

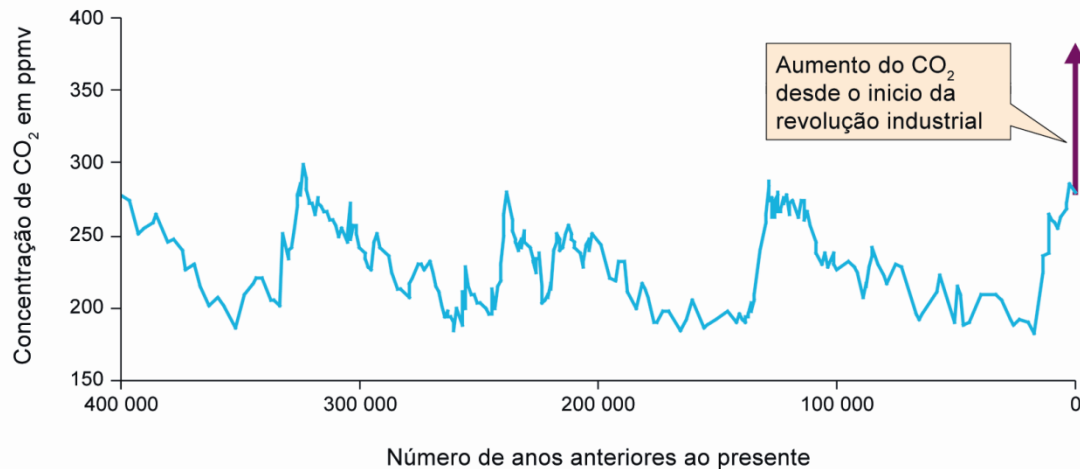
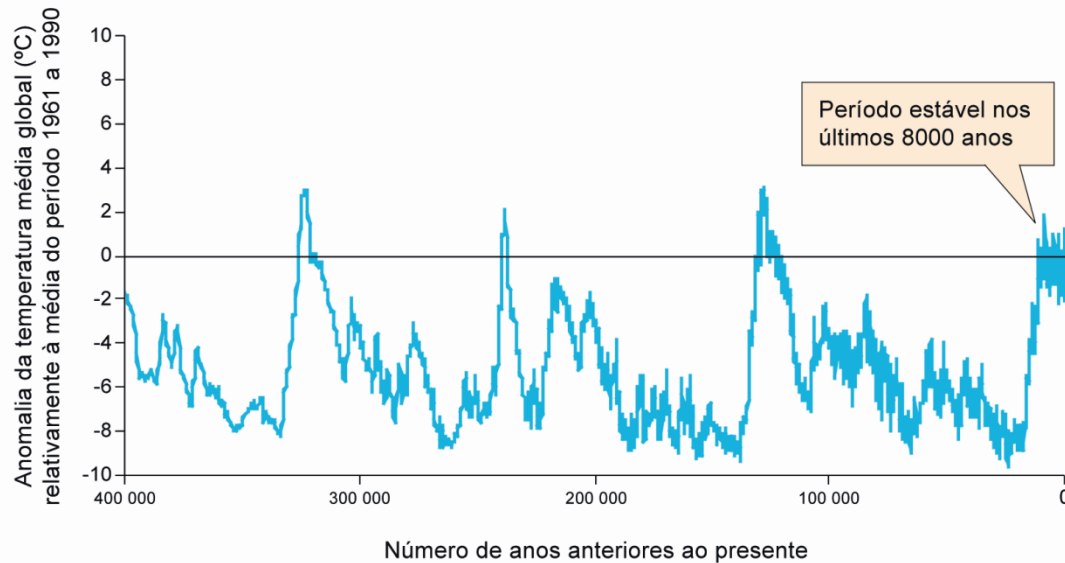
# **Climatização em Cenários de Alterações Climáticas**

**FILIPPE DUARTE SANTOS**

**CCIAM – Centre for Climate Change Impacts, Adaptation and  
Modelling**

**FCUL – Faculdade de Ciências da Universidade de Lisboa**  
[www.sim.ul.pt](http://www.sim.ul.pt)

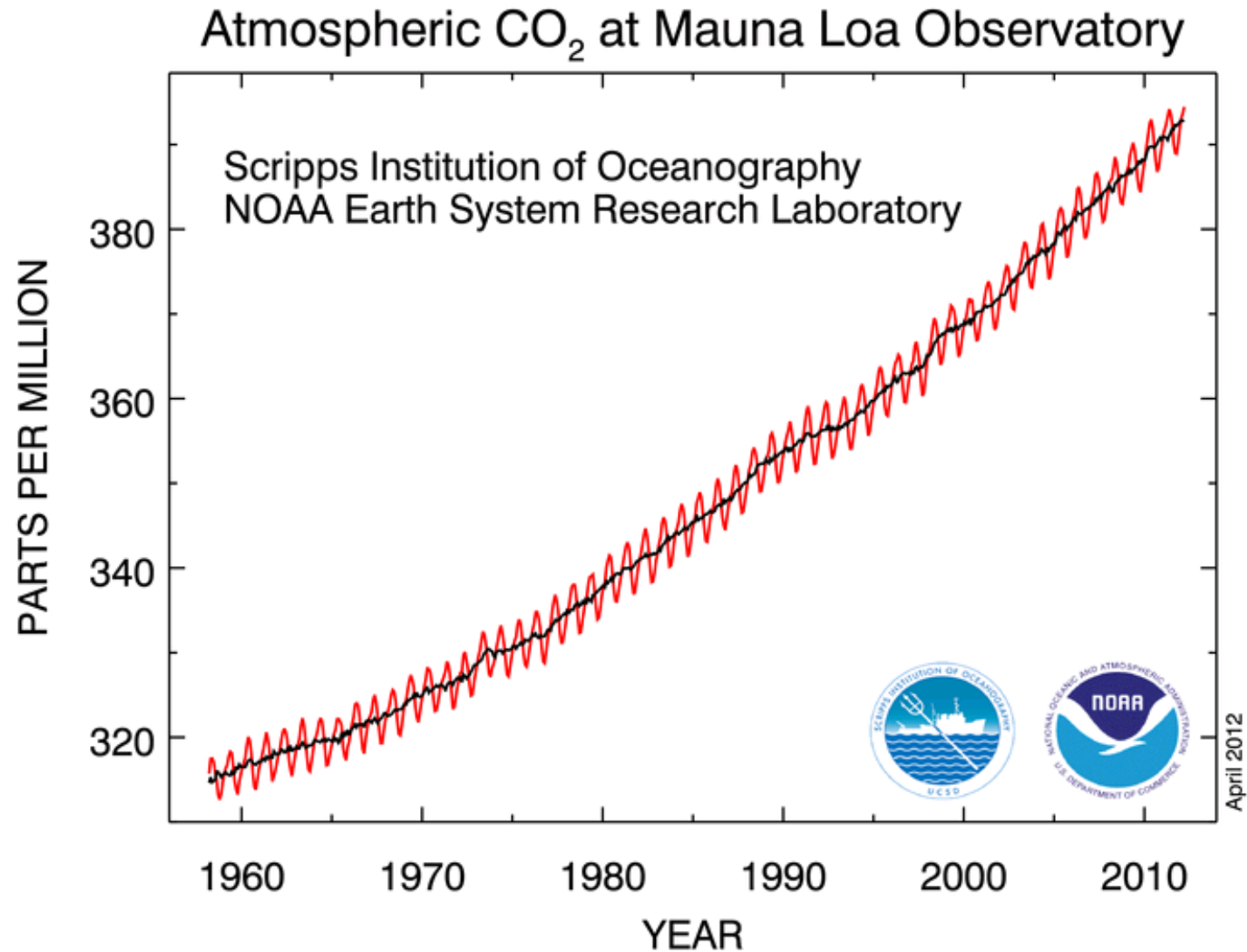
**XX Congresso Nacional da Ordem dos Engenheiros**  
**Porto, 18 de Outubro de 2014**



Reconstituição da evolução da temperatura média global da baixa atmosfera, representada por meio da anomalia relativamente à média do período de 1961 a 1990, e da concentração atmosférica do CO<sub>2</sub> nos últimos 400 000 anos (Petit, 1999). Figura adaptada de EEA, 2004. Repare-se na correlação que se observa entre os dois registos. O aumento da concentração do CO<sub>2</sub> a partir da revolução industrial e até ao presente está indicado por um vector aproximadamente vertical devido à escala de tempo utilizada na figura

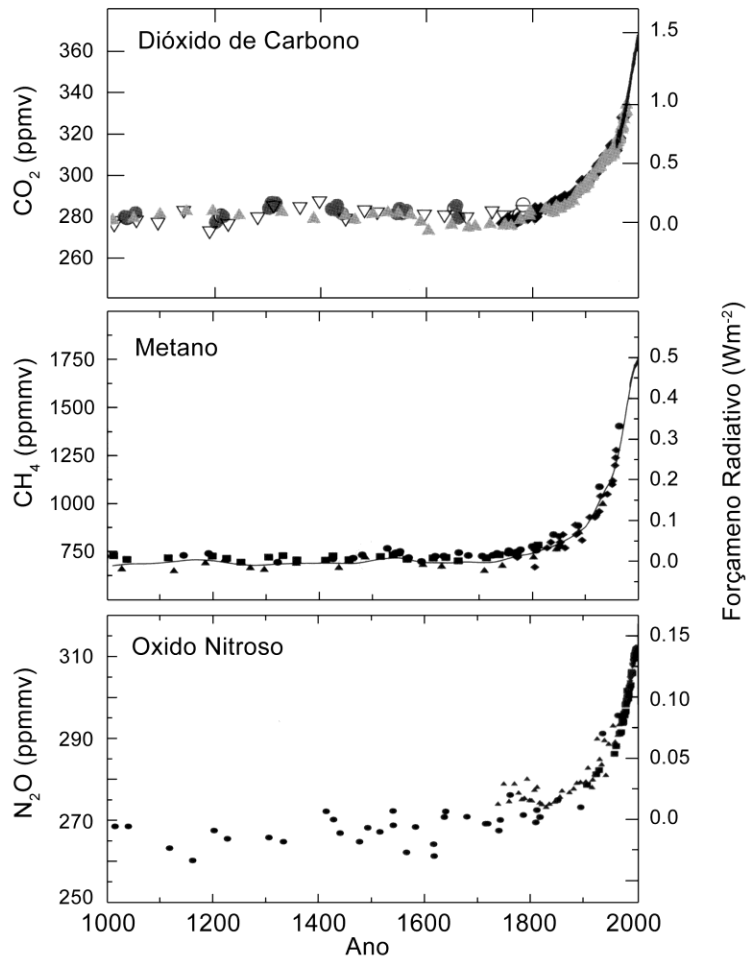
**Fonte, Petit et al., 1999**

# Keeling's Mauna Loa Curve

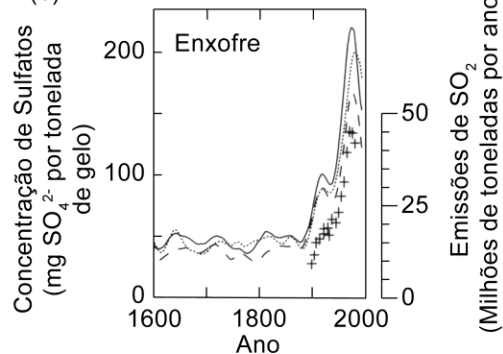


Source: NOAA, <http://www.esrl.noaa.gov/gmd/obop/mlo/>

(a)



(b)

