

# Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report

## An introduction to climate change science and the IPCC

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and to IPCC & Hugues Goosse for some of the slides

# Plan

- **Climate and weather**
- **Greenhouse effect**
- **Carbon cycle**
- **IPCC**

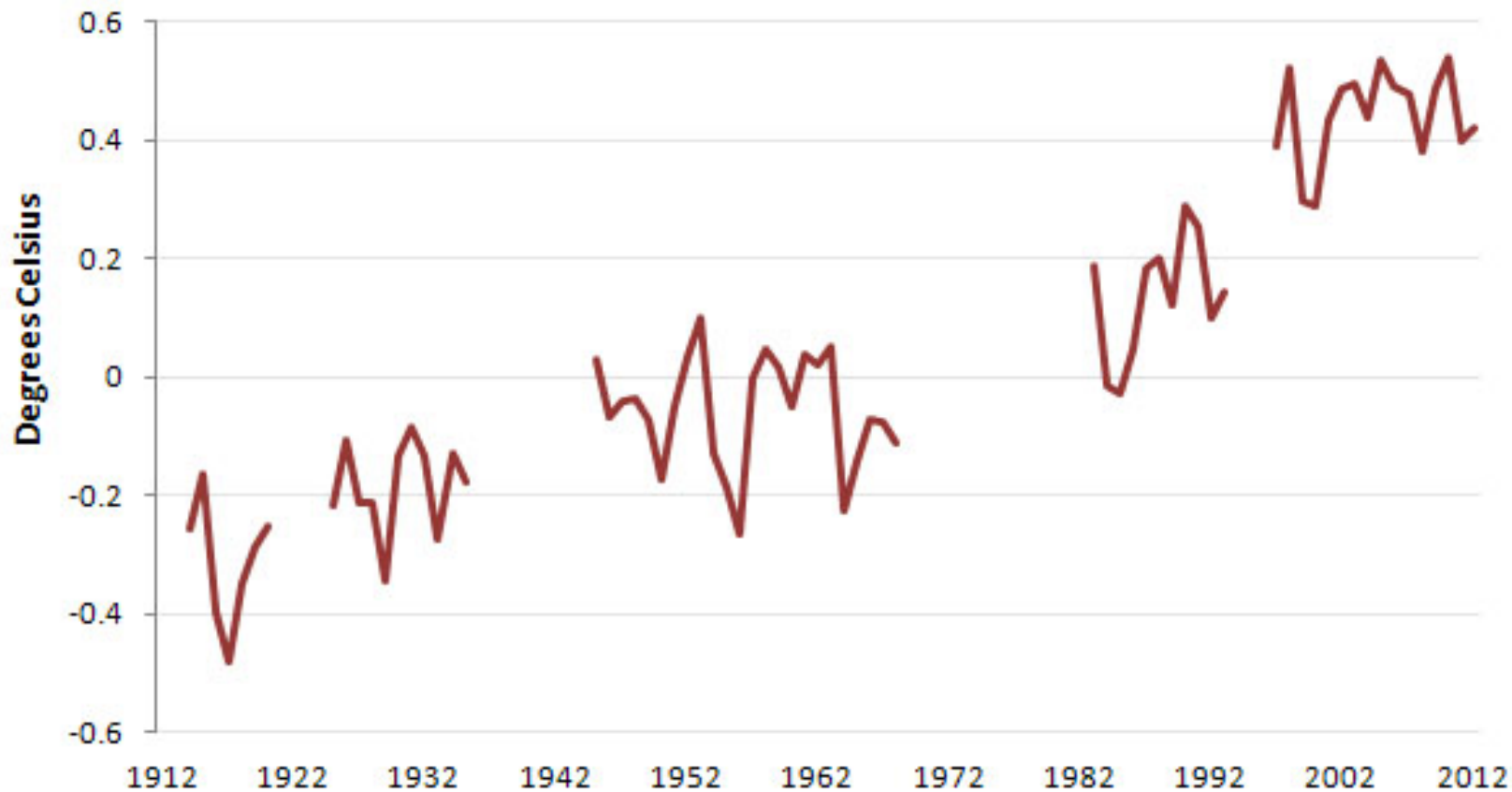
# Lying With Statistics, Global Warming Edition

## Temperature Change From 1961-1990 Average



# Lying With Statistics, Global Warming Edition

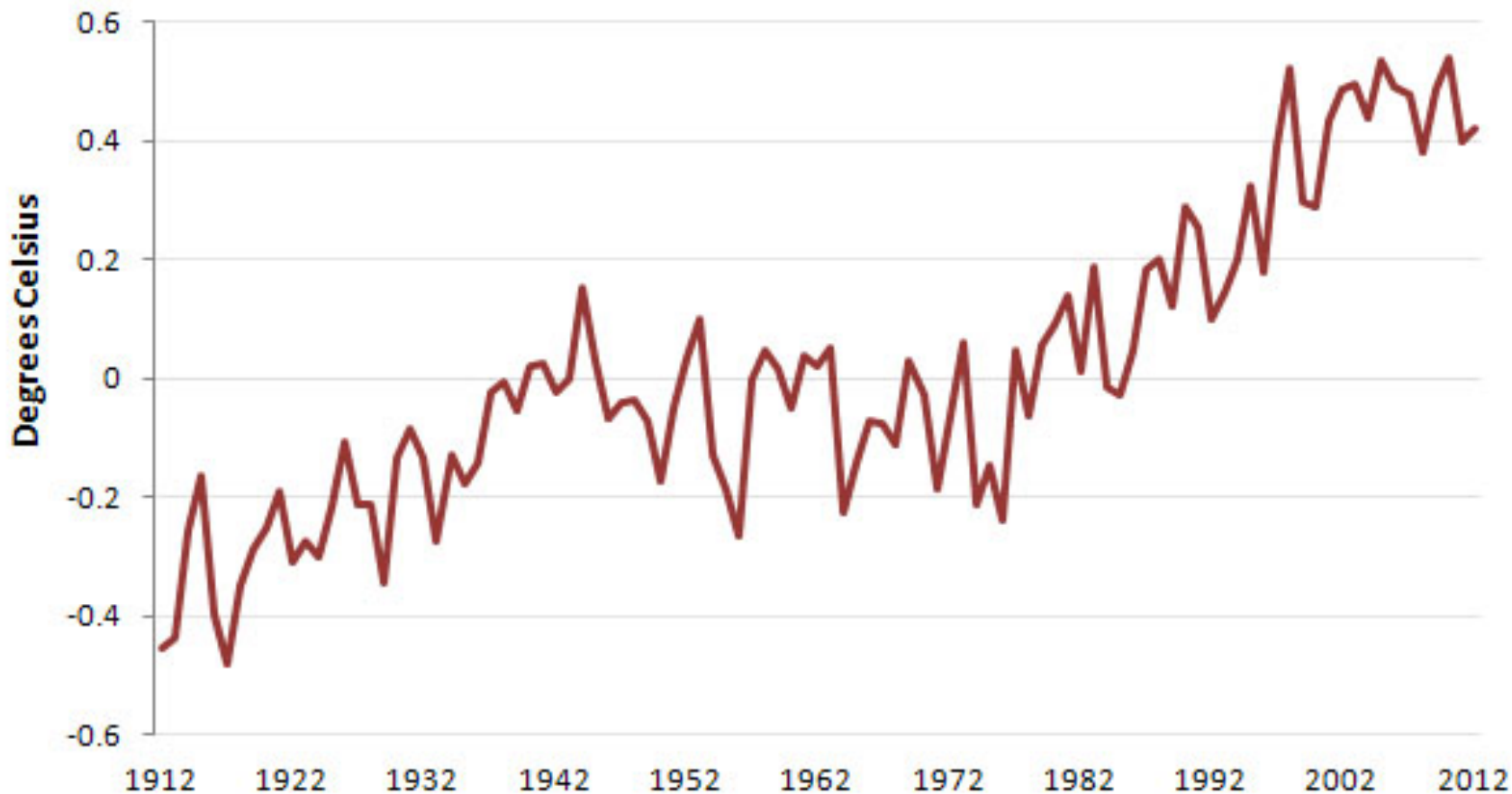
## Temperature Plateaus — 1912-2012





# Lying With Statistics, Global Warming Edition

## Temperature Change From 1961-1990 Average



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

# Definition of climate

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**Climate** is traditionally **defined** as the description in terms of the **mean and variability of relevant atmospheric variables** such as temperature, precipitation and wind. The climate could thus be viewed as a synthesis or an aggregate of weather.

