Ministério da Ciência e Tecnologia

Instituto Nacional de Pesquisas Espaciais – INPE
Centro de Ciência do Sistema Terrestre – CCST

Workshop de Apresentação da Ferramenta GLOBIO para a Projeção de Cenários para Biodiversidade

Modelagem da Interação Biosfera-Atmosfera no INPE

Gilvan Sampaio
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Rio de Janeiro – 25Mar2009

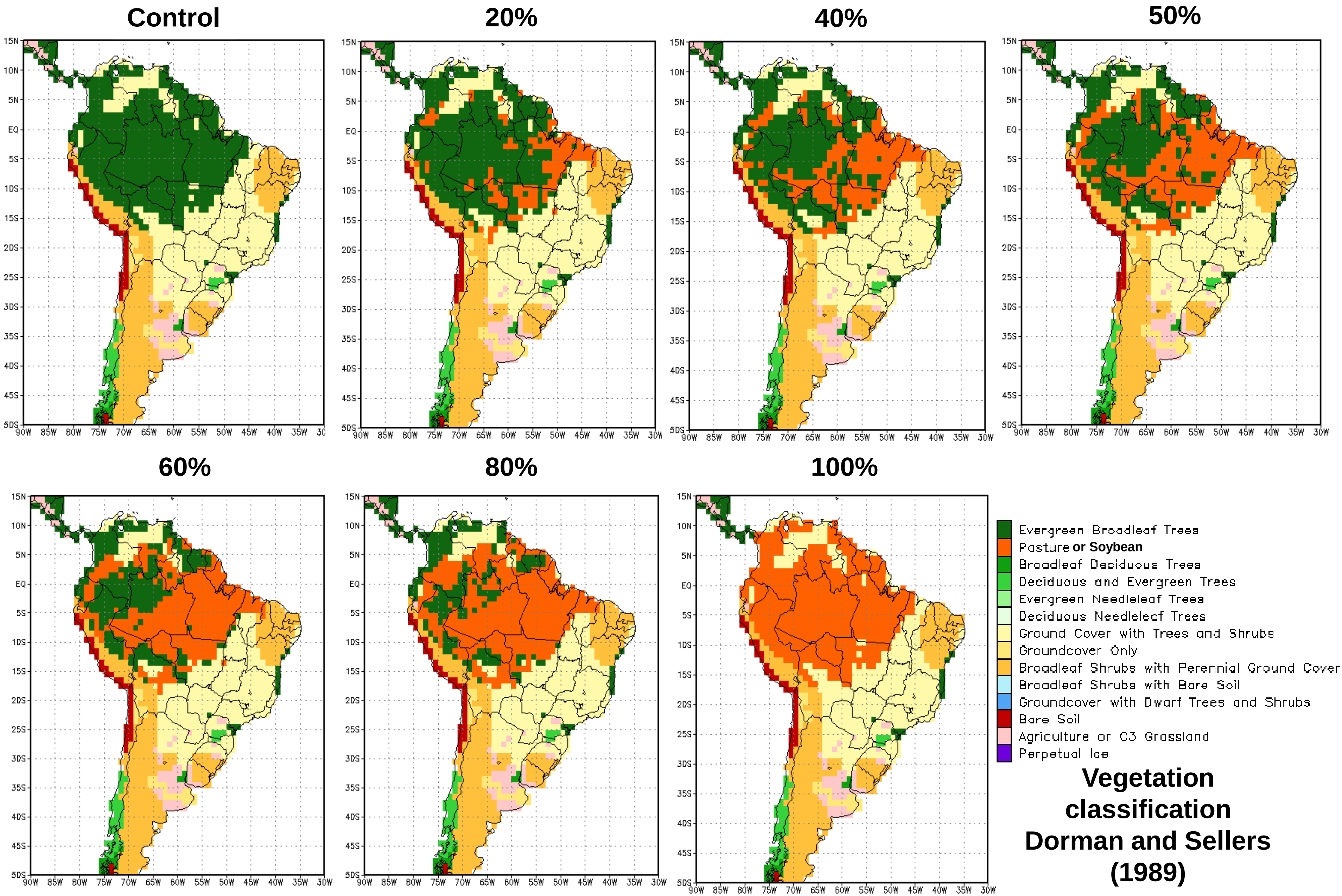
Regional Climate Change Over Eastern Amazonia Caused by Pasture and Soybean Cropland Expansion

Gilvan Sampaio[1*], Carlos Nobre[1], Marcos H. Costa[2], Prakki Satyamurty[1], Britaldo S. Soares-Filho[3] and Manoel F. Cardoso[1]

[1] CPTEC/INPE
[2] UFV
[3] UFMG

Geophys. Res. Lett., 34, L17709.
13sep2007

PROJECTED SCENARIOS

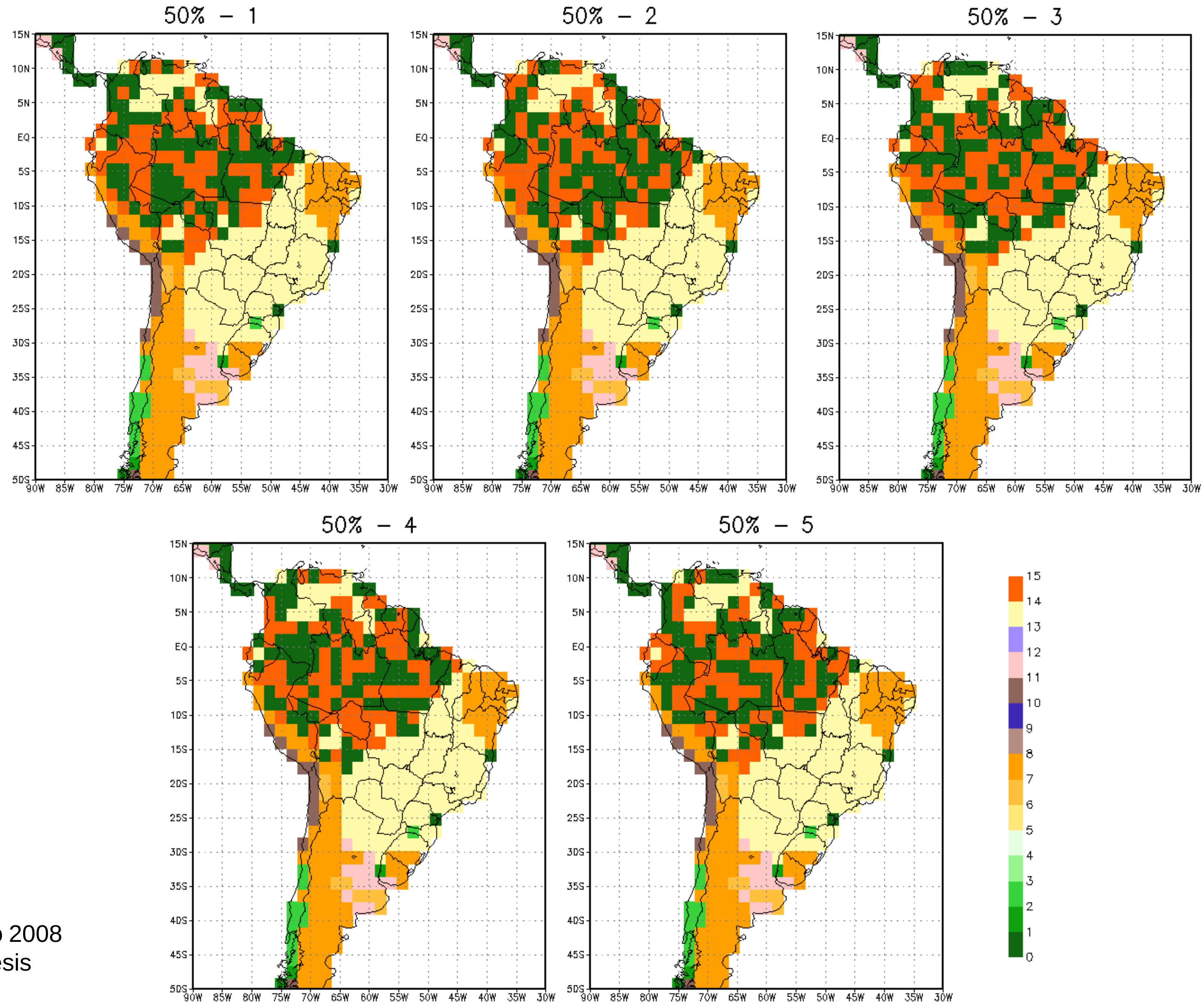


Vegetation classification Dorman and Sellers (1989)

