Impacts of climate change and the need for adaptation:
The IPCC case for action, with GMES help

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GMES Forum, Lille, 17-9-2008

Outline

- How does IPCC work?
- What does IPCC tell us about impacts & adaptation (World & Europe)?
  - IPCC Group 1: climatology
  - IPCC Group 2: impacts, vulnerability, & adaptation
  - IPCC Group 3: mitigation
- Something for GMES?

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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 with Al Gore**
- **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 adaptation?

- 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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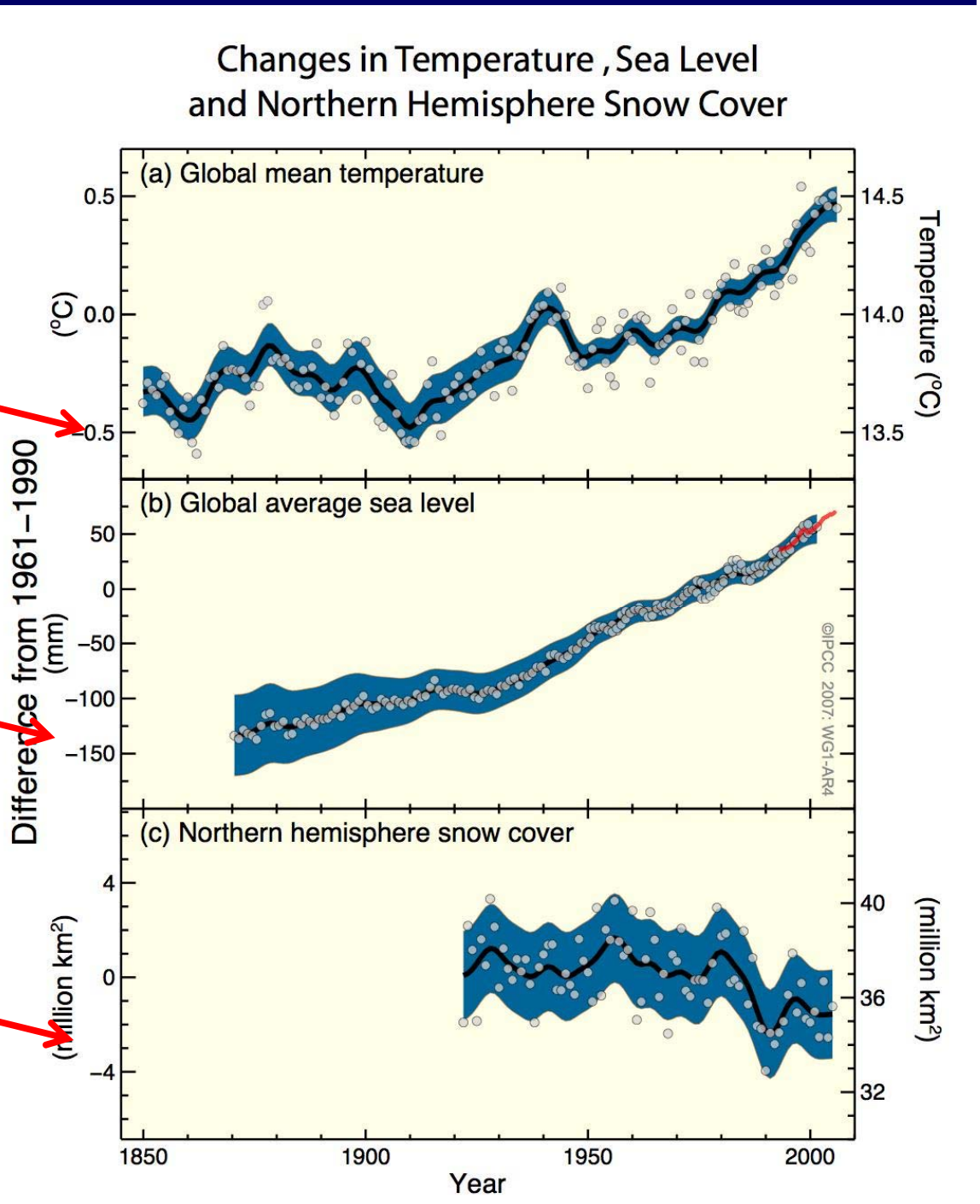
Warming is Unequivocal

