

An introduction to climate change:

It is Still Time to Act!

***An Overview Based on the IPCC
Fifth Assessment Report (AR5)***

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**Masterclass CACHE (Calcium in a CHanging
Environment, www.cache-itn.eu), Brussels, 7 Feb. 2017**

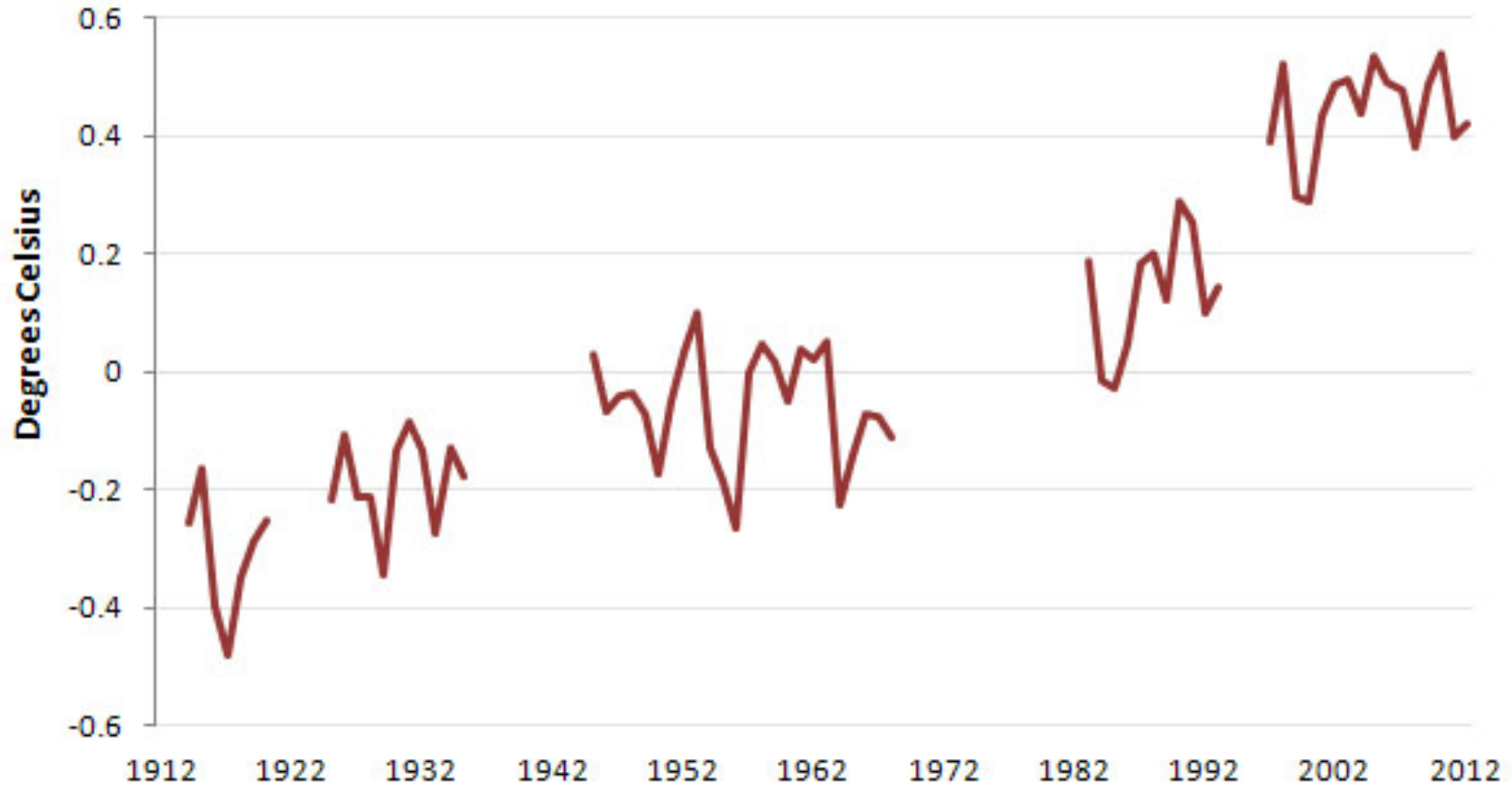
**Thanks to the Walloon Government and to my team at the
Université catholique de Louvain for their support**

Temperature Change From 1961-1990 Average



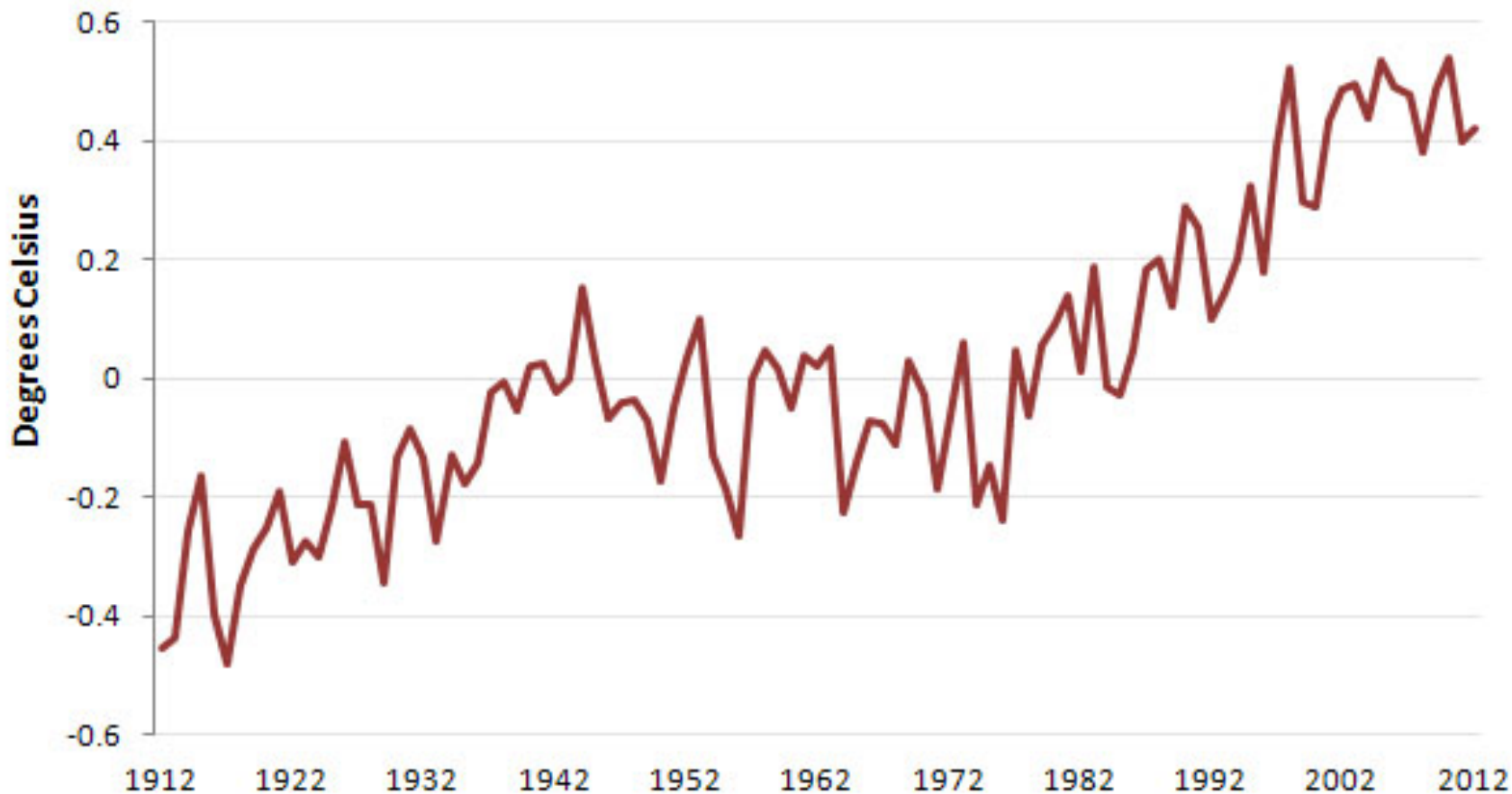
Lying With Statistics, Global Warming Edition

Temperature Plateaus — 1912-2012



Lying With Statistics, Global Warming Edition

Temperature Change From 1961-1990 Average



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 Organization

UNEP= United Nations Environment Programme

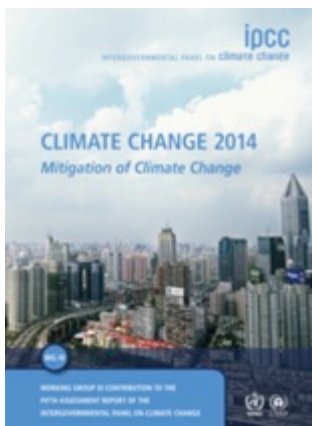




What is happening in the climate system?



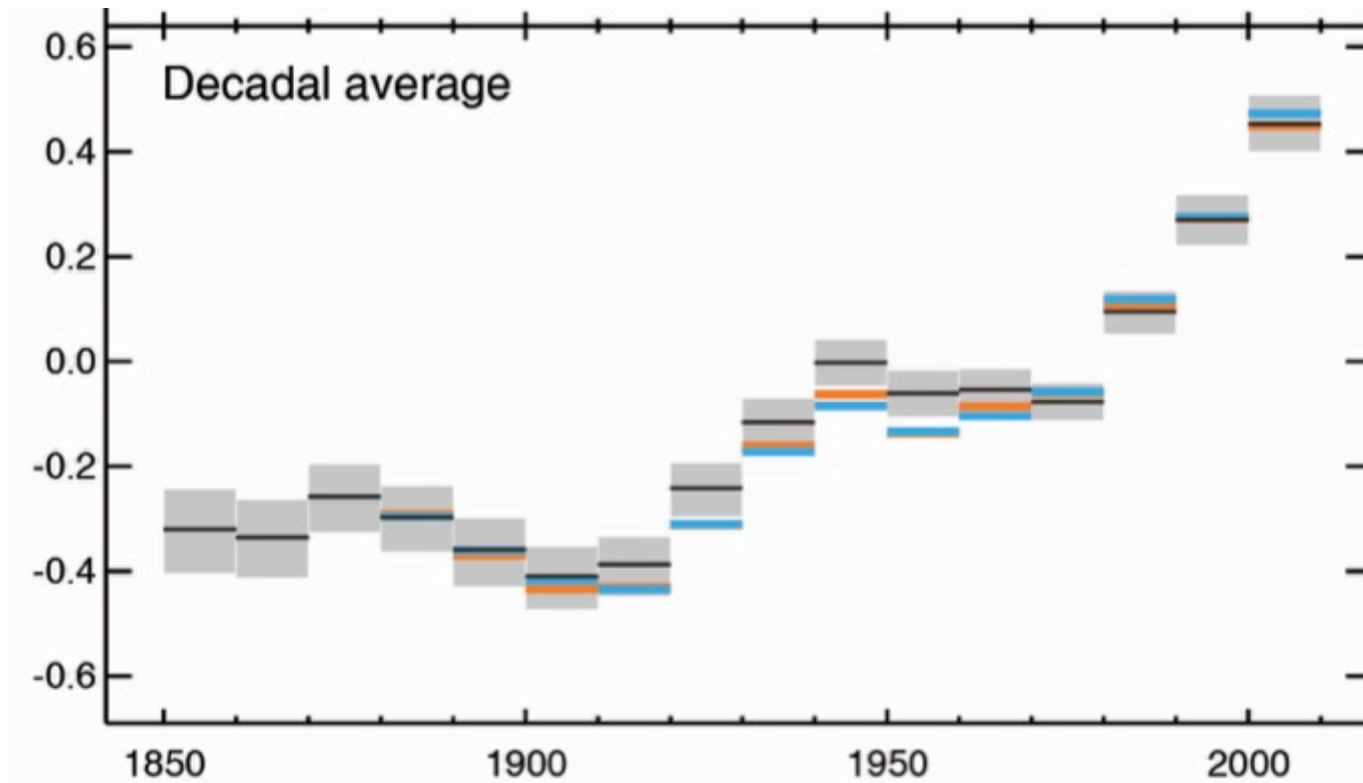
What are the risks?



What can be done?

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**



(IPCC 2013, Fig. SPM.1a)

Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850.

In the Northern Hemisphere, 1983–2012 was *likely* the warmest 30-year period of the last 1400 years (*medium confidence*).

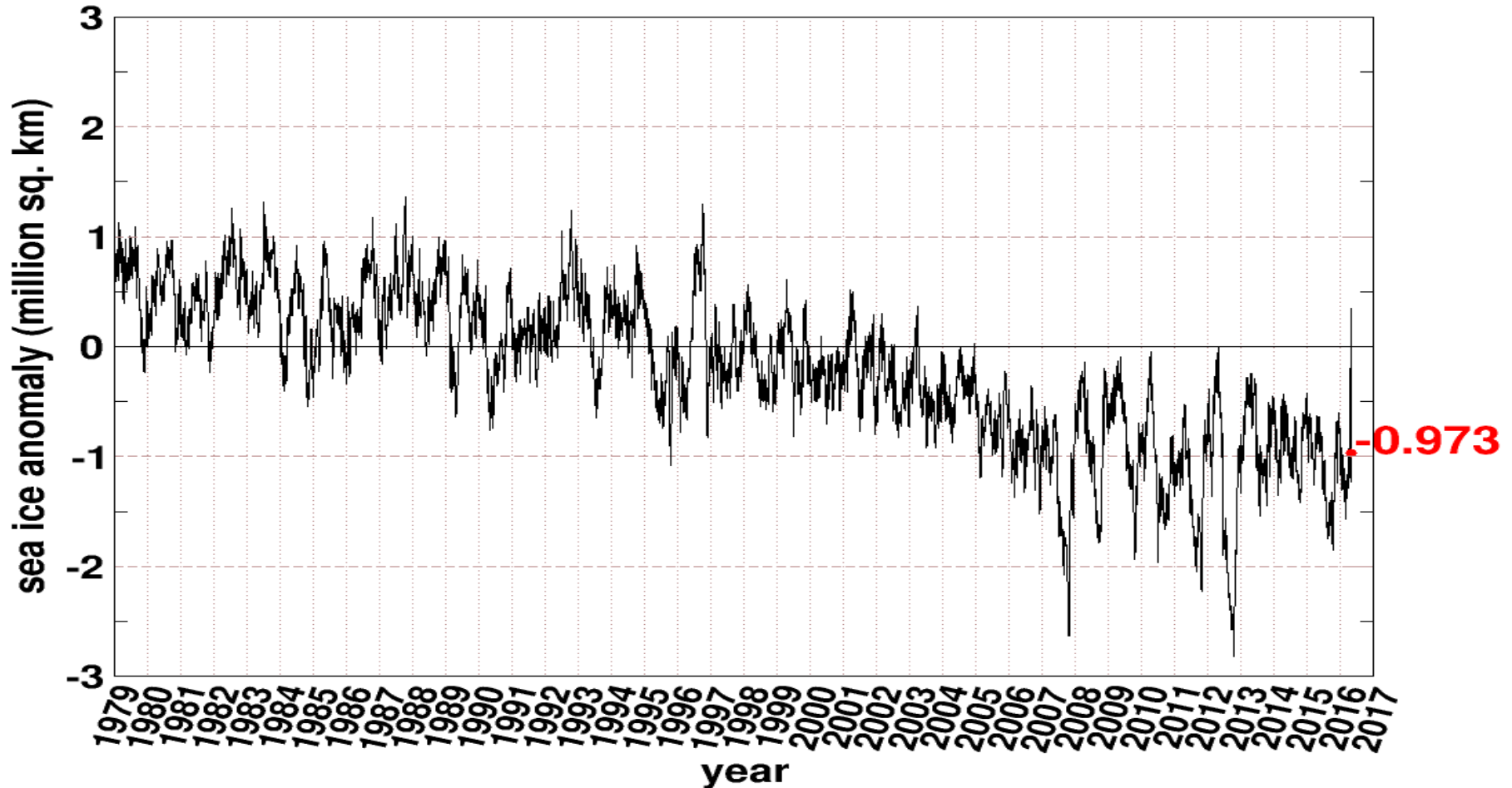
Since 1950, extreme hot days and heavy precipitation have become more common



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

Arctic Sea Ice Cover (1979-2016)

Northern Hemisphere Sea Ice Anomaly
Anomaly from 1979-2008 mean



Plateau Glacier (1961) (Alaska)



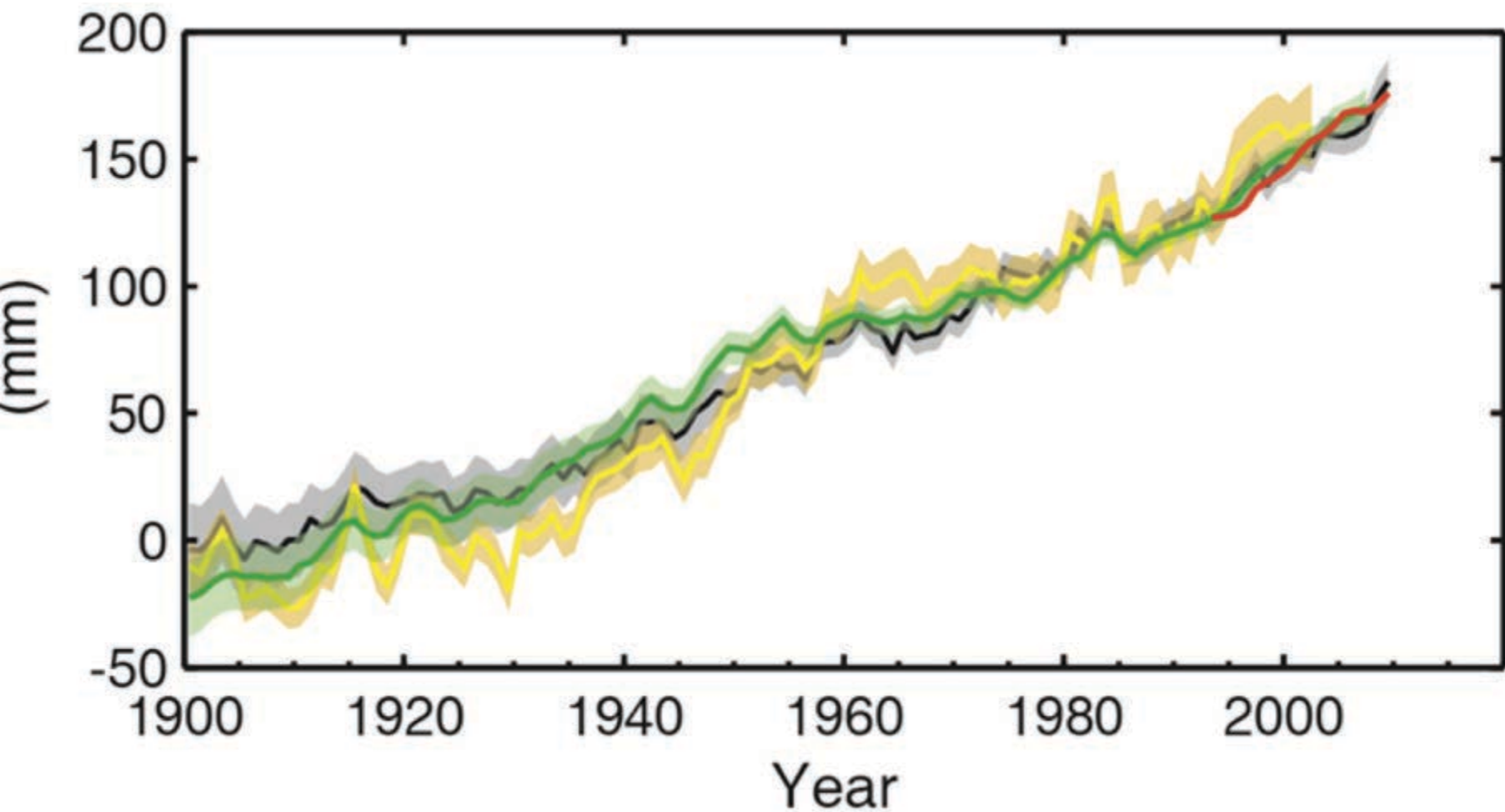
http://www.weather.com/news/science/environment/alaskas-glaciers-capturing-earth-changing-our-eyes-20131125?cm_ven=Email&cm_cat=ENVIRONMENT_us_share

Plateau Glacier (2003) (Alaska)

