Climate change and IPCC: The role of scenarios

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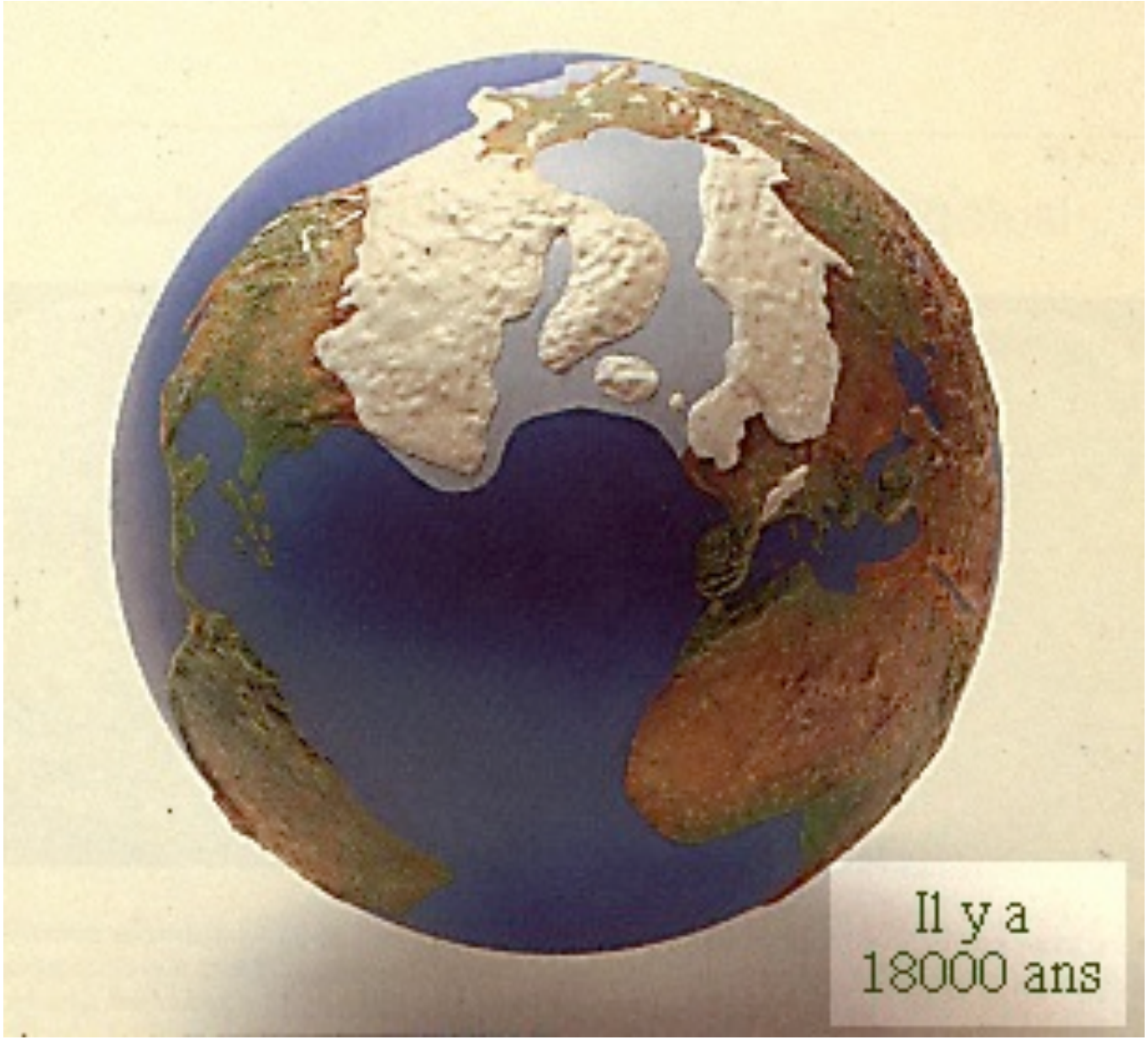
Science for scenarios, Ecole de physique des Houches, 2-7 Feb 2014

Thanks to Philippe Marbaix, Richard Moss, and Malte Meinshausen for some slides, to the Belgian Science Policy Office for its support, and to Bruna Gaino for her help

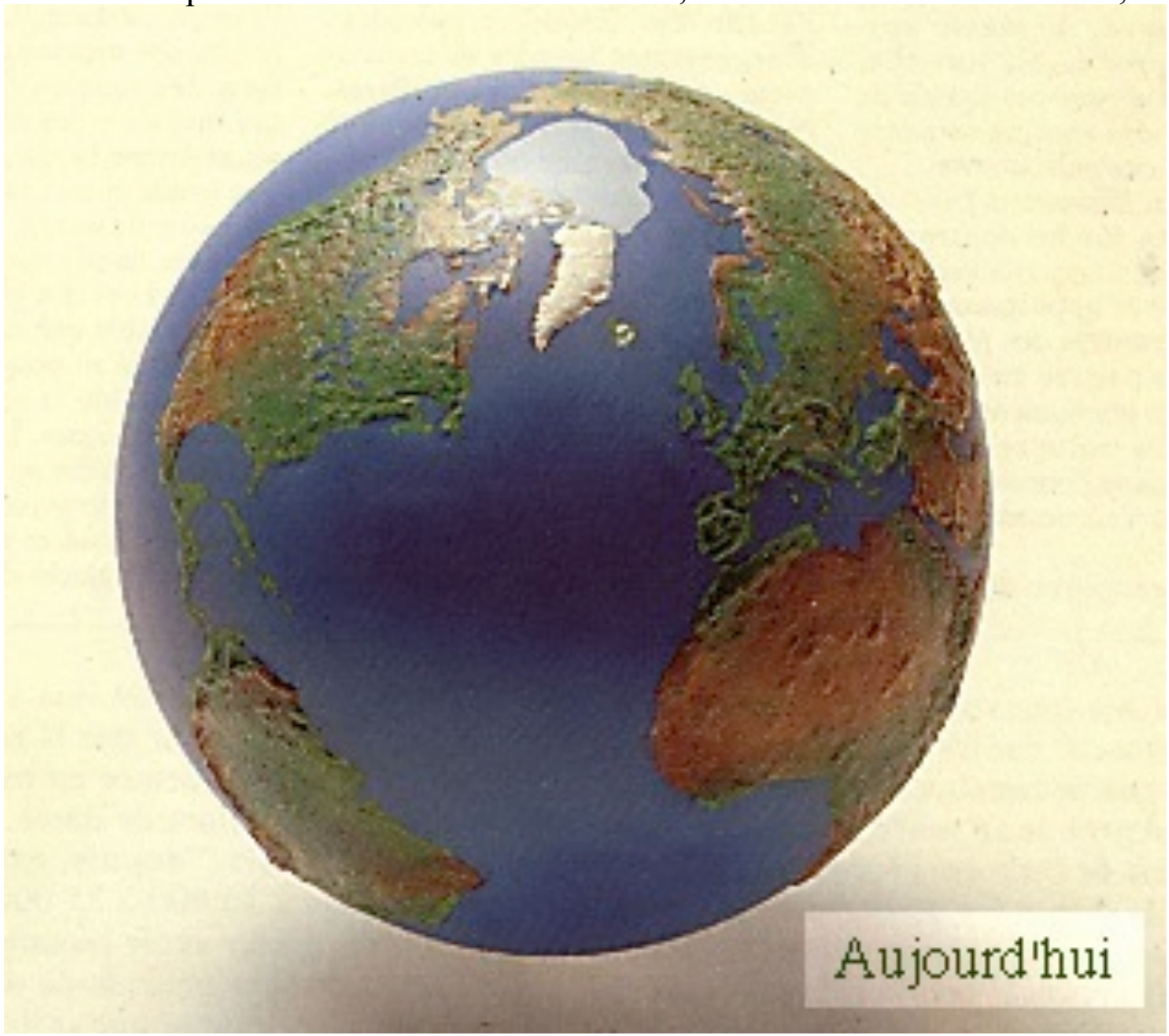
18-20000 years ago (Last Glacial Maximum)

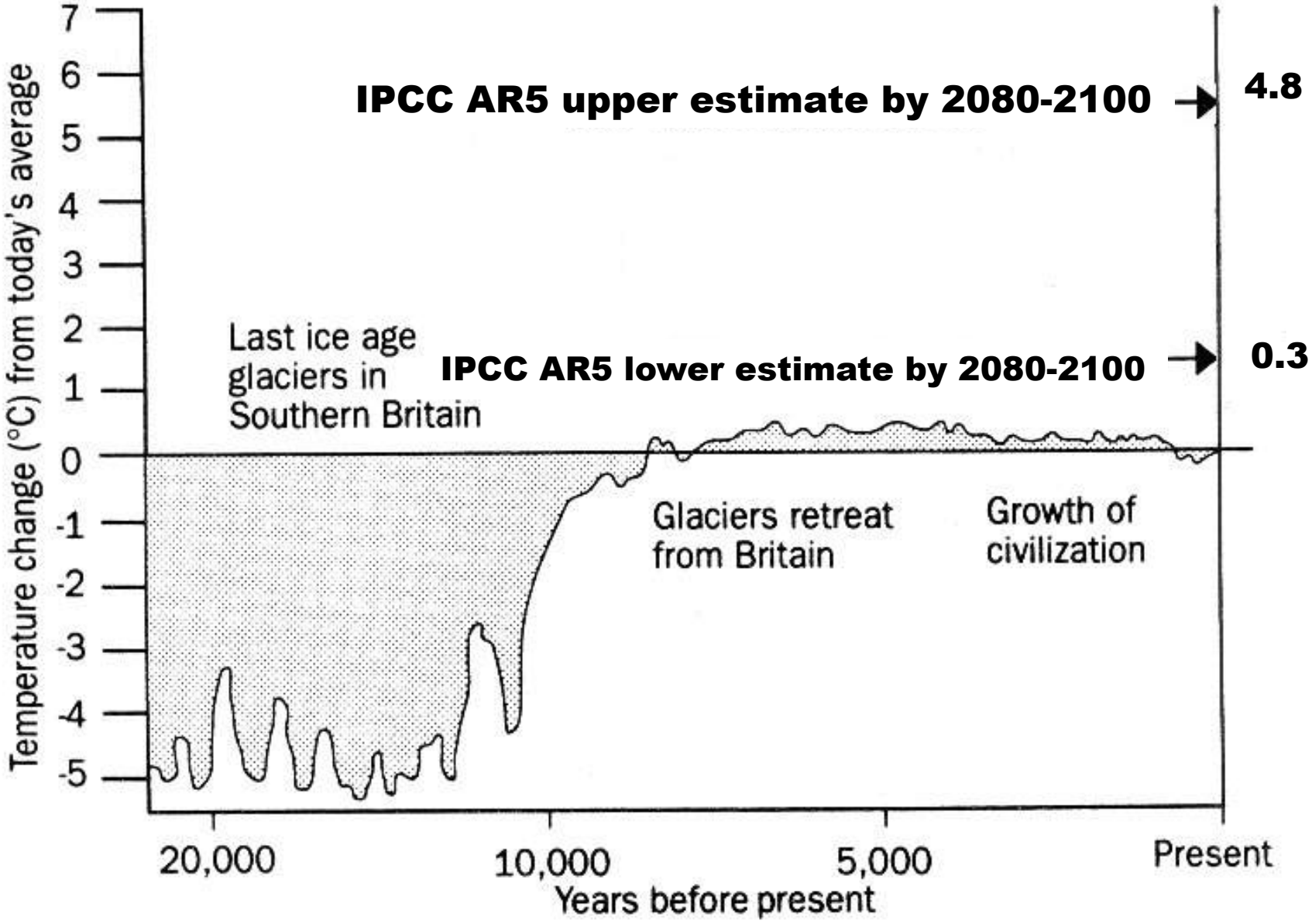
With permission from Dr. S. Joussaume, in « Climat d'hier à demain », CNRS éditions.



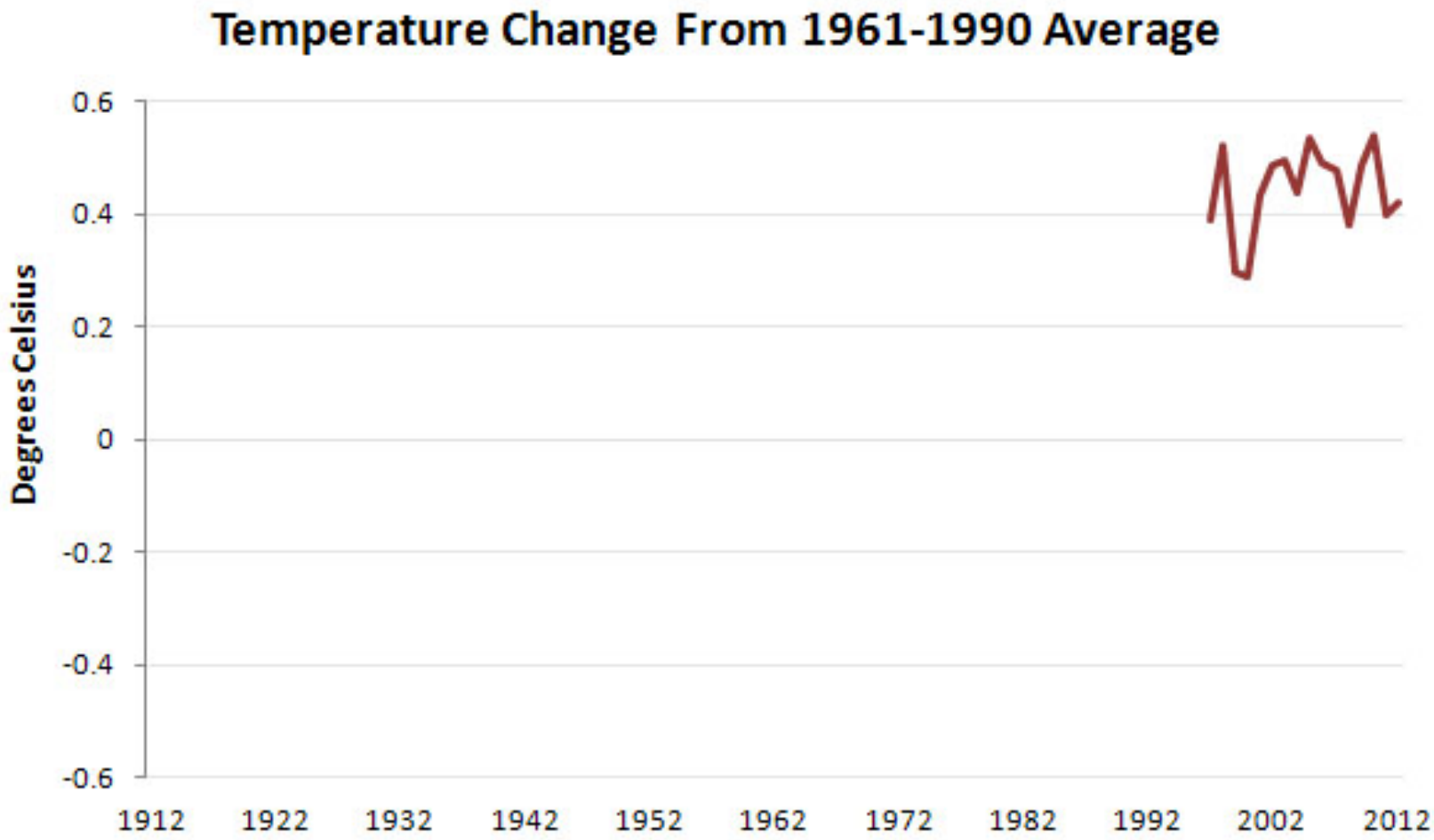
Today, with +4-5°C globally

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

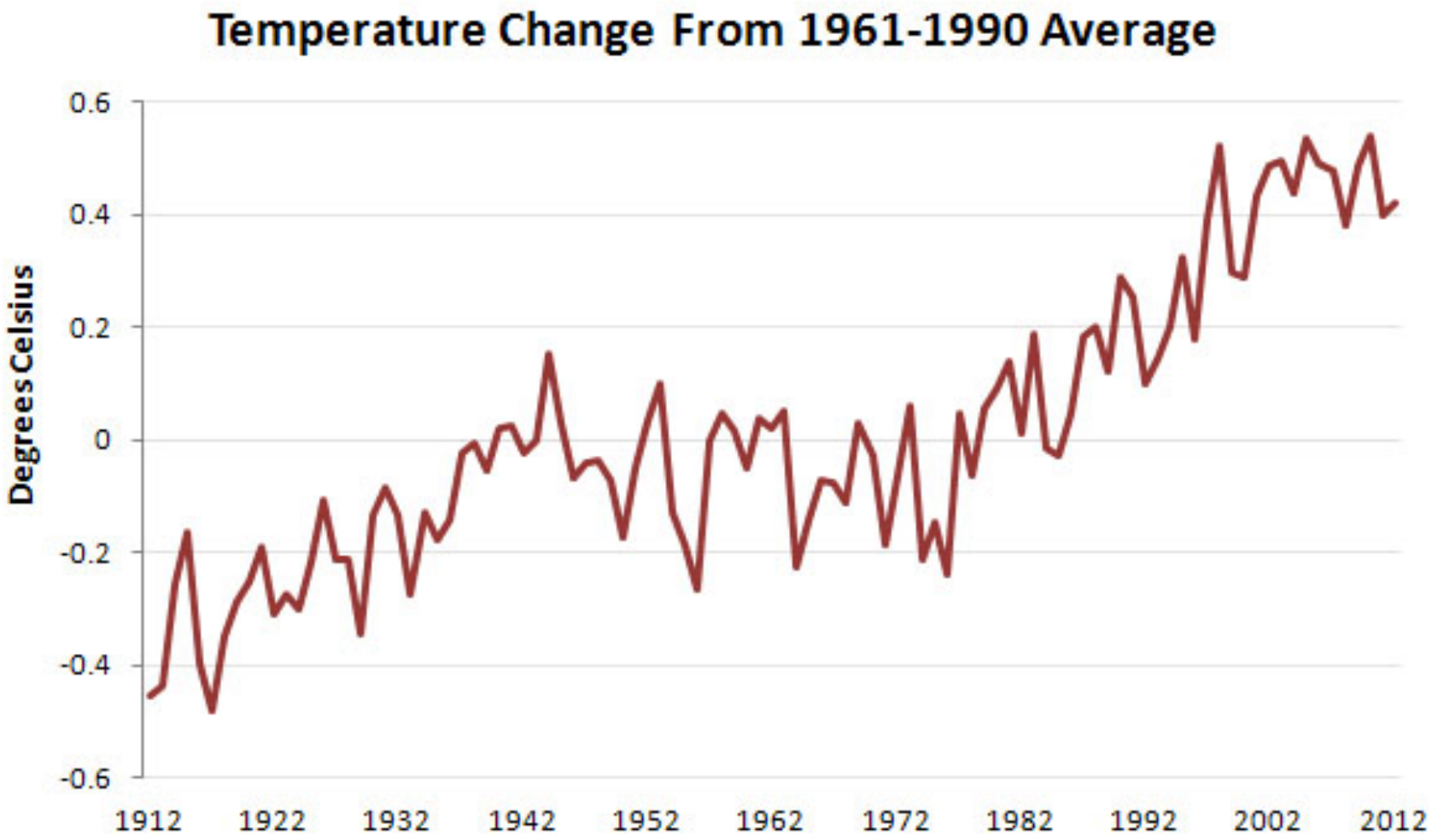




Adapted from: International Geosphere Biosphere Programme Report no.6, Global Changes of the Past, July1988

