A climate scenario taking into account land-use change

Aurore VOLDOIRE, Jean-François ROYER

CNRM/GMGEC

aurore.voldoire@meteo.fr

METEO FRANCE

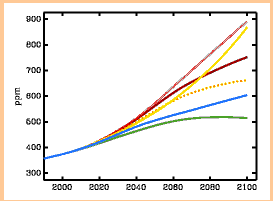
Outline

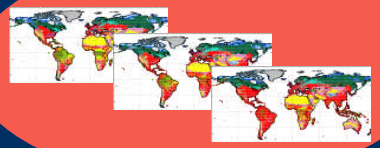
- Introduction :
  - Why take into account vegetation changes inside climate scenarios?
  - Why take into account land-use changes inside climate scenarios?
- Chosen method : Coupling CNRM-CM3 with IMAGE2.2
  - Description of the coupling scheme
  - The simulation
- Results
  - Simulated climate perspective
  - Vegetation perspective
- Conclusions / Future work

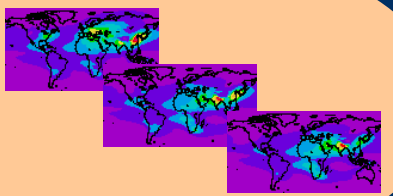
Why include vegetation changes within climate scenarios?

Vegetation

CO_2







Aérosols

indirect effects

direct effect

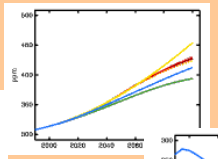
GCM

Ozone chemistry

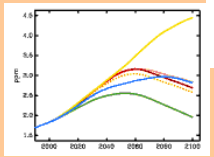
B2
B1
A2
A1F
A1T
A1B

Other greenhouse gases (GHGs)

