The IPCC, Bali climate negotiations and beyond: which implications for research?

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Invited talk at the EC DG RTD Debate, Brussels, 20-05-2008

What is the IPCC?

- **IPCC : Intergovernmental Panel on Climate Change (GIEC in French)**
- **Created by World Meteorological Organisation (WMO) & United Nations Environment Programme (UNEP) in 1988**
- **Mandate : assess the science of climate change, impacts and adaptation, mitigation options**
- **Publishes consensus reports (1990, 1996, 2001, 2007) (Cambridge University Press)**
  Advises Climate Change Convention
- **Web :** http://www.ipcc.ch

IPCC Structure

- **3 Working Groups, 1 Task Force**
- WG1: Physical basis for climate change
- WG2: Impacts, adaptation & vulnerability
  - Plenary: Brussels 2-6 April 2007
- WG3: Mitigation (emission reductions)
- TF: Emission inventories (methodologies)

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IPCC writing cycle (4 years, 2500 scientists)

- **Plenary decides table of content of reports**
- **Bureau appoints world-class scientists as authors, based on publication record**
- **Authors assess all scientific literature**
- ***Draft* – Expert review (+ Review editors)**
- ***Draft 2 (+ Draft 1 Summary for Policy Makers (SPM)* – Combined expert/government review**
- ***Draft 3 (+ Draft 2 SPM)*– Government review of SPM**
- **Approval Plenary (interaction authors – governments) – *SPM and full report***

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⌘**IPCC Working Group I: climatology**

Key points from the WG1 IPCC AR4 Report

- **Warming of the climate system is unequivocal**
- **Very high confidence that net effect of human activities since 1750 = warming**
- **Last 50 years likely to be highest temperature in at least last 1300 yrs**
- **Most of this warming is very likely due to increase in human greenhouse gases**
- **Without emission reduction policies, global temperature could increase by 1.1 to 6.4°C, or even higher in 2100 compared to 1990**
- **Sea level could increase by 18 to 59 cm, or more**
- **Frequency/intensity of several extreme phenomena due to increase (ex: heat waves, droughts, floods, …)**

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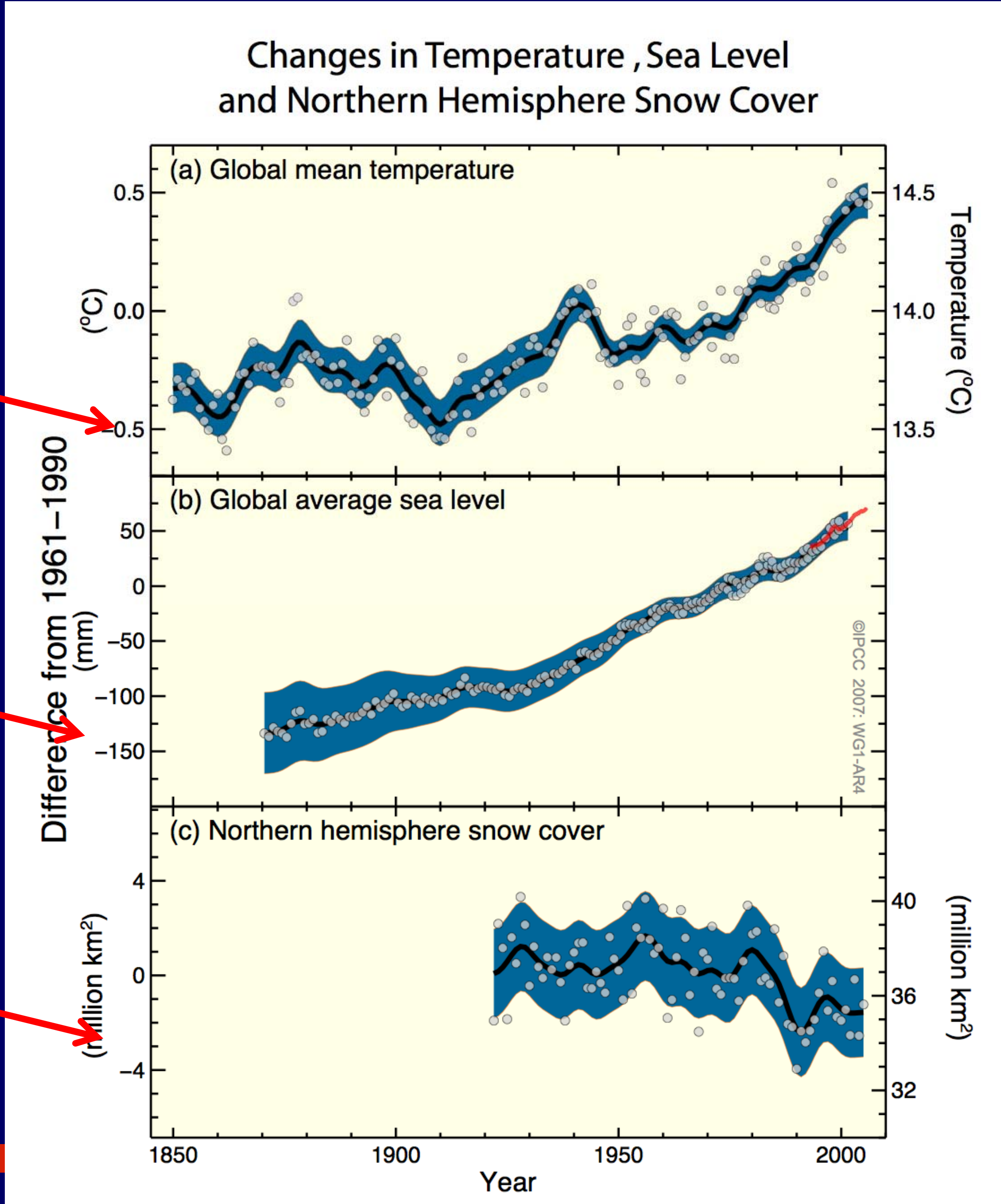
Warming is Unequivocal

