Climate Modelling Informing the Politics of the Earth

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Politics of the Earth International Summer School,

Sciences Po, Paris, 6 September 2016

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

Plan

- Where do I speak from?
- The IPCC
- Policy relevance of the carbon cycle
- Some sources of uncertainty
- The « carbon budget »
- Conclusions

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Where do I speak from?

- 1957 : Born: IGY, Sputnik, Keeling curve CO2 Mauna Loa
- 1972 : Astronomy / Environment : Limits to Growth at school, 3nd Earth Day, creation of UNEP
- 1973 : Total solar eclipse in Kenya : astronomy, but drought as well
- 1979 : First World Climate Conference in Geneva : Science and Policy

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Where do I speak from?

- 1980 : Physics Master, EBM and CO_2 (Apartheid, development, UNEP, desertification)
- 1982 : I meet Steve Schneider, NCAR : science-policy interface, nuclear winter, climate science communication
- 1986 : Tchernobyl : the day I came back from NCAR after Ph.D.!
- 1992 : Rio Summit, UN Conf on Env & Development, Council on Sustainable Development

Where do I speak from?

- 1995 : IPCC WGI Final Plenary in Madrid ; Famous sentence « The balance of evidence suggests a discernible influence of human activities on climate »
- 1997 : Kyoto
- 1998 : IPCC author with Steve Schneider
- 2002 : IPCC Bureau (for 13 years) (and UCL prof, Interdisciplinary Master in Science & Management of the Environment, until now)

Where do I speak from?

- 2008 : IPCC Vice-Chair (until 2015),
- 2010 Copenhagen, Himalaya error, IPCC-bashing/ reform
- 2013 : First Interdisciplinary Symposium on Sustainable development in Belgium
- 2015 : Candidate IPCC Chair (56 countries voted for me) / book about my turbulent experiences / COP21
- 2016 : Lubricating the climate-science policy interface/ decarbonizing my way of life /IPCC back to basics

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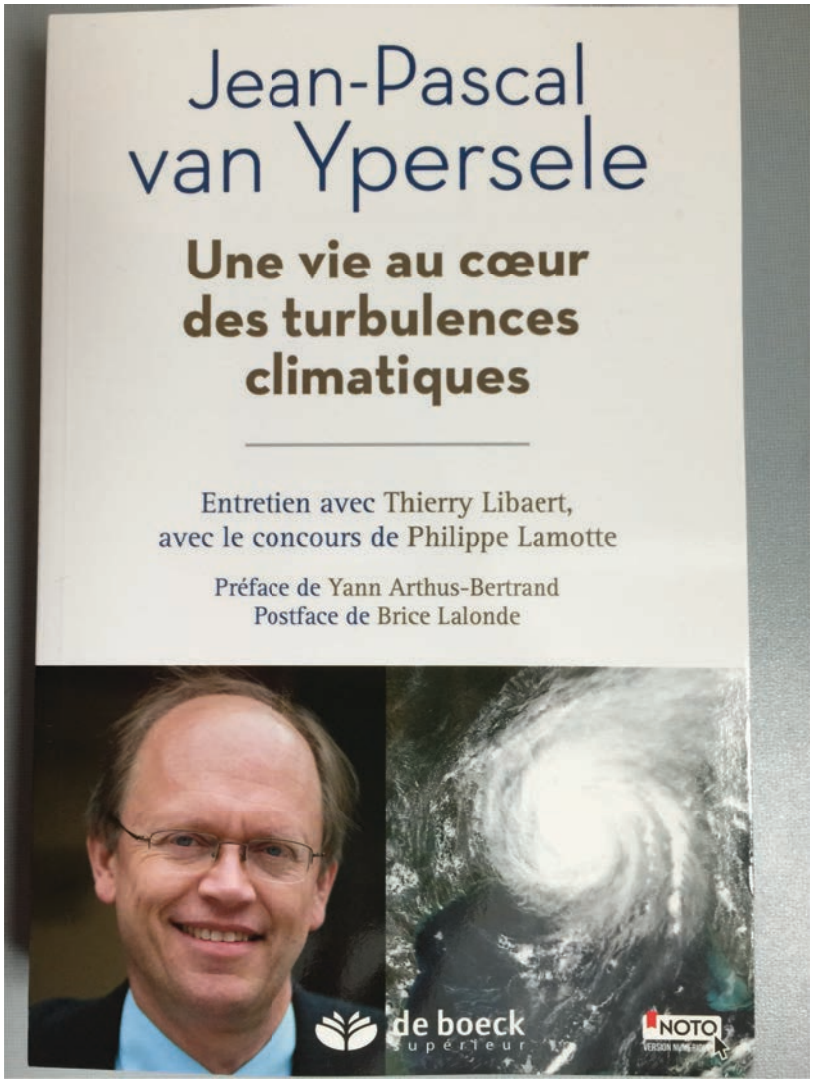
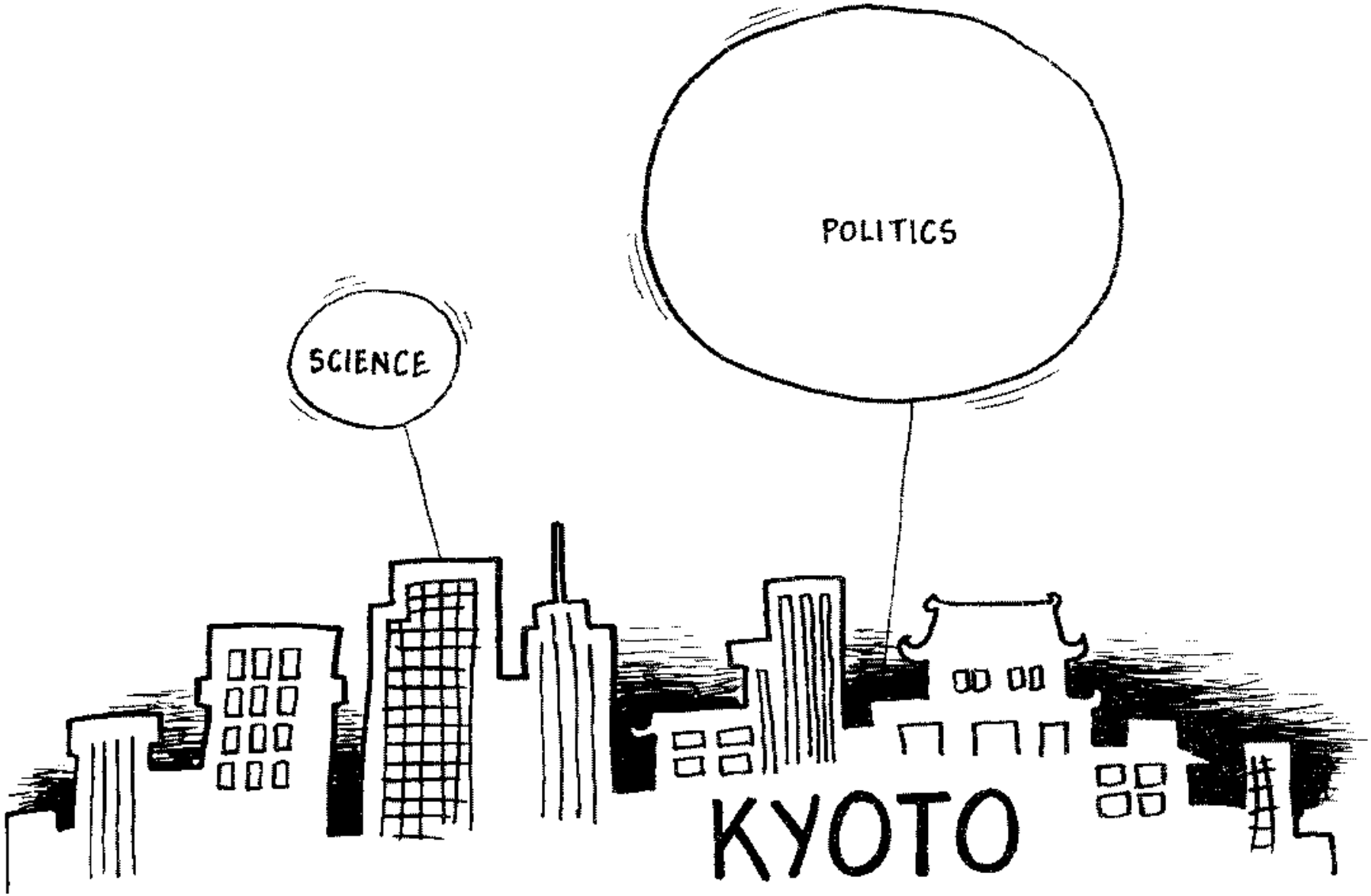
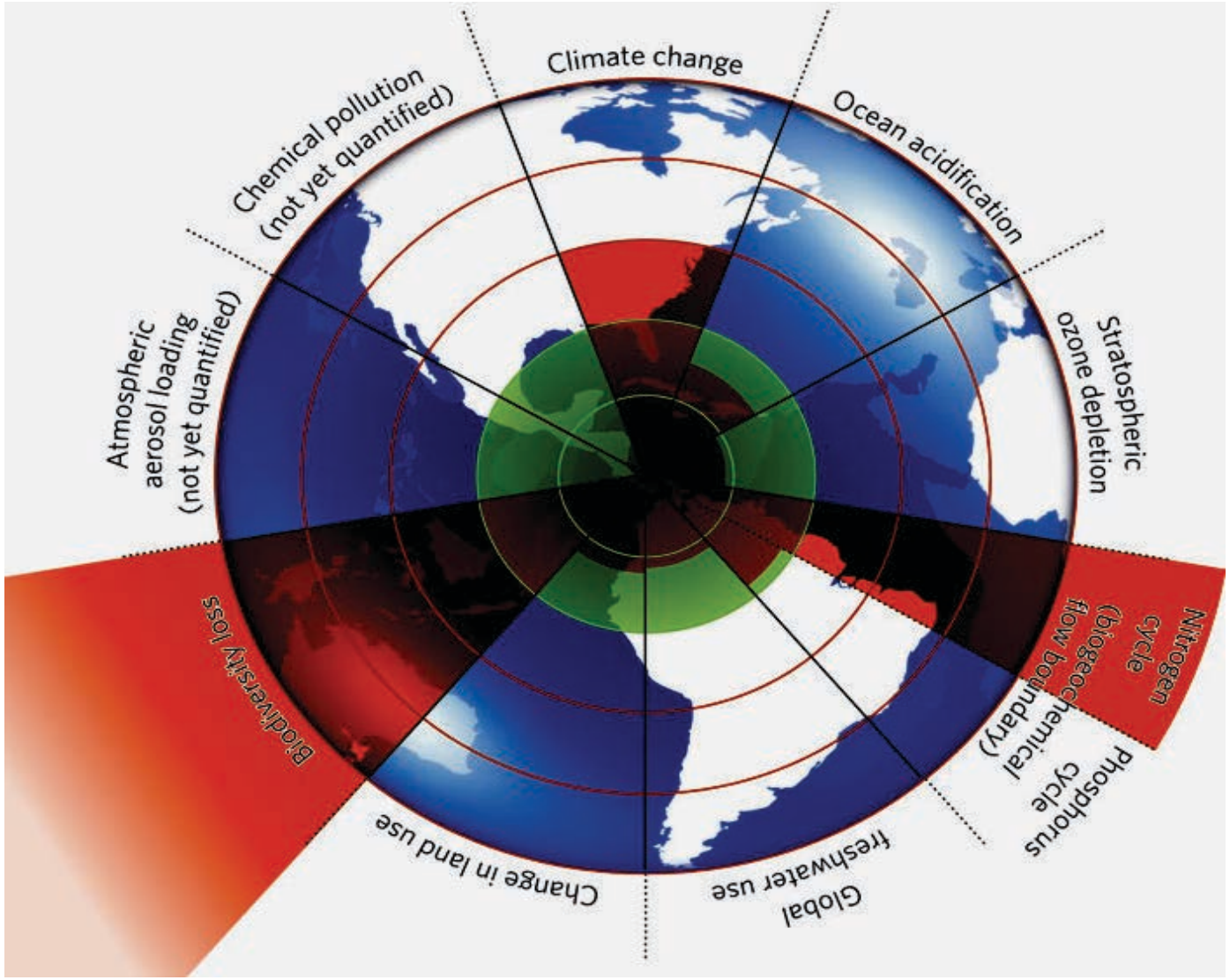
Publié chez De Boeck supérieur, octobre 2015





