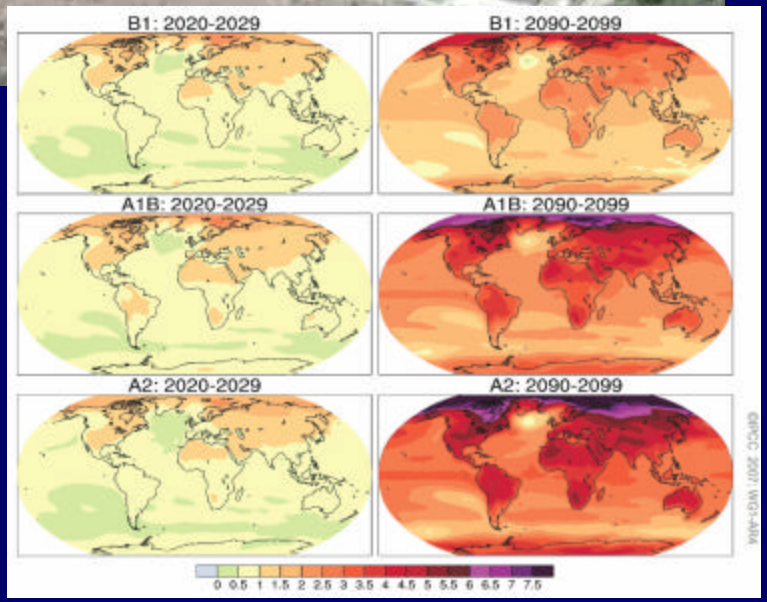
IPCC Fourth Assessment Report

Findings on the *Physical Basis of Climate Change* and

***Adaptation, Impacts and Vulnerability* (WG1 and WG2)**



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http://wwa.colorado.edu/ for IPCC info click on "water and climate"

http://www.cdc.nc

Western Water Assessment

WMO

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

UNEP

Colorado
University of Colorado at Boulder

Intergovernmental Panel on Climate Change: Fourth Assessment Report, 2007

"The Intergovernmental Panel on Climate Change (IPCC) has been established by WMO and UNEP to assess scientific, technical and socio- economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation."

-- Main activity is to provide an assessment of the state of knowledge on climate change based on peer-reviewed and published scientific/technical literature
-- Provide assessments in regular intervals, 1990, 1995, 2001, 2007

Working Groups:
Working Group I: The Physical Science Basis, Feb. 2007
Working Group II: Adaptation, Impacts and Vulnerability, April 2007
Working Group III: Limiting green house gas emissions and other mitigation strategies, May 2007

IPCC Web Address: http://www.ipcc.ch/ **or** http://wwa.colorado.edu/ click on "water and climate"

Direct Observations of Recent Climate Change

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level."

Working Group 1 *Summary for Policymakers*

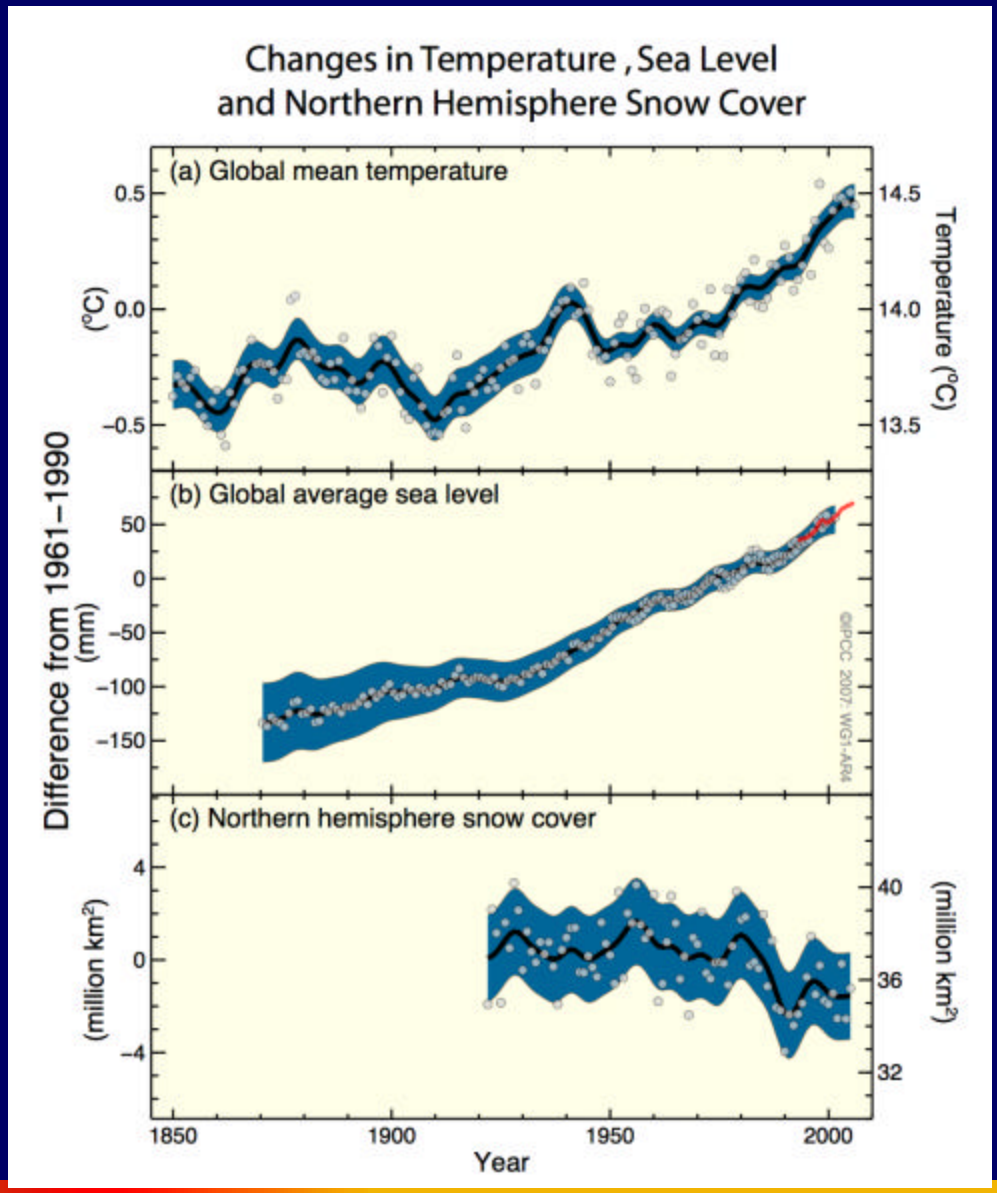
Direct Observations of Recent Climate Change

Global mean temperature:

•Updated 100-year linear trend of **0.74 °C or 1.3 °F** [0.56 - 0.92 °C, 1.08 - 1.6 °F] for 1906-2005

