

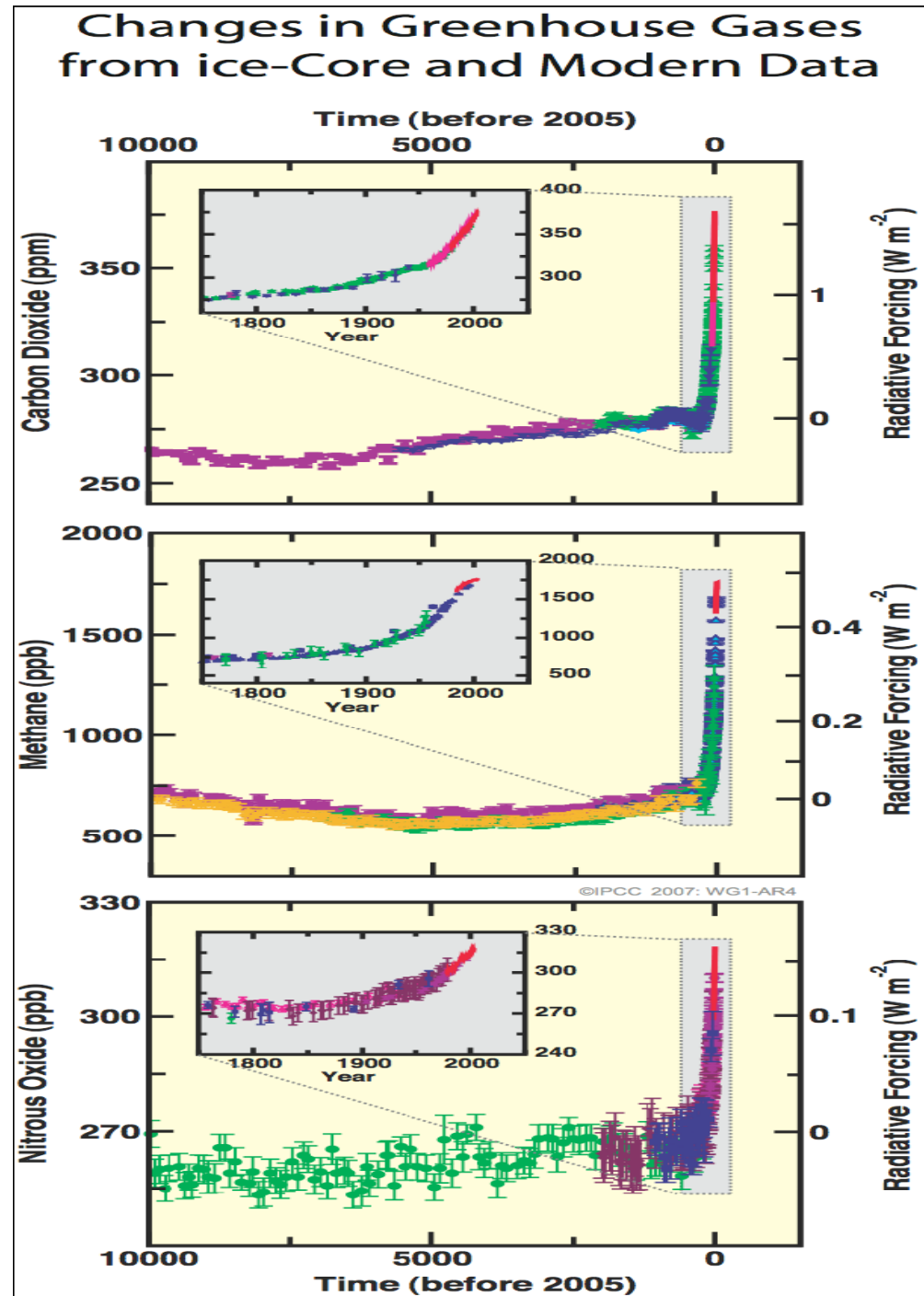
Changements climatiques: de nombreuses certitudes, de nombreuses incertitudes

Hervé Le Treut

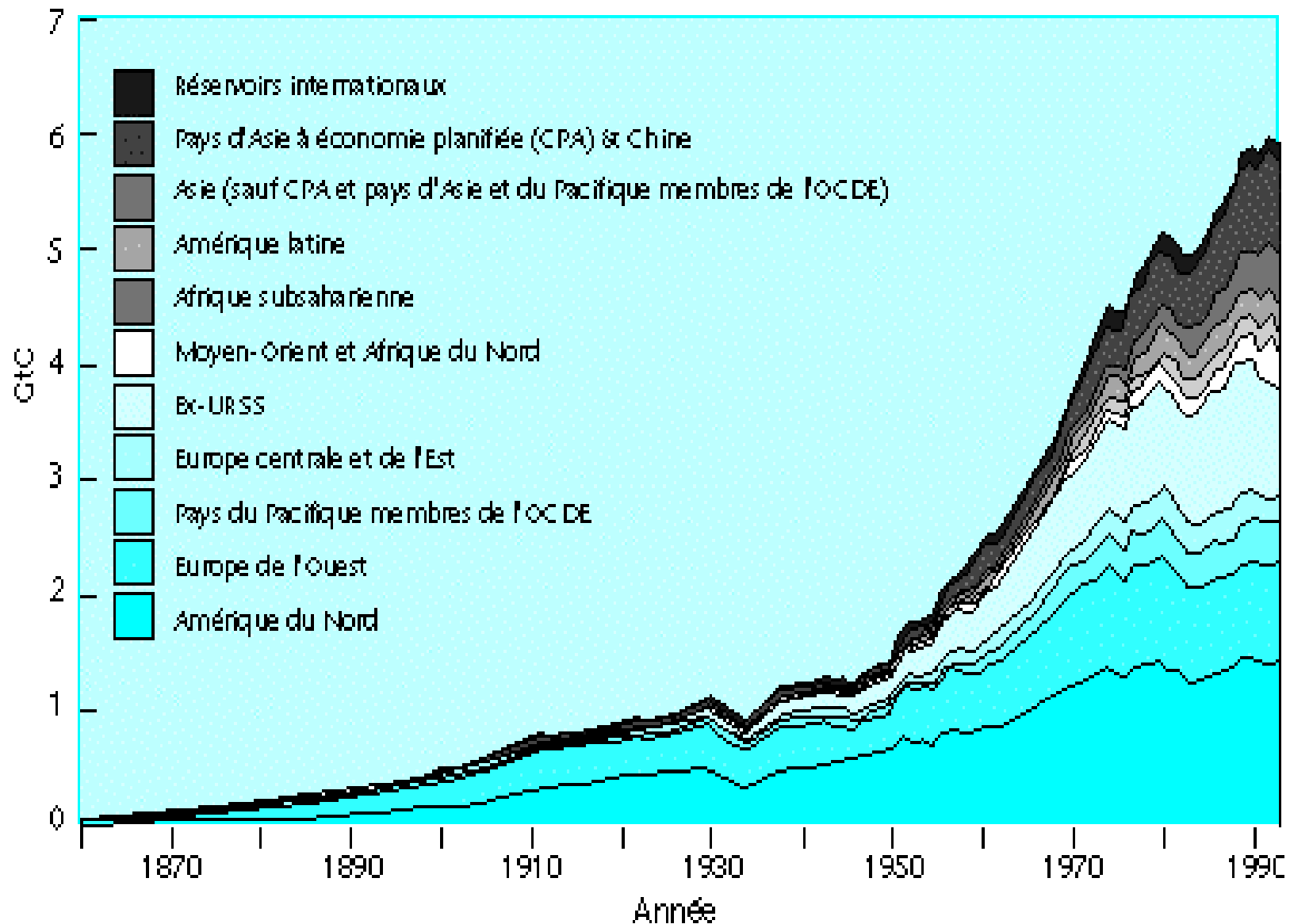
Le climat dans lequel
se sont développés nos
civilisations:

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

IPCC, 2007

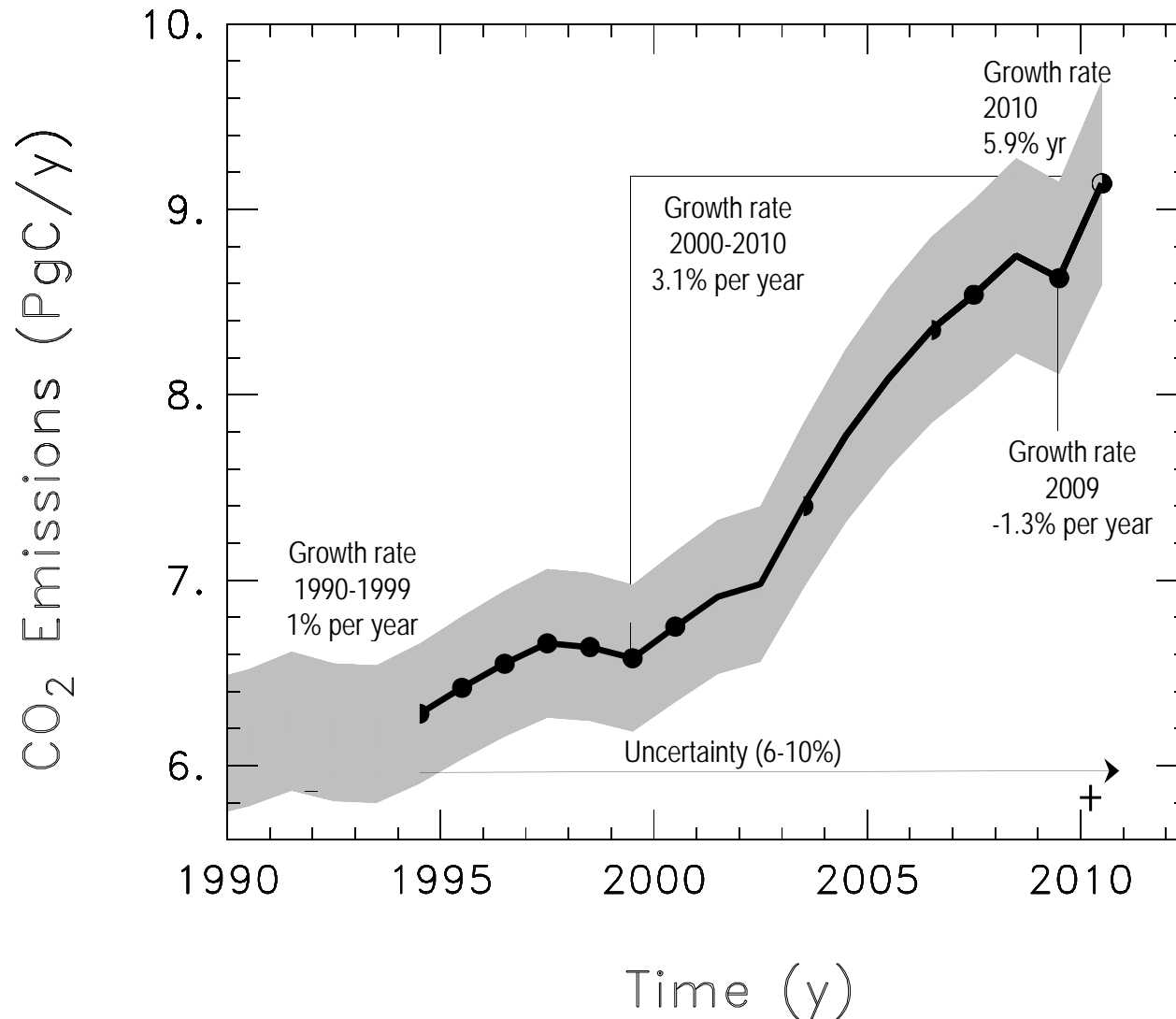


La combustion des combustibles fossiles: 5 milliards de tonnes par an en plus entre 1945 et 1995



