# Accumulation des gaz à effet de serre et responsabilités historiques

**Jean-Pascal van Ypersele**
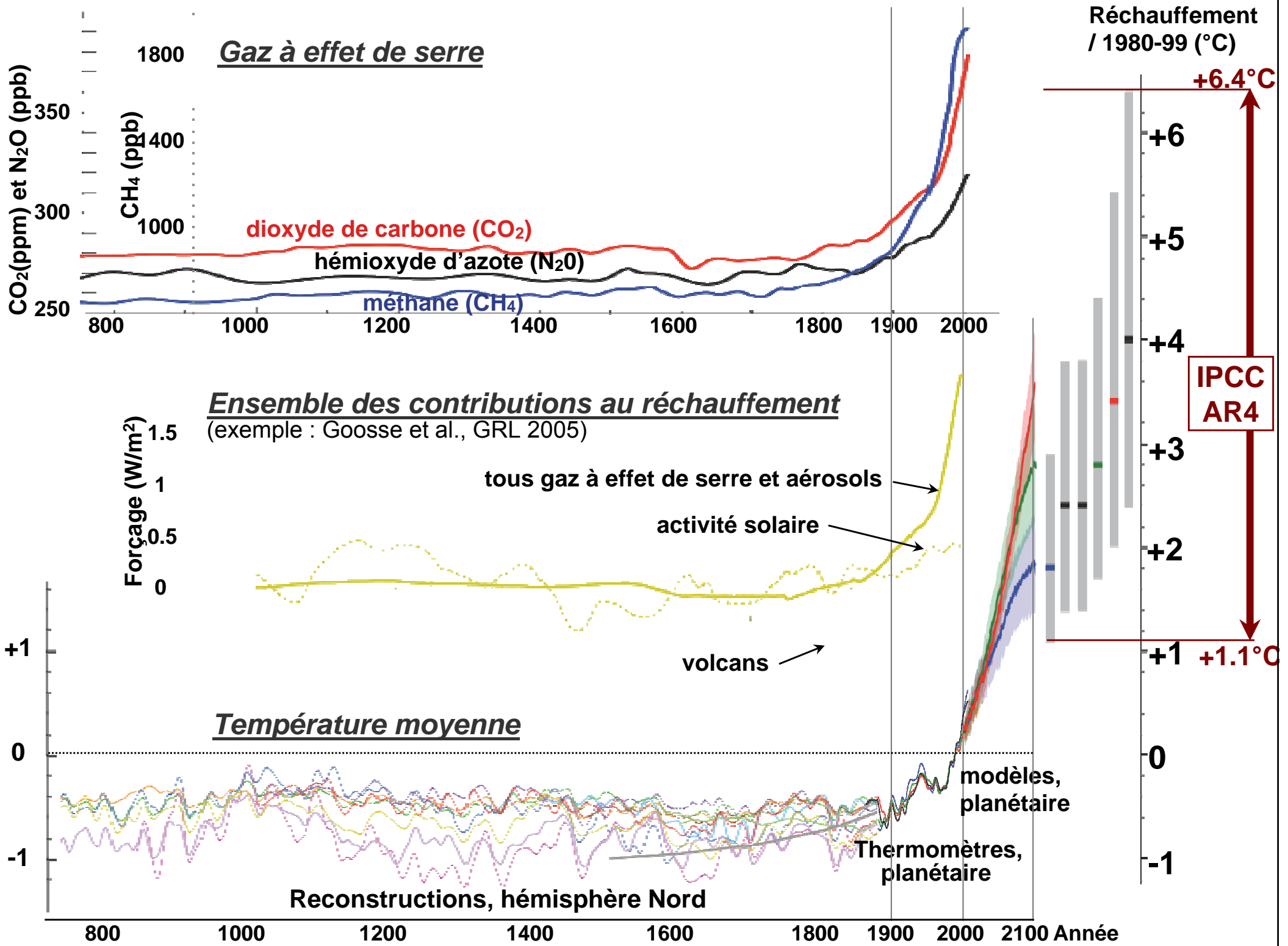
**UCL-ASTR**

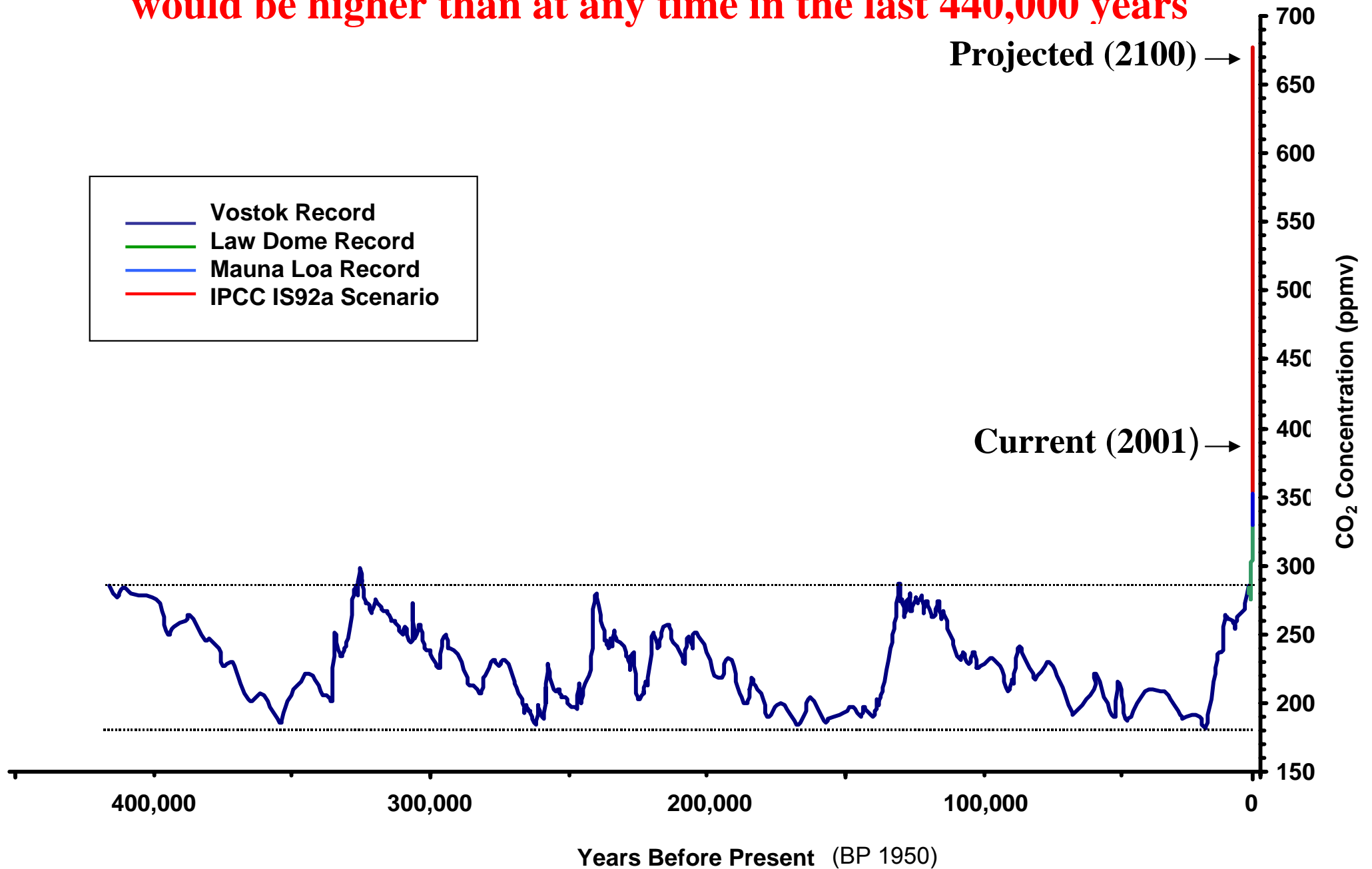**(Université catholique de Louvain, Institut d'astronomie et de géophysique G. Lemaître)**