Source: Soares-Filho et al., 2006 and Amazon Scenarios Project, LBA

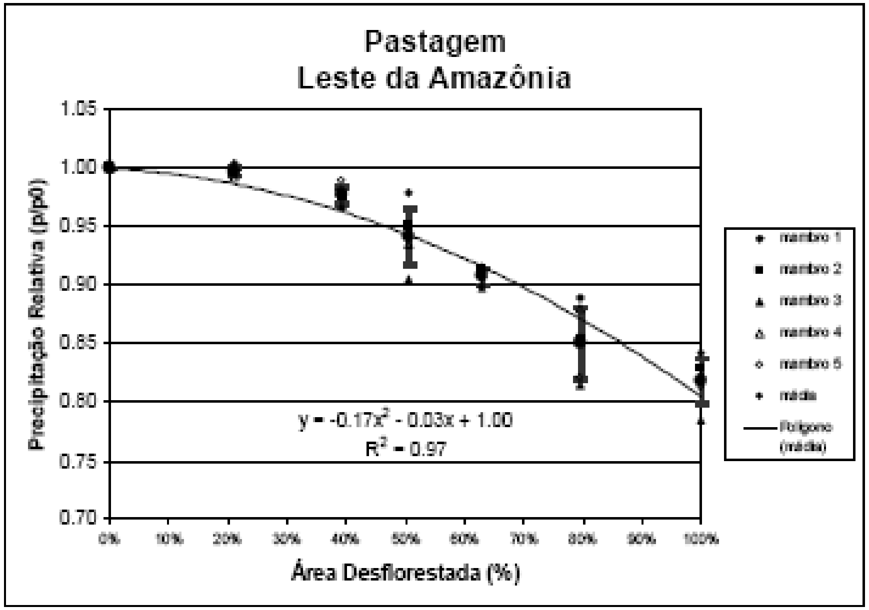
Sampaio et al., 2007

Random Deforestation Scenarios (example of 50% deforestation)



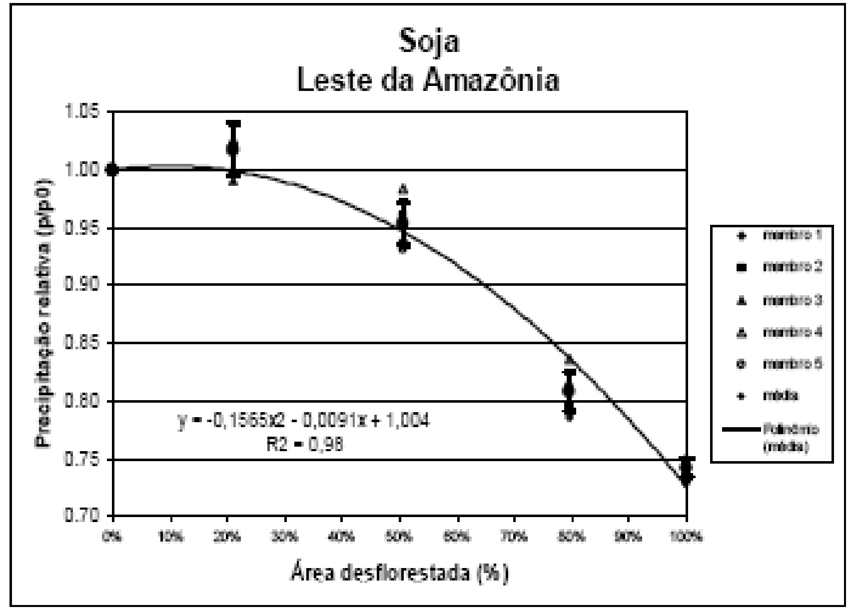
Sampaio 2008
PhD Thesis

PASTURE



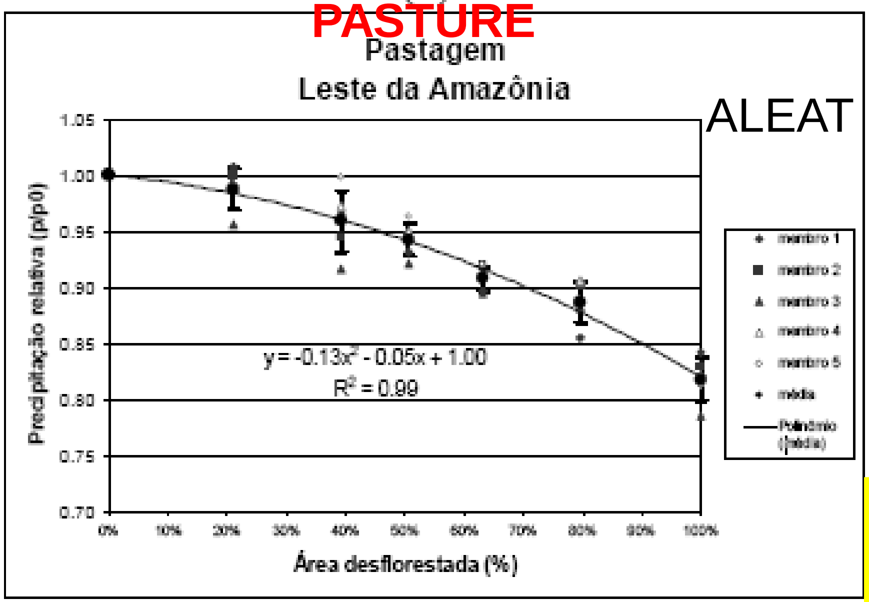
(a)

SOYBEAN



(b)

PASTURE



(c)

Precipitation (100% de desf.)

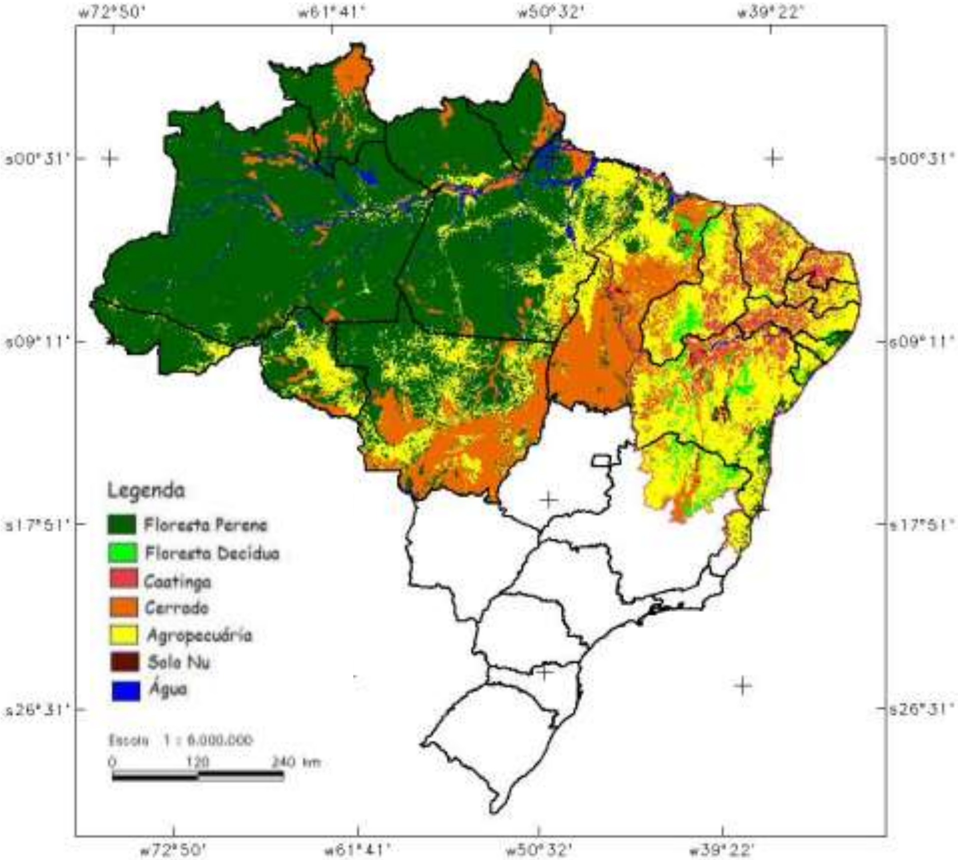
Period	All Pasture	All Soybean
Annual	**-18,2%**	**-25,8%**
ASO	**-42,0%**	**-47,4%**