Rising atmospheric temperature

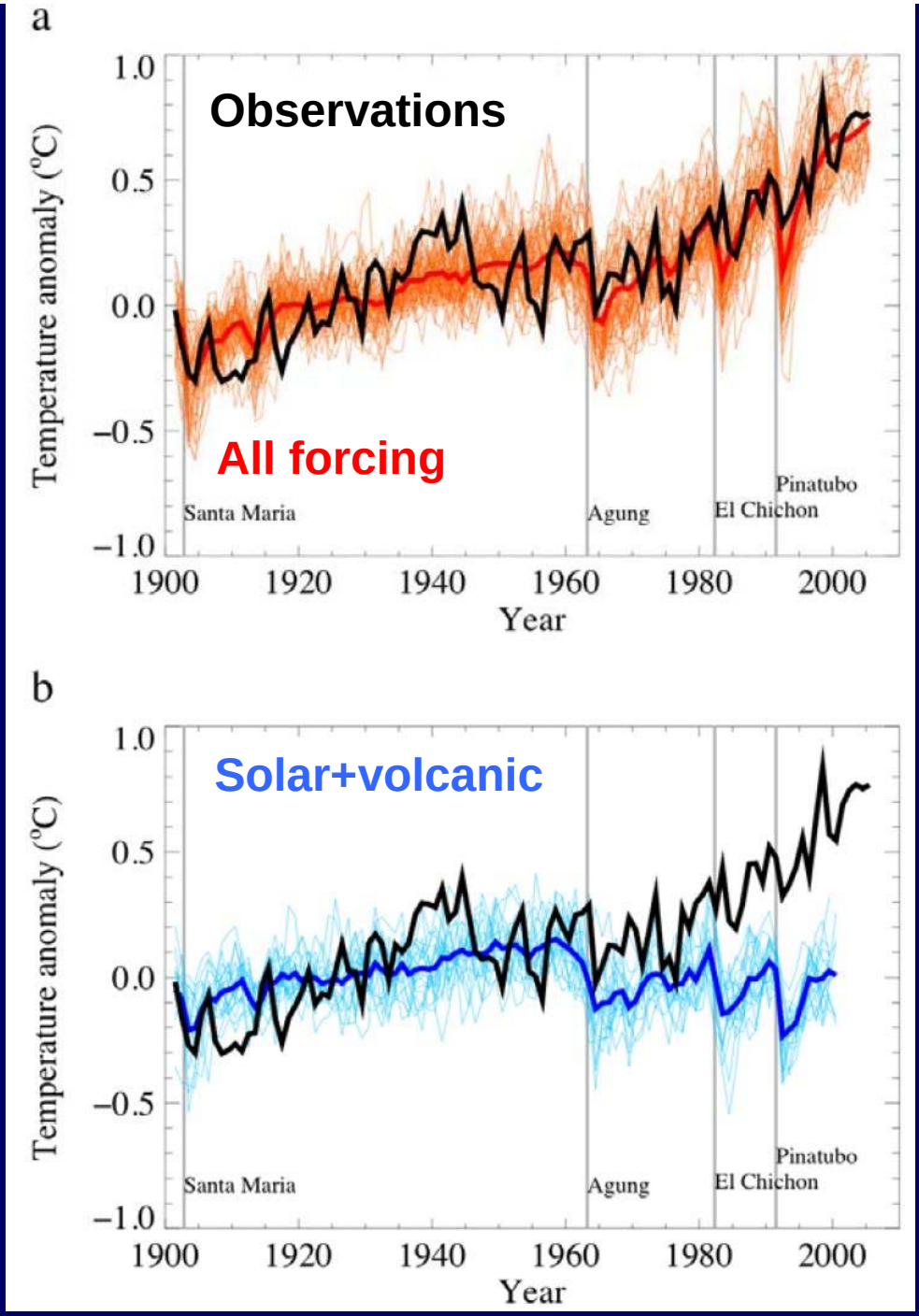
Rising sea level

Reductions in NH snow cover



Attribution

- are observed changes consistent with
- ☑ expected responses to forcings
- ☒ inconsistent with alternative explanations



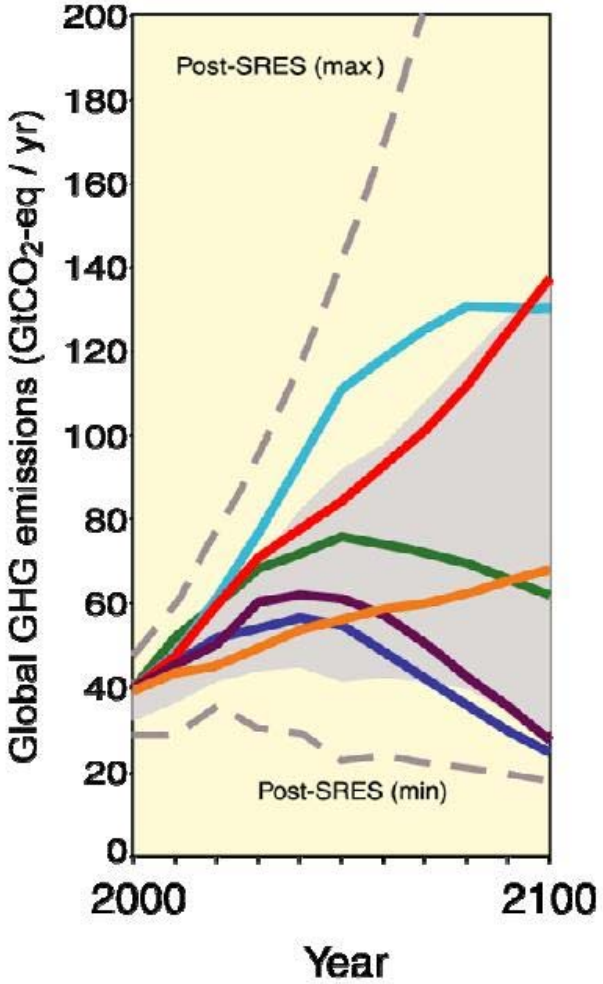
Understanding and Attributing Climate Change

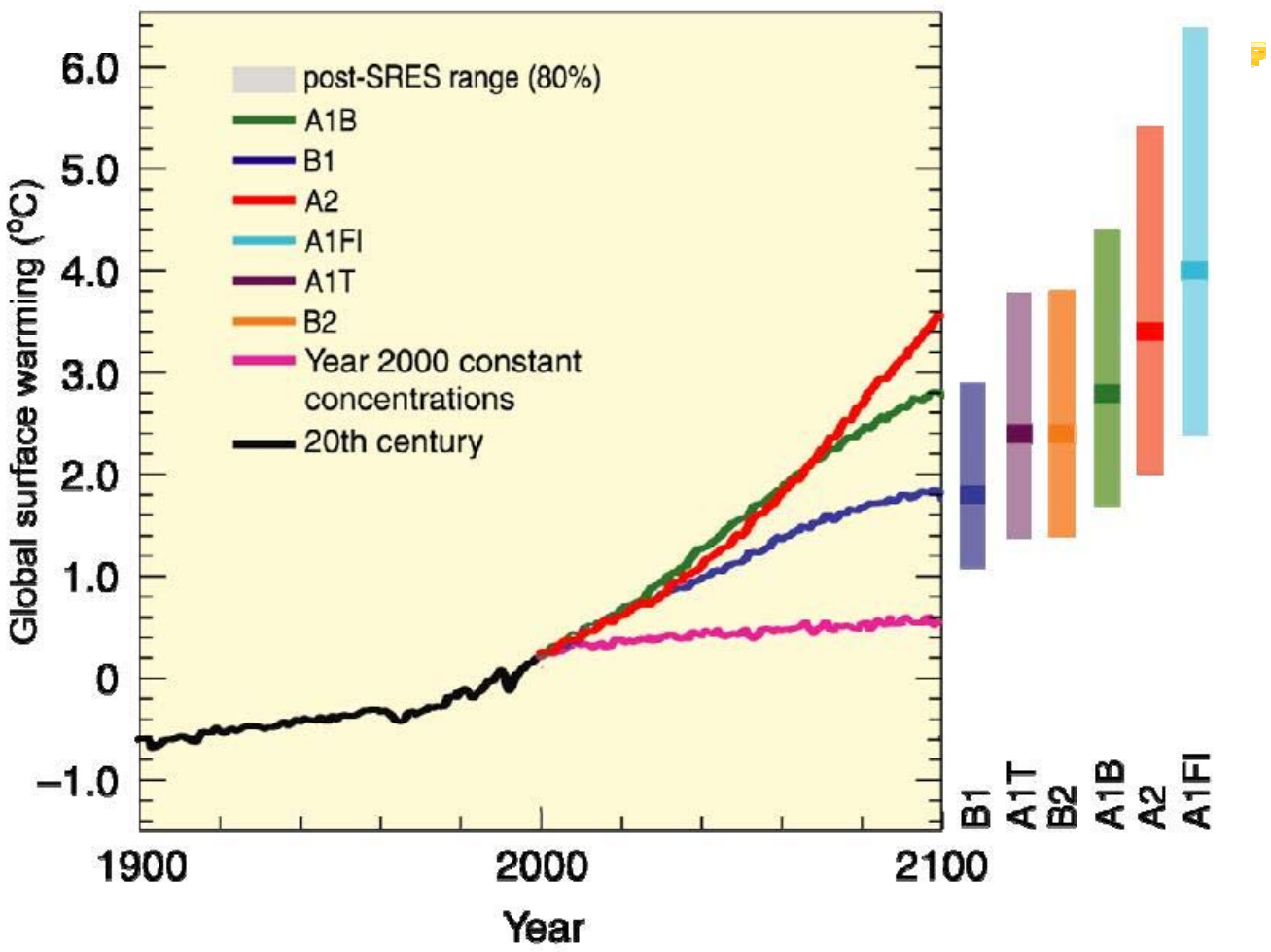
- **Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely (>90%) due to the observed increase in anthropogenic greenhouse gas concentrations.**

- **This is an advance since the TAR's conclusion that "most of the observed warming over the last 50 years is likely (>66%) to have been due to the increase in greenhouse gas concentrations".** .