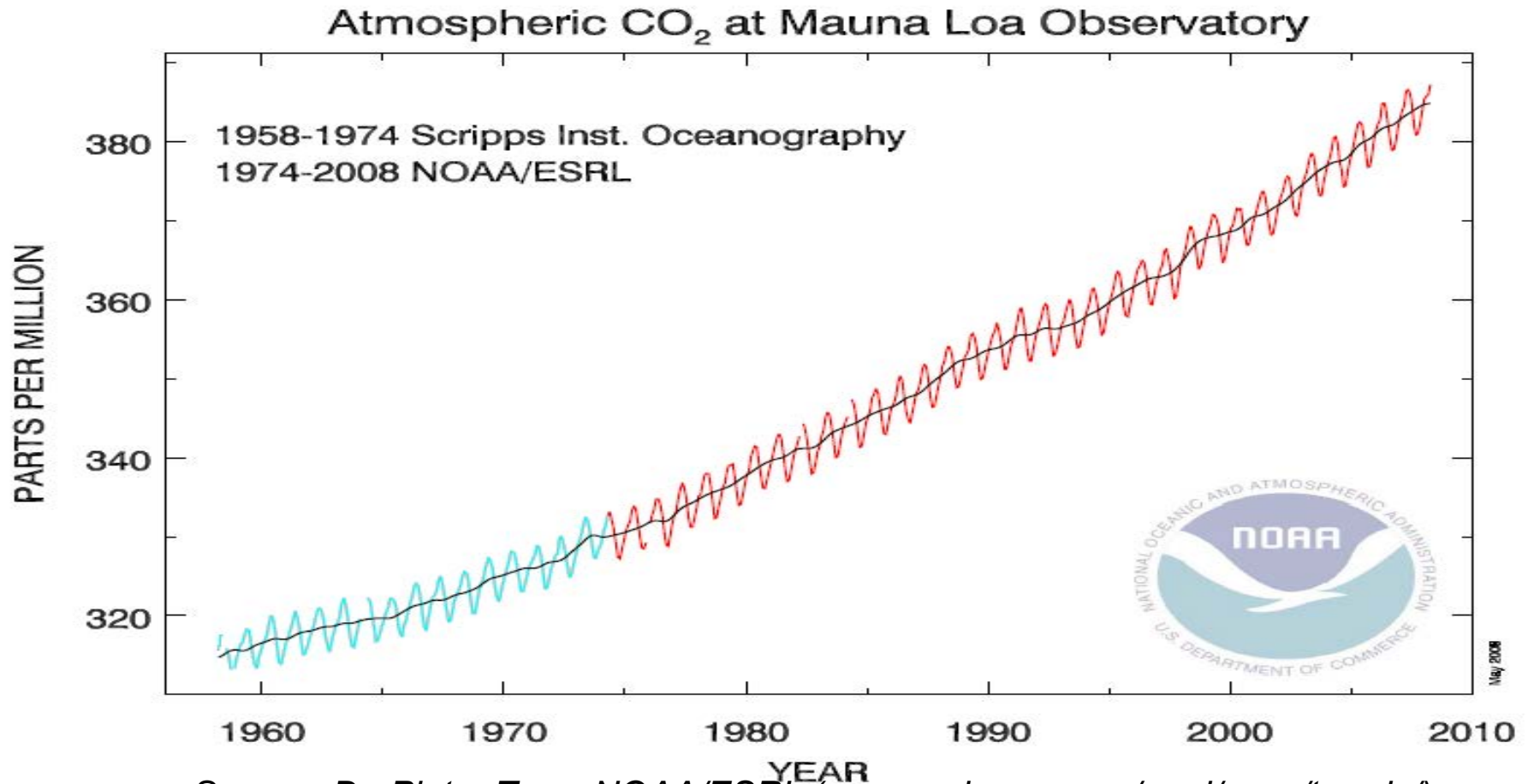


http://www.weather.com/news/science/environment/alaskas-glaciers-capturing-earth-changing-our-eyes-20131125?cm_ven=Email&cm_cat=ENVIRONMENT_us_share

Change in average sea-level change



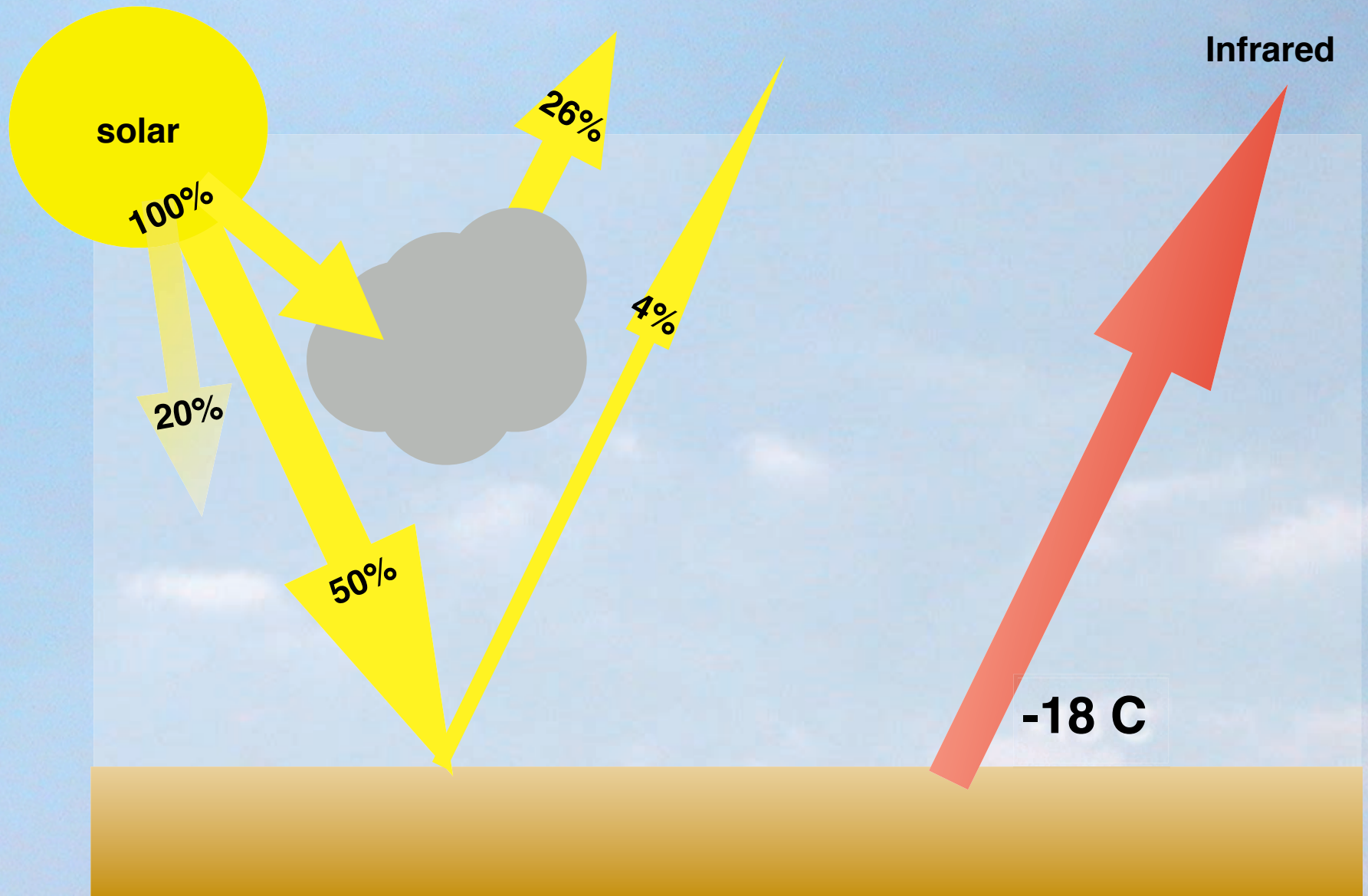
CO₂ concentration measured at Mauna Loa (3400 m)

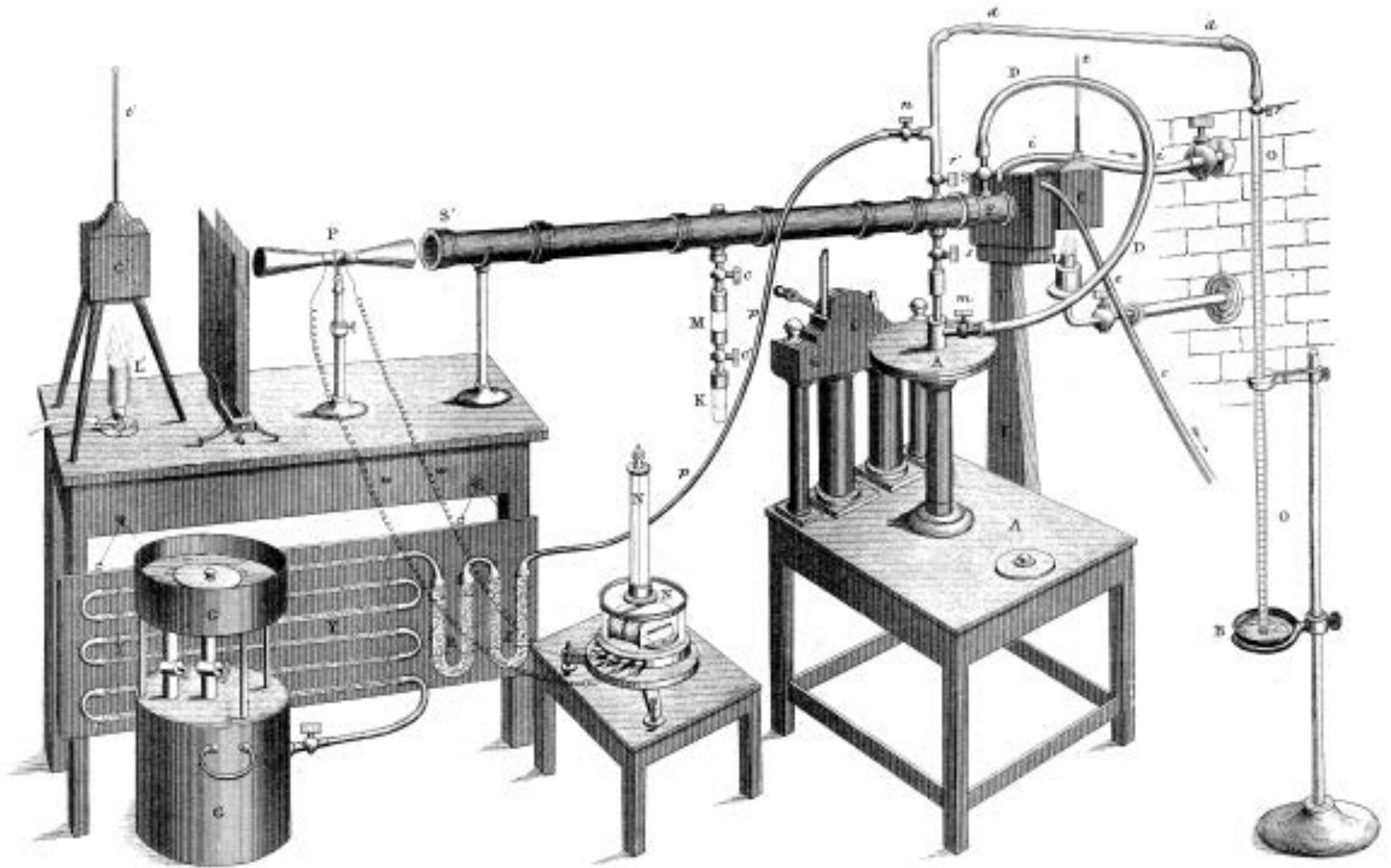


Source: Dr. Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/)

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(vanypersele@astr.ucl.ac.be)

Without Greenhouse Effect





Tyndall (1861) mesure l'absorption du rayonnement par les gaz

With Greenhouse Effect

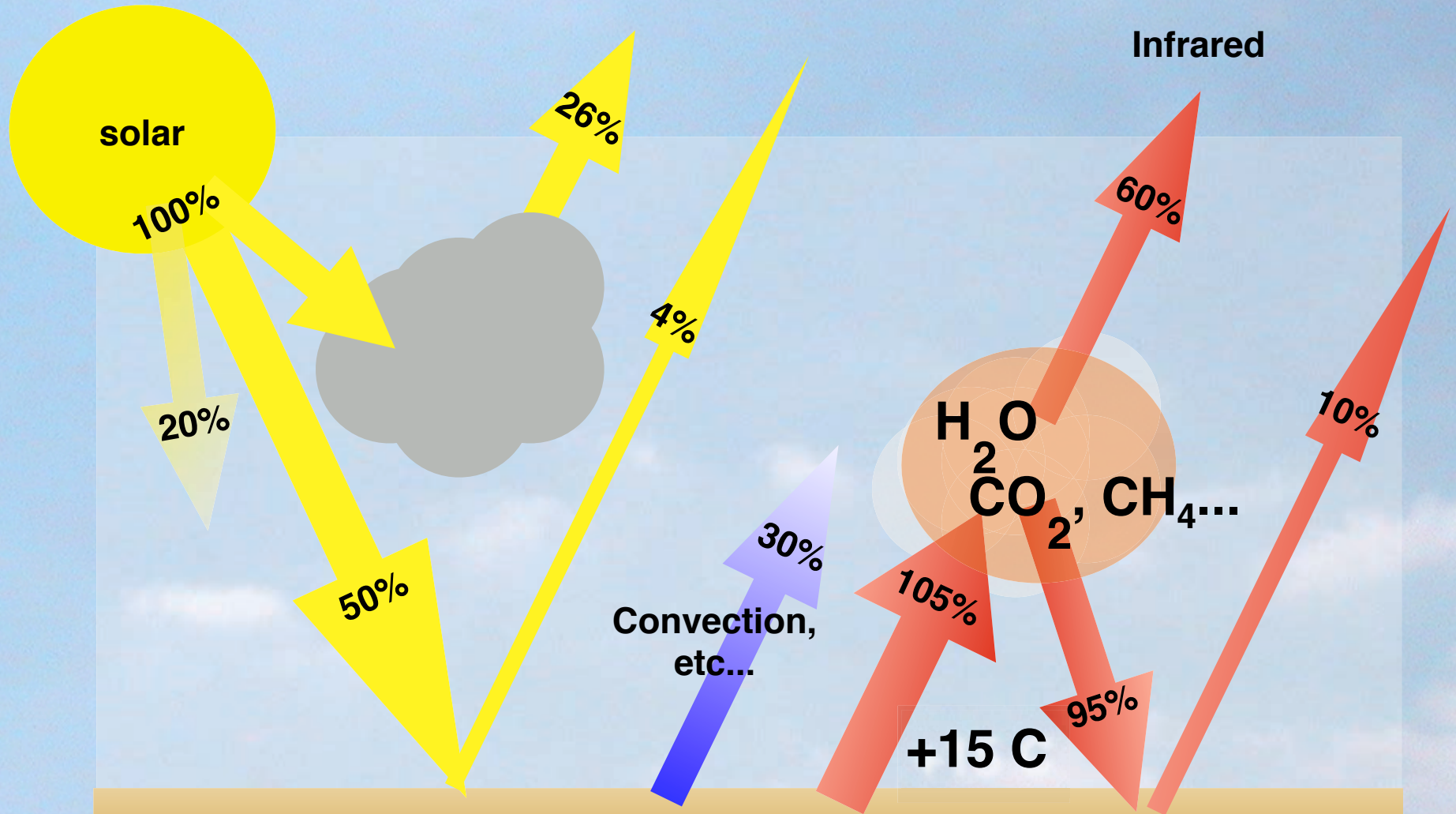
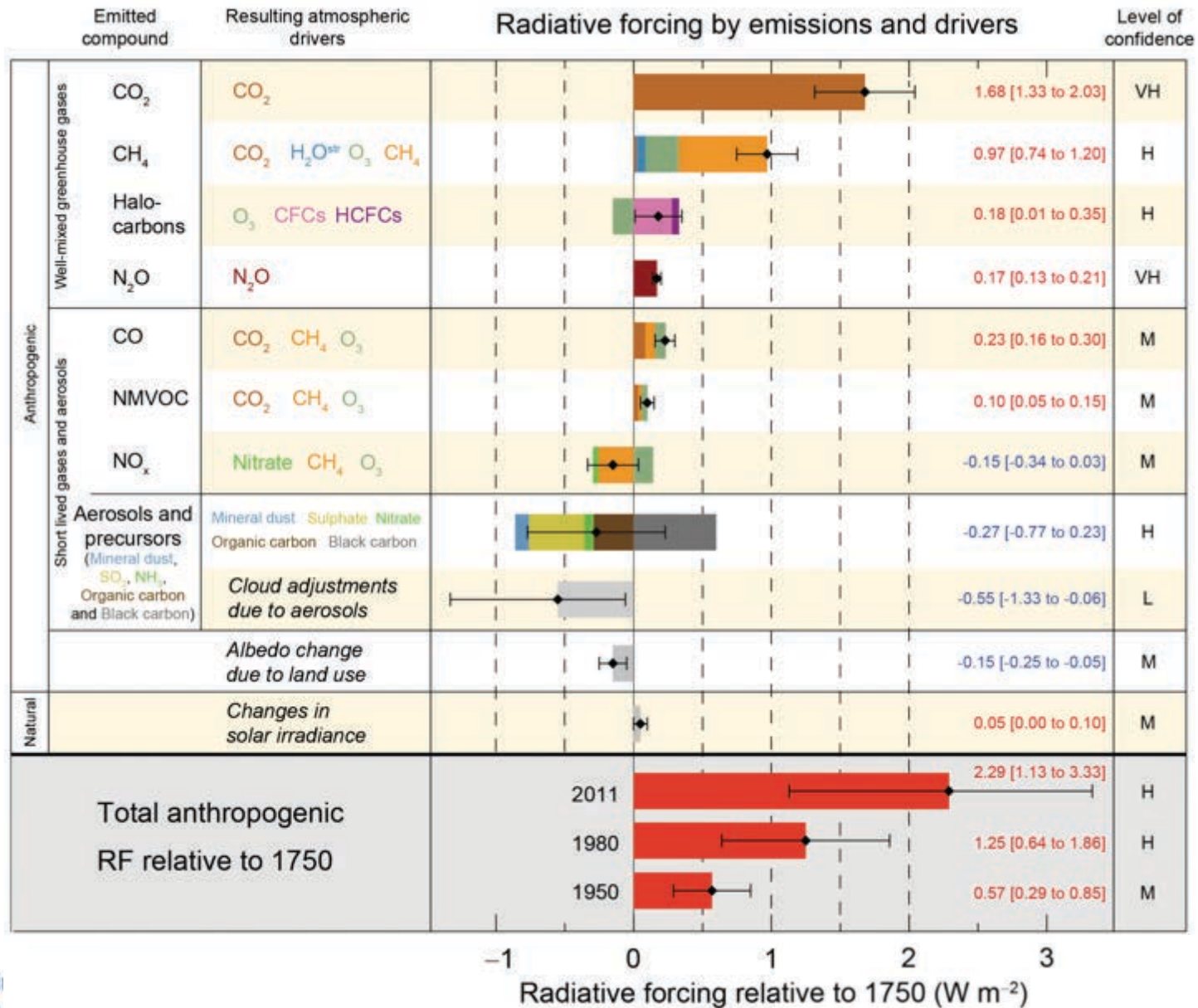