International Energy Agency

Fossil Fuel & Cement CO₂ Emissions

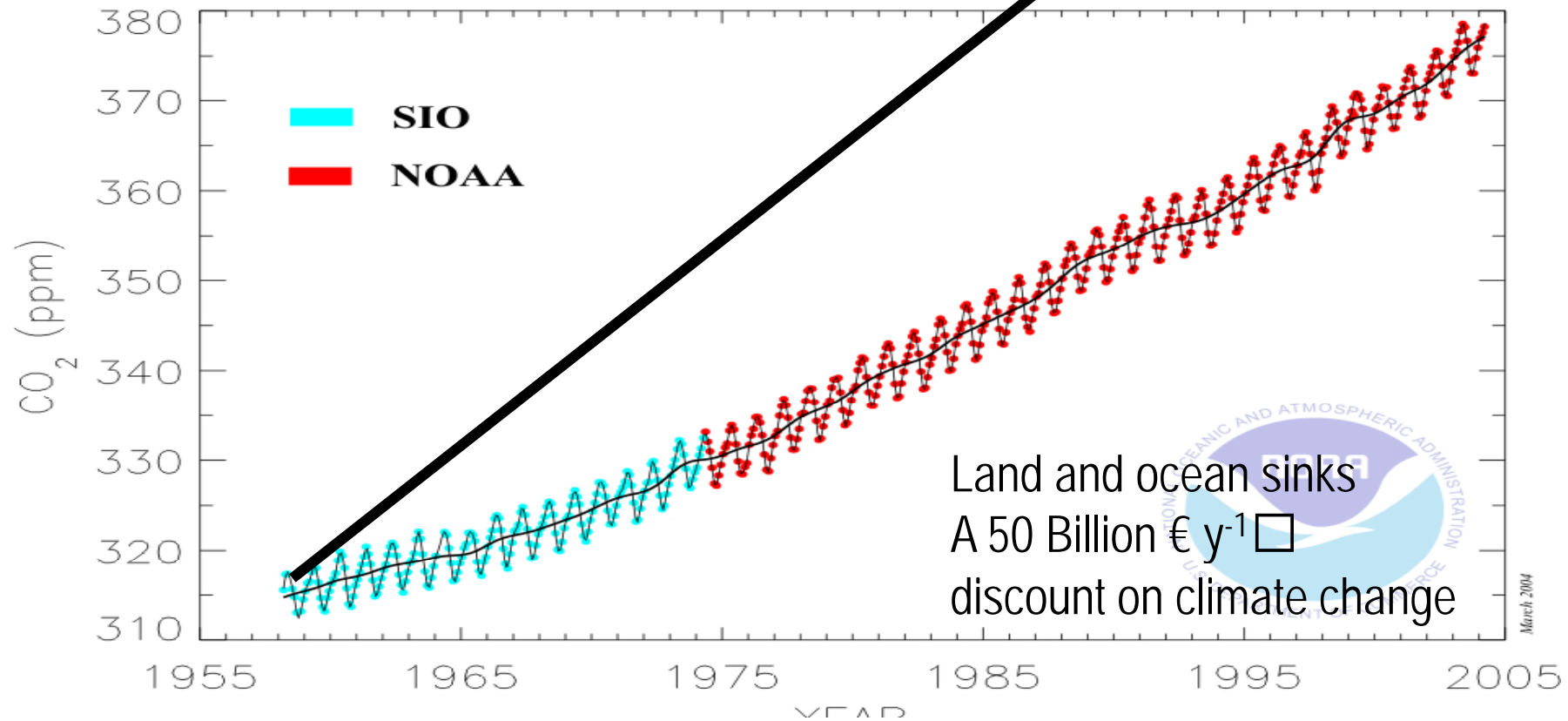


Et presque 3 milliards de tonne de C en plus depuis 2000

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


The Earth without carbon cycle

Mauna Loa Monthly Mean Carbon Dioxide



The Human Perturbation of the CO₂ Budget (2000-2009)

7.7±0.5 PgC y⁻¹



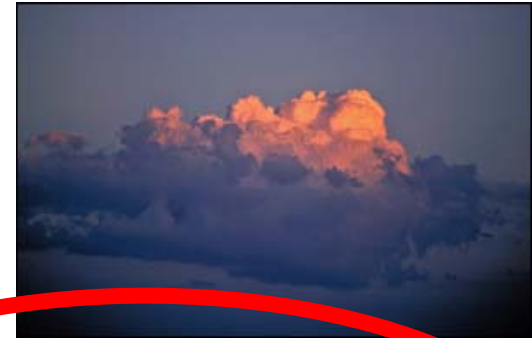
1.1±0.7 PgC y⁻¹

+



2009)
4.1±0.1 PgC y⁻¹

47%



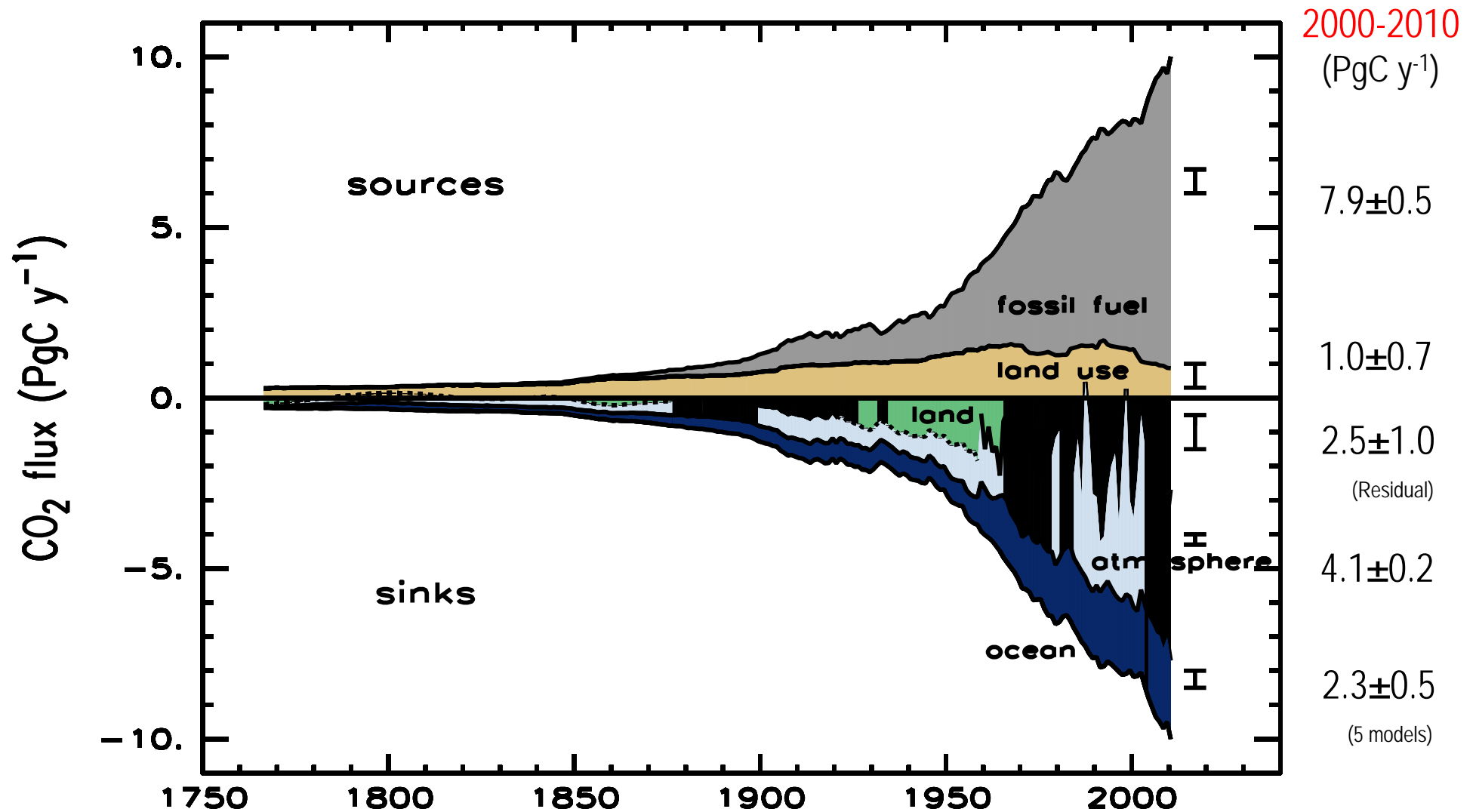
2.4 PgC y⁻¹
27%
Calculated as the residual



