A mudança climática: Kyoto e cenários de aquecimento global

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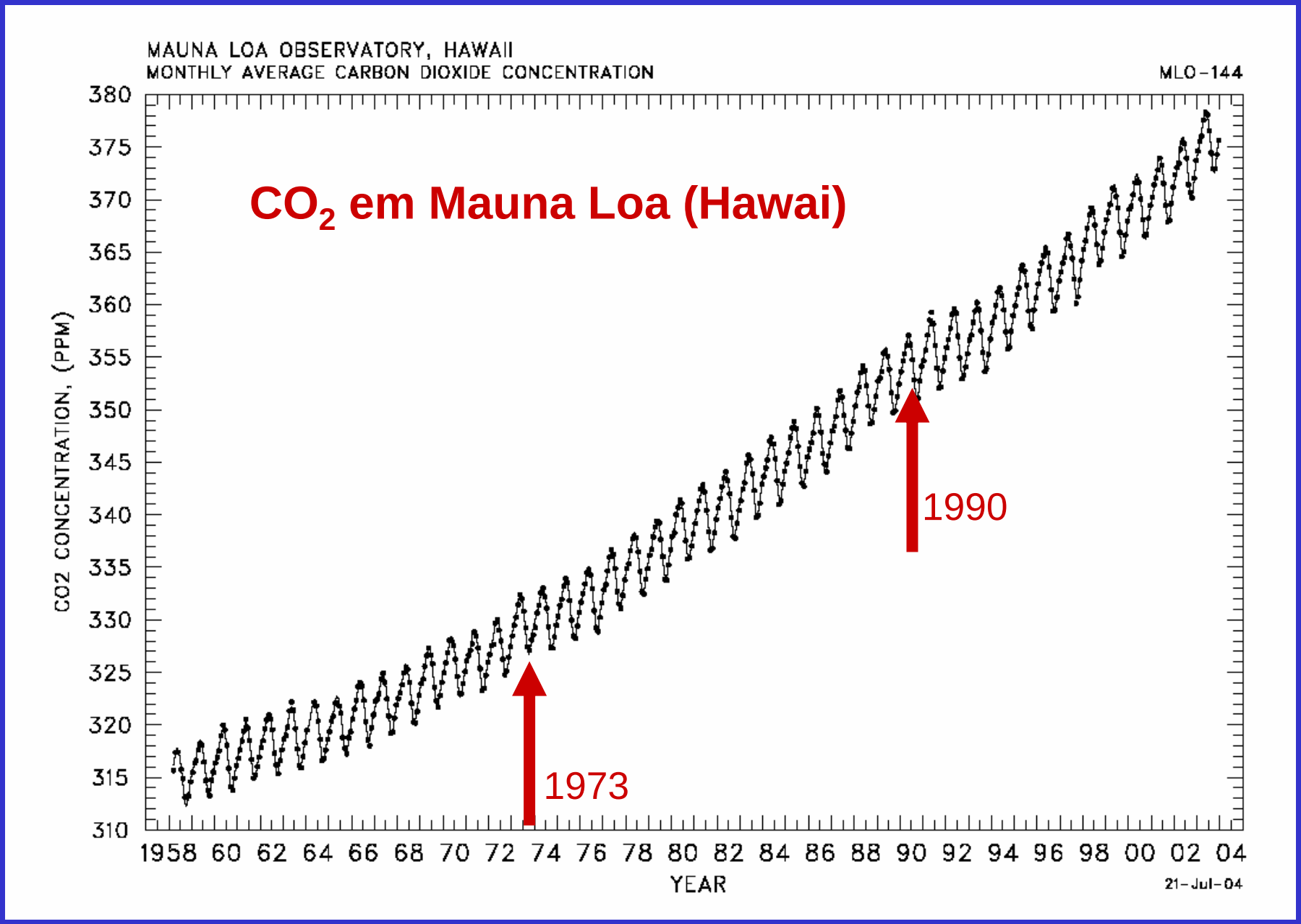
www.cgul.ul.pt

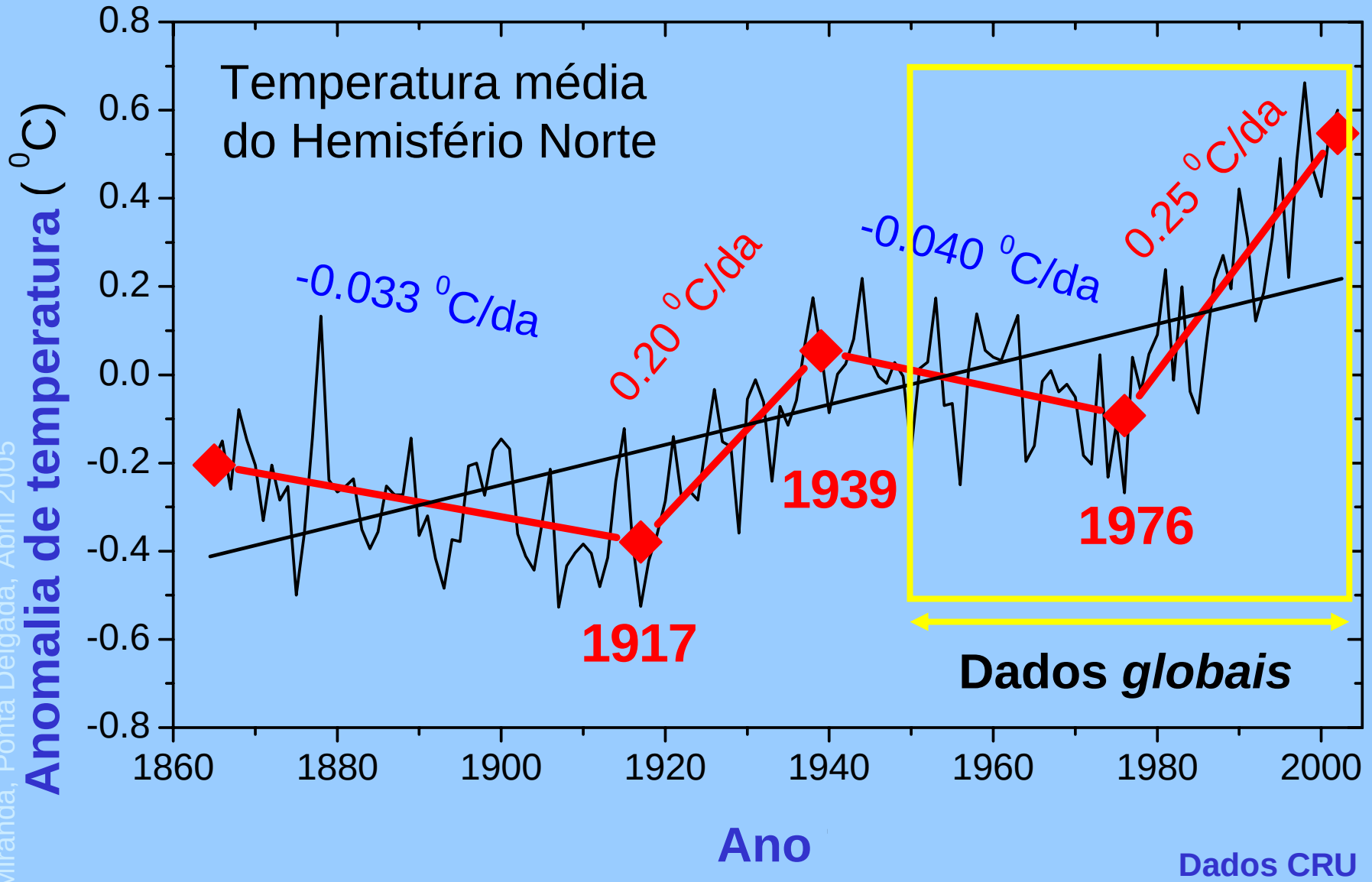
Contribuições
Projecto CLIMAAT (E B Azevedo)
Projecto SIAM (M A Valente, A Tomé, R Trigo, M F Coelho, A Aguiar, E B Azevedo)

Universidade de Lisboa, Faculdade de Ciências,
Centro de Geofísica
(*Laboratório Associado*)

S. Miguel, 1 de Abril 2005

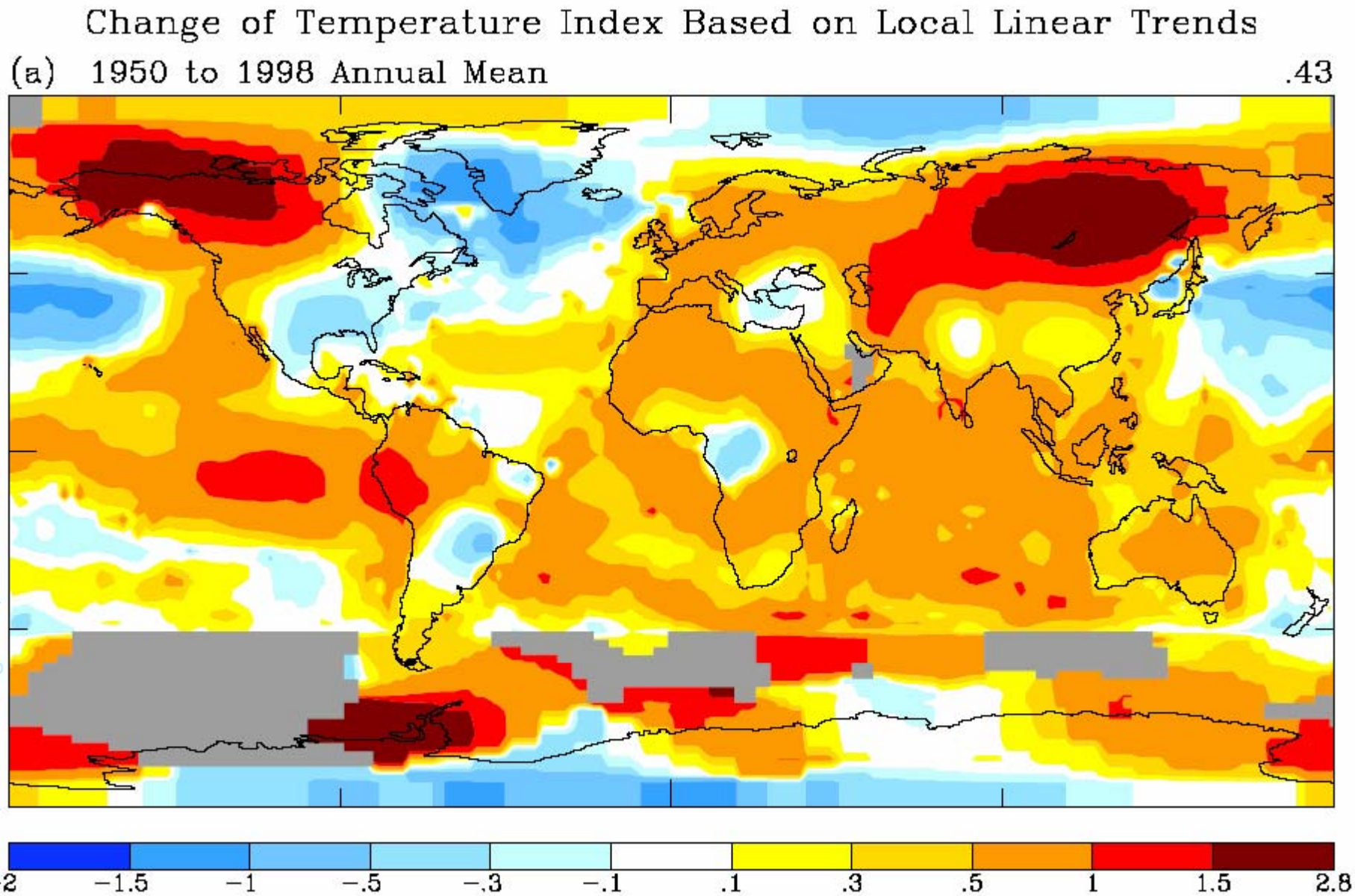

MAUNA LOA OBSERVATORY, HAWAII
MONTHLY AVERAGE CARBON DIOXIDE CONCENTRATION
MLO-144
CO2 CONCENTRATION, (PPM)
380
375
370
365
360
355
350
345
340
335
330
325
320
315
310
1958 60 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 00 02 04
YEAR
21-Jul-04
CO2 em Mauna Loa (Hawai)
1973
1990

1 – Aquecimento global



Tomé and Miranda (GRL,2004)

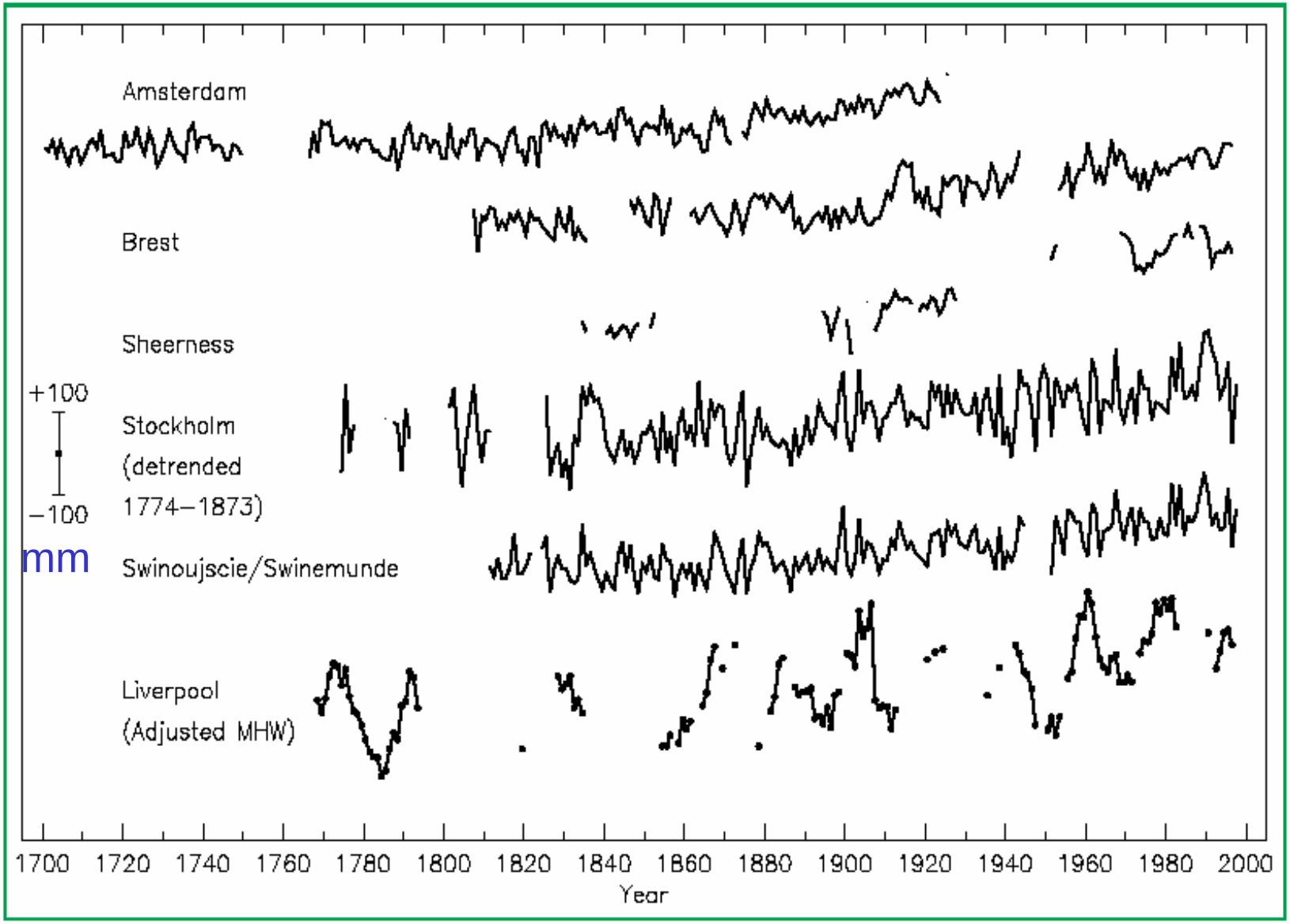
P Miranda, Ponta Delgada, Abril 2005

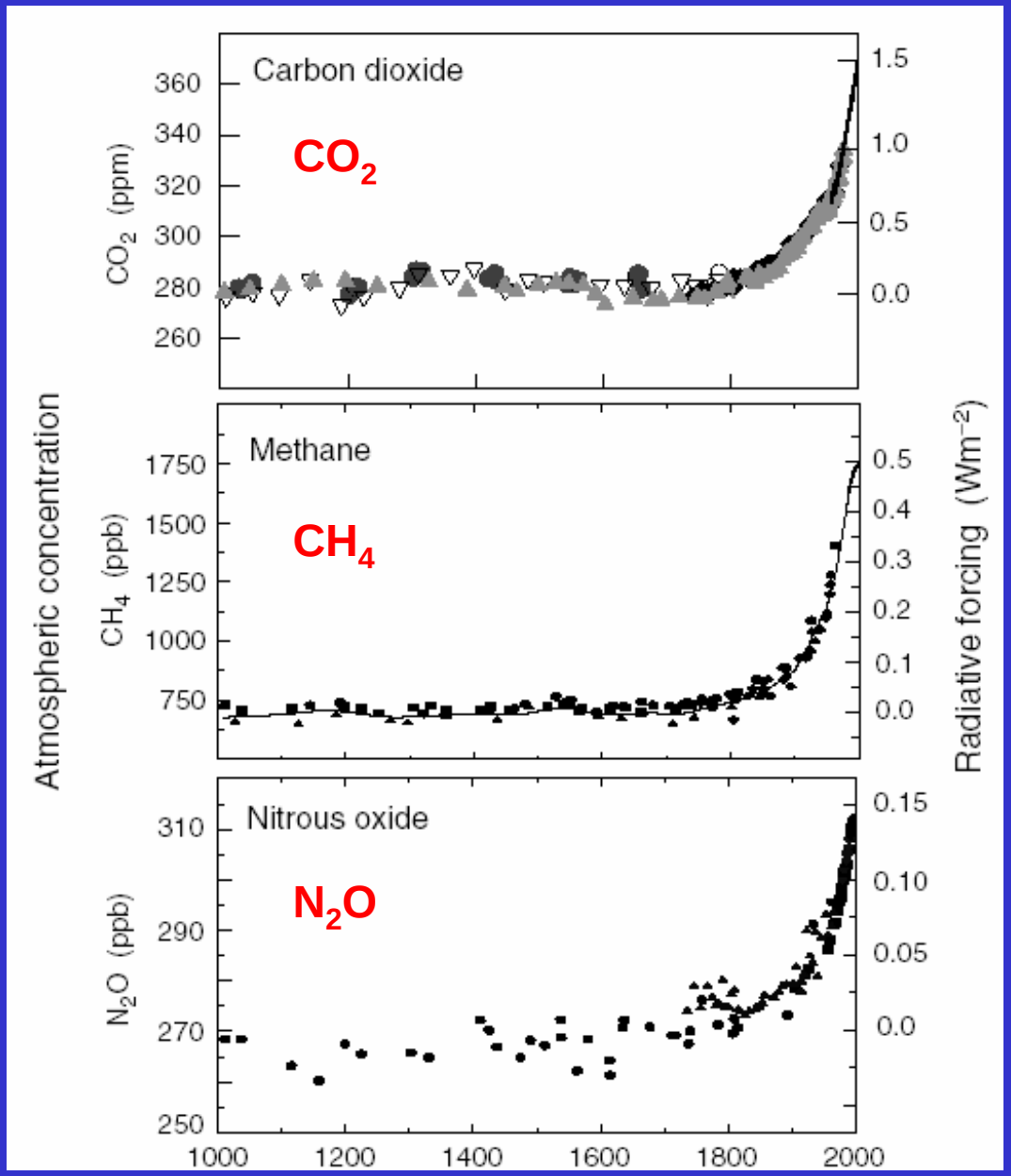


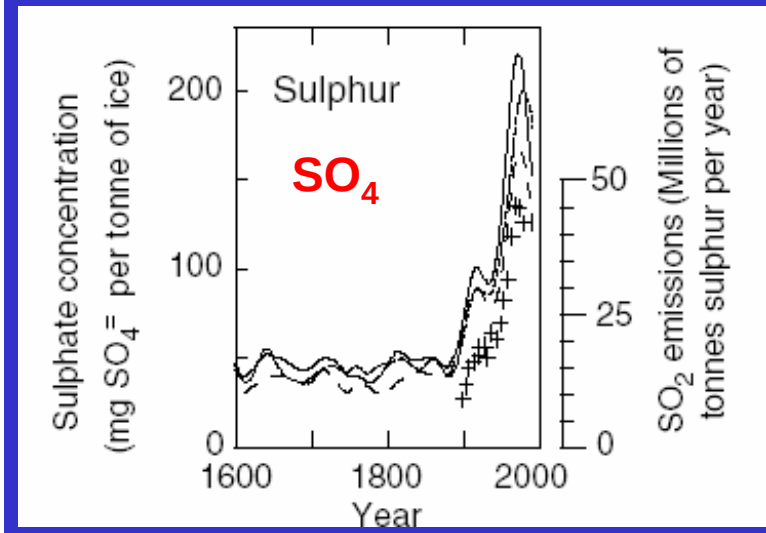
P. Miranda, Ponta Delgada., Abril 2005

Hansen et al (1999)

Nível do mar


Amsterdam
Brest
Sheerness
+100
Stockholm
(detrended
1774–1873)
−100
mm
Swinoujscie/Swinemunde
Liverpool
(Adjusted MHW)
1700
1720
1740
1760
1780
1800
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
Year