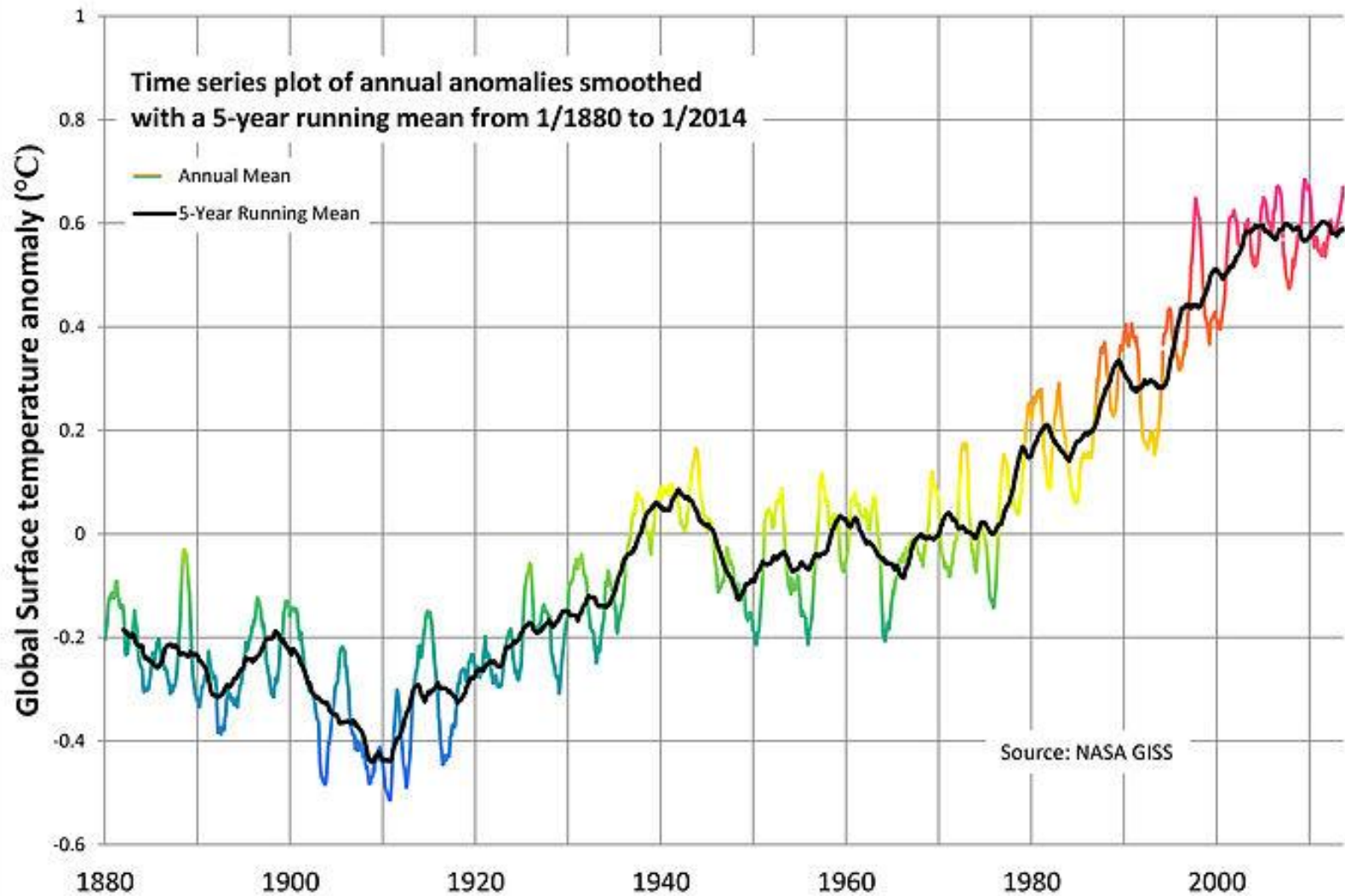


Evolução das concentrações de vários componentes da atmosfera (IPCC, 2001a). (a) Concentrações de três dos principais gases com efeito de estufa (GEE), com emissões antropogénicas – CO<sub>2</sub>, CH<sub>4</sub> e N<sub>2</sub>O – nos últimos 1 000 anos. Dados obtidos a partir de furos nos gelos da Antárctica e Gronelândia e de observações directas nas últimas décadas (indicada por uma linha no caso do CO<sub>2</sub>). No gráfico relativo ao CH<sub>4</sub> a curva representa a média global. O forçamento radiativo provocado pela presença destes gases na atmosfera está representado à direita. No caso do CH<sub>4</sub> e N<sub>2</sub>O a concentração está representada em partes por milhar de milhão em volume (ppmmv). (b) Concentrações de sulfatos obtidas a partir de furos nos gelos da Gronelândia em três locais (curvas) e emissões totais de SO<sub>2</sub> na Europa e nos Estados Unidos da América (indicadas com +).

**Fonte, IPCC**

## Global Land-Ocean Temperature Index

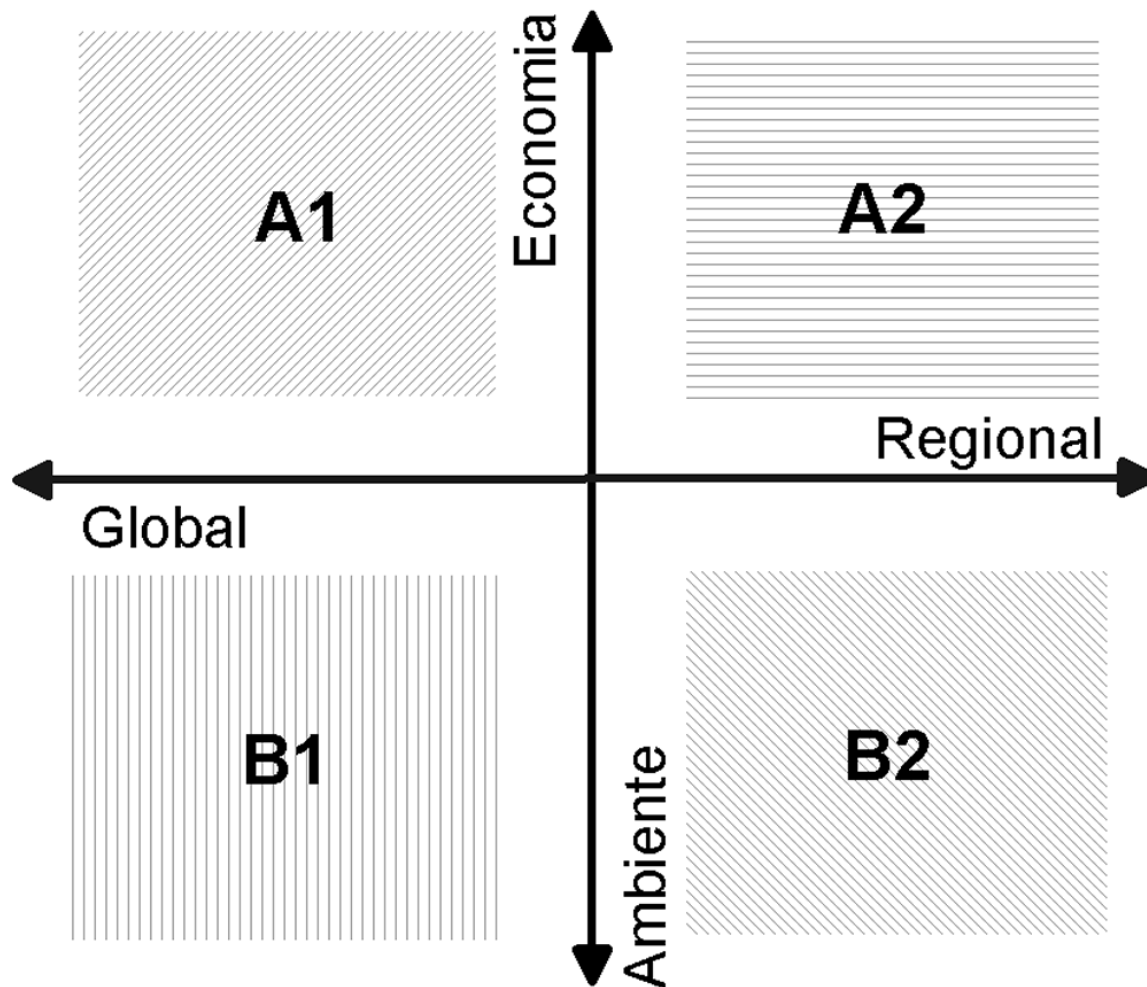
Base period 1951-1980



**SOURCE. NASA GISS**

# Cenarização *IPCC*

## *Special Report on Emission Scenarios*

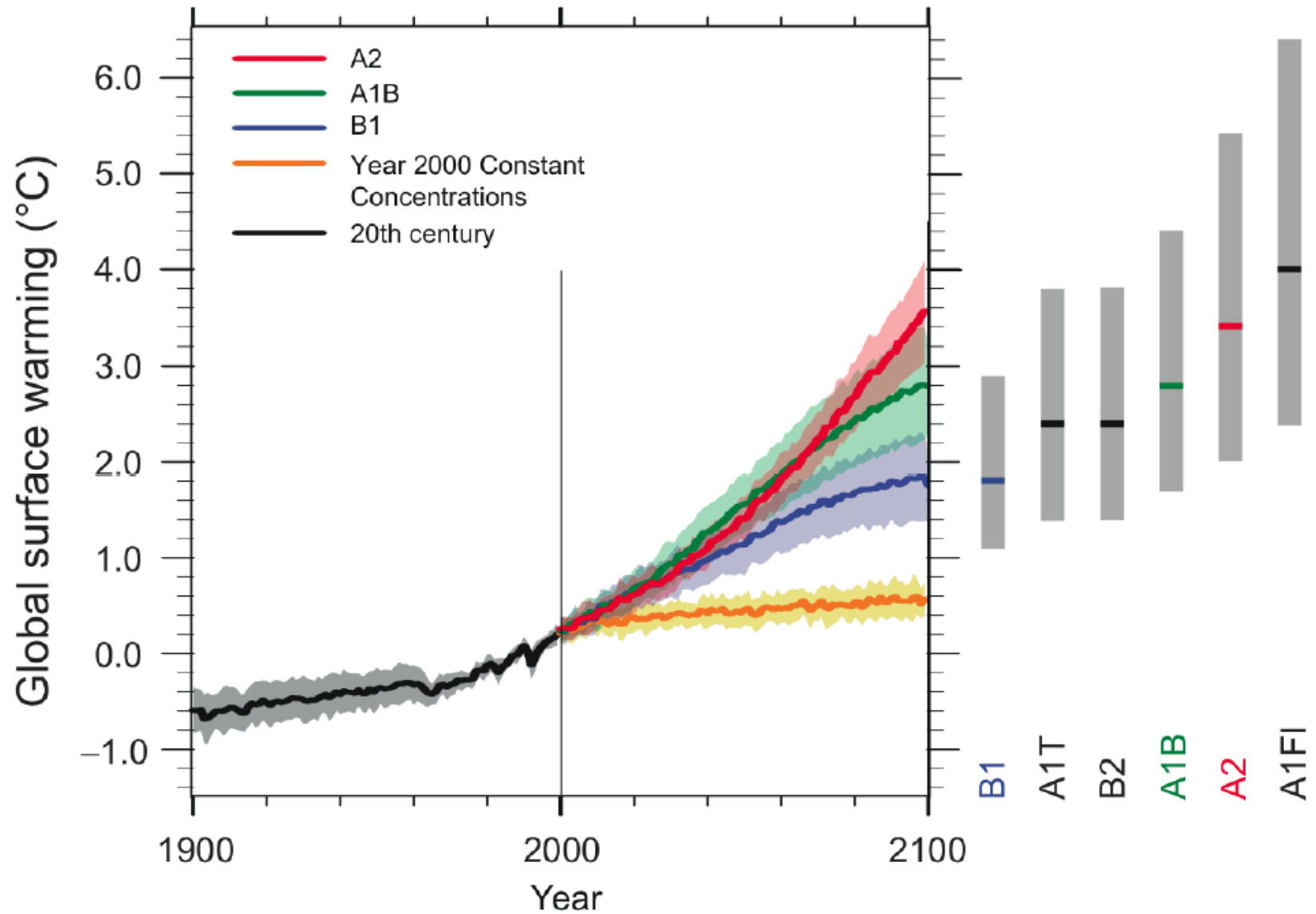


Fonte, SIAM

	População	Economia	Ambiente	Equidade	Tecnologia	Globalização	Emissões
<b>A1-FI</b>							
<b>A2</b>							
<b>B1</b>							
<b>B2</b>							

Fonte, SIAM

# Multi-model Averages and Assessed Ranges for Surface Warming



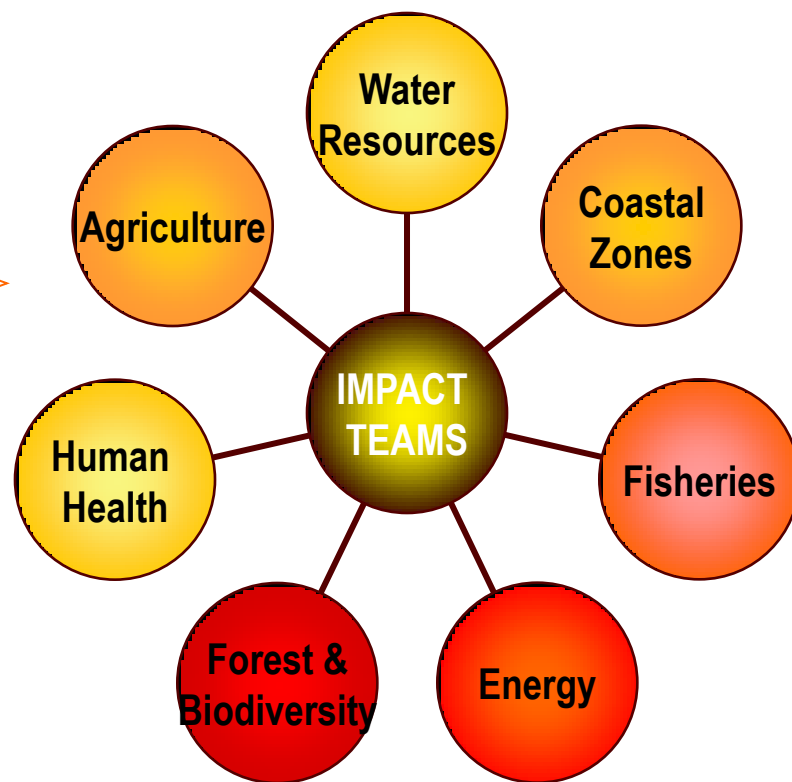
**Source, IPCC 4th Assessment Report. 2007**





# Climate Change in Portugal: Scenarios, Impacts and Adaptation Measures (SIAM Project)

- SIAM I study was the first integrated study on the impacts of climate change in Portugal (and in any Southern European country)
  - Integration Team
  - Scenario Teams
    - Climate
    - Socio-economic
  - Impact Teams



