



Mudanças Climáticas no Estado de São Paulo: Passado, Presente e Futuro

Tércio Ambrizzi

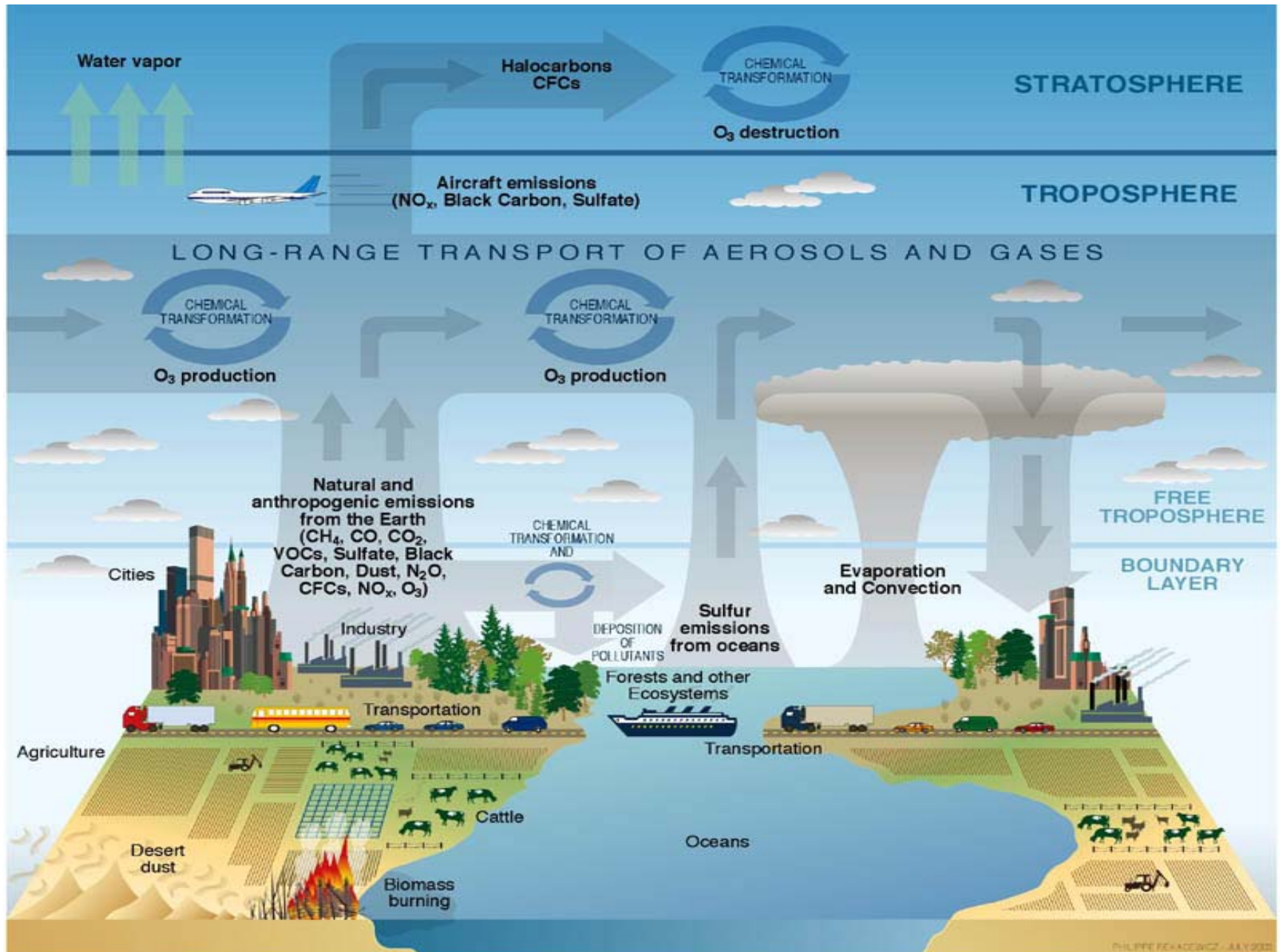
Departamento de Ciências Atmosféricas

Universidade de São Paulo

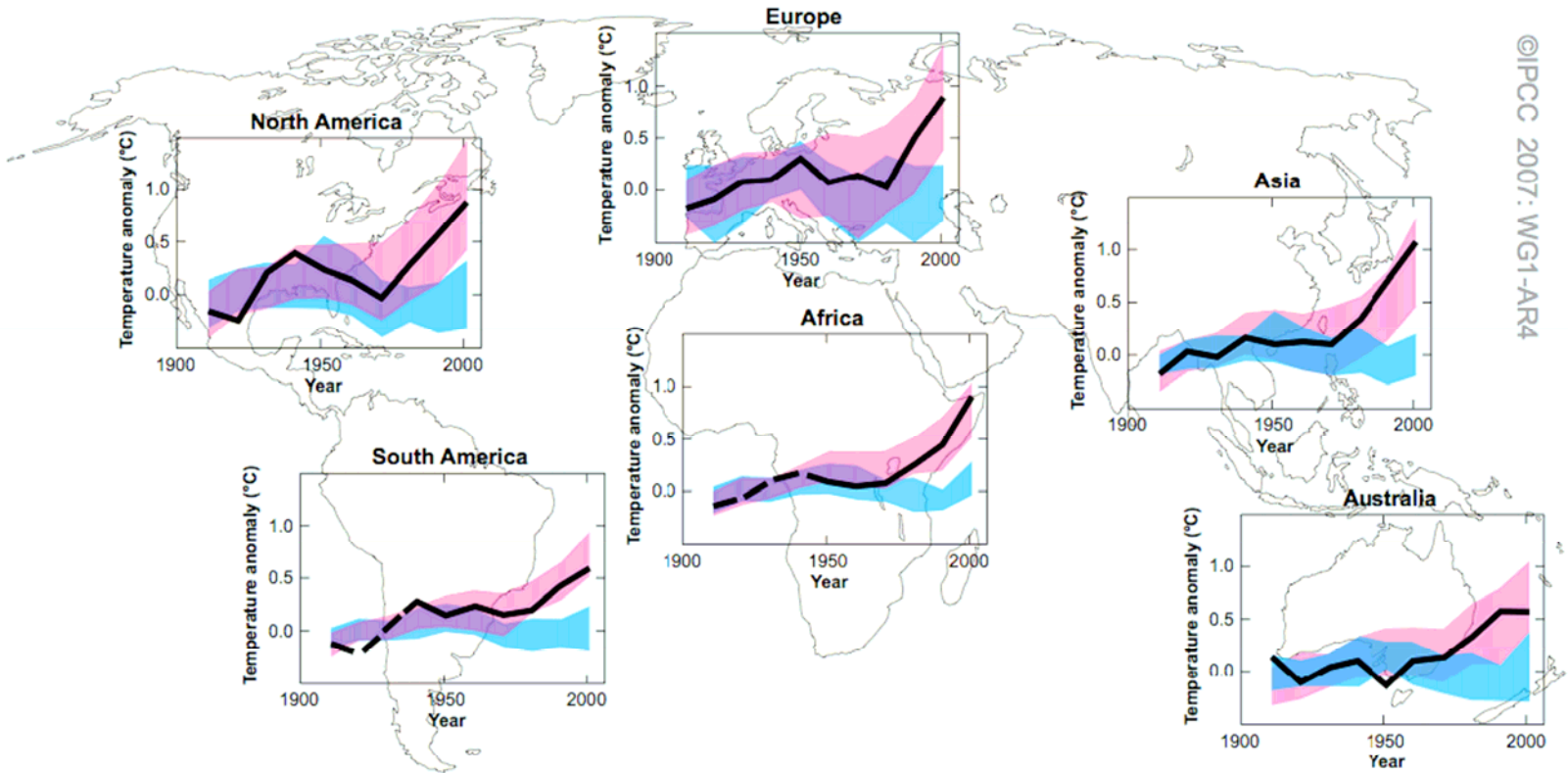
Impactos das Mudanças Climáticas e Cenários no Estado de São Paulo

CETESB – São Paulo

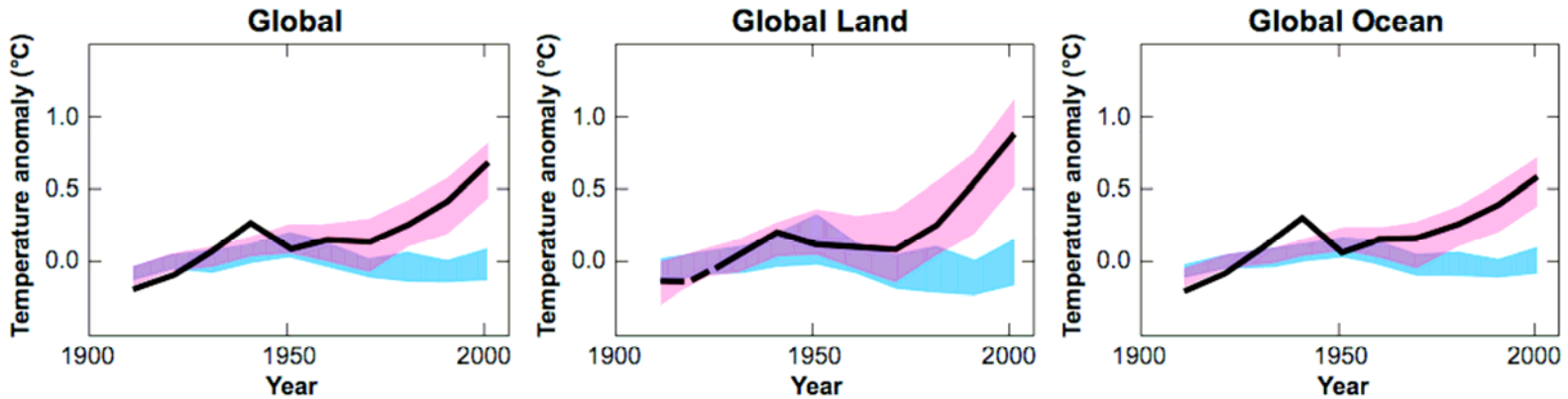
Junho/2007



Global and Continental Temperature Change



©IPCC 2007: WG1-AR4



(IPCC 2007)

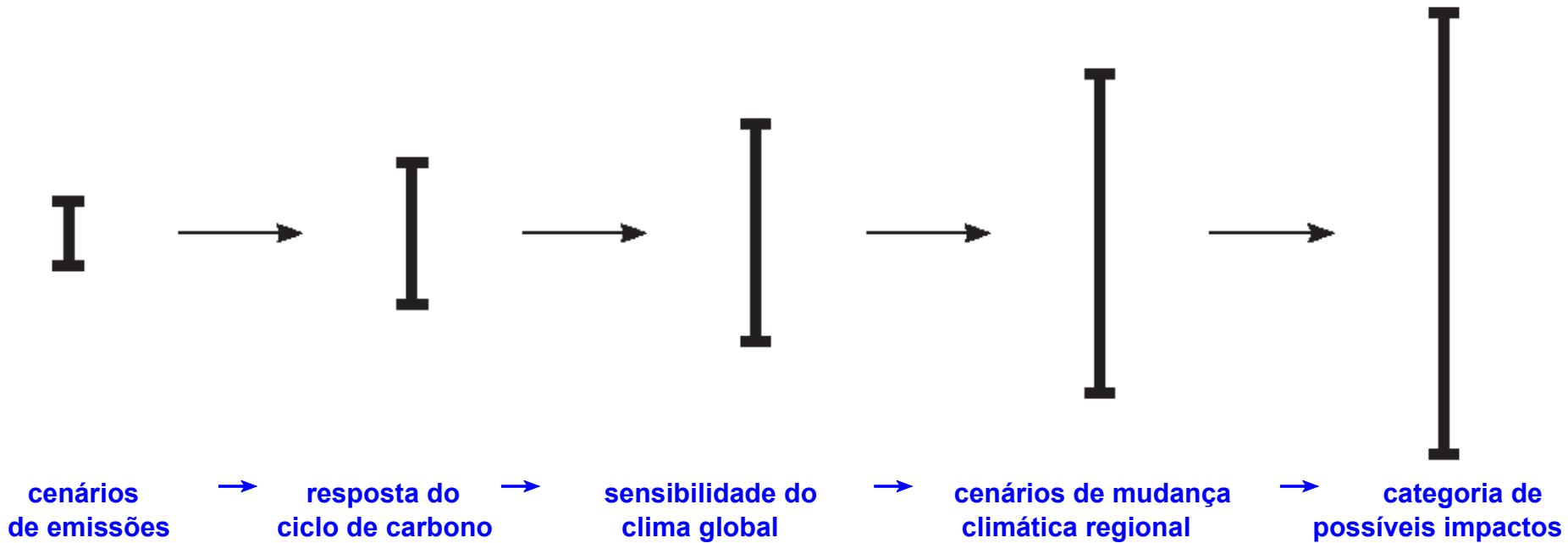
O que são cenários?

Um cenário é:

“Uma descrição de um estado futuro do mundo, coerente, internamente consistente e plausível”

- *Não é um prognóstico ou uma previsão*
- *É como uma série de imagens de como poderíamos ver o mundo no futuro*

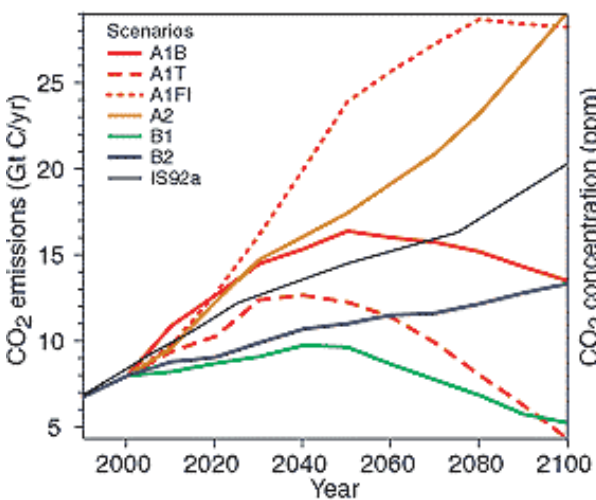
É importante ter em mente que



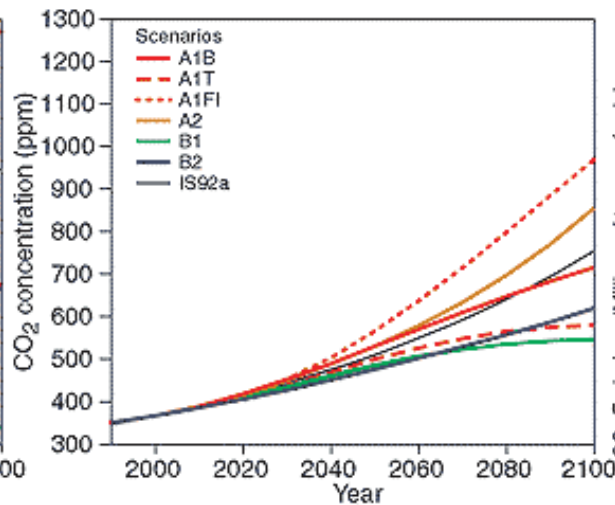
Cascata de incertezas na relação entre emissões e impactos