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 [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.

What does IPCC tell us about 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)

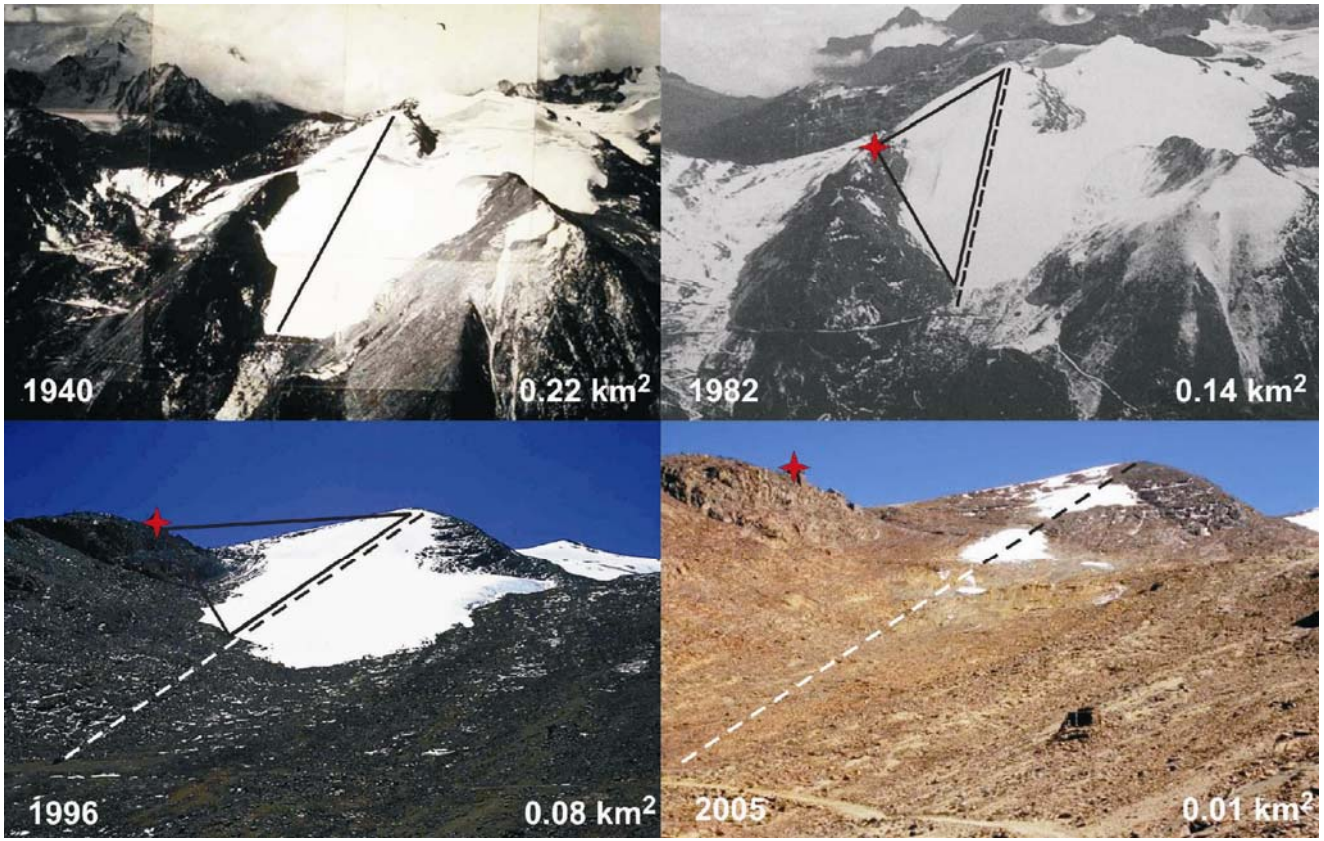
- Adaptation practices
- Adaptation vs. mitigation
- Key vulnerabilities
- Sustainability