<http://www.siam.fc.ul.pt>

# Mais Informação ...

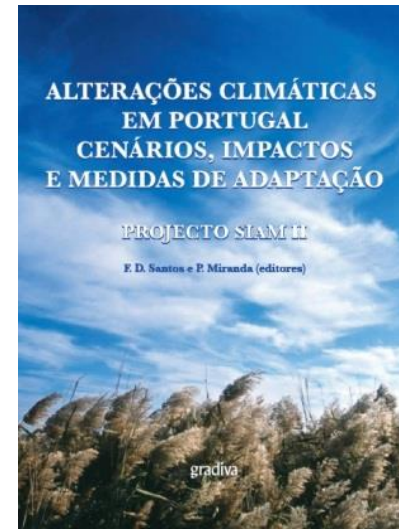
## **SIAM Project :**

**Climate Change in Portugal: Scenarios, Impacts and Adaptation Measures**

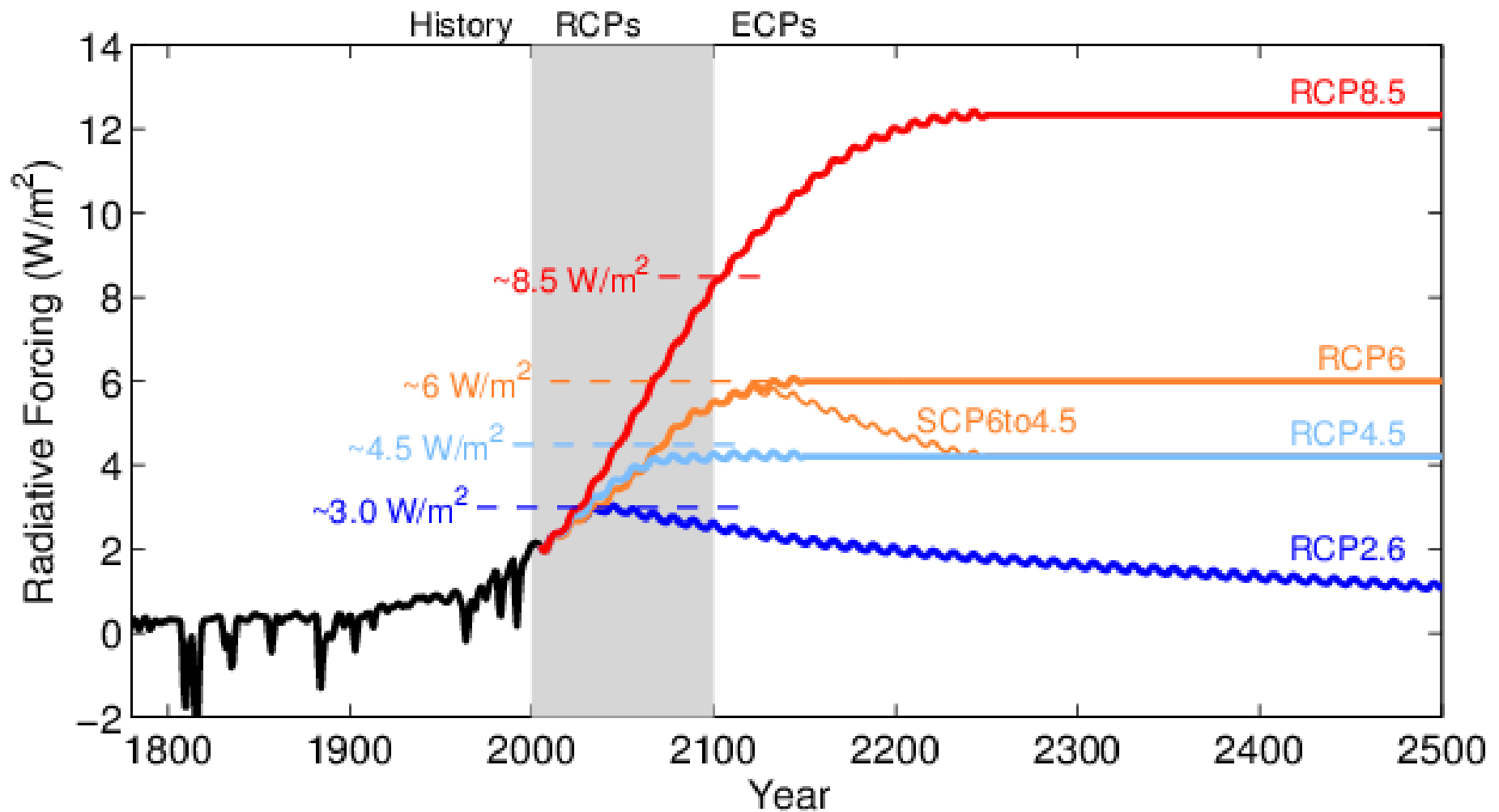
**<http://www.siam.fc.ul.pt/>**



**SIAM I - 2002**



**SIAM II - 2006**



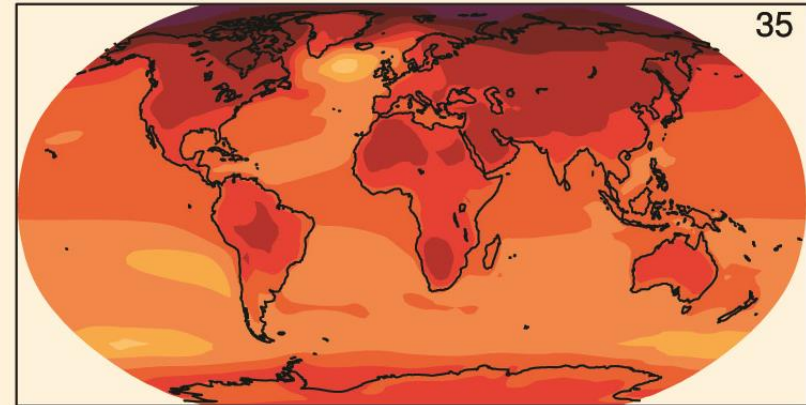
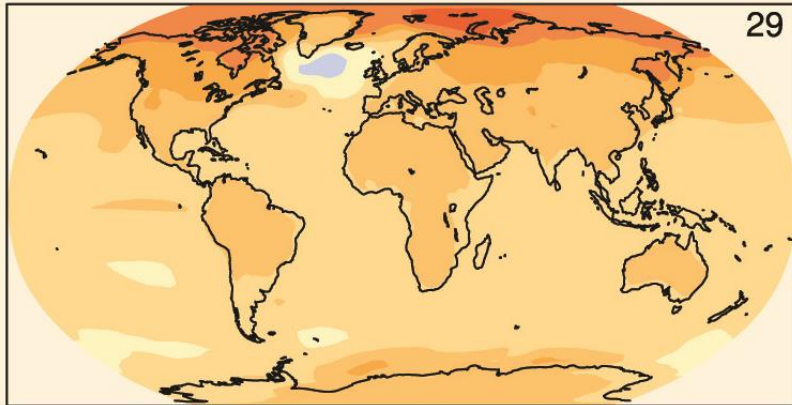
**4 Representative Concentration Pathways**  
**IPCC, 5th Assessment Report, 2013-2014**

## RCP 2.6

## RCP 8.5

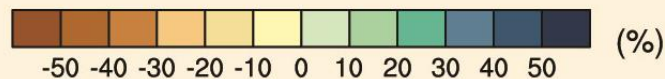
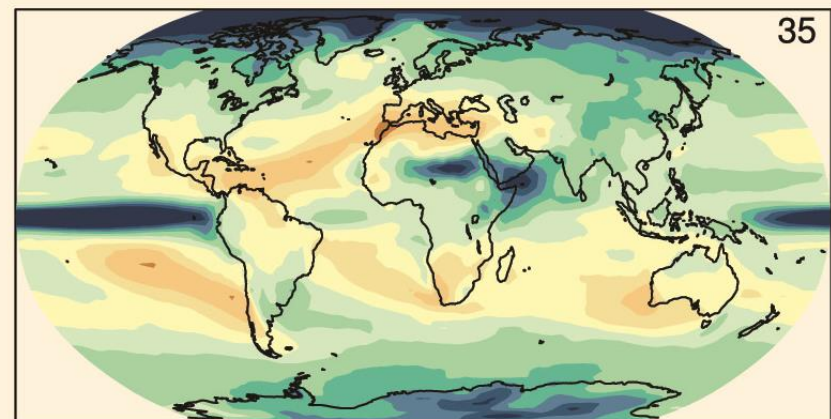
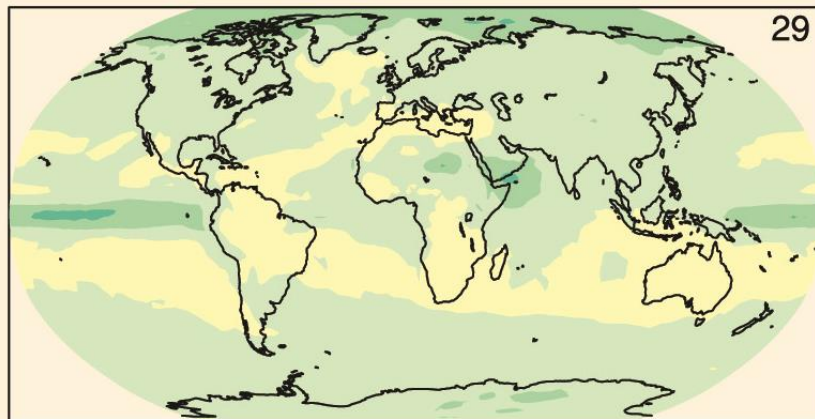
Change in average surface air temperature (1986 - 2005 to 2081 - 2100)

a)



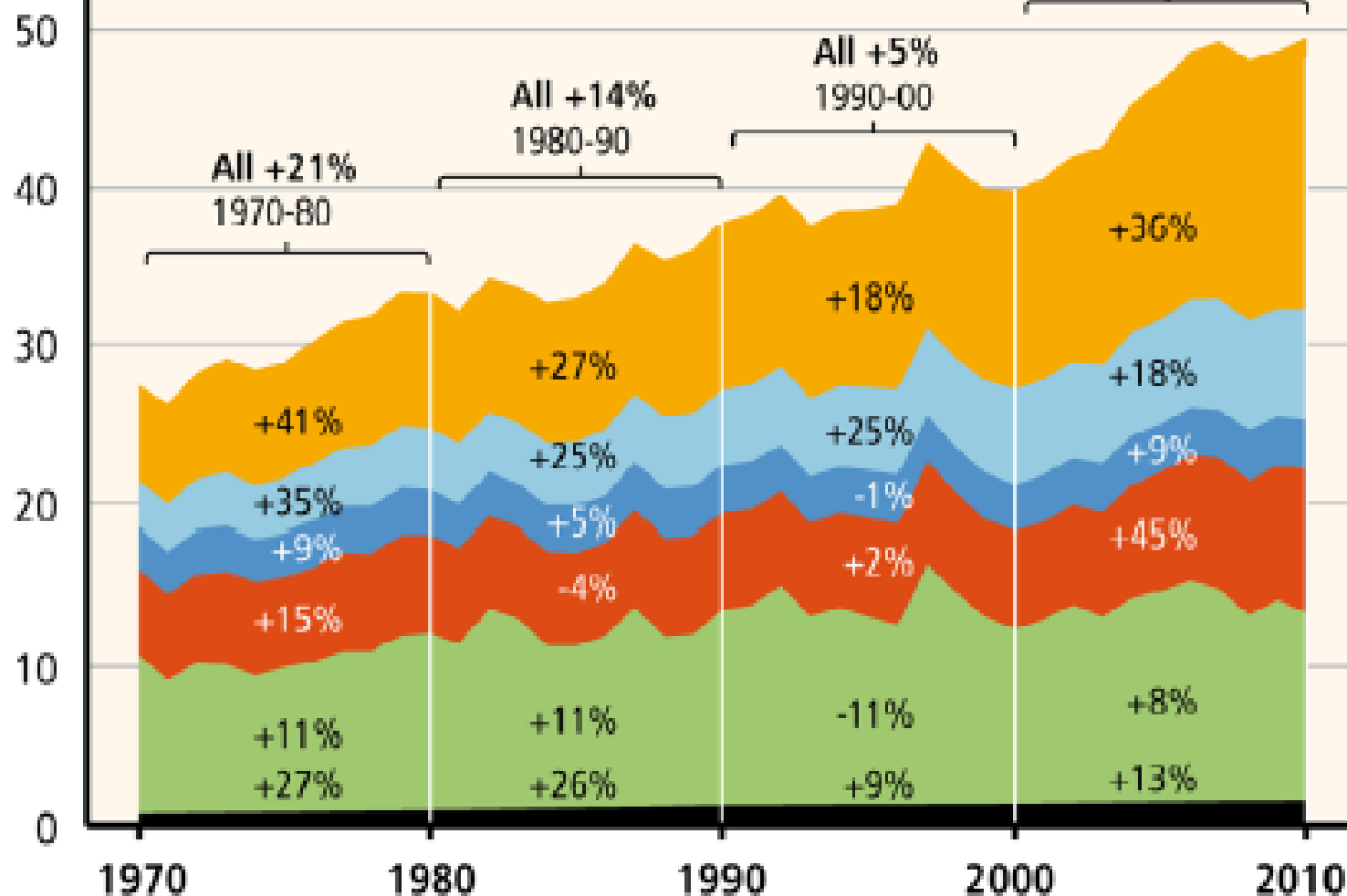
b)

Change in average precipitation (1986 - 2005 to 2081 - 2100)