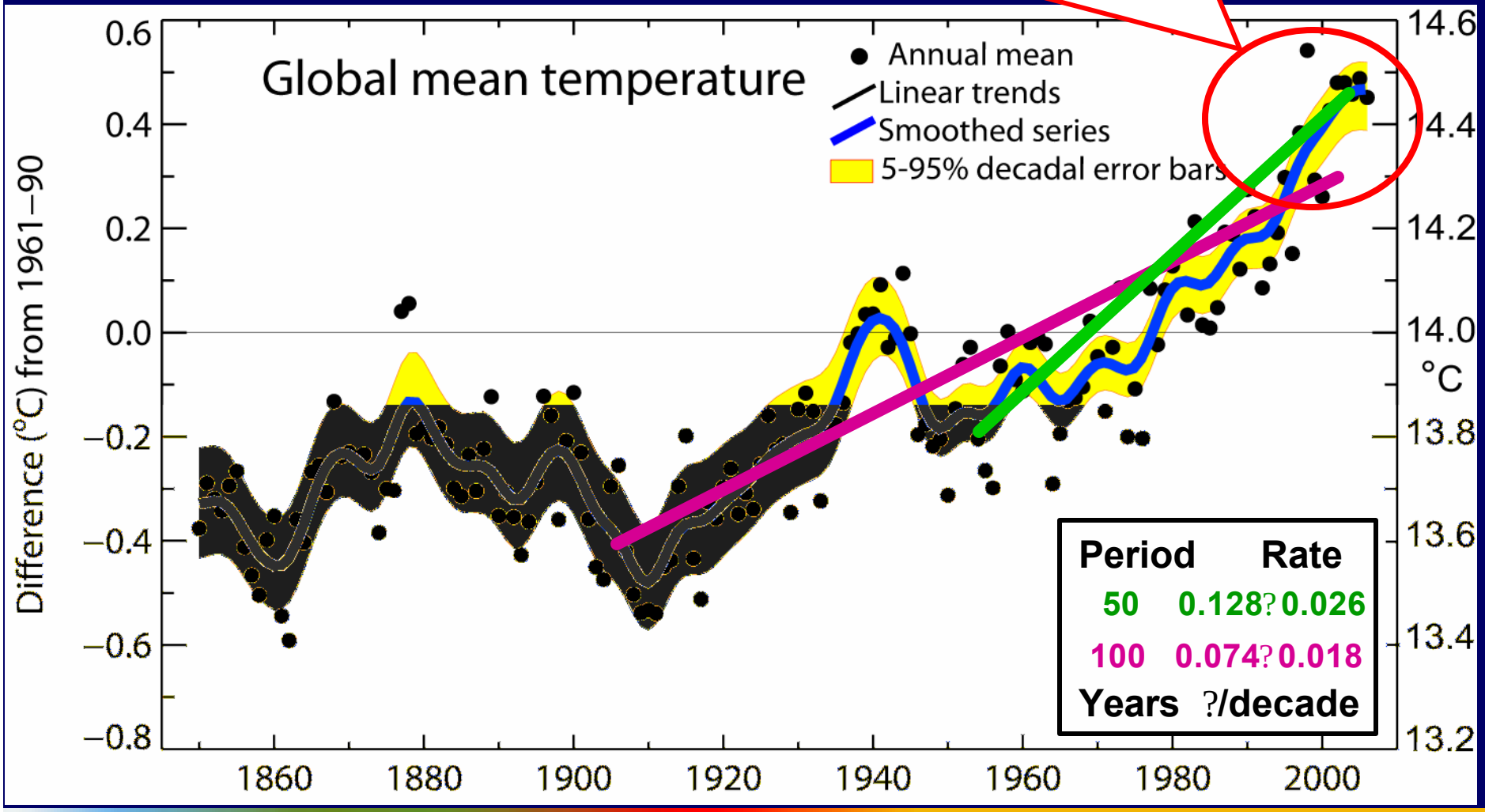
Global average sea level

Northern hemisphere snow cover



Global mean temperatures are rising faster with time

Warmest 12 years:
1998, 2005, 2003, 2002, 2004, 2006,
2001, 1997, 1995, 1999, 1990, 2000



Direct Observations of Recent Climate Change

At continental, regional, and ocean basin scales, numerous long-term changes in climate have been observed. These include:

- Widespread changes in precipitation amounts, ocean salinity, wind patterns
- Aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones
- Cold days, cold nights and frost less frequent
- Hot days, hot nights, and heat waves more frequent

Regional (Continental-scale) Observations of Change: Precipitation, Increased Drought

- Significantly **increased precipitation** in eastern parts of North and South America, northern Europe and northern and central Asia.
- The **frequency of heavy precipitation** events has increased over most land areas (consistent with warming and increases of atmospheric water vapour)
- **Drying** in the Sahel, the Mediterranean, southern Africa and parts of southern Asia.
- **More intense and longer droughts** observed since the 1970s, particularly in the tropics and subtropics.

Human and Natural Drivers of Climate Change

- "Changes in the atmospheric abundance of greenhouse gases and aerosols, in solar radiation and in land surface properties alter the energy balance of the climate system."

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are needed to see this picture.

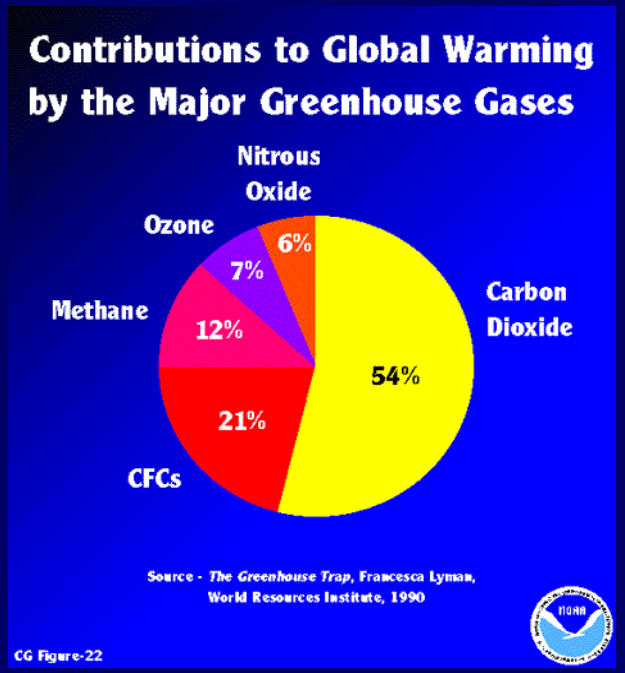
EPA figure

Human and natural drivers of climate change

"Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."

- Annual **emissions of CO_2** from fossil fuel burning increased from an average of **6.4** GtCper year in the 1990s, to **7.2** GtC per year in 2000-2005

- Other GHGs have also increased: Global atmospheric concentration of **nitrous oxide** increased from pre-industrial value of about **170 parts per billion to 319 ppb** in 2005.