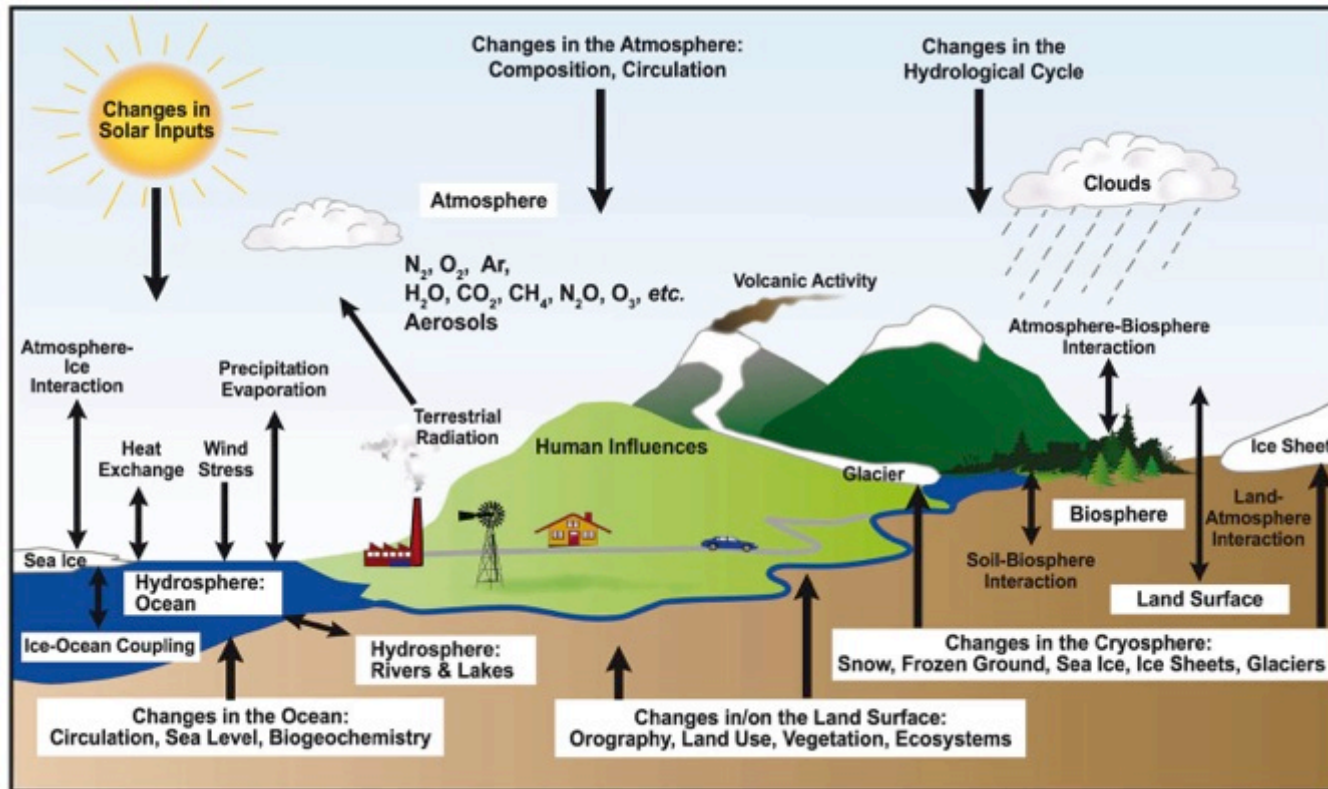
**30 years** is the classical period for **performing the statistics** used to defined climate.

But this period is indicative and the definition should not mask the fact that **climate could change rapidly**.



# Definition of climate

Climate is now more and more defined in a wider sense as the statistical description of the climate system. This includes the analysis of the behavior of its five major components: the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere.

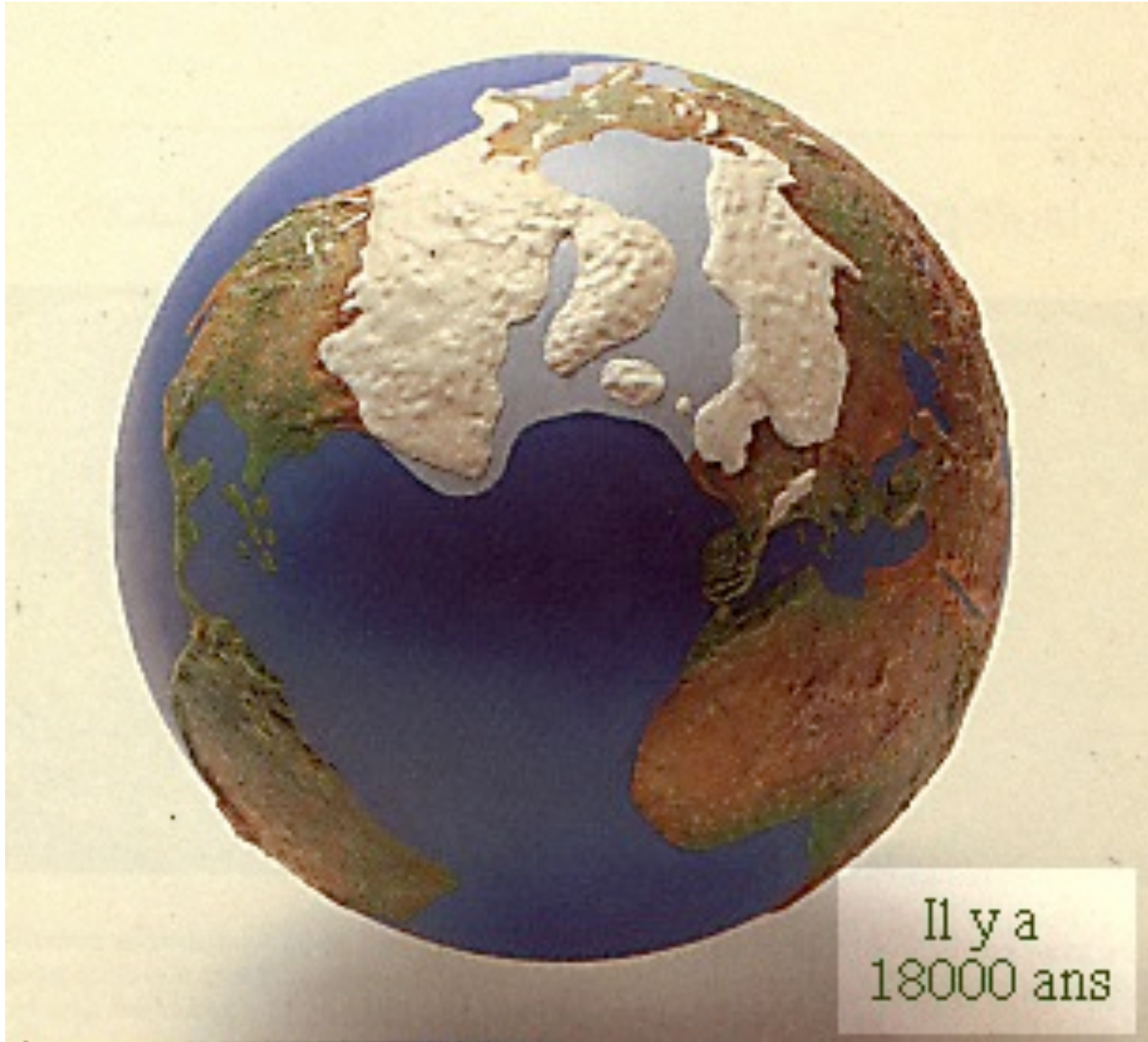


Figure

IPCC(2007)