26%
2.3±0.4 PgC y⁻¹



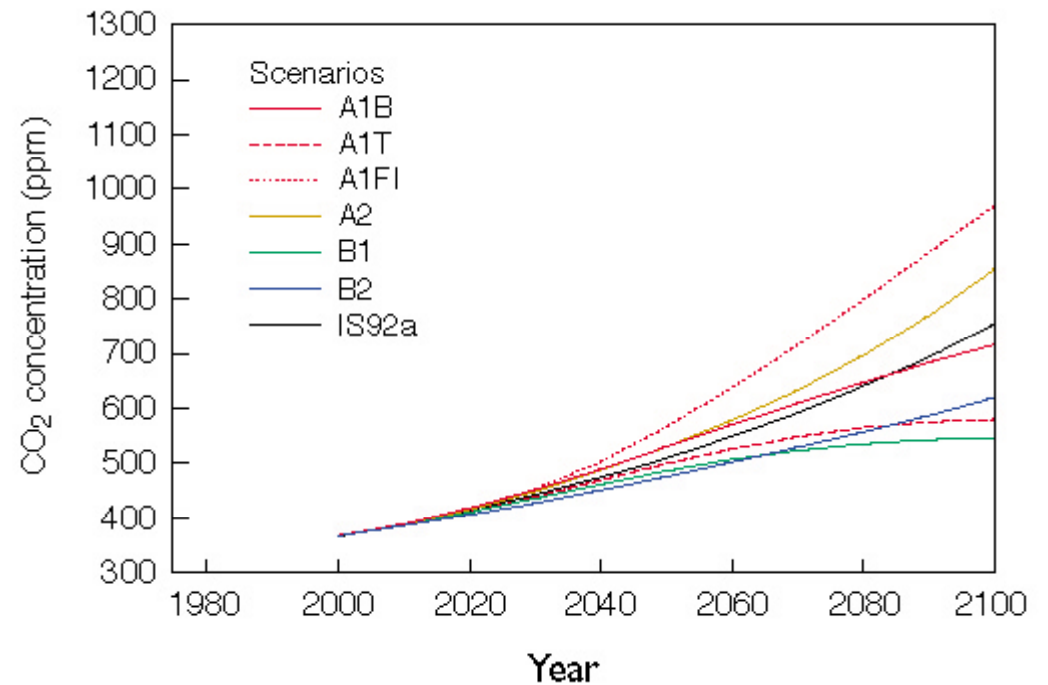
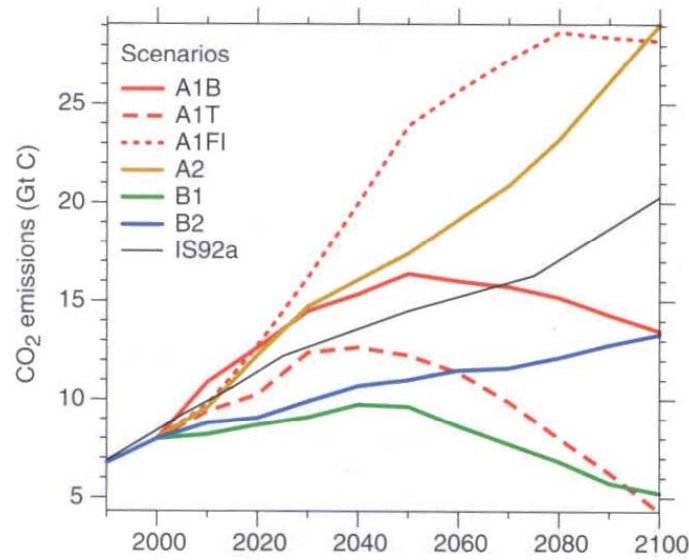
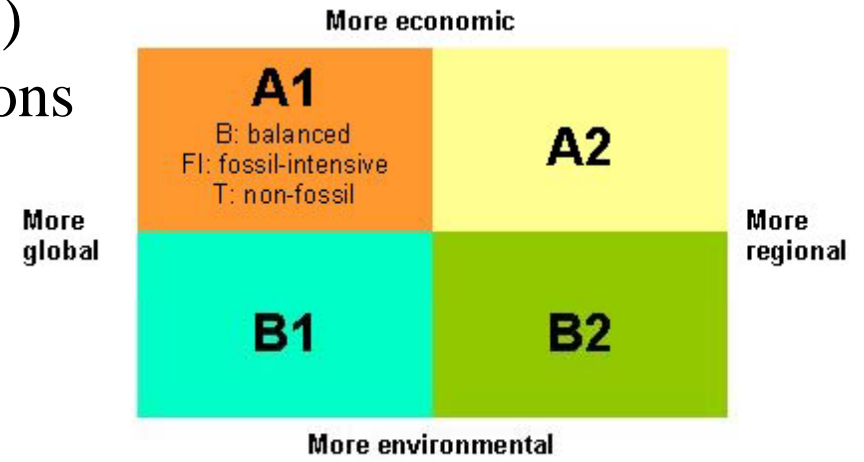
Human Perturbation of the Global Carbon Budget



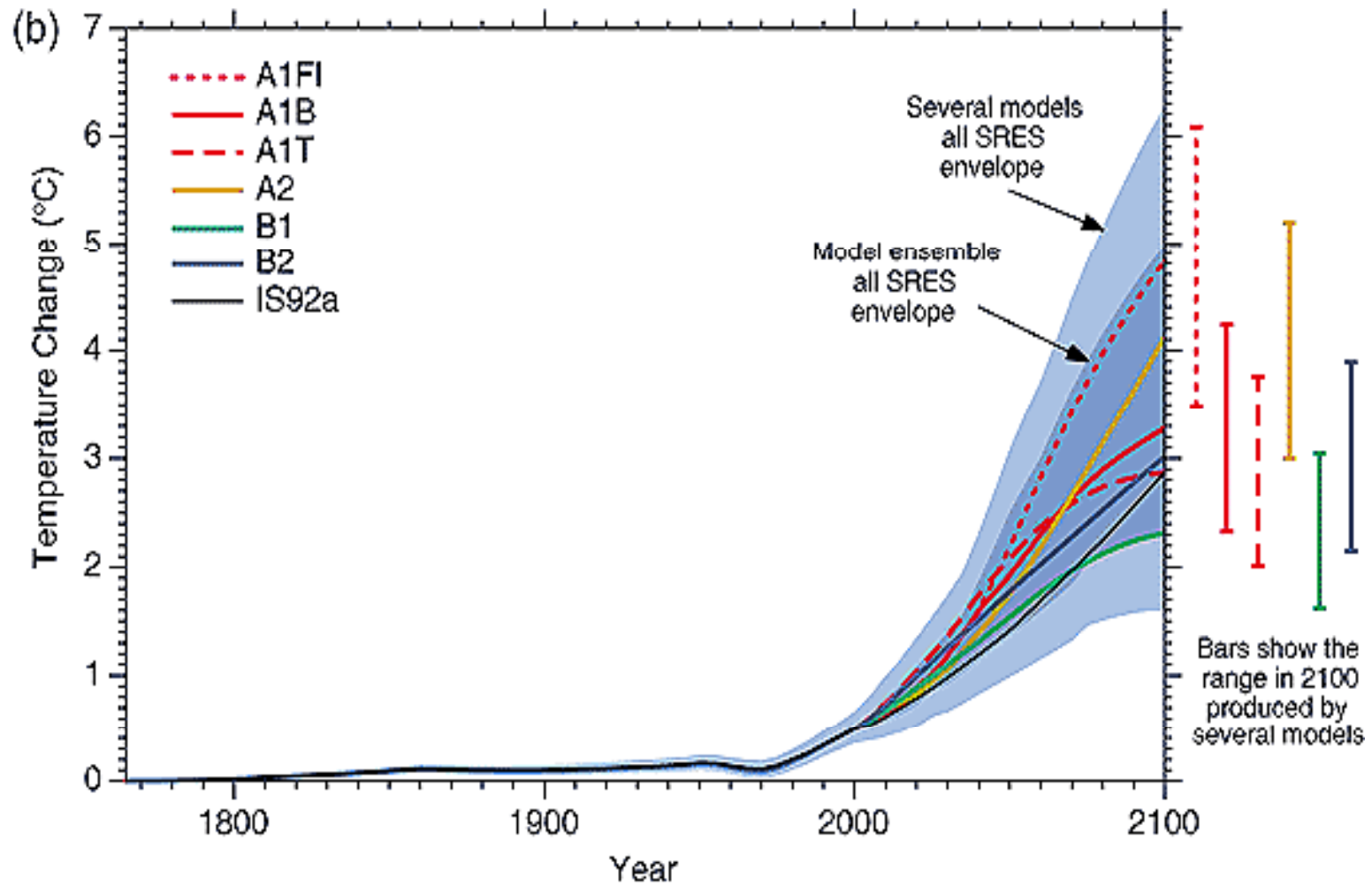
Remarkable linearity of sinks response to emissions forcing
 Land sinks are sensitive to climate, at least on interannual time scale

Les scénarios du GIEC (SRES, 1999)

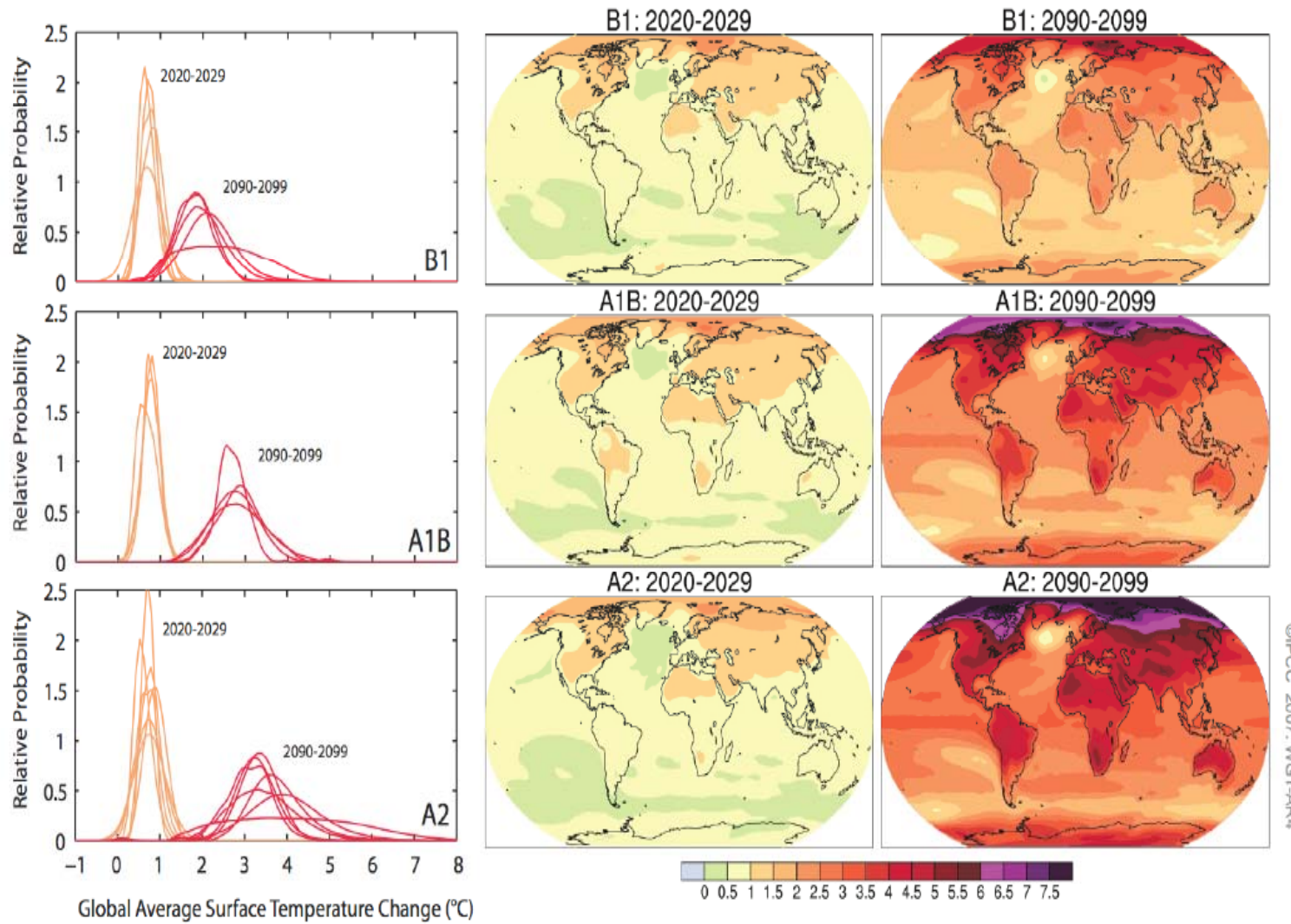
Une première approche des interactions sociétés-climat



