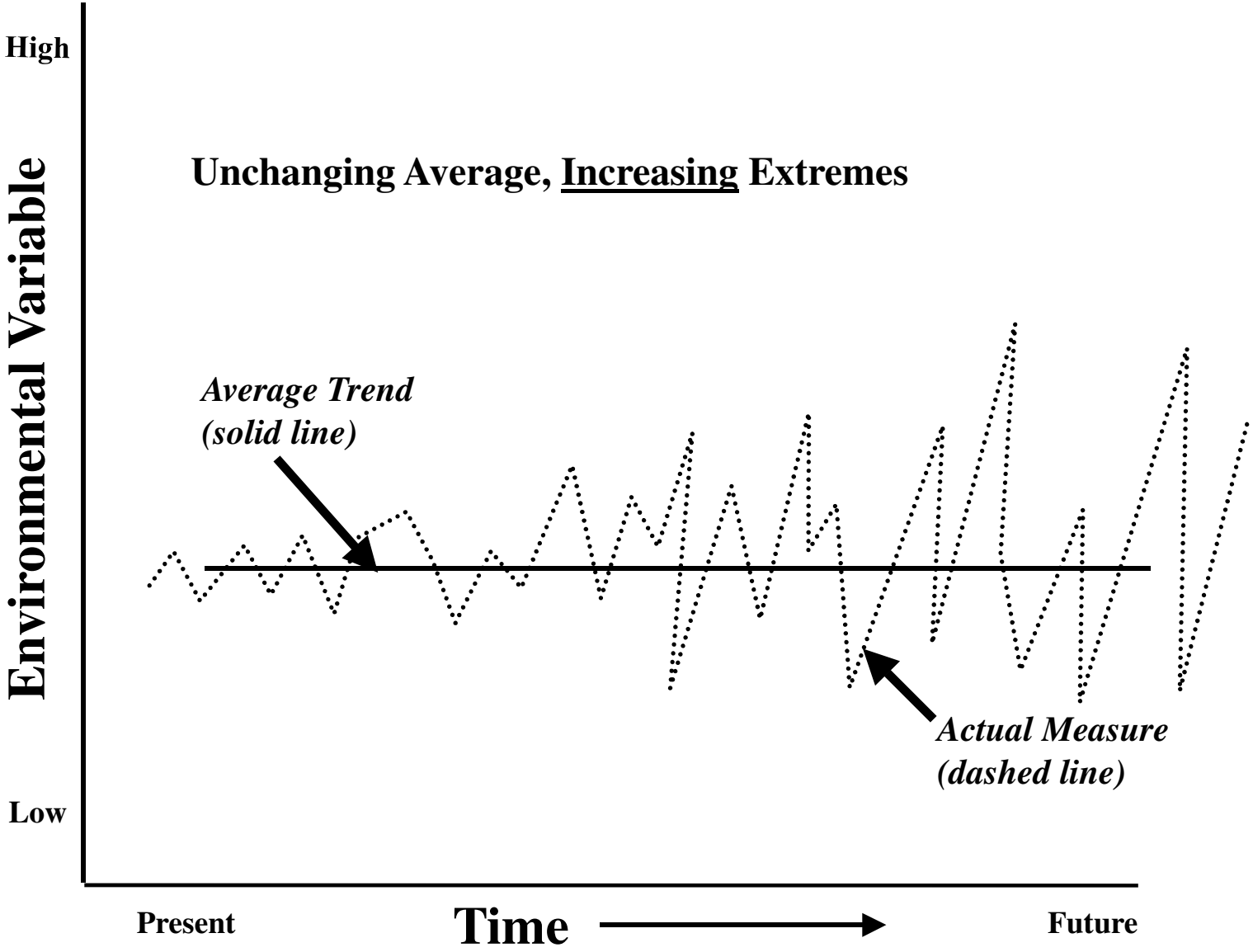

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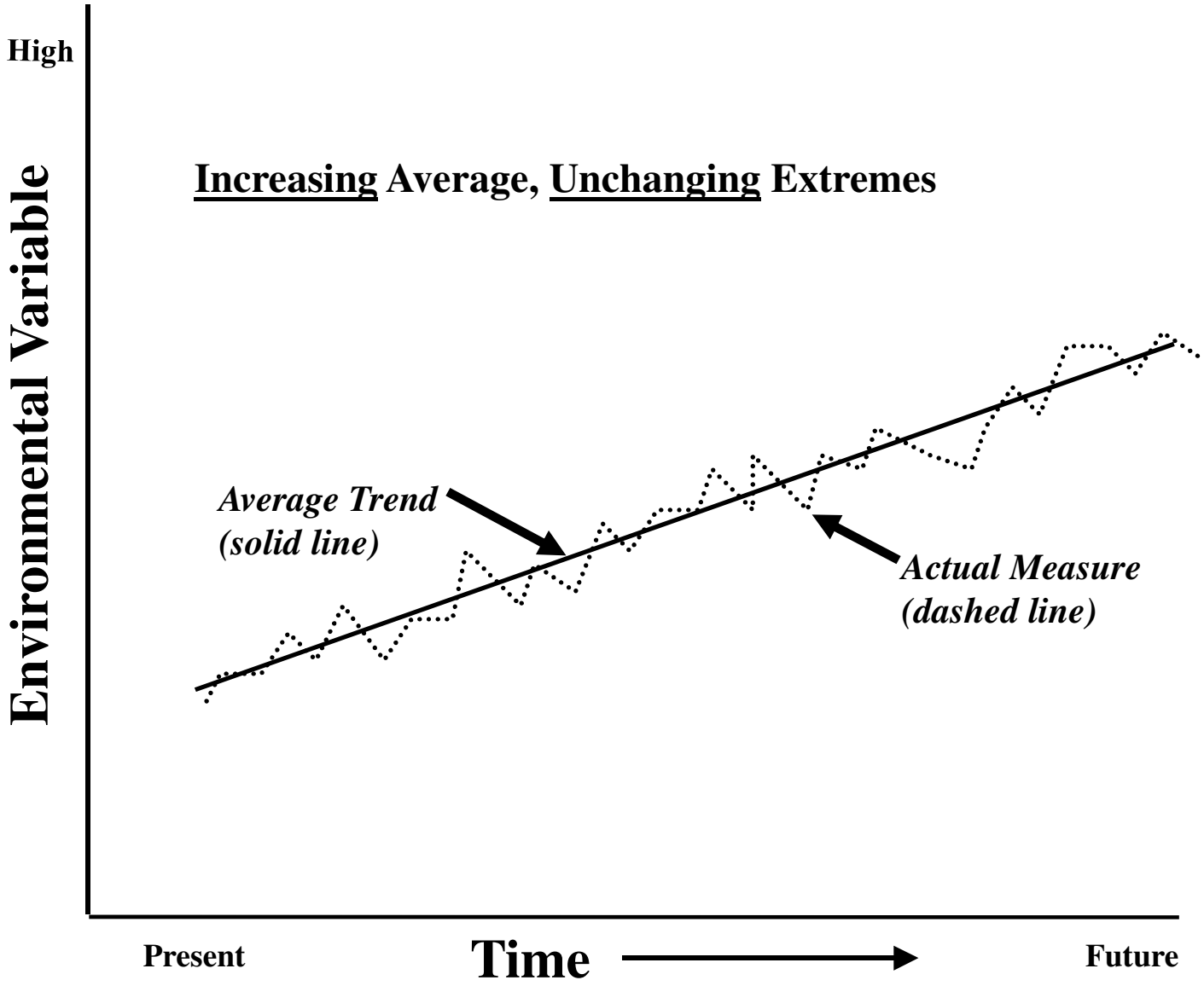

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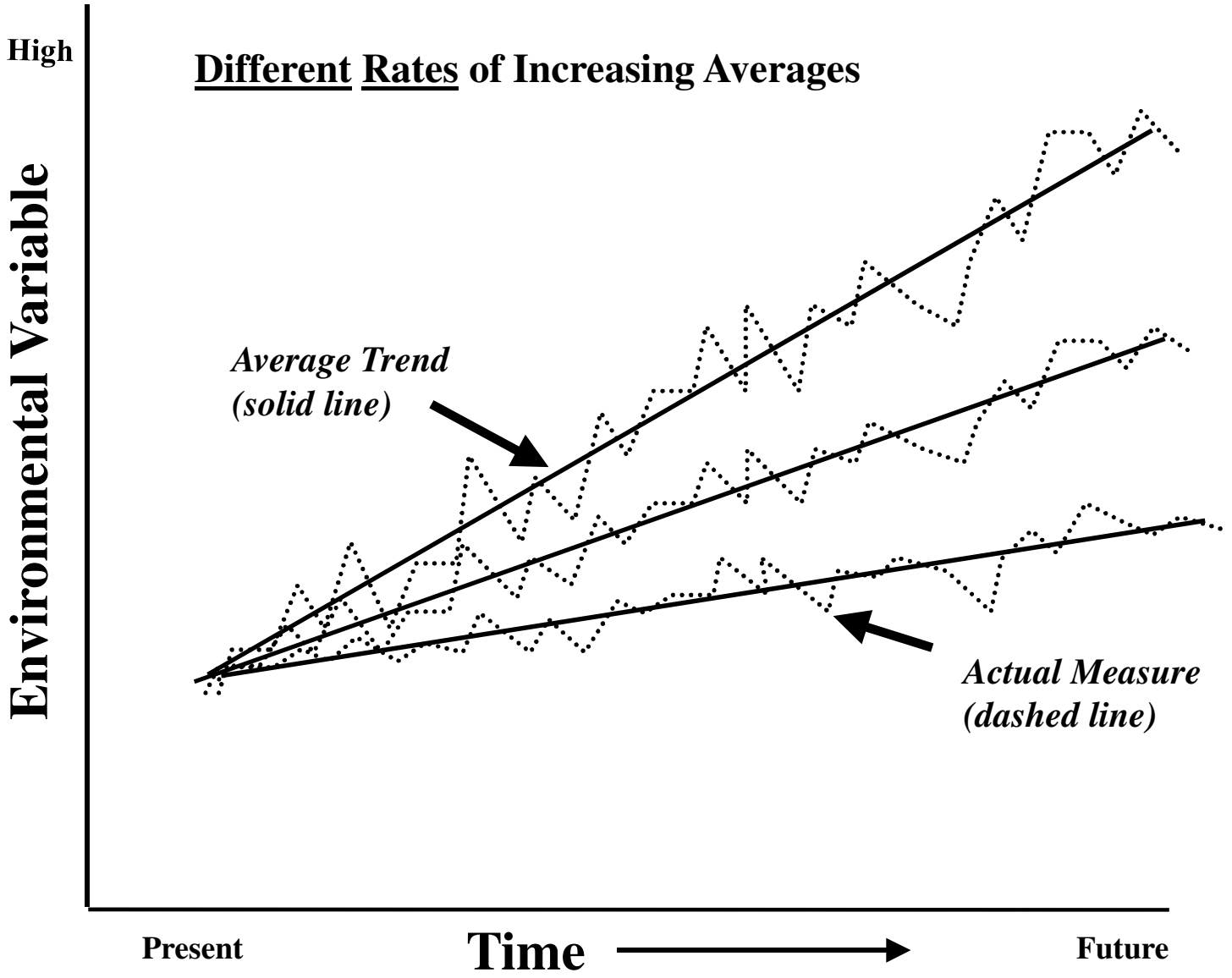

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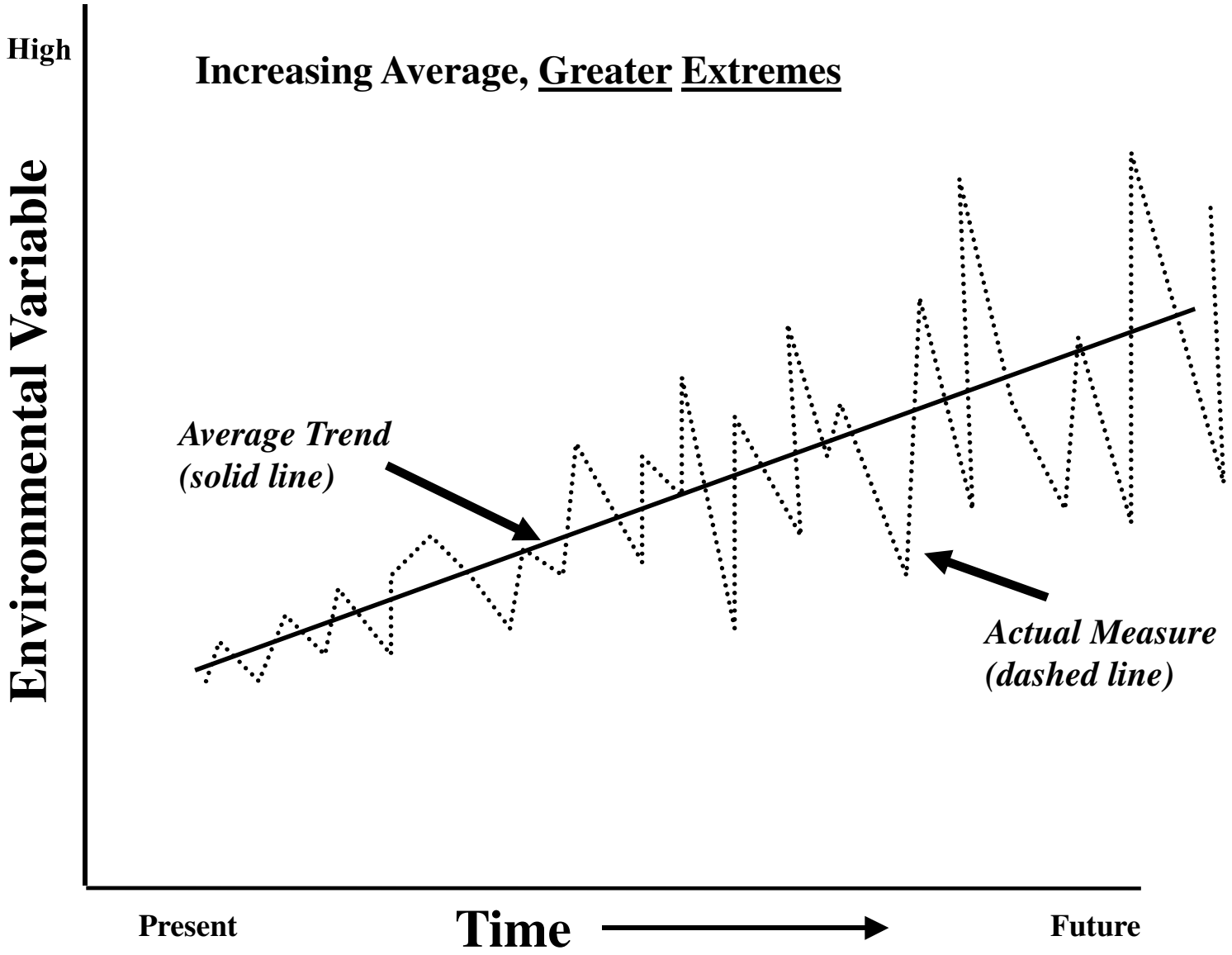