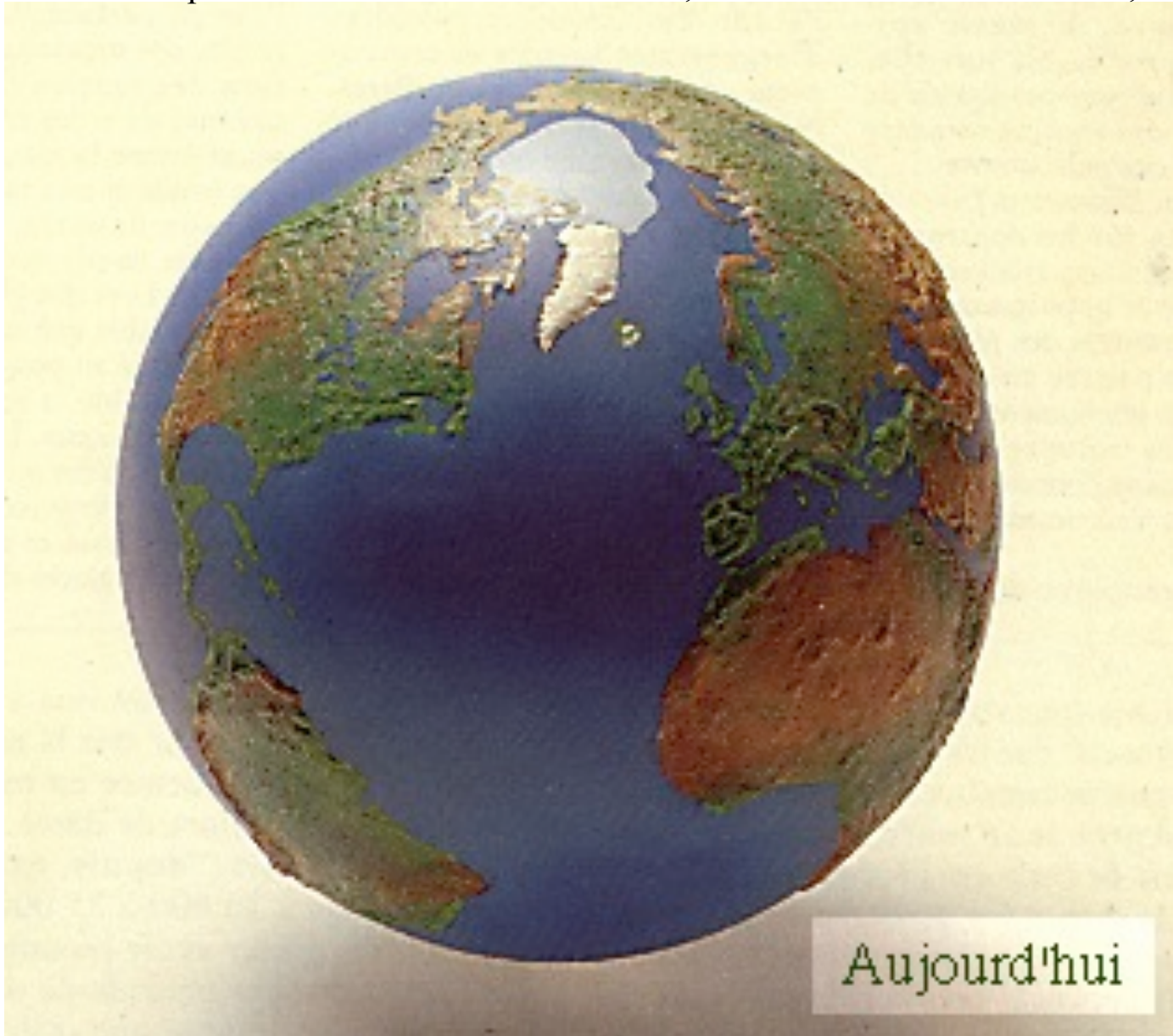
# 18-20000 years ago (Last Glacial Maximum)

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

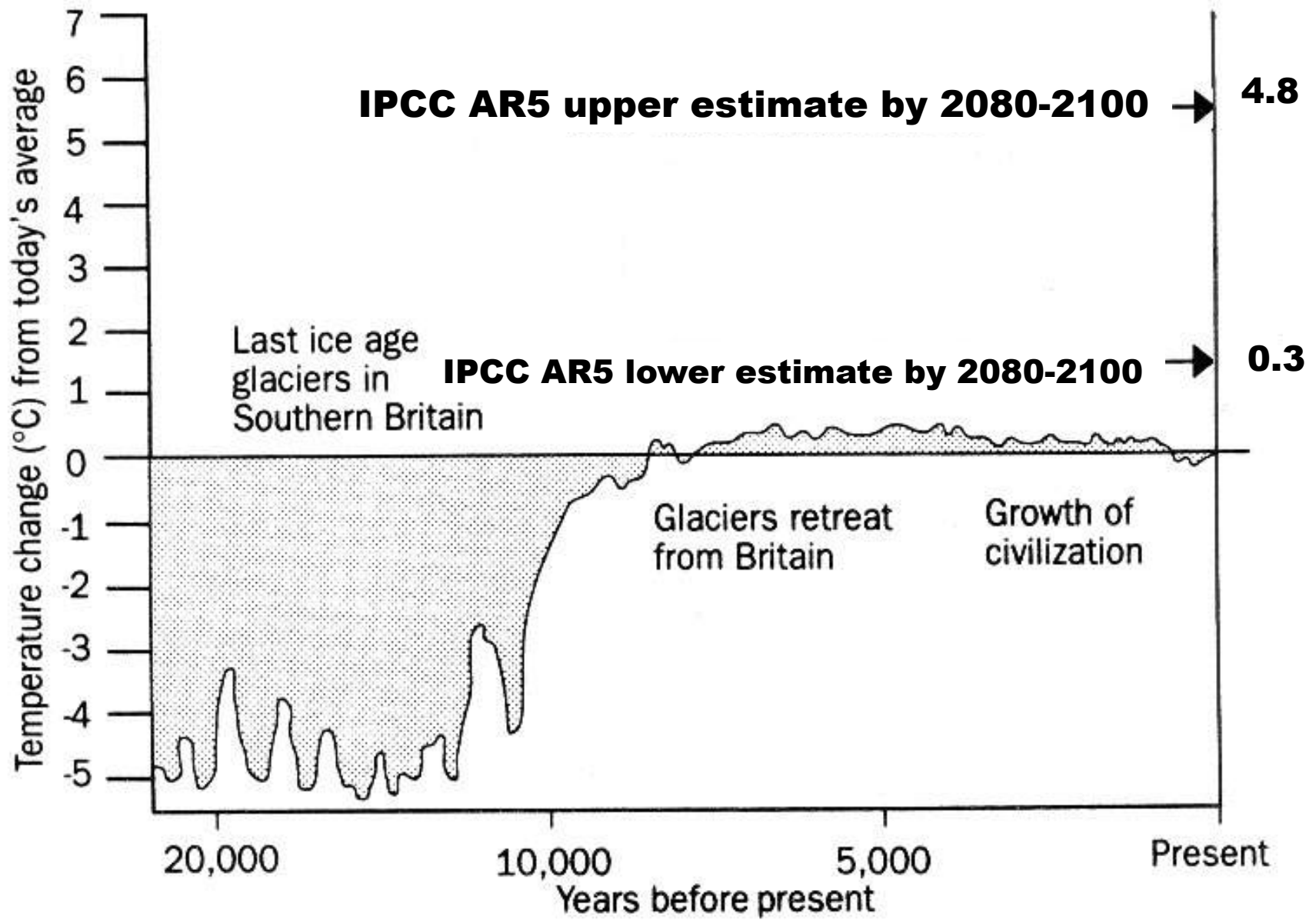


# Today, with +4-5°C globally

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, July 1988

# Discovery of the Greenhouse Effect

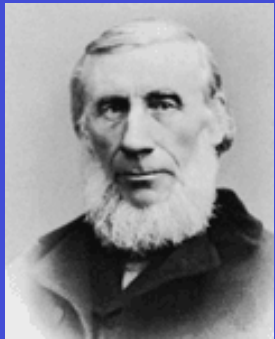
## Joseph Fourier (1827)

Recognized that gases in the atmosphere might trap the heat received from the Sun.



## James Tyndall (1859)

Careful laboratory experiments demonstrated that several gases could trap infrared radiation. The most important was simple water vapor. Also effective was carbon dioxide, although in the atmosphere the gas is only a few parts in ten thousand.