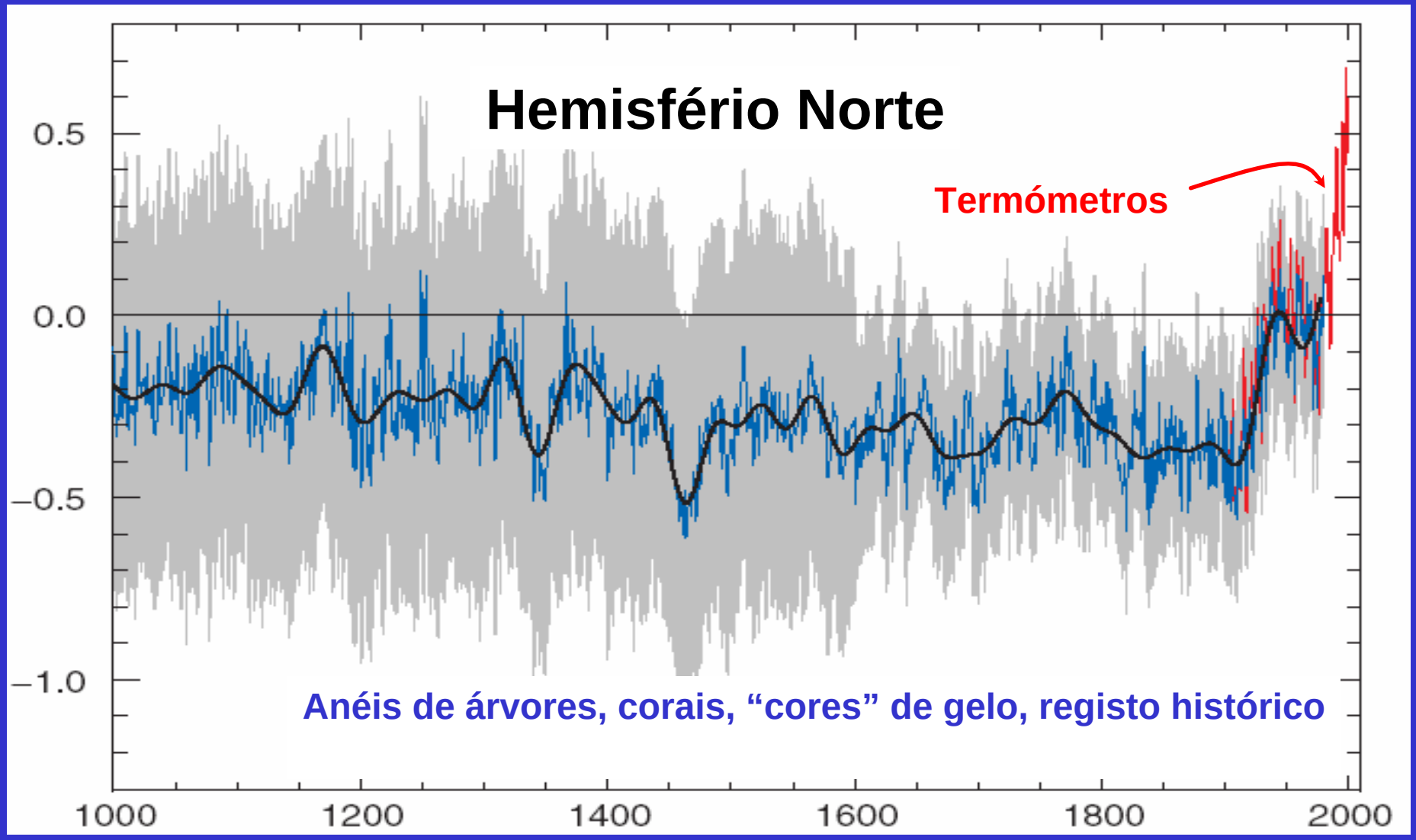




P Miranda, Ponta Delgada, Abril 2005

http://www.ipcc.ch

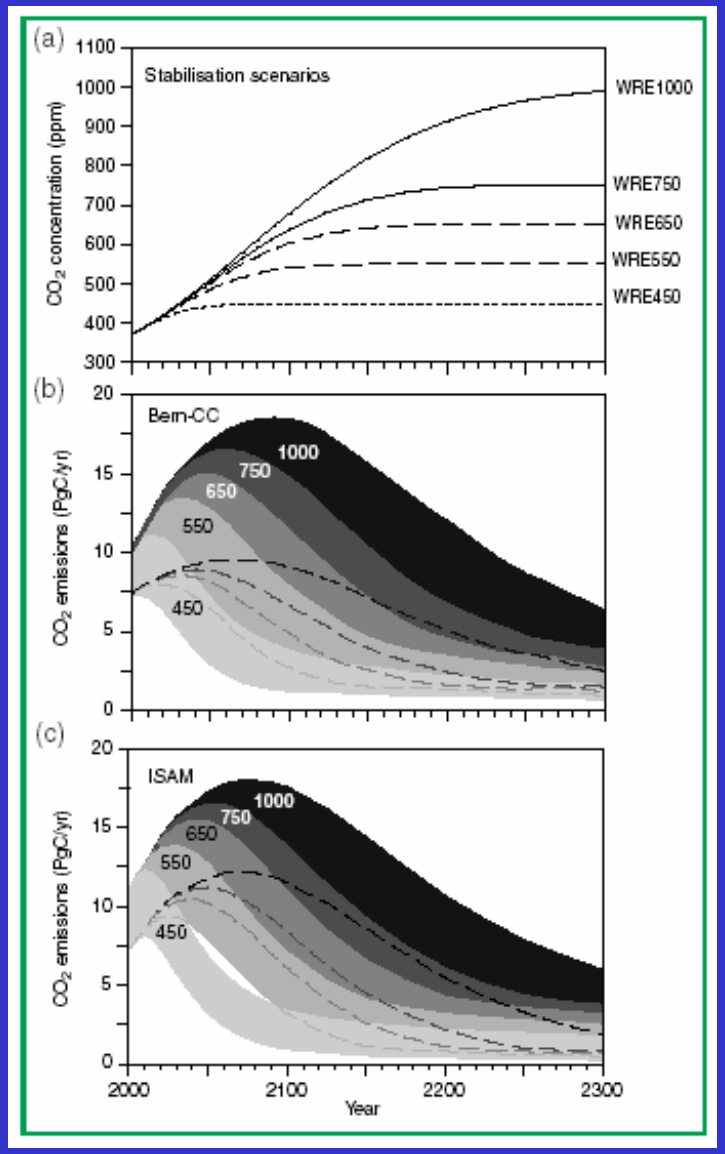
Temperatura no último milénio

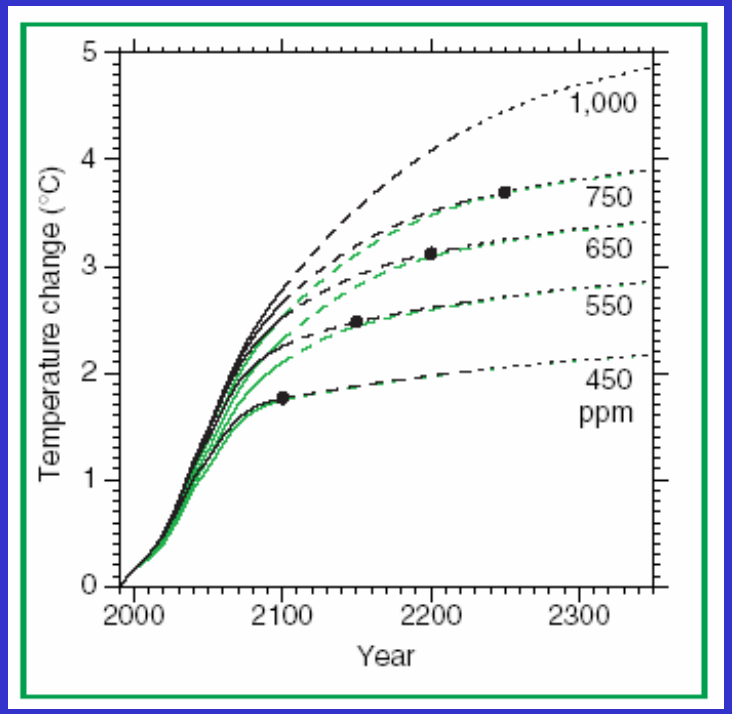


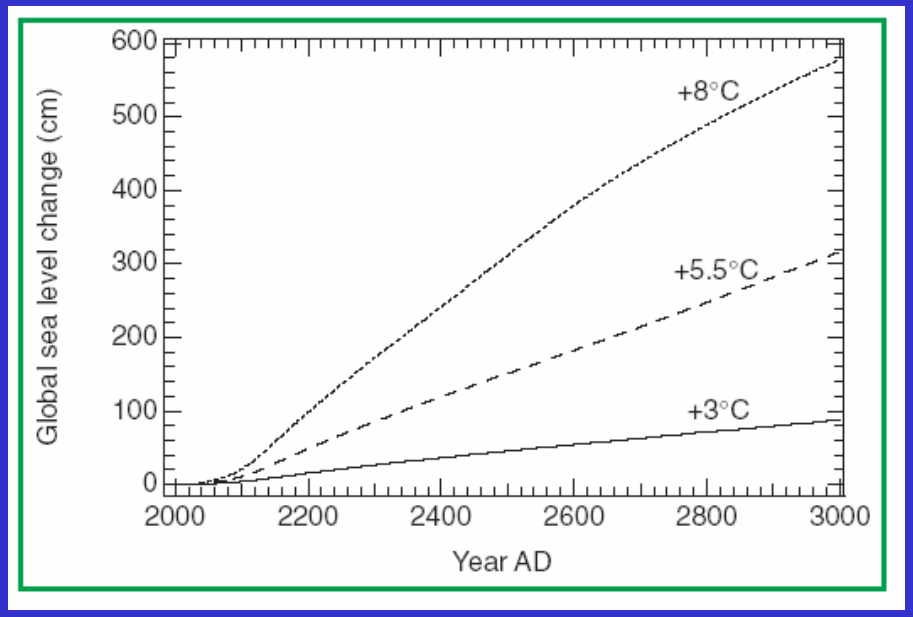
Ano

Mann 2004

Cenários de estabilização IPCC



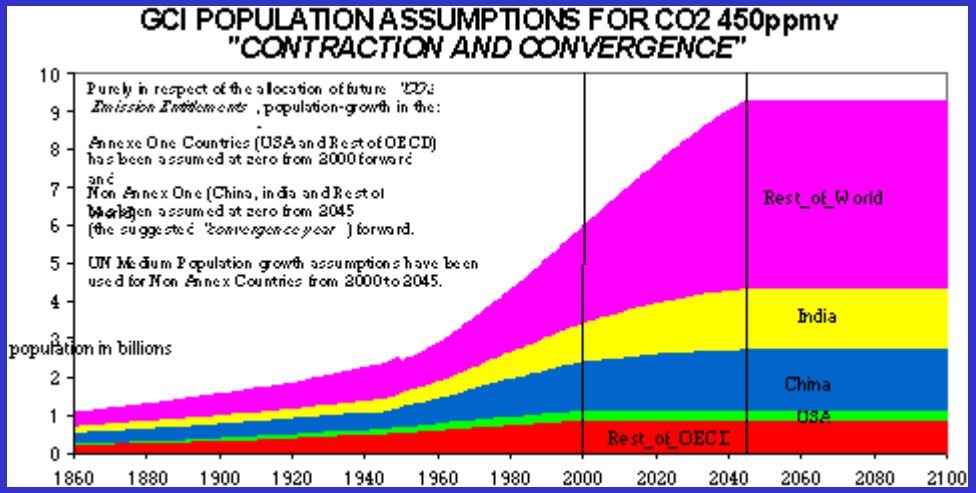


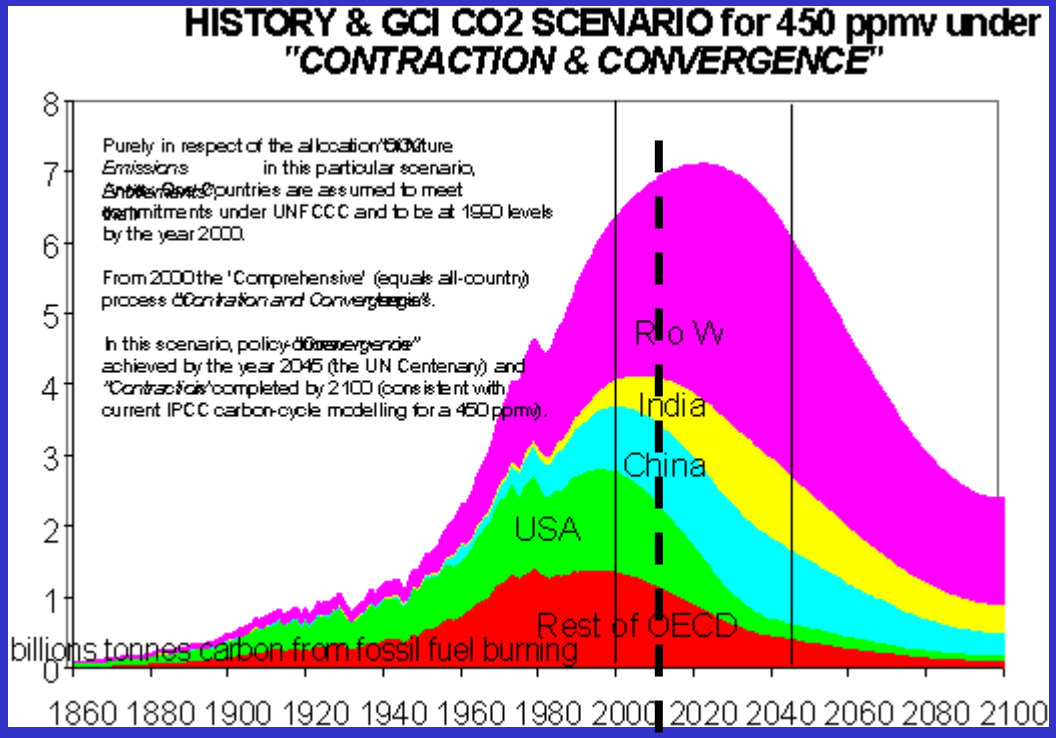


Kyoto

redução de ~6% nos países industrializados até 2012

Pós 2012 ?



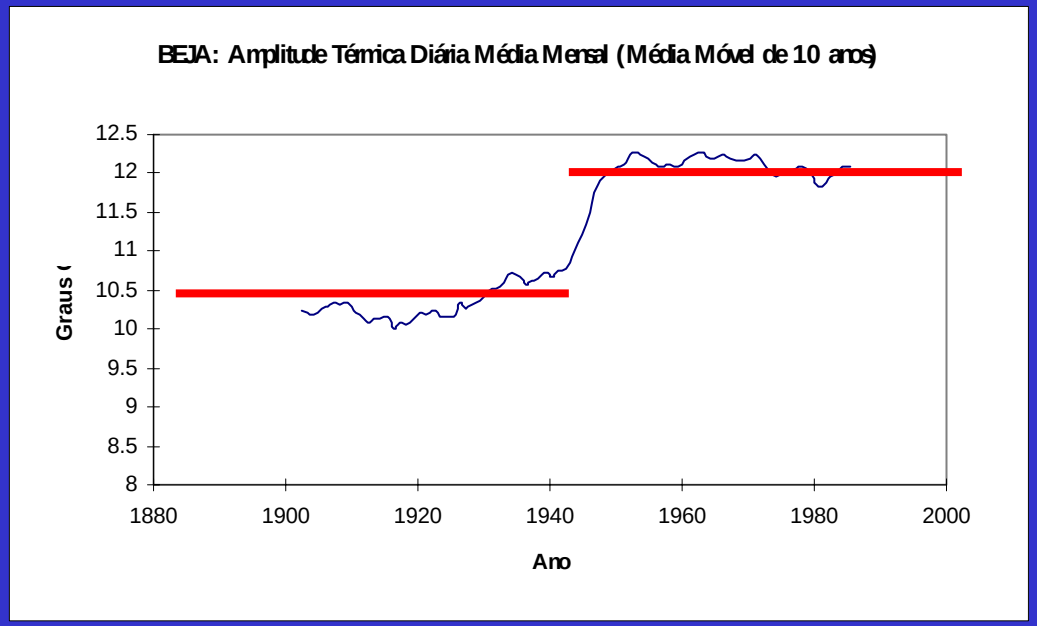


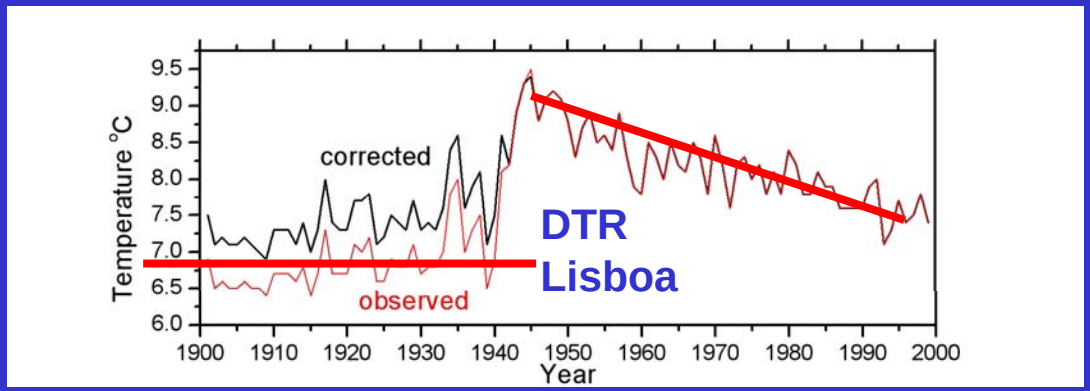
2012 (horizonte de Kyoto)