O CLIMA GLOBAL NO SÉCULO 21

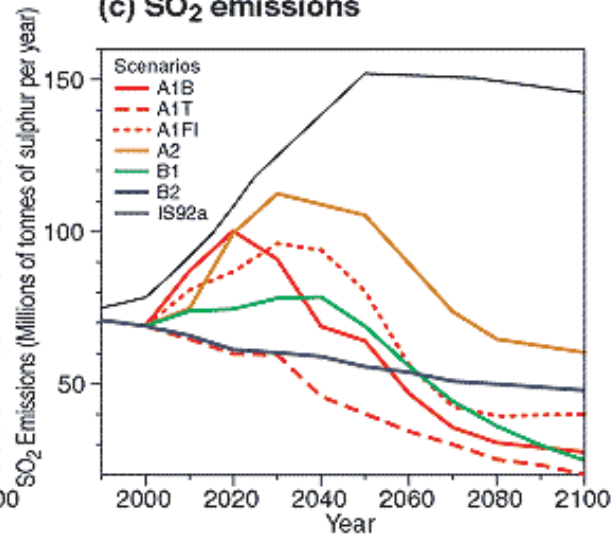
(a) CO₂ emissions



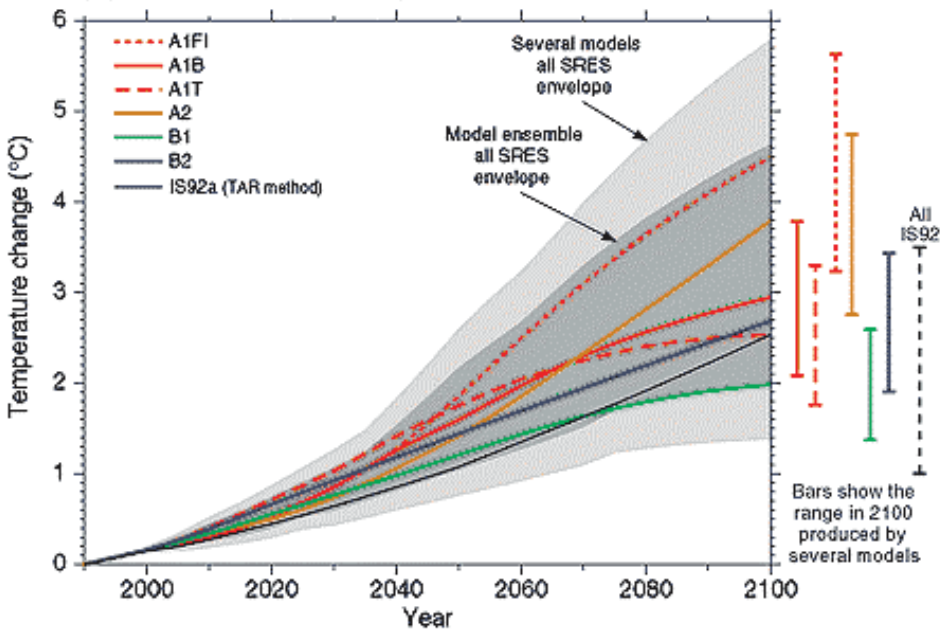
(b) CO₂ concentrations



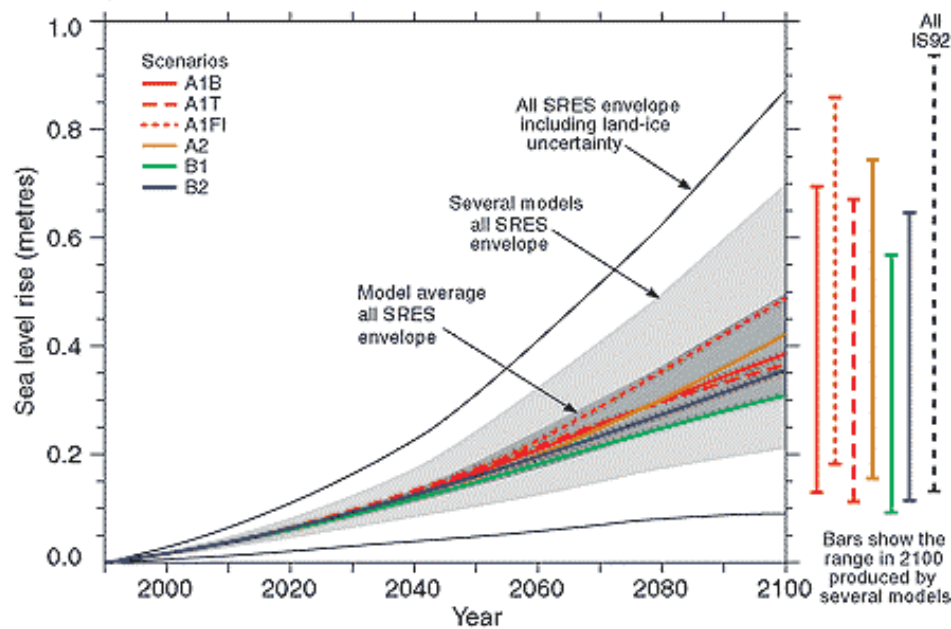
(c) SO₂ emissions



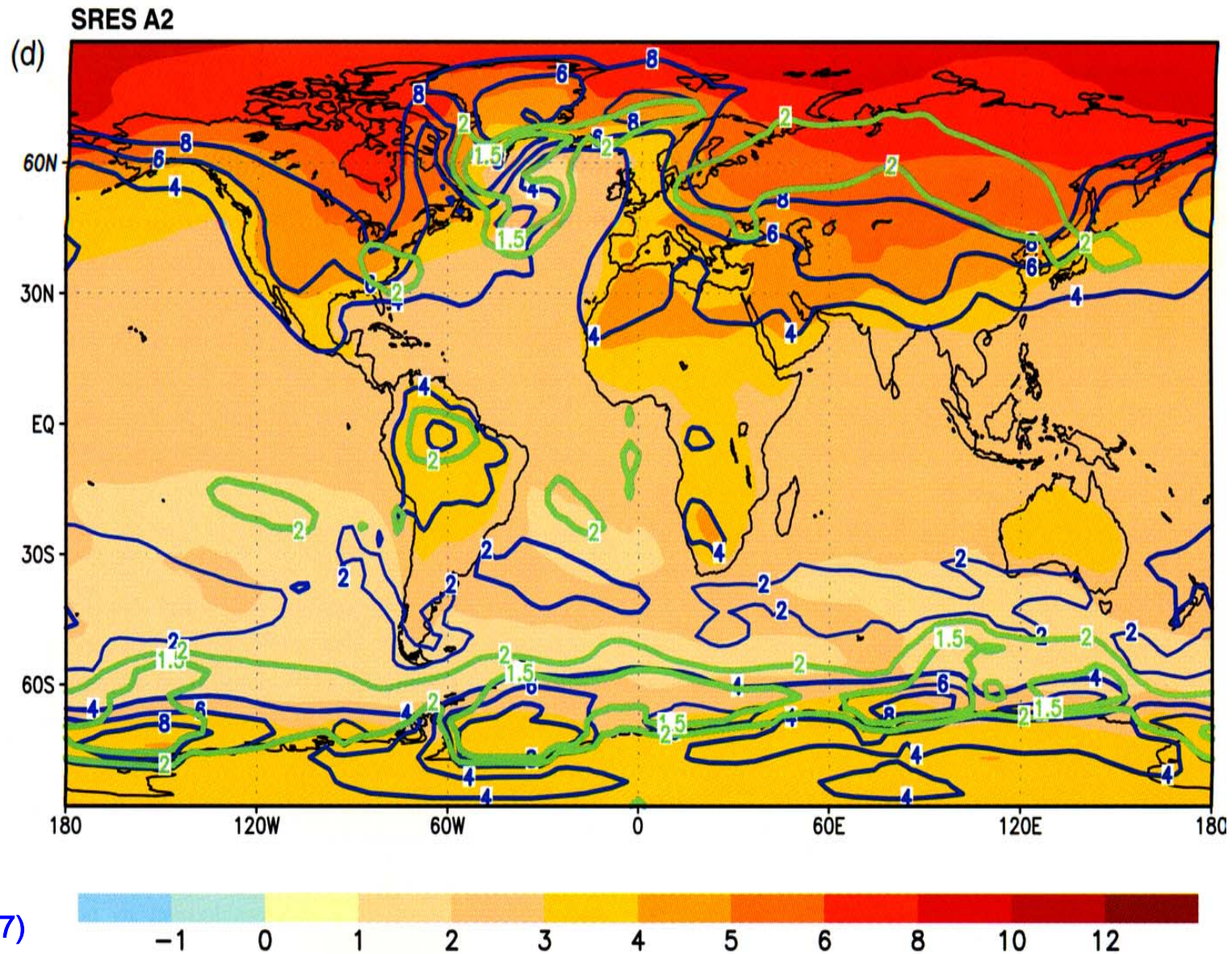
(d) Temperature change



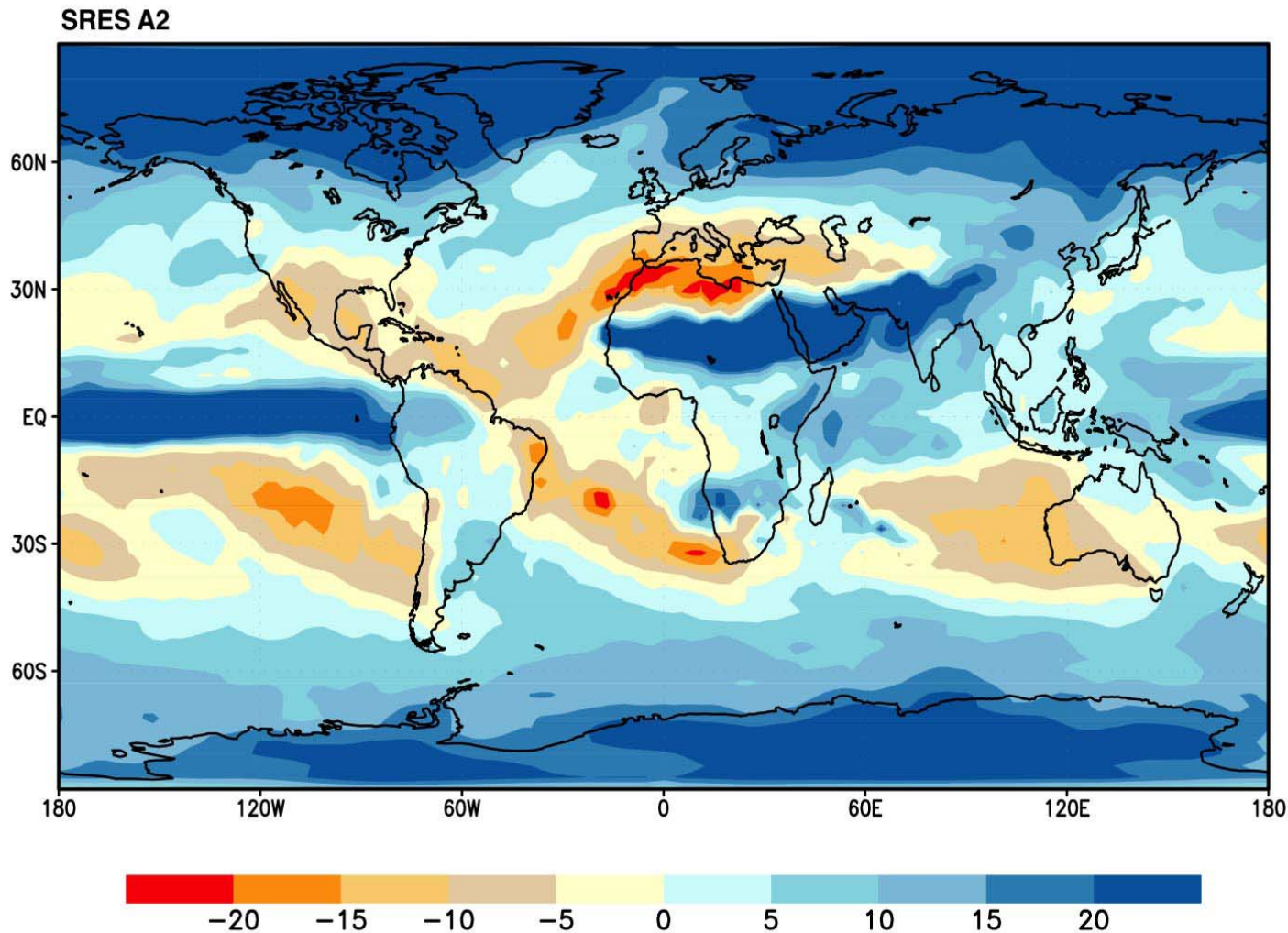
(e) Sea level rise



Projeção do aquecimento regional em 2070, com relação a 1990:efeitos regionais muito diferenciados



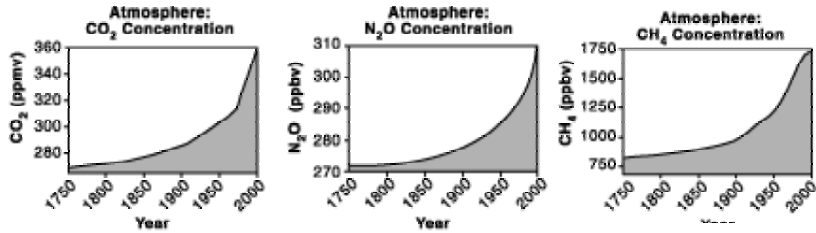
Mudança média anual na precipitação: 2100 relativo a 1990



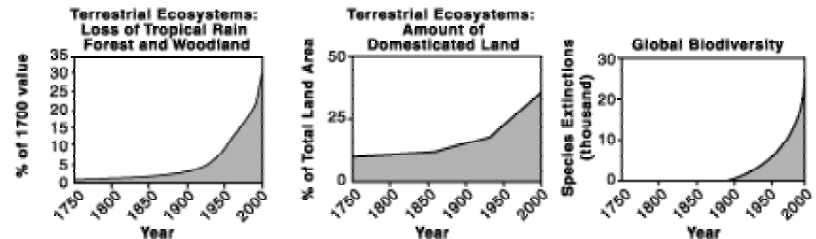
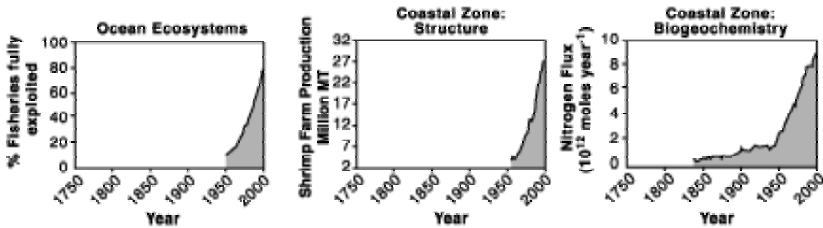
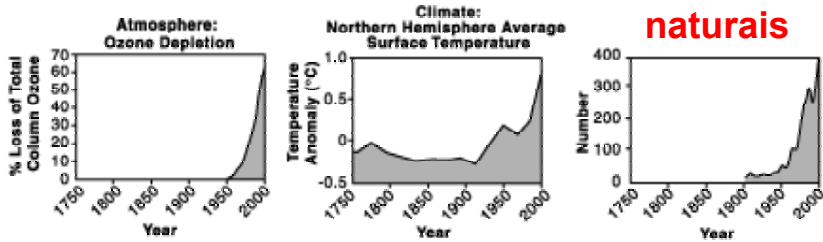
Deverá haver aumento de precipitação em algumas áreas, enquanto em outras haverá redução.

Mais mudanças do que imaginamos...

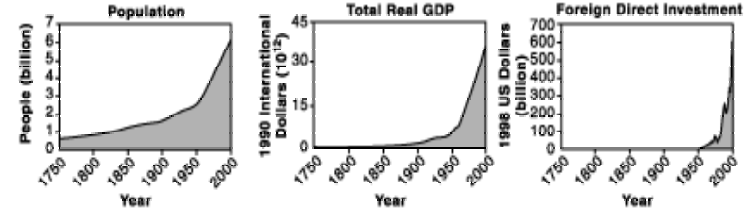
Concentração de GHG



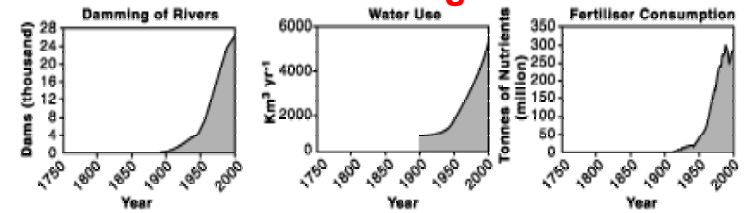
Desastres naturais



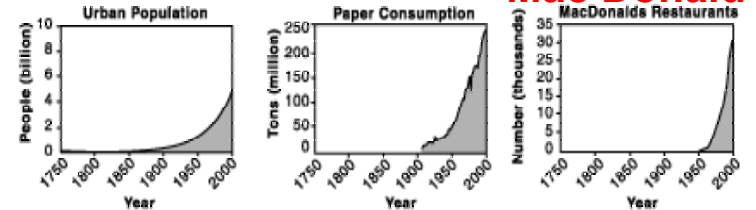
População



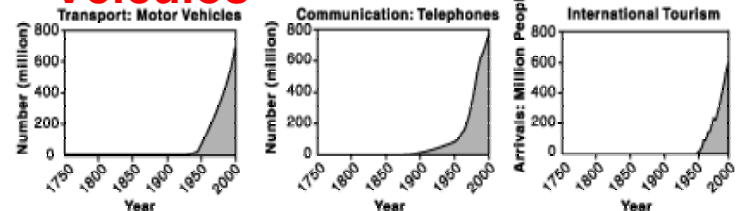
Uso de água



Mac Donald's



Veículos



VARIABILIDADE CLIMÁTICA OU MUDANÇA CLIMÁTICA? IMPACTOS REGIONAIS...



