A Realidade Climática Atual:
Mais Extremos, Menos Tempo para Agir

Pedro Matos Soares | pmsoares@fc.ul.pt

14 abril | 17h30 - 18h30 | CIUL

PONTO DE ENCONTRO
LISBOA E NOVA

The Hard Truth - climate and much more...

Climate crisis

This article is more than 2 months old

'Like a blowtorch': Mediterranean on

Turkey

Climate science

Helen Sullivan
Tondo in Paler
agencies

Wed 26 Jul 2023 16.5

Damian Carrington
Environment editor
@dpcarrington

Jon Henley Europe correspondent
@jonhenley

Zambia

'Crippling' drought in Z
hunger for millions, say

Collins Nzovu says country's plight is foreta
will increasingly afflict region as climate br

Fiona Harvey Environment editor

Tue 28 May 2024 05.00 BST

Share

Children fetch water using a wheelbarrow in Lilanda t
February and there is little prospect of saving the maize
Mukwazhi/AP

Severe drought in Zambia is threatening hunger for millions of people, cutting off electricity for long periods and destroying the country's social fabric and economy, the environment minister has warned, in a harbinger of what is in store for the region as the climate crisis worsens.

Collins Nzovu said the "crippling drought" his country was experiencing hammered home the message that developing countries were facing catastrophe from the climate crisis, even as richer countries failed to muster financial help for the most afflicted.

"What has happened this year is that we received well below the normal

The drought has affected about 50 million people in the Horn of Africa directly and another 100 million in the wider area. About 20 million people

India

Amrit Dhillon in Delhi and Agence France-Presse

Wed 29 May 2024 11.43 BST

Share

Delhi temperature hits 50.5C as India's capital records hottest day

Authorities warn of water shortages as temperatures reach nine degrees higher than expected

Record breaking heat hits Delhi – in pictures

Children run behind a truck spraying water along a street in Delhi. Photograph: Arun Sankar/AFP/Getty Images

Temperatures in Delhi have hit a record high of 50.5C (122.9F), as authorities warned of water shortages in India's capital.

The India Meteorological Department (IMD), which reported "severe heat-wave conditions", recorded the temperature in the suburb of Mungeshpur on Wednesday afternoon, breaking the landmark 50C measurement for the first time in the city.

A taxi driver drinks from a bottle during afternoon heat in Kolkata as a heatwave grips India. Photograph: Debarchan Chatterjee/NurPhoto/Shutterstock

A severe heatwave has swept across much of Asia, causing deaths and school closures in India and record-breaking temperatures in China.

Maximiliano Herrera, a climatologist and weather historian, described the unusually high temperatures as the "worst April heatwave in Asian history".

Brazil

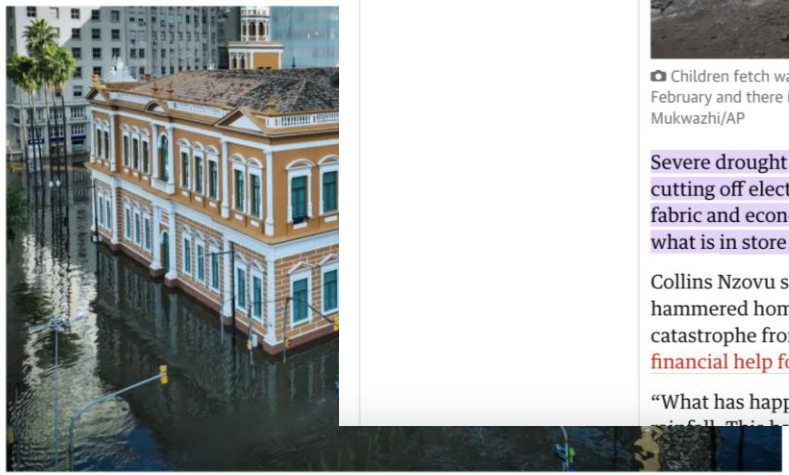
Brazil counts cost
with little hope of

Death toll in southern state of Rio
authorities plan four 'tent cities'

Tiago Rogero in Rio de Janeiro

Sun 19 May 2024 11.30 BST

Share



Members of the municipal guard on a boat guard the flooded streets near Porto Alegre city hall in Rio Grande do Sul on Friday. Photograph: Jefferson Bernardes/Getty Images

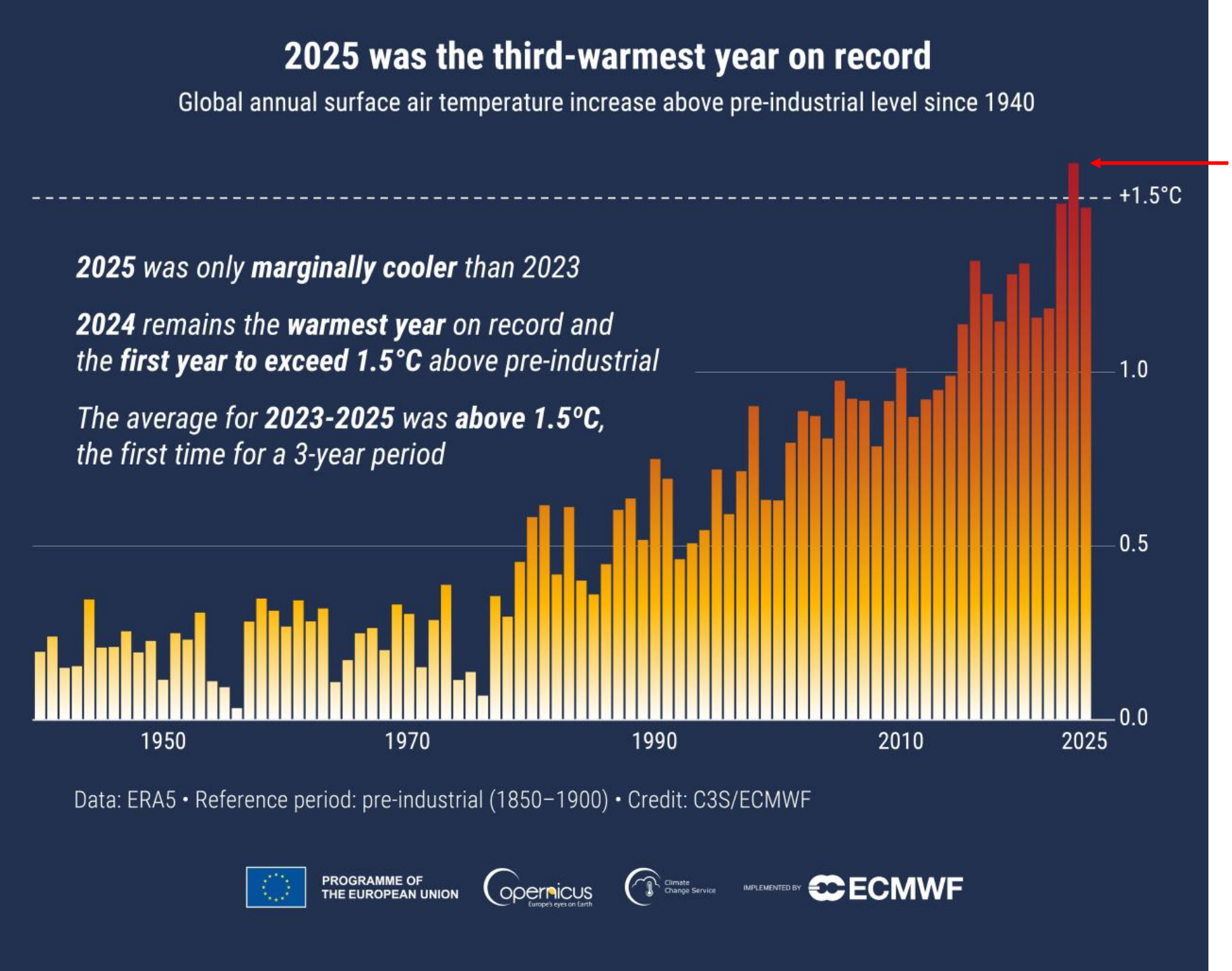
Three weeks after one of Brazil's worst-ever floods hit its southernmost state,

emperatures in the

en broken for a

experts issued a warning that this yea

with them the warmest days ever reco



Yearly scale

2024 was the warmest year since global records began in 1850 by a wide margin.

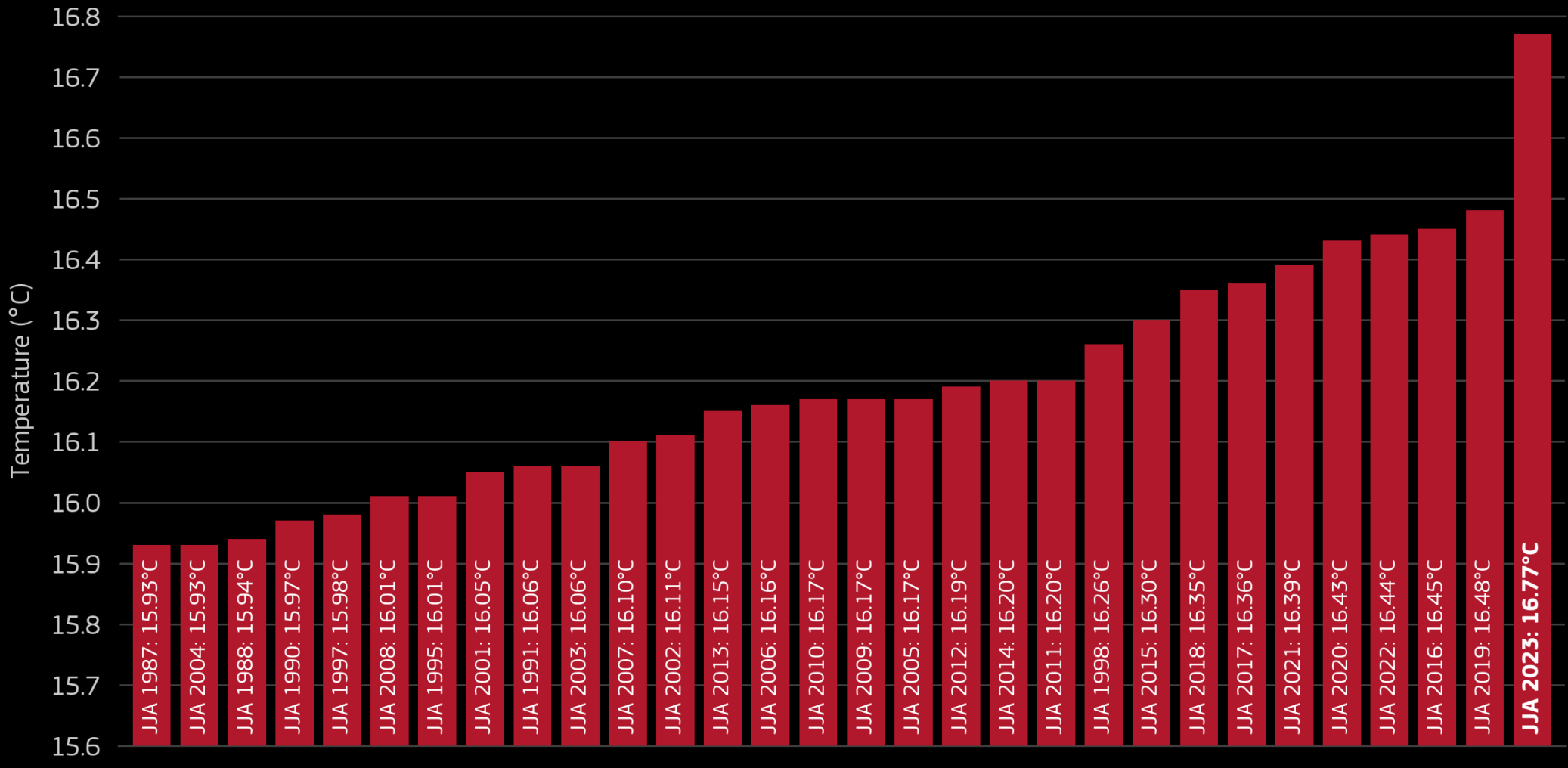
It was +1.60 ºC above the pre-industrial average (1850-1900).

The 12 warmest years in the historical record have all occurred in (2014-2025).

THE 30 WARMEST BOREAL SUMMERS (JJA) GLOBALLY

Data: Global-mean surface air temperatures from ERA5 • Credit: C3S/ECMWF

Climate Change Service
climate.copernicus.eu



PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

IMPLEMENTED BY ECMWF

Seasonal scale

+0.29 °C

the previous record jump...

