Climate Change and *Laudato Sí*: The Scientific Basis

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

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Twitter: @JPvanYpersele

European Federation of Catholic Universities, Salamanca (Spain), 27 May 2016

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

Avril 2015, Kenya, région de Machakos

A Christian View on Climate Change

The Implications of Climate Change for Lifestyles and EU Policies

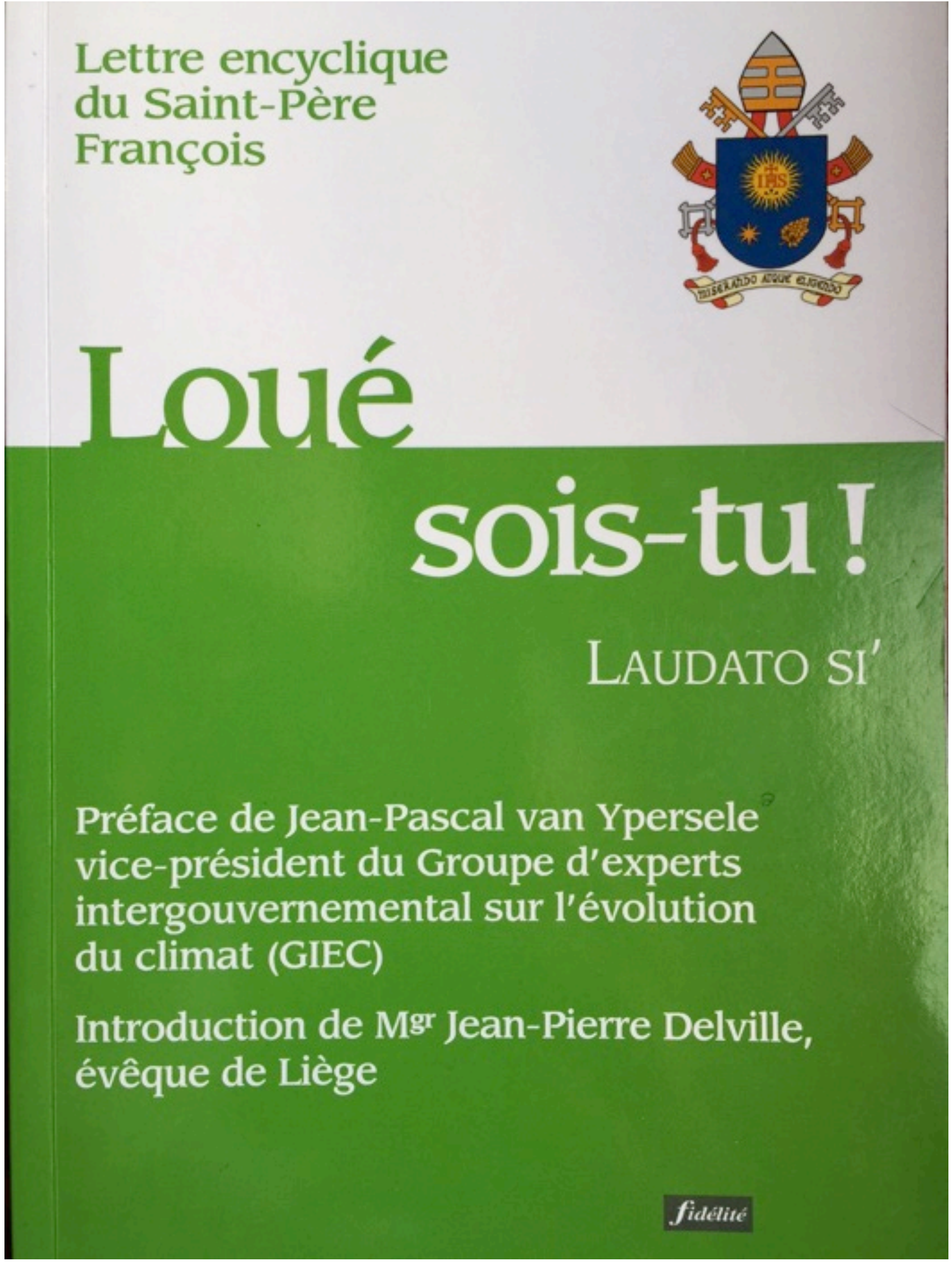
A Report to the Bishops of COMECE

COMECE

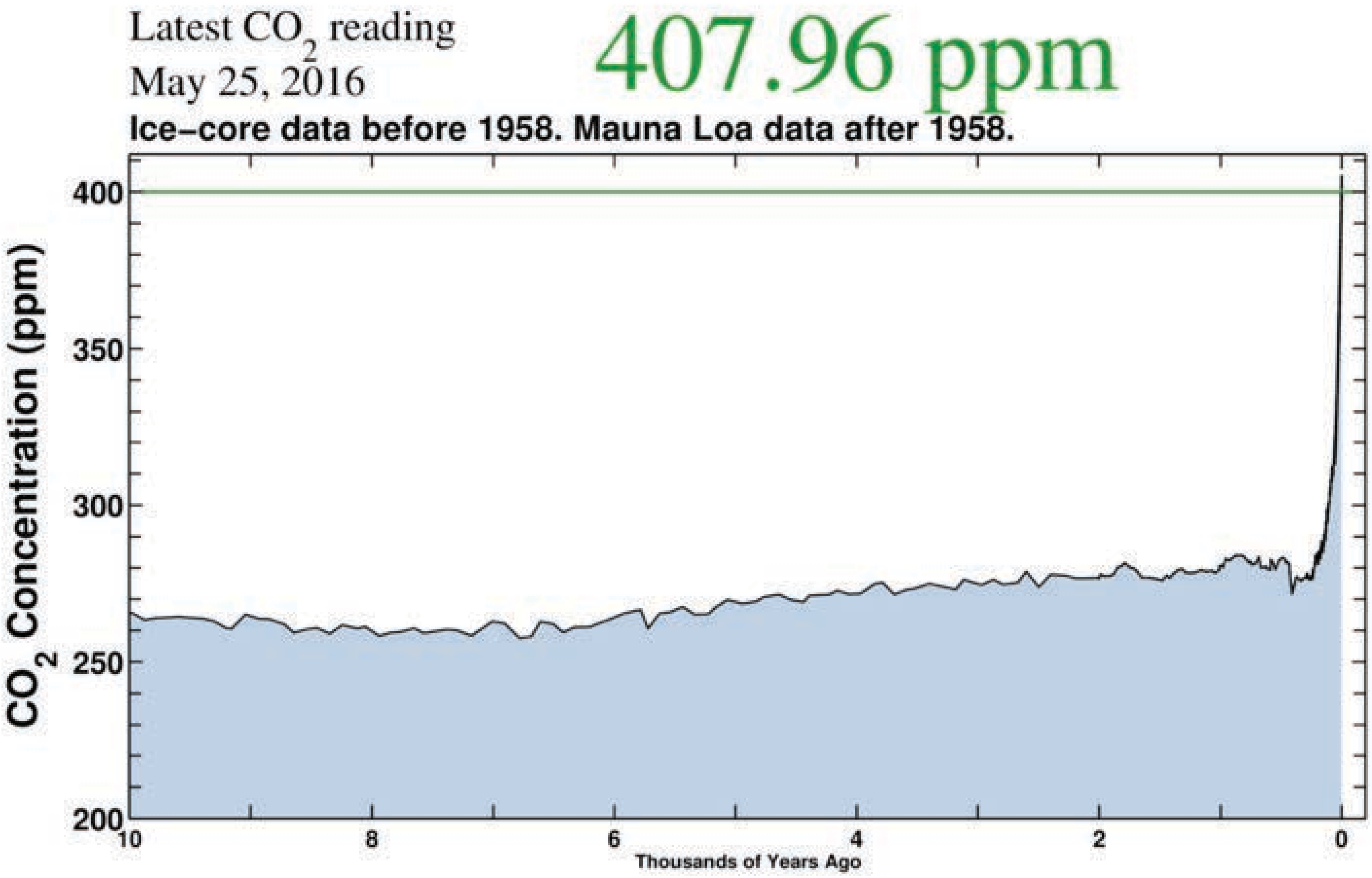
Secretariat of the Commission of the Bishops' Conferences of the European Community

From the COMECE report (2008):

- « … It would also be an important signal to all Christians and the world (…) if a major encyclical on environmental issues… » (p. 24)

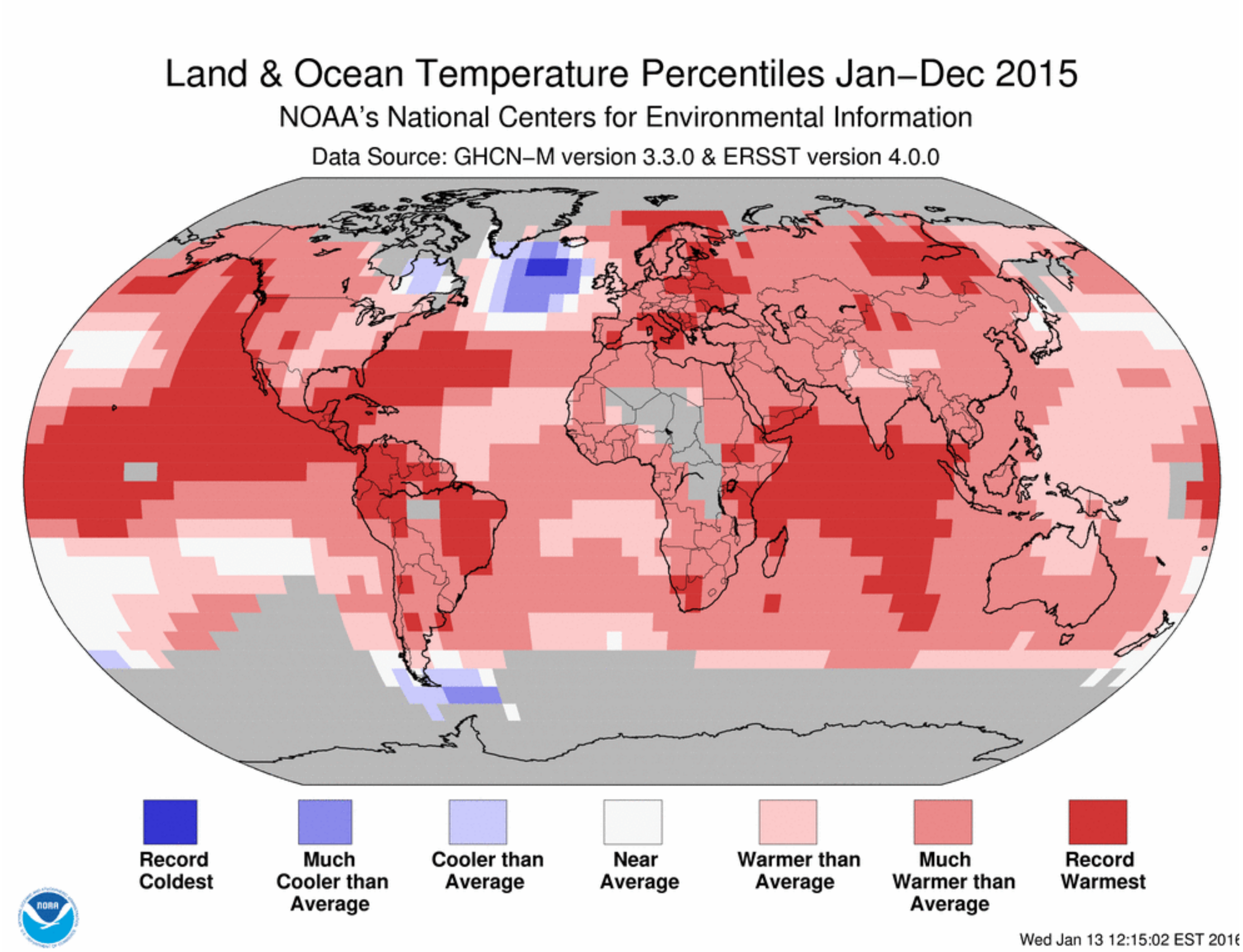

Lettre encyclique
du Saint-Père
François
MISERANDO ATQUE ELIGENDO
Loué
sois-tu !
LAUDATO SI'
Préface de Jean-Pascal van Ypersele
vice-président du Groupe d'experts
intergouvernemental sur l'évolution
du climat (GIEC)
Introduction de Mgr Jean-Pierre Delville,
évêque de Liège
fidélité

Concentration en CO_2, le 25 mai 2016 (Courbe de Keeling)

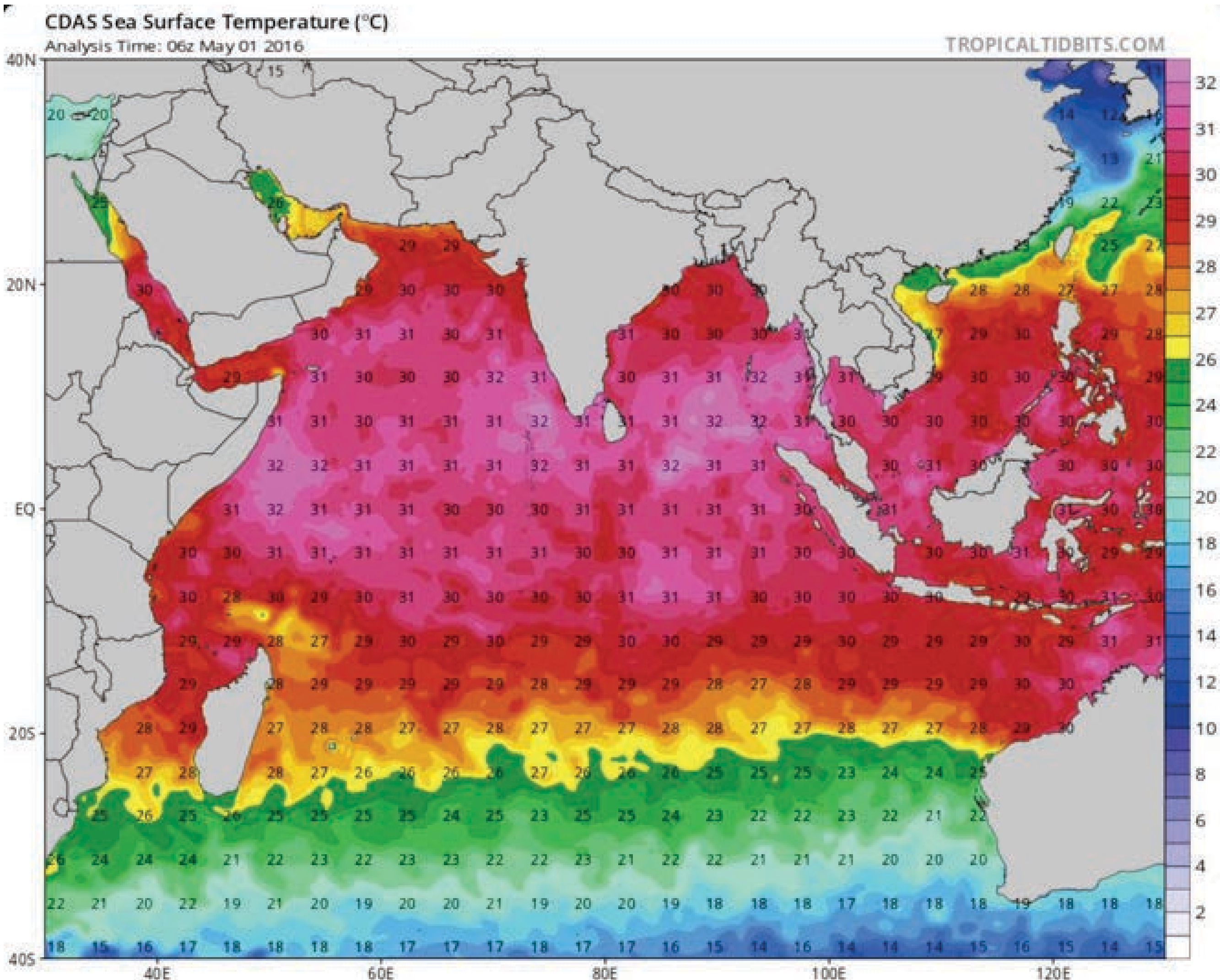


Source: scripps.ucsd.edu/programs/keelingcurve/

2015= année la plus chaude depuis 1880



The northern Indian Ocean is really just incredibly warm right now (end of April 2016). Numerous 32°C surface temperature

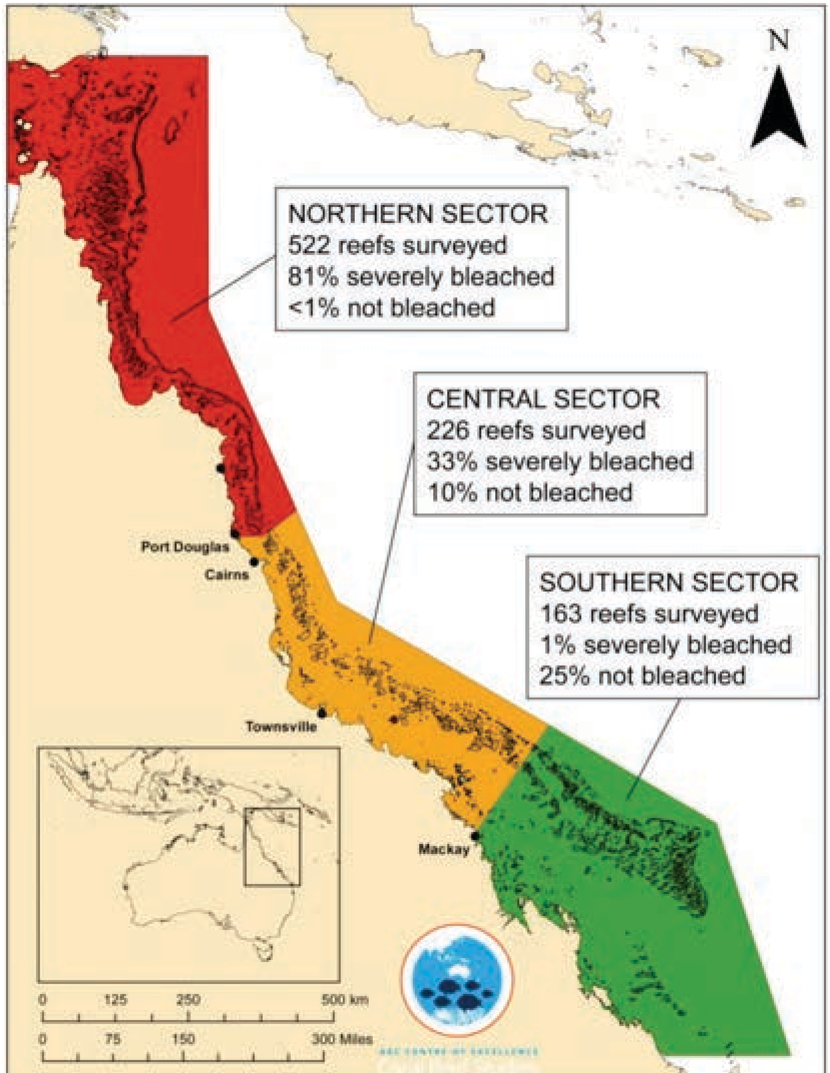


https://twitter.com/anthonywx/status/726766892103438337

Les récifs coralliens meurent

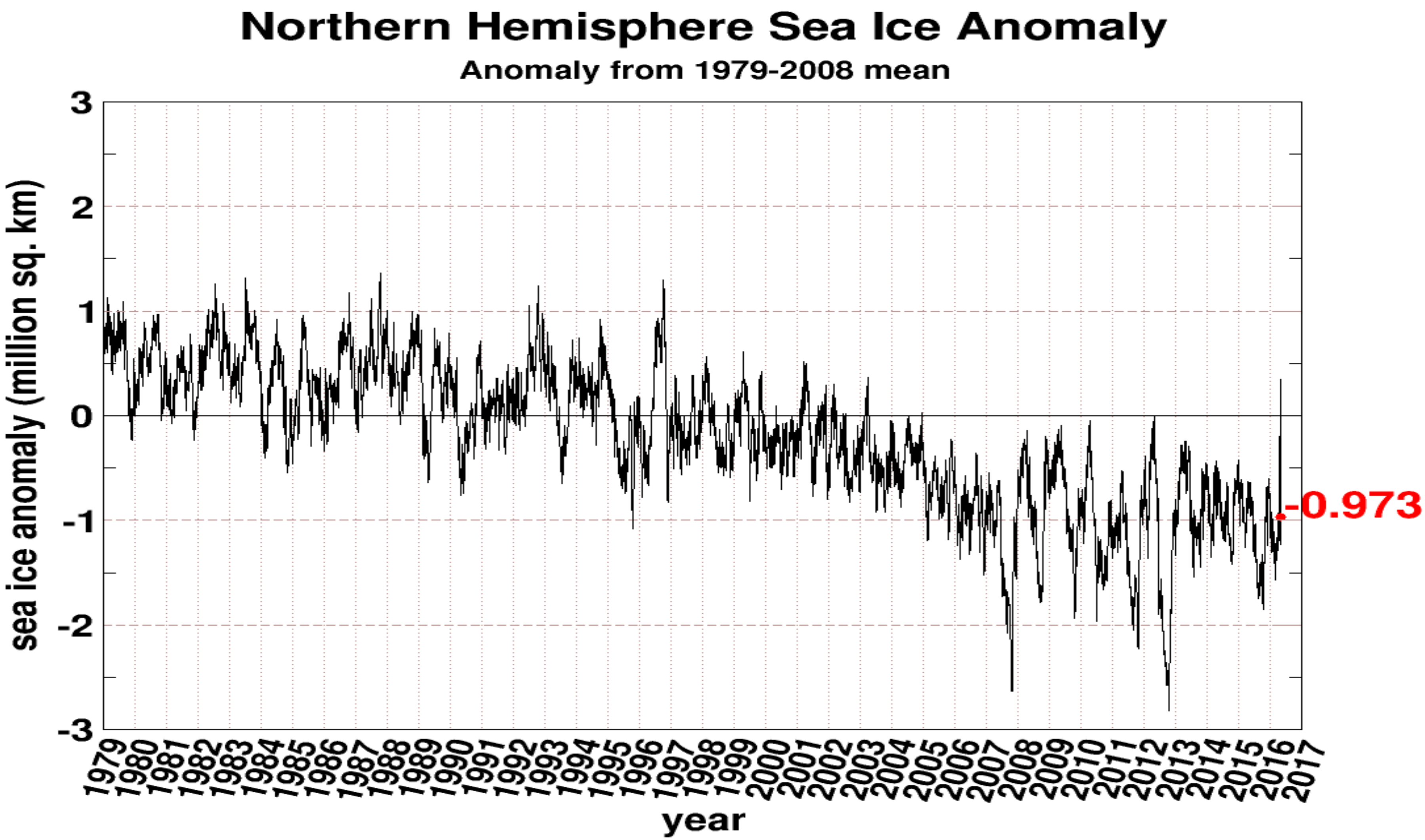
American Samoa (from www.globalcoralbleaching.org)

Only 7% of the Great Barrier Reef has avoided coral bleaching



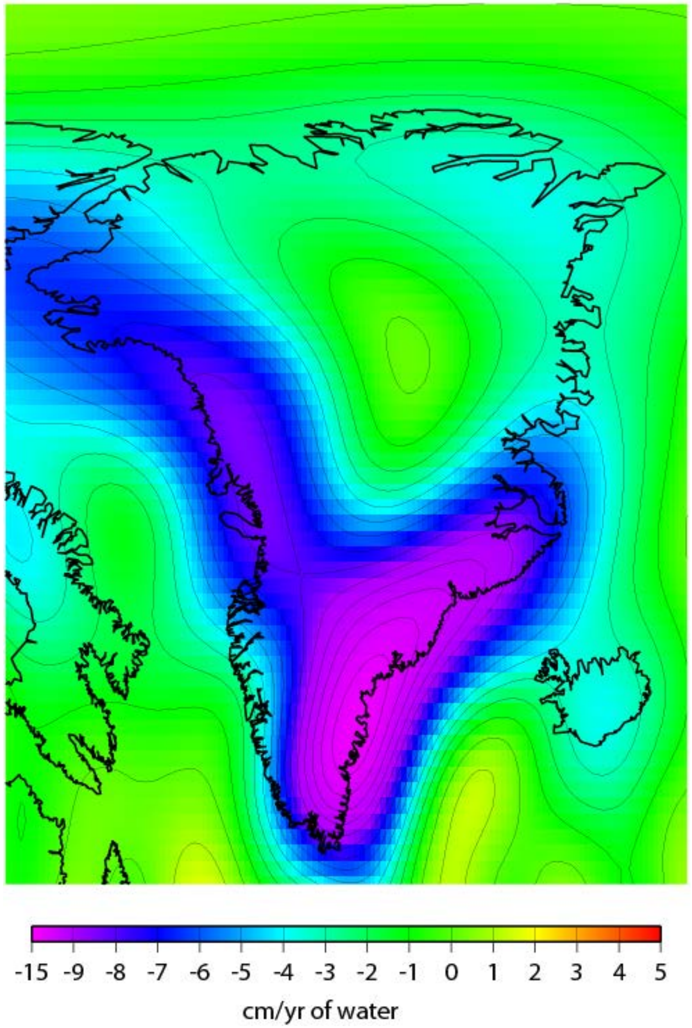
JCU Australia - ARC Centre of Excellence for Coral Reef Studies / Tom Bridge and James Kerry