## Svante Arrhenius (1896)

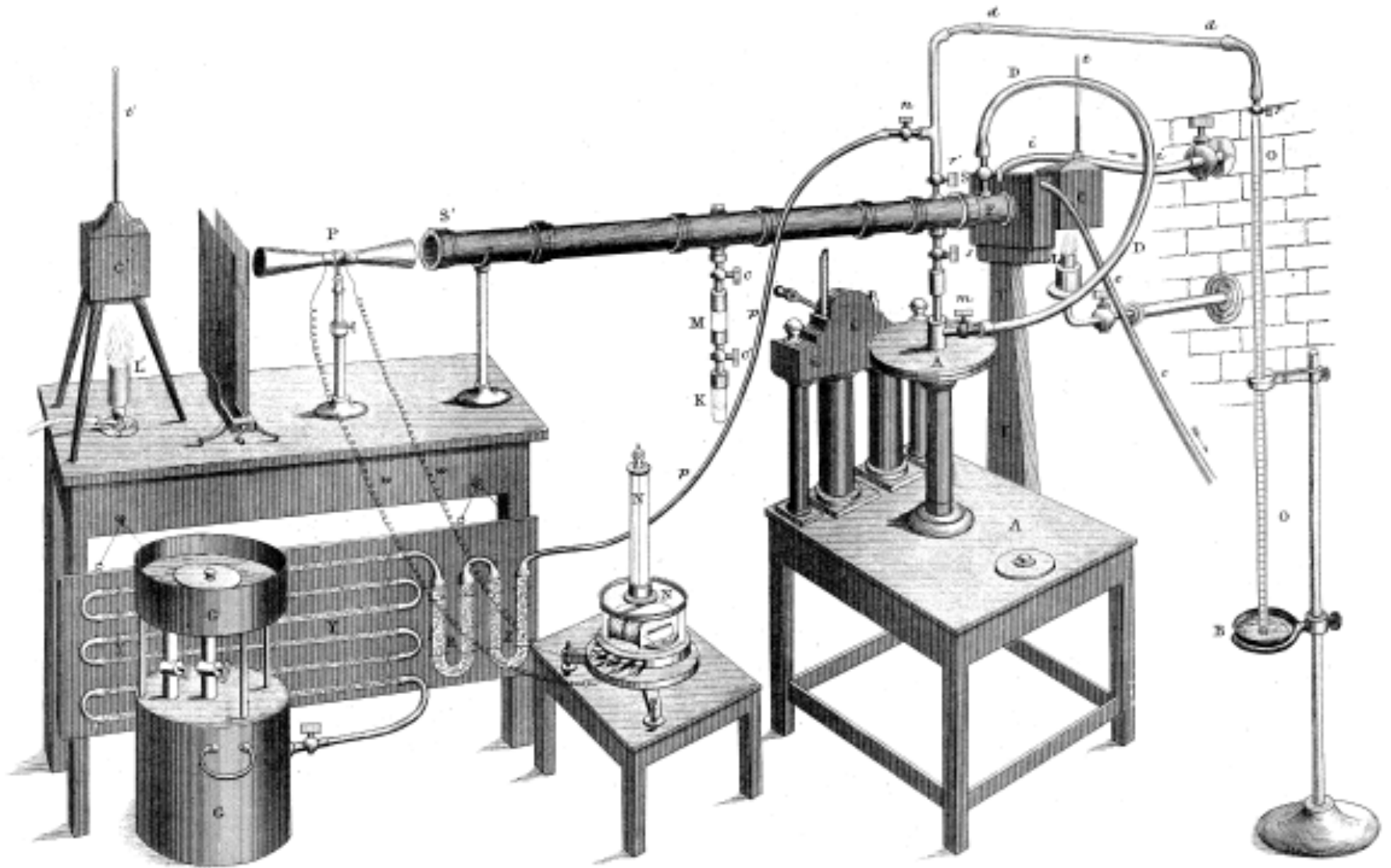
Performed numerical calculations that suggested that doubling the amount of carbon dioxide in the atmosphere could raise global mean surface temperatures by 5-6°C.



## Guy Callendar (1939)

Argued that rising levels of carbon dioxide were responsible for measurable increases in Earth surface temperatures. Estimated that doubling the amount of CO<sub>2</sub> in the atmosphere could raise global mean surface temperatures by 2°C.





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

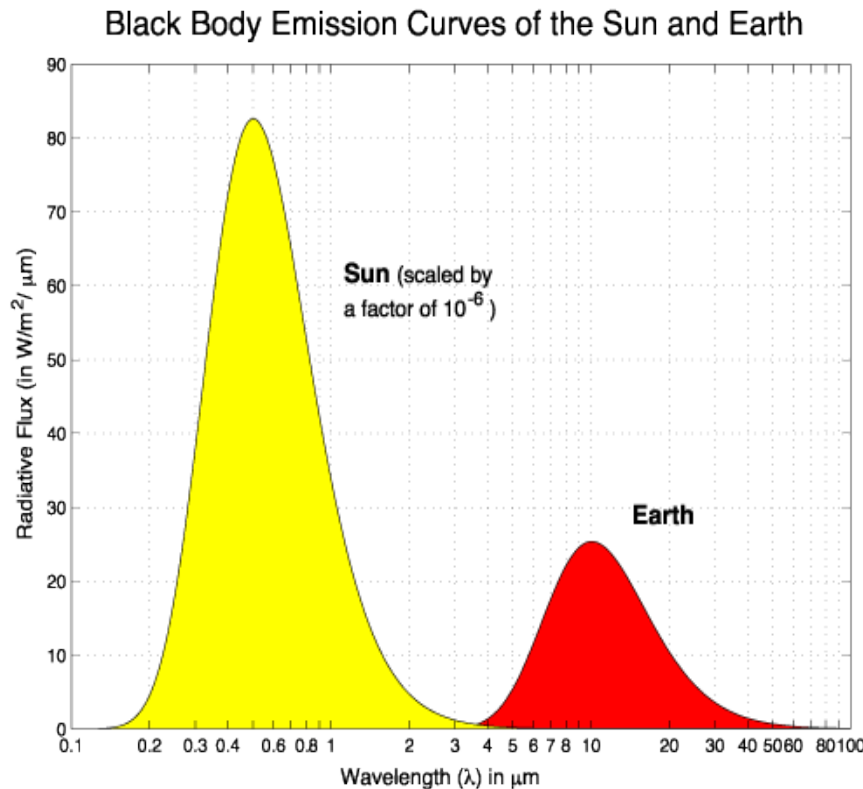


# John Tyndall (Ireland, 1859)

- “Approximate results were easily obtainable, but I aimed at **exact measurements**”
- “... during the seven weeks just referred to, I experimented from 8 to 10 hours daily
- “It is **exceedingly probable** that the absorption of the solar rays by the atmosphere, as established by M. Pouillet, is mainly due to the watery vapour contained in the air.”
- “Every variation of this constituent (aqueous vapour) must produce a change in climate. Similar remarks would apply to the **carbonic acid** diffused through the air.”

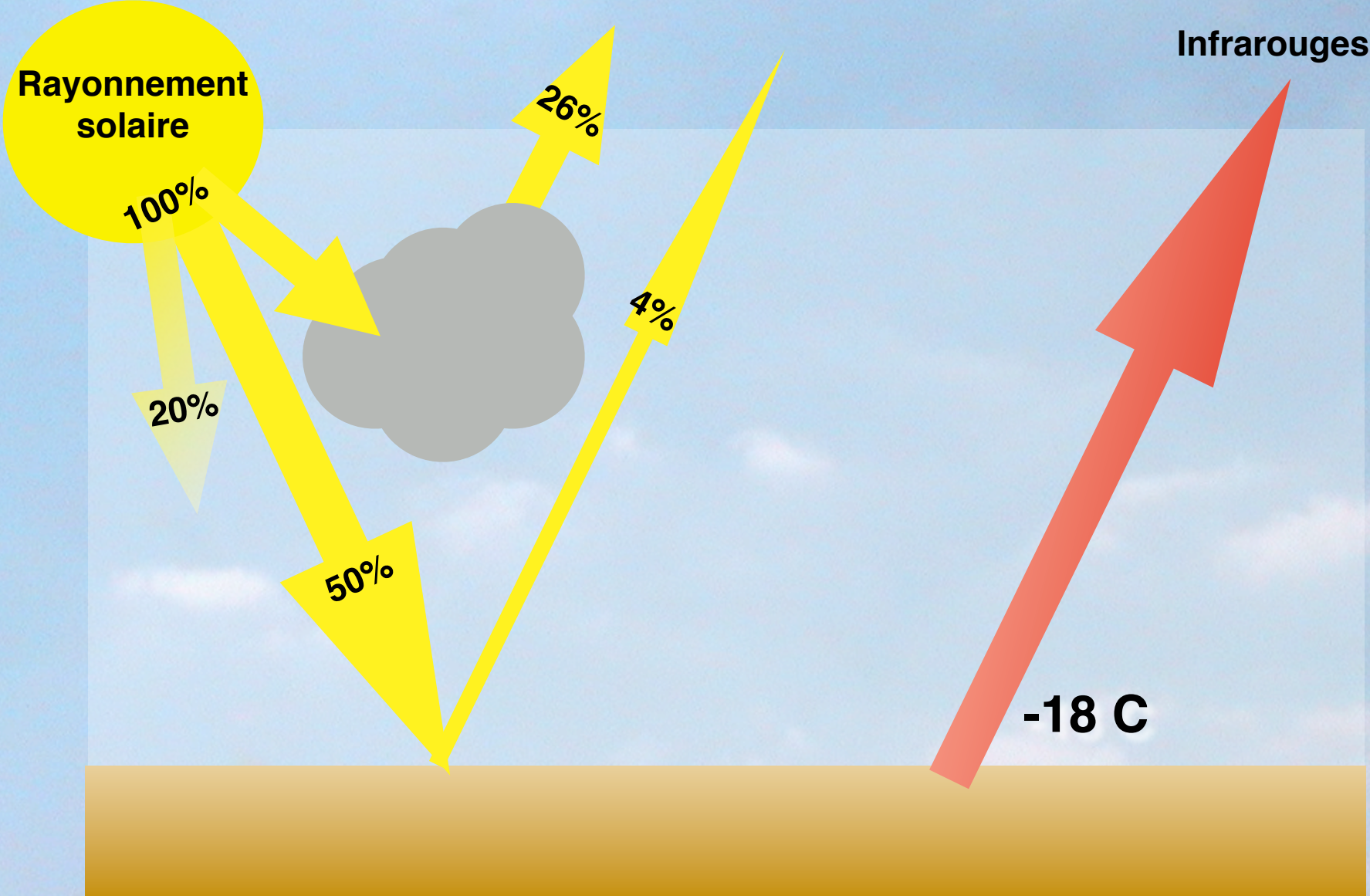
# 2.1.1 The heat balance at the top of the atmosphere: a global view