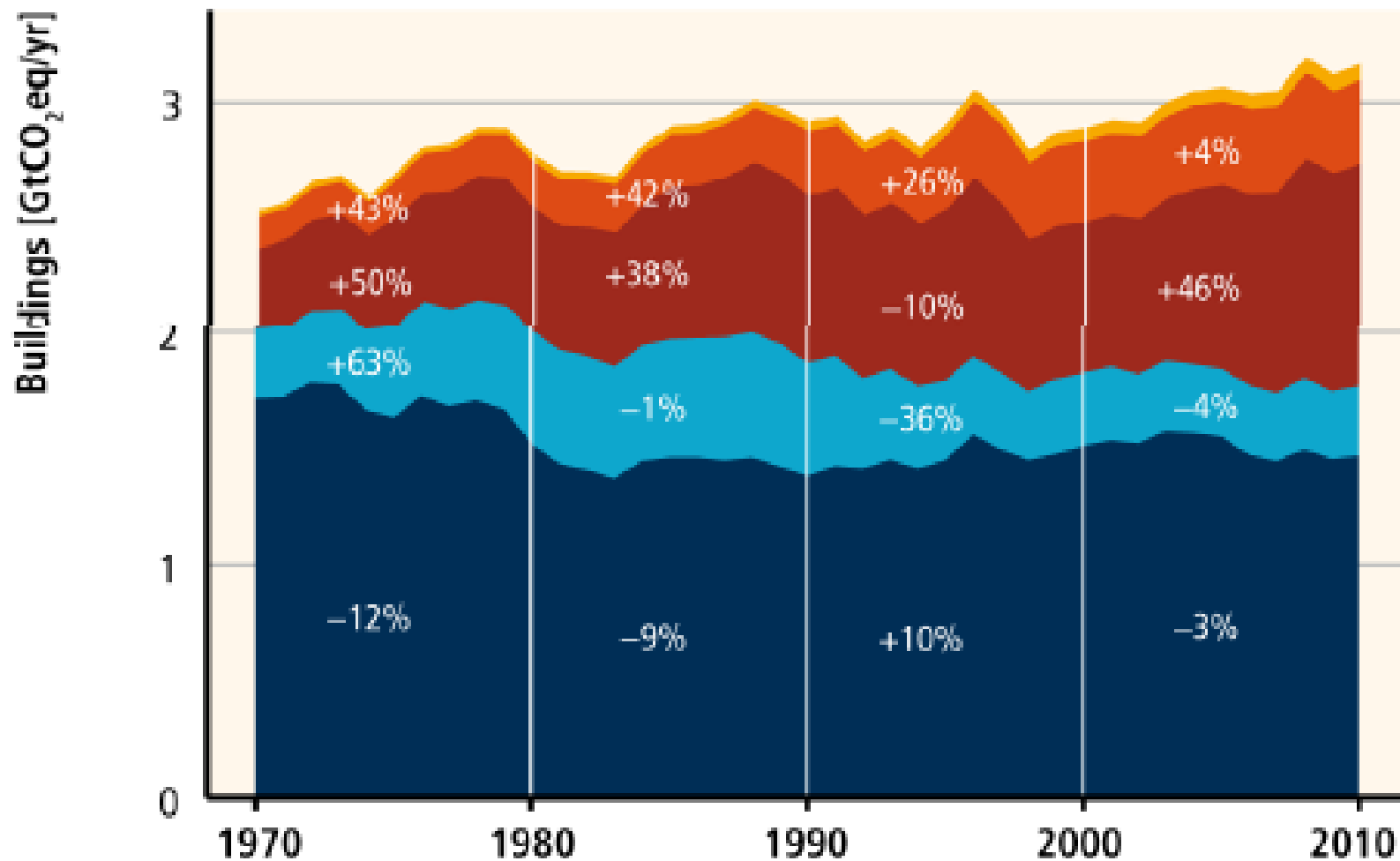


World by Sector [GtCO<sub>2</sub>eq/yr]

## Emissões globais de gases com efeito de estufa por sector



IPCC, AR5, 2013-2014



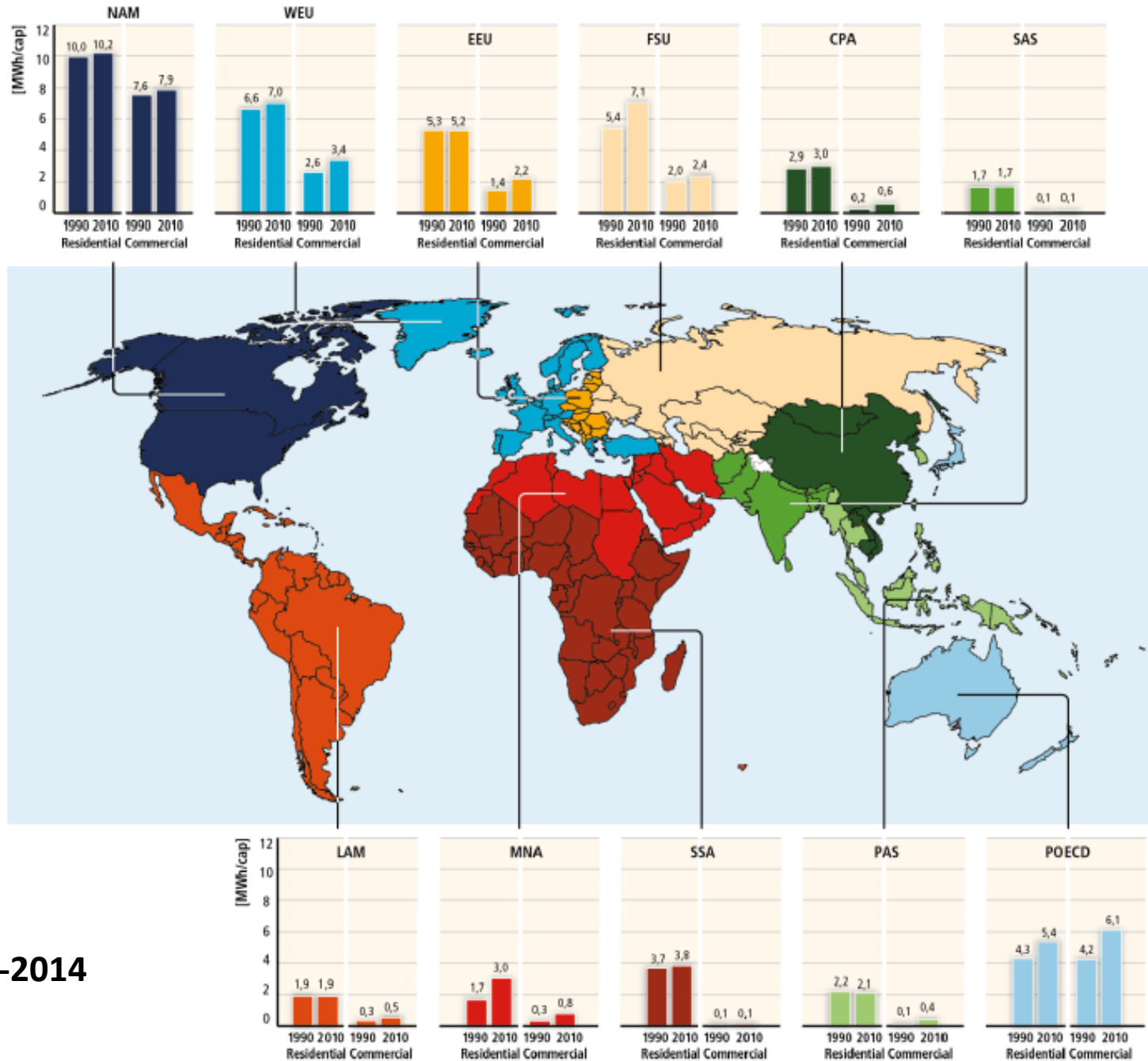
- International Transport
- Low-Income Countries
- Lower-Middle-Income Countries
- Upper-Middle-Income Countries
- High-Income Countries from Non-OECD-1990
- High-Income Countries from OECD-1990

## Emissões dos edifícios por grandes regiões do mundo

IPCC, AR5, 2013-2014

# Sectores Residencial e Comercial 1990-2010

IPCC, AR5, 2013-2014  
IEA, 2013



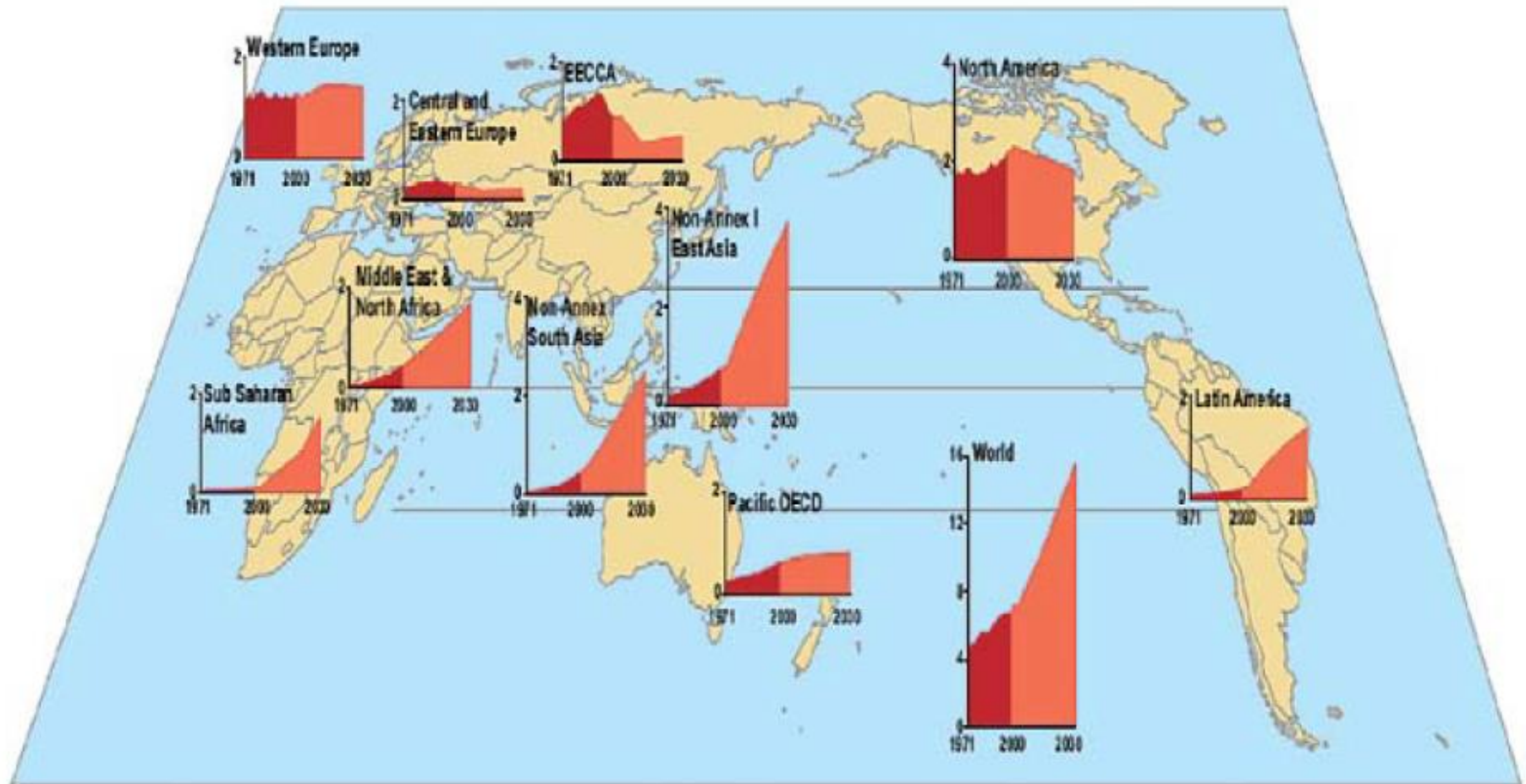
**Figure 9.3.** Annual per capita final energy use of residential and commercial buildings for eleven regions (GEA RC11, see Annex II.2.4) in 1990 and 2010. Data from (IEA, 2013).