P Miranda, Ponta Delgada, Abril 2005

2 – As séries históricas portuguesas

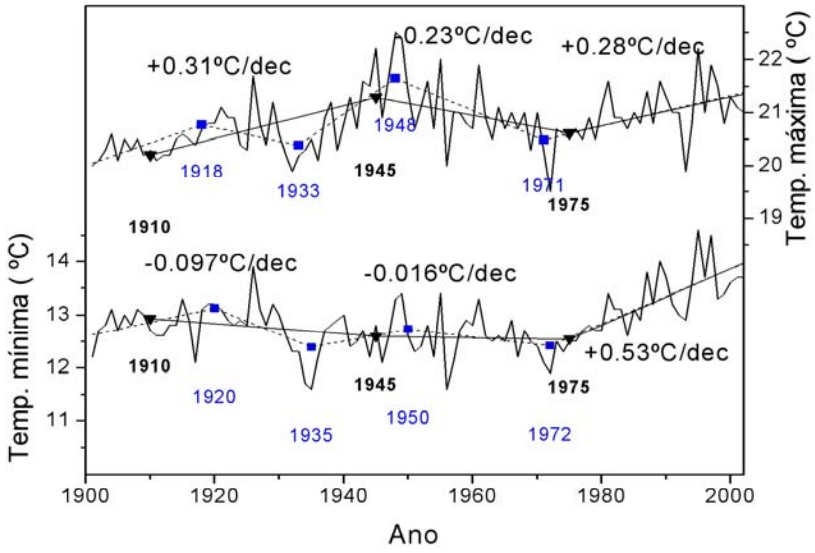
O problema da homogeneização



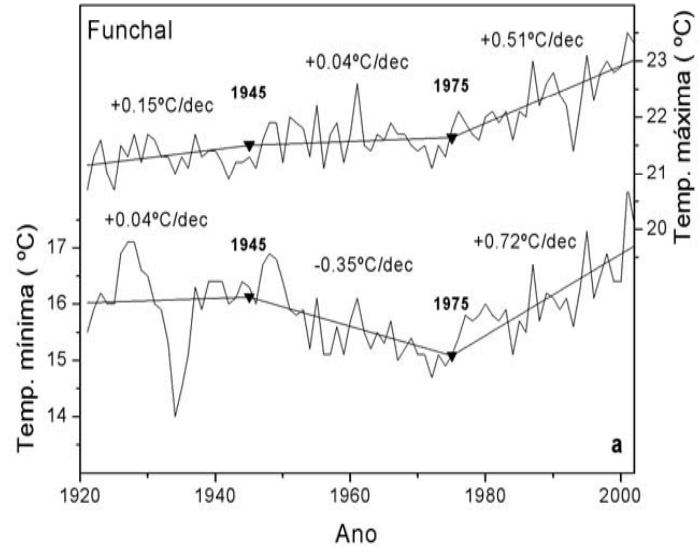


Temperatura observada 1901-2002

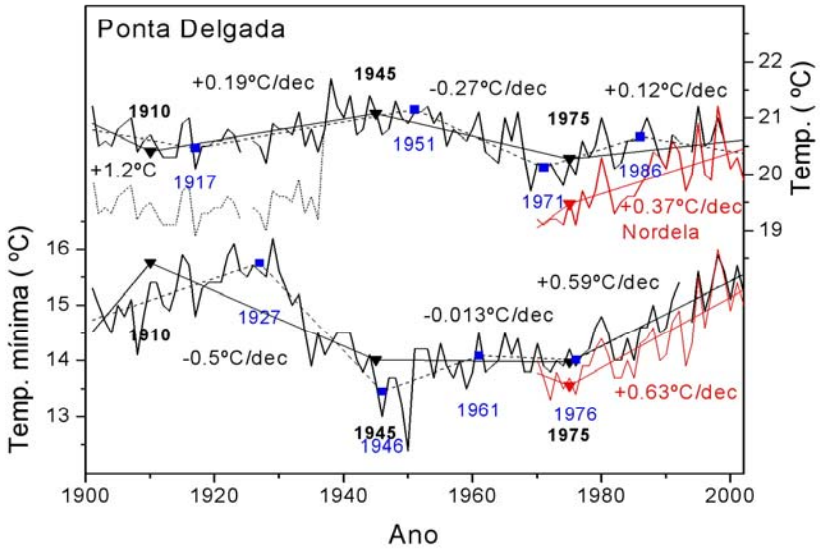
Lisboa



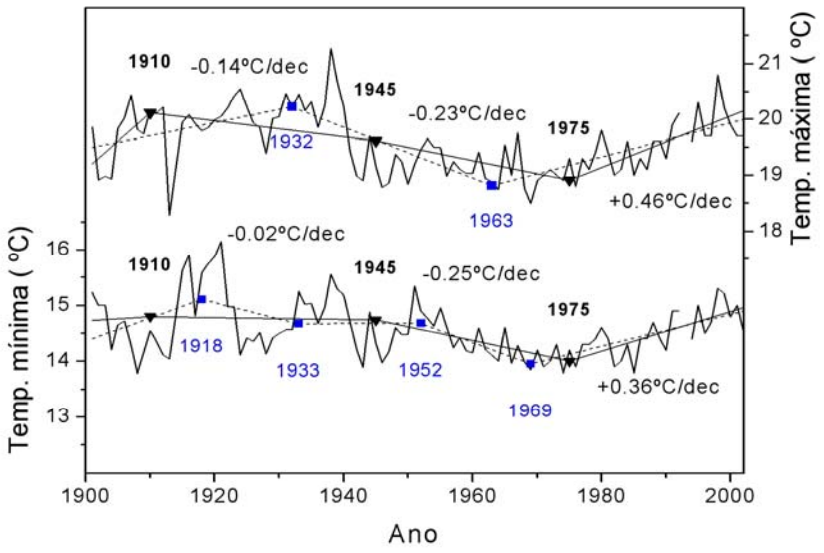
Funchal



Ponta Delgada



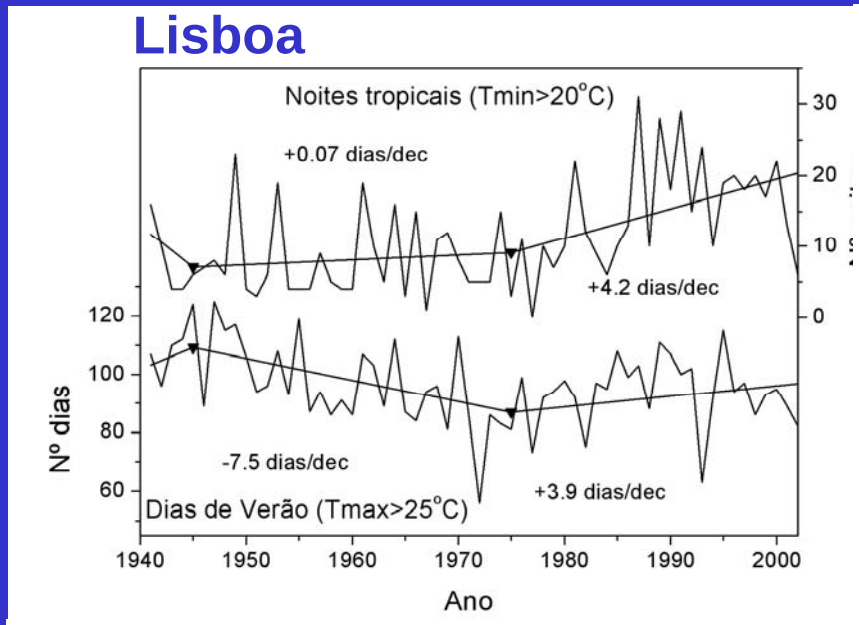
Angra do Heroísmo

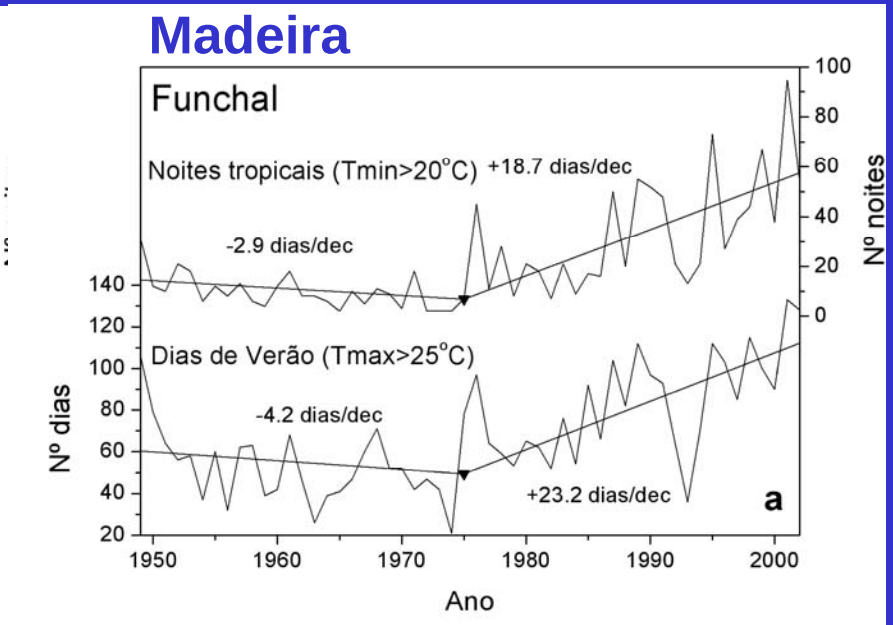


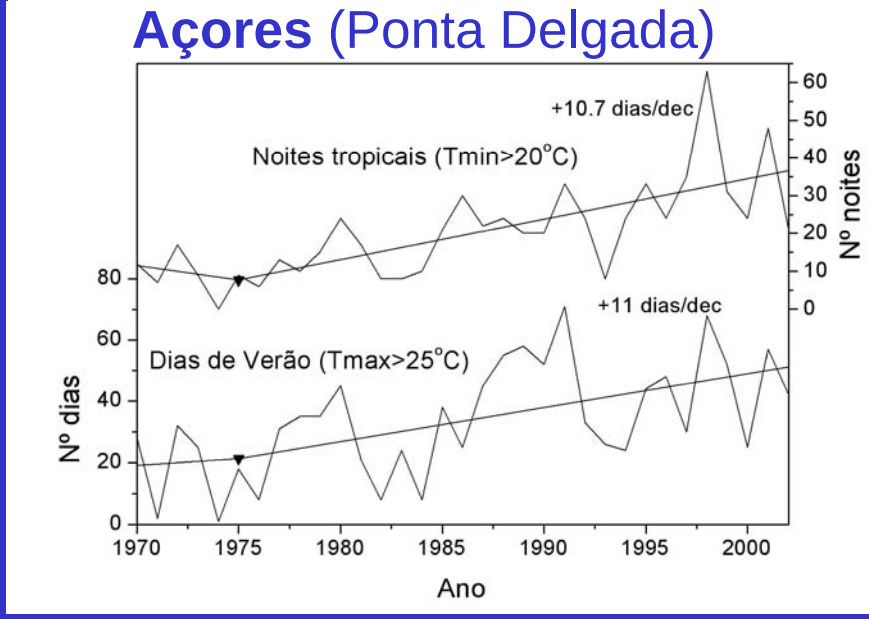
P Miranda, Ponta Delgada, Abril 2005

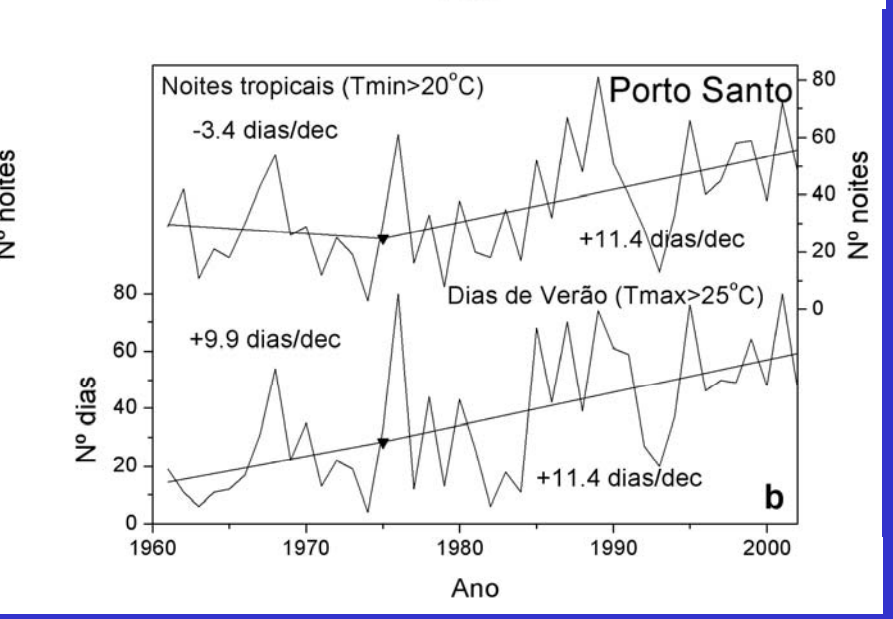
Tomé & Miranda, Geophysical Res. Lett, 2004

índices térmicos



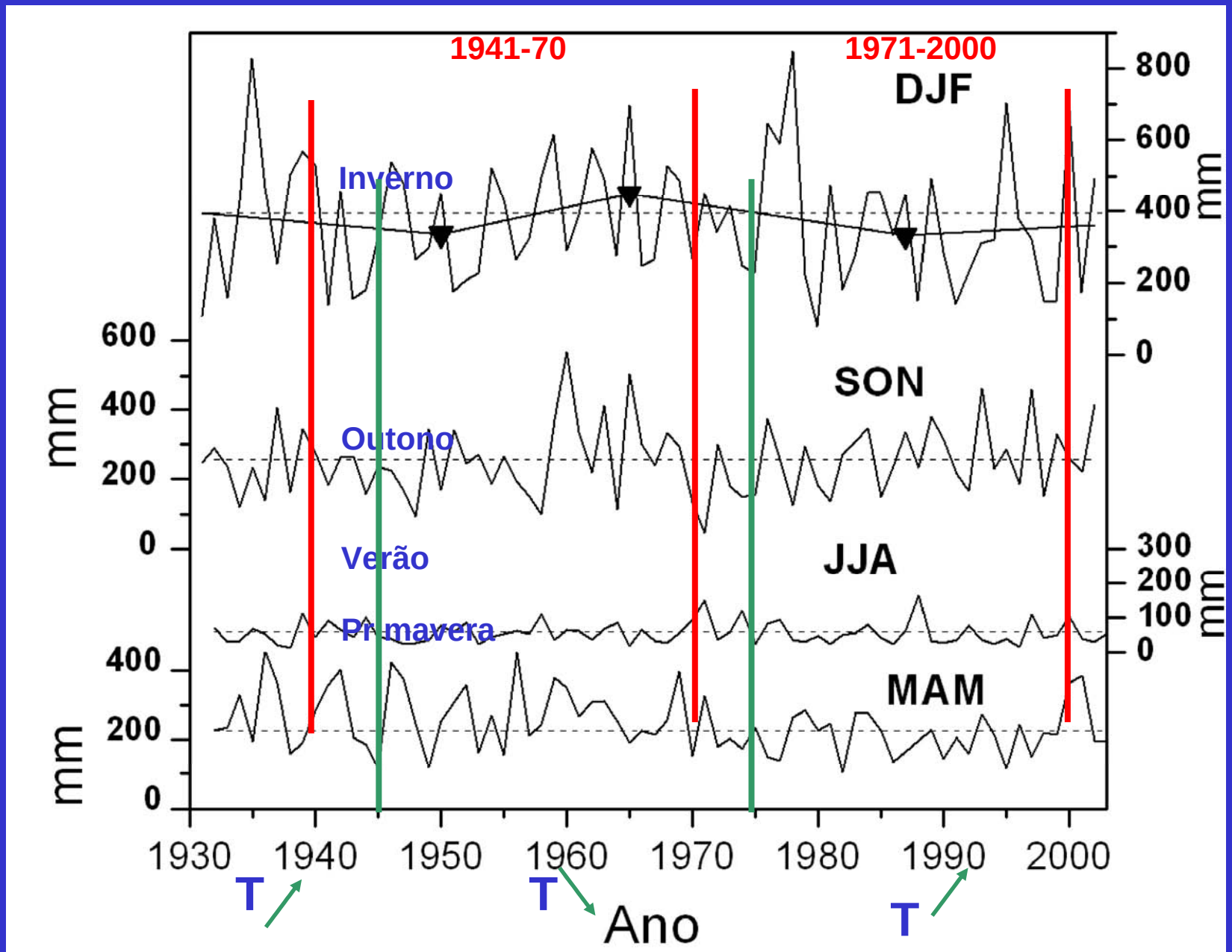




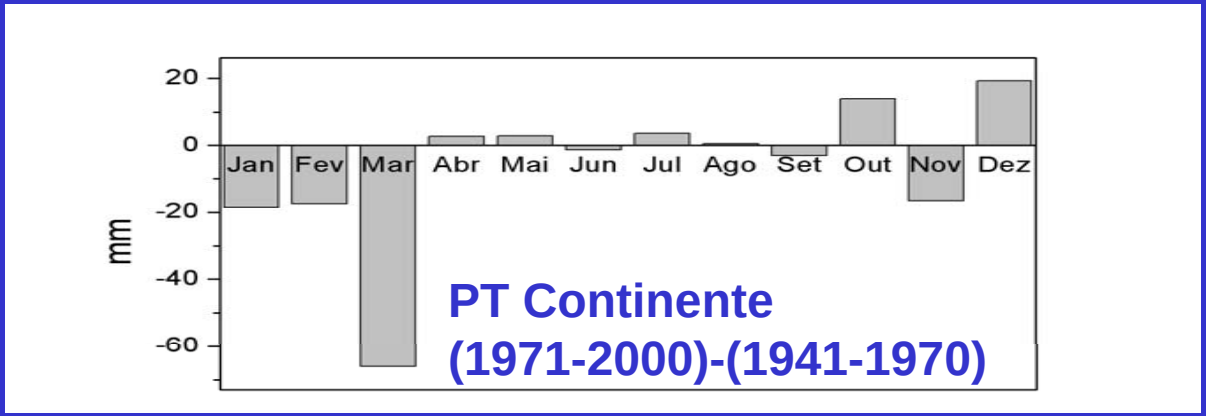


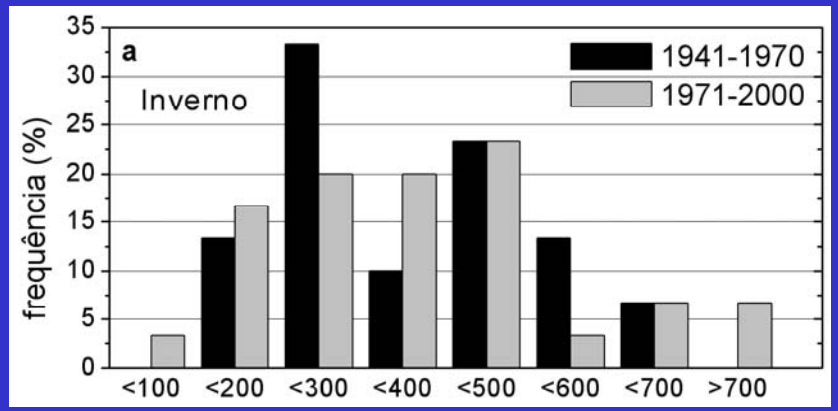
P Miranda, Ponta Delgada, Abril 2005

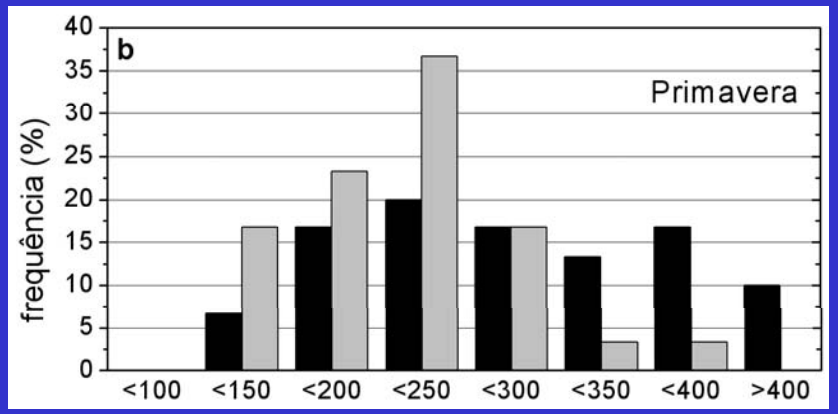
Precipitação sasonal (média de Portugal continental)