WMO

UNEP

The Chacaltaya glacier and ski-lift, Bolivia

Skiing was no longer possible after 2004

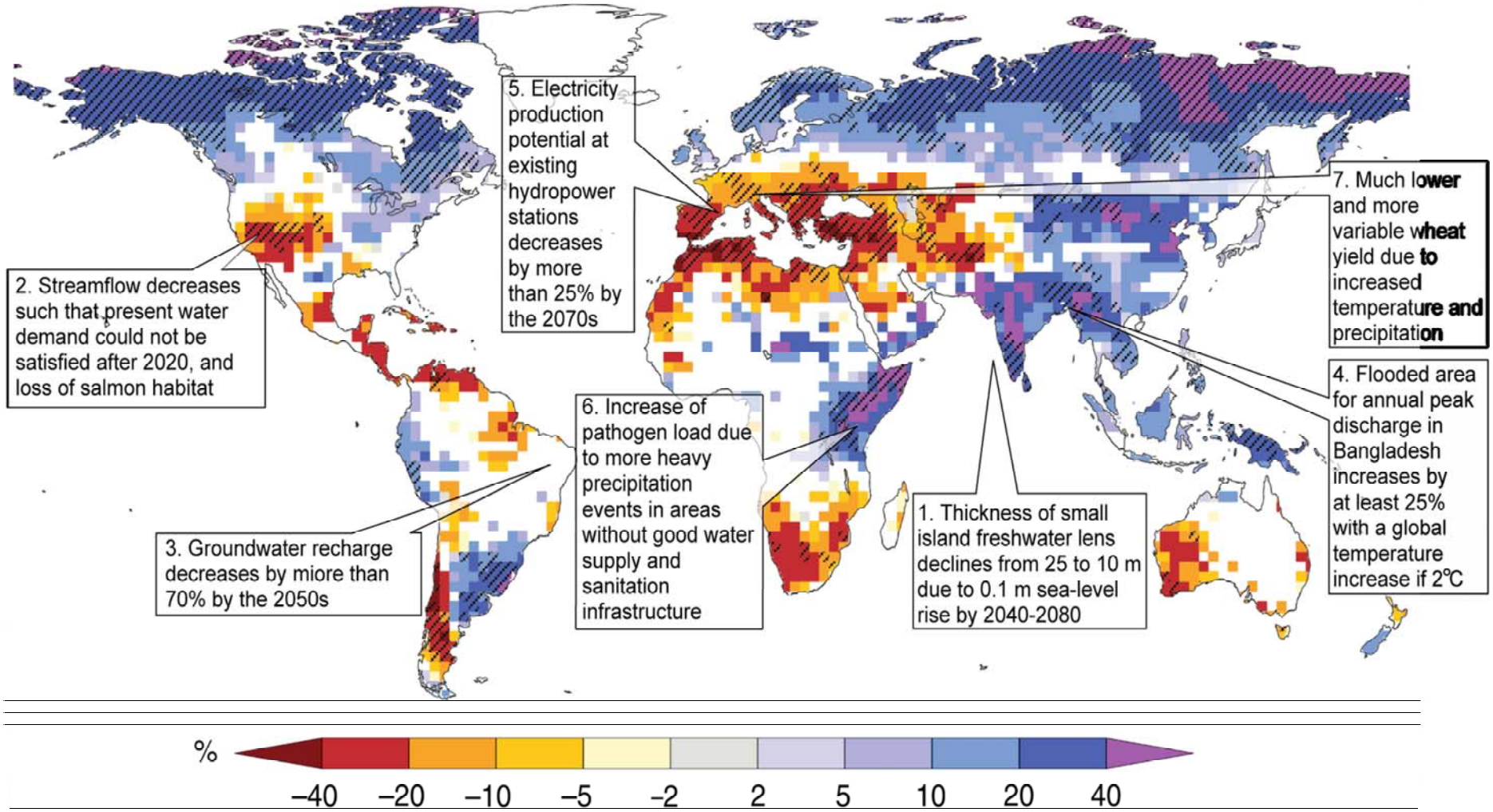


Source: IPCC WG2

WMO

UNEP

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 below + 1m

(Time 2001)

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

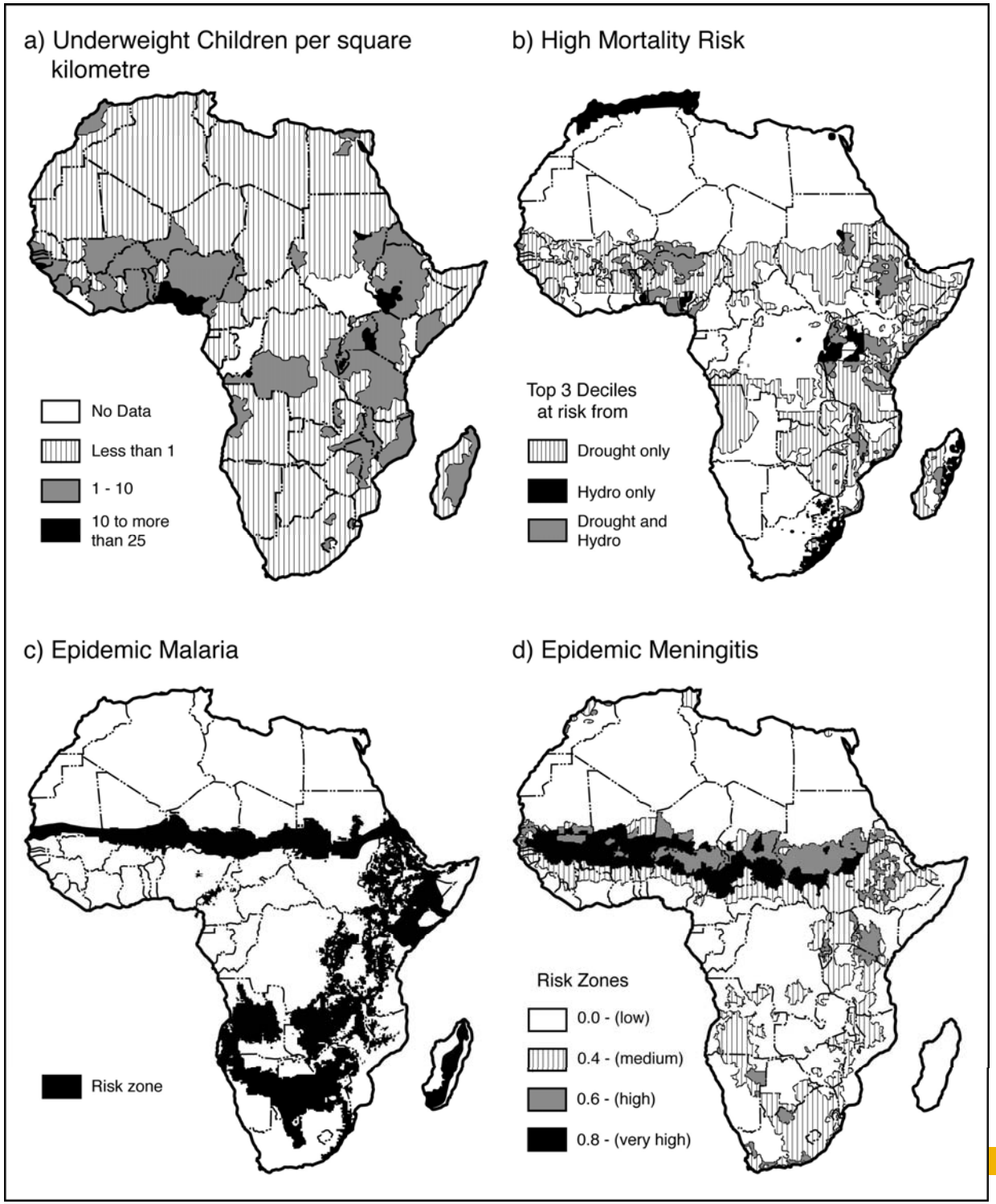
if ΔT 1.5°C - 2.5°C (above 1990 temperature)

Regions most affected

- The Arctic
- Sub-Saharan Africa
- Small islands
- African & Asian megadeltas

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

- The poor
- Young children
- The elderly



Vulnerability to climate change can be made worse by the presence of other stresses:

Multiple stresses in Africa (Ch 9)

