Institut Pierre Simon Laplace

Institut de recherche en sciences de l'environnement

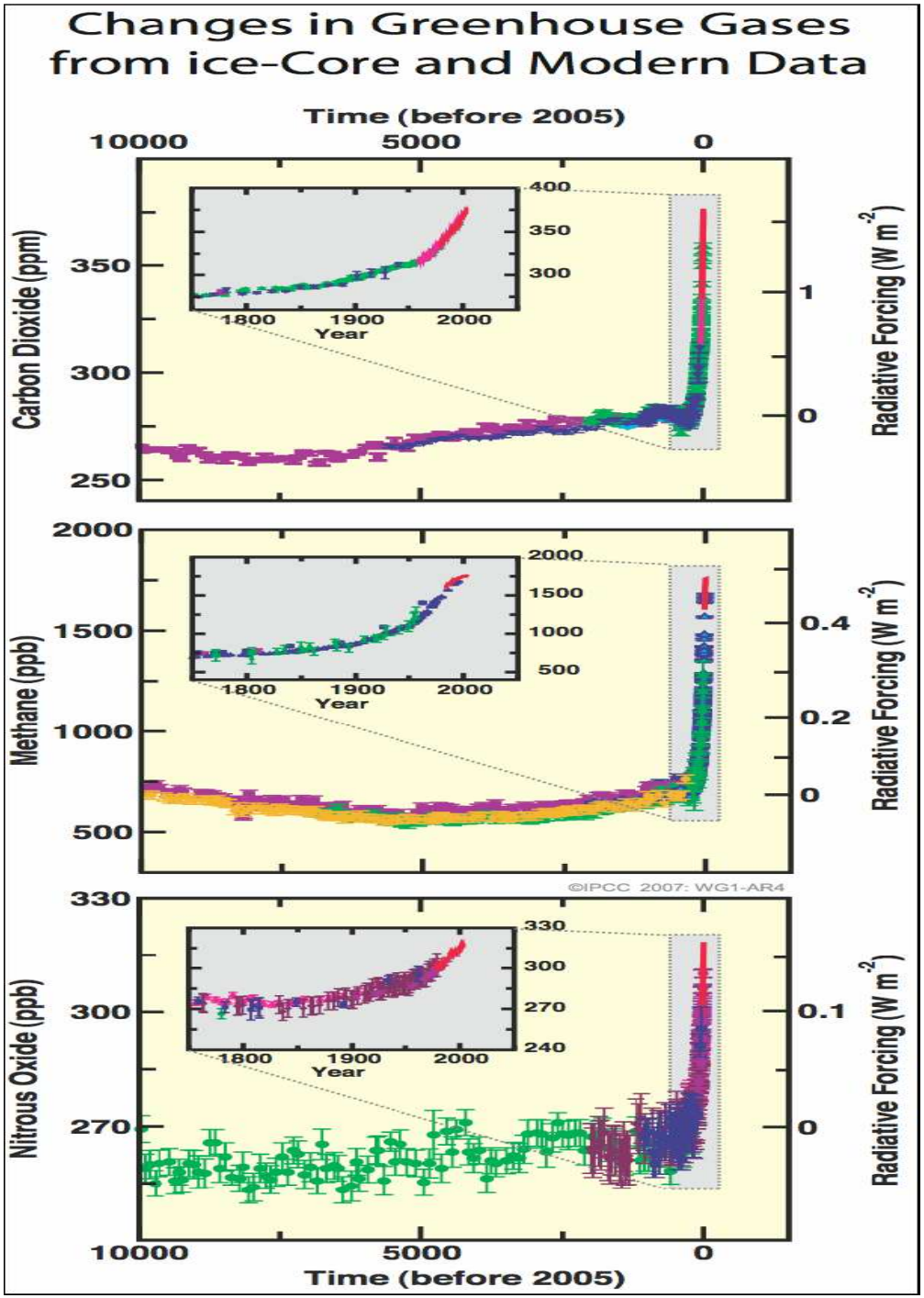
Changements climatiques: nouveaux enjeux

Hervé Le Treut

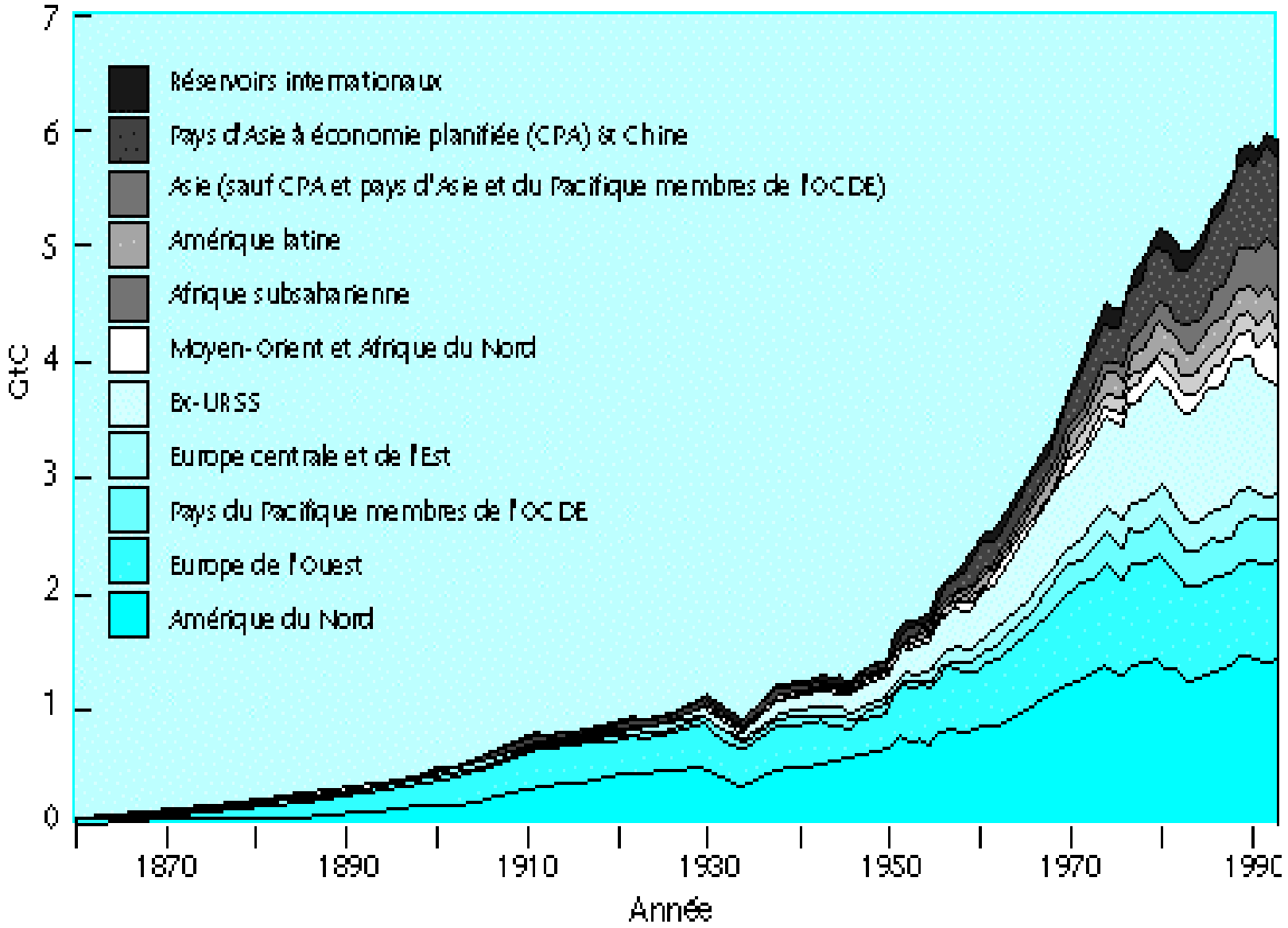
Le climat dans lequel se sont développés nos civilisations:

10 000 ans
de « quasi-stabilité »
et quelques décennies de changement

IPCC, 2007

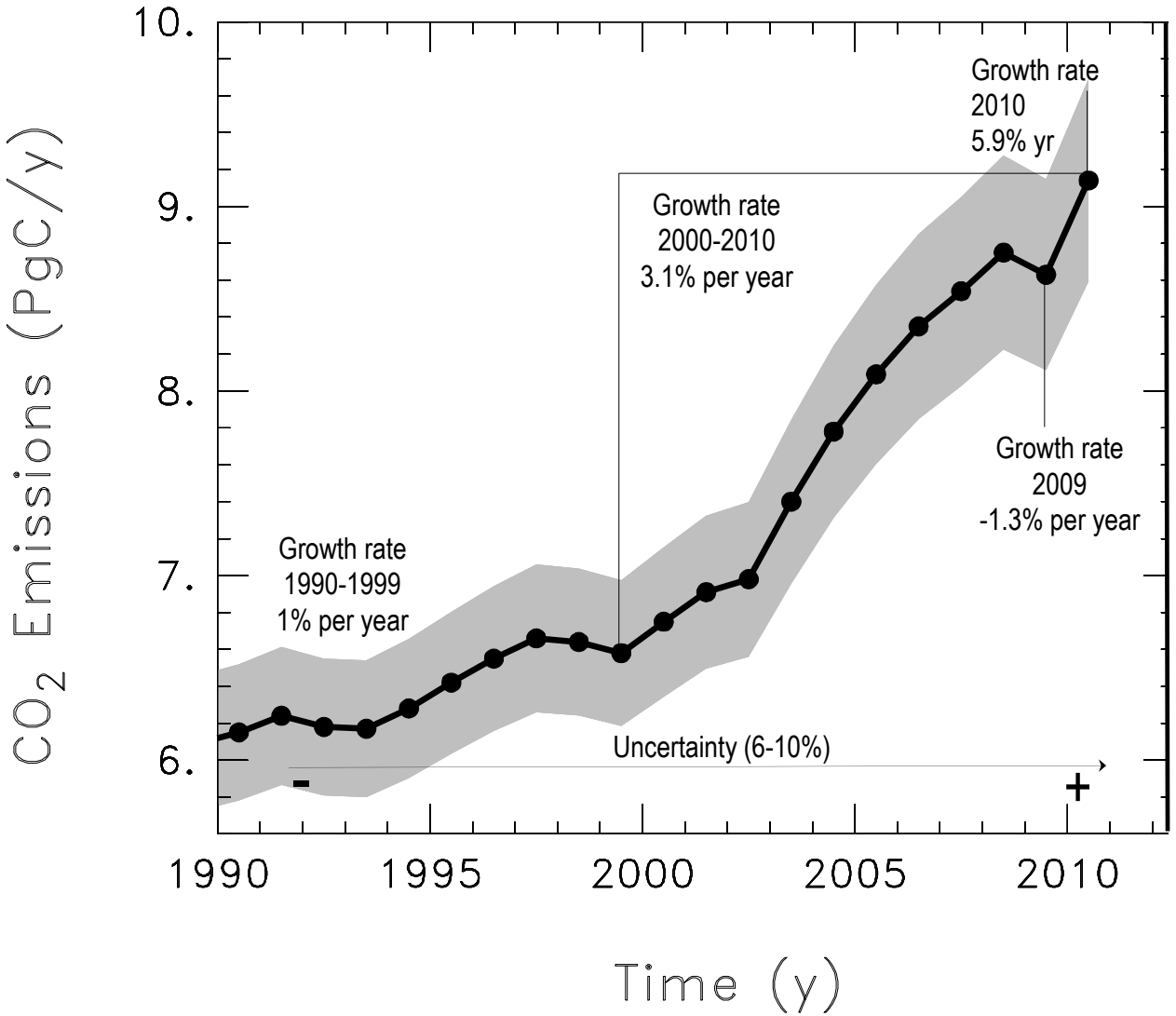


La combustion des combustibles fossiles: 5 milliards de tonnes par an en plus entre 1945 et 1995