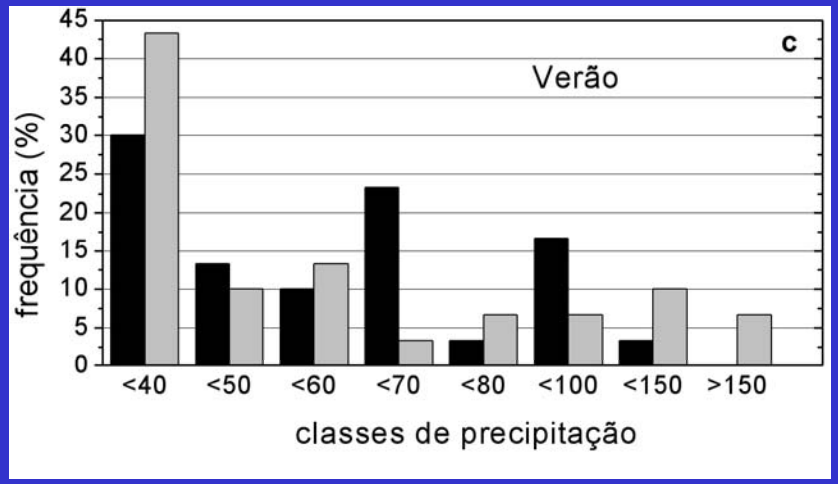


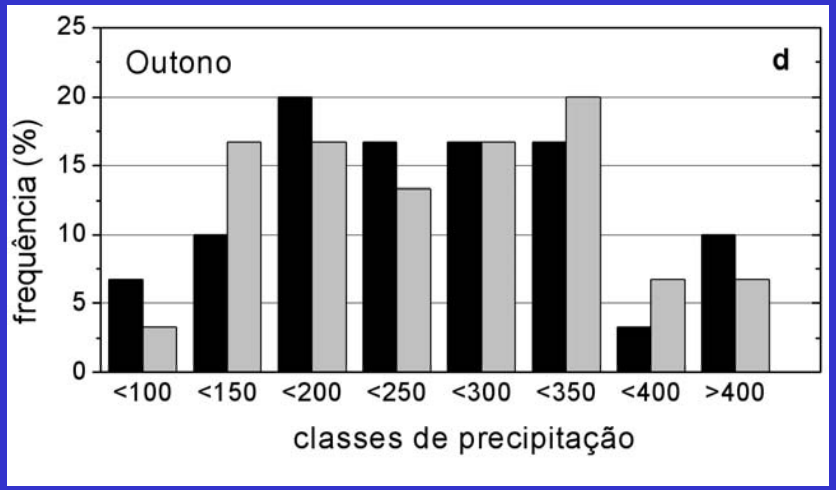
P Miranda, Ponta Delgada, Abril 2005





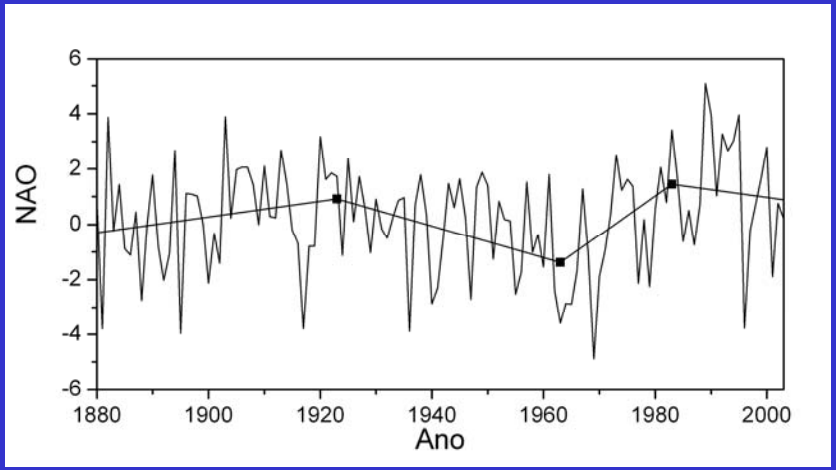


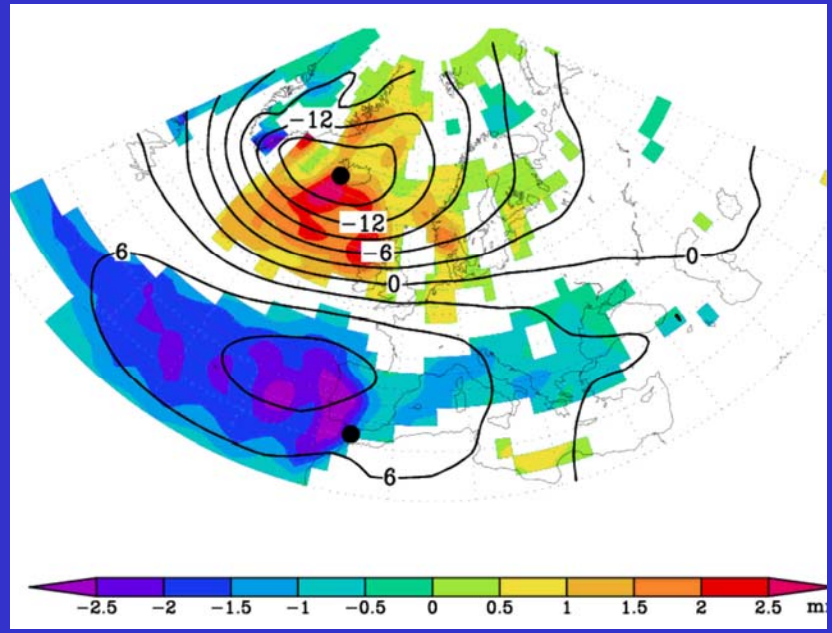


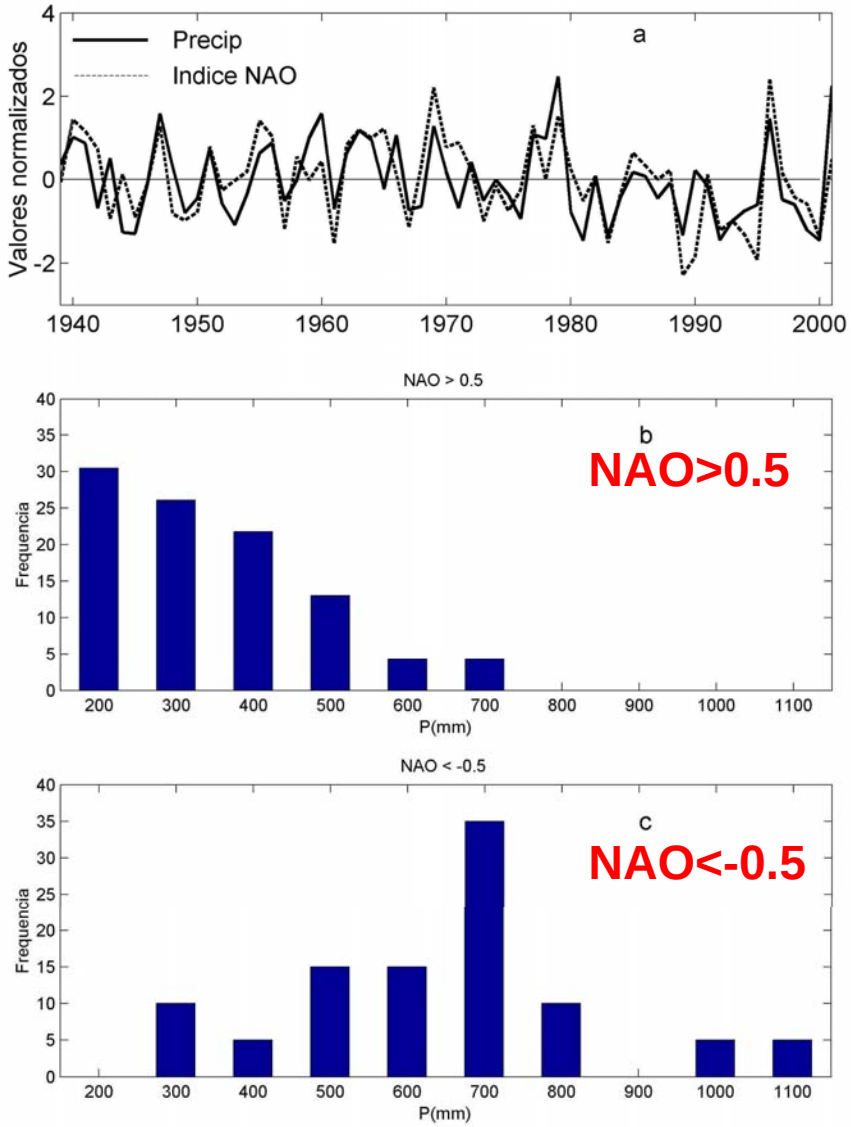


P Miranda, Ponta Delgada, Abril 2005

3 – A oscilação do Atlântico Norte - NAO



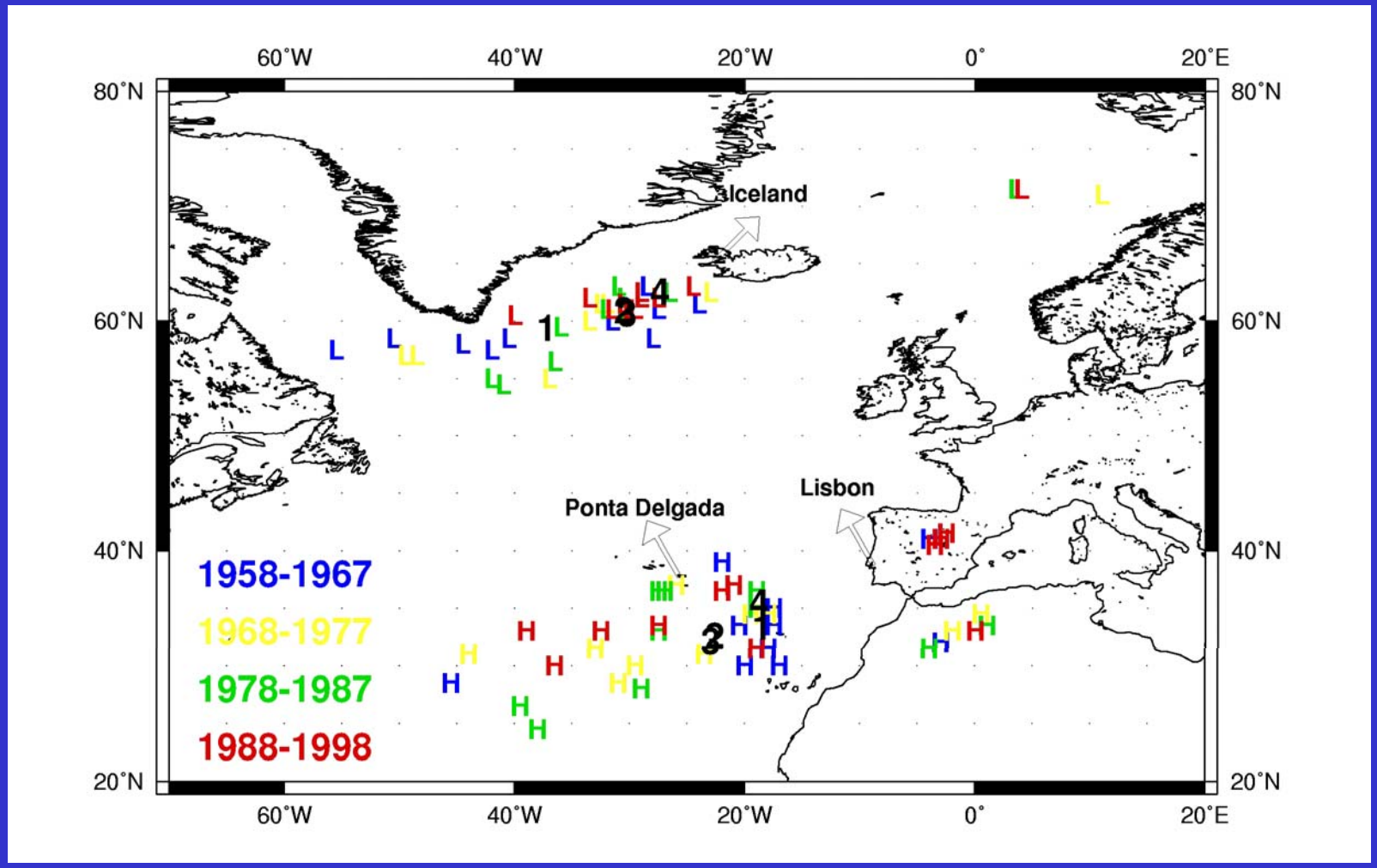




Trigo et al, Clim. Dyn., 2004.

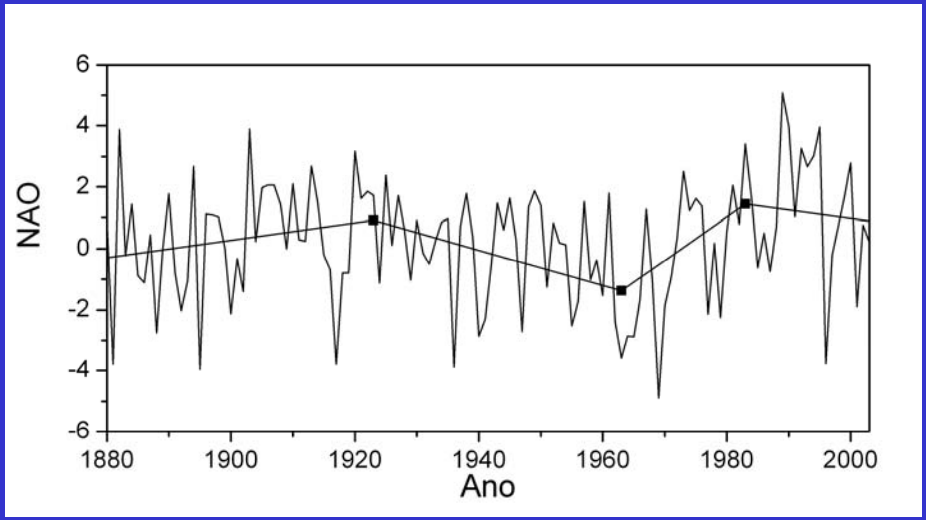
O que se passa com a evolução da NAO?

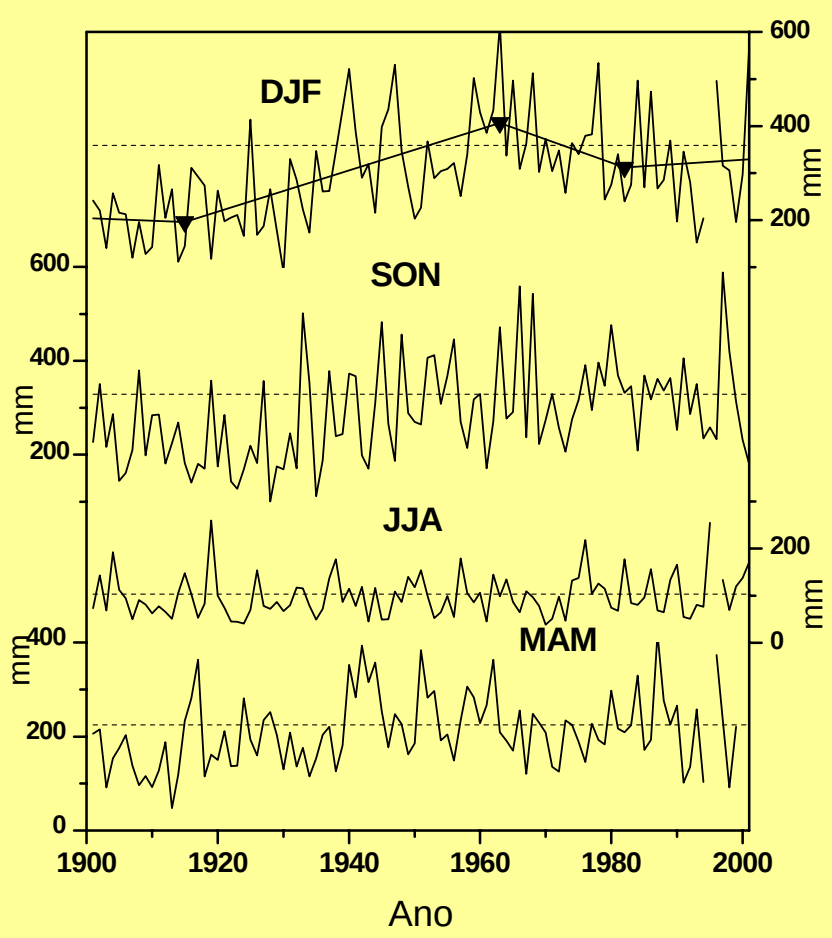
Evolução do Anticiclone dos Açores e da Depressão da Islândia
Médias anuais e decadais



Tomé, Miranda e Santos, WRR 2004

Precipitação em Ponta Delgada





P Miranda, Ponta Delgada, Abril 2005

3 – Alguns Factos

Aumentou a concentração de diversos poluentes, incluindo gases de estufa

Perda de Ozono estratosférico

Aumento da temperatura média, mas especialmente da mínima

Aumento de nebulosidade/aerossol

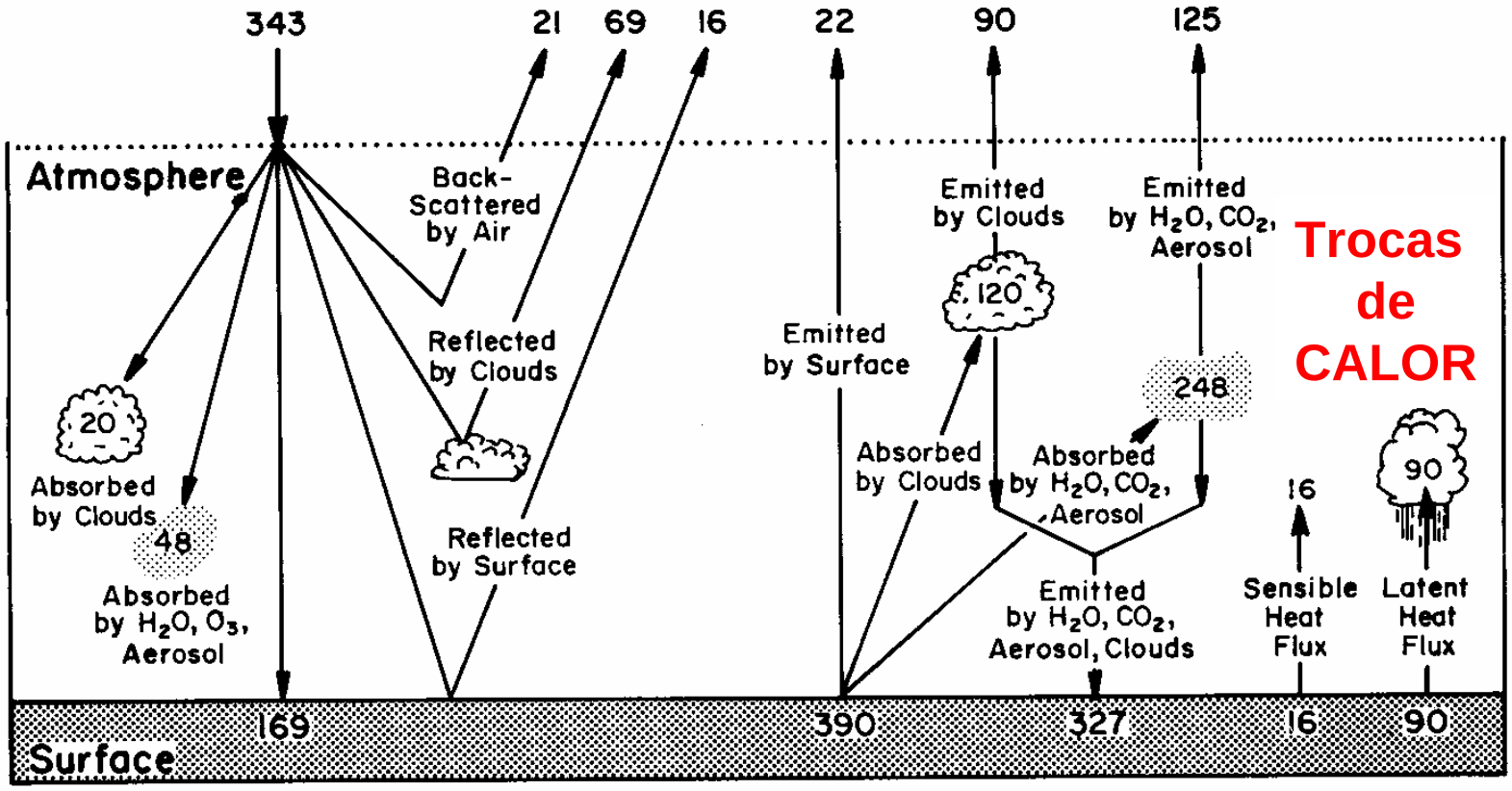
Em Portugal continental

Possível alteração do regime de precipitação (mas será significativa?), associada à NAO

Fluxos de energia

SOLAR **INFRAVERMELHA**

100% incidente = 30% reflectida + 70% Outgoing Longwave Flux

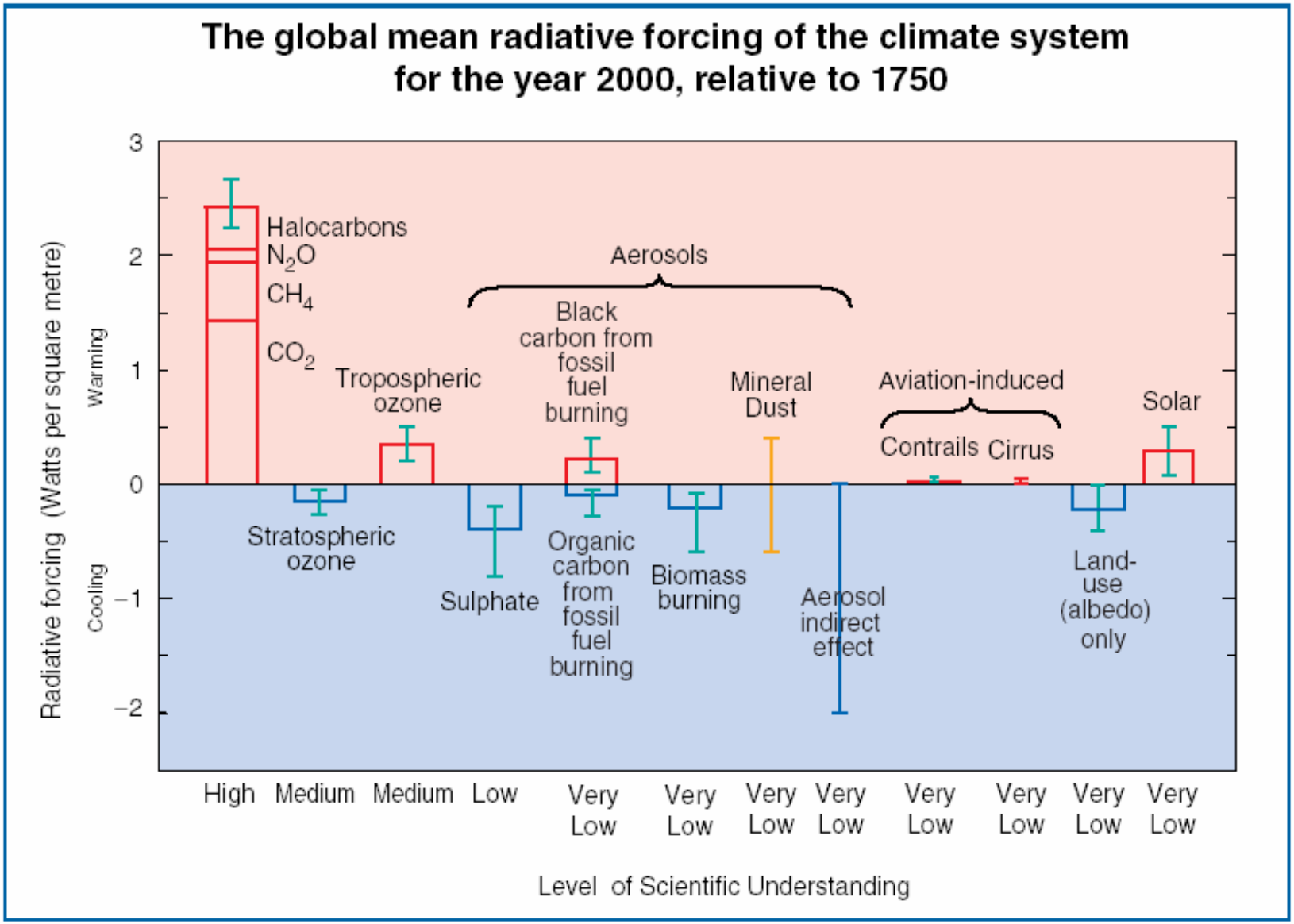


Trocas de CALOR

49% -113% 95% -5% -26%

P Miranda, Ponta Delgada, Abril 2005

Forçamentos



Mecanismos de regulação térmica

Forçamento externo

+- Radiação solar incidente →+-aquecimento

Gases de estufa

+- Radiação atmosférica descendente →+-aquecimento

Desregulação (Feedback gelo/albedo)

T↓ →+gelo →+albedo →-radiação

Estabilização

T↓ →-plantas →+CO_2 →+efeito de estufa → T↑

Efeitos das nuvens ?