Surface de la glace de mer arctique (écart par rapport à la moyenne)

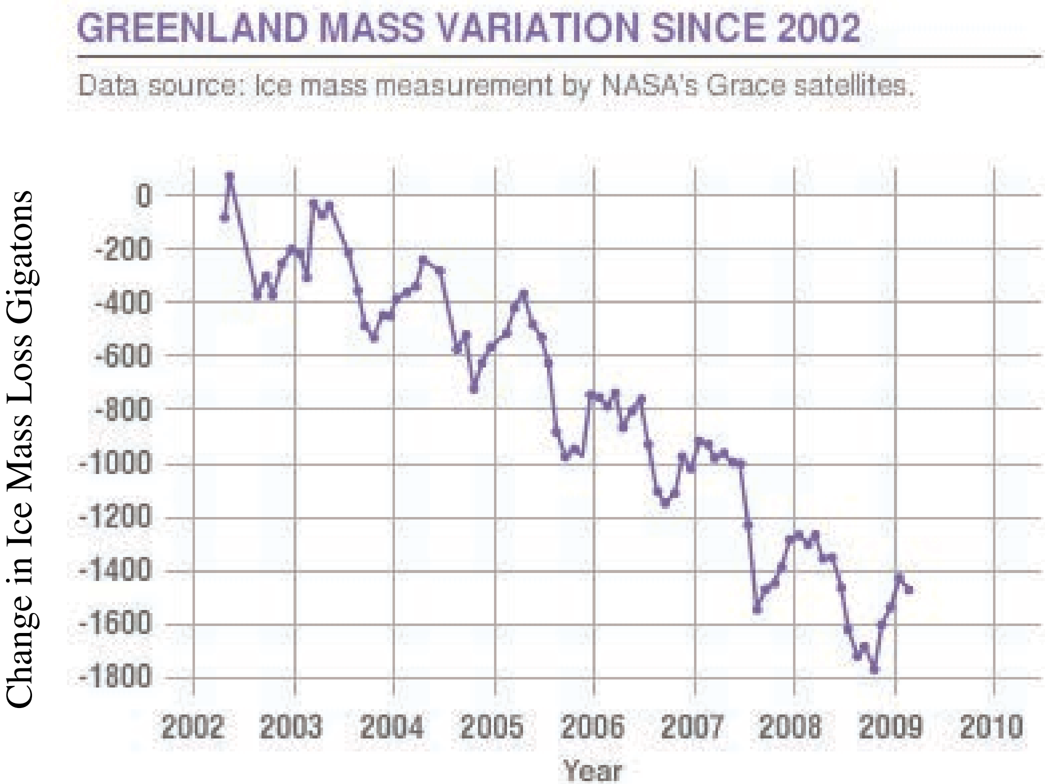


Greenland Ice Mass Loss 2002-2009
Derived From NASA GRACE Gravity Mission

Greenland



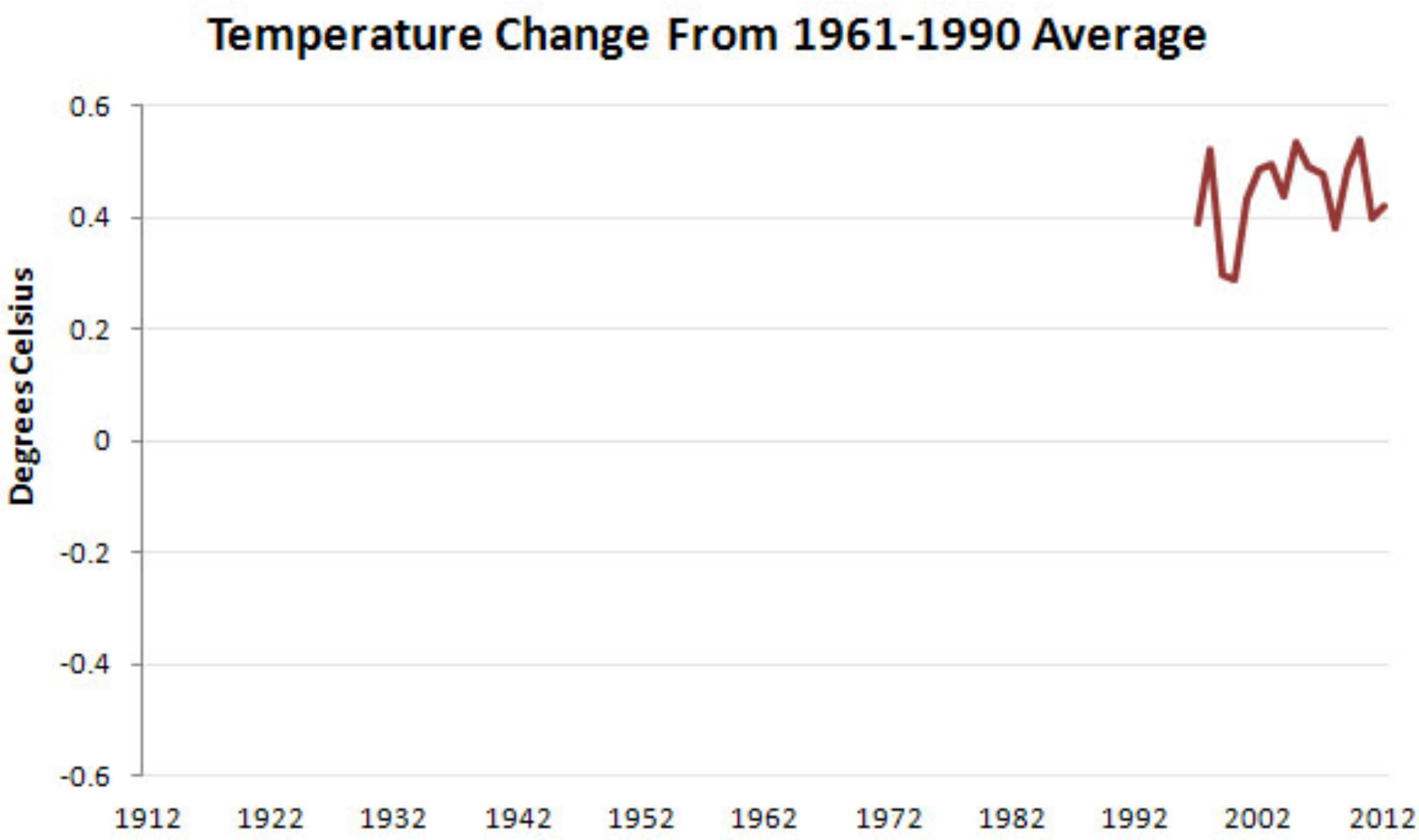
J. Wahr, U. Colorado



Velicogna, Geophysical Research Letters, 2009

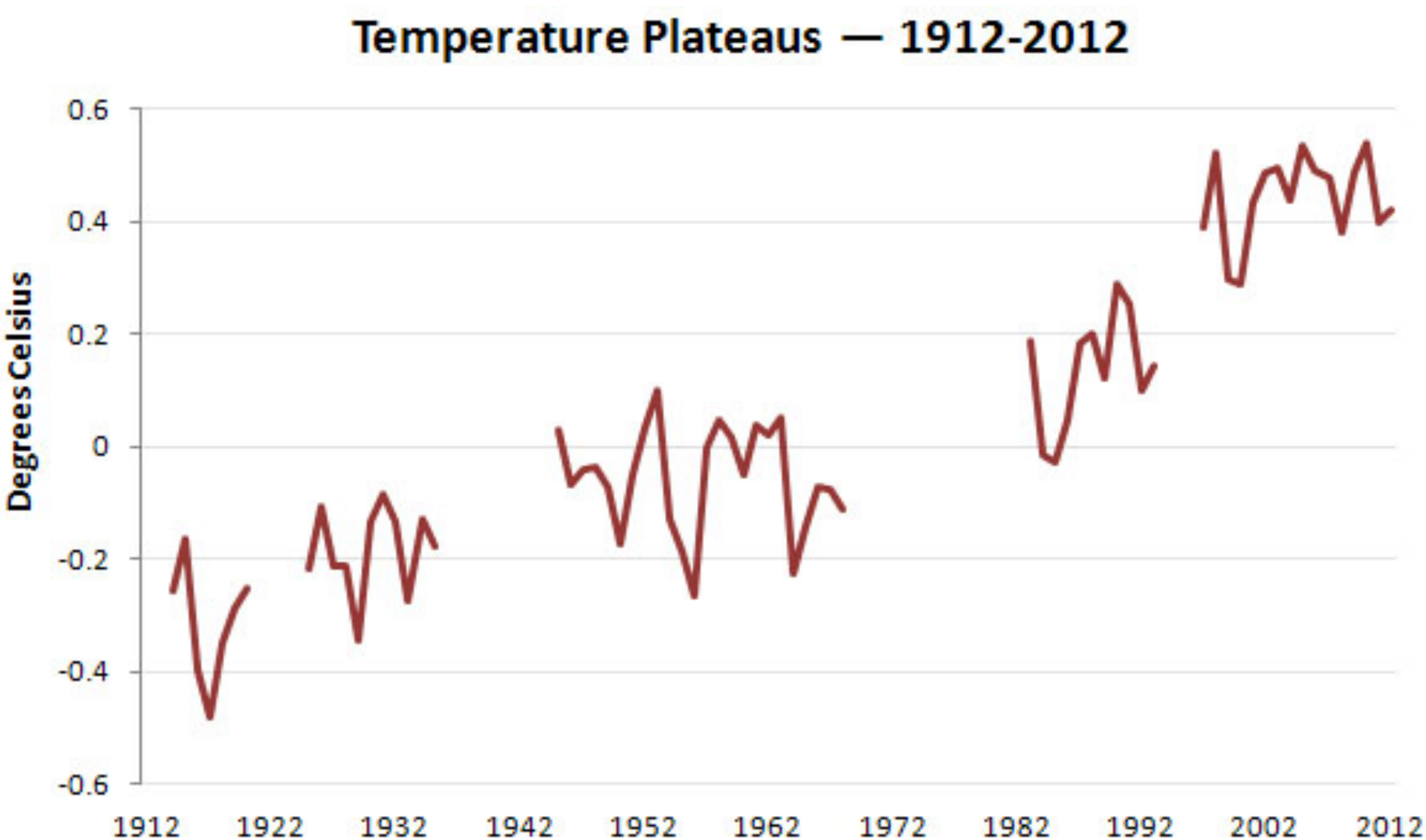
•Contributes to sea level rise

B. Holt - JPL



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

Lying With Statistics, Global Warming Edition



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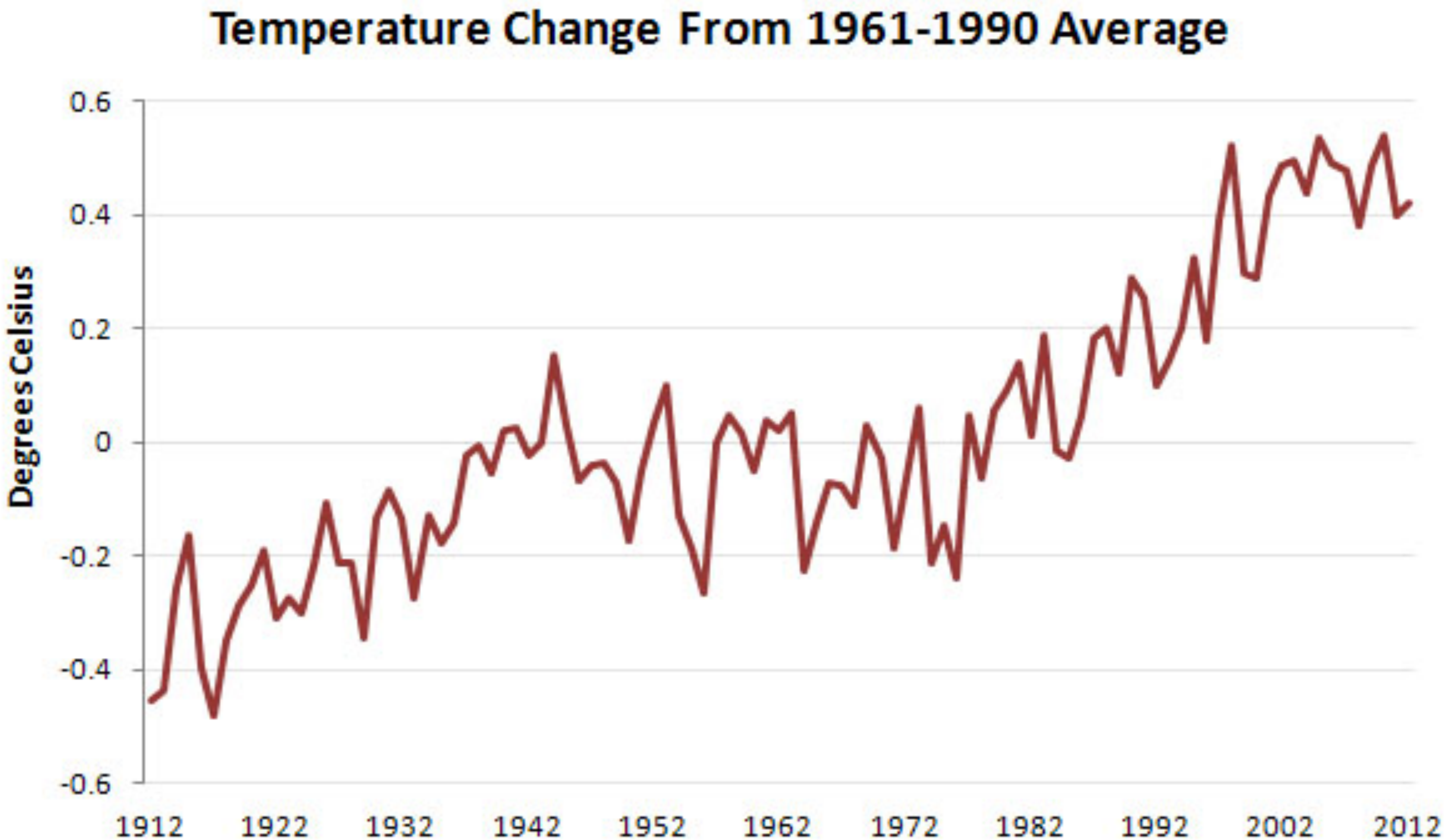
Lying With Statistics, Global Warming Edition



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

Why the IPCC ?

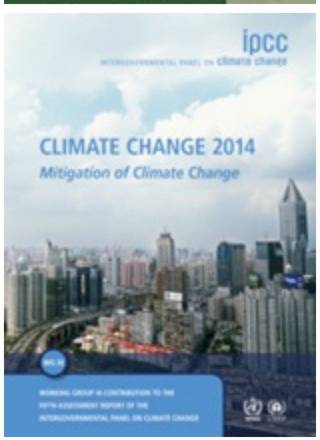
Established by WMO and UNEP in 1988

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 Organization

UNEP= United Nations Environment Programme



What is happening in the climate system?

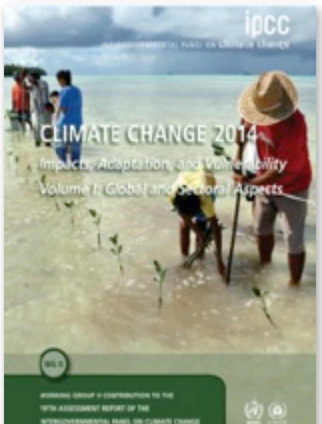
What are the risks?

What can be done?

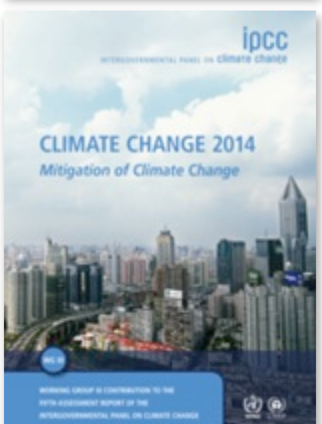
ipcc
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

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



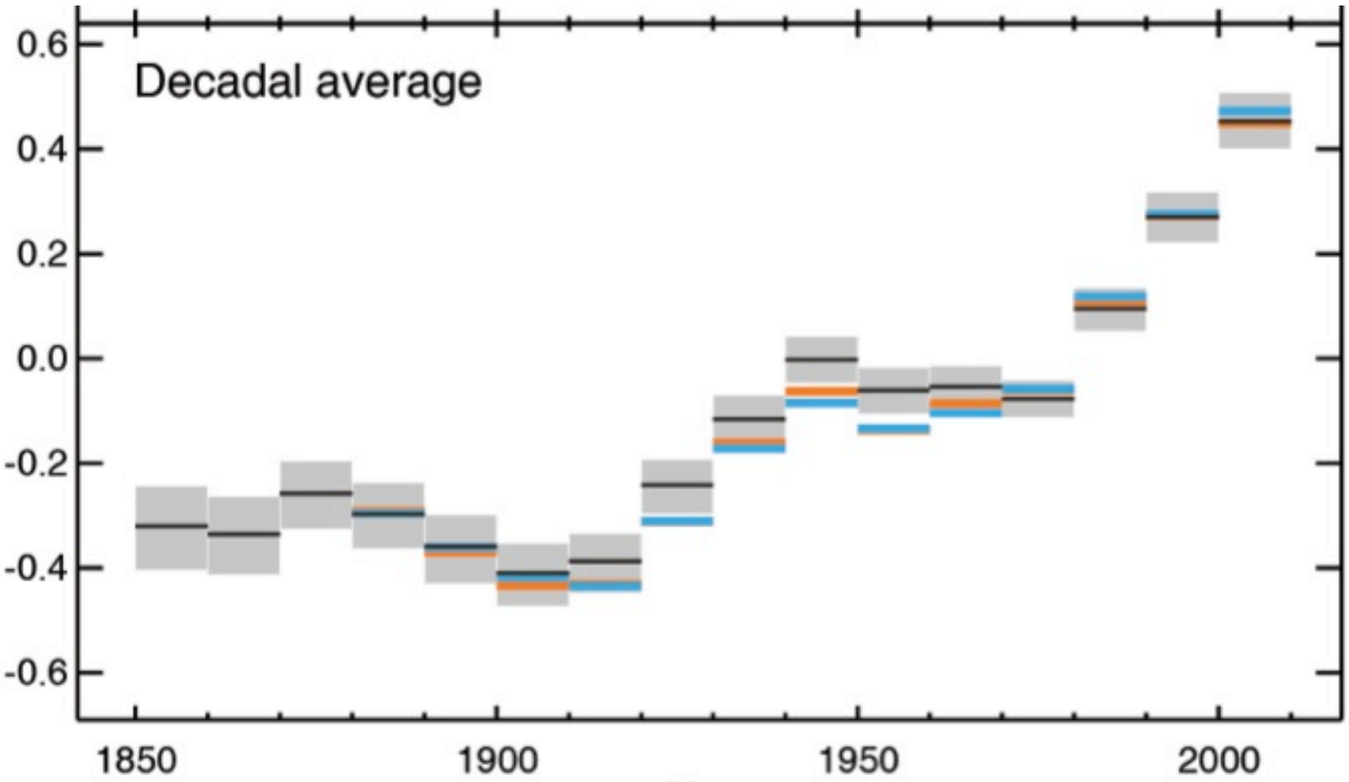
WG II (Impacts, Adaptation and Vulnerability): 243 lead authors, 2000 pages, 50.492 review comments



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

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

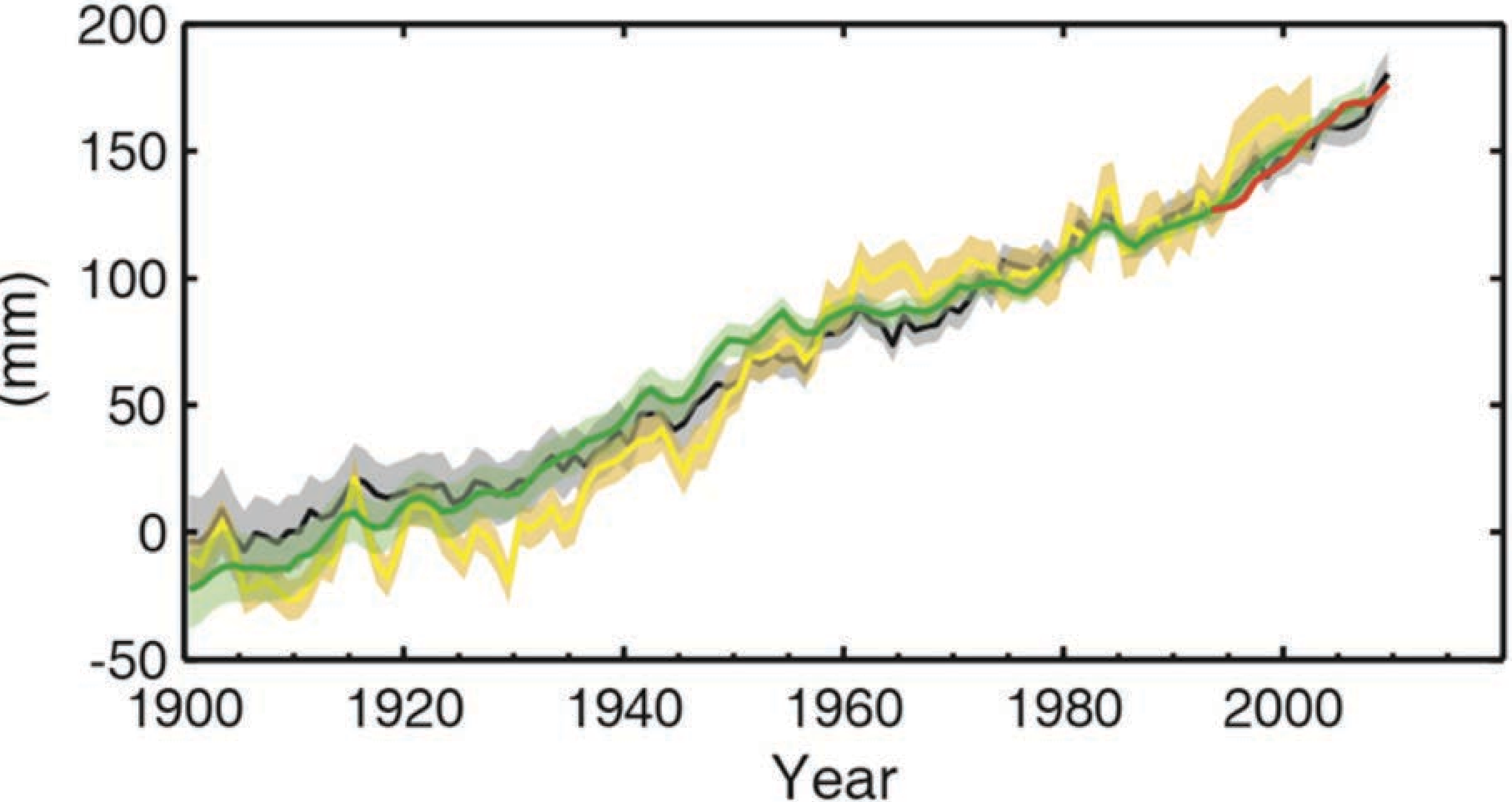
Plateau Glacier (1961)
(Alaska)