Rising atmospheric temperature

Rising sea level

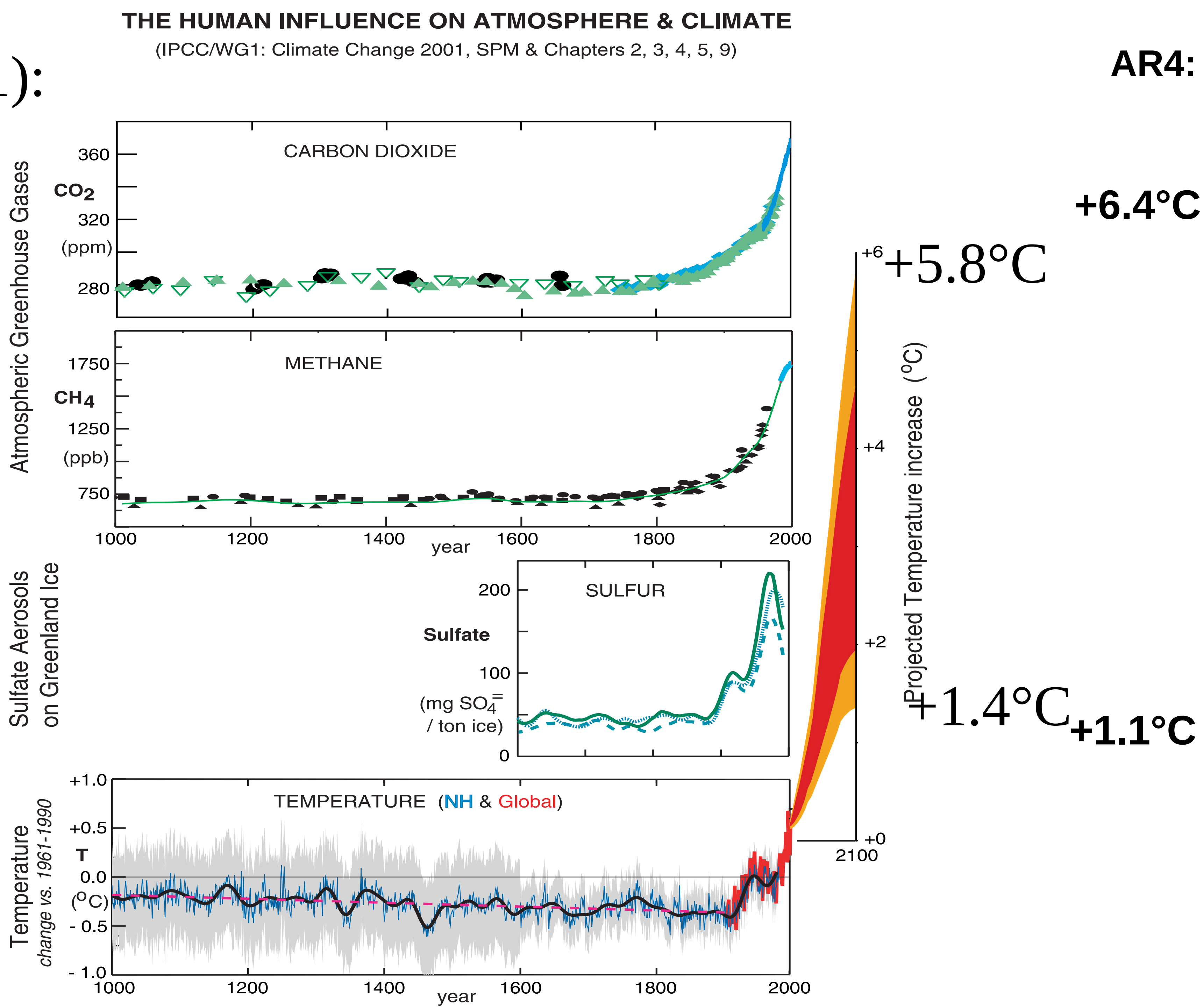
Reductions in NH snow cover



IPCC

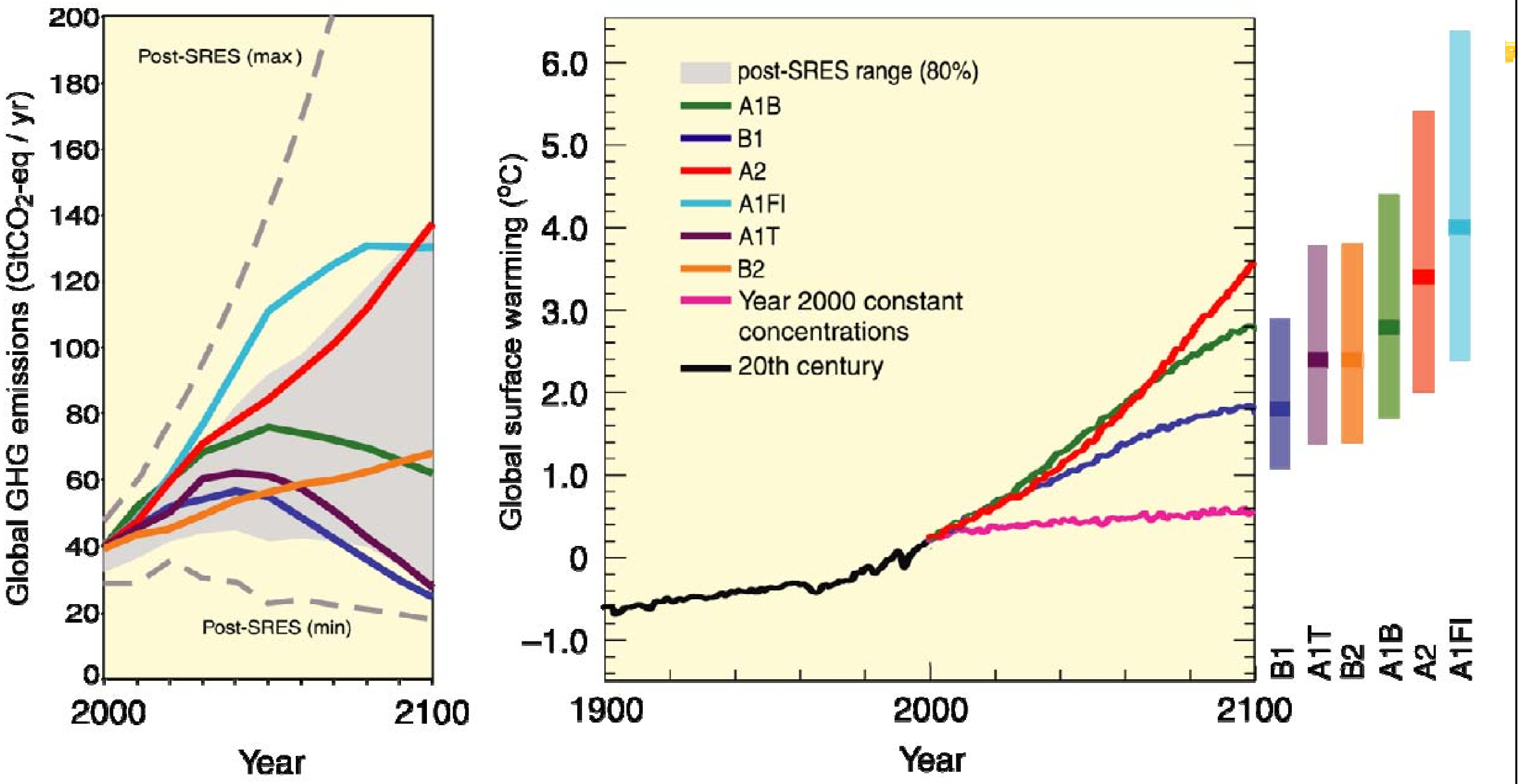
TAR (2001):

AR4:



Source: IPCC, AR4

Projections du climat futur en l'absence de mesures



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Projected globally averaged surface warming and sea level rise at the end of the 21st century (IPCC WG1 AR4)

	Temperature Change (°C at 2090-2099 relative to 1980-1999) [a]		Sea Level Rise (m at 2090-2099 relative to 1980-1999)
Case	Best estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations [c]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

NB: add 0.5°C to get pre-industrial reference

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Climate change and extremes
(IPCC AR4 WG1)

Post 1960 **21th century**

Phenomenon[a] and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of a human contribution to observed trend [b]	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	*Very likely* [c]	*Likely* [d]	*Virtually certain* [d]
Warmer and more frequent hot days and nights over most land areas	*Very likely* [e]	*Likely (nights)* [d]	*Virtually certain* [d]
Warm spells / heat waves. Frequency increases over most land areas	*Likely*	*More likely than not* [f]	*Very likely*
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*Likely*	*More likely than not* [f]	*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 some regions since 1970	*More likely than not* [f]	*Likely*
Increased incidence of extreme high sea level (excludes tsunamis) [g]	*Likely*	*More likely than not* [f, h]	*Likely* [i]

Virtually certain > 99%, very likely > 90%, likely > 66%, more likely than not > 50%

What if the Gulf Stream is affected?

- Based on current model simulations, it is *very likely* that the meridional overturning circulation (MOC) of the Atlantic Ocean will slow down during the 21st century.
  - **longer term changes not assessed with confidence**
- Temperatures in the Atlantic region are projected to increase despite such changes due to the much larger warming associated with projected increases of greenhouse gases.

- IPCC Working Group II: Impacts, Vulnerability, and adaptation

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Following addressed by WG II:

- Impacts observed so far

- Future scenarios
- Impacts on sectors:
  - Water
  - Ecosystems
  - Agriculture, forestry, fisheries
  - Coasts
  - Settlements and industry
  - Health

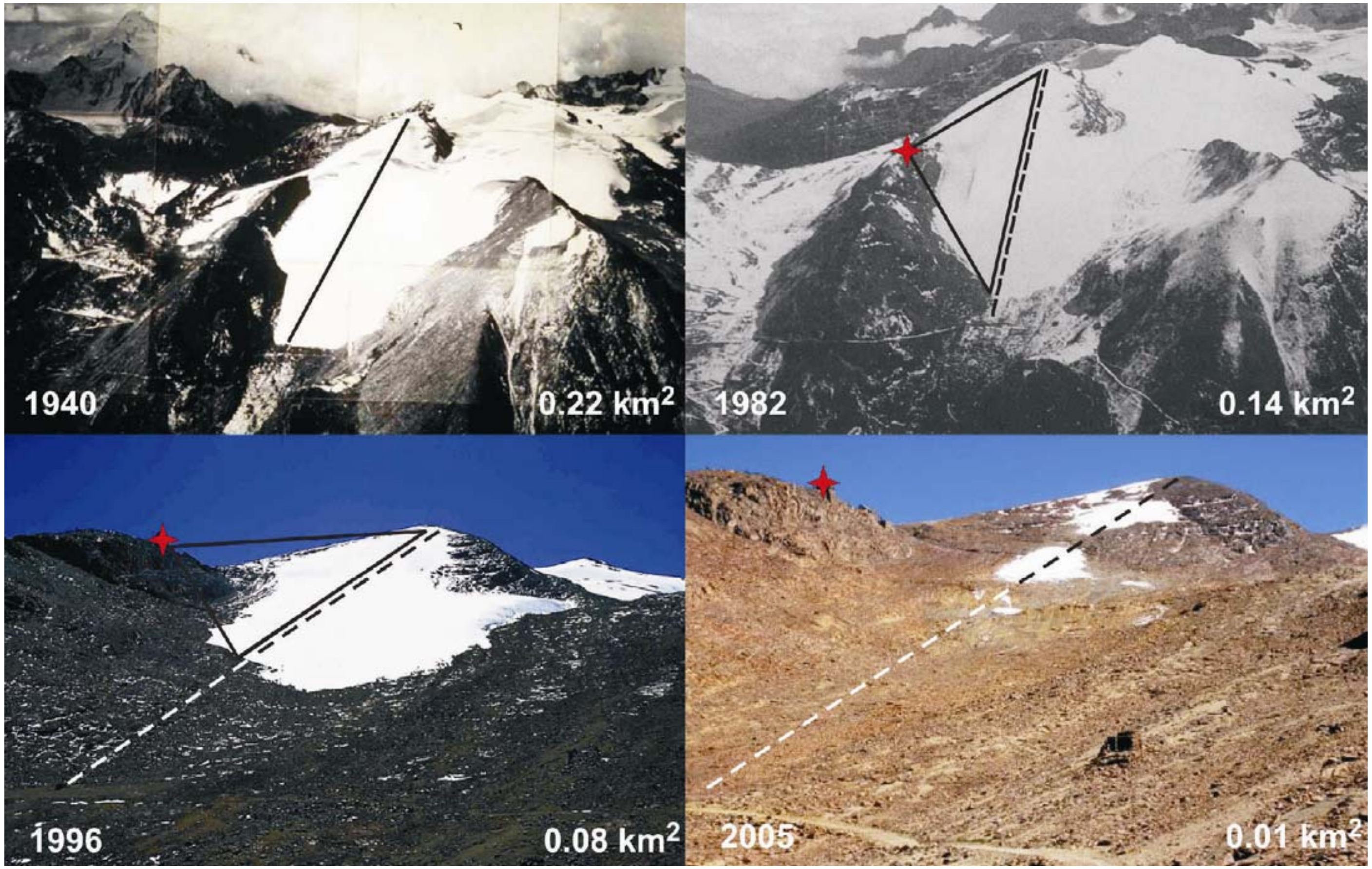
Following addressed (cont.):

- Impacts on regions:
  - Africa, Asia, Australia and New Zealand, Latin America, North America, Polar regions, Small islands, and
  - Europe (including the Alps)

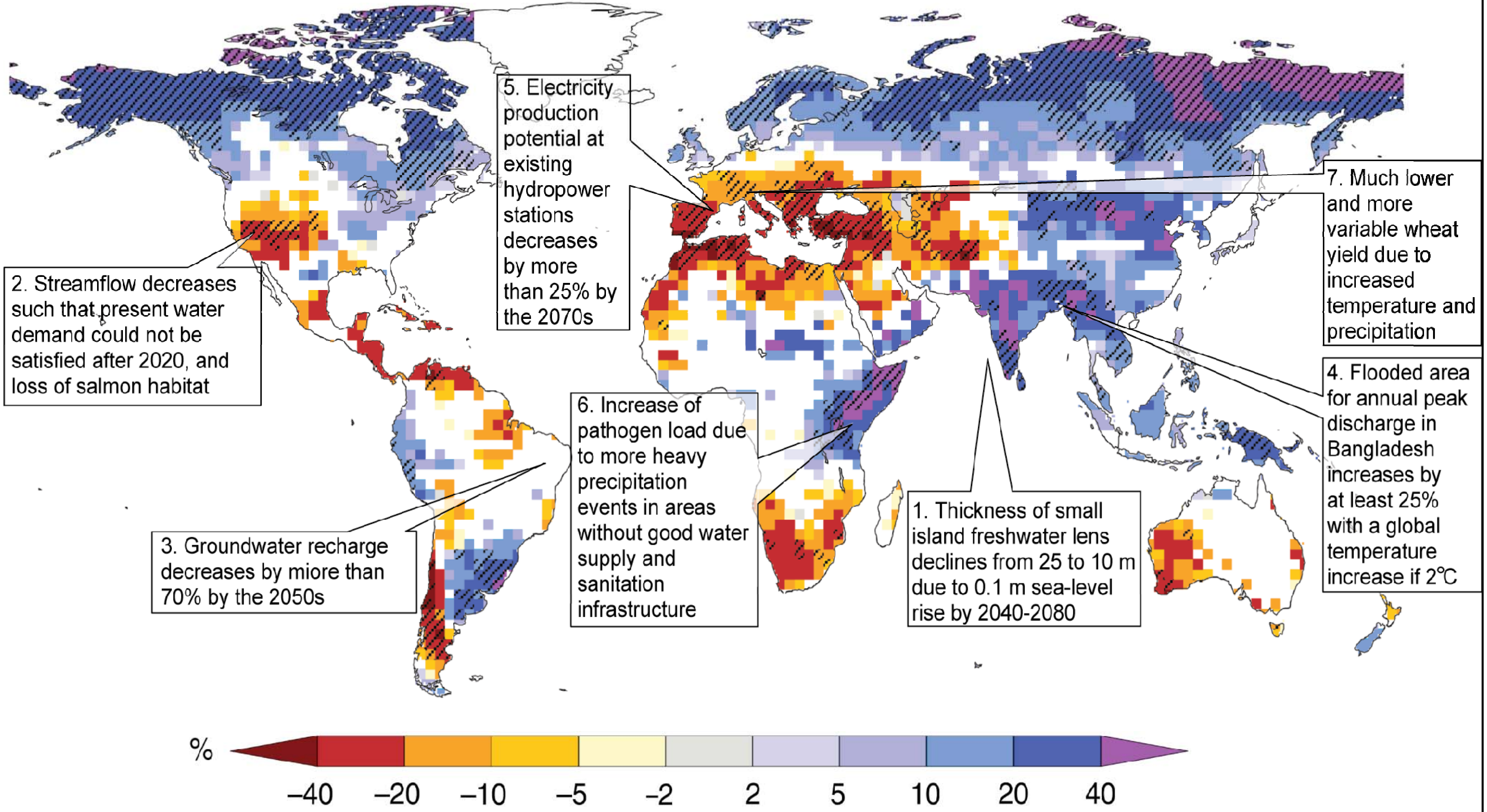
- Adaptation practices
- Adaptation vs. mitigation
- Key vulnerabilities
- Sustainability