Agarwal et al., 1999

9 Planetary Boundaries; 3 crossed already



Source: Rockström et al 2009

Children from Machakos (Kenya), April 2015

Why the IPCC ?

Established by WMO and UNEP in 1988

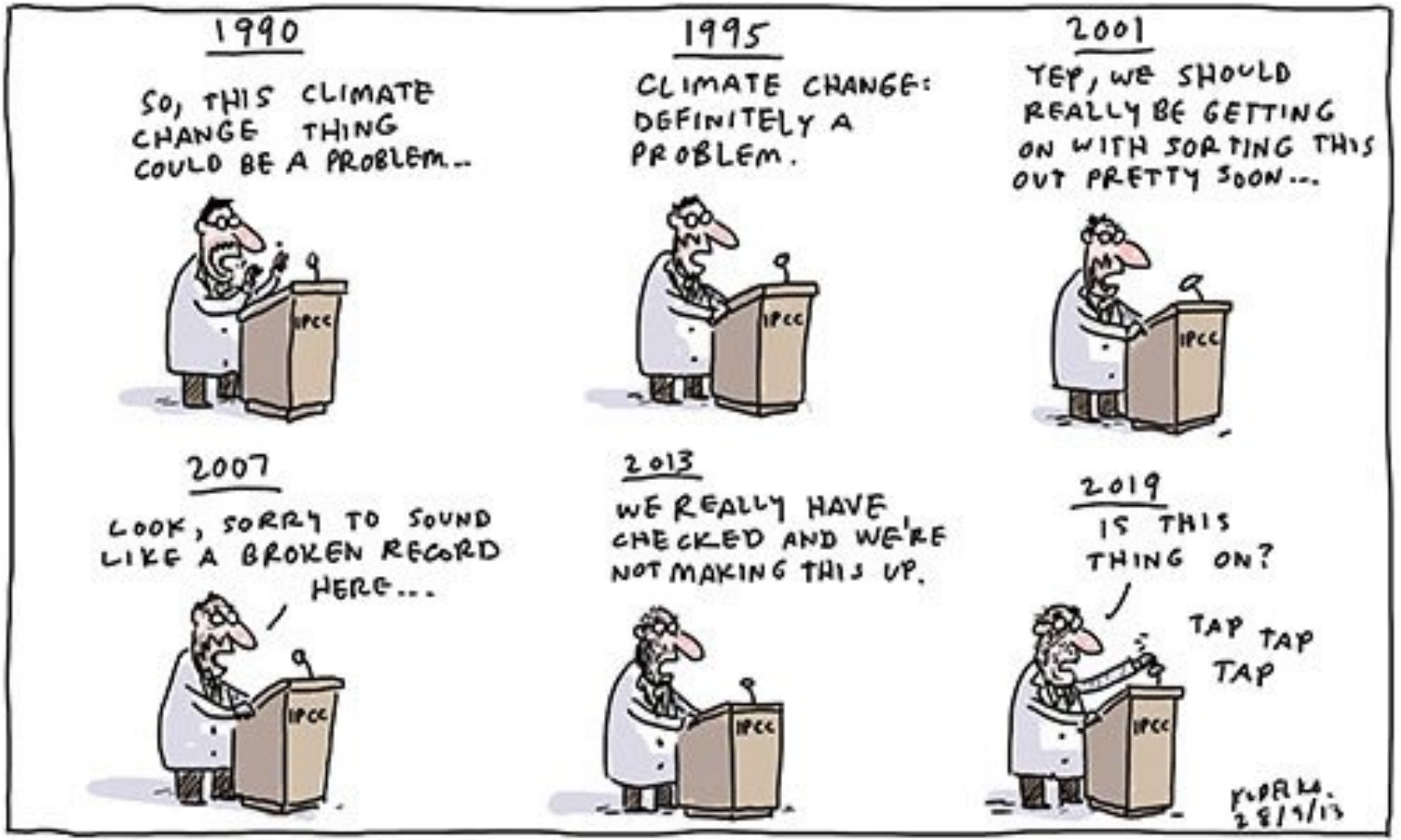
to provide **policy-makers** with an **objective source of information** about

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

WMO=World Meteorological Organizatior

UNEP= United Nations Environment Programme

None So Deaf



http://www.kudelka.com.au/2013/09/none-so-deaf/

Key messages from the IPCC WG1 Report (1)

- **Certain:**
  - Emissions resulting from **human activities are substantially increasing** the atmospheric concentrations of the **greenhouse gases**: CO2, CH4, CFC, and N2O
- Calculated **with confidence**:
  - Under the business as usual scenario, **temperature will increase by about 3°C by 2100** (uncertainty range: **2 to 5°C**), and **sea level will increase by 60 cm** (uncertainty range: **30 to 100 cm**)

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Key messages from the IPCC WG1 Report (2)

- With an increase in the mean temperature, **episodes of high temperature** will most likely become **more frequent**
- Rapid changes in climate will change the composition of ecosystems; **some species** will be unable to adapt fast enough and **will become extinct**.
- Long-lived gases (**CO2**, N2O and CFCs) **would require immediate reduction** in emissions from human activities **of over 60% to stabilise their concentration at today's levels**.

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Oops…

- … this was from the IPCC **first** assessment report, published 26 years ago (1990)!

- Was anybody really listening?

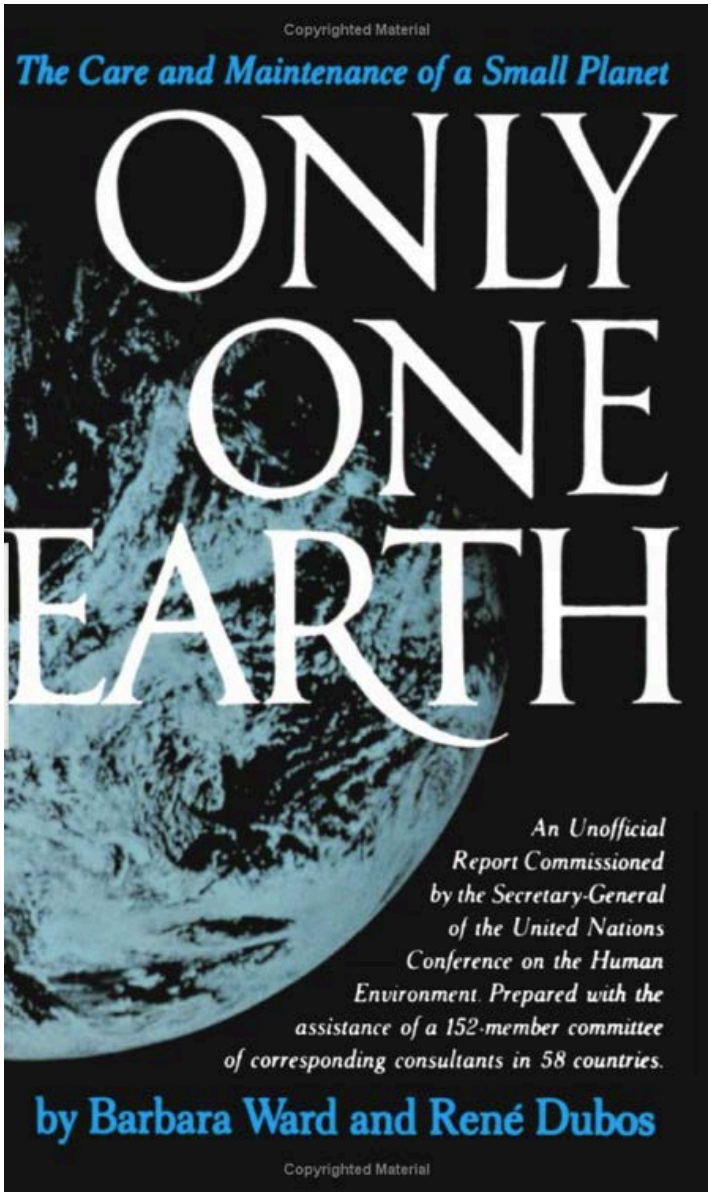
When does this quote date from?