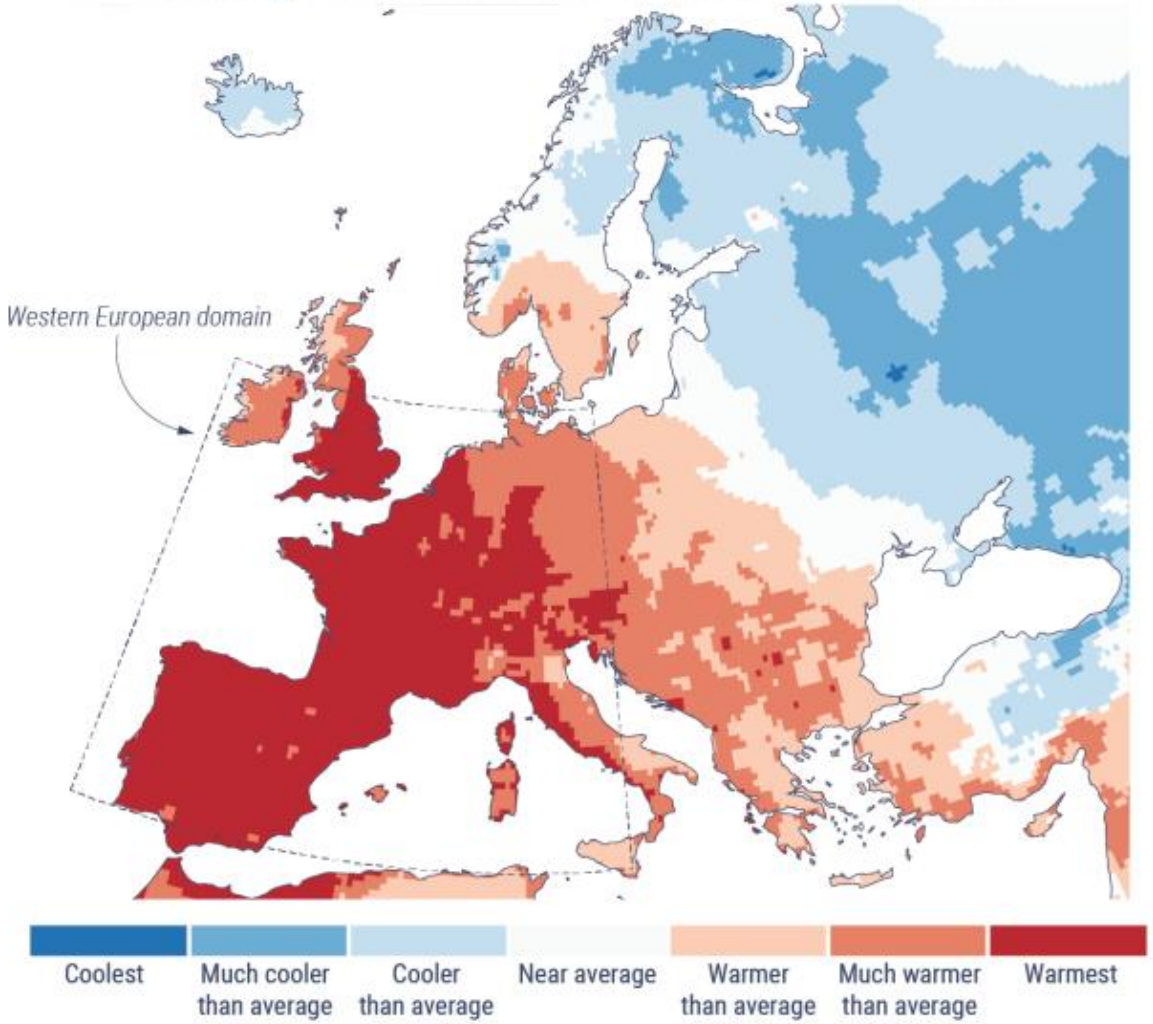
+0.06 °C

~5x

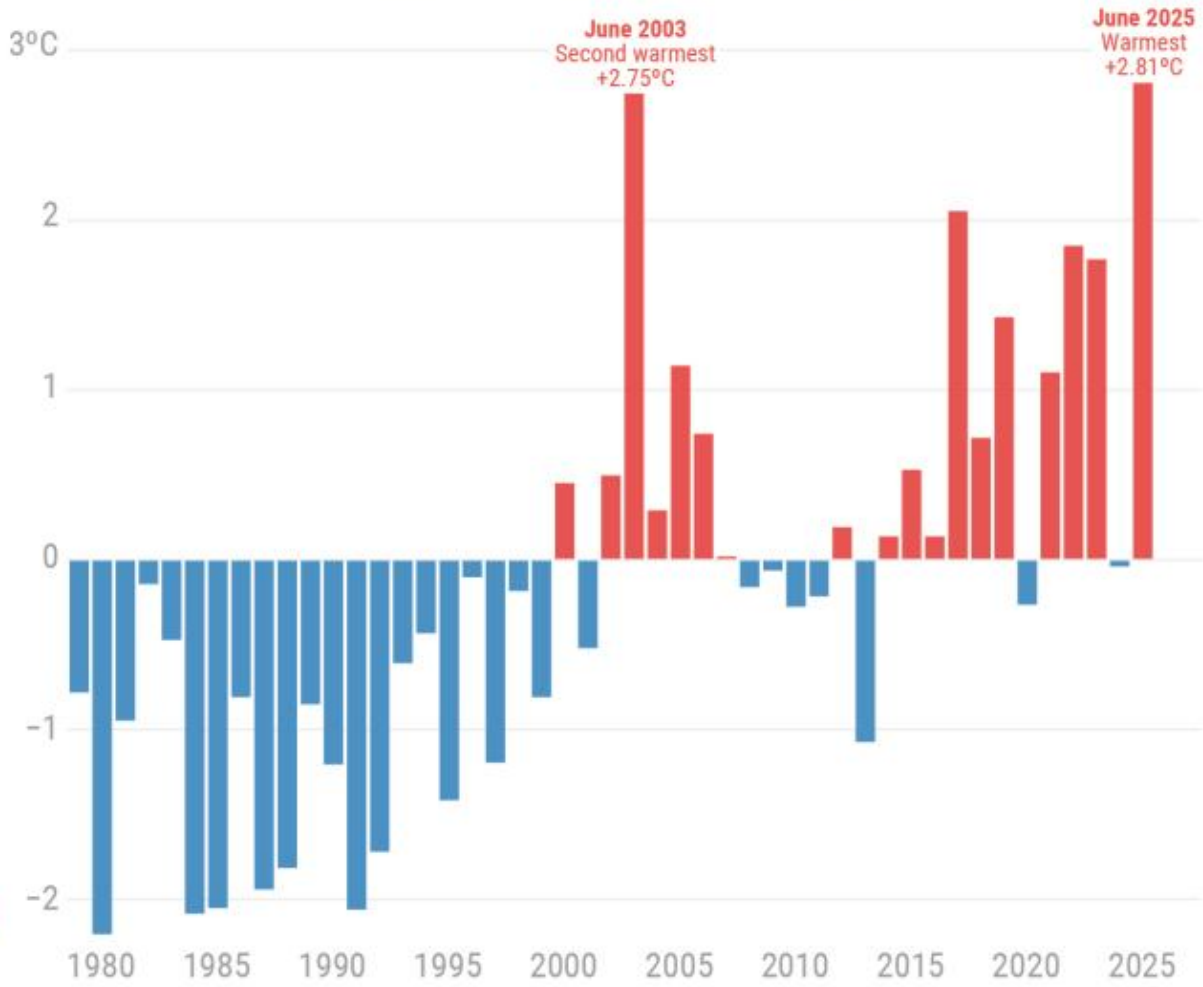
Surface air temperature anomalies

Data: ERA5 • Reference period: 1991–2020 • Credit: C3S/ECMWF

Average anomalies from 17 June to 2 July 2025



Anomalies in June in western Europe



PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

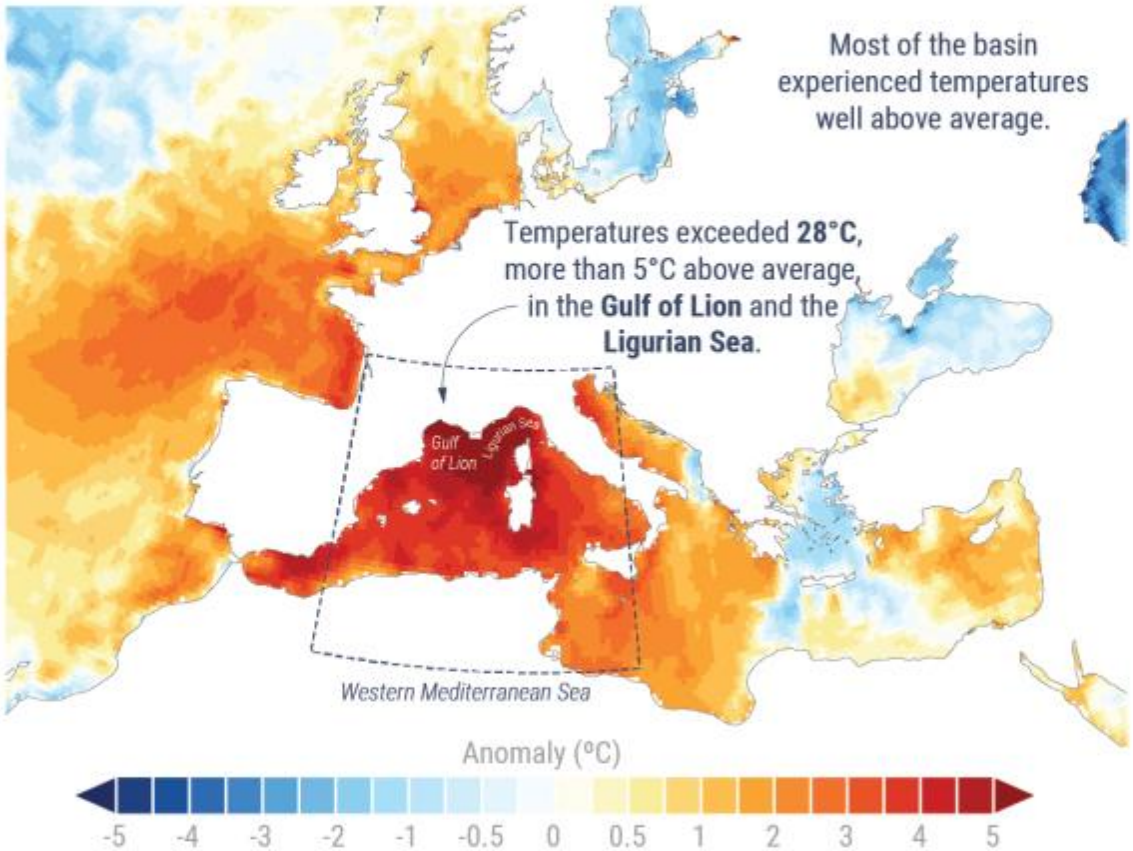
Climate Change Service

IMPLEMENTED BY ECMWF

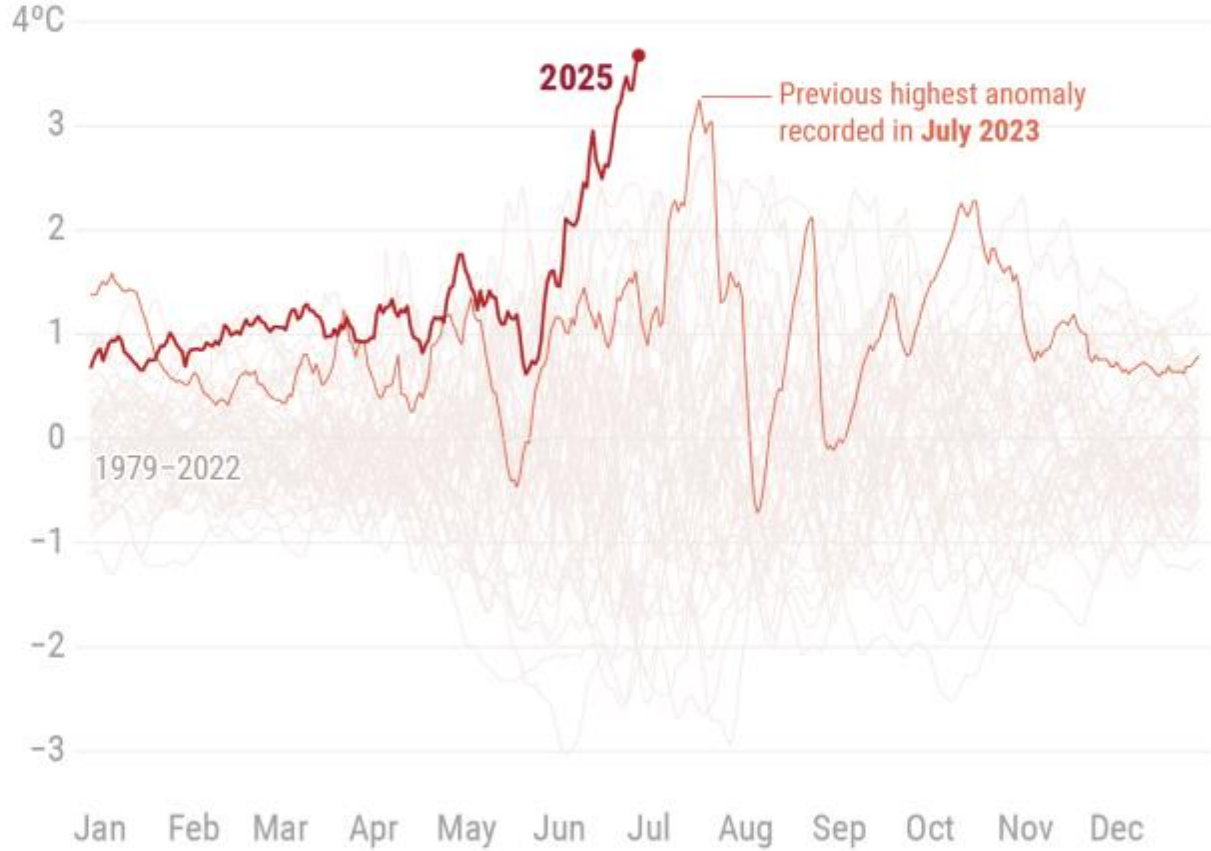
Sea surface temperature anomaly in the western Mediterranean Sea

