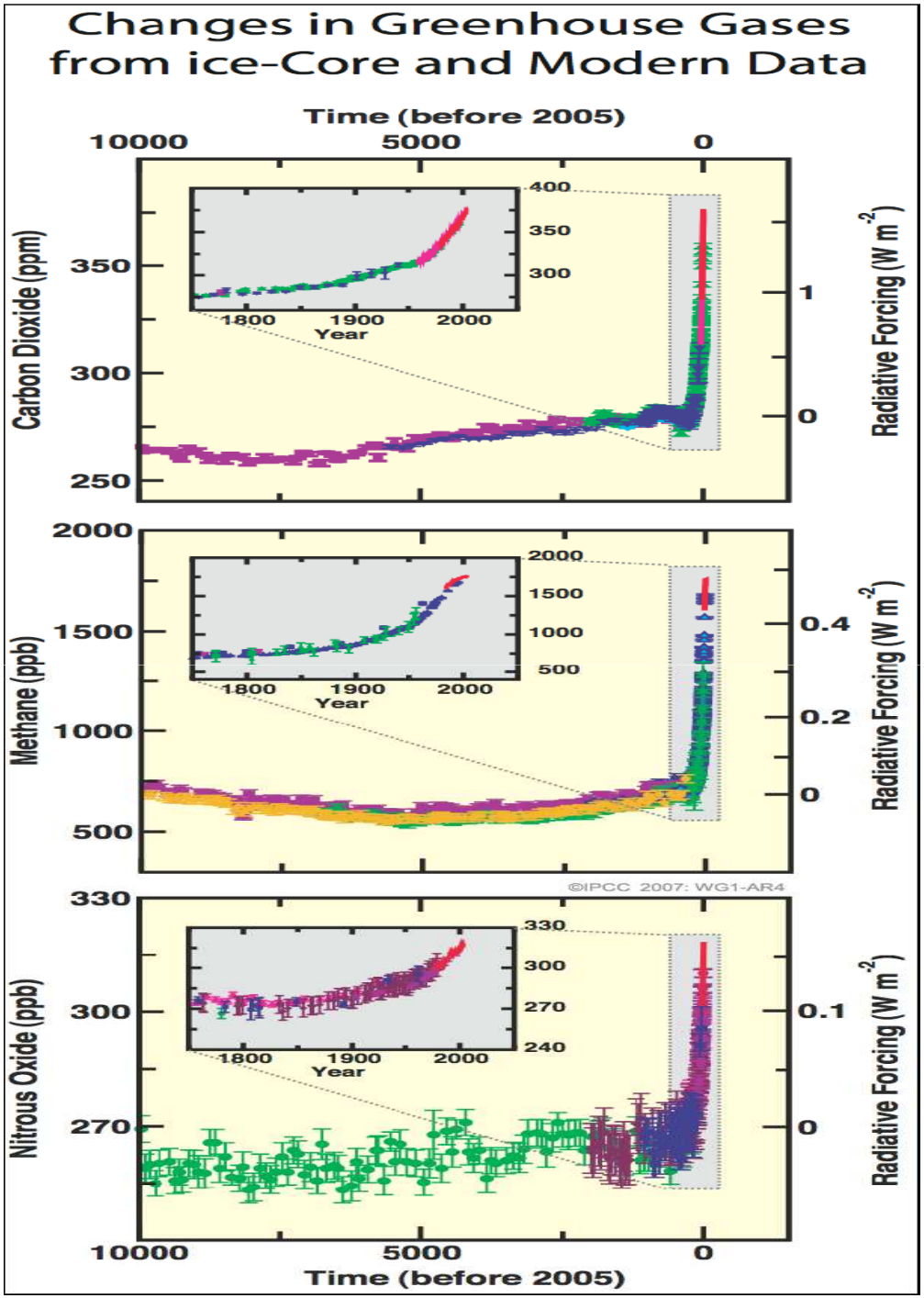
Institut Pierre Simon Laplace

Institut de recherche en sciences de l'environnement

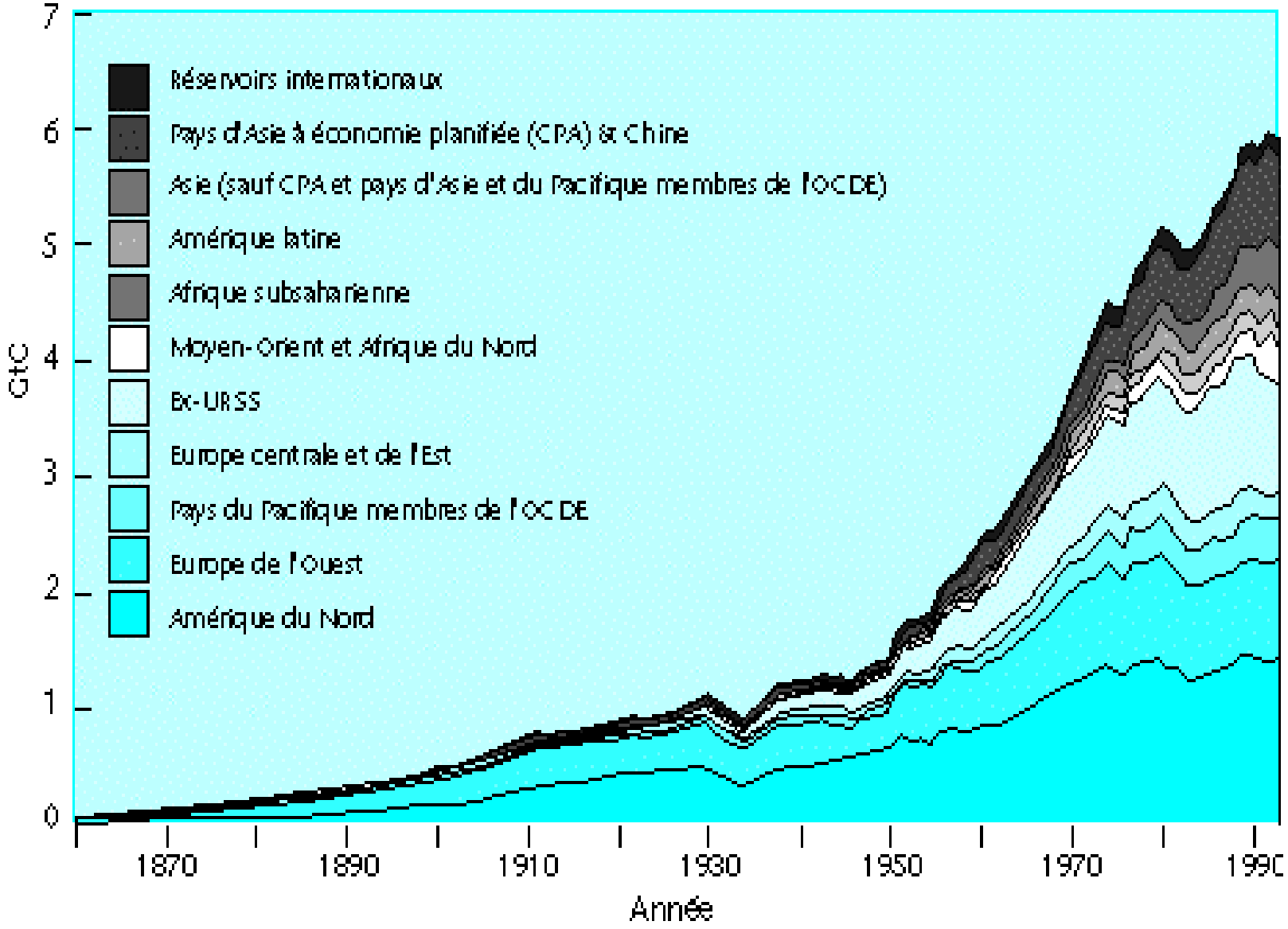
Changements climatiques: Les enjeux de la recherche