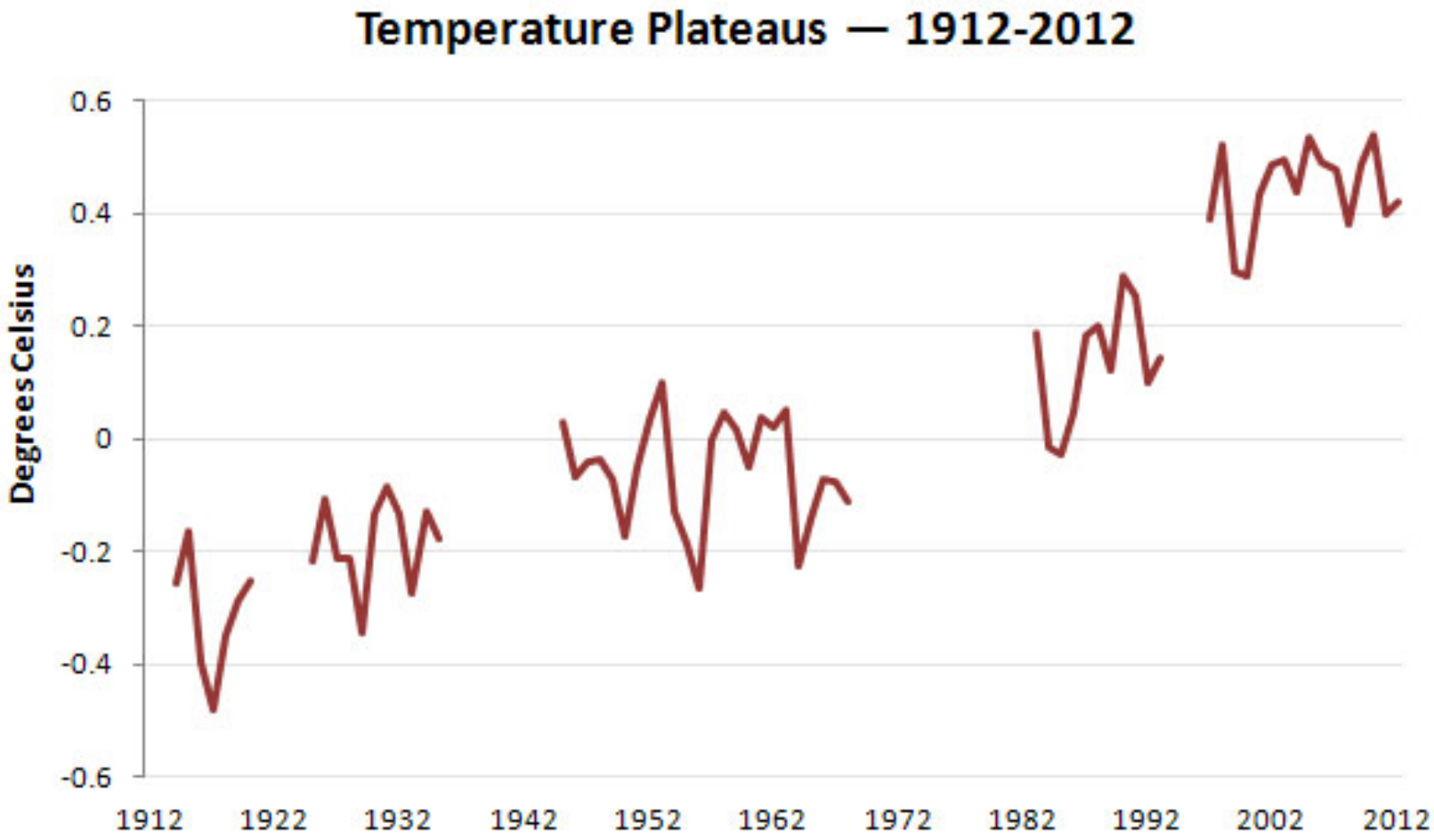


http://www.motherjones.com/kevin-drum/2012/10/lying-statistics-global-warming-edition



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

Lying With Statistics, Global Warming Edition



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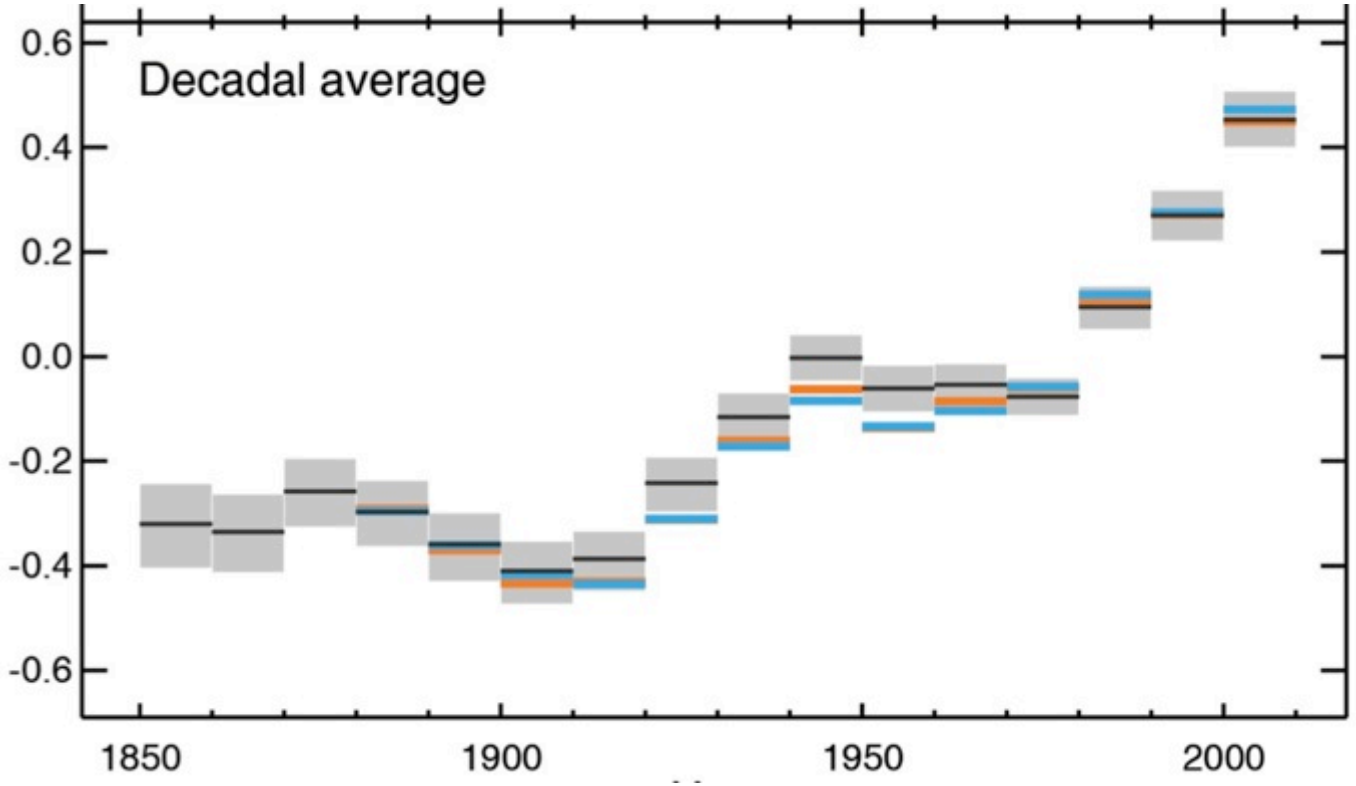

(IPCC 2013, Fig. SPM.1a)

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*).

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.

WMO=World Meteorological Organization

UNEP= United Nations Environment Programme

What is the IPCC (GIEC in French) ?

- IPCC : Intergovernmental Panel on Climate Change
- Created by World Meteorological Organisation (WMO) & United Nations Environment Programme (UNEP) in 1988
- Mandate : assess the science of climate change, impacts and adaptation, mitigation options
- Publishes consensus reports (1990, 1996, 2001, 2007) (Cambridge University Press)
  Advises Climate Change Convention
- Nobel Peace prize (2007)
- Web : http://www.ipcc.ch

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IPCC Reports are policy-relevant, NOT policy-prescriptive

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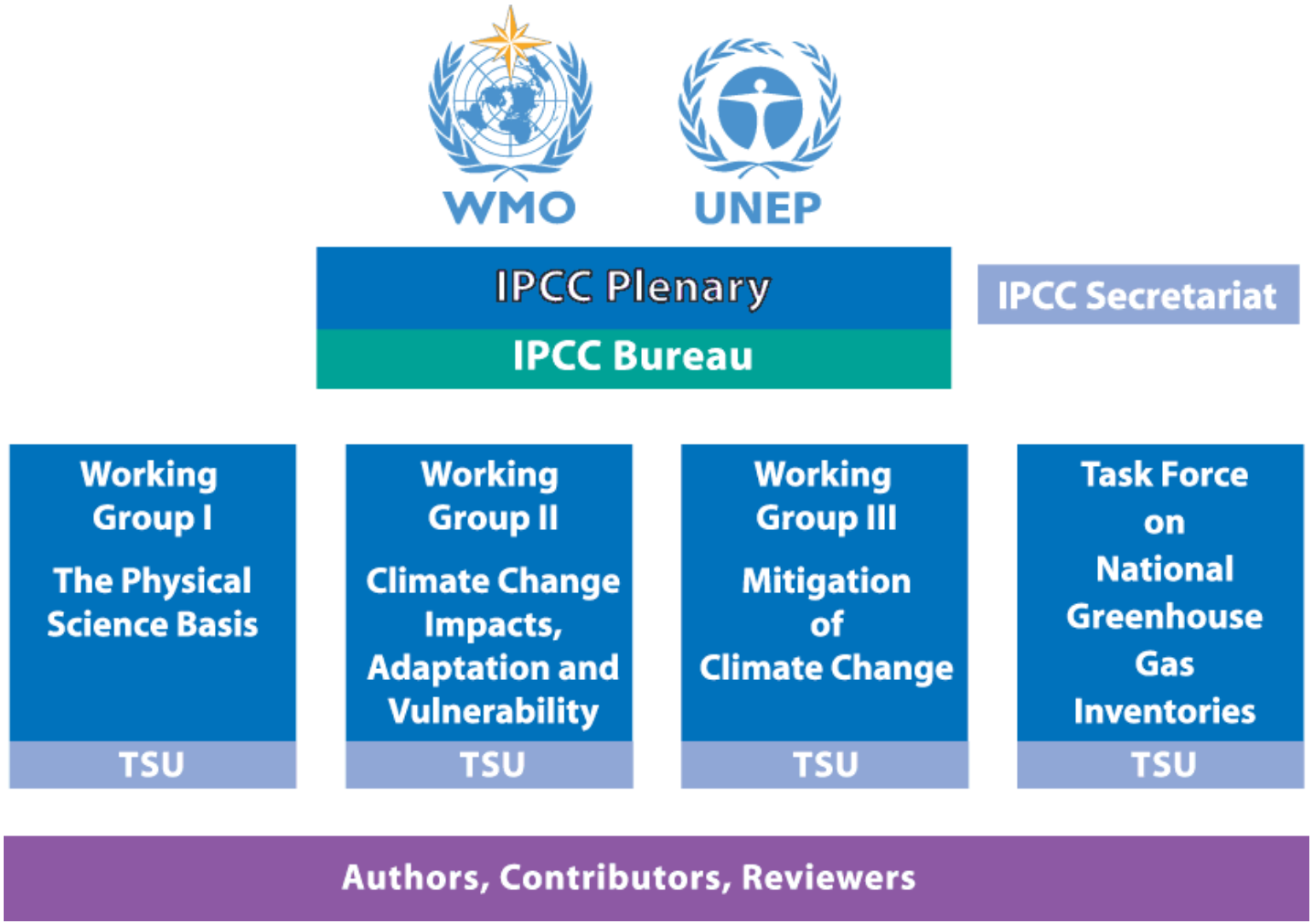
Structure of the Intergovernmental Panel on Climate Change



IPCC writing cycle (4 years, 831 Lead authors)

- **Plenary decides table of content of reports**
- **Bureau appoints world-class scientists as authors, based on publication record**
- **Authors assess all scientific literature**
- ***Draft* – Expert review (+ Review editors)**
- ***Draft 2 (+ Draft 1 Summary for Policy Makers (SPM)* – Combined expert/government review**
- ***Draft 3 (+ Draft 2 SPM)*– Government review of SPM**
- **Approval Plenary (interaction authors – governments) – *SPM and full report***
- ***NB: the scientists have the last word!***

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(vanypersele@astr.ucl.ac.be)

Completed IPCC Reports

4 Assessment Reports *(1990,1995, 2001, 2007, [2013-14])*

1992 Supplementary Report and 1994 Special Report

8 Special Reports *(1997,1999, 2000, 2005, 2011)*

Guidelines for National GHG Inventories, Good Practice Guidance *(1995-2006)*

6 Technical Papers *(1996-2008)*

The IPCC assessments have influenced global action on an unprecedented scale

1. The First Assessment Report (FAR, 1990) had a major impact in defining the content of the UNFCCC
2. The Second Assessment Report (SAR, 1996) was largely influential in defining the provisions of the Kyoto Protocol
3. The Third Assessment Report (TAR, 2001) focused attention on the impacts of climate change and the need for adaptation
4. The Fourth Assessment Report (AR4, 2007) informed the decision on the ultimate objective (2°C) and is creating a strong basis for a post Kyoto Protocol agreement (IPCC received Nobel Peace Prize in 2007)
5. The Fifth Assessment Report (AR5, 2013-14) will inform the review of the 2°C objective, and be the context for preparing the Paris 2015 agreement

The Fifth Assessment Report (AR5)

- **WG I**: The Physical Science Basis
  end September 2013
- **WG II**: Impacts, Adaptation and Vulnerability
  end March 2014
- **WG III**: Mitigation of Climate Change
  mid April 2014
- **AR5 Synthesis Report** (SYR)
  October 2014

Key SPM Messages

19 Headlines

on less than 2 Pages

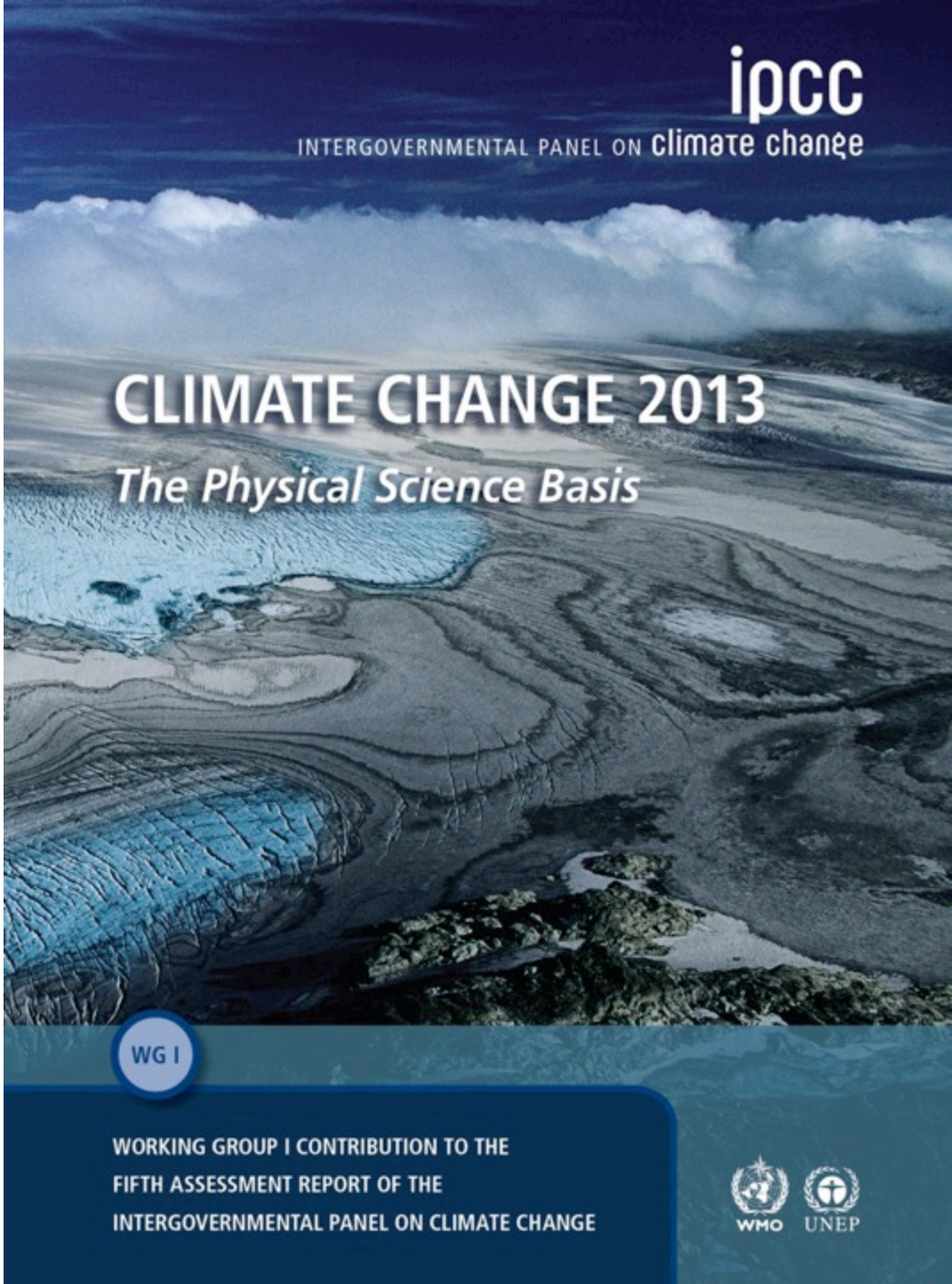
Summary for Policymakers
~14,000 Words

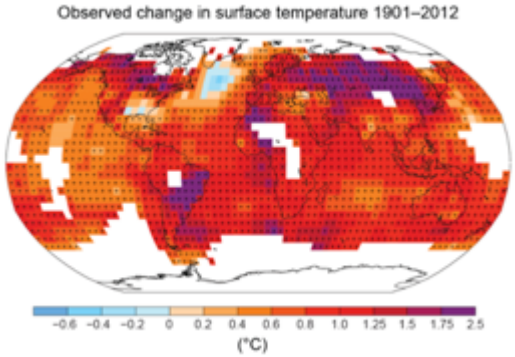
14 Chapters
Atlas of Regional Projections

54,677 Review Comments
by 1089 Experts

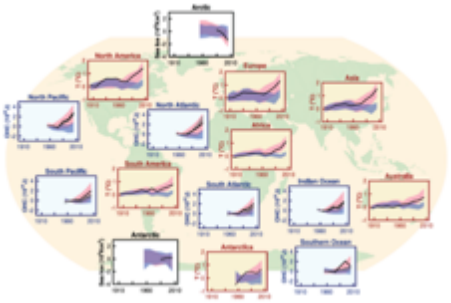
2010: 259 Scientists Selected

2009: WGI Outline Approved

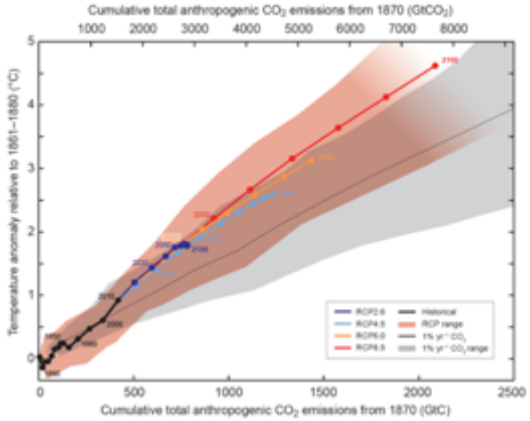




Warming of the climate system is unequivocal, [...]



