The Challenges and Opportunities of Climate Change

The IPCC Fifth Assessment Report (AR5) and Better Communication on Water & Climate

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IPCC Vice-Chair

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Social Perceptions of Water & Climate Workshop, « We Are Water » Foundation & International Association of Broadcast Meteorology, Barcelona, Catalogna, 20 March 2015

Thanks to the Belgian Federal Science Policy Office (BELSPO) and the Ministry of Foreign Affairs, and to my team at the Université catholique de Louvain for their support

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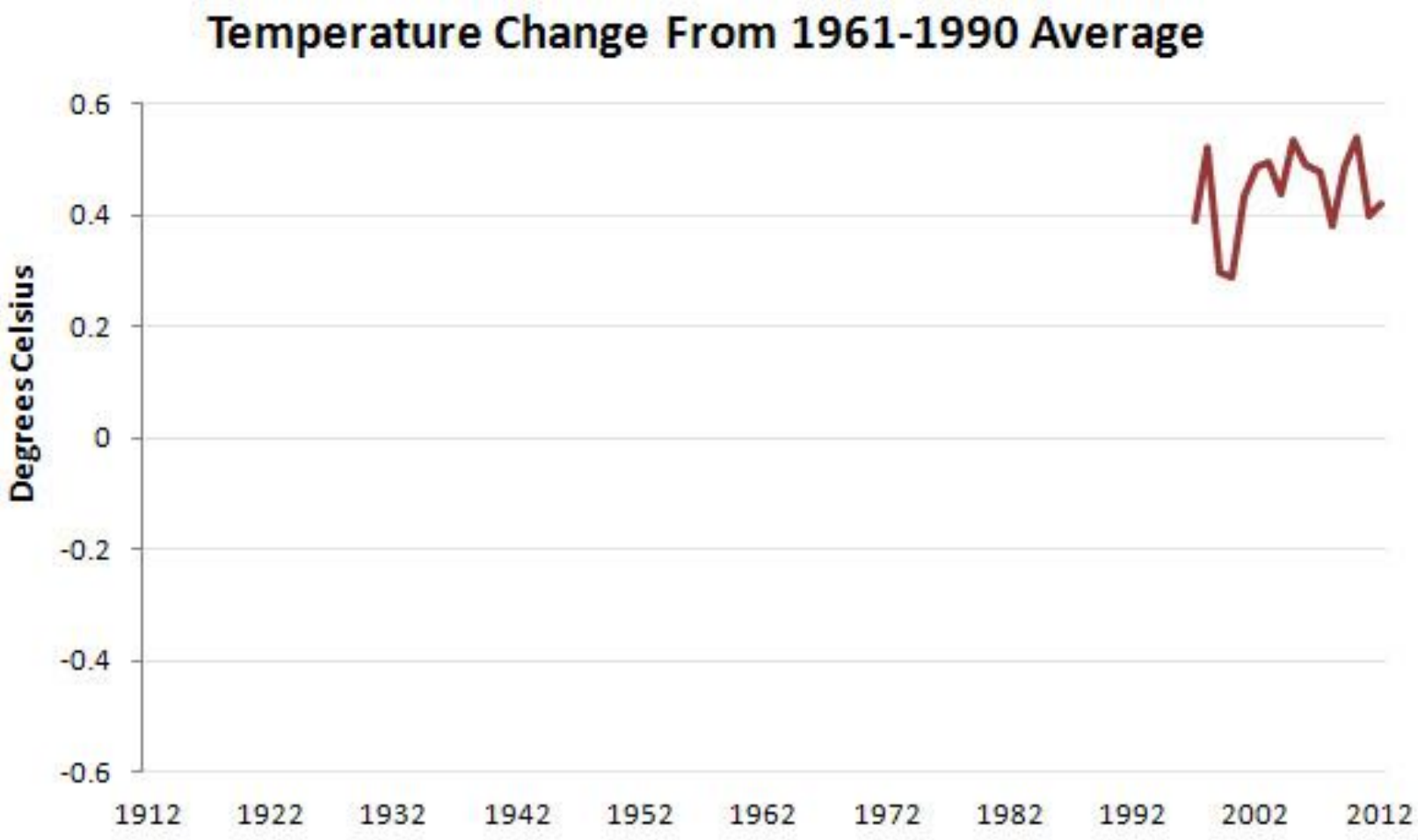
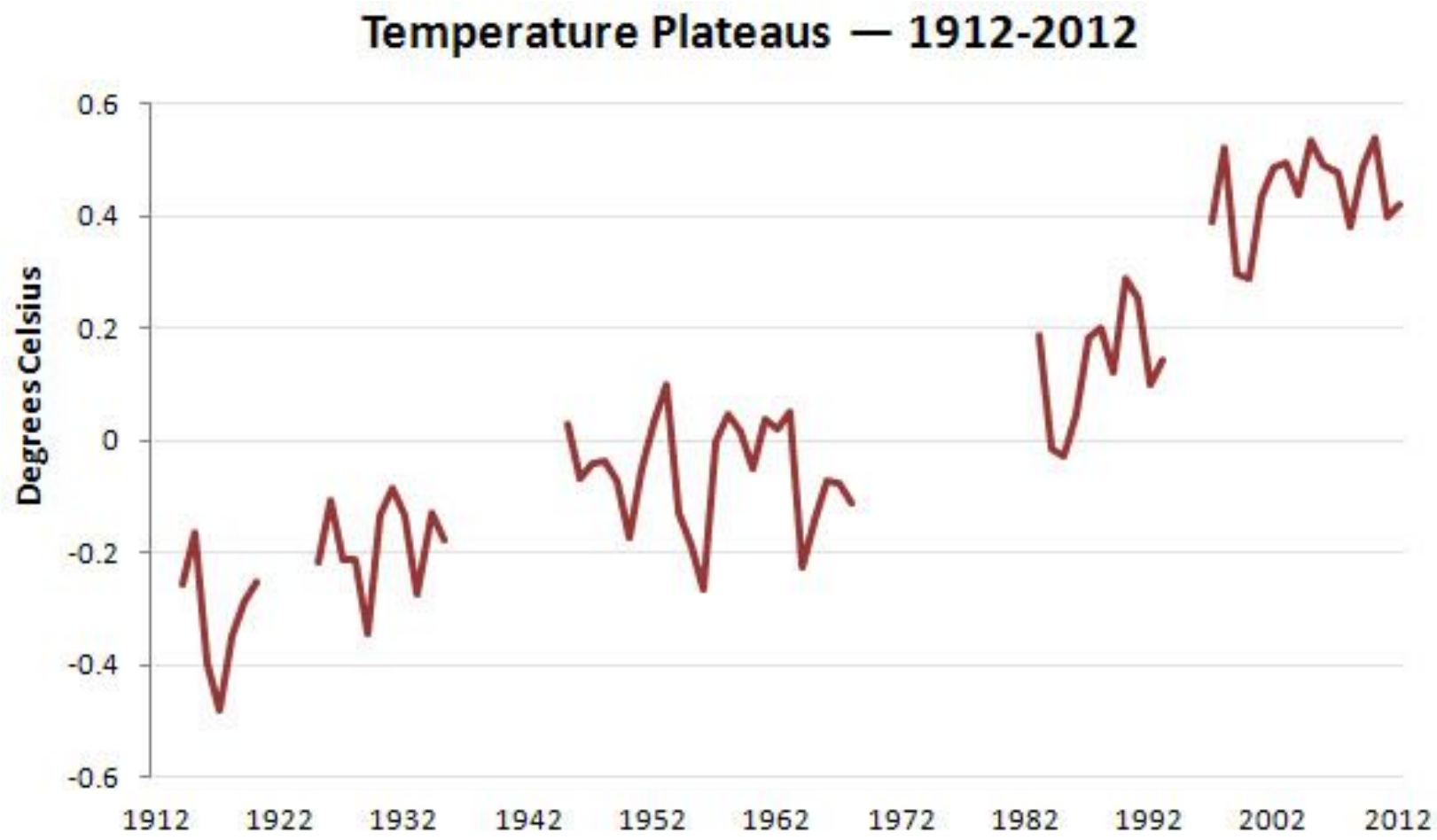
Lying With Statistics, Global Warming Edition



http://www.motherjones.com/kevin-drum/2012/10/lying-statistics-global-warming-edition

Lying With Statistics, Global Warming Edition



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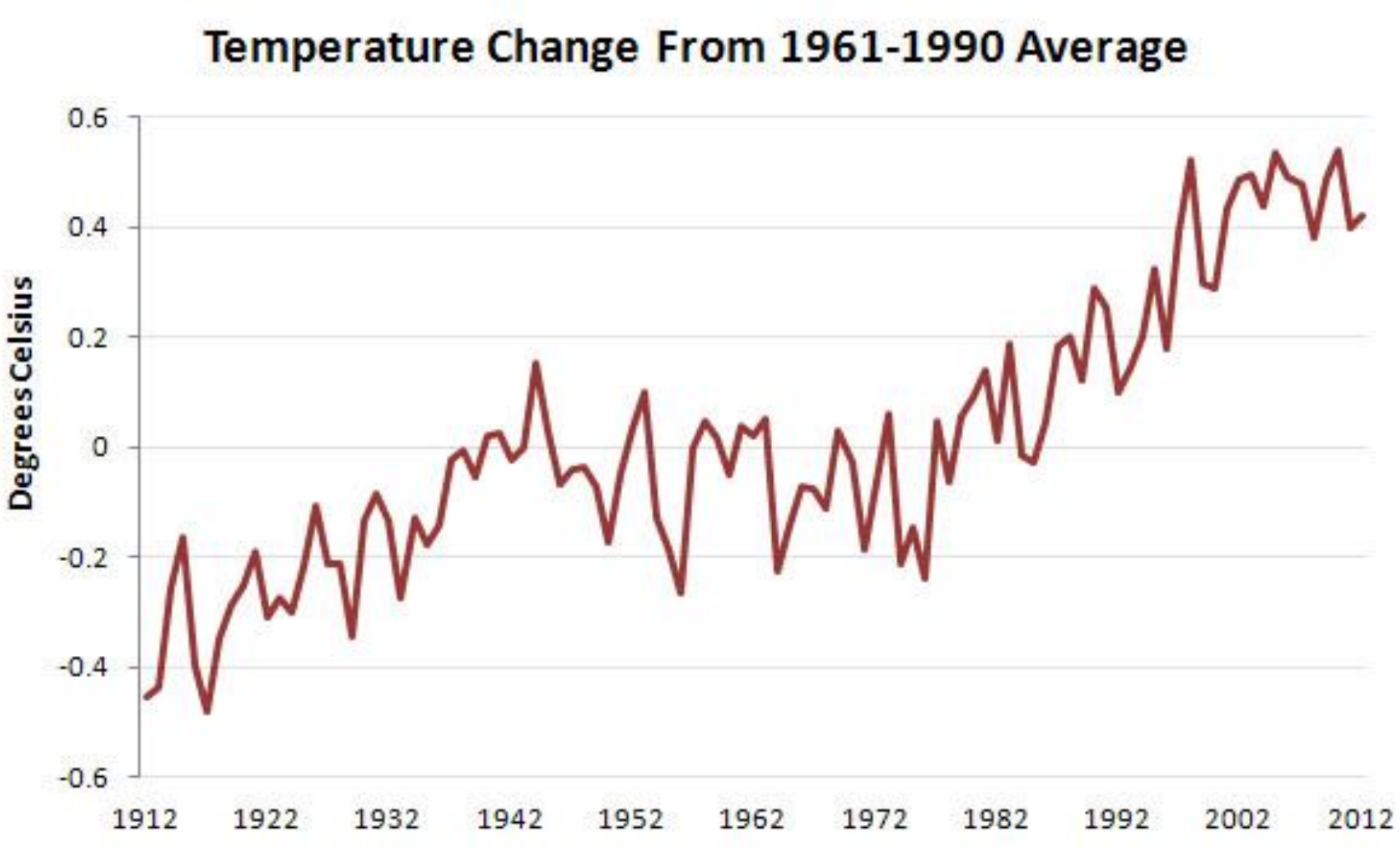


http://www.motherjones.com/kevin-drum/2012/10/lying-statistics-global-warming-edition

Why the IPCC ?

Established by WMO and UNEP in 1988

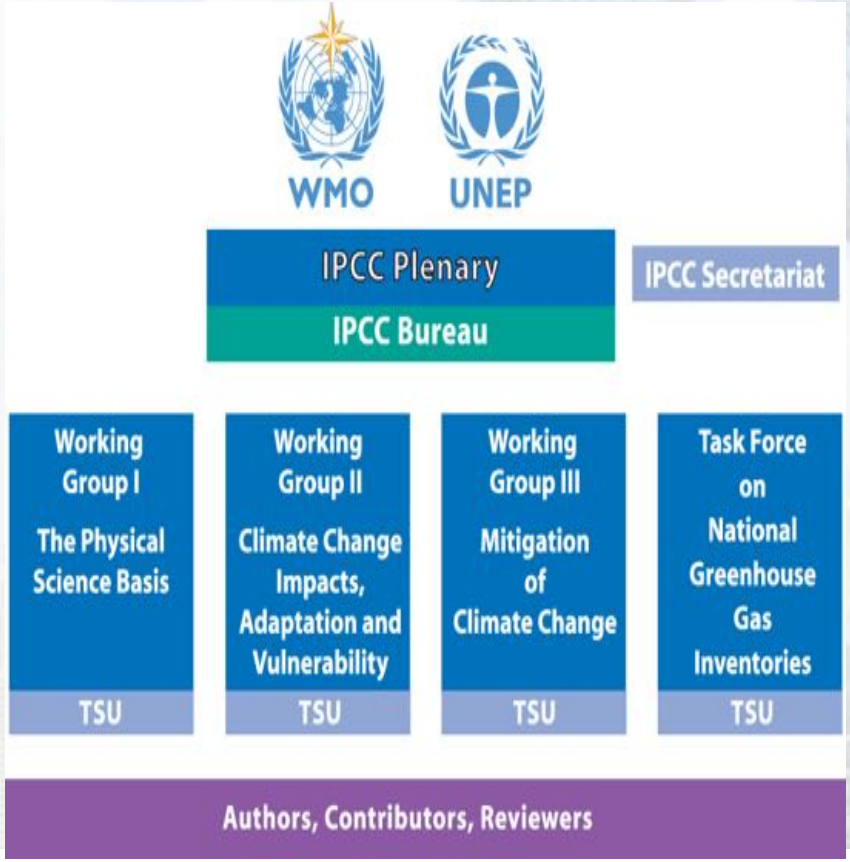
to provide **policy-makers** with an **objective source of information** about

- causes of climate change,
- potential environmental and socio-economic impacts,
- possible response options (adaptation & mitigation).

WMO=World Meteorological Organizatior

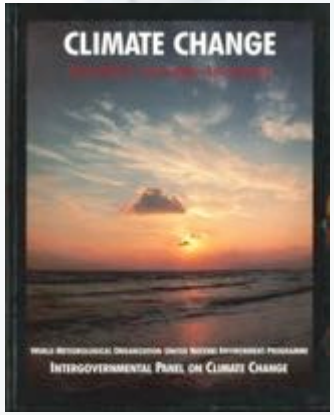
UNEP= United Nations Environment Programme

Inter-governmental Panel on Climate Change (IPCC): Organization Structure

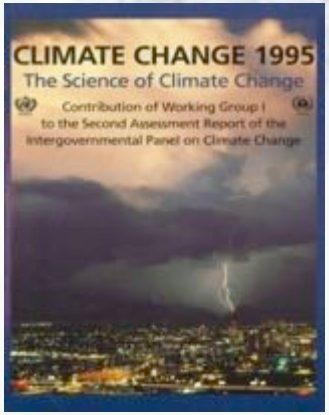


- IPCC plenary comprises of all countries in the world
- IPCC Bureau comprises of 34 elected members; IPCC elects its Bureau every 6-7 years
- 3 Working Groups & a Task Force on National Greenhouse Gas Inventories
- Authors, Contributors, Reviewers, Review Editors

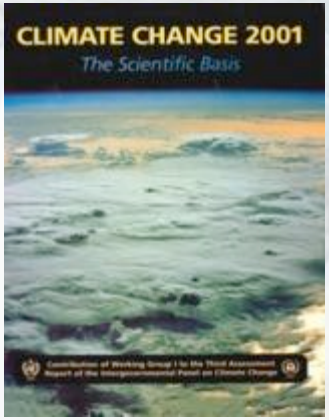
IPCC Assessment Reports



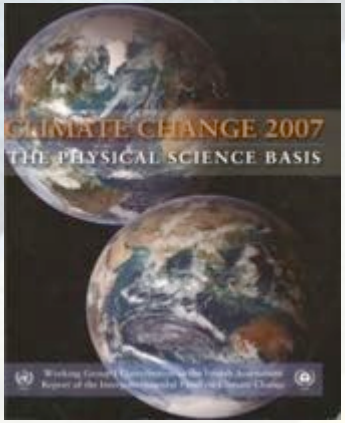
FAR 1990



SAR 1995



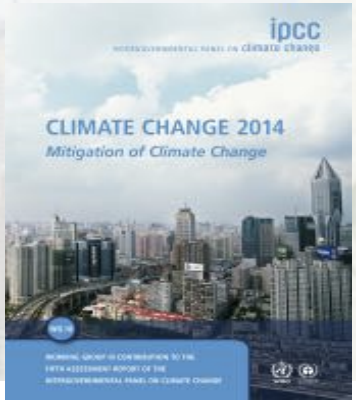
TAR 2001



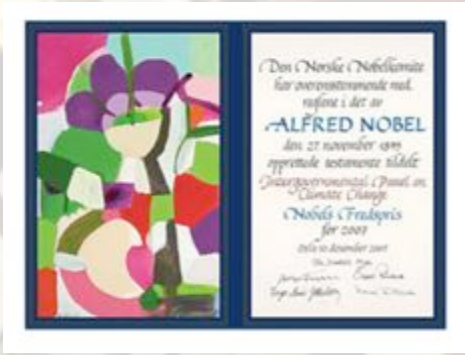
AR4 2007

AR5 WGI 2013

AR5 WGII 2014



AR5 WGIII 2014



IPCC AR5 Synthesis Report

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CLIMATE CHANGE AND WATER

IPCC Technical Paper VI

WMO

Intergovernmental Panel on Climate Change

UNEP

IPCC Technical Paper on Climate Change and Water

- ***Freshwater resources are vulnerable and have the potential to be strongly impacted by climate change, with wide-ranging consequences for human societies and ecosystems.***
- **Observed warming over several decades has been linked to changes in the large-scale hydrological cycle**
- **Climate model simulations for the 21st century are consistent in projecting precipitation increases in high latitudes (very likely) and parts of the tropics, and decreases in some subtropical and lower mid-latitude regions (likely)**
- **By the middle of the 21st century, annual average river runoff and water availability are projected to increase as a result of climate change at high latitudes and in some wet tropical areas, and decrease over some dry regions at mid-latitudes and in the dry tropics.**

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IPCC Technical Paper on Climate Change and Water

- **Increased precipitation intensity and variability are projected to increase the risks of flooding and drought in many areas.**
- **Water supplies stored in glaciers and snow cover are projected to decline in the course of the century**
- **Higher water temperatures and changes in extremes, including floods and droughts, are projected to affect water quality and exacerbate many forms of water pollution**
- ***Globally, the negative impacts of future climate change on freshwater systems are expected to outweigh the benefits*** **(*high confidence*).**

Jean-Pascal van Ypersele
(vanypersele@astr.ucl.ac.be)

IPCC Technical Paper on Climate Change and Water

- **Changes in water quantity and quality due to climate change are expected to affect food availability, stability, access and utilisation.**
- **Climate change affects the function and operation of existing water infrastructure – including hydropower, structural flood defences, drainage and irrigation systems – as well as water management practices.**
- ***Current water management practices may not be robust enough to cope with the impacts of climate change***
- ***Climate change challenges the traditional assumption that past hydrological experience provides a good guide to future conditions.***

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IPCC Technical Paper on Climate Change and Water

- **Adaptation options designed to ensure water supply during average and drought conditions require integrated demand-side as well as supply-side strategies**
- **Mitigation measures can reduce the magnitude of impacts of global warming on water resources, in turn reducing adaptation needsh**
- **Water resources management clearly impacts on many other policy areas**
- **Several gaps in knowledge exist in terms of observations and research needs related to climate change and water.**

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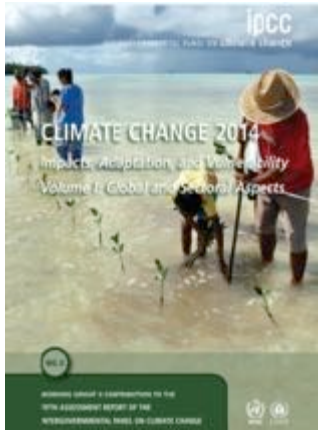
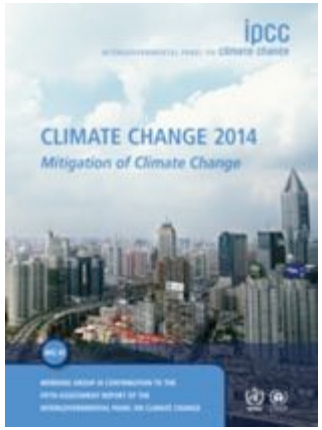
AR5 is the best ever

- Better integration of Mitigation and Adaptation
- Improved risk-management approach
- Evolving away from the non-mitigation SRES scenarios (SRES= Special Report on Emission Scenarios, 2000)
- Special effort to provide regional information when available
- Sustainable development & equity aspects
- More comprehensive treatment of economic aspects, and of cross-cutting issues
- Emerging issues handled (acidification, …)
- Better handling & communication of uncertainties





What is happening in the climate system?

What are the risks?

What can be done?