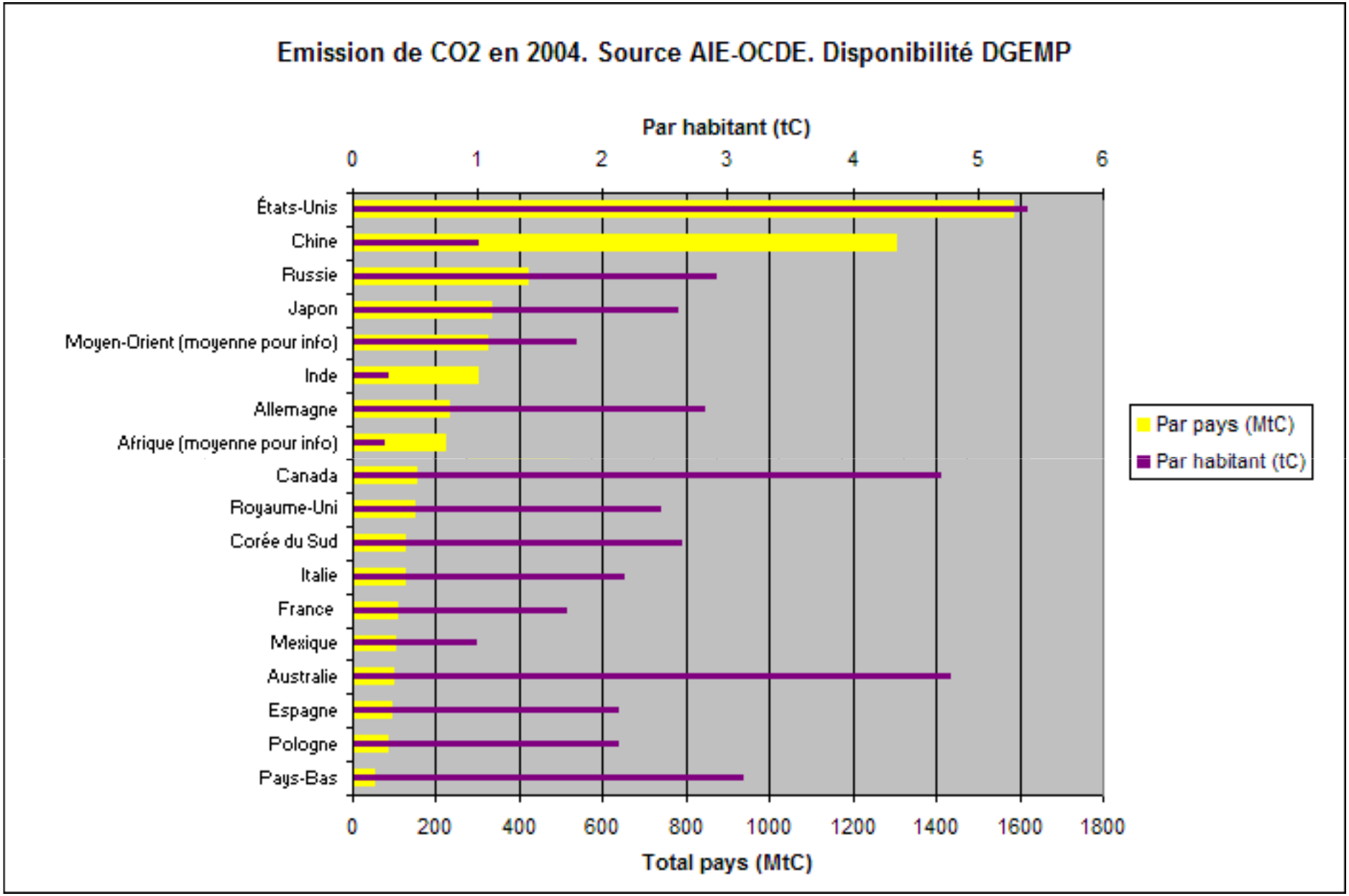
Hervé Le Treut

10 000 ans d’histoire
des gaz à effet de serre

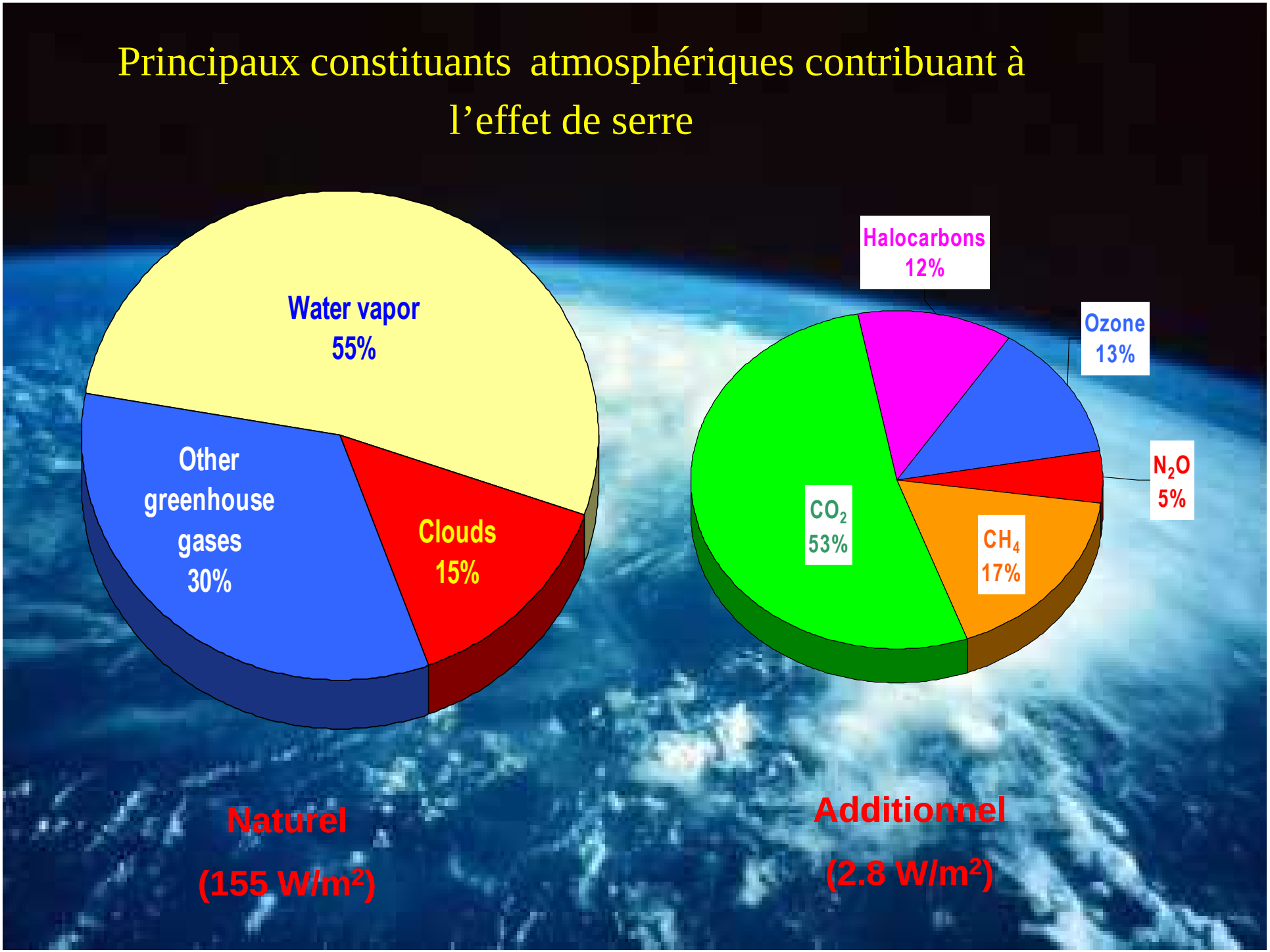


Les émissions anthropiques de dioxyde de carbone ont augmenté au cours des dernières décennies.

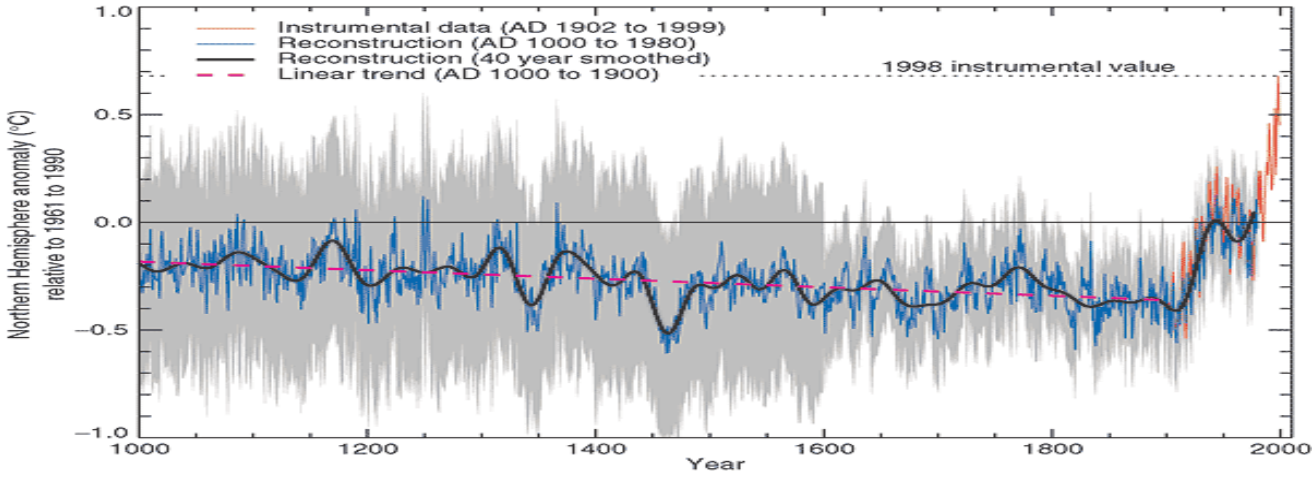



Emission de CO2 en 2004. Source AIE-OCDE. Disponibilité DGEMP
Par habitant (tC)
0
1
2
3
4
5
6
États-Unis
Chine
Russie
Japon
Moyen-Orient (moyenne pour info)
Inde
Allemagne
Afrique (moyenne pour info)
Canada
Royaume-Uni
Corée du Sud
Italie
France
Mexique
Australie
Espagne
Pologne
Pays-Bas
0
200
400
600
800
1000
1200
1400
1600
1800
Total pays (MtC)
Par pays (MtC)
Par habitant (tC)

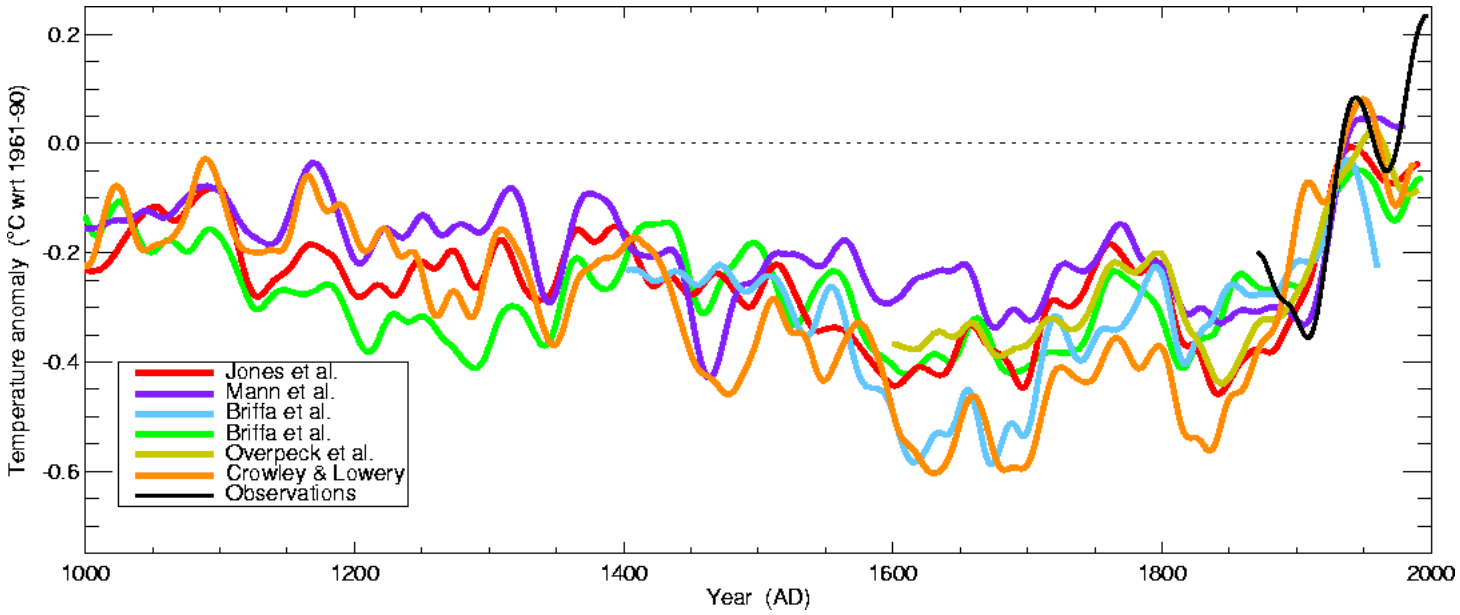
Principaux constituants atmosphériques contribuant à l'effet de serre



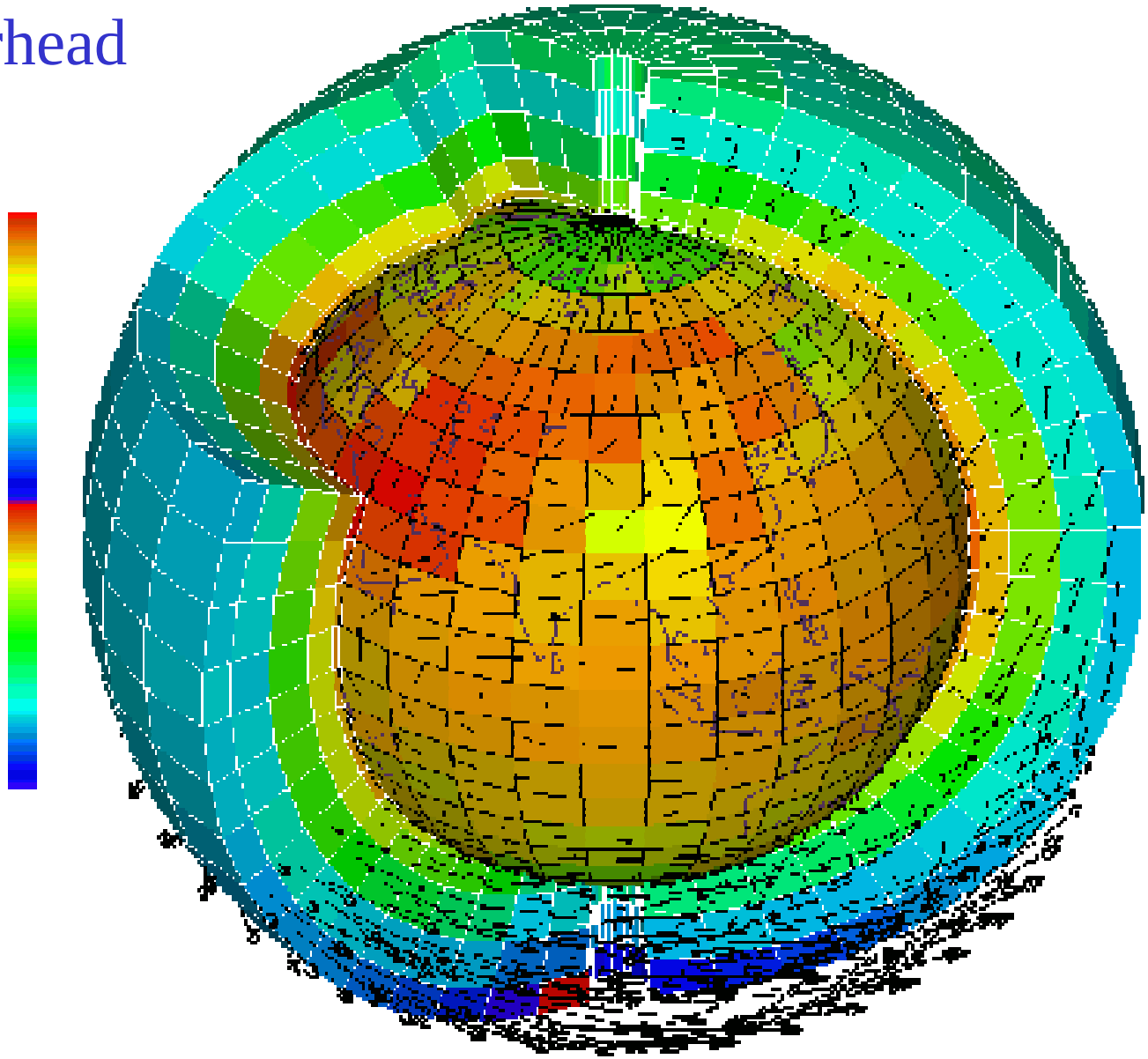
Un effet important ?



