



*Bioenergia e Sustentabilidade:
a perspectiva da indústria.
FAPESP 18 de Novembro de 2013*

Segurança ambiental e climática

*Paulo Artaxo
Instituto de Física
Universidade de São Paulo*

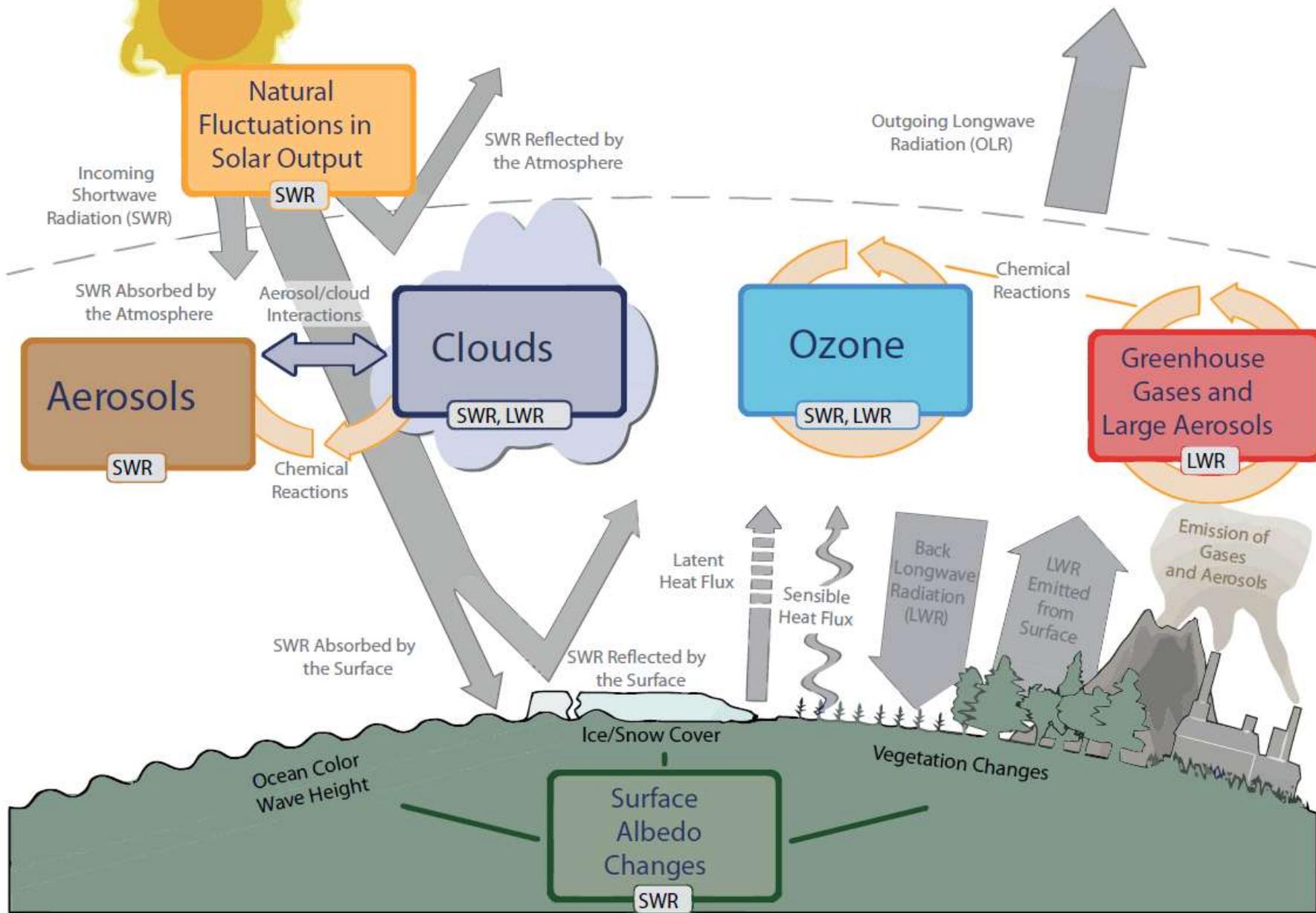
O que é “segurança ambiental e climática”?

Quais os driving forces?

- **Aumento lento e gradual da temperatura (já em andamento)**
- **Alterações no padrão de precipitação: difícil de medir, difícil de modelar...**
- **Os chamados “tipping points”: A não linearidade do sistema climático**
- **O aumento da frequência dos eventos climáticos extremos (secas, inundações, furacões, etc.)**
- **Impactos na produtividade agrícola e produção de biocombustíveis**
- **Importantes links de mudanças climáticas com perda de biodiversidade**
- **Links com segurança alimentar**



Principais agentes do sistema climático global

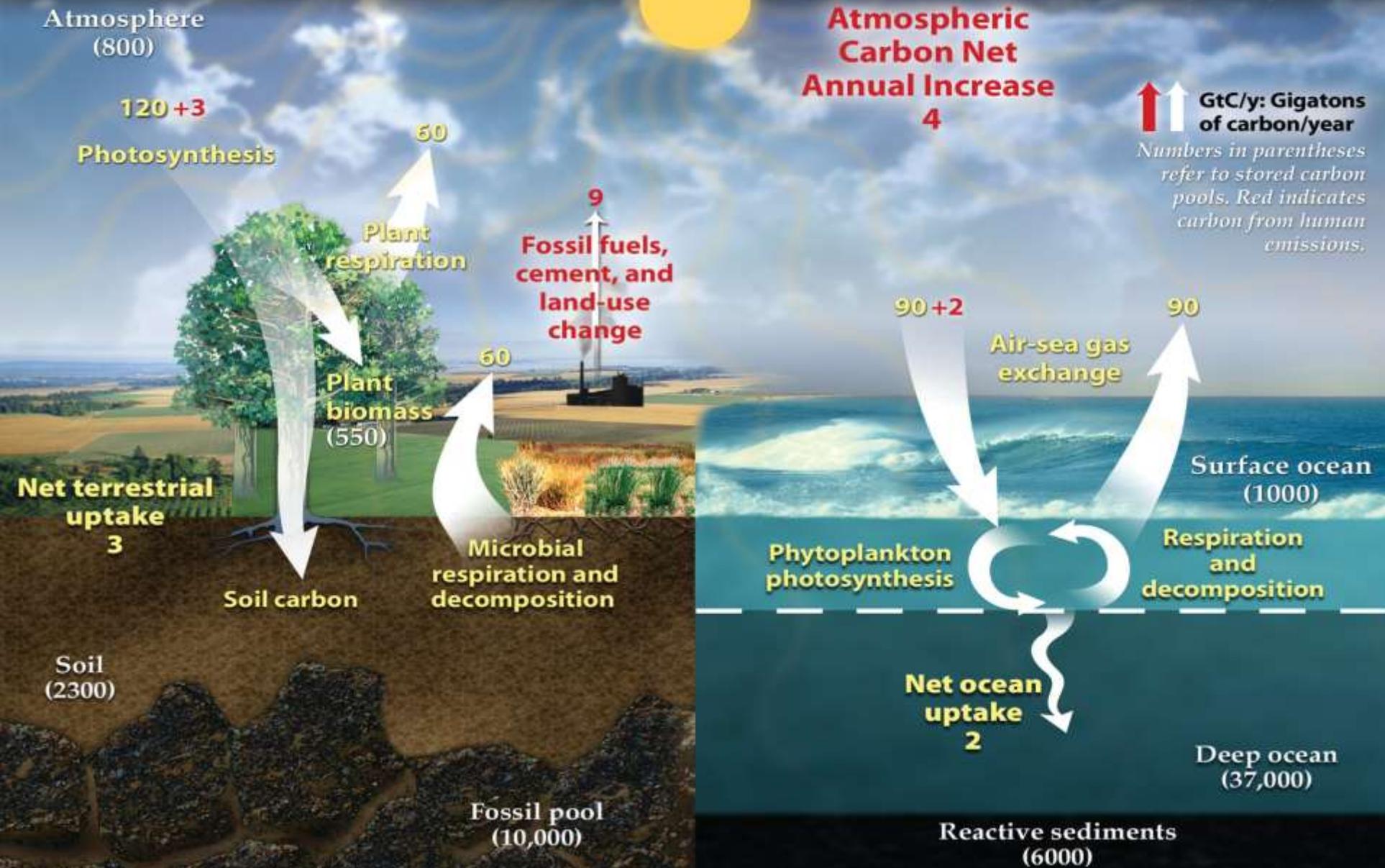


Nosso clima depende das interações entre a biosfera e a atmosfera

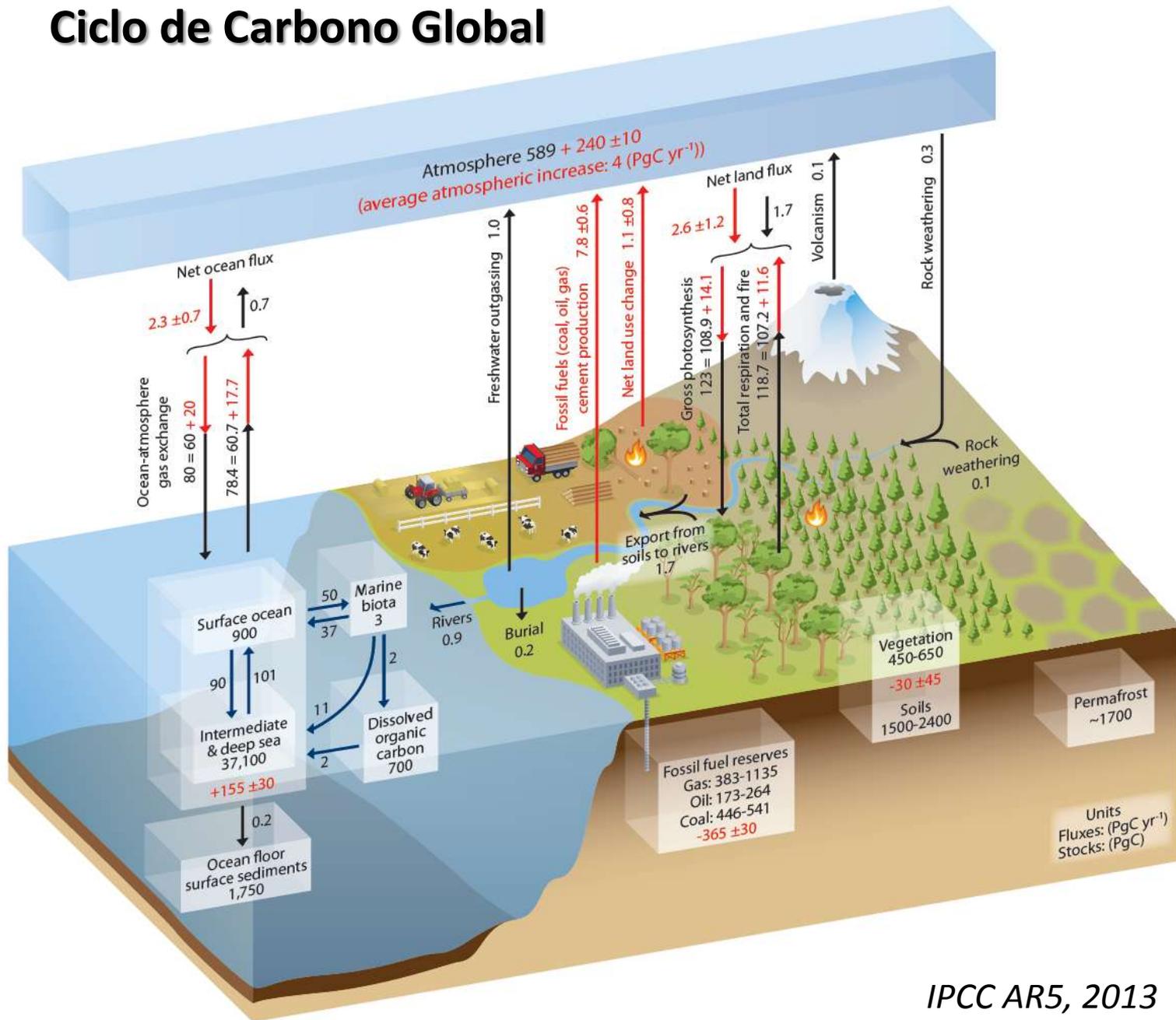


Human Perturbations of the Global Carbon Cycle

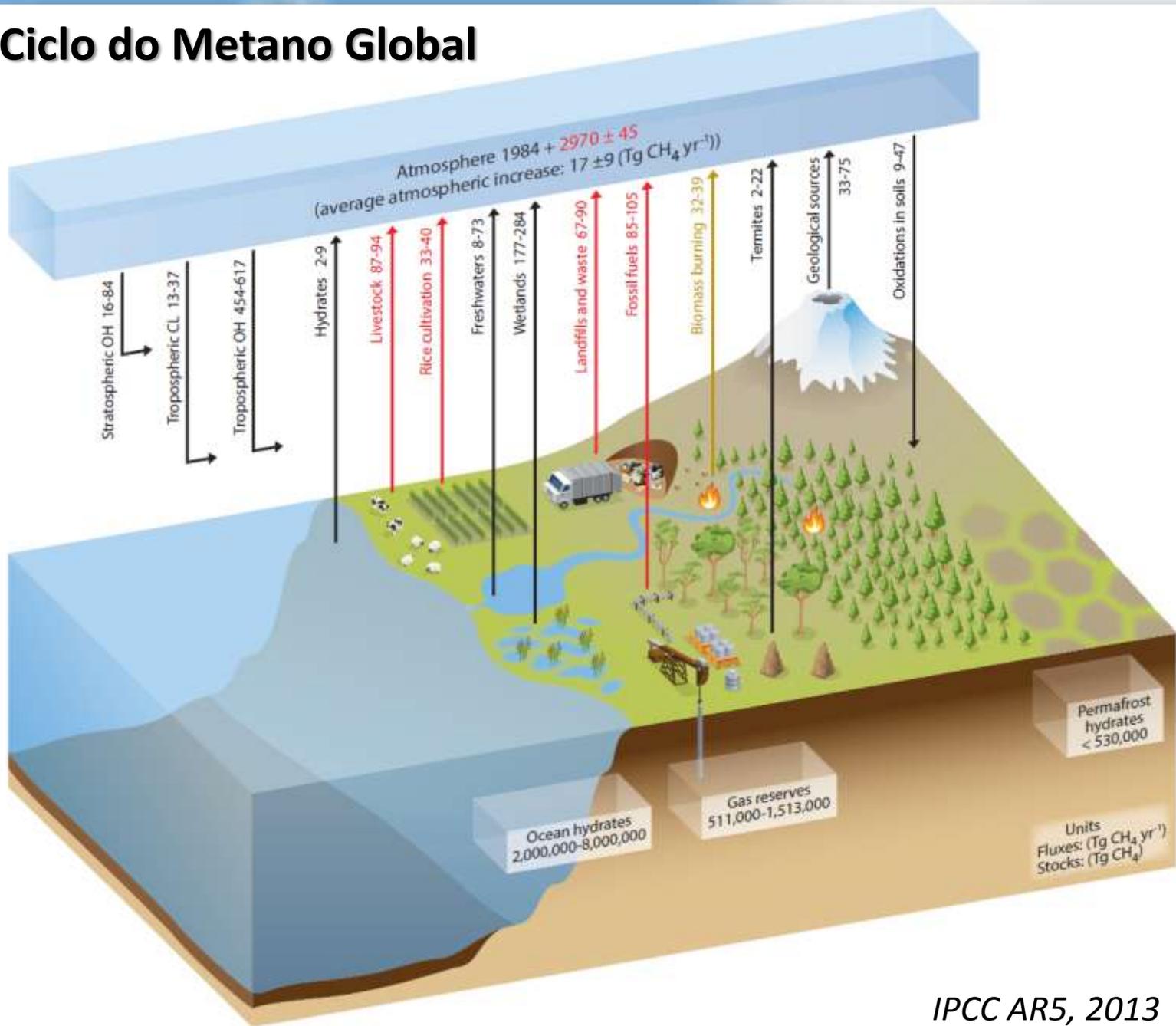
(Global Carbon Project 2010)