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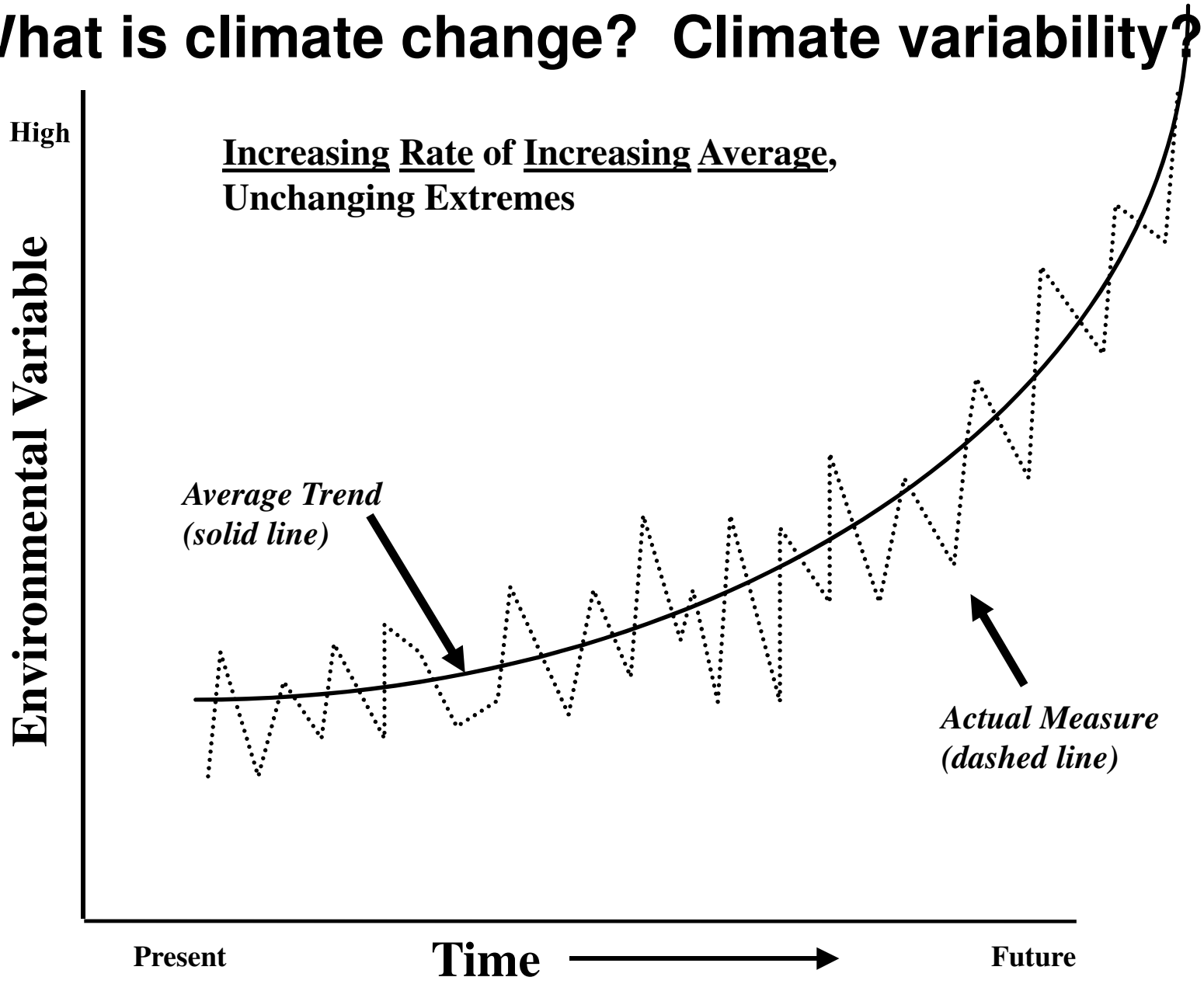

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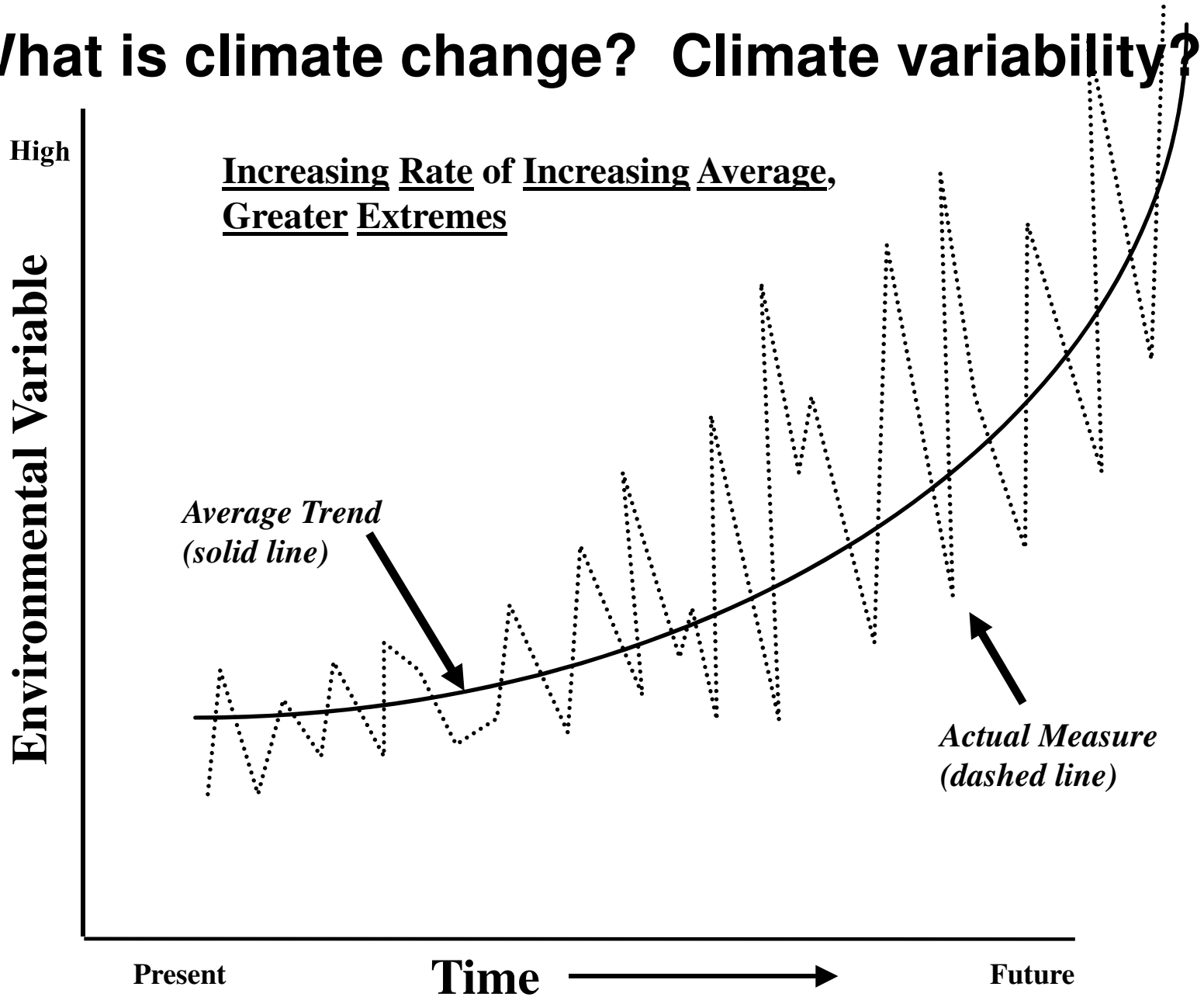
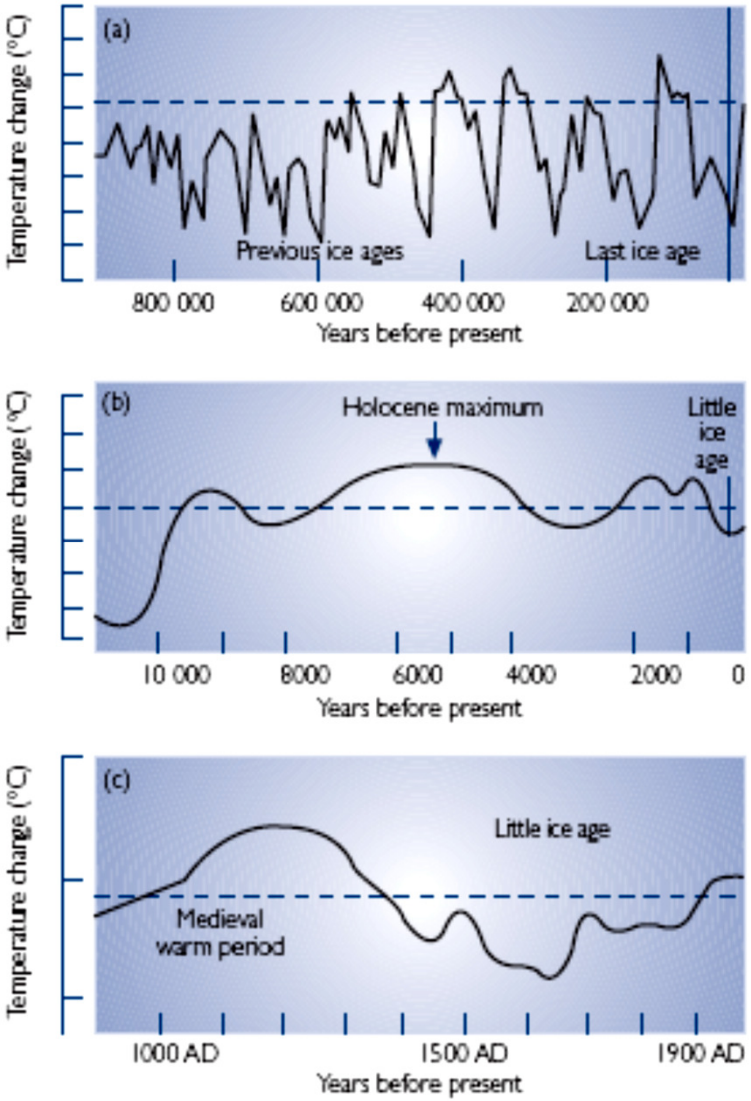