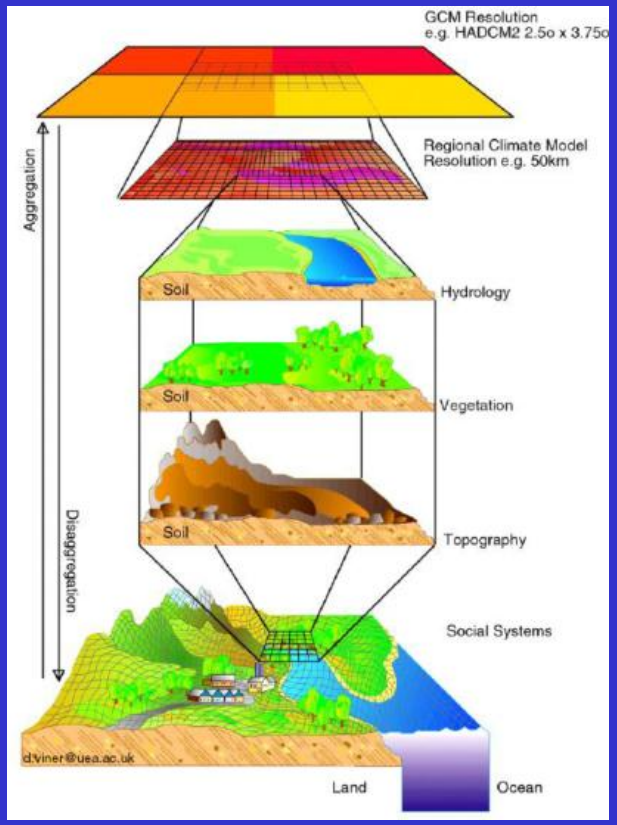
T↑ → + nuvens →

altas→ + efeito de estufa→T↑

baixas → + albedo → T↓

4 – Modelos

Se queremos incluir vários processos em simultâneo ou processos de transporte calor, temos que recorrer a modelos

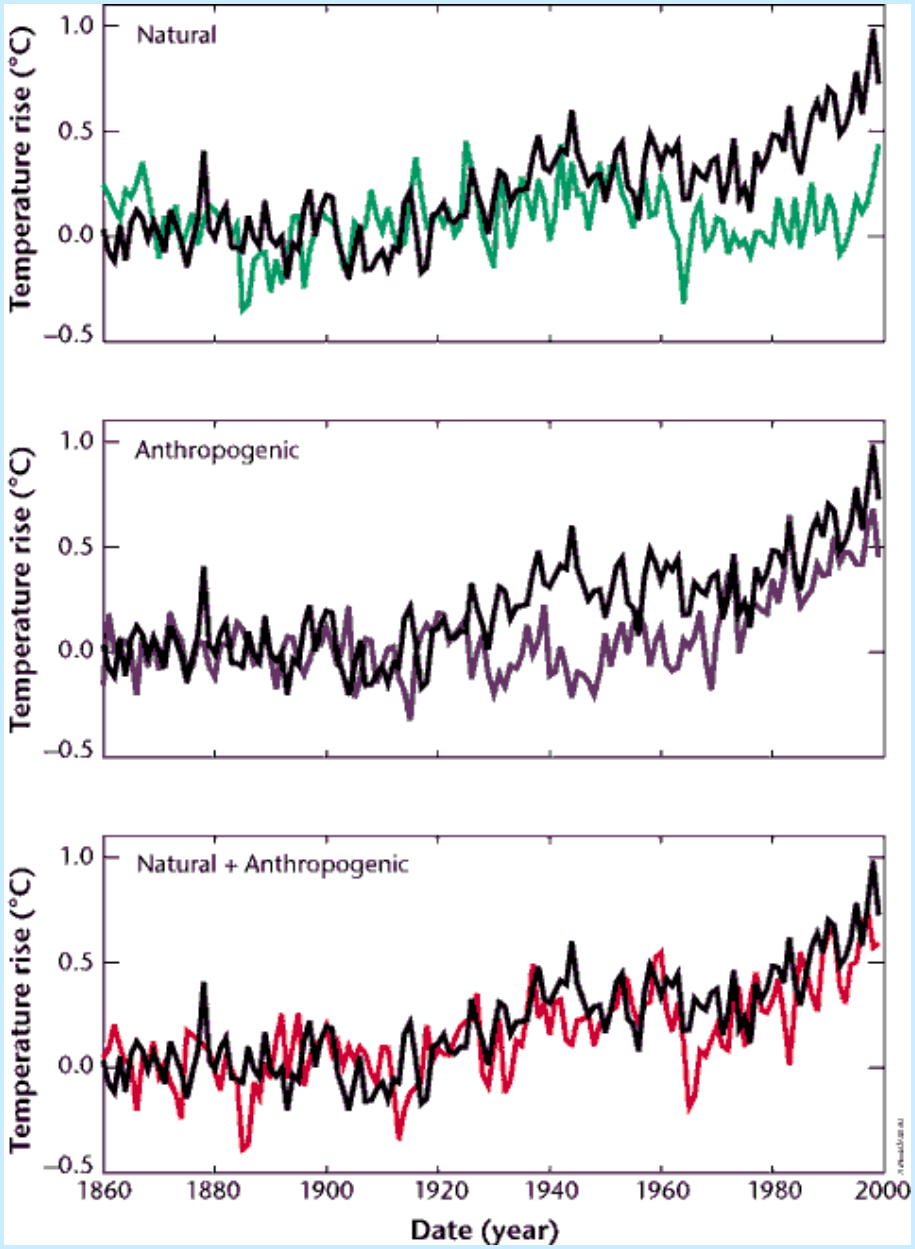


Reprodução do clima do século XX
Modelo Global do Hadley Centre (UK)

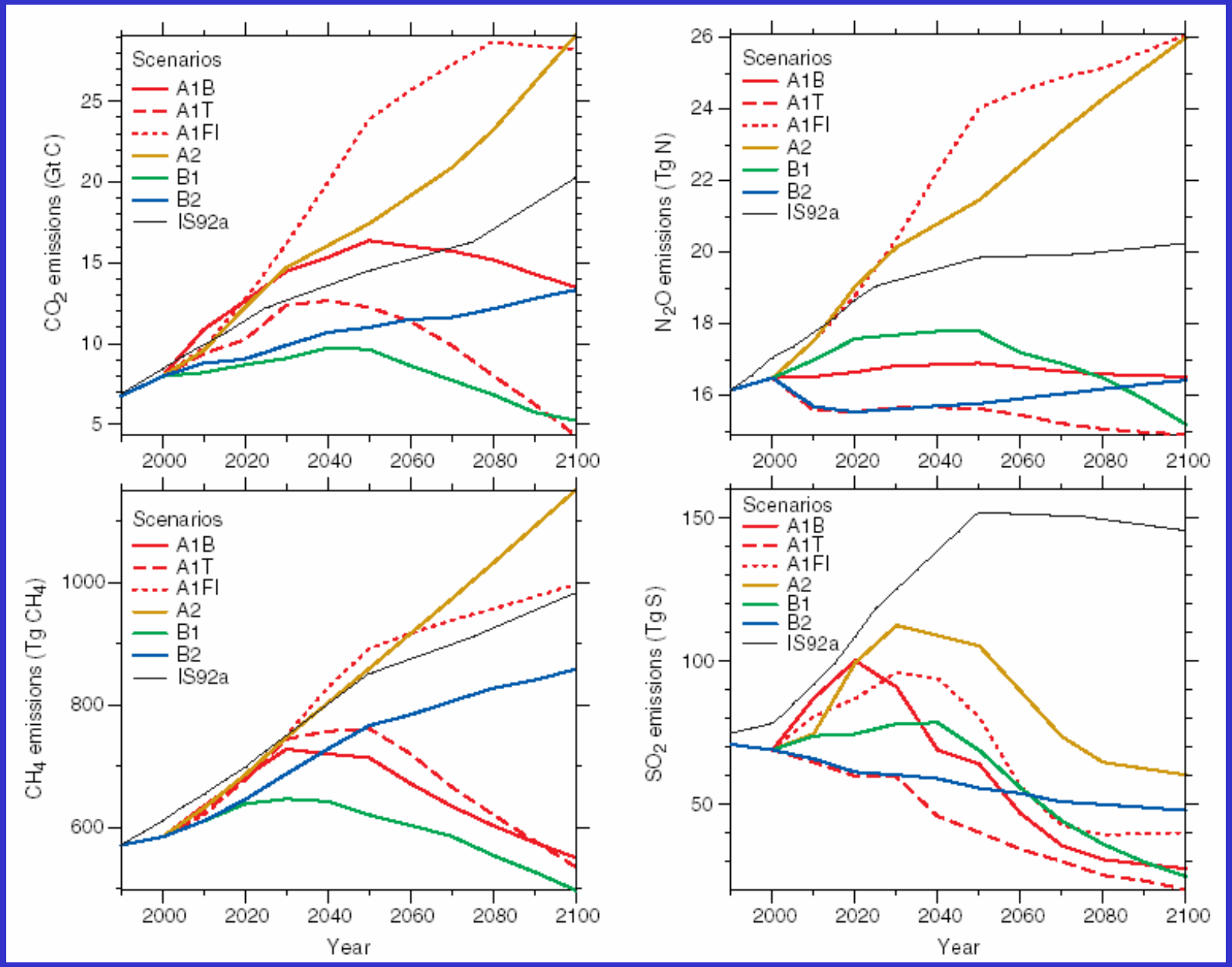
Com forçamentos observados:

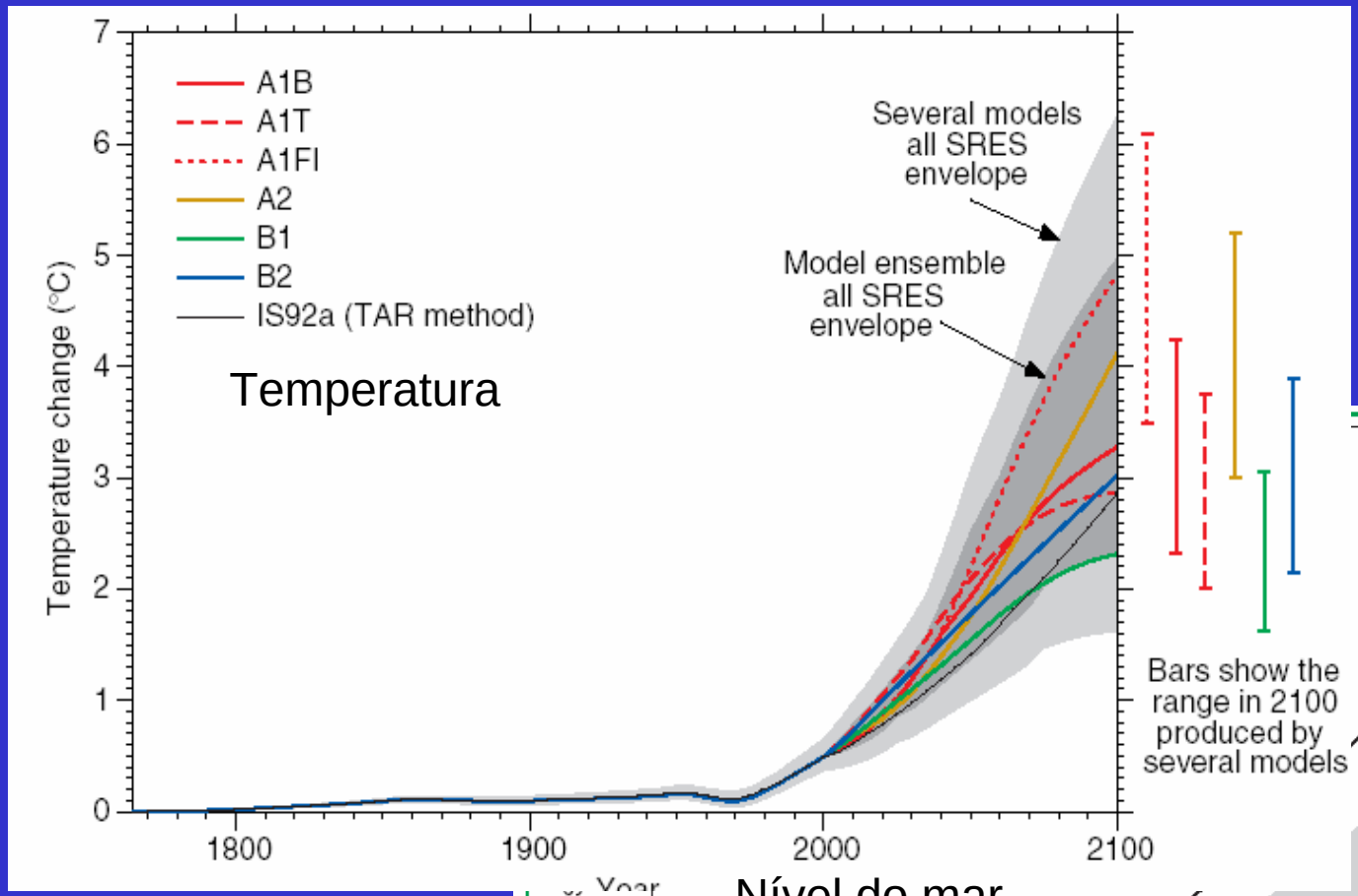
Vulcões, El Niño
Actividade solar
Emissões de gases de estufa e aerossol

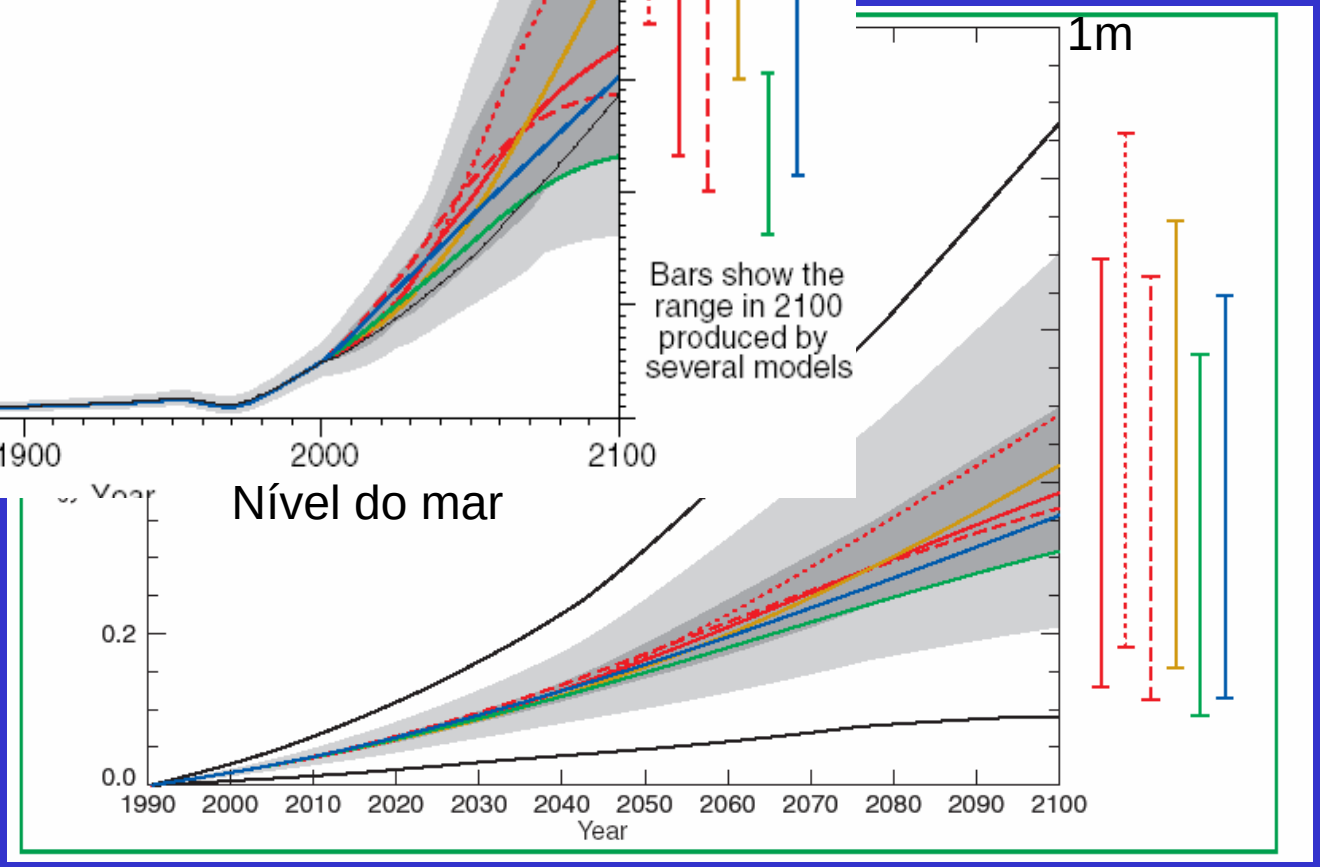
O aquecimento global ultrapassou o nível do ruído climático