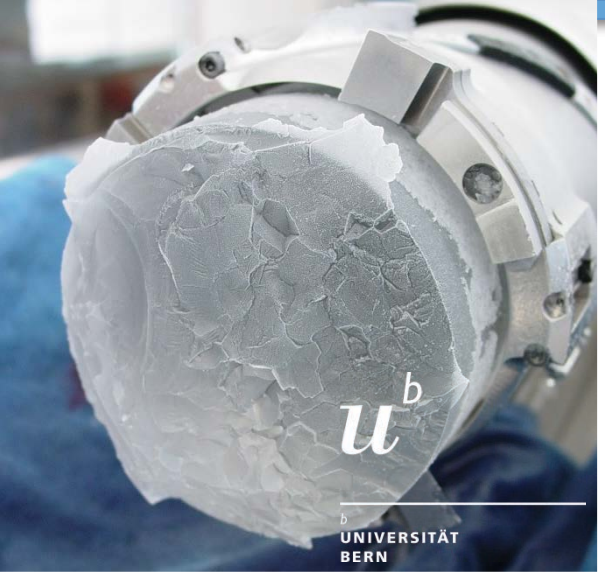
"It may require only a very small percentage of change in the planet's balance of energy to modify average temperatures by 2°C. Downward, this is another ice age; upward, a return to an ice-free age. In either case, the effects are global and catastrophic. "

When does this quote date from?

"... The sum of all likely fossil-fuel demands in the early decades of the [21st] century might … greatly increase the emission of carbon dioxide into the atmosphere and by doing so bring up average surface temperature uncomfortably close to that rise of 2°C which might set in motion the long-term warming up of the planet."

Barbara Ward & René Dubos, 1972



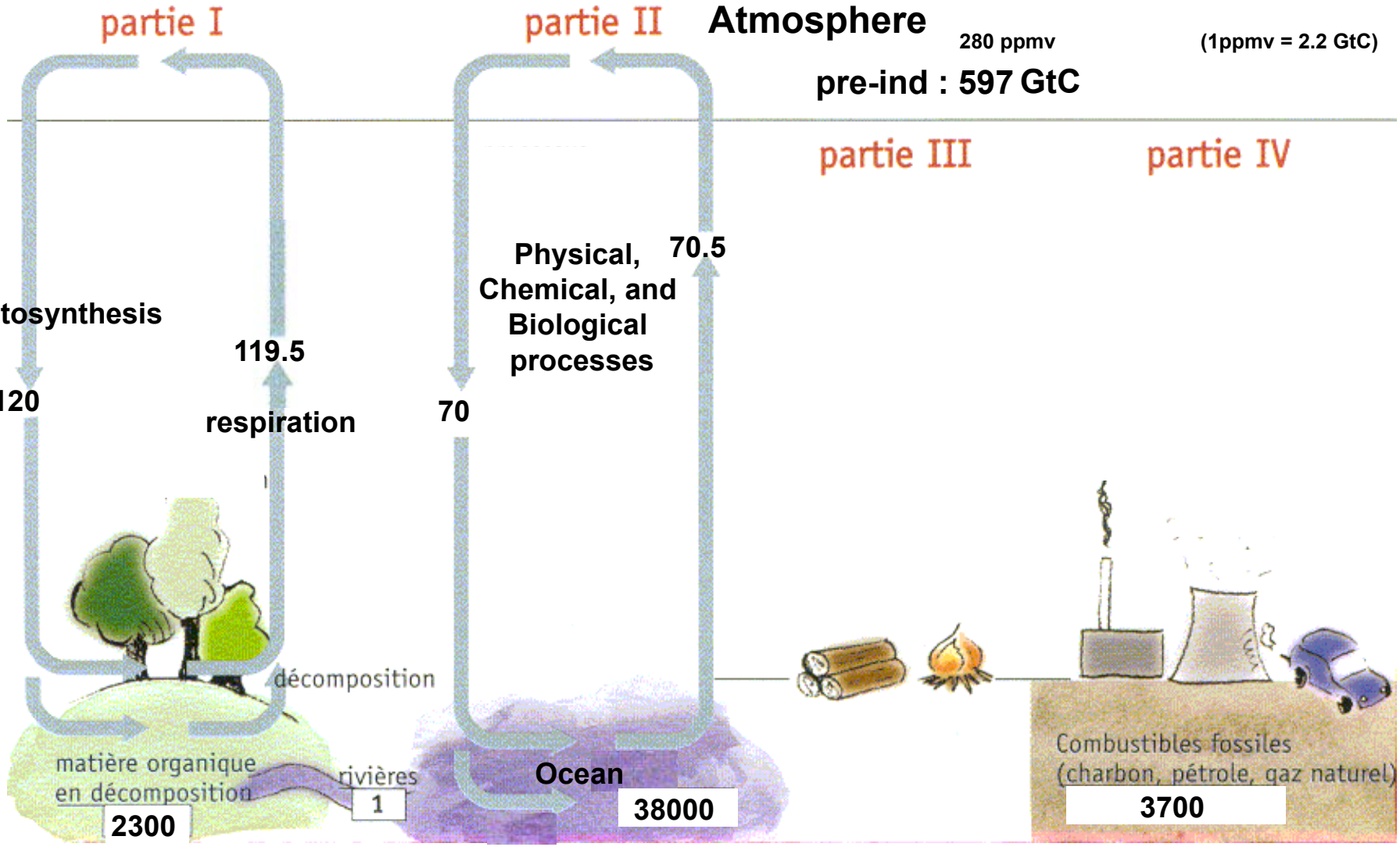


Atmospheric concentrations of CO_2

(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 $GtCO_2$)

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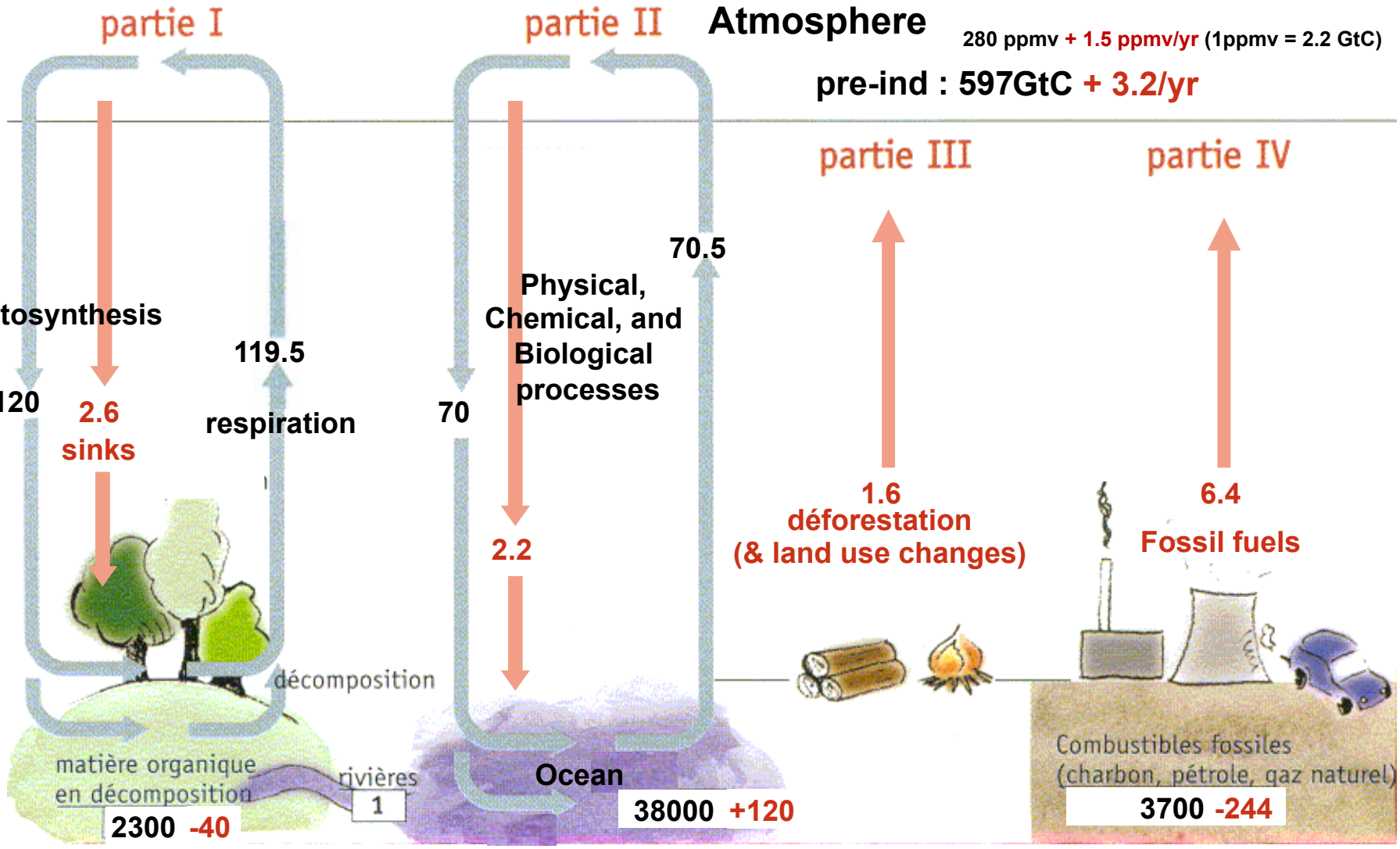
Carbon cycle: perturbed by human activities

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



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

Stocks!