International Energy Agency

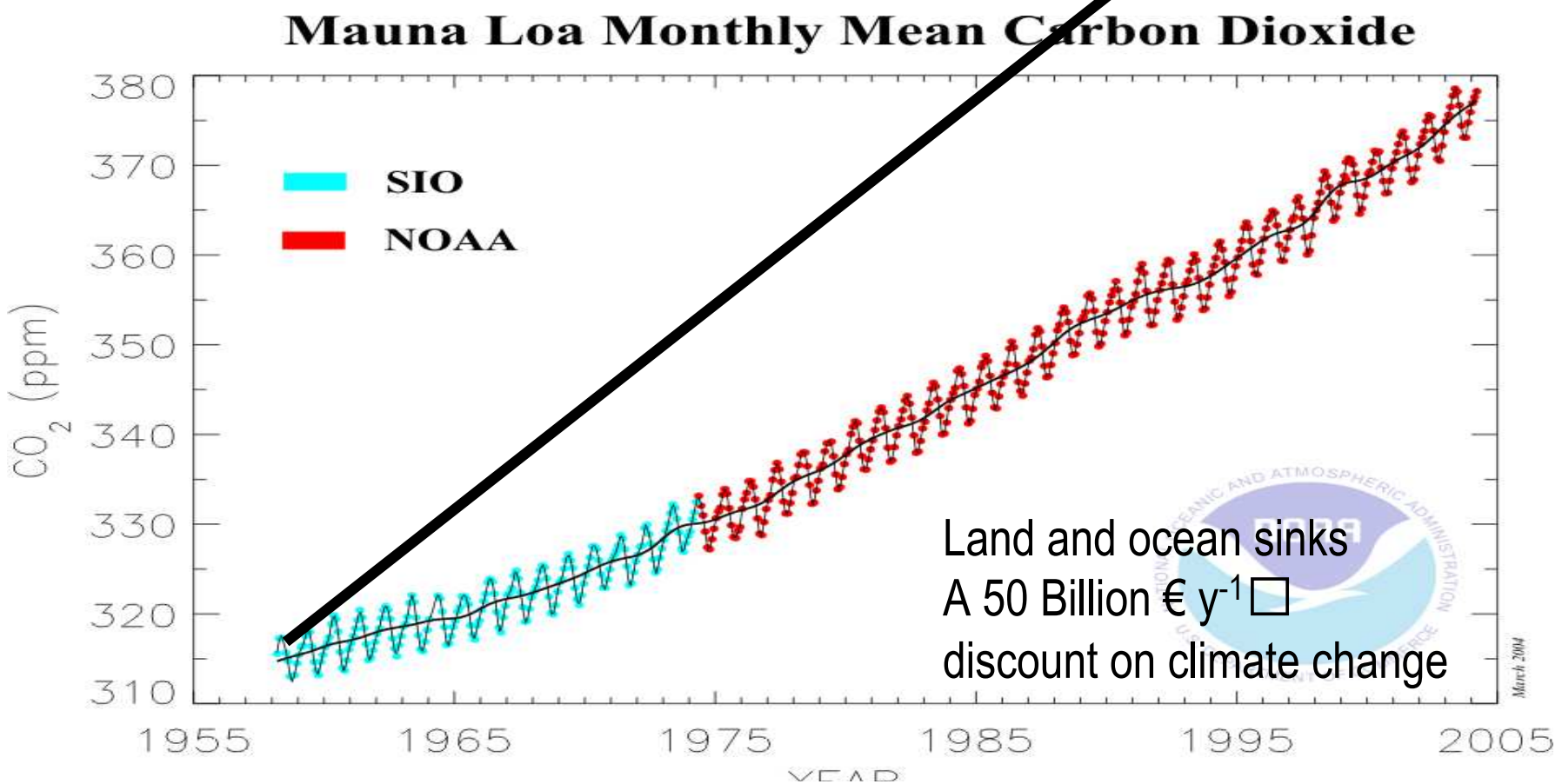
Fossil Fuel & Cement CO_2 Emissions



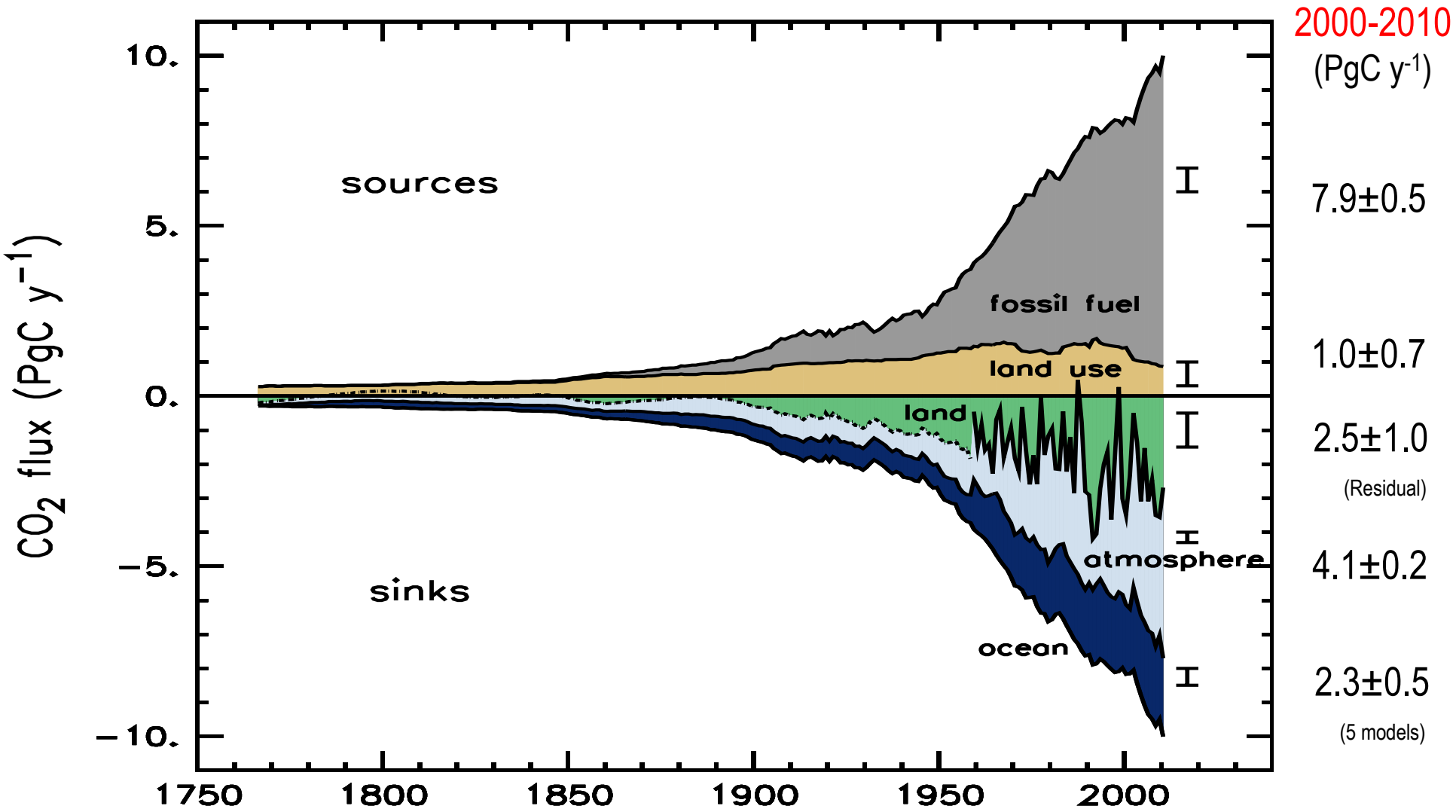
Et presque 3 milliards de tonne de C en plus depuis 2000

During the anthropocene, the carbon cycle is driven by fossil fuel emissions, and limited by sinks

The Earth without carbon cycle

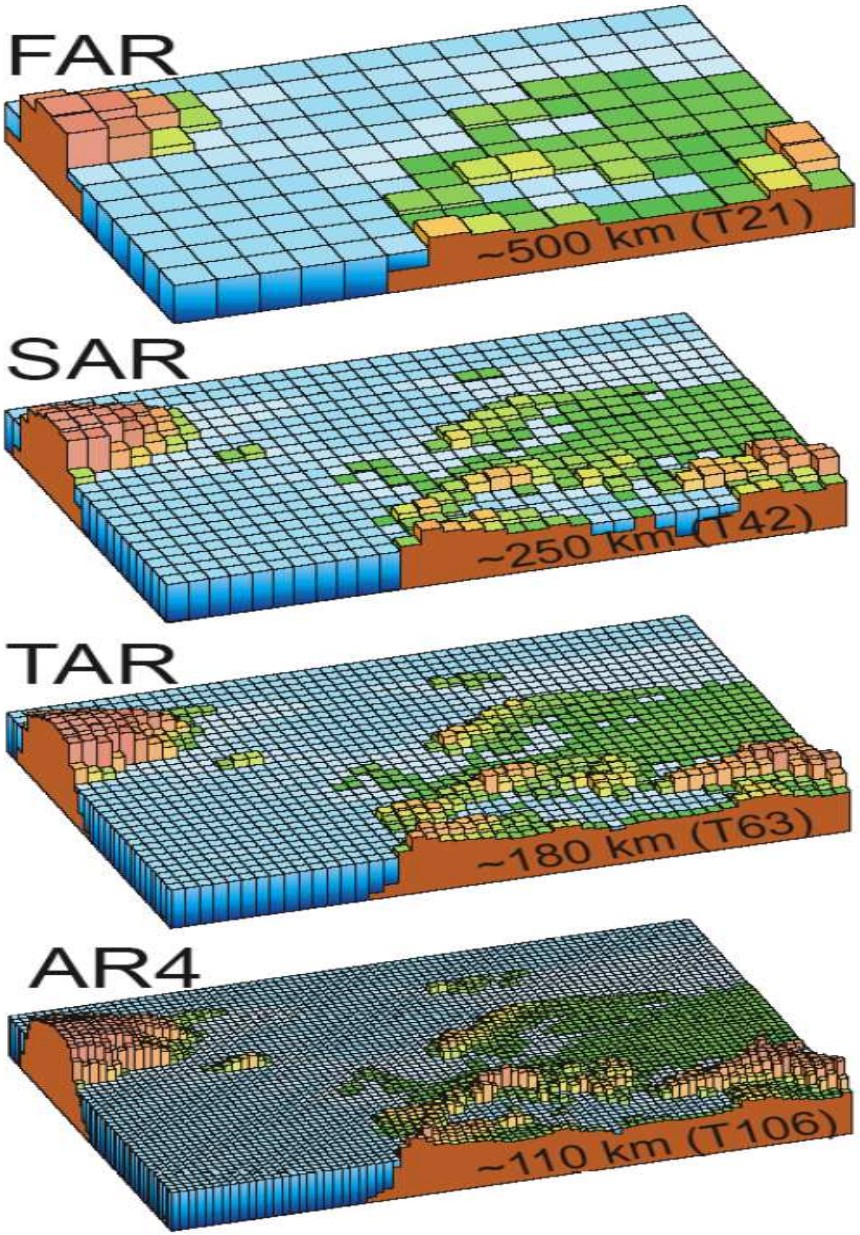


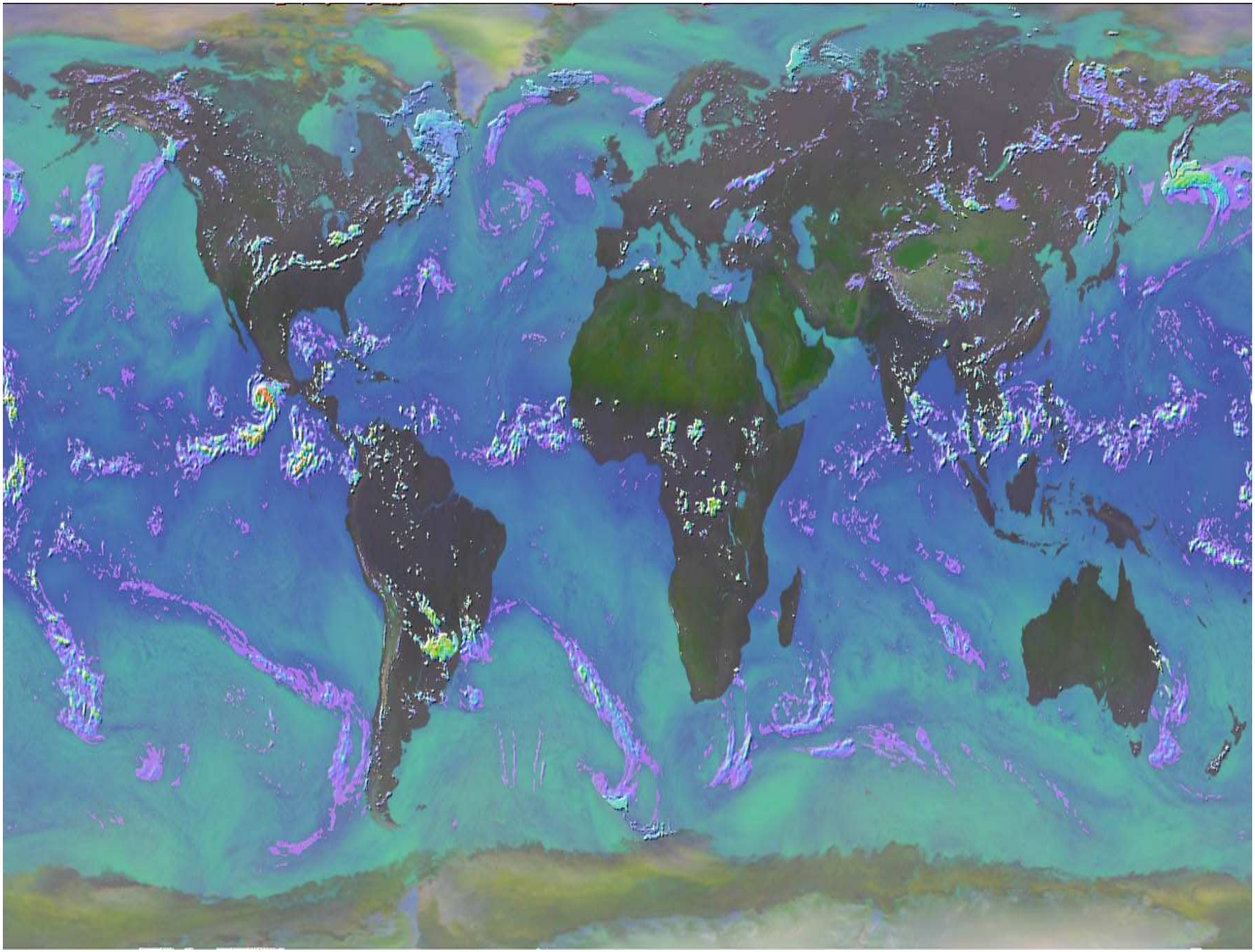
Human Perturbation of the Global Carbon Budget



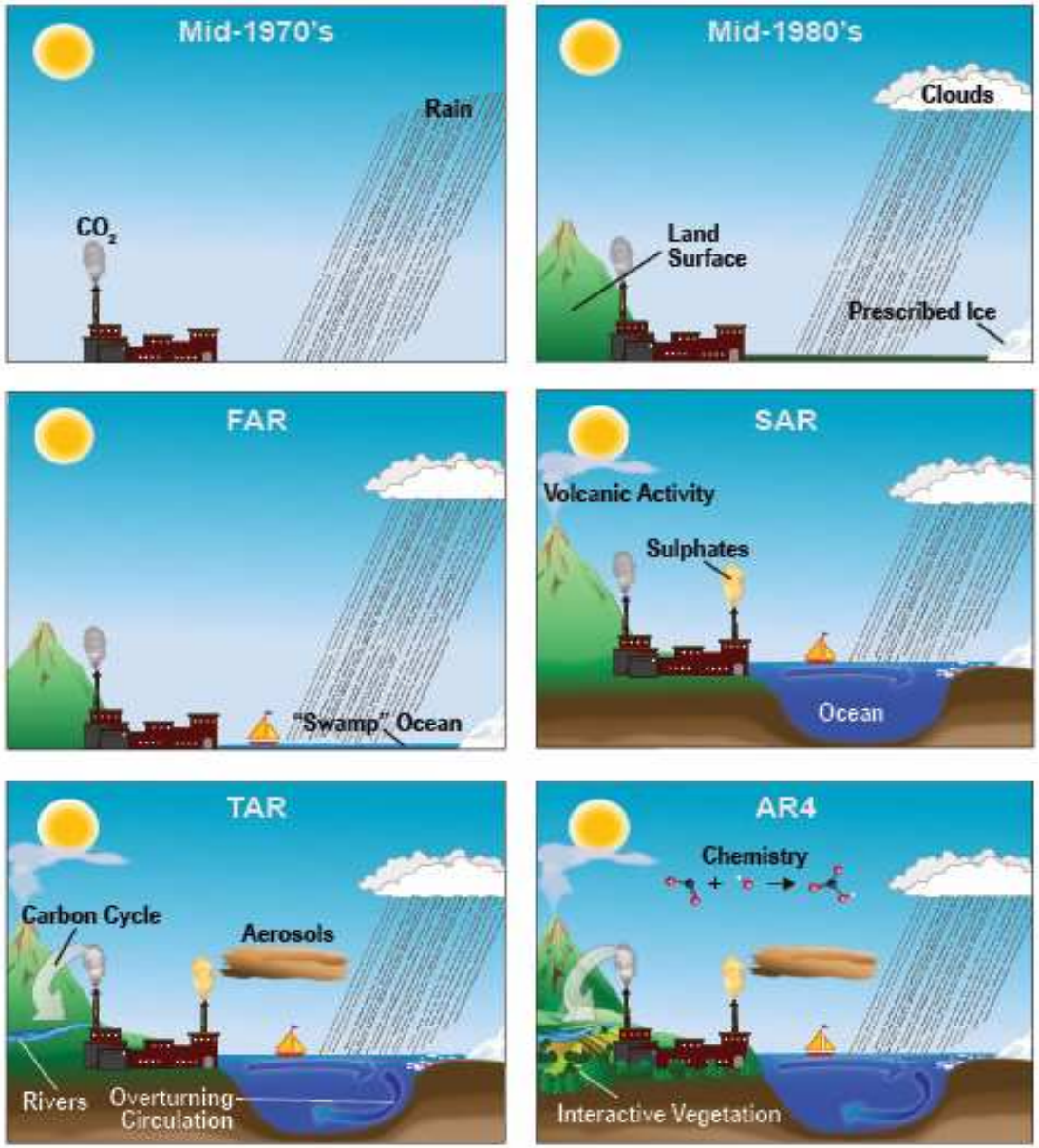
Remarkable linearity of sinks response to emissions forcing

Land sinks are sensitive to climate, at least on interannual time scale


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



The World in Global Climate Models

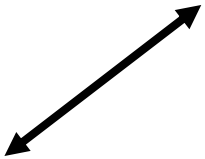


Modèle de « processus »:

LES
Nuages
Modèles fonctionnels de végétation
Modèles radiatifs ligne à ligne
….