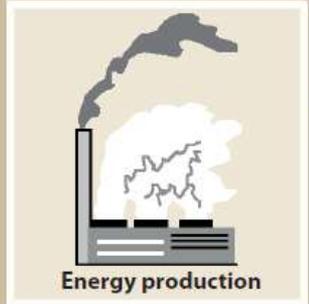


Ciclo de Carbono Global

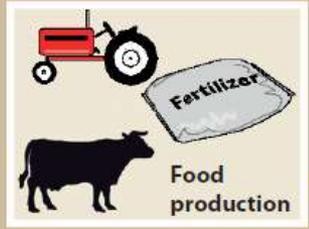


Ciclo do Metano Global





Energy production

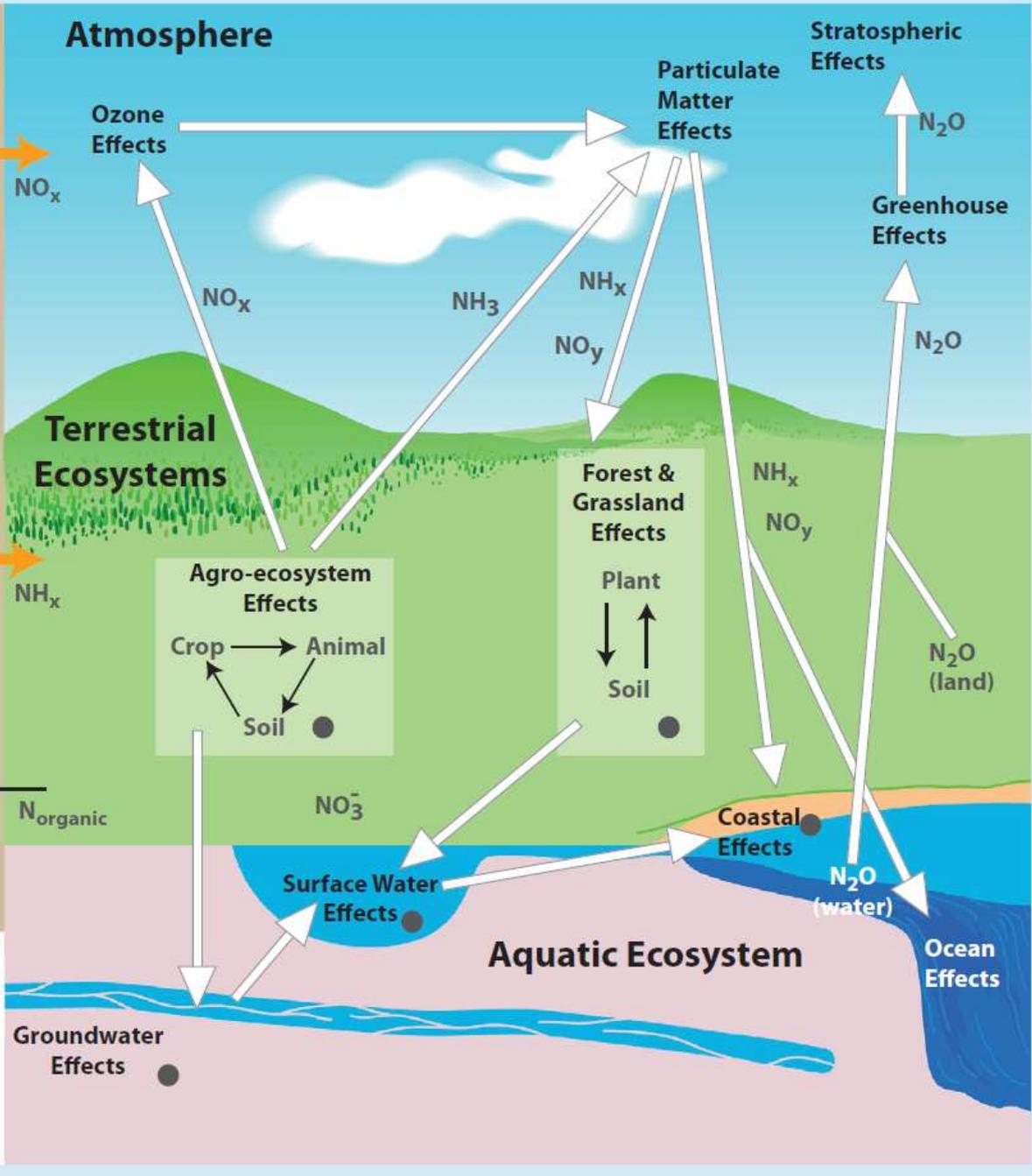


Food production

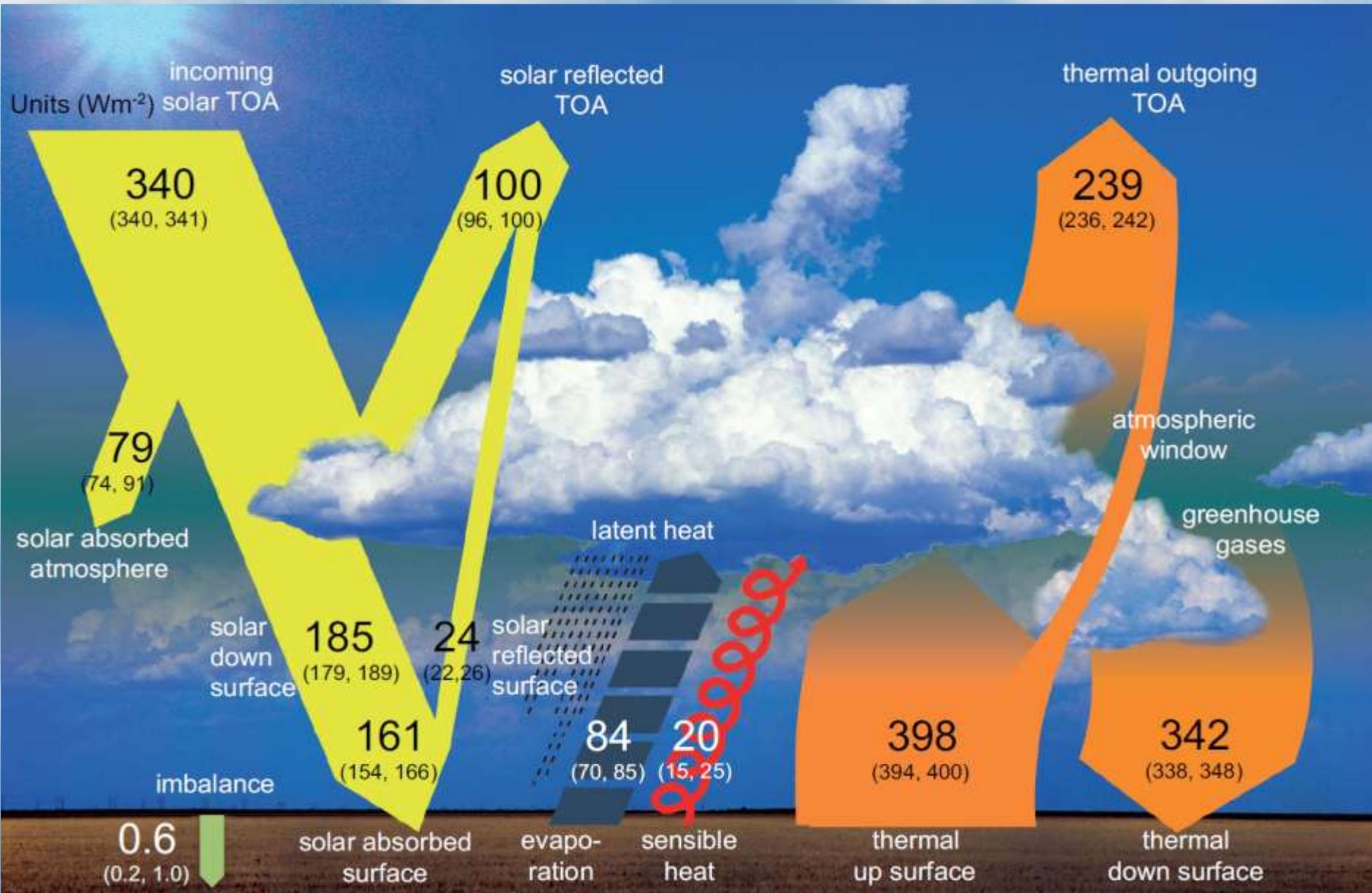


People (food; fiber)

The Nitrogen Cascade



Balanço de energia sob condições climáticas atuais

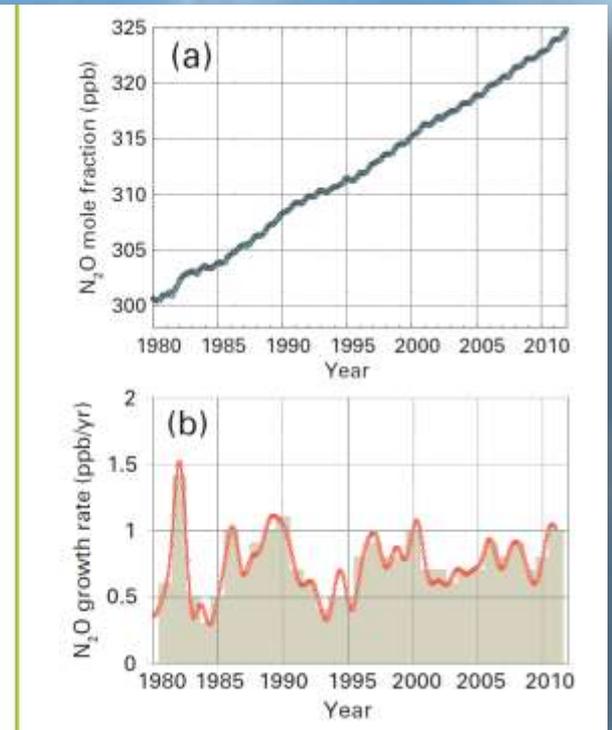
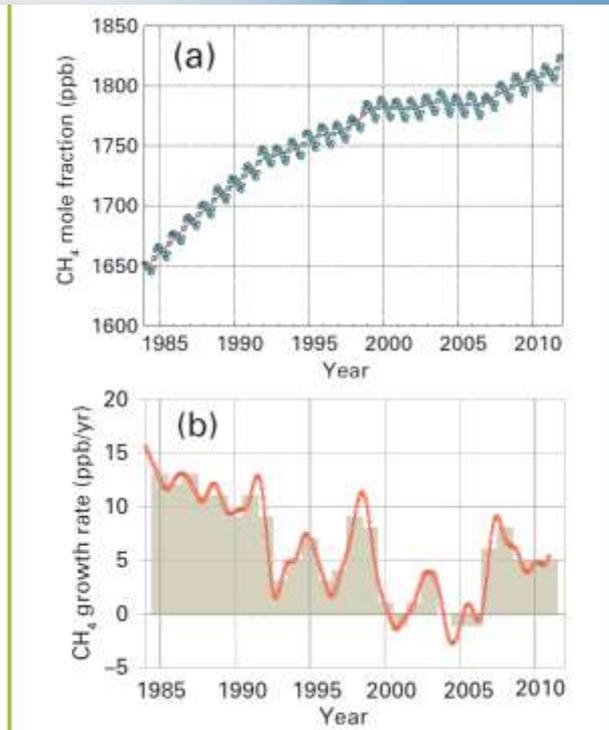
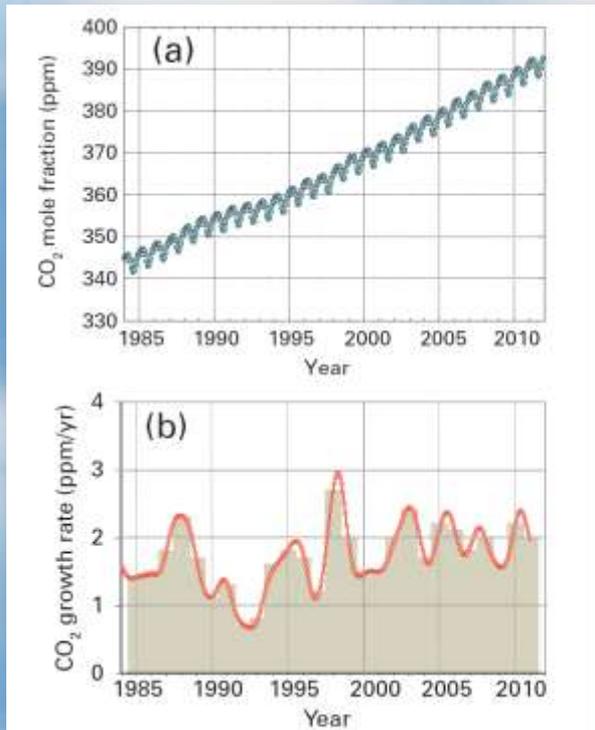


CO₂, CH₄ e N₂O de 1985 a 2011

40% aumento desde 1850

158% aumento desde 1850

20% aumento desde 1850



Globally averaged CO₂ mole fraction (a) and its growth rate (b) from 1984 to 2011.

Globally averaged CH₄ mole fraction (a) and its growth rate (b) from 1984 to 2011.

Globally averaged N₂O mole fraction (a) and its growth rate (b) from 1980 to 2011.