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

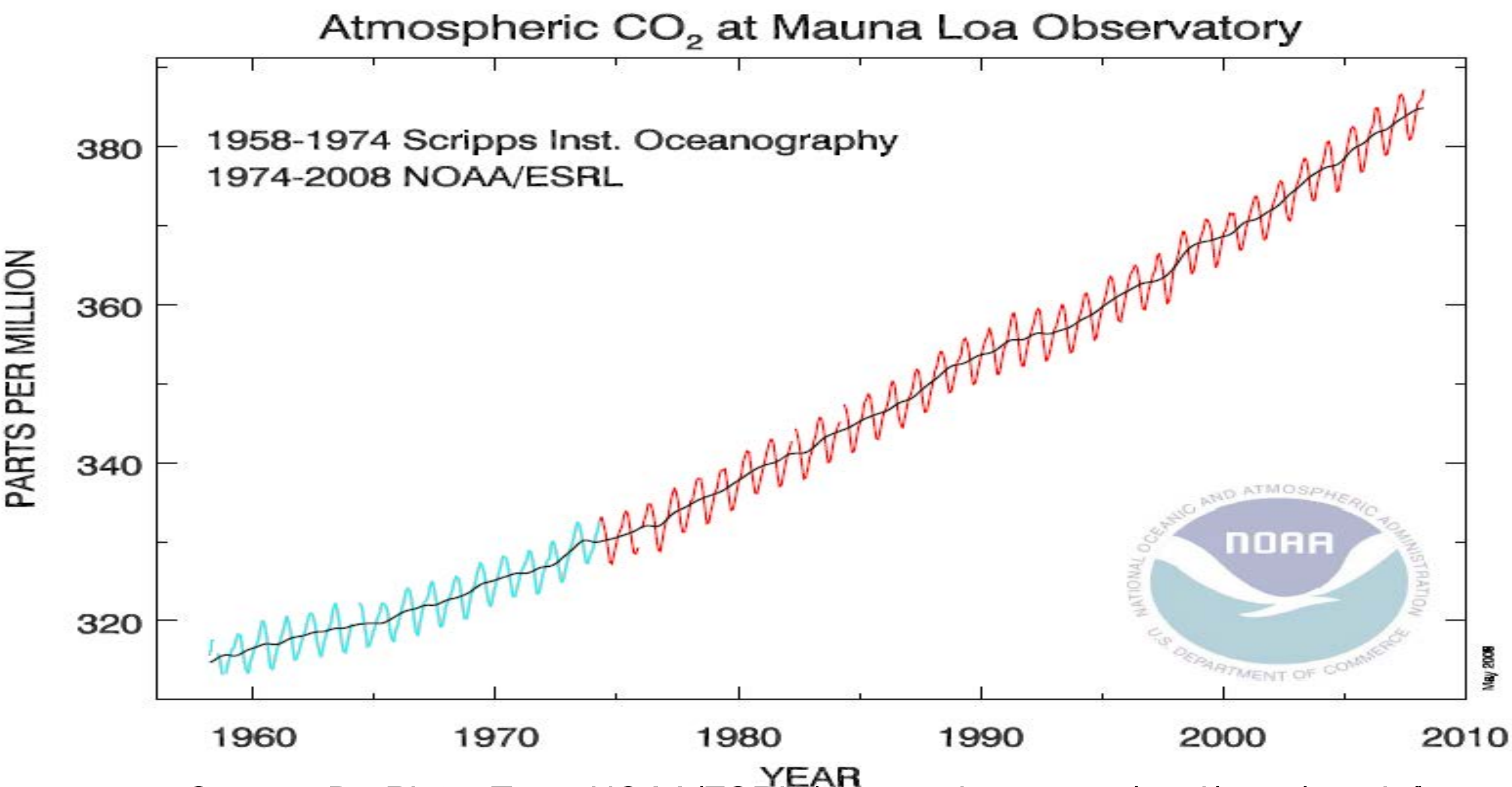
Plateau Glacier (2003)
(Alaska)

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



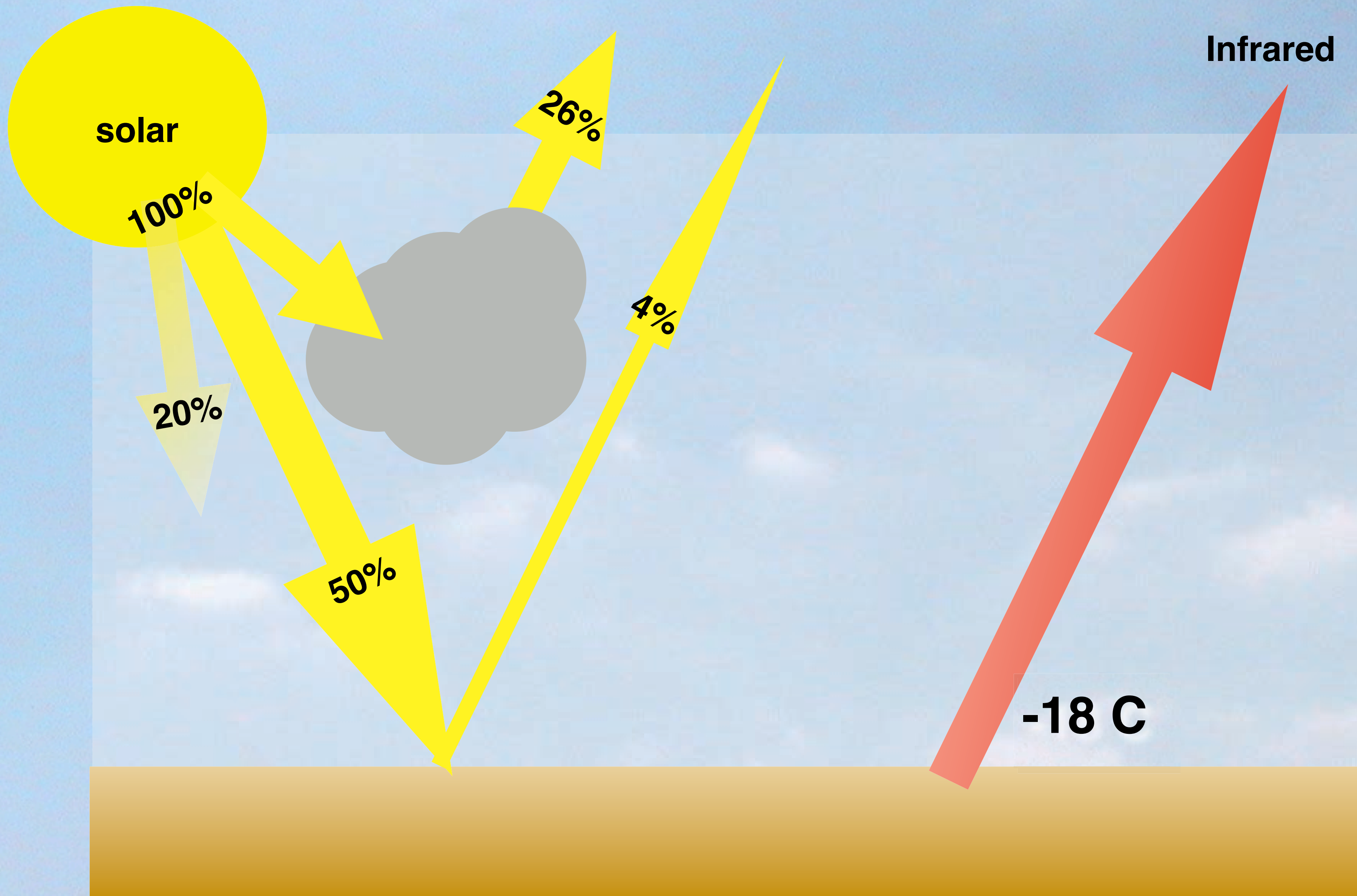
CO_2 concentration measured at Mauna Loa (3400 m)



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

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

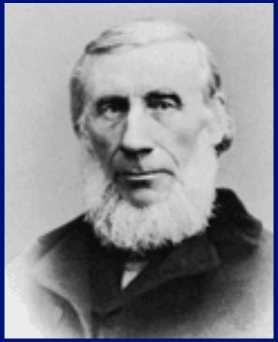
Without Greenhouse Effect



Discovery of the Greenhouse Effect

Joseph Fourier (1827)

Recognized that gases in the atmosphere might trap the heat received from the Sun.

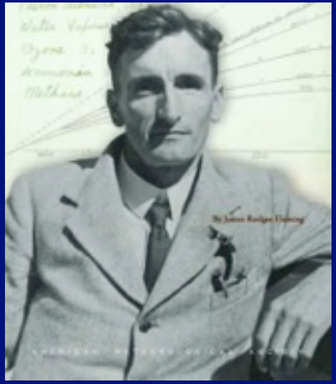


John Tyndall (1859)

Careful laboratory experiments demonstrated that several gases could trap infrared radiation. The most important was simple water vapor. Also effective was carbon dioxide, although in the atmosphere the gas is only a few parts in ten thousand.

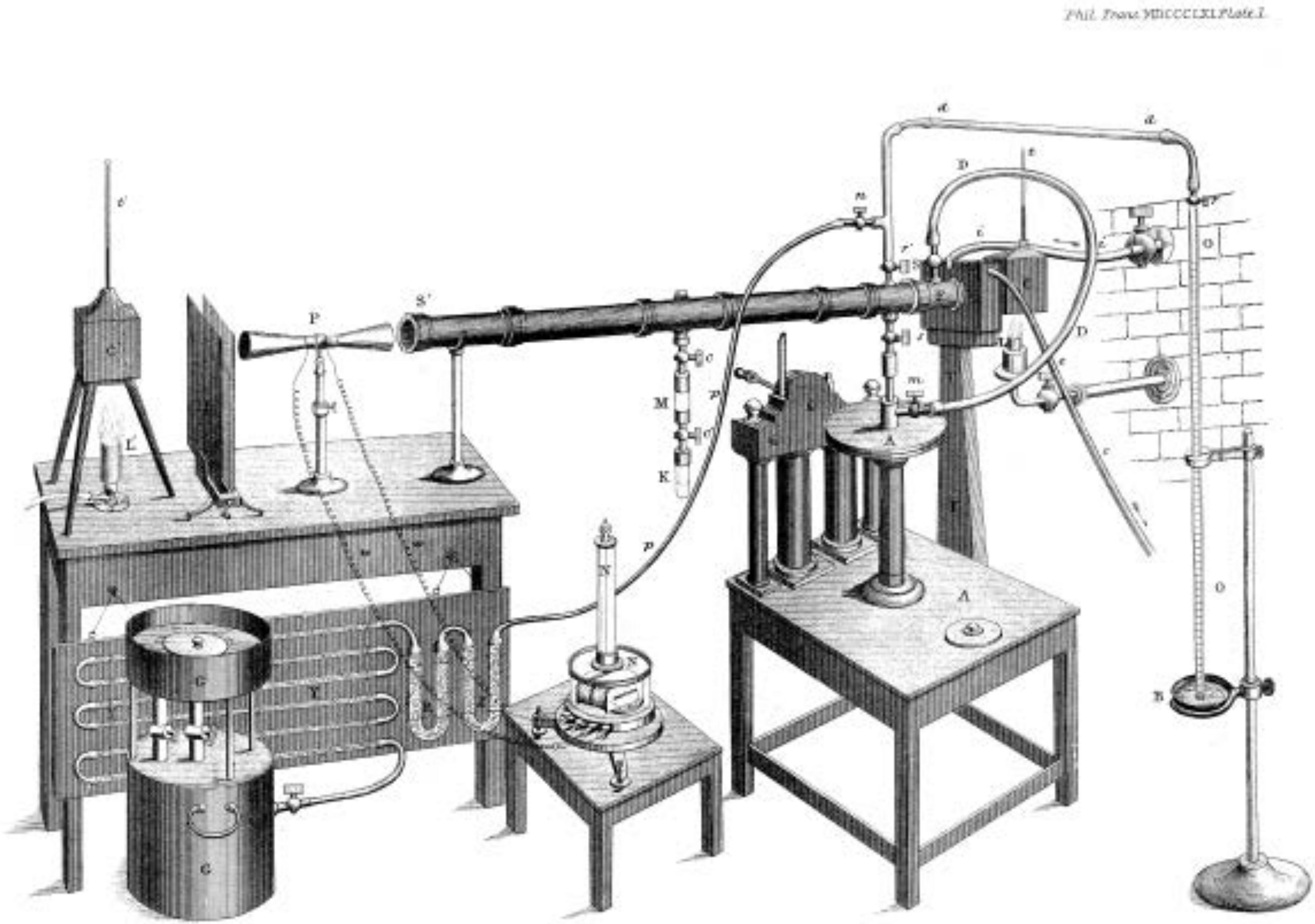
Svante Arrhenius (1896)

Performed numerical calculations that suggested that doubling the amount of carbon dioxide in the atmosphere could raise global mean surface temperatures by 5-6°C. (not reliable yet : errors & lack of appropriate data)



Guy Callendar (1939)

Argued that rising levels of carbon dioxide were responsible for measurable increases in Earth surface temperatures. Estimated that doubling the amount of CO_2 in the atmosphere could raise global mean surface temperatures by 2°C.



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

With Greenhouse Effect

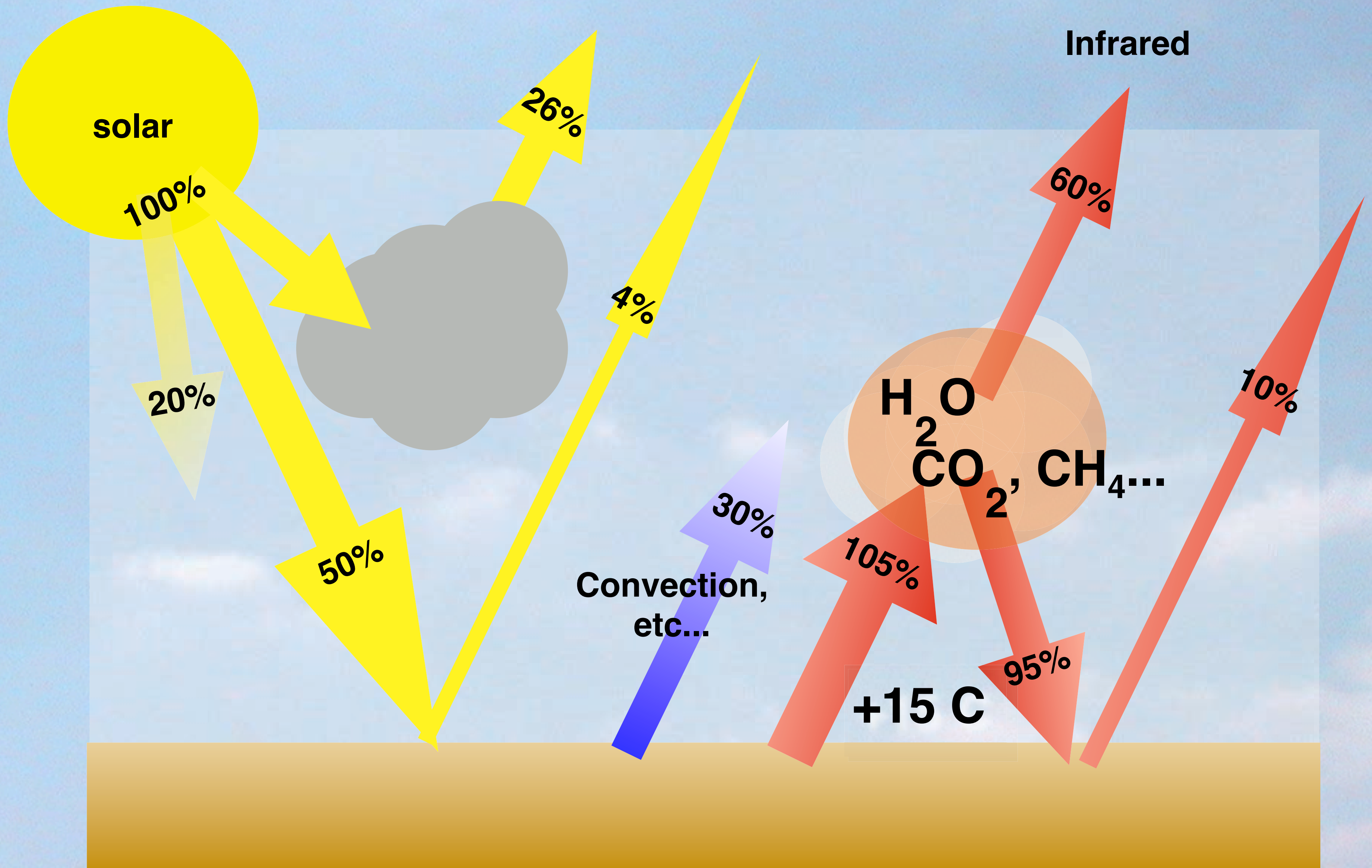
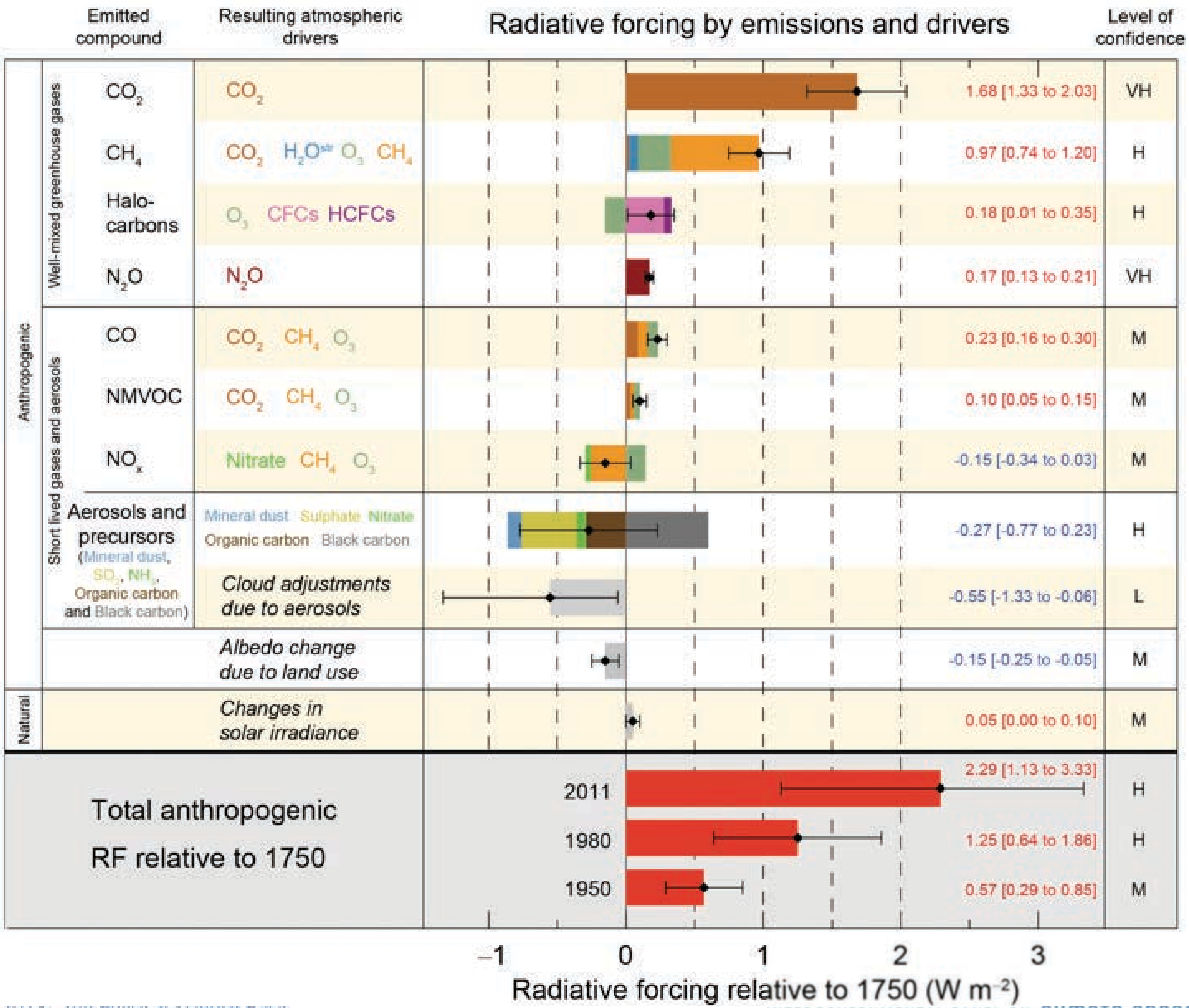
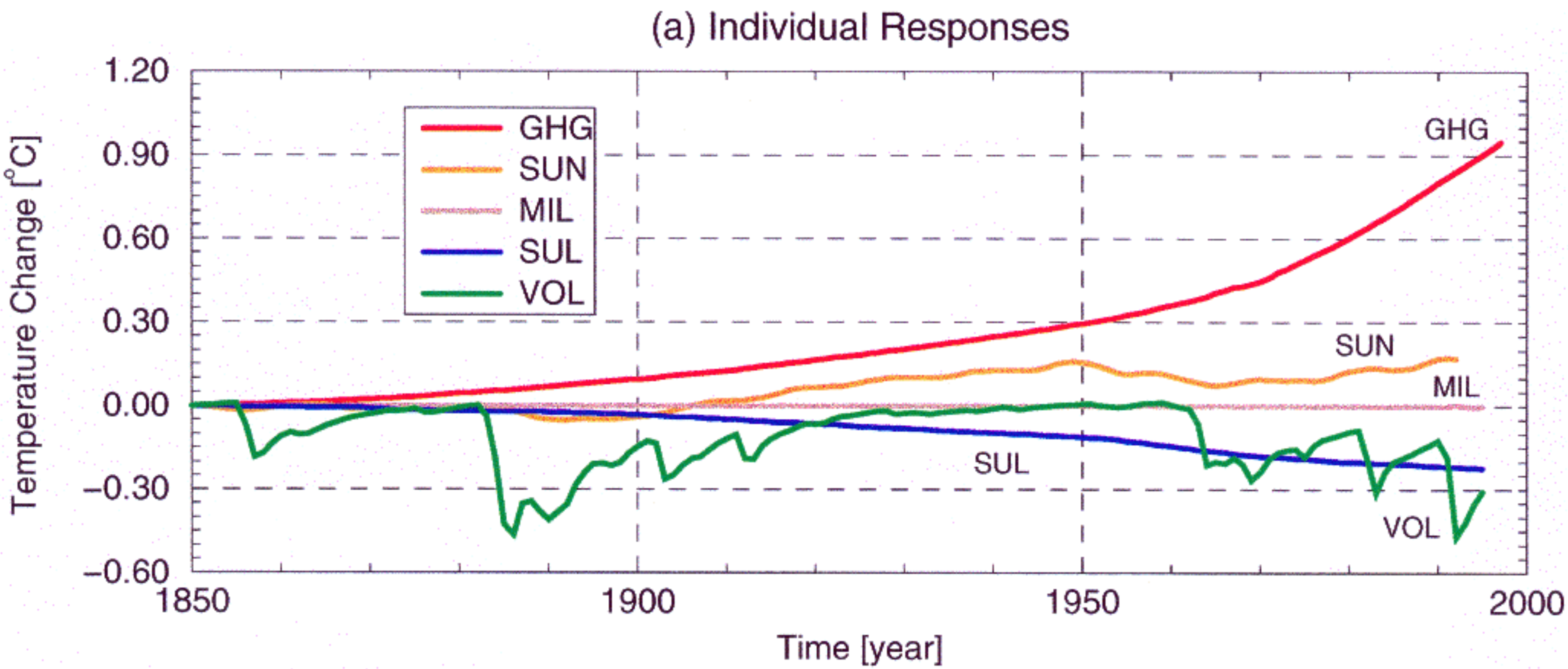


