Le réchauffement climatique: remettons les pendules à l'heure

Pr Jean-Pascal van Ypersele
Vice-président du GIEC

UCL-TECLIM
(Université catholique de Louvain, Centre de recherche sur la Terre et le climat Georges Lemaître)

Toile: **www.climate.be**
Courriel: **vanyp@climate.be**
Twitter: @JPvanYpersele

Louvain-la-Neuve, 29 avril 2014

Merci aux collègues de TECLIM, à la Maison des Sciences et au Kot ASTRO

Pourquoi le GIEC (IPCC en anglais)?

(Groupe d'experts Intergouvernemental sur l'Evolution du Climat)

GIEC : Groupe d'experts Intergouvernemental sur l'Evolution du Climat (=IPCC en anglais)

- Créé par les Nations unies (OMM et PNUE) en 1988
- Environ 10000 scientifiques y ont participé (auteurs + relecteurs critiques)
- Mandat : **évaluer** les informations scientifiques, techniques et socio-économiques liées à la compréhension des risques associés aux changements climatiques (base scientifique, impacts potentiels, prévention et adaptation).
- Publie des rapports (1990, 1996, 2001, 2007, 2013-2014 en cours) (Cambridge University Press) qui font autorité. (Prix Nobel de la Paix 2007!)
- **Web: www.ipcc.ch**

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

What is happening in the climate system?

What are the risks?

What can be done?

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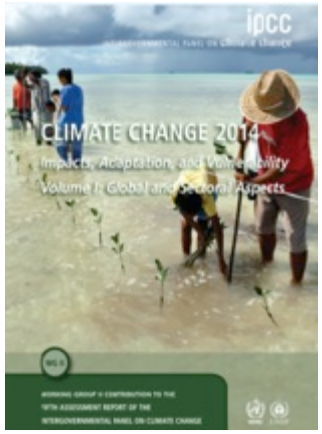
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

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



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

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

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INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

Définitions

- **Système climatique: constitué par l'atmosphère, les océans, la cryosphère (glace), la surface des continents, la biosphère…**
- **Le climat = *moyenne* de l'état de ce système, en particulier du *temps* sur 30 ans, + *variabilité* autour de cette moyenne**

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

Le système climatique terrestre

- Machine thermique alimentée en énergie par le Soleil (1400 Wm-2 au sommet de l'atmosphère)
- « Sphère » en rotation→dynamique des fluides complexe
- Océan= 70% de la surface,
- Très fine atmosphère (N_2, O_2, H_2O, CO_2,…)
- Effet de serre
- Cycles bio-géo-chimiques

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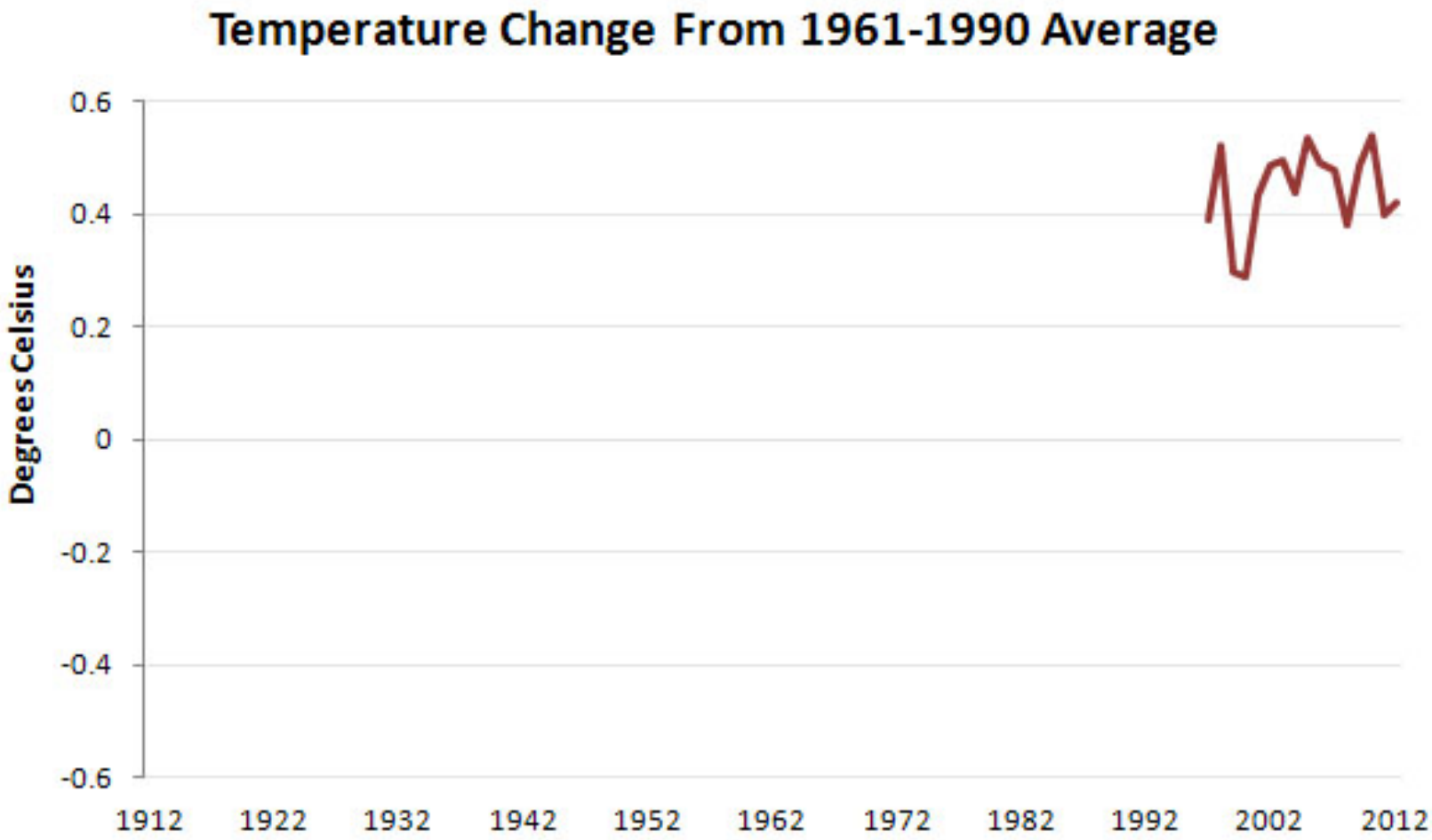
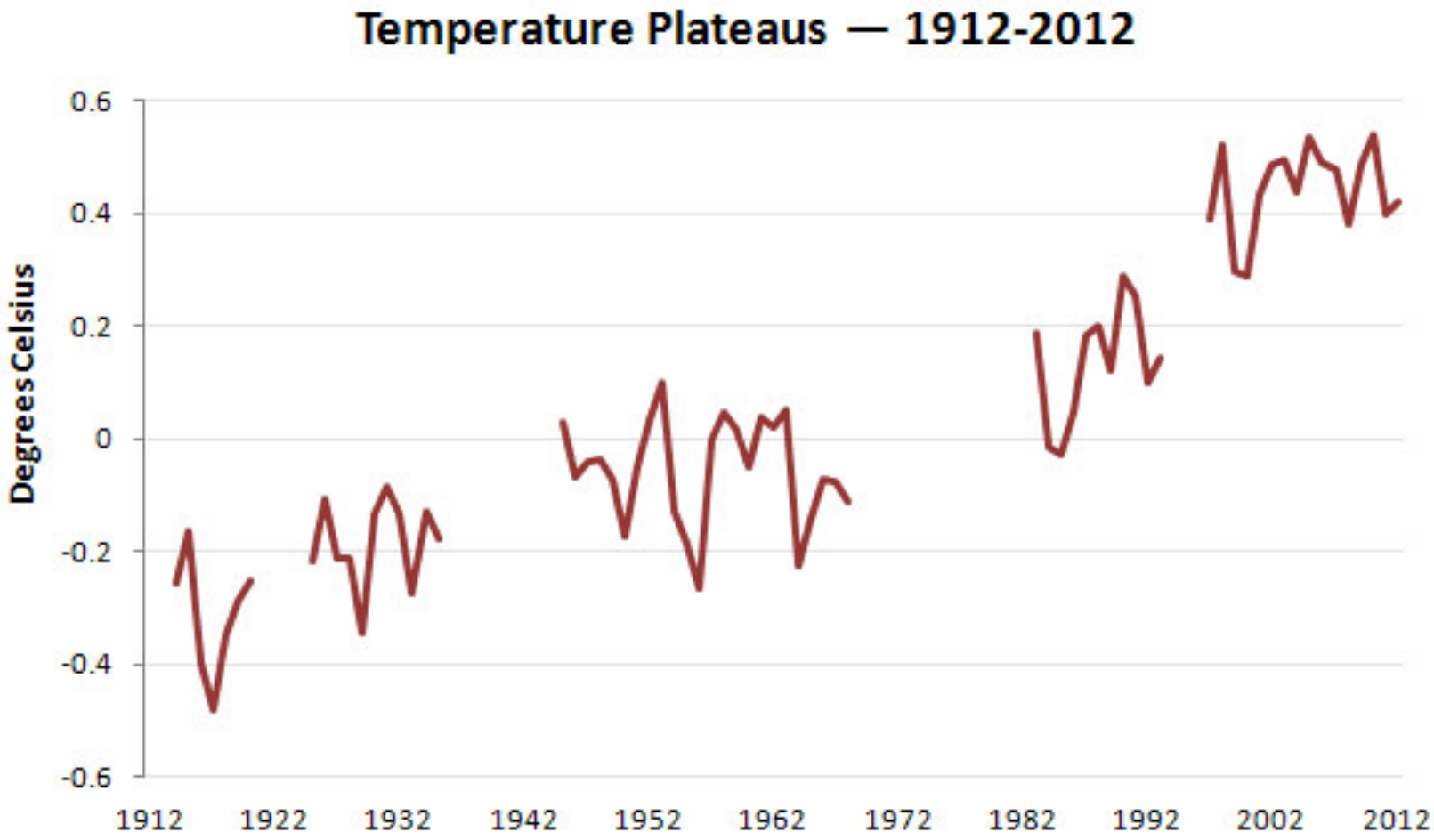
(vanypersele@astr.ucl.ac.be)



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

Lying With Statistics, Global Warming Edition



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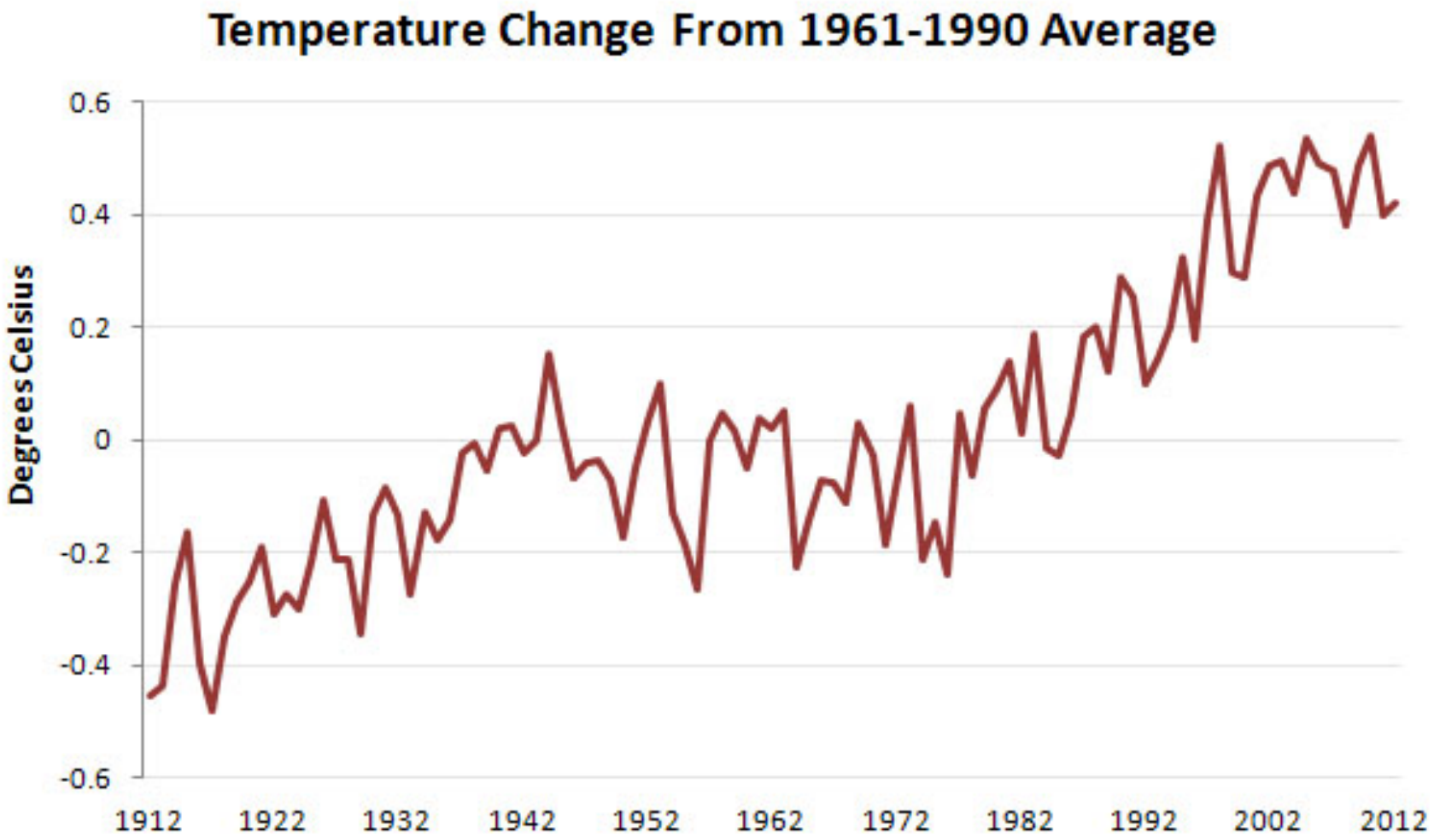
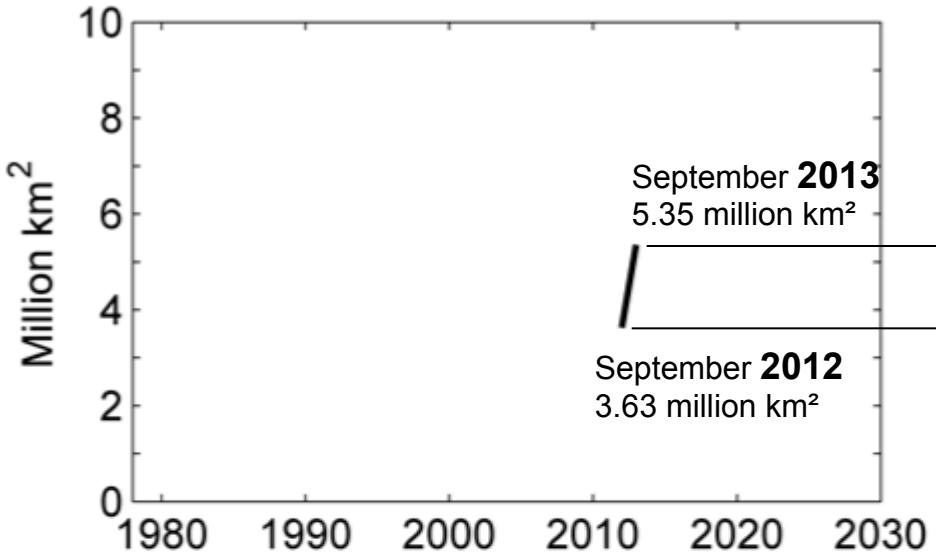
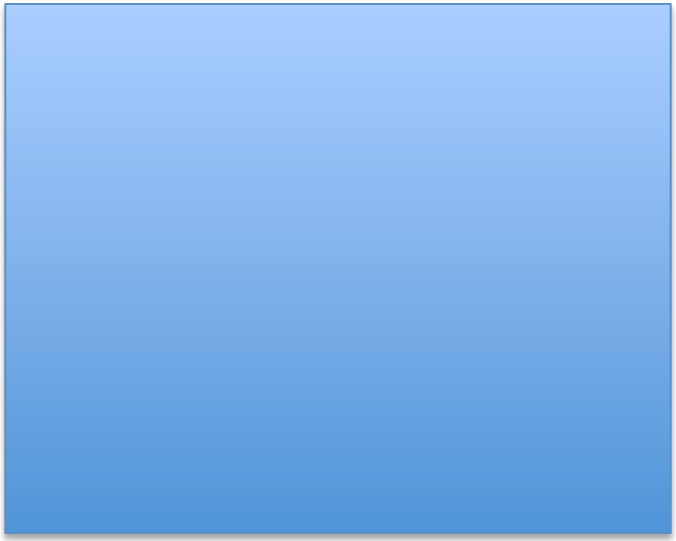
Lying With Statistics, Global Warming Edition

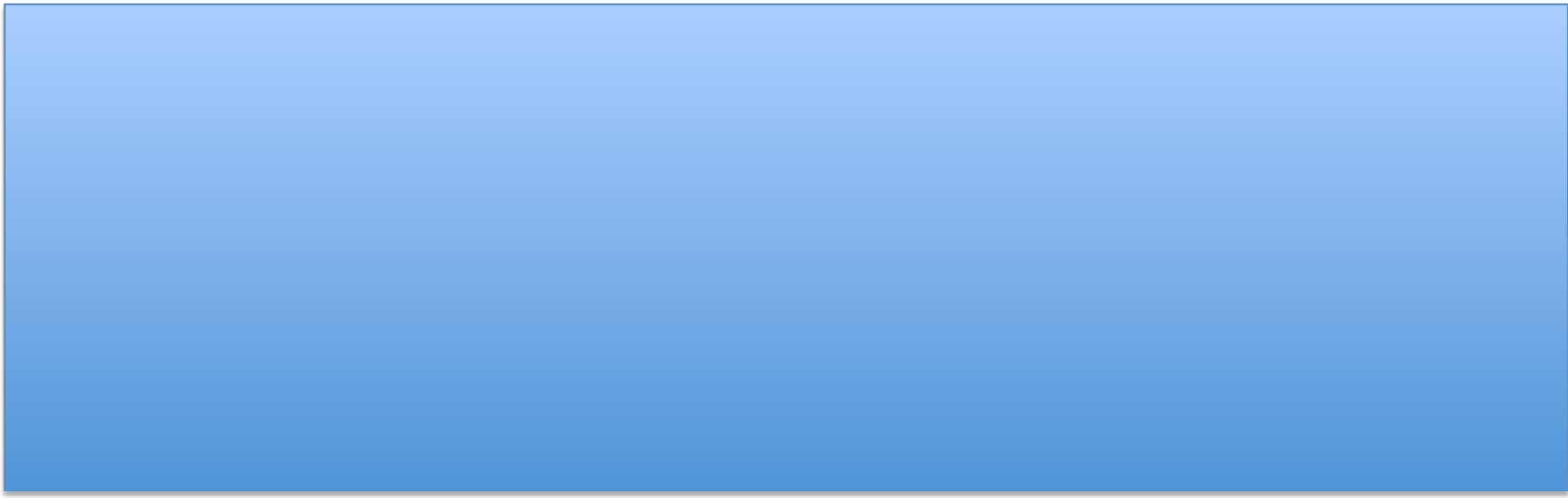


http://www.motherjones.com/kevin-drum/2012/10/lying-statistics-global-warming-edition