Data: ERA5 • Reference period: 1991–2020 • Credit: C3S/ECMWF

Anomalies on 30 June 2025



Daily anomalies since 1979



PROGRAMME OF THE EUROPEAN UNION

opernicus Europe's eyes on Earth

Climate Change Service

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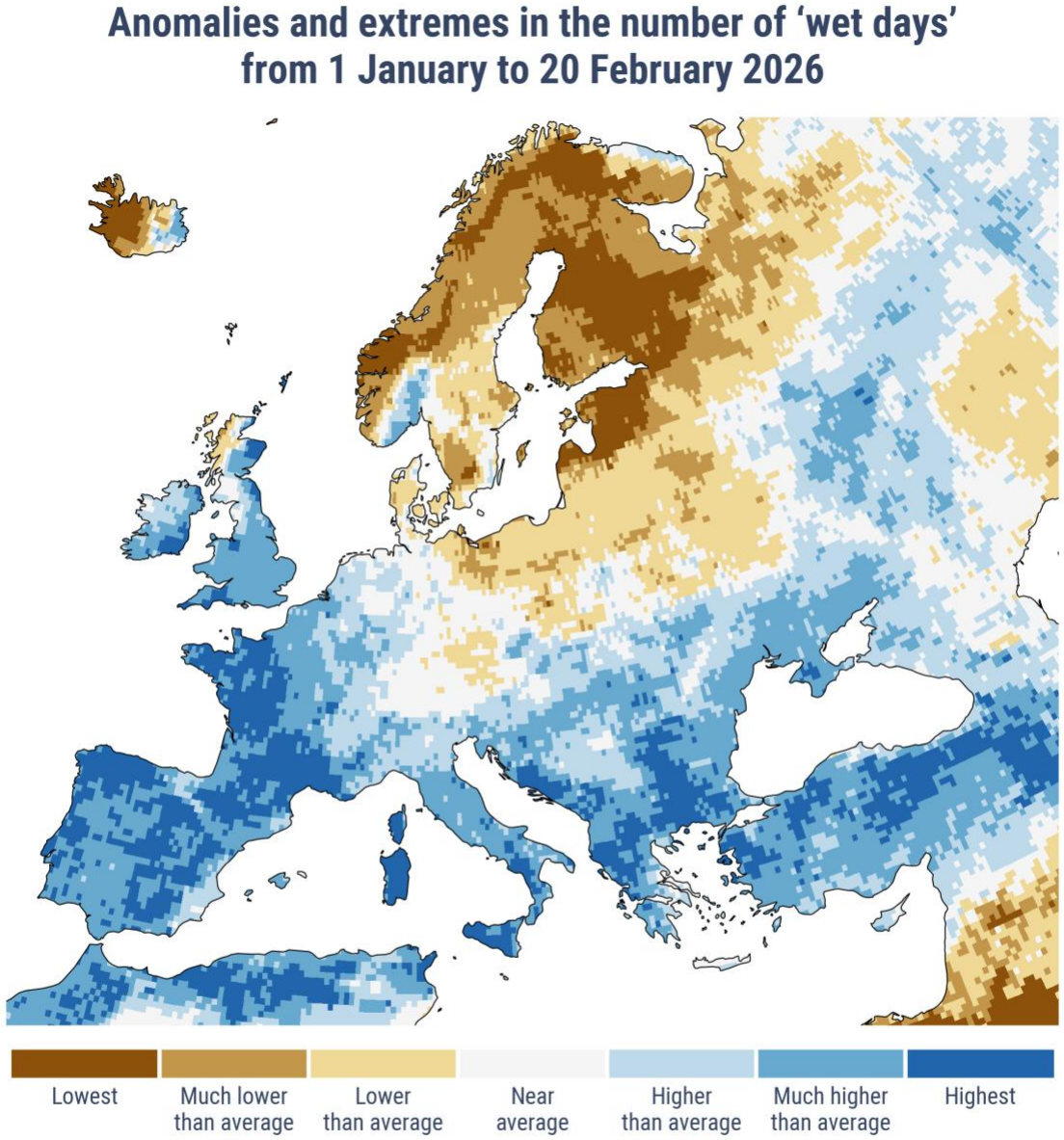
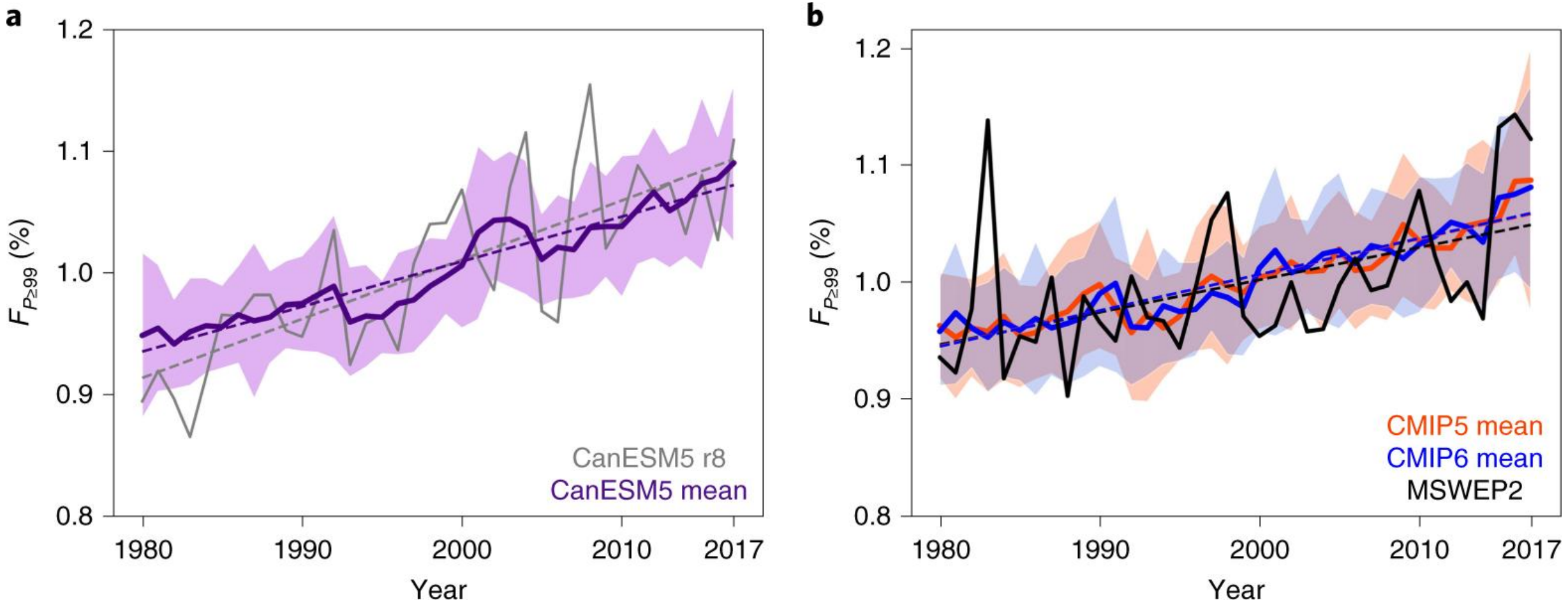
Exceptionally wet conditions in western Europe, during fifth-warmest February globally

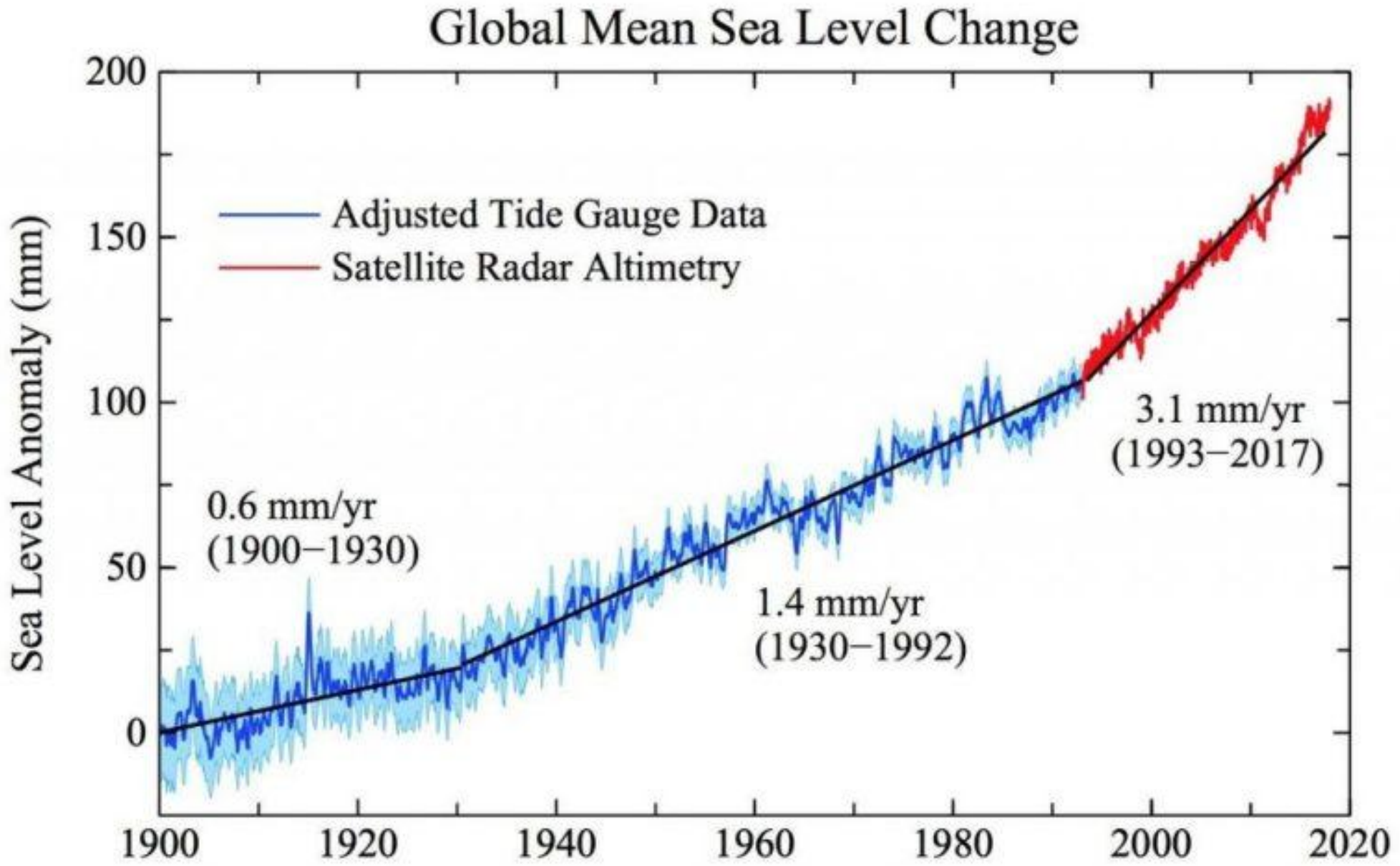


Historical change in extreme precipitation occurrence



a, Change in the frequency with which precipitation events in the ≥99th percentile occur each year over recent decades ($F_{P\geq99}$) in a single realization of one GCM from CMIP6 (CanESM5), and the mean of 20 realizations from that same GCM. The frequency of occurrence is calculated for each grid cell before taking annual and global averages (Methods). The shading denotes ±1 standard deviation across the model ensembles, while the dashed lines show the trends. **b**, Historical time series and trends in $F_{P\geq99}$ for MSWEP2 (black) along with the CMIP5 (orange) and CMIP6 (blue) ensemble means.

Sea level rise = warming (expansion) + melting



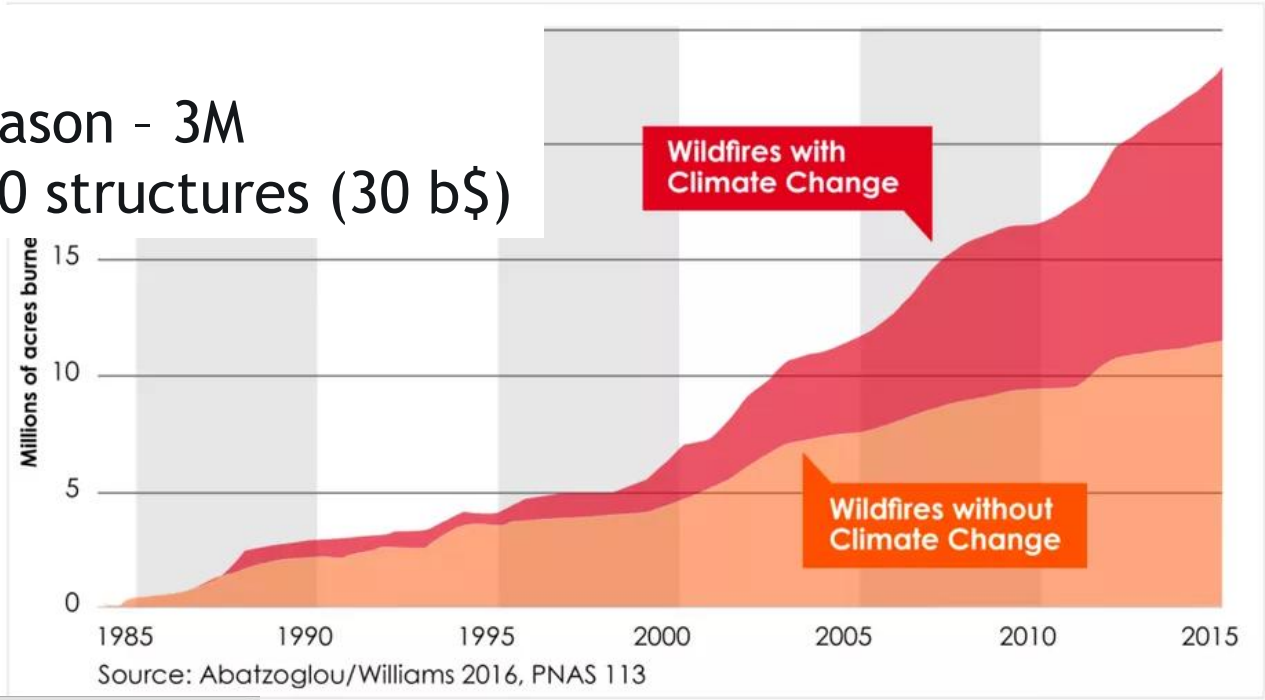
5x

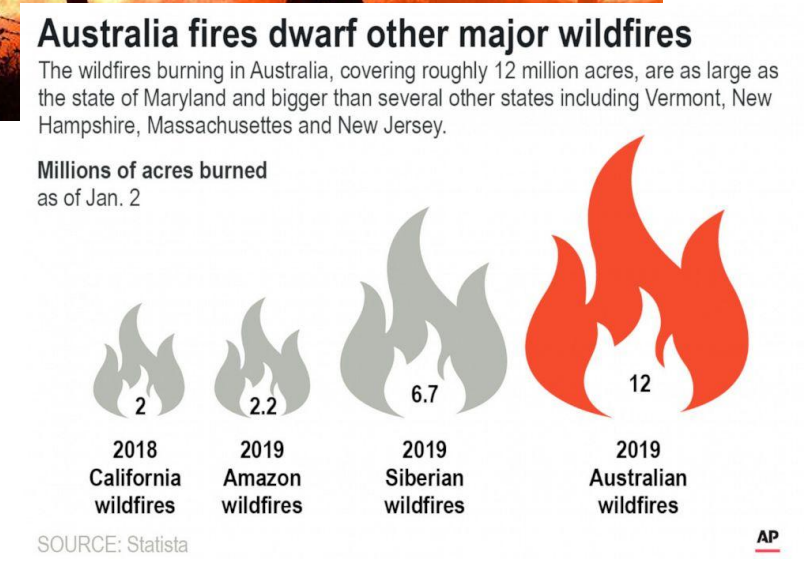
Fires

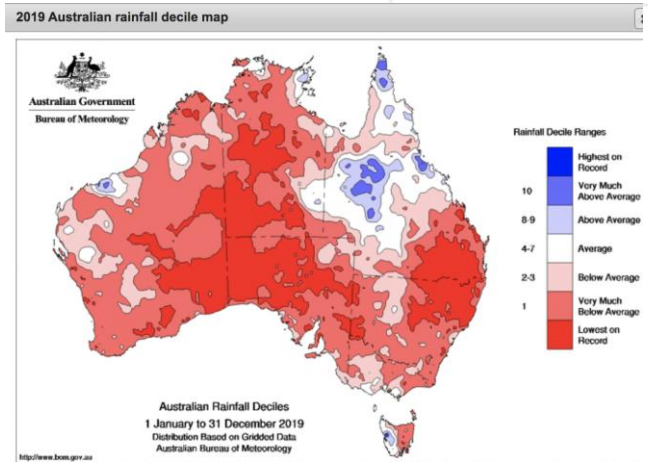
California

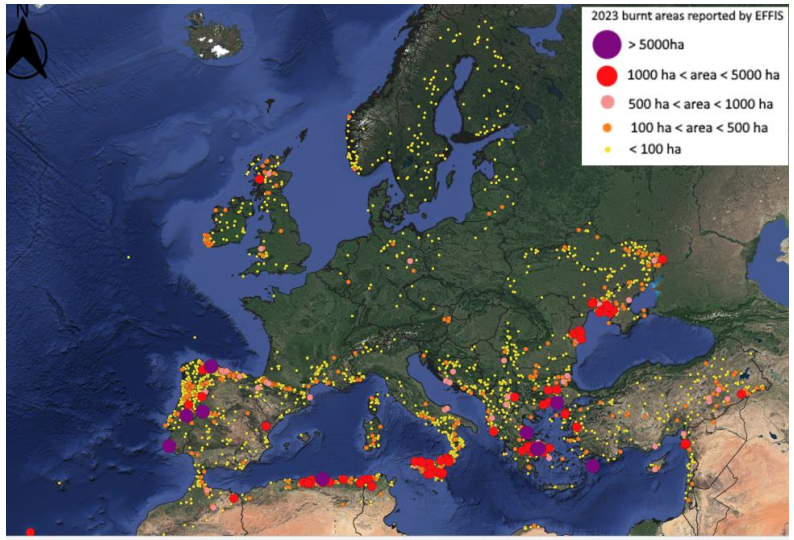
2020 worst fire season – 3M

2025 winter 18 000 structures (30 b$)









