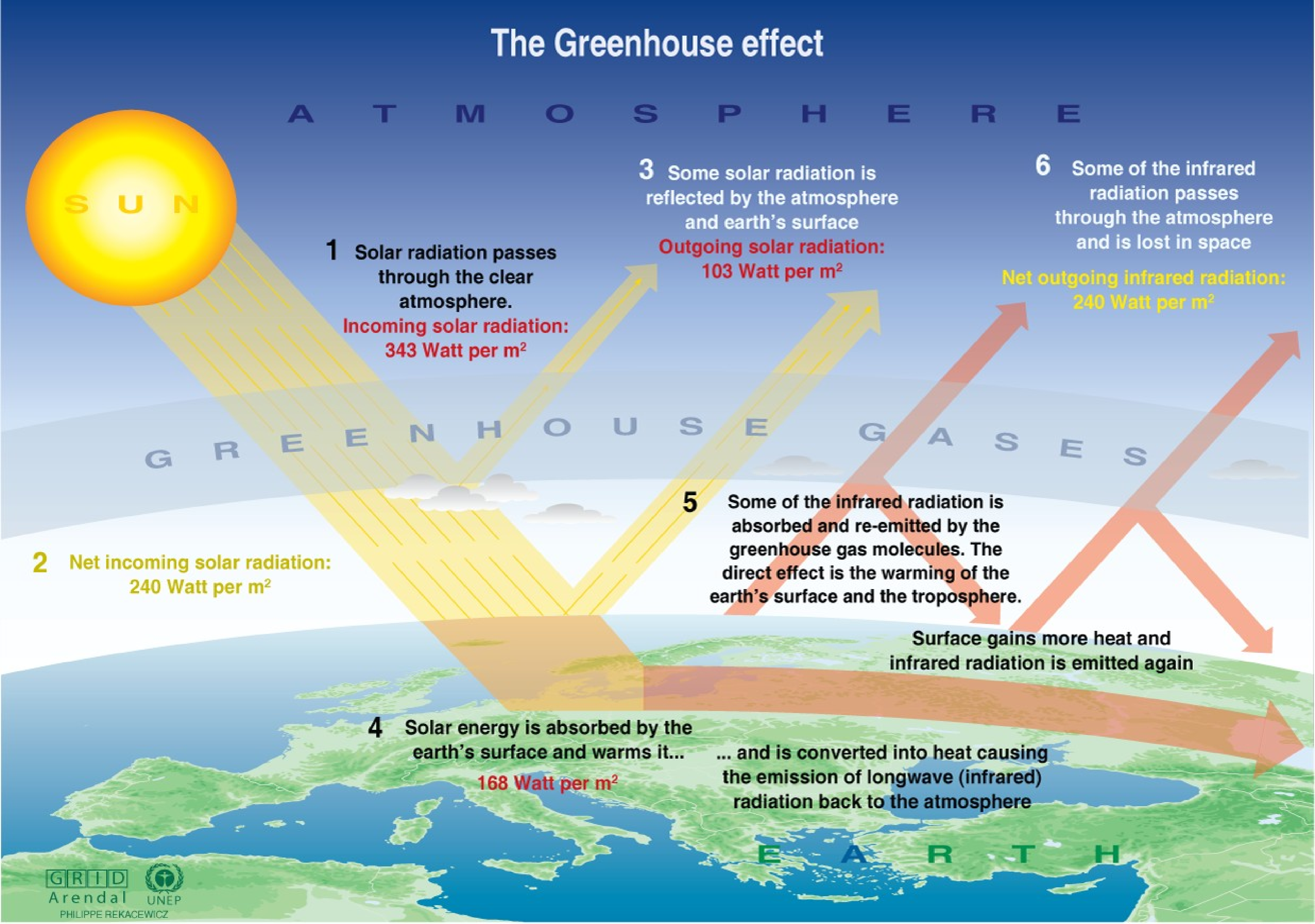
Climate Change and the Energy Challenge

Arthur Lyon Dahl Ph.D.

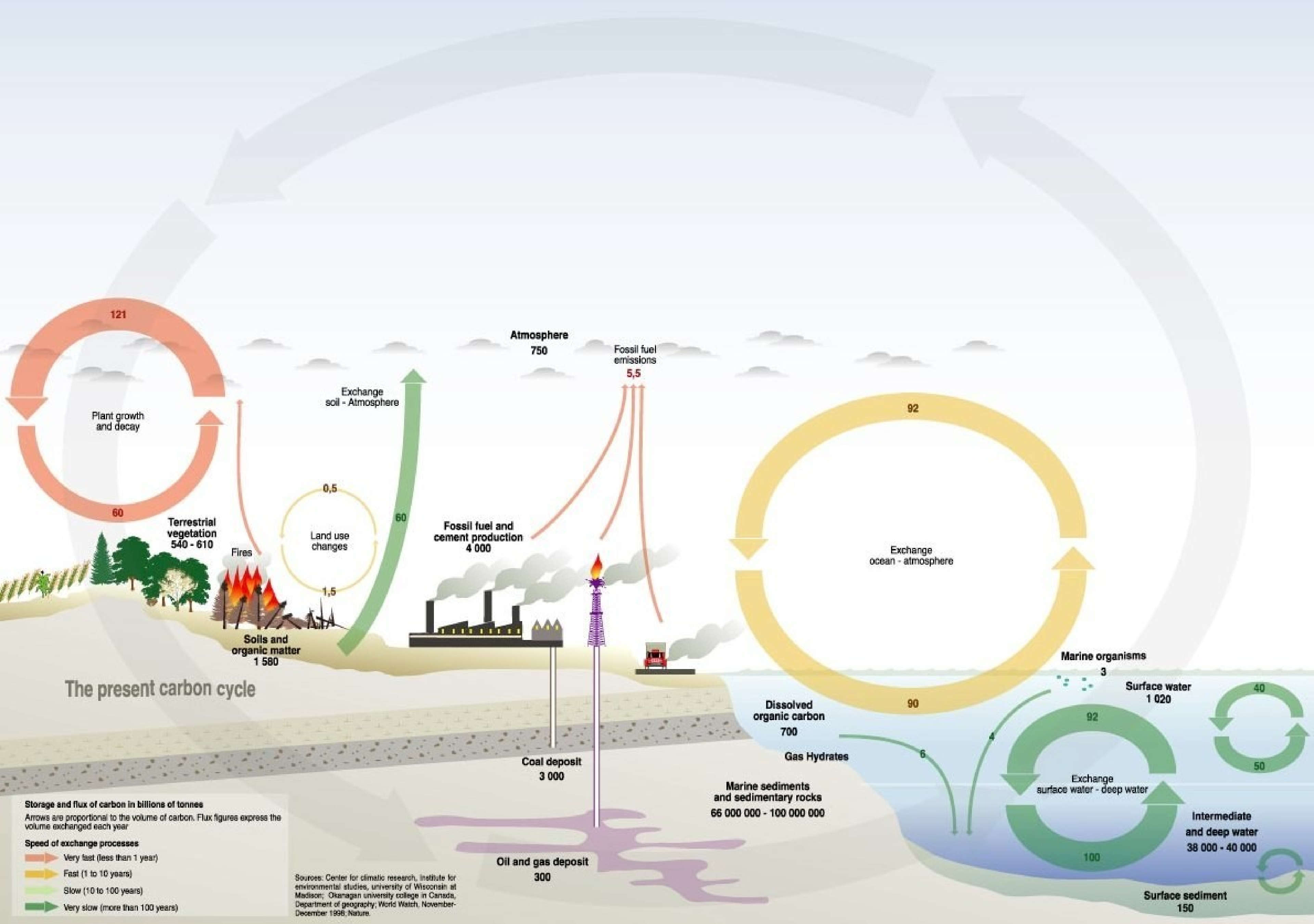
International Environment Forum (IEF)
http://iefworld.org

September 2013



Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

Carbon Cycle



Atmospheric CO_2 Concentration

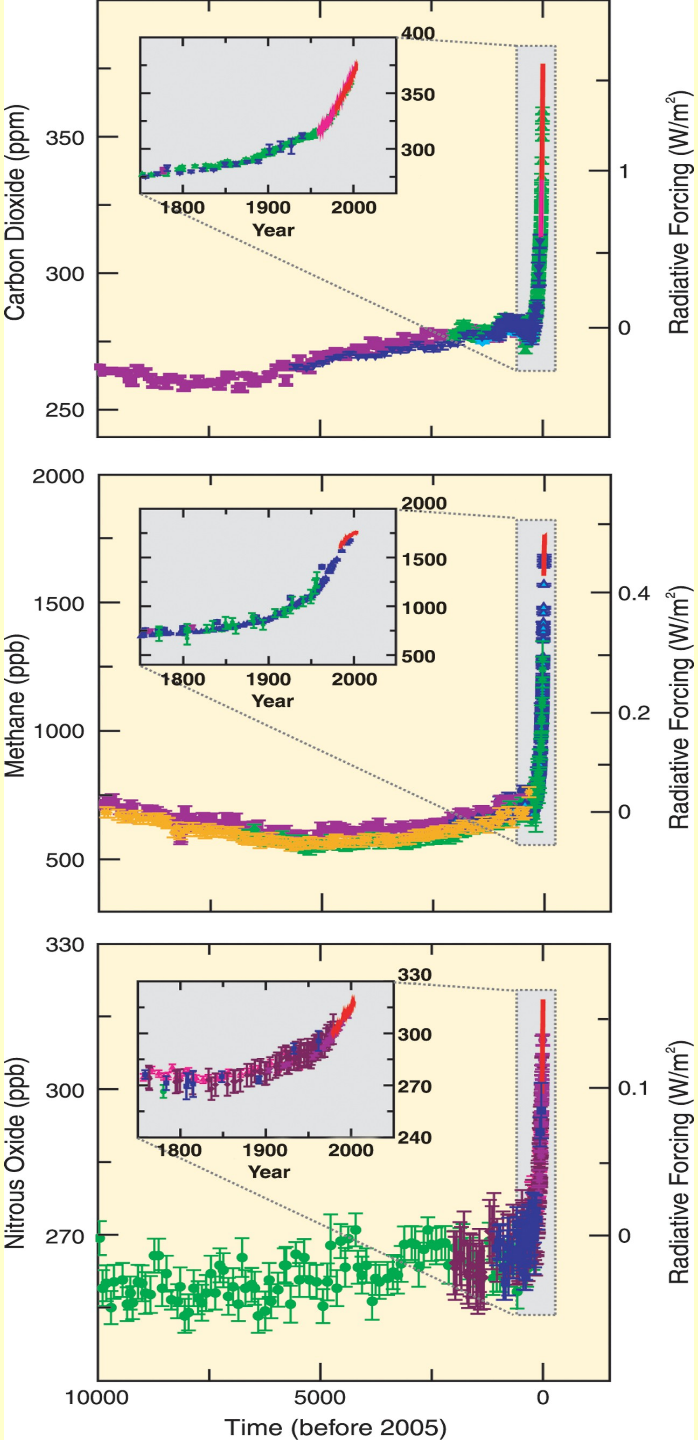
- Present CO_2 concentration reached 400 ppm in 2013, 40% above pre-industrial levels
- Highest in at least 2 million years
- Growth rate accelerating, now **1.9** ppm/yr
- 20-35% will remain in atmosphere for several centuries
- To prevent dangerous climate change, the concentration should stay below 350 ppm