The Chacaltaya glacier and ski-lift, Bolivia

Skiing was no longer possible after 2004



Water at the end of the 21st century for SRES A1B



TP Figure 3.4: Ensemble mean change of annual runoff, in percent, between present (1980-1999) and 2090-2099 for the SRES A1B emissions scenario (based on Milly et al., 2005).

WMO

UNEP

Effects on Nile delta: 10 M people above 1m

(Time 2001)

WMO

UNEP

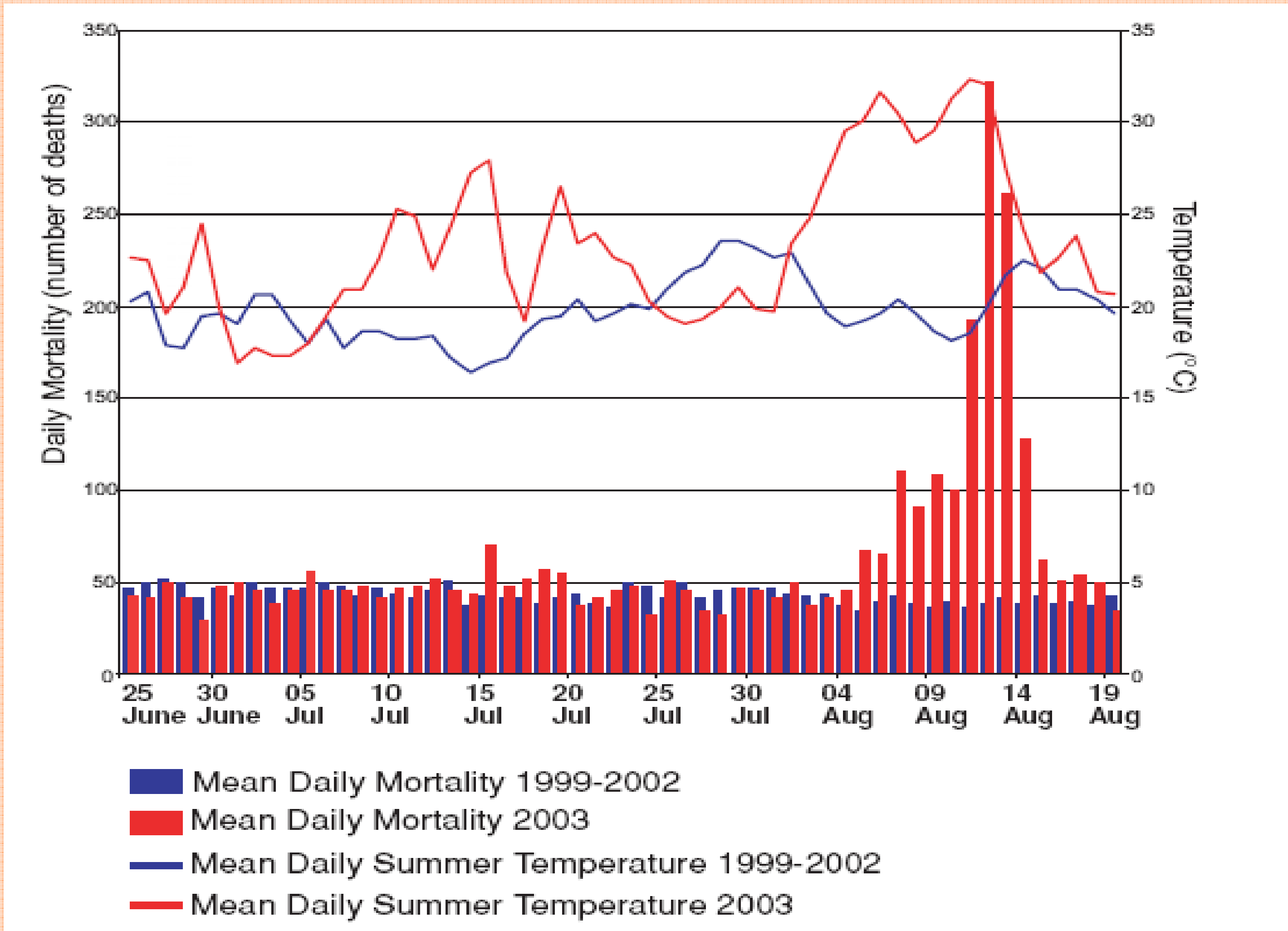
20% - 30% of plants and animals species at increased risk of extinction

if ΔT 1.5°C - 2.5°C (above 1990 temperature)

WMO

UNEP

Daily mortality in Paris (summer 2003) (IPCC AR4 Ch 8)



WMO

UNEP

Ice sheet melting

- Melting of the Greenland ice sheet
  - Total melting would cause 7 m SLR contribution
- Melting of the West Antarctic Ice Sheet
  - Total melting would cause 5 m SLR contribution
- Warming of 1 – 4^{o}C over present-day temperatures would lead to partial melting over centuries to millennia

WMO

UNEP

With 1 metre sea-level rise: 63000 ha below sea-level in Belgium (likely in 22nd century, not impossible in 21st century) (NB: flooded area depends on protection)

Source: N. Dendoncker (Dépt de Géographie, UCL), J.P. van Ypersele et P. Marbaix (Dépt de Physique, UCL) (www.climate.be/impact)

With 8 metre sea-level rise: 3700 km² below sea-level in Belgium

(very possible in year 3000)

(NB: flooded area depends on protection)

Source: N. Dendoncker (Dépt de Géographie, UCL), J.P. van Ypersele et P. Marbaix (Dépt de Physique, UCL) (www.climate.be/impact)

Adaptation will be necessary to address unavoidable impacts

WMO

UNEP

⌘IPCC Working Group III: Mitigation

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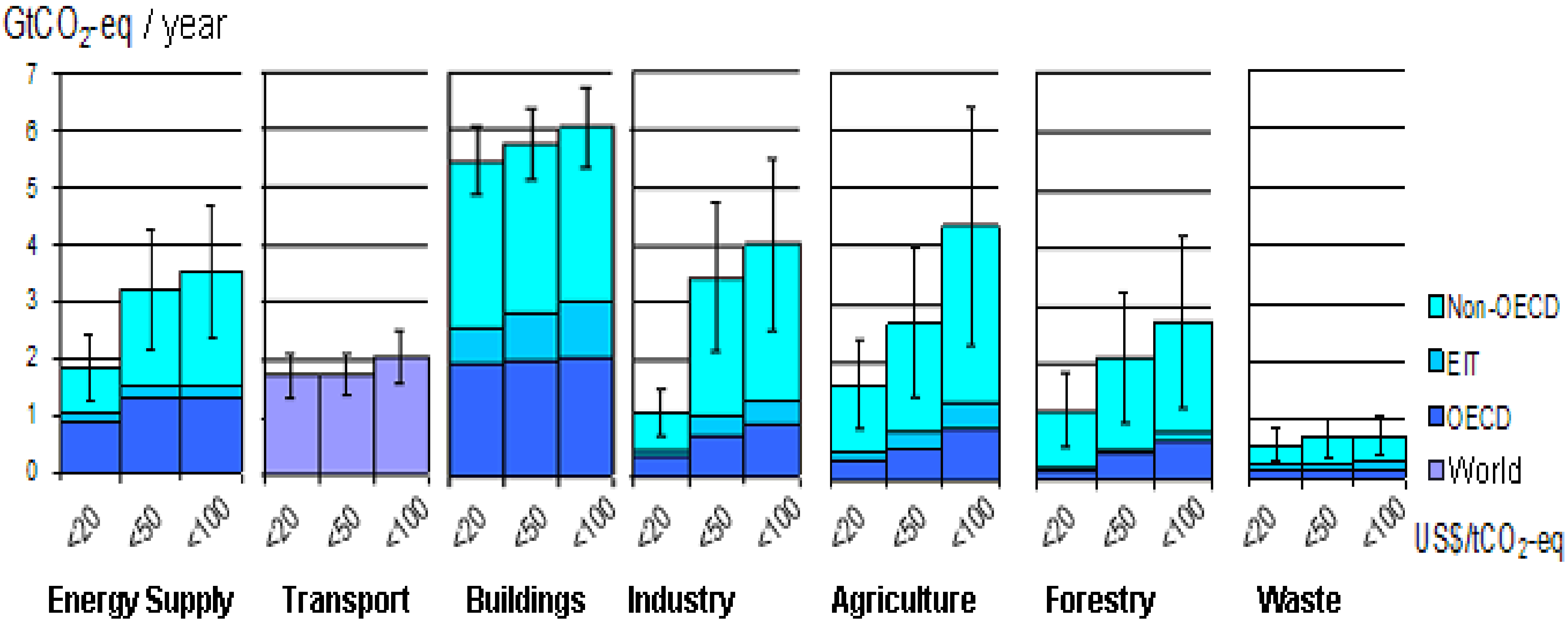
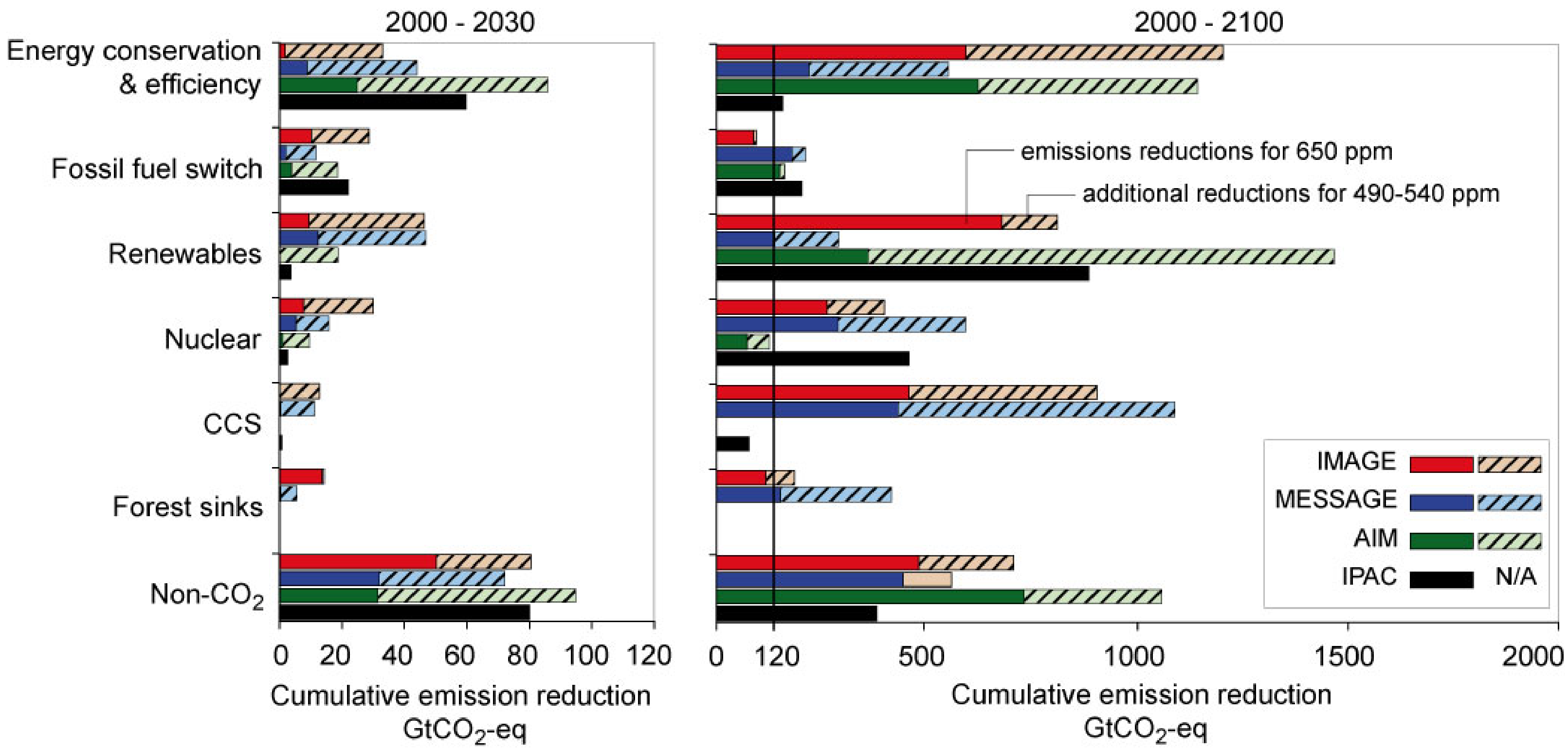
All sectors and regions have the potential to contribute by 2030