Outside the Earth's atmosphere, a surface at the mean Earth-Sun distance perpendicular to the rays receives about  $1368 \text{ W/m}^2$ . This is called the **total solar irradiance** (TSI). To achieve a heat balance, the Earth emits radiations, in the infra-red part of the spectrum.



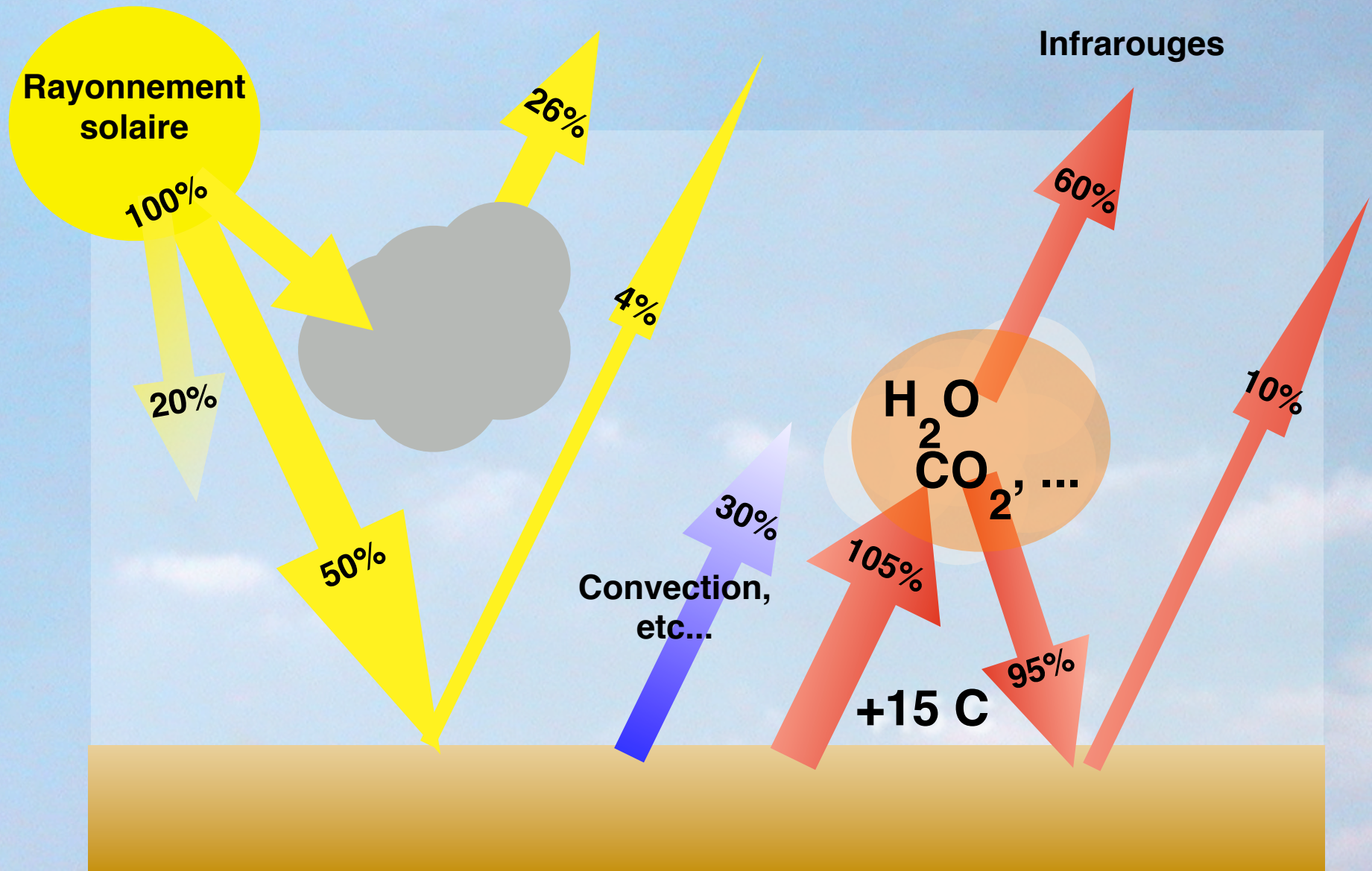
Spectrum of the energy received from the Sun and emitted by the Earth at the top of the atmosphere. Figure from Y. Kushnir.