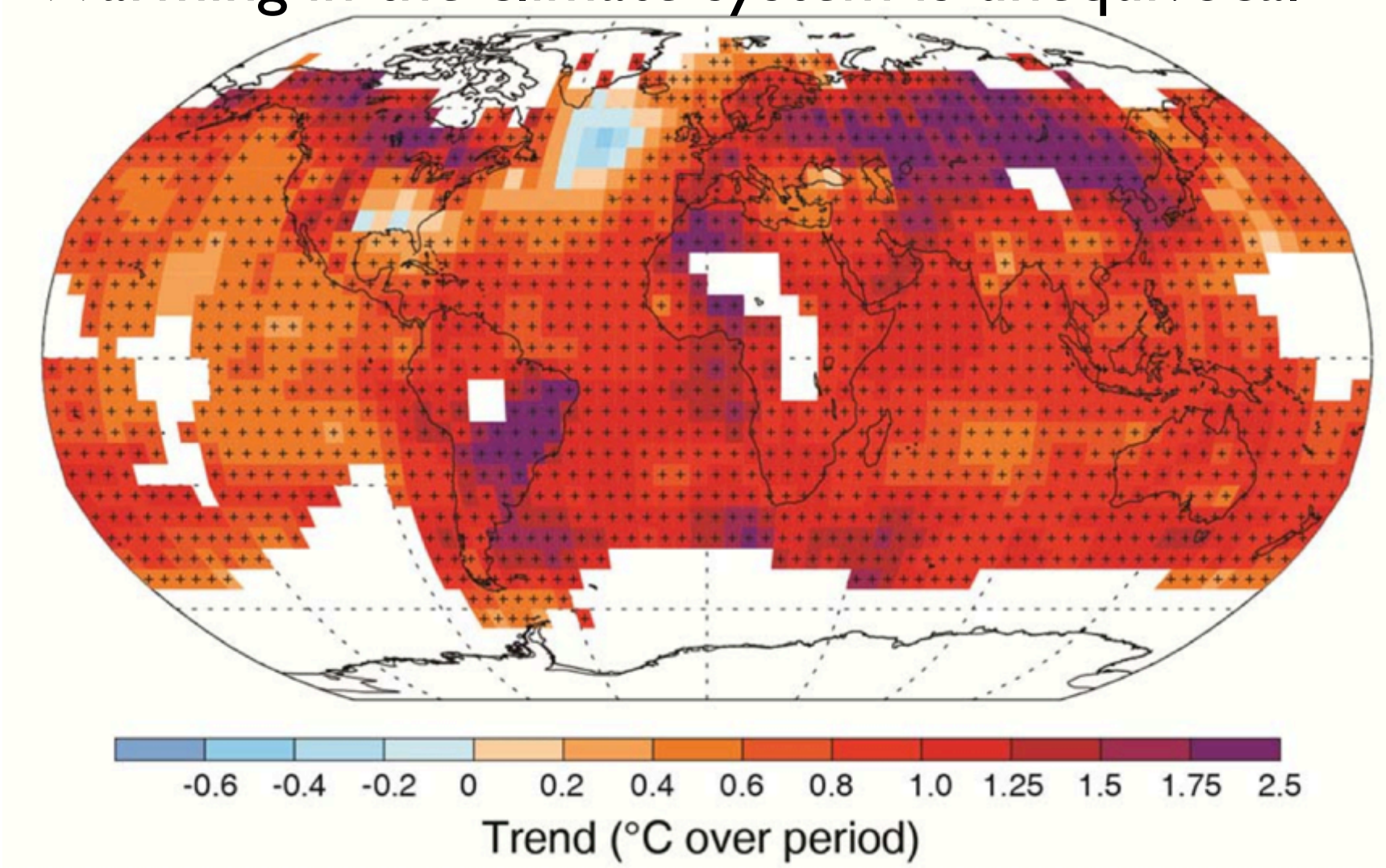
Human influence on the climate system is clear.



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

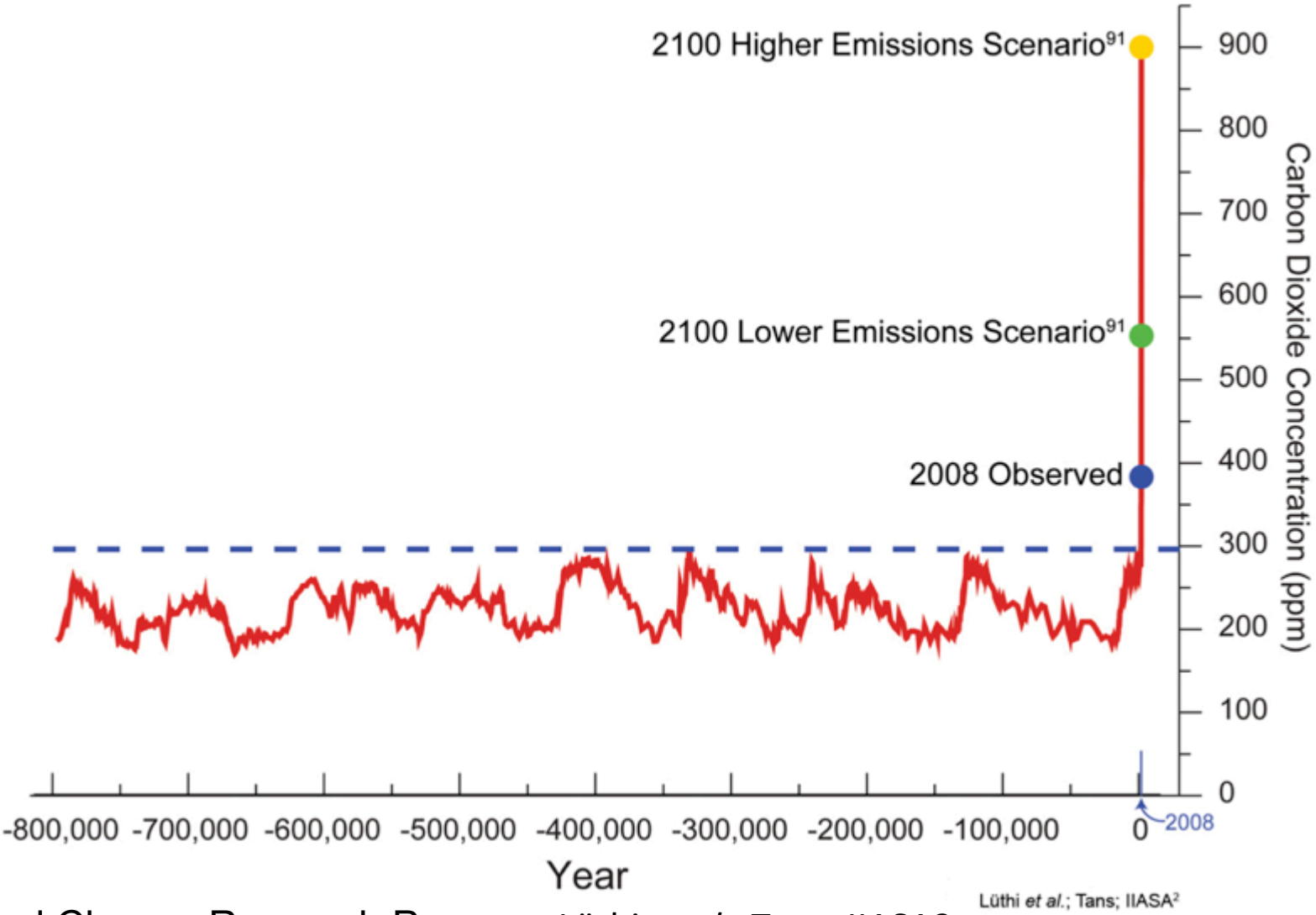
Change in average surface temperature 1901-2012

Warming in the climate system is unequivocal



AR5 WGI SPM - Approved version / subject to final copyedit

Atmospheric CO_2 over the last 800000 years



U.S. Global Change Research Program:Lüthi *et al.*; Tans; IIASA2

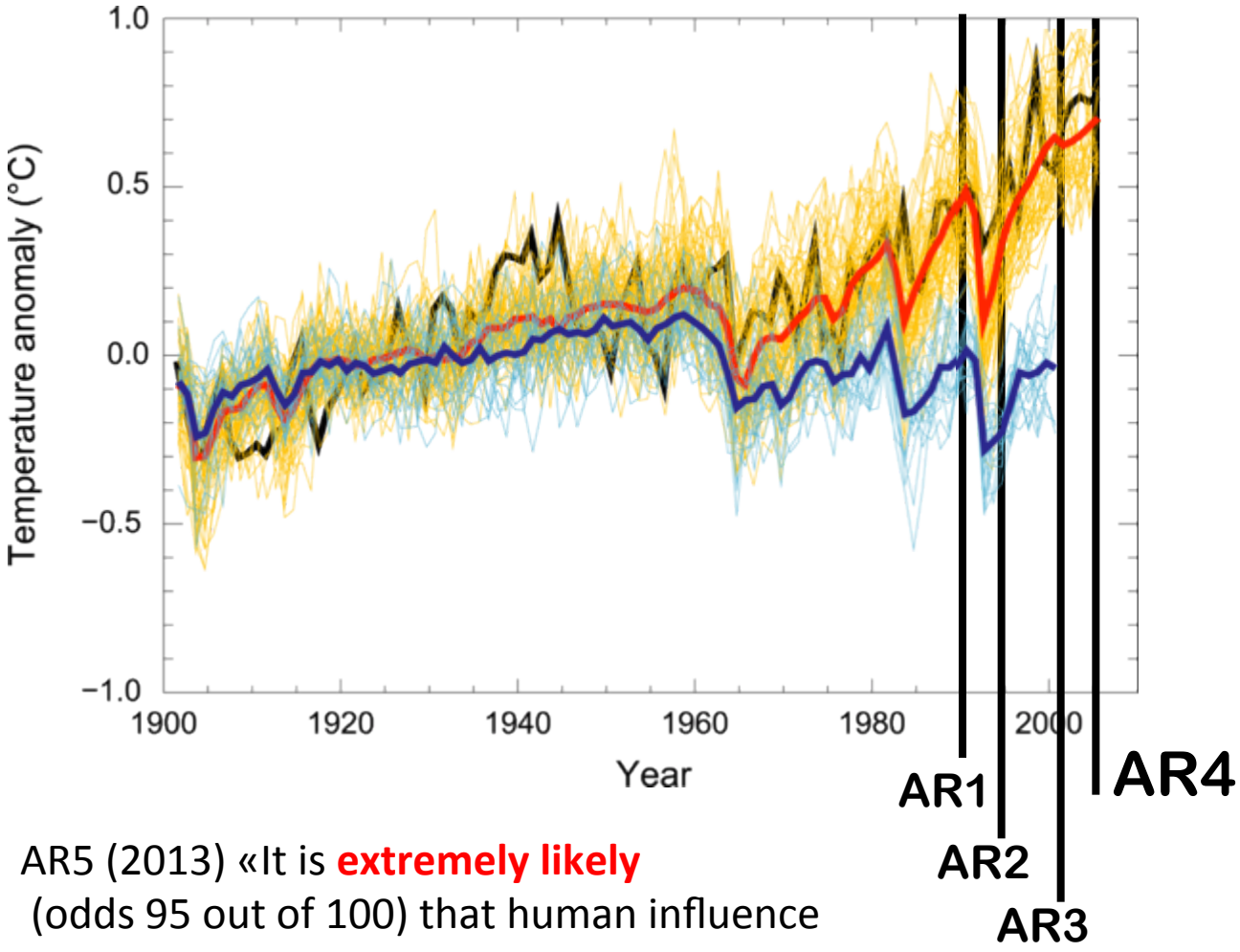
A Progression of Understanding: Greater and Greater Certainty in Attribution

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… »