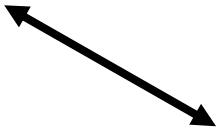
Données de campagnes (in situ, satellitaires)

Etudes en laboratoire



Mesures à grande échelle

Réanalyses, données satellitaires

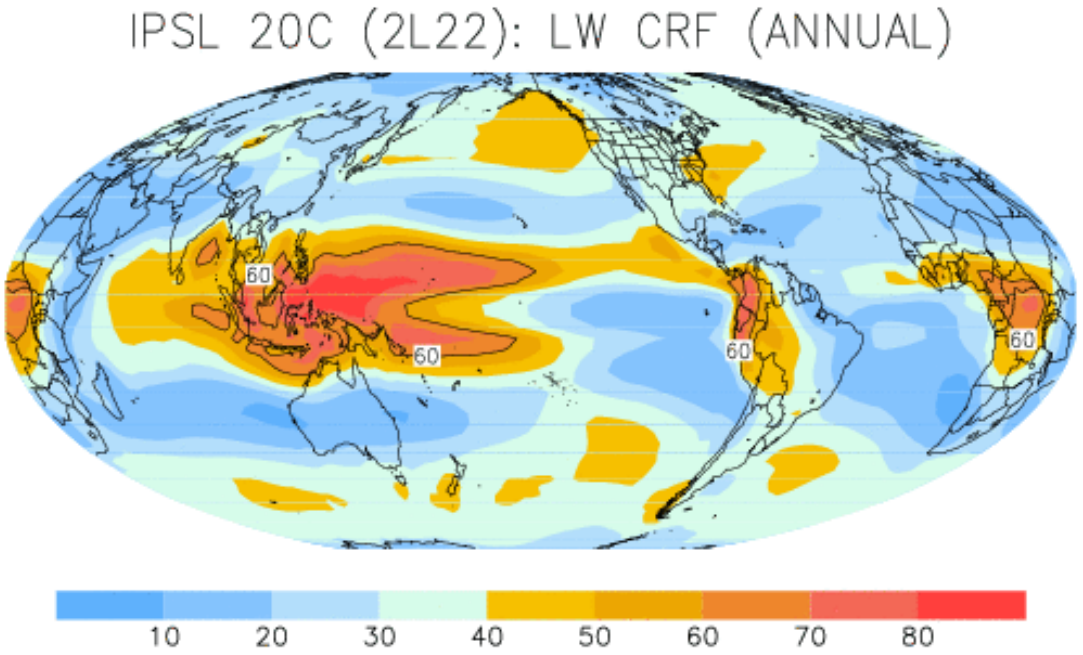


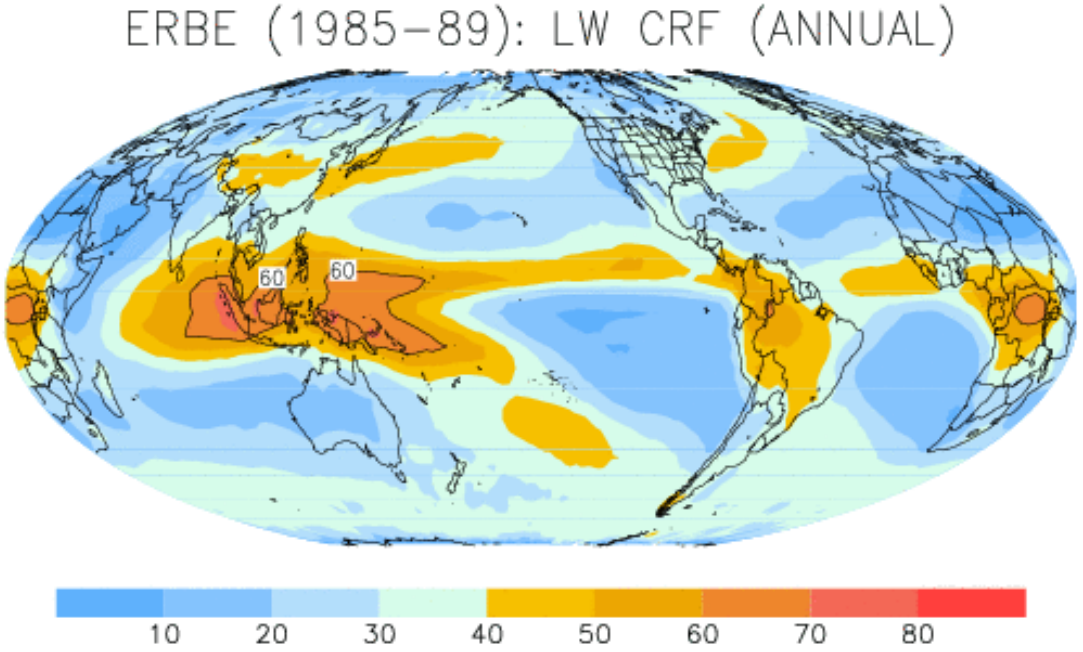
EVALUATION
(AMIP, CMIP, …)
Systématique depuis 1990

Modèles « réalistes »:

Couplés / Atmosphère seule
Equations primitives / Equations simplifiées
Résolution variable

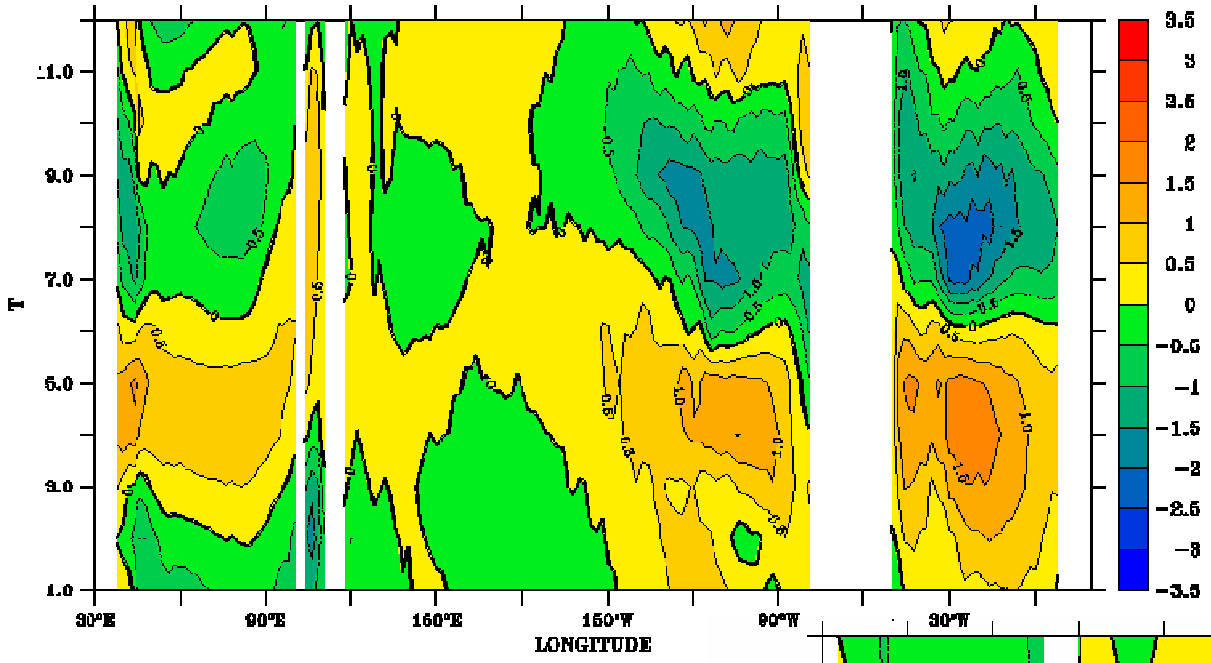
Observed and Simulated Cloud Radiative Forcing: LW



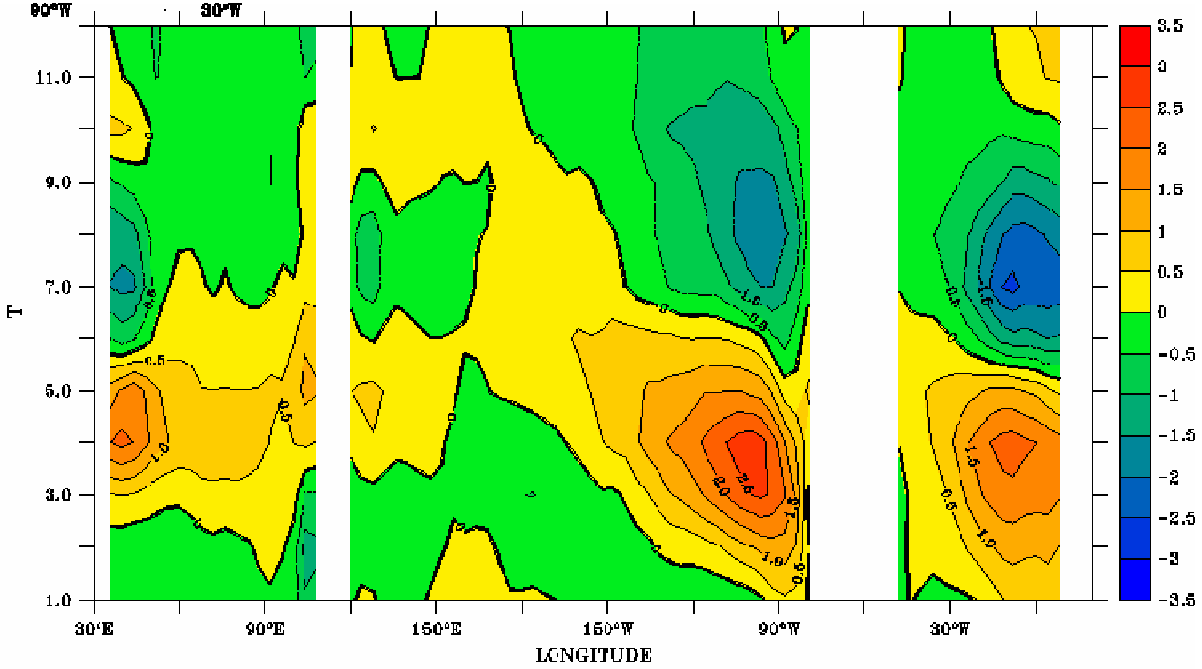


IPSL CM4.1

Observed and Simulated Seasona Cycle of the Sea-Surface Temperatures at the Equator (2°N-2°S)

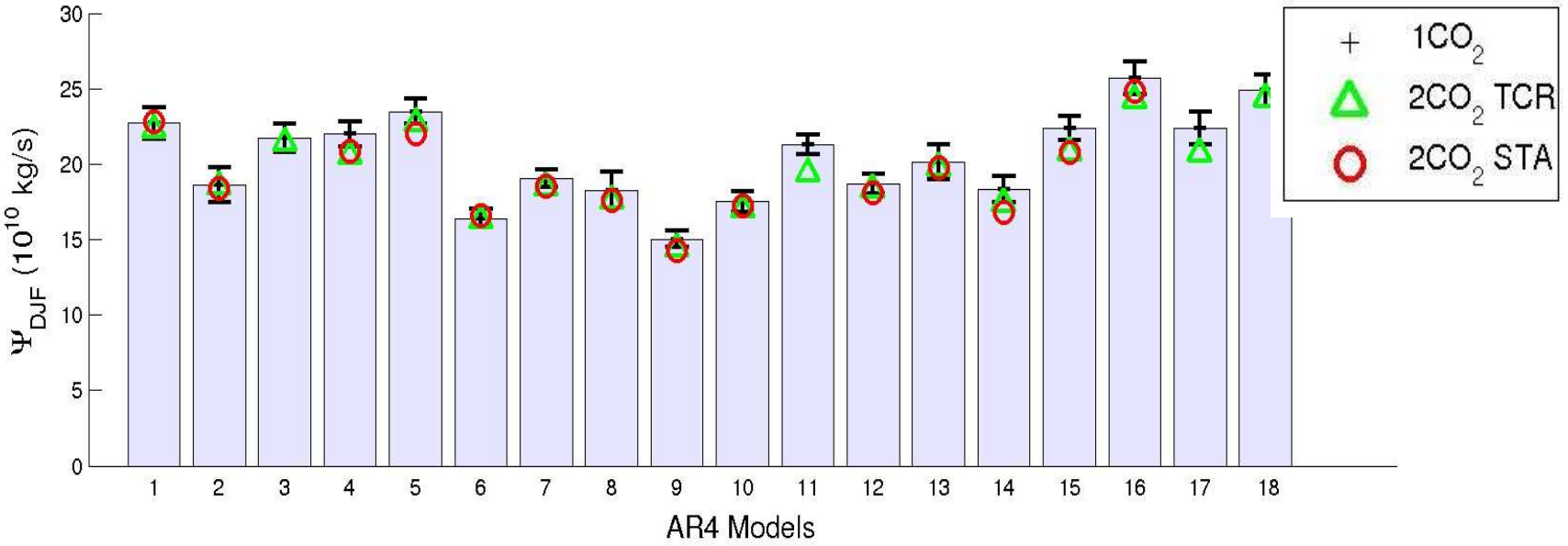


Reynolds

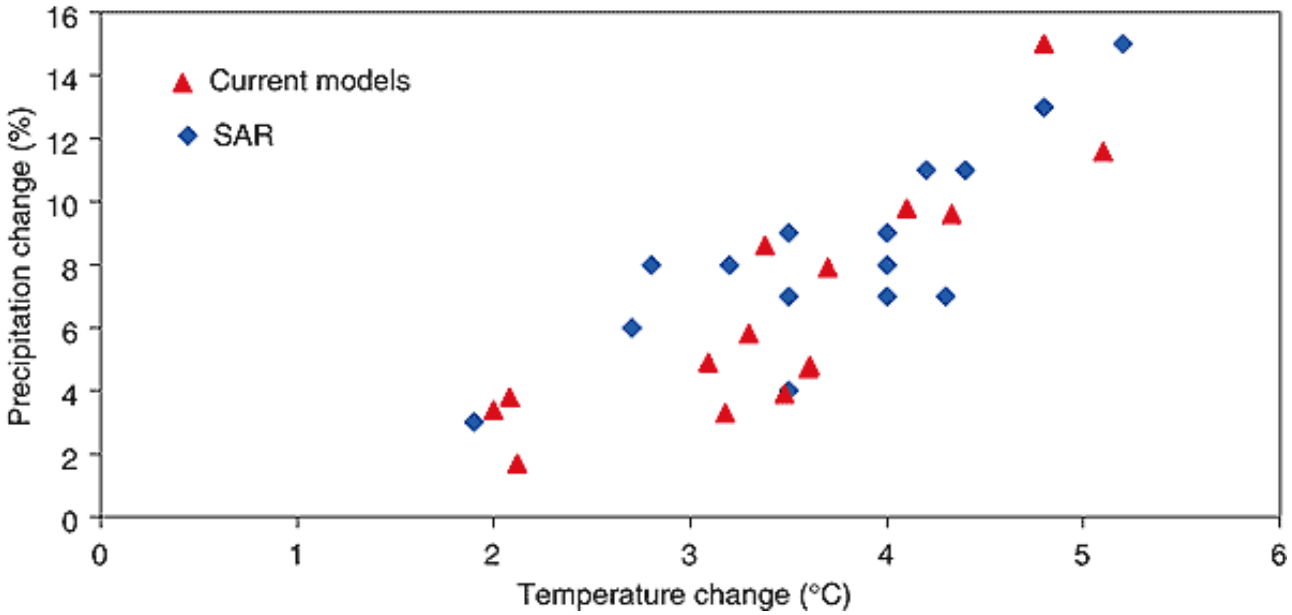


Hadley mass transport (DJF, winter cell) and its dependence on CO2 doubling

AR4 models



La première approche des changements climatiques: la sensibilité du cliamt



DT dans fourchette de 1.5°C à 4.5°C: presque inchangé depuis Charney (1979)

New observational devices are necessary: the example of the Aqua train:
Aura, Parasol, Calipso, Cloudsat, Aqua, OCO.
Crédits : CNES octobre 2004, illustration P. Carril

Des programmes internationaux

WCRP
World Climate Research Programme

Climate Variability & Predictability
CLIVAR
World Climate Research Programme

WCRP·SCAR·IASC
clic

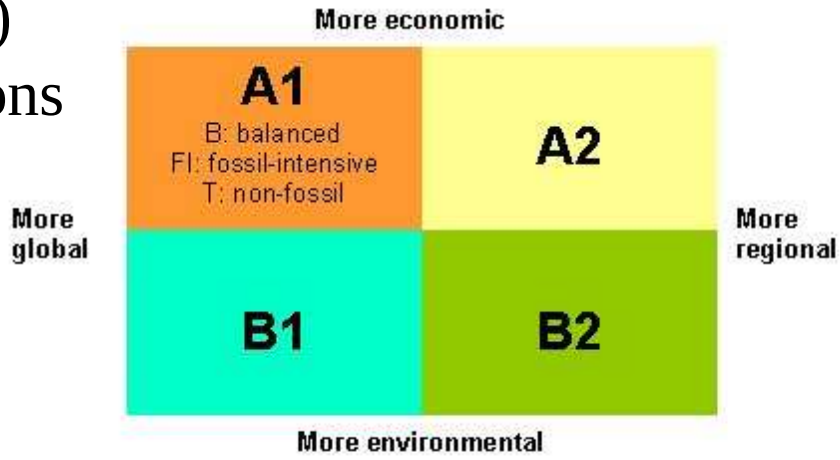
SPARC
WCRP

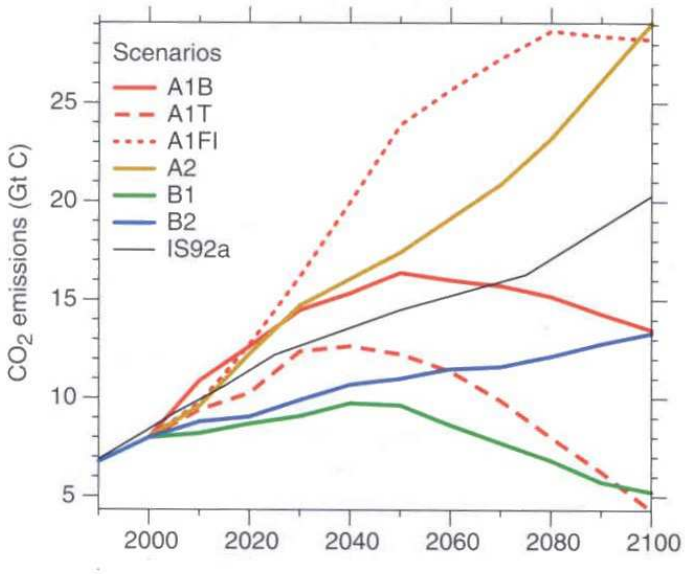
Global Energy and Water Cycle Experiment
GEWEX
WCRP