Changes in greenhouse gas concentrations

CO_2

Methane

Nitrous oxides



IPCC 2007

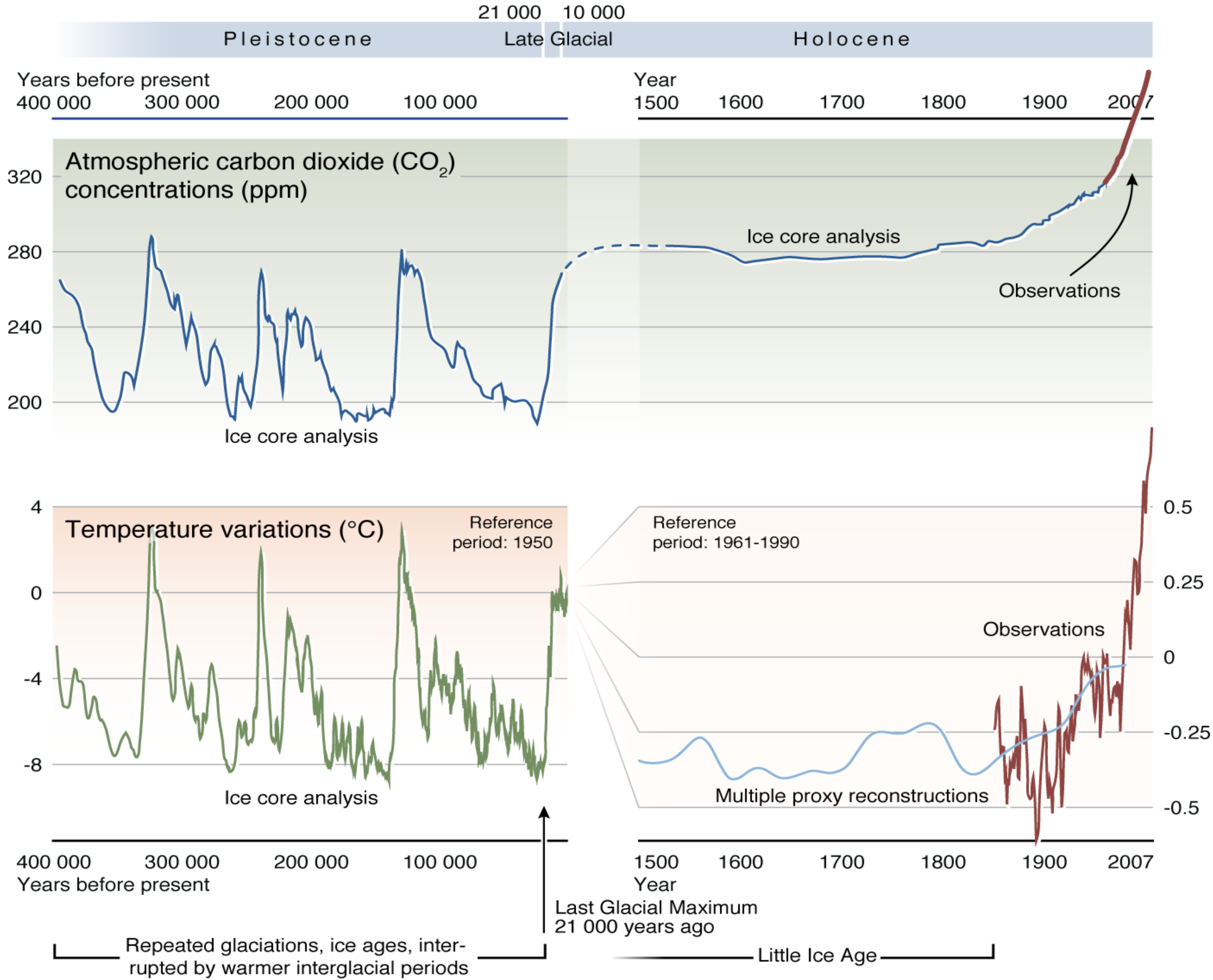
Carbon emissions

- Carbon emissions from fossil fuel combustion and cement production were 8.7 Gt in 2008, 41% higher than 1990
- Tropical deforestation 1.5 Gt/year, 15% of total anthropogenic emissions
- Fossil fuel emissions expected to rise to 12-18 Gt/yr by 2050 (2-3 times level in 2000)
- Total past emissions 500 billion tonnes carbon
- Expect to emit another 500 billion tonnes next 30 years
- Must stay below 1 trillion tonnes to avoid < 2°C rise

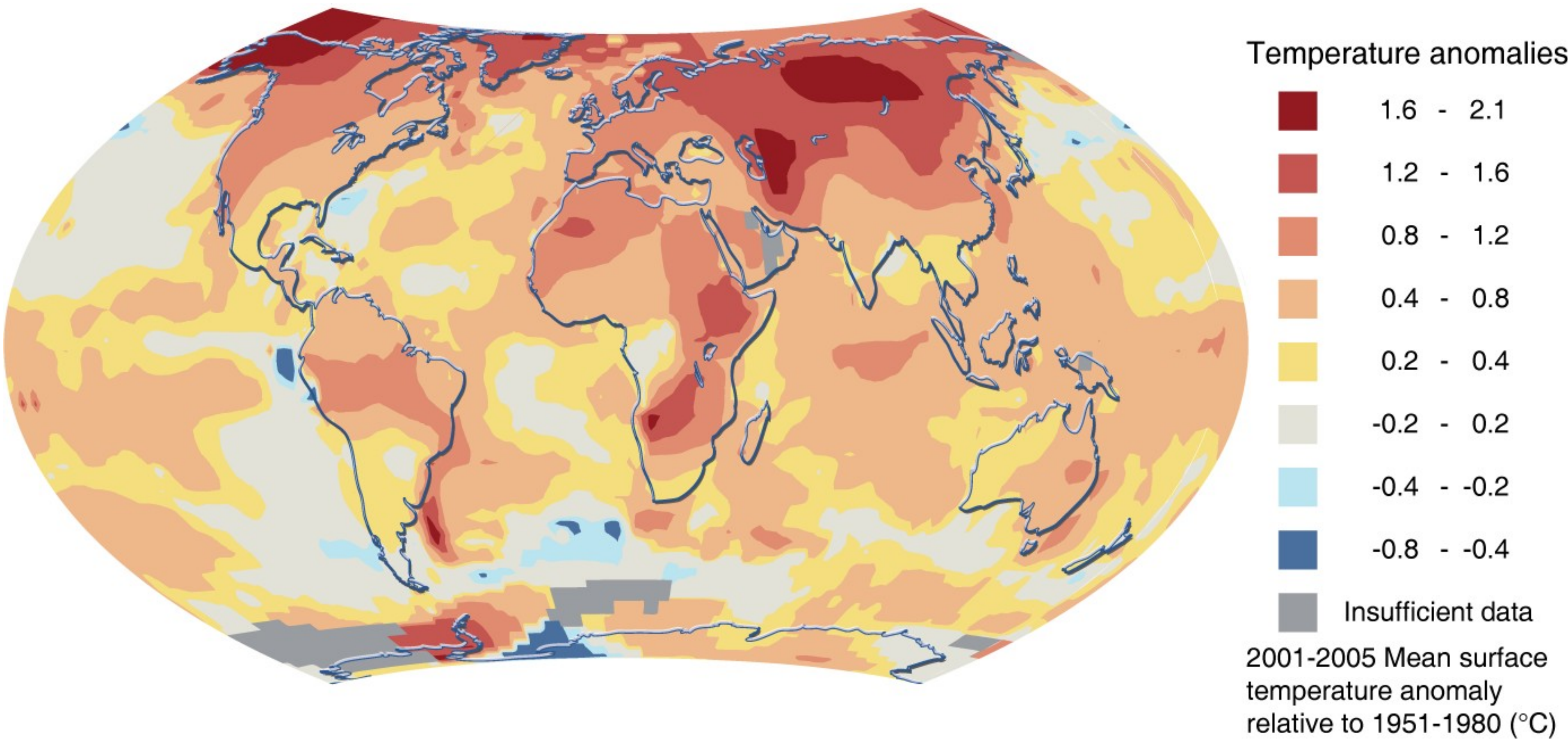
We are all responsible for climate change

- Everyone benefiting from the burning of fossil fuels is at fault
- Everyone involved in land clearing or benefiting from land use changes is a contributor
- How much we are responsible depends on our country of residence, lifestyle and consumption patterns, with the rich most responsible
- The poor will be the greatest victims of climate change, while contributing the least to the problem
- This is an ethical human rights dilemma