# Cycle de l'énergie et effet de serre

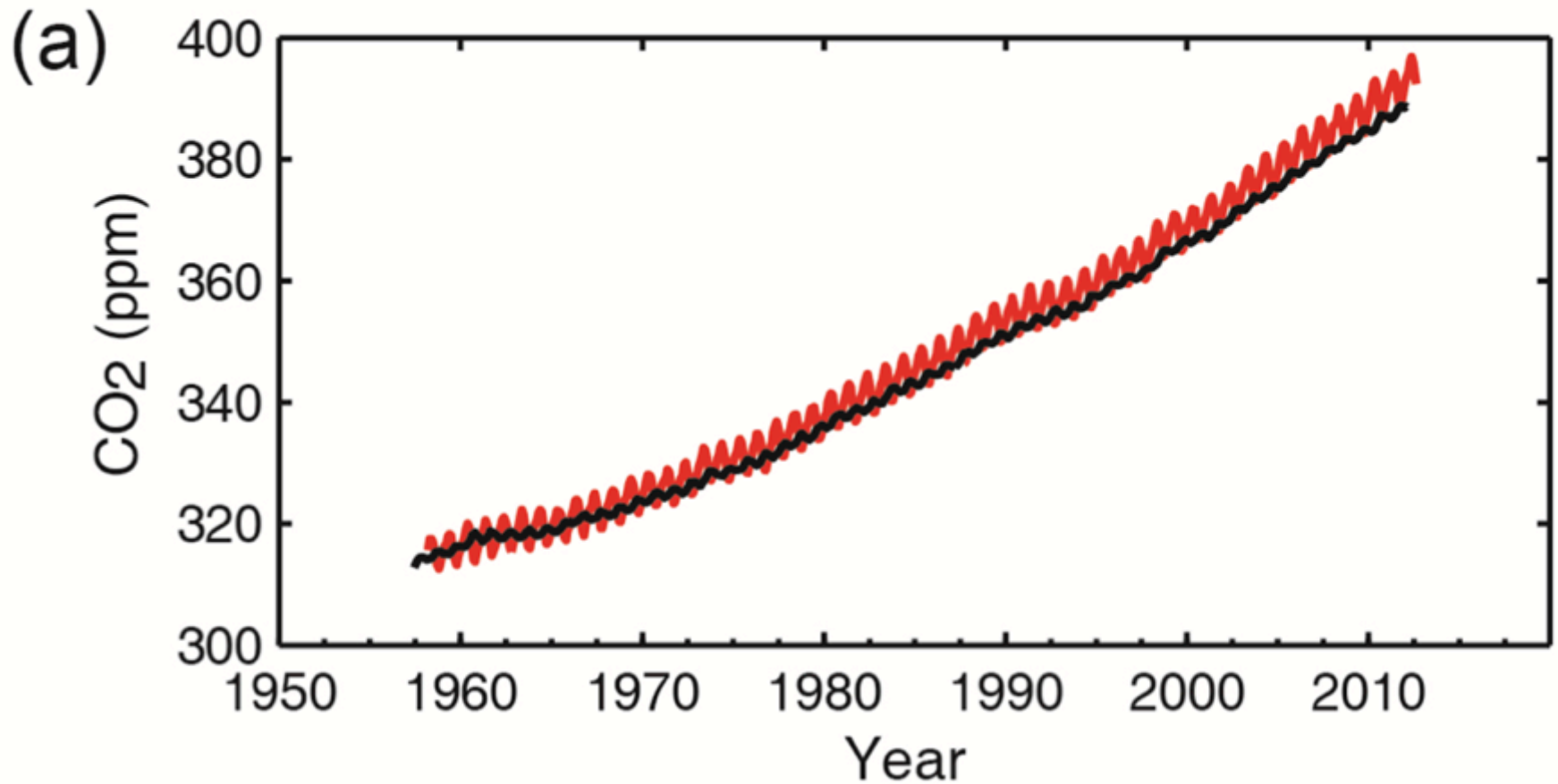




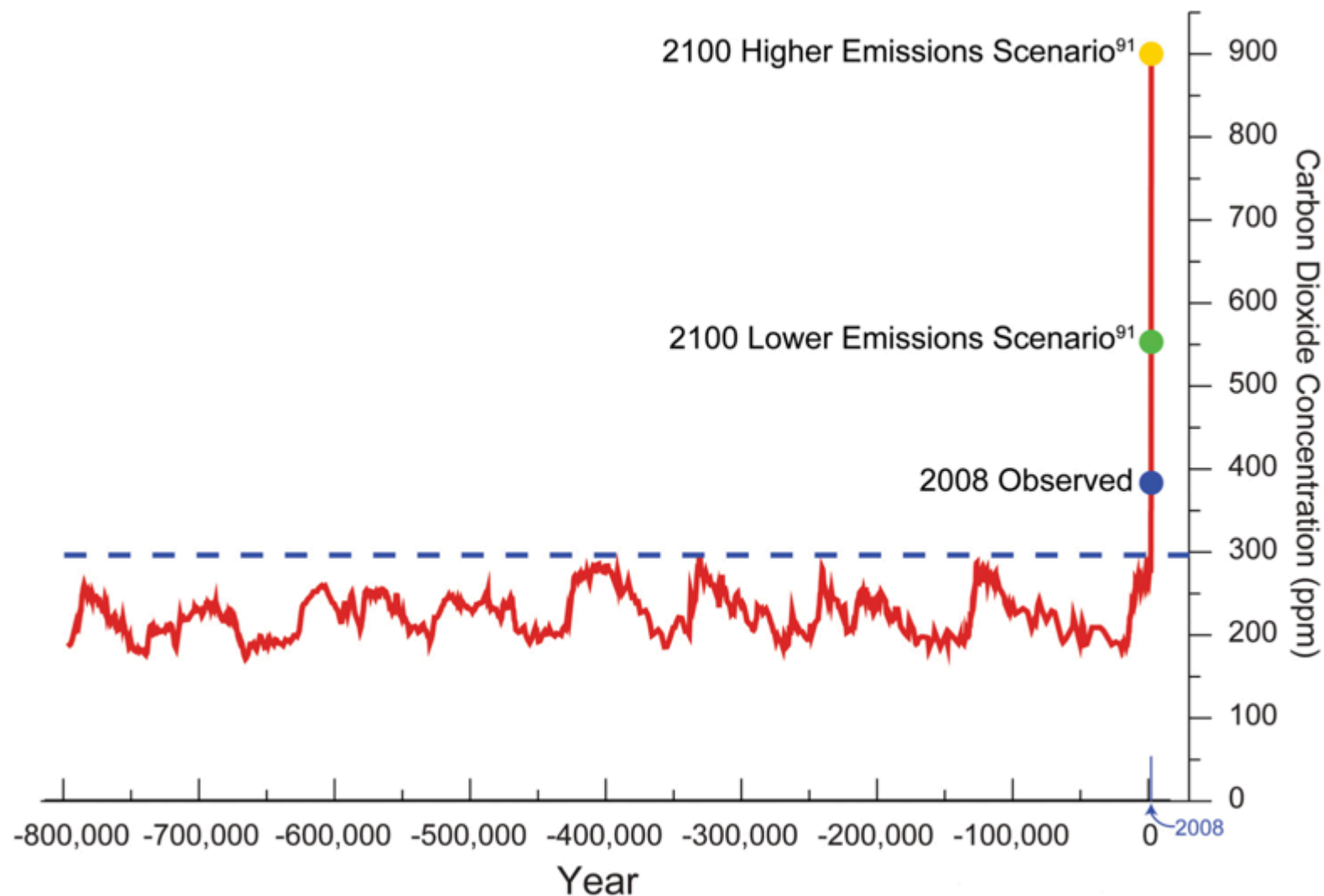
# Cycle de l'énergie et effet de serre



# Atmospheric CO<sub>2</sub> concentration

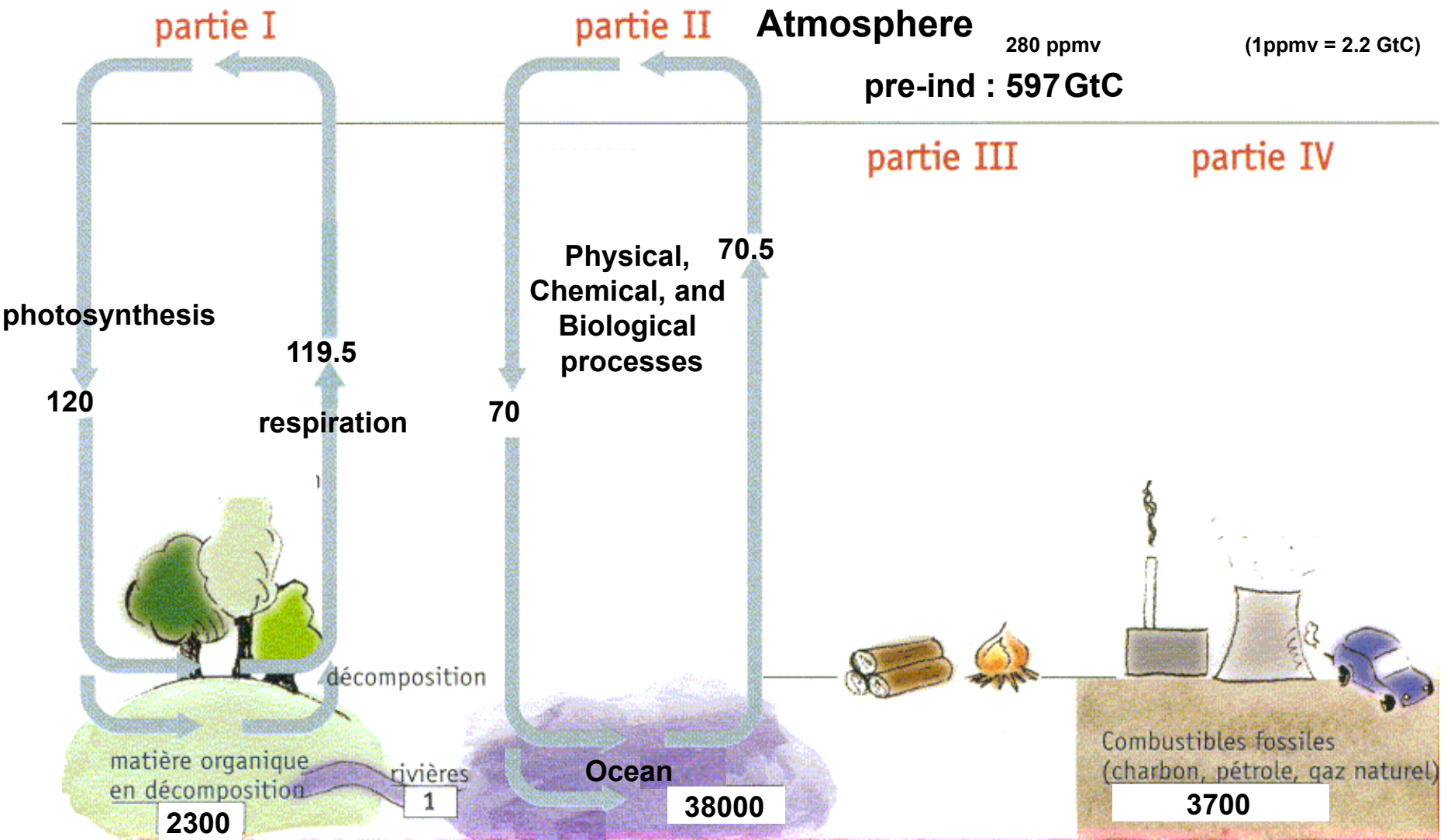


# Atmospheric CO<sub>2</sub> over the last 800,000 years



Lüthi *et al.*; Tans; IIASA<sup>2</sup>