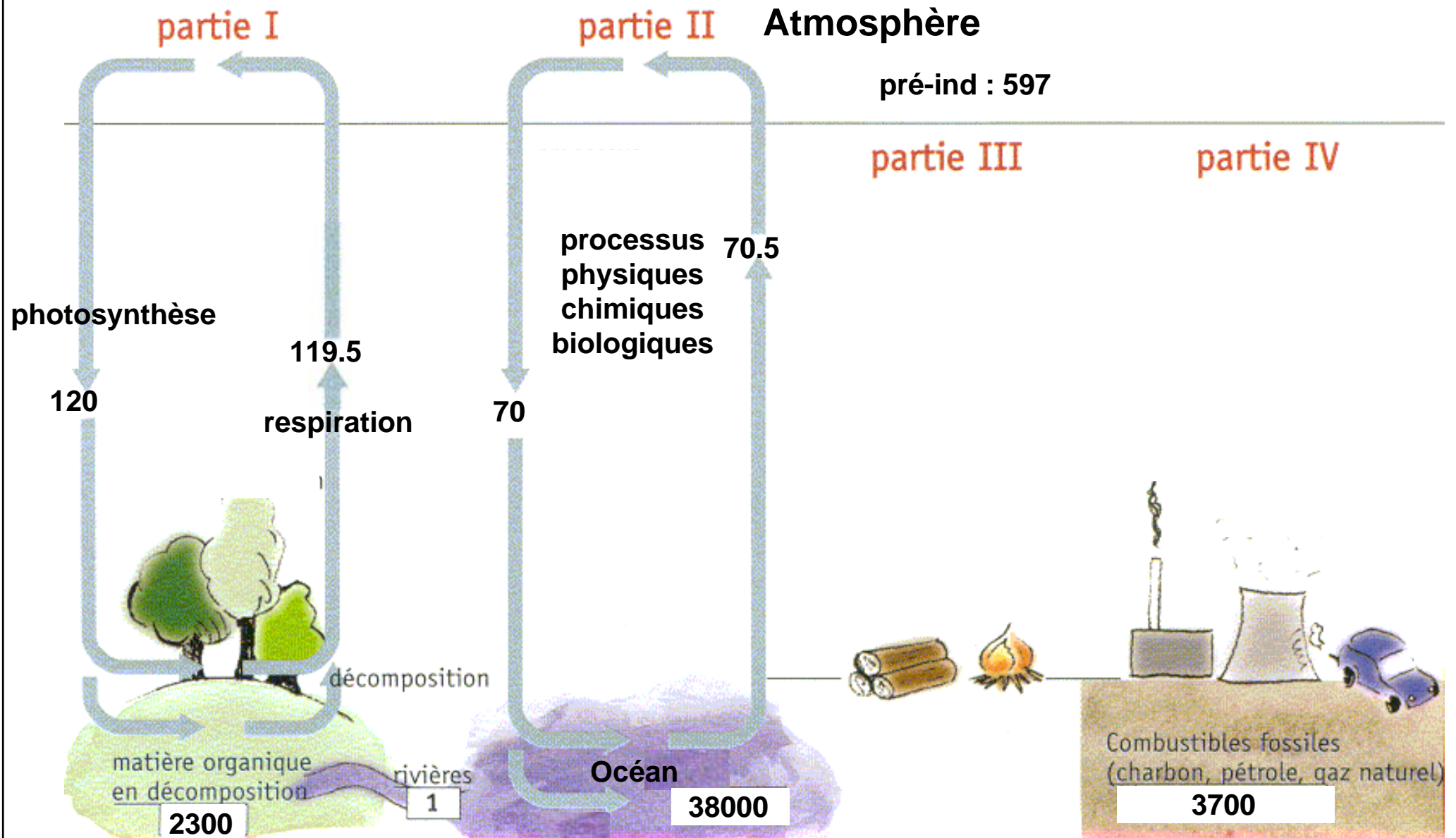**Toile:      www.climate.be**
**Courriel:  vanyp@climate.be**

**Leçon 7, Chaire Francqui, ULB, Bruxelles, 17-4-2008**

Gaz à effet de serre

CO₂(ppm) et N₂O (ppb) / CH₄ (ppb)

dioxyde de carbone (CO₂)

hémioxyde d'azote (N₂0)

méthane (CH₄)

Ensemble des contributions au réchauffement
(exemple : Goosse et al., GRL 2005)

Forçage (W/m²)

tous gaz à effet de serre et aérosols

activité solaire

volcans

Température moyenne

modèles, planétaire

Thermomètres, planétaire

Reconstructions, hémisphère Nord

Réchauffement / 1980-99 (°C)

+6.4°C

IPCC AR4

+1.1°C

Année

**Projected levels of atmospheric CO₂ during the next 100 years would be higher than at any time in the last 440,000 years**

# Cycle du carbone

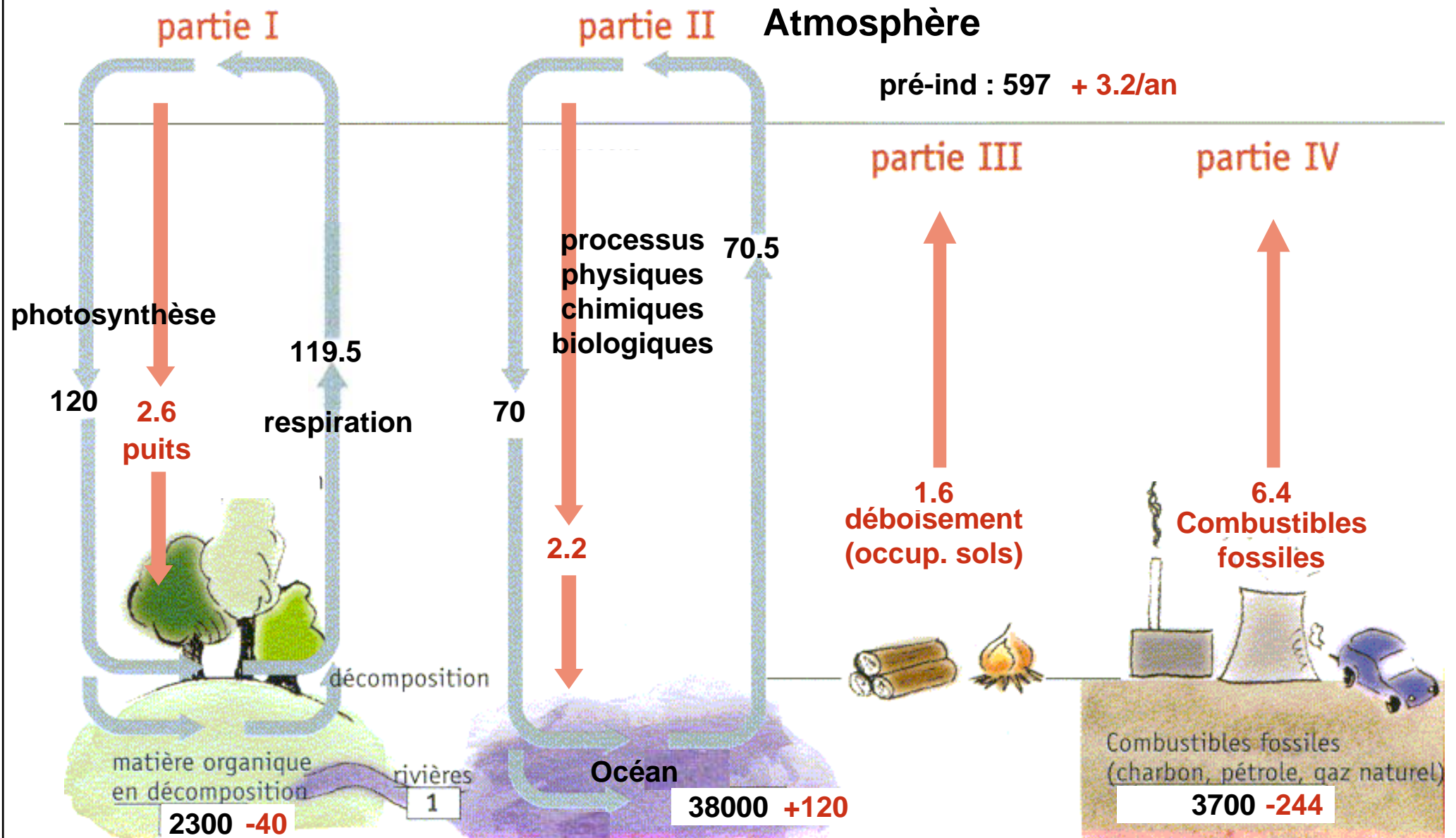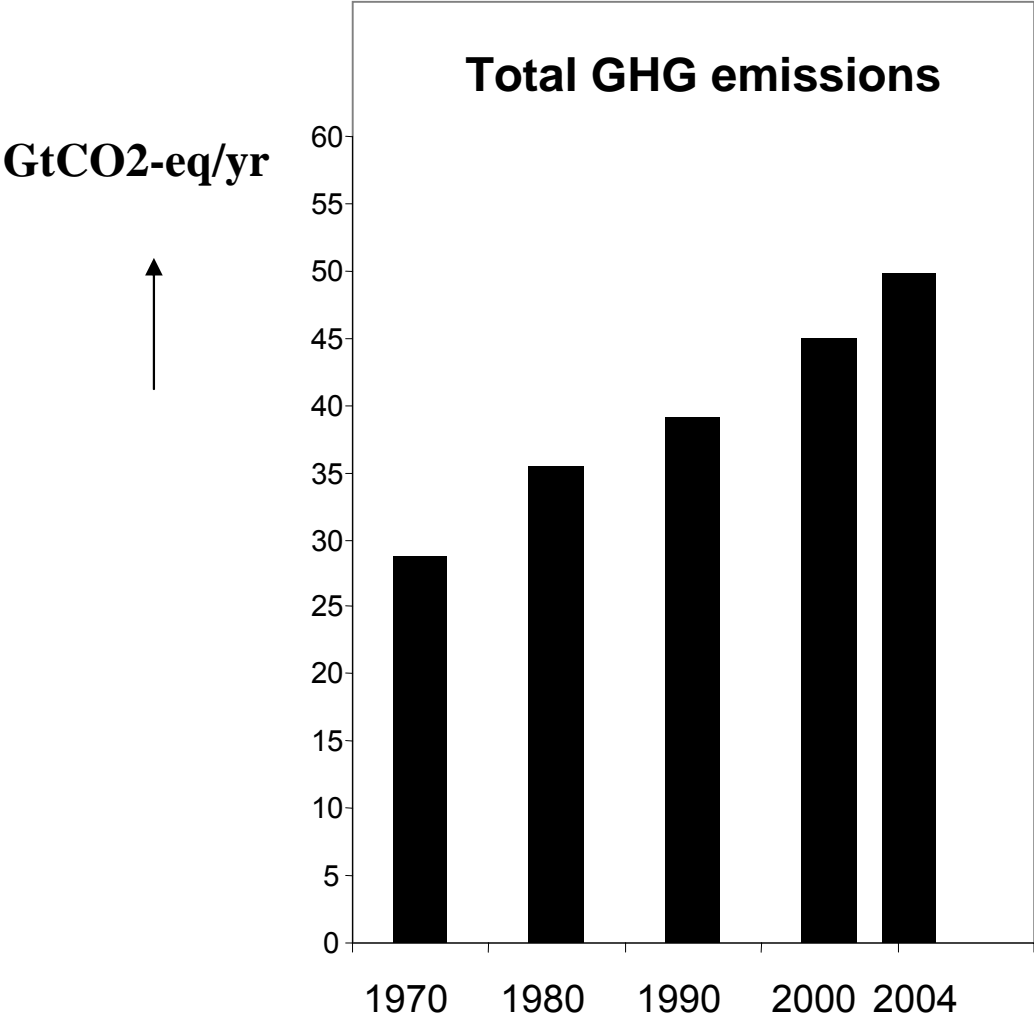partie I       partie II    **Atmosphère**