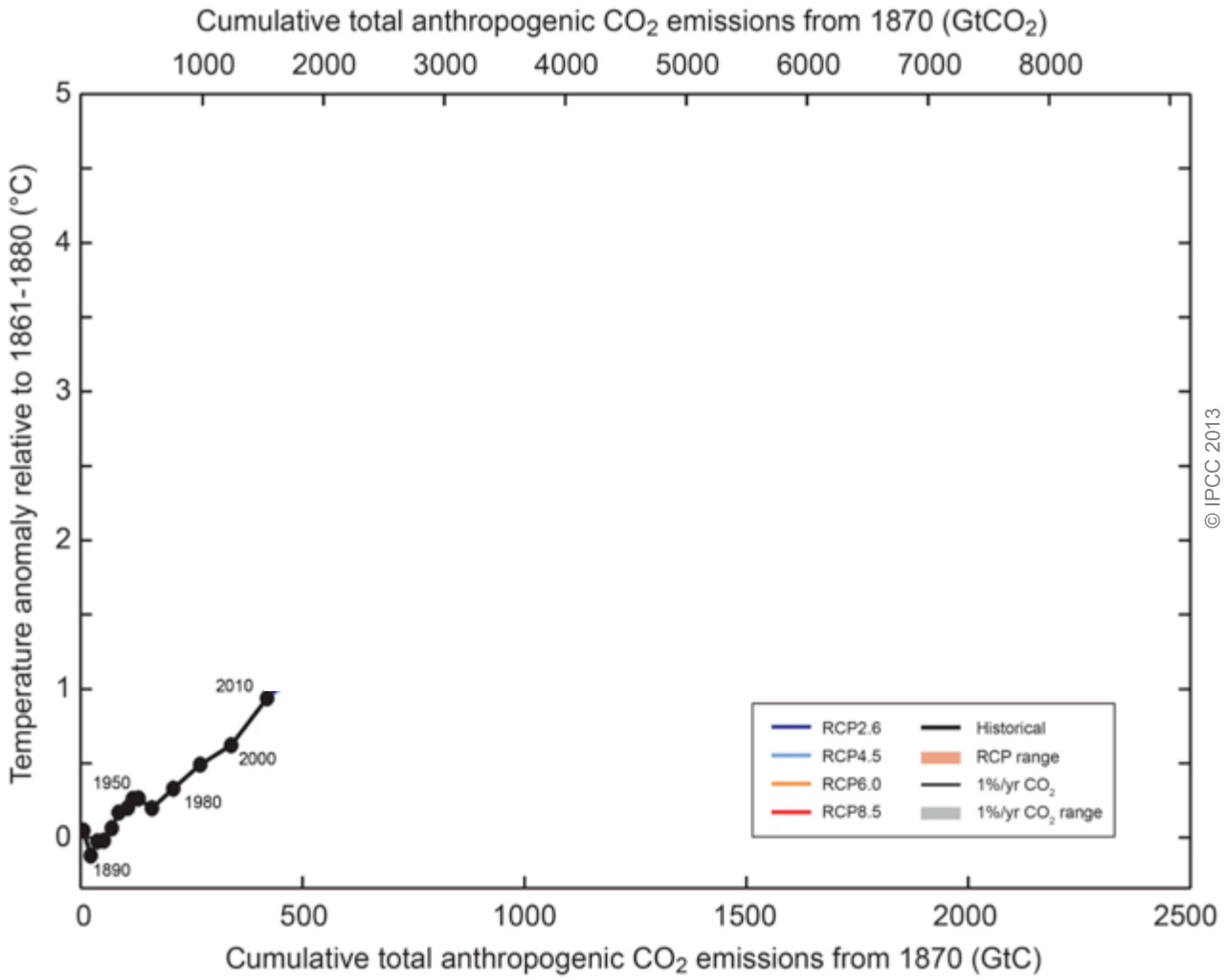


Fig. SPM.10

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

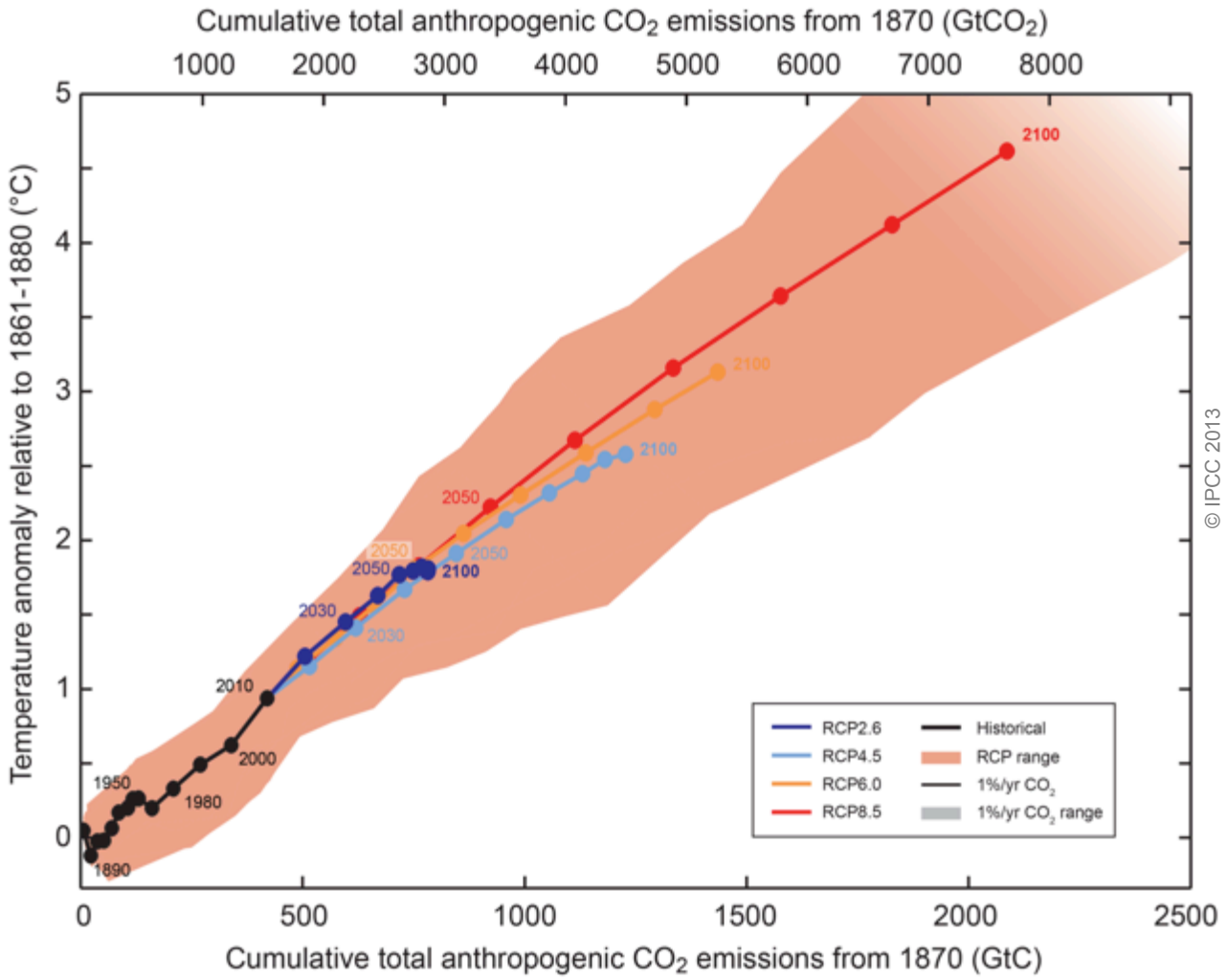
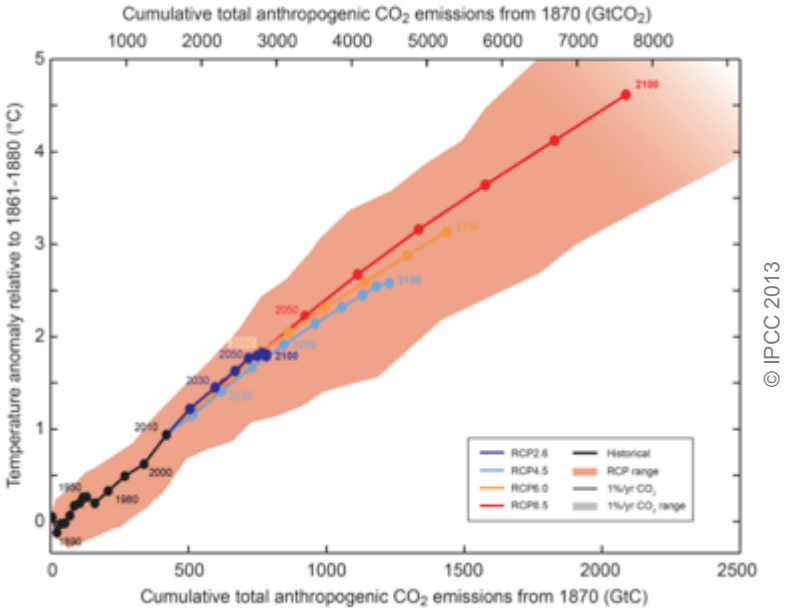


Fig. SPM.10

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



Limiting warming to *likely* less than 2°C since 1861-1880 requires cumulative CO_2 emissions to stay below 1000 GtC. Until 2011, over 50% of this amount has been emitted.

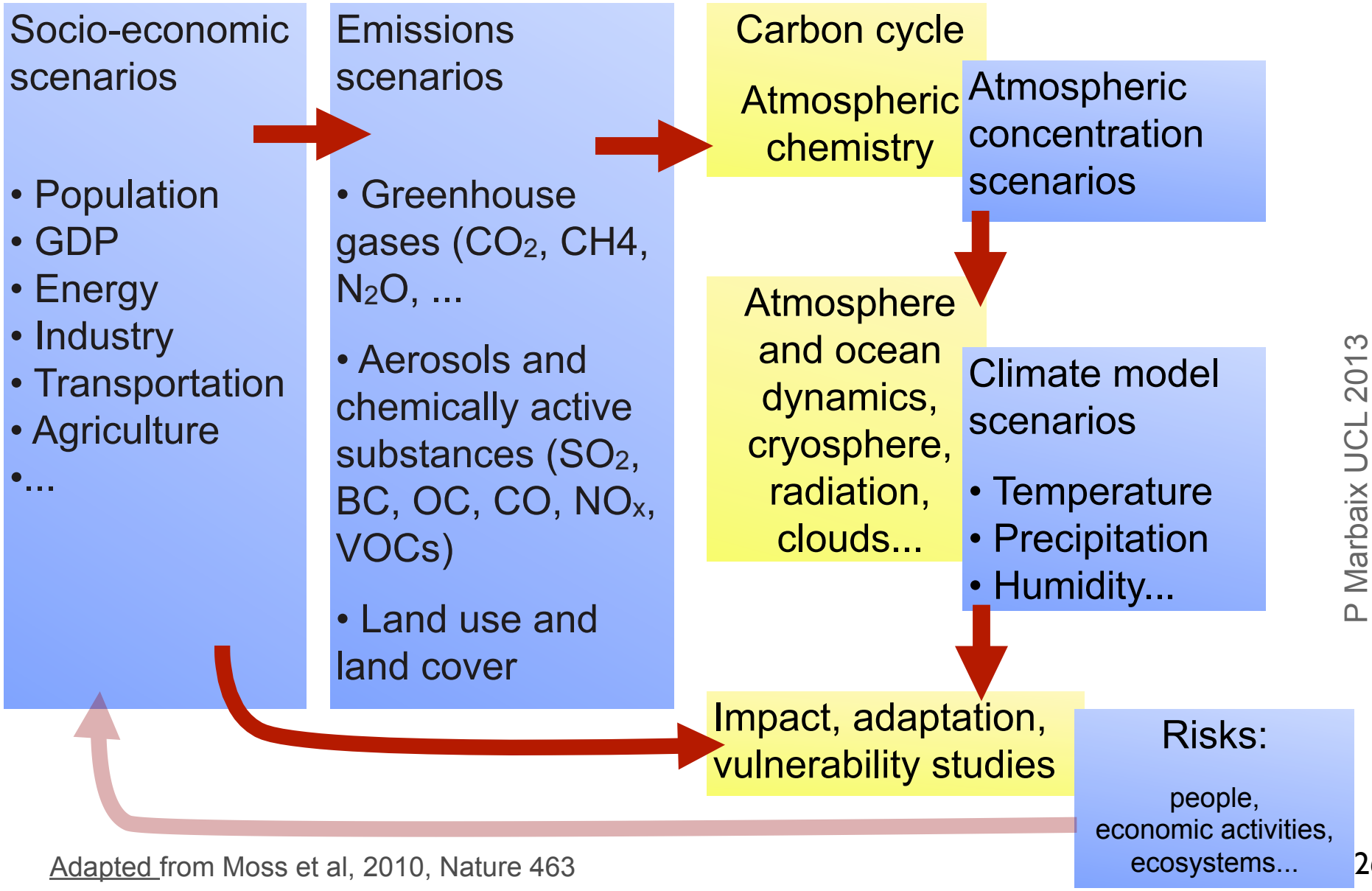
Accounting for other forcings, the upper amount of cumulative CO_2 emissions is 800 GtC; over 60% have been emitted by 2011.

Scenario definition (IPCC WGI AR5 Glossary, 2013)

Scenario: A **plausible** description of how the future **may** develop based on a **coherent and internally consistent set of assumptions about key driving forces** (e.g., rate of technological change, prices) **and relationships**. Note that scenarios are **neither predictions nor forecasts**, but are **useful to provide a view of the implications** of developments and actions.

See also Climate scenario, Emission scenario, Representative Concentration Pathways and SRES scenarios.

Scenarios: socio-economic, emissions, concentrations, climate change

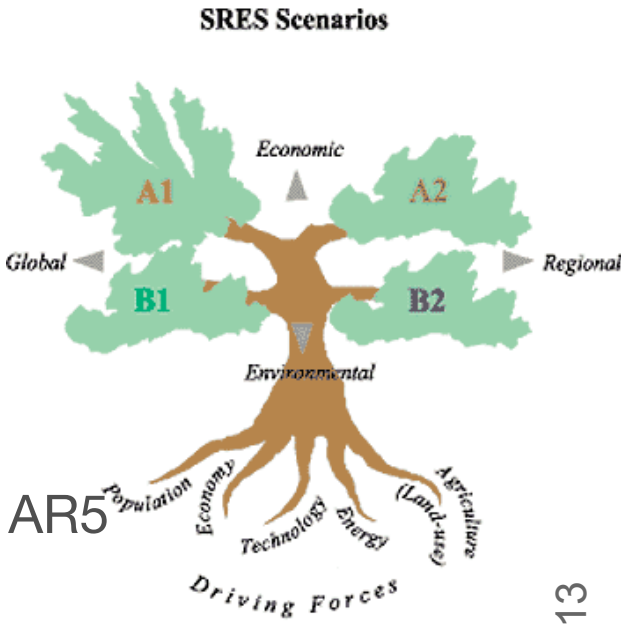


Adapted from Moss et al, 2010, Nature 463

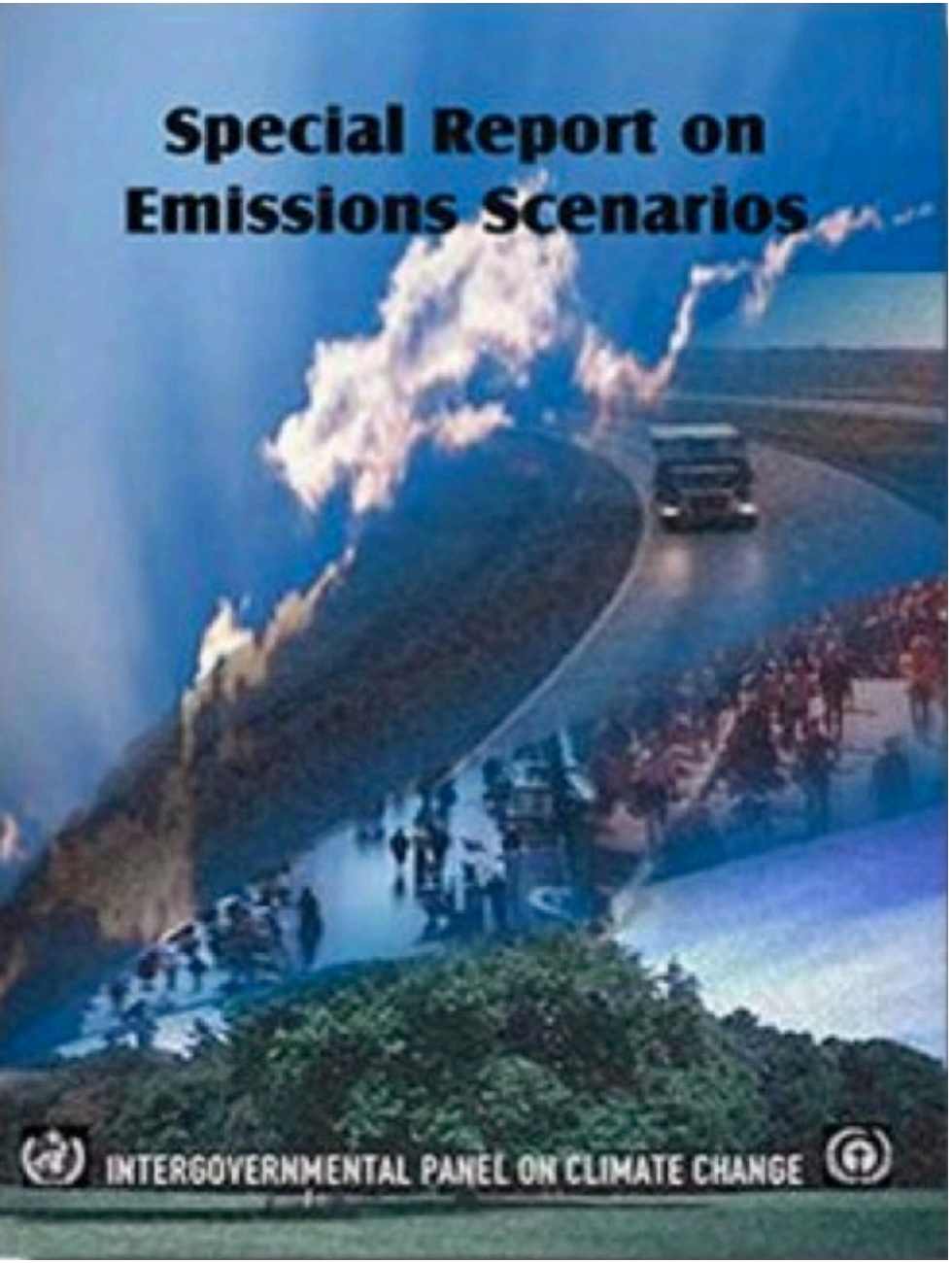
P Marbaix UCL 2013

Scénarios @ IPCC : where we come from

- IPCC 1990 : SA90, baseline & mitigation policy
- IPCC 1992 : IS92, no climate policy
- IPCC 2000 : Special Report on Emission Scenarios (SRES), no climate policy, but detailed analysis of drivers, socio-economic storylines...
  - → Assessment reports : TAR, AR4, still part of AR5



- Others outside IPCC (ex. WRE (1996) stabilization)



N. Nakicenovic & R. Swart (Eds), 2000

Remark: ***No mitigation policies implied in any SRES scenario***

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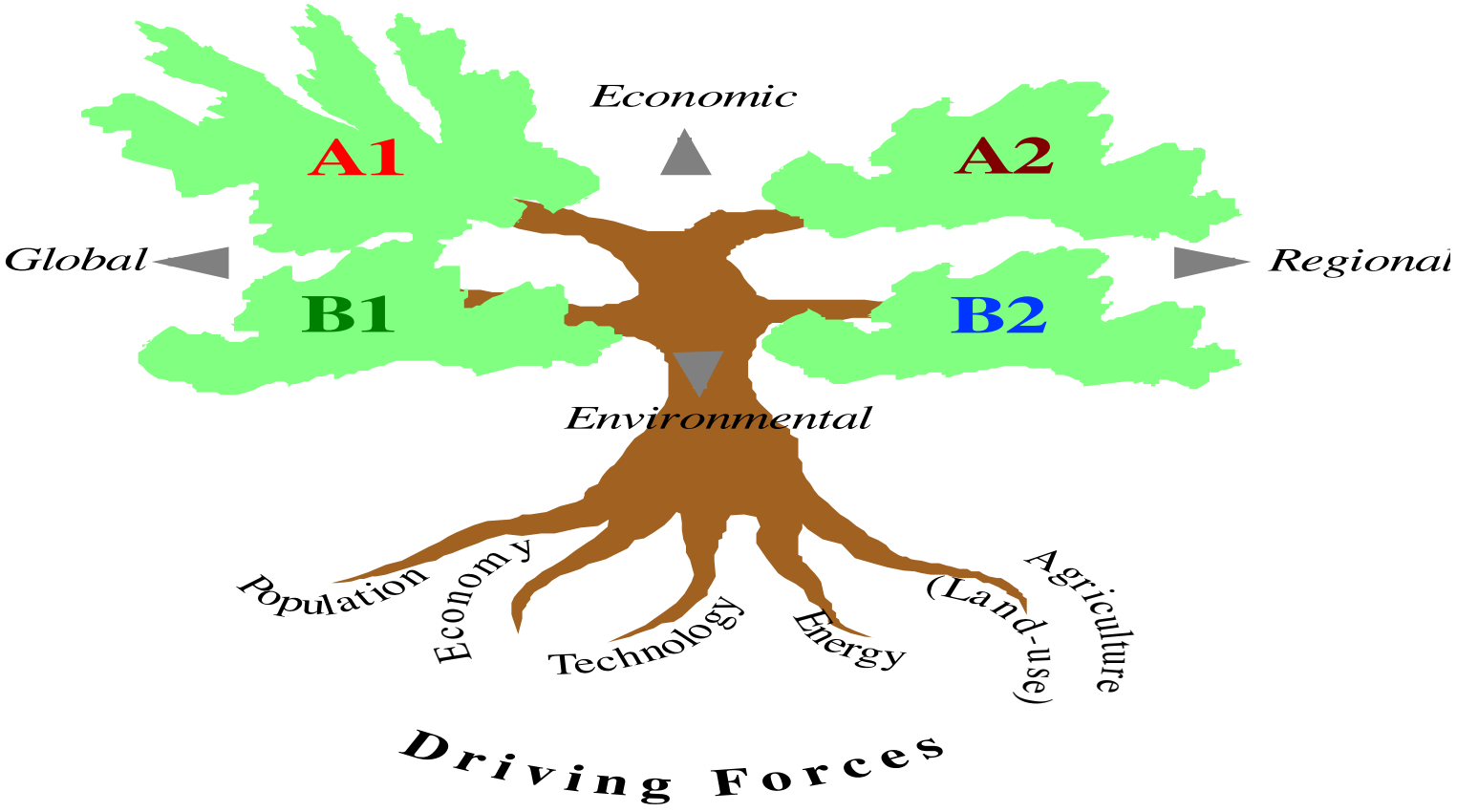
INTERGOVERNMENTAL PANEL ON climate change