Carbon dioxide and temperature



Temperature increase last 50 years

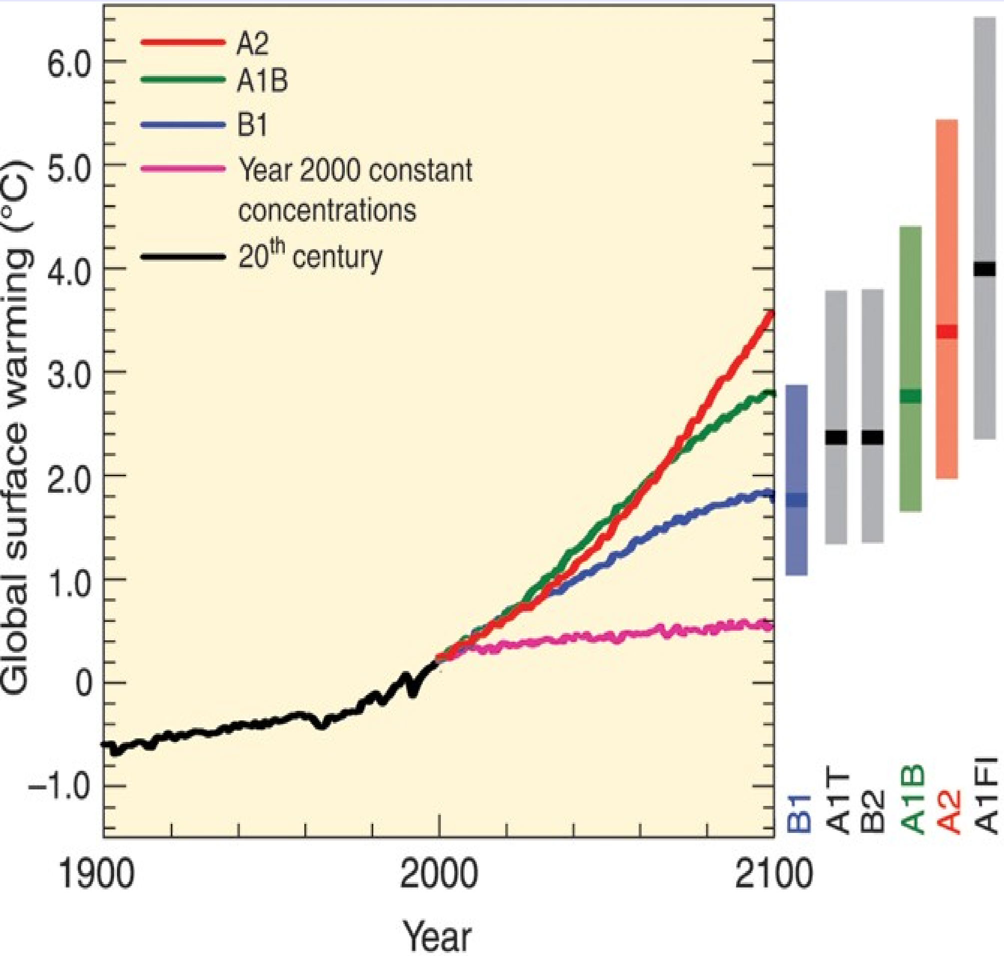


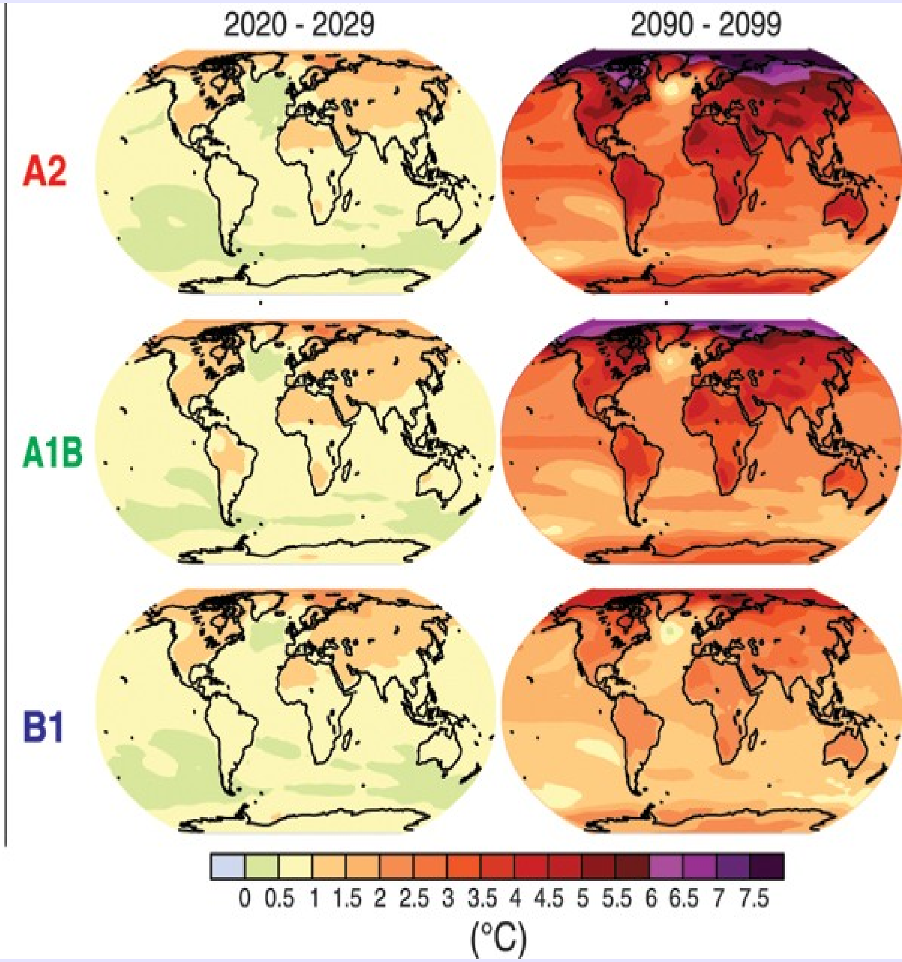
Signs of Climate Change

- Many species are changing their latitudinal and altitudinal distributions in response to rising temperatures
- Coral reefs have suffered bleaching and mortality from unusually high temperatures
- The number of category 5 cyclones (hurricanes) has increased in all oceans over the last 30 years
- The last 12 years have seen 11 of the warmest years ever recorded

What the models say

IPCC 2007





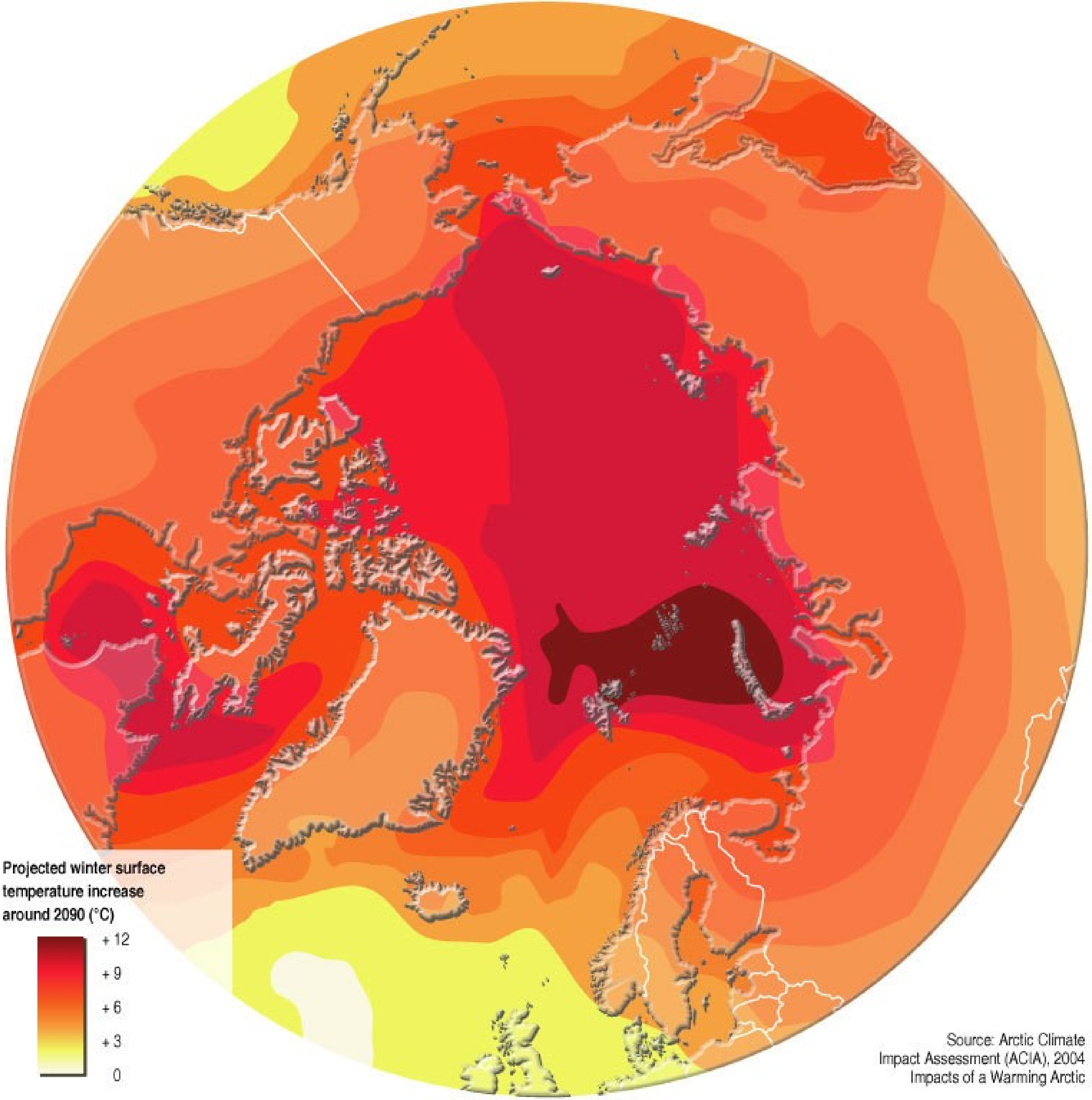
Polar areas are changing fastest

- 14% of the permanent ice in the Arctic Ocean melted in 2005; 23% more in 2007; North-West Passage opened in 2008; worst melting ever in 2012; now mostly thin first- year ice; permanent ice in the Arctic Ocean may be gone by 2015-2030
- Greenland glaciers have doubled their rate of flow in the last few years, now raising sea level 0.83 mm per year
- West Antarctic ice sheet is adding another 0.55 mm per year, and accelerating; Pine Island Glacier passed tipping point 1996, could add 26-52 cm by 2100

