MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Measure of the impacts of, vulnerability and adaptation to climate change in South America

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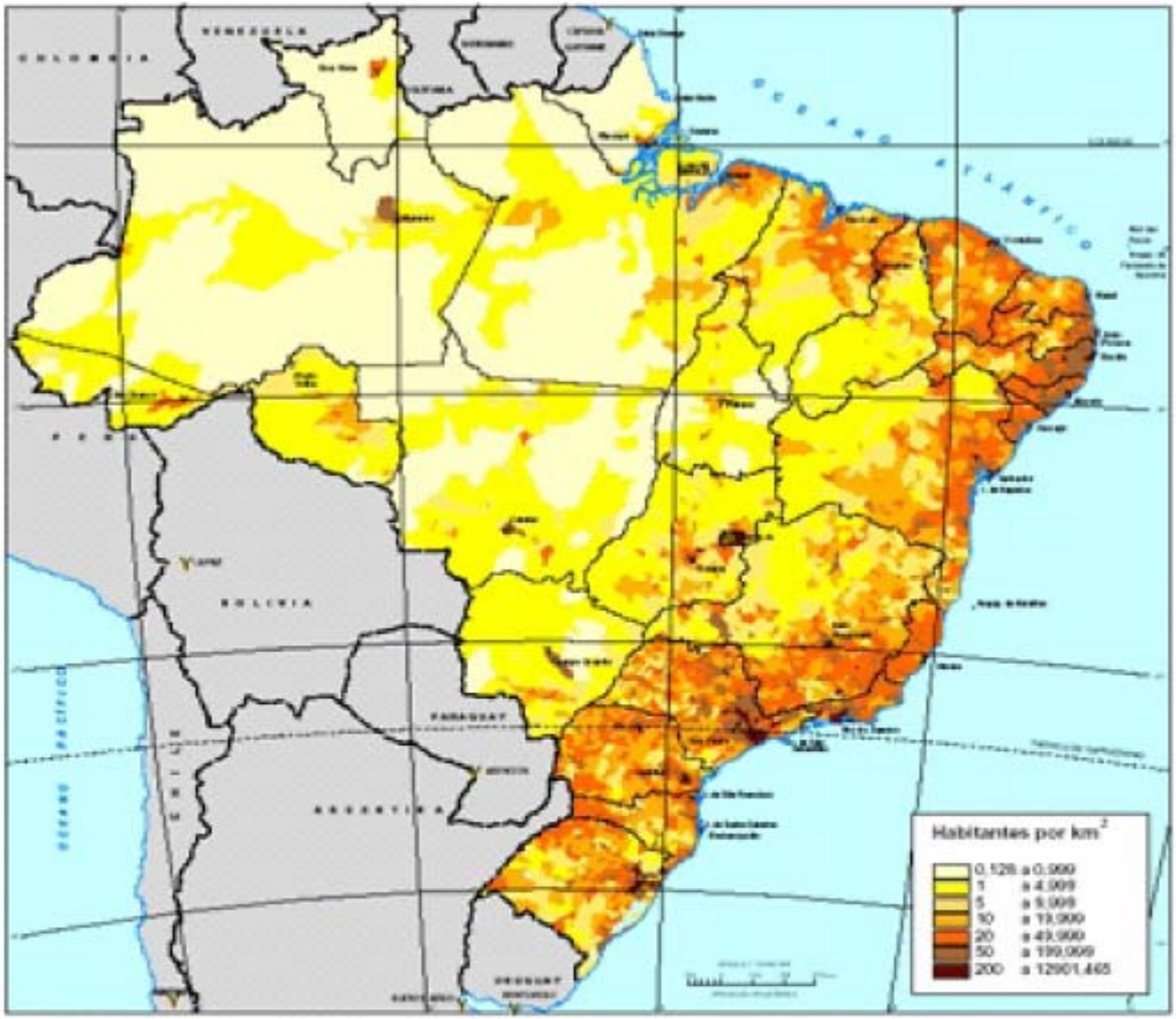
Contents…

- Climate change in Brazil, impacts, vulnerability
- Future climate change scenarios and the Amazon, results from downscaling experiments in Brazil
- Hots spots for climate change: Amazonia (biodiversity and social), Northeast Brazil (social) southern Brazil (agriculture and hydroelectric generation)
- Adaptation and mitigation alternatives: Deforestation, environmental services, biofuel

Population density in Brazil (IBGE 2000)



Fonte: IBGE, 2000a.

TABLE 1

Human development index

UNDP (2007)

HDI rank [a]	Human development index (HDI) value 2005	Life expectancy at birth (years) 2005	Adult literacy rate (% aged 15 and above) 1995-2005 [b]	Combined gross enrolment ratio for primary, secondary and tertiary education (%) 2005	GDP per capita (PPP US$) 2005	Life expectancy index	Education index	GDP index	GDP per capita (PPP US$) rank minus HDI rank [c]
HIGH HUMAN DEVELOPMENT									
70 Brazil	0.800	71.7	88.6	87.5 [h]	8,402	0.779	0.883	0.740	-3

TABLE 2

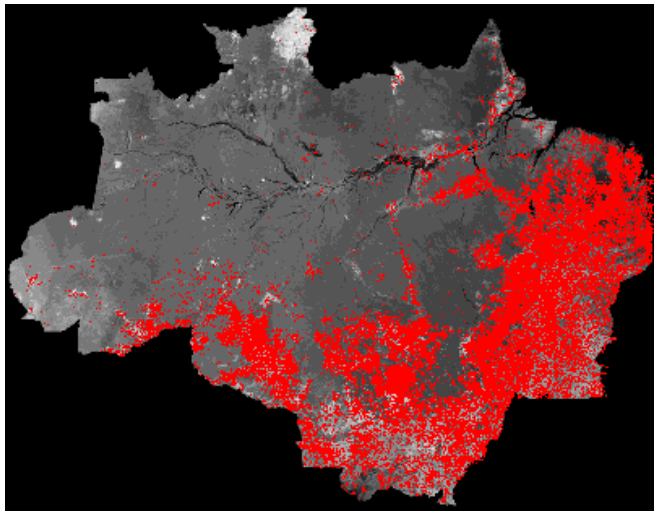
Monitoring human development: enlarging people's choices...

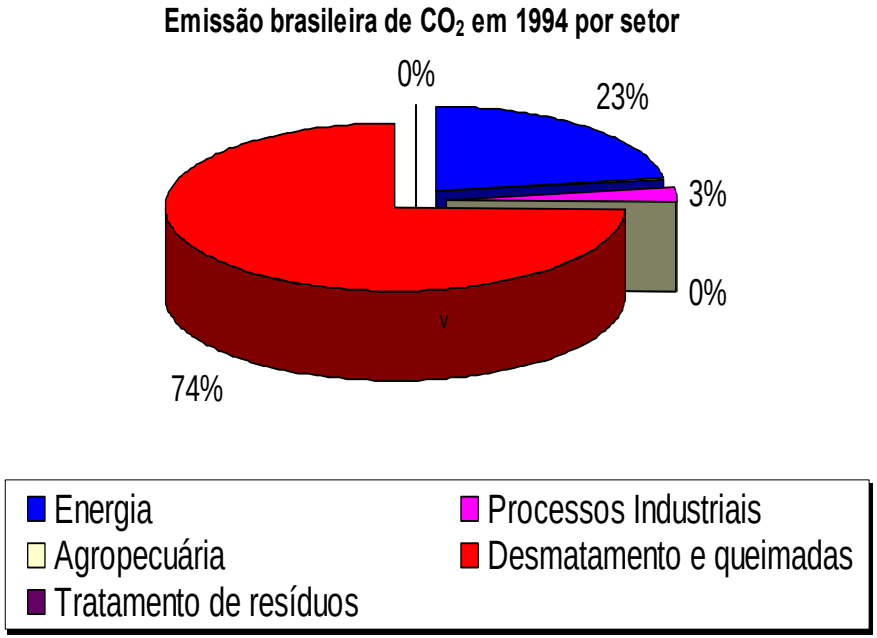
Human development index trends

HDI rank	1975	1980	1985	1990	1995	2000	2005
70 Brazil	0.649	0.685	0.700	0.723	0.753	0.789	0.800

¾ of Brazilian GHG emissions come from Deforestation

MCT (2004)

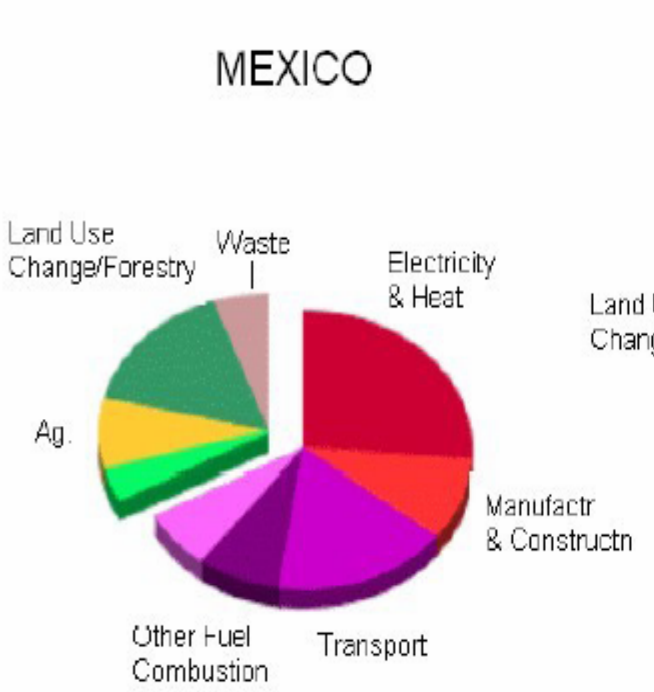


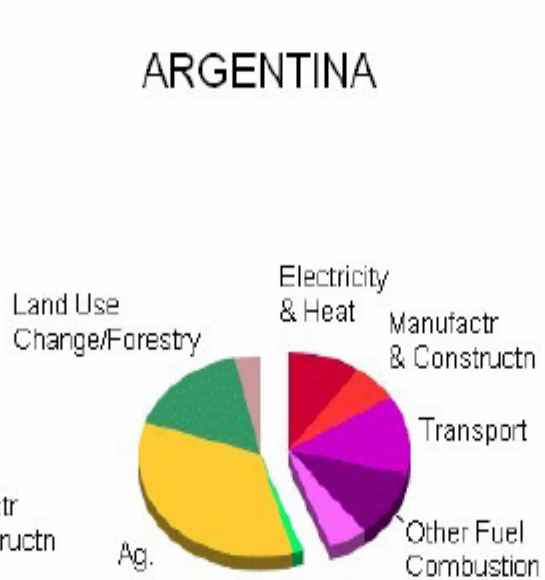


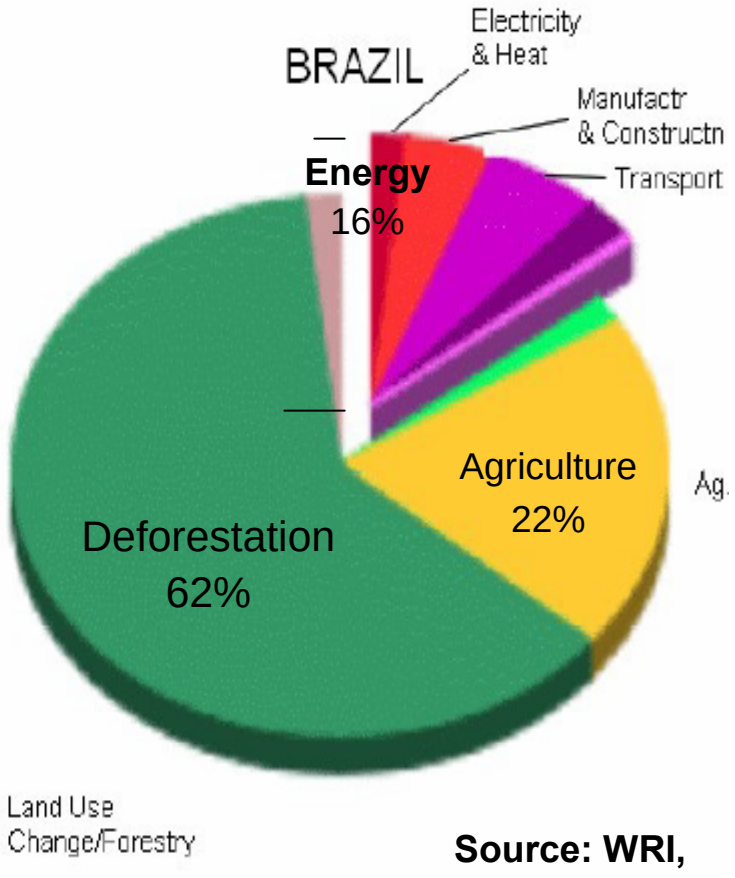
Brazilian emissions of CO_2 (per capita):

