Climate Change: Challenges & Opportunities

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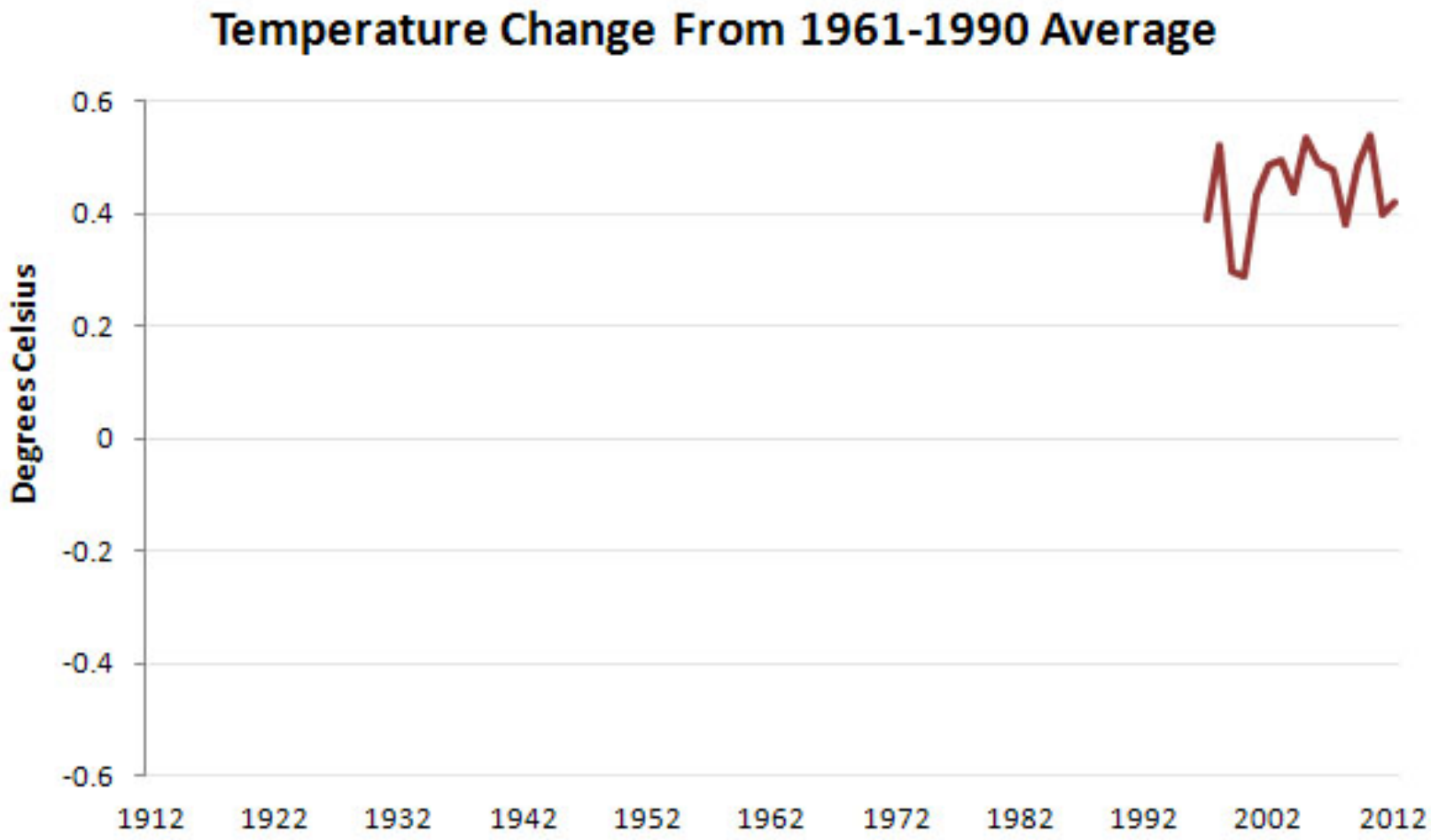
Former IPCC Vice-Chair (2008- oct. 2015)

Twitter: @JPvanYpersele

CERIS, Brussels, 3 December 2016

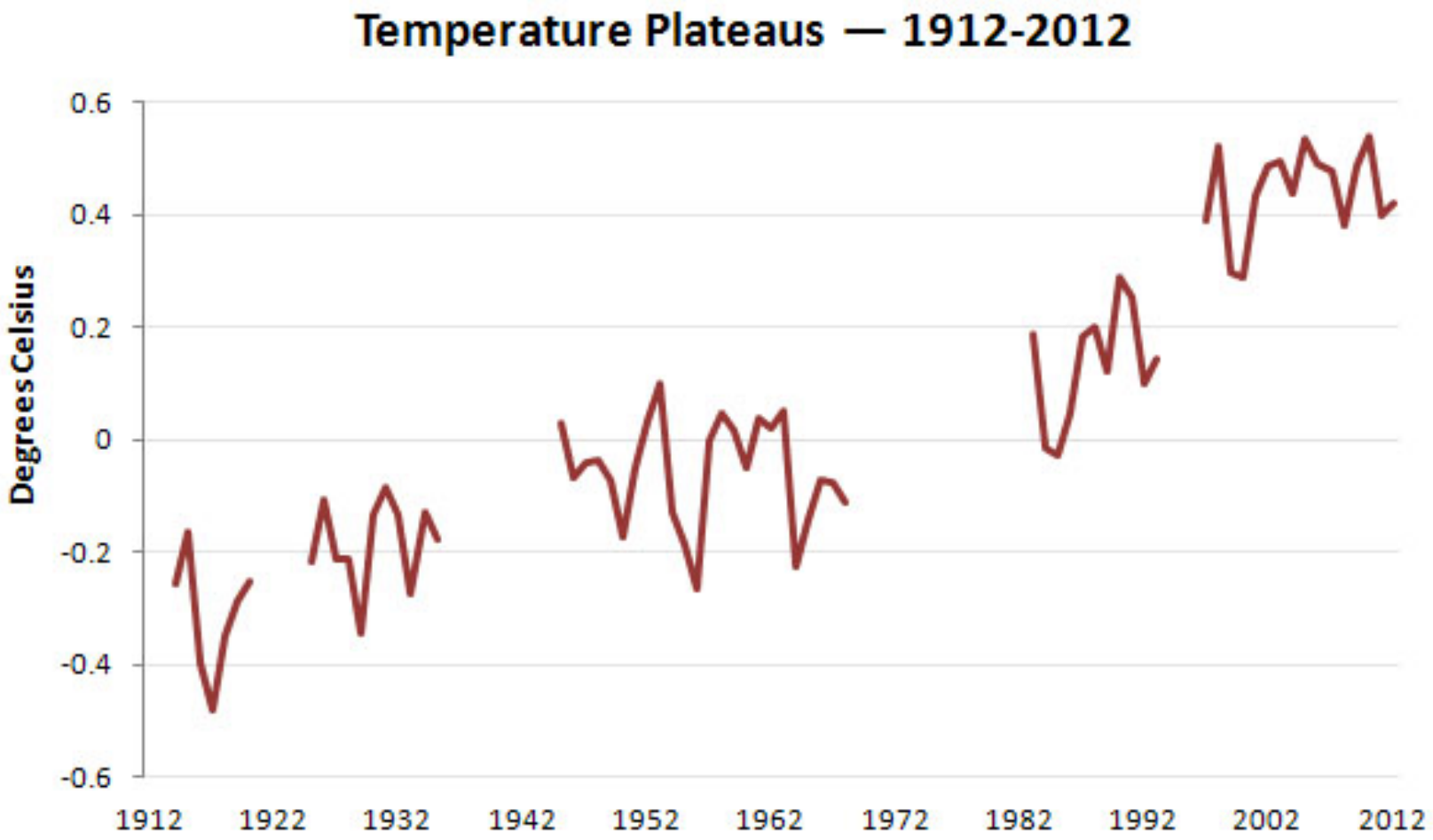
Thanks to the Walloon Government (funding the Walloon Platform for IPCC) and to my team at the Université catholique de Louvain for their support

Let us think about the future of these children from Machakos in a warming climate



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

Lying With Statistics, Global Warming Edition



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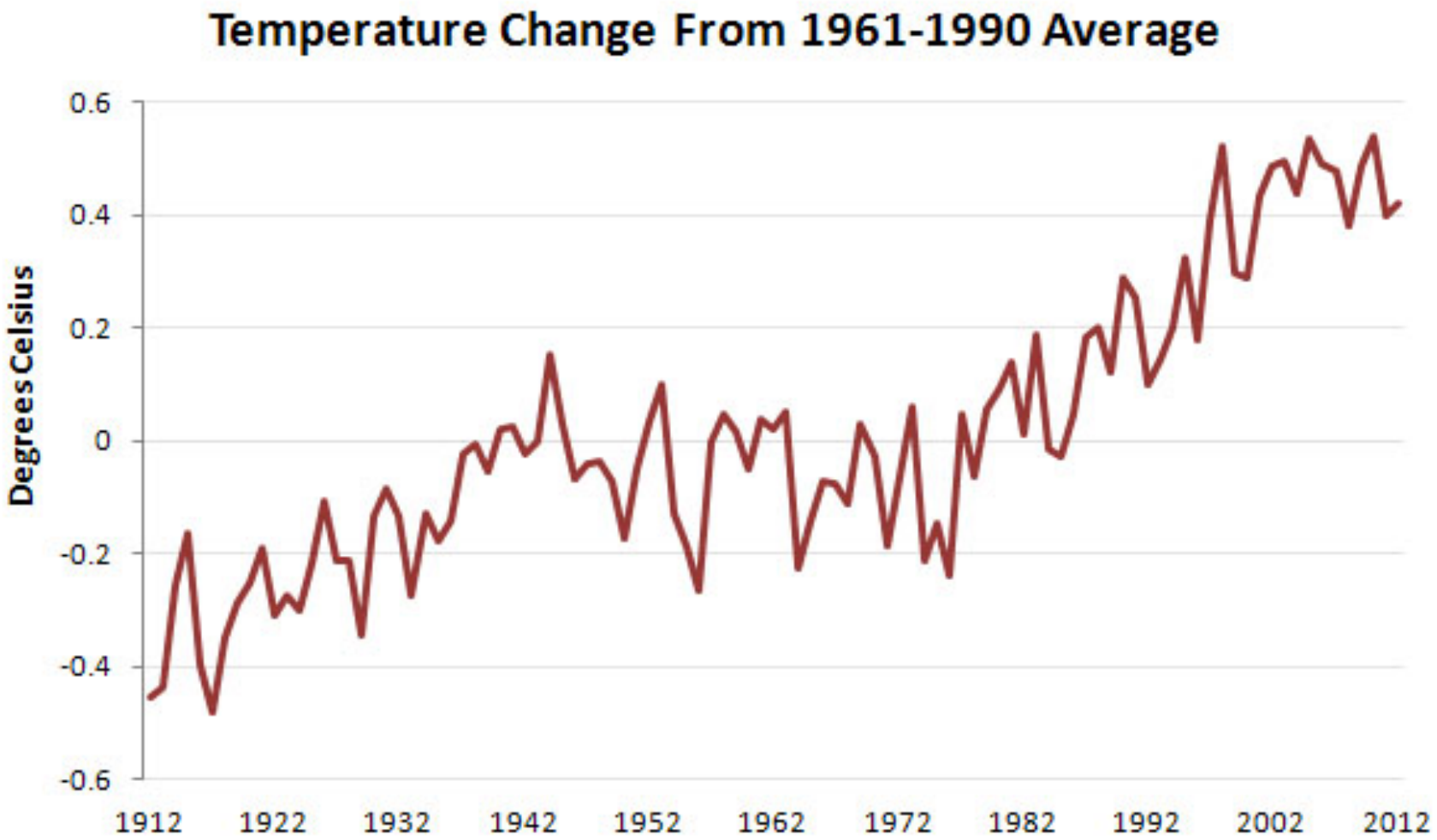
Lying With Statistics, Global Warming Edition



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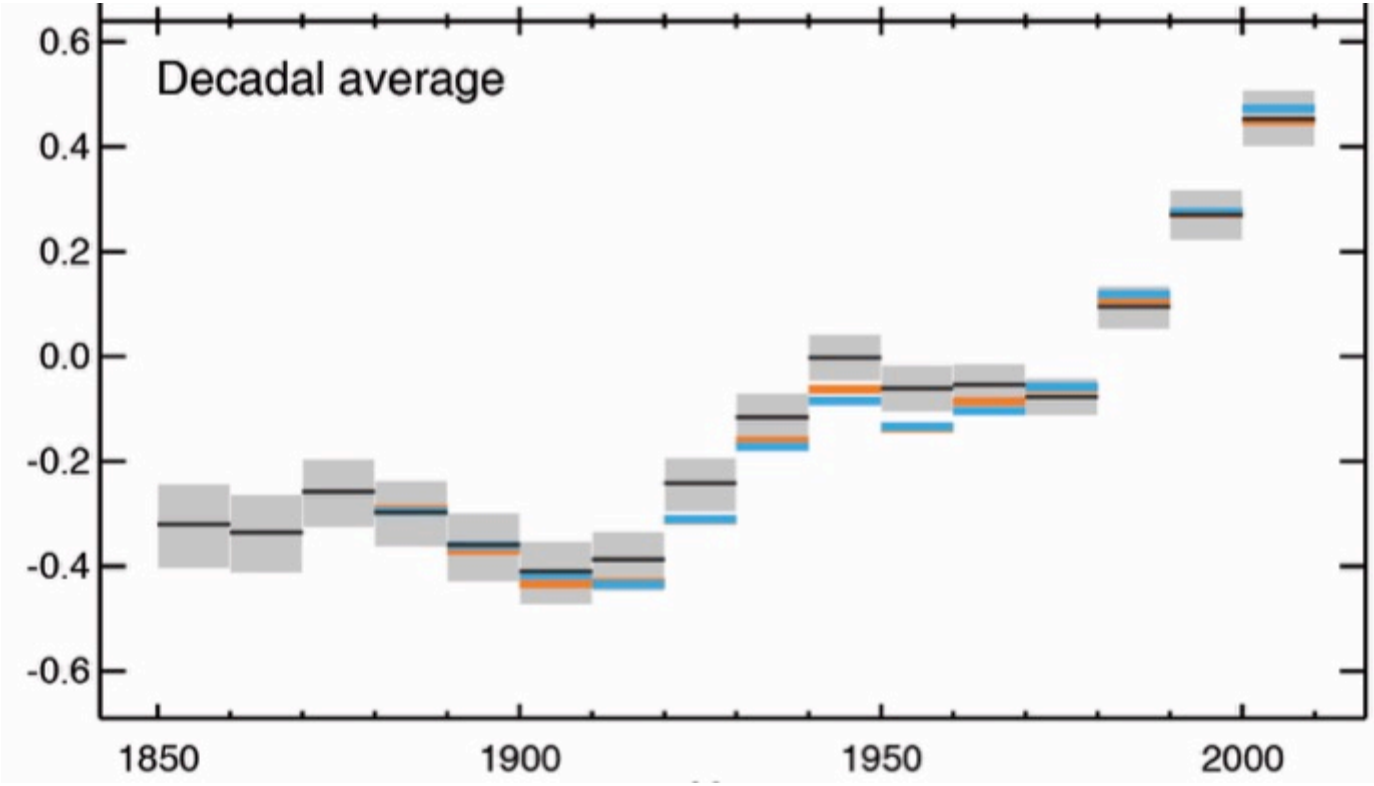
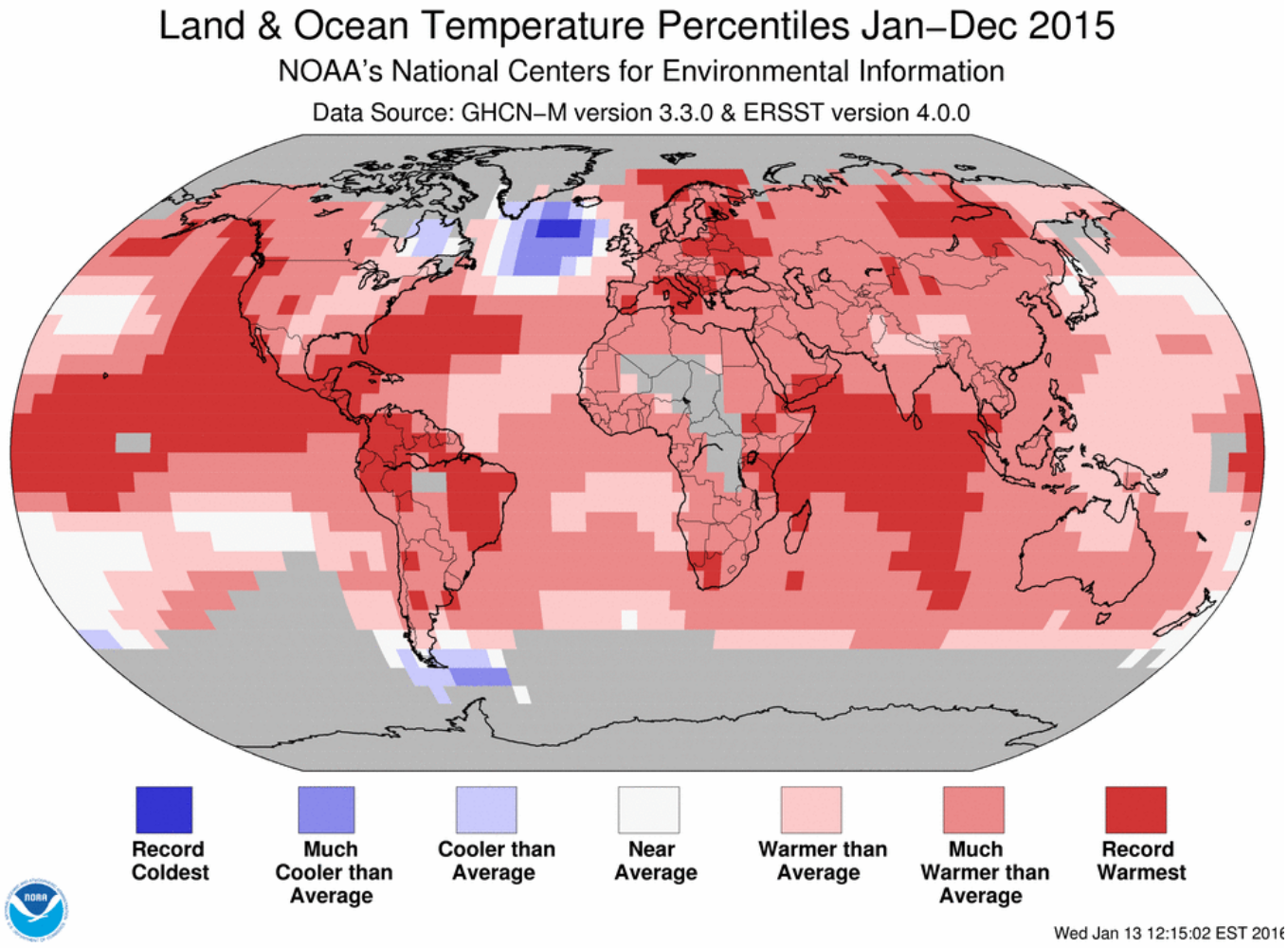


(IPCC 2013, Fig. SPM.1a)

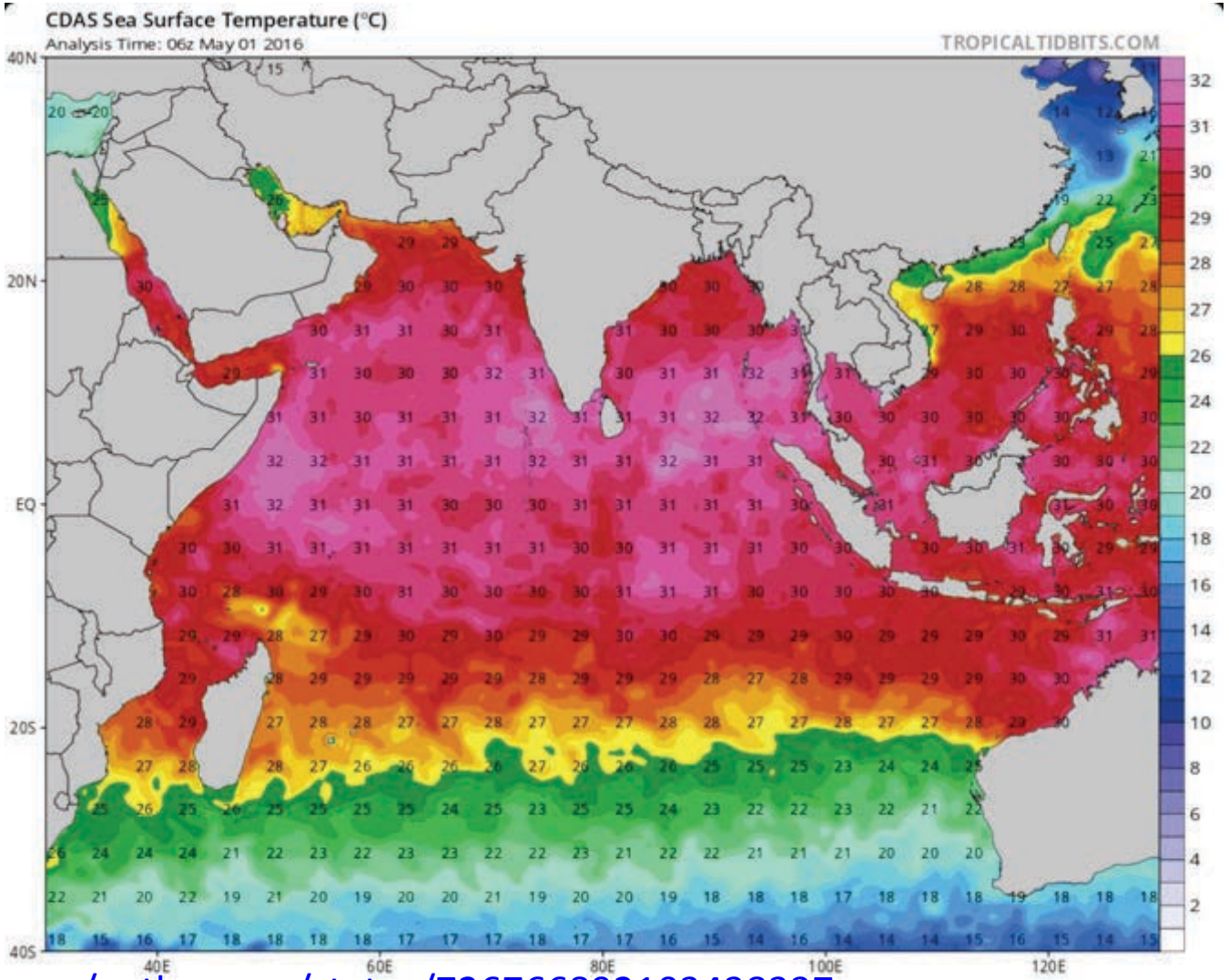
Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850.