Arctic Methane

- Warming temperatures in the Arctic are releasing methane from permafrost and hydrates under the sea
- Plumes of gas a kilometer in diameter have been observed in the East Siberian Sea
- The release of 50 gigatonnes of methane over a decade will bring forward the date of a global 2°C increase by 15-35 years
- The resulting impacts from flooding, sea level rise, damage to agriculture and human health will cost $60 trillion (the size of the global economy in 2012)

Arctic Temperature Scenario 2090

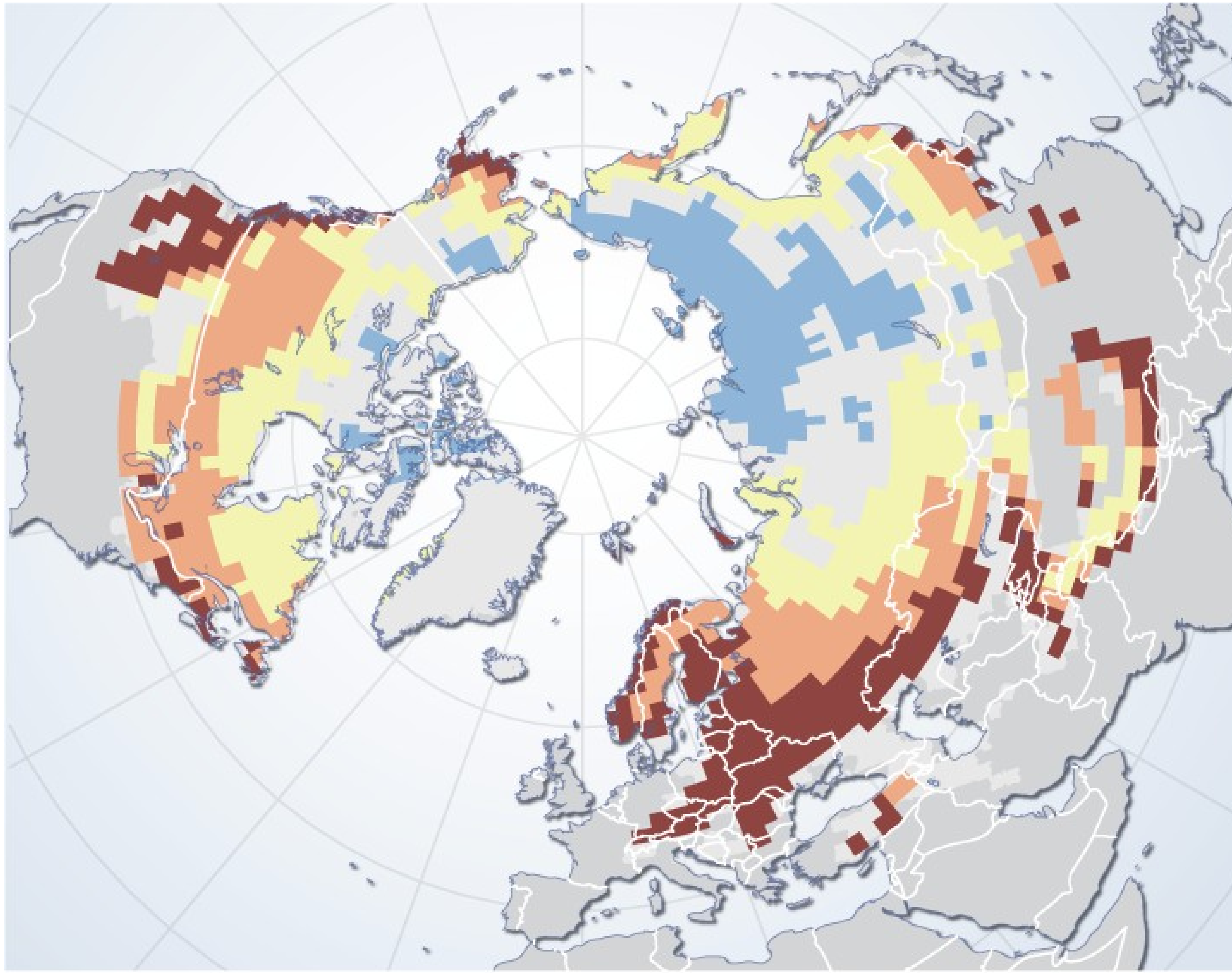


Arctic Sea Ice September 1982 and 2008

20,000 km³ | 8,000 km³

Reduction in Snow

2080-2100



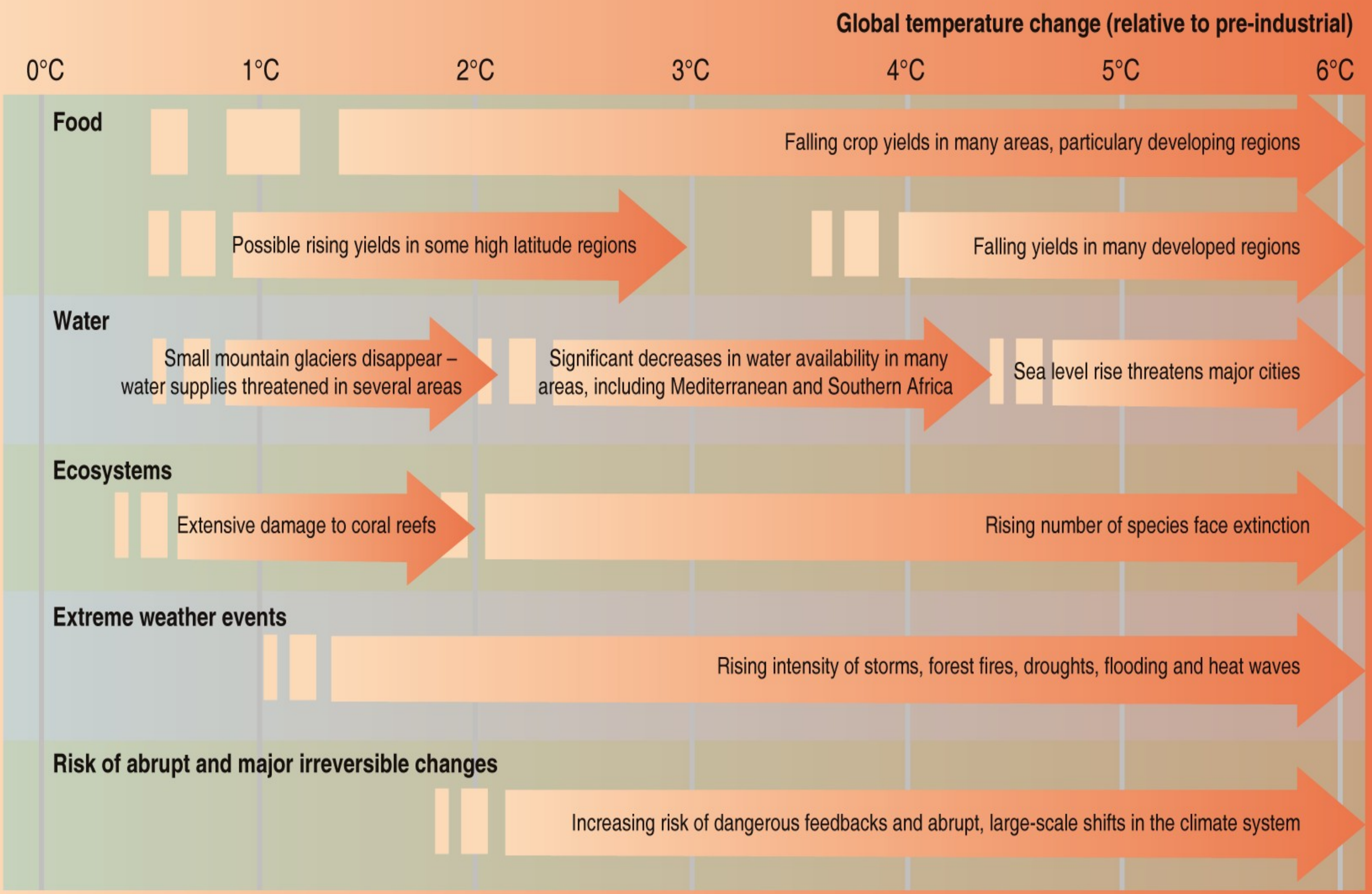
Projected % change in SWE between 1981-2000 and 2081-2100 by the ECHAM5 model (scenario SRES A2)

There is little time left to act

- Global temperatures have already risen 0.76°C and will probably rise a further 3°, or even up to 4.5-5° by 2100
- Oceans have stored 80% of heat added to climate system since 1961, but this may reverse
- Sea level rise has doubled in 150 years to 2 mm/year, and recent polar melting is adding another 2 mm/year
- Recent surge in CO_2 levels from 5% less uptake by sinks

We may soon be approaching a tipping point where runaway climate change would be catastrophic