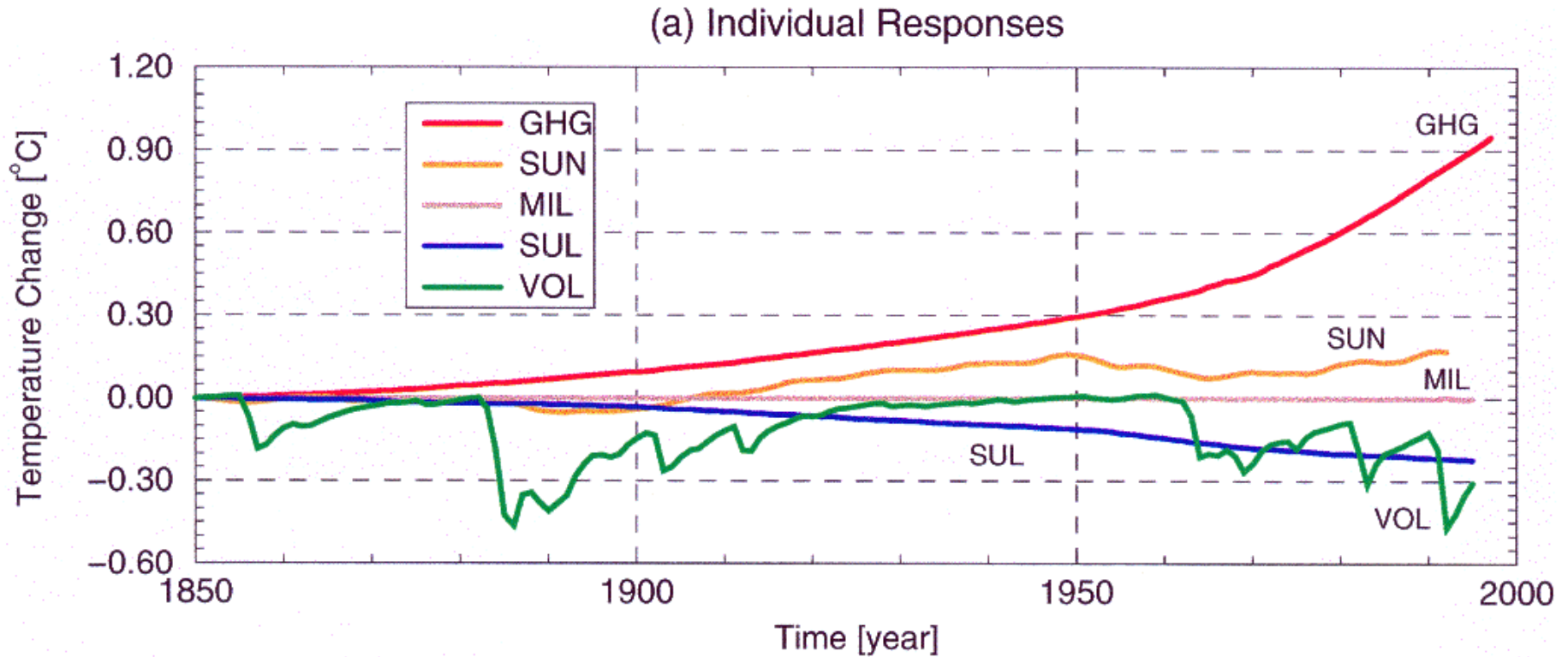
Figure SPM.5

Radiative forcing estimates in 2011 relative to 1750

All Figures © IPCC 2013

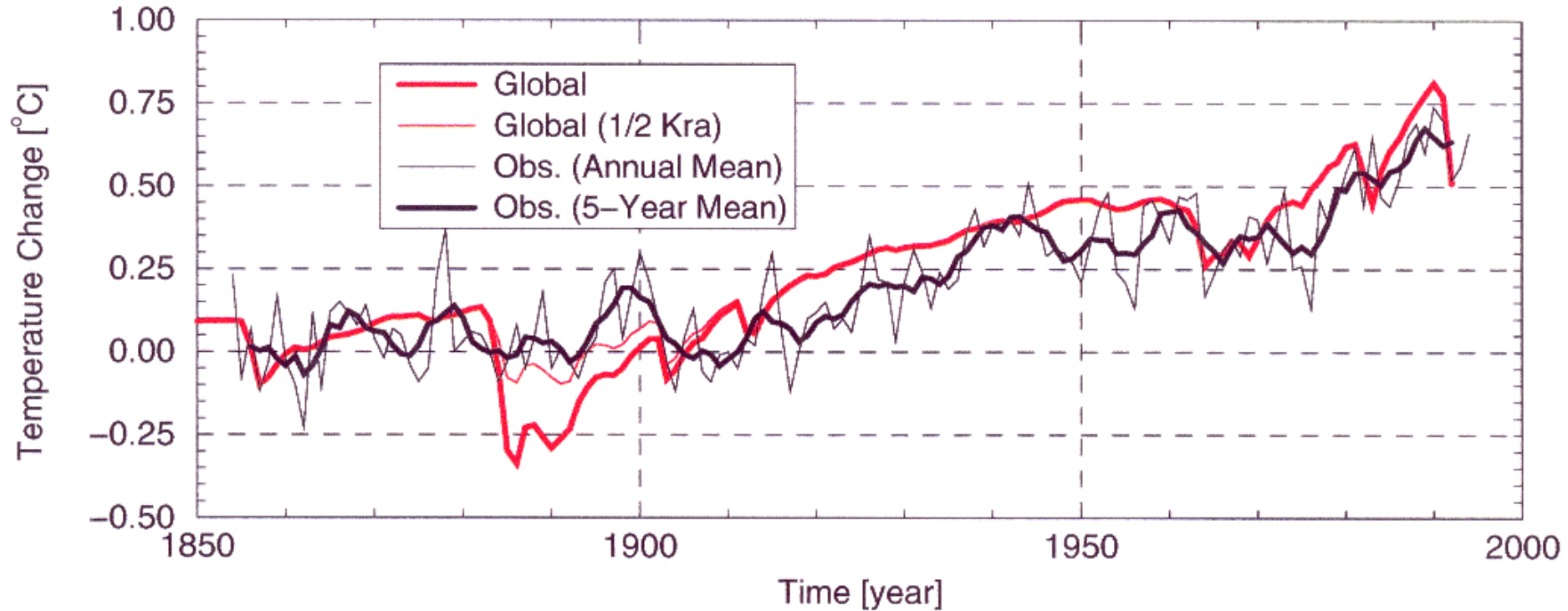


Separate effect of different factors in the 2-dimensional climate model at UCL



Combined effect of all factors in the 2-dimensional climate model at UCL

(c) Global Response



A Progression of Understanding: Greater and Greater Certainty in Attribution

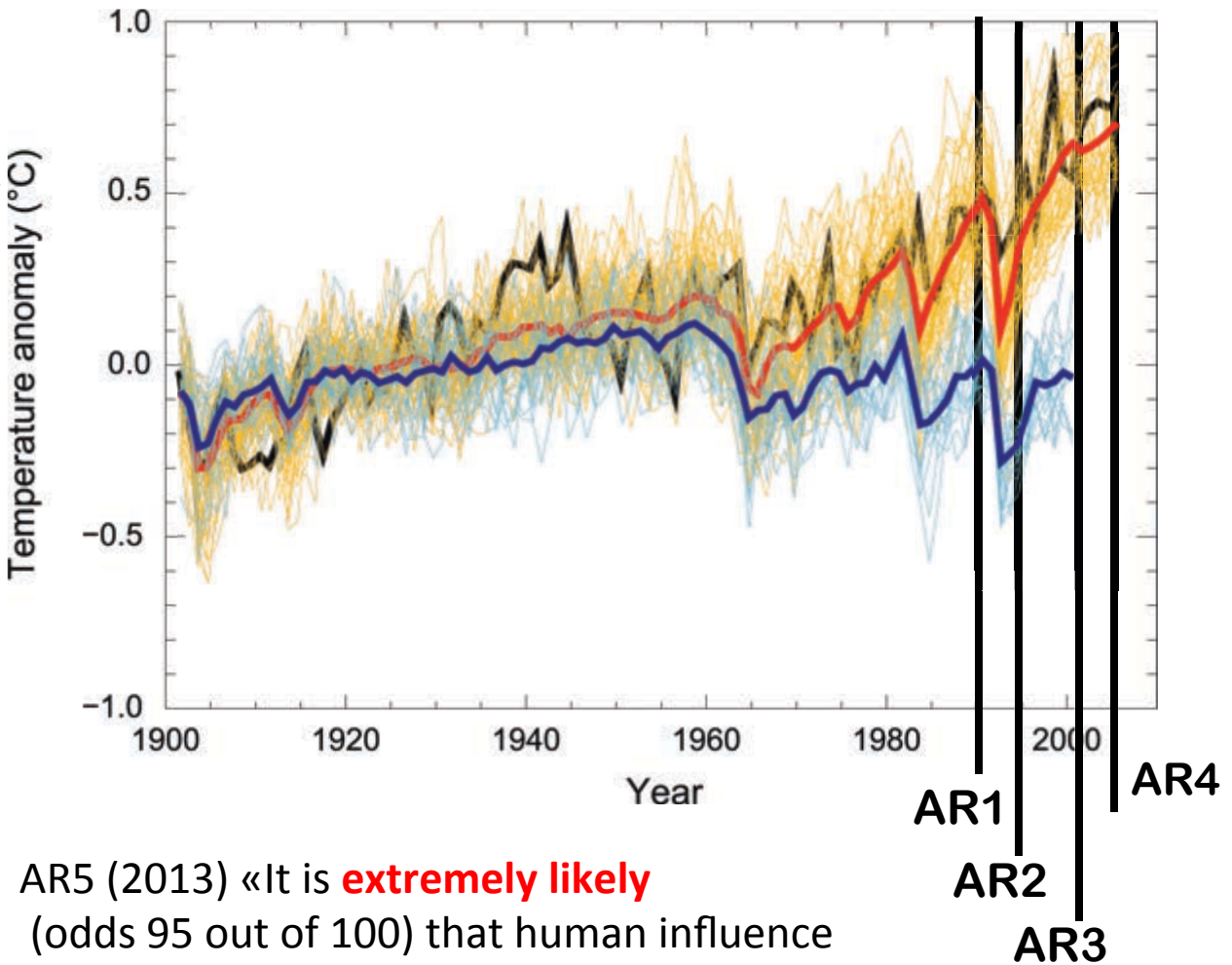
AR1 (1990):

“unequivocal detection not likely for a decade”

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

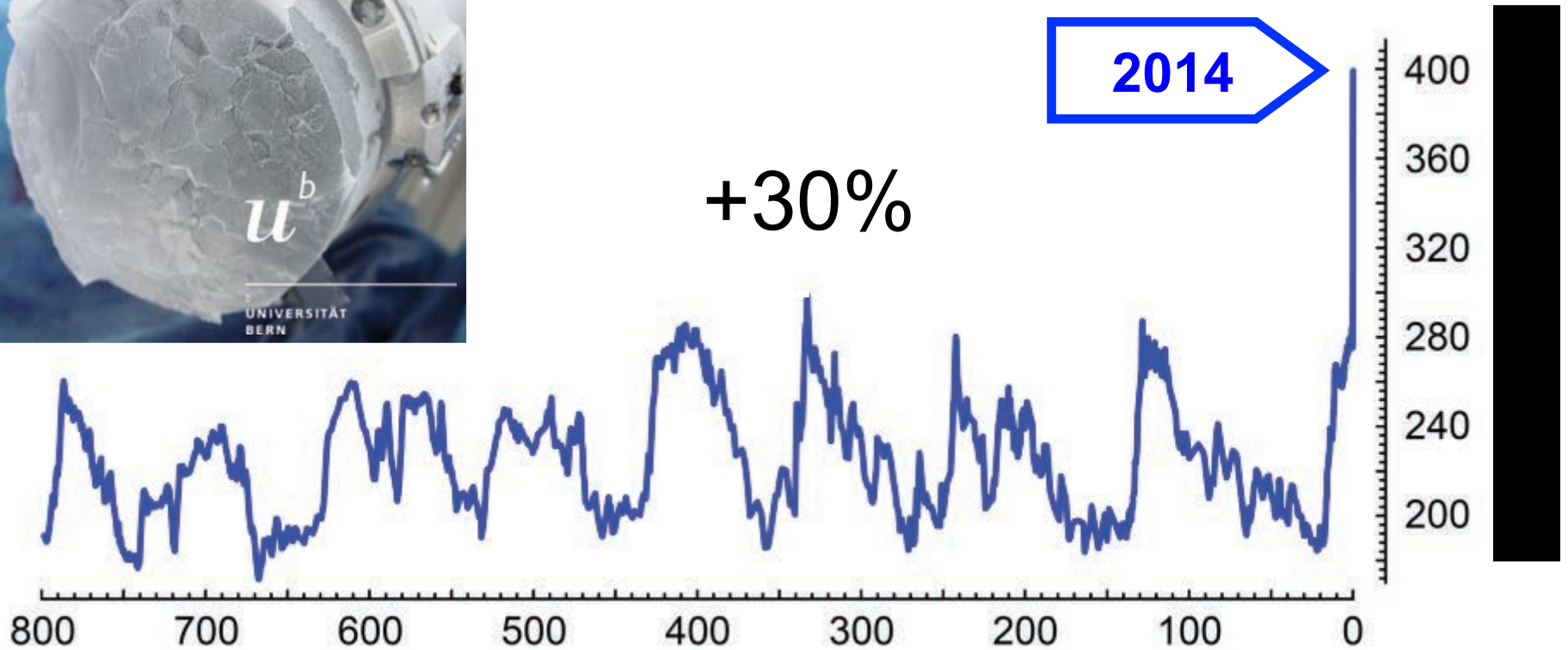
AR3 (2001): “most of the warming of the past 50 years is **likely** (odds 2 out of 3) due to human activities”

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... »

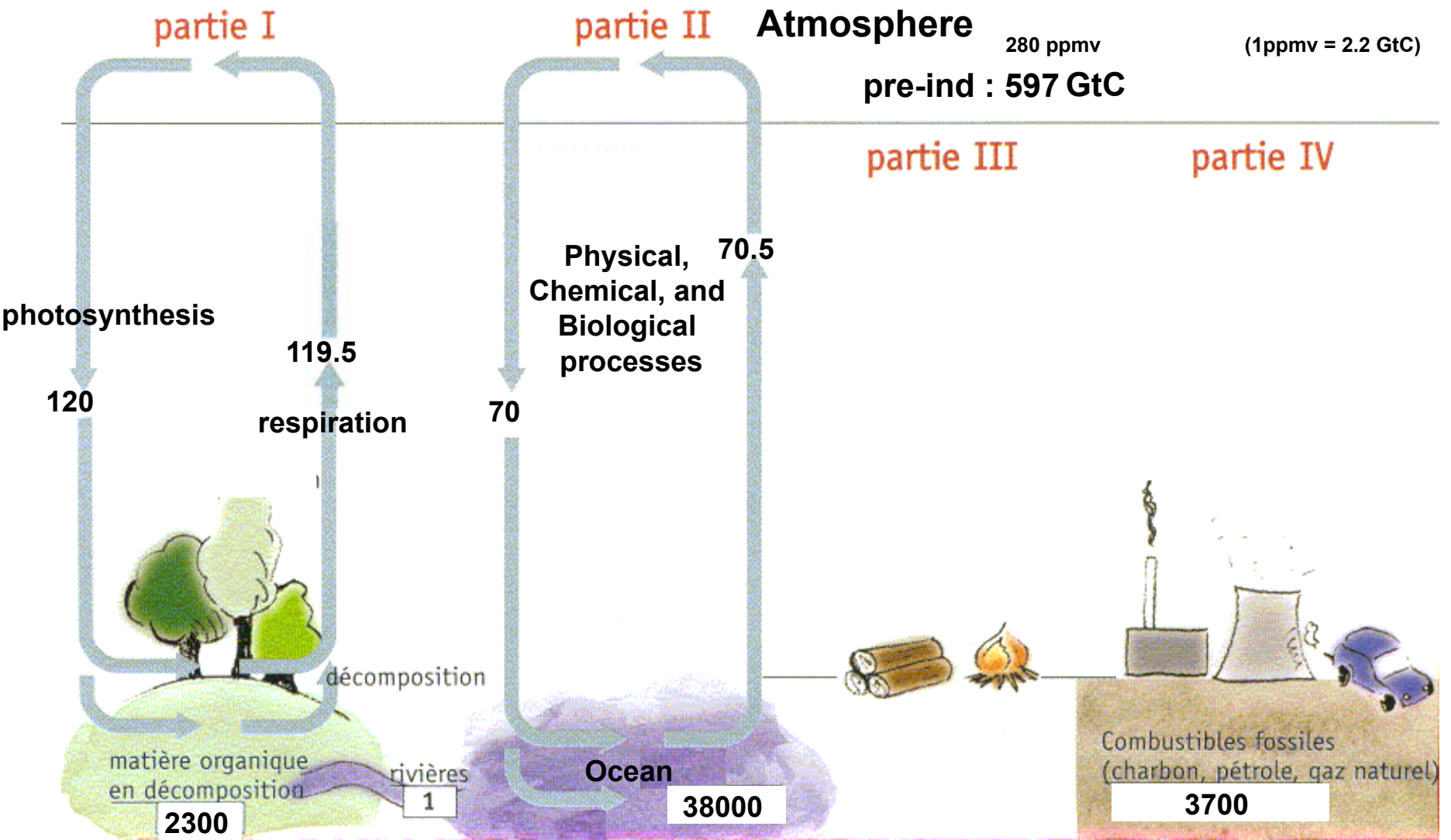
Atmospheric concentrations of CO₂



(Lüthi et al., 2008, NOAA)

The concentrations of CO₂ have increased to levels unprecedented in at least the last 800,000 years.

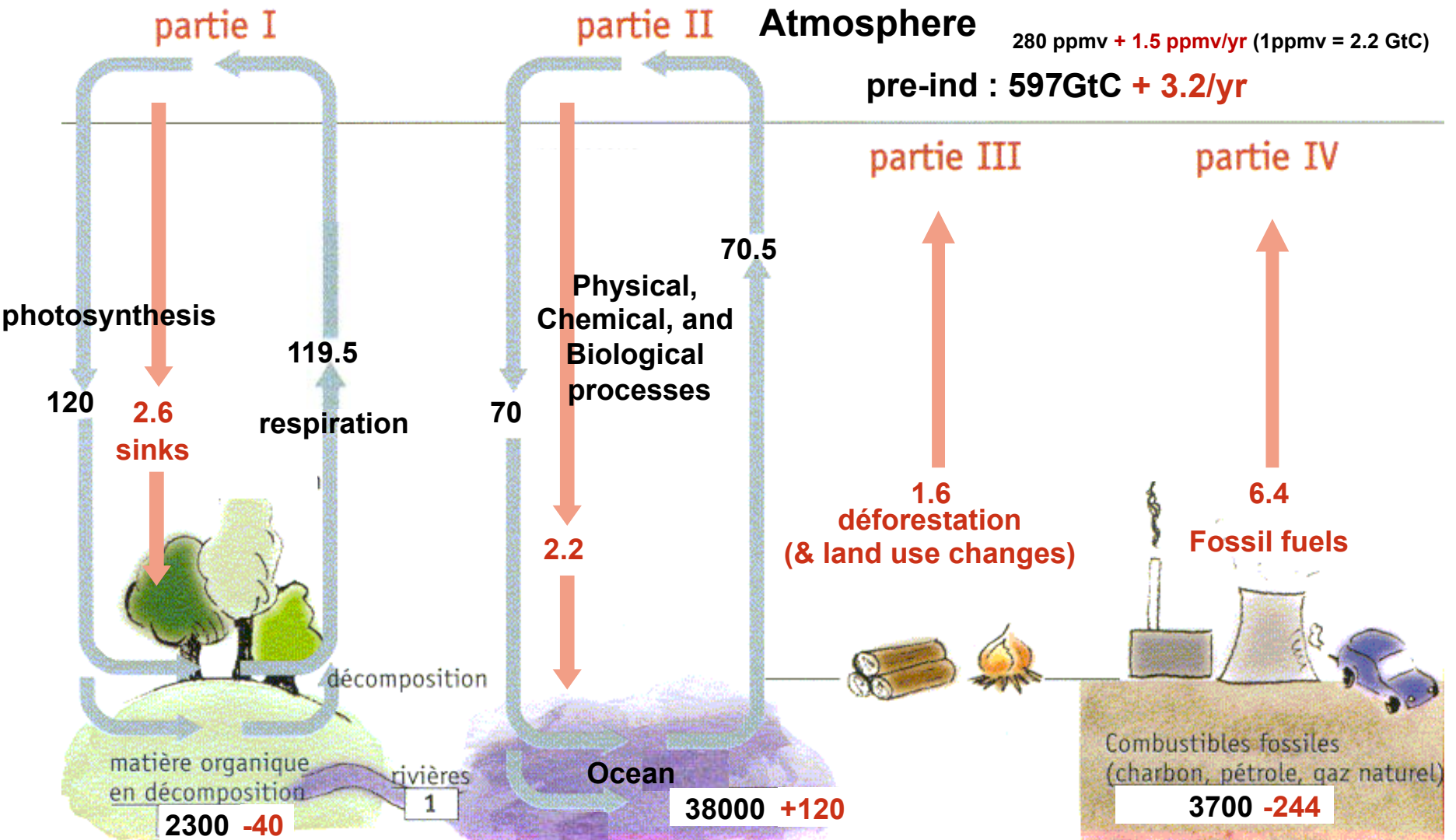
Carbon cycle: unperturbed fluxes



Units: GtC (billions tons of carbon) or GtC/year (multiply by 3.7 to get GtCO₂)

Carbon cycle: perturbed by human activities

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



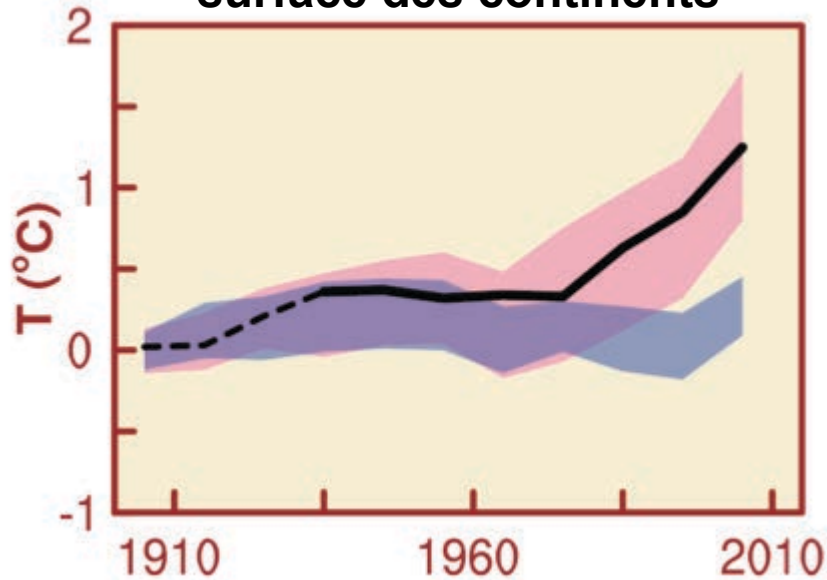
Units: GtC (billions tons of carbon) or GtC/year

Stocks!