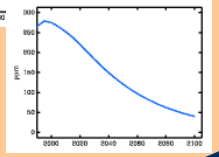
N_2O



CH_4

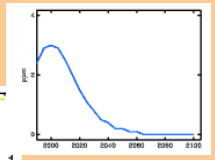


CFC11

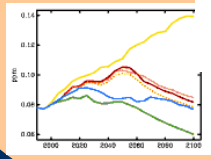


Ozone precursors

Halons

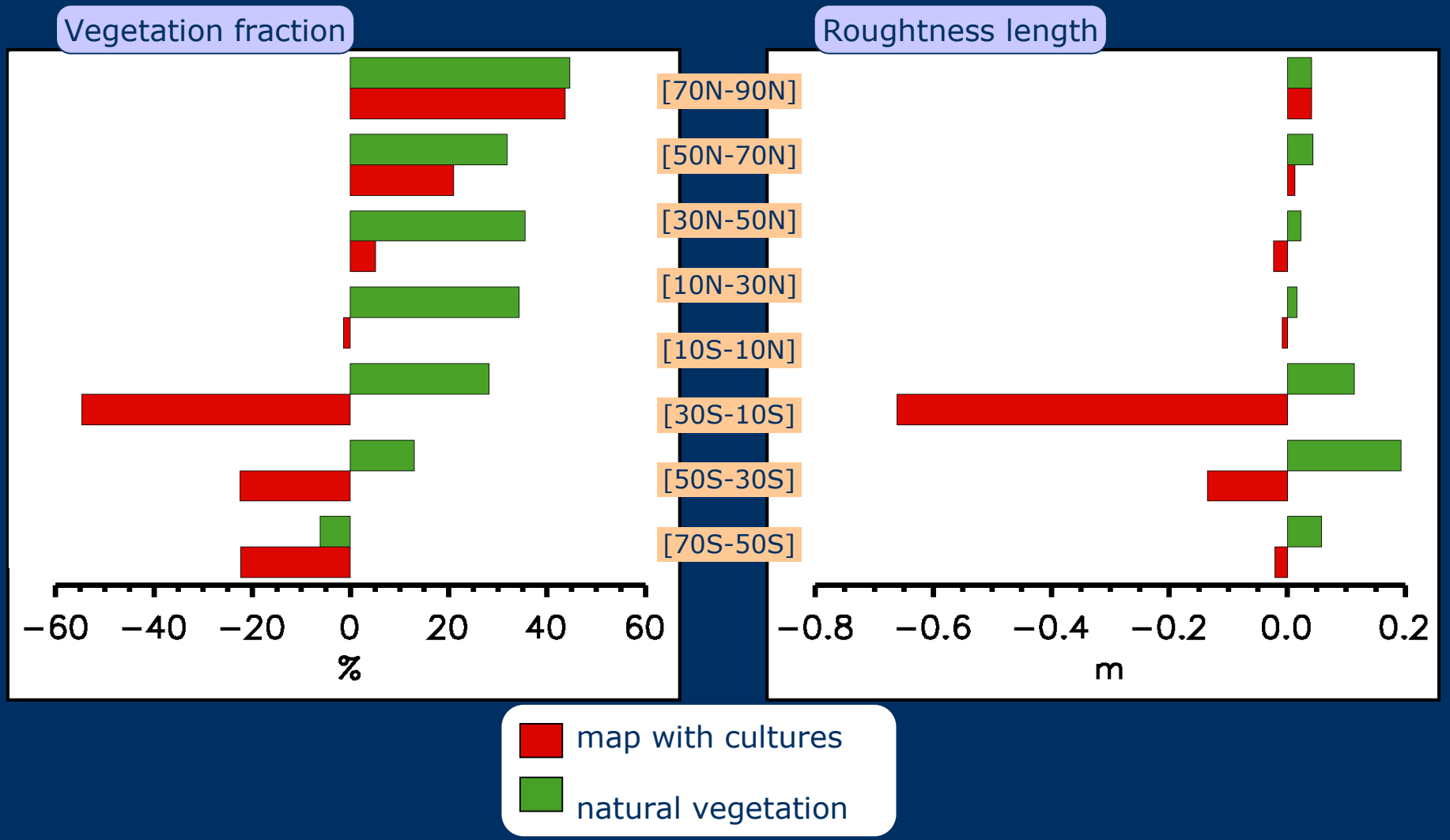


CO



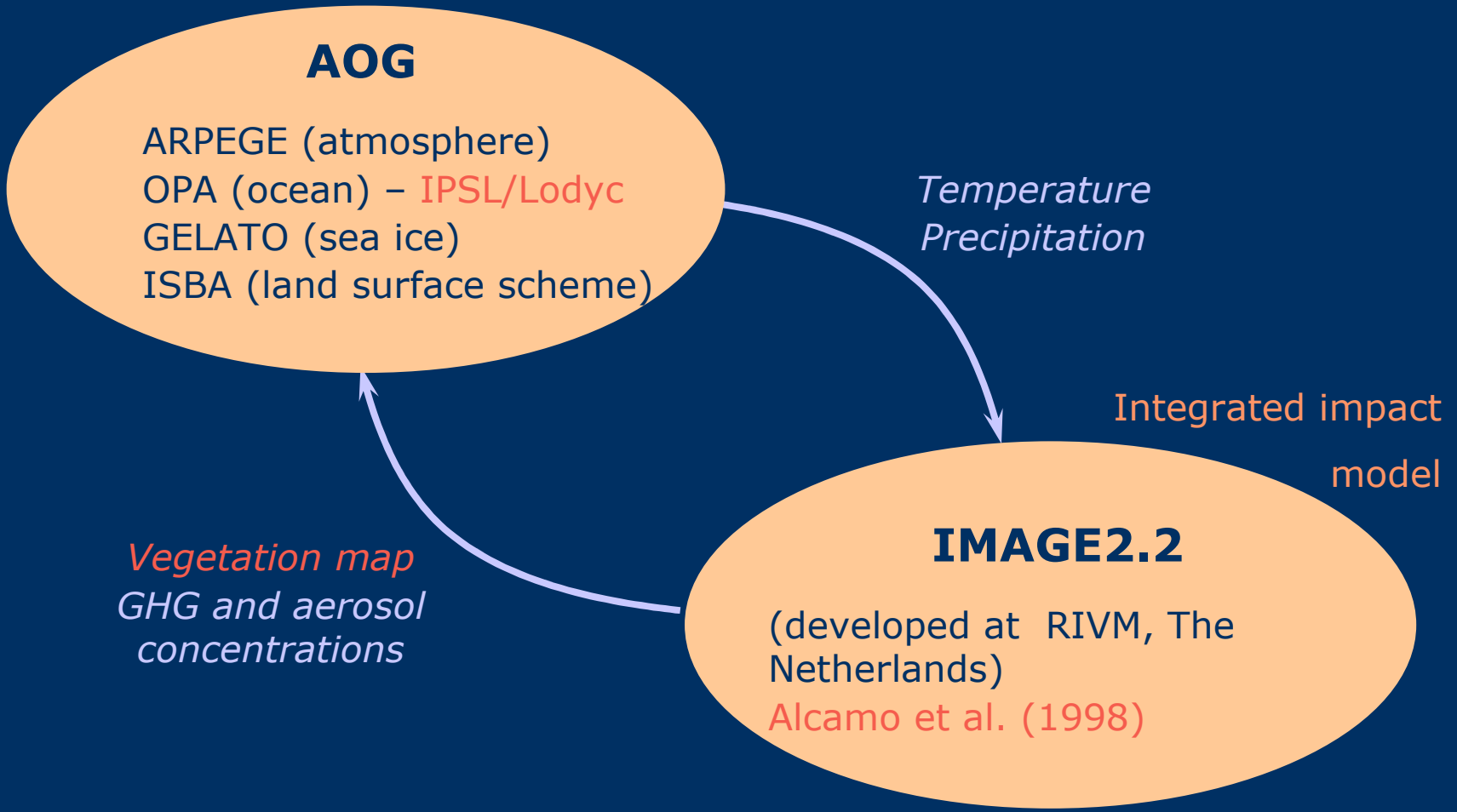
Importance of land use

Zonal anomalies of surface properties
[2090-2099] – [1970-1979]