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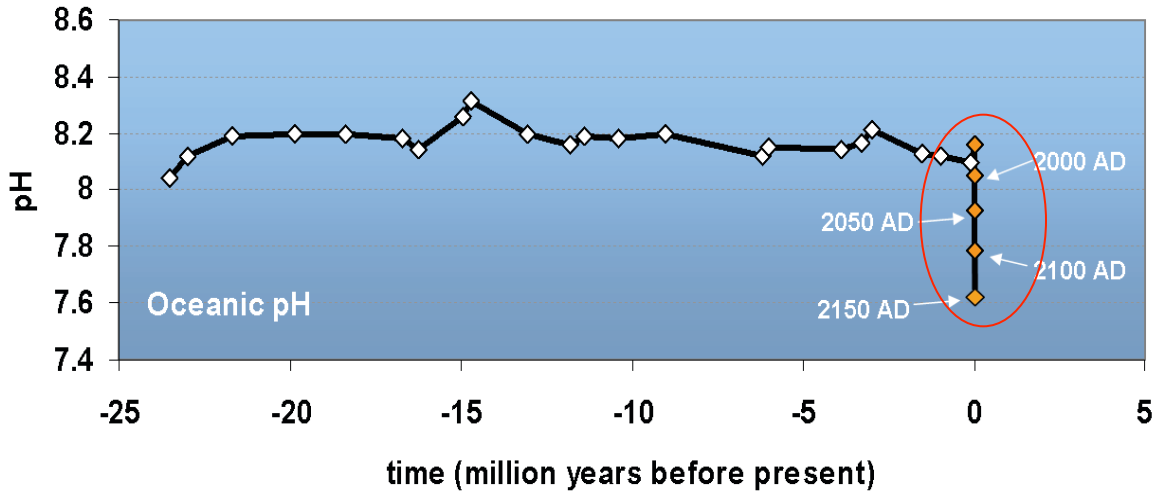
Oceans are Acidifying Fast ……..

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

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)**

Climatic Change: Are We on the Brink of a Pronounced Global Warming? (Broecker,1975)

Table 1. Reconstruction and prediction of atmospheric CO_2 contents based on fuel consumption data.

Year	Chemical fuel CO_2 ($\times 10^{16}$ g)	Excess atmospheric CO_2* ($\times 10^{16}$ g)	Excess atmospheric CO_2 (%)	Excess atmospheric CO_2 (ppm)	CO_2 content of the atmosphere† (ppm)	Global temperature increase‡ (°C)
1900	3.8	1.9	0.9	2	295	0.02
1910	6.3	3.1	1.4	4	297	.04
1920	9.7	4.8	2.2	6	299	.07
1930	13.6	6.8	3.1	9	302	.09
1940	17.9	8.9	4.1	12	305	.11
1950	23.3	11.6	5.3	16	309	.15
1960	31.2	15.6	7.2	21	314§	.21
1970	44.0	22.0	10.2	29	322§	.29
1980‖	63	31	14	42	335	.42
1990‖	88	44	20	58	351	.58
2000‖	121	60	28	80	373	.80
2010‖	167	83	38	110	403	1.10

*On the assumption that 50 percent of the CO_2 produced by the burning of fuel remains in the atmosphere. †The preindustrial atmospheric partial pressure of CO_2 is assumed to be 293 ppm. ‡Assumes a 0.3°C global temperature increase for each 10 percent rise in the atmospheric CO_2 content. §Value observed on Hawaii for 1960, 314 ppm; value for 1970, 322 ppm (*8*). ‖Post-1972 growth rate taken to be 3 percent per year.

Once upon a time, a US climatologist said this in Belgium (1):

- **Net accumulation of carbon as CO_2 in the atmosphere is about 3 gigatons per year. There is no quantitative explanation why the annual accumulation is 3 GtC when emissions are 8 GtC.**
- **There is no reason to expect that existing trends between emissions and atmospheric buildup will continue in the future.**

Once upon a time, a US climatologist said this in Belgium (2):

- **Projections are based on unverified models of natural and social science.**
- **Results from climate models are known to be wrong.**
- **It is impossible today to project future impacts of climate change.**
- **Progress to advance the science will require major effort and many years of study.**

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- **This US climatologist was a science advisor to Exxon-Mobil, with a Ph.D in astrophysics, and he knew very well what he was doing: sowing doubt**

- **He was speaking to the Belgian delegation about to leave for the final negotiations of the Kyoto Protocol**

- **This was at a lunch event organised by the Belgian Federation of the Oil Industry (Fédération pétrolière)**

Uncertainty ?

- Example from IPCC AR5: Between (1986-2005) and (2081-2100), the "likely" change projected in global mean surface air temperature ranges from 0.3 to 4.8 °C:

Sources of uncertainty about future climatic change - Two main reasons:

- Uncertainty about how much climate forcing humans will do, principally through fossil fuel consumption. - **Emission scenarios** (Depends on political decisions, economic events, technical innovation and diffusion.)
- Uncertainty about how the climate system will respond to climate forcing by humans - **Climate Sensitivity**.(Depends on natural processes.)

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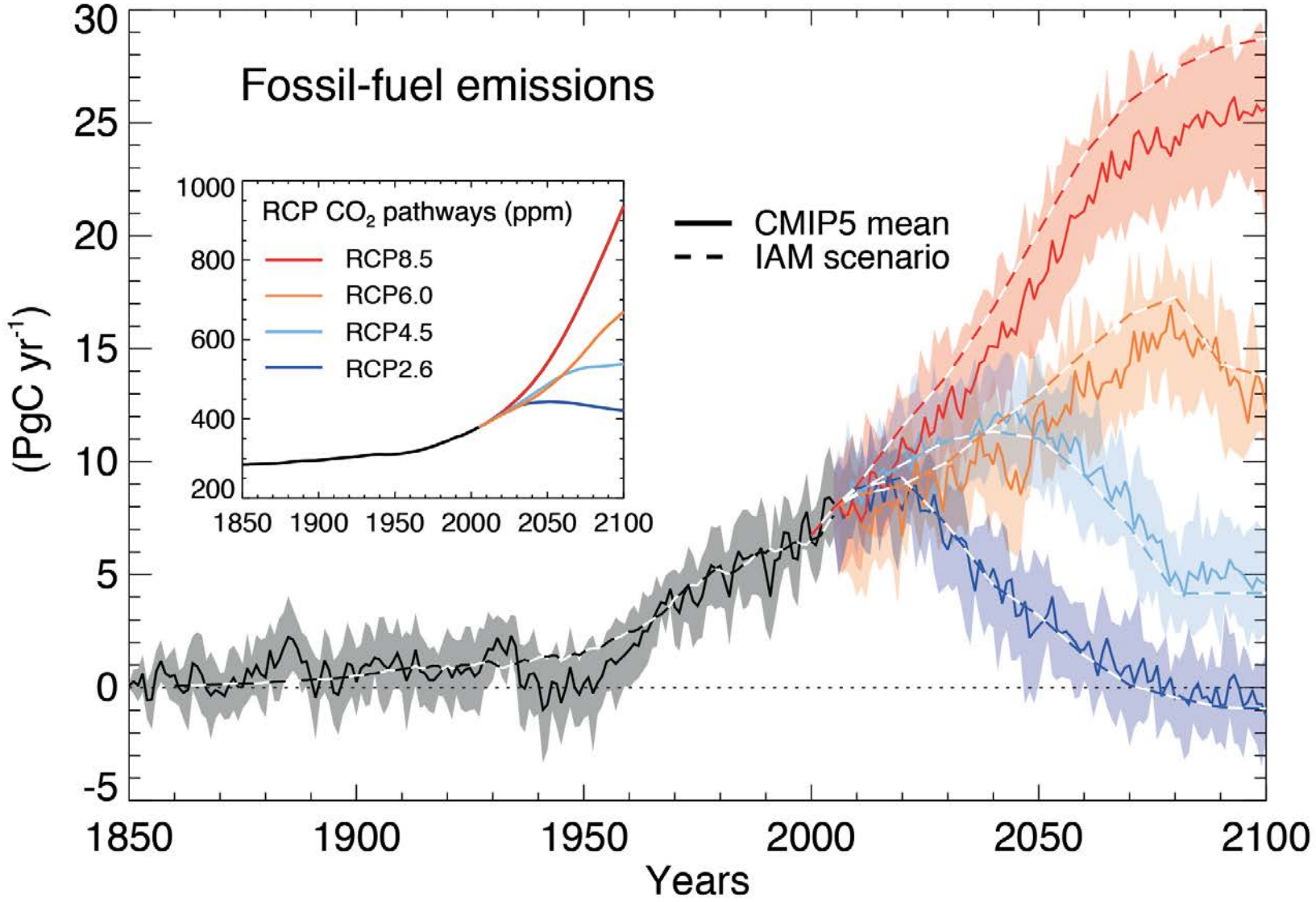
Adapted from a slide from D. Hartmann

Concentration and emission scenarios



IPCC AR5 WGI TS, Fig TS19

(Equilibrium) Climate sensitivity

- Steady state change in the annual global mean surface temperature following a doubling of the CO_2 concentation

$$\mathbf{1.5°C < \Delta T < 4.5°C}$$

- (likely range, high confidence, same as in 1990…)