Evento Katrina – Agosto 2005

O verão de 2003 foi o mais quente nos últimos anos na Europa

Portugal:
fogo nas
florestas

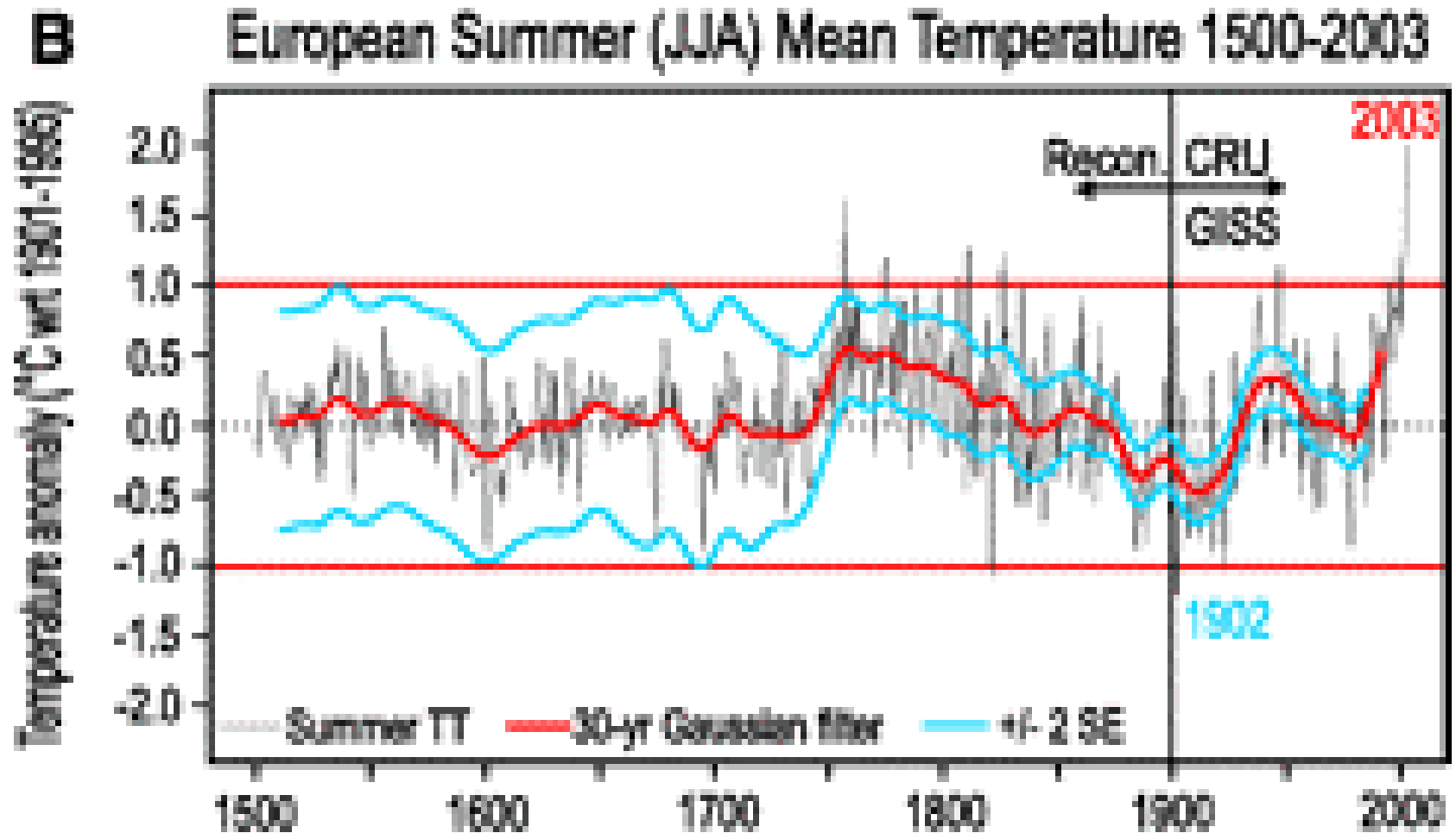


França: + de
14.000 mortes
relacionadas
com o calor



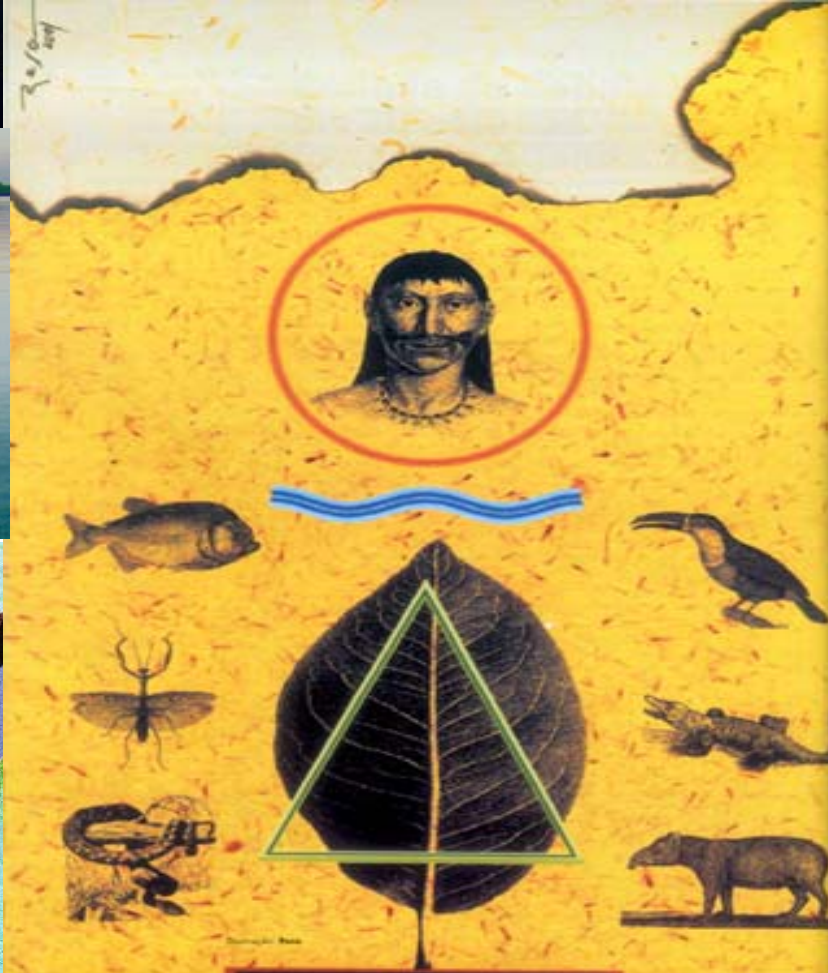
UK e Alemanha:
atrasos no sistema de
transporte ferroviário
(dilatação dos trilhos)

Muito provavelmente um dos verões mais quentes dos últimos 500 anos



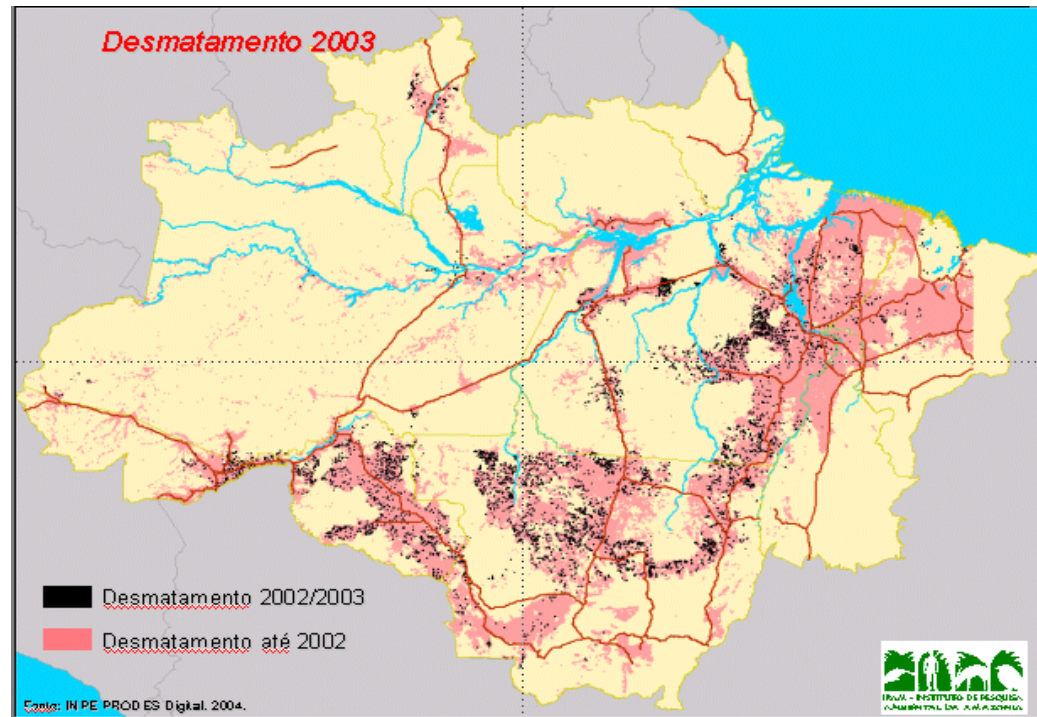
Amazônia

- 6 milhões de km² de floresta tropical
- 1/3 da biodiversidade do planeta
- chuva abundante (2-3 m anualmente)
- 18% da água doce do globo despejada nos oceanos
- diversidade biológica, ecossistêmica e de etnias

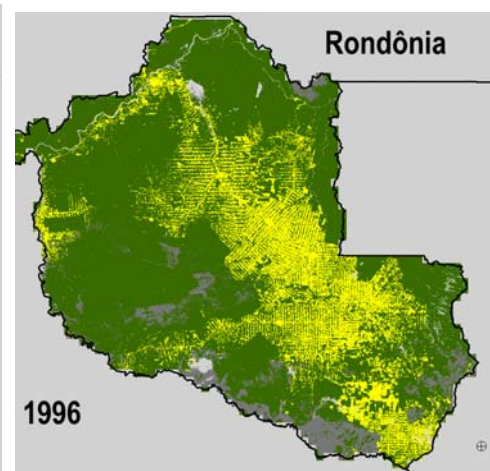
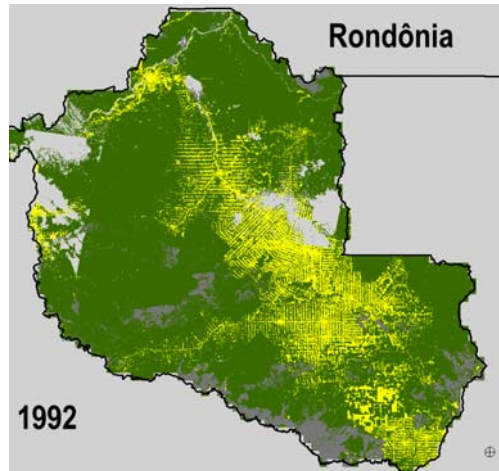
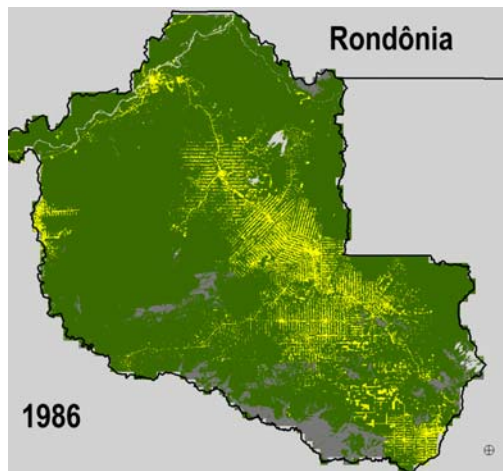




RONDÔNIA

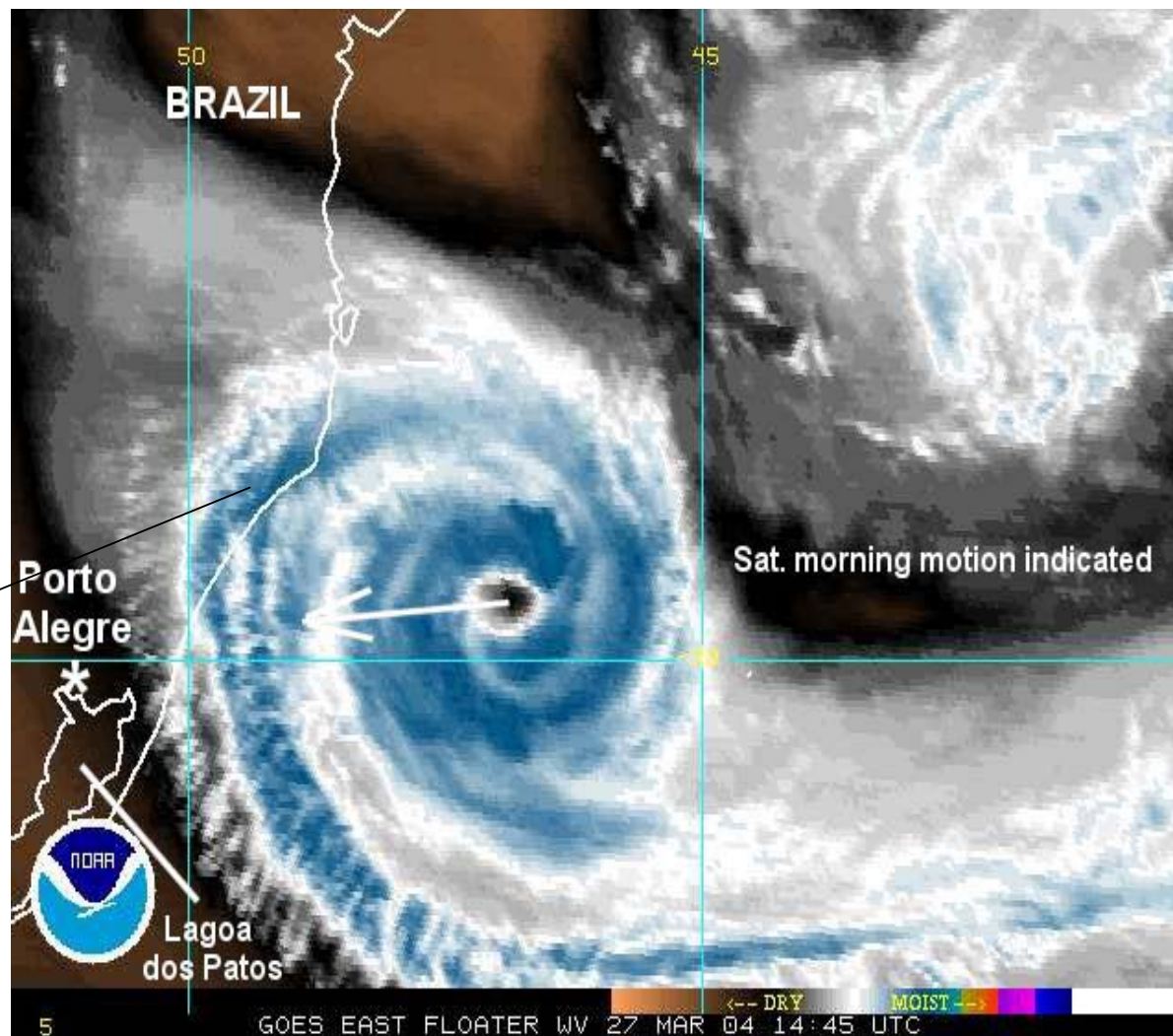


Mudanças no uso da terra...

