An introduction to climate change

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

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Former IPCC Vice-Chair (2008-2015)

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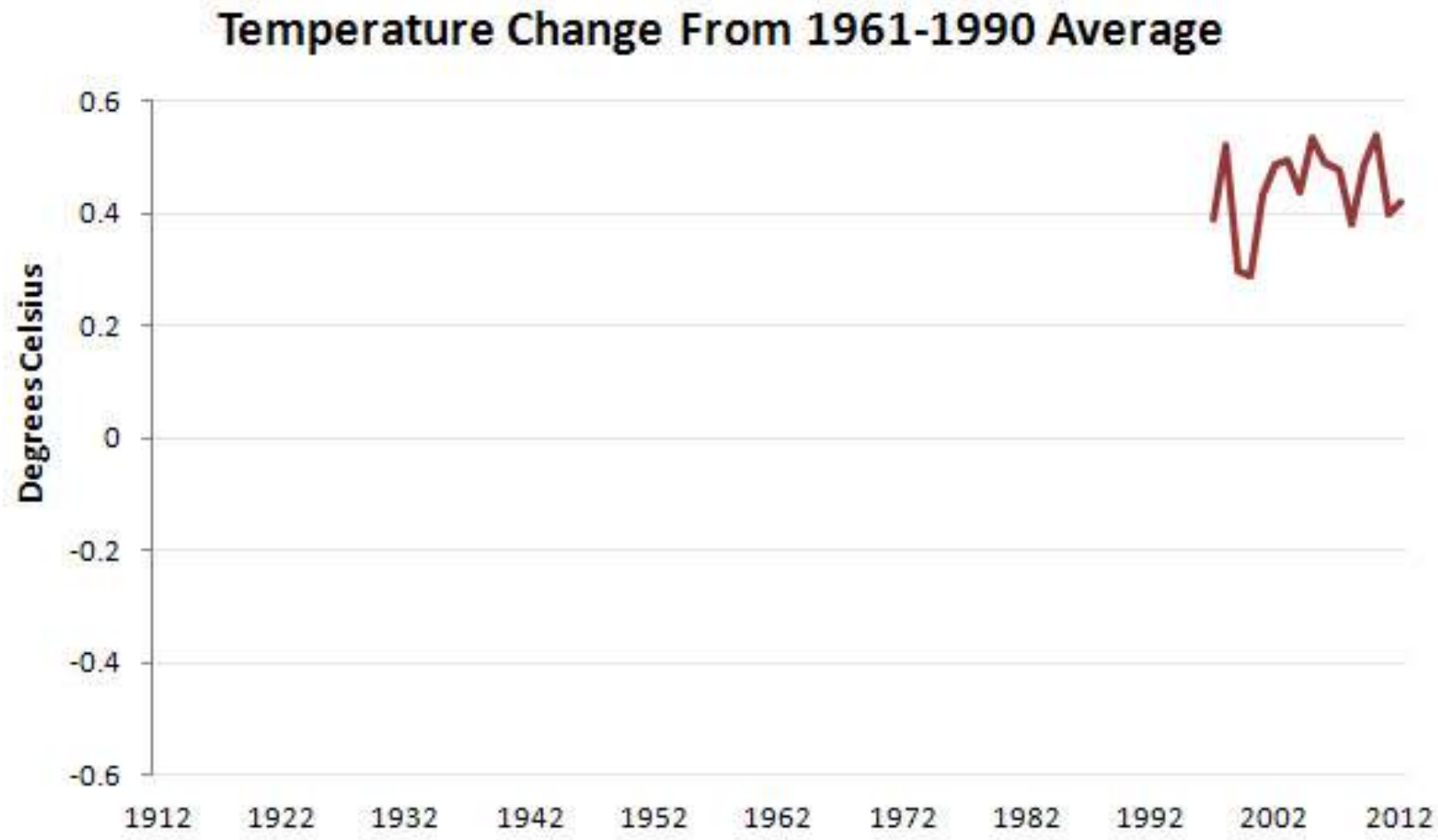
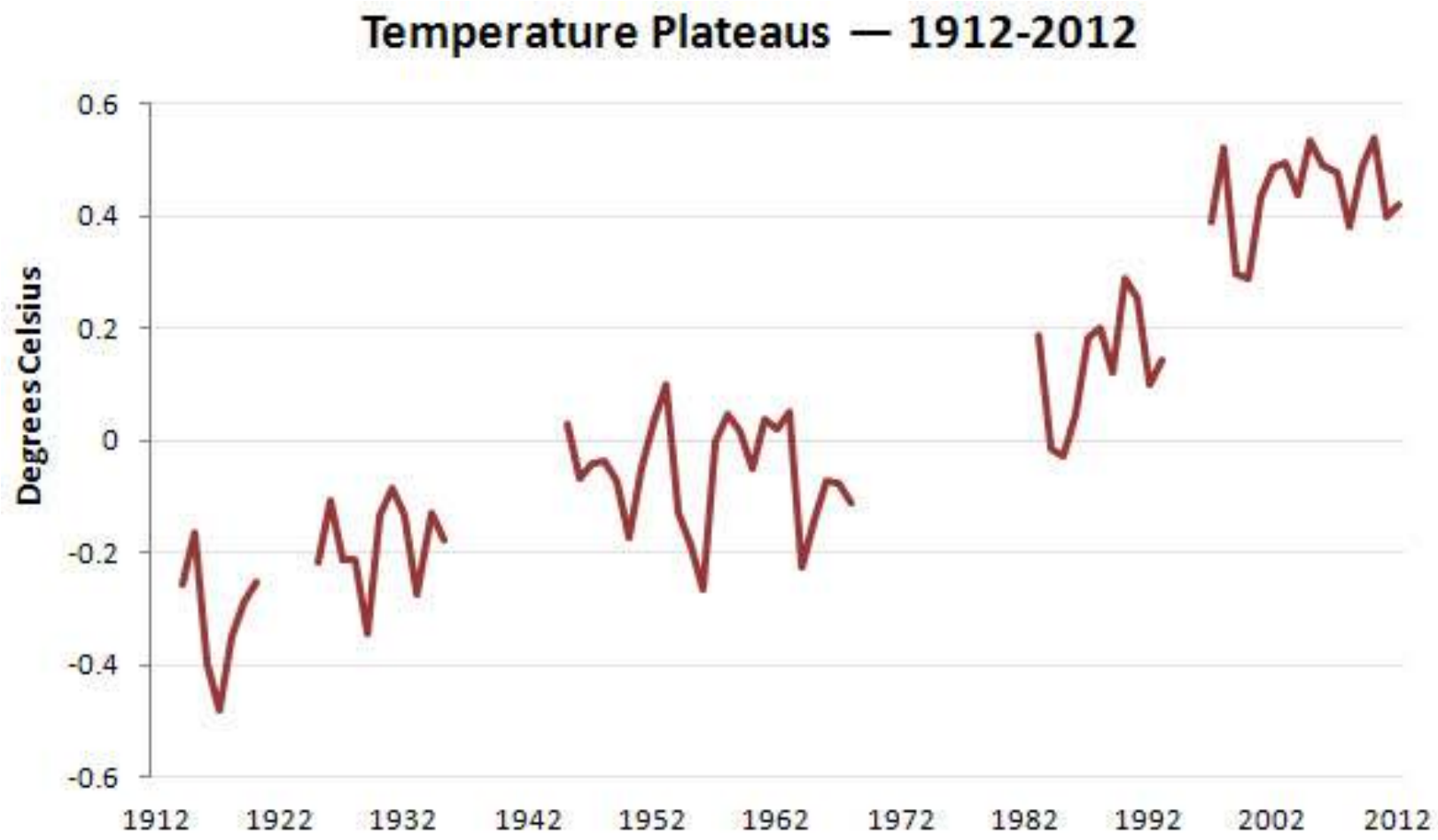
Infocycle BTC (Belgian Technical Cooperation), Brussels, 18 September 2017

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



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

Lying With Statistics, Global Warming Edition



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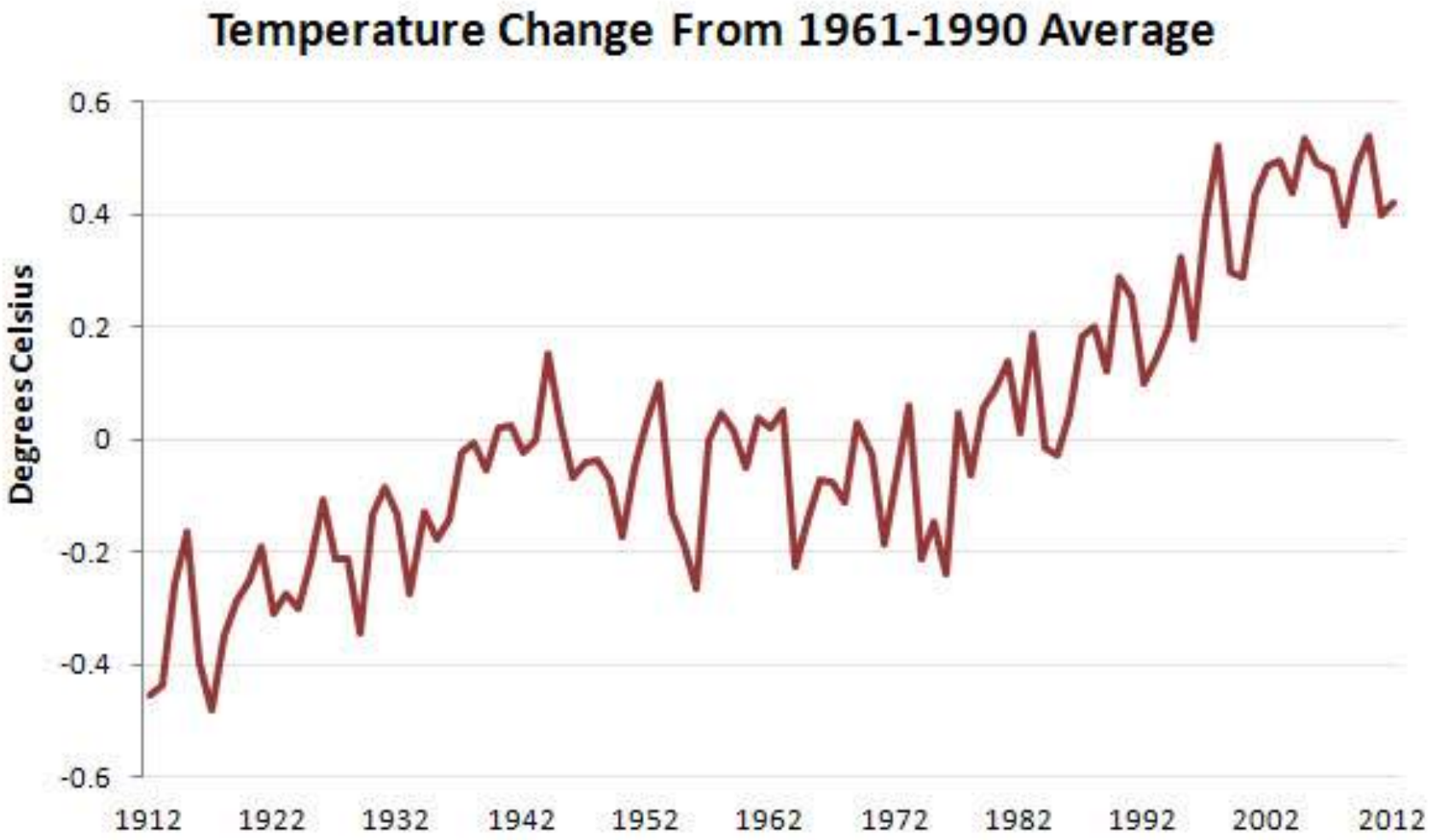
Lying With Statistics, Global Warming Edition



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

Why the IPCC ?

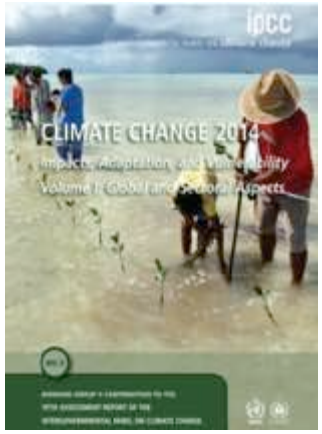
Established by WMO and UNEP in 1988

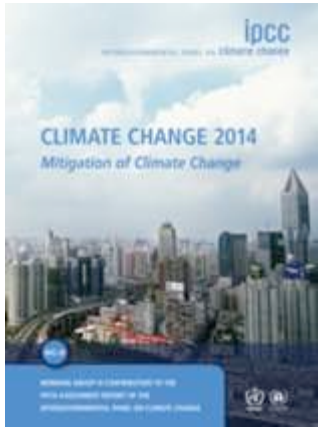
to provide **policy-makers** with an **objective source of information** about

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

WMO=World Meteorological Organizatior

UNEP= United Nations Environment Programme





What is happening in the climate system?

What are the risks?

What can be done?

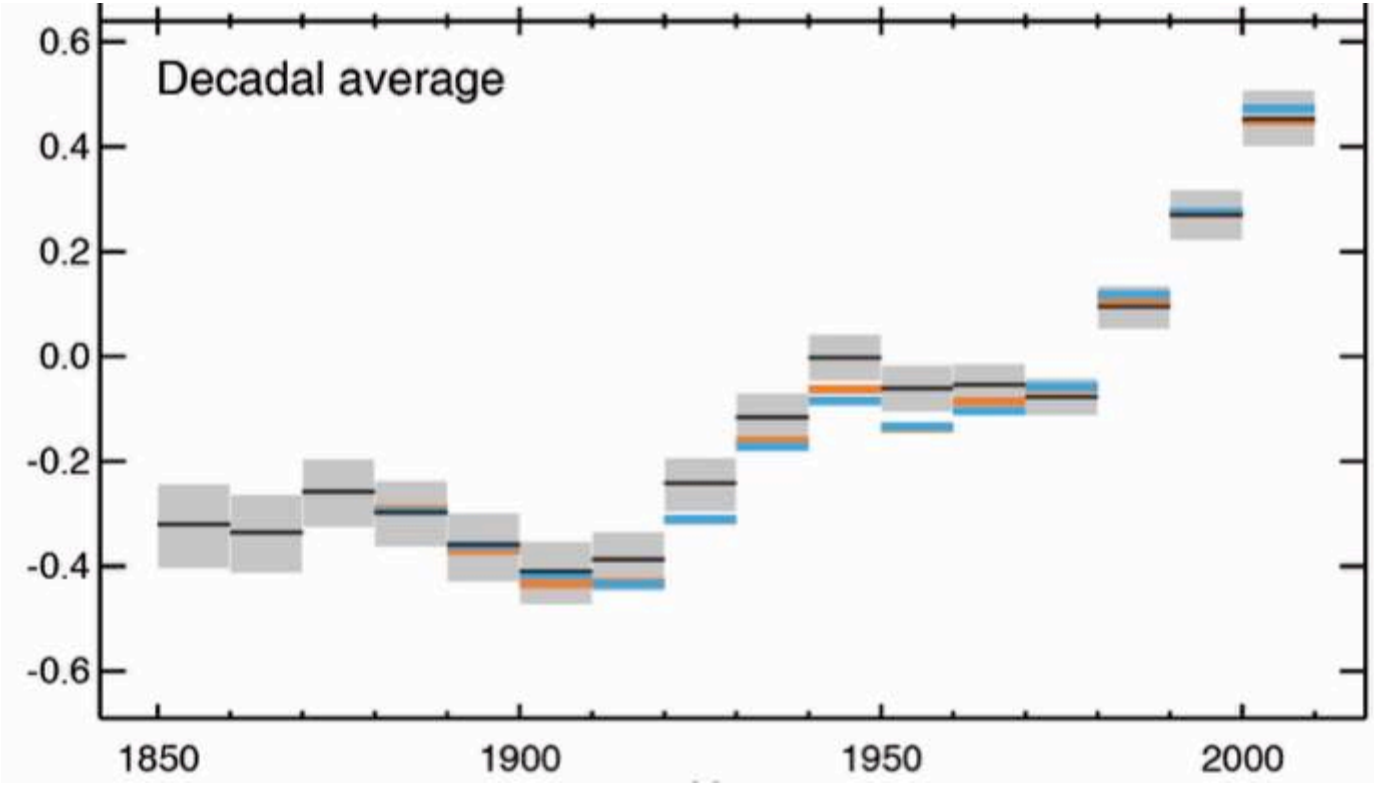
ipcc
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

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 INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP



(IPCC 2013, Fig. SPM.1a)

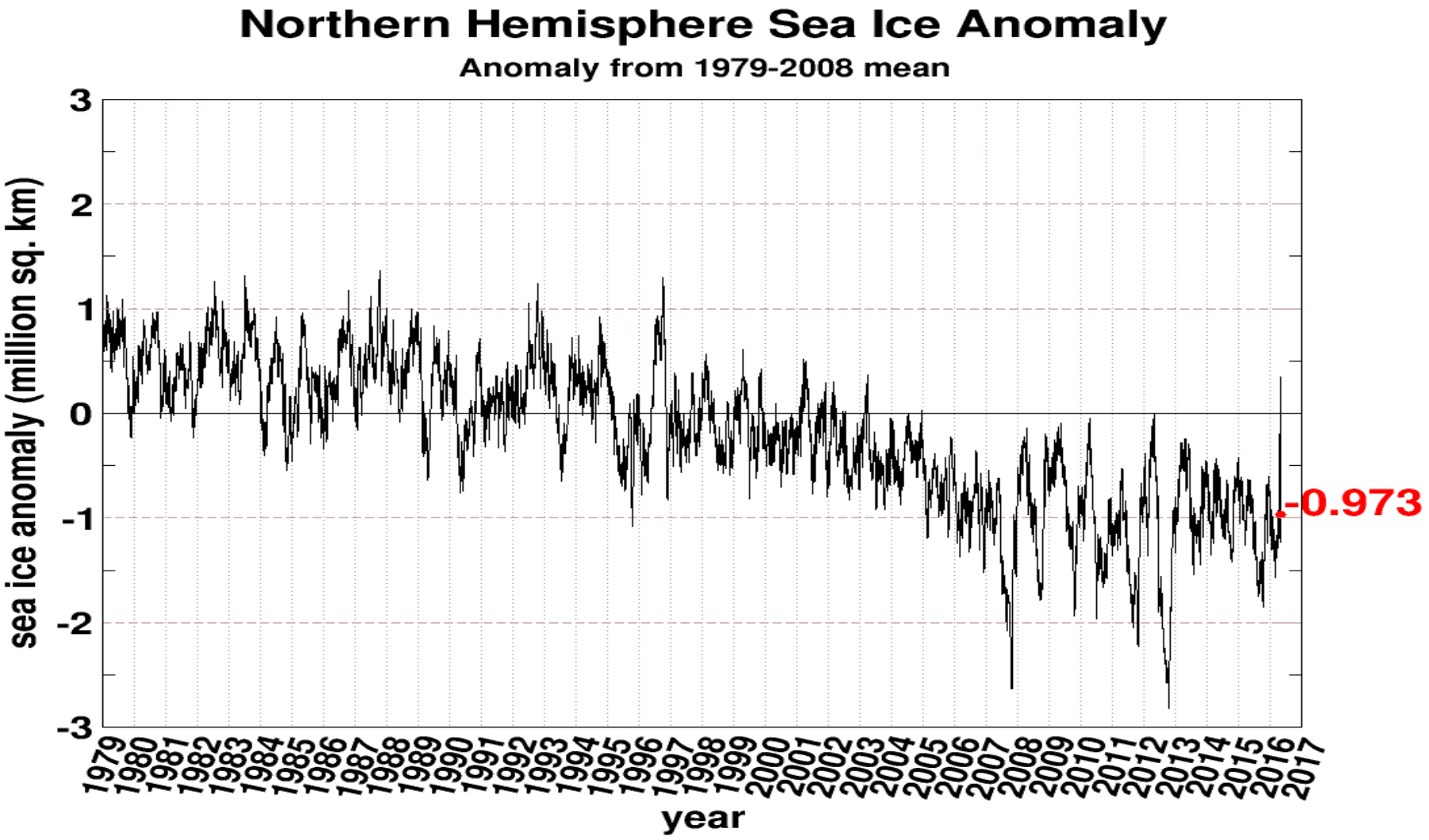
Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850.

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)



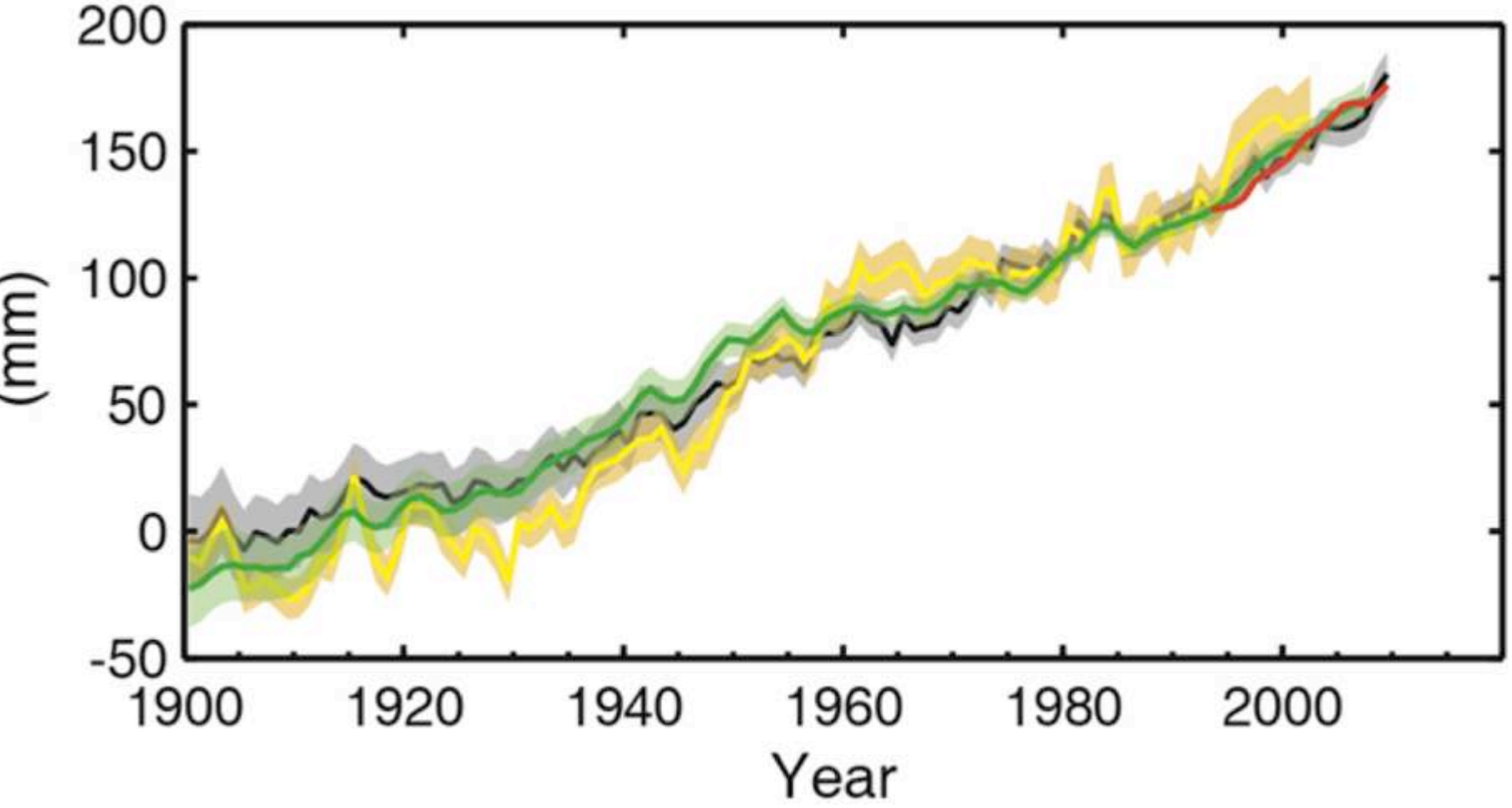
Plateau Glacier (1961)
(Alaska)

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

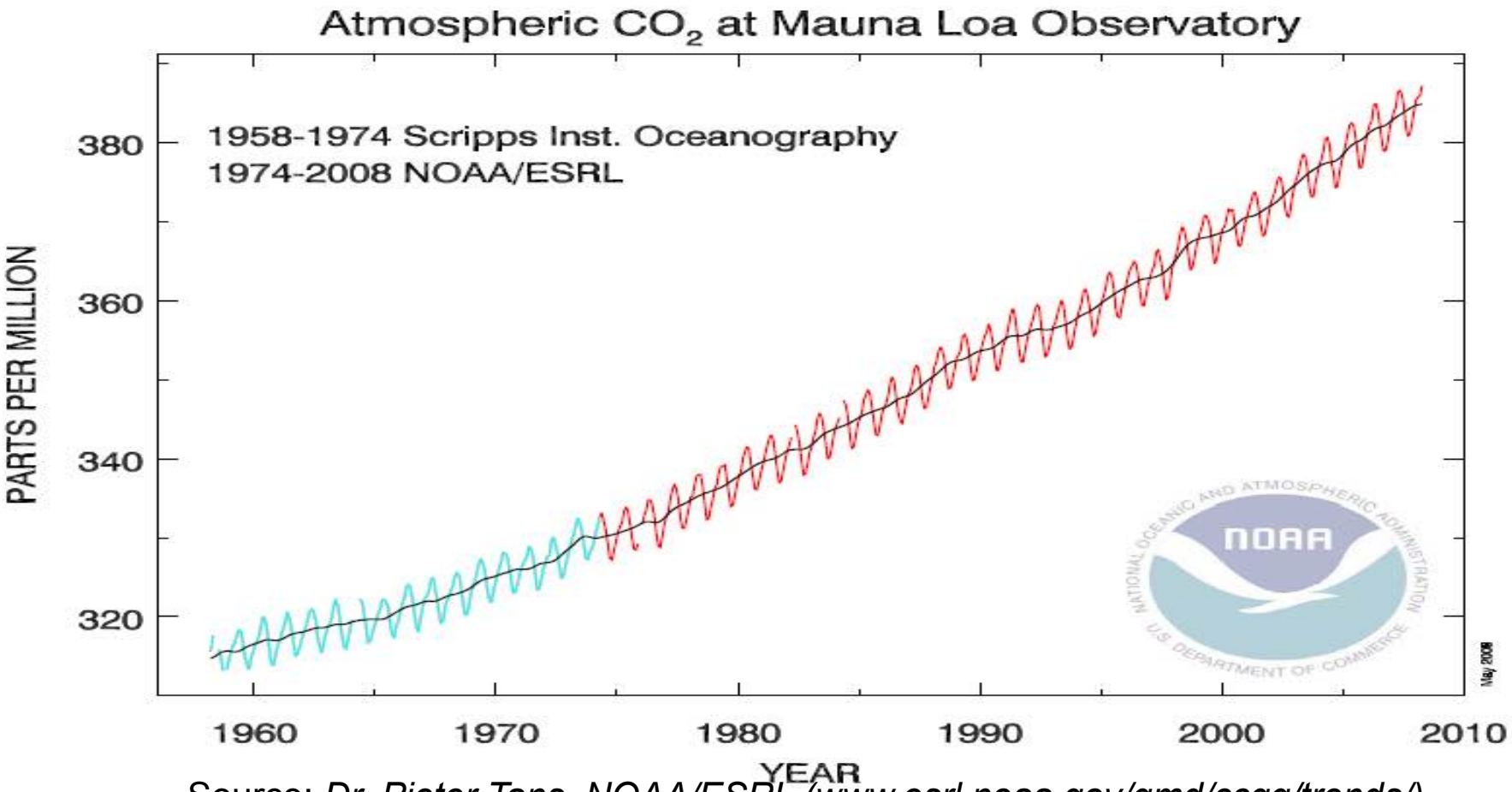
Plateau Glacier (2003)
(Alaska)