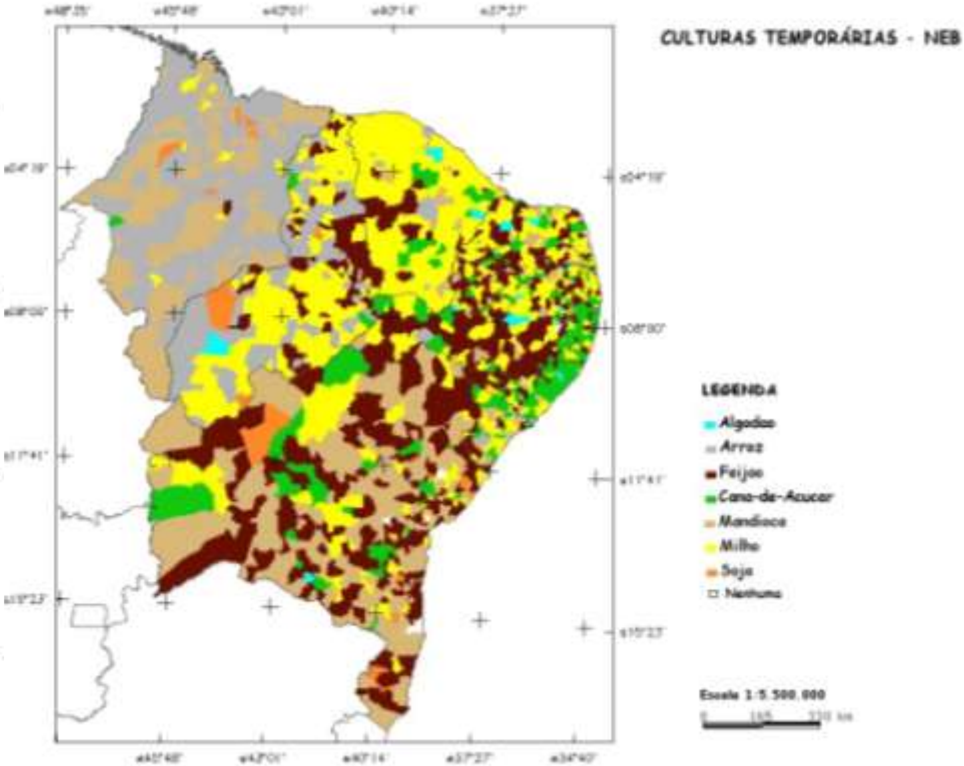
decrease in precipitation associated with pasture or soybean expansion

The reduction in precipitation occurs mainly during the **dry season**, and is more evident when the deforested area is larger than 40% !

Sampaio *et al.*, 2007
Geophys. Res. Lett., 34

Elaboração de representação espacial atualizada do uso e cobertura da terra na Amazônia e no NE brasileiro.





CPTEC Potential Vegetation Model – CPTEC-PVM

Oyama and Nobre (2003, 2004)

- The Potential Vegetation Model (PVM) uses 5 climate parameters to represent the (SiB) biome classification.

- CPTEC-PVM is able to represent quite well the world's biome distribution.

- A dynamical vegetation model was constructed by coupling CPTEC-PVM to the CPTEC Atmospheric GCM (CPTEC-DVM).

CPTEC-PVM was coupled to the CPTEC AGCM

Vegetation = f_1 (climate variables)
= f_1 (g_0, g_5, Tc, h, s)

g_0 = degree-days above 0 C
g_5 = degree-days above 5 C
Tc = mean temperature of the coldest month
h = aridity index
s = sesonality index

f_1 is a highly nonlinear function

Vegetation Model
CPTEC PVM

COUPLING

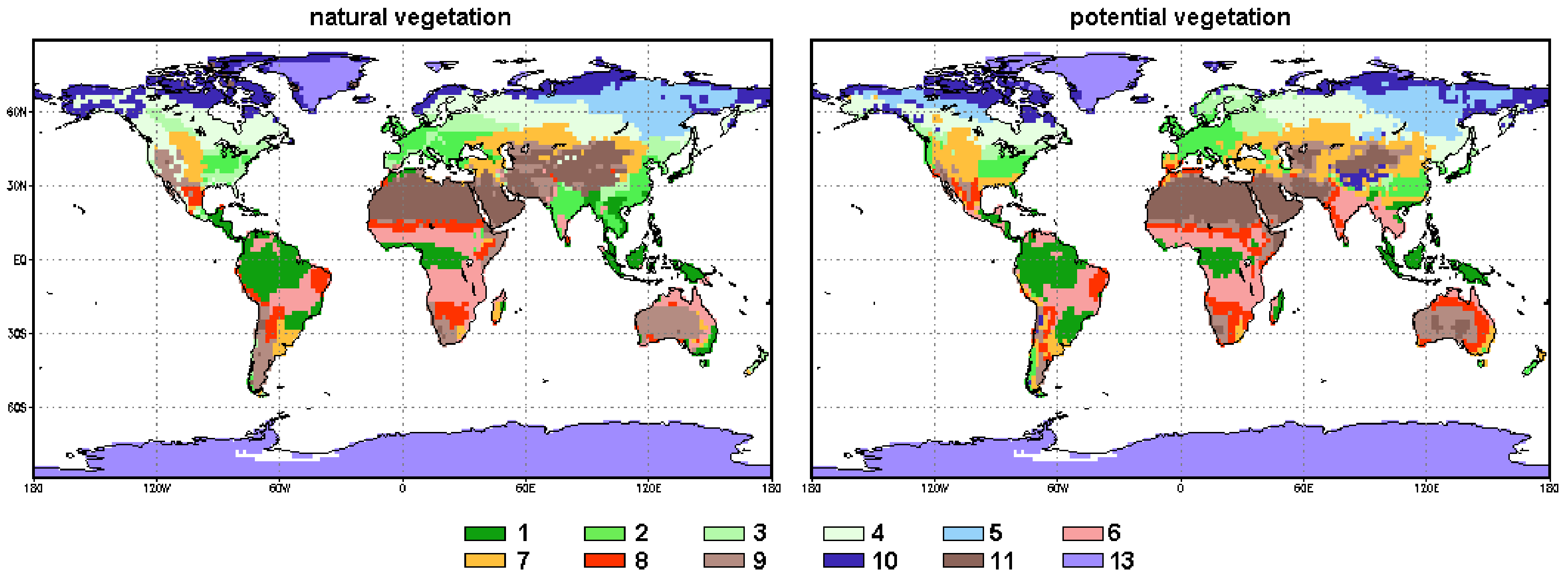
Atmospheric Model
CPTEC AGCM

Climate = f_2 (vegetation)
= f_2 (AGCM coupled to vegetated land surface scheme)

f_2 is also a nonlinear function

Visual Comparison of CPTEC-PVM versus Natural Vegetation Map

CPTEC-PBM



SiB Biome Classification

1 Broadleaf-evergreen trees (tropical forest)
2 Broadleaf-deciduous trees (temperate forest)
3 Broadleaf and needleleaf trees (mixed forest)
4 Needleleaf-evergreen trees (boreal forest)
5 Needleleaf-deciduous trees (larch)
6 Broadleaf trees with groundcover (savanna)
7 Groundcover only (grasslands)
8 Broadleaf shrubs with perennial groundcover (caatinga)
9 Broadleaf shrubs with bare soil (semi-desert)
10 Dwarf trees and shrubs with groundcover (tundra)
11 Bare soil (desert)
13 Perpetual ice