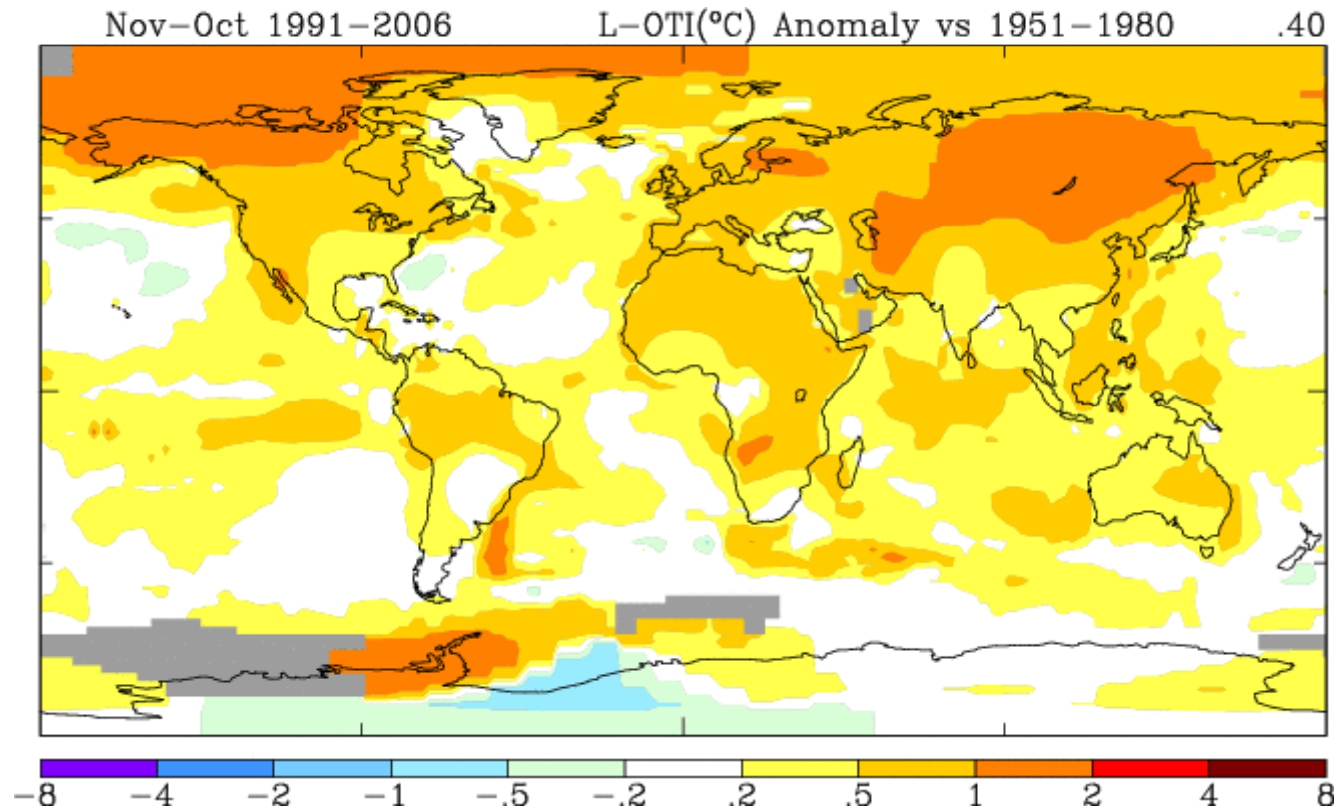
Un exemple de communication mal comprise: GIEC 2001



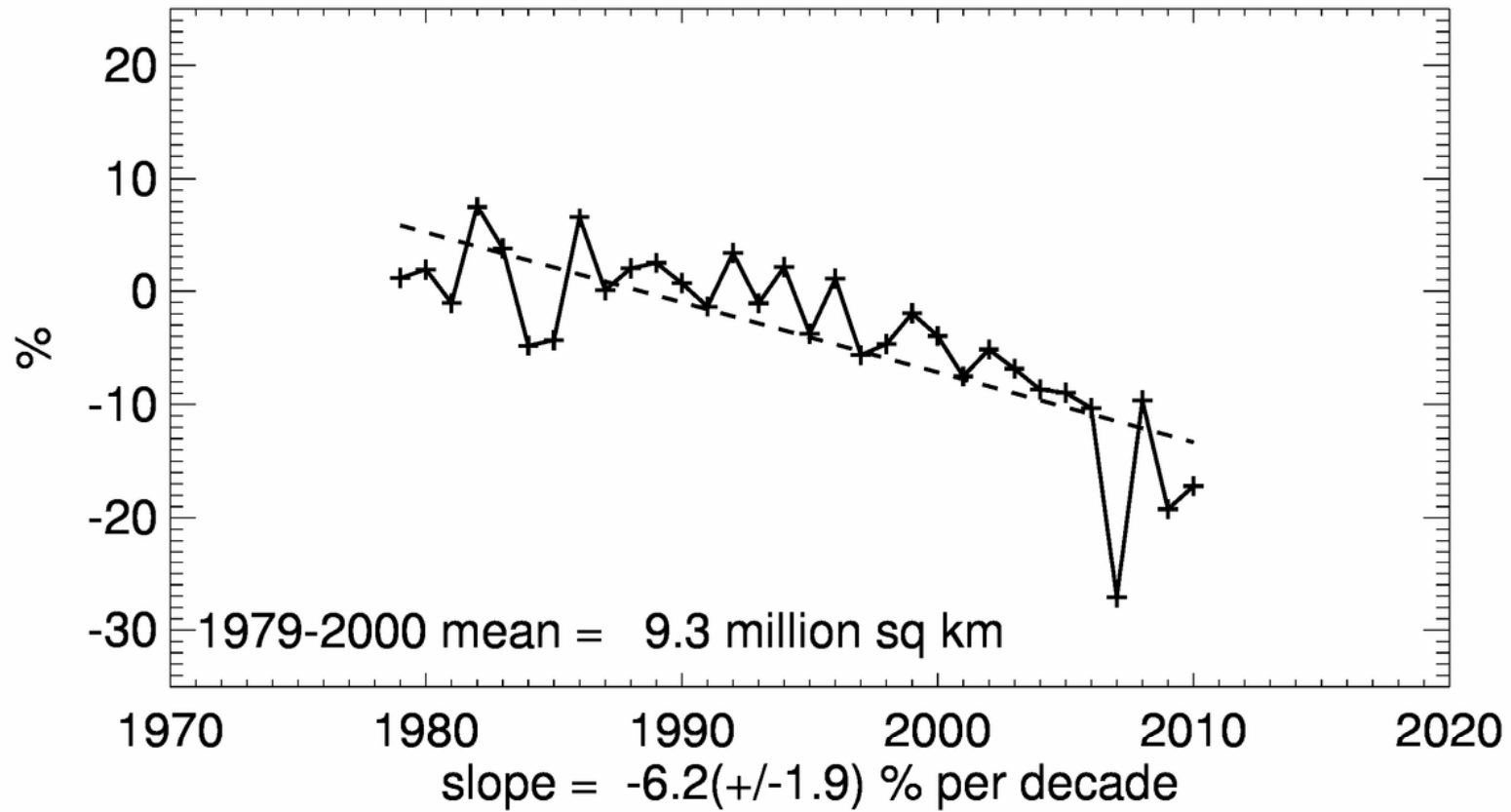
AOGCM Projections of Surface Temperatures