# Carbon cycle: unperturbed fluxes



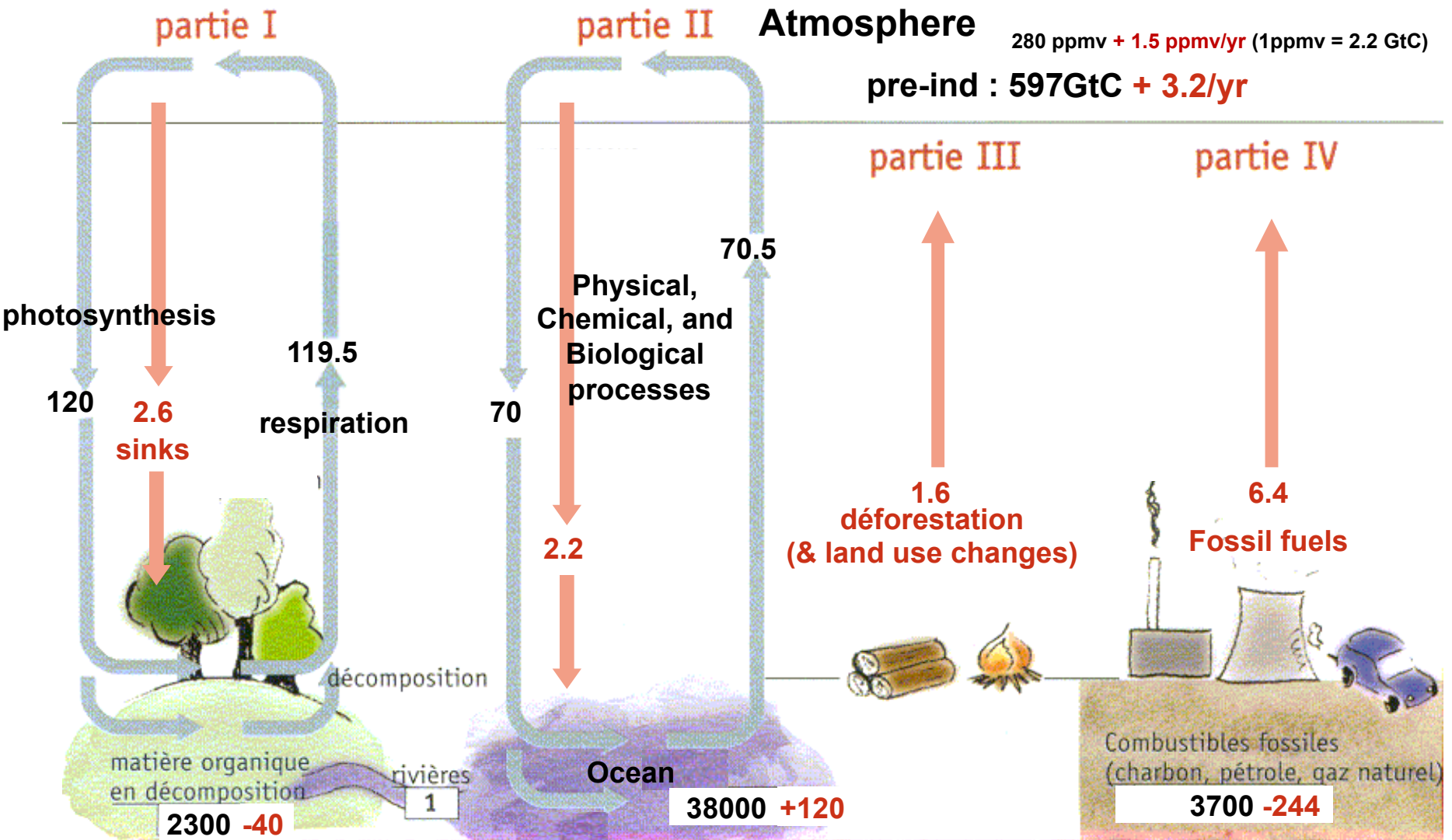
Units: GtC (billions tons of carbon) or GtC/year (multiply by 3.7 to get GtCO<sub>2</sub>)

Source: JP van Ypersele, vanyp@climate.be



# Carbon cycle: perturbed by human activities

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

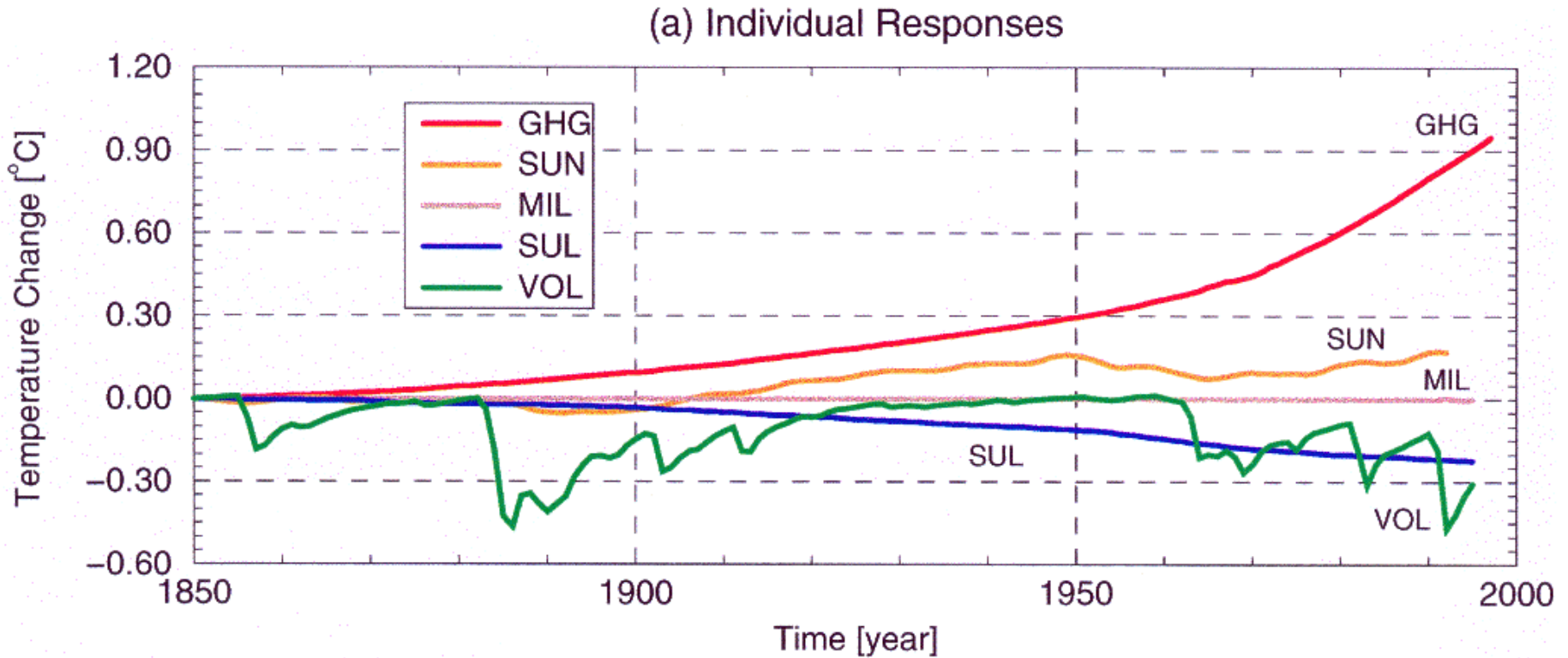


Units: GtC (billions tons of carbon) or GtC/year

Stocks!