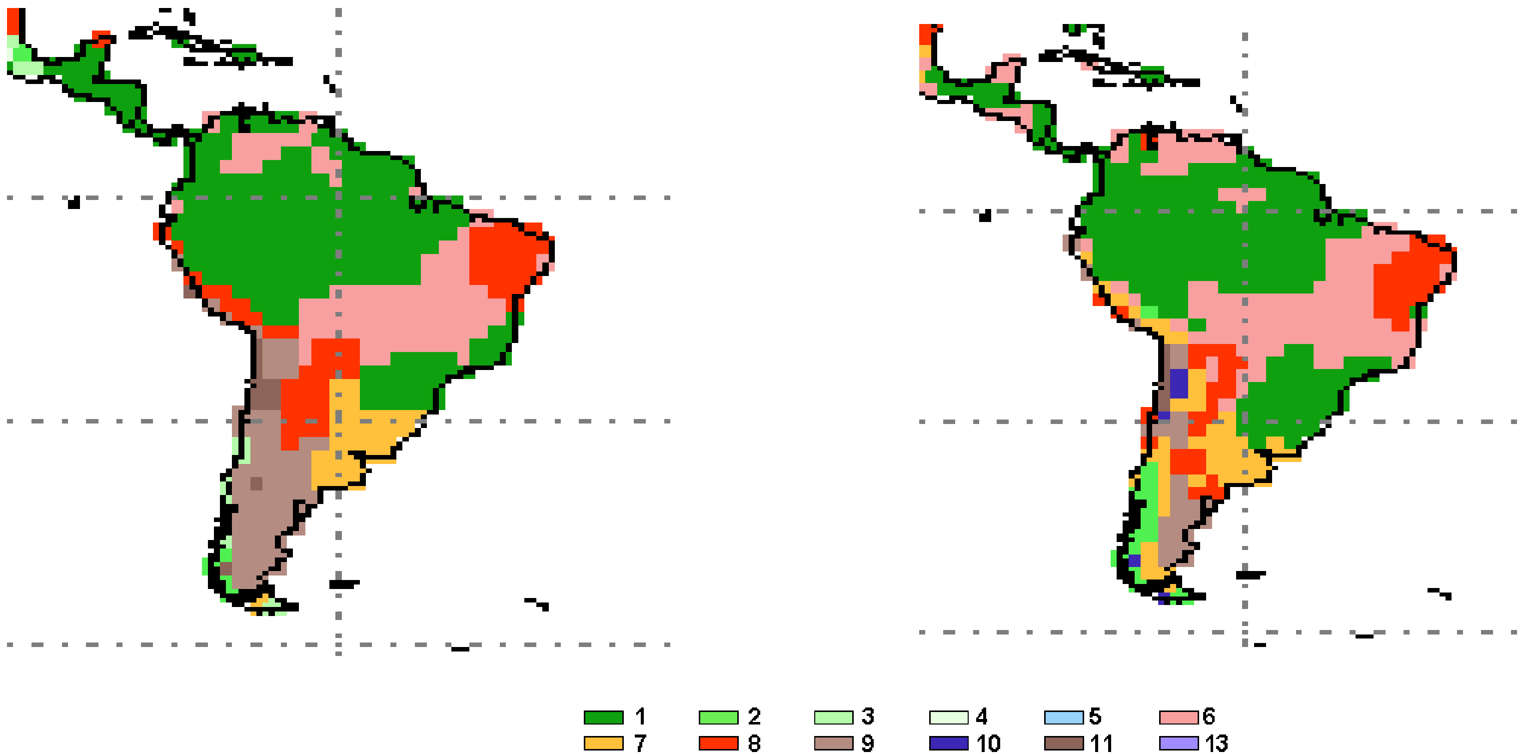
62% agreement on a global 2 deg x 2 deg grid

Oyama and Nobre, 2002

Visual Comparison of CPTEC-PVM versus Natural Vegetation Map

NATURAL VEGETATION

POTENTIAL VEGETATION



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SiB Biome Classification

Oyama and Nobre, 2002

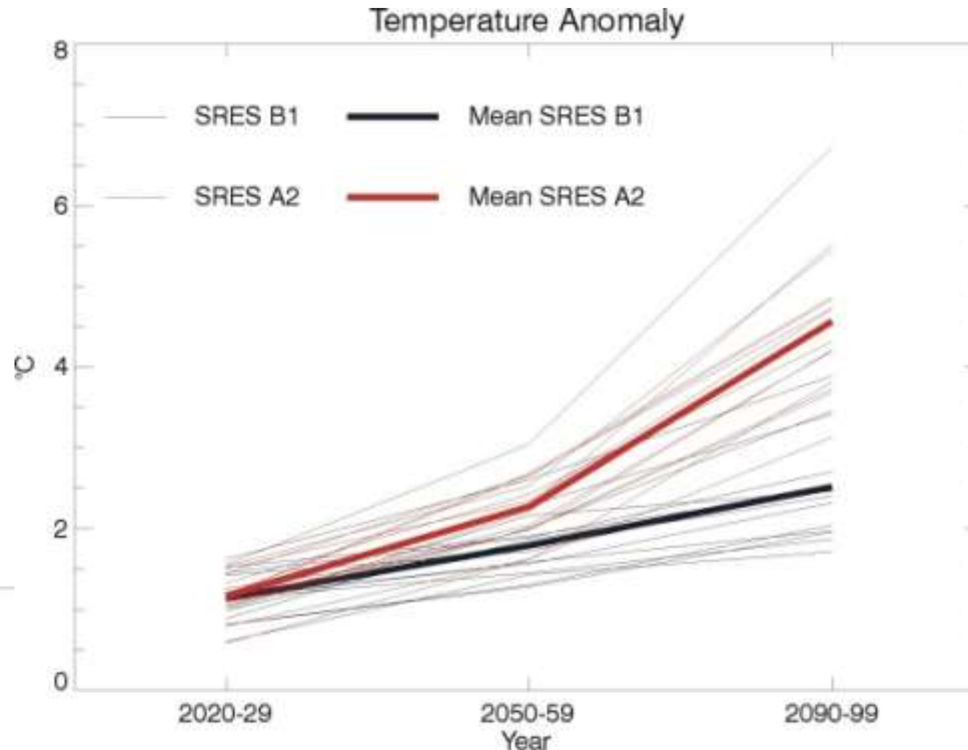
Climate change consequences on the biome distribution in tropical South America

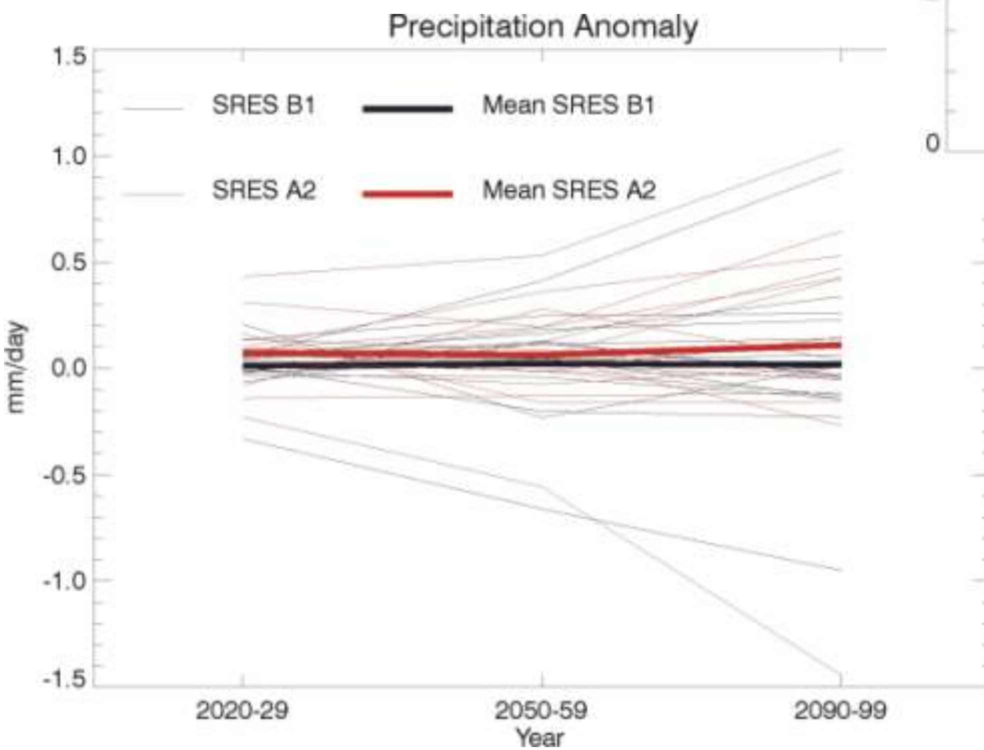
Luis Salazar[1], C. Nobre[1] and M. D. Oyama[2] (2007)

