The projected effects of climate change in Europe

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Conference “Climate change – can soil make a difference?”, CEC, Brussels, 12-6-2008

Outline

- **How does IPCC work?**
- **What does IPCC tell us climate change (World & Europe)?**
  - **IPCC Group 1: climatology**
  - **IPCC Group 2: impacts, vulnerability, & adaptation**
  - **IPCC Group 3: mitigation**

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How does IPCC work?

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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
- **Nobel Peace Prize 2007**
- **Web : http://www.ipcc.ch**

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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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What does IPCC tell us about climate science?

- **WG1: climatology**

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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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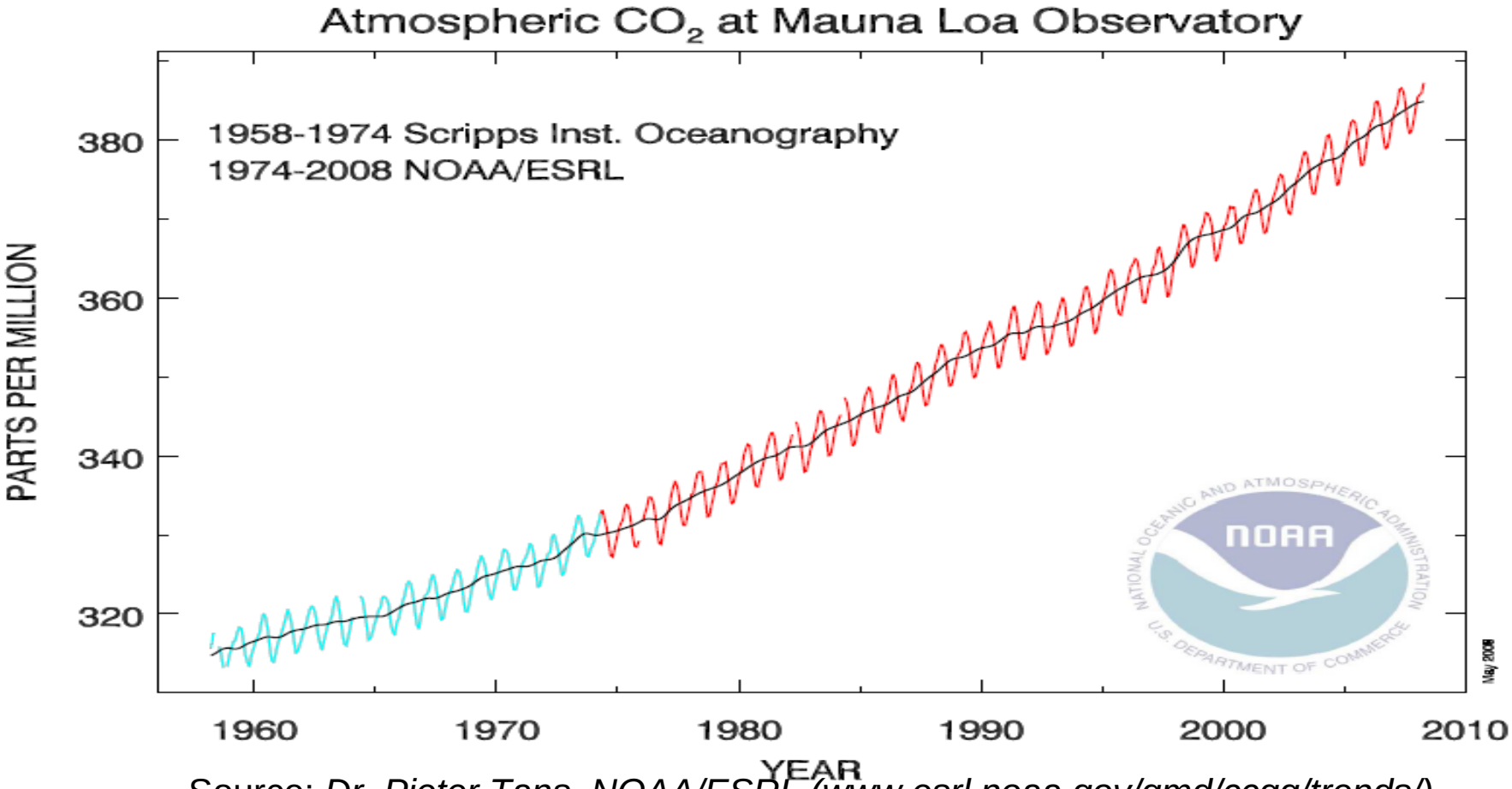
CO_2 concentration measured at Mauna Loa (3400 m)



Source: *Dr. Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/)*

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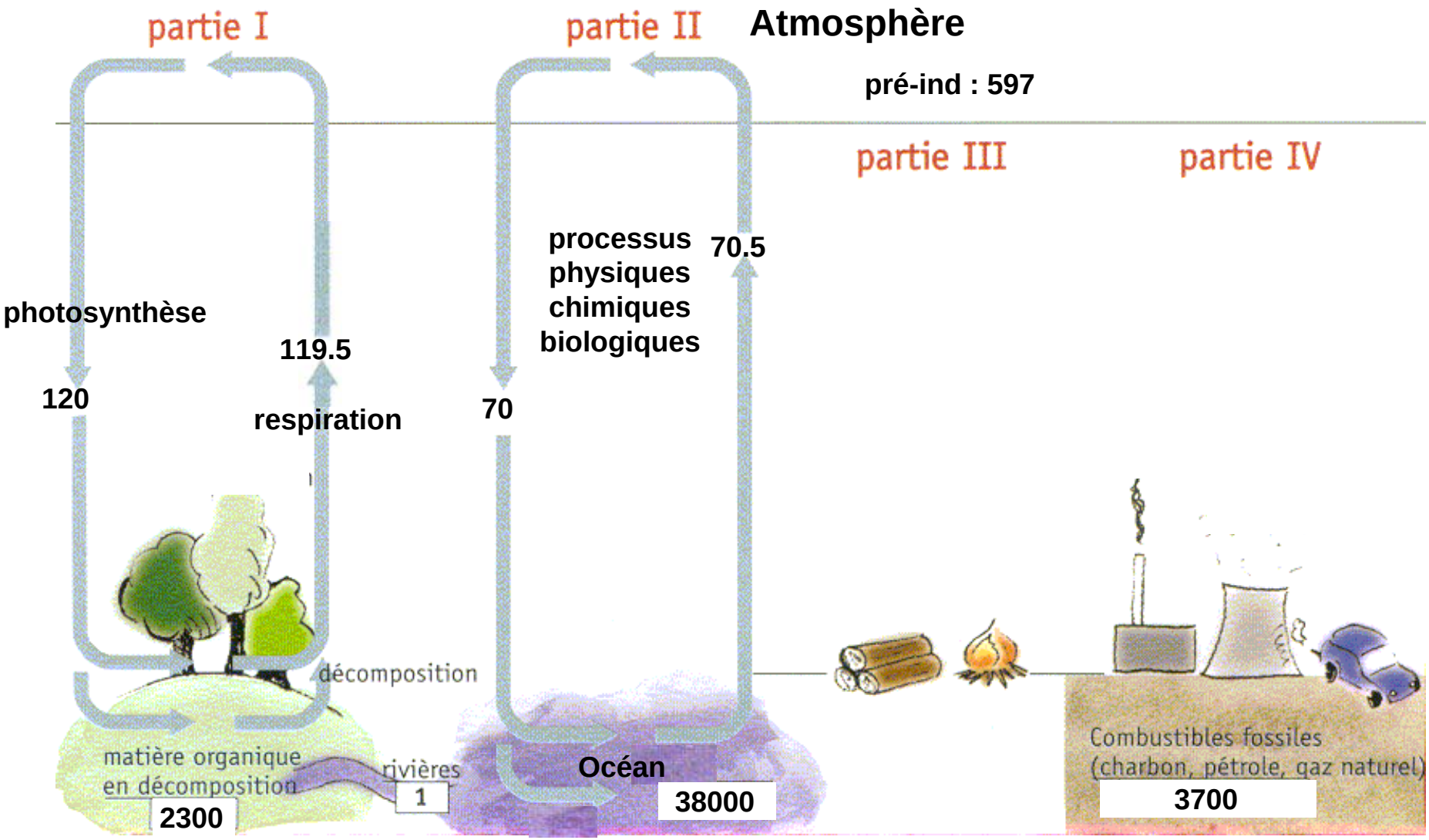
Cycle du carbone