Observed Arctic September sea ice extent

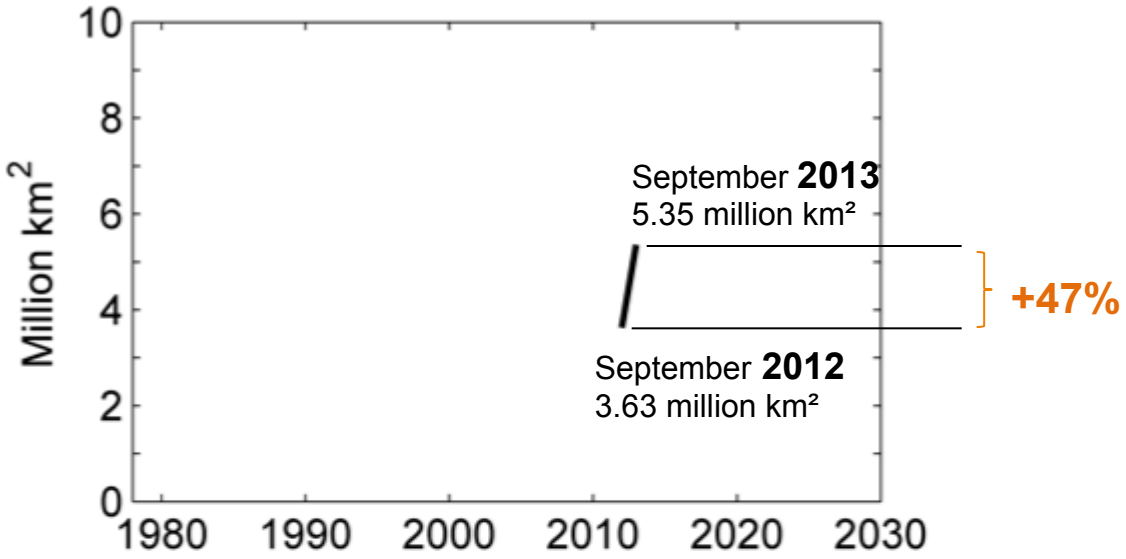






Credit: F. Massonnet, UCL, 2013
Sea ice extent data: www.nsidc.org

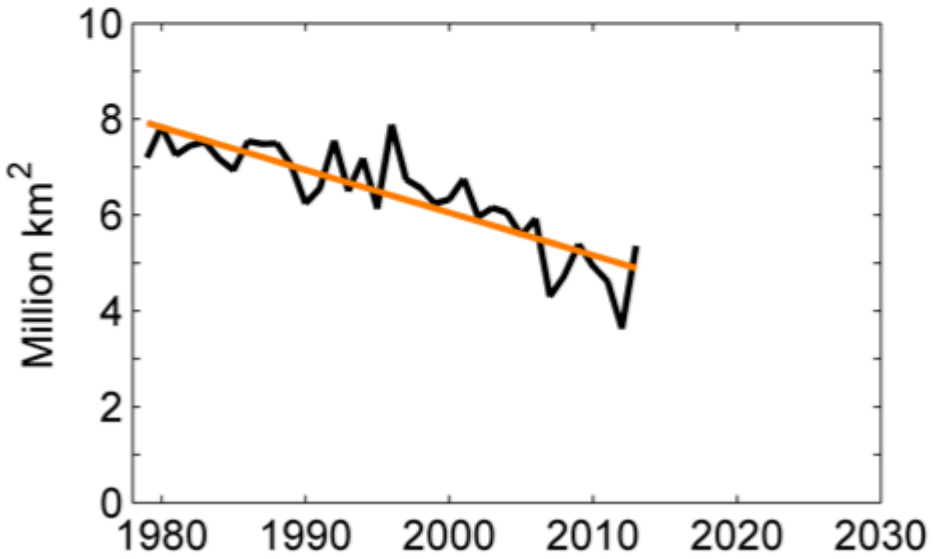
Observed Arctic September sea ice extent



Cherry-picking analysis

-« Arctic sea ice cover is rebounding »

-« Climate is cooling »



Scientific approach: the full view

-Variability of September sea ice extent at the interannual time scale is important

-Significant negative trend over record period (1979-2013): −0.89 million km²/ decade

-September 2013 sea ice extent is 6th lowest on record and 16.5% below 1979-2013 average

Credit: F. Massonnet, UCL, 2013
Sea ice extent data: www.nsidc.org

Principaux messages du SPM

19 messages-clés

En moins de 2 pages

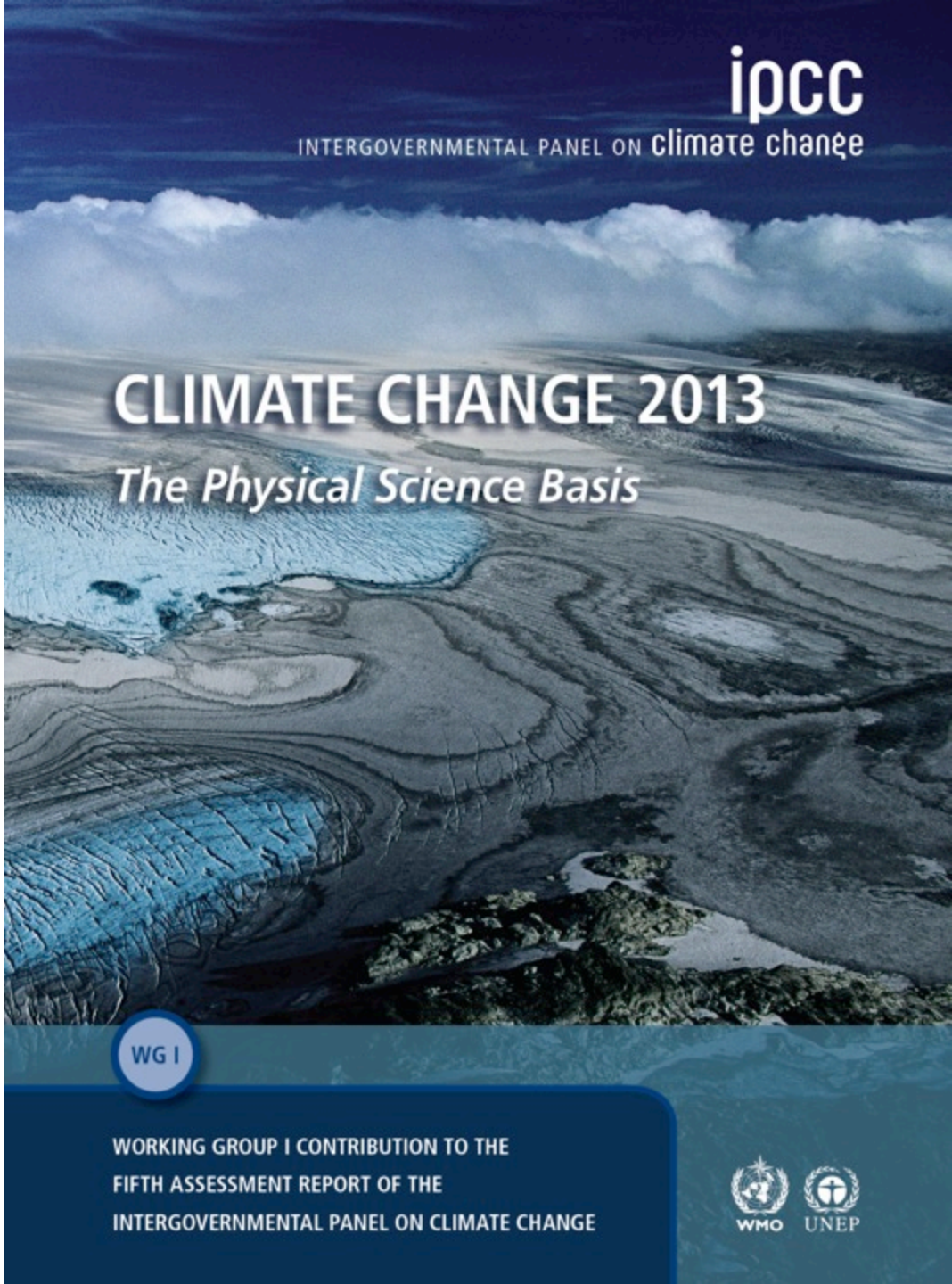
Résumé pour les décideurs
~14.000 Mots

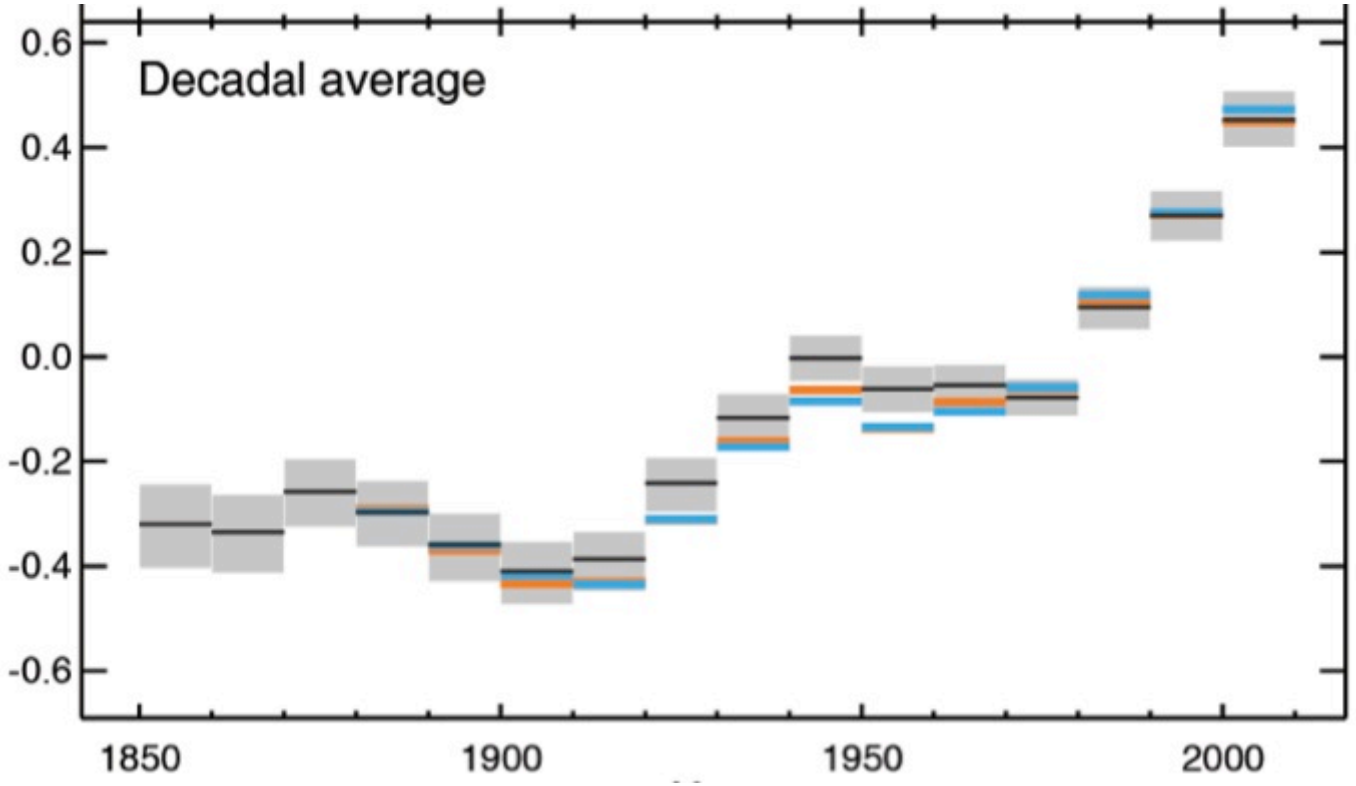
14 Chapitres
Atlas des Projections Régionales

54.677 Commentaires
de 1089 Experts

2010: 209 Auteurs sélectionnés

2009: les grandes
lignes du WGI approuvées



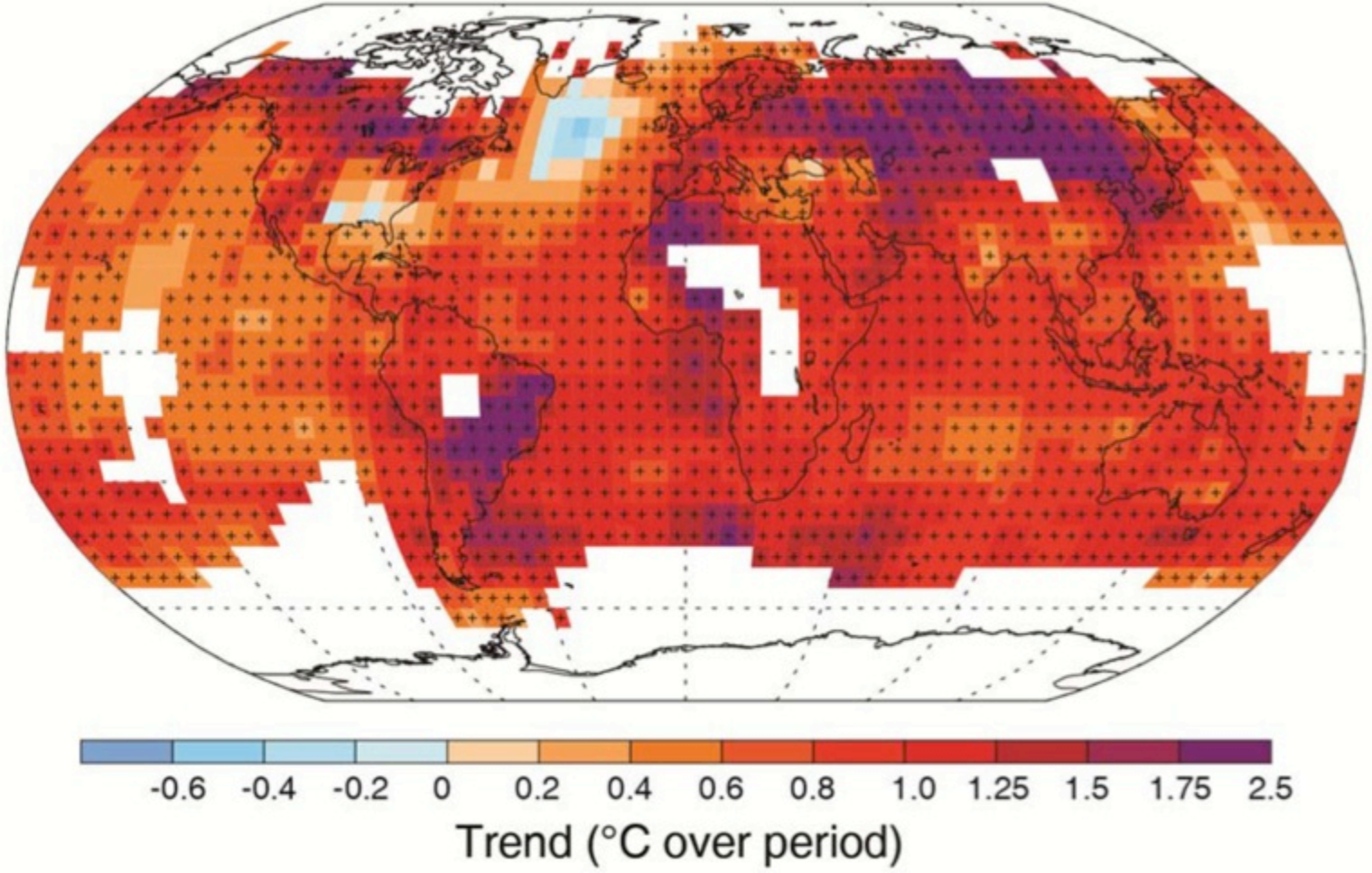


(IPCC 2013, Fig. SPM.1a)

Chacune des trois dernières décennies a été successivement plus chaude à la surface de la Terre que toutes les décennies précédentes depuis 1850

Dans l'hémisphère nord, la période 1983–2012 a probablement été la période de 30 ans la plus chaude des 1400 dernières années (degré de confiance moyen).

Evolution de la température moyenne en surface 1901-2012: +0.89°C



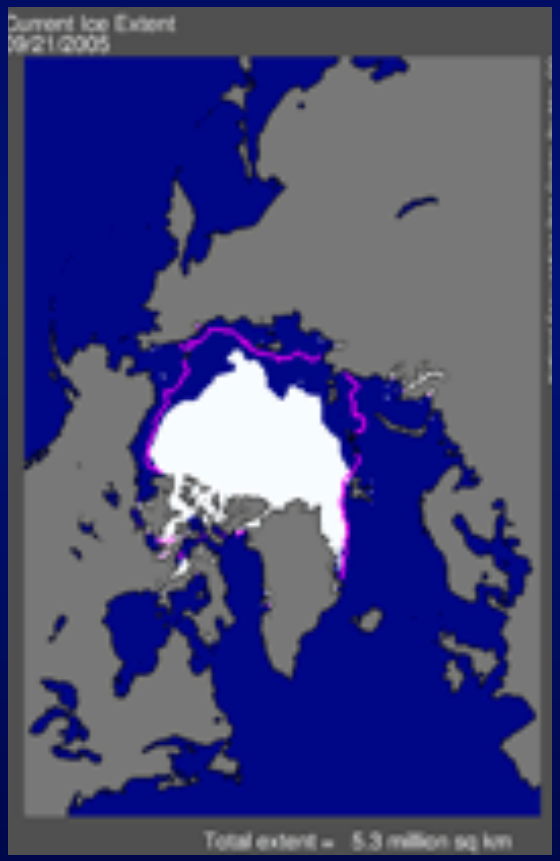
(IPCC 2013, Fig. SPM.1b)

Le réchauffement du système climatique est sans équivoque

Extension of the Arctic ice cap

September 1979

September 2005



September 2007

The pink line indicates the average ice cap extension since 1979

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

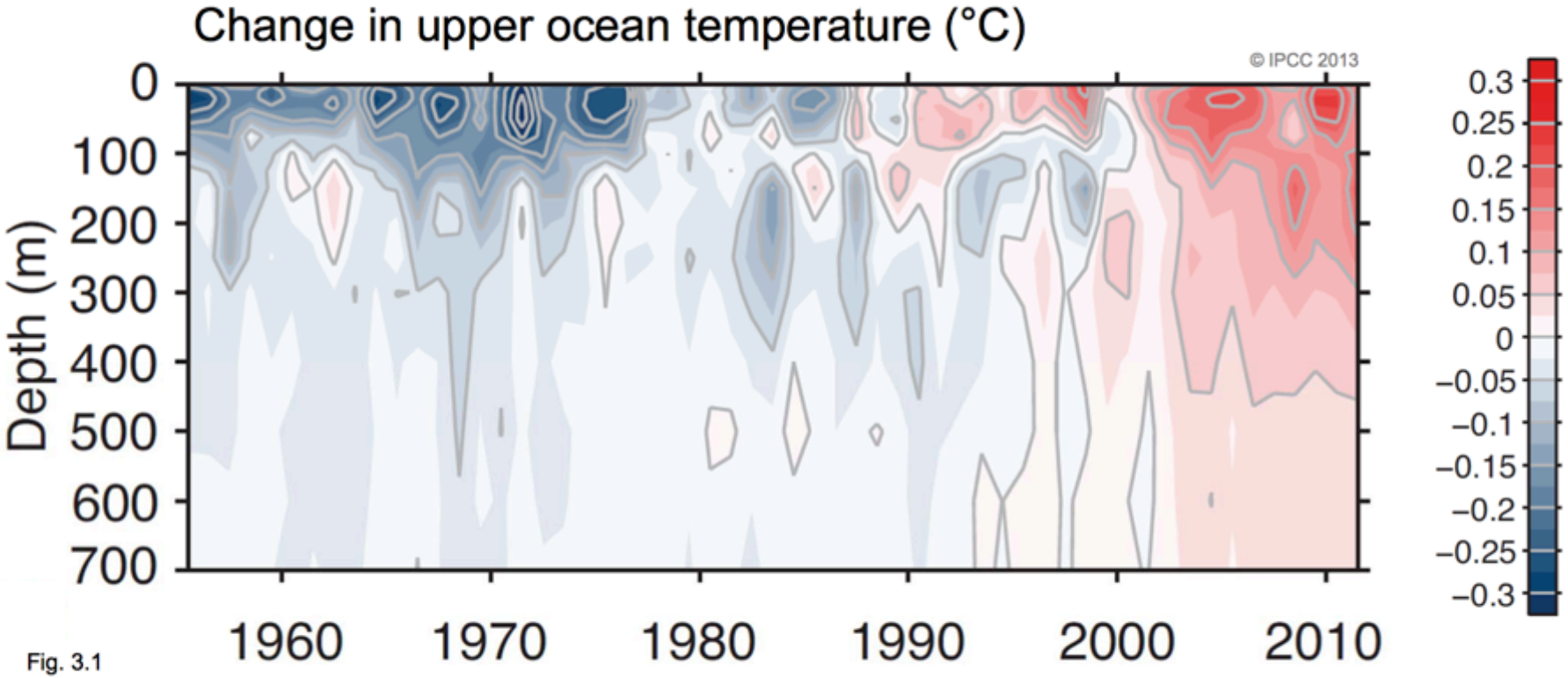


Fig. 3.1

It is *virtually certain* that the upper ocean (0-700 m) warmed from 1971 to 2010, [...]. It is *likely* that the ocean warmed between 700 and 2000 m from 1957 to 2009.