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

2015= warmest year since 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

Six weeks worth of rain has fallen in three days over parts of France (May 2016)

Markus Schreiber / AP

The Louvre and Musée d'Orsay in Paris evacuated their vaults (May 2016)

Geoffroy Van Der Hasselt / Getty Images

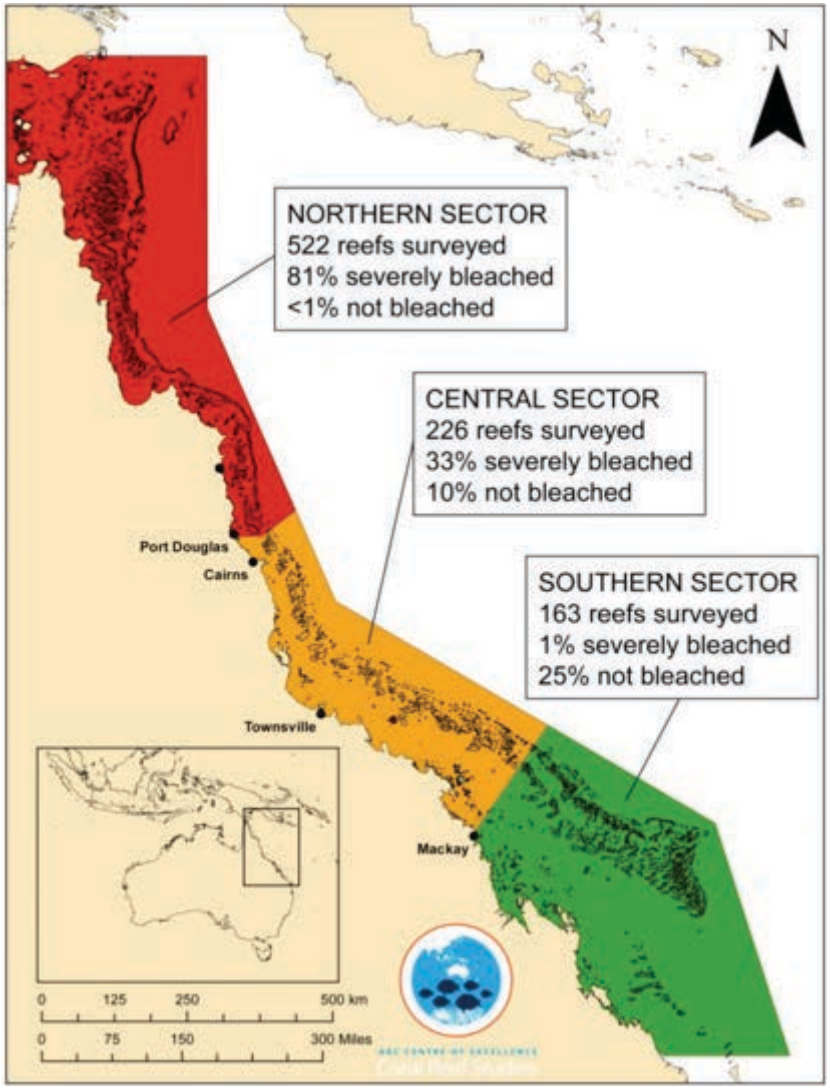
In Germany, many residents weren't prepared for the mass flooding as the rain pelted down (May 2016)

Matthias Schrader / AP

Coral reefs are dying

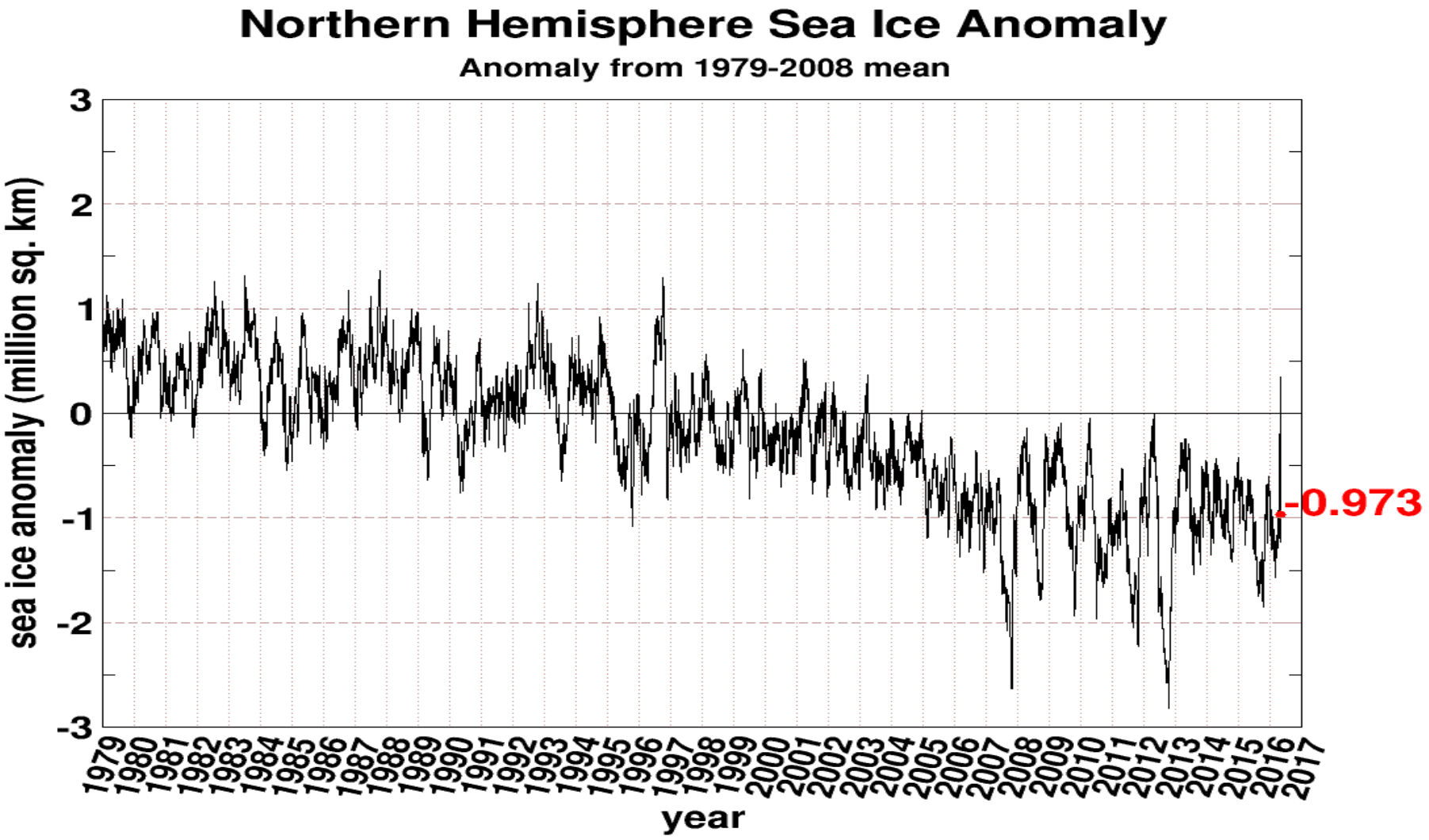
American Samoa (from www.globalcoralbleaching.org)

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

Arctic Sea Ice Cover (1979-2016)



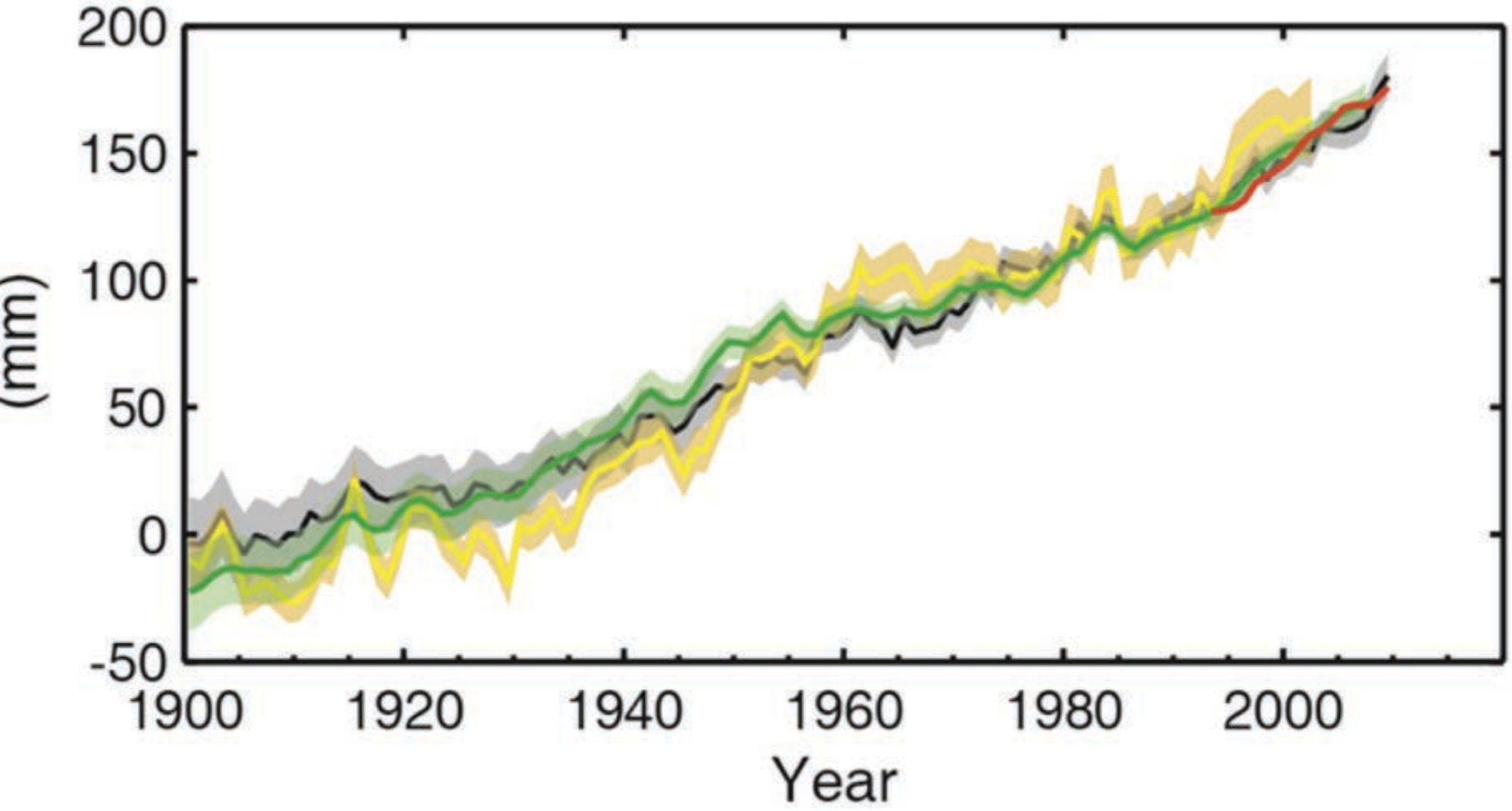
Plateau Glacier (1961)
(Alaska)

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)

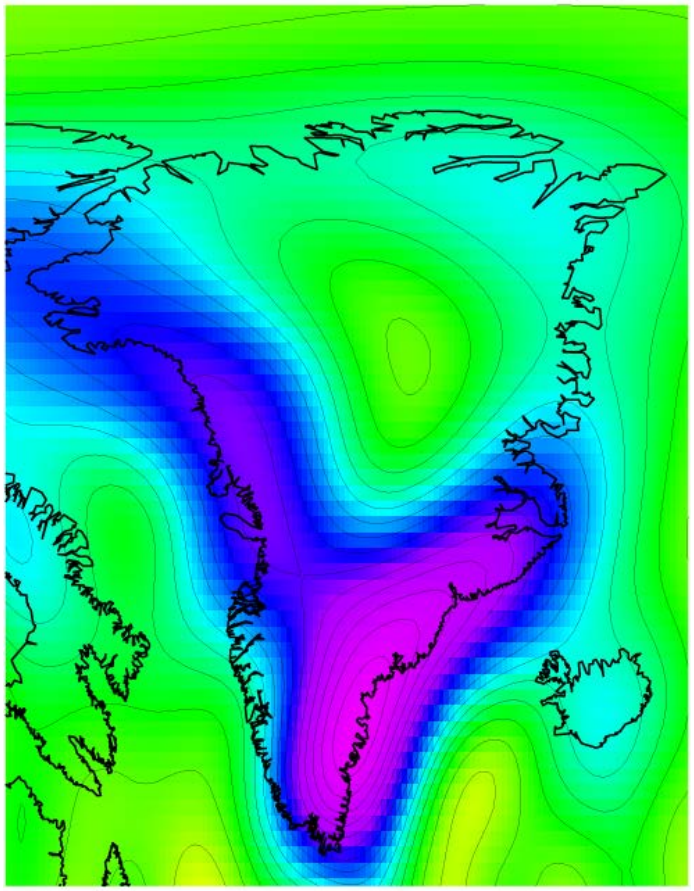
http://www.weather.com/news/science/environment/alaskas-glaciers-capturing-earth-changing-our-eyes-20131125?cm_ven=Email&cm_cat=ENVIRONMENT_us_share

Change in average sea-level change

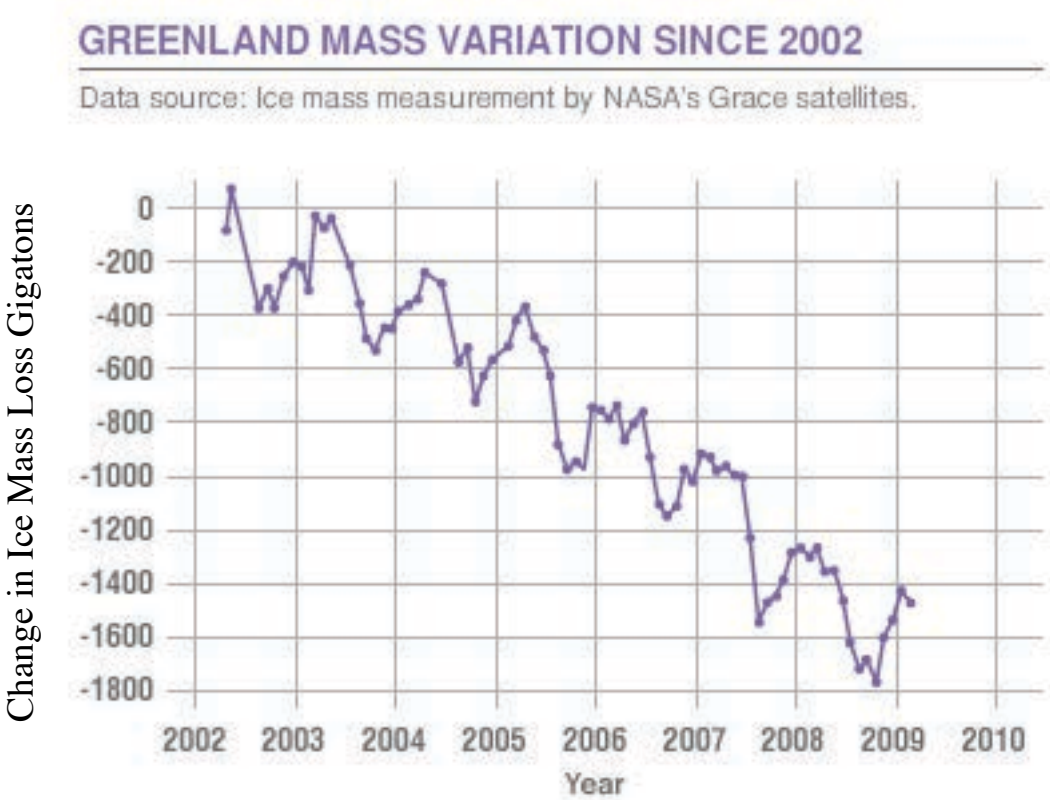


Greenland Ice Mass Loss 2002-2009 Derived From NASA GRACE Gravity Mission

Greenland



J. Wahr, U. Colorado



Velicogna, Geophysical Research Letters, 2009

•Contributes to sea level rise

B. Holt - JPL

Why the IPCC ?

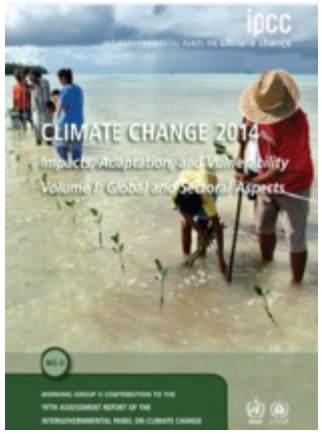
Established by WMO and UNEP in 1988

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?

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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

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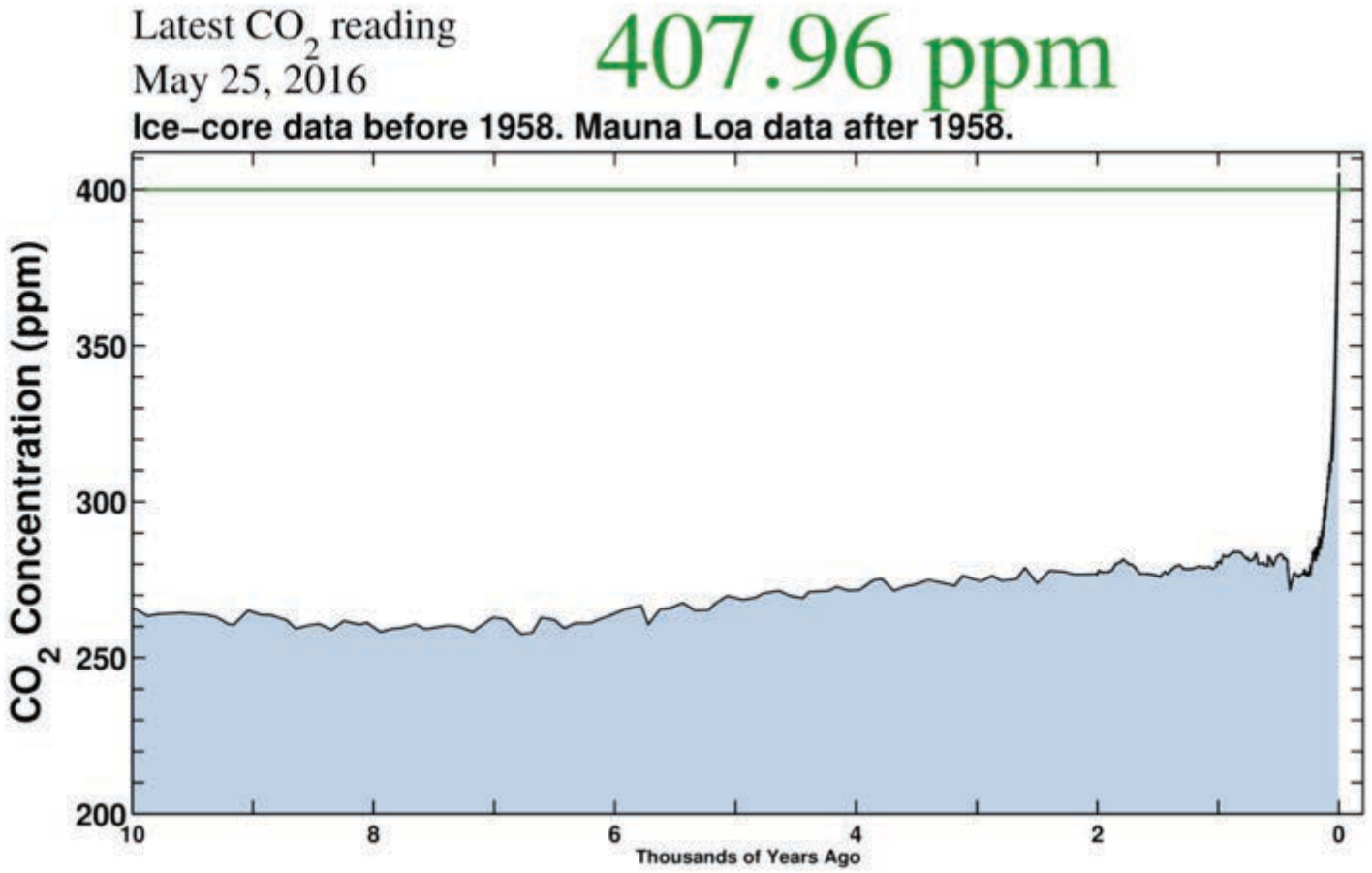
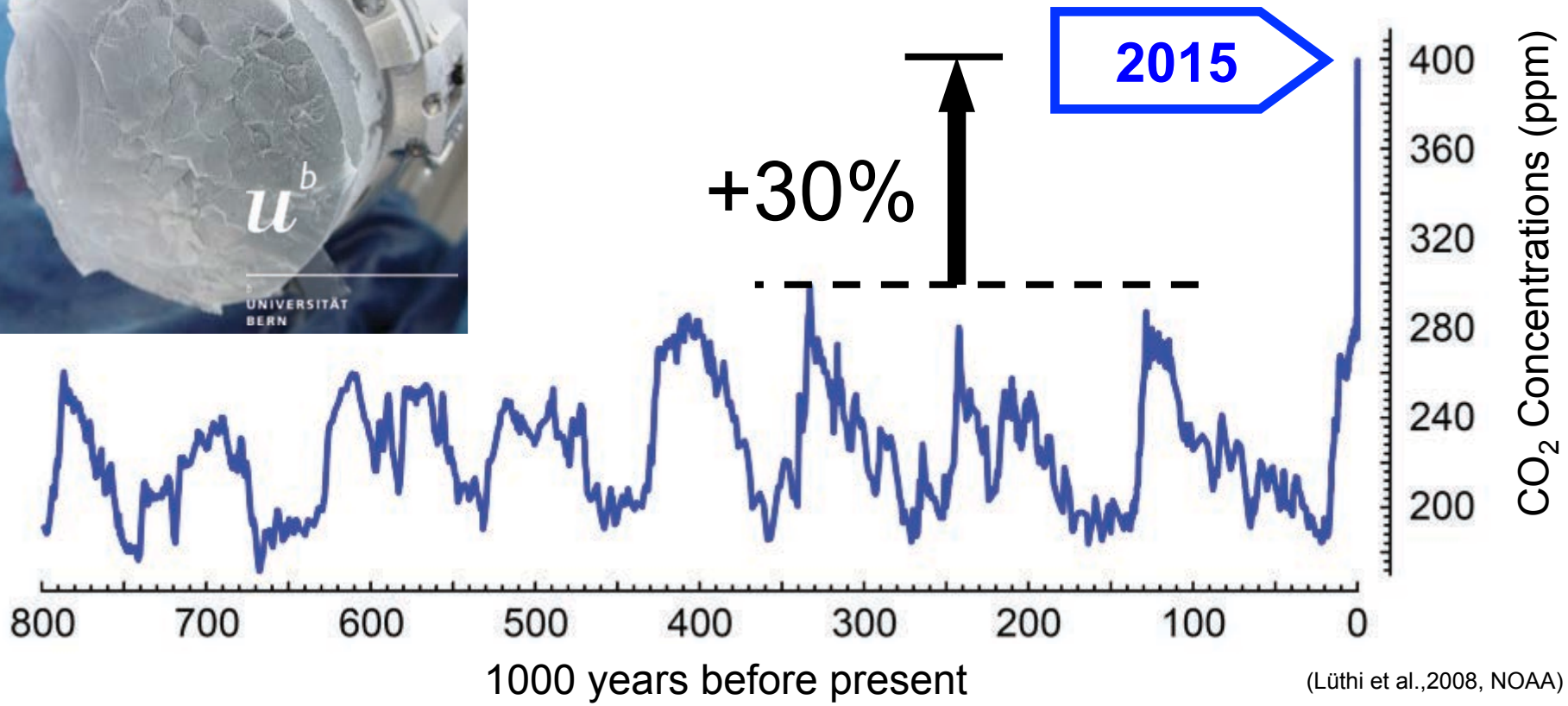
CO_2 Concentration, 25 May 2016 (Keeling curve)