Global Temperature Variations on Three Time Scales



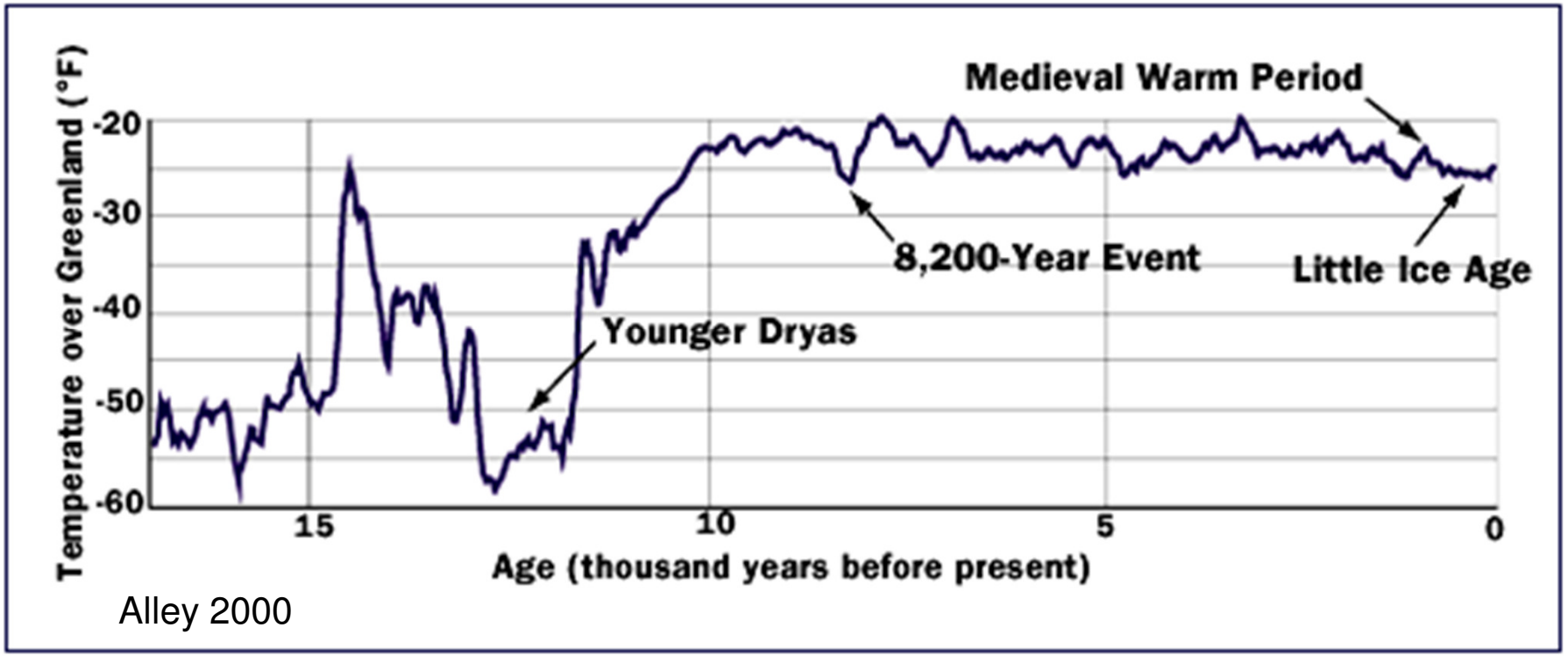
Last million years

Last 10,000 years

Last 1,000 years

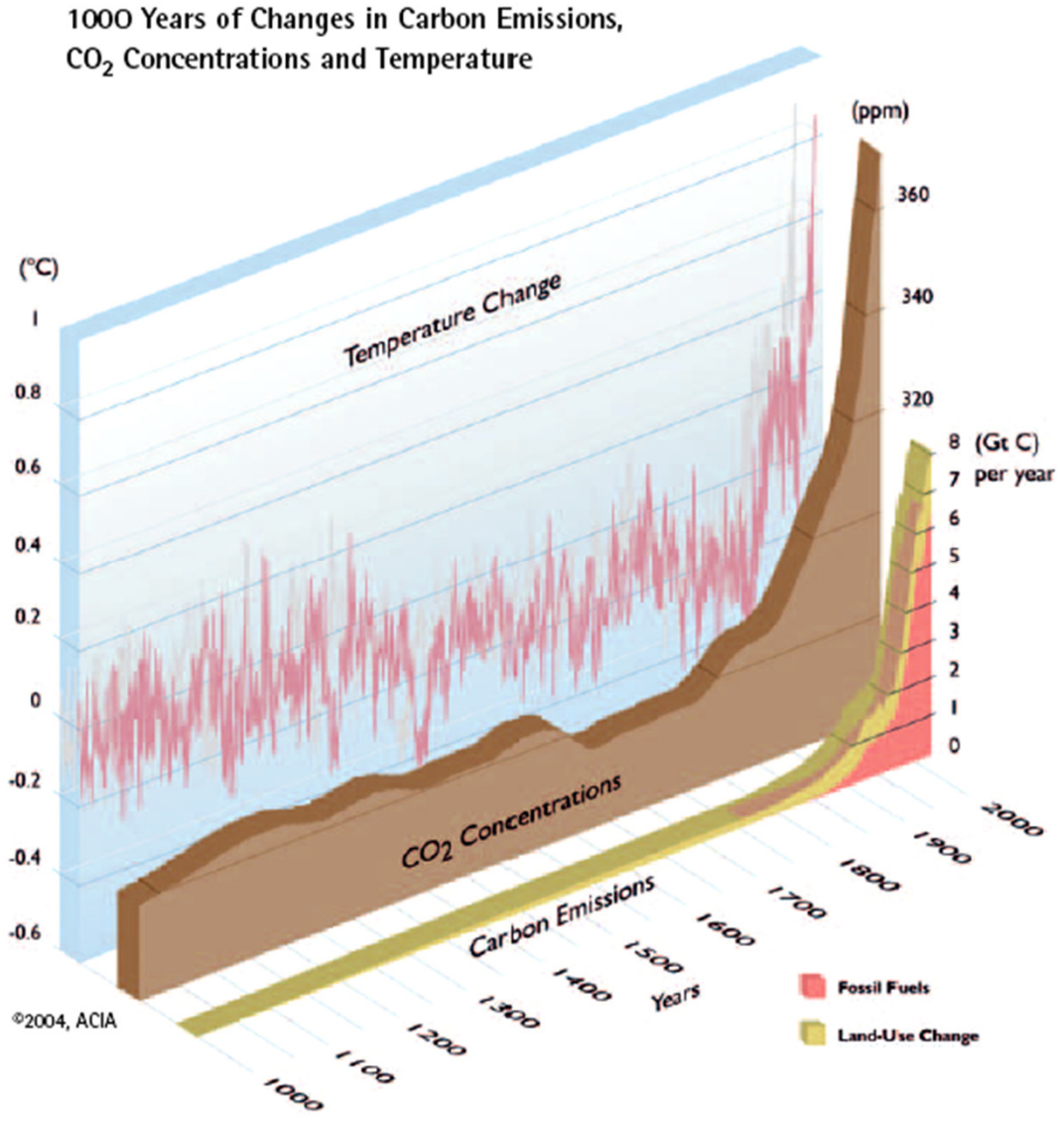
Folland et al. 1990

Temperature over Greenland over Past 17,000 Years

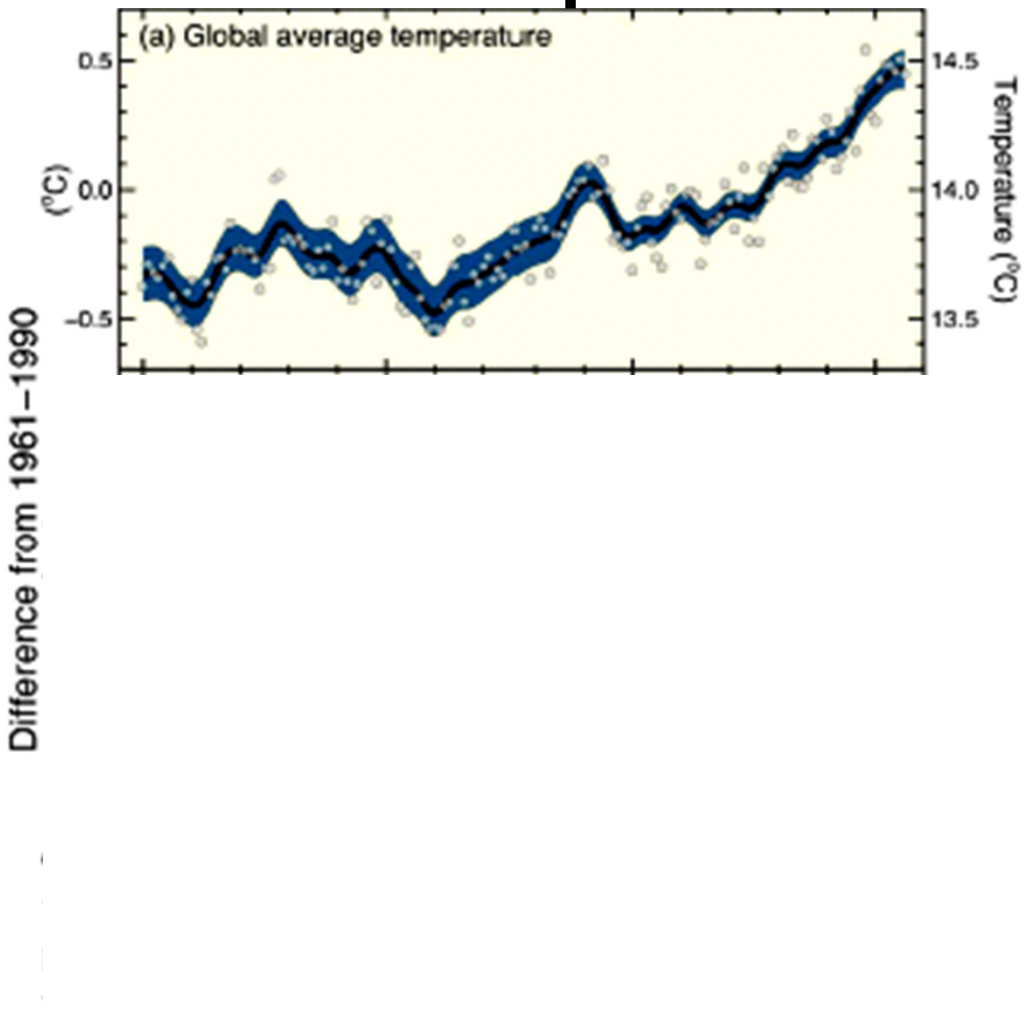


Alley 2000

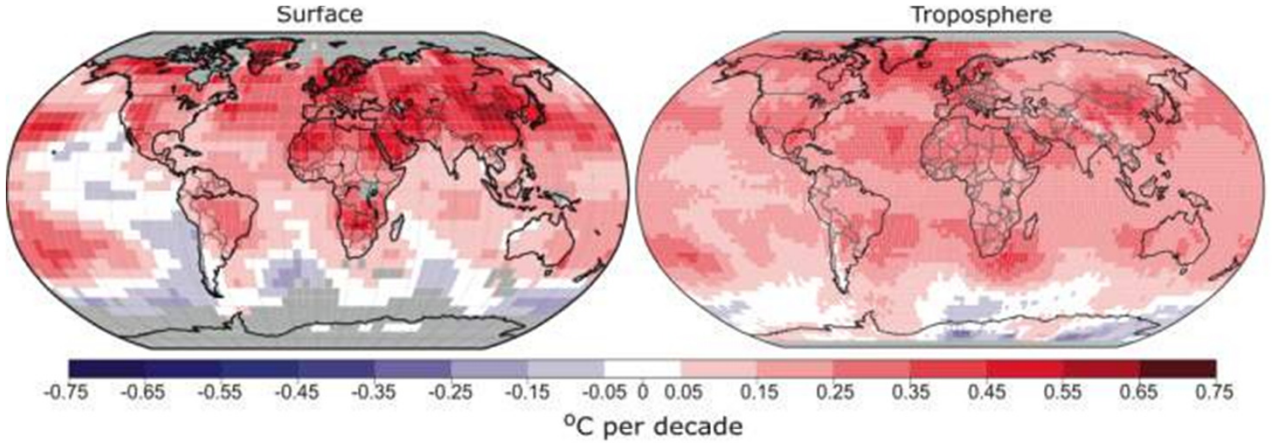
1,000 Years of Changes in Carbon Emissions, CO_2 Concentrations, and Temperature



150 Years of Changes in Temperature, Sea Level, and Northern Hemisphere Snow Cover



Temperatures are Rising at an Increasing Rate



Increasing temperature (C) per decade at Earth's Surface and Troposphere

Temperatures are Increasing at an Increasing rate during recent times

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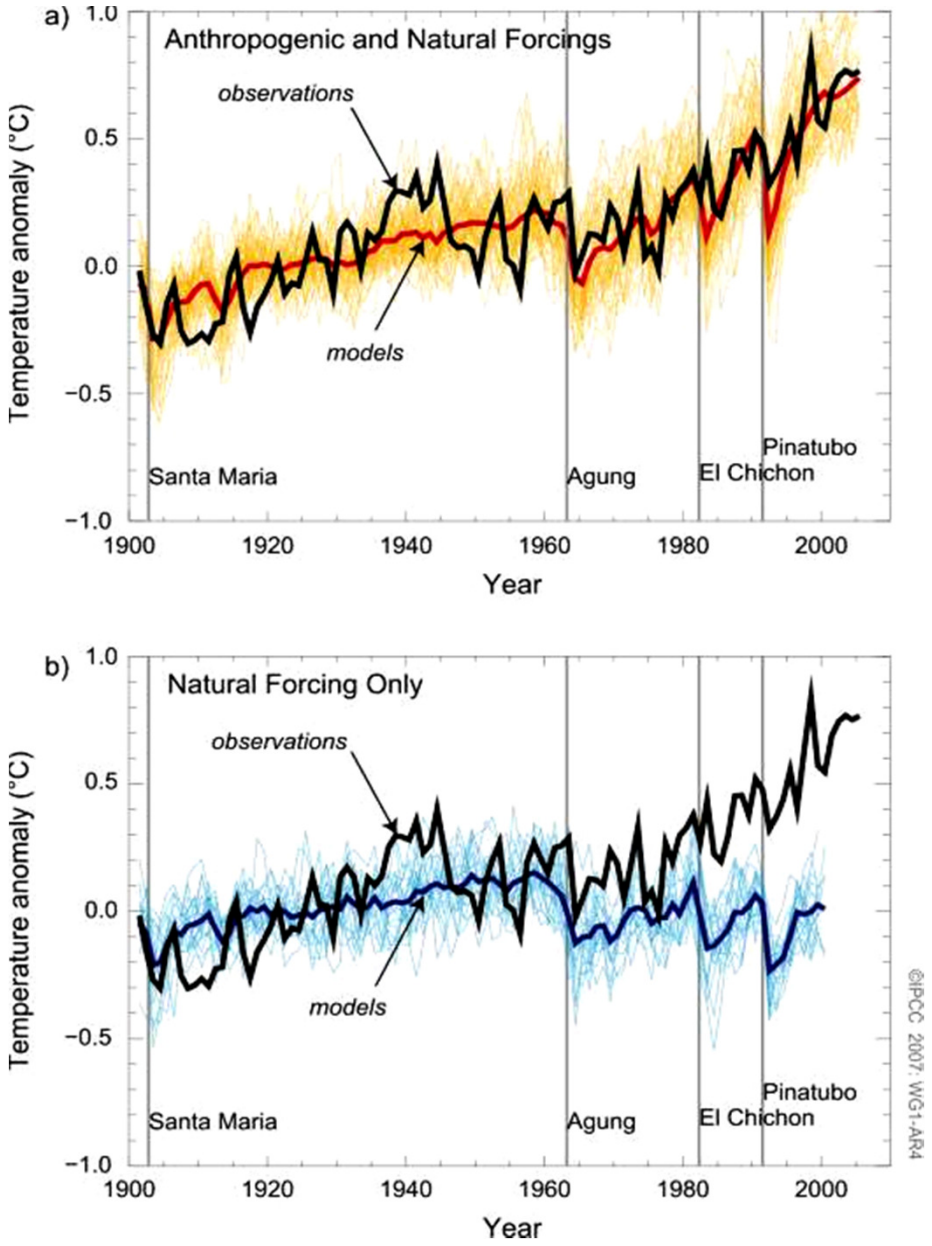
Temperature Rise due mostly to Human Factors