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



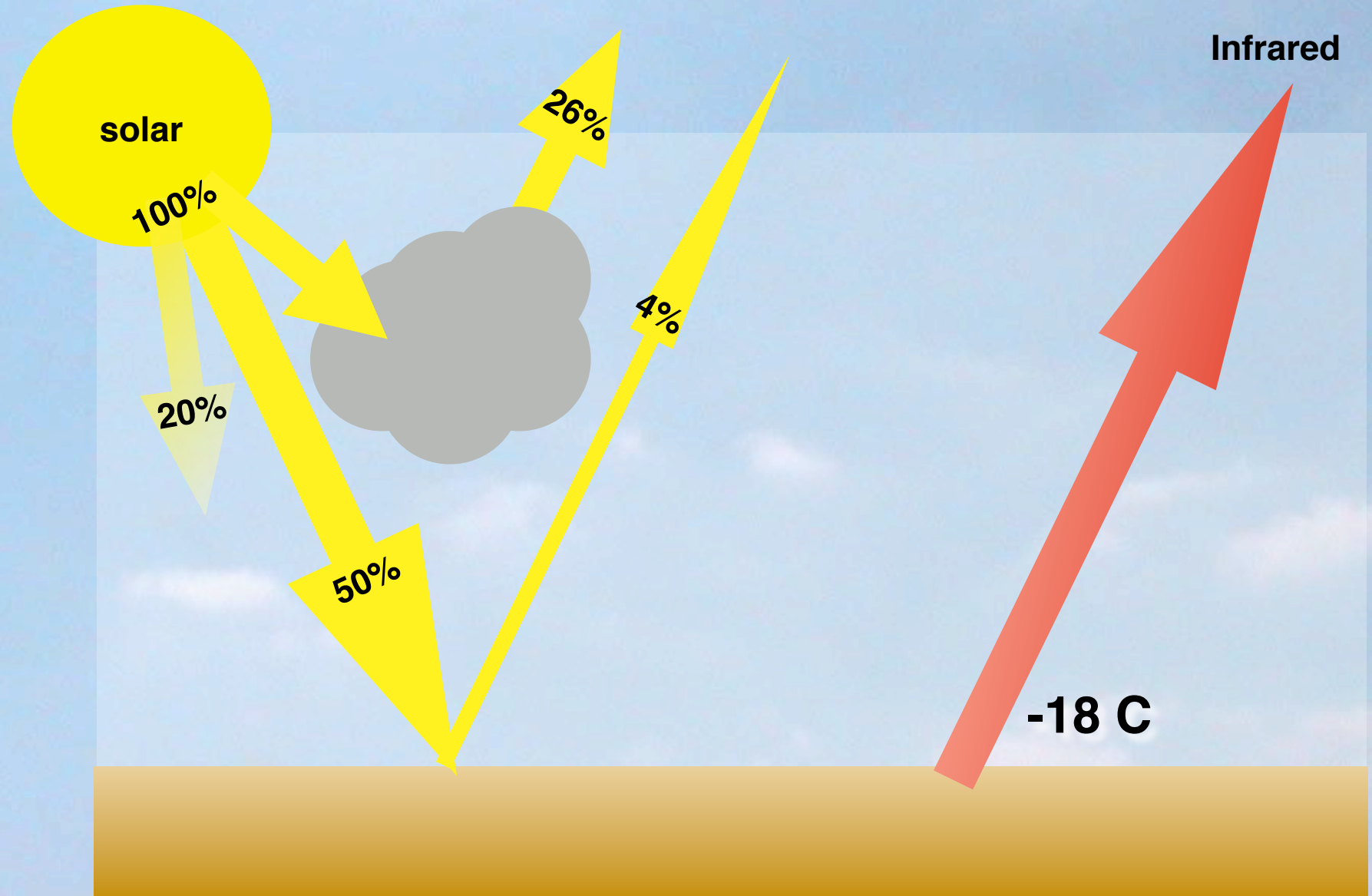
CO_2 concentration measured at Mauna Loa (3400 m)

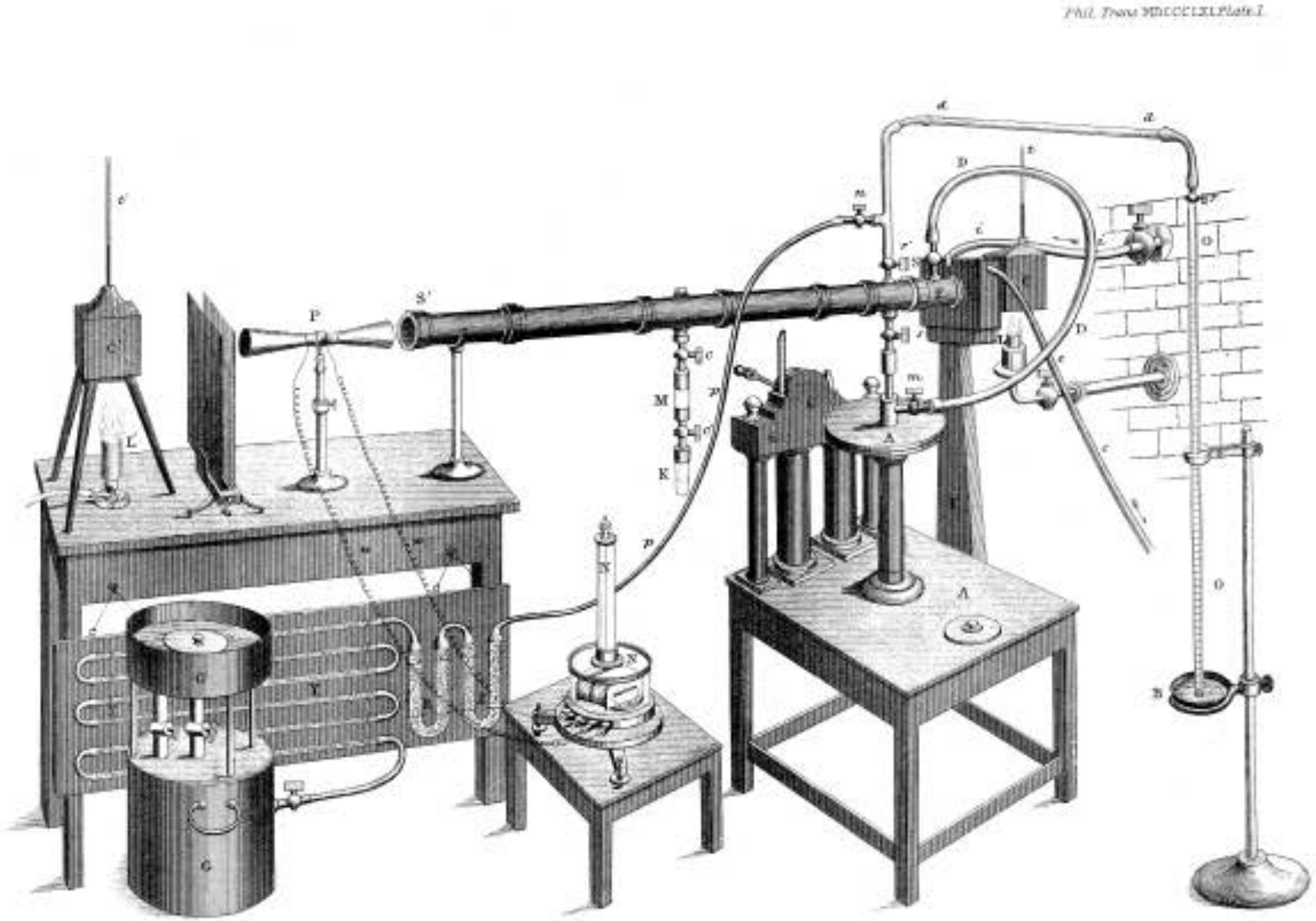


Source: *Dr. Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/)*

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

Without Greenhouse Effect





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

With Greenhouse Effect

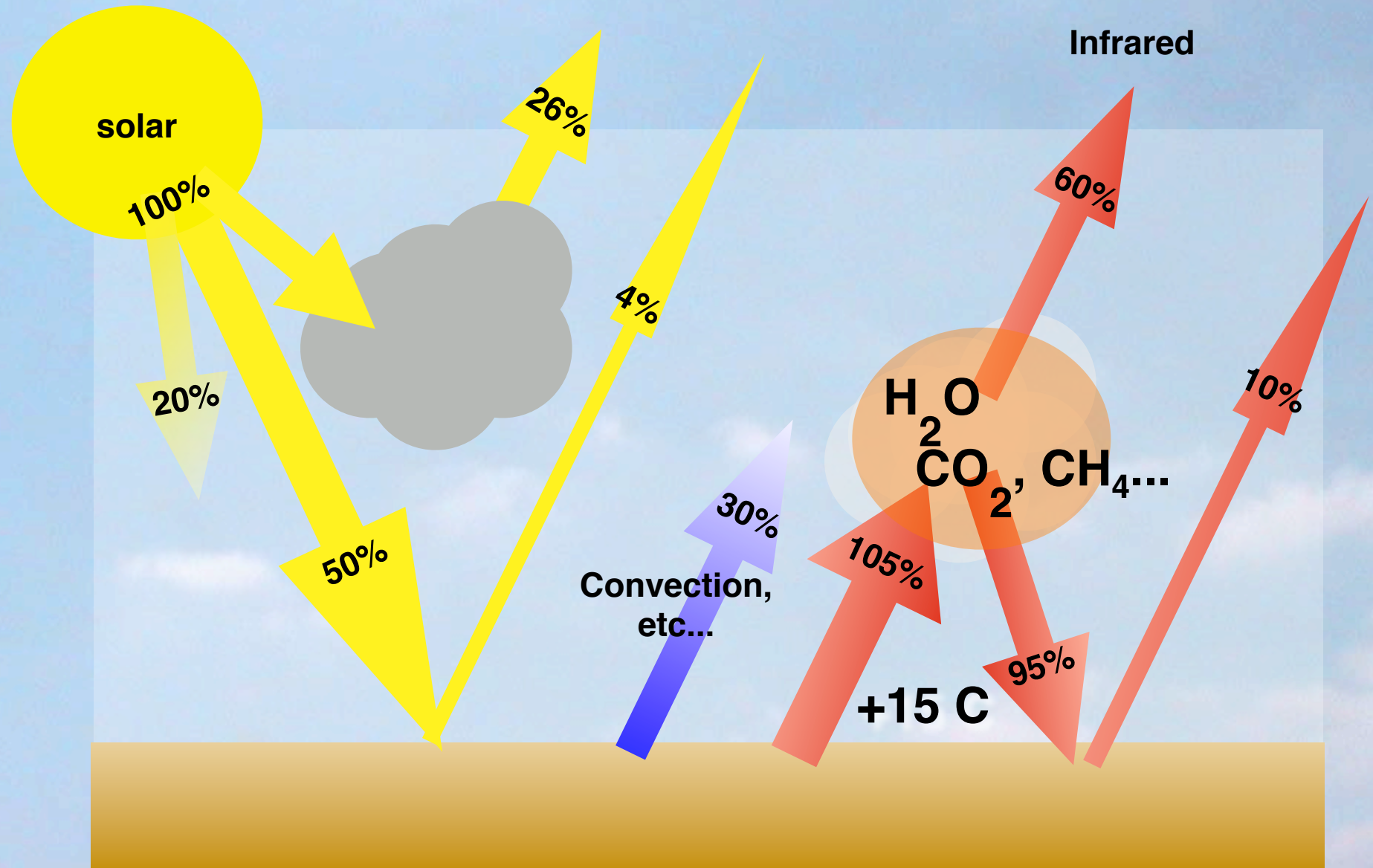
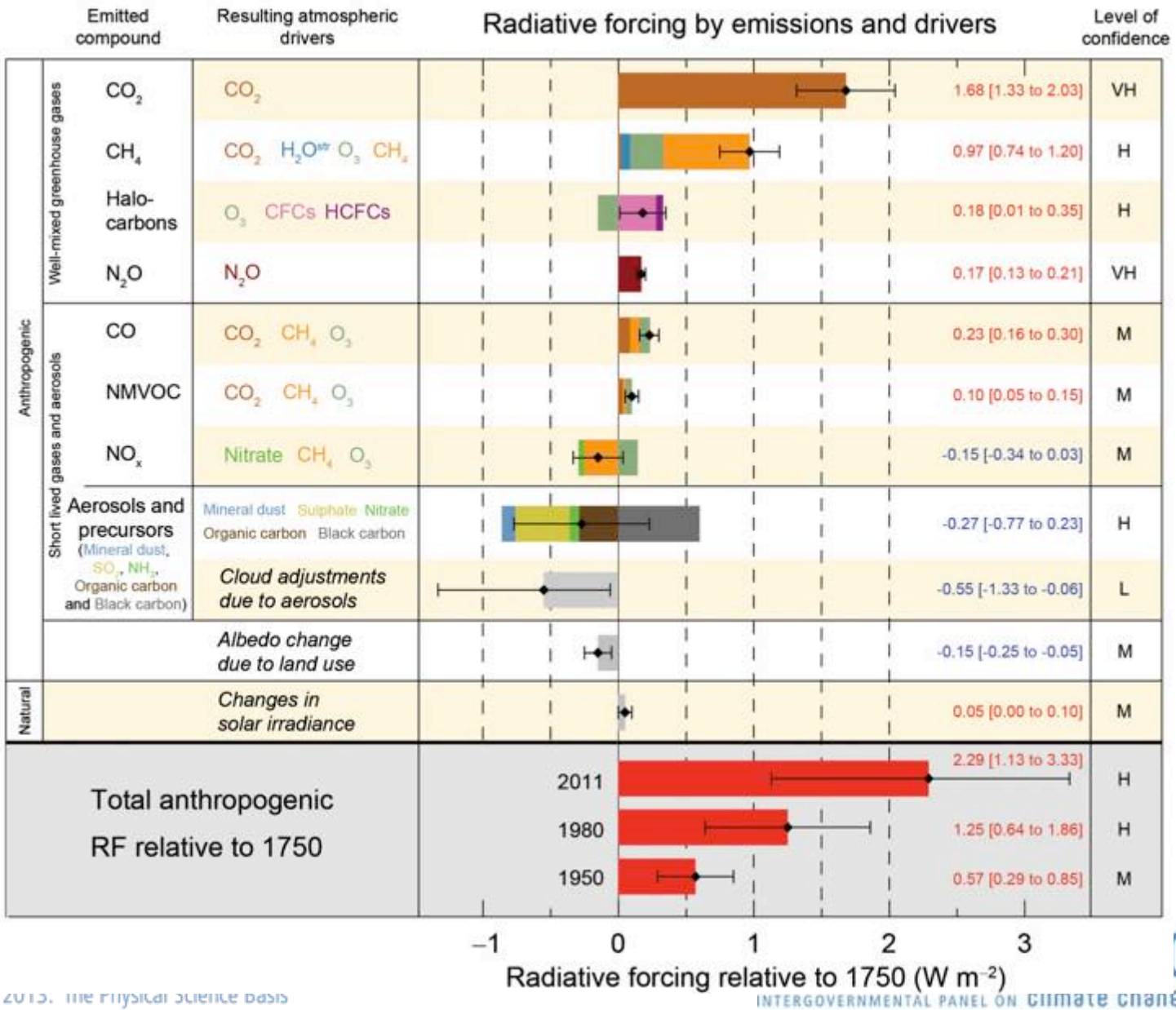
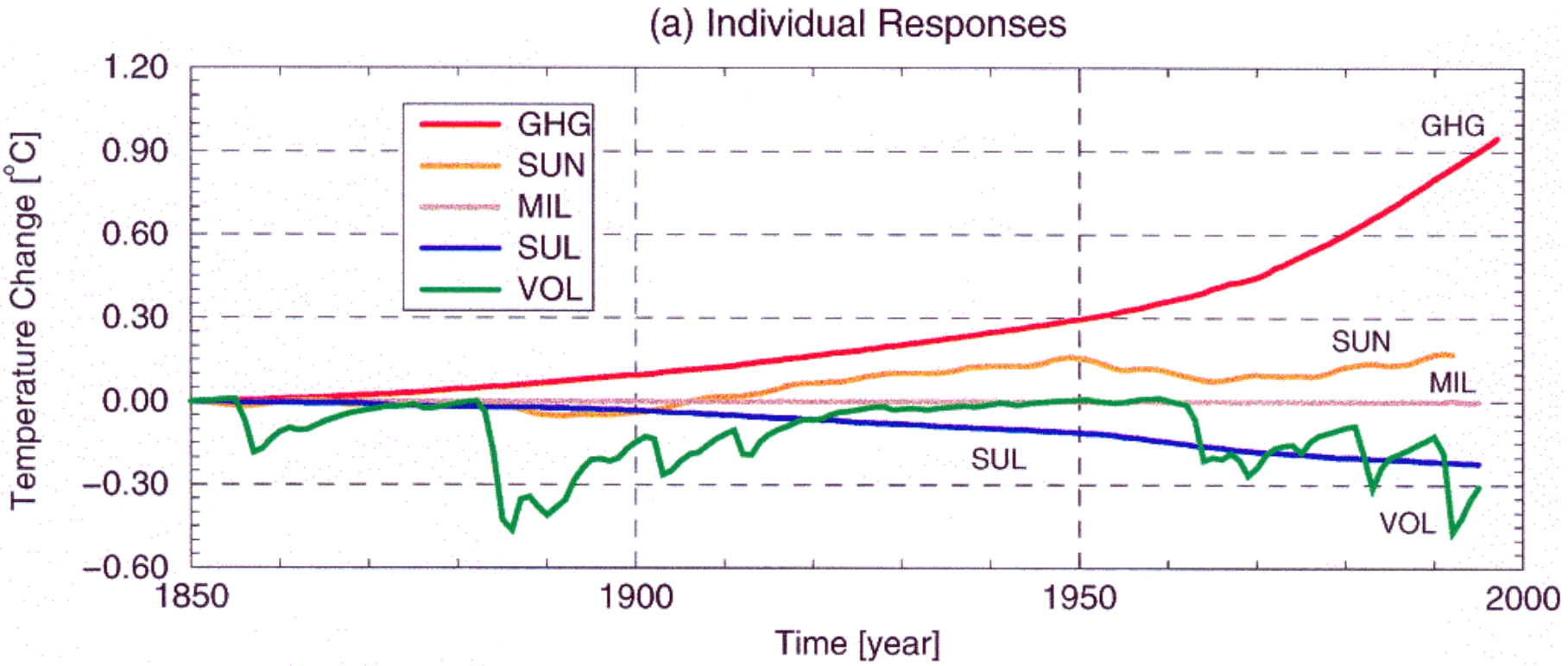


Figure SPM.5

Radiative forcing estimates in 2011 relative to 1750

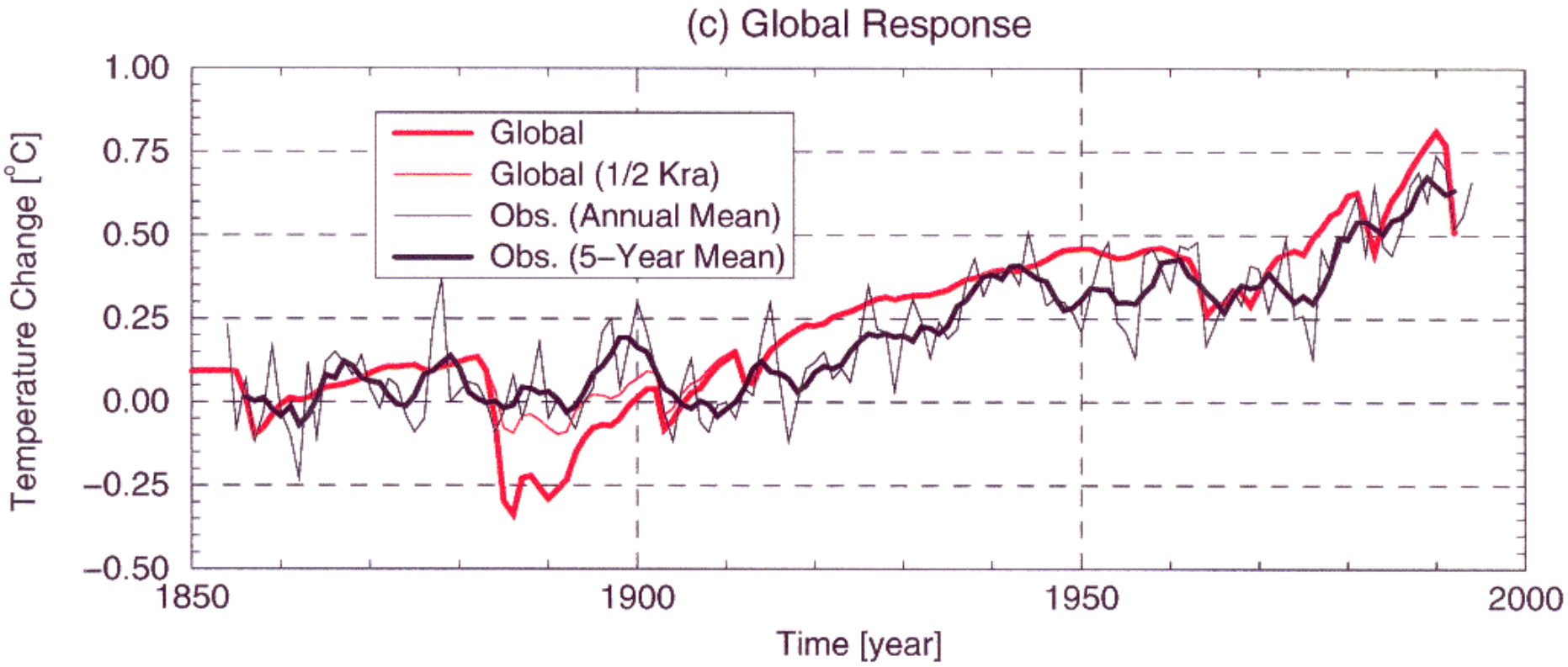


Separate effect of different factors in the 2-dimensional climate model at UCL



Bertrand et al. 2001

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



Bertrand et al. 2001

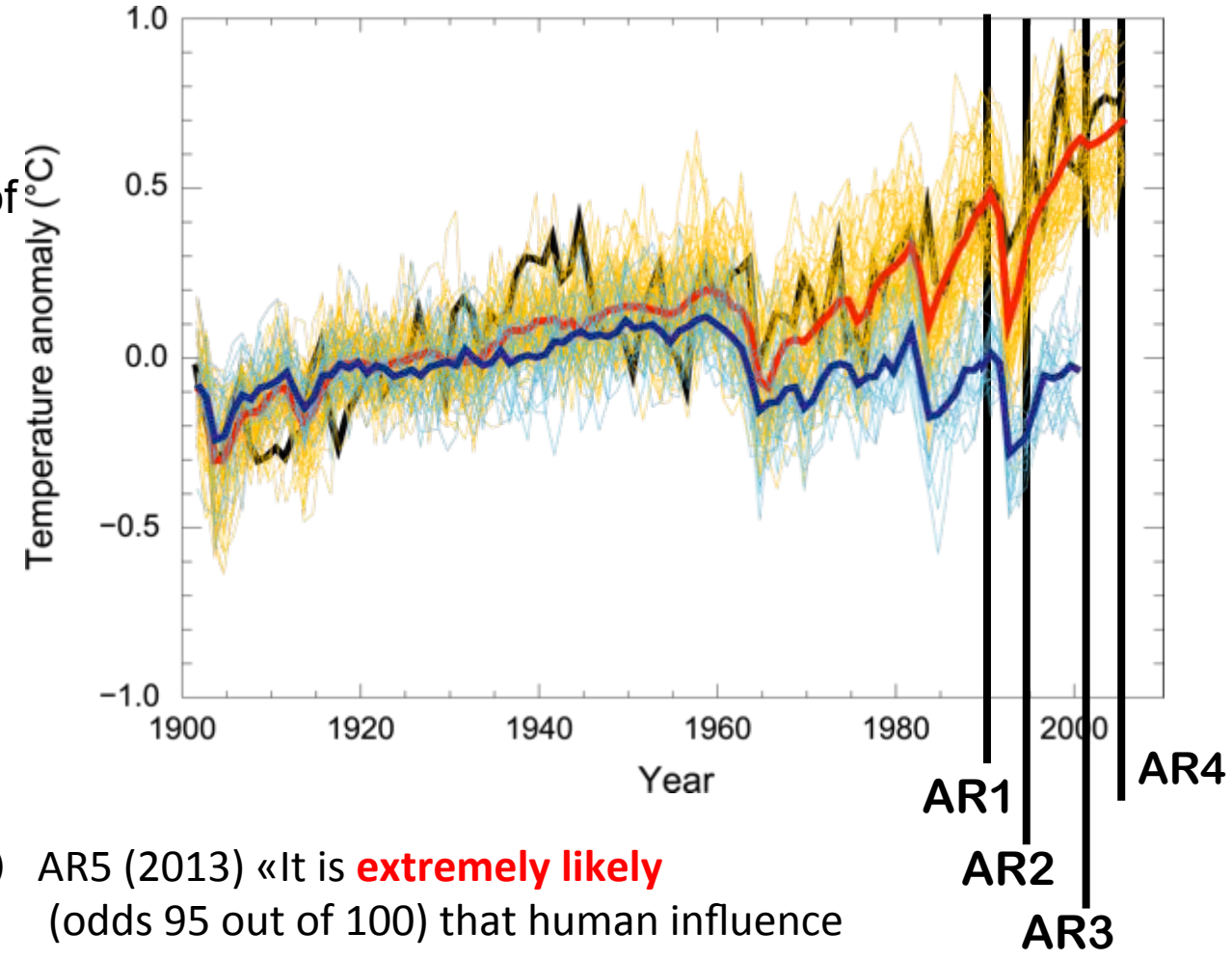
A Progression of Understanding: Greater and Greater Certainty in Attribution