UNEP

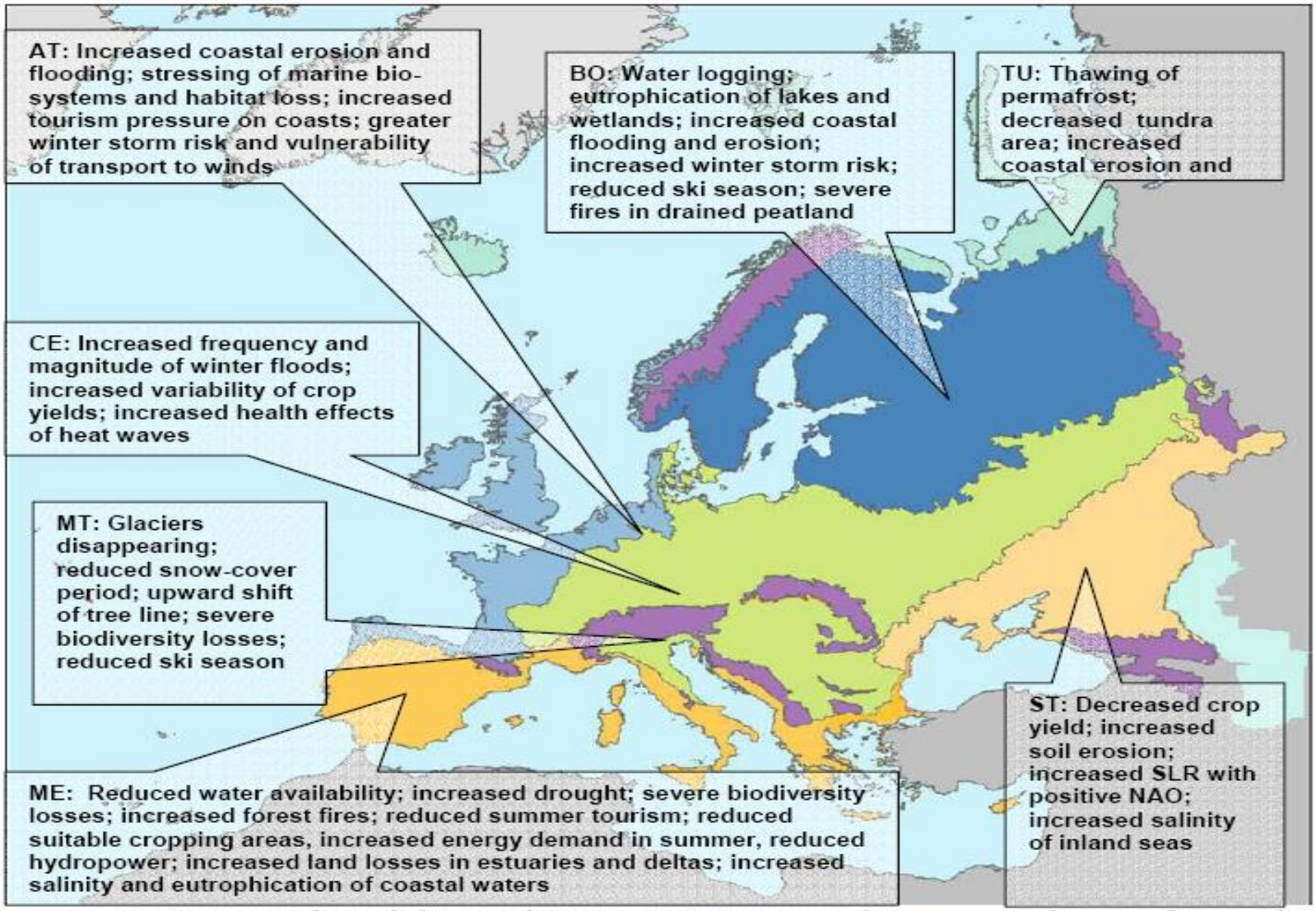


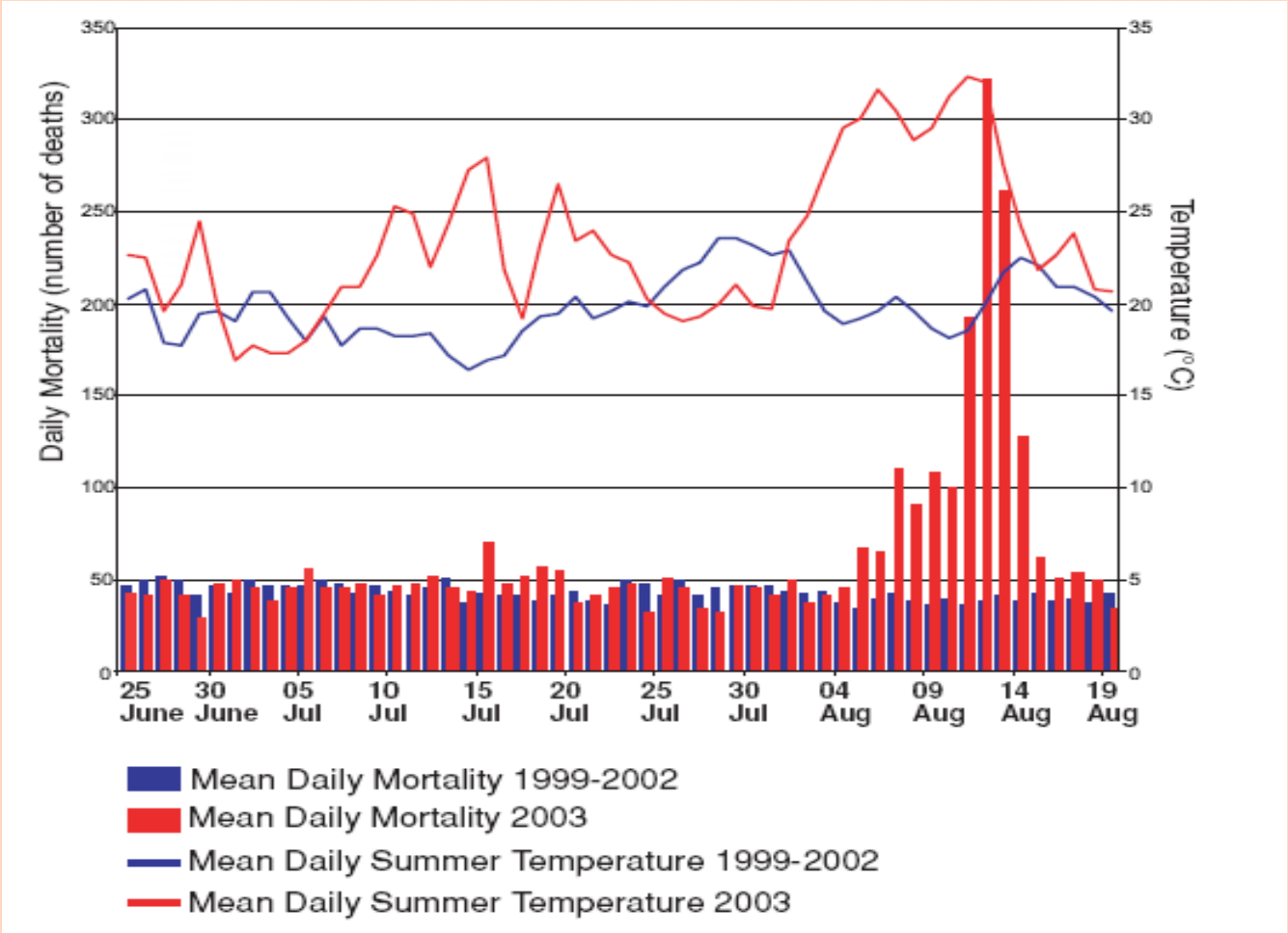
Figure 12.3: *Key vulnerabilities of European systems and sectors to climate change during the 21st century for the main biogeographic regions of Europe (EEA 2004a): TU (Tundra, pale turquoise); BO (Boreal, dark blue); AT (Atlantic, light blue); CE (Central, green [includes the Pannonian Region]); MT (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.