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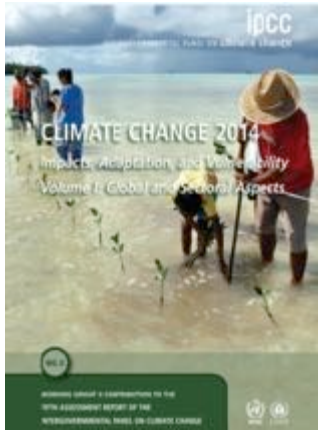
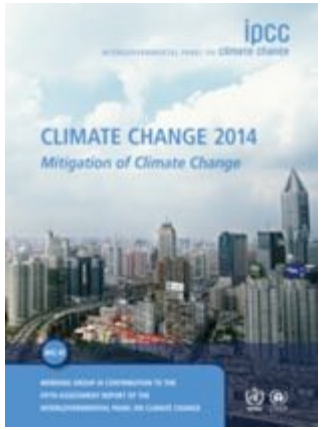
WG I (Physical science basis): 209 lead authors, 2014 pages, 54.677 review comments



WG II (Impacts, Adaptation and Vulnerability): 243 lead authors, 2500 pages, 50.492 review comments



WG III (Mitigation of Climate Change): 235 coordinating and lead authors, 2000 pages, 38.315 review comments

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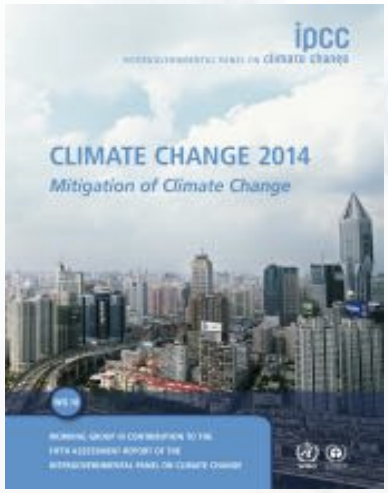
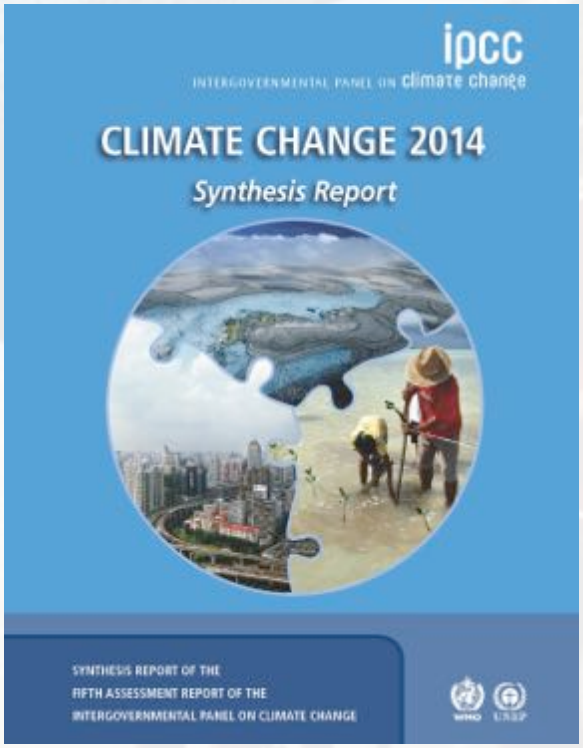
AR5 WGI 2013

AR5 WGII 2014



AR5 WGIII 2014



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Key messages from IPCC AR5

- **Human influence on the climate system is clear**
- **Continued emissions of greenhouse gases will increase the likelihood of severe, pervasive and irreversible impacts for people and ecosystems**
- **While climate change is a threat to sustainable development, there are many opportunities to integrate mitigation, adaptation, and the pursuit of other societal objectives**
- **Humanity has the means to limit climate change and build a more sustainable and resilient future**

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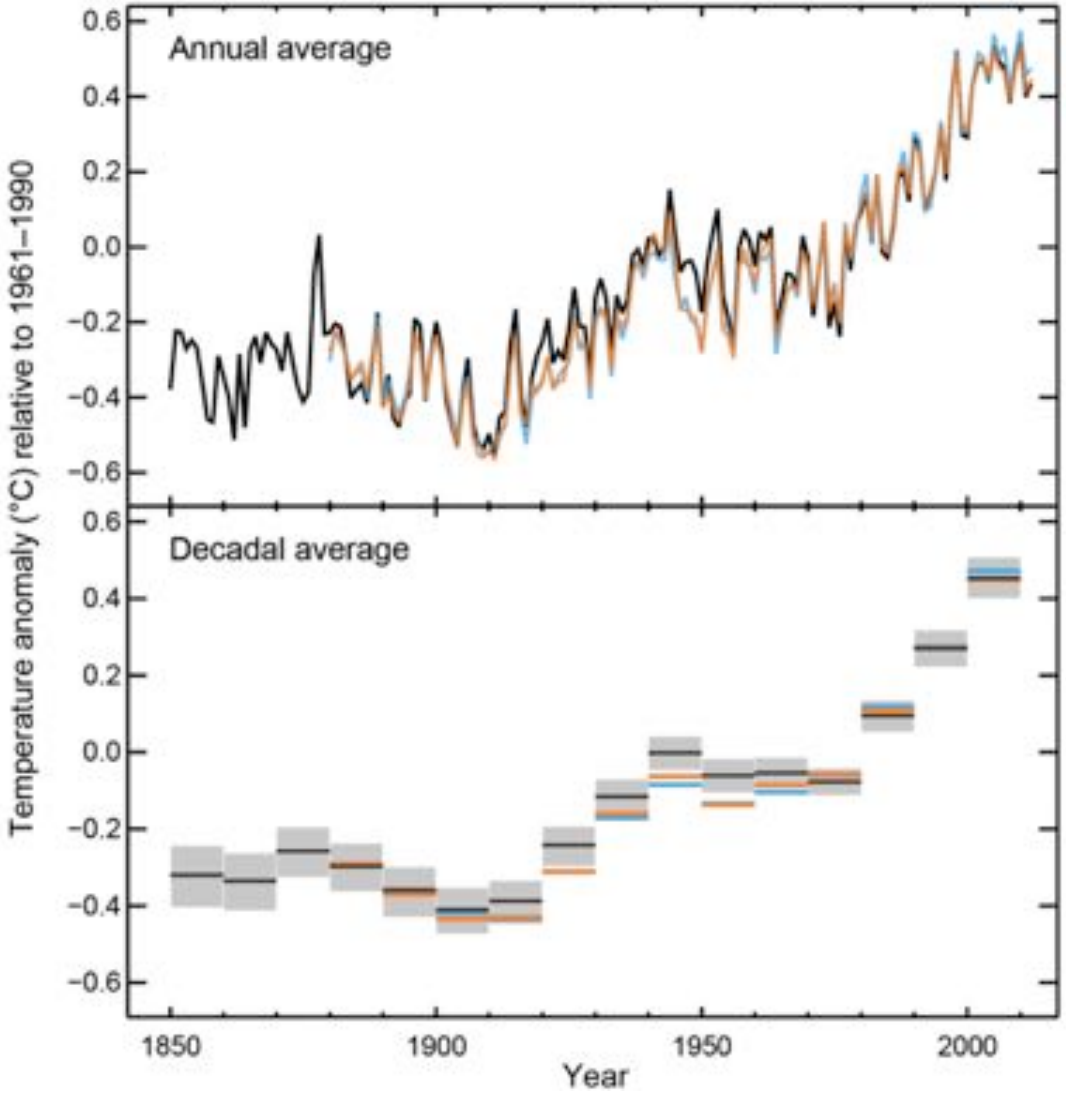
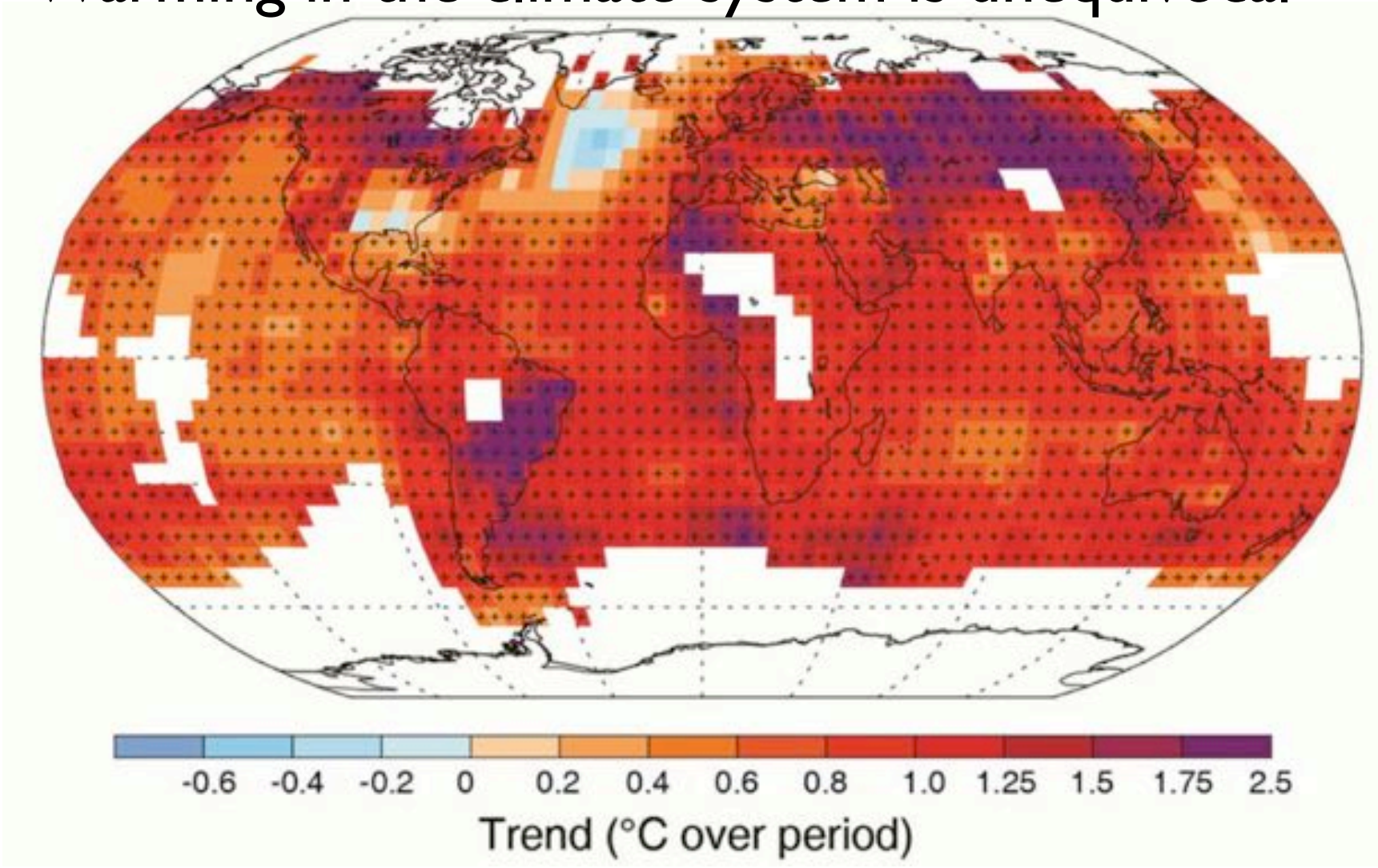
Figure SPM.1a Surface Temperature

Observed globally averaged combined land and ocean surface temperature anomaly 1850-2012



Change in average surface temperature 1901-2012

Warming in the climate system is unequivocal



IPCC AR5 WGI Fig. SPM 1b

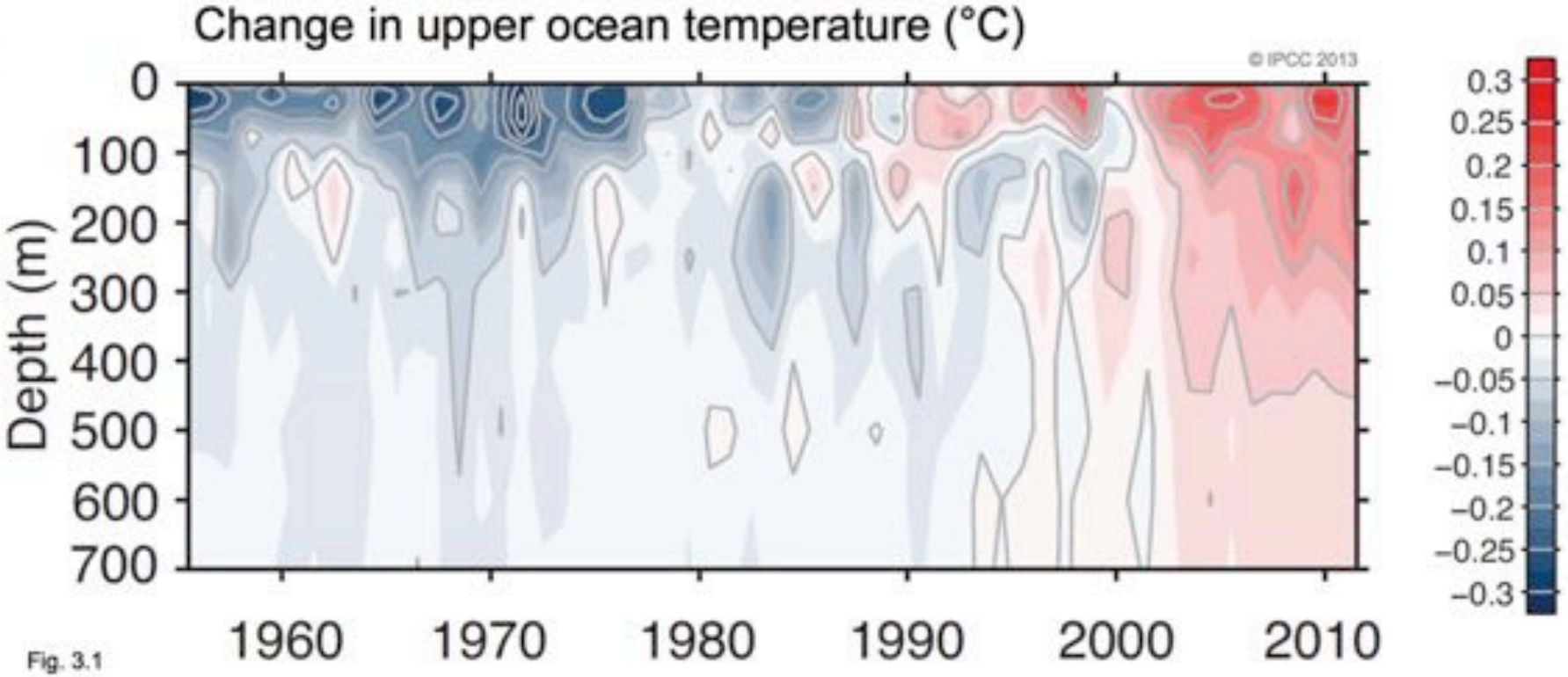


Fig. 3.1

It is *virtually certain* that the upper ocean (0-700 m) warmed from 1971 to 2010, [...]. It is *likely* that the ocean warmed between 700 and 2000 m from 1957 to 2009.

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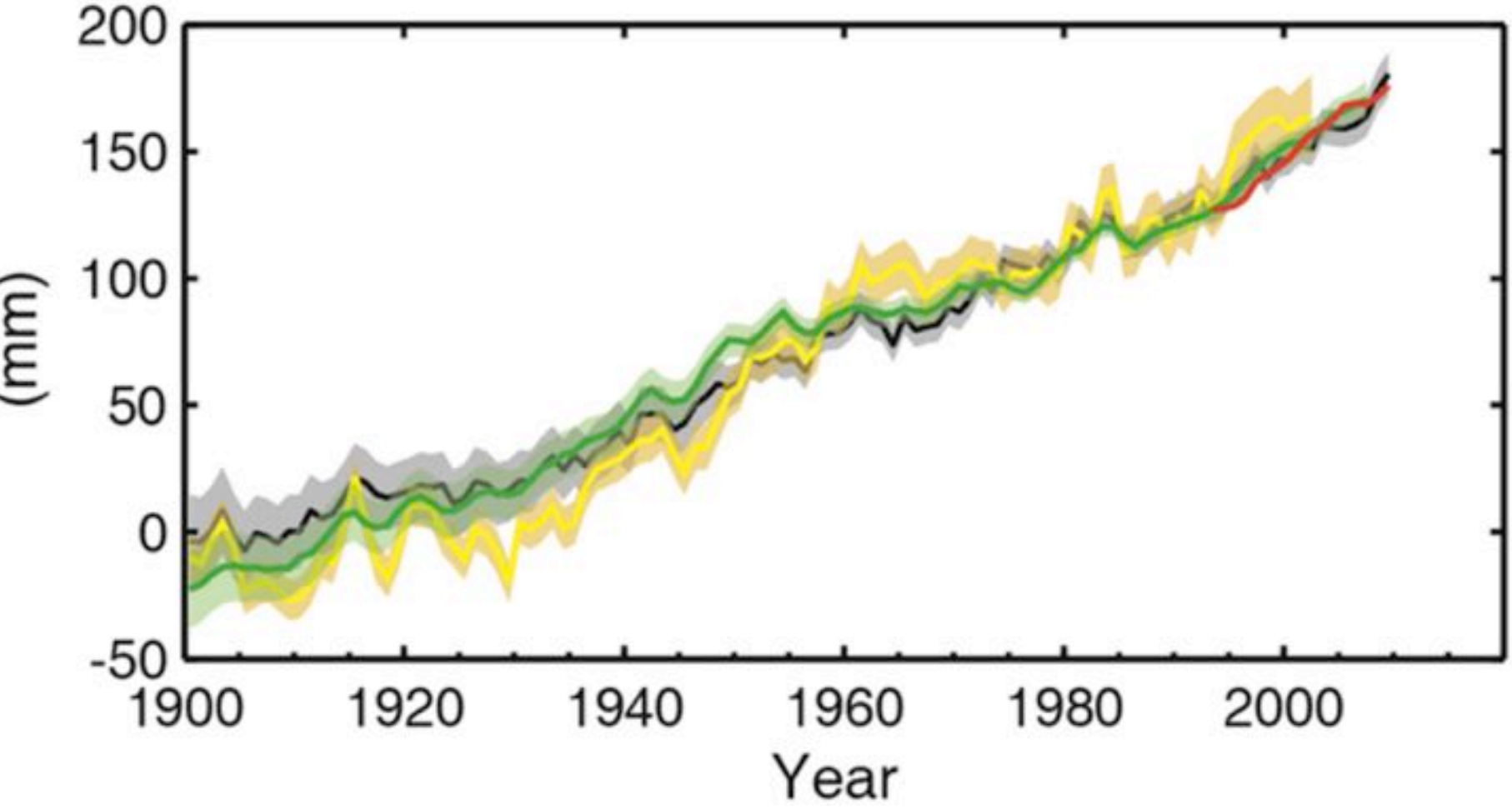
Change in average sea-level change



AR5 WGI SPM - Approved version / subject to final copyedit

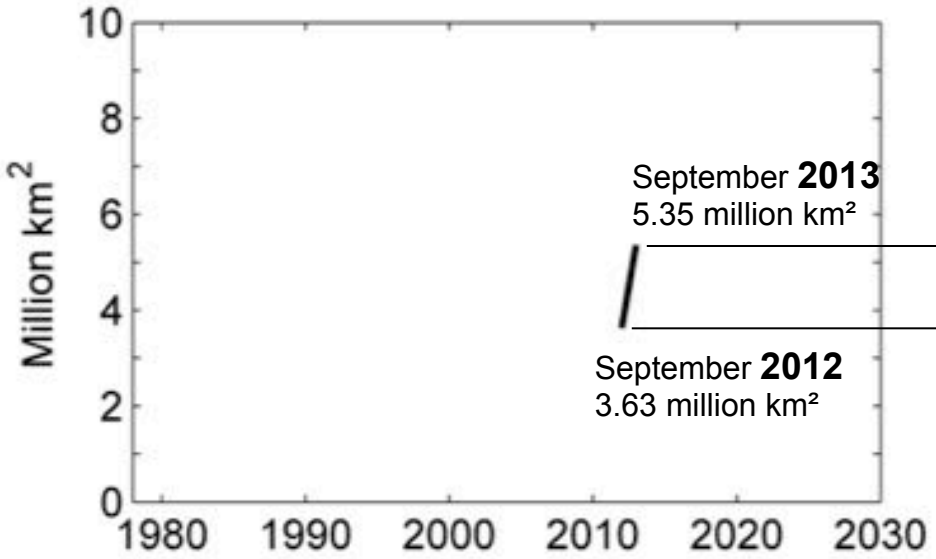
Plateau Glacier (1961)
(Alaska)

http://www.weather.com/news/science/environment/alaskas-glaciers-capturing-earth-changing-our-eyes-20131125?cm_ven=Email&cm_cat=ENVIRONMENT_us_share

Plateau Glacier (2003)
(Alaska)