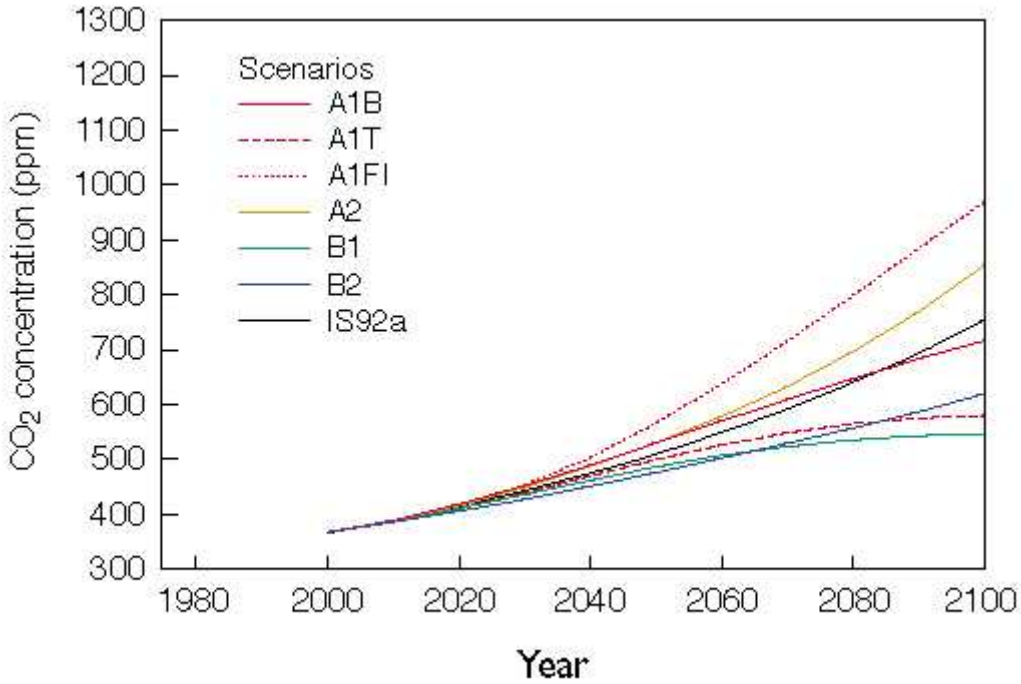
+WGCM, ….

+ GEO/GCOS,

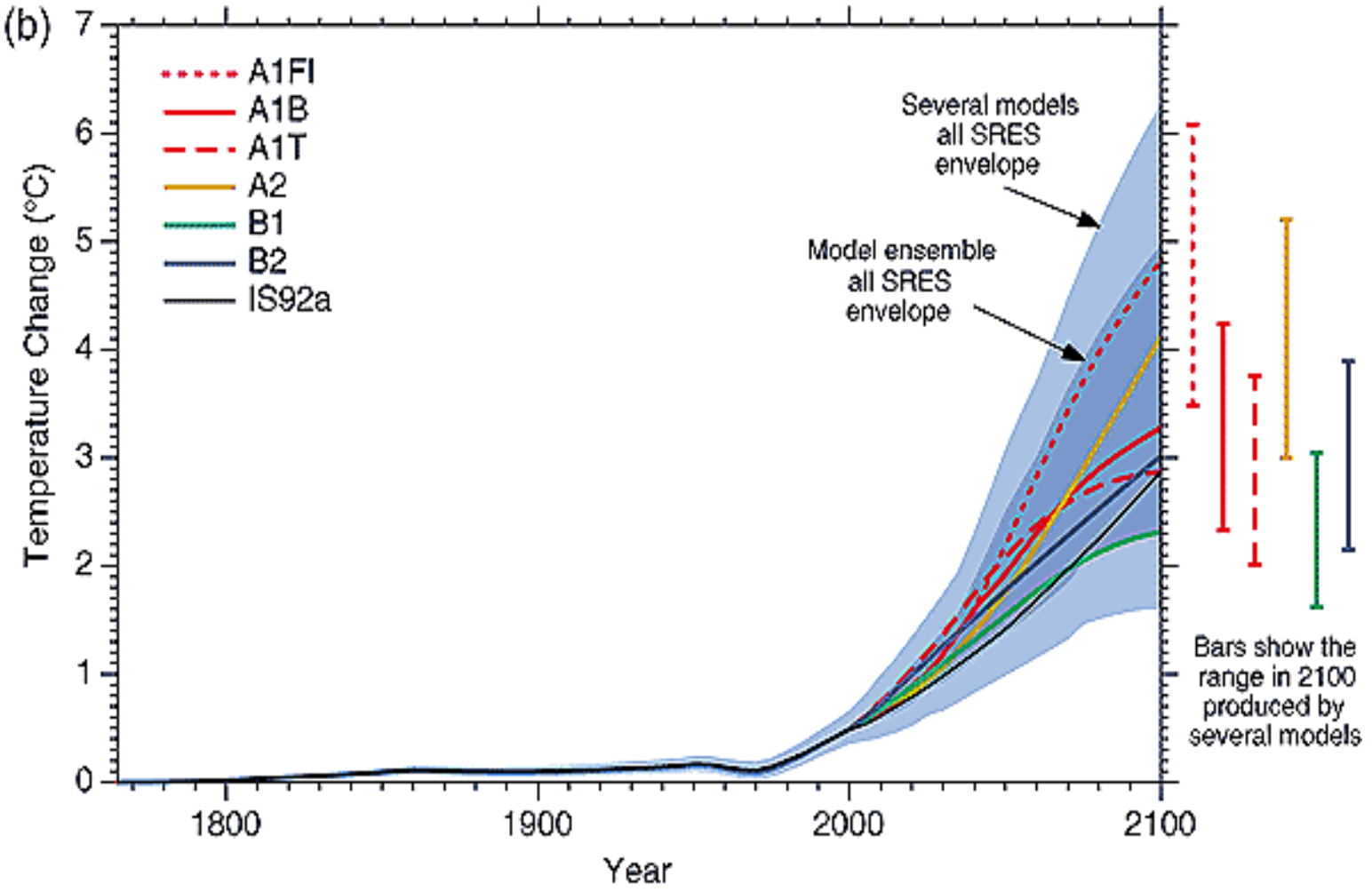
Les scénarios du GIEC (SRES, 1999)
Une première approche des interactions sociétés-climat



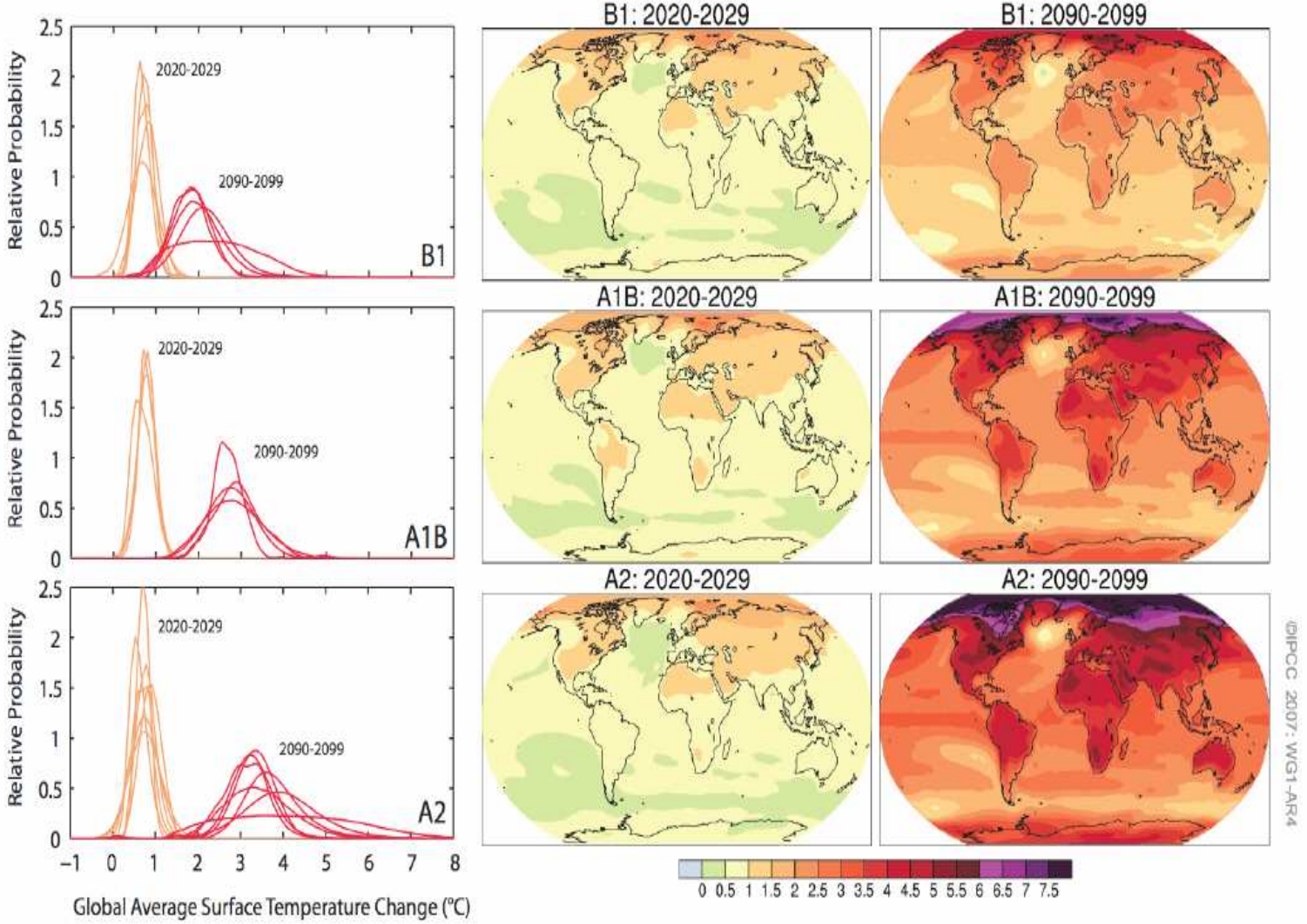




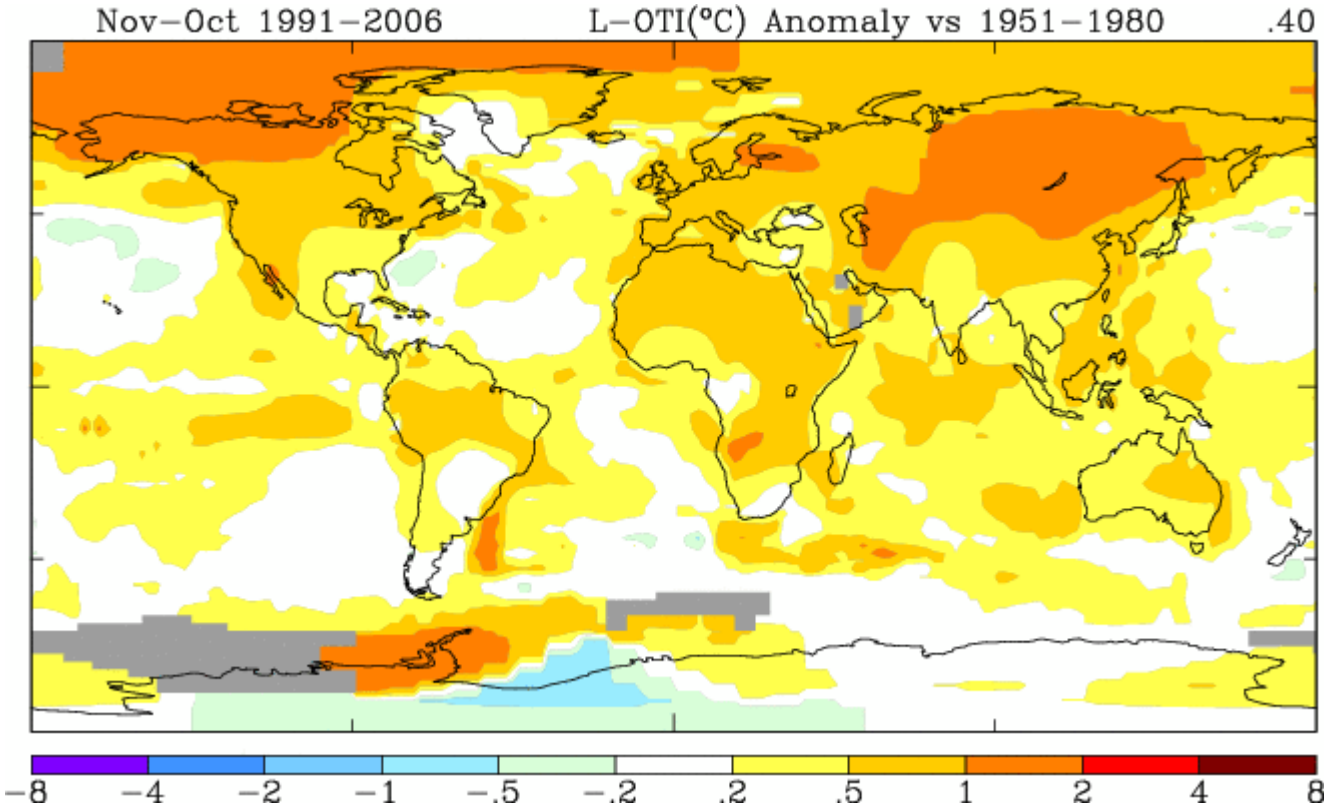
Un exemple de communication mal comprise: GIEC 2001