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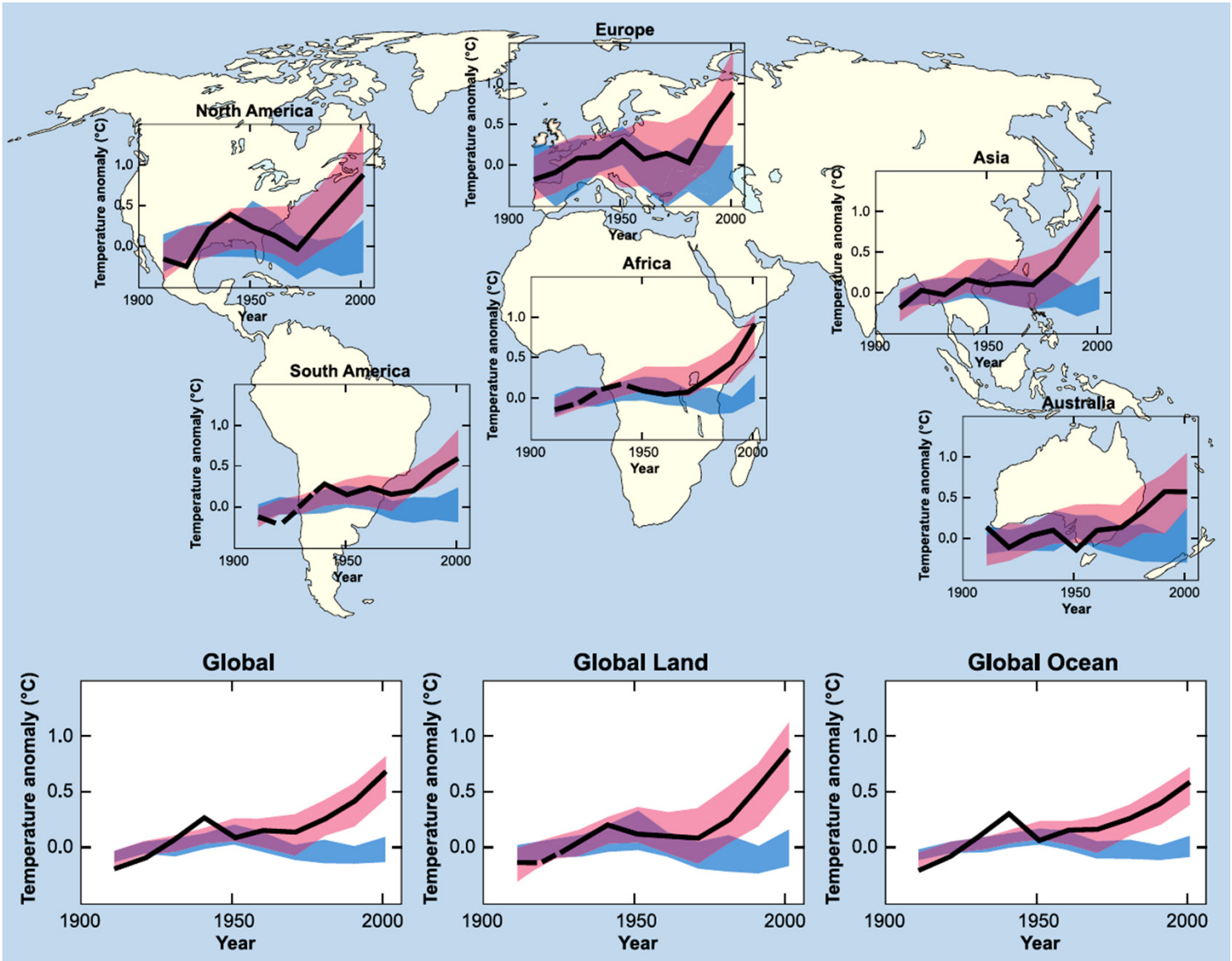
Temperature Rise Occurring Globally



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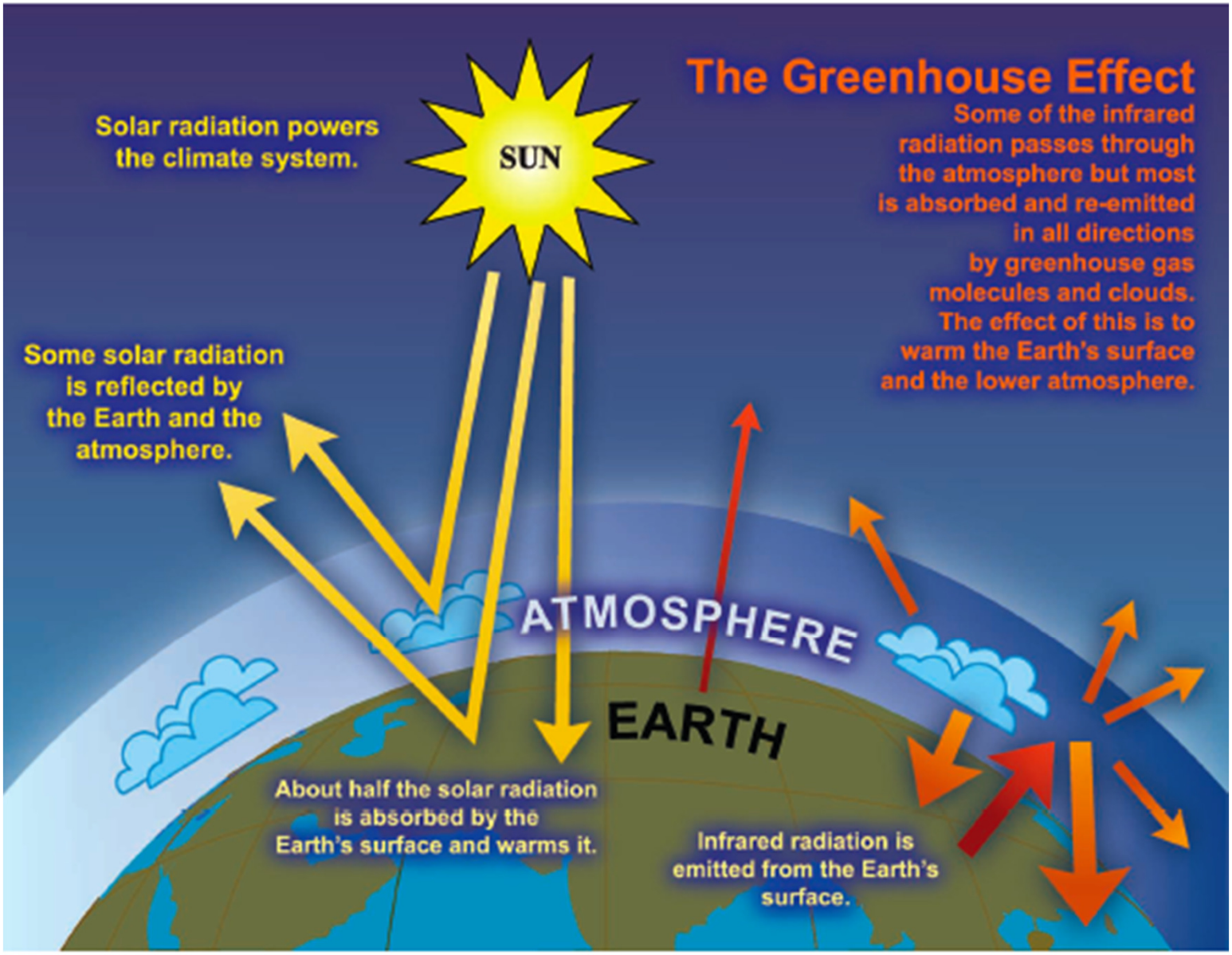
The Greenhouse Effect



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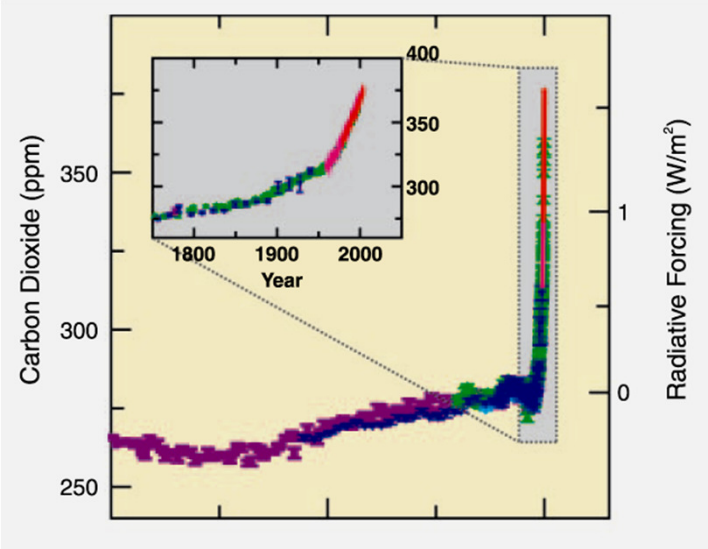
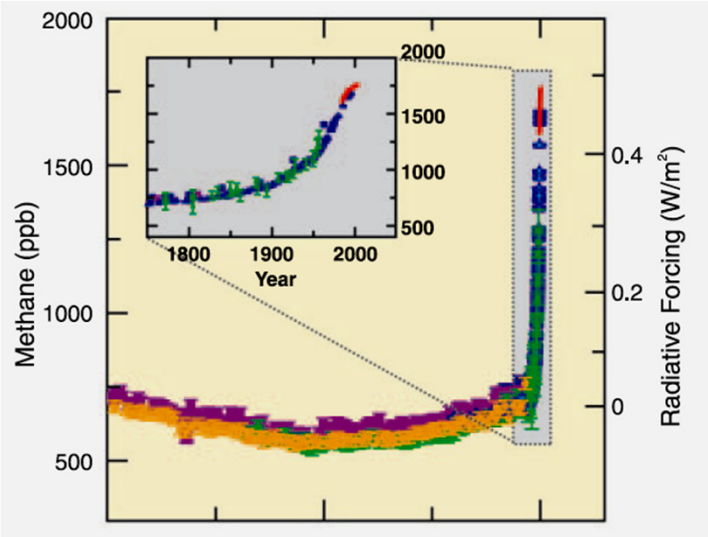
The Greenhouse Effect

- Natural greenhouse effect keeps the Earth warm enough (average about 15C, 60F) to be **habitable**
- Greenhouse gases (e.g. carbon dioxide, methane, nitrous oxide) and water vapor trap heat and **warm the earth's surface**
- Basic principles of greenhouse effect **well understood**
- For a given concentration of greenhouse gases, the resulting amount of **radiative forcing** (or heat trapping of energy) can be **predicted with precision**
- Exactly how the Earth's **climate will respond** to enhanced greenhouse gases also depends on **complex interactions** between the atmosphere, oceans, land, ice, and biosphere

Concentrations of Greenhouse Gases over the Last 10,000 Years





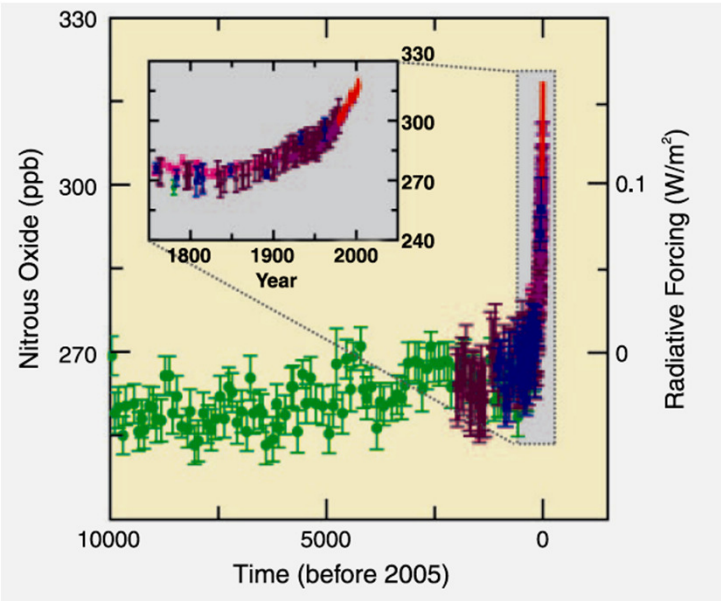


Figure 2.3. Atmospheric concentrations of CO_2, CH_4 and N_2O over the last 10,000 years (large panels) and since 1750 (inset panels). Measurements are shown from ice cores (symbols with different colours for different studies) and atmospheric samples (red lines). The corresponding radiative forcings relative to 1750 are shown on the right hand axes of the large panels. {WGI Figure SPM.1}

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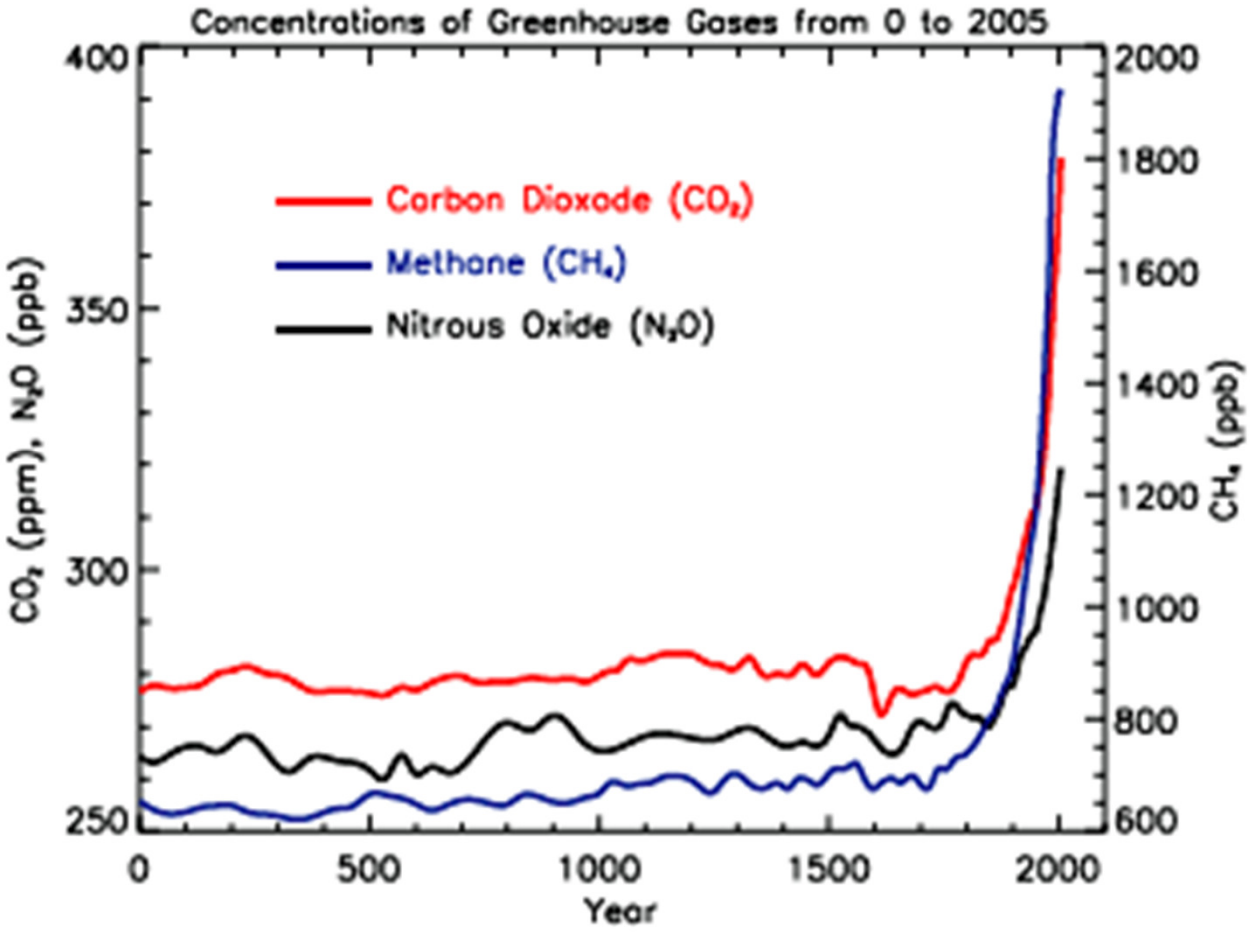
Concentrations of Greenhouse Gases in the Past 2,000 Years