# Projecções das emissões dos edifícios para o período de 2001-2030 com base em cenários socioeconómicos e climáticos

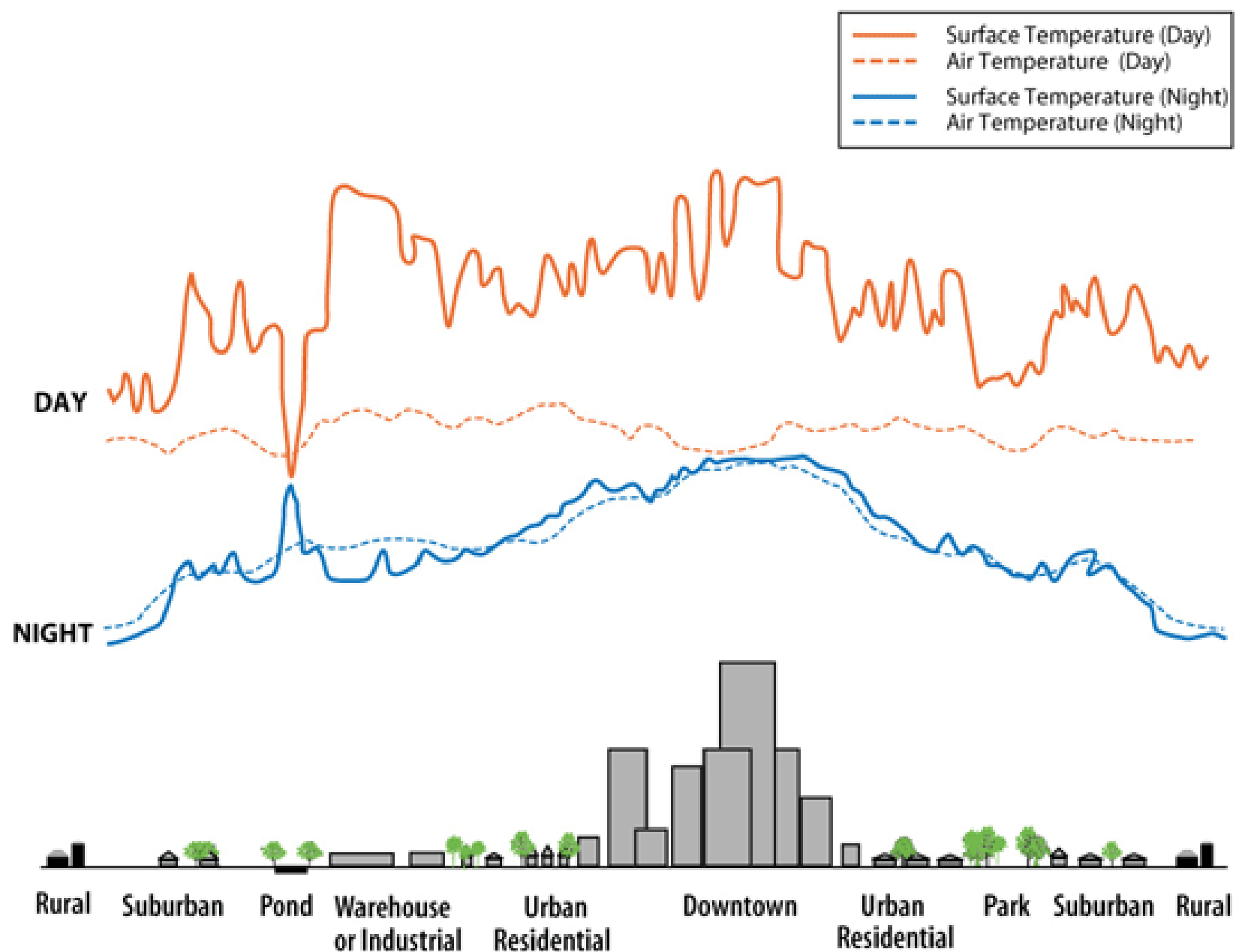
**Figure 1. CO<sub>2</sub> emissions from buildings (including through the use of electricity) – IPCC High Growth Scenario.**

Note: Dark red: historic emissions. Light red: projections 2001 – 2030. 2000 – 2010 data adjusted to actual 2000 carbon dioxide emissions. EECCA= Countries of Eastern Europe, the Caucasus and Central Asia. Source: Levine et al, 2007.



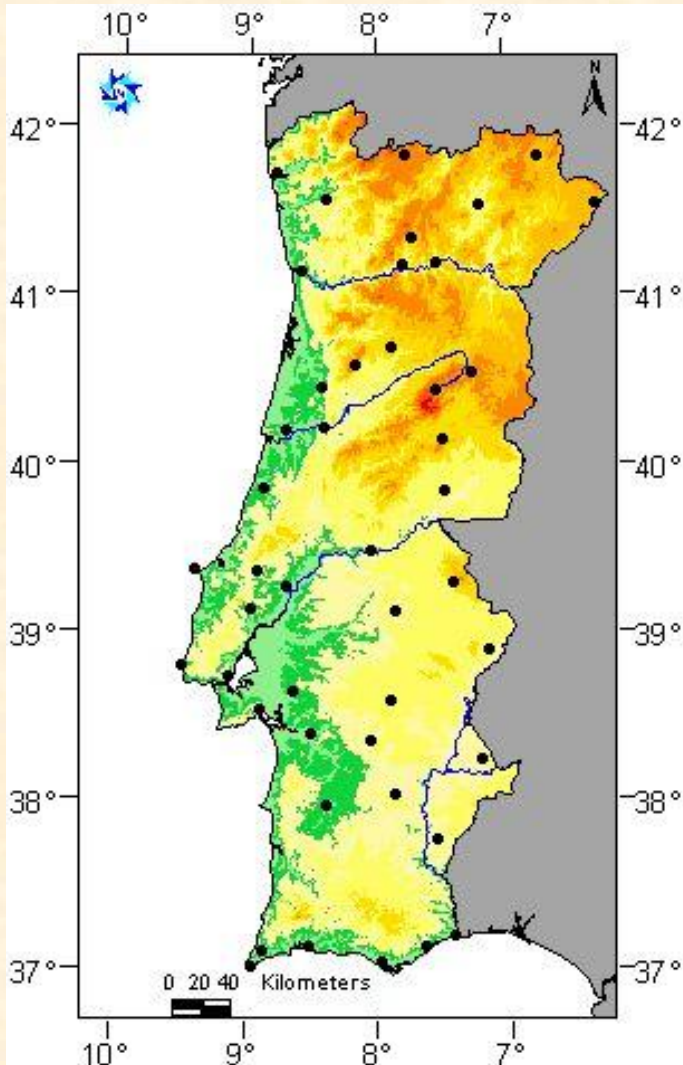
Source: Levine et al., 2007



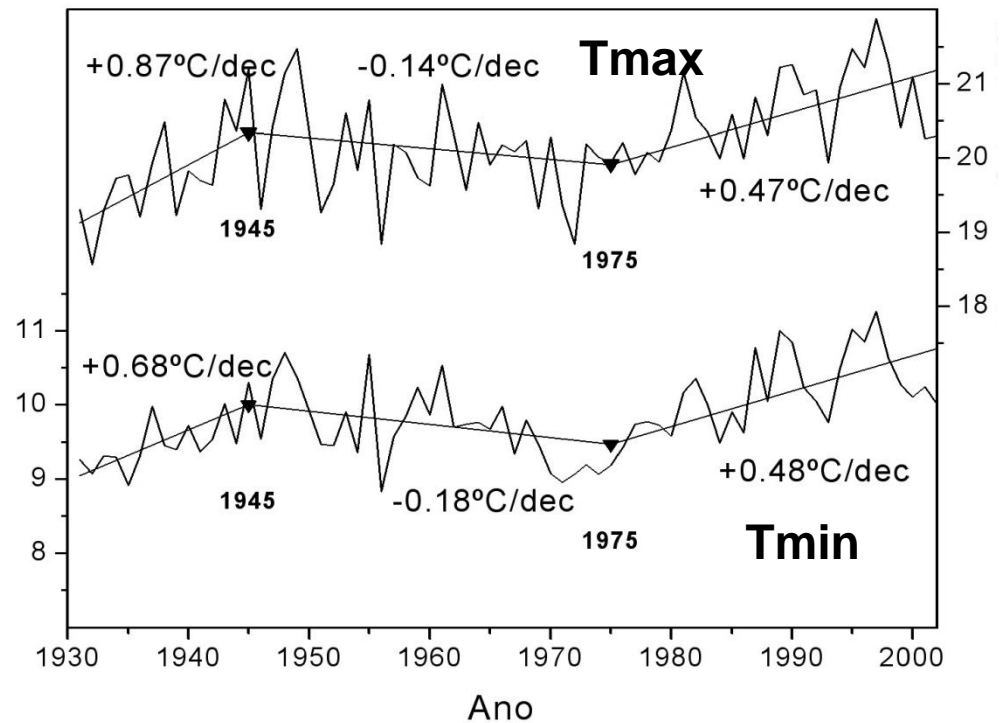


**Efeito de ilha de calor nas zonas urbanas. Importância dos espaços verdes nas cidades**

## 2 – Historical Series

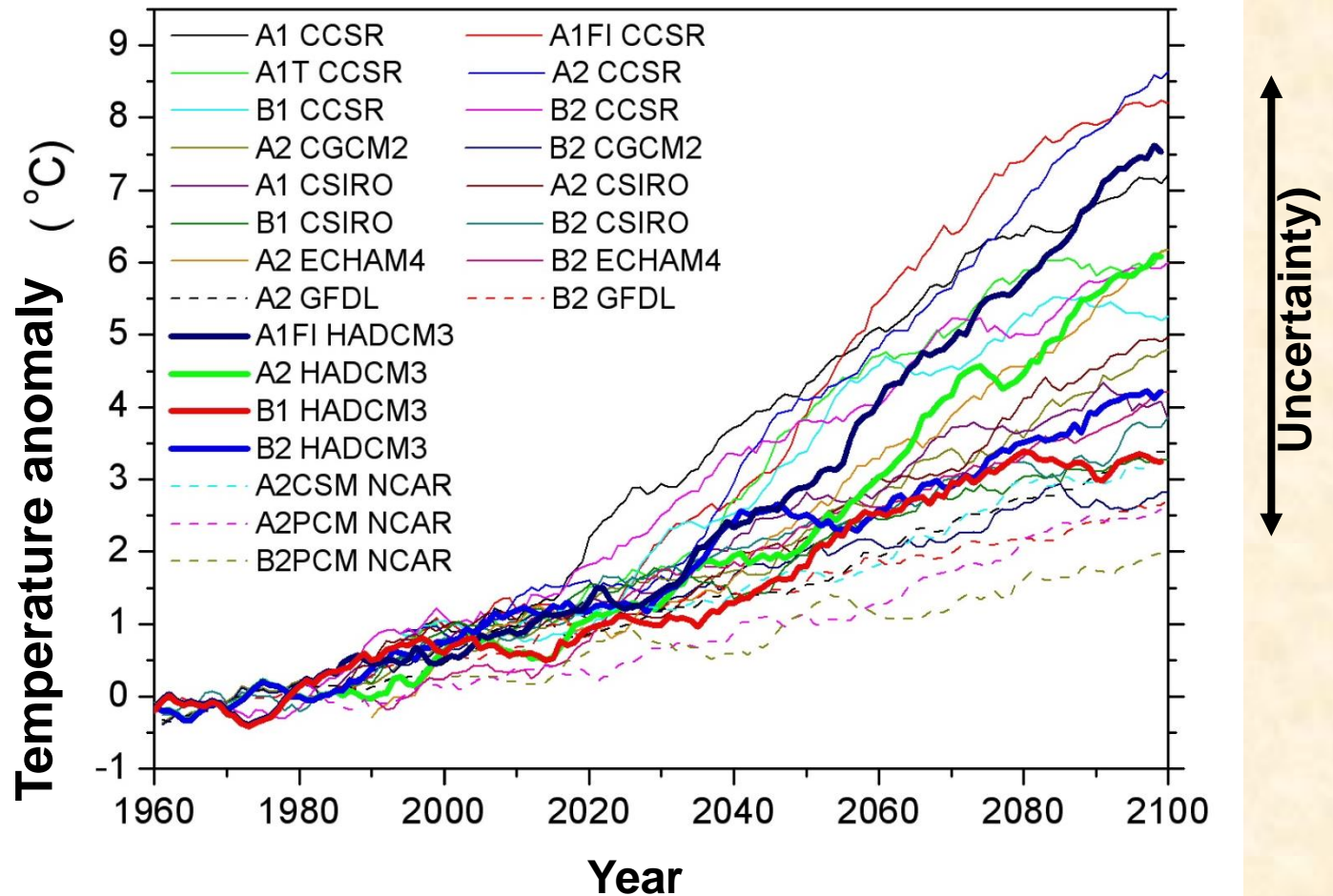
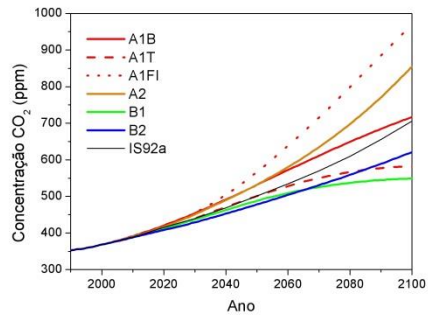