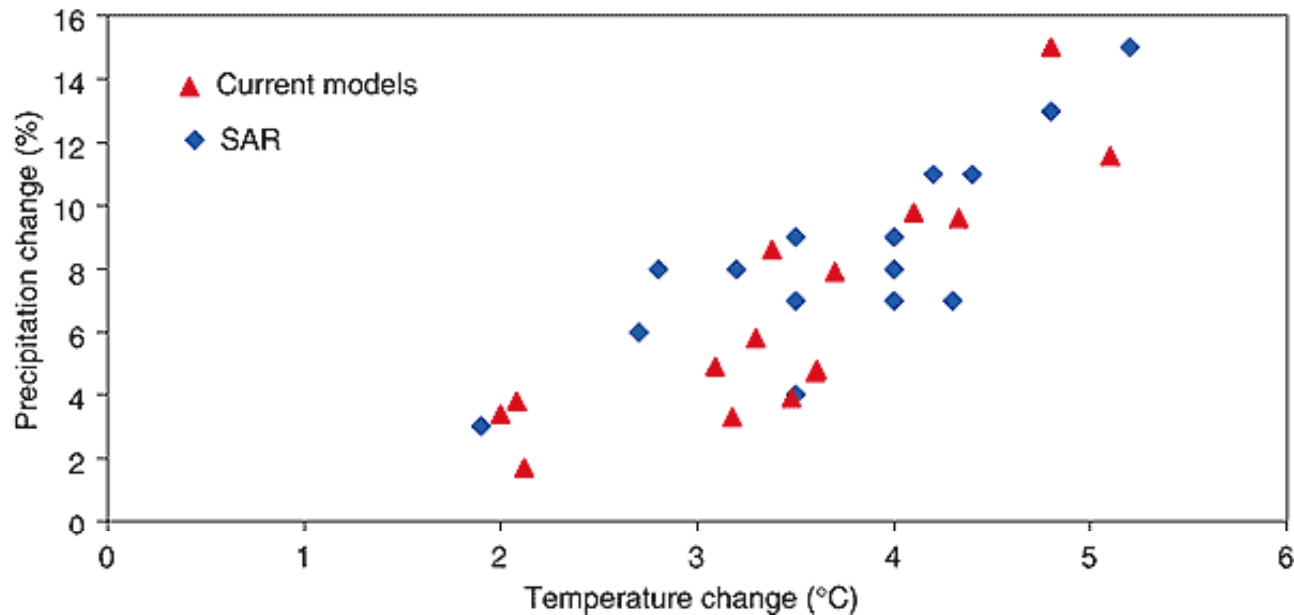
Changements observés



Northern Hemisphere Extent Anomalies Oct 2010



La première approche des changements climatiques: la sensibilité du cliamt

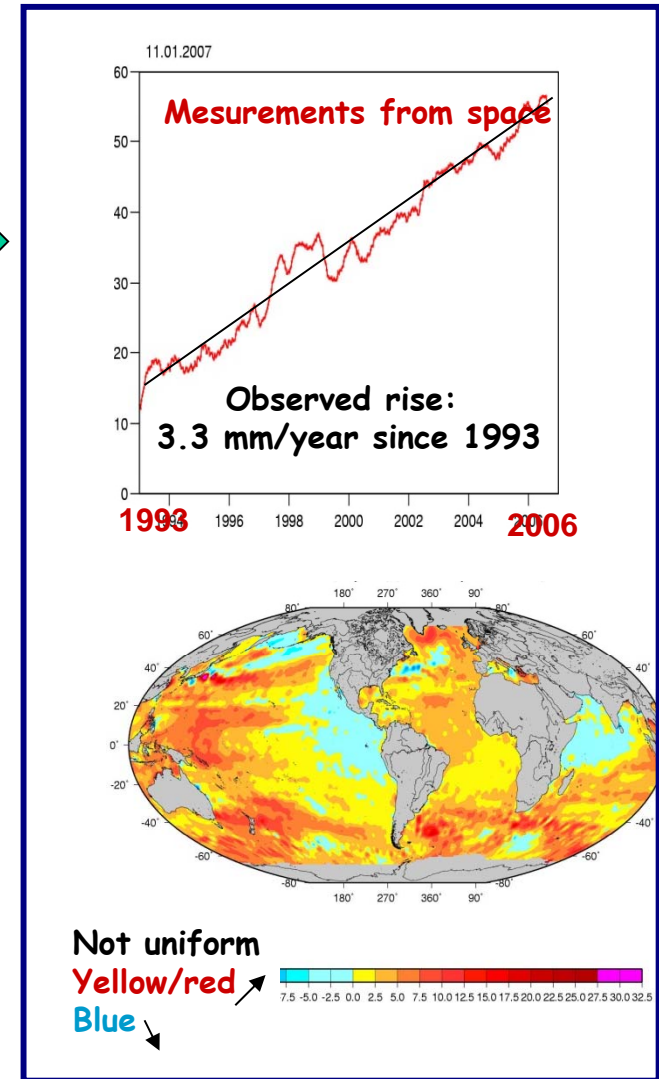
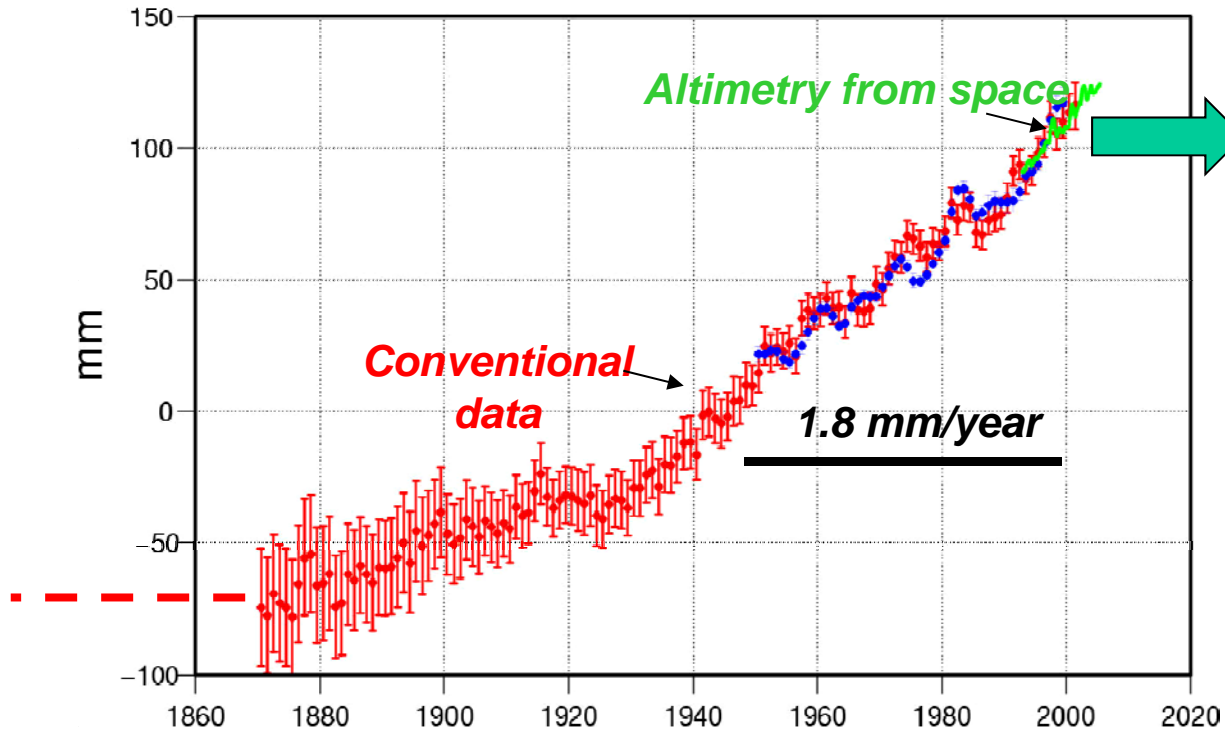


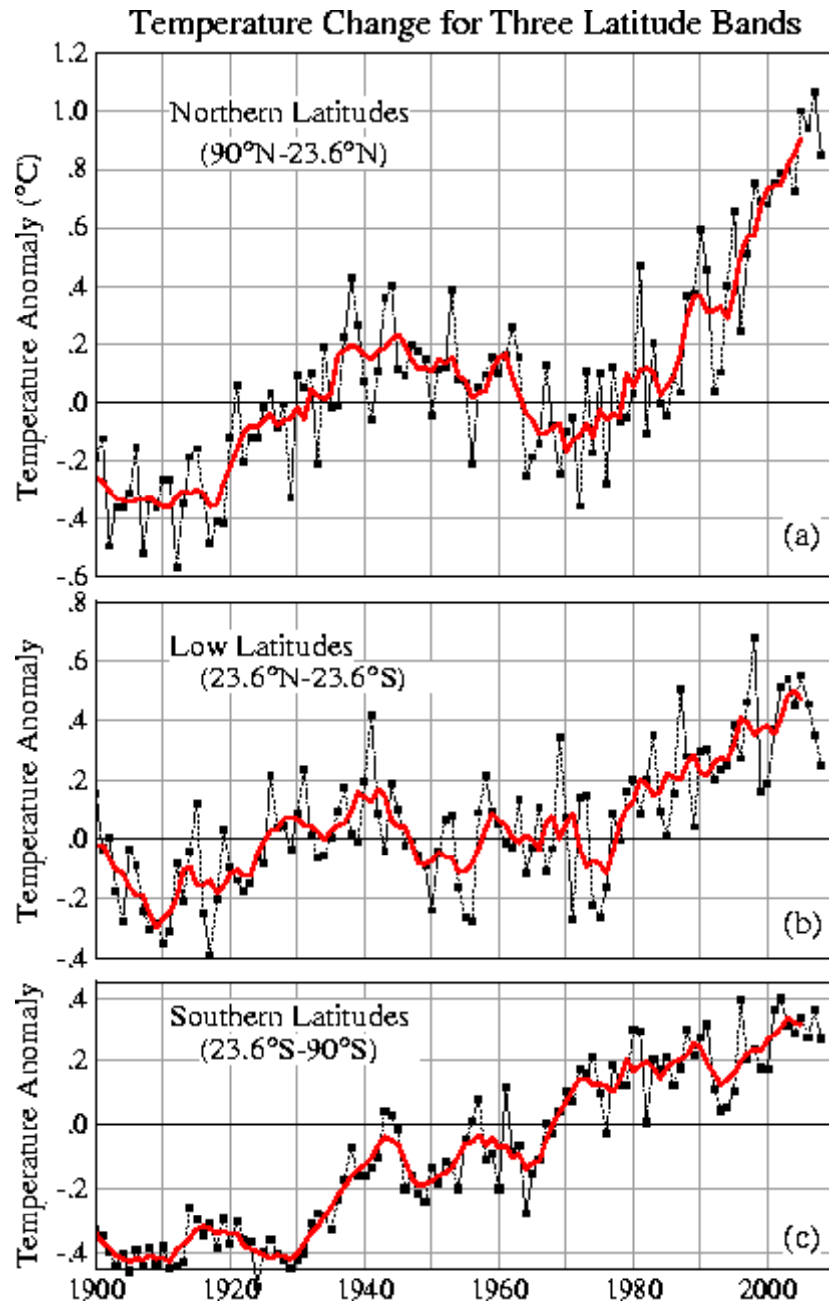
DT dans fourchette de 1.5°C à 4.5°C: presque inchangé depuis Charney (1979)



New observational devices are necessary: the example of the Aqua train:
[Aura, Parosol, Calipso, Cloudsat, Aqua, OCO.](#)
[Crédits : CNES octobre 2004, illustration P. Carril](#)

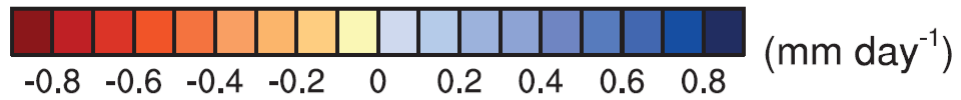
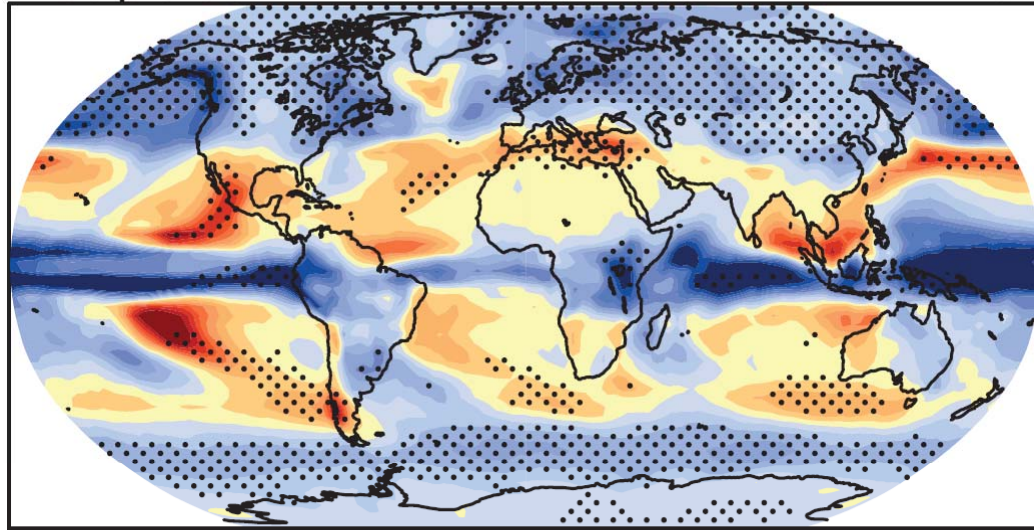
Sea-level rise throughout the 20th century