Para onde vão as emissões antropogênicas de CO₂ (média 2002-2011)

8.3 ± 0.4 PgC/yr 90%



1.0 ± 0.5 PgC/yr 10%



+

4.3 ± 0.1 PgC/yr 46%



2.6 ± 0.8 PgC/yr 28%

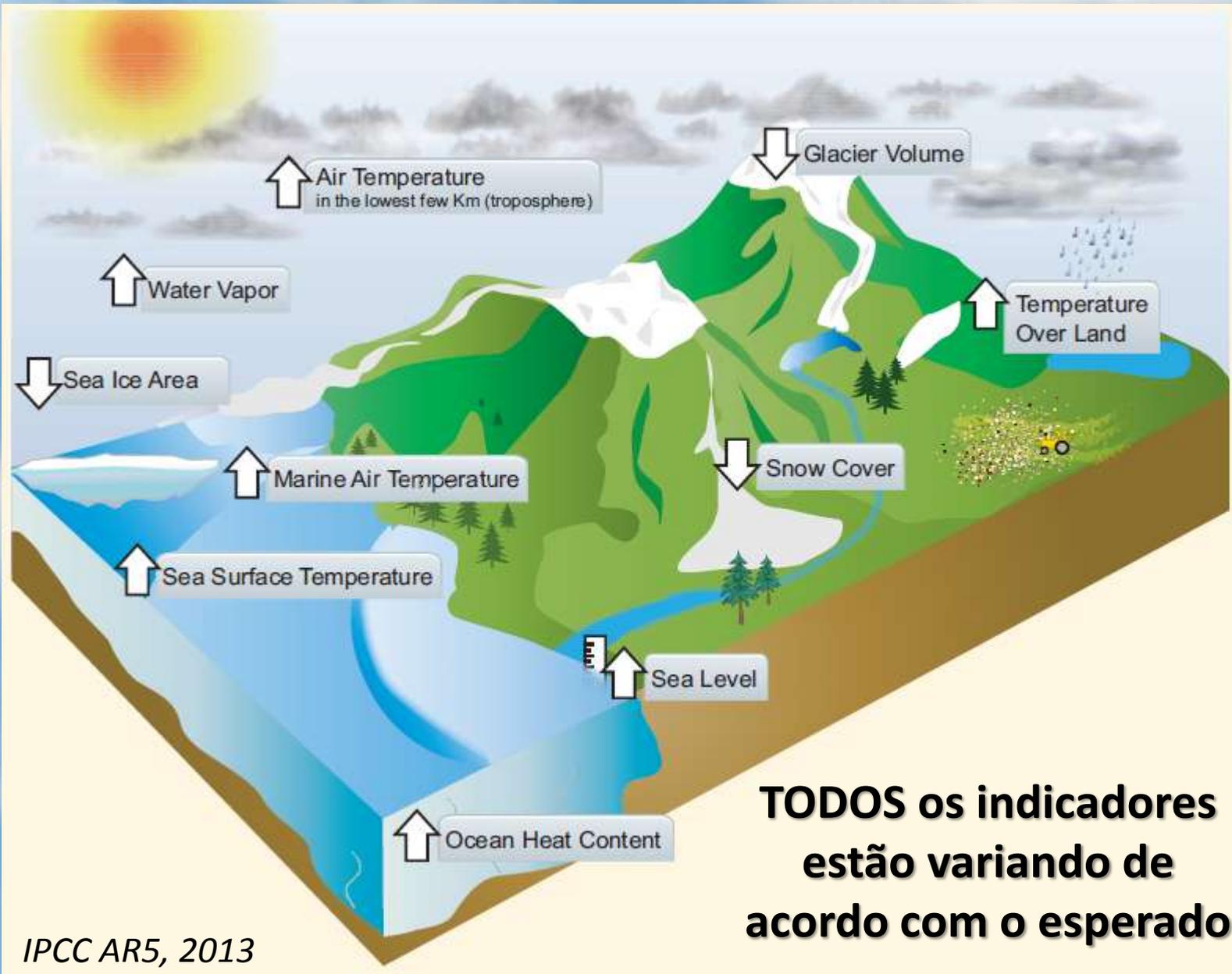


2.5 ± 0.5 PgC/yr 26%

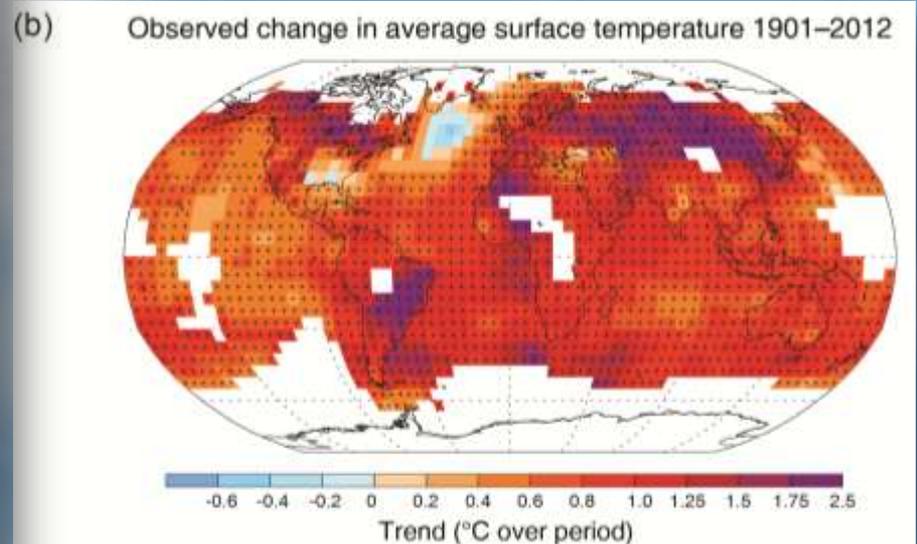
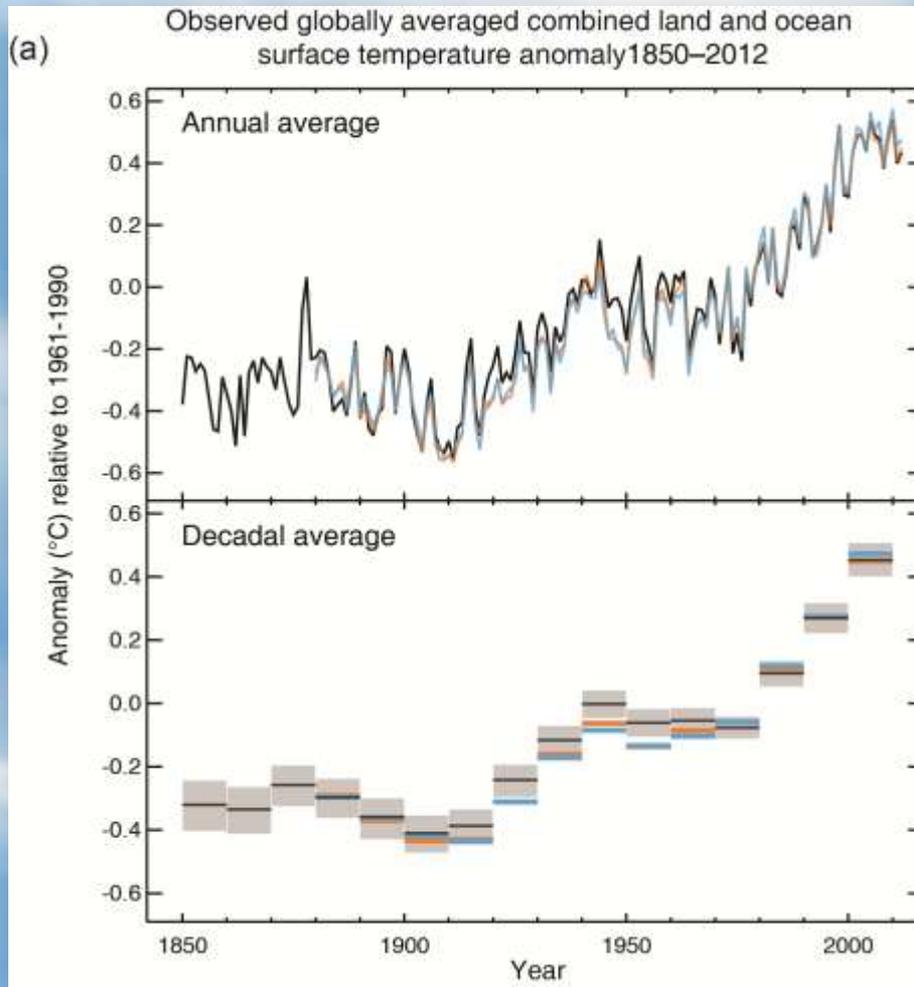


1 PgC = 10¹⁵ g C

Dez indicadores de um mundo em aquecimento

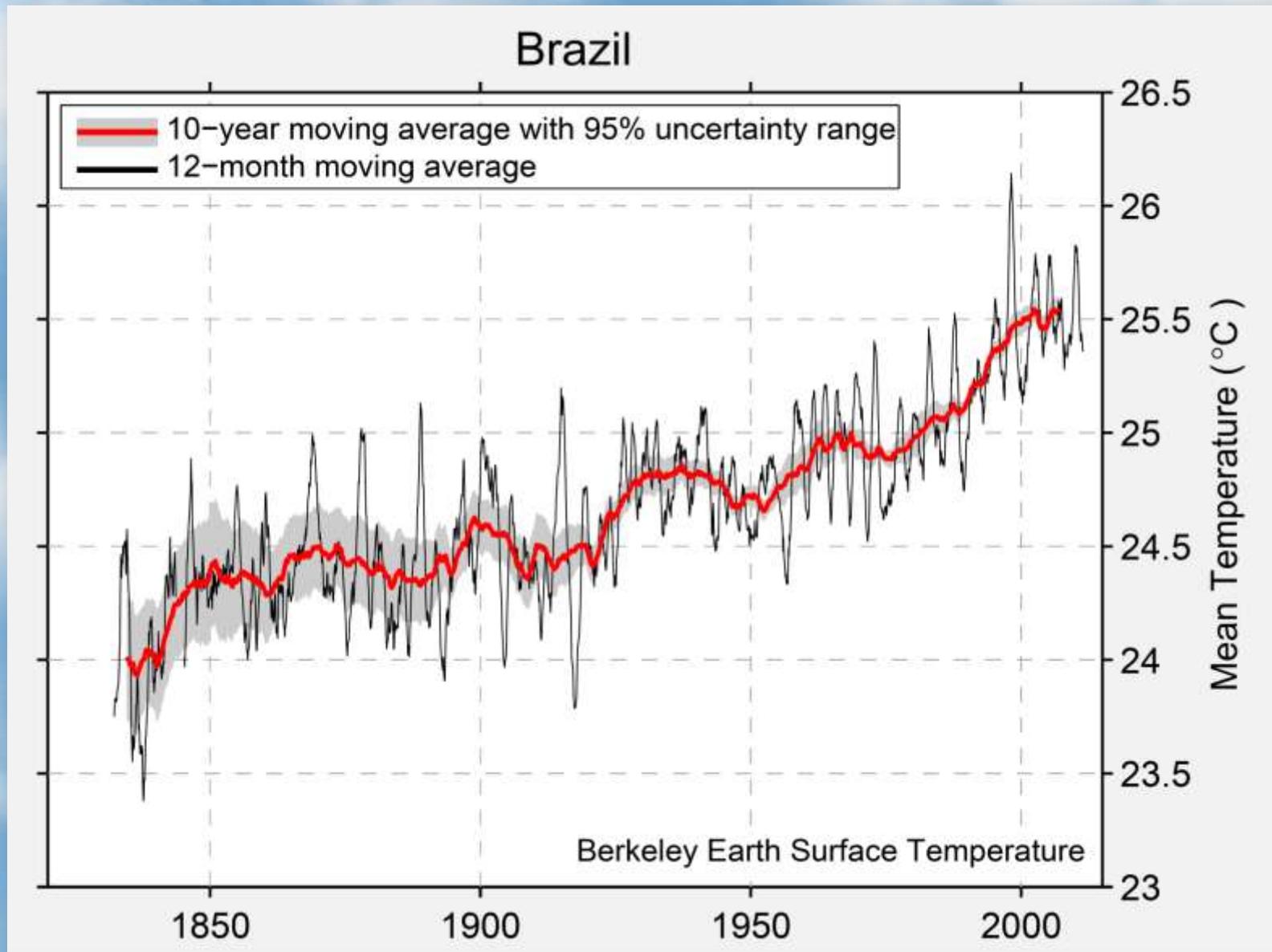


Aumento médio da temperatura observado de 1850-2012: 1.0 °C

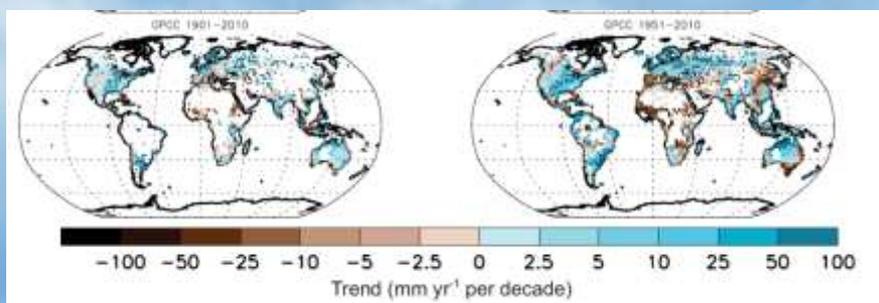


Distribuição espacial

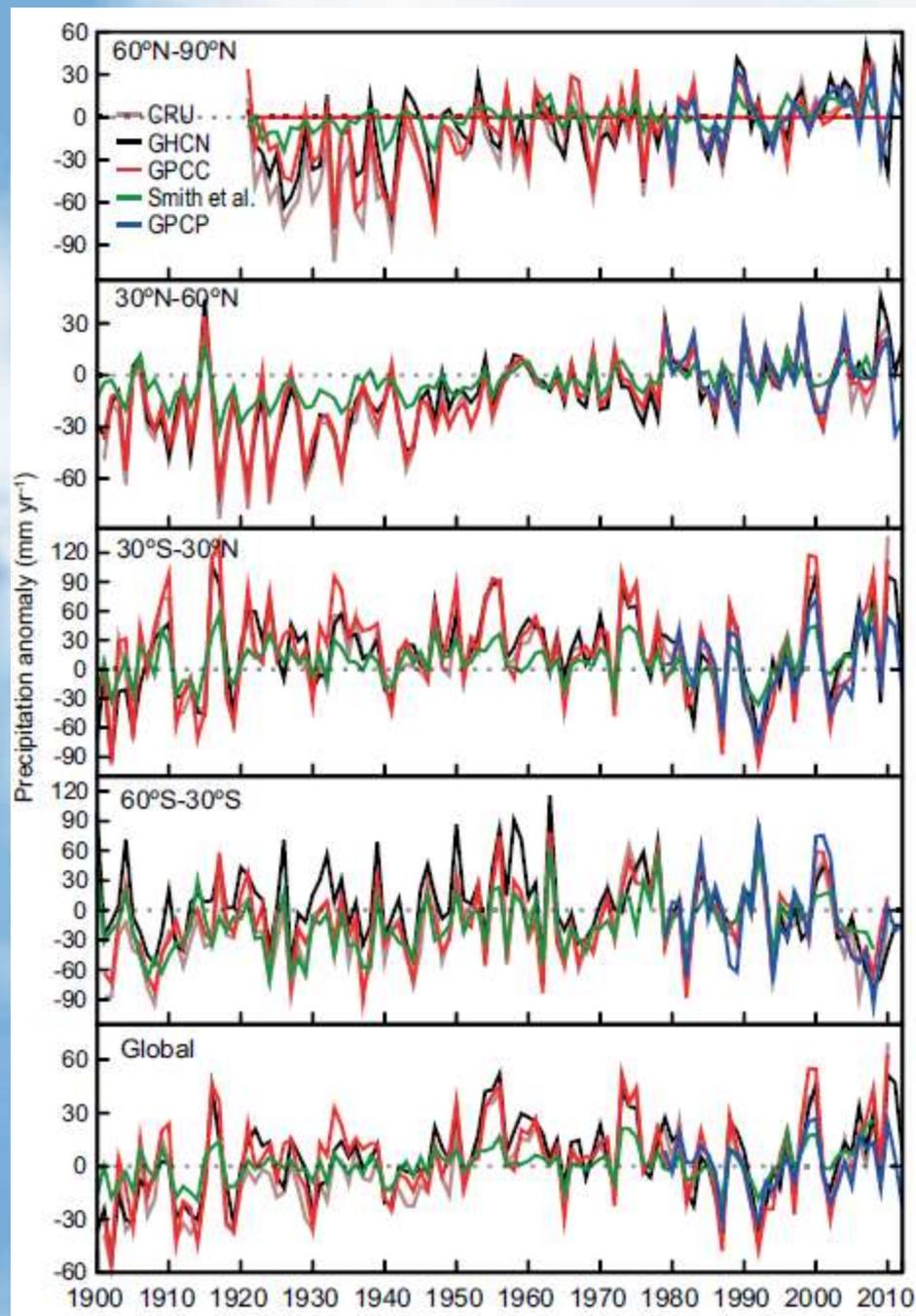
Brazil: Berkeley Earth Surface Temperature