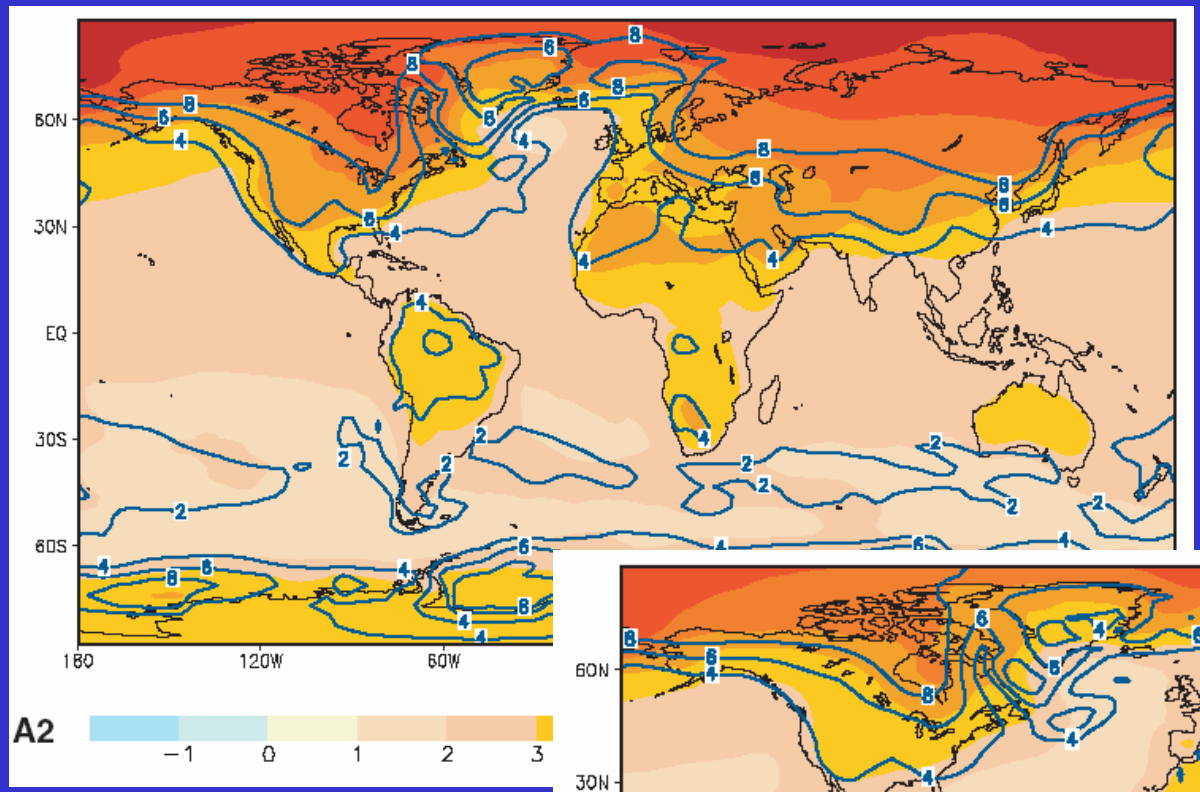
5 – Cenários: SRES

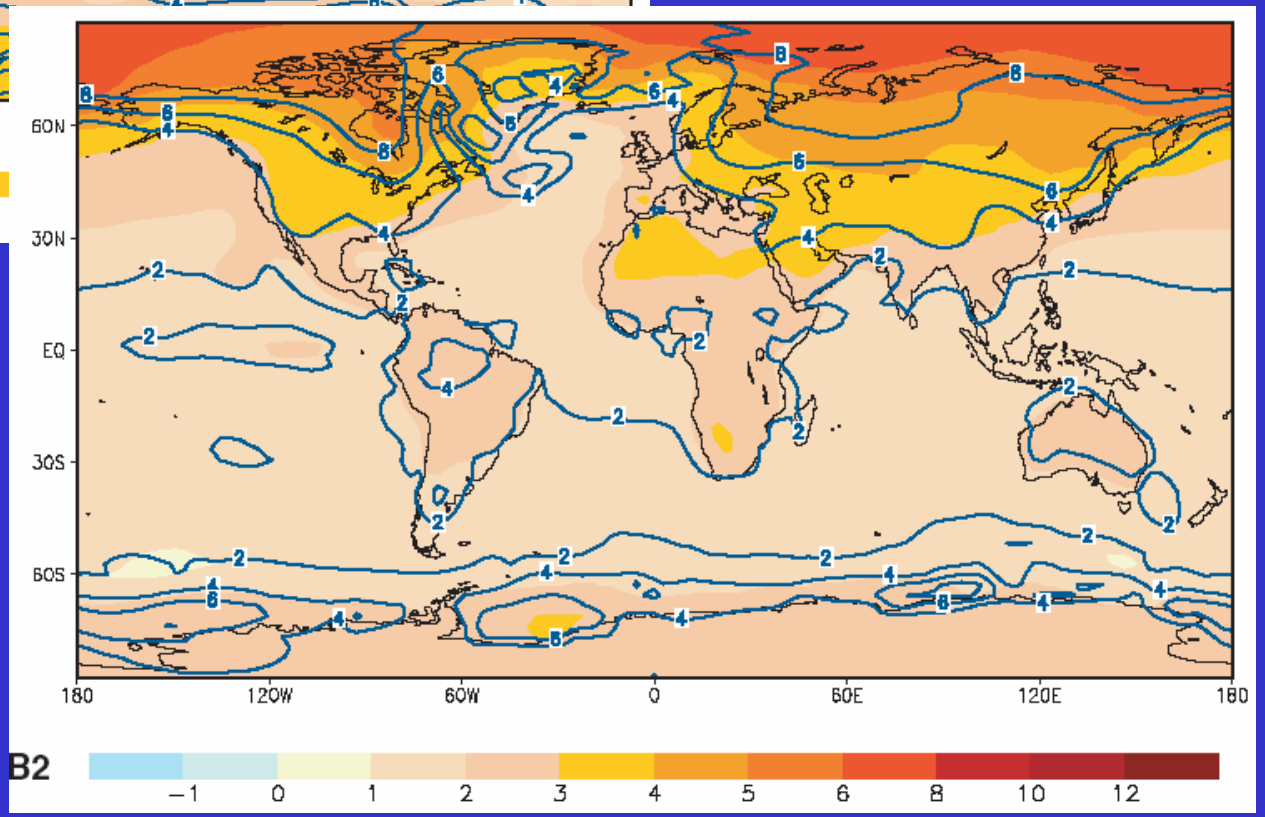






P Miranda, Ponta Delgada, Abril 2005

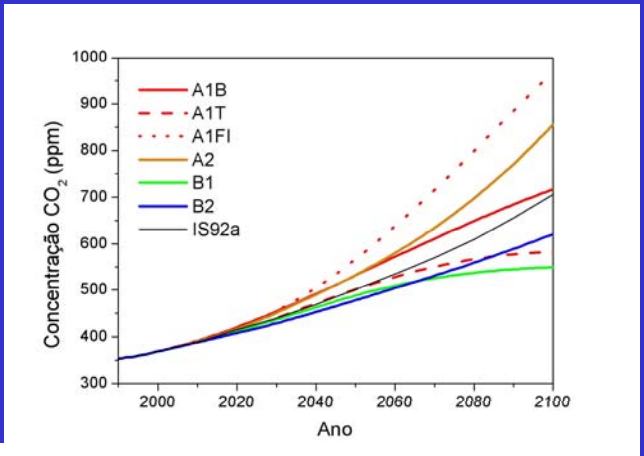


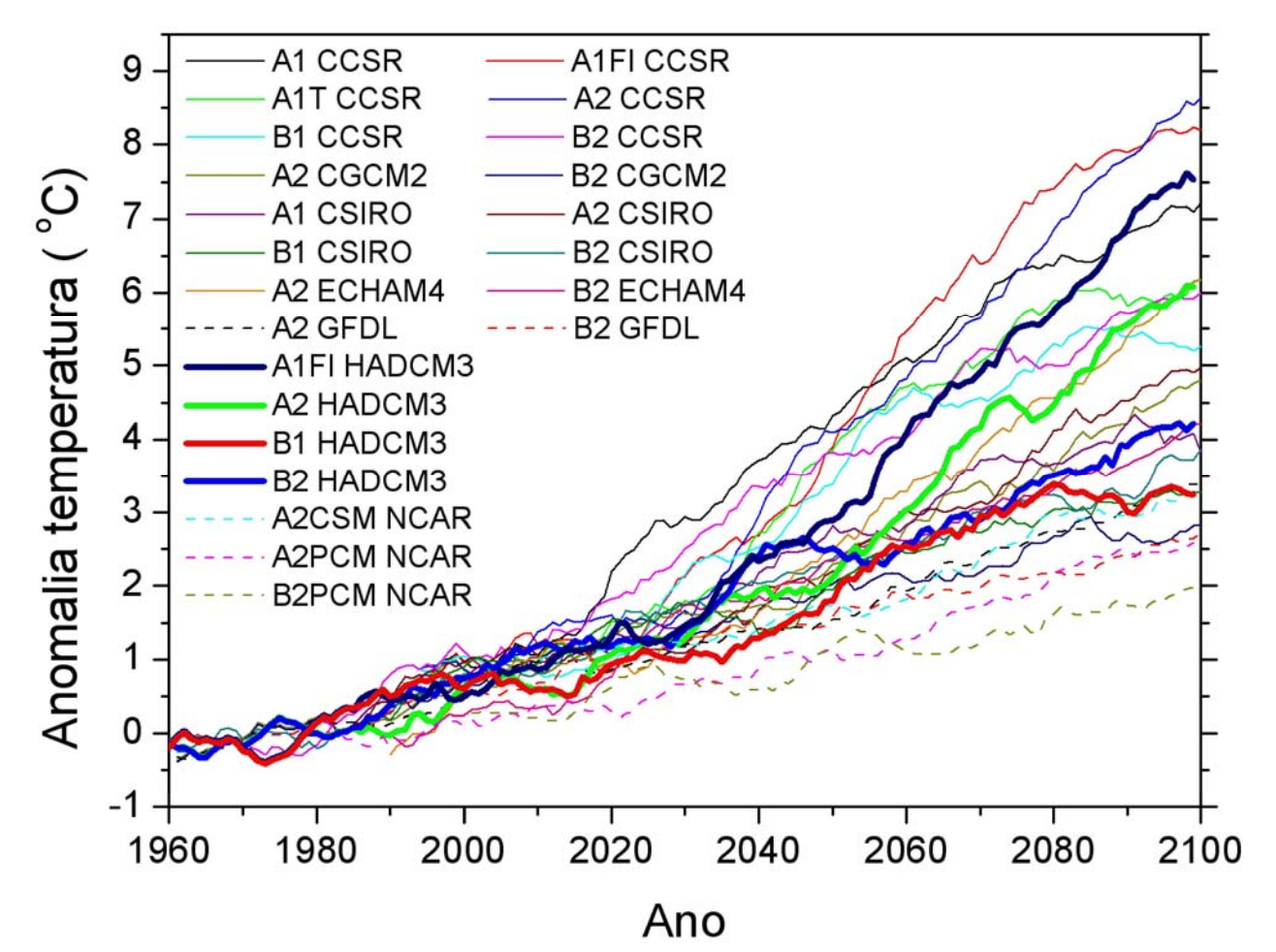


P Miranda, Ponta Delgada, Abril 2005

Cenários de mudança climática

Temperatura média na Península Ibérica





Incerteza?

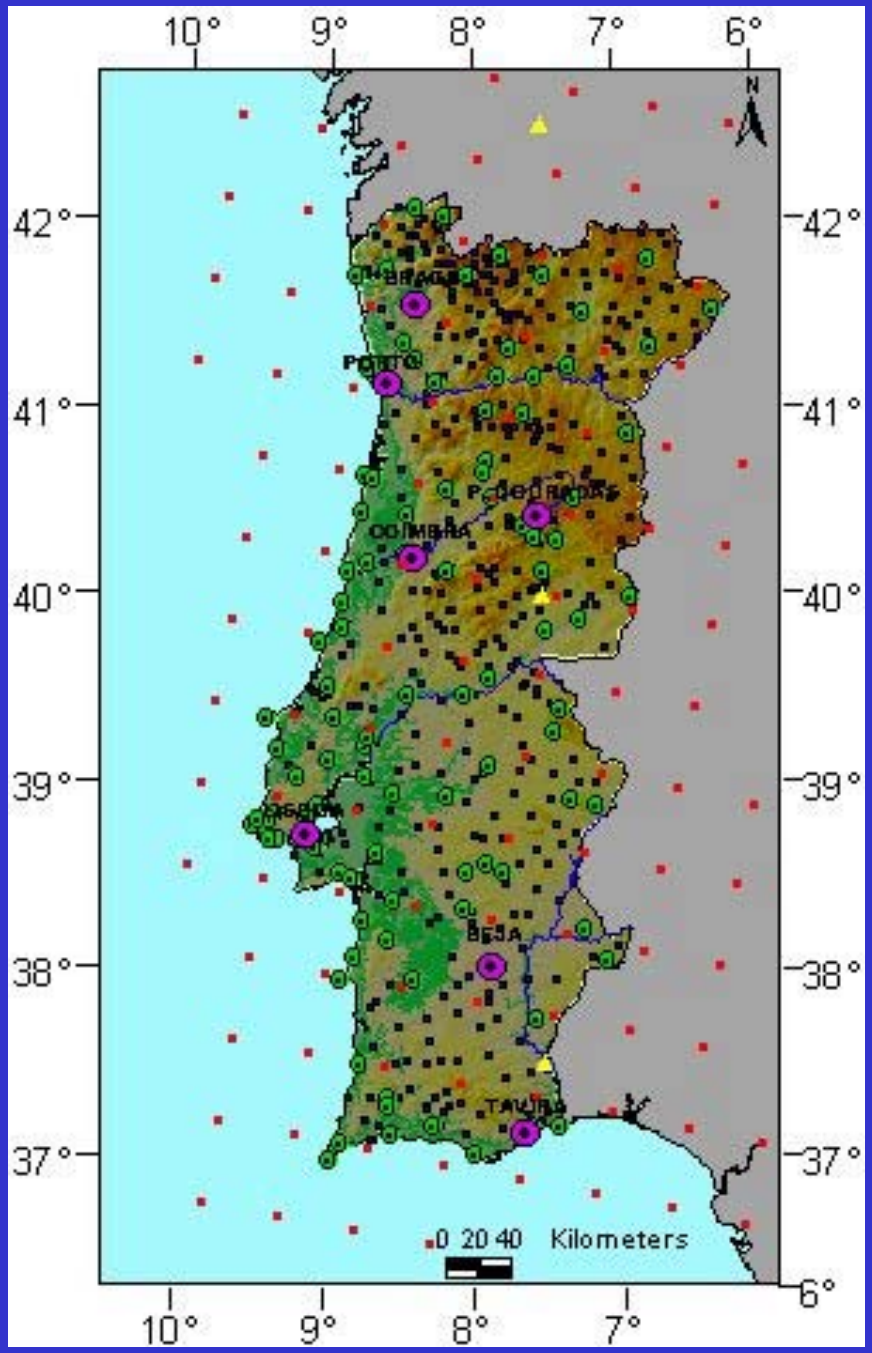
P Miranda, Ponta Delgada, Abril 2005

6 – CENÁRIOS Climáticos Regionais

Rede meteorológica e pontos de grelha de modelos

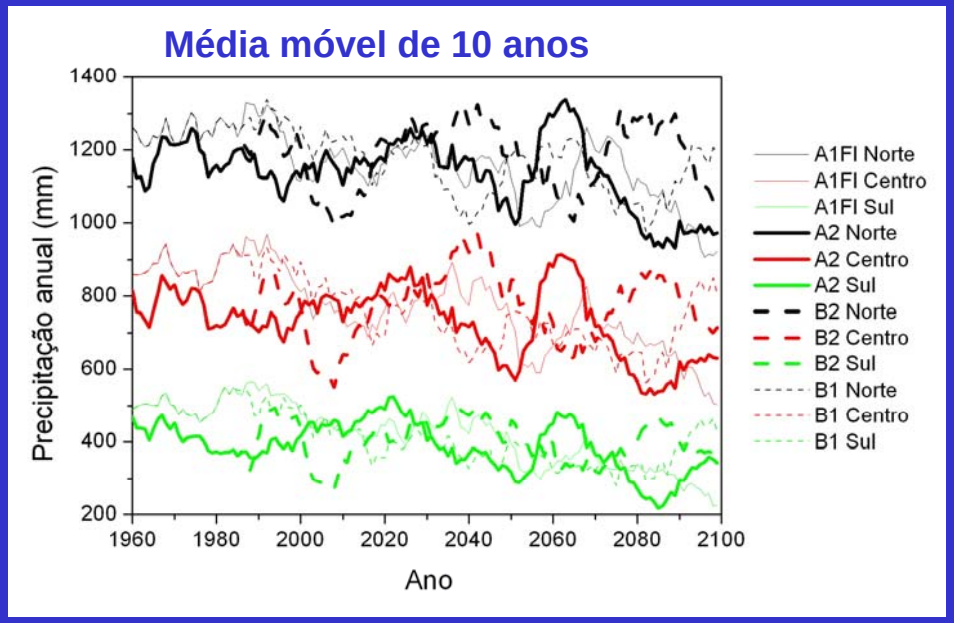
Modelo HadCM3 (300x300 km)
2x150 anos de simulação

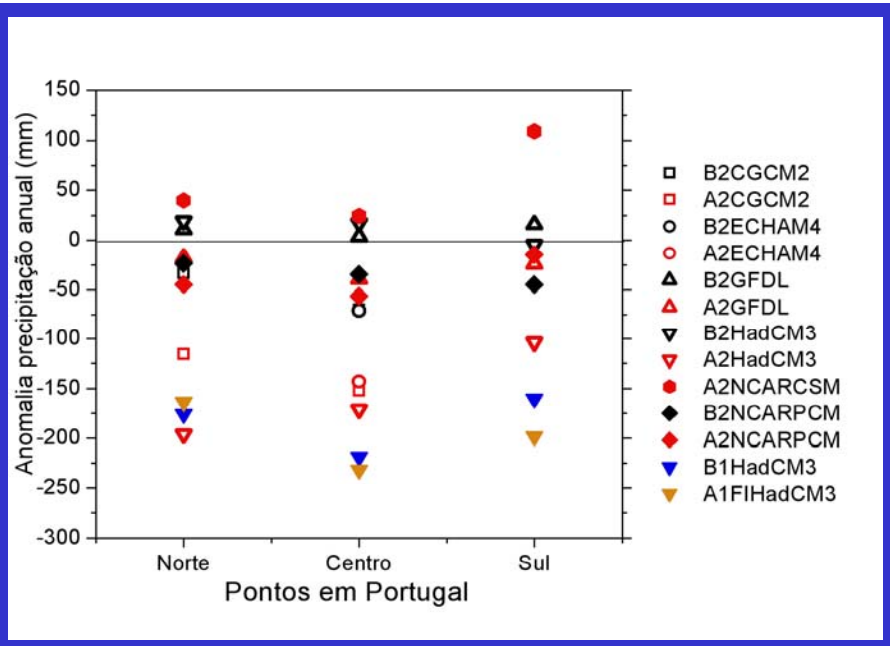
Modelo HadRM (50x50 km)
2x20 anos de simulação
forçado por HadCM2/3

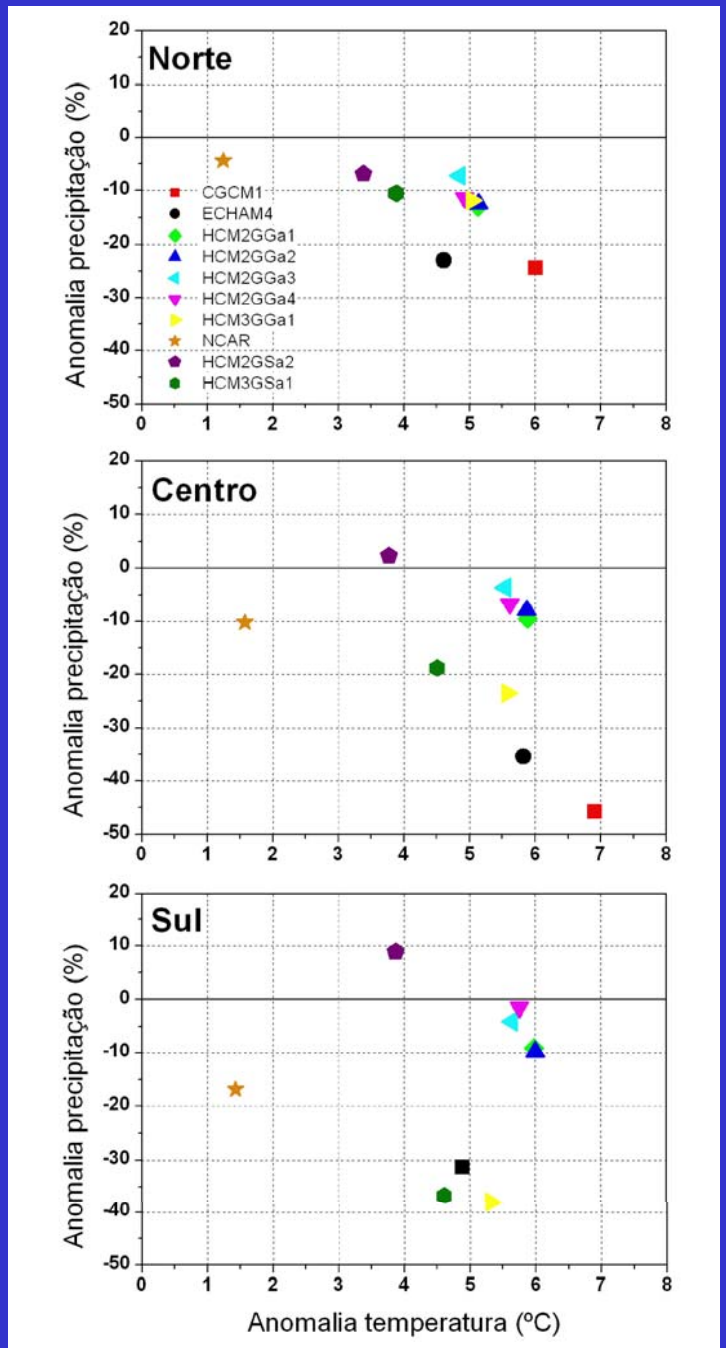


- HadCM
- HadRM
- Main Meteorologic Stations
- Meteorologic Stations
- Udometric Stations

Precipitação







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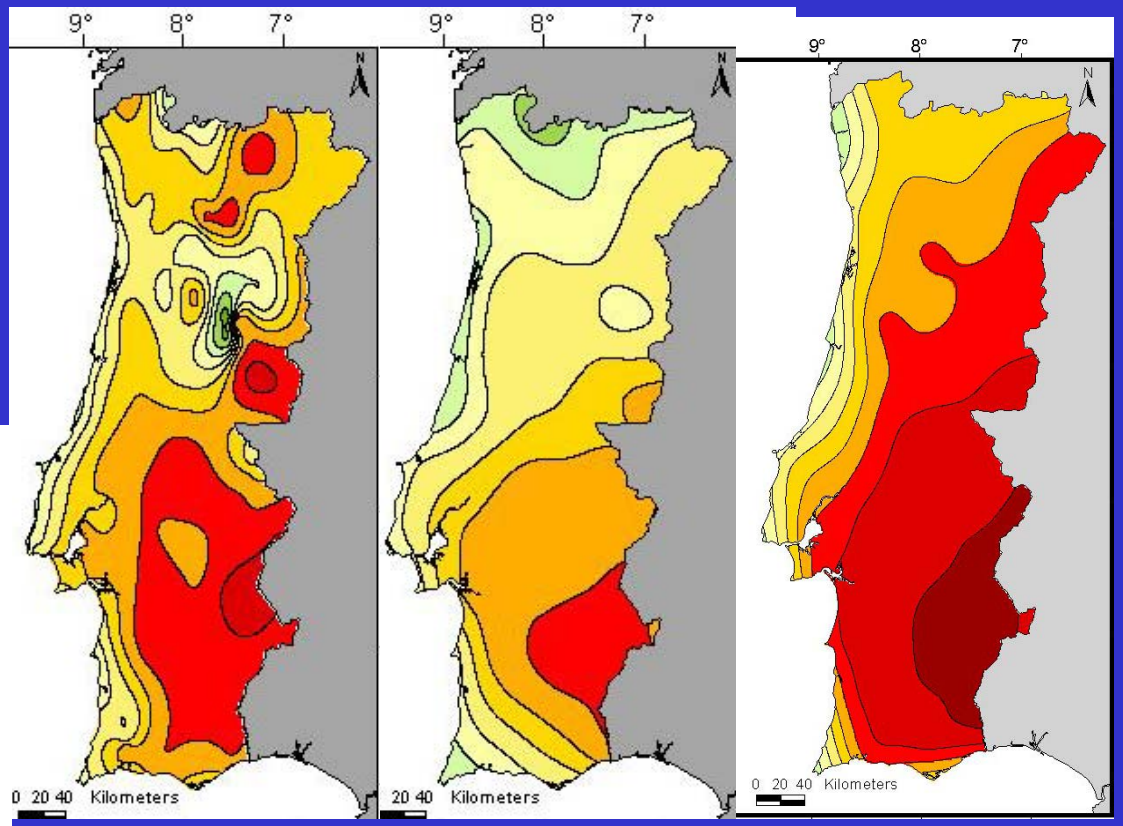
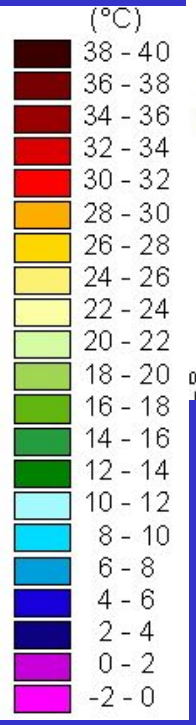
Temperatura máxima JJA