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

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

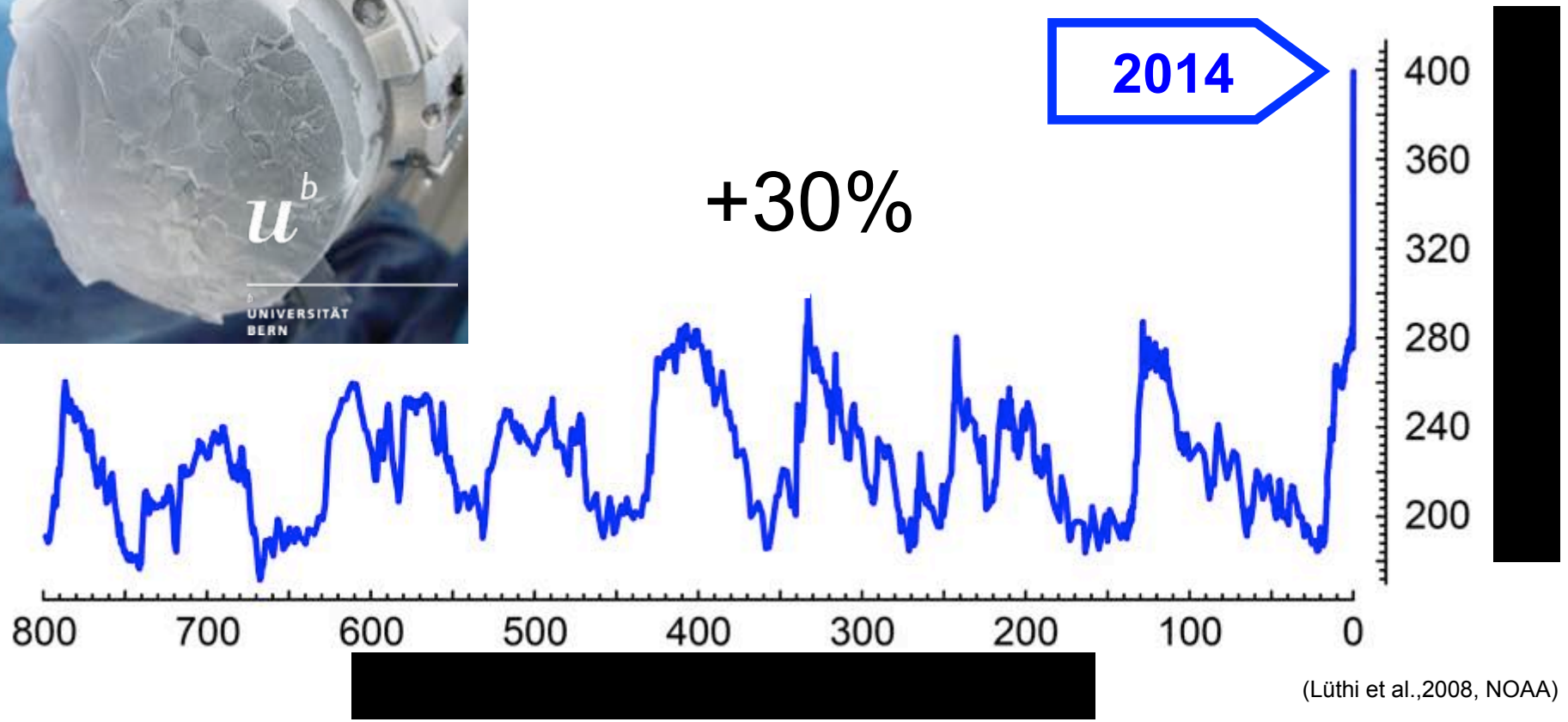
AR3 (2001): "most of the warming of the past 50 years is **likely** (odds 2 out of 3) due to human activities"

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… »

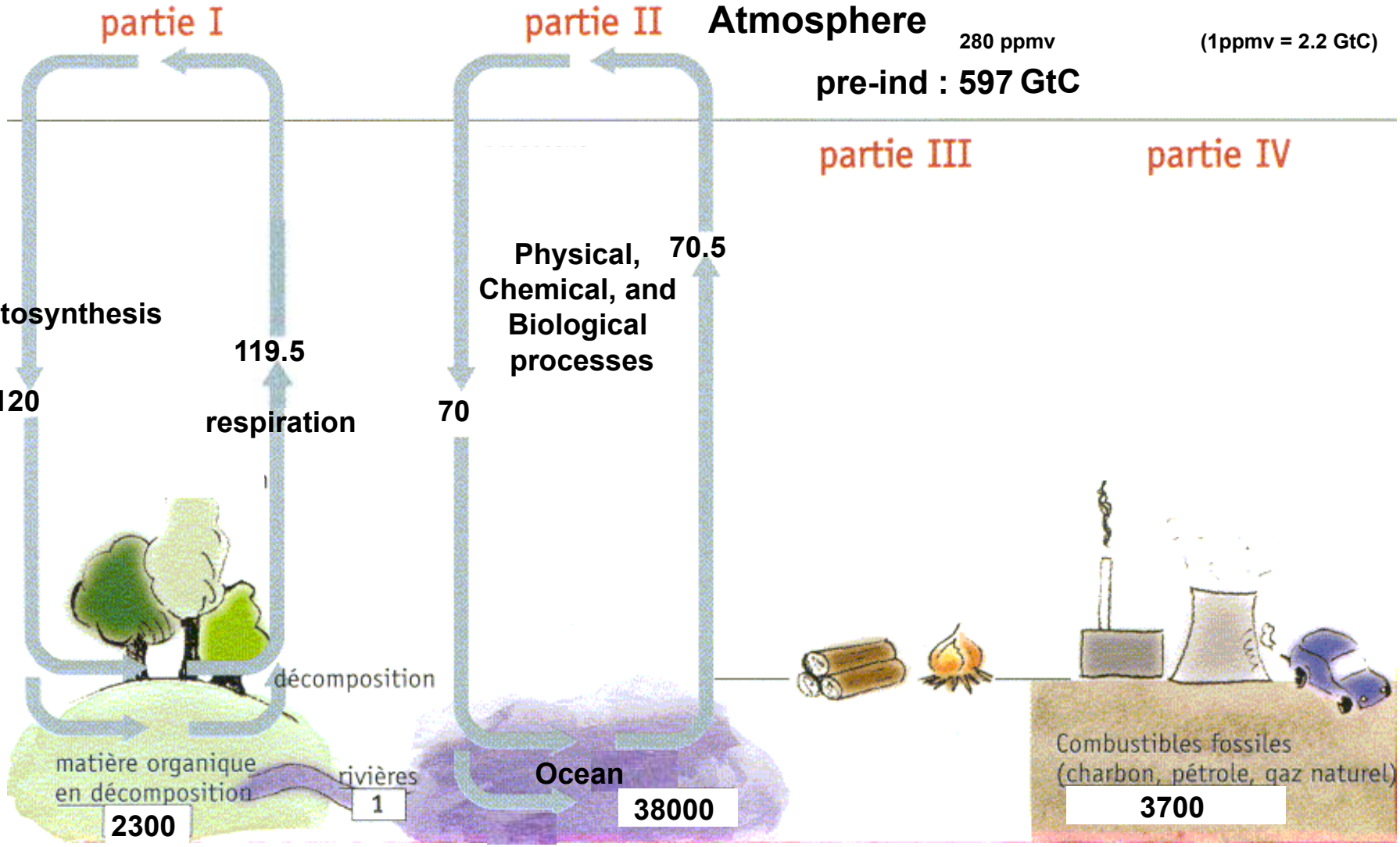
Atmospheric concentrations of CO_2



(Lüthi et al.,2008, NOAA)

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

Carbon cycle: unperturbed fluxes

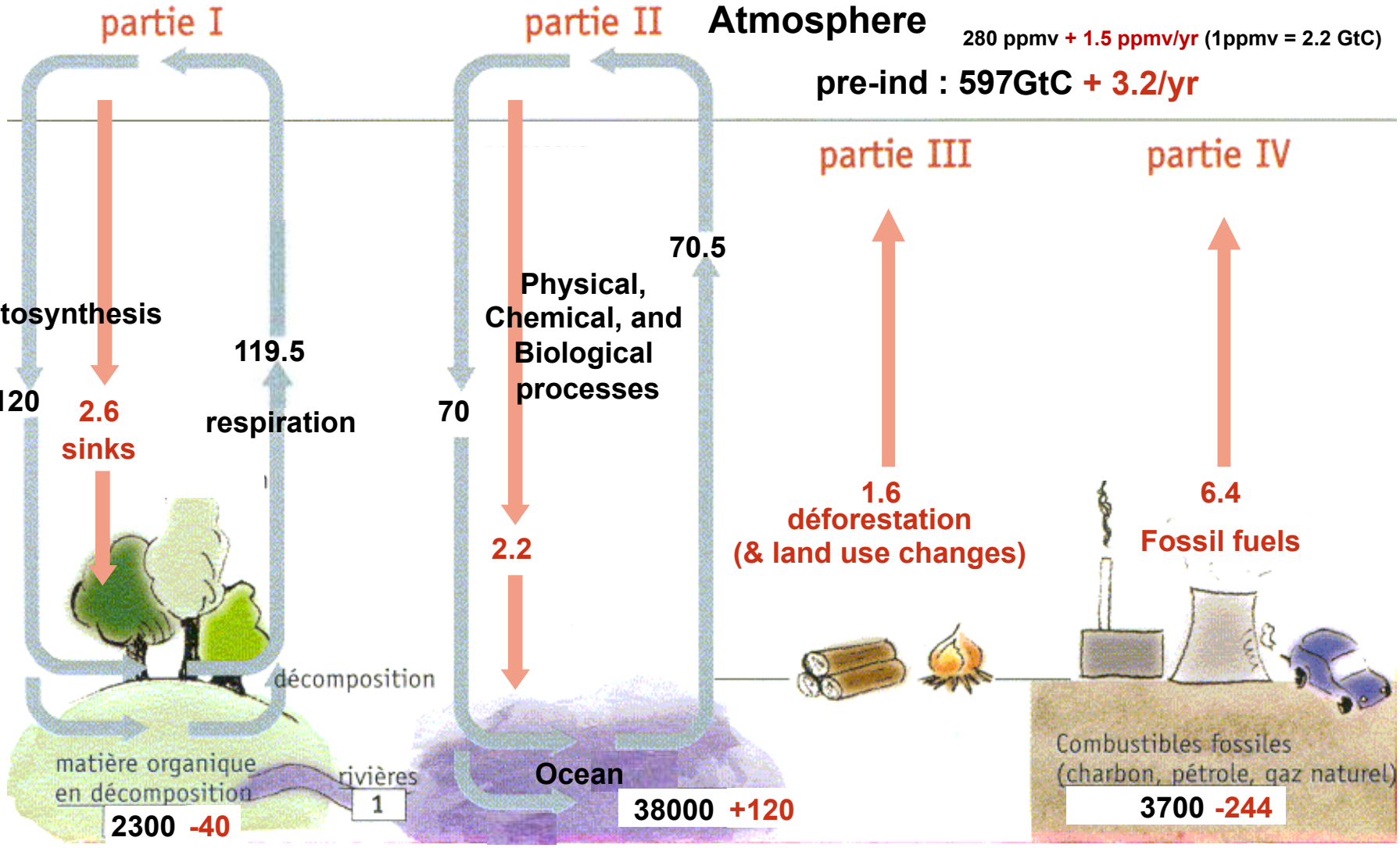


Units: GtC (billions tons of carbon) or GtC/year (multiply by 3.7 to get $GtCO_2$)

vanyp@climate.be

Carbon cycle: perturbed by human activities

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



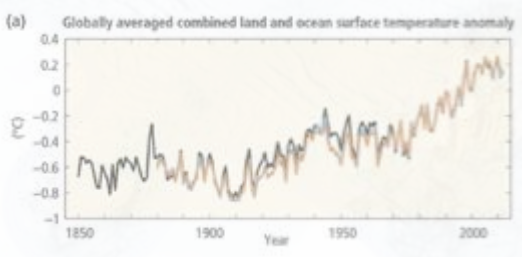
Units: GtC (billions tons of carbon) or GtC/year

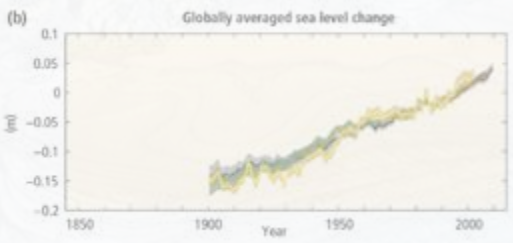
Stocks!

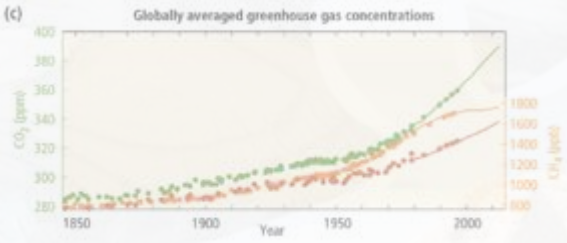
vanyp@climate.be

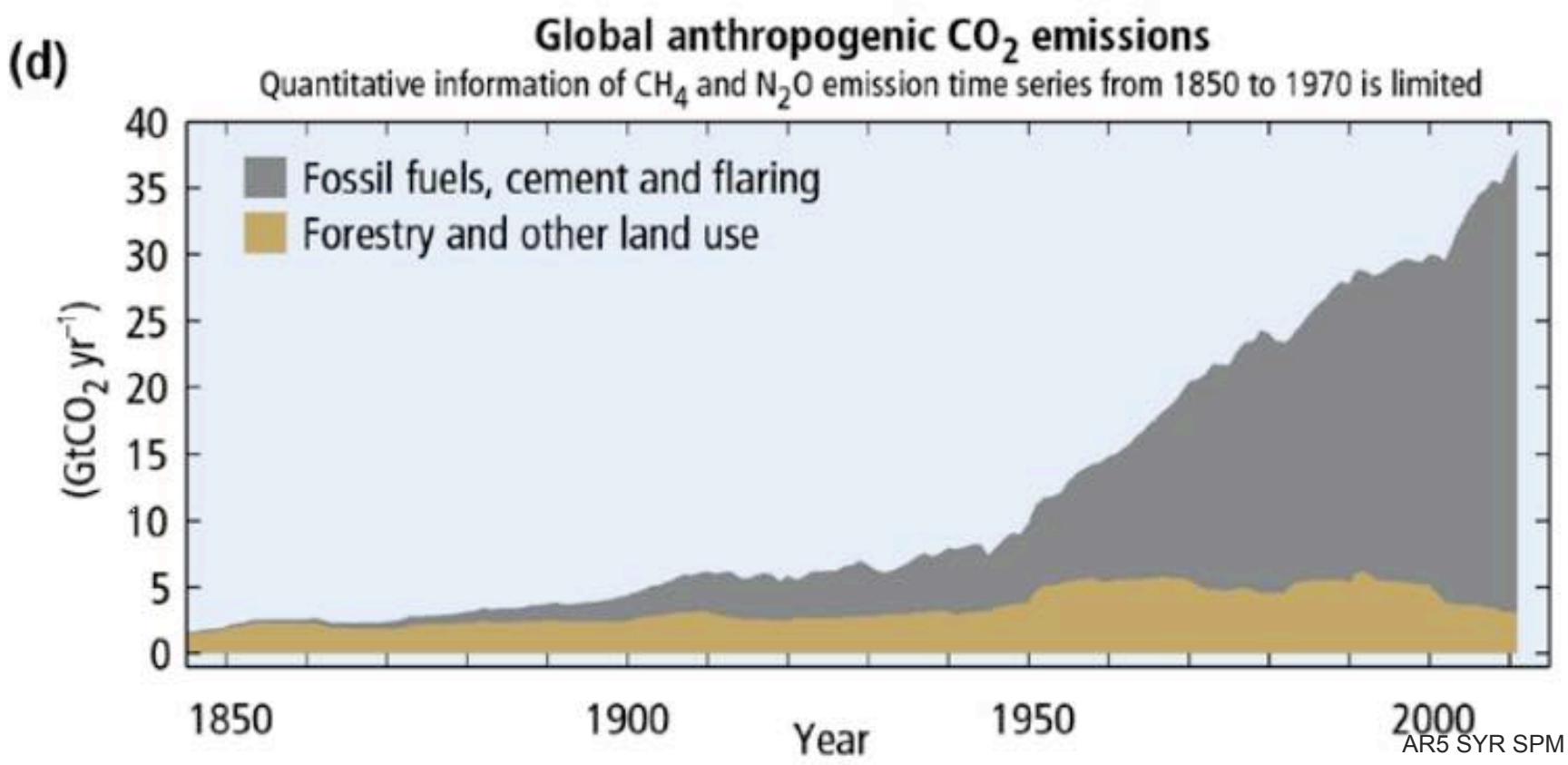
The carbon cycle is policy-relevant

- **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
(°C)
Year


(b)
Globally averaged sea level change
(m)
Year


(c)
Globally averaged greenhouse gas concentrations
Year


(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
$(GtCO_2\ yr^{-1})$
Year

AR5 SYR SPM

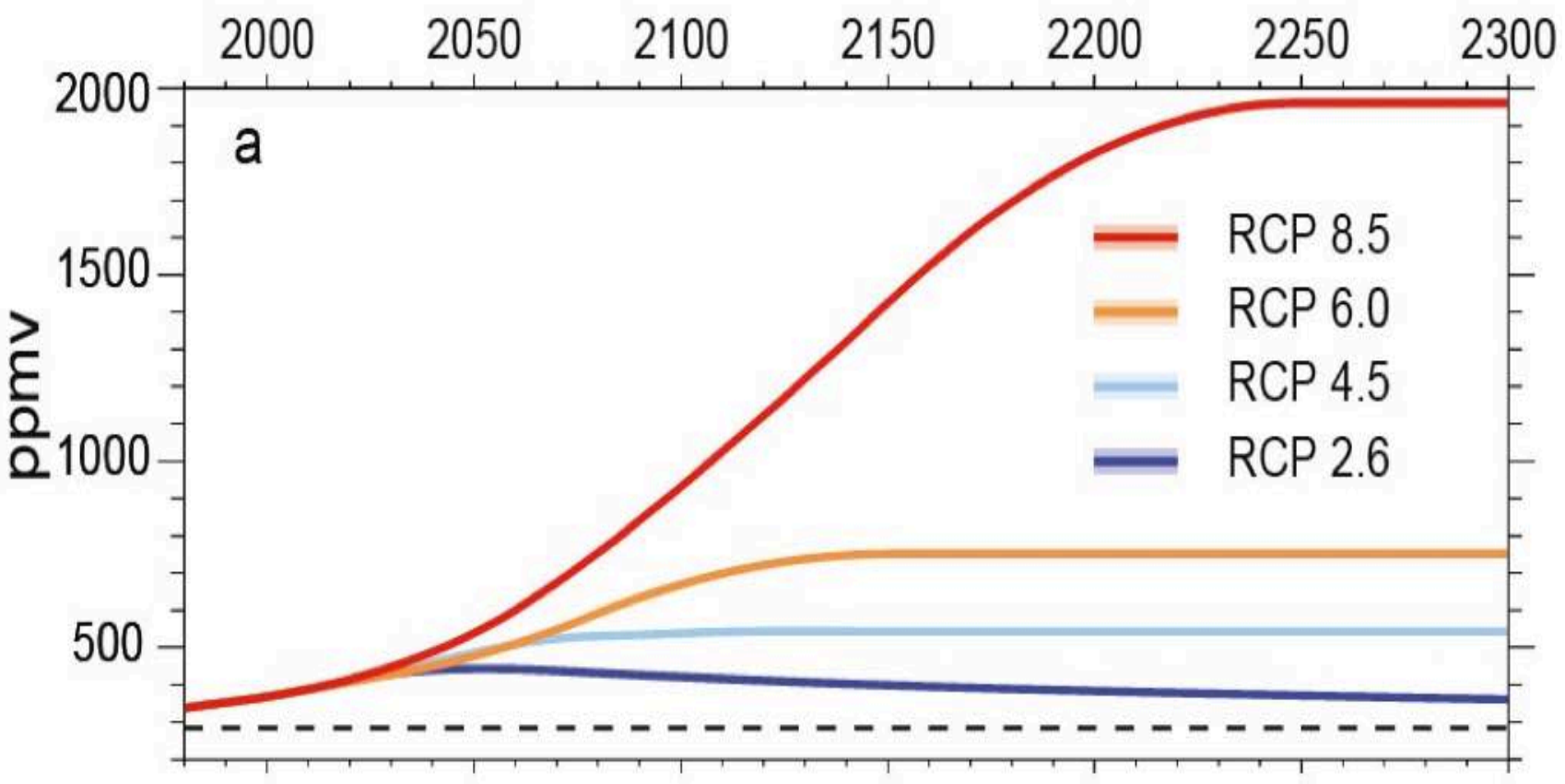
Sources of emissions

Energy production remains the primary driver of GHG emissions

2010 GHG emissions

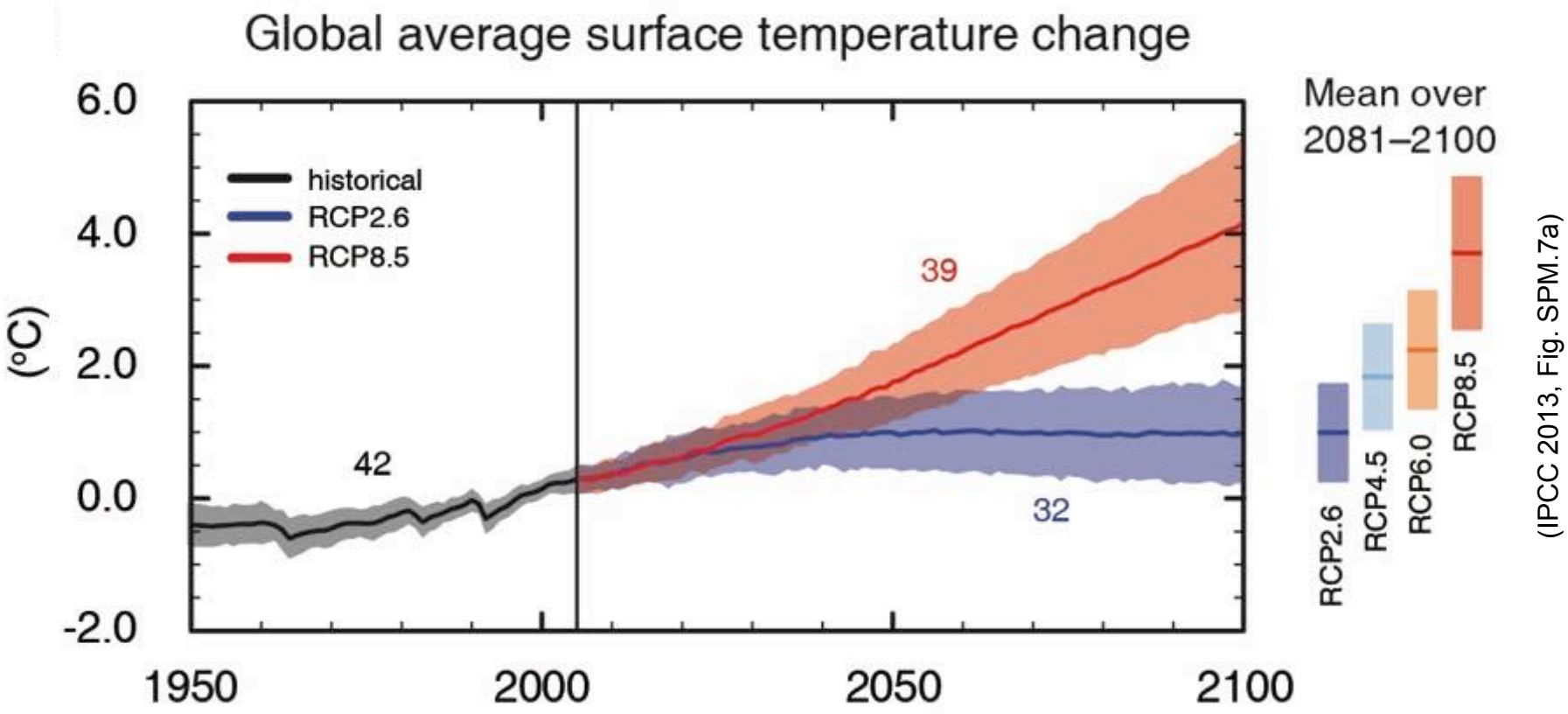
AR5 WGIII SPM

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

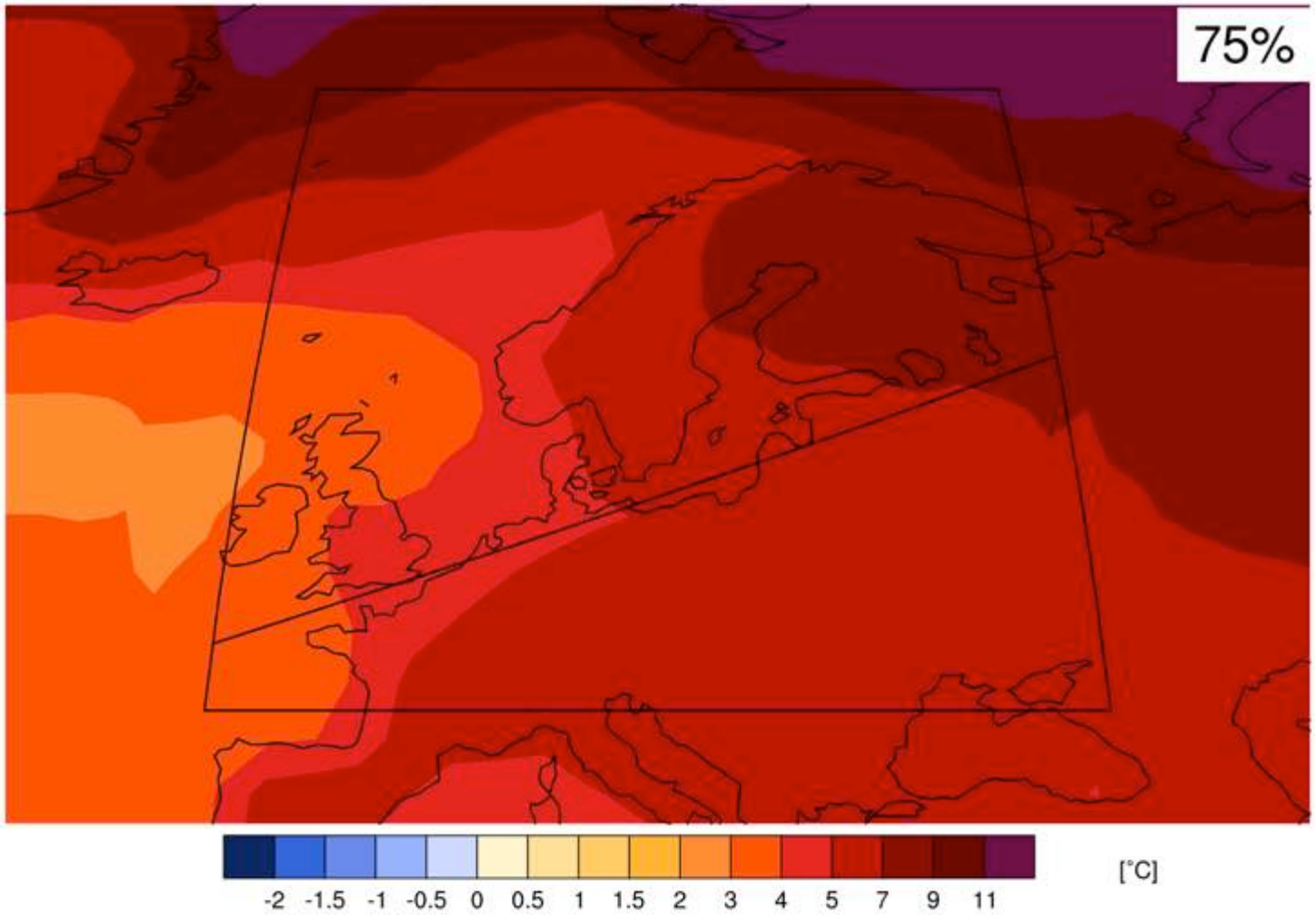
18-20000 years ago (Last Glacial Maximum)

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

Today, with +4-5°C globally

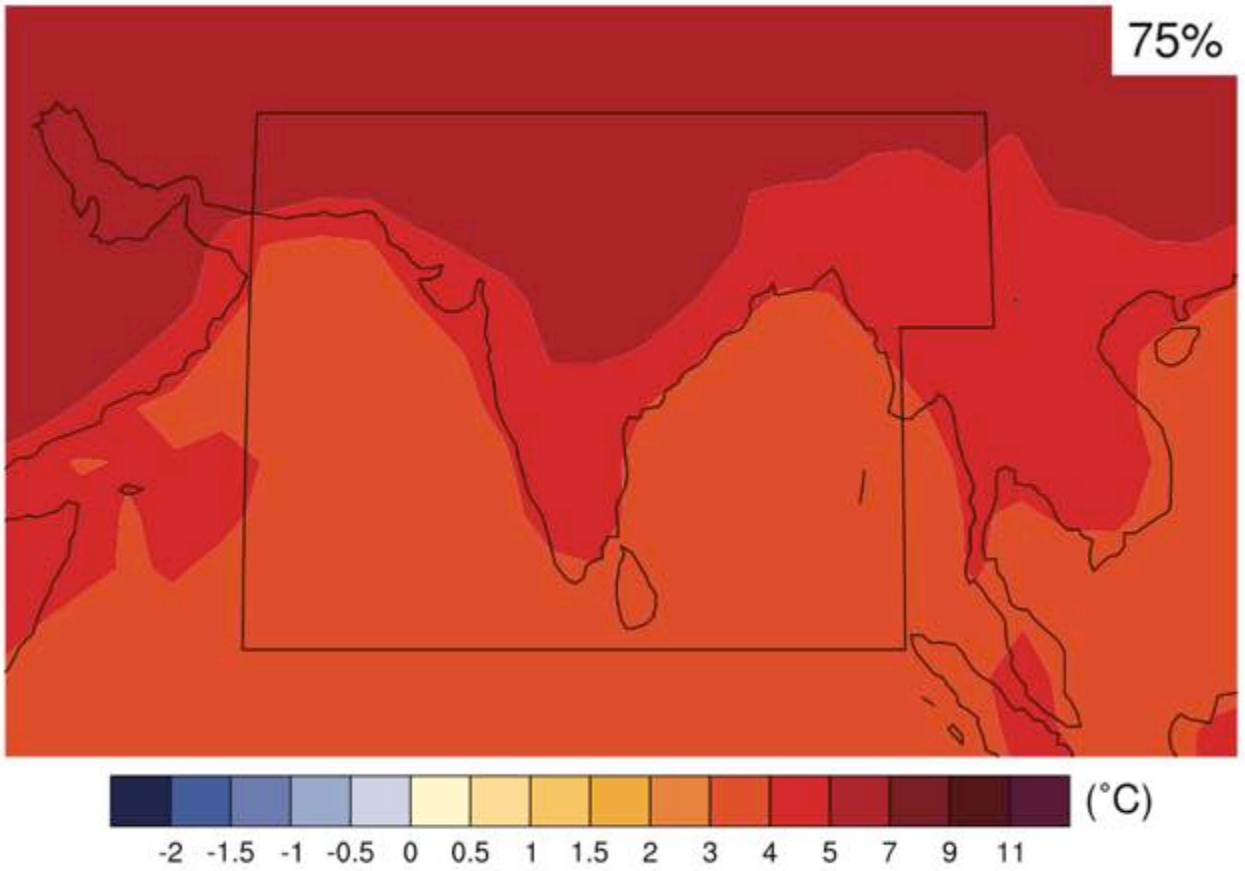
With permission from Dr. S. Joussaume, in « Climat d'hier à demain », CNRS éditions.