**Não observa-se
tendências globais na
alteração da precipitação,
mas regionalmente sim.**



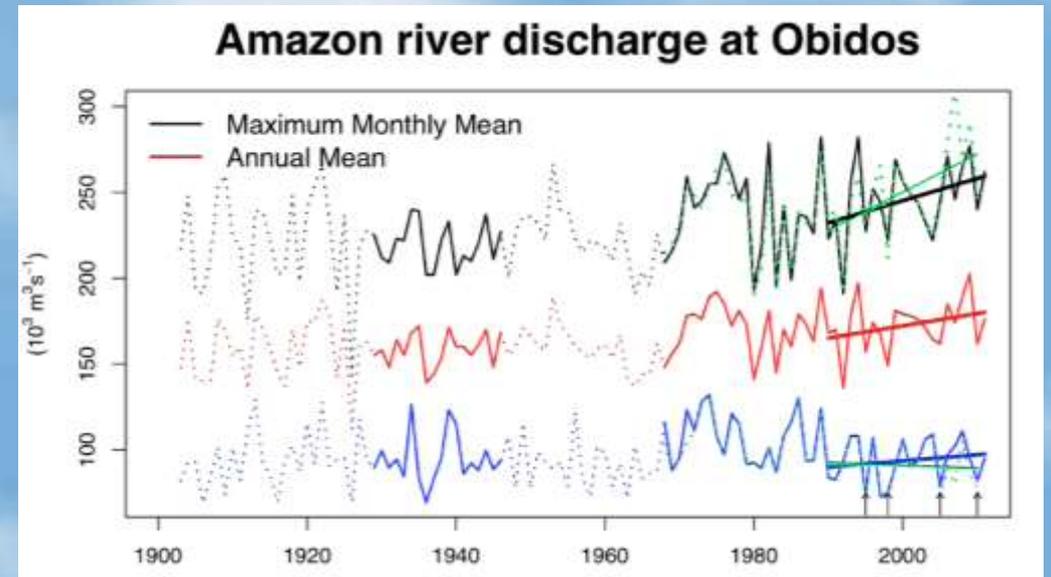
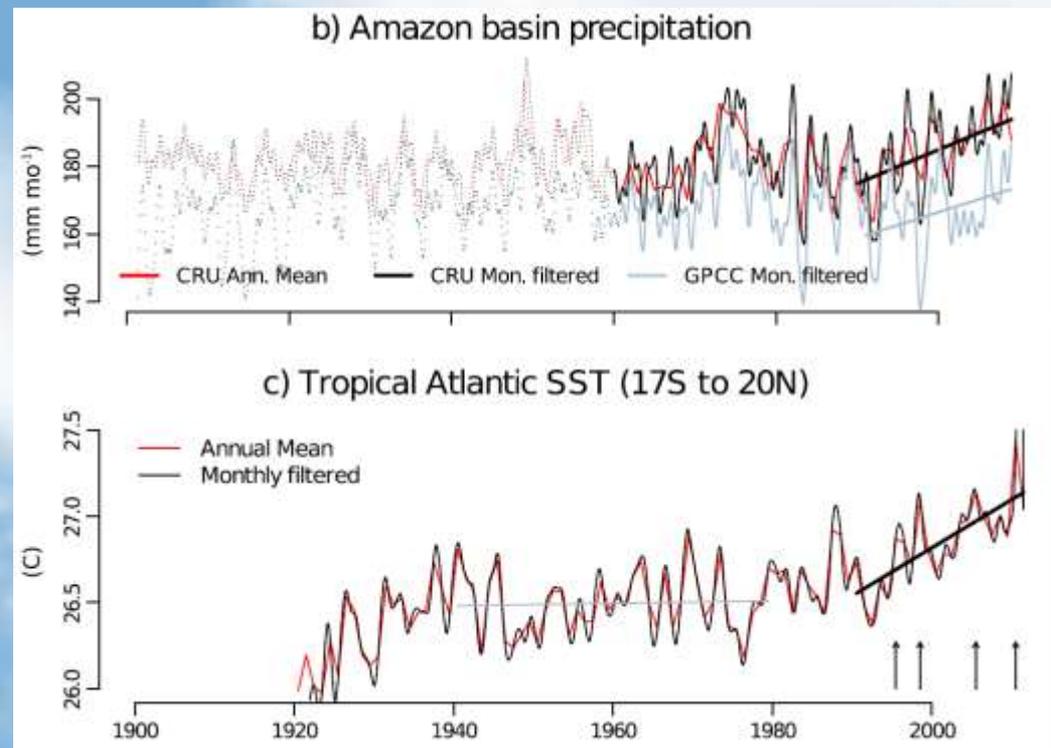
**Aumento de precipitação na Bacia do
Prata: aprox. 30% nos últimos 50 anos**



Is the Amazonian hydrological cycle intensifying?

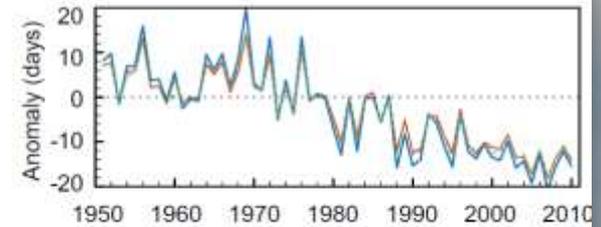
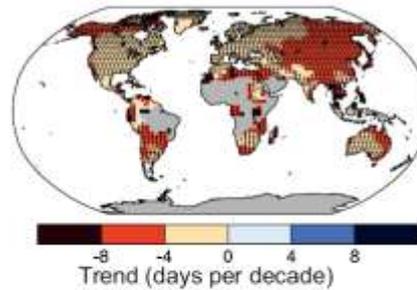
Tropical Atlantic sea surface temperature

Maximum monthly, annual mean and minimum monthly mean Amazon river discharge at Óbidos and in green maximum and minimum daily mean river discharge, (*Gloor et al. GRL 2013*).

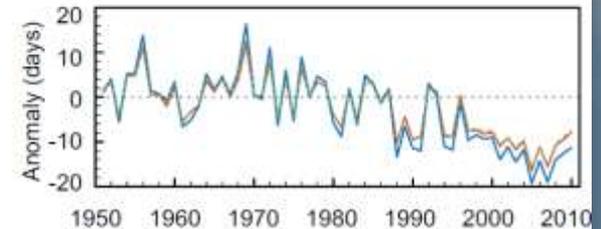
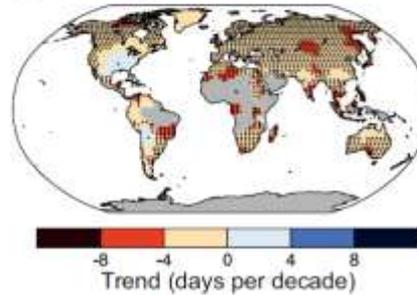


Observações de extremos climáticos de temperatura

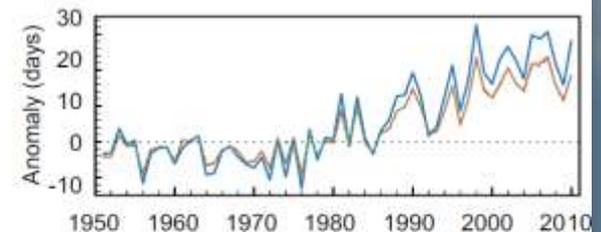
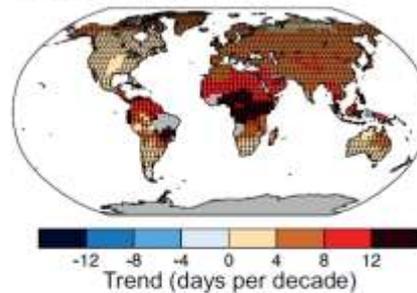
(a) Cold Nights



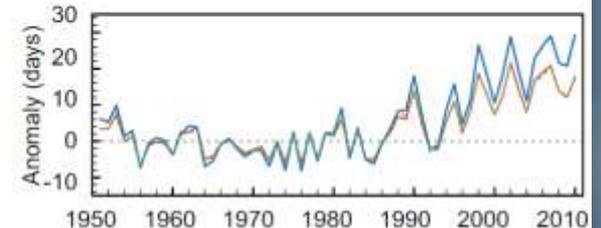
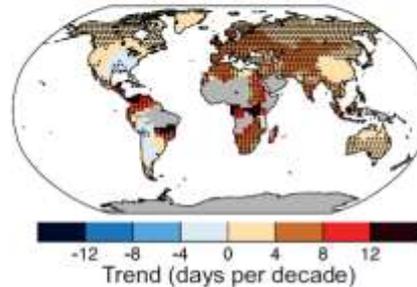
(b) Cold Days



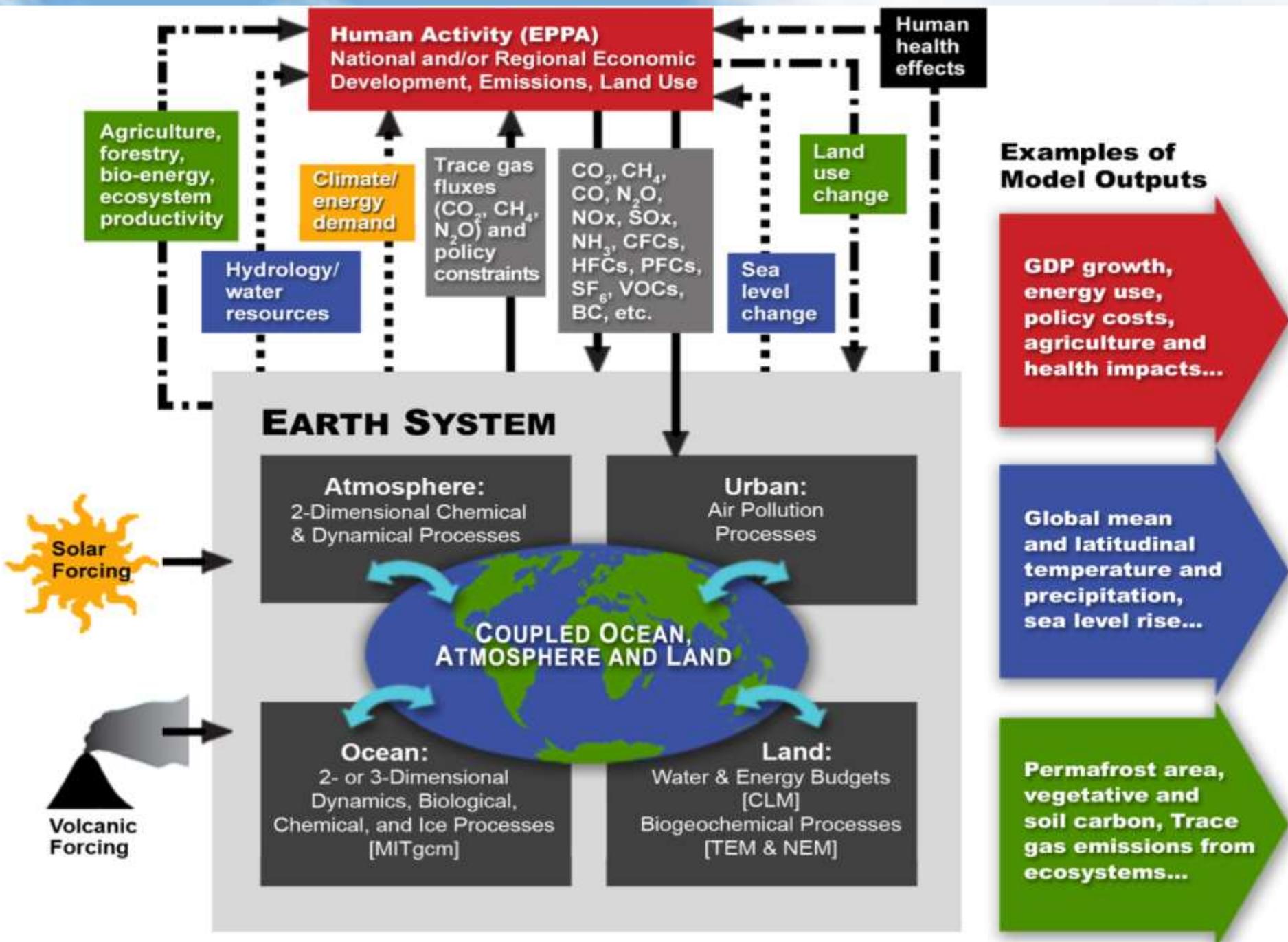
(c) Warm Nights



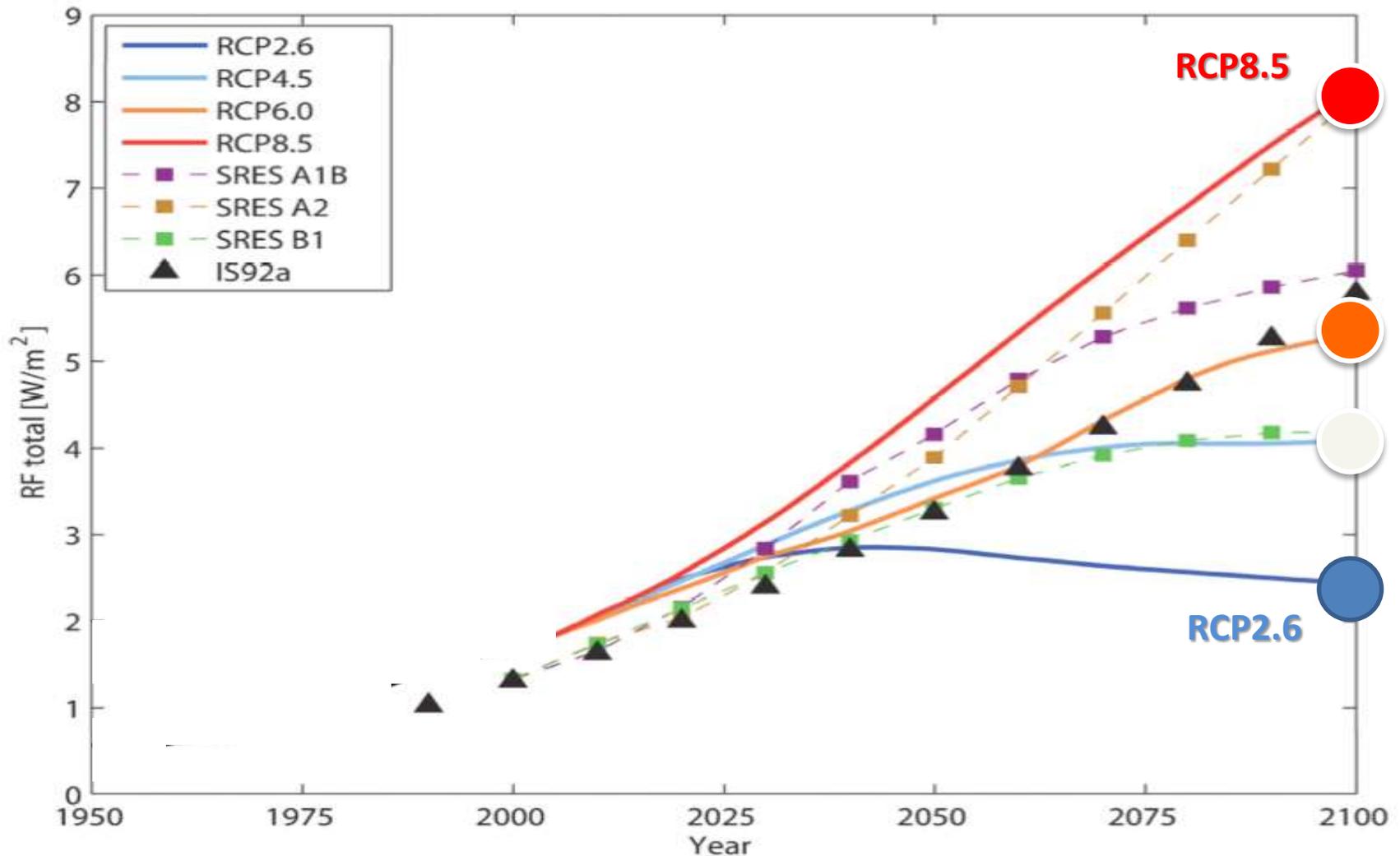
(d) Warm Days



— HadEX2
— HadGHCND
... GHCNDEX



Cenários de Emissões e “RCP - Representative Concentrations Pathways”