## OBSERVATIONS Temperature in Continental Portugal

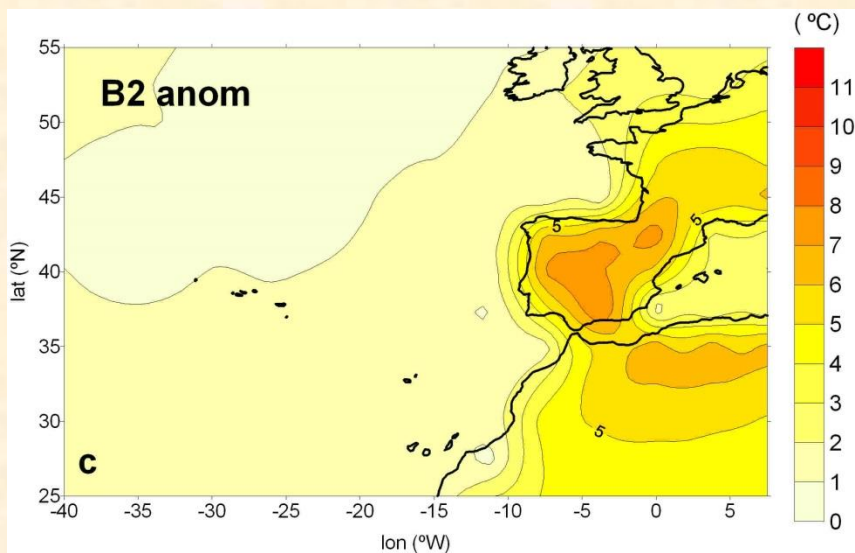
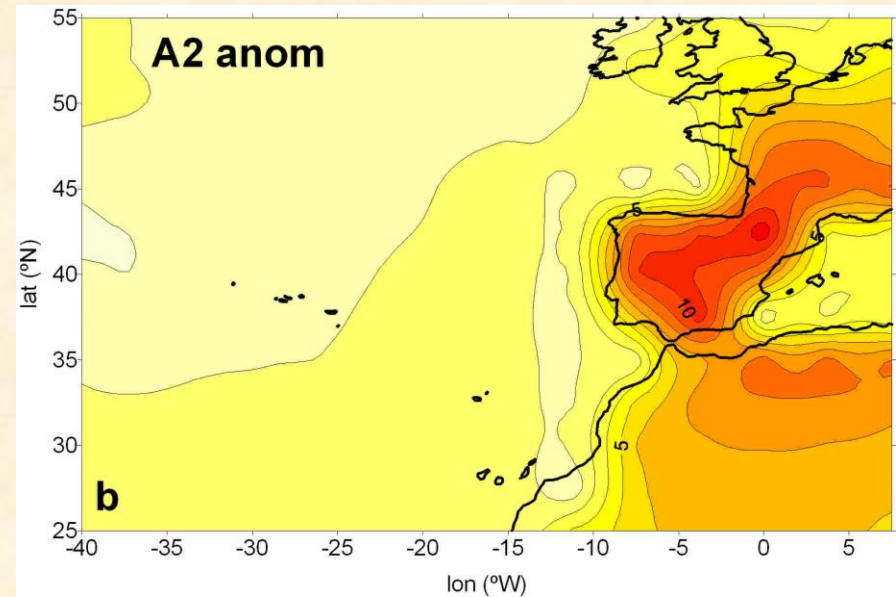
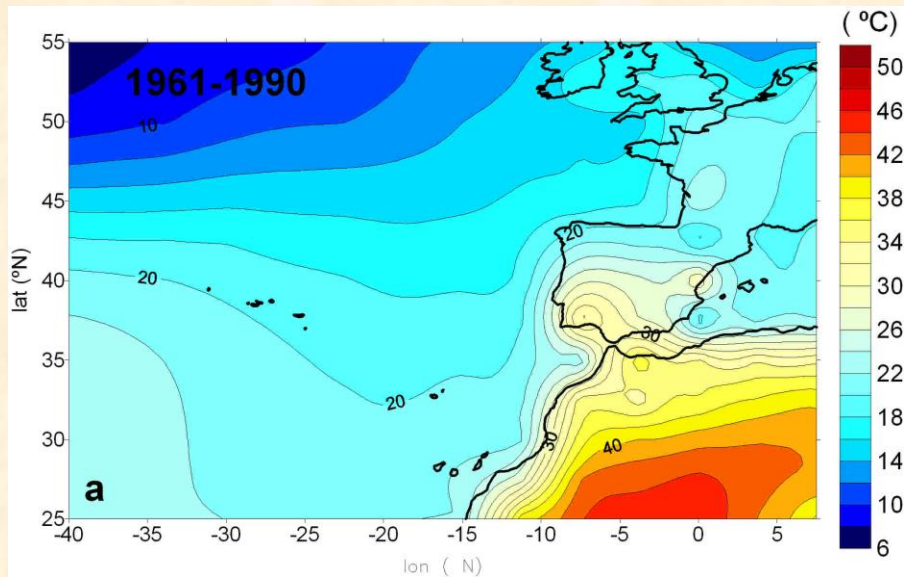


**FORTE: SIAM I**

# Mean Temperature on The Iberian Peninsula

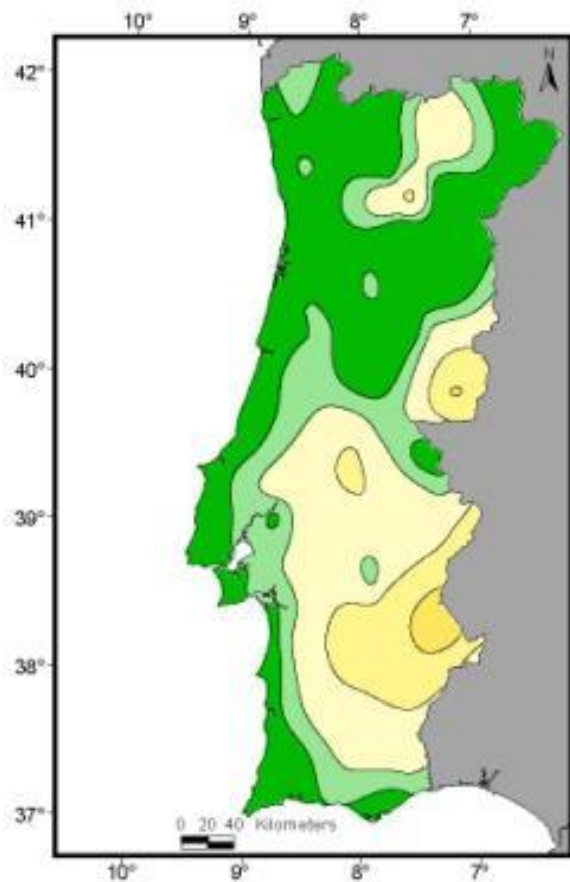


FONTE: SIAM I

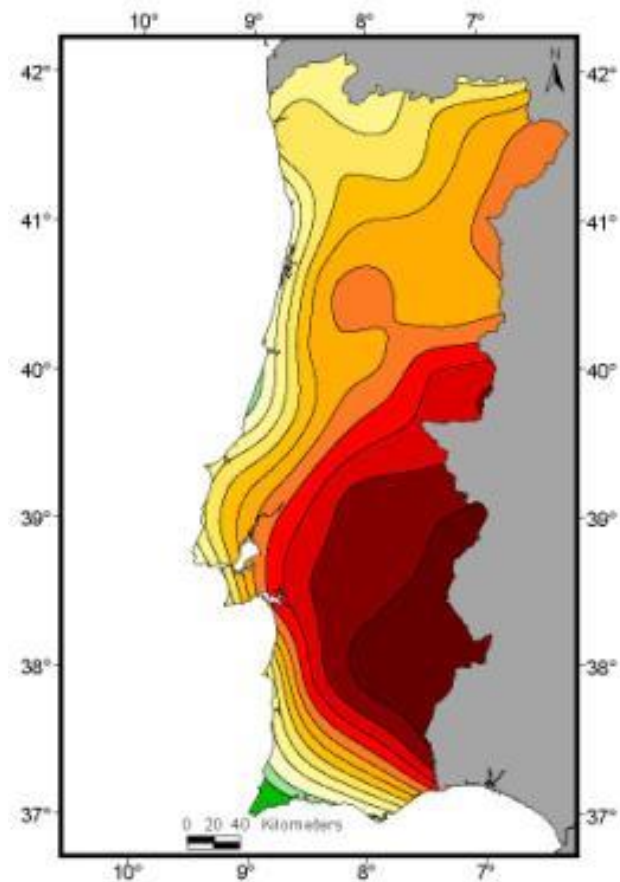
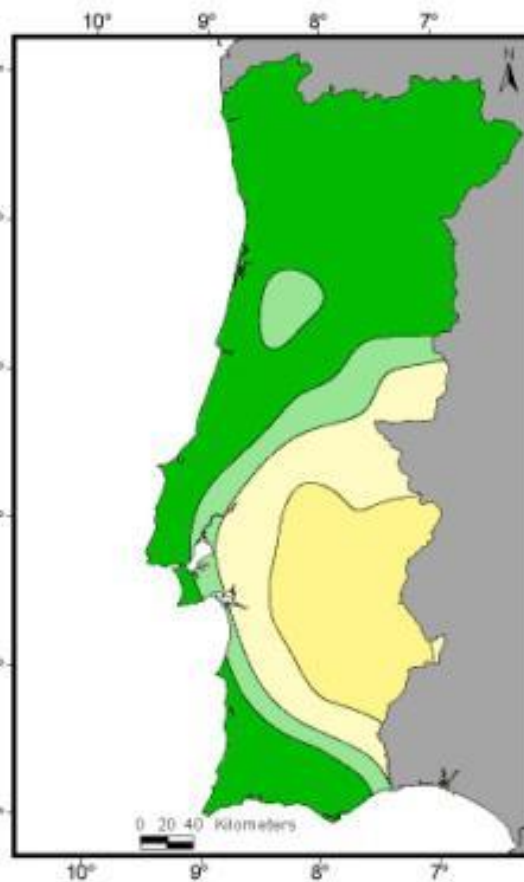


Temperatura máxima no Verão (JJA) no Atlântico Norte obtida com o HadCM3: (a) controlo (1961-1990); (b) anomalia (A2); (c) anomalia (B2). Anomalias calculadas entre o período 2070-2099 e o período de controlo.

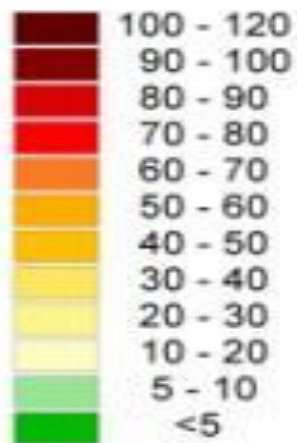




**1961 - 1990**



**2080 - 2100**

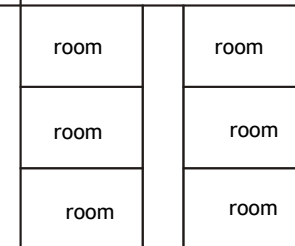
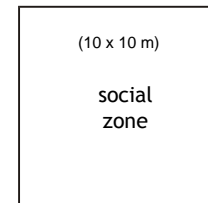
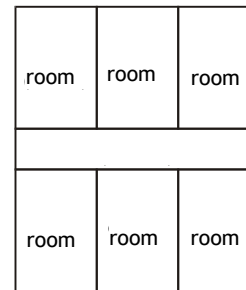
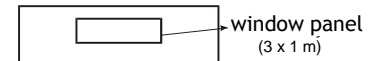
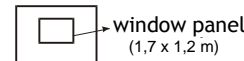
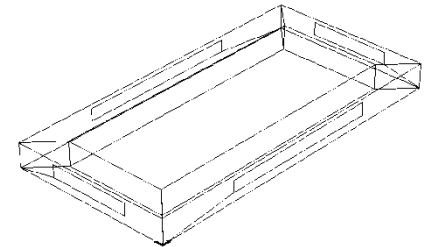
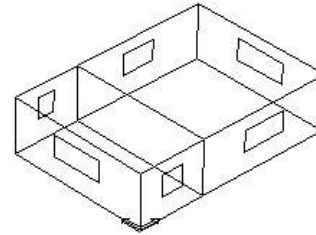


Número de dias por ano com  
temperaturas máximas superiores a  
35° C (dias quentes)

**SIAM II**

## What we examined

- Dwellings:
  - 'Villas' (isolated residences)
  - Apartments (multi-storey buildings)
- Offices (open space)
- Hotels (4 star)

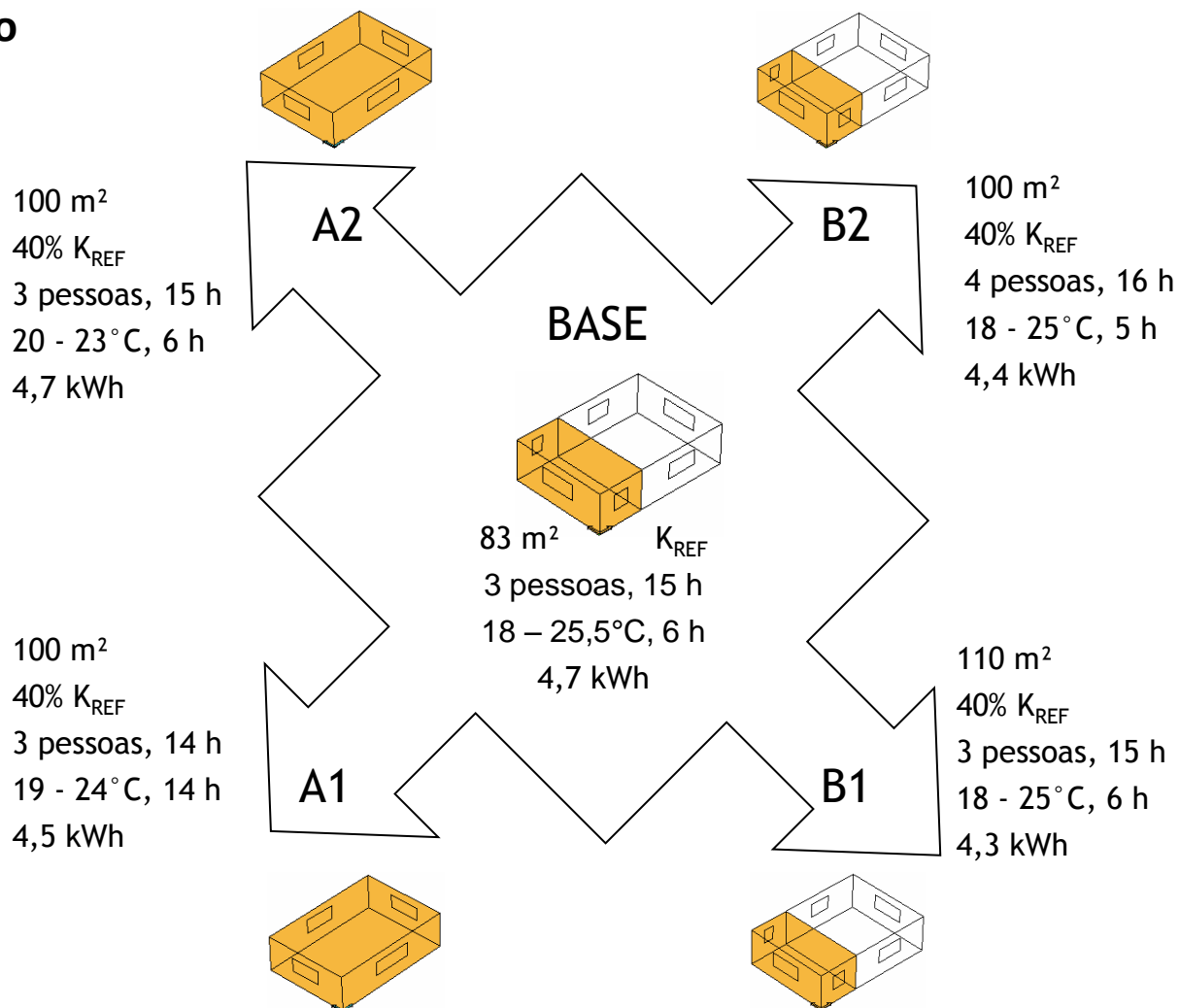


# Aspectos mais importantes da cenarização socioeconómica do sector residencial:

- Área de permanência
- Tempo de permanência
- Banda de conforto térmico
- Consumo energético