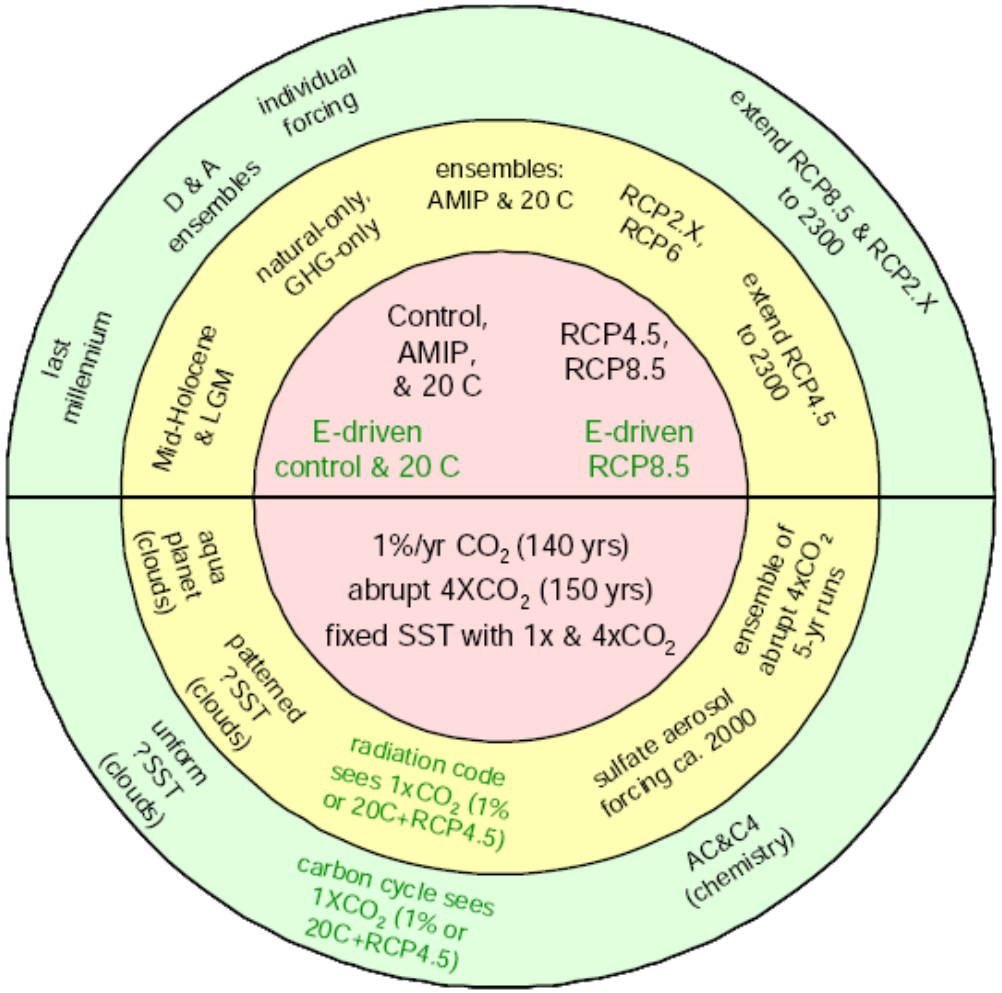
AOGCM Projections of Surface Temperatures



Changements observés

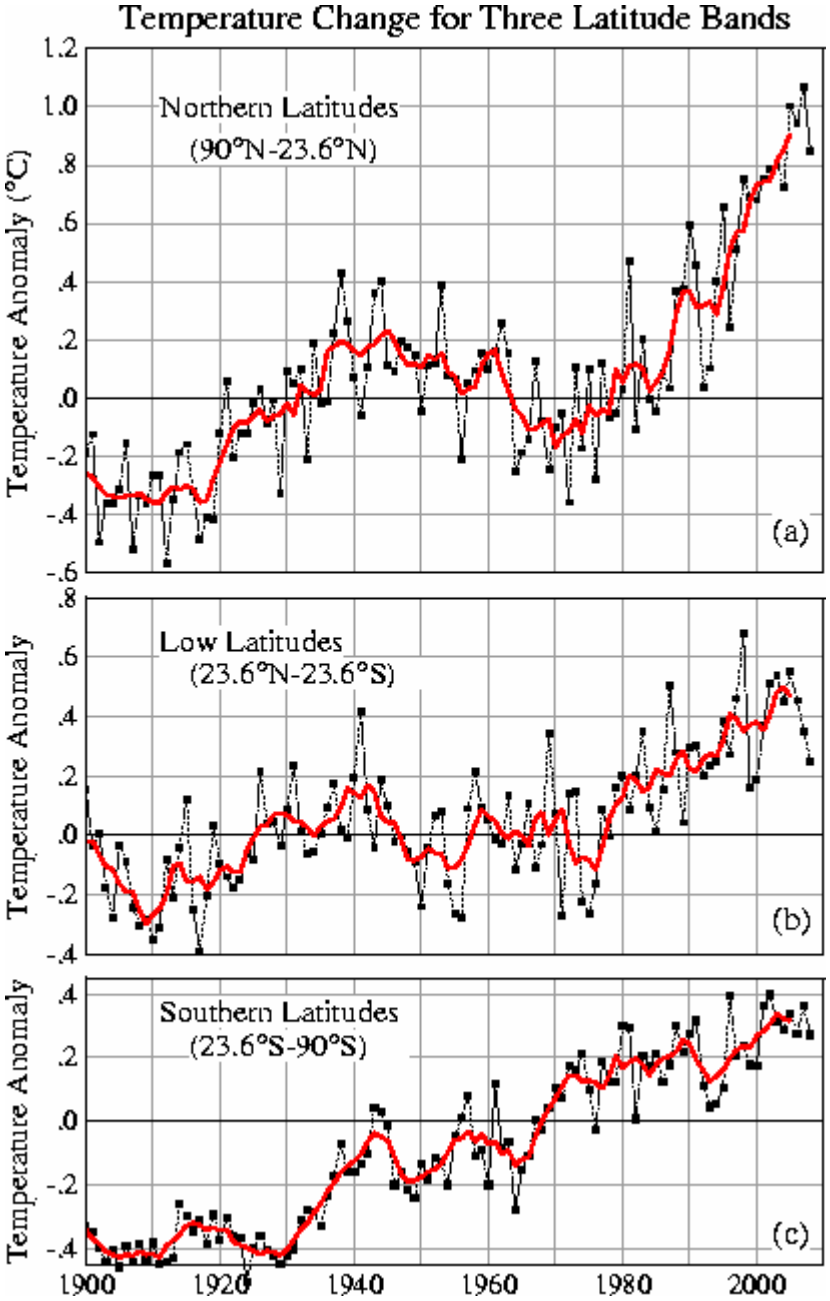


International programs feed the IPCC reports

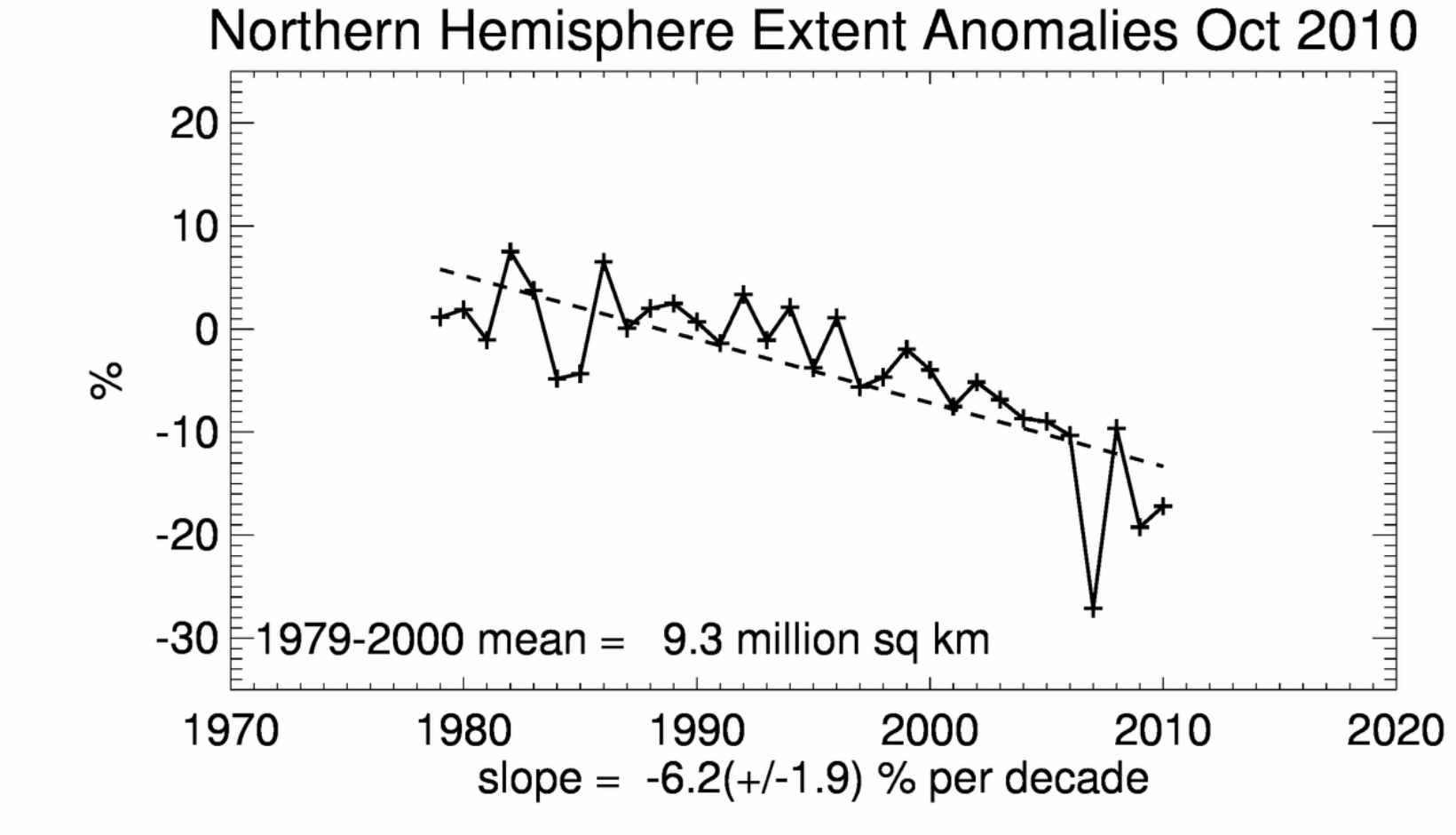


This is the case of CMIP5,

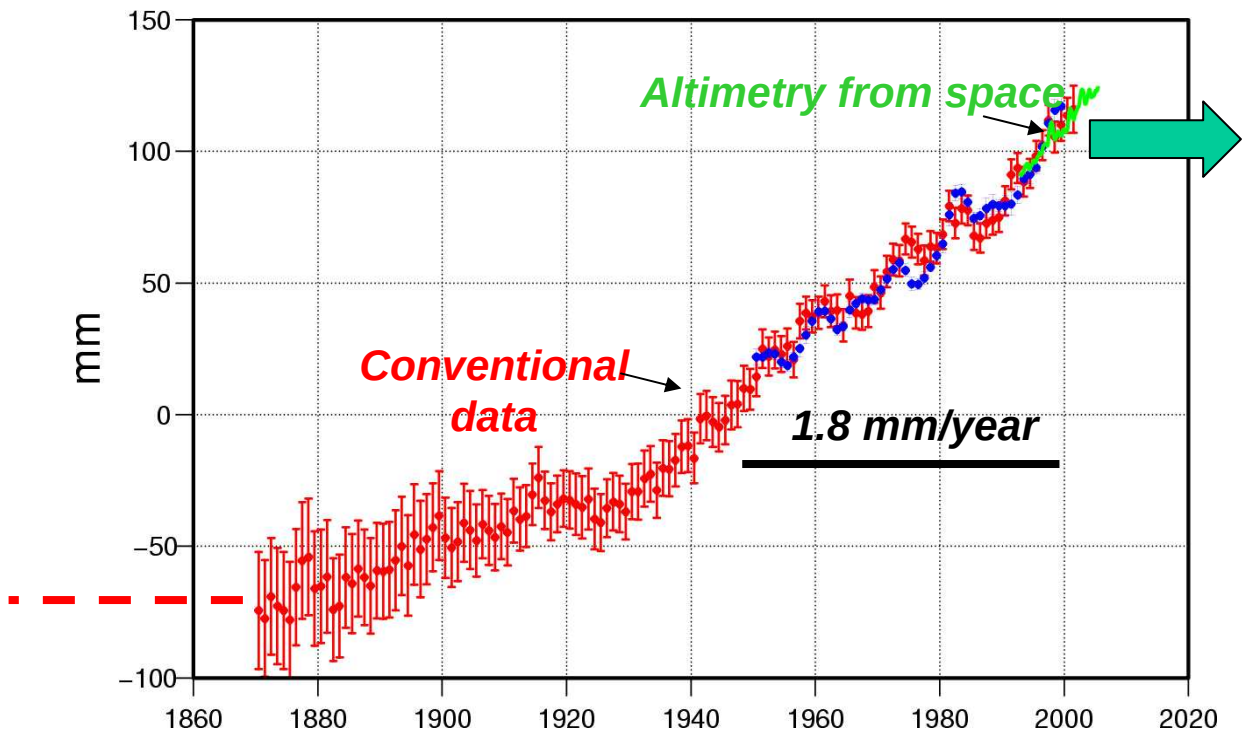
the new WCRP Coupled Model Intercomparison Program,
which should constitute a strong contribution to the IPCC AR5