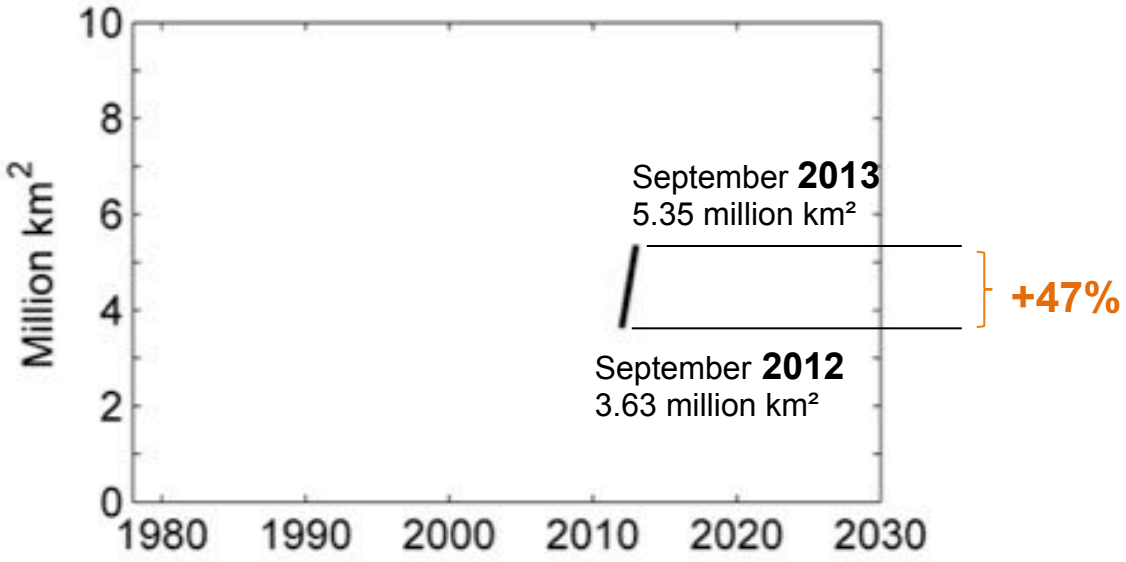
http://www.weather.com/news/science/environment/alaskas-glaciers-capturing-earth-changing-our-eyes-20131125?cm_ven=Email&cm_cat=ENVIRONMENT_us_share

Observed Arctic September sea ice extent



Credit: F. Massonnet, UCL, 2013
Sea ice extent data: www.nsidc.org

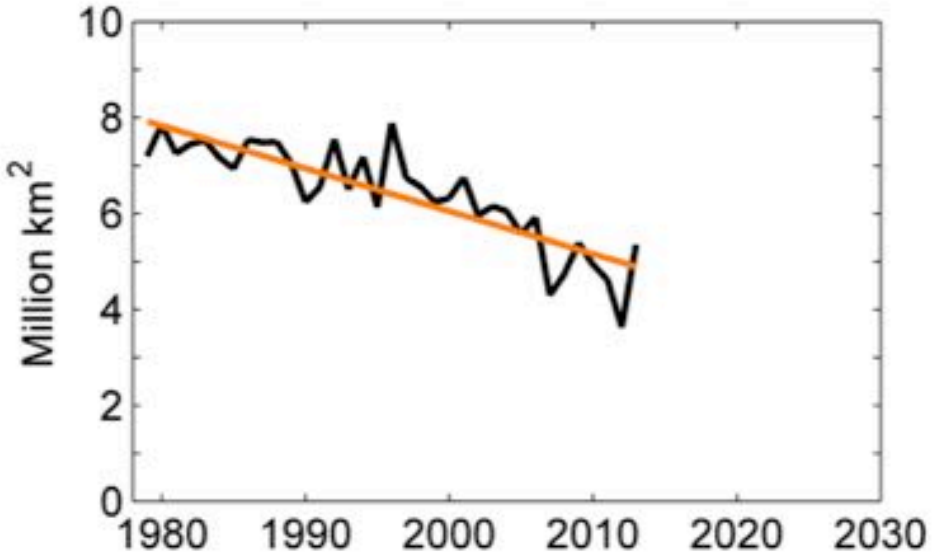
Observed Arctic September sea ice extent



Cherry-picking analysis

-« Arctic sea ice cover is rebounding »

-« Climate is cooling »



Scientific approach: the full view

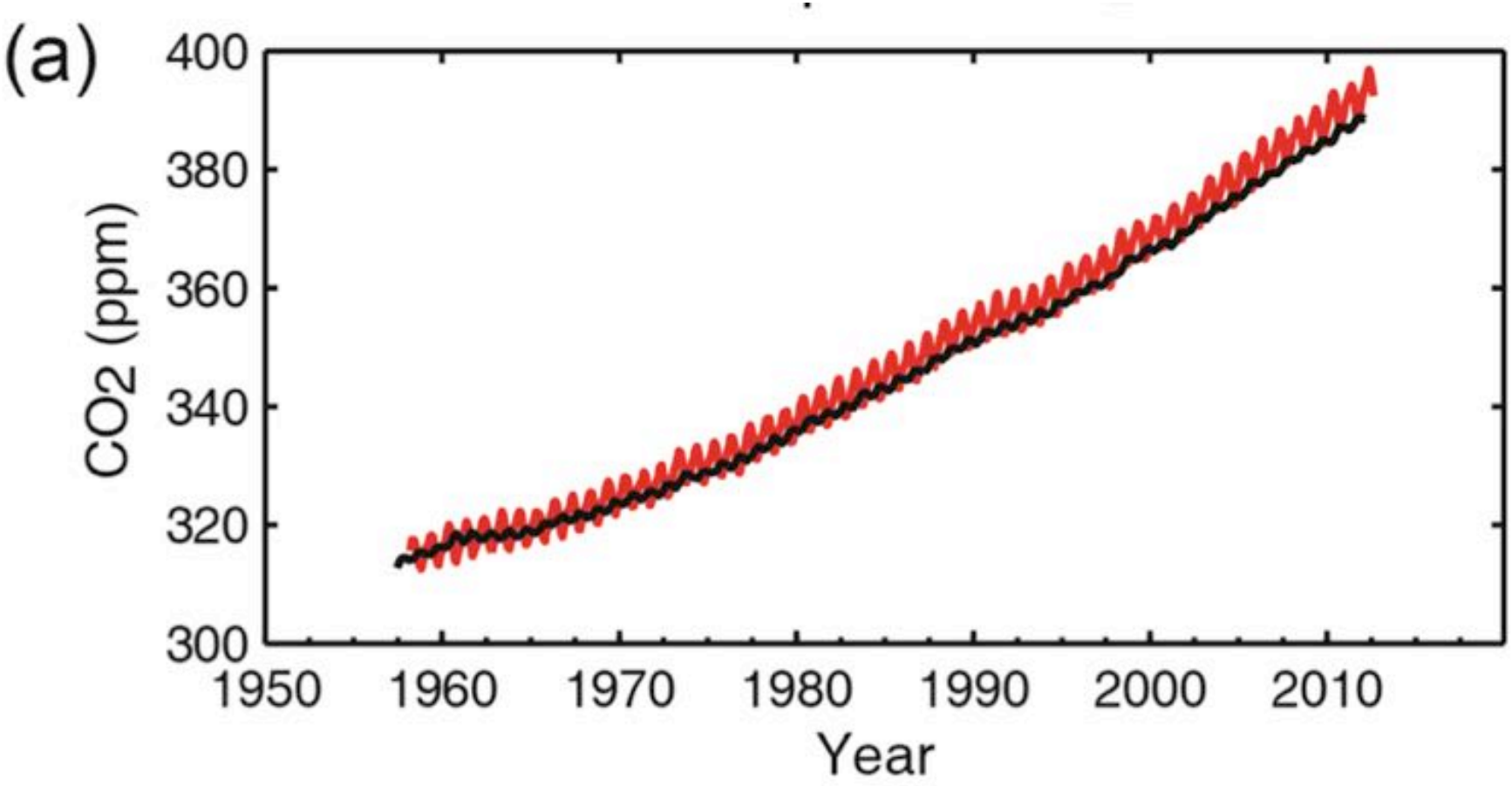
-Variability of September sea ice extent at the interannual time scale is important

-Significant negative trend over record period (1979-2013): −0.89 million km²/ decade

-September 2013 sea ice extent is 6th lowest on record and 16.5% below 1979-2013 average

Credit: F. Massonnet, UCL, 2013
Sea ice extent data: www.nsidc.org

Atmospheric CO_2 concentration

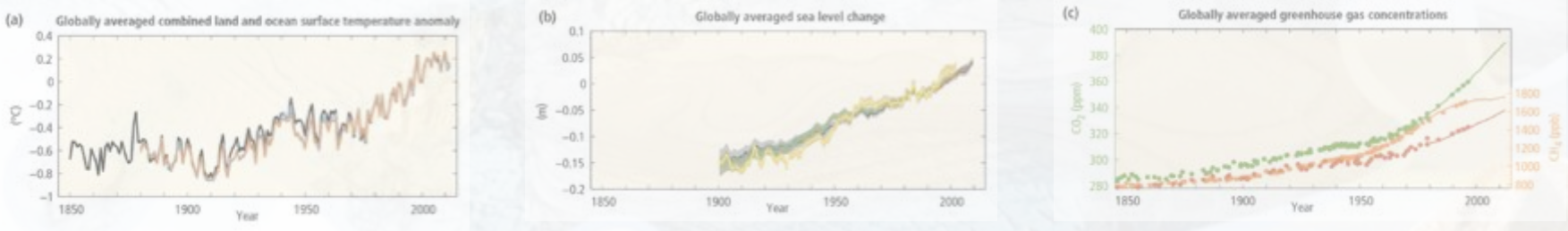


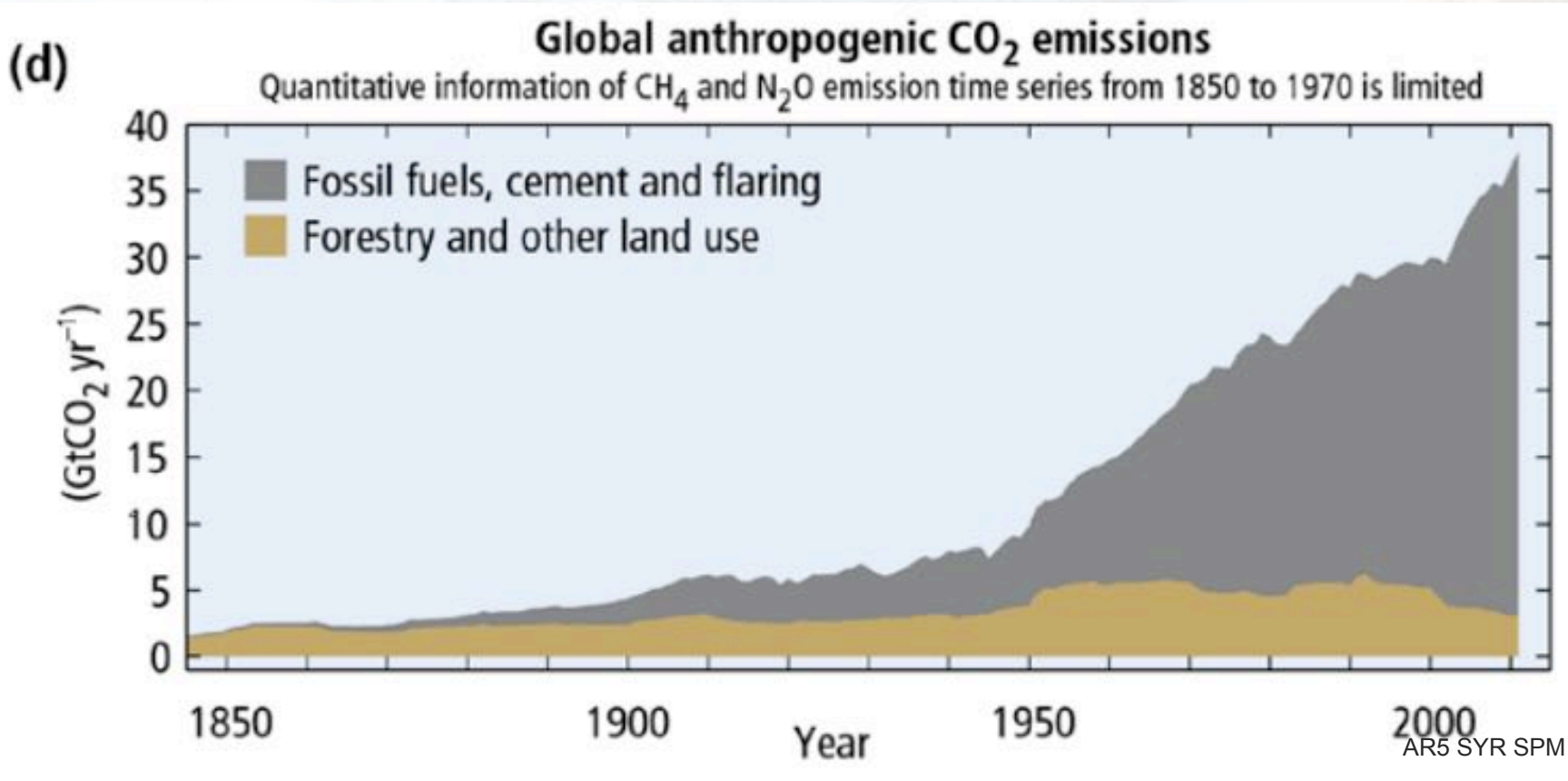
AR5 WGI SPM - Approved version / subject to final copyedit

Atmospheric concentrations of CO_2

(Lüthi et al.,2008, NOAA)

The concentrations of CO_2 have increased to levels unprecedented in at least the last 800,000 years.





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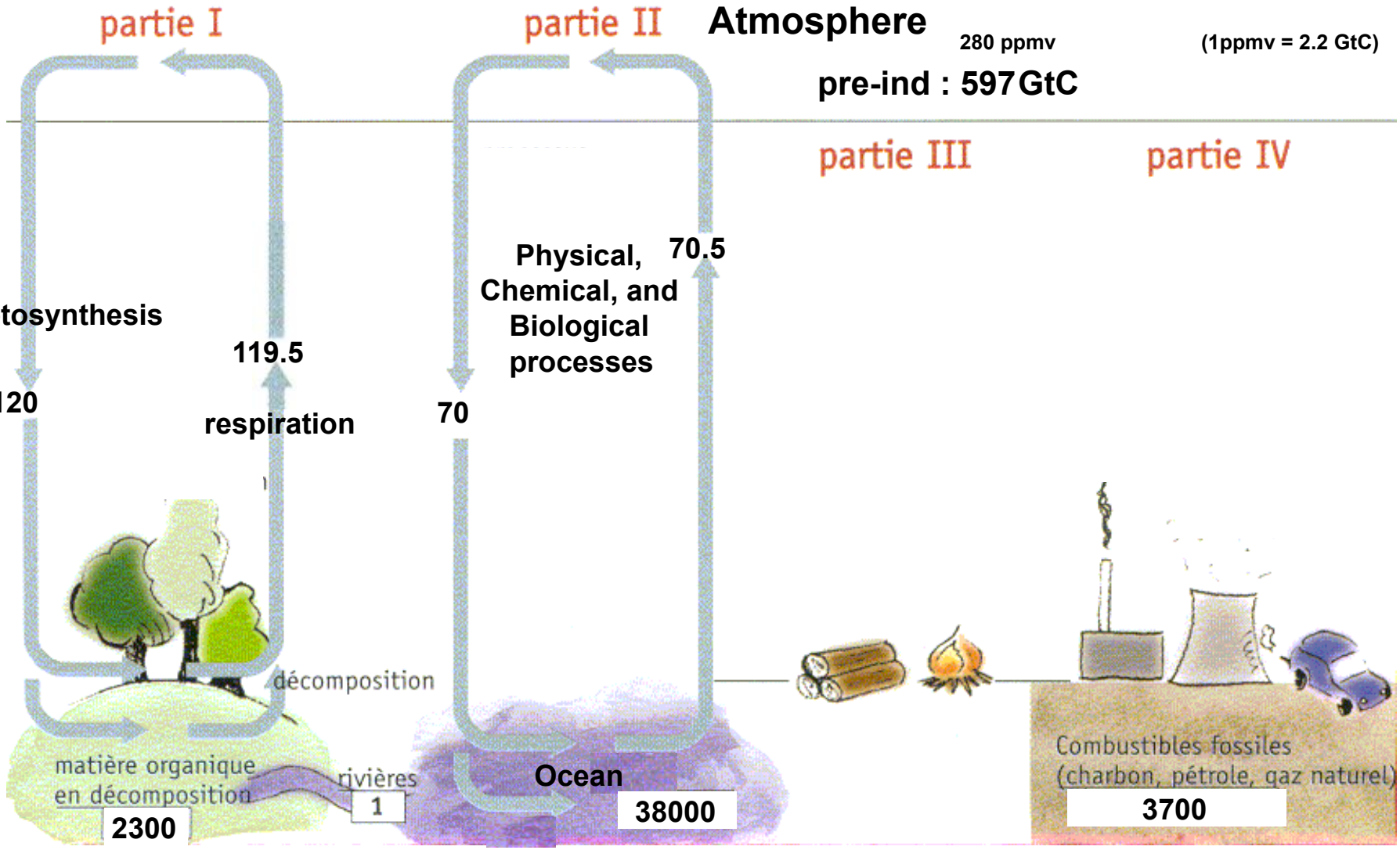
Carbon cycle: unperturbed fluxes

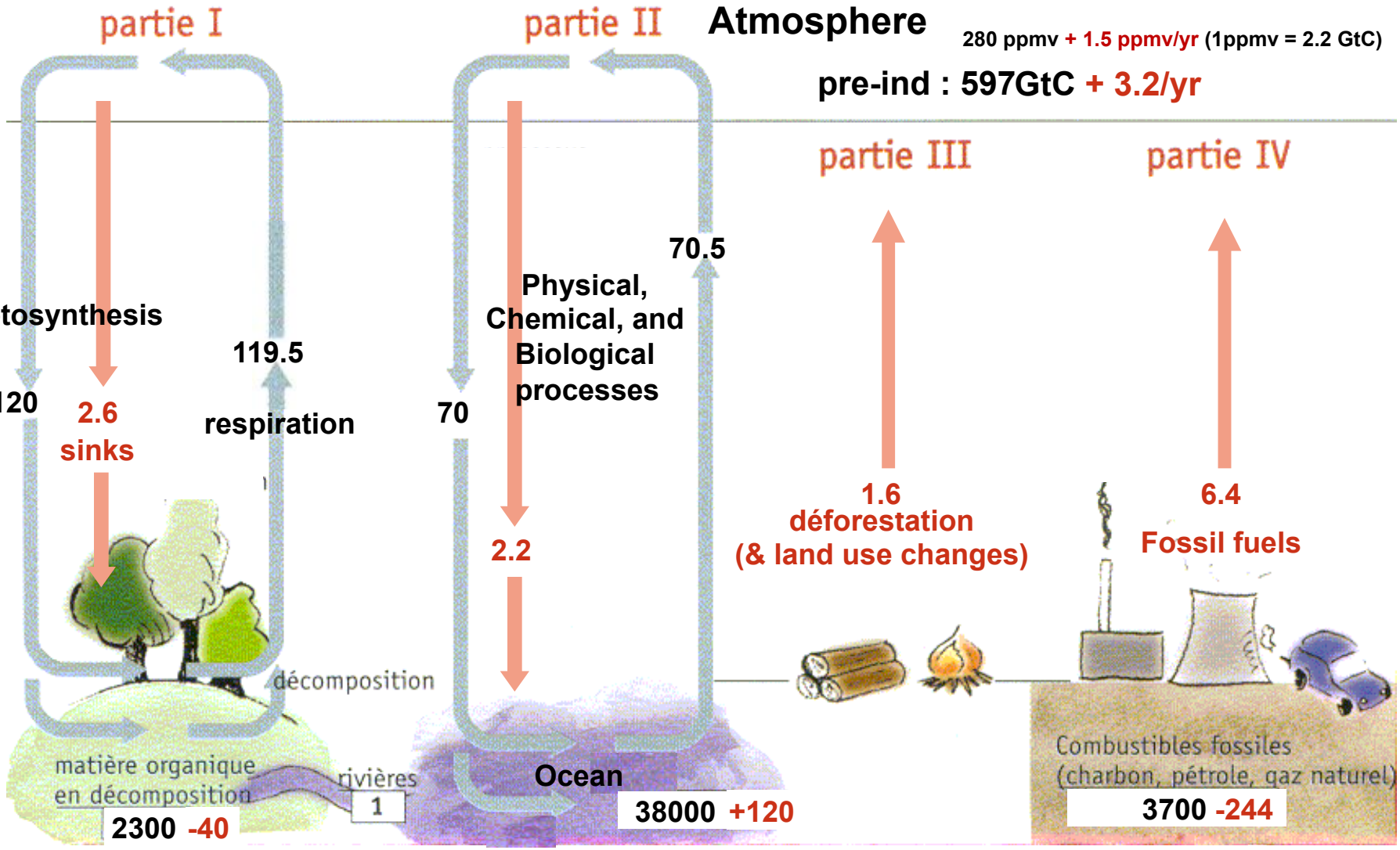


Units: GtC (billions tons of carbon) or GtC/year (multiply by 3.7 to get $GtCO_2$)

vanyp@climate.be

Carbon cycle: perturbed by human activities

(numbers for the decade 1990-1999s, based on IPCC AR4)



Units: GtC (billions tons of carbon) or GtC/year

Stocks!