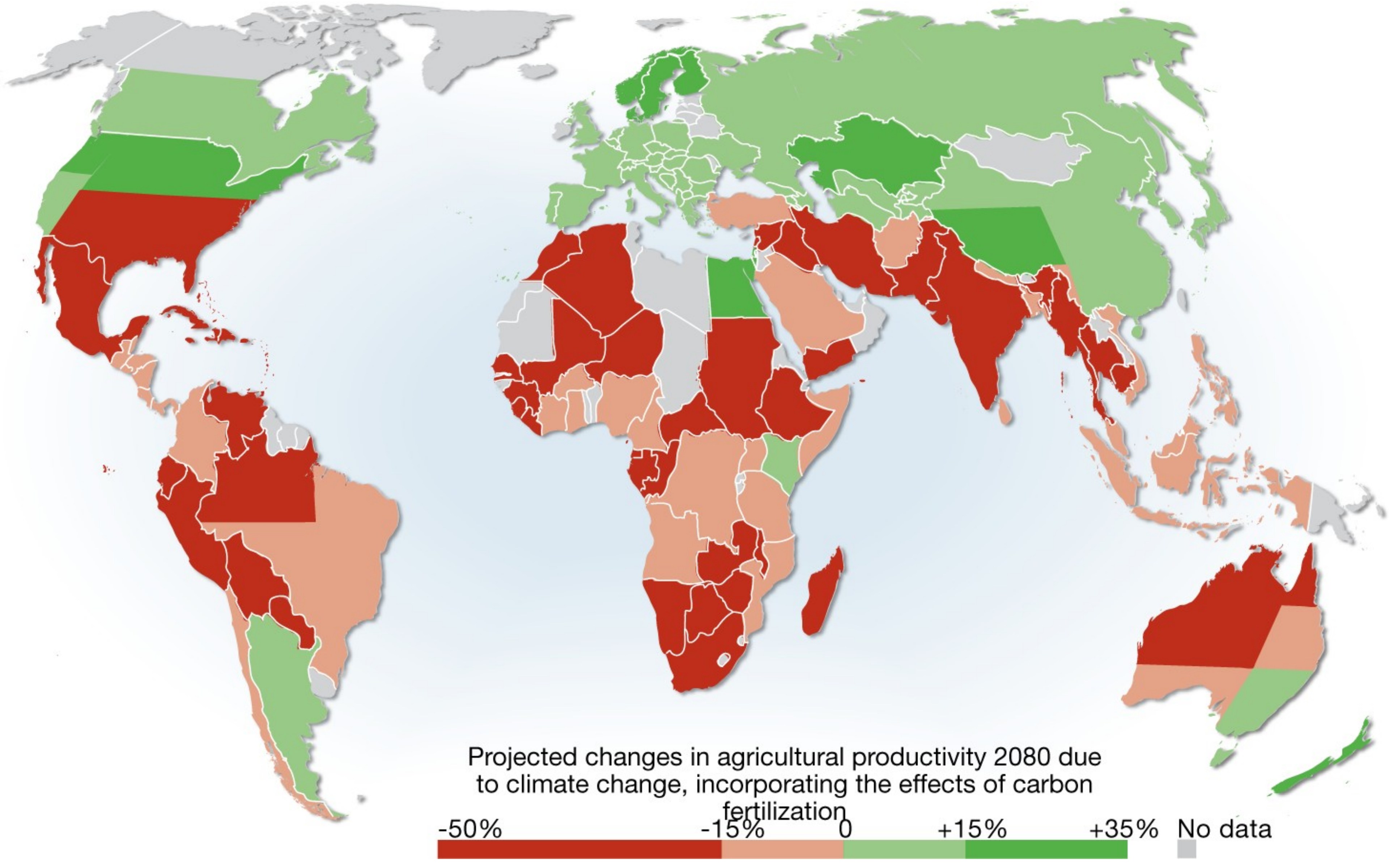
Projected impact of climate change



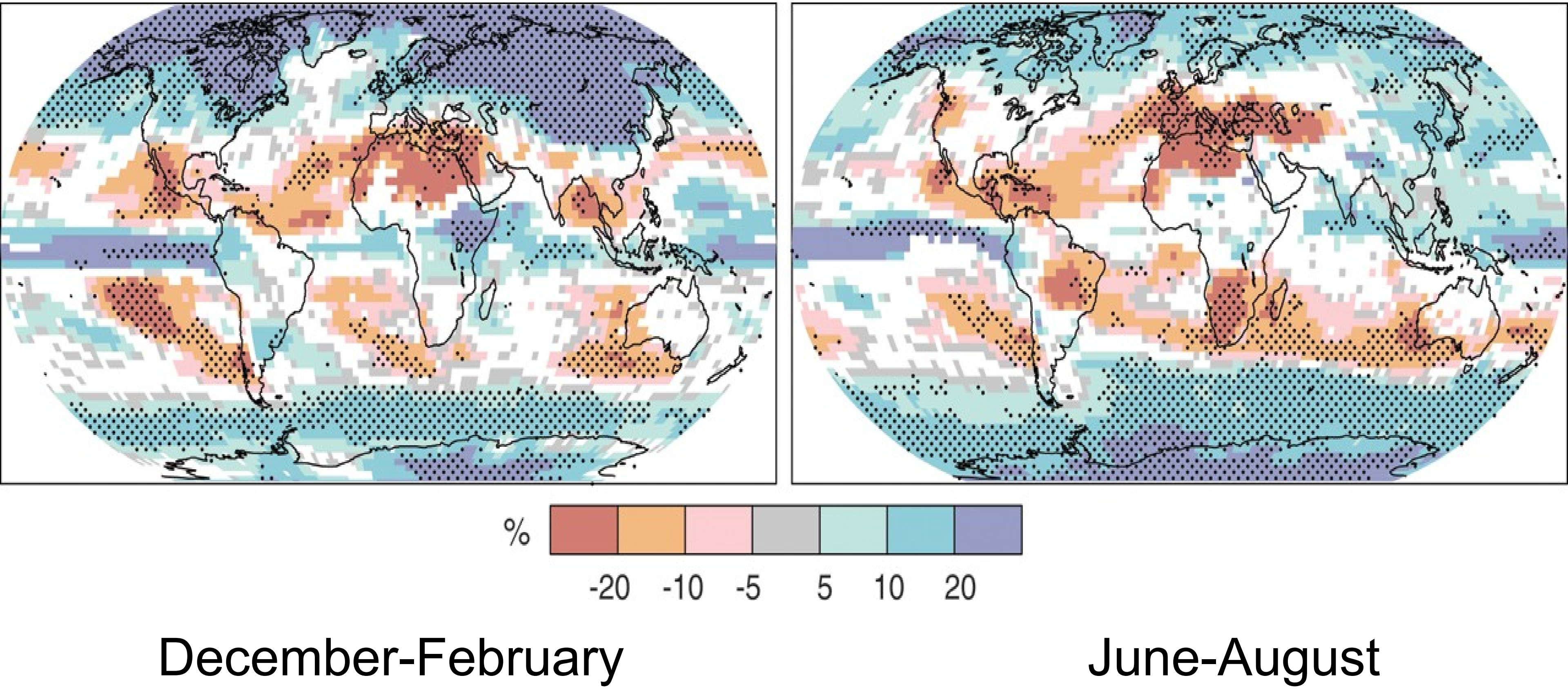
SOURCE: Stern Review

IAASTD/Ketill Berger, UNEP/GRID-Arendal

Agricultural Productivity 2080



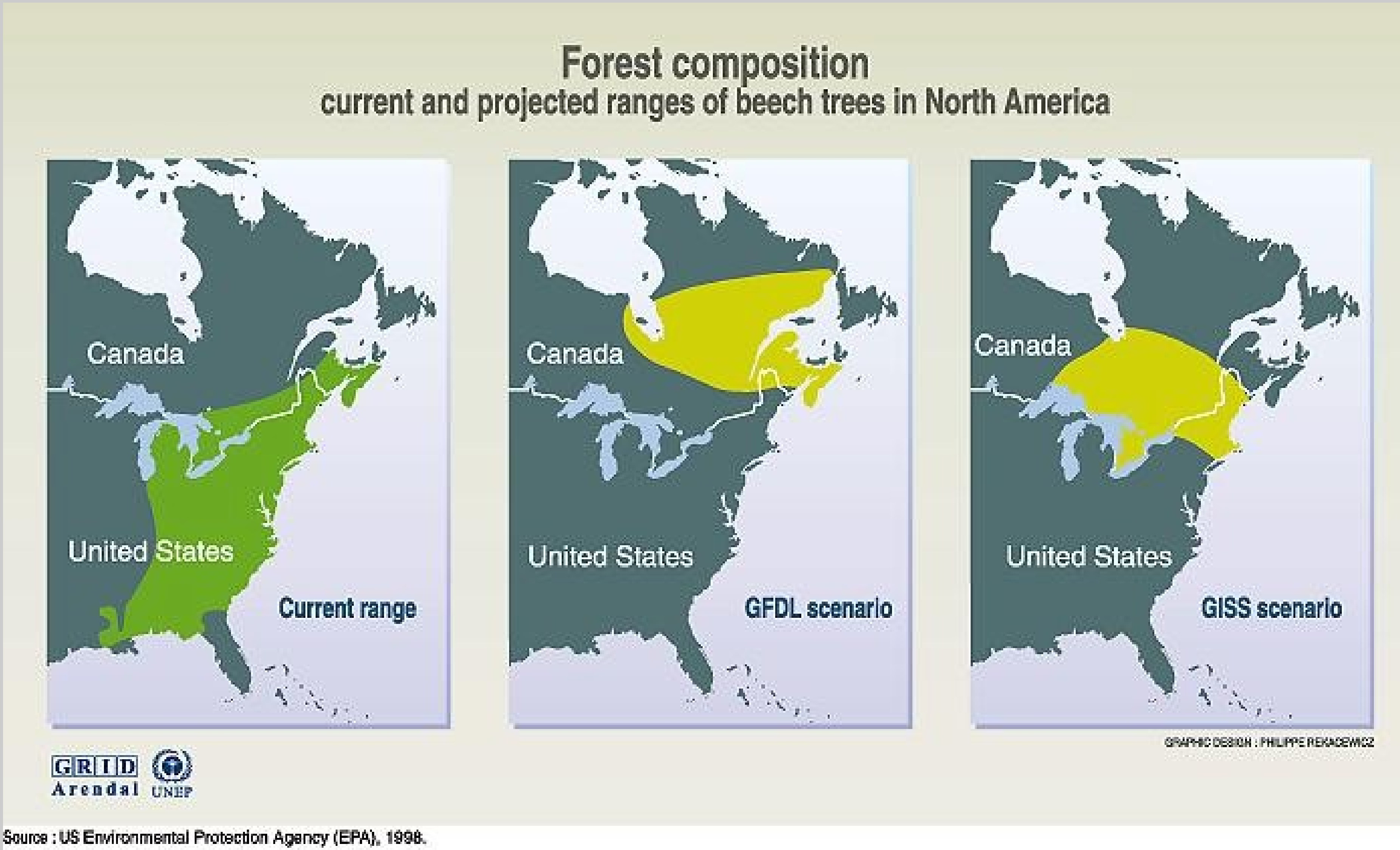
Predicted changes in precipitation



Percent change 1900-1999 to 2000-2099

IPCC 2007

Biodiversity Impacts

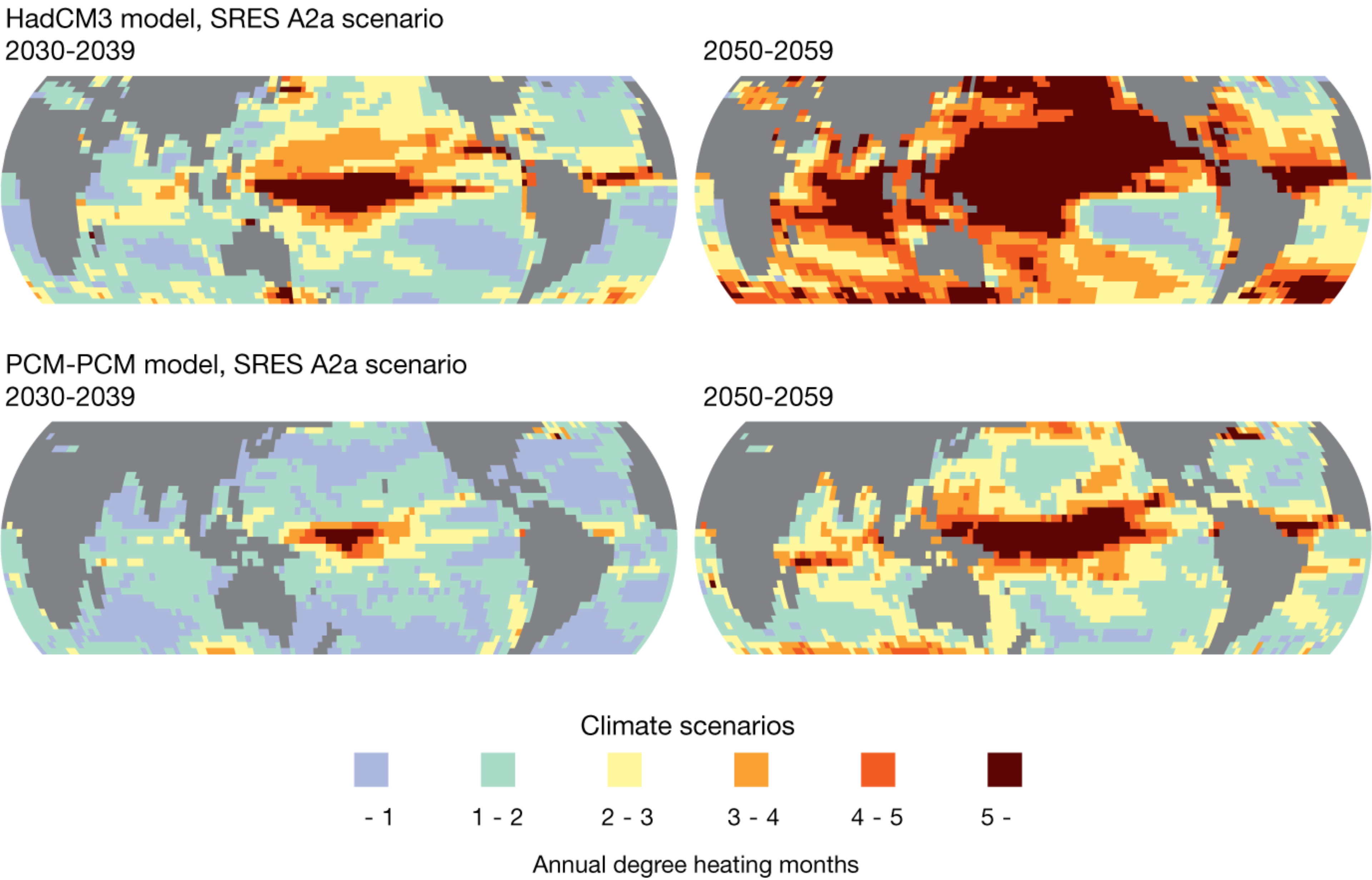


Coral reefs protect tropical coasts and provide fish but global warming could bleach and kill them

Coral reefs and CO_2

- Mass coral bleaching started at 320 ppm CO_2 in atmosphere
- Highly destructive sporadic mass bleaching at 340 ppm
- At 387+ ppm, most reefs committed to irreversible decline with annual bleaching
- 450 ppm will produce rapid and terminal reef decline world wide
- At 600 ppm reefs will be eroding geological structures; mass species extinctions