**pré-ind : 597**

partie III      partie IV

**processus** **70.5**
**physiques**
**chimiques**
**biologiques**

**photosynthèse**

**119.5**

**120**

**respiration**    **70**

décomposition

matière organique
en décomposition    rivières    **Océan**

**2300**    **1**    **38000**

Combustibles fossiles
(charbon, pétrole, gaz naturel)

**3700**

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**Unités: GtC (milliards de tonnes de carbone) ou GtC/an**

# Cycle du carbone



partie I

partie II

**Atmosphère**

**pré-ind : 597  + 3.2/an**

partie III

partie IV

**processus physiques chimiques biologiques** **70.5**

**photosynthèse**

**119.5**

**120**  **2.6 puits**

**respiration**

**70**

**2.2**

**1.6 déboisement (occup. sols)**

**6.4 Combustibles fossiles**

décomposition

matière organique en décomposition

rivières 1

**Océan**

Combustibles fossiles (charbon, pétrole, gaz naturel)

**2300 -40**

**38000 +120**

**3700 -244**

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**Unités: GtC (milliards de tonnes de carbone) ou GtC/an**

# Between 1970 and 2004 global greenhouse gas emissions have increased by 70 %



GtCO2-eq/yr

Total GHG emissions

# Carbon dioxide is the largest contributor



Gt CO$_2$eq/yr

- HFCs, PFCs, SF$_6$
- N$_2$O other
- N$_2$O agriculture
- CH$_4$ waste and other
- CH$_4$ agriculture
- CH$_4$ energy[1]
- CO$_2$ decay and peat[2]
- CO$_2$ deforestation[3][4]
- CO$_2$ other[5]
- CO$_2$ fossil fuel use

1970   1980   1990   2000 2004

CANADA
2.3%

FORMER SOVIET UNION
13.7%

EUROPE
27.7%

UNITED STATES
30.3%

MIDDLE EAST
2.6%

CHINA, INDIA, AND
DEVELOPING ASIA
12.2%

JAPAN
3.7%

SOUTH AND
CENTRAL AMERICA
3.8%

AFRICA
2.5%

AUSTRALIA
1.1%

## Contributions to Global Warming

Areas are proportional to historic carbon dioxide emissions
from fossil fuel combustion, 1900–1999

INDUSTRIALIZED

DEVELOPING

EQUAL AREA WORLD: areas are proportional to actual physical sizes

Underlying data sources:
United States Department of Energy,
Energy Information Administration
and the Carbon Dioxide Information
Analysis Center
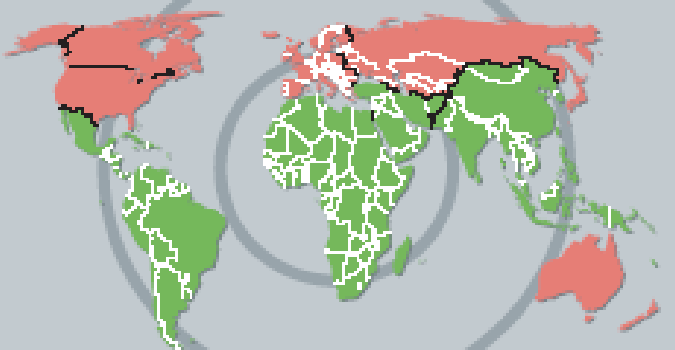
World
Resources
Institute

http://www.wri.org/
1-202-729-7600
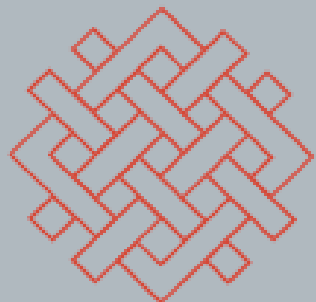
W R I

Map by Equator Graphics, Inc.