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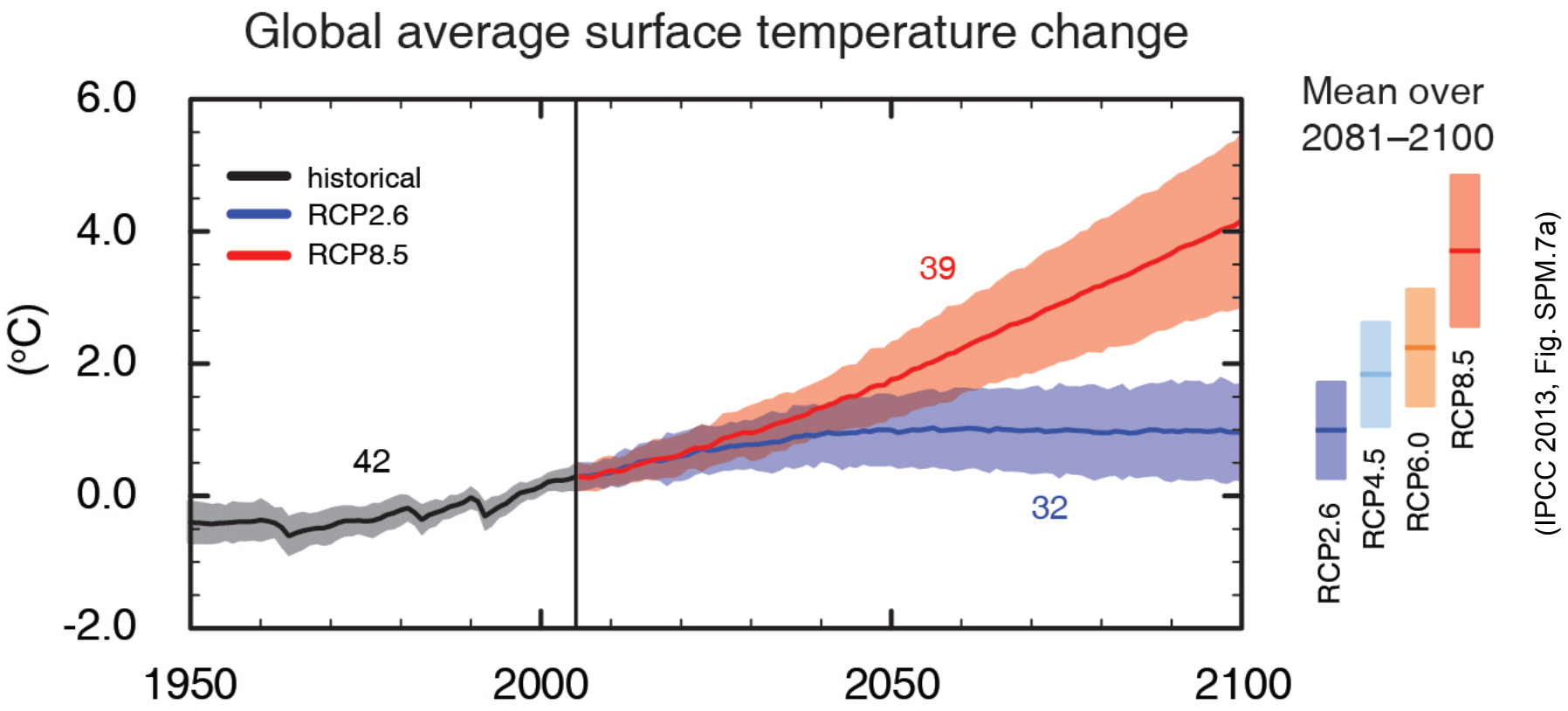
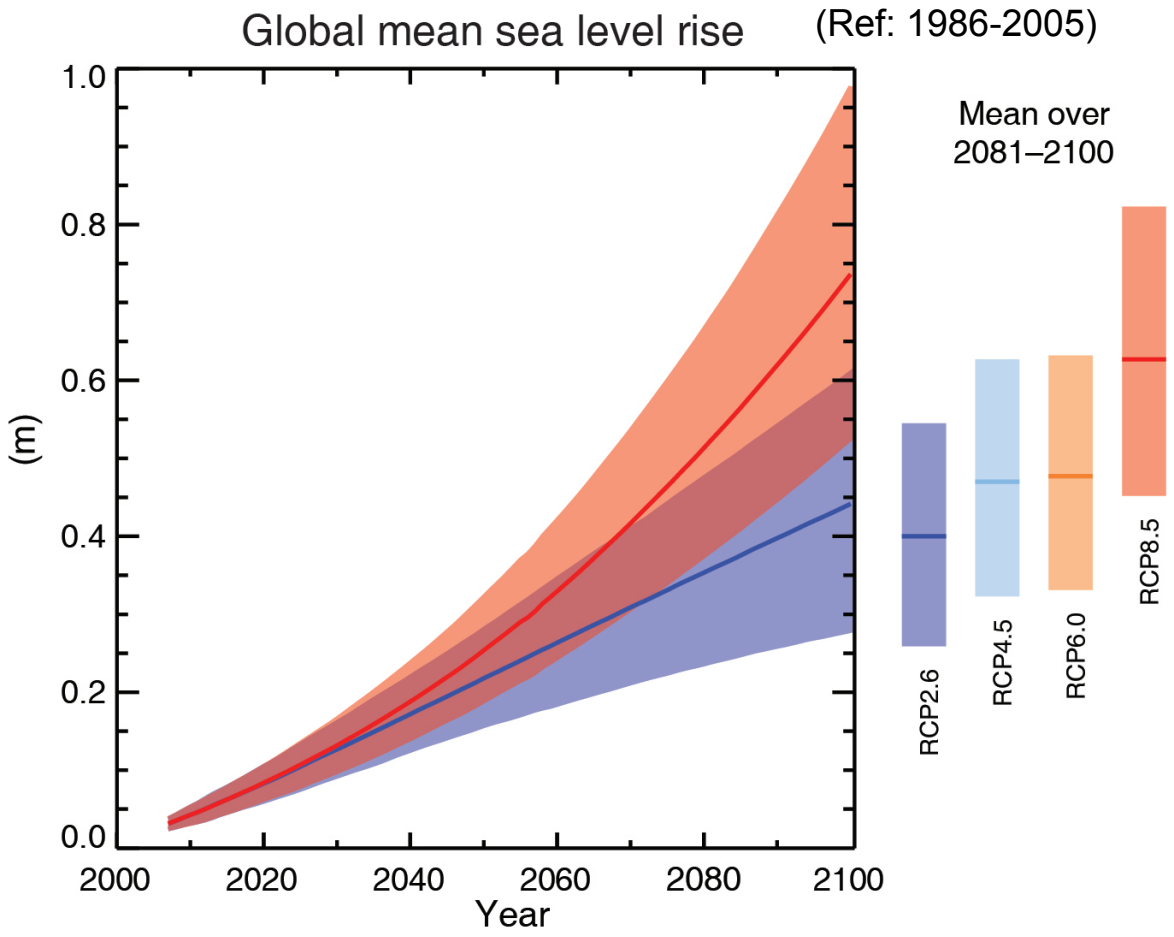


Only the lowest (RCP2.6) scenario maintains the global surface temperature increase above the pre-industrial level to less than 2°C with at least 66% probability



(IPCC 2013, Fig. SPM.9)

Sea level due to continue to increase

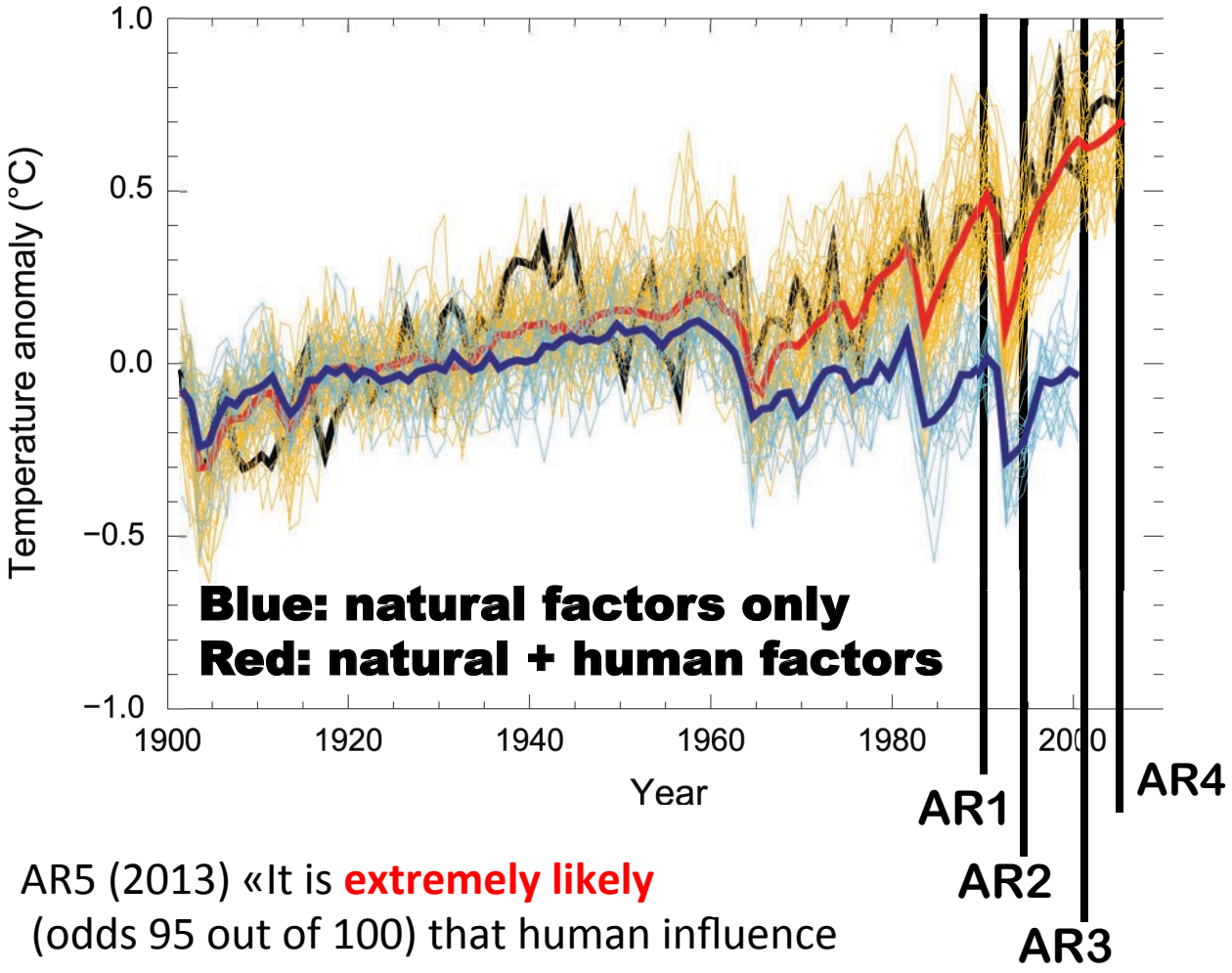
A Progression of Understanding: Greater and Greater Certainty in Attribution

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"