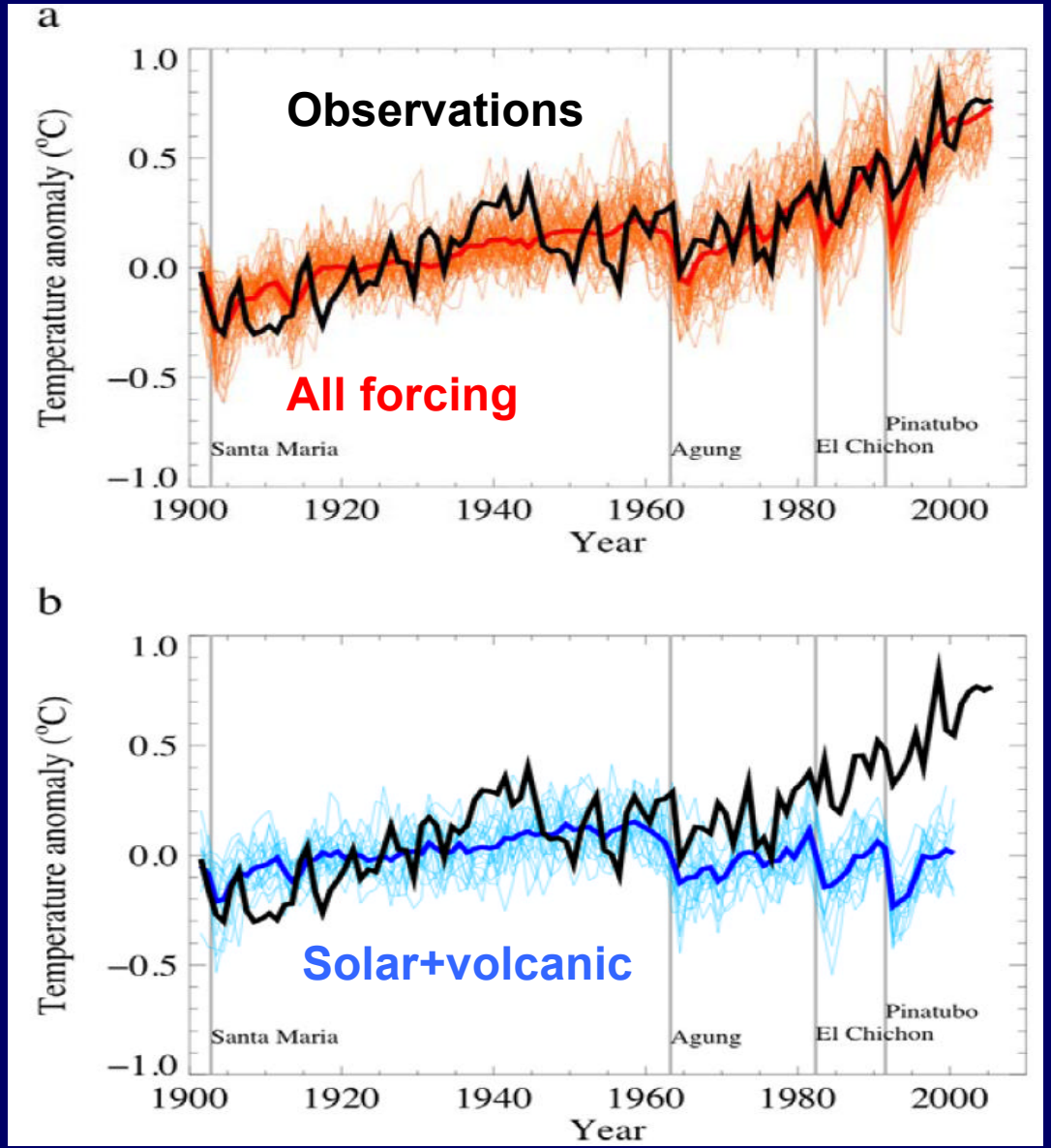
NOAA figure

Understanding and Attributing Climate Change

- Continental warming

  likely shows a significant anthropogenic contribution over the past 50 years

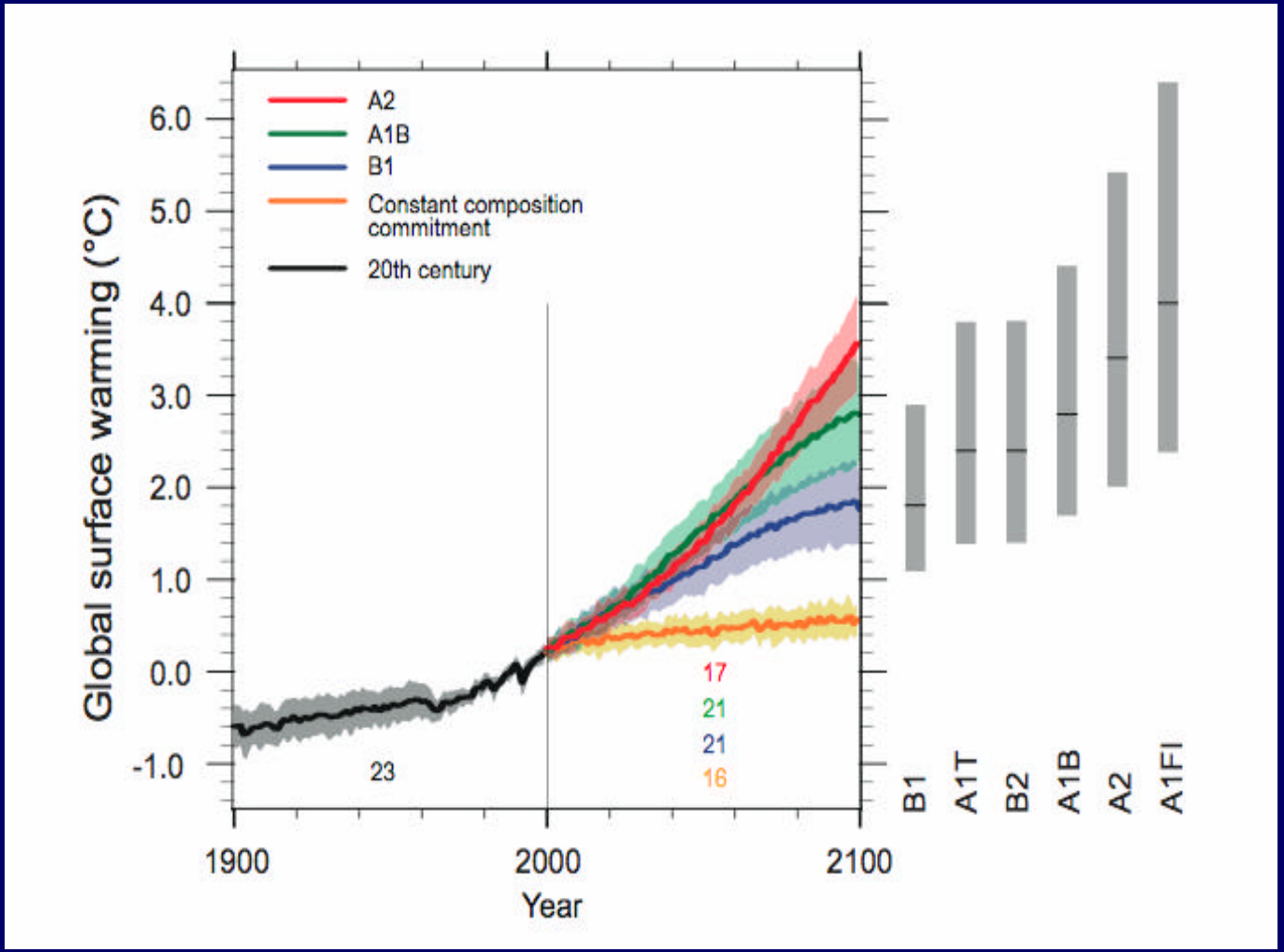
- *Very unlikely* due to known natural causes alone