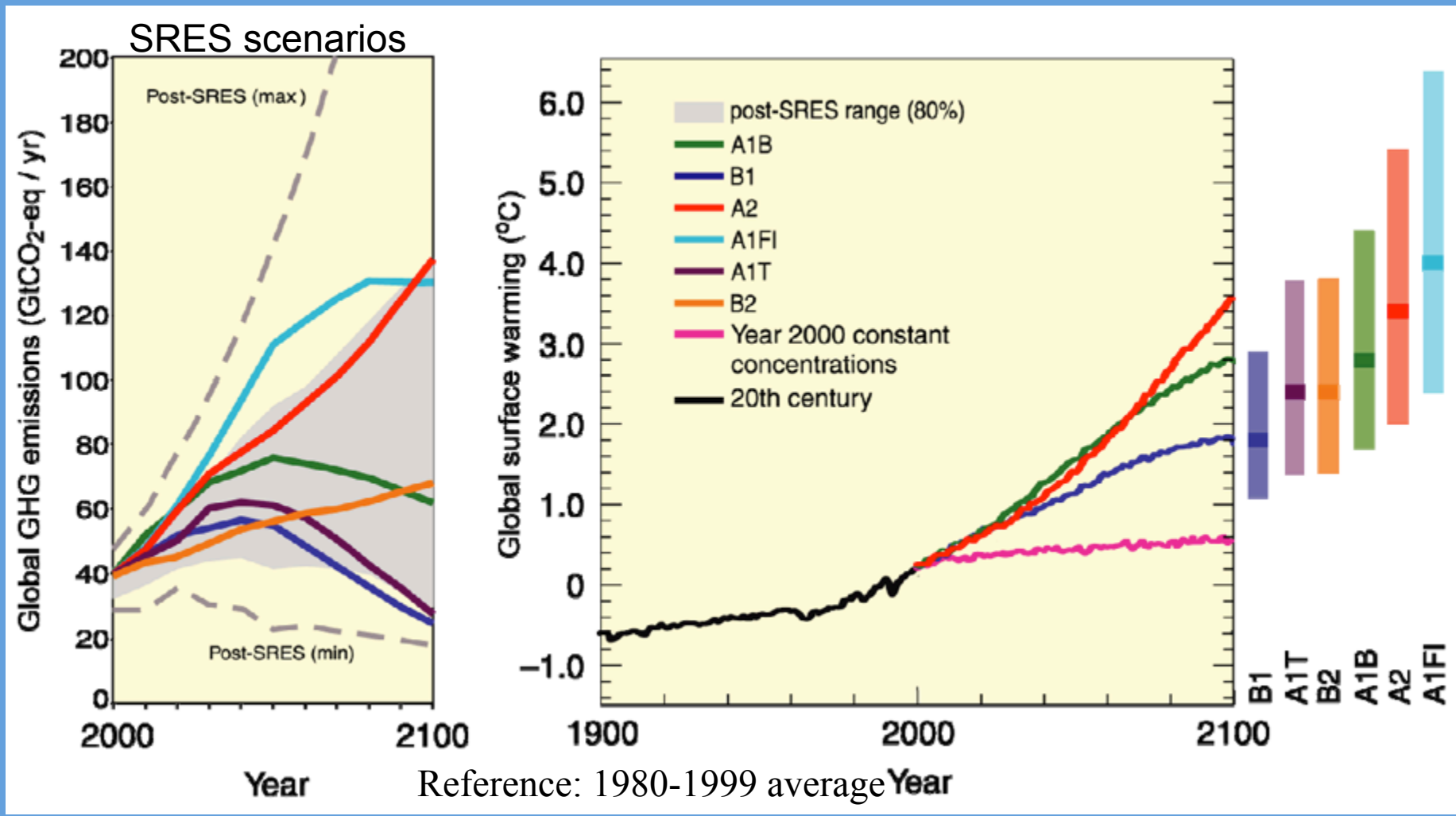
WMO UNEP

SRES Scenarios: Extensively used in CC Research and Assessments since 2000



Source: IPCC, AR4 (2007)

Climate projections without mitigation



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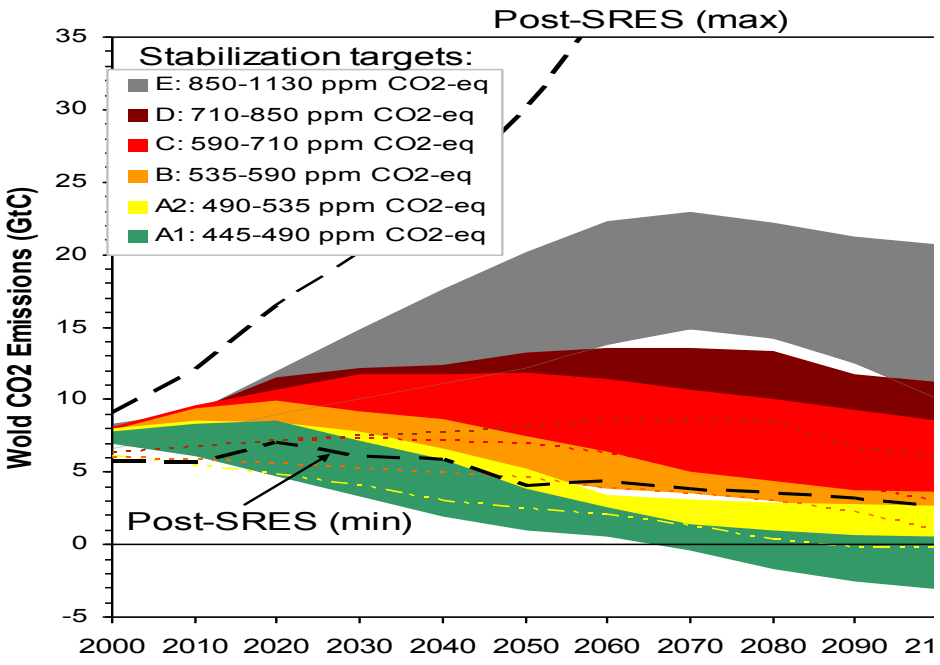
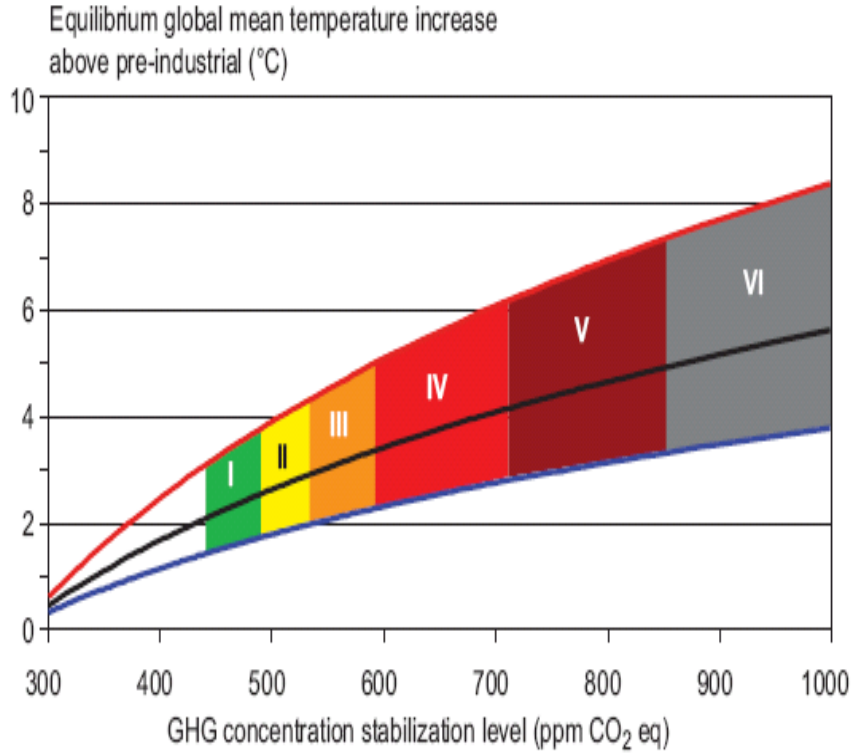
Stabilization in AR4: From equilibrium global temperature to concentrations to emissions (without using SRES)



Multigas and CO2 only studies combined



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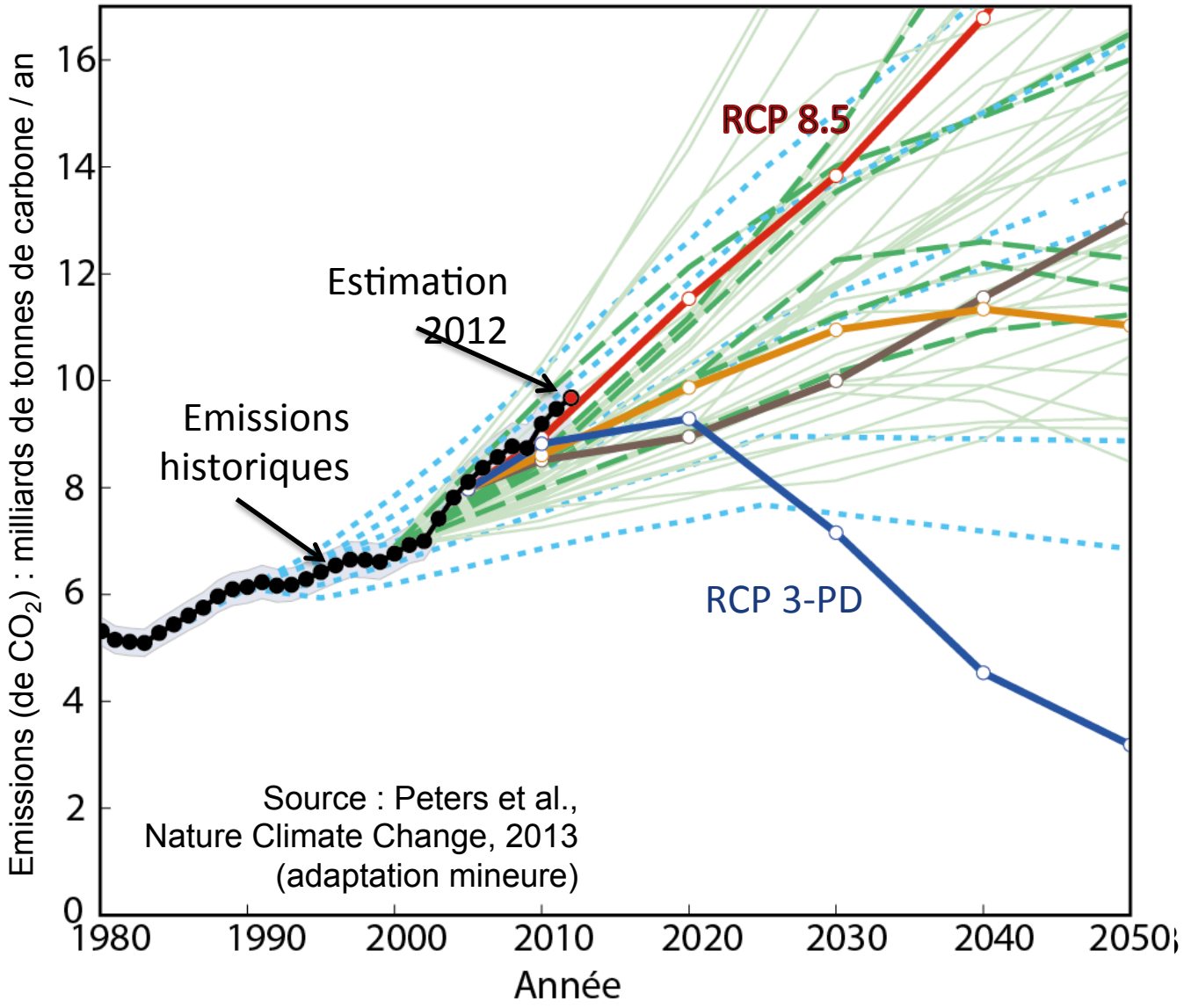
AR4: Emission peaking & reductions, concentrations, temperature, & sea-level rise due to thermal expansion

Category	CO_2 concentration at stabilisation (2005 = 379 ppm)[b]	CO_2-equivalent concentration at stabilisation including GHGs and aerosols (2005=375 ppm)[b]	Peaking year for CO_2 emissions[a,c]	Change in global CO_2 emissions in 2050 (percent of 2000 emissions)[a,c]	Global average temperature increase above pre-industrial at equilibrium, using 'best estimate' climate sensitivity[d,e]	Global average sea level rise above pre-industrial at equilibrium from thermal expansion only[f]
	ppm	ppm	year	percent	°C	metres
I	350 – 400	445 – 490	2000 – 2015	-85 to -50	2.0 – 2.4	0.4 – 1.4
II	400 – 440	490 – 535	2000 – 2020	-60 to -30	2.4 – 2.8	0.5 – 1.7
III	440 – 485	535 – 590	2010 – 2030	-30 to +5	2.8 – 3.2	0.6 – 1.9
IV	485 – 570	590 – 710	2020 – 2060	+10 to +60	3.2 – 4.0	0.6 – 2.4
V	570 – 660	710 – 855	2050 – 2080	+25 to +85	4.0 – 4.9	0.8 – 2.9
VI	660 – 790	855 – 1130	2060 – 2090	+90 to +140	4.9 – 6.1	1.0 – 3.7

AR4 SYR Table 5,1

Les émissions récentes sont dans le haut de la gamme considérée par les scientifiques

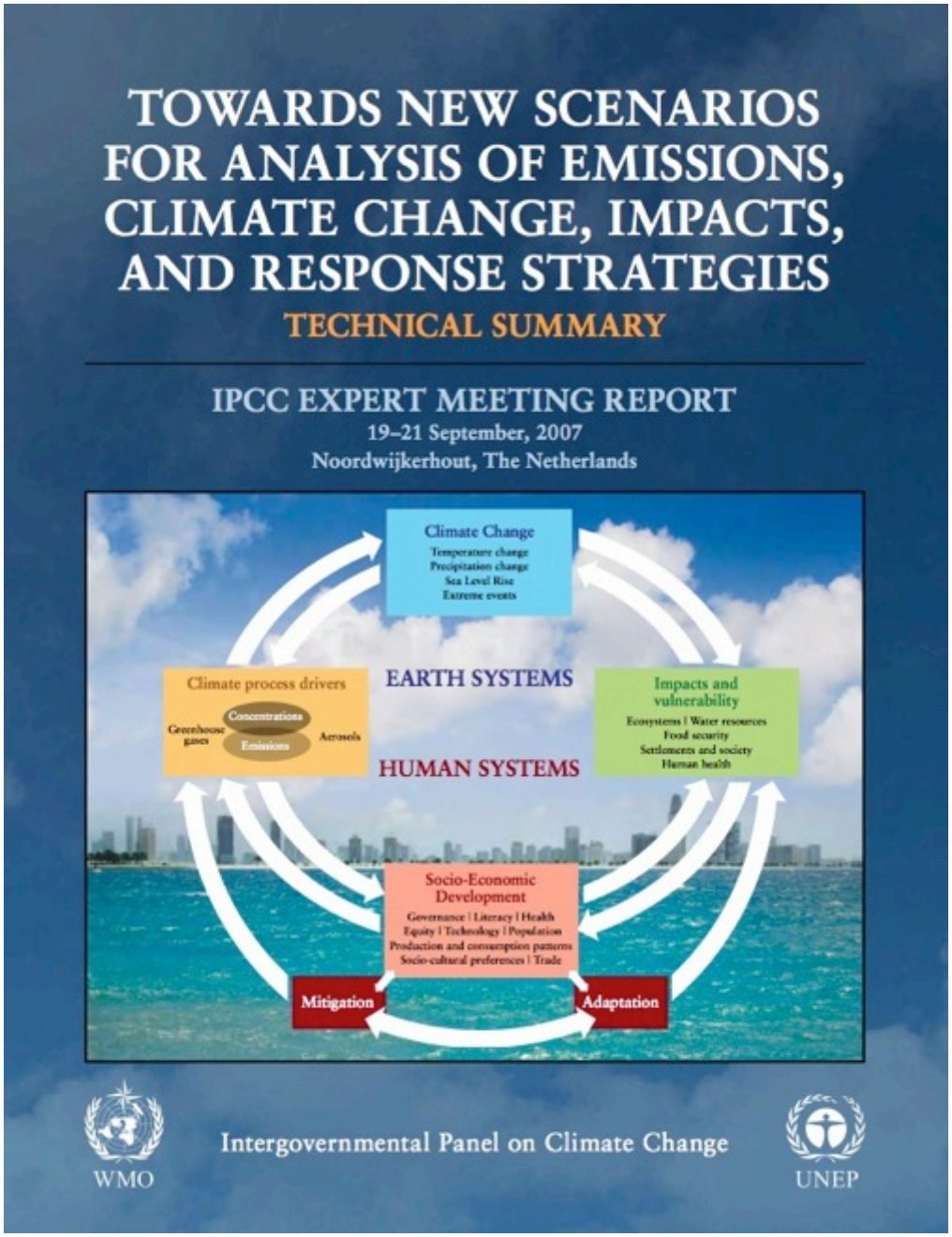


IPCC Decision (Mauritius, April 2006)

- IPCC expressed in 2005 the **need for new emission scenarios**, to be available well before completion of a possible AR5.
- The Panel recognized that the **development of scenarios for AR5 would be undertaken by the scientific community**.
- The **IPCC may catalyze such work** so as to promote its readiness in time for the AR5 cycle.

IPCC Decision (Bangkok, May 2007)

- Recalls its **support for decoupling** the climate modeling work from the emission scenario development work, in order to allow climate modelers a quick start.
- IPCC now requests the Steering Committee on New Scenarios to **prepare a few benchmark concentration scenarios** through the IPCC Expert Meeting in Noordwijkerhout (NL)
- These benchmark concentration **scenarios should be compatible with the full range** of stabilization, mitigation and baseline emission scenarios available **in** the current scientific **literature**.