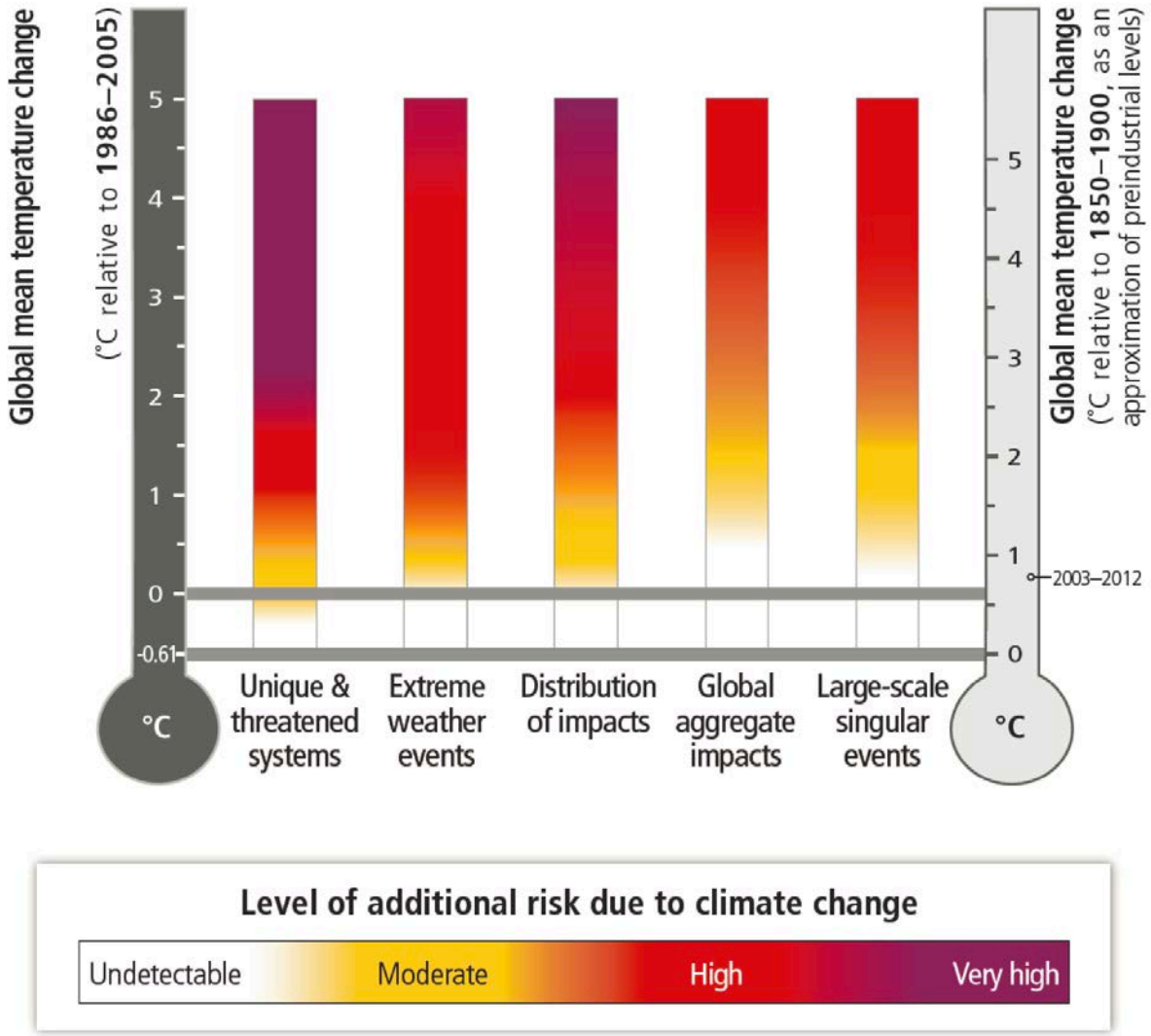
AR5 (2013) «It is **extremely likely** (odds 95 out of 100) that human influence has been the dominant cause… »

Effects of a 1 m Sea-Level Rise in the Nile Delta (>10 million people live at less than 1 m a.s.l.)

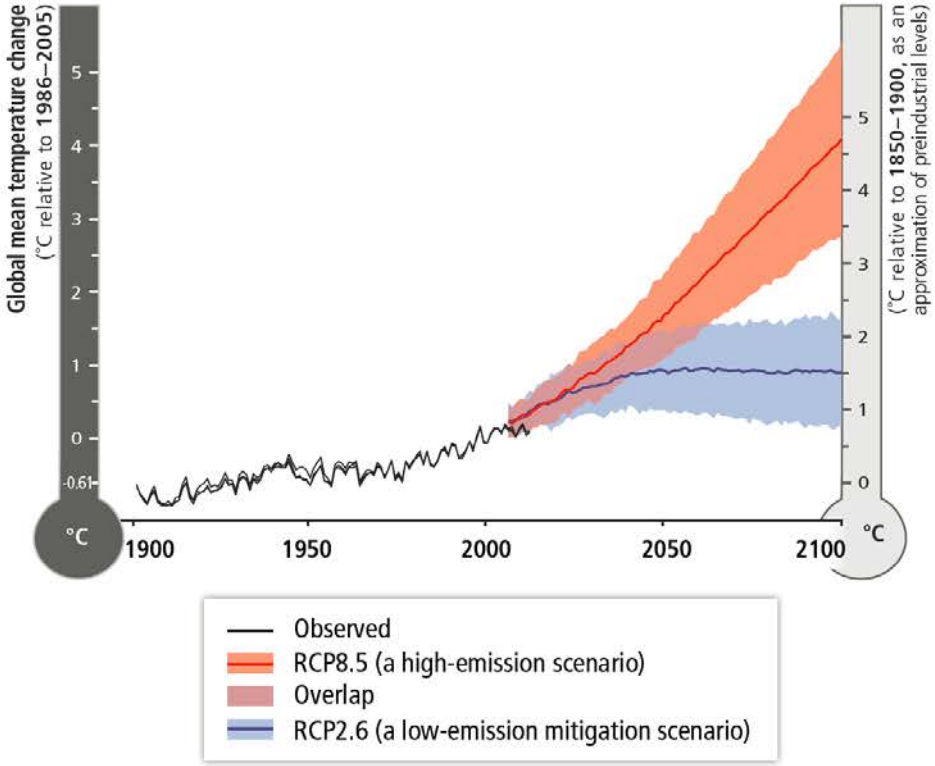
(Time 2001)

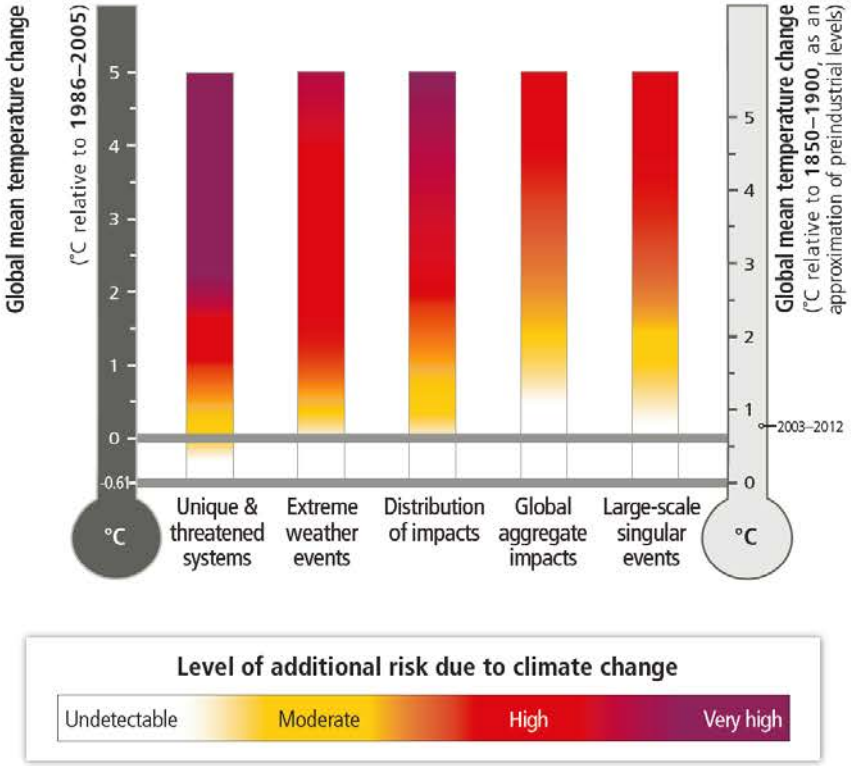
Risk = Hazard x Vulnerability x Exposure (Katrina flood victim)