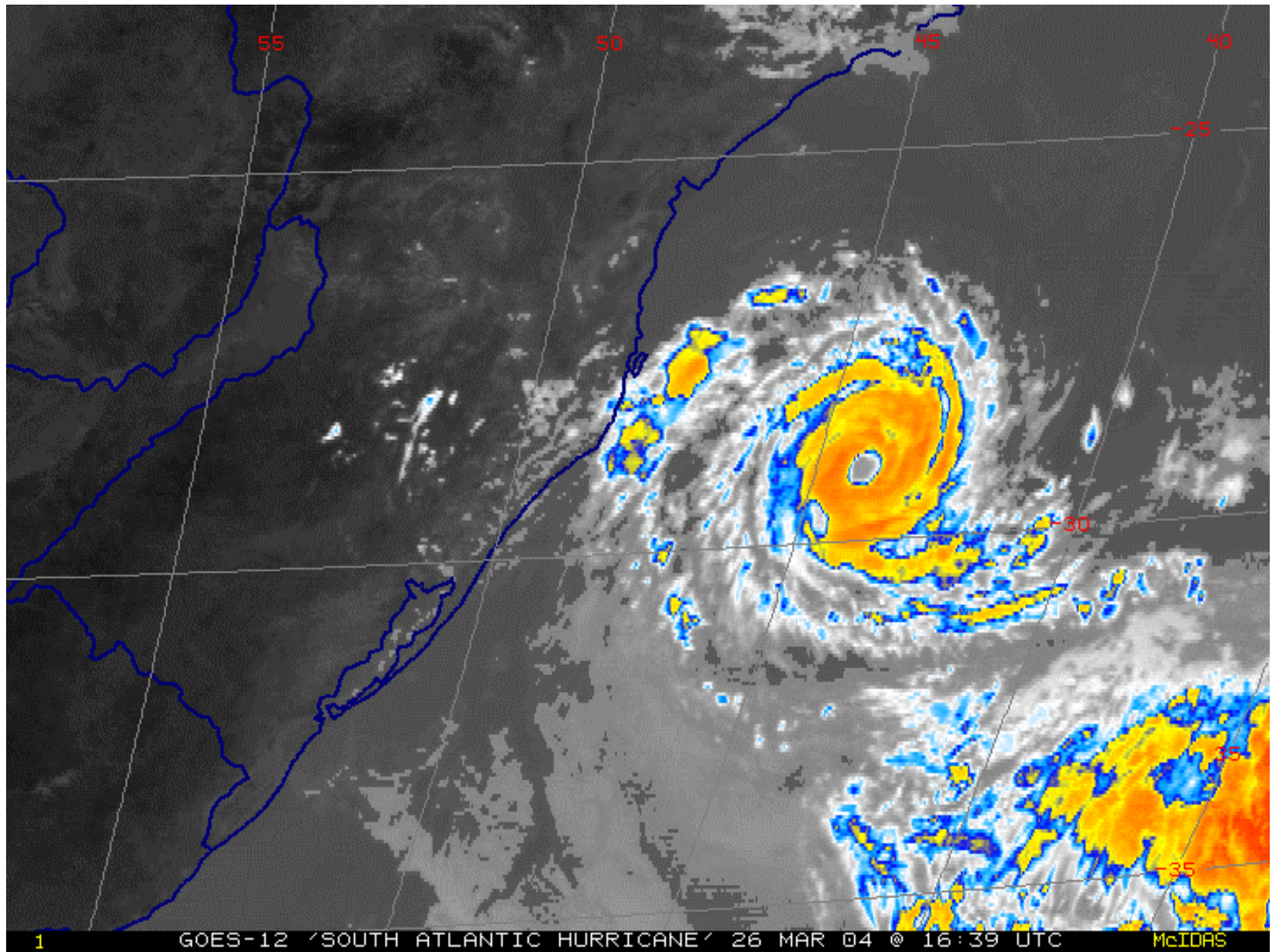


Catarina: O primeiro furacão no oceano Atlântico Sul?

Estado de Santa Catarina



“Furacão Catarina”, 27 Março de 2004 at 11:04:45 Local Time



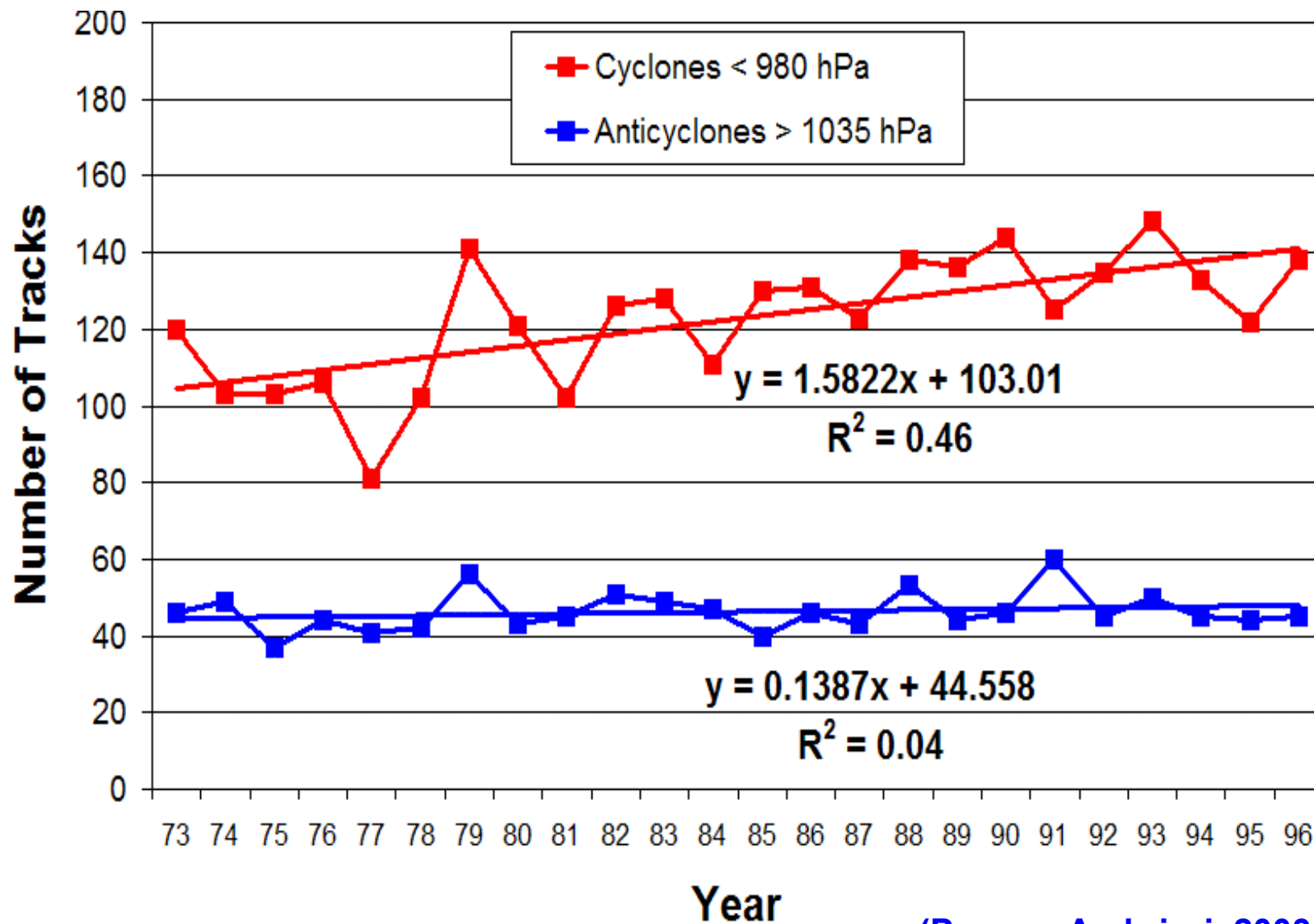
1

GOES-12 / SOUTH ATLANTIC HURRICANE / 26 MAR 04 @ 16:39 UTC

McIDAS

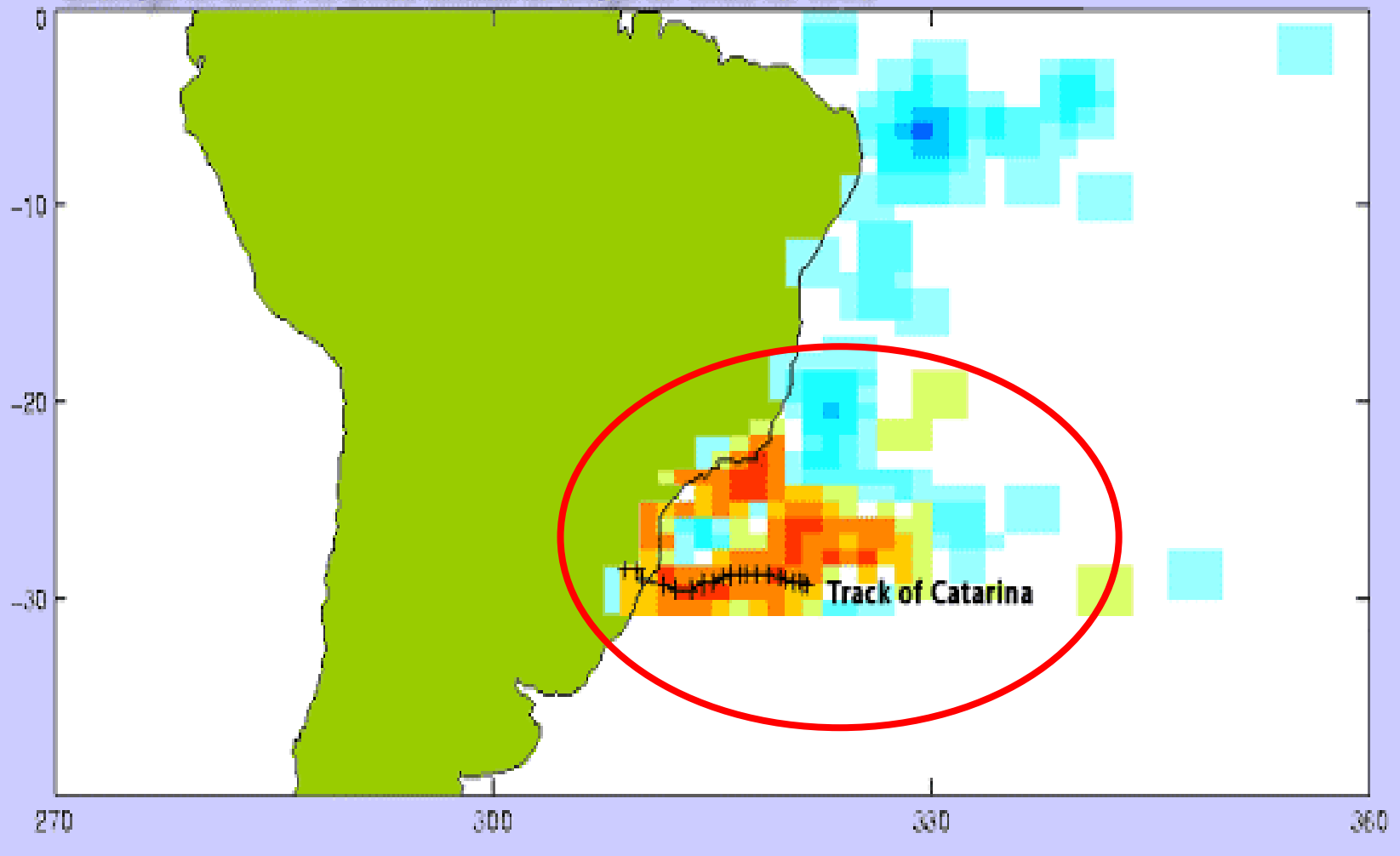


Tendências positivas do número de ciclones extratropicas intensos no Hemisfério Sul



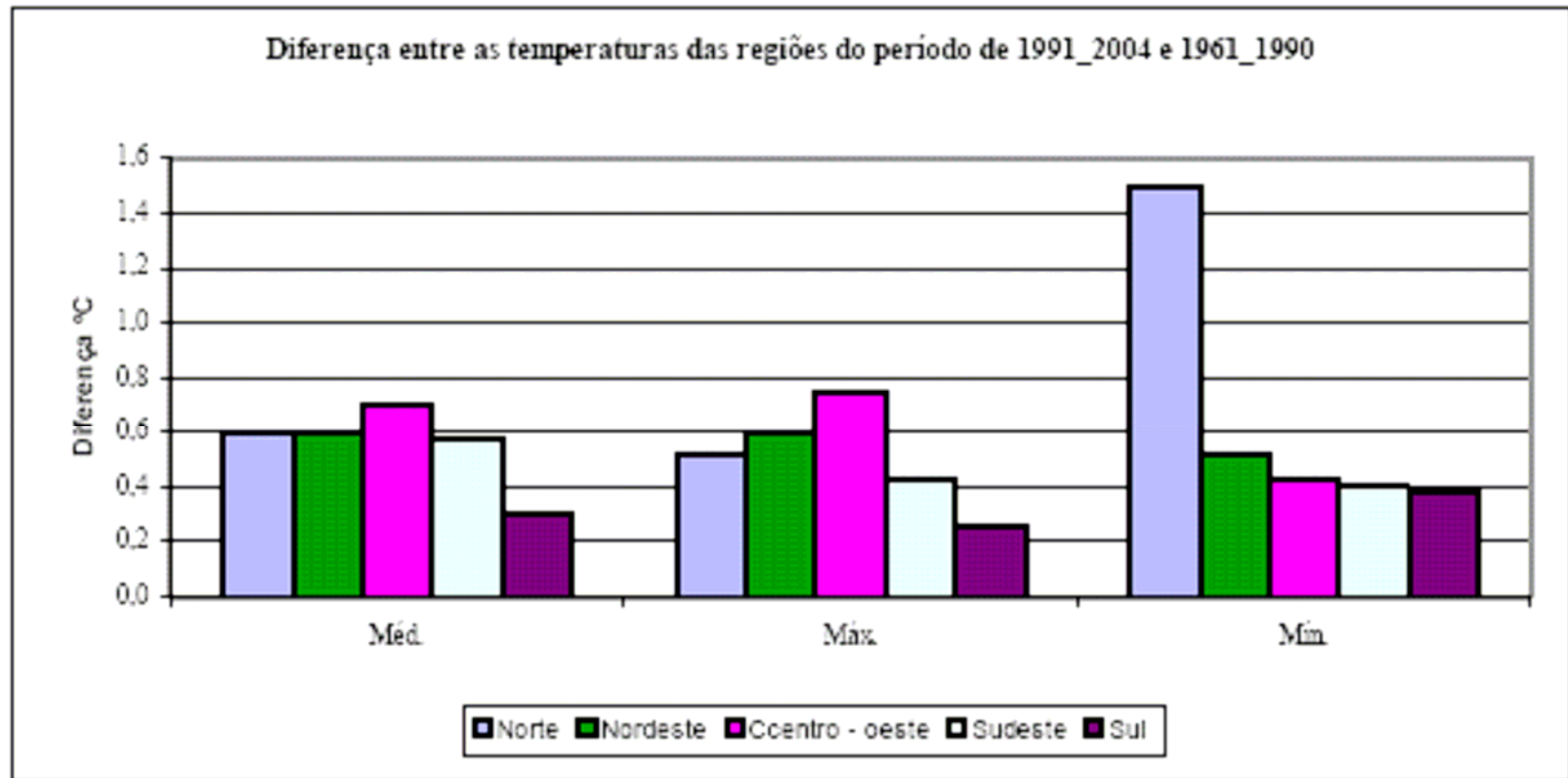
Future change in tropical storm genesis,
average of 2070 to 2100 minus average of 1960 to 1990

IPCC- A2



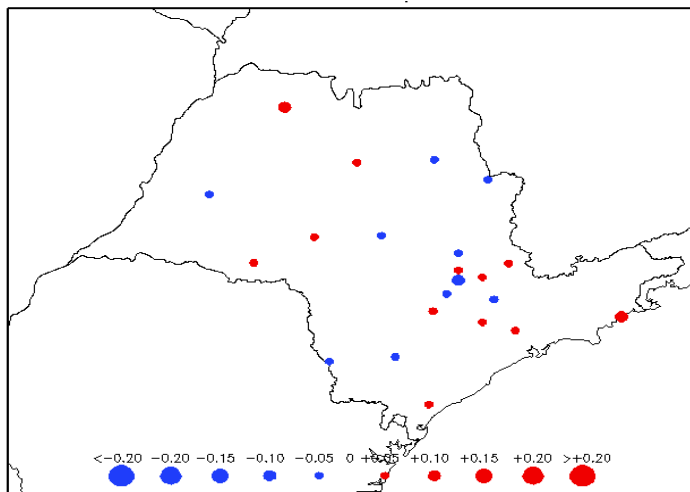
Na figura acima, as cores vermelhas mostram onde o modelo espera que haja um aumento na atividade de tempestades. As cruzes pretas mostram a trajetório do furação Catarina.

Diferença entre as temperaturas médias (média, máxima e mínima) do período de 1991 a 2004 e do período de 1961 a 1990.