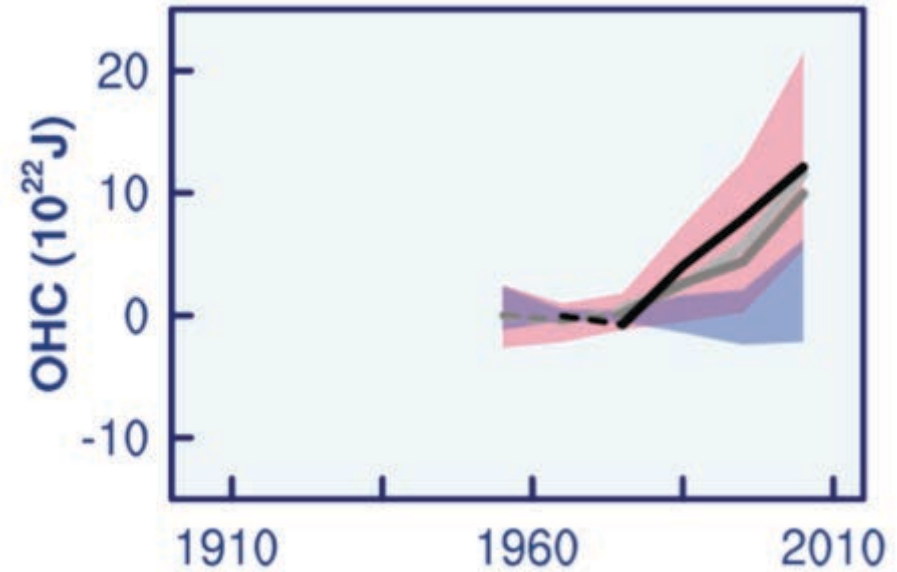
The carbon cycle is policy-relevant

- CO₂ accumulates in the atmosphere as long as human emissions are larger than the natural absorption capacity**
- Historical emissions 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)**

Température moyenne surface des continents



Contenu thermique des océans



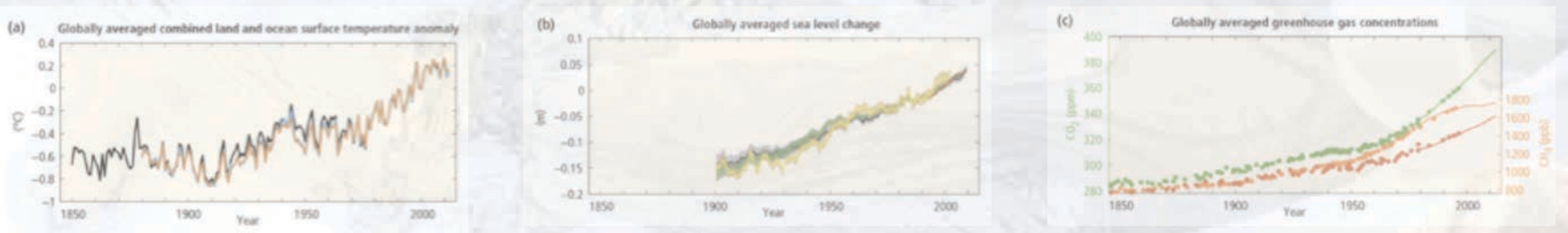
(IPCC 2013, Fig. SPM.6)

Noir: observations

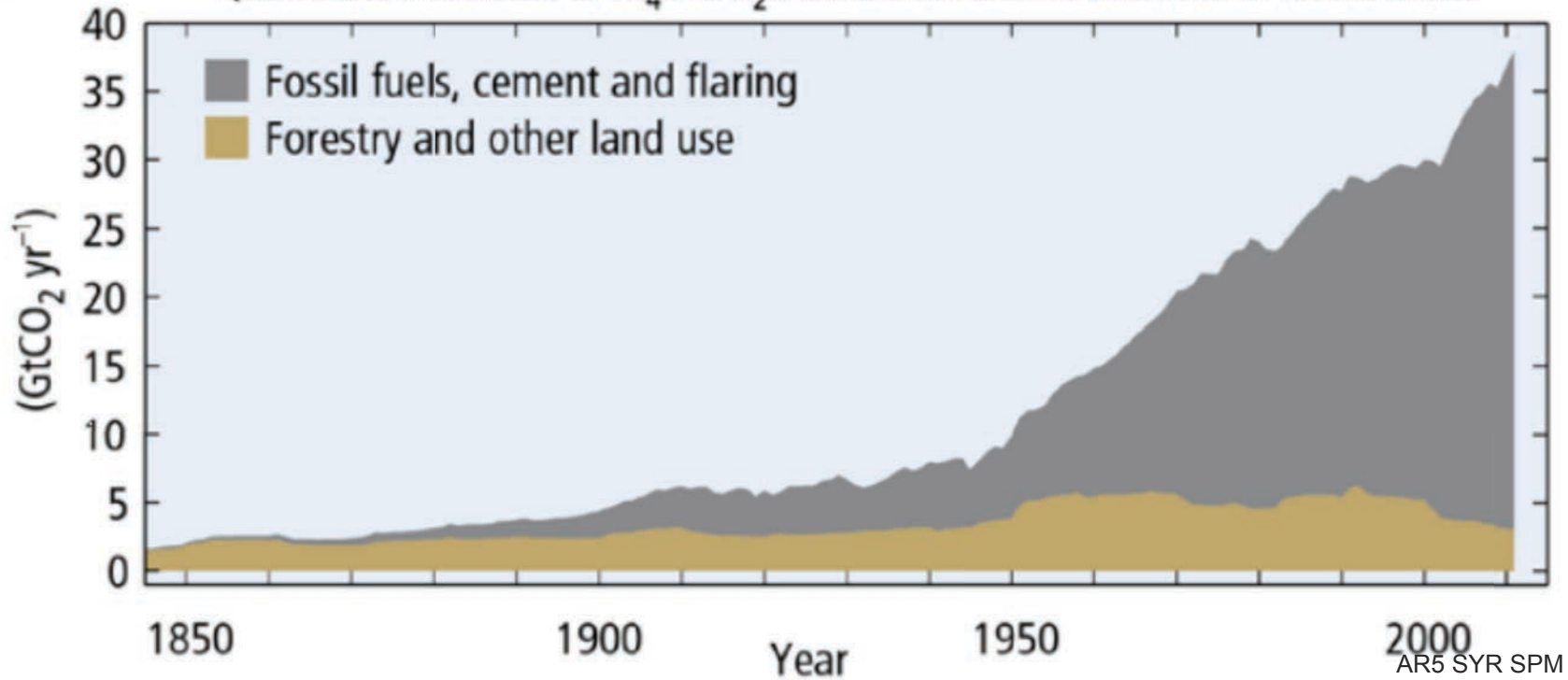
Bleu: simulations avec seuls facteurs naturels

Rose: simulations avec facteurs naturels & humains

L'influence humaine sur le système climatique est sans équivoque; Il est *extrêmement probable* (95%) que l'influence humaine a été la cause principale du réchauffement depuis le milieu du 20^{ème} siècle



(d) Global anthropogenic CO₂ emissions
 Quantitative information of CH₄ and N₂O emission time series from 1850 to 1970 is limited



AR5 SYR SPM

Sources of emissions

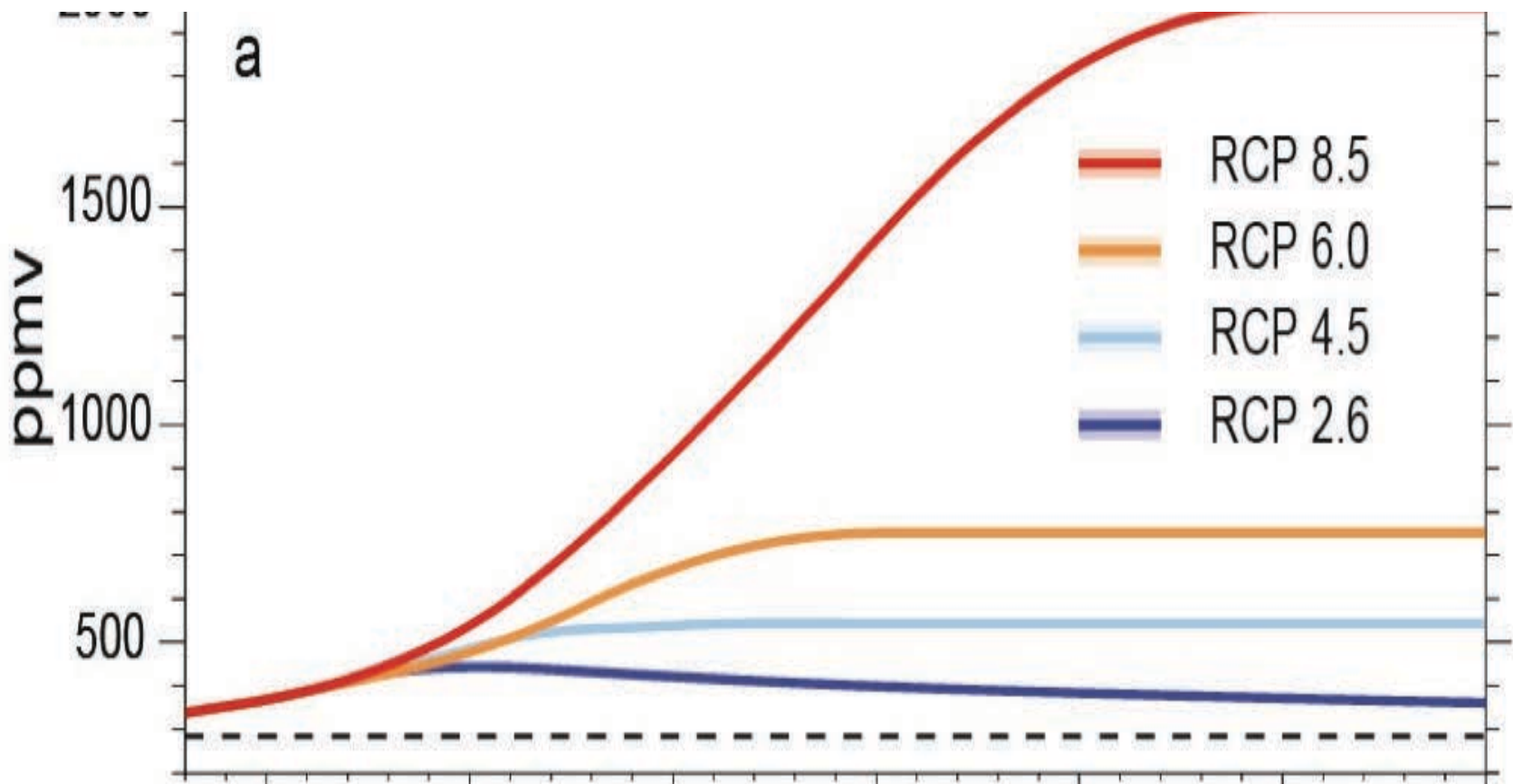
Energy production remains the primary driver of GHG emissions



2010 GHG emissions

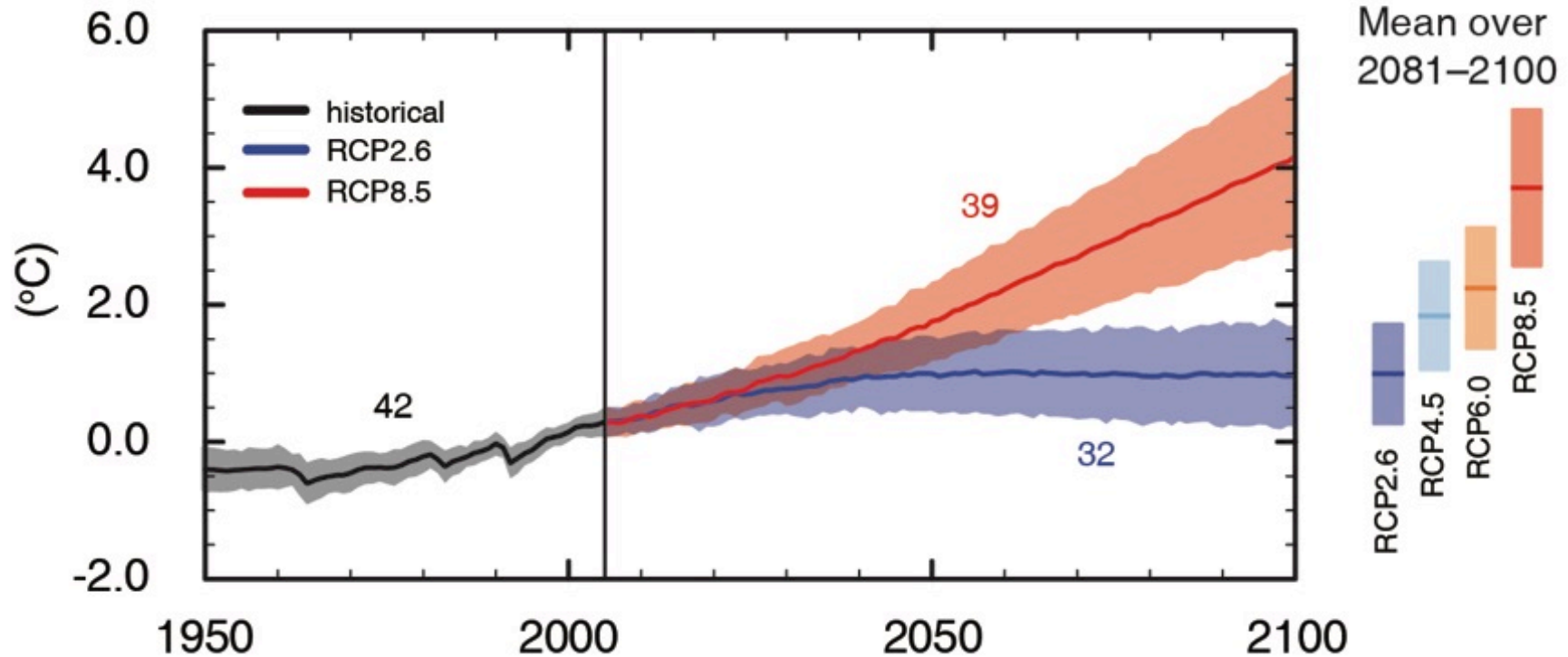
AR5 WGIII SPM

RCP Scenarios: Atmospheric CO₂ concentration



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

Global average surface temperature change



(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

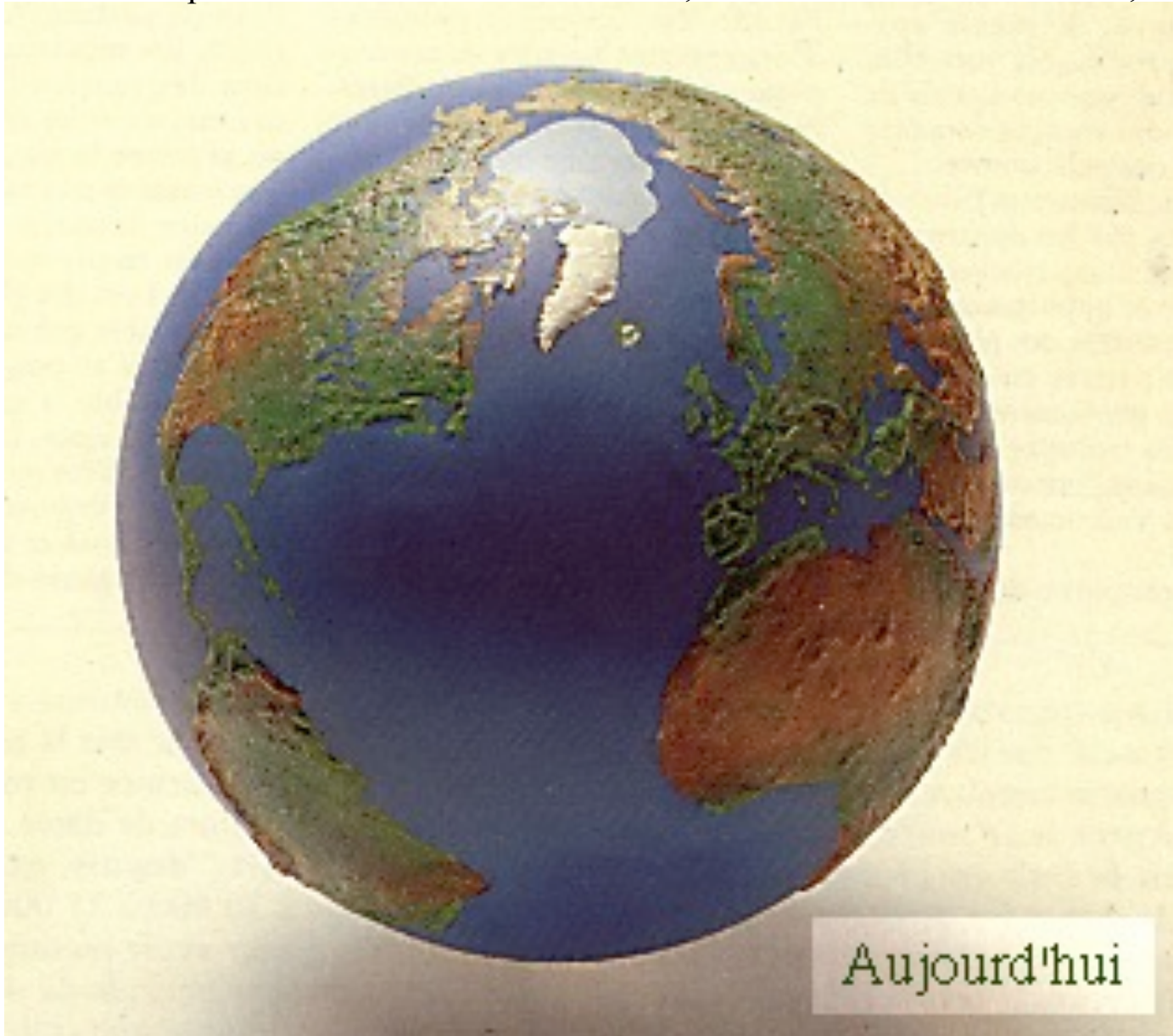
18-20000 years ago (Last Glacial Maximum)

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

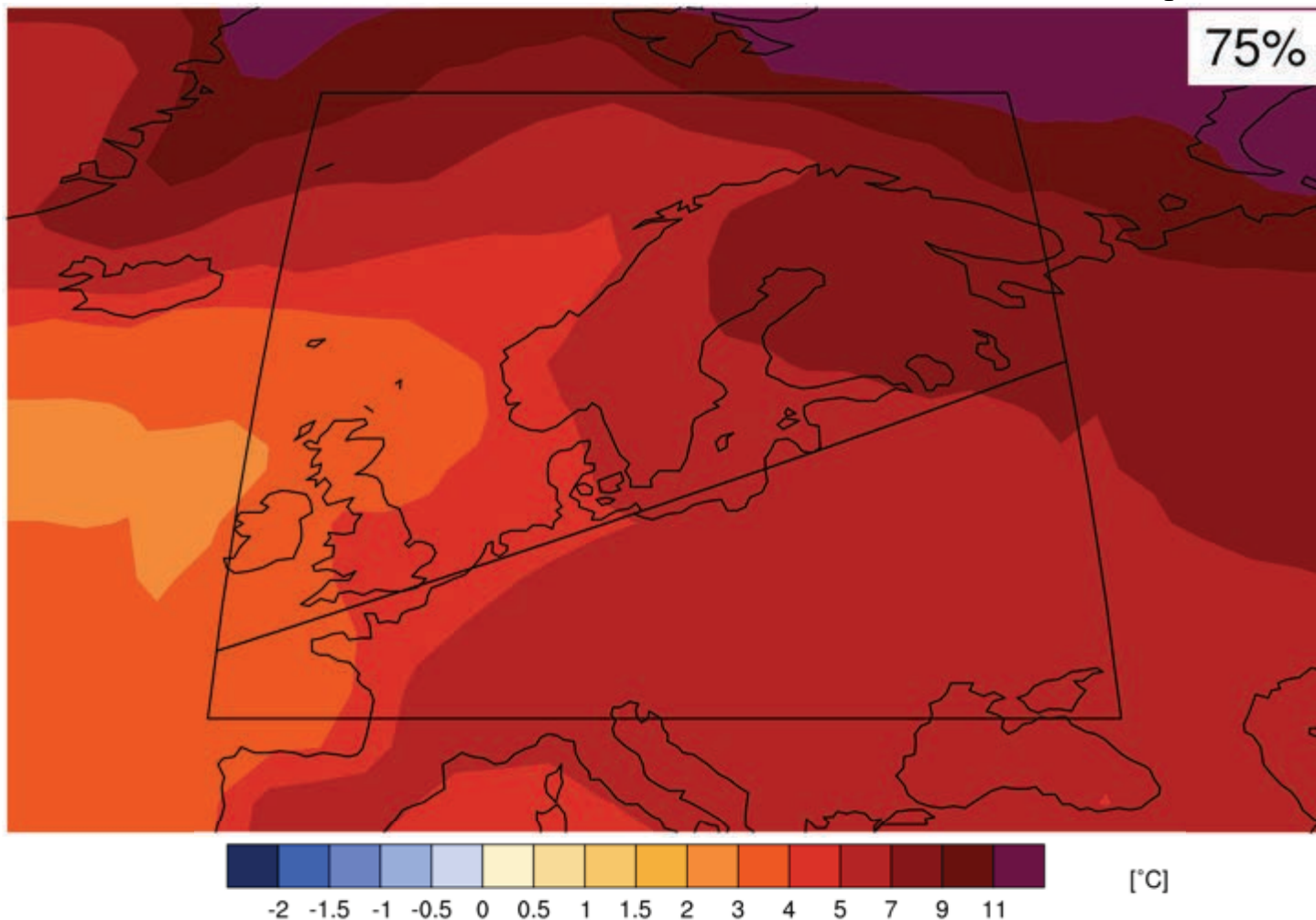


Today, with +4-5°C globally

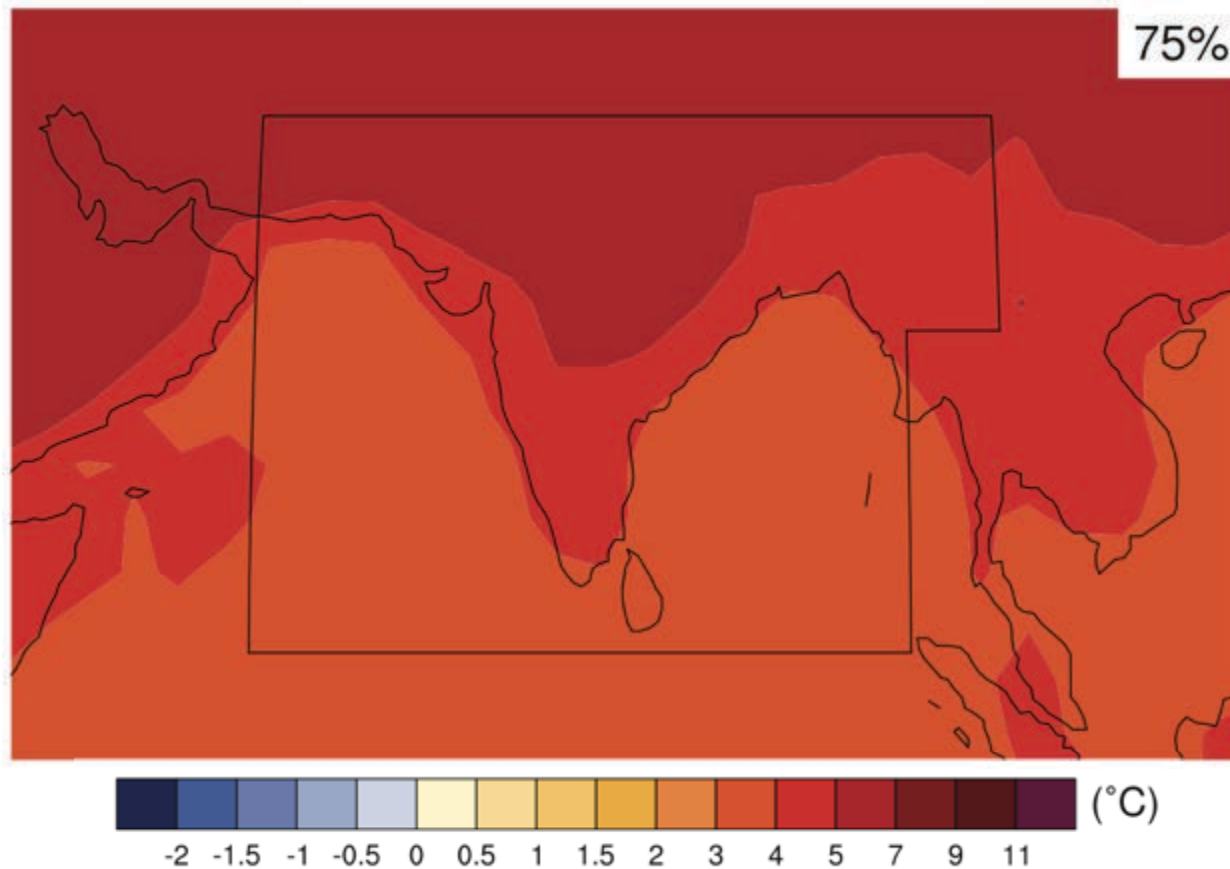
With permission from Dr. S. Joussaume, in « Climat d'hier à demain », CNRS éditions.