IPCC Expert Meeting Report,

Noordwijkerhout, 2008

R. Moss & al., Noordwijkerhout, 2008

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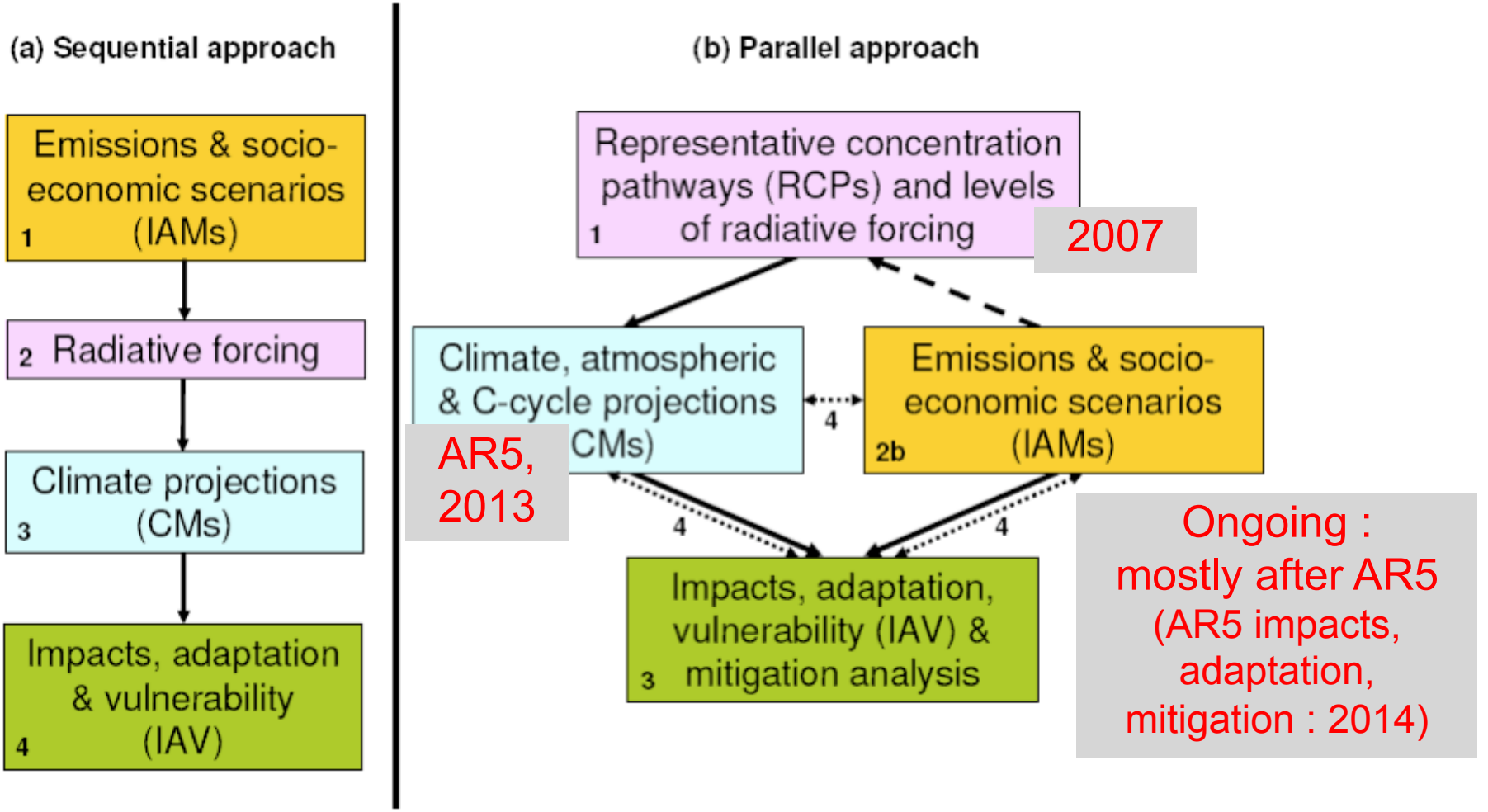
RCPs : «Representative Concentration Pathways» & «Parallel process» : accelerating the process -> projections

SRES > AR4

AR5



Source : IPCC expert meeting report, «Towards new scenarios...», 2008

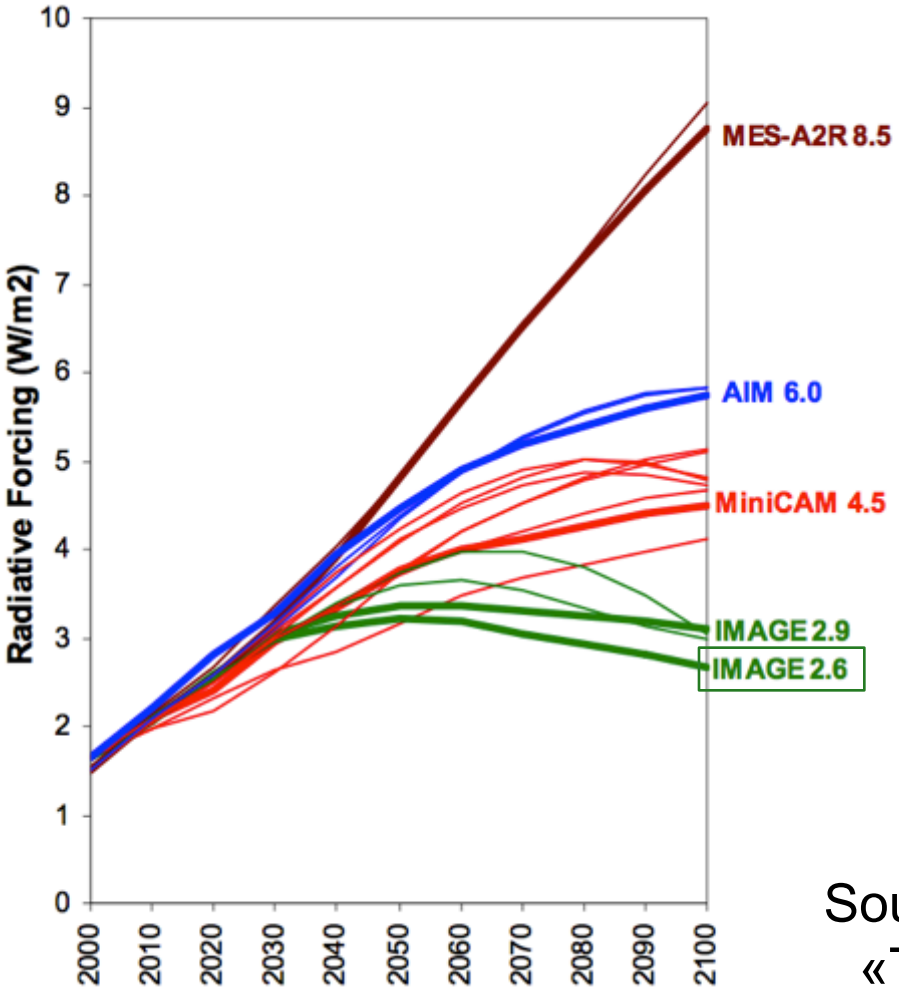
Representative Concentration Pathways (RCPs)

- **RCPs were selected from literature (in 2007, hence not new / AR4 re emissions)**
- **Criteria:**
  - **compatibility with the full range of scenarios in the scientific literature (with & without mitigation and stabilization)**
  - **even number of scenarios : avoid suggesting a «best estimate»**
  - **availability of data for all relevant forcing agents and land use**
  - **sufficiently different so the climate model simulations can be distinguished**

Representative concentration pathways

All selected from existing literature (slightly updated)

Wide range of possible futures, including mitigation



RCP8.5: 8.5 W/m^2 in 2100, continue to increase

RCP6 : 6 W/m^2, then stabilisation

RCP4.5 : 4.5 W/m^2 in 2100, then stabilisation

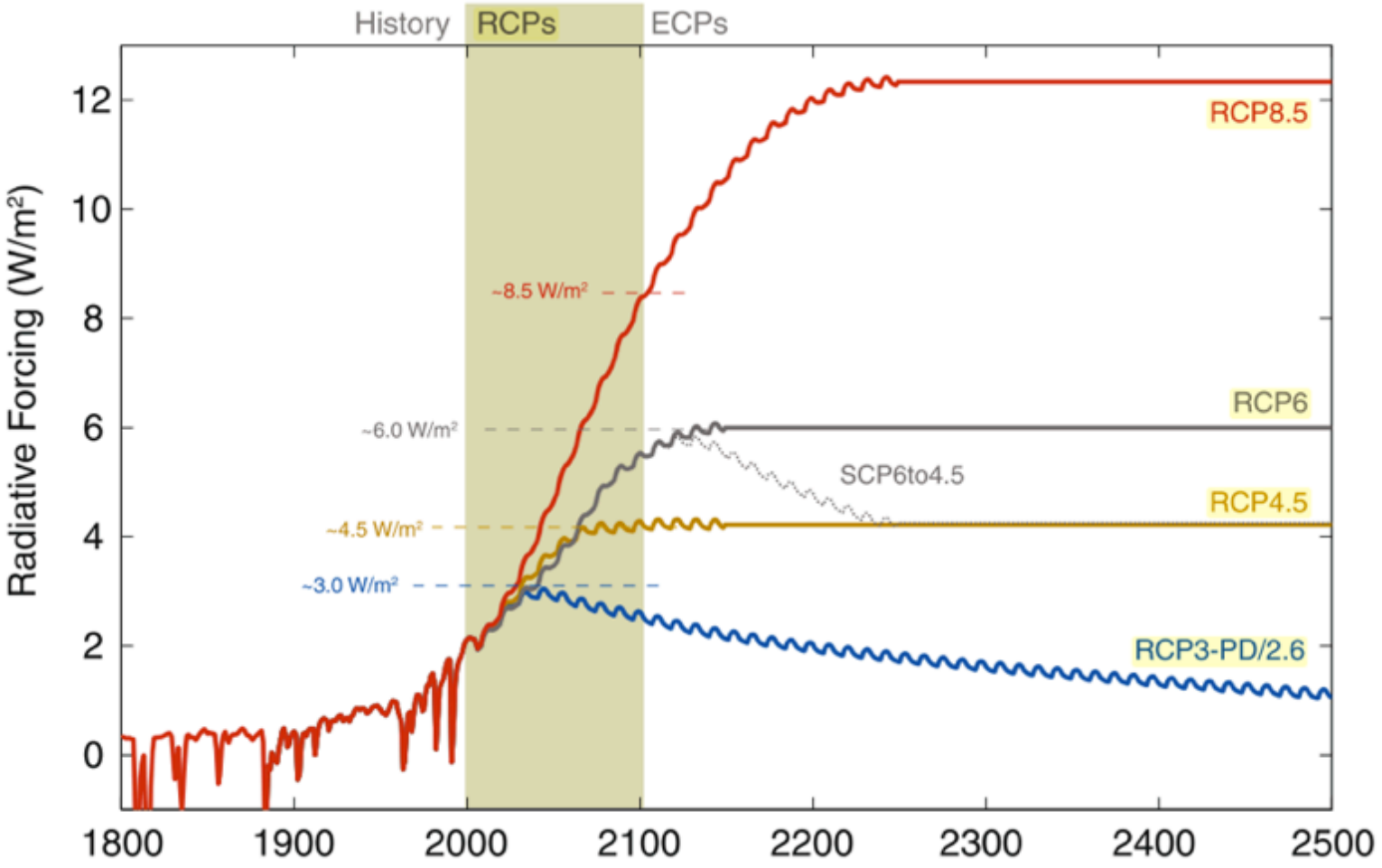
RCP3-PD : peak in radiative forcing ~3 W/m^2, then decline

Decision : use RCP 2.6

Source : IPCC expert meeting report, «Towards new scenarios...», 2008

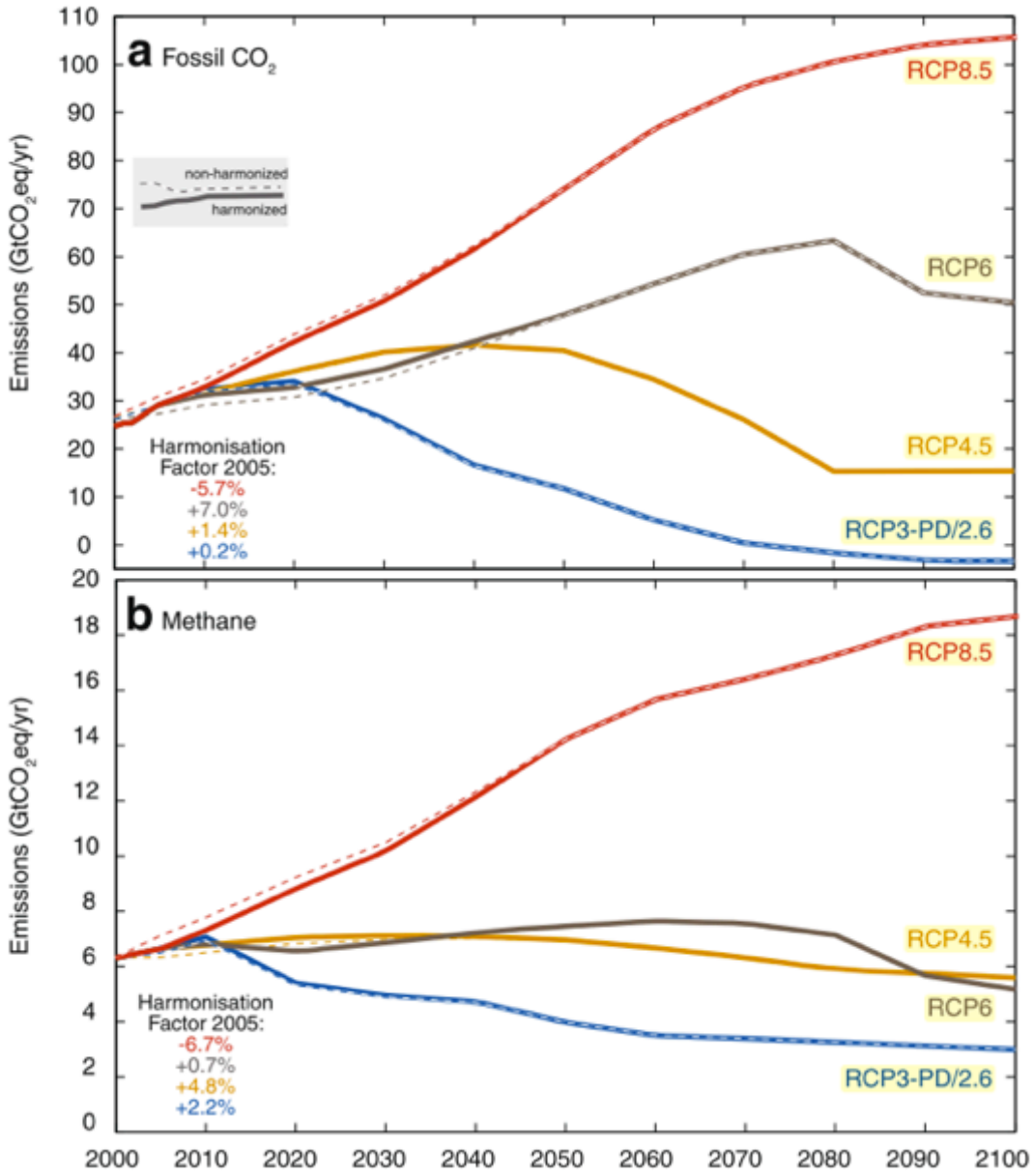
RCPs : extension beyond 2100

> 2100 : schematic extension, no socio-economic background, important for climate projections -> long term changes



Source: Meinshausen et al., Climatic Change, 2011

RCPs : Emission pathways



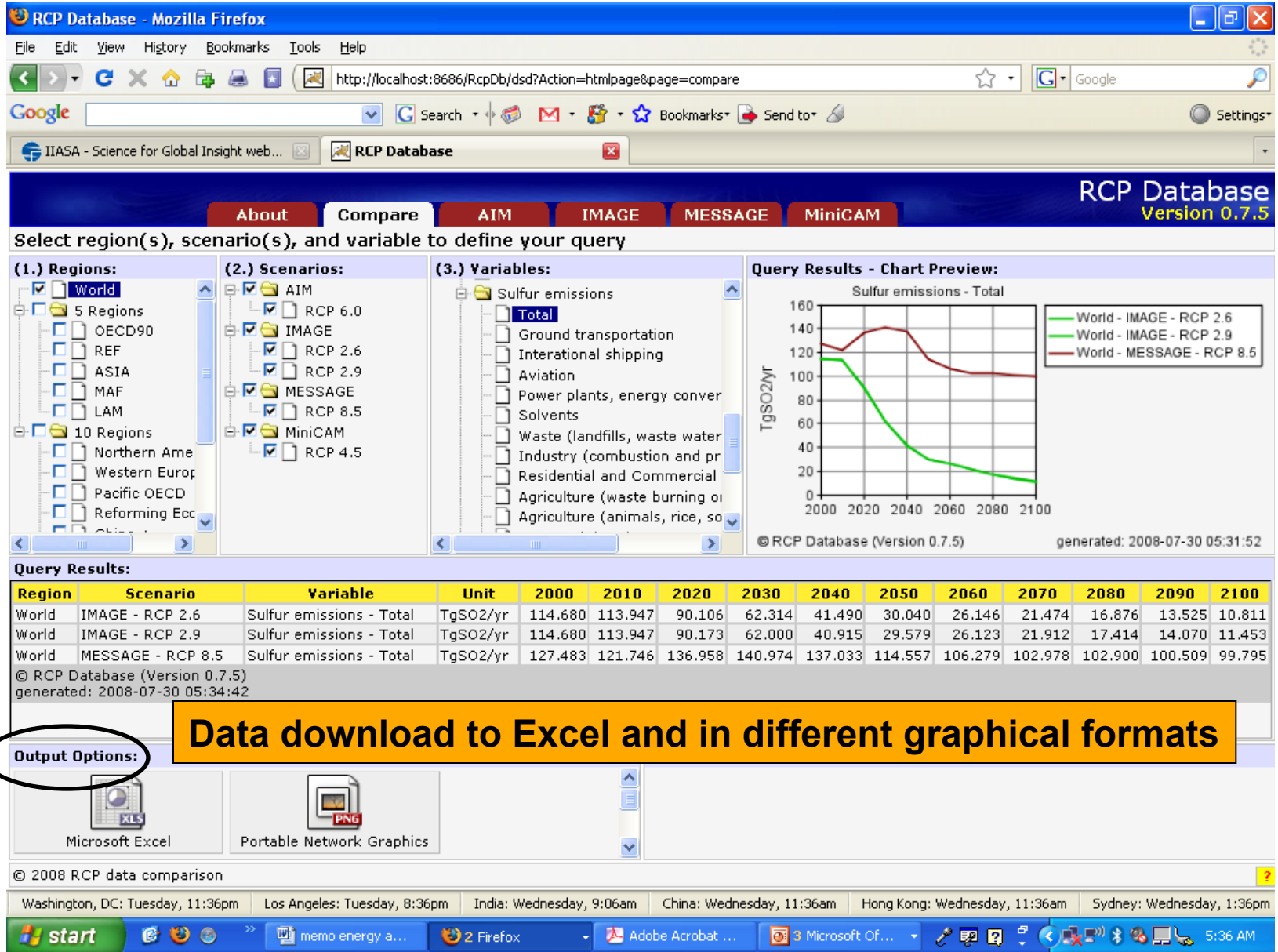
All data for emissions & concentrations publicly available

Source:
Meinshausen et al., Climatic Change, 2011

The IPCC has a catalytic role, and the Integrated Assessment Modeling Consortium (IAMC) delivers the scenario work

International Institute for Applied Systems Analysis (IIASA)	Energy Modeling Forum (EMF) Stanford University	National Institute for Environmental Studies (NIES)
➢Australian Bureau of Agricultural and Resource Economics (ABARE) - *Hom Pant* ➢Business Council for Sustainable Development – Argentina - *Virginia Vilariño* ➢CEA-LERNA, University of Social Sciences - *Marc Vielle* ➢Centre for International Climate and Energy Research (CICERO), University of Oslo - *H.Asbjorn Aaheim* ➢Argonne National Laboratory - *Donald Hanson* ➢Centre International de Recherche sur l'Environnement et le Developpement, EHESS - U.A. CNRS 940 (CIRED) - *Jean-Charles Hourcade* ➢CRA International - *Brian Fischer* ➢Dept. of Energy, Transport, Environment, DIW Berlin - *Claudia Kemfert* ➢Electric Power Research Institute (EPRI) - *Richard Richels* ➢Energy Research Institute, National Development and Reform Commission (NDRC) - *Kejun Jiang*	➢Freelance Professional Economist - *Thomas Rutherford* ➢Hamburg University and Economic and Social Research Institute (ESRI) - *Richard Tol* ➢Indian Institute of Management - *Priyadarshi Shukla* ➢Institut d'Economie et de Politique de l'Energie, IEPE-CNRS - *Patrick Criqui* ➢International Institute for Applied Systems Analysis (IIASA) - *Nebojsa Nakicenovic, Keywan Riahi* ➢IPCC and San Marcos University - *Eduardo Calvo* ➢National Institute for Environment Studies (NIES) - Mikiko Kainuma ➢Ohio State University - Brent Sohngen ➢Pacific Northwest National Laboratory, Joint Global Change Research Institute at the University of Maryland - *Jae Edmonds, Hugh Pitcher, Ronald Sands, Steve Smith* ➢Programa de Planejamento Energético - PPE/COPPE/UFRJ - *Emilio Lèbre La Rovere*	➢Purdue University - *Thomas Hertel* ➢RAND - *Rob Lempert* ➢Research Institute of Innovative Technology for the Earth (RITE) - *Keigo Akimoto* ➢Stanford University - *John Weyant* ➢Texas A&M University - *Bruce McCarl* ➢The Institute of Applied Energy - *Atsushi Kurosawa* ➢The Netherlands Environmental Assessment Agency (MNP) - *Detlef van Vuuren* ➢Universidad de Los Andes / Universidad Nacional de Colombia - *Jose Eddy Torres* ➢Universidad Iberoamericana Puebla - *Maria Eugenia Ibarraran Viniegra* ➢US Environmental Protection Agency - *Francisco de la Chesnaye, Allen Fawcett, Steven Rose*