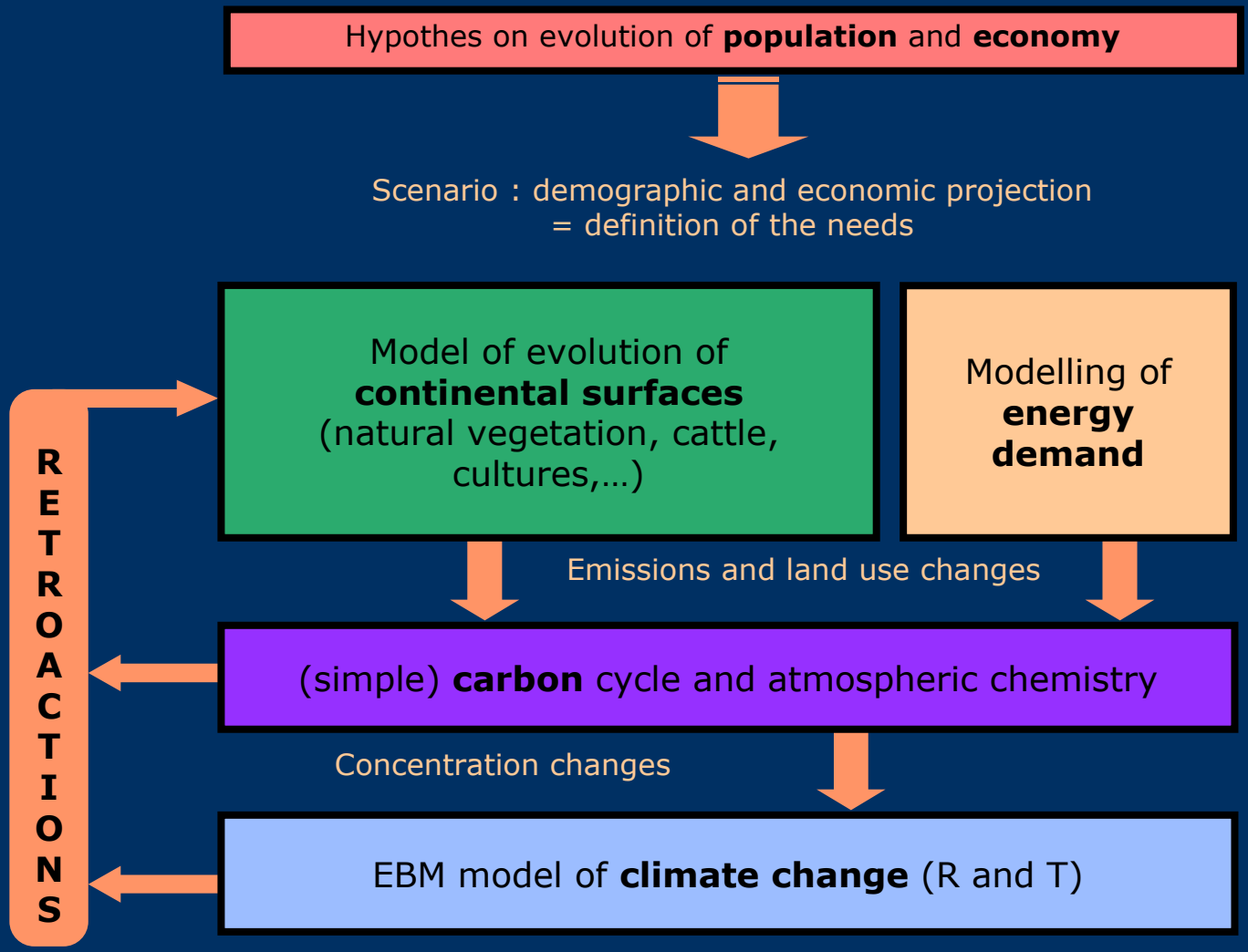


The chosen approach

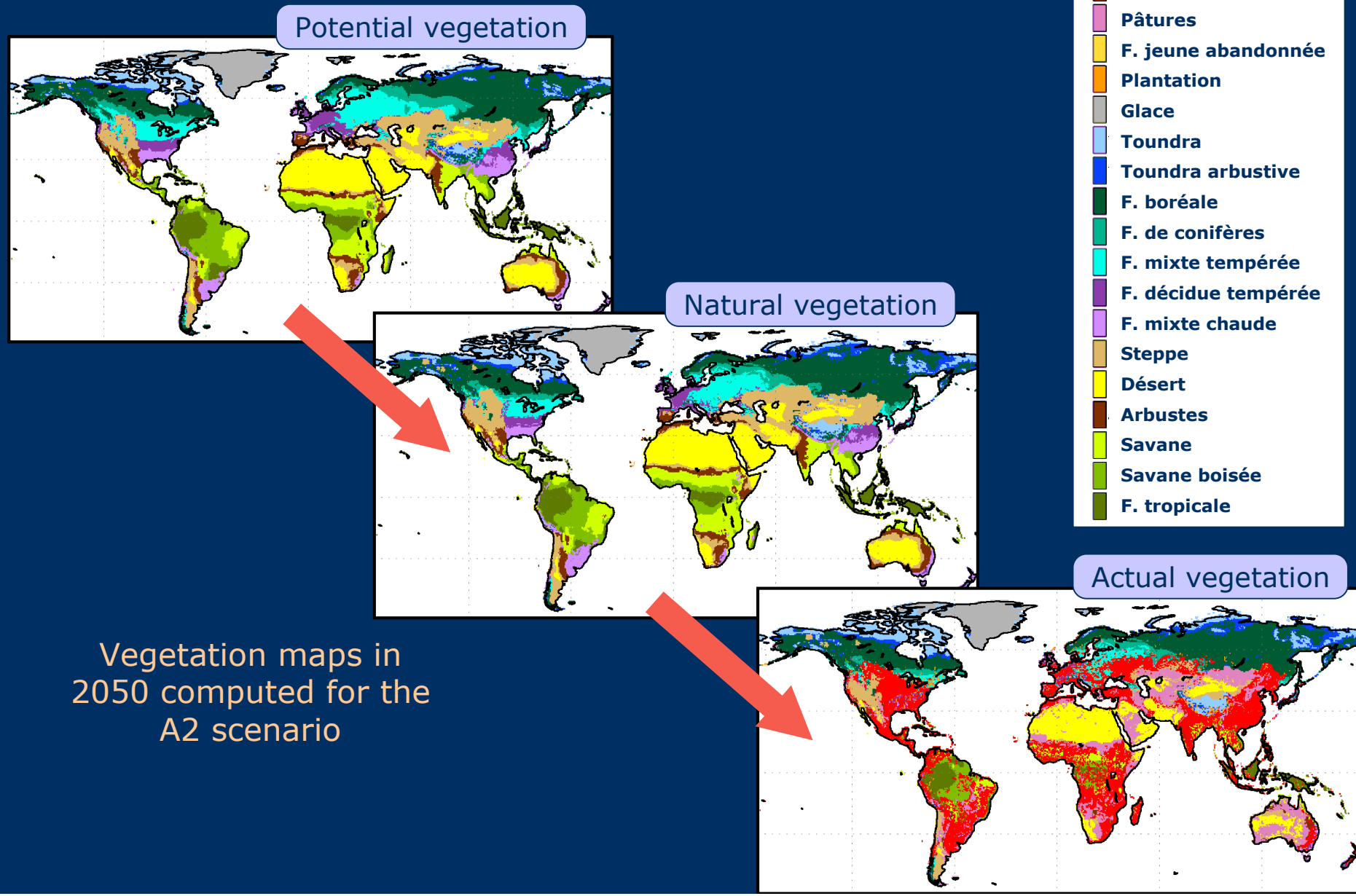
General circulation Model



Components of the IMAGE model

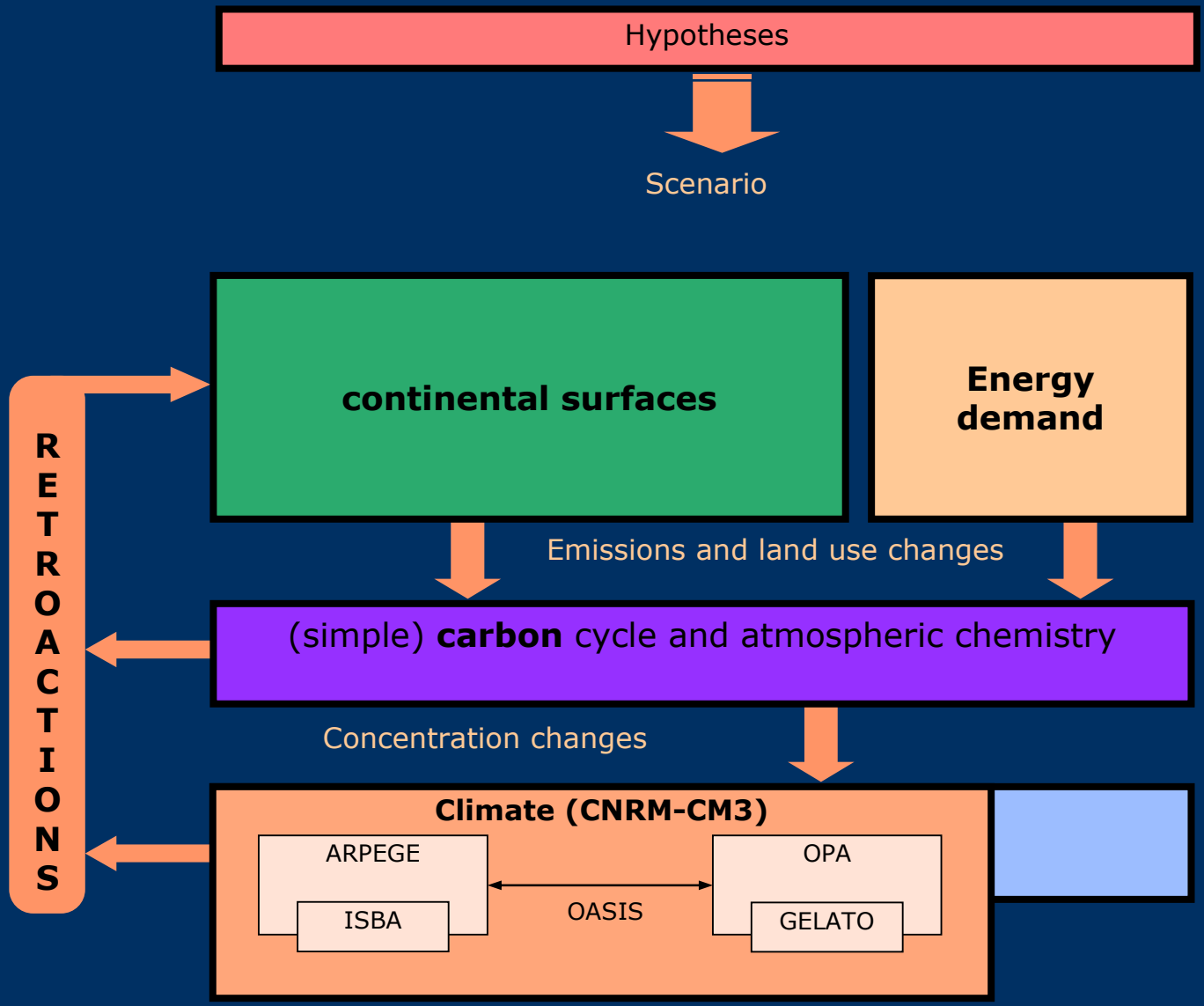


Simulation method of the vegetation cover

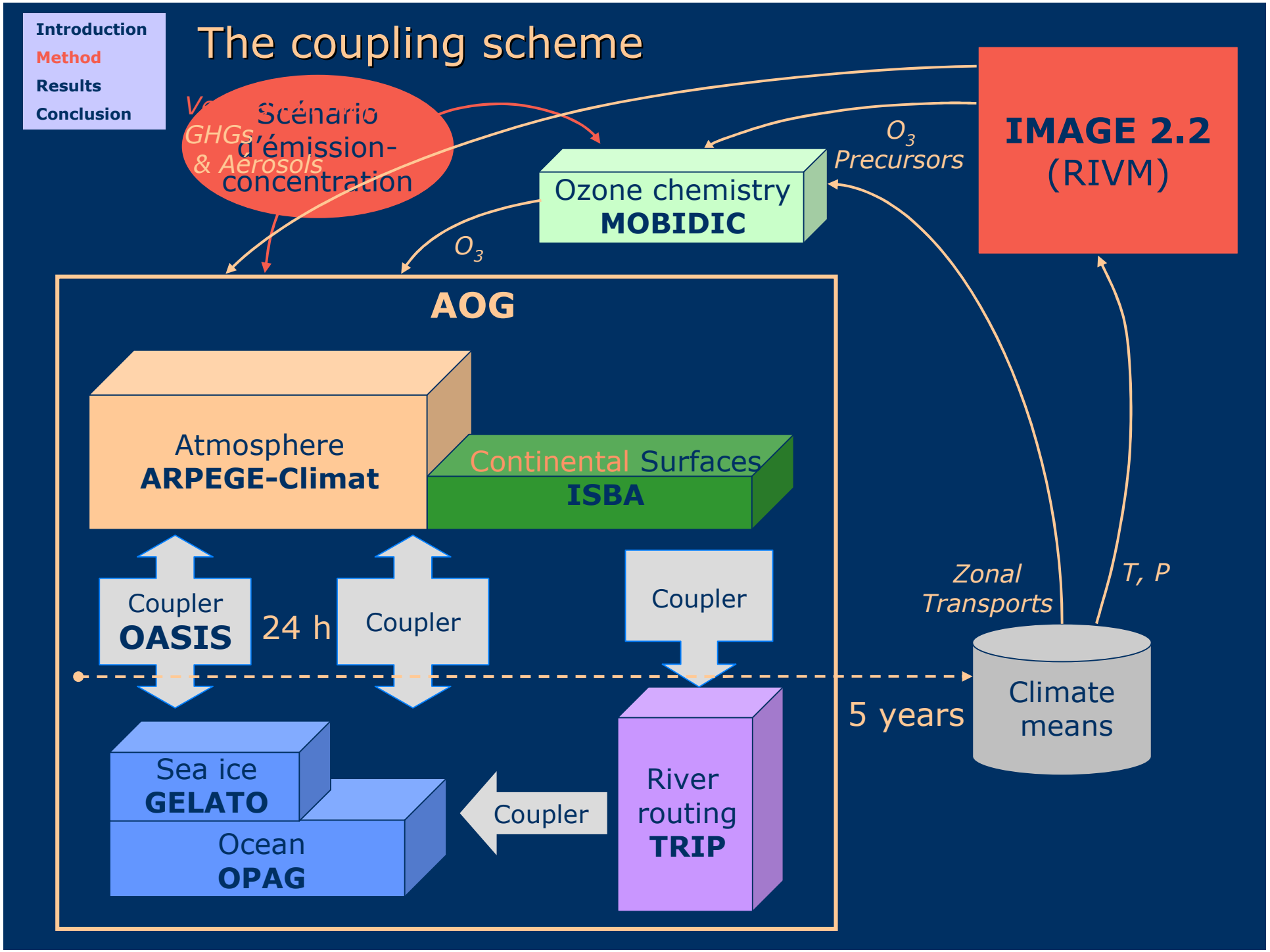


Vegetation maps in 2050 computed for the A2 scenario

Introduction of ARPEGE/OPA/GELATO inside IMAGE2.2



