



Plano Intermunicipal

Adaptação às Alterações Climáticas do Algarve

## CLIMA 2018

Evento "Adaptação às Alterações Climáticas na Região do Algarve (Plano Intermunicipal - AMAL)"

Universidade do Algarve, Faro  
23 de novembro de 2018

Financiado por:



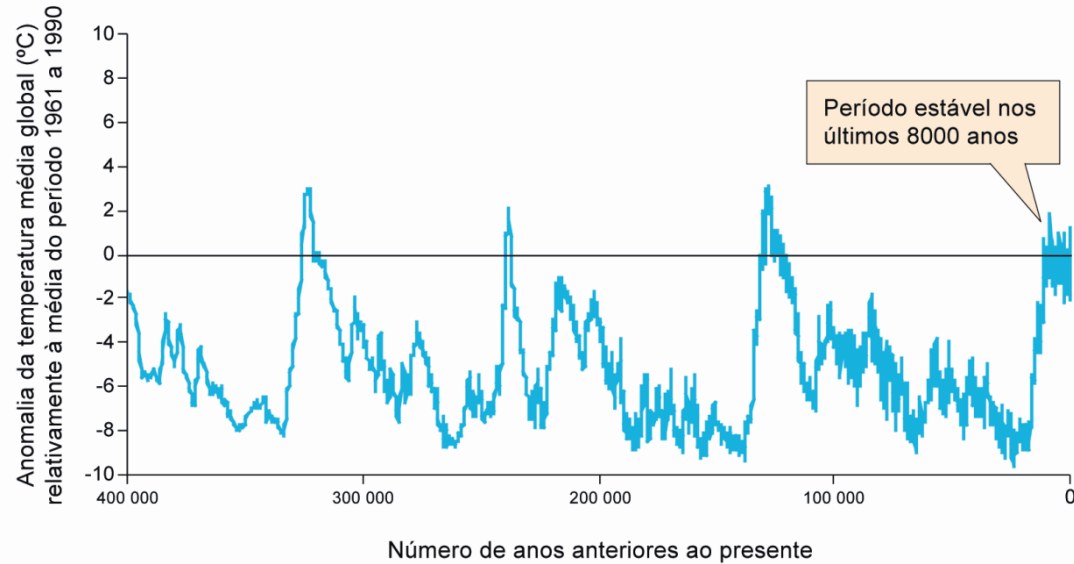


# Alterações Climáticas Globais

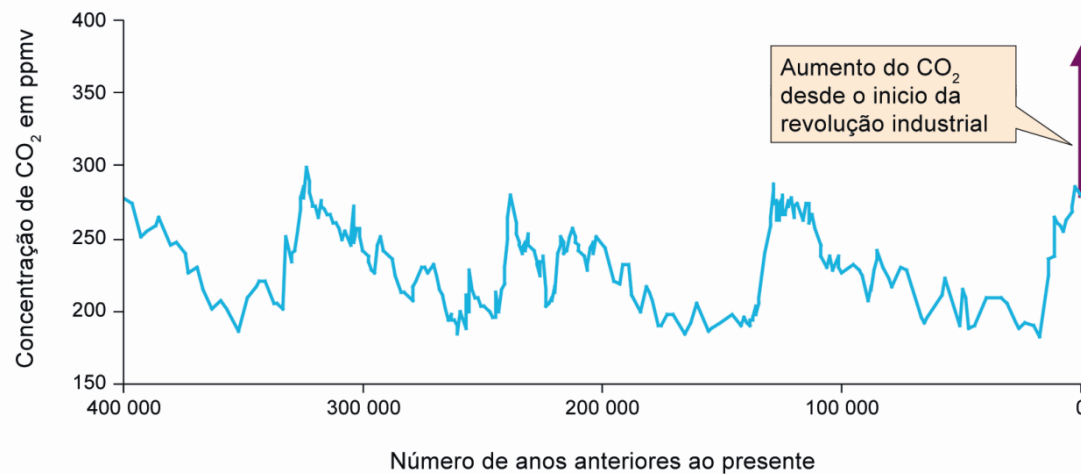
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Filipe Duarte Santos, [fdsantos@fc.ul.pt](mailto:fdsantos@fc.ul.pt)

# Evolução da temperatura média global desde há 400000 anos



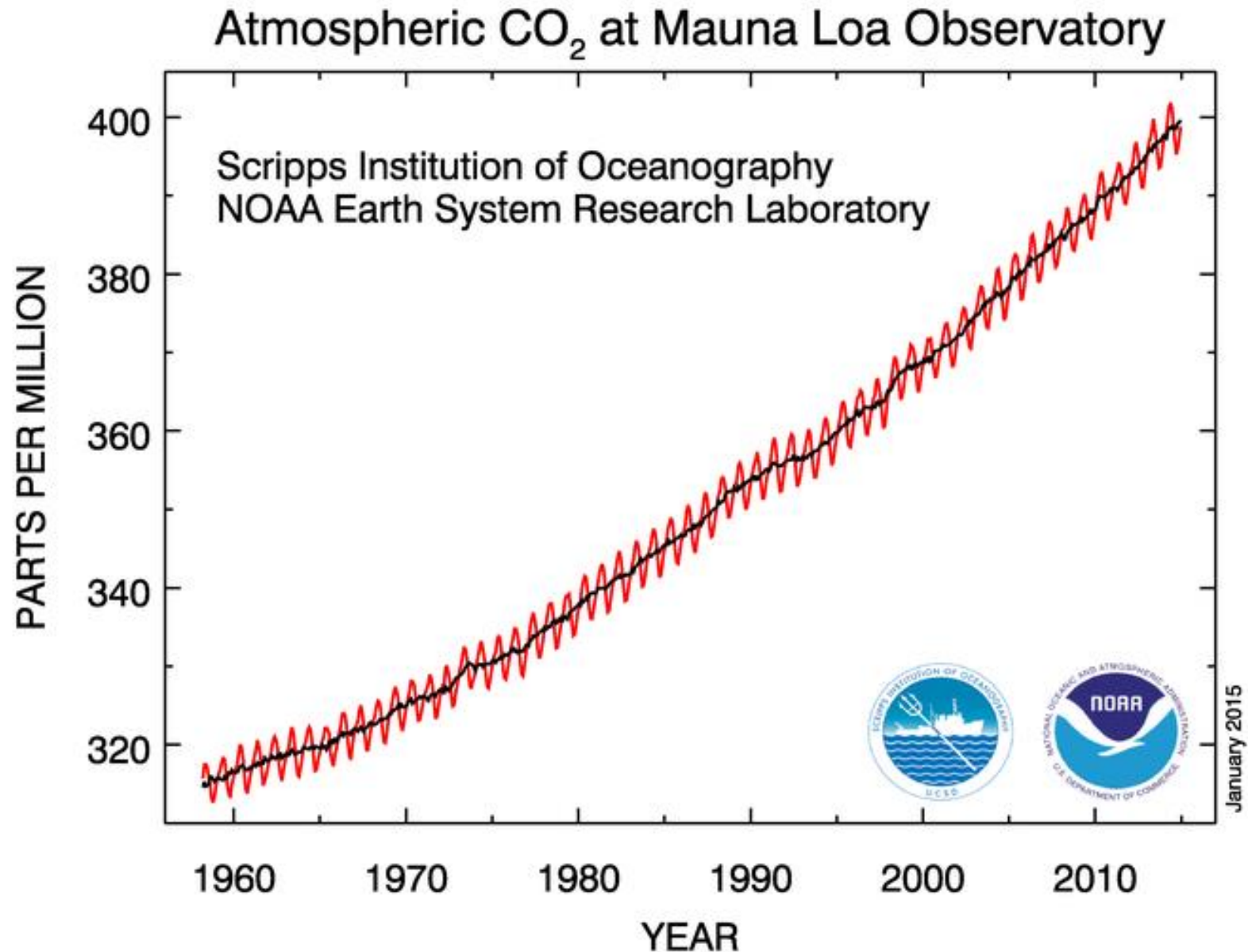
# Evolução da concentração atmosférica de CO<sub>2</sub>



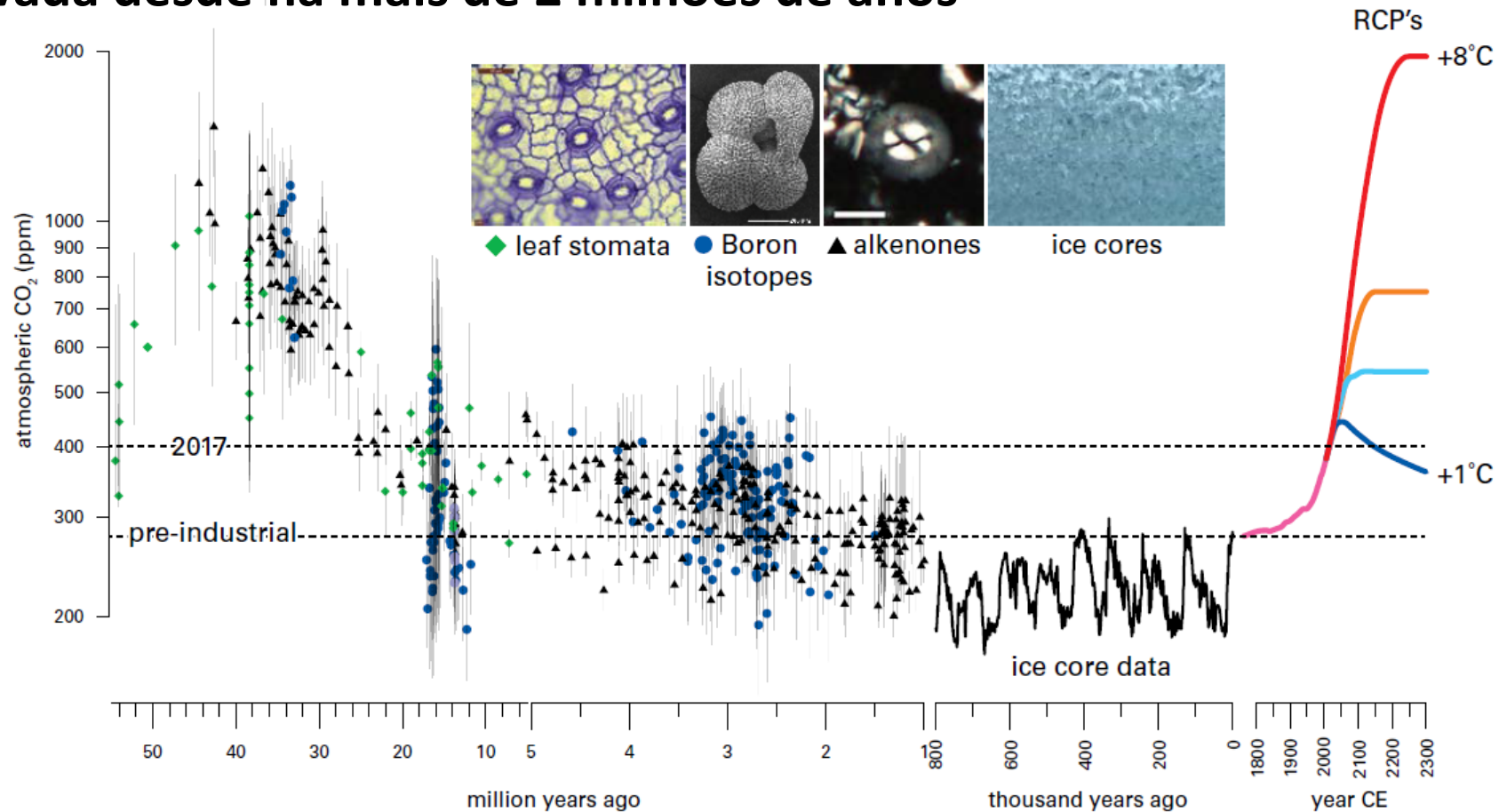
Reconstituição da evolução da temperatura média global da baixa atmosfera, representada por meio da anomalia relativamente à média do período de 1961 a 1990, e da concentração atmosférica do CO<sub>2</sub> nos últimos 400 000 anos (Petit, 1999). Figura adaptada de EEA, 2004. Repare-se na correlação que 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**

# Concentração do dióxido de carbono aumentou de 42% desde o século XVIII



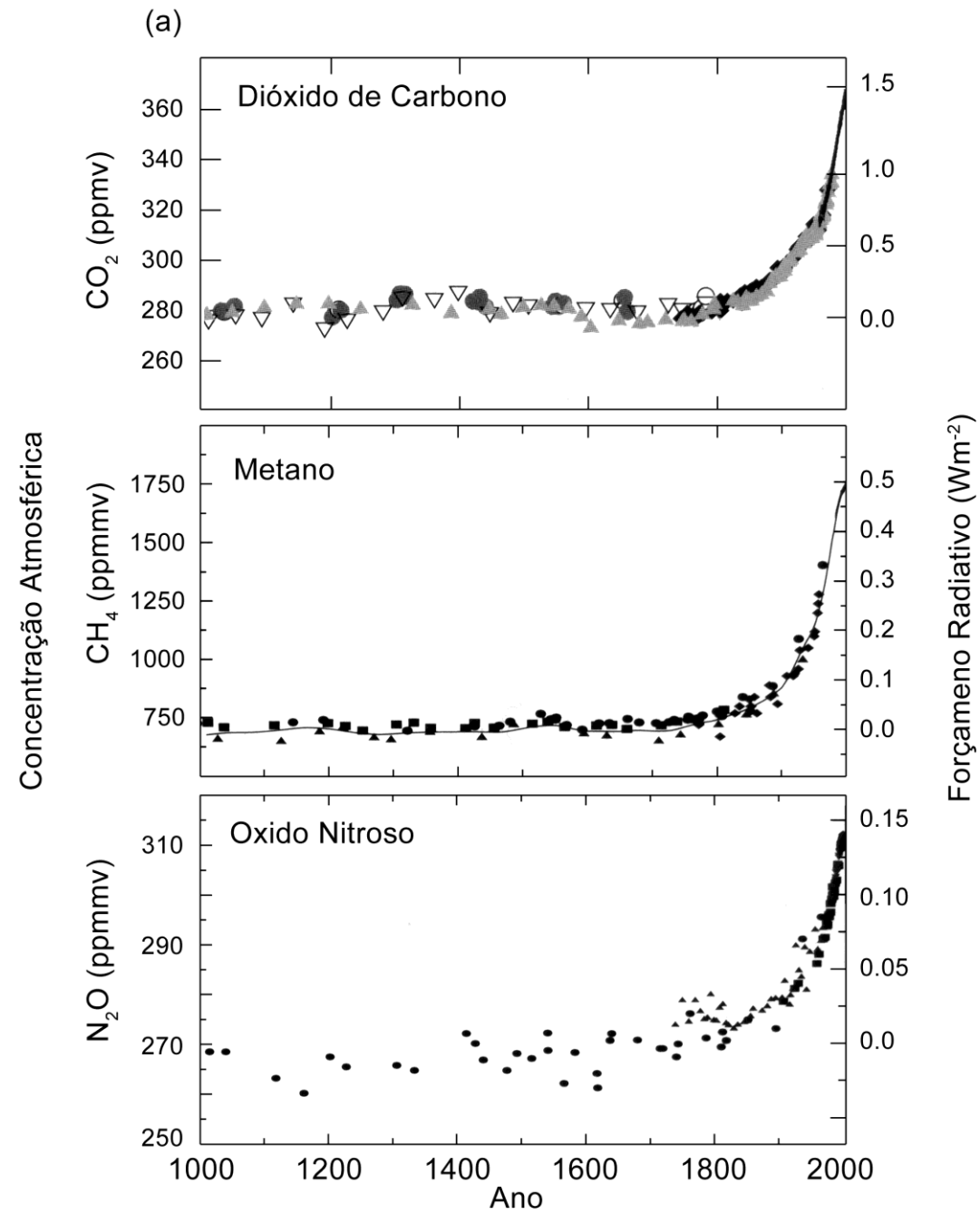
# A concentração atmosférica atual (2017) de CO<sub>2</sub> é a mais elevada desde há mais de 2 milhões de anos



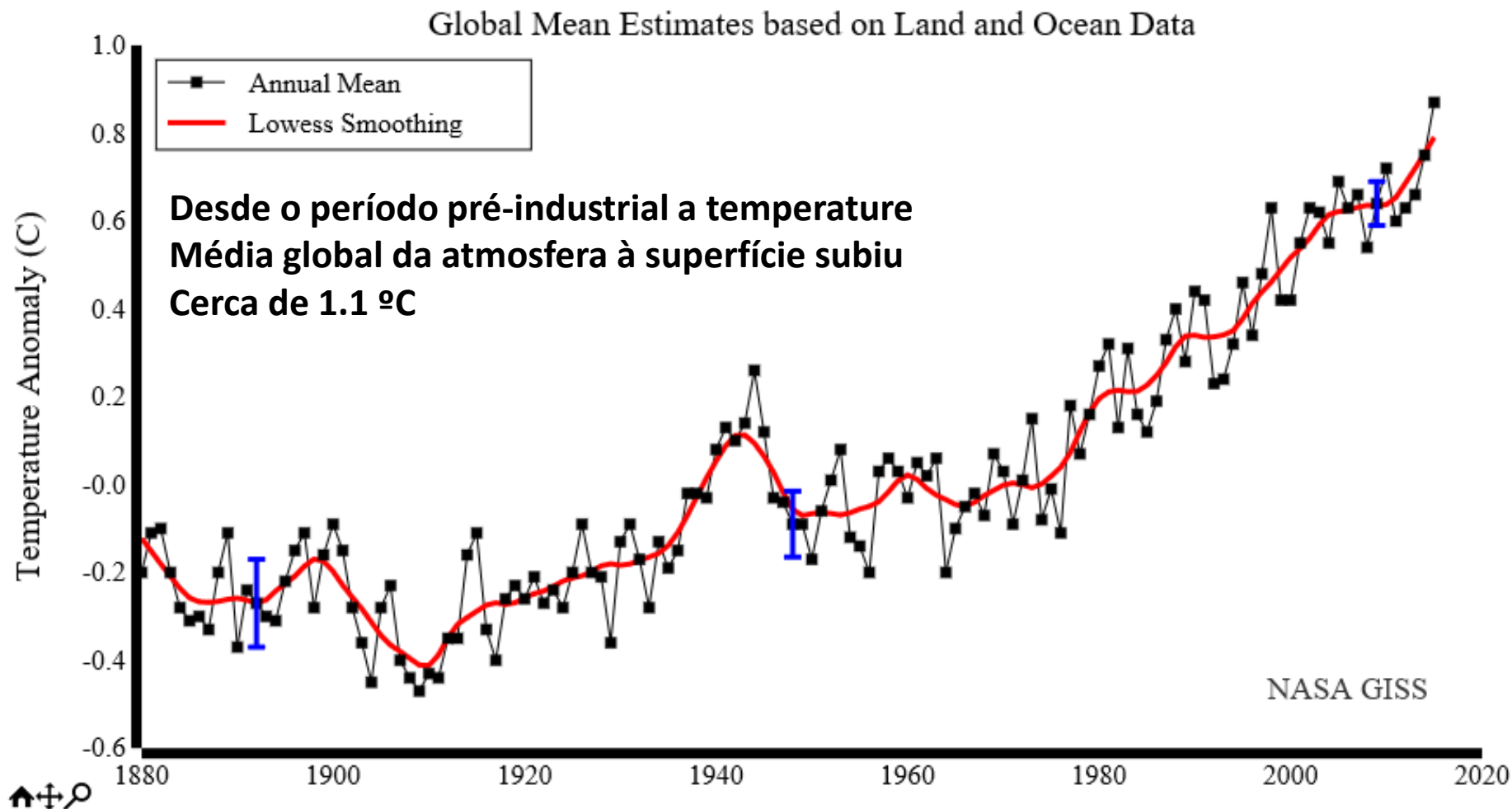
## Reconstituição por meio de estudos de paleoclimatologia

Reconstructions of atmospheric CO<sub>2</sub> over the past 55 million years are generated from proxy data that include boron isotopes (blue circles), alkenones (black triangles) and leaf stomata (green diamonds). Direct measurements from the past 800 000 years are acquired from Antarctic ice cores and modern instruments (pink). Future estimates include representative concentration pathways (RCPs) 8.5 (red), 6 (orange), 4.5 (light blue) and 2.6 (blue). References for all data shown in this plot are listed in the extended version online (<http://www.wmo.int/pages/prog/arep/gaw/ghg/ghg-bulletin13.html>). CE = Common Era.