RCP Database (Google: IIASA RCP)



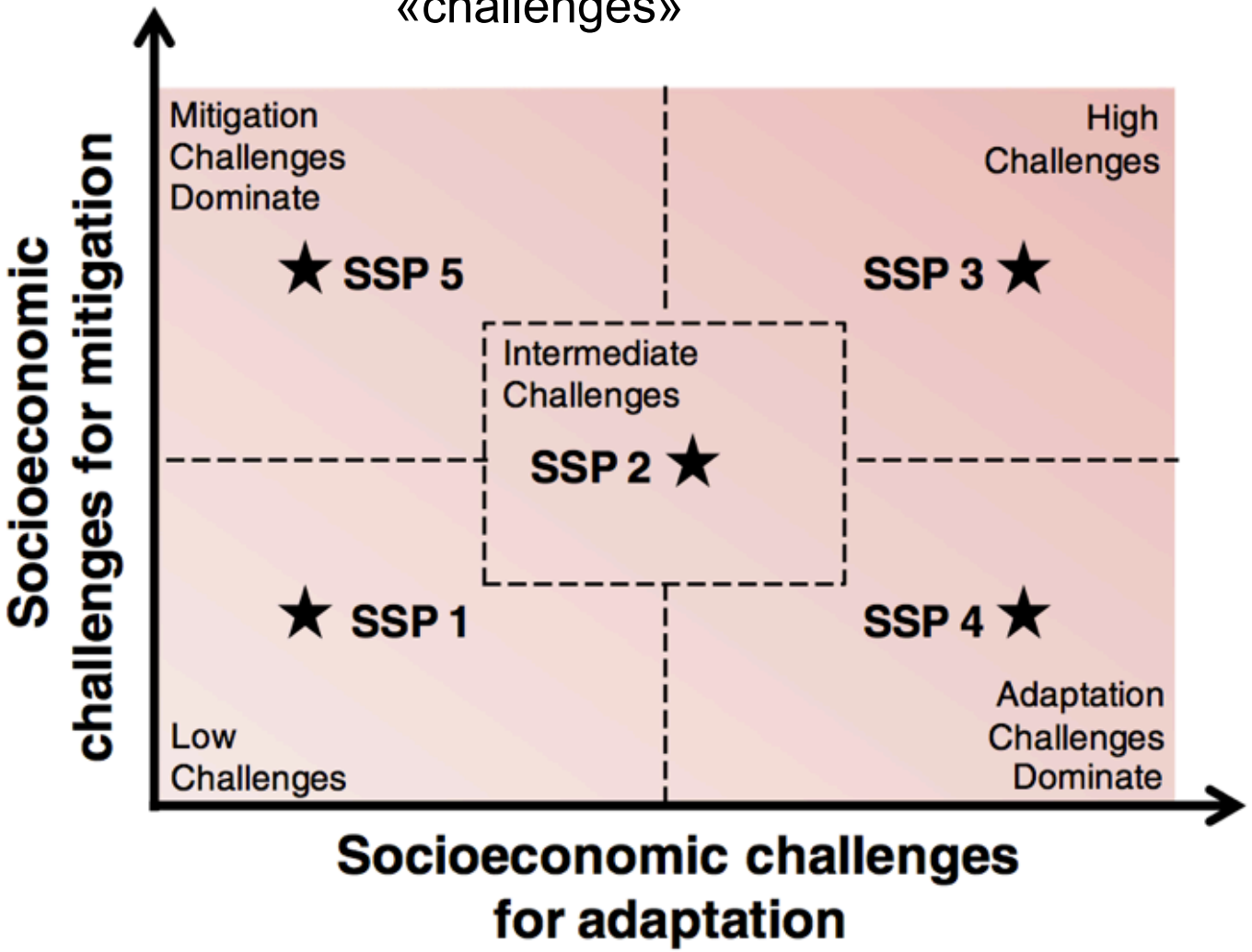
Data download to Excel and in different graphical formats

From Kathy Hibbard

UNEP

Socio-economic aspects : SSPs

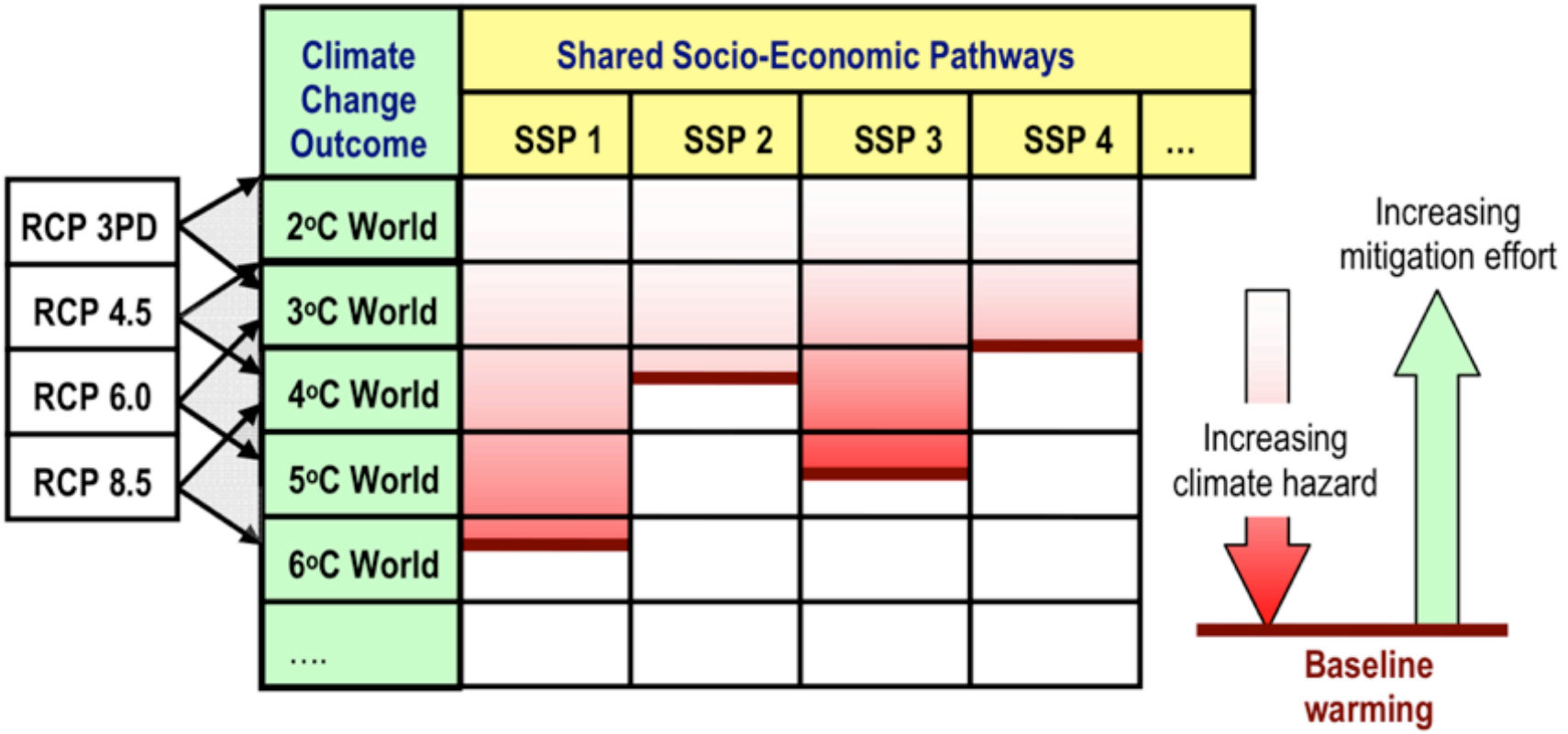
«Inverse approach», compared to SRES : starting from climate «challenges»



From O' Neill et al., Climatic Change, October 2013

Socio-economic aspects : SSP and SPA

«Shared climate Policy Assumptions» (SPA), to supplement the non-climate policy SSPs. Combination of SSP + SPA links to a RCP



From Kriegler et al., Glob. Env. Change, 2012

What the RCPs (Representative Concentration Pathways) are:

- **Consistent sets of projections** of only the components of radiative forcing that are meant **to serve as input for** climate **modelling**, pattern scaling, and atmospheric chemistry modelling.
- **Named according** to their 2100 **radiative forcing** level (based on the forcing of greenhouse gases and other forcing agents)**.**
- Chosen for scientific purposes to represent the **span of the radiative forcing literature at the time** of their selection and thus facilitate the mapping of a broad climate space.

Adapted from the RCP database on www.IIASA.ac.at
JPvY

ipcc
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

What the RCPs (Representative Concentration Pathways) are:

- They **jump-start the scenario development** across research communities from which uncertainties about socioeconomic, climate, and impact futures can be explored.
- They constitute **just the beginning of the parallel process of developing new scenarios** for the IPCC's fifth Assessment Report.
- The RCPs aim at providing a **consistent** analytical thread **across scientific communities**.

Adapted from the RCP database on www.IIASA.ac.at
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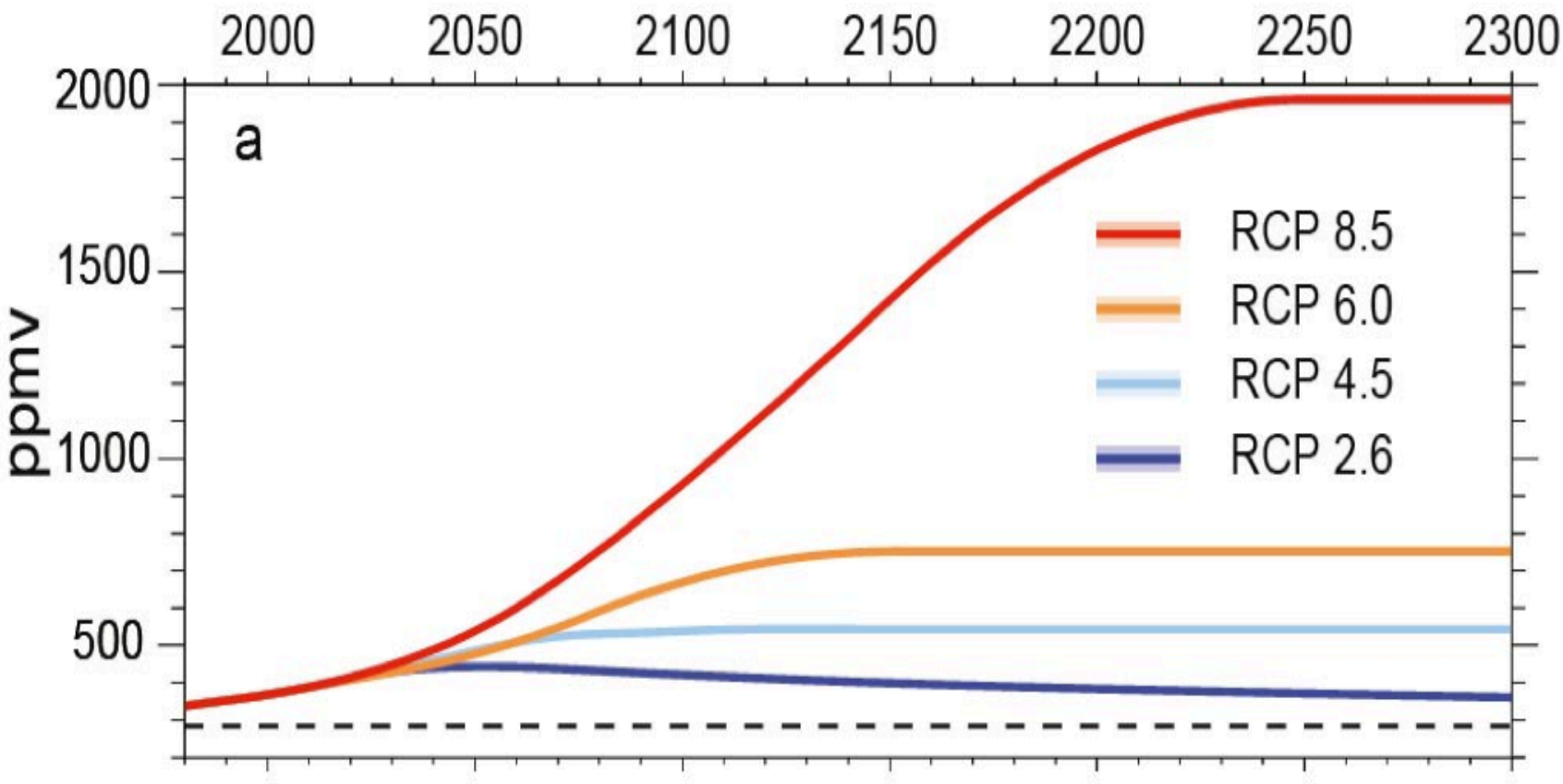
What the RCPs (Representative Concentration Pathways) are NOT:

- The RCPs are not new, fully integrated scenarios (i.e., they are **not a complete package of socioeconomic, emissions, and climate projections**).
- The radiative forcing estimates on which they are based do not include direct impacts of land use (albedo) or the forcing of mineral dust.
- The RCPs are **not forecasts or boundaries for potential emissions, land-use, or climate change**.
- They are **not policy prescriptive** in that they **do not represent specific futures with respect to climate policy** action (or no action) or technological, economic, or political viability of specific future pathways or climates.

Adapted from the RCP database on www.IIASA.ac.at

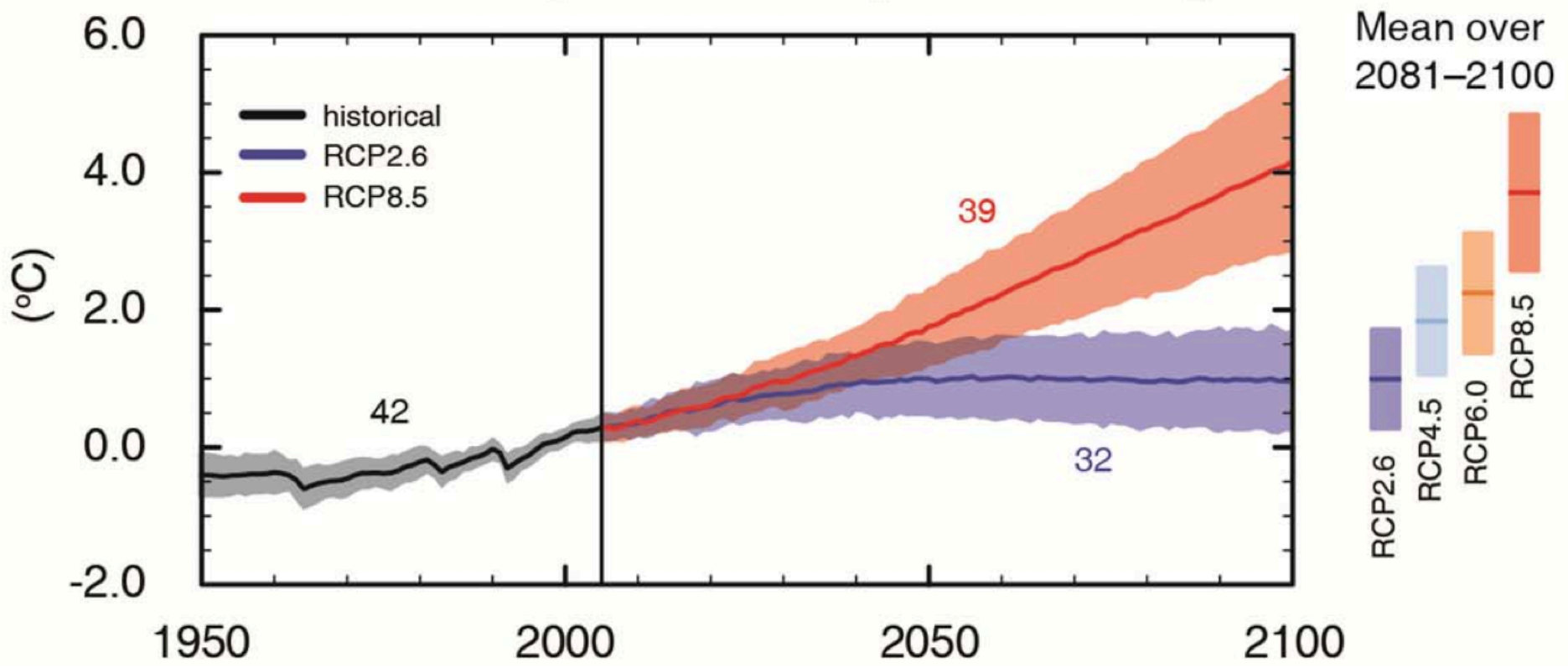
JPvY

Atmospheric CO_2 concentration



Most CMIP5 runs are based on the concentrations, but emissions-driven runs are available for RCP 8.5

Global average surface temperature change



RCP2.6 RCP8.5

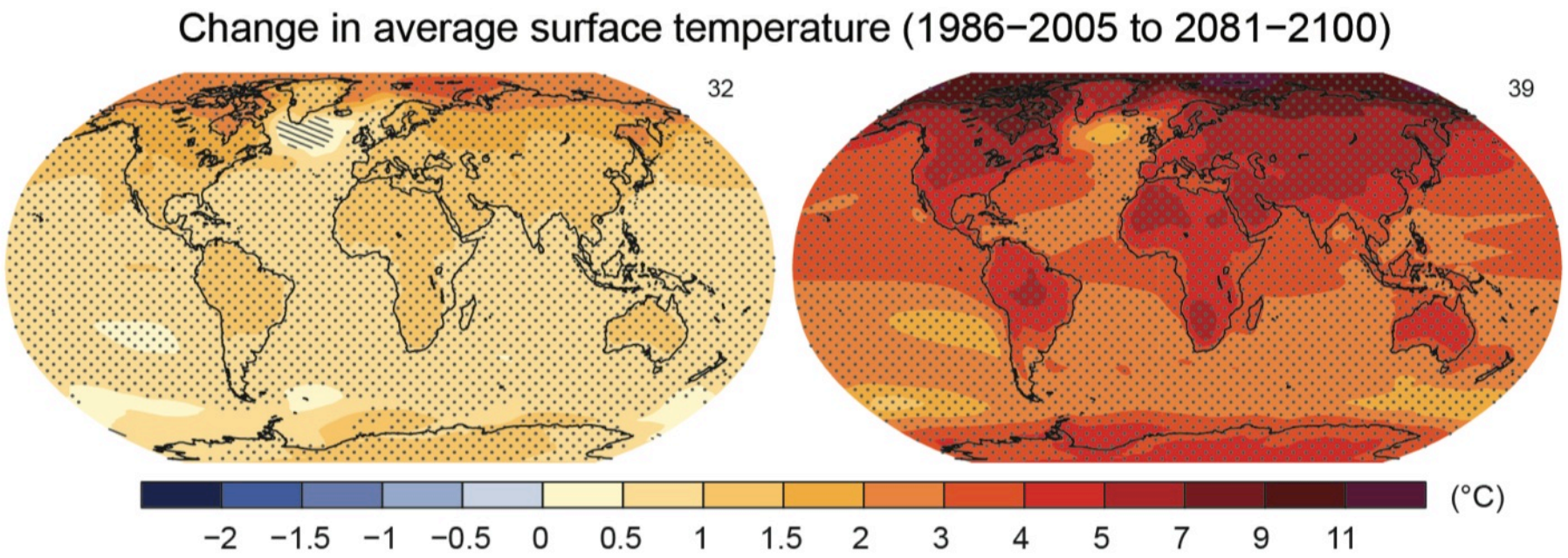


Fig. SPM.8

We have a choice.