WMO UNEP

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



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.**

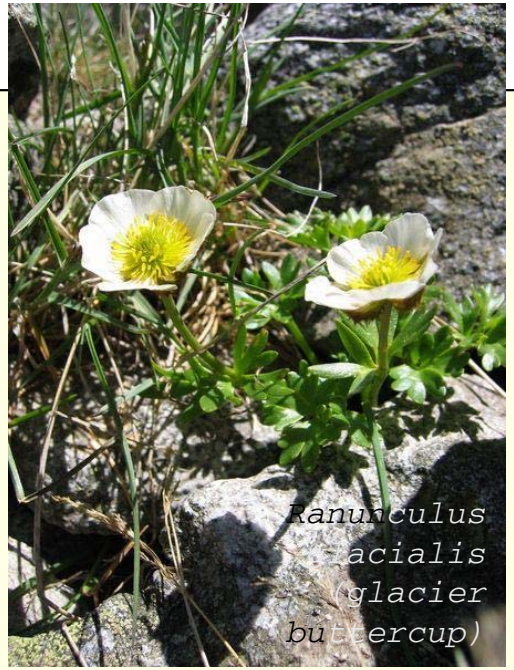
WMO UNEP

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 at risk in the Alps and other European mountains

One study estimated up to 60% of Alpine plants at risk



Alectoris graeca (Rock partridge)

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Source: A. Fischlin, IPCC AR4 WG2 Chap. 4

Terrestrial Ecosystems in Europe

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

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.**

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)

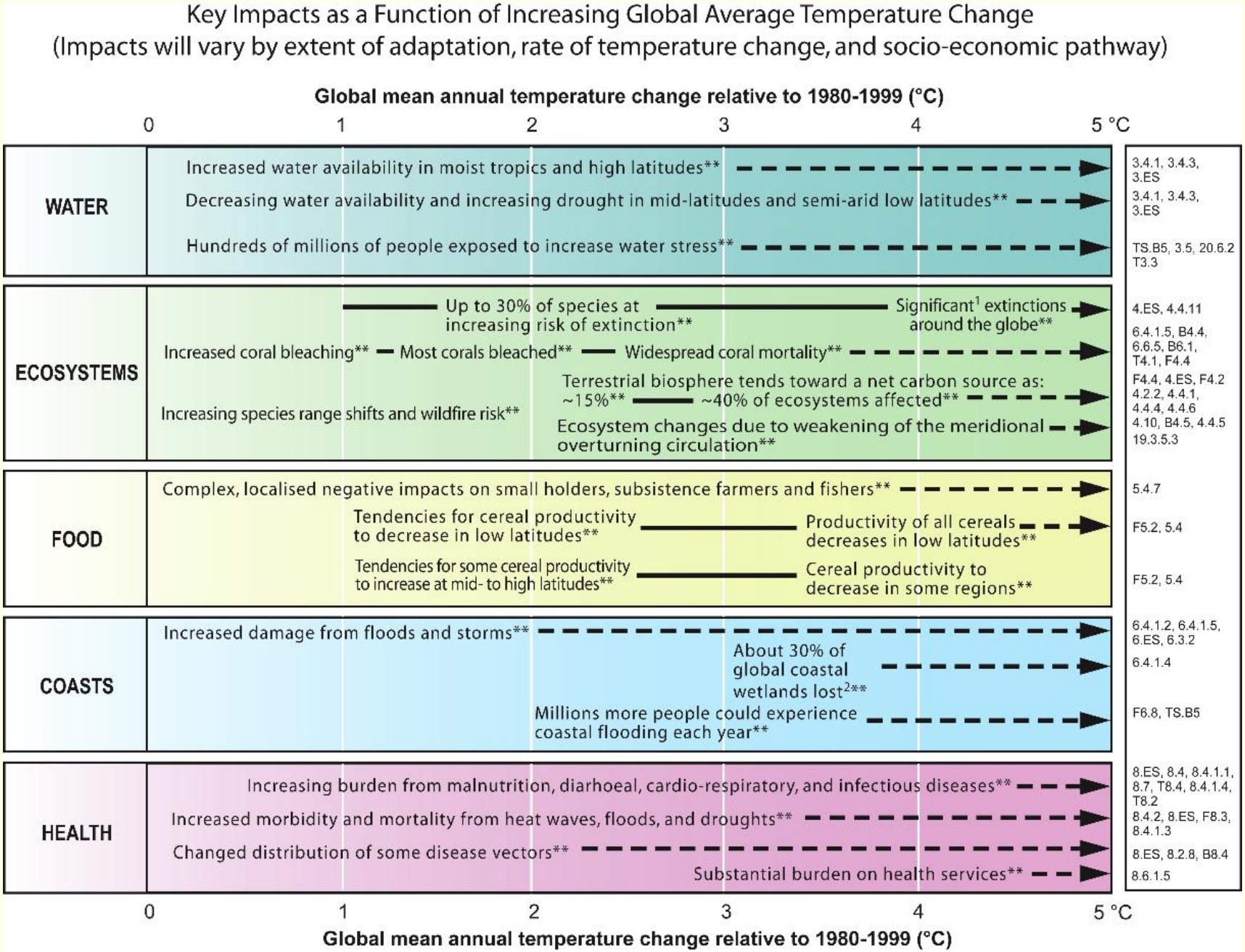
With 8 metre sea-level rise: 3700 km^2 below sea-level in Belgium

(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



Source: IPCC AR4 WG2 SPM

[1] Significant is defined here as more than 40%.
[2] Based on average rate of sea level rise of 4.2 mm/year from 2000 to 2080.

What does IPCC tell us about mitigation?