IPCC 2007 -AR4
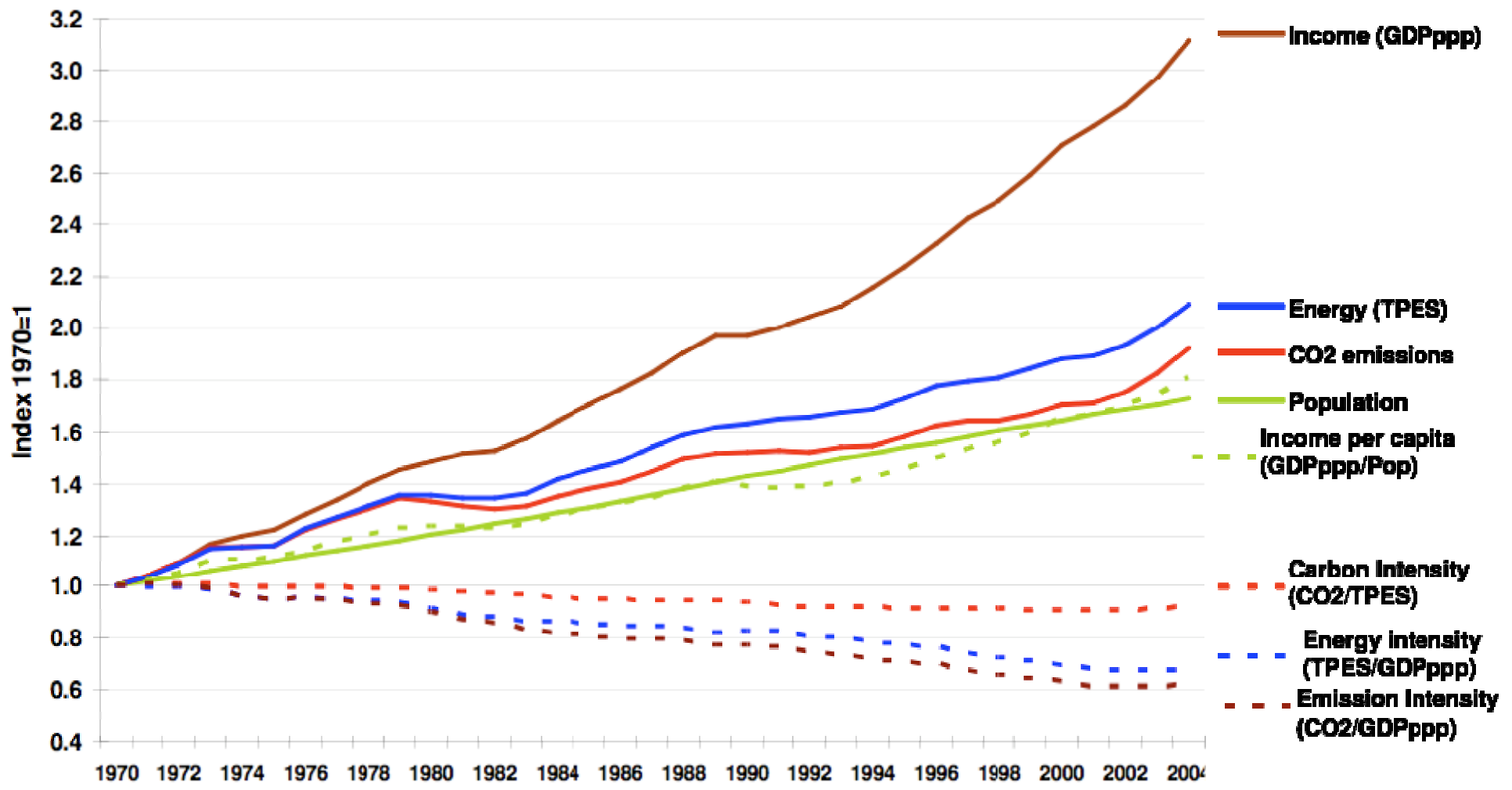
# Population-environnement

y **L'équation de *Ehrlich-Holdren* (1971)**

$$Impact = Population \, x \, \frac{Impact}{capita}$$

y **Variante utilisée pour les émissions de $CO_2$ :**

$$CO_2 = Pop. \, x \, \frac{\$GNP}{capita} \, x \, \frac{CO_2}{\$GNP}$$

$$(Affluence)(Technology)$$

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# *Regional emissions - GHG/cap in 2004*
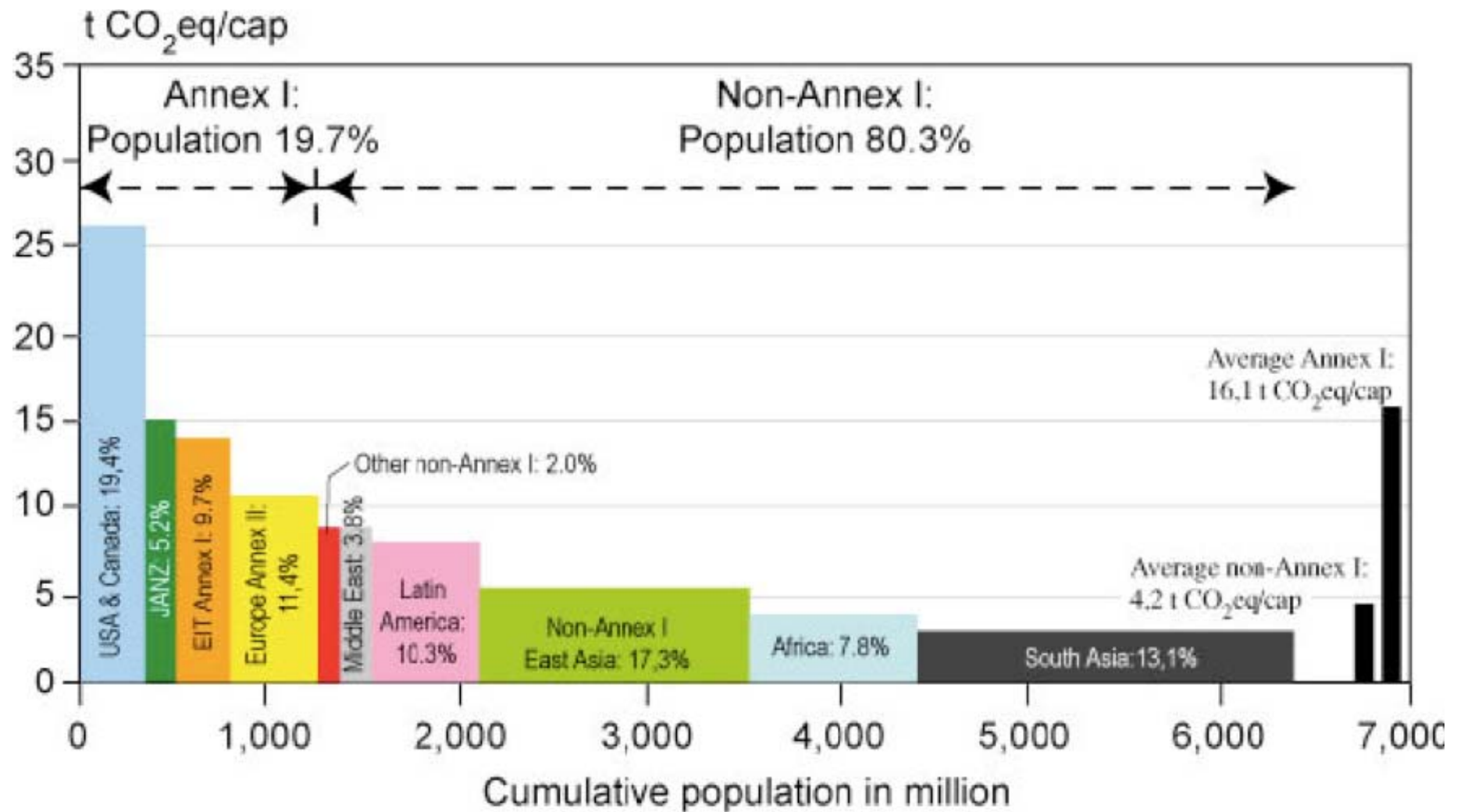
| Table: Croissance démographique et émissions passées | Année | 1950 MtCO$_2$ | 1990 MtCO$_2$ |
|---|---|---|---|
| Données réelles : Source: Marland and Boden (1991) | PD | 5358 | 14665 |
| | PeD | 462 | 6676 |
| | TOT | 5821 | 21341 |
| 1: Pop. PD = données réelles | PD | 5358 | 14665 |
|   Pop. PeD = valeur en 1950 | PeD | 462 | 2786 |
| CO$_2$/cap PD = données réelles | TOT | 5821 | 17452 |
| CO$_2$/cap PeD = données réelles | Diff(%) | 0 | -18.2 |
| 2: Pop. PD = 1950 value | PD | 5358 | 9778 |
|   Pop. PeD = données réelles | PeD | 462 | 6676 |
| CO$_2$/cap PD = données réelles | TOT | 5821 | 16454 |
| CO$_2$/cap PeD = données réelles | Diff(%) | 0 | -22.9 |
| 4: Pop. PD = données réelles | PD | 5358 | 8149 |
|   Pop. PeD = données réelles | PeD | 462 | 6676 |
| CO$_2$/cap PD = valeur en 1950 | TOT | 5821 | 14825 |
| CO$_2$/cap PED = données réelles | Diff(%) | 0 | -30.5 |

# THE ROLE OF POPULATION GROWTH IN GLOBAL WARMING (11)

y **Main results**

x · *Scenario 1:*

Blocking LDCs populations at 1950 level and leaving $CO_2$/capita rates evolve as they did historically would have led in 1990 to world emissions of 17.5 $10^9$ tonnes of $CO_2$, instead of the observed 21.3 $10^9$ tonnes, i.e., a reduction of 18%.

x · *Scenario 2:*

Conversely, if MDCs populations were kept at their 1950 level and $CO_2$/capita rates evolve as they did historically, the reduction in 1990 would have been higher: -23%.

x · *Scenario 4:*

If we block the $CO_2$/capita in MDCs at their 1950 values and have the MDCs and LDCs populations grow as they really did, the world emissions are significantly less than observed in 1990: -31%.