- CO_2 must be kept below 350 ppm

Climate change and coral reefs



The most vulnerable areas risking catastrophic collapse this century

- Arctic Ocean and Greenland ice sheet
- Amazon rain forest
- Northern boreal forests
- El Nino affecting weather in North America, South-East Asia and Africa (3°C rise)
- Collapse of West African monsoon
- Erratic Indian summer monsoon

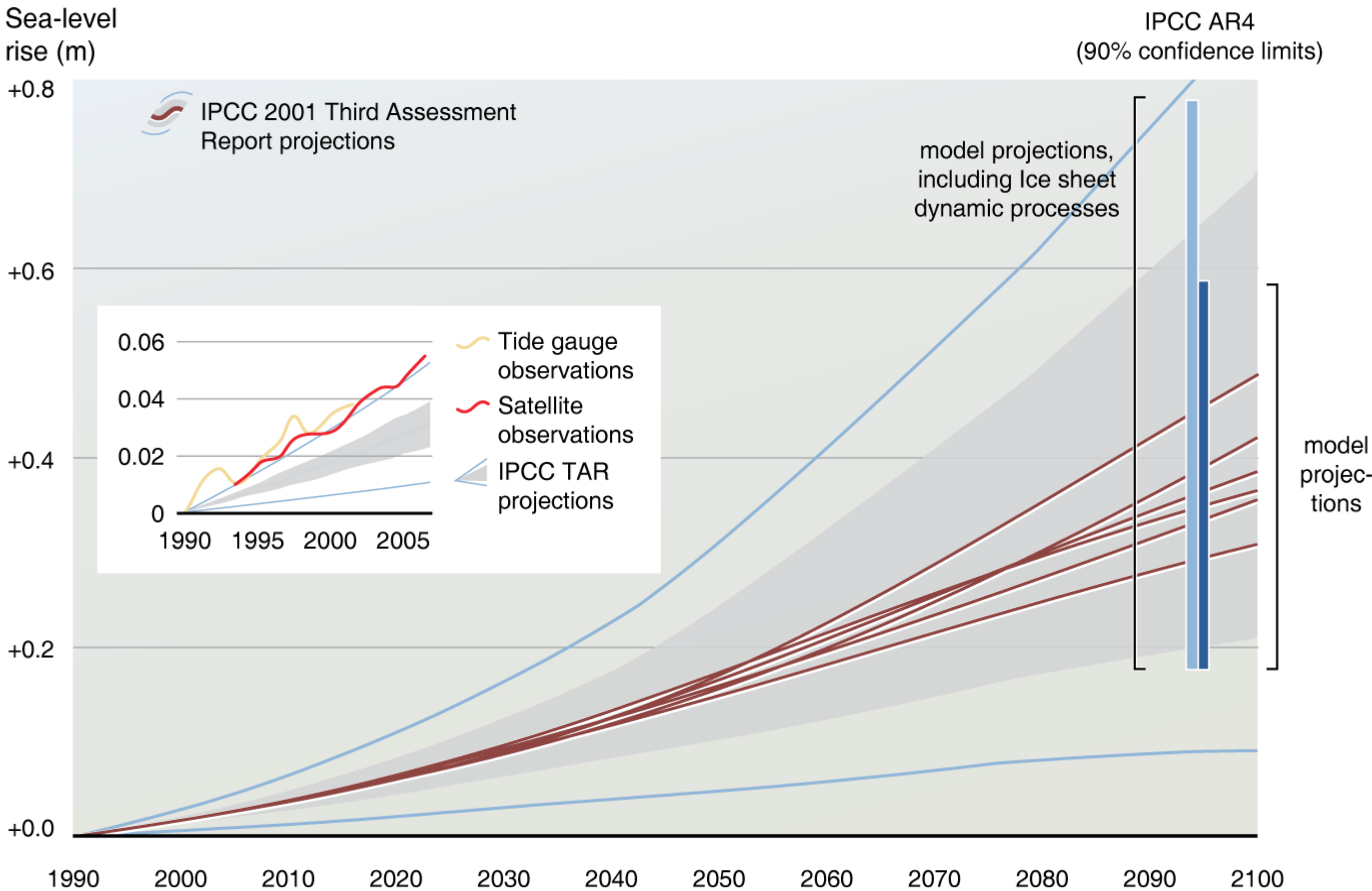
Human Impacts of Climate Change

- Increased damage from extreme weather events: floods, droughts, cyclones
- Less winter snowfall, melting glaciers, water shortages
- Changing conditions for agriculture and forestry, shifting fish stocks
- Sea level rise, flooding low-lying areas and islands
- Millions of environmental refugees (500m-1b)
- High costs of mitigation and adaptation
- Greatest impact on the poor