- 0,5 ton C/year from fossil origin
- 1,5 ton C/year from mean deforestation
- 1,0 ton C/year from 2007 deforestation

Importance of the energy sector in the emissions of Greenhouse Gases in Latin America





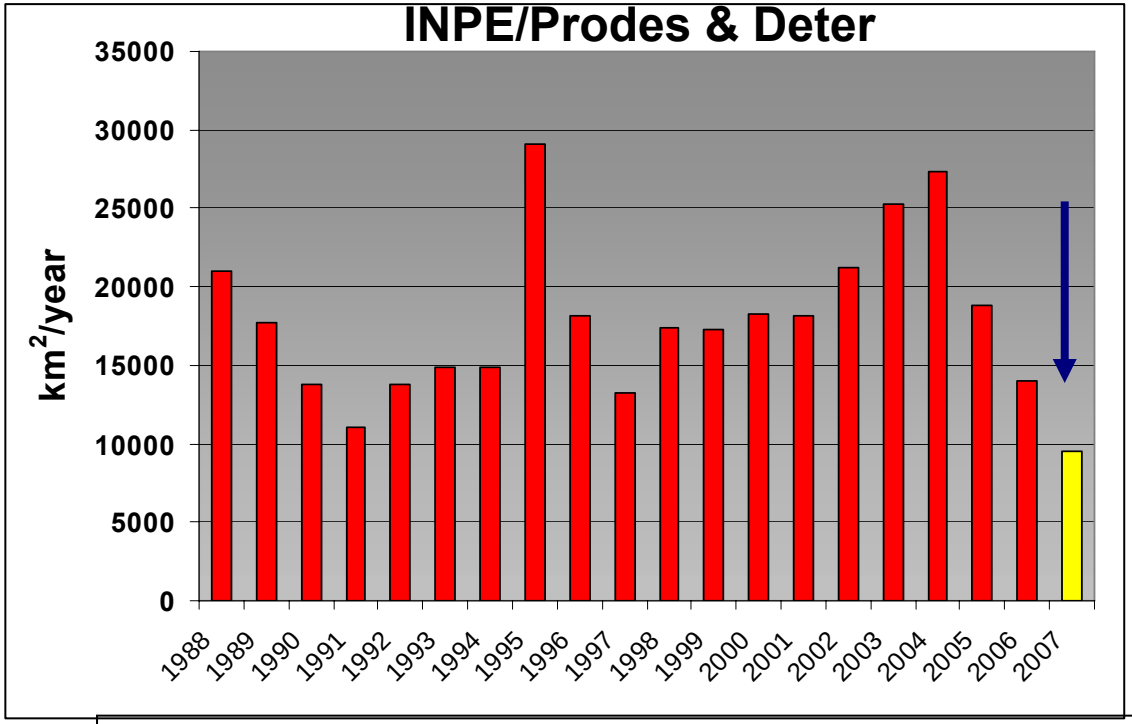


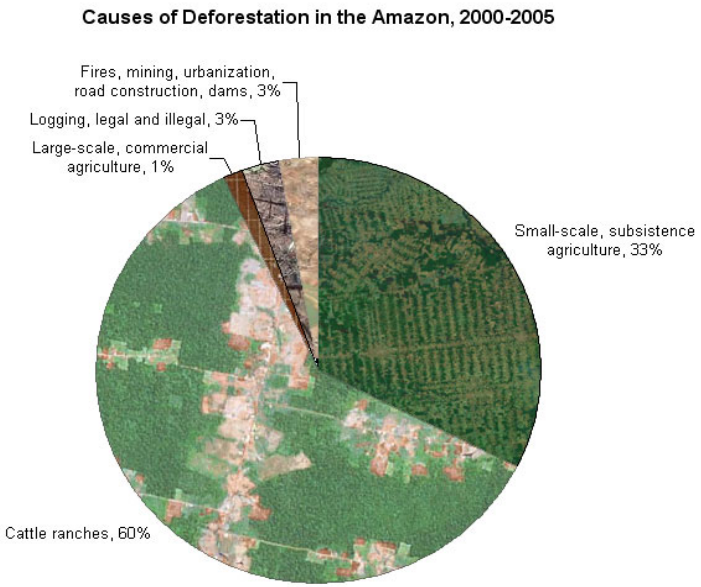
Total (2000):
Mexico 166MtC
Argentina 92MtC
Brazil 604MtC

Source: WRI, 2007

Avoided emissions from deforestation reductions make more sense

- 2004: 27.361 km² deforested in Brazilian Amazon
- 2005 – 2007: ~60% reduction in deforestation
- 2007-08 goin up again



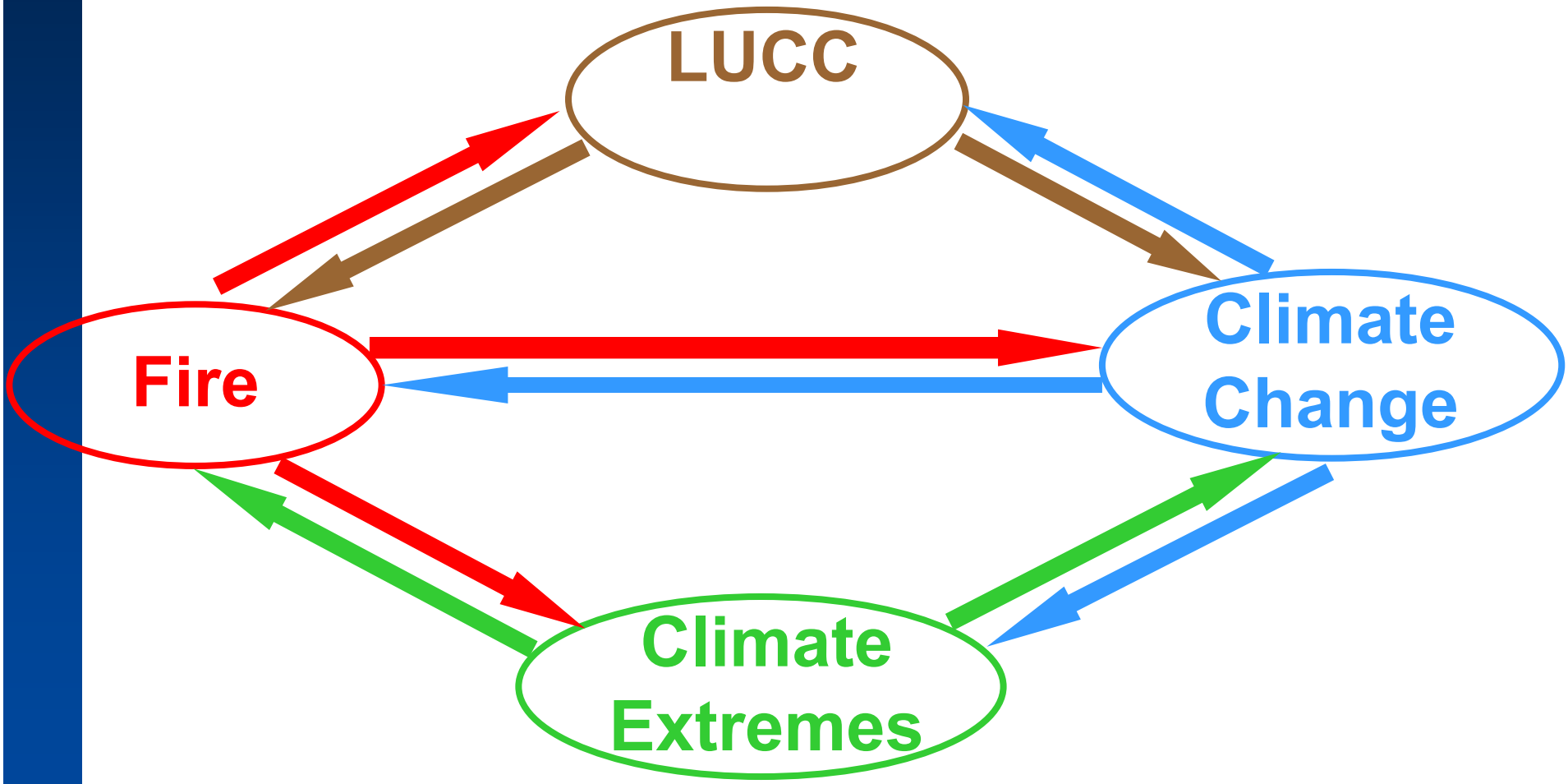


≈17,000 km² avoided deforestation in 3 years (base line at 20,000 km²/year)

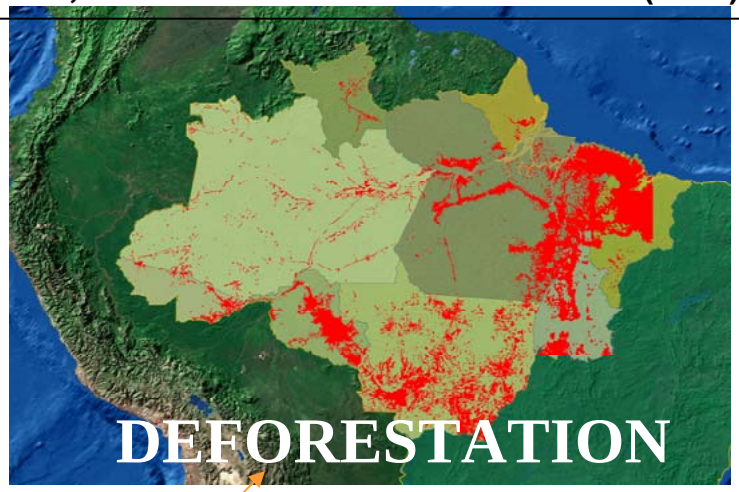
220 Mton C avoided emissions

~ US$ 2.2 bn value in carbon

The ecosystems of Amazonia are subjected to a suite of environmental drivers of change



In 2007, total deforested area (clear-cutting) is 700,000 km2 in Brazilian Amazonia (18%)



Anthropogenic and Natural Drivers of Environmental Change in Amazonia

Source: Greenpeace/Daniel Beltra

Are hydrological extremes becoming more frequent?