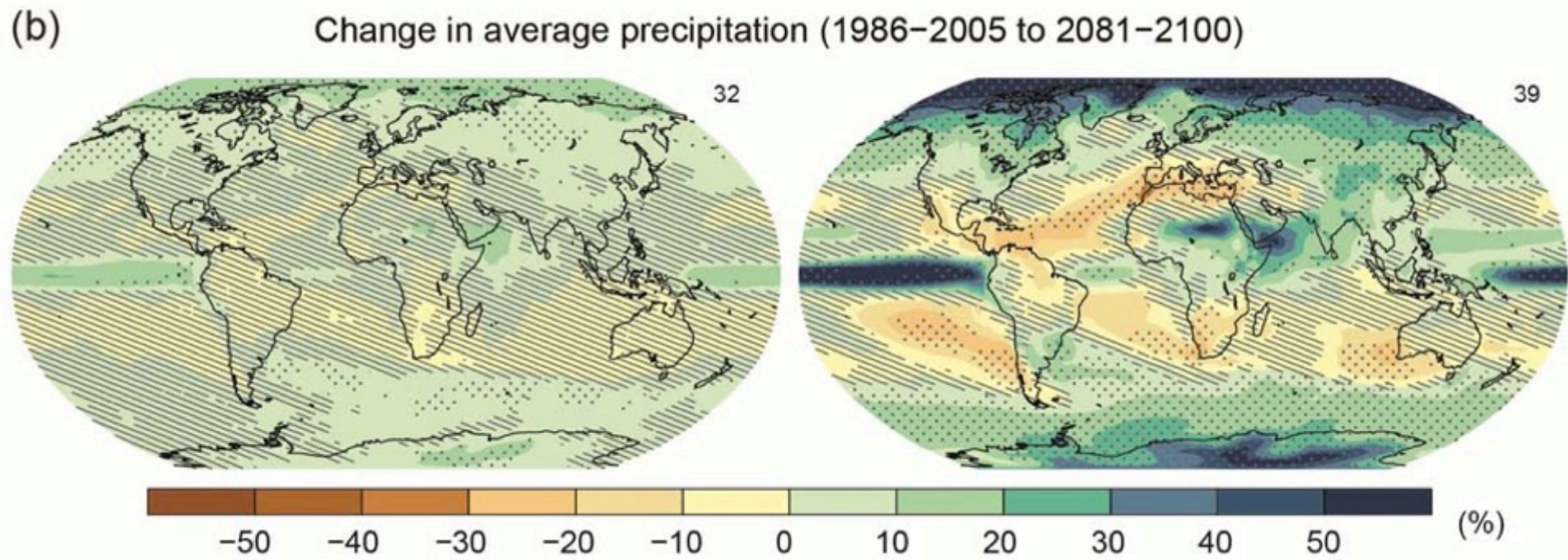
North Europe - Map of temperature changes: 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario (annual)



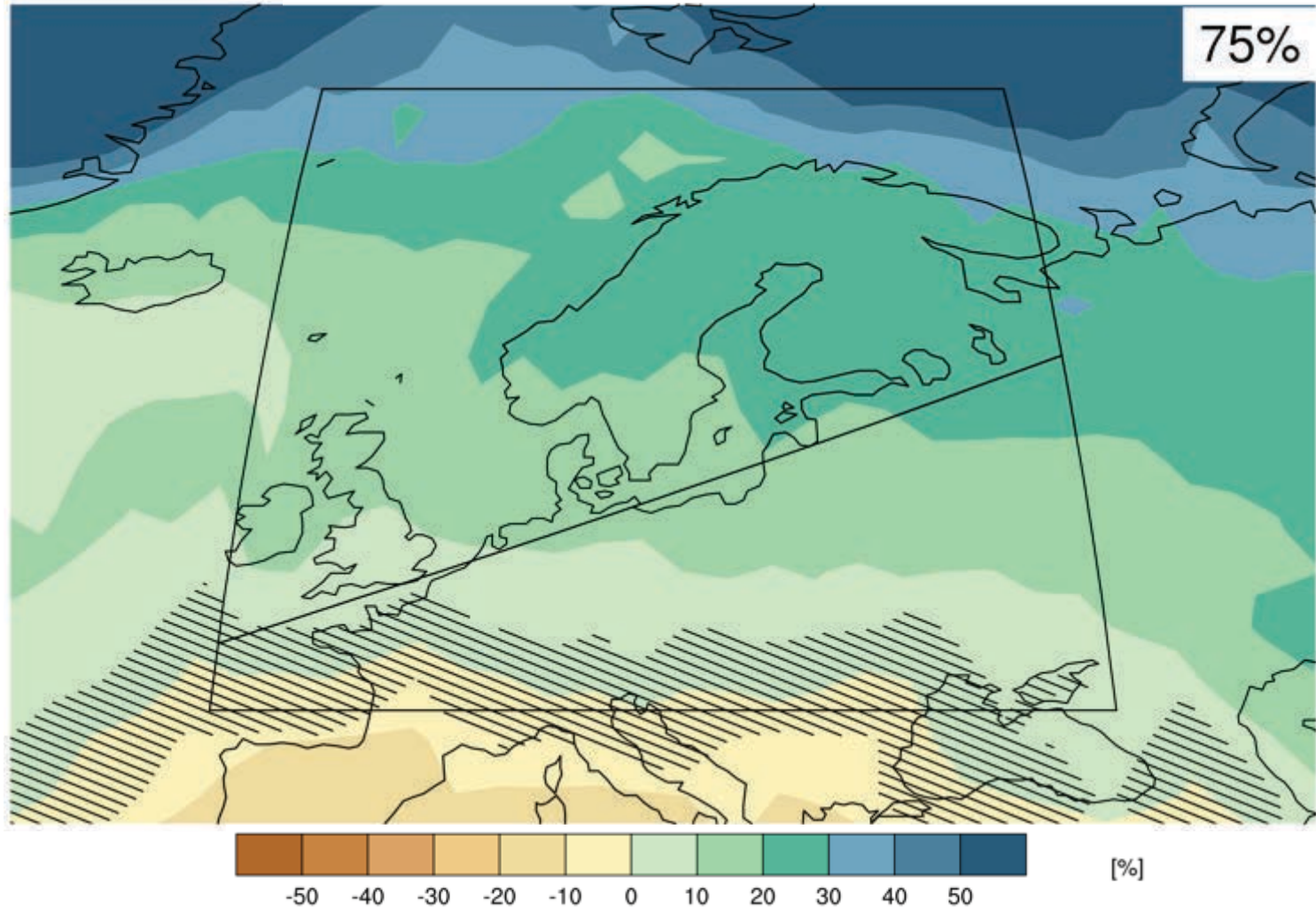
Maps of temperature changes in 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario

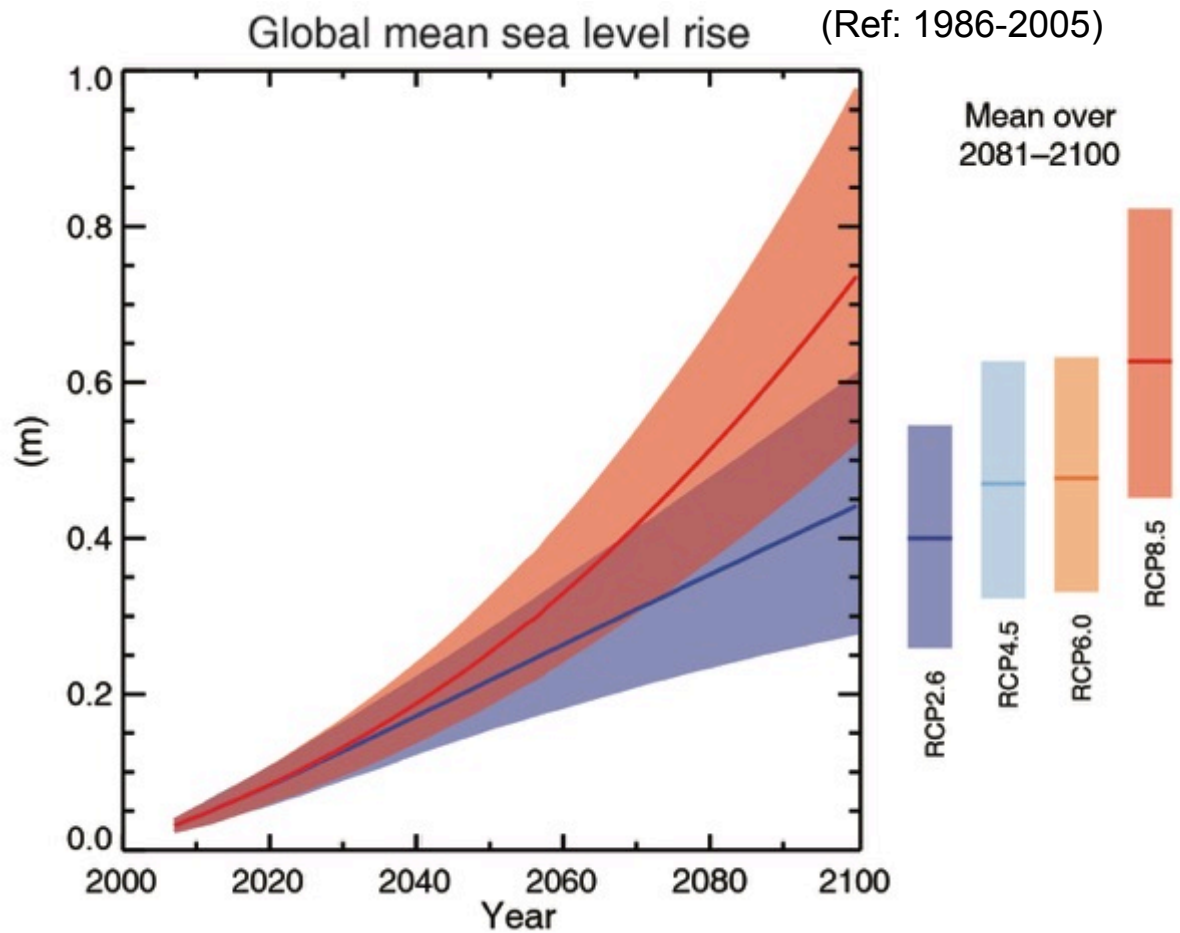


Annual rainfall projections



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





(IPCC 2013, Fig. SPM.9)

Sea level due to continue to increase

**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: J.P. van Ypersele et P. Marbaix (2004) See www.climate.be/impacts

Effets sur le Delta du Nil, où vivent plus de 10 millions de personnes à moins d'1 m d'altitude



(Time 2001)

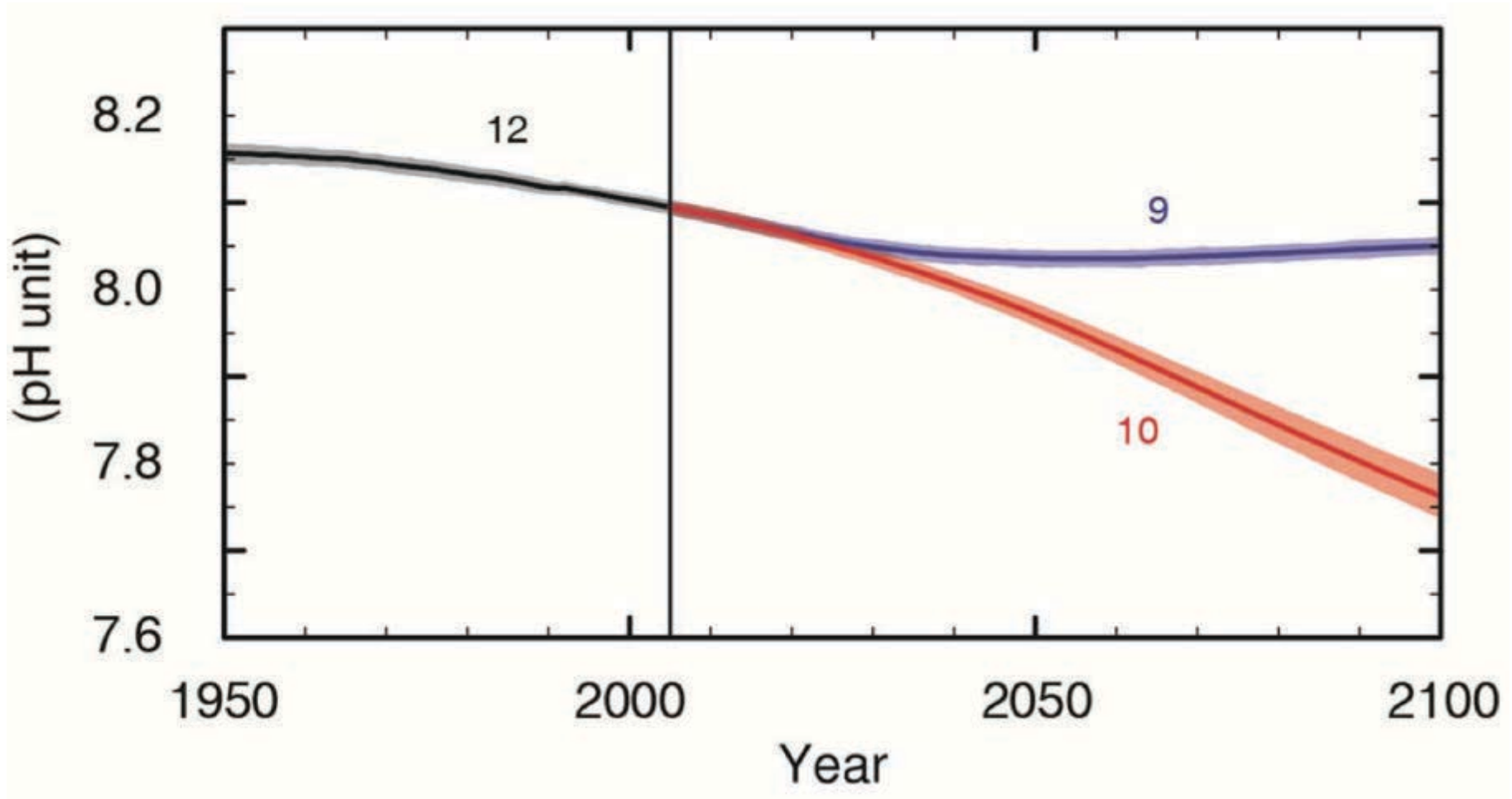
**With 8 metre sea-level rise: 3700 km² below sea-level in Belgium
(very possible in year 3000)
(NB: flooded area depends on protection)**



Source: J.P. van Ypersele et P. Marbaix (2004) See www.climate.be/impacts

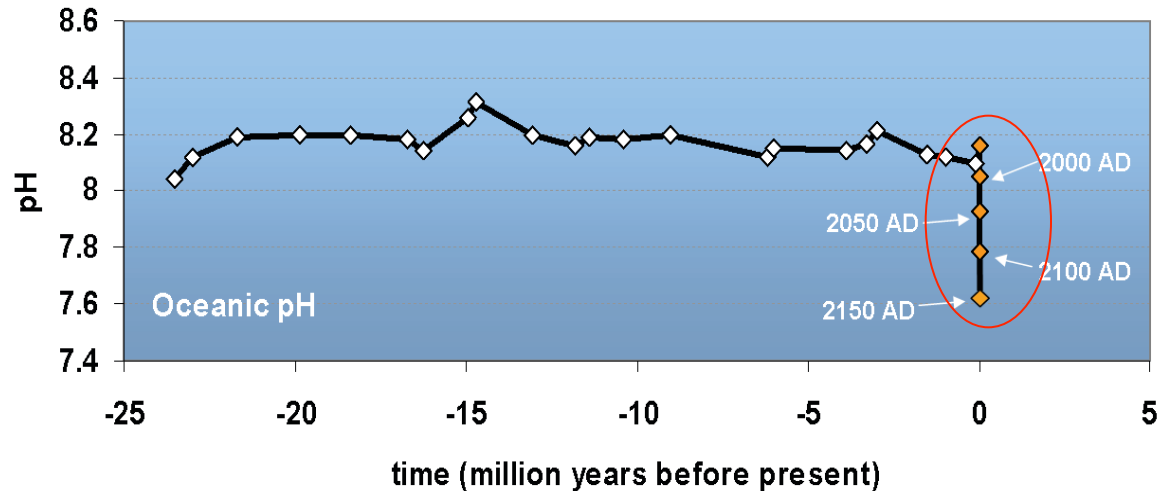
Global ocean surface pH (projections)

Ocean Acidification, for RCP 8.5 (orange) & RCP2.6 (blue)



Oceans are Acidifying Fast

Changes in pH over the last 25 million years



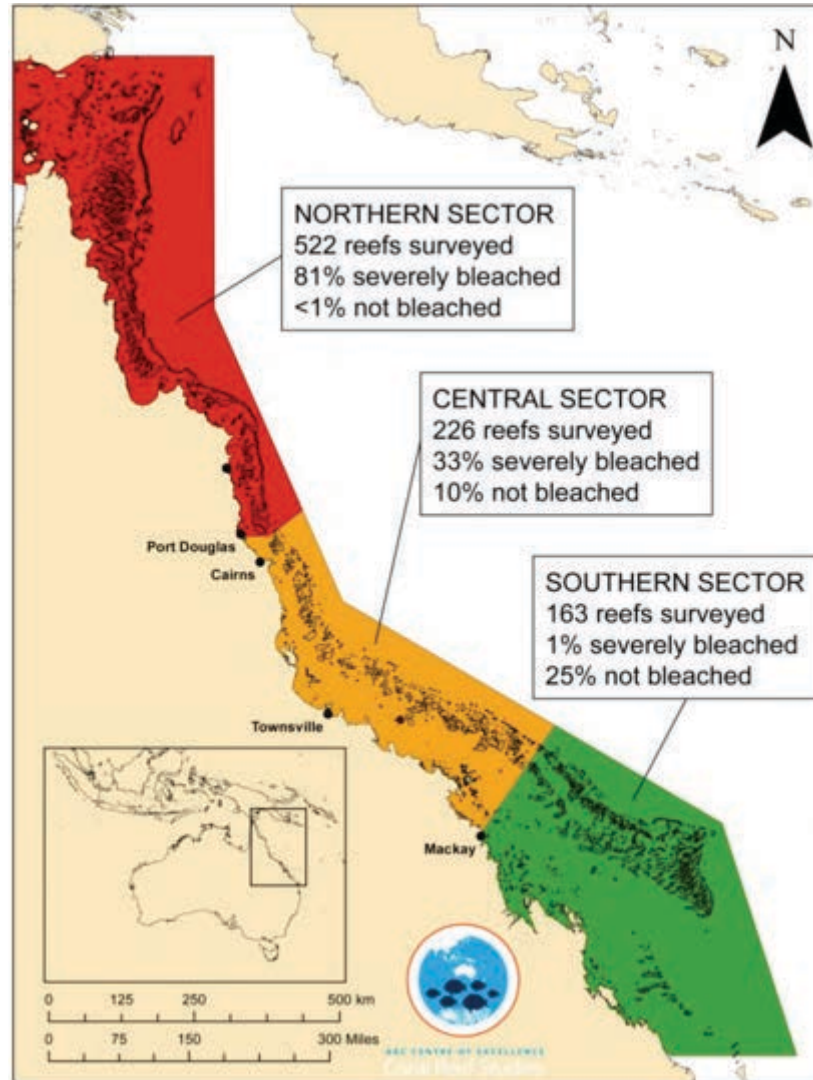
“Today is a rare event in the history of the World”

- It is happening now, at a **speed and to a level** not experienced by marine organisms for about 60 million years
- Mass extinctions linked to previous ocean acidification events
- Takes 10,000' s of years to recover