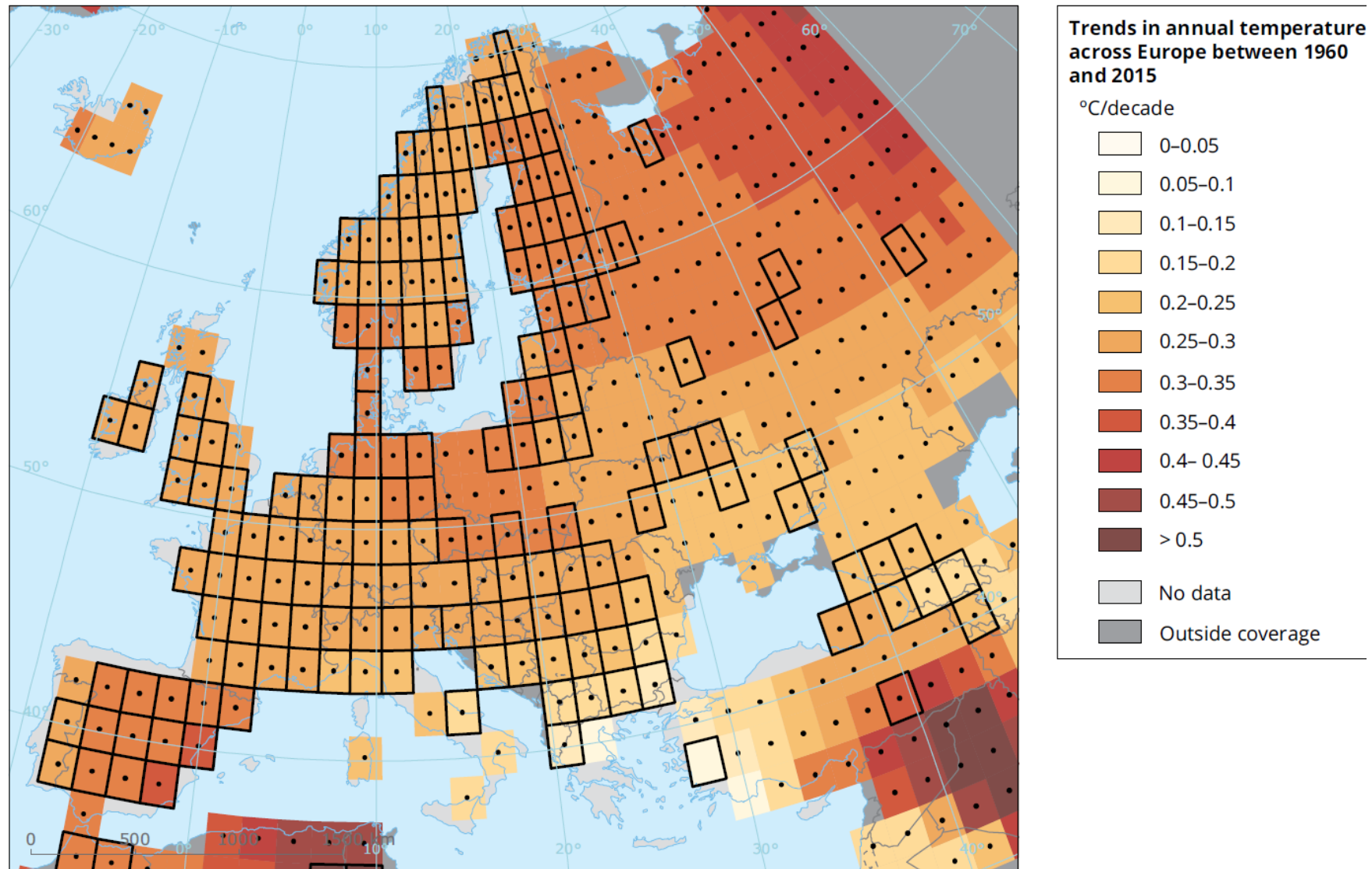
Fonte IPCC AR4



# Variação da temperatura média global da atmosfera à superfície desde 1880



# Aumento da temperatura média anual no período 1960-2015

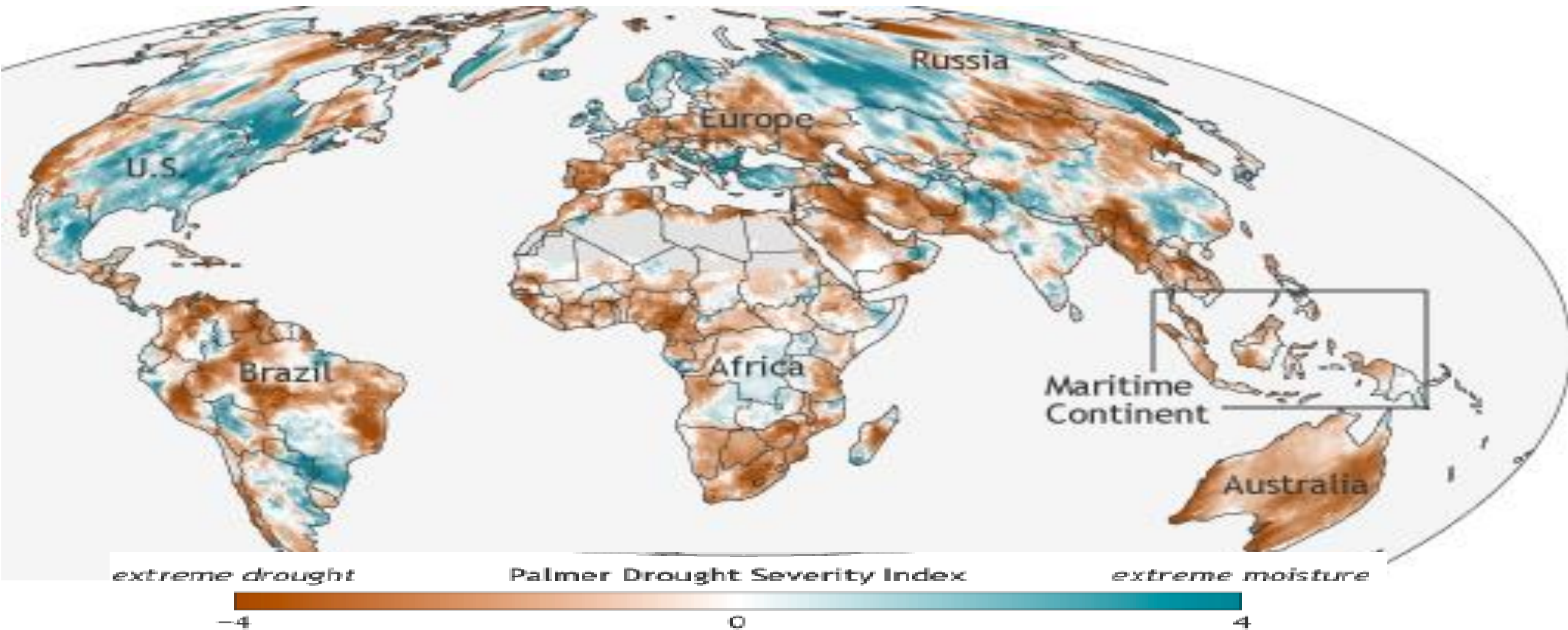


**Note:** Grid boxes outlined with solid black lines contain at least three stations and so are likely to be more representative of the grid box than those that are not outlined. Significance (at the 5 % level) of the long-term trend is shown by a black dot (which is the case for almost all grid boxes in this map).

**Source:** EEA and UK Met Office, based on the E-OBS dataset (updated from Haylock et al., 2008).

**Fonte, EEA, 2016**





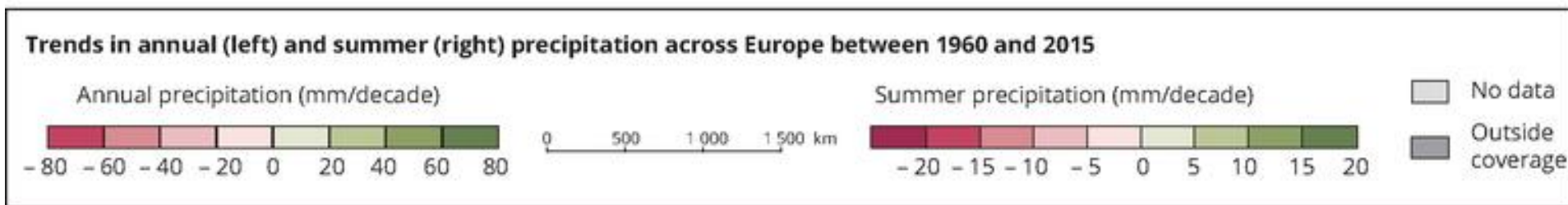
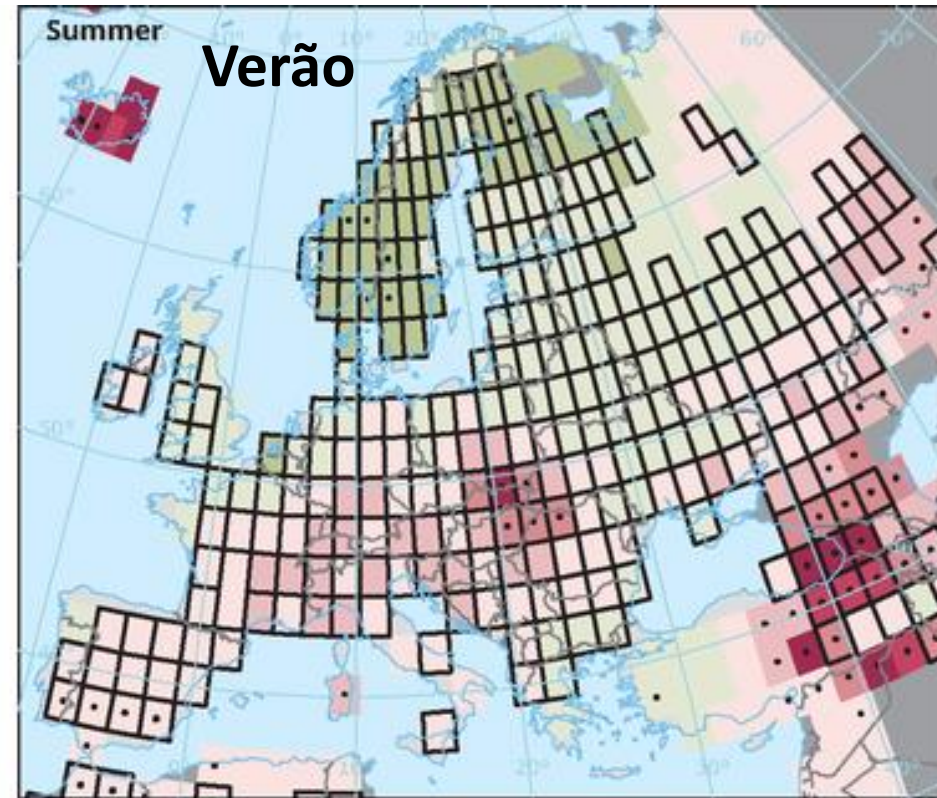
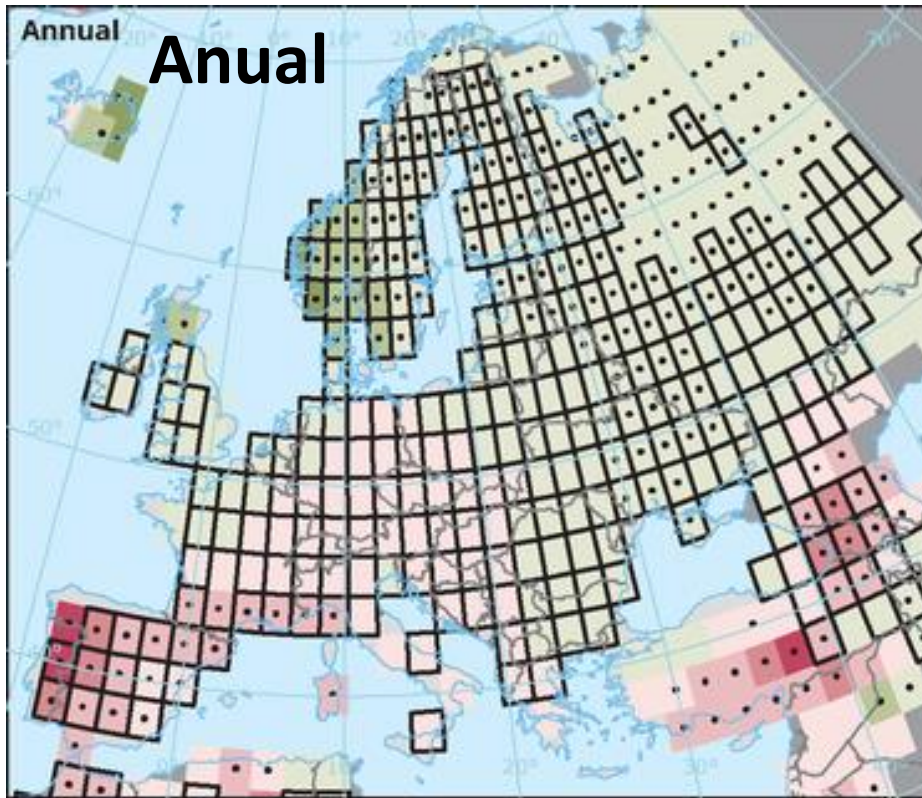
## Secas em 2015 à escala global

14% da área terrestre estiveram nesse ano em seca severa ou extrema, a percentagem mais elevada de área desde que começaram os registos deste indicador em 1950

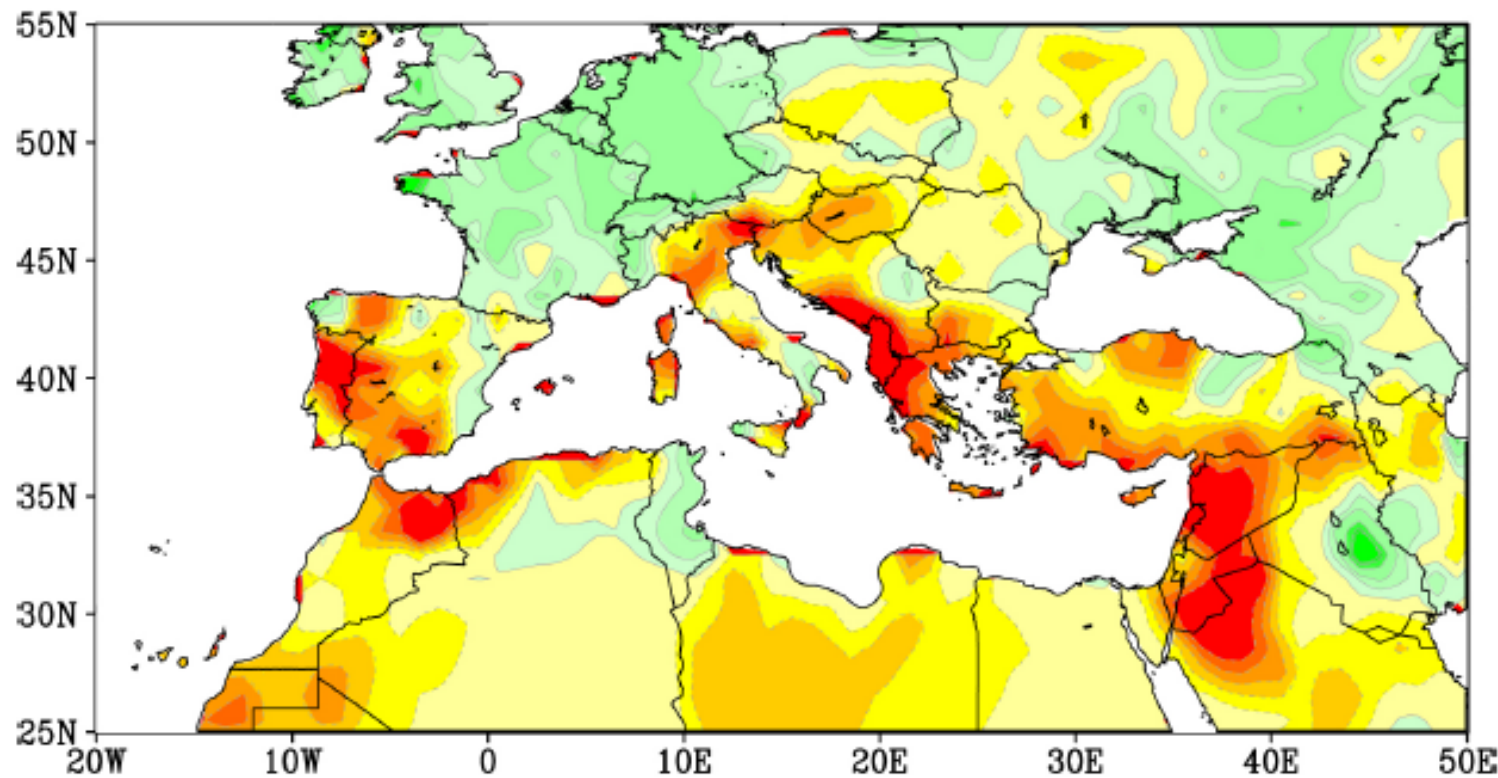
FONTE: <https://climate.gov/print/816791>

# Variação da precipitação média por década no período de 1960 a 2015

Fonte, EEA, 2016

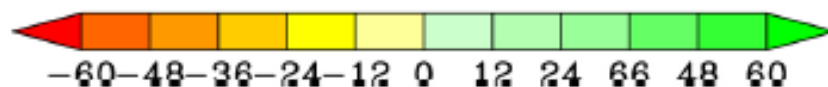


**Em Portugal, redução média de 40mm por década**



## Precipitação de 1971 a 2010 menos a de 1902 a 1970

Millimeters



*Figure 1. Observed time series of Mediterranean (30N-45N; 10W-40E) cold season (Nov-Apr) precipitation for the period 1902-2010 (top) and the observed change in cold season precipitation for the period 1971-2010 minus 1902-1970 (bottom). Anomalies (mm) are relative to the 1902-2010 period. Solid curve is the smoothed precipitation time series using a 9-pt Gaussian filter. Data is from the Global Precipitation Climatology Center (GPCC).*

Fonte, IPMA



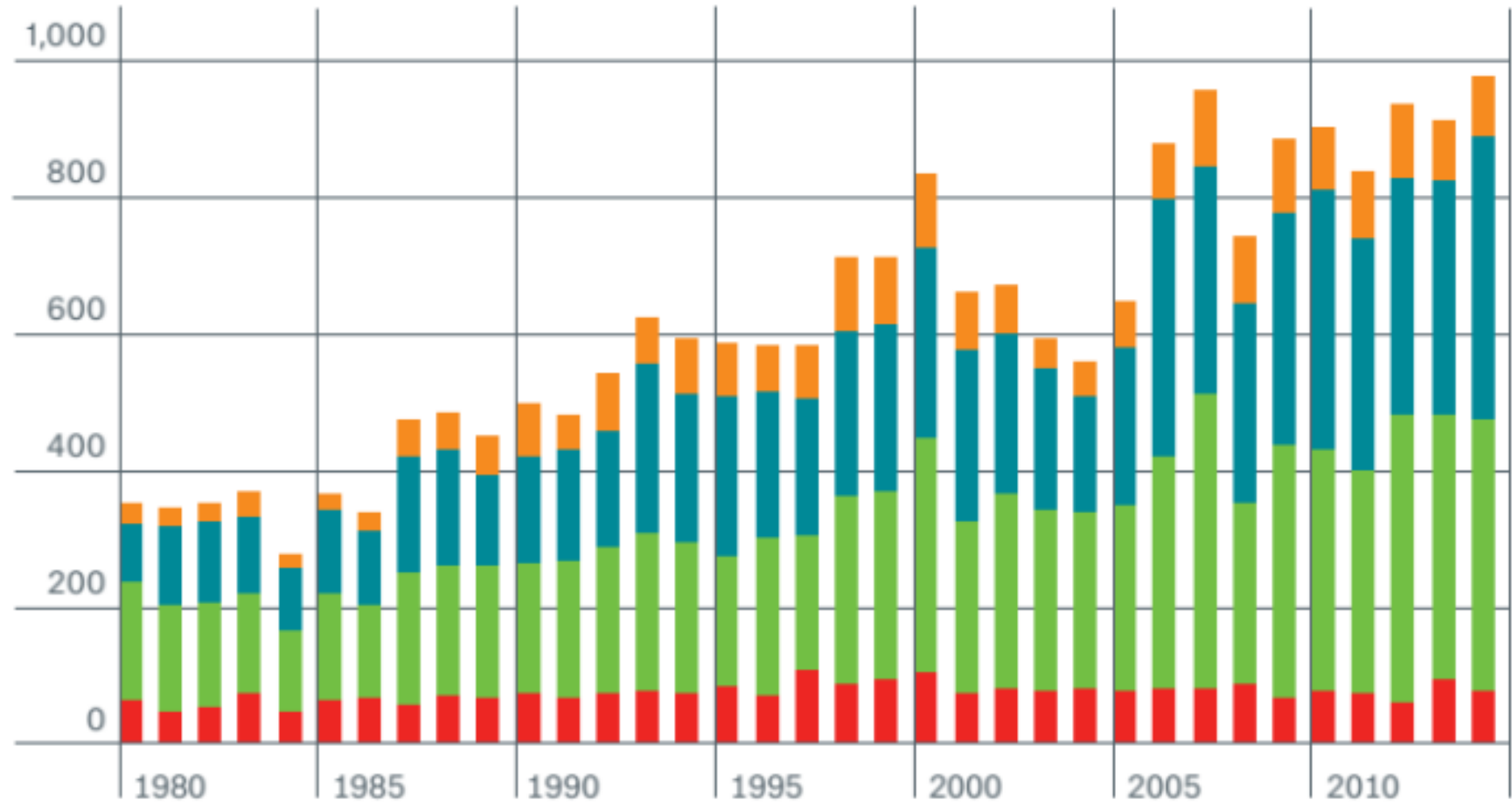
**Varição decadal da precipitação em Portugal Continental**



# Número de eventos extremos que causaram danos

Geophysical events (earthquake, tsunami, volcanic activity)

Number of loss events 1980-2014



- Meteorological events (tropical storm, extratropical storm, convective storm, local storm)
- Hydrological events (flood, mass movement)
- Climatological events (extreme temperatures, drought, wildfire)