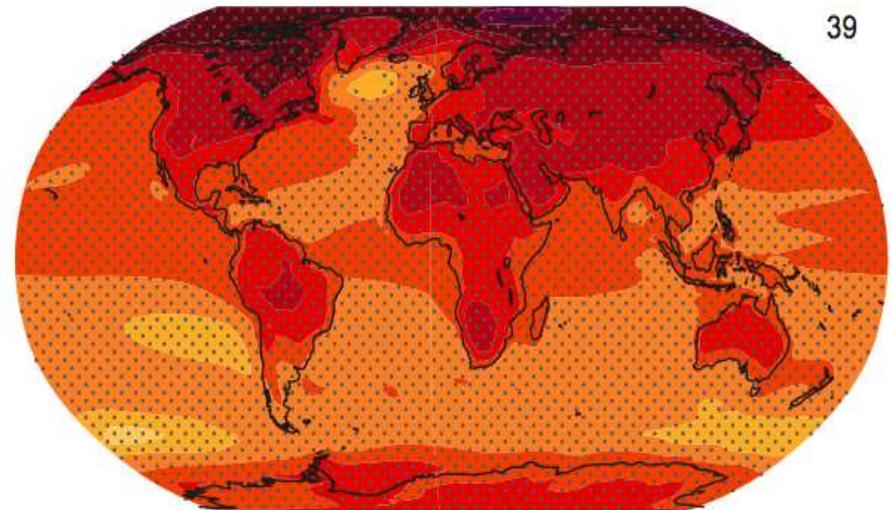
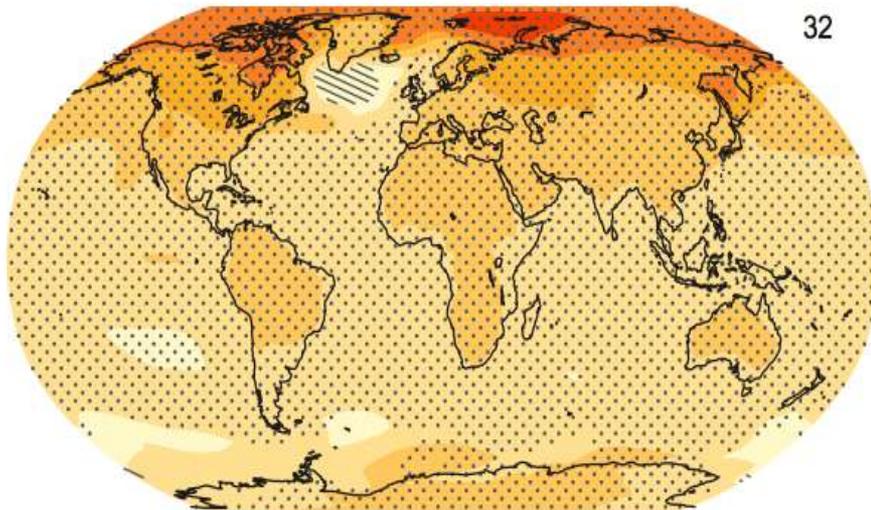
Projeção de aumento de temperatura em dois cenários

RCP 2.6

RCP 8.5

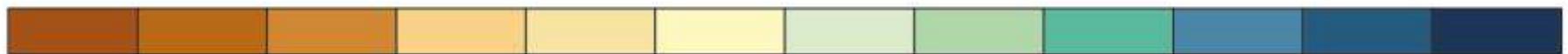
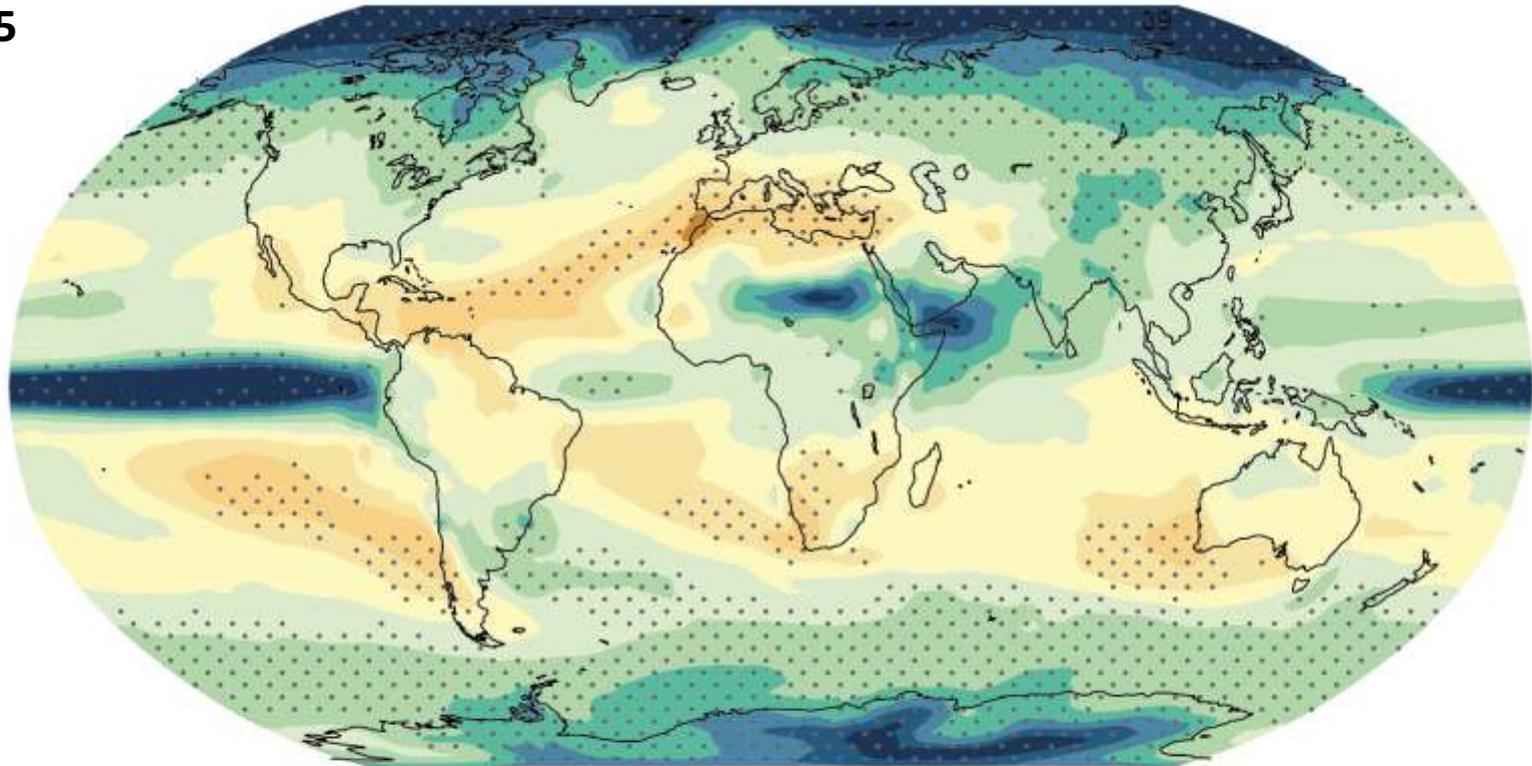
(a)

Change in average surface temperature (1986–2005 to 2081–2100)



Projeções de mudanças na precipitação 1986-2005 to 2081-2100

RCP8.5



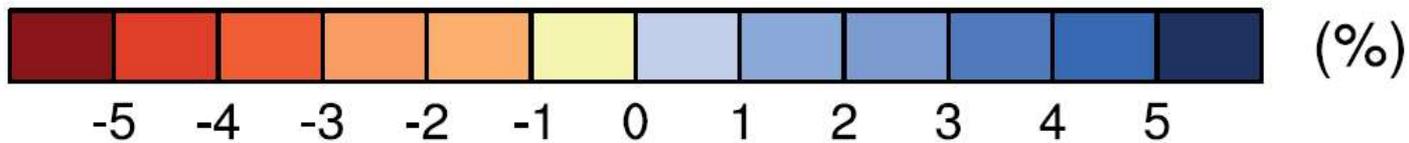
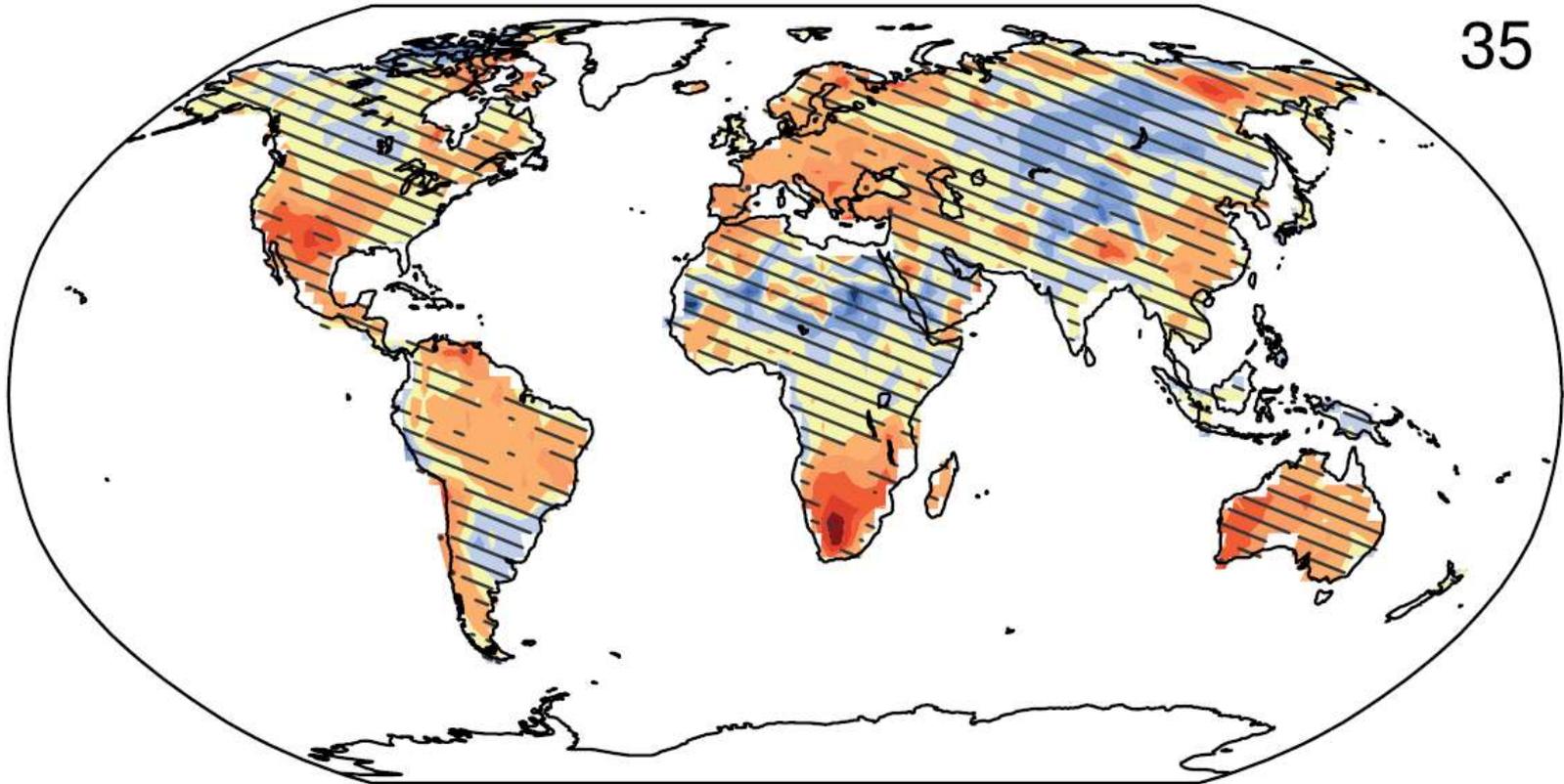
-50 -40 -30 -20 -10 0 10 20 30 40 50

Precipitation change (%)

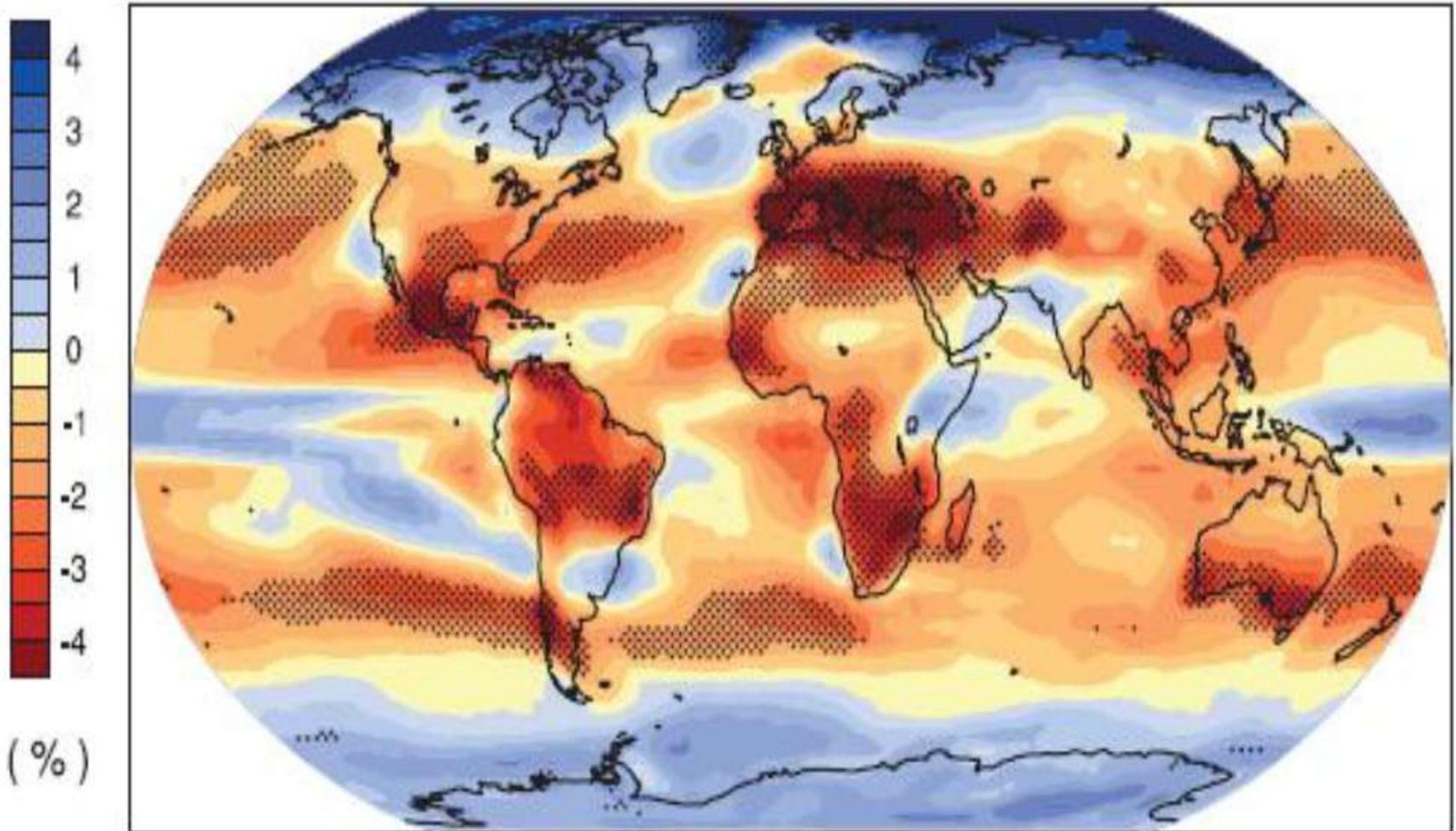
Previsão de alteração de umidade do solo para o período de 2016–2035 relativo à 1986–2005 (Cenário RCP4.5 CMIP5)