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



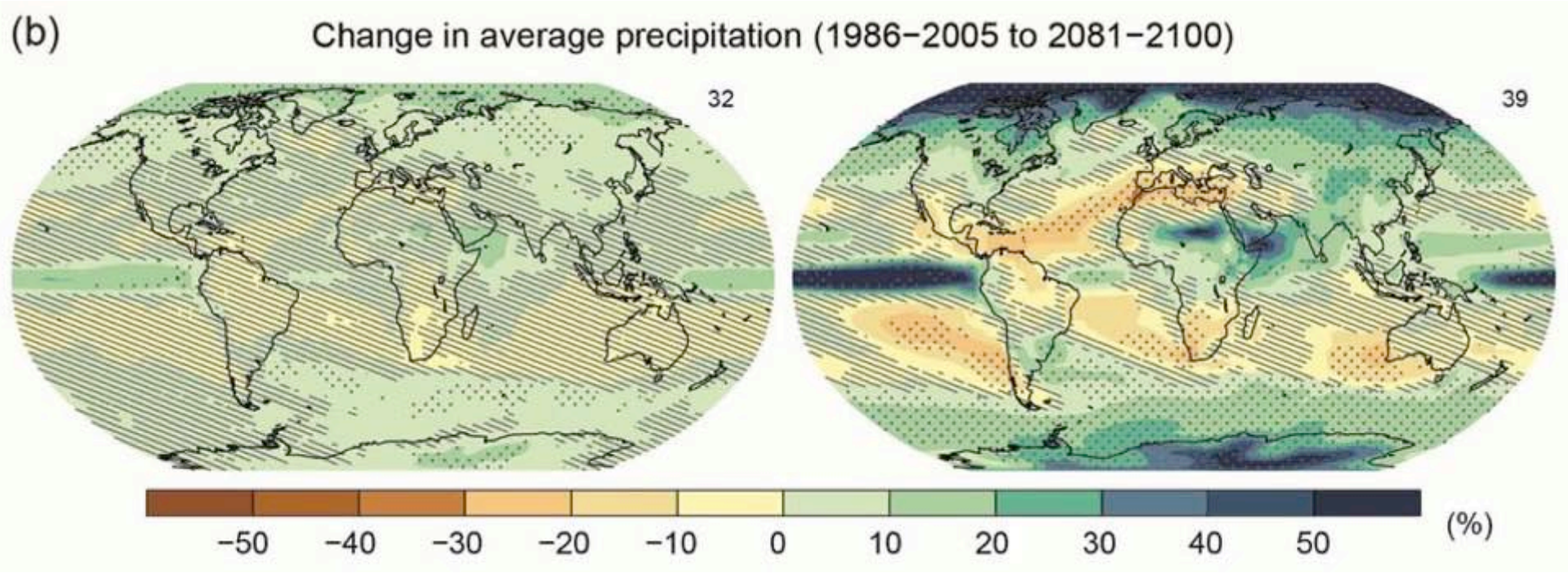
IPCC WG1 Fifth Assessment Report (Final Draft)

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

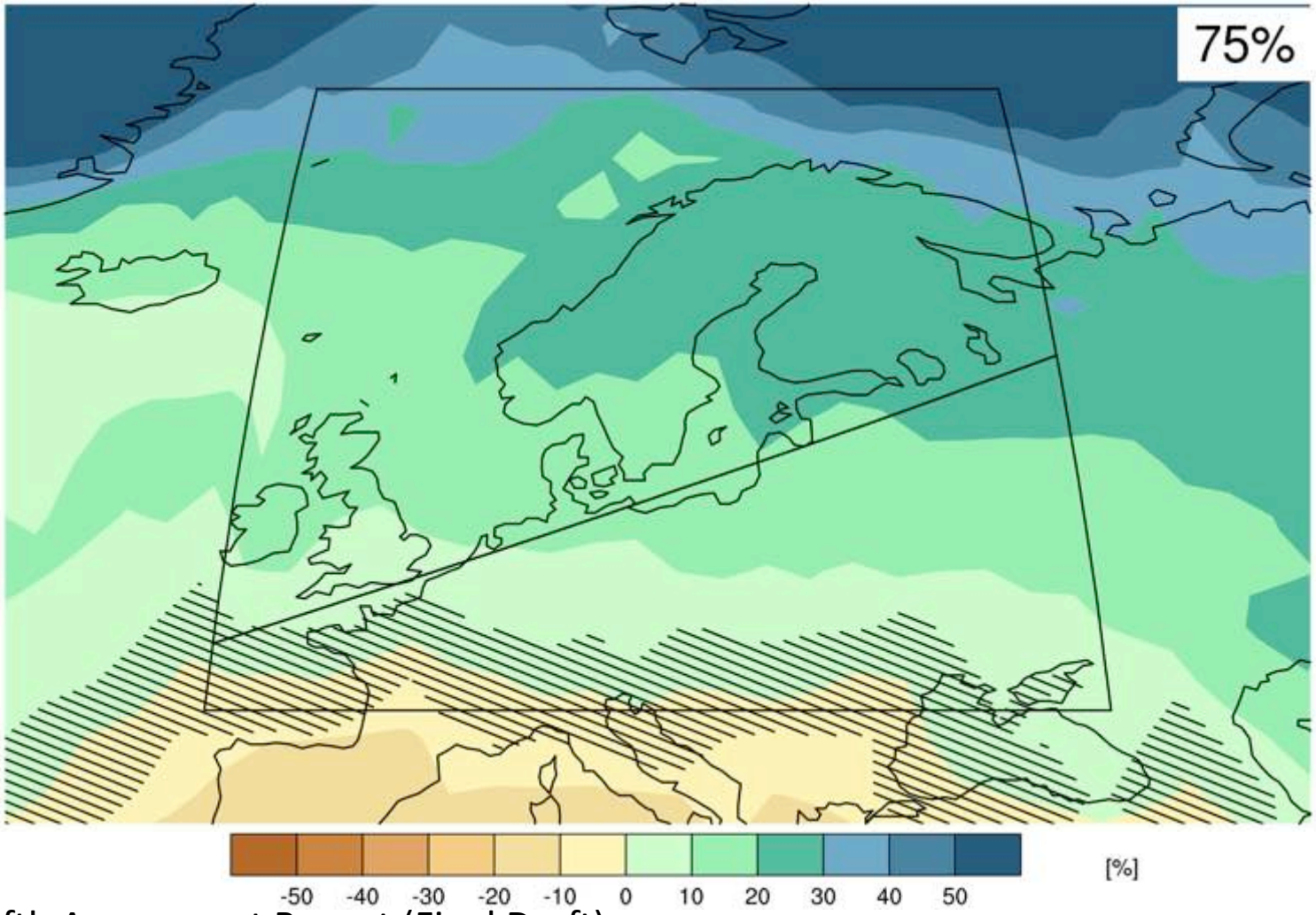


IPCC, WGI, Annex I: Atlas of Global and Regional Climate Projections Supplementary Material RCP8.5

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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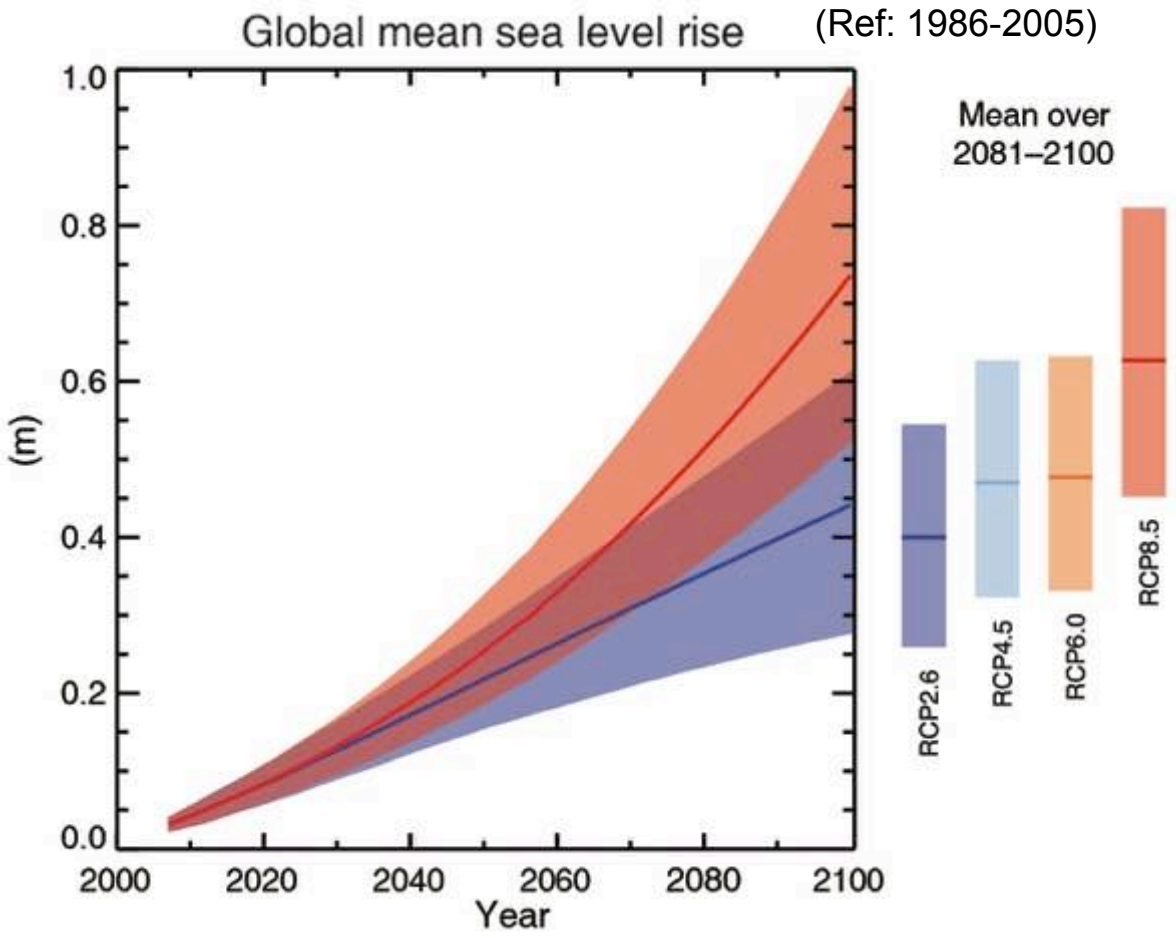
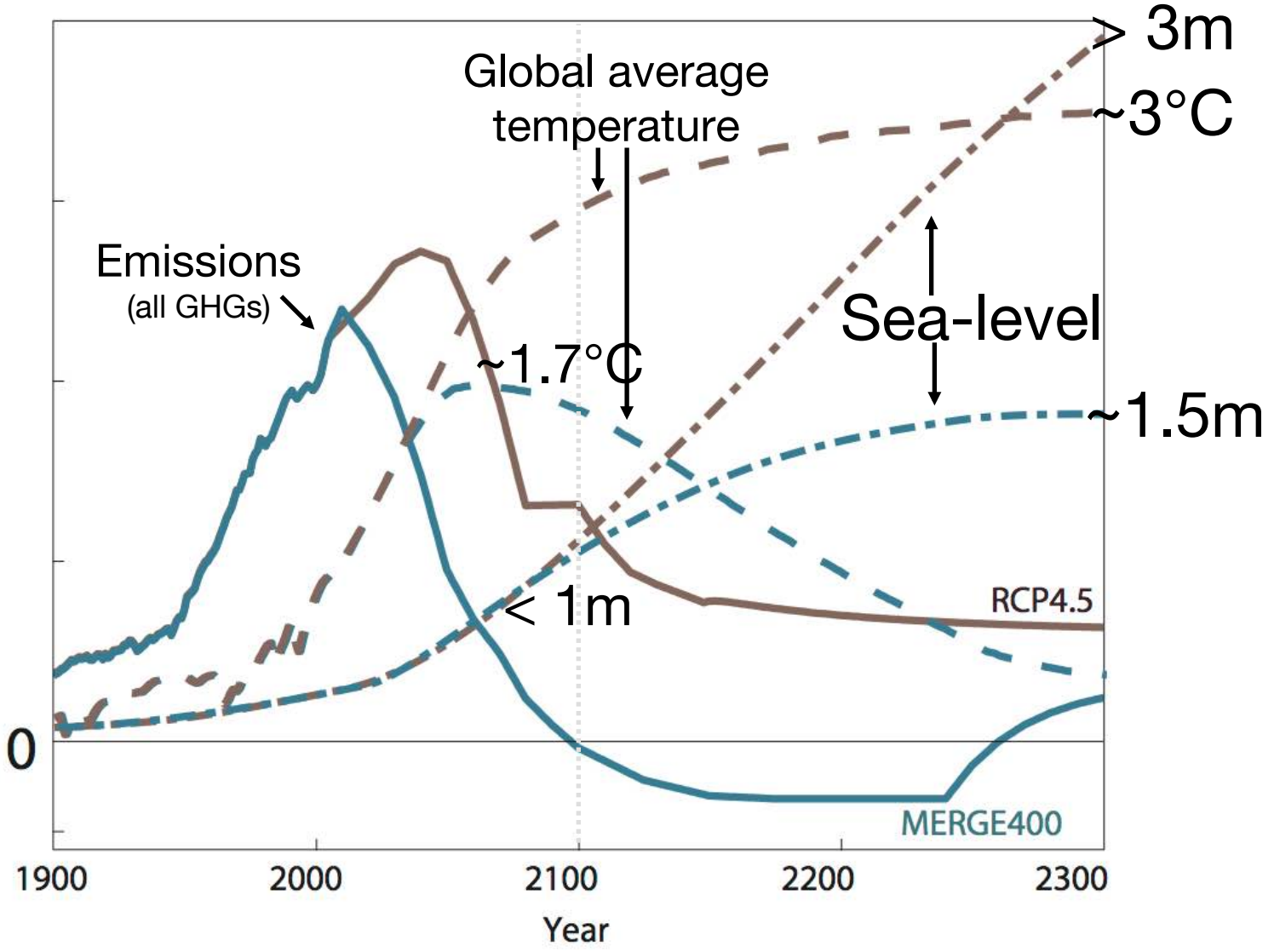


(IPCC 2013, Fig. SPM.9)

Sea level due to continue to increase

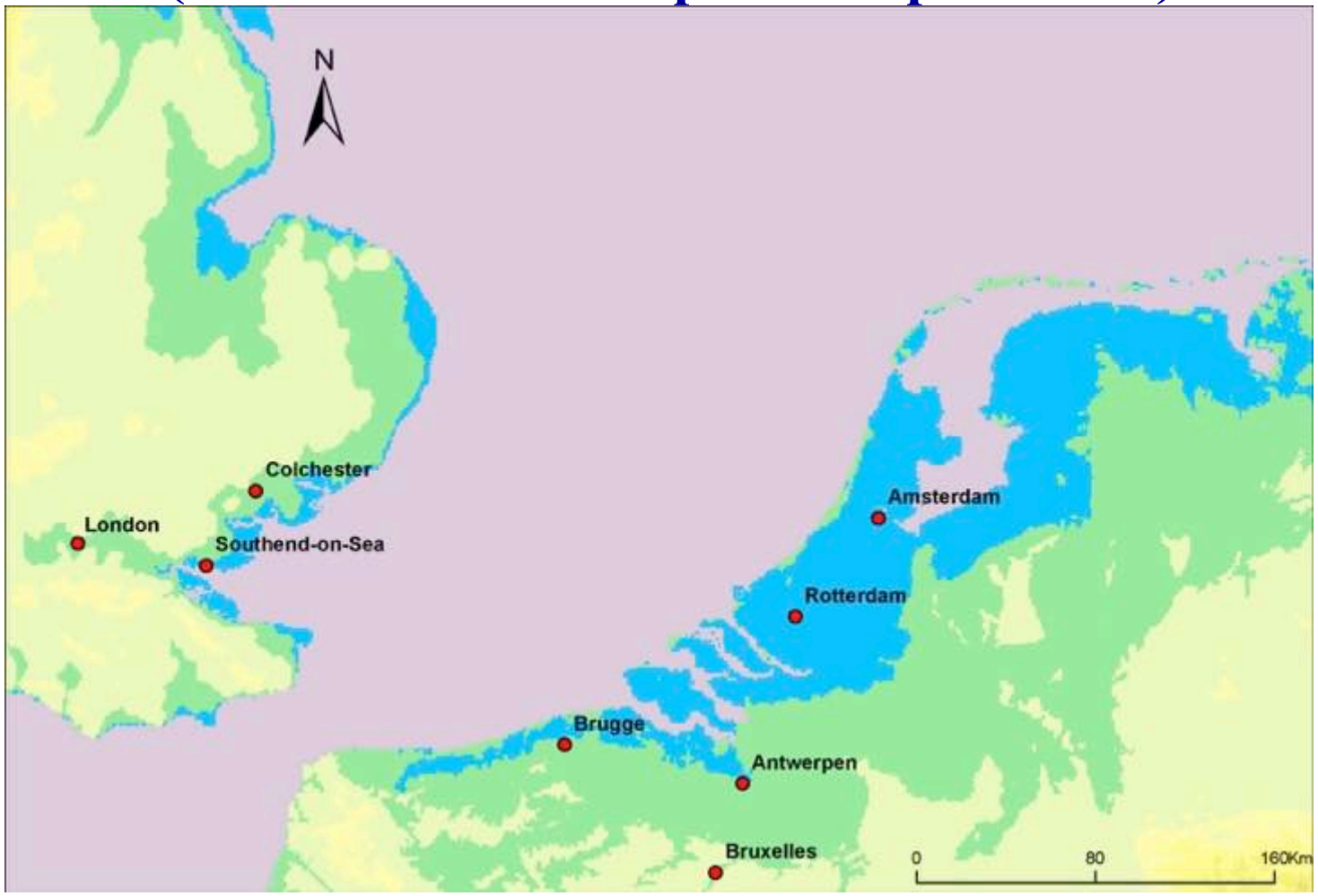
Emissions (-> concentrations) -> temperature -> sea-level



Source: adapted from Schaeffer et al., Nature clim. chg. (2012)

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

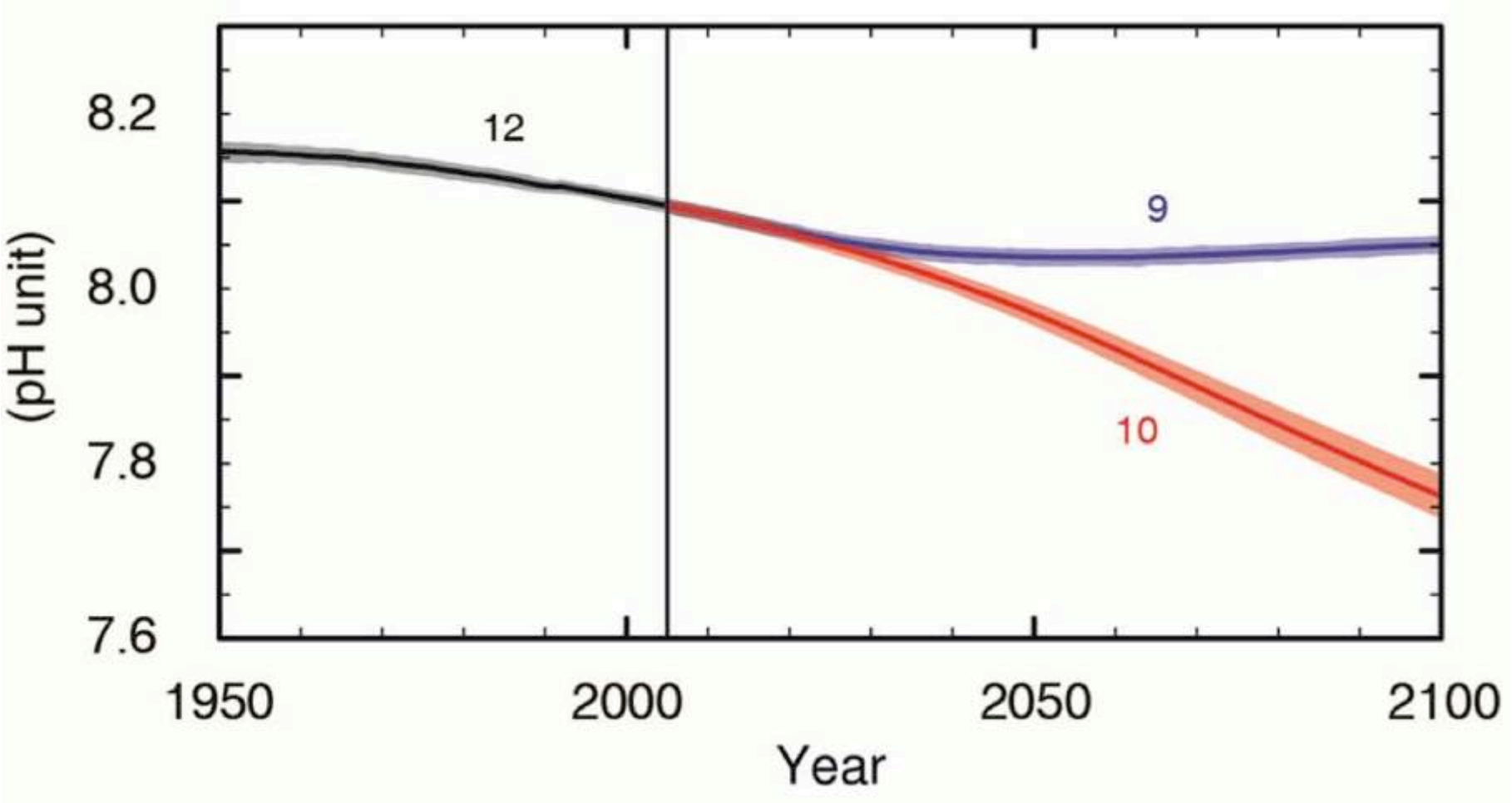
(Time 2001)

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

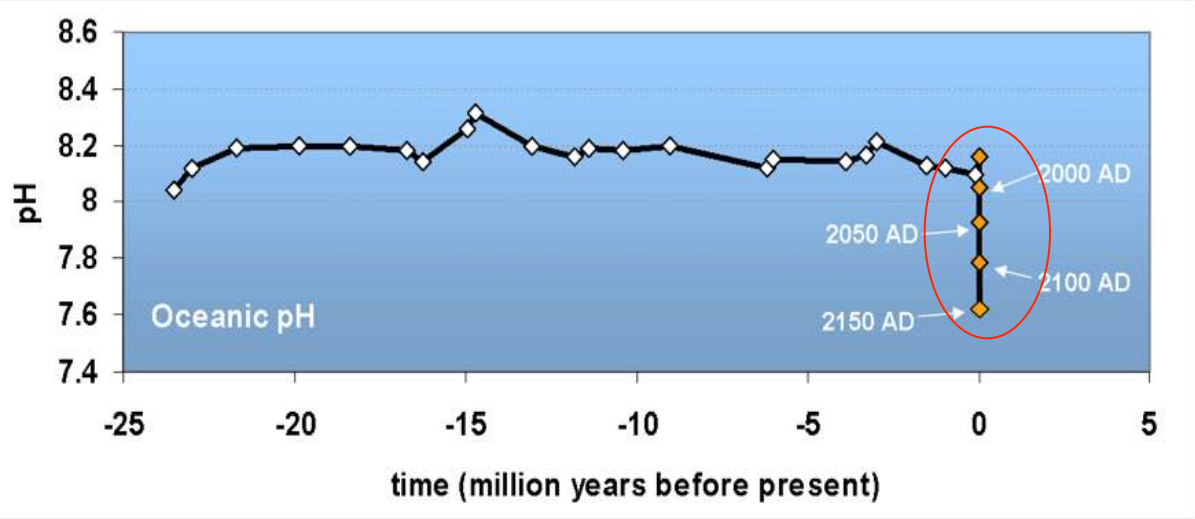
Global ocean surface pH (projections)

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



Oceans are Acidifying Fast …….