Observações 1961-1990

HadRM2

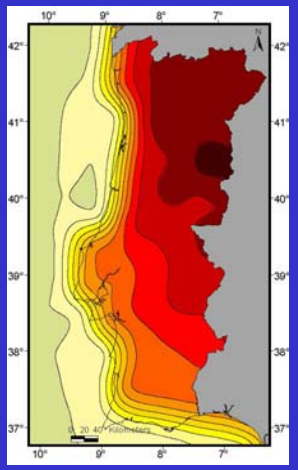
HadRM3

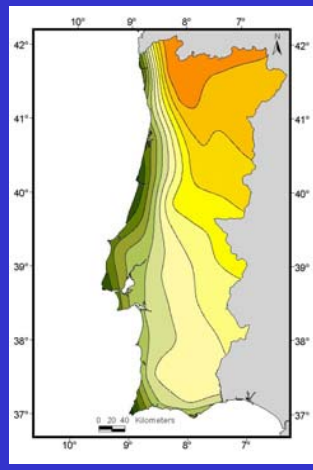
Controlo HadRM

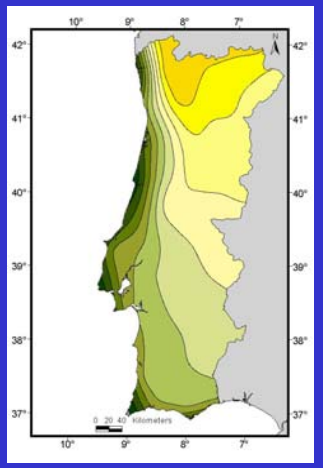
Anomalia Temp Cenários

IS92A

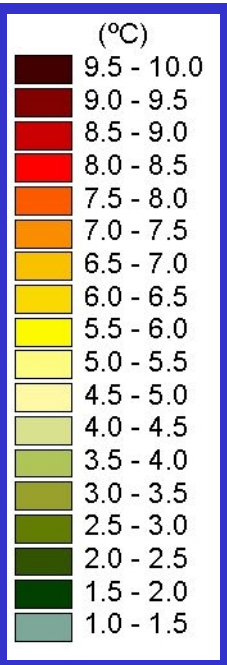
A2



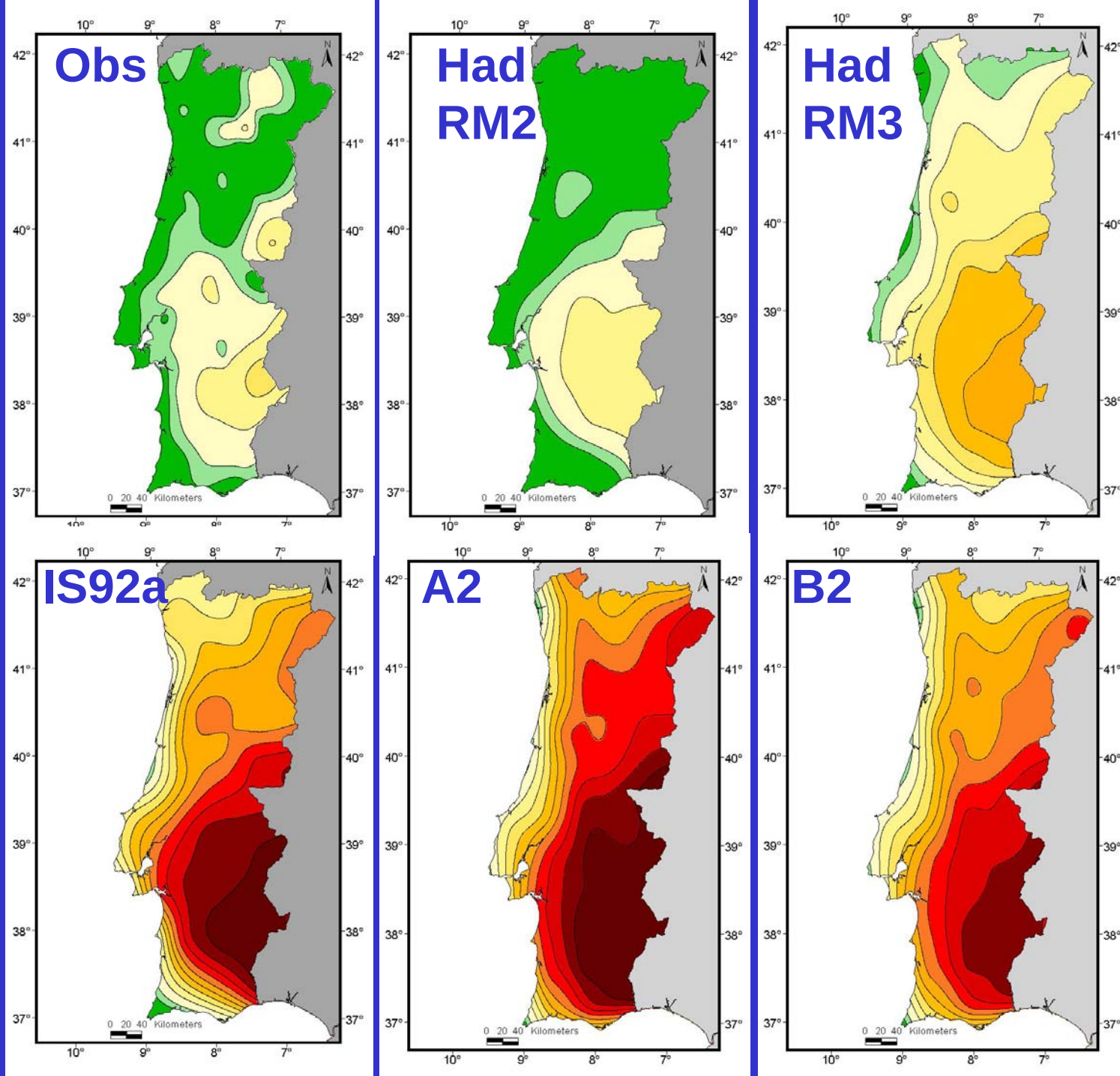




B2



Nº dias T>35º

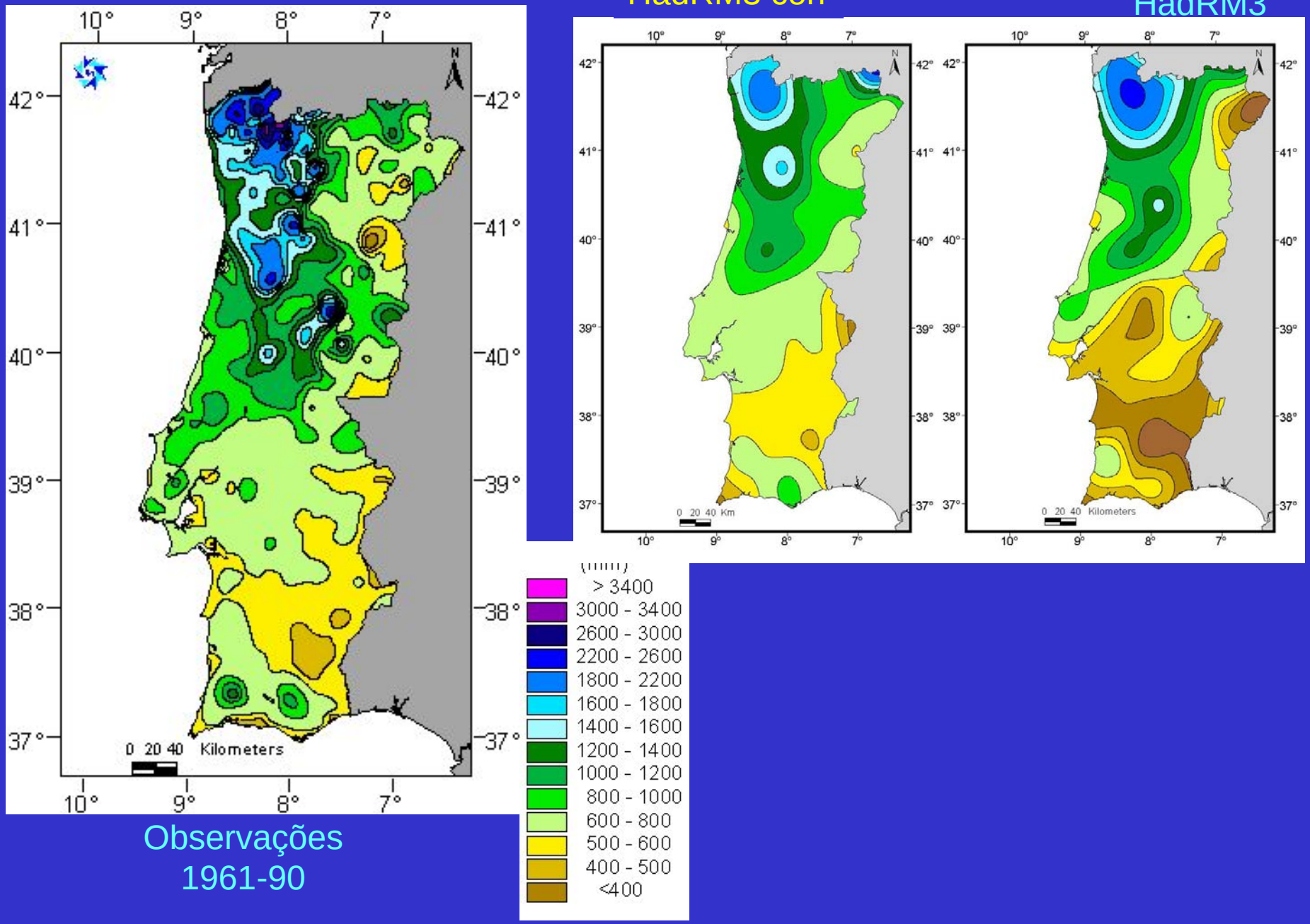

Obs
Had RM2
Had RM3
IS92a
A2
B2
0 20 40 Kilometers
100 - 120
90 - 100
80 - 90
70 - 80
60 - 70
50 - 60
40 - 50
30 - 40
20 - 30
10 - 20
5 - 10
<5

Precipitação Anual

Simulação controlo

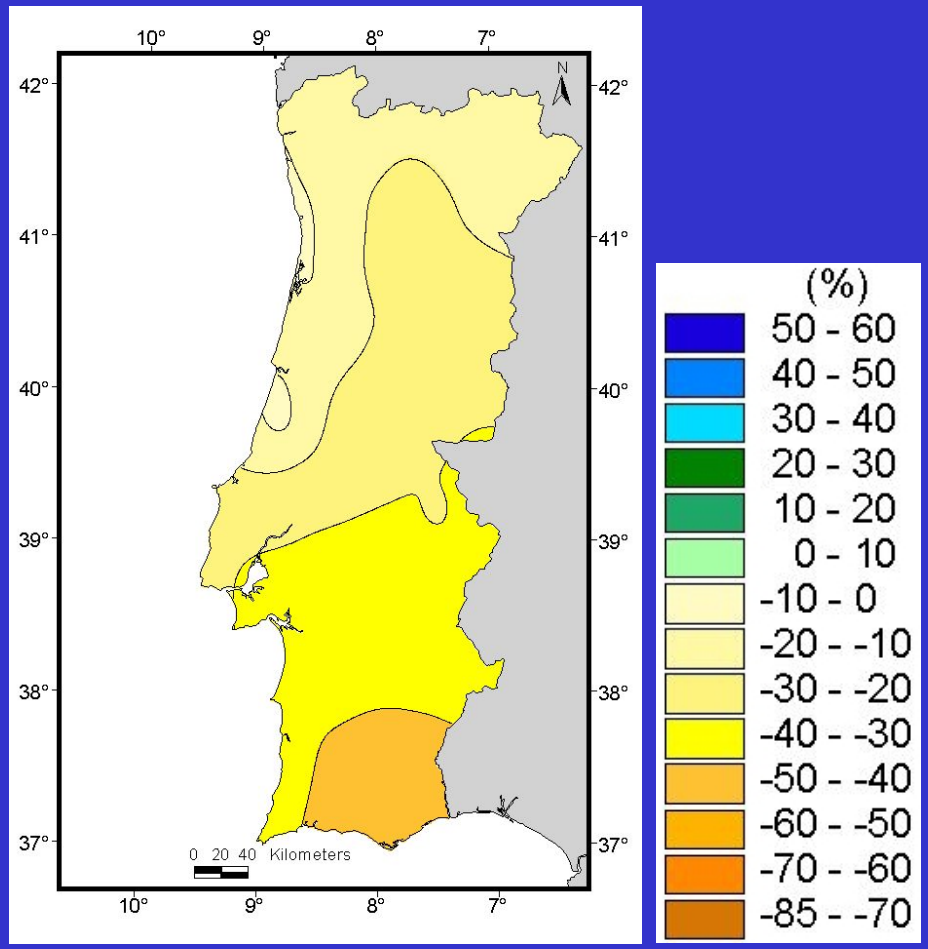
HadRM3 corr

HadRM3

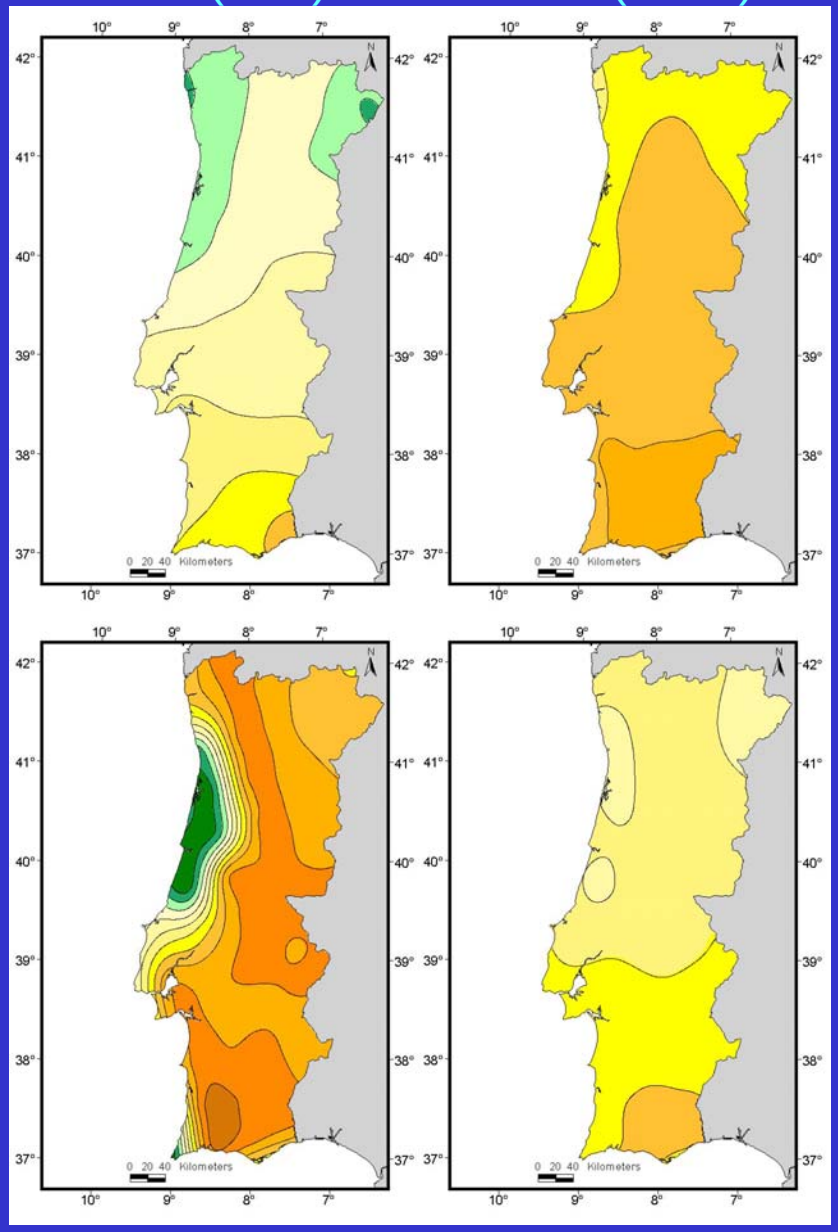


Observações
1961-90

Anomalia da precipitação
Cenário A2



Inverno (DJF) Primavera (MAM)



Verão (JJA) Outono (SON)

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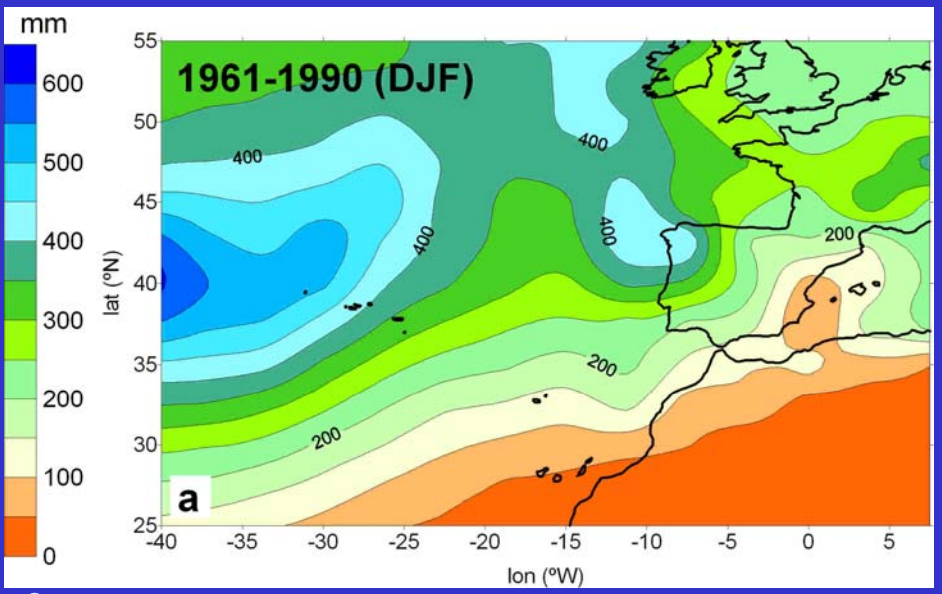

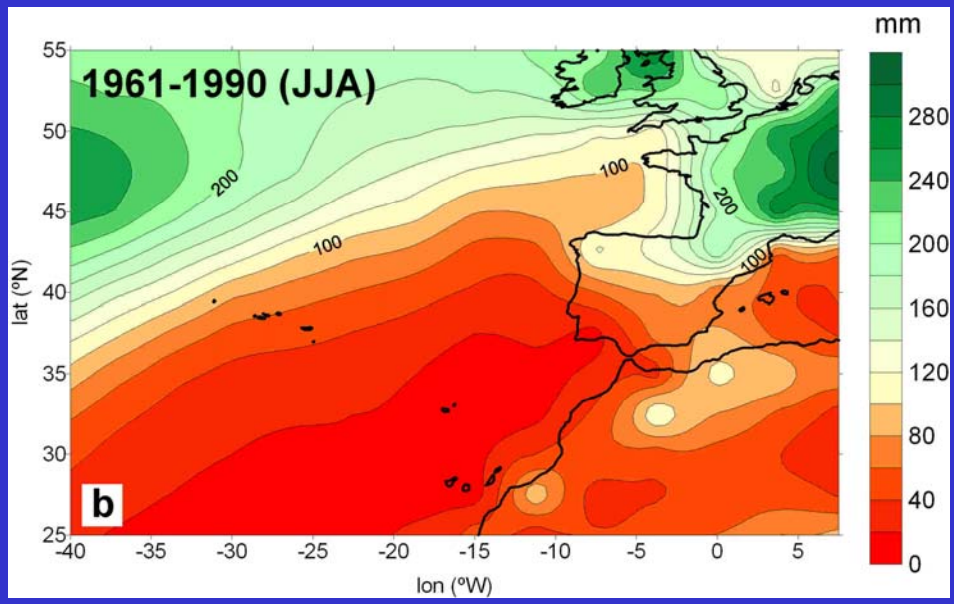

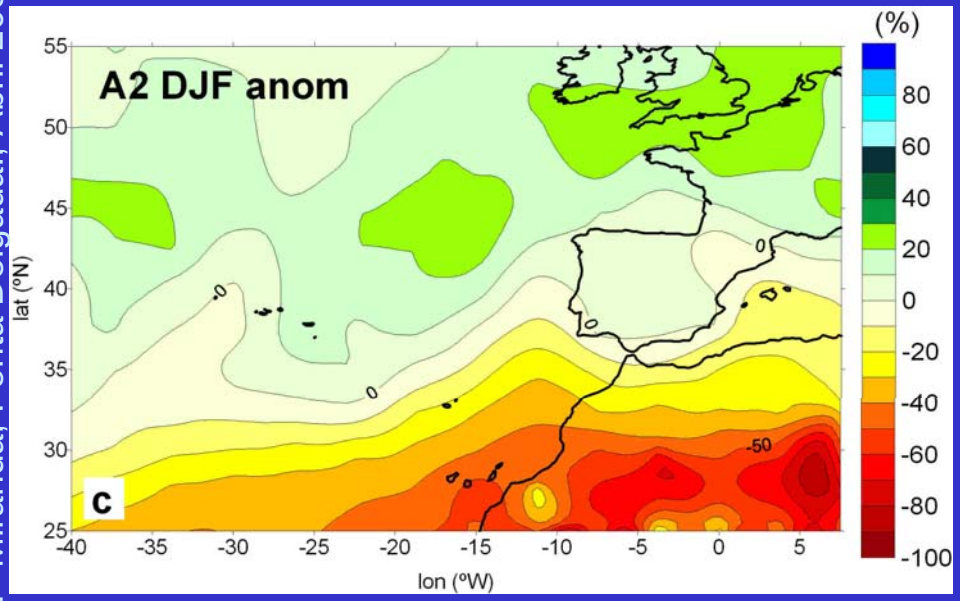

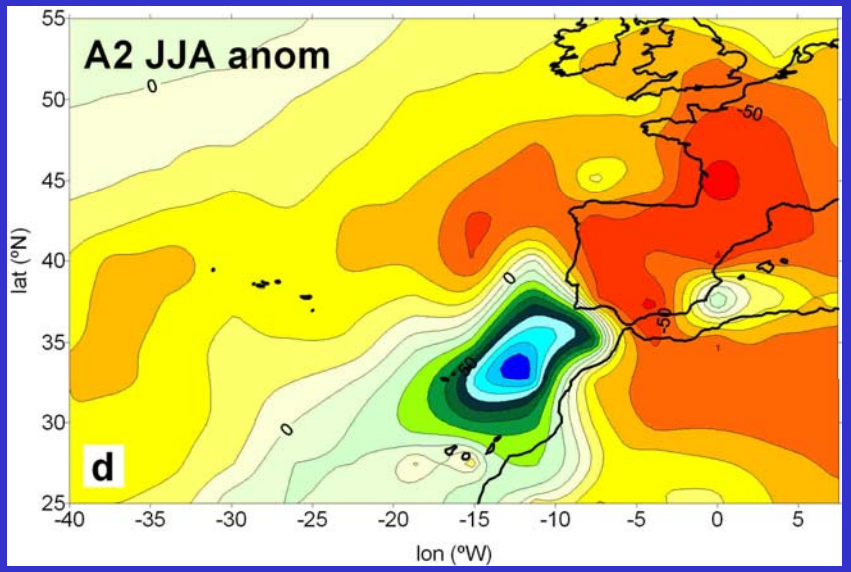

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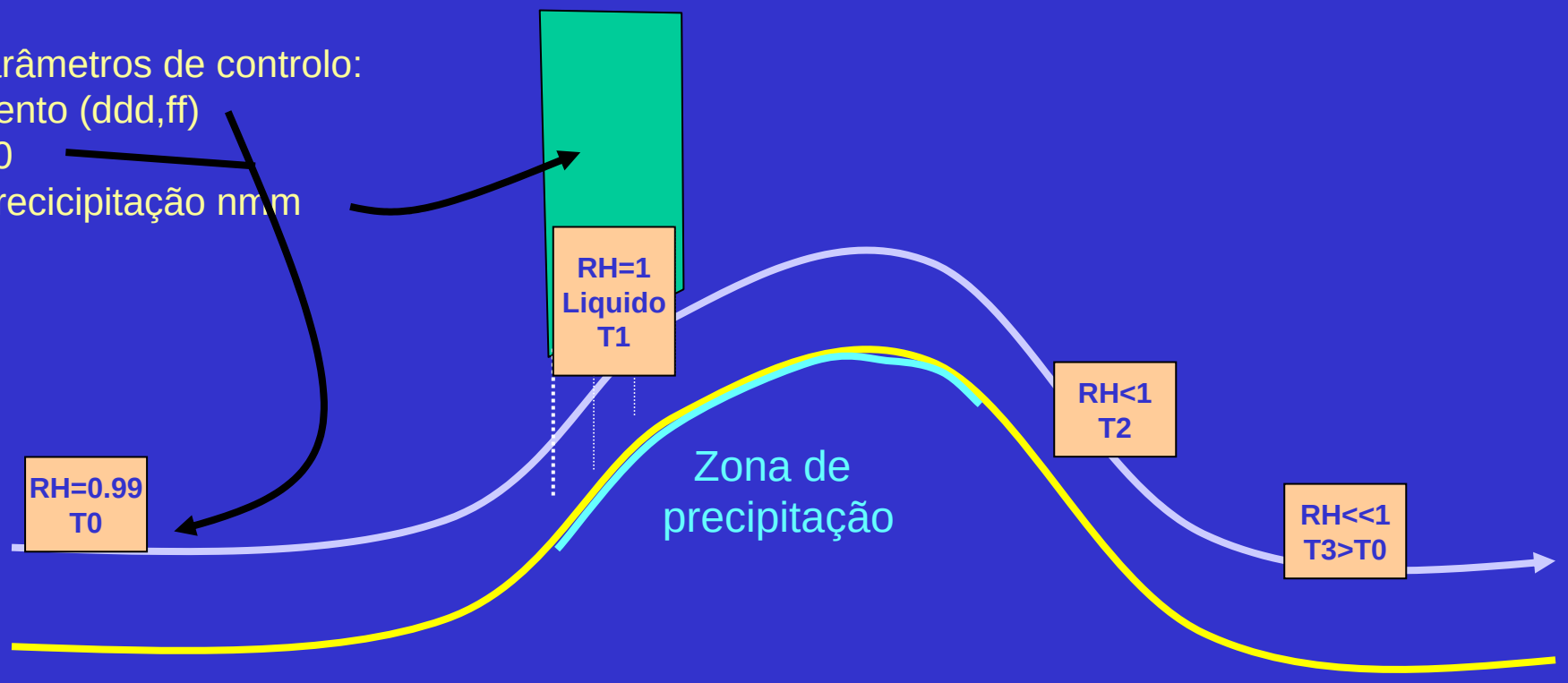
Regionalização de cenários em ilhas