2023 worst fire season

Canada – 34M acres

Australia fires compared to other major fire events

FIRE NAME	YEAR	NUMBER OF ACRES BURNED
Australia bushfires*	2019–20	25.5M
Brazilian Amazon fires over 12 months	2019	17.5M
Siberia fires in July	2019	6.4M
Alaska fires over the summer	2019	2.5M
Worst California wildfire season	2018	1.9M
Peshtigo fire: Worst fire in US history	1871	1.2M
Australia's Black Saturday bushfires	2009	1.1M
Latest California wildfire season	2019	260K
California Camp Fire	2018	153K

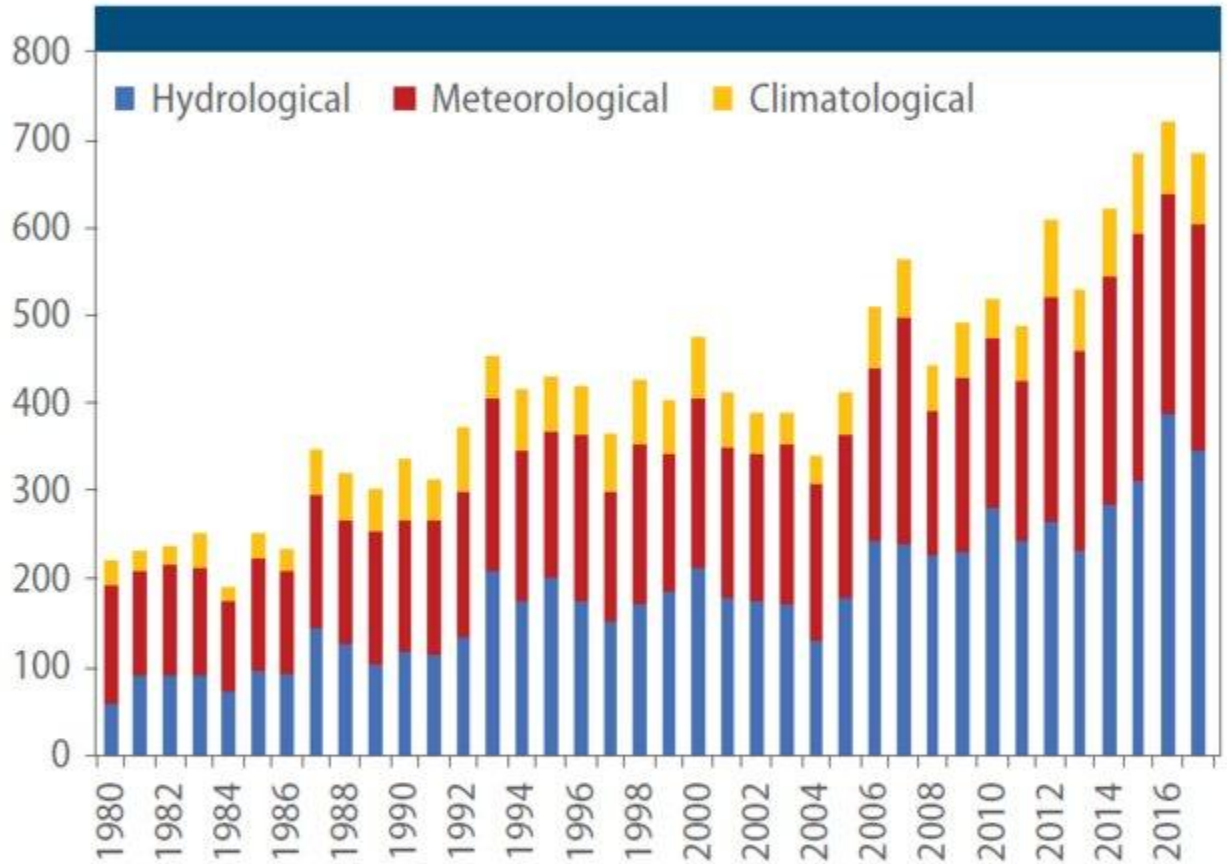
*As of January 7, 2020

Sources: Reuters; IPNE; NASA; Cal Fire; Weather.gov; National Museum Australia

INSIDER

Figure 2

Number of relevant weather-related loss events worldwide, 1980–2017



Source: Munich Re NatCatSERVICE.

Note: Hydrological events include flooding (river floods, flash floods and storm surges) and wet mass movements (rock fall, landslides, avalanches and subsidence). Meteorological events include storms (tropical, extratropical and local windstorms). Climatological events include extreme temperatures (heat waves, freeze and extreme winter conditions), droughts and wildfires.

Lost an estimated **USD 3.8 trillion** worth of crops and livestock production due to disaster events over the past **three decades!**

European Environment Agency

Between 1980 and 2022, weather- and climate-related extremes caused economic losses of assets estimated at **EUR 650 billion** in the EU Member States, of which EUR 59.4 billion in 2021 and EUR 52.3 billion in 2022.

*This map denotes the approximate location for each of the **18 separate billion-dollar weather and climate disasters that impacted the United States in 2022.***

How do we study the present climate and project the future climate?

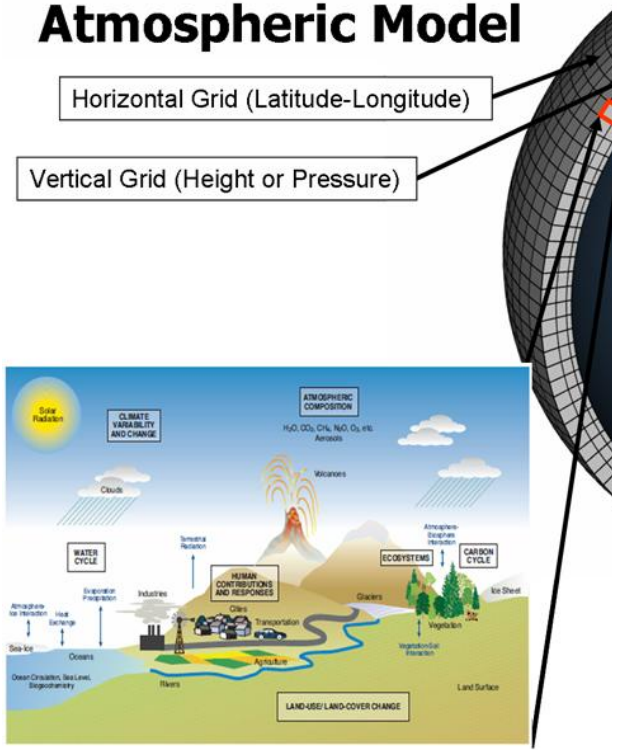
Observations
Climate Models
Reanalysis

only
Models

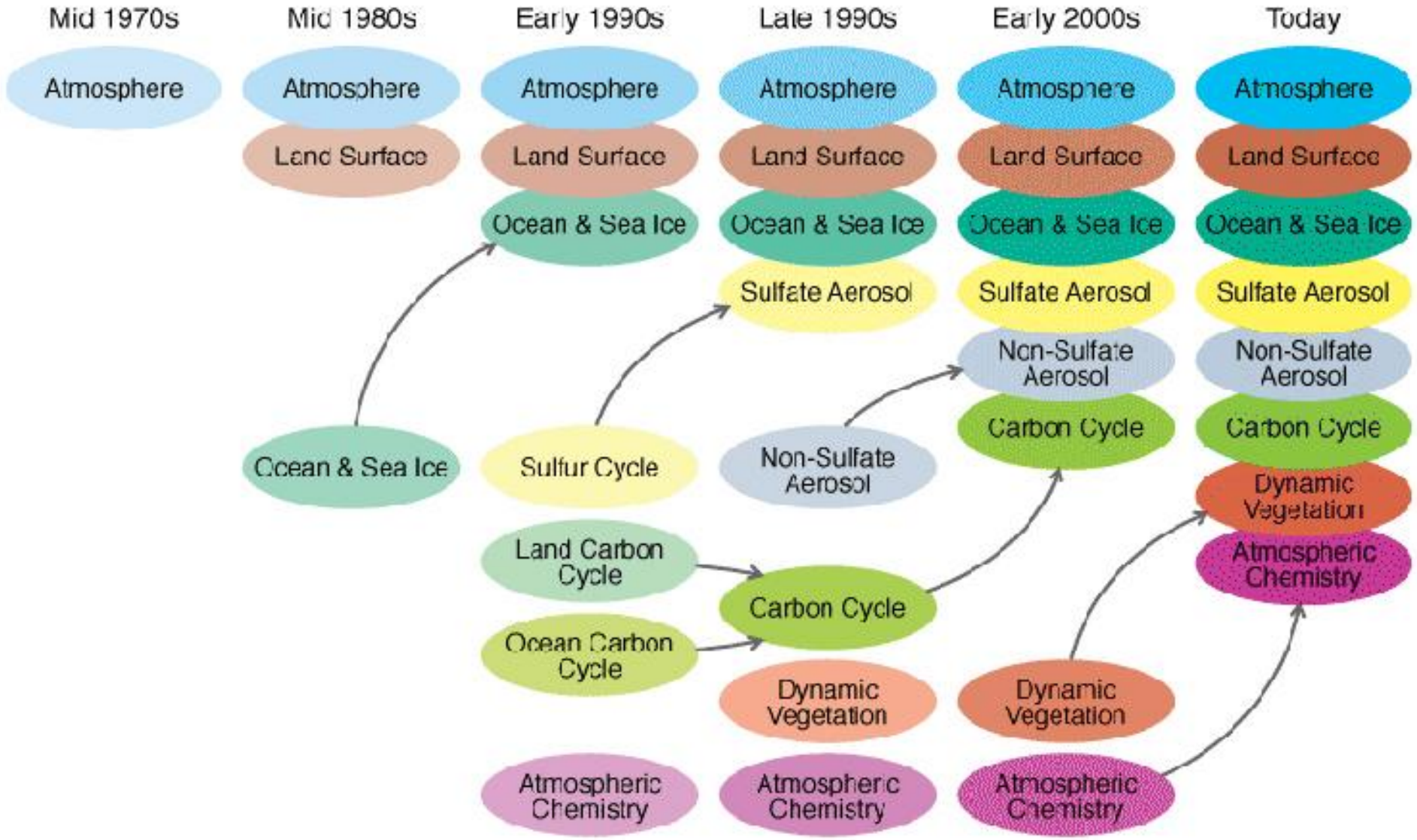
Global
Climate
Models
GCMs
Earth System
Models
ESMs