Note: estimates do not include non-technical options, such as lifestyle changes.

Role of Technology, following IPCC AR4

- **The range of stabilization levels can be achieved by**
  - **deployment of a portfolio of technologies that are currently available and**
  - **those that are expected to be commercialised in coming decades.**
- **This assumes that appropriate and effective incentives are in place for development, acquisition, deployment and diffusion of technologies and for addressing related barriers**



How can emissions be reduced?

Sector	(Selected) Key mitigation technologies and practices currently commercially available.
Energy Supply	efficiency; fuel switching; nuclear power; renewable (hydropower, solar, wind, geothermal and bioenergy); combined heat and power; early applications of CO2 Capture and Storage
Transport	More fuel efficient vehicles; hybrid vehicles; biofuels; modal shifts from road transport to rail and public transport systems; cycling, walking; land-use planning
Buildings	Efficient lighting; efficient appliances and airco; improved insulation ; solar heating and cooling; alternatives for fluorinated gases in insulation and aplliances

How can emissions be reduced?

Sector	**(Selected) Key mitigation technologies and practices currently commercially available.**
Industry	More efficient electrical equipment; heat and power recovery; material recycling; control of non-CO_2 gas emissions
Agriculture	Land management to increase soil carbon storage; restoration of degraded lands; improved rice cultivation techniques; improved nitrogen fertilizer application; dedicated energy crops
Forests	Afforestation; reforestation; forest management; reduced deforestation; use of forestry products for bioenergy
Waste	Landfill methane recovery; waste incineration with energy recovery; composting; recycling and waste minimization

Changes in lifestyle and behaviour patterns can contribute to climate change mitigation

- Changes in occupant behaviour, cultural patterns and consumer choice in buildings.
- Reduction of car usage and efficient driving style, in relation to urban planning and availability of public transport
- Staff training, reward systems, regular feedback and documentation of existing practices in industrial organizations

Stabilisation levels and equilibrium global mean temperatures

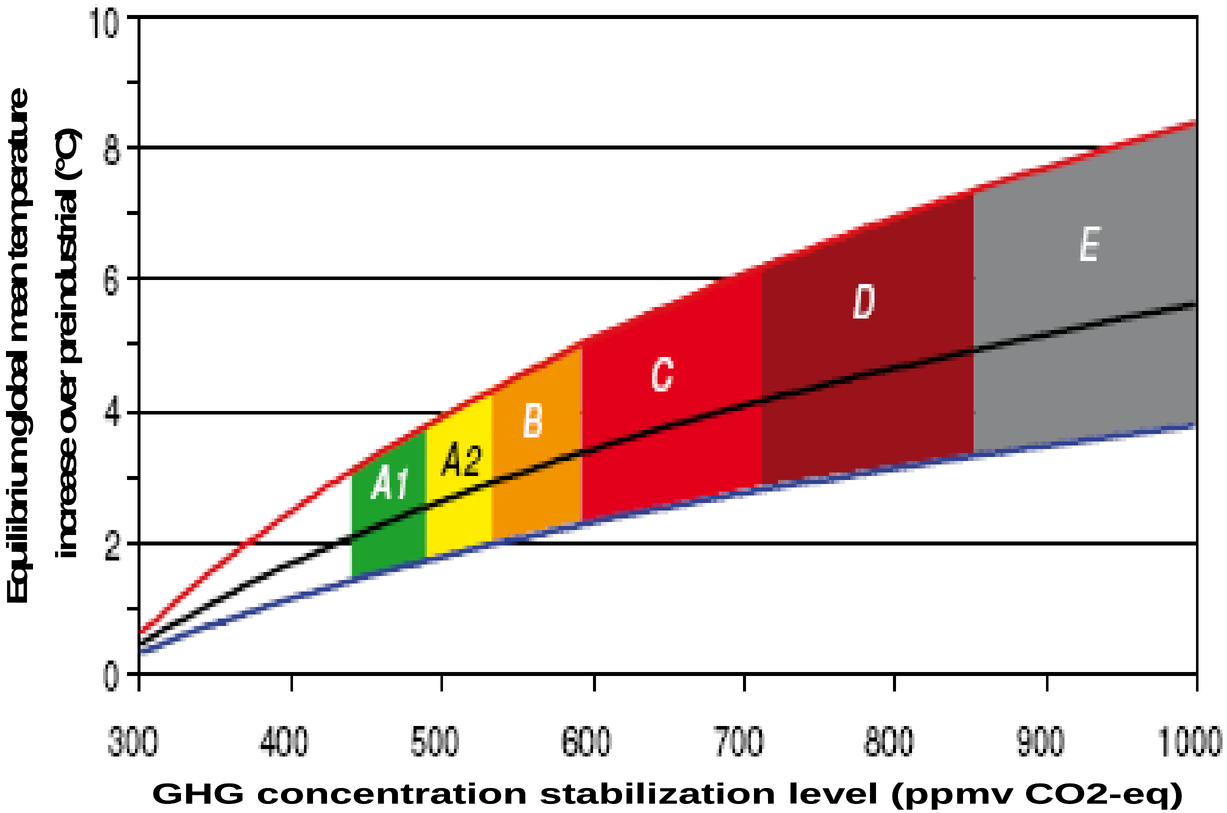


***Figure SPM 8**: Stabilization scenario categories as reported in Figure SPM.7 (coloured bands) and their relationship to equilibrium global mean temperature change above pre-industrial, using (i) "best estimate" climate sensitivity of 3℃ (black line in middle of shaded area), (ii) upper bound of likely range of climate sensitivity of 4.5℃ (red line at top of shaded area) (iii) lower bound of likely range of climate sensitivity of 2℃ (blue line at bottom of shaded area). Coloured shading shows the concentration bands for stabilization of greenhouse gases in the atmosphere corresponding to the stabilization scenario categories. The data are drawn from AR4 WGI, Chapter 10.8.*

Long term mitigation (after 2030)

- The lower the stabilization level, the more quickly emissions would need to peak and to decline thereafter
- Mitigation efforts over the next two to three decades will have a large impact on opportunities to achieve lower stabilization levels

Stab level (ppm CO2-eq)	Global Mean temp. increase at equilibrium (ºC)	Year CO2 needs to peak	Reduction in 2050 compared to 200
445 – 490	2.0 – 2.4	2000 - 2015	-85 to -50
490 – 535	2.4 – 2.8	2000 - 2020	-60 to -30
535 – 590	2.8 – 3.2	2010 - 2030	-30 to +5
590 – 710	3.2 – 4.0	2020 - 2060	+10 to +60
710 – 855	4.0 – 4.9	2050 - 2080	+25 to +85
855 – 1130	4.9 – 6.1	2060 - 2090	+90 to +140

Test yourself effect of different scenarios and uncertainties with the Java Climate Model:

- ⌘www.climate.be/JCM: interactive climate model developed by Dr. Ben Matthews (UCL) with support from Belgian Science Policy Office

What are the macro-economic costs in **2050**?

Stabilization levels (ppm CO_2-eq)	Median GDP reduction[1] (%)	Range of GDP reduction [2] (%)	Reduction of average annual GDP growth rates [3] (percentage points)
590-710	0.5	-1 – 2	< 0.05
535-590	1.3	Slightly negative - 4	<0.1
445-535[4]	Not available	< 5.5	< 0.12

[1] This is global GDP based market exchange rates.
[2] The median and the 10th and 90th percentile range of the analyzed data are given.
[3] The calculation of the reduction of the annual growth rate is based on the average reduction during the period till 2050 that would result in the indicated GDP decrease in 2050.
[4] The number of studies that report GDP results is relatively small and they generally use low baselines.