Unités: GtC (milliards de tonnes de carbone) ou GtC/an

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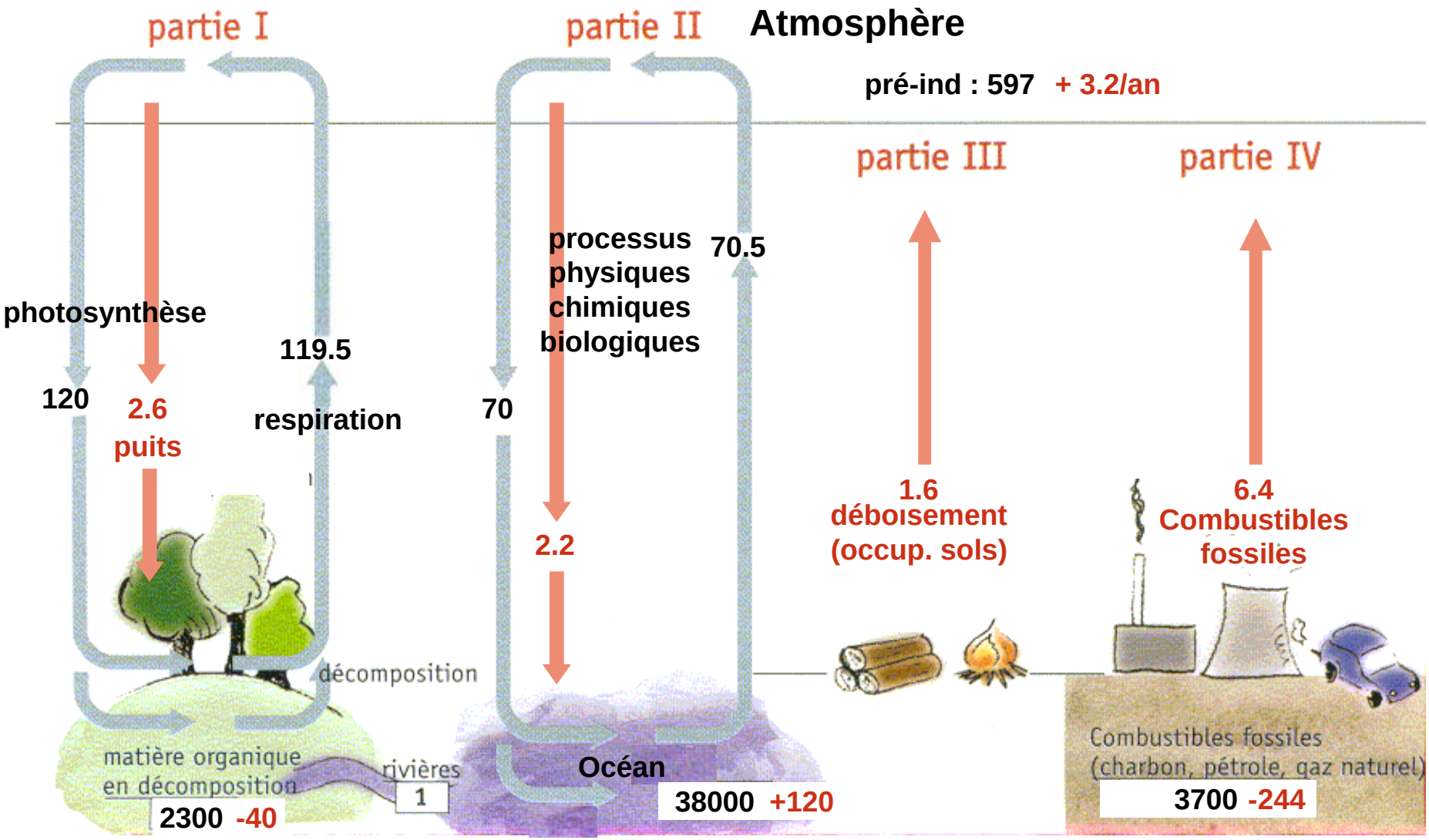
Cycle du carbone



Unités: GtC (milliards de tonnes de carbone) ou GtC/an

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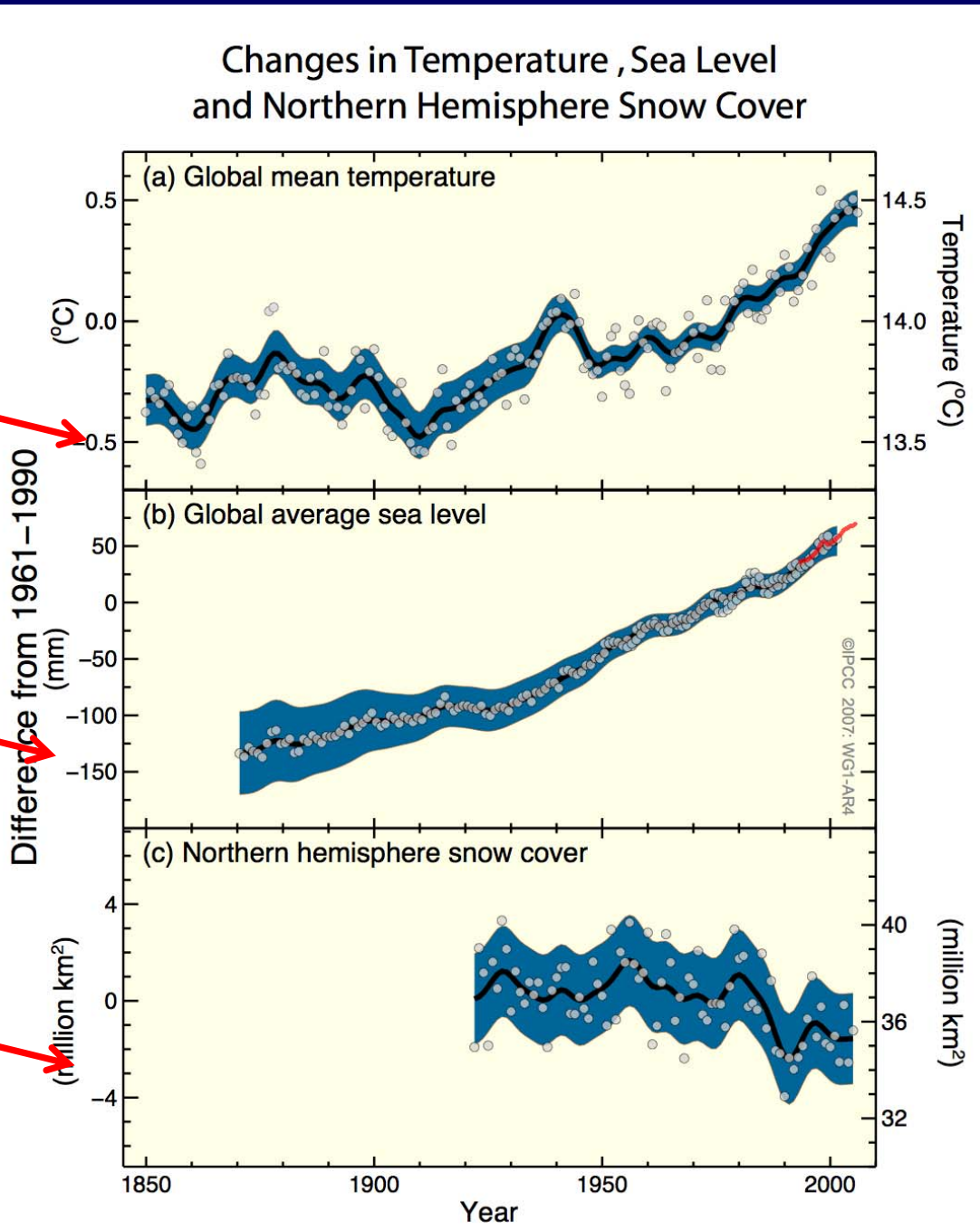
Warming is Unequivocal