Figure SPM.5

Radiative forcing estimates in 2011 relative to 1750

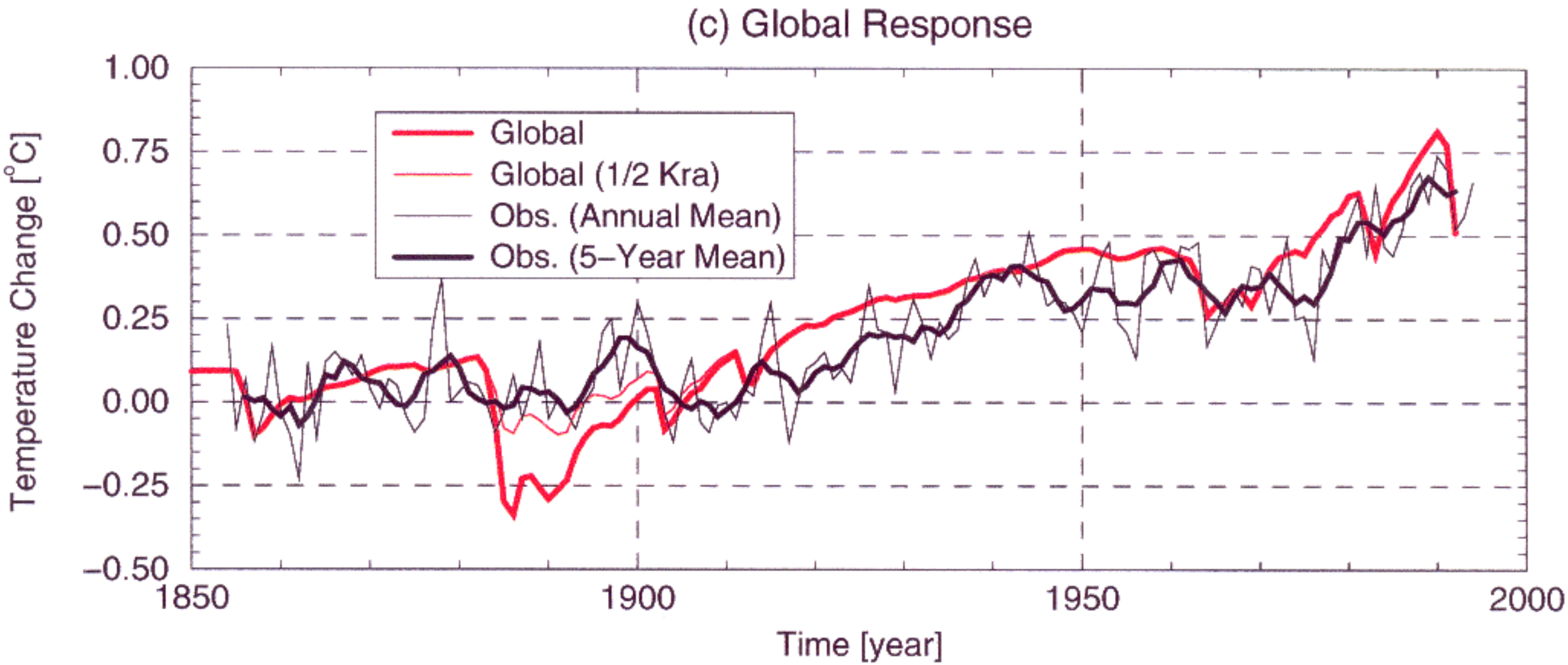


Separate effect of different factors in the 2-dimensional climate model at UCL



Bertrand et al. 2001

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



Bertrand et al. 2001

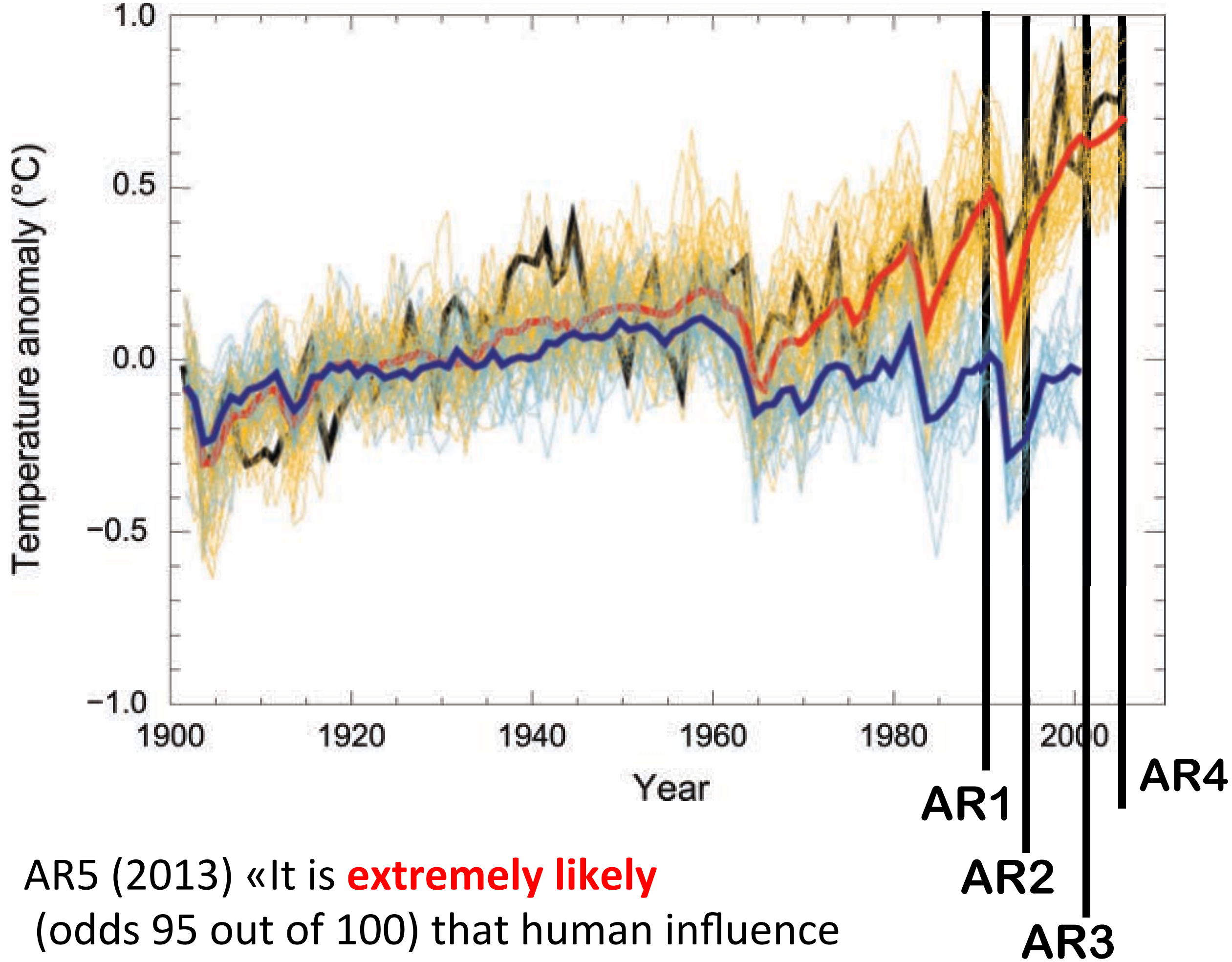
A Progression of Understanding: Greater and Greater Certainty in Attribution

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

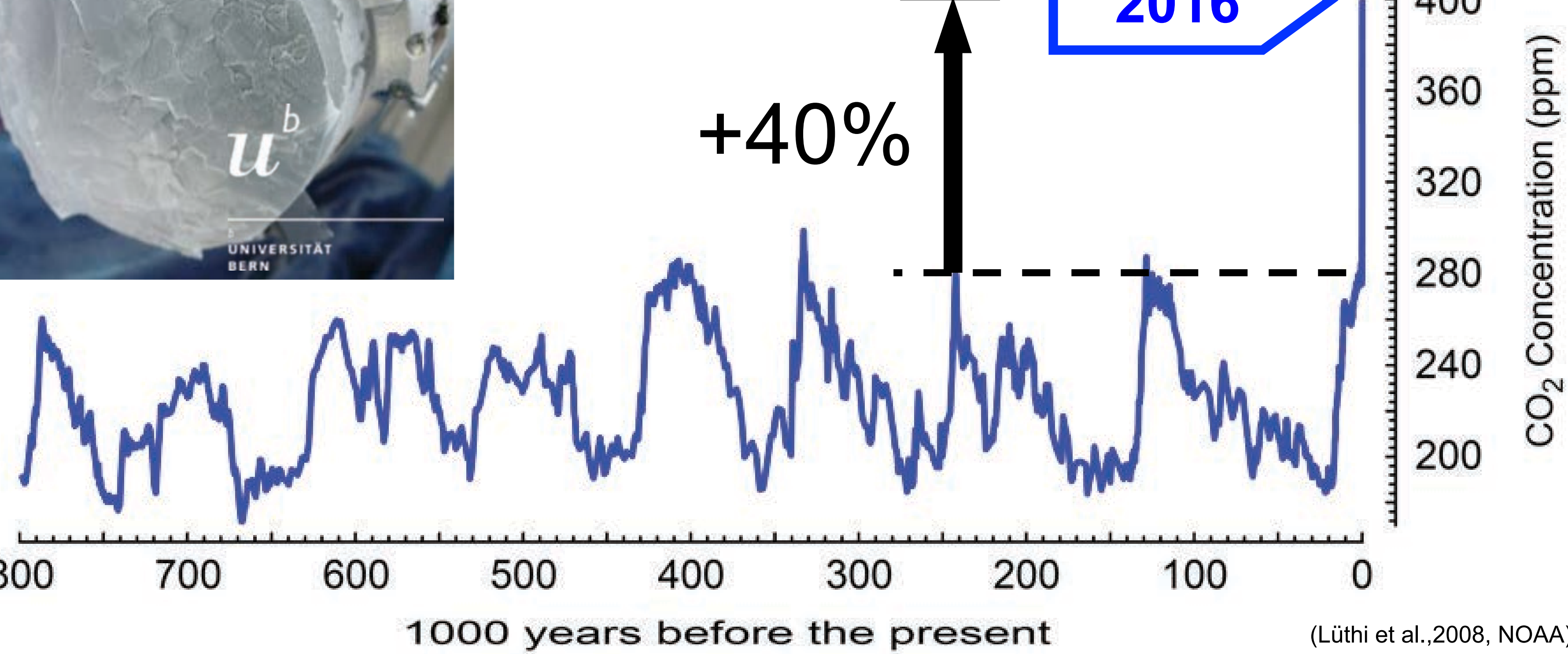
AR2 (1995): "balance of evidence suggests **discernible** human influence"

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"



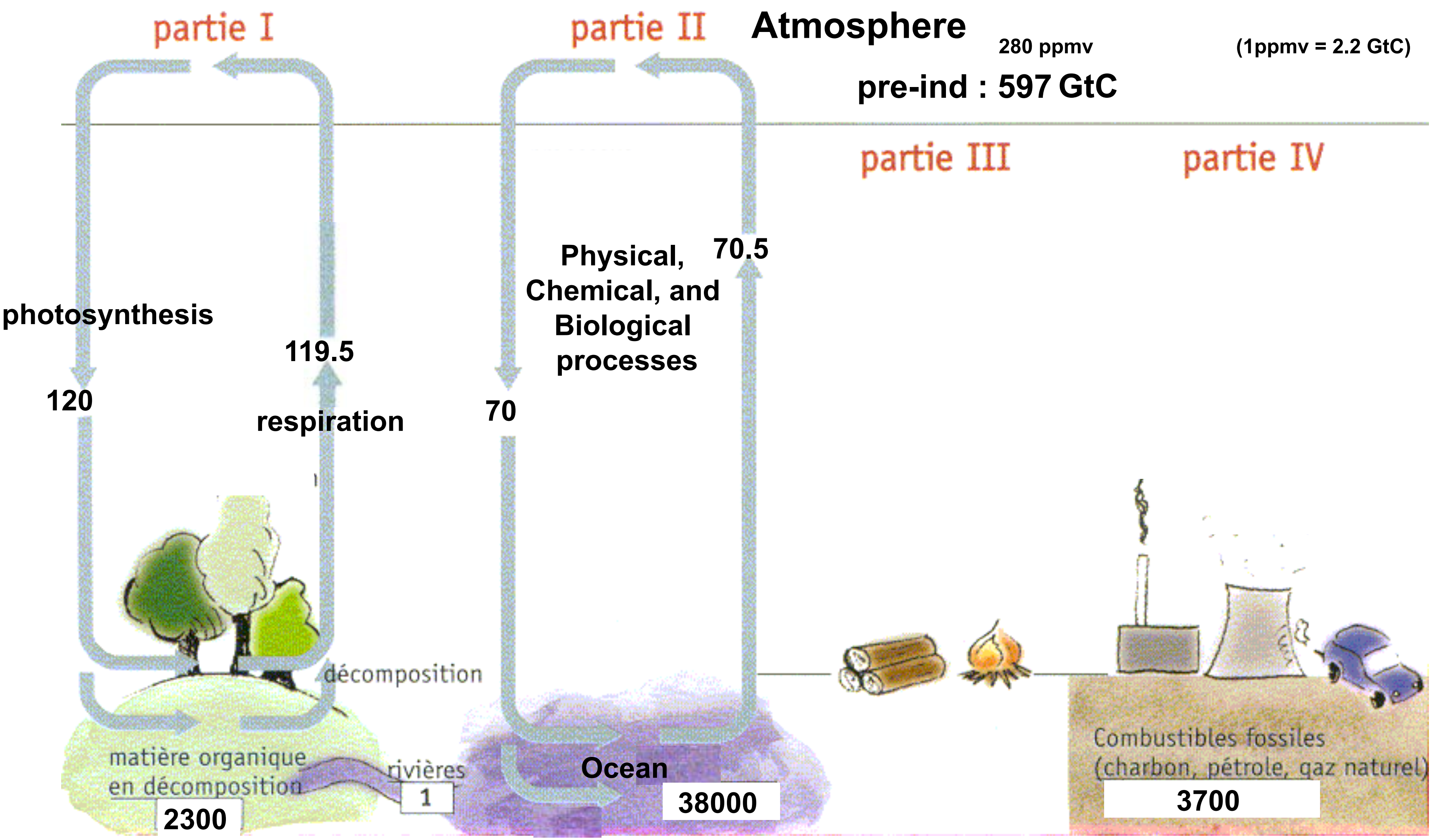
AR5 (2013) «It is **extremely likely** (odds 95 out of 100) that human influence has been the dominant cause… »



(Lüthi et al.,2008, NOAA)

Les concentrations atmosphériques en dioxyde de carbone (CO_2) ont augmenté jusqu'à des niveaux sans précédent au cours des 800 000 dernières années

Carbon cycle: unperturbed fluxes

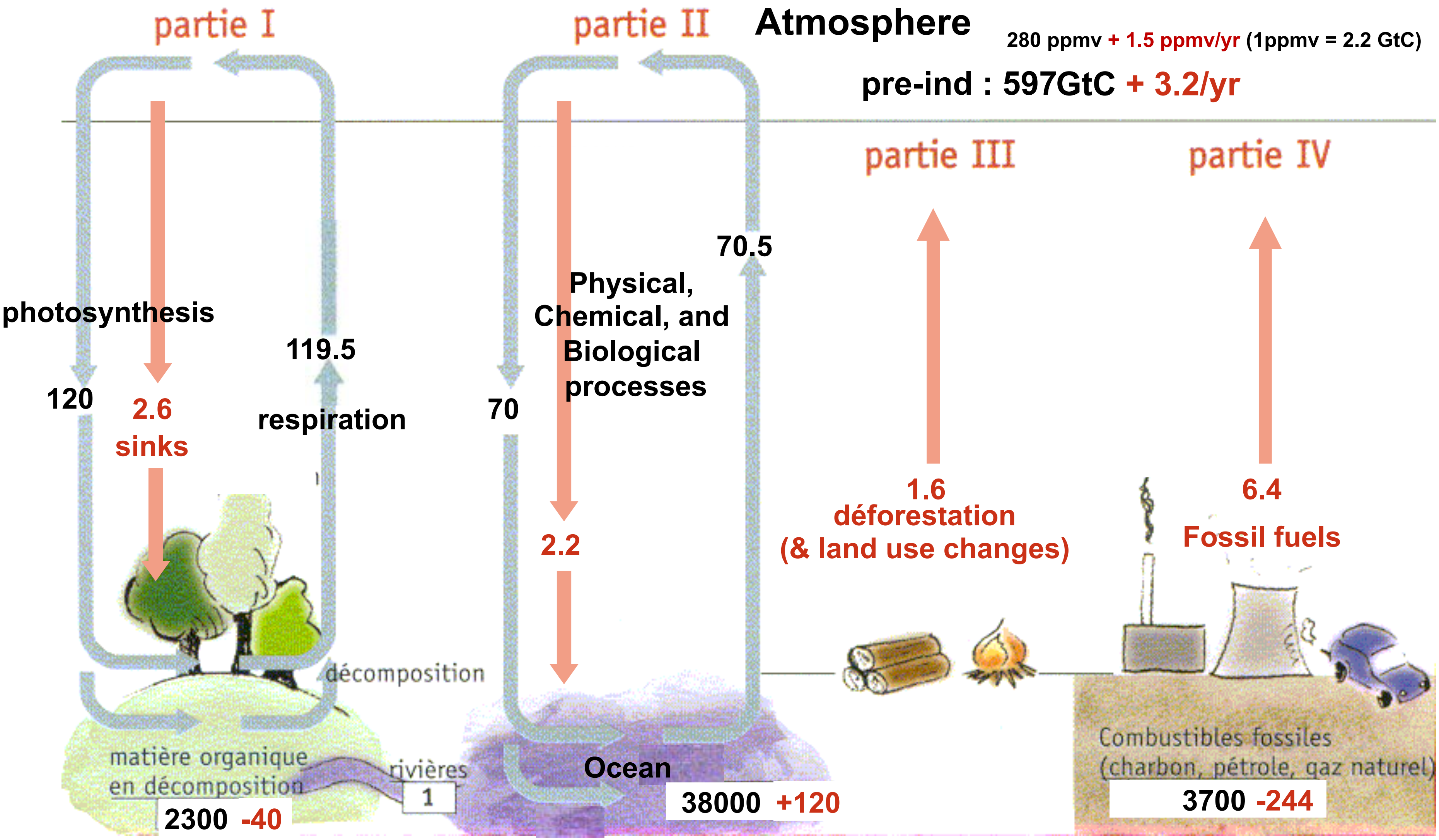


Units: GtC (billions tons of carbon) or GtC/year (multiply by 3.7 to get $GtCO_2$)

vanyp@climate.be

Carbon cycle: perturbed by human activities

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



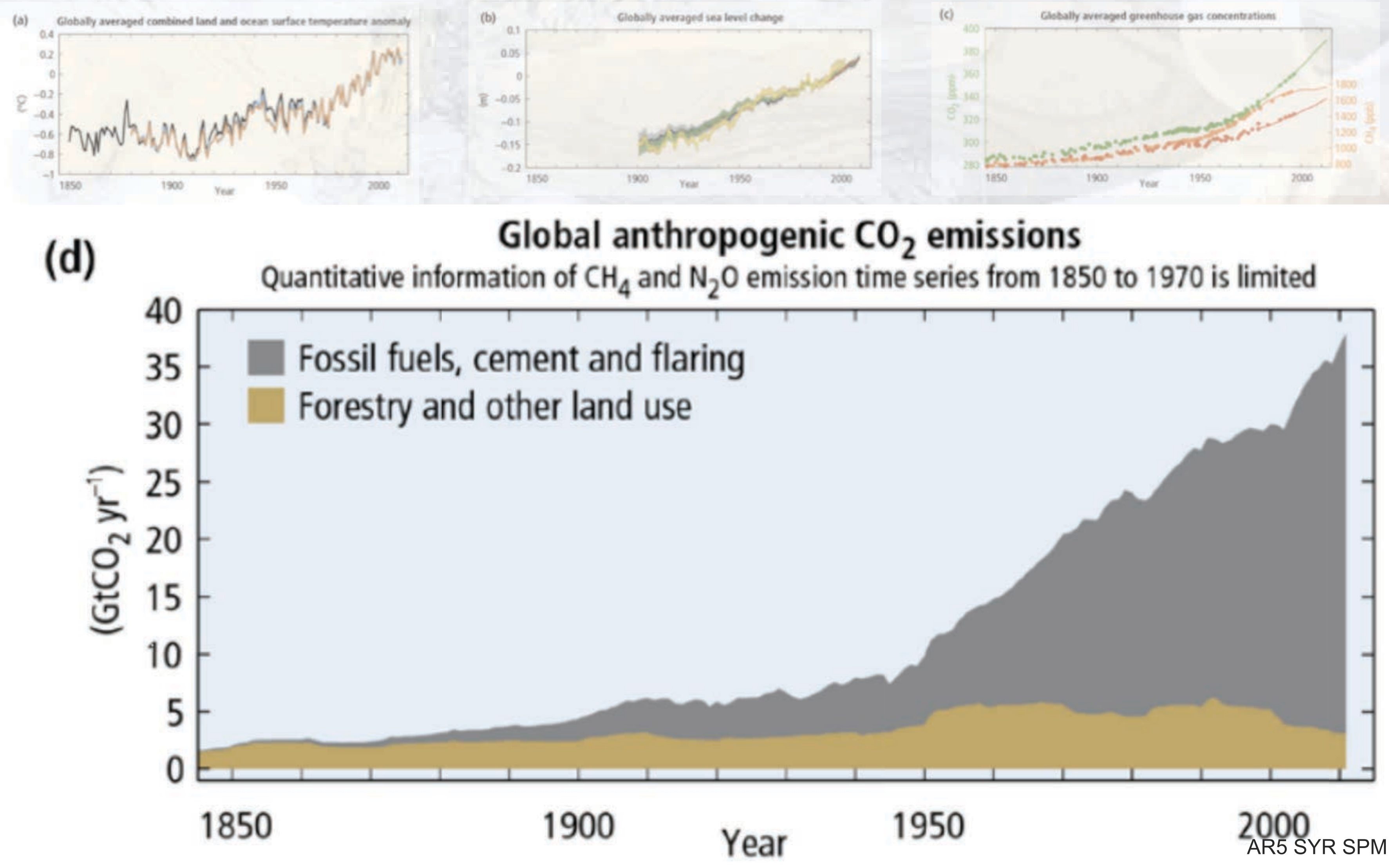
Units: GtC (billions tons of carbon) or GtC/year

Stocks!

vanyp@climate.be

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 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)
Globally averaged combined land and ocean surface temperature anomaly
(b)
Globally averaged sea level change
(c)
Globally averaged greenhouse gas concentrations
(d)
Global anthropogenic CO_2 emissions
Quantitative information of CH_4 and N_2O emission time series from 1850 to 1970 is limited
Fossil fuels, cement and flaring
Forestry and other land use
($GtCO_2\ yr^{-1}$)
0
5
10
15
20
25
30
35
40
1850
1900
1950
2000
Year