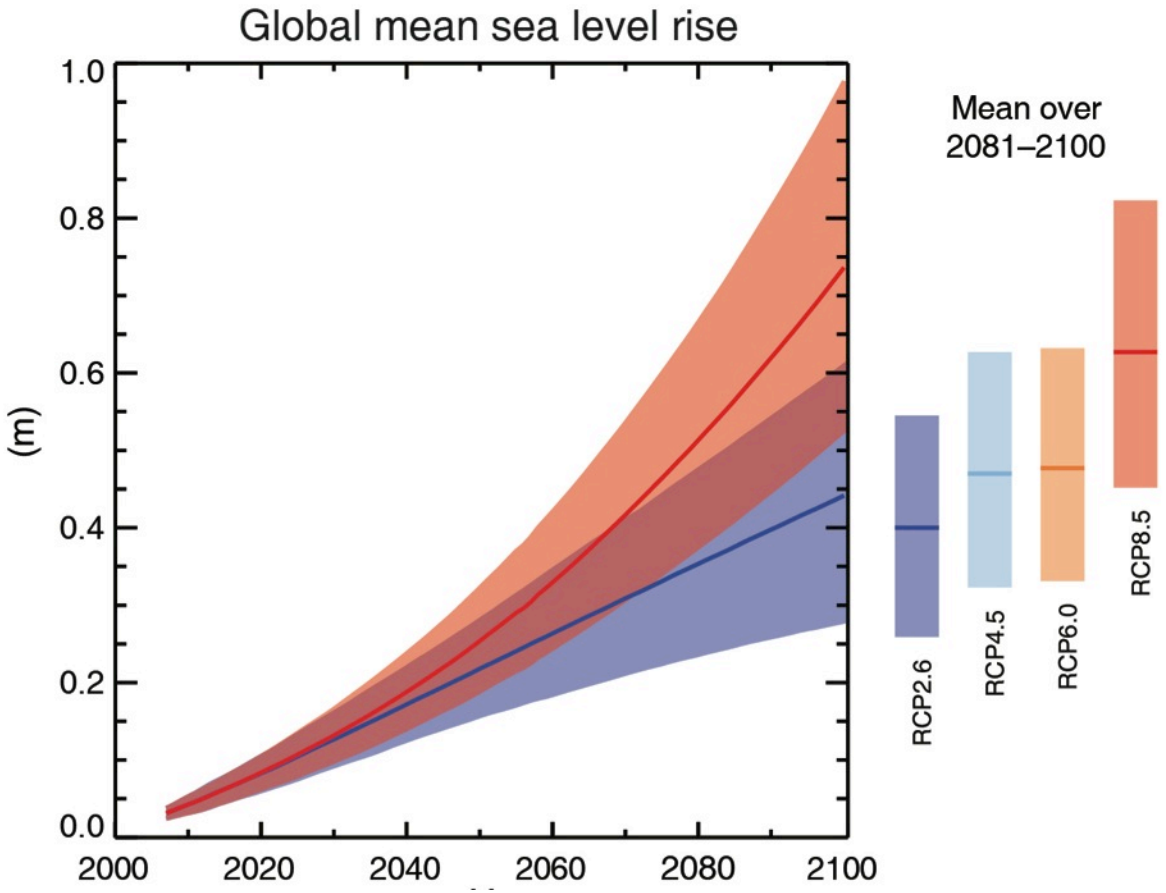
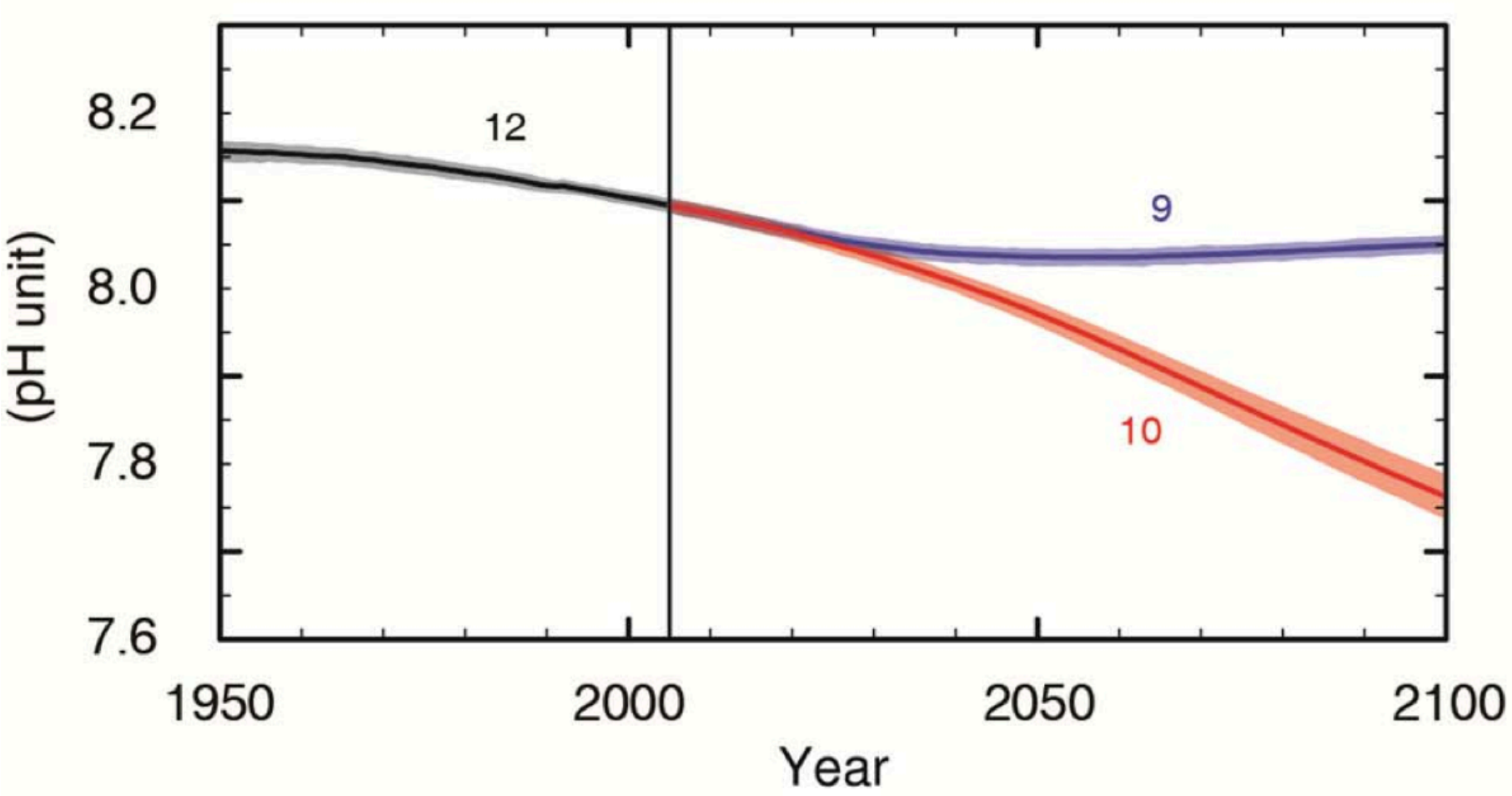


Fig. SPM.9

RCP2.6 (2081-2100), *likely* range: **26 to 55 cm**

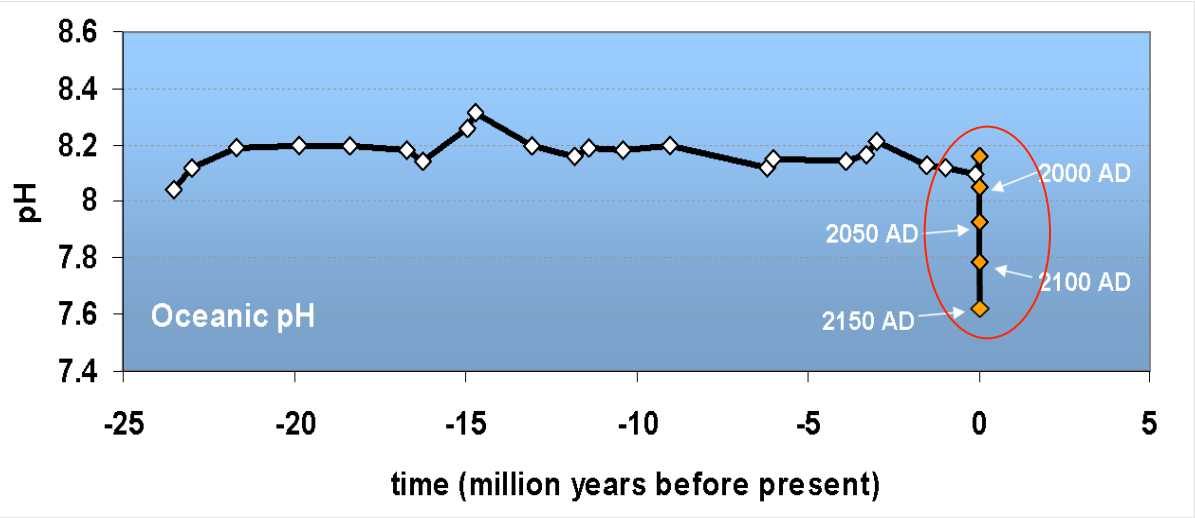
RCP8.5 (in 2100), *likely* range: **52 to 98 cm**

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



Oceans are Acidifying Fast …….

Changes in pH over the last 25 million years



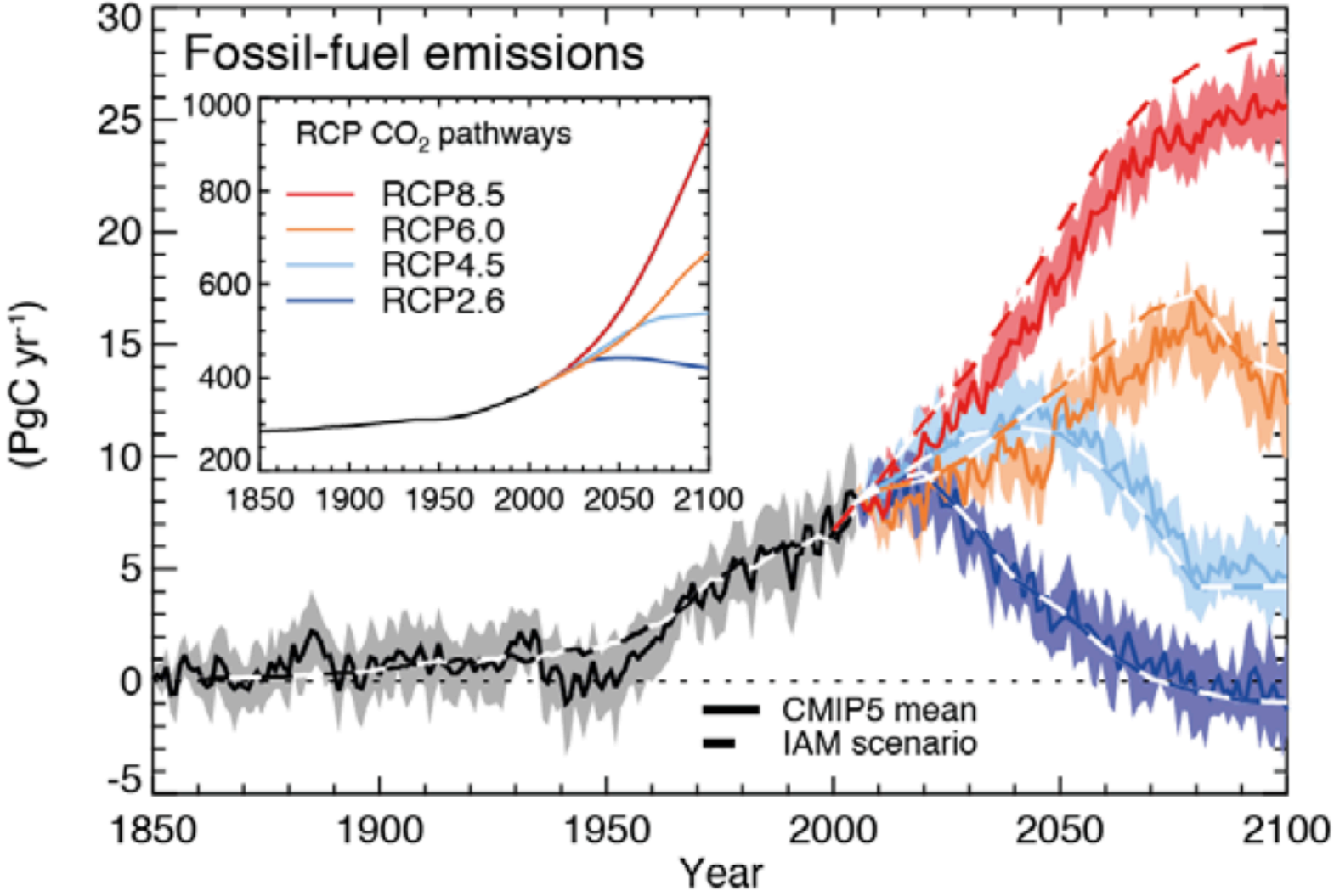
"Today is a rare event in the history of the World"

- **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

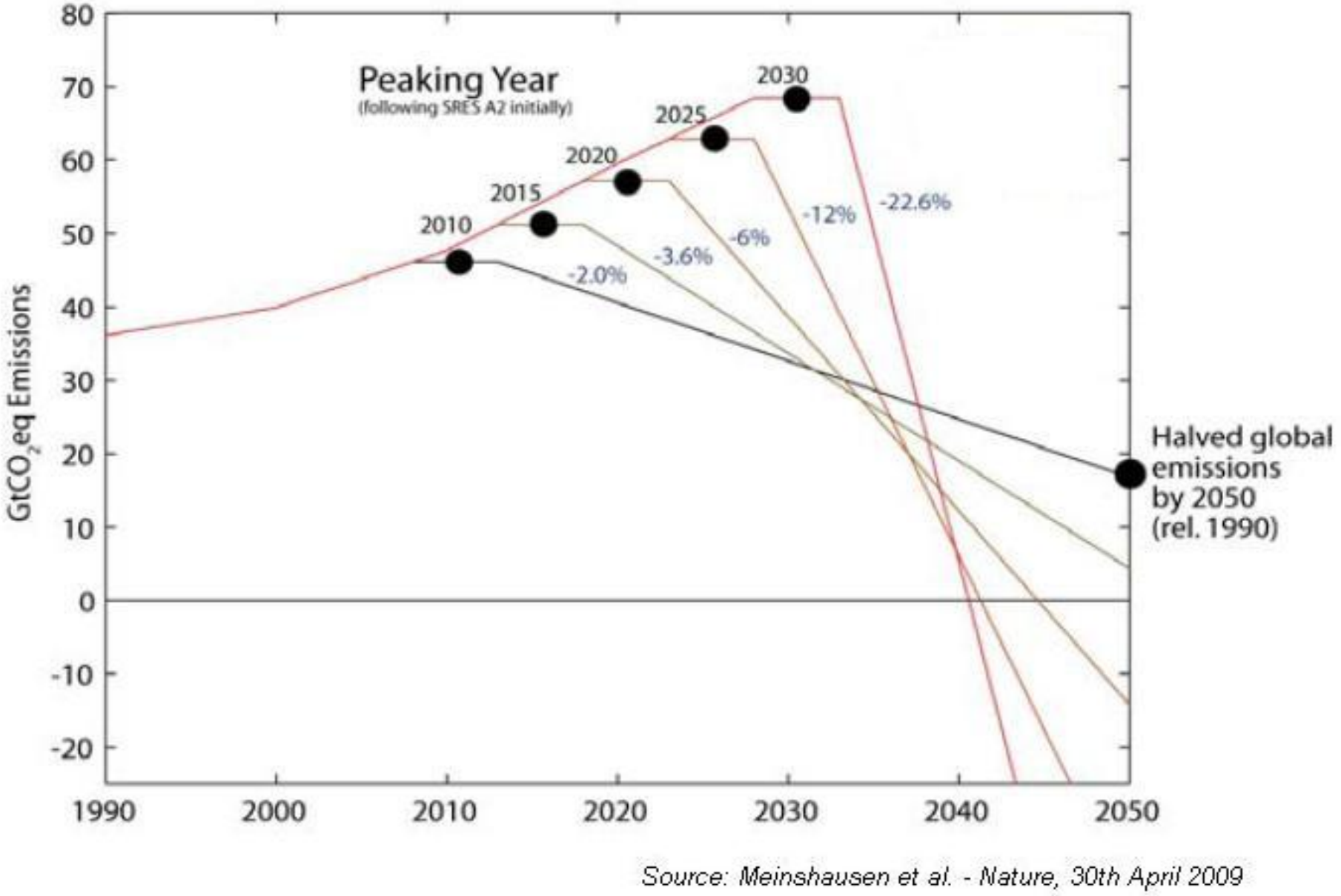
Slide courtesy of Carol Turley, PML

Compatible fossil fuel emissions simulated by the CMIP5 models for the four RCP scenarios



AR5 WGI TS – Approved version/subject to final copy edit

The more we wait, the more difficult it will be



Source: Meinshausen et al. - Nature, 30th April 2009

"By assessing a wide range of possible futures through scenarios the IPCC is policy relevant without being policy prescriptive"

Useful links:

- www.ipcc.ch : IPCC
- www.climatechange2013.org : IPCC WGI AR5
- www.climate.be/vanyp : my slides and other documents
- www.skepticalscience.com: excellent responses to contrarians arguments
- **On Twitter: @JPvanYpersele**

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