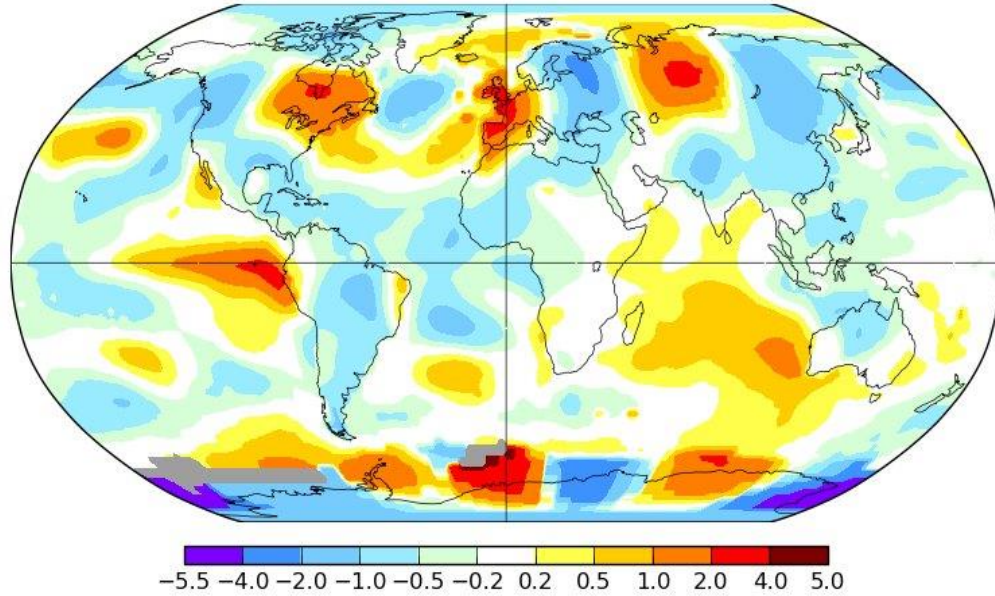
Source: Munich Re NatCatSERVICE

Eventos relacionados com o clima

June 1976

L-OTI(°C) Anomaly vs 1951-1980

-0.15



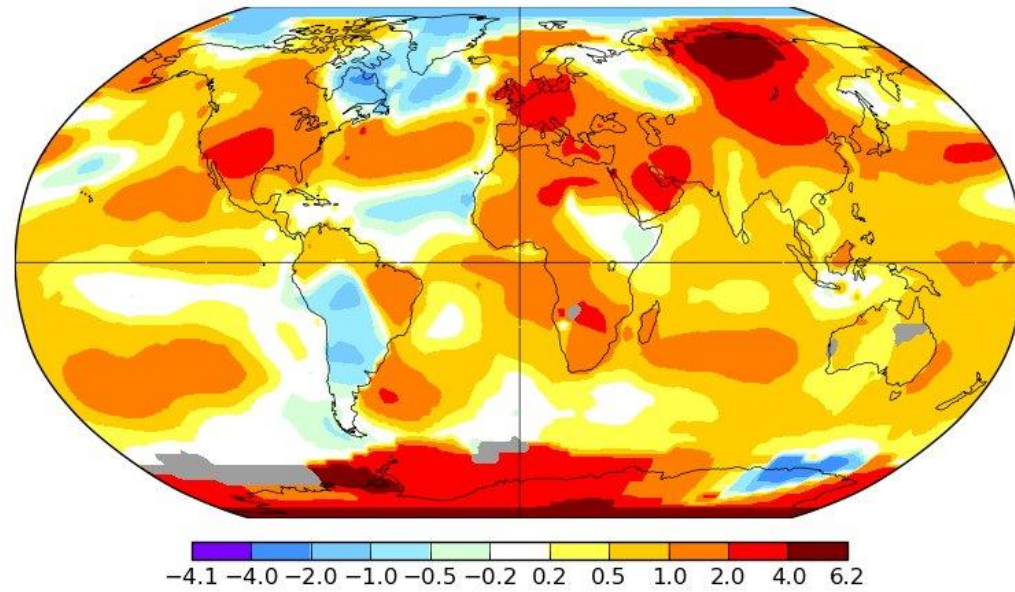
**More intense heat waves**

**June 2018**

June 2018

L-OTI(°C) Anomaly vs 1951-1980

0.78



**June 1976**

**Source: NASA GISS**

# Onda de calor na Europa em 2003

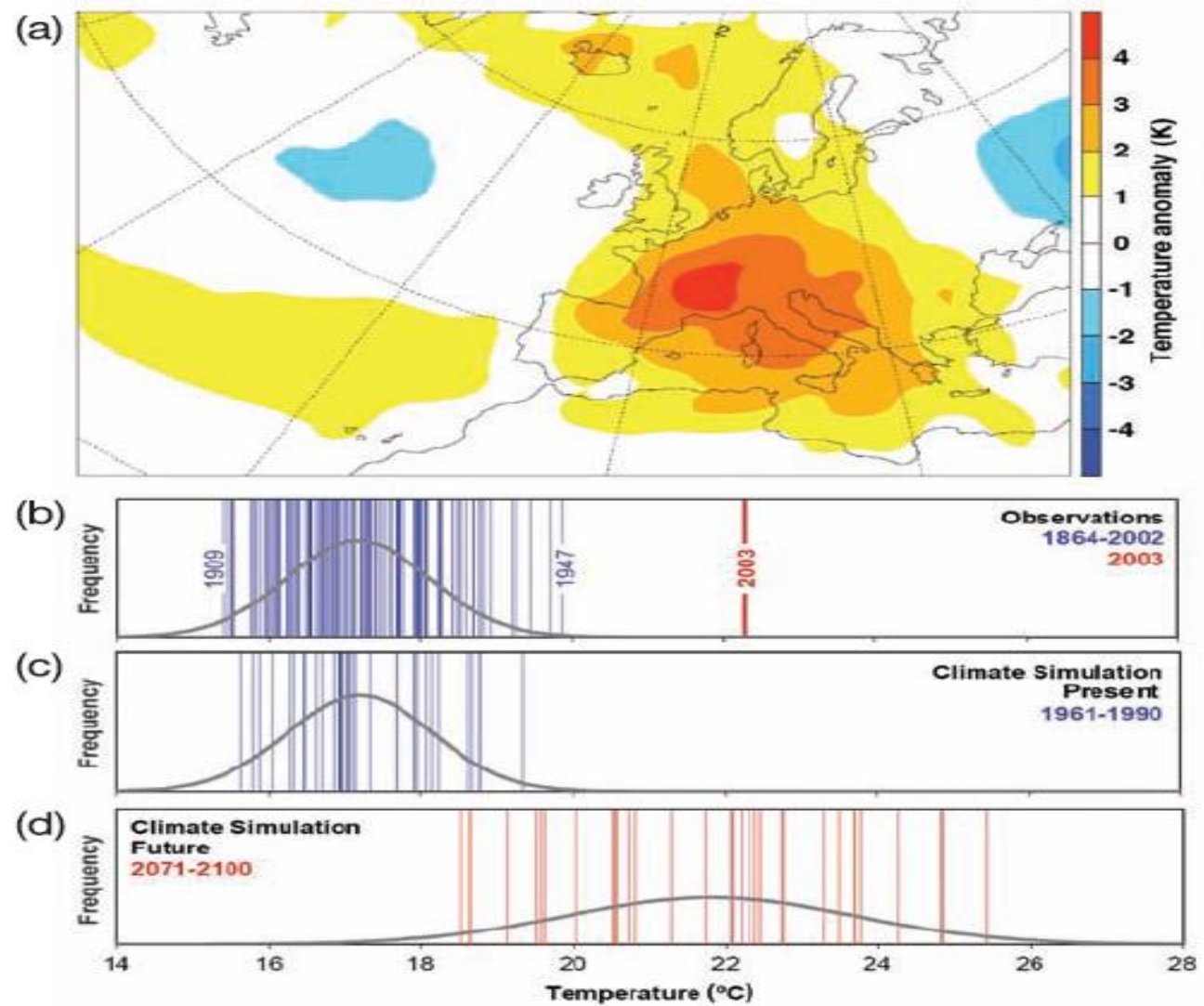
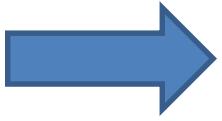
Observações



Cenário para o passado

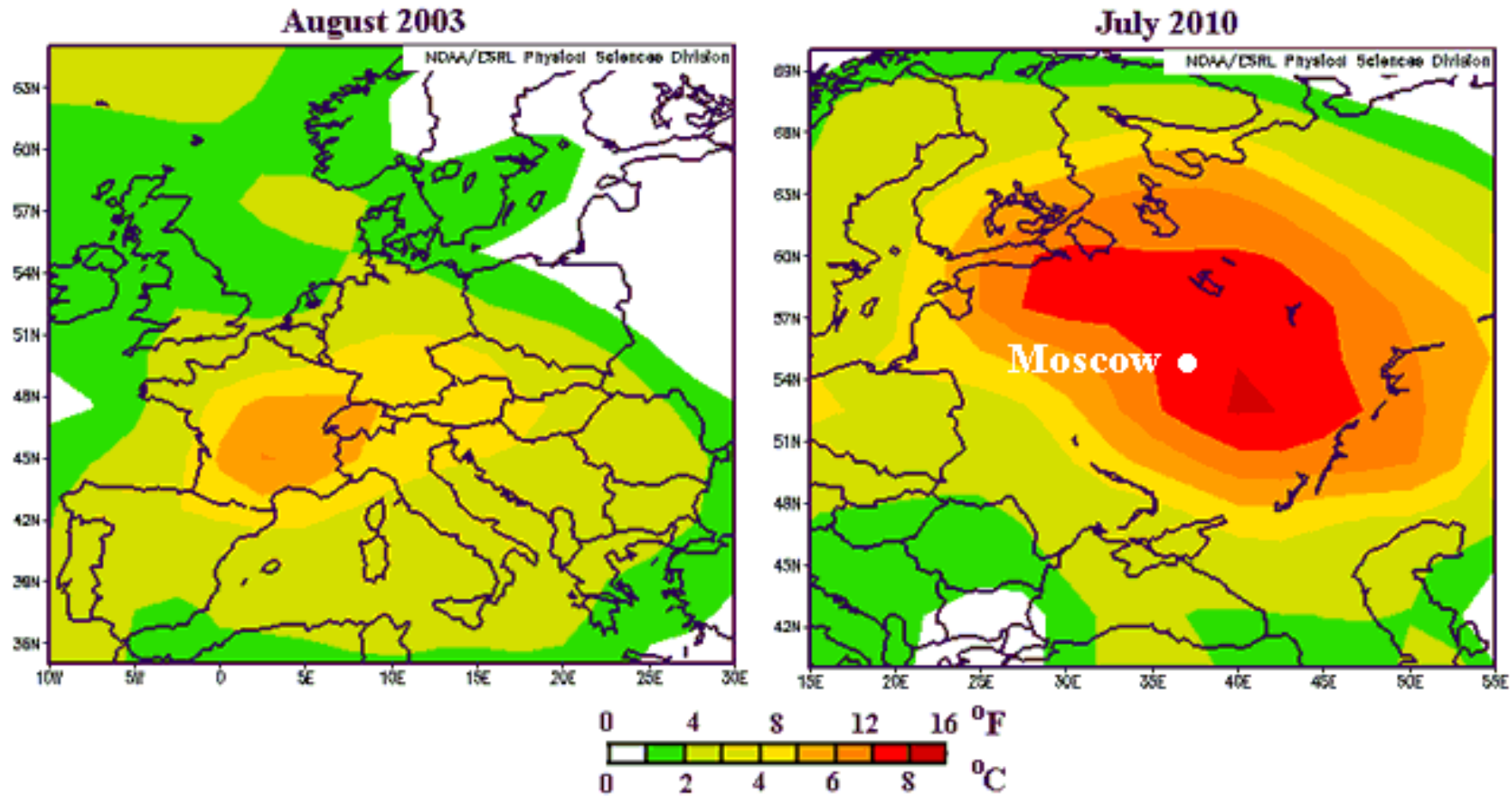


Cenário para o futuro



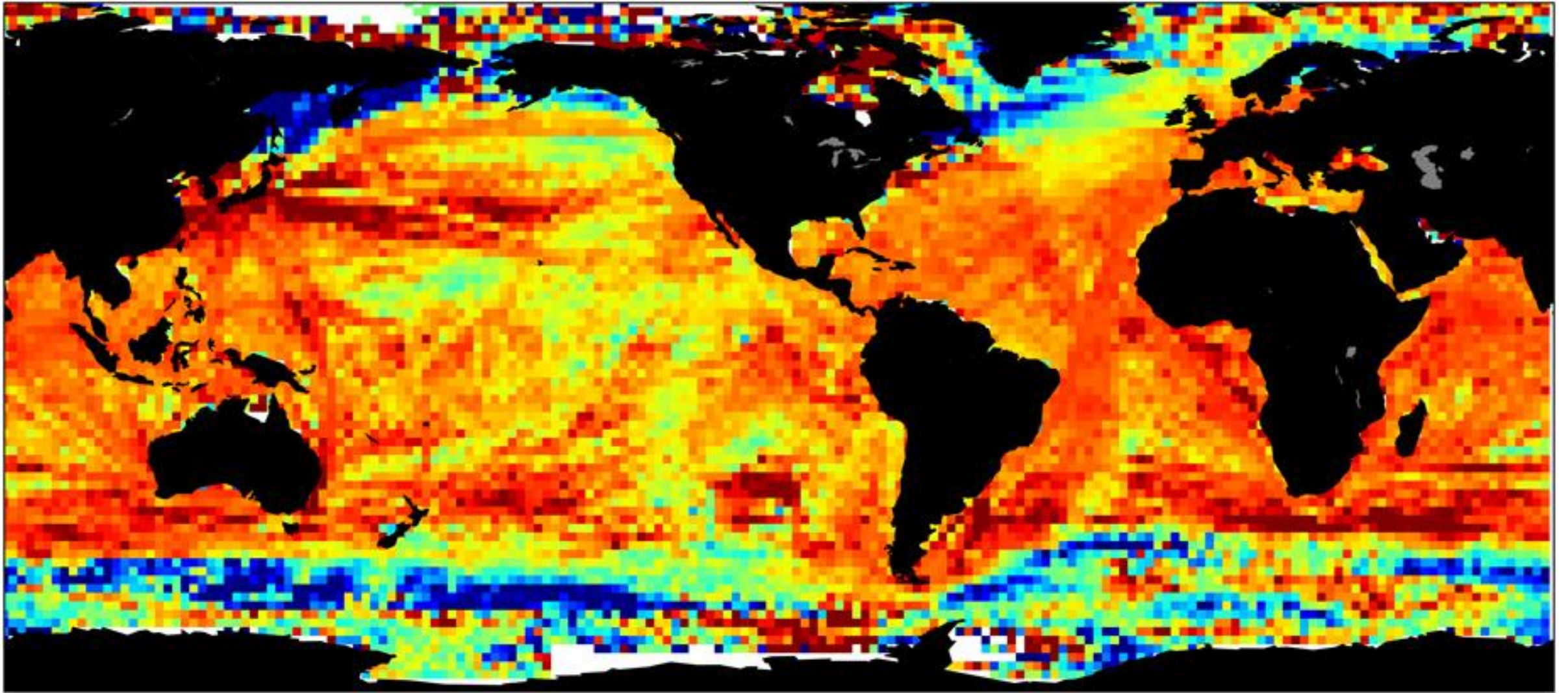
**Figure TS.13.** Characteristics of the summer 2003 heatwave: (a) JJA temperature anomaly with respect to 1961-1990; (b-d) June, July, August temperatures for Switzerland; (b) observed during 1864-2003; (c) simulated using a regional climate model for the period 1961-1990; (d) simulated for 2071-2100 under the SRES A2 scenario. The vertical bars in panels (b-d) represent mean summer surface temperature for each year of the time period considered; the fitted Gaussian distribution is indicated in black. Reprinted by permission from Macmillan Publishers Ltd. [Nature] (Schär et al., 2004), copyright 2004, [F12.4].

## Departure of Temperature from Average for Two Great Heat Waves

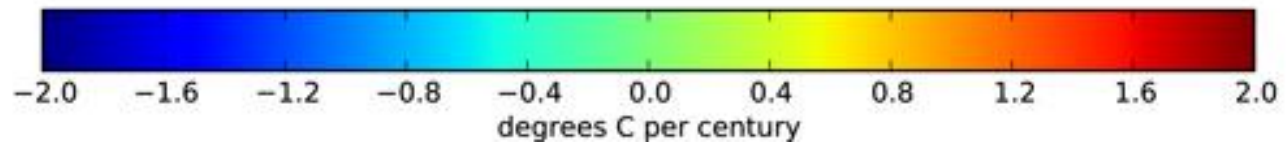


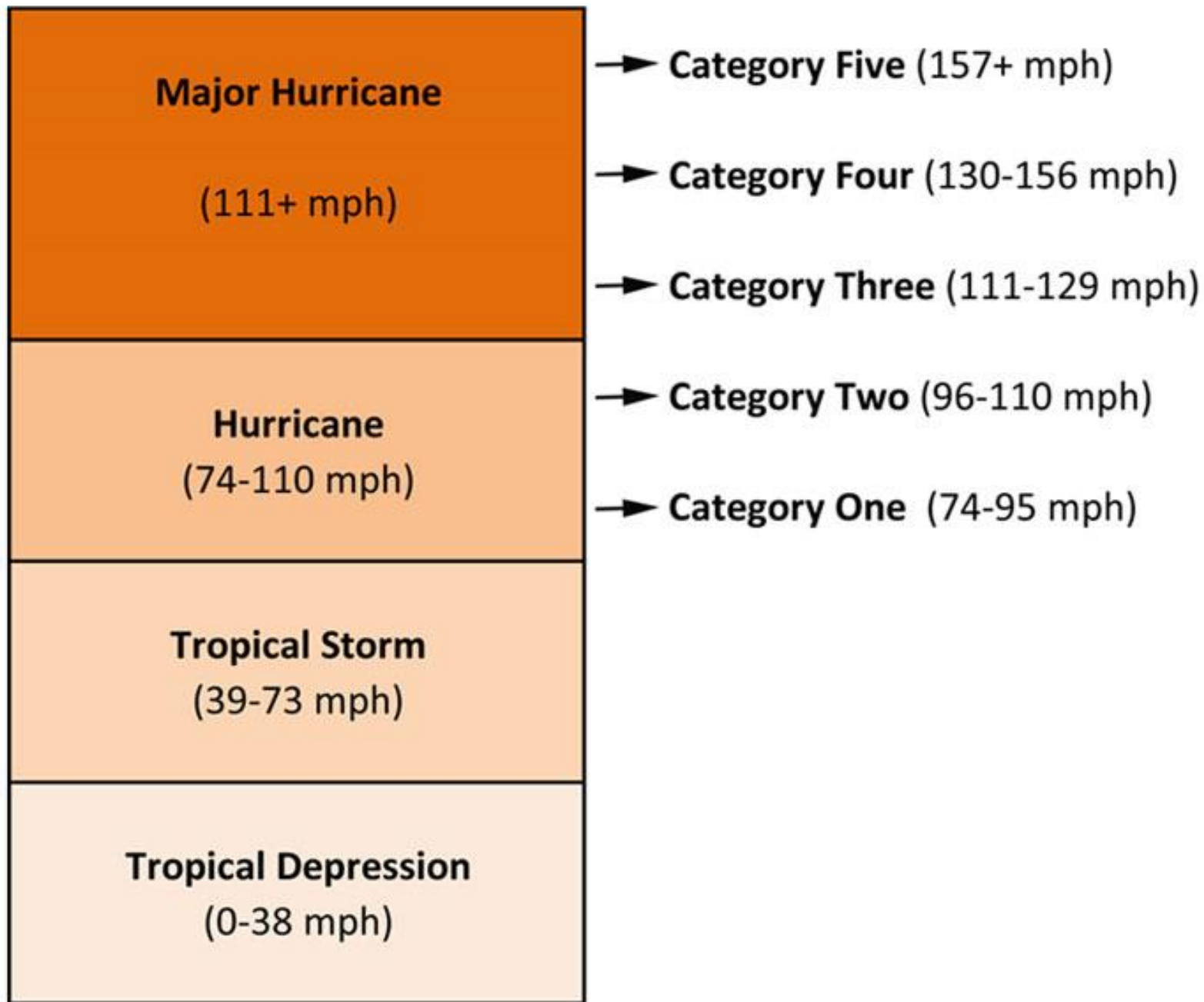
**Figure 1.** A comparison of August temperatures, the peak of the great European heat wave of 2003 (left) with July temperatures from the Great Russian Heat Wave of 2010 (right) reveals that this year's heat wave is more intense and covers a wider area of Europe.





## Changes in Sea-Surface Temperature Since 1900





**Major Hurricane**

(111+ mph)

→ **Category Five** (157+ mph)

→ **Category Four** (130-156 mph)

→ **Category Three** (111-129 mph)

**Hurricane**

(74-110 mph)

→ **Category Two** (96-110 mph)

→ **Category One** (74-95 mph)

**Tropical Storm**

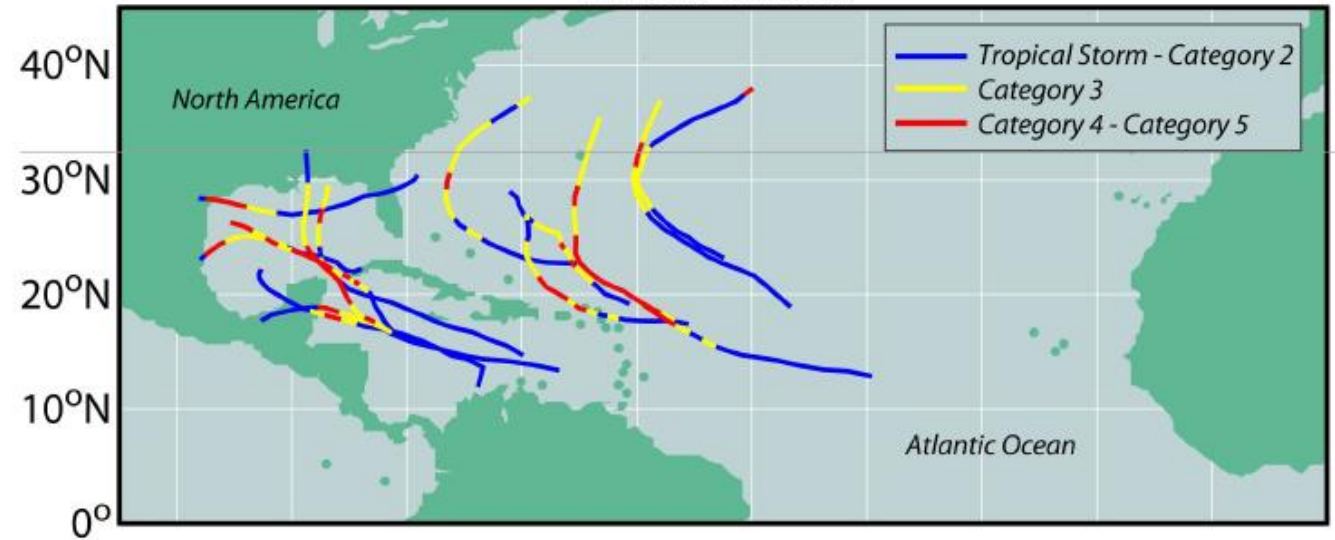
(39-73 mph)

**Tropical Depression**

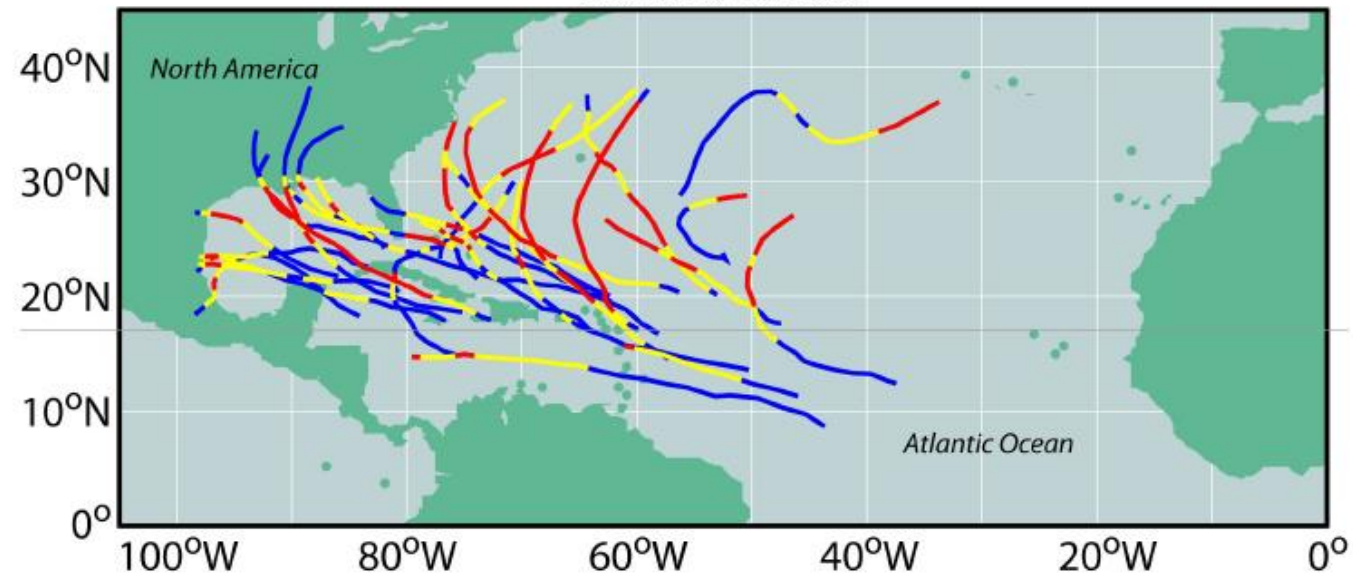
(0-38 mph)