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# Emissions historiques : $CO_2$

**GtC / an**

**Emissions cumulées**

| | GtC | % |
|---|---|---|
| Annexe B | 231 | 72.5 |
| Non B | 81.4 | 25.6 |
| Trafic **International** | 6.1 | 1.9 |

Pays en développement

Pays hors annexe B

Pays développés

Pays annexe B

Trafic aérien et maritime int.

www.climate.be/jcm

1800  1825  1850  1875  1900  1925  1950  1975  2000

# Emissions historiques : $CO_2$-éq



t $CO_2$ /an

Emissions cumulées

|  | t$CO_2$ | % |
|---|---|---|
| Annexe B | 1226 | 54.6 |
| Non B | 1018 | 45.4 |

Pays hors annexe B

Pays annexe B

www.climate.be/jcm
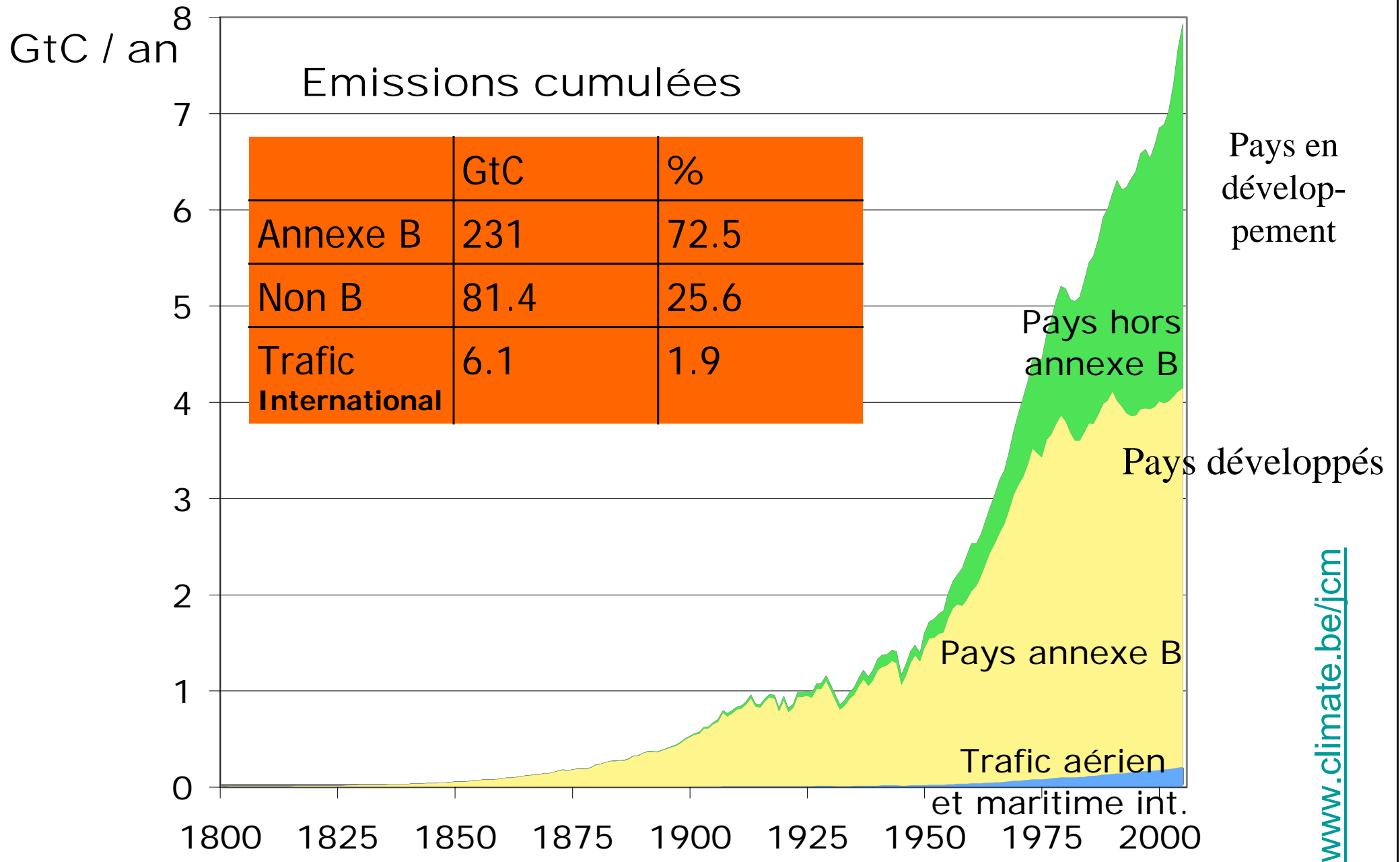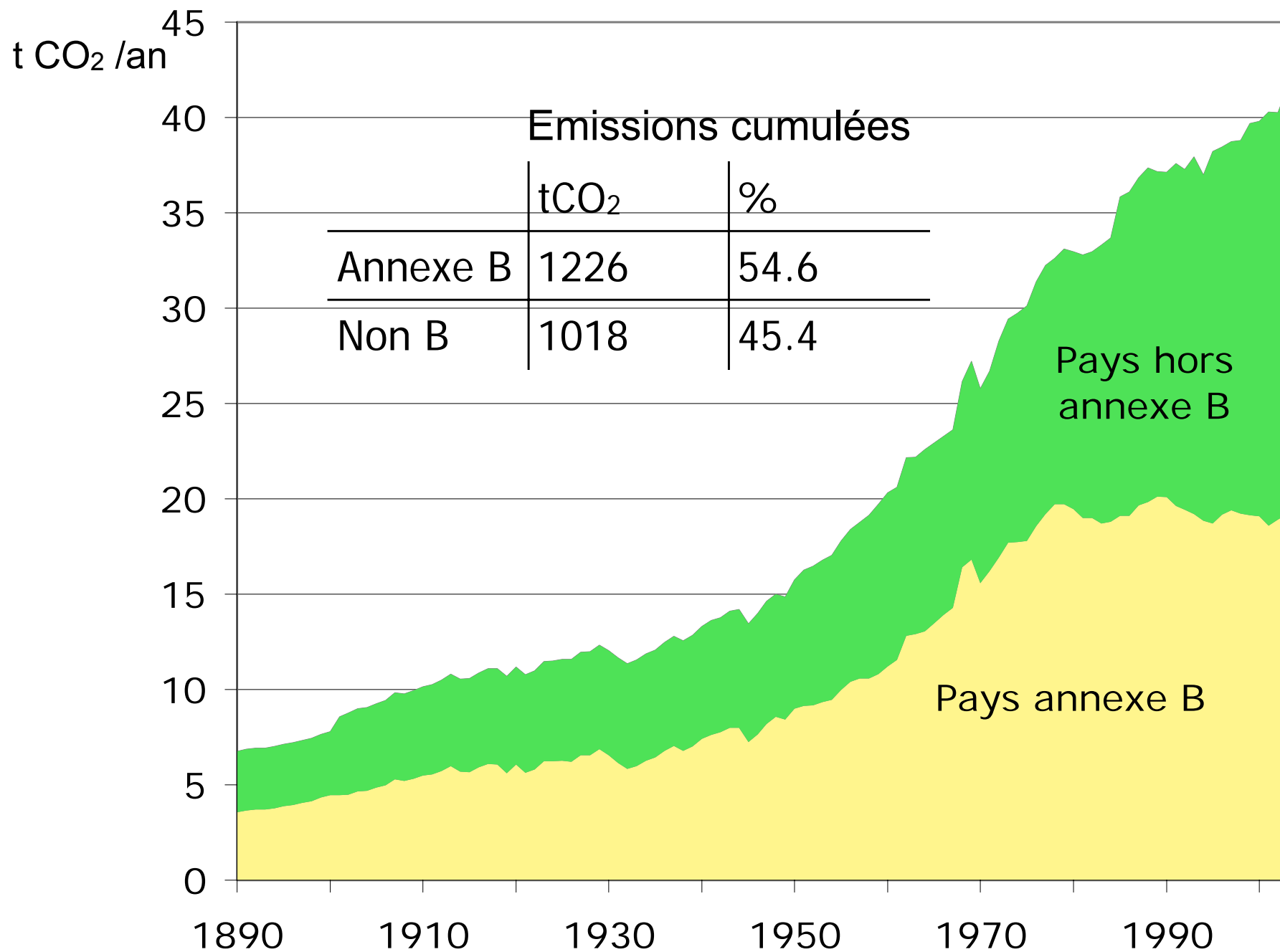
# Il existe une inertie significative dans le système climatique