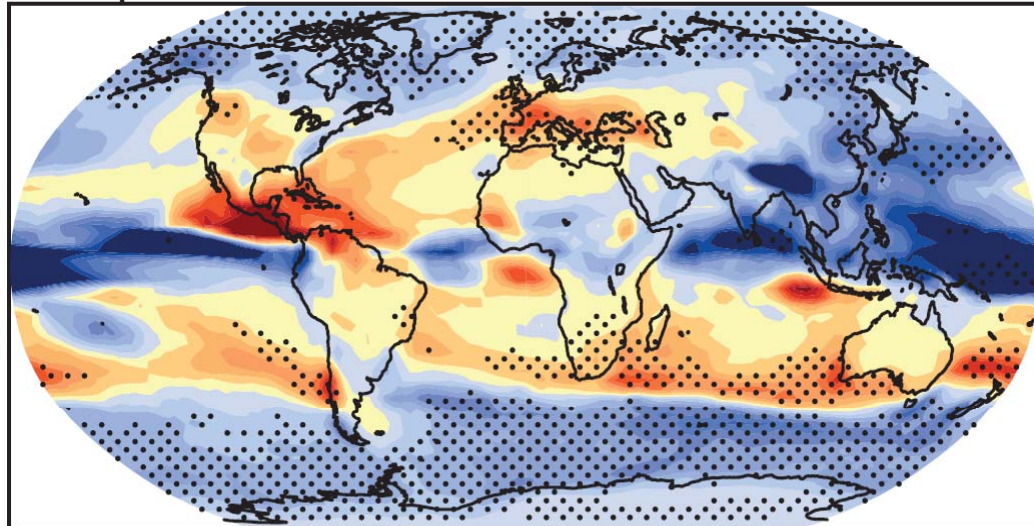


Variabilité
naturelle et action
de l'homme se
superposent

Precipitation A1B: 2080-2099 DJF



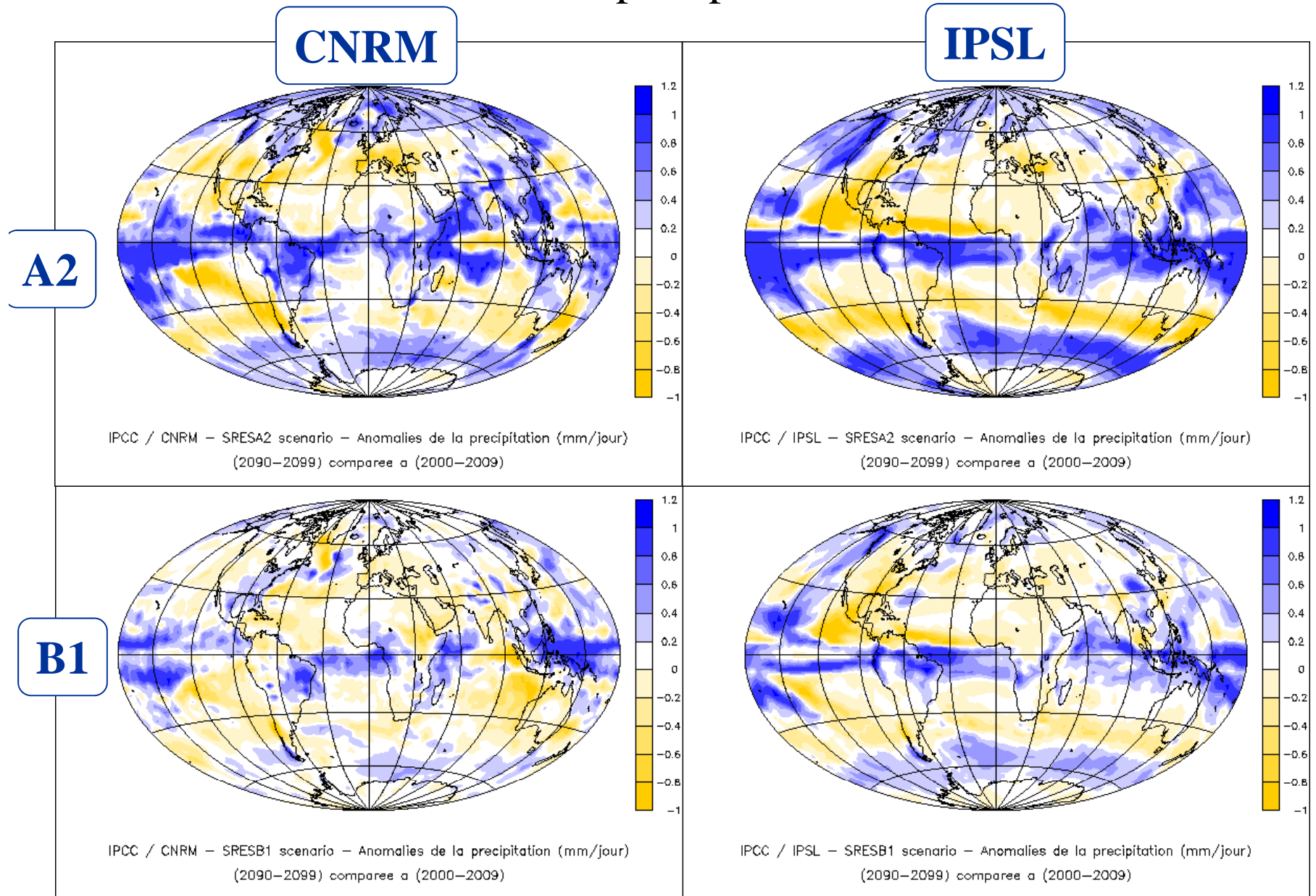
Precipitation A1B: 2080-2099 JJA



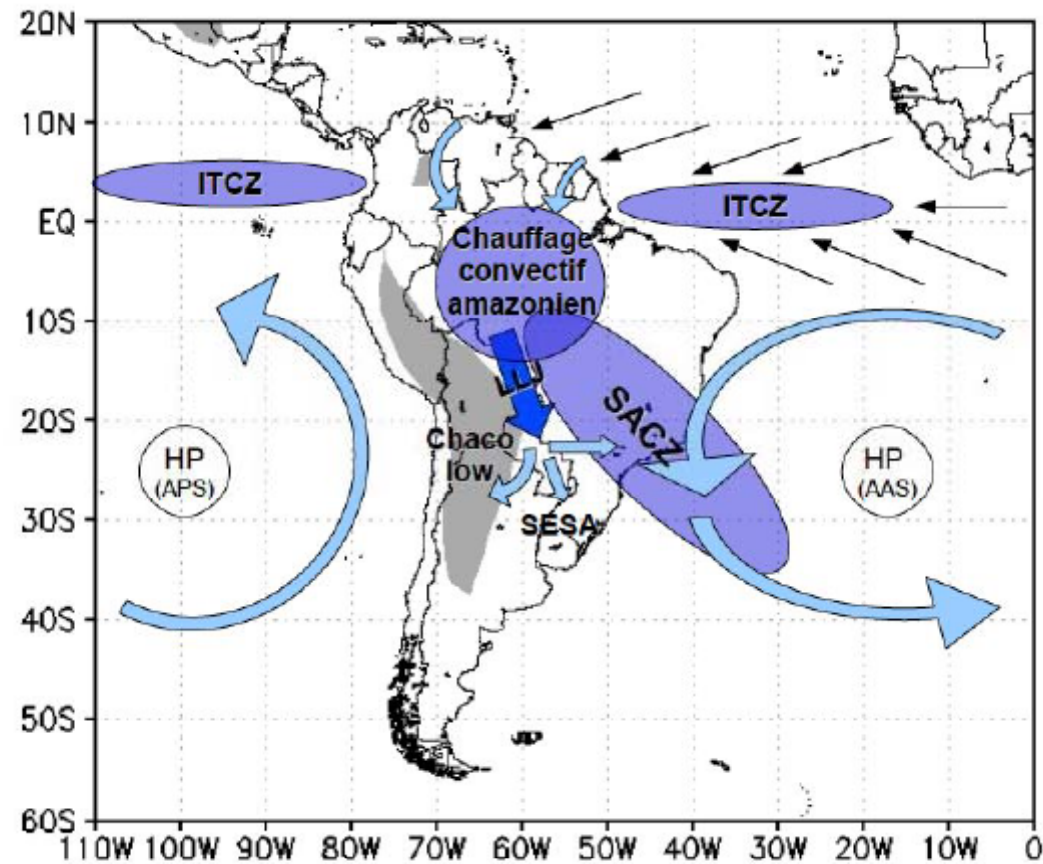
Precipitation changes

AR4

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

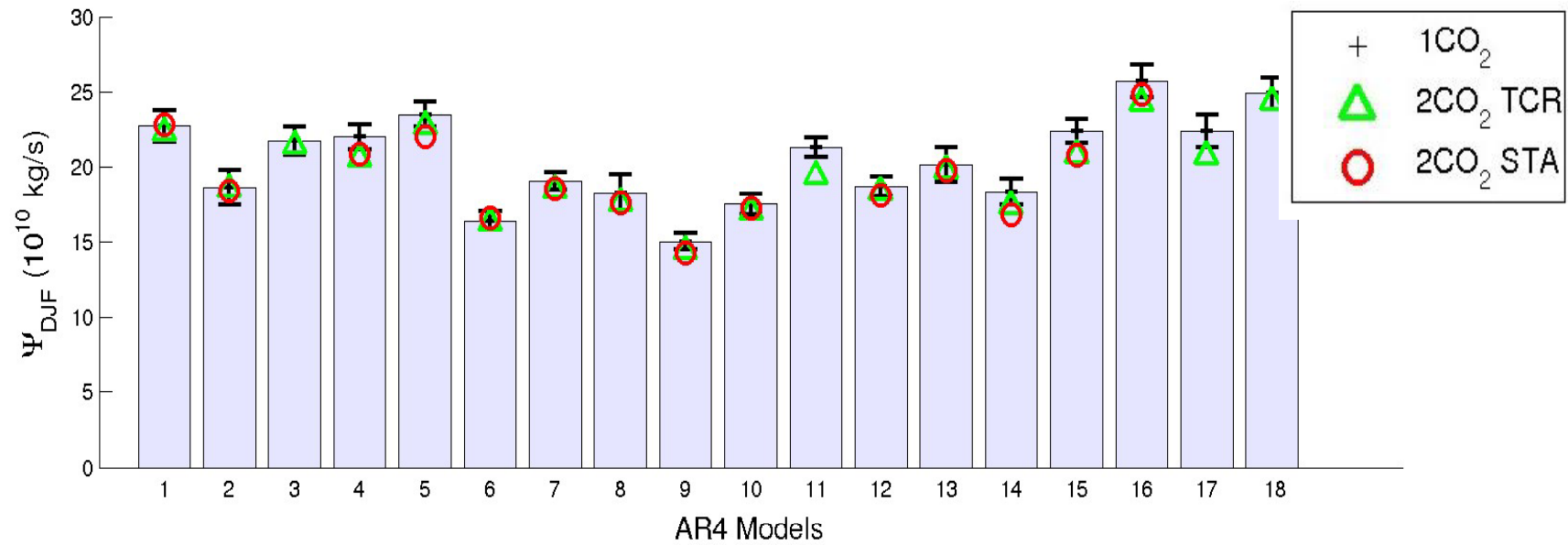


All regional studies must be adapted to a specific context

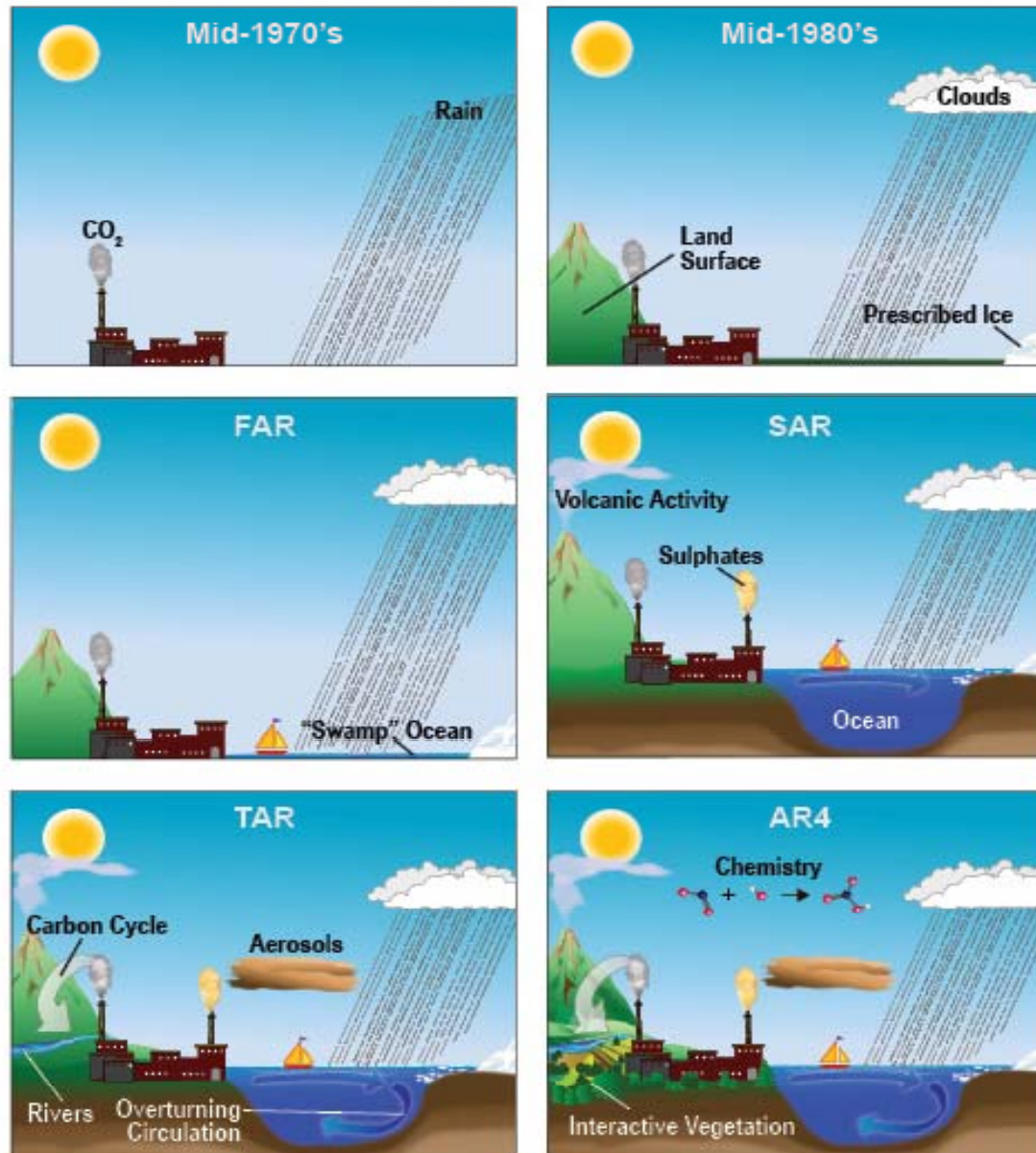


Hadley mass transport (DJF, winter cell) and its dependence on CO₂ doubling

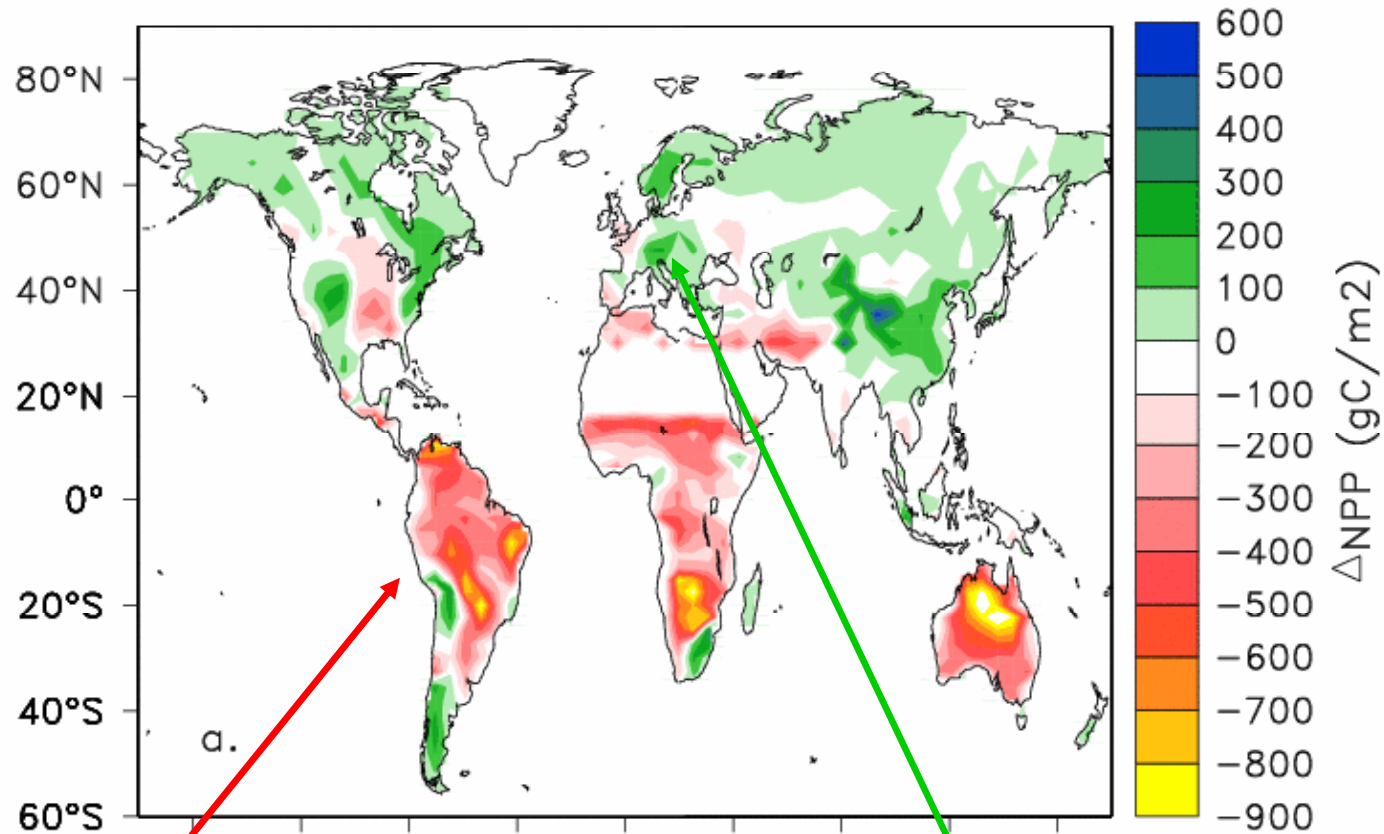
AR4 models



The World in Global Climate Models



The response of NPP to climate

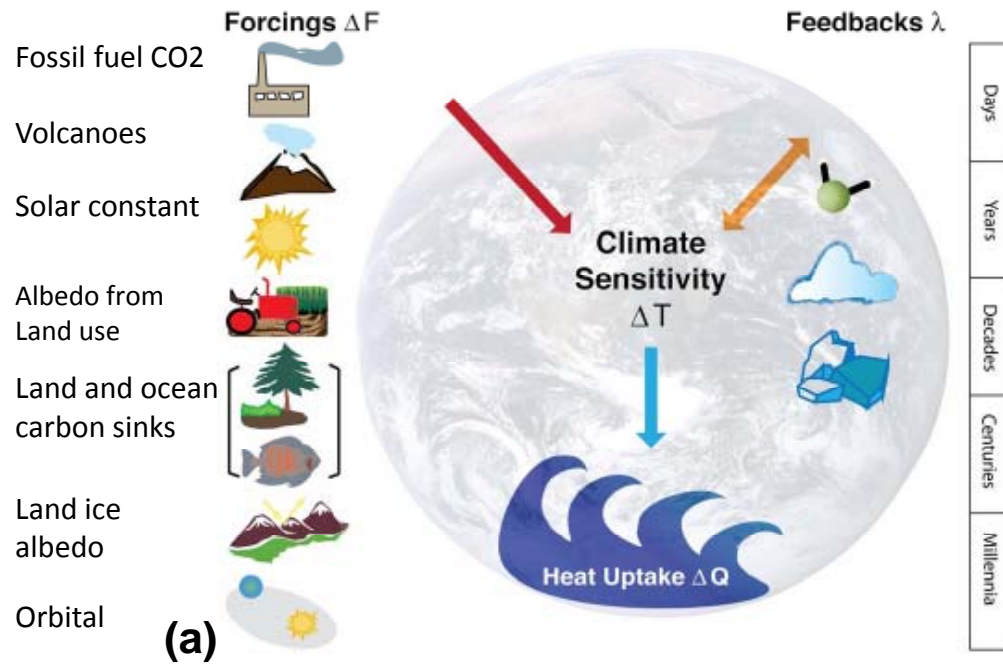


**Increase in
soil aridity**

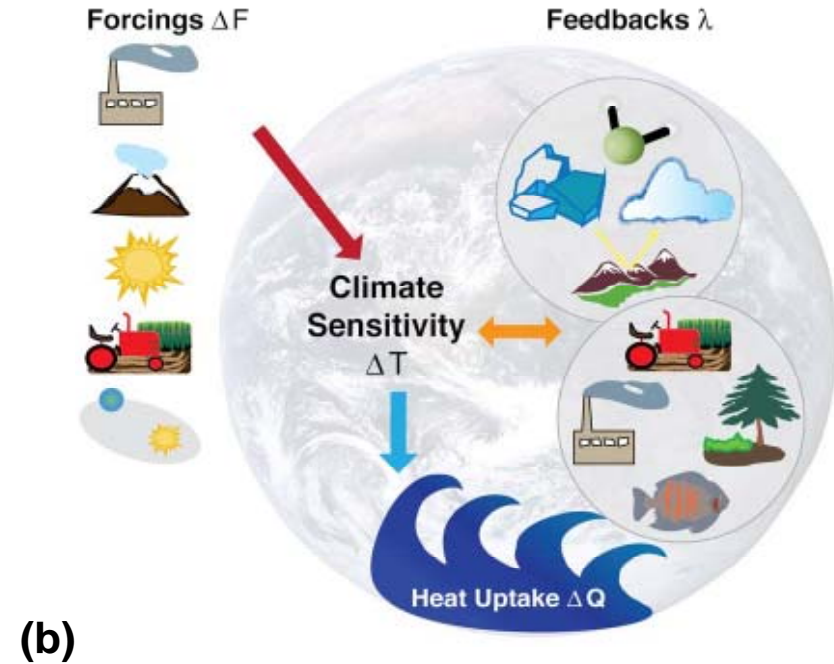
**Extension of the
growing season**

Feedbacks and climate sensitivity definition