Turley et al. 2006

Slide courtesy of Carol Turley, PML

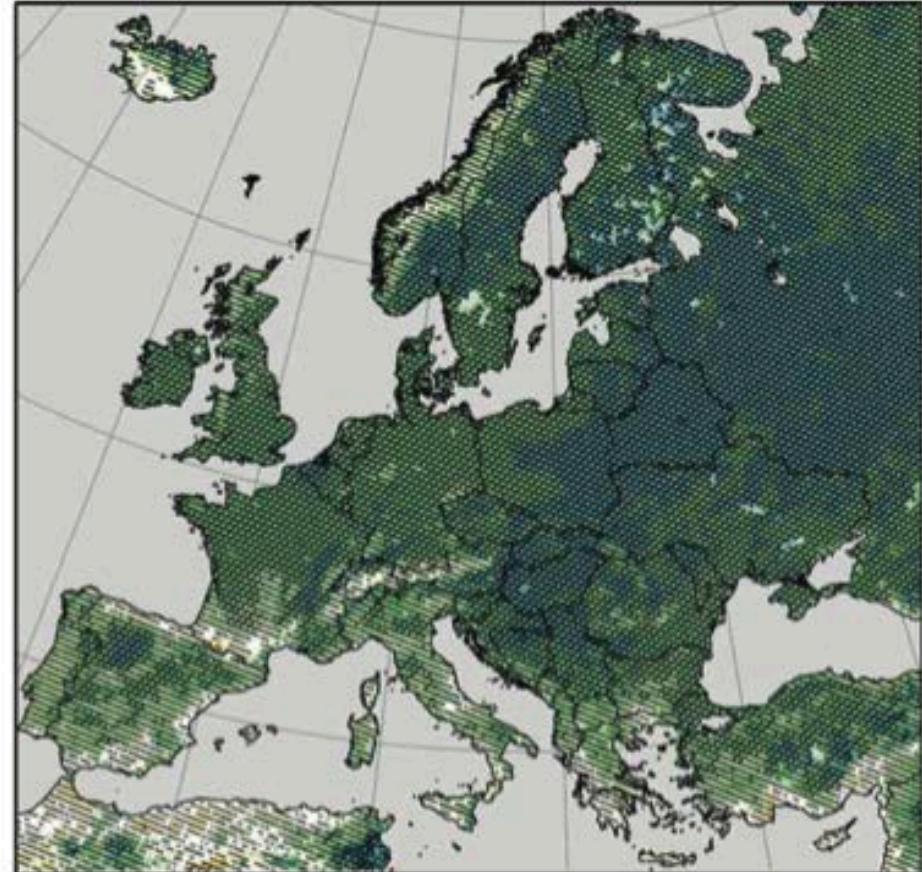
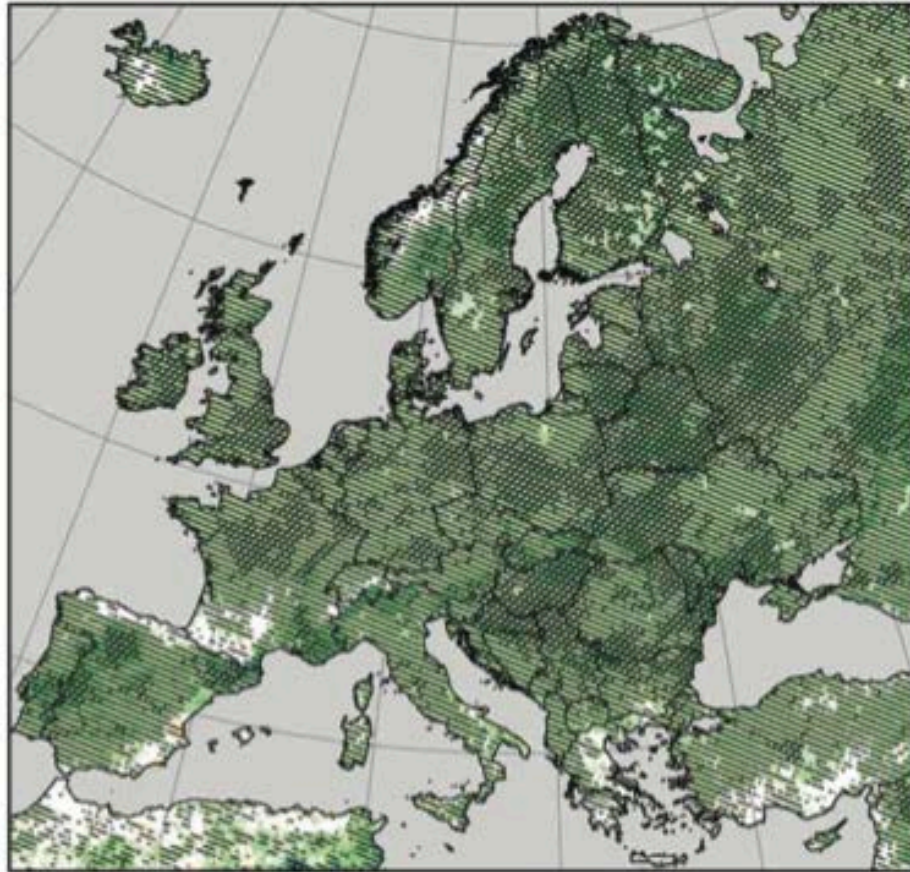
Only 7% of the Great Barrier Reef has avoided coral bleaching (May 2016)



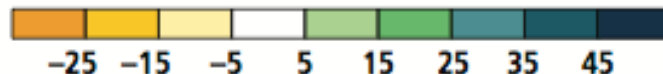
DJF seasonal changes in heavy precipitation (%), 2071-2100 compared to 1971-2000

RCP4.5

RCP8.5



Seasonal changes in heavy
precipitation in percent



//// Significant change

\\\\ Robust change

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)



Potential Impacts of Climate Change



Food and water shortages



Increased displacement of people



Increased poverty



Coastal flooding

AR5 WGII SPM



ADAPTATION IS

ALREADY OCCURRING

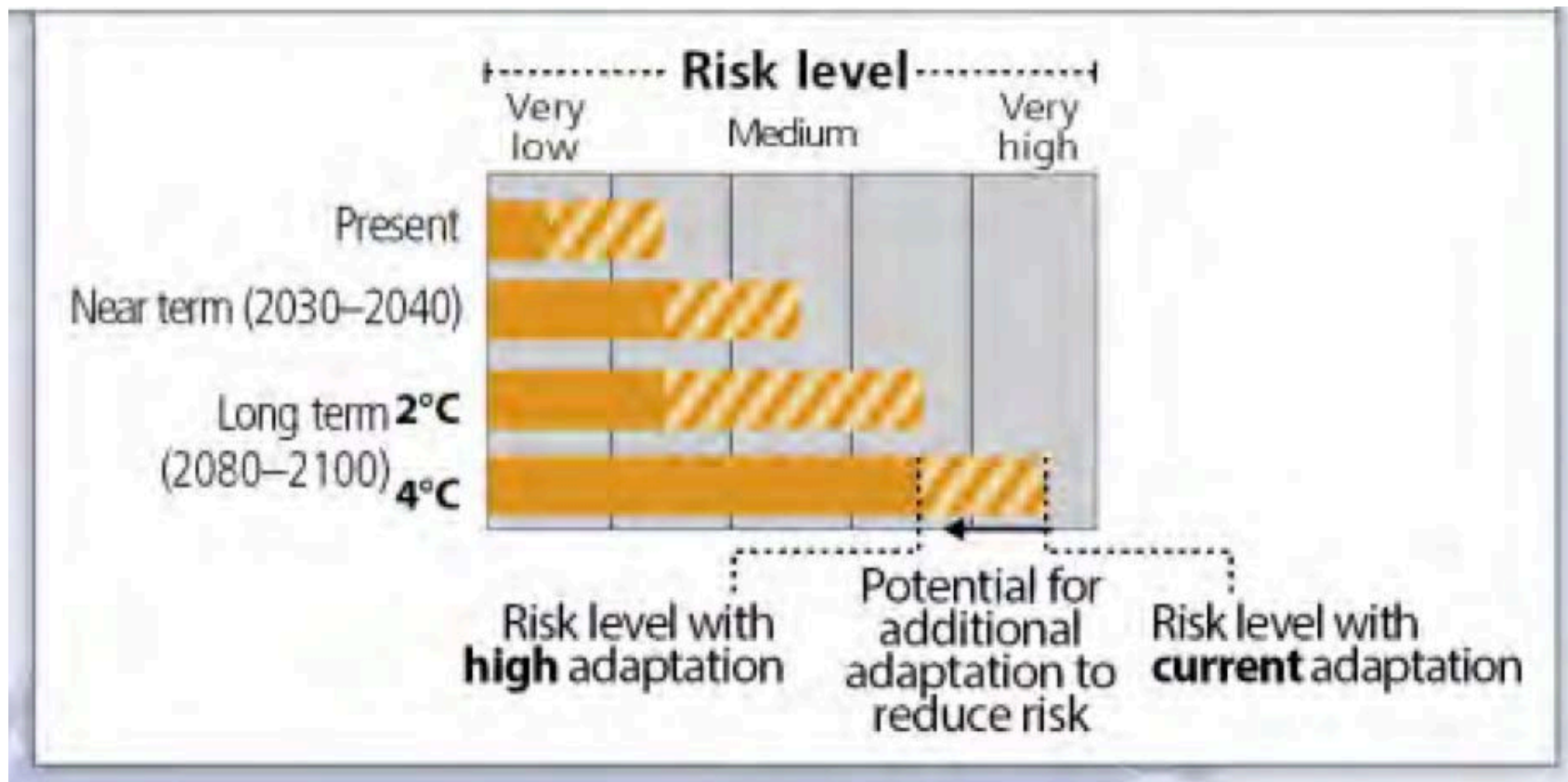
Flood risk adaptation in Bangladesh (example): cyclone shelters, awareness raising, forecasting and warning



photo: Dr Thorsten Klose/German Red Cross (2010), evaluation of the Community Based Disaster Preparedness Programme run by the Red Cross in 1996-2002

Regional key risks and potential for risk reduction through adaptation

Representative key risks for each region for

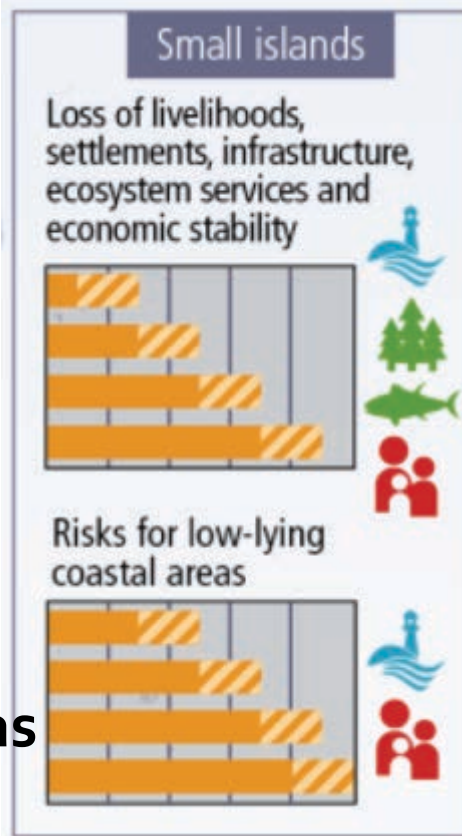


Regional key risks and potential for risk reduction: Small Islands

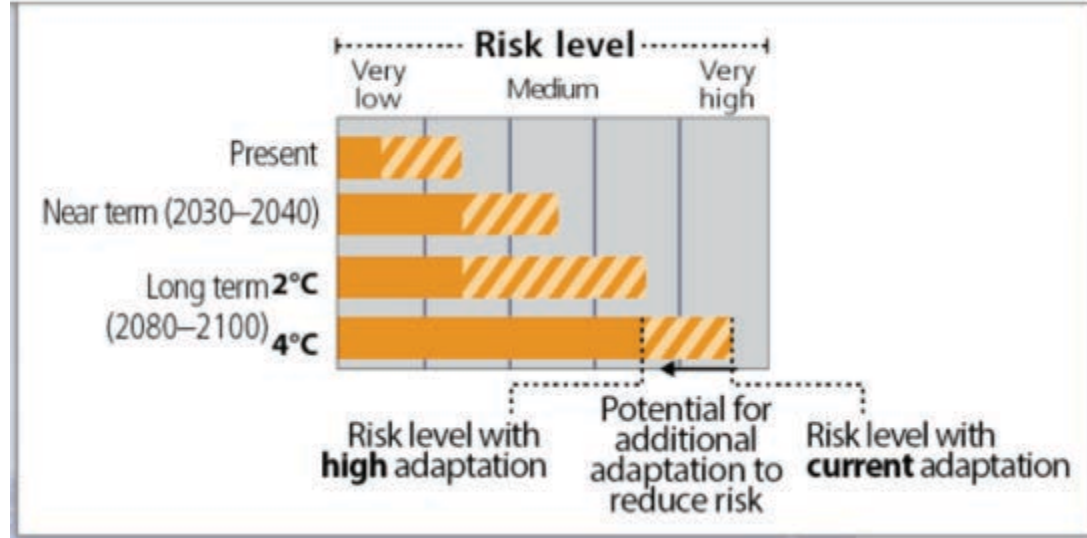
Representative key risks for each region for



Losses

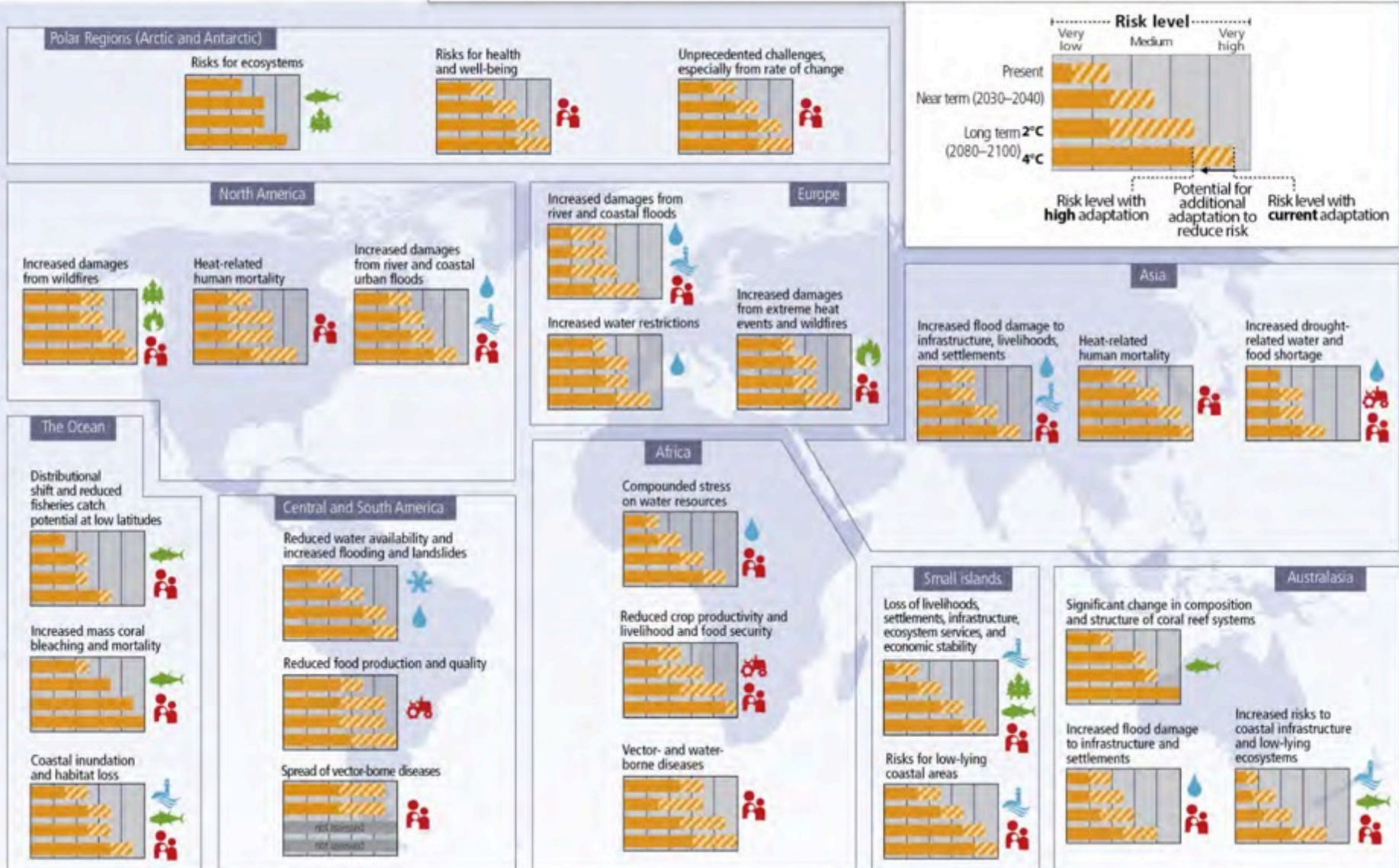


Risk to coastal areas



Regional key risks and potential for risk reduction

Representative key risks for each region for

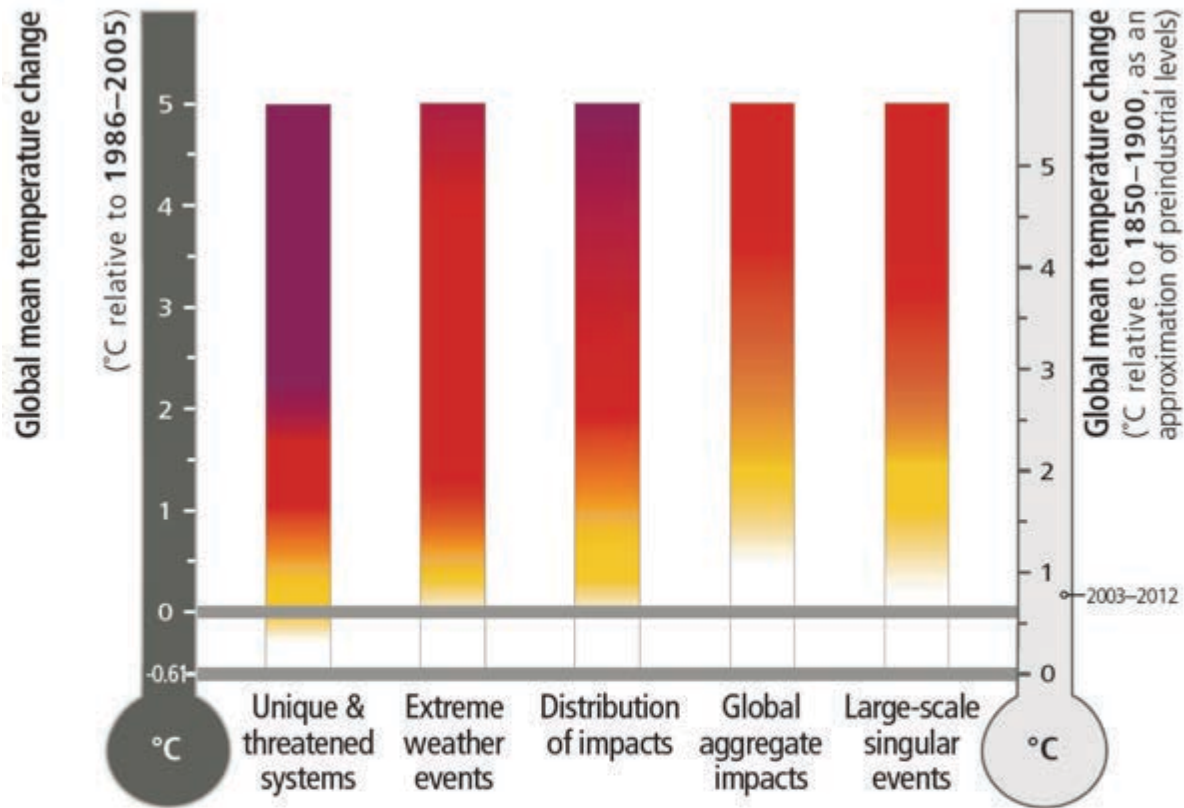




RISKS OF
CLIMATE CHANGE

INCREASE

WITH CONTINUED
HIGH EMISSIONS

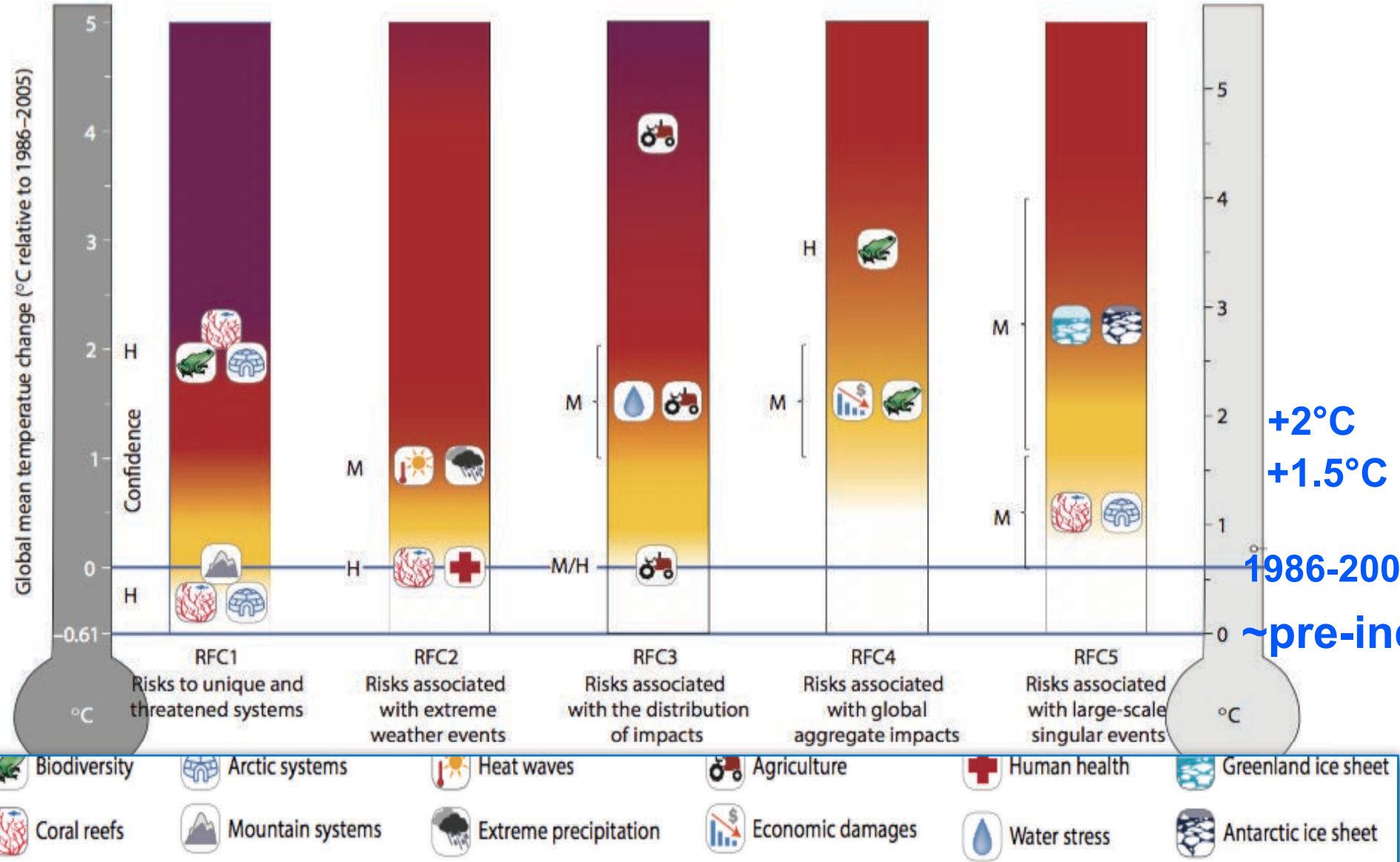


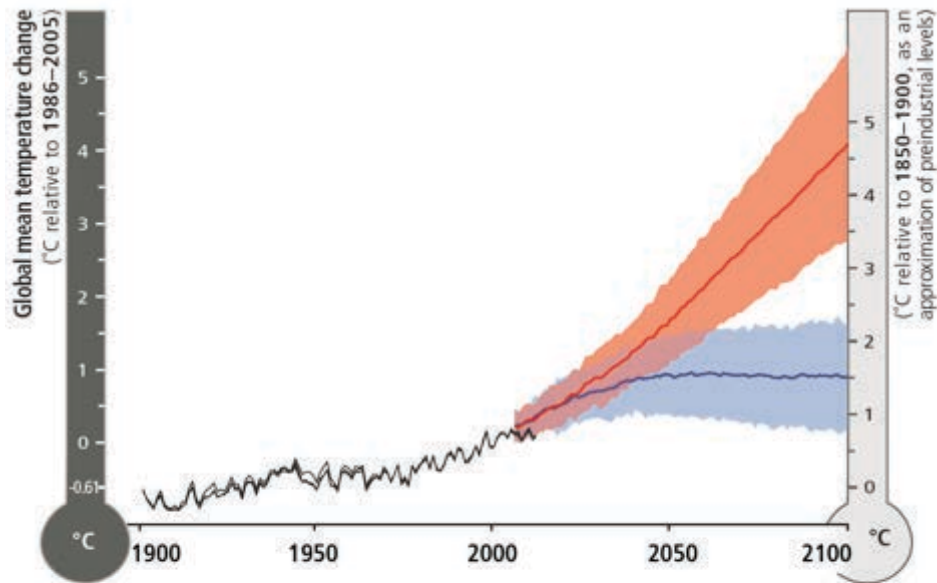
Level of additional risk due to climate change