- WG3

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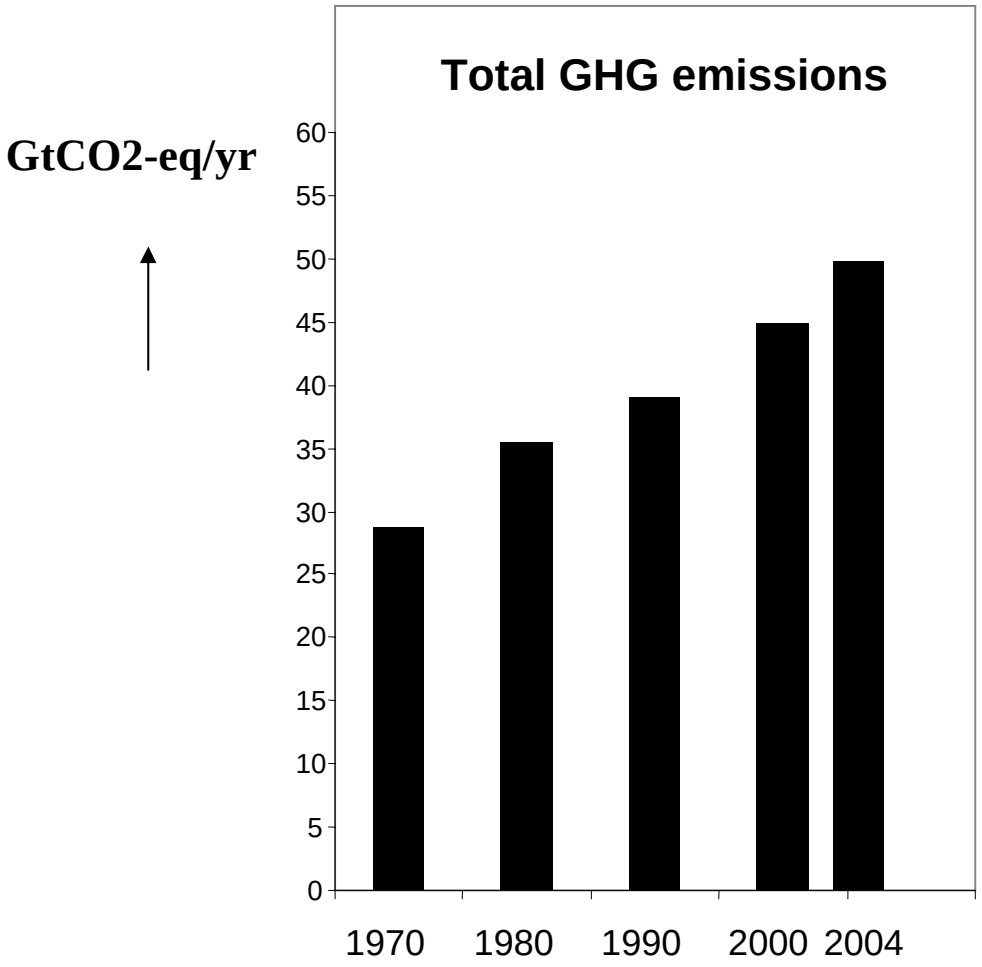
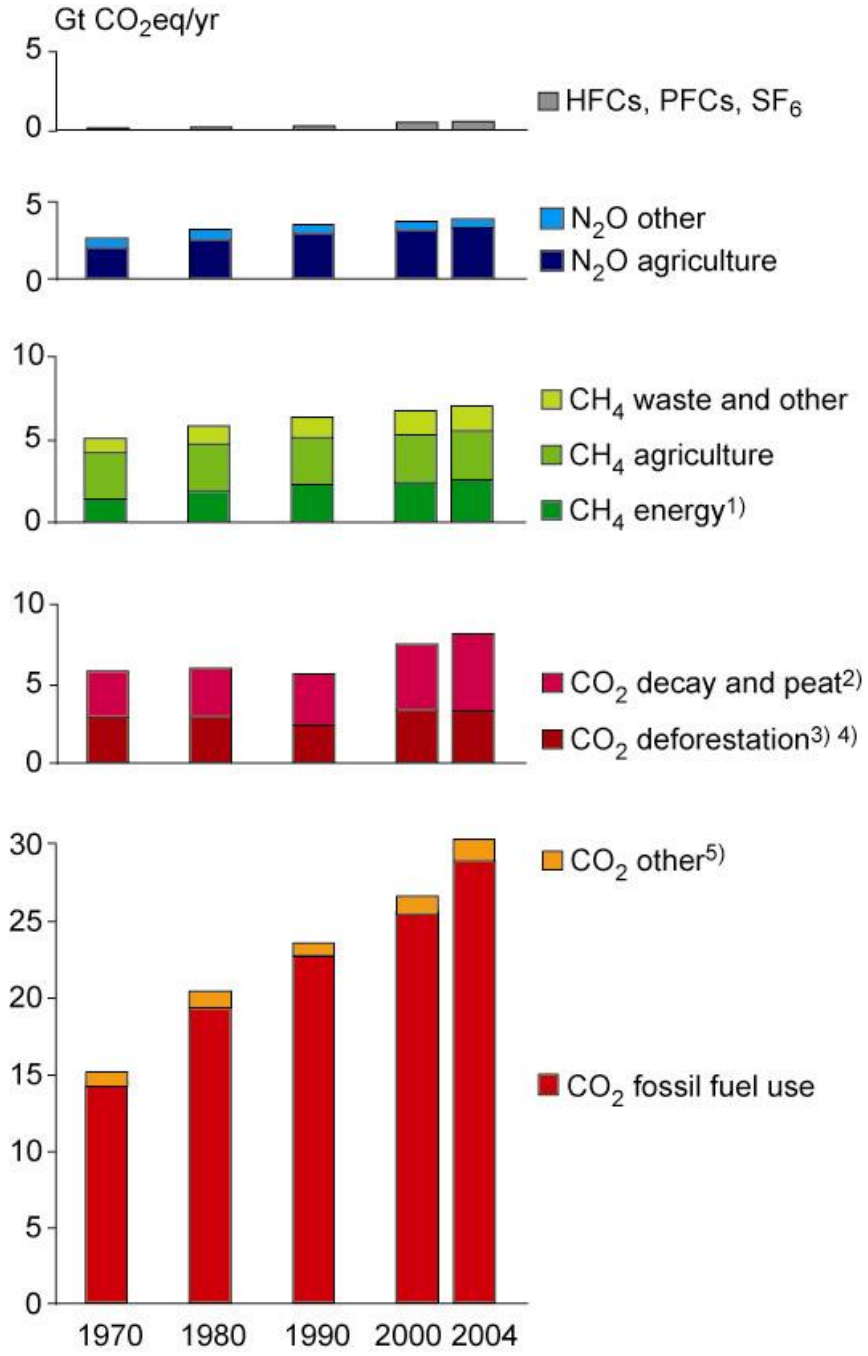
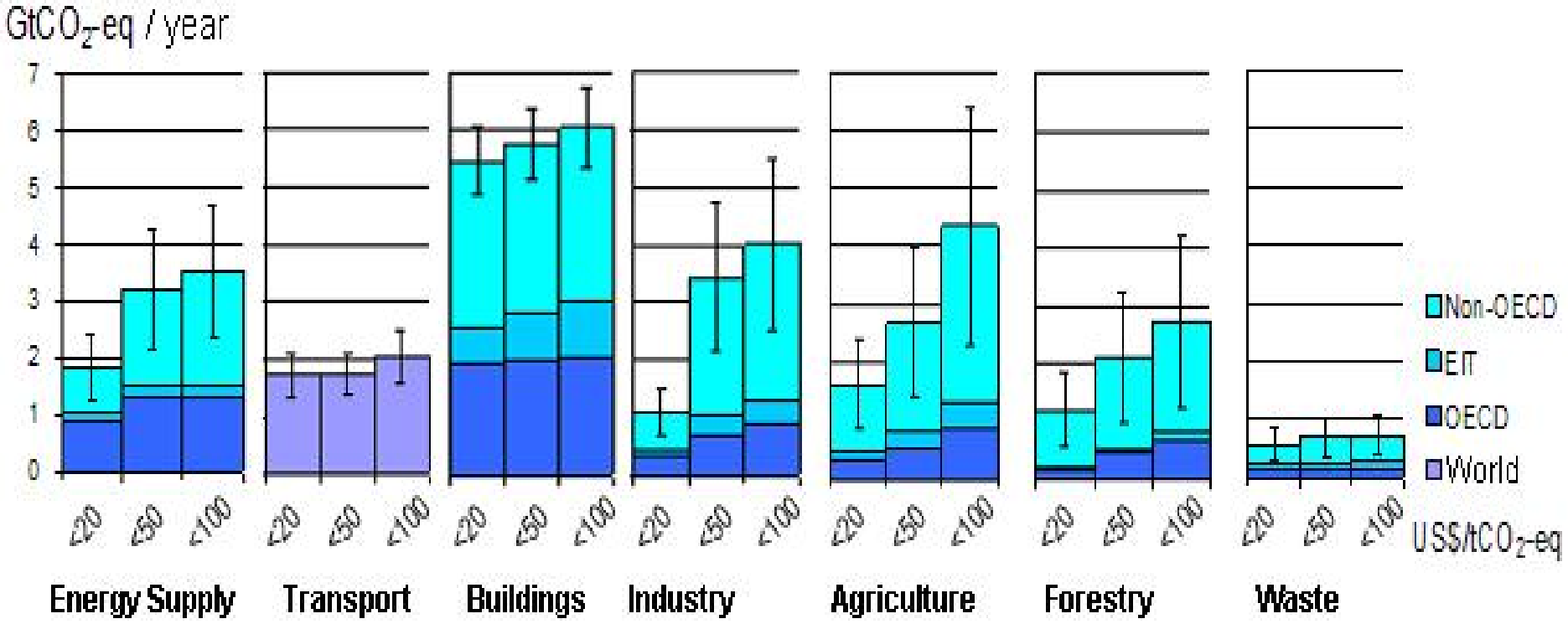
Between 1970 and 2004 global greenhouse gas emissions have increased by 70 %



