

Aspects scientifiques du changement climatique : A quoi devons-nous nous attendre ?

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Vice-président du GIEC de 2008 à 2015

Twitter: @JPvanYpersele

Journée EcoCir-AWAC sur "Le nouveau Plan Air-Climat-Energie : ce qui va changer ?»

Louvain-la-Neuve, le 25 mai 2016

Merci aux Services fédéraux (belges) de la Politique scientifique (BELSPO), au Gouvernement wallon et à mon équipe à l'Université catholique de Louvain pour leur soutien

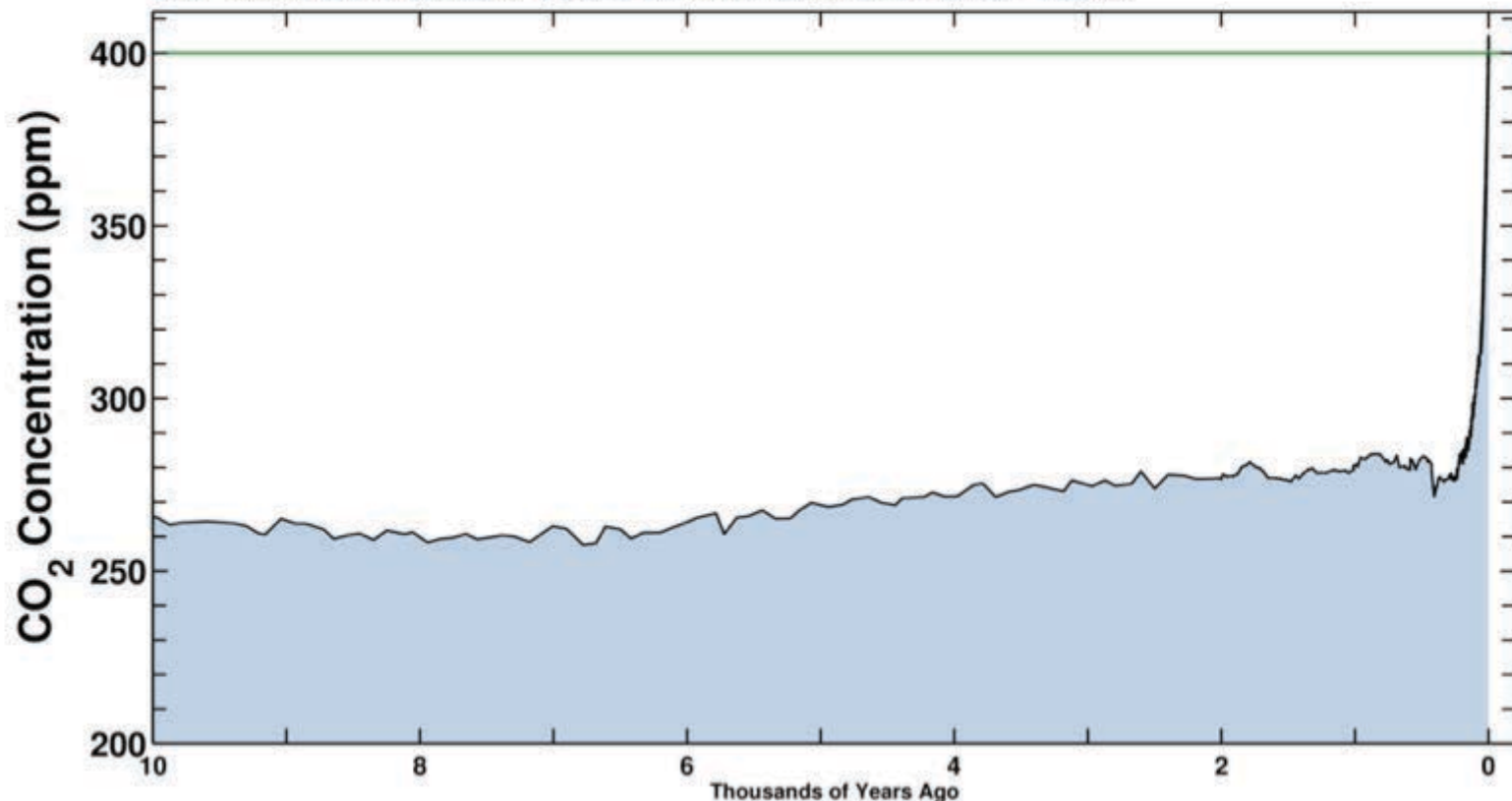
Concentration en CO₂, le 21 mai 2016 (Courbe de Keeling)

Latest CO₂ reading

May 21, 2016

407.12 ppm

Ice-core data before 1958. Mauna Loa data after 1958.



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

Global Temperature Anomalies video (1880-2015)

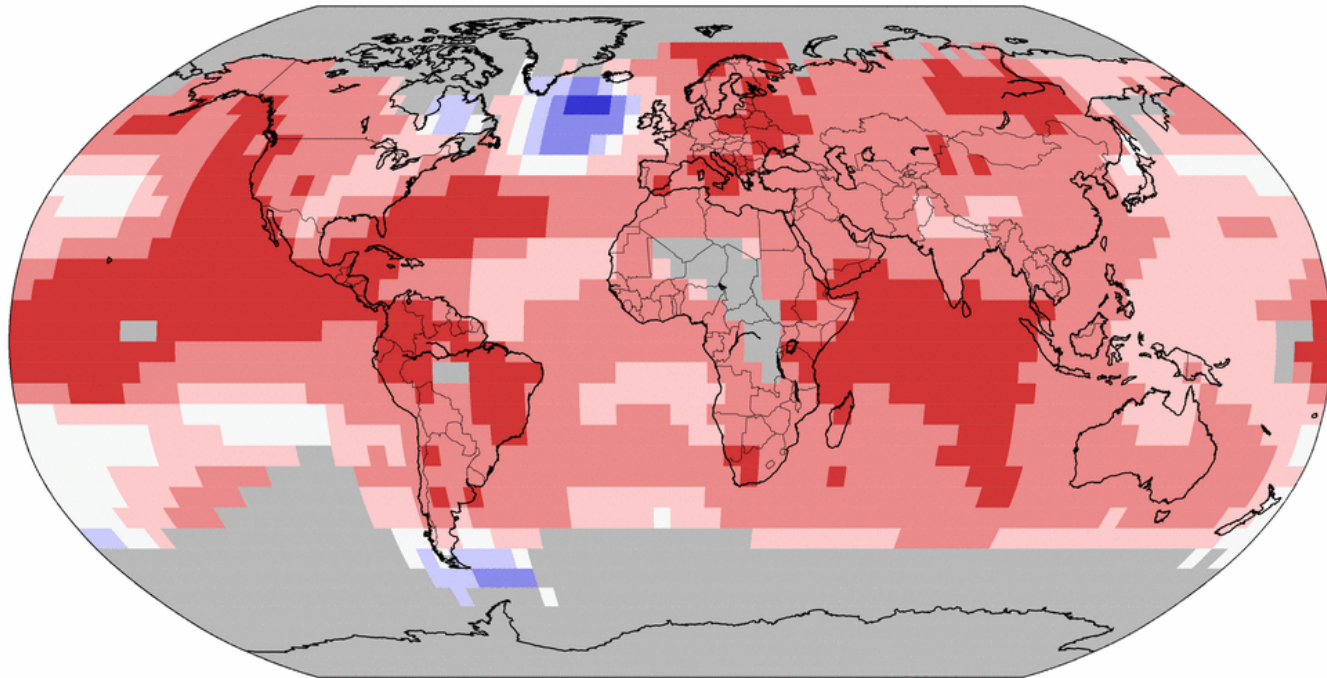
- https://youtu.be/SWPzGo_C010 (30 s)
- From Nasa Climate Change
- This color-coded map in Robinson projection displays a progression of changing global surface temperature anomalies from 1880 through 2015. Higher than normal temperatures are shown in red and lower than normal temperatures are shown in blue. The final frame represents the global temperatures 5-year averaged from 2010 through 2015. Scale in degree Celsius.

2015= année la plus chaude depuis 1880

Land & Ocean Temperature Percentiles Jan–Dec 2015


NOAA's National Centers for Environmental Information

Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0




Record
Coldest


Much
Cooler than
Average


Cooler than
Average


Near
Average


Warmer than
Average


Much
Warmer than
Average


Record
Warmest



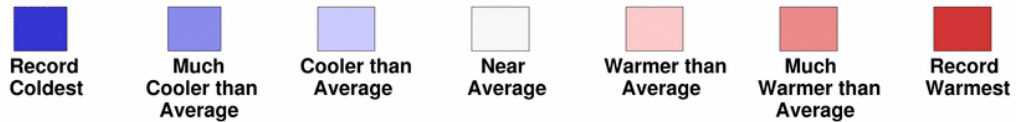
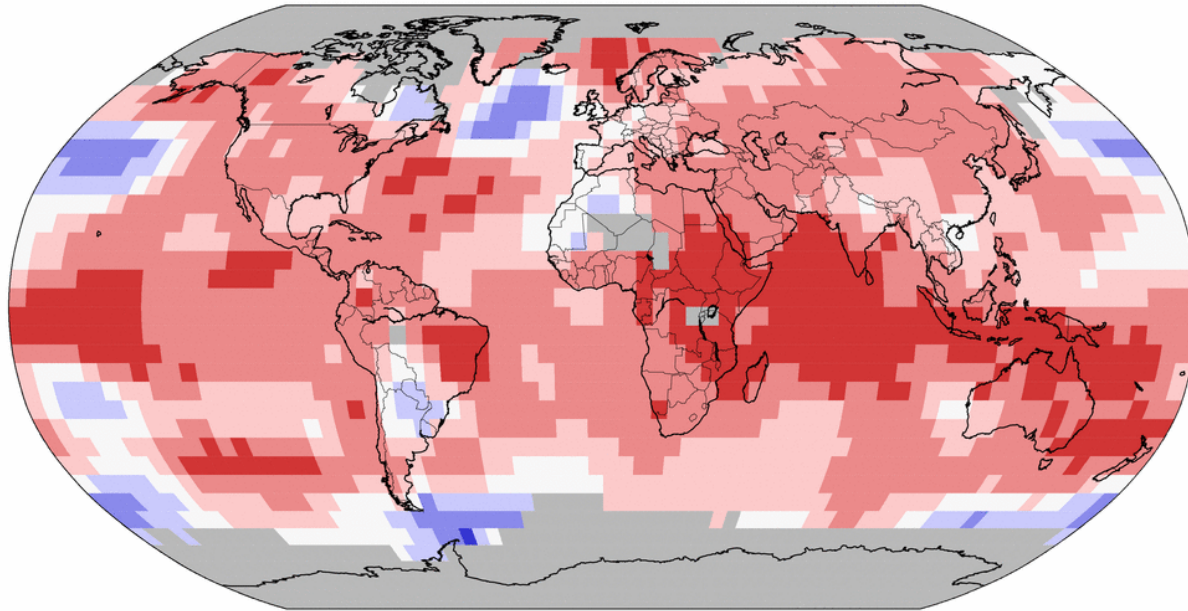
Wed Jan 13 12:15:02 EST 2016

Mars 2016: record battu

Land & Ocean Temperature Percentiles Mar 2016

NOAA's National Centers for Environmental Information

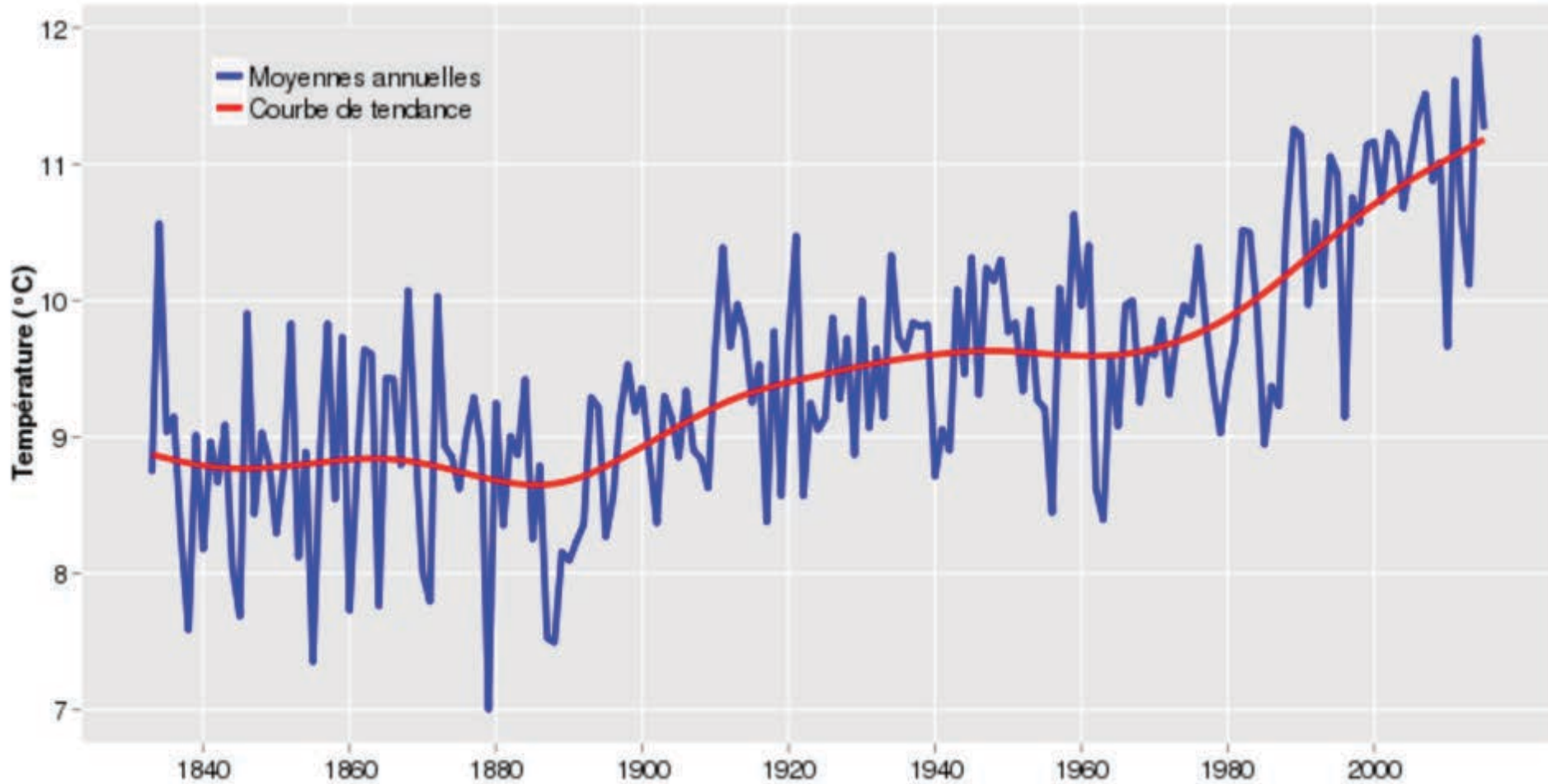
Data Source: GHCN-M version 3.3.0 & ERSST version 4.0.0