Undetectable Moderate High Very high

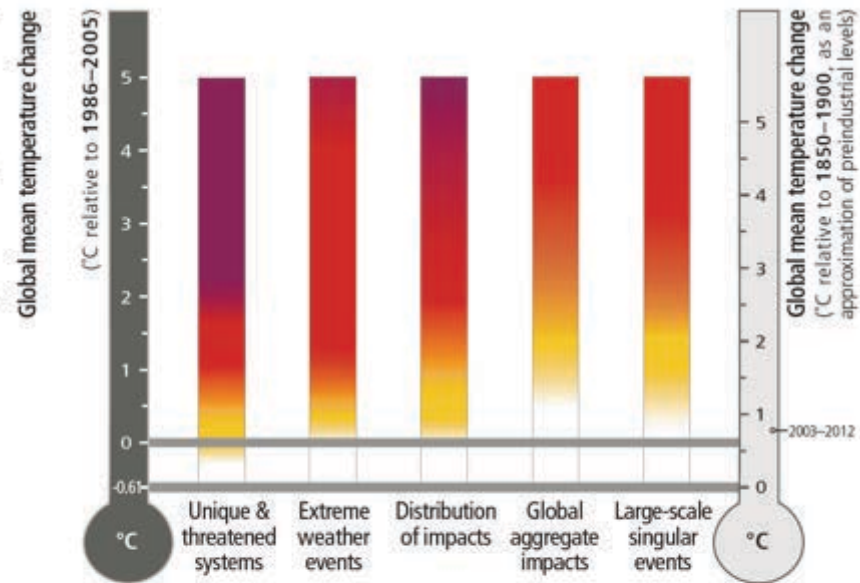
IPCC reasons for concern / climate change risks

(Nat Climate Change 2017)





- Observed
- RCP8.5 (a high-emission scenario)
- Overlap
- RCP2.6 (a low-emission mitigation scenario)



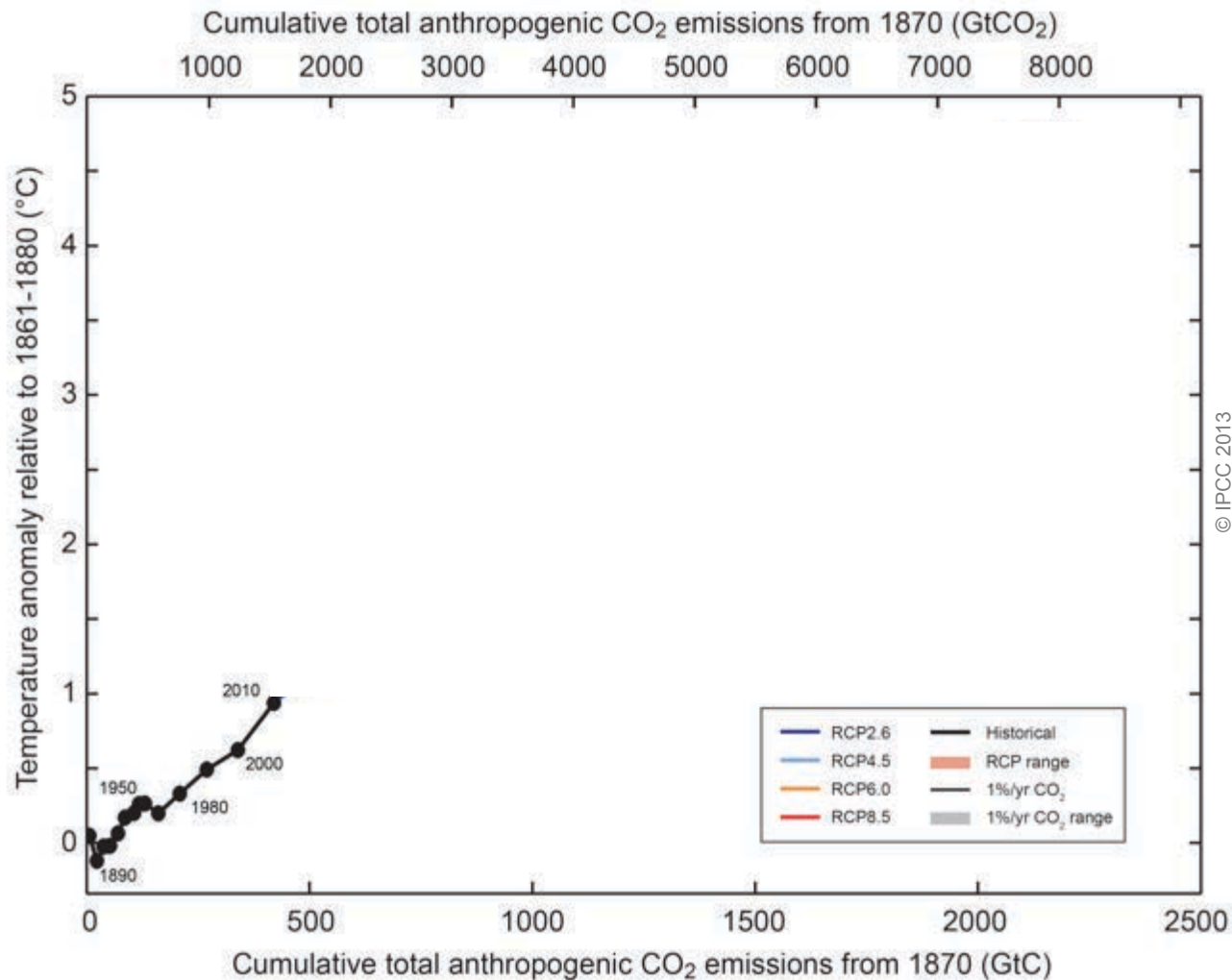


Fig. SPM.10

Cumulative emissions of CO₂ largely determine global mean surface warming by the late 21st century and beyond.

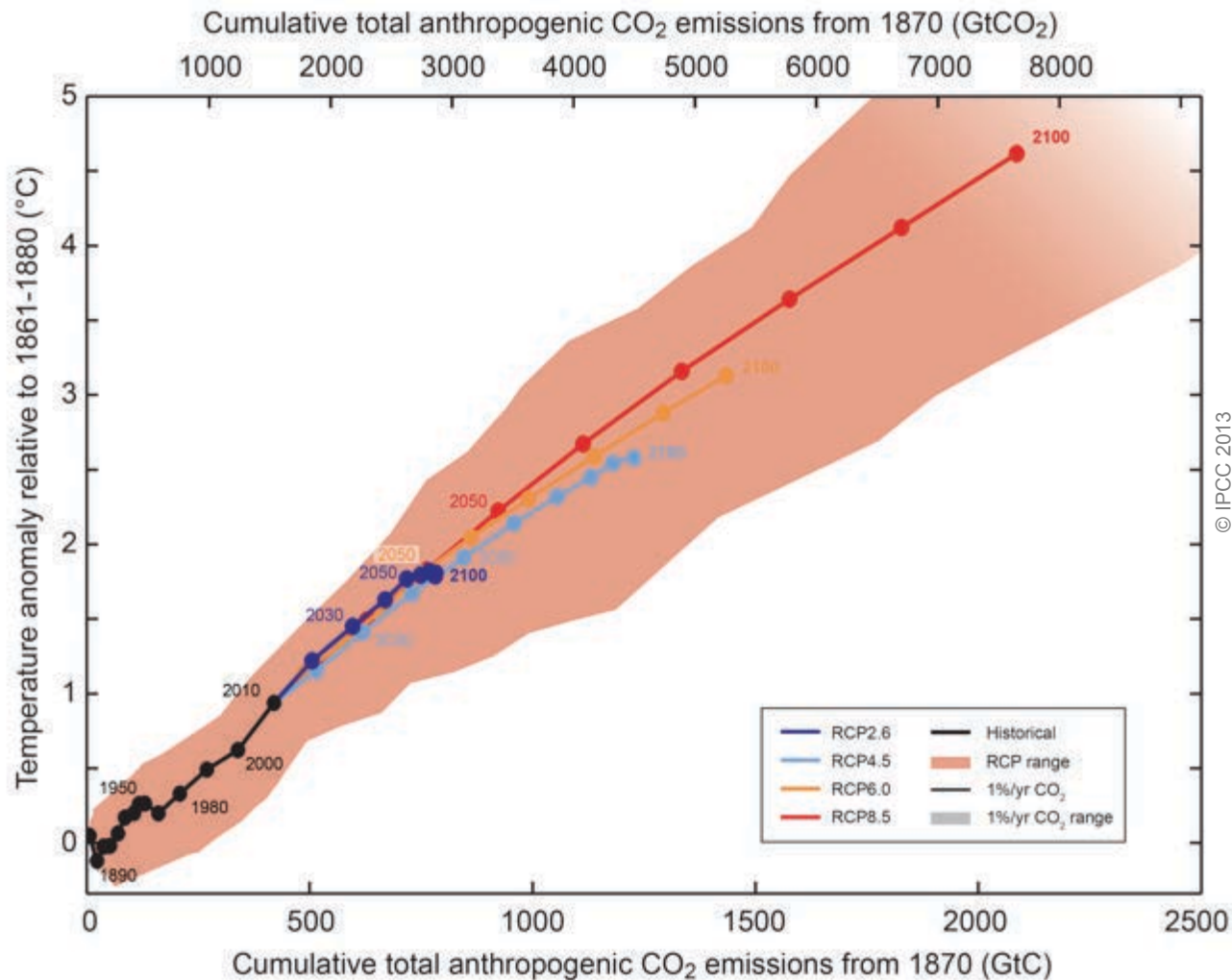
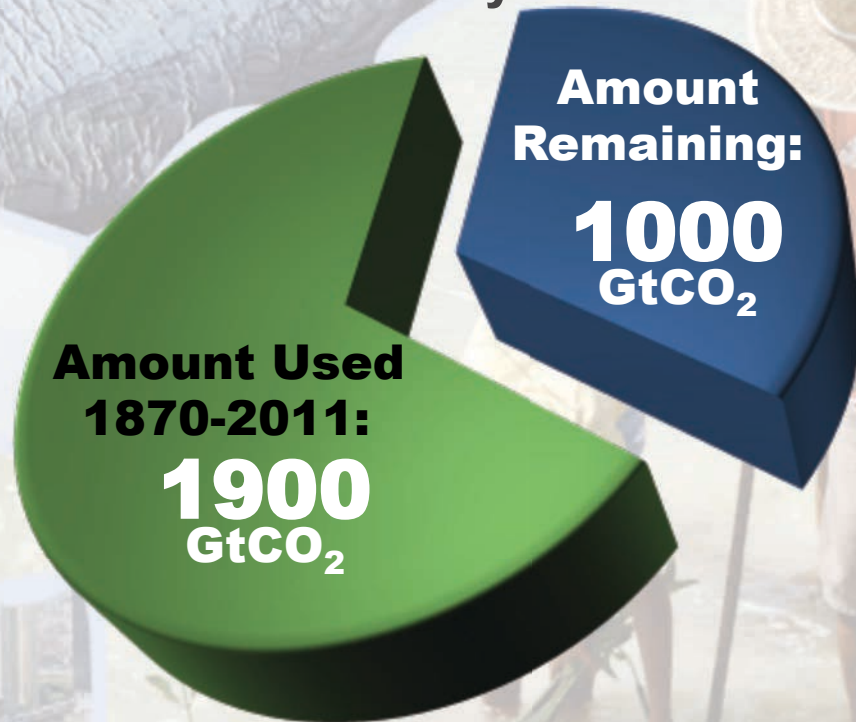


Fig. SPM.10

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

The window for action is rapidly closing

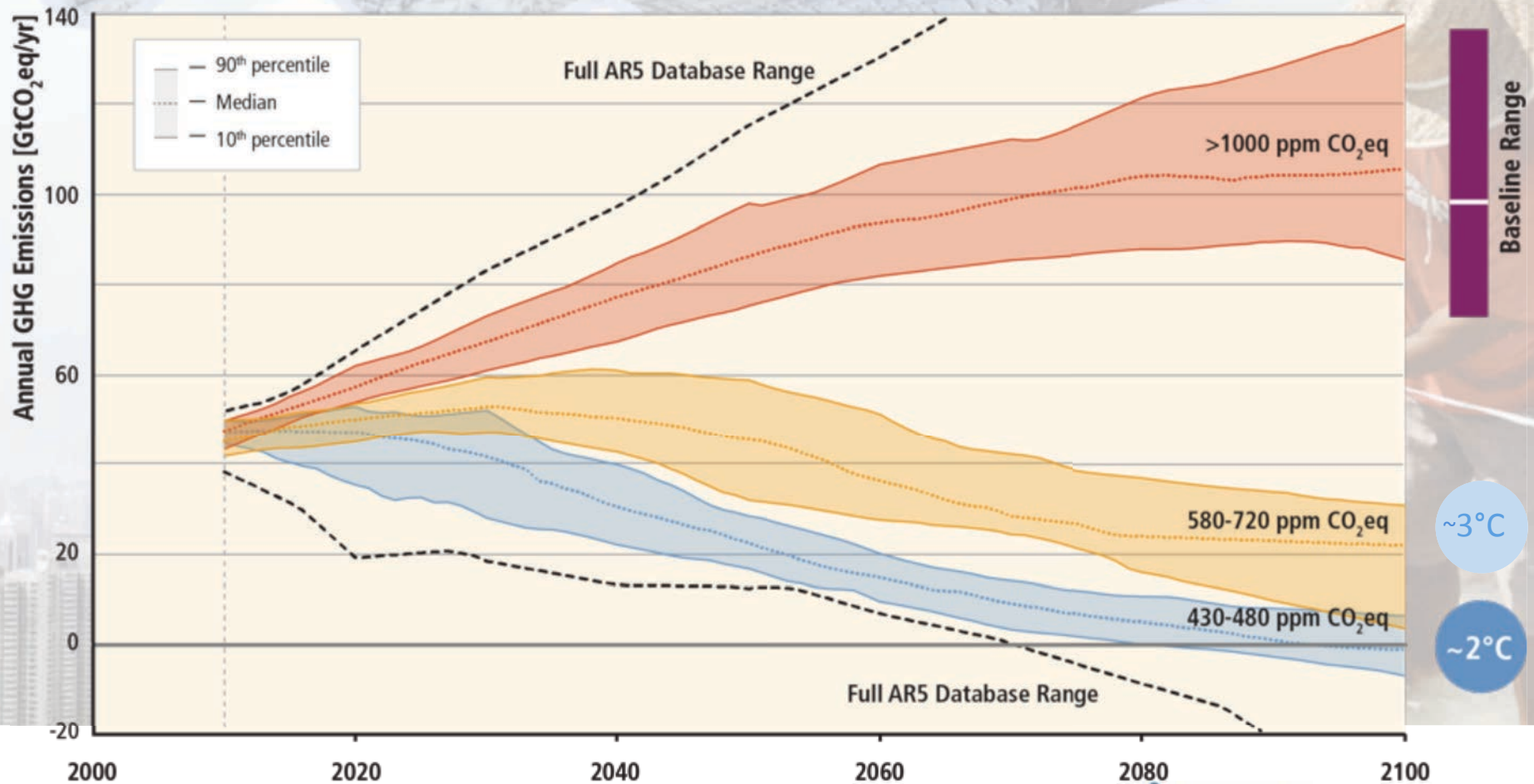
65% of the carbon budget compatible with a 2°C goal is already used
NB: this is with a probability greater than 66% to stay below 2°C



NB: Emissions in 2011: 38 GtCO₂/yr

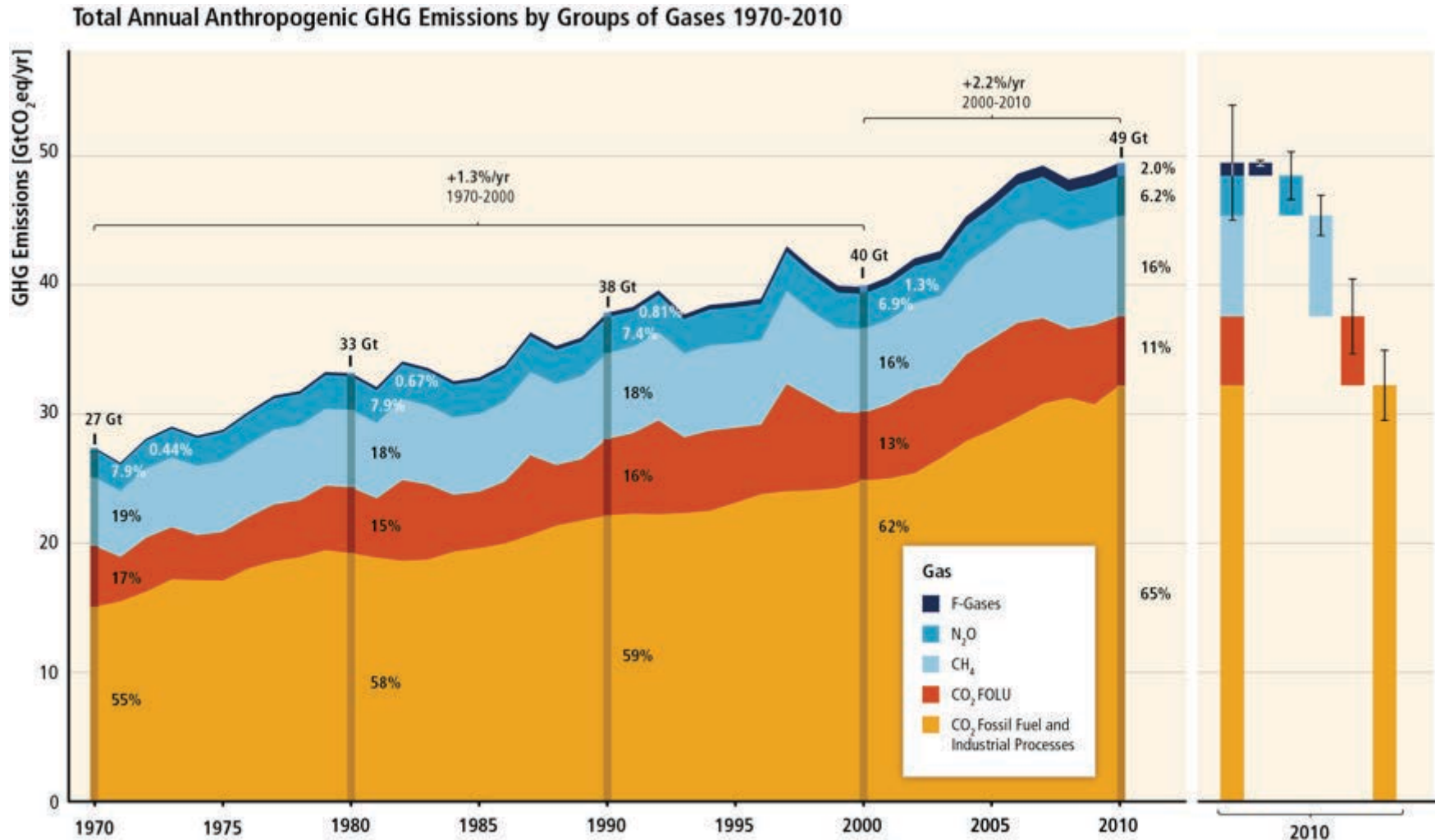
AR5 WGI SPM

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



Based on Figure 6.7

GHG emissions accelerate despite reduction efforts. Most emission growth is CO₂ from fossil fuel combustion and industrial processes.