Mann, IPCC, 2001



L. Fairhead



Teraflops

Gigaflops

Megaflops

X
Earthsimulator

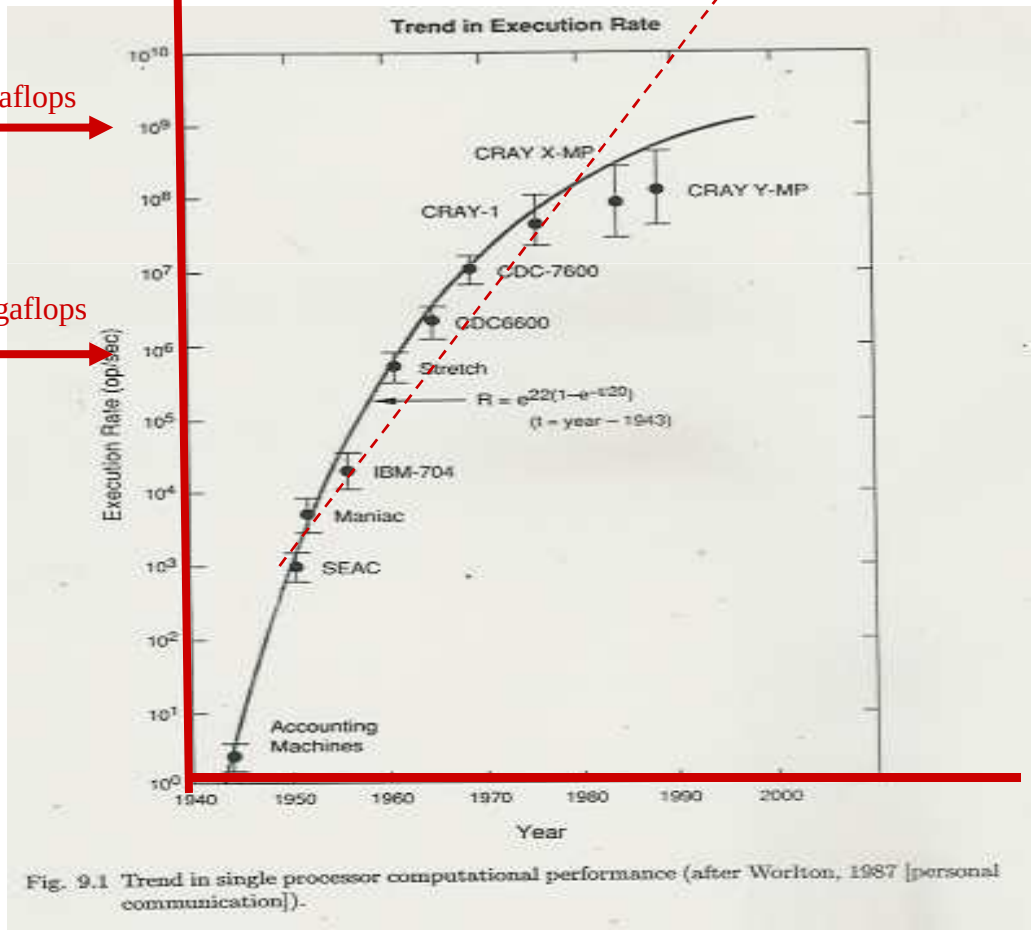


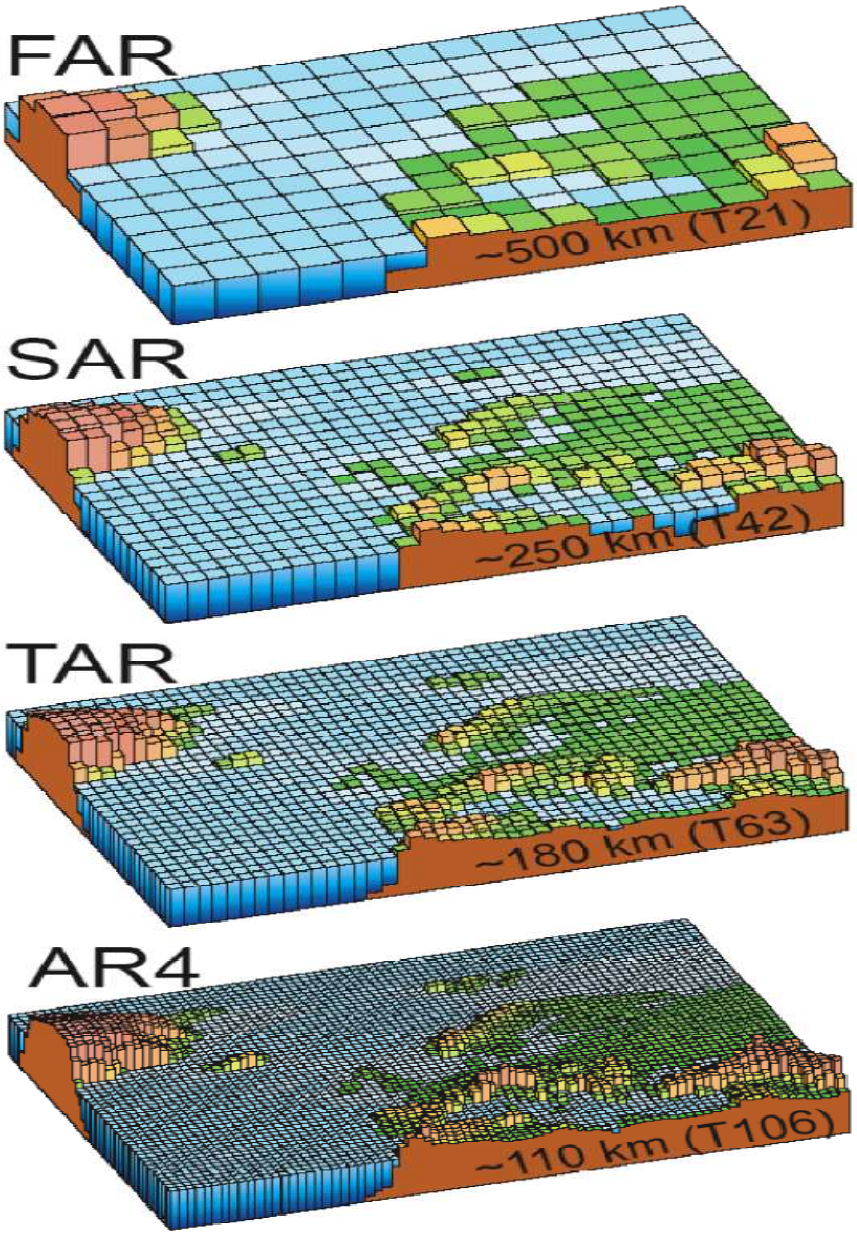
Fig. 9.1 Trend in single processor computational performance (after Worlton, 1987 [personal communication]).

→ 2010?: modèles globaux non-hydrostatiques, 3.5km de résolution

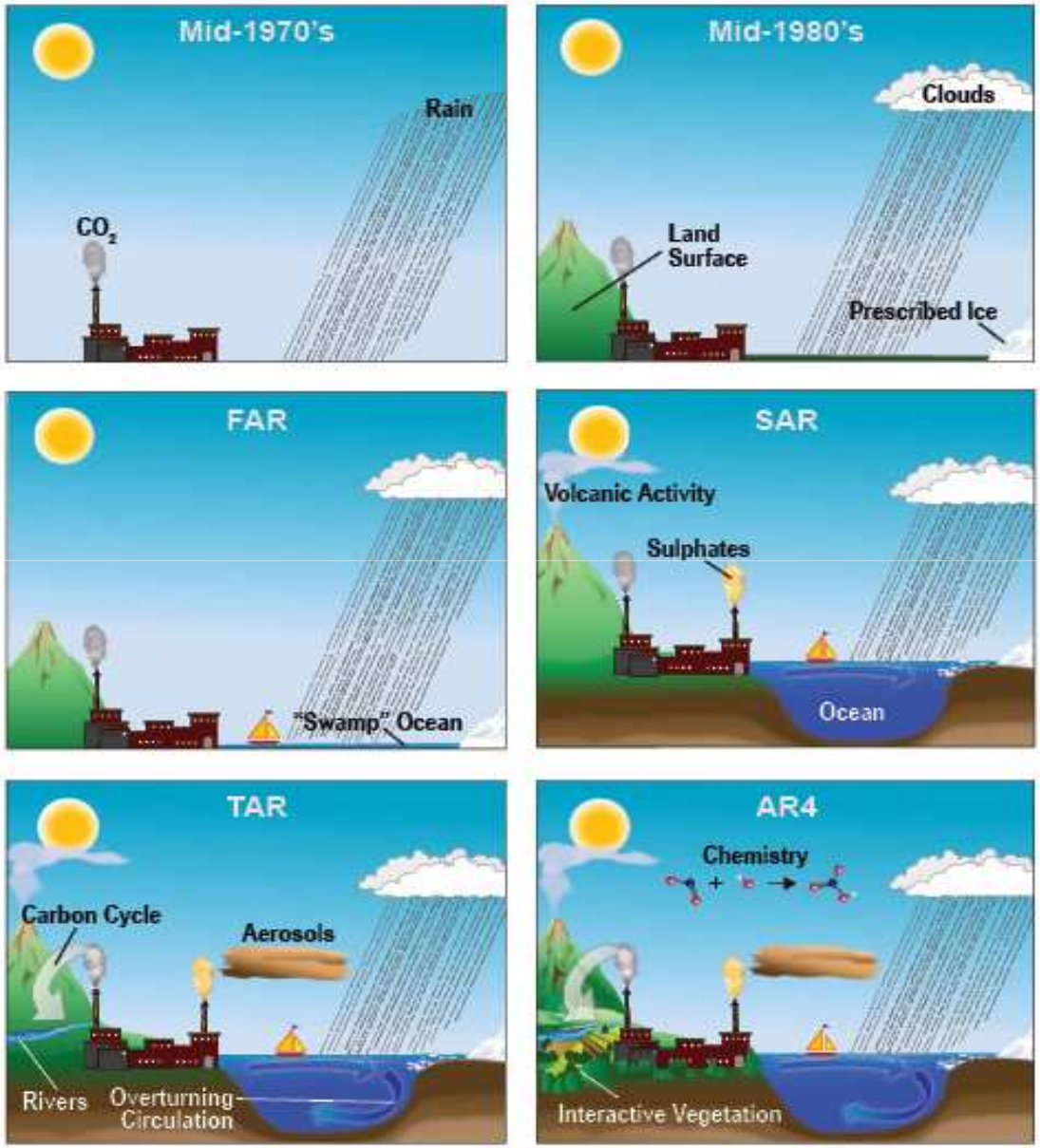
→ 2000: modèles couplés océan-atmpsphère, 300 km de résolution

→ 1980: modèles climatiques atmosphériques hydrostatiques, 500 km de résolution

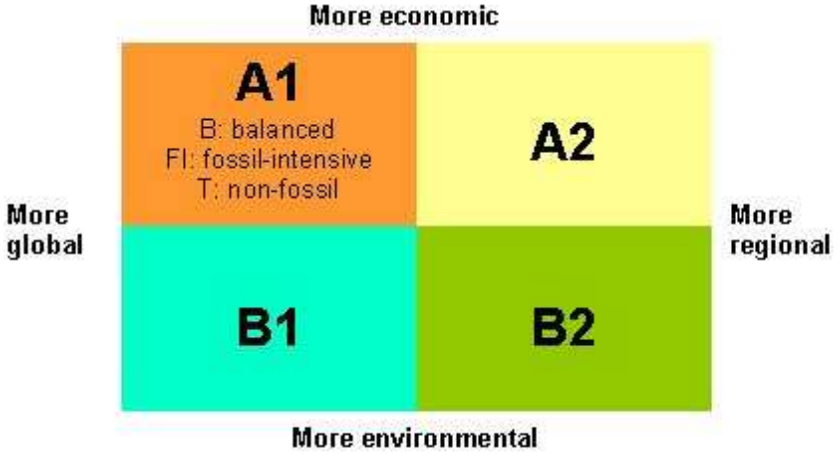
→ 1950: modèles quasigéostrophiques

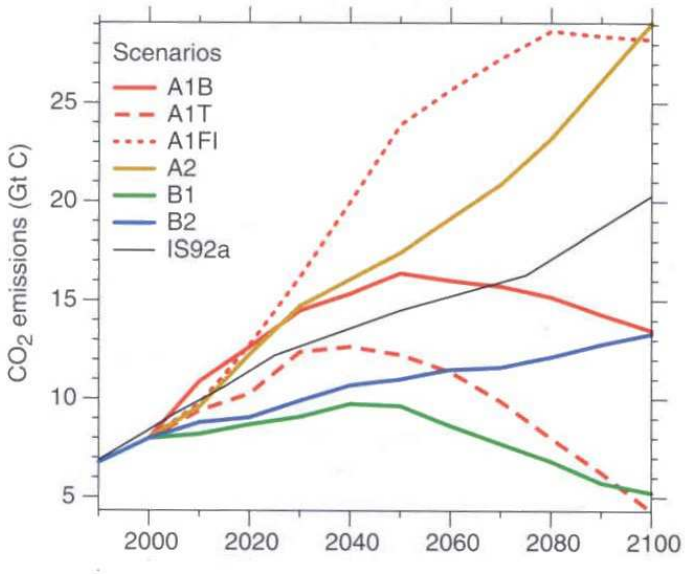

FAR
~500 km (T21)
SAR
~250 km (T42)
TAR
~180 km (T63)
AR4
~110 km (T106)