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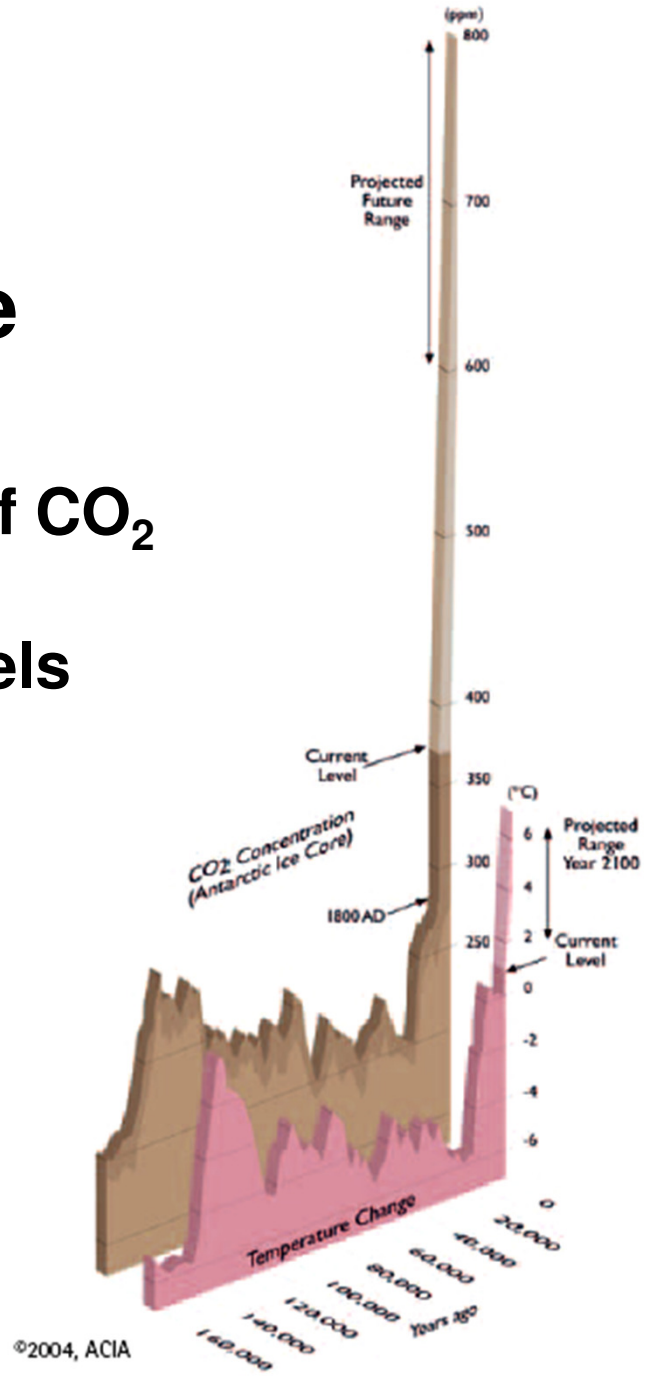
Atmospheric CO_2 Concentration and Temperature Change

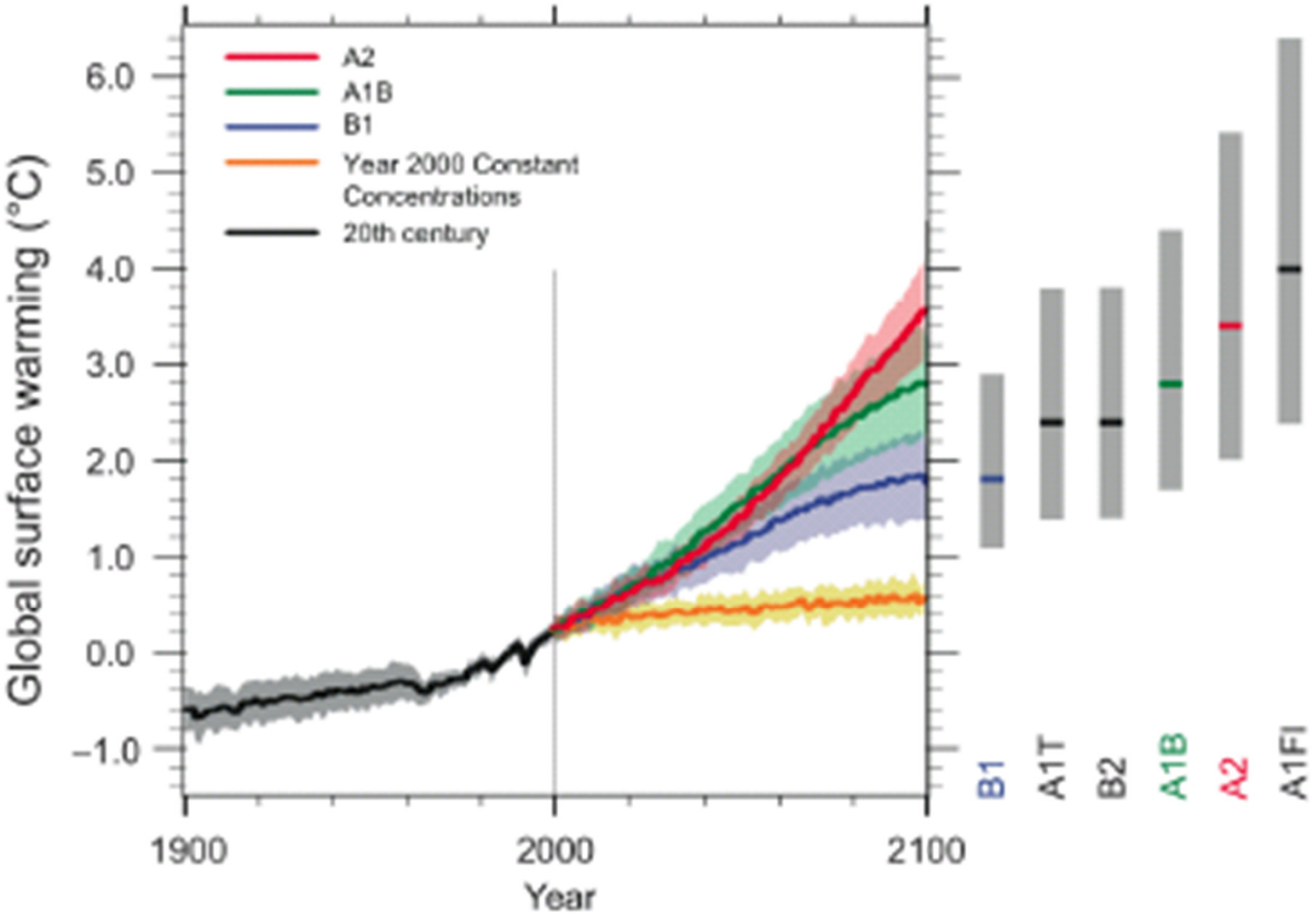
Projected concentrations of CO_2 during the 21st century are 2-4 times pre-industrial levels



Greenhouse Gases are Increasing

- Atmospheric concentrations of greenhouse gases have **increased significantly since industrial revolution**
- Carbon dioxide +30%; Methane +100%; Nitrous oxide +15%
- Greenhouse gas concentrations **projected to reach double pre-industrial levels by about 2060**
- Many greenhouse gases **remain in atmosphere** for a long time (decades to centuries)
- Projected CO_2 concentration levels are **significantly higher** than any observed over the past 160,000 years

Global Average Surface Temperature



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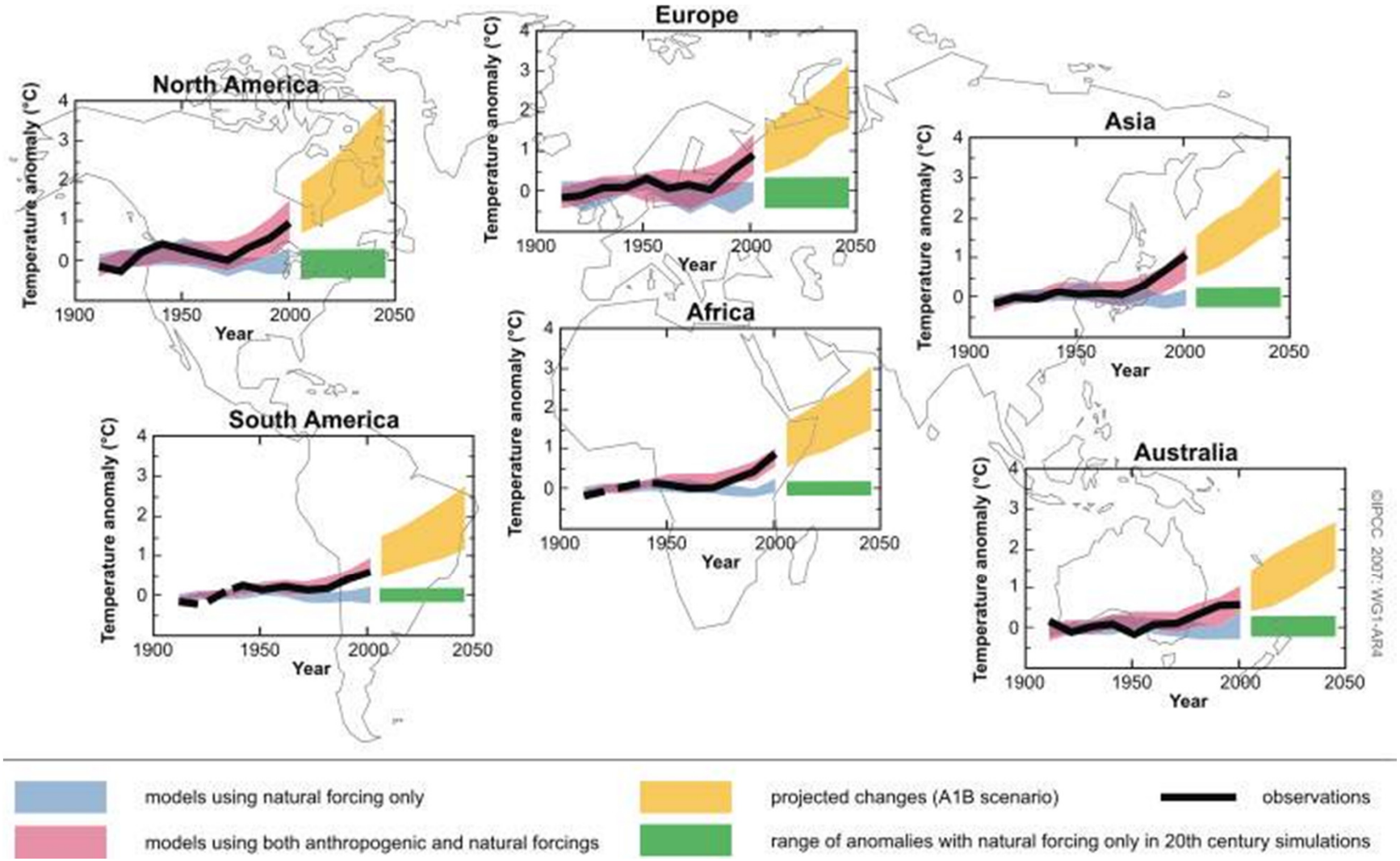
Surface Temperature Anomalies