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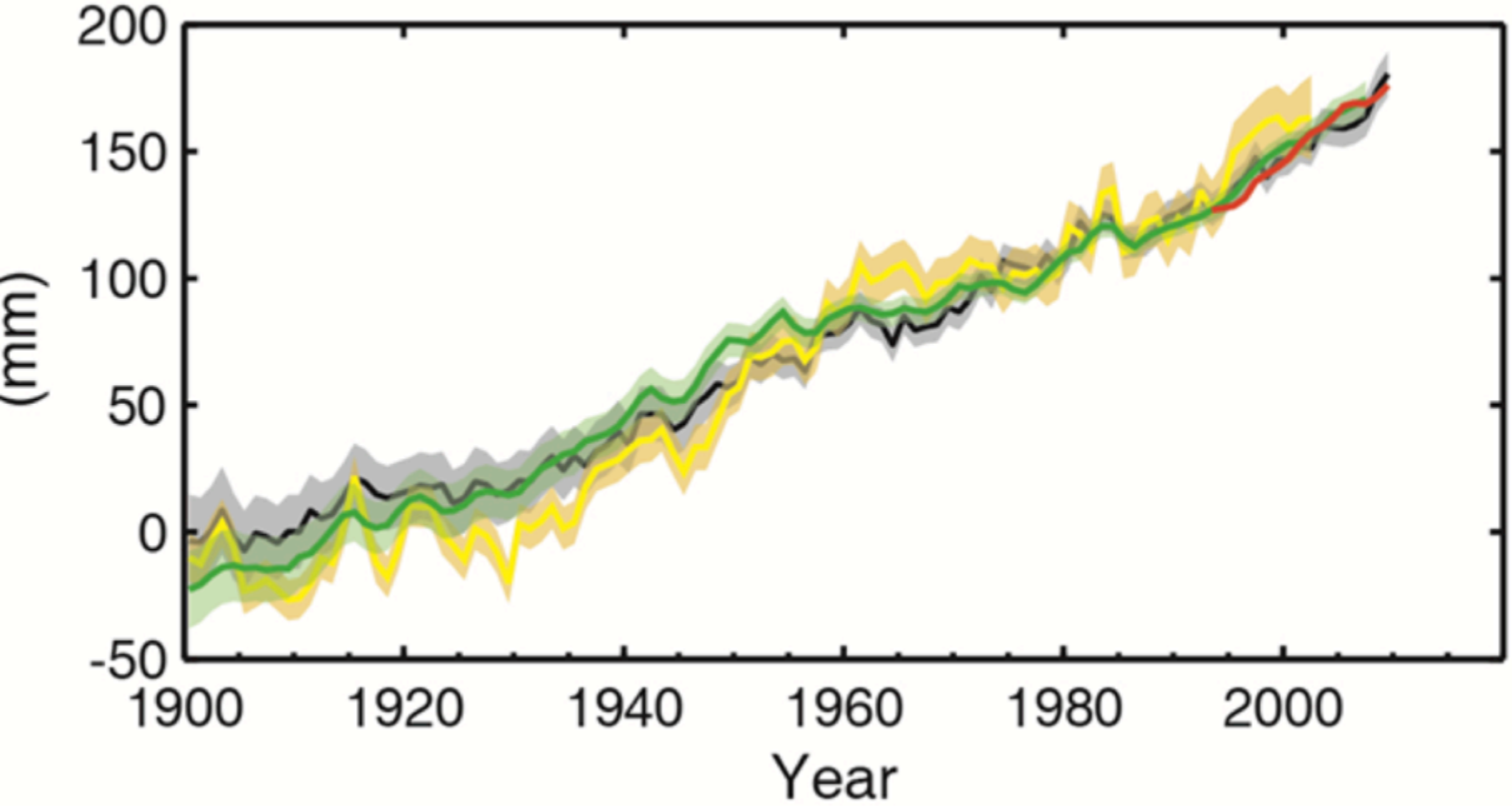
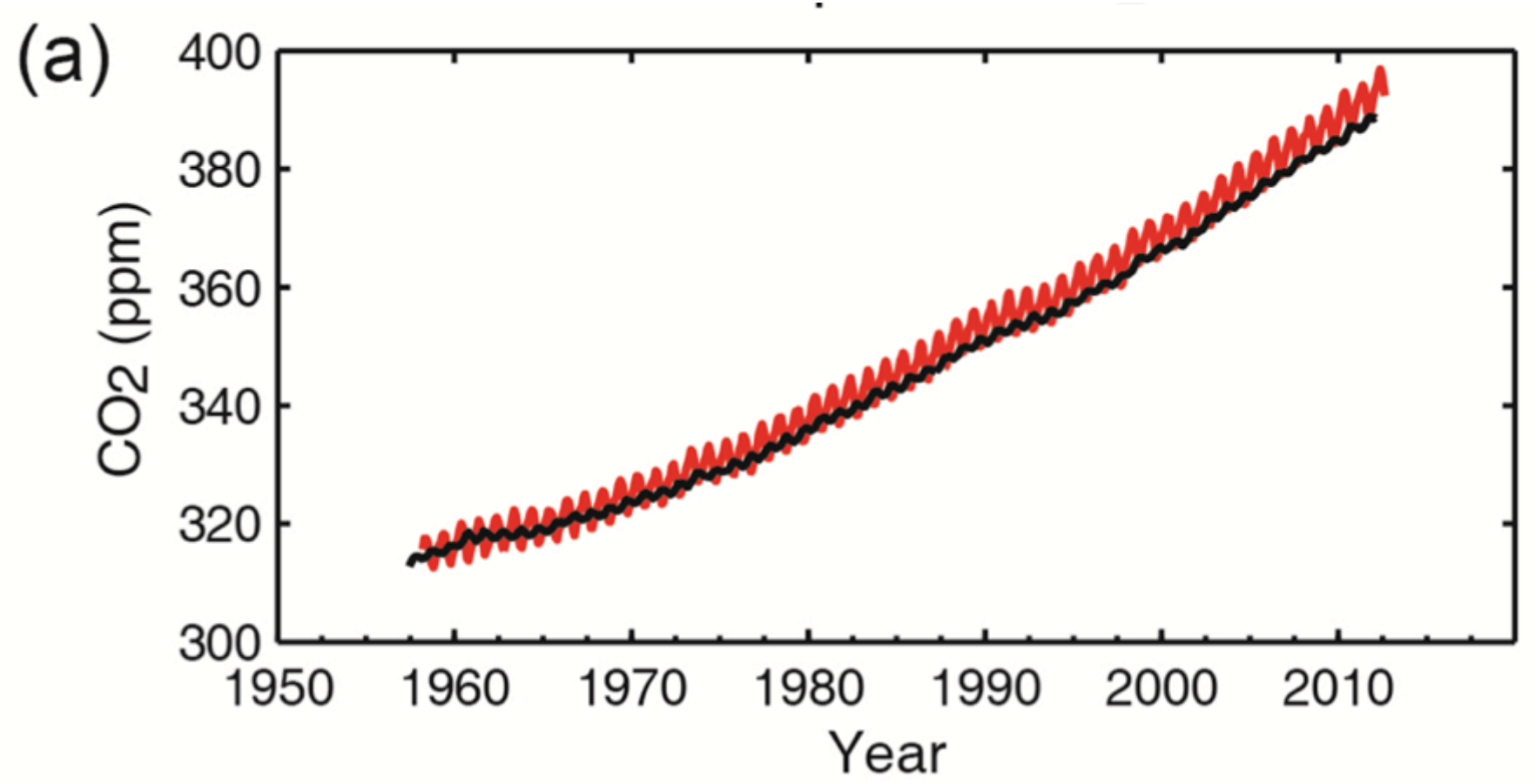
Change in average sea-level



Atmospheric CO_2 concentration



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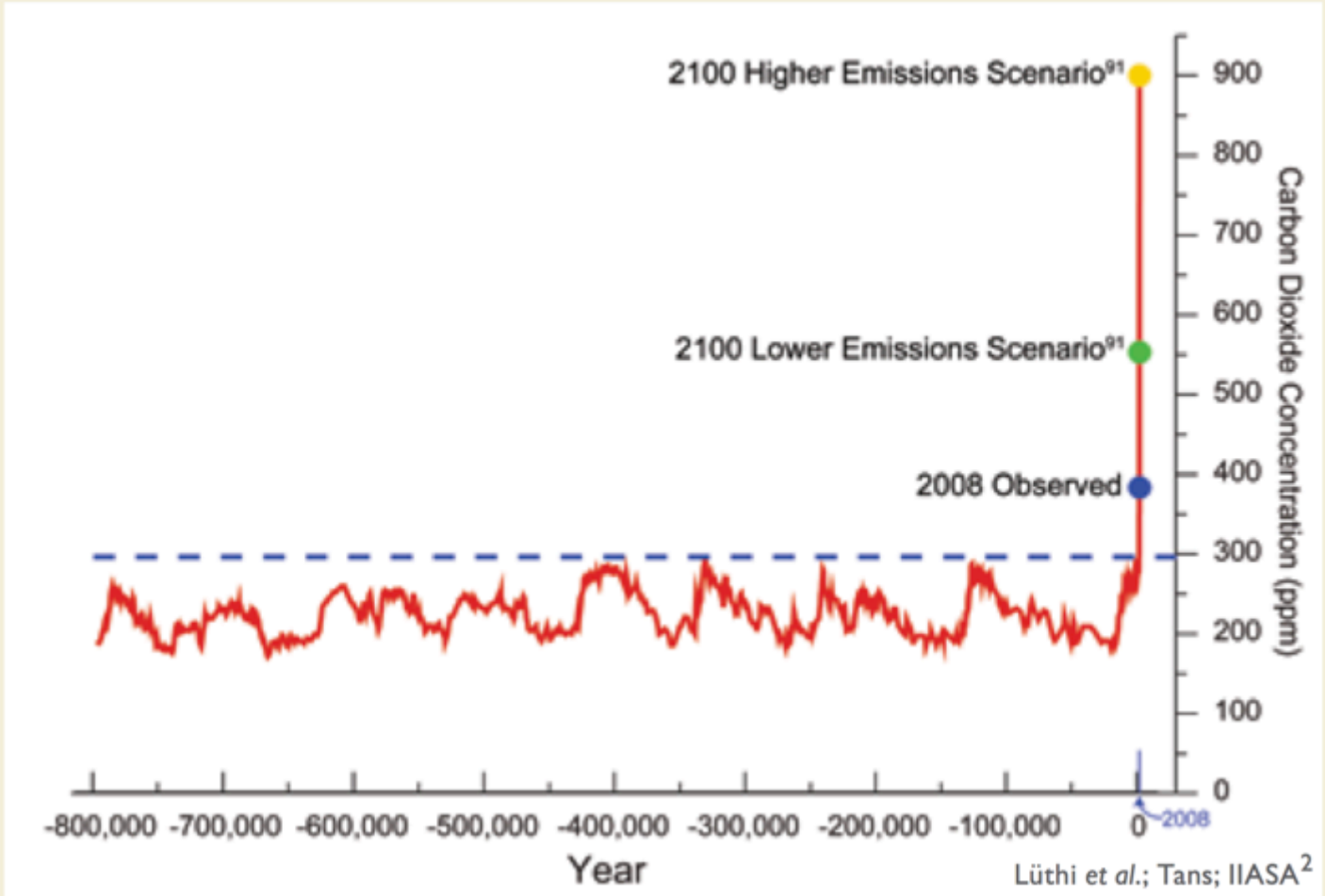
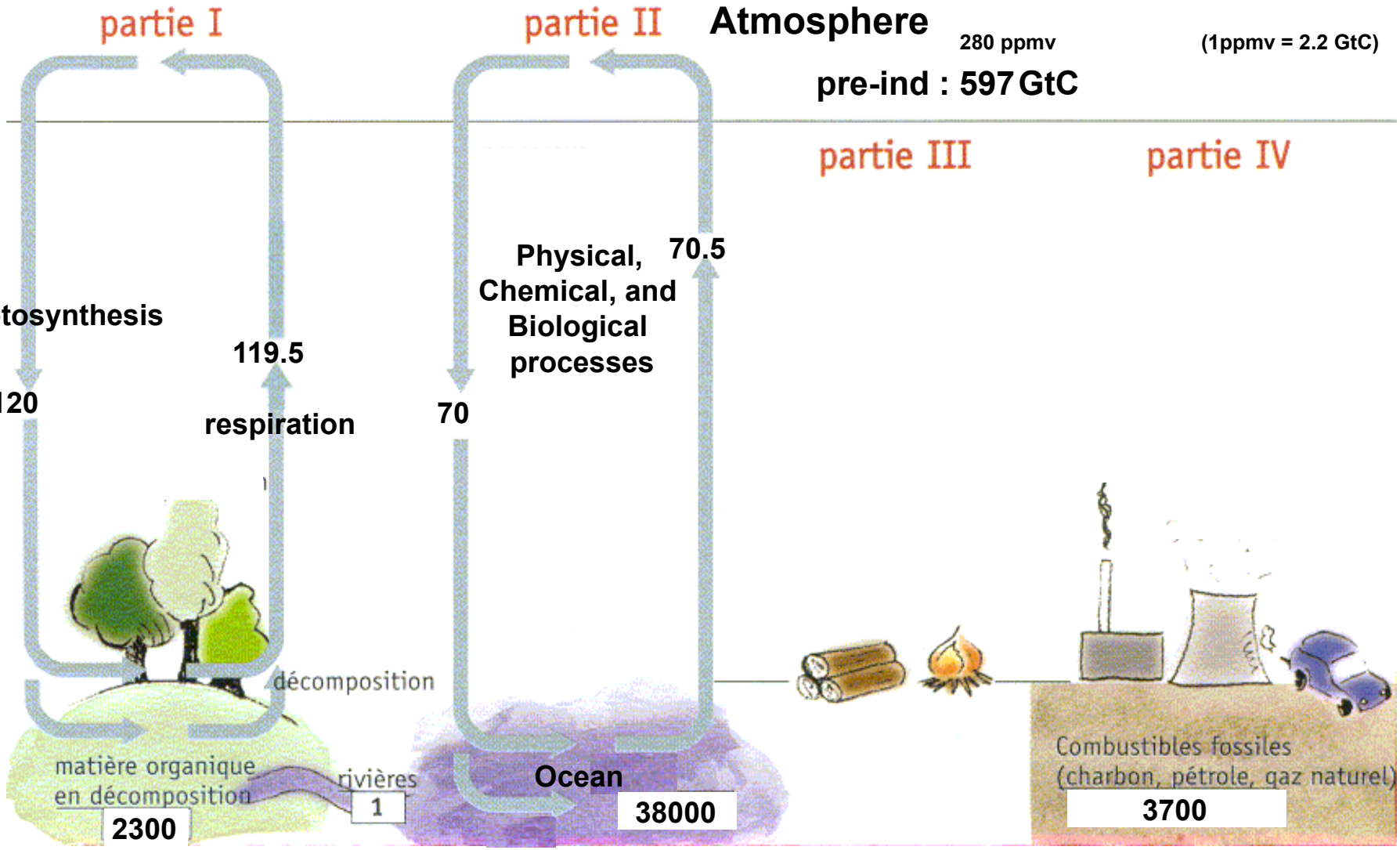
La concentration en CO_2 depuis 800 000 ans et d'ici 2100



http://www.globalchange.gov/images/cir/pdf/Global.pdf

Carbon cycle: unperturbed fluxes

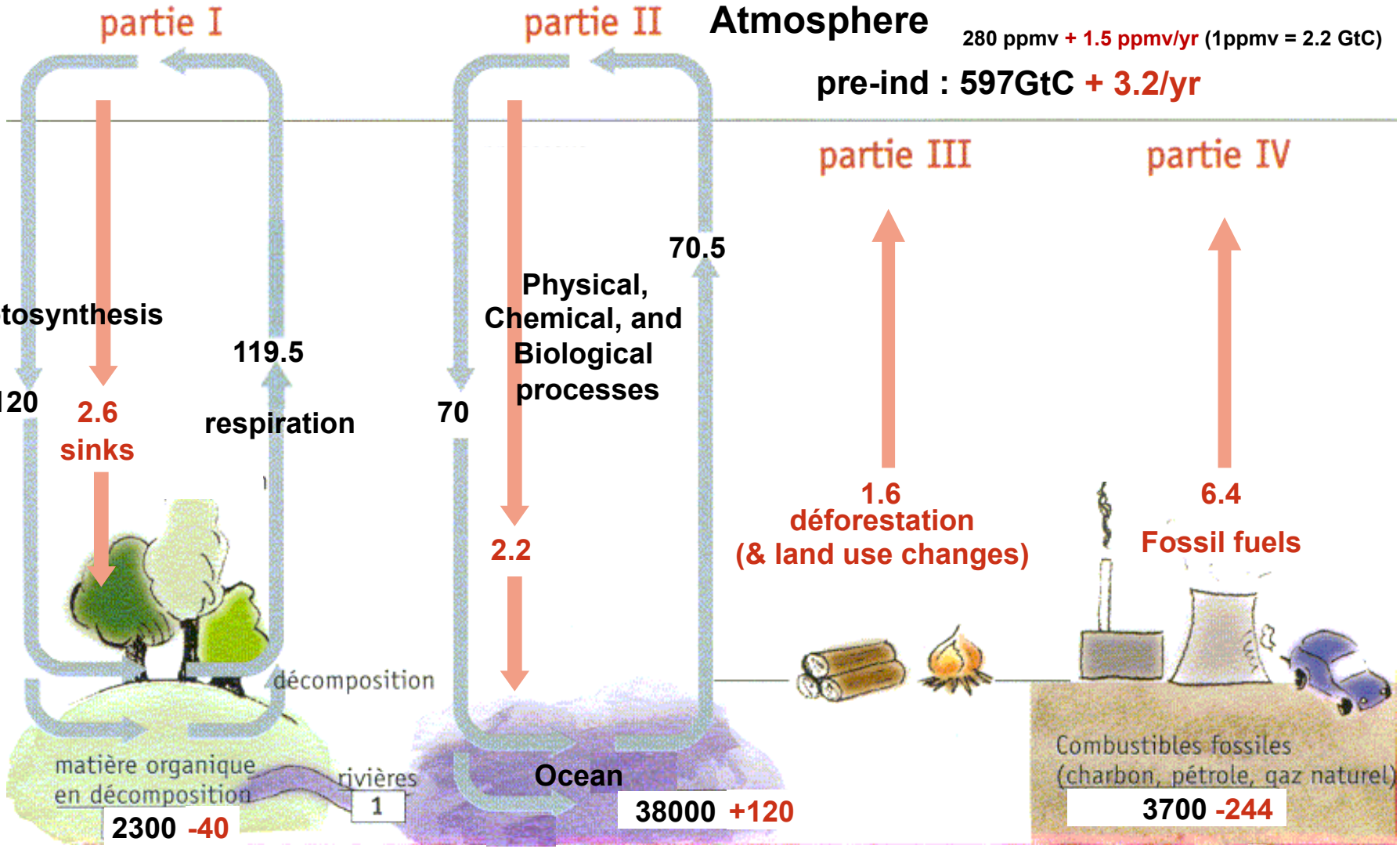


Units: GtC (billions tons of carbon) or GtC/year (multiply by 3.7 to get $GtCO_2$)

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!