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



AR5, WGII, Box SPM.1 Figure 1





ipcc
INTERGOVERNMENTAL PANEL ON climate change

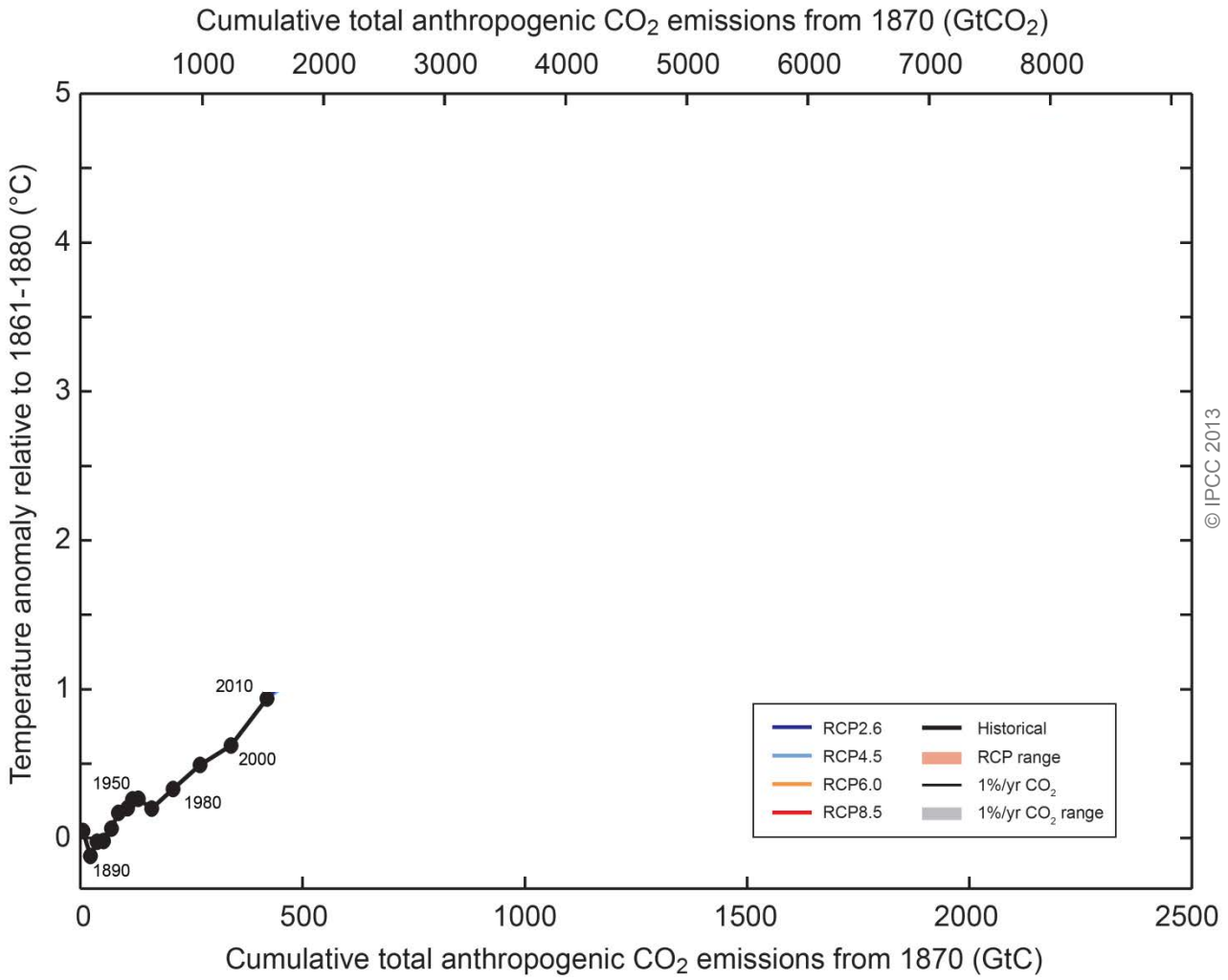


Fig. SPM.10

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

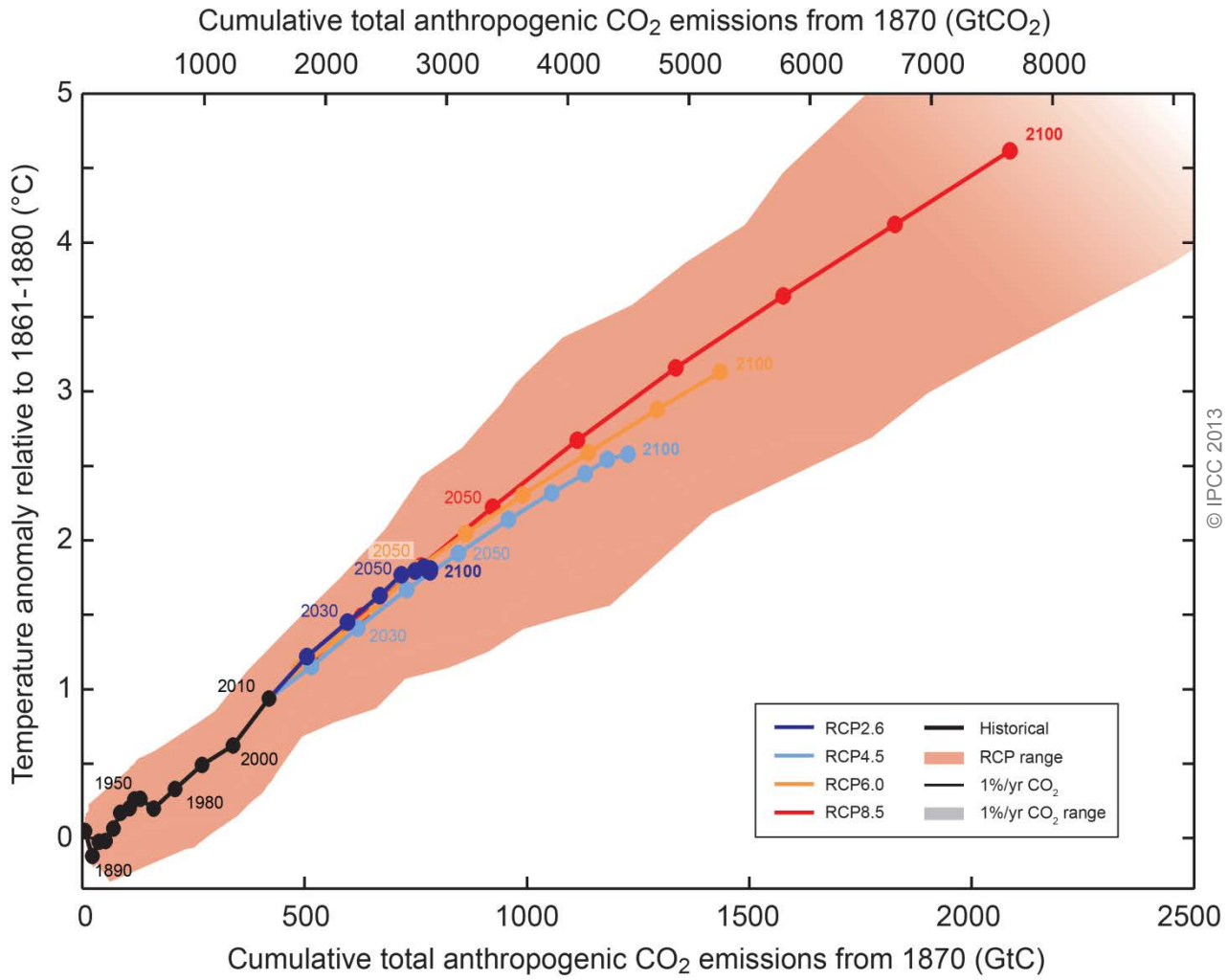
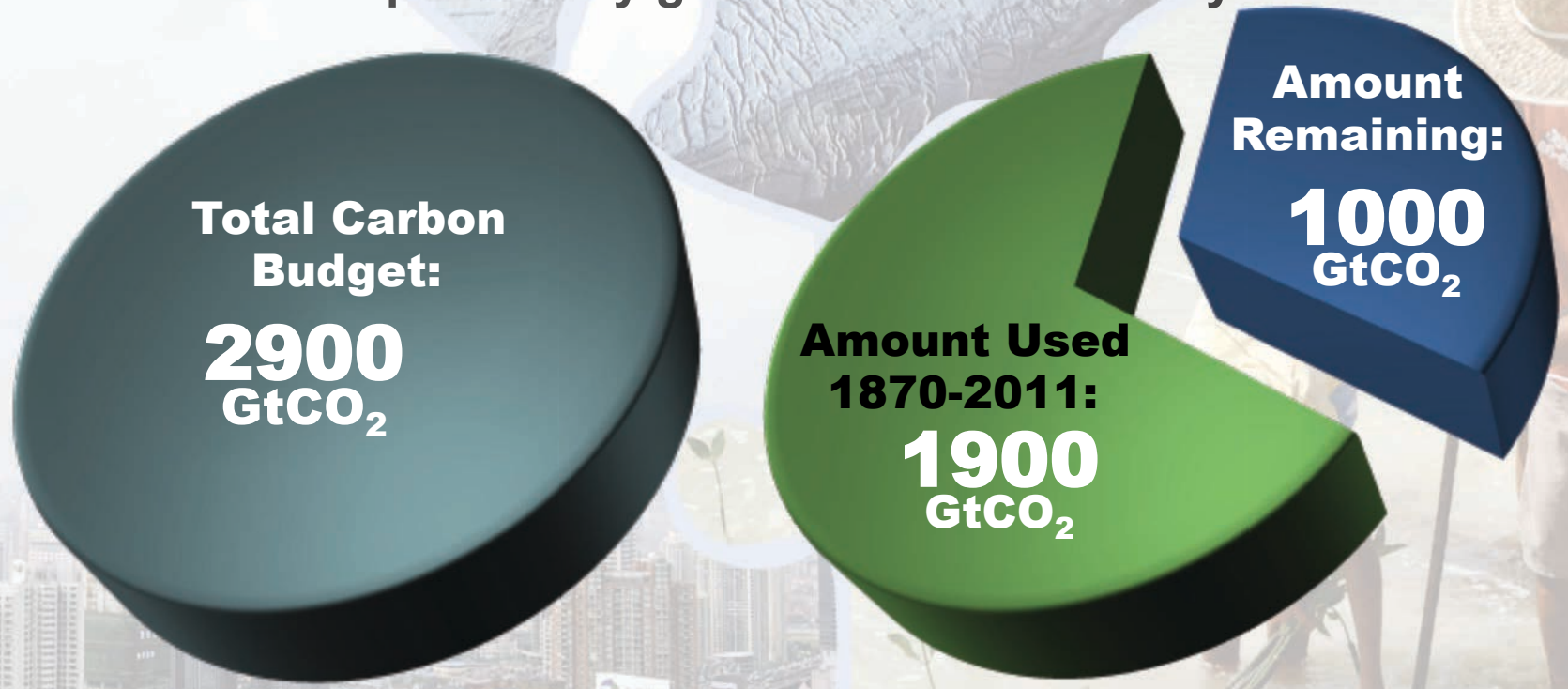