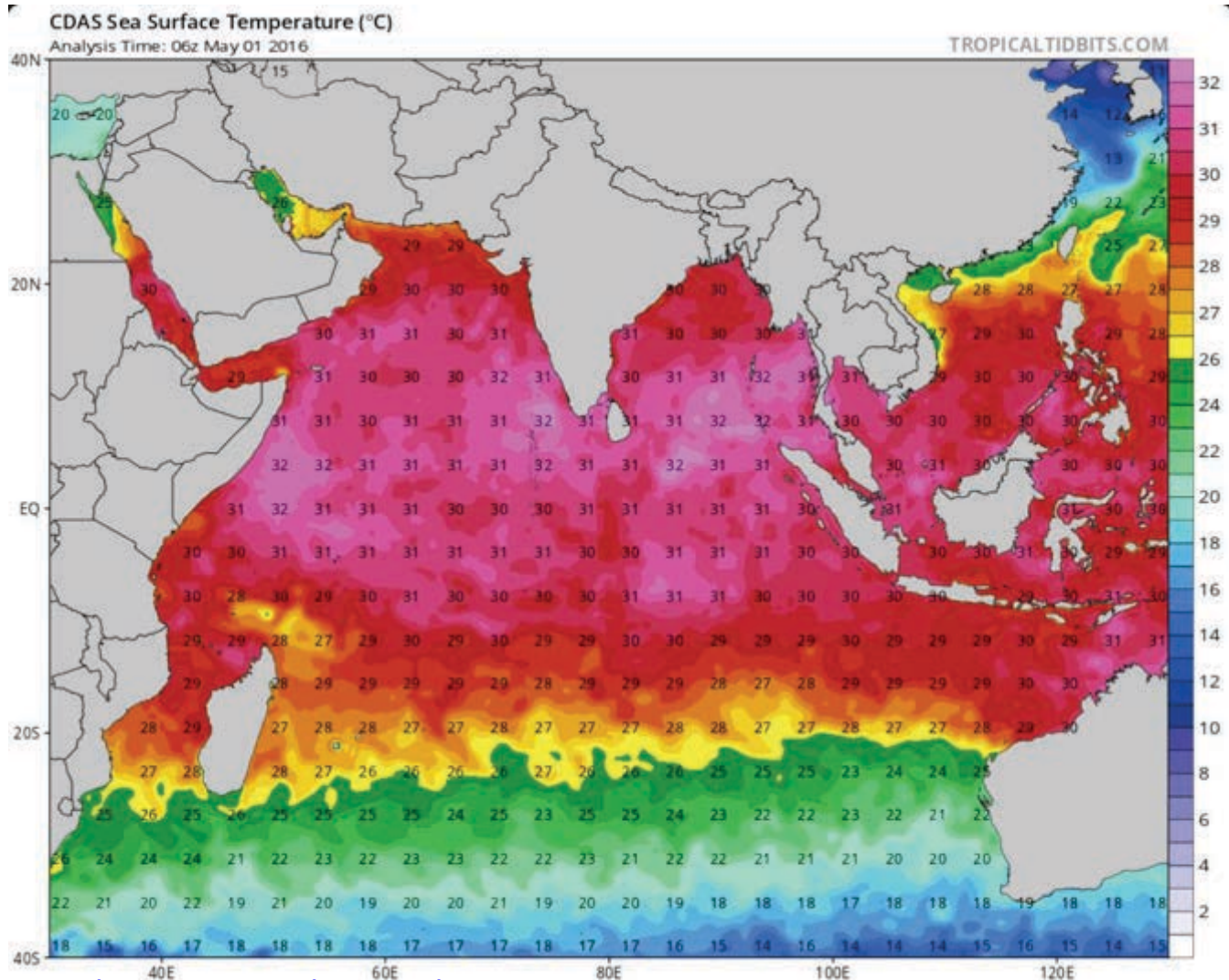
Fri Apr 15 07:06:08 EDT 2016

Uccle n'est pas en reste:

Evolution de la température moyenne annuelle à Bruxelles - Uccle de 1833 à 2015



**The northern Indian Ocean is really just
incredibly warm right now (end of April 2016).
Numerous 32°C surface temperature**



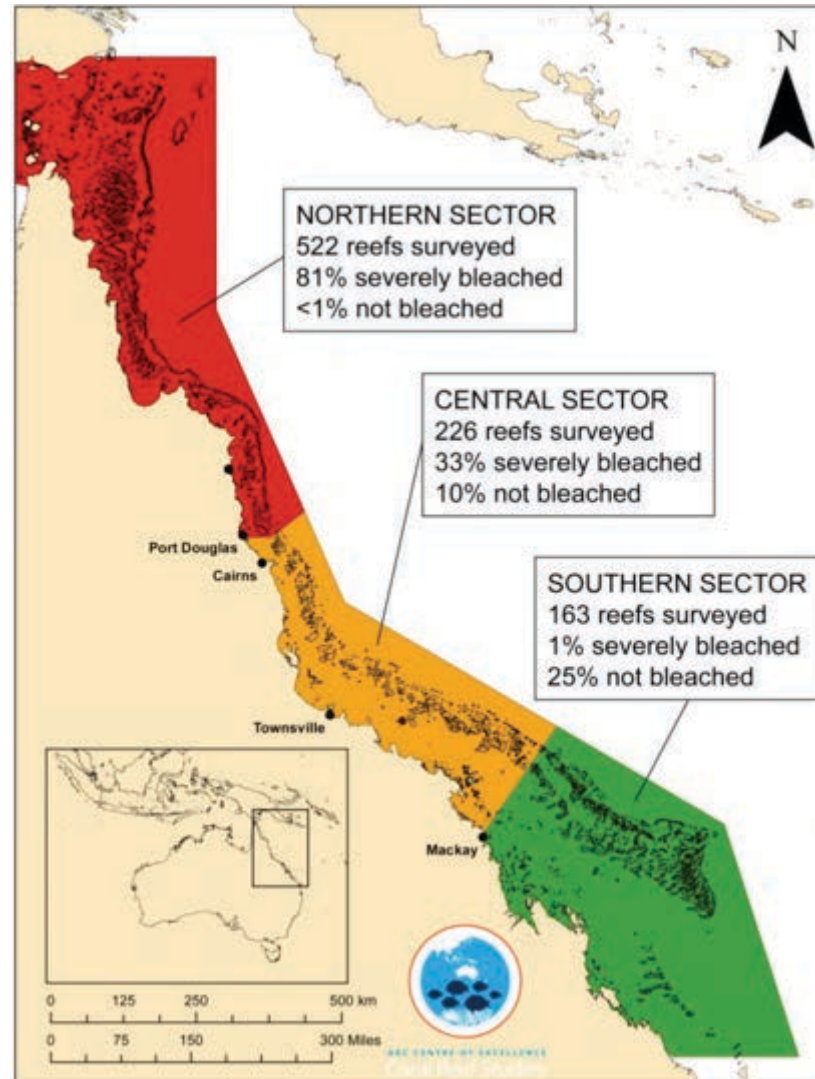
<https://twitter.com/anthonywx/status/726766892103438337>

Les récifs coralliens meurent



American Samoa (from www.globalcoralbleaching.org)

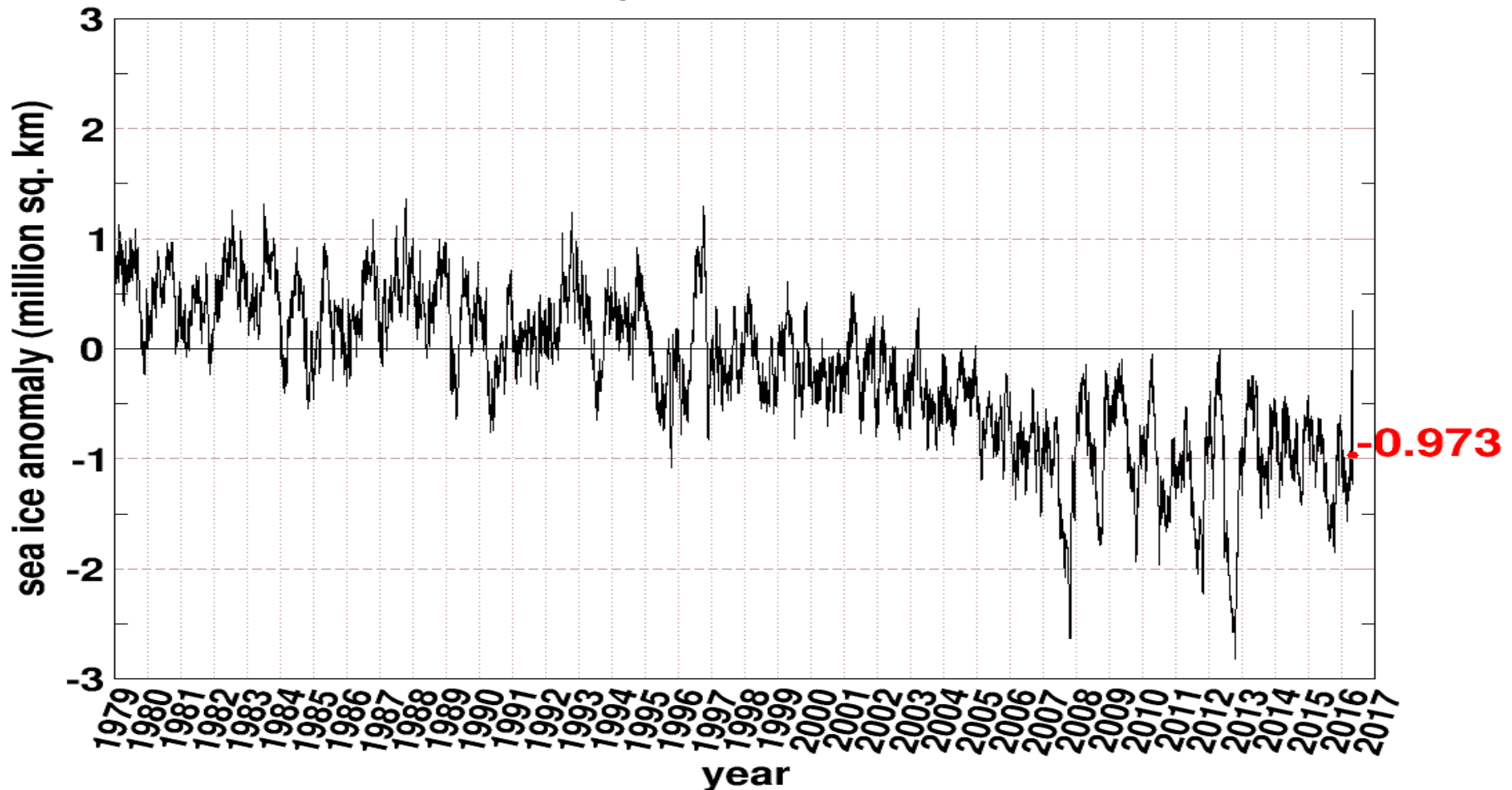
Only 7% of the Great Barrier Reef has avoided coral bleaching



Surface de la glace de mer arctique (écart par rapport à la moyenne)

Northern Hemisphere Sea Ice Anomaly

Anomaly from 1979-2008 mean



Qori Kalis Glacier (Pérou): juillet 1978



Source: Dr. Lonnie Thompson (OSU),
via <http://climate.nasa.gov/images-of-change#543-melting-qori-kalis-glacier-peru>