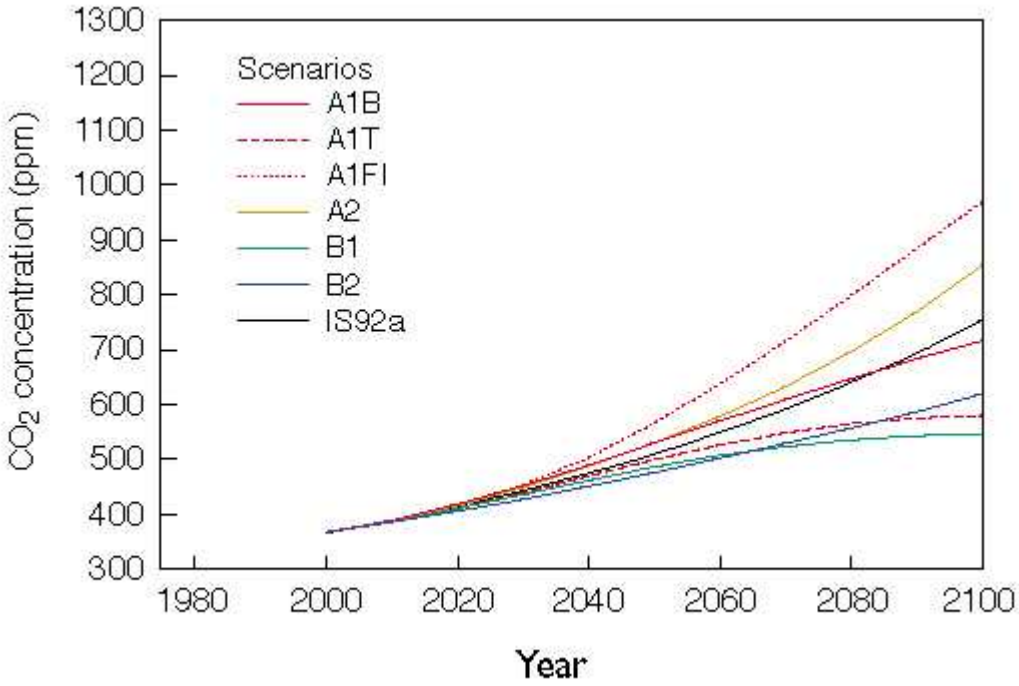
The World in Global Climate Models



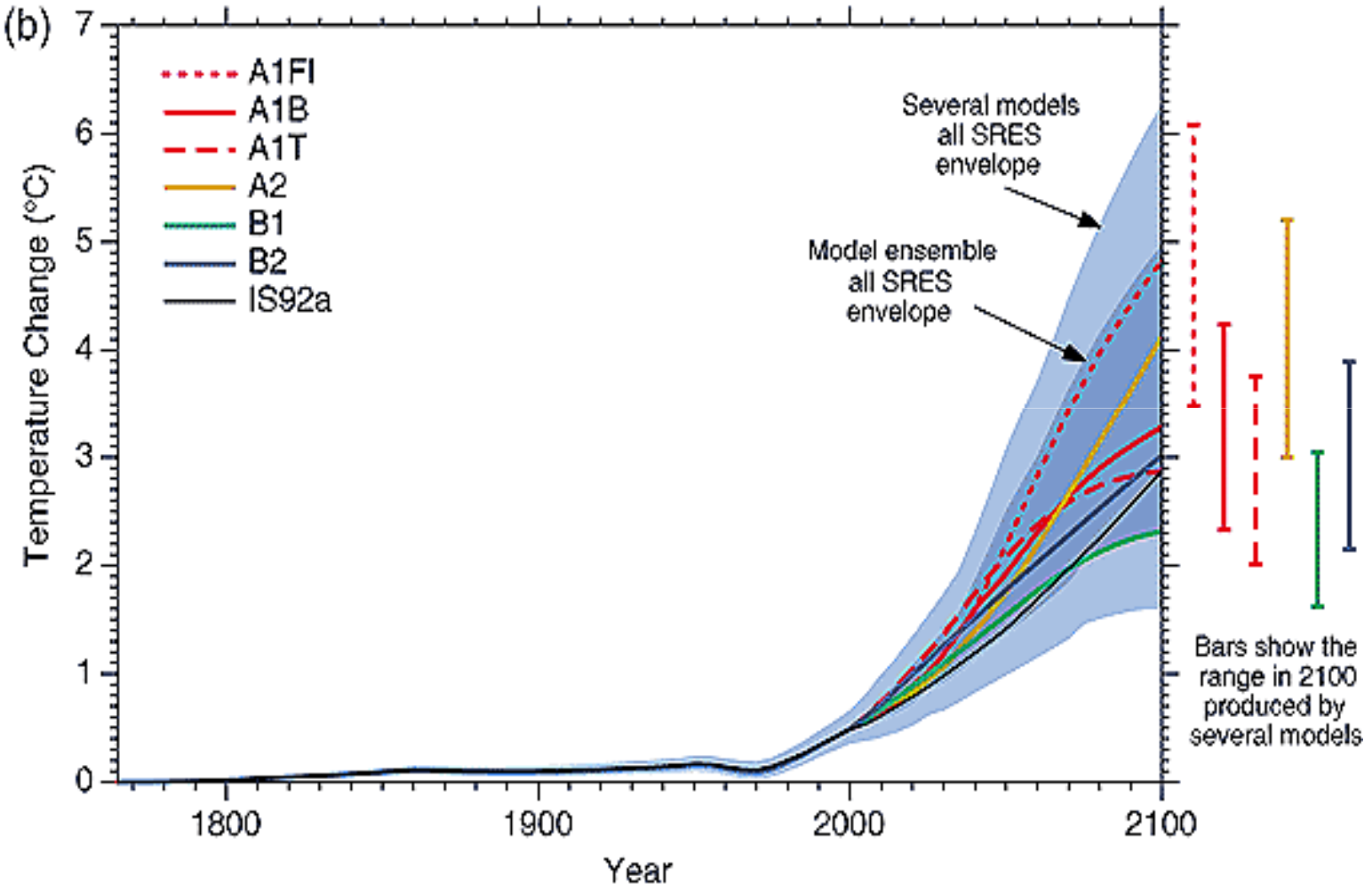
Les scénarios du GIEC: un outil de réflexion sur le futur



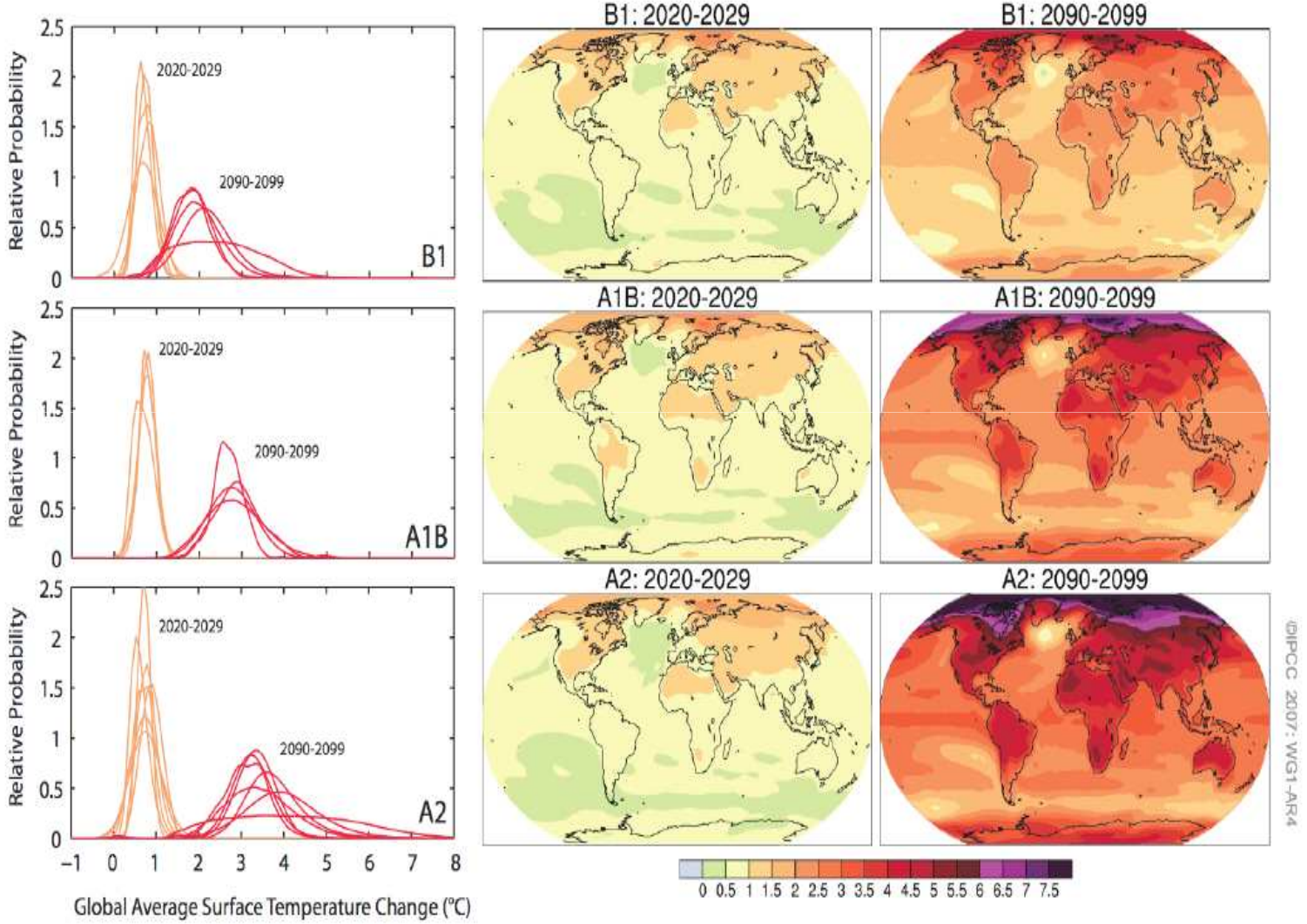




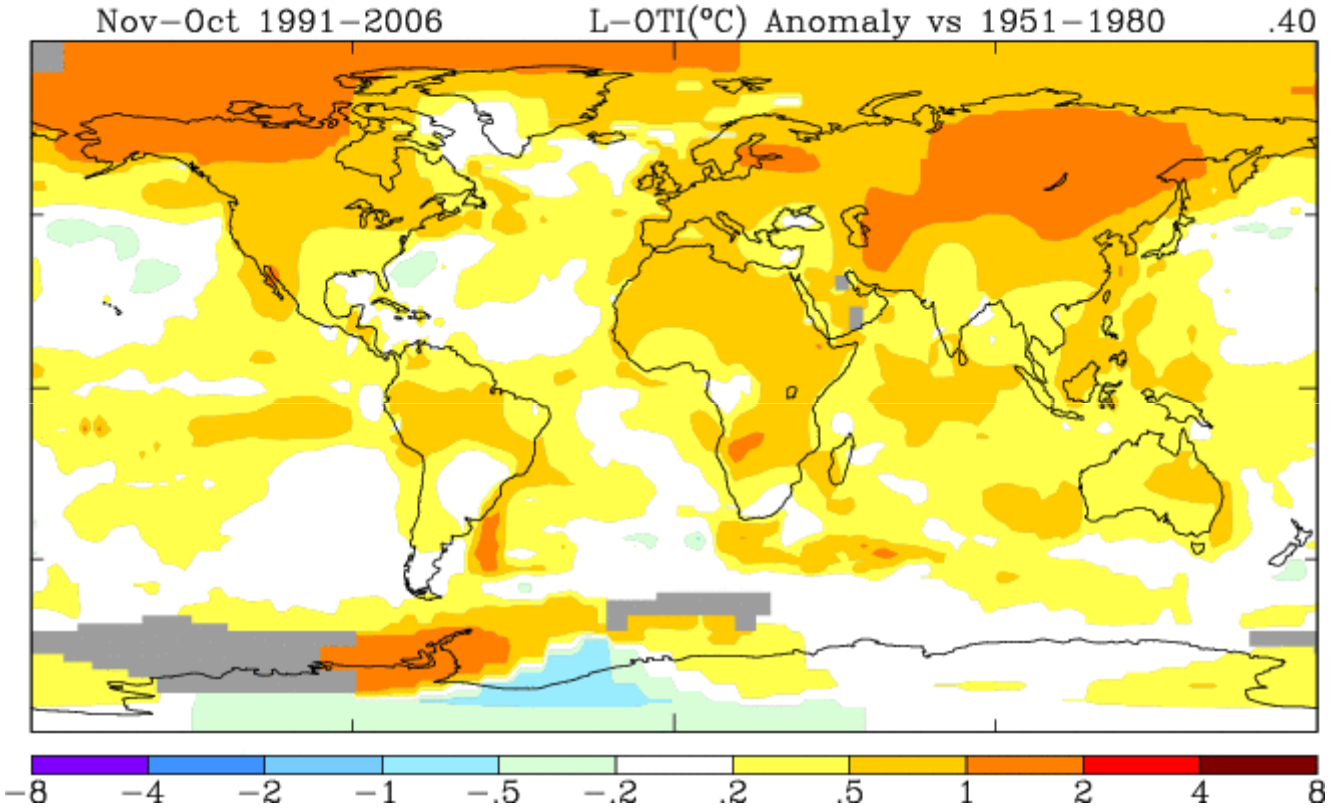
Un exemple de communication mal comprise: GIEC 2001