The coupling scheme



Scenario simulation

Equilibration of the carbon cycle model

- historical emissions of CO2
- historical concentrations of other GHGs

Evaluation of vegetation maps with the observed climate

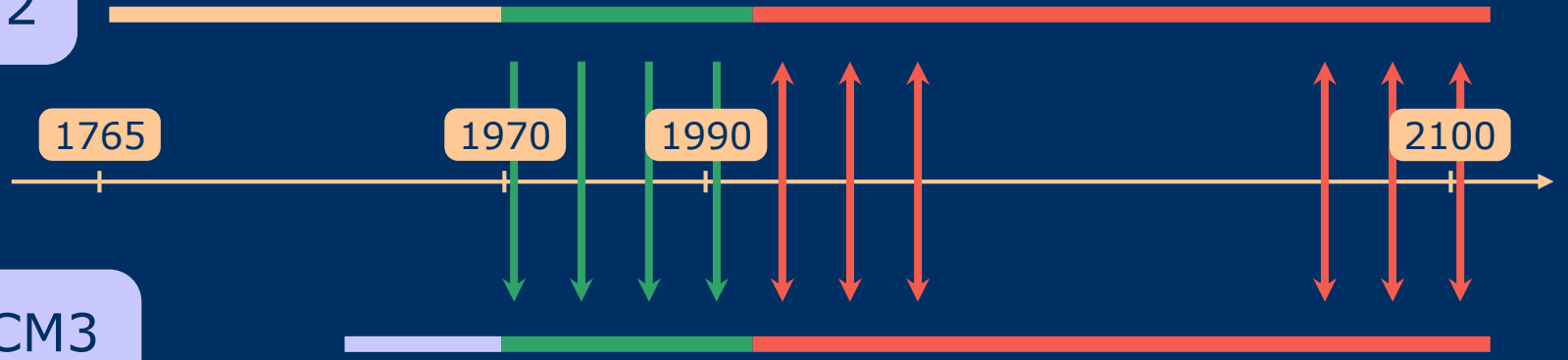
⇨ emissions due to simulated land use, others are historical

First coupled simulation with an A2 scénario:

A2-IM-CM3

Scenario

IMAGE2.2



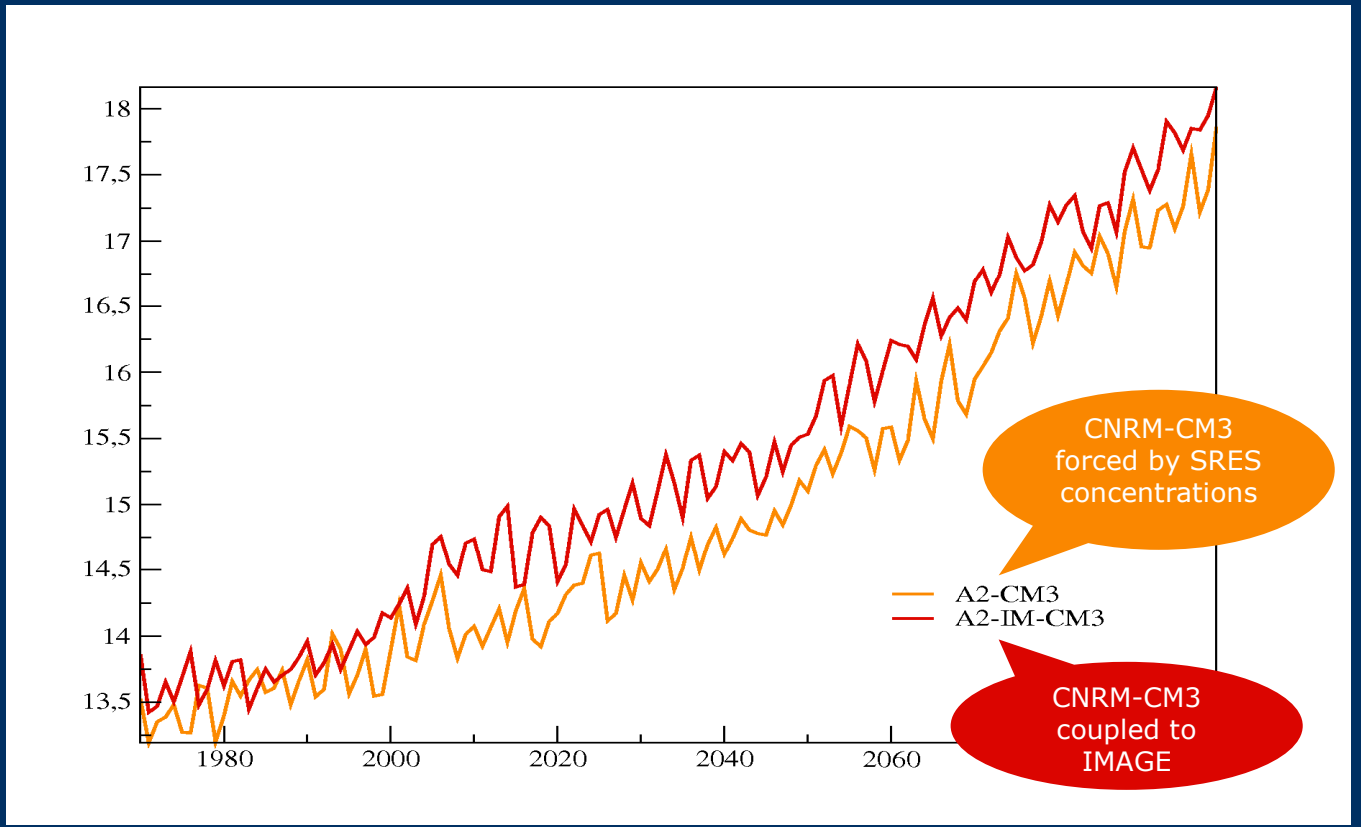
CNRM-CM3

Forcings produced by IMAGE

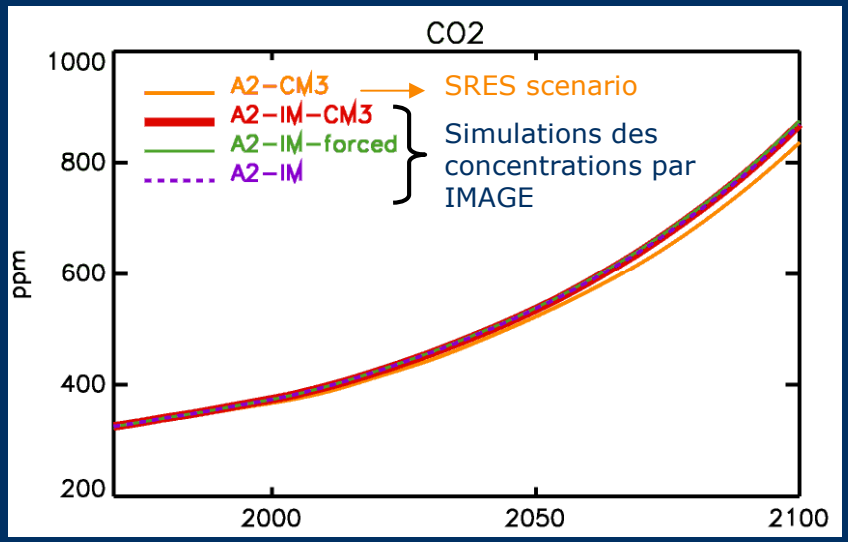
Full coupling

20 years of simulation with constant forcings (1970)