Δ Soil Moisture

35



Mean changes in total cloud area fraction



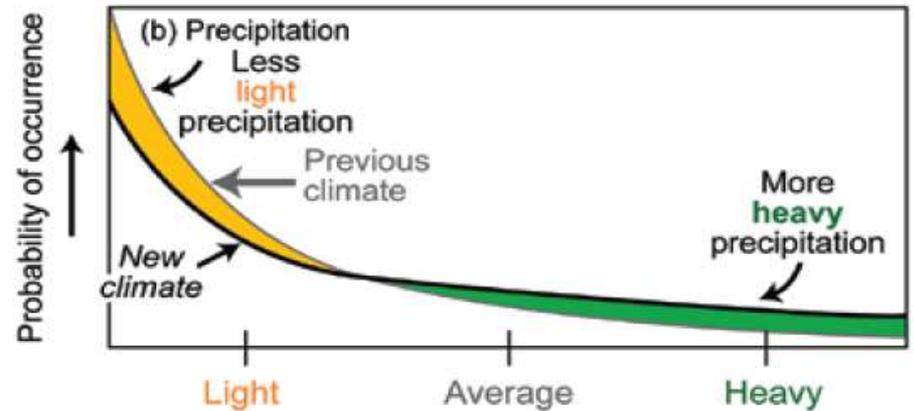
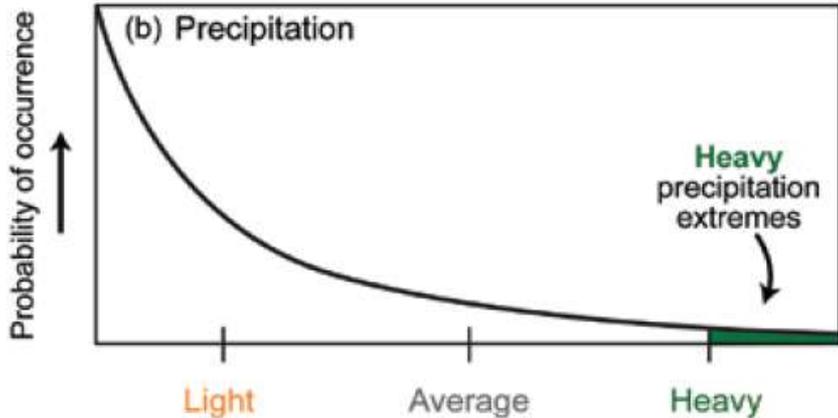
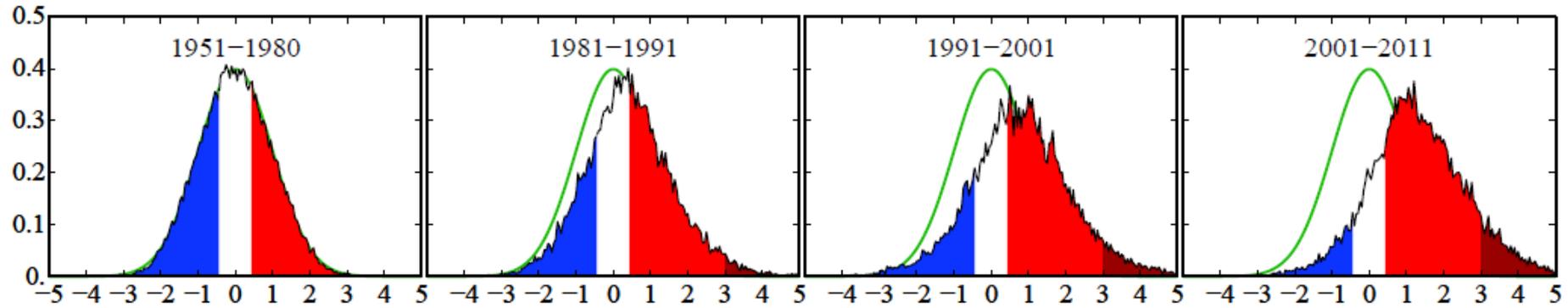
Multi model mean changes in total cloud area fraction . Changes are given as annual means for the SRES A1B scenario for the period 2080 to 2099 relative to 1980 to 1999.

Aumento da temperatura pode estar aumentando a frequência de eventos climáticos extremos

Extreme summer heat anomalies now cover about 10% of land area, up from 0.2%.

This is based on observations, not models.

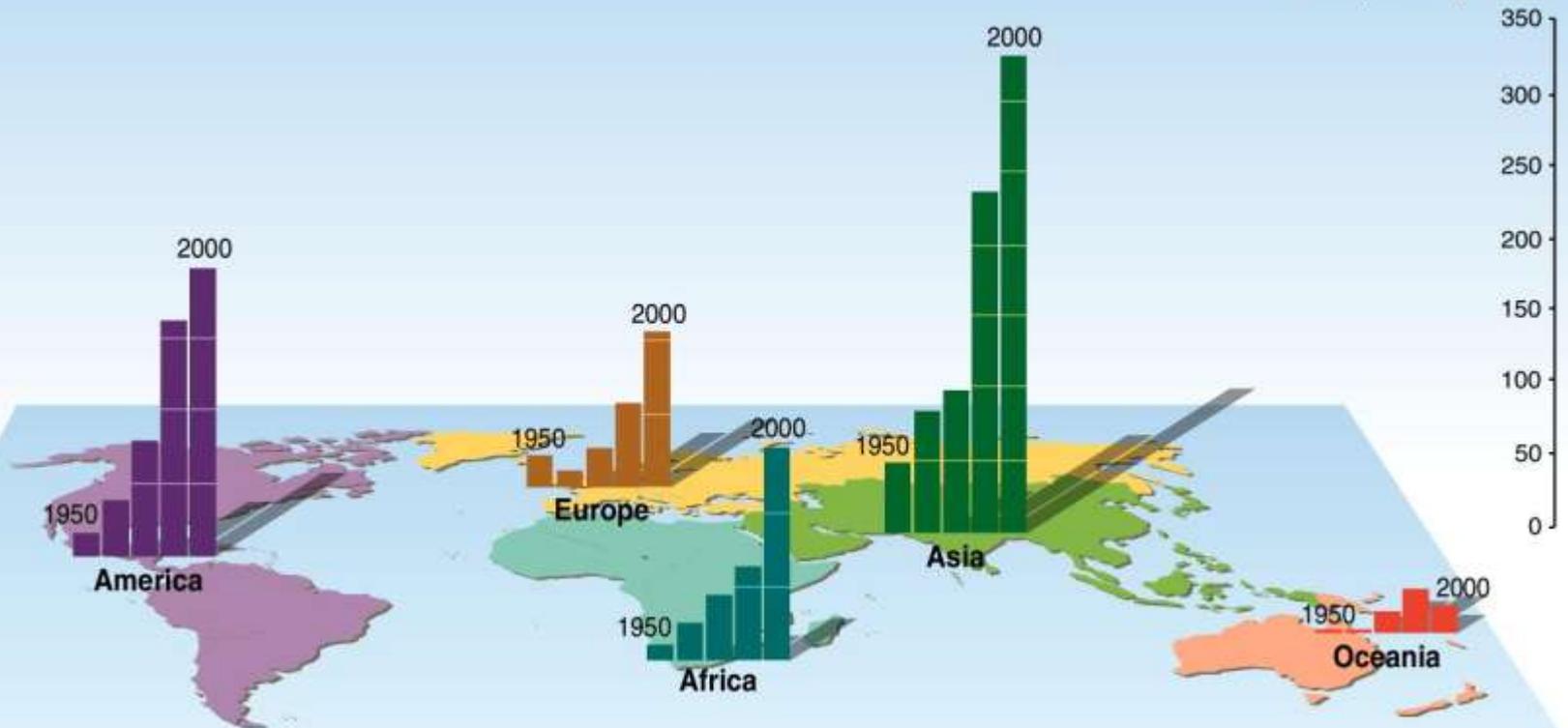
Shifting Distribution of Summer Temperature Anomalies



Increase of incidence of extreme climatic events 1950-2000

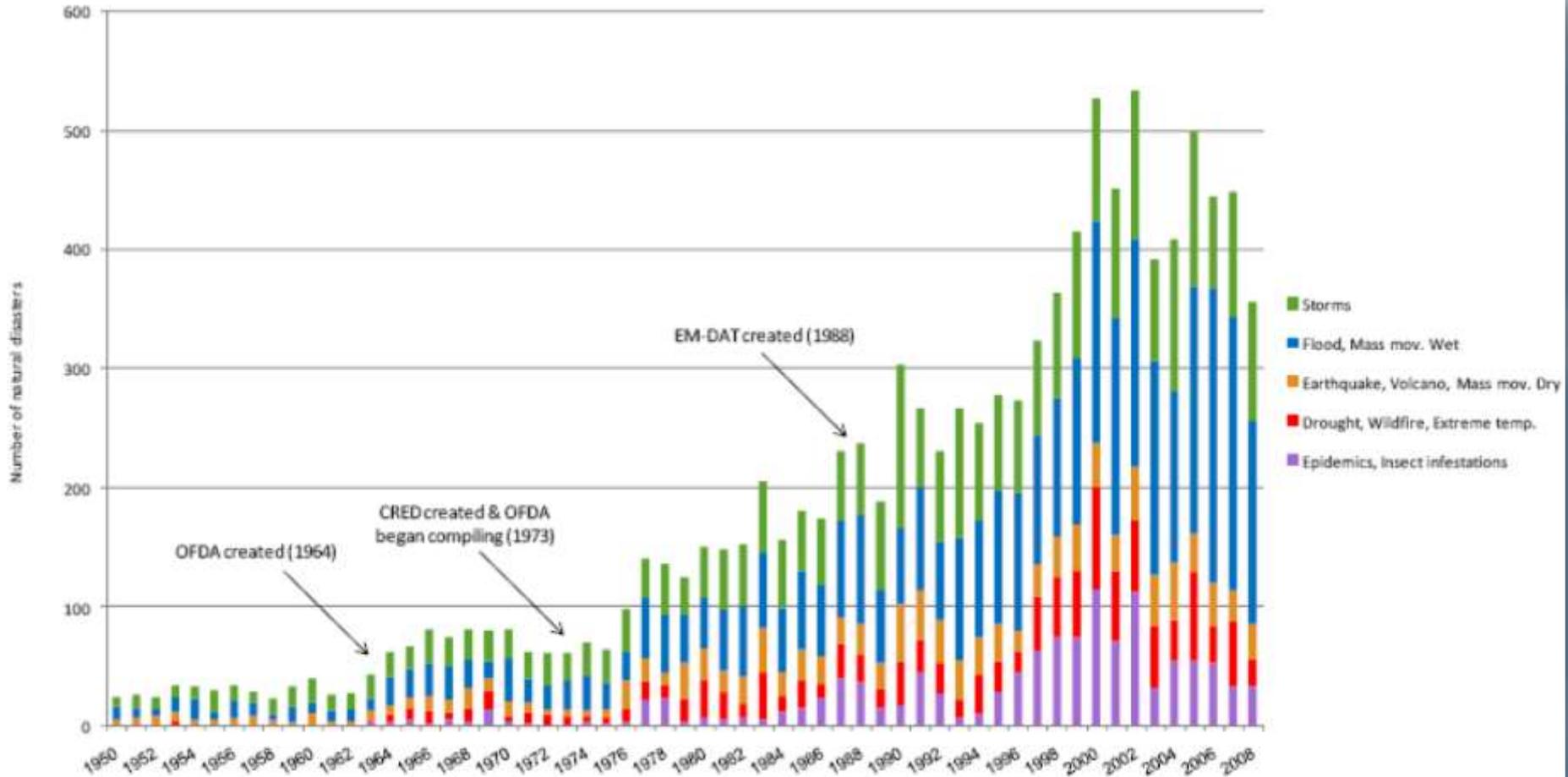
Floods

Number of events
Data plotted by decade

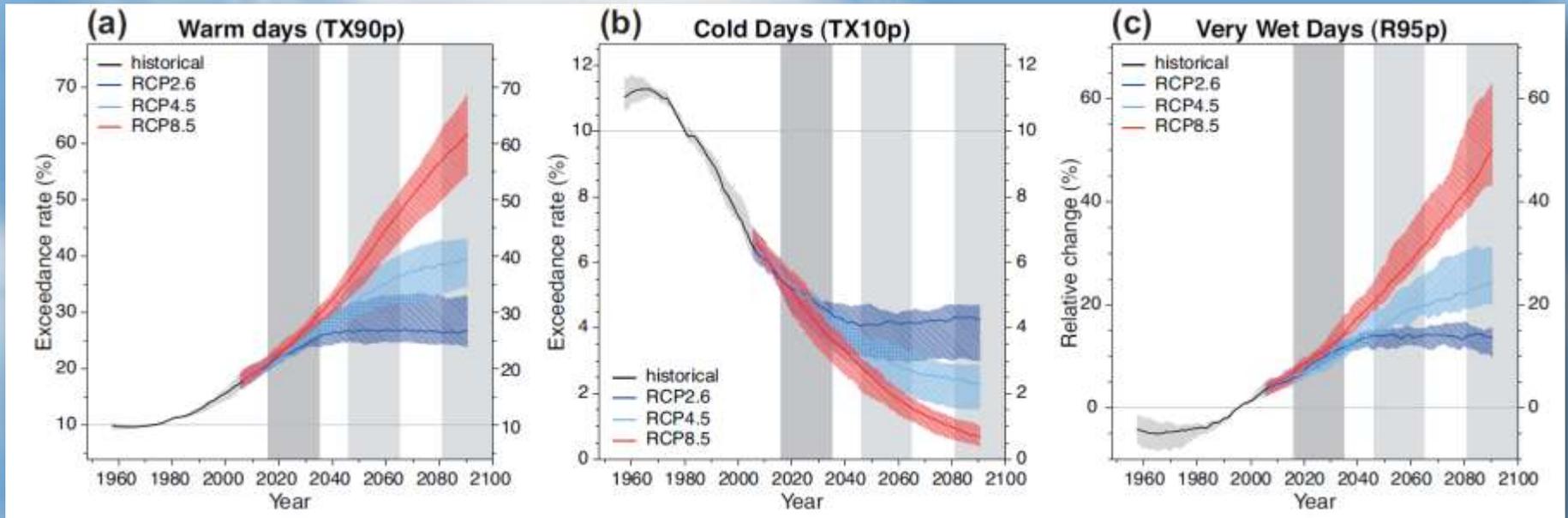


Source: Millennium Ecosystem Assessment

Aumento da incidência de eventos climáticos extremos – 1950-2008



Projeções globais da ocorrência de (a) Dias quentes (TX90p), (b) Dias Frios (TX10p) e (c) Precipitação de dias muito chuvosos