Fig. SPM.10

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

The window for action is rapidly closing

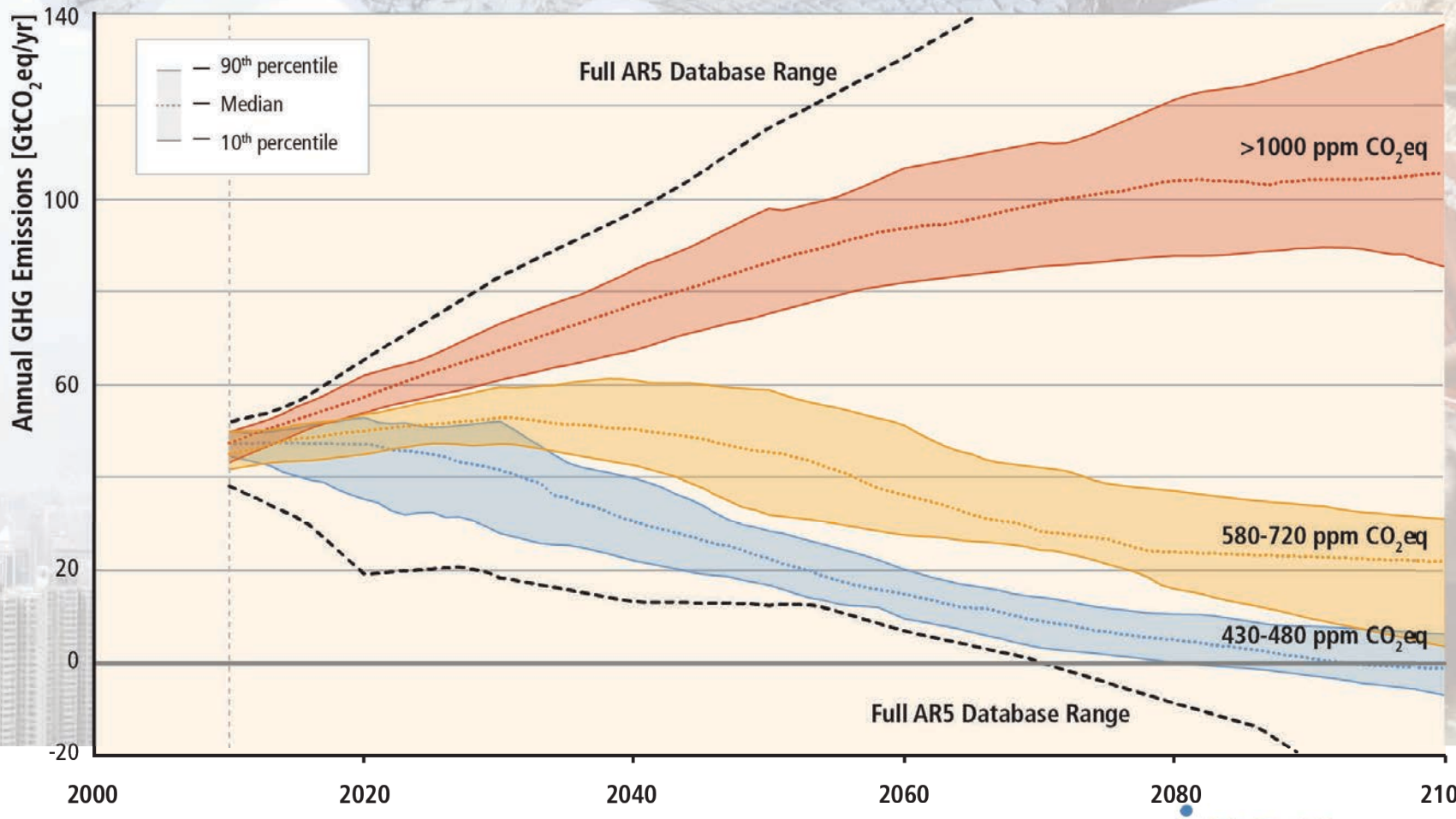
65% of the carbon budget compatible with a 2°C goal is already used
NB: this is with a probability greater than 66% to stay below 2°C



NB: Emissions in 2011: 38 GtCO2/yr

AR5 WGI SPM

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



Based on Figure 6.7

AR5 WGIII SPM

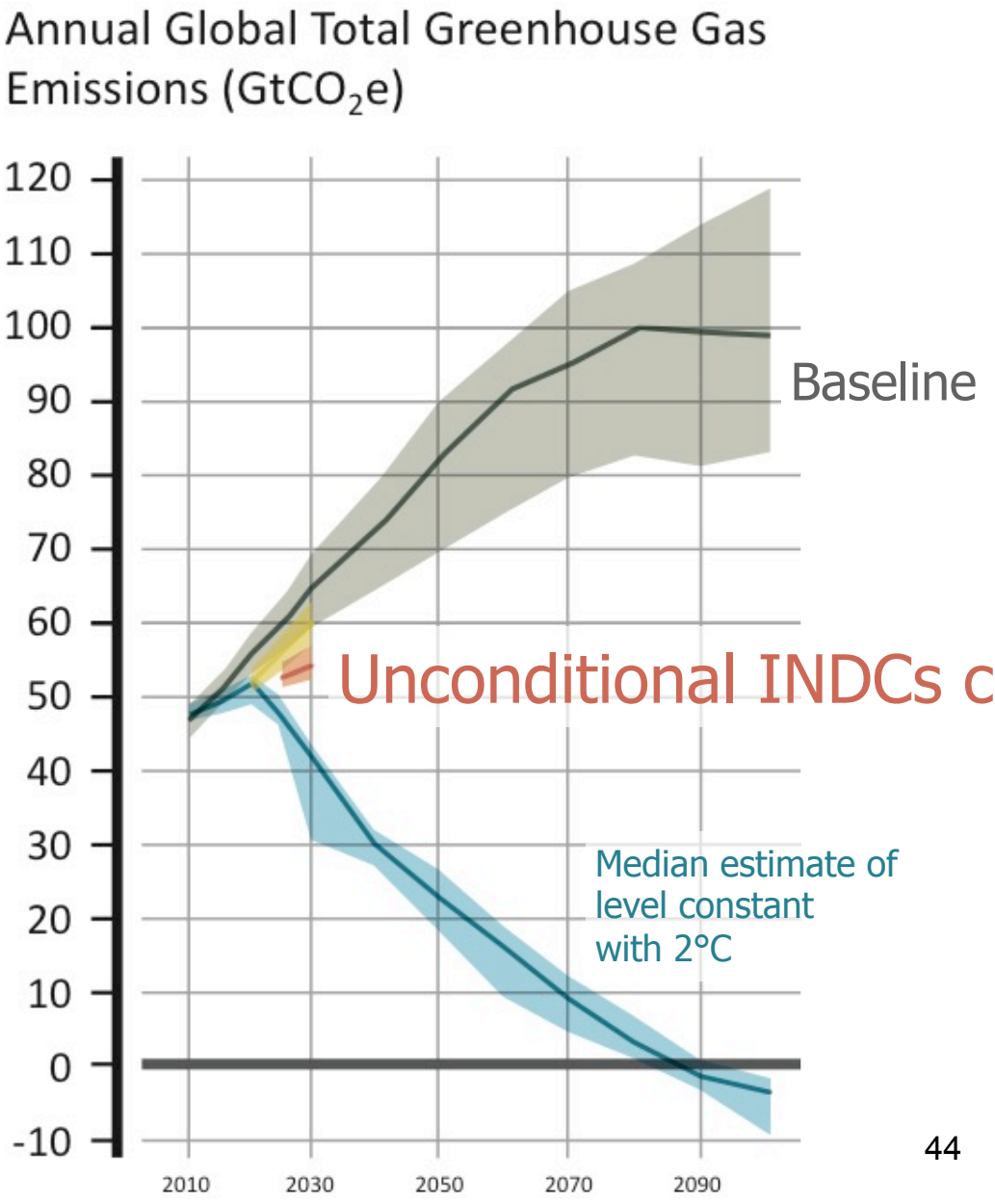
IPCC AR5 Synthesis Report

INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

Intended Nationally Determined Contributions (INDCs)

- UN emissions gap report



Conclusions

- Knowledge about the climate system is still imperfect
- But what we knew 40 years ago was more than enough to act
- A key problem is short-termism among political leaders

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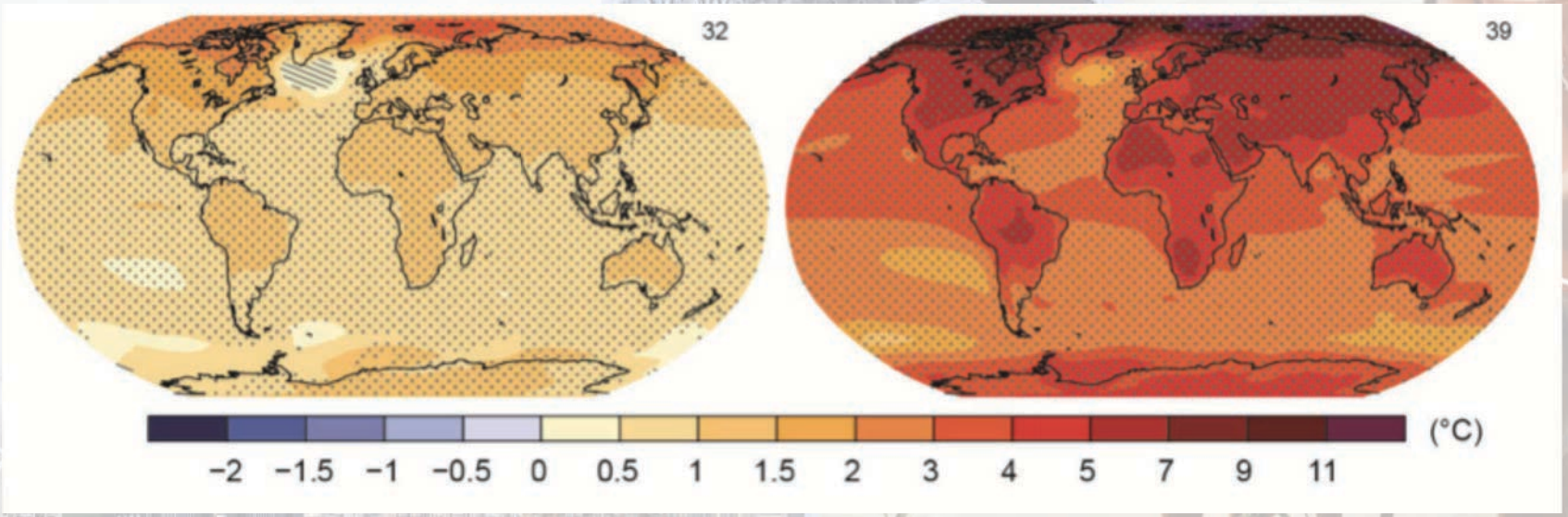
Humanity still has the choice

With substantial mitigation

Without additional mitigation



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

AR5 WGI SPM

Trying to be coherent…

Useful links:

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