Global Climate

Schematic for Global Atmospheric Model



Development of Climate Models



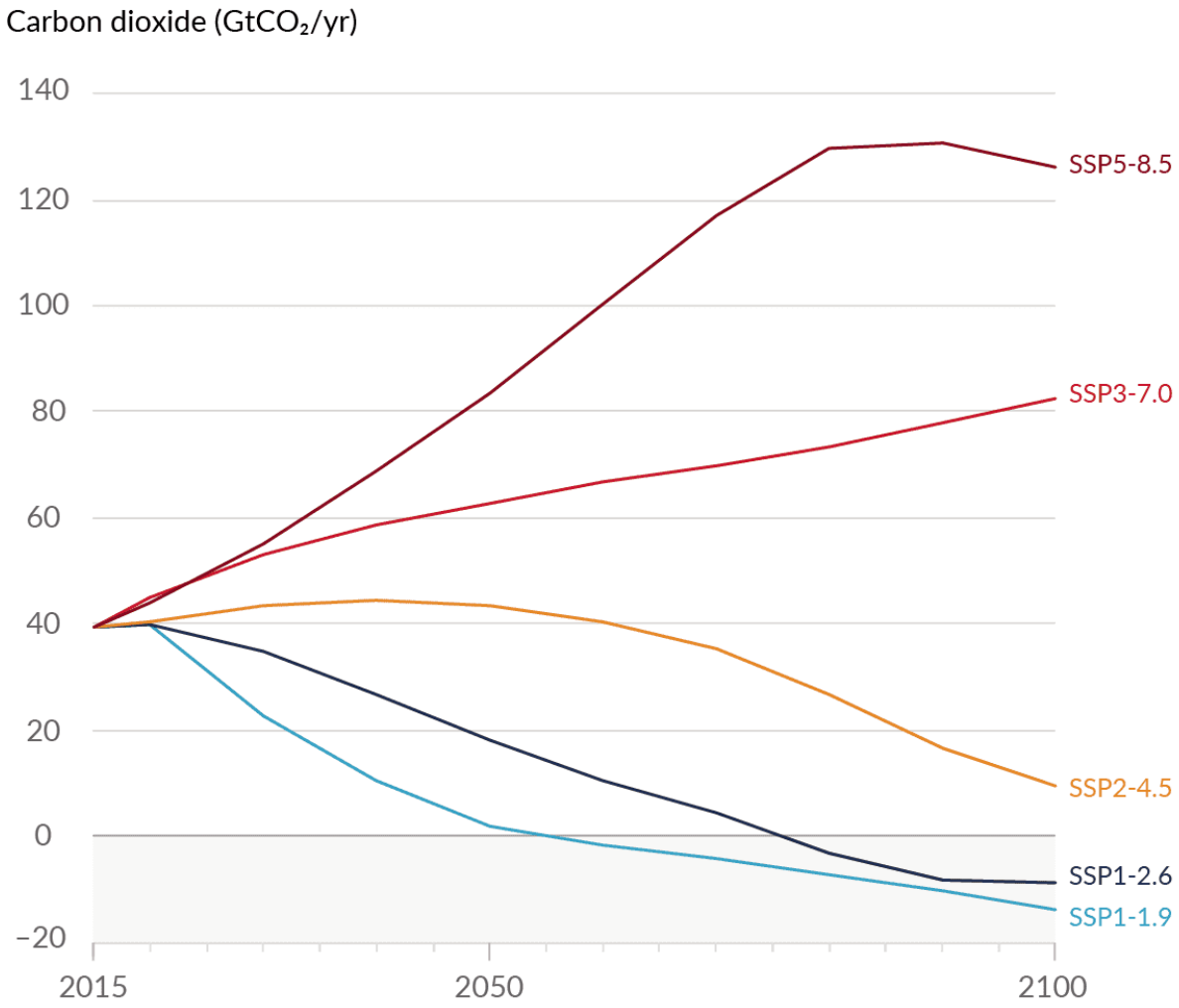
Future Global climate

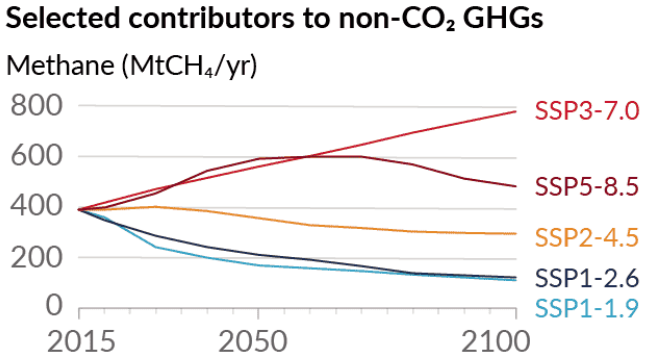
IPCC AR6 CMIP6
Earth System Modelling

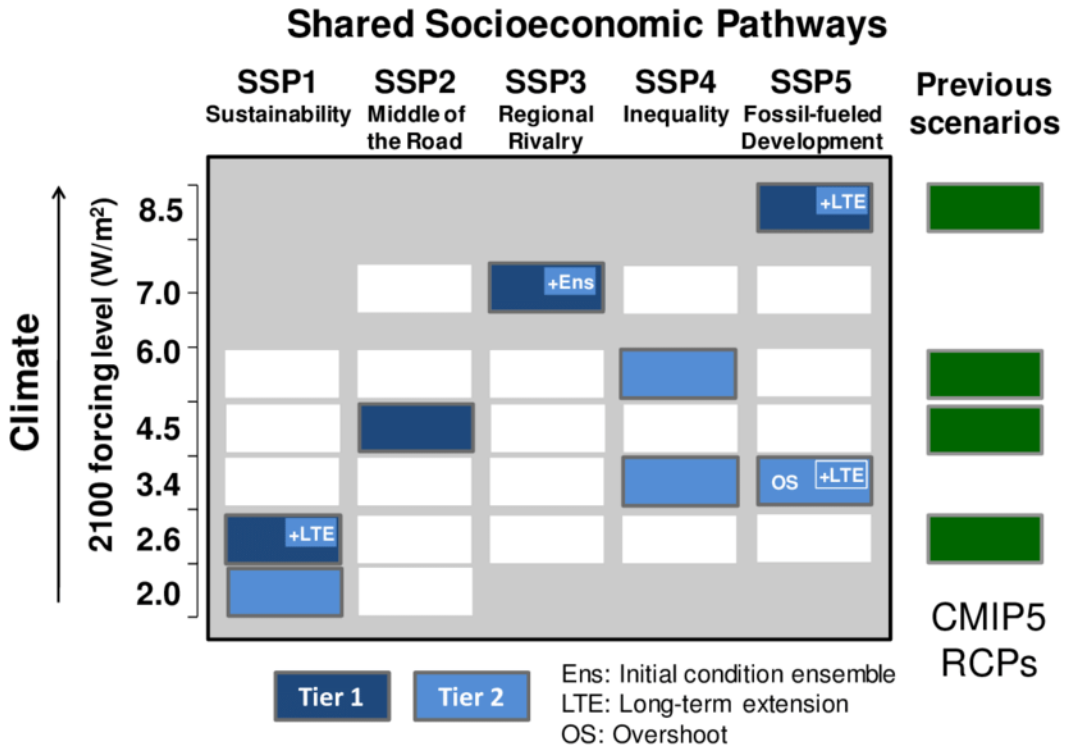
IPCC - Intergovernmental Panel on Climate Change
AR6 – Assessment Report 6
CMIP6 - Coupled Model Intercomparison Project Phase 6

Shared socioeconomic pathways and Future Emissions

(a) Future annual emissions of CO_2 (left) and of a subset of key non-CO_2 drivers (right), across five illustrative scenarios

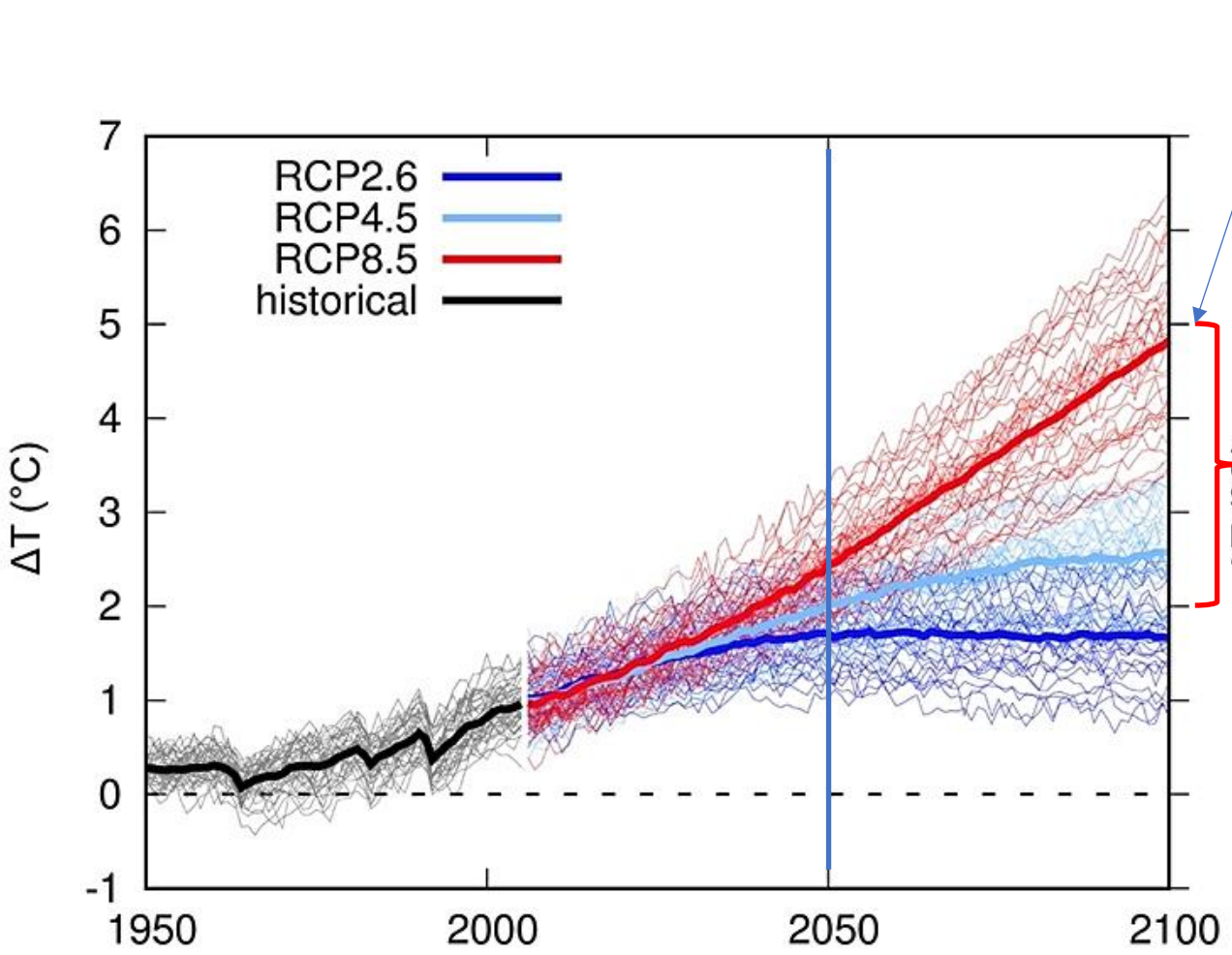




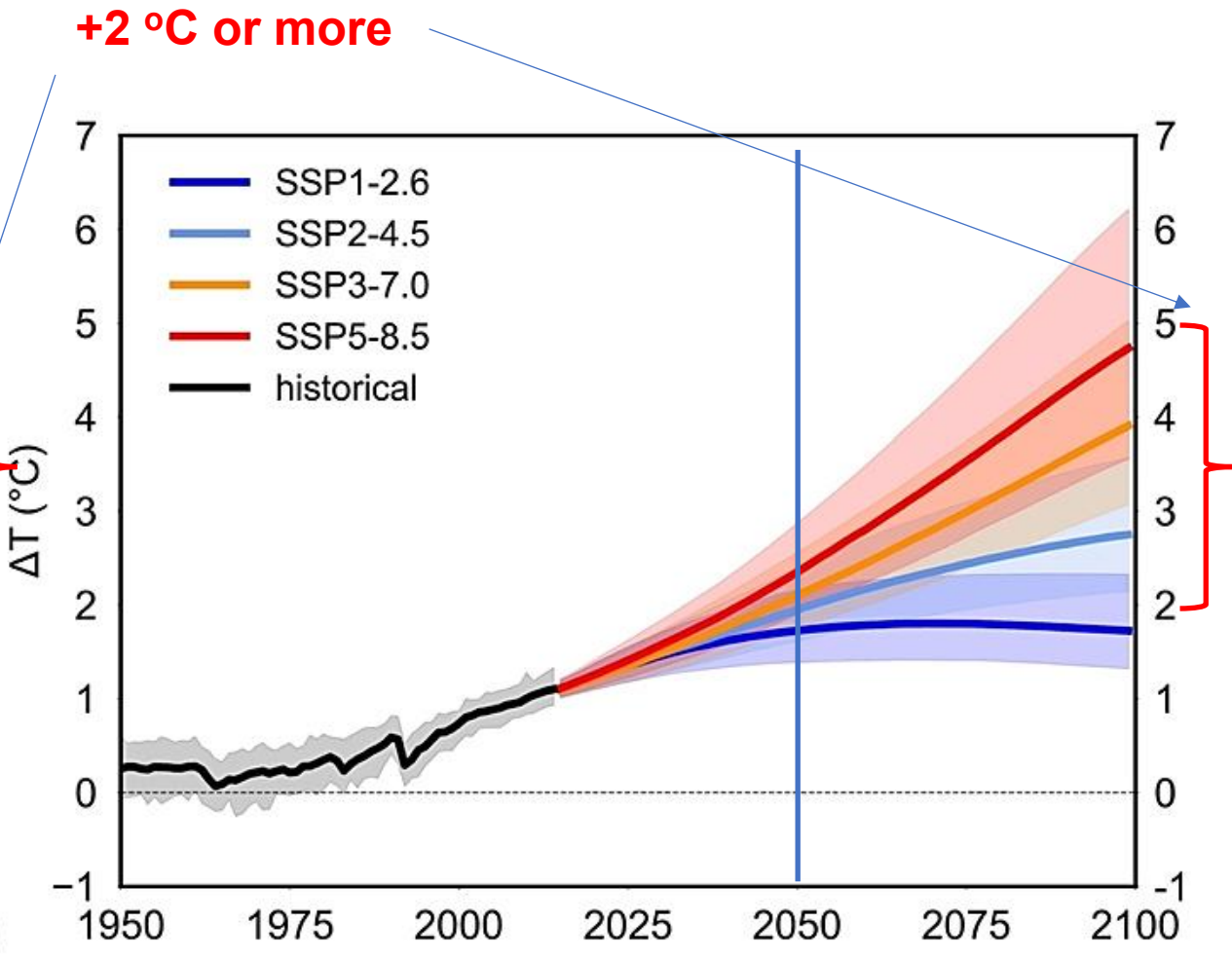


IPCC AR6 WGI, 2021

Human activities affect all the major climate system components, with some responding over decades and others over centuries



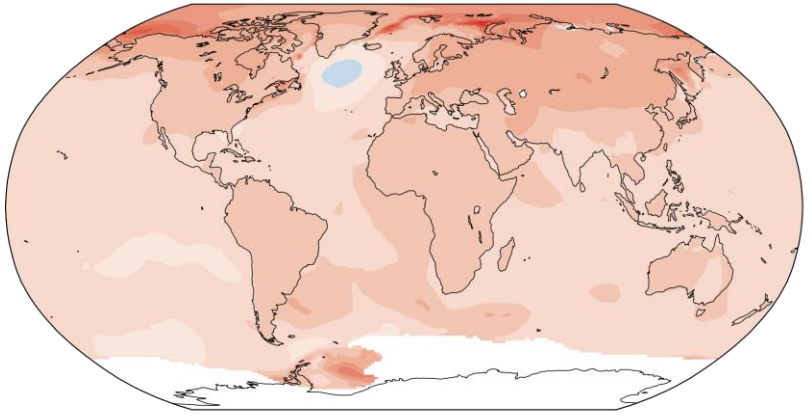
+2 °C or more



IPCC AR6 WGI, 2021

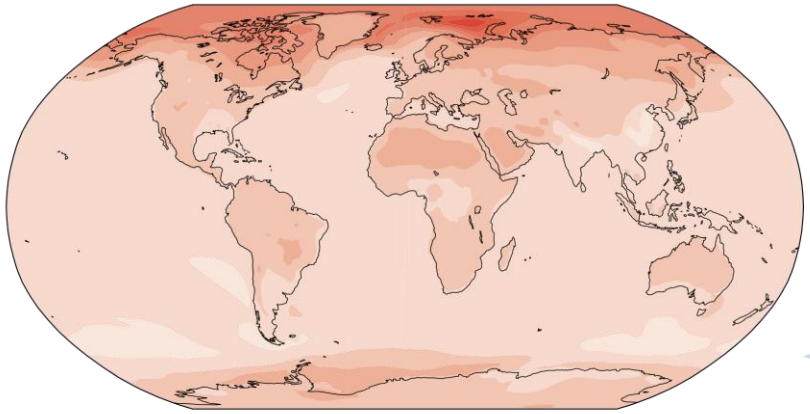
Annual mean temperature change (°C) relative to 1850-1900