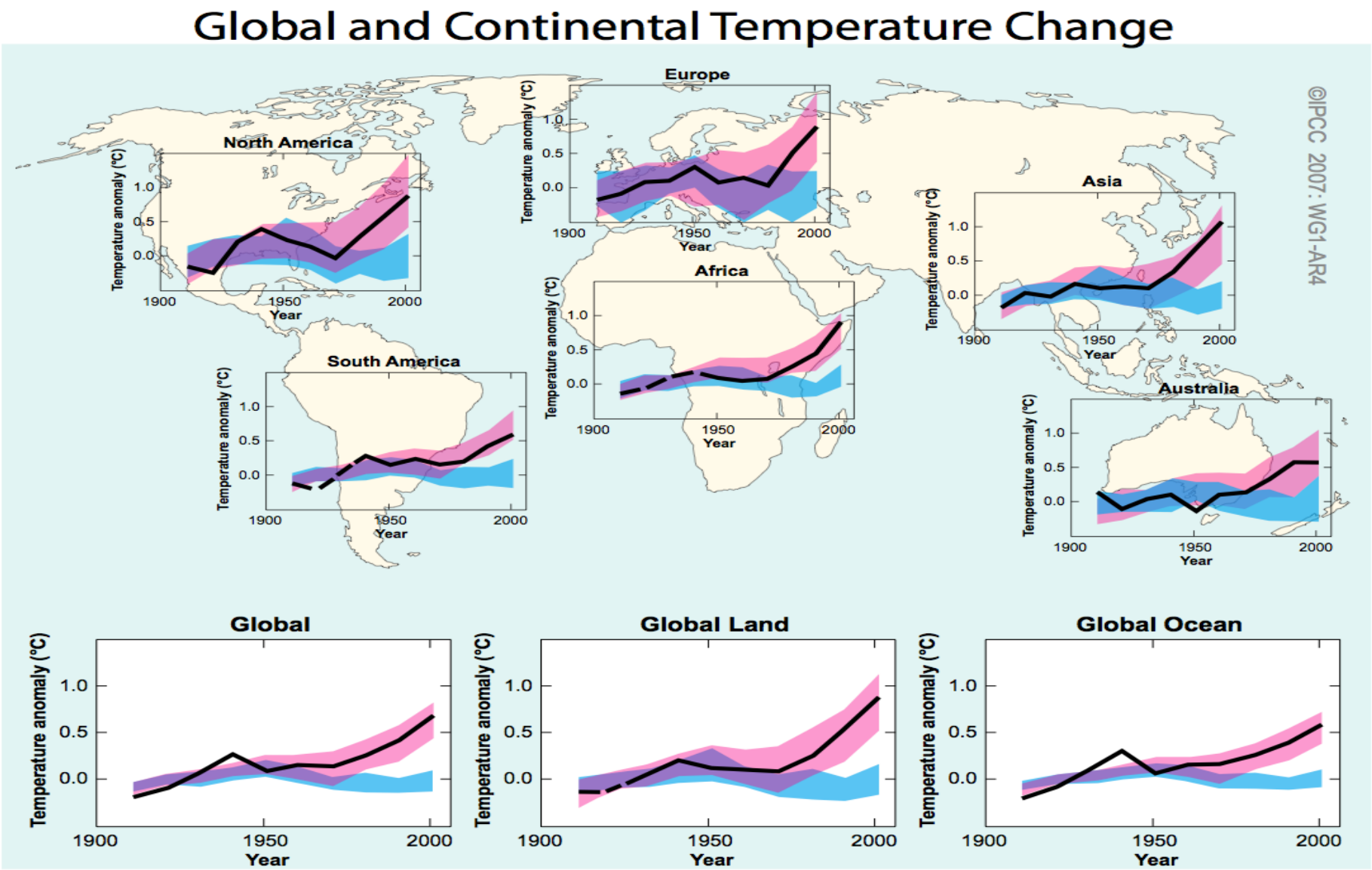
Rising atmospheric temperature

Rising sea level

Reductions in NH snow cover

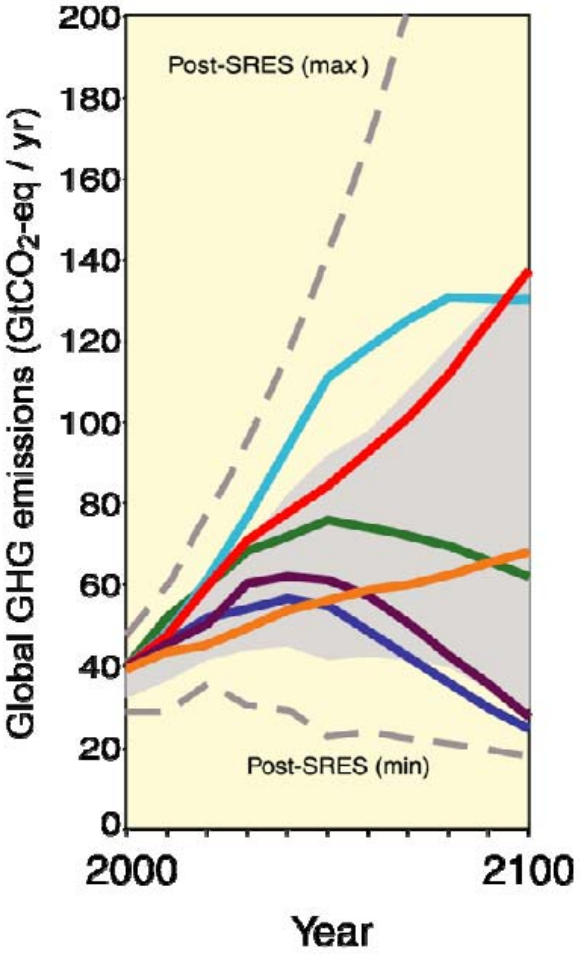


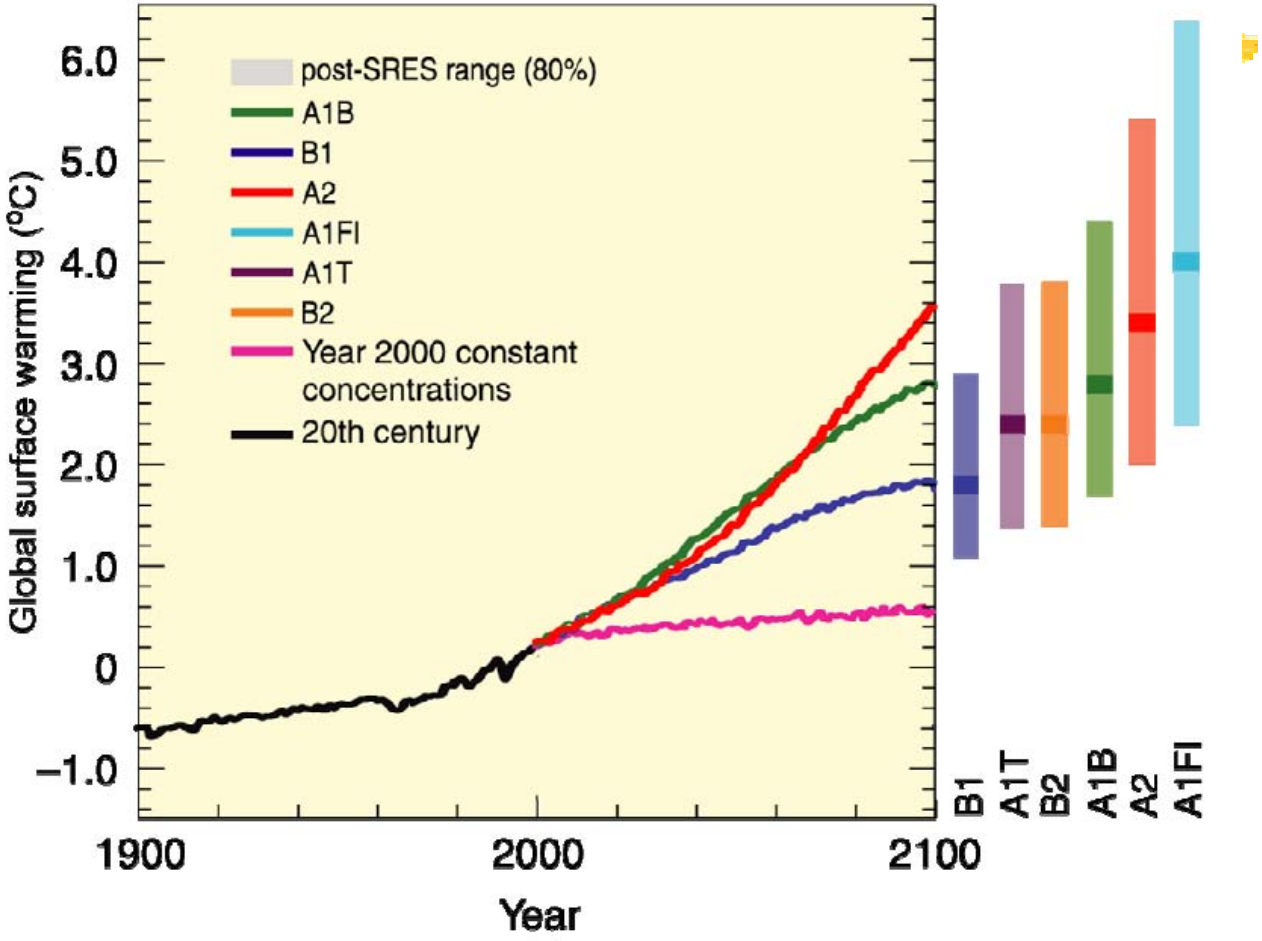
Understanding and Attributing Climate Change



Source: IPCC, AR4 (2007)

Climate projections without mitigation





NB: écart par rapport à la moyenne 1980-1999

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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 [b]	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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A personal word of caution on the « Best estimate » range [+1.8 to 4°C]

- **The « likely » range spans 1.1 to 6.4°C (for 2095 / / 1990)**
- **Add 0.5°C if ref=pre-industrial:**
  - **Best estimates: +2.3 to 4.5°C**
  - **Likely range: 1.6 to 6.9°C**

- **These global values translate into higher values over continents (~+0.2-0.4°C) ➔ Likely range: 1.8 to 7.3°C**

- **Seasonal effects (Prudence):**