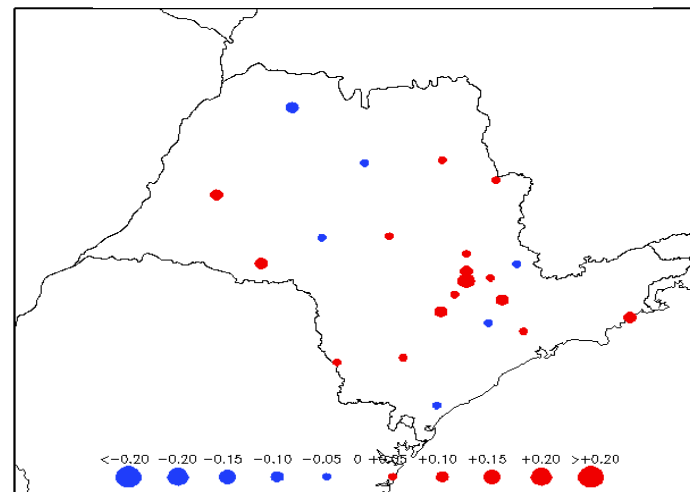


TENDÊNCIA ANUAL DAS Tmax E Tmin

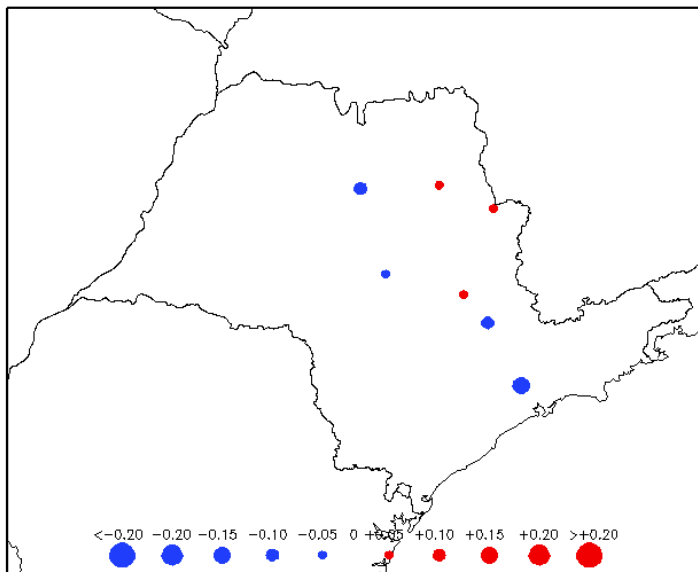
Temperatura máxima



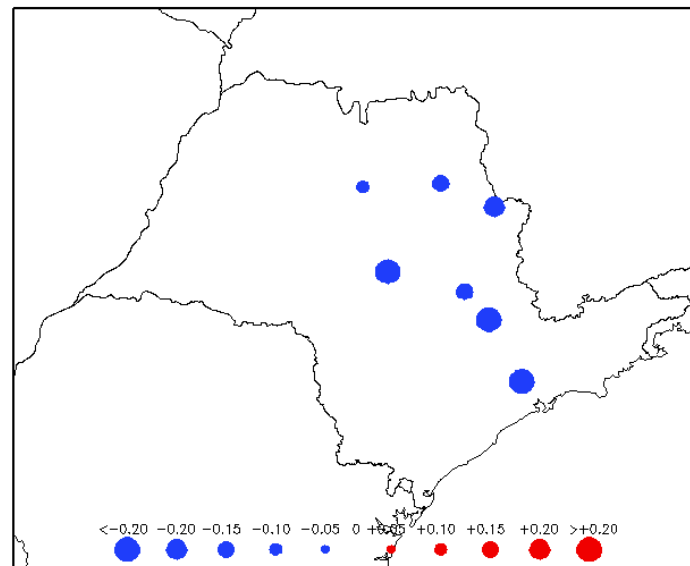
Temperatura mínima



Dias frios



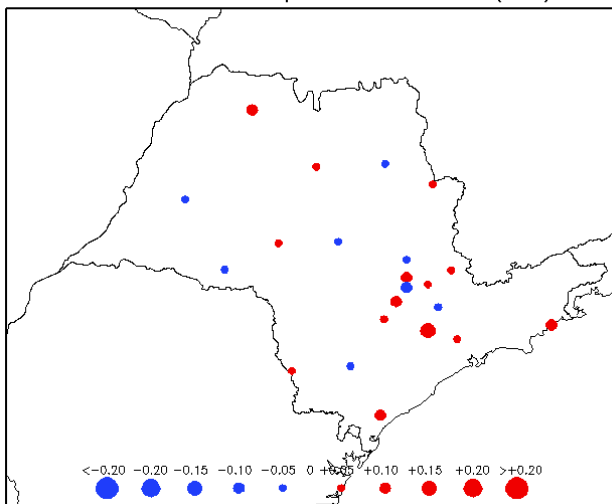
Noites frias



TENDÊNCIA SAZONAL DA Tmax

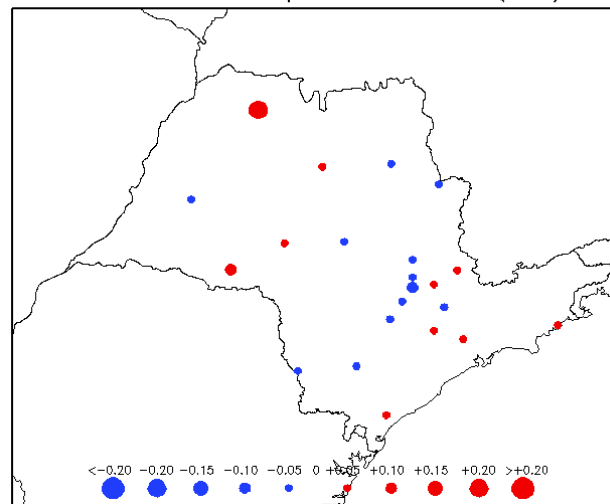
DJF

Tendencia da Temperatura Maxima (DJF)



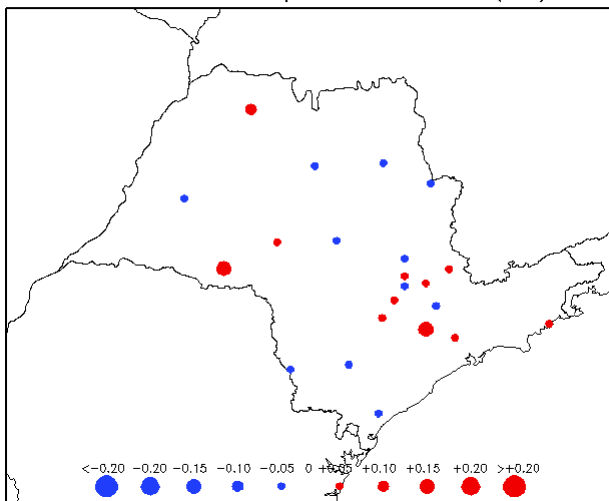
SON

Tendencia da Temperatura Maxima (SON)



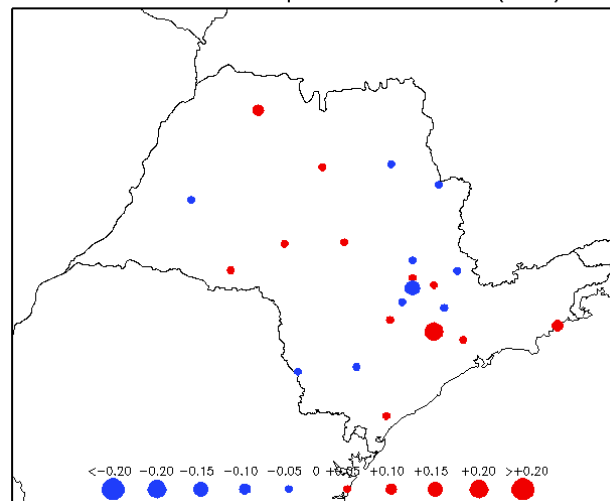
JJA

Tendencia da Temperatura Maxima (JJA)



MAM

Tendencia da Temperatura Maxima (MAM)



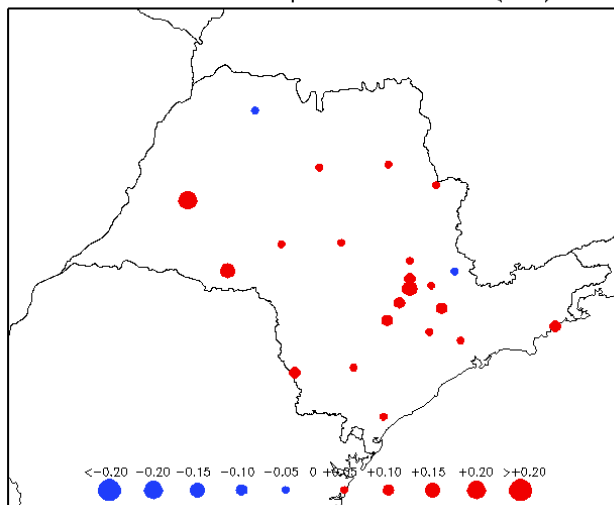
Dufek
e

Ambrizzi (2005)

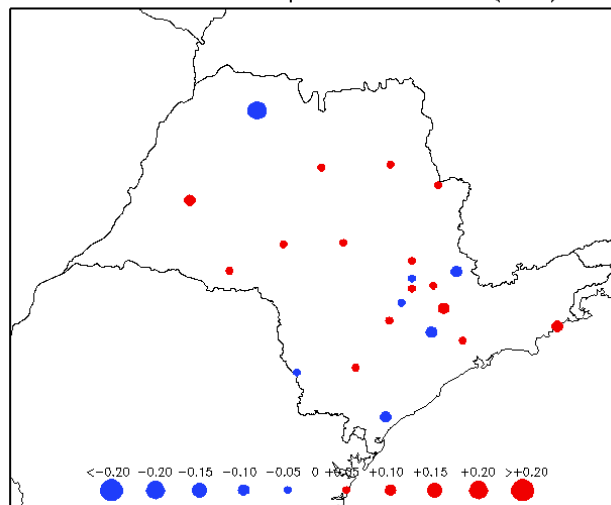
TENDÊNCIA SAZONAL DA T_{min}

DJF

Tendencia da Temperatura Mínima (DJF)



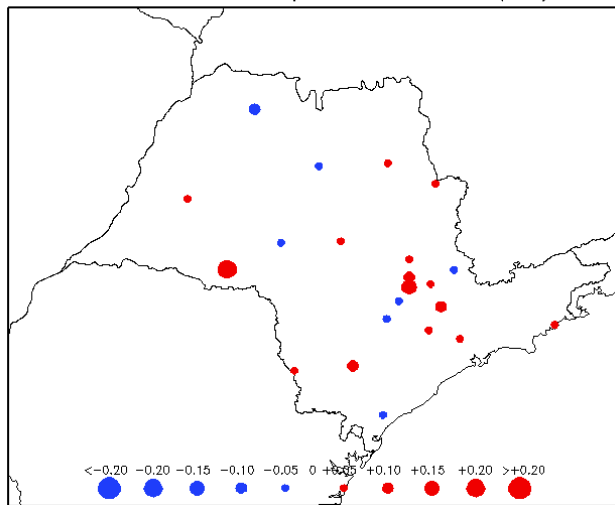
Tendencia da Temperatura Mínima (MAM)



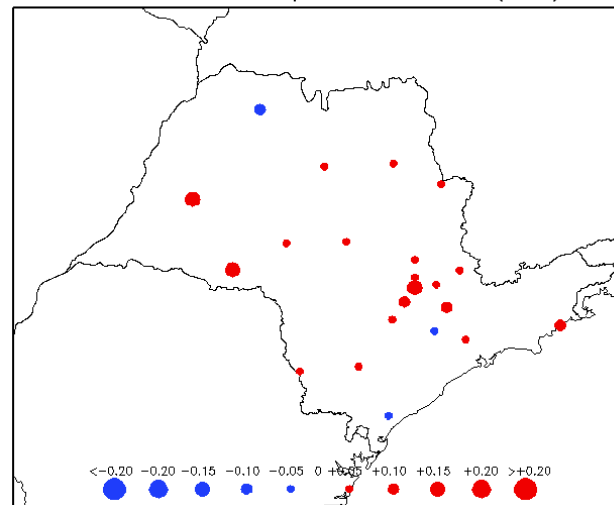
MAM

JJA

Tendencia da Temperatura Mínima (JJA)



Tendencia da Temperatura Mínima (SON)



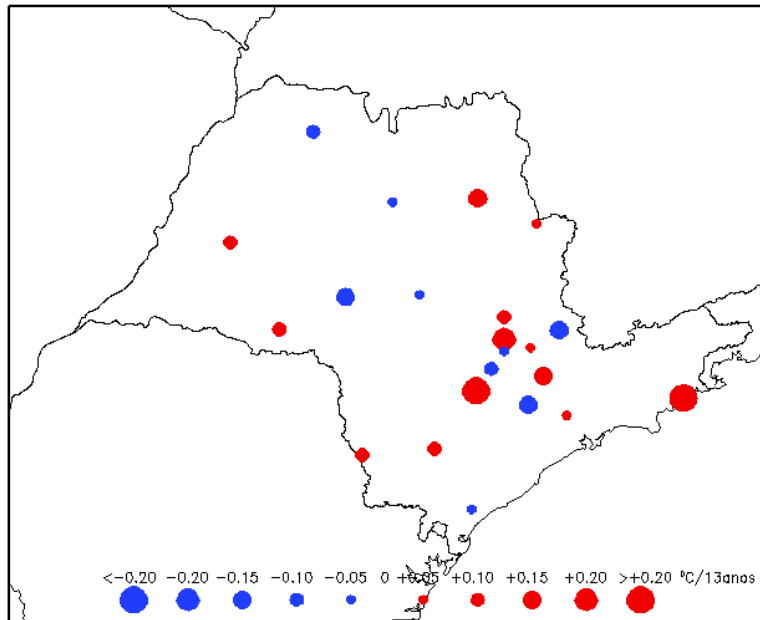
SON

Dufek
e

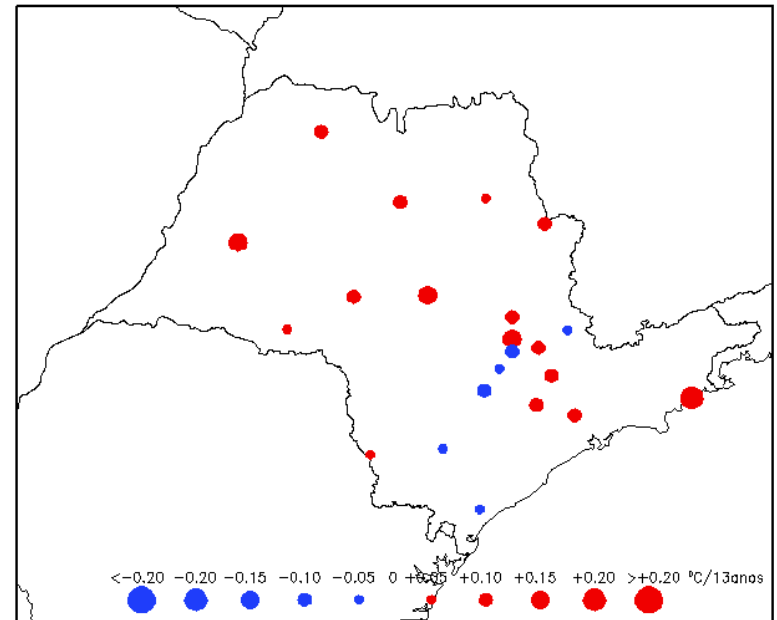
Ambrizzi (2005)