The importance of a "price of carbon"

- Policies that provide a real or implicit price of carbon could create incentives for producers and consumers to significantly invest in low-GHG products, technologies and processes.
- Such policies could include economic instruments, government funding and regulation
- For stabilisation at around 550 ppm CO2eq carbon prices should reach 20-80 US$/tCO2eq by 2030 (5-65 if "induced technological change" happens)
- At these carbon prices large shifts of investments into low carbon technologies can be expected

International agreements

- Notable achievements of the UNFCCC/Kyoto Protocol that may provide the foundation for future mitigation efforts:
  - global response to the climate problem,
  - stimulation of an array of national policies,
  - the creation of an international carbon market and
  - new institutional mechanisms
- Future agreements:
  - Greater cooperative efforts to reduce emissions will help to reduce global costs for achieving a given level of mitigation, or will improve environmental effectiveness
  - Improving, and expanding the scope of, market mechanisms (such as emission trading, Joint Implementation and CDM) could reduce overall mitigation costs

Bali action plan (december 2007)

- ***The Conference of the Parties,***
- ***(…) Responding*** **to the findings of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change that warming of the climate system is unequivocal, and that delay in reducing emissions significantly constrains opportunities to achieve lower stabilization levels and increases the risk of more severe climate change impacts,**
- ***Recognizing*** **that deep cuts in global emissions will be required to achieve the ultimate objective of the Convention and emphasizing the urgency (NOTE 1) to address climate change as indicated in the Fourth Assessment Report of the IPCC,**
- **1. *Decides* to launch a comprehensive process to enable the full, effective and sustained implementation of the Convention through long-term cooperative action, now, up to and beyond 2012, in order to reach an agreed outcome and adopt a decision at its fifteenth session, by addressing, inter alia: …**
- **Note 1: Contribution of Working Group III to the Fourth Assessment Report of the IPCC, Technical Summary, pages 39 and 90, and Chapter 13, page 776.**

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Contribution of Working Group III to the Fourth Assessment Report of the IPCC,

- **Technical Summary, page 39:**

Table TS.2: *Classification of recent (Post-Third Assessment Report) stabilization scenarios according to different stabilization targets and alternative stabilization metrics [Table 3.5].*

Category	Additional radiative forcing (W/m^2)	CO_2 concentration (ppm)	CO_2-eq concentration (ppm)	Global mean temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity[a], [b] (°C)	Peaking year for CO_2 emissions[c]	Change in global CO_2 emissions in 2050 (% of 2000 emissions)[c]	No. of assessed scenarios
I	2.5-3.0	350-400	445-490	2.0-2.4	2000 - 2015	-85 to -50	6
II	3.0-3.5	400-440	490-535	2.4-2.8	2000 - 2020	-60 to -30	18
III	3.5-4.0	440-485	535-590	2.8-3.2	2010 - 2030	-30 to +5	21
IV	4.0-5.0	485-570	590-710	3.2-4.0	2020 - 2060	+10 to +60	118
V	5.0-6.0	570-660	710-855	4.0-4.9	2050 - 2080	+25 to +85	9
VI	6.0-7.5	660-790	855-1130	4.9-6.1	2060 - 2090	+90 to +140	5
						Total	177

Notes:

a) Note that global mean temperature at equilibrium is different from expected global mean temperatures in 2100 due to the inertia of the climate system.

b) The simple relationships $T_{eq} = T_{2\times CO2} \times \ln([CO_2]/278)/\ln(2)$ and $\Delta Q = 5.35 \times \ln([CO_2]/278)$ are used. Non-linearities in the feedbacks (including e.g., ice cover and carbon cycle) may cause time dependence of the effective climate sensitivity, as well as leading to larger uncertainties for greater warming levels. The best-estimate climate sensitivity (3 °C) refers to the most likely value, that is, the mode of the climate sensitivity PDF consistent with the WGI assessment of climate sensitivity and drawn from additional consideration of Box 10.2, Figure 2, in the WGI AR4.

c) Ranges correspond to the 15th to 85th percentile of the Post-Third Assessment Report (TAR) scenario distribution. CO_2emissions are shown, so multi-gas scenarios can be compared with CO_2-only scenarios.

Note that the classification needs to be used with care. Each category includes a range of studies going from the upper to the lower boundary. The classification of studies was done on the basis of the reported targets (thus including modelling uncertainties). In addition, the relationship that was used to relate different stabilization metrics is also subject to uncertainty (see Figure 3.16).

Contribution of Working Group III to the Fourth Assessment Report of the IPCC,

- **Technical Summary, page 39**

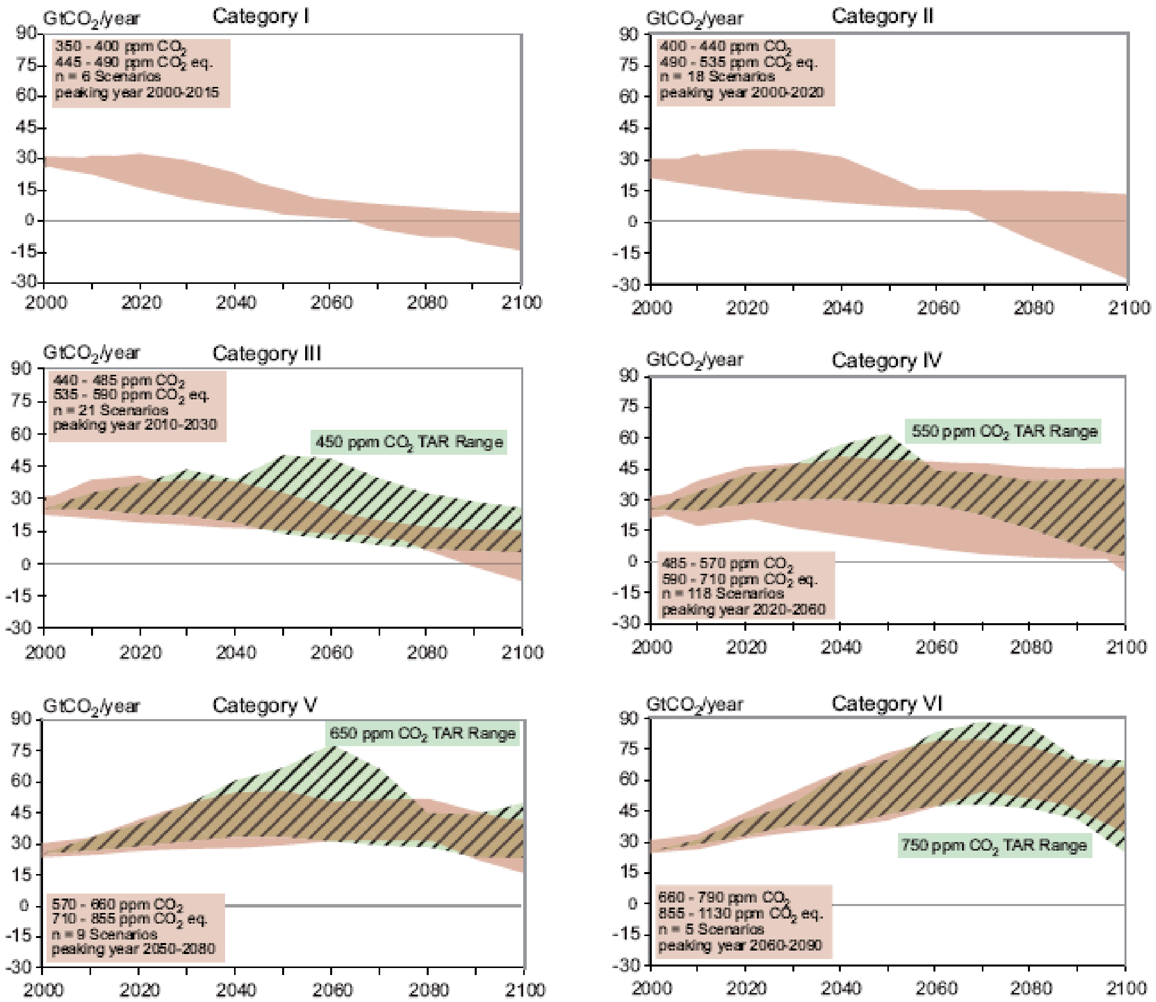

Figure TS.8: *Emission pathways of mitigation scenarios for alternative categories of stabilization targets (Category I to VI as defined in the box in each panel). Lightbrown shaded areas give the CO_2 emissions for the recent mitigation scenarios developed post-TAR. Green shaded and hatched areas depict the range of more than 80 TAR stabilization scenarios (Morita et al., 2001). Category I and II scenarios explore stabilization targets below the lowest of TAR. Base year emissions may differ between models due to differences in sector and industry coverage. To reach the lower stabilization levels some scenarios deploy removal of CO_2 from the atmosphere (negative emissions) using technologies such as biomass energy production utilizing carbon capture and storage [Figure 3.17].*

Contribution of Working Group III to the Fourth Assessment Report of the IPCC,

- **Technical Summary, pages 90:**

Regime stringency: linking goals, participation and timing

Under most equity interpretations, developed countries as a group would need to reduce their emissions significantly by 2020 (10–40% below 1990 levels) and to still lower levels by 2050 (40–95% below 1990 levels) for low to medium stabilization levels (450–550ppm CO_2-eq) (see also Chapter 3). Under most of the regime designs considered for such stabilization levels, developing-country emissions need to deviate below their projected baseline emissions within the next few decades (*high agreement, much evidence*). For most countries, the choice of the long-term ambition level will be more important than the design of the emission-reduction regime [13.3].

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Contribution of Working Group III to the Fourth Assessment Report of the IPCC,

- **Chapter 13, page 776:**

Box 13.7 The range of the difference between emissions in 1990 and emission allowances in 2020/2050 for various GHG concentration levels for Annex I and non-Annex I countries as a group[a]

Scenario category	Region	2020	2050
A-450 ppm CO_2-eq[b]	Annex I	–25% to –40%	–80% to –95%
	Non-Annex I	Substantial deviation from baseline in Latin America, Middle East, East Asia and Centrally-Planned Asia	Substantial deviation from baseline in all regions
B-550 ppm CO_2-eq	Annex I	-10% to -30%	-40% to -90%
	Non-Annex I	Deviation from baseline in Latin America and Middle East, East Asia	Deviation from baseline in most regions, especially in Latin America and Middle East
C-650 ppm CO_2-eq	Annex I	0% to -25%	-30% to -80%
	Non-Annex I	Baseline	Deviation from baseline in Latin America and Middle East, East Asia

Notes:

[a] The aggregate range is based on multiple approaches to apportion emissions between regions (contraction and convergence, multistage, Triptych and intensity targets, among others). Each approach makes different assumptions about the pathway, specific national efforts and other variables. Additional extreme cases – in which Annex I undertakes all reductions, or non-Annex I undertakes all reductions – are not included. The ranges presented here do not imply political feasibility, nor do the results reflect cost variances.

[b] Only the studies aiming at stabilization at 450 ppm CO_2-eq assume a (temporary) overshoot of about 50 ppm (See Den Elzen and Meinshausen, 2006).