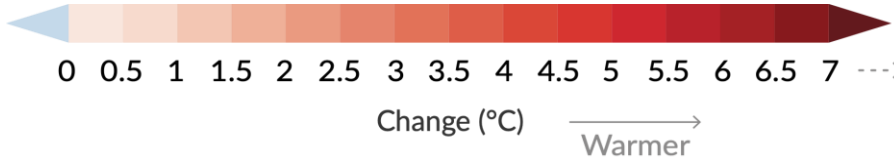
Observed change per **1°C** global warming



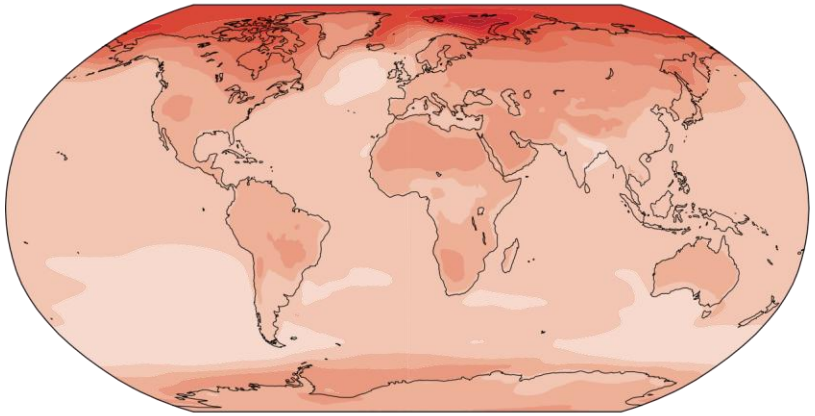
1850–2020

Simulated change at **1°C** global warming

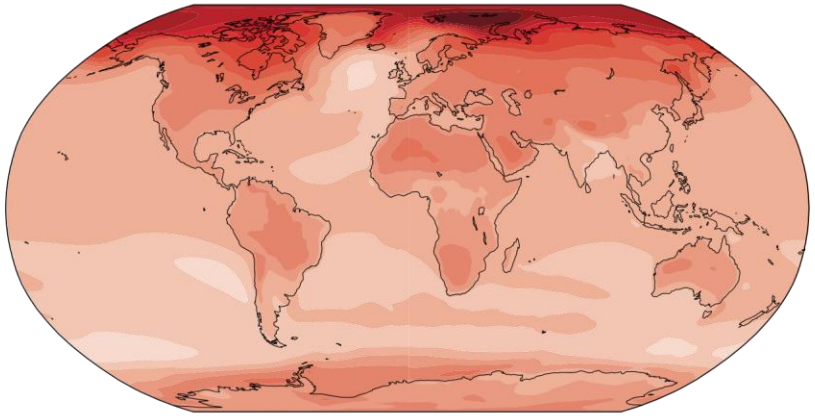




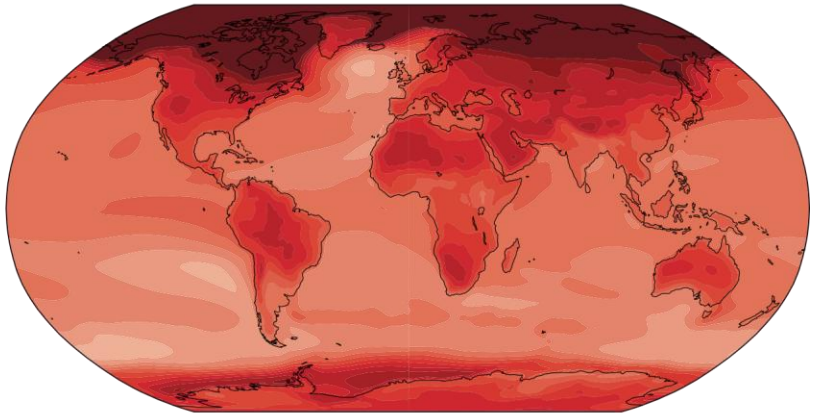
Simulated change at **1.5°C** global warming



Simulated change at **2°C** global warming



Simulated change at **4°C** global warming



With every increment of global warming, changes get larger in regional mean temperature, precipitation and soil moisture

IPCC AR6 WGI, 2021

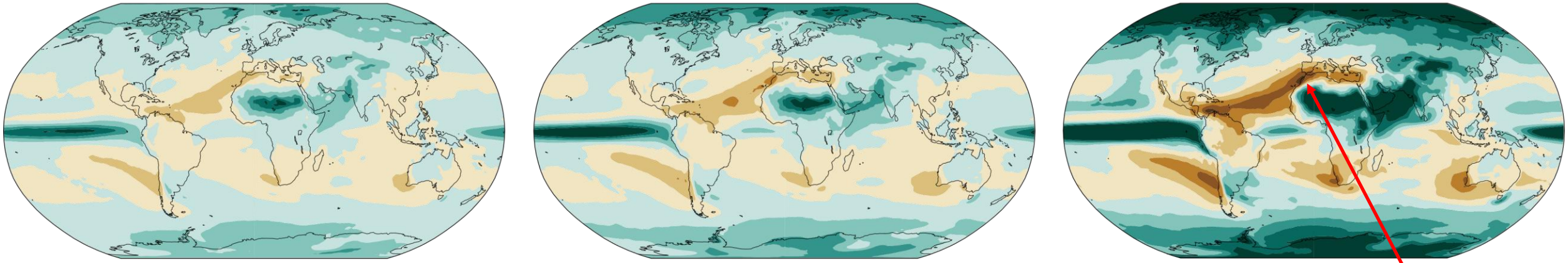
Annual mean precipitation change (%) relative to 1850-1900

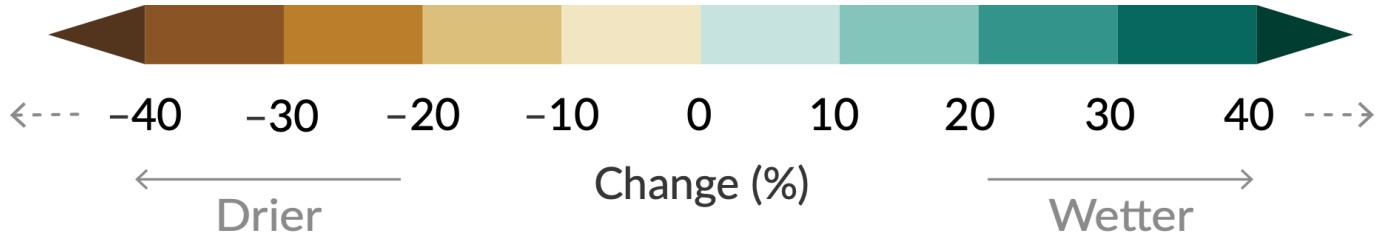
-10 to -20%

Simulated change at **1.5°C** global warming

Simulated change at **2°C** global warming

Simulated change at **4°C** global warming



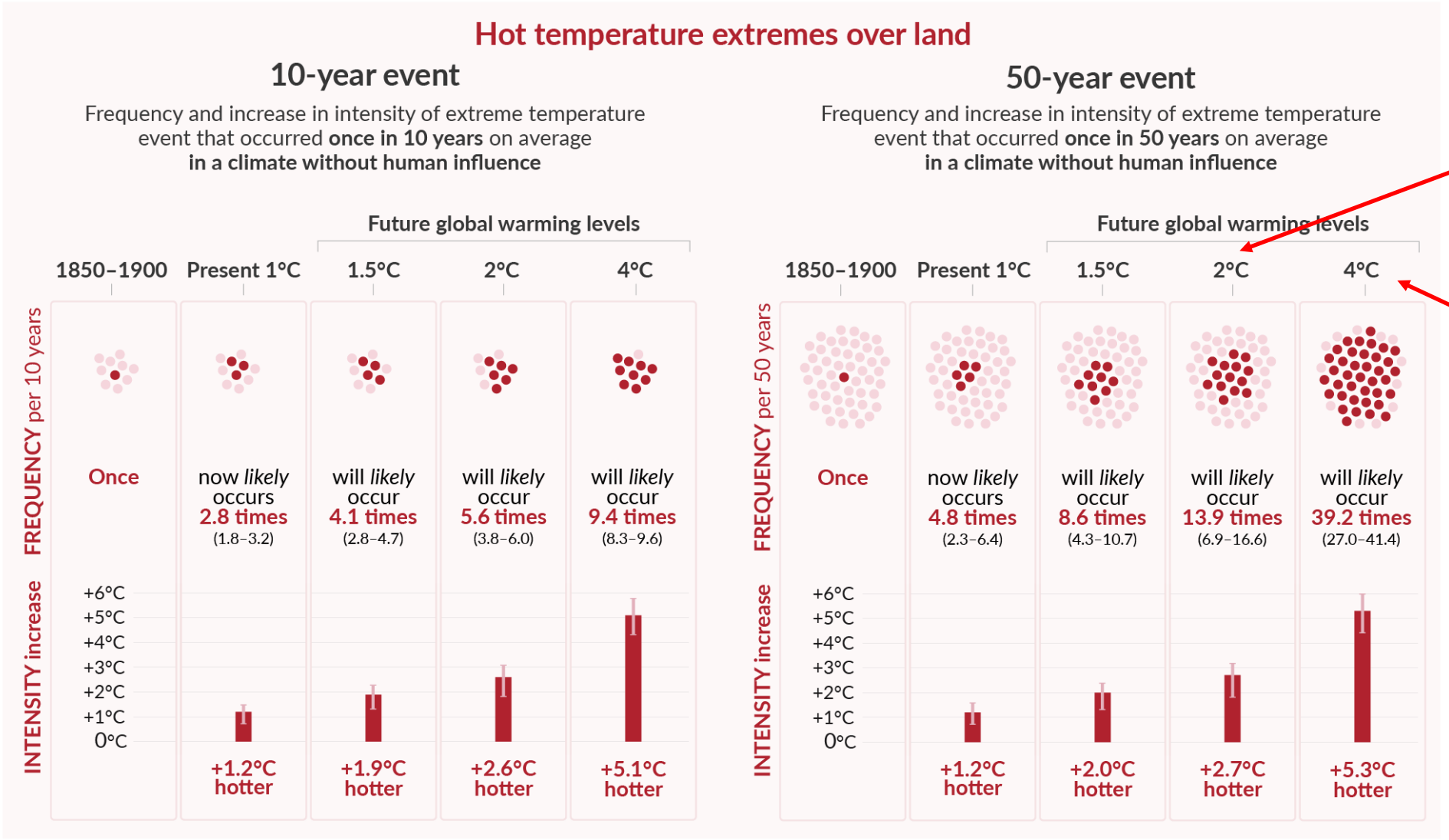


-20 to -40%

IPCC AR6 WGI, 2021

Projected changes in extremes are larger in frequency and intensity with every additional increment of global warming

Mitigation is vital



IPCC AR6 WGI, 2021

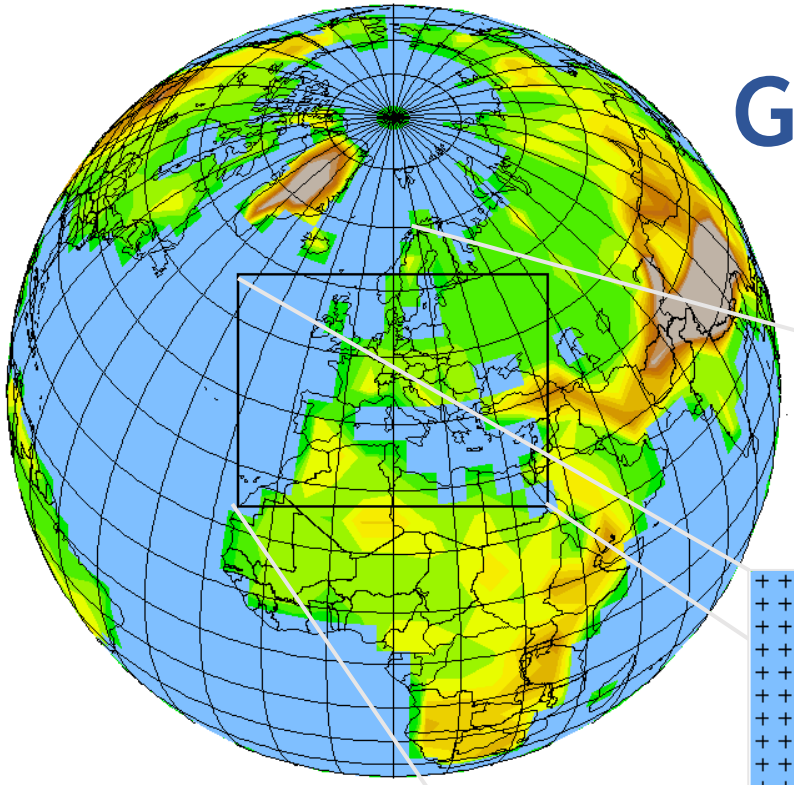
Global to regional climate and its impacts | Physical Modelling

Climate change impacts are felt at the regional and local scales!!!