Qori Kalis Glacier (Pérou): juillet 2011

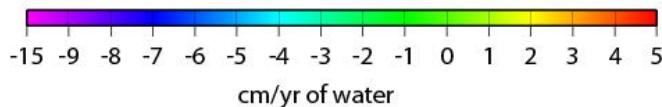
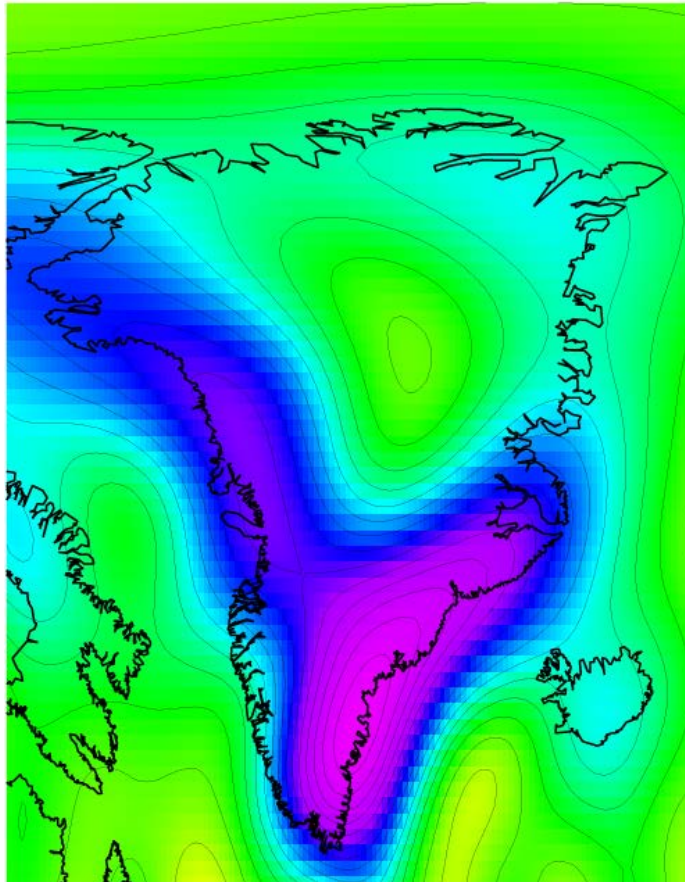


Source: Dr. Lonnie Thompson (OSU),
via <http://climate.nasa.gov/images-of-change#543-melting-qori-kalis-glacier-peru>

Greenland Ice Mass Loss 2002-2009

Derived From NASA GRACE Gravity Mission

Greenland

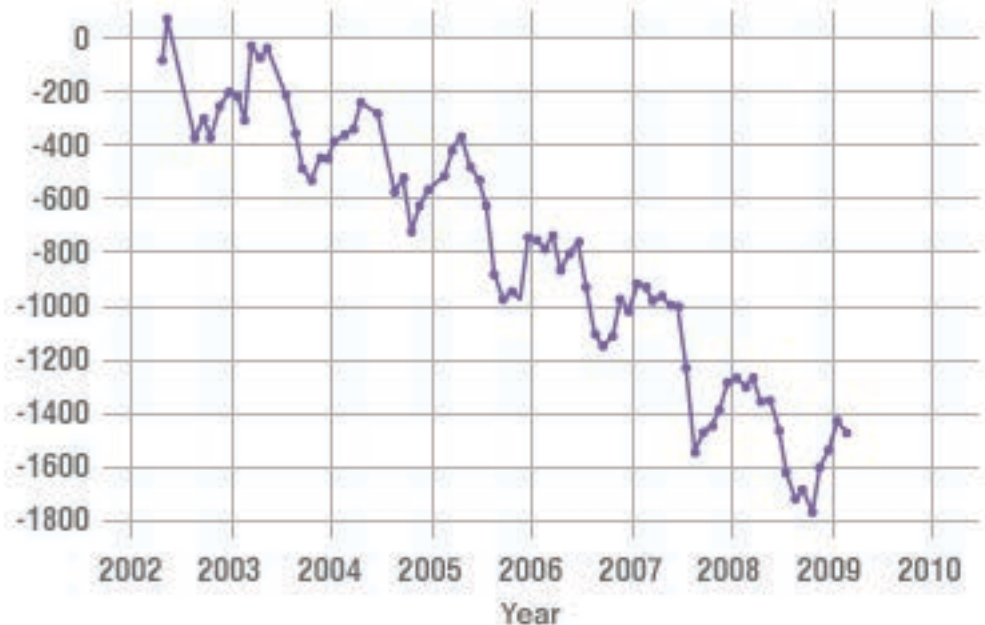


J. Wahr, U. Colorado

GREENLAND MASS VARIATION SINCE 2002

Data source: Ice mass measurement by NASA's Grace satellites.

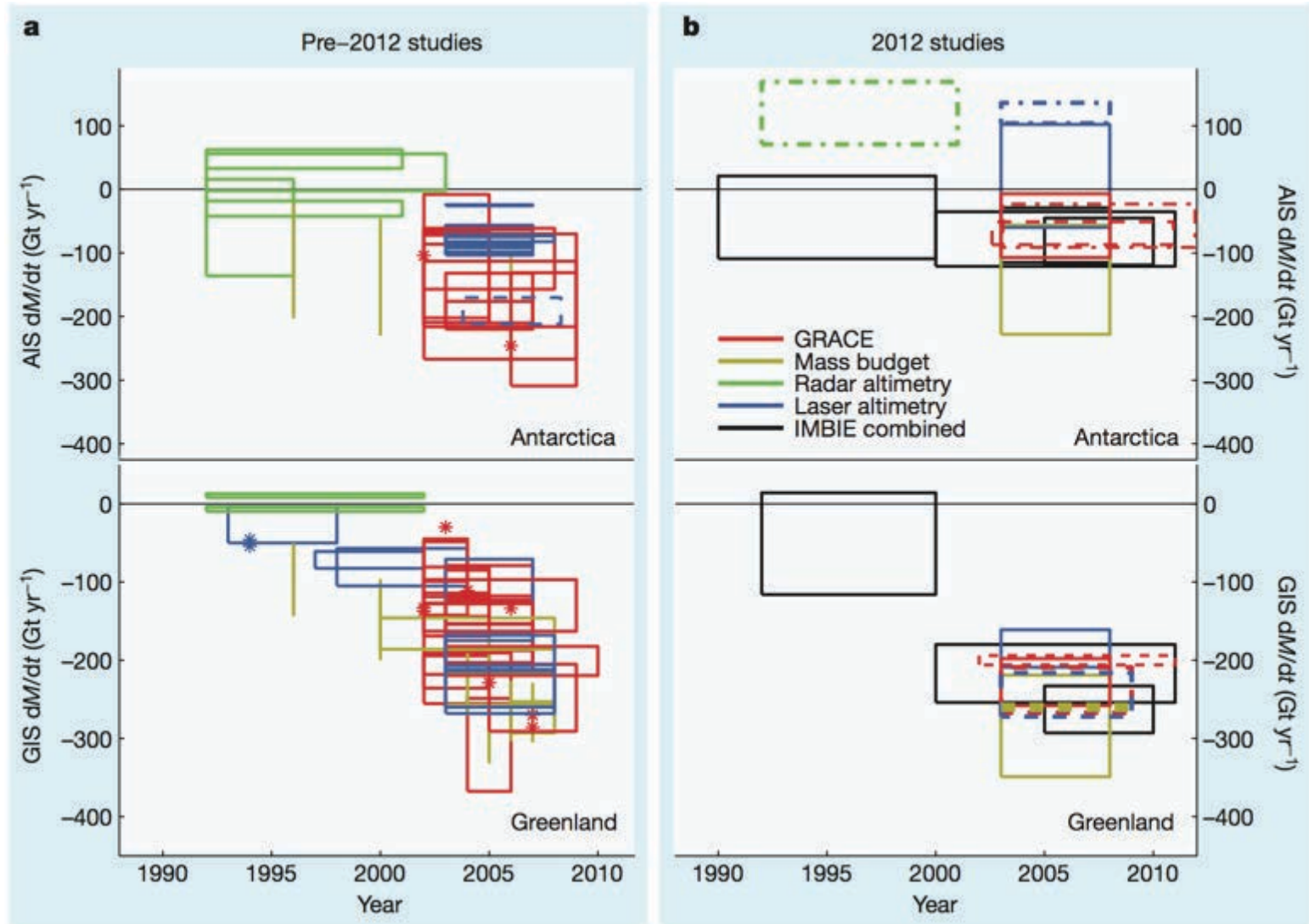
Change in Ice Mass Loss Gigatons



Velicogna, Geophysical Research Letters, 2009

•Contributes to sea level rise

Summary of estimates of rates of ice mass change for Antarctica and Greenland



Pourquoi le GIEC (Groupe d'experts

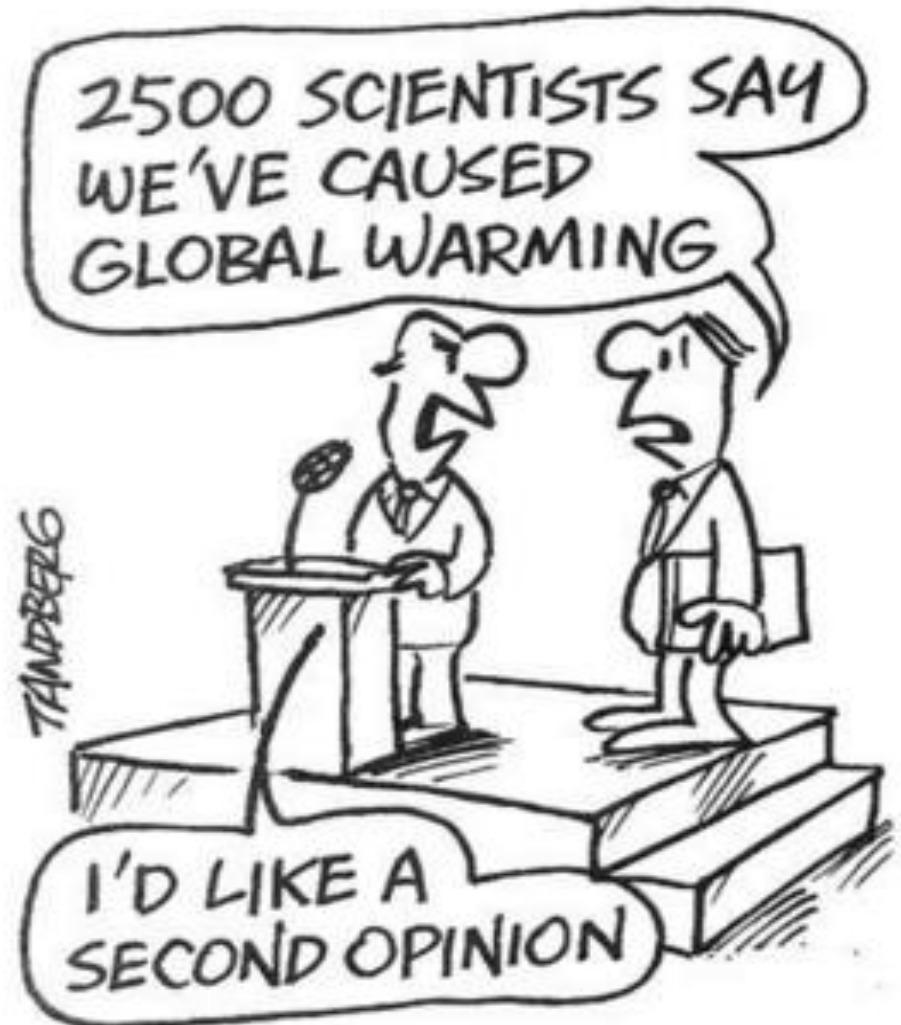
Intergouvernemental sur l'Evolution du Climat) ?

Etabli par l'OMM et le PNUE en 1988

Mandat: fournir aux décideurs une **source objective d'information** à propos:

- des causes des changements climatiques
- des scénarios possibles d'évolution
- des conséquences observées ou futures pour l'environnement et les activités humaines
- les options de réponse possibles (adaptation & atténuation = réduction des émissions).

OMM = Organisation Météorologique Mondiale
PNUE = Programme des Nations Unies pour l'Environnement

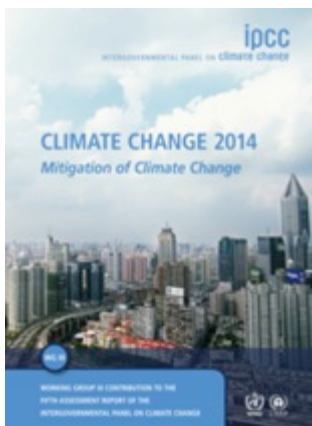




Que se passe-t-il dans le système climatique ?



Quels sont les risques ?