# Modeled Category 4 & 5 Hurricane Tracks

*Present Climate*



*Warmed Climate*



**Source: Bender et al., Science, 2010**

**Pinhal de Leiria,  
Estrada perto de  
São Pedro  
de Moel Após o  
ciclone pós-tropical  
Leslie,  
foto de 23-10-2018**



# Evolução do Índice de Aridez em Portugal continental nos últimos 50 anos

Semi-arid  
Dry/Sub-humid  
Subhumid wet  
Humid

1960-1990

IGClima  
1a5000  
■ Semi-árido  
■ Subhúmido Seco  
■ Subhúmido Húmido  
■ Húmido

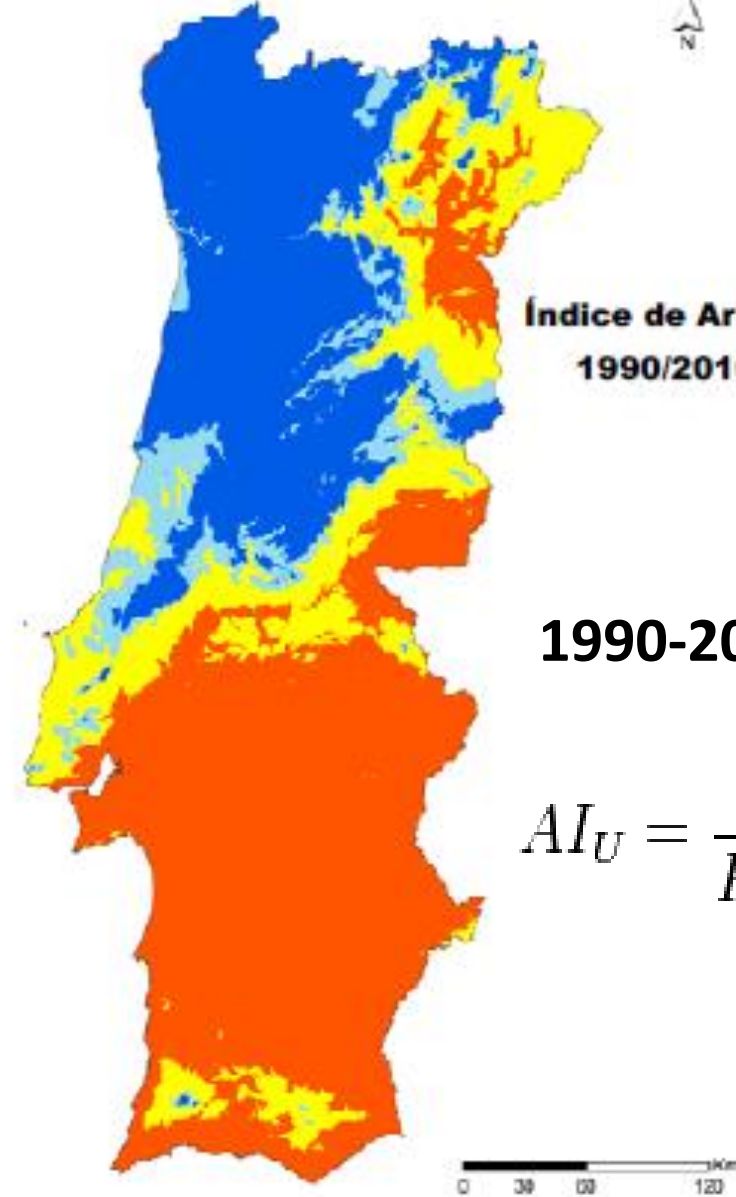
Índice de Aridez  
1960/1990



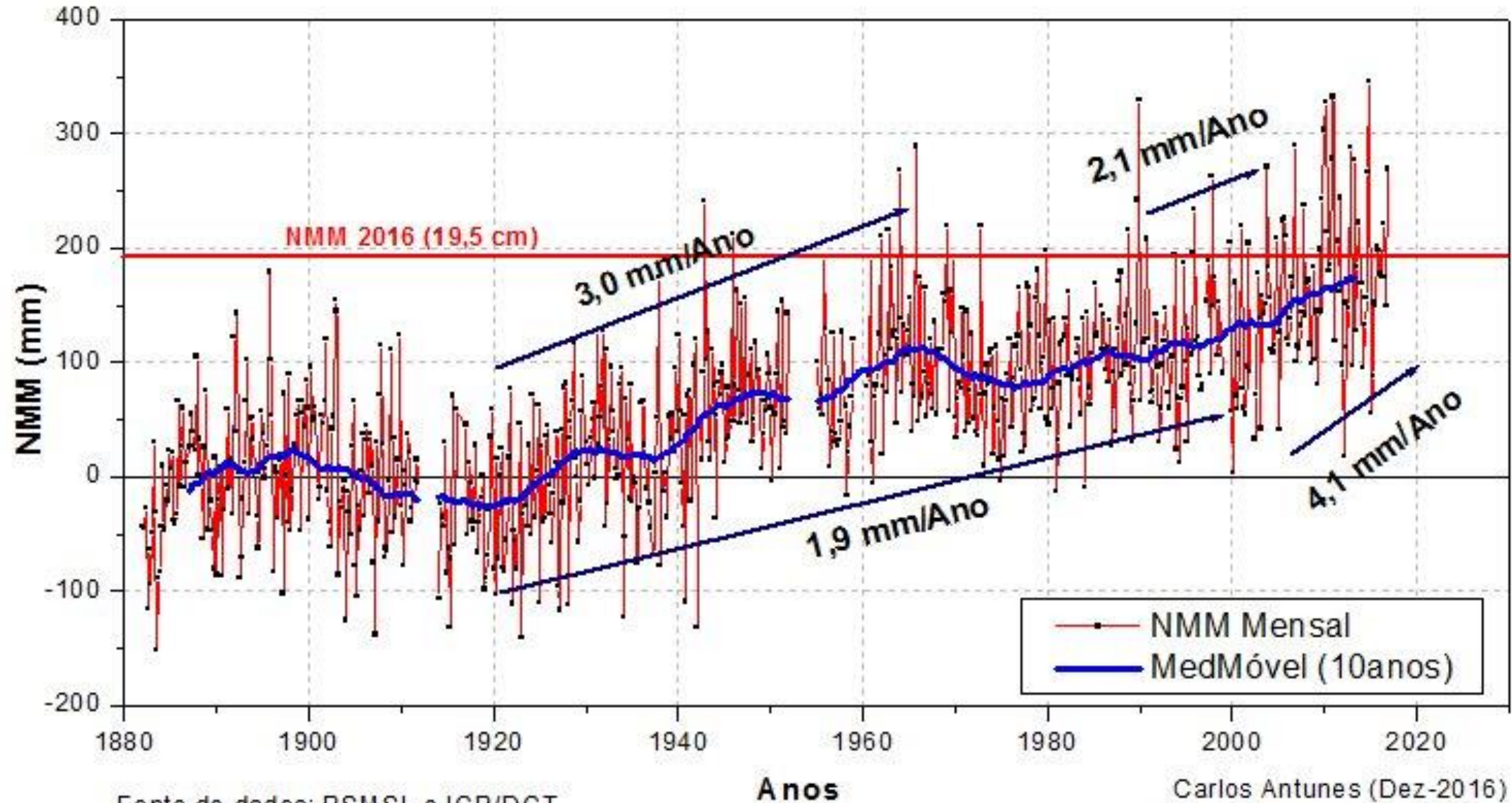
Índice de Aridez  
1990/2010

1990-2010

$$AI_U = \frac{P}{PET}$$



# CA SCAIS - VARIAÇÃO DO NÍVEL MÉDIO DO MAR



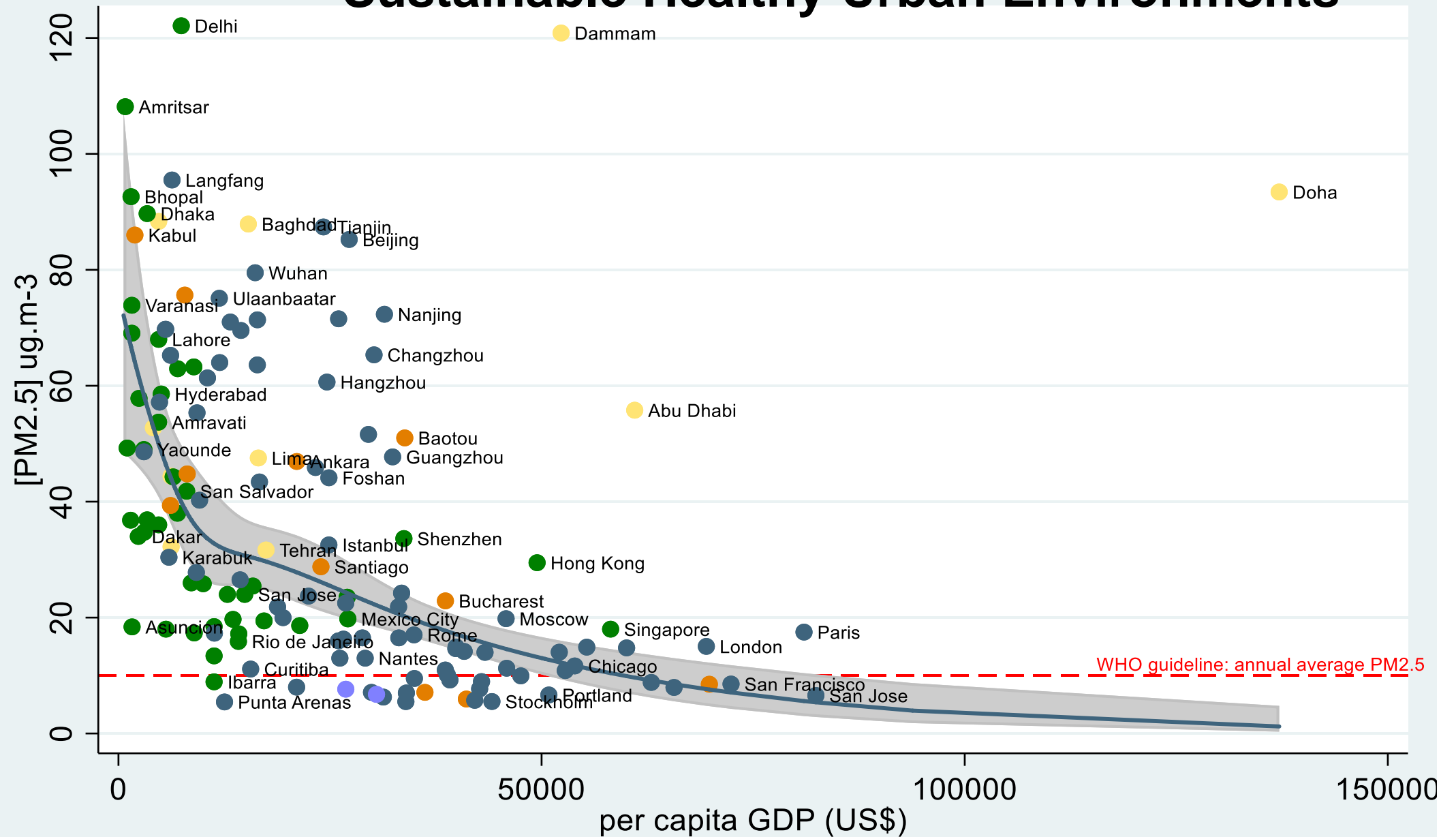
Fonte de dados: PSMSL e IGP/DGT

Carlos Antunes (Dez-2016)  
Eng. Geoespacial - FCUL

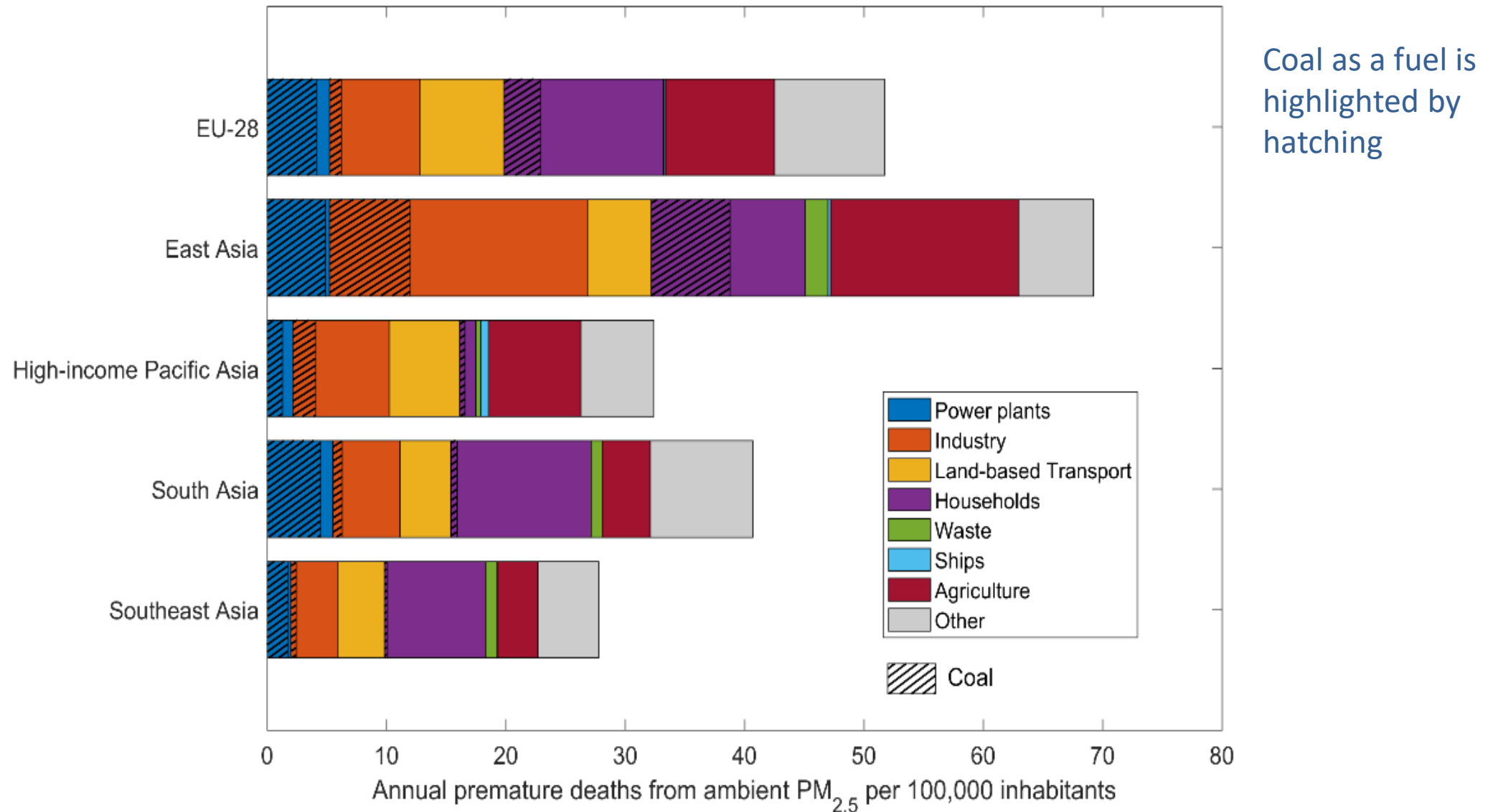
**NMM com dados Analógicos (1882-2003) & Digitais (2003-2016)**

# Air pollution: annual average PM<sub>2.5</sub>, SHUE database cities

## Sustainable Healthy Urban Environments











# Premature mortality from ambient PM<sub>2.5</sub> in 2015 by pollution source



Source: The 2018 Report of The Lancet Countdown on Health and Climate Change, *Lancet* in press

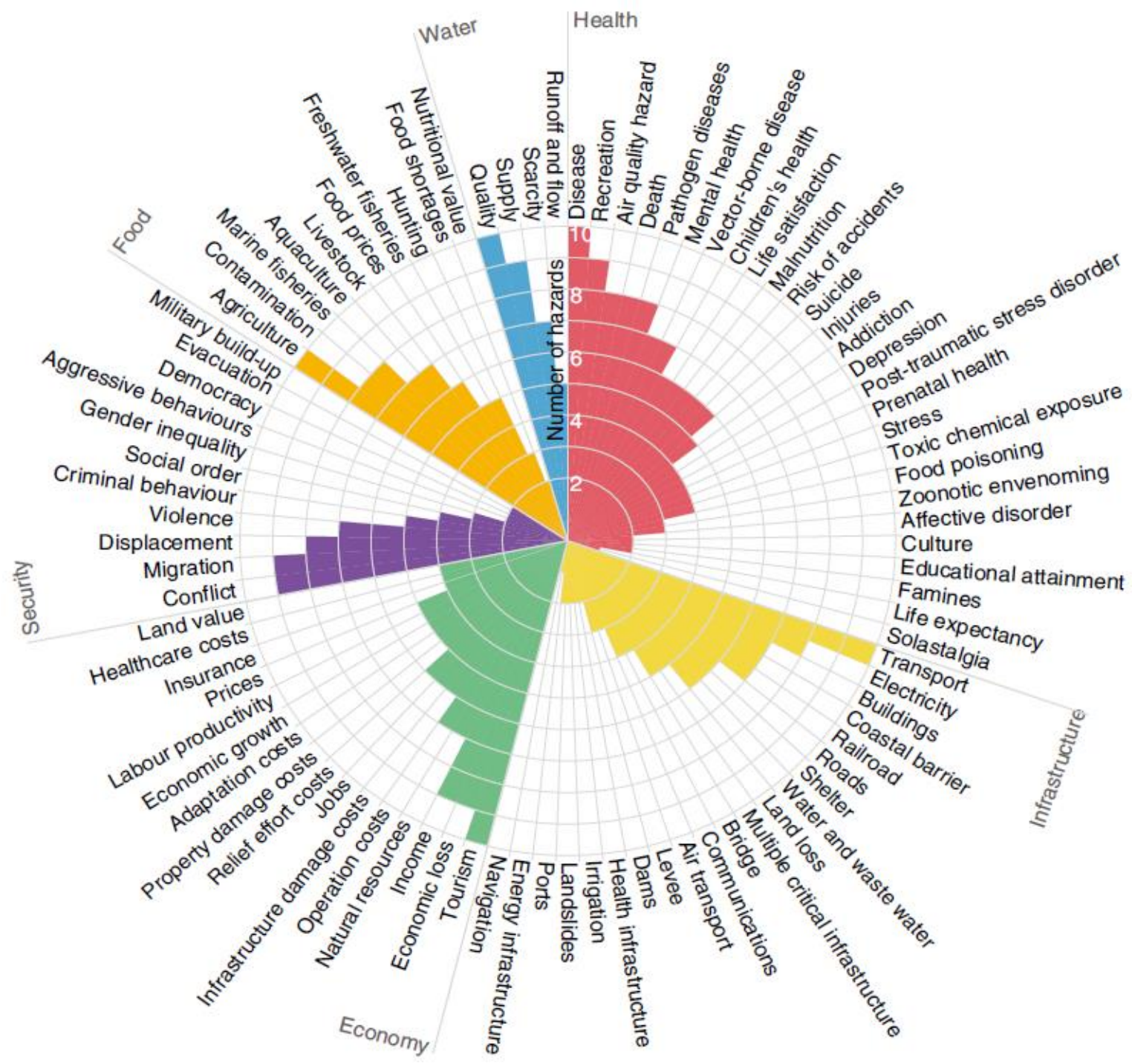


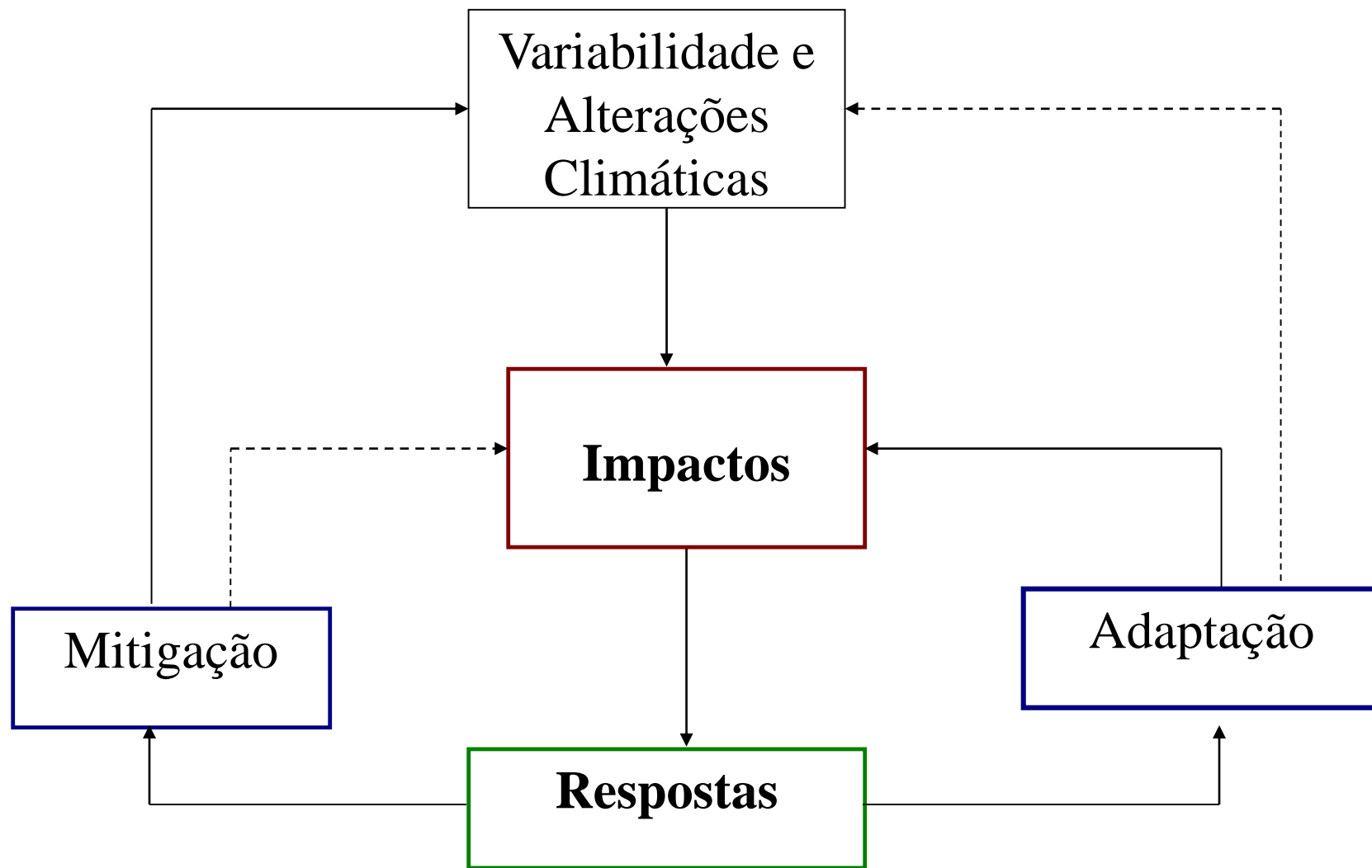
# Broad threat to humanity from cumulative climate hazards intensified by greenhouse gas emissions

Camilo Mora <sup>1\*</sup>, Daniele Spirandelli<sup>2,3</sup>, Erik C. Franklin<sup>1,4</sup>, John Lynham<sup>5,6</sup>, Michael B. Kantar <sup>7</sup>, Wendy Miles<sup>8,9</sup>, Charlotte Z. Smith <sup>10</sup>, Kelle Freel<sup>4</sup>, Jade Moy<sup>11</sup>, Leo V. Louis<sup>12</sup>, Evan W. Barba<sup>4</sup>, Keith Bettinger<sup>13</sup>, Abby G. Frazier <sup>13,14</sup>, John F. Colburn IX<sup>15</sup>, Naota Hanasaki <sup>16</sup>, Ed Hawkins <sup>17</sup>, Yukiko Hirabayashi<sup>18</sup>, Wolfgang Knorr<sup>19</sup>, Christopher M. Little <sup>20</sup>, Kerry Emanuel<sup>21</sup>, Justin Sheffield <sup>22,23</sup>, Jonathan A. Patz<sup>24</sup> and Cynthia L. Hunter<sup>11</sup>

**Publicado a 19 de novembro de 2018**

**Fig. 1 | Observed impacts on humanity from climate hazards.** Six different aspects of human systems are shown (health, food, water, infrastructure, economy and security), with their subcategories for which impacts were observed. The heights of the bars indicate the number of hazards implicated in the impacts. Here we analysed ten climate hazards. The complete table of climate hazards and human aspects impacted is available at <http://impactsofclimatechange.info>.