  - **N. Europe: larger warming in winter than in summer**
  - **S. and Central Europe: larger warming in summer than in winter**

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A personal word of caution on the « Best estimate » range [+1.8 to 4°C]

- **« Likely » means over 66% assessed likelihood. You still have a 34% likelihood of being out of the range. A first guess is 17% probability of being above 7.3°C (annual value), and still higher seasonally.**

- **Using the « best estimates » values is misleading for policy purposes!!**

- **Good news: all this is *without* specific climate mitigation**

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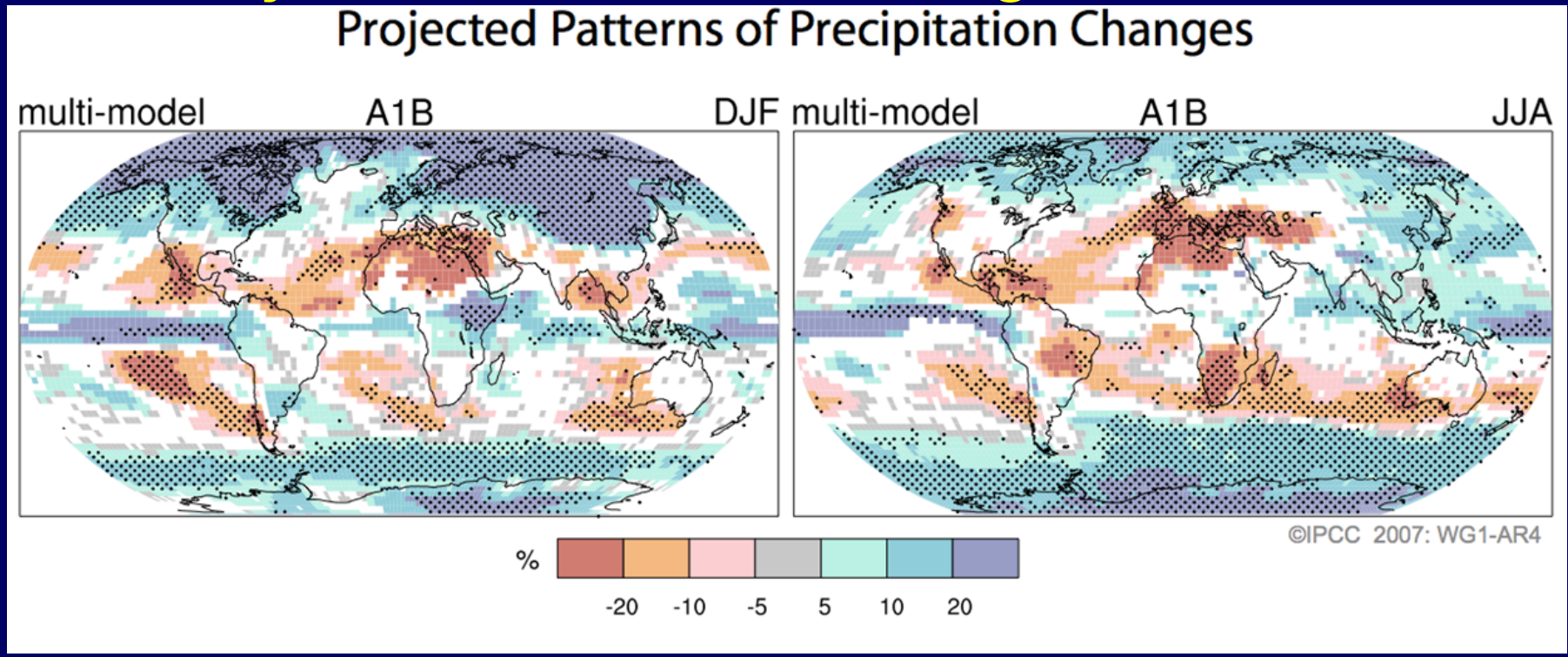
Projections of Future Changes in Climate



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.

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.

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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What does IPCC tell us about impacts and adaptation?