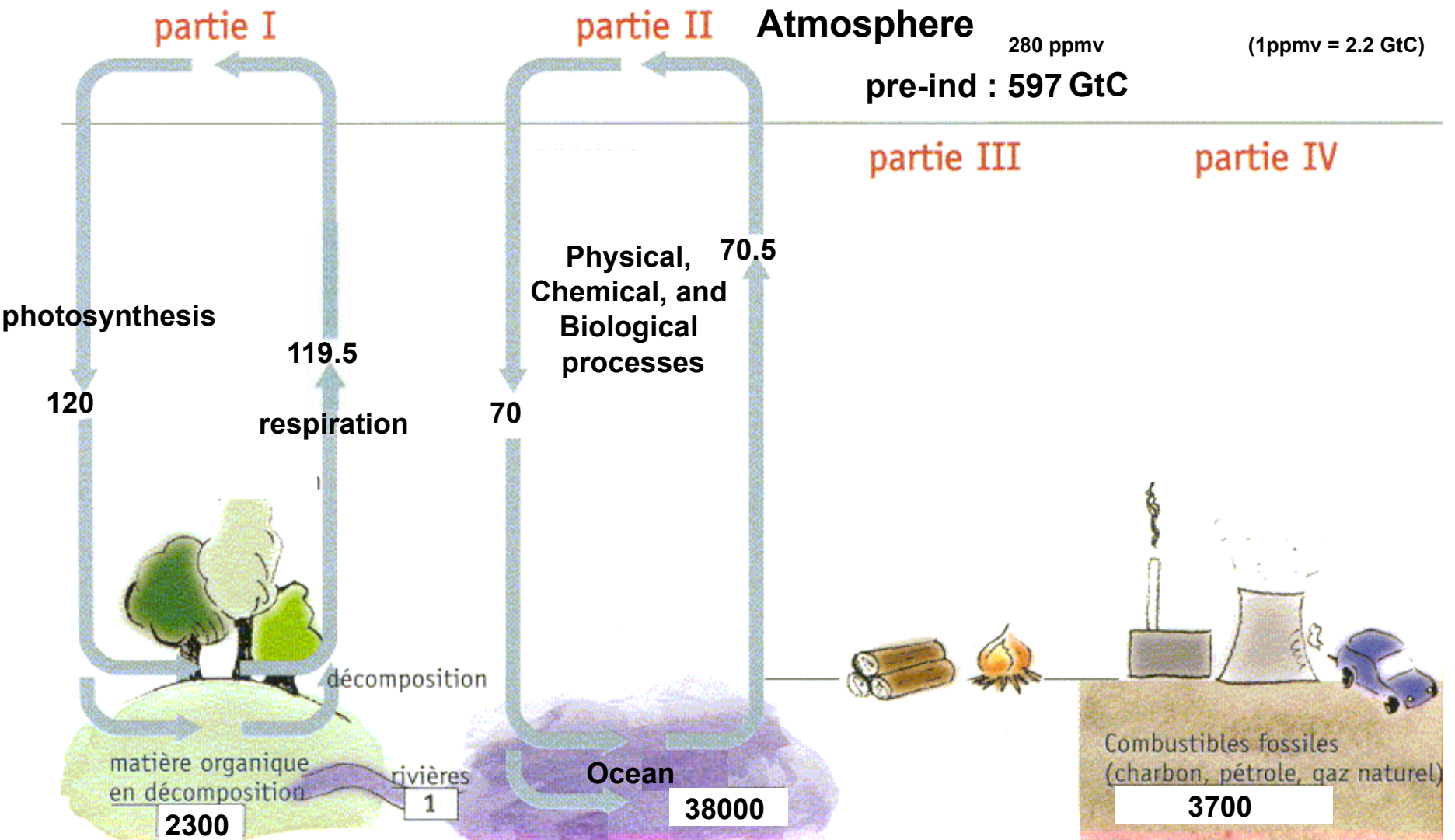
Que peut-on faire ?

Messages clés

- **L'influence humaine sur le système climatique est claire**
- **La poursuite des émissions de gaz à effet de serre augmentera le risque d'impacts graves, répandus et irréversibles pour les populations et les écosystèmes**
- **Alors que les changements climatiques représentent une menace pour le développement durable, il existe de nombreuses opportunités pour intégrer l'atténuation, l'adaptation, et la poursuite d'autres objectifs sociétaux**
- **L'Humanité a les moyens de limiter les changements climatiques et de construire un avenir plus durable et plus résilient**

AR5 WGI SPM, AR5 WGII SPM, AR5 WGIII SPM

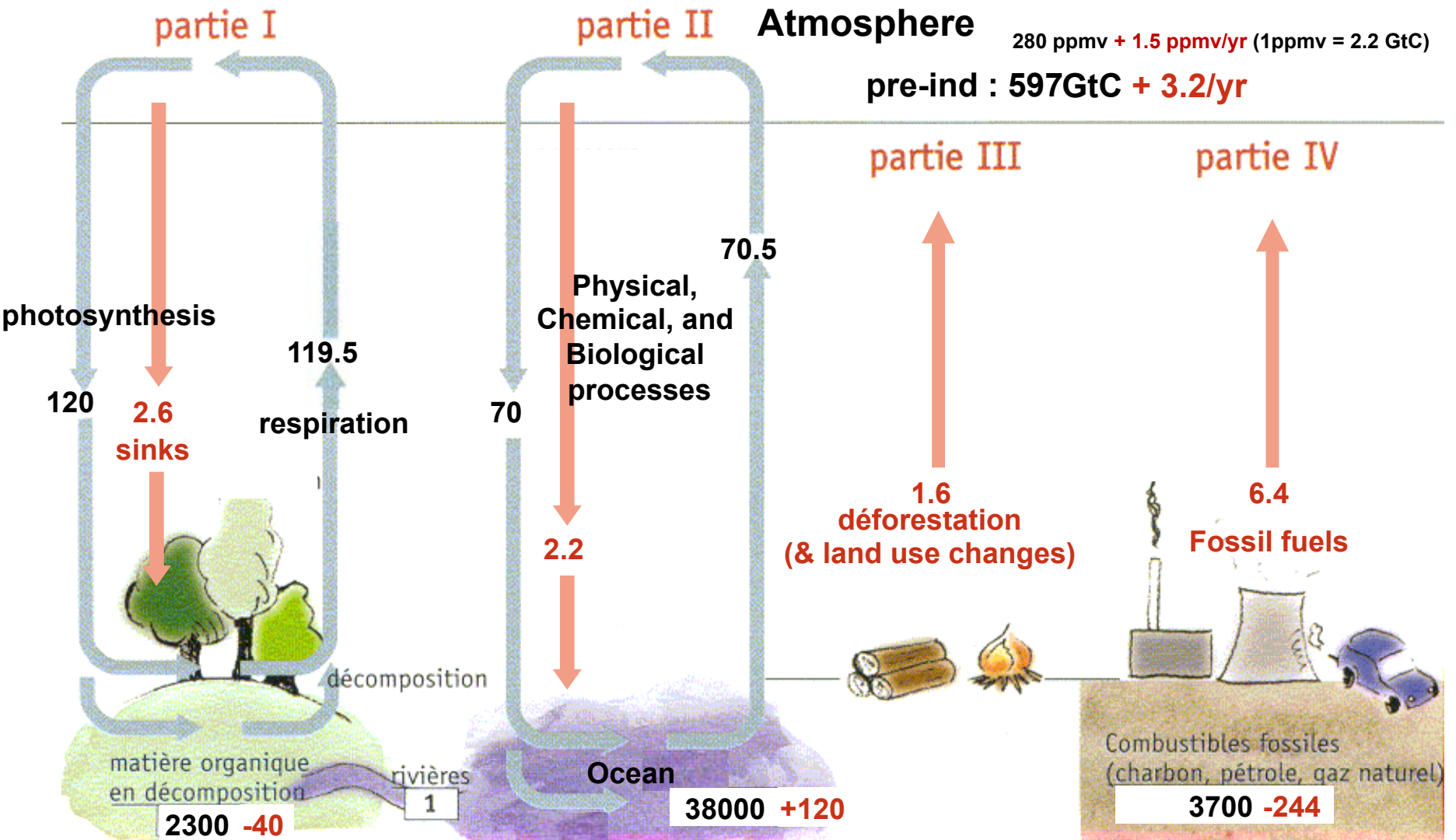
Carbon cycle: unperturbed fluxes



Units: GtC (billions tons of carbon) or GtC/year (multiply by 3.7 to get GtCO₂)

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!

A Progression of Understanding: Greater and Greater Certainty in Attribution

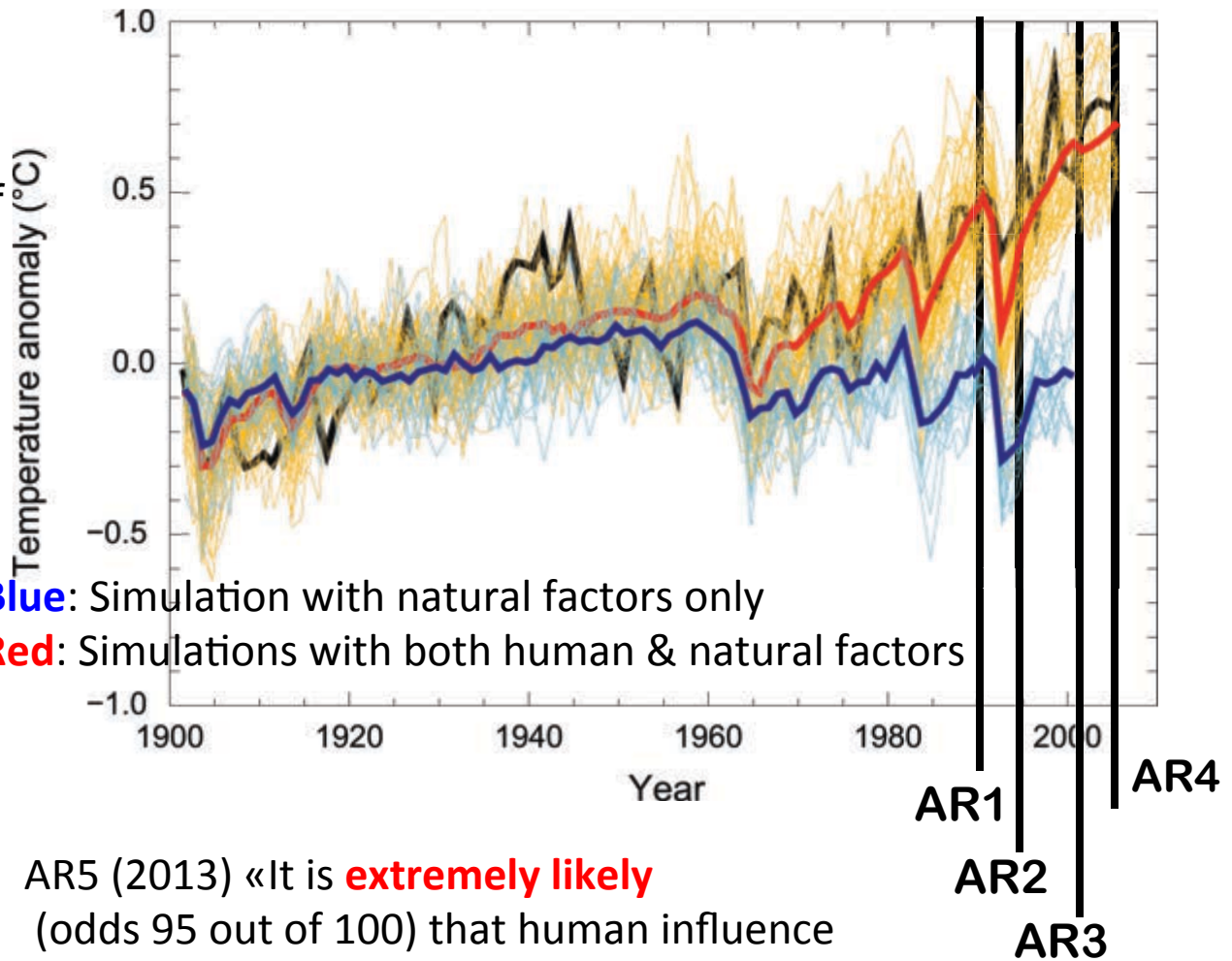
AR1 (1990):

“unequivocal detection not likely for a decade”