Carbon dioxide is the largest contributor



All sectors and regions have the potential to contribute by 2030



Source: IPCC AR4 WG3 SPM

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

Long term mitigation (after 2030)

Source: IPCC AR4 WG3

- 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 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

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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What are the macro-economic costs (of mitigation) in 2030?

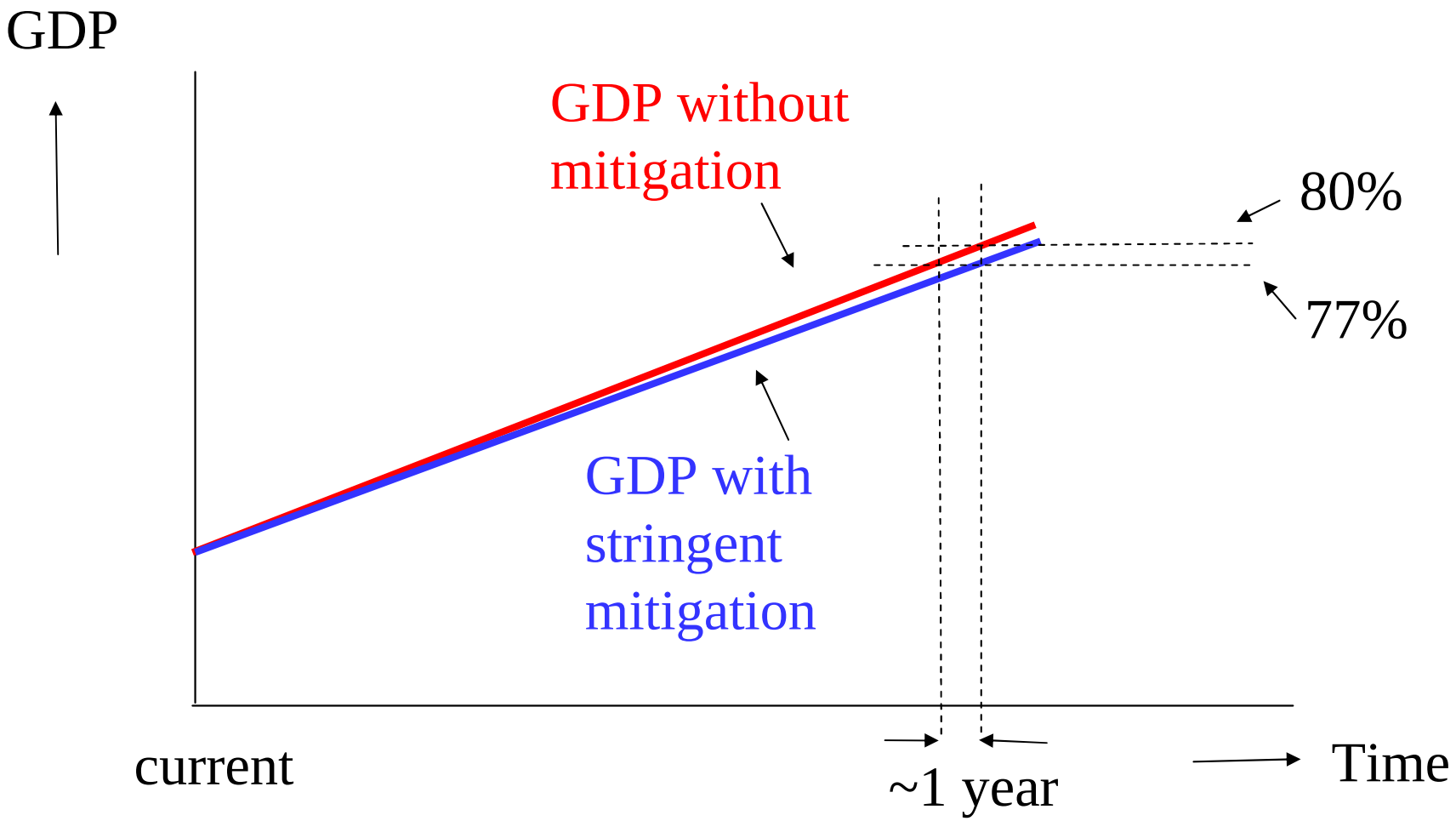
Source: IPCC AR4 WG3

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	0.2	-0.6 – 1.2	< 0.06
535-590	0.6	0.2 – 2.5	<0.1
445-535 [4]	Not available	< 3	

Rem: This leaves a lot of money to fund adaptation in both developed & developing countries

[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 2030 that would result in the indicated GDP decrease in 2030.
[4] The number of studies that report GDP results is relatively small and they generally use low baselines.

Illustration of cost numbers



Something for GMES?

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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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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)

- 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**.
- JPvY remark: pay attention to **long term continuity**, and **need for in situ surface measurements** as well

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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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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!**
- **GMES can certainly contribute, but please pay attention to long term continuity, and need for in situ surface measurements as well**

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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/vanyp: my slides
- www.climate.be/JCM: interactive climate model

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