AR5 SYR SPM

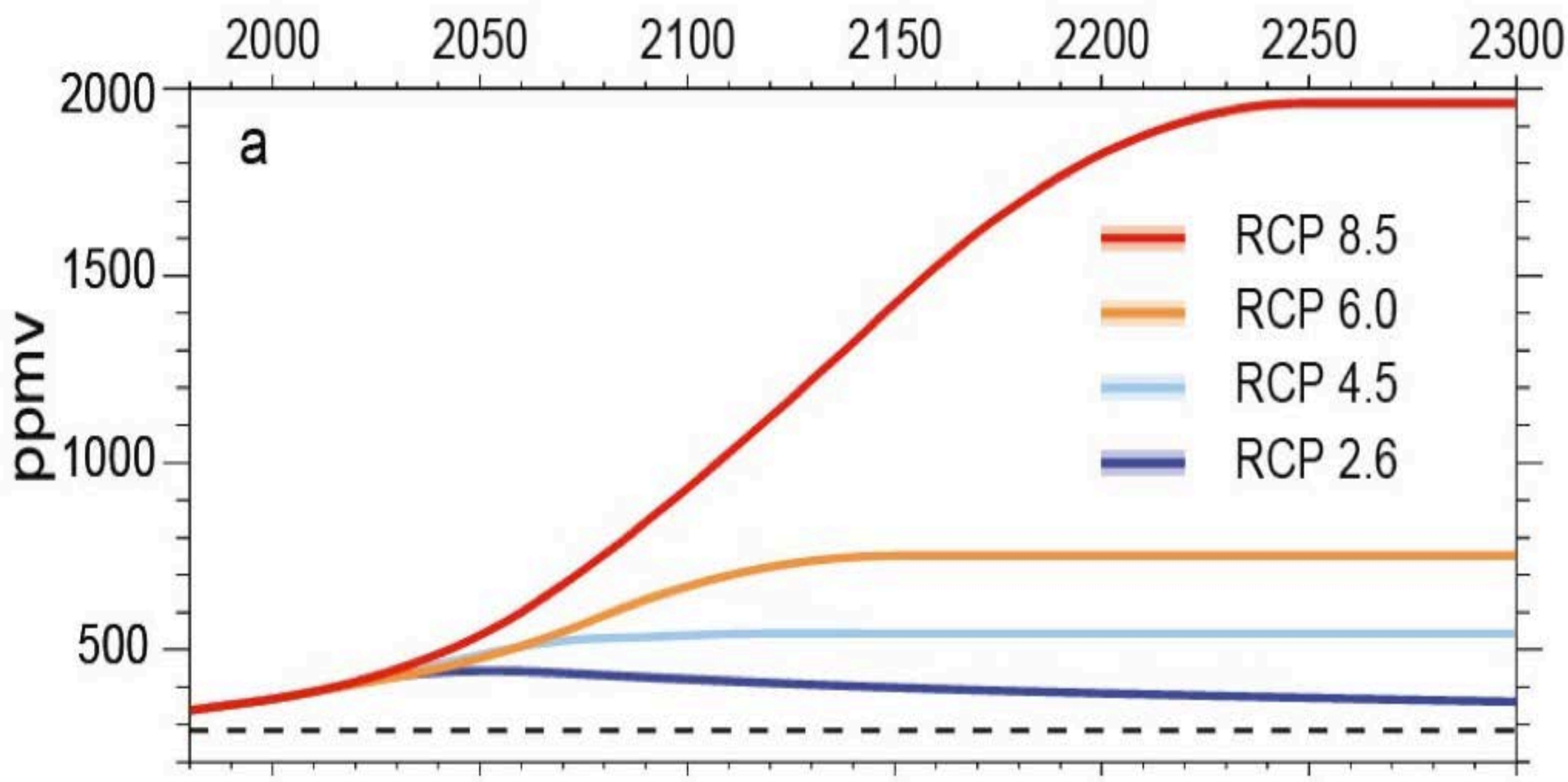
Sources of emissions

Energy production remains the primary driver of GHG emissions

2010 GHG emissions

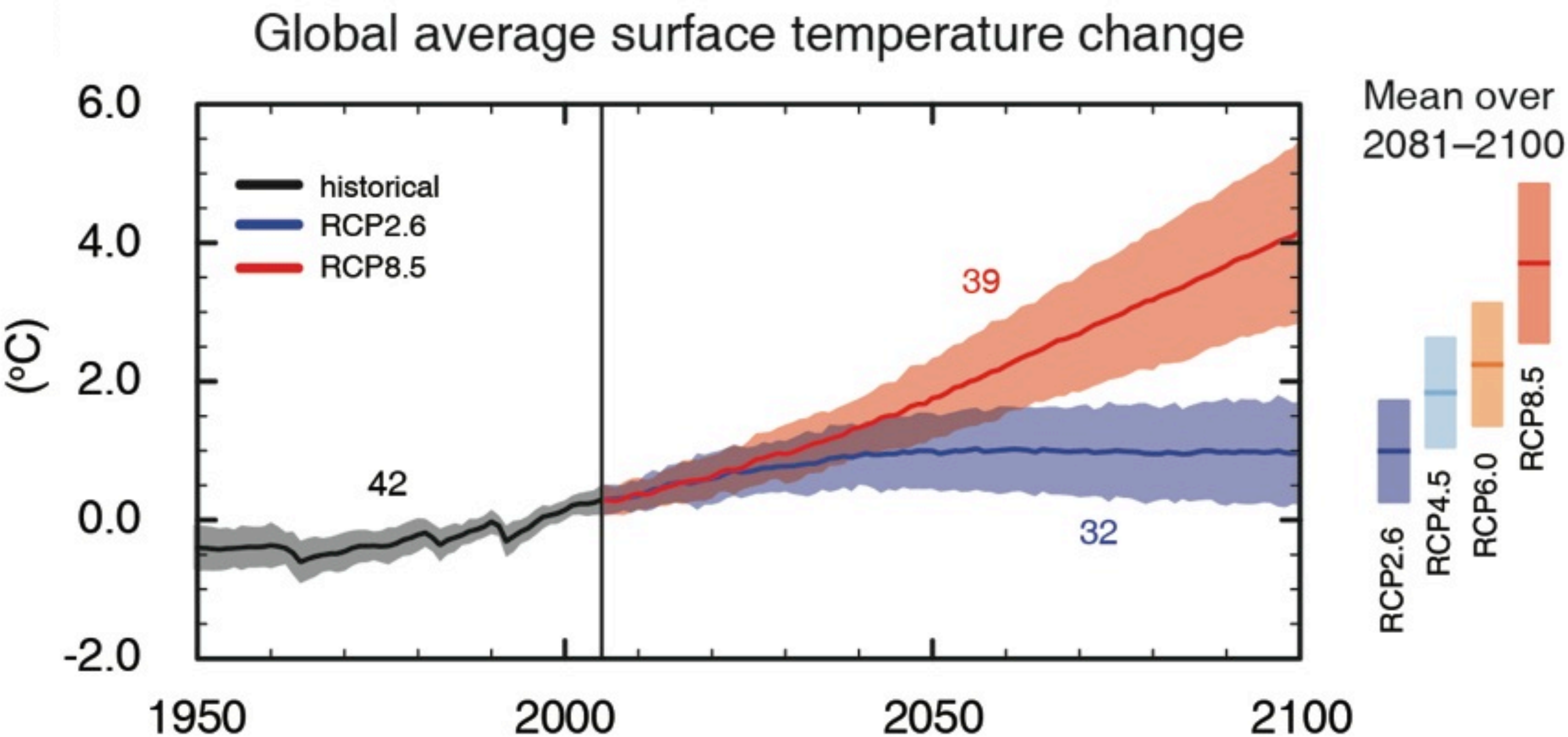
AR5 WGIII SPM

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

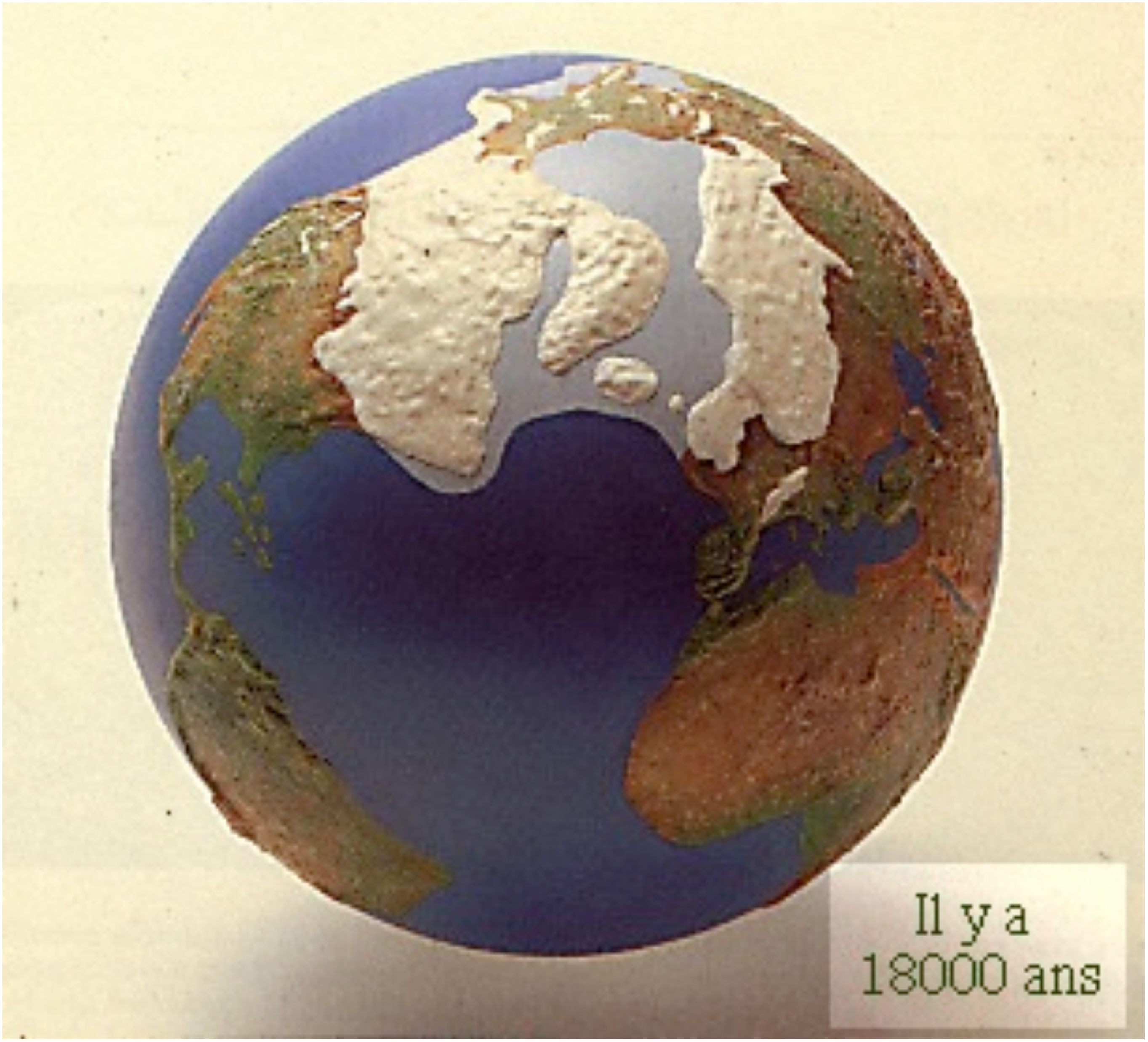


(IPCC 2013, Fig. SPM.7a)

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

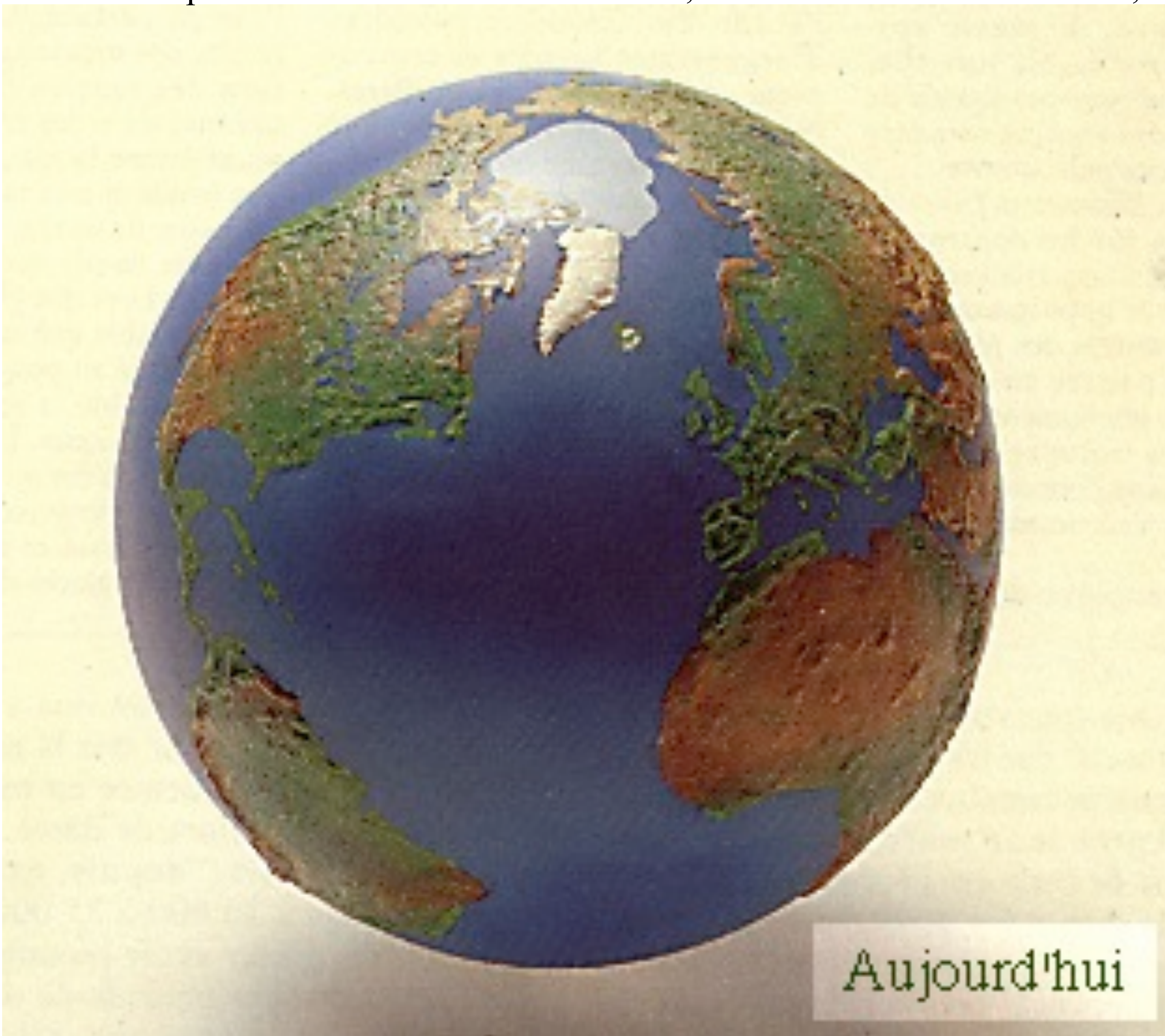
18-20000 years ago (Last Glacial Maximum)

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

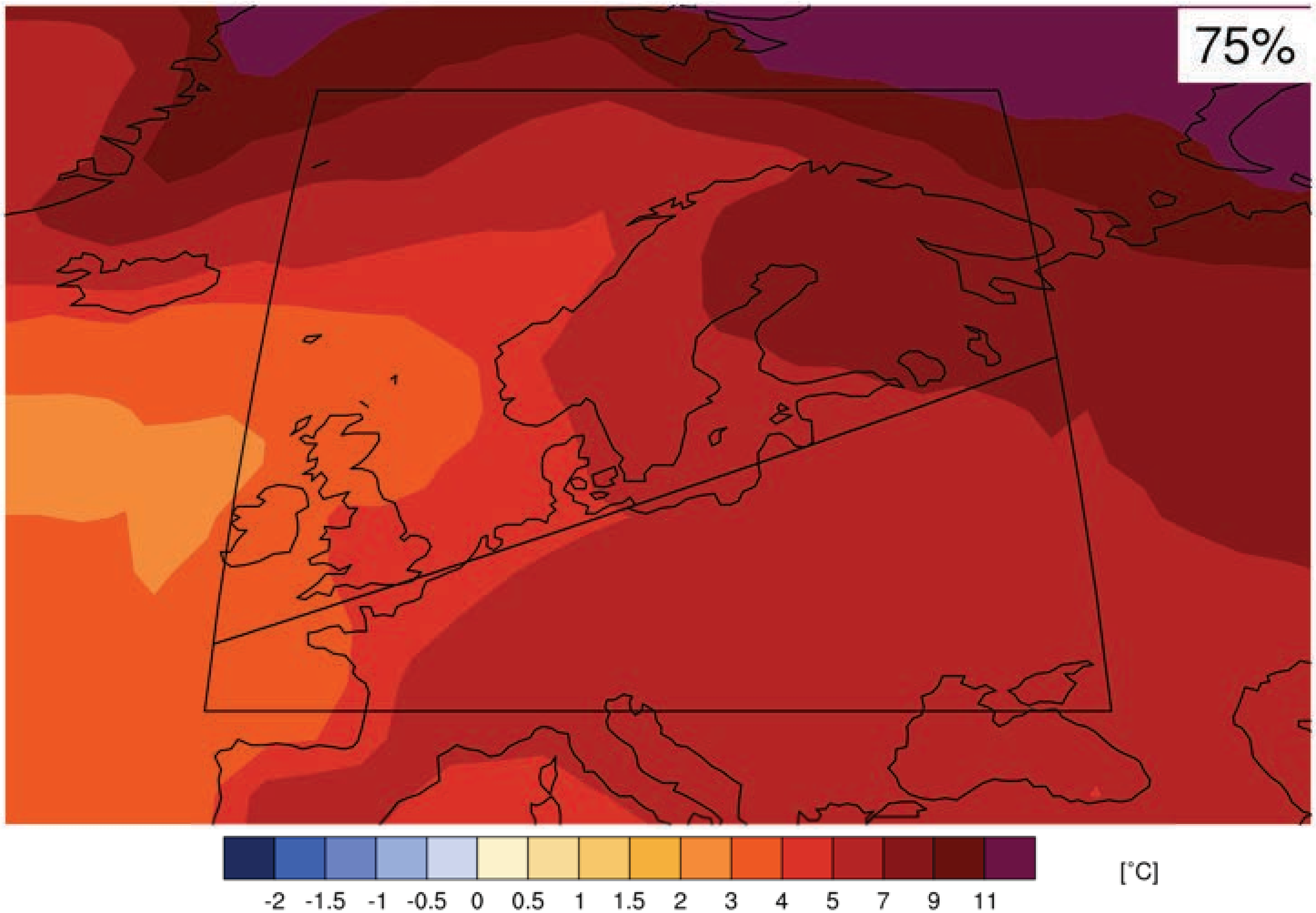


Today, with +4-5°C globally

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

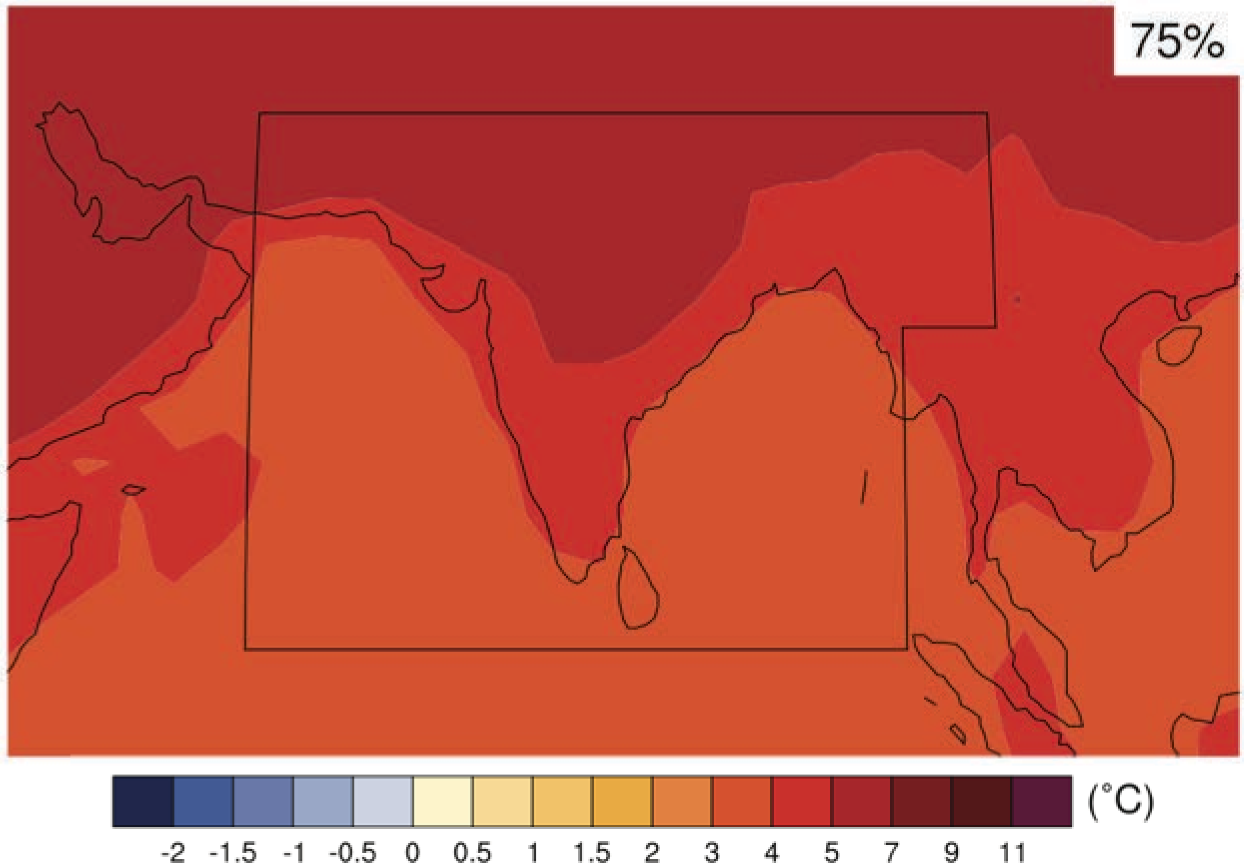


North Europe - Map of temperature changes: 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario (annual)



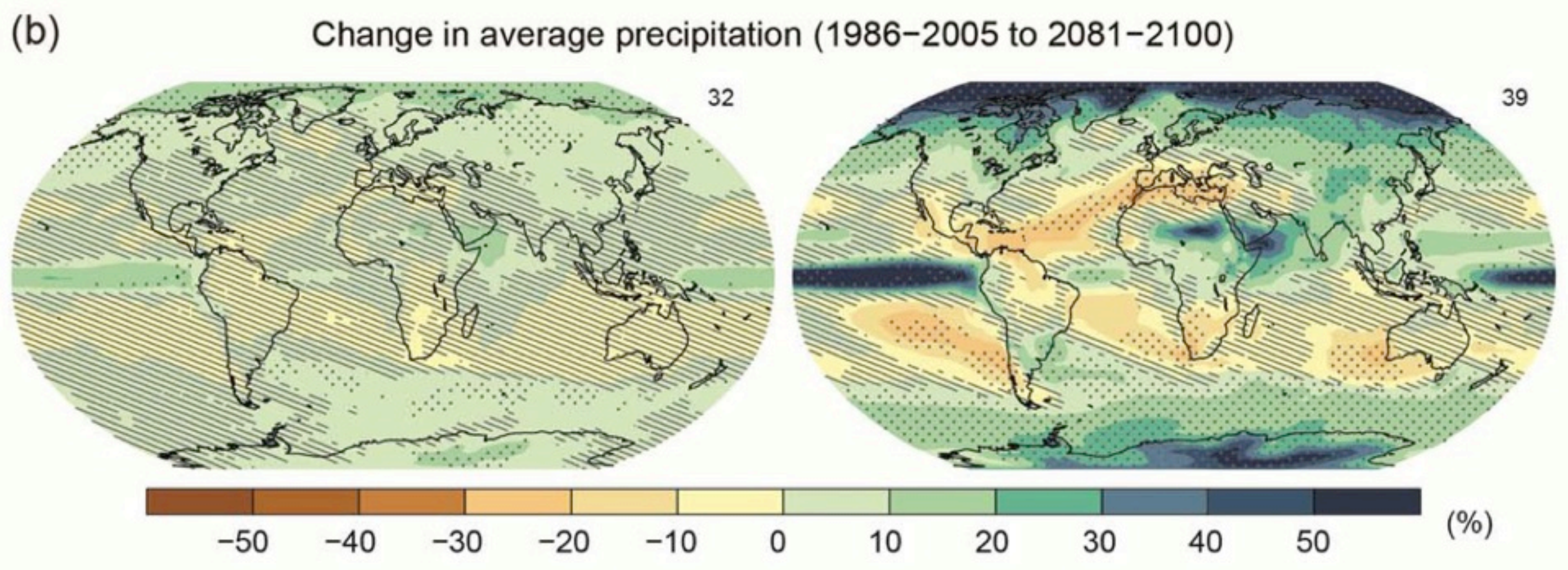
IPCC WG1 Fifth Assessment Report (Final Draft)