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

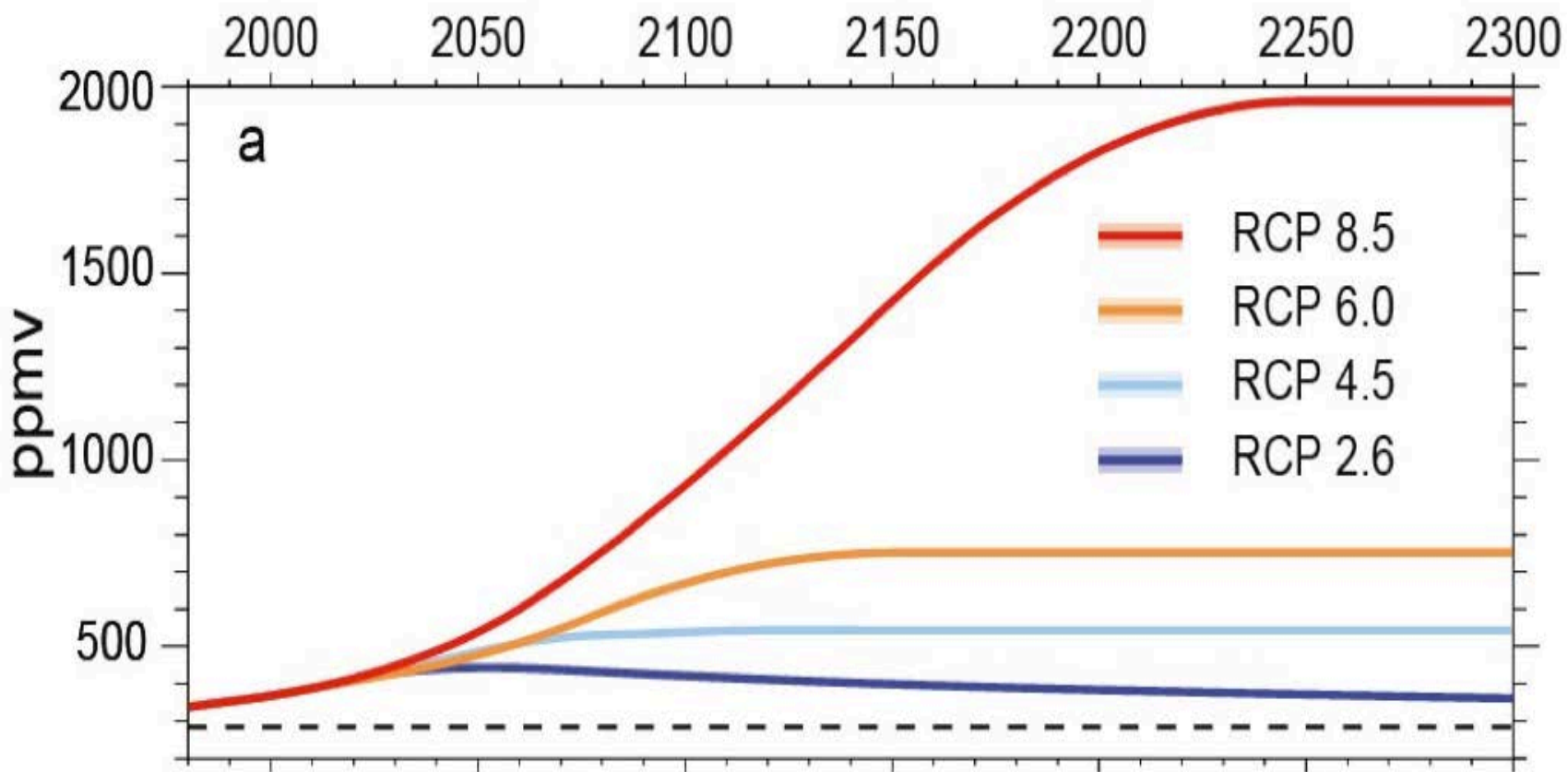
AR3 (2001): “most of the warming of the past 50 years is **likely** (odds 2 out of 3) due to human activities”

AR4 (2007): “most of the warming is **very likely** (odds 9 out of 10) due to greenhouse gases”



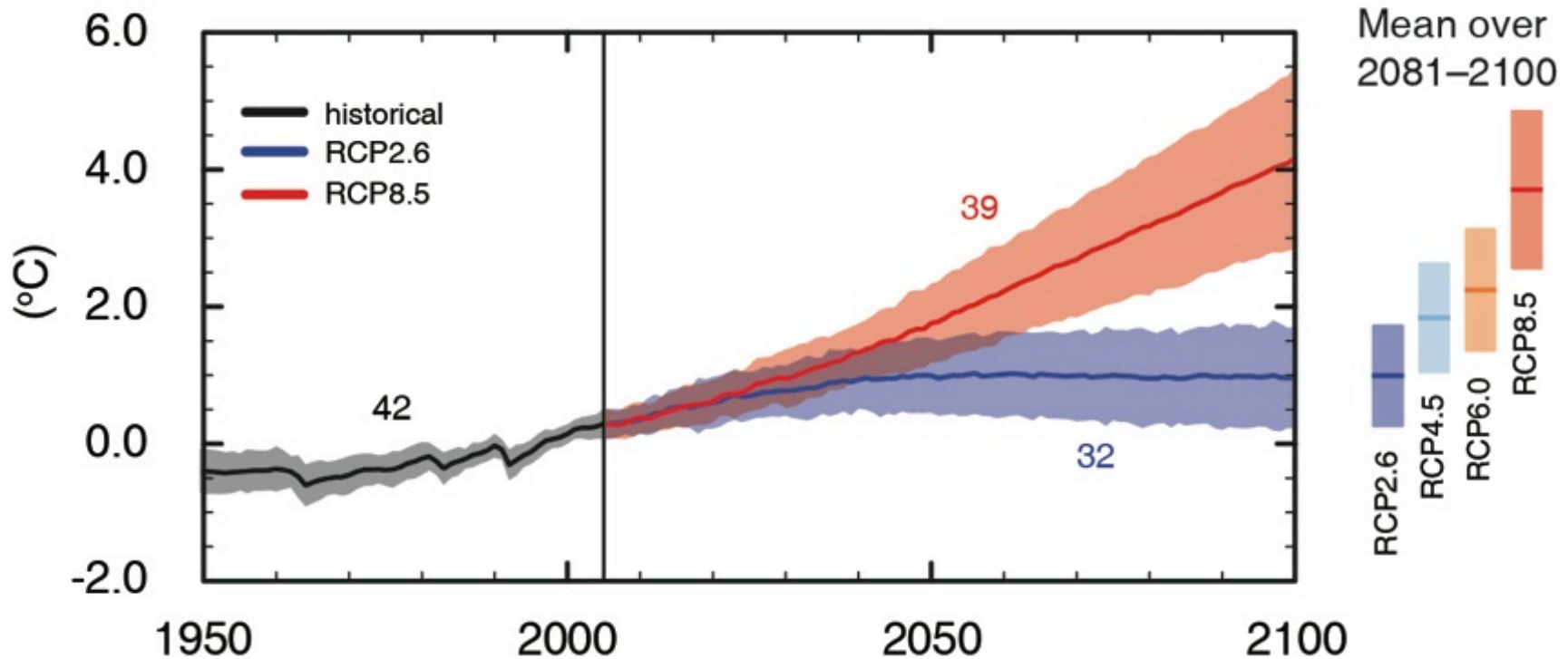
AR5 (2013) «It is **extremely likely** (odds 95 out of 100) that human influence has been the dominant cause... »

RCP Scenarios: Atmospheric CO₂ concentration



Three stabilisation scenarios: RCP 2.6 to 6
One Business-as-usual scenario: RCP 8.5

Global average surface temperature change (Ref: 1986-2005)



(IPCC 2013, Fig. SPM.7a)

Seul le scénario d'émissions le plus bas (RCP2.6) permet de maintenir l'augmentation de la température moyenne du globe en surface en-dessous de 2°C (relativement à 1850-1900) avec une probabilité d'au moins 66%.

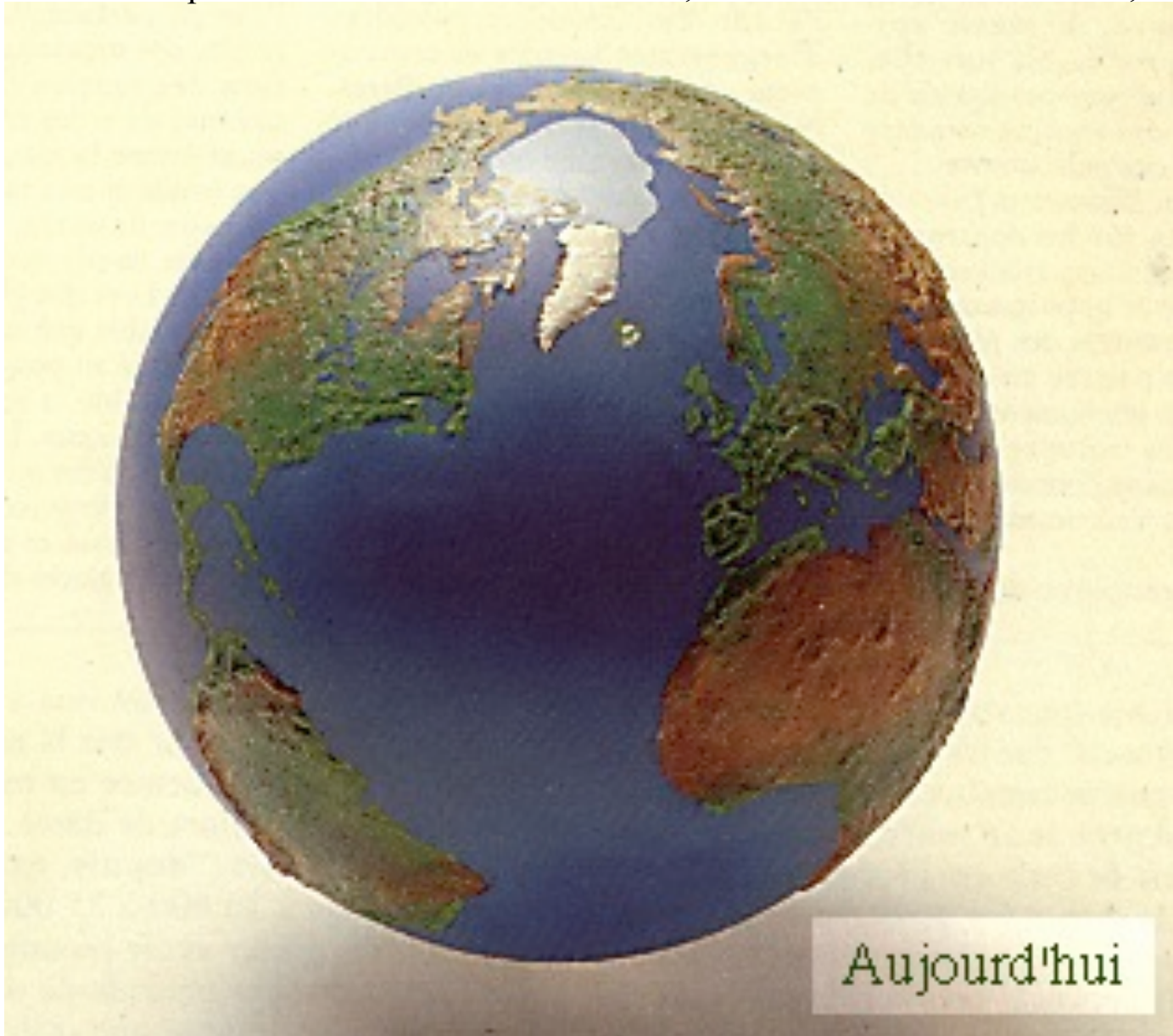
18-20000 years ago (Last Glacial Maximum)