- **WG2: 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

WMO

UNEP

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

WMO

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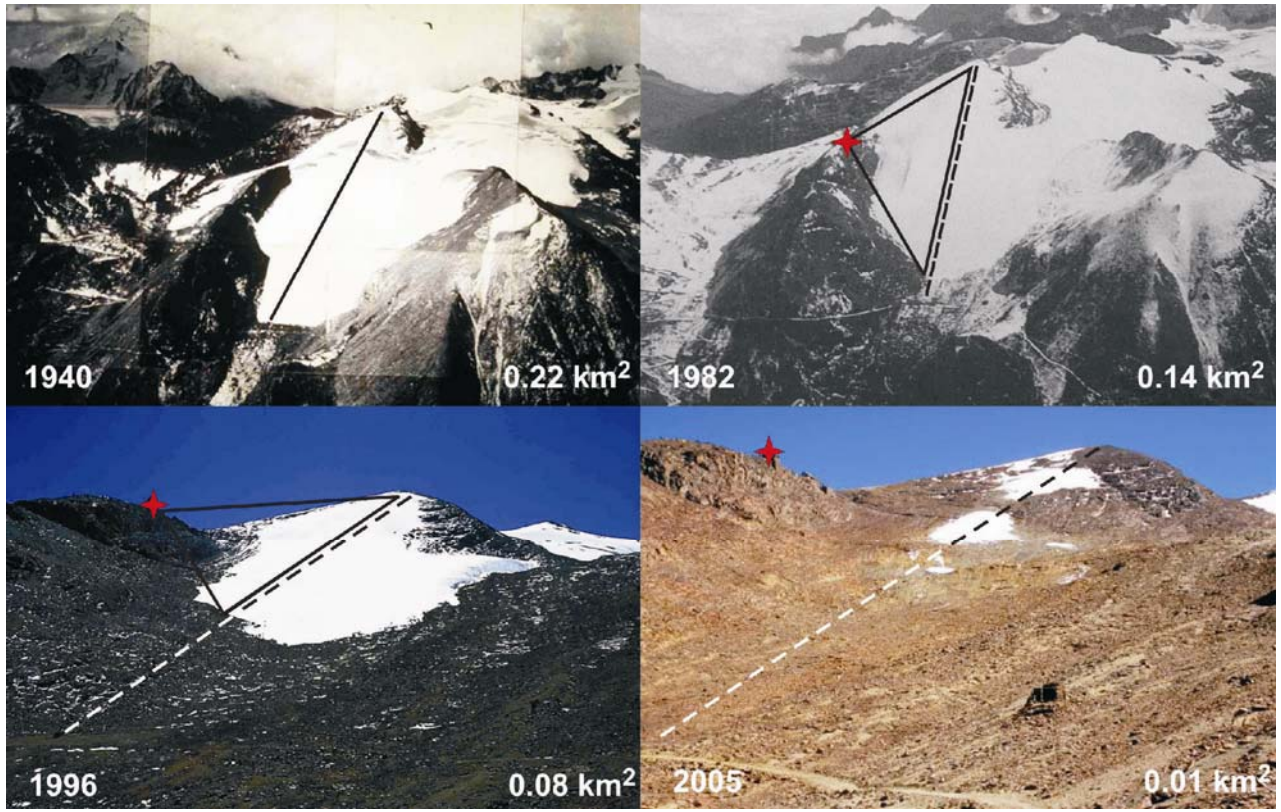
The Chacaltaya glacier and ski-lift, Bolivia

Skiing was no longer possible after 2004



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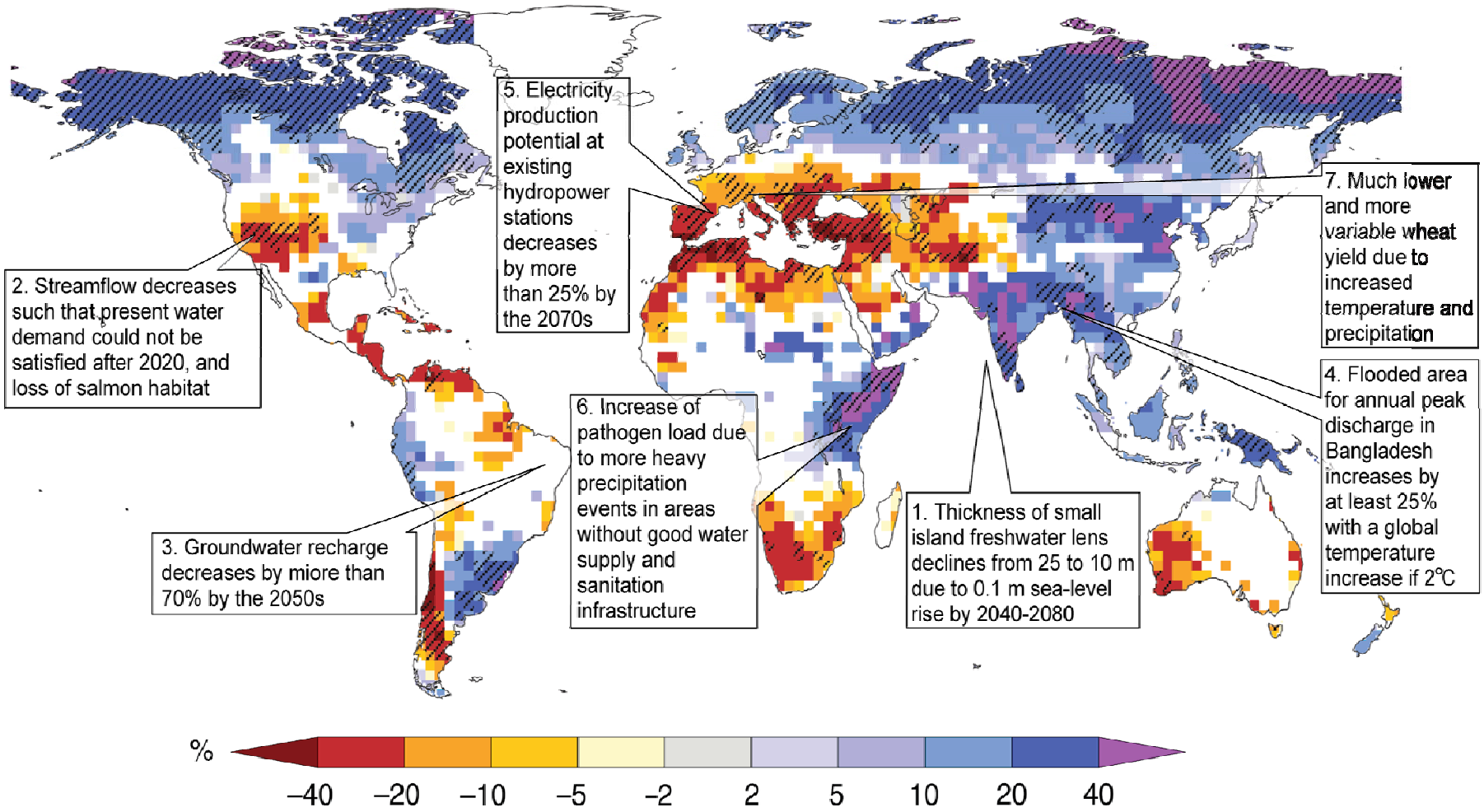
Water at the end of the 21st century for SRES A1B



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).