[1] CPTEC/INPE
[2] IAE-CTA

Geophys. Res. Lett., 34, L09708,
doi:10.1029/2007GL029695

Climate Change Scenarios for Amazonia

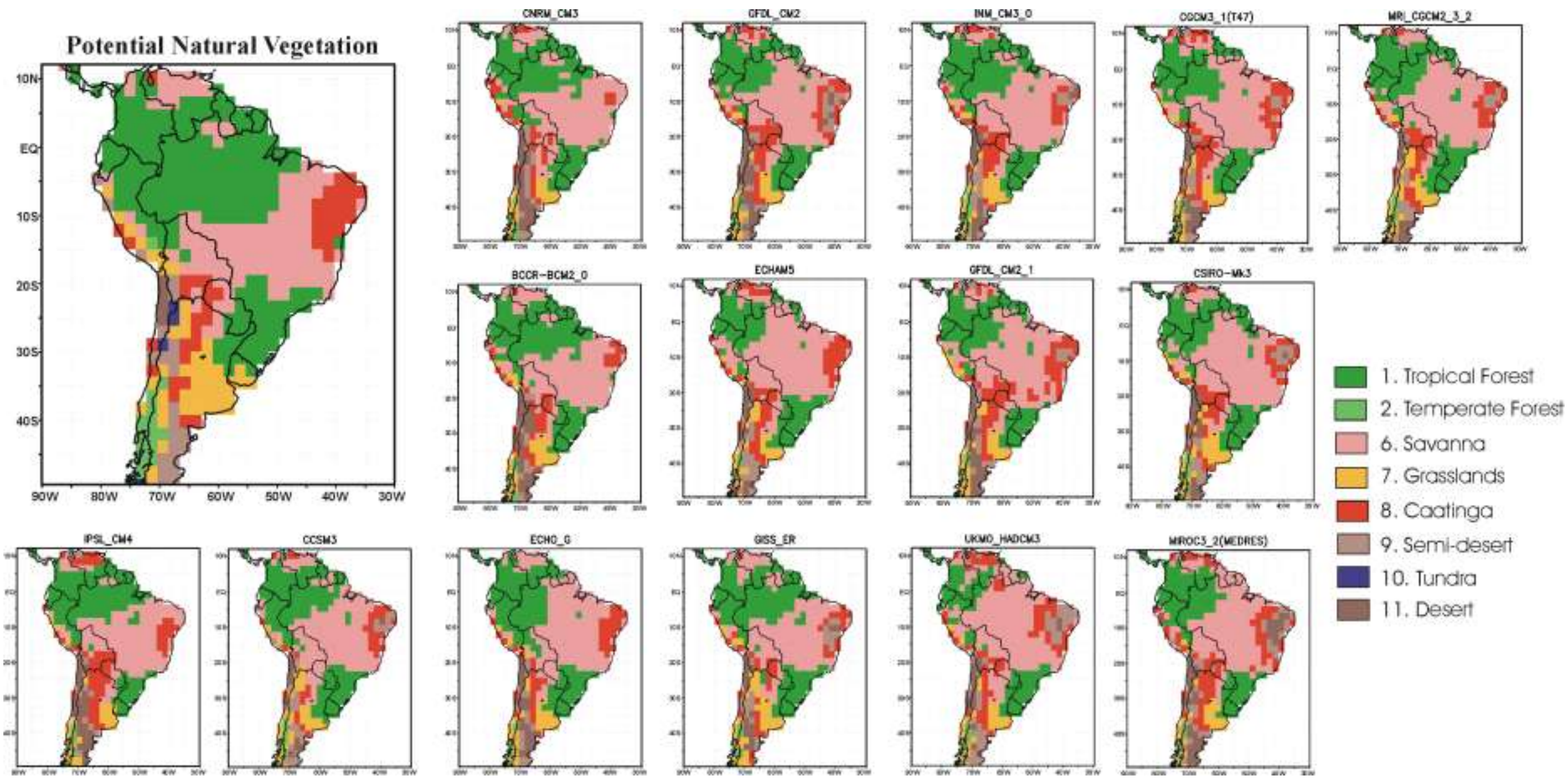




Results from 15 AOGCMs for the SRES A2 and B1 emissions scenarios, prepared for the IPCC/AR4.

Models: BCCR-BCM2.0, CCSM3, CGCM3.1(T47), CNRM-CM3, CSIRO-MK3, ECHAM5, GFDL-CM2, GFDL-CM2.1, GISS-ER, INM-CM3, IPSL-CM4, MIROC3.2 (MEDRES), MRI-CGCM2.3.2, UKMO-HADCM3, ECHO-G

Climate Change Consequences on the Biome distribution in tropical South America

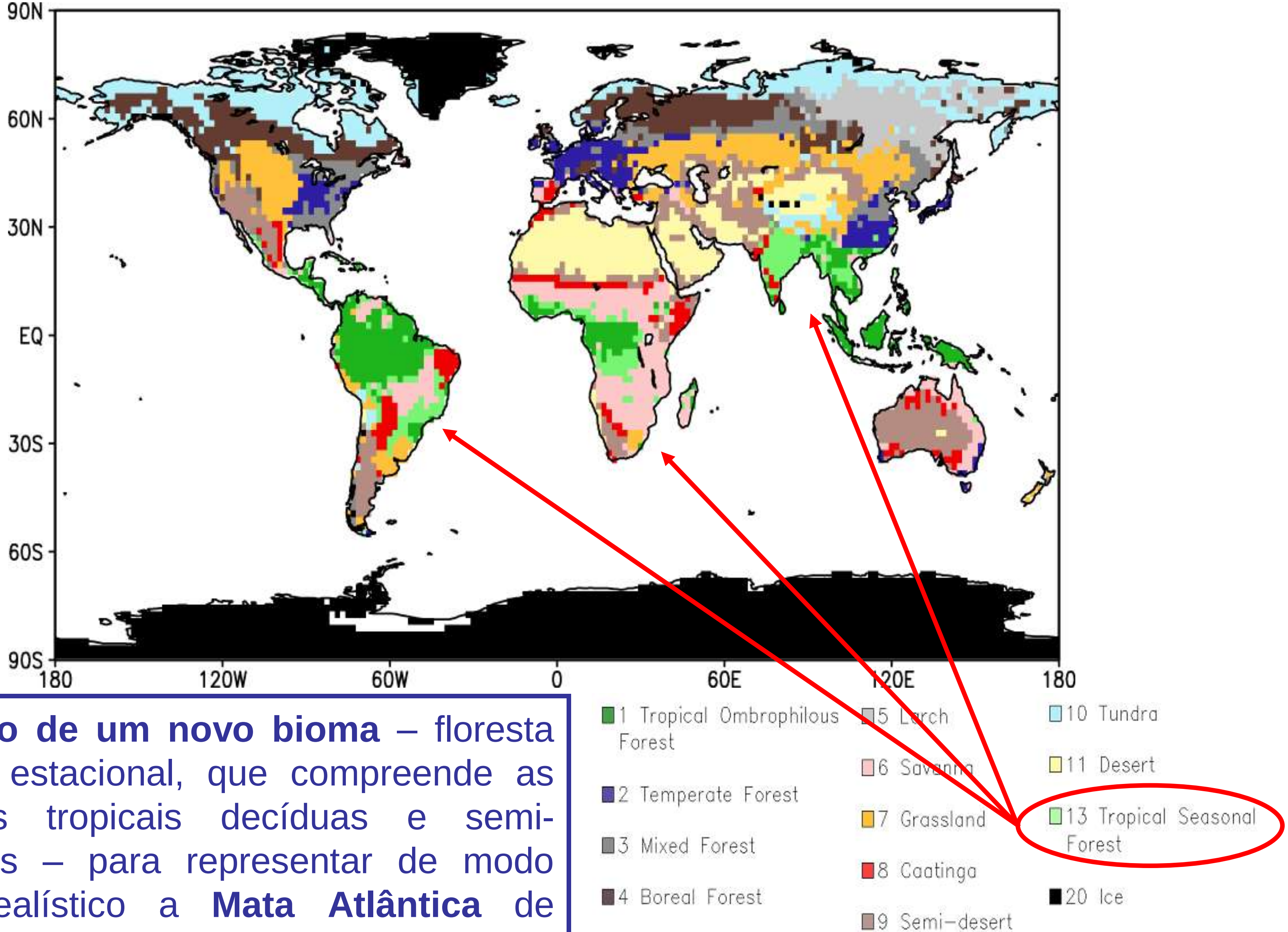


Projected distribution of natural biomes in South America for 2090-2099 from 15 AOGCMs for the A2 emissions scenarios.

Substituição da floresta tropical por savana !