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

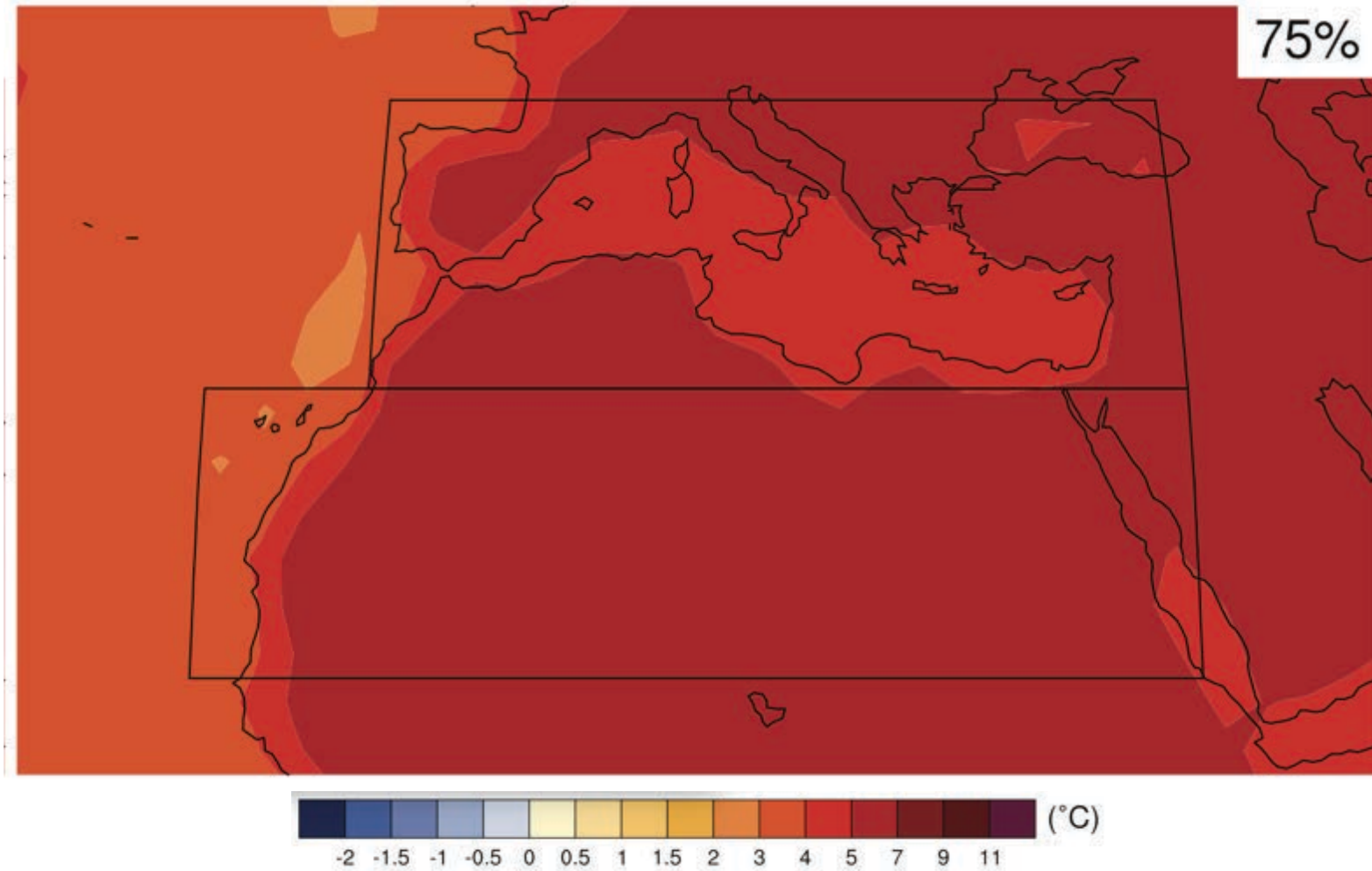


Today, with +4-5°C globally

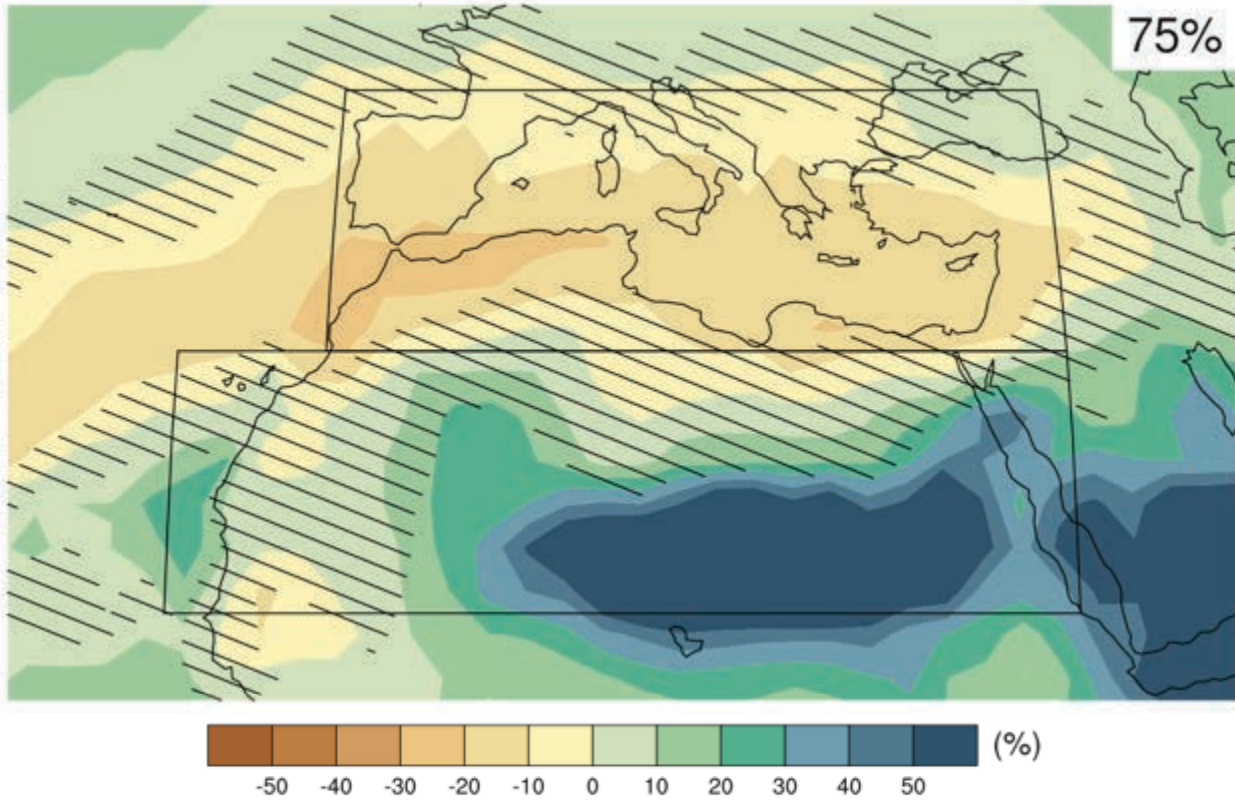
With permission from Dr. S. Joussaume, in « Climat d'hier à demain », CNRS éditions.



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



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



**With 1 metre sea-level rise: 63000 ha below sea-level in Belgium (likely in 22nd century, not impossible in 21st century)
(NB: flooded area depends on protection)**



Source: N. Dendoncker (Dépt de Géographie, UCL), J.P. van Ypersele et P. Marbaix (Dépt de Physique, UCL) (www.climate.be/impact)

With 8 metre sea-level rise: 3700 km² below sea-level in Belgium

(very possible in year 3000)

(NB: flooded area depends on protection)



Source: N. Dendoncker (Dépt de Géographie, UCL), J.P. van Ypersele et P. Marbaix (Dépt de Physique, UCL) (www.climate.be/impact)

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

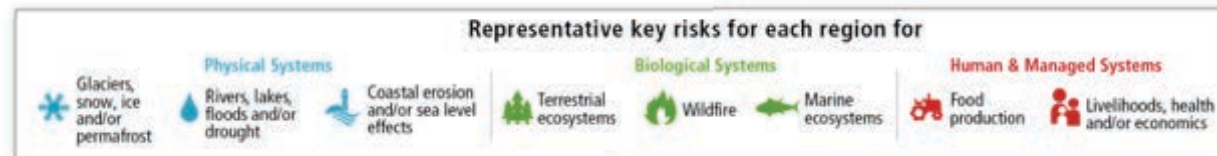
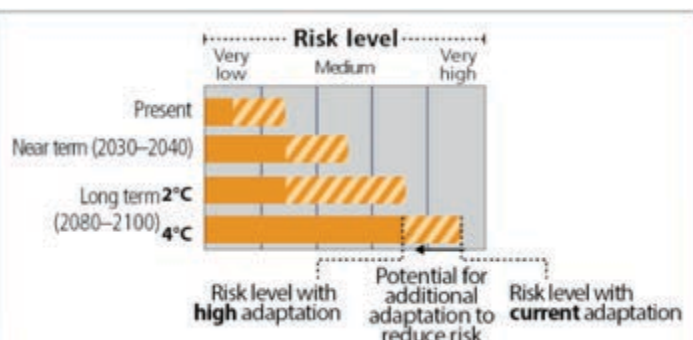
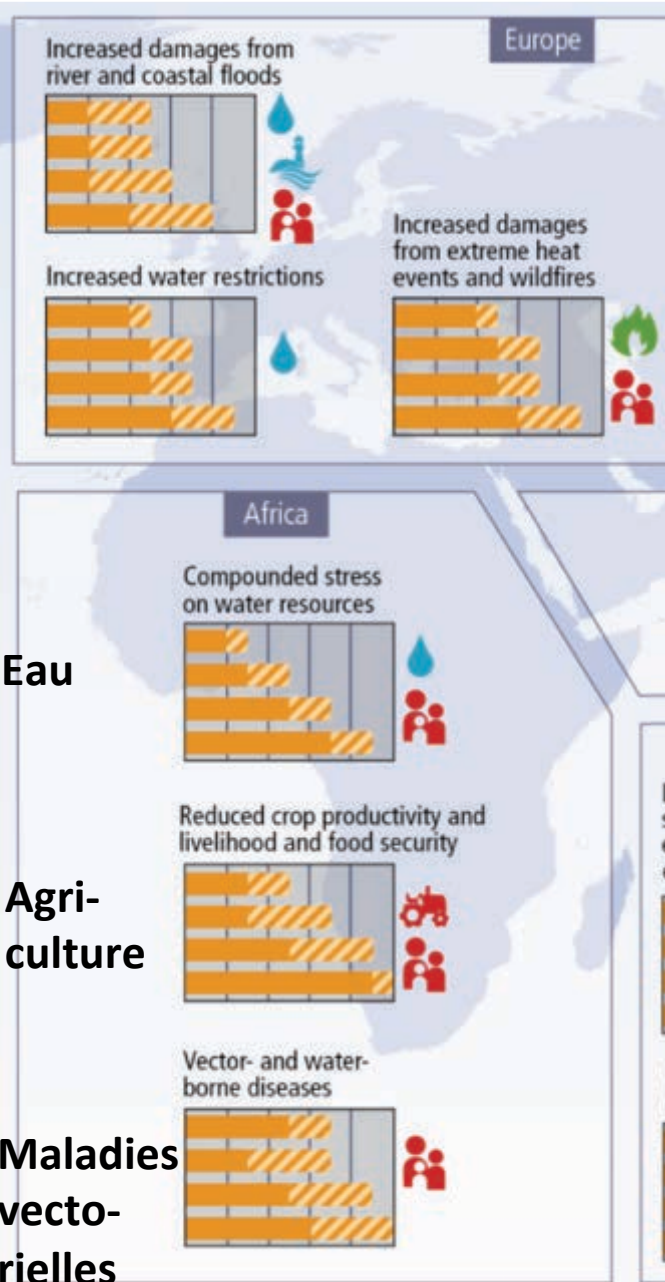


(Time 2001)

Risque = Aléa x Vulnérabilité x Exposition (Victimes des inondations après Katrina)



Risques clés à l'échelle régionale et potentiel de réduction du risque par l'adaptation: Europe & Afrique