"The 2005 Western Amazon drought: one of the the most intense drought of the last 100 years"

Northeast Brasil, → the most vulnerable region to climate variability and change

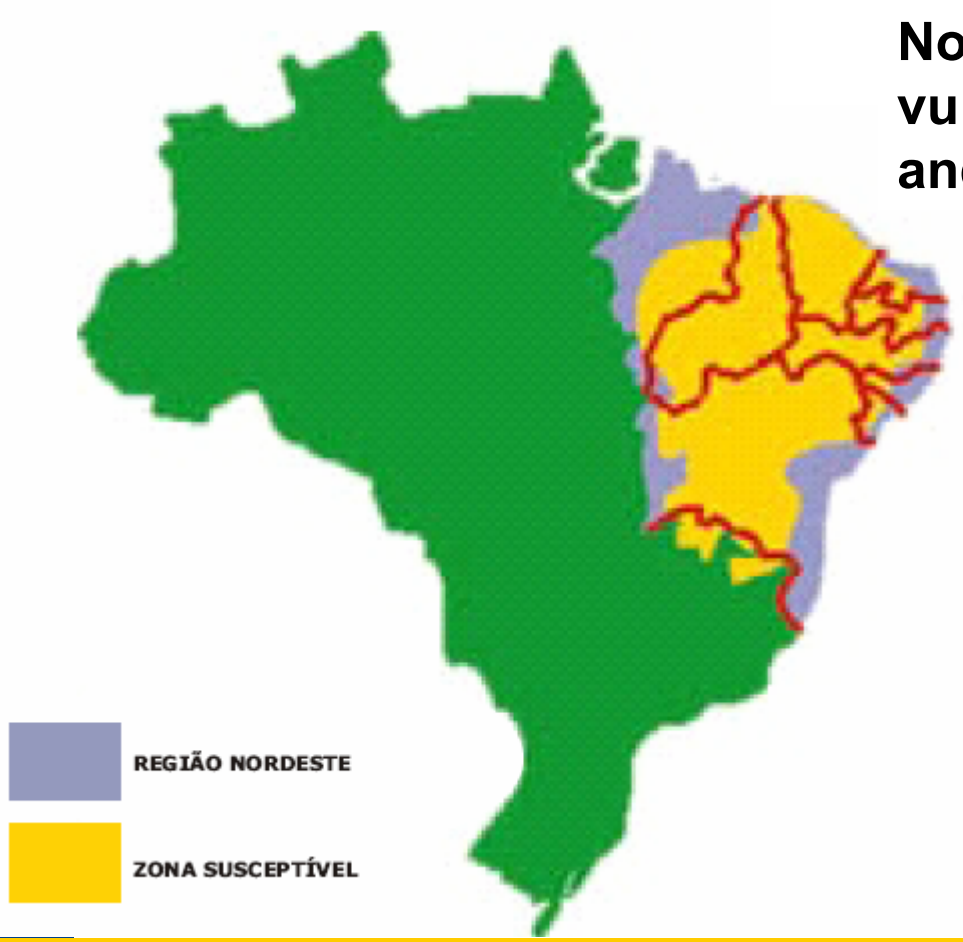
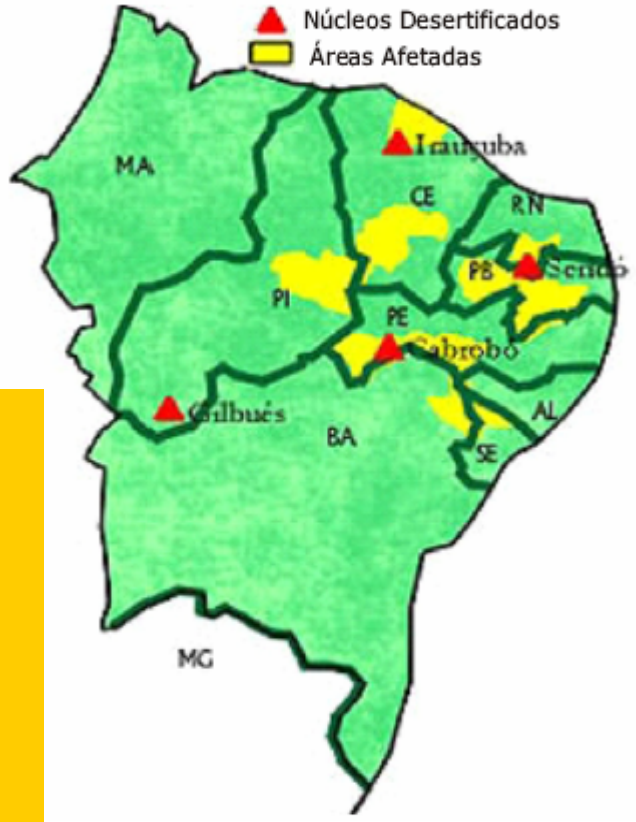


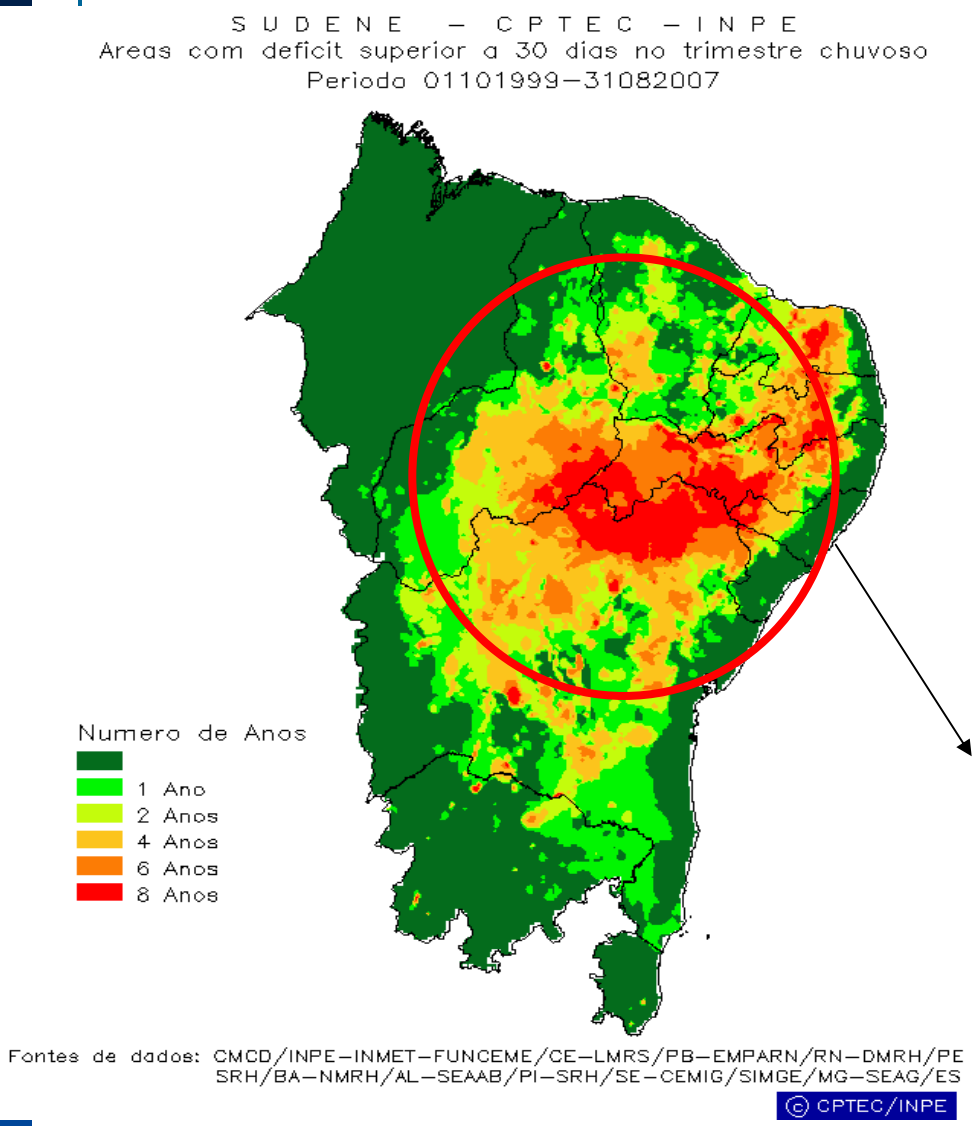
Figura 4.2 - Áreas afetadas e núcleos desertificados



The semiarid region of Northeast Brazil is affected by desertification. It has a population of about 31.6 million people (19% of the total Brazilian population)

-According to the Brazilian Institute for Geography and Statistics (IBGE), the HDI in the Northeast Brazil states reaches 0.517, lower than the national HDI of 0.8. The simarid region of Northeast Brazil (about 86% of the total of the region) exhibits a HDI=0.405.

CGEE MAE (2008)