Changes in pH over the last 25 million years



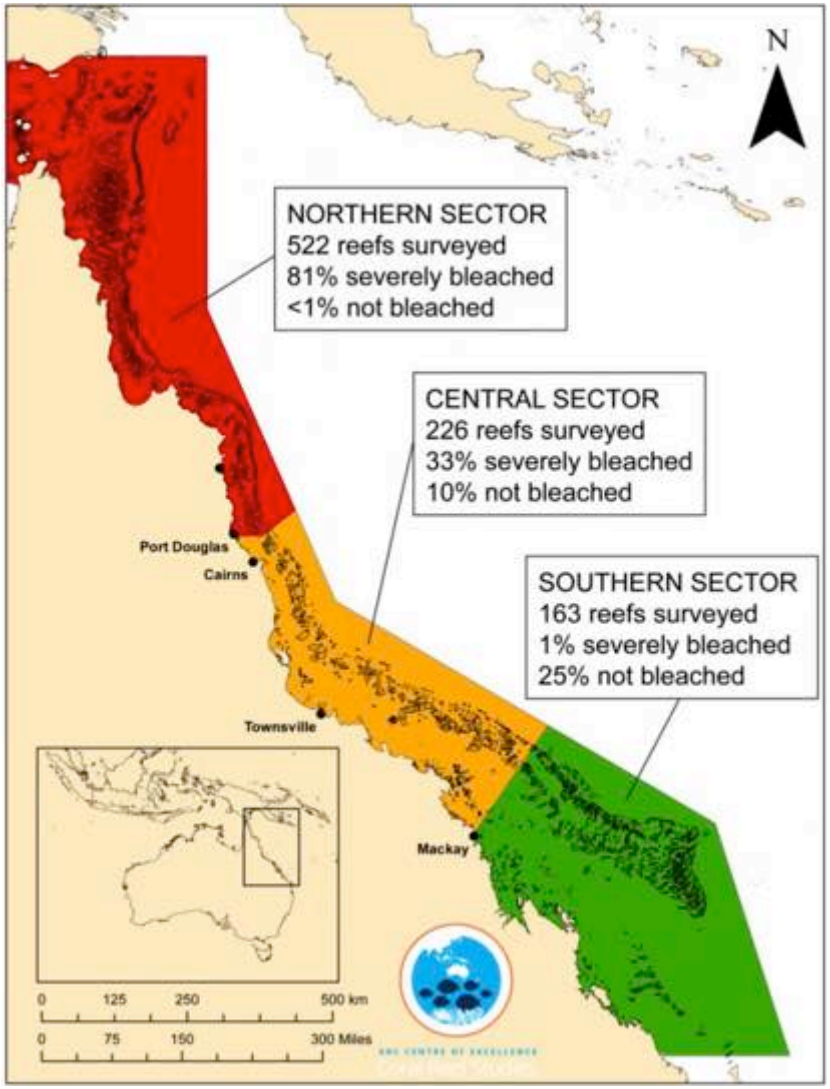
"Today is a rare event in the history of the World"

- **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

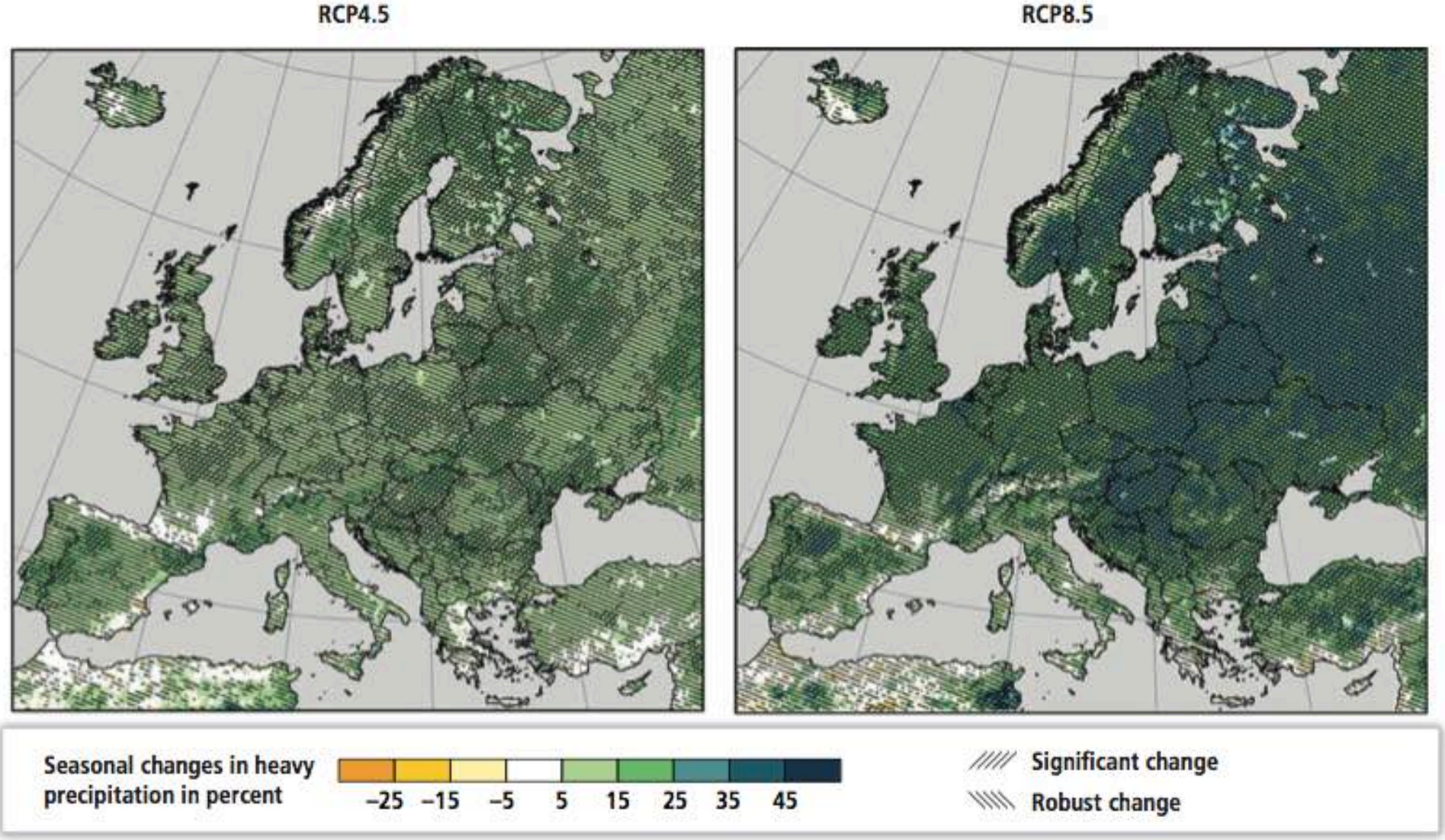
Slide courtesy of Carol Turley, PML

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



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

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



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

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

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

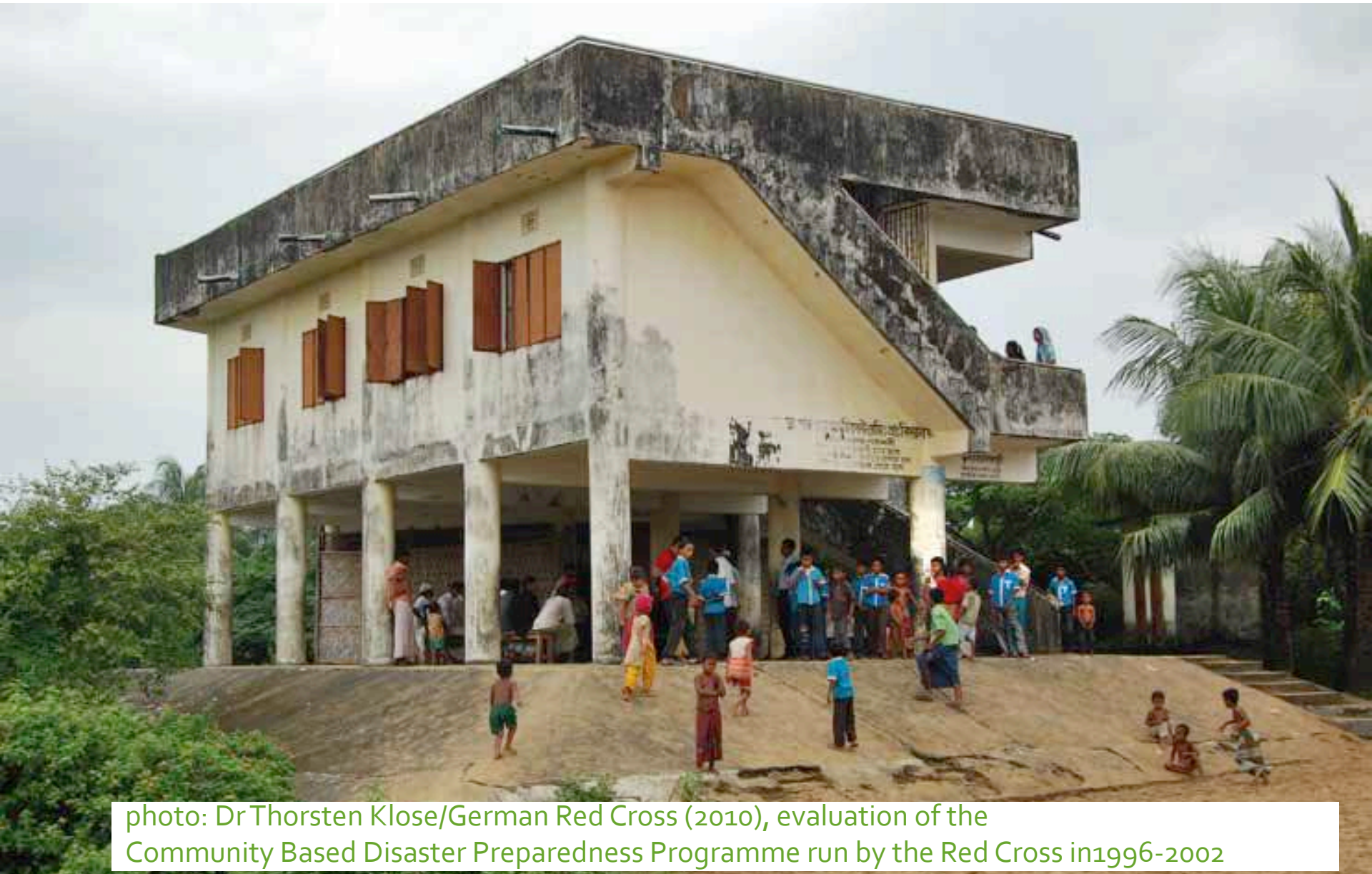
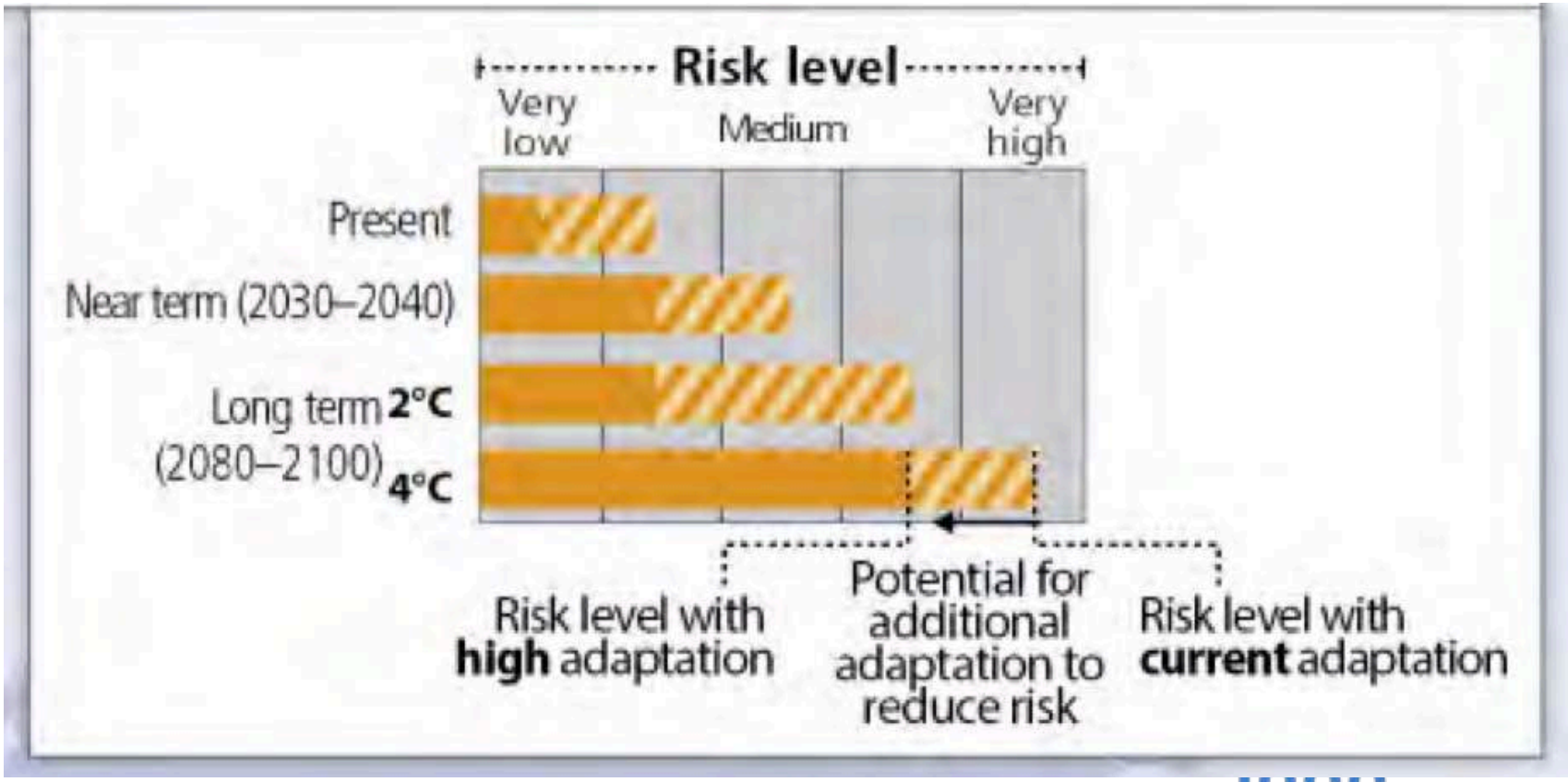


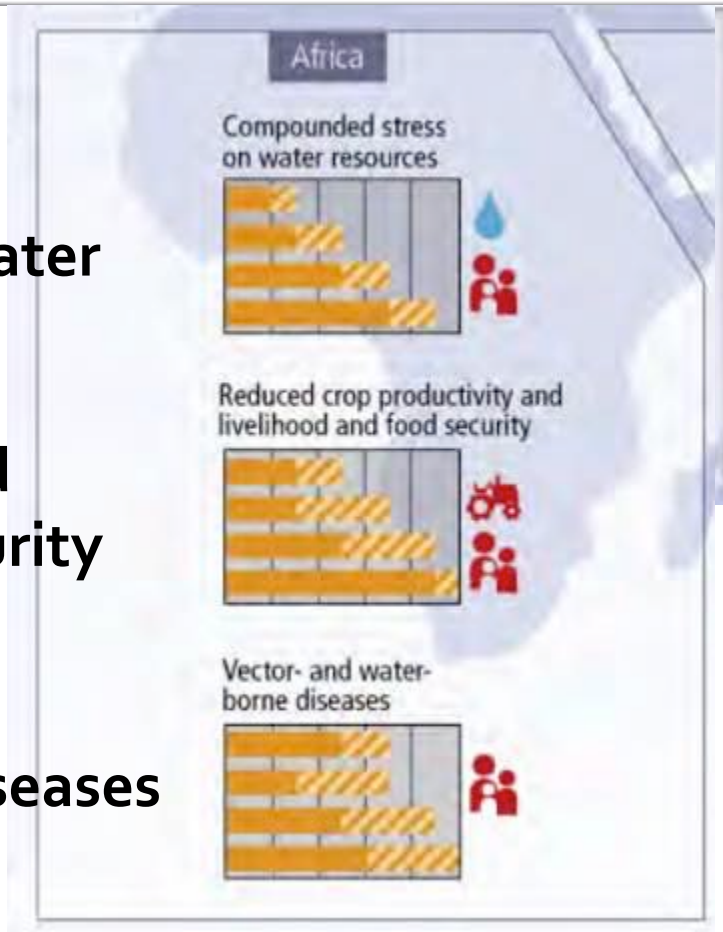
photo: Dr Thorsten Klose/German Red Cross (2010), evaluation of the Community Based Disaster Preparedness Programme run by the Red Cross in1996-2002

Regional key risks and potential for risk reduction through adaptation



IPCC, AR5, SPM, Figure SPM.8

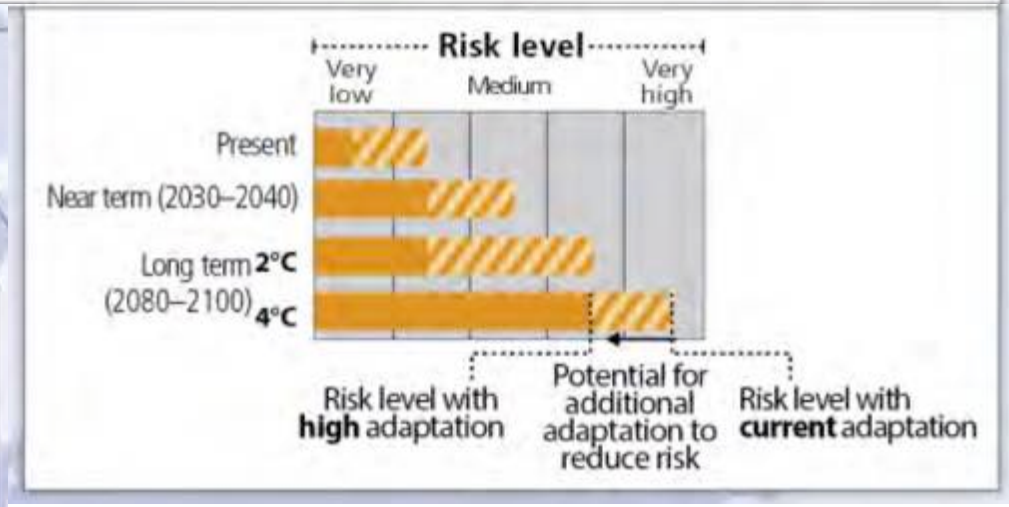
Regional key risks and risk reduction through adaptation



Water

Food security

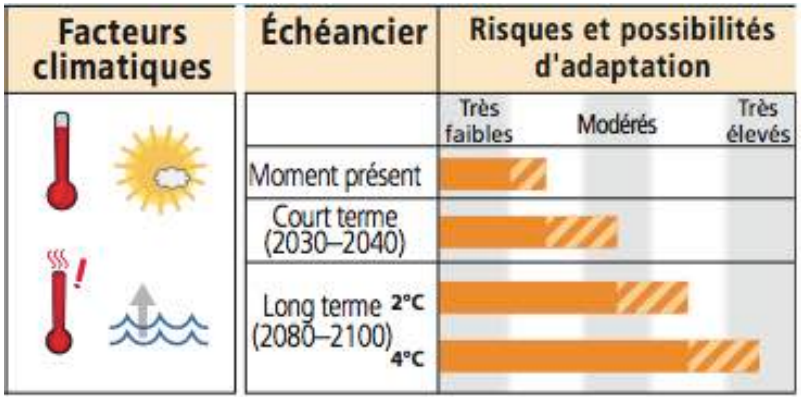
Diseases

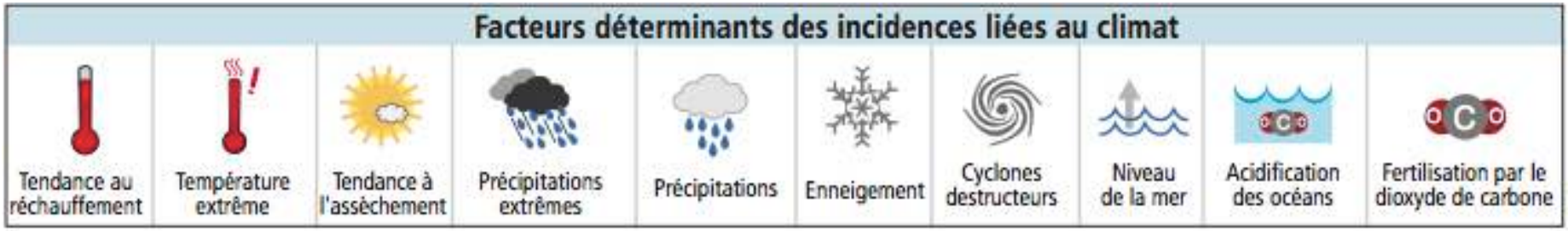


IPCC, AR5, SPM, Figure SPM.8

Risque majeur pour l'Afrique: eau

Aggravation des pressions exercées sur les ressources hydriques déjà lourdement sollicitées par la surexploitation et la dégradation, et qui feront face à l'avenir à une demande accrue. Stress dû à la sécheresse exacerbé dans les régions africaines déjà exposées à ce fléau (degré *de confiance élevé).*

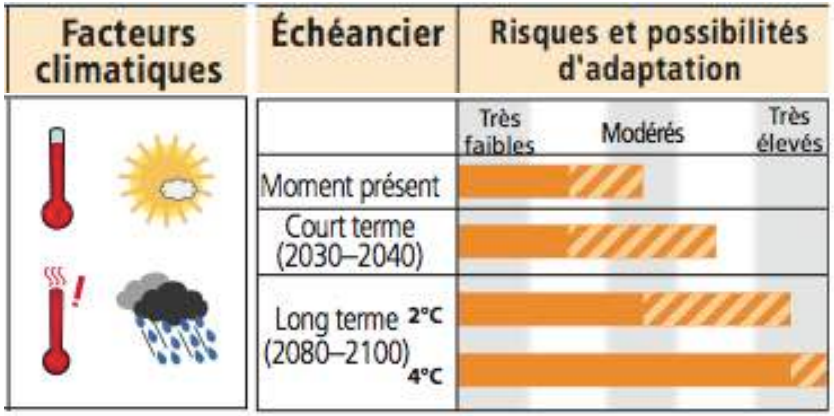


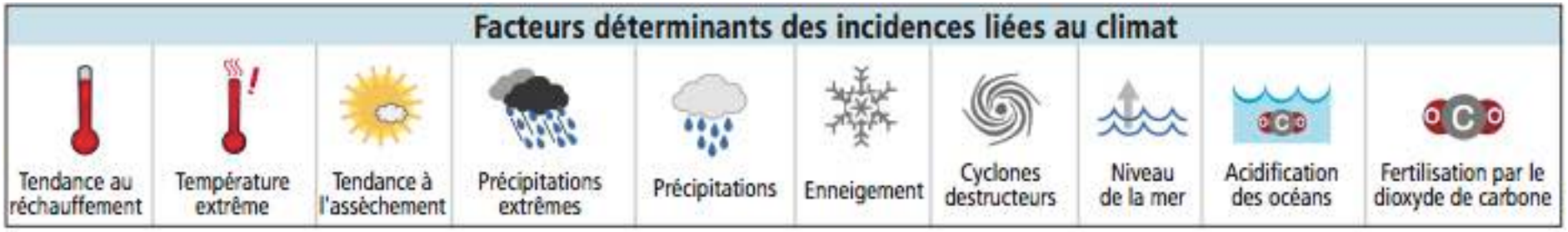


IPCC, AR5, GT II, RID, p. 21

Risque majeur pour l'Afrique: agriculture

Baisse de la productivité des cultures due à la chaleur et à la sécheresse — dont les conséquences sur les moyens de subsistance et la sécurité alimentaire des pays, des régions et des ménages pourraient être graves — ainsi qu'aux dommages causés par les ravageurs, les maladies et les inondations sur l'infrastructure des systèmes alimentaires (degré *de confiance élevé)*

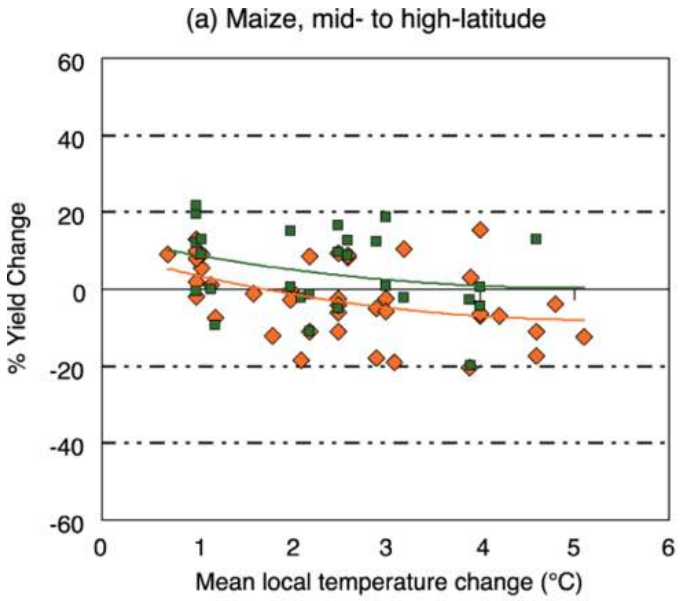


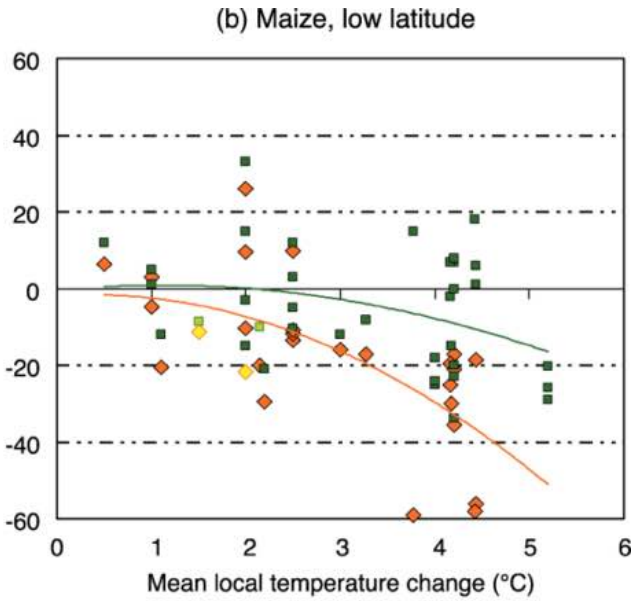


IPCC, AR5, GT II, RID, p. 21

Figure TS.7. Sensitivity of cereal yield to climate change

Maïs





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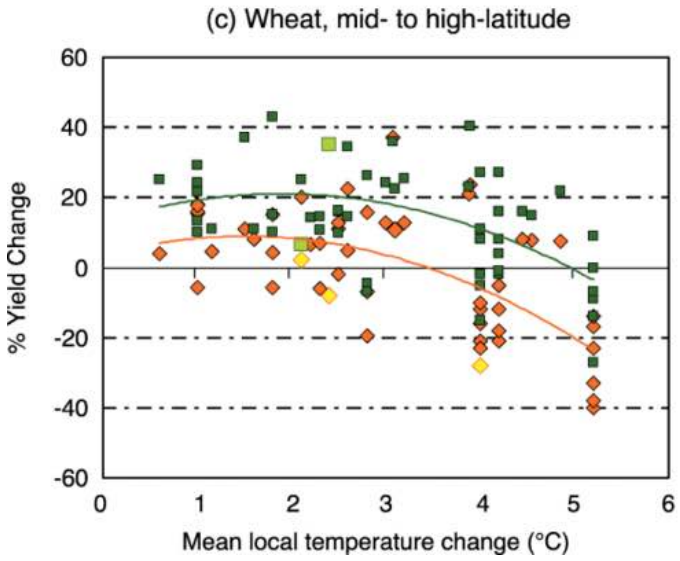
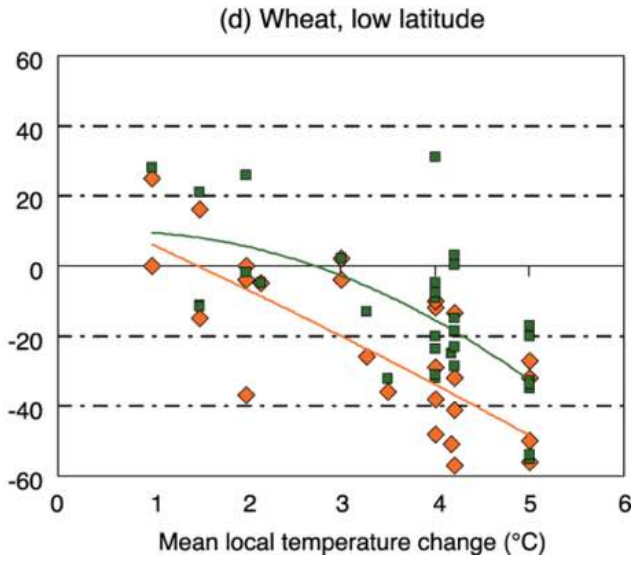