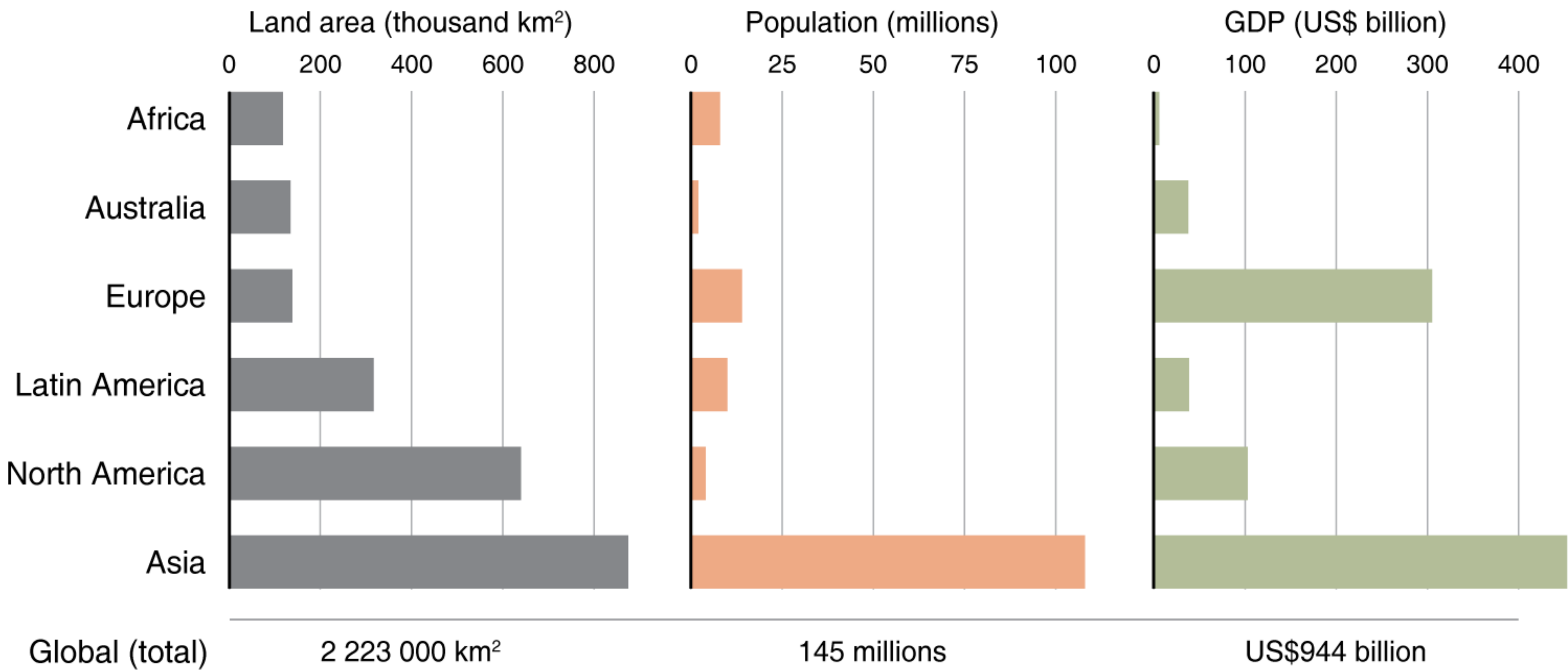
Accelerating sea level rise

- IPCC (2007) forecast sea level rise 19-59 cm by 2100. Actual rise 3.4 mm/yr 80% above this
- Thermal expansion 20-50 cm by 2100
- Greenland adding 0.83mm/yr; Antarctica 0.55mm/yr
- Present estimate 80cm to 2m by 2100 and continuing for several meters
- This would displace 130 million people living within 1 m of mean sea level by 2100
- In Europe, 13 million people displaced and $600b in lost property

Projected sea level rise to 2100
(IPCC 2007)



Effects of 1m Sea Level Rise



If you lived on a coral island
What would you do if the sea level rose?

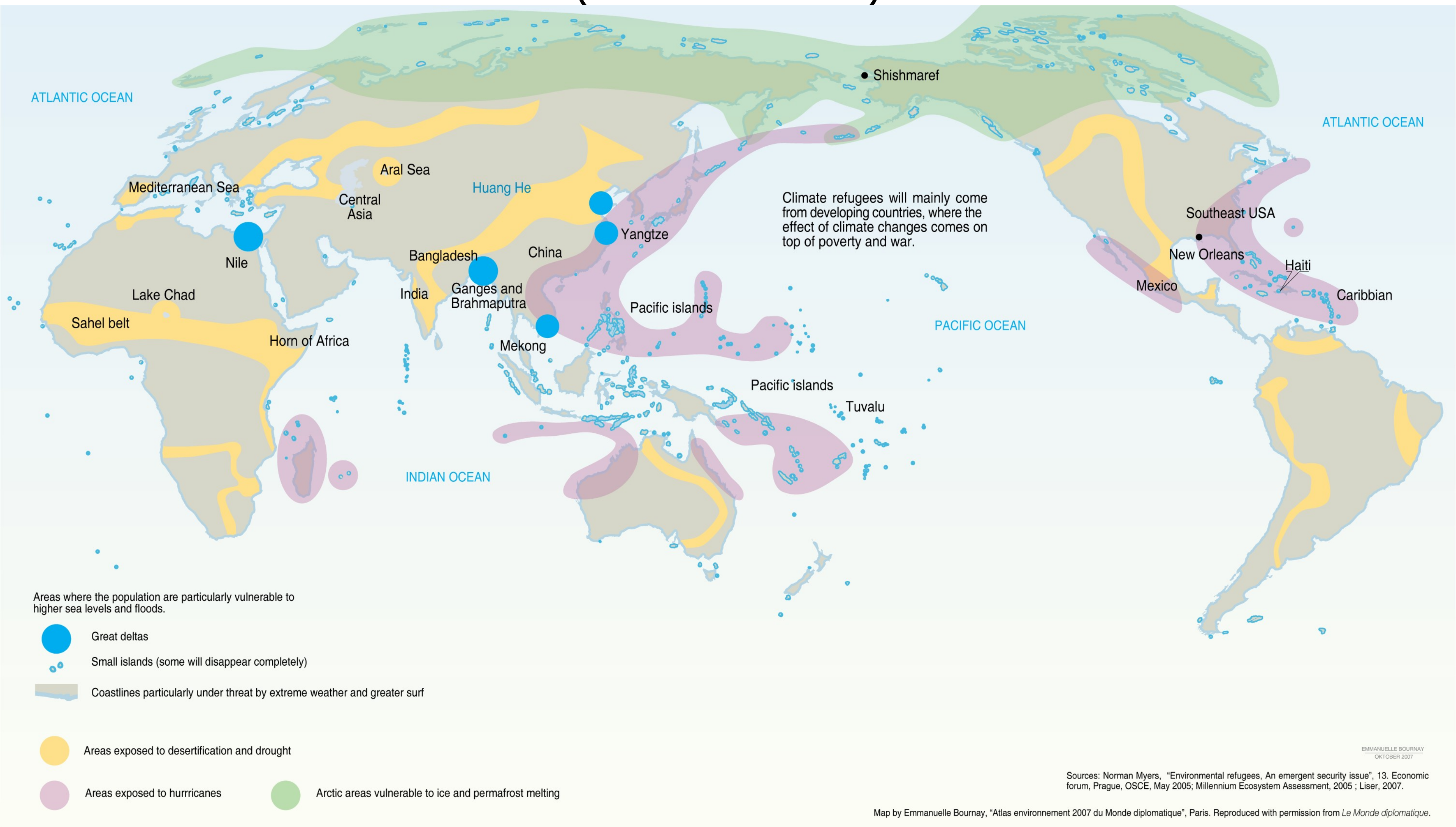
Carrie Bow Cay, Belize, Research Station of the Smithsonian Institution

Tuvalu is already being flooded

(BBC News)

Predicted Climate Refugees 2100

(IAASTD 2008)



Threat to Security

- If climate change goes unchecked, its effects will be catastrophic “on the level of nuclear war”.
- ‘The security dimension will come increasingly to the forefront as countries begin to see falls in available resources and economic vitality, increased stress on their armed forces, greater instability in regions of strategic import, increases in ethnic rivalries, and a widening gap between rich and poor’.

International Institute for Strategic Studies, *Strategic Survey 2007* (September 2007)

A 'perfect storm' by 2030

- UK Chief Scientist (19 March 2009): the world faces a 'perfect storm' of problems in 2030 as food, energy and water shortages interact with climate change to produce public unrest, cross-border conflicts and mass migrations

Effect on the economy

- The Stern Report estimated the annual cost of uncontrolled climate change at more than $660 billion (5 to 20% of global GDP, as compared to 1% for control measures for greenhouse gases).
- Climate change represents the greatest market failure in human history

The double economic challenge

"On current trends, ...humanity will need twice as much energy as it uses today within 35 years.... Produce too little energy, say the economists, and there will be price hikes and a financial crash unlike any the world has ever known, with possible resource wars, depression and famine. Produce the wrong sort of energy, say the climate scientists, and we will have more droughts, floods, rising seas and worldwide economic disaster with runaway global warming."

John Vidal in *The Guardian Weekly*, 9-15 February 2007, Energy supplement, p. 3

We shall probably do both at the same time

Climate Change requires interstate collaboration

- We all cause the problem, and will be the victims
- Planetary problem, common but differentiated responsibility
- Major ethical issue: rich can afford to adapt, refuse to mitigate; the poor suffer the consequences

Governments have failed to control greenhouse gases

- UN Framework Convention on Climate Change (Rio, 1992) call for controls
- Kyoto Protocol on reduction of greenhouse gases – return emissions to 1990 levels by 2012
- China and India have doubled CO_2 production since 1990, US +20%, Australia +40%