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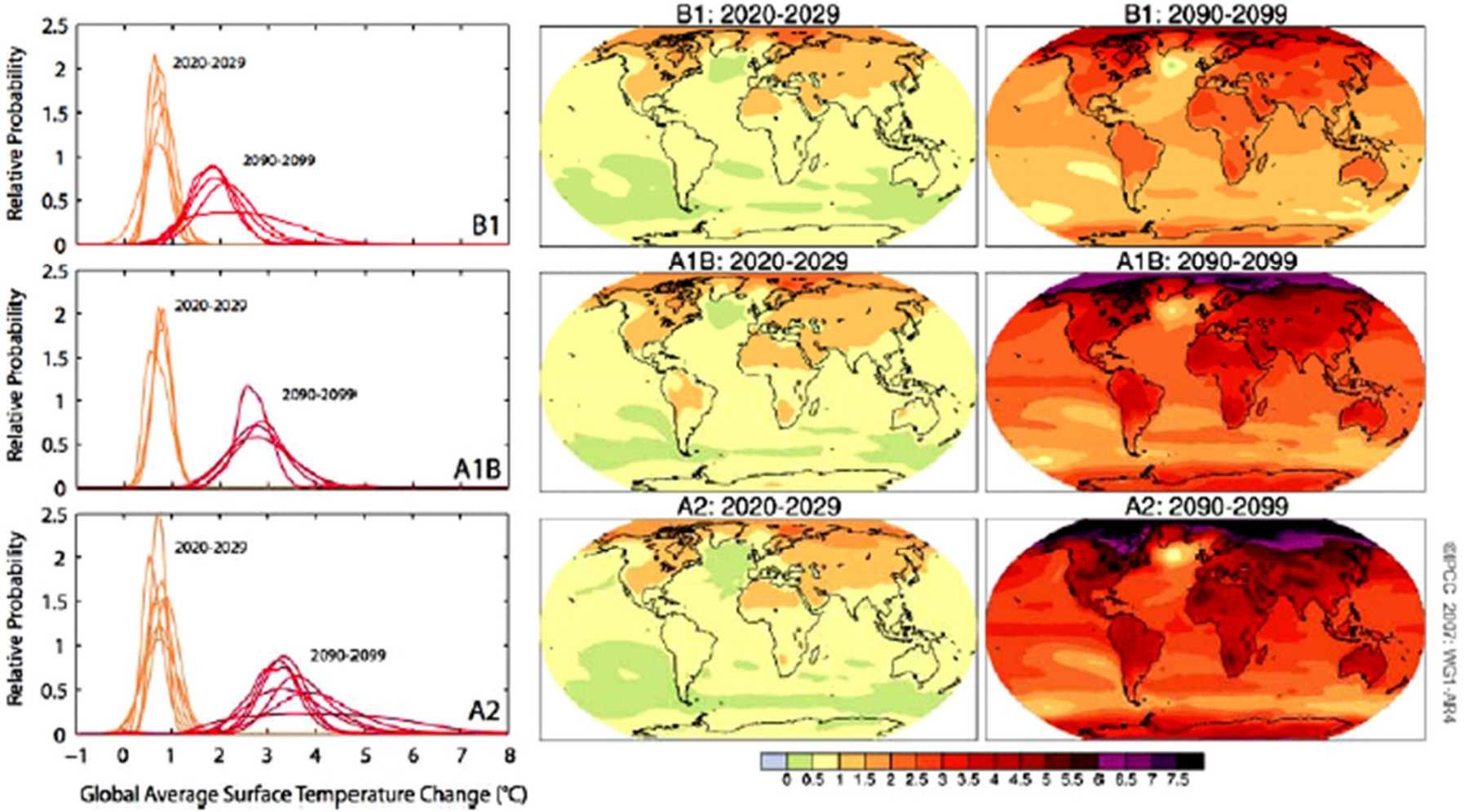
Projected Surface Temperatures



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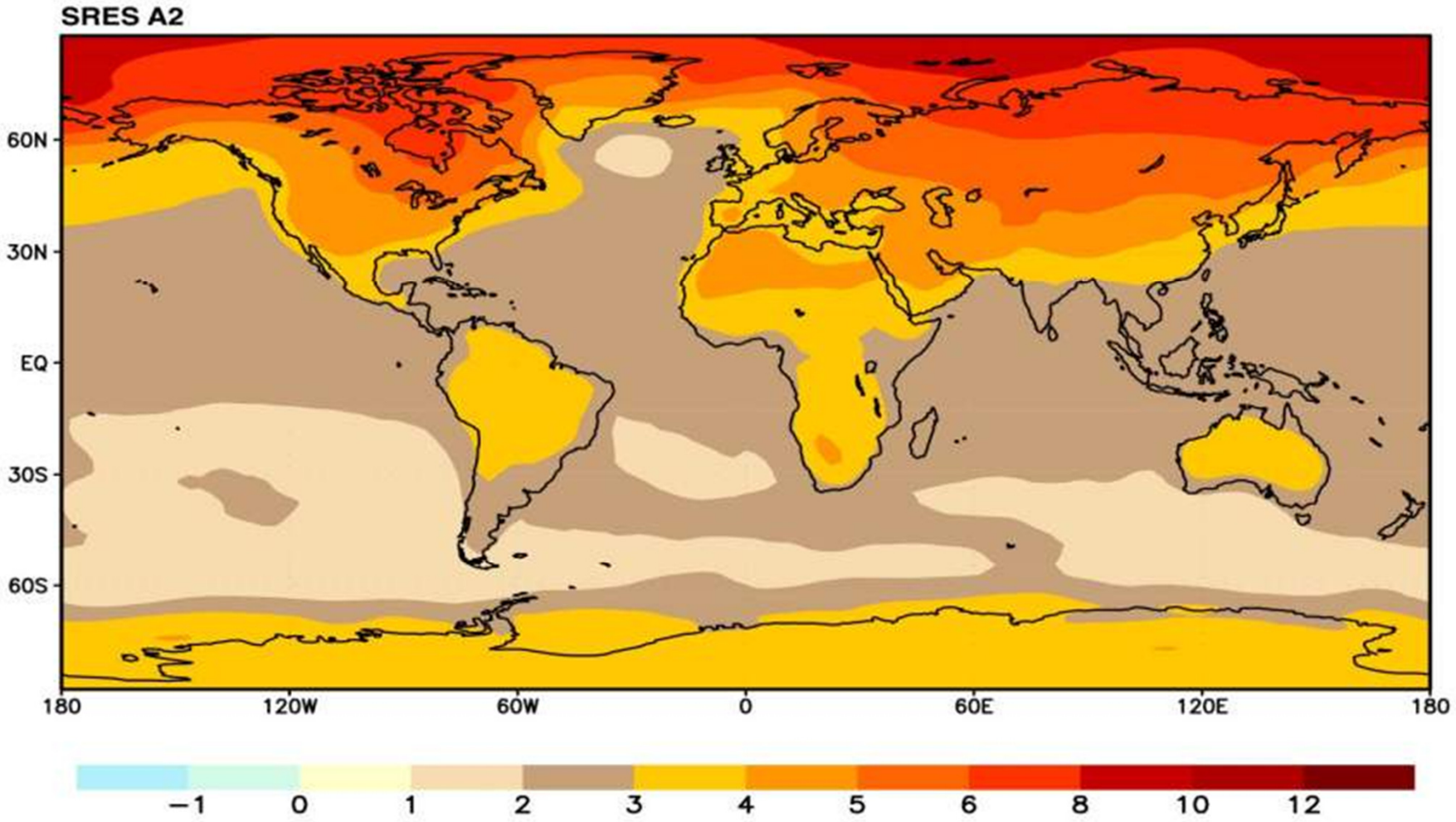
Land Areas Warm More than Oceans with Greatest Warming at High Latitudes



Annual mean temperature change, 2071 to 2100 relative to 1990.
Global average in 2085 = 3.1°C.
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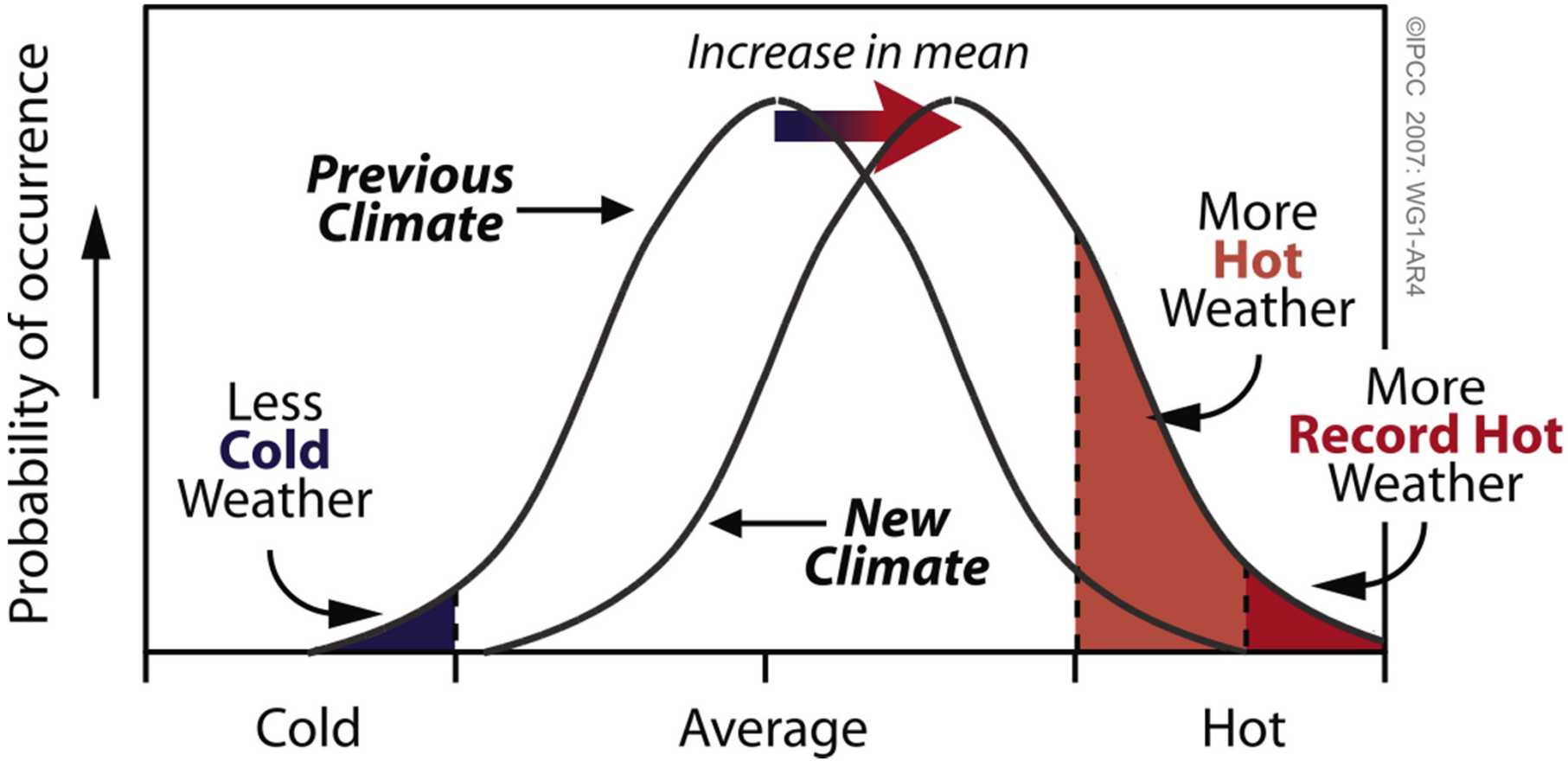
Effect of Extreme Temperatures When Mean Temperature Increases



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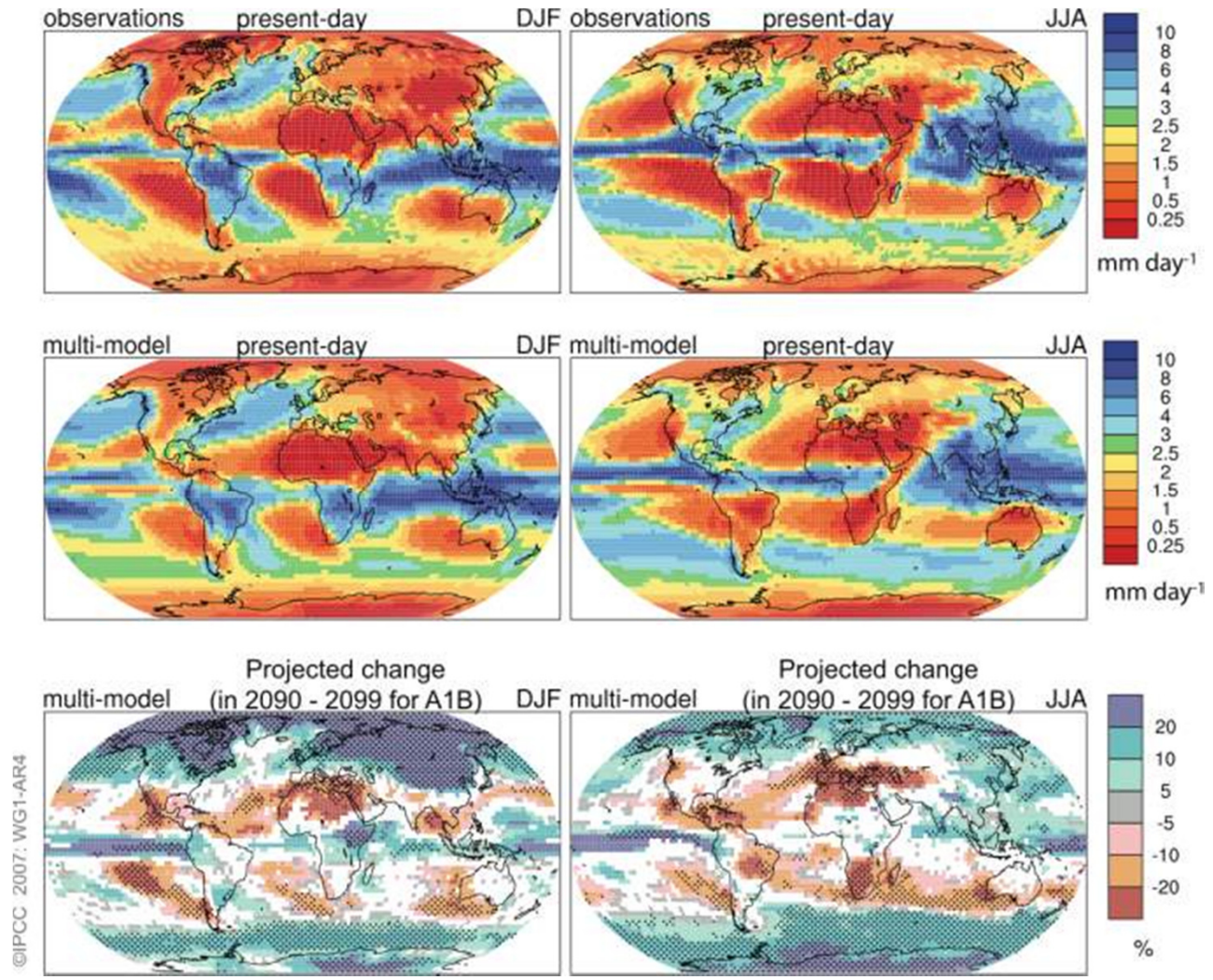
Observed, Modeled, and Projected Precipitation