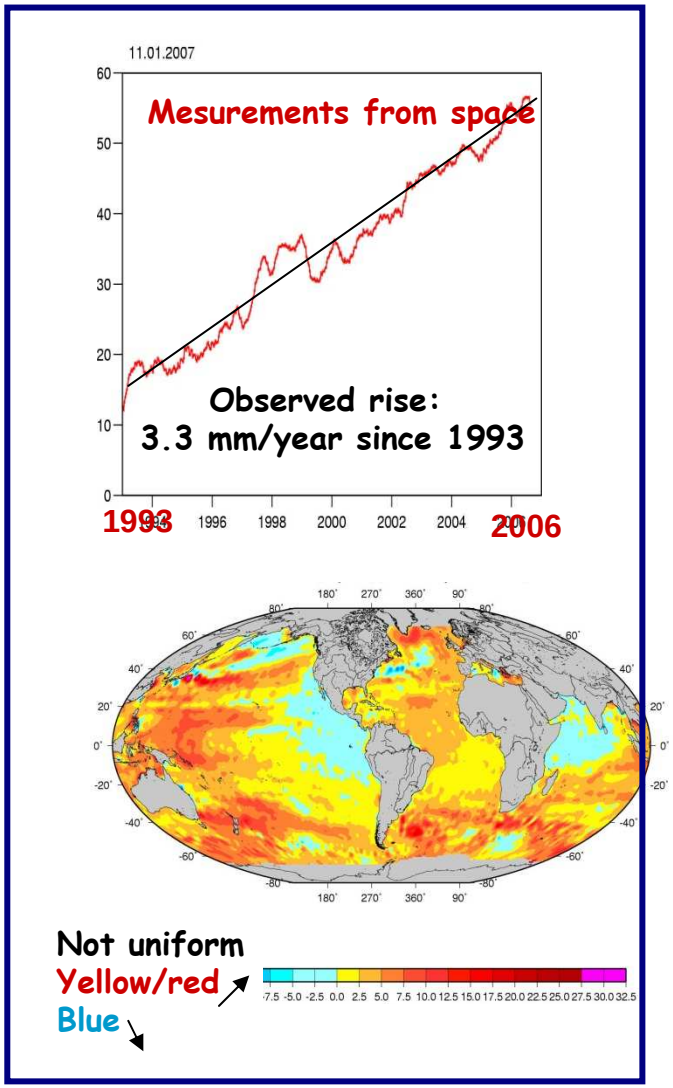


Variabilité naturelle et action de l'homme se superposent

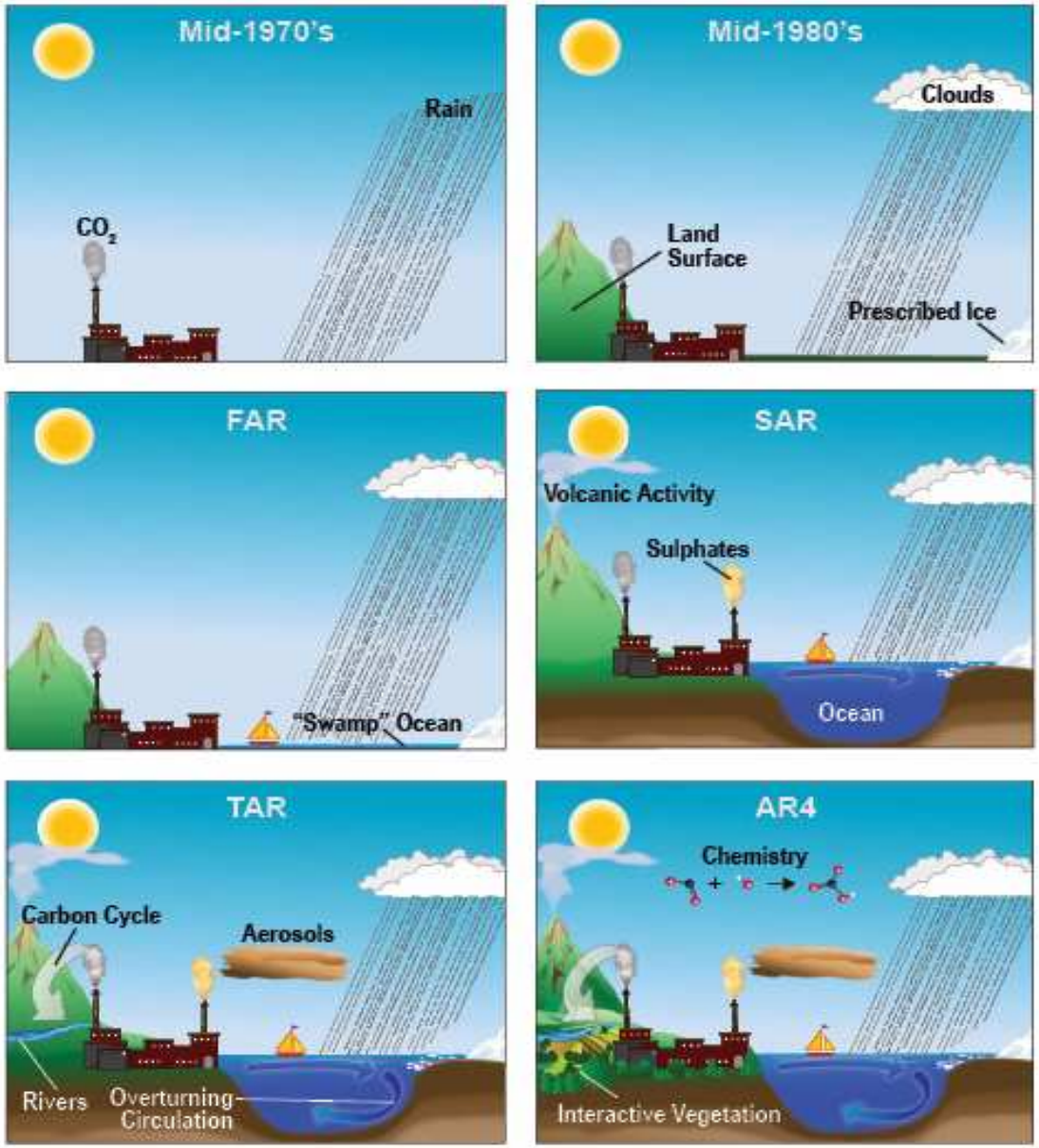

Northern Hemisphere Extent Anomalies Oct 2010
20
10
0
-10
-20
-30
%
1979-2000 mean = 9.3 million sq km
1970
1980
1990
2000
2010
2020
slope = -6.2(+/-1.9) % per decade

Sea-level rise throughout the 20th century

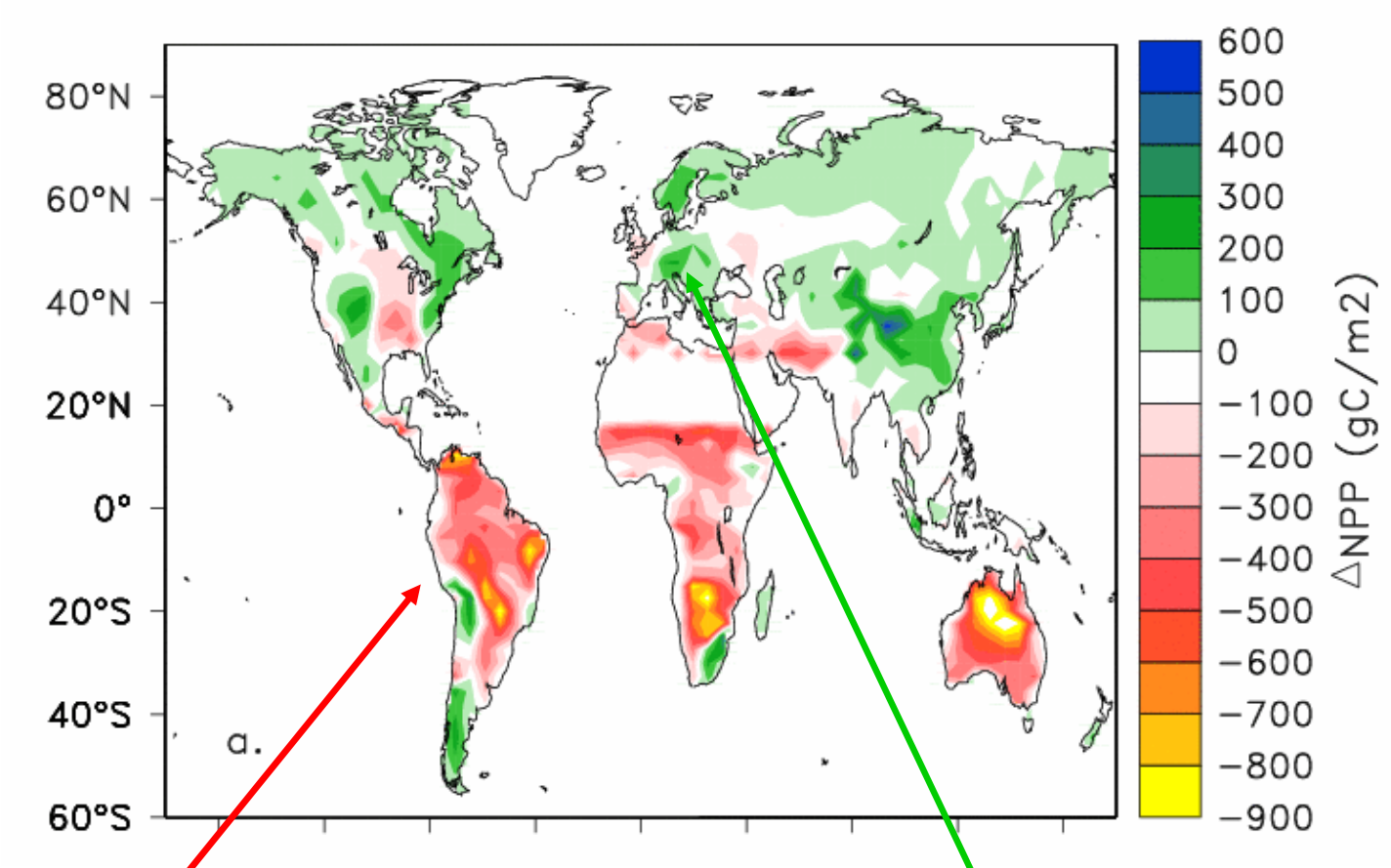




The World in Global Climate Models



The response of NPP to climate



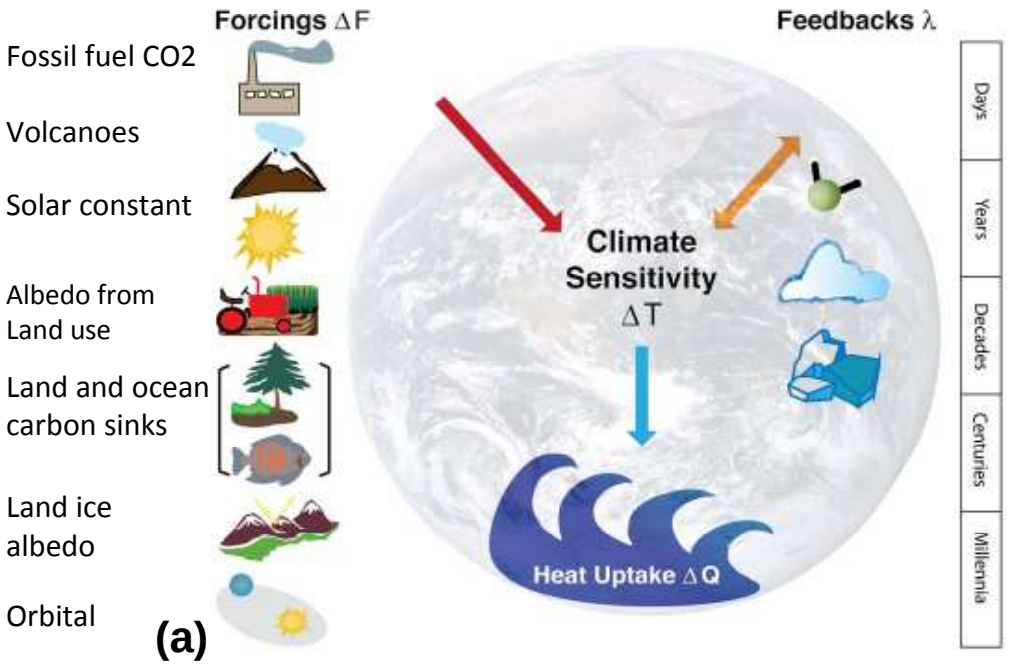
Increase in soil aridity

Extension of the growing season

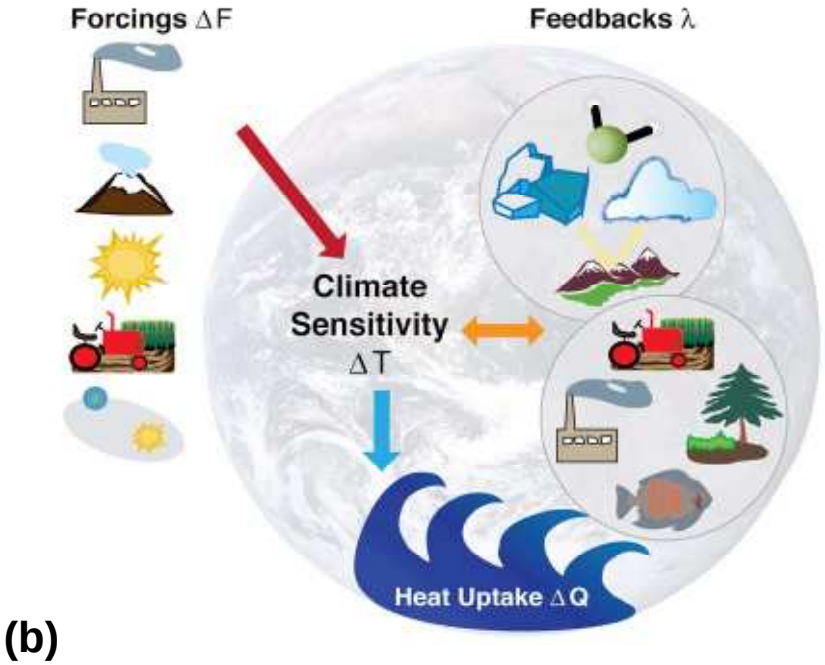
Berthelot et al., 2002

Feedbacks and climate sensitivity definition

In absence of feedback 2xCO2 -> 1°C warming



Charney sensitivity
3°C per 2x CO2



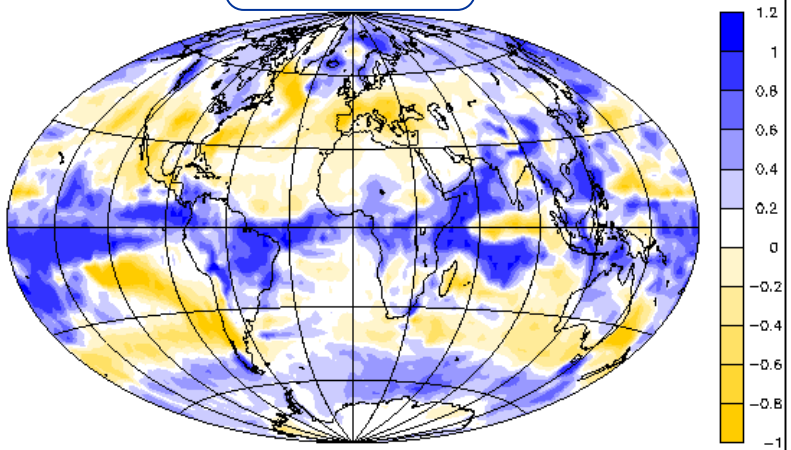
Long term climate sensitivity
6°C per 2xCO2

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

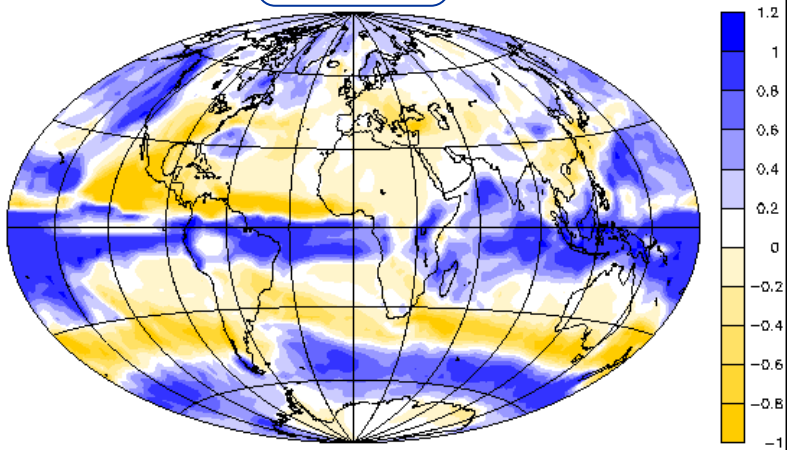
CNRM

IPSL

A2

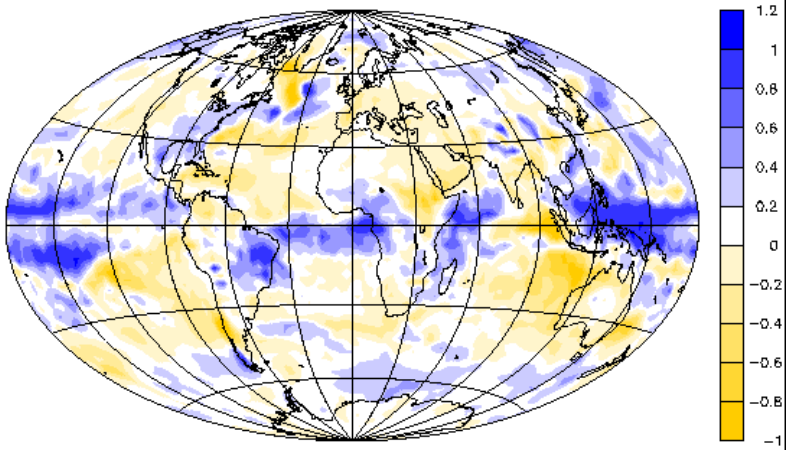


IPCC / CNRM – SRESA2 scenario – Anomalies de la precipitation (mm/jour)
(2090–2099) comparee a (2000–2009)

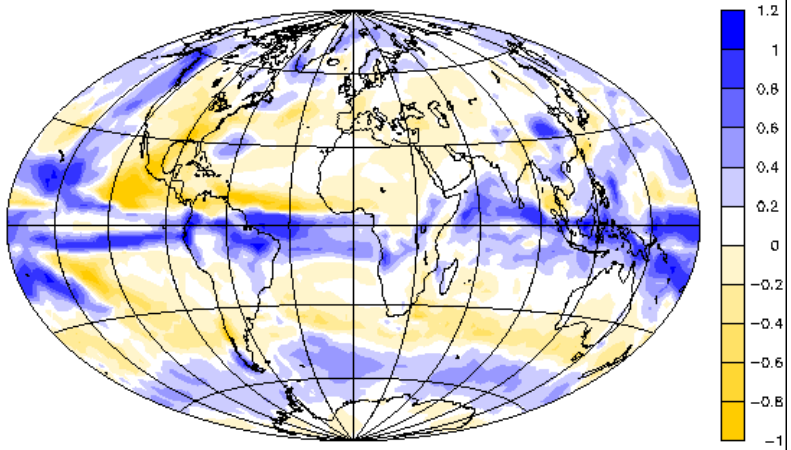


IPCC / IPSL – SRESA2 scenario – Anomalies de la precipitation (mm/jour)
(2090–2099) comparee a (2000–2009)