Projections of Future Changes in Climate

Best estimate for low scenario (B1) is 1.8°C at end of 21st century (*likely* range is 1.1°C to 2.9°C)

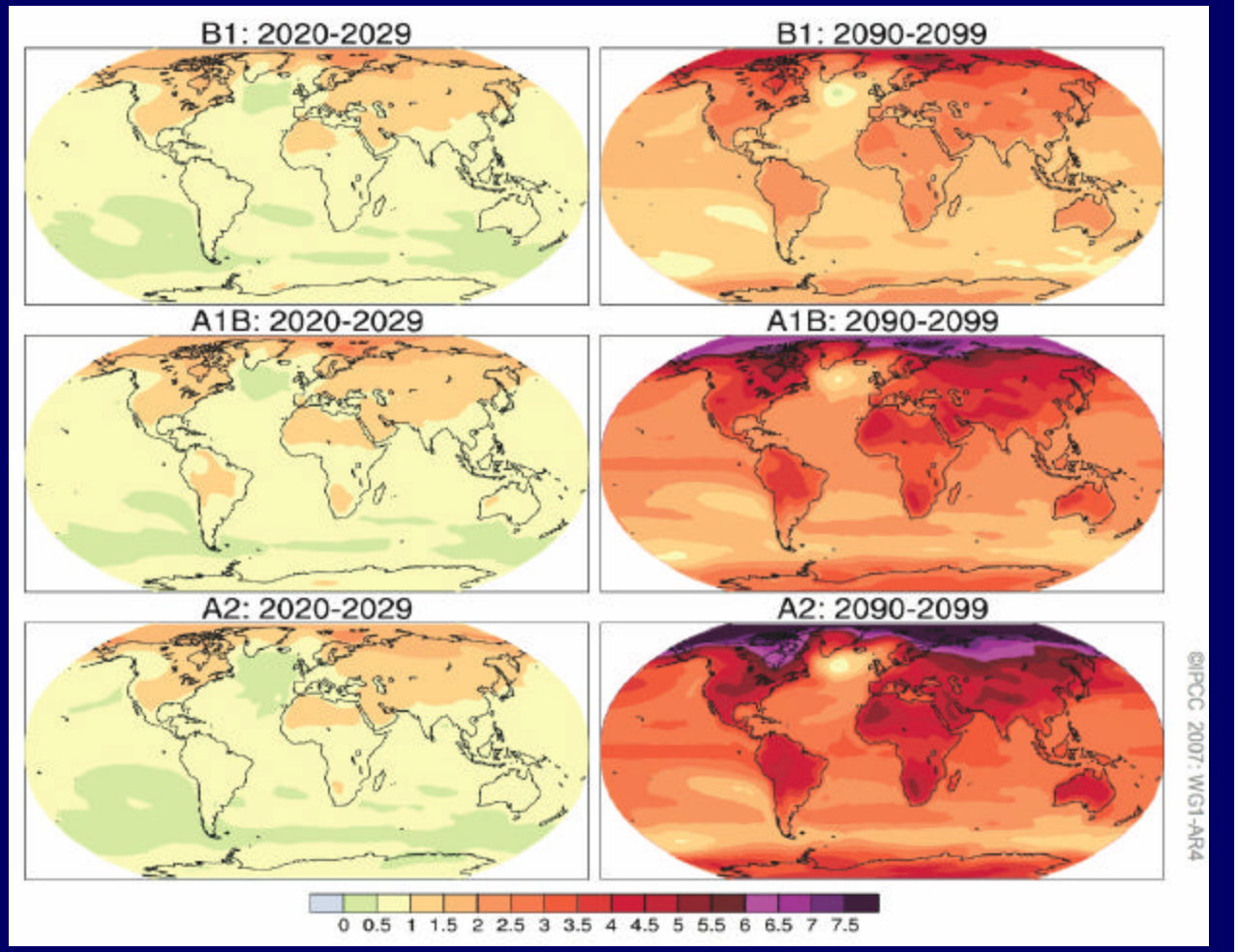
Highest scenario (A1FI) is 4.0°C at end of 21st century (*likely* range is 2.4°C to 6.4°C)



Projections of Future Changes in Climate

Projected warming in 21st century will vary spatially, expected to be:

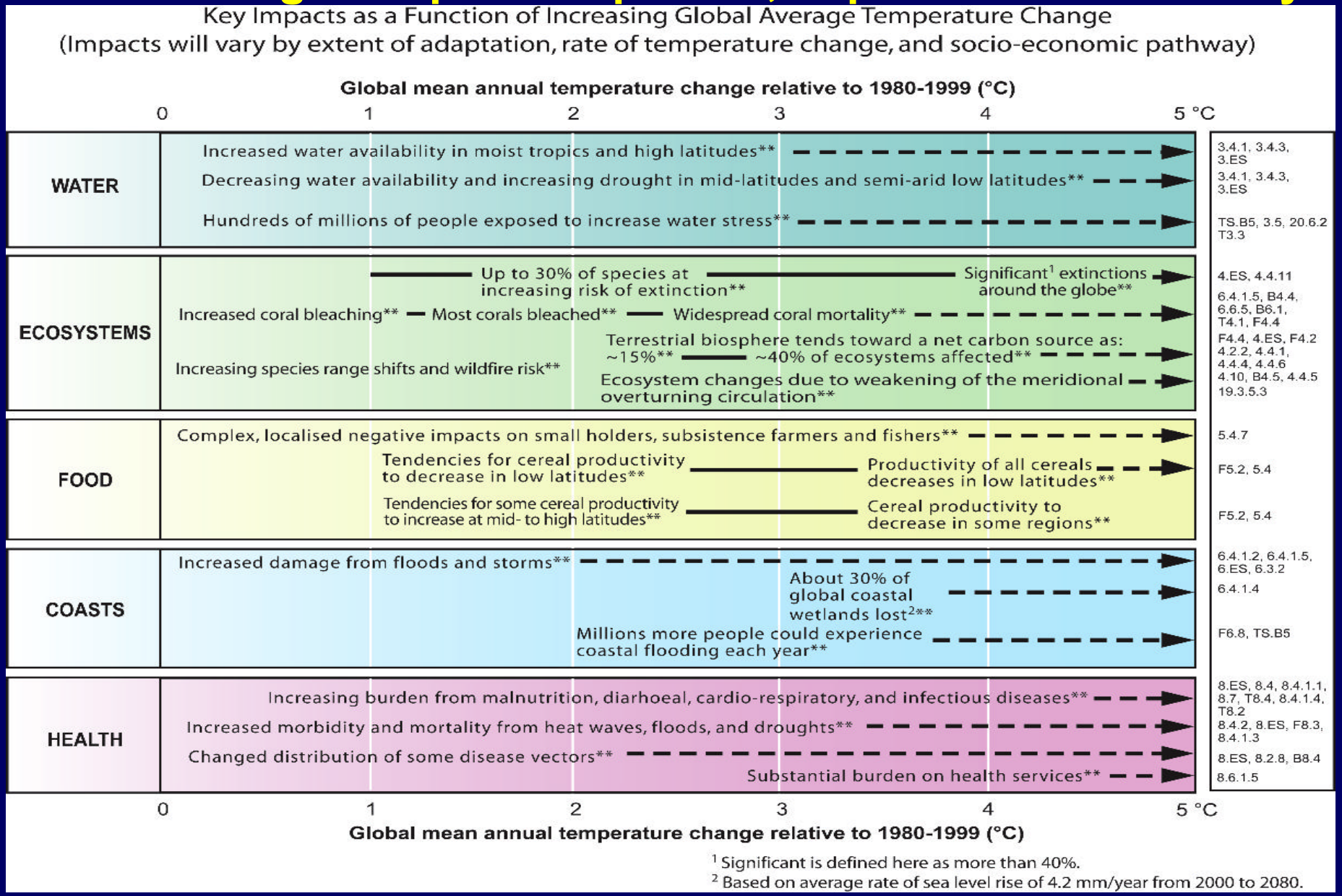
- **greatest** over land and at most high northern latitudes
- and **least** over the Southern Ocean and parts of the North Atlantic Ocean