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Effects on Nile delta: 10 M people above 1m

(Time 2001)

WMO

UNEP

Regions most affected

- The Arctic
- Sub-Saharan Africa
- Small islands
- Megadeltas

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UNEP

In all regions, there are some areas and communities which are particularly vulnerable

- The poor
- Young children
- The elderly

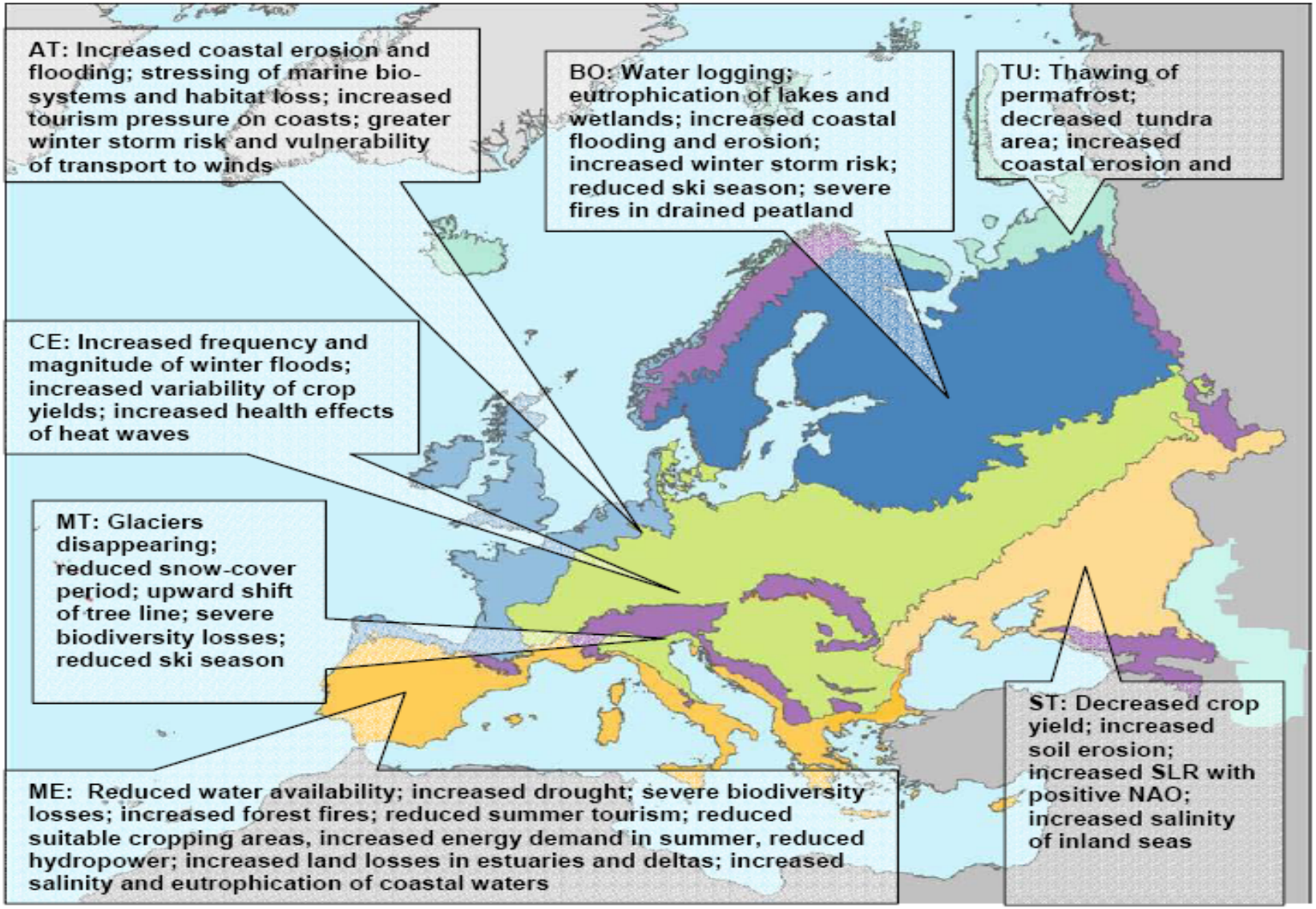

Figure 12.3: *Key vulnerabilities of European systems and sectors to climate change during the 21st century for the main biogeographic regions of Europe (EEA 2004a): TU (Tundra, pale turquoise); BO (Boreal, dark blue); AT (Atlantic, light blue); CE (Central, green [includes the Pannonian Region]); MT (Mountains, purple); ME (Mediterranean, orange [includes the Black Sea region]); ST (Steppe, cream); SLR (sea-level raise); NAO (North Atlantic Oscillation).*

Excerpts from IPCC AR4 WG2 (Chapter Europe)

- **For the first time, wide ranging impacts of changes in current climate have been documented in Europe**
  - retreat of glaciers, lengthening of growing season, shift of species, heat wave in 2003, ...
- **Climate-related hazards will mostly increase, although changes will vary geographically**
  - More winter floods in maritime regions, snowmelt-related floods in Central and E. Europe, flash floods throughout Europe.
  - Coastal flooding related to increasing storminess and sea level rise is likely to threaten up to 2.5 million additional people annually.
  - Some impacts may be positive, as in reduced risk of extreme cold events. However, on balance, health risks are very likely to increase.

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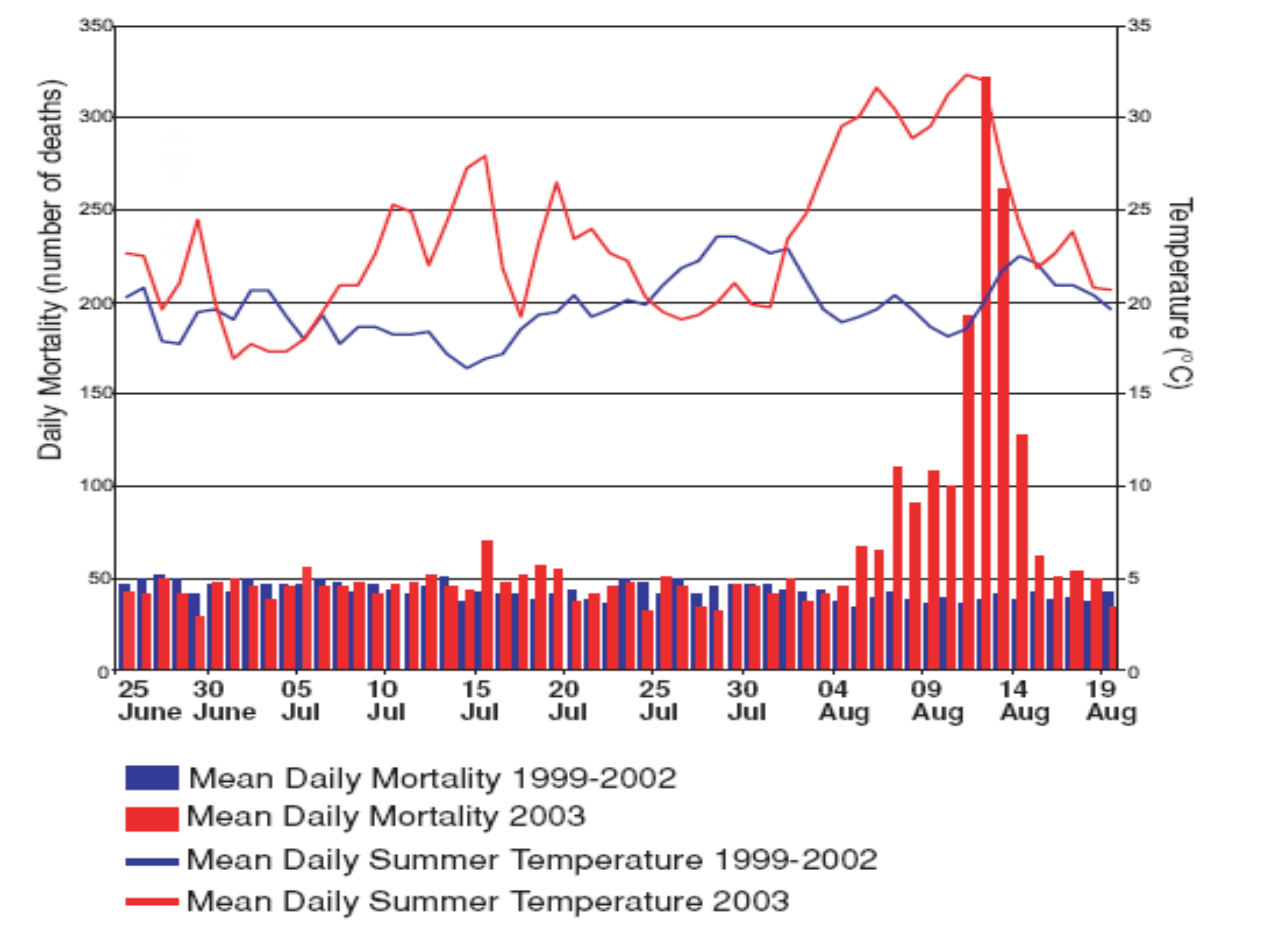
Daily mortality in Paris (summer 2003) (IPCC AR4 Ch 8)