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

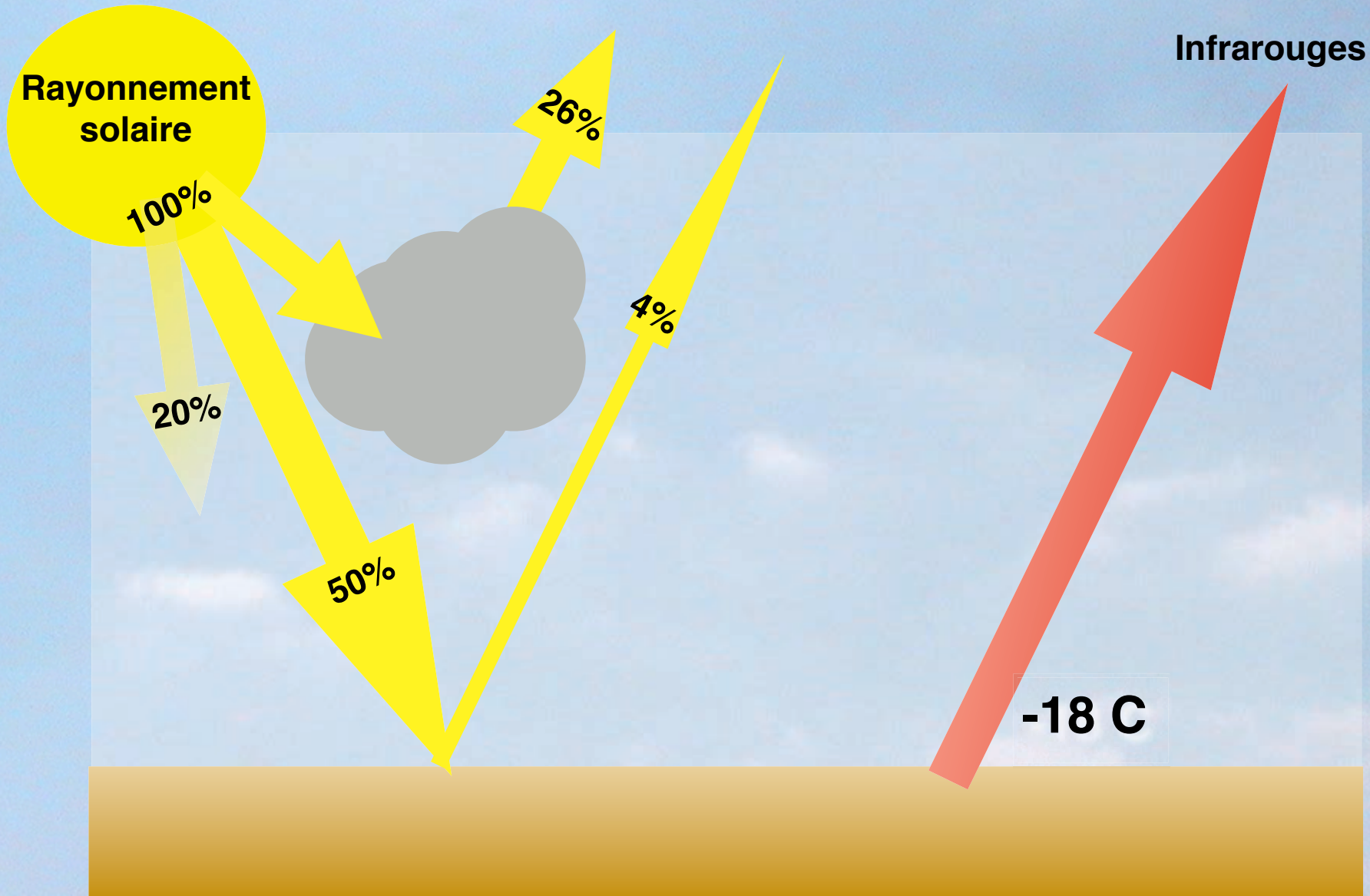
Atmospheric concentrations of CO_2



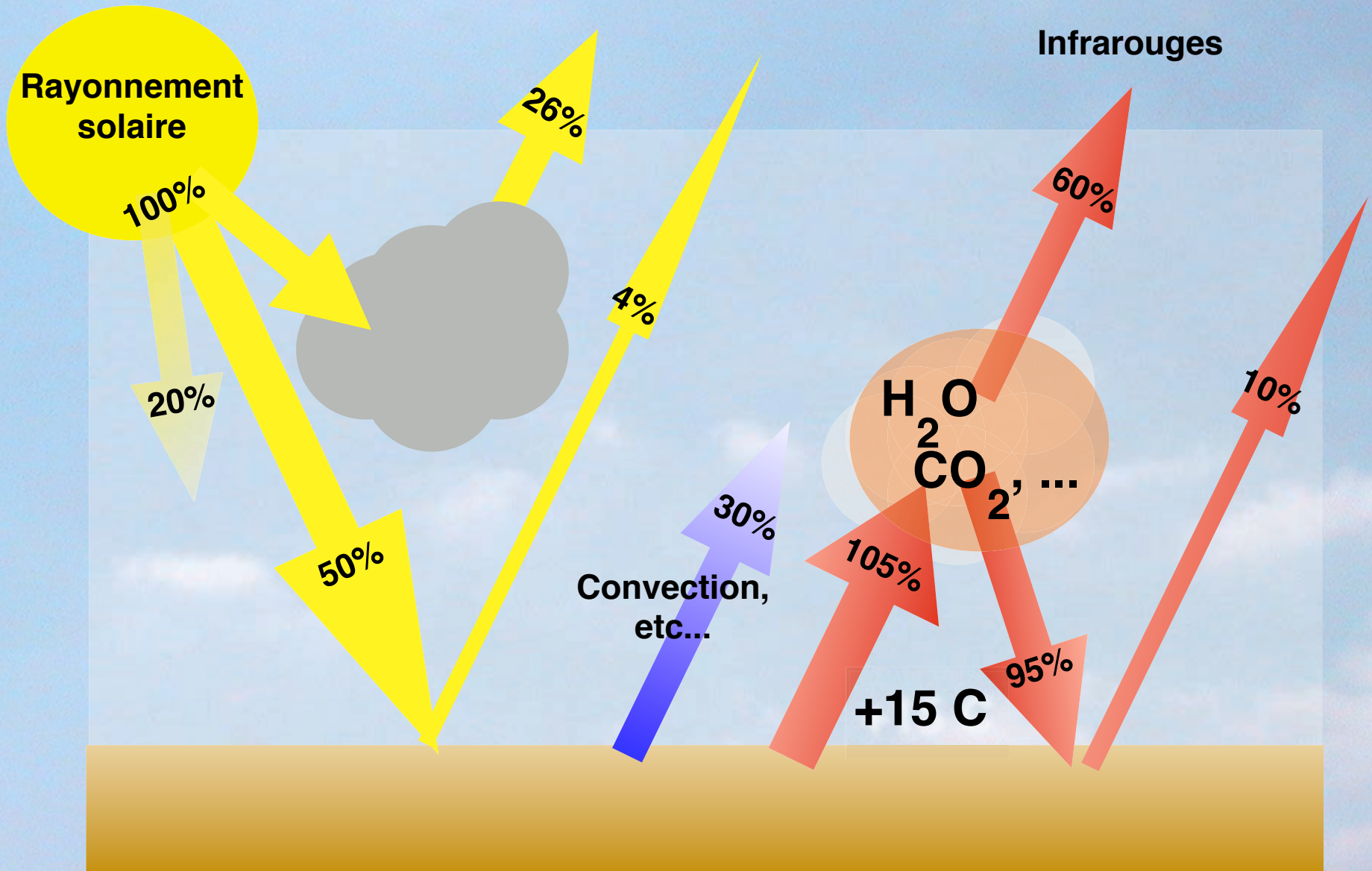
(Lüthi et al.,2008, NOAA)

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

Cycle de l'énergie et effet de serre



Cycle de l'énergie et effet de serre



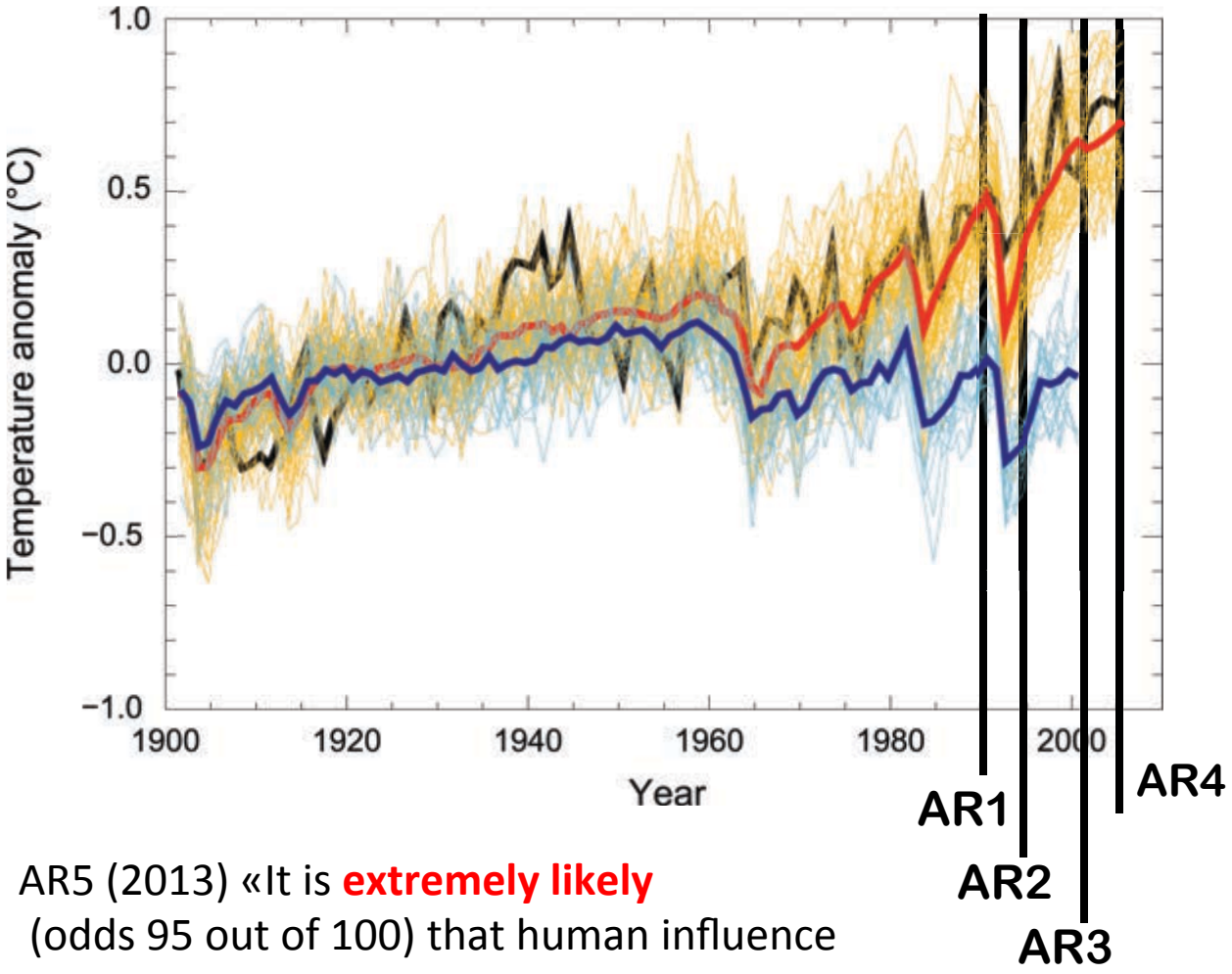
A Progression of Understanding: Greater and Greater Certainty in Attribution

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

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

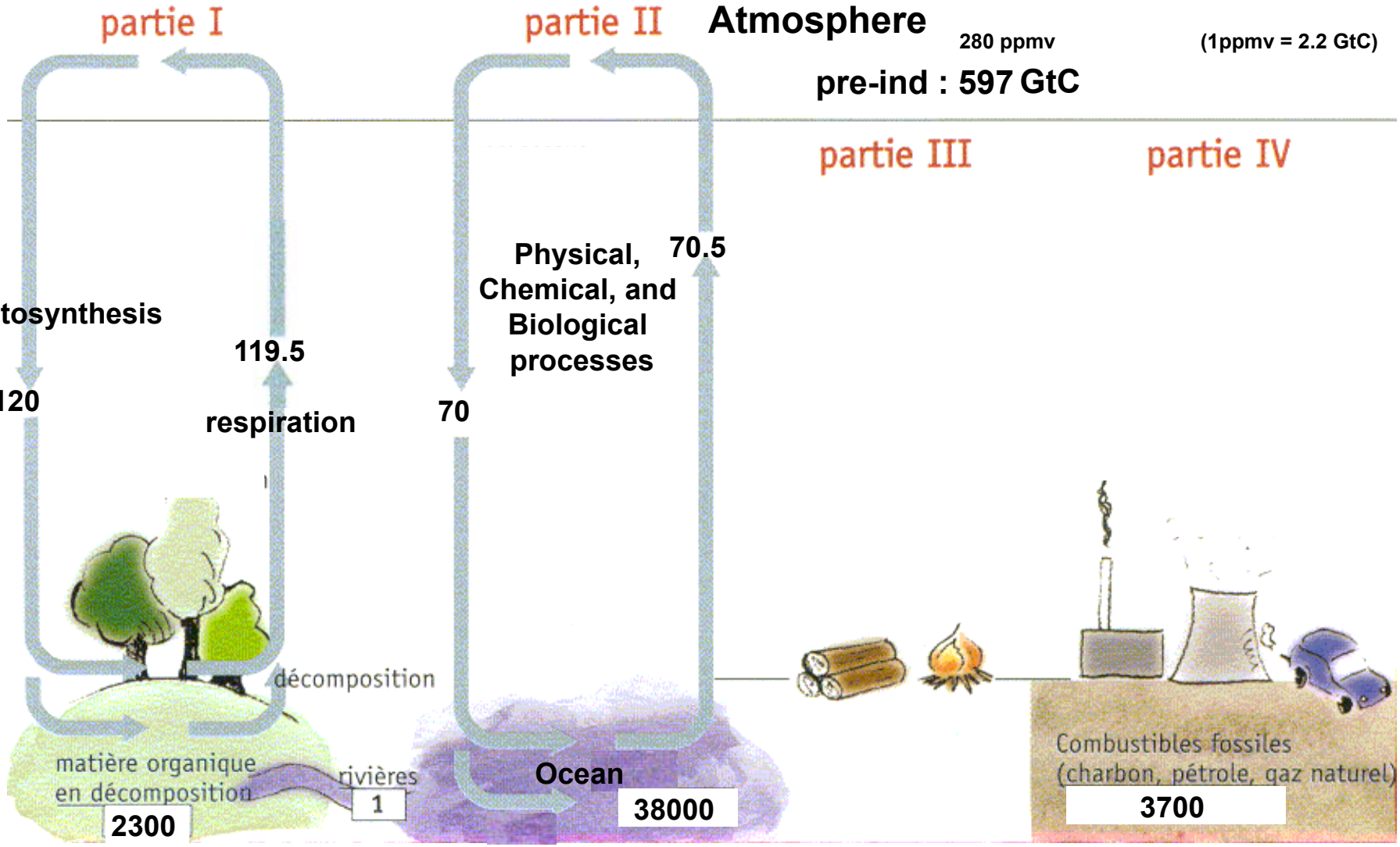
AR3 (2001): "most of the warming of the past 50 years is **likely** (odds 2 out of 3) due to human activities"

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… »

Carbon cycle: unperturbed fluxes

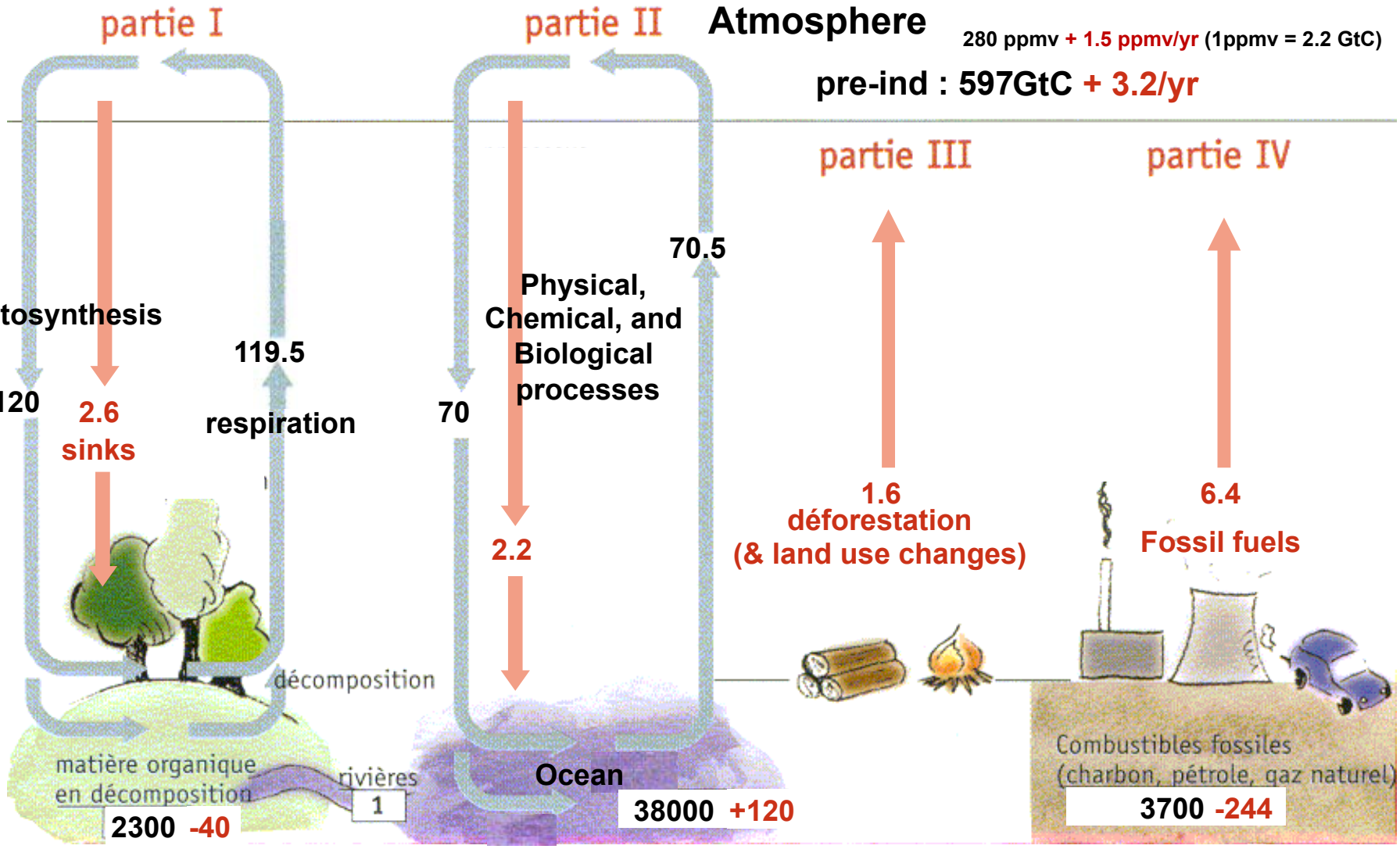


Units: GtC (billions tons of carbon) or GtC/year (multiply by 3.7 to get $GtCO_2$)

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

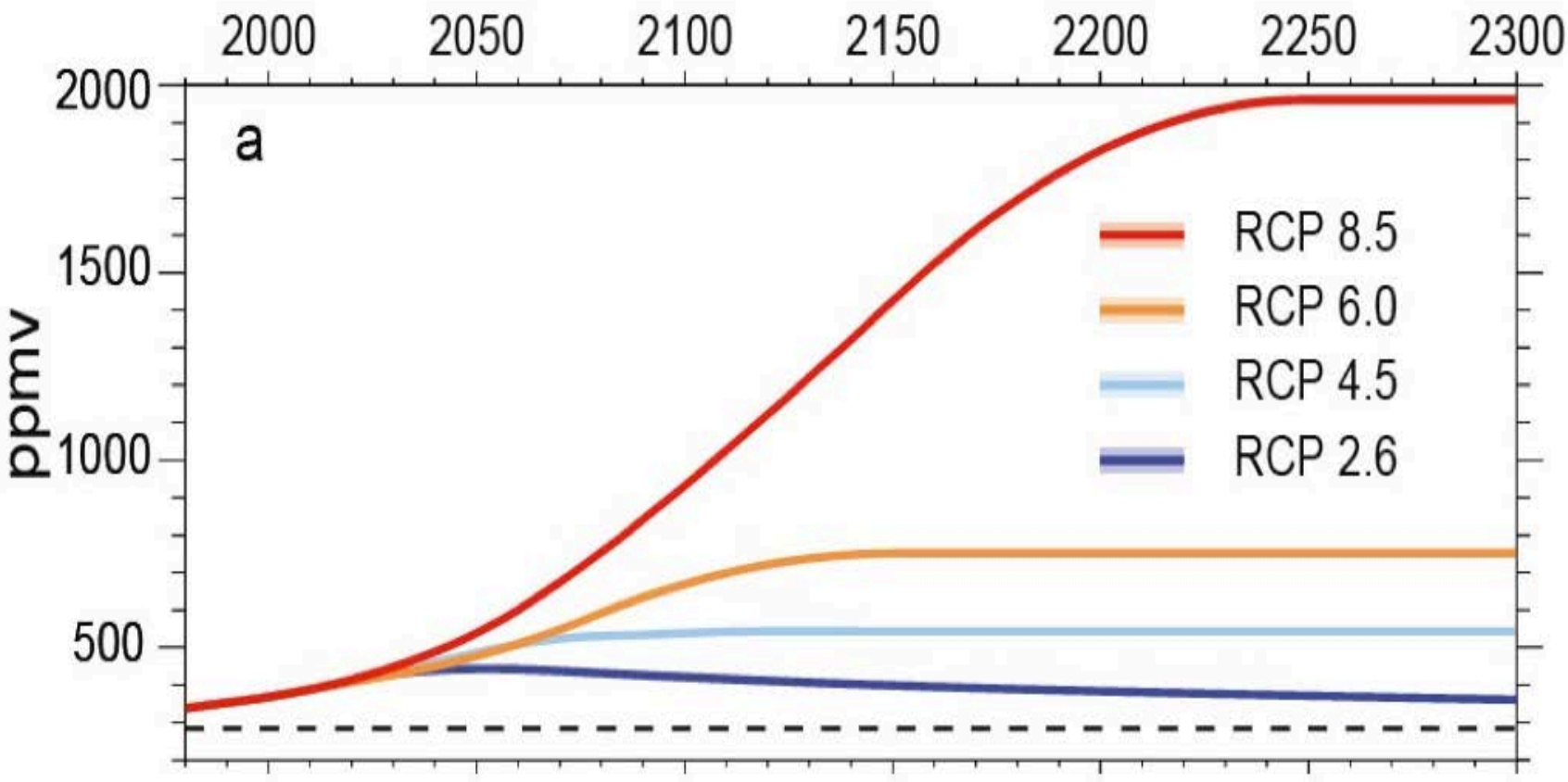
Stocks!