Pic d'émission du $CO_2$

0 à 80 ans

Stabilisation du $CO_2$

50 à 300 ans

Augmentation du niveau des mers due à la fonte des glaces: Plusieurs millénaires

Augmentation du niveau des mers due à l'expansion thermique

Siècle à millénaire

Stabilisation de la température

Quelques siècles

Aujourd'hui

100 ans

1000 ans
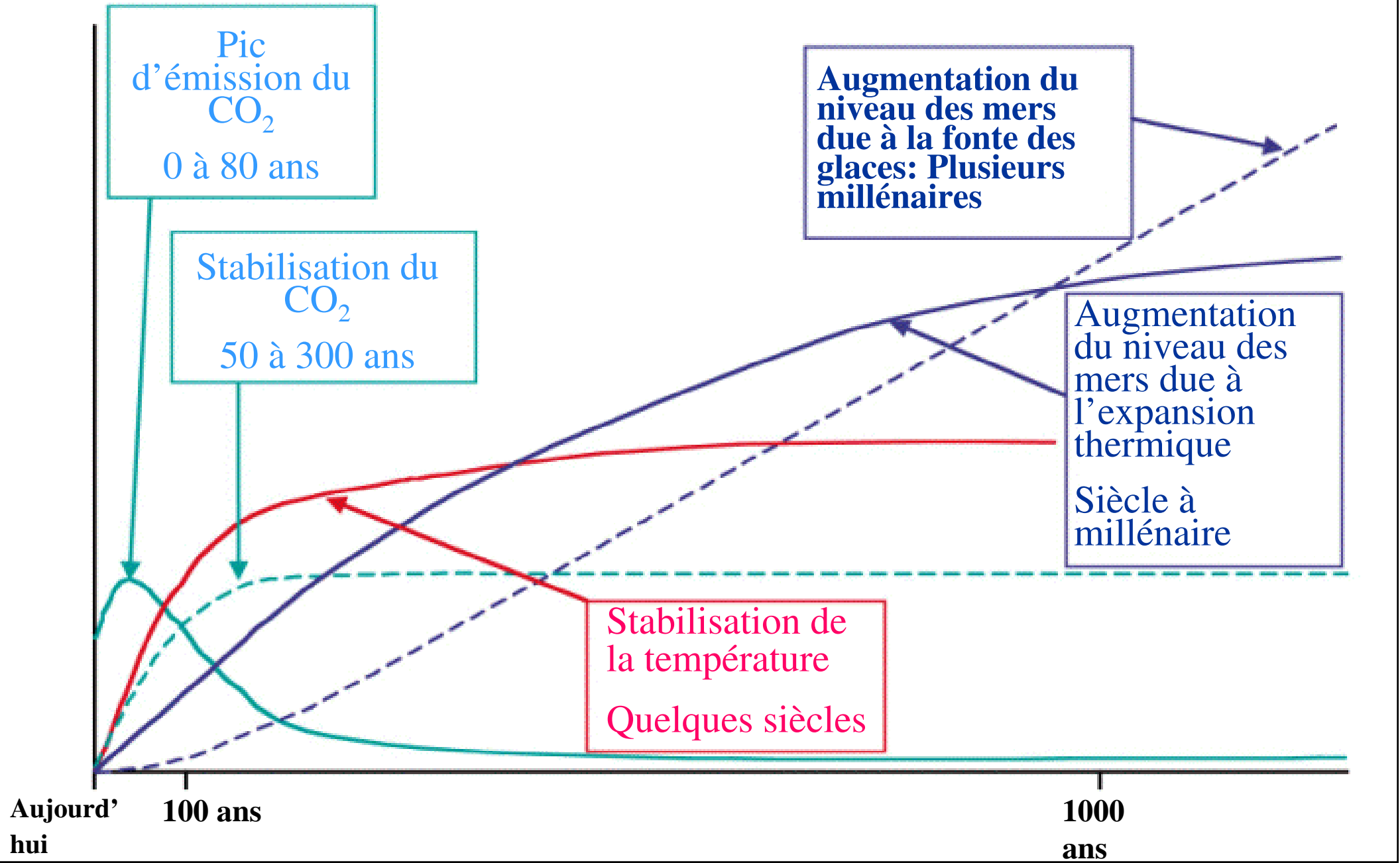
**North + South carbon emissions**

