IPCC Fourth Assessment Report Synthesis Report

Presentation to the UN Climate Change Conference

Bali, Indonesia

7 December 2007

AR4 Synthesis Report Topics

1. Observed changes in climate and their effects
2. Causes of change

   Martin Manning

3. Climate change and its impacts

   Ron Stouffer

4. Adaptation and mitigation options

   Leonard Bernstein

5. The long term perspective

   Bill Hare

6. Robust findings and key uncertainties

AR4 SYR Core Writing Team

Lenny Bernstein, Peter Bosch, Osvaldo Canziani, Zhenlin Chen, Renate Christ, Ogunlade Davidson, William Hare, Saleemul Huq, David Karoly, Vladimir Kattsov, Zbigniew Kundzewicz, Jian Liu, Ulrike Lohmann, Martin Manning, Taroh Matsuno, Bettina Menne, Bert Metz, Monirul Mirza, Neville Nicholls, Leonard Nurse, Rajendra Pachauri, Jean Palutikof, Martin Parry, Dahe Qin, Nijavalli Ravindranath, Andy Reisinger, Jiawen Ren, Keywan Riahi, Cynthia Rosenzweig, Matilde Rusticucci, Stephen Schneider, Youba Sokona, Susan Solomon, Peter Stott, Ronald Stouffer, Taishi Sugiyama, Rob Swart, Dennis Tirpak, Coleen Vogel, Gary Yohe

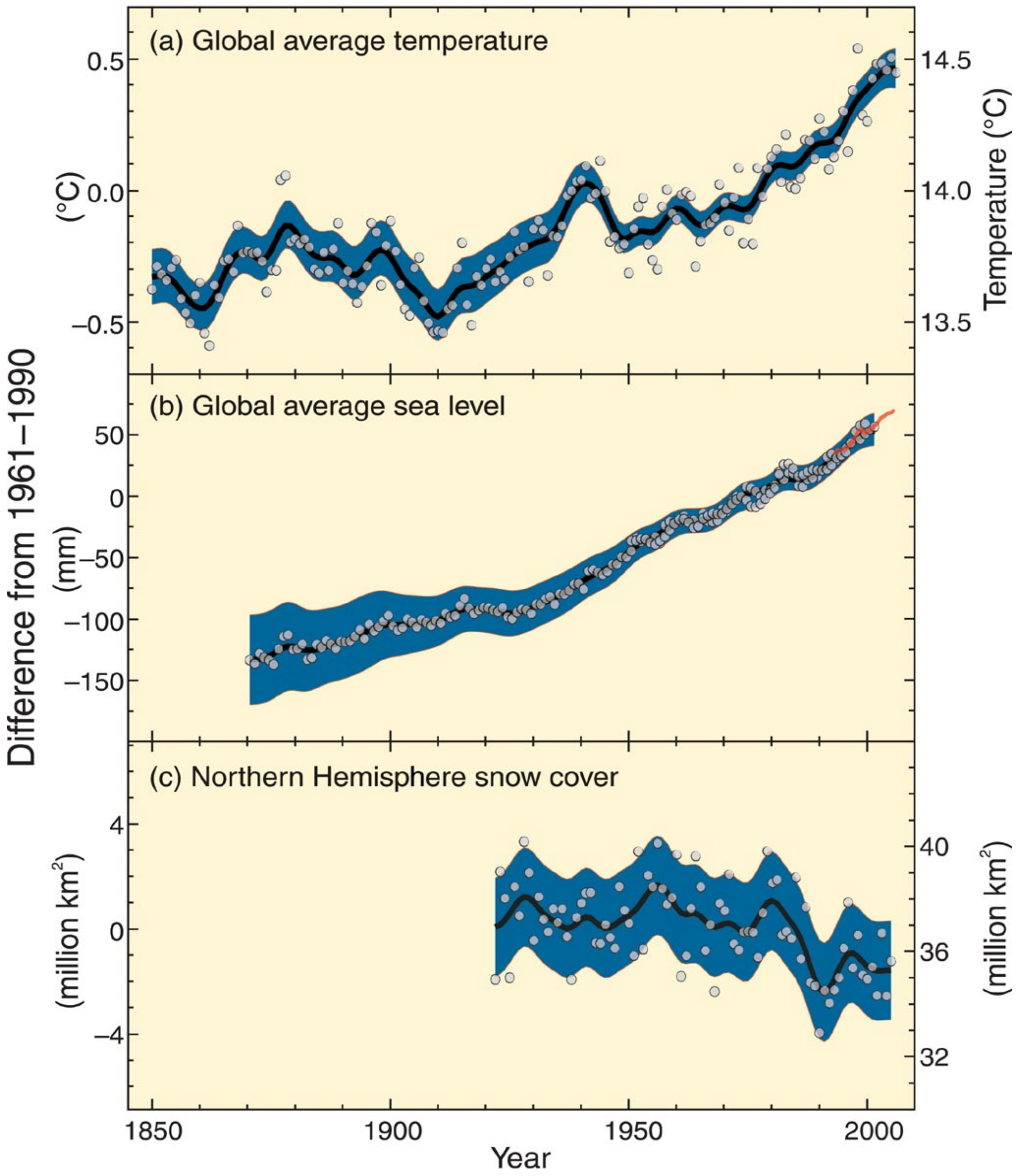
IPCC Fourth Assessment Report

Synthesis Report

Topic 1: Observed changes in climate and their effects

Topic 2: Causes of change

1. Observed climate change



100-yr warming trend (1906-2005) of 0.74°C.

Increased since TAR.

Sea level rise:

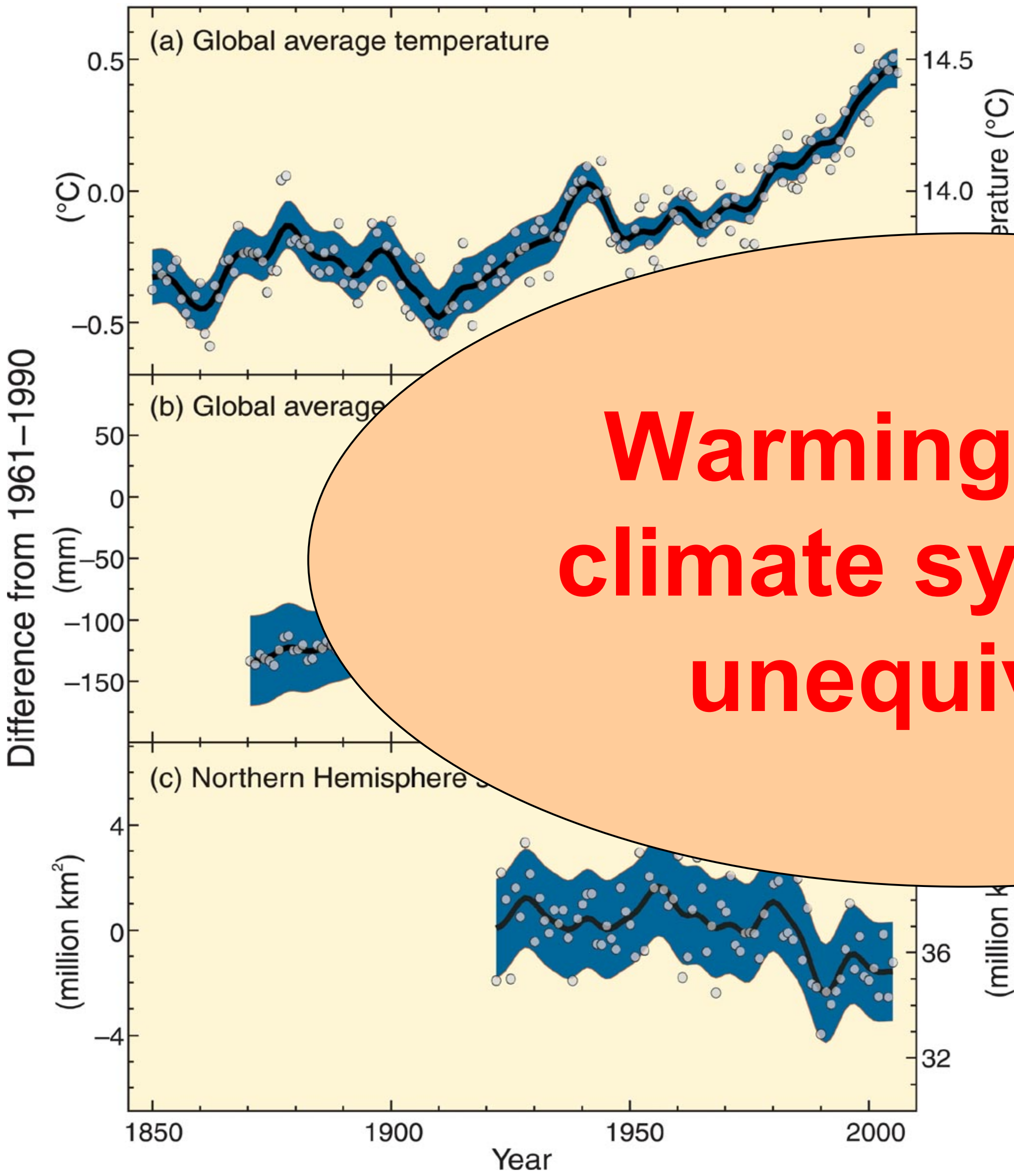
1960 – 2003: 1.8 mm per yr

1993 – 2003: 3.1 mm per yr

Decreasing:

- snow and ice extent
- Arctic sea ice extent
- Mountain glaciers

1. Observed climate change



100-yr warming trend (1906-2005) of 0.74°C.

...eased since TAR.

...mm per yr

...mm per yr

Warming of the climate system is unequivocal

Decreasing:

- snow and ice extent
- Arctic sea ice extent
- Mountain glaciers

Observed change at continental, regional and ocean basin scales

Over 1900 – 2005:

- Precipitation increased significantly in: eastern parts of North and South America + Northern Europe + Northern and Central Asia.
- Precipitation decreased in: Sahel + Mediterranean + Southern Africa + parts of Southern Asia.

Since 1970 or earlier:

- Area affected by drought increased
- Cold extremes less frequent
- Heat waves more frequent (most land areas)
- Heavy precipitation events more frequent (most areas)
- Intense tropical cyclone activity increased in N Atlantic

Many Natural Systems are Affected

Changes in snow, ice and frozen ground

- Increased number and size of glacial lakes
- Ground instability in mountain & permafrost regions
- Changes in some Arctic and Antarctic ecosystems

Hydrological system changes

- Increased runoff
- Earlier spring peak discharge (glacier & snow-fed rivers)
- Altered thermal structure and water quality (rivers & lakes)

Many Natural Systems are Affected (2)

Recent warming in terrestrial ecosystems

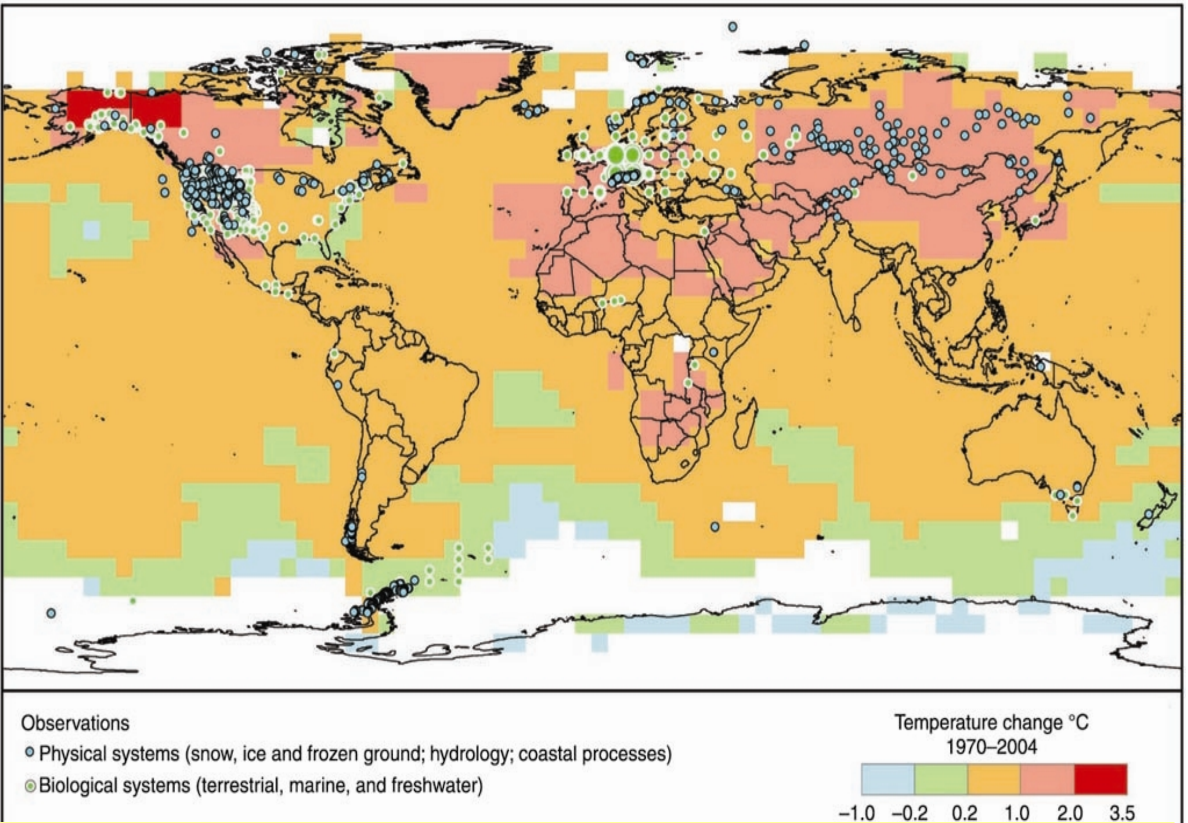
- Spring events occur earlier in year
- Plant and animal ranges shift poleward or upward

Rising water temperatures

Changes in ice cover, salinity, oxygen, circulation

- Shifts in ranges and other changes in algal, plankton and fish abundance

Observed changes in Physical and Biological systems



However - notable lack of geographical balance in data and literature, with marked scarcity in developing countries.