vanyp@climate.be

The carbon cycle is policy-relevant

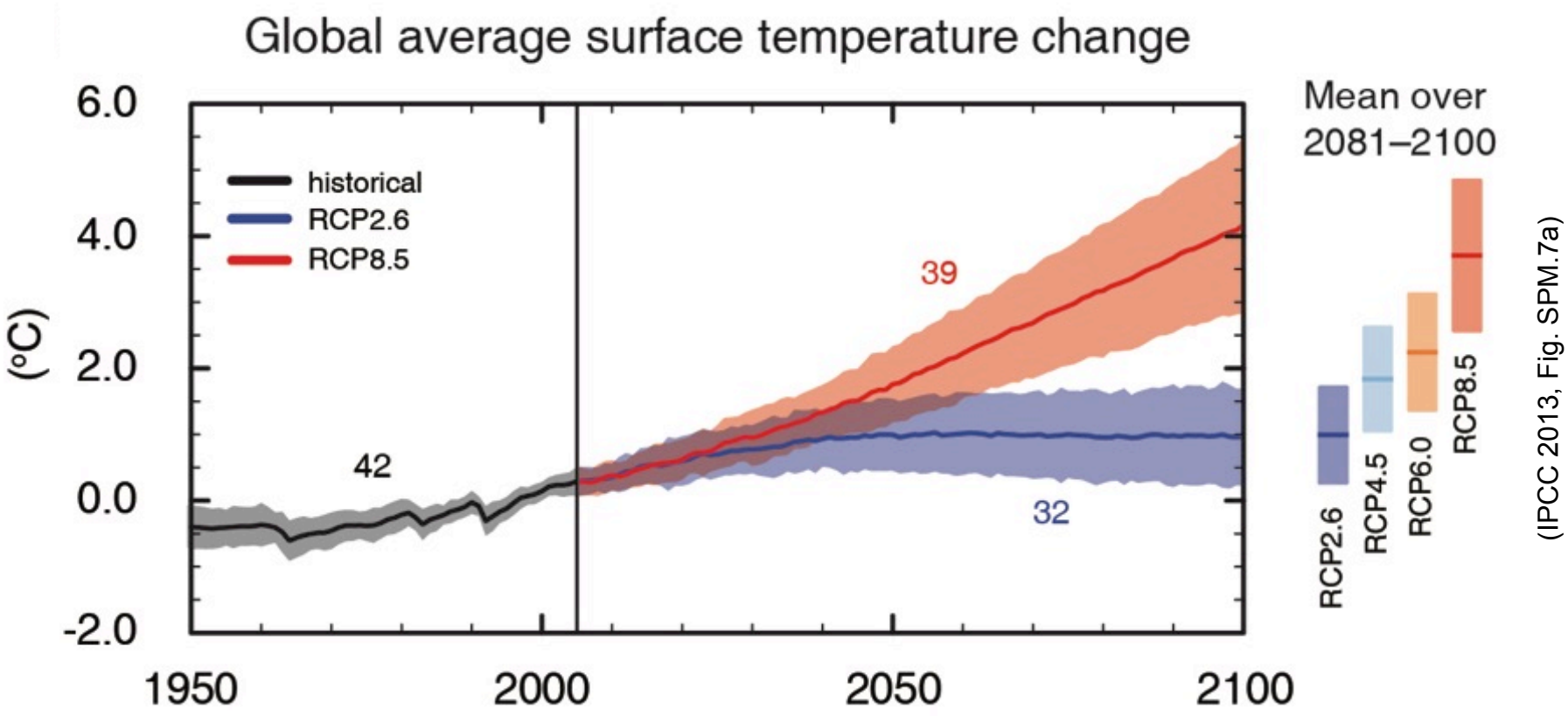
- **CO_2 accumulates in the atmosphere as long as human emissions are larger than the natural absorption capacity**
- **Historical emissions from developed countries therefore matter for a long time**
- **As warming is function of cumulated emissions, the carbon « space » is narrowing fast (to stay under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

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)

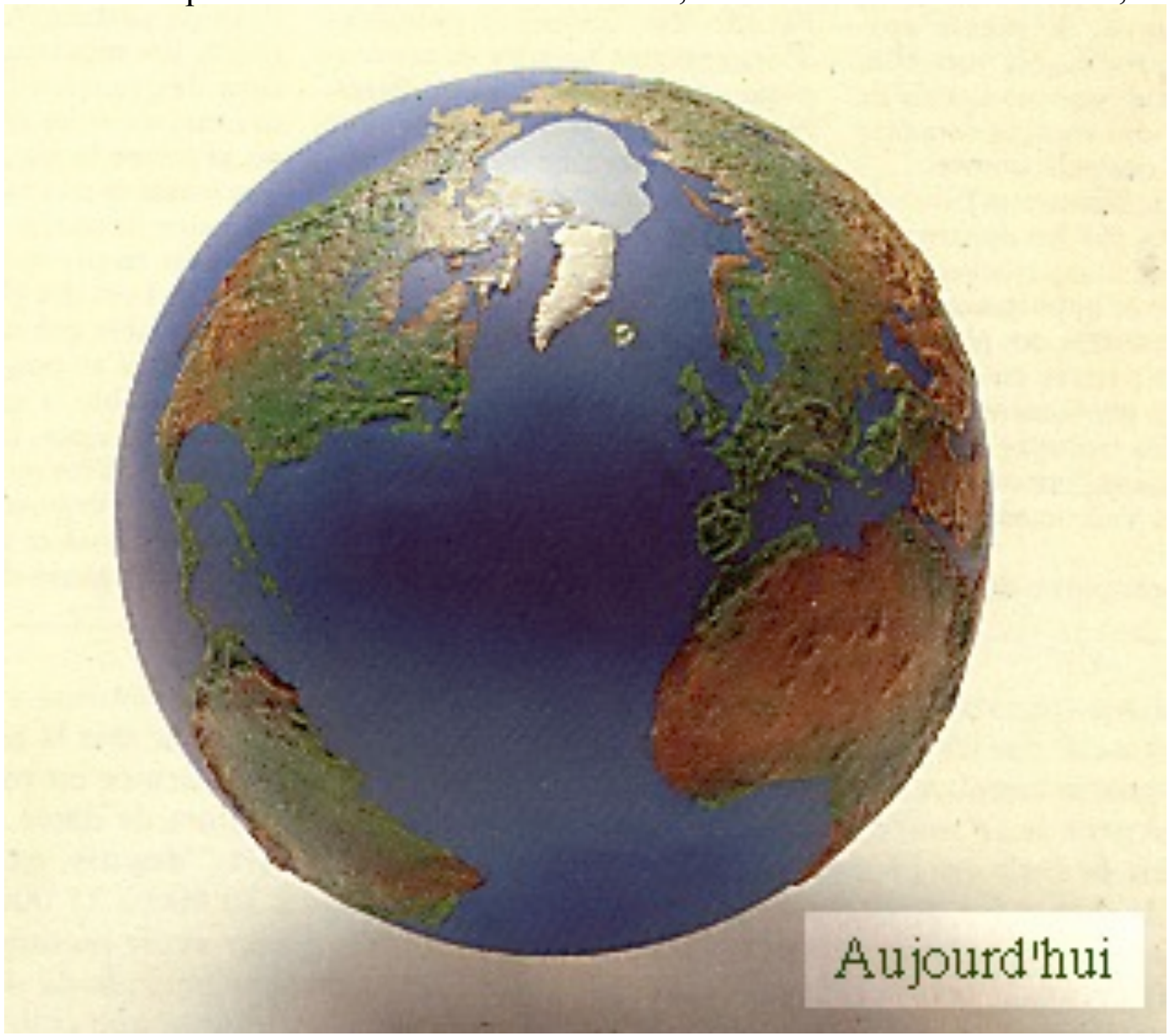
Only the lowest (RCP2.6) scenario maintains the global surface temperature increase above the pre-industrial level to less than 2°C with at least 66% probability

18-20000 years ago (Last Glacial Maximum)

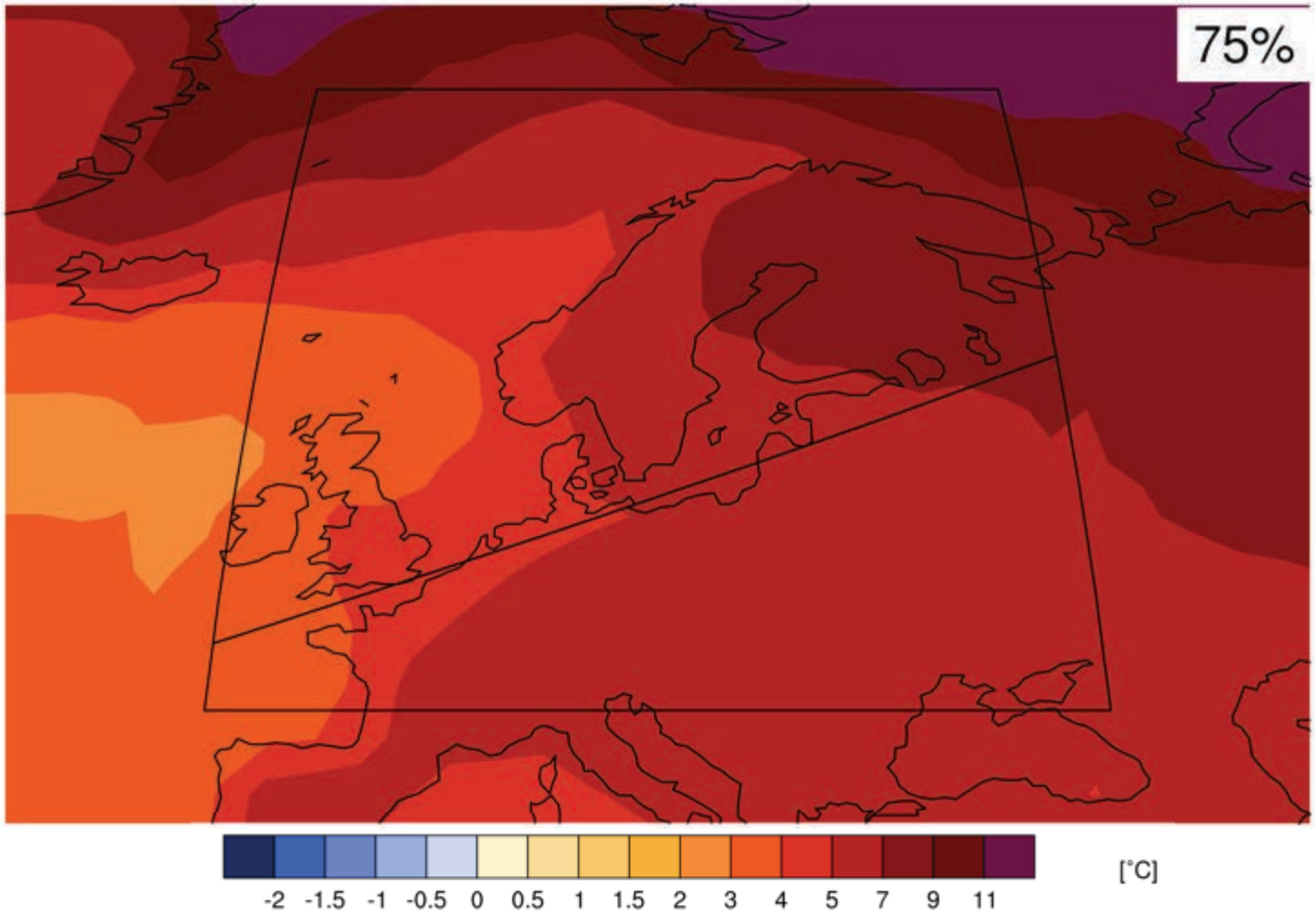
With permission from Dr. S. Joussaume, in « Climat d'hier à demain », CNRS éditions.

Today, with +4-5°C globally

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

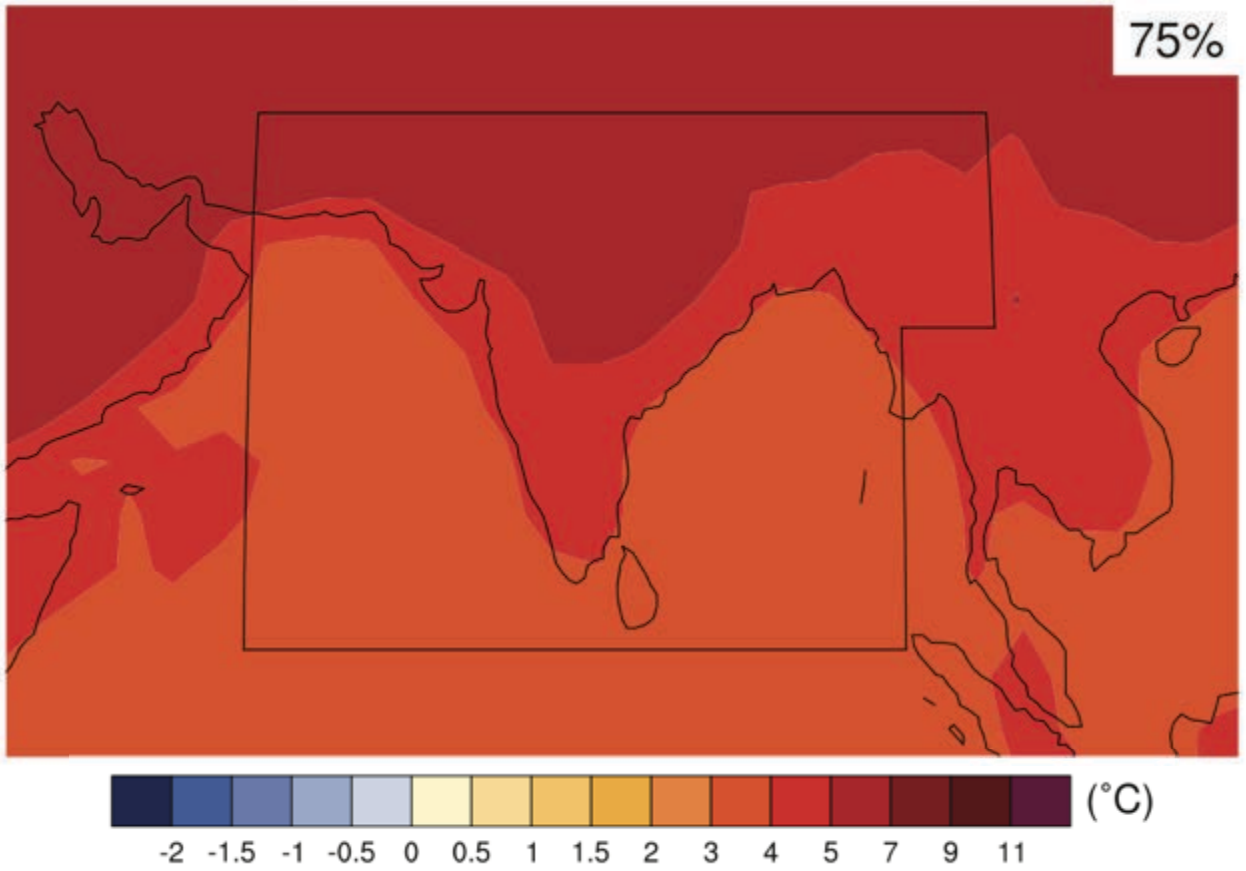


North Europe - Map of temperature changes: 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario (annual)



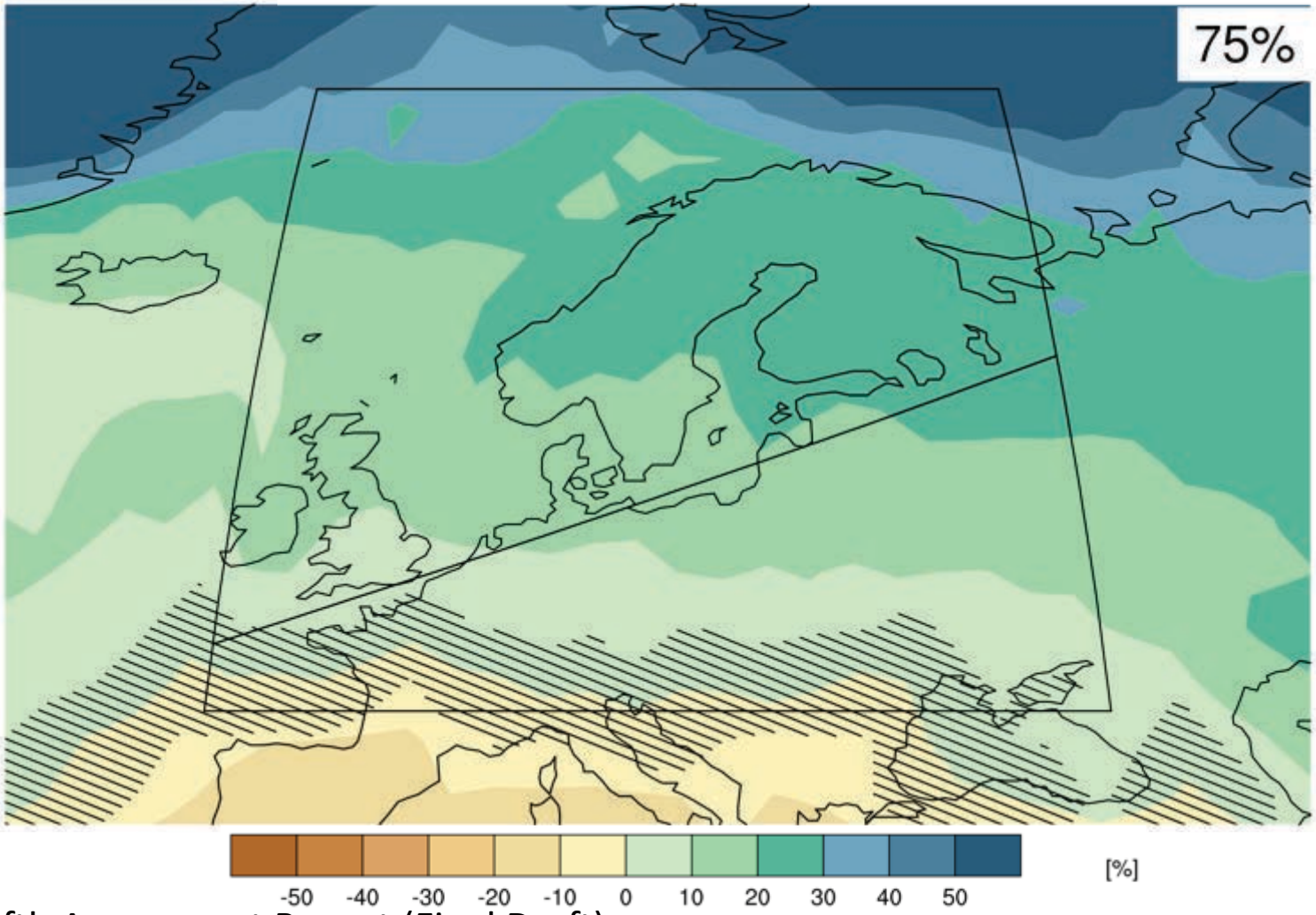
IPCC WG1 Fifth Assessment Report (Final Draft)

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

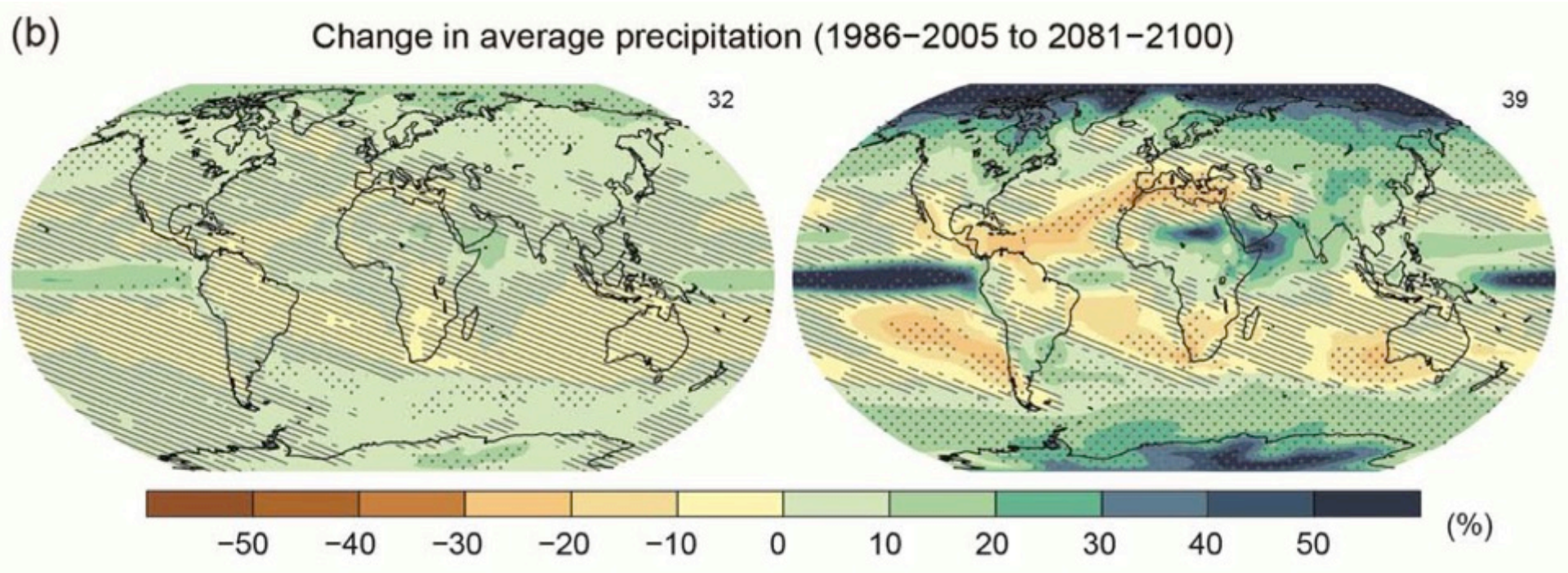
North Europe - Map of precipitation changes in 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario (annual)



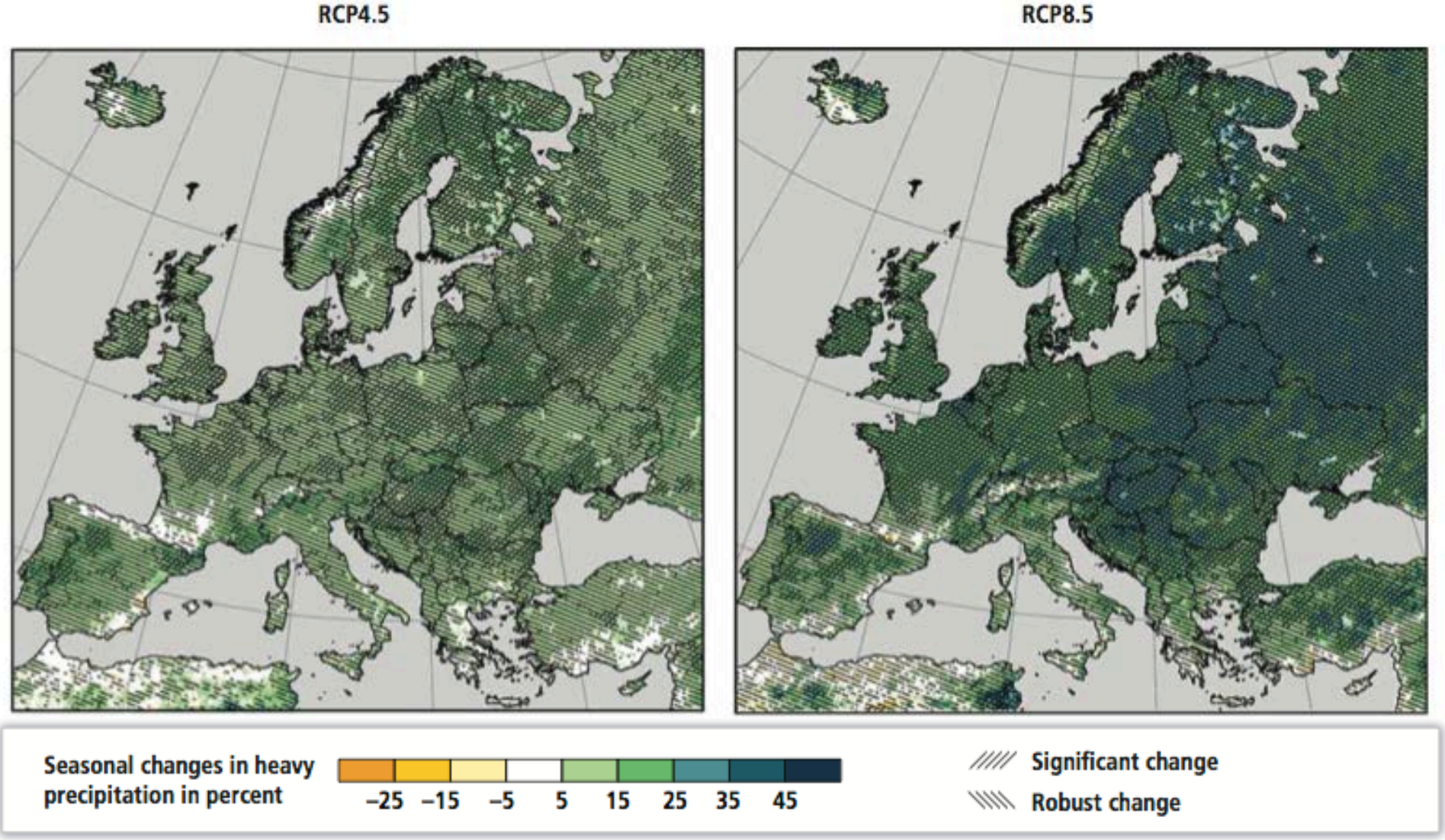
IPCC WG1 Fifth Assessment Report (Final Draft)