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The carbon cycle is policy-relevant

- **CO_2 accumulates in the atmosphere as long as human emissions are larger than the natural absorption capacity**
- **Historical emissions (mostly from developed countries) therefore matter for a long time**
- **As warming is function of cumulated emissions, the carbon « space » is narrowing fast (to stay under 1.5 or 2°C warming)**

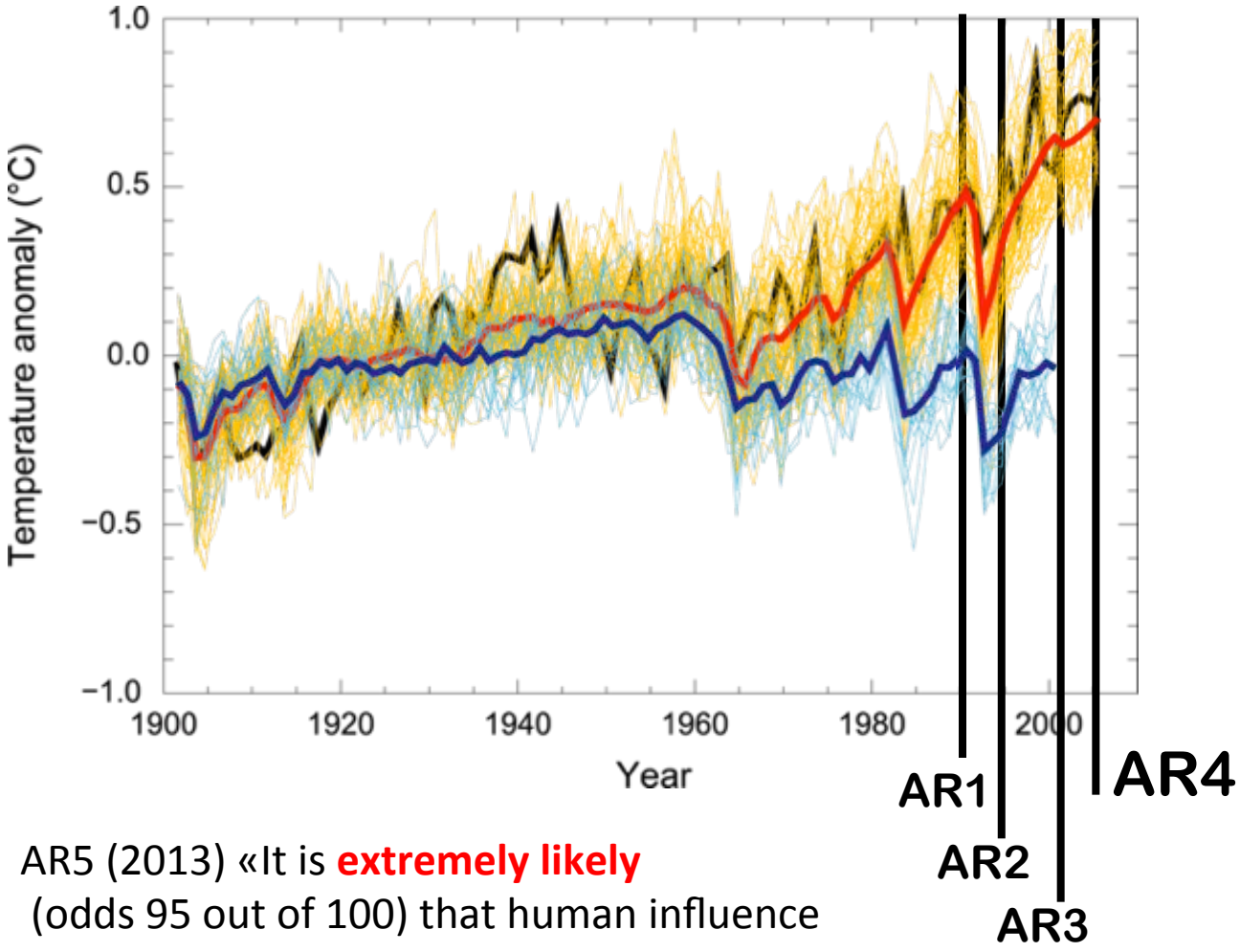
A Progression of Understanding: Greater and Greater Certainty in Attribution

AR1 (1990): "unequivocal detection not likely for a decade"

AR2 (1995): "balance of evidence suggests **discernible** human influence"

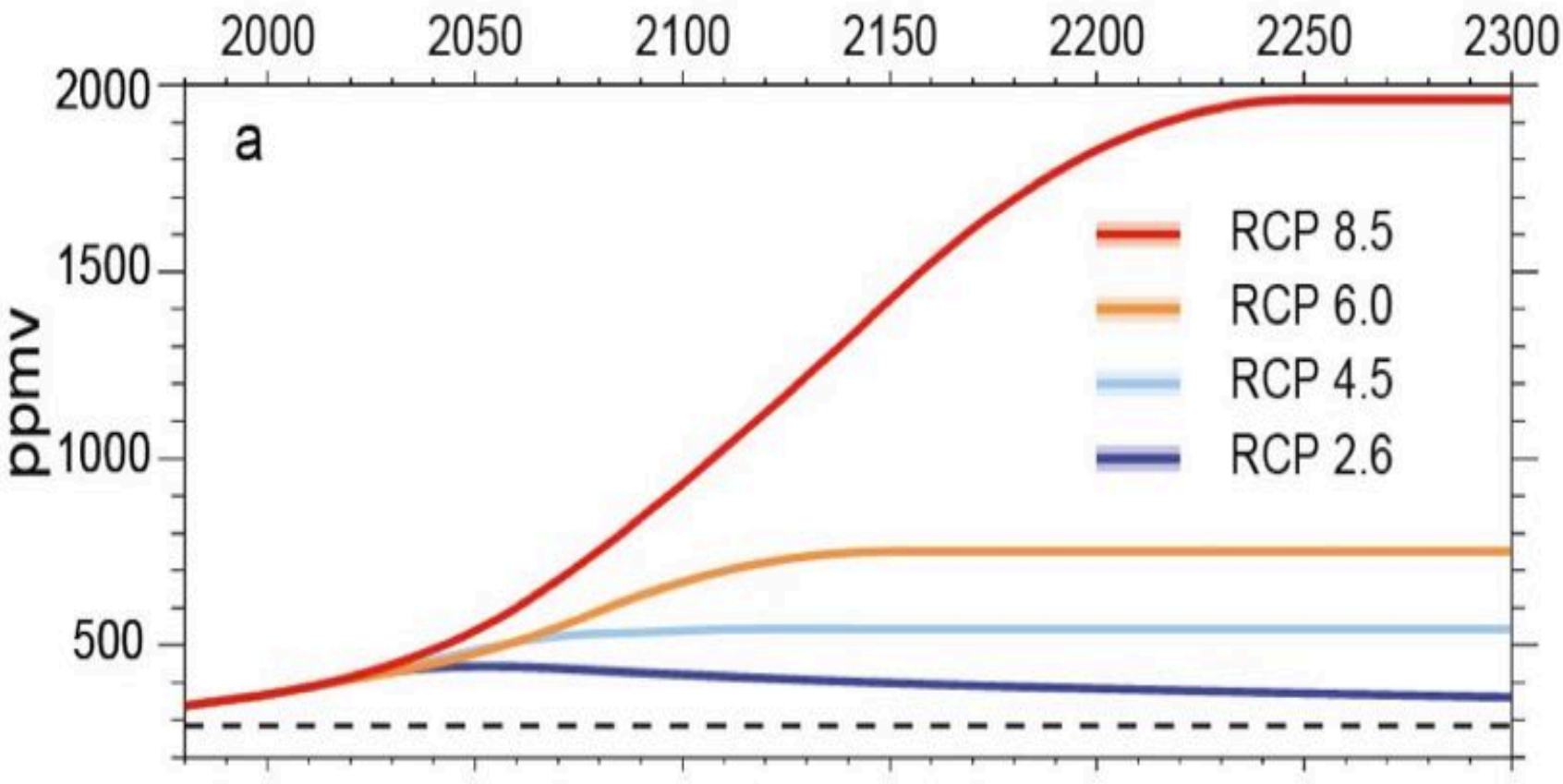
AR3 (2001): "most of the warming of the past 50 years is **likely** (odds 2 out of 3) due to human activities"

AR4 (2007): "most of the warming is **very likely** (odds 9 out of 10) due to greenhouse gases"



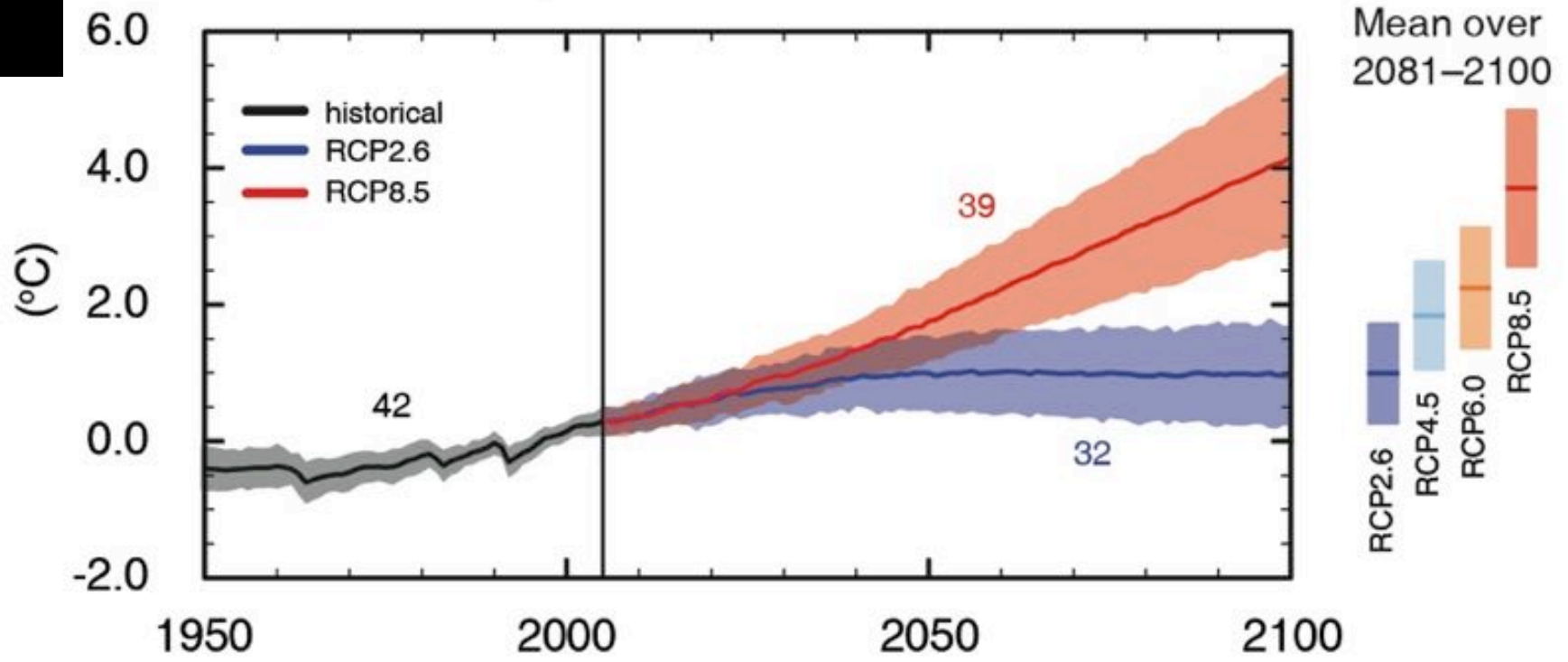
AR5 (2013) «It is **extremely likely** (odds 95 out of 100) that human influence has been the dominant cause… »

RCP Scenarios: Atmospheric CO_2 concentration



Three stabilisation scenarios: RCP 2.6 to 6
One Business-as-usual scenario: RCP 8.5

AR5, chapter 12. WGI- Adopted version / subject to final copyedit



(IPCC 2013, Fig. SPM.7a)

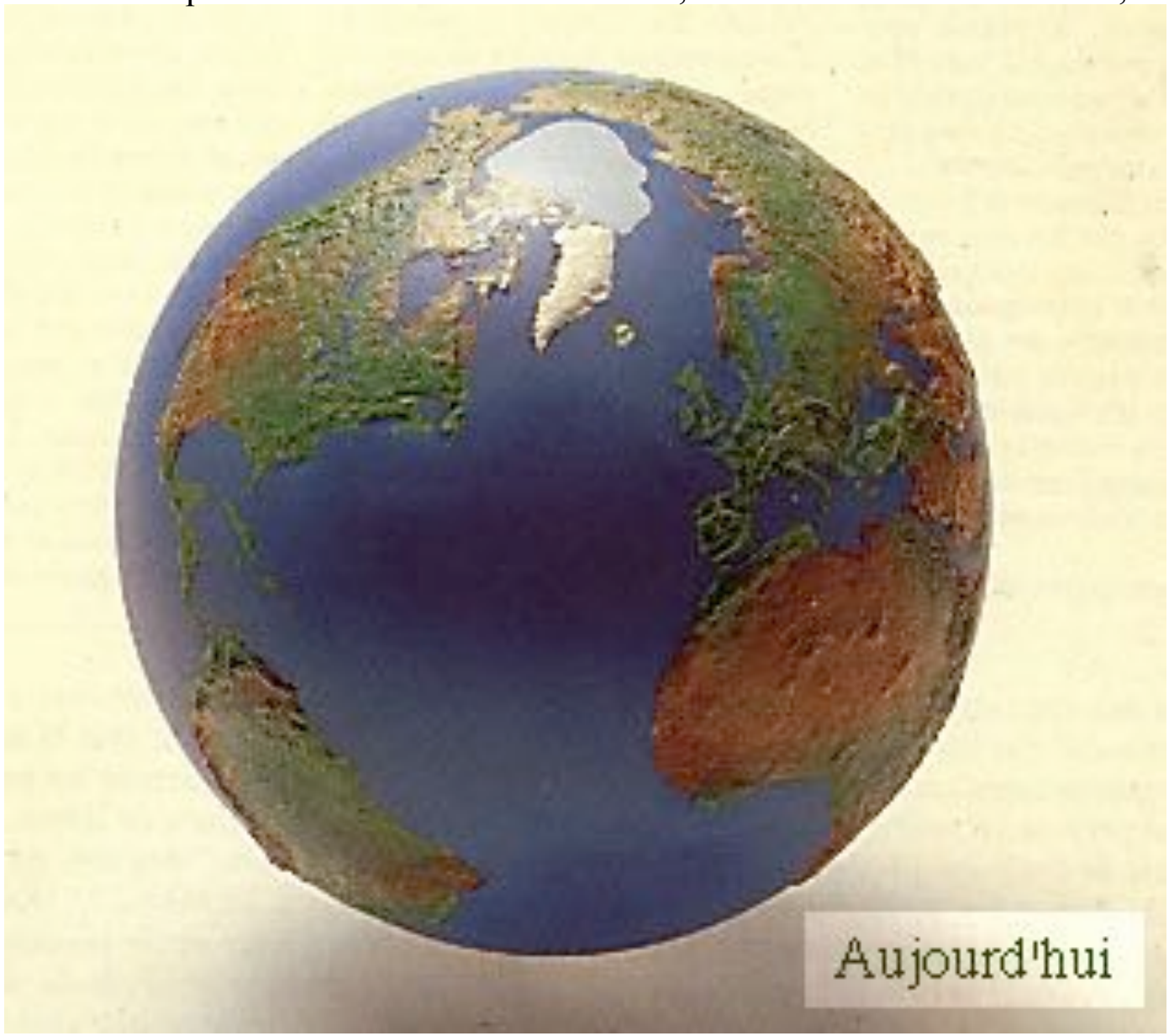
Only the lowest (RCP2.6) scenario maintains the global surface temperature increase above the pre-industrial level to less than 2°C with at least 66% probability

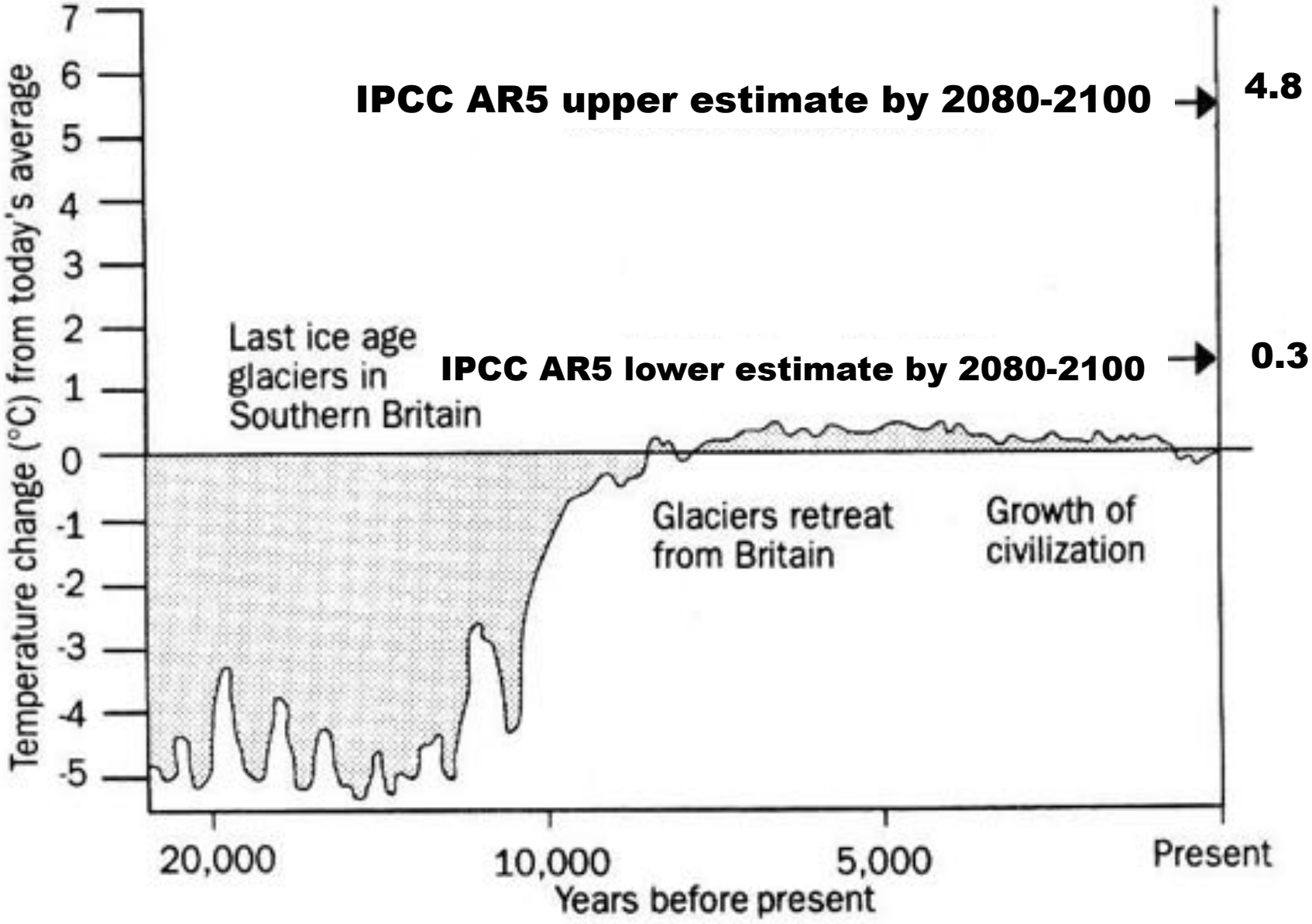
18-20000 years ago (Last Glacial Maximum)

With permission from Dr. S. Joussaume, in « Climat d'hier à demain », CNRS éditions.

Today, with +4-5°C globally

With permission from Dr. S. Joussaume, in « Climat d'hier à demain », CNRS éditions.