Literature survey criteria

At least 20 years of data, ending in 1990 or later

Finds:

~75 studies

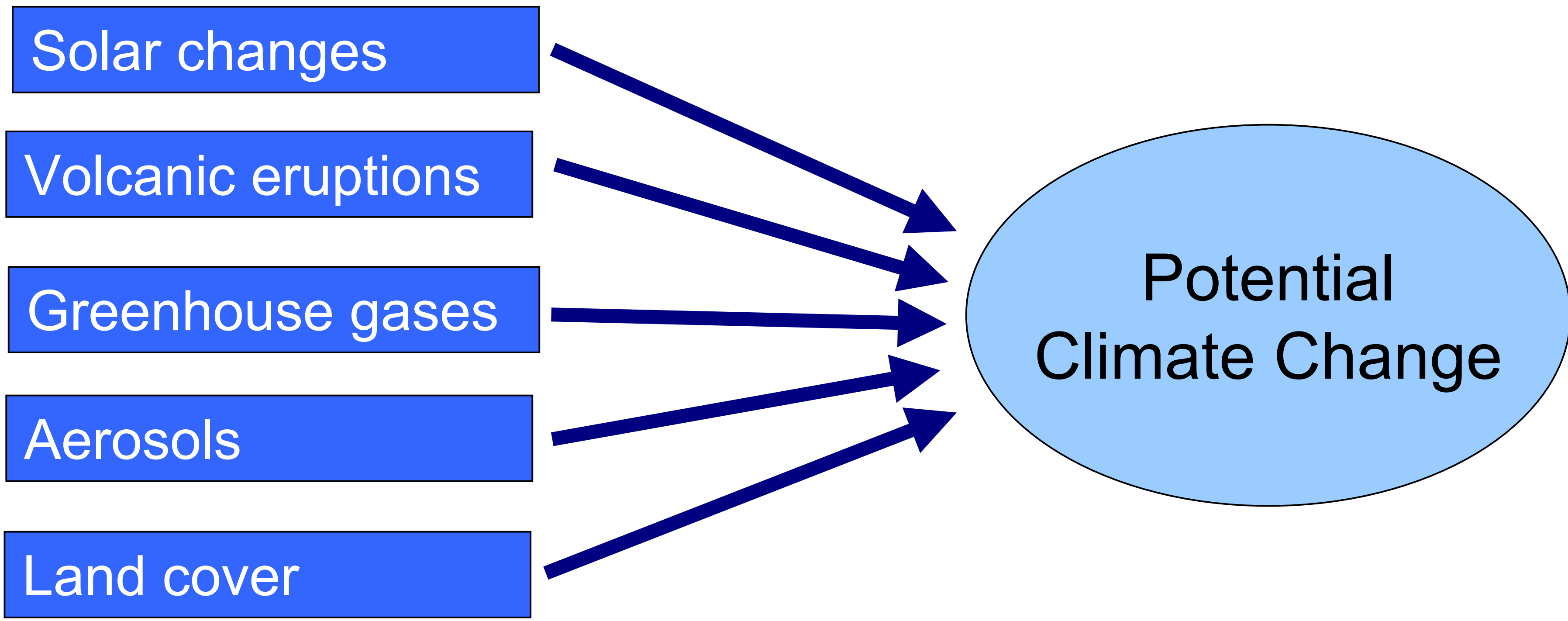
~765 data series of **physical** processes

>28,000 data series of **biological** species

Result:

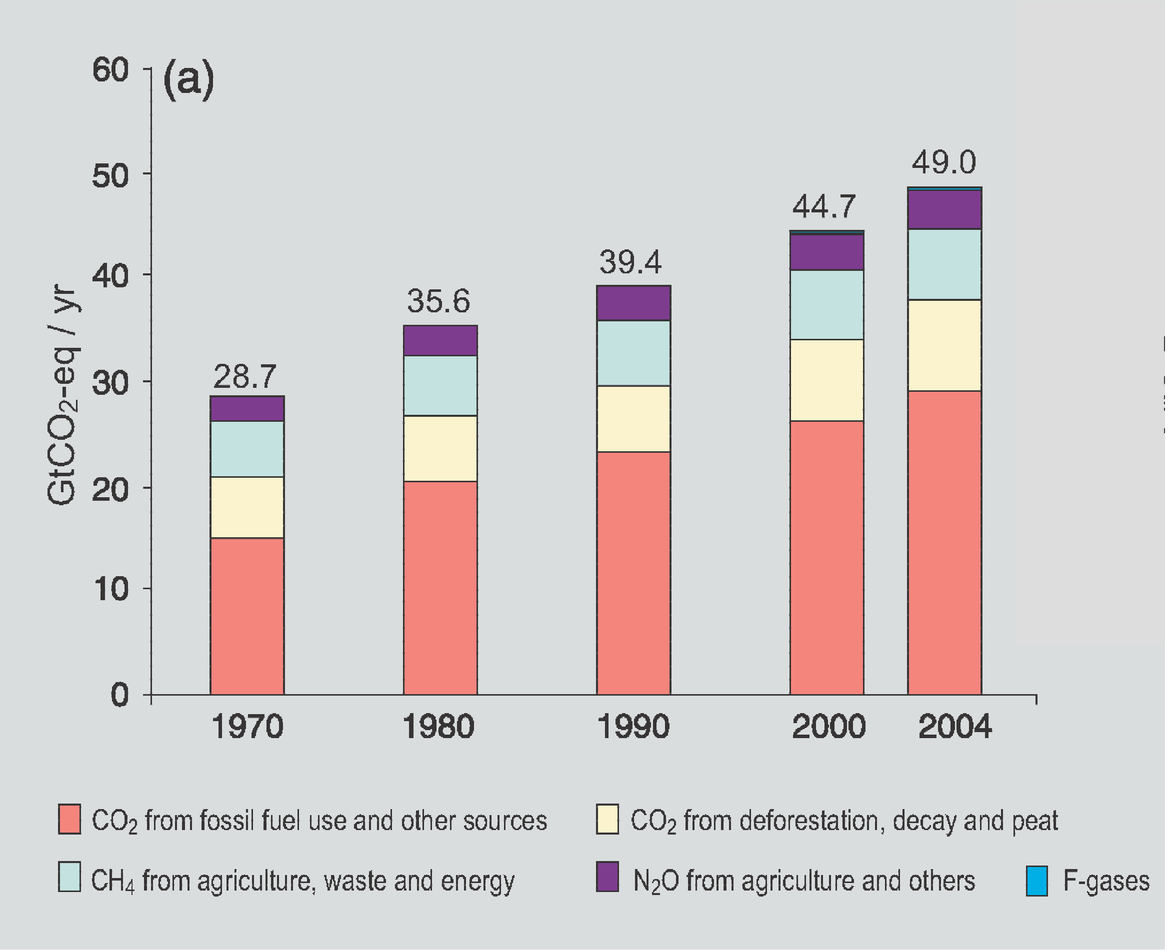
>89% consistent with warming

2. Causes of Change



There are both natural and anthropogenic drivers of climate change

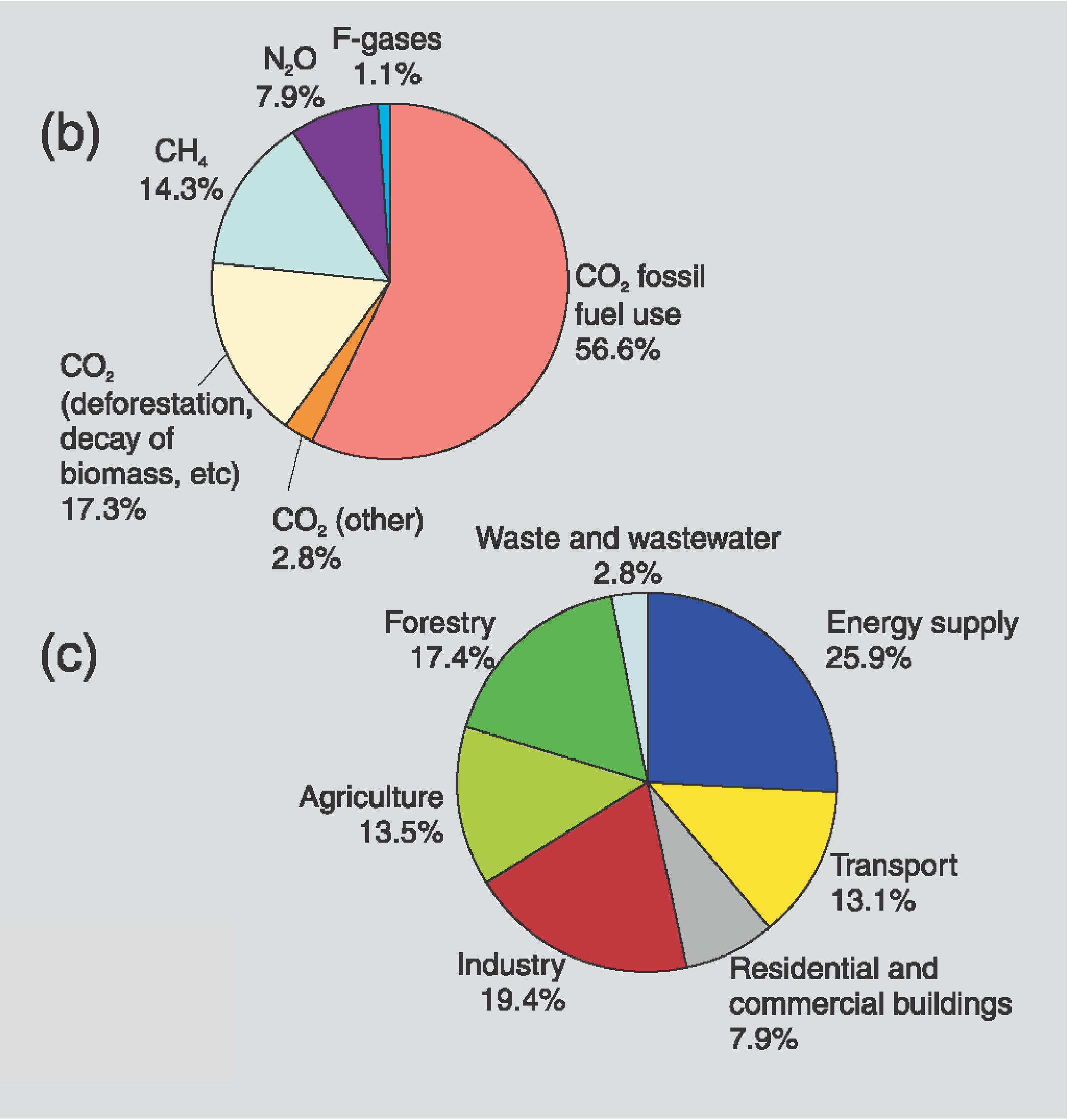
Growth in greenhouse gas (GHG) emissions



Anthropogenic GHG emissions grew by 70% between 1970 and 2004, from 28.7 to 49 $GtCO_2$-eq