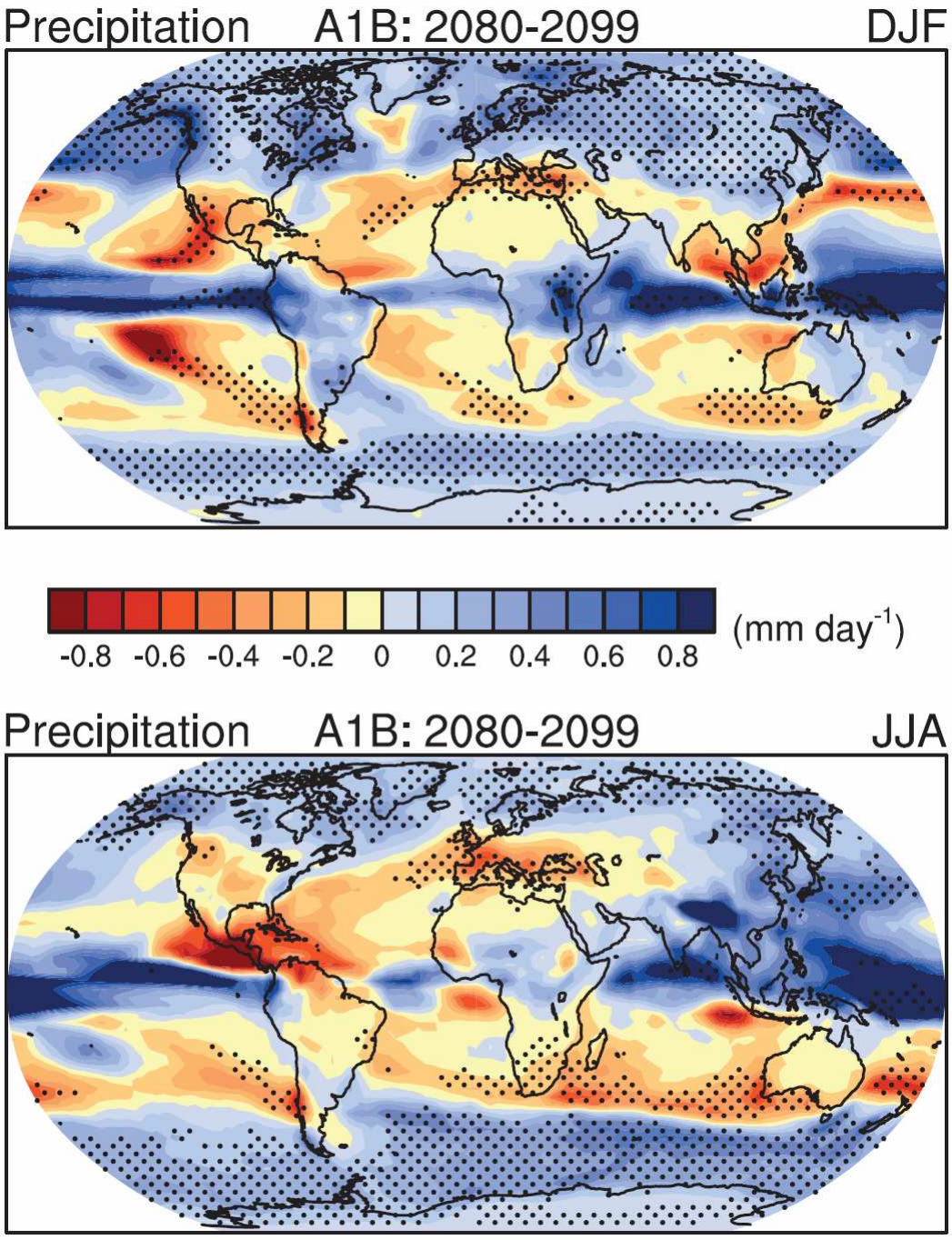
B1



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)

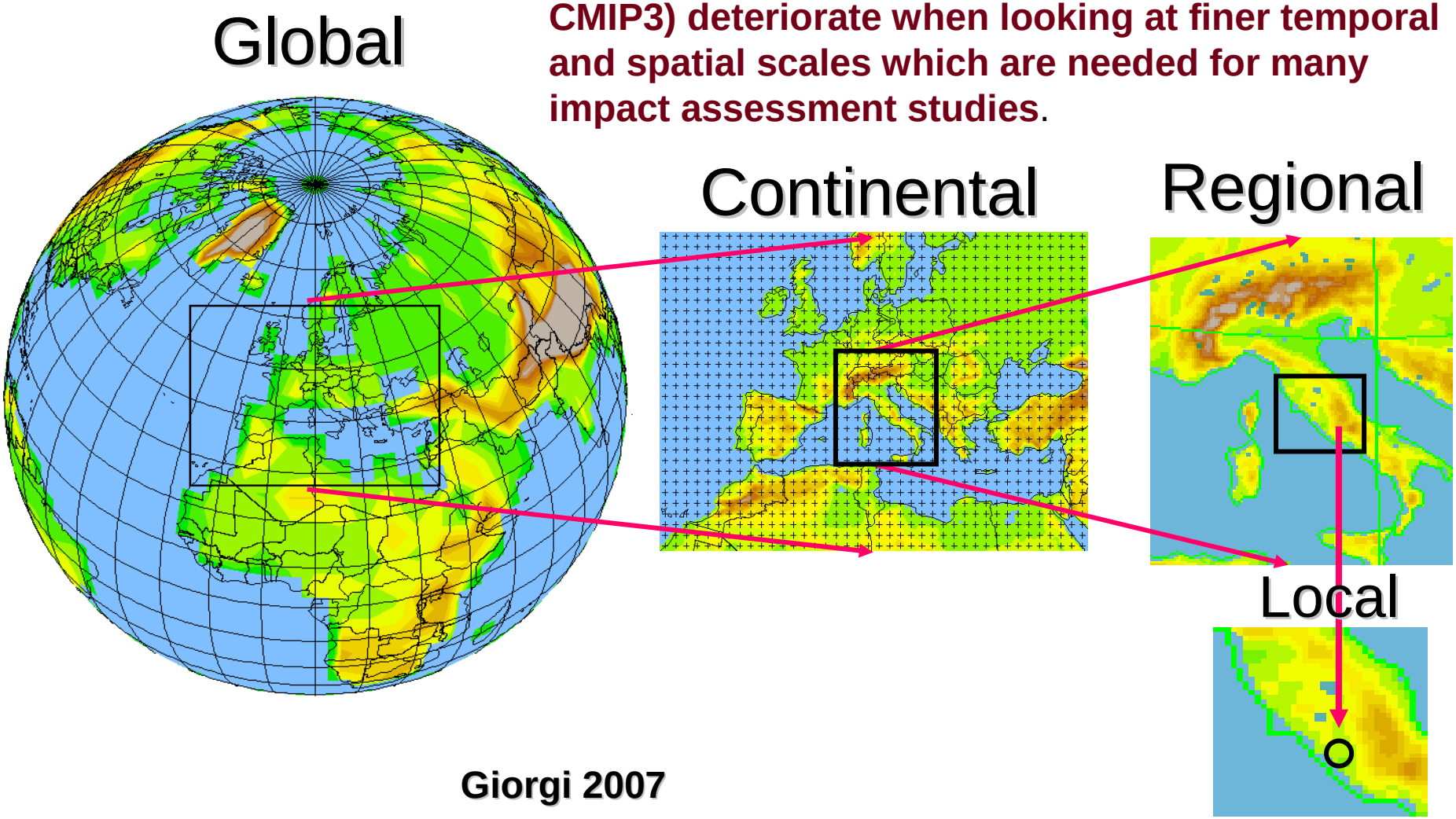


Precipitation changes

AR4

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

Scénarios climatiques : indices sur la France métropolitaine pour les modèles français ARPEGE-Climat et LMDz et quelques projections pour les DOM-COM

26 janvier 2011

Yannick Peings, Météo-France/CNRM

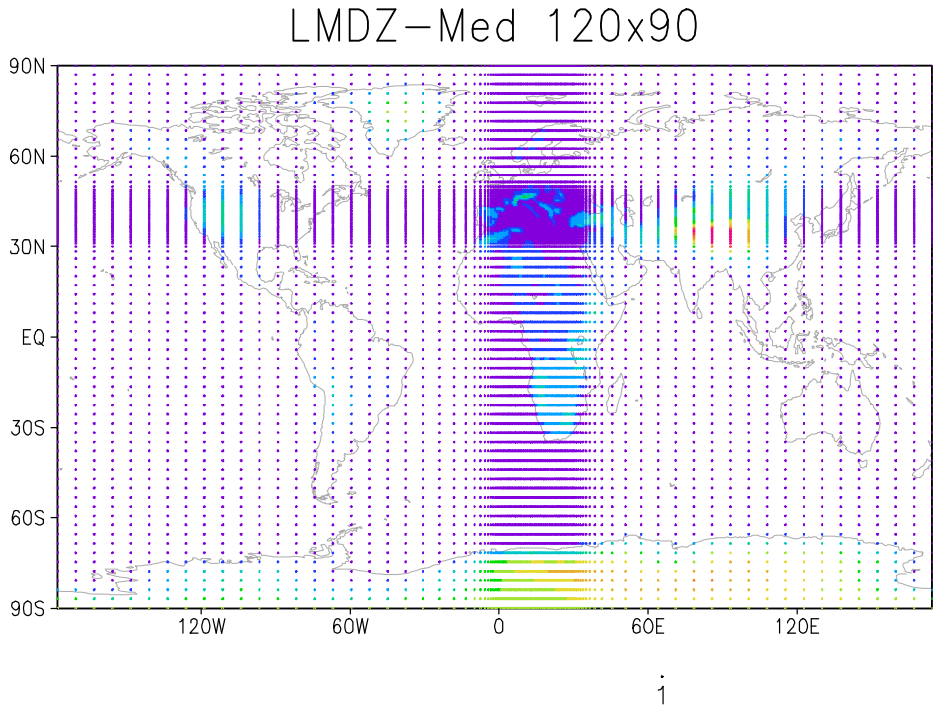
Marc Jamous, IPSL

Serge Planton, Météo-France/CNRM

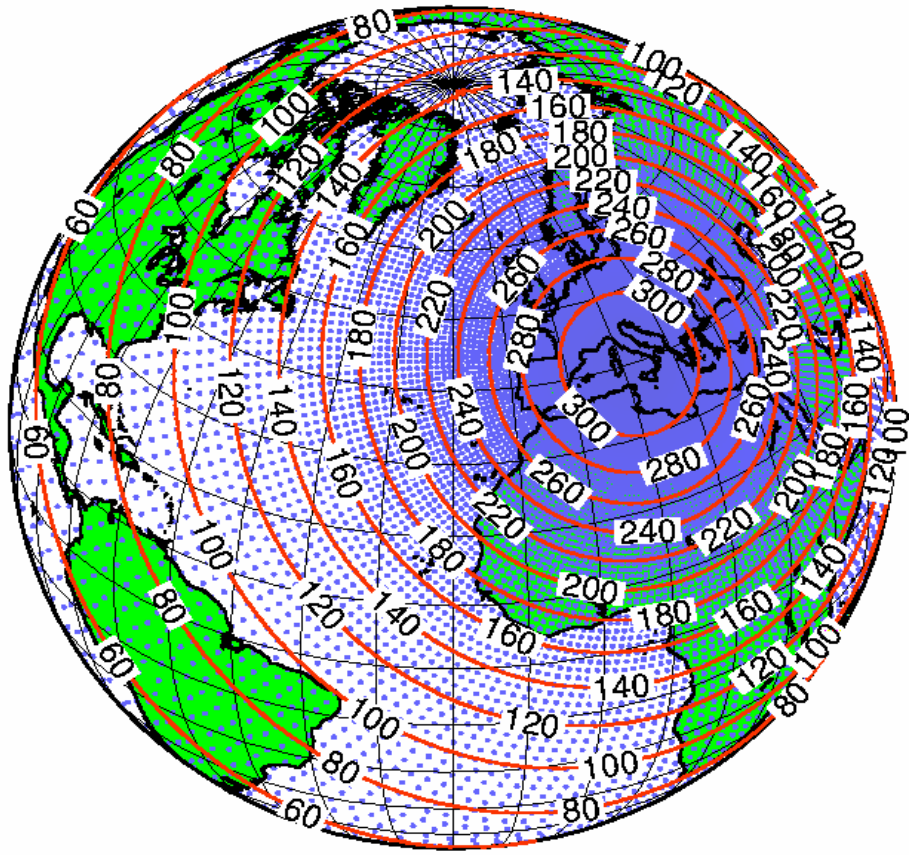
Hervé Le Treut, IPSL

Mission confiée à Jean Jouzel

Two French zoomed climate models



LMDZ-Mediterranean
(IPSL, Paris)



Arpege-Mediterranean
(Météo-France, Toulouse)

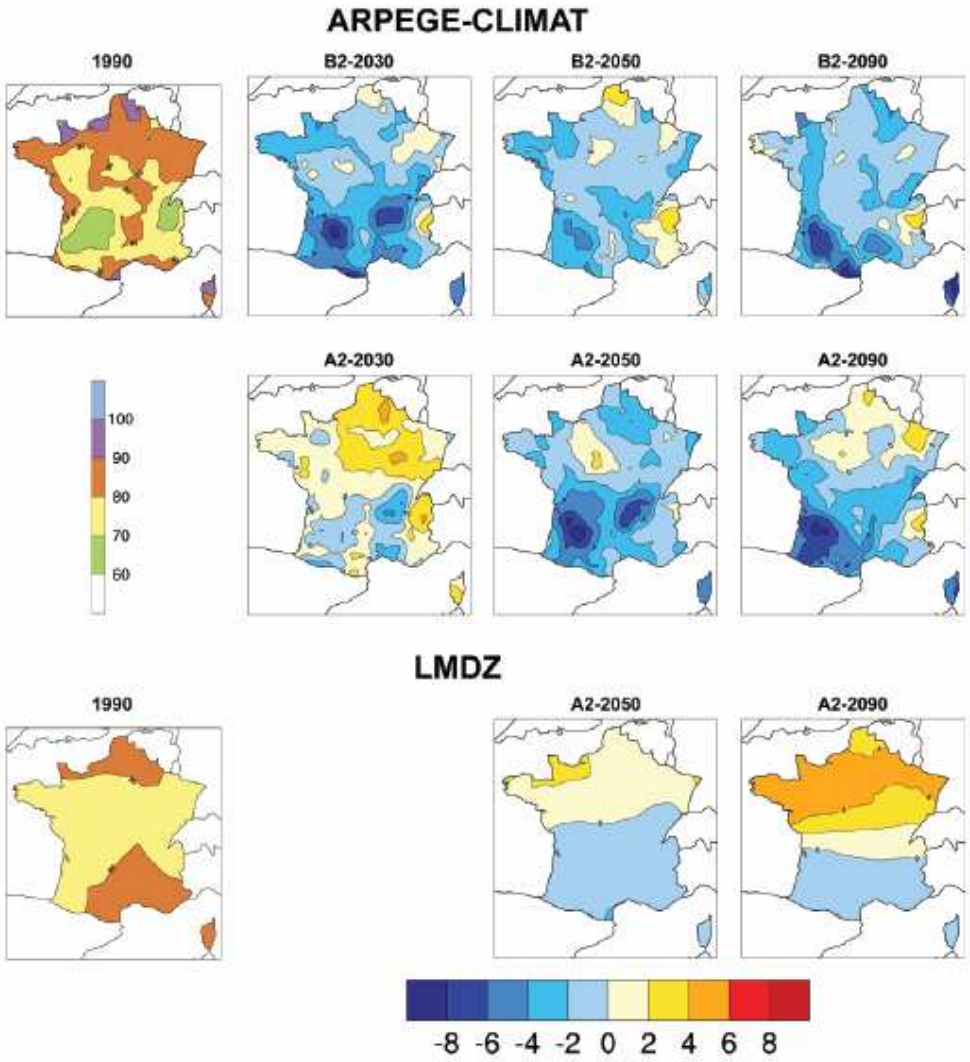


Figure V01-hiver. Vent maximal hivernal, pour la période de référence et les écarts entre les scénarios et la référence. Unité : km/h.