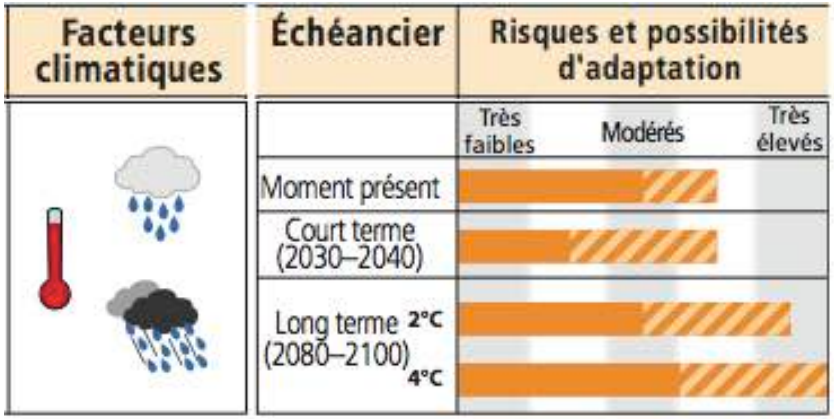


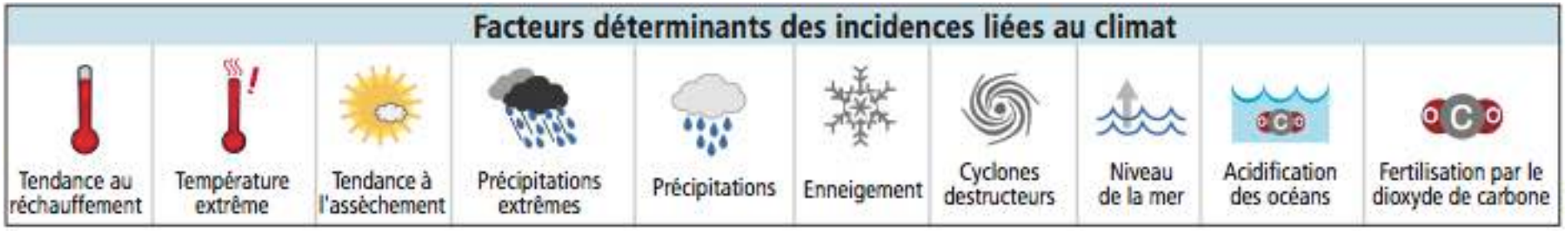
WMO

UNEP

Risque majeur pour l'Afrique: santé

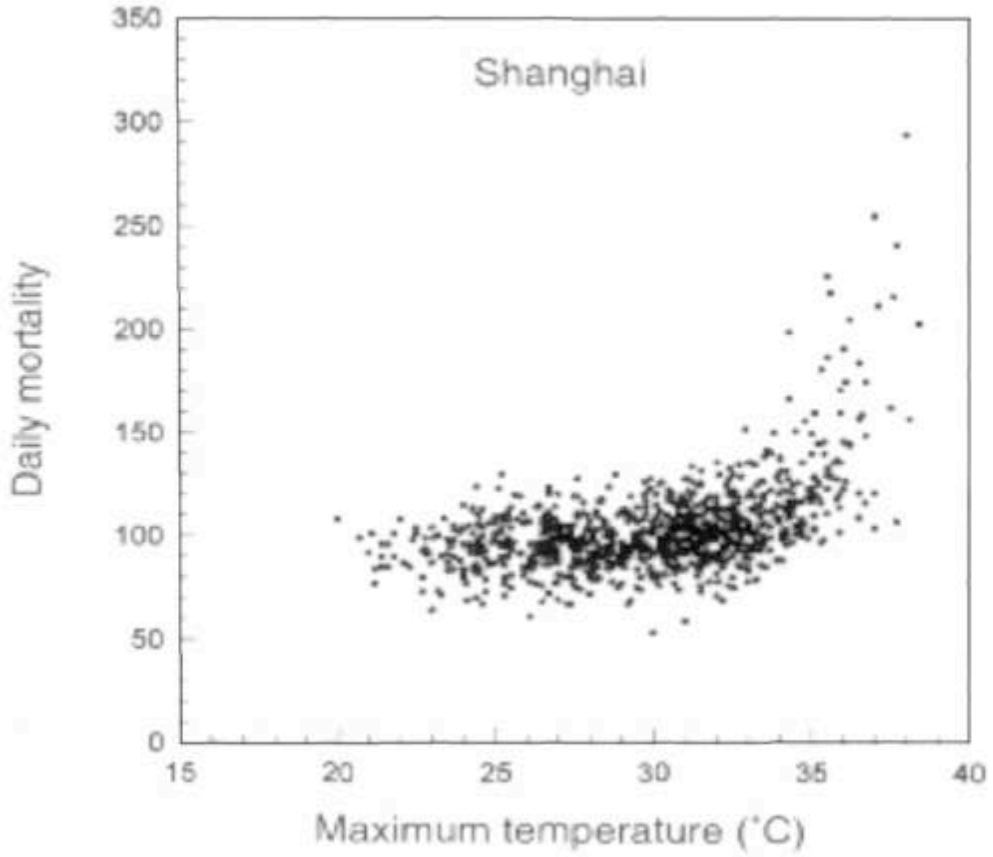
Variations de l'incidence et de l'extension géographique des maladies à transmission vectorielle ou d'origine hydrique dues à l'évolution des températures et des précipitations moyennes et de leur variabilité, en particulier aux limites de leurs aires de répartition (degré *de confiance moyen)*





IPCC, AR5, GT II, RID, p. 21

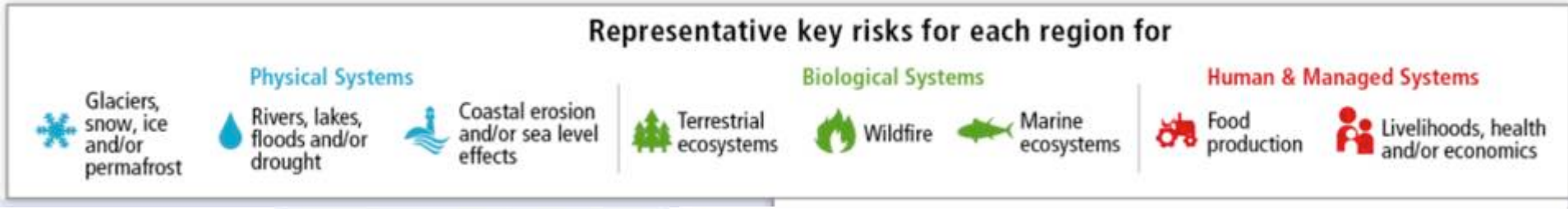
Relationship between maximum temperature and mortality in Shanghai, China, 1980-89



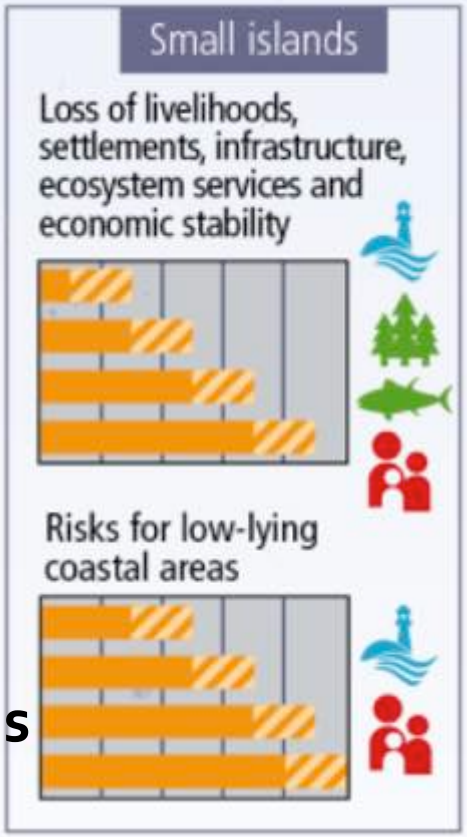
Référence : CILIMATE CHANGE AND HUMAN HEALTH, 1996

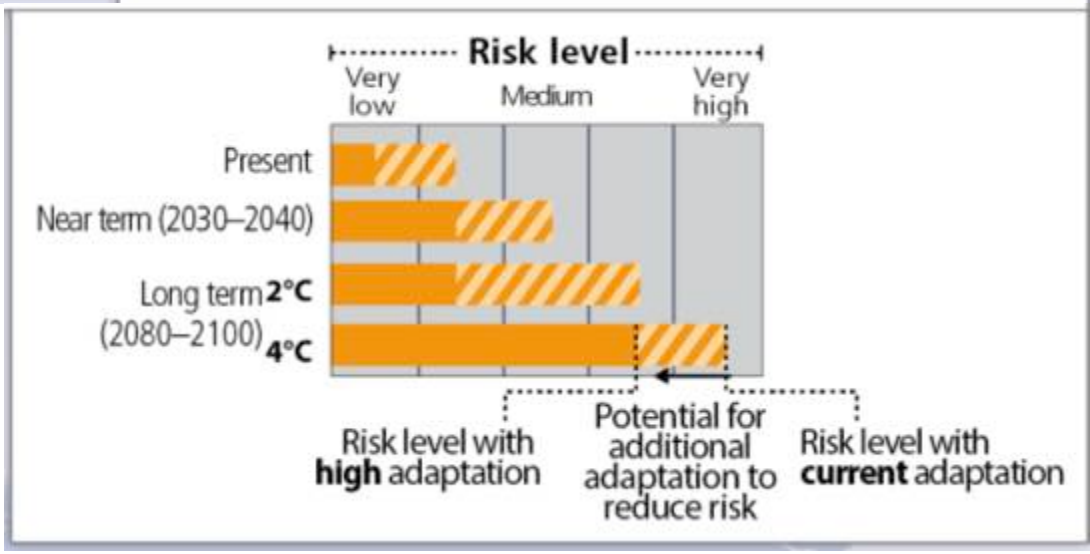
Jean-Pascal van Ypersele
(vanypersele@astr.ucl.ac.be)

Regional key risks and potential for risk reduction: Small Islands



Losses





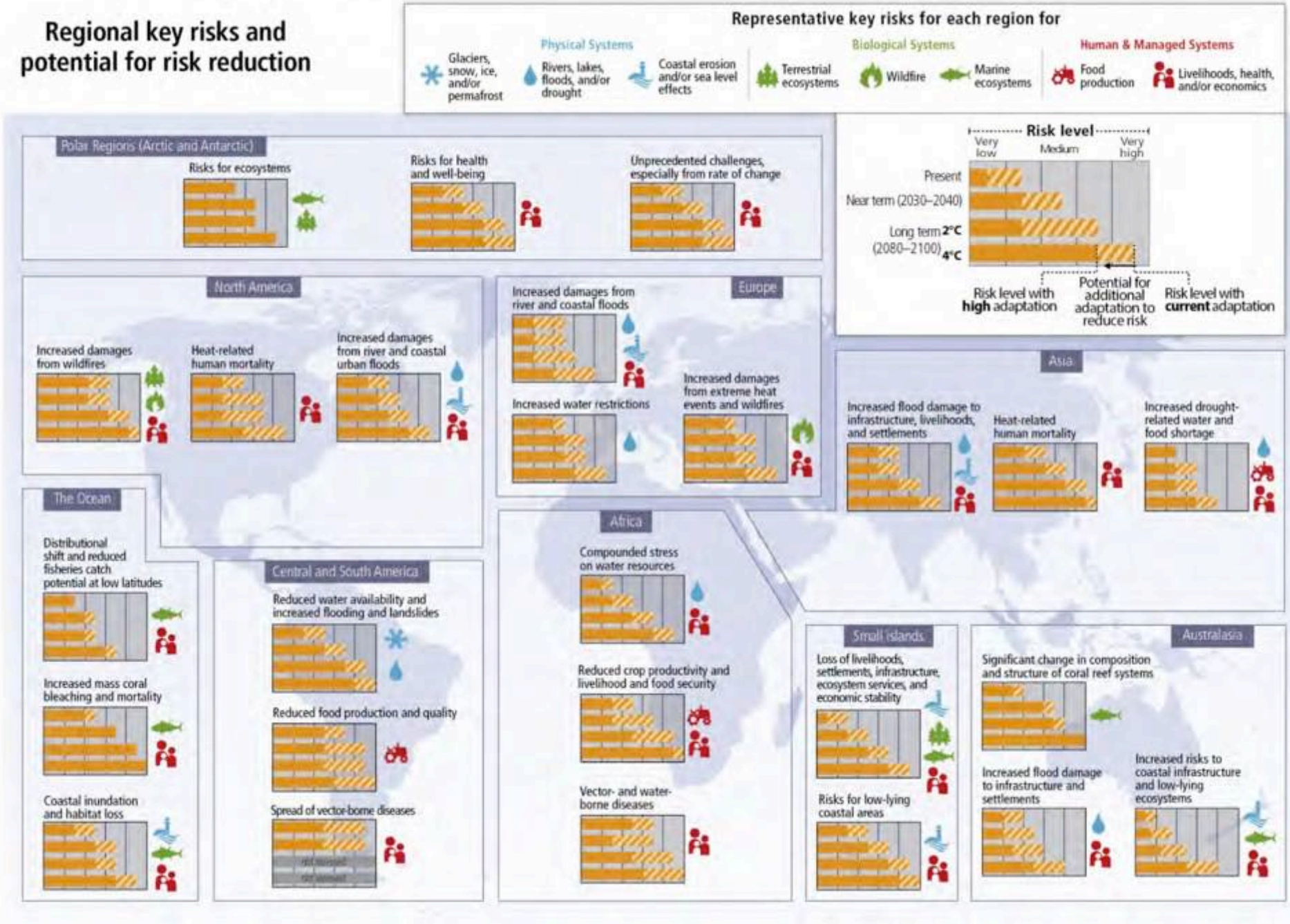
Risk to coastal areas

IPCC, AR5, SYR, SPM 8

ipcc INTERGOVERNMENTAL PANEL ON climate change

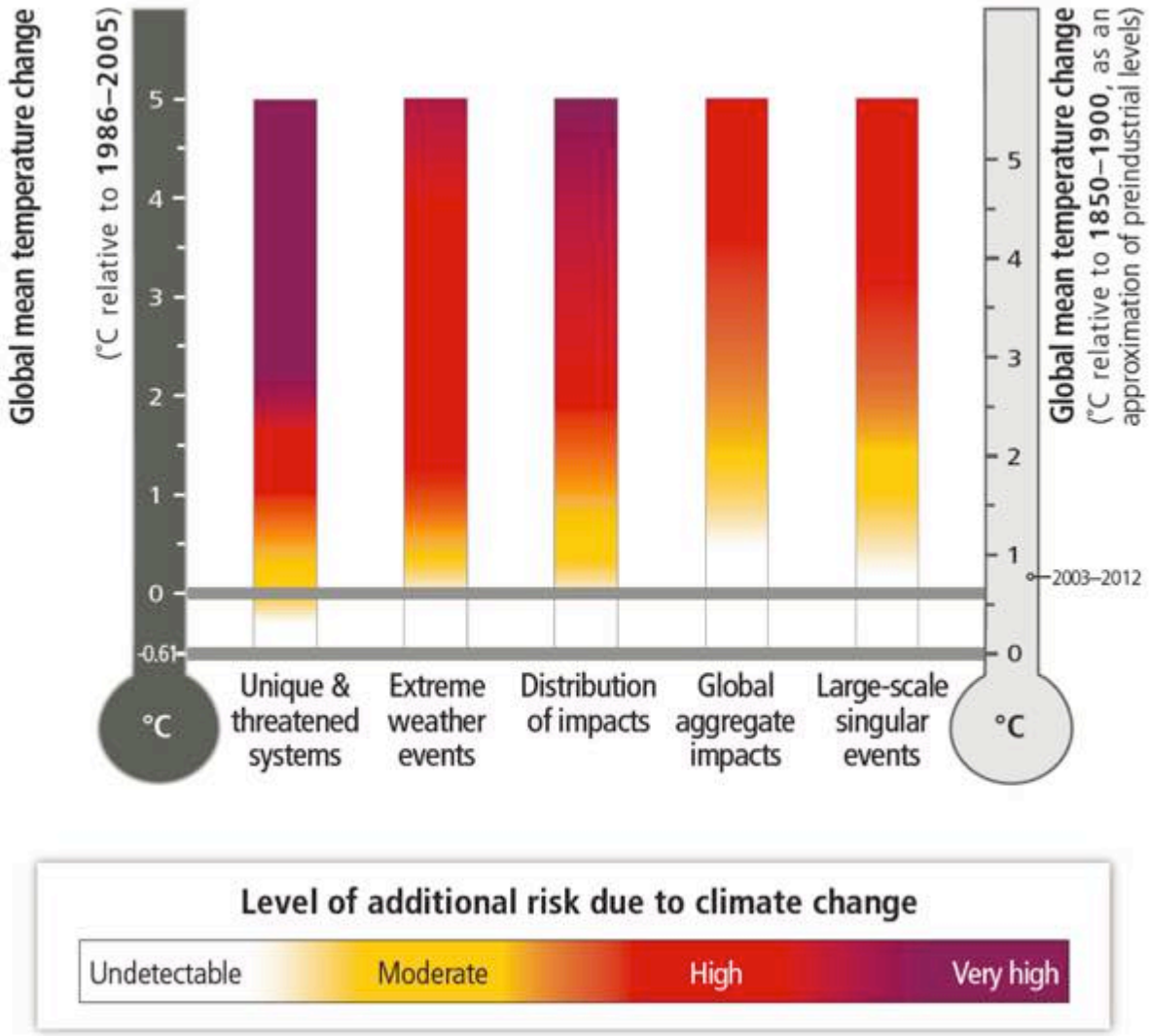
WMO UNEP

Regional key risks and potential for risk reduction



IPCC, AR5, SPM, Figure SPM.8

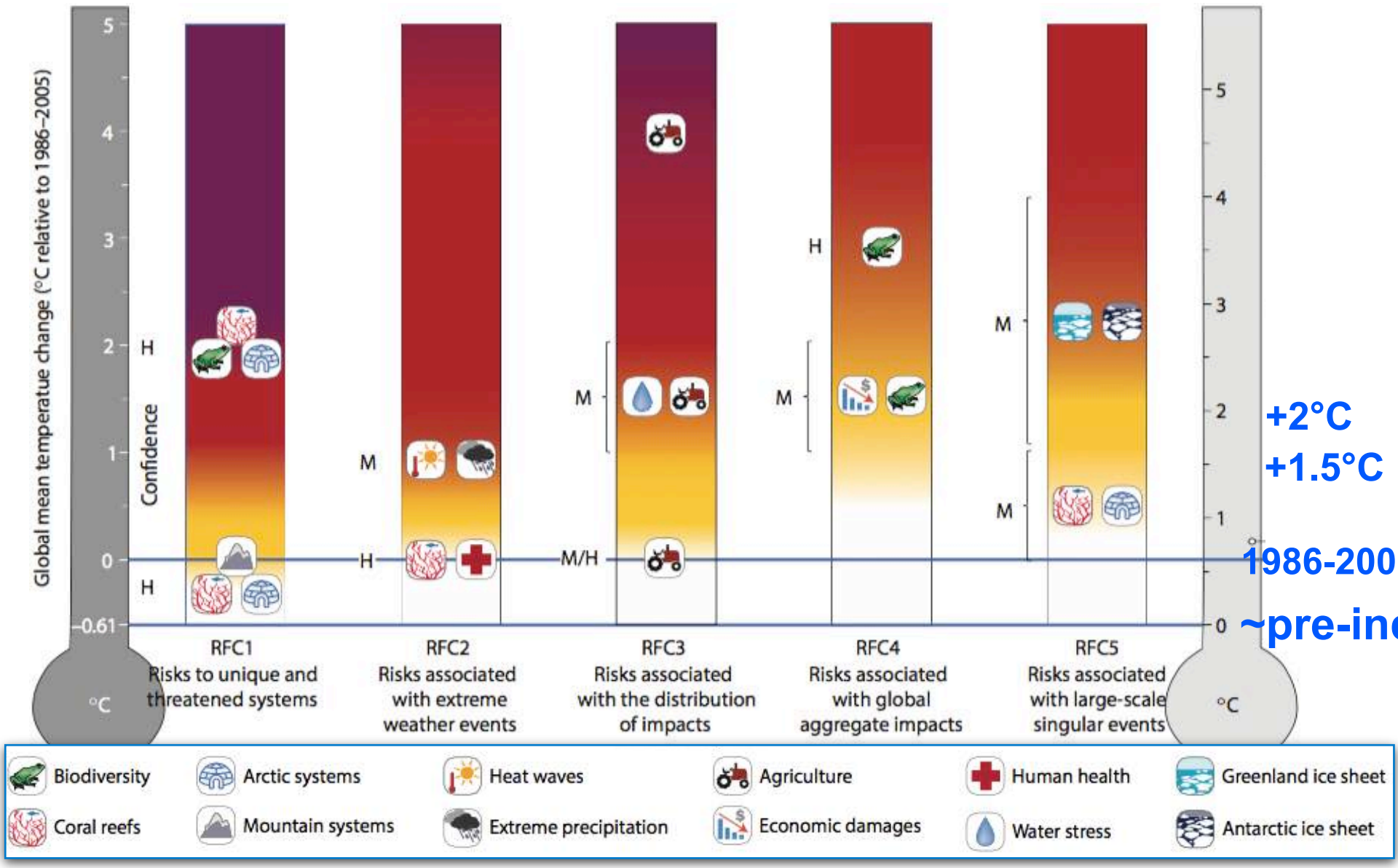

RISKS OF
CLIMATE CHANGE
INCREASE
WITH CONTINUED
HIGH EMISSIONS
ipcc
INTERGOVERNMENTAL PANEL ON Climate change

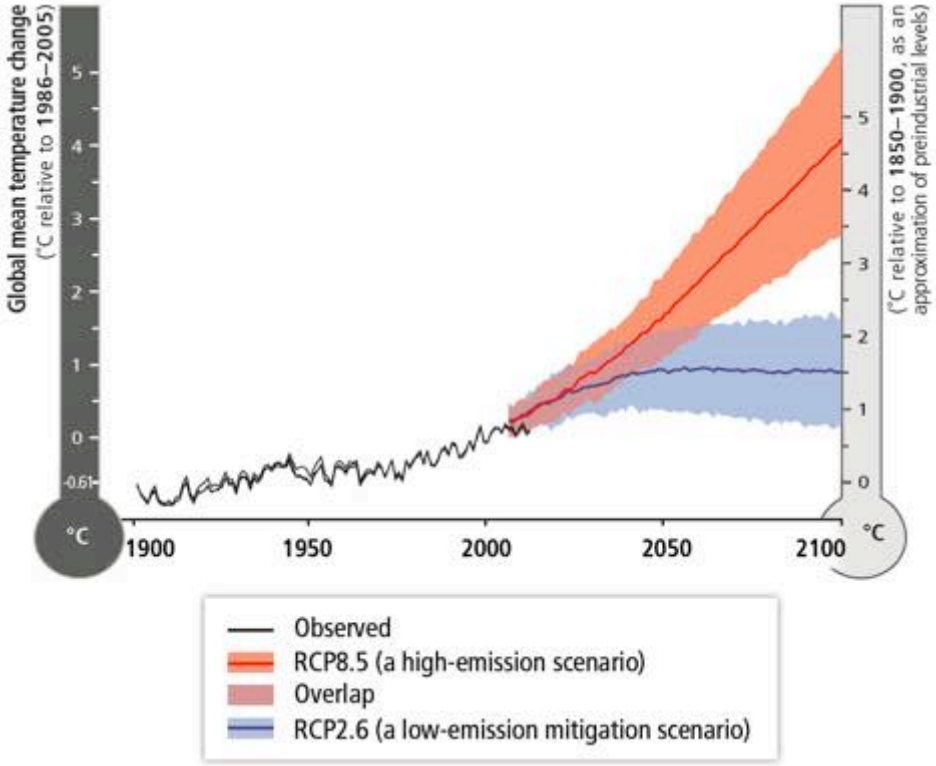


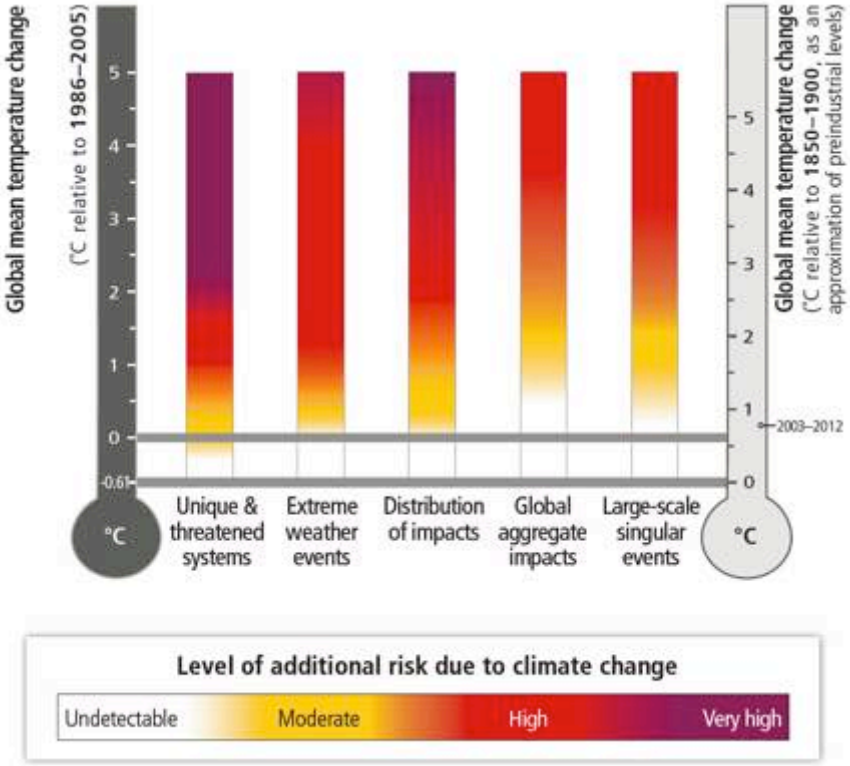
AR5, WGII, Box SPM.1 Figure 1

IPCC reasons for concern / climate change risks

(Nat Climate Change 2017)