AOGCM Projections of Surface Temperatures

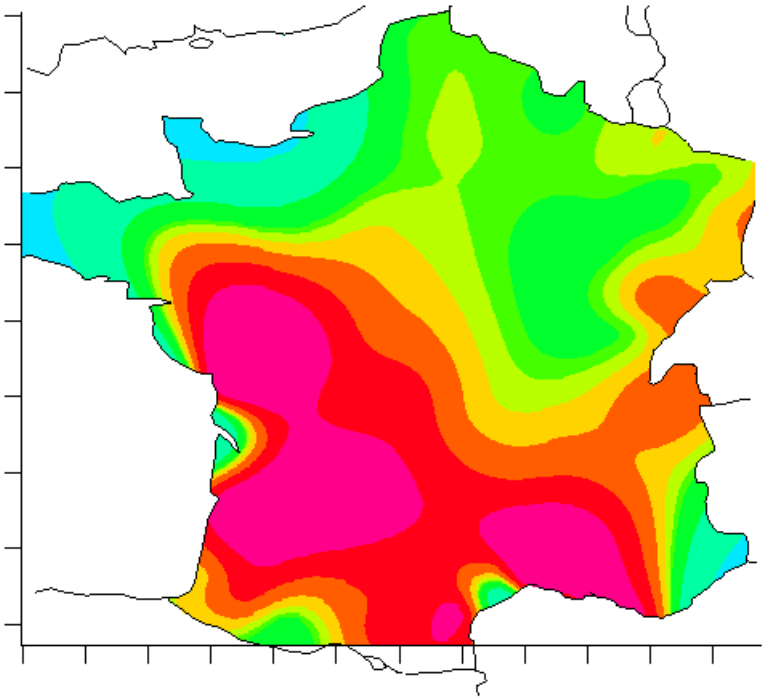


Changements observés

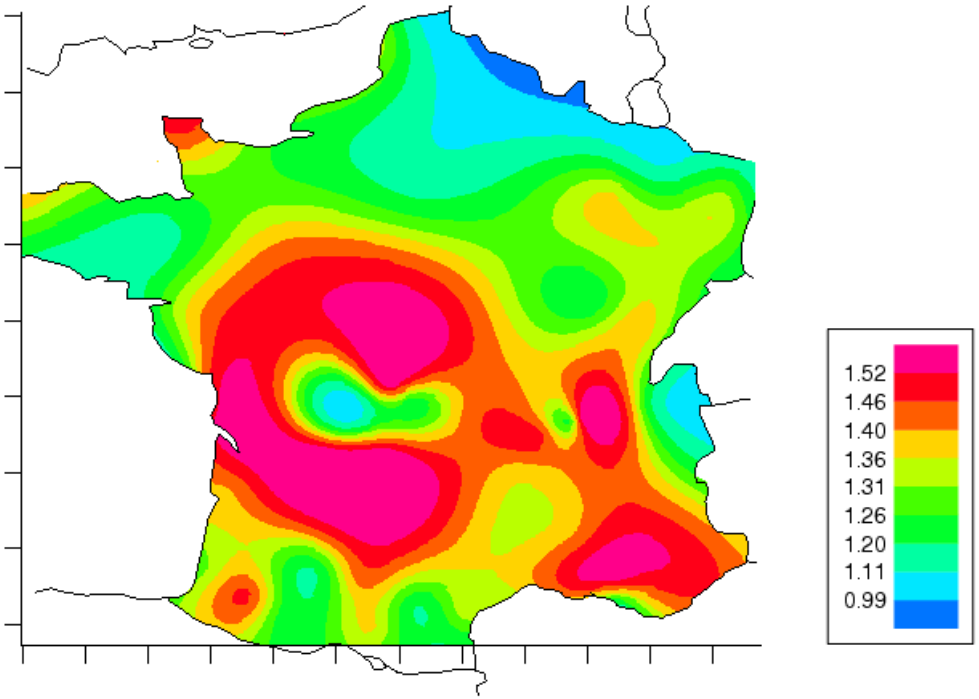


Changement de température minimale journalière d'été

Détection/attribution à l'échelle régionale

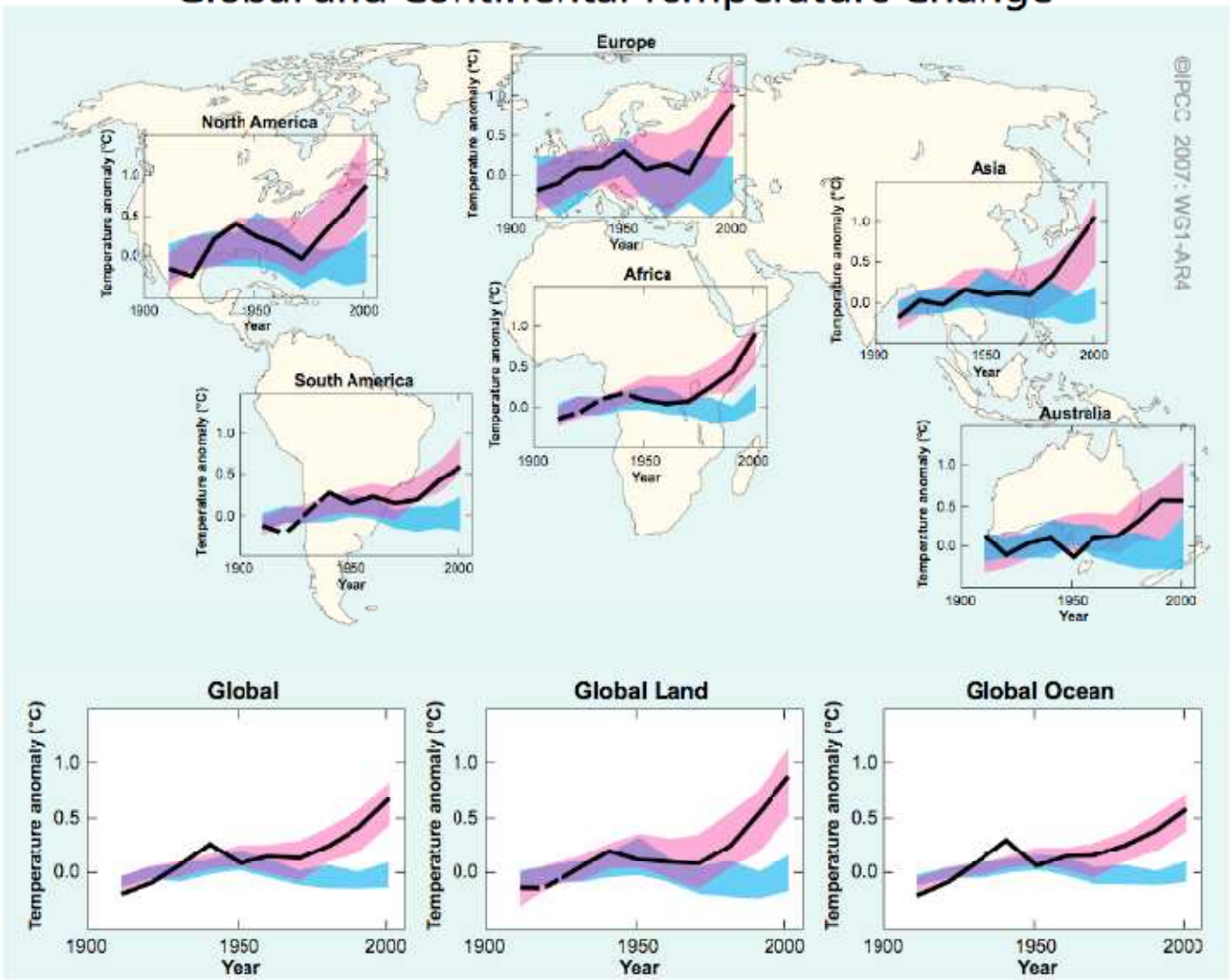


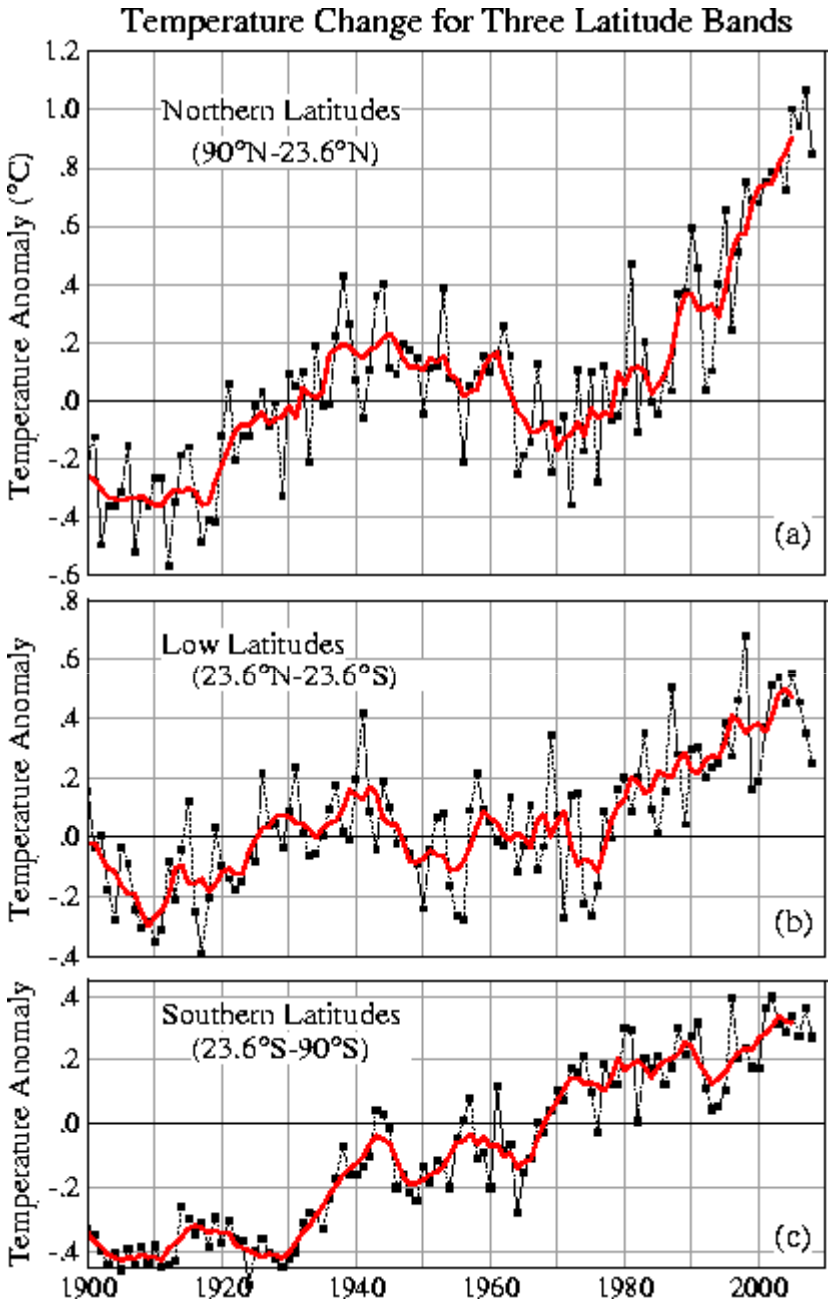
Empreinte adimensionnelle de Tn simulée par ARPEGE