Annual emissions of CO_2 grew by about 80% between 1970 and 2004

CO_2 is the dominant anthropogenic GHG

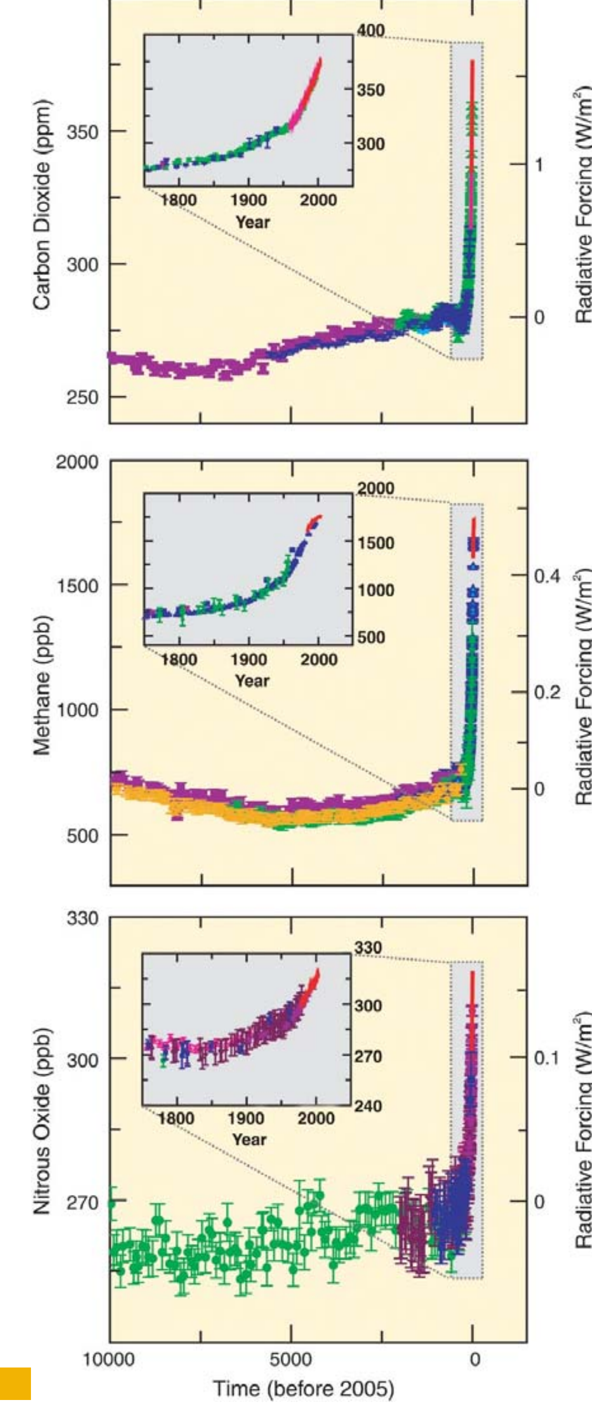


In 2004, CO_2 emissions were about 77% of GWP-weighted emissions of GHGs

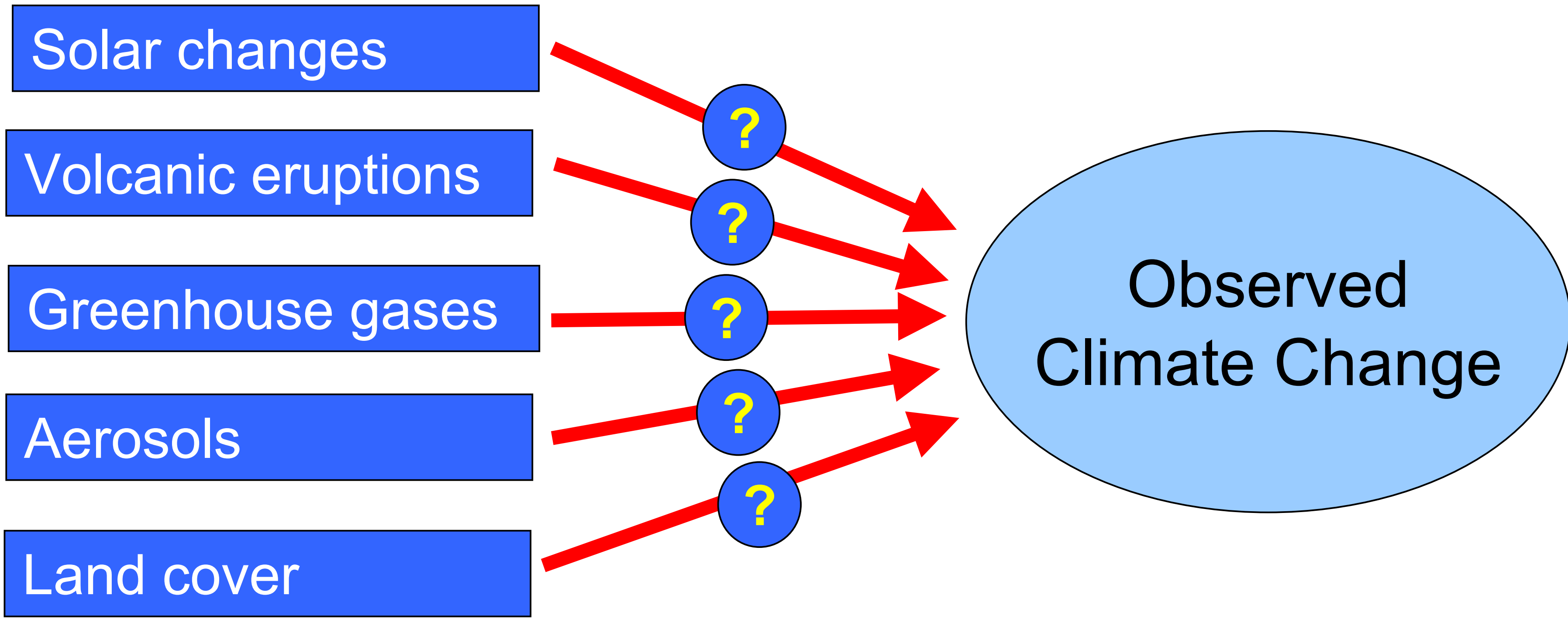
Many sectors contribute. (Forestry includes deforestation)

Atmospheric Concentrations

- Global atmospheric concentrations of CO_2, CH_4 and N_2O have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values
- Atmospheric concentrations of CO_2 and CH_4 in 2005 exceed by far the natural range over the last 650,000 years
- There is *very high confidence* that the net effect of human activities since 1750 has been warming

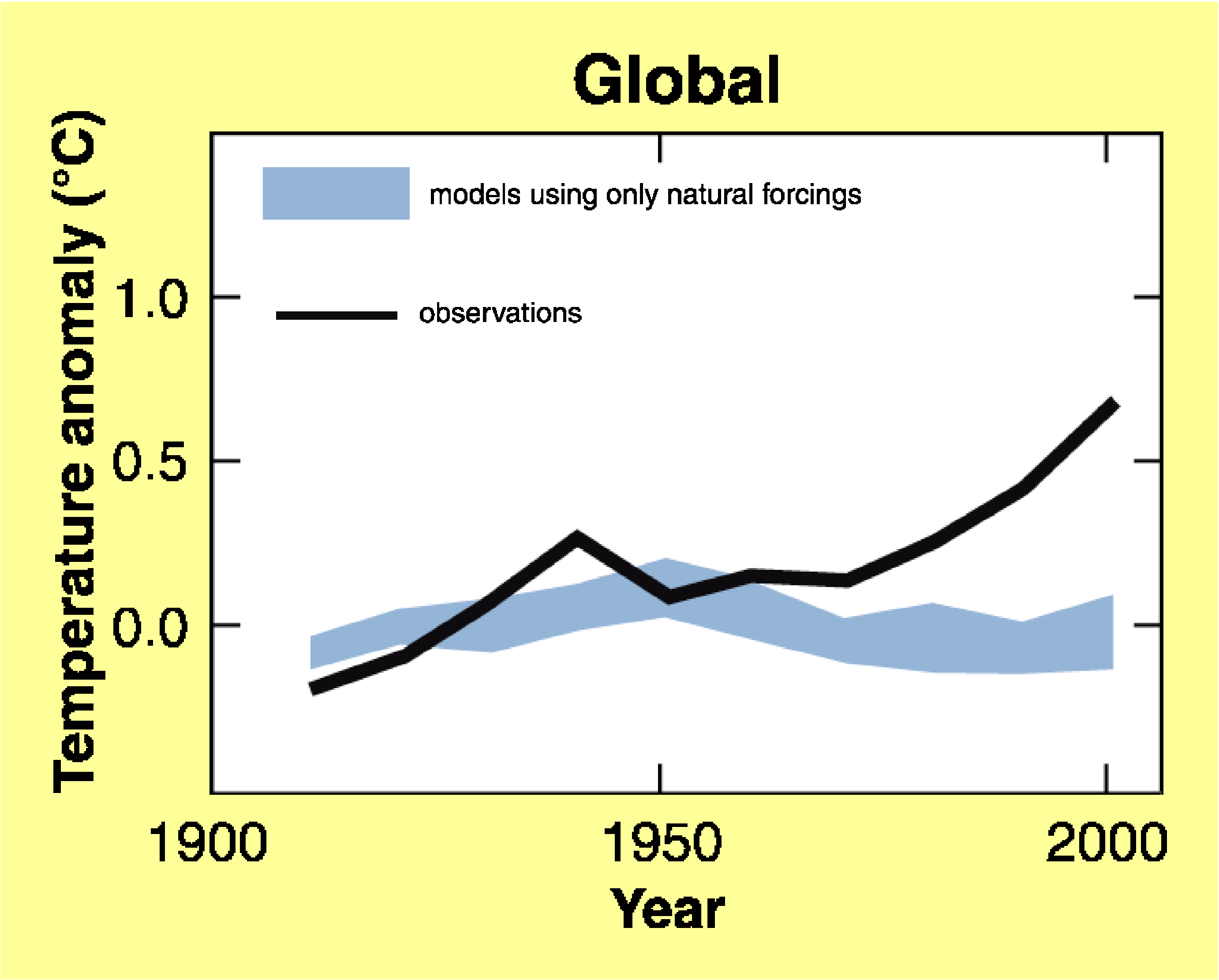


Attribution of observed climate change



Evaluates whether observed changes are quantitatively consistent with the expected response to external forcings - and inconsistent with alternative physically plausible explanations.

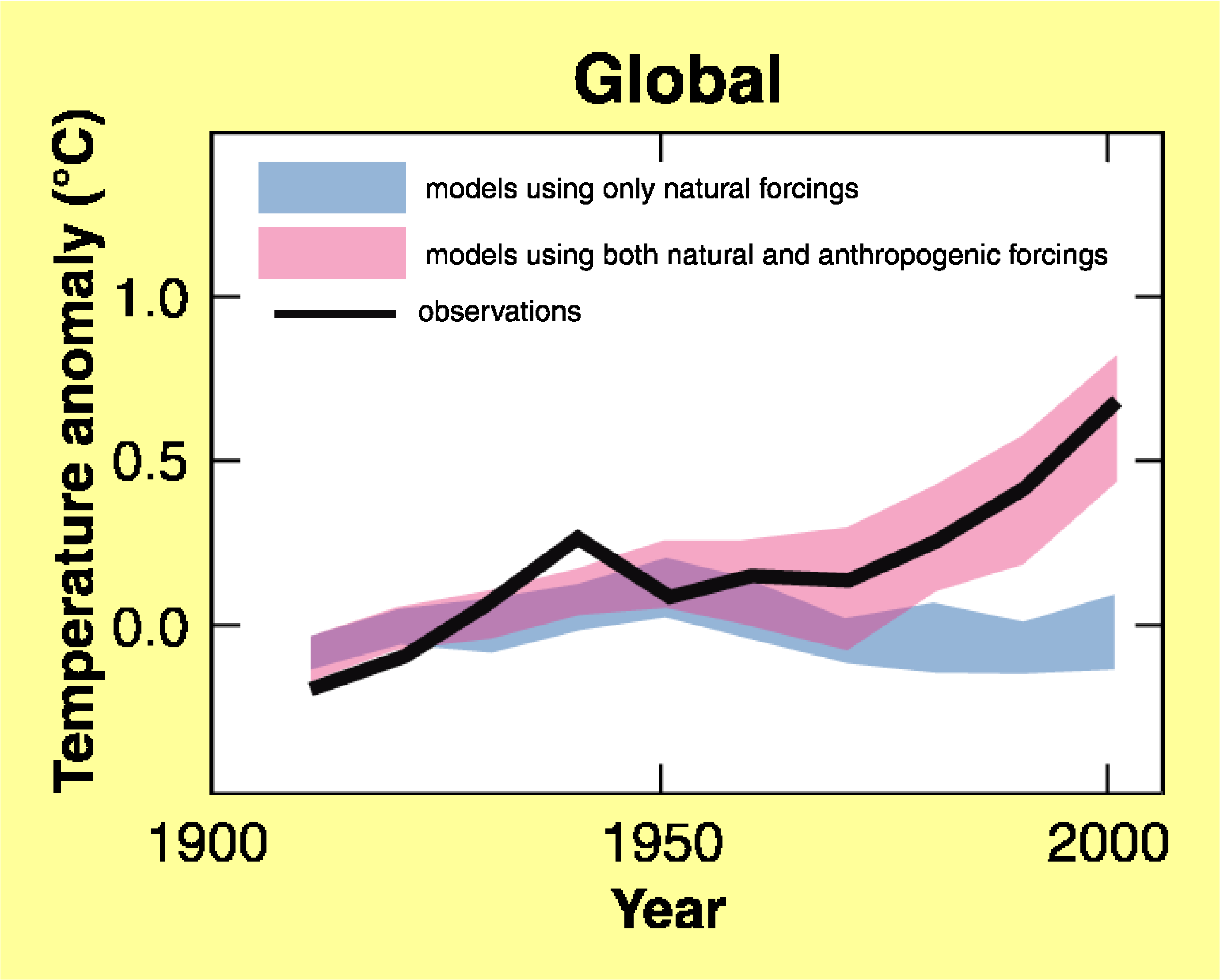
Natural forcings would have led to cooling since 1950