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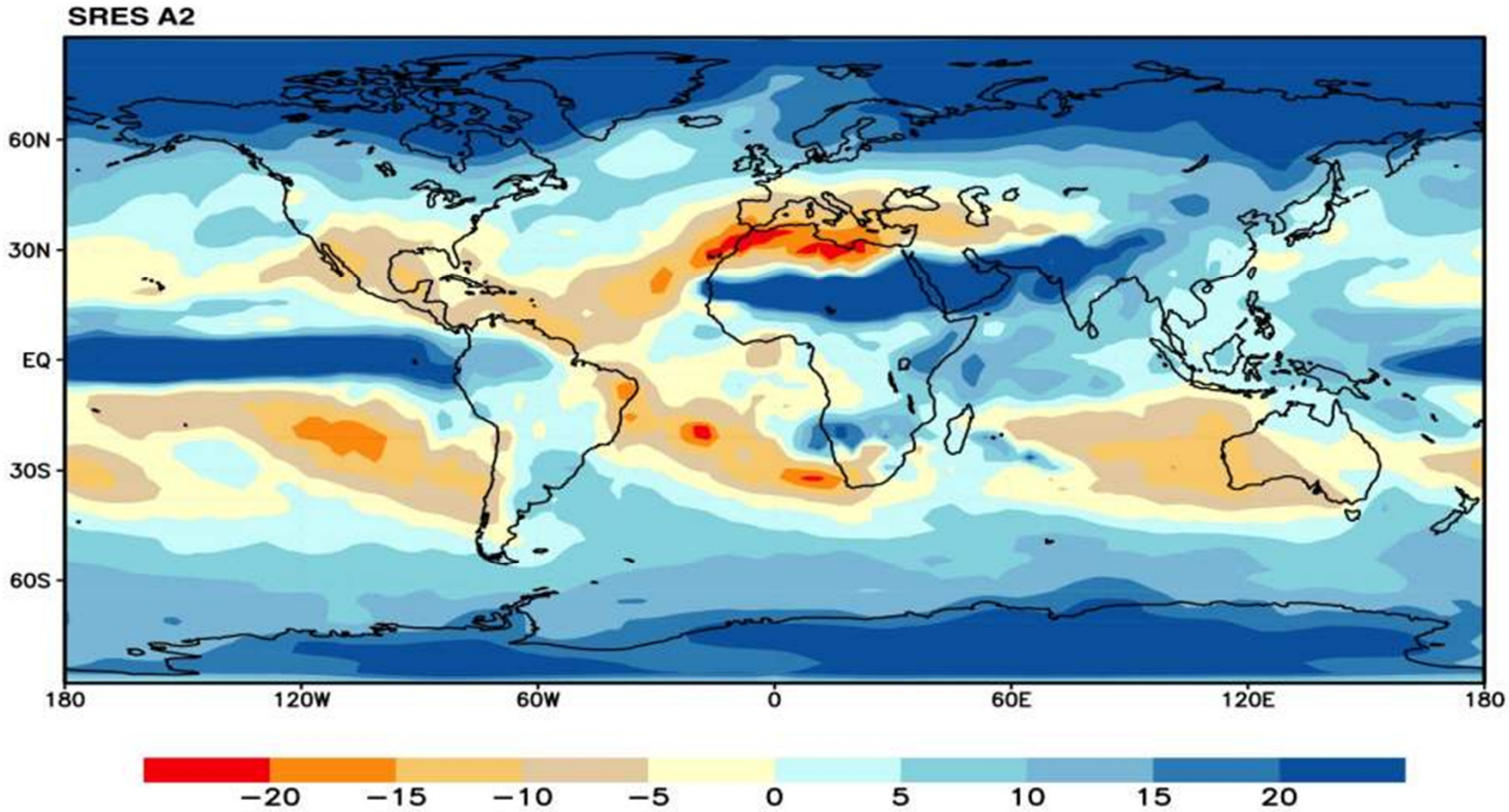
Some Areas are Projected to Become Wetter, Others Drier



Annual mean precipitation change: 2071 to 2100 relative to 1990.

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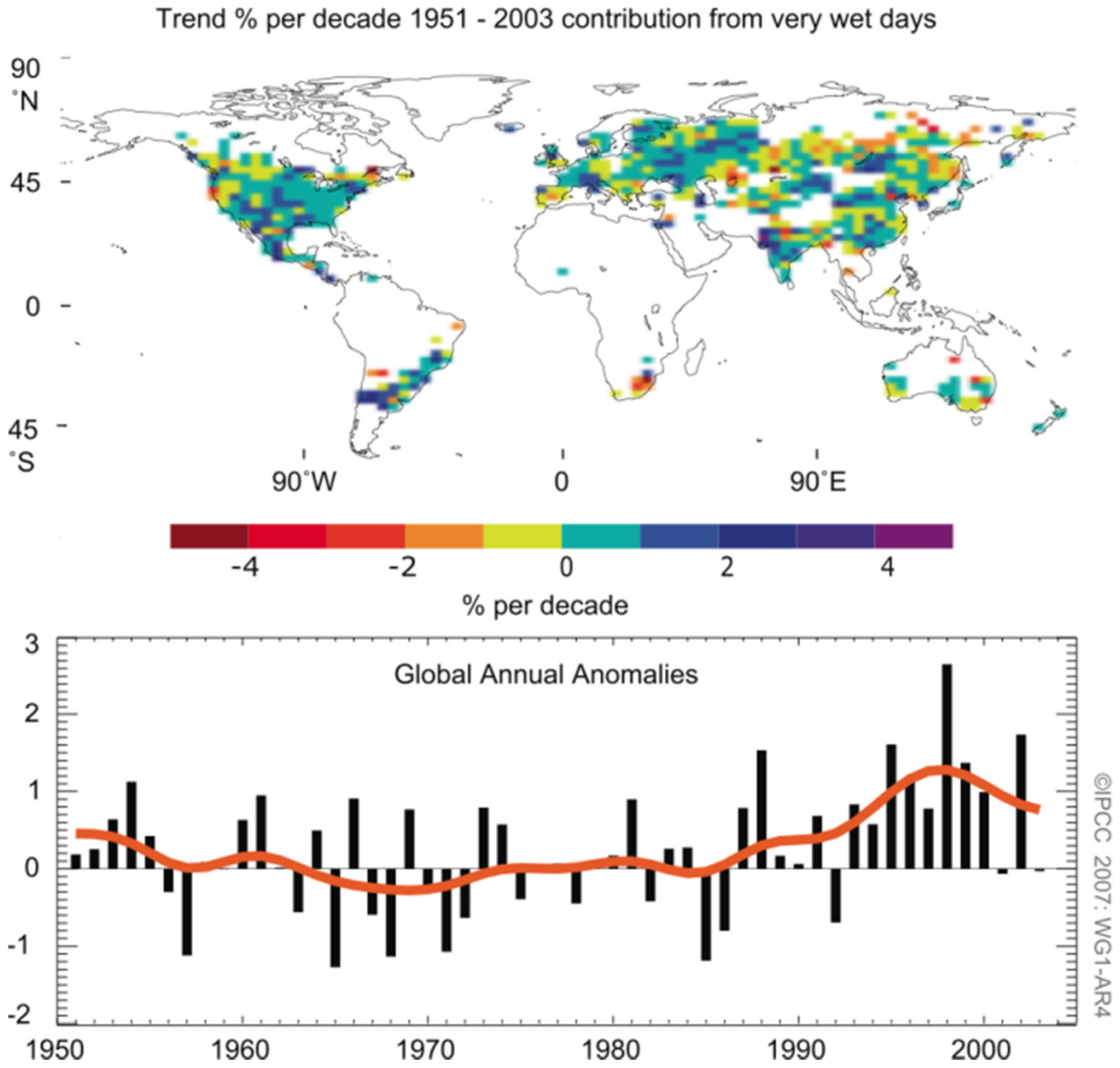
Trend % per decade 1951 - 2003 contribution from very wet days
90 °N
45
0
45 °S
90°W
0
90°E
-4
-2
0
2
4
% per decade
Global Annual Anomalies
3
2
1
0
-1
-2
1950
1960
1970
1980
1990
2000
©IPCC 2007: WG1-AR4

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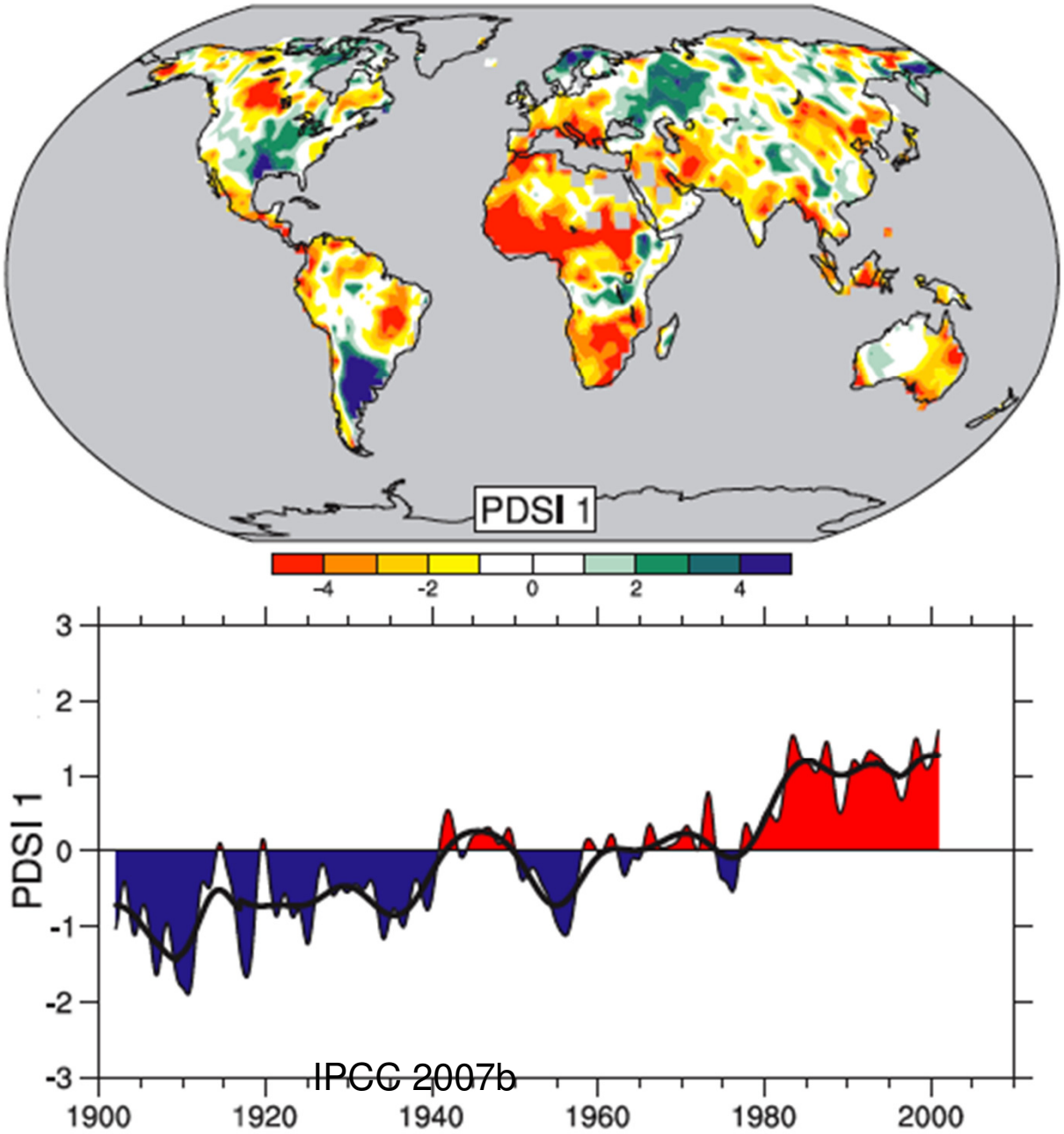
Palmer Drought Severity Index



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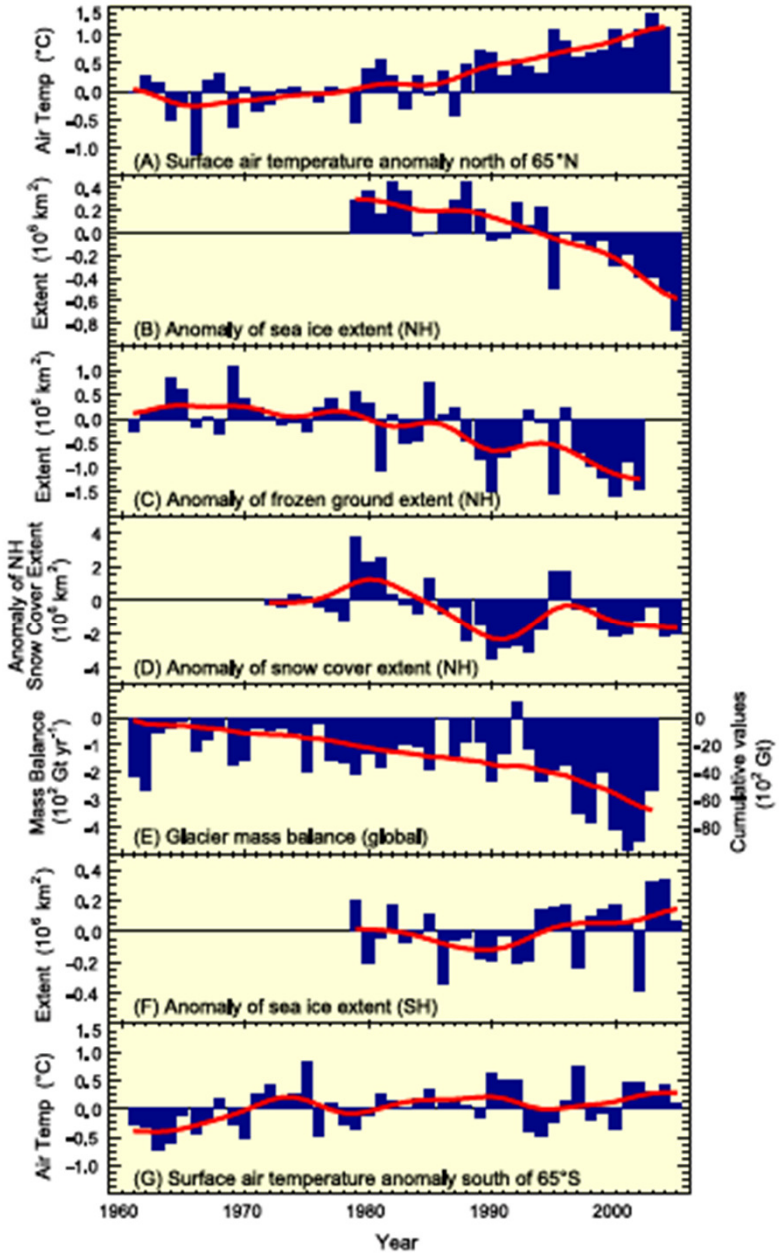
Recent Trends in Climate Sensitive Indicators