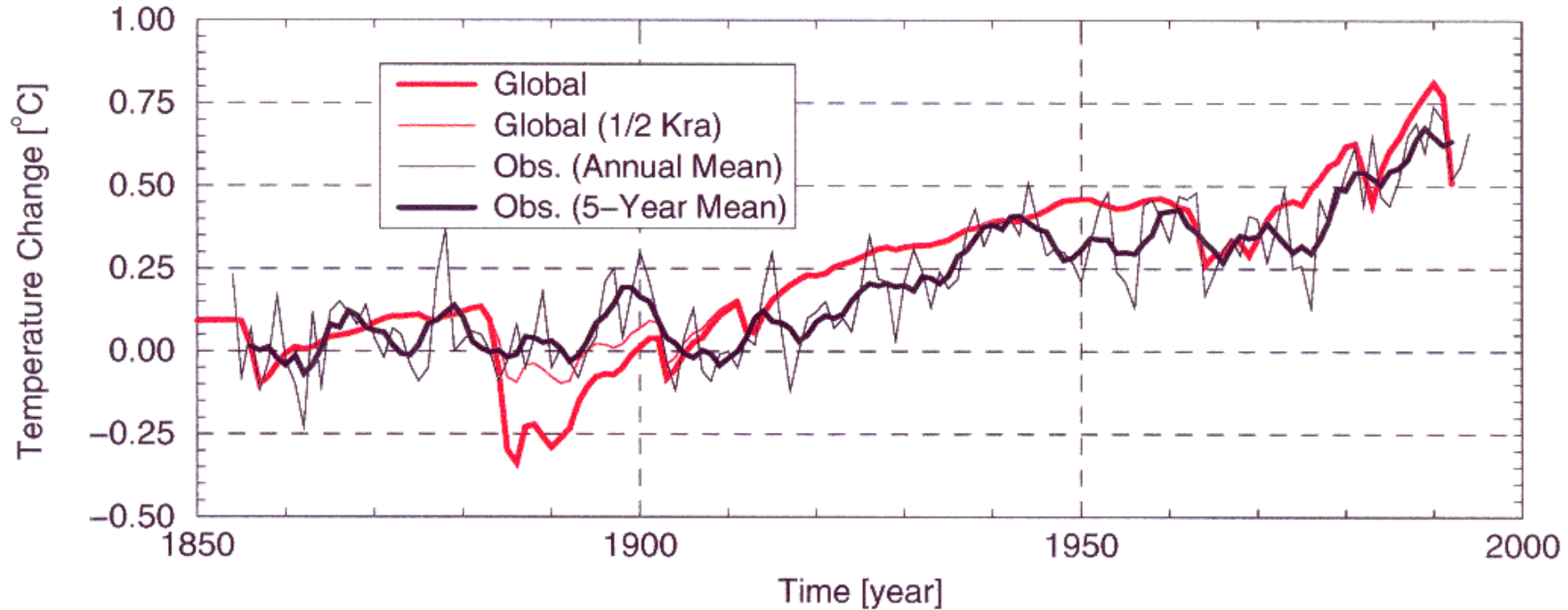
Source: JP van Ypersele, vanyp@climate.be

# Separate effect of different factors in the 2-dimensional climate model at UCL



# Combined effect of all factors in the 2-dimensional climate model at UCL

(c) Global Response



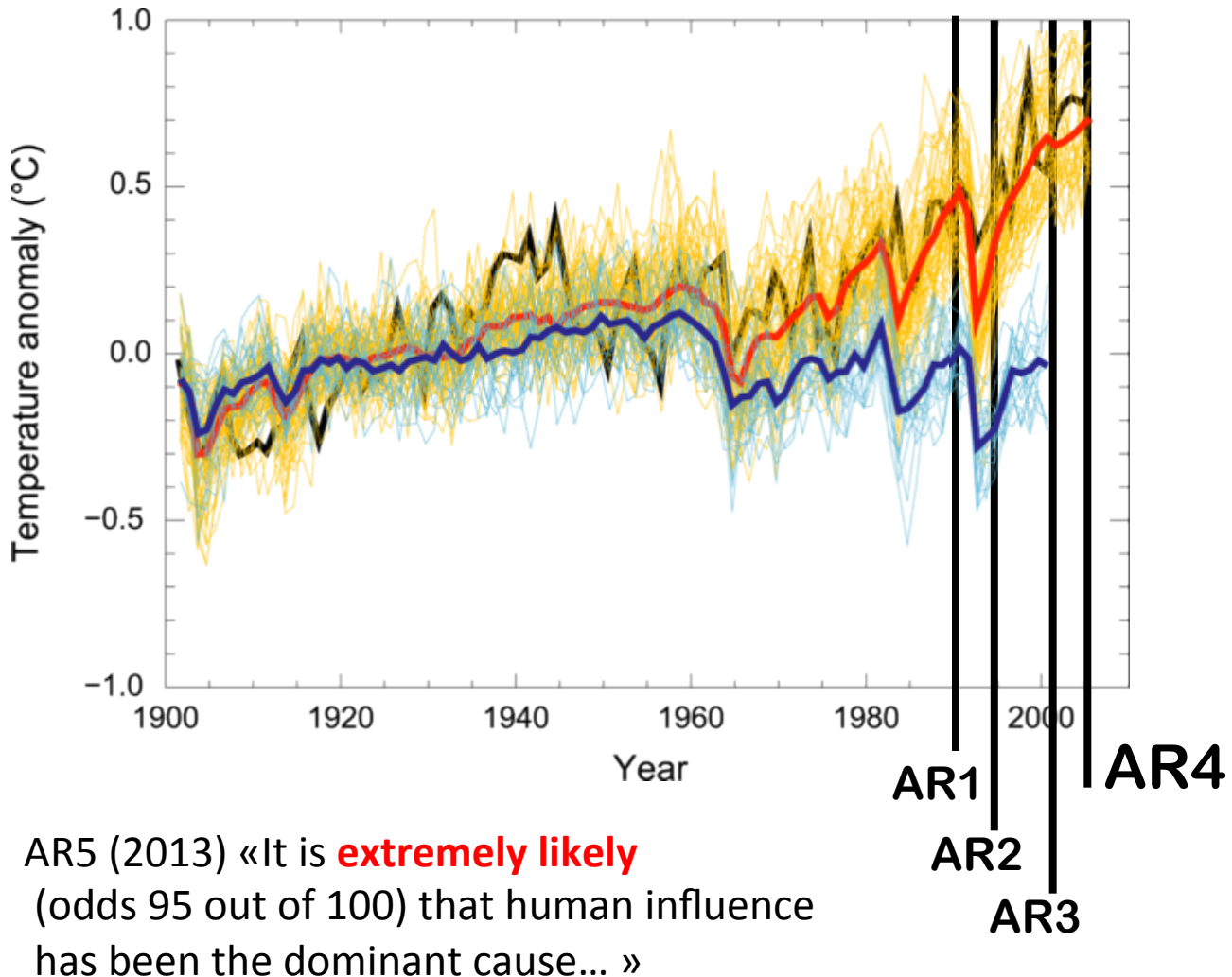
# A Progression of Understanding: Greater and Greater Certainty in Attribution

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... »



# 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.

**IPCC**=Intergovernmental Panel on Climate Change (GIEC en français)

**WMO**=World Meteorological Organization

**UNEP**= United Nations Environment Programme



IPCC Reports are  
policy-relevant,  
NOT  
policy-prescriptive

# IPCC writing cycle (5 years, 2500 scientists)

- 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!***

# Completed IPCC Reports

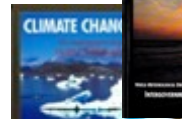
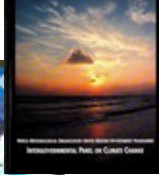
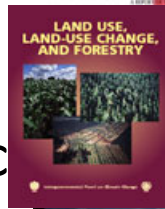
5 Assessment Reports (1990, 1995, 2001, 2007, 2013-14)

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**
- 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****

# Recent/Coming IPCC Products

- ***2011: Special report on Renewable Energy Sources and Climate Change Mitigation***
- ***2011: Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation***
- ***2013: AR5 WGI report (physical science)***
- ***2014: AR5 WGII (Impacts & Adaptation); WGIII (Mitigation), Synthesis Report***
- ***All available on [www.ipcc.ch](http://www.ipcc.ch)***

# Useful links:



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

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