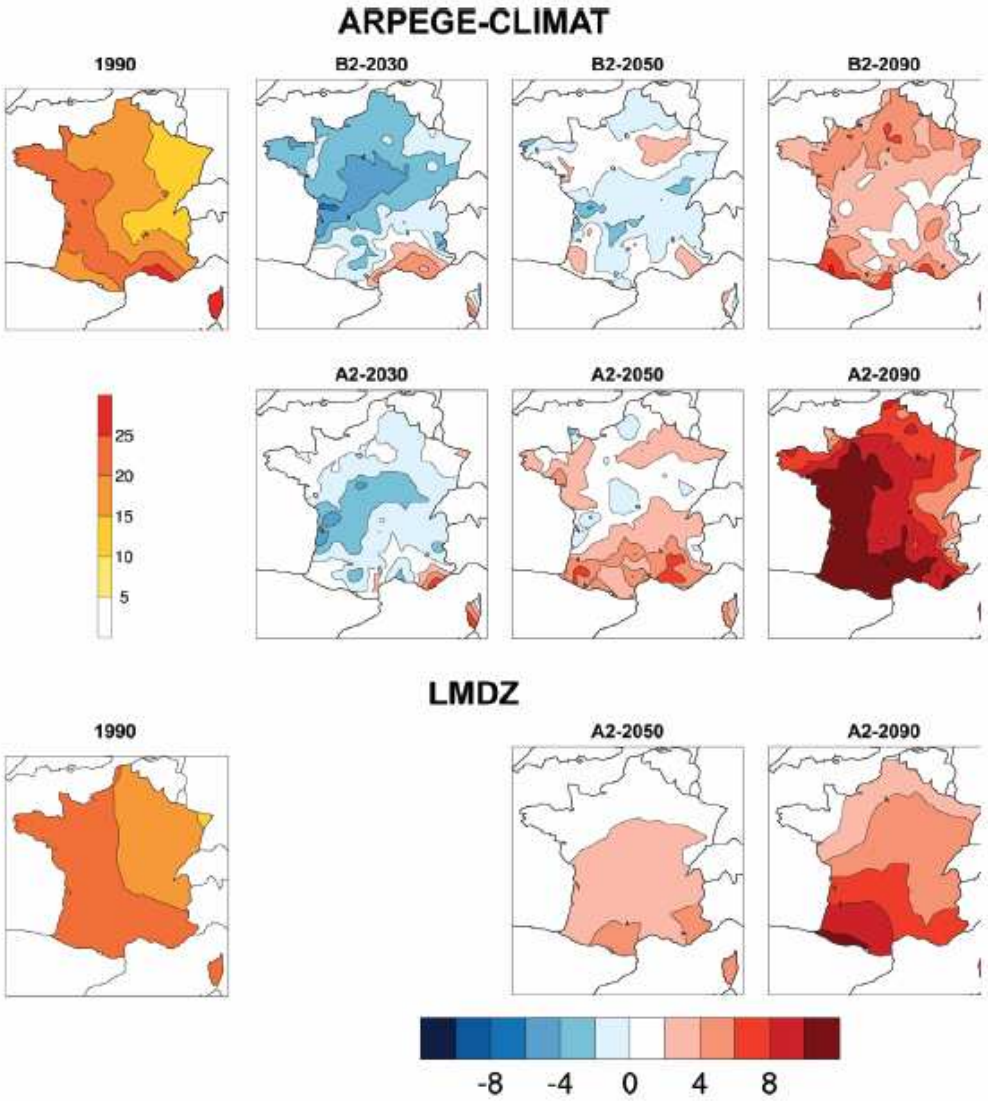
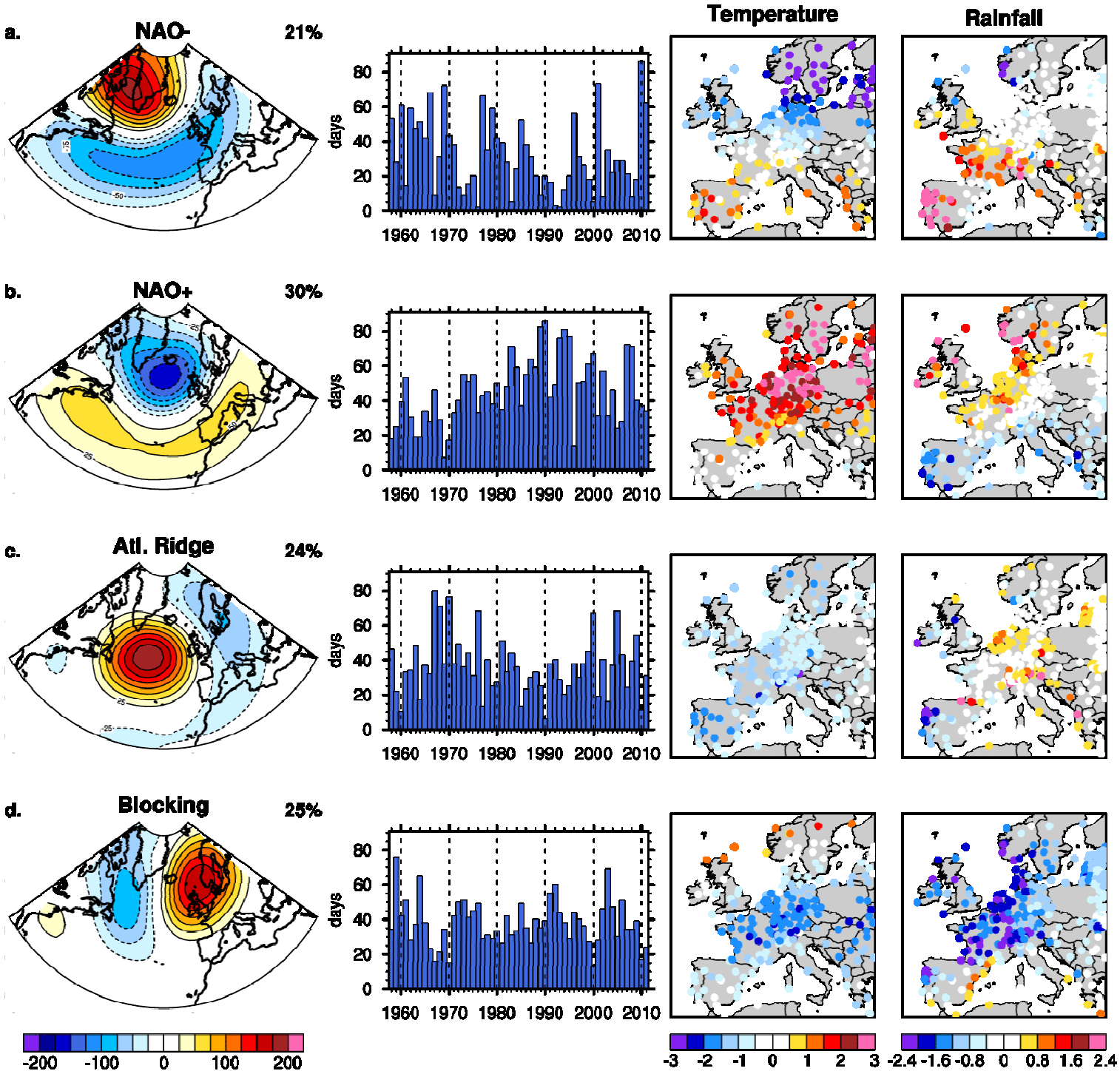
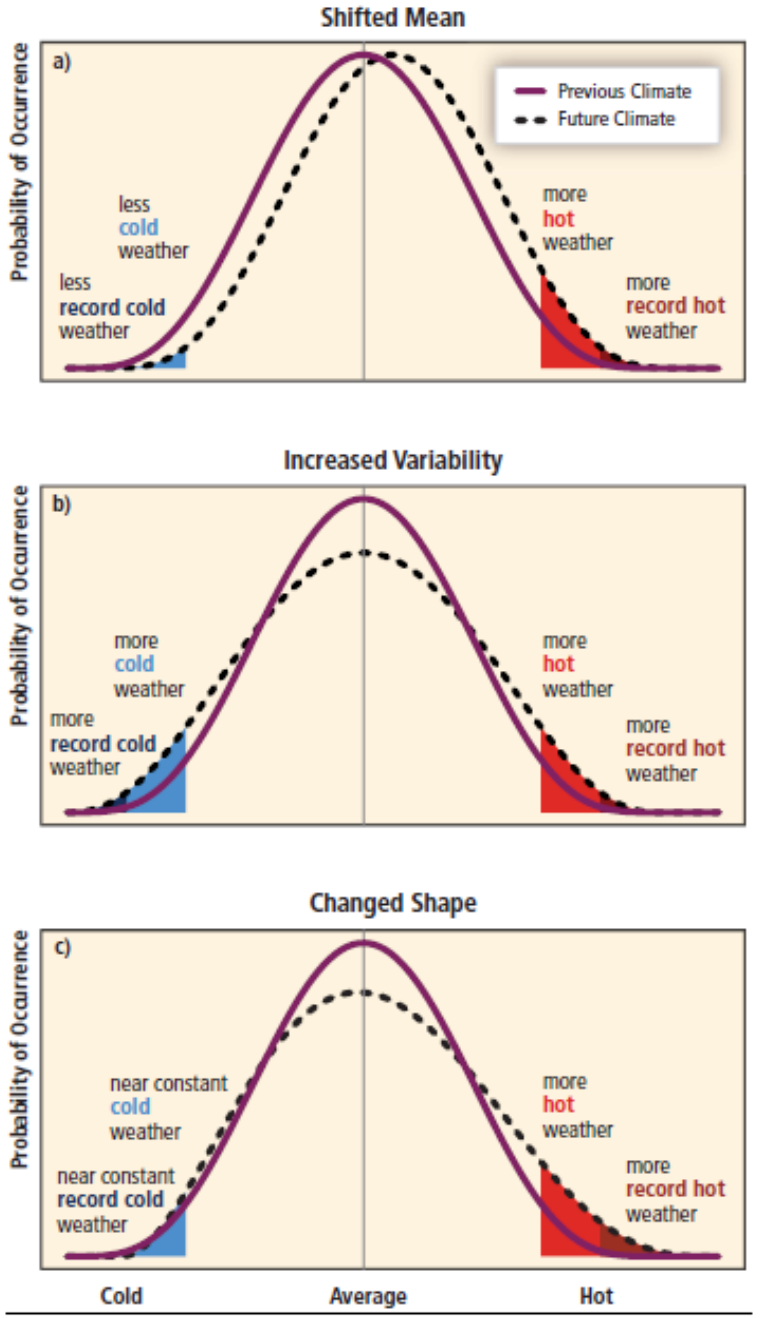


Figure P04-été. Nombre estival de jours consécutifs avec moins de 1 mm de précipitations, pour la période de référence et les écarts entre les scénarios et la référence. Unité : jour.

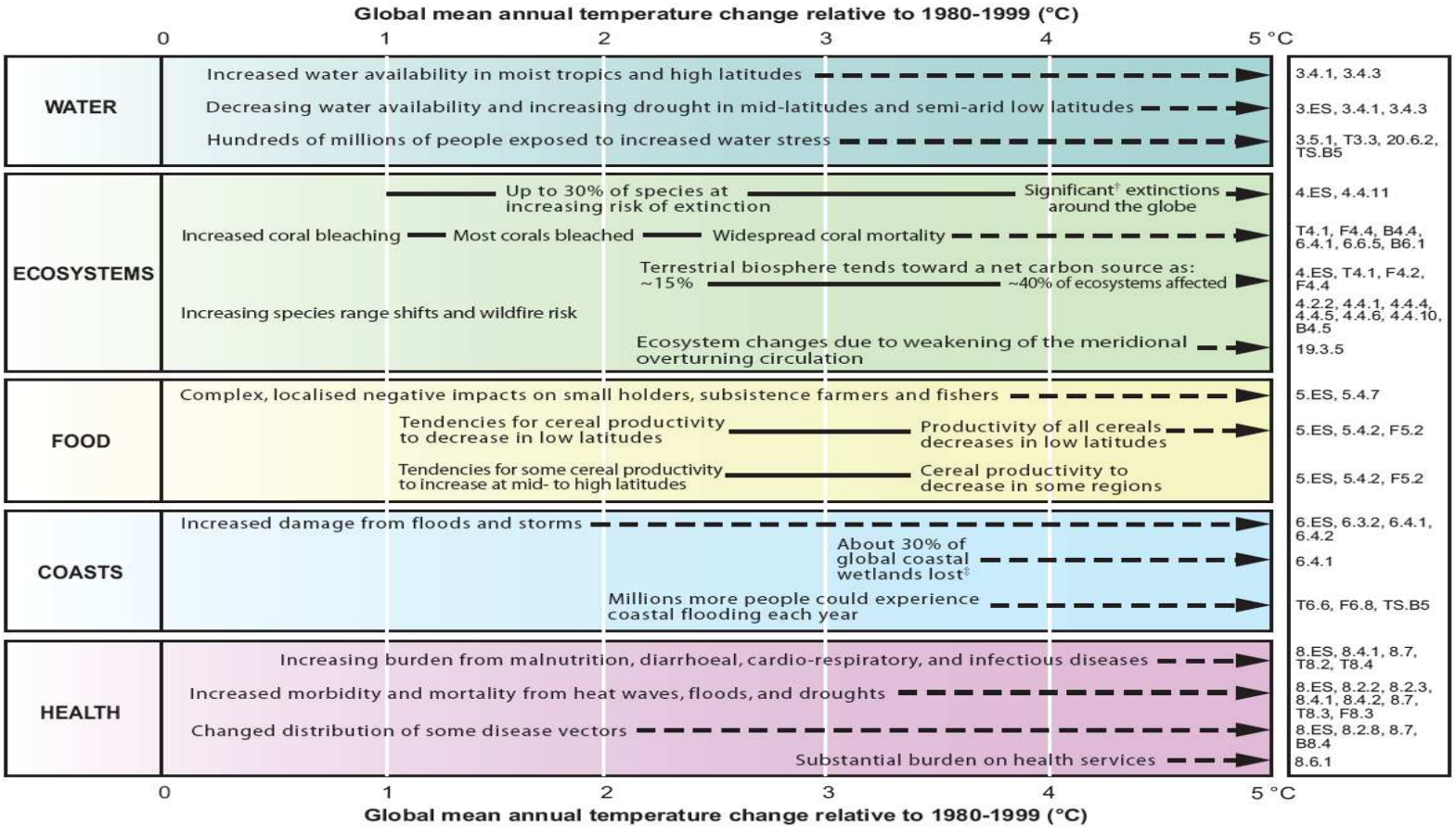

a.
NAO-
21%
b.
NAO+
30%
c.
Atl. Ridge
24%
d.
Blocking
25%
Temperature
Rainfall
days
0
20
40
60
80
1960
1970
1980
1990
2000
2010
-200
-100
0
100
200
-3
-2
-1
0
1
2
3
-2.4
-1.6
-0.8
0
0.8
1.6
2.4

Extreme events respond to specific statistics, and their number may increase out of proportion compared with the mean climate



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

Conclusions

- Il n'y a pas de solutions que les experts peuvent imposer: il s'agit de vrais choix de sociétés (avec des aspects éthiques, des notions de justice et d'injustice) qui doivent être l'objet de débats citoyens, mais doivent s'appuyer sur une expertise multidisciplinaire

- Probable nécessité de séparer deux échelles de temps: l'horizon à quelques décennies, l'horizon plus lointain.

Table SPM-1. Recent trends, assessment of human influence on the trend, and projections for extreme weather events for which there is an observed late 20th century trend. {Tables 3.7, 3.8, 9.4, Sections 3.8, 5.5, 9.7, 11.2-11.9}

Phenomenon[a] and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of a human contribution to observed trend [b]	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	*Very likely* [c]	*Likely* [e]	*Virtually certain* [e]
Warmer and more frequent hot days and nights over most land areas	*Very likely* [d]	*Likely (nights)* [e]	*Virtually certain* [e]
Warm spells / heat waves. Frequency increases over most land areas	*Likely*	*More likely than not* [f]	*Very likely*
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*Likely*	*More likely than not* [f]	*Very likely*
Area affected by droughts increases	*Likely* in many regions since 1970s	*More likely than not*	*Likely*
Intense tropical cyclone activity increases	*Likely* in some regions since 1970	*More likely than not* [f]	*Likely*
Increased incidence of extreme high sea level (excludes tsunamis) [g]	*Likely*	*More likely than not* [f, h]	*Likely* [i]

IPCC-GIEC / 2007

The difference between risks and vulnerability has been emphasized in the recent IPCC/SREX report on extreme events:

SREX SPM Graphics