Decadal averages of observed and simulated global average surface temperature

Shaded band shows 5 – 95% range from climate model simulations

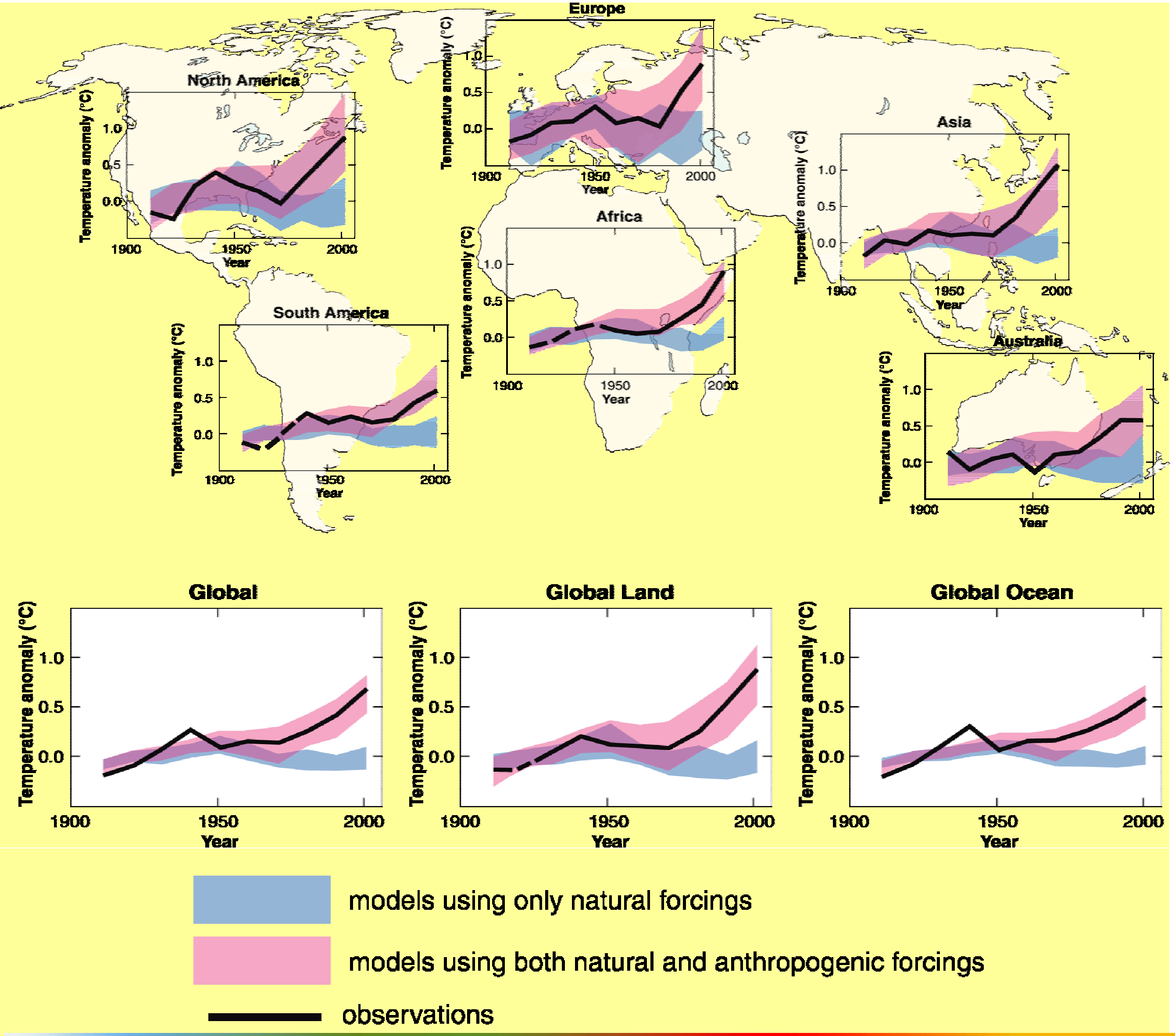
Observed warming simulated only by models that include anthropogenic forcings



Decadal averages of observed and simulated global average surface temperature.

Shaded band shows 5 – 95% range from climate model simulations

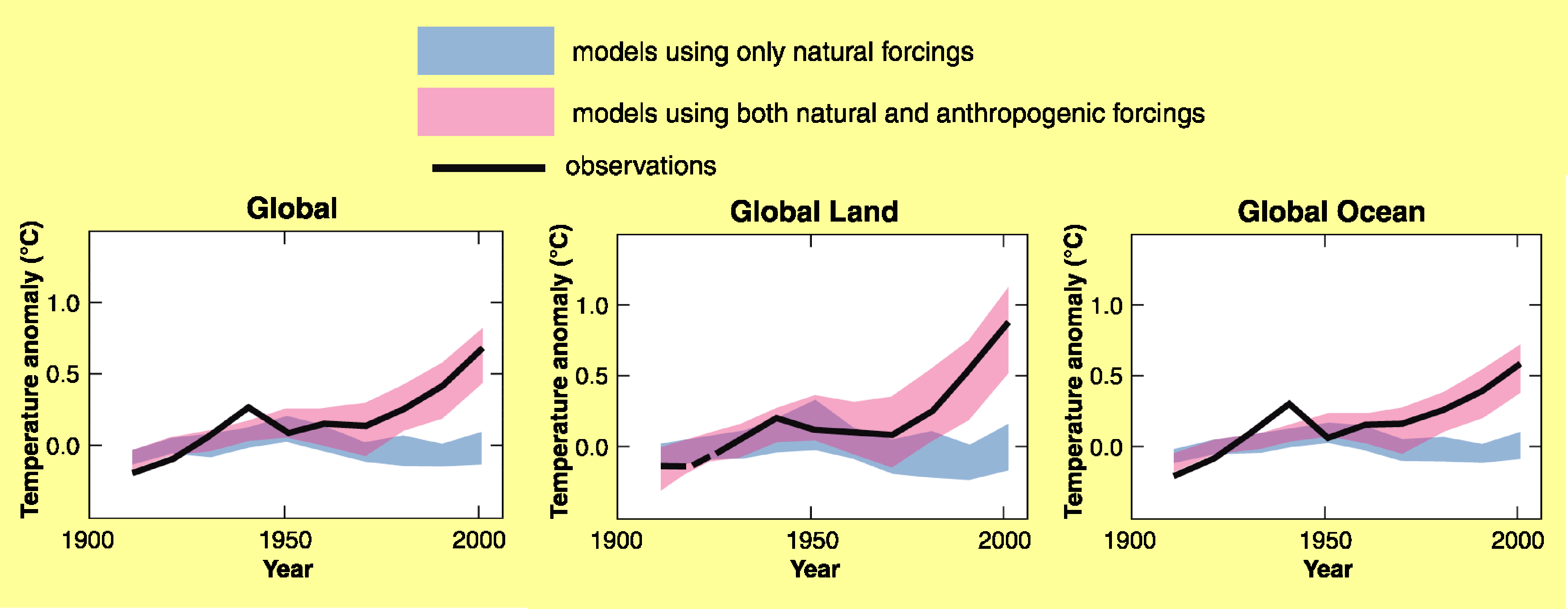
Global and continental temperature change



Note patterns of observed and simulated warming differ by continent and for land vs ocean.

Shaded band shows 5 – 95% range from climate model simulations

Warming due to greenhouse gases explains many observed features – such as the land warming faster than the oceans



Attribution of climate responses and effects

- Most of the observed increase in globally-averaged temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic GHG concentrations

- Advances since the TAR show that discernible human influences extend beyond average temperature to other aspects of climate

- Anthropogenic warming over the last three decades has *likely* had a discernible influence at the global scale, on observed changes in many physical and biological systems

IPCC Fourth Assessment Report

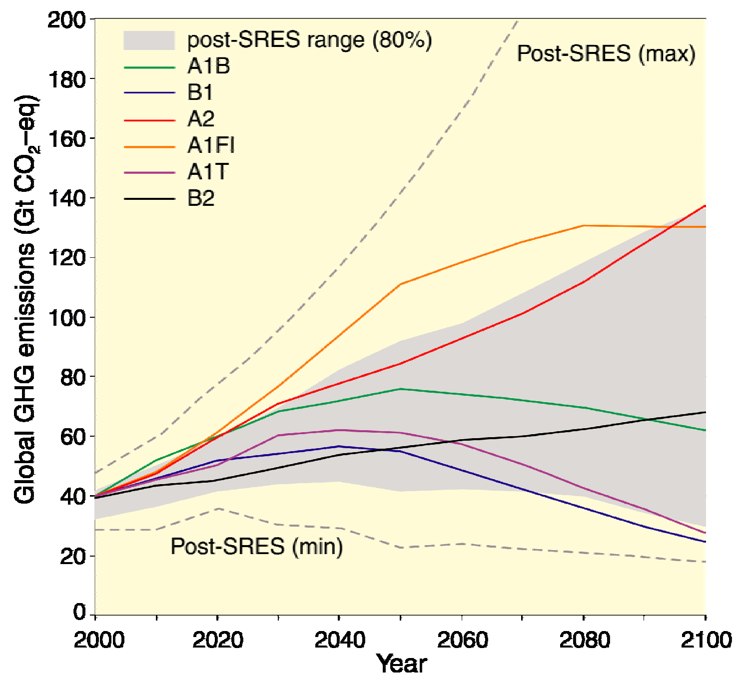
Synthesis Report

Topic 3

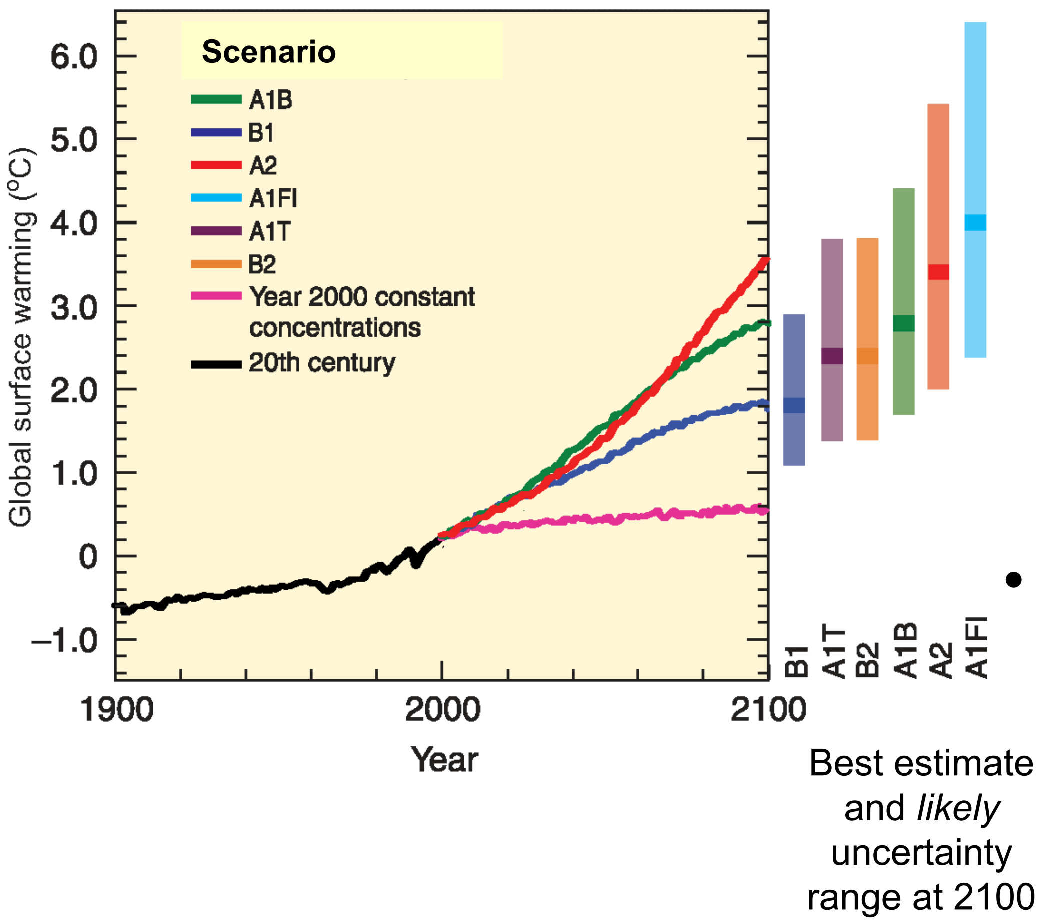
Projected climate change
and its impacts

Special Report on Emission Scenarios (SRES, 2000) and Post-SRES scenarios

- SRES emission scenarios used to make projections of 21st century changes.
- There is *high agreement* and *much evidence* that with current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades.