Salazar et al., 2007

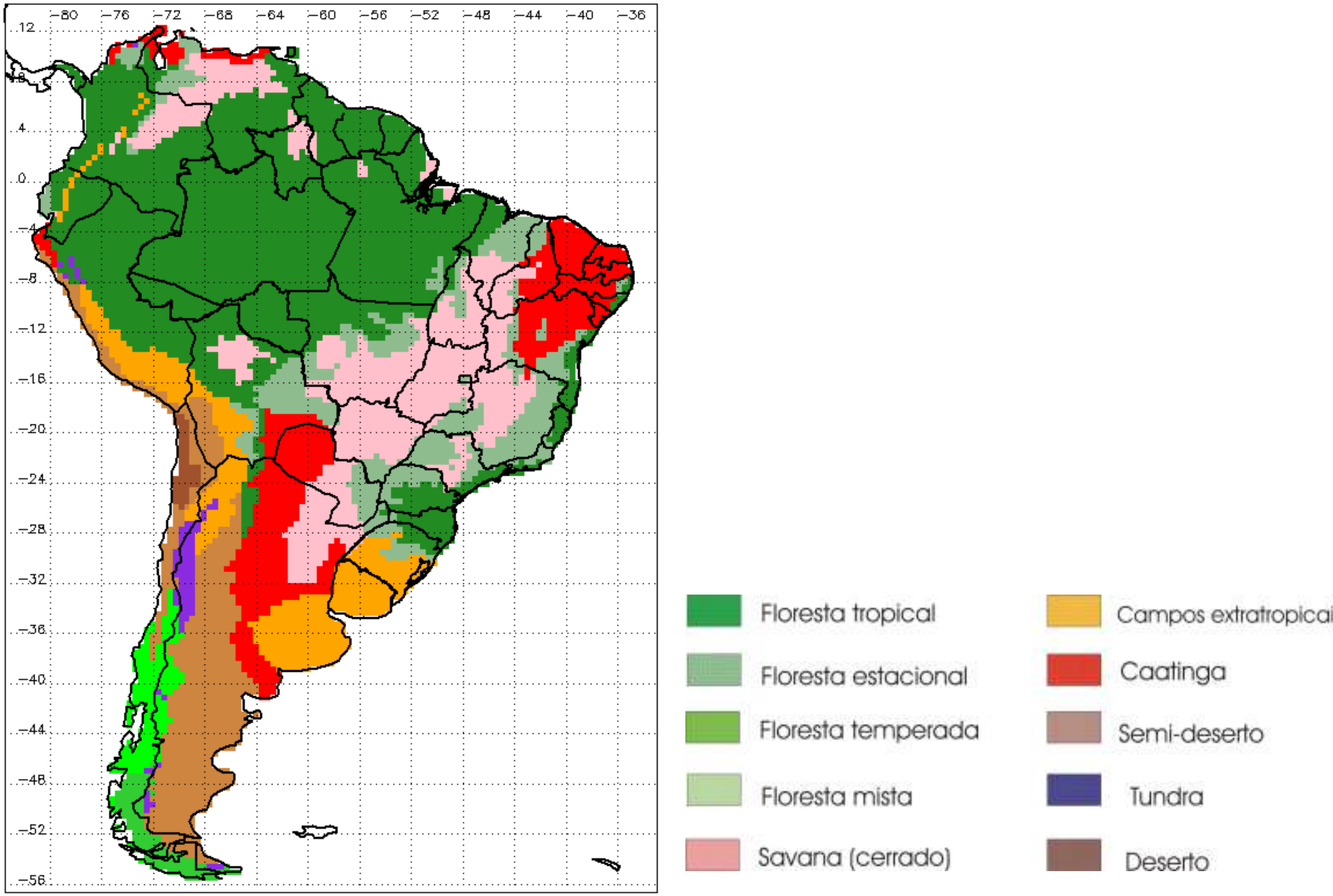
Novo Mapa Global de Vegetação Natural



Inclusão de um novo bioma – floresta tropical estacional, que compreende as florestas tropicais decíduas e semi-decíduas – para representar de modo mais realístico a **Mata Atlântica** de interior e as florestas secas estacionais da Índia.

Lapola et al., 2007

Mapa de Vegetação Natural para América do Sul na Resolução de 50 km de Lat-Lon



Fonte: Salazar 2007 Trabalho de doutorado em andamento

Long-term potential for fires in estimates of the occurrence of savannas in the tropics

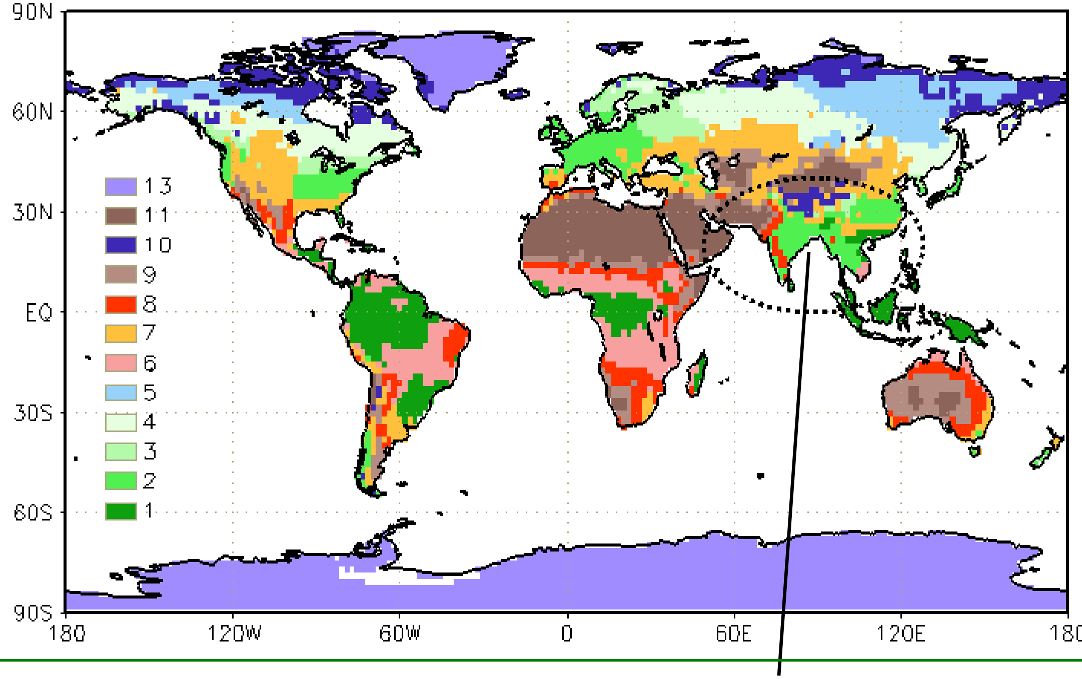
Manoel F. Cardoso[1], Carlos A. Nobre[1], David M. Lapola[1], Marcos D. Oyama[2] and Gilvan Sampaio[1]

[1] CPTEC/INPE
[2] IAE-CTA

Global Ecology and Biogeography, (2007)
DOI: 10.1111/j.1466-8238.2007.00356.x

Impact of using the new fire parameterization in the biome estimates of the CPTEC Potential Vegetation Model:

Major vegetation types:
(1) broadleaf-evergreen trees (tropical forest),
(2) broadleaf-deciduous trees (temperate forest)
(3) broadleaf and needleleaf trees (mixed forest)
(4) needleleaf-evergreen trees (boreal forest)
(5) needleleaf-deciduous trees (larch),
(6) broadleaf trees with groundcover (savanna)
(7) groundcover only (prairie, steppes)
(8) broadleaf shrubs with perennial groundcover (caatinga)
(9) broadleaf shrubs with bare soil (semi-desert)
(10) dwarf trees and shrubs with groundcover (tundra)
(11) bare soil (desert)
(13) ice.



Accounting for fires corrected important differences between previous model estimates and reference data for the position of natural savannas in the tropics. In specific, large areas in India and SE Asia that were initially estimated as savannas are now corrected to dry forests.

Cardoso et al. (2007), in press

Introduzindo um sub-modelo de carbono no Potential Vegetation Model para estudos com concentrações variáveis de CO_2 (paleoclima e climas futuros)