**450 ppmv stabilization scenario**



$t\ C \times 10^9$

Years
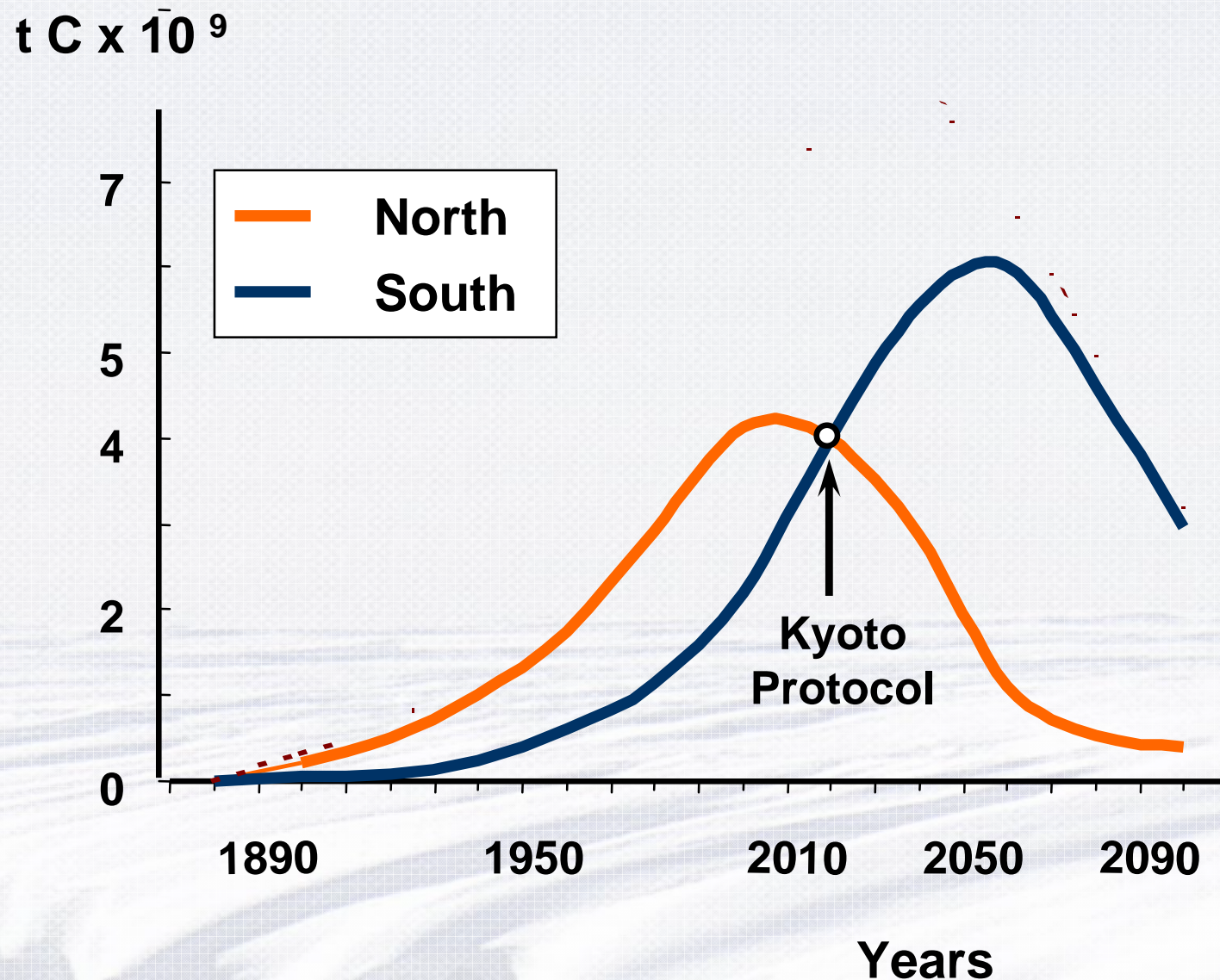
carbon emissions

ultimate climate challenge
0.5 tonnes per capita
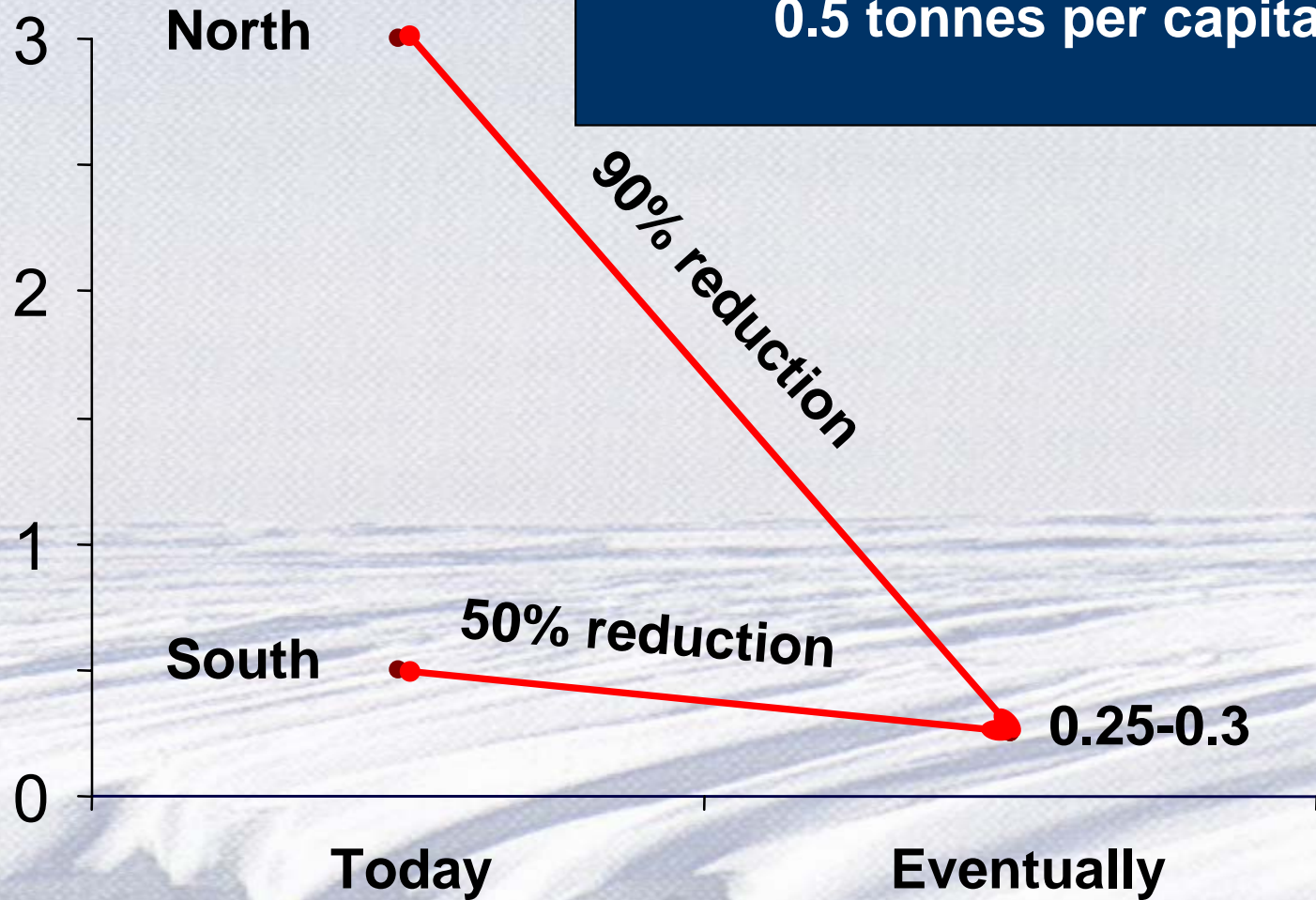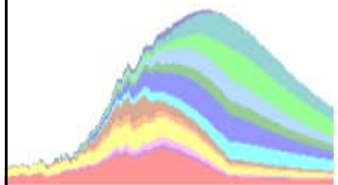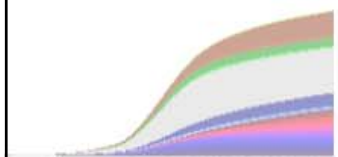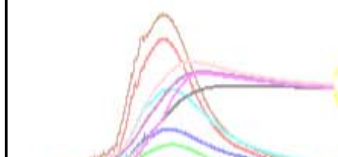
t. C / capita /year

3 — North

2

1

South

90% reduction

50% reduction

0.25-0.3

0

Today          Eventually

Source : *Sivan Kartha et al,* 1998
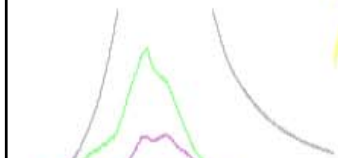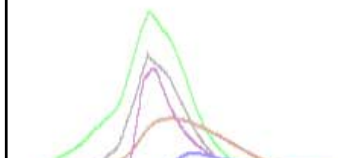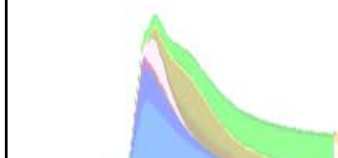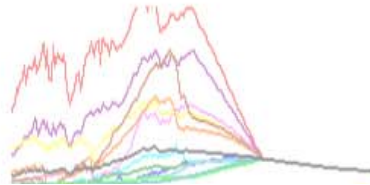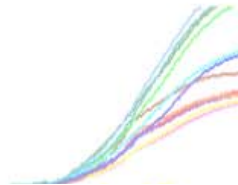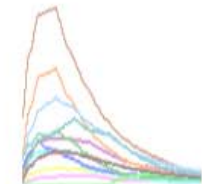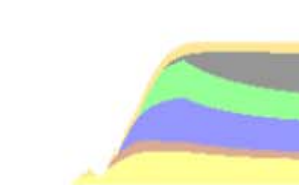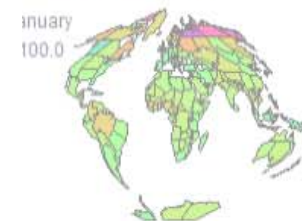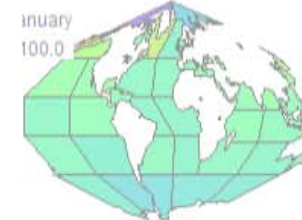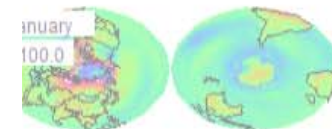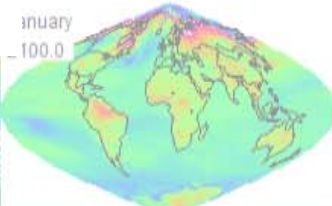
# *Java Climate Model*

## *jcm.chooseclimate.org*

*In preparing positions for the role-play, the students used the Java Climate Model to explore options and uncertainties.*

*By selecting parameters / indicators, same model can "justify" diverse positions*

*Works in web browser, Instantly responding graphics,*

*Cause-effect from emissions to impacts,*

*Based on IPCC-TAR methods / data,*

*Flexible stabilisation scenarios*

*Regional distributions of responsibility and climate.*

*Transparent, open-source code,*

*Interface in 10 languages, 50000 words documentation*

# Stabilisation scenarios
## in Java Climate Model

(Article 2:
critical limits => critical levels => emissions
pathways)

## Inverse calculation to stabilise

- CO$_2$ concentration (as IPCC "S"/ WRE scenarios)

- Radiative Forcing (all-gases, "CO$_2$ equivalent")

- Global Temperature (e.g. to stay below 2C limit)

- (Sea-level -difficult due to inertia in ocean / ice)