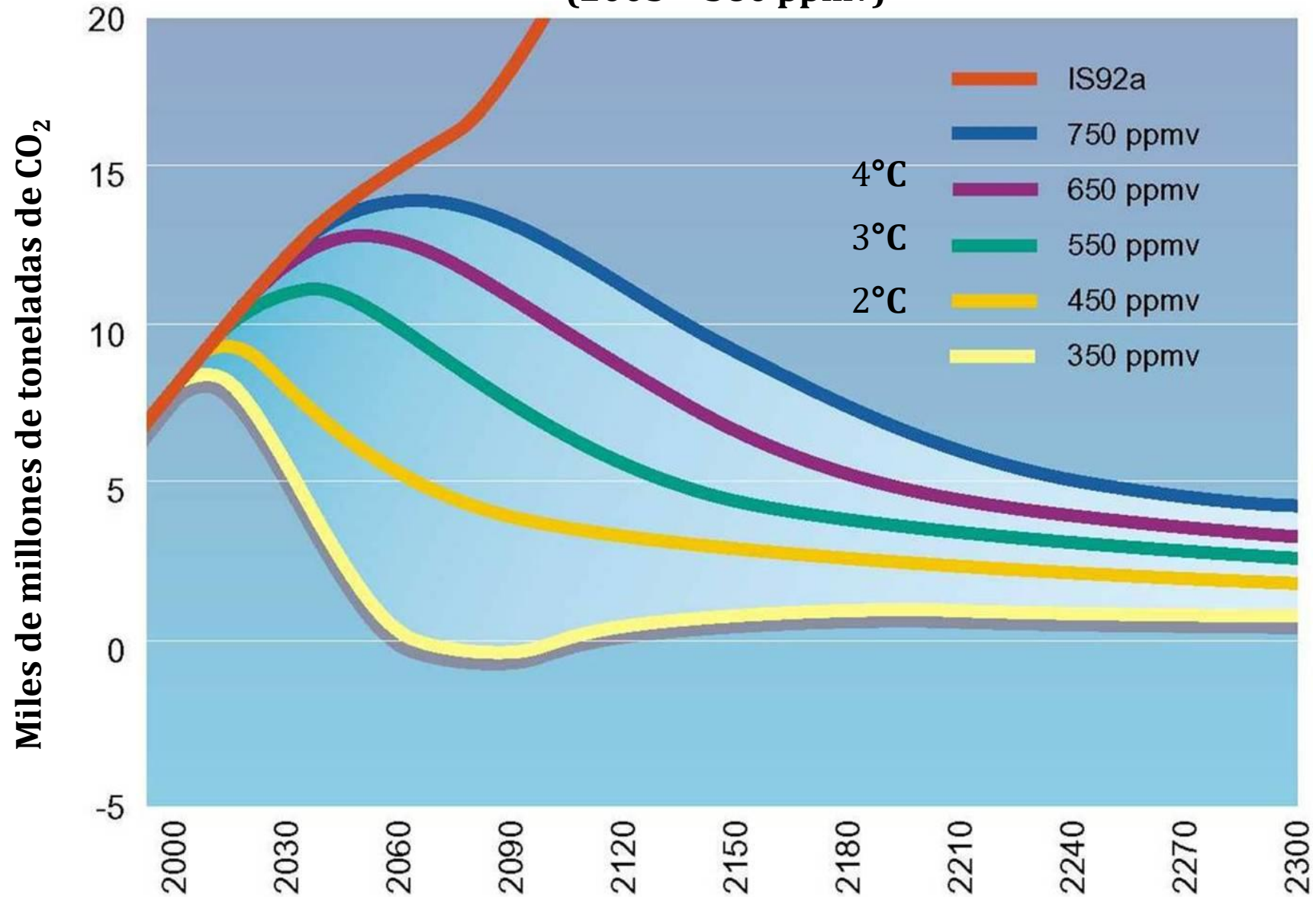




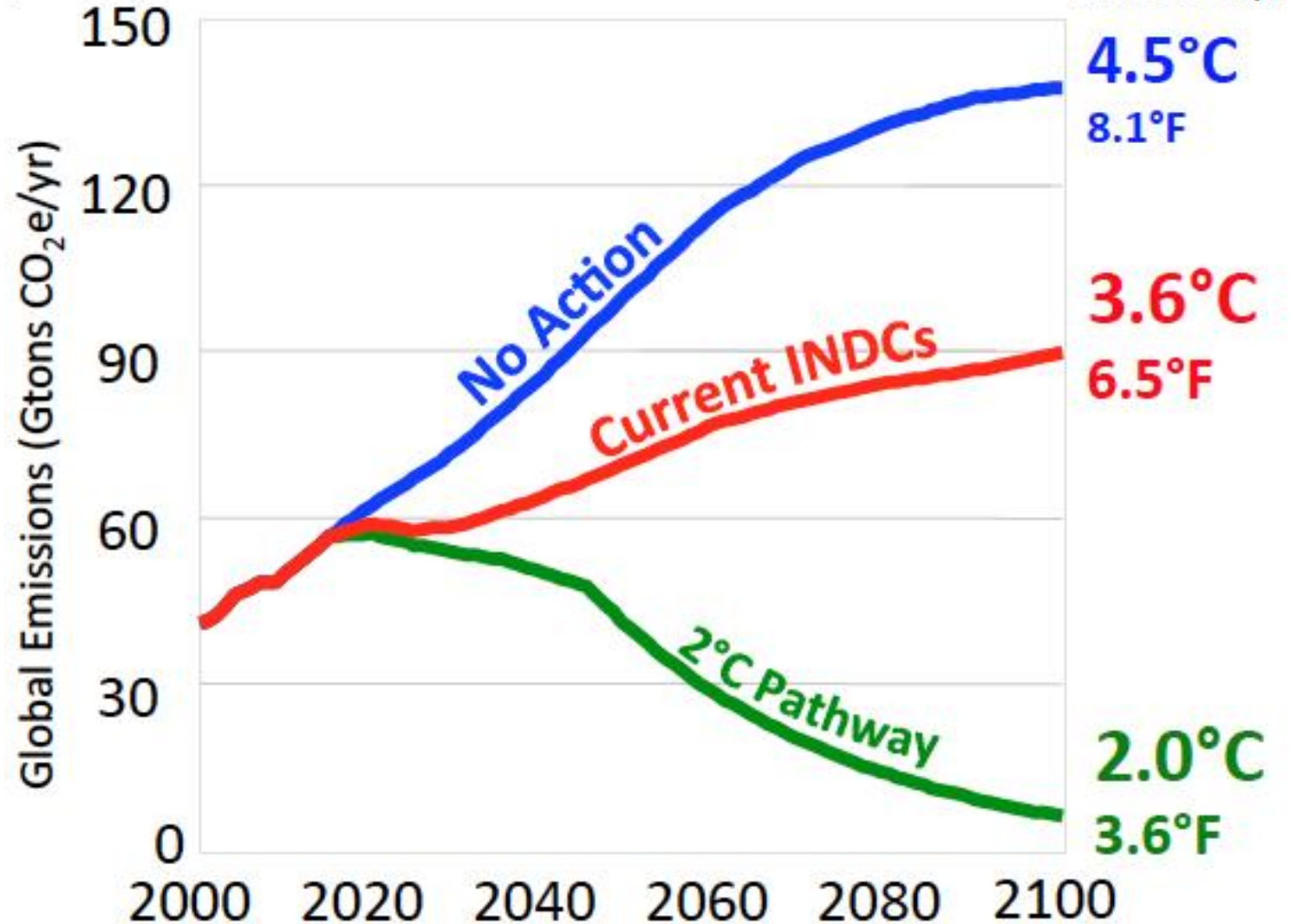
————— Efeitos directos ou retroacção  
- - - - - Efeitos indirectos

# Trajectórias das emissões de CO<sub>2</sub>e

(2005 = 380 ppmv)



Projeção das emissões globais com base nas “Contribuições nacionais voluntárias de redução das emissões” (INDC) feitas para o Acordo de Paris



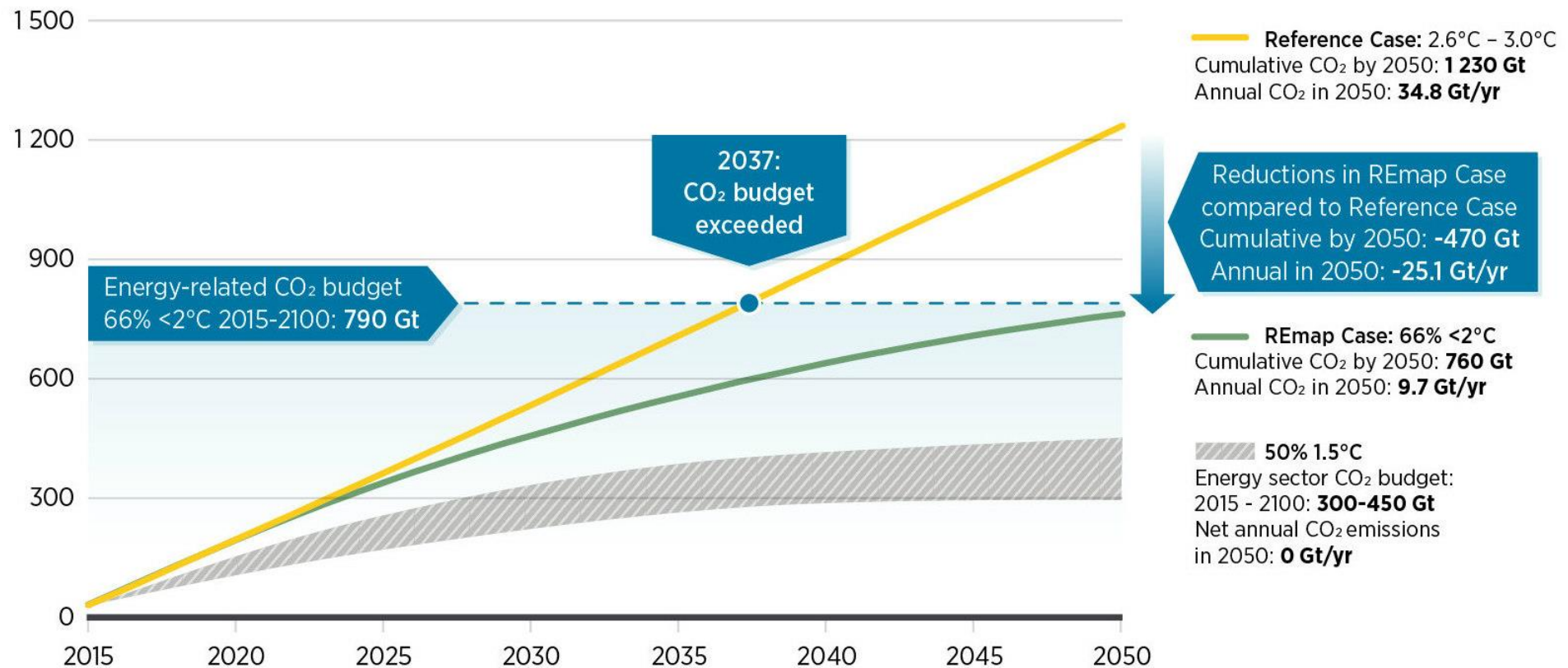
Impact of national climate pledges (aka INDCs) on world's greenhouse gas emissions measured in CO2 equivalents (CO2e).

# In under 20 years, the global energy-related CO<sub>2</sub> emissions budget to keep warming below 2°C would be exhausted. Source:

IRENA, 2018, Global Energy Transformation: A roadmap to 2050, International Renewable Energy Agency, Abu Dhabi

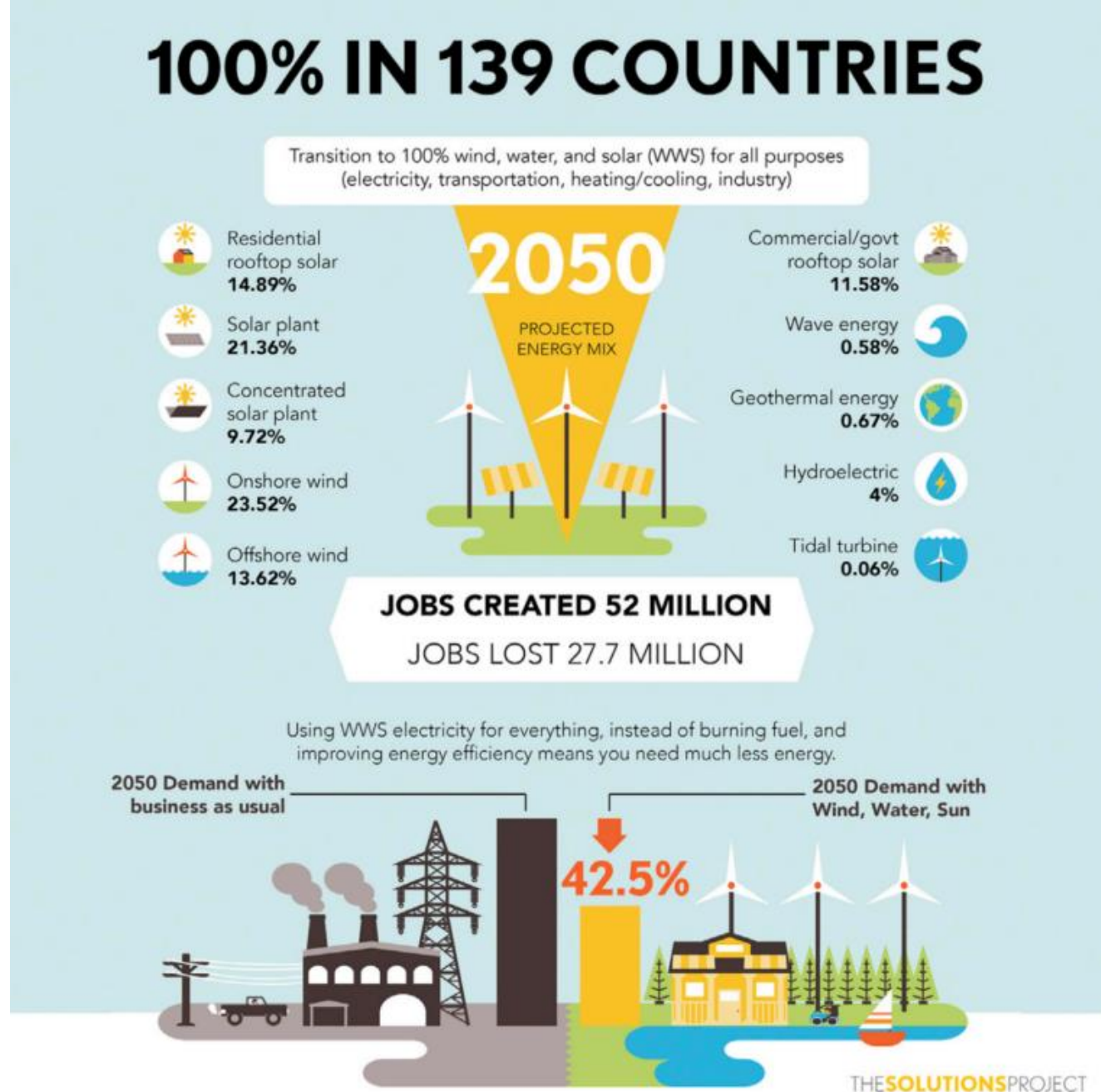
**Annual CO<sub>2</sub> emissions from fossil fuel uses and industry in 2014: 35,7 GtCO<sub>2</sub>**  
**Emissions and the emissions gap, 2015-2050**

Cumulative energy-related carbon emissions (Gt CO<sub>2</sub>)



**IPCC AR5 established in 2014 that the CO<sub>2</sub> emissions budget is 870 a 1240 GtCO<sub>2</sub>**

É possível  
descarbonizar a  
economia  
mundial  
até 2050 com  
aumento do  
número de  
empregos no  
setor da energia  
e diminuição da  
procura de  
energia



Fonte: Jacobson, 2018

# Low-cost solution to the grid reliability problem with 100% penetration of intermittent wind, water, and solar for all purposes

Mark Z. Jacobson<sup>a,1</sup>, Mark A. Delucchi<sup>b</sup>, Mary A. Cameron<sup>a</sup>, and Bethany A. Frew<sup>a</sup>

<sup>a</sup>Department of Civil and Environmental Engineering, Stanford University, Stanford, CA 94305; and <sup>b</sup>Institute of Transportation Studies, University of California, Berkeley, CA 94720

Edited by Stephen Polasky, University of Minnesota, St. Paul, MN, and approved November 2, 2015 (received for review May 26, 2015)

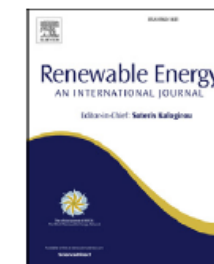


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## Renewable Energy

journal homepage: [www.elsevier.com/locate/renene](http://www.elsevier.com/locate/renene)

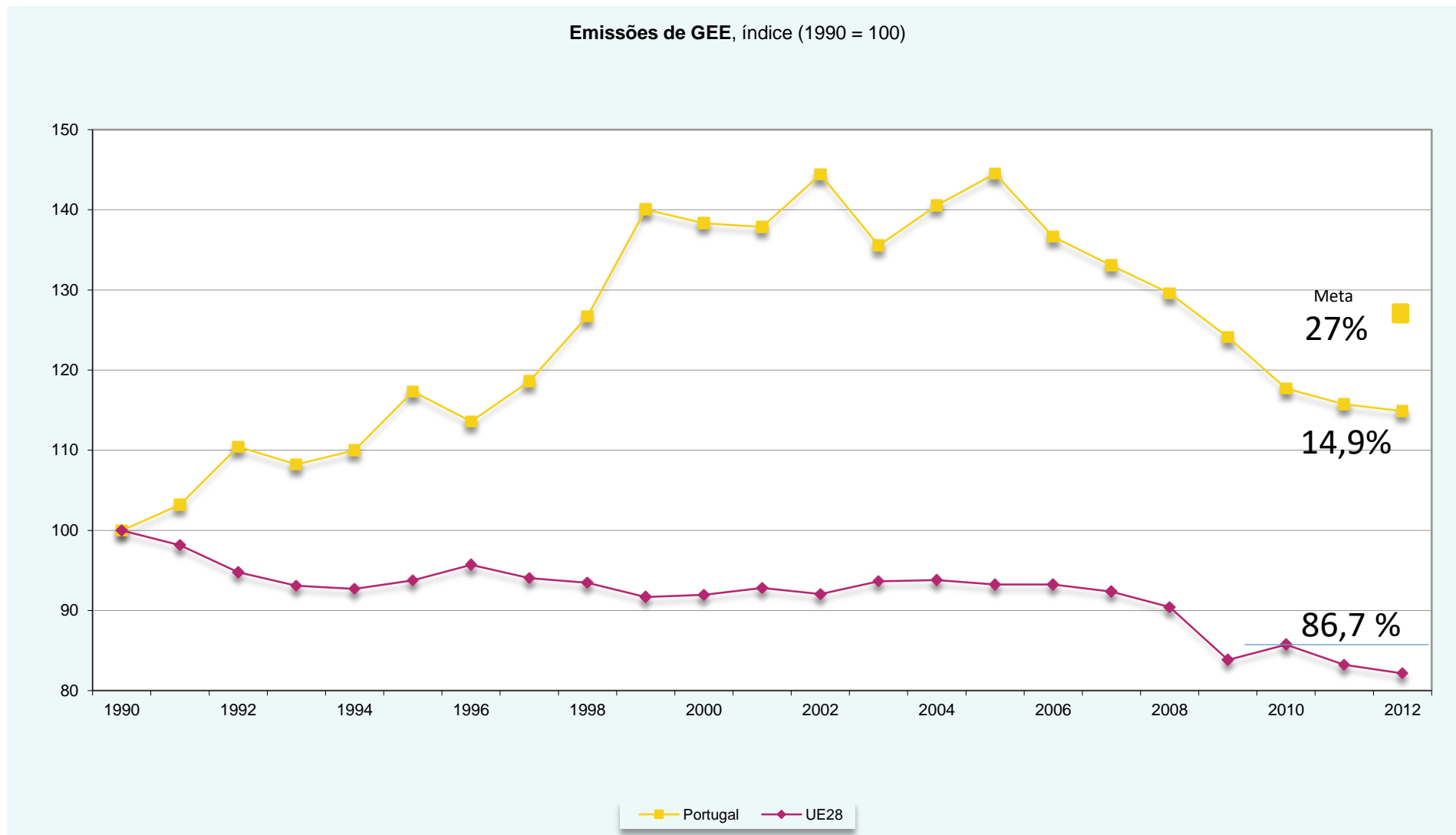


Matching demand with supply at low cost in 139 countries among 20 world regions with 100% intermittent wind, water, and sunlight (WWS) for all purposes