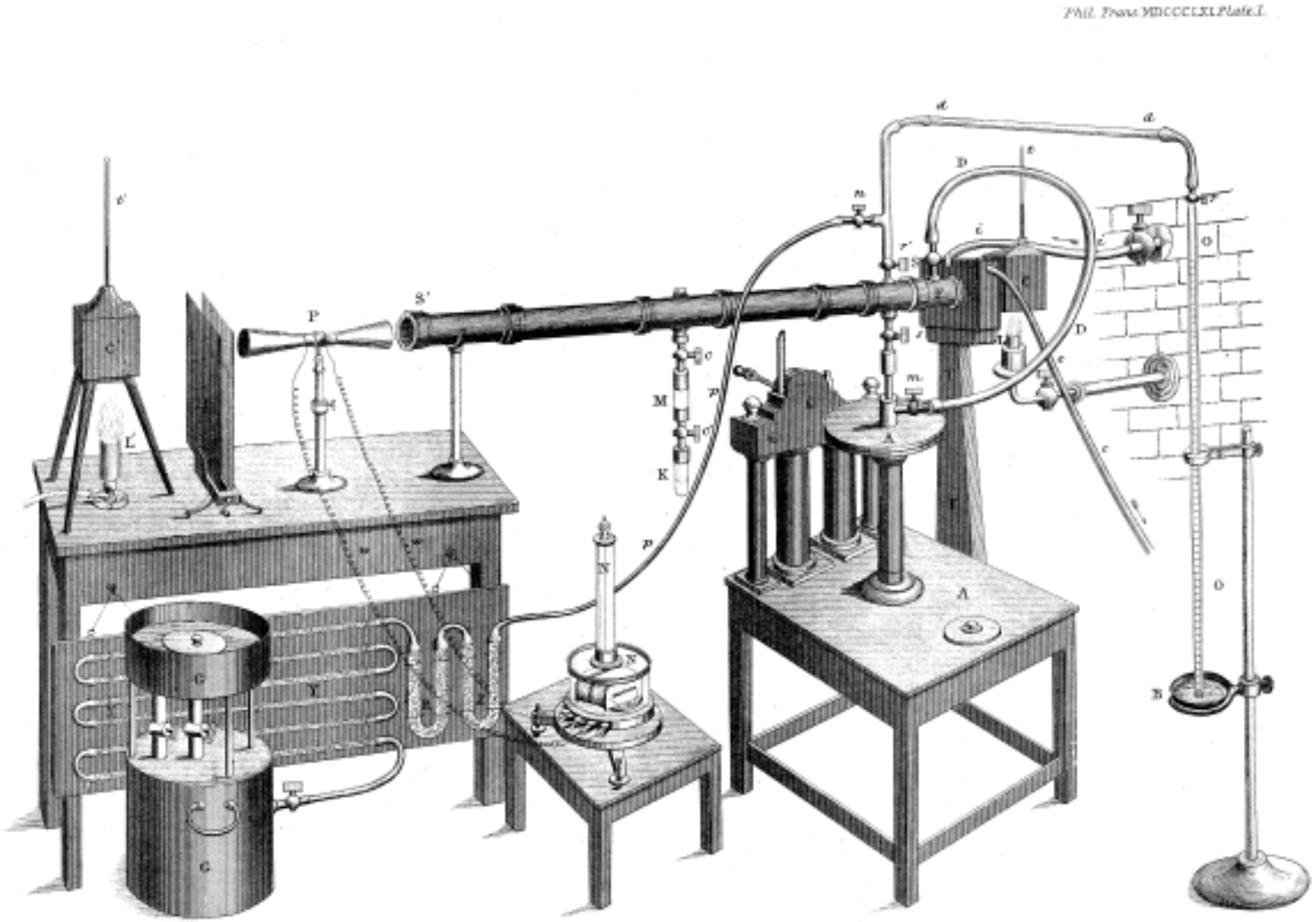
vanyp@climate.be

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.

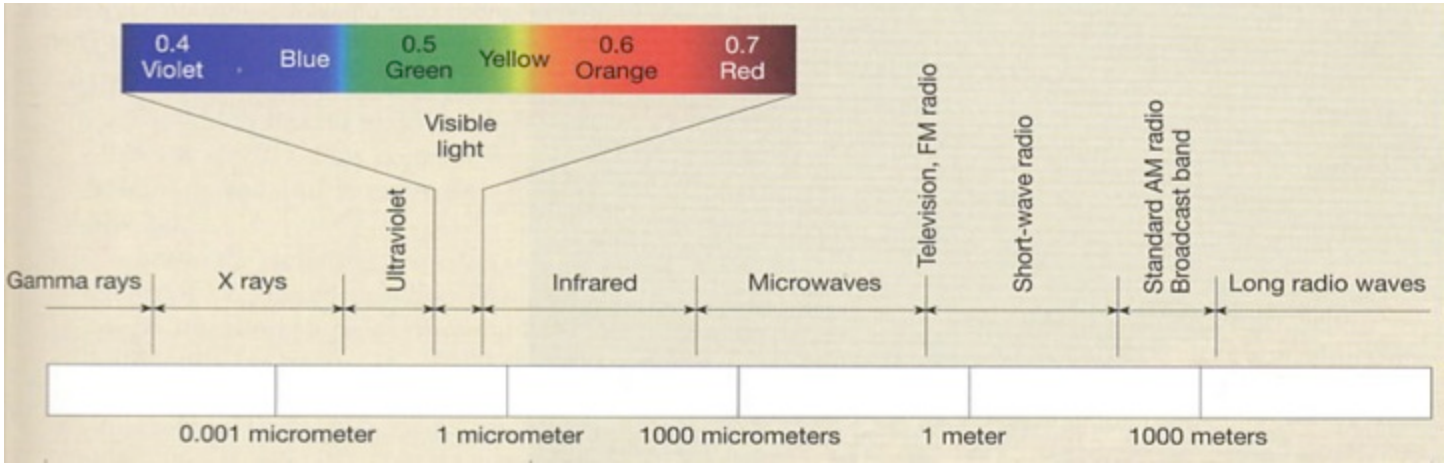
Year	Chemical fuel CO_2 ($\times 10^{16}$ g)	Excess atmospheric CO_2* ($\times 10^{16}$ g)	Excess atmospheric CO_2 (%)	Excess atmospheric CO_2 (ppm)	CO_2 content of the atmosphere† (ppm)	Global temperature increase‡ (°C)
1900	3.8	1.9	0.9	2	295	0.02
1910	6.3	3.1	1.4	4	297	.04
1920	9.7	4.8	2.2	6	299	.07
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.

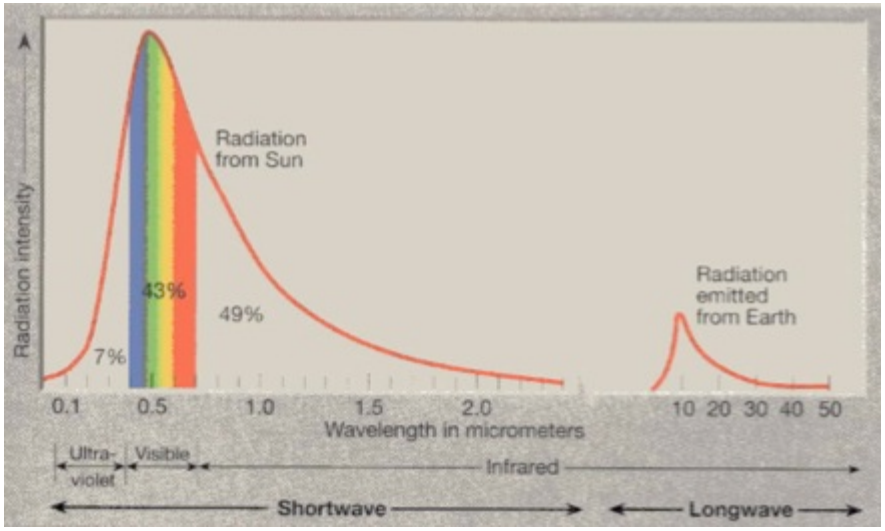


Tyndall (1861) mesure l'absorption du rayonnement par les gaz

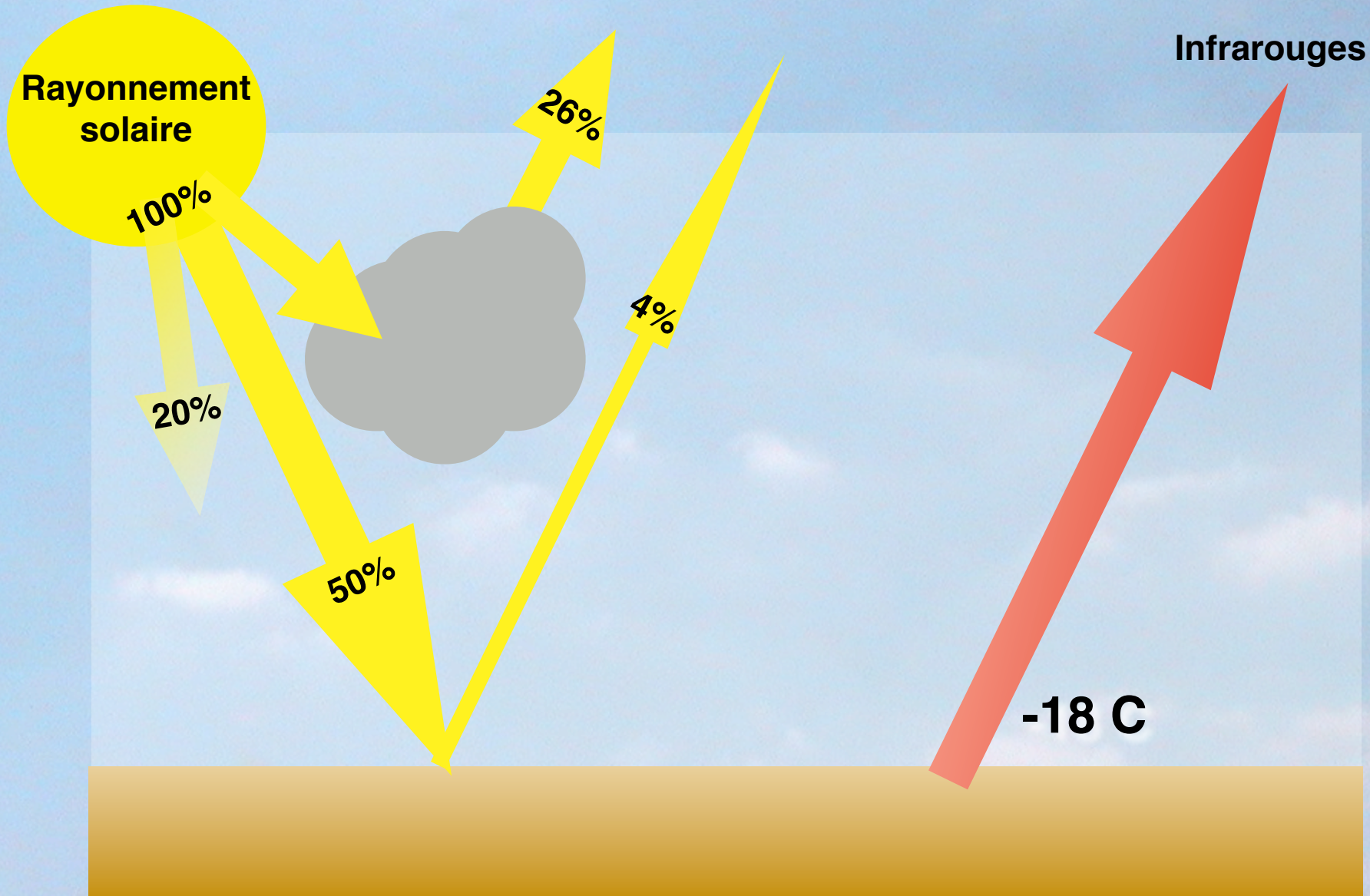
Spectre du rayonnement électromagnétique



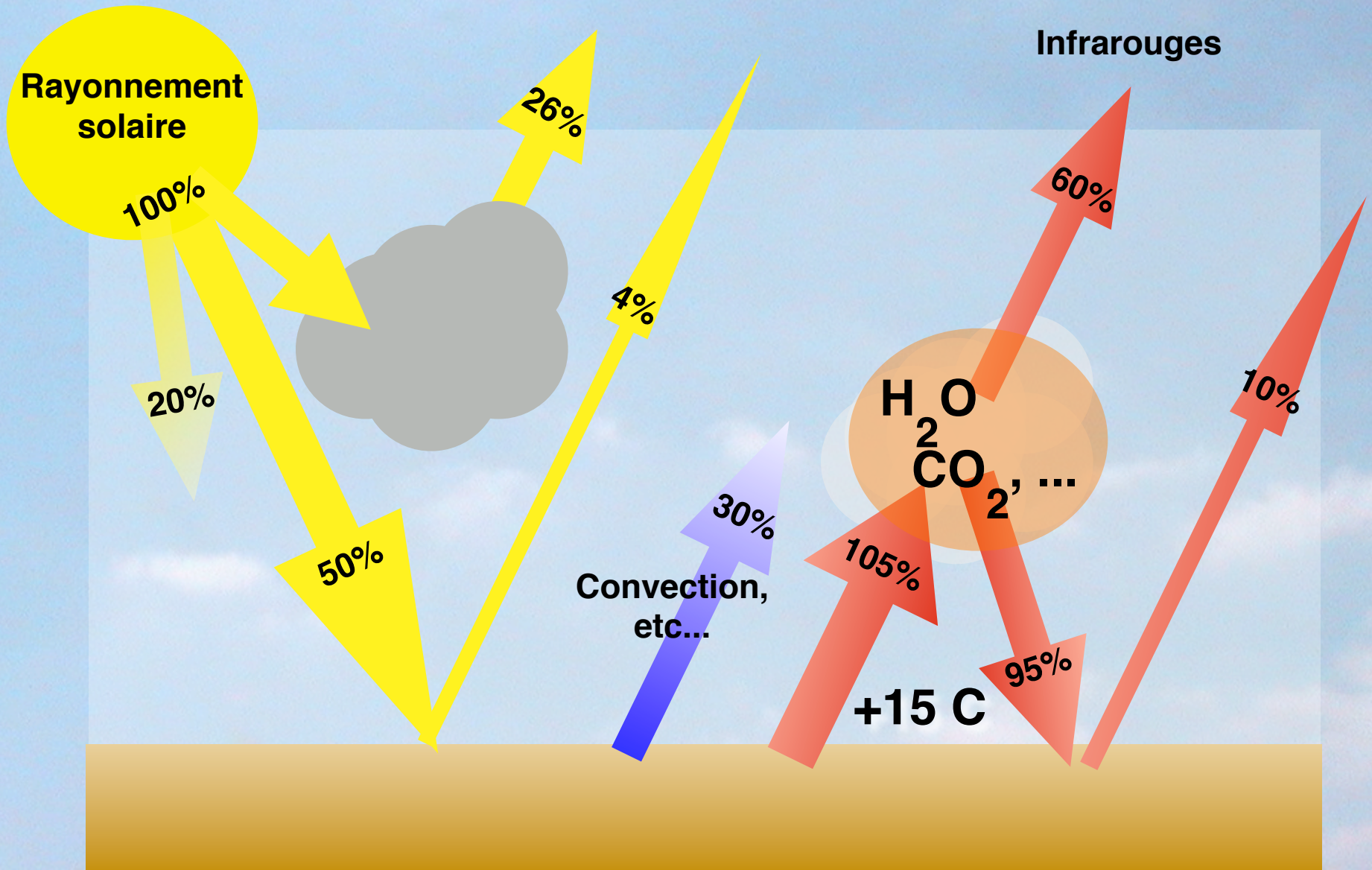
Spectres des rayonnements solaire et terrestre