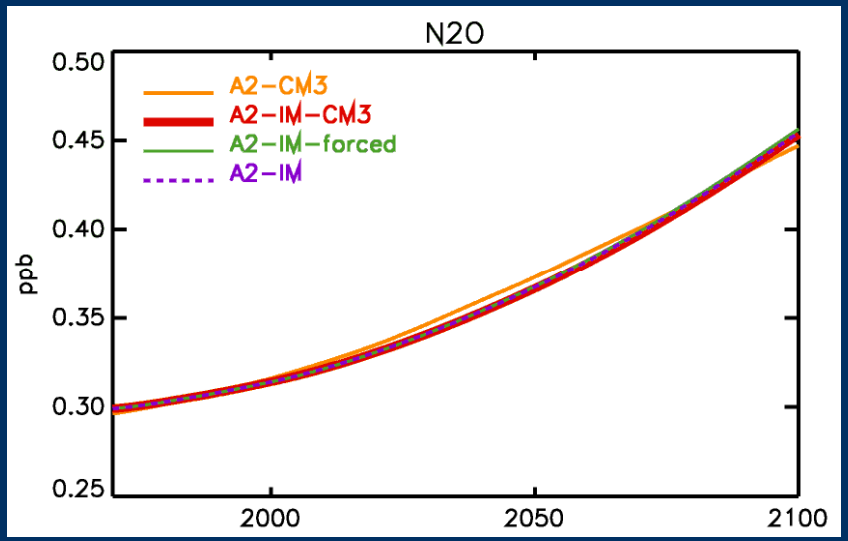
Simulated global temperature change

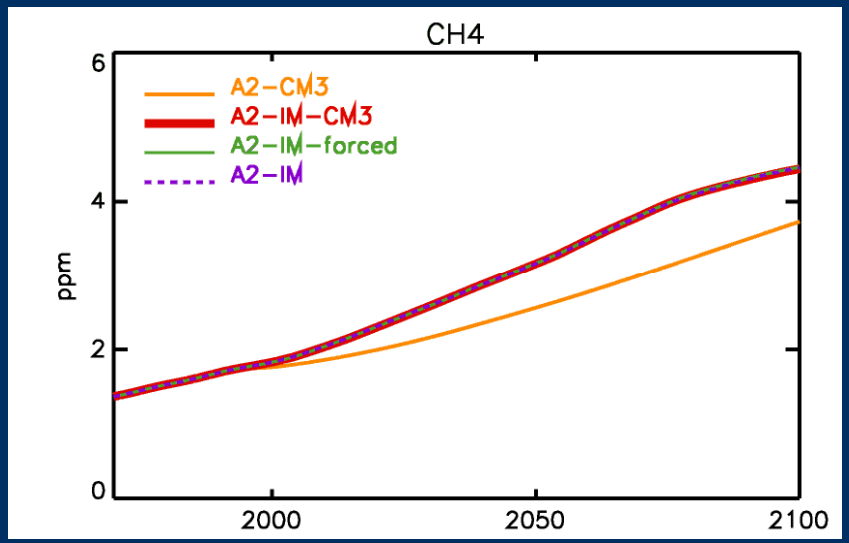


concentration scenarios



- The concentration scenarios produced by IMAGE do not depend much on the the simulated climatic change
- The SRES concentration scenario is not much different from the IMAGE scenario
- No explanation for the sudden change observed in temperature