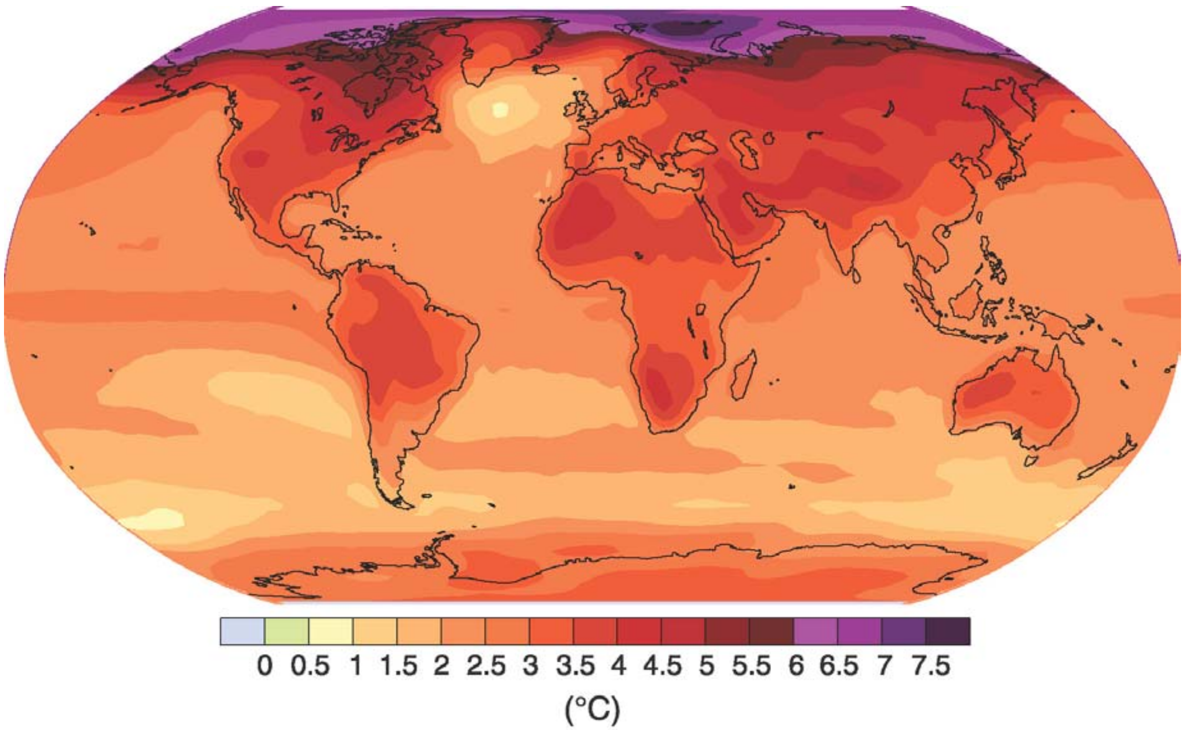


Projection of future changes in climate



- Range of projections is broadly consistent with the TAR.
  - High end of range is larger than in TAR.
  - Broader range of available models suggests stronger climate-carbon cycle feedbacks.
- Sea level rise projections for the 21st century are consistent with the TAR.
  - Uncertainty hinders making reliable estimates of the upper bound.

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



Surface Warming Pattern
A1B, 2090-2099
relative to 1980-1999

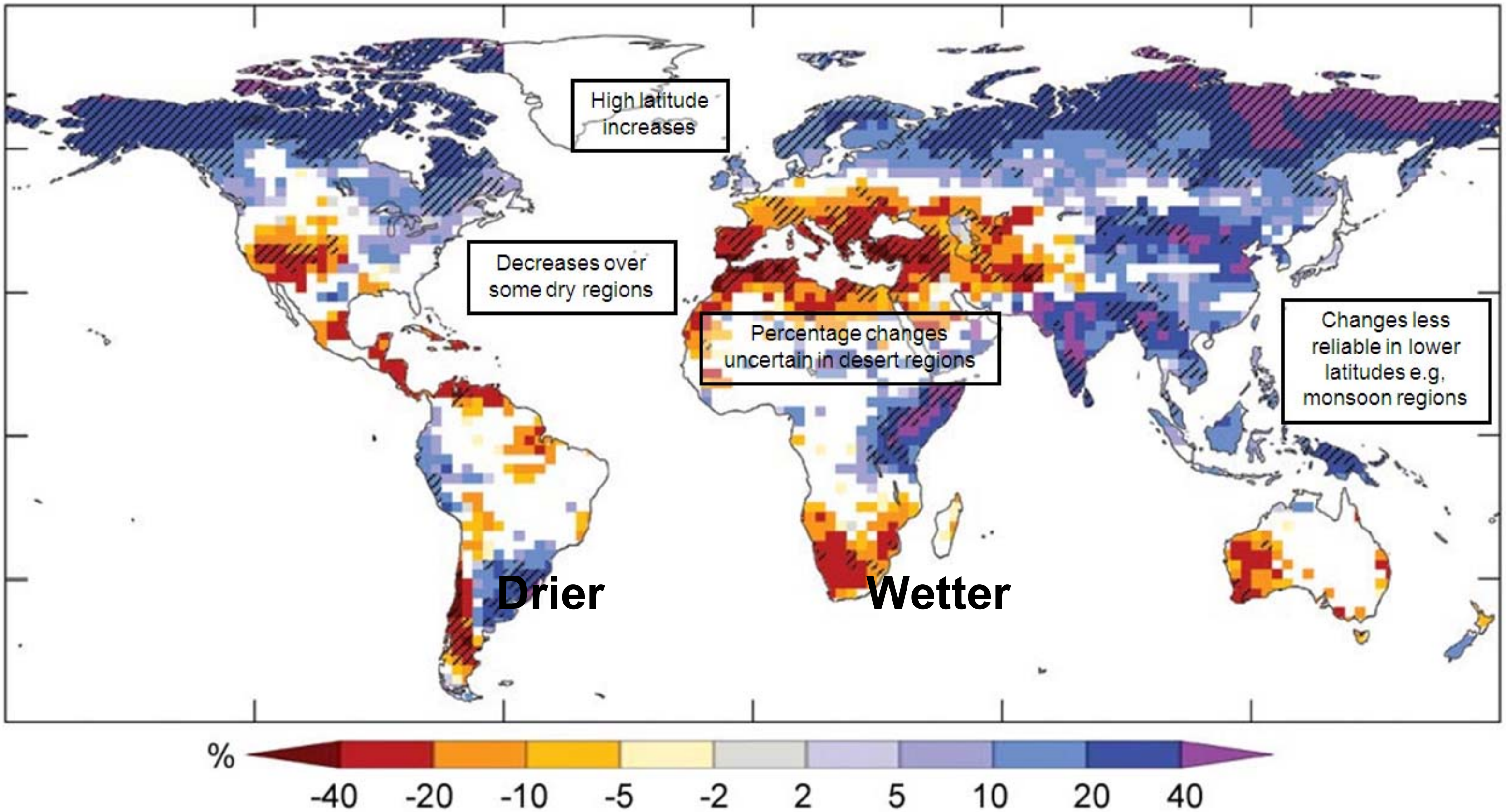
- Continuing recent observed trends in contraction of snow covered area, increases in thaw depth over most permafrost regions, and decrease in sea ice extent
- In some projections using SRES scenarios, Arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century

Other examples of regional changes

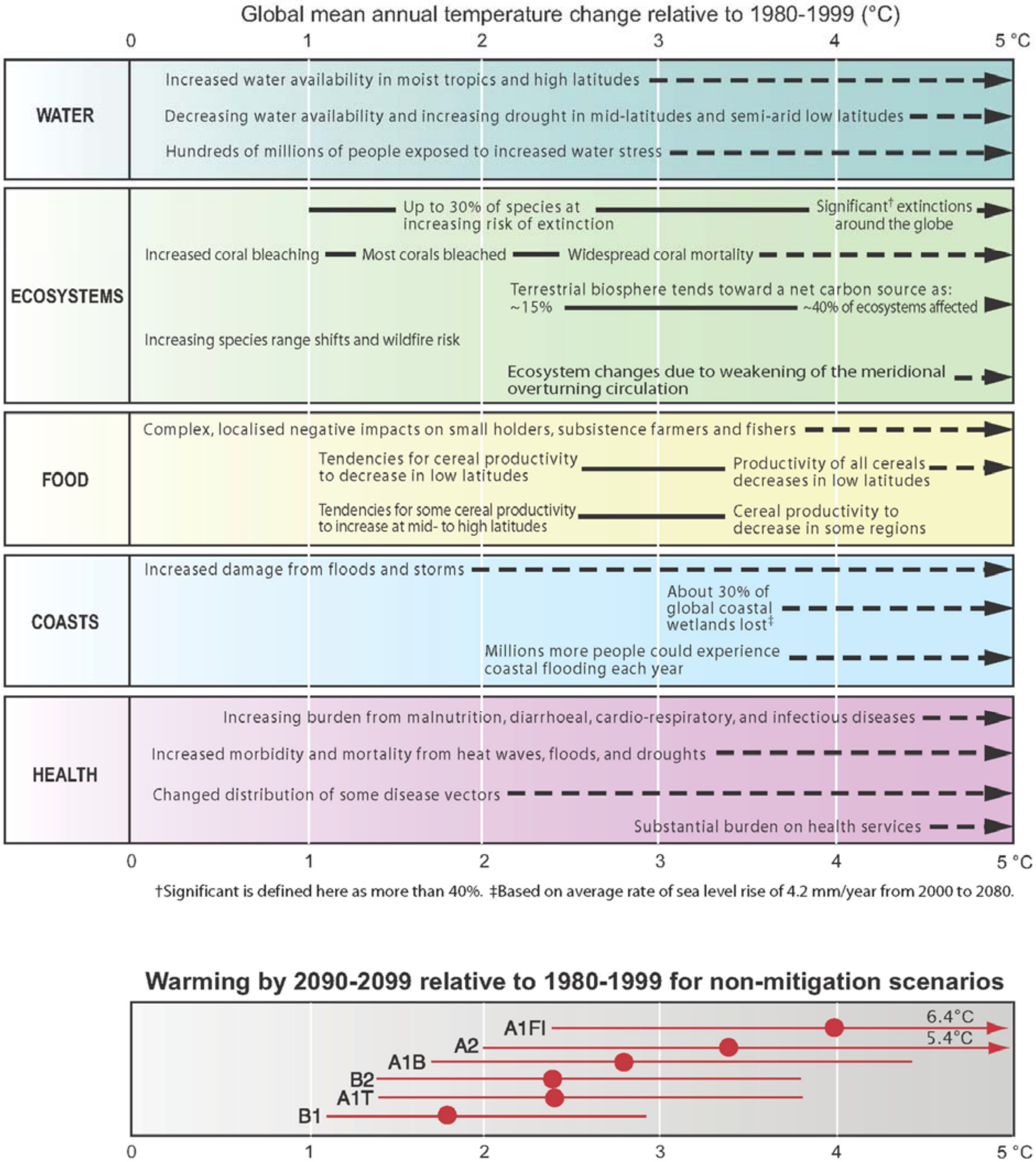
- *Very likely* increase in frequency of hot extremes, heat waves, and heavy precipitation
- *Likely* increase in tropical cyclone intensity; less confidence in global decrease of tropical cyclone numbers
- Poleward shift of extra-tropical storm tracks with consequent changes in wind, precipitation, and temperature patterns
- *Very likely* precipitation increases in high latitudes and *likely* decreases in most subtropical land regions, continuing observed recent trends

21st Century Water Availability (Runoff) Changes

(Annually averaged)



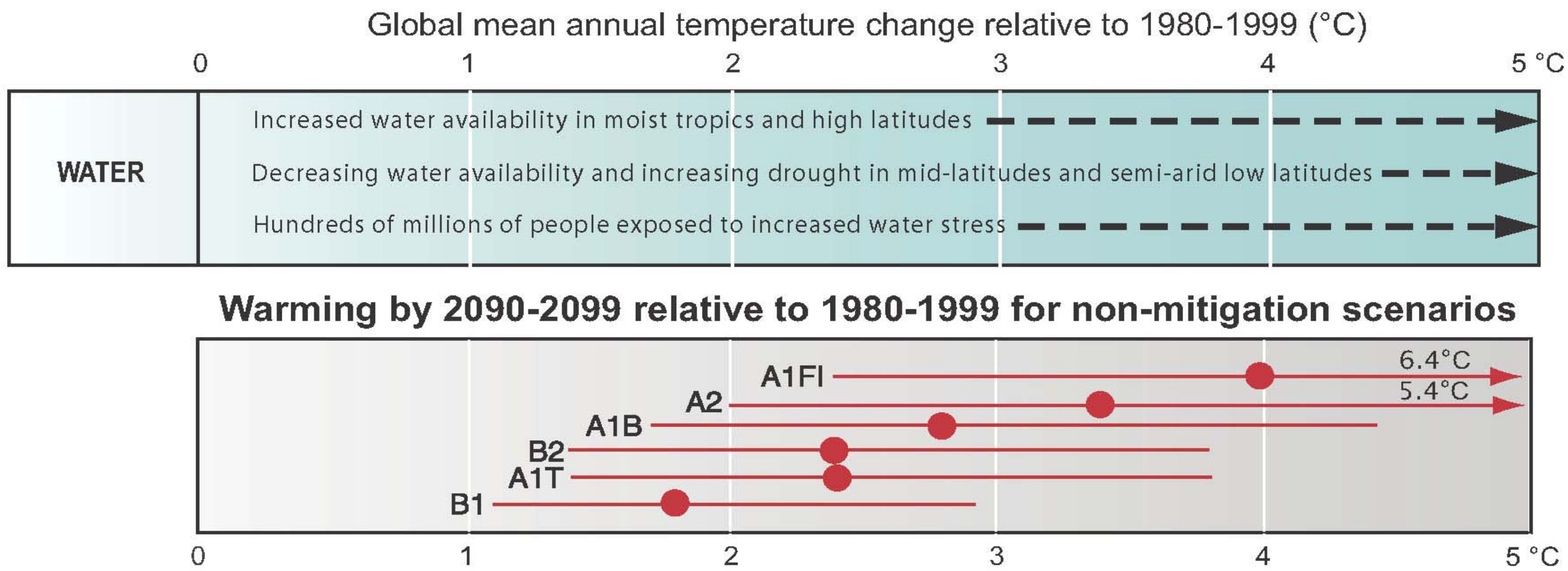
- *Very likely* runoff will increase in high latitudes.
- *Likely* runoff will decrease over some subtropical and tropical regions.