Adapted from: International Geosphere Biosphere Programme Report no.6, Global Changes of the Past, July1988

RCP2.6 RCP8.5

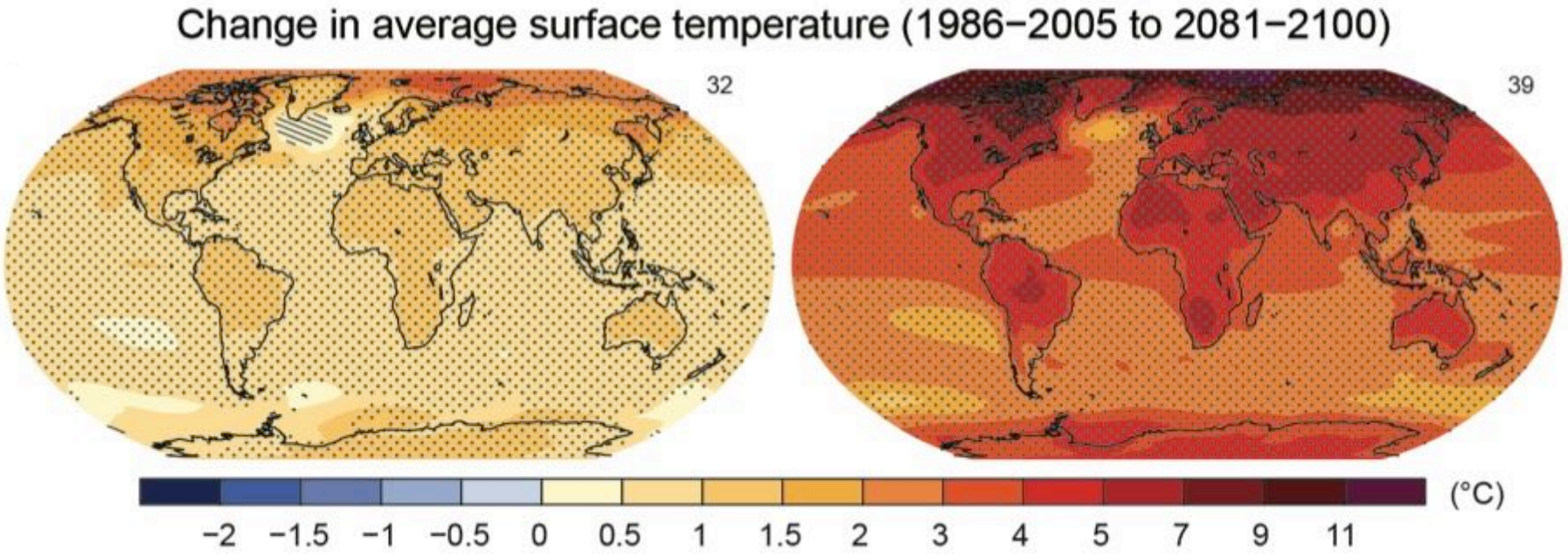
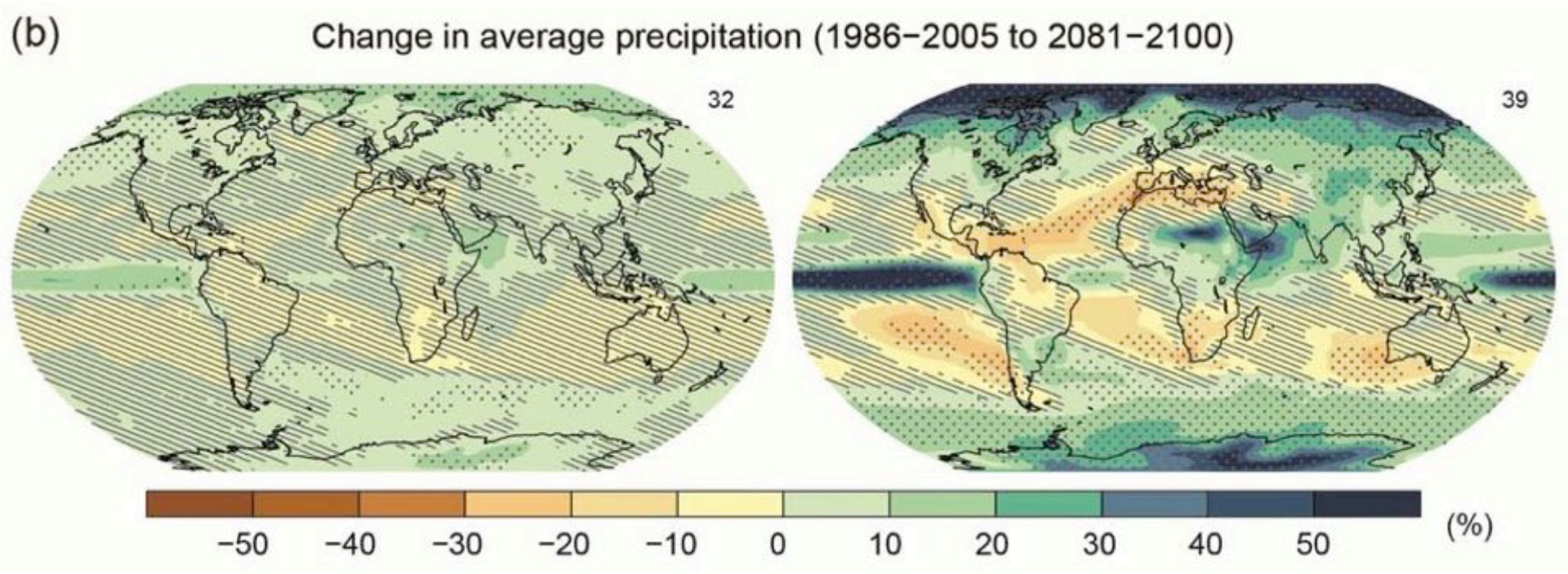


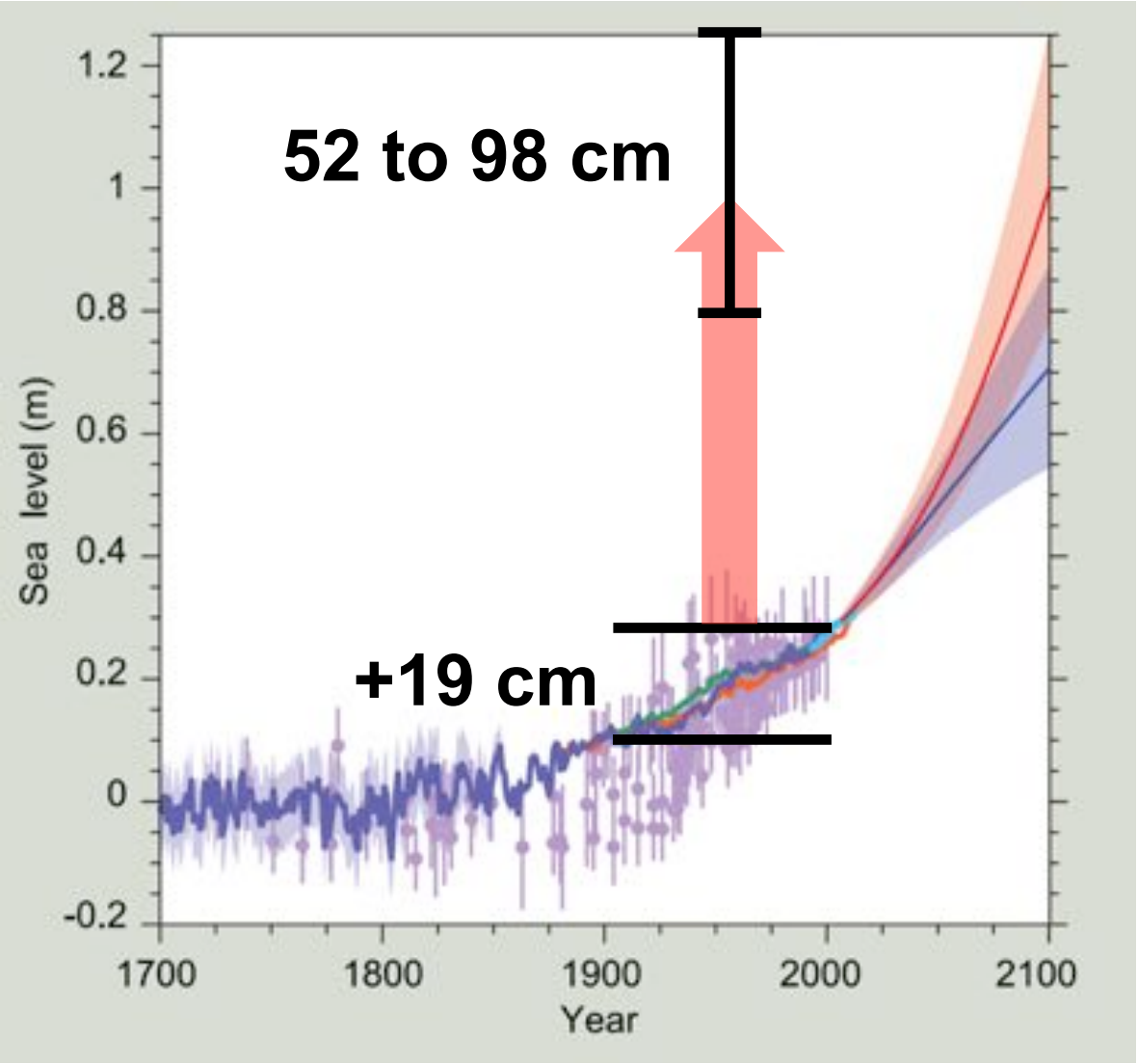
Fig. SPM.8

Humanity has the choice

Projected Change in Precipitation



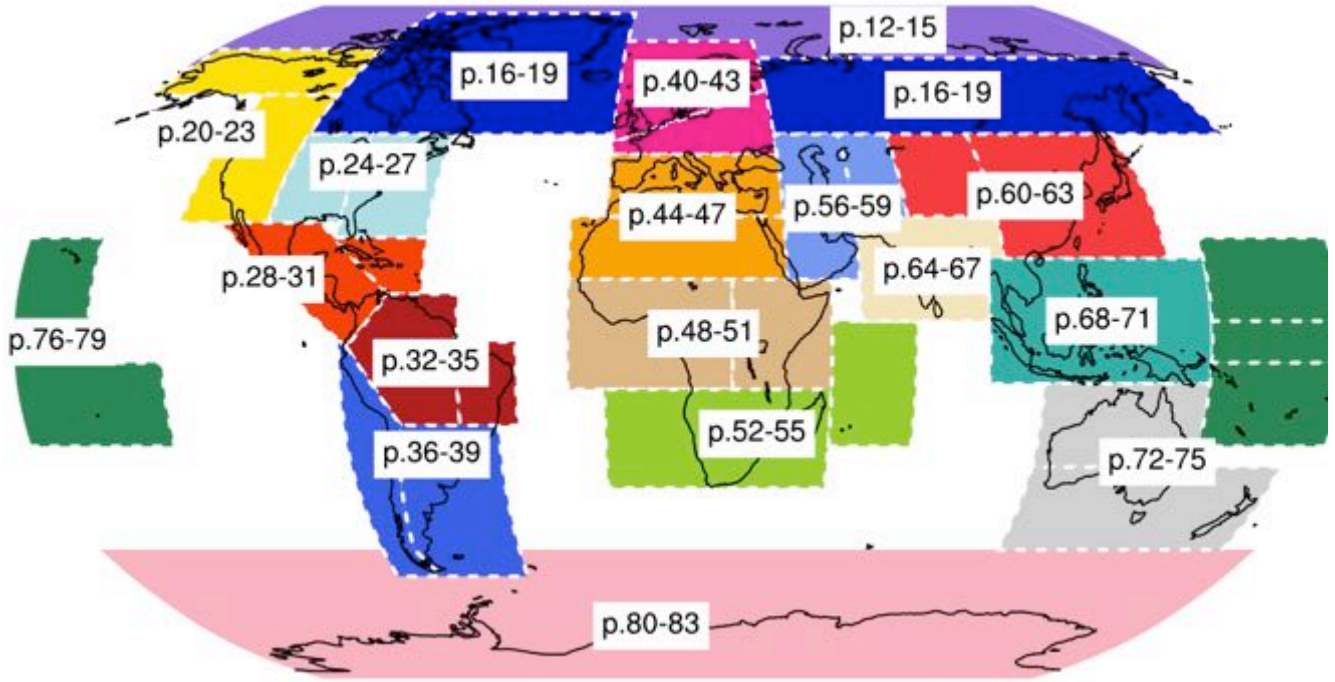
Sea Level



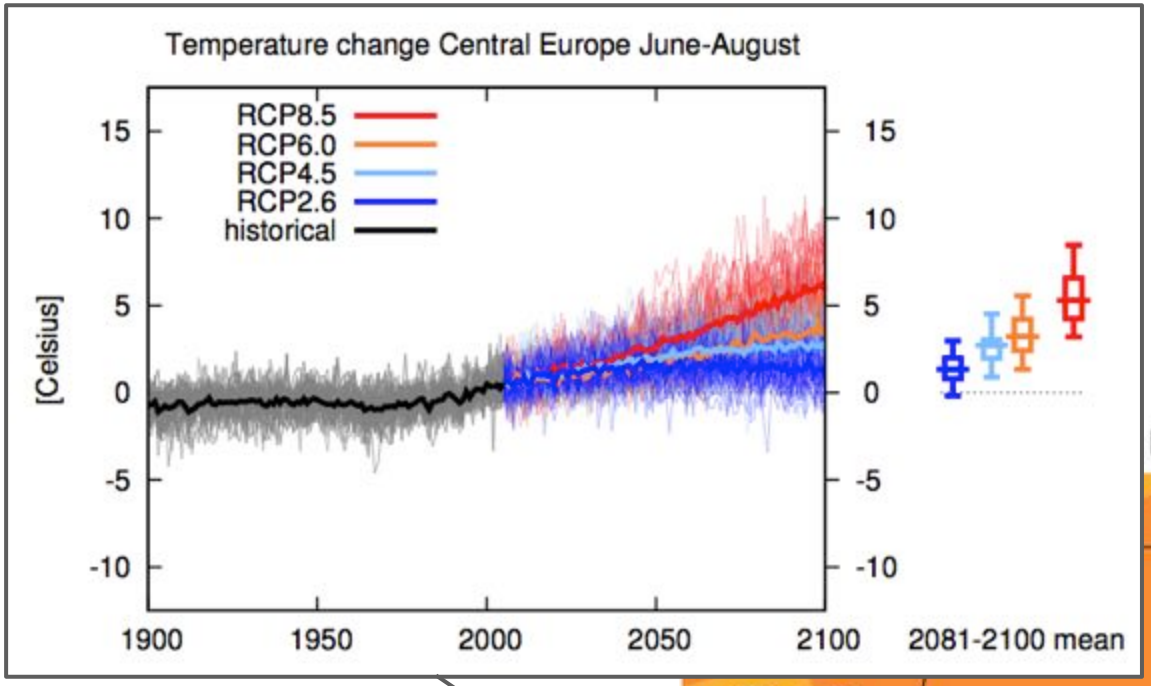
IPCC 2013, TFE.2, Fig. 2

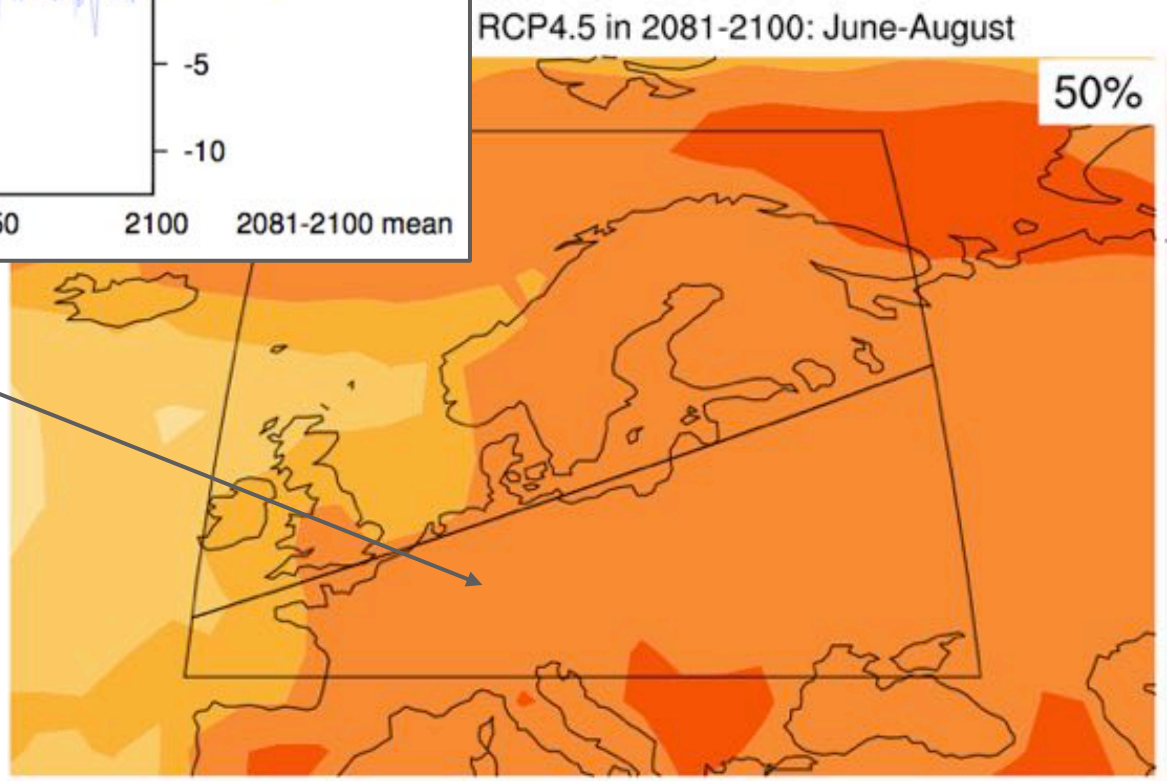
AR5 WGI Regional Atlas

- Addition to previous reports
- > 70 pages of maps, for RCP4.5 only:
  temperature and precipitation changes
  (winter & summer average climate, including model uncertainties)
- Other RCPs & seasons are available as suppl. material



Regional Atlas - «Central Europe», summer temp.

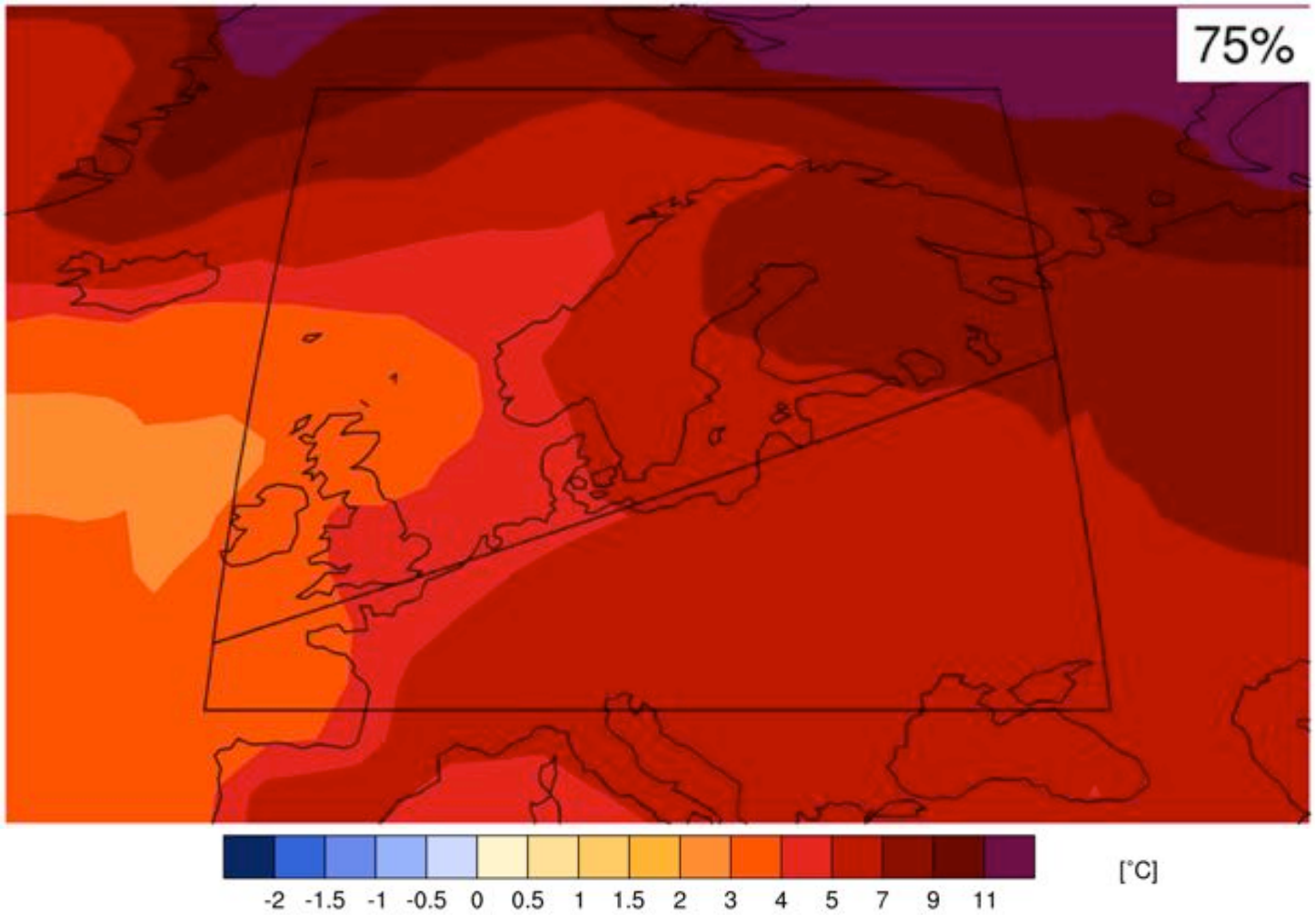




Median of multi-model distribution, average temp change JJA, 2081-2100

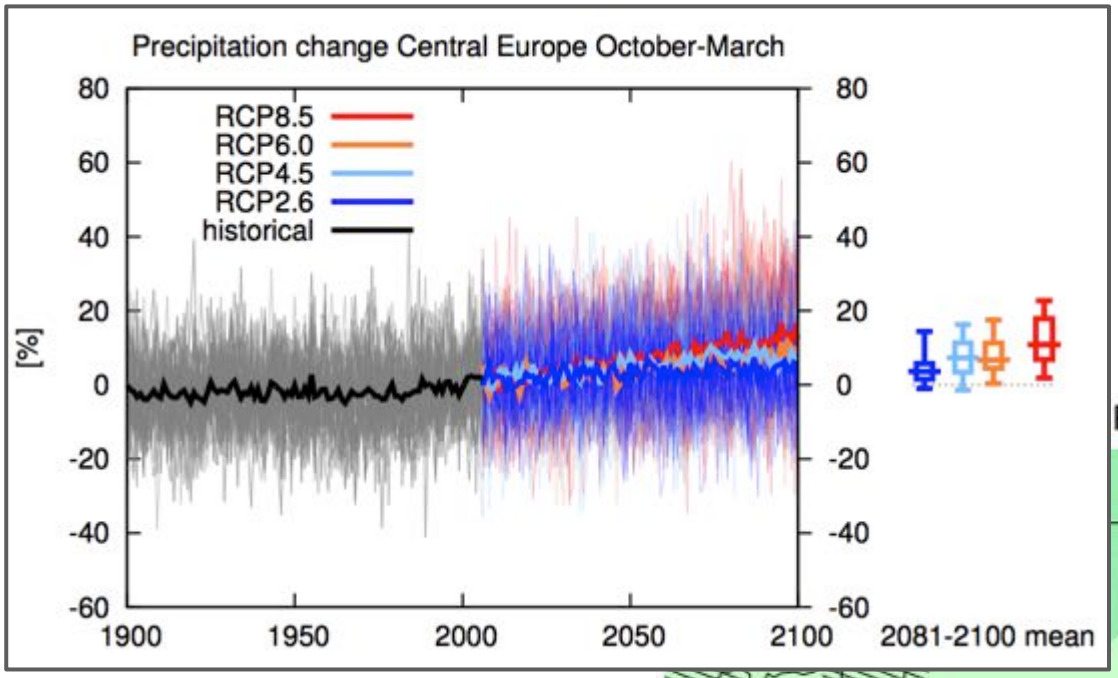
°C / 1985-2005

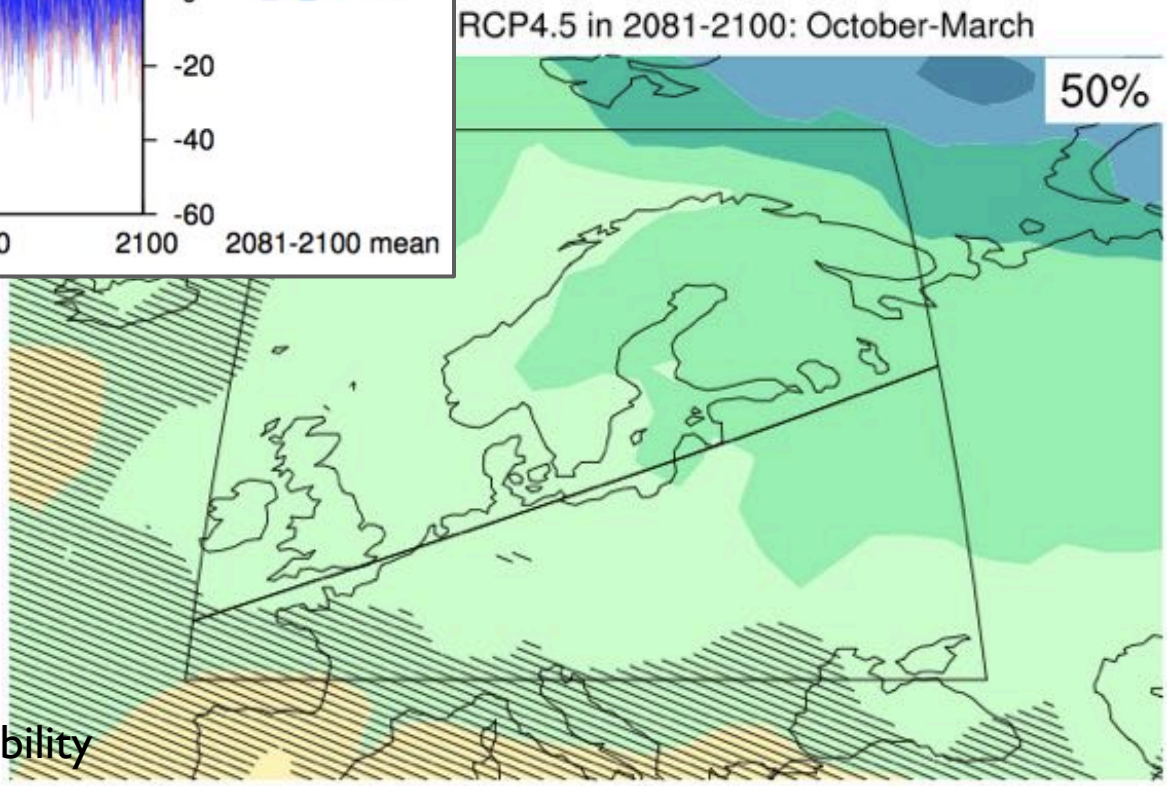
North Europe - Map of temperature changes: 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario (annual)