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Excerpts from IPCC AR4 WG2 (Chapter Europe)

- **Climate change is likely to magnify regional differences of Europe's natural resources and assets.**
- **Water stress will increase over Central and S. Europe, as well as the number of people living in river basins under high water stress.**

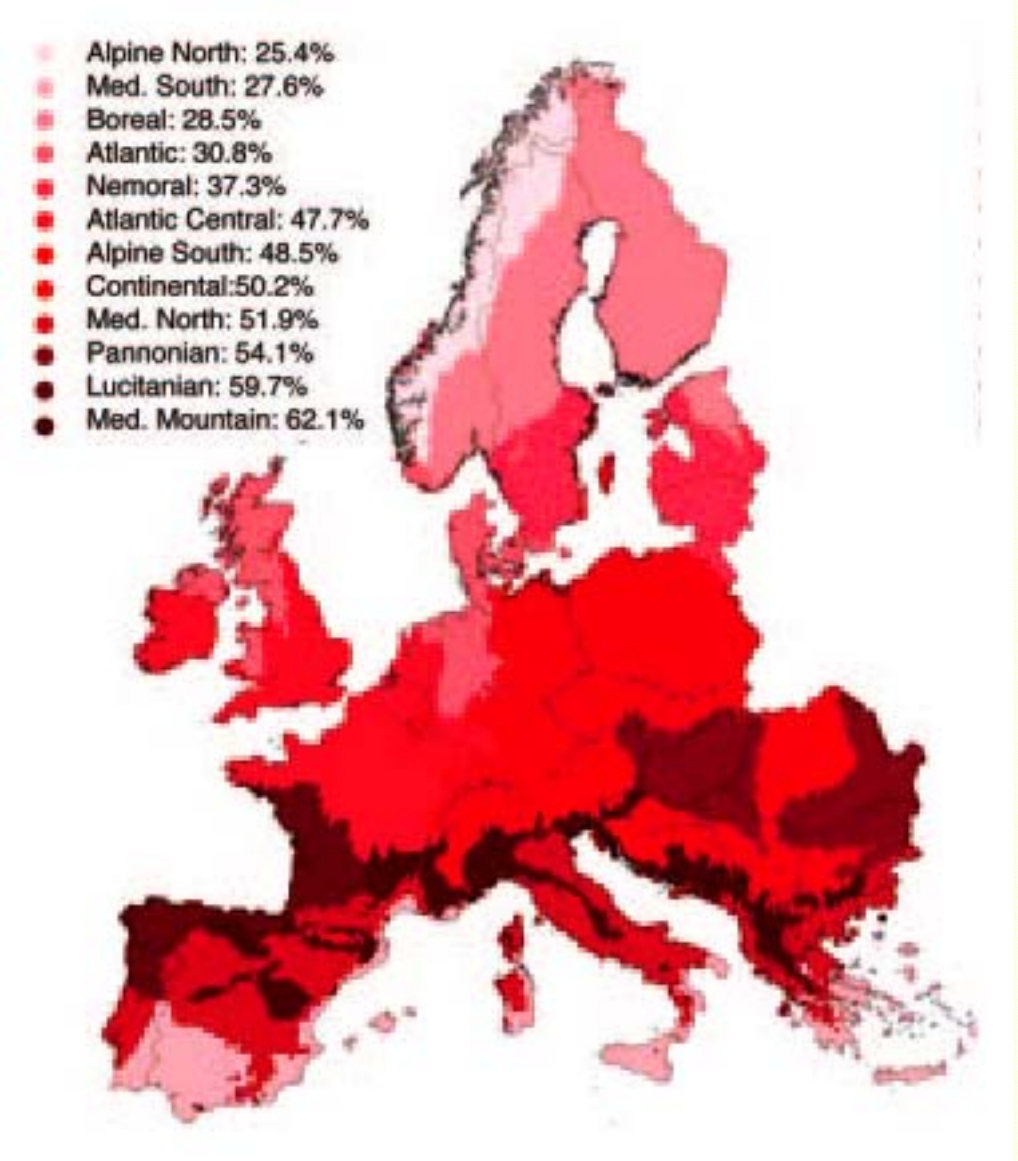
WMO UNEP

Excerpts from IPCC AR4 WG2 (Chapter Europe)

- **It is anticipated that Europe's natural (eco)systems and biodiversity will be substantially affected by climate change. The great majority of organisms and ecosystems are likely to have difficulty in adapting to climate change.**
  - **A large percentage of the European flora is likely to become vulnerable, endangered, or committed to extinction by the end of this century.**
  - **Options for adaptation are likely to be limited for many organisms and ecosystems.**
  - **Low-lying, geologically-subsiding coasts are likely to be unable to adapt to sea-level rise.**
  - **New sites for conservation may be needed.**

Species in Europe

- 12,500 plants
- 123 reptiles
- 62 amphibians
- 514 birds
- 187 mammals
- 358 freshwater fis
- >200,000 invertel



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Terrestrial Ecosystems in Europe

- Greatest impacts on
  - –arctic regions
  - –moisture-limited ecosystems of southern and eastern Europe
  - –mediterranean

WMO UNEP

Excerpts from IPCC AR4 WG2 (Chapter Europe)

- **Climate change is estimated to pose challenges to many European economic sectors and alter the distribution of economic activity.**
  - **Agriculture will have to cope with increasing water demand for irrigation in S. Europe.**
  - **Peak electricity demand is likely to shift in some locations from winter to summer.**
  - **Winter tourism in mountain regions is anticipated to face reduced snow cover.**

Excerpts from IPCC AR4 WG2 (Chapter Europe)

- **Adaptation to climate change is likely to benefit from experiences gained in reactions to extreme climate events, by specifically implementing proactive climate change risk management adaptation plans.**
- **Although the effectiveness and feasibility of adaptation measures are expected to vary greatly, only a few governments and institutions have systematically and critically examined a portfolio of measures.**

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

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 km^2 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