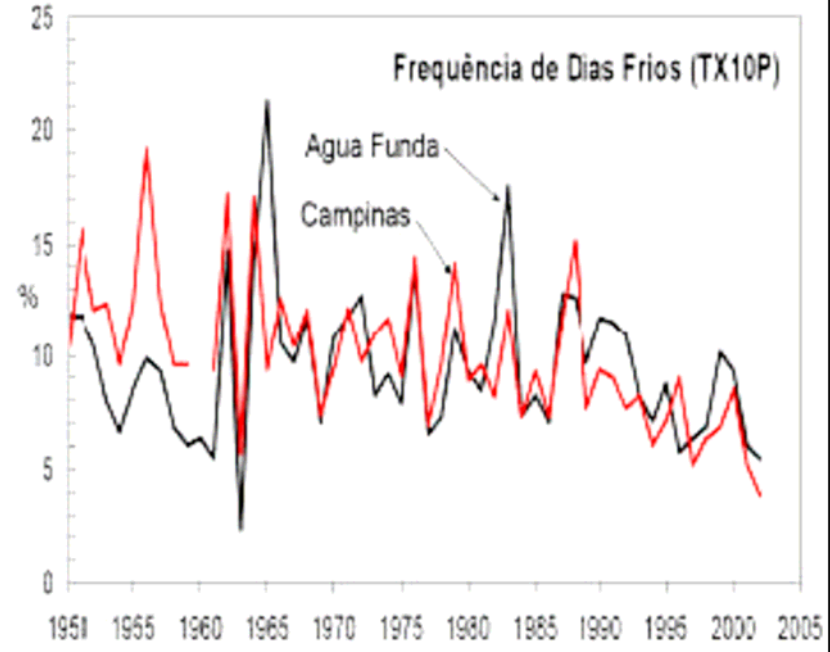
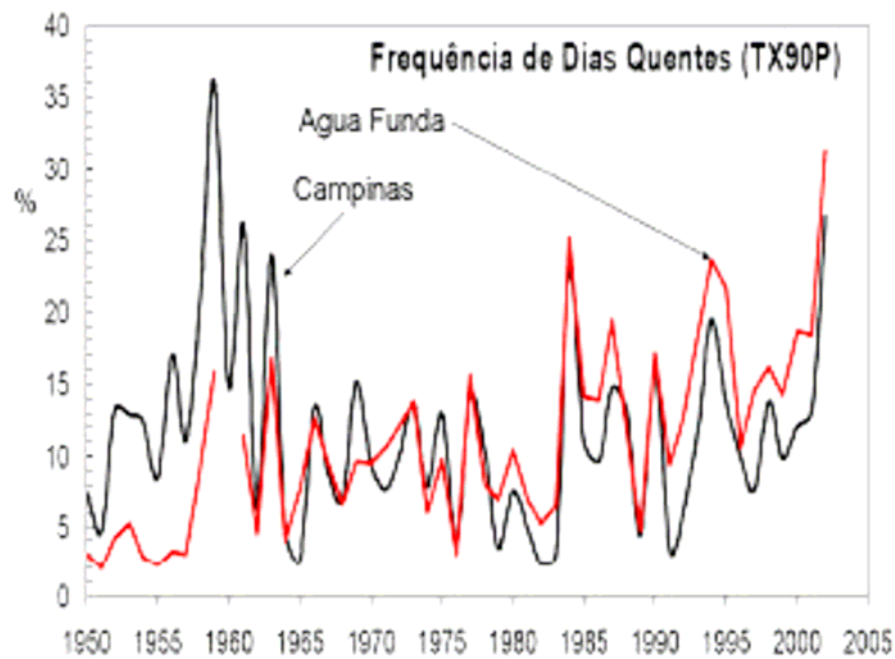
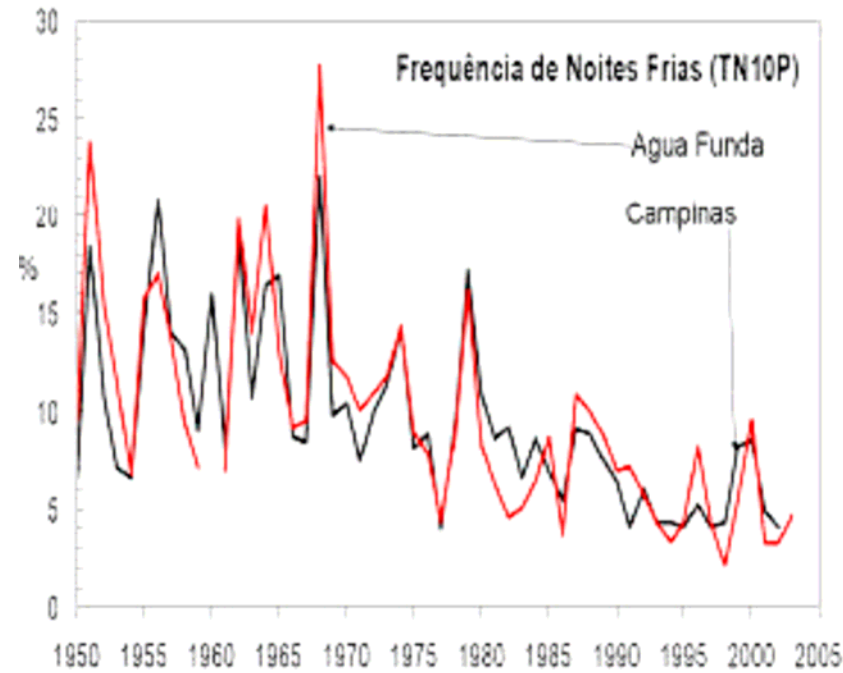
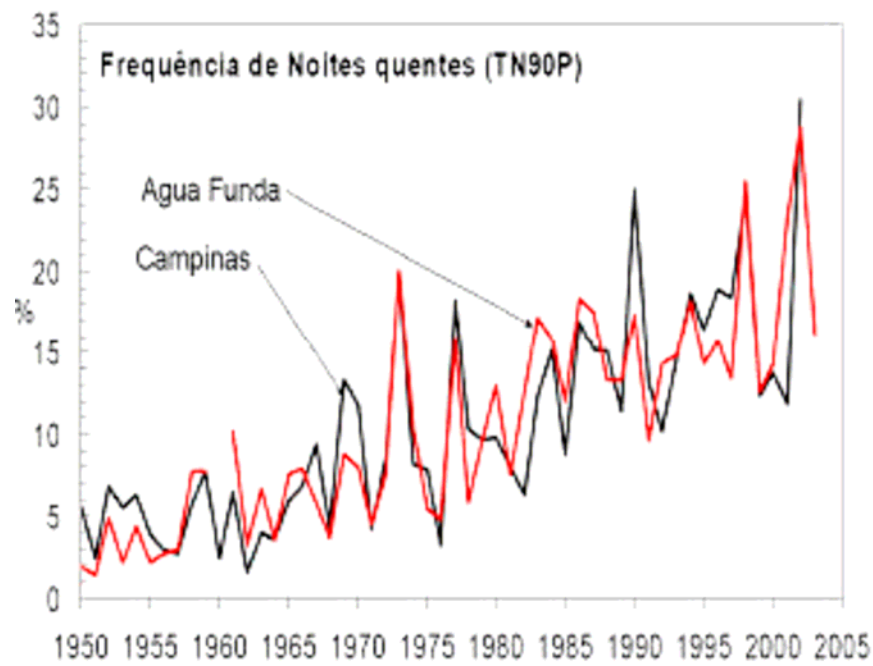
TENDÊNCIA ANUAL DA T_{max} E T_{min} PARA OS ULTIMOS 10 ANOS

Tendencia Anual da Temperatura Mínima: 1990 a 2002

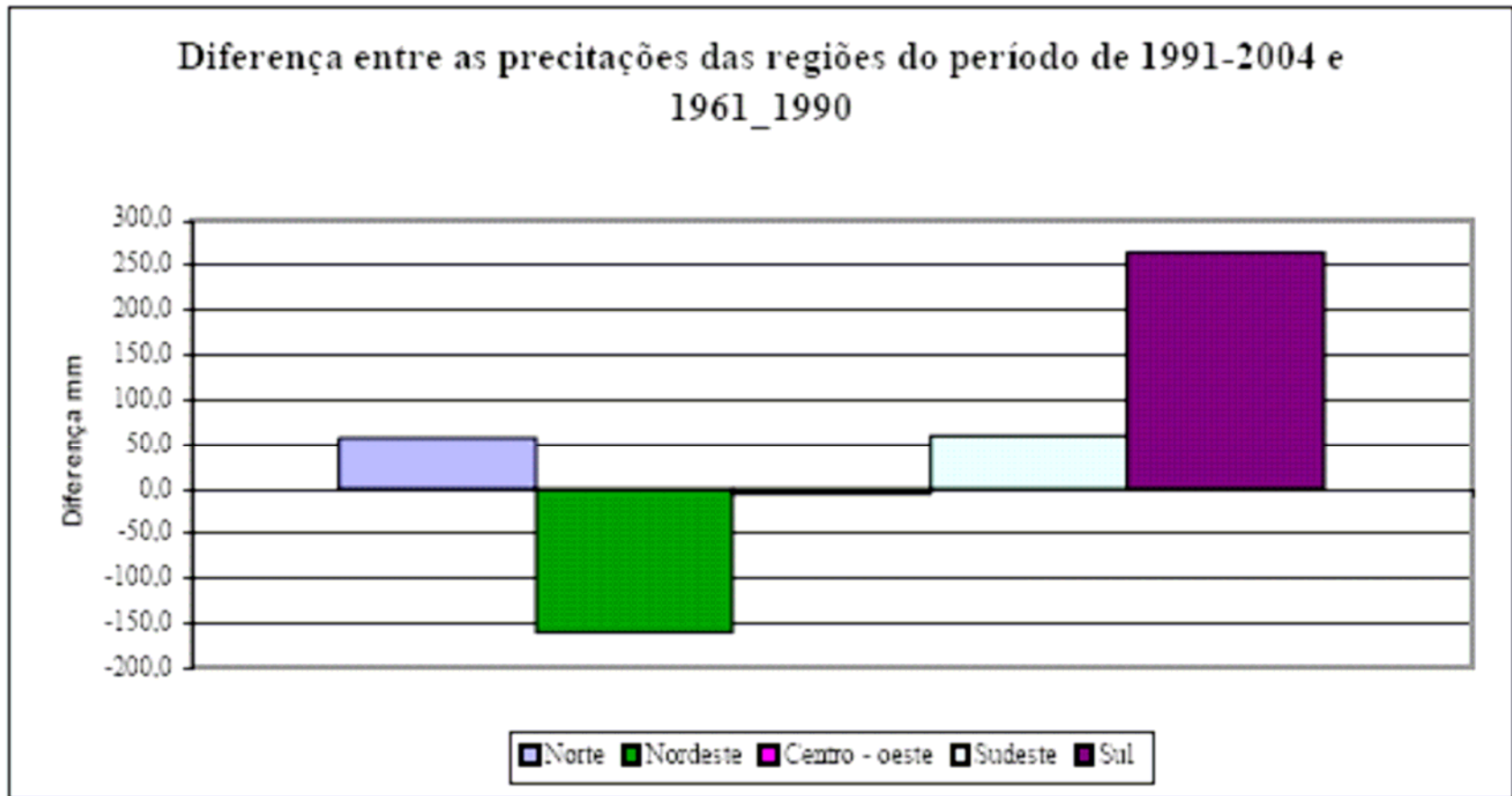


Tendencia Anual da Temperatura Máxima: 1990 a 2002



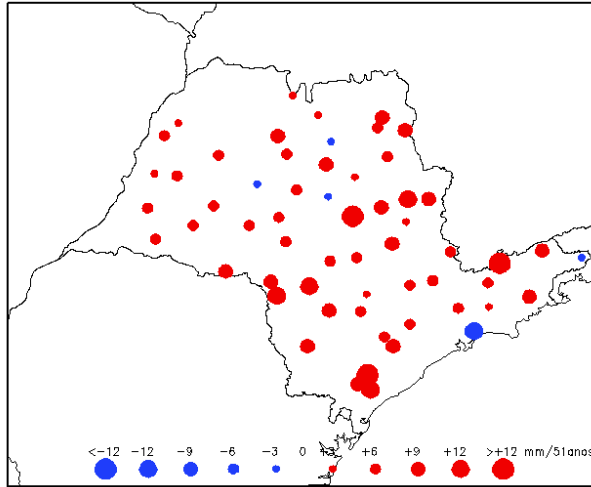


Diferença entre as precipitações médias do período de 1991 a 2004 e do período de 1961 a 1990

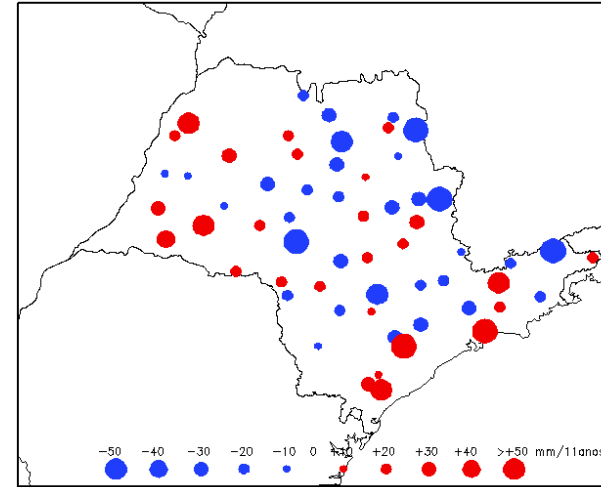


TENDÊNCIA ANUAL E DOS ÚLTIMOS 10 ANOS DA PRECIPITAÇÃO NO ESTADO DE SÃO PAULO

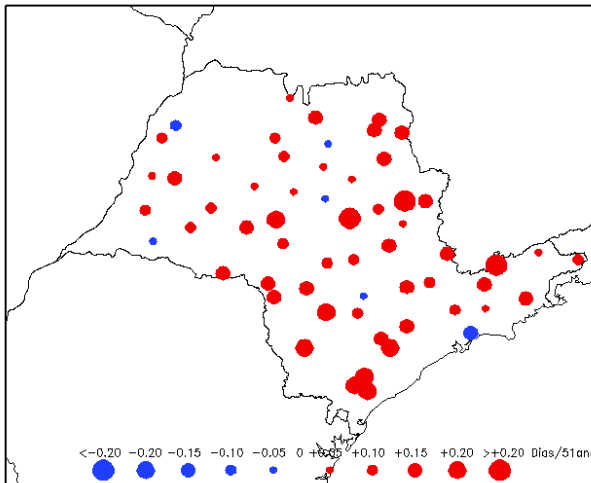
Tendência Anual do PRCPTOT: 1950 a 2000



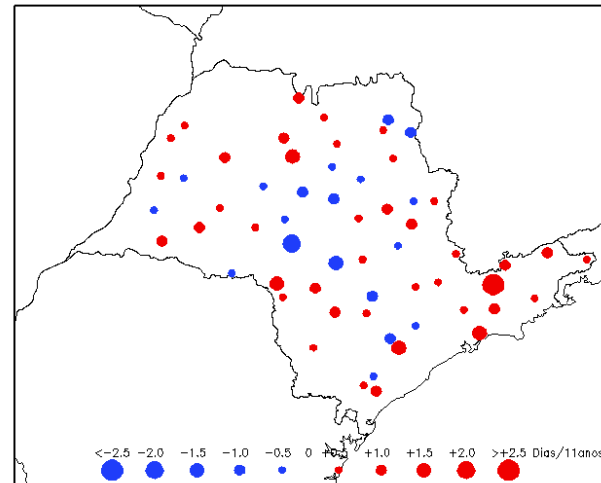
Tendência Anual do PRCPTOT: 1990 a 2000



Tendência Anual do R20mm: 1950 a 2000

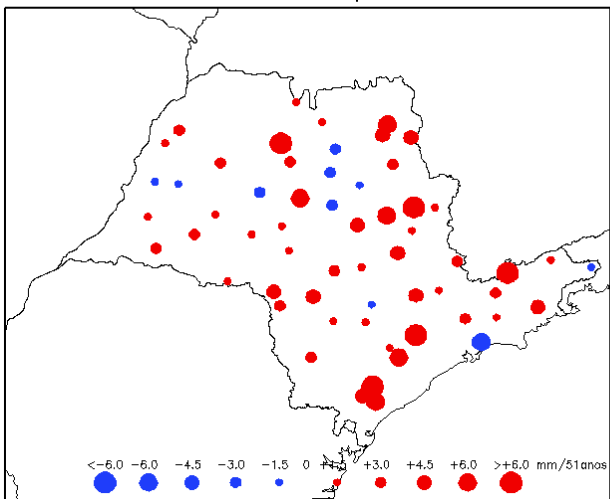


Tendência Anual do R20mm: 1990 a 2000

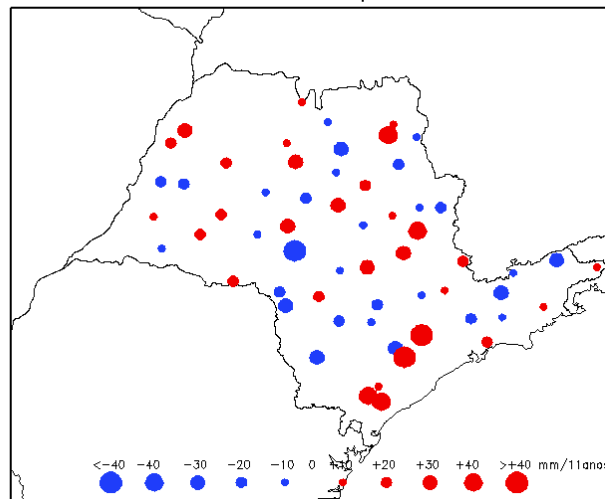


TENDÊNCIA ANUAL E DOS ULTIMOS 10 ANOS DE EVENTOS EXTREMOS DE PRECIPITAÇÃO

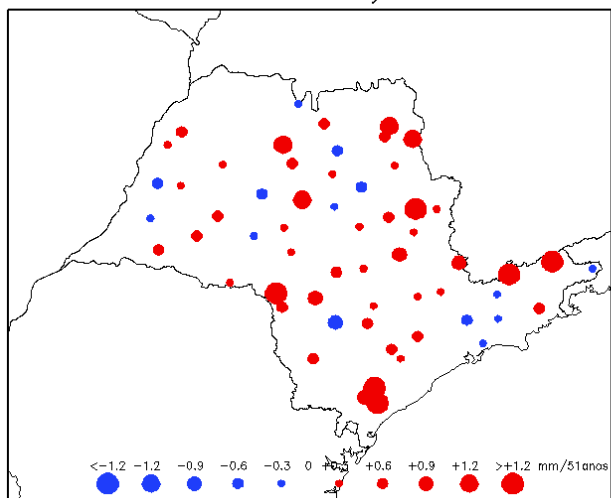
Tendencia Anual do R95p: 1950 a 2000



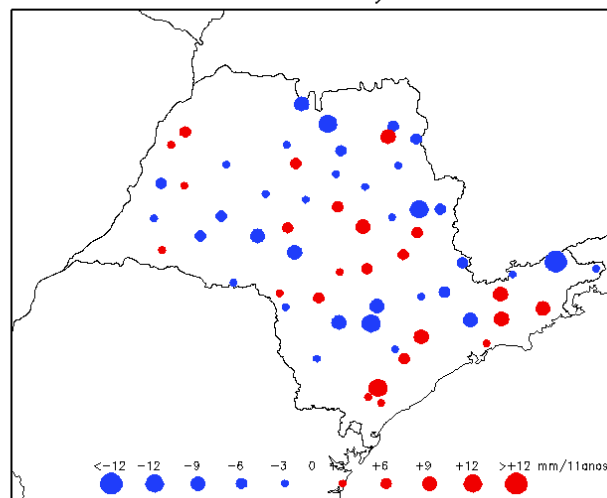
Tendencia Anual do R95p: 1990 a 2000



Tendencia Anual do RX5day: 1950 a 2000



Tendencia Anual do RX5day: 1990 a 2000



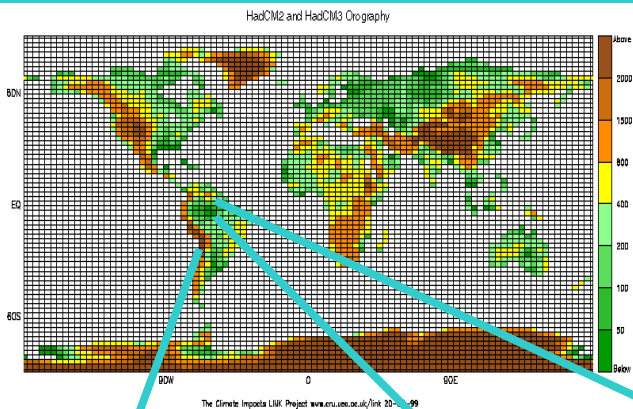
CREAS- Cenários de Mudanças Climáticas Regionais para a América do Sul – Estratégias