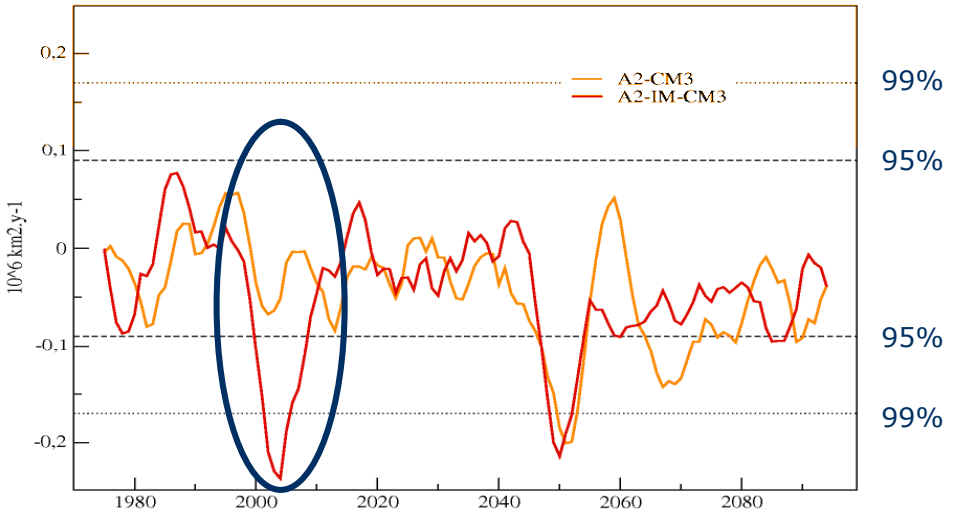




Abrupt change of the arctic sea-ice cover

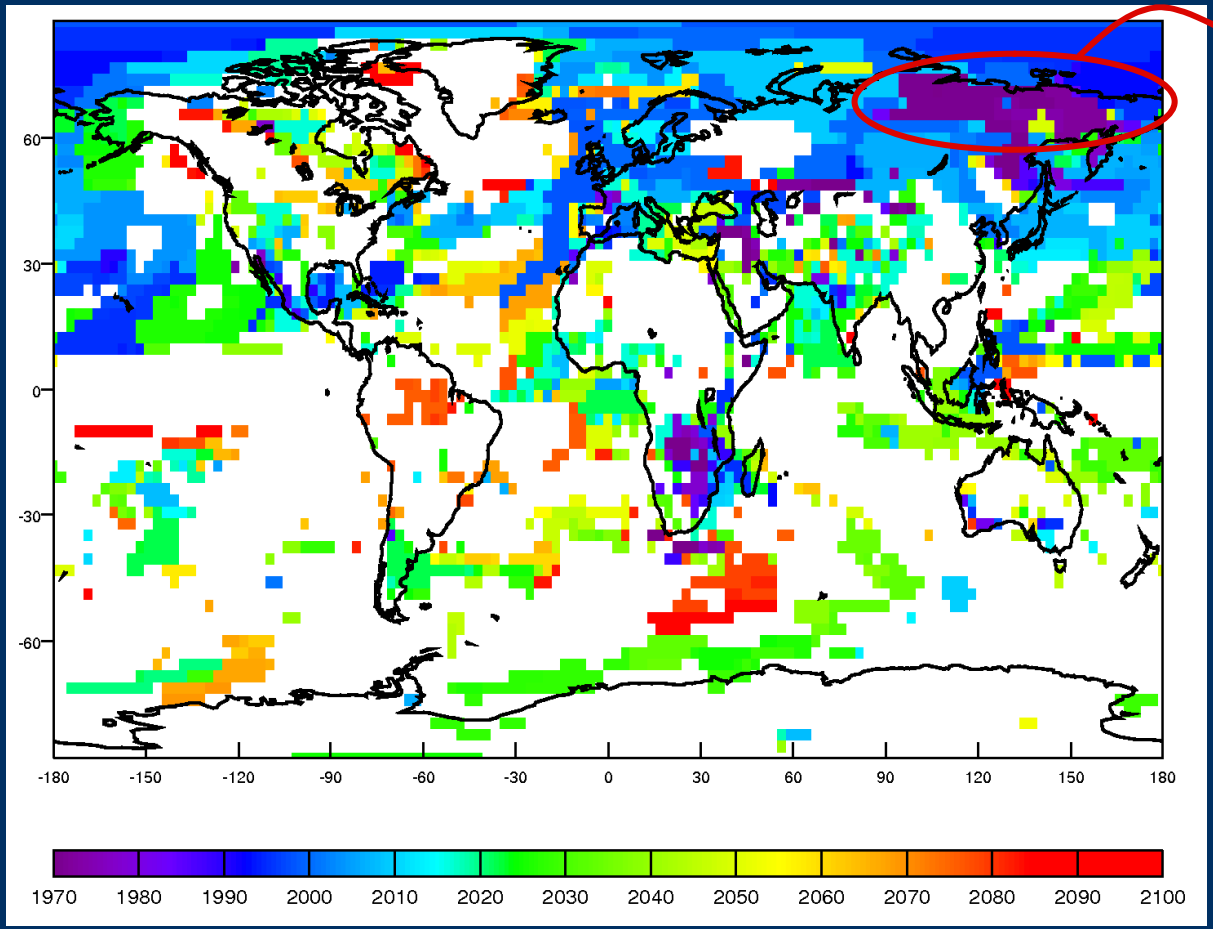
Aire de la glace en Arctique

Tendance glissante sur 15 ans de l'aire de glace Arctique



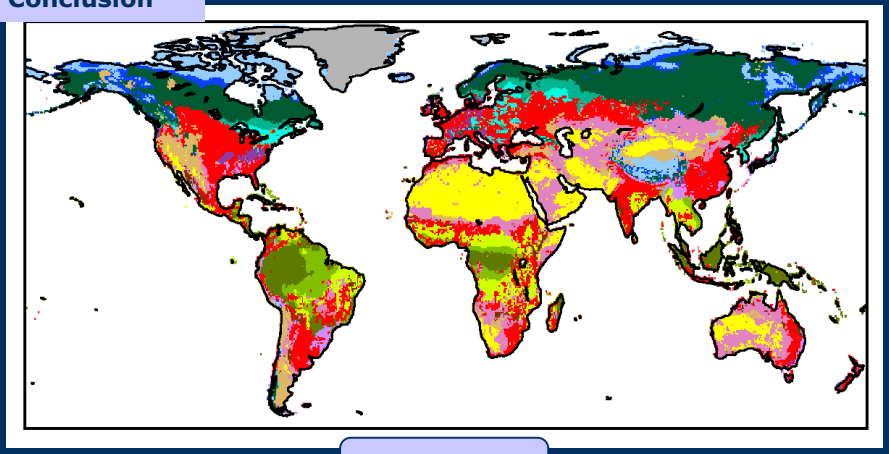
Geographic distribution of the warming

Date from which the IMAGE/CNRM-CM3 simulation stays warmer than the CNRM-CM3 in annual mean over the following 15 years

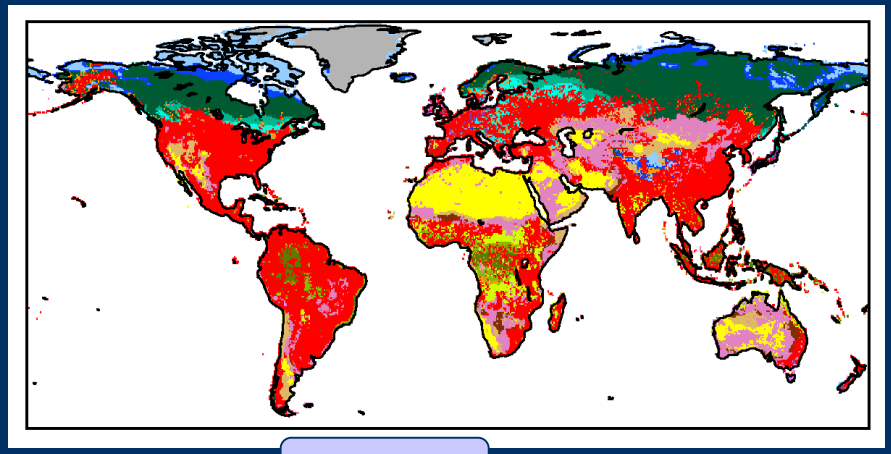


Region where the vegetation albedo is smaller when using the IMAGE vegetation map

Simulated change of vegetation

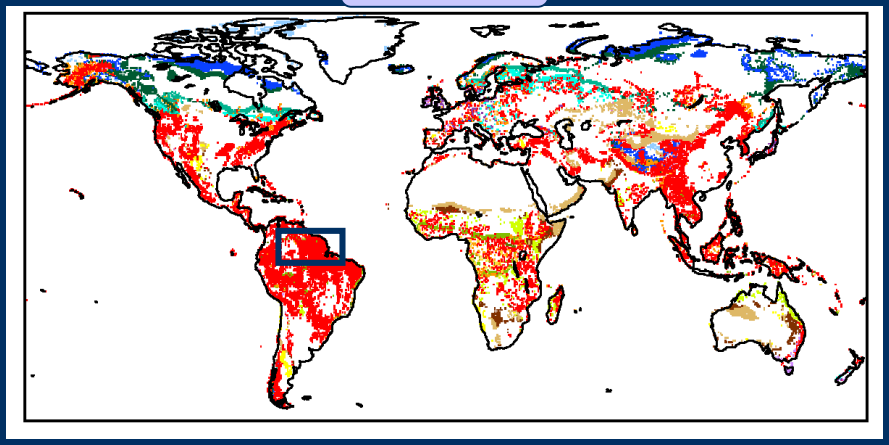


1970



2100

Différence

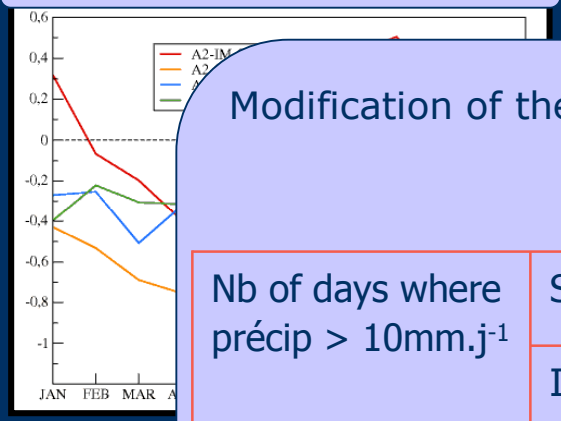


- Cultures
- Pâtures
- F. jeune abandonnée
- Plantation
- Glace
- Toundra
- Toundra arbustive
- F. boréale
- F. de conifères
- F. mixte tempérée
- F. décidue tempérée
- F. mixte chaude
- Steppe
- Désert
- Arbustes
- Savane
- Savane boisée
- F. tropicale