Inclusão do Ciclo de Carbono no CPTEC PVM

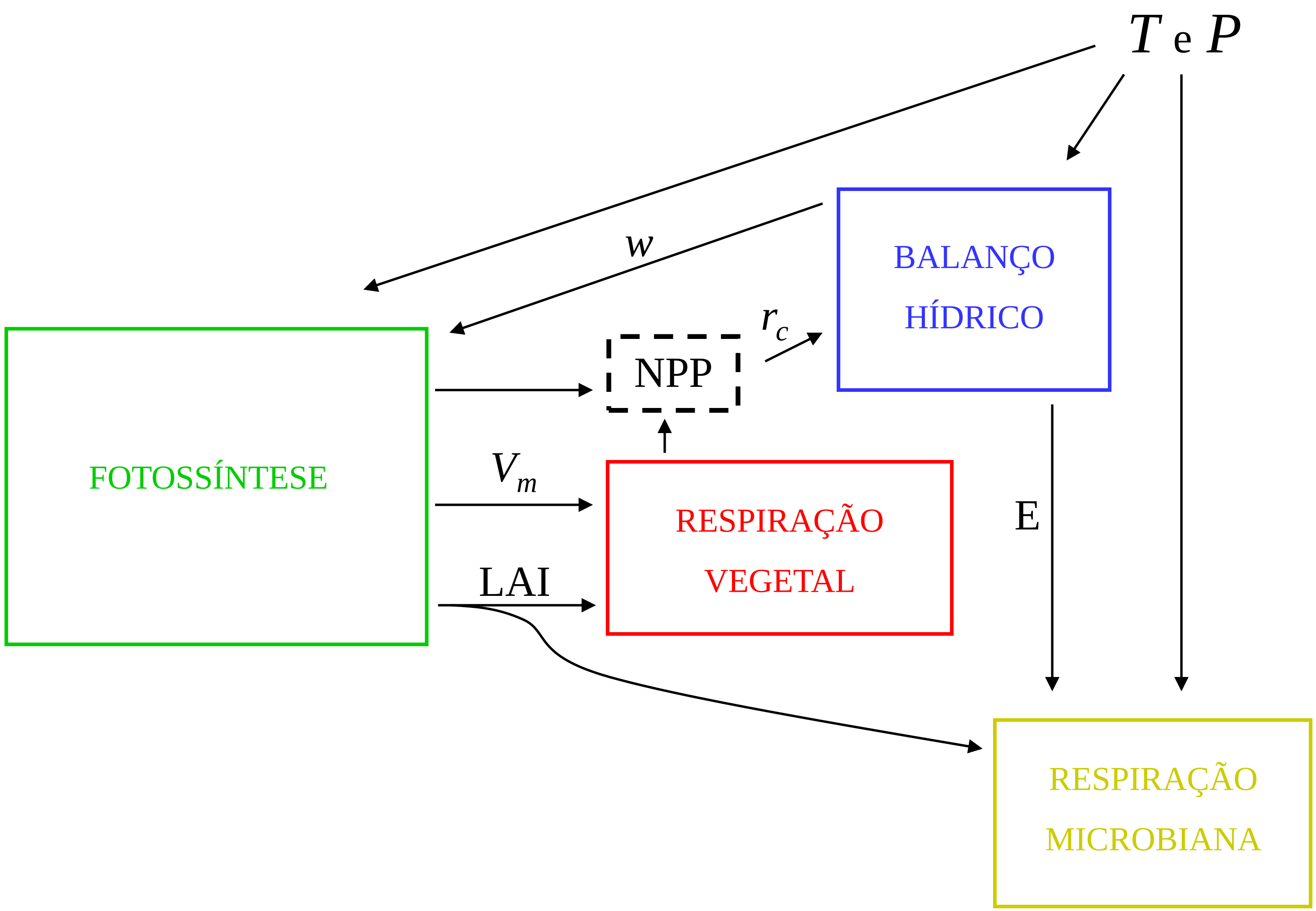
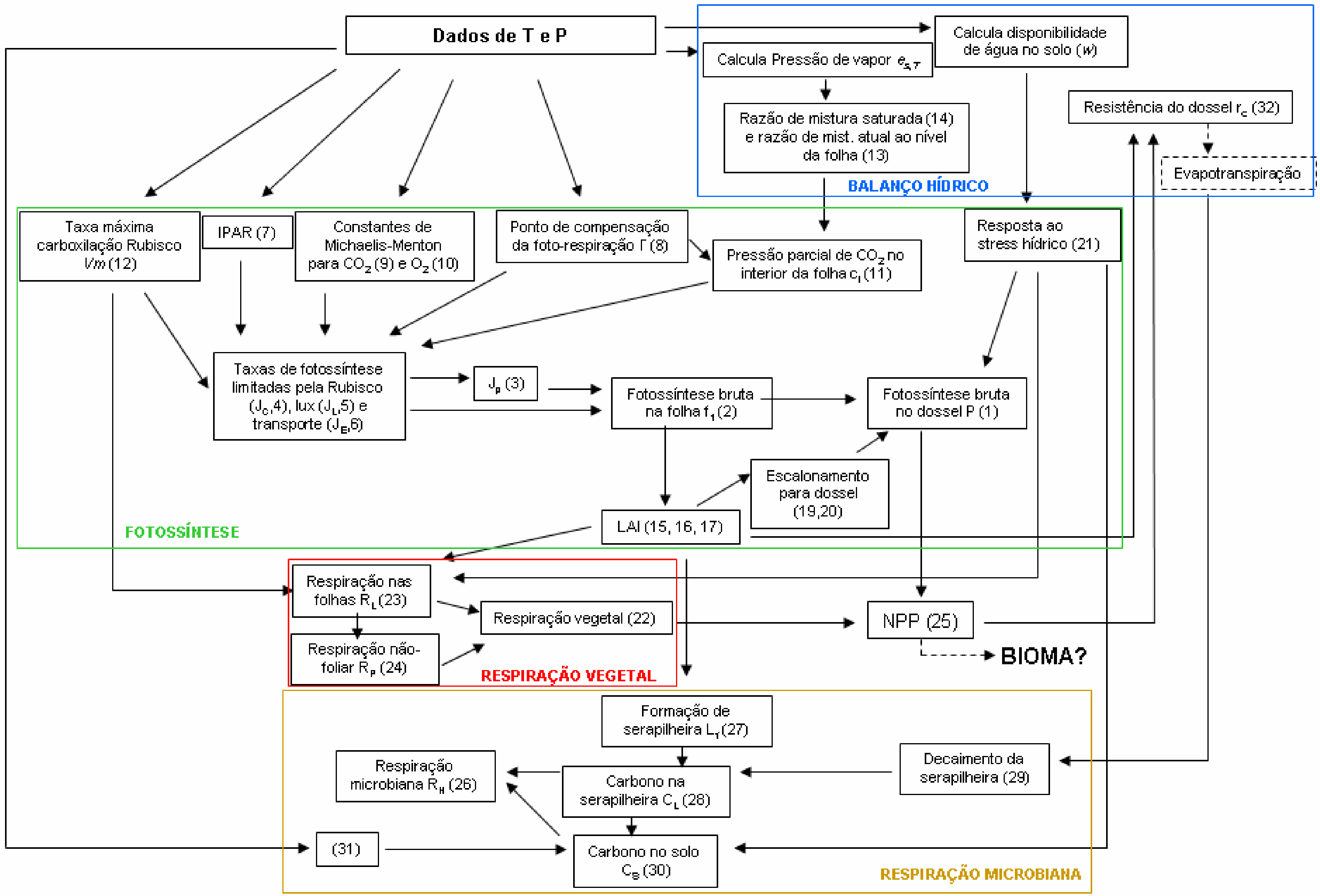
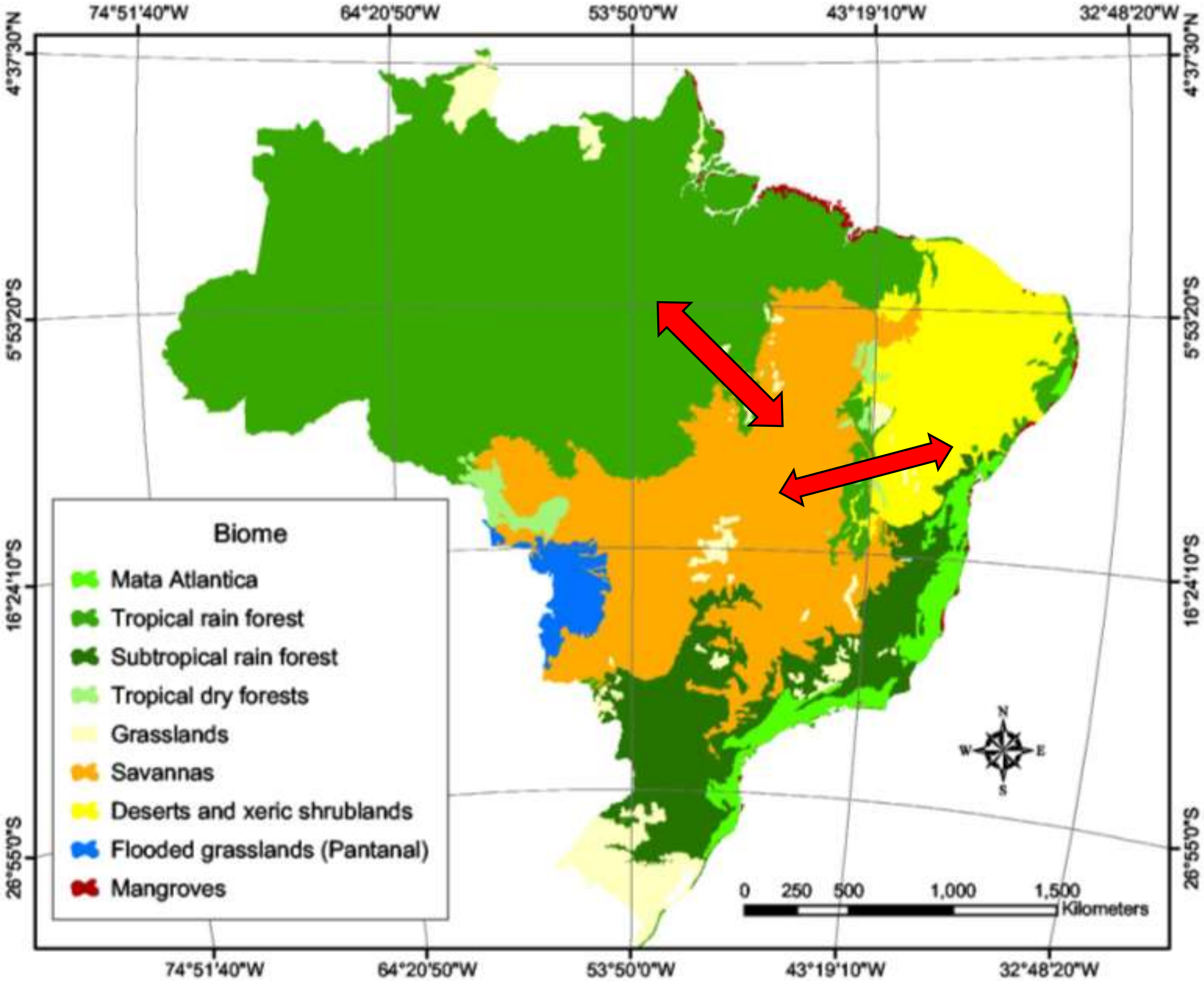