Some extreme unusual events during 2007-2010- South America



Drought Solimões river (2010)

Drought S. Venezuela (2009)



Floodings in the Amazon (2009)



Rainfall Alagoas (2010)



Storm Agatha Central America (2010)



Rainfall Rio de Janeiro (2010)

Floods Colombia (2008)

Cold Wave Bolivia (2010)



Rainfall São Paulo (2010)

Rainfalls/Landslides Andes Central Peru (2009)

Rainfalls/Landslides Ilha Grande (2010)

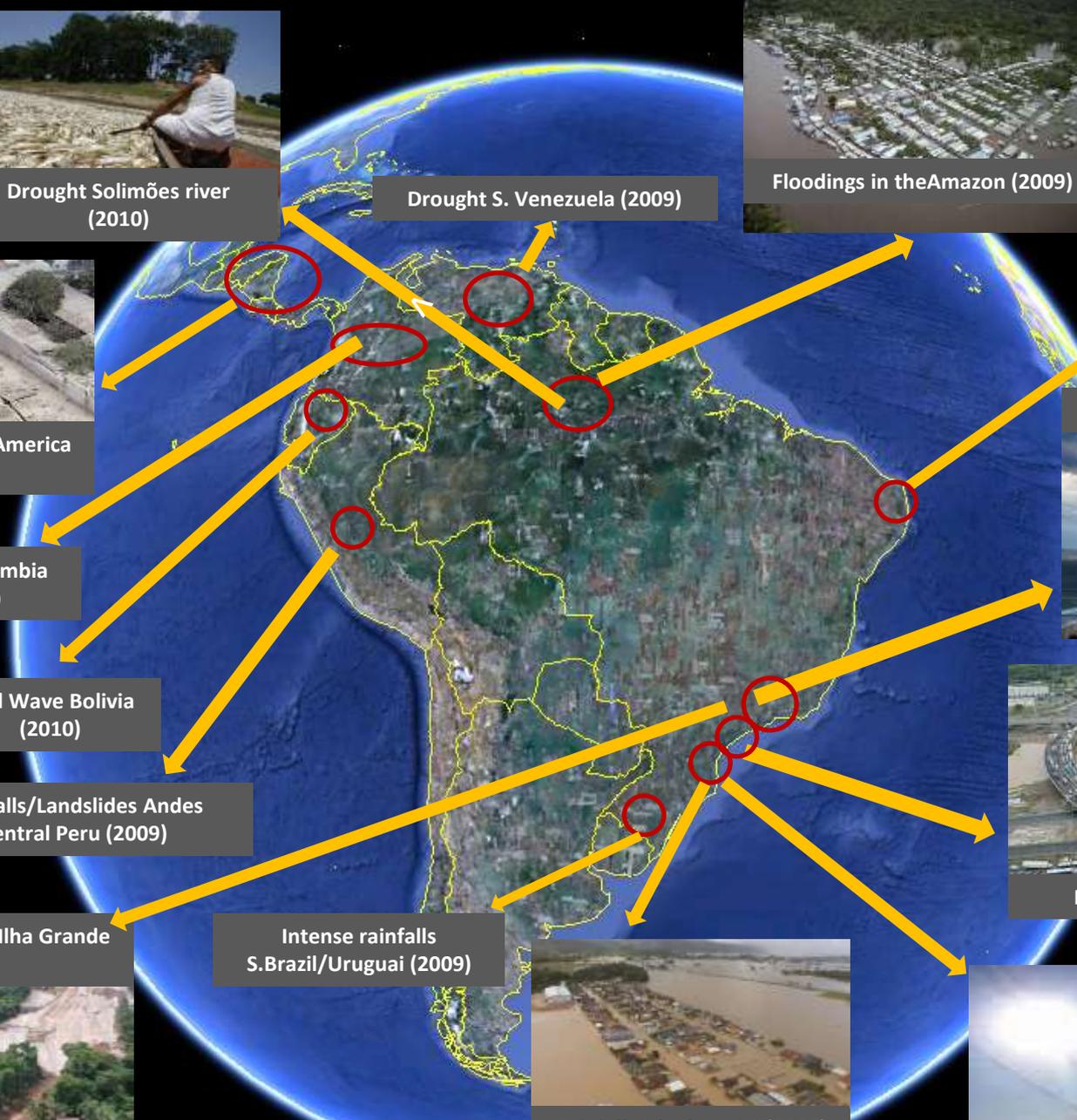
Intense rainfalls S. Brazil/Uruguay (2009)



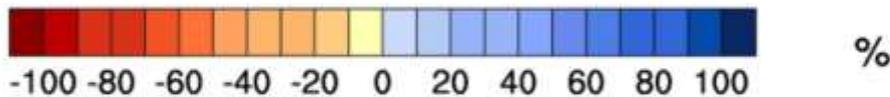
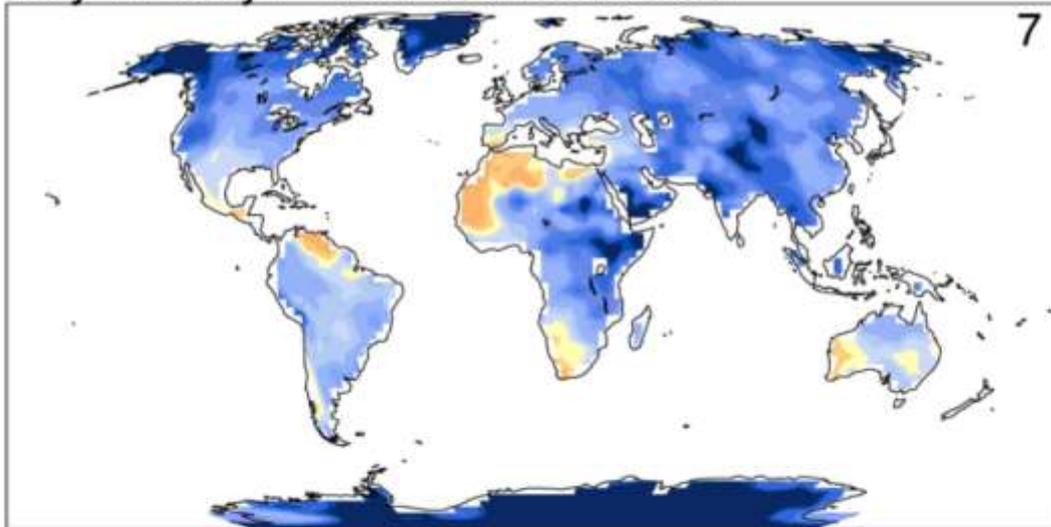
Rainfall Vale do Itajaí (2008)



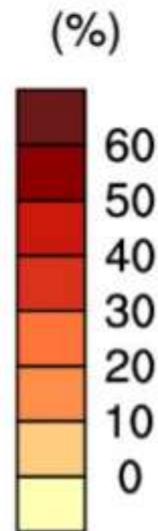
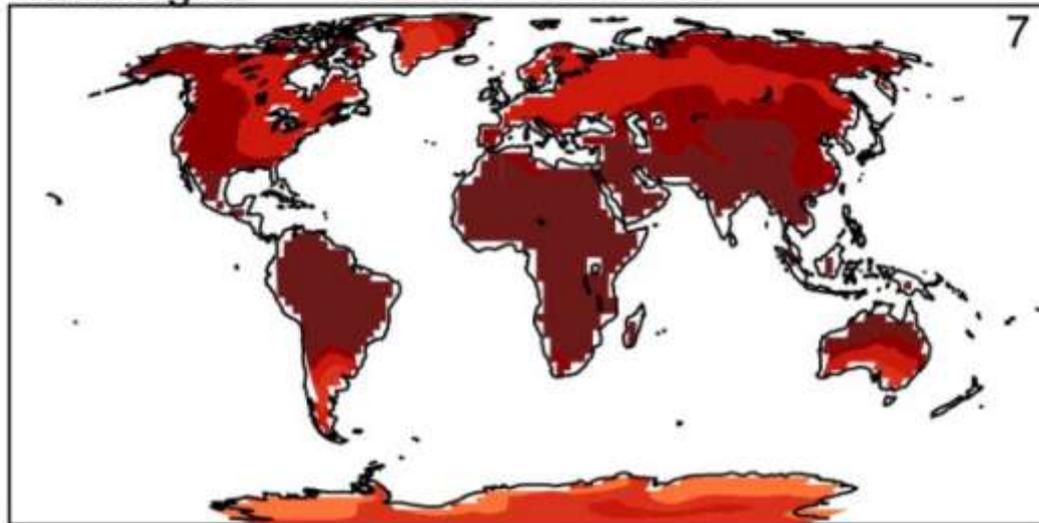
Heat Wave Santos (2010)



very wet days RCP85: 2081-2100



warm nights RCP85: 2081-2100



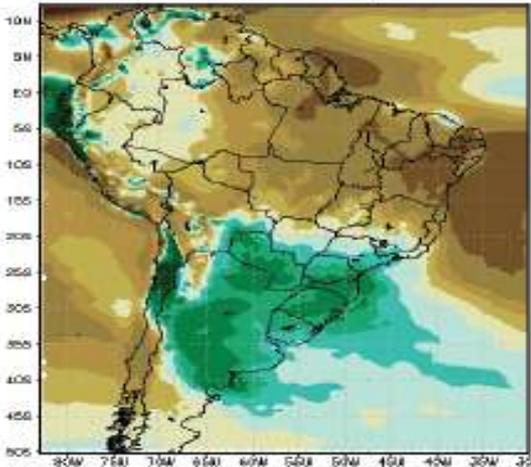
Frequência de eventos extremos 2081-2100

Changes in selected extreme indices in 2100

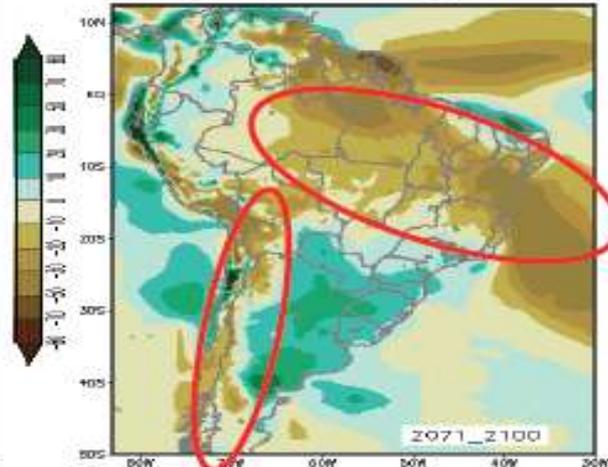
Future climate scenarios in South America by 2100

Marengo et al 2012,
Chou et al 2012

Annul Precipitation

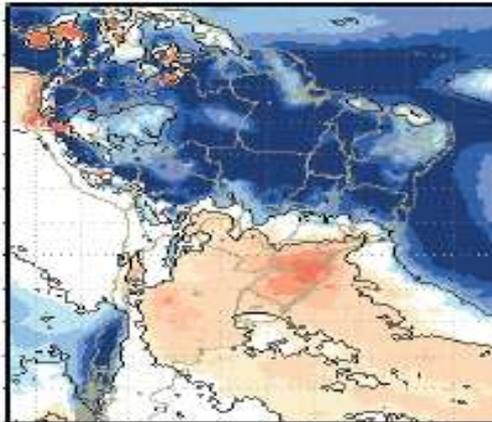


Precipitation-Evaporation

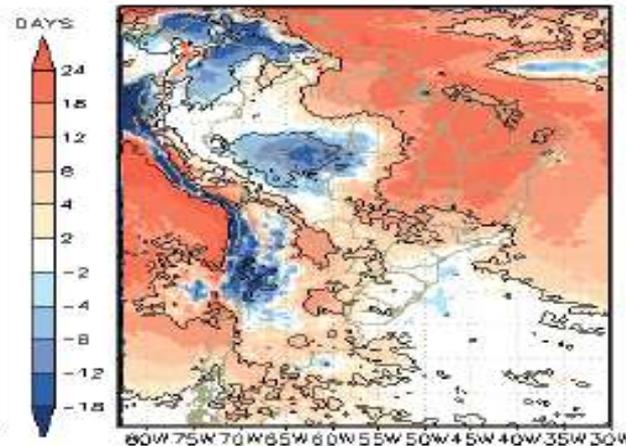


Future climate
change scenarios
by 2100 as
derived from the
Eta 40 km

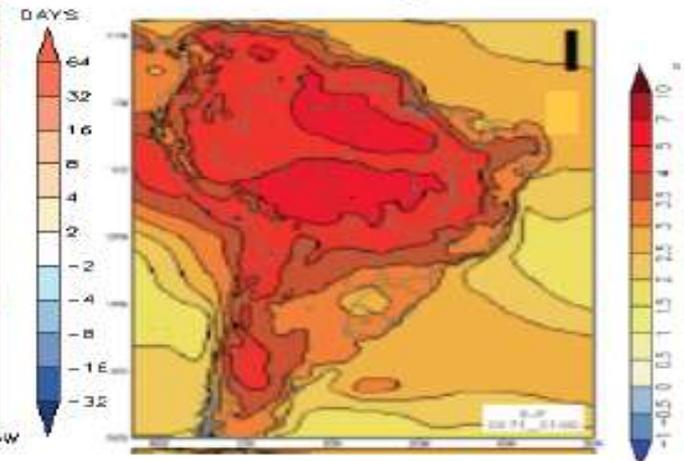
Heavy precipitation



Consecutive dry days



Mean temperature



Decade
(30-year mean
centred on)

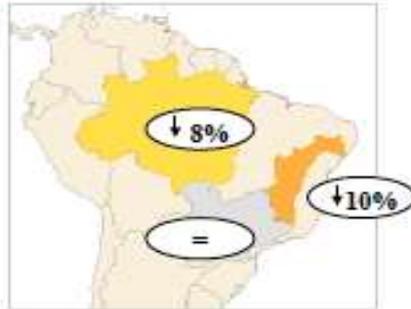
% change in summer
(DJF) rainfall relative to
1961-90 mean