More systematic understanding of the timing and magnitude of impacts related to differing amounts and rates of climate change.

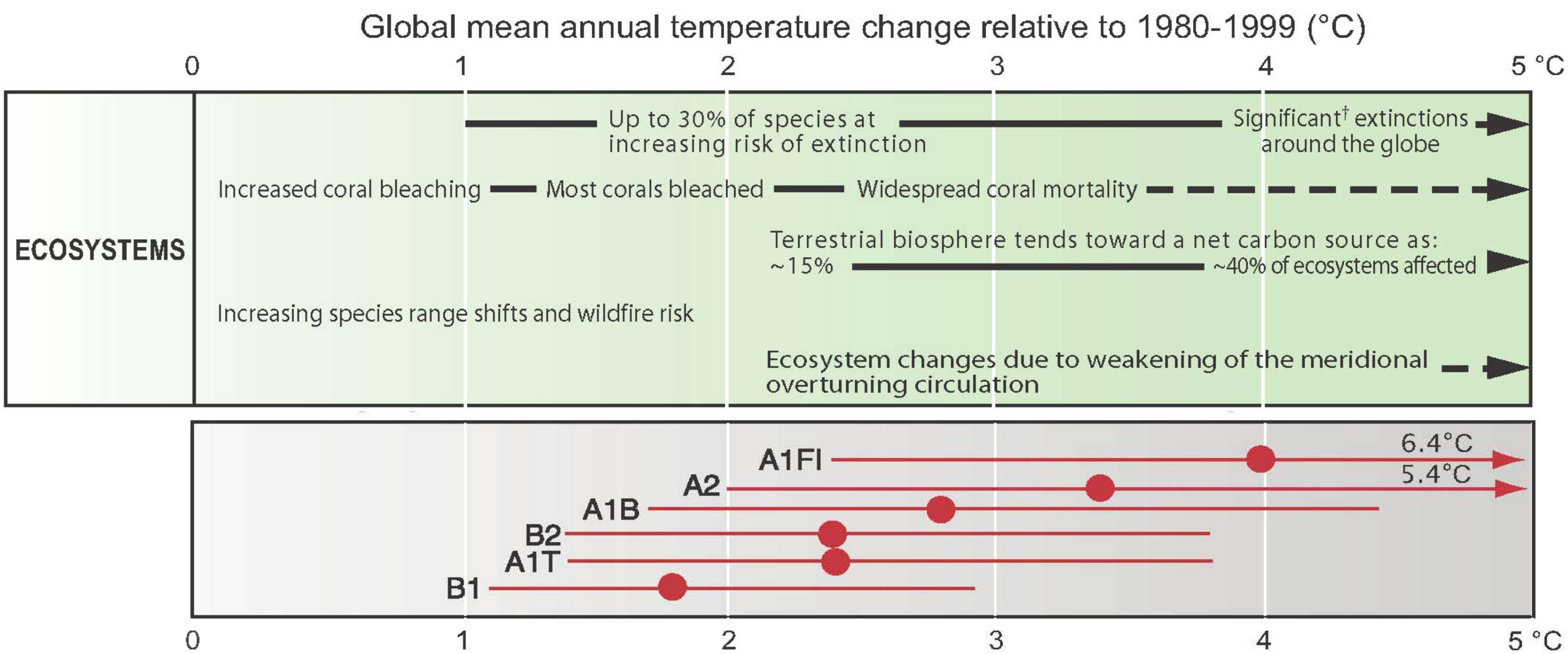
Water

There is high confidence that hundreds of millions of people will be exposed to increased water stress



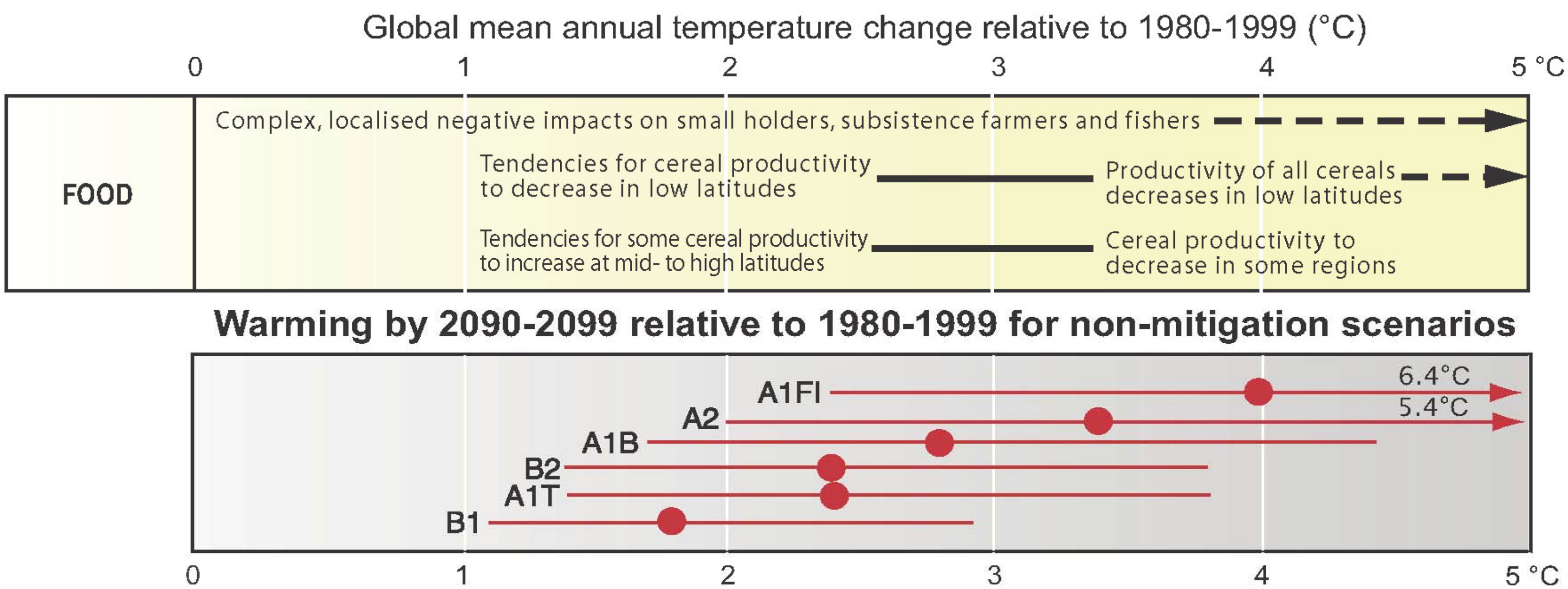
Ecosystems

There is high confidence that many species are at increasing risk of extinction with increasing temperature.



Food

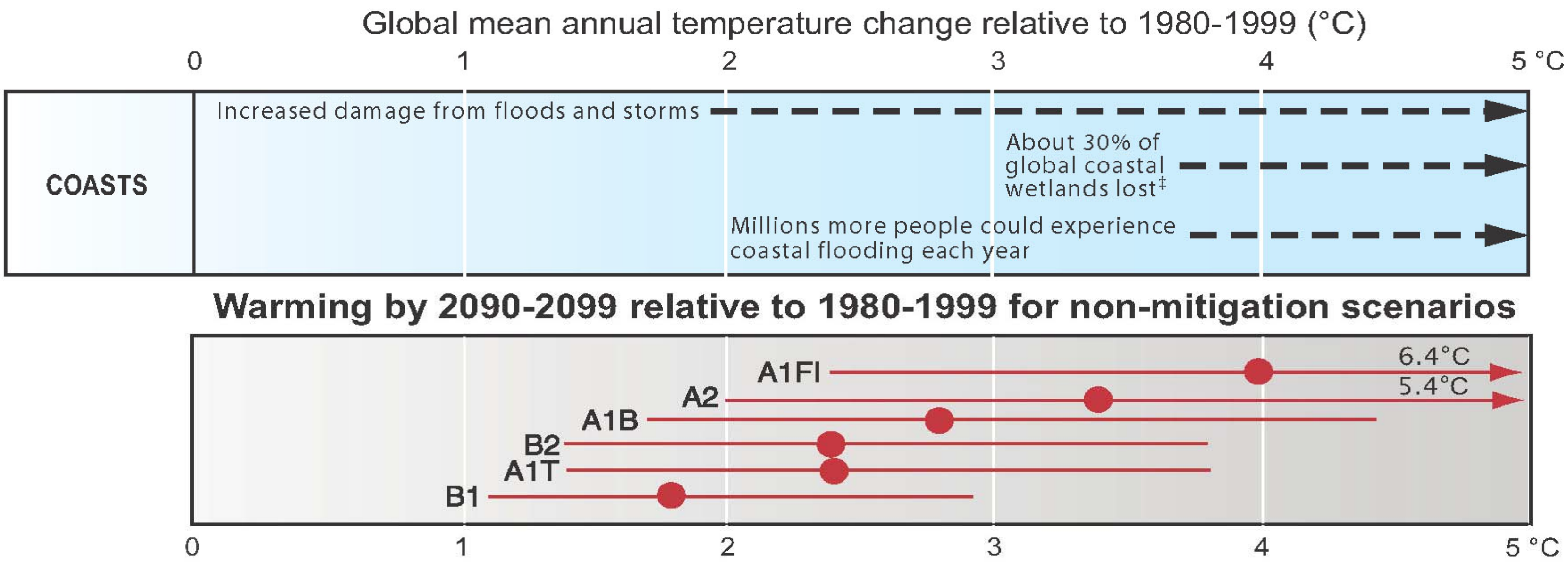
Globally food production is projected to increase at local temperature increases of 1-3 °C; decreases projected above (medium confidence).



Coasts

There is high confidence that millions of people could experience more coastal flooding if global temperature increases more than 2C in this century.

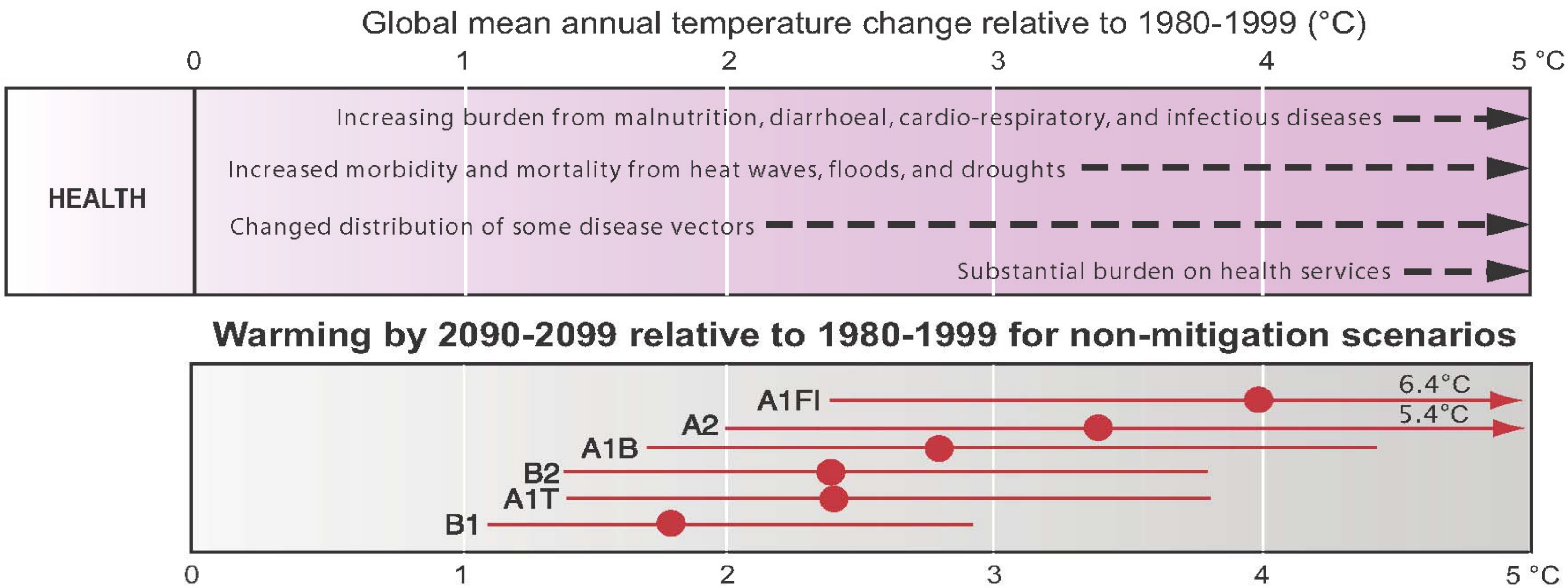
Sea level has very long times and will continue to rise for centuries after stabilization of GHG.



Health

The health status of millions of people is projected to be affected through, for example:

- Increases in malnutrition
- Increased deaths, diseases and injury due to extreme weather events
- Increased burden of diarrhoeal diseases
- Increased frequency of cardio-respiratory diseases due to changes in air quality
- Altered spatial distribution of some infectious diseases.