Annual rainfall projections

RCP2.6 **RCP8.5**



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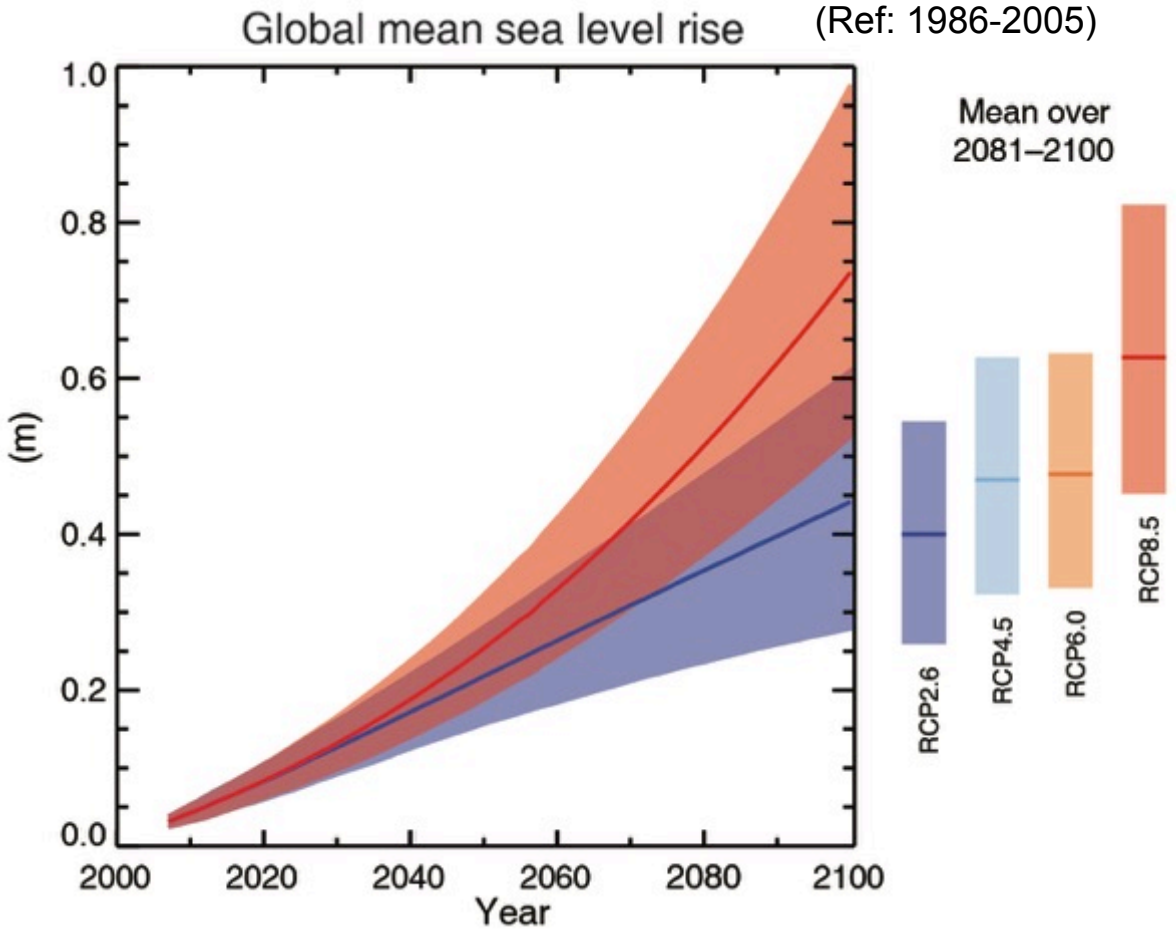
IPCC, AR5, WG II, Chap. 14, p. 852



(IPCC 2013, Fig. SPM.9)

Sea level due to continue to increase

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

(Time 2001)

On the frontline: The Maldives

In front of Environment Ministry, Maldives, Aug. 2015

In front of Ministry of Foreign Affairs, Maldives, Aug. 2015

MINISTRY OF FOREIGN AFFAIRS

VULNERABILITY AND EXPOSURE

IN THE ENTIRE WORLD

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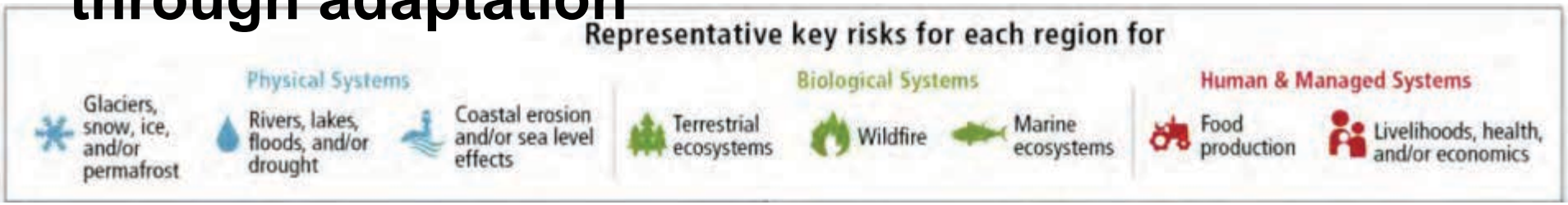
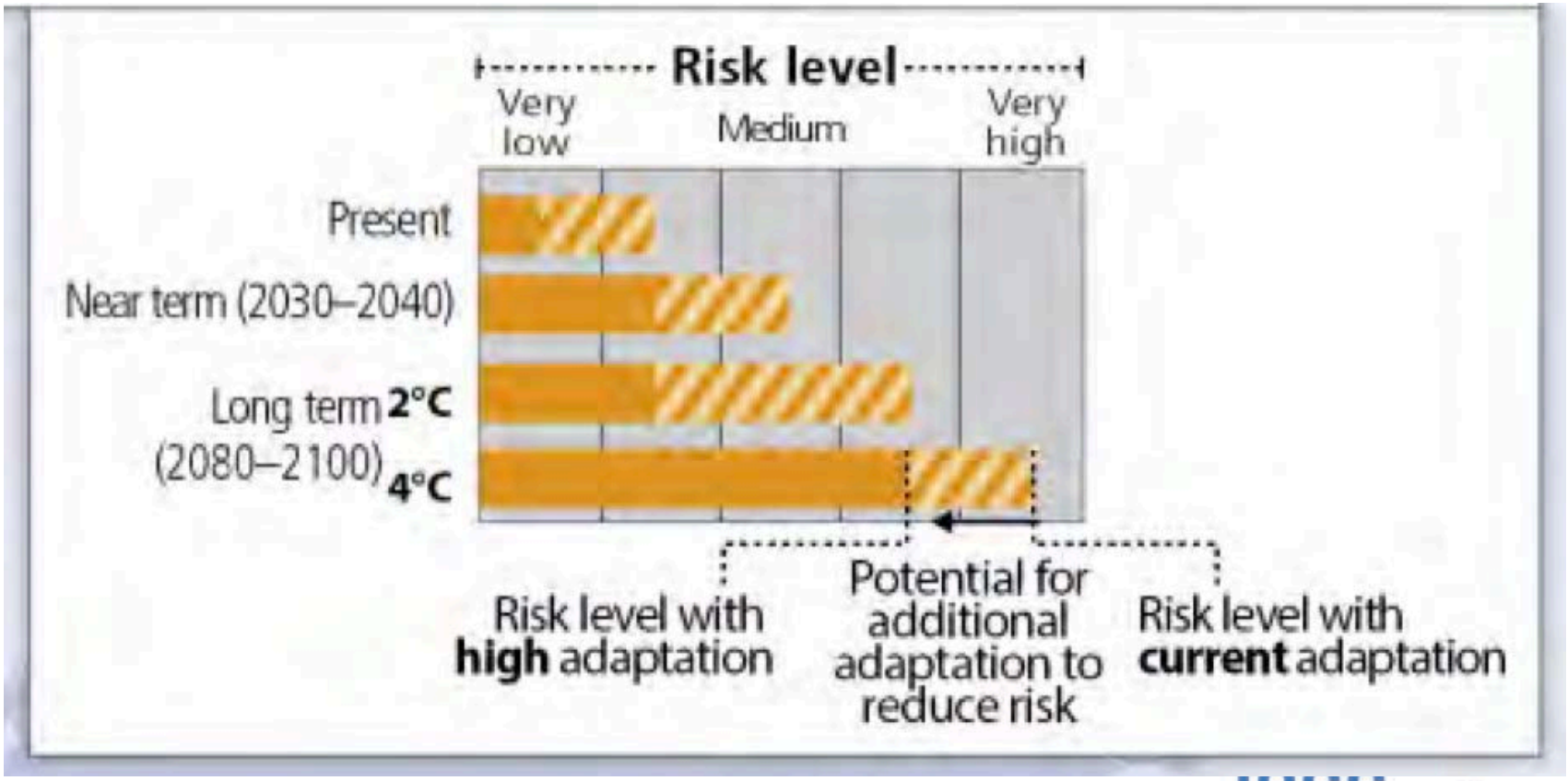
INTERGOVERNMENTAL PANEL ON climate change

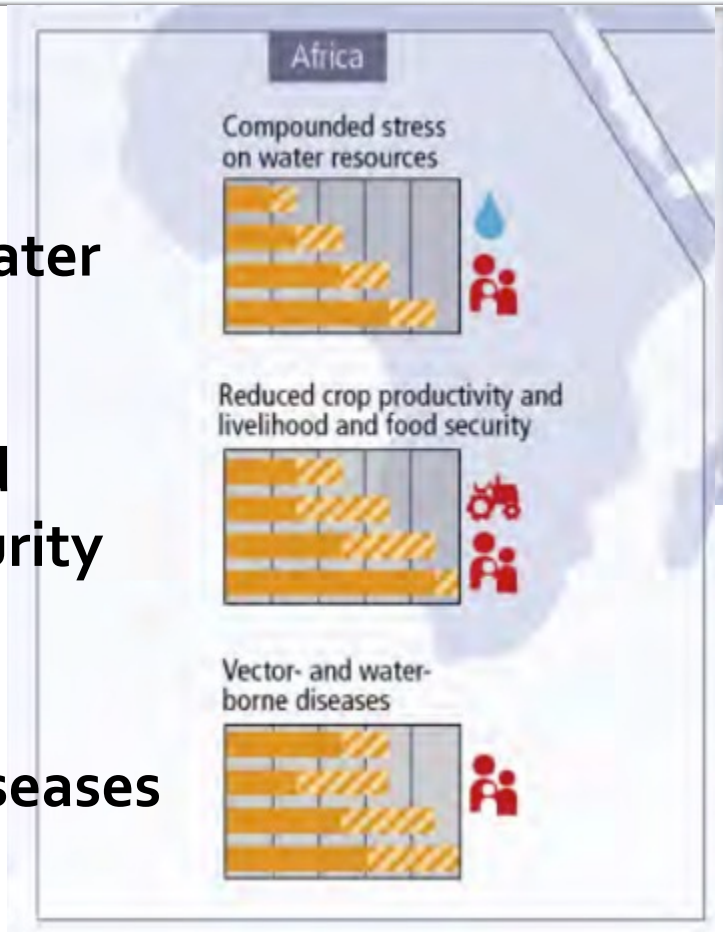
Regional key risks and potential for risk reduction through adaptation





IPCC, AR5, SPM, Figure SPM.8

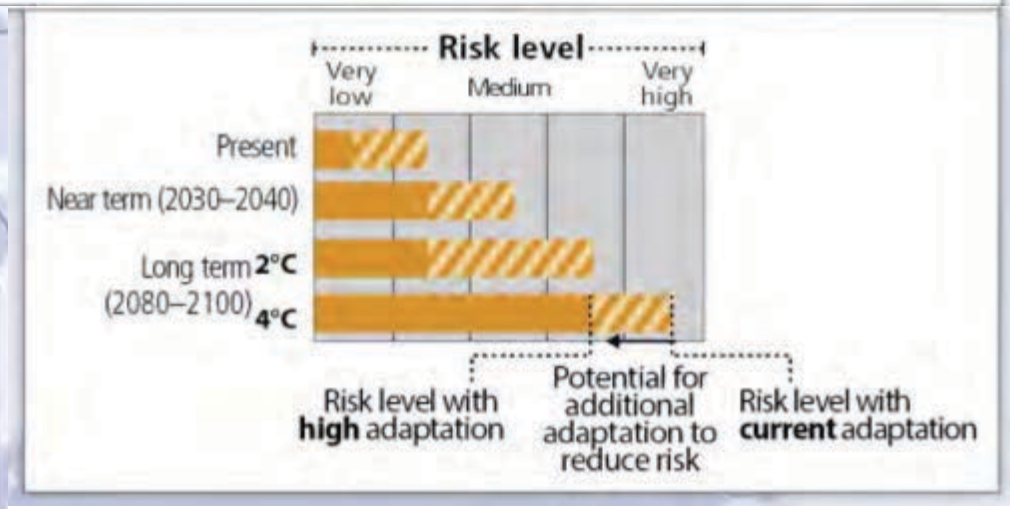
Regional key risks and risk reduction through adaptation: Africa



Water

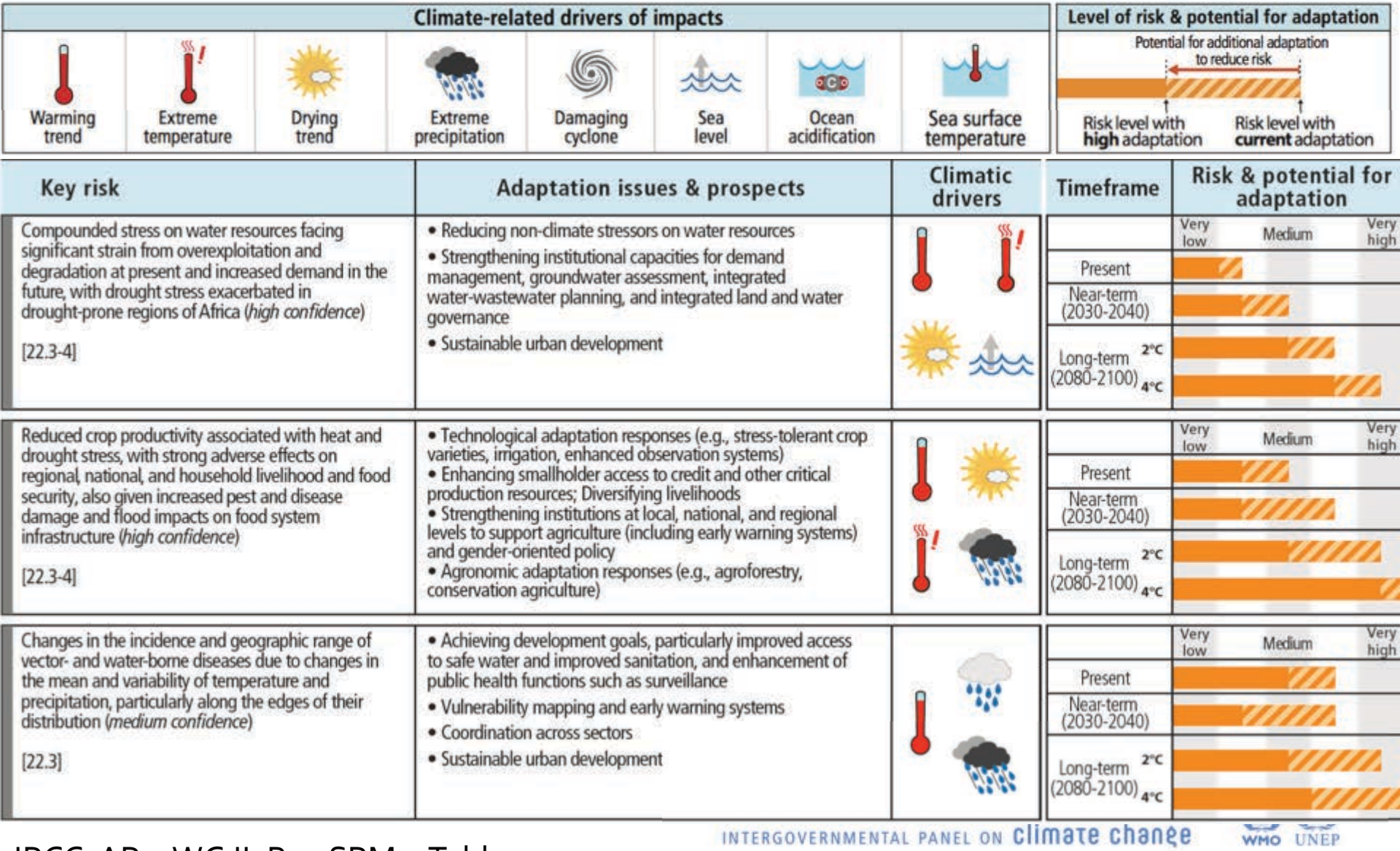
Food security

Diseases



IPCC, AR5, SPM, Figure SPM.8

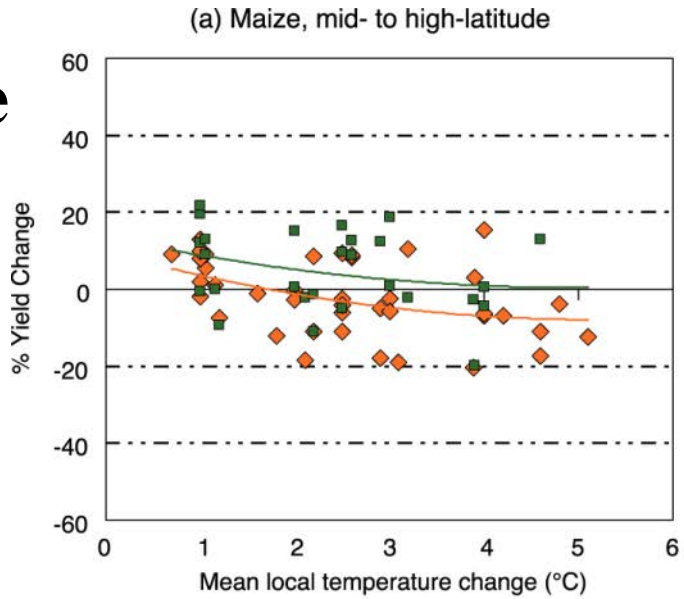
Selected key risks and potential for adaptation for Africa the present day to the long term

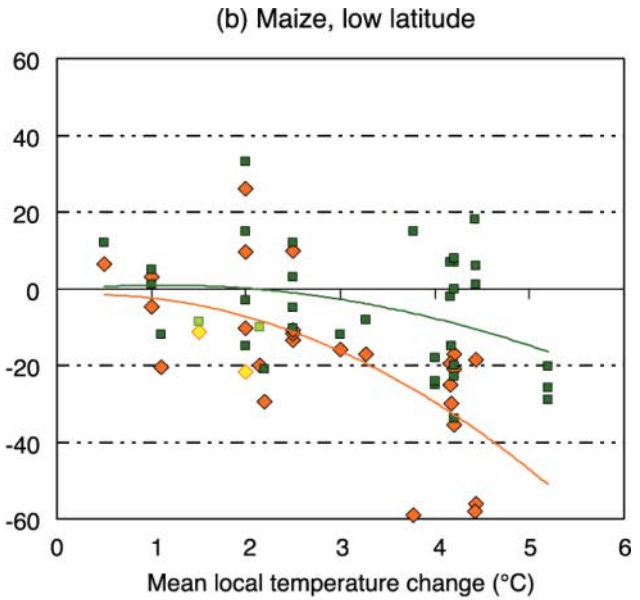


IPCC, AR5, WG II, Box SPM.2 Table 1

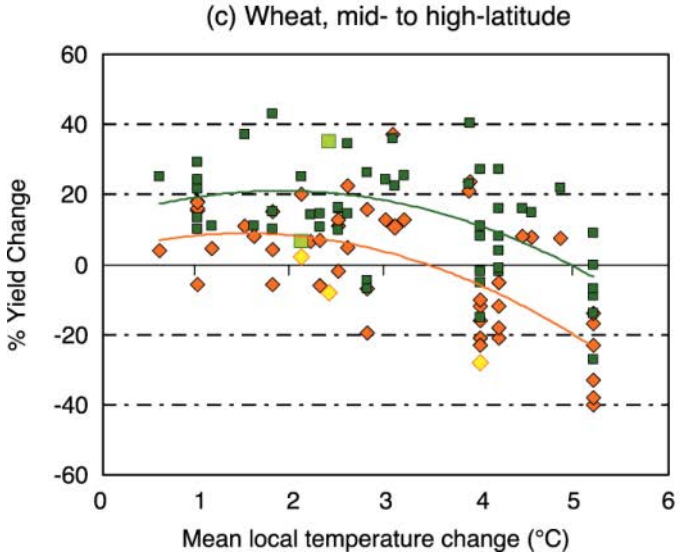
Figure TS.7. Sensitivity of cereal yield to climate change