## Climatização

### Sector residencial



FONTE: SIAM II

# Projecto SIAM I

## Modelo Climático HadCM3

### Região Sul de Portugal

## Climatização

menos aquecimento, mais arrefecimento

### O Sector Energético

#### Impactos : Procura

- Subida do mar
- Termoelectricidade
- Hidroelectricidade
- Perdas eléctricas
- Sistemas solares
- Outros sistemas
- Águas quentes

#### ► Edifícios

- Veículos

#### Adaptações

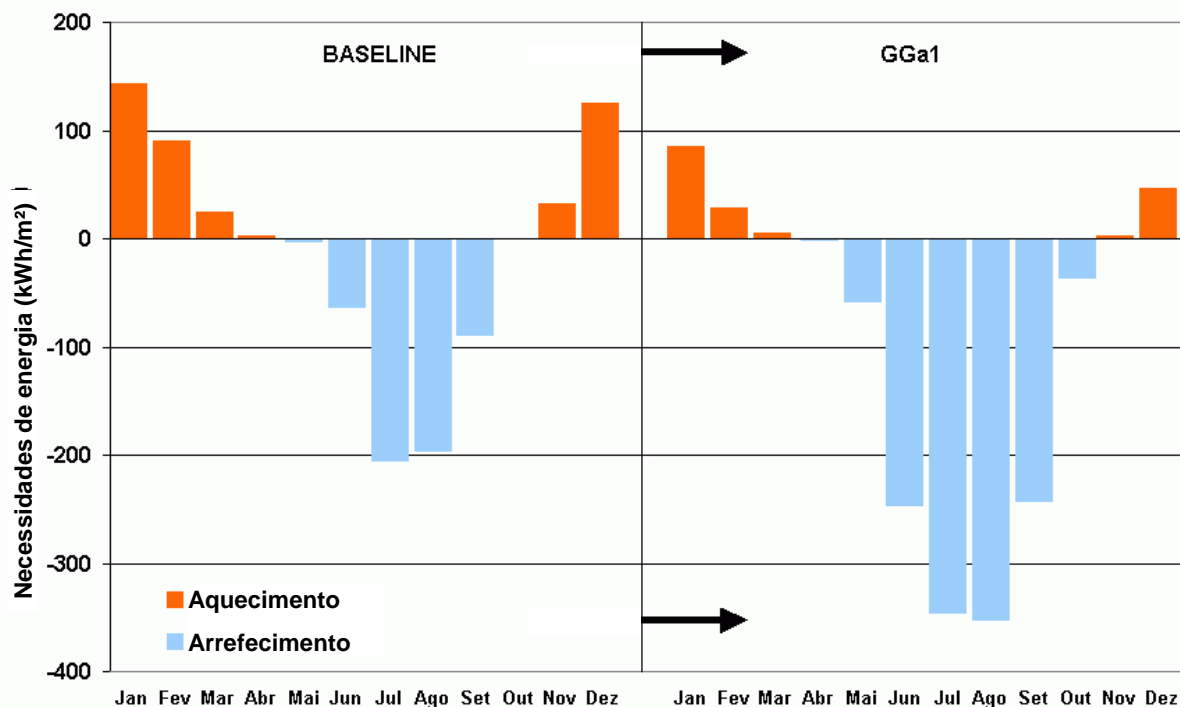
#### Interacções

#### Conclusões

Temperatura ↑  
Radiação solar ↑

Necessidades de aquecimento ↓

Necessidades de arrefecimento ↑

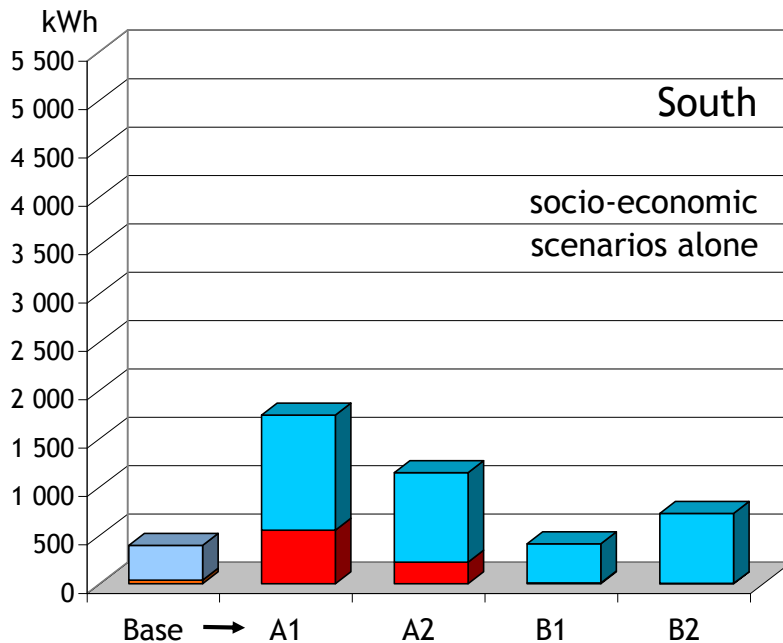




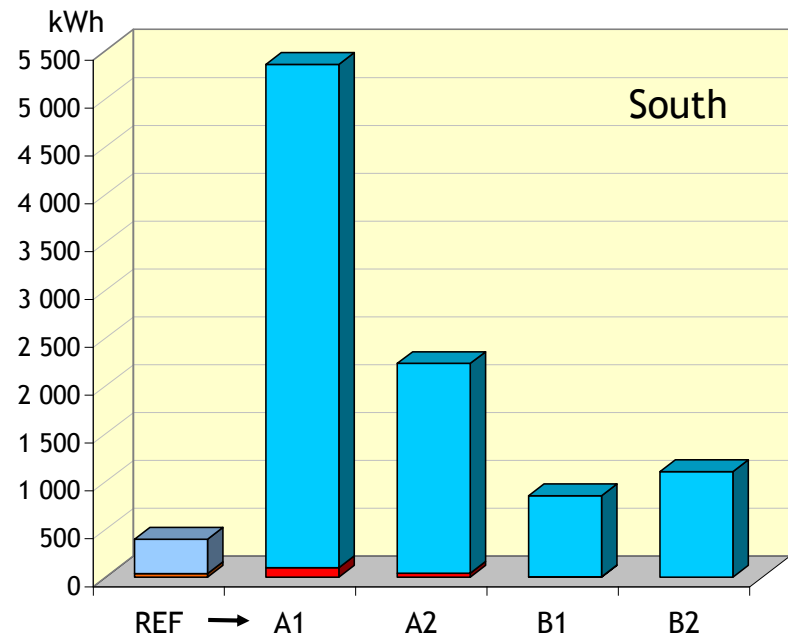
# Residences

(scale of the impacts changes !)

## Change in energy use



**Presente**

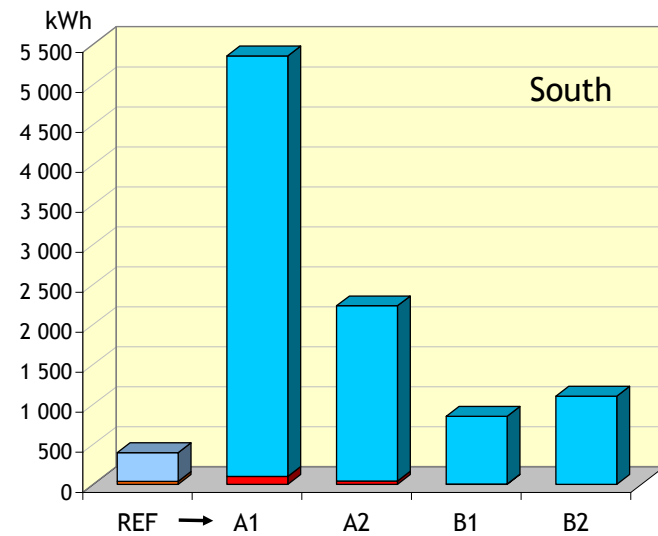
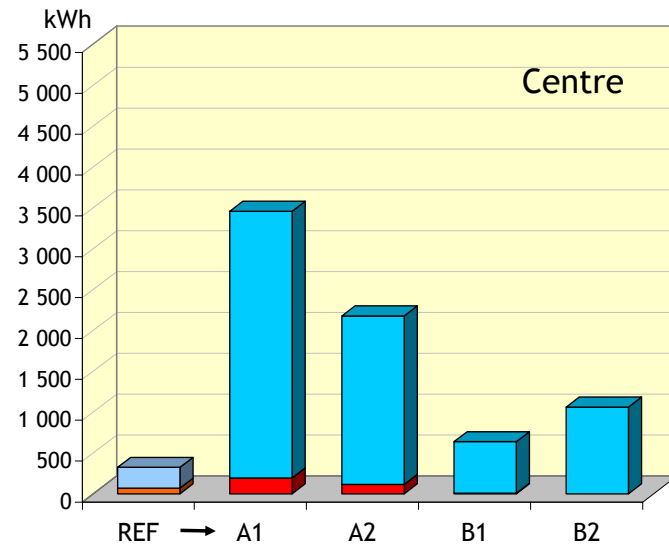
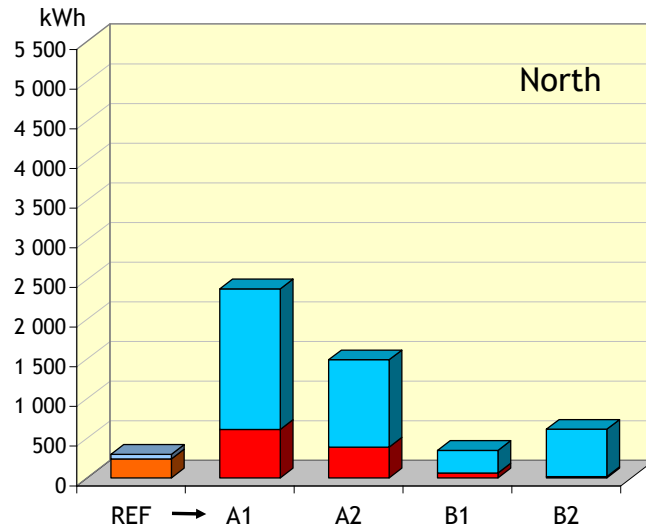


**2071 a 2100**

**FONTE: SIAM II**

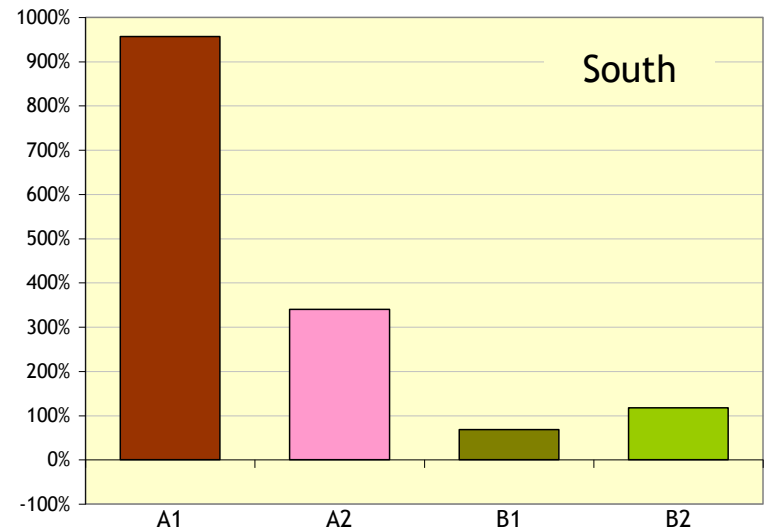
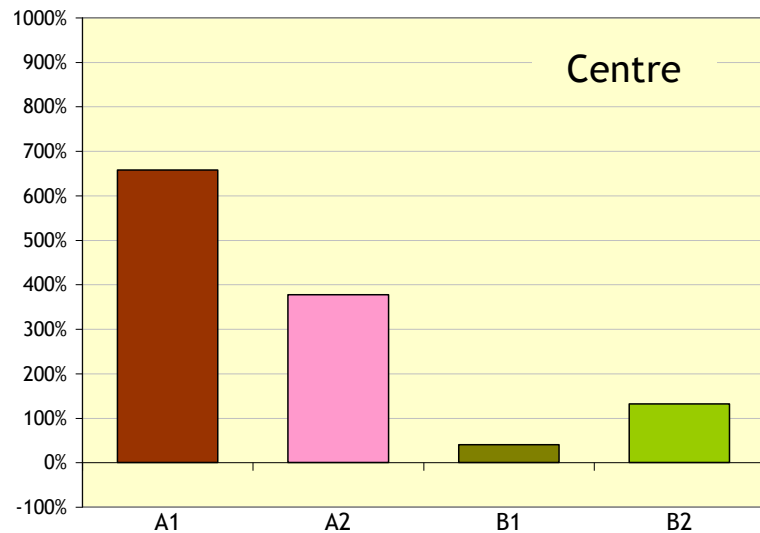
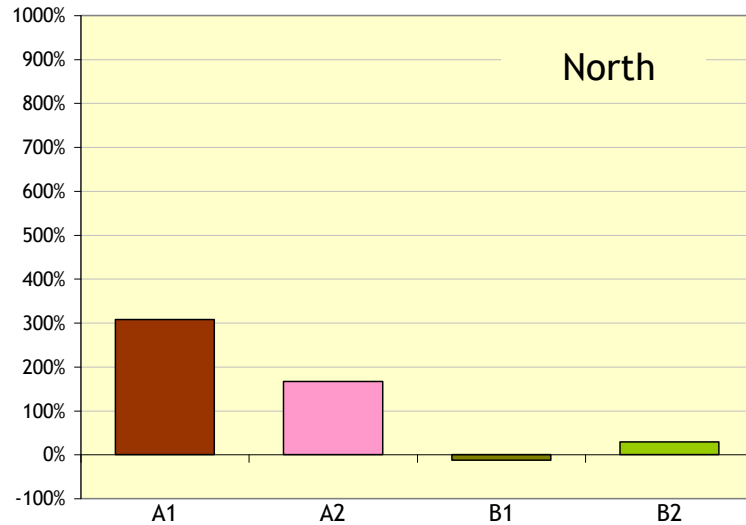
# Residences