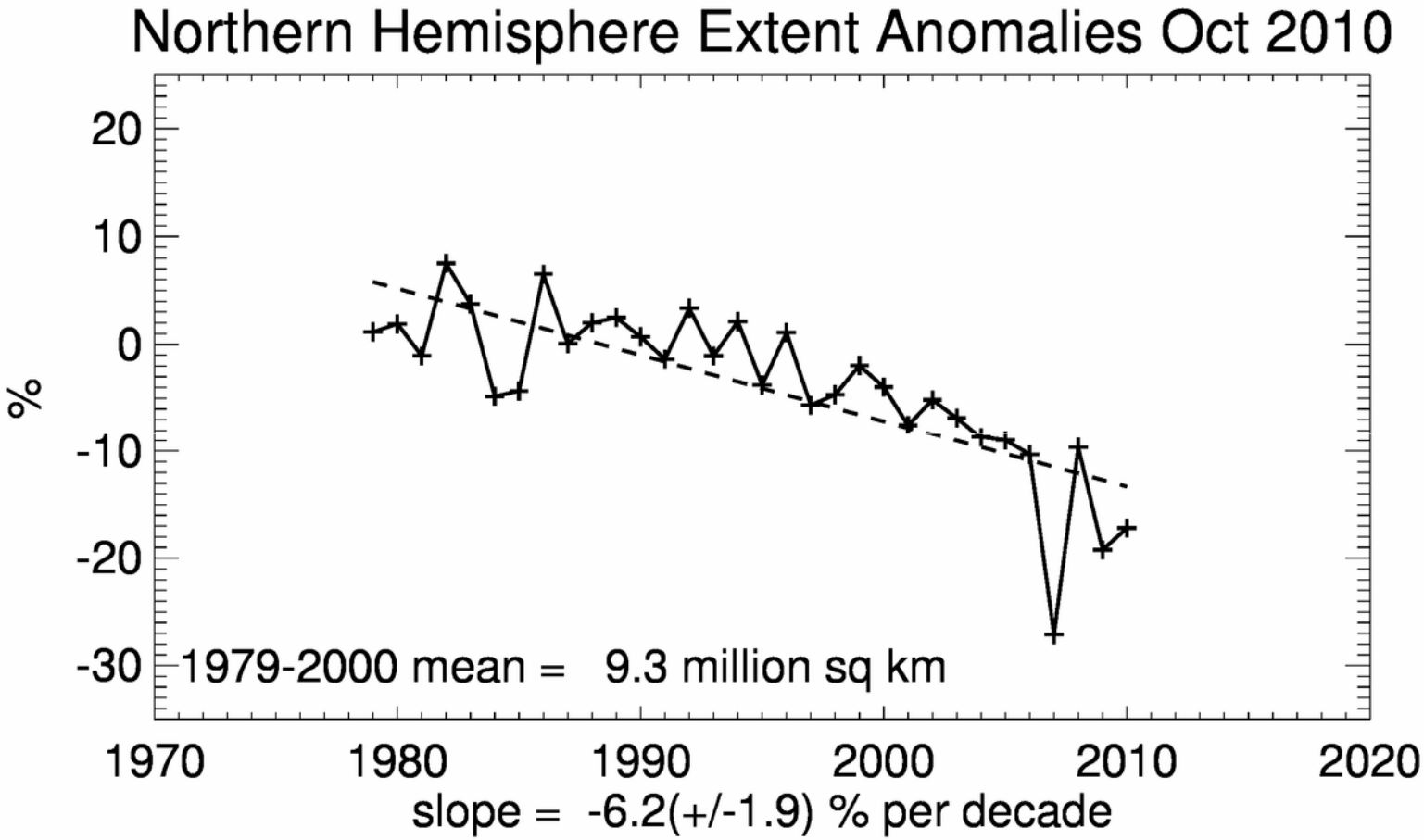
Tendance de Tn d'été observée sur la période 1971-2000 (℃./siècle)

Global and Continental Temperature Change

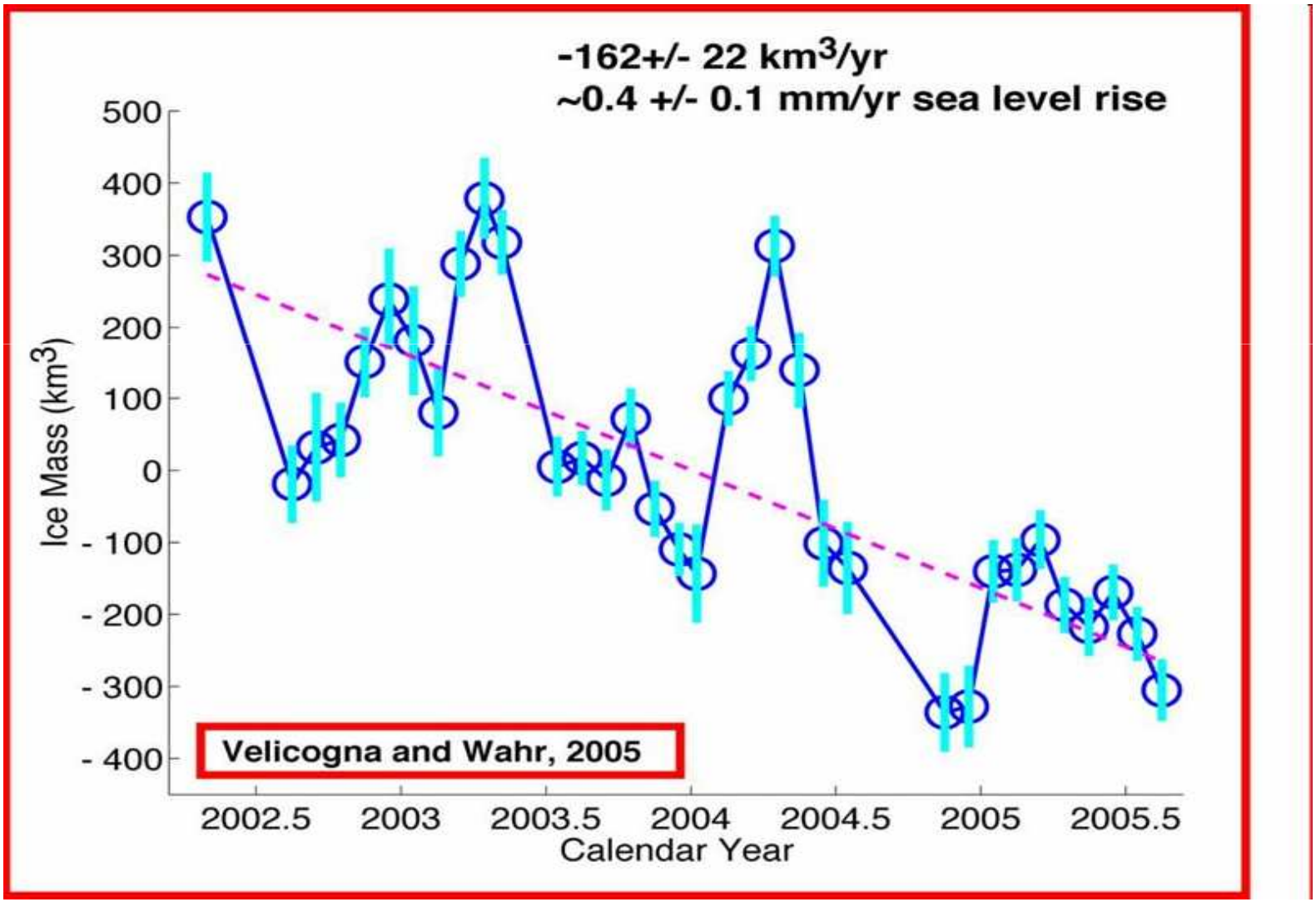




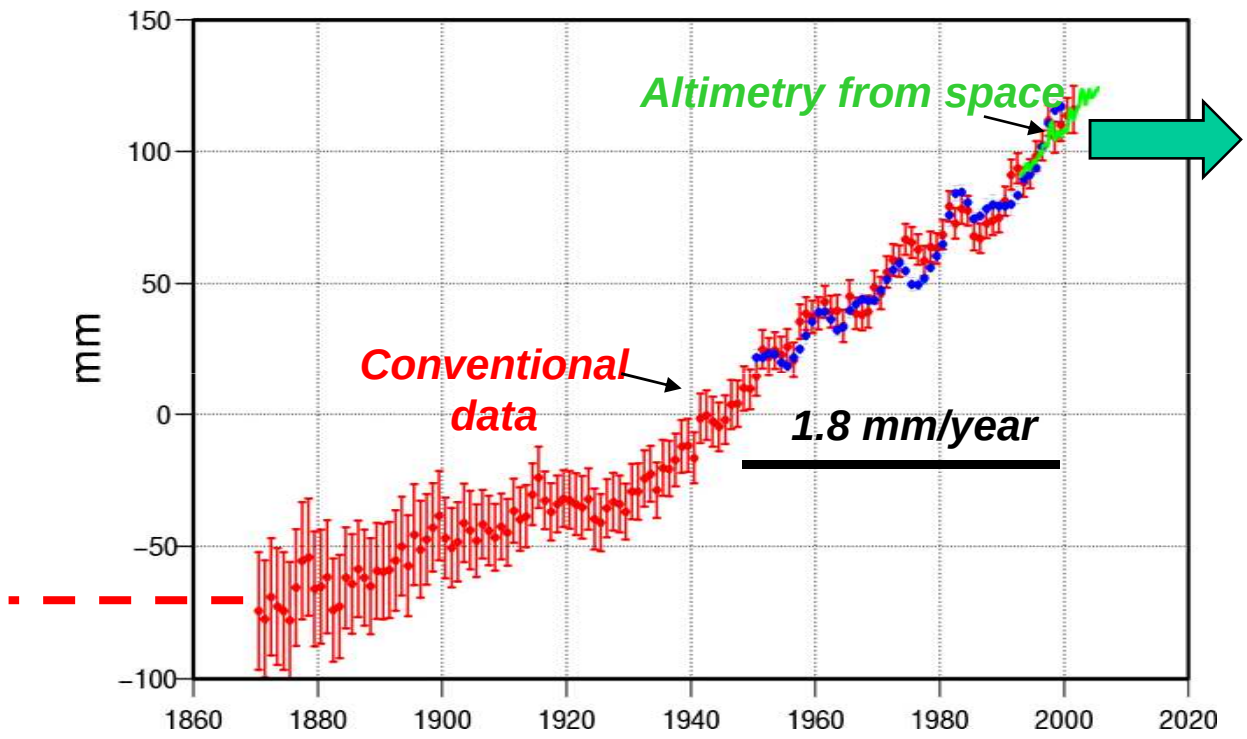
Variabilité naturelle et action de l'homme se superposent

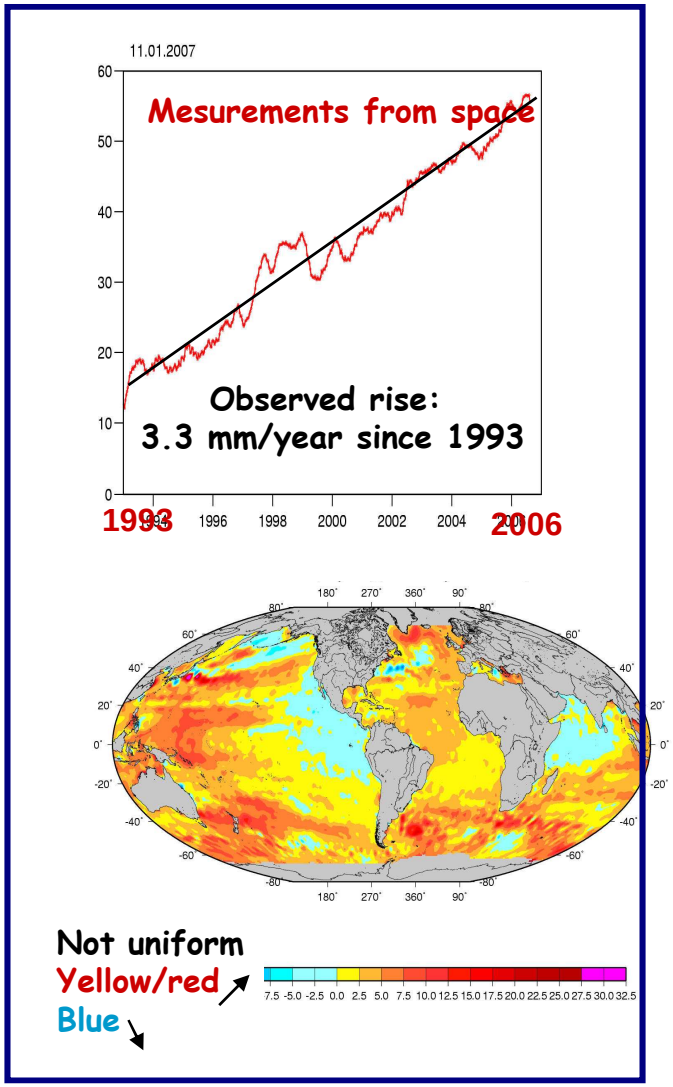

Northern Hemisphere Extent Anomalies Oct 2010
20
10
0
-10
-20
-30
%
1979-2000 mean = 9.3 million sq km
1970
1980
1990
2000
2010
2020
slope = -6.2(+/-1.9) % per decade