Projections of Future Changes in Climate

- **Area covered by snow** is projected to contract
- *Very likely* that **hot extremes, heat waves, and heavy precipitation events** will continue to become more frequent
- *Likely* that future **tropical cyclones** more intense, less confidence in decrease of total number
- **Extra-tropical storm tracks** projected to move poleward with consequent changes in wind, precipitation, and temperature patterns
- Anthropogenic warming and sea level rise would **continue for centuries** due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilized.

IPCC Working Group 2: Adaptation, Impacts & Vulnerability



Risks in the Western U.S.

- The West has characteristics that make it highly vulnerable for climate change including:
- U.S. West economies are closely linked with climate-sensitive resources
  - Dependence on highly utilized water resources for regional economies
  - Tourism, i.e skiing, lake and water sports
  - Agriculture
- The West is prone to impacts of weather events (including drought)
- Rapid urbanization and population growth

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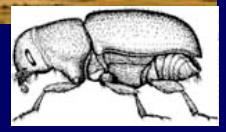
Impacts relevant to the Western US

- Warmer and fewer cold days and nights are *virtually certain* as are warmer/more frequent hot days and nights over most land areas



  - negative effects on water resources relying on snow melt
  - declining air quality in cities
  - increased disturbances from pests and diseases
  - reduced agricultural yields in warmer regions due to heat stress
  - wild fire danger increases
  - reduced hydropower generation potentials
  - increased risk of heat related mortality

- High elevation warming projected to cause decreased snowpack, more winter flooding, and reduced summer flows (*very high confidence)*
  - Streamflow changes projected beyond 2020 indicate that it may not be possible to fulfill all of the present-day water demands, even with adapted reservoir management.
  - By 2050 the Sacramento and Colorado River deltas could experience dramatic increases in salinity and subsequent ecosystem disruption.

Adaptation on Global & Regional Scales

Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

•Resilience of a society to adjust to a changing climate

- Adaptation to climate change is already taking place, but on a limited basis
- Adaptive capacity is uneven across and within societies
- Adaptive responses take time to fully implement, so likely more effective with time

A portfolio of adaptation and mitigation measures can diminish the risks associated with climate change. Responses include:

- purely technical (e.g. improve water use efficiency such as timers on sprinkler systems, irrigation efficiency, demand management e.g. through metering and pricing)
- behavioral (e.g. alternative recreation choices or timing)
- managerial (e.g. dry farming practices; improve the tradability of water rights)
- policy (drought warning systems; incorporation of climate into policies an planning; economic subsidies for disaster management or adaptive measures)

Thank You!