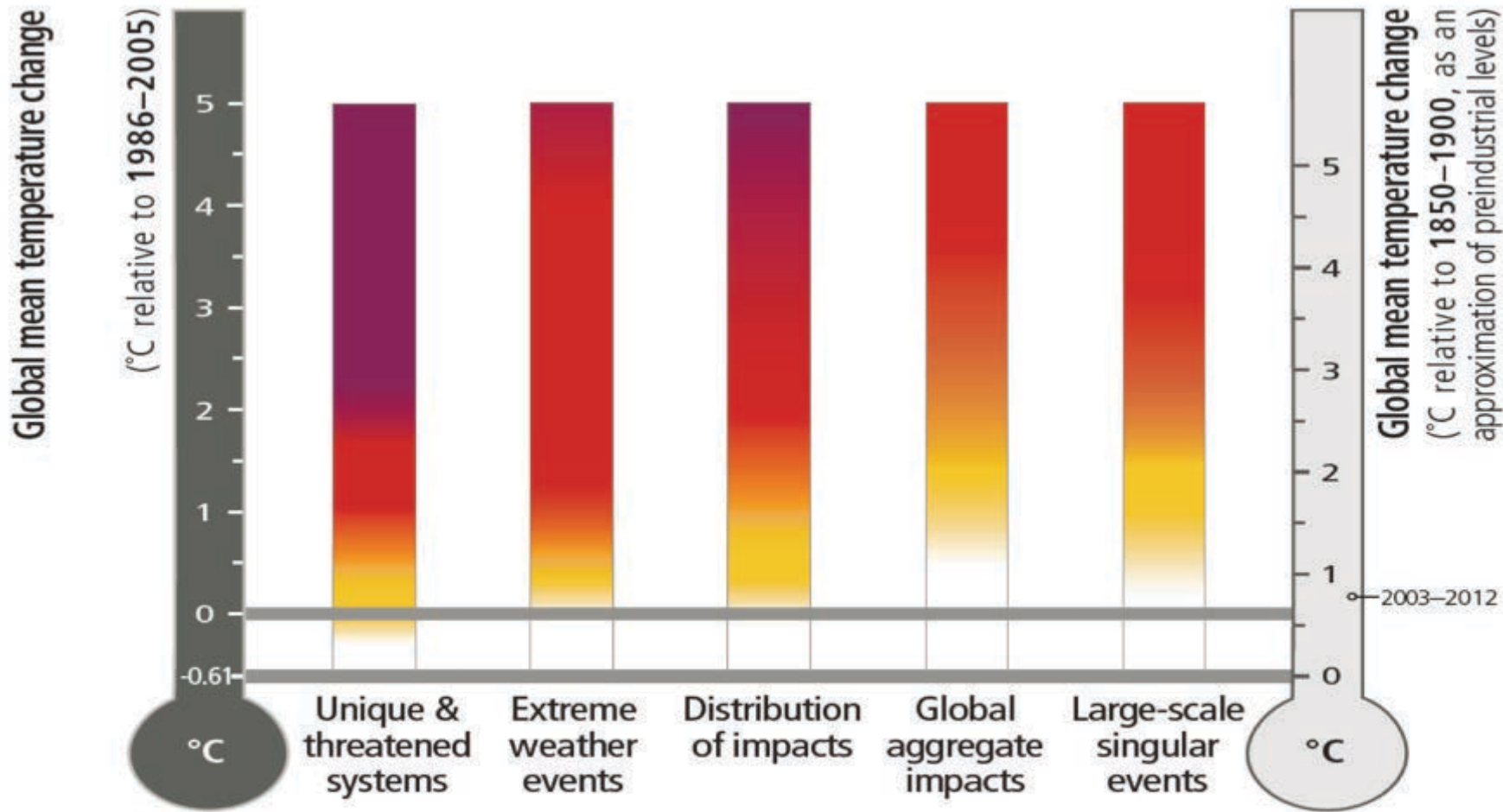




LES RISQUES DES
CHANGEMENTS CLIMATIQUES

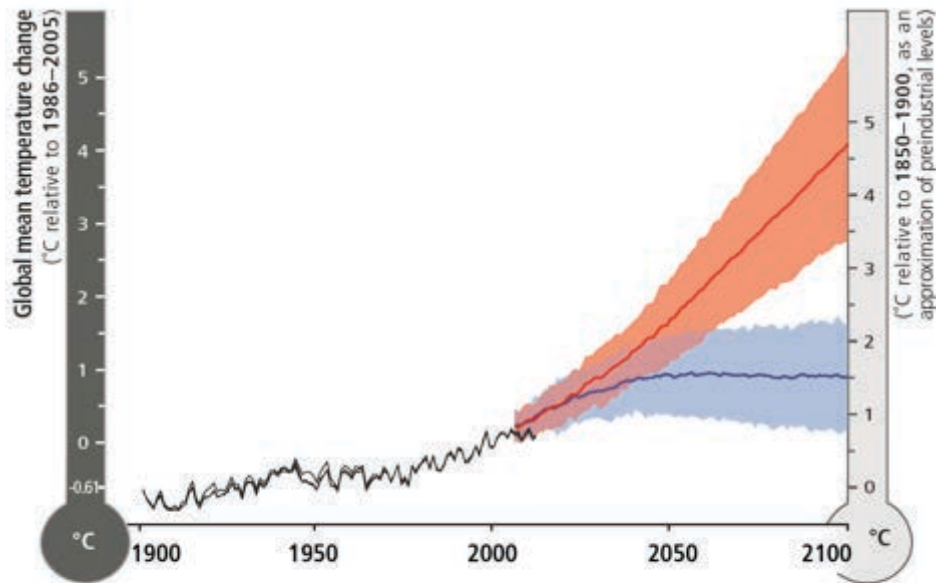
AUGMENTENT

AVEC DES
EMISSIONS EN
CROISSANCE
CONTINUE

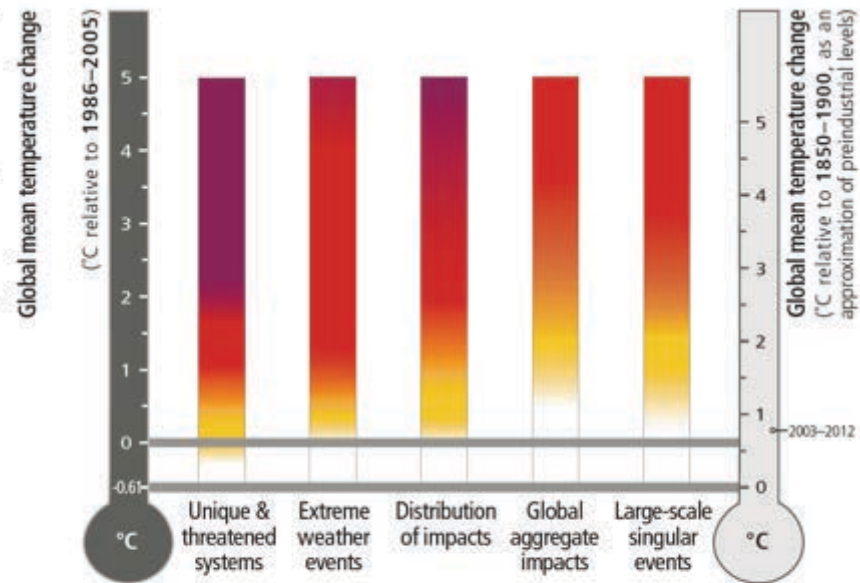


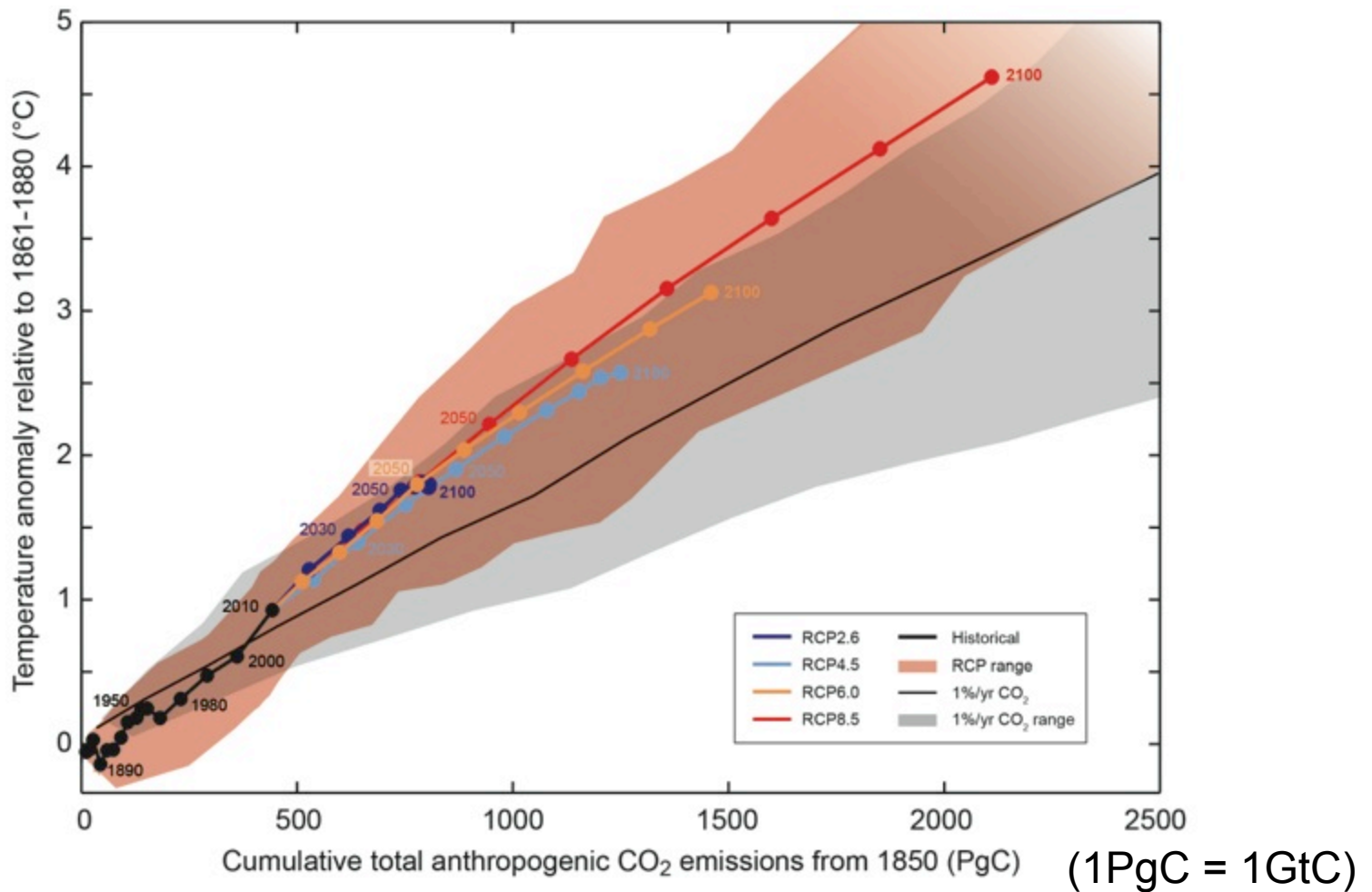
Level of additional risk due to climate change





- Observed
- RCP8.5 (a high-emission scenario)
- Overlap
- RCP2.6 (a low-emission mitigation scenario)



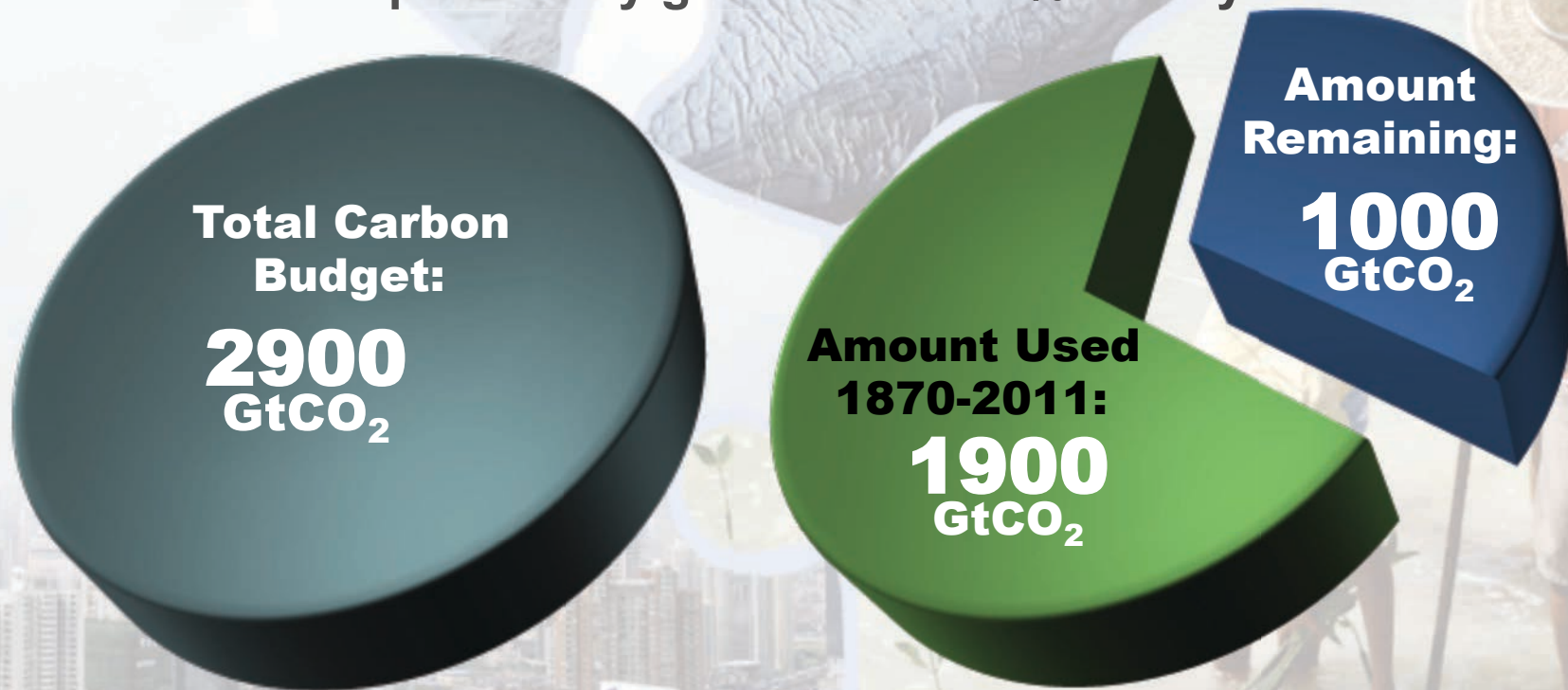


(IPCC 2013, Fig. SPM.10)

Le total des émissions de CO₂ cumulées détermine dans une large mesure la moyenne globale du réchauffement en surface vers la fin du XXI^{ème} siècle et au delà