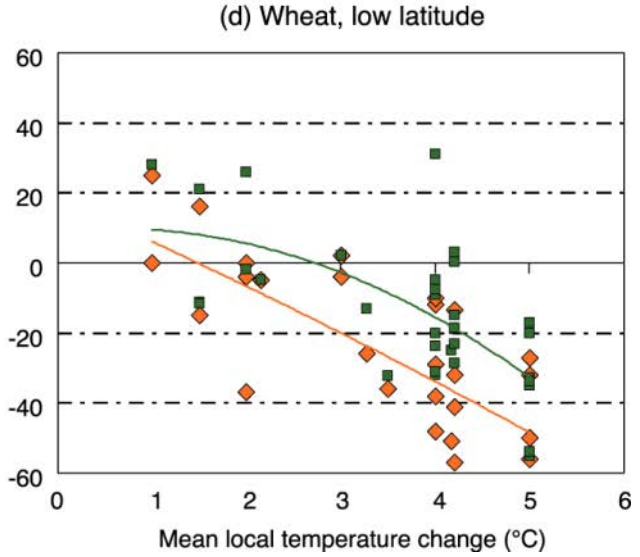
Maize





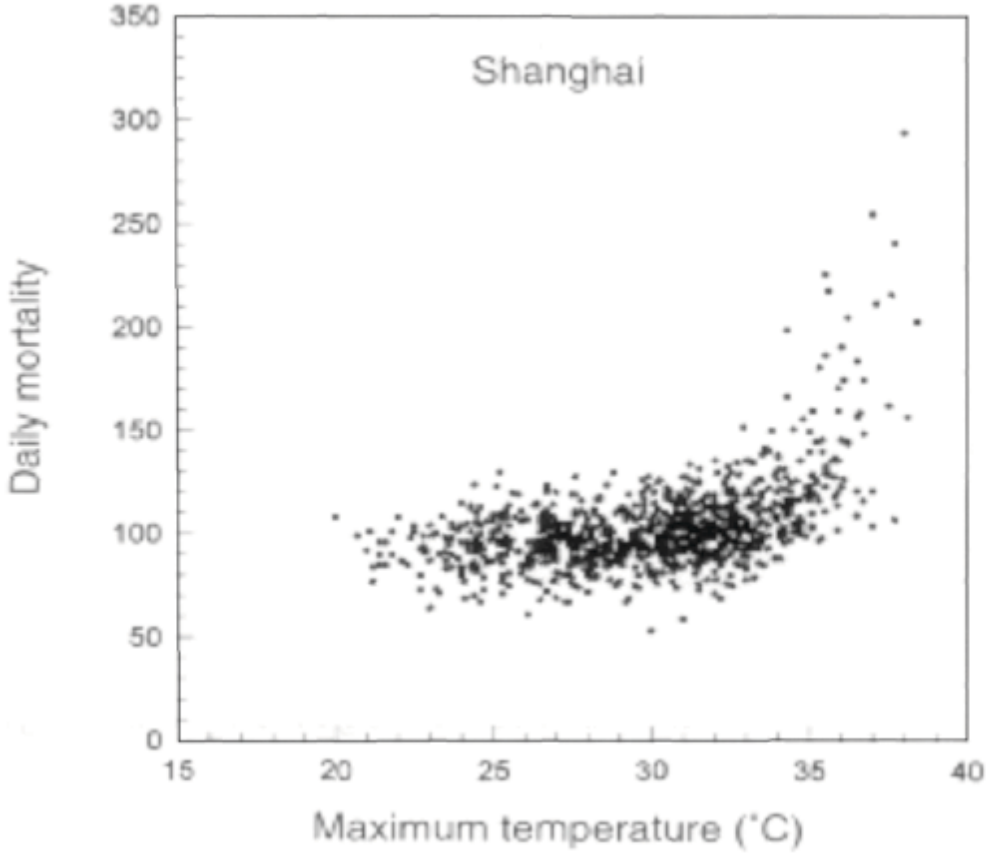
Wheat





IPCC AR4 WGII

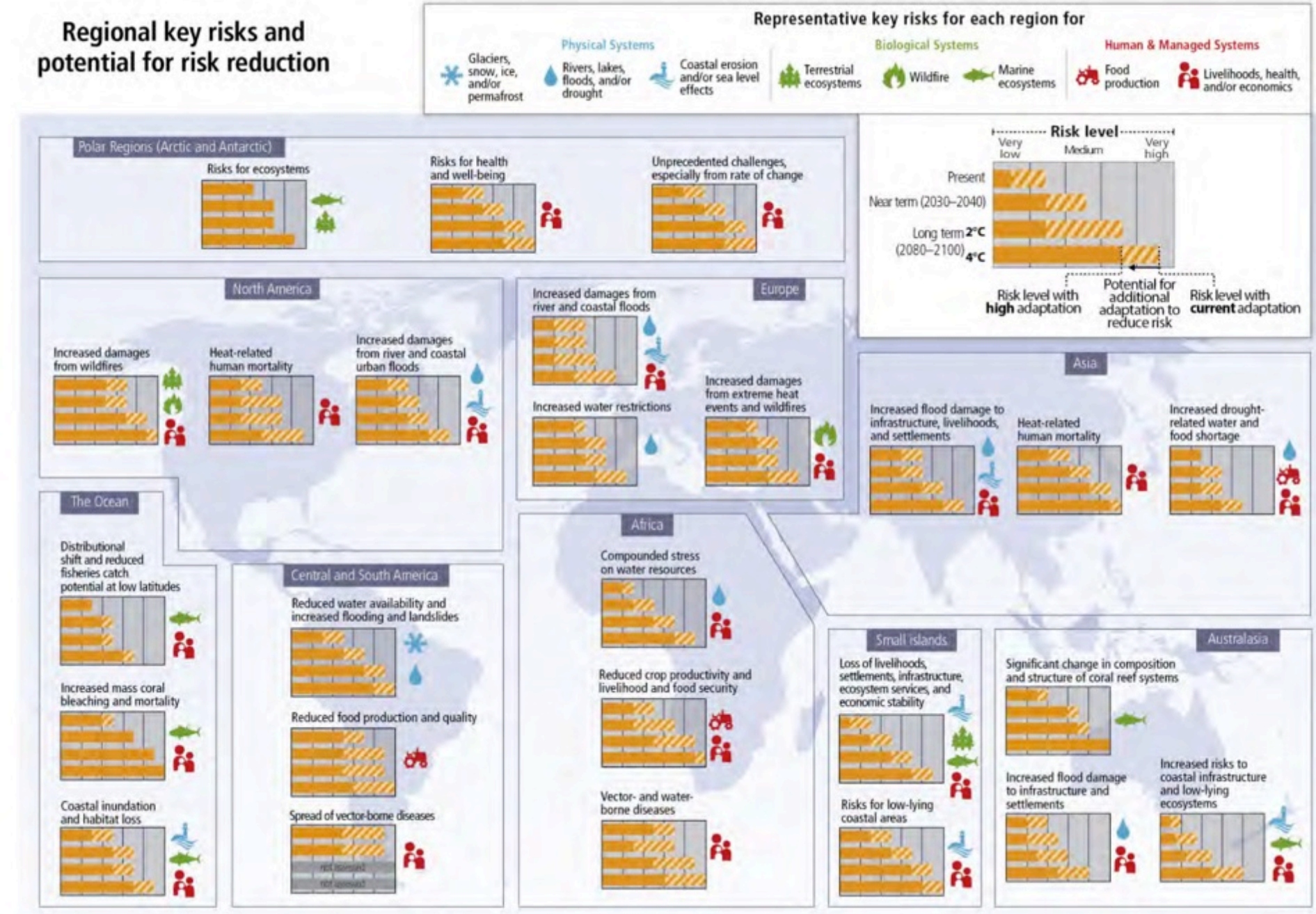
Relationship between maximum temperature and mortality in Shanghai, China, 1980-89



Référence : CILIMATE CHANGE AND HUMAN HEALTH, 1996

Jean-Pascal van Ypersele
(vanyp@climate.be)

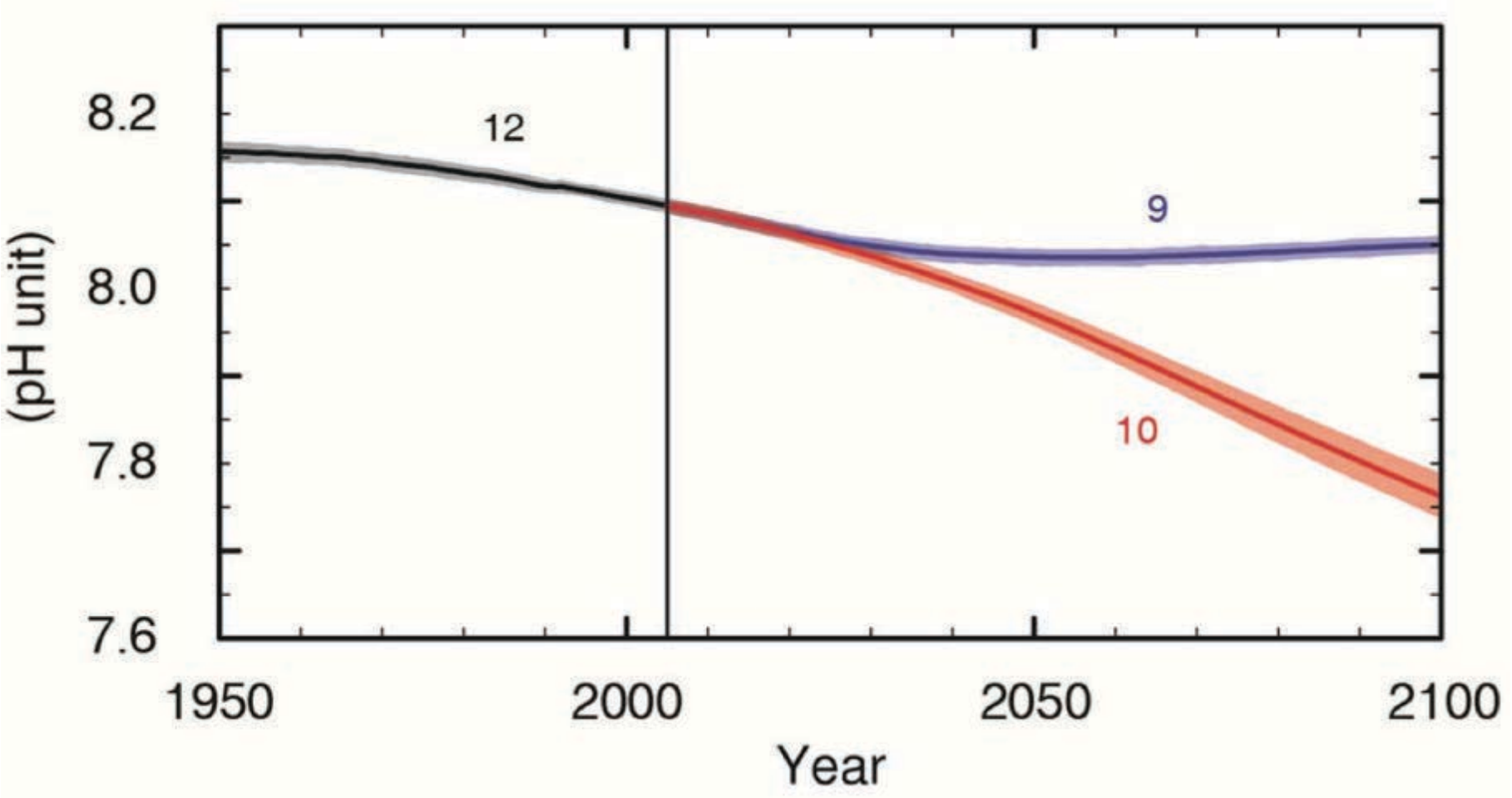
Regional key risks and potential for risk reduction



IPCC, AR5, SPM, Figure SPM.8

Global ocean surface pH (projections)

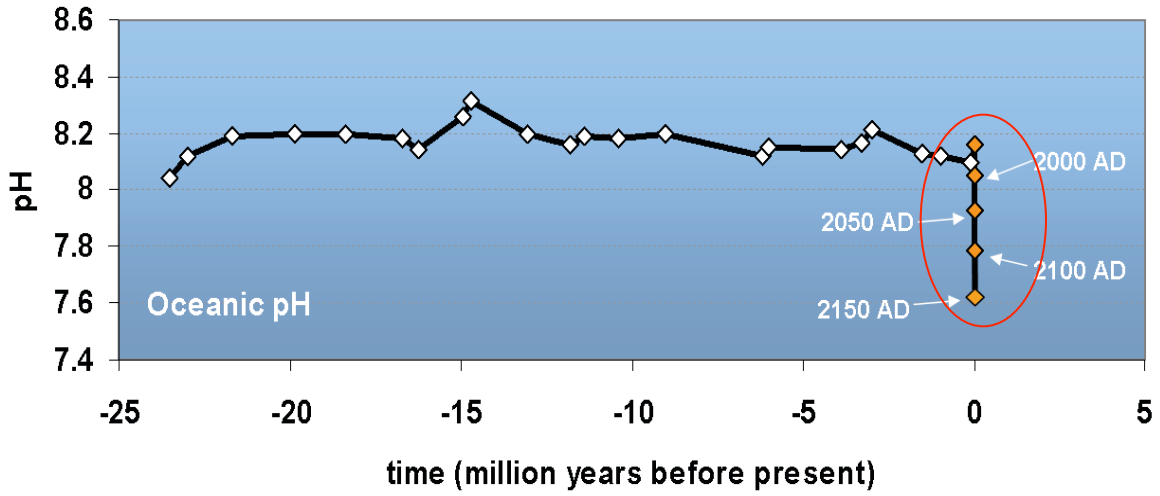
Ocean Acidification, for RCP 8.5 (orange) & RCP2.6 (blue)



IPCC AR5 WGI, Fig SPM 07

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

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

Potential Impacts of Climate Change

Food and water shortages

Increased displacement of people

Increased poverty

Coastal flooding

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Risk = Hazard x Vulnerability x Exposure (Katrina flood victim, New Orleans, 2005)

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

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

RISKS OF
CLIMATE CHANGE
INCREASE
WITH CONTINUED
HIGH EMISSIONS
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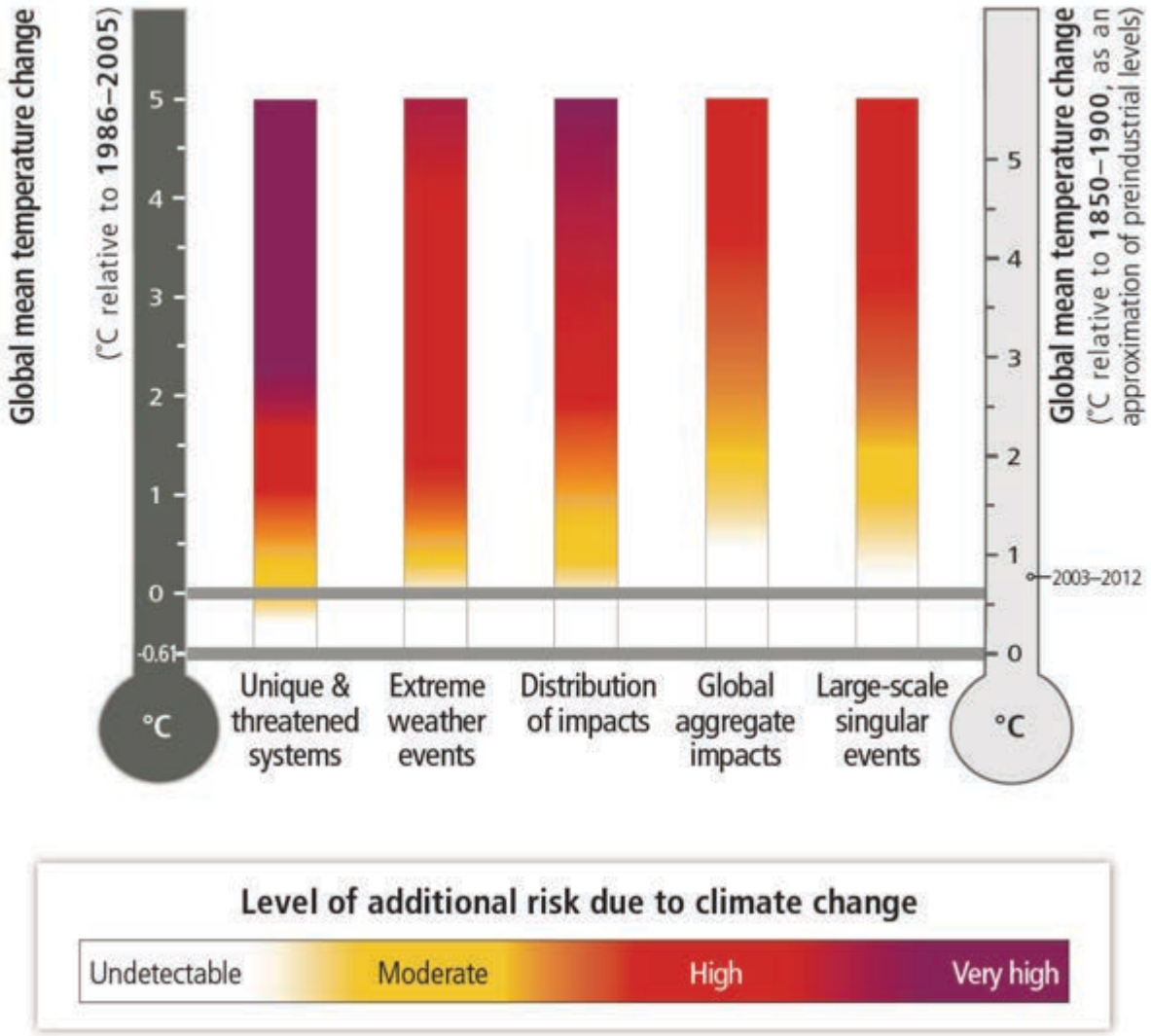
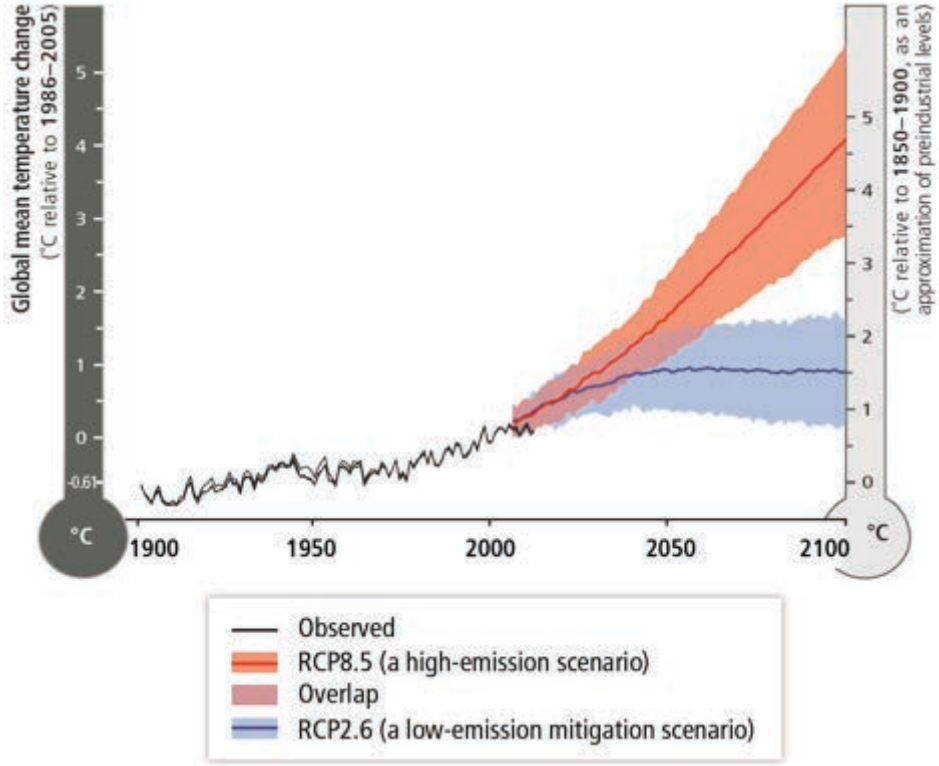
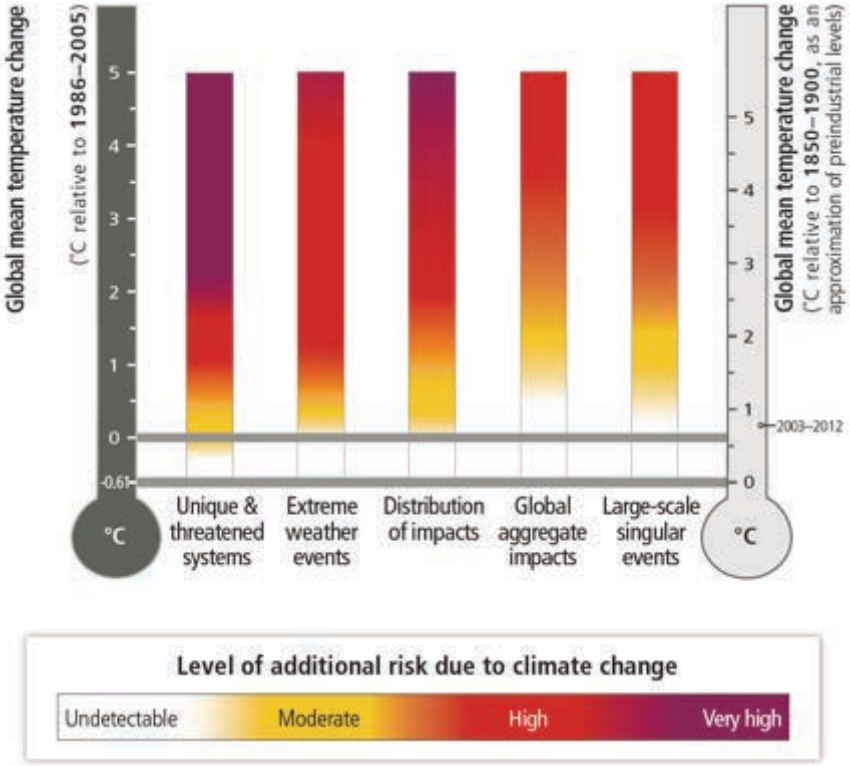


AR5, WGII, Box SPM.1 Figure 1





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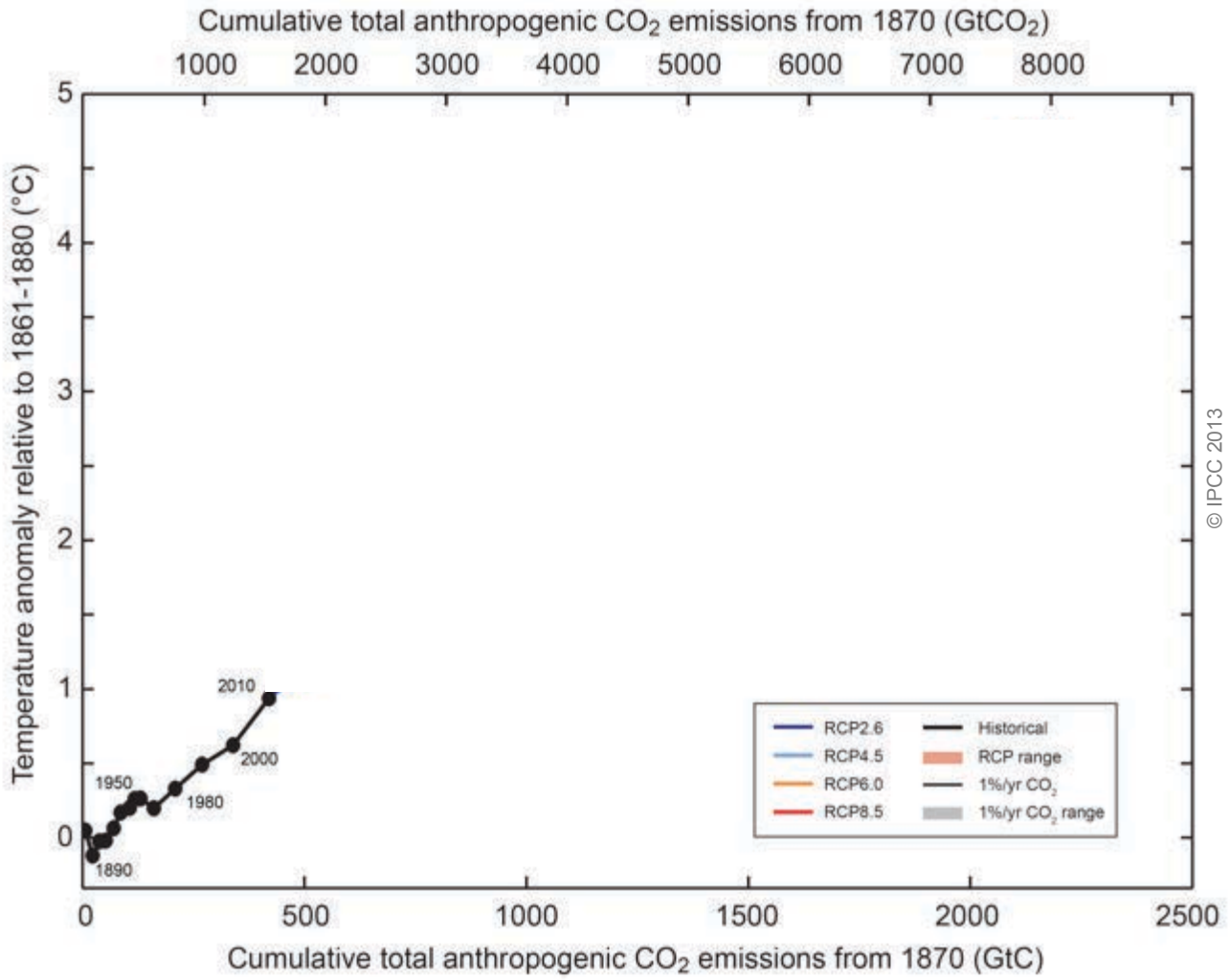