Climate information at local scales is essencial to assess climate change impacts

Statistical downscaling (AI)

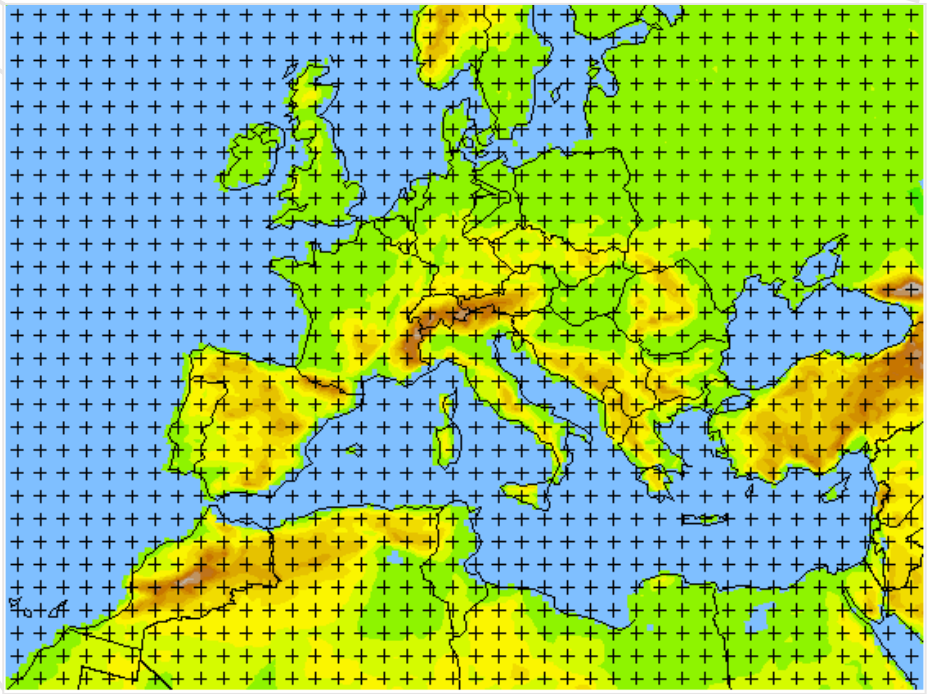
Dynamical downscaling
Regional Climate Modelling



GCM

RCM Nesting
GCM forces the RCM in the lateral boundaries and in the ocean surface (~12km)

RCM



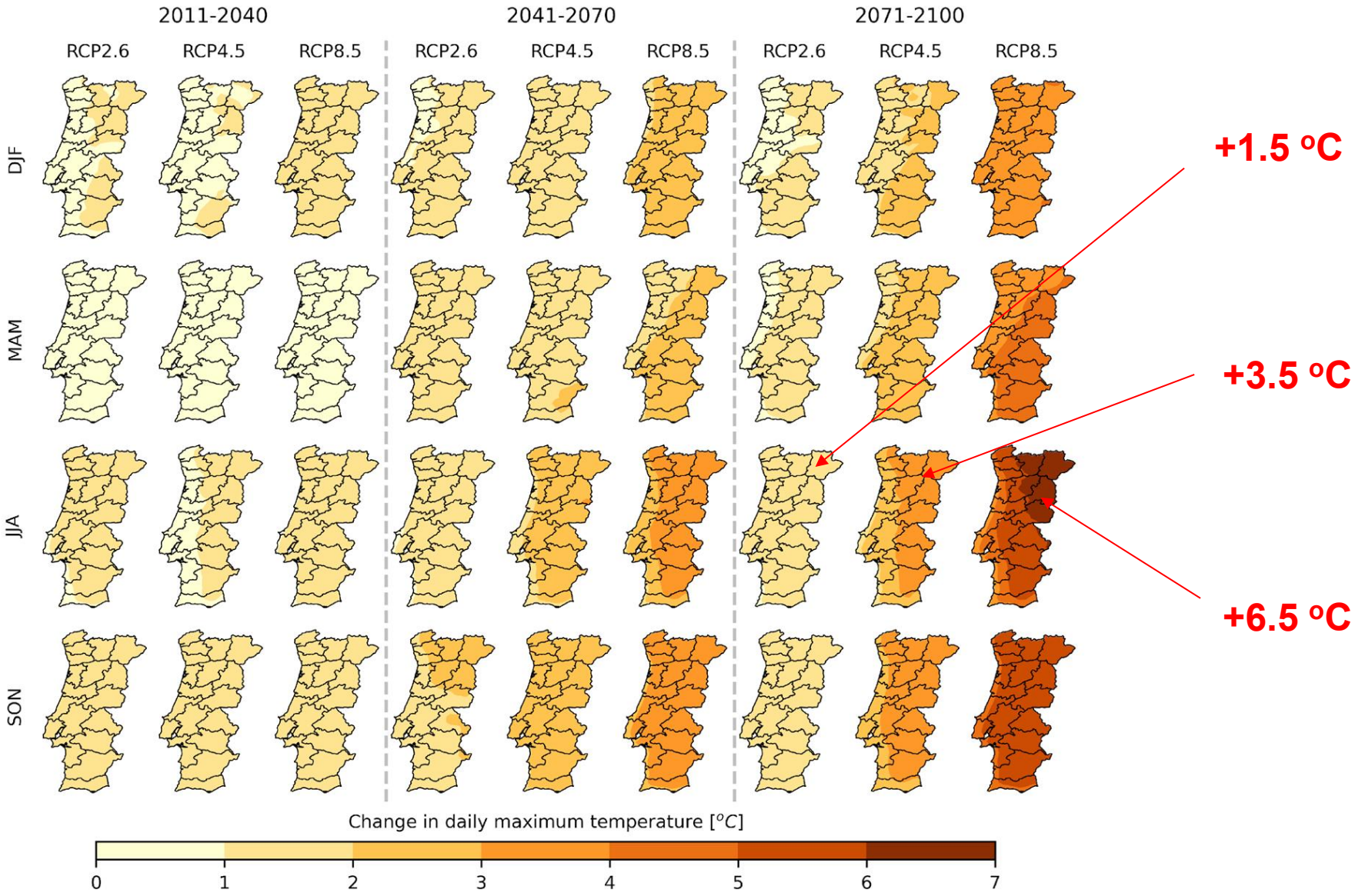
Mapping the Future: example

National Roadmap For Adaptation XXI

Portuguese territorial climate change vulnerability assessment for the 21st century

WP2 - Climate Projections, Extremes and Indices

Seasonal Maximum Temperature



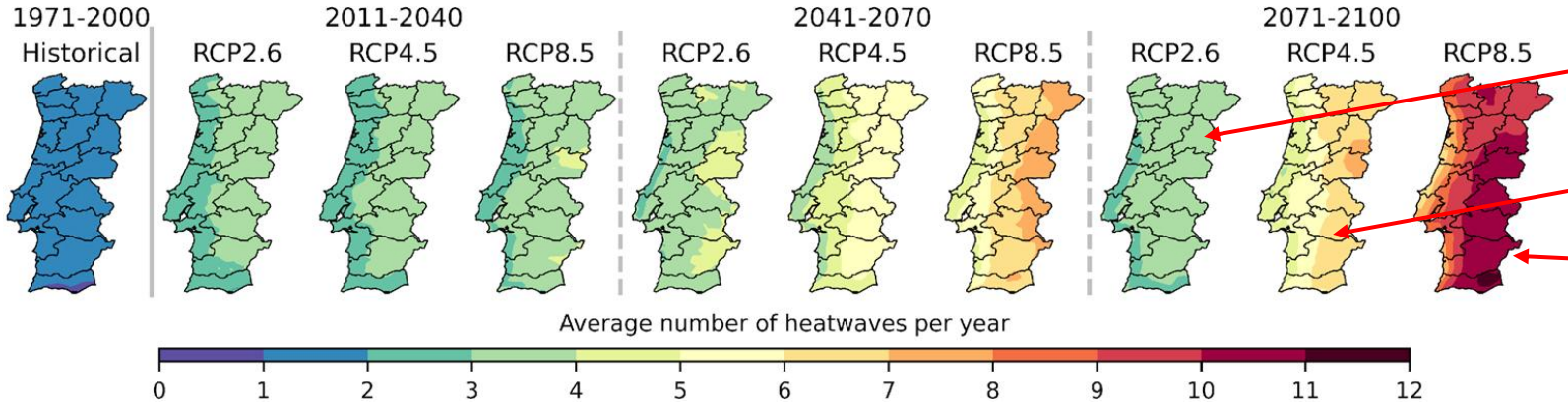
Lima et al. 2023a

WP2 - Climate Projections, Extremes and Indices

Ciências ULisboa

Heatwaves

Number of HWs per year

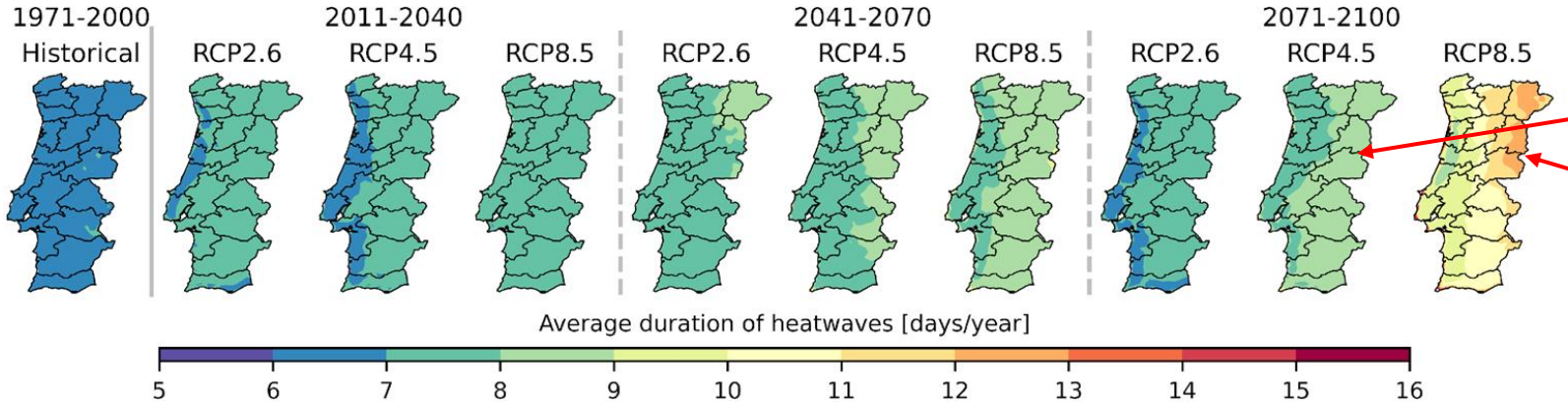


3 HWs

6 HWs

10 HWs

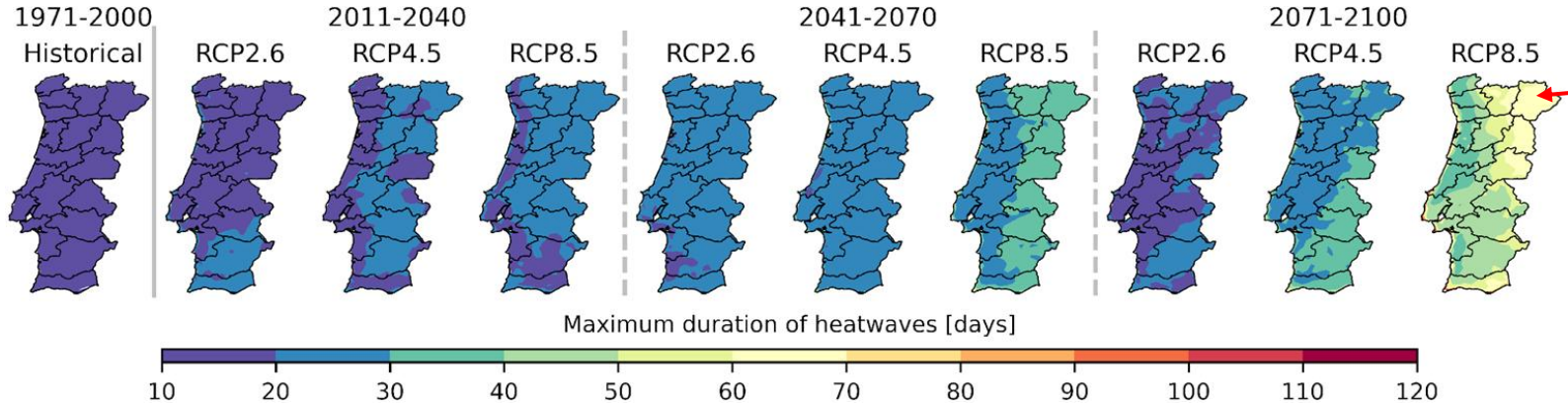
HWs Mean Duration



8 days

12 days

HWs Max duration



2 months

Cardoso et al. 2023

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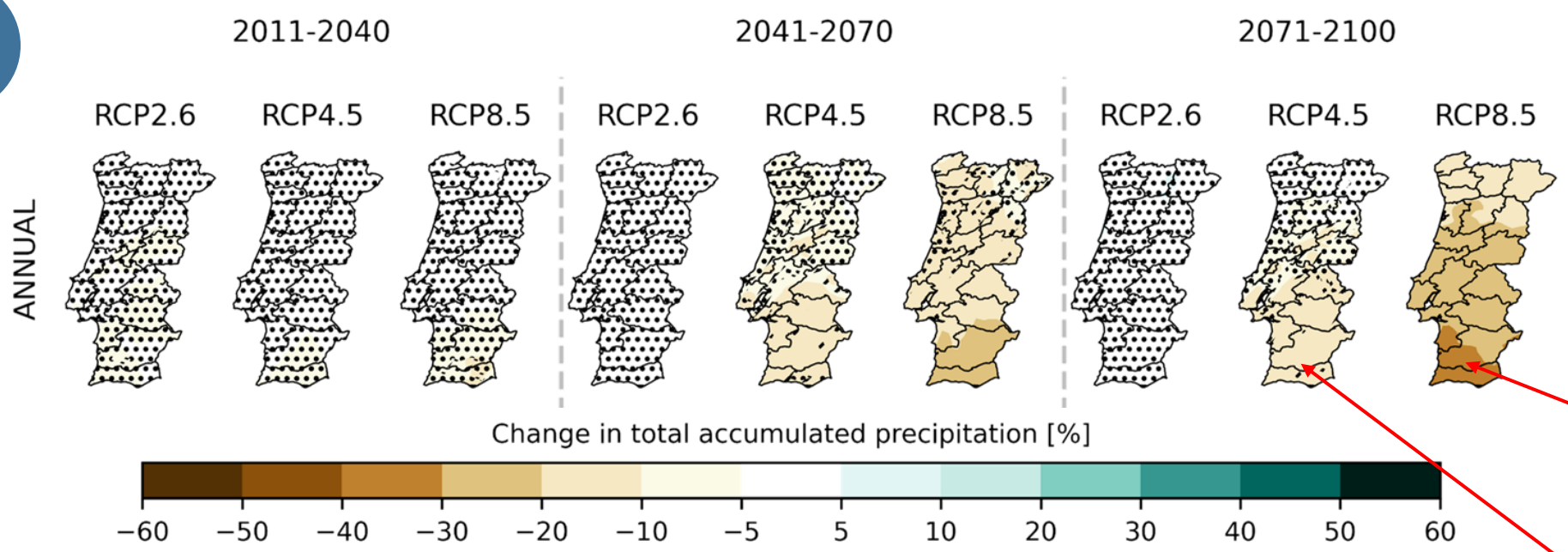
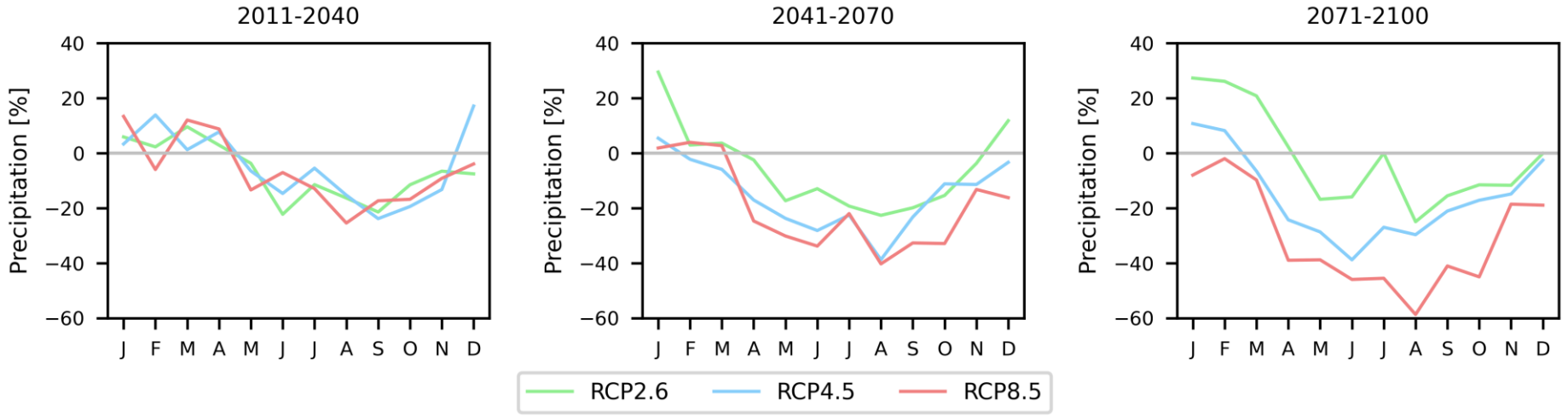
Annual Precipitation