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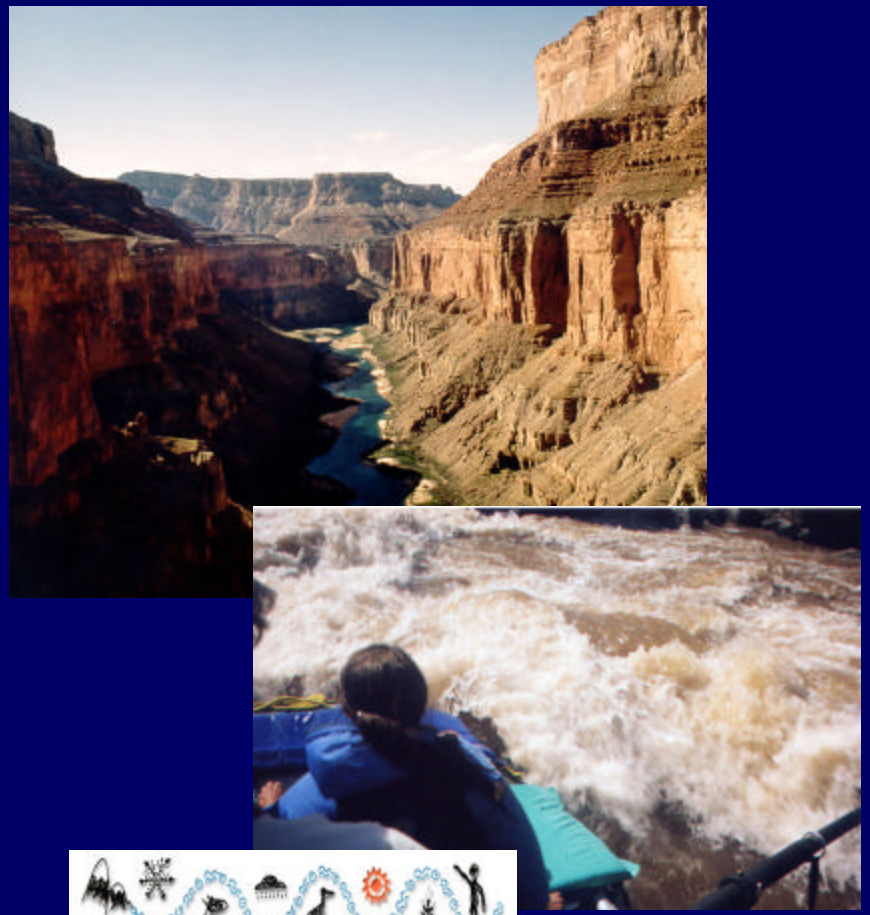
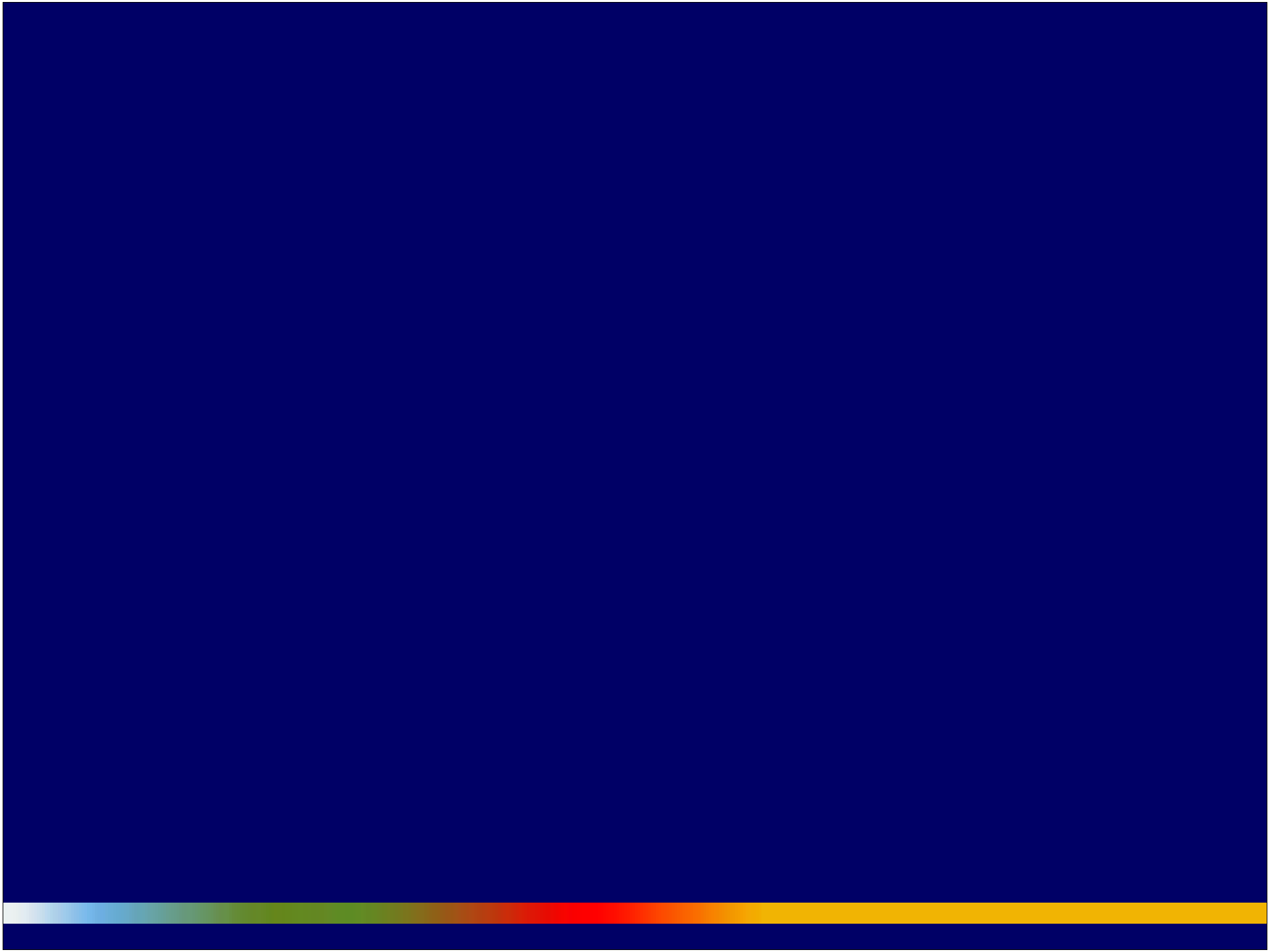
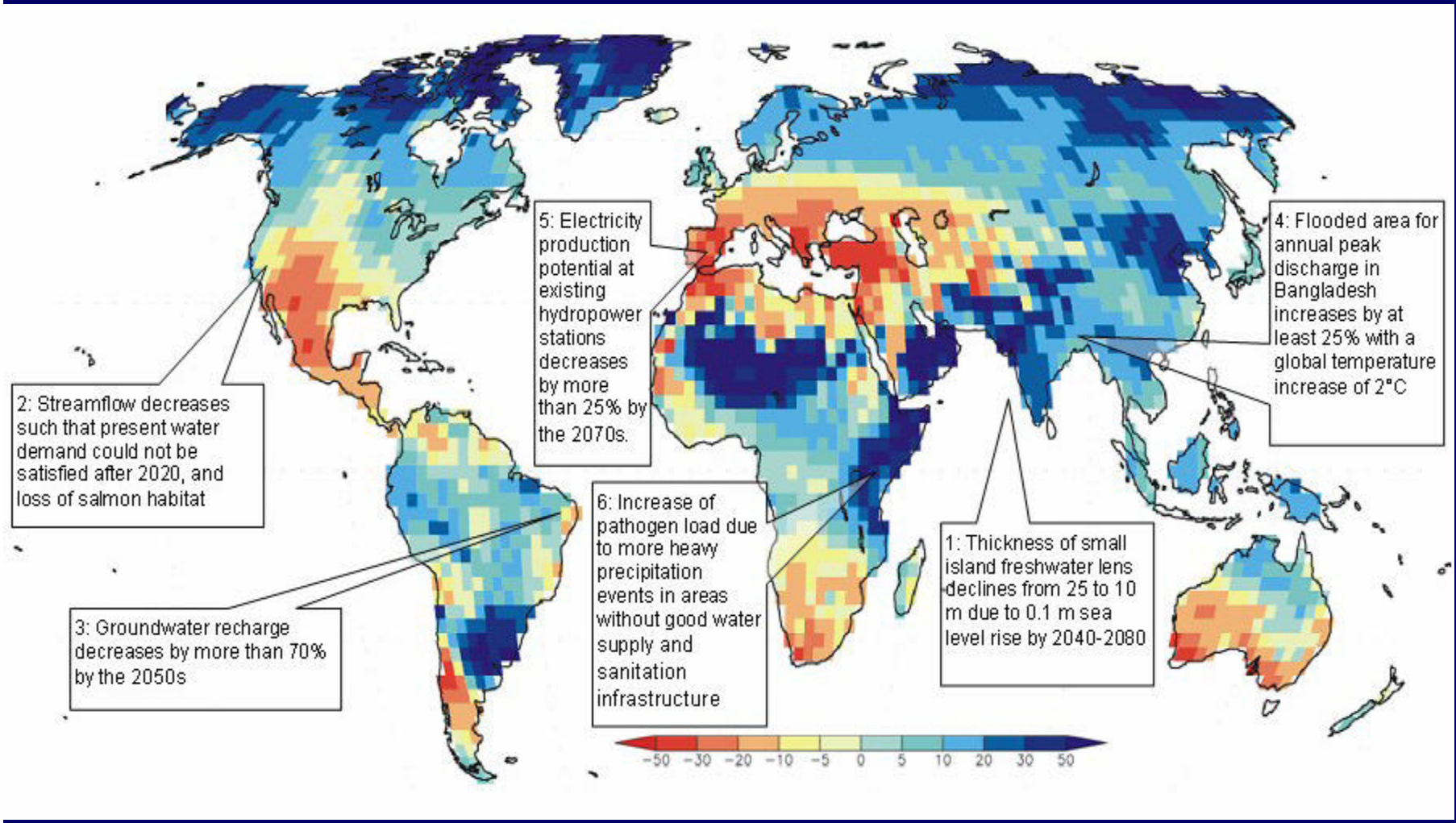


Western Water Assessment



Water


5: Electricity production potential at existing hydropower stations decreases by more than 25% by the 2070s.
4: Flooded area for annual peak discharge in Bangladesh increases by at least 25% with a global temperature increase of 2°C
2: Streamflow decreases such that present water demand could not be satisfied after 2020, and loss of salmon habitat
6: Increase of pathogen load due to more heavy precipitation events in areas without good water supply and sanitation infrastructure
1: Thickness of small island freshwater lens declines from 25 to 10 m due to 0.1 m sea level rise by 2040-2080
3: Groundwater recharge decreases by more than 70% by the 2050s
−50 −30 −20 −10 −5 0 5 10 20 30 50