Limiting Temperature Increase to 2°C



Measures exist to achieve the substantial emissions reductions required to limit likely warming to 2°C



A combination of adaptation and substantial, sustained reductions in greenhouse gas emissions can limit climate change risks



Implementing reductions in greenhouse gas emissions poses substantial technological, economic, social, and institutional challenges



But delaying mitigation will substantially increase the challenges associated with limiting warming to 2°C

AR5 WGI SPM, AR5 WGII SPM, AR5 WGIII SPM

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 CO₂-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.**

Mitigation Measures



More efficient use of energy



Greater use of low-carbon and no-carbon energy

- Many of these technologies exist today
- But worldwide investment in **research** in support of GHG mitigation is small...



Improved carbon sinks

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



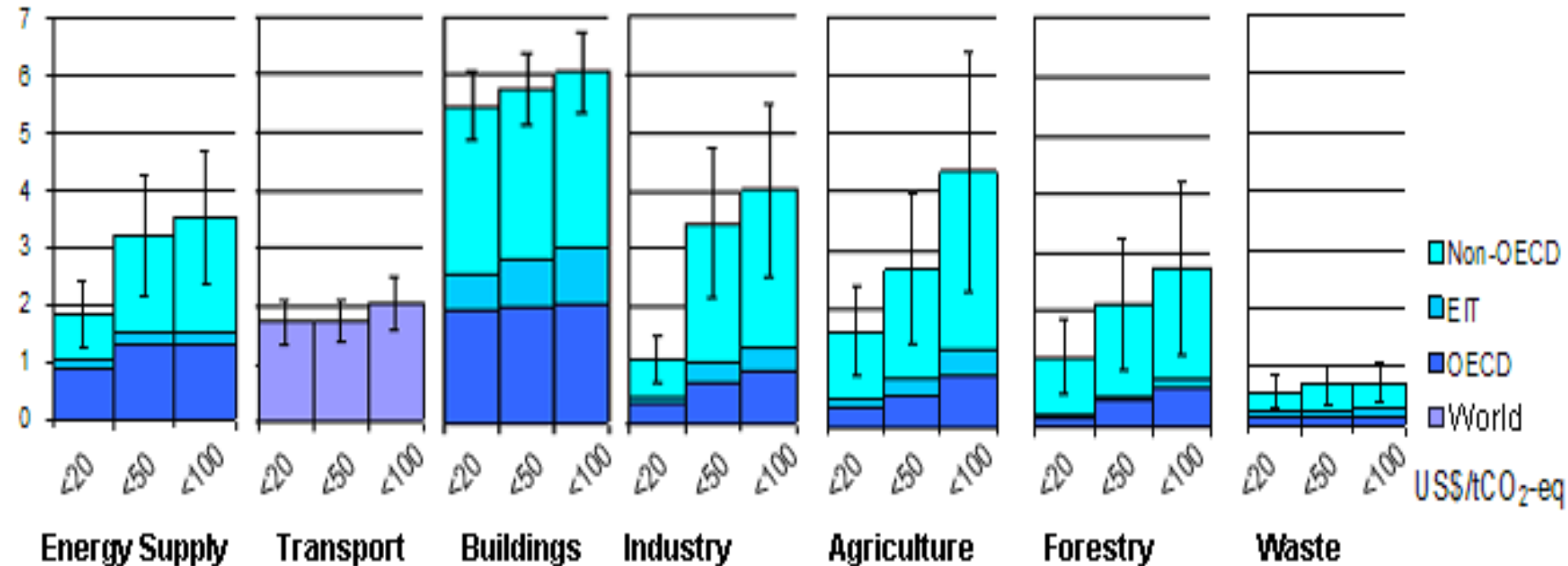
Lifestyle and behavioural changes

AR5 WGIII SPM

- **Mitigation requires major technological and institutional changes including the upscaling of low- and zero carbon energy (quadrupling from 2010 to 2050 for the scenario limiting warming below 2°C)**

All sectors and regions have the potential to contribute by 2030

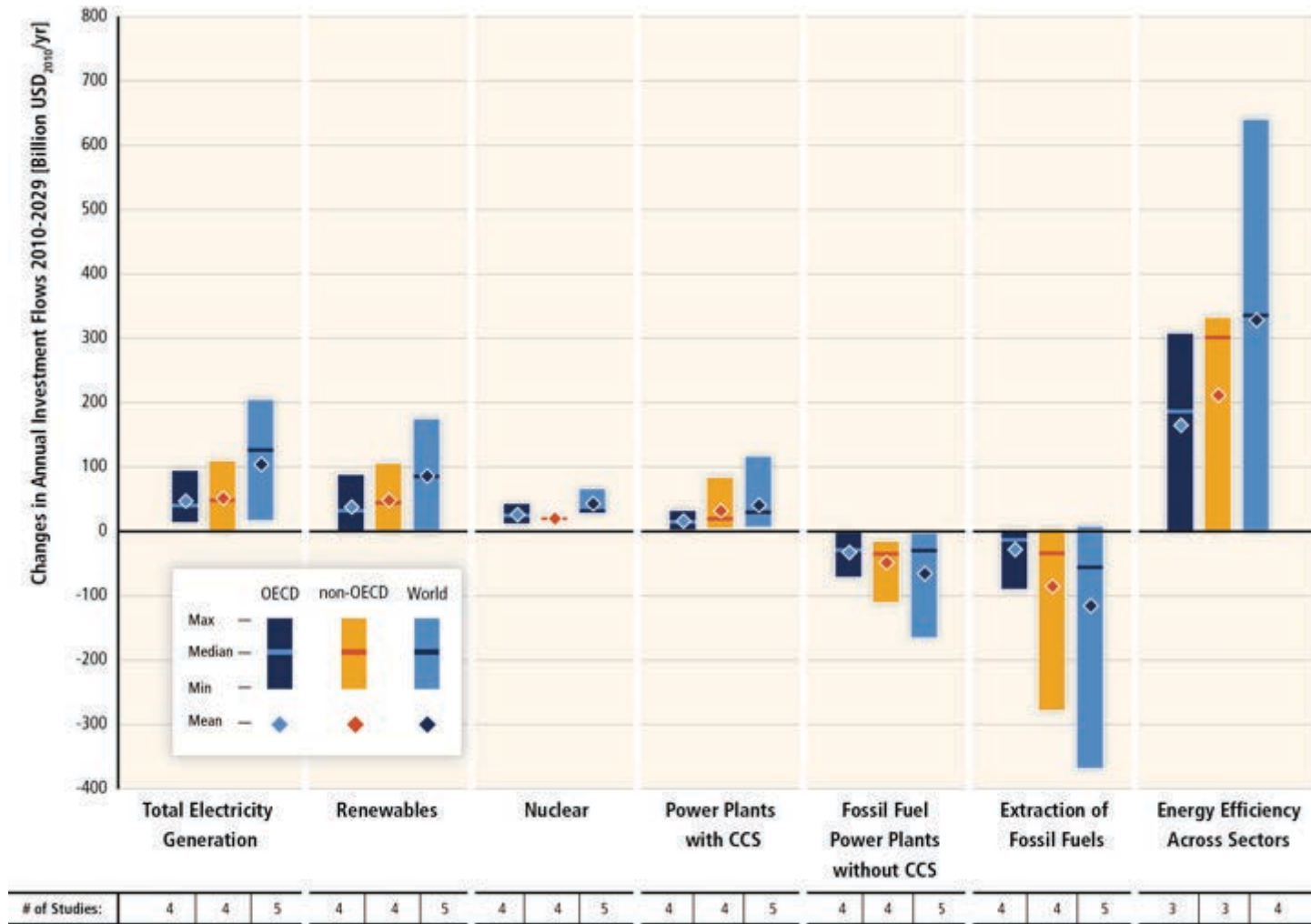
GtCO₂-eq / year (avoided emissions: the higher, the better)



IPCC AR4 (2007)

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

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



- **Substantial reductions in emissions would require large changes in investment patterns e.g., from 2010 to 2029, in billions US dollars/year:**


(mean numbers rounded, IPCC AR5 WGIII Fig SPM 9)

- **energy efficiency: +330**
- **renewables: + 90**
- **power plants w/ CCS: + 40**
- **nuclear: + 40**
- **power plants w/o CCS: - 60**
- **fossil fuel extraction: - 120**

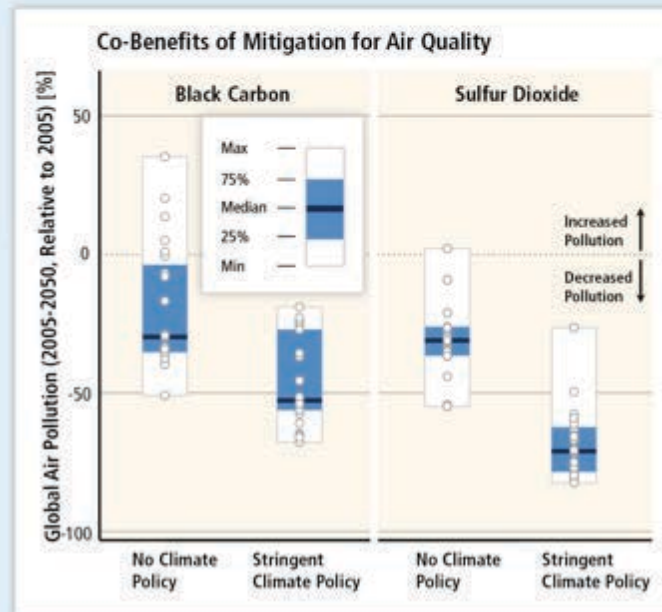
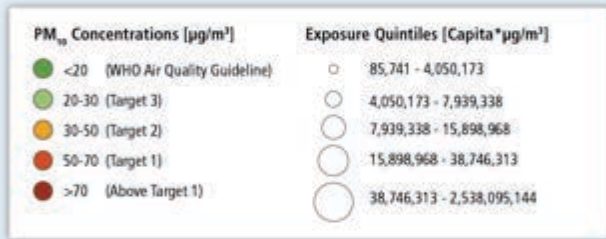
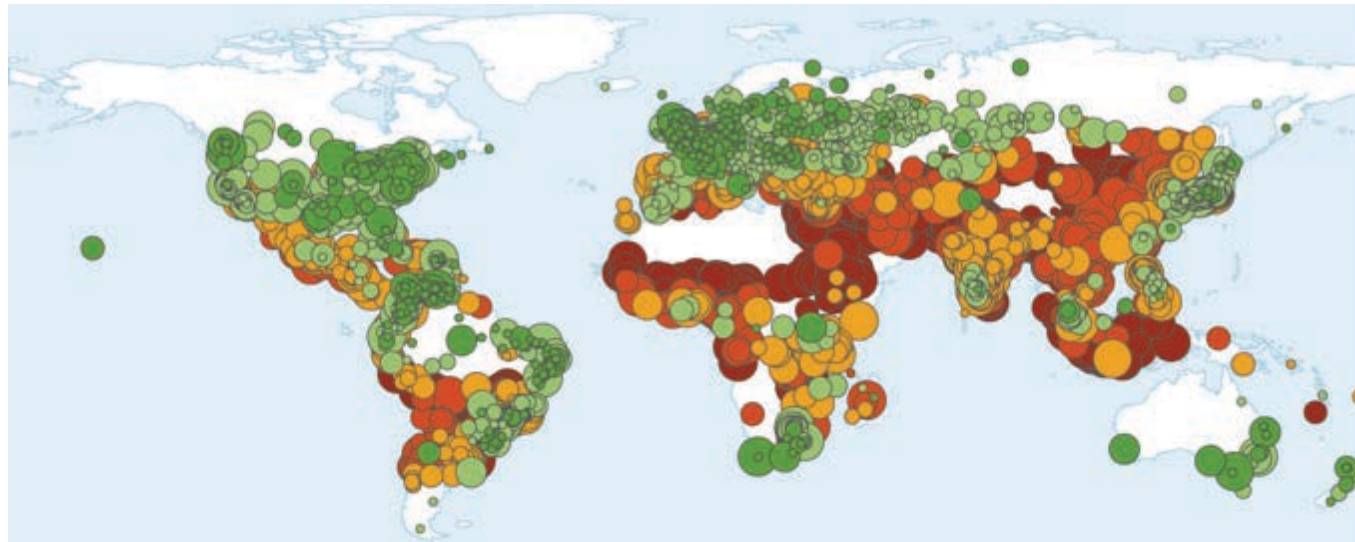
Ambitious Mitigation Is Affordable

- 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

An aerial photograph of a city, likely Hong Kong, showing a dense urban landscape with numerous high-rise buildings and a complex multi-level highway interchange in the foreground. The image is overlaid with a semi-transparent blue filter.

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.



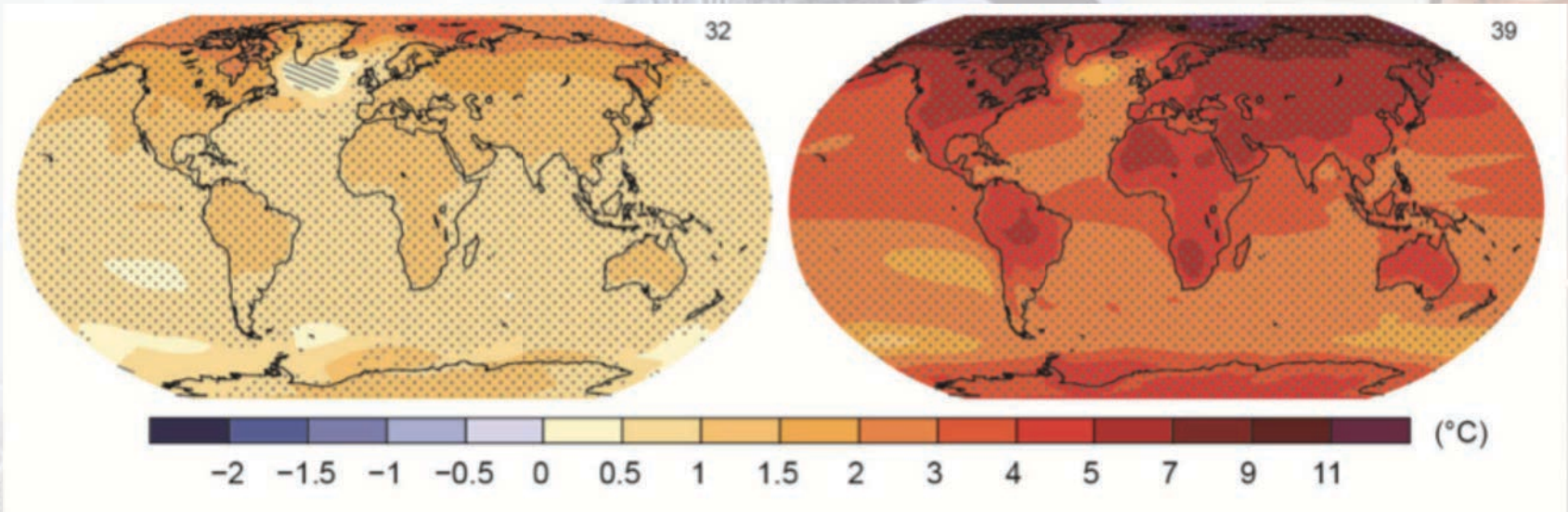
SUSTAINABLE DEVELOPMENT GOALS



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

With substantial mitigation

Without additional mitigation



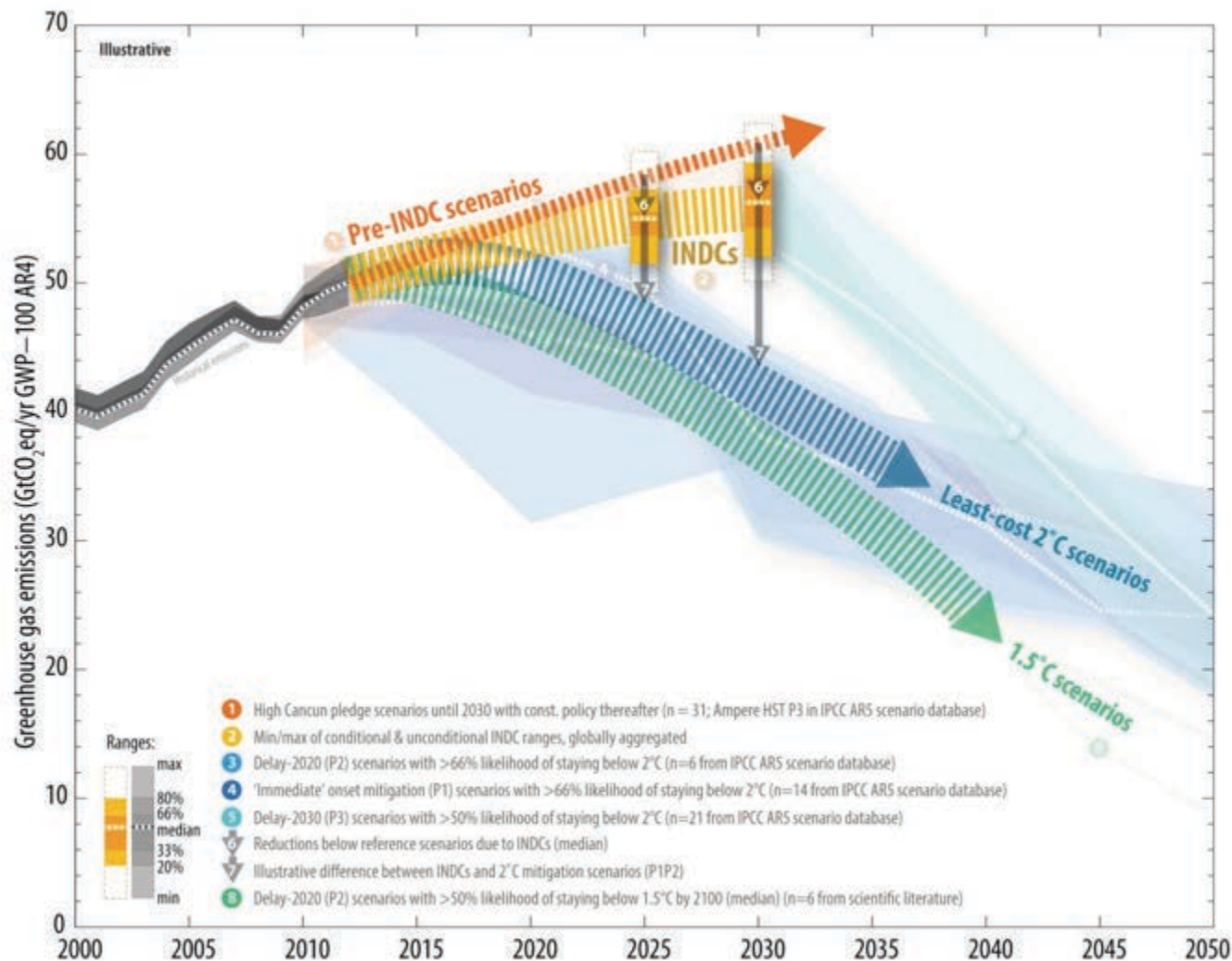
Change in average surface temperature (1986–2005 to 2081–2100)

AR5 WGI SPM

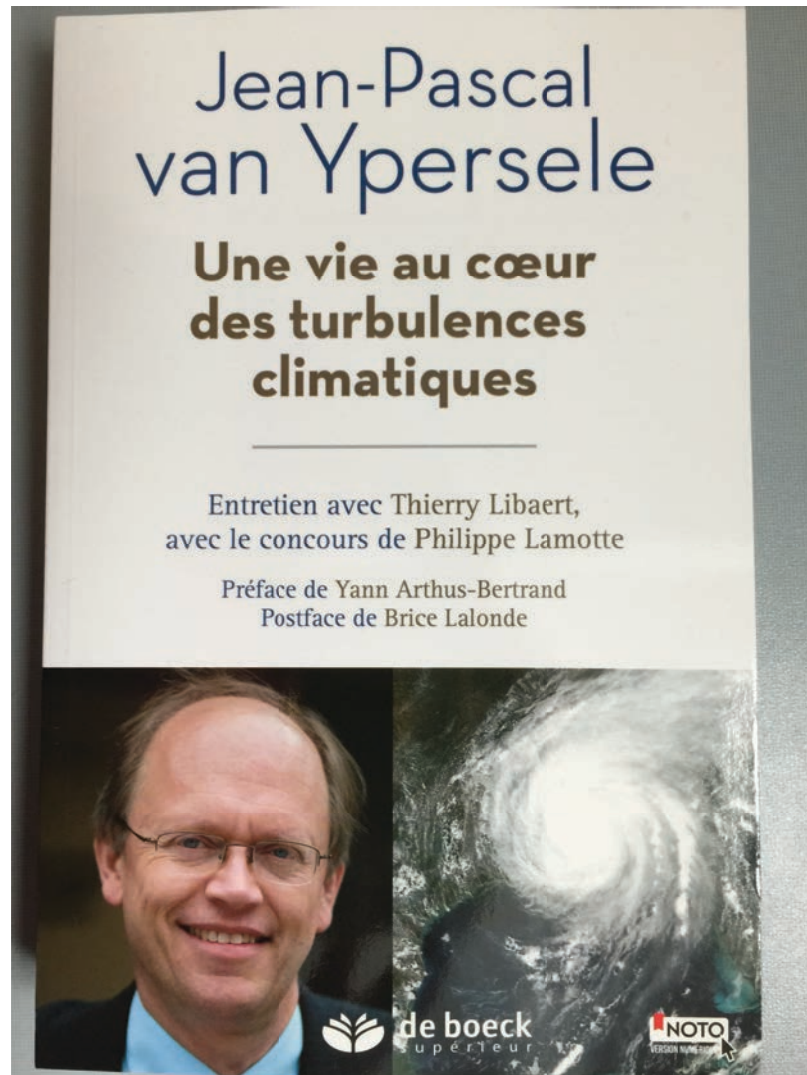
The Hidden IPCC Message:

- **If it's possible and not enough happens, what is lacking?**
- ***Political will, at the appropriate scale***

Comparison of global emission levels in 2025 and 2030 resulting from the implementation of the intended nationally determined contributions



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E-book: 13 euros**



Useful links:

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