Climate Change Science Congress

Copenhagen, March 2009

Climate Change Conference

Copenhagen, December 2009

Failure in Copenhagen

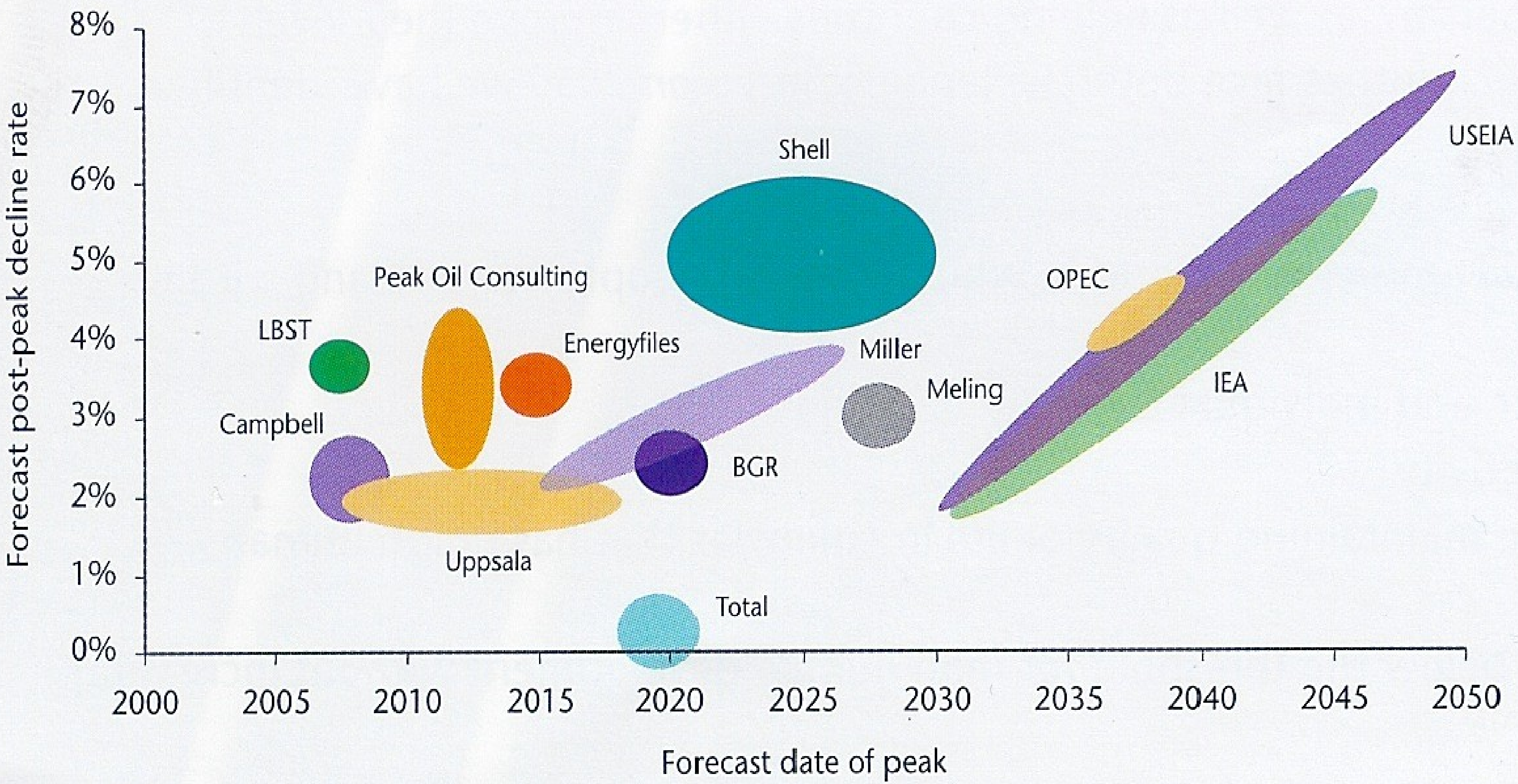
- Kyoto Protocol was intended to demonstrate that the countries that caused the problem would respect their commitments to take action first (not solve climate change)
- They proved they were not trustworthy
- Without confidence, the negotiations were very difficult
- Ethical issues were raised but then ignored
- Some countries intentionally blocked progress
- In the end, the most powerful made a deal among themselves, but failed to agree on binding reductions in CO_2 emissions
- Failure of intergovernmental machinery; failure to consider common interest
- A system founded on national sovereignty cannot address urgent global problems effectively

Addiction to fossil energy

- Industrial economy depends on cheap energy
- Transportation, communications, trade, agriculture, urbanization, consumer lifestyle all depend on abundant energy
- Energy demand is rising rapidly and the fossil fuel supply is shrinking
- Adaptation will be extremely expensive and the struggle for diminishing resources globally destabilizing
- A fossil-fuel-based civilization is unsustainable

Forecasts of Peak Oil

(WBCSD, *Vision 2050*, 2010)



e: UKERC, *The Global Oil Depletion Report*, 2009

Alternative fossil fuels

- Coal – larger reserves but high mining impact, less energy density, high pollution and CO_2 emissions
- Gas – less polluting, but reserves also limited
- Methane hydrates in ocean sediments – extraction difficulties, potent greenhouse gas

Fossil fuels and climate change

- The accepted limit for global warming without significant damage to the planet is 2°C, and this is probably too high
- The estimated remaining capacity of the atmosphere to absorb carbon without going past this limit is 565 gigatons of CO_2, which may be reached in 16 years
- Proven oil, coal and gas reserves total 2,795 gigatons (not counting unconventional sources)
- To prevent catastrophic climate change, 80% of proven reserves need to be taken off asset accounts and left in the ground

Fracking

- Hydraulic fracturing (fracking) of shale can make new gas and oil reserves available (15 bB in California's Monterey shale)
- Requires large amounts of water and toxic chemicals, many drill pads and deep wells with road access
- Well life is short and abandoned wells are often left unplugged (20,000 in Wyoming alone)
- 9% of methane produced leaks into the atmosphere
- Surface spills are common, and fracking fluids can contaminate groundwater
- Extracting more fossil carbon will just make climate change worse

The Nuclear Option?

- Cannot scale up to make a significant difference
- Uranium reserves are expected to be exhausted in 60-100 years
- Research costs and development highly subsidized, including by military uses
- High energy input in construction and fuel fabrication, not carbon free
- Risks of accidents uninsurable, unmanageable (Fukushima)
- Decommissioning costs not included (UK $140b)
- UK unable to privatize its nuclear industry
- High waste disposal costs are imposed on future generations, with no safe long-term disposal yet found
- Fusion *still* "40 years" off

Energy investment challenges

- The International Energy Agency estimates needed investment in energy infrastructure at $22,000bn by 2030 to replace ageing capacity and meet growing demand (2% global GDP, $130 per person per year)
- Responding to climate change would add $2,000bn

The energy transition is possible

- Wind, tidal and wave turbines; photovoltaic panels; hydroelectricity; geothermal energy can be scaled up today to meet 100% of energy needs
- Conversion to renewables will reduce demand by 32%
- Battery-electric and hydrogen fuel cell vehicles
- Technologies combined and coordinated over a global grid
- Fossil fuels can be phased out in 20-40 years
- No nuclear, carbon capture or biofuels

Jacobson and DeLucchi 2009

HOW DOES NATURE DO IT? Energy management in the coral reef ecosystem:

- Efficient solar energy capture by generating large surface area
- Efficient energy transfers within system, symbioses
- Little waste, effective recycling
- High complexity and integration
- Maximizes total productivity, not just most productive

Energy Efficiency

- Energy efficiency could halve the growth in primary energy demand by 2035, with oil demand peaking in 2020
- Additional investment of $11.8 trillion more than offset by reduced fuel expenditures
- Economic output increased $18 trillion
- Global warming limited to 3°C

IEA World Energy Outlook 2012


Plants are highly efficient
solar energy devices

Bio-fuels

- Wood
- Dung, animal wastes
- Ethanol
- Biodiesel
- Coconut, palm, rapeseed oils
- Bagass (sugar cane waste)
- Biogas

but their production will compete with food production and other land uses

Problems with biofuels

- Most present biofuel crops require high energy inputs to grow, harvest and process, with little net CO_2 benefit (maize ethanol 0-12%, soy biodiesel 41%)
- Competition with food production, raising food prices
- Pressure to clear tropical forest for oil palm and soybeans
- Area not sufficient to meet present fuel needs (US only 5%)

Technologies for solar energy capture

- Photovoltaic
- Solar water heaters
- Parabolic reflectors (need steering)
- Tubular captors with reflectors
- Greenhouse effect
- Passive solar heating in buildings

but solar energy is diffuse, not concentrated

Indirect solar power

- Water – hydroelectric power is widely used where resources permit
- Wind – commercially viable as part of a mix of energy sources
- Tides – selected locations
- Waves – engineering challenges
- OTEC ocean thermal energy conversion
- Chimney effect (air thermal gradients)
- Renewables will be a third of electricity generation by 2035

Centralized versus decentralized

- The Western economic system has encouraged centralized energy systems (large generating stations, large dams, large refineries, extensive power grids)
- Transmission produces large losses
- Small-scale systems close to users do not interest large corporations
- Solar energy and most renewables are inherently decentralized
- The economic system biases technology choice

Barriers to change

"… the biggest obstacles to the take up of technologies such as renewable sources of energy and "clean coal" lie in vested interests, cultural barriers to change and simple lack of awareness."

- Avoiding Dangerous Climate Change, UK Meteorological Office - from http://www.unepfi.org/ebulletin

Moral and ethical challenge

Mitigation of climate change... asks profound moral and ethical questions of our generation. In the face of clear evidence that inaction will hurt millions of people and consign them to lives of poverty and vulnerability, can we justify inaction? No civilized community adhering to even the most rudimentary ethical standards would answer that question in the affirmative, especially one that lacked neither the technology nor the financial resources to act decisively.

UNDP Human Development Report 2007/2008, p. 68

Ways forward

Harness all available sources of energy on the surface of the planet (UN estimated investment required $20 trillion over 2 decades)

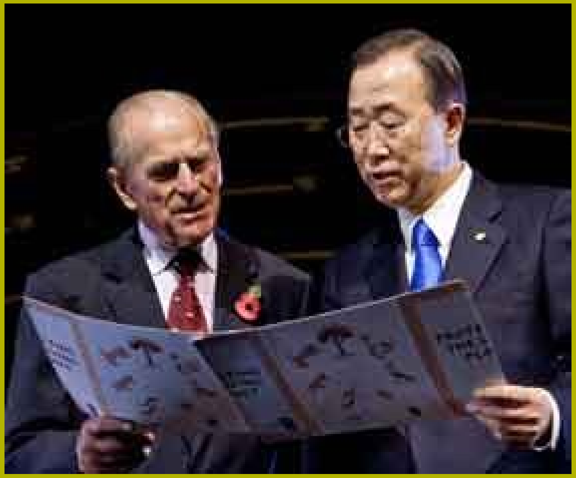
Reduce environmental impact to sustainable limits

Accelerate the transition to reduce the shock

Create global governance mechanisms to manage this global challenge

Share the cost, effort and benefits globally with equity and justice

The Windsor Celebration of Action Plans on Climate Change 2009



Things you can do

- Walk, bicycle or use public transport
- Make your personal residence energy efficient (light bulbs, appliances,no standby, heating/cooling, etc.)
- Choose electricity from renewable sources if available
- Consume less, buy local
- Consider the energy implications of everything you do

Building a sustainable energy future is a major challenge for your generation

Thank you