Fig. SPM.10

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

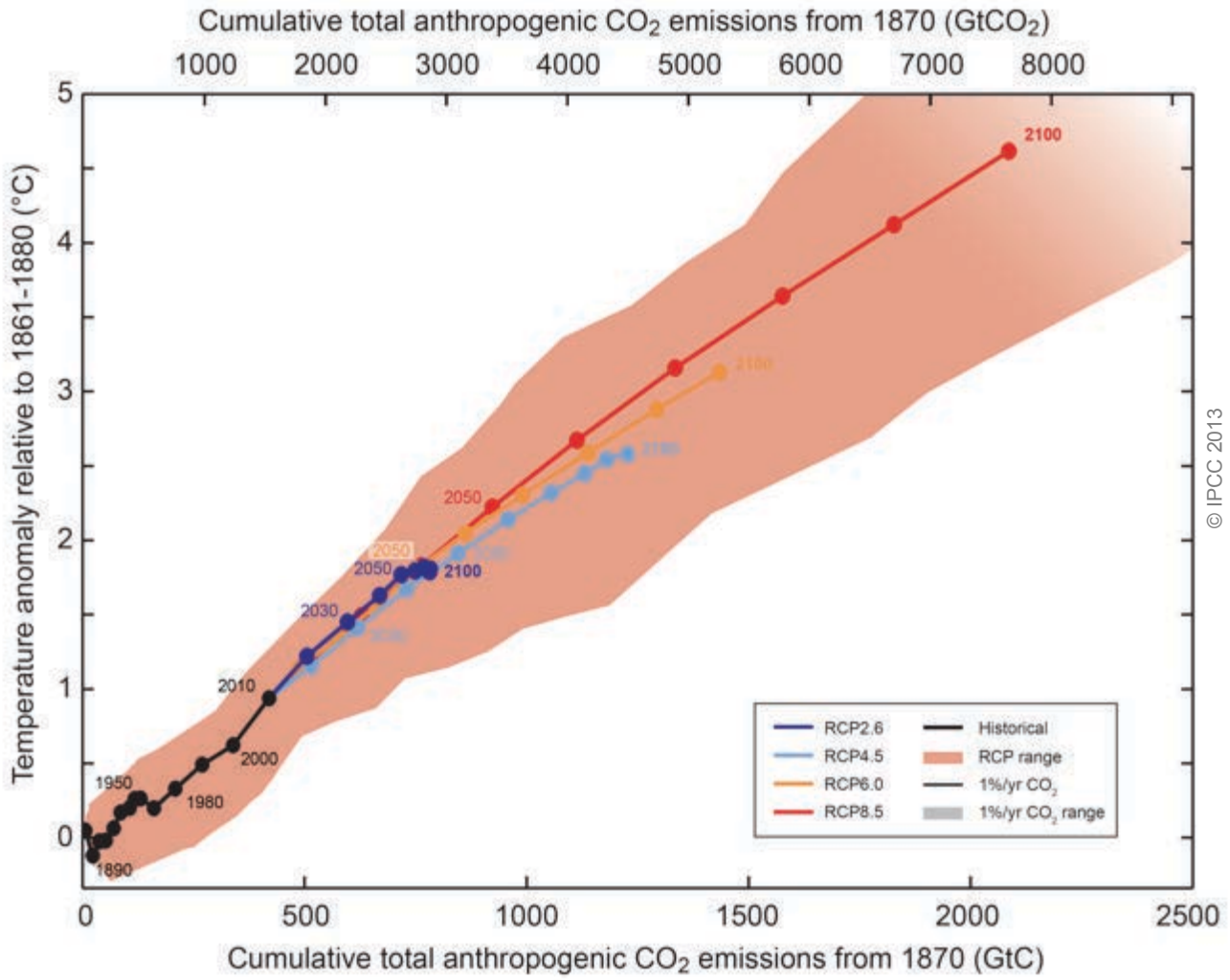
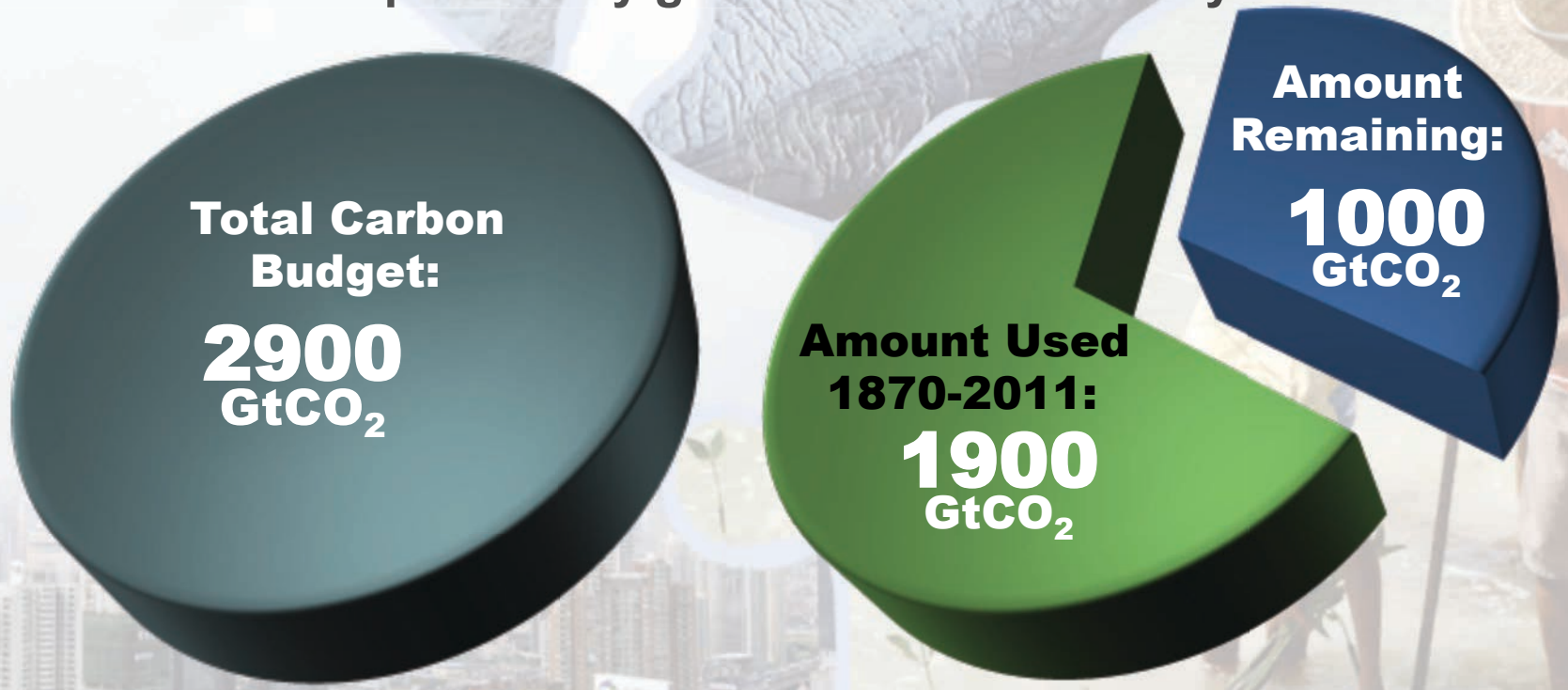


Fig. SPM.10

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

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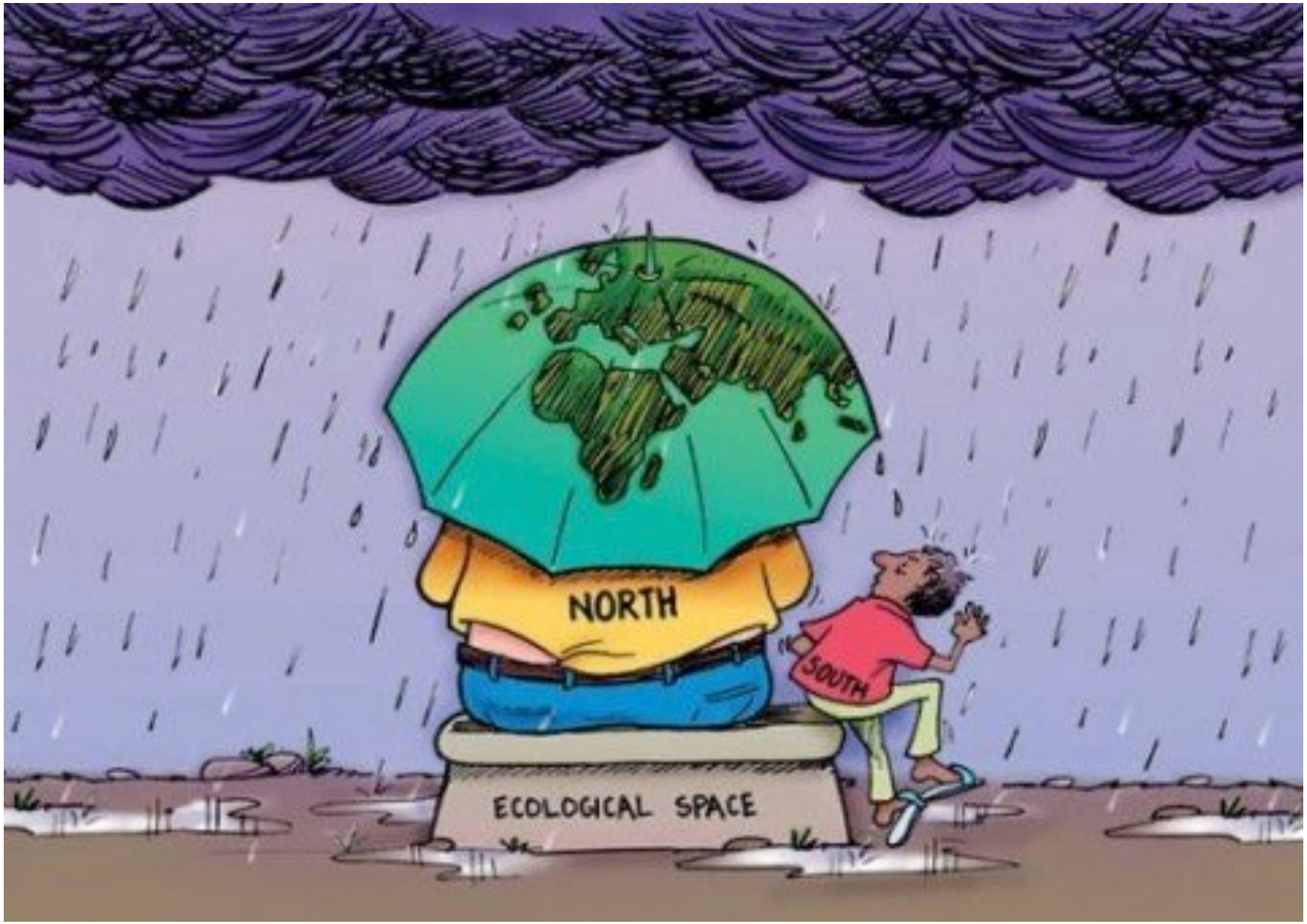
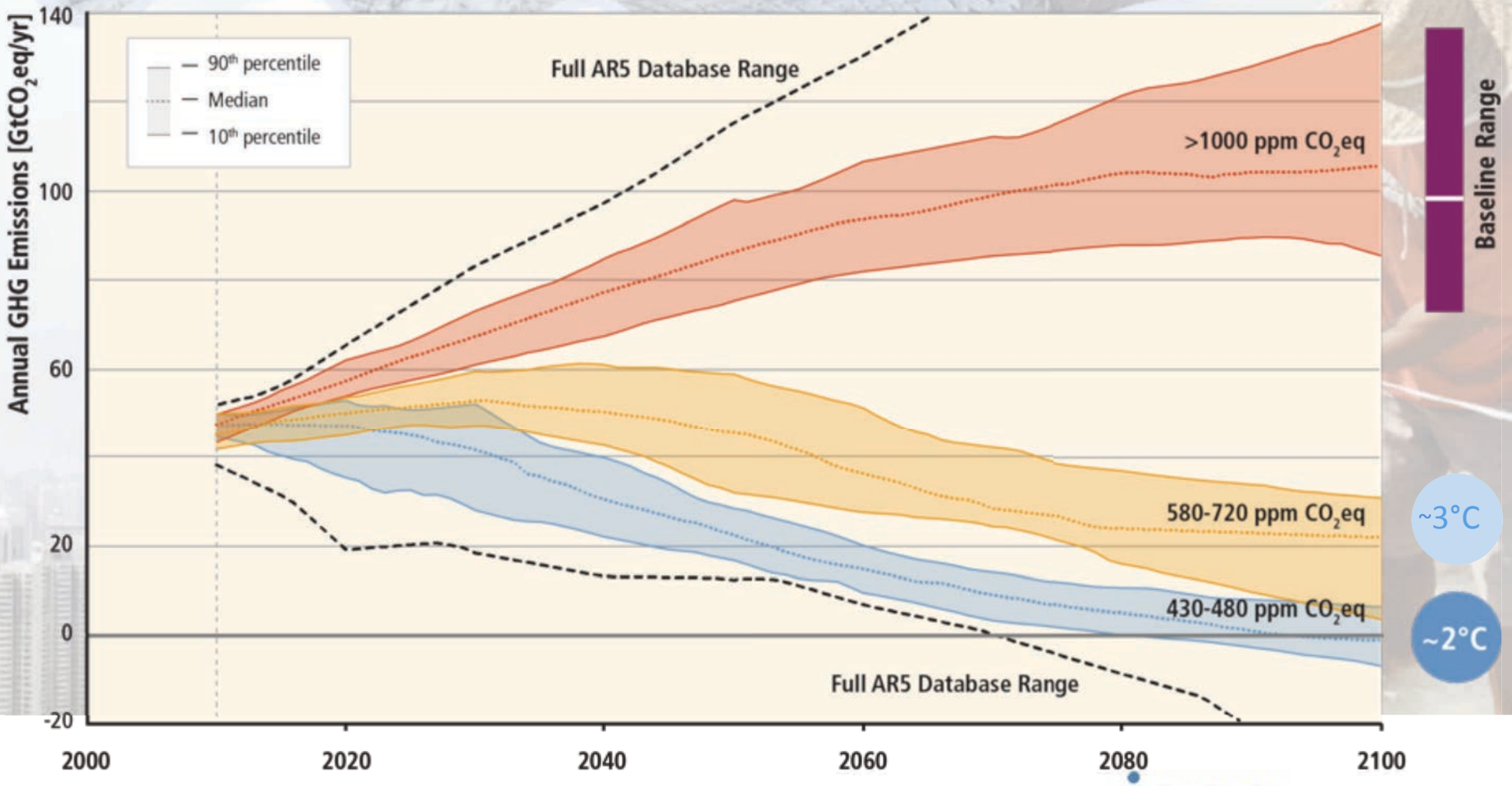
IPCC, AR5, WG III, TS, p. 39



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

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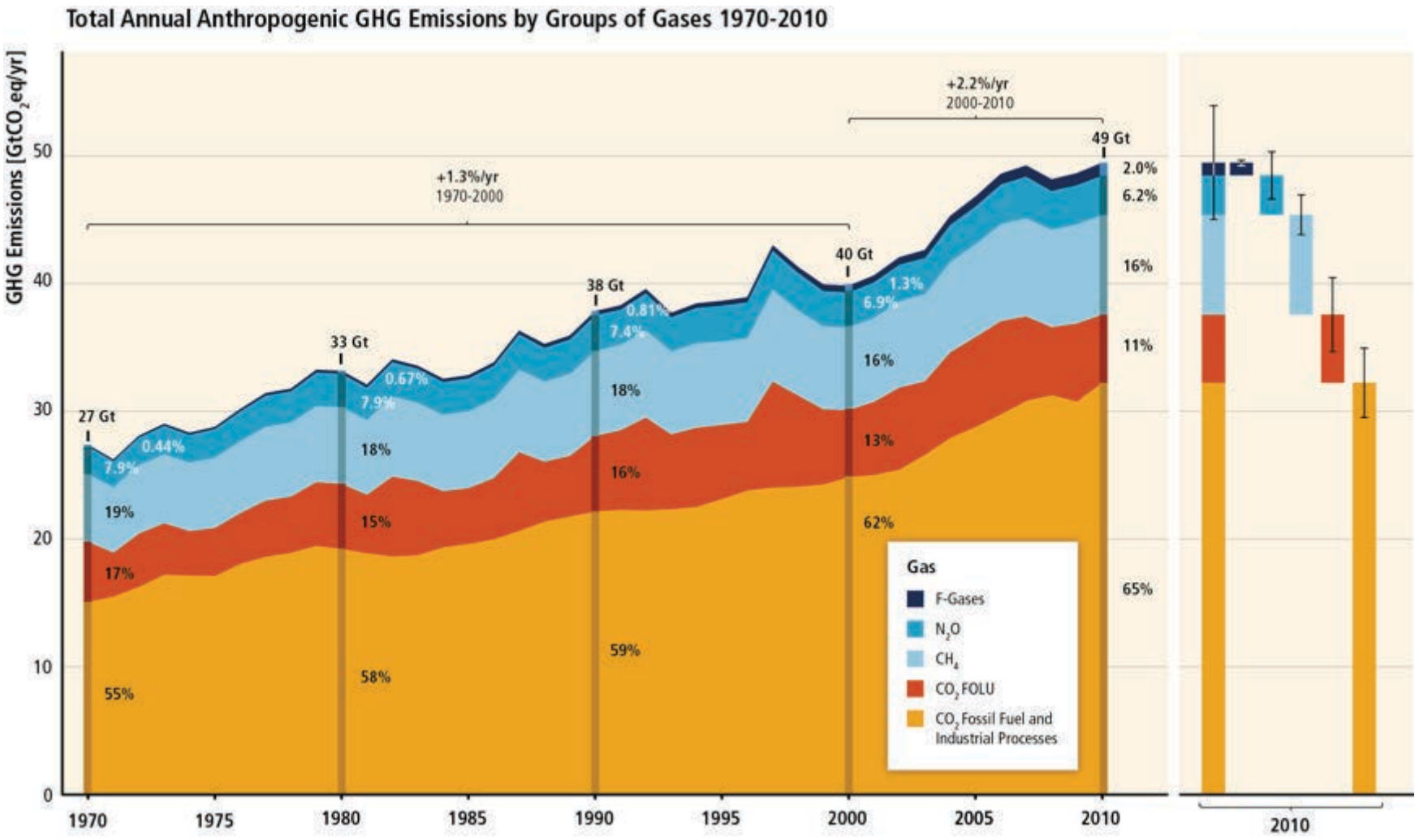
GHG emissions accelerate despite reduction efforts. Most emission growth is CO_2 from fossil fuel combustion and industrial processes.



Working Group III contribution to the
IPCC Fifth Assessment Report

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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

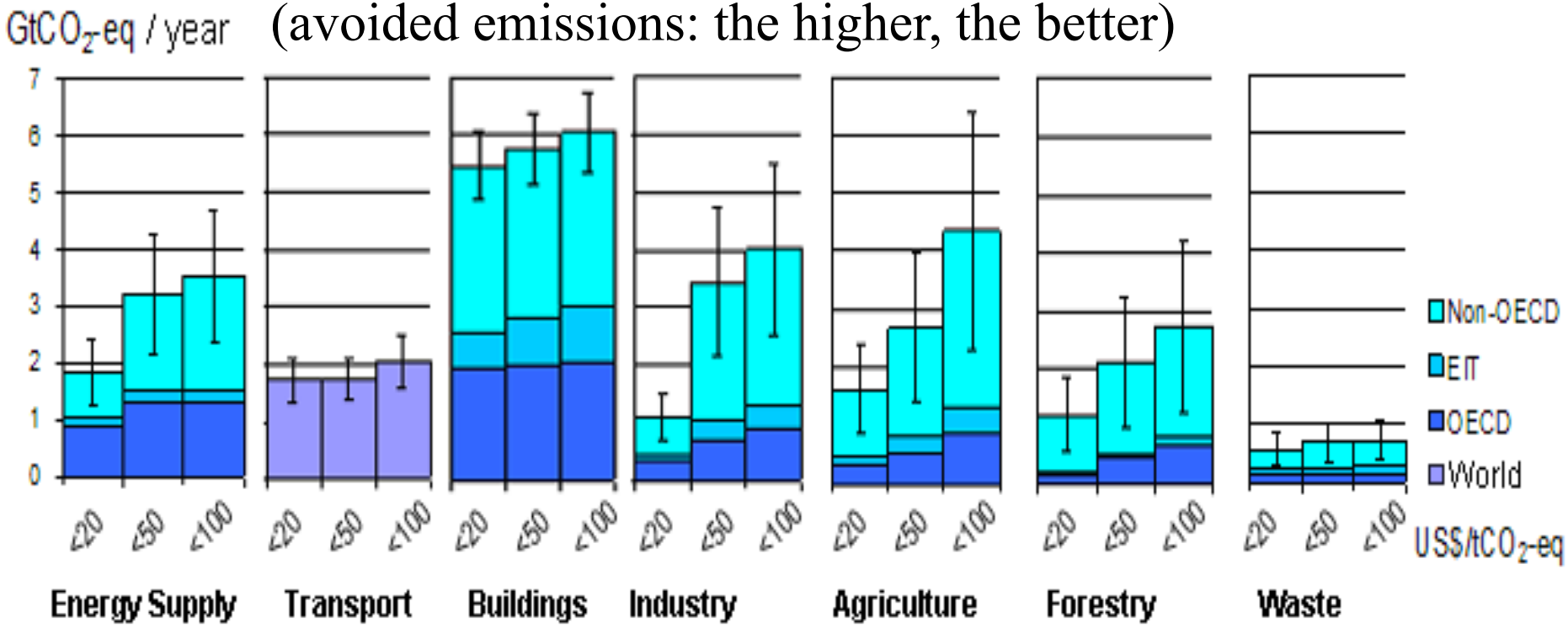
- **Reduced deforestation** and improved forest management and planting of new forests
- **Bio-energy with carbon capture and storage**

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



IPCC AR4 (2007)