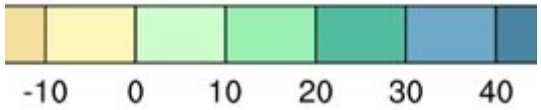
IPCC WG1 Fifth Assessment Report (Final Draft)

Regional Atlas - «Central Europe», precipitation





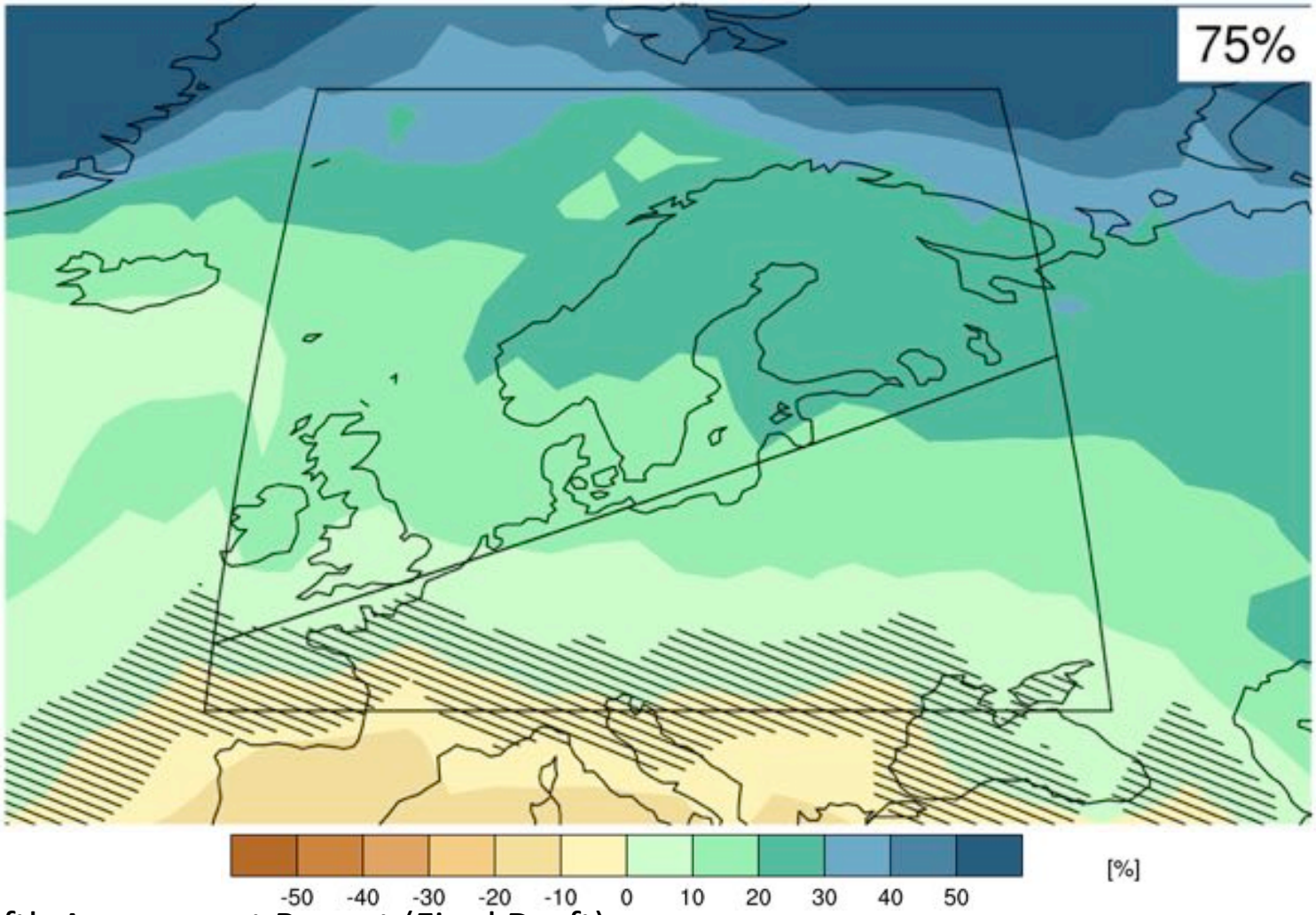
Median of multi-model distribution, average over October-March, 2081-2100



% 1985-2005

(hatching : change < present day variability for 20 years periods)

North Europe - Map of precipitation changes in 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario (annual)



IPCC WG1 Fifth Assessment Report (Final Draft)

Since 1950, extreme hot days and heavy precipitation have become more common

There is evidence that anthropogenic influences, including increasing atmospheric greenhouse gas concentrations, have changed these extremes

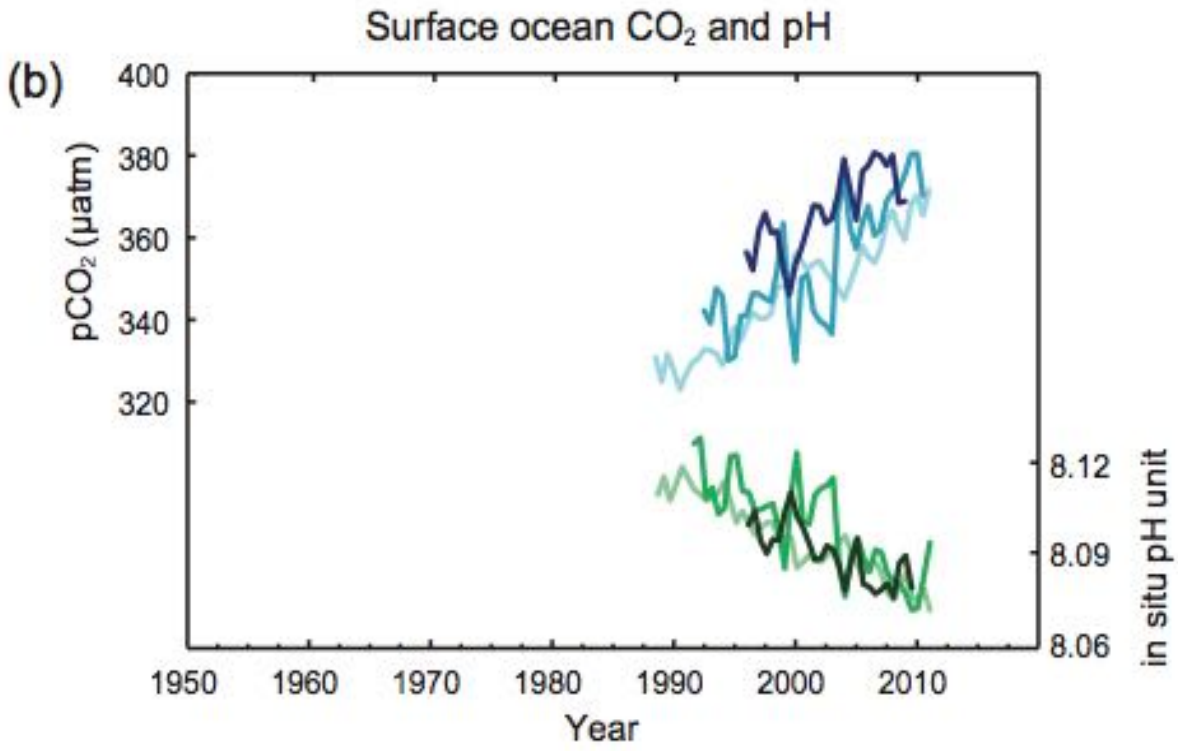
More heavy precipitation and more droughts….

Extreme weather and climate events

Phenomenon and direction of trend	Assessment that changes occurred (typically since 1950 unless otherwise indicated)	Assessment of a human contribution to observed changes	Likelihood of further changes	
			Early 21st century	Late 21st century
Warmer and/or fewer cold days and nights over most land areas	*Very likely*	***Very likely***	*Likely*	***Virtually certain***
Warmer and/or more frequent hot days and nights over most land areas	*Very likely*	***Very likely***	*Likely*	***Virtually certain***
Warm spells/heat waves. Frequency and/or duration increases over most land areas	***Medium confidence*** on a global scale Likely in large parts of Europe, Asia and Australia	***Likely***	Not formally assessed	***Very likely***
Heavy precipitation events. Increase in the frequency, intensity, and/or amount of heavy precipitation	*Likely more land areas with increases than decreases*	***Medium confidence***	*Likely* over many land areas	***Very likely*** over most of the mid-latitude land masses and over wet tropical regions
Increases in intensity and/or duration of drought	***Low confidence*** on a global scale Likely changes in some regions	***Low confidence***	*Low confidence*	***Likely*** *(medium confidence)* on a regional to global scale
Increases in intense tropical cyclone activity	***Low confidence*** in long term (centennial) changes Virtually certain in North Atlantic since 1970	***Low confidence***	*Low confidence*	***More likely than not*** in the Western North Pacific and North Atlantic
Increased incidence and/or magnitude of extreme high sea level	*Likely* (since 1970)	***Likely***	*Likely*	***Very likely***

IPCC, AR5, Table SPM.1

Oceanic uptake of CO_2 has resulted in acidification of the ocean



The pH of ocean surface water has decreased by 0.1 (*high confidence*), corresponding to a 26% of increase in acidity, measured as hydrogen ion concentration

AR5 SYR; AR5 WG1 SPM.4b

Impacts are already underway

- Tropics to the poles
- On all continents and in the ocean
- Affecting rich and poor countries (but the poor are more vulnerable everywhere)




AR5 WGII SPM

Risk = Hazard x Vulnerability x Exposure (Katrina flood victim)

AP Photo - Lisa Krantz (http://lisakrantz.com/hurricane-katrina/zspbn1k4cn17phidupe4f9x5t1mzdr)

Potential Impacts of Climate Change

Food and water shortages

Increased displacement of people

Increased poverty

Coastal flooding

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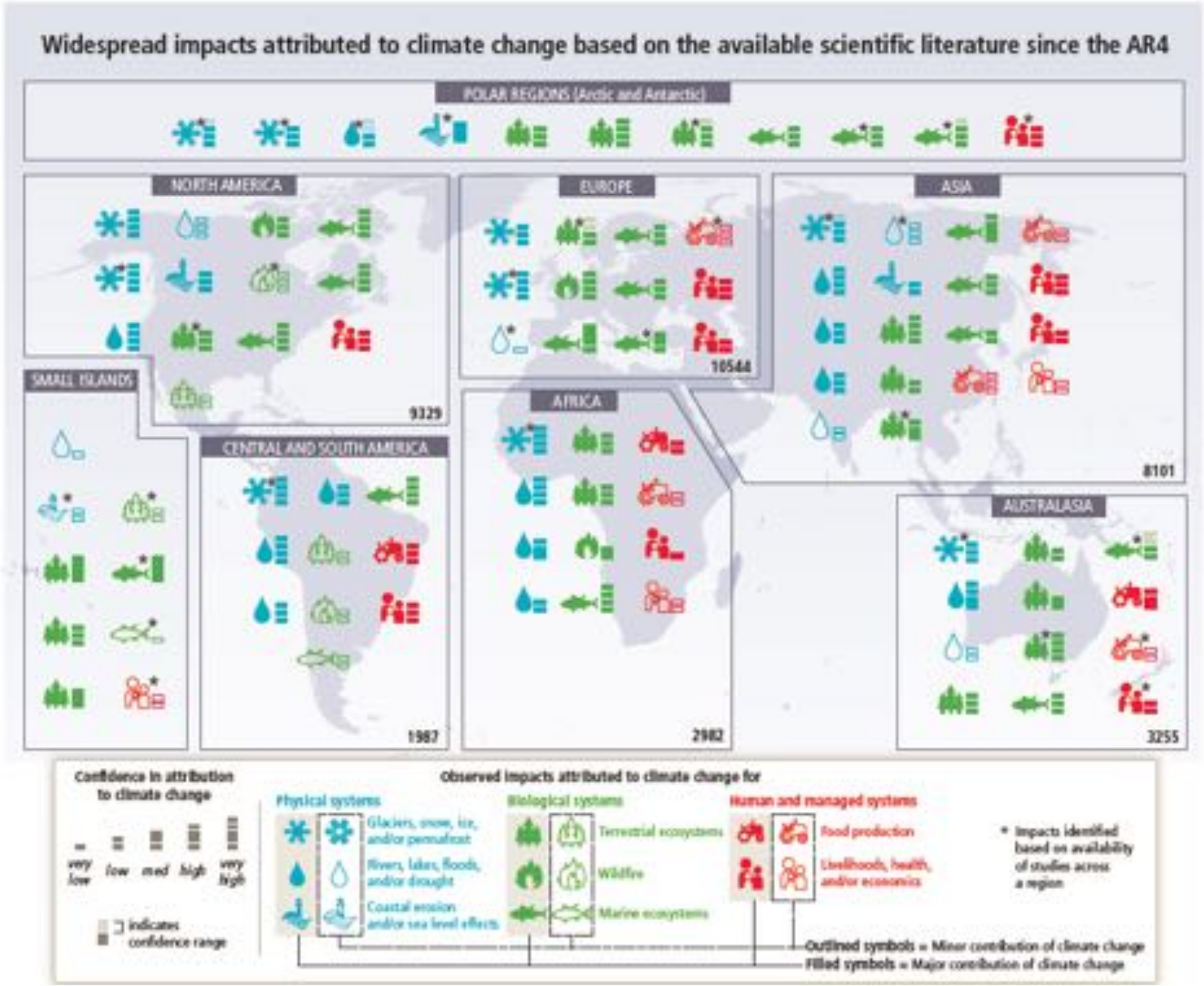
Widespread impacts attributed to climate change based on the available scientific literature since the AR4
POLAR REGIONS (Arctic and Antarctic)
NORTH AMERICA
9329
EUROPE
10544
ASIA
8101
SMALL ISLANDS
CENTRAL AND SOUTH AMERICA
1987
AFRICA
2982
AUSTRALASIA
3255
Confidence in attribution to climate change
very low
low
med
high
very high
indicates confidence range
Observed impacts attributed to climate change for
Physical systems
Glaciers, snow, ice, and/or permafrost
Rivers, lakes, floods, and/or drought
Coastal erosion and/or sea level effects
Biological systems
Terrestrial ecosystems
Wildfire
Marine ecosystems
Human and managed systems
Food production
Livelihoods, health, and/or economics
* Impacts identified based on availability of studies across a region
Outlined symbols = Minor contribution of climate change
Filled symbols = Major contribution of climate change

From AR5 WGII Europe Chapter

- **increases in winter wind speed extremes** over Central and Northern Europe [medium confidence]
- **damages from storms** in central Europe [low confidence] may increase due to climate change
- Climate change is expected to magnify regional differences within Europe for agriculture and forestry because **water stress** was **projected to increase** over central and southern Europe

From AR5 WGII Europe Chapter

- Regional and global climate simulations project (medium confidence) an increase in duration and intensity of **droughts** in central and southern Europe
- Some **pests**, like the European corn borer could also extend their climate niche in Central Europe.
- In the EU15, **river flooding** could affect 250,000-400,000 additional people by the 2080s (SRES A2 and B2 scenarios) and more than doubling annual average damages, with Central and Northern Europe and the UK most affected

Prague, June 2013…

From AR5 WGII Europe Chapter

- **Livestock production is adversely affected by heat.** With grass based livestock systems, model simulations (A1B scenario, ensemble of downscaled GCMs) show by end of century […] higher risks of summer – autumn **production failures in Central Europe**
- Projected increased late summer warming events will favour **diffusion of bark beetle** […] in lowland parts of central Europe

From AR5 WGII Europe Chapter

- In western and central Europe, projected future changes could **benefit wine quality**

ADAPTATION IS

ALREADY OCCURRING

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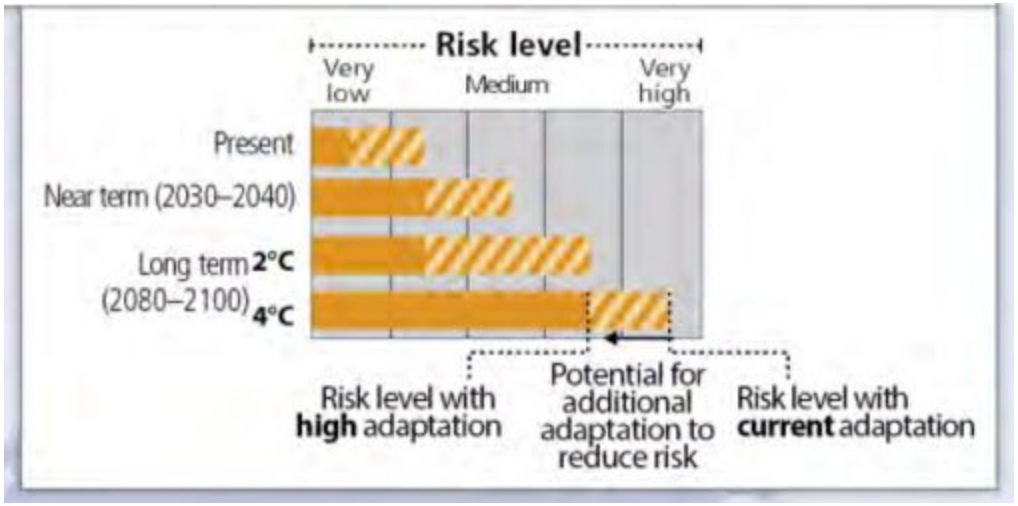
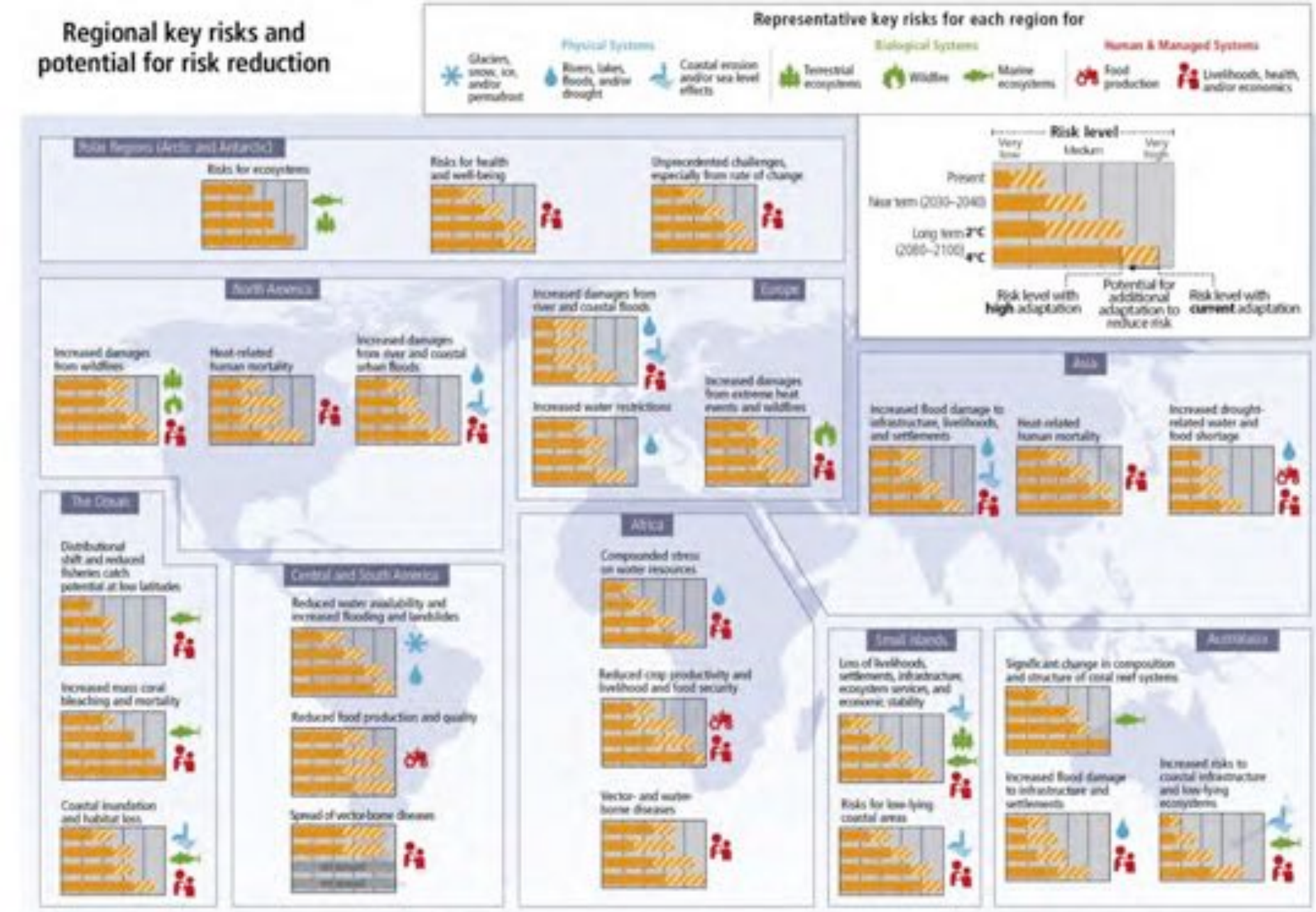
Regional key risks and potential for risk reduction through adaptation