Evolution de la masse du Groenland

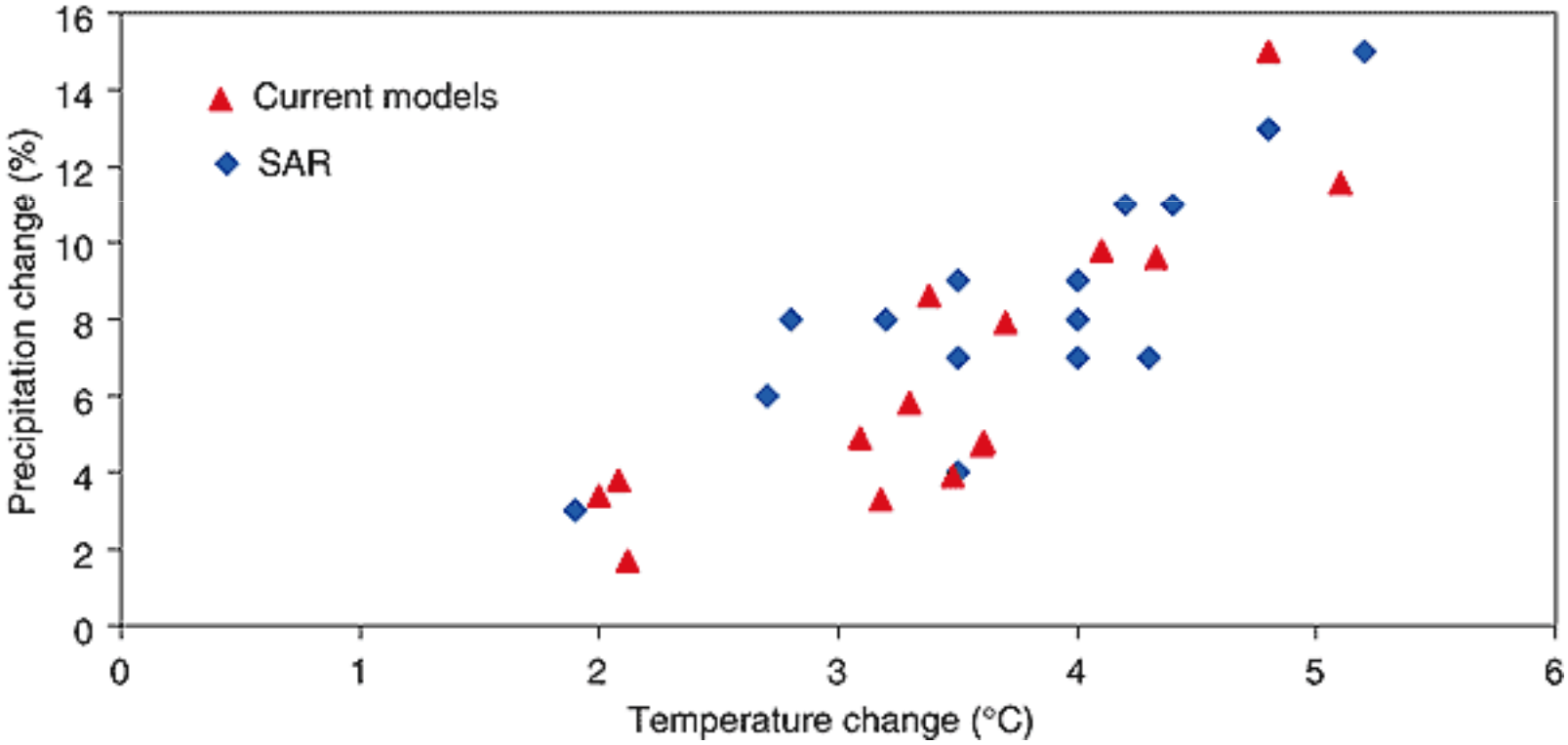


Sea-level rise throughout the 20th century

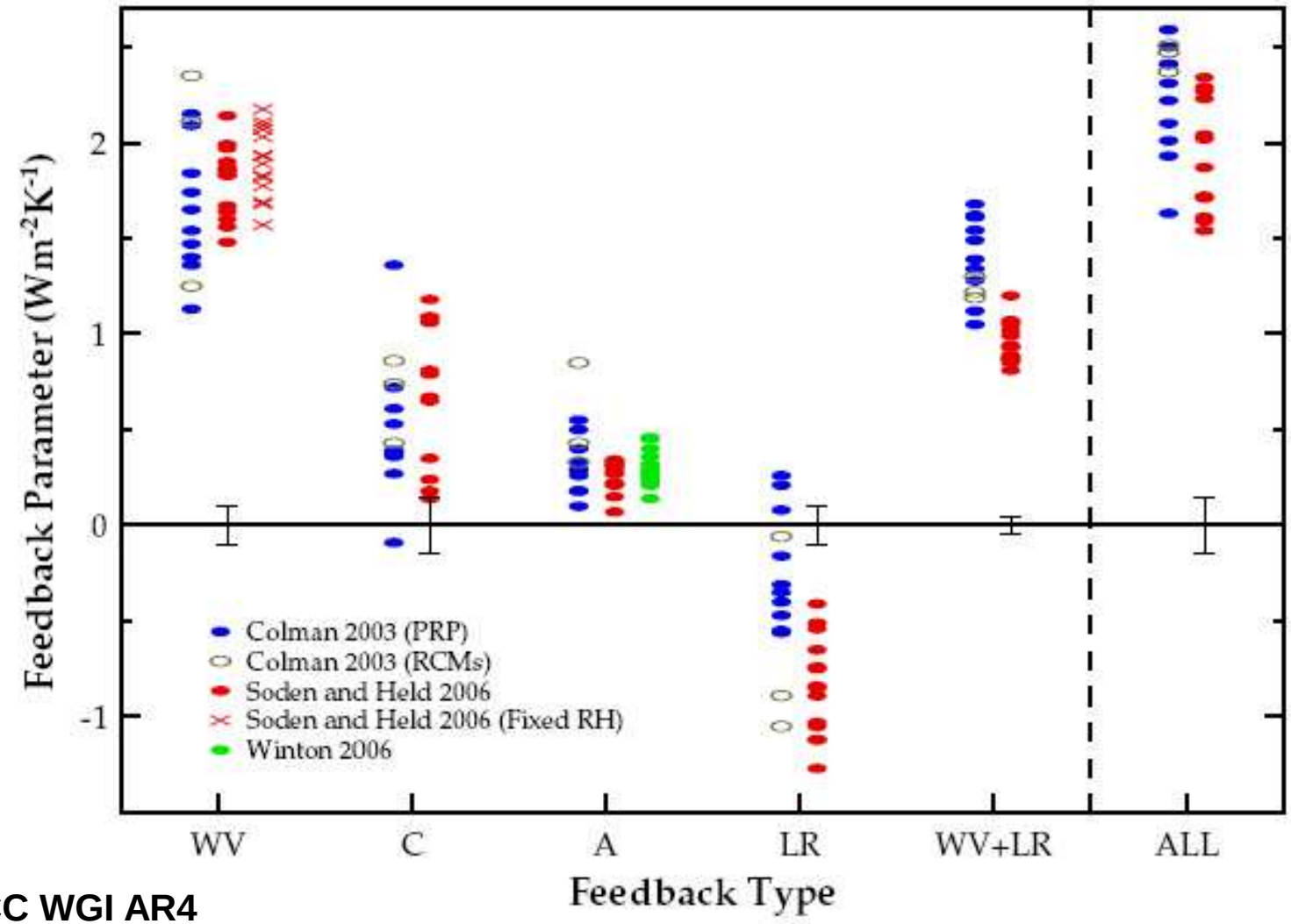




Unmodified for the last 20 years



Strength and inter-model spread of various feedbacks on climate sensitivity



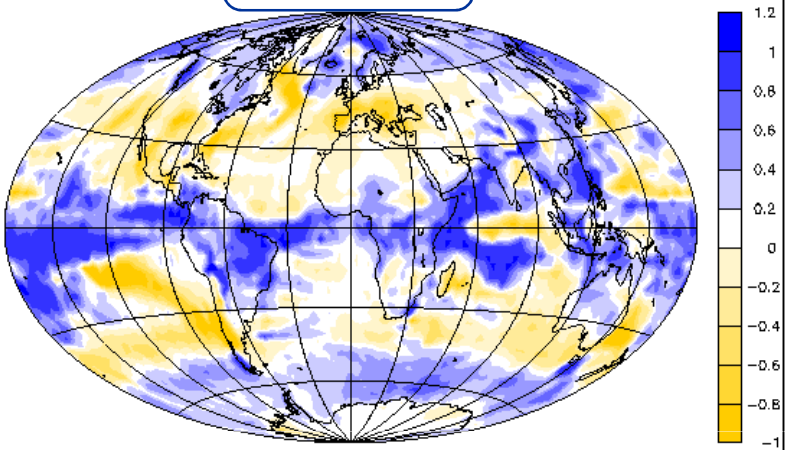
Source : IPCC WGI AR4

L’évolution du climat pour deux modèles et deux scénarios: les précipitations

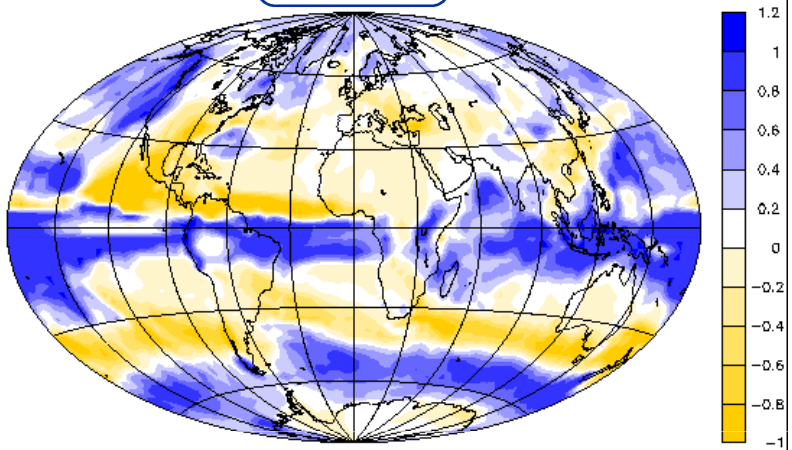
CNRM

IPSL

A2

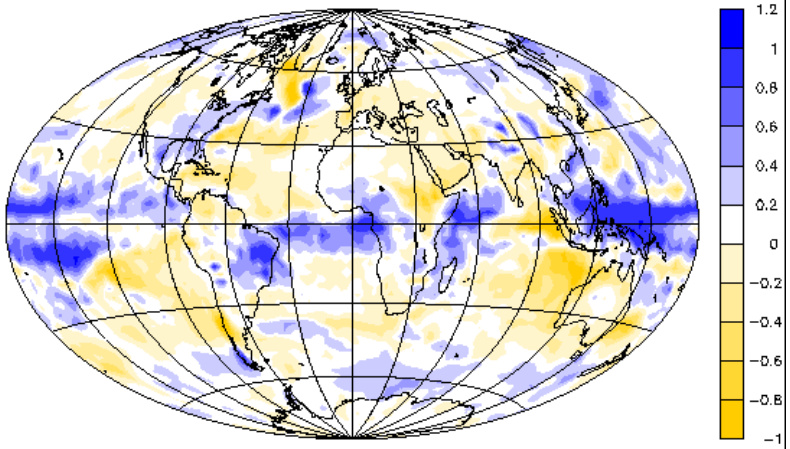


IPCC / CNRM – SRESA2 scenario – Anomalies de la precipitation (mm/jour)
(2090–2099) comparee a (2000–2009)

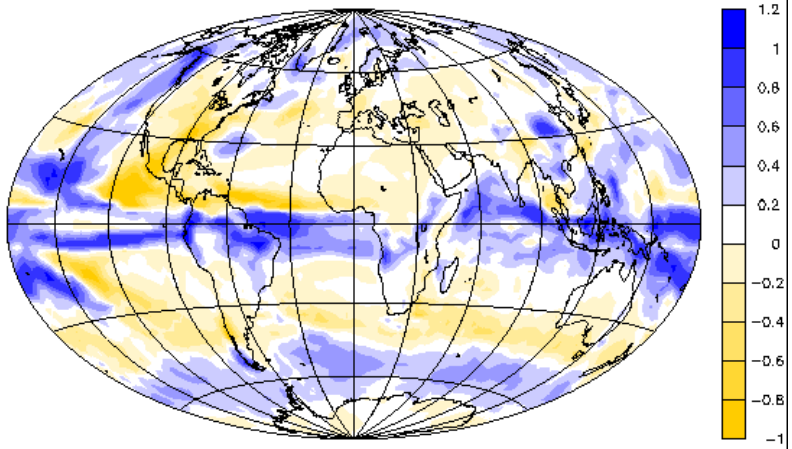


IPCC / IPSL – SRESA2 scenario – Anomalies de la precipitation (mm/jour)
(2090–2099) comparee a (2000–2009)

B1



IPCC / CNRM – SRESB1 scenario – Anomalies de la precipitation (mm/jour)
(2090–2099) comparee a (2000–2009)