Change in annual
mean
temperature in
the basins and
Brazil

Change in
annual mean
temperature:
Global

Atmospheric
CO₂
concentrations

2020s

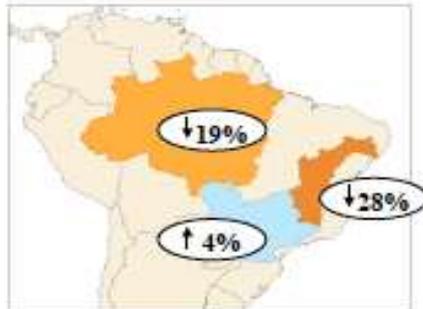


AMZ: +2.0°C
SF: +1.9°C
PAR: +1.8°C
+1.7 °C

+1.3 °C

418 ppm

2050s

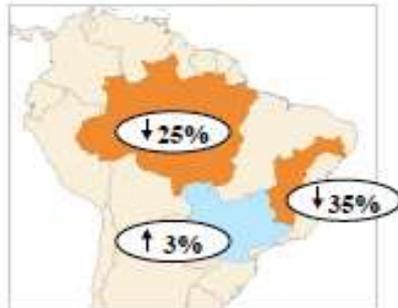


AMZ: +3.6°C
SF: +3.2°C
PAR: +3.8°C
+3.0 °C

+2.5 °C

523 ppm

2080s



AMZ: +4.9°C
SF: +4.1°C
PAR: +4.1°C
+4.2 °C

+3.3 °C

638 ppm

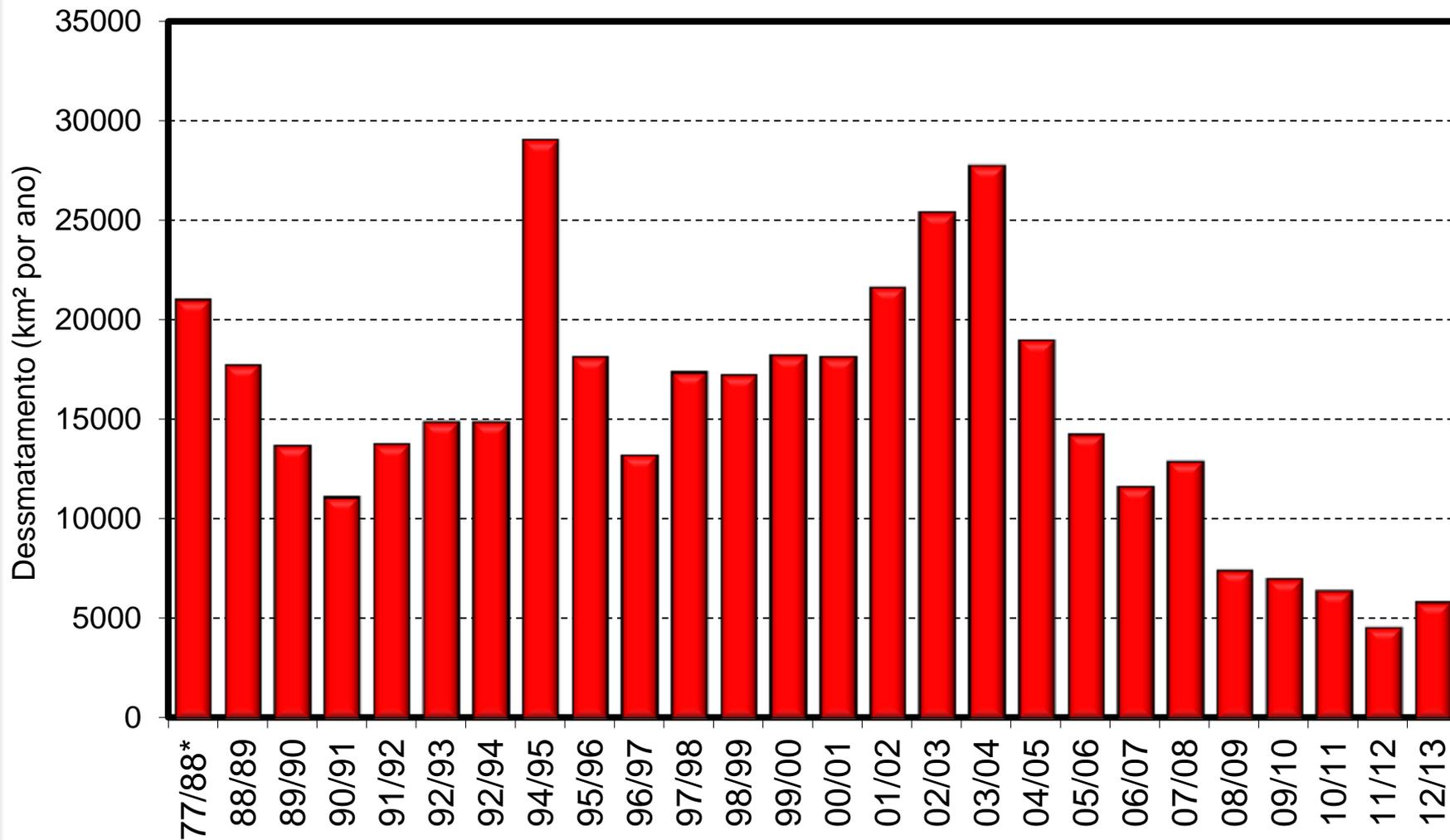
Marengo et al (2011b)

Vulnerabilidade nas grandes cidades

América Latina: 80% população urbana em 2012



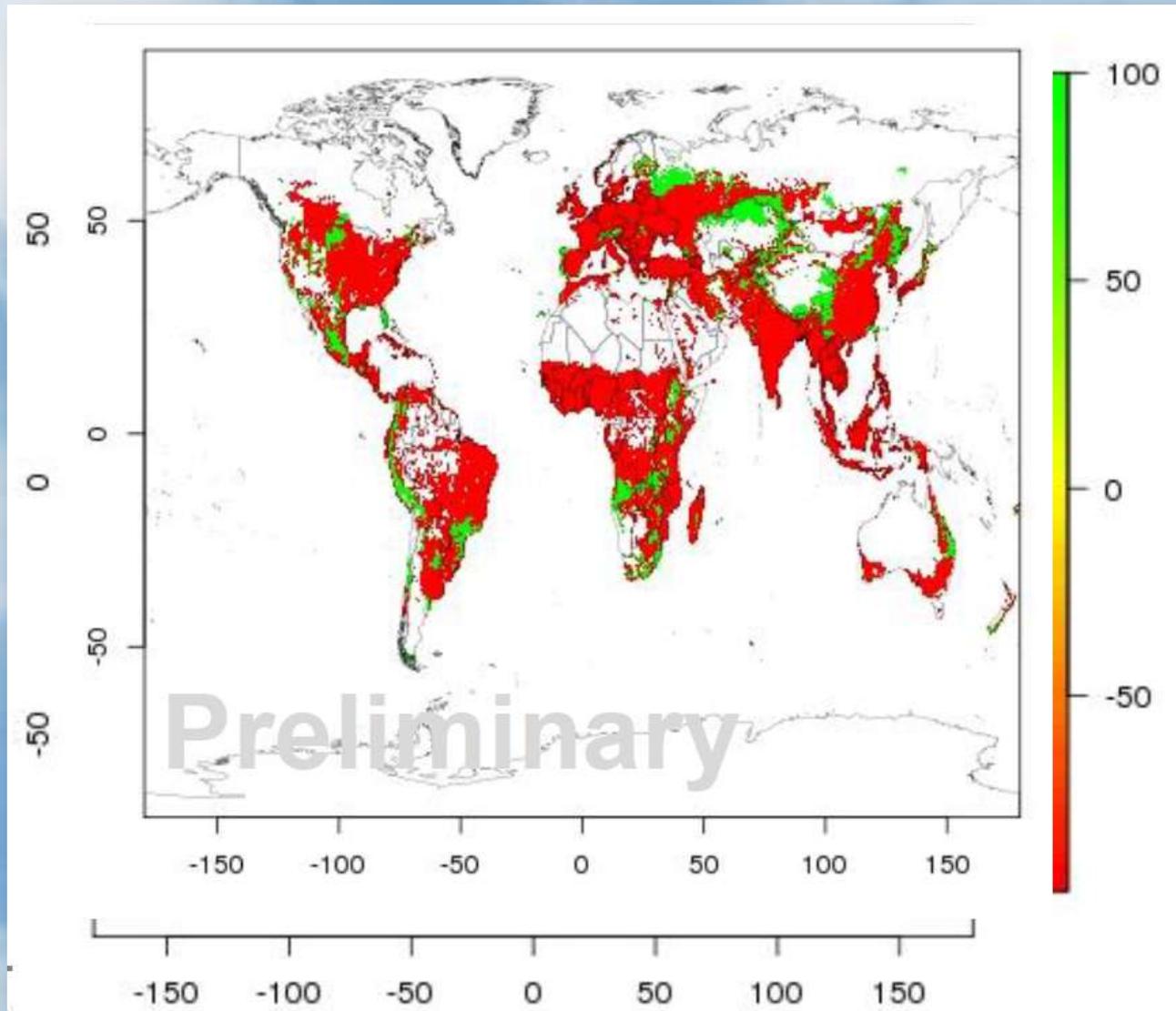
Desmatamento na Amazônia 1977-2013 em km² por ano



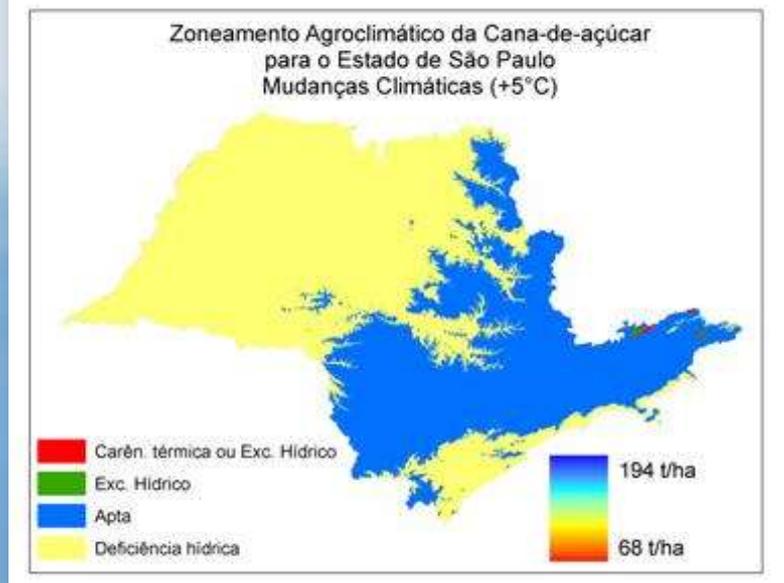
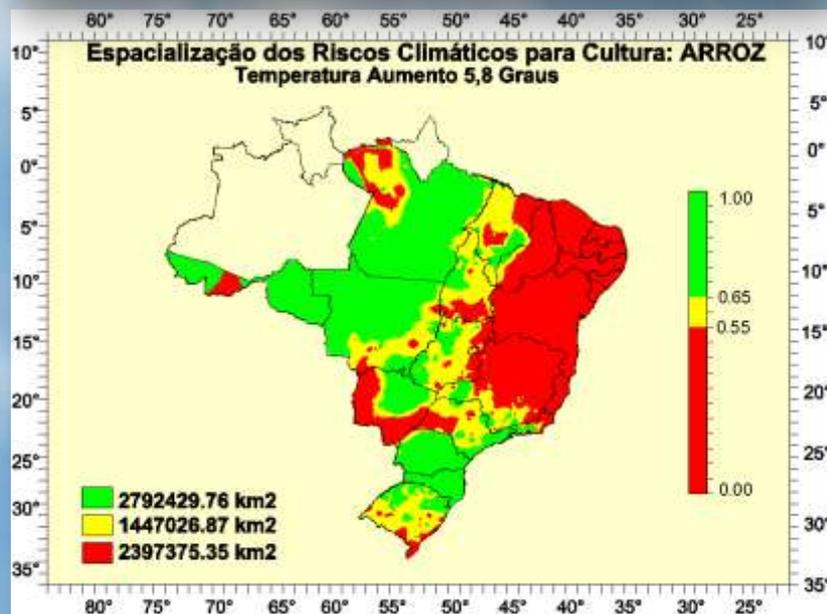
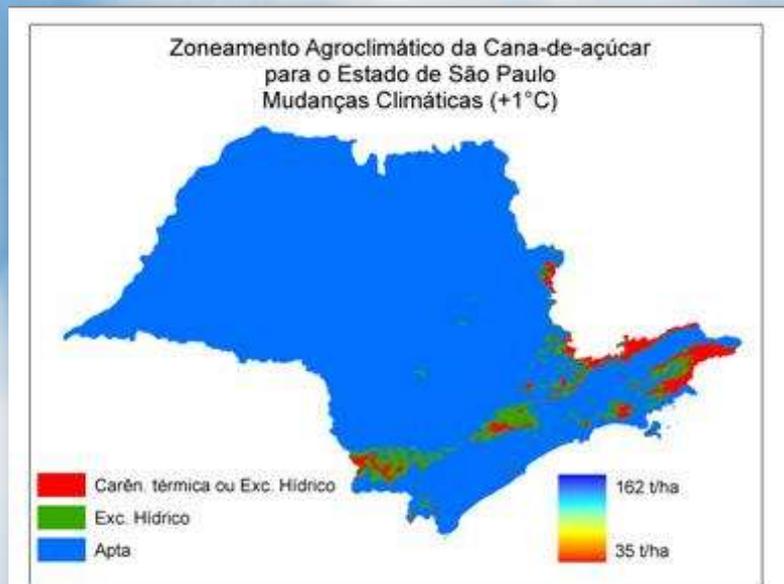
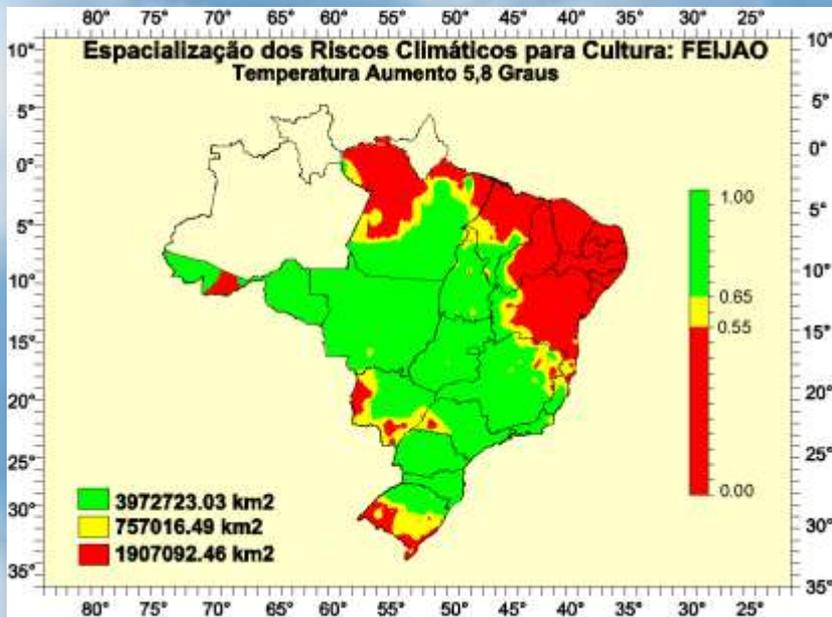
Relative change in calorie availability 2069-2099 vs. 1980-2010

HadGEM2-ES RCP 8.5
No CO₂ fertilization

12 crops: wheat, rice, maize, soy, cassava, millet, groundnuts, rapeseed, sugar beet, sugar cane, sunflower, field peas



Espacialização do risco climático para Feijão, Arroz e Cana-de-açúcar





Uma nova era ambiental já começou, com maiores riscos.

Adaptação à esta nova realidade é urgente...

Obrigado pela atenção !!!