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

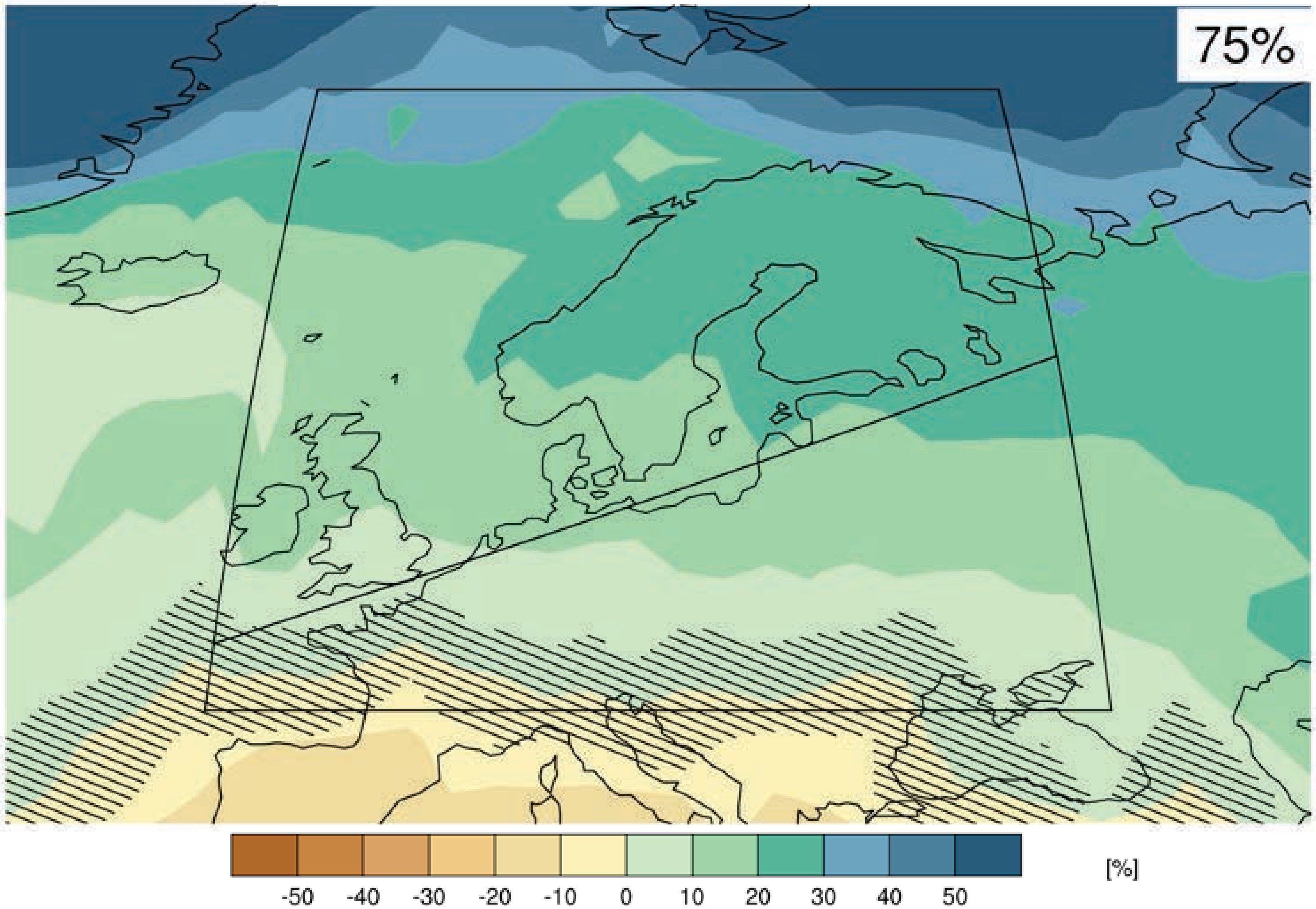


IPCC, WGI, Annex I: Atlas of Global and Regional Climate Projections Supplementary Material RCP8.5

Annual rainfall projections



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



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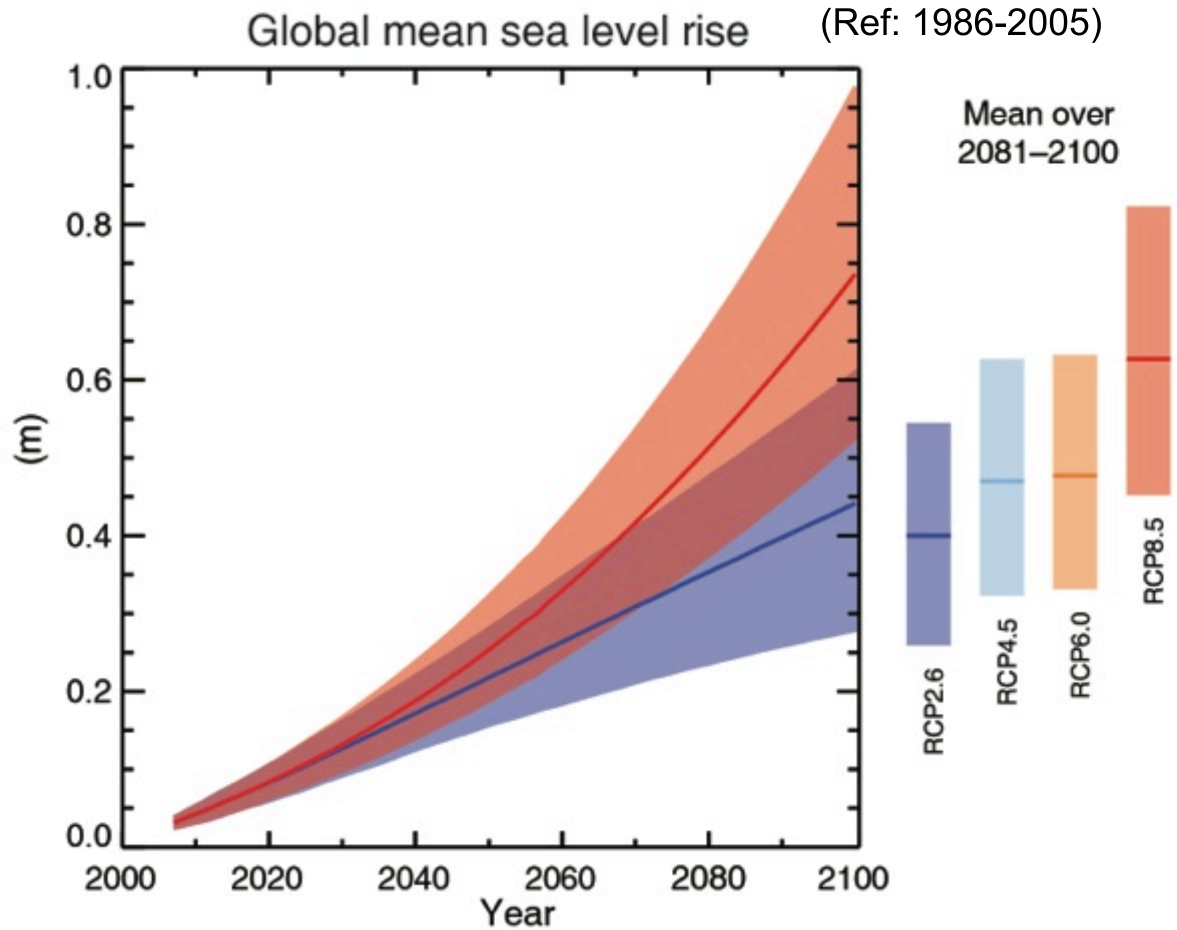


(IPCC 2013, Fig. SPM.9)

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

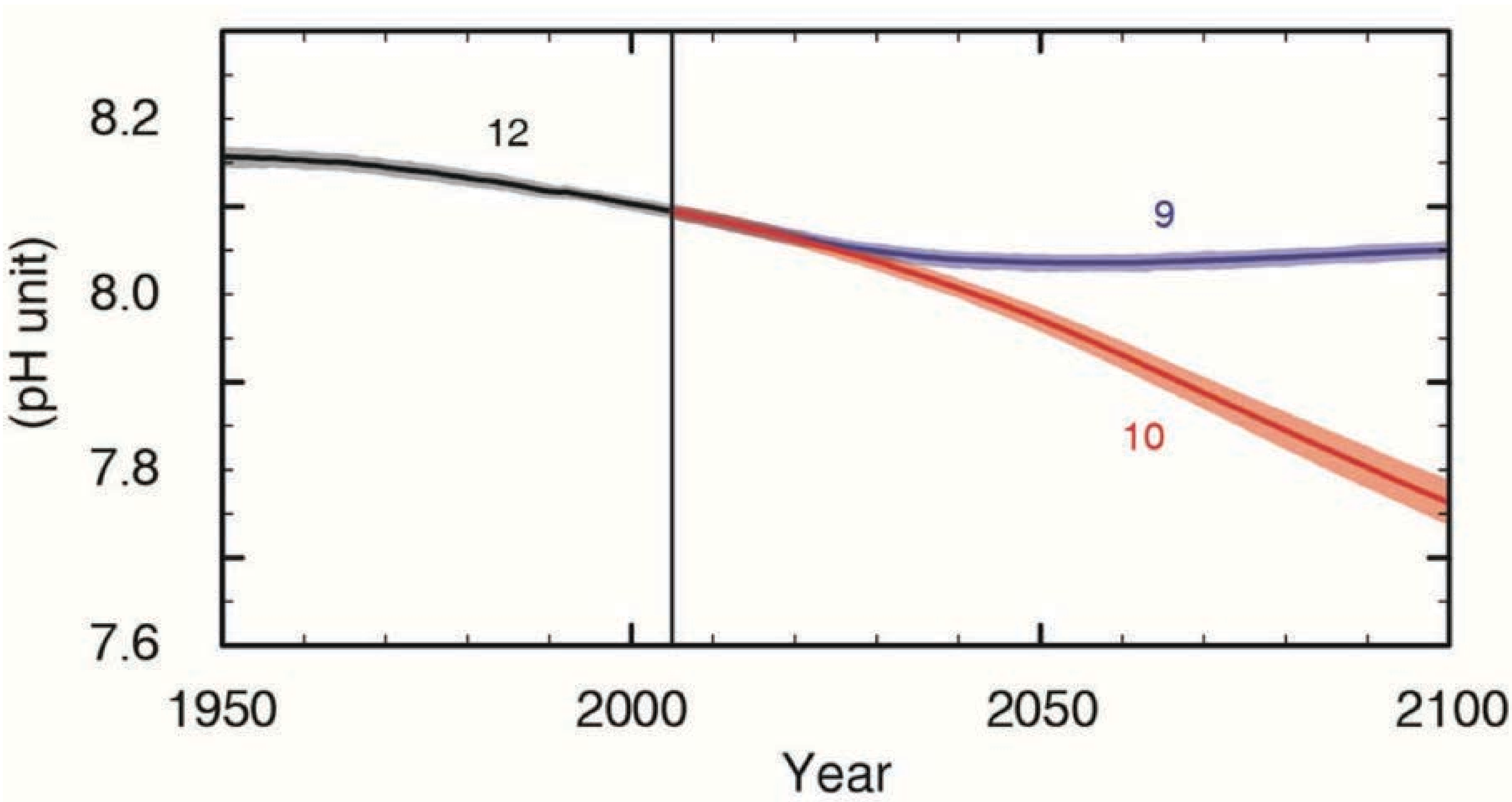
(Time 2001)

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

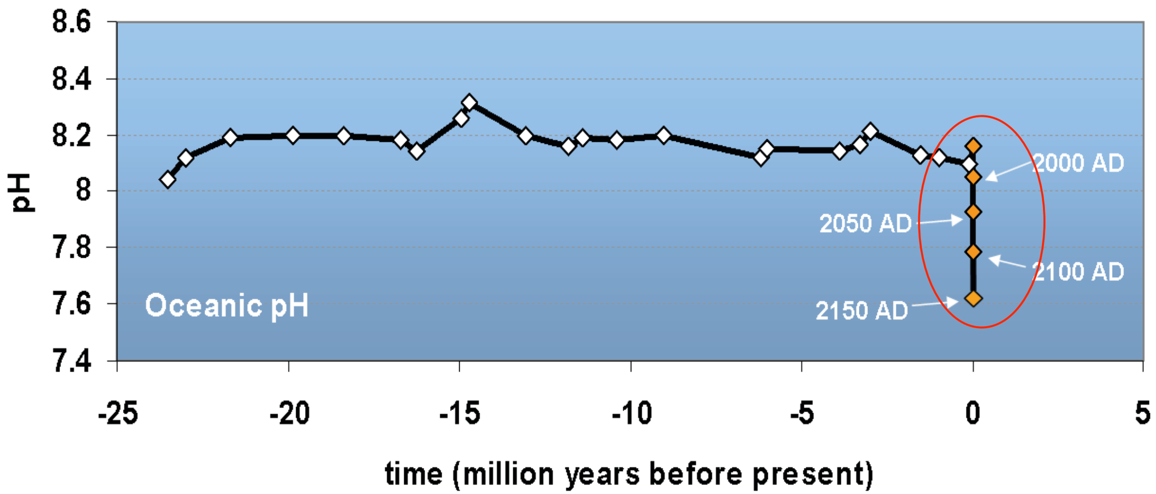
Global ocean surface pH (projections)

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**

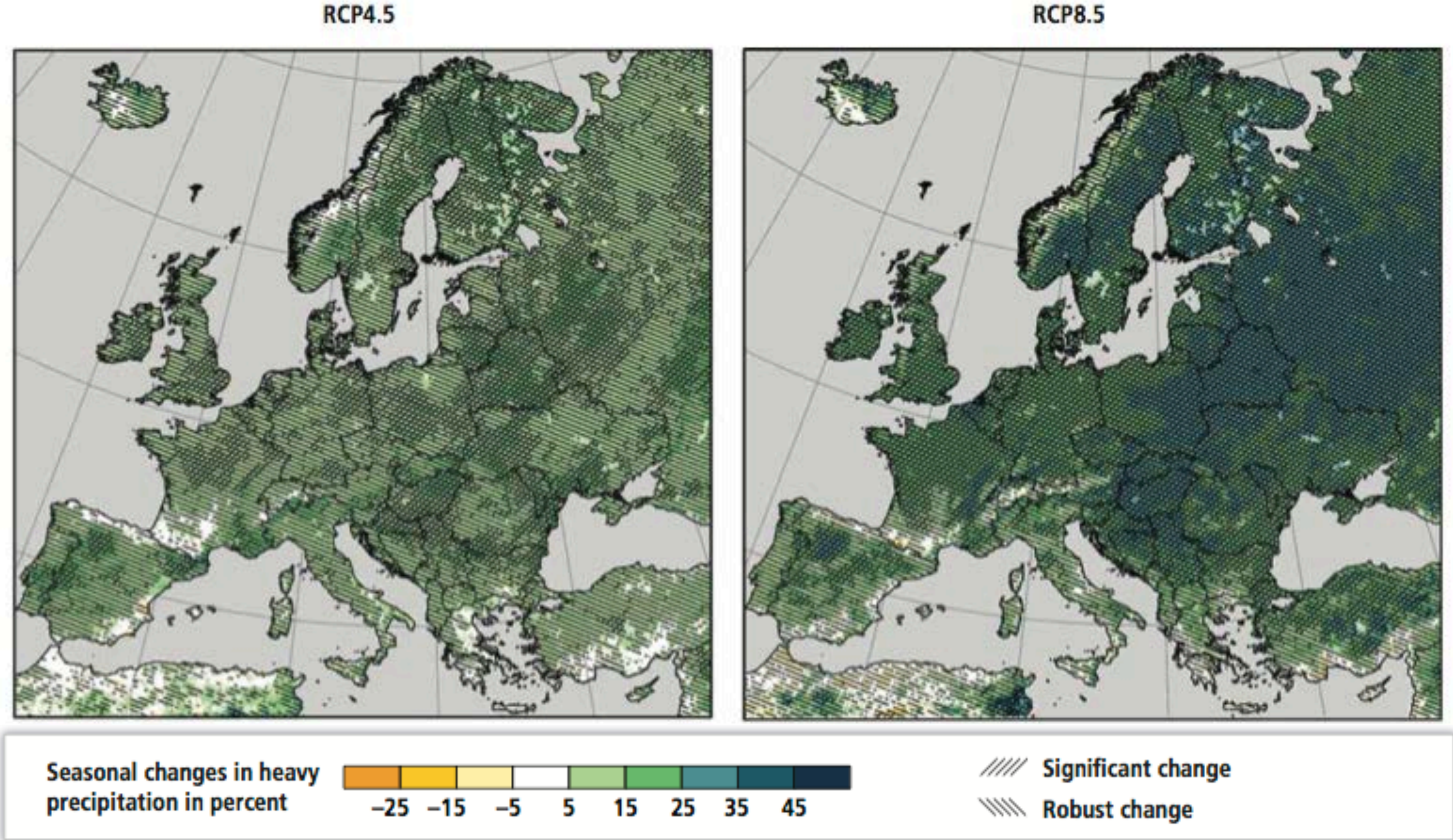
- **Mass extinctions linked to previous ocean acidification events**

- **Takes 10,000's of years to recover**

Turley et al. 2006

Slide courtesy of Carol Turley, PML

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



IPCC, AR5, WG II, Chap. 23, p. 1277

National Assessments

In Kenya, a study by the Stockholm Environment Institute (SEI) estimated the economics of climate change under a range of scenarios and estimated that, **by 2050, more than 300,000 people could be flooded per year under a high-emissions scenario**.

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WMO UNEP

IPCC, AR5, WG II, Chap. 14, p. 852

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

AR5 WGII SPM


ADAPTATION IS
ALREADY OCCURRING
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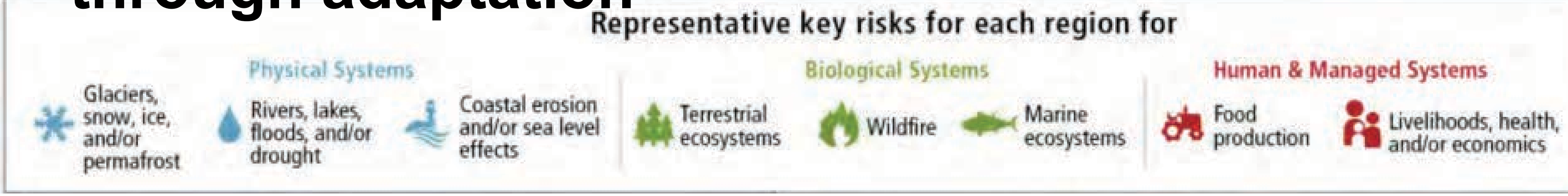
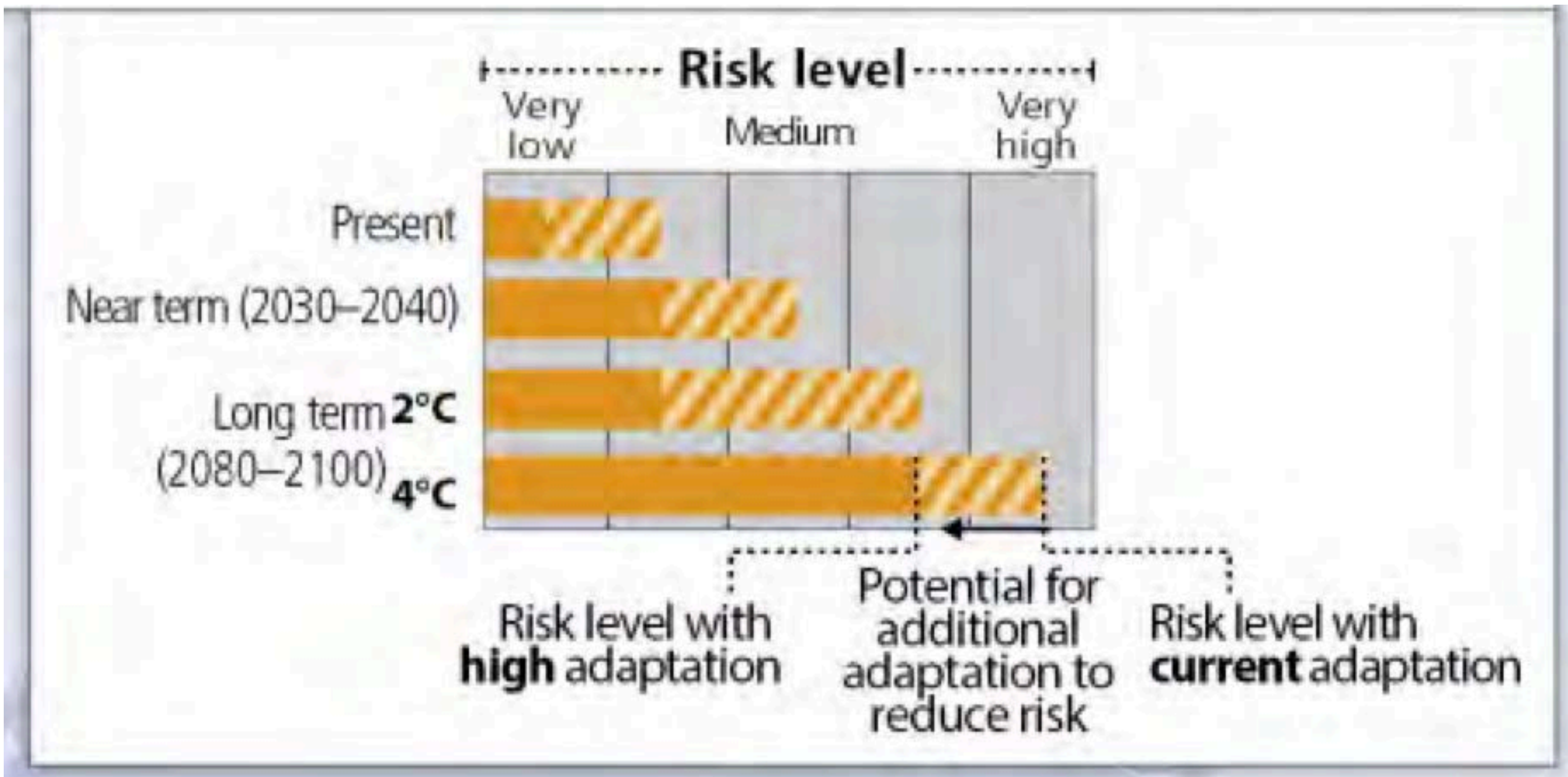
INTERGOVERNMENTAL PANEL ON climate change

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 in1996-2002

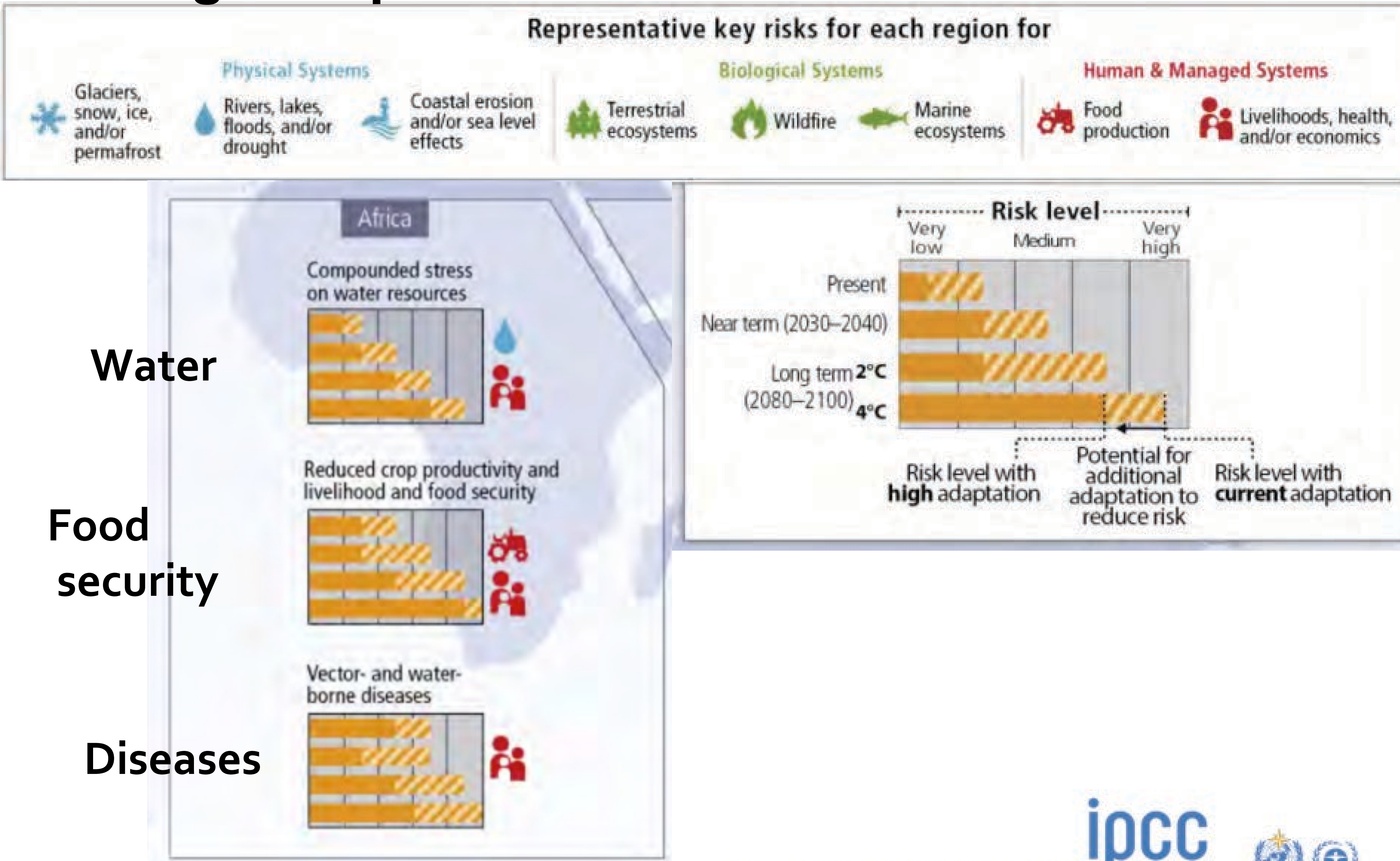
Regional key risks and potential for risk reduction through adaptation