ipcc
INTERGOVERNMENTAL PANEL ON climate change

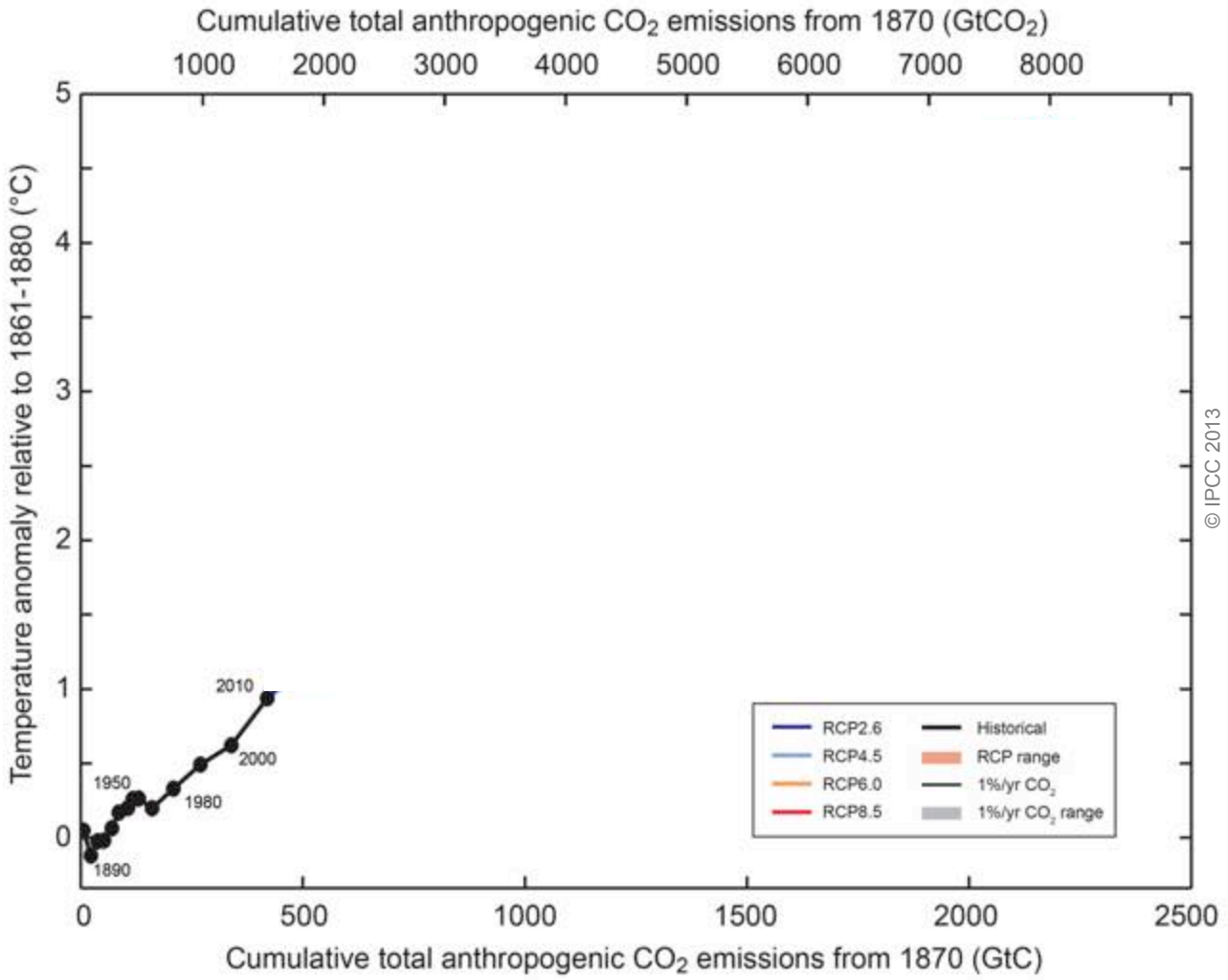


Fig. SPM.10

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

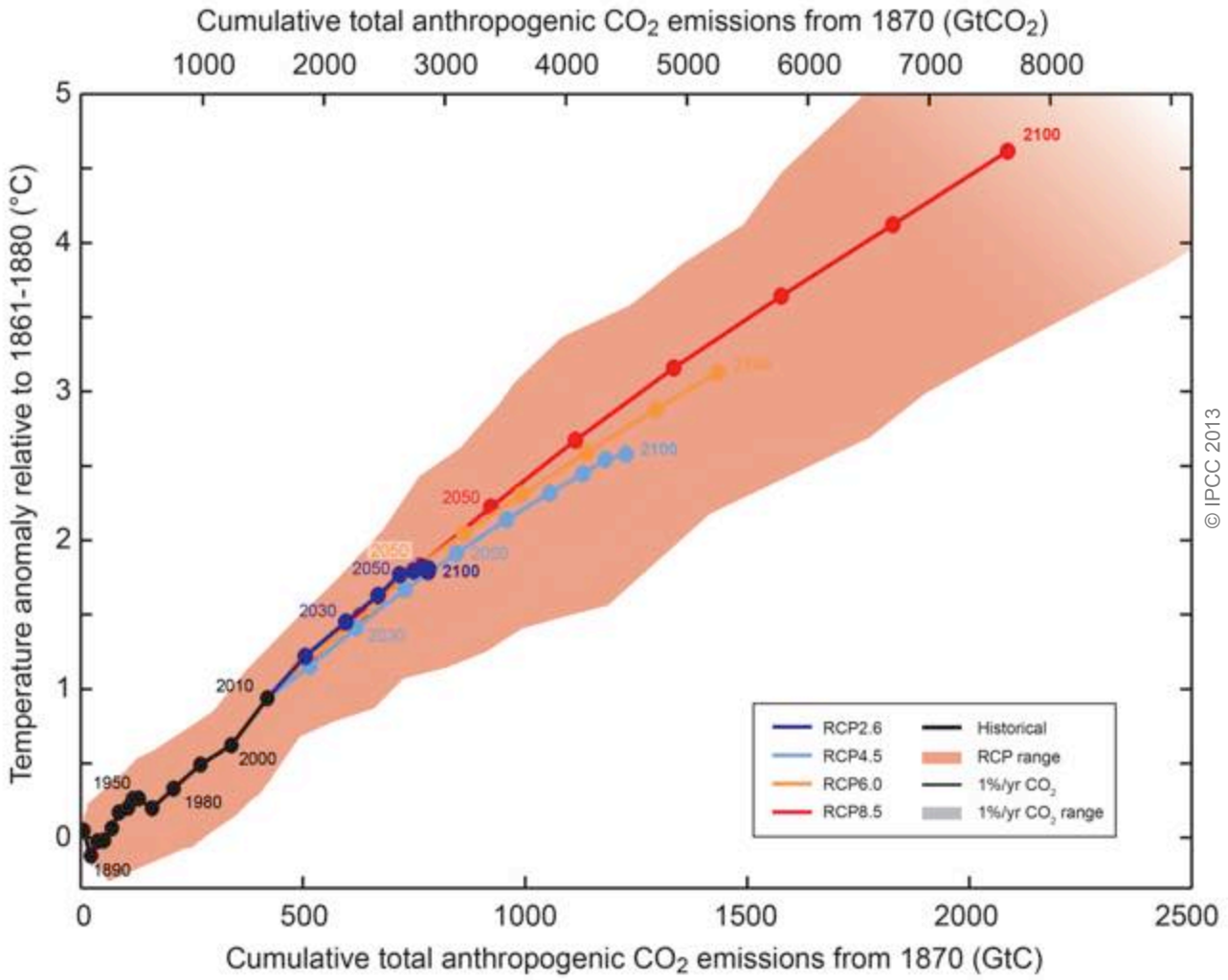
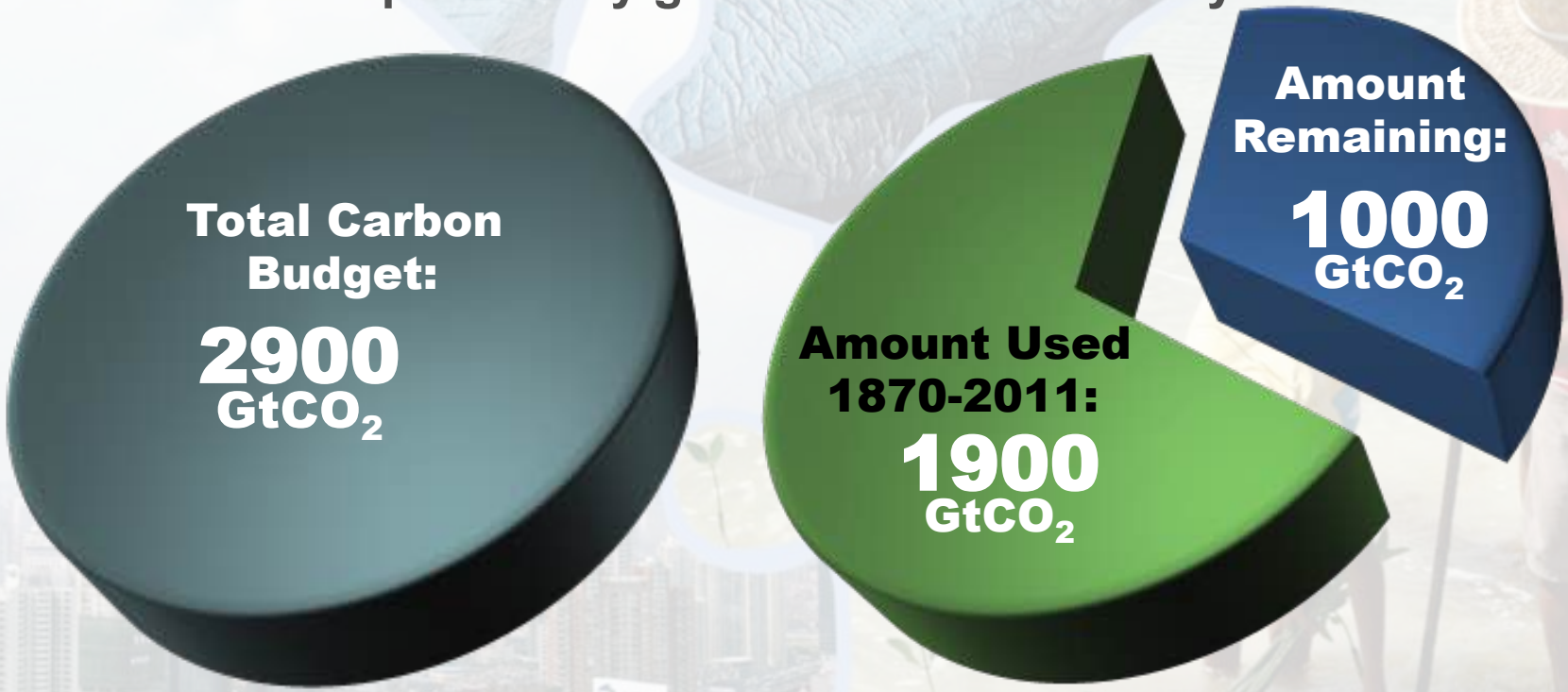


Fig. SPM.10

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

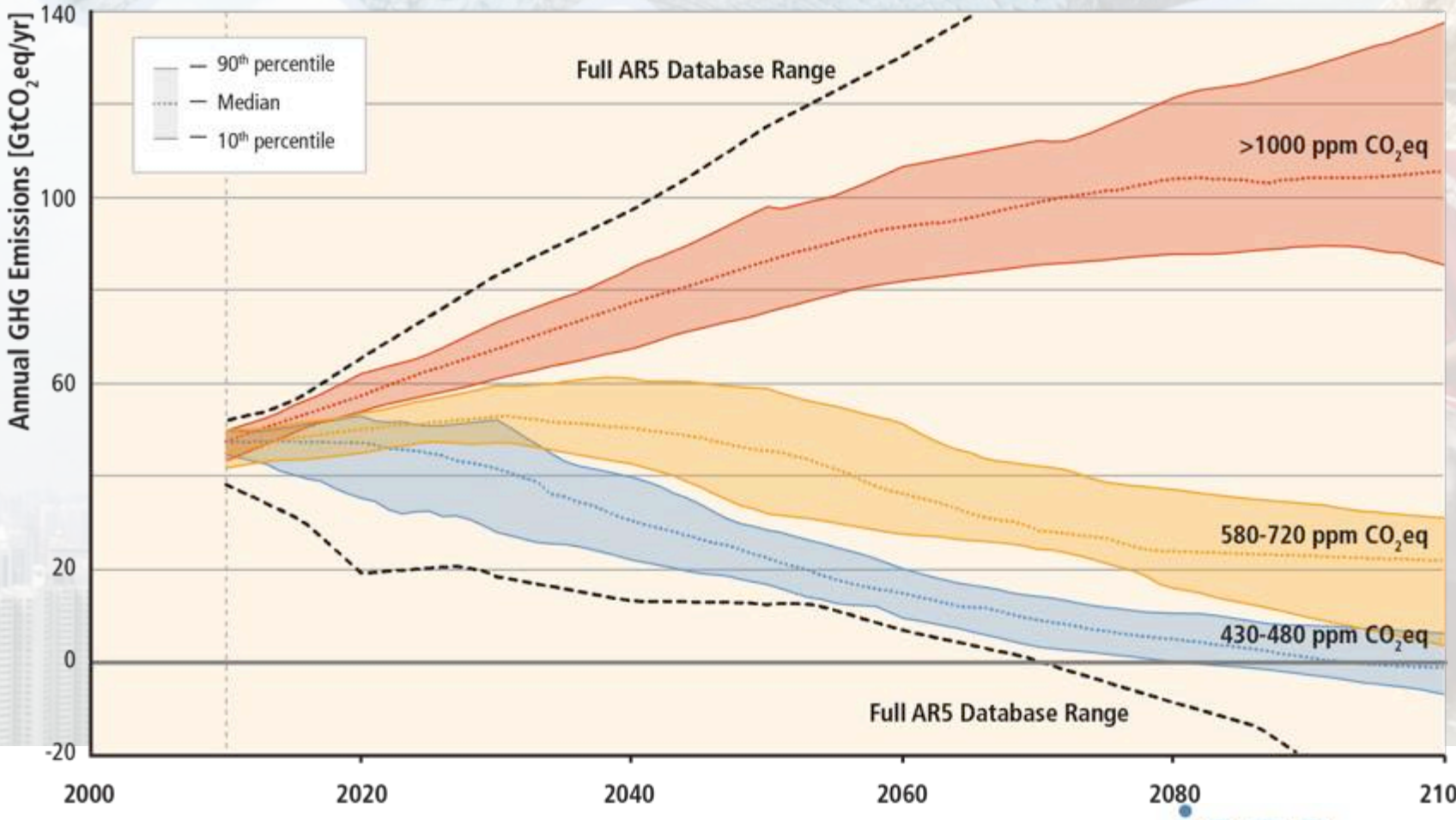


NB: Emissions in 2011: 38 GtCO2/yr

AR5 WGI SPM

Source: Centre for Science and Environment, Delhi

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



Based on Figure 6.7

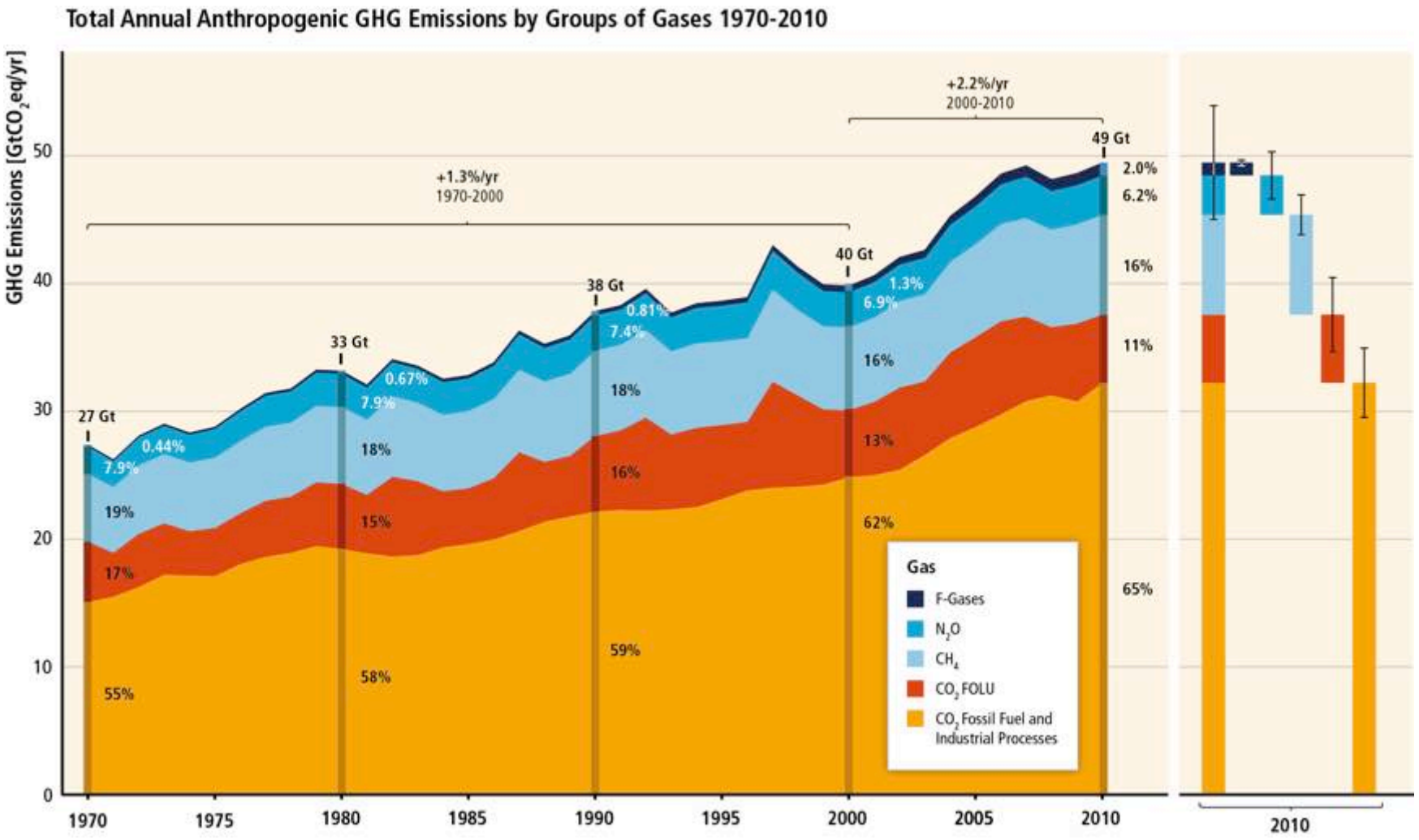
AR5 WGIII SPM

IPCC AR5 Synthesis Report

ipcc INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

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

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

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**

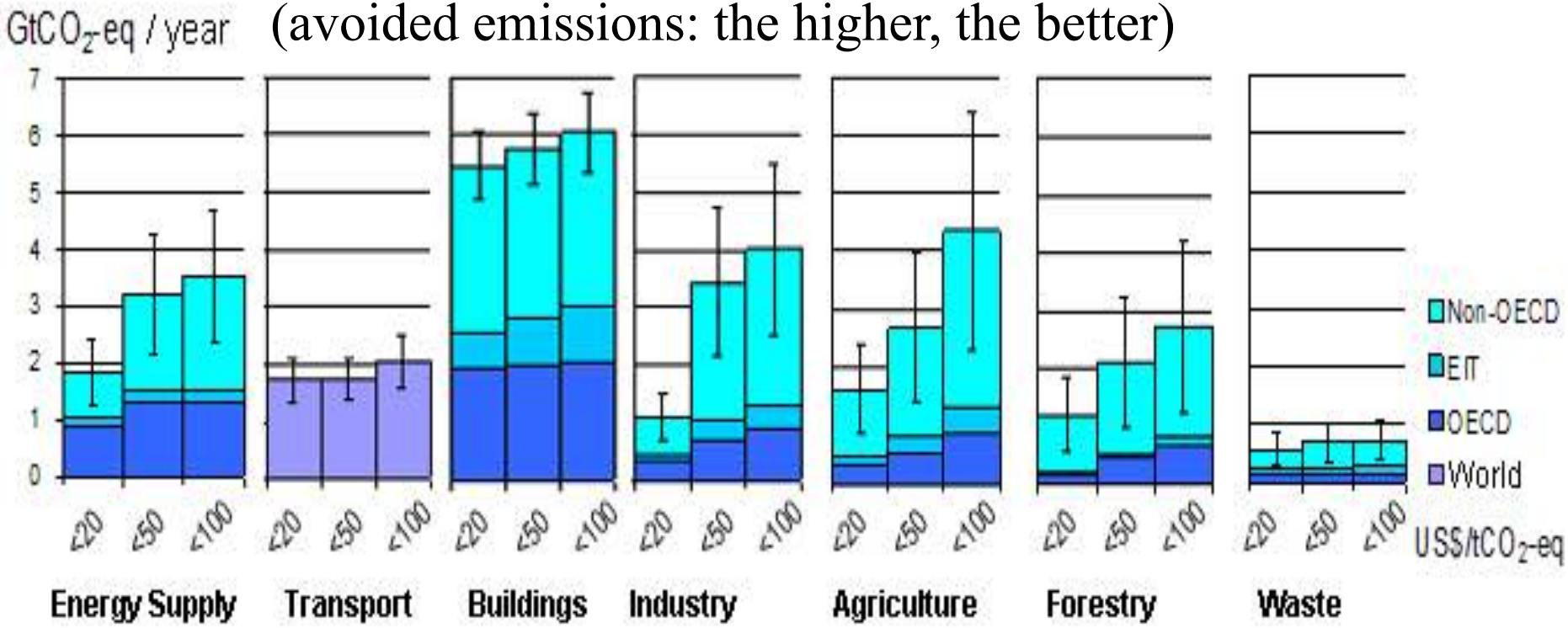
Lifestyle and behavioural changes

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

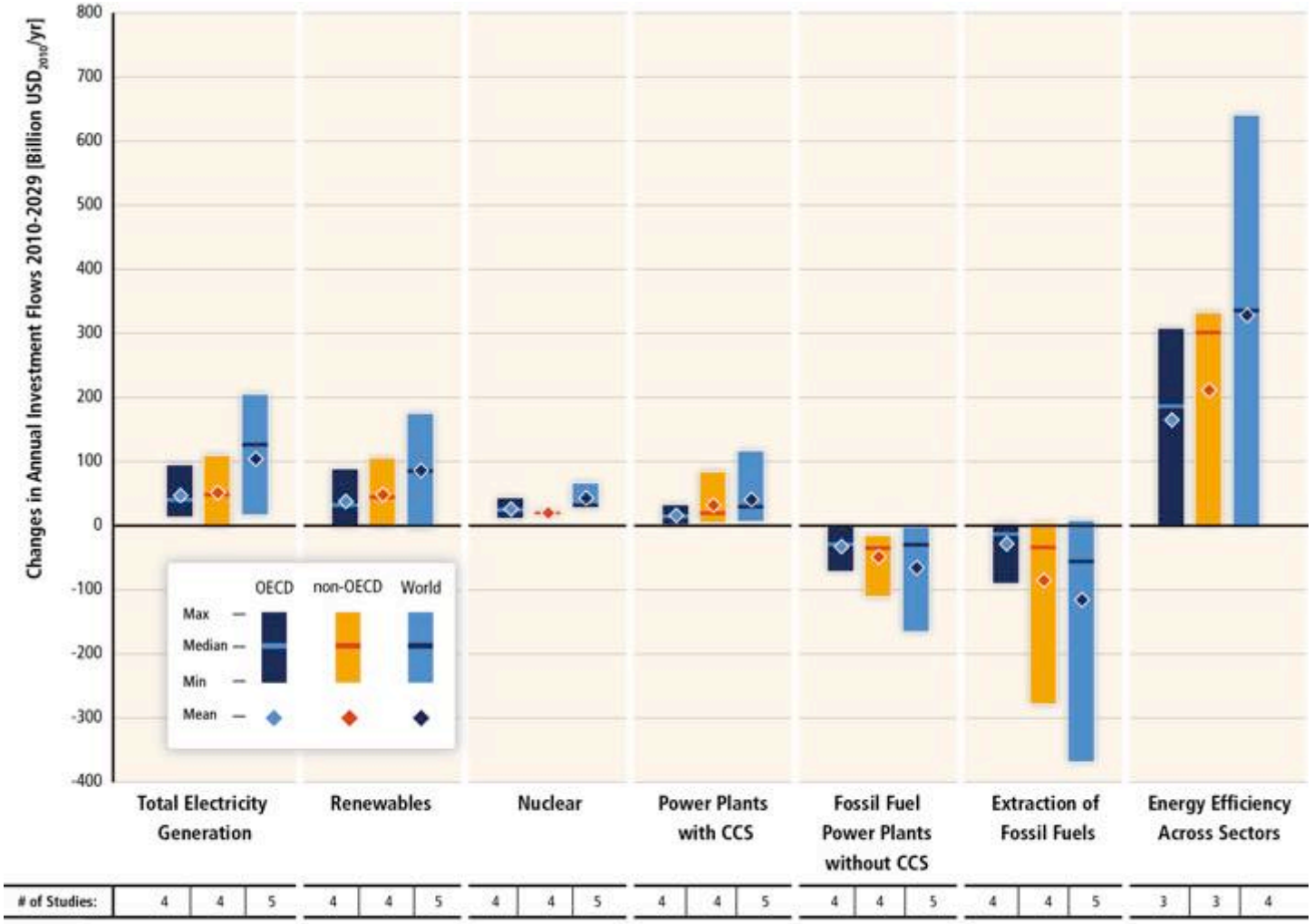
(avoided emissions: the higher, the better)



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.



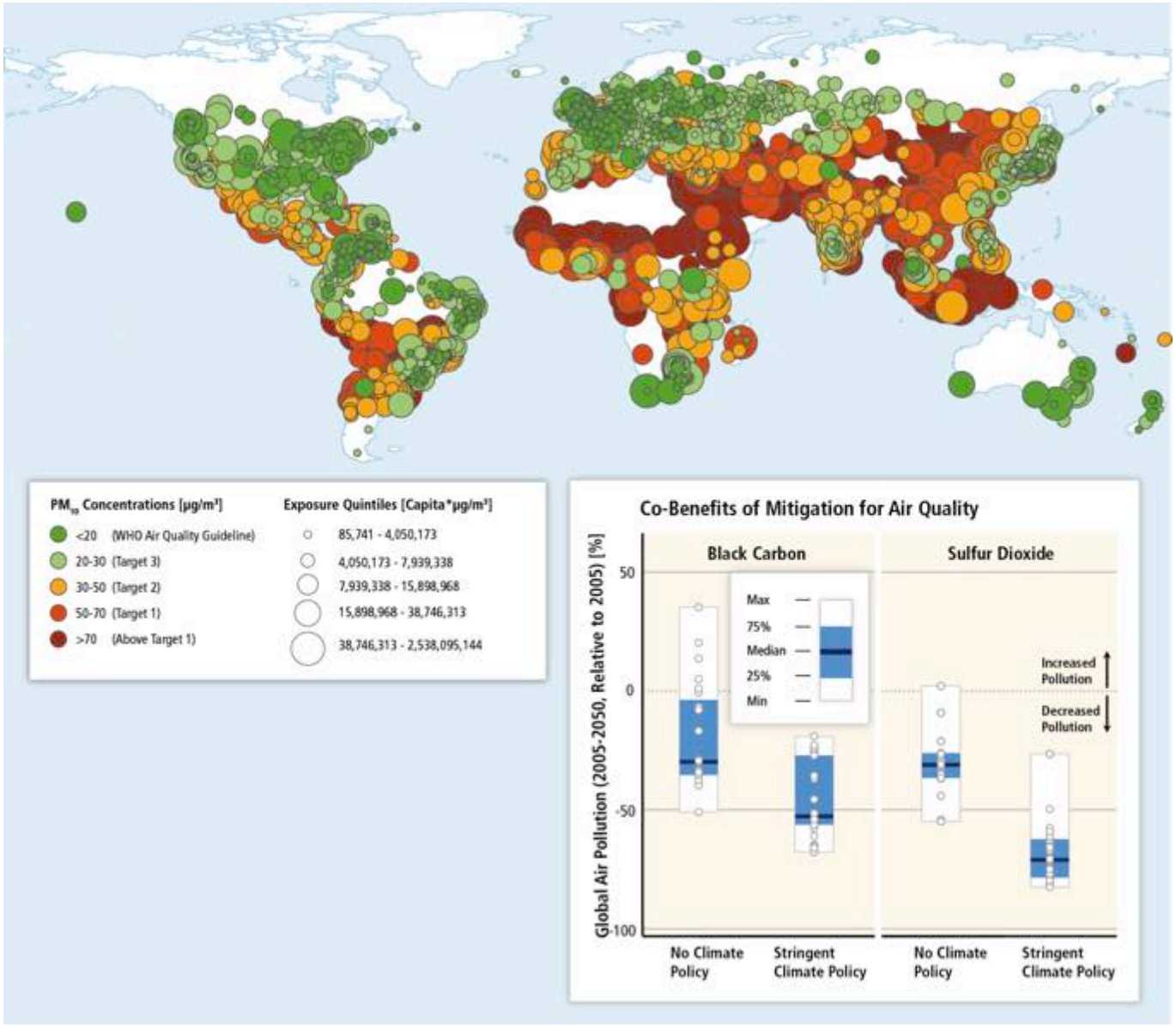
- **Substantial reductions in emissions would require large changes in investment patterns e.g., from 2010 to 2029, in billions US dollars/year:**
  (mean numbers rounded, IPCC AR5 WGIII Fig SPM 9)
- **energy efficiency: +330**
- **renewables: + 90**
- **power plants w/ CCS: + 40**
- **nuclear: + 40**
- **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


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 Hidden IPCC Message:

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

Dear President Obama
& The United States Congress,

Tomorrow
leaders from 192 countries
will gather at
The UN Climate Change Conference
in Copenhagen
to determine
the fate of our planet.