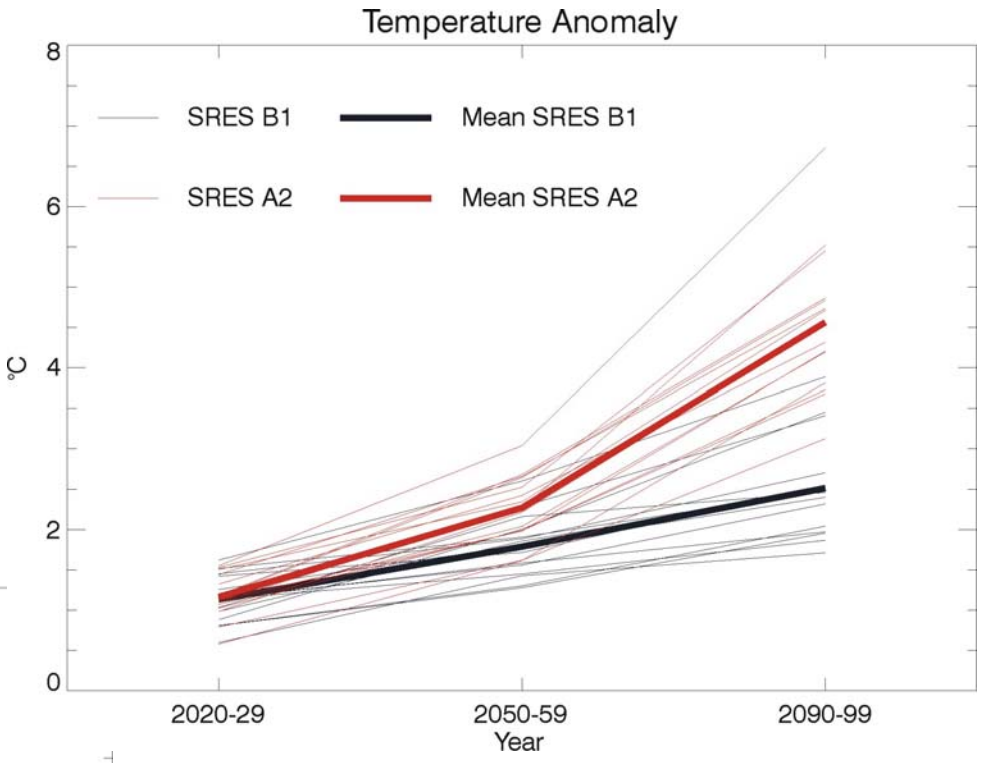


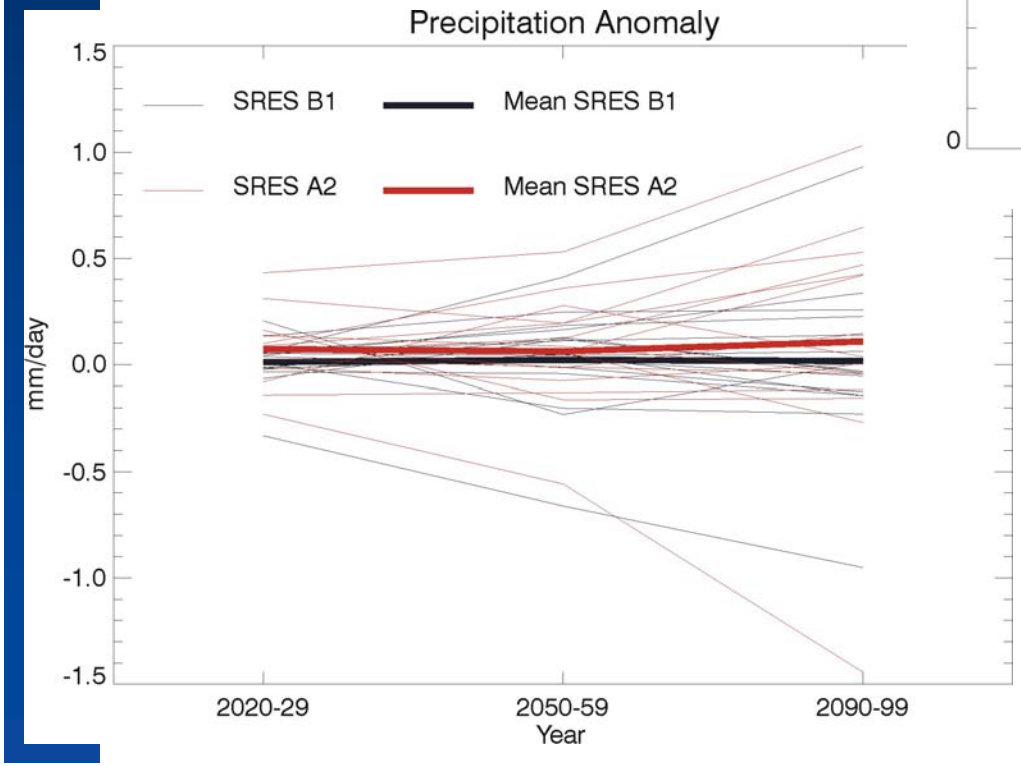
Water stress → Index of vulnerability, aread affected by consecutive drought years during 1999-2007

Semiarid region: Areas affected by 30 consecutive drought days during the rainy season in 1999-2007.

Climate Change projections in South America

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

IPCC

There is a generalized consensus among IPCC-AR4 models that precipitation changes projected over South America are mainly:

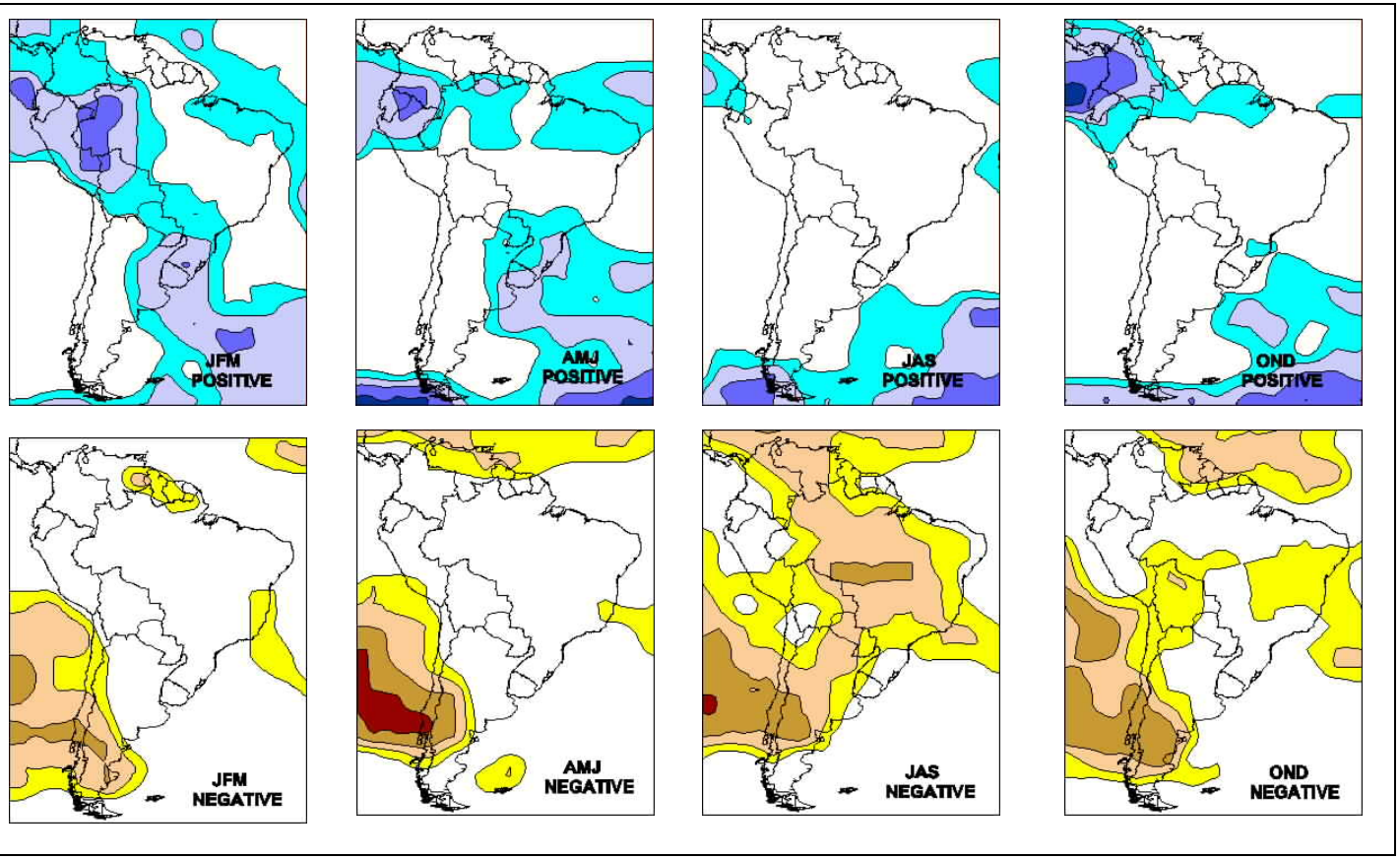
i) Increase of summer precipitation over southeastern subtropical South America and northern Andes;

ii) Reduction of winter precipitation over most of the continent; and

iii) Reduction of precipitation along the southern Andes.

(+)

(-)



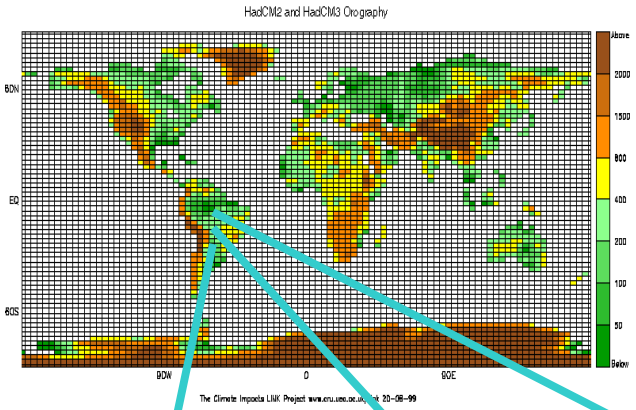
Vera et al. (2006)

Number of models depicting (1st row) positive changes and (2nd row) negative changes between 2070-2099 and 1970-1999 periods. Contour level is 1, values larger than 4 are shaded.

Regional Climate Change Scenarios in South America (INPE, MMA-PROBIO)

Downscaling

Modelos do IPCC: HadAM3



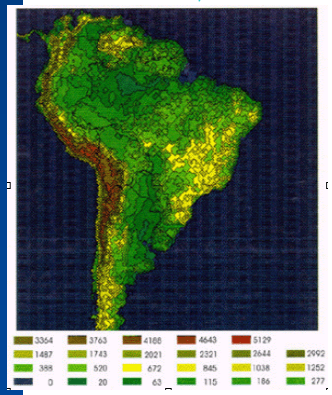
Climatology 1961-90

IPCC Scenarios A2, B2

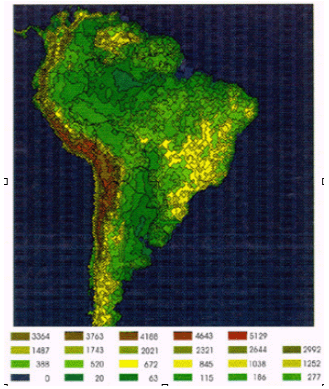
Climate anomalies (future-present), from regional mulimodel ensemble Time slices 2071-2100, A2, B2

Climatology regional model 1961-90

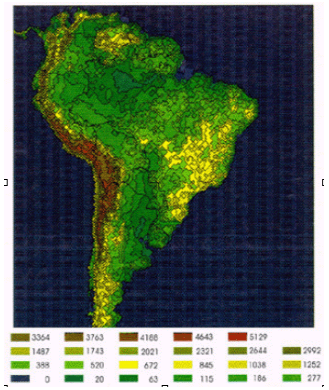
Regional models



RegCM3



HadRM3



Eta CCS

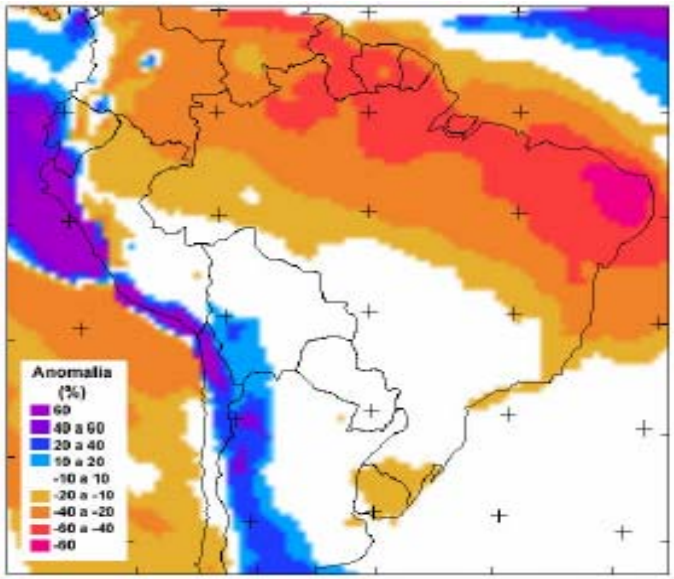
Maps of climate anomalies, and indices of extremes (Regional multimodel ensemble) 2071-2100, A2, B2

Rainfall anomalies (%) (Annual) [(2071-2100)- (1961-90)]