*JCM core science very similar to IPCC-TAR models, b*ut (unlike TAR SYR) JCM stabilisation scenarios include mitigation of *all* (21) greenhouse gases and aerosols, scaled w.r.t. SRES baseline.
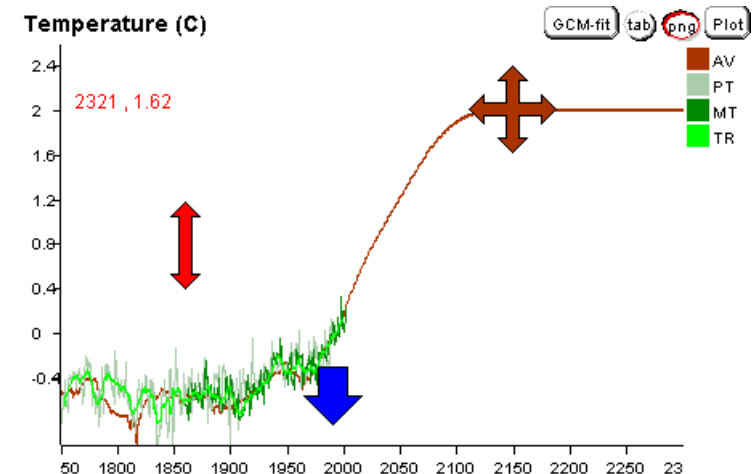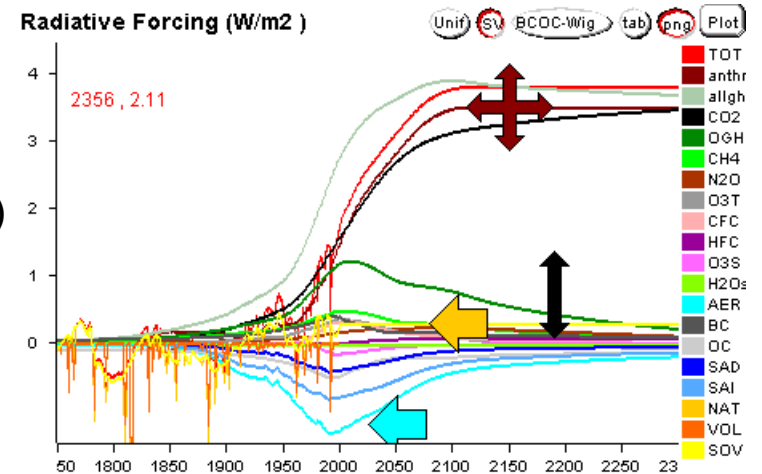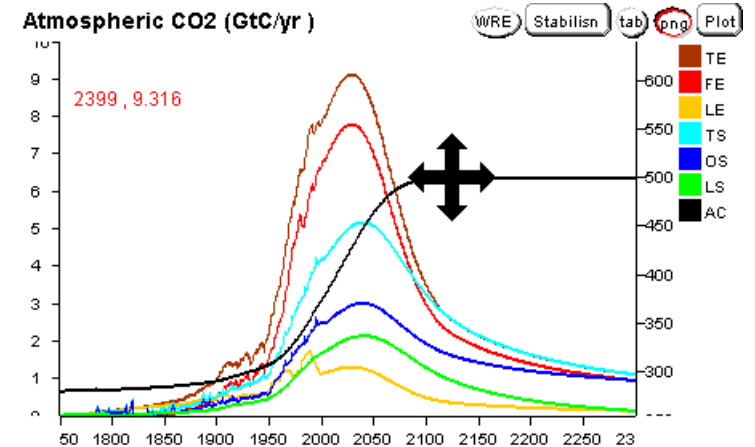
# Vous pouvez essayer:

z **jcm.chooseclimate.org** :

**(modèle interactif du Dr Ben Matthews (UCL, réseau Climneg)**

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# Climate injustice

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# Climate injustice

- z **Where the climate injustice is** (non exhaustive list)
    - y **1) Climate change is mostly produced by the accumulation of developed countries emissions**
    - y **2) Climate change will affect first those who are the least responsible, making the Millennium Development Goals yet more elusive**
    - y **3) Some OECD countries use excuse that total emissions of developing countries will soon overpass those of OECD to refuse to assume their responsibilities**
    - y **4) The quota allocation method used in the Kyoto protocol ignores the need to have per capita emissions « contract and converge »**

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# Climate inustice (2)

z **How to reduce climate injustice** (non exhaustive list)

- y **1) Explain/expose differences between emissions and concentration, between total emissions and per capita emissions**

- y **2) Implement meaningful adaptation policies, integrated in the (sustainable) development process and funded following the polluter's pays principle**

- y **3) See 1), and develop real partnership with developing countries to address common threat; Promote technology transfers**

- y **4) Use « Contraction and Convergence » as long-term framework, on ethical basis. Use it as guide to assign quotas over the next commitment period.**

- y **5) Take the logic of the market approach to the extreme, and follow Anil Agarwal's proposal: « one human = one GHG unit; & allow global trade of allowances »**

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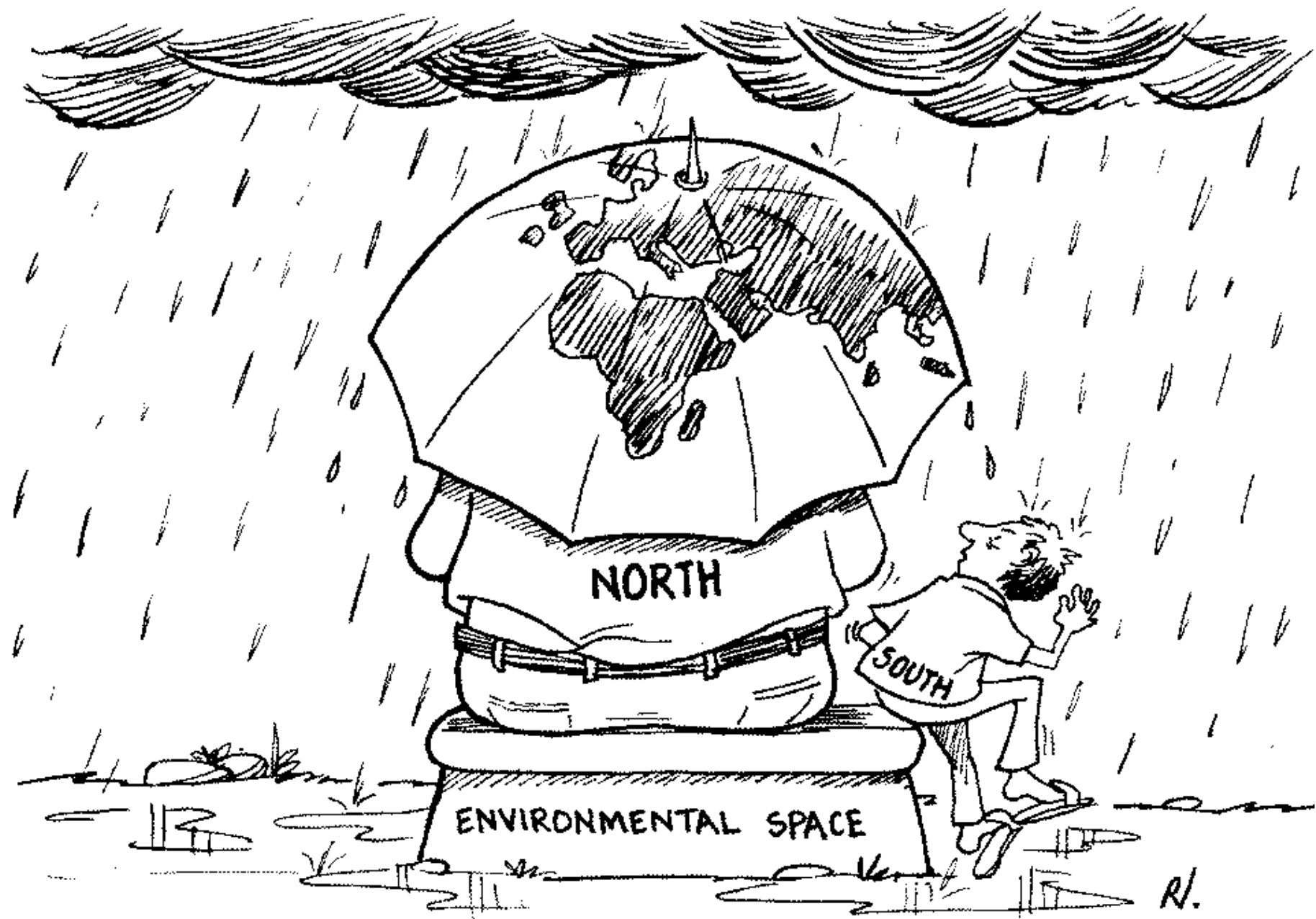
Agarwal et al., 1999

# Pour en savoir plus…

z www.climate.be : ASTR-UCL

z www.ipcc.ch : IPCC ou GIEC

z www.unfccc.int : Convention & Protocole

z www.cfdd.be : Conseil fédéral développement durable

z www.climat.be : campagne climat du Gvt

z **jcm.chooseclimate.org** : modèle interactif du Dr B. Matthews, UCL-ASTR

z www.realclimate.org: réponse aux sceptiques

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# Pour en savoir plus…

z Changements climatiques, impasses et perspectives (Points de vue du Sud), Editions Syllepse (voir www.cetri.be)

z **www.match-info.net : Research group on Modelling and assessment of contributions to climate change**

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