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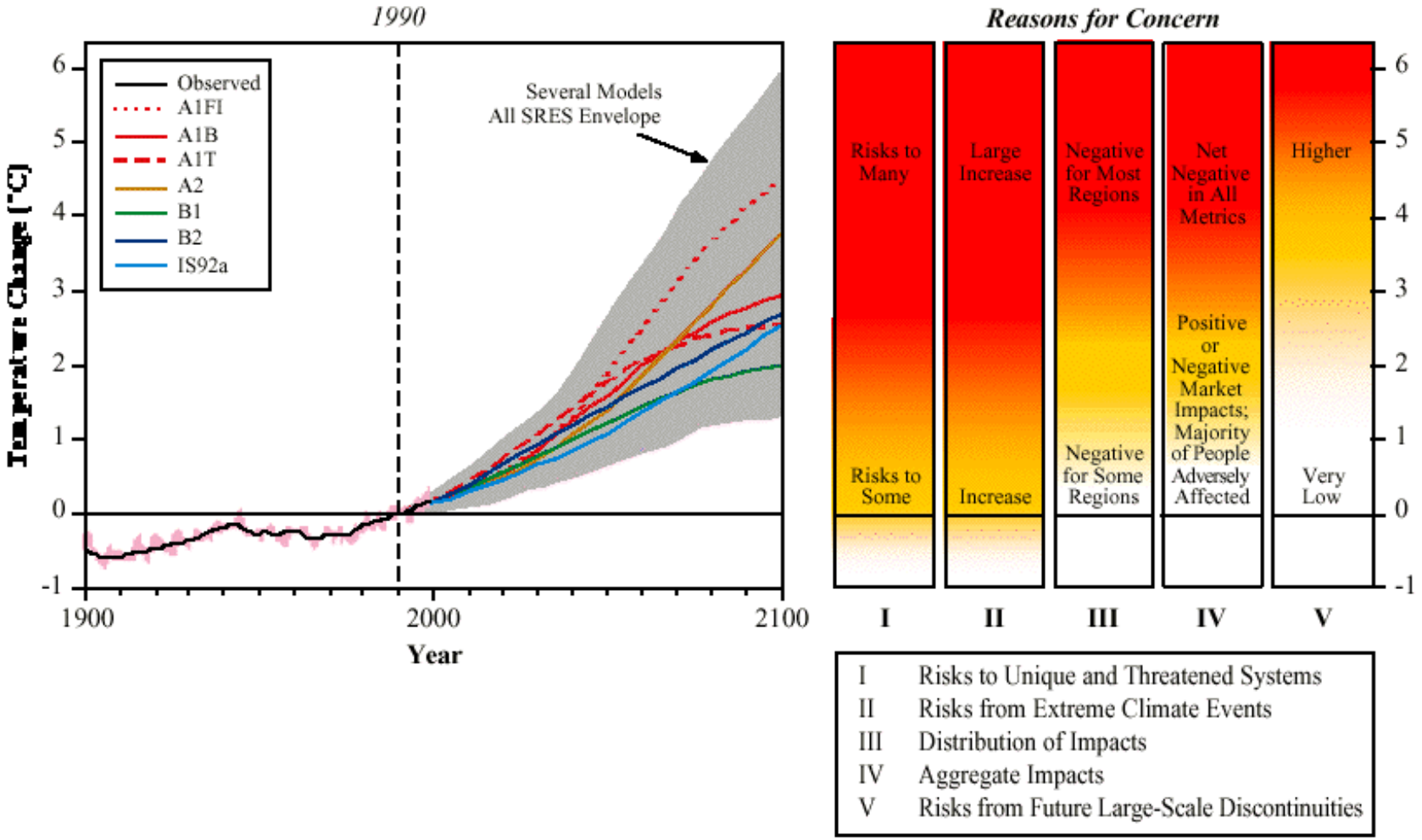
IPCC 2001:


1990
Observed
A1FI
A1B
A1T
A2
B1
B2
IS92a
Several Models
All SRES Envelope
Temperature Change (°C)
Year
1900
2000
2100
Reasons for Concern
Risks to Many
Risks to Some
Large Increase
Increase
Negative for Most Regions
Negative for Some Regions
Net Negative in All Metrics
Positive or Negative Market Impacts; Majority of People Adversely Affected
Higher
Very Low
I
II
III
IV
V
I Risks to Unique and Threatened Systems
II Risks from Extreme Climate Events
III Distribution of Impacts
IV Aggregate Impacts
V Risks from Future Large-Scale Discontinuities

What does IPCC tell us on mitigation?

- **WG3: Mitigation**

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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 (°C)	Year CO2 needs to peak	Reduction in 2050 compared to 2000
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

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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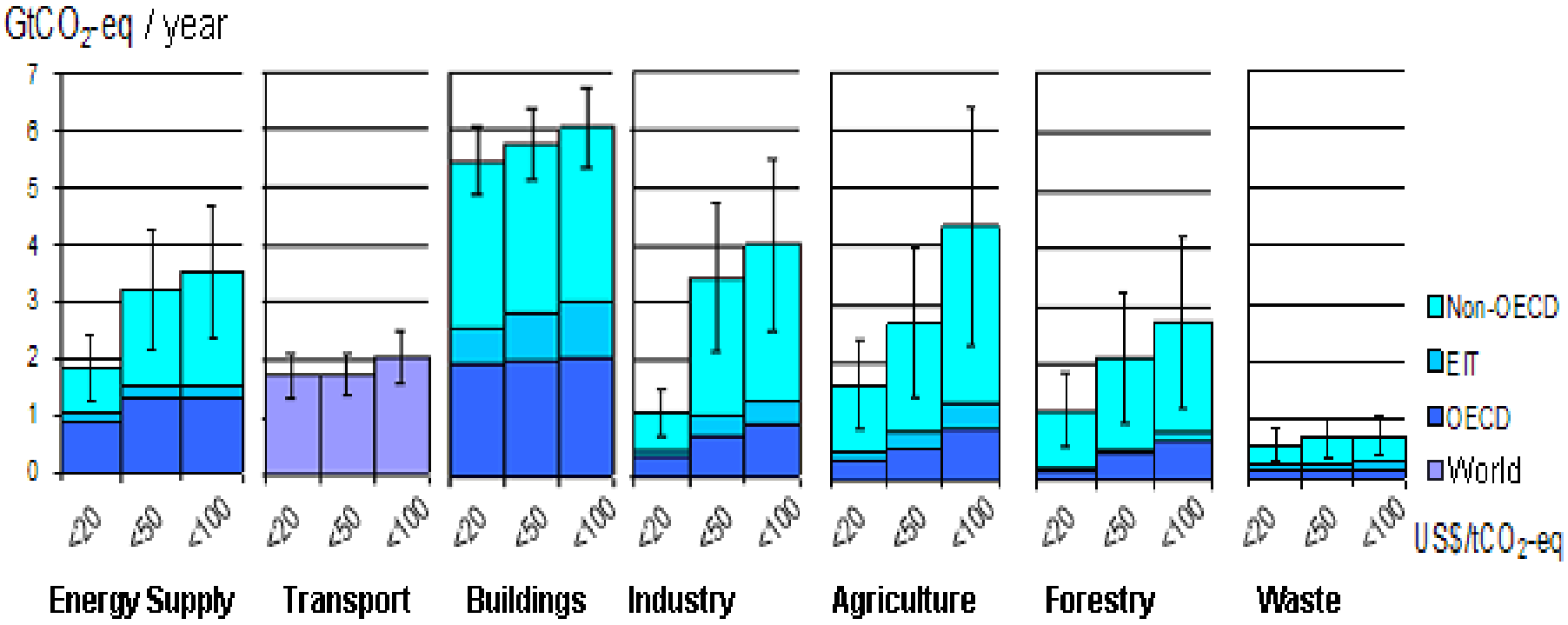
All sectors and regions have the potential to contribute by 2030



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

Conclusion

- **Climate is changing due to our activities**
- **…and faster than we change our activities**
- ***M*itigation is essential to prevent the avoidable**
- ***A*daptation is essential to cope with the unavoidable (due to inertia & lack of mitigation)**
- **The more integrated *M&A* are in all policies, the more efficient and cheap they will be**
- **Please use and peruse the IPCC reports!**

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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.'***

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Useful links:

- www.ipcc.ch : IPCC
- www.climate.be/JCM: interactive climate model

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