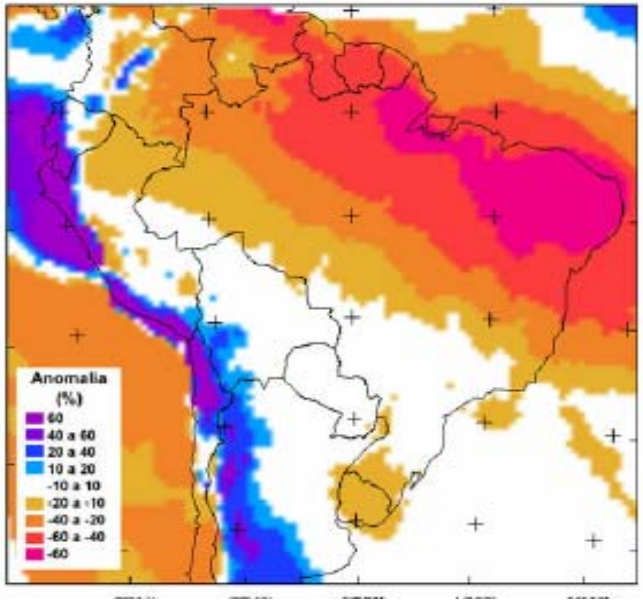
INPE CLIMATE REPORT

CREAS PROJECT
Ensemble of 3 regional models

Marengo et al. (2008)
Ambrizzi et al. (2008)

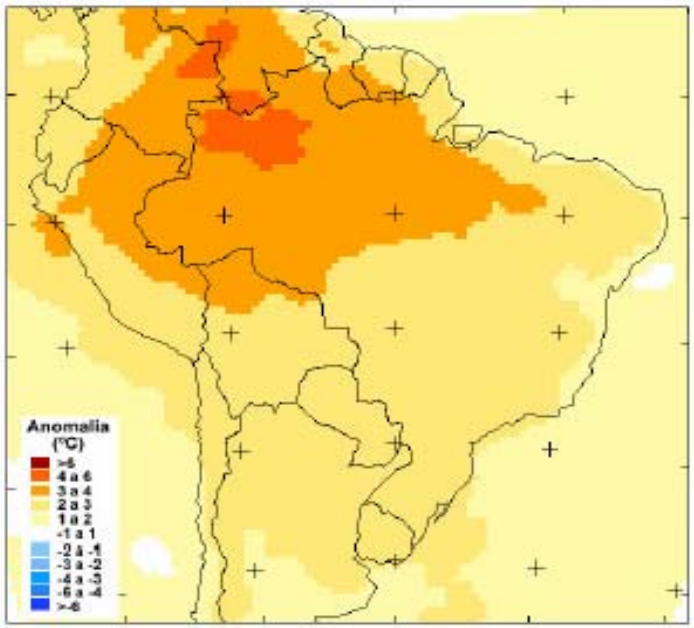


B2

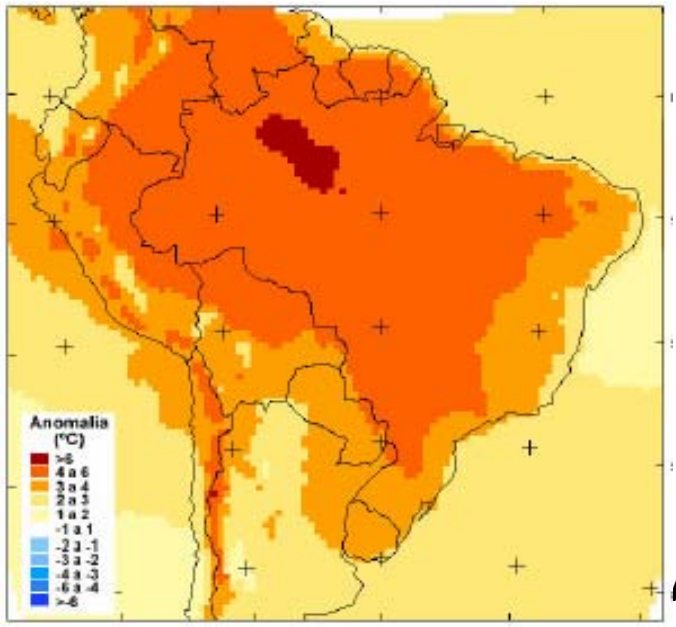


A2

Temperature anomalies (C) Annual [(2071-2100)- (1961-90)]

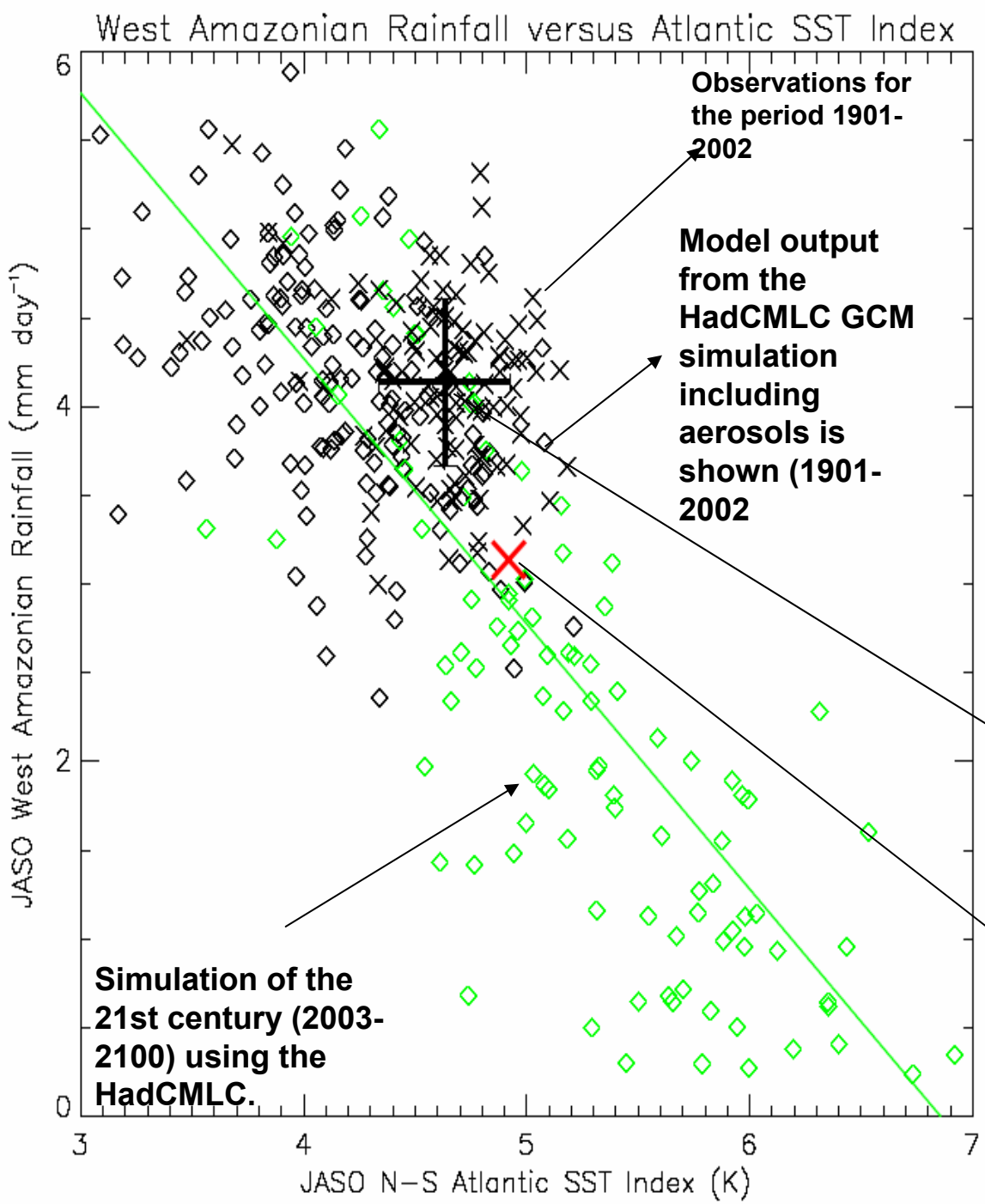


B2



A2

Possible impacts and changes in extremes



Drought of Amazonia 2005:

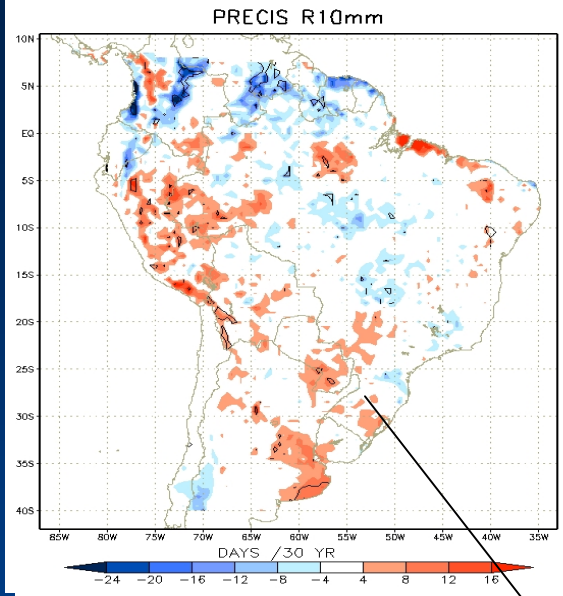
Relationship between July-October anomalies in rainfall in Western

Amazonia and in the Index of the north-south SST gradient across the tropical Atlantic ocean (Cox et al. 2008, Marengo et al. 2008 a, b)

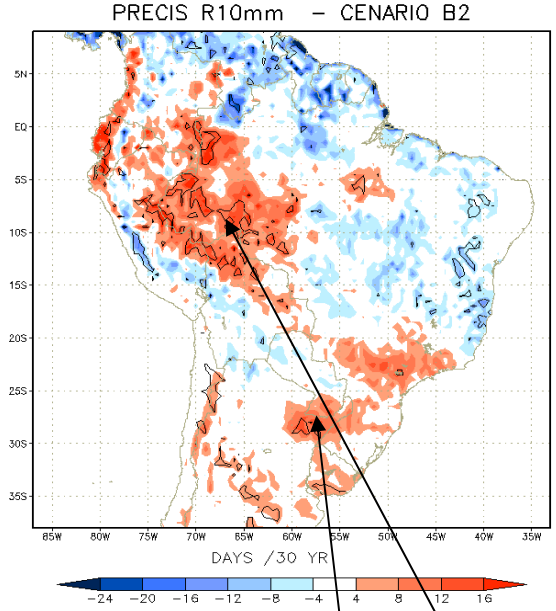
PRECIS-Intense rainfall index (R10) [(2071-2100)- (1961-90)]