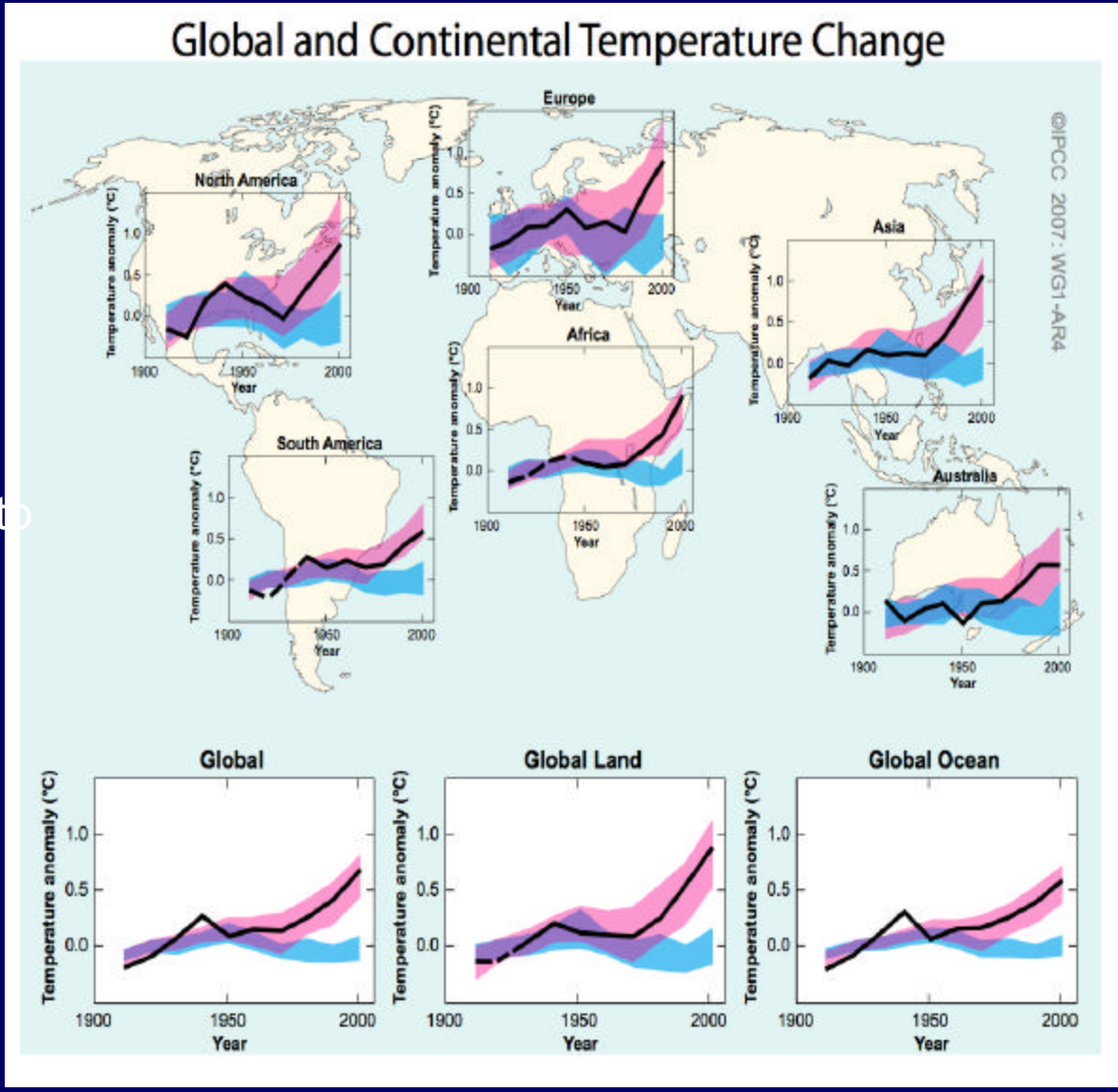
Understanding and Attributing Climate Cha

Continental warming

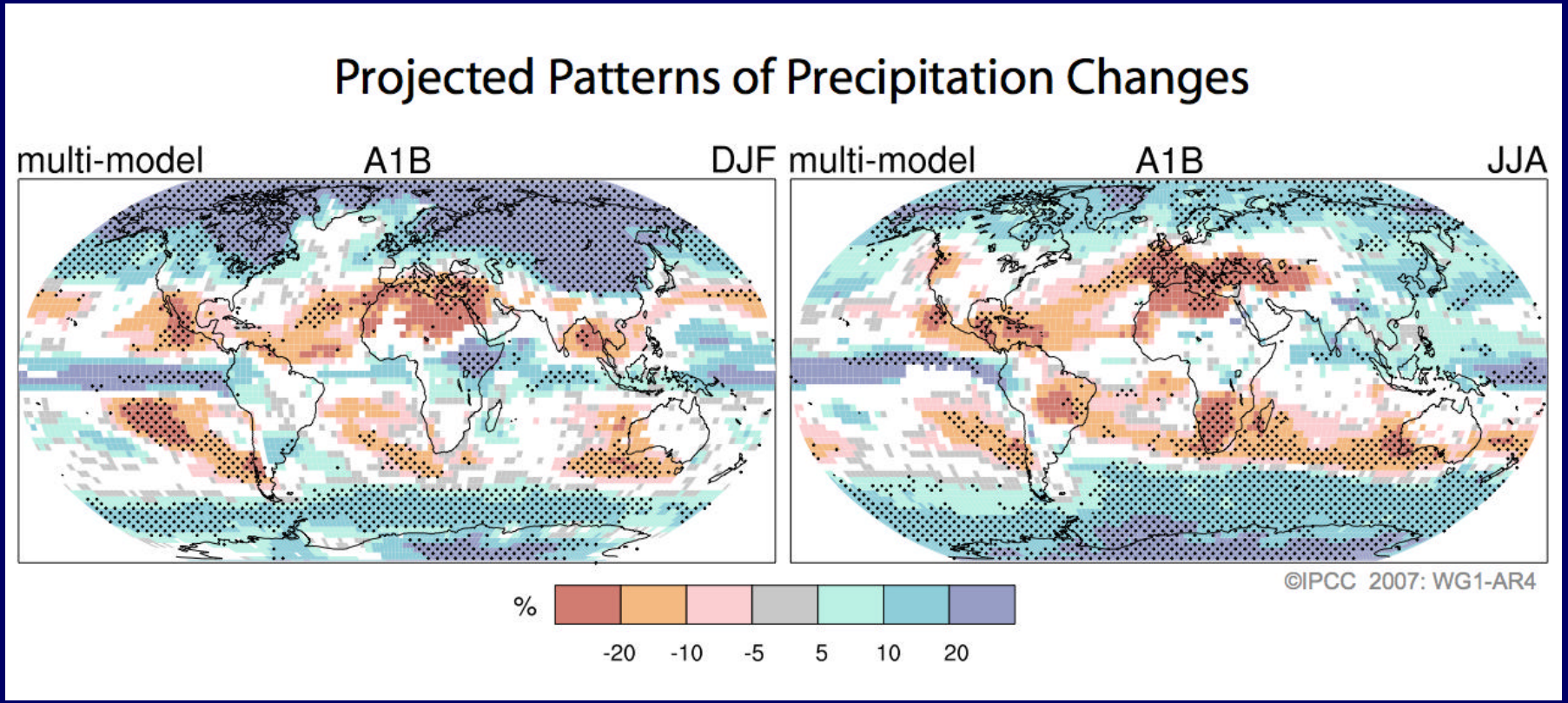
likely shows a significant anthropogenic contribution over the past 50 years