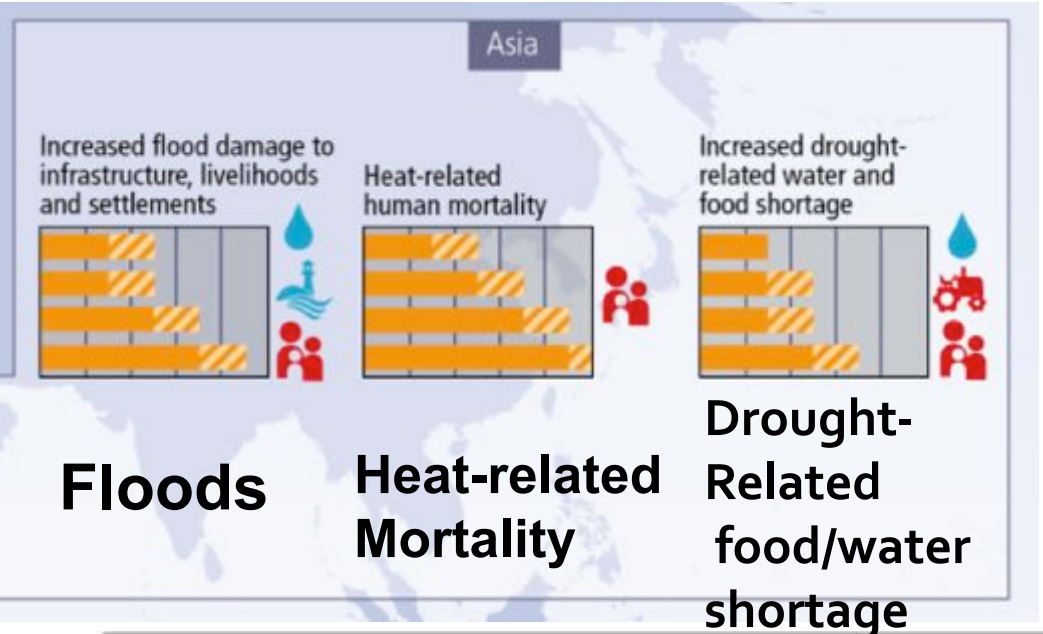
IPCC, AR5, SPM, Figure SPM.8

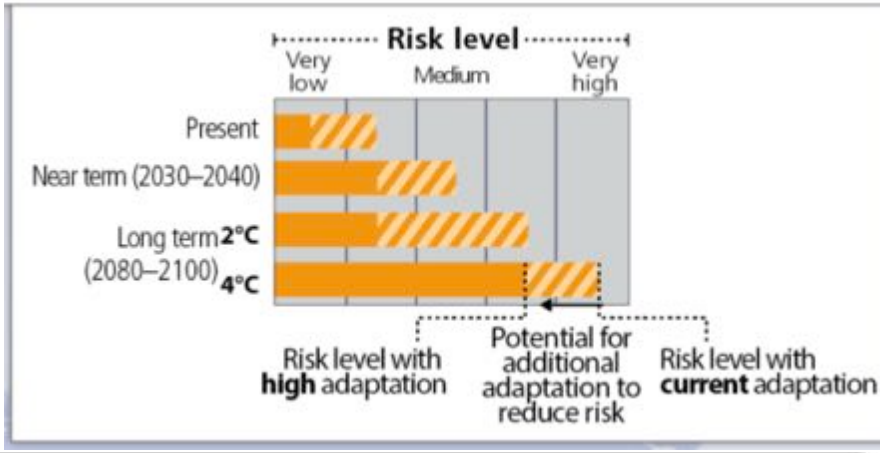
Regional key risks and potential for risk reduction



IPCC, AR5, SPM, Figure SPM.8

Regional key risks and potential for risk reduction: Asia





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IPCC, AR5, SYR, SPM.8

Future food supply and demand

Rice is a key staple crop in Asia and 90% or more of the world's rice production is from Asia. An Asia-wide study revealed that climate change scenarios (using 18 GCMs for A1B, 14 GCMs for A2, and 17 GCMs for B1) **would reduce rice yield over a large portion of the continent** (Masutomi et al., 2009). The most vulnerable regions were **western Japan**, eastern China, the southern part of the Indochina peninsula, and the northern part of South Asia.

IPCC, AR5, WG II, Chap. 24, p.1345

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RISKS OF
CLIMATE CHANGE
INCREASE
WITH CONTINUED
HIGH EMISSIONS
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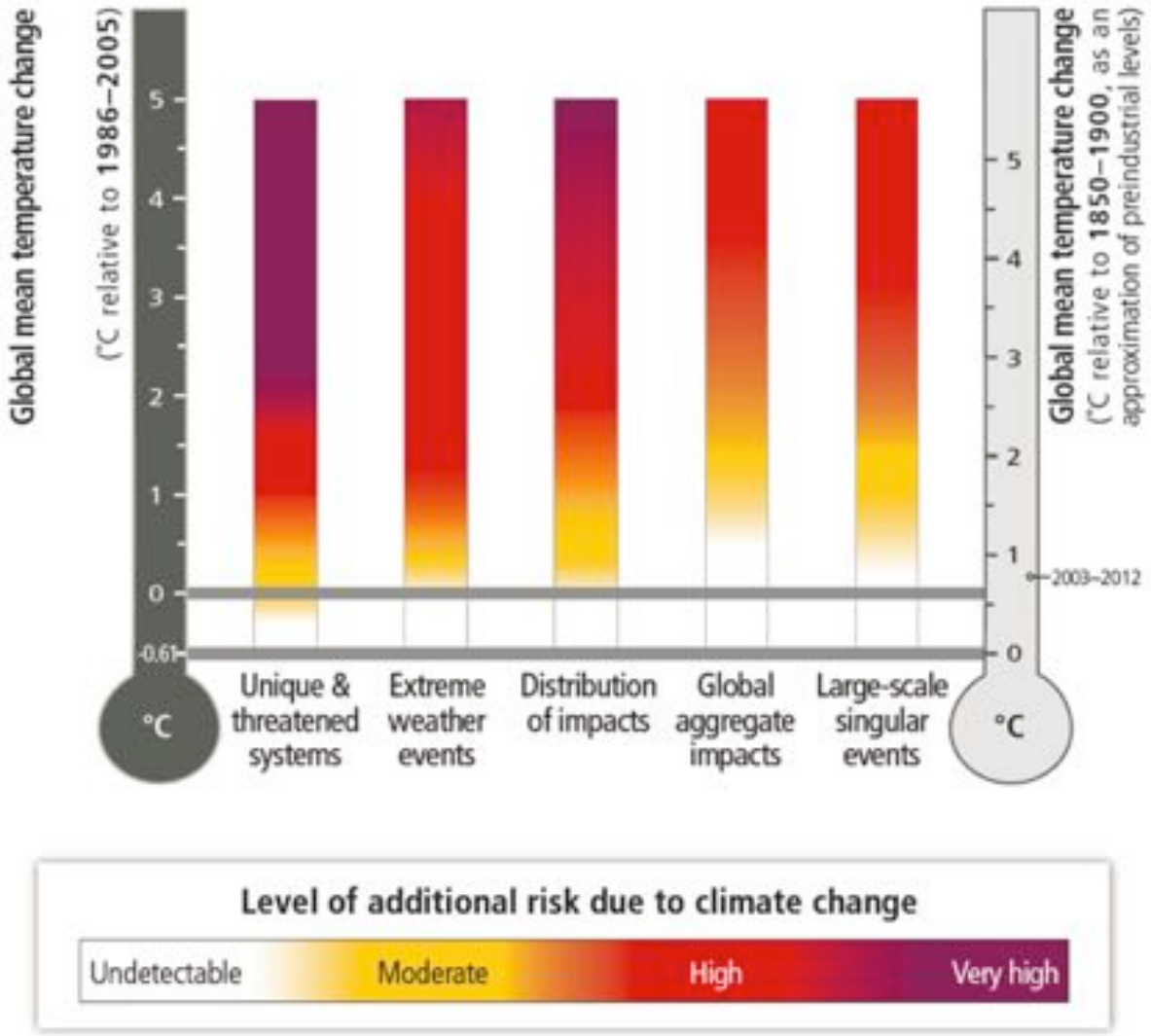
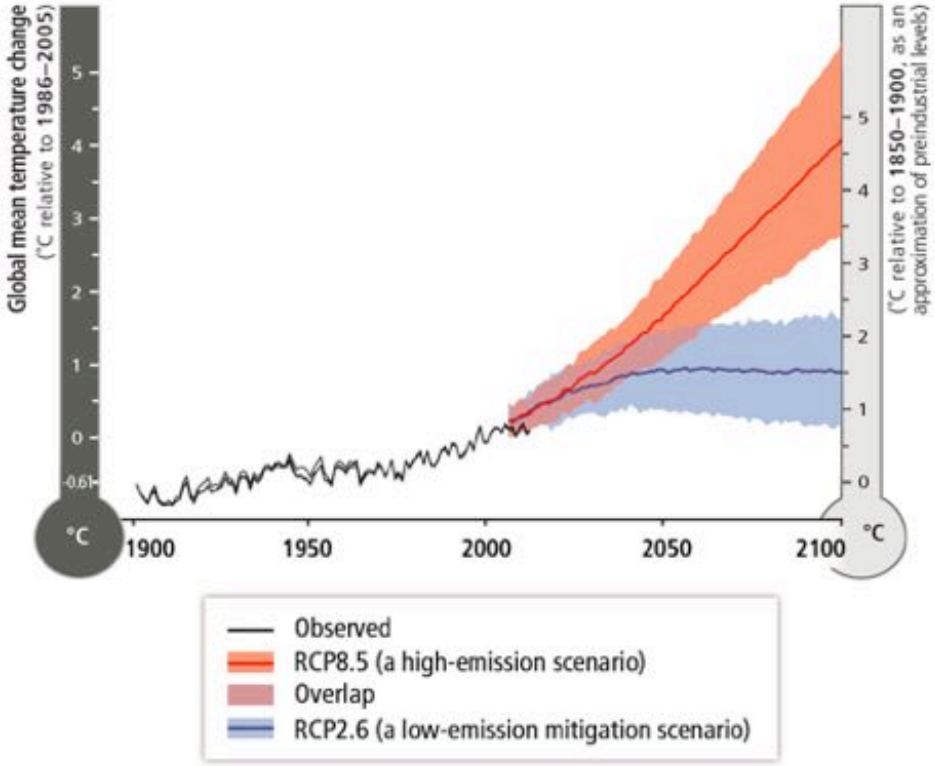
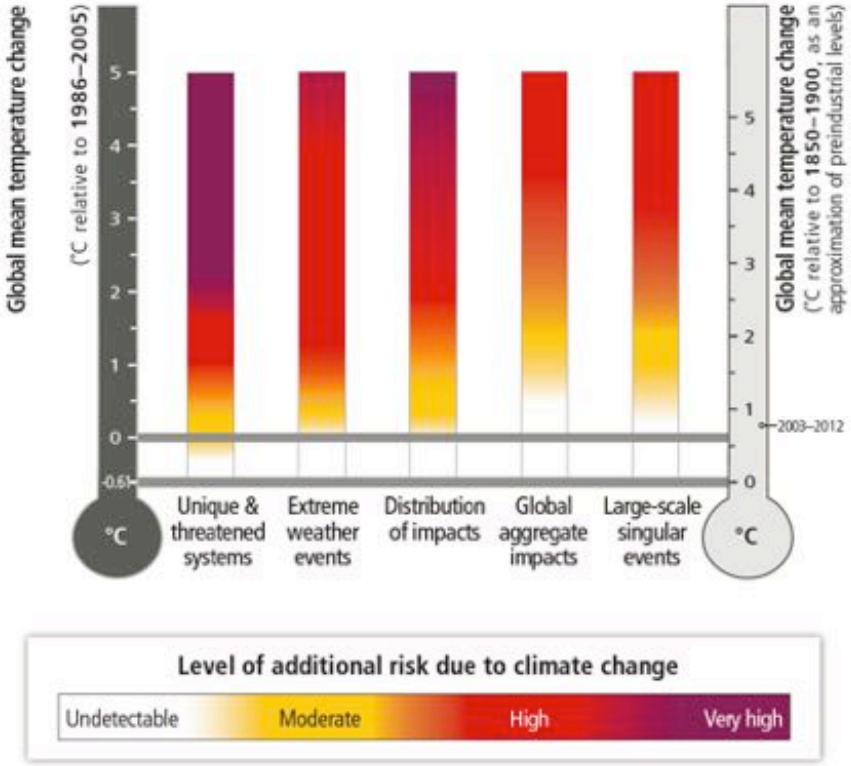
Reasons for concern



AR5, WGII, Box SPM.1 Figure 1





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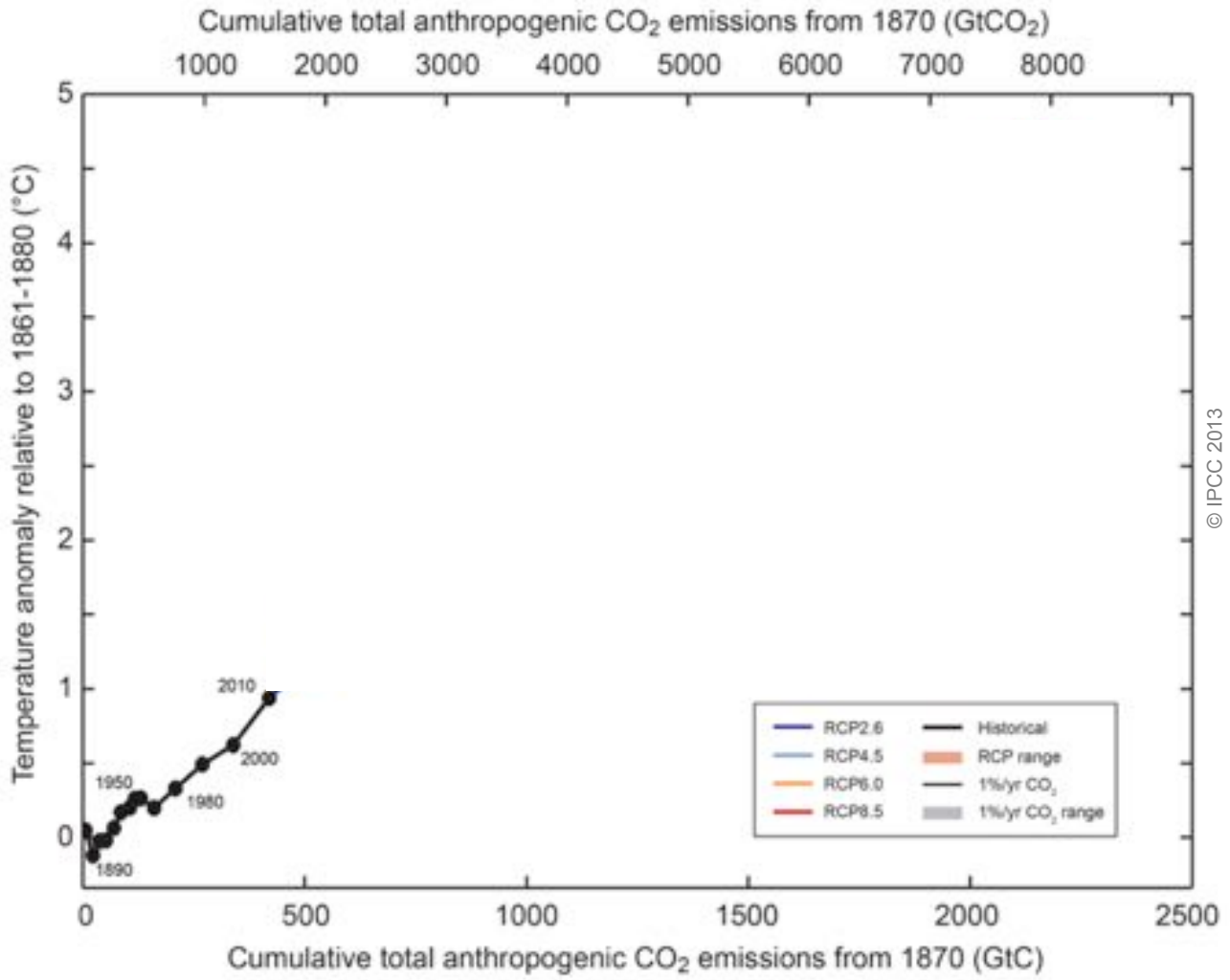


Fig. SPM.10

Cumulative emissions of CO_2 largely determine global mean surface warming by the late 21st century and beyond.