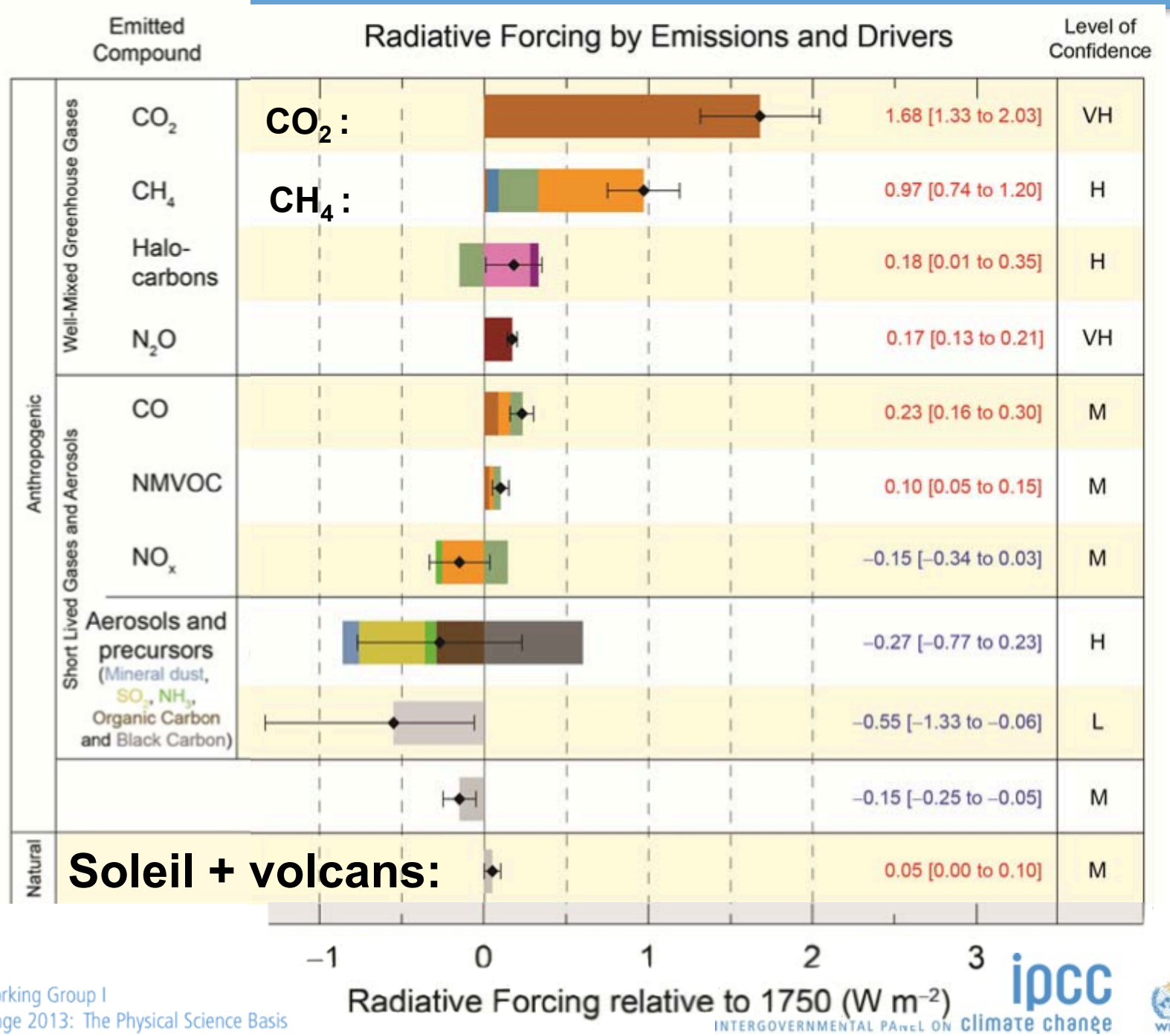


Cycle de l’énergie et effet de serre

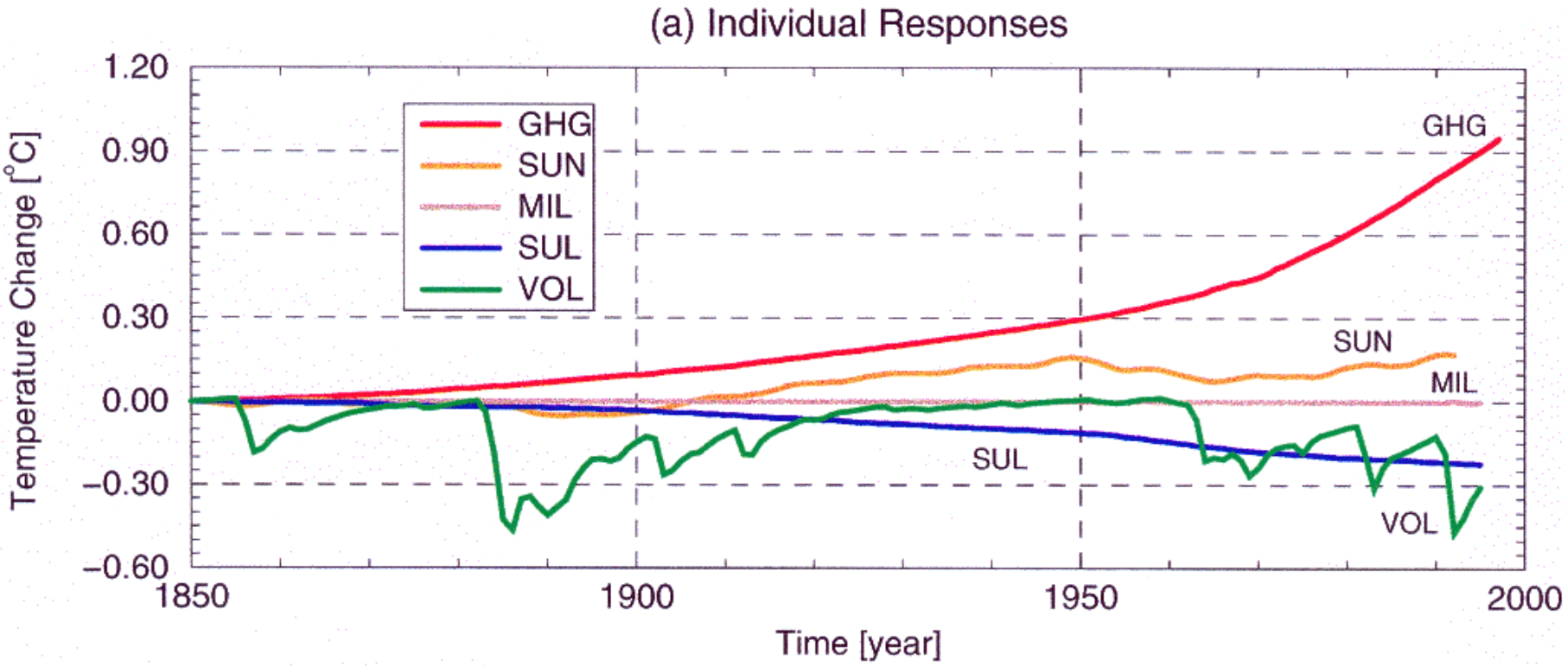


Cycle de l'énergie et effet de serre



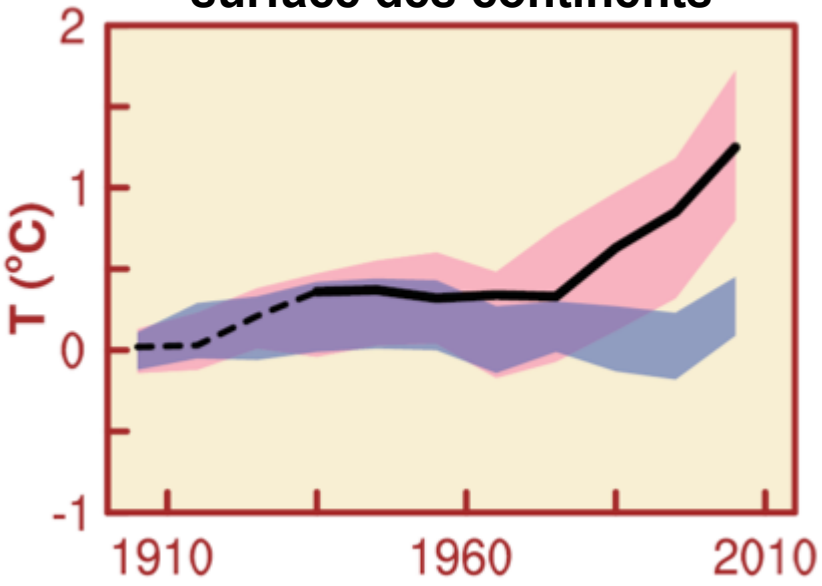

Emitted Compound
Radiative Forcing by Emissions and Drivers
Level of Confidence
Anthropogenic
Well-Mixed Greenhouse Gases
CO2
CH4
Halo-carbons
N2O
Short Lived Gases and Aerosols
CO
NMVOC
NOx
Aerosols and precursors (Mineral dust, SO2, NH3, Organic Carbon and Black Carbon)
Natural
CO2 :
CH4 :
Soleil + volcans:
1.68 [1.33 to 2.03]
VH
0.97 [0.74 to 1.20]
H
0.18 [0.01 to 0.35]
H
0.17 [0.13 to 0.21]
VH
0.23 [0.16 to 0.30]
M
0.10 [0.05 to 0.15]
M
–0.15 [–0.34 to 0.03]
M
–0.27 [–0.77 to 0.23]
H
–0.55 [–1.33 to –0.06]
L
–0.15 [–0.25 to –0.05]
M
0.05 [0.00 to 0.10]
M
–1
0
1
2
3
Radiative Forcing relative to 1750 (W m–2)

Effet des différents facteurs sur le modèle 2D de LLN

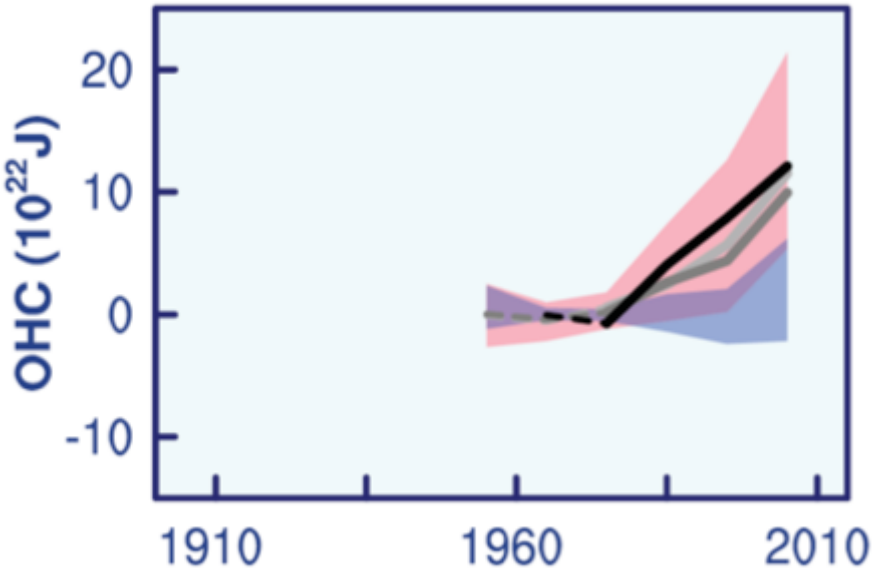


Bertrand et al. 2001

Température moyenne surface des continents



Contenu thermique des océans



(IPCC 2013, Fig. SPM.6)

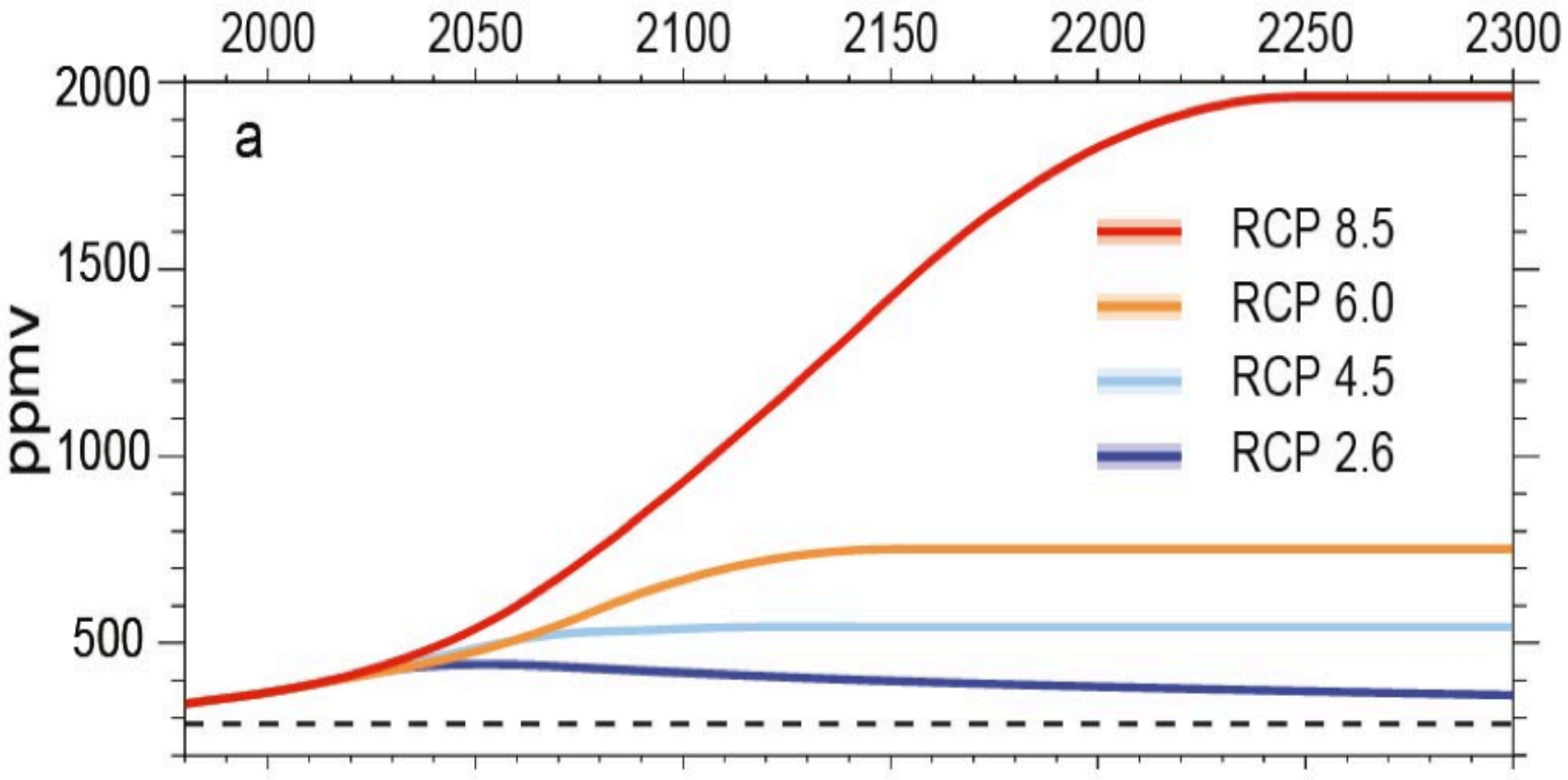
Noir: observations

Bleu: simulations avec seuls facteurs naturels

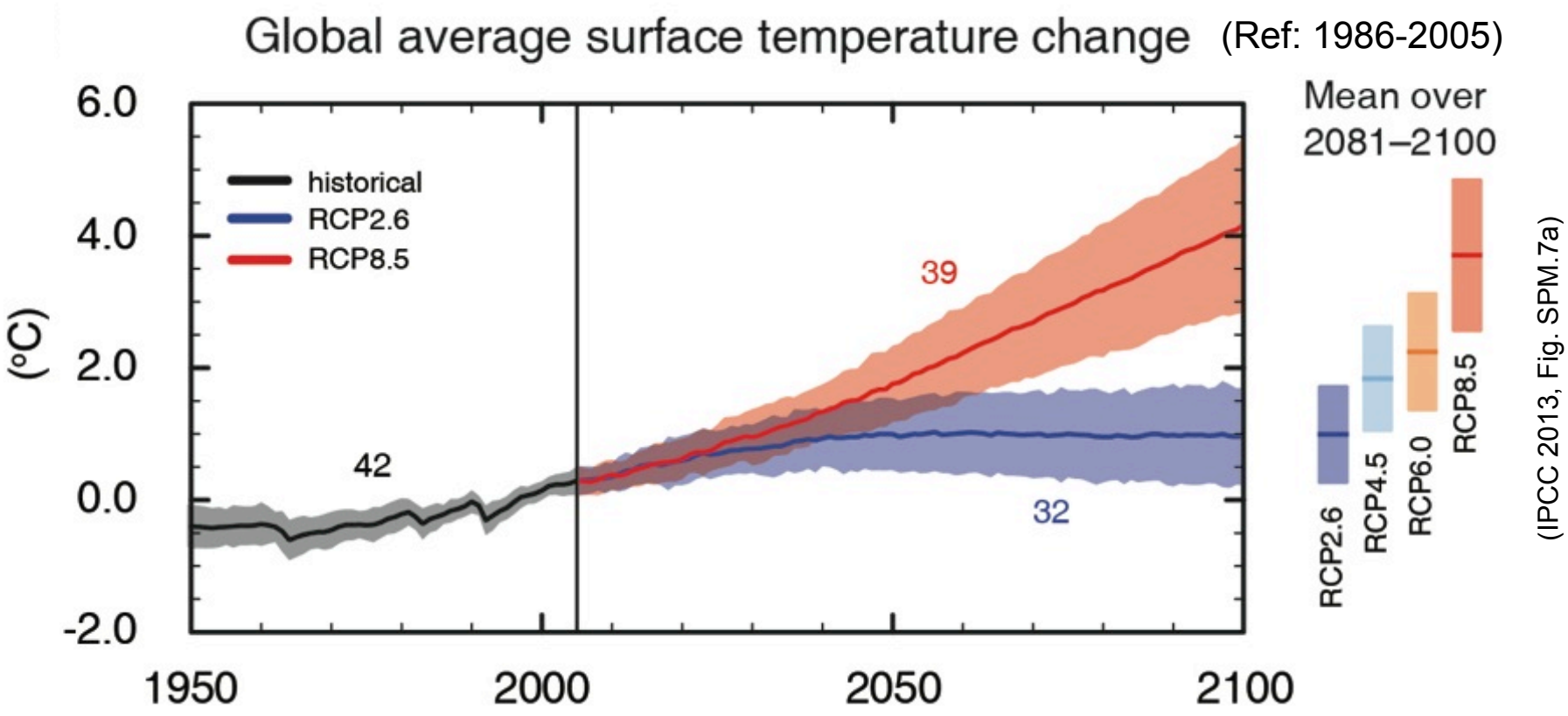
Rose: simulations avec facteurs naturels & humains

L'influence humaine sur le système climatique est sans équivoque; Il est *extrêmement probable* (95%) que l'influence humaine a été la cause principale du réchauffement depuis le milieu du 20ème siècle

Atmospheric CO_2 concentration



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



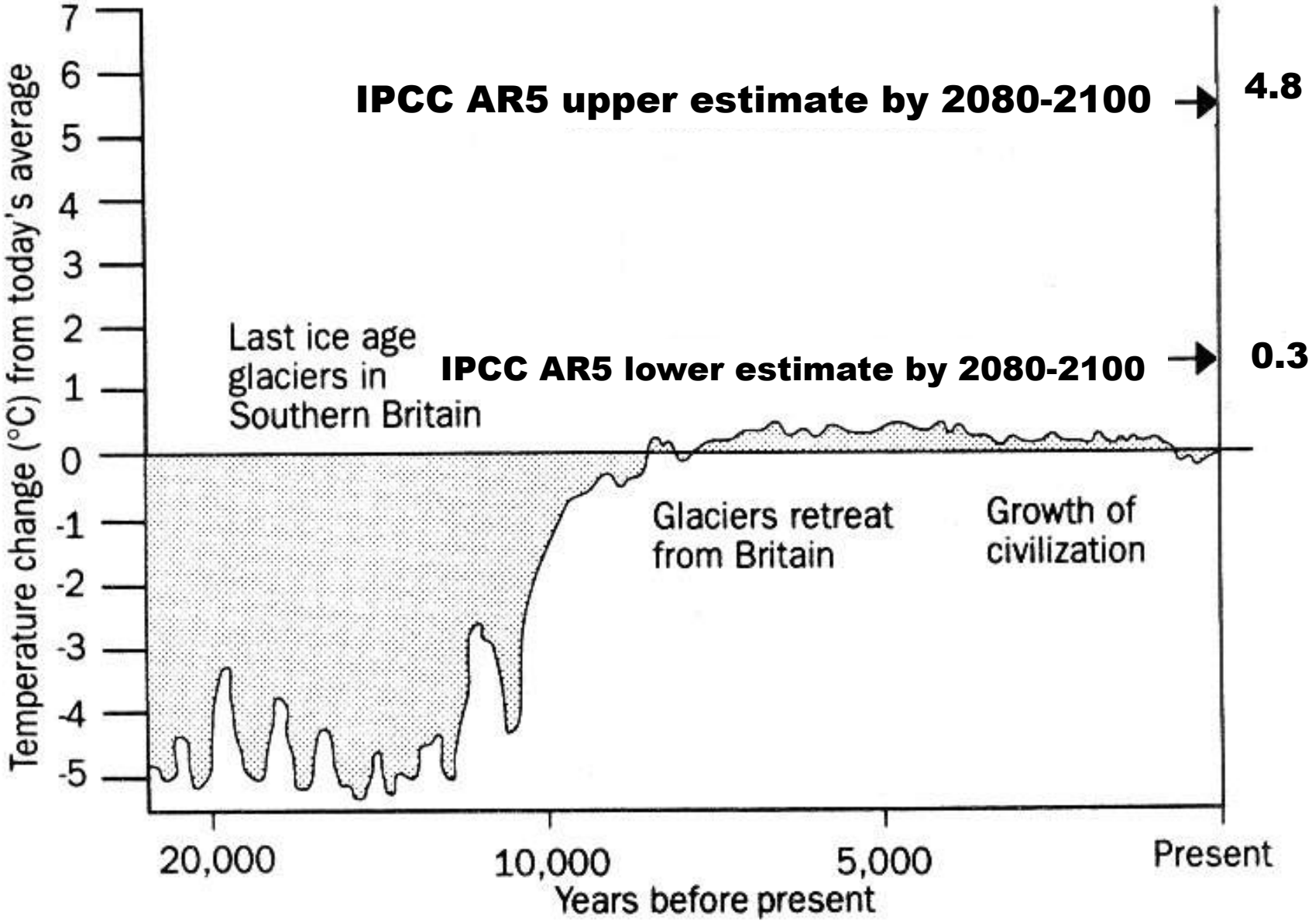
Le changement de la température moyenne du globe en surface pour la fin du XXI^e^ siècle dépassera *probablement* 1,5°C relativement à 1850-1900 pour tous les scénarios sauf pour le RCP2.6.
Dépassement *probable* de 2°C pour RCP6 et RCP8.5

Global mean surface temperature change projections

Increase from end of 20th century to end of 21st century

	mean	likely range
RCP2.6	1.0	0.3 to 1.7
RCP4.5	1.8	1.1 to 2.6
RCP6	2.2	1.4 to 3.1
RCP8.5	3.7	2.6 to 4.8

(°C)