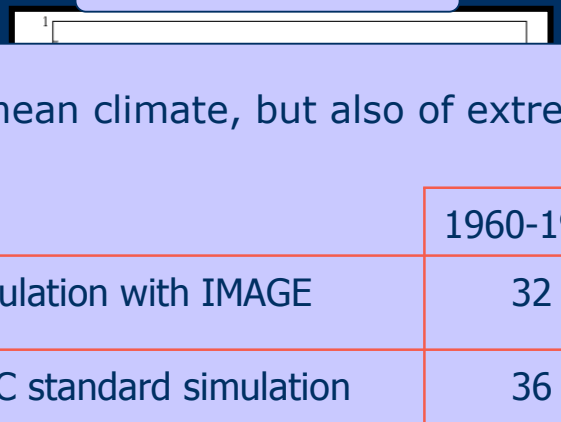
Seasonal cycle anomaly over Amazonia

Computed as difference between the 2070-2099 and the 1960-1989 periods

Daily thermal amplitude

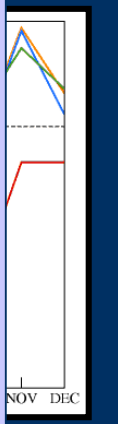


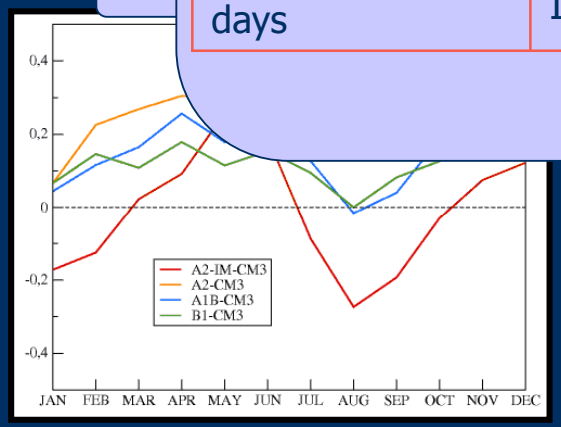
Precipitation

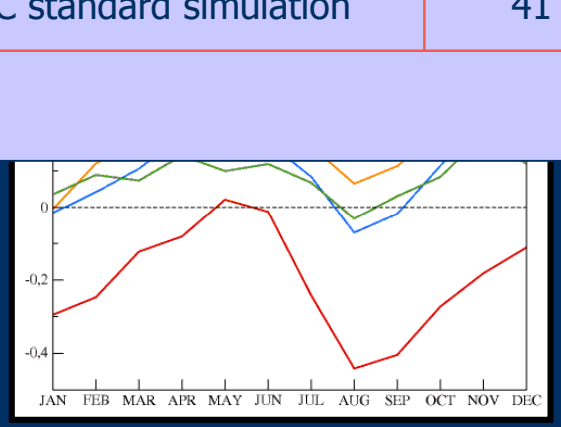


Modification of the mean climate, but also of extremes :

		1960-1999	2070-2099	Différence
Nb of days where précip > 10mm.j^{-1}	Simulation with IMAGE	32	33	+1
	IPCC standard simulation	36	39	+3
Maximum Nb of consecutive dry days	Simulation with IMAGE	36	44	+8
	IPCC standard simulation	41	39	-2

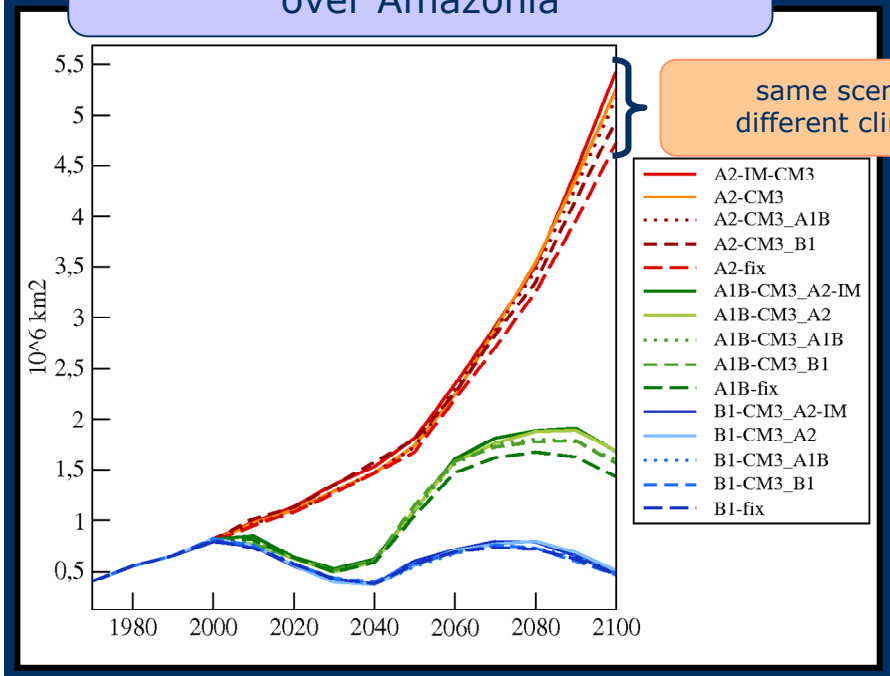






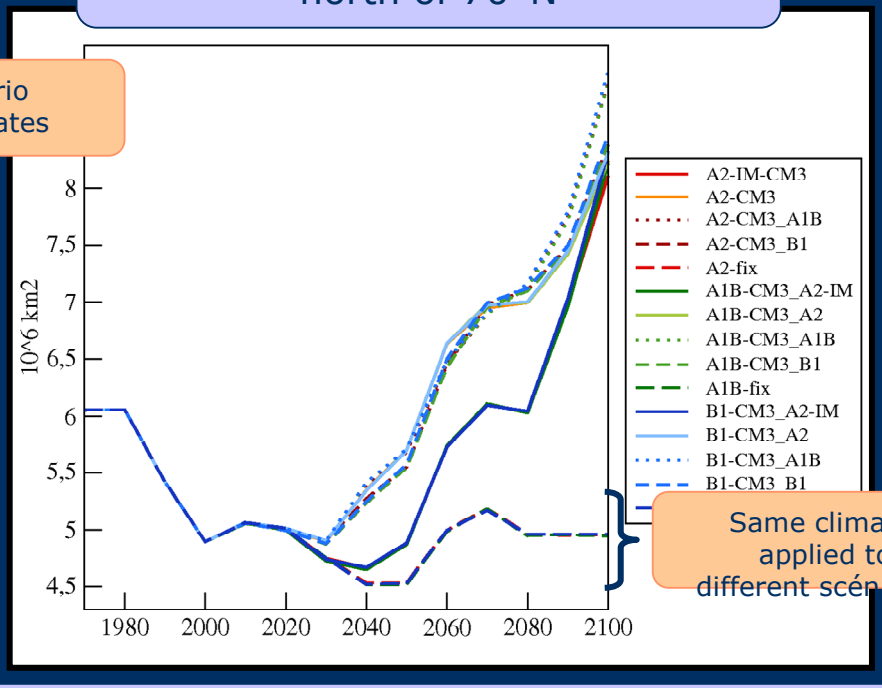
Perspective from IMAGE

Evolution of cultivated surface over Amazonia



same scenario
different climates

Evolution boral forest surface north of 70°N



Same climate
applied to
different scénarios

- The surface of **cultures** is determined mainly by **demographic** constrainsts and by the **evolution of agricultural practices** ⇨ climate is a secondary factor
- **Natural vegetation** evolves mainly under the action of **climate** but is a slow phenomenon ⇨ possible retroactions at longer term than the century

Synthesis

Though this work does not show clear evidence of an impact of future vegetation changes on climate, it brings some useful informations :

⇨ Shows the feasibility of the IMAGE2.2-GCM coupling

⇨ An impact on climate is found locally (important in term of variability)

⇨ But no important retroaction is found at the decennal time scale

⇨ weak impact of climate on modeling of cultures inside IMAGE

⇨ The century time-scale is somewhat short to detect the appearance of a retroaction between natural vegetation change and climate

Future perspectives

Remarks :

- To simulate only the natural evolution of vegetation is not realistic (the evolution of cultivated surfaces is very important)
- The evolution of the surface of cultures depends mainly on the chosen economic scenario

Proposition :

Use of projections of land-use produced by IMAGE (or other impact Assessment Models) for each scenario directly in GCMs, in addition to simulations of natural vegetation dynamic vegetation models.