The window for action is rapidly closing

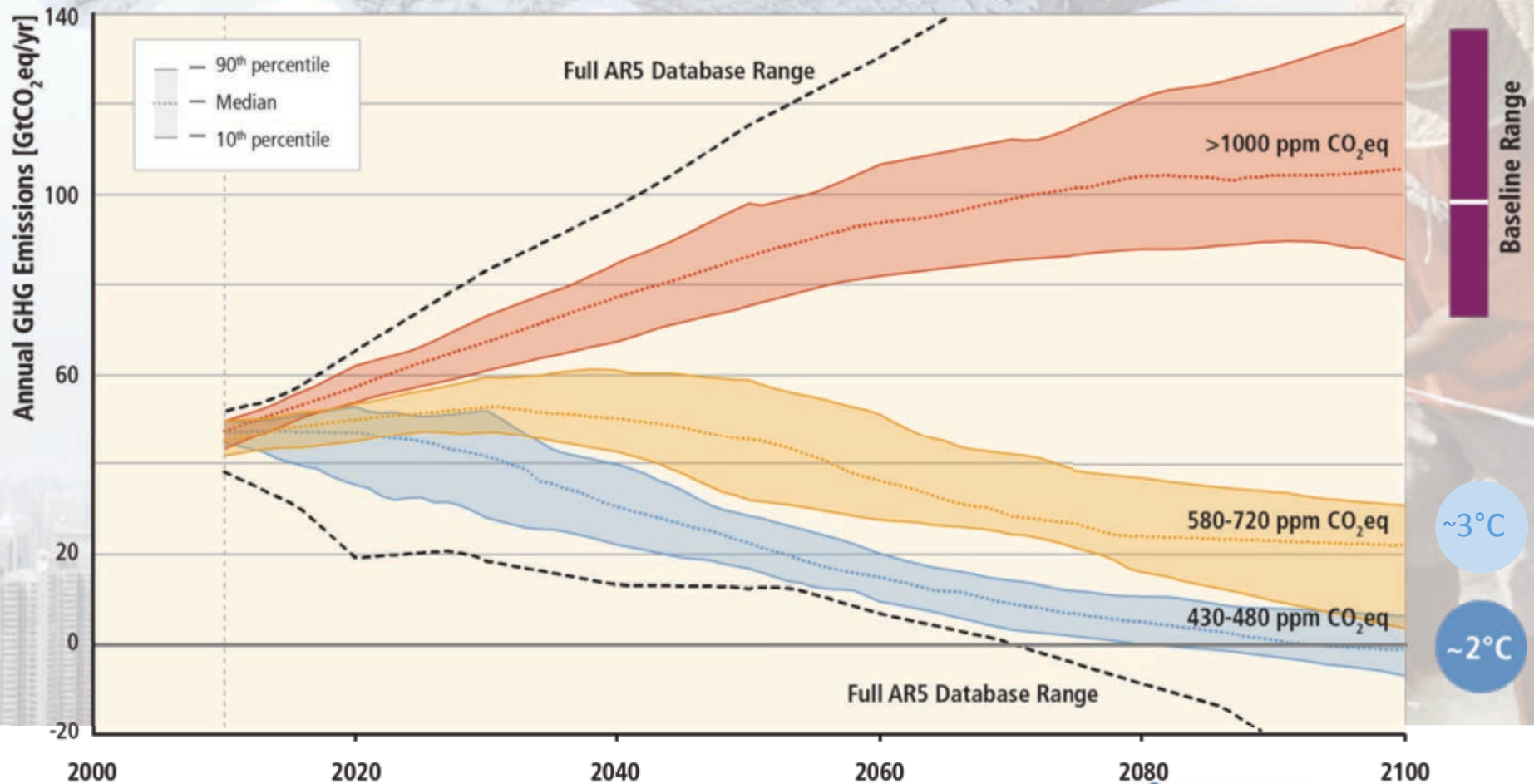
65% of the carbon budget compatible with a 2°C goal is already used
NB: this is with a probability greater than 66% to stay below 2°C



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

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

- **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**

RCP2.6

RCP8.5

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

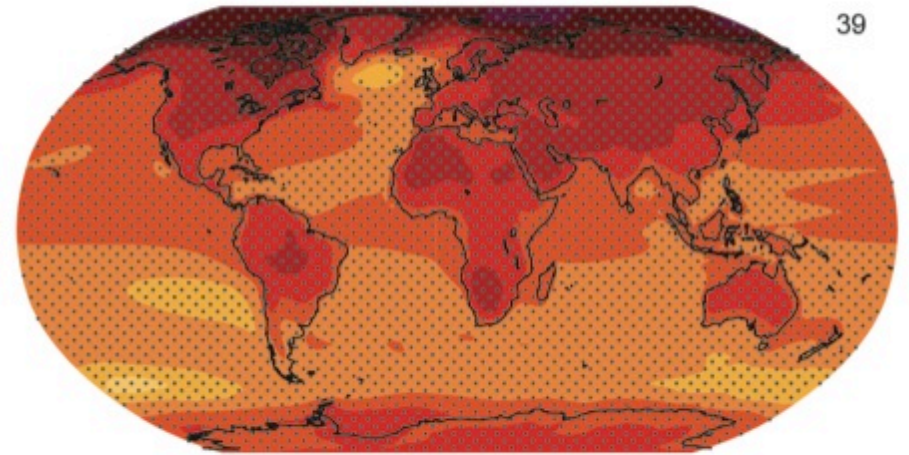
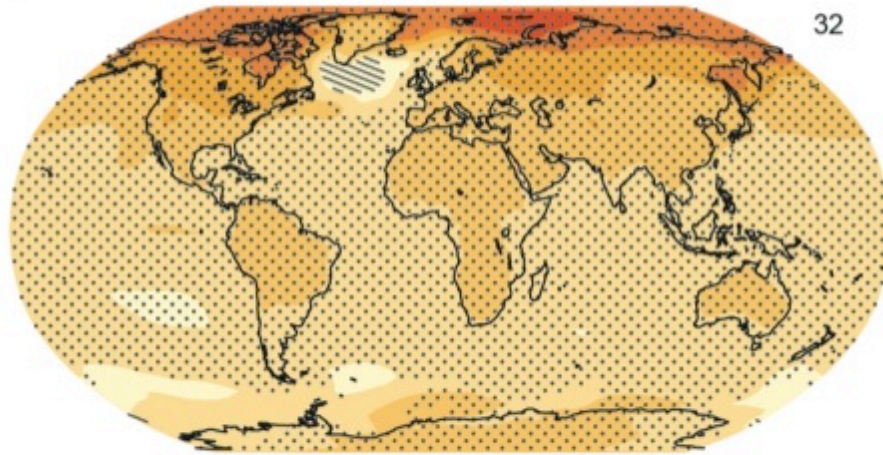


Fig. SPM.8

L'Humanité a le choix

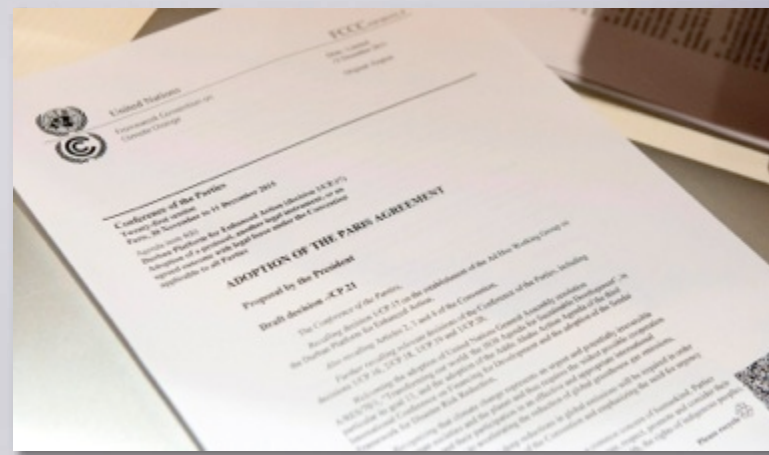


Isaac Cordal

Sur les Changements Climatiques 2015

COP21/CMP11

Paris, France

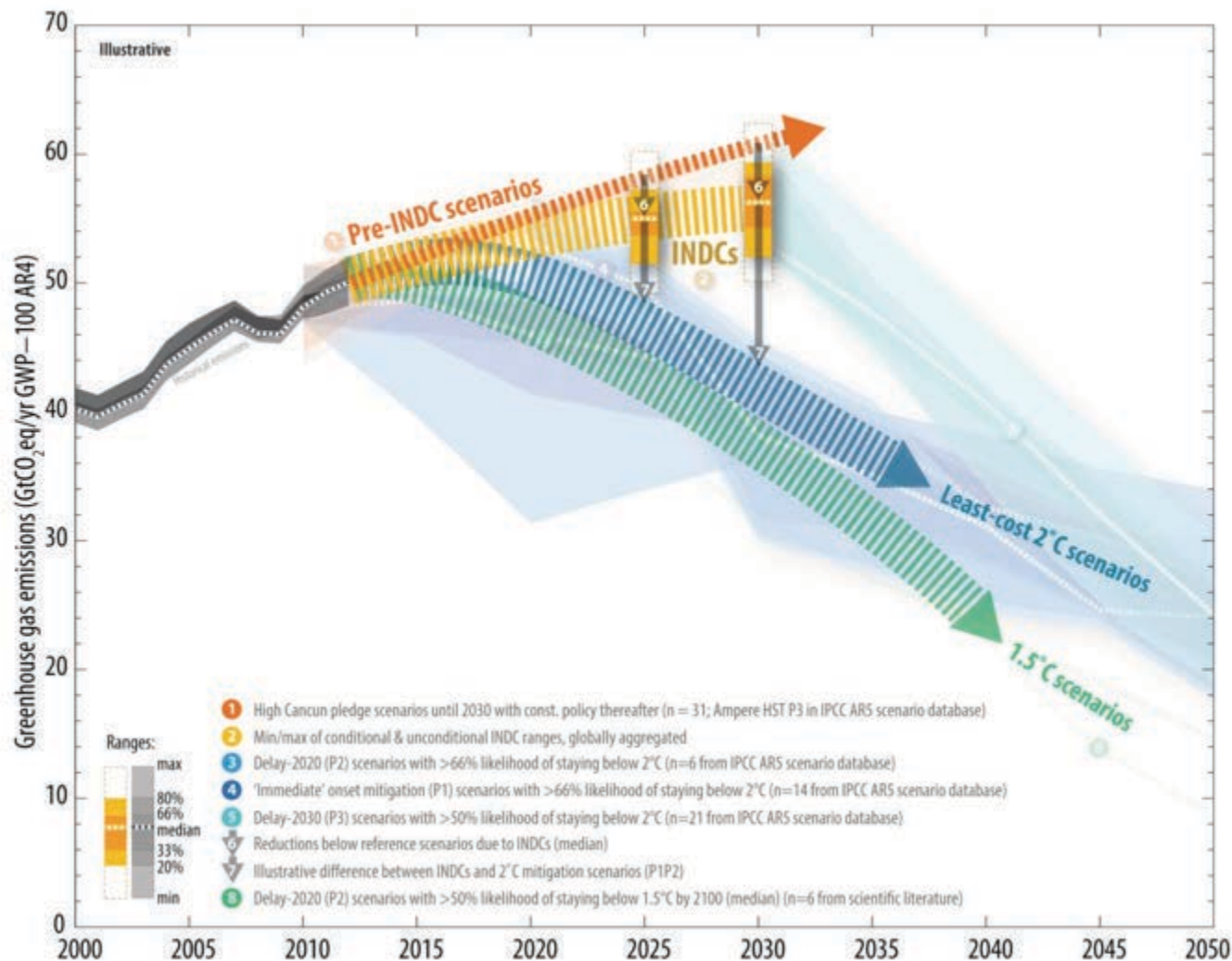


“Getting 196 Countries To Agree On Climate Change Was The Easy Part. Now comes the real work.”

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



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

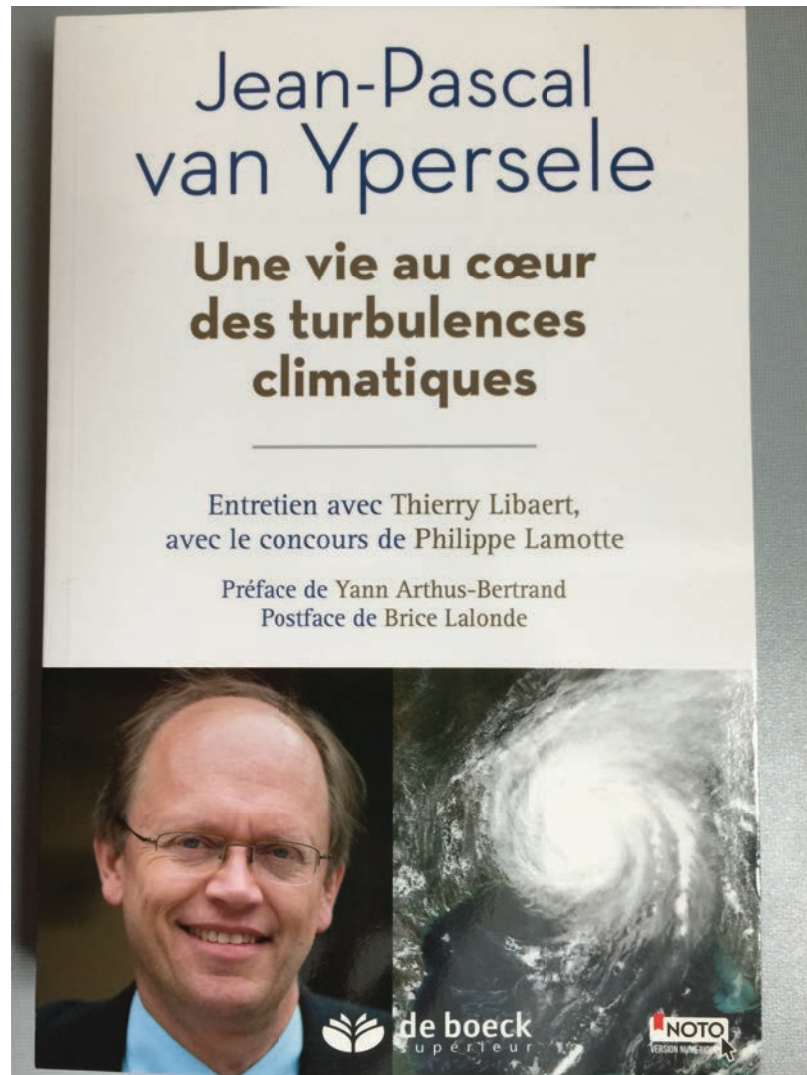


Leaders Aim to Put a Price on Half of All Global Carbon Emissions



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

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



Pour en savoir plus :

- www.ipcc.ch : GIEC ou IPCC
- www.climate.be/vanyp : beaucoup de mes dias

Sur Twitter: @JPvanYpersele

– @IPCC_CH