Mark Z. Jacobson <sup>a,\*</sup>, Mark A. Delucchi <sup>b</sup>, Mary A. Cameron <sup>a</sup>, Brian V. Mathiesen <sup>c</sup>





1990, Portugal: 62,1 MtCO<sub>2</sub>e  
 1990, UE28: 5735,1 MtCO<sub>2</sub>e

PT - 1,08% da EU e 0,16% das emissões globais

Fonte: Eurostat



## Evolução das emissões de gases com efeito de estufa em Portugal 1990 - 2016

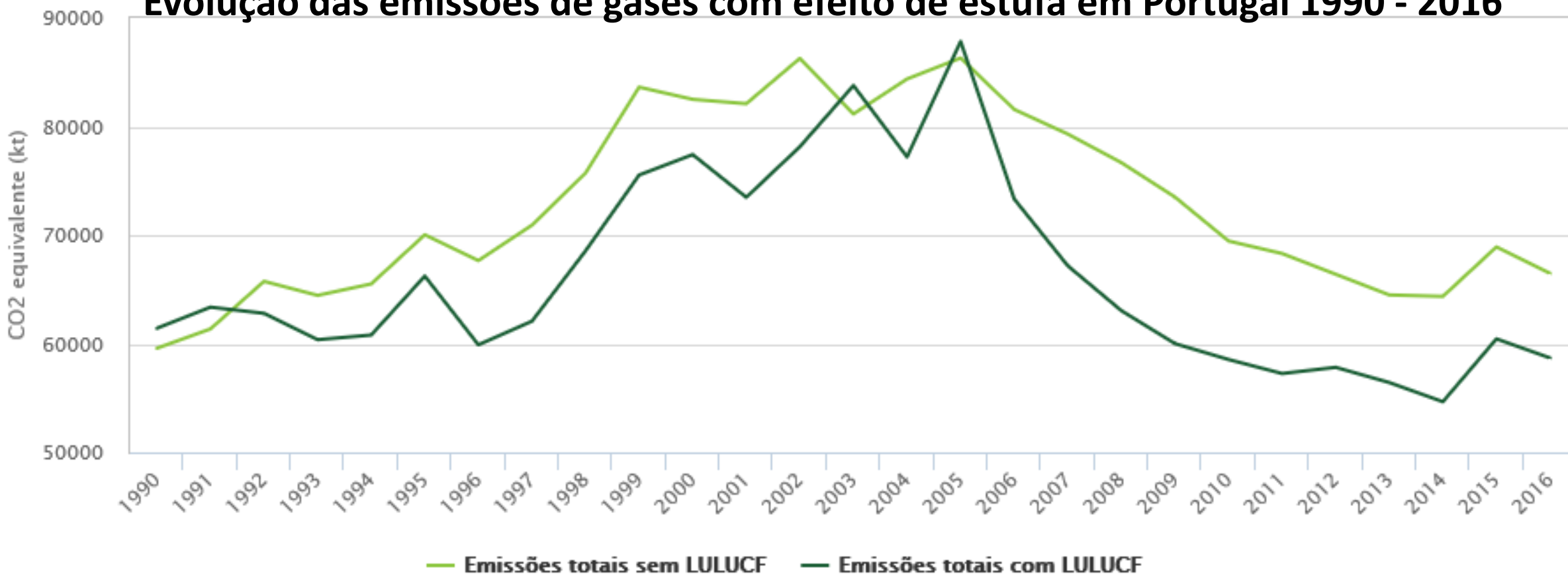


GRÁFICO INTERATIVO

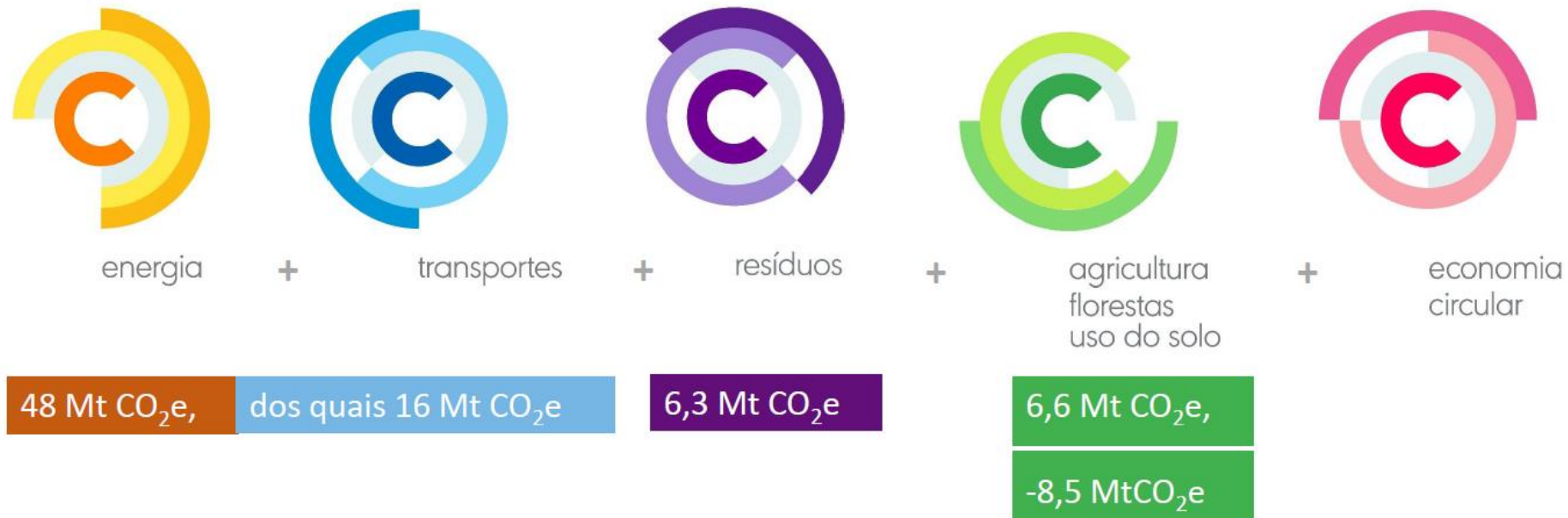
As emissões de GEE subiram 7,1% de 2014 para 2015. A razão desta subida resulta de 2015 ter sido um ano seco e da quebra da hidroeletricidade ter sido compensada com o uso de carvão. As emissões de CO<sub>2</sub> do setor da energia em 2015 subiram 8,6% relativamente a 2014, tendo sido esta a segunda maior subida da UE. No ano corrente de 2017 a quebra na hidroeletricidade será cerca de 60% relativamente à média devido à seca prolongada. Acresce que os dramáticos e extensos fogos florestais deste ano provocaram emissões elevadas de CO<sub>2</sub> e de outros gases com efeito de estufa da ordem de 8 megatoneladas de CO<sub>2</sub> equivalente até ao final de outubro de 2017.

# Neutralidade carbónica de Portugal em 2050

## Objetivo estabelecido em 2016 pelo governo



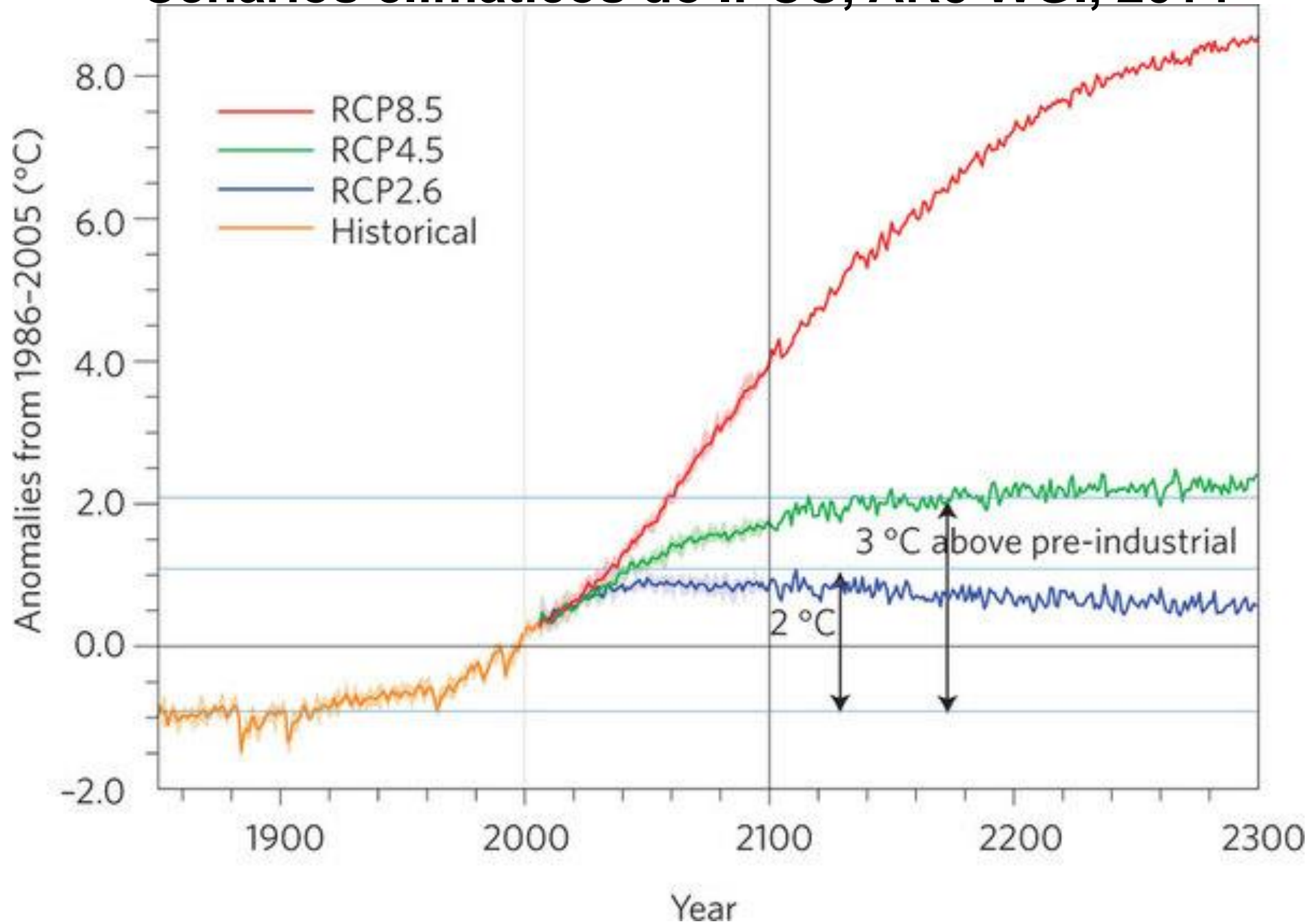
## NEUTRALIDADE CARBÓNICA



**2015**, APA (2017)

**Passar de cerca de 70 MtCO<sub>2</sub> para cerca de 10MtCO<sub>2</sub> em 2050**

# Cenários climáticos do IPCC, AR5 WGI, 2014

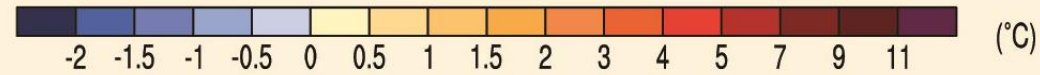
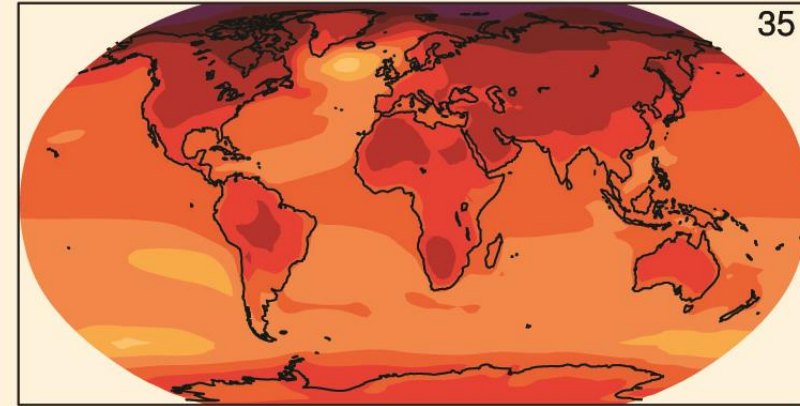
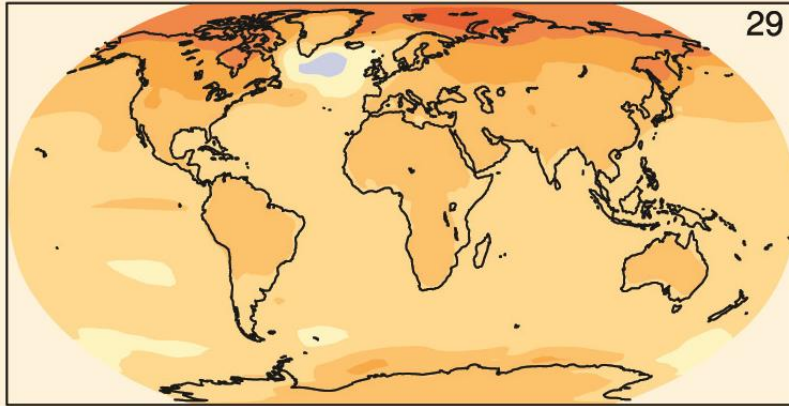


## RCP 2.6

## RCP 8.5

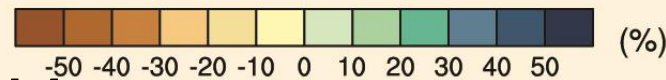
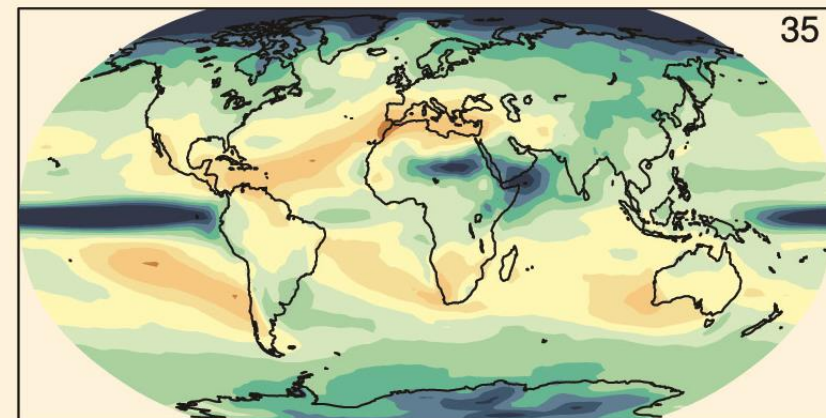
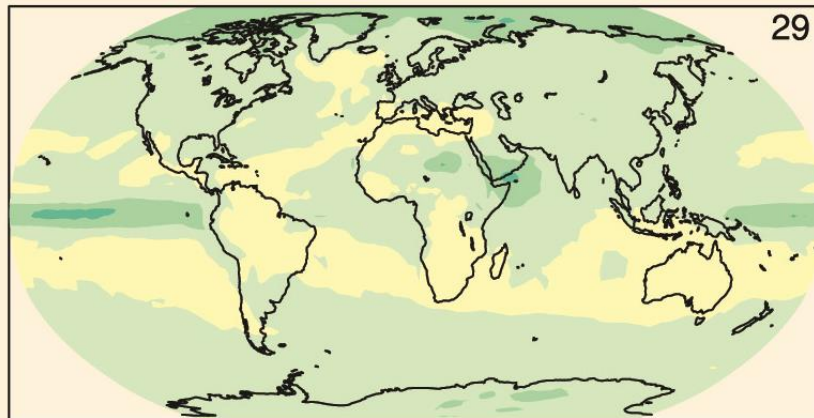
Change in average surface air temperature (1986 - 2005 to 2081 - 2100)

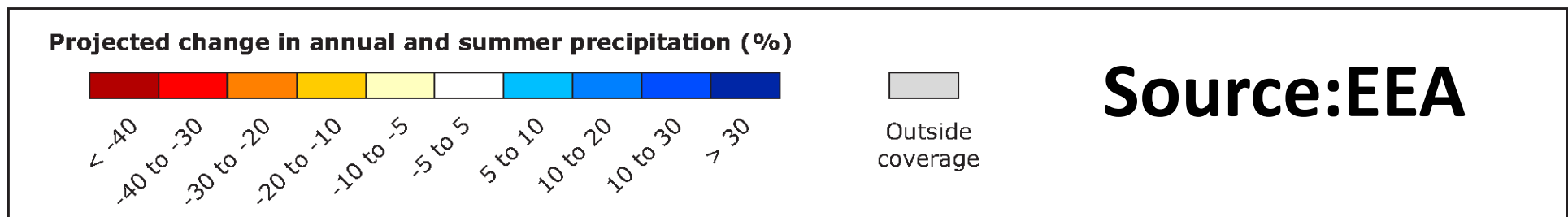
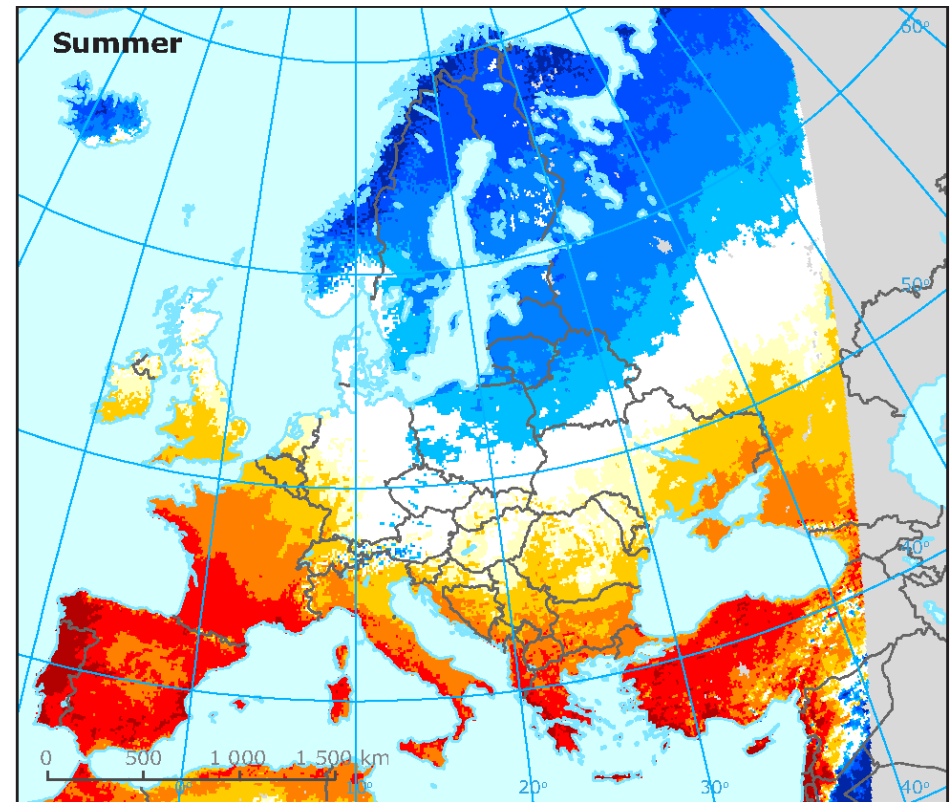
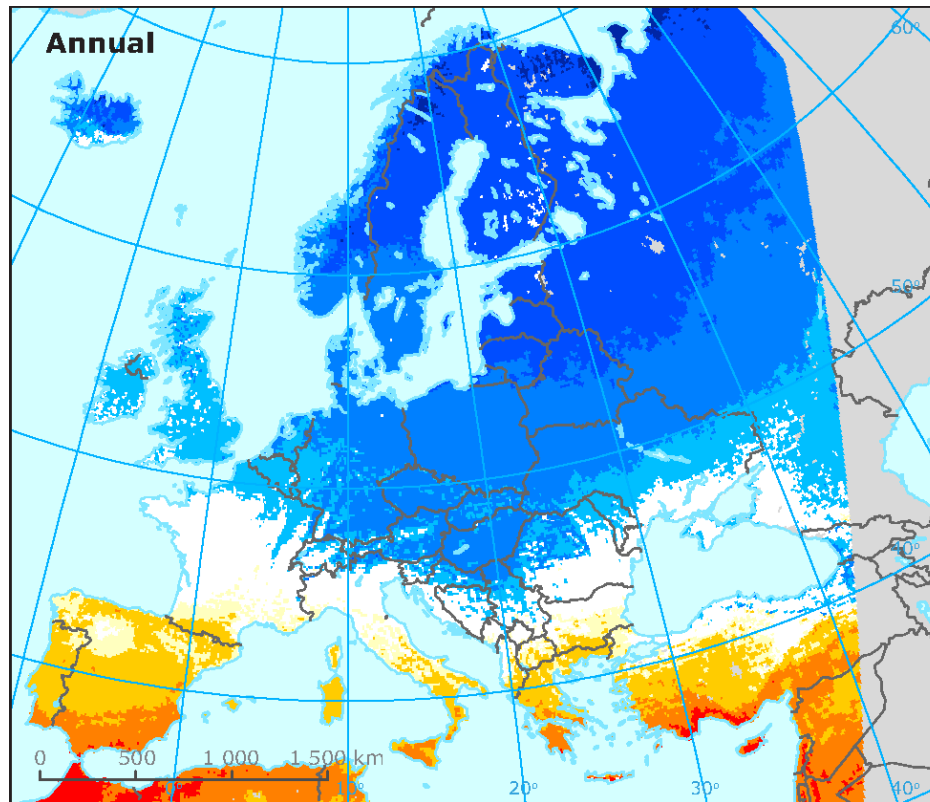
a)



b)