Some regions are *likely* to be especially affected

- The Arctic, because of the impacts of high rates of projected warming on natural systems and human communities
- Africa, because of low adaptive capacity and projected climate change impacts
- Small islands, where there is high exposure of population and infrastructure to projected climate change impacts
- Asian and African megadeltas, due to large populations and high exposure to sea level rise, storm surges and river flooding.

Anthropogenic warming and sea level rise would continue for centuries, even if GHG concentrations were to be stabilized.

Anthropogenic warming could lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change.

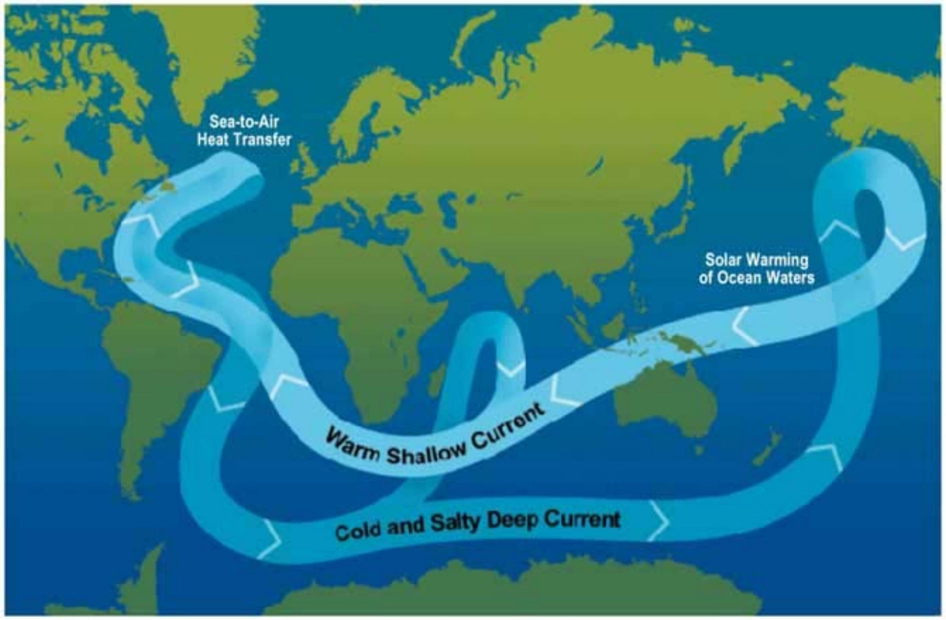
- Partial loss of ice sheets on polar land could imply meters of sea level rise, major changes in coastlines and inundation of low-lying areas, with greatest effects in river deltas and low-lying islands.
- Such changes are projected to occur over millennial time scales, but more rapid sea level rise on century time scales cannot be excluded.

Anthropogenic warming could lead to some impacts that are abrupt or irreversible

- There is *medium confidence* that approximately 20-30% of species assessed so far are *likely* to be at increased risk of extinction if increases in global average warming exceed 1.5-2.5^{o}C (relative to 1980-1999).
- As global average temperature increase exceeds about 3.5^{o}C, model projections suggest significant extinctions (40-70% of species assessed) around the globe.

Anthropogenic warming could lead to some impacts that are abrupt or irreversible

Ocean Circulation Conveyor Belt



The ocean plays a major role in the distribution of the planet's heat through deep sea circulation. This simplified illustration shows this "conveyor belt" circulation which is driven by differences in heat and salinity. Records of past climate suggest that there is some chance that this circulation could be altered by the changes projected in many climate models, with impacts to climate throughout lands bordering the North Atlantic.

- Based on current model simulations, the Meridional Overturning Circulation (MOC) of the Atlantic Ocean will *very likely* slow down during the 21st century; nevertheless temperatures over the Atlantic and Europe are projected to increase.
- The MOC is *very unlikely* to undergo a large abrupt transition during the 21st century.
- Longer-term MOC changes cannot be assessed with confidence.

IPCC Fourth Assessment Report

Synthesis Report

Topic 4

Adaptation and mitigation options

A Wide Array of Adaptation Options is Available, but More Extensive Adaptation is Required to Reduce Vulnerability to Climate Change

- There are barriers, limits and costs, which are not fully understood
- Societies around the world have a long record of adapting to weather- and climate-related events
- Some planned adaptation is already occurring
- There are viable adaptation options that can be implemented in some sectors at low cost
- Comprehensive estimates of global cost and benefits of adaptation are limited

Adaptation Options – Water Sector

- *Adaptation Options:* Expanded rainwater harvesting; Water storage, conservation and re-use; Efficient water use and irrigation; Desalination
- *Policy Framework:* National water polices; Integrated water resource management
- *Constraints:* Financial, human resources and physical barriers
- *Opportunities:* Integrated water resource management; Synergies with other sectors

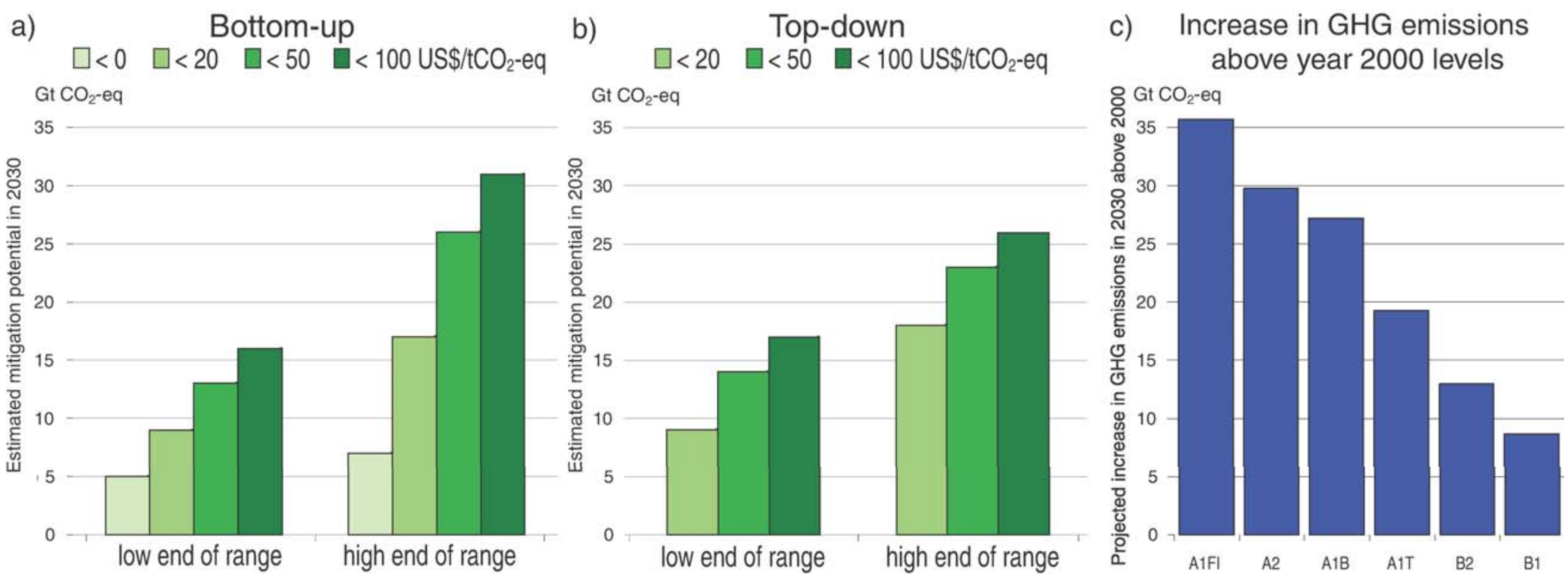
Adaptive Capacity is Intimately Connected to Social and Economic Development

- Unevenly distributed across and within societies
- Capacity to adapt is dynamic and is influenced by a society's productive base
- It is also affected by multiple climate and non-climate stresses, as well as development policy

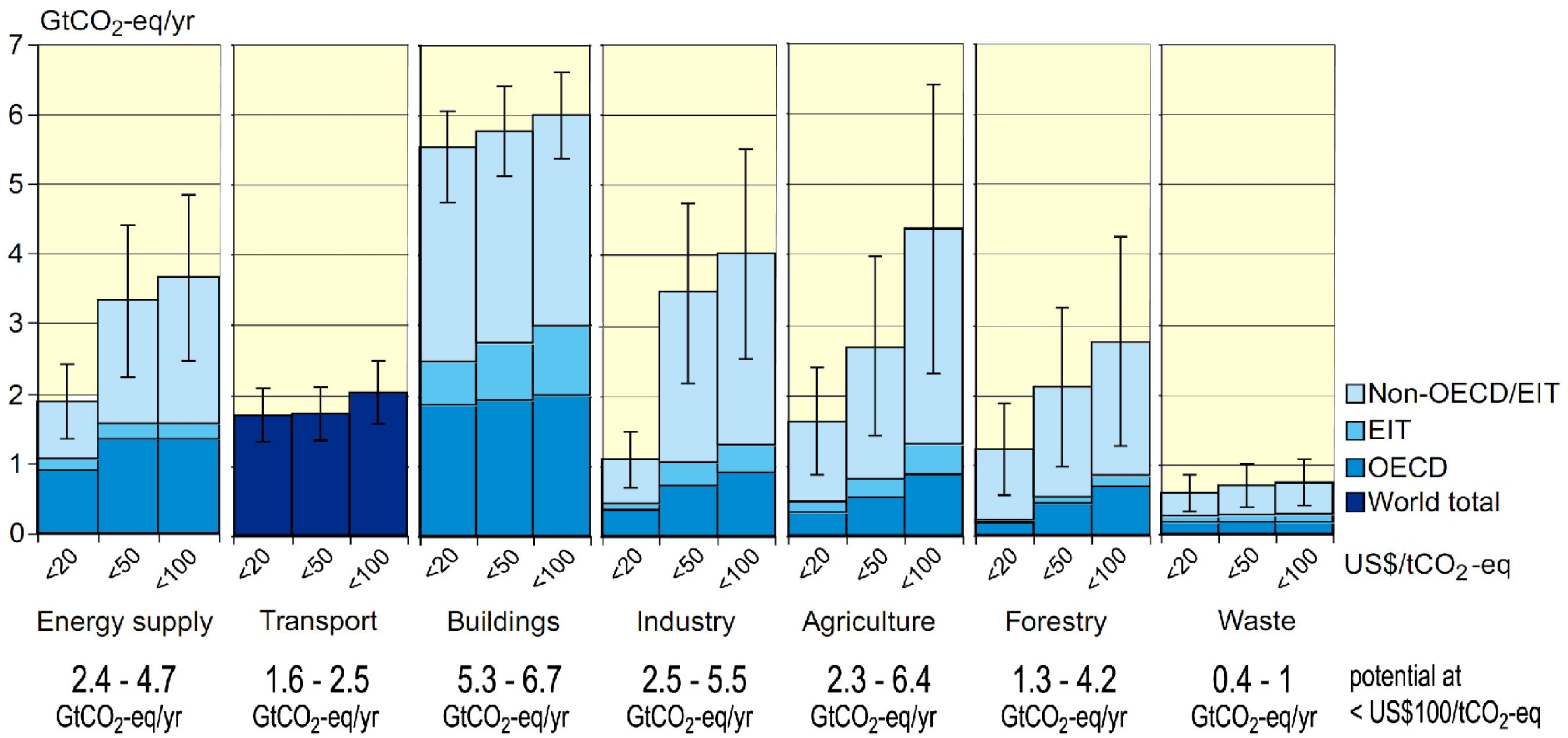
There is Substantial Economic Potential for Mitigation of GHG Emissions

- Agreement between top-down and bottom-up studies at the global level, but substantial differences at the sectoral level
- No one technology can provide all of the potential
- Energy infrastructure investment decisions, expected to exceed $20 trillion up to 2030, will have long-term impacts on GHG emissions
- Life style and behavioral changes can contribute to mitigation across all sectors

Economic Mitigation Potential Could Offset Projected Growth in Emissions to 2030 or Reduce Below Current Levels



Economic Mitigation Potential in 2030 is Spread Across All Sectors and Regions



Mitigation Options – Building Sector

- *Mitigation Options:* Efficient lighting and daylighting; more efficient electrical appliances, heating and cooling; passive and active solar design; alternative refrigeration fluids

- *Policy Options:* Appliance standards and labeling; Building codes and certification; Demand-side management programs; Public sector leadership programs; Incentives for energy service companies

- *Constraints:* Need for periodic revision of standards; Enforcement difficulties

- *Opportunities:* Attractive for new buildings; Expanded market for energy-efficient products

A Wide Variety of Policies and Instruments are Available to Governments to Create the Incentives for Mitigation Action

- Their applicability depends on national circumstances and sectoral context
- An effective carbon price signal could realize significant mitigation potential
- Mitigation actions can provide near-term co-benefits
- Annex I country actions may affect the global economy and emissions
  - The scale of carbon leakage remains uncertain
  - Spillover effects depend on policy decisions and oil markets

Many Options Exist for Reducing GHG Emissions through International Cooperation

Notable achievements of the UNFCCC and Kyoto Protocol:

-Establishment of a global response to climate change

-Stimulation of national policies

-Creation of an international carbon market

-Establishment of new institutional mechanism that may provide the foundation for future mitigation

-Progress on addressing adaptation and suggestion of additional initiative

Greater cooperative efforts and expansion of market mechanisms will help reduce the global cost of achieving a given level of mitigation

Some Climate Response Options Can Realize Synergies and Avoid Conflicts with Other Dimensions of Sustainable Development

- Both synergies and trade-offs exist between adaptation and mitigation
- Non-climate polices can significantly affect emissions, adaptive capacity and vulnerability
- Climate change will interact with other environmental and natural resource concerns
- It is *very likely* that climate change will slow the pace of progress towards sustainable development

Integrating Climate Change Considerations into Development Decisions – Selected Examples

Sector	**Non-climate Change Policy Instrument or Action**
Macro-Economy	Implement non-climate taxes/subsidies and/or other fiscal and regulatory policies that promote sustainable development
Electricity	Adoption of cost-effective renewables; Demand-side management programs; Transmission and distribution loss reduction
Petroleum Imports	Diversify imported and domestic fuel mix; Reduce energy intensity to improve energy security
Insurance	Differentiated premiums; Liability insurance exclusions; Improved terms for green products
Forestry	Adoption of forest conservation and sustainable management practices

IPCC Fourth Assessment Report

Synthesis Report

Topic 5

The long-term perspective

Role of science

- Determining what constitutes "dangerous anthropogenic interference with the climate system" in relation to Article 2 of the UNFCCC involves value judgements

- Science can support informed decisions , including by providing criteria for judging which vulnerabilities might be labelled "key"

“Reasons for concern” identified in Third Assessment Report

- Risks to unique and threatened systems
- Risks of extreme weather events
- Distribution of impacts and vulnerabilities
- Aggregate impacts
- Risks of large-scale singularities

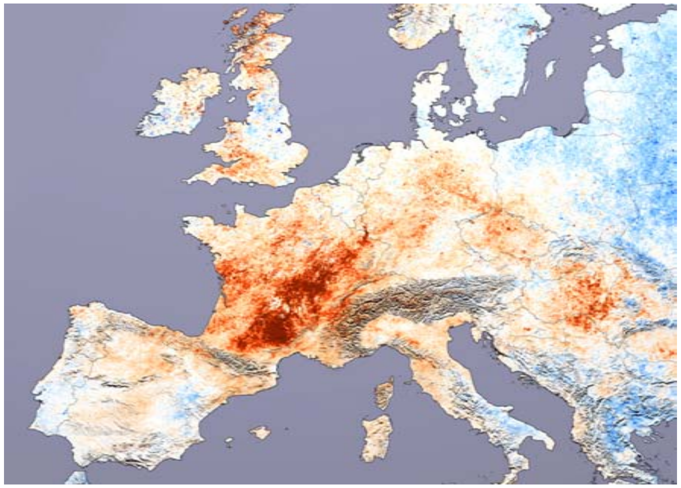
“Reasons for concern” identified in the TAR remain a viable framework to consider key vulnerabilities.

- Many risks identified with higher confidence
- Some risks larger or occur at lower increases in temperature
- Due to:
  - Better understanding of magnitude of impacts and risks
  - More precise identification of the circumstances that make systems and regions especially vulnerable
  - Growing evidence that risk of very large impacts on multiple century time scales would continue to increase

Risks to unique and threatened systems

- New and stronger evidence of observed impacts
- Confidence has increased that a 1-2^{o}C increase in global mean temperature above 1990 levels poses significant risks…, including many biodiversity hotspots
- Increases in sea surface temperature of about 1-3^{o}C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatization by corals
- Increasing vulnerability of indigenous communities in the Arctic and small island communities to warming is projected

Risks of extreme weather events



- Responses to some recent extreme climate events reveal higher levels of vulnerability in both developing and developed countries

- Higher confidence in projected increases in droughts, heat-waves, and floods as well as their adverse impacts
  - Increased water stress and wild fire frequency
  - Adverse effects on food production and health
  - Increased flood risk, extreme high sea level, and damage to infrastructure

Distribution of impacts and vulnerabilities

AFP Photo

- Sharp differences across regions
- Those in weakest economic position often most vulnerable
- Increasing evidence of greater vulnerability of specific groups such as the poor and elderly
- Increased evidence that low-latitude and less-developed areas generally face greater risk
  - Eg. dry areas and mega-deltas

Aggregate impacts

- Initial net market-based benefits from climate change are projected to peak at a lower magnitude of warming, while damages would be higher for larger magnitudes of warming.
- Net costs of impacts of increased warming are projected to increase over time
- Aggregate impacts also quantified in other metrics
  - Likely adverse effects on hundreds of millions of people through increased coastal flooding, reductions in water supplies, increased malnutrition and increased health impacts.

Risks of large-scale singularities

- Better understanding than in the TAR that the risk that additional sea level rise from both the Greenland and possibly Antarctic ice sheets may be larger than projected and could occur on century time scales
- Ice dynamical processes seen in recent observations but not fully included in ice sheet models could increase the rate of ice loss

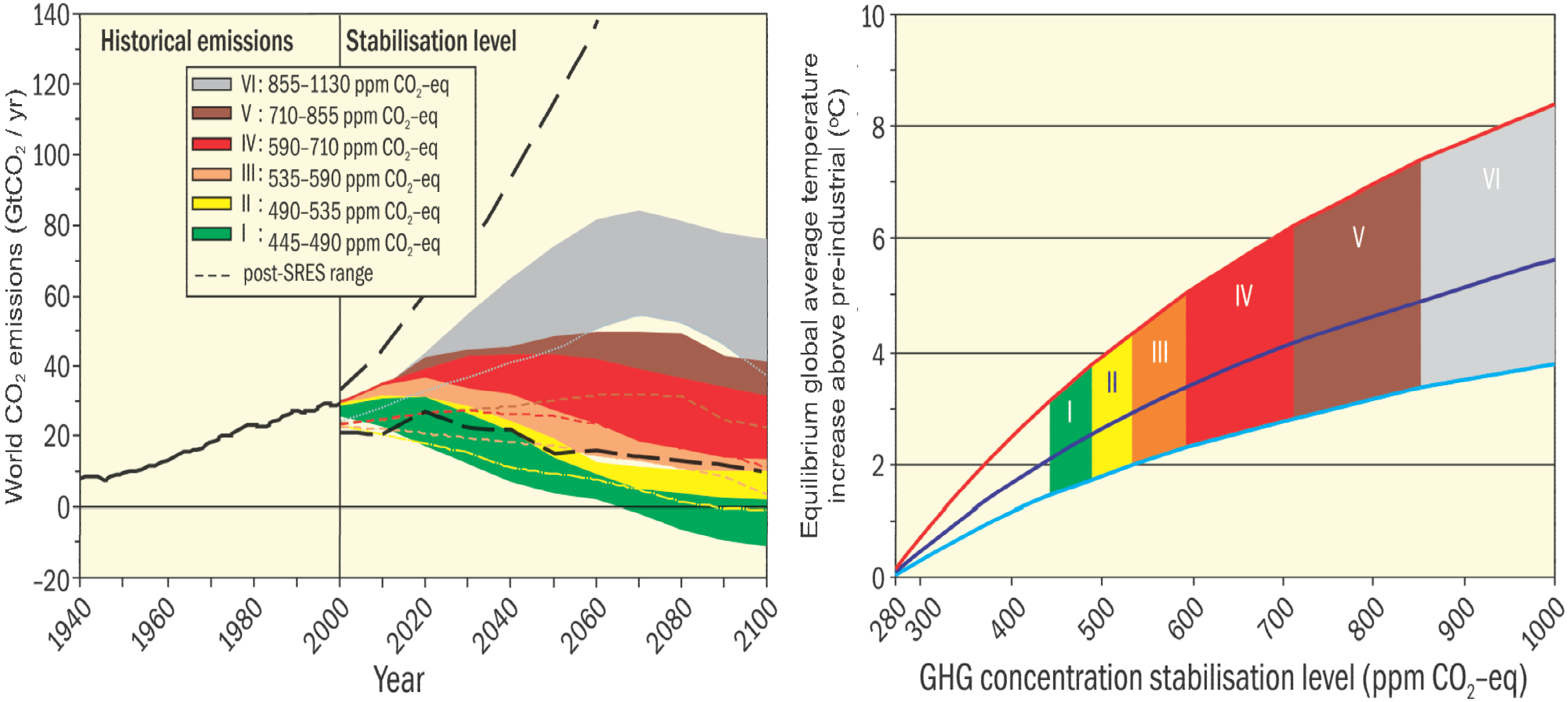
Neither adaptation nor mitigation alone can avoid all climate change impacts.

- Can complement each other and together can significantly reduce risks of climate change
- Adaptation is necessary in short and longer term to address impacts resulting from warming that would occur even for the lowest stabilisation scenarios assessed
  - There are barriers, limits and costs, but these are not fully understood
  - Unmitigated climate change would, in the long term, be likely to exceed capacity of natural, managed and human systems to adapt

Many impacts can be reduced, delayed or avoided by mitigation.

- Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower stabilisation levels
- Early mitigation actions would avoid further locking in carbon intensive infrastructure and reduce climate change and associated adaptation needs
- Delayed emission reductions significantly constrain the opportunities to achieve lower stabilisation levels and increase the risk of more severe climate change impacts

The lower the stabilisation level the earlier emissions must go down



Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower stabilisation levels

Category	CO_2 concentration at stabilization (2005 = 379 ppm) [b]	CO_2-equivalent concentration at stabilization including GHGs and aerosols (2005 = 375 ppm) [b]	Peaking year for CO_2 emissions [a,c]	Change in global CO_2 emissions in 2050 (% of 2000 emissions) [a,c]	Global average temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity [d], [e]	Global average sea level rise above pre-industrial at equilibrium from thermal expansion only [f]	Number of assessed scenarios
	ppm	ppm	year	percent	°C	metres	
I	350 – 400	445 – 490	2000 – 2015	-85 to -50	2.0 – 2.4	0.4 – 1.4	6
II	400 – 440	490 – 535	2000 – 2020	-60 to -30	2.4 – 2.8	0.5 – 1.7	18
III	440 – 485	535 – 590	2010 – 2030	-30 to +5	2.8 – 3.2	0.6 – 1.9	21
IV	485 – 570	590 – 710	2020 – 2060	+10 to +60	3.2 – 4.0	0.6 – 2.4	118
V	570 – 660	710 – 855	2050 – 2080	+25 to +85	4.0 – 4.9	0.8 – 2.9	9
VI	660 – 790	855 – 1130	2060 – 2090	+90 to +140	4.9 – 6.1	1.0 – 3.7	5

Sea level rise under warming is inevitable

- Thermal expansion would continue for many centuries after concentrations have stabilised
- Eventual sea level rise much larger than projected for the 21st century
- Eventual contributions from Greenland ice sheet loss could be several metres should warming in excess of 1.9-4.6°C above pre-industrial be sustained over many centuries
  - larger than from thermal expansion
  - long time scales of response to warming imply that stabilisation at or above present levels would not stabilise sea level for many centuries

High agreement and *much evidence* that all stabilisation levels assessed can be achieved

- Deployment of a portfolio of technologies that are either currently available or expected to be commercialised in coming decades
- Assuming appropriate and effective incentives are in place for development, acquisition, deployment and diffusion and addressing related barriers

The macro-economic costs of mitigation generally rise with the stringency of the stabilisation target

For specific countries and sectors, costs vary considerably from the global average

Stabilisation levels (ppm CO_2-eq)	Median GDP reduction [a] (%)		Range of GDP reduction [b] (%)		Reduction of average annual GDP growth rates (percentage points) [c], [e]	
	2030	2050	2030	2050	2030	2050
445 – 535 [d]	Not available		< 3	< 5.5	< 0.12	< 0.12
535 – 590	0.6	1.3	0.2 to 2.5	slightly negative to 4	< 0.1	< 0.1
590 – 710	0.2	0.5	-0.6 to 1.2	-1 to 2	< 0.06	< 0.05

Costs of climate change

- Impacts of climate change are *very likely* to impose net annual costs which will increase over time as global temperatures increase

- Aggregate estimates of costs mask significant differences in impacts across sectors, regions and populations and *very likely* underestimate damage costs because they cannot include many non-quantifiable impacts

Responding to climate change involves an iterative risk management process

- Includes both adaptation and mitigation, takes into account climate change damages, co-benefits, sustainability, equity, and attitudes to risk
- Limited, early results do not as yet permit an unambiguous determination of emissions pathway or stabilisation level where benefits exceed costs
- Choices about scale and timing of mitigation involve balancing economic costs of more rapid emission reductions now against the corresponding medium-term and long-term climate risks of delay

Synthesis Report can be downloaded from

http://www.ipcc.ch/

Back-up slides

Article 2 of the UNFCCC

- "The ultimate objective of this Convention and any related legal instruments ….is to achieve…stabilization of greenhouse gas concentrations in the atmosphere at a level that would **prevent dangerous anthropogenic interference with the climate system**. Such a level should be achieved within a time-frame sufficient to allow **ecosystems** to adapt naturally to climate change, to ensure that **food production** is not threatened and to enable **economic development to proceed in a sustainable manner**."