HadRM3

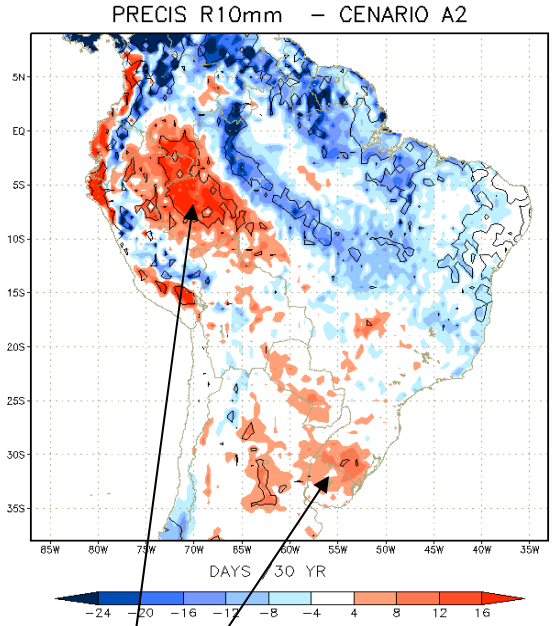
1961-90



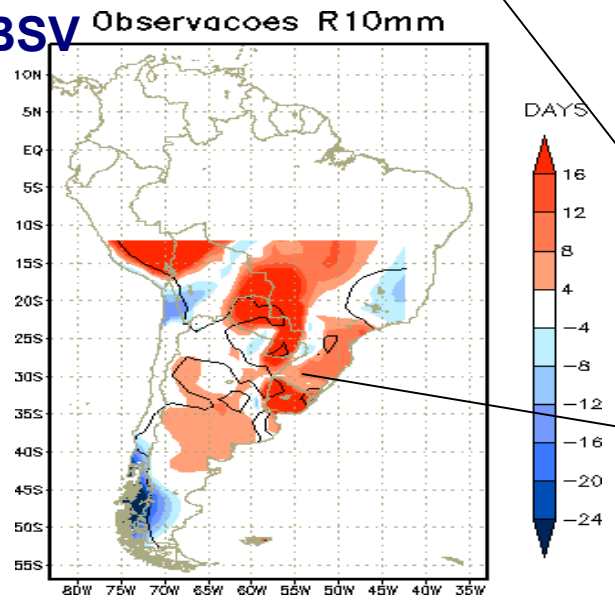
2071-2100, B2



2071-2100, A2



OBSV



Increase in the frequency of intense rainfall events until 2100

Increase in the frequency of intense rainfall events during 1961-2000

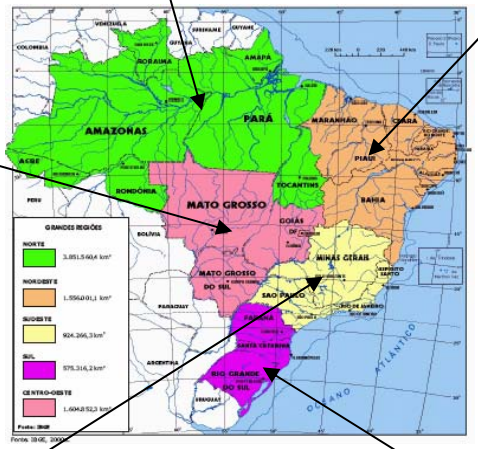
Summary of future climate change scenarios for the end of the XXI Century and possible impacts in Brazil

INPE

AMAZON REGION
A2: 4-8 C warmer, 15-20% less rainfall.
B2: 3-5 C warmer, 5-15 % less rainfall
Possible impacts: High frequency of dry spells in eastern Amazonia and intense rainfall events in western Amazonia, losses in natural ecosystems, rain forest and biodiversity. Low river levels affecting transportation and commerce. Possible impacts on moisture transport and rainfall in Southeastern South America. Impacts on hydroelectric generation. More favorable conditions for spread of forest fires. Impacts on health and commerce due to smoke.

NORTHEAST BRAZIL
A2: 2-4 C warmer, 15-20% less rainfall.
B2: 1-3 C warmer, 10-15 % less rainfall
Possible impacts: High frequency of dry spells and evaporation rates and low soil moisture levels affecting levels of channels and reservoirs. Losses in natural ecosystems caatinga.Tendency towards aridization and desertification in the semiarid region. Water scarsity. Waves of climate refugees migrating towards large cities agravating social problems. Impacts on human health

WEST CENTRAL BRAZIL
A2: 3-6 C warmer,
B2: 2-4 C warmer,
Possible impacts: High frequency of intense rainfall events and dry spells. High evaporation rates and lower soil moisture can affect agriculture (coffee) and hydroelectric generation. Soil erosion due to high temperatures and intense dry spells can affect agriculture and natural ecosystems Pantanal and cerrado. .



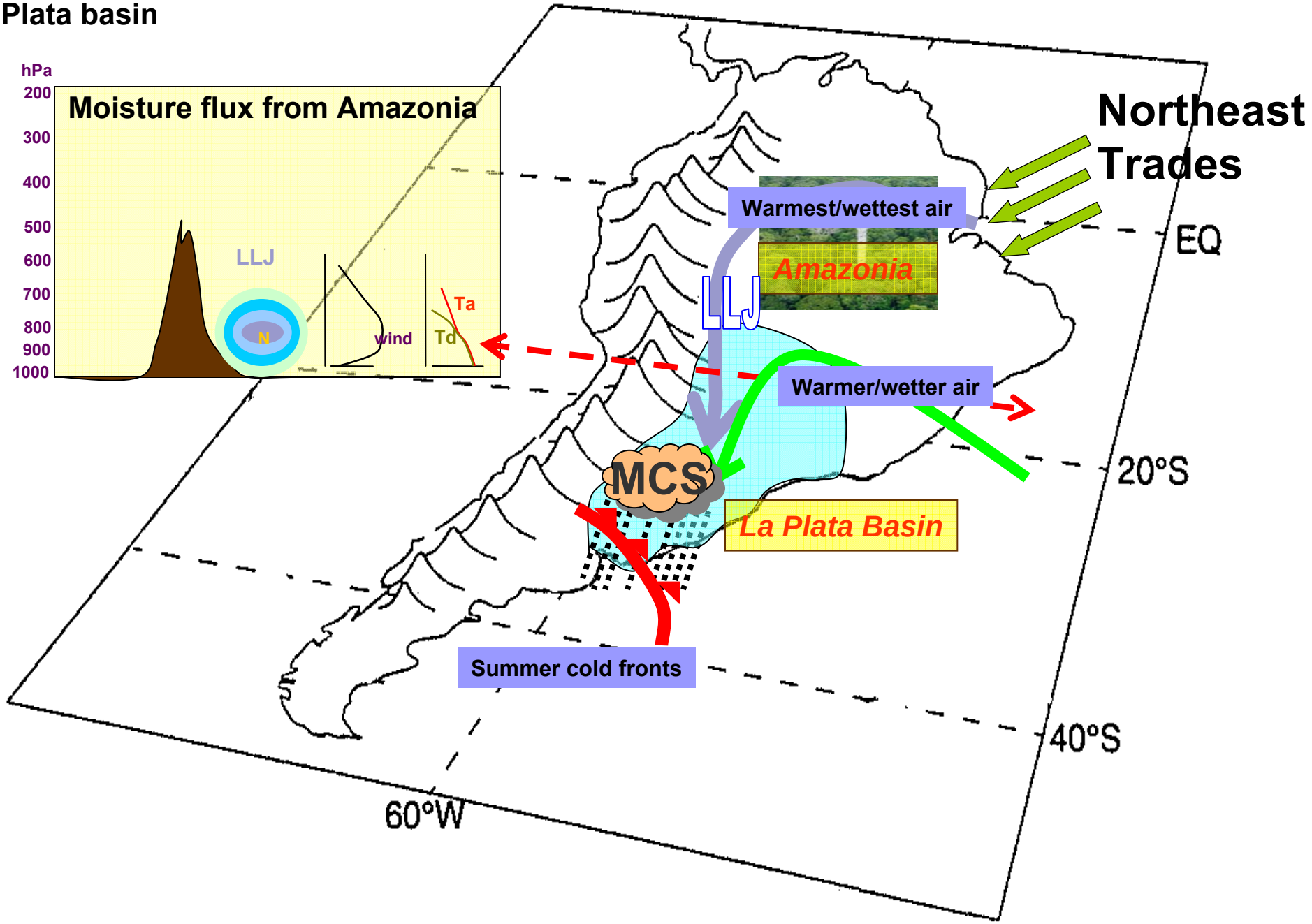
SOUTHEASTERN BRAZIL
A2: 3-6 C warmer,
B2: 2-3 C warmer,
Possible impacts: High frequency of intense rainfall events. High evaporation rates and lower soil moisture can affect agriculture (coffee) and hydroelectric generation. High temperatures and intense rainfall can affect human health. Possible sea level rise.

Sources: INPE, MMA-PROBIO, EMBRAPA, CEPAGRI

SOUTHERN BRAZIL
A2: 2-4 C warmer, 5-10% more rainfall.
B2: 1-3 C warmer, 0-5 % more rainfall
Possible impacts: High frequency of intense rainfall events, increase in warm nights frequency (reduction of cold nights). Intense rainfall and high evaporation due to dry spells can affect agriculture (weath and soybean). Losses in natural ecosystems. High temperatures and intense rainfall can affect human health

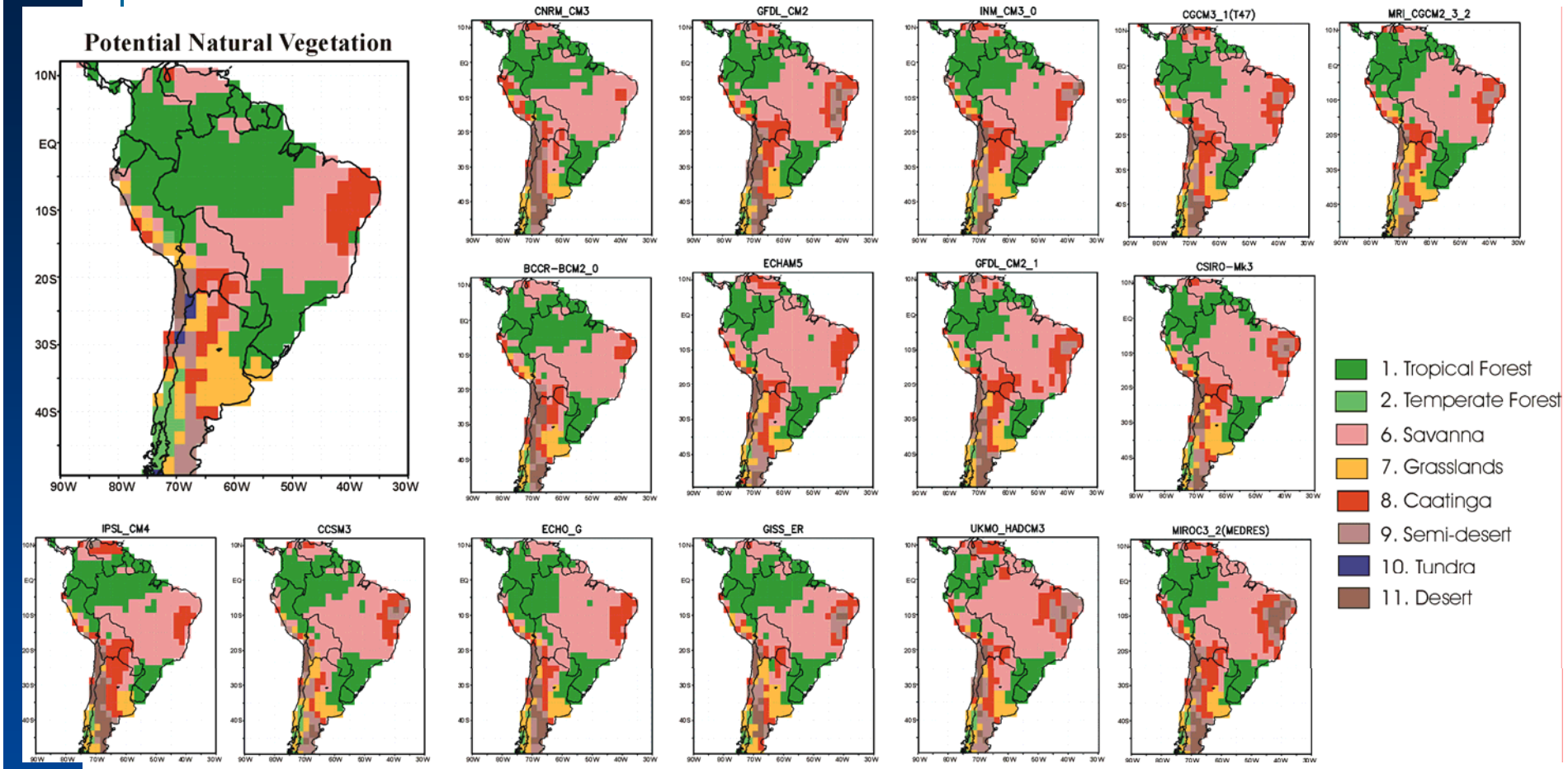
Climate Change in Amazonia may induce climate change in the Parana-La Plata basin

INPE



What are the likely biome changes in Tropical South America due to Global Warming scenarios of climate change?