extremely unlikely without external forcing

- very unlikely due to known natural causes alone



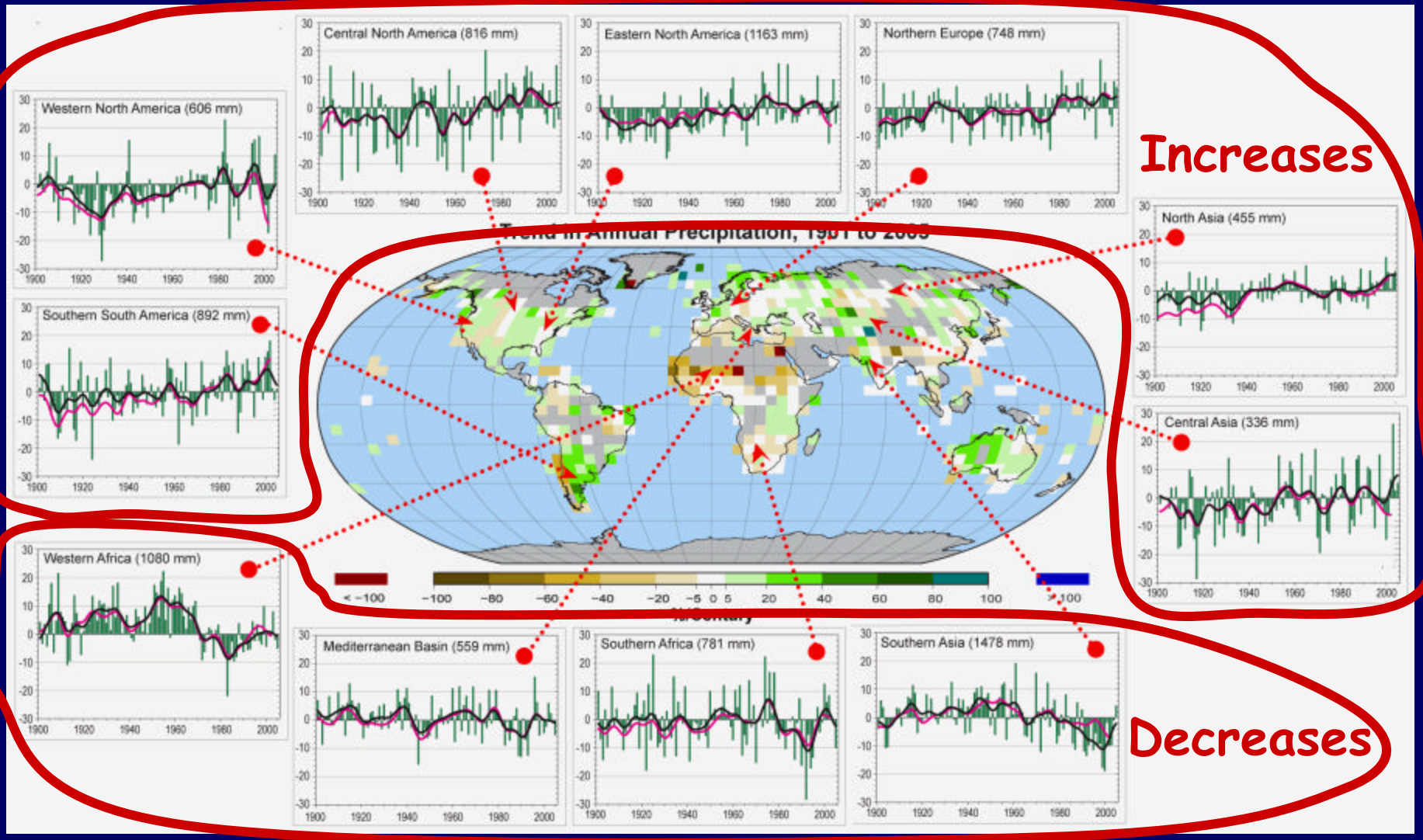
Projections of Future Changes in Climate



Precipitation increases *very likely* in high latitudes

Decreases *likely* in most subtropical land regions

Land precipitation is changing significantly over broad areas



Smoothed annual anomalies for precipitation (%) over land from 1900 to 2005; other regions are dominated by variability.

WGIII: Mitigation Strategies

Table SPM 3: *Key mitigation technologies and practices by sector. Sectors and technologies are listed in no particular order. Non-technological practices, such as lifestyle changes, which are cross-cutting, are not included in this table (but are addressed in paragraph 7 in this SPM).*

Sector	Key mitigation technologies and practices currently commercially available.	Key mitigation technologies and practices projected to be commercialized before 2030.
Energy Supply [4.3, 4.4]	Improved supply and distribution efficiency; fuel switching from coal to gas; nuclear power; renewable heat and power (hydropower, solar, wind, geothermal and bioenergy); combined heat and power; early applications of CCS (e.g. storage of removed CO_2 from natural gas)	Carbon Capture and Storage (CCS) for gas, biomass and coal-fired electricity generating facilities; advanced nuclear power; advanced renewable energy, including tidal and waves energy, concentrating solar, and solar PV.
Transport [5.4]	More fuel efficient vehicles; hybrid vehicles; cleaner diesel vehicles; biofuels; modal shifts from road transport to rail and public transport systems; non-motorised transport (cycling, walking); land-use and transport planning	Second generation biofuels; higher efficiency aircraft; advanced electric and hybrid vehicles with more powerful and reliable batteries
Buildings [6.5]	Efficient lighting and daylighting; more efficient electrical appliances and heating and cooling devices; improved cook stoves, improved insulation ; passive and active solar design for heating and cooling; alternative refrigeration fluids, recovery and recycle of fluorinated gases	Integrated design of commercial buildings including technologies, such as intelligent meters that provide feedback and control; solar PV integrated in buildings
Industry [7.5]	More efficient end-use electrical equipment; heat and power recovery; material recycling and substitution; control of non-CO_2 gas emissions; and a wide array of process-specific technologies	Advanced energy efficiency; CCS for cement, ammonia, and iron manufacture; inert electrodes for aluminium manufacture
Agriculture [8.4]	Improved crop and grazing land management to increase soil carbon storage; restoration of cultivated peaty soils and degraded lands; improved rice cultivation techniques and livestock and manure management to reduce CH_4 emissions; improved nitrogen fertilizer application techniques to reduce N_2O emissions; dedicated energy crops to replace fossil fuel use; improved energy efficiency	Improvements of crops yields
Forestry/forests [9.4]	Afforestation; reforestation; forest management; reduced deforestation; harvested wood product management; use of forestry products for bioenergy to replace fossil fuel use	Tree species improvement to increase biomass productivity and carbon sequestration. Improved remote sensing technologies for analysis of vegetation/ soil carbon sequestration potential and mapping land use change
Waste [10.4]	Landfill methane recovery; waste incineration with energy recovery; composting of organic waste; controlled waste water treatment; recycling and waste minimization	Biocovers and biofilters to optimize CH_4 oxidation