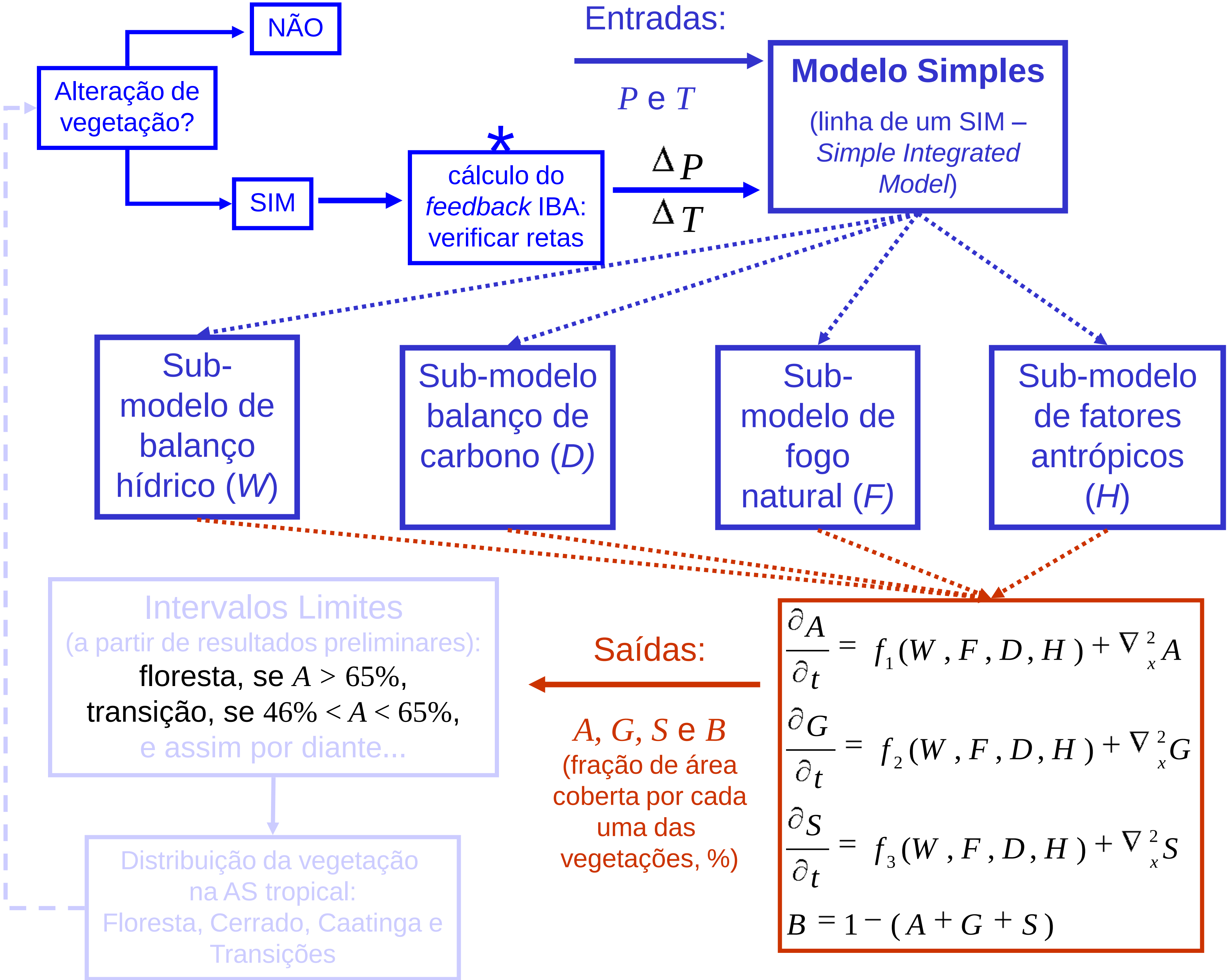
Diagrama esquemático simplificado do sub-modelo de ciclo de carbono proposto, apresentando os processos que influenciam em cada compartimento. *T*: temperatura; *P*: precipitação; *w*: água no solo; *Vm*: taxa de carboxilação da Rubisco; *LAI*: índice de área foliar; *NPP*: produtividade primária líquida; *rc*: resistência do dossel; *E*: evapotranspiração. Fonte: Lapola, 2007.



Sequência detalhada de cálculo do sub-modelo de ciclo de carbono. Os números entre parênteses indicam as equações apresentadas em Lapola, 2007.

Estabilidade do equilíbrio bioma-clima na América do Sul




NÃO
Alteração de vegetação?
SIM
*
cálculo do *feedback* IBA: verificar retas
Entradas:
P e T
ΔP
ΔT
Modelo Simples
(linha de um SIM – *Simple Integrated Model*)
Sub-modelo de balanço hídrico (*W*)
Sub-modelo balanço de carbono (*D*)
Sub-modelo de fogo natural (*F*)
Sub-modelo de fatores antrópicos (*H*)
$\frac{\partial A}{\partial t} = f_1(W, F, D, H) + \nabla_x^2 A$
$\frac{\partial G}{\partial t} = f_2(W, F, D, H) + \nabla_x^2 G$
$\frac{\partial S}{\partial t} = f_3(W, F, D, H) + \nabla_x^2 S$
$B = 1 - (A + G + S)$
Saídas:
A, G, S e B
(fração de área coberta por cada uma das vegetações, %)
Intervalos Limites
(a partir de resultados preliminares):
floresta, se $A > 65\%$,
transição, se $46\% < A < 65\%$,
e assim por diante...
Distribuição da vegetação na AS tropical:
Floresta, Cerrado, Caatinga e Transições

Center of Earth System Science

- Create the **Brazilian Model of the Global Climate System**
- Produce and disseminate operational climate predictions and scenarios on time scales of decades to centuries.
- Generate the Brazilian contribution to IPCC AR5.
- Graduate program on Earth System Science.

Brazilian Model of the Global Climate System

•Creation of a model that incorporates consistently the interactions between the relevant hydro-bio-physical-chemical processes of the global climate system.

•We will use INPE´s experience in ocean-atmosphere-biosphere-cryosphere-hydrosphere coupled model to incorporate components represented by candidate models such as:

- Global climate model from CPTEC.
- Global ocean model from GFDL (MOM4 and its components of sea ice, and marine biogeochemical cycles).
- IBIS land surface model (*Integrated Biosphere Simulator*; Foley et al., 1996; Kucharik et al., 2000).
- Atmospheric chemistry model CATT.
- A hydrological surface model.

Brazilian Model of the Global Climate System

Main Institutions:

- INPE
- University of Viçosa (UFV)
- University of São Paulo (USP)
- Brazilian Community with expertise in climate modeling

Established partnership with other Institutions:

NCAR, UK Hadley Centre, Max Planck Institut, University of Wisconsin, University of Minnesota, Woods Hole Research Center, MIT, CNRS, University of Toronto, University of British Columbia

✓**Close and synergic cooperation with the Brazilian Climate Change Network (Rede CLIMA) and the FAPESP Global Climate Change Research Program.**

✓New Brazilian Supercomputer Laboratory is being implemented at the National Institute for Space Research (INPE).

Processes to be represented

Fluxes of radiation, energy and mass	**IBIS 2.6**
Complete terrestrial carbon cycle	**IBIS 2.6**
Vegetation dynamics	**IBIS 2.6**
Specific representation of South American ecosystems	**IBIS 2.9**
Crops	**Agro-IBIS/IBIS 2.9**
Seasonal flooded areas	**First release**
Fires (ignition, combustion, spreading, emissions)	**First release**
Anthropogenic land use (deforestation)	**First release**
Recovery of abandoned land	**IBIS 2.6**
Effects of nutrient stress of the vegetation recovery	**First release**
Ice sheets	**First release**

Brazilian Model of the Global Climate System

Land Surface Modeling

- Represent processes that are important to us and may be considered secondary in other models
- Benefit from and integrate with multiple large research programs in Brazil, like LBA, PRODES, GEOMA, etc.
- Simulate effects of deforestation and rising CO_2 concentration on the Amazon climate and feedbacks on forest structure, considering
  - biophysical effects (exchange of mass & energy)
  - physiological effects
  - biogeochemical feedbacks through atmospheric CO_2 concentrations