Problemas:

Efeitos aerodinâmicos
Efeitos de mesoscala na precipitação
Nível de condensação
Definição da atmosfera de referência

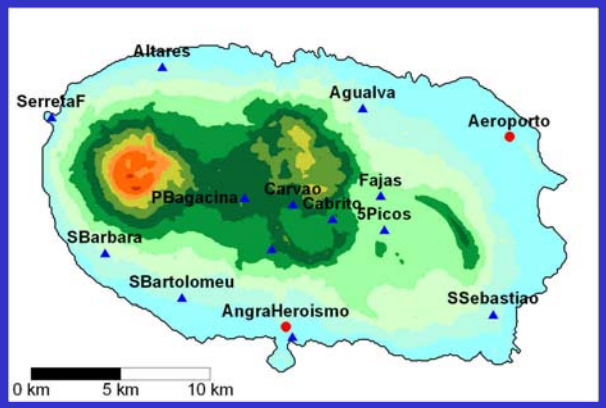
Parâmetros de controlo:
- Vento (ddd,ff)
- T0
- Precicipitação nmm

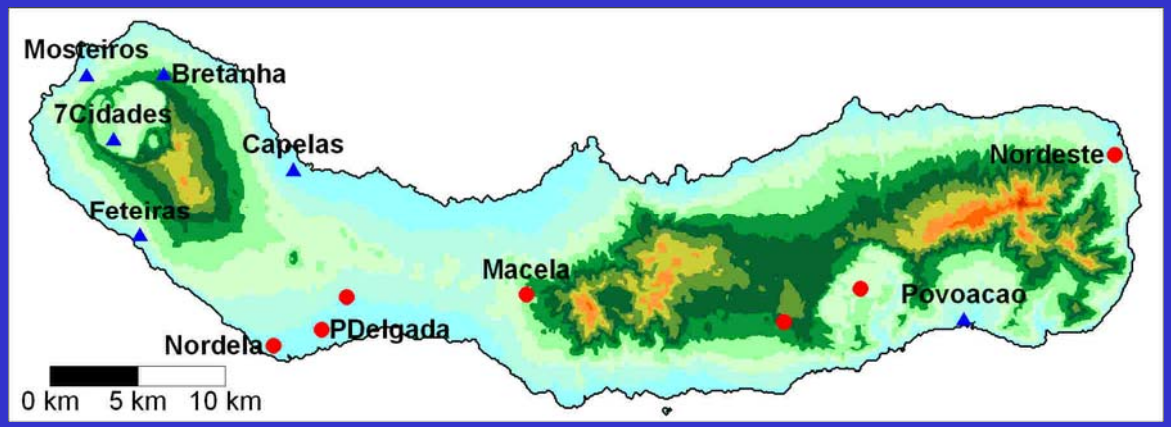


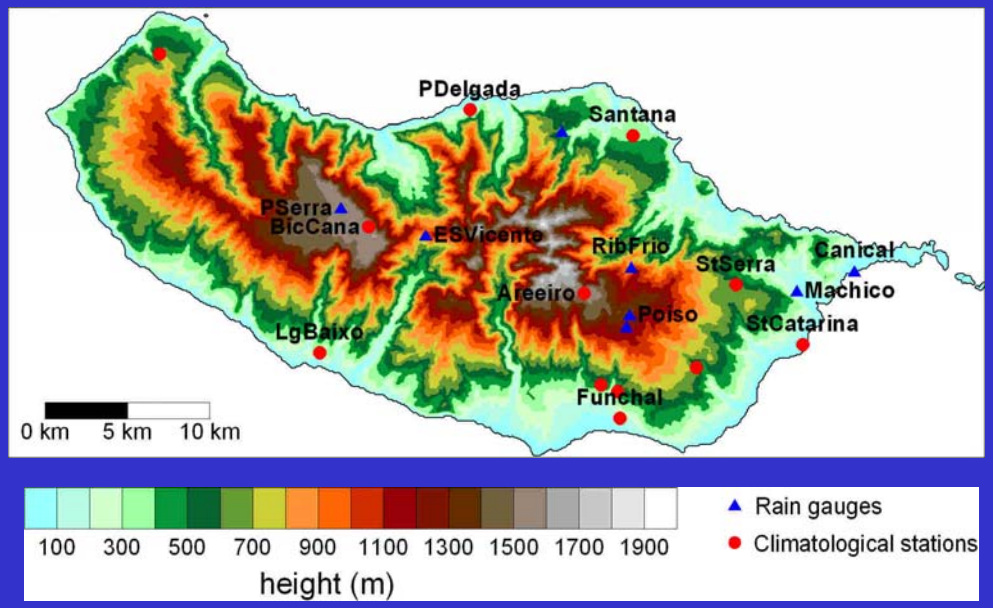
Modelo CIELO (Azevedo, 1998)

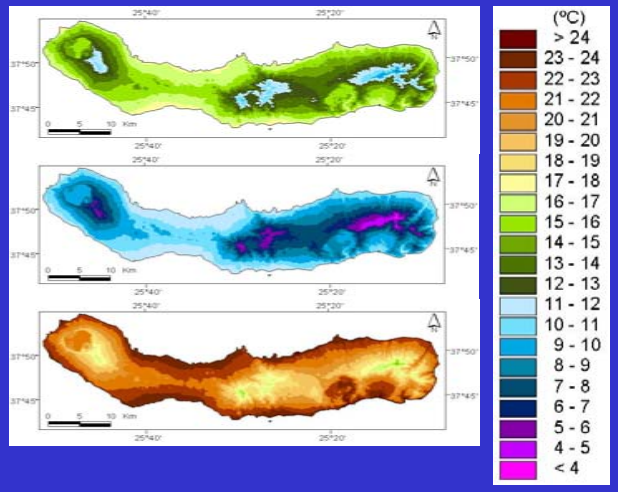
Efeito de Fohen

Topografia das ilhas

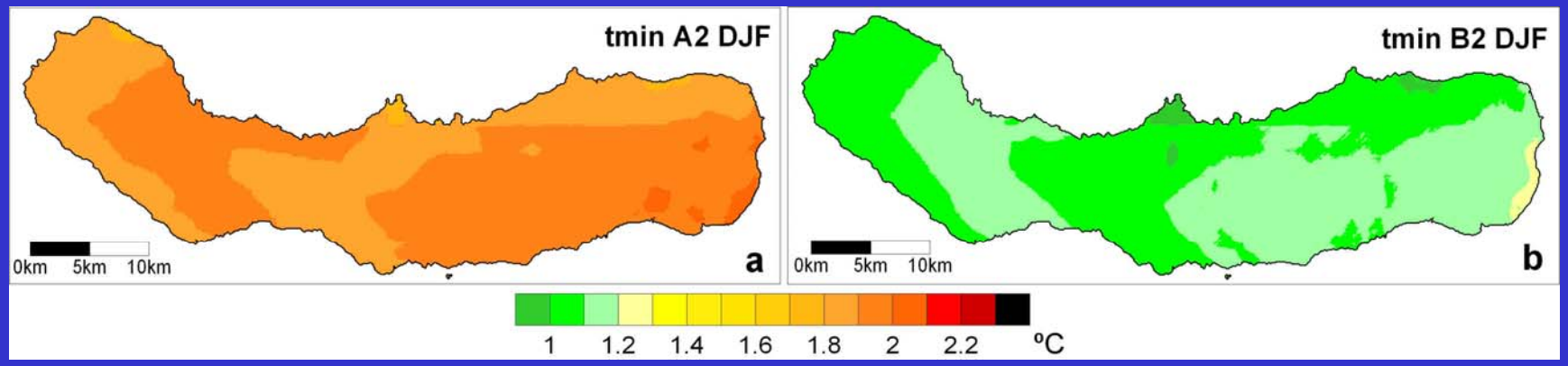


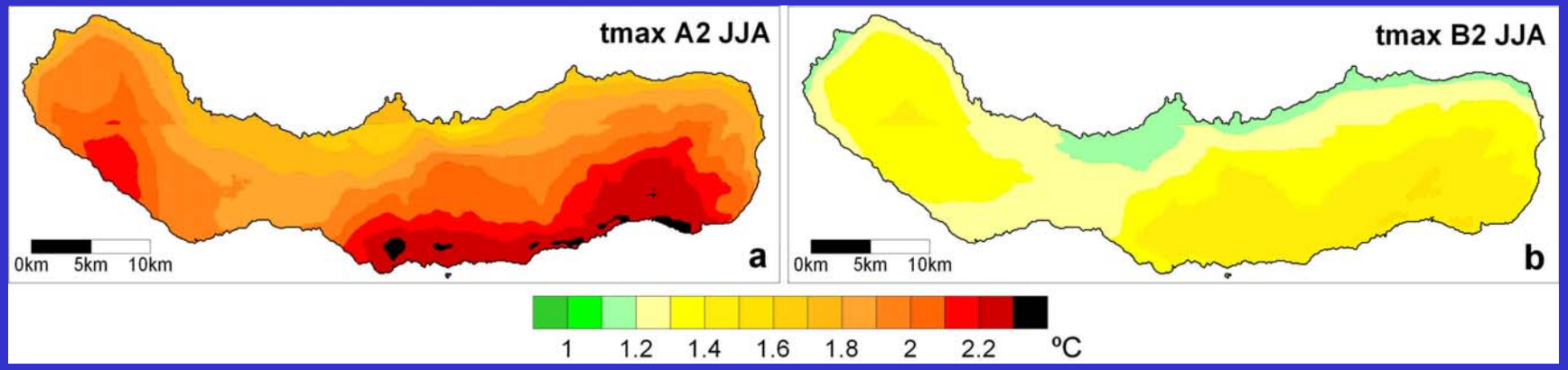






Variação de temperatura





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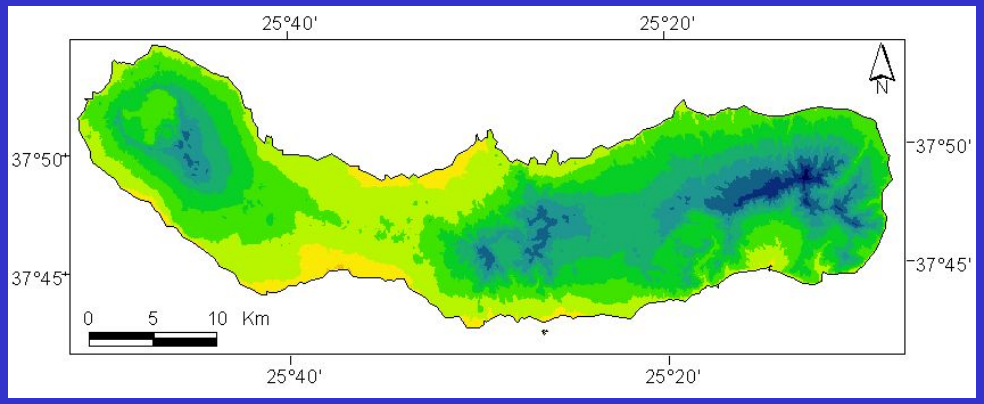
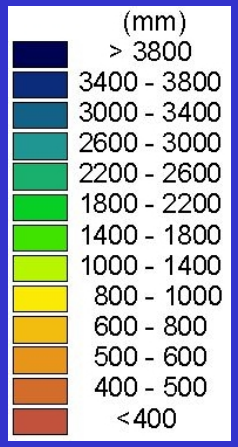
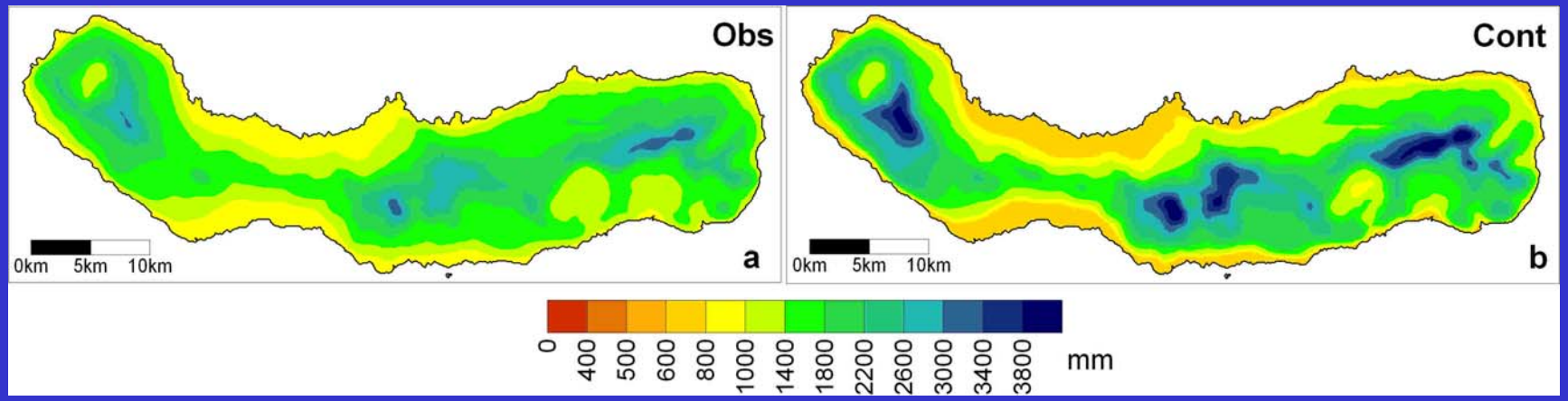
Validação do CIELO e do cenário de controlo







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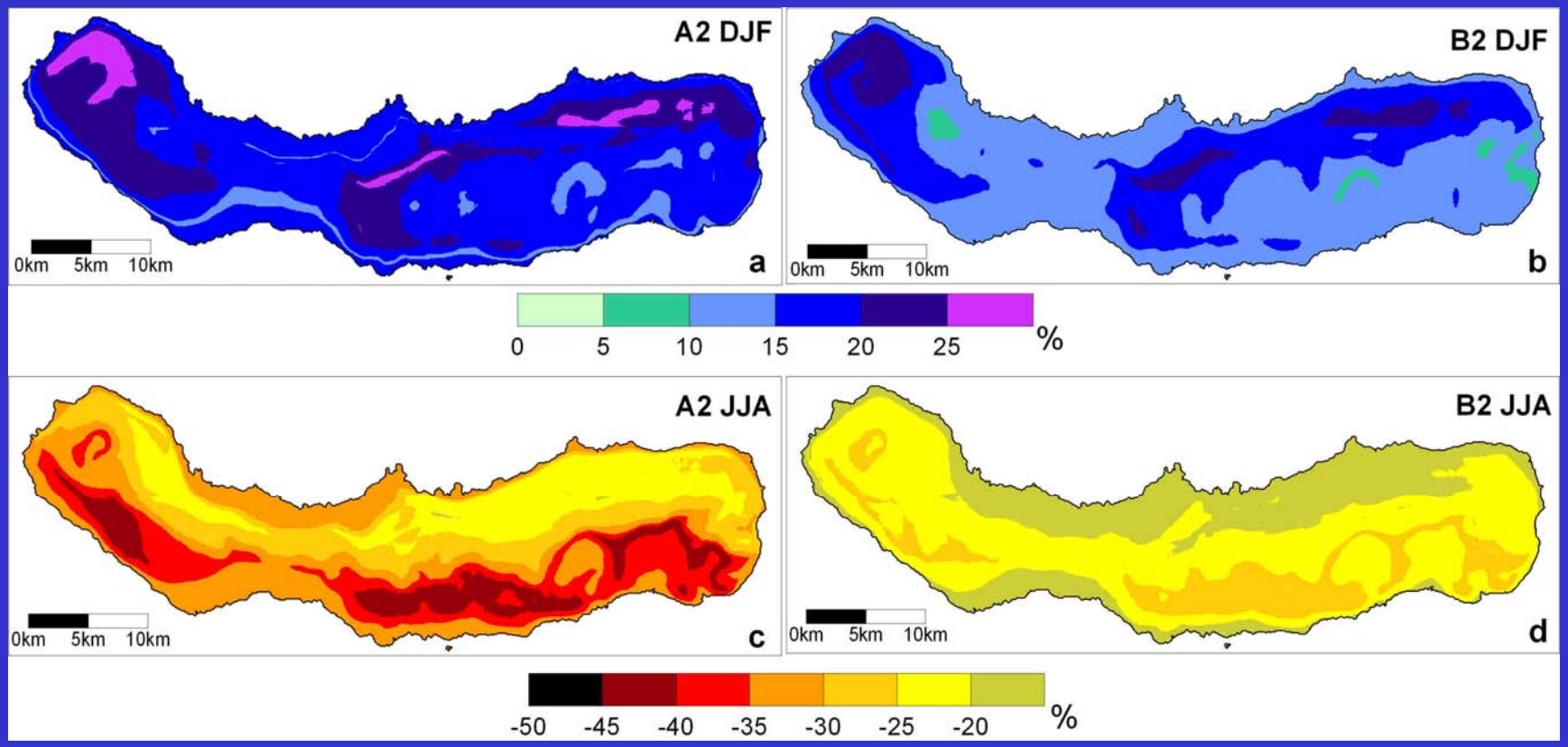
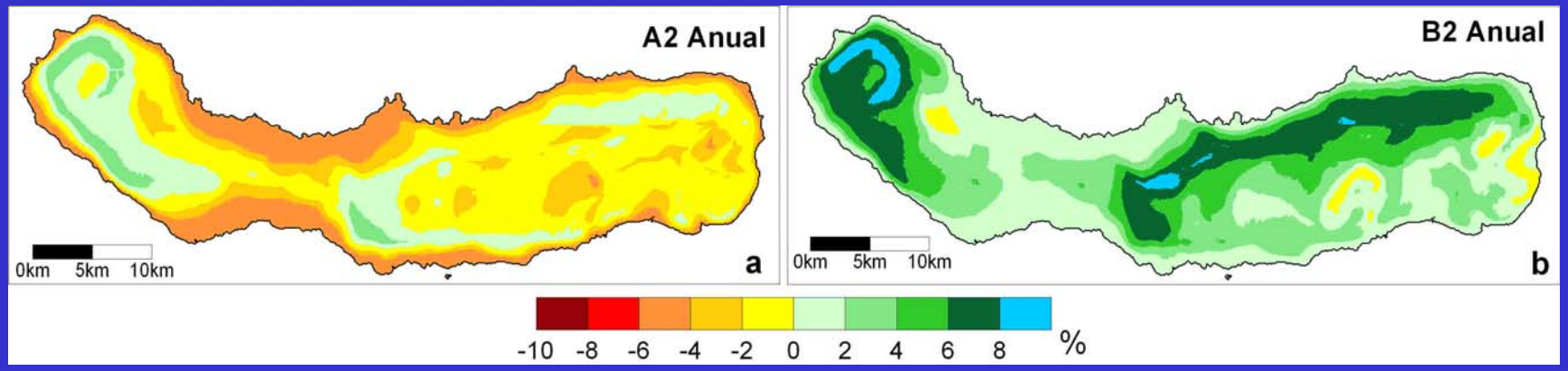
Variação da Precipitação





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7 – Conclusões

Observações portuguesas são consistentes com um padrão de aquecimento global em aceleração, apresentando taxas de aquecimento acima da média global.

Tendências da precipitação nas últimas décadas indicam: redução da precipitação de Março no Continente, aumento de variabilidade de Inverno, forte anticorrelação com a NAO, maior frequência de seca.

Os cenários disponíveis sugerem importantes alterações climáticas no continente e nas ilhas.

Aquecimento é mais dramático no Continente e mais moderado nos Açores

A alteração do regime de precipitação é preocupante no Continente (menos precipitação, redução da duração da estação chuvosa) e na Madeira (muito menos chuva de Inverno e anual), sugerindo alterações no sentido da desertificação.

Metodologias desenvolvidas no CGUL (+ e downloads em www.cgul.ul.pt)

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Trigo et al, *Climate Dyn.,* 2004

Tomé, Miranda & Santos, *World Res. Rev*, 2004

Santos, Valente, Miranda, Aguiar, Azevedo, Tomé & Coelho, *World Res. Rev*, 2004

Publicações SIAM

Miranda et al., 2001, 20th Century Portuguese Climate..., in Santos et al, SIAM, Gradiva.

Miranda et al., 2005, O clima de Portugal ..., in Santos et al, SIAM2, Gradiva.