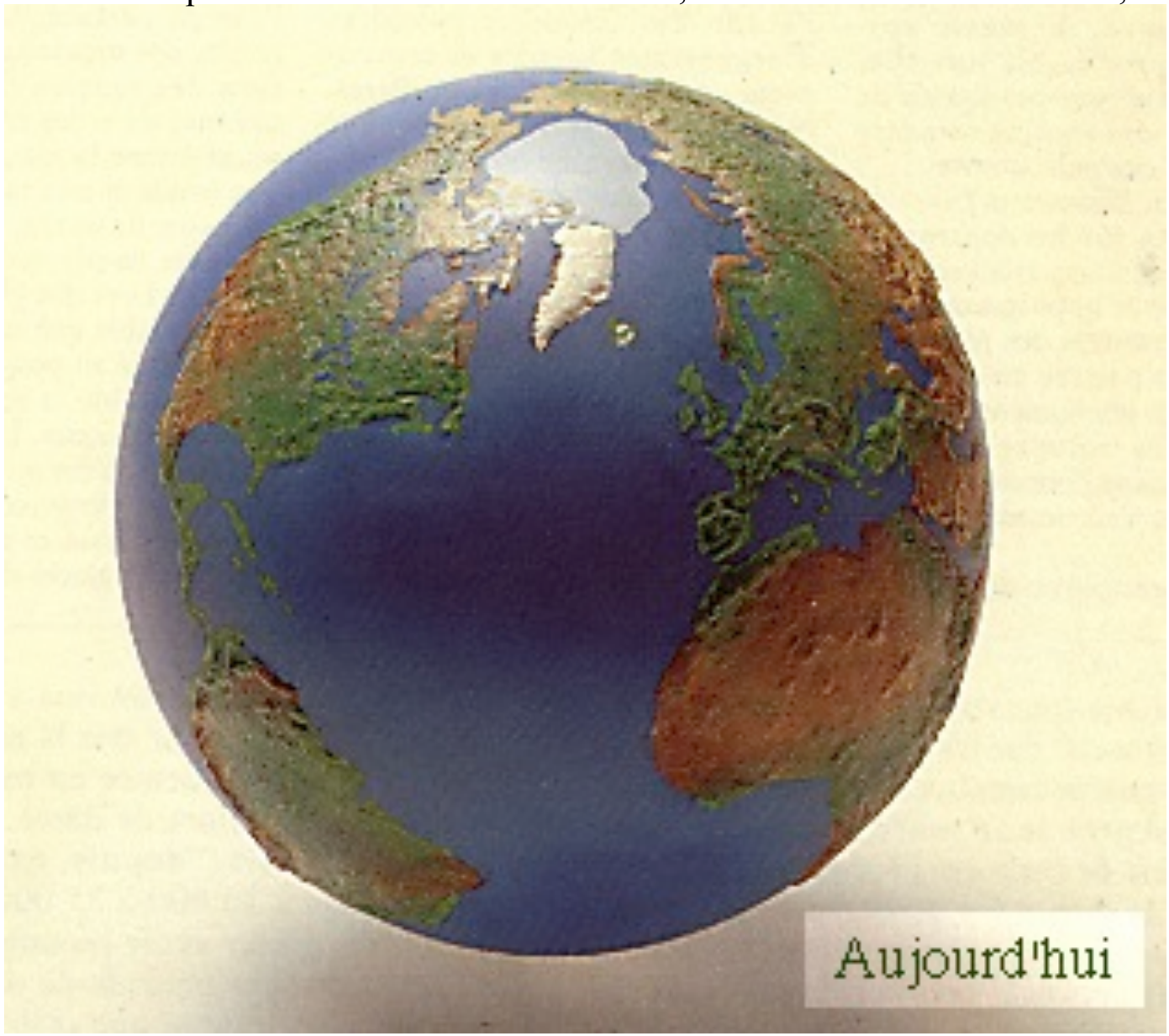
Adapted from: International Geosphere Biosphere Programme Report no.6, Global Changes of the Past, July1988

18-20000 years ago (Last Glacial Maximum)

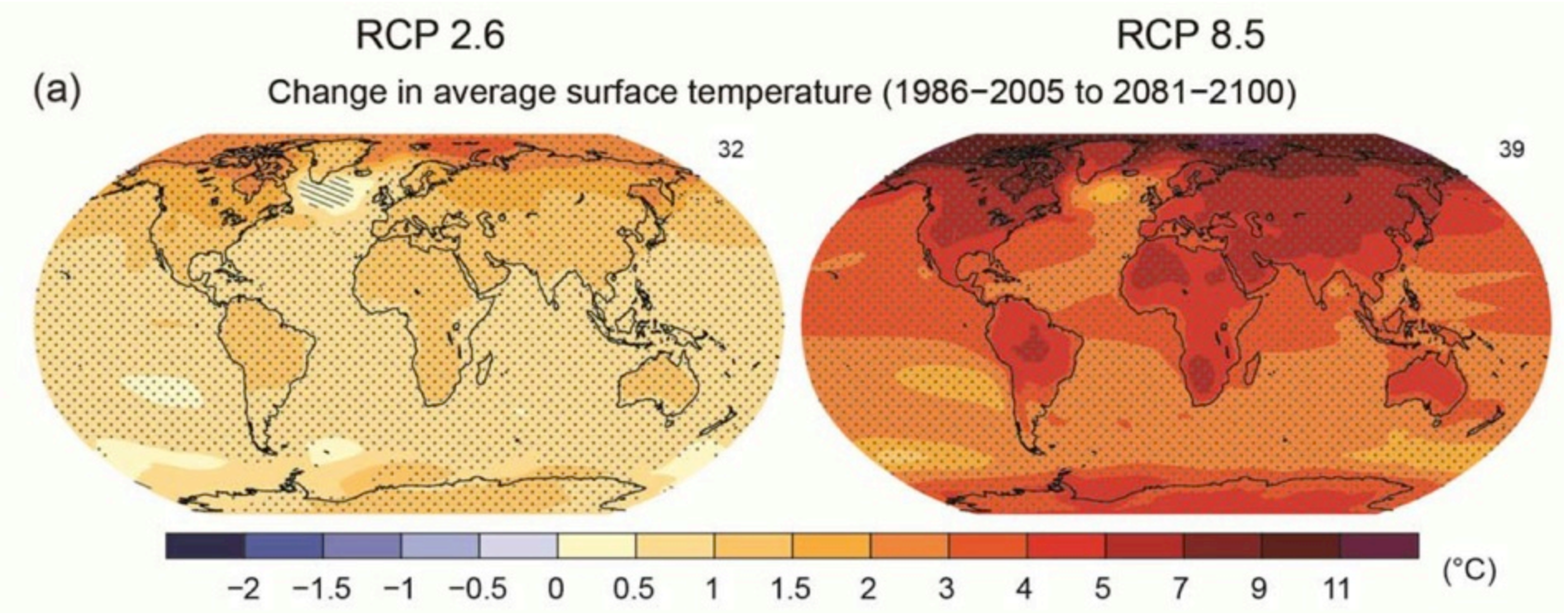
With permission from Dr. S. Joussaume, in « Climat d'hier à demain », CNRS éditions.

Today, with +4-5°C globally

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



Surface temperature projections



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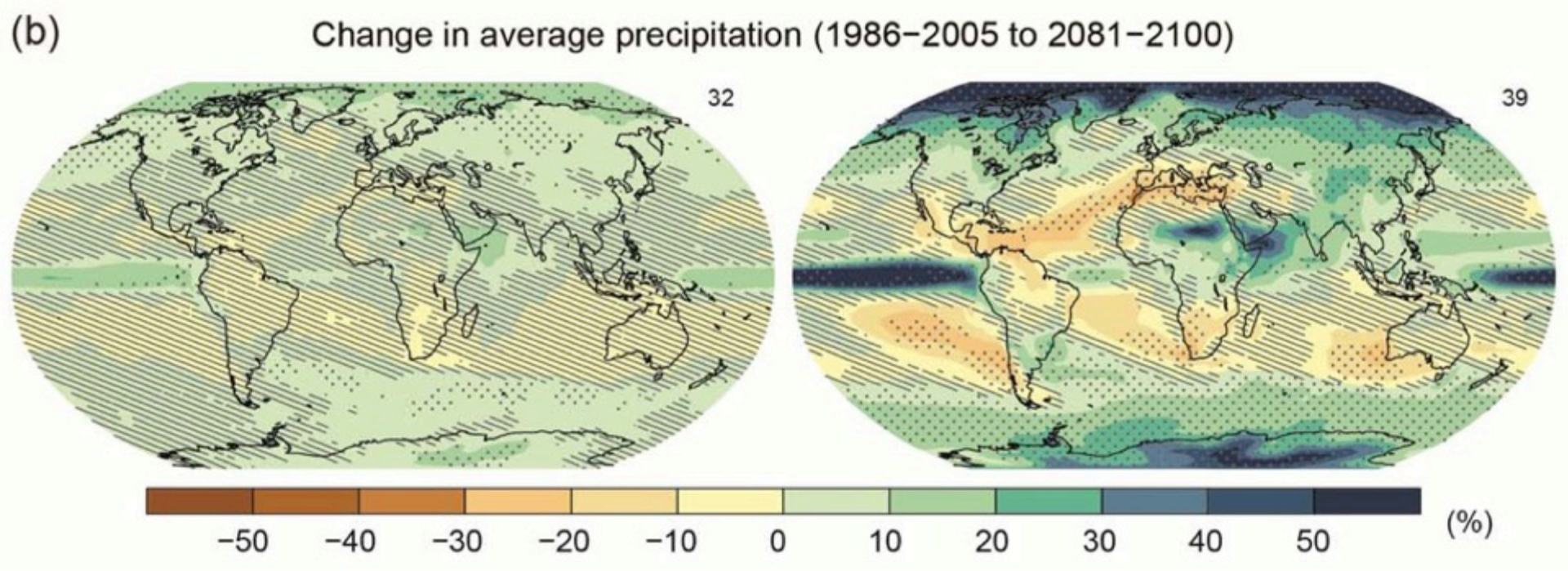
Precipitation projections



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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

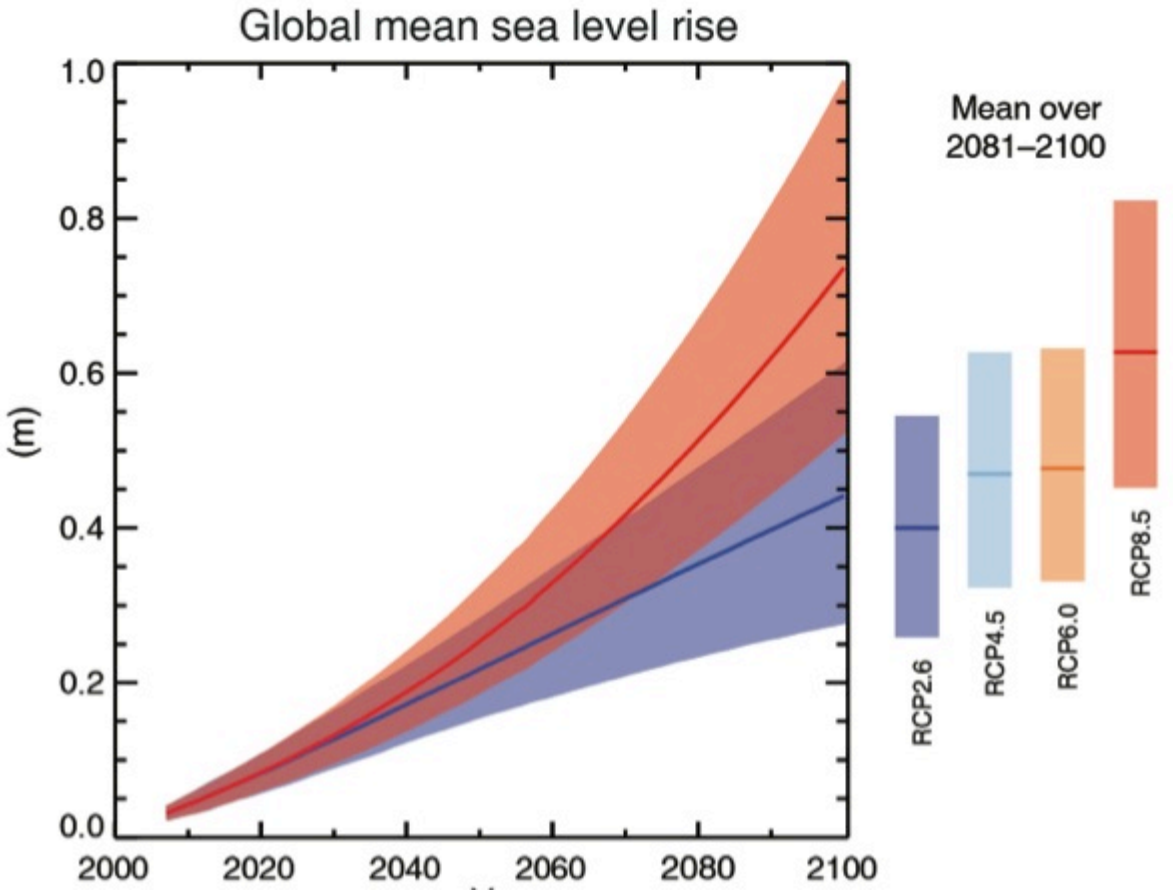


Fig. SPM.9

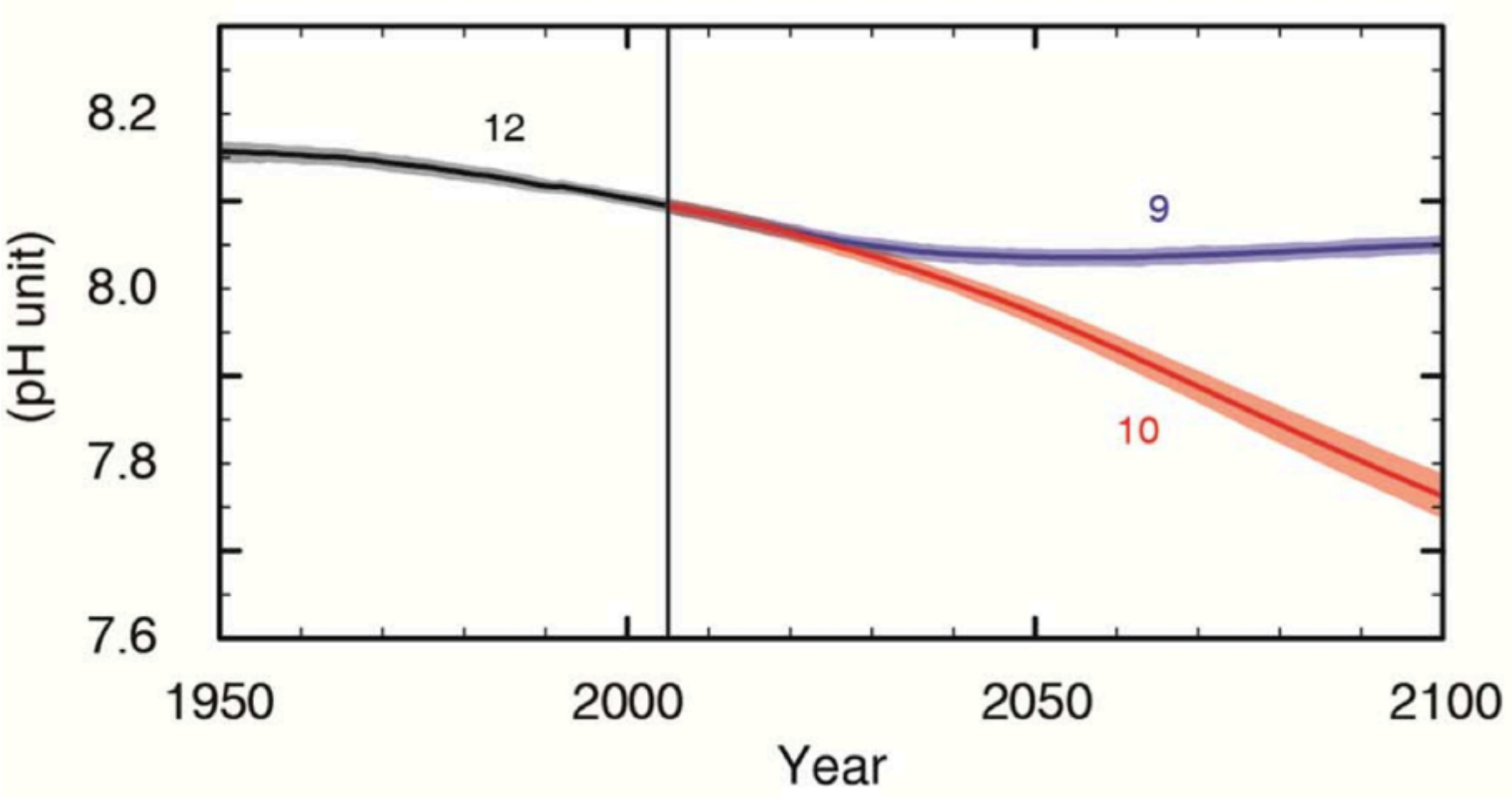
RCP2.6 (2081-2100), *likely* range: **26 to 55 cm**

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

(Reference level: 1986-2005)

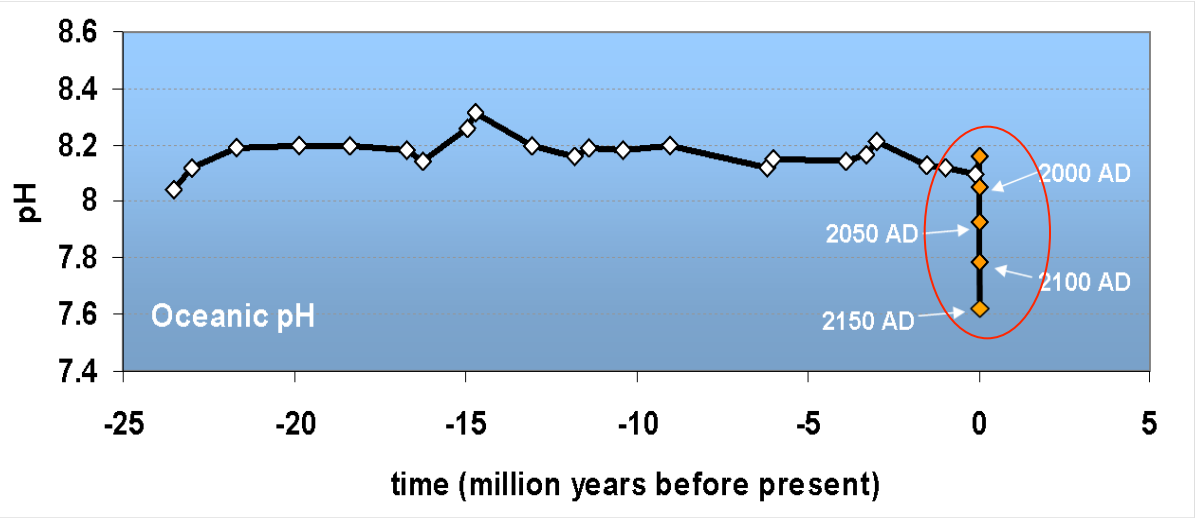
Global ocean surface pH (projections)