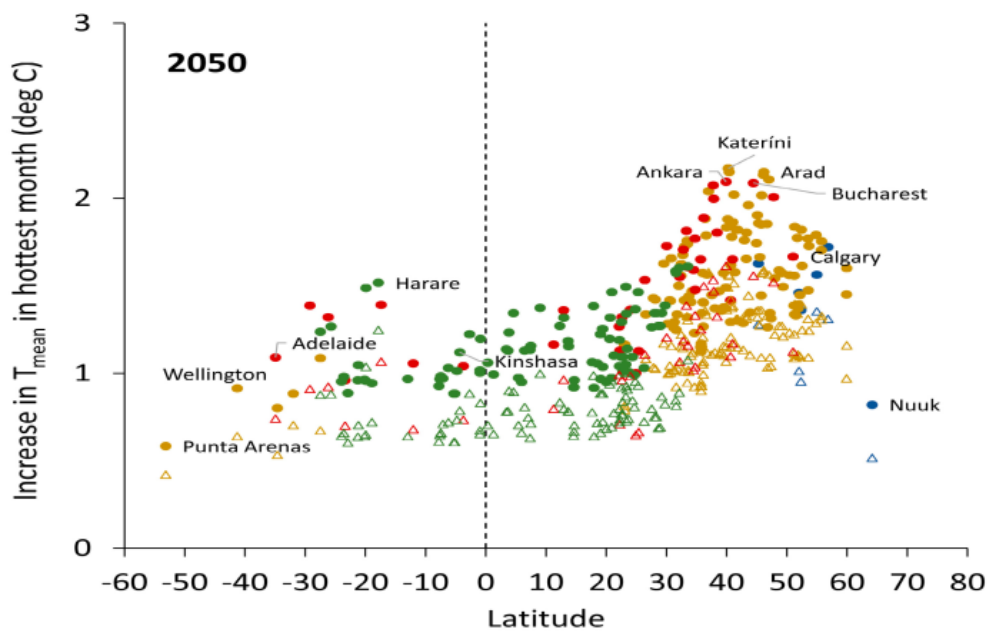
Change in average precipitation (1986 - 2005 to 2081 - 2100)



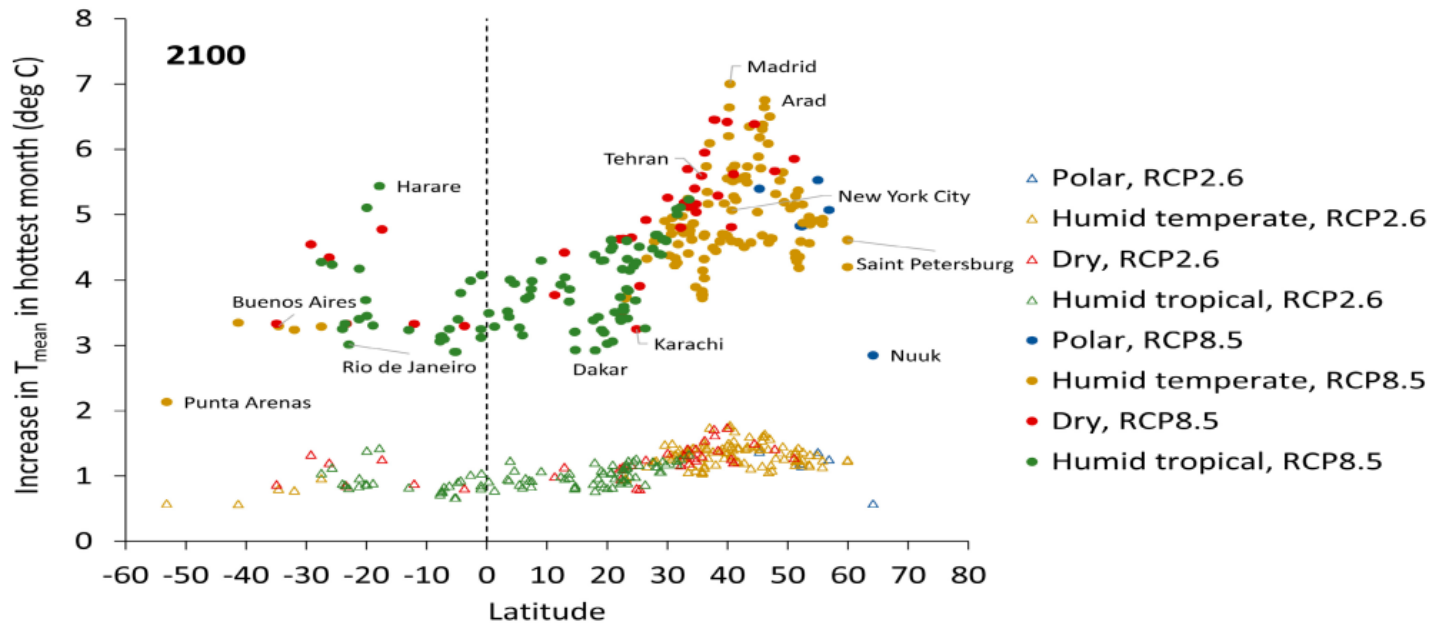


Projected changes in annual (left) and summer (right) precipitation (%) in the period 2071-2100 compared to the baseline period 1971-2000 for the forcing scenario RCP 8.5. Model simulations are based on the multi-model ensemble average of RCM simulations from the EURO-CORDEX initiative.

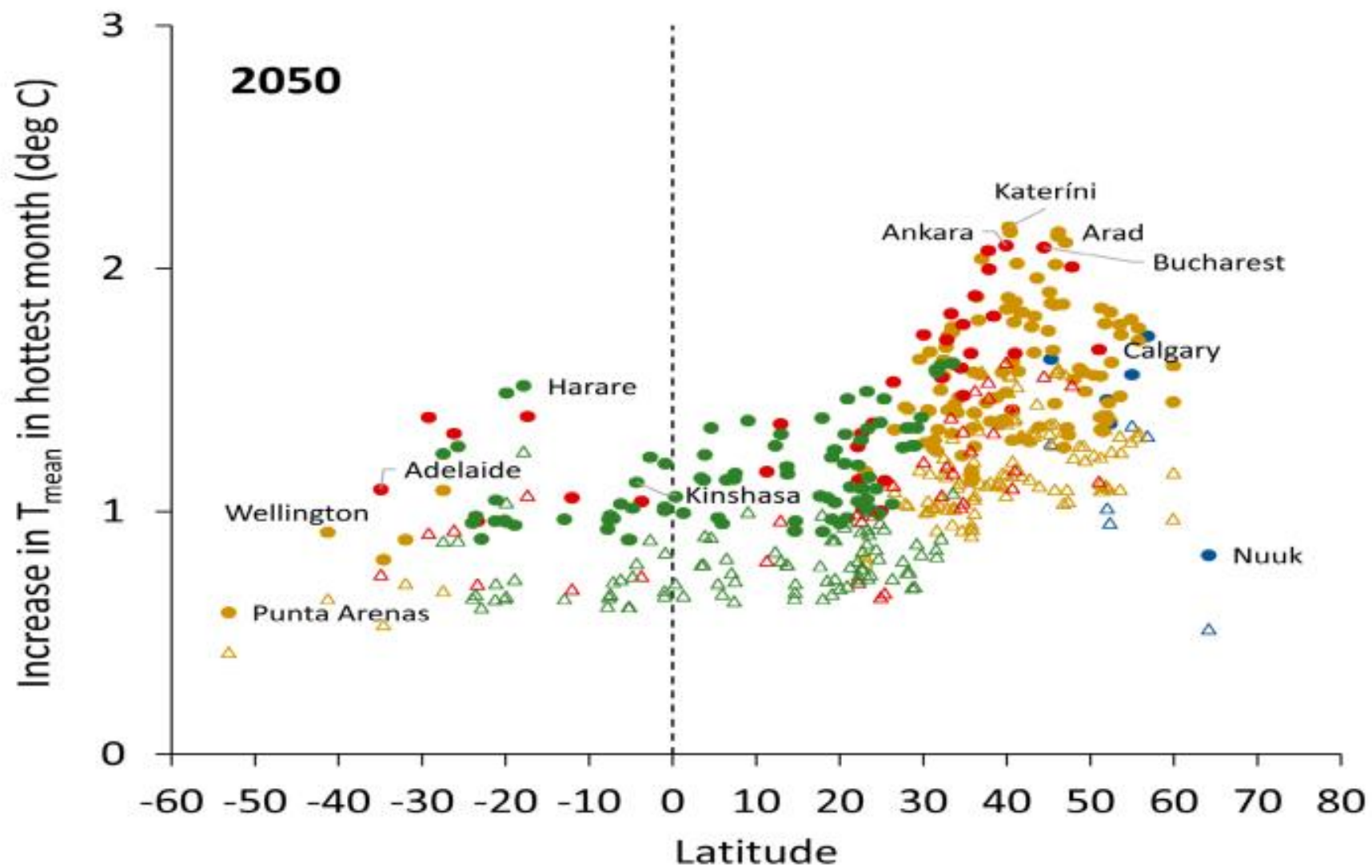
**Aumento da temperature média no  
mês mais quente em 2050 e em 2100  
nas cidades da base de dados SHUE  
nos cénarios climáticos RCP2.6 e RCP8.5  
(Milner et al Climate 2018)**



(a)

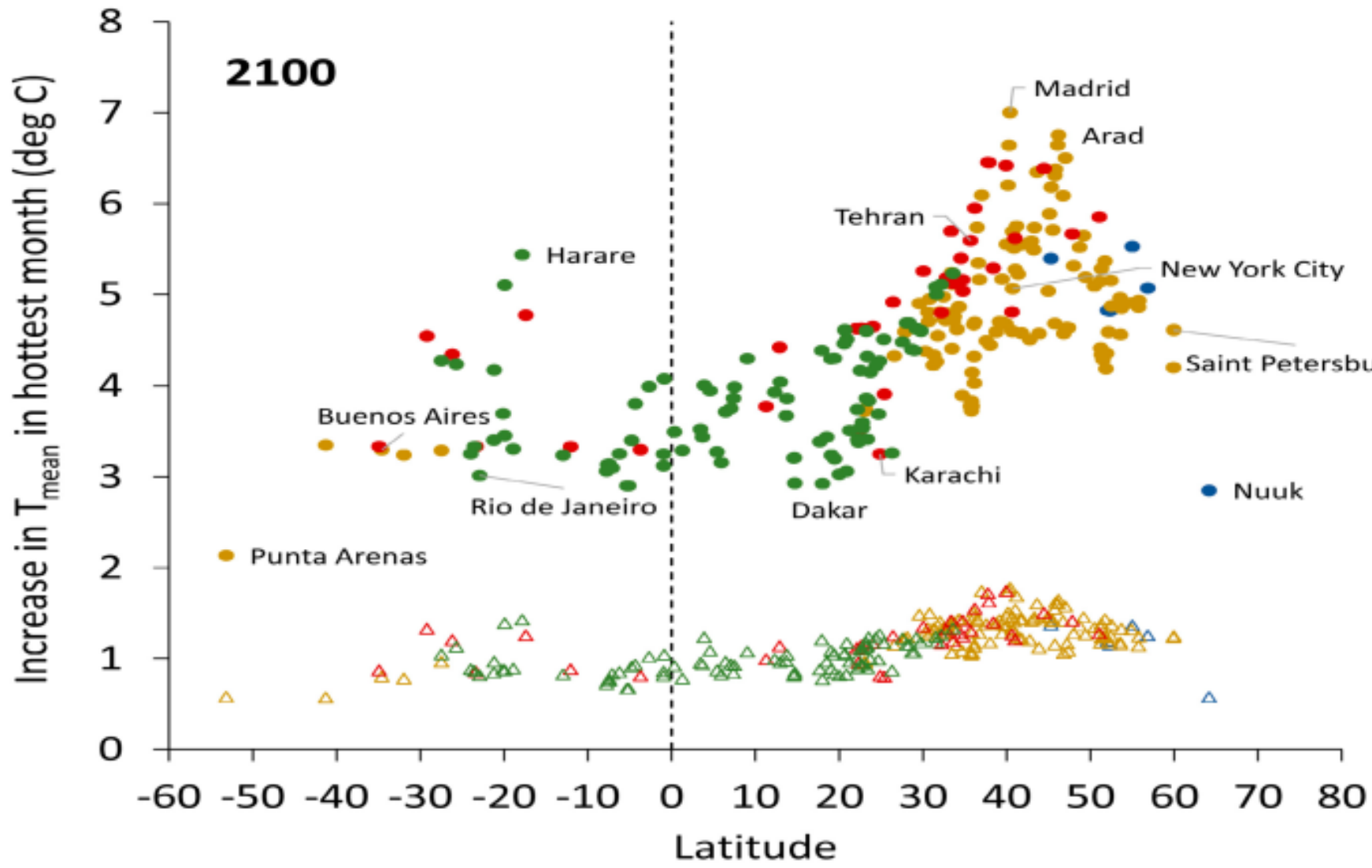


(b)



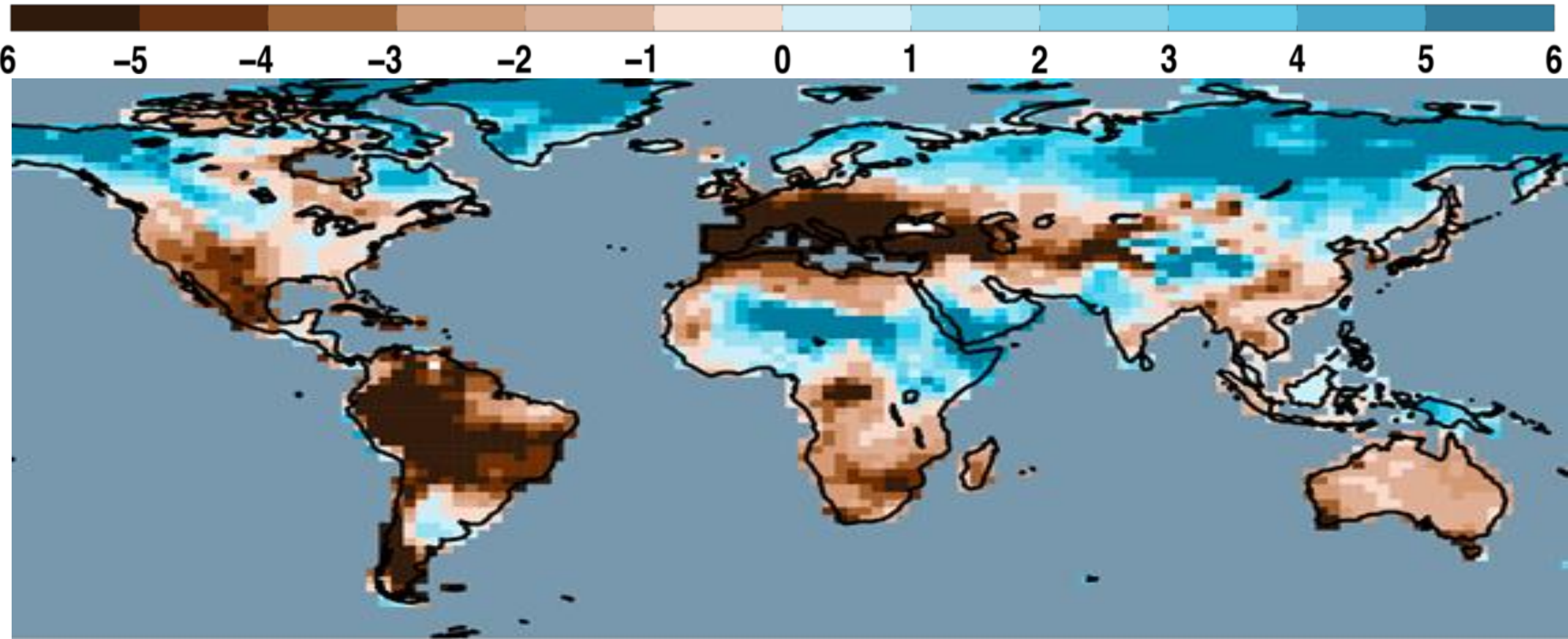
(a)





- △ Polar, RCP2.6
- △ Humid temperate, RCP2.6
- △ Dry, RCP2.6
- △ Humid tropical, RCP2.6
- Polar, RCP8.5
- Humid temperate, RCP8.5
- Dry, RCP8.5
- Humid tropical, RCP8.5

(b)