IPCC, AR5, SPM, Figure SPM.8

Regional key risks and risk reduction through adaptation



IPCC, AR5, SPM, Figure SPM.8

ipcc INTERGOVERNMENTAL PANEL ON climate change

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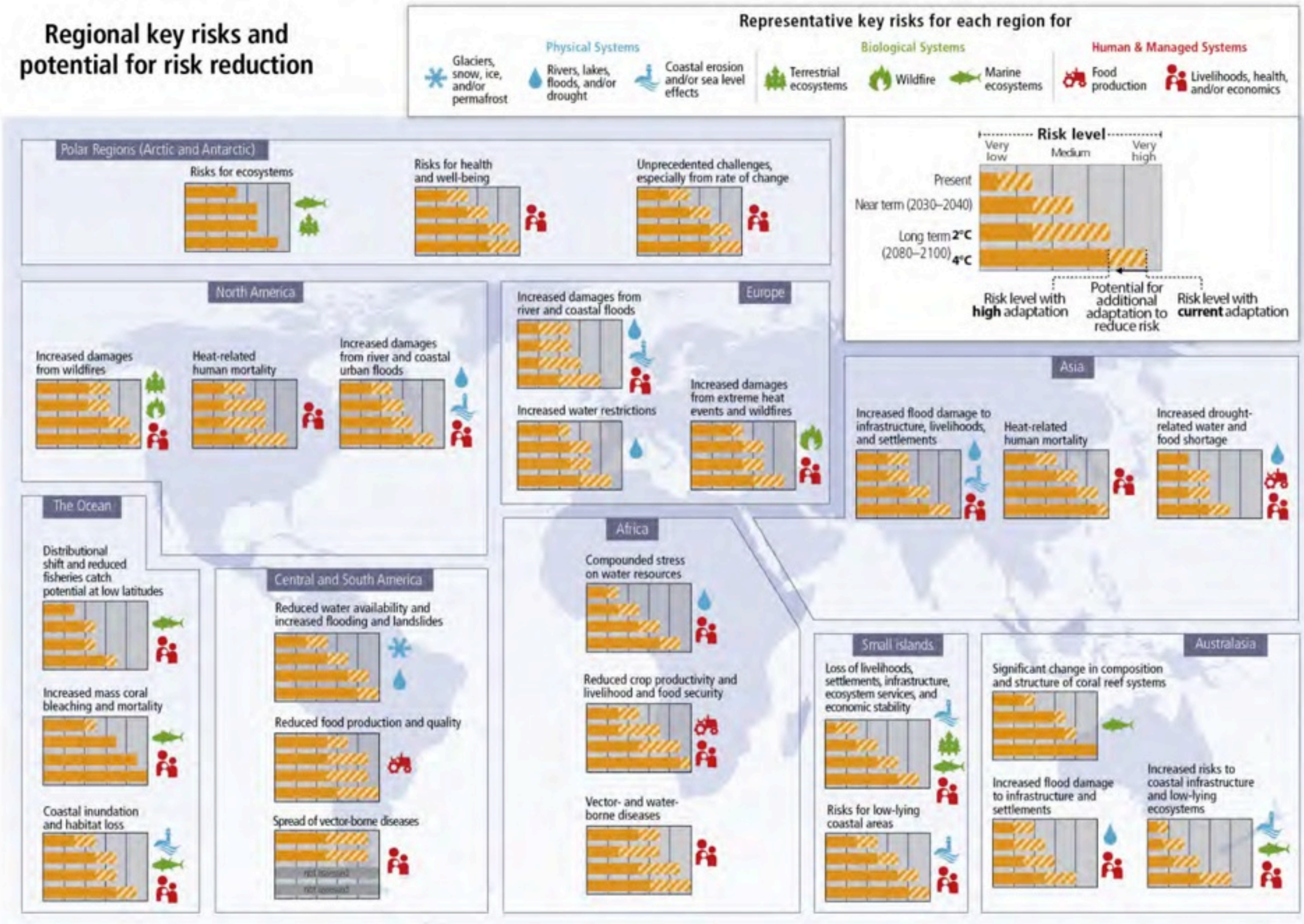

IPCC, AR5, SPM, Figure SPM.8


RISKS OF
CLIMATE CHANGE
INCREASE
WITH CONTINUED
HIGH EMISSIONS
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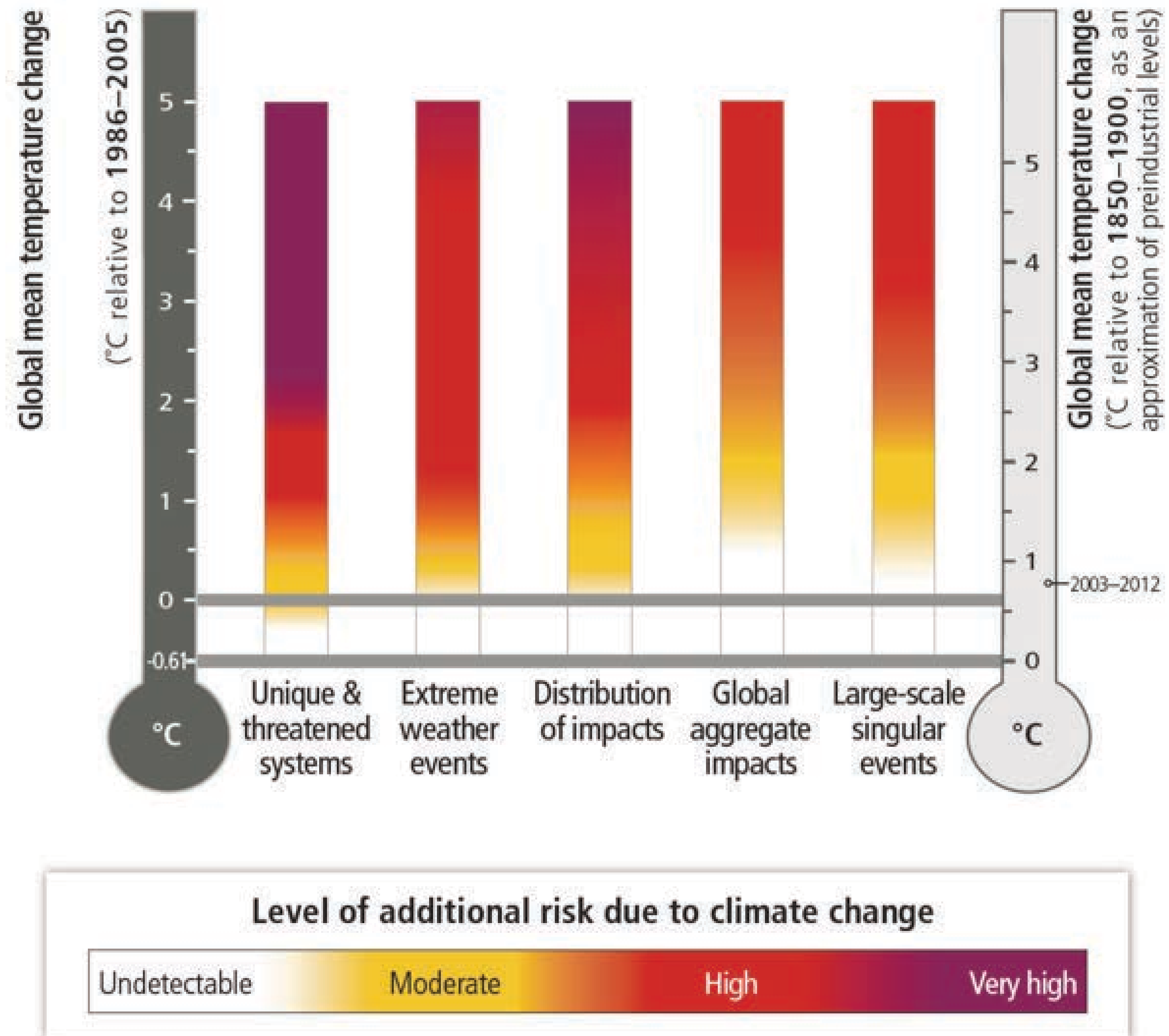
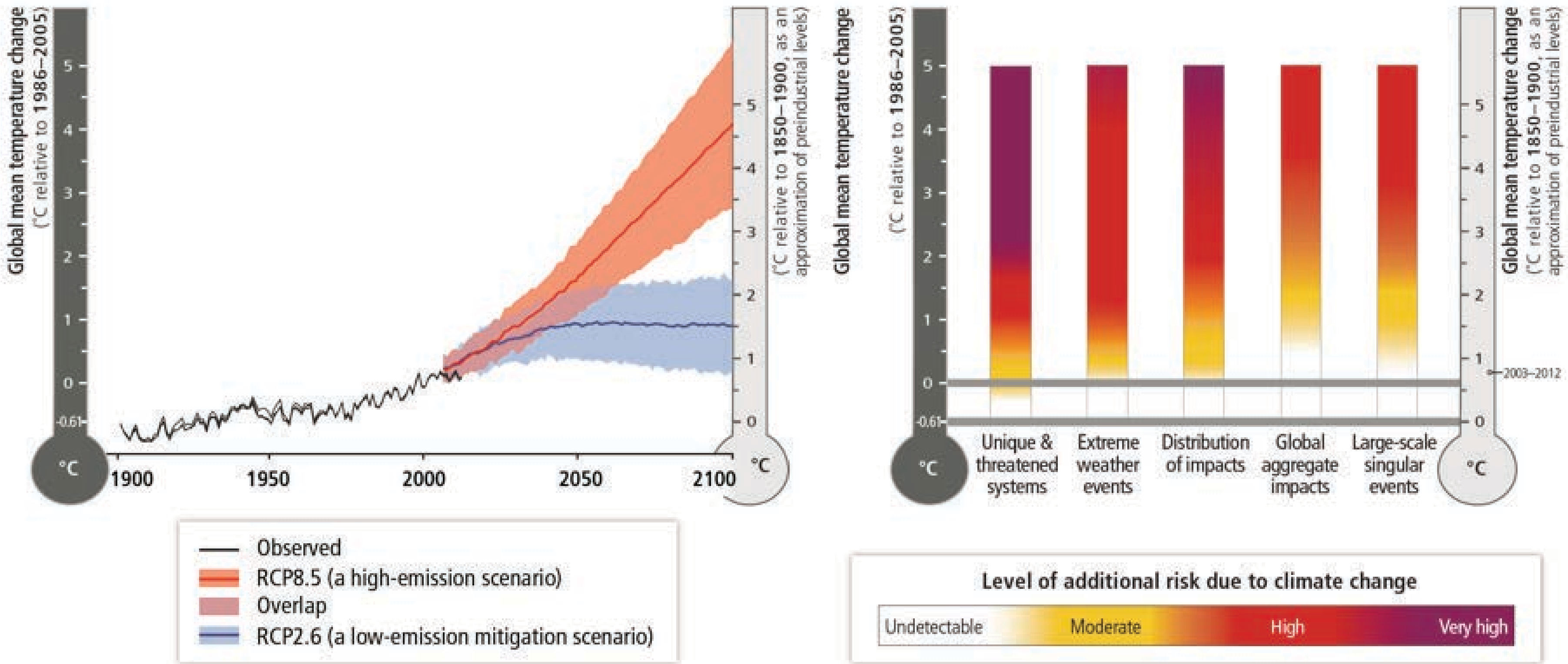


AR5, WGII, Box SPM.1 Figure 1



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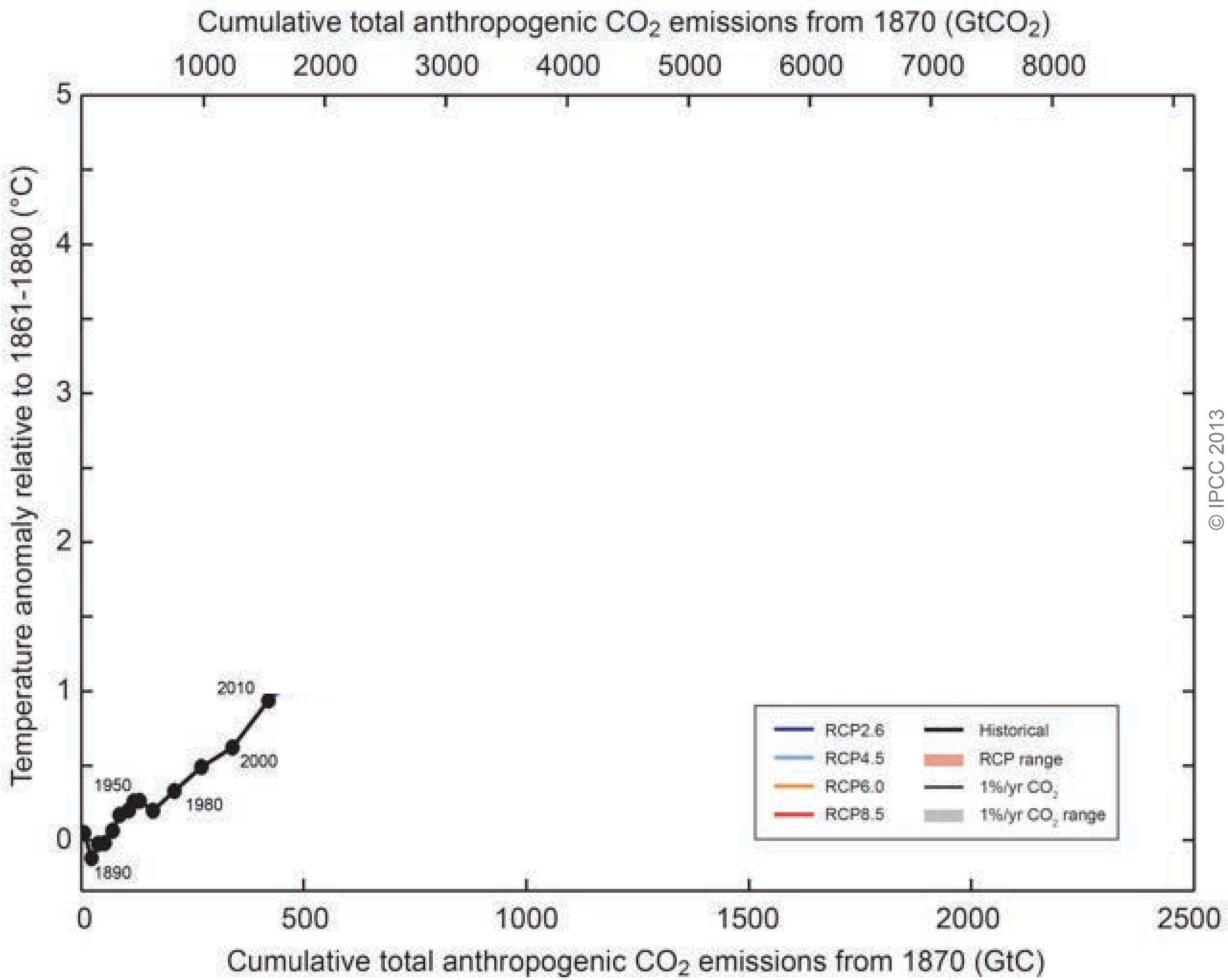


Fig. SPM.10

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

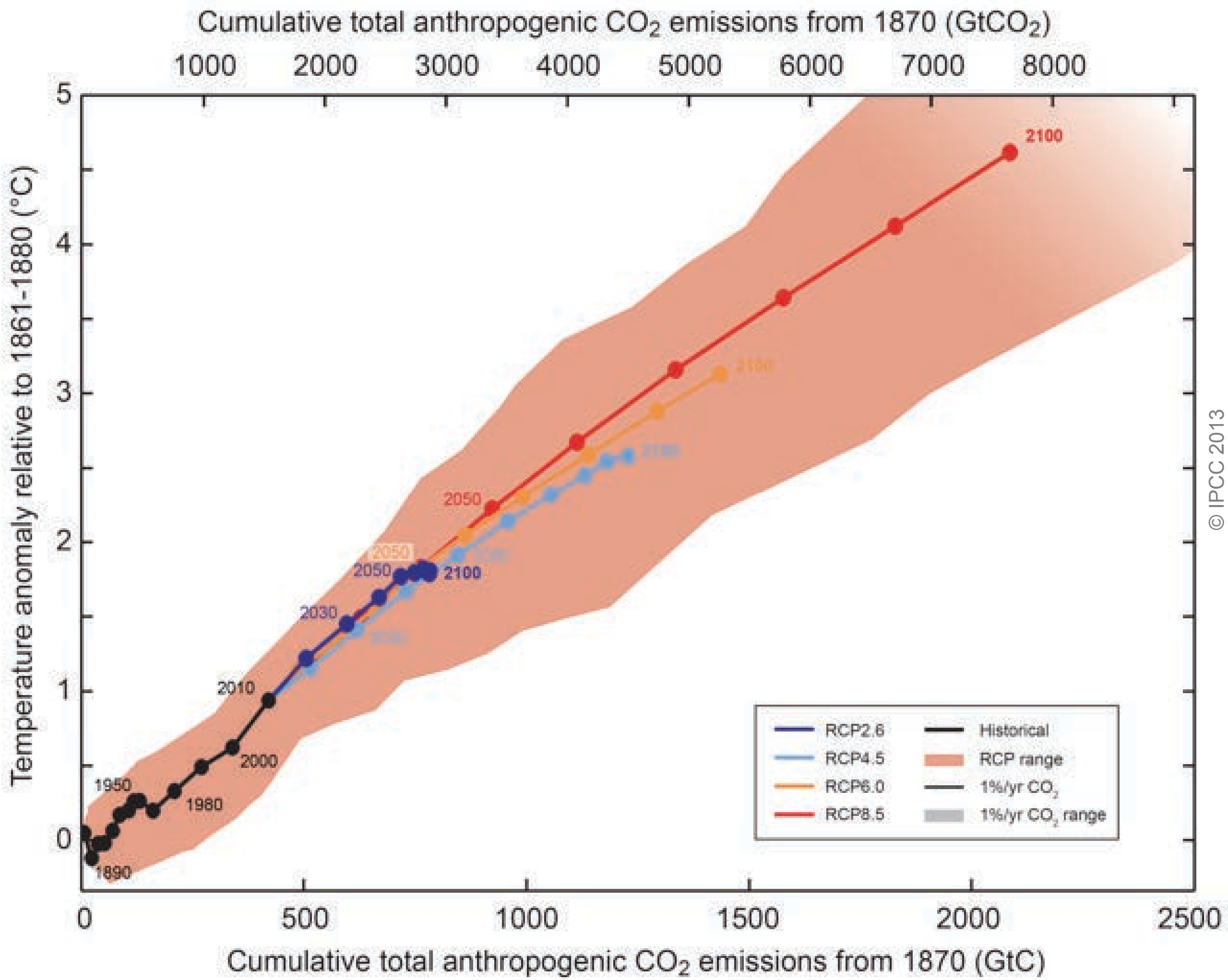
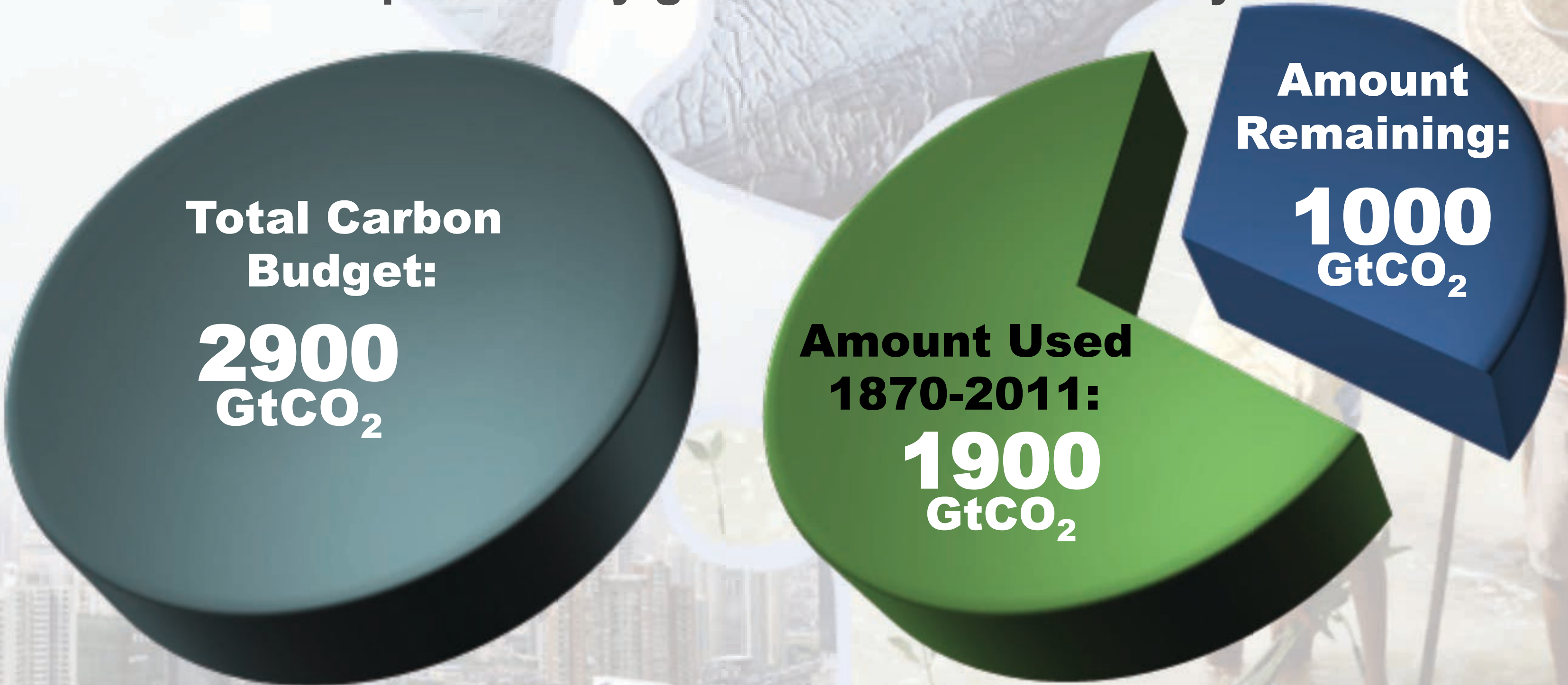


Fig. SPM.10

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

AR5 WGI SPM

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Historical Responsibility

International cooperation on climate change involves ethical considerations, including equitable effort-sharing.

These questions include how much overall mitigation is needed to avoid **'dangerous interference with the climate system'**, how the effort or **cost of mitigating climate change should be shared among countries** and between the present and future, how to account for such factors as **historical responsibility for GHG emissions**, and how to choose among alternative policies for mitigation and adaptation. Ethical issues of well- being, **justice**, fairness, and rights are all involved. Ethical analysis can identify the different ethical principles that underlie different viewpoints, and distinguish correct from incorrect ethical reasoning.