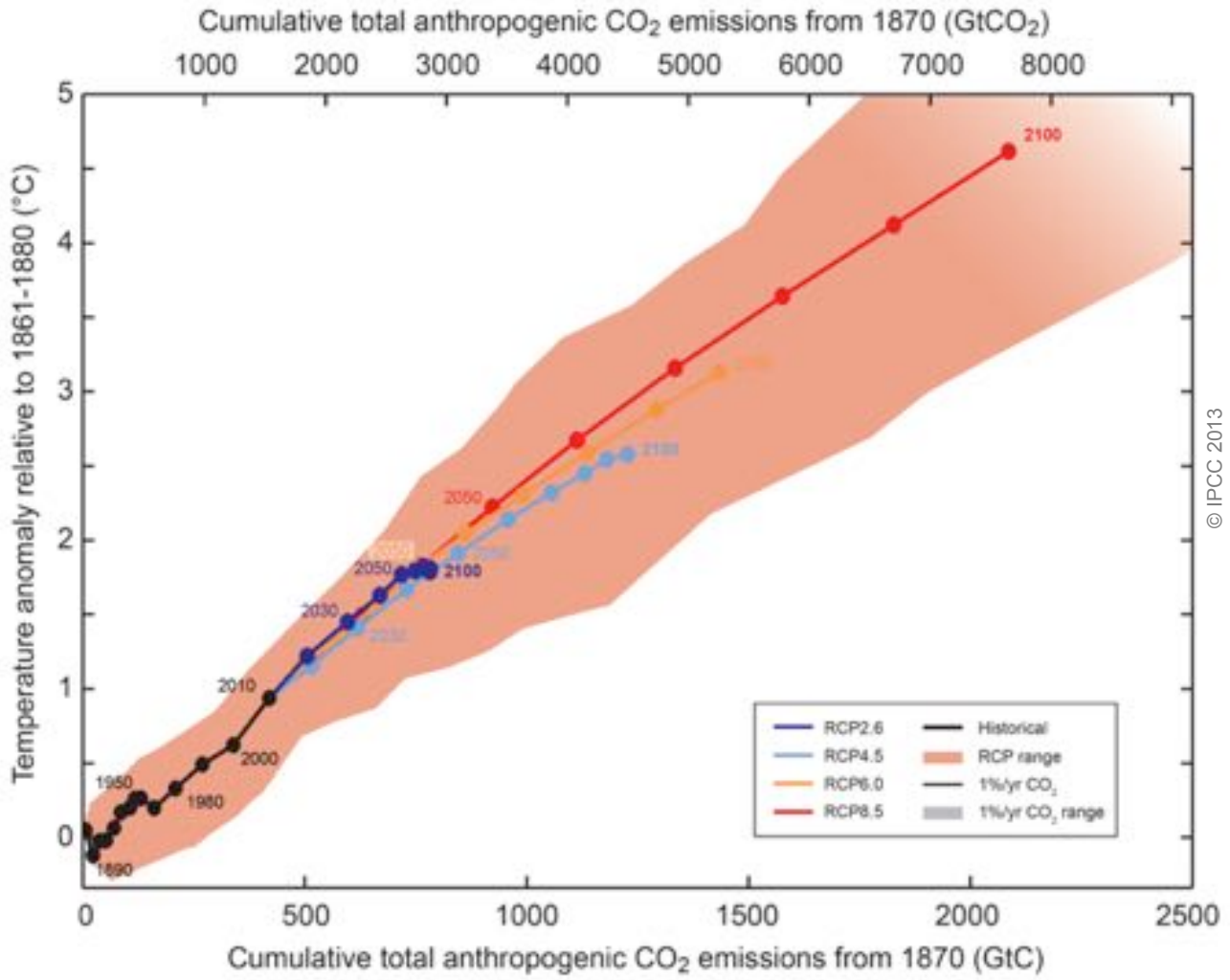
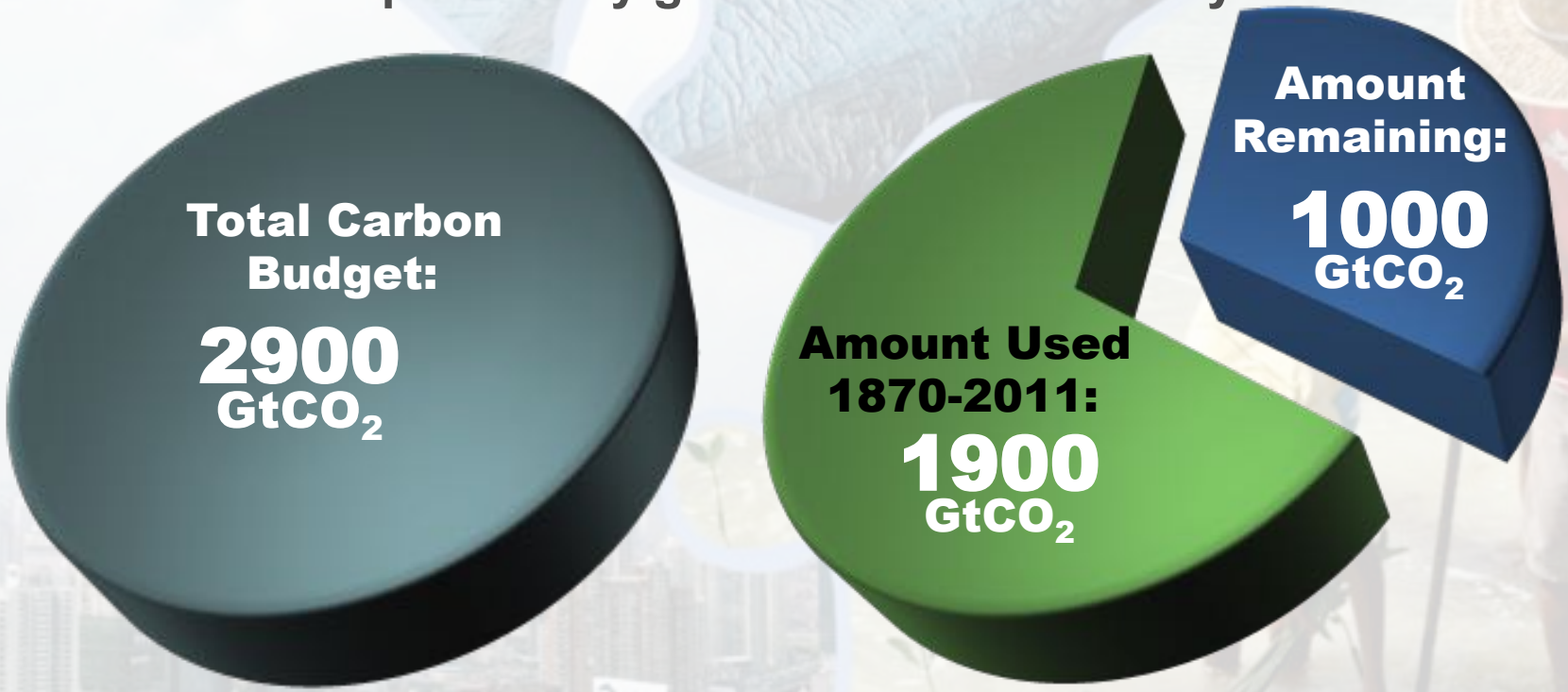


Fig. SPM.10

Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.

The window for action is rapidly closing

65% of the carbon budget compatible with a 2°C goal is already used
NB: this is with a probability greater than 66% to stay below 2°C



NB: Emissions in 2011: 38 GtCO2/yr

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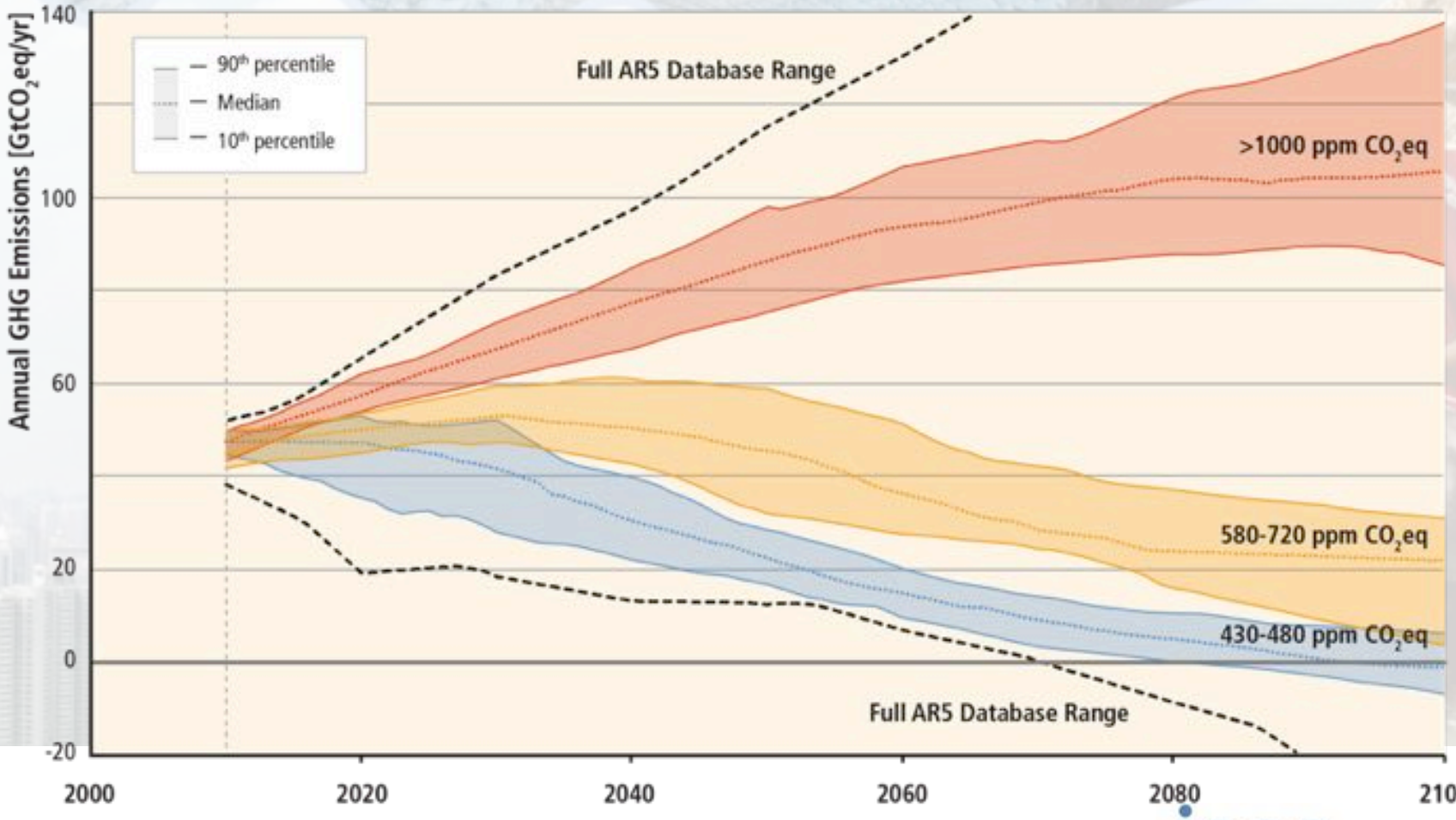
Stabilization of atmospheric concentrations requires moving away from the baseline – regardless of the mitigation goal.



Based on Figure 6.7

AR5 WGIII SPM

IPCC AR5 Synthesis Report

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Can temperature rise still be kept below 1.5 or 2°C (over the 21st century) compared to pre-industrial ?

- **Many scenario studies confirm that it is technically and economically feasible to keep the warming below 2°C, with more than 66% probability ("likely chance").** This would imply limiting atmospheric concentrations to 450 ppm CO_2-eq by 2100.
- **Such scenarios** for an above 66% chance of staying below 2°C **imply reducing by 40 to 70% global GHG emissions compared to 2010 by mid-century, and reach zero or negative emissions by 2100.**

Can temperature rise still be kept below 1.5 or 2°C (over the 21st century) compared to pre-industrial ?

- **These scenarios are characterized by rapid improvements of energy efficiency and a near quadrupling of the share of low-carbon energy supply (renewables, nuclear, fossil and bioenergy with CCS), so that it reaches 60% by 2050.**
- **Keeping global temperature increase below 1.5°C would require even lower atmospheric concentrations (<430 ppm CO_2eq) to have a little more than 50% chance.** There are not many scenario studies available that can deliver such results, **requiring even faster reductions** in the medium term, indicating how difficult this is.

Mitigation Measures

More efficient use of energy

Greater use of low-carbon and no-carbon energy

- Many of these technologies exist today

Improved carbon sinks

- Reduced deforestation and improved forest management and planting of new forests
- Bio-energy with carbon capture and storage

Lifestyle and behavioural changes

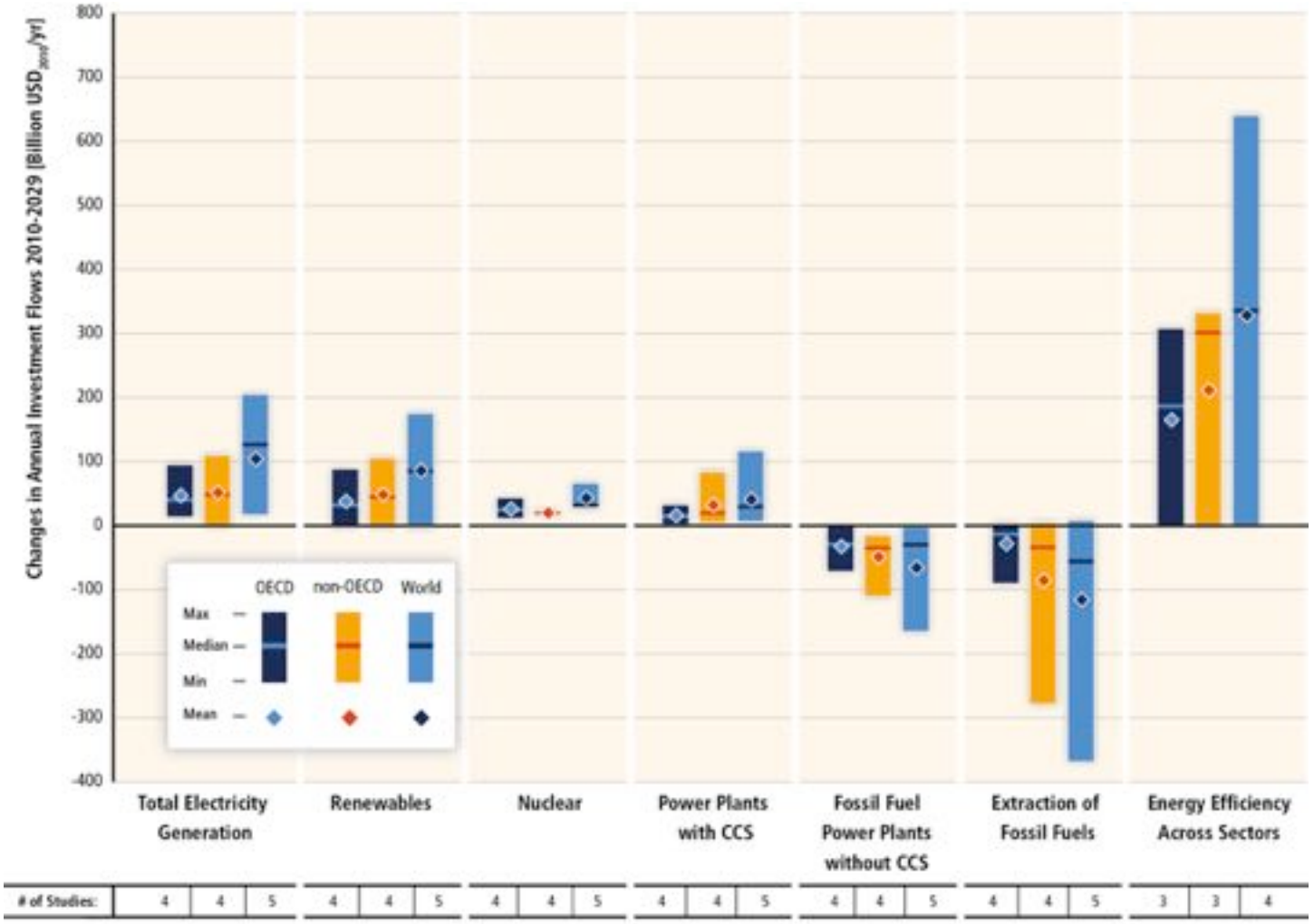
AR5 WGIII SPM

Ambitious Mitigation Is Affordable

- ➜ Economic growth reduced by ~ 0.06%
  (BAU growth 1.6 - 3%/year)
- ➜ This translates into delayed and not forgone growth
- ➜ Estimated cost does not account for the benefits of reduced climate change
- ➜ Unmitigated climate change would create increasing risks to economic growth and efforts to eradicate poverty

AR5 WGI SPM, AR5 WGII SPM

Substantial reductions in emissions would require large changes in investment patterns.

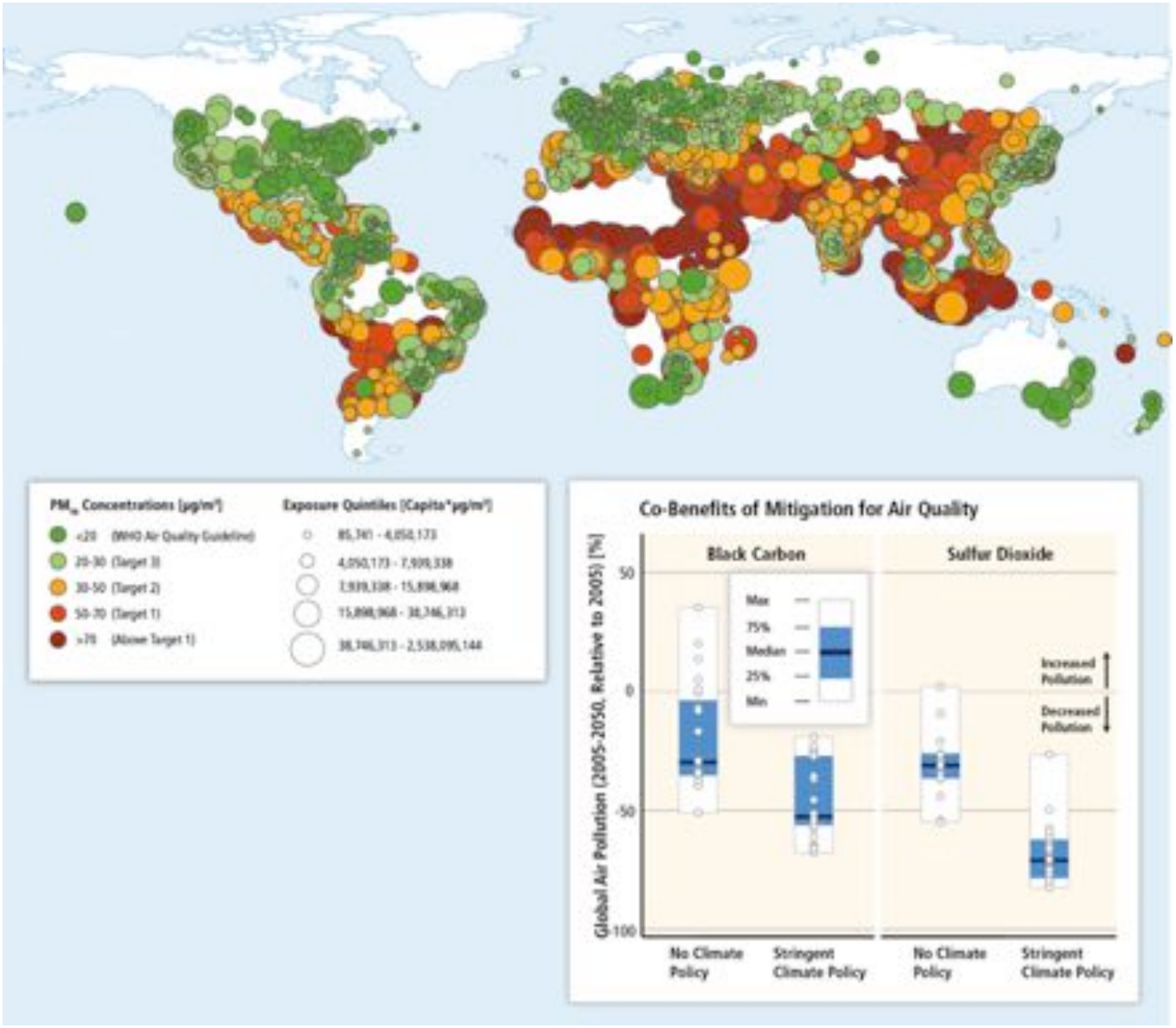



Mitigation options are available in every major sector.

Effective mitigation will not be achieved if individual agents advance their own interests independently.

- Existing and proposed **international climate change cooperation** arrangements vary in their focus and degree of centralization and coordination.
- Issues of **equity, justice, and fairness** arise with respect to mitigation and adaptation.
- Climate policy may be informed by a consideration of a diverse array of risks and uncertainties, some of which are difficult to measure, notably events that are of low probability but which would have a significant impact if they occur.


Delaying additional mitigation to 2030 will substantially increase the challenges associated with limiting warming over the 21st century to below 2°C relative to pre-industrial levels.

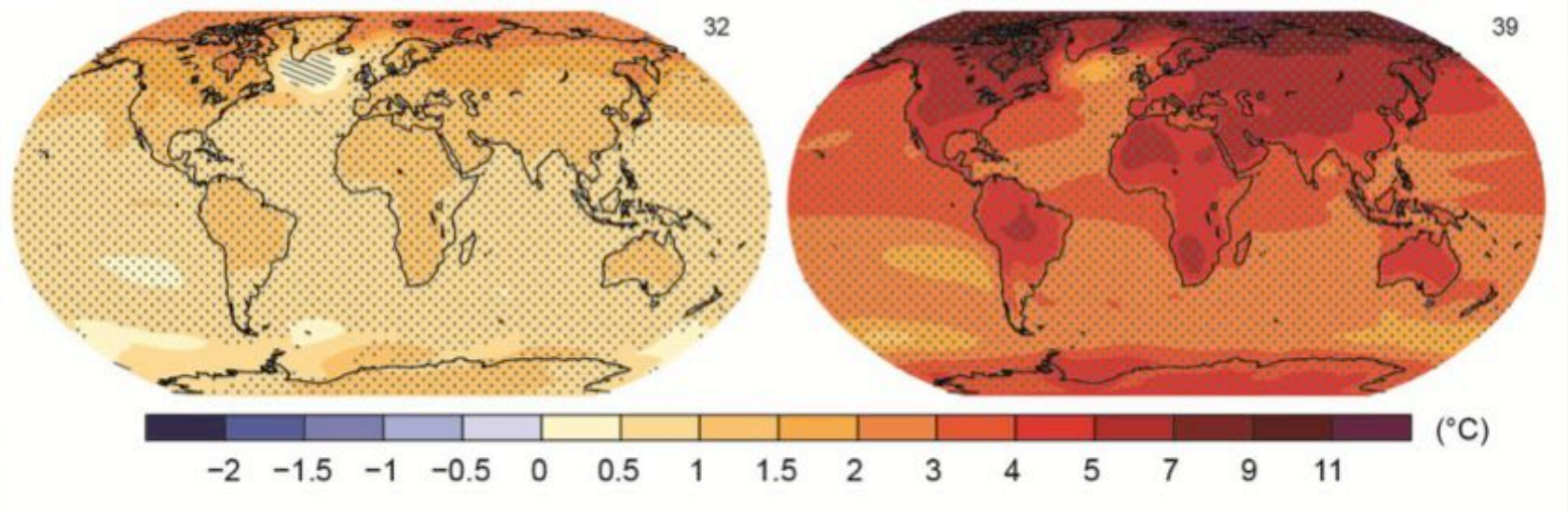


Mitigation can result in large co-benefits for human health and other societal goals.

The Choices Humanity Makes Will Create Different Outcomes (and affect prospects for effective adaptation)

With substantial mitigation

Without additional mitigation



Change in average surface temperature (1986–2005 to 2081–2100)

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Useful links:

- www.ipcc.ch : IPCC (reports and videos)
- www.climate.be/vanyp : my slides and candidature to become IPCC Chair
- www.skepticalscience.com: excellent responses to contrarians arguments
- **On Twitter: @JPvanYpersele and @IPCC_CH**