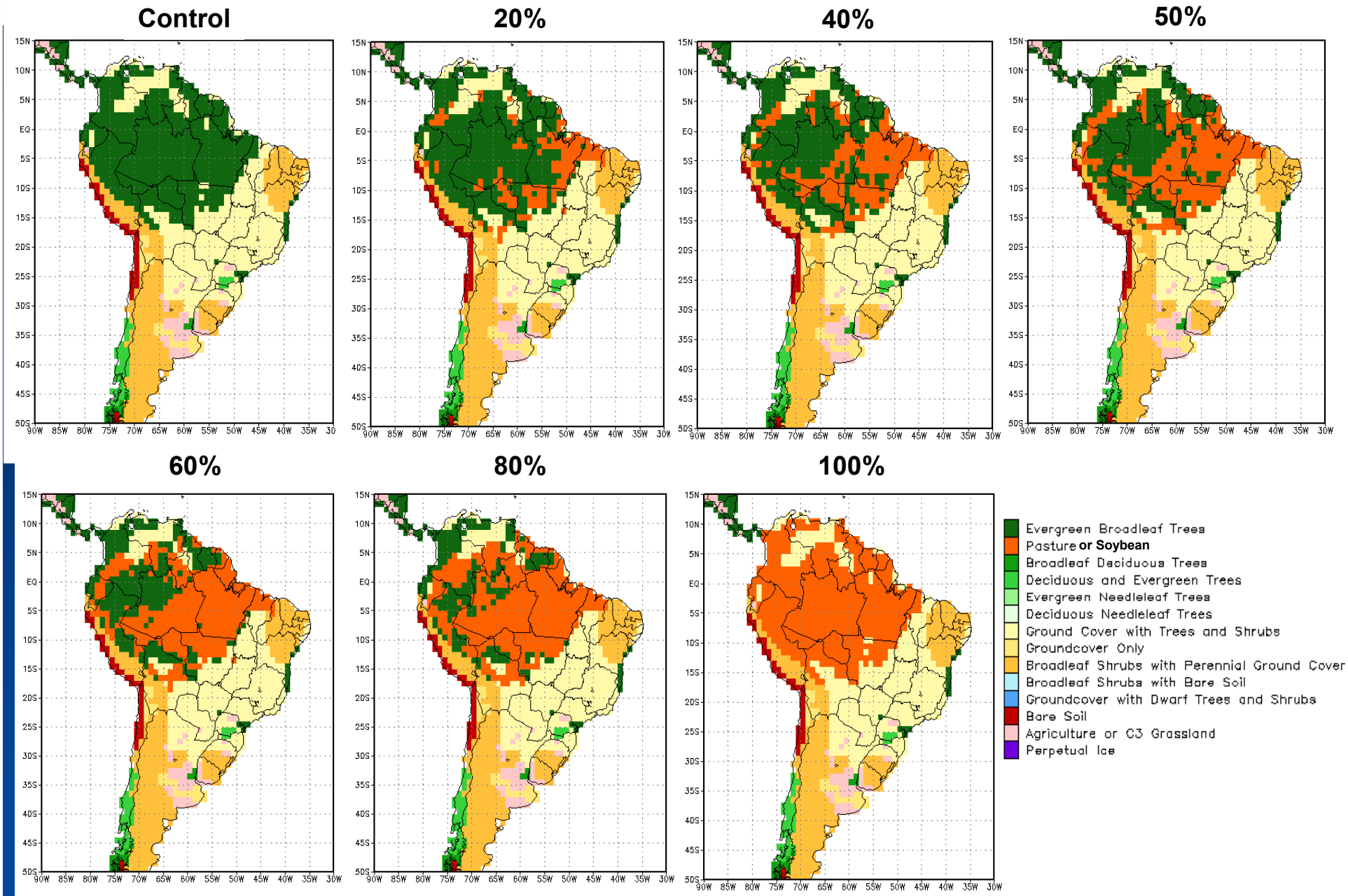
Climate Change Consequences on the Biome distribution in tropical South America



Projected distribution of natural biomes in South America for 2090-2099 from 15 AOGCMs for the A2 emissions scenarios, calculated by using CPTEC-INPE PVM.

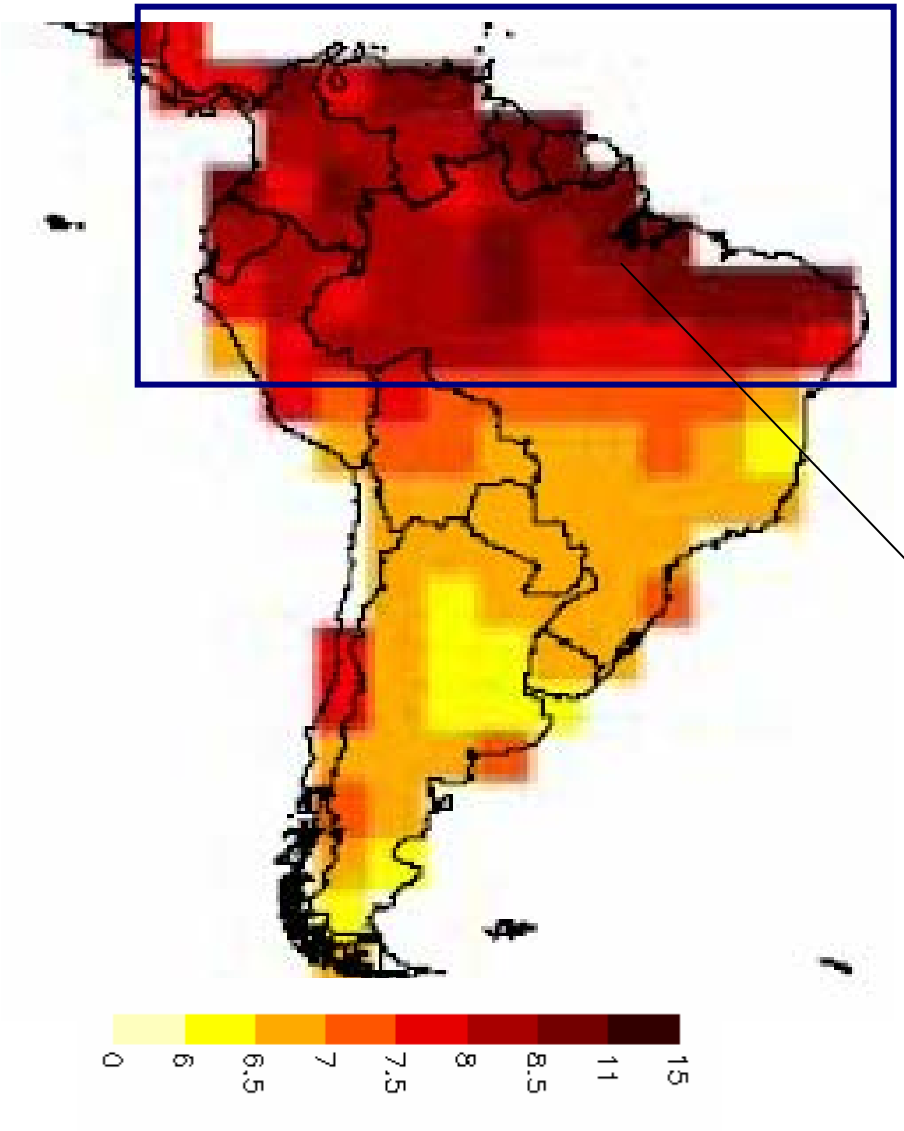
Salazar et al., 2007

Yes- About 40% of deforestation (Sampaio 2008)



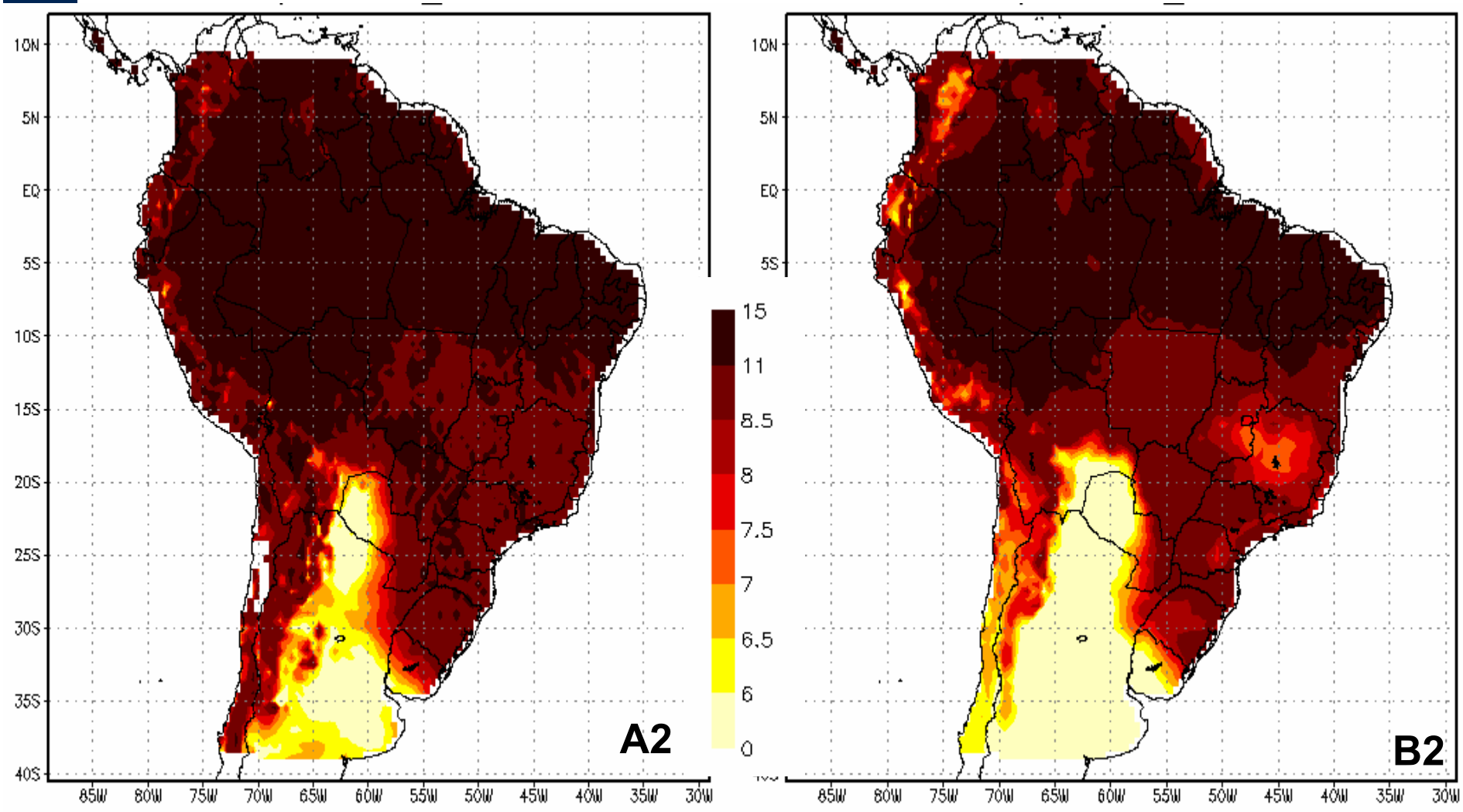
Source: Soares-Filho et al., 2006 - Amazon Scenarios Project, LBA

Values of the CCI (Climate Change Index) for South America (Baettig et al. 2007) for 2071-2100 relative to 1961-90. Map was derived using the IPCC AR4 AOGCMs for A2 scenario.