As business leaders we are optimistic that President Obama is attending Copenhagen with emissions targets. Additionally, we urge you, our government, to strengthen and pass United States legislation, and lead the world by example. We support your effort to ensure meaningful and effective measures to control climate change, an immediate challenge facing the United States and the world today. Please don't postpone the earth. If we fail to act now, it is scientifically irrefutable that there will be catastrophic and irreversible consequences for humanity and our planet.

We recognize the key role that American innovation and leadership play in stimulating the worldwide economy. Investing in a Clean Energy Economy will drive state-of-the-art technologies that will spur economic growth, create new energy jobs, and increase our energy security all while reducing the harmful emissions that are putting our planet at risk. We have the ability and the know-how to lead the world in clean energy technology to thrive in a global market and economy. But we must embrace the challenge today to ensure that future generations are left with a safe planet and a strong economy.

Please allow us, the United States of America, to serve in modeling the change necessary to protect humanity and our planet.

In partnership,

[illegible]

If you want to go quickly, go alone. If you want to go far, go together. african proverb

[illegible]

As business leaders we are optimistic that President Obama is attending

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Graydon Carter, Editor, Vanity Fair Deepak Chopra, Adjunct Professor, Kellogg School of Business and Management Yvon Chouinard, Founder, Patagonia
Ben Cohen, Jerry Greenfield, Co-founders, Ben & Jerry's Gregory Colbert, Creator, Ashes & Snow Kenneth Cole, Chairman, Kenneth Cole
Paulette Cole, CEO & Creative Director, ABC Home, ABC Carpet & Home Tom Colicchio, Chef & Owner, Craft Restaurants
Kit Crawford, Gary Erickson, Co-Owners & Co-CEOs, Clif Bar & Company Steve Ells, Founder, Chairman & Co-CEO, Chipotle Mexican Grill, Inc.
Eileen Fisher, CEO, Eileen Fisher Walt Freese, CEO, Ben & Jerry's Homemade
Mitchell Gold, Chairman, Bob Williams, President, Co-Founders, Mitchell Gold + Bob Williams Matt Goldman, Co-Founder & CEO, Blue Man Group

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Seth Goldman, CEO, Honest Tea Robert Grebler, Founder, Pokonobe Associates, Jenga Licensor Adrian Grenier, Reckless Productions
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Jeffrey Hollender, CEO, Seventh Generation Kate Hudson, David Babaii, Co-Founders, David Babaii for WildAid Mike Kaplan, CEO, Aspen Skiing Company
Michael Kieschnick, President, Credo Mobile Sheryl Leach, Creator & Founder of Barney Sven-Olof Lindblad, Founder, Lindblad Expeditions
Danny Meyer, CEO, Union Square Hospitality Group Laura Michalchyshyn, President & GM, Planet Green, Discovery Communications
Will Raap, Chairman & Founder, Gardener's Supply Company Horst Rechelbacher, Founder, Aveda, Founder & CEO, Intelligent Nutrients
David Rockwell, Founder & Owner, Rockwell Group Maury Rubin, Founder, Chef & CEO, City Bakery, Birdbath Green Bakery
Michael Rupp, CEO & President, The Rockport Company Gordon Segal, Chairman, Crate & Barrel Jeff Skoll, Founder, Participant Media and Skoll Foundation
Harvey Spevak, CEO, Equinox Greg Steltenpohl, Founder, Odwalla Michelle Stein, President, Aeffe USA
Martha Stewart, Founder, Martha Stewart Living Omnimedia, Inc. Jeffrey Swartz, CEO, Timberland Tom Szaky, CEO, TerraCycle
Donald J. Trump, Chairman and President, Donald J. Trump Jr., EVP, Eric F. Trump, EVP, Ivanka M. Trump, EVP, The Trump Organization
Jean-Georges Vongerichten, Executive Chef & Owner, Jean-Georges Management LLC

if you want to go quickly, go alone. if you want to go far, go together. african prove

Business leaders, sign onto this initiative: businessleaders4environmentalchange.

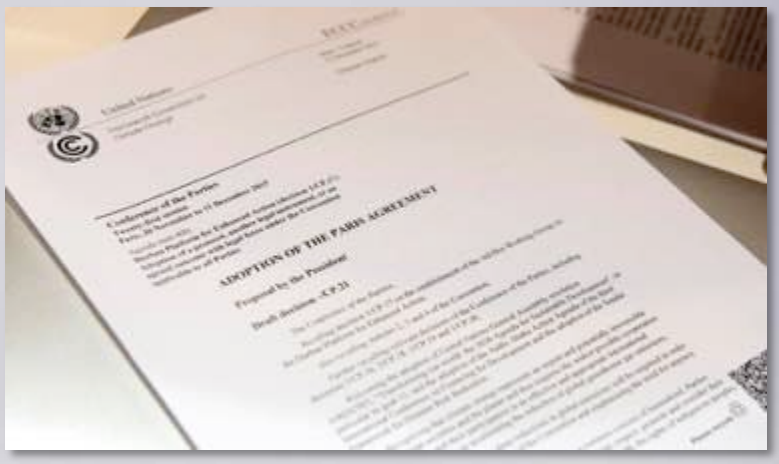
Process

1992	United Nations Framework Convention on Climate Change
1997	Kyoto Protocol
2009/ 2010	Copenhagen Accord & Cancún Agreements
2011	Durban Platform Start Negotiation 2015 Agreement
2012	Kyoto Protocol : 2e verbintenissenperiode
2015	Akkoord van Parijs

ur les Changements Climatiques 2015

COP21/CMP11

Paris, France



The Paris Agreement : Key elements


Nations Unies

FCCC/CP/2015/L.9/Rev.1

Convention-cadre sur les changements climatiques

Distr. limitée
12 décembre 2015
Français
Original : anglais

- Binding
- Universal
- Fair
- Ambitious
- Dynamic
- Transparent

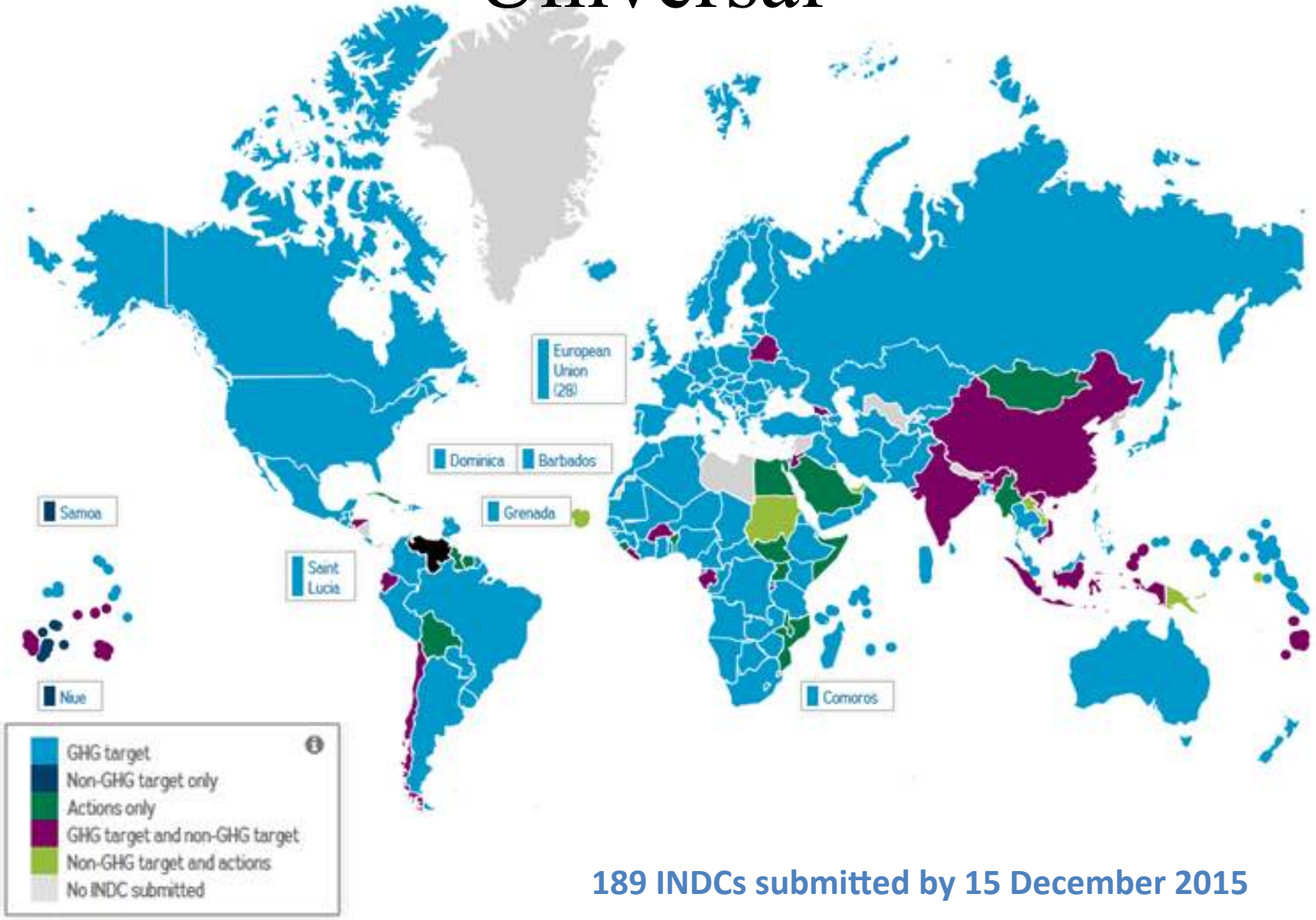
GE.15-21932 (F) 151215 161215

Merci de recycler

- *Vision / Long term objectives*
- *Différentiation of efforts*
- *Ambition cycle*
- *Mitigation*
- *Adaptation / Loss & Damages*
- *Financial flows*
- *Transparency & compliance*

- Main text: 25 pages (English version)
- Accompanying COP Decision (implementation plan and pre-2020 action): 36 pages

Universal



189 INDCs submitted by 15 December 2015

Source : World Resources Institute

Paris Agreement

- Article 2:
  - (…) to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:
    - Holding the increase in the global average temperature to **well below 2 °C** above pre-industrial levels and to **pursue efforts** to limit the temperature increase to **1.5 °C** above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;
    - **Increasing the ability to adapt** (…) and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production;
    - Making **finance flows consistent** with a pathway towards low greenhouse gas emissions and climate-resilient development

Paris Agreement

- Article 3:
  - As nationally determined contributions to the global response to climate change, **all Parties** are to undertake and communicate ambitious efforts (…) with the view to achieving the purpose of this Agreement as set out in Article 2.

    The efforts of all Parties will represent **a progression over time**, while recognizing the **need to support developing country** Parties for the effective implementation of this Agreement.

Paris Agreement

- Article 4:
  - 1. (…) Parties aim to reach **global peaking** of greenhouse gas emissions **as soon as possible**, recognizing that **peaking will take longer for developing country Parties**,
  - and to undertake **rapid reductions thereafter in accordance with best available science**,
  - so as to achieve a **balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century**, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty
  - 3. **Each Party's successive nationally determined contribution will represent a progression**(…)

Paris Agreement

- Article 4 (cont.):
  - 4. Developed country Parties should continue taking the lead by undertaking economy-wide absolute emission reduction targets.
  - Developing country Parties should continue enhancing their mitigation efforts, and are encouraged to move over time towards economy-wide emission reduction or limitation targets in the light of different national circumstances.
  - **Each Party shall communicate a nationally determined contribution every five years**
  - Parties shall take into consideration in the implementation of this Agreement the concerns of

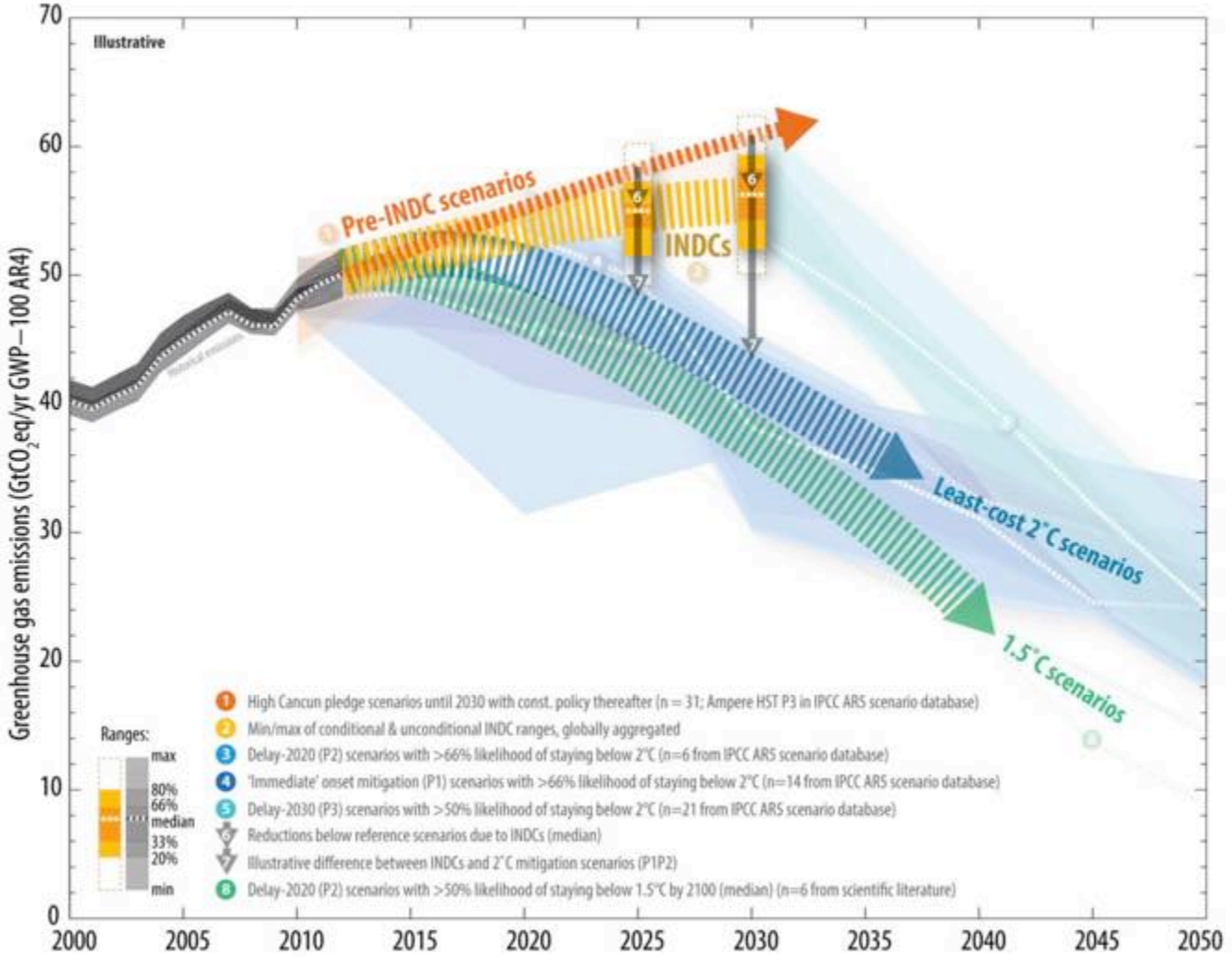
Paris Agreement

- Article 5:
  - Parties should take action to conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases (…) including forests.
  - Parties are encouraged to take action to implement and support (…) policy approaches and positive incentives for activities relating to reducing emissions from deforestation and forest degradation,
- Article 6
  - 4. A mechanism to contribute to the mitigation of greenhouse gas emissions and support sustainable development is hereby established under the authority and guidance of the Conference of the Parties (…) for use

Paris Agreement

- Article 7
  - Parties hereby establish the global goal on adaptation of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change
- Article 8
  - Parties recognize the importance of averting, minimizing and **addressing loss and damage** associated with the adverse effects of climate change, including extreme weather events and slow onset events, and the role of sustainable development in reducing the risk of loss and damage.

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

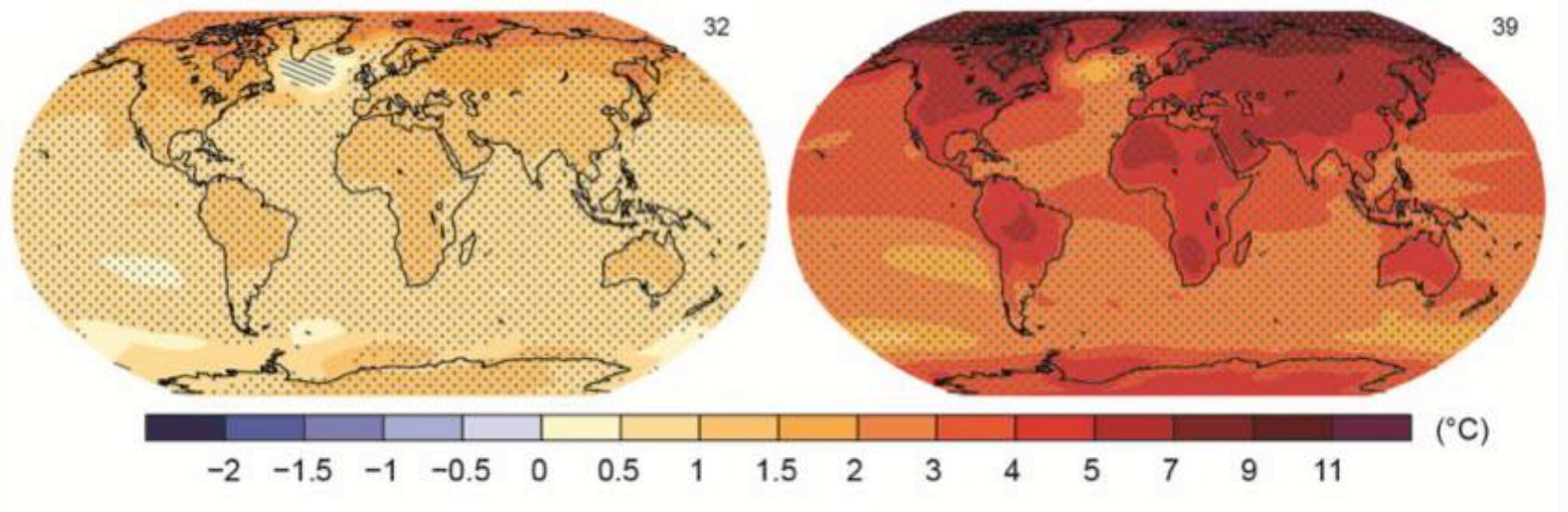


UNFCCC, Aggregate effect of the intended nationally determined contributions: an update http://unfccc.int/resource/docs/2016/cop22/eng/02.pdf

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

With substantial mitigation

Without additional mitigation

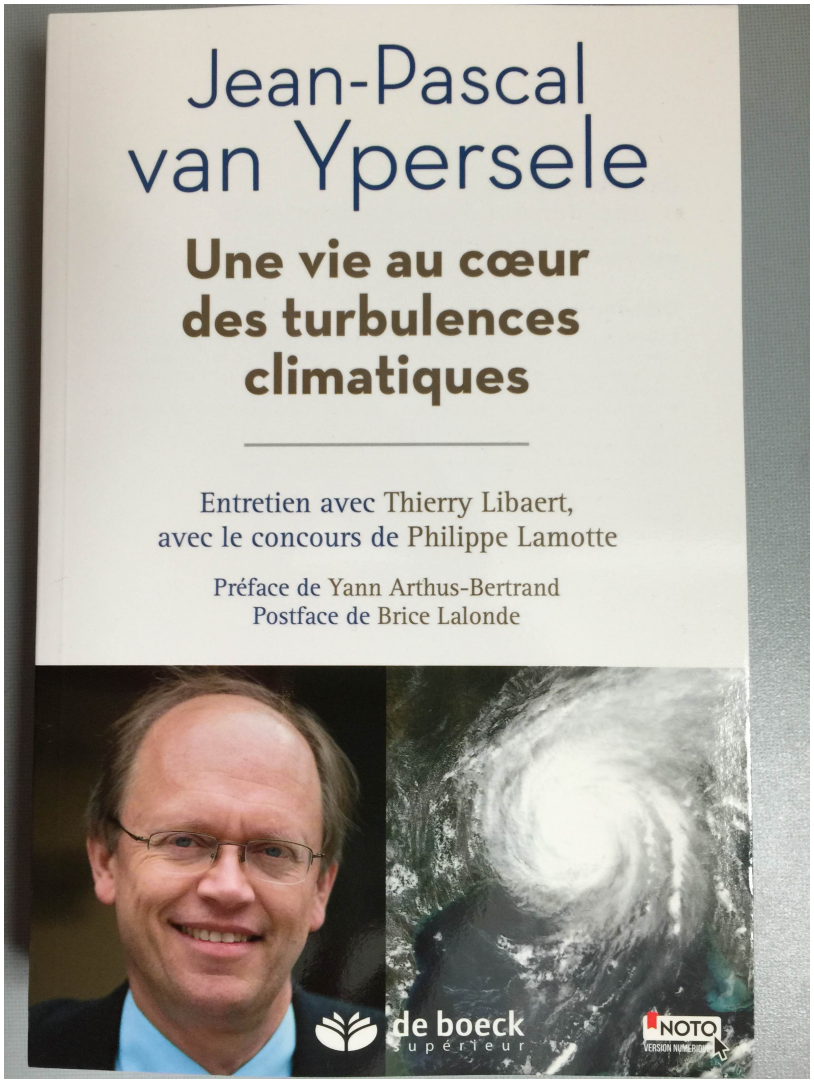


Change in average surface temperature (1986–2005 to 2081–2100)

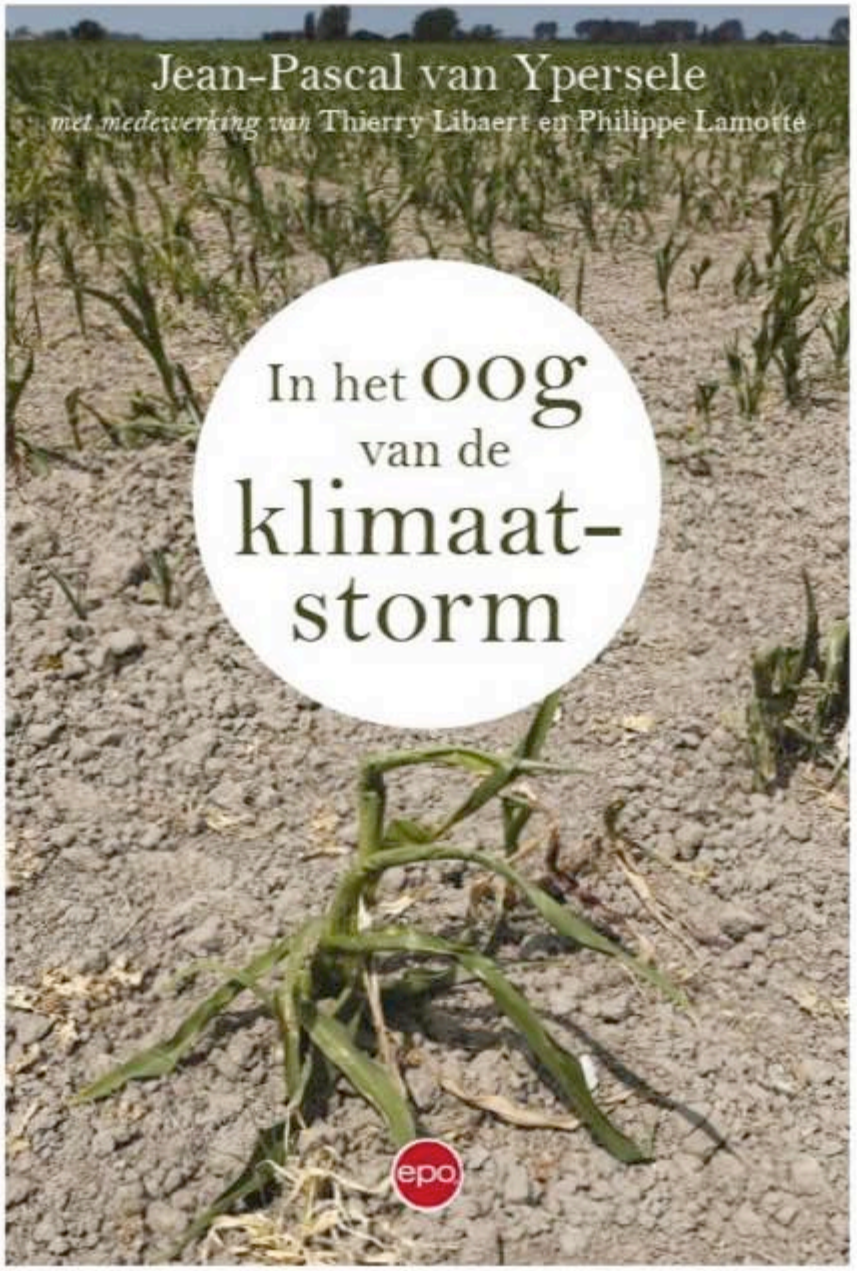
AR5 WGI SPM

Publié chez De Boeck supérieur,
octobre 2015
Broché: 16 euros
E-book: 13 euros

Straks in het Nederlands
(« In het oog van de klimaatstorm », bij EPO)



Straks (eind 2017) in het Nederlands (« In het oog van de klimaatstorm », bij EPO.be, 17 euros)



Pier Vellinga, 2011: Hoezo klimaatverandering , Feiten, fabels en open vragen, Uitgeverij Balans.

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**