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My main «certainties »

- Anthropogenic greenhouse gases will continue to warm the climate unless deep emission reductions are made
- Even with the « optimistic » models, the projected warming has no equivalent for at least 10000 years
- The system inertia is huge (carbon cycle, sea level rise, energy system)
- Stabilising clmate requires deep, global reductions

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Some WGI key uncertainties after IPCC TAR (third assessment report)

- Cloud microphysics
- Radiative effects of aerosols
- Biosphere-atmosphere interactions
- Stability of ice sheets
- Oceanic circulation stability
- Distribution of rainfall
- Frequency & intensity of extreme events

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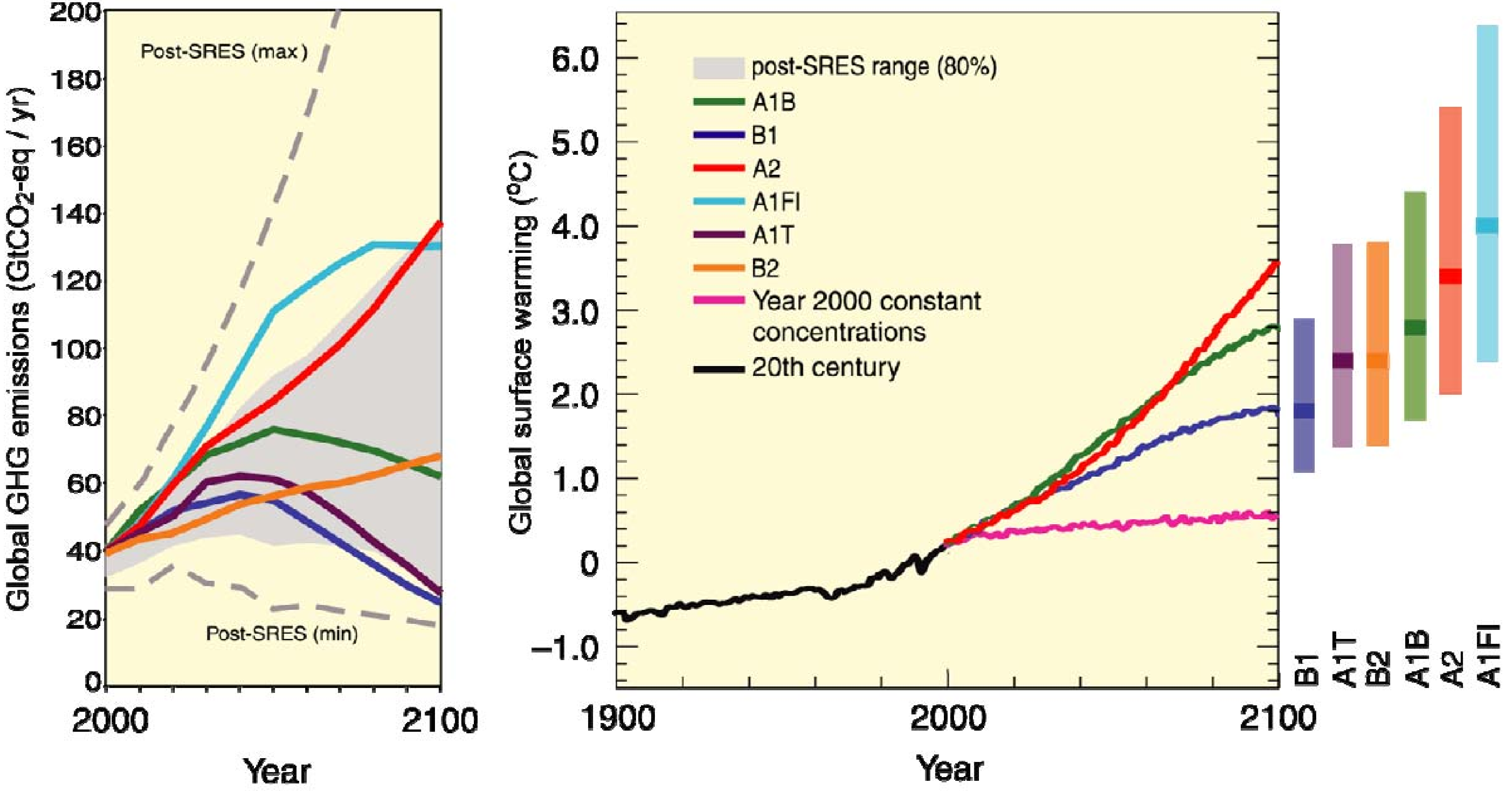
Source: IPCC, AR4

Projections du climat futur en l'absence de mesures



Projected globally averaged surface warming and sea level rise at the end of the 21st century (IPCC WG1 AR4)

	Temperature Change (°C at 2090-2099 relative to 1980-1999) [a]		Sea Level Rise (m at 2090-2099 relative to 1980-1999)
Case	Best estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations [c]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
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NB: add 0.5°C to get pre-industrial reference

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Observed changes in climate and their effects, and their causes: key uncertainties (IPCC AR4 SYR)

- **Climate data coverage remains limited in some regions and there is a notable *lack of geographic balance in data and literature on observed changes* in natural and managed systems, with marked scarcity in developing countries.**

- **Effects of climate changes on human and some natural systems are difficult to detect due to *adaptation and non-climatic drivers*.**

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Observed changes in climate and their effects, and their causes: key uncertainties (IPCC AR4 SYR)

- ***Analysing and monitoring extremes*** **including drought, tropical cyclones, extreme temperatures, and the frequency and intensity of** ***precipitation*** **is more difficult than for climatic averages as it requires longer data time-series of higher spatial and temporal resolution.**

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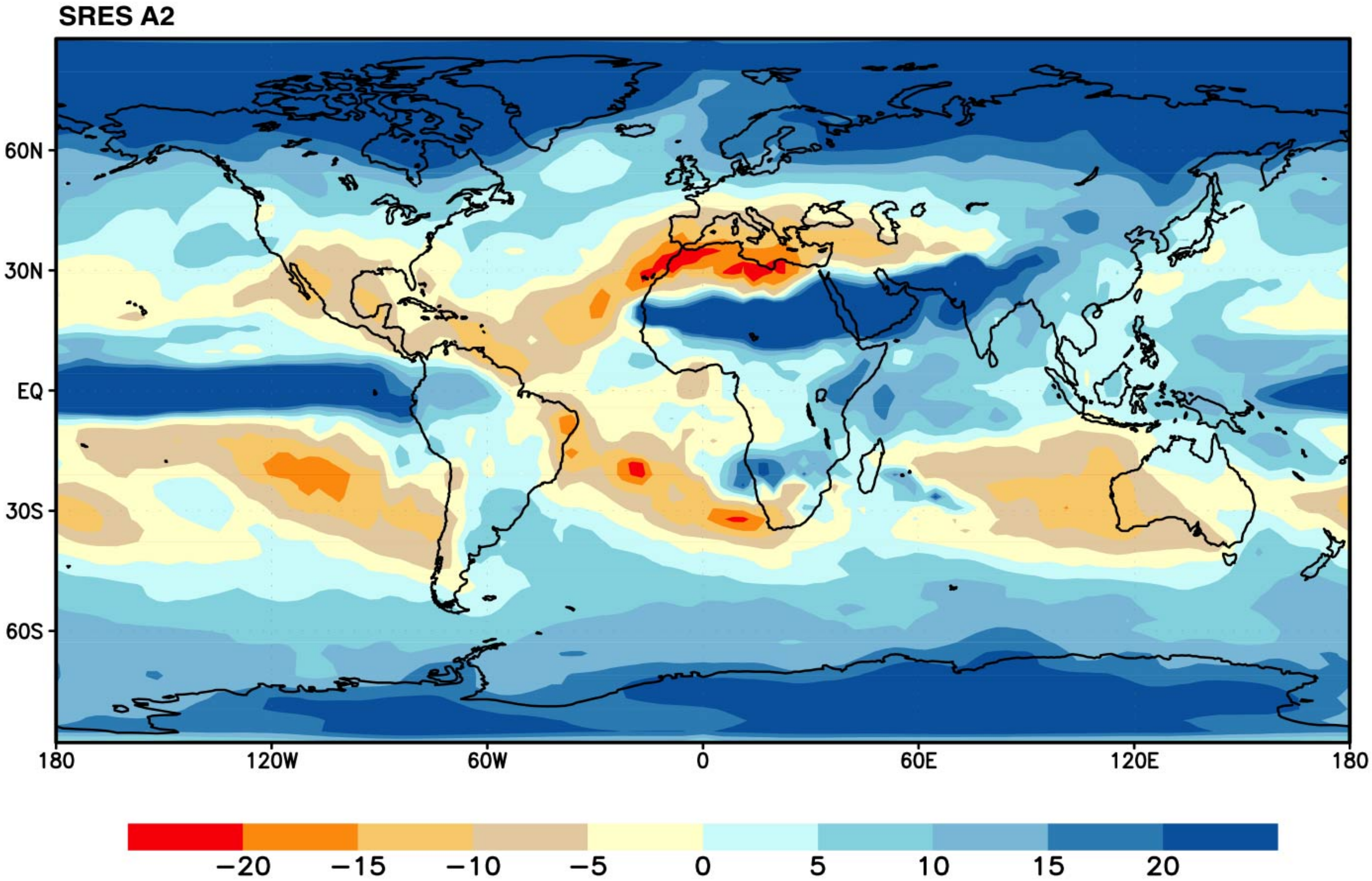
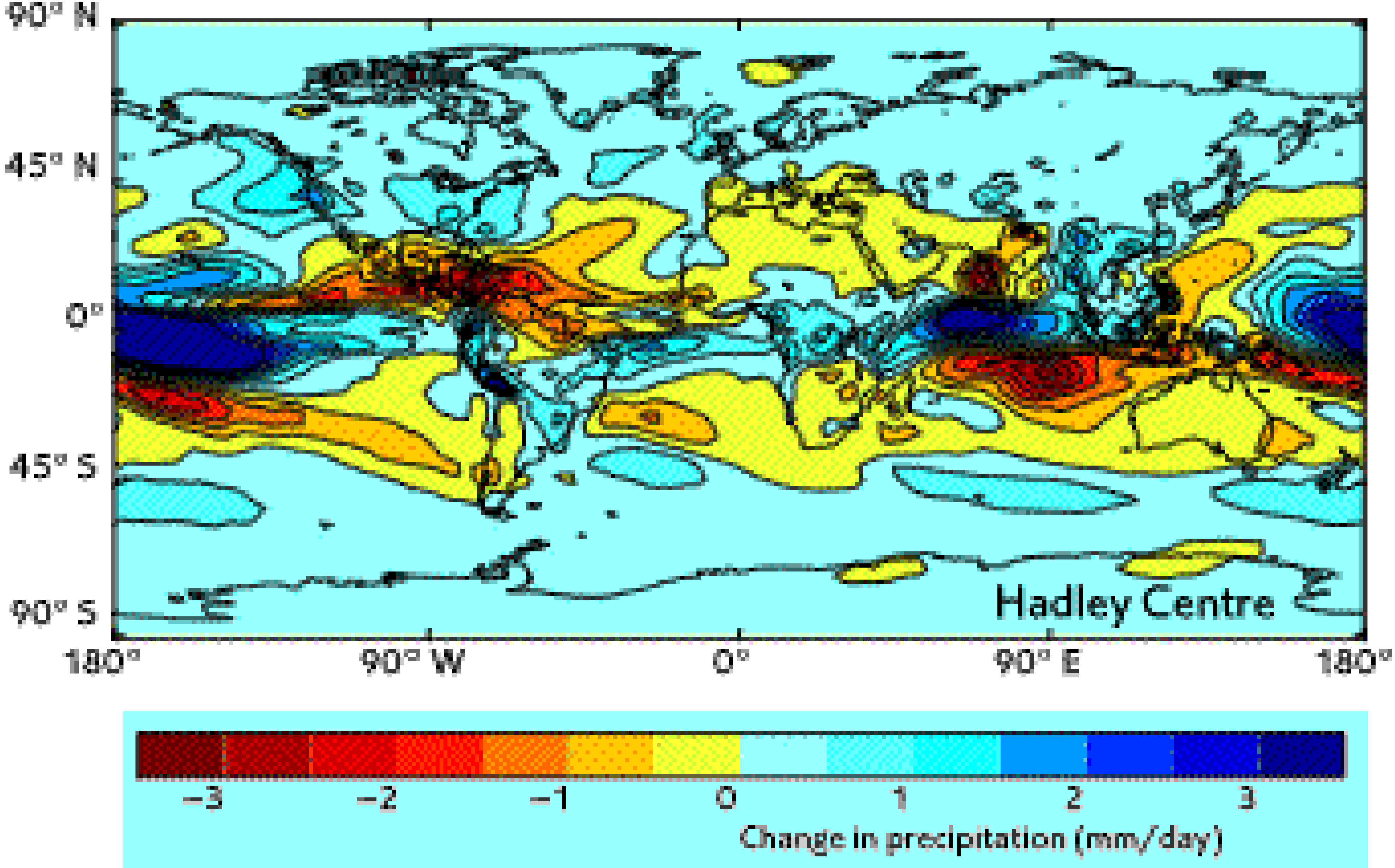
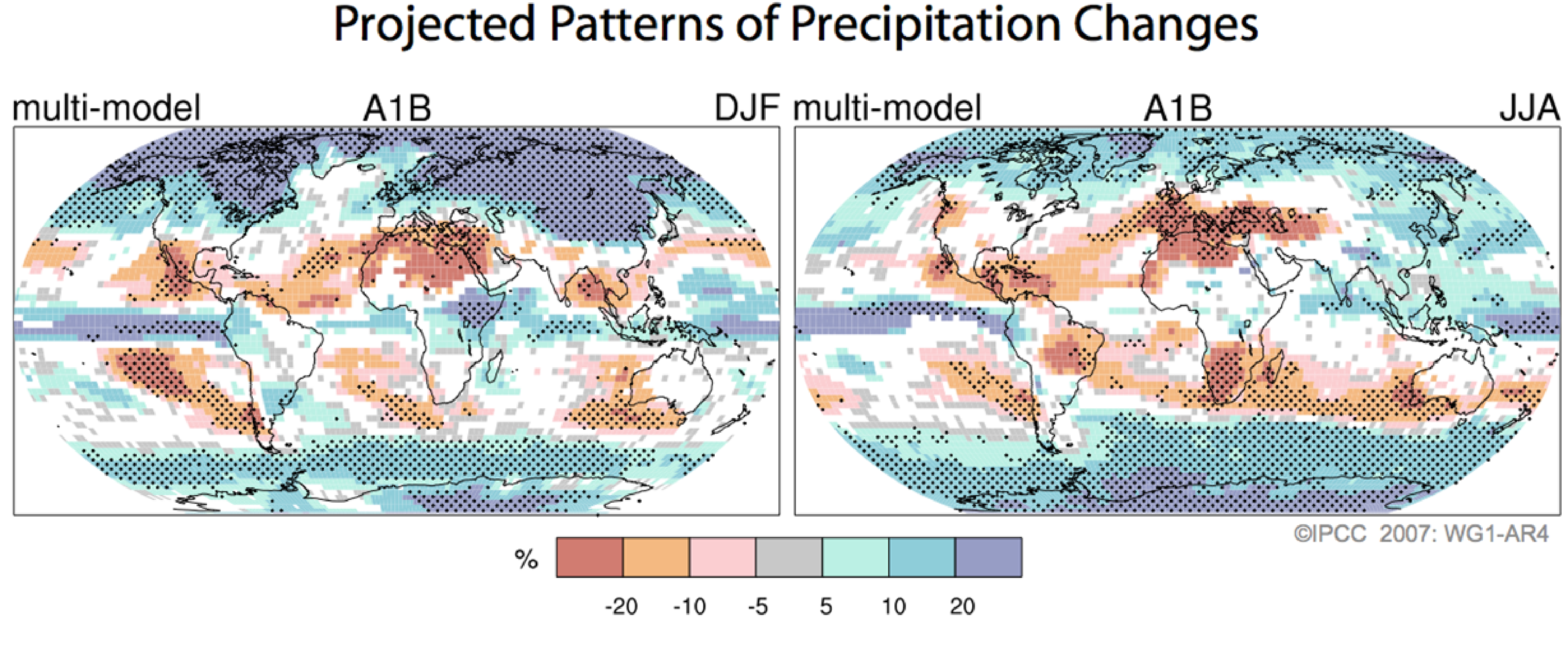
Precipitation changes in 2080:
results from one climate model for scenario A2