Most vulnerable regions to climate change

Values of the CCI (Climate Change Index) for South America. Mean from 3 regional climate models (50 km), using Baettig´s methodology, for 2071-2100 relative to 1961-90. CLIMATE CHANGE VULNERABILITY INDEX



Climate change: Official statistics + Research = Vulnerability, mitigation, adaptation

Official Statistics (environmental-climate, hydrology, land use change, social, economical...)→ Monitoring, projections for the future

Research community: modelling, data processing and statistical analyses, new methods for vulnerability and risk assessments,

Production of integrated vulnerability indices (HDI, ..) and definition of new indices of vulnerability

Impact studies, vulnerability assessments, mitigation strategies

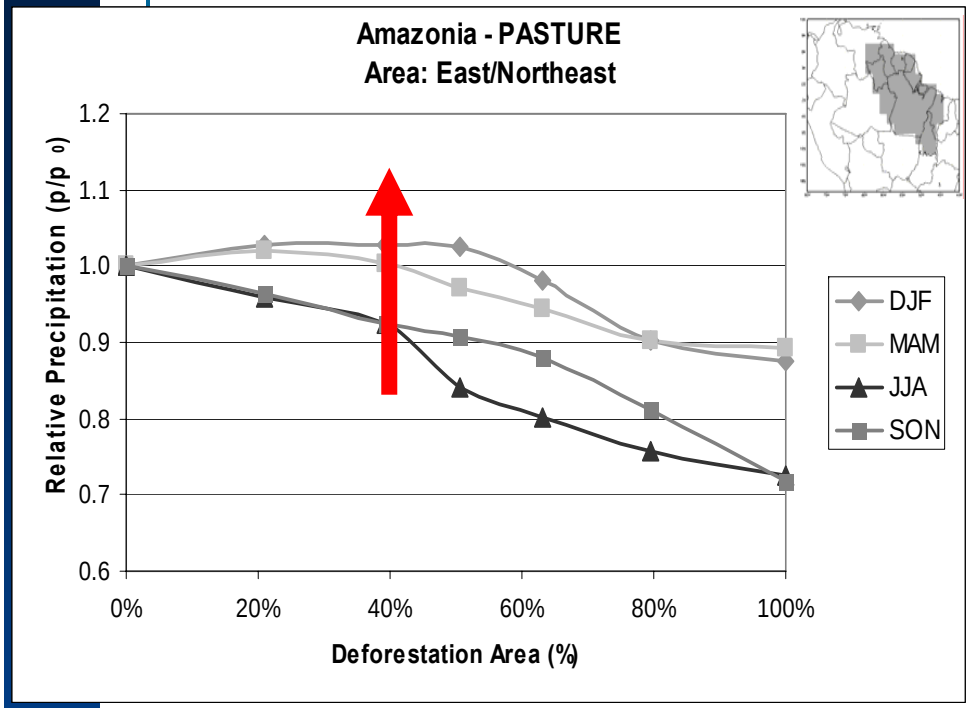
Regional, sectorial analyses of vulnerability to climate change (agriculture, health, energy, biodiversity...)

Environmental policies directed to mitigation and adaptation

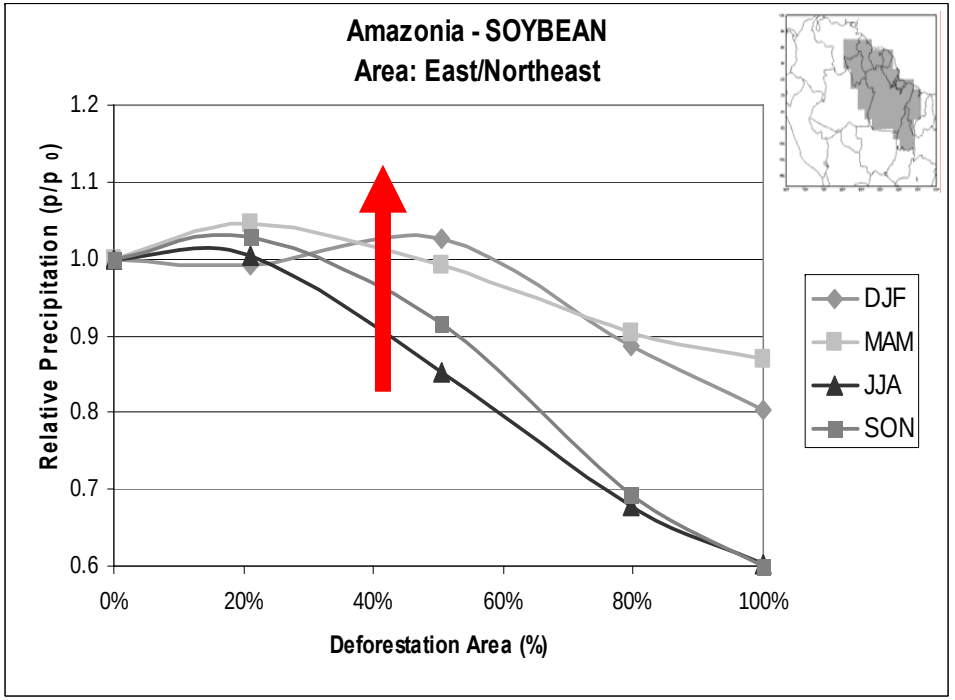
Reduction in GHG emissions, in deforestation, biofuels

Precipitation

PASTURE



SOYBEAN



Precipitation Anomaly (%)

Season	All Pasture	All Soybean
JJA	**-27.5%**	**-39.8%**
SON	**-28.1%**	**-39.9%**

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

Sampaio et al., 2007

Environmental services, adaptation and mitigation options

The ethical dimensions of Global Environmental Change

This is an issue of ethics and justice: the people [and other forms of life] most likely to bear the brunt of Global Environmental Change are those who have contributed least to it

Historical contributions to CO_2 emissions:

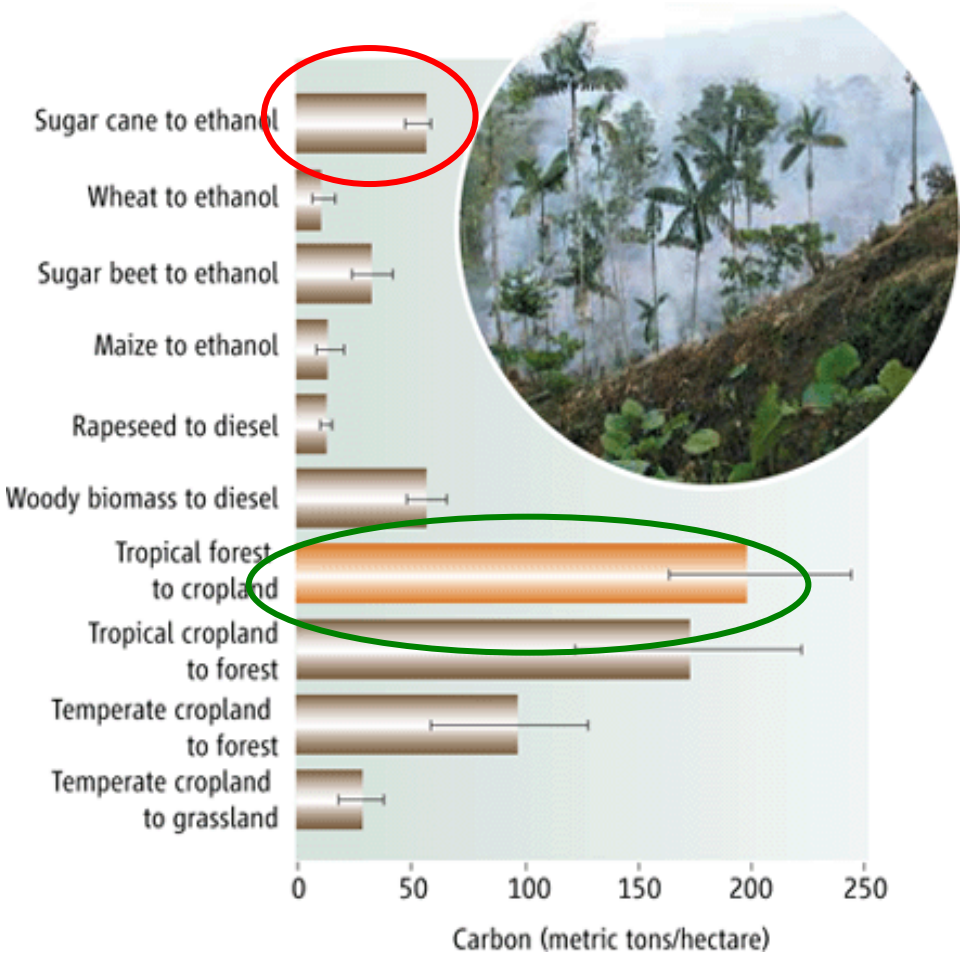
Europe	**30%**
USA	**28%**
China	**8%**
Amazonia	**1%**

Main environmental services provided by tropical forest

- Stability of the hydrological cycle and climate in the region
- Stability of soil and agriculture
- Carbon storage, storing and sequestering carbon
- Moisture recycling and transport to other regions
- Keeping large biodiversity
- Opportunities for ecological services and sustainable use of resources

Biofuels are no panacea …

- **If the prime object of biofuels is mitigation of CO_2-driven global warming, in the short term (30 years or so) it is better to focus on increasing the efficiency of fossil fuel use**
- **Conversion of large areas of land to biofuel crops may place additional strains on the environment**



Righelato and Spracklen, *Science* 17.Aug.2007

PALM

CASTOR OIL

COTTON

ANIMAL FAT

SUNFLOWER

SOY

PEANUTS

RAPESEED

Biofuels crops+sugar cane

- Climate change is a serious issue in Brazil, changes in extremes have been affecting population and possible impacts may have large social, economical and political impacts: eg. drought of Amazonia in 2005

- The synergistic combination of regional climate changes caused by both global warming and land cover change over the next several decades, exacerbated by increased drought and forest fire frequency, could tip the biome-climate state to a new stable equilibrium with '*savannization*' of parts of Amazonia and catastrophic species losses, and "*aridization*" in Northeast Brazil, with huge negative social impacts

- CO_2 "fertilization" effects could increase forest resilience, but with less efficiency with continued warming and deforestation.

- Biofuel use does not guarantee reduction in GHG emissions

- Reduction in emission of GHG from industrial activities and from deforestation is a major goal from the Brazilian Govermenmt, keeping in mind that the economical growth of Brazil should continue in a sustainable development goal

- Need for a strong interaction between academics and goverment