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

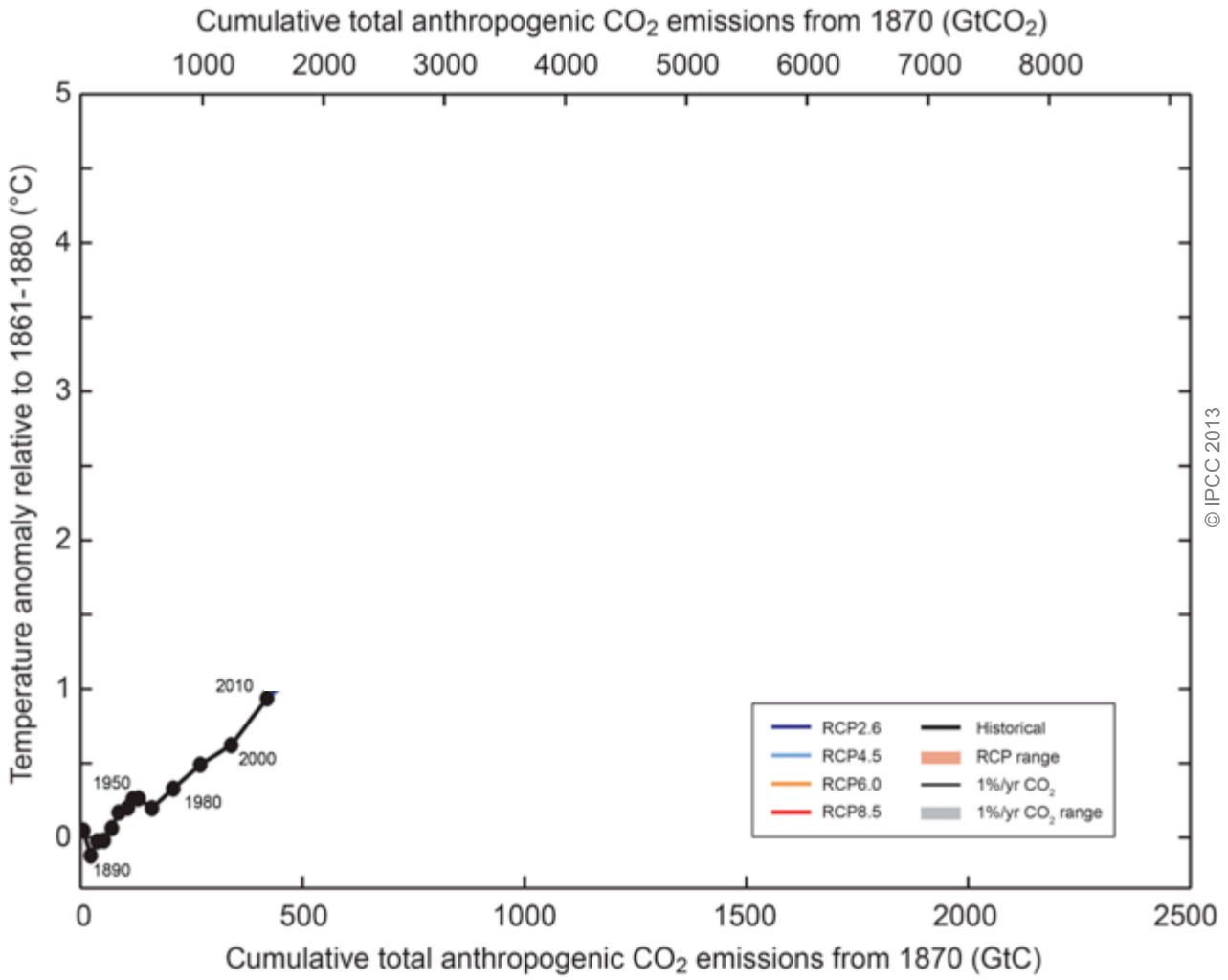


Fig. SPM.10

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

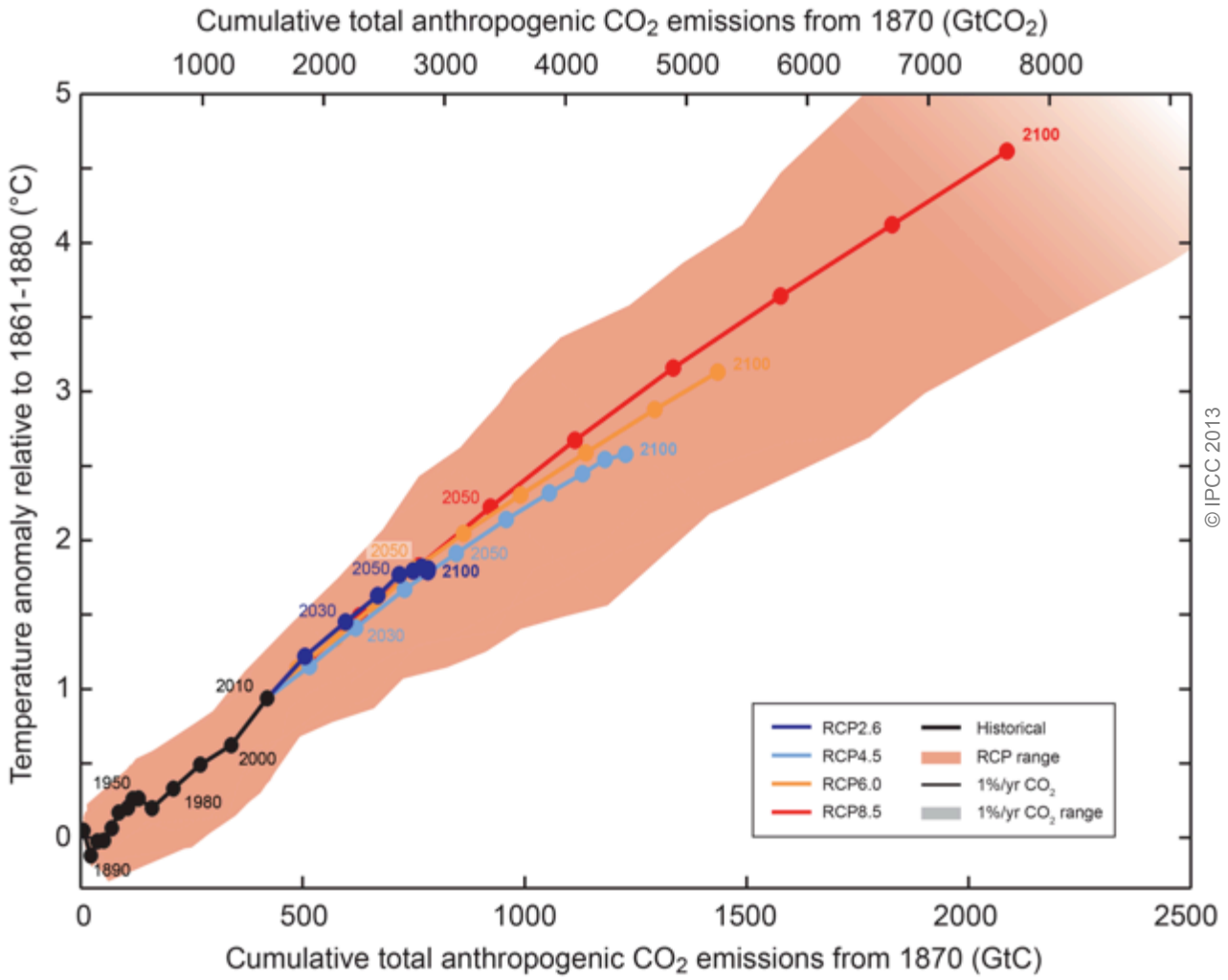
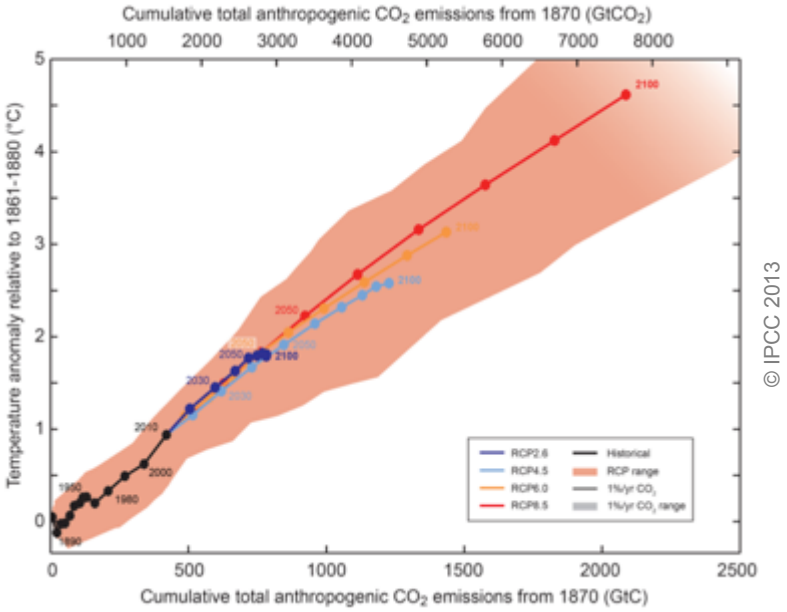


Fig. SPM.10

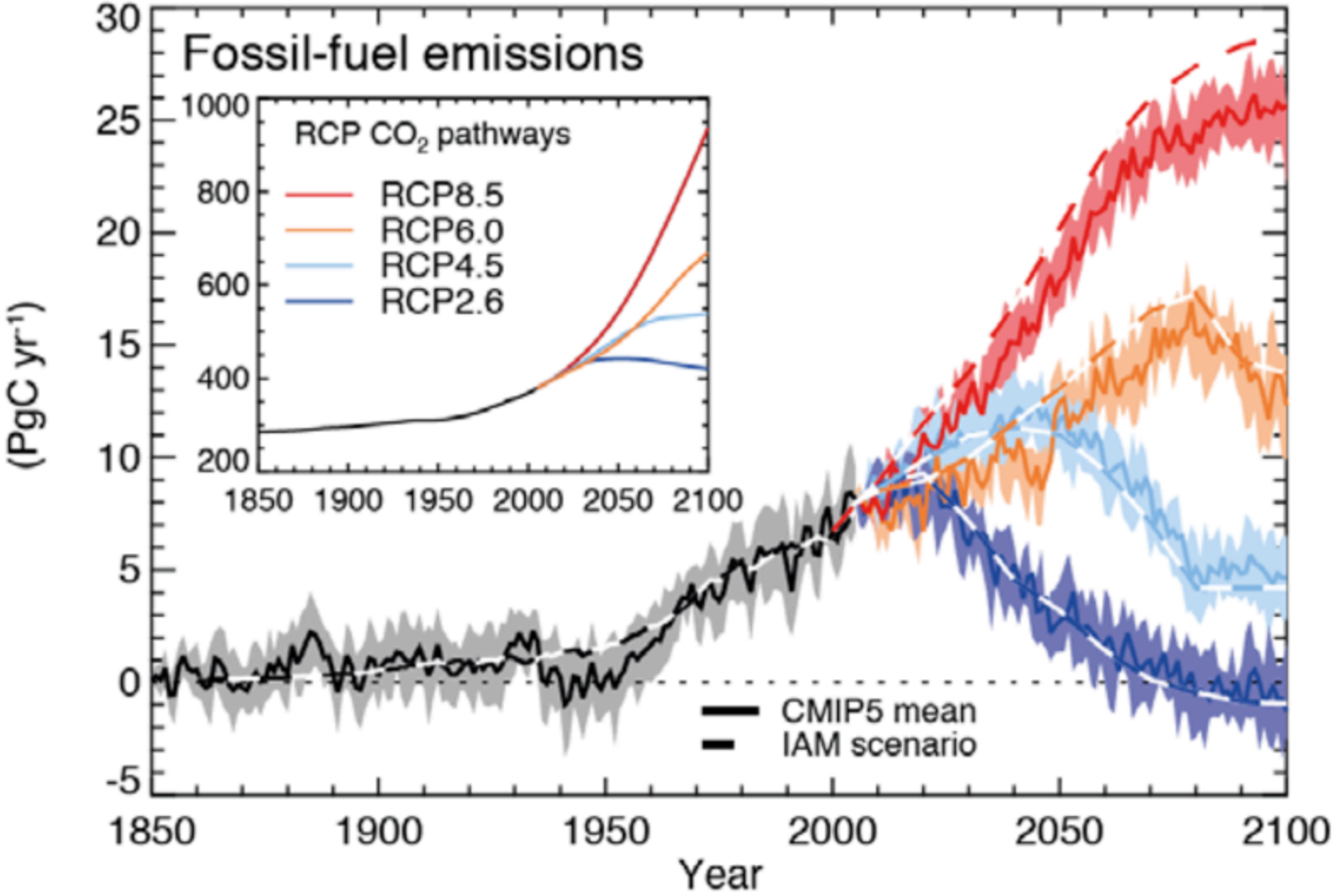
Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.



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.

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



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

RCP2.6 RCP8.5

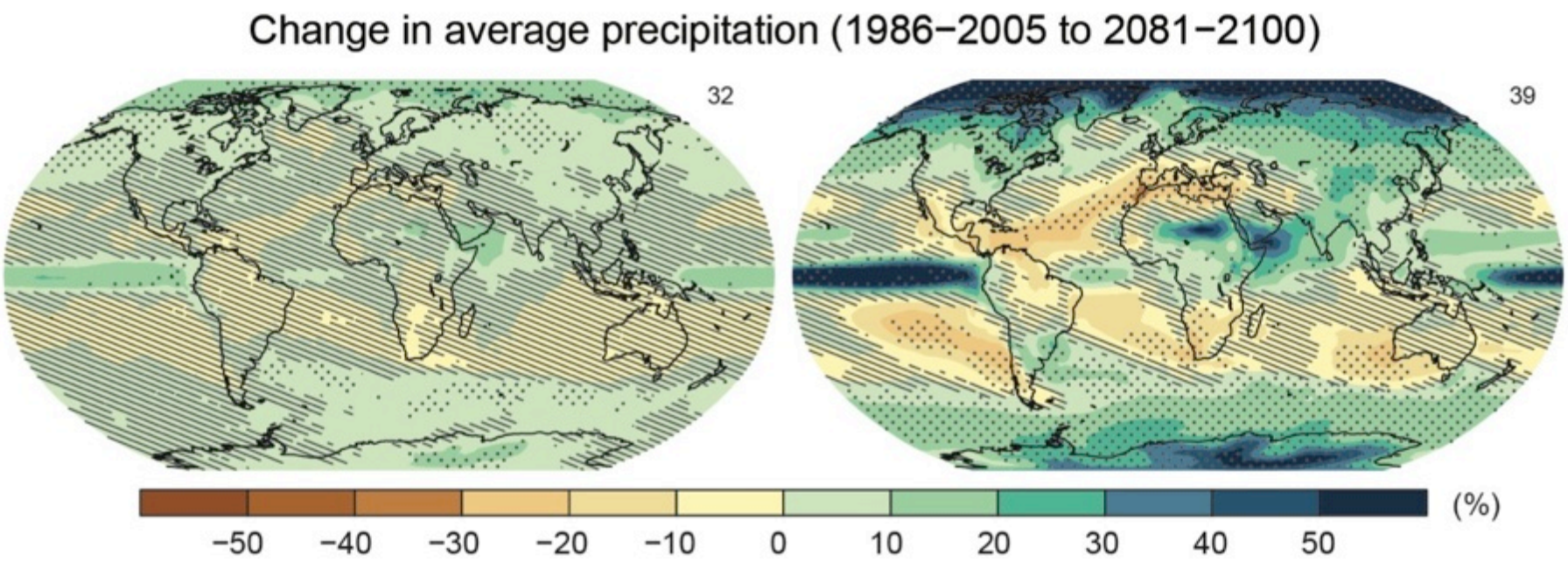
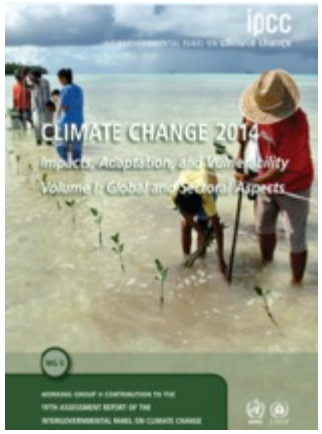


Fig. SPM.8

We have a choice.



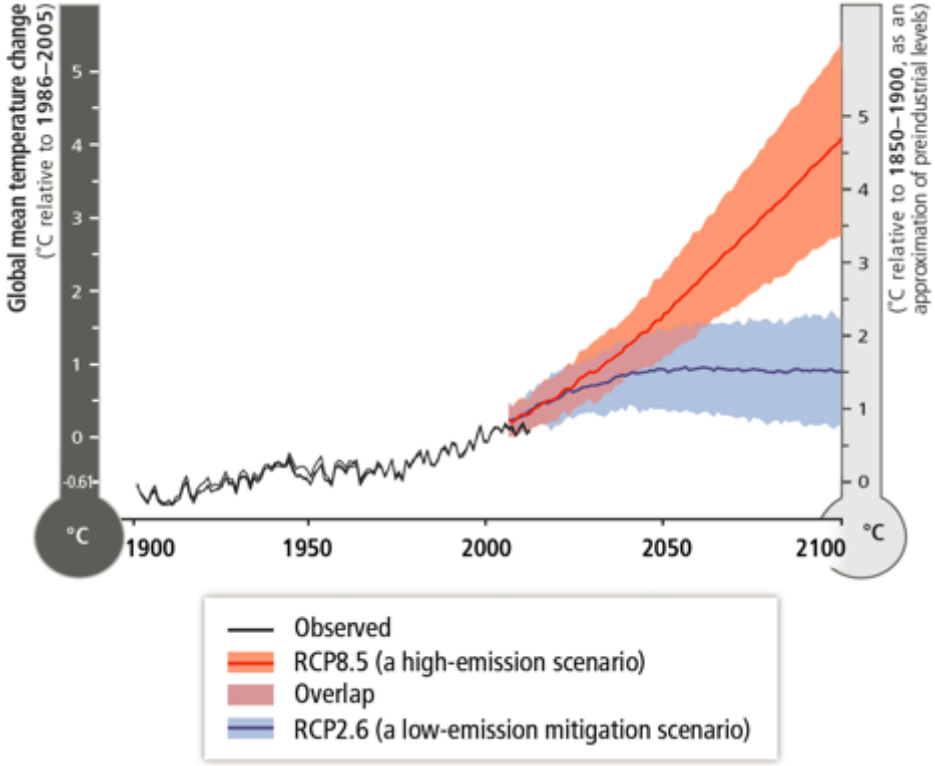
What are the risks?