(all changes included now)



# Residences

(all changes included now)

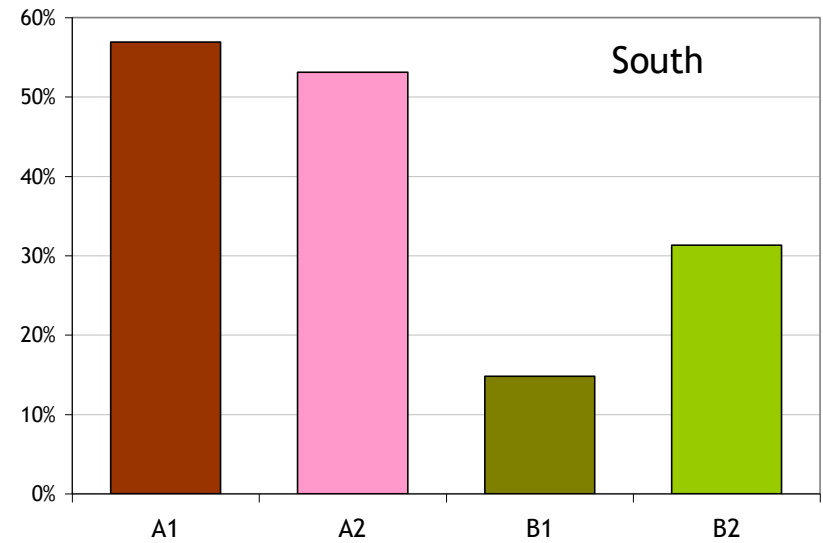
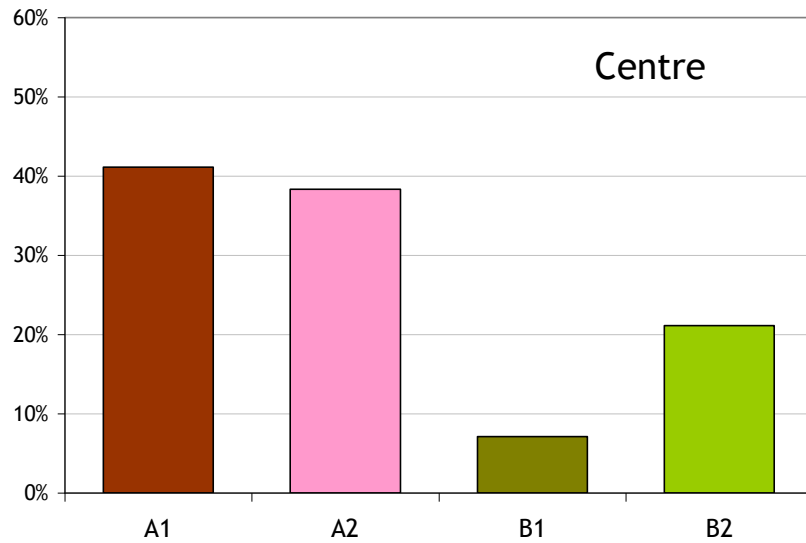


**Fonte: SIAM II**

**Percentage variation in the energy use**

# Hotels

## Percentage variation in the energy use



**Fonte: SIAM II**

# Final remarks

- Detailed studies of the impact of global warming in buildings require the convergence of a lot of skills and data: surveys, statistics, climate models, synthetic meteorological sequences, thermal behavior software, socio-economic and technological scenarios
- For the currently mild climate of Portugal, the global warming impacts are negative: there is an additional yearly demand, due to excess cooling requirements not compensated by savings in heating
- Caution: the impacts depend very much on building types, local climate (large climate diversity in the country) and socio-economic scenarios !

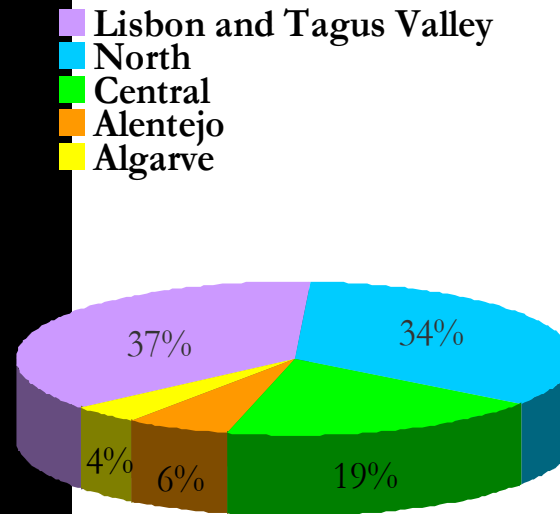
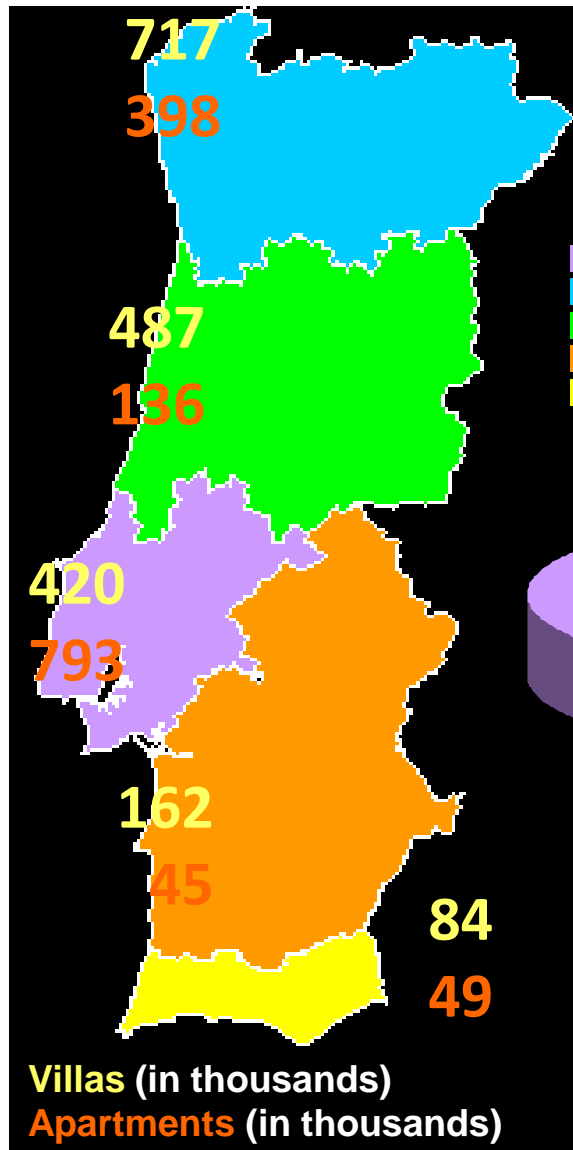
# Final remarks

Range of impacts (in Portugal), with socio-economic and technological effects included

- Residences: -10 % to +1000%
- Offices: +5% to 50%
- Hotels: +7% to 57%
- Improvement of regulations in the direction, for instance, better insulation would be a positive step
- Projected energy savings with better insulation are at least in part offset by global warming
- The problem becomes yet more complicated if the building's life cycle and the slow renovation rate is taken into account
- Only careful studies of possible adaptations can yield sound recommendations

Obrigado pela vossa atenção

# Portugal



Population  
~10 million

Permanently  
occupied dwelling  
~3,3 millions

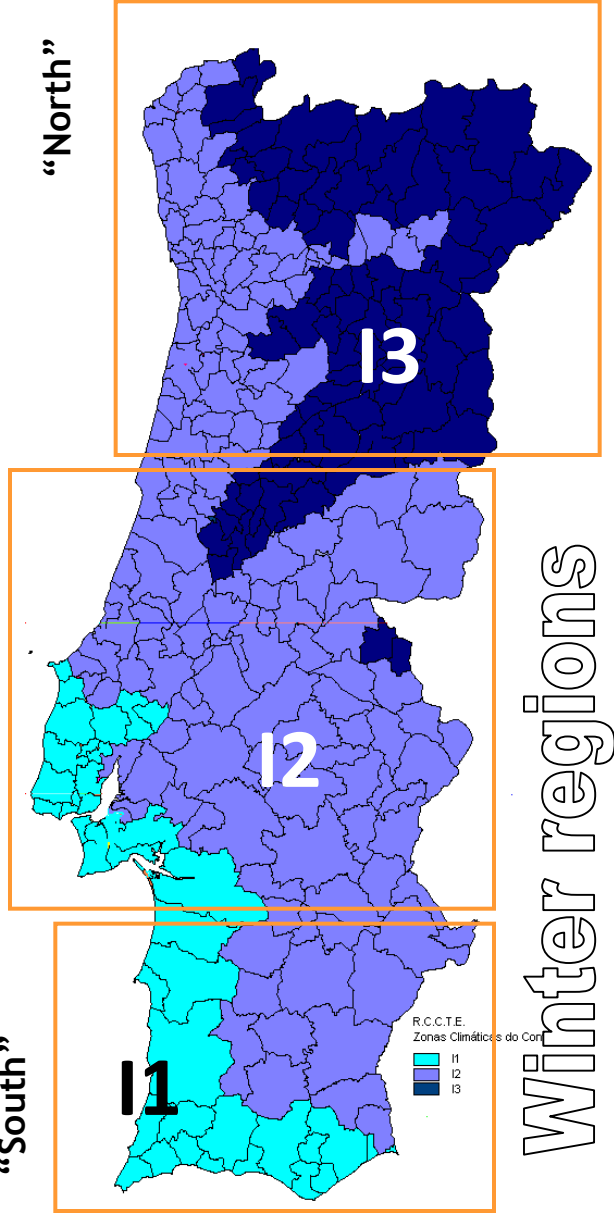


# Portugal

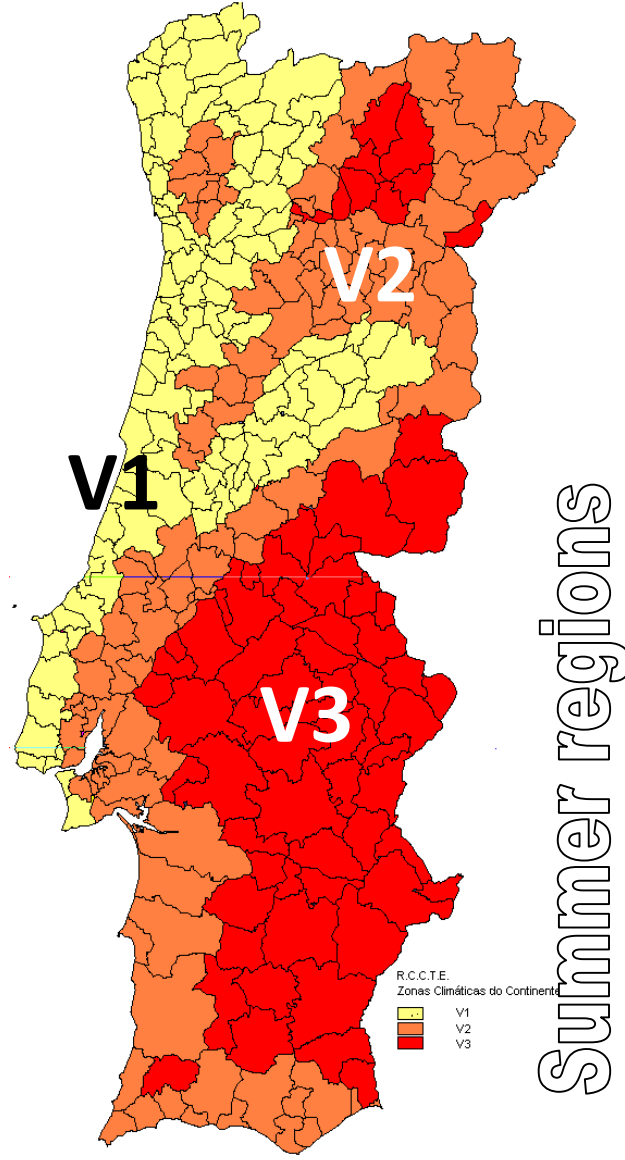
“Centre”

“North”

“South”



Winter regions



Summer regions