Modelos globais IPCC (HadCM3)

Cenários futuros IPCC A2, B2

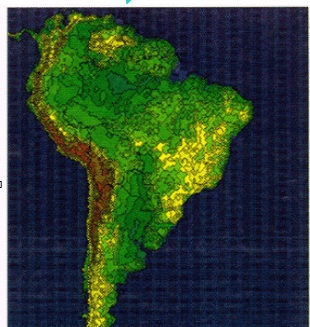
Controle 1961-90

Mapas de mudanças climáticas A2, B2 menos controle, 2071-2100 e outros períodos

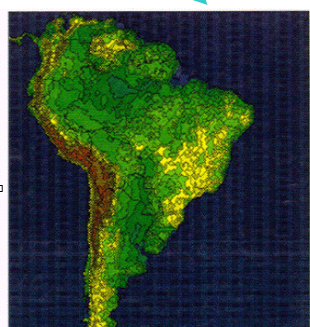


Controle modelos regionais 1961-90

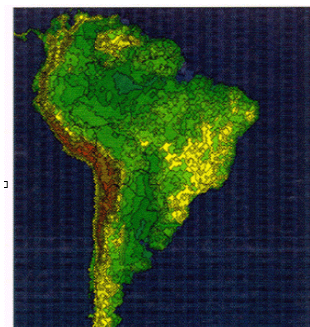
Downscaling



RegCM3/USP
50 km



HadRM3/PRECIS
50 km



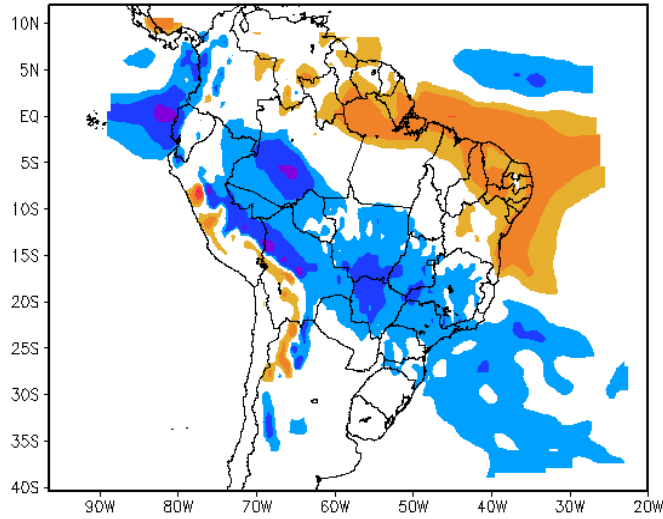
Eta/CPTEC
40 km

Mapas de mudanças climáticas A2, B2 para 2071-2100, e outros períodos (países da América do Sul e outras regiões)

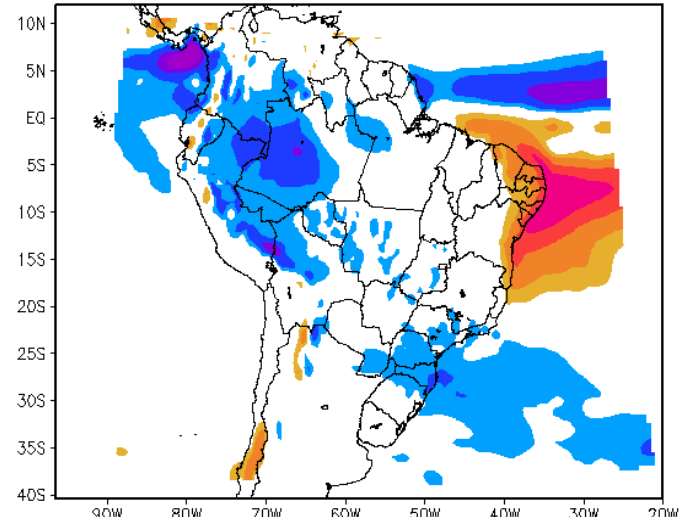
Média sazonal A2 DJF – anomalias de precipitação (mm/dia) – [(2071-2085)-(1961-90)]

HadRM3P

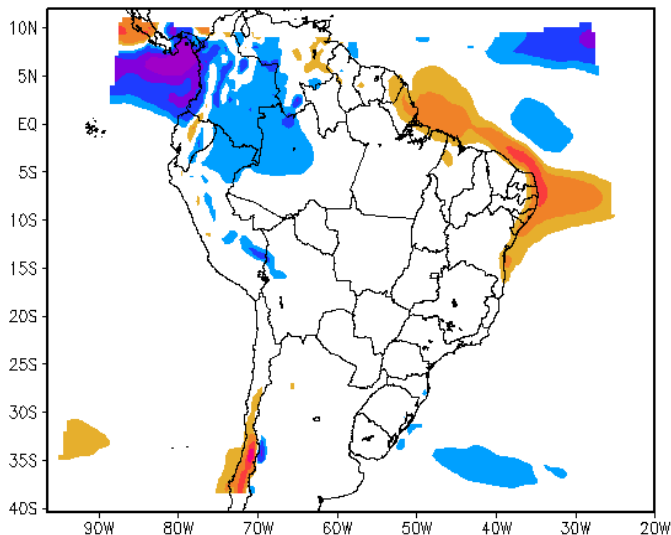
SCENARIO: A2 – Baseline
Seasonal Mean – DJF



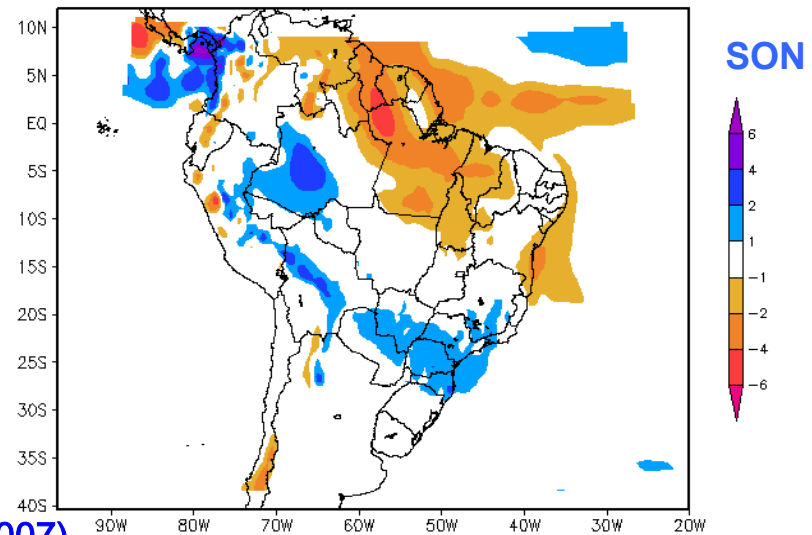
SCENARIO: A2 – Baseline
Seasonal Mean – MAM



SCENARIO: A2 – Baseline
Seasonal Mean – JJA



SCENARIO: A2 – Baseline
Seasonal Mean – SON

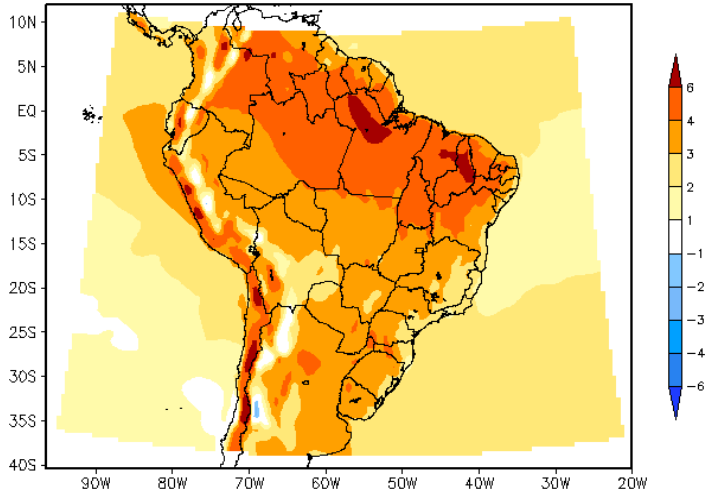


(Ambrizzi et al 2007)

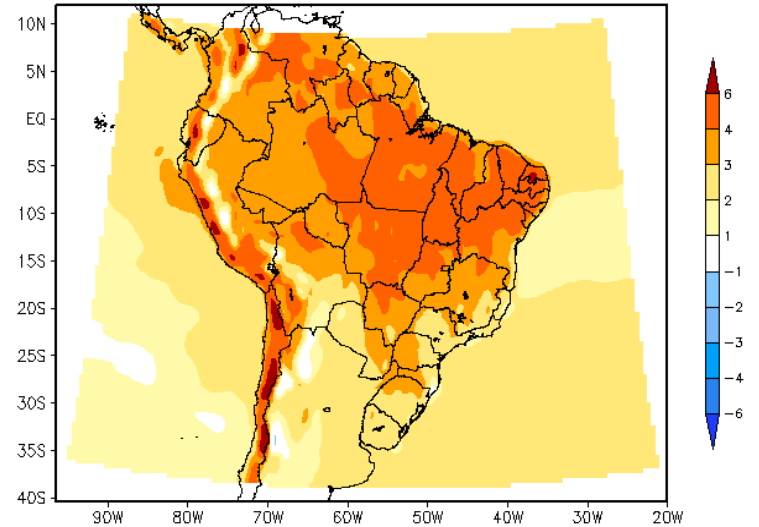
Média sazonal DJF A2 – anomalias de temperatura (°C) – [(2071-2085)-(1961-90)]

HadRM3P

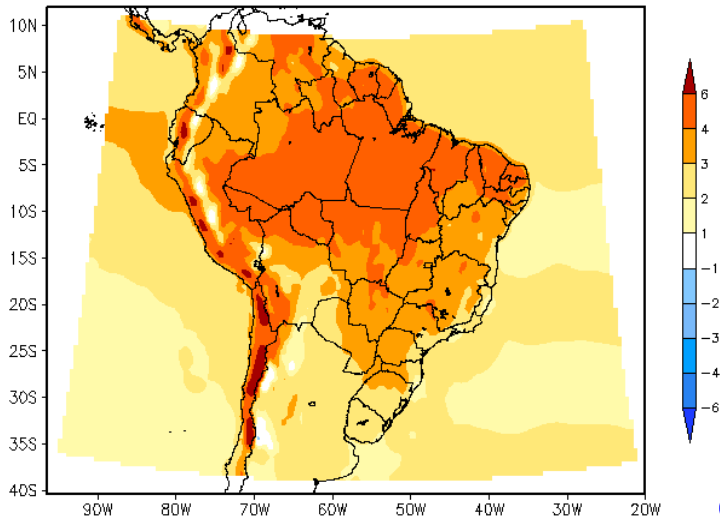
SCENARIO: A2 – Baseline
Seasonal Mean – DJF



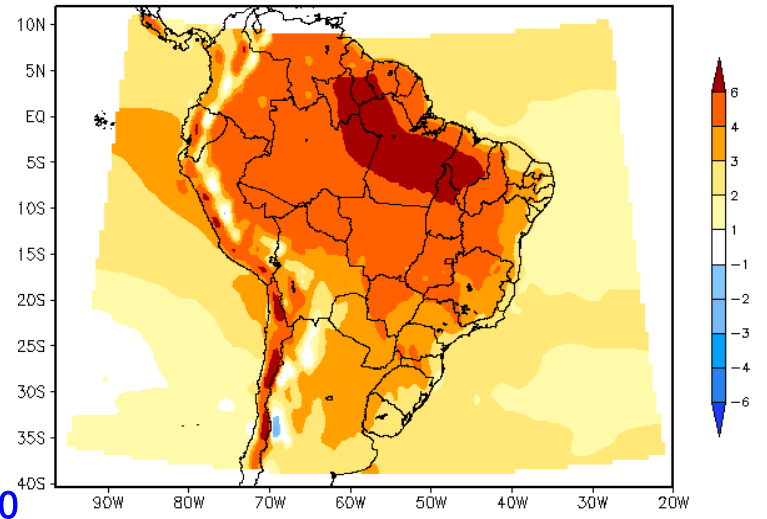
SCENARIO: A2 – Baseline
Seasonal Mean – MAM



SCENARIO: A2 – Baseline
Seasonal Mean – JJA



SCENARIO: A2 – Baseline
Seasonal Mean – SON



(Ambrizzi et al 200 ,

BRAZIL

Area 8.574.761 km²

Population 169.590.693 ind

Mean Discharge 182.633 m

A: Area
P: Population
D: Mean Discharge

AMAZÔNIA:

LAT: 4,5° N- 12°S
LON: 46,5° W- 74,5° W

NORDESTE:

LAT: 2° N- 16,5°S
LON: 32,5° W- 45° W

Amazonia

Nordeste

PANTANAL:

LAT: 13,5° N- 23°S
LON: 52° W- 60,5° W

Pantanal

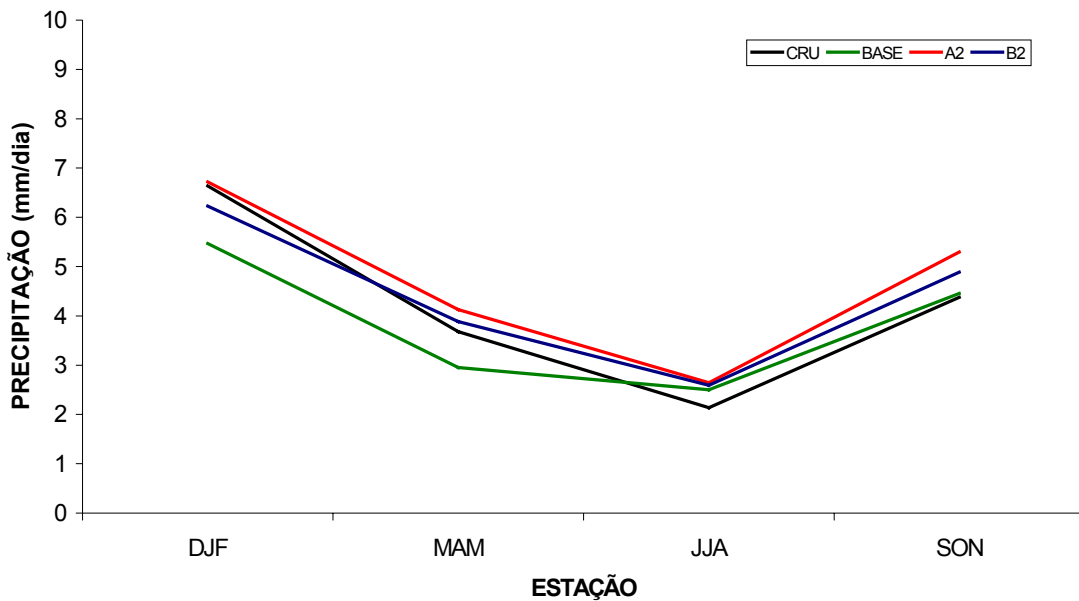
SUL-PARANÁ:

LAT: 17° N- 33,5°S
LON: 43,5° W- 54° W

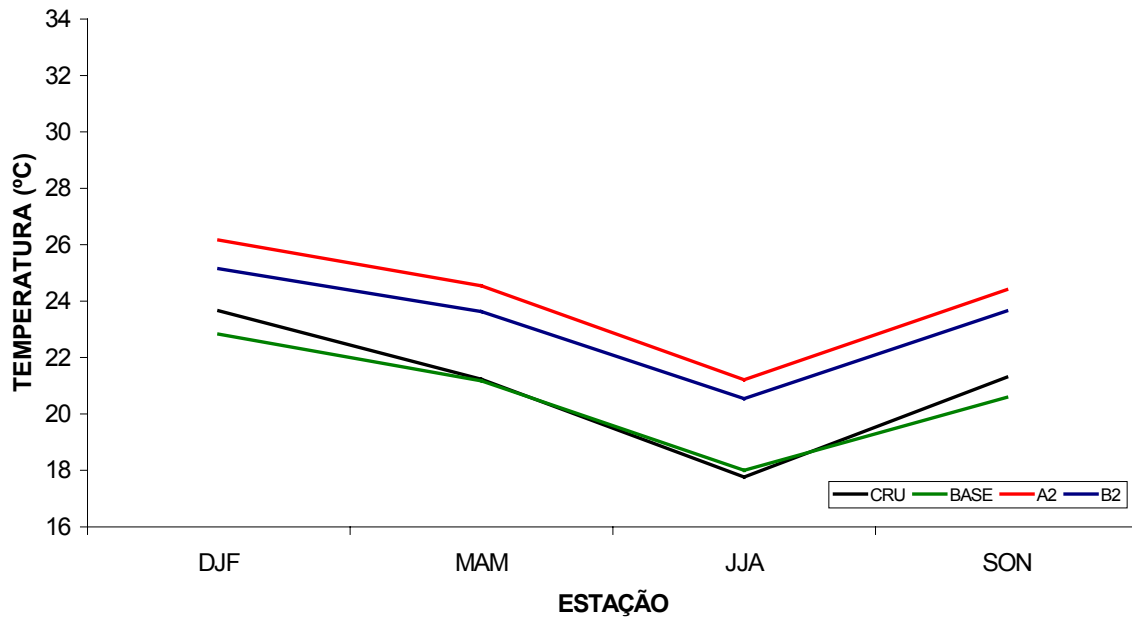
Sul-Parana

SUL

PRECIS

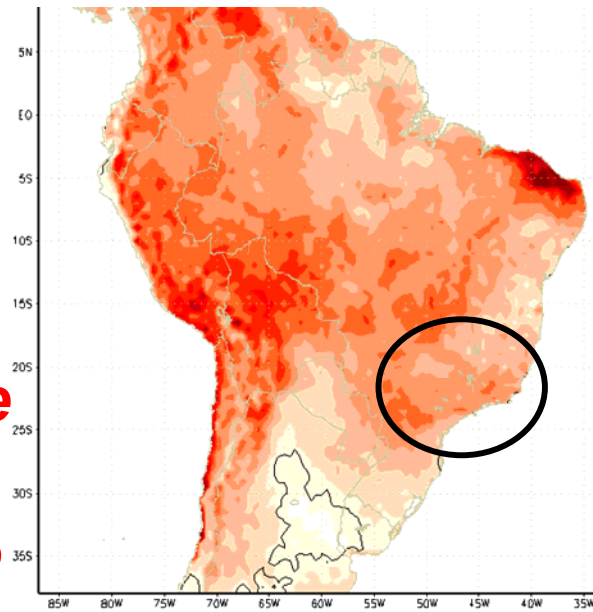


SUL

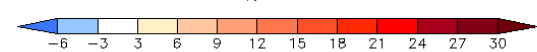
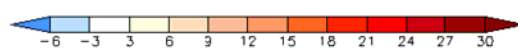
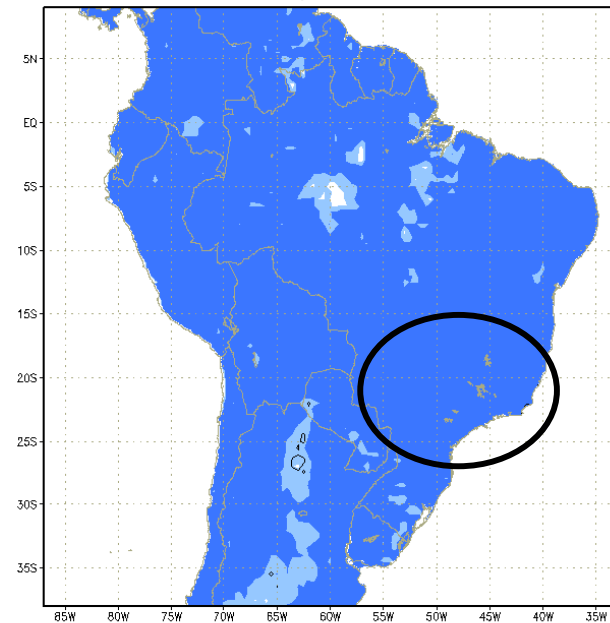


(Ambrizzi et al 2007)

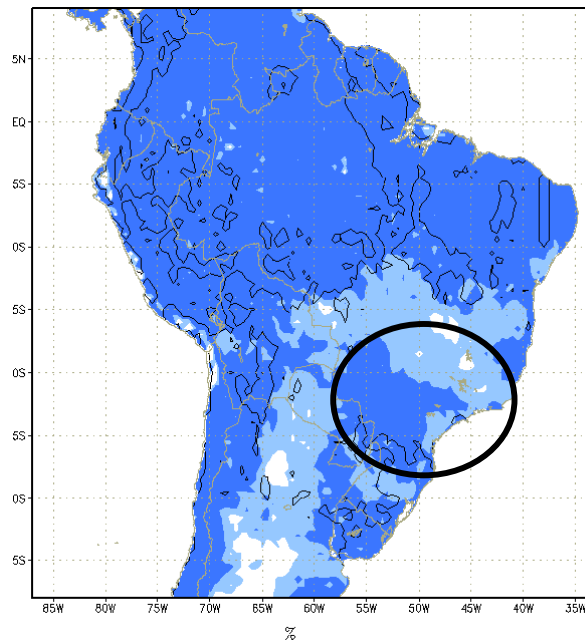
*noites
quentes*



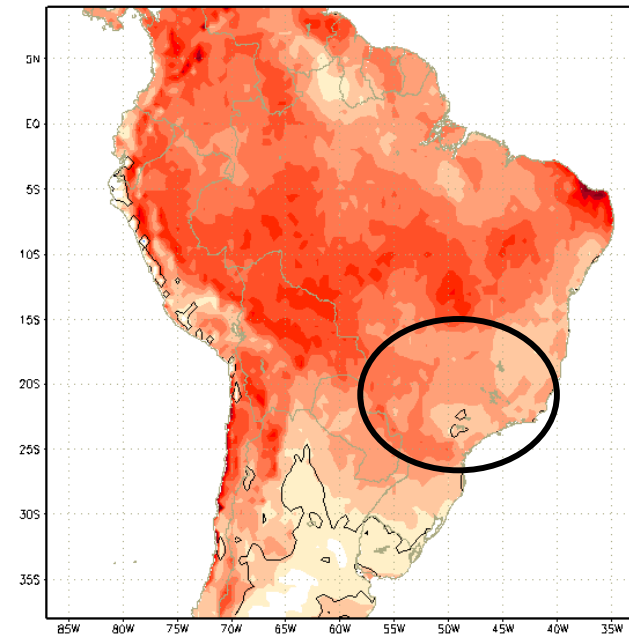
*noites
frias*



**Tendências de
temperatura
simulada pelo
modelo
regional
Precis
(2071-2100)**



*dias
quentes*

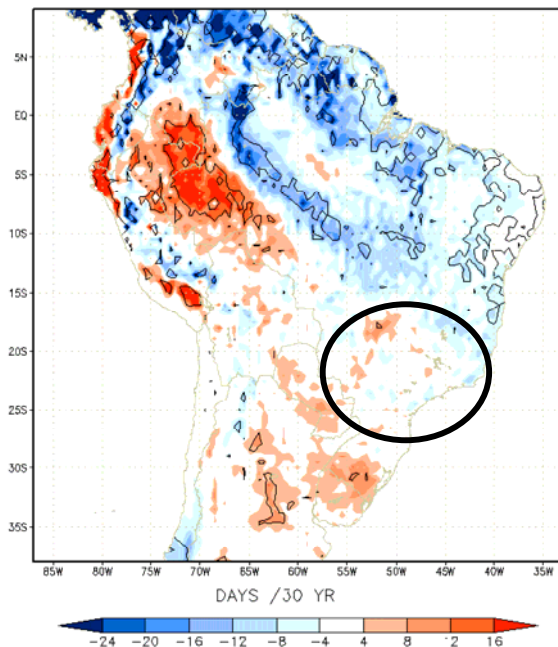


dias frios

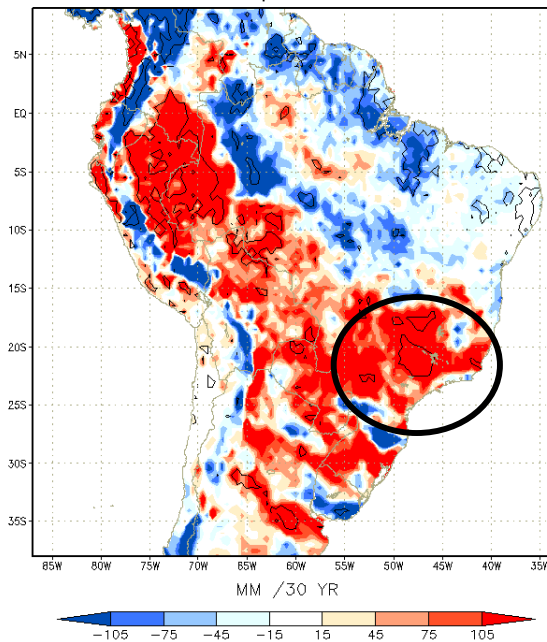
(Marengo et al 2007)

Tendências de precipitação simulada pelo modelo regional Precis (2071-2100)

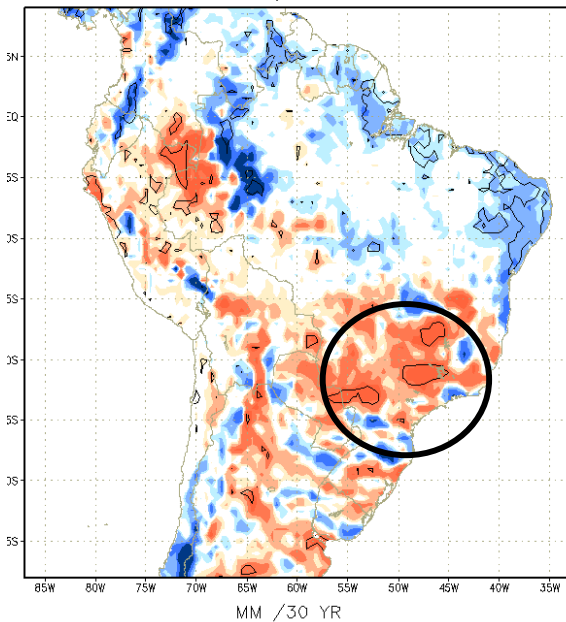
PRECIS R10mm - CENARIO A2



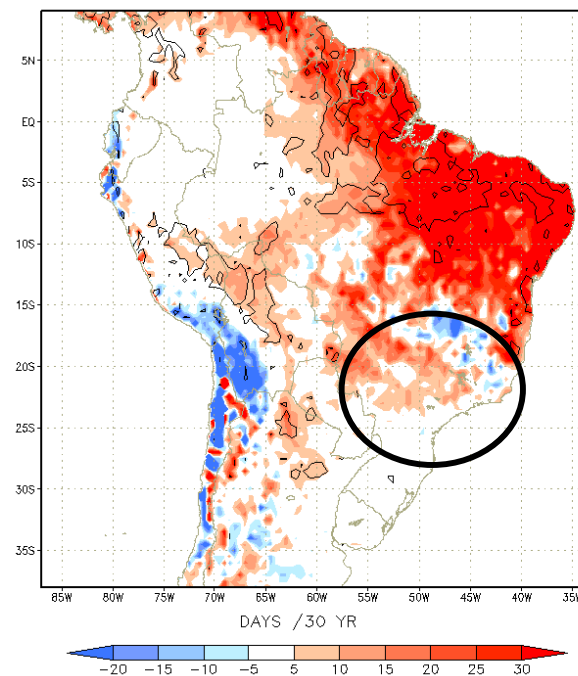
PRECIS R95p - CENARIO A2



PRECIS Rx5day - CENARIO A2



PRECIS CDD - CENARIO A2

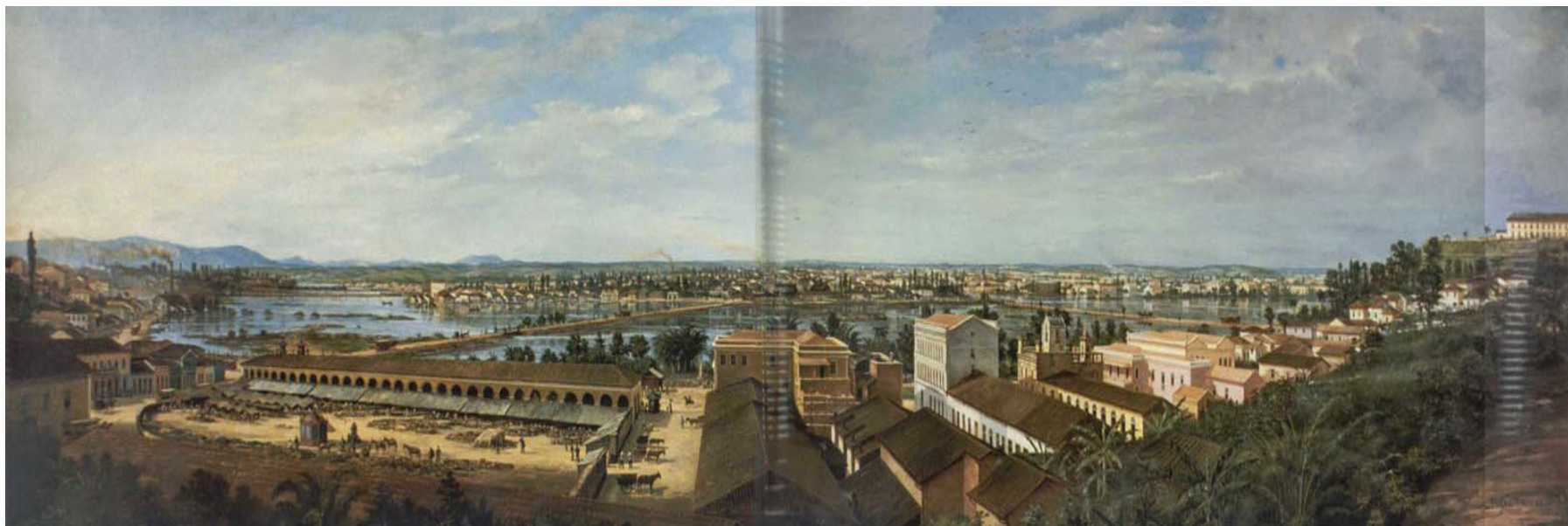


(Marengo et al 2007)

INUNDAÇÃO NA CIDADE DE SÃO PAULO VERÃO DE 2004



INUNDAÇÃO NA CIDADE DE SÃO PAULO FINAL DO SÉCULO 19



Benedito Calixto 1853-1927
Inundação na Várzea do Carmo

Cortesia de Augusto Toledo de Machado – CTA/CPTEC- INPE
(a obra encontra-se no Museu do Ipiranga)

Aquecimento Global



Enchente generalizada na Europa

Agosto de 2002



Rio Danúbio
Budapeste
Hungria



Rio Mueglitz
Dresden
Alemanha

Galeria de arte alagada
Dresden
Alemanha



Rio Kamp
Viena, Áustria



Kralupy, Rep. Tcheca



Havel/Praga, Rep. Tcheca

Lago Dillon, Colorado, 8 de Agosto de 2002

Cortesía: R. Anthes



Os modelos de clima indicam que um dos principais efeitos do aumento nos gases estufa será o aquecimento global

Há evidências de que o aquecimento do último século é de origem antropogênica

Se não forem tomadas atitudes para reduzir as emissões as conseqüências para muitas sociedades e ecossistemas podem ser sérias

As sociedades ou ecossistemas que estão em maior risco são aqueles que têm menor capacidade de adaptação

Mesmo que persistam certas incertezas, sabe-se o suficiente para afirmar que a mudança climática é real e séria



GRUPO DE ESTUDOS CLIMÁTICOS

OBRIGADO PELA ATENÇÃO