Air Temperature

Sea Ice

Frozen Ground

Snow Cover

Glacier Mass

Sea Ice Anomaly

Temp Anomaly

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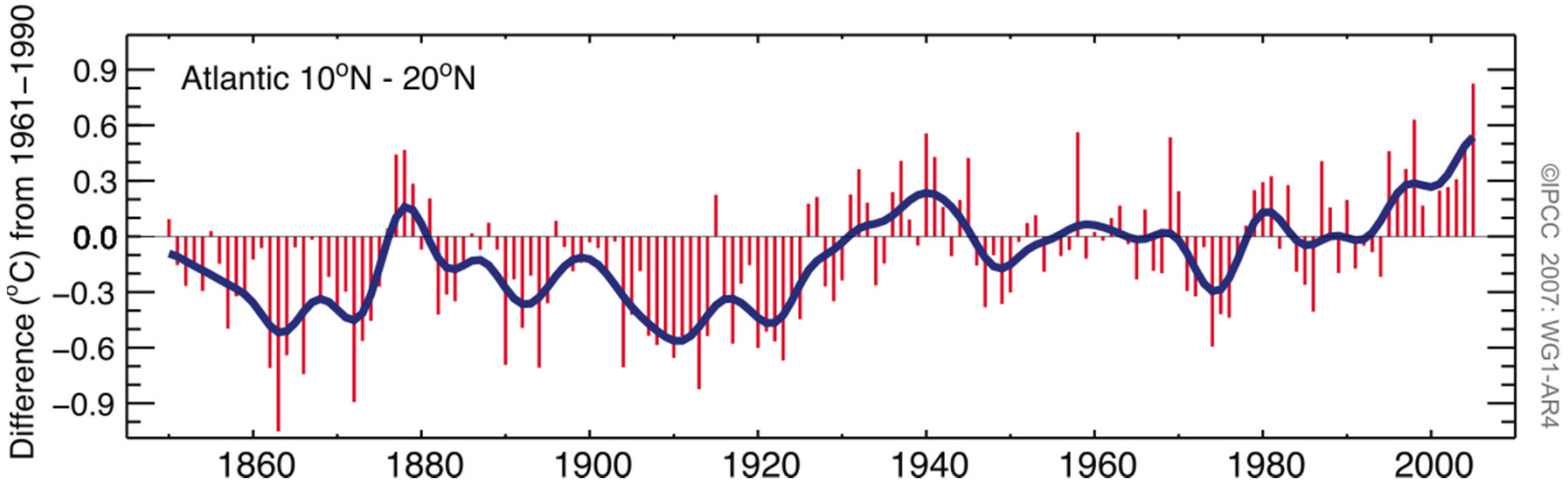
Tropical Atlantic Sea Surface Temperature Anomalies (°C)



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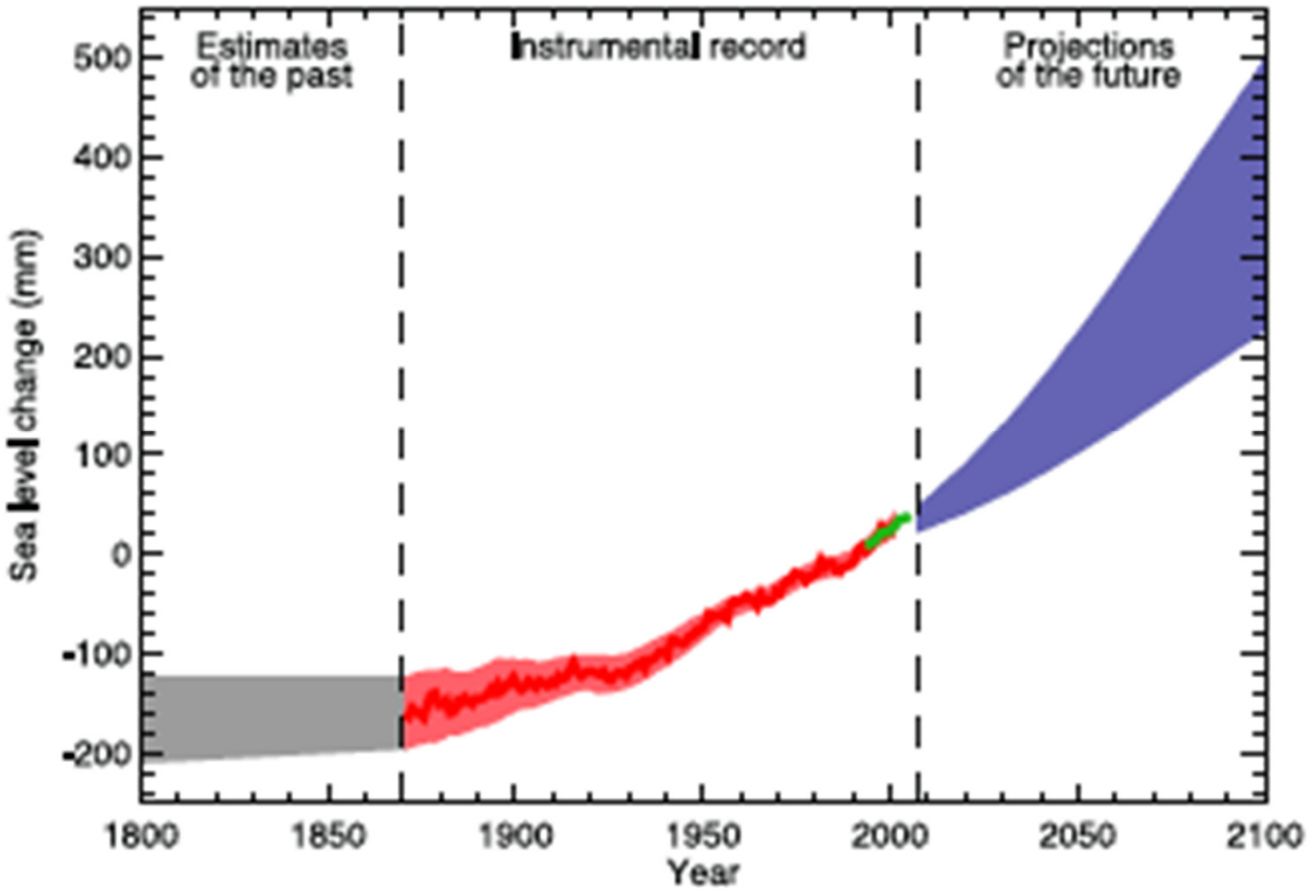
Sea Level Rise



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IPCC Conclusions

Phenomenon and Direction of Trend	Likelihood that trend occurred in 20th Century	Likelihood of a Human Contribution to Observed Trend	D	Likelihood of Future Trend Based on Projections for 21st Century
Warmer and fewer cold days and nights over most land areas	Very likely	Likely	*	Virtually certain
Warmer and more frequent hot days and nights over most land areas	Very likely	Likely (nights)	*	Virtually certain
Warm spells / heatwaves: frequency increases over most land areas	Likely	More likely than not		Very likely
Heavy precipitation events: frequency (or proportion of total rainfall from heavy falls) increases over most areas	Likely	More likely than not		Very likely
Area affected by droughts increases	Likely in many regions since 1970s	More likely than not	*	Likely
Intense tropical cyclone activity increases	Likely in many regions since 1970s	More likely than not		Likely
Increased incidence of extreme high sea level	Likely	More likely than not		Likely

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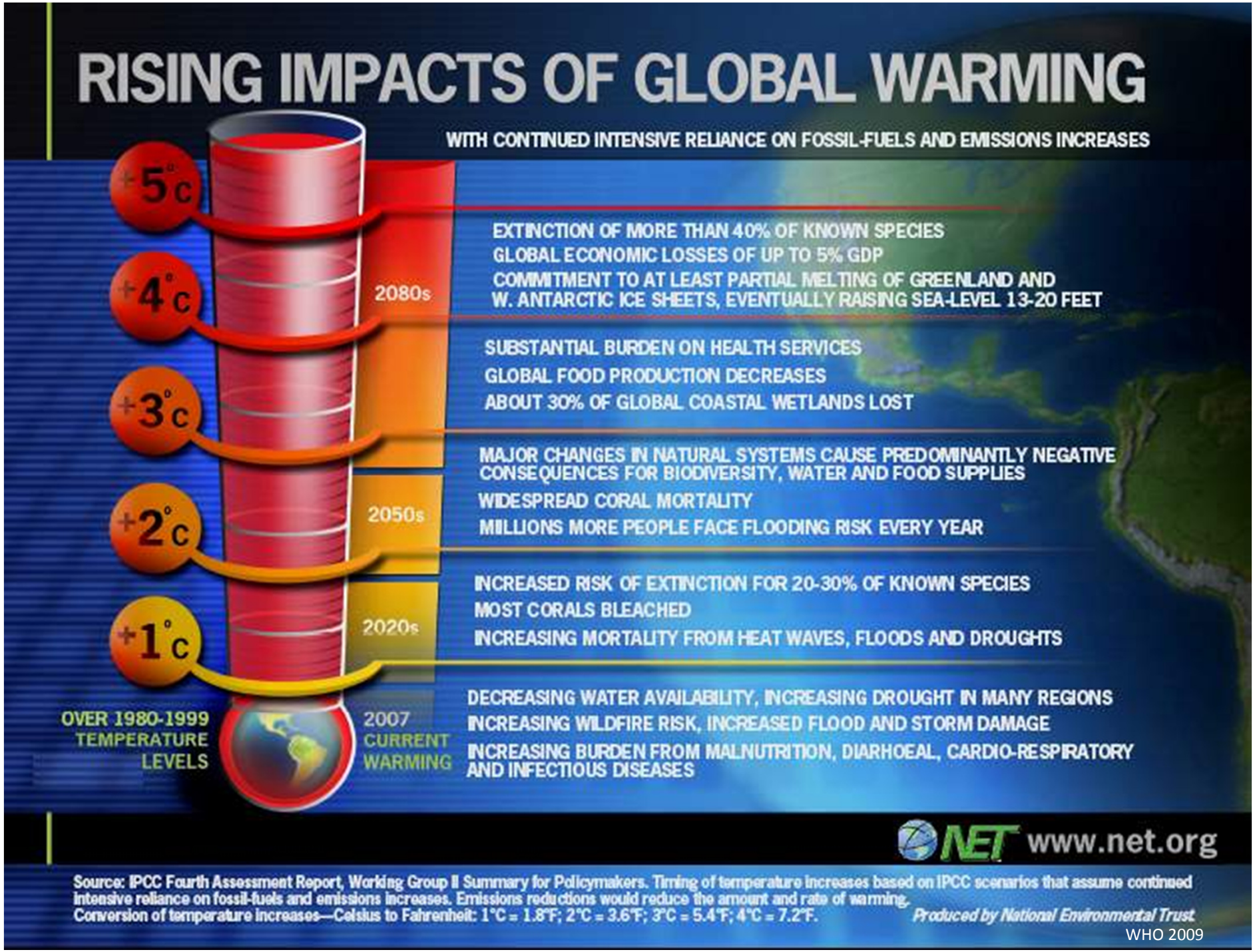
RISING IMPACTS OF GLOBAL WARMING
WITH CONTINUED INTENSIVE RELIANCE ON FOSSIL-FUELS AND EMISSIONS INCREASES
+5°C
+4°C
+3°C
+2°C
+1°C
2080s
2050s
2020s
EXTINCTION OF MORE THAN 40% OF KNOWN SPECIES
GLOBAL ECONOMIC LOSSES OF UP TO 5% GDP
COMMITMENT TO AT LEAST PARTIAL MELTING OF GREENLAND AND W. ANTARCTIC ICE SHEETS, EVENTUALLY RAISING SEA-LEVEL 13-20 FEET
SUBSTANTIAL BURDEN ON HEALTH SERVICES
GLOBAL FOOD PRODUCTION DECREASES
ABOUT 30% OF GLOBAL COASTAL WETLANDS LOST
MAJOR CHANGES IN NATURAL SYSTEMS CAUSE PREDOMINANTLY NEGATIVE CONSEQUENCES FOR BIODIVERSITY, WATER AND FOOD SUPPLIES
WIDESPREAD CORAL MORTALITY
MILLIONS MORE PEOPLE FACE FLOODING RISK EVERY YEAR
INCREASED RISK OF EXTINCTION FOR 20-30% OF KNOWN SPECIES
MOST CORALS BLEACHED
INCREASING MORTALITY FROM HEAT WAVES, FLOODS AND DROUGHTS
DECREASING WATER AVAILABILITY, INCREASING DROUGHT IN MANY REGIONS
INCREASING WILDFIRE RISK, INCREASED FLOOD AND STORM DAMAGE
INCREASING BURDEN FROM MALNUTRITION, DIARHOEAL, CARDIO-RESPIRATORY AND INFECTIOUS DISEASES
OVER 1980-1999 TEMPERATURE LEVELS
2007 CURRENT WARMING
NET www.net.org
Source: IPCC Fourth Assessment Report, Working Group II Summary for Policymakers. Timing of temperature increases based on IPCC scenarios that assume continued intensive reliance on fossil-fuels and emissions increases. Emissions reductions would reduce the amount and rate of warming.
Conversion of temperature increases—Celsius to Fahrenheit: 1°C = 1.8°F; 2°C = 3.6°F; 3°C = 5.4°F; 4°C = 7.2°F.
Produced by National Environmental Trust

WHO 2009

Discussion

Questions?

Thoughts?

Concerns?

Suggestions?

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