Precipitation changes in 2080: results from another climate model for similar scenario



Projections of Future Changes in Climate



Changes are plotted only where more than 66% of the models agree on the sign of the change. The stippling indicates areas where more than 90% of the models agree on the sign of the change.

Brand new in AR4: Drying in much of the subtropics, more rain in higher latitudes, continuing the broad pattern of rainfall changes already observed.

Observed changes in climate and their effects, and their causes: key uncertainties (IPCC AR4 SYR)

- **Difficulties remain in reliably *simulating and attributing observed temperature changes* to natural or human causes *at smaller than continental scales*. At these smaller scales, factors such as land-use change and pollution also complicate the detection of anthropogenic warming influence on physical and biological systems.**

- **The magnitude of *CO2 emissions from land-use* change and from individual *methane* sources remain as key uncertainties.**

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Drivers and projections of future climate changes and their impacts: key uncertainties (IPCC AR4 SYR)

- **Uncertainty in *equilibrium climate sensitivity* creates uncertainty in the expected warming for a given CO2-eq stabilisation scenario. Uncertainty in the *carbon cycle feedback* creates uncertainty in the emission trajectory required to achieve a particular stabilisation level.**

- ***Aerosol impacts* on the magnitude of the temperature response, *clouds and precipitation* remain uncertain.**

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- **Models differ considerably in their estimates of the strength of different feedbacks in the climate system, particularly *cloud feedbacks, oceanic heat uptake, and carbon cycle feedbacks*, although progress has been made in these areas. Also, the confidence in projections is higher for some variables (e.g. temperature) than for others (e.g. precipitation), and is higher for larger spatial scales and longer time averaging periods.**

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Drivers and projections of future climate changes and their impacts: key uncertainties (IPCC AR4 SYR)

- **Future changes in the *Greenland and Antarctic ice sheet* mass, particularly due to changes in ice flow, are a major source of uncertainty that *could increase sea level rise* projections. The uncertainty in the penetration of the heat into the oceans also contributes to the future sea level rise uncertainty.**

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Drivers and projections of future climate changes and their impacts: key uncertainties (IPCC AR4 SYR)

- ***Large scale ocean circulation changes*** **beyond the 21st century cannot be reliably assessed because of uncertainties in the meltwater supply from Greenland ice sheet and model response to the warming.**

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Drivers and projections of future climate changes and their impacts: key uncertainties (IPCC AR4 SYR)

⌘ **Projections of climate change and its impacts beyond about 2050 are strongly scenario- and model-dependent, and improved projections would require improved understanding of sources of uncertainty and enhancements in systematic observation networks.**