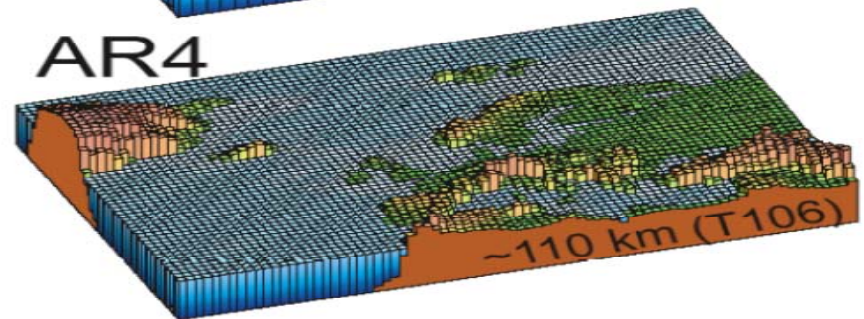
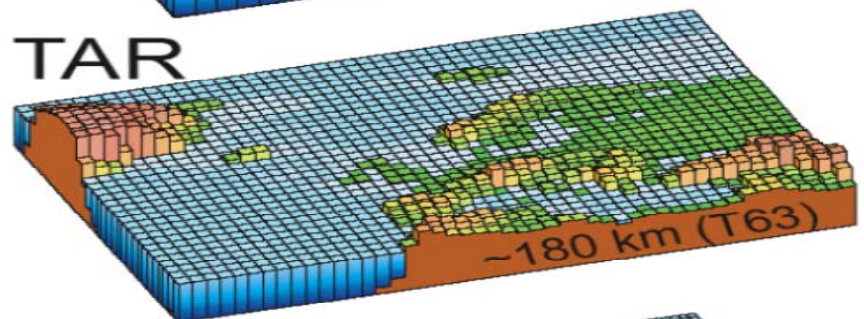
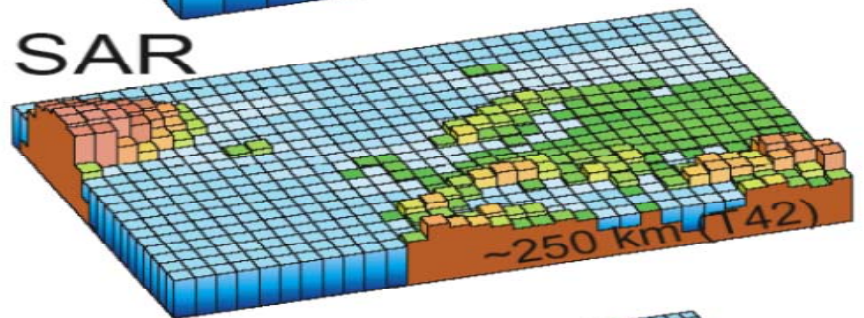
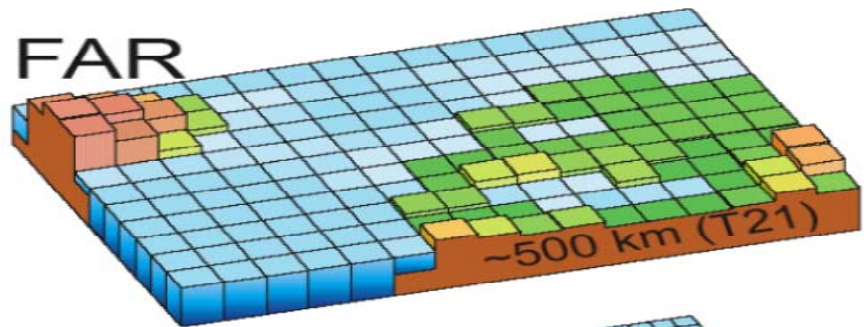
In absence of feedback $2xCO_2 \rightarrow 1^\circ C$ warming



Charney sensitivity
 $3^\circ C$ per $2x CO_2$



Long term climate sensitivity
 $6^\circ C$ per $2xCO_2$



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

SREX SPM Graphics

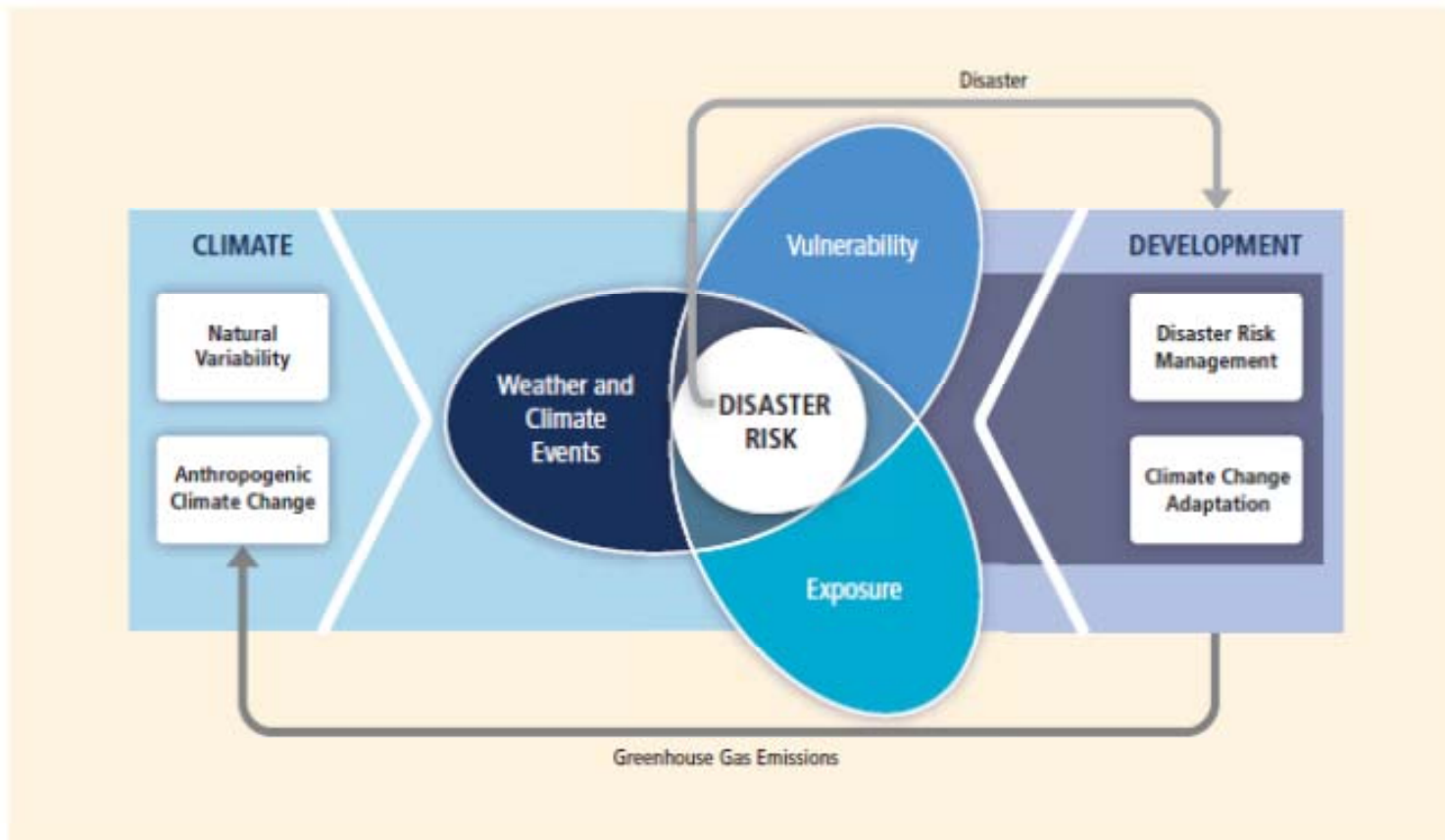


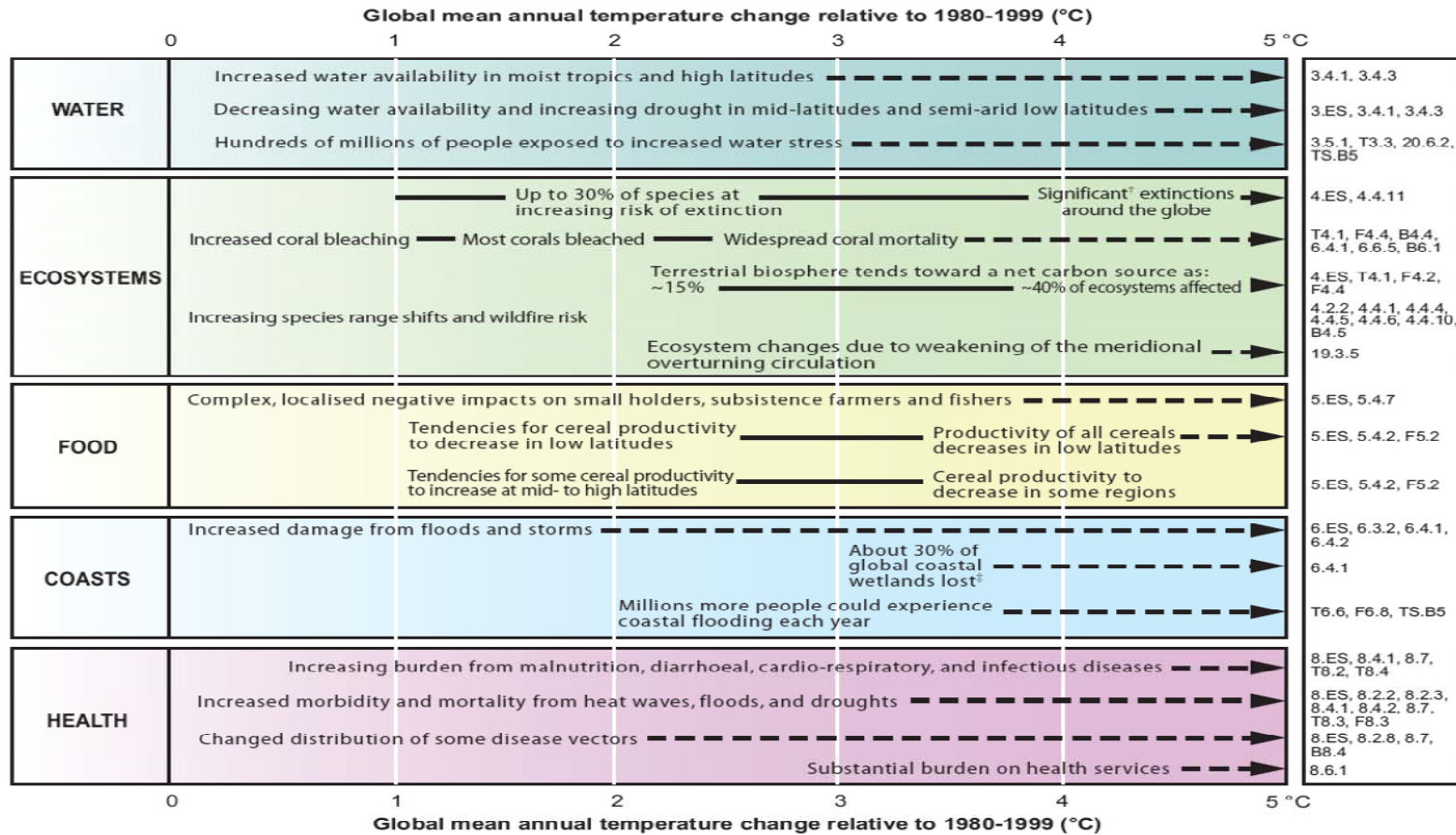
Table SPM-1. Recent trends, assessment of human influence on the trend, and projections for extreme weather events for which there is an observed late 20th century trend. {Tables 3.7, 3.8, 9.4, Sections 3.8, 5.5, 9.7, 11.2-11.9}

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	<i>Very likely^c</i>	<i>Likely^e</i>	<i>Virtually certain^e</i>
Warmer and more frequent hot days and nights over most land areas	<i>Very likely^d</i>	<i>Likely (nights)^e</i>	<i>Virtually certain^e</i>
Warm spells / heat waves. Frequency increases over most land areas	<i>Likely</i>	<i>More likely than not^f</i>	<i>Very likely</i>
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	<i>Likely</i>	<i>More likely than not^f</i>	<i>Very likely</i>
Area affected by droughts increases	<i>Likely in many regions since 1970s</i>	<i>More likely than not</i>	<i>Likely</i>
Intense tropical cyclone activity increases	<i>Likely in some regions since 1970</i>	<i>More likely than not^f</i>	<i>Likely</i>
Increased incidence of extreme high sea level (excludes tsunamis) ^g	<i>Likely</i>	<i>More likely than not^{f, h}</i>	<i>Likelyⁱ</i>

IPCC-GIEC / 2007

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.

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.