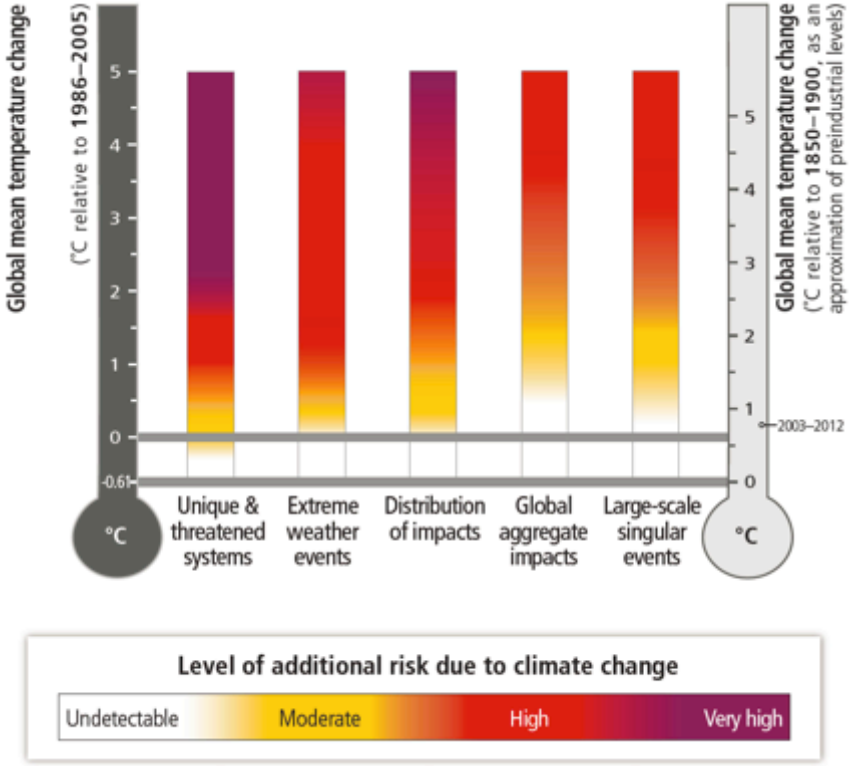
Effects on Nile delta: 10 M people above 1m

(Time 2001)

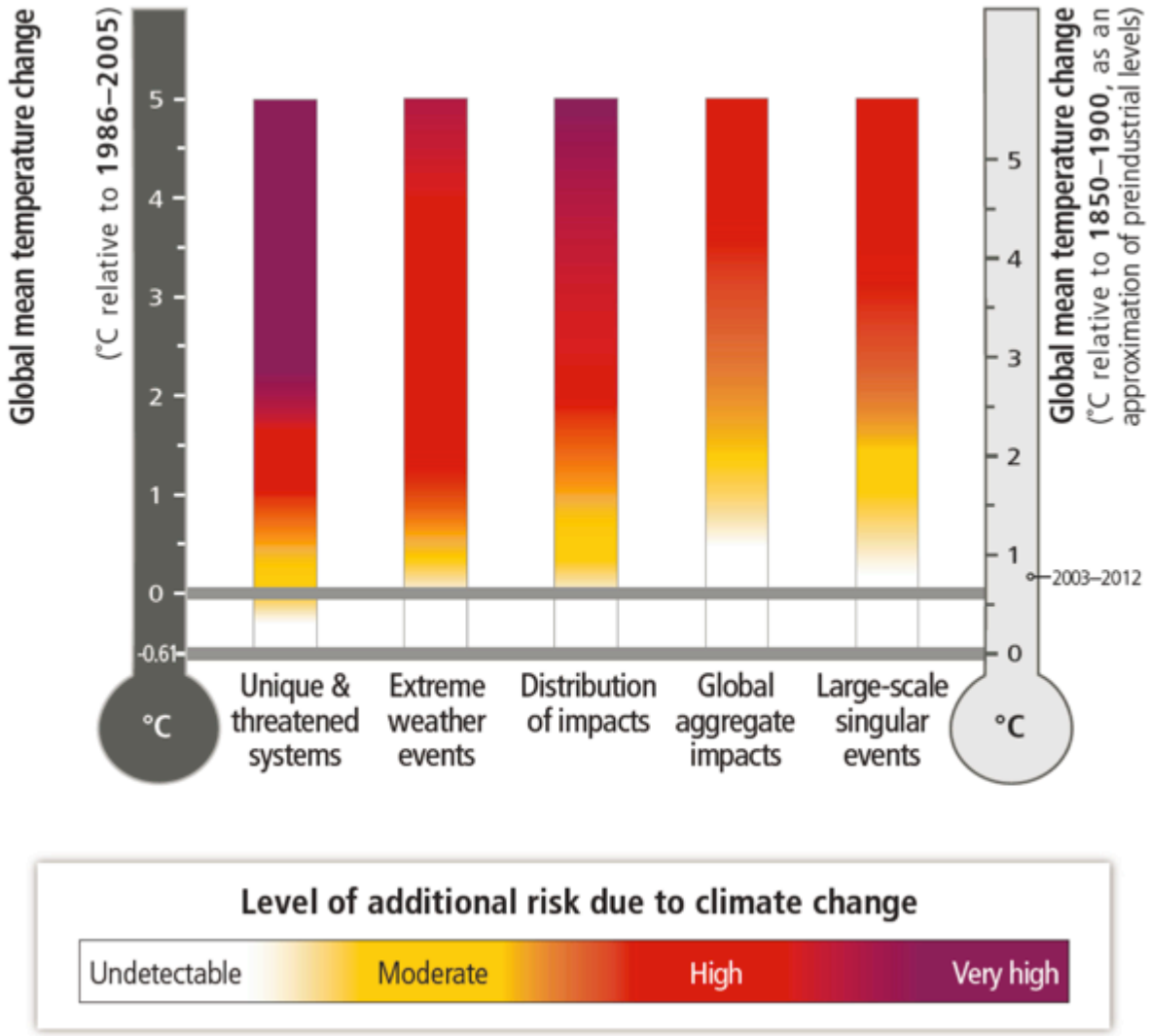
Risk = Hazard x Vulnerability x Exposure (Katrina flood victim)

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



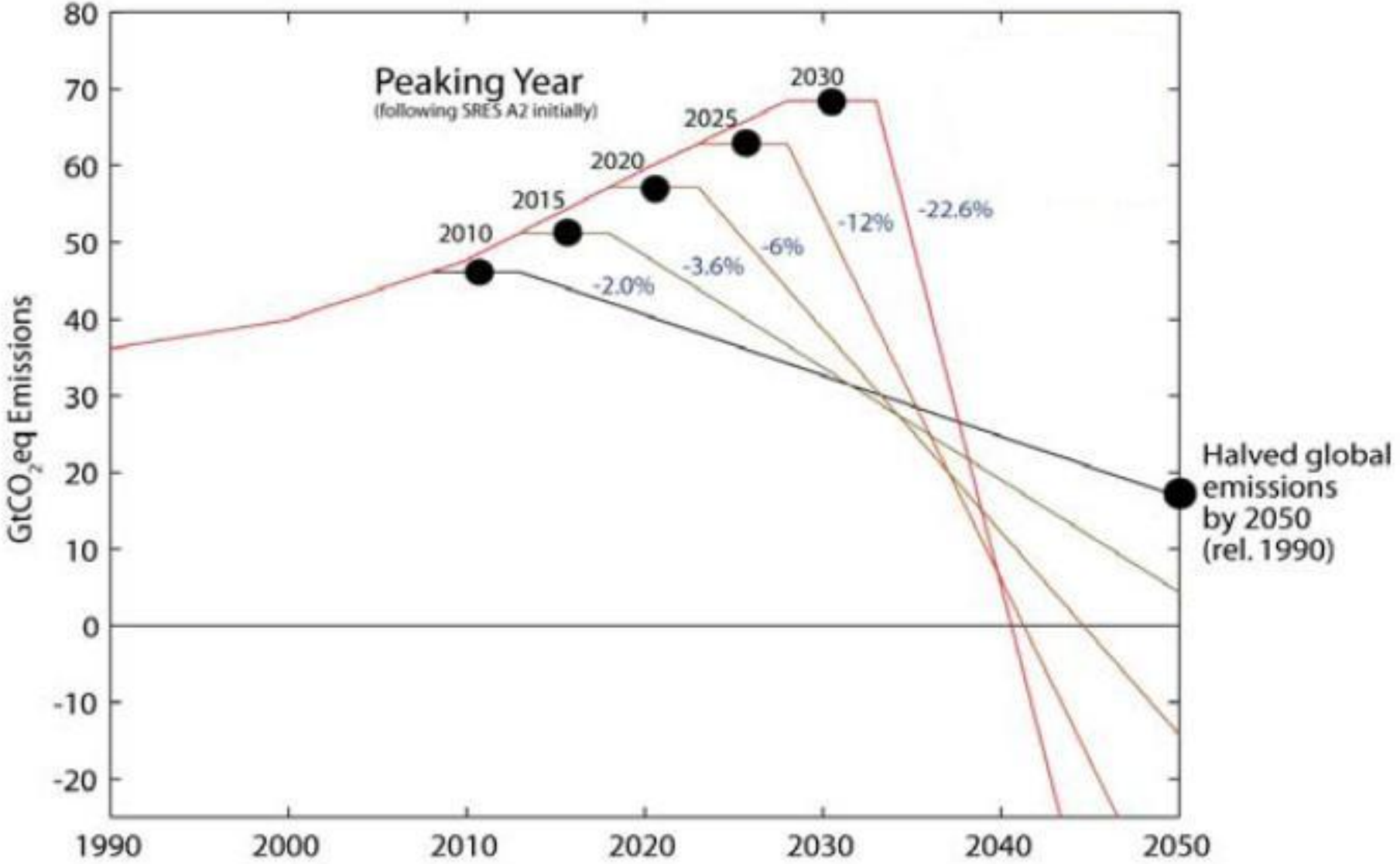


ipcc
INTERGOVERNMENTAL PANEL ON climate change



AR5, WGII, Box SPM.1 Figure 1

The more we wait, the more difficult it will be



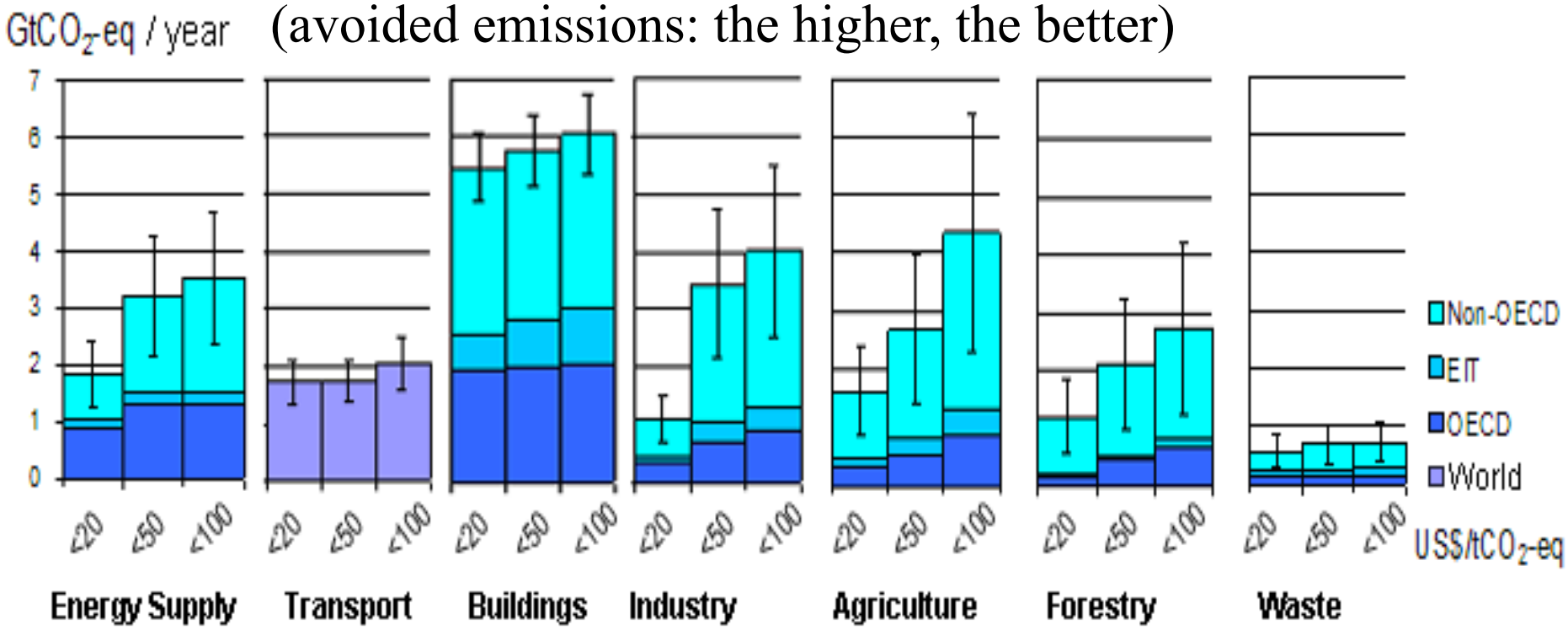
Source: Meinshausen et al. - Nature, 30th April 2009

What can be done?

ipcc
INTERGOVERNMENTAL PANEL ON climate change

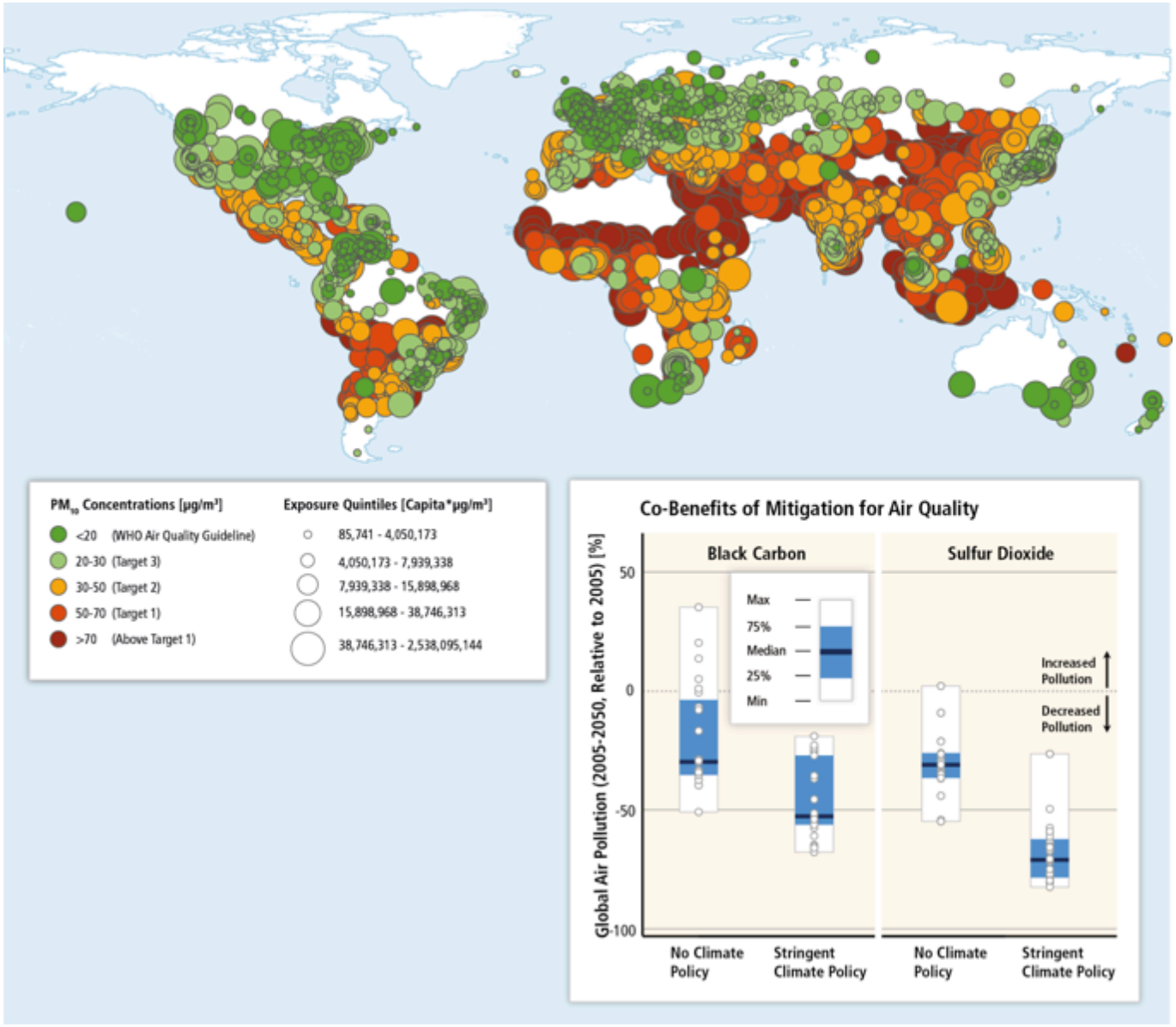
WMO UNEP

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.

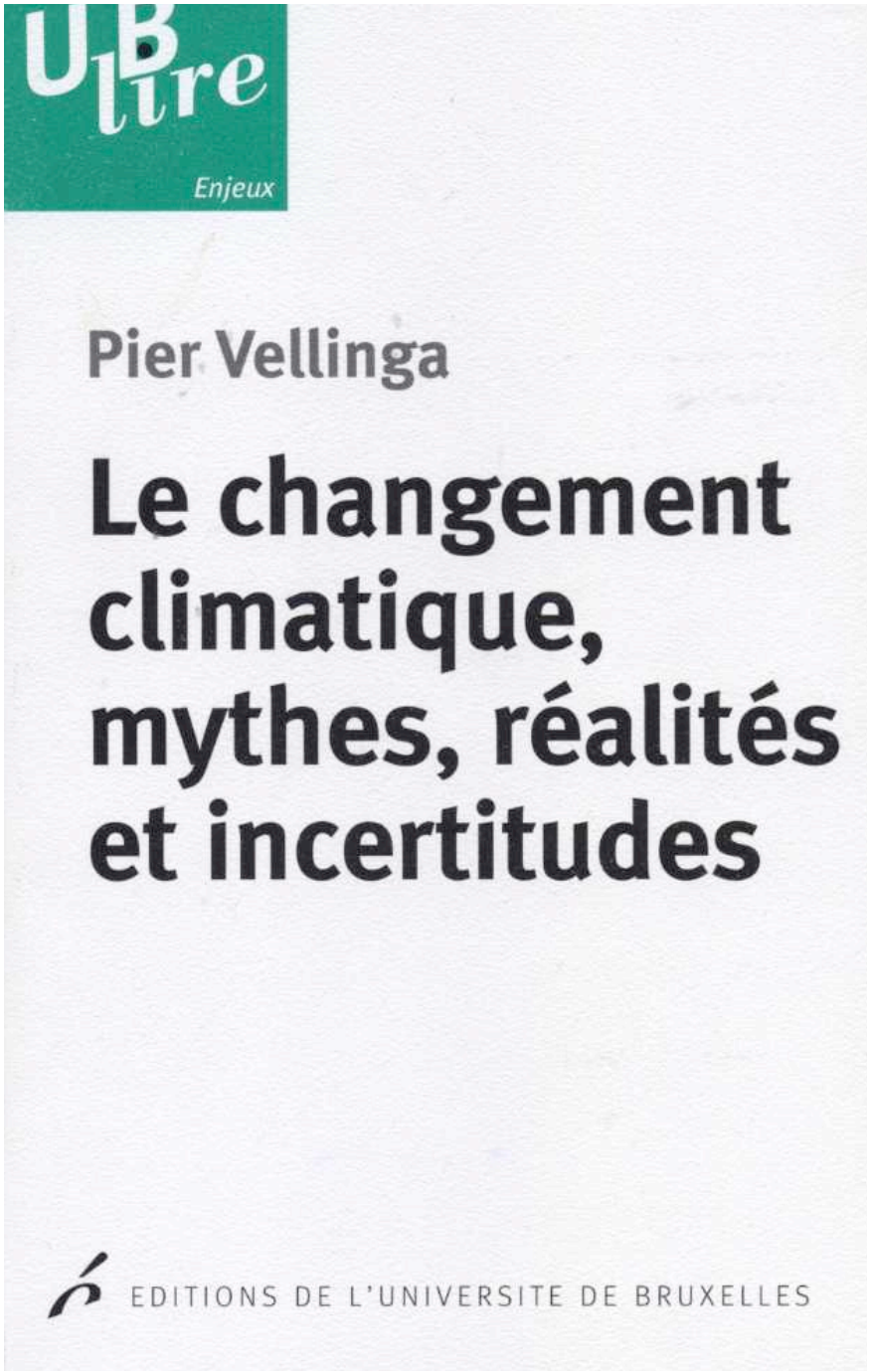


Mitigation can result in large co-benefits for human health and other societal goals.

Pour en savoir plus :

- www.ipcc.ch : GIEC ou IPCC
- www.climatechange2013.org : GIEC WGI
- www.climate.be/vanyp : beaucoup de mes dias et d'autres documents
- www.climate.be/pendules : ressources faciles d'accès pour « remettre les pendules à l'heure »
- www.climate.be/desintox : réponses à la désinformation

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



Pier Vellinga, 2013: Le changement climatique, mythes, réalités et incertitudes, Editions de l'université de Bruxelles, 8 €

IPCC WGI in video:

Can be found with the following Google keywords:

Working group I IPCC (9 minutes): youtube climate change 2013 IPCC

Direct link:
http://www.youtube.com/watch?v=6yiTZm0y1YA&feature=youtu.be

IGBP (4 minutes): youtube climate change 2013 IGBP

Direct link:
http://www.youtube.com/watch?v=_EWOrZQ3L-c