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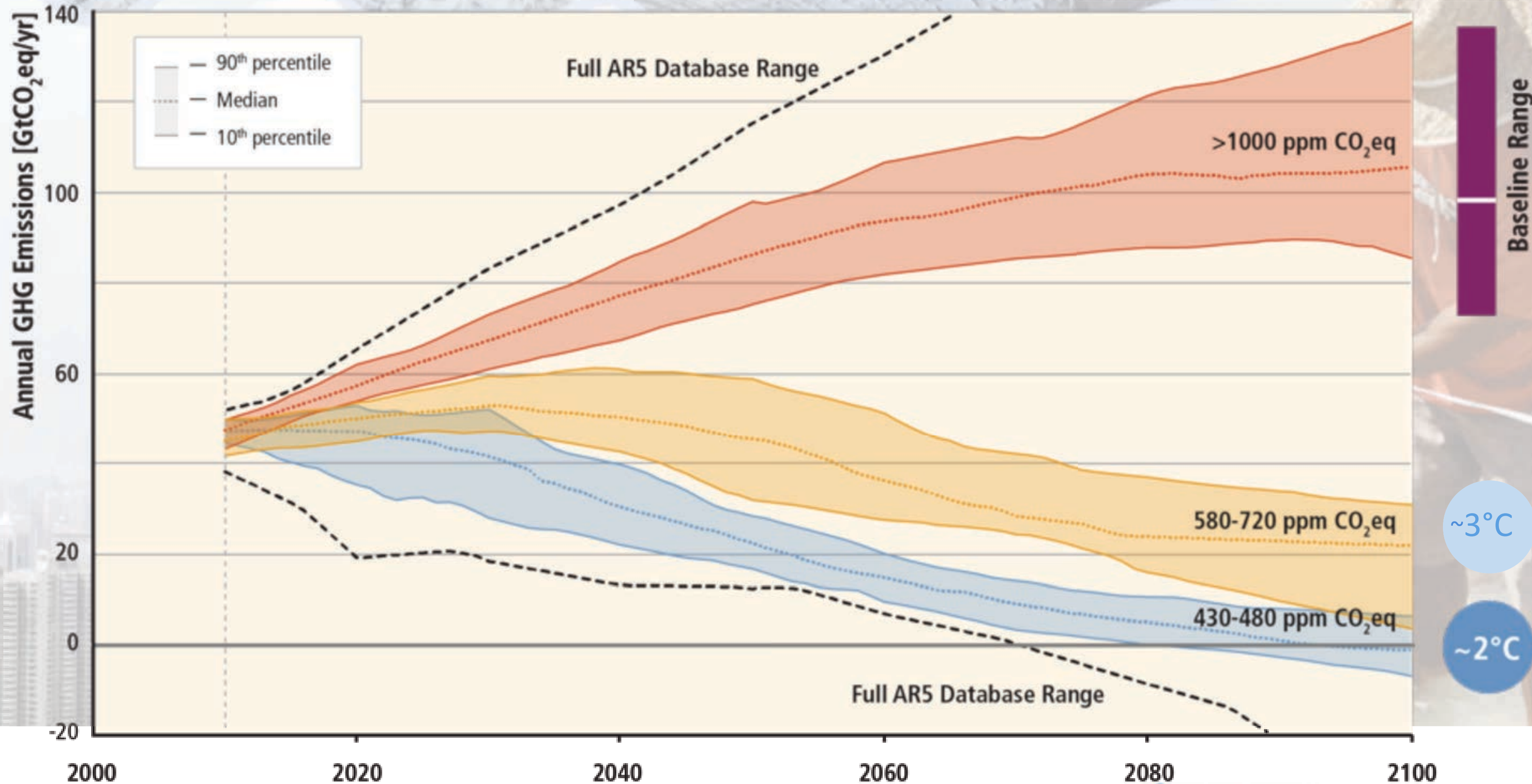
IPCC, AR5, WG III, TS, p. 39


NORTH
SOUTH
ECOLOGICAL SPACE

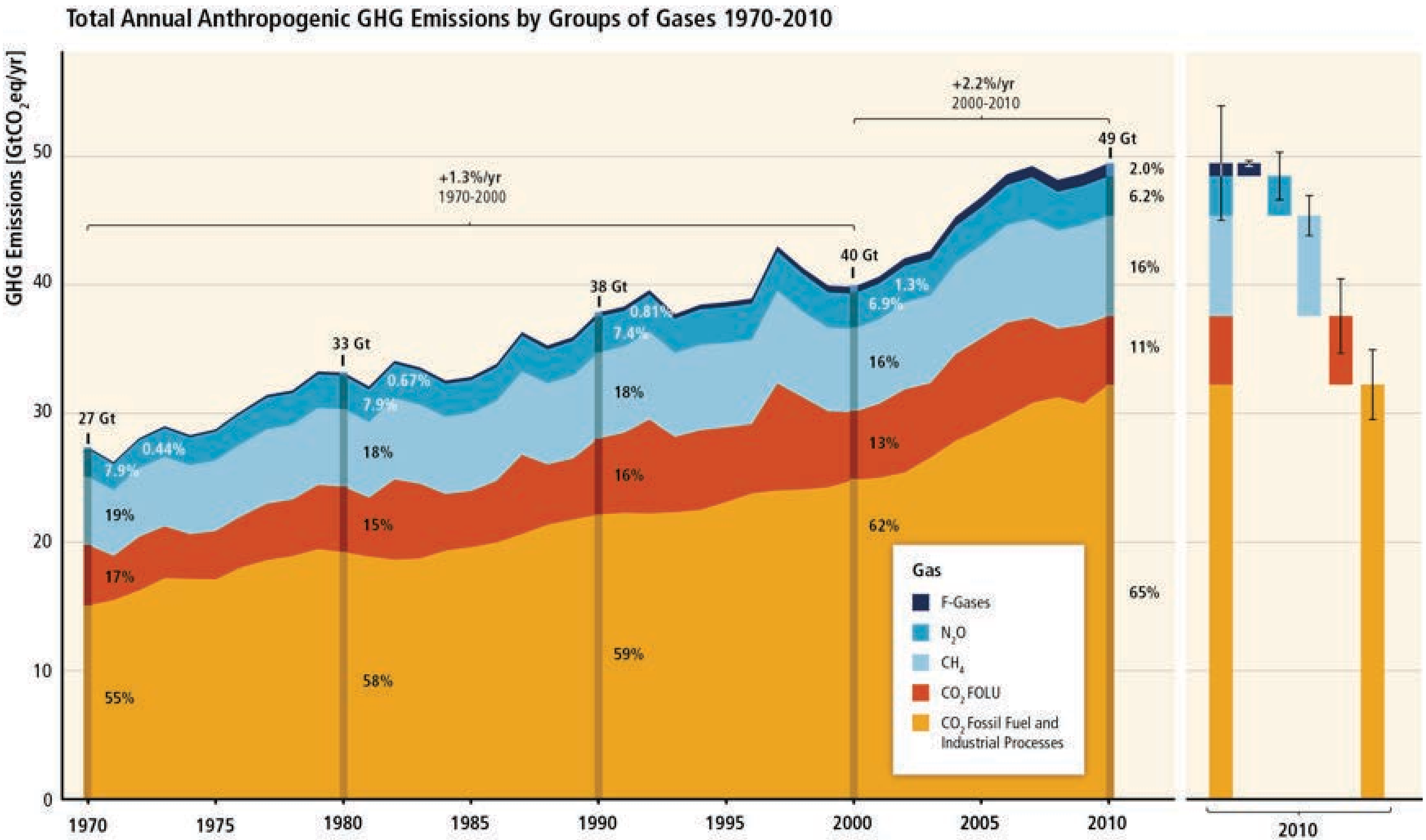
Stabilization of atmospheric concentrations requires moving away from the baseline – regardless of the mitigation goal.



Based on Figure 6.7

AR5 WGIII SPM

GHG emissions accelerate despite reduction efforts. Most emission growth is CO_2 from fossil fuel combustion and industrial processes.



Working Group III contribution to the
IPCC Fifth Assessment Report

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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

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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.**

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**

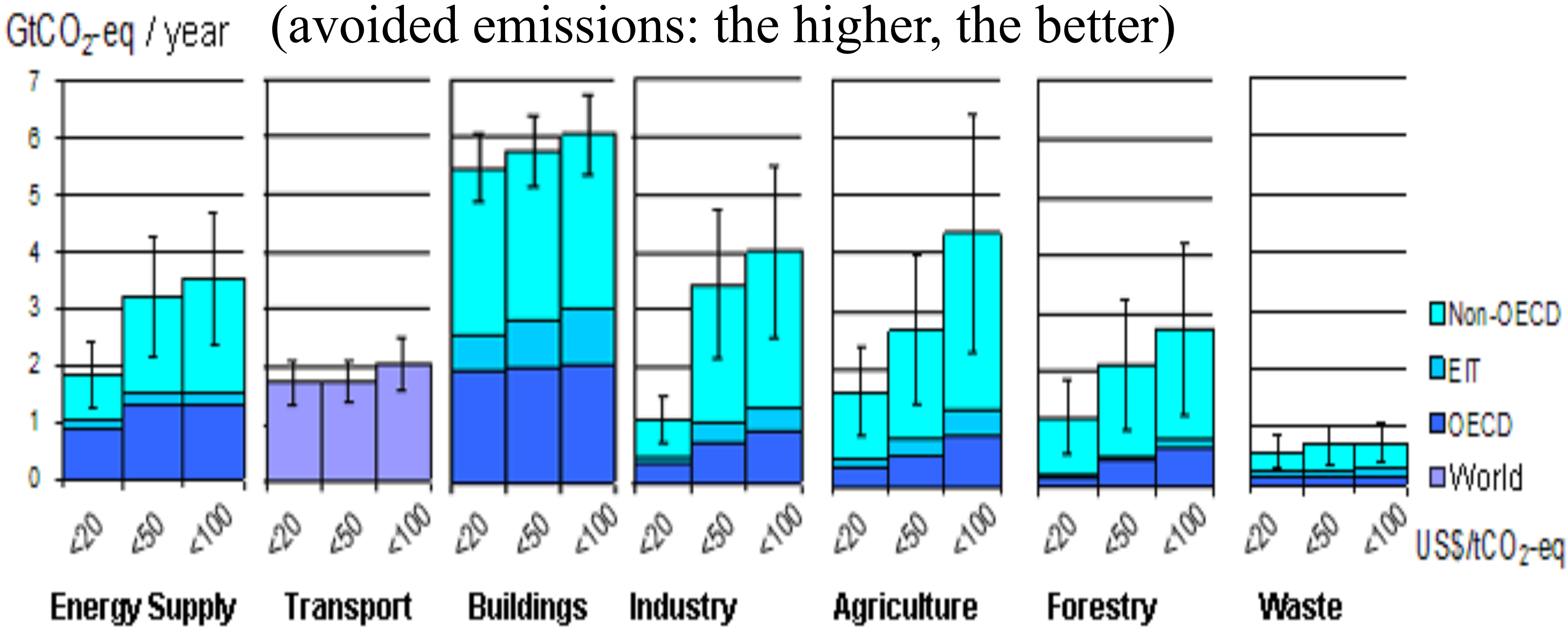
Lifestyle and behavioural changes

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

(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 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**

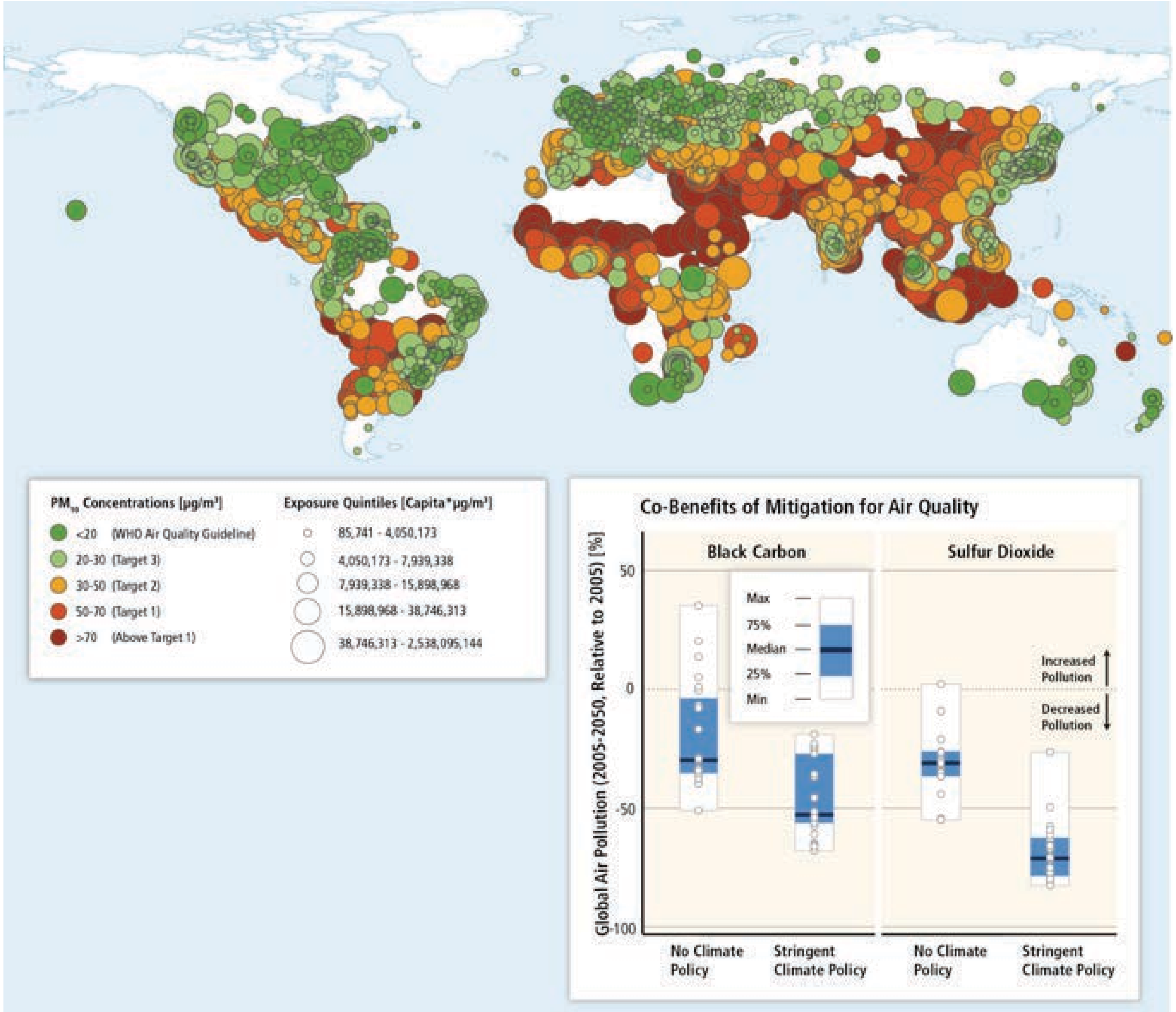
Since AR4, there has been an increased focus on policies designed to integrate multiple objectives, increase co-benefits and reduce adverse side-effects.

- **Sector-specific policies** have been more widely used than economy-wide policies.
- **Regulatory approaches and information** measures are widely used, and are often environmentally effective.
- Since AR4, **cap and trade** systems for GHGs have been established in a number of countries and regions.
- In some countries, **tax-based policies** specifically aimed at reducing GHG emissions–alongside technology and other policies–have helped to weaken the link between GHG emissions and GDP
- The **reduction of subsidies** for GHG-related activities in various sectors can achieve emission reductions, depending on the social and economic context.

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.

- **Sustainable development and equity provide a basis for assessing climate policies and highlight the need for addressing the risks of climate change**

- **Issues of equity, justice, and fairness arise with respect to mitigation and adaptation**

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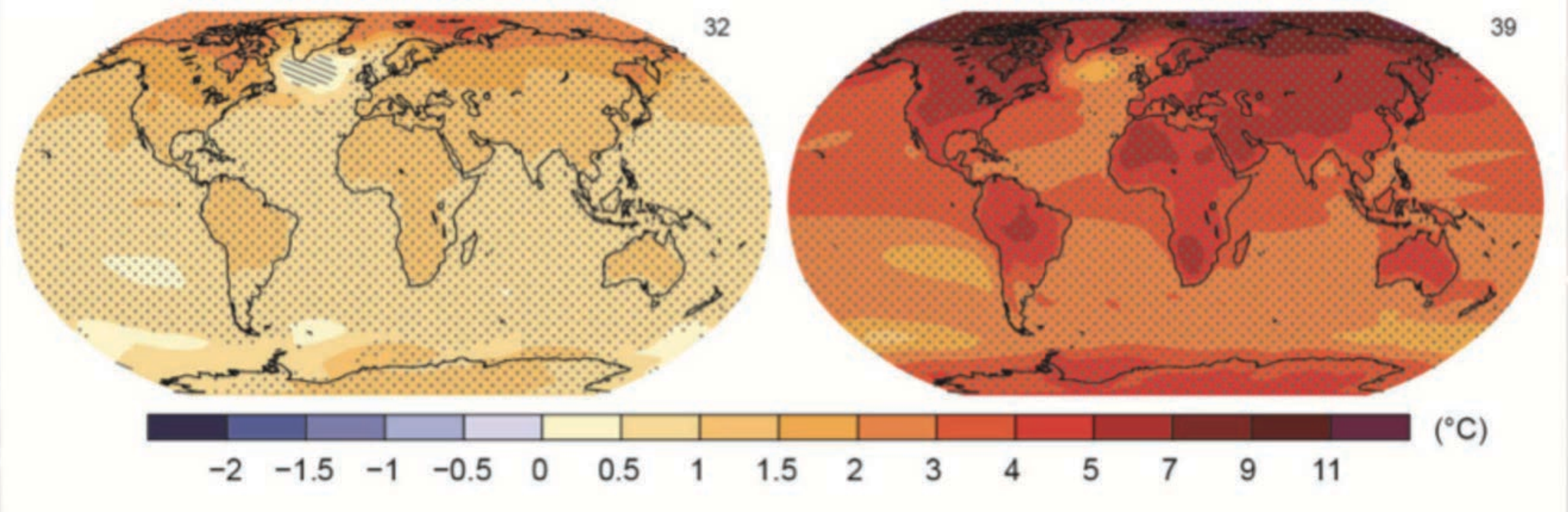
AR5, WGIII, SPM

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***

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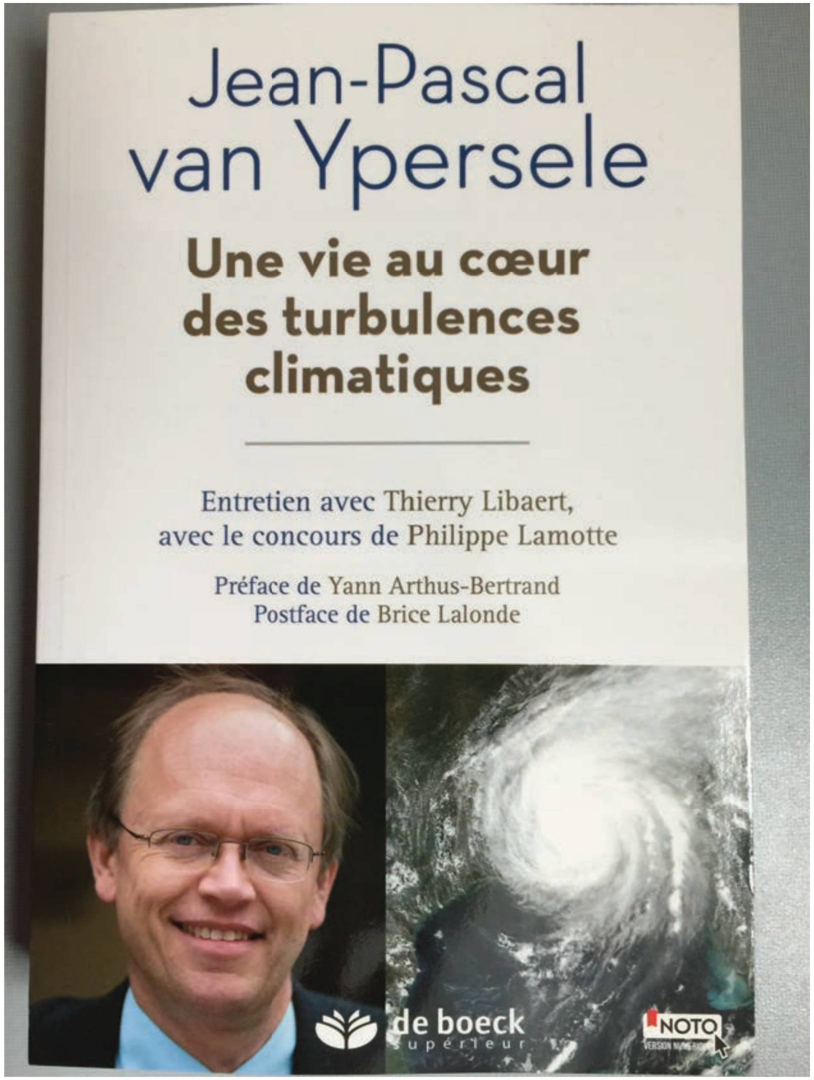

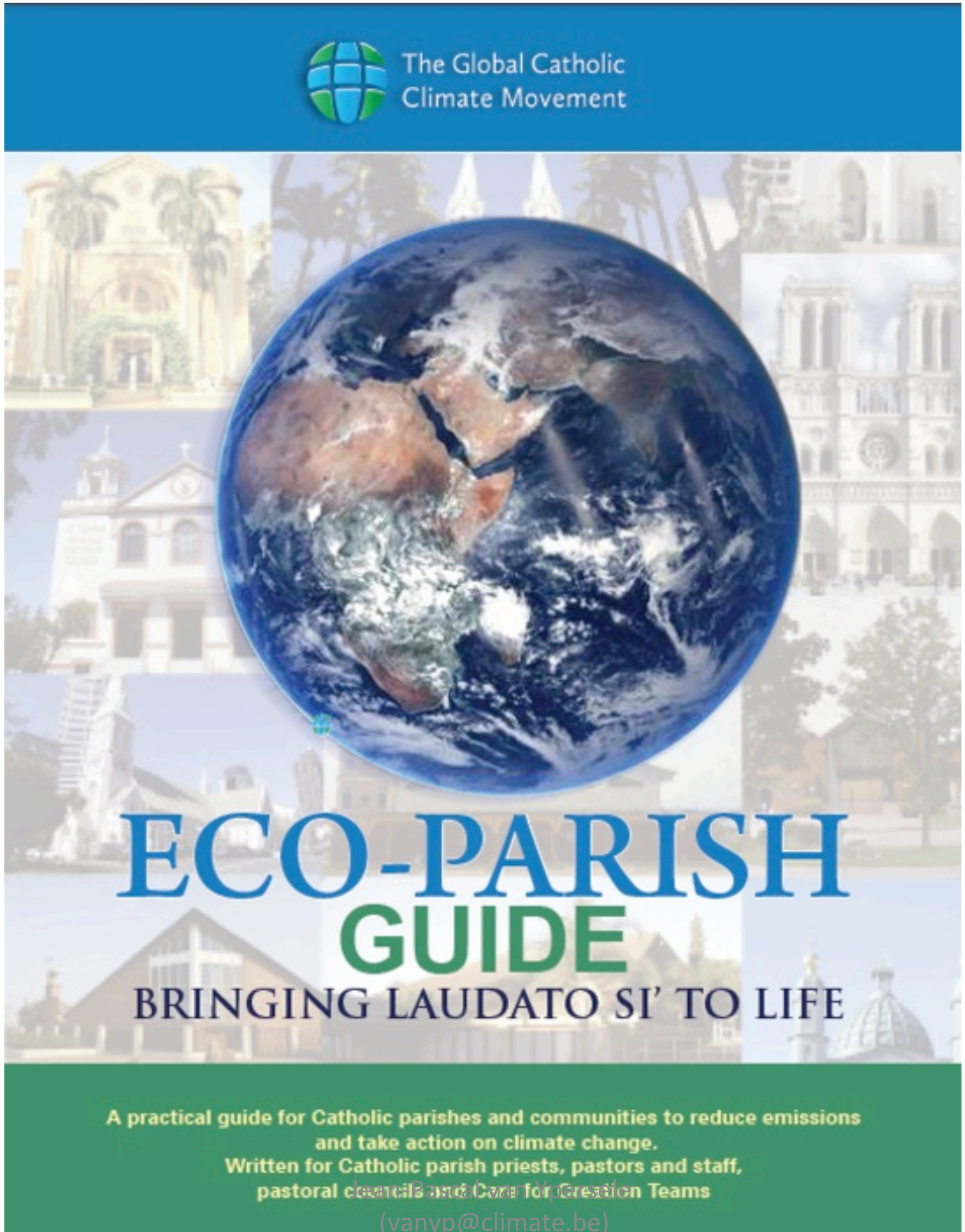

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The GLOBAL CATHOLIC CLIMATE MOVEMENT (GCCM) offers this Climate Action Guide for Catholic Parishes to assist parish leaders and members in bringing the Papal encyclical Laudato Si' to life. We welcome all who may find it useful.

GREEN GUIDE FOR UNIVERSITIES

IARU PATHWAYS TOWARDS SUSTAINABILITY

INTERNATIONAL ALLIANCE OF RESEARCH UNIVERSITIES

SUSTAINIA

CONTENTS

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

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