*extreme drought*

Palmer Drought Severity Index

*extreme moisture*

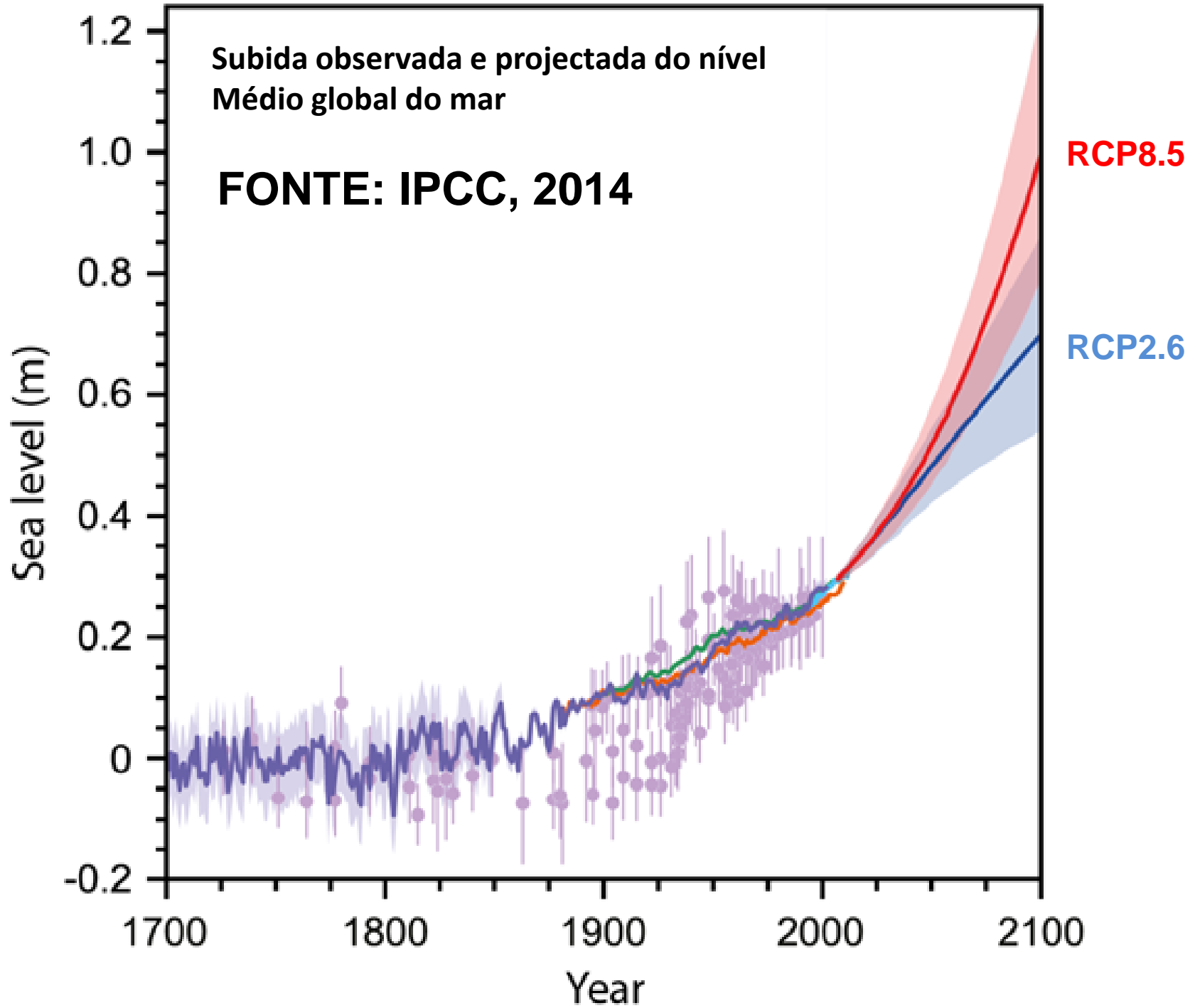
-4

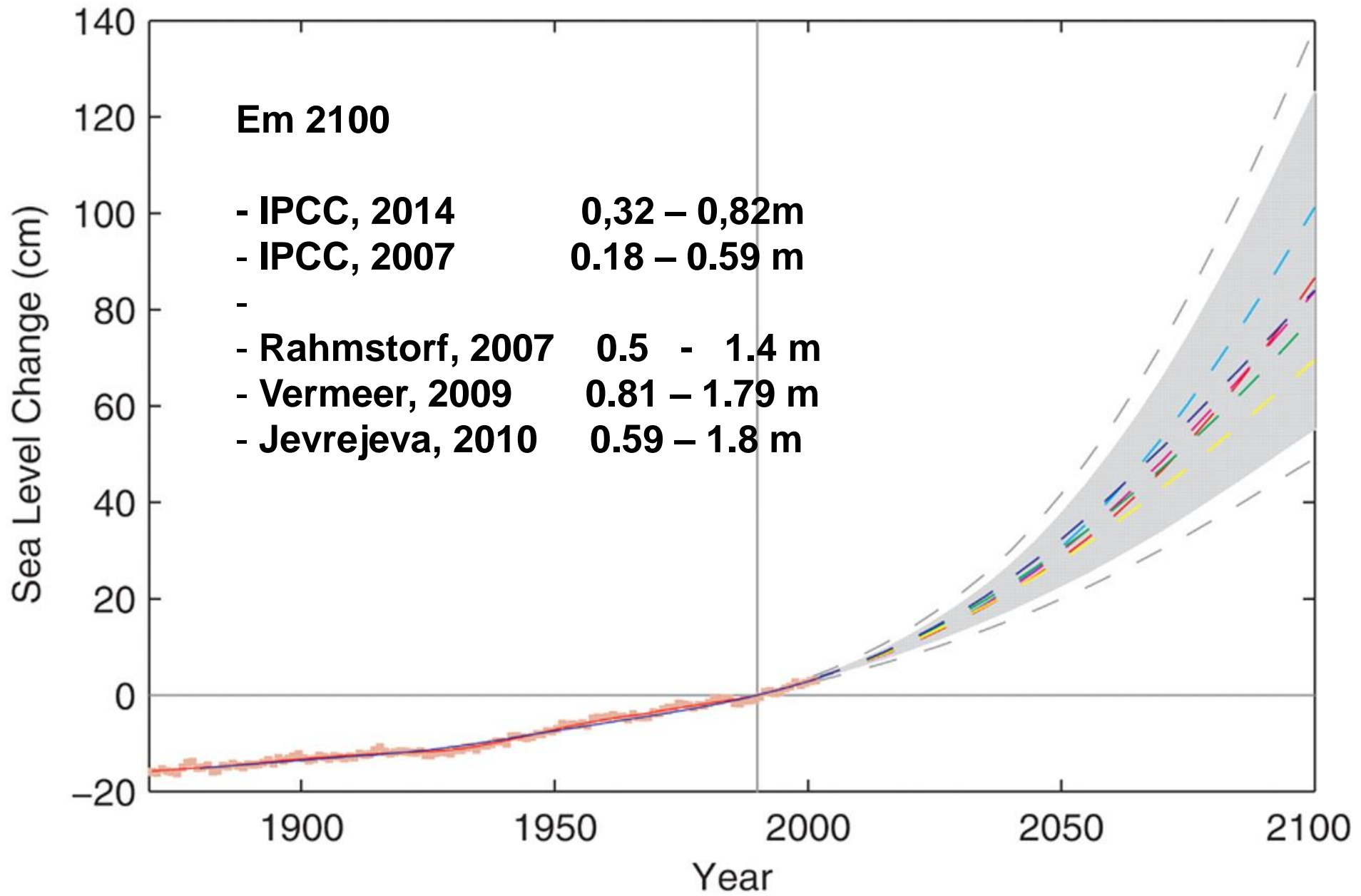
0

4

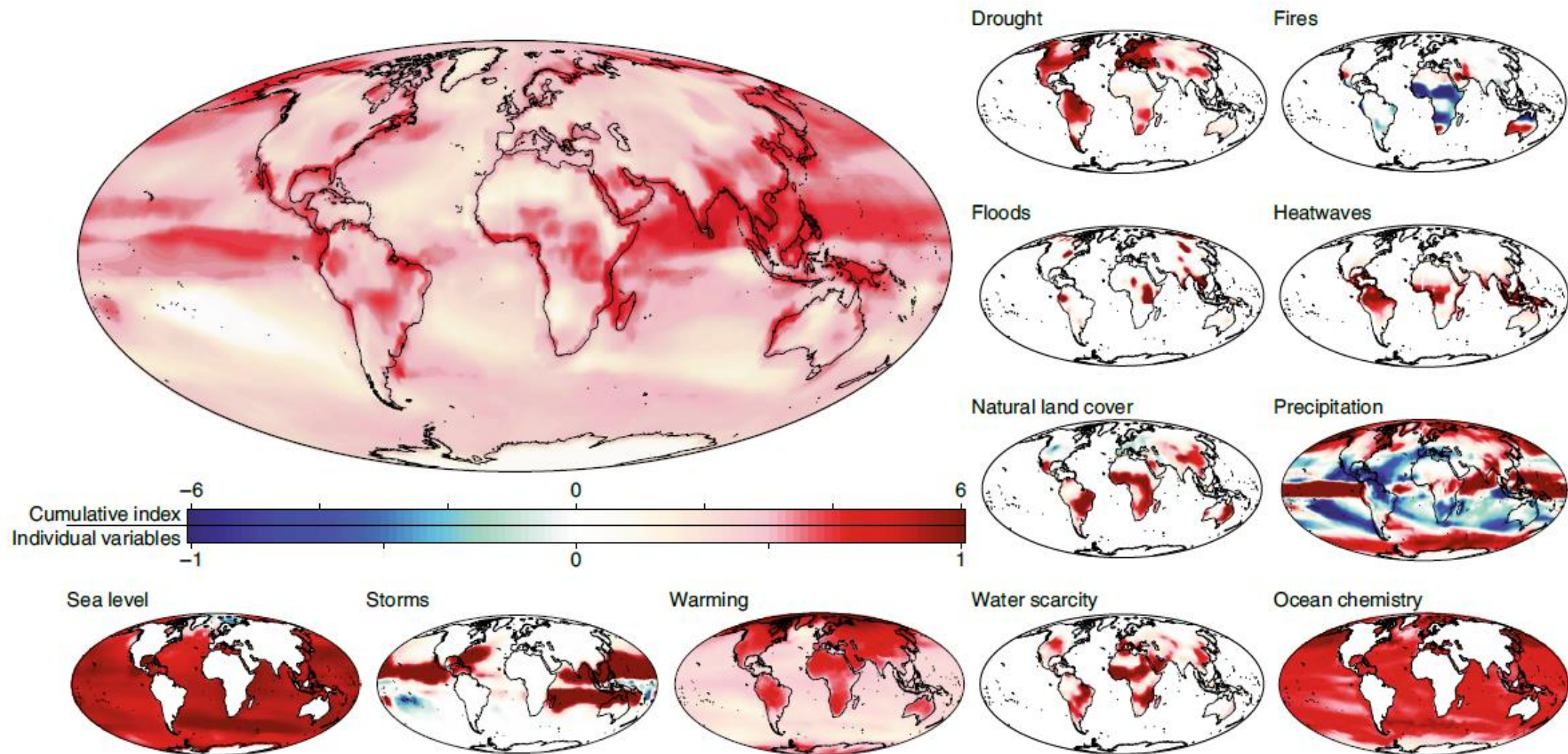
***Projected Drought: 2100- 4°C***

***NOAA-Princeton Model. Cook et al, 2014***



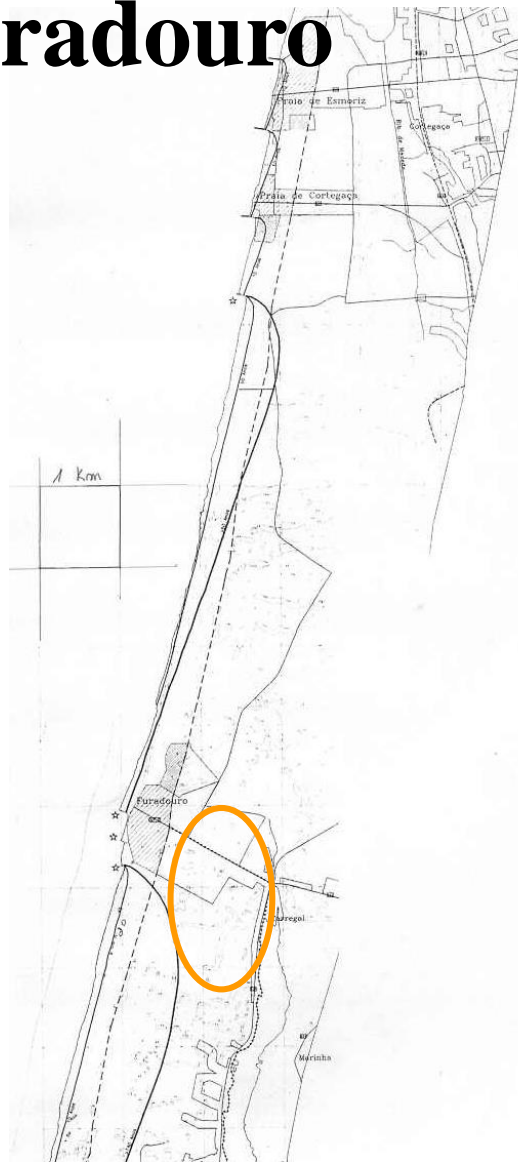


**Rahmstorf, 2007**

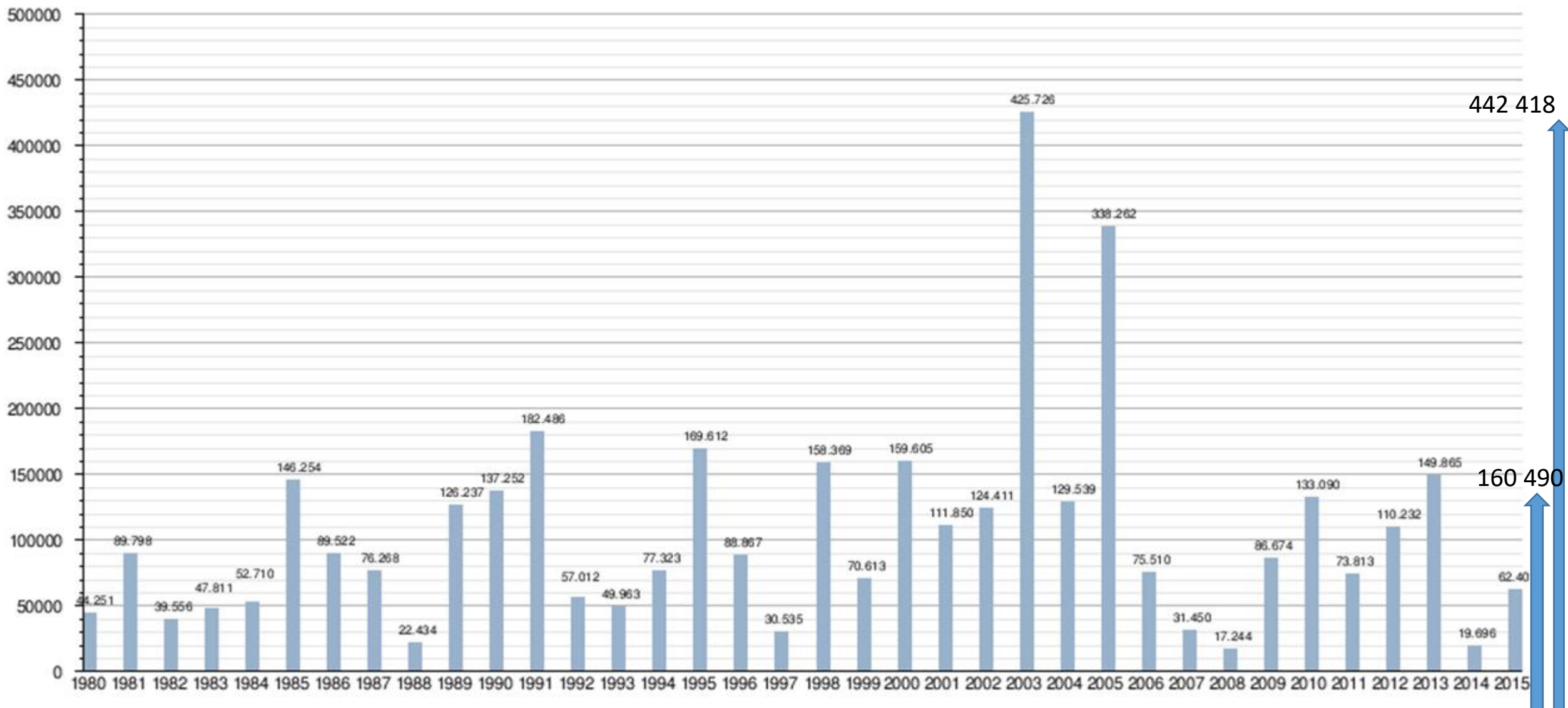


**Fig. 2 | Global map of cumulative climate hazards.** The main map shows the cumulative index of climate hazards, which is the summation of the rescaled change in all hazards between 1955 and 2095. Smaller maps indicate the difference for each individual hazard for the same time period. Individual hazards were rescaled to be normalized between  $-1$  and  $1$ . Negative values indicate a decrease in the given hazard, whereas positive values represent an increase relative to the 1950s baseline values. The largest value in the cumulative index was six (that is, cumulatively, the equivalent to the largest change in six climate hazards occurred for any one cell). Plots are based on RCP 8.5, results for all three mitigation scenarios are provided in Supplementary Figs. 1-3. An interactive data visualization is available at <https://maps.esri.com/MoraLab/CumulativeChange/index.html> and time-series animations at [http://impactsOfclimatechange.info/HumanImpacts/HeatWaves\\_rcp26.html](http://impactsOfclimatechange.info/HumanImpacts/HeatWaves_rcp26.html).

# Furadouro

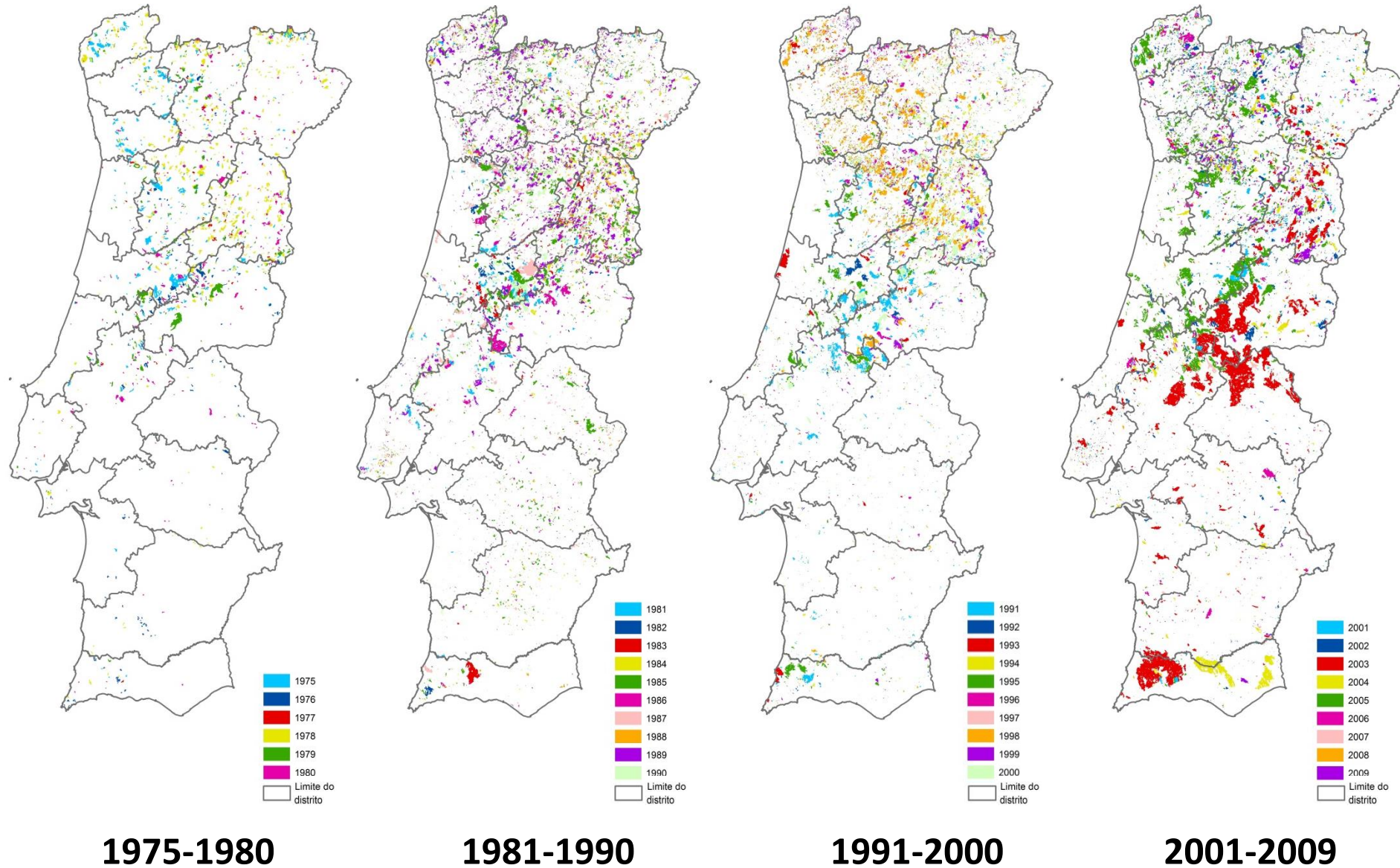


Quais os fundos que vão suportar a defesa de todas as povoações costeiras em Portugal construídas em costas arenosas baixas contra a erosão e a subida do nível médio global do mar?



Os dados foram recolhidos dos RELATÓRIOS ANUAIS DE ÁREAS ARDIDAS E OCORRÊNCIAS relativos a cada ano e editados pela Autoridade Florestal Nacional - <http://www.afn.min-agricultura.pt>

# Perímetros das áreas queimadas em Portugal Continental (satélite Landsat)



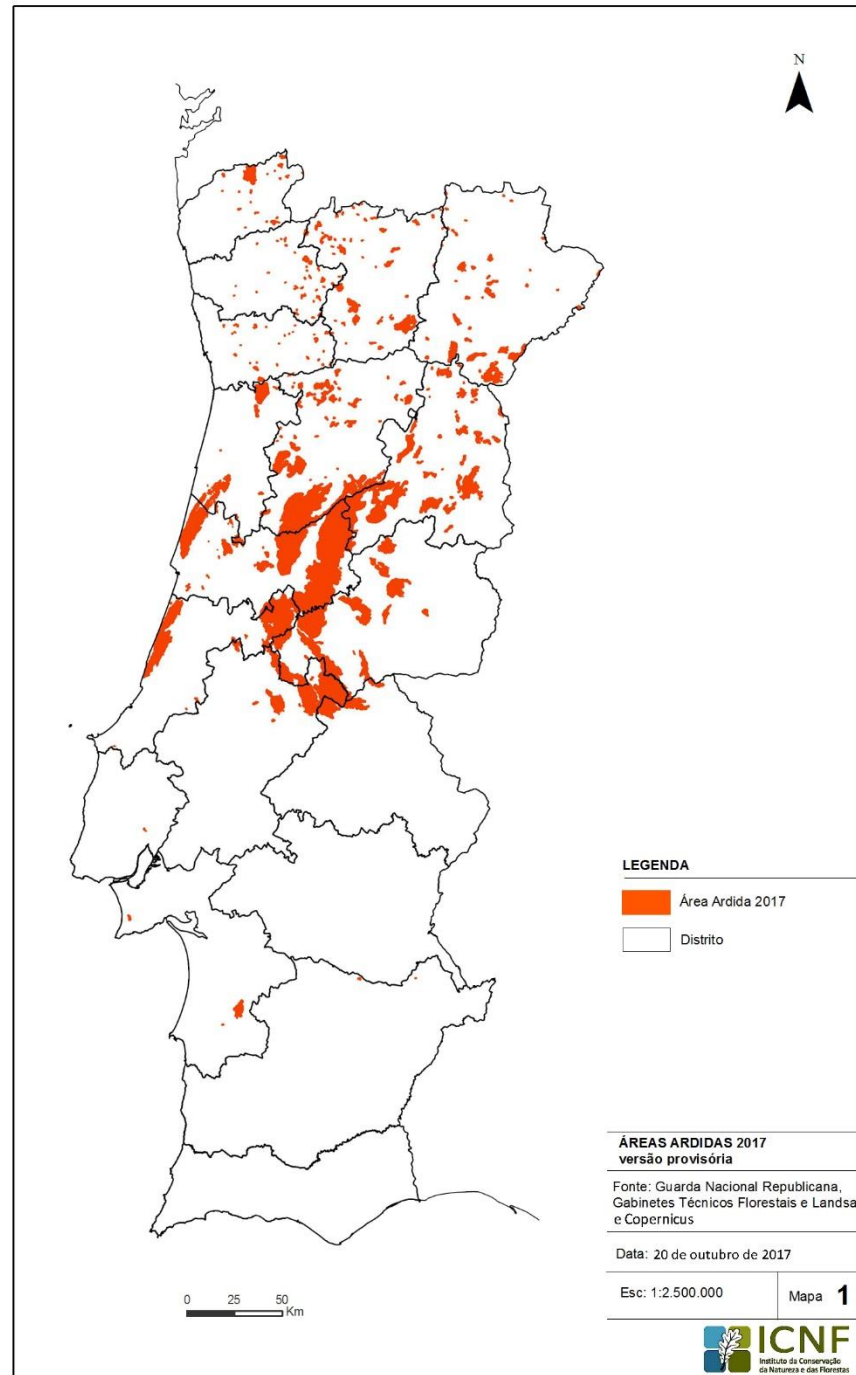
Fonte: João Silva et al., 2015



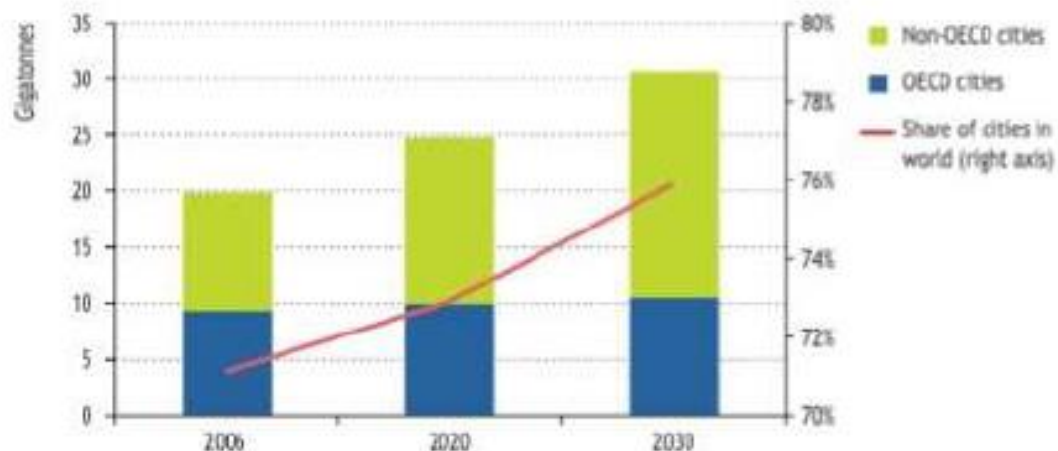
## Área ardida em 2017

A floresta está a tornar-se insustentável em várias regiões do país, especialmente a monocultura de pinheiros e eucaliptos

Fonte: ICNF



## Cities' Contribution To Global GHG Emissions



> 70%

of global energy-related  
CO<sub>2</sub> emissions are  
attributable to cities

[www.ghgprotocol.org/city-accounting](http://www.ghgprotocol.org/city-accounting)

Source: World Energy Outlook

### De acordo com o IPCC:

- As áreas urbanas são responsáveis por cerca de 71 a 76% das emissões relacionadas com energia
- As cidades produzem quase metade (37% a 49%) das emissões de GEE mundiais

<http://www.un.org/climatechange/summit/wp-content/uploads/sites/2/2014/07/CITIES-Cities-Climate-Finance-Leadership-Alliance.pdf>

## “Grey”

- Soluções tecnológicas e de **engenharia e construção** que tornam as **infra-estruturas** mais capazes de lidar com eventos extremos
- Ex: Reforço de segurança de Edifícios ou de defesas costeiras, recolocação de areia e muros

## “Green”

- Melhorar a resiliência de **ecossistemas**
- limitar a perda de **biodiversidade**,
- Limitar a degradação dos ecossistemas e
- restaurar o ciclo da **água**
- Ex: diversificação de culturas, reforço de defesas naturais como dunas e zonas húmidas, corredores verdes, reflorestação

## “Soft”

- Desenho e aplicação de **políticas e procedimentos**
- **Divulgação** de informação **científica**
- **Sensibilização**
- Incentivos **económicos e seguros**
- Construção de **capacidade adaptativa**
- Ex: legislação e normas, gestão da água, sistemas de alerta, monitorização de eventos extremos, gestão e planeamento territorial

# Medidas de adaptação

## Building on strong public-private partnerships

### 1 RAISE AWARENESS OF SOCIO-ECONOMIC BENEFITS OF PREVENTION AND RISK TRANSFER MEASURES

- Document and share good practices demonstrating socio-economic benefits of prevention and risk transfer measures and their interlinkages



1

### 2 EXPAND RISK MODELLING CAPACITIES

- Sharing risk knowledge and expertise with the public sector
- Contribute to the development of next generation of forward-looking models in partnership with scientific community



2

Recommendations

### 4 RESILIENCE OF MEGA-CITIES AND URBAN AREAS

- Explore and realise the role of insurance in enhancing resilience of mega-cities and urban systems



4

### 3 RESILIENCE OF CRITICAL INFRASTRUCTURE

- Explore and realise the role of the insurance industry in investing and building critical infrastructure



3

Obrigado pela vossa atenção

Coordenado por:



Elaborado por:



Comunicado por:



Cofinanciado por:



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Fundo de Coesão