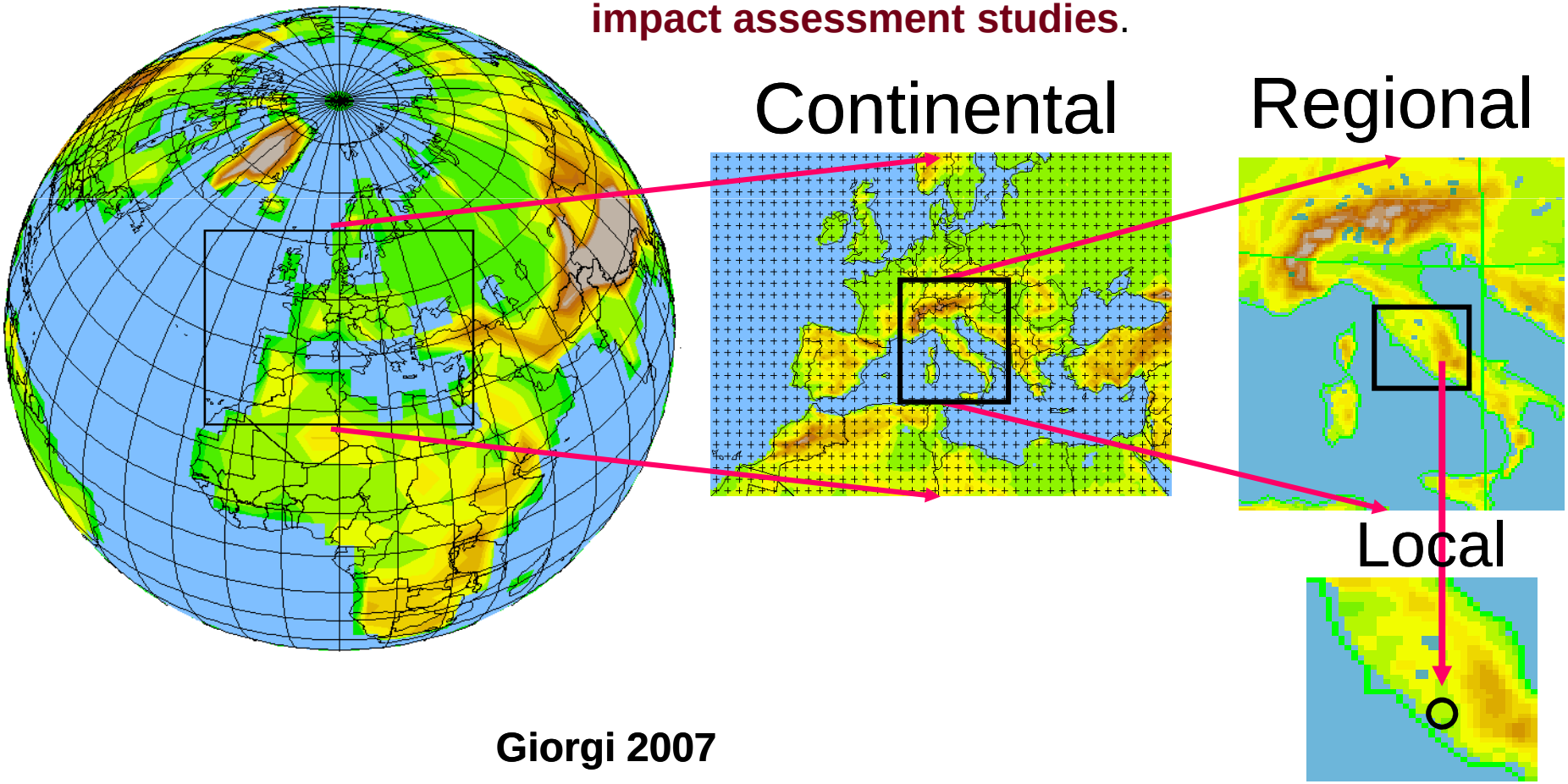


IPCC / IPSL – SRESB1 scenario – Anomalies de la precipitation (mm/jour)
(2090–2099) comparee a (2000–2009)

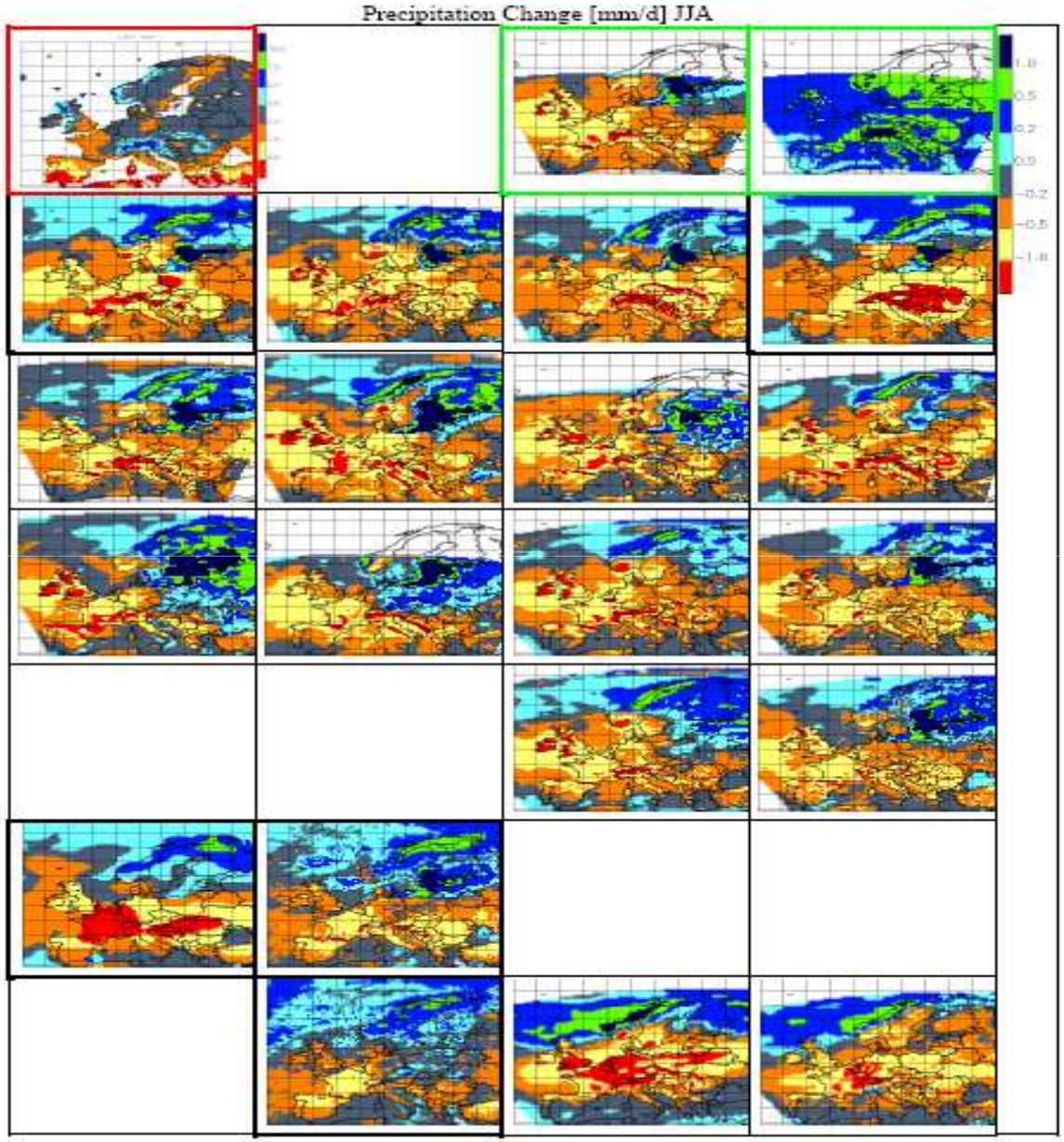
Illustration des 6 satellites composant l'A-train.
De gauche à droite :
Aura, Parasol, Calipso, Cloudsat, Aqua, OCO.
Crédits : CNES octobre 2004, illustration P. Carril

Climate projections on regional and local scales

Performance of current AOGCMs (like those from CMIP3) deteriorate when looking at finer temporal and spatial scales which are needed for many impact assessment studies.

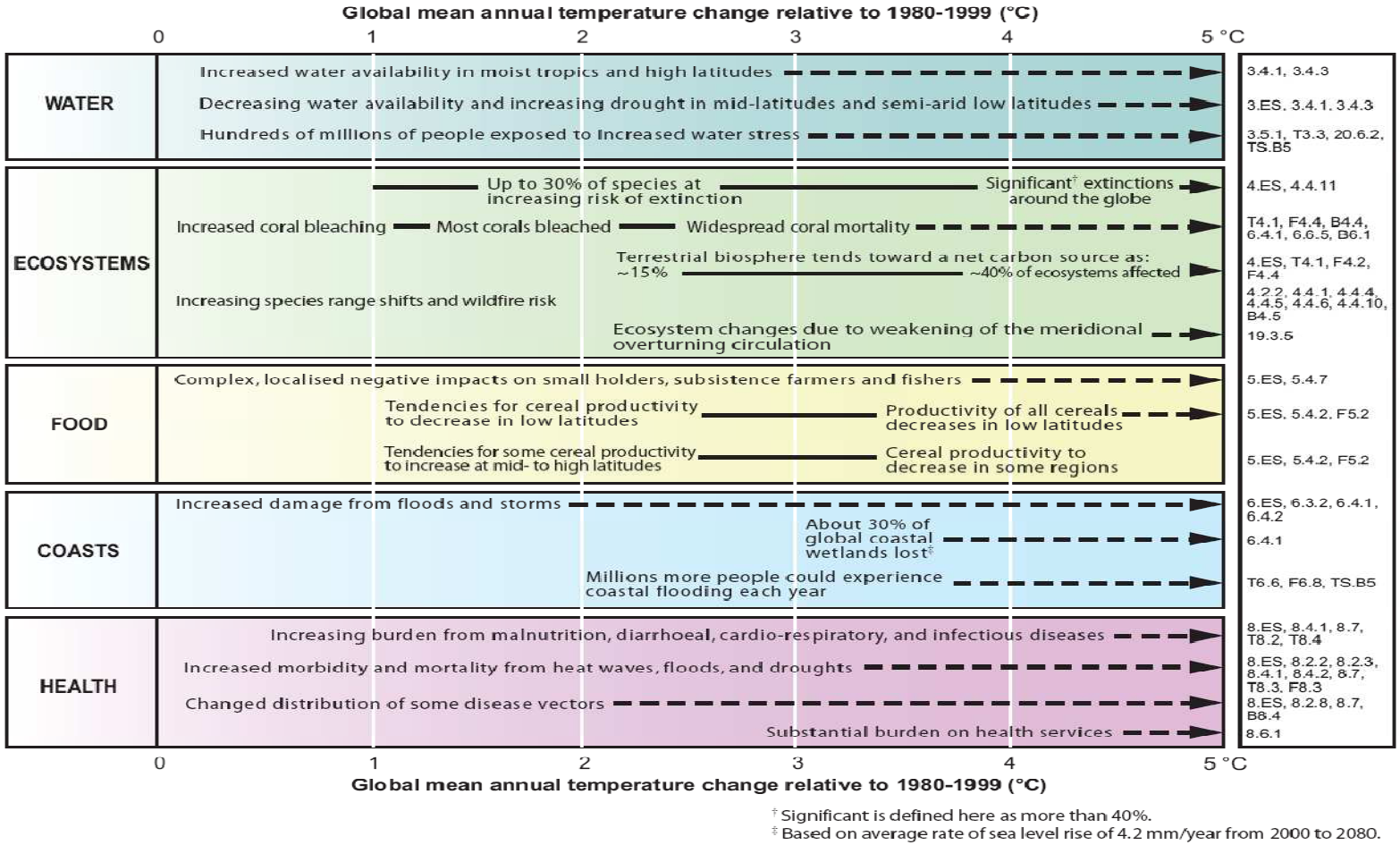


Giorgi 2007


Precipitation Change [mm/d] JJA
1.0
0.5
0.2
0.0
-0.2
-0.5
-1.0

Key impacts as a function of increasing global average temperature change

(Impacts will vary by extent of adaptation, rate of temperature change, and socio-economic pathway)



† Significant is defined here as more than 40%.
‡ Based on average rate of sea level rise of 4.2 mm/year from 2000 to 2080.

Figure SPM.2. *Illustrative examples of global impacts projected for climate changes (and sea level and atmospheric carbon dioxide where relevant) associated with different amounts of increase in global average surface temperature in the 21st century [T20.8]. The black lines link impacts, dotted arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left-hand side of the text indicates the approximate onset of a given impact. Quantitative entries for water stress and flooding represent the additional impacts of climate change relative to the conditions projected across the range of Special Report on Emissions Scenarios (SRES) scenarios A1FI, A2, B1 and B2 (see Endbox 3). Adaptation to climate change is not included in these estimations. All entries are from published studies recorded in the chapters of the Assessment. Sources are given in the right-hand column of the Table. Confidence levels for all statements are high.*

IPCC, WG2