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

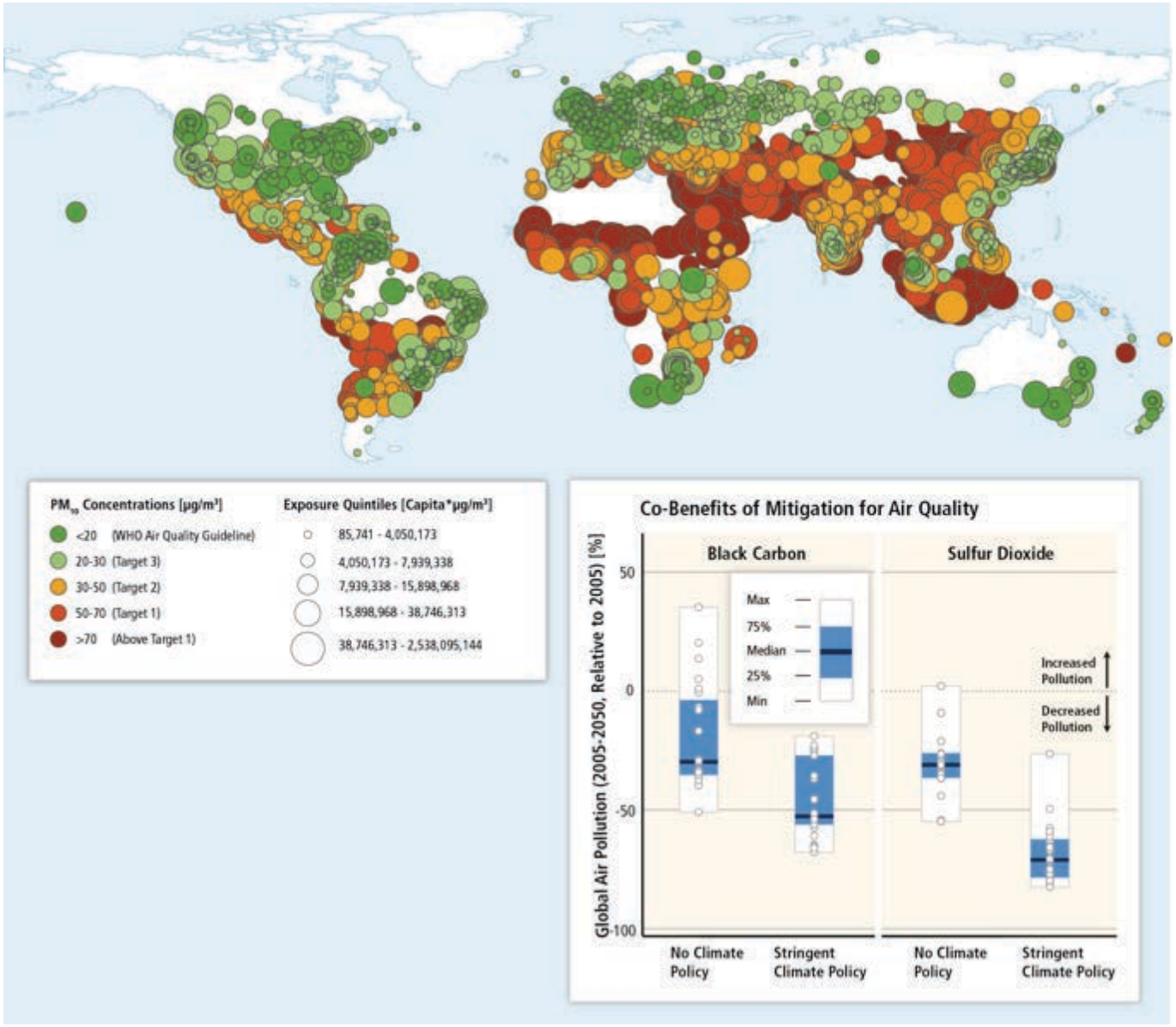
- **Substantial reductions in emissions would require large changes in investment patterns e.g., from 2010 to 2029, in billions US dollars/year:**
  (mean numbers rounded, IPCC AR5 WGIII Fig SPM 9)
- **energy efficiency: +330**
- **renewables: + 90**
- **power plants w/ CCS: + 40**
- **nuclear: + 40**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

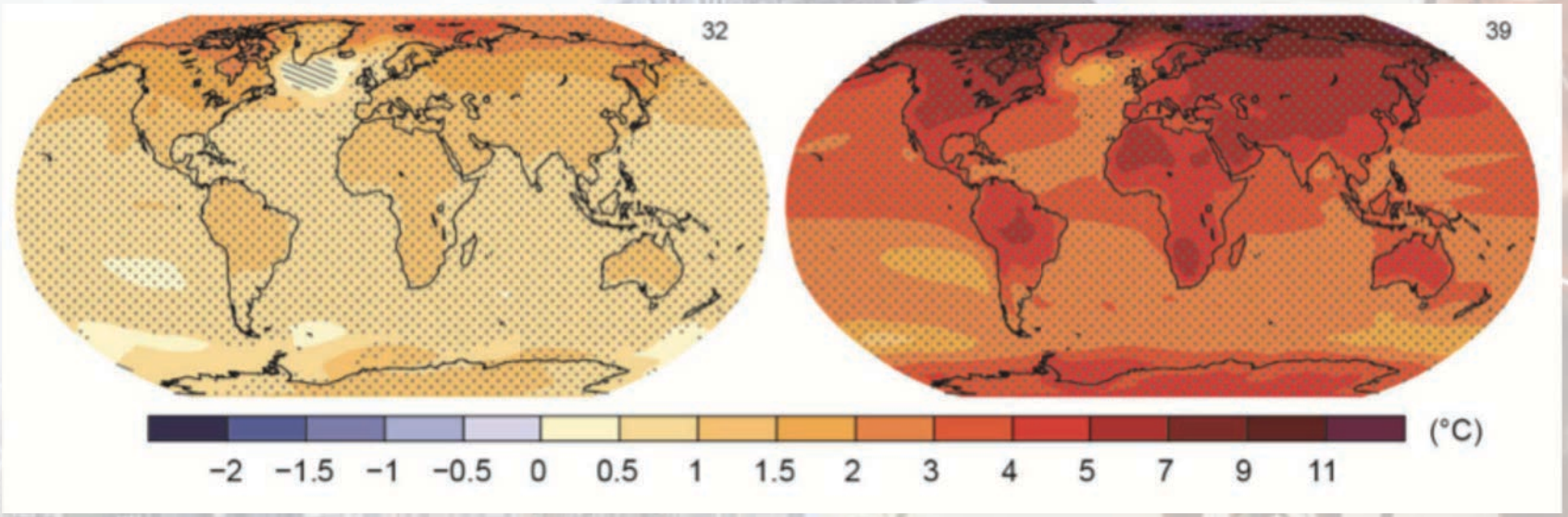


Mitigation can result in large co-benefits for human health and other societal goals.

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

With substantial mitigation

Without additional mitigation



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

AR5 WGI SPM

The Hidden IPCC Message:

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

Process

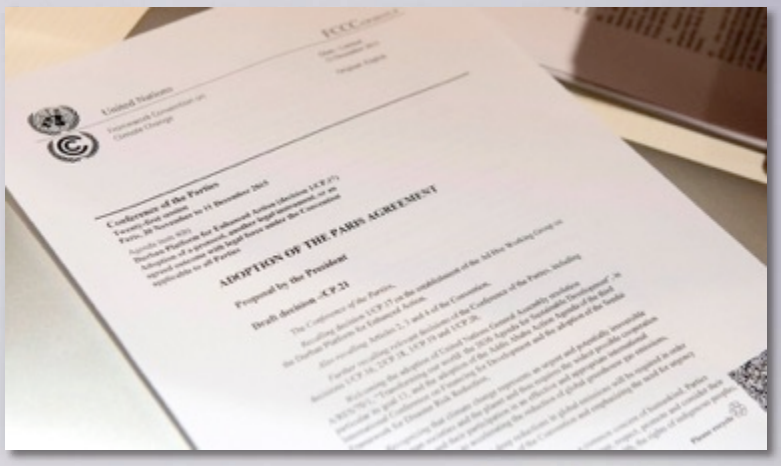
1992	United Nations Framework Convention on Climate Change	United Nations Framework Convention on Climate Change
1997		Kyoto Protocol
2009/ 2010	COP15 COPENHAGEN; COP16 CMP6 México2010	Copenhagen Accord & Cancún Agreements
2011	COP17/CMP7 UNITED NATIONS CLIMATE CHANGE CONFERENCE 2011 DURBAN, SOUTH AFRICA	Durban Platform Start Negotiation 2015 Agreement
2012	DOHA 2012 UN CLIMATE CHANGE CONFERENCE COP18·CMP8	Kyoto Protocol : 2e verbintenissenperiode
2015	PARIS2015 COP21·CMP11	Akkoord van Parijs

- 196 Parties
- 150 Heads of State and Govt
- 36.276 participants

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

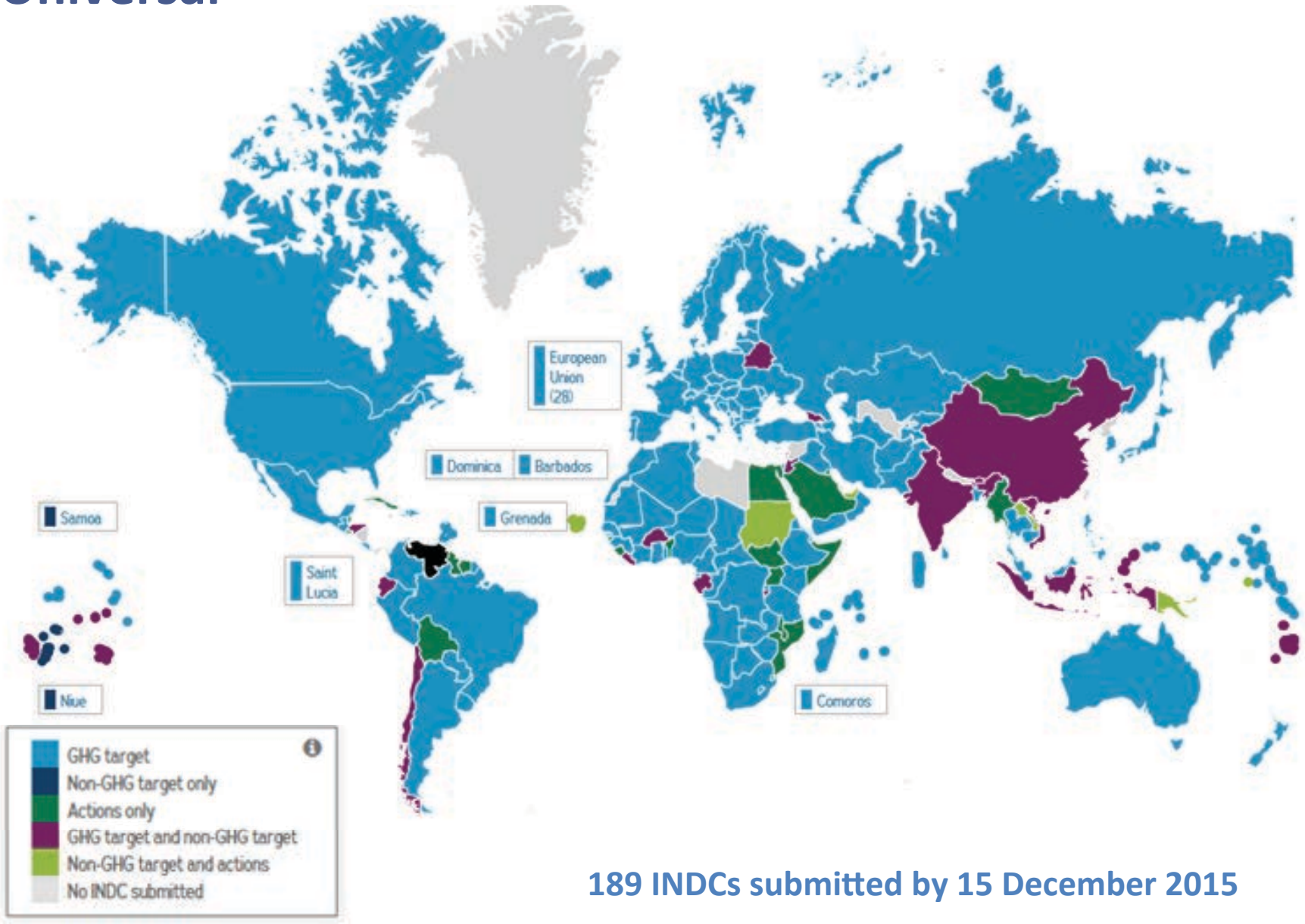
GE.15-21932 (F) 151215 161215

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

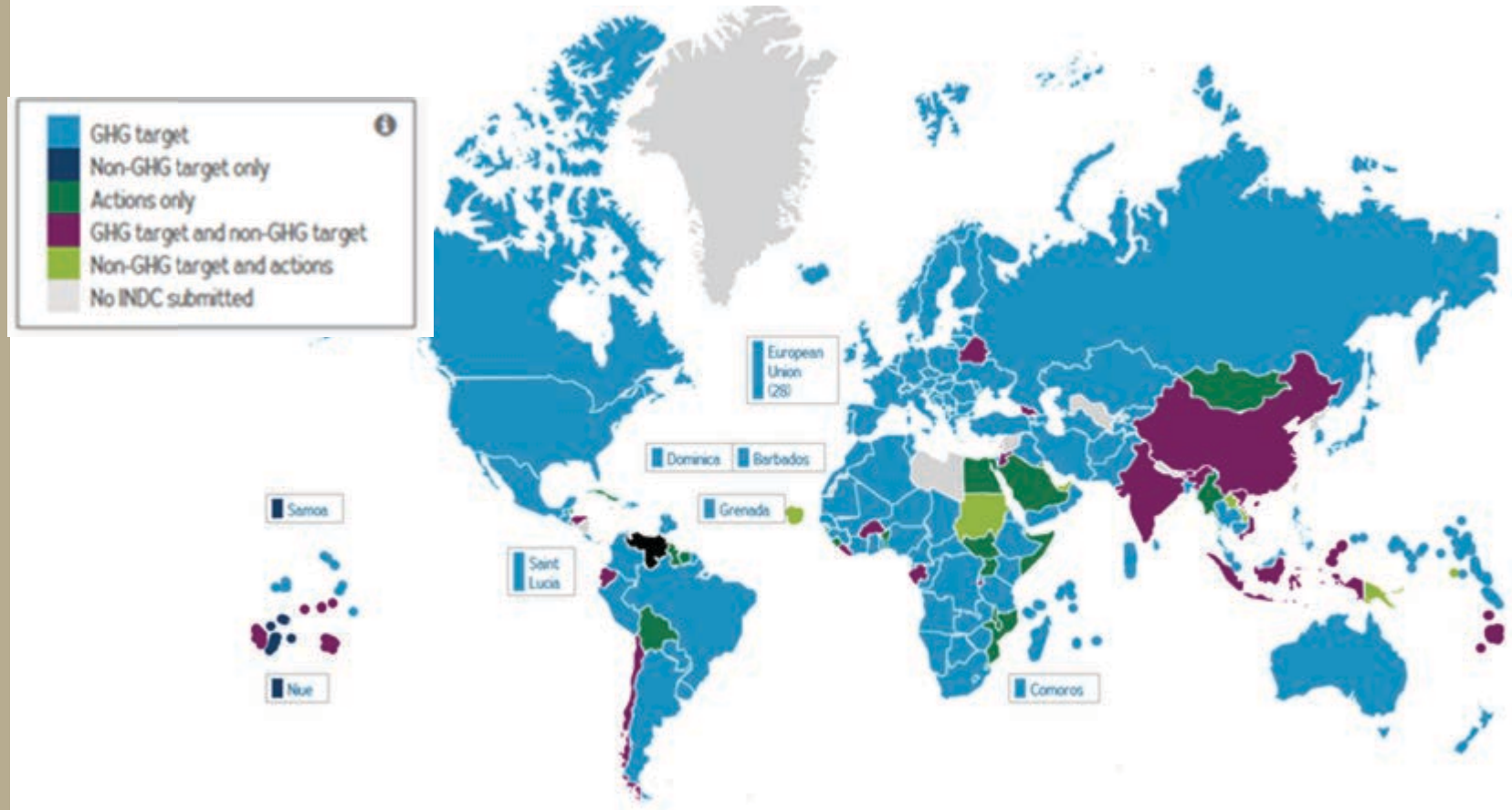


189 INDCs submitted by 15 December 2015

Source : World Resources Institute

Paris agreement: universal, differentiated, transparent

- Obligation to maintain successive targets and to pursue domestic measures
- Obligation to report information necessary to track progress



Source : World Resource 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 Parties with economies most affected by the impacts of response measures, particularly developing country Parties.

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 by Parties on a voluntary basis.
  -

Paris Agreement

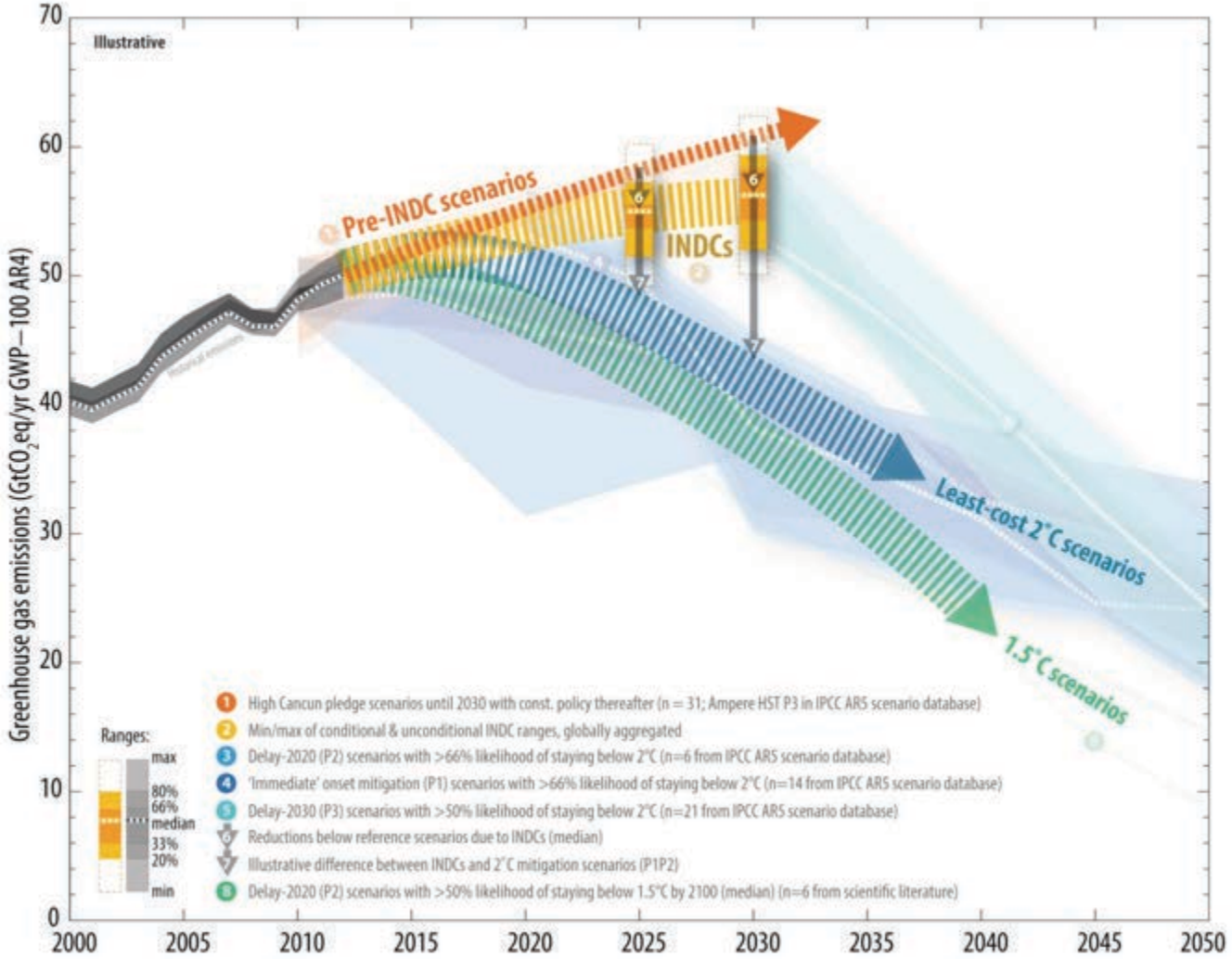
- Article 7
  - Parties hereby establish the global goal on adaptation of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change
- Article 8
  - Parties recognize the importance of averting, minimizing and **addressing loss and damage** associated with the 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.

"Getting 196 Countries To Agree On Climate Change Was The Easy Part. Now comes the real work."

(C. Figueres, World Economic Forum 2016, Davos)

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.

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



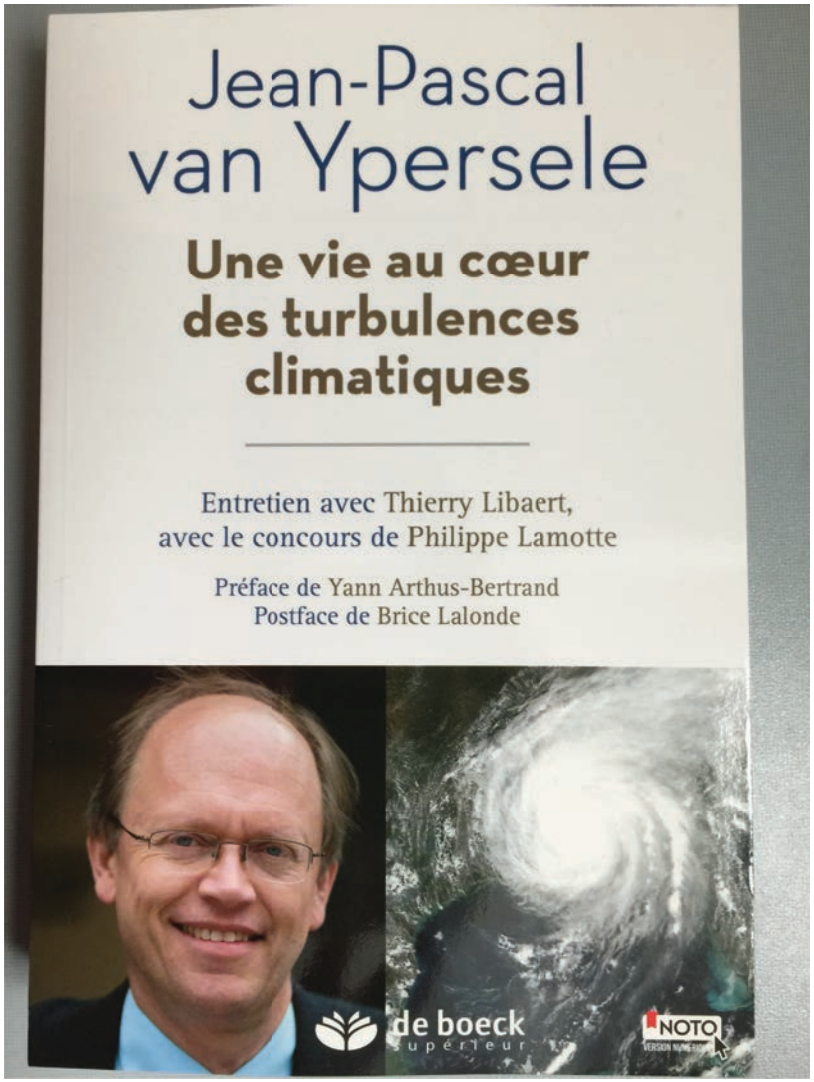
UNFCCC, Aggregate effect of the intended nationally determined contributions: an update
http://unfccc.int/resource/docs/2016/cop22/eng/02.pdf

Leaders Aim to Put a Price on Half of All Global Carbon Emissions

http://www.worldbank.org/en/news/feature/2016/04/21/leaders-aim-to-put-a-price-on-half-of-all-global-carbon-emissions?CID=CCG_TT_climatechange_EN_EXT

Trying to be coherent (external insulation)

Publié chez De Boeck supérieur,
octobre 2015
Broché: 16 euros
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**