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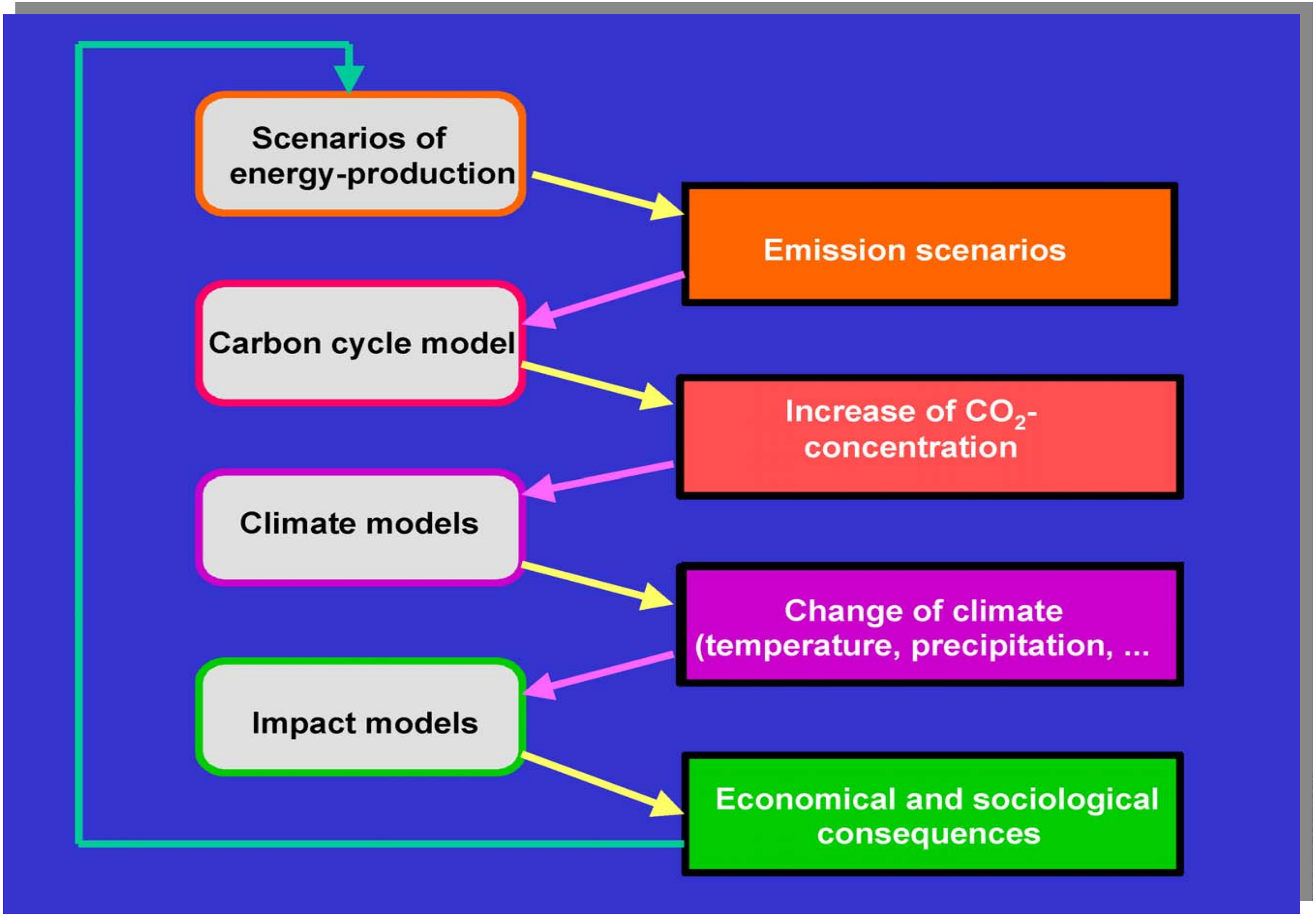
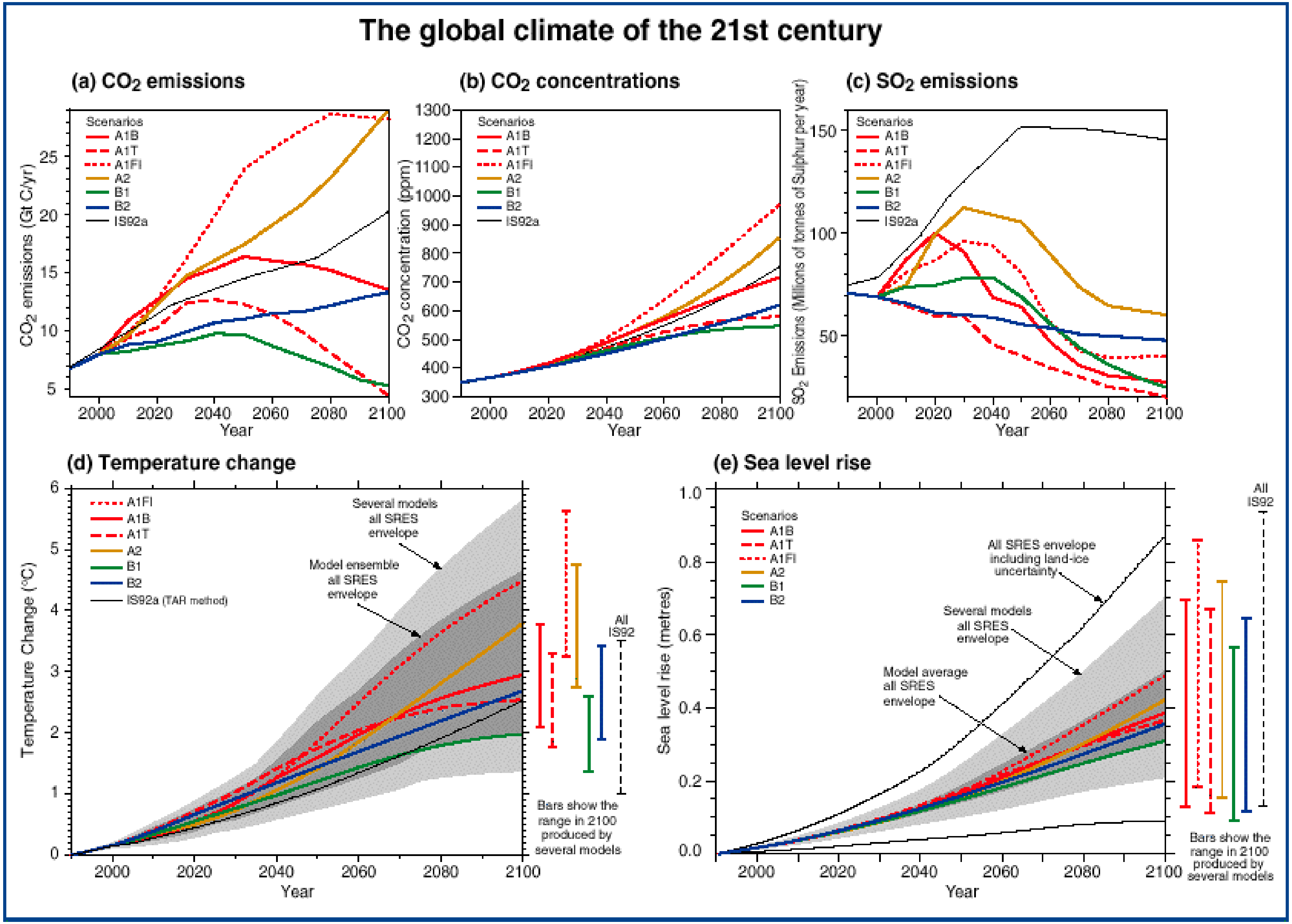
Source: Hadley Centre

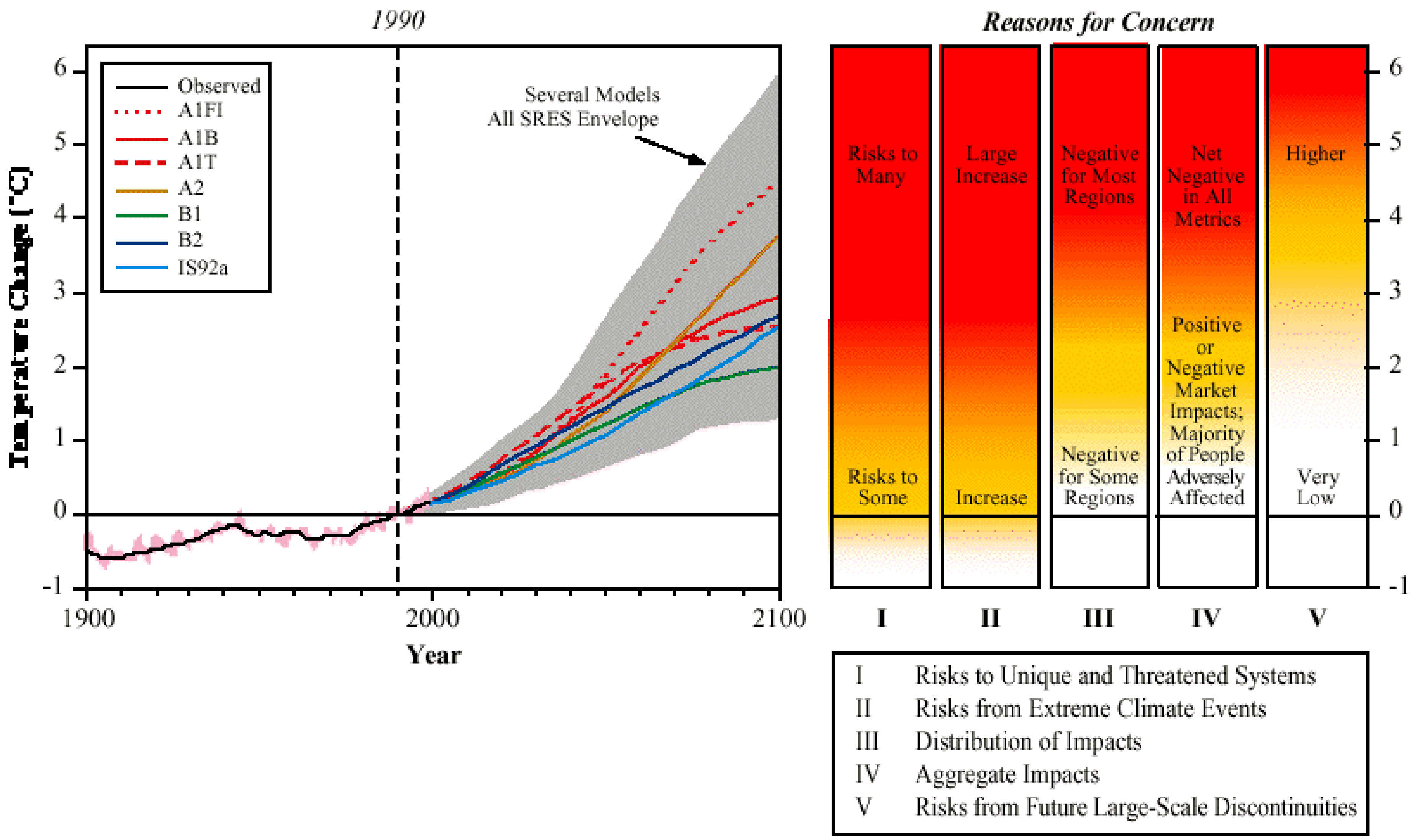


The information chain leading to a climate projection



NB: Temperature and sea-level curves are from IPCC AR3 (2001)

IPCC 2001 « reasons for concern »:



Drivers and projections of future climate changes and their impacts: key uncertainties

- **Impacts research is hampered by uncertainties surrounding *regional projections of climate change, particularly precipitation*.**
- **Understanding of *low-probability/high-impact events*, and the cumulative impacts of *sequences of smaller events* which is required for risk-based approaches to decision-making, is generally limited.**

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Responses to climate change: key uncertainties

- **Understanding of *how development planners incorporate information about climate variability and change into their decisions* is limited. This limits the integrated assessment of vulnerability.**

- **The evolution and utilisation of adaptive and mitigative capacity depend on underlying long-term socio-economic development pathway**

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Responses to climate change: key uncertainties

- ***Barriers, limits and costs of adaptation are not fully understood*, partly because effective adaptation measures are highly dependent on specific geographical and climate risk factors as well as institutional, political and financial constraints.**

Responses to climate change: key uncertainties

- **Estimates of mitigation costs and potentials depend on assumptions about future socio-economic growth, technological change and consumption patterns. Uncertainty arises in particular from assumptions regarding the *drivers of technology diffusion and the potential of long-term technology performance and cost improvements*.**

- **The *effects of non-climate policies on emissions* are poorly quantified.**

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Responses to climate change: key uncertainties

- **Little is known about the effect of *changes in behaviour and lifestyles***

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My key messages on top of those of IPCC

- The challenge is still underestimated by policy-makers
- WG1-related: keep & expand; to believe that since we now know enough to act, there is no more need for physical climatology research would big MISTAKE
- WG2-related: needs some help to structure; feed better adaptation work
- WG3-related: wider participation of economists & social scientists is needed; Work on feasibility and costs of low scenarios is essential
- All 3 scientific communities (WG1, 2 & 3) need to improve interdisciplinary collaboration

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Final remark

- **There is a need to improve the science policy-interface. This could also be the subject of some research (social science/policy)**

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John Holdren, President of the American Association for the Advancement of Science

- ***'We basically have three choices – mitigation, adaptation, and suffering.***
- ***We're going to do some of each. The question is what the mix is going to be.***
- ***The more mitigation we do, the less adaptation will be required, and the less suffering there will be.'***

Useful links:

- www.ipcc.ch : IPCC
- www.unfccc.int : Climate Convention
- www.climate.be/impacts: report on impacts for Belgium
- www.climate.be/JCM: interactive climate model, freely available, (developed at UCL with support of Belgian Science Policy Office)
- www.climate.be/vanyp: some presentations

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