WP2 - Climate Projections, Extremes and Indices

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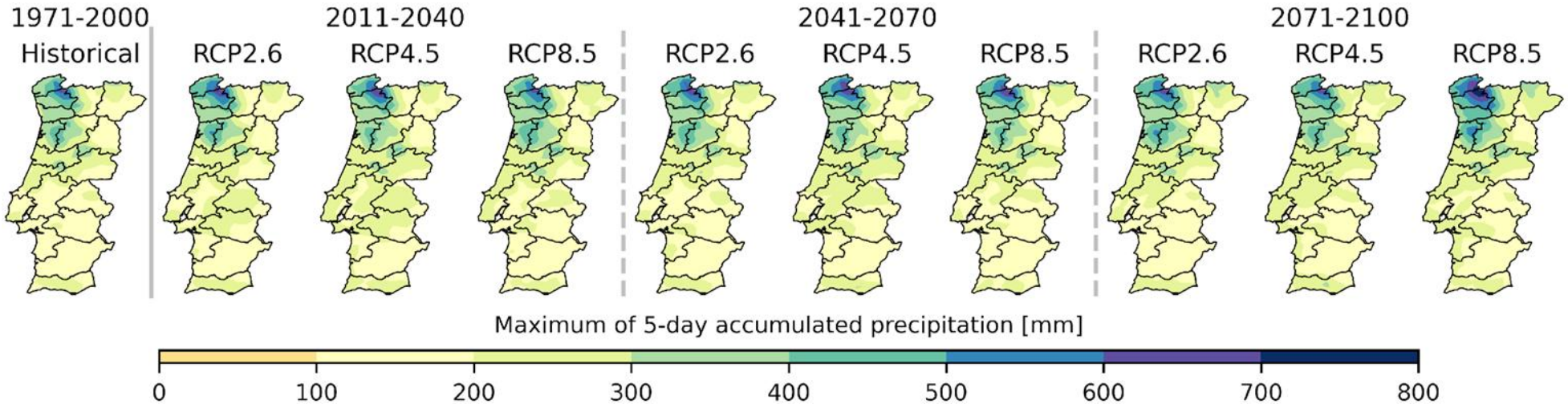
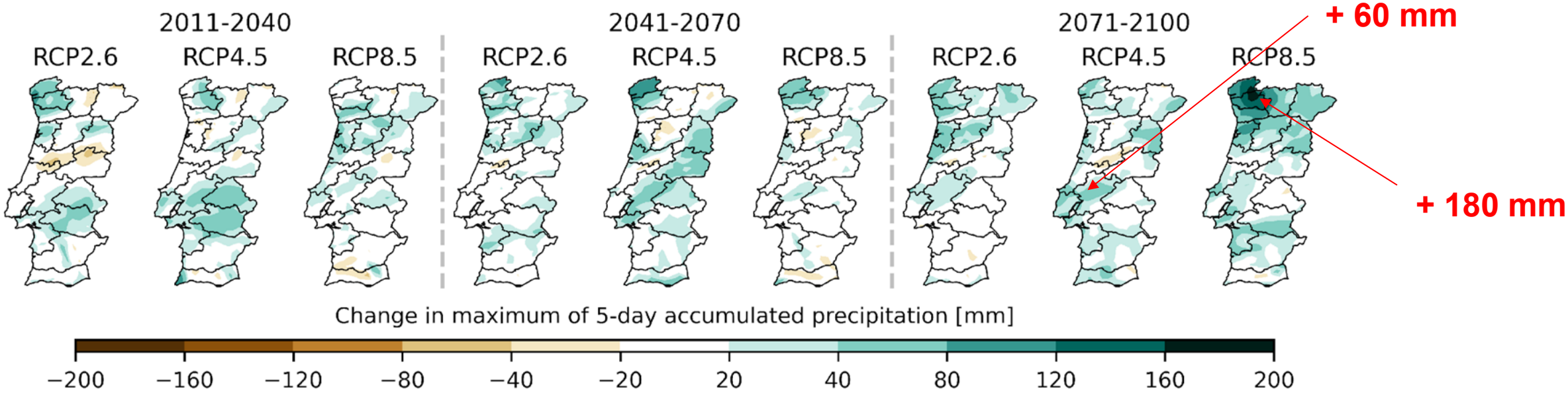
Precipitation Extremes

Maximum accumulated precipitation over a period of 5 consecutive days

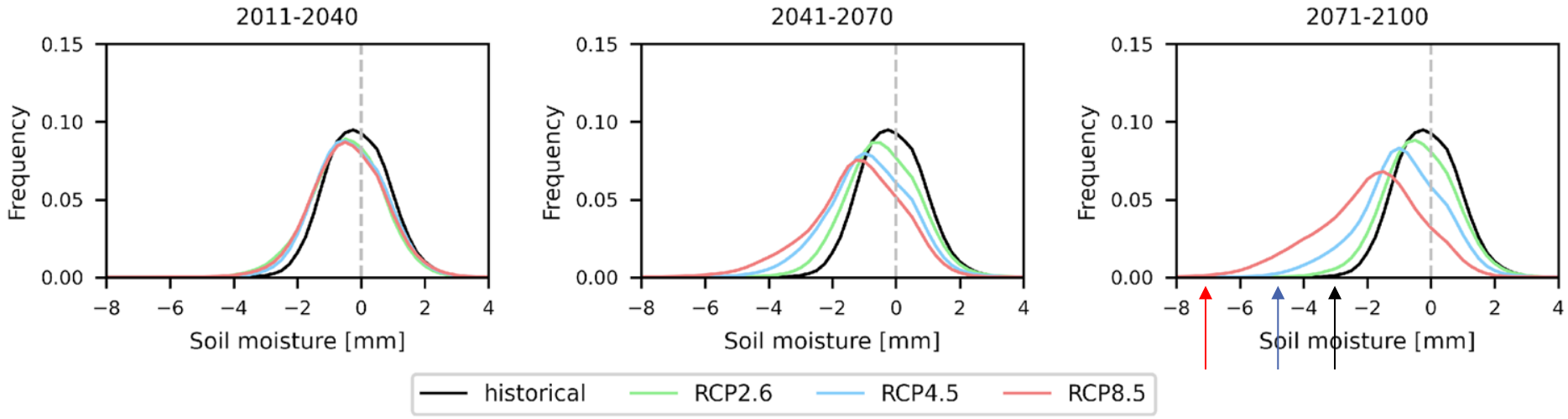




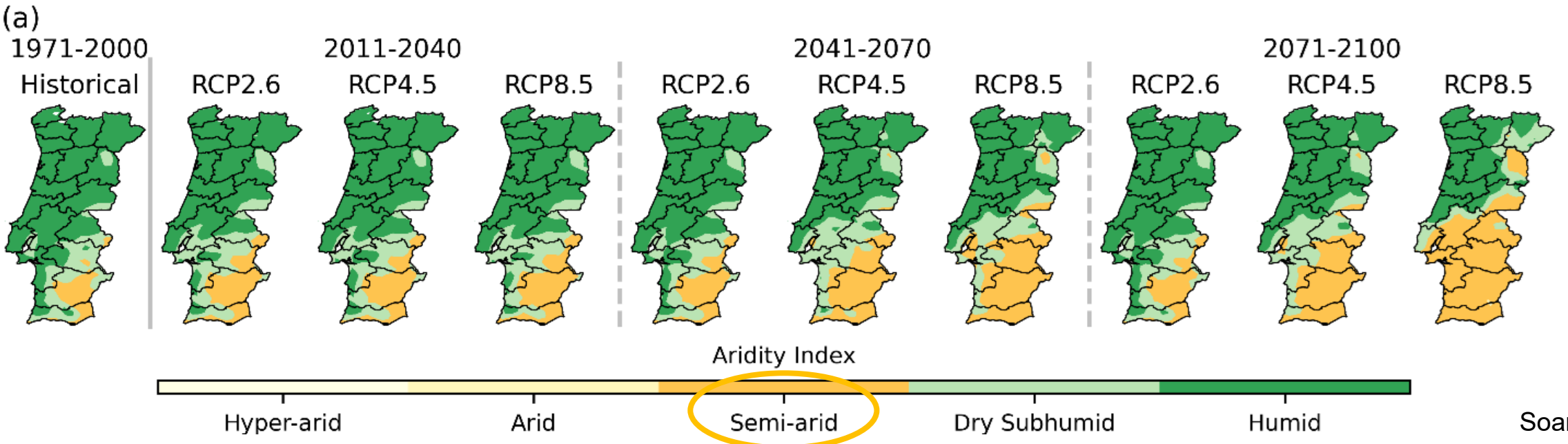
WP2 - Climate Projections, Extremes and Indices

Soil Moisture

Standardized anomaly of soil moisture – Mainland Portugal



Aridity Index



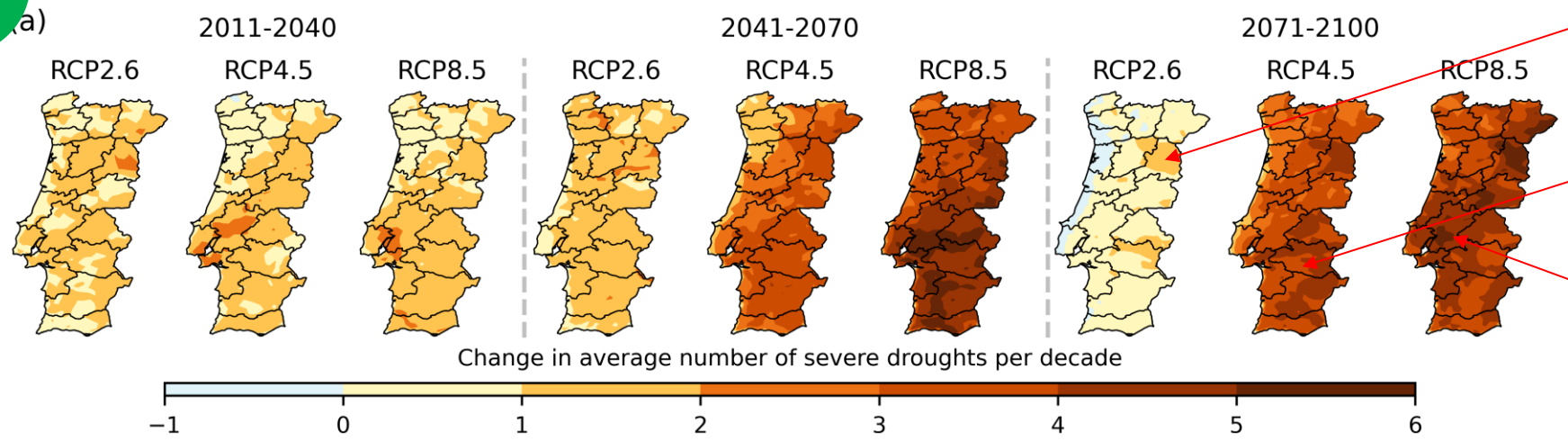
Soares et al. 2022

Modelling Sectoral Impacts | Droughts

Ciências ULisboa

Severe drought

Change in the number of severe droughts per decade

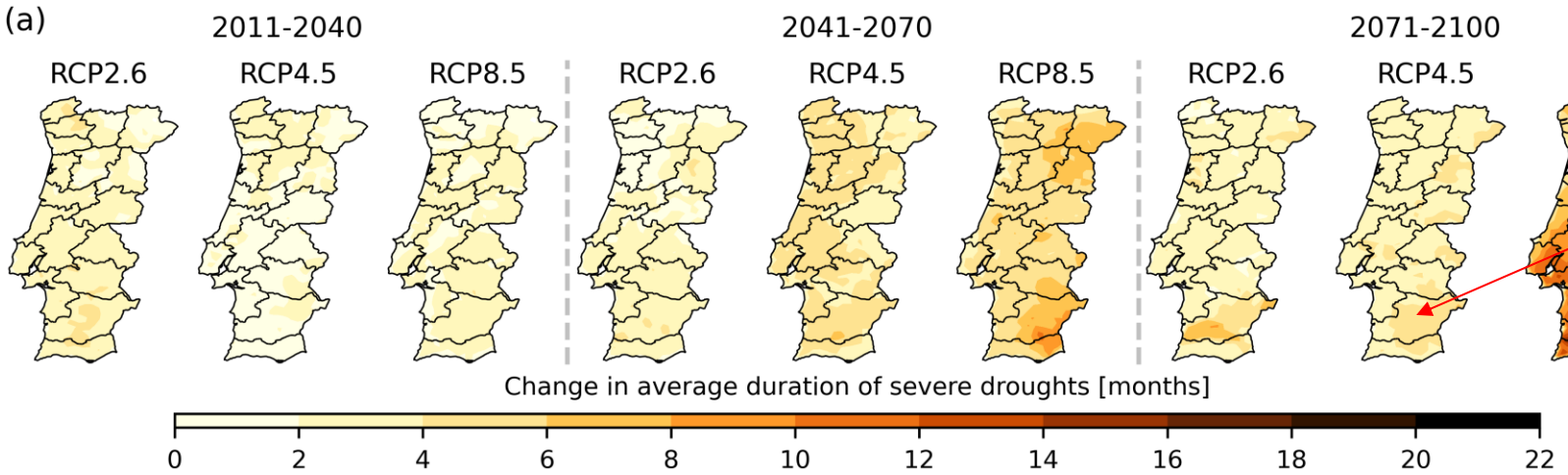


+1/decade

+3 a +4/decade

+5/decade

Change in the mean duration of severe droughts



+5 months

+19 months

Soares et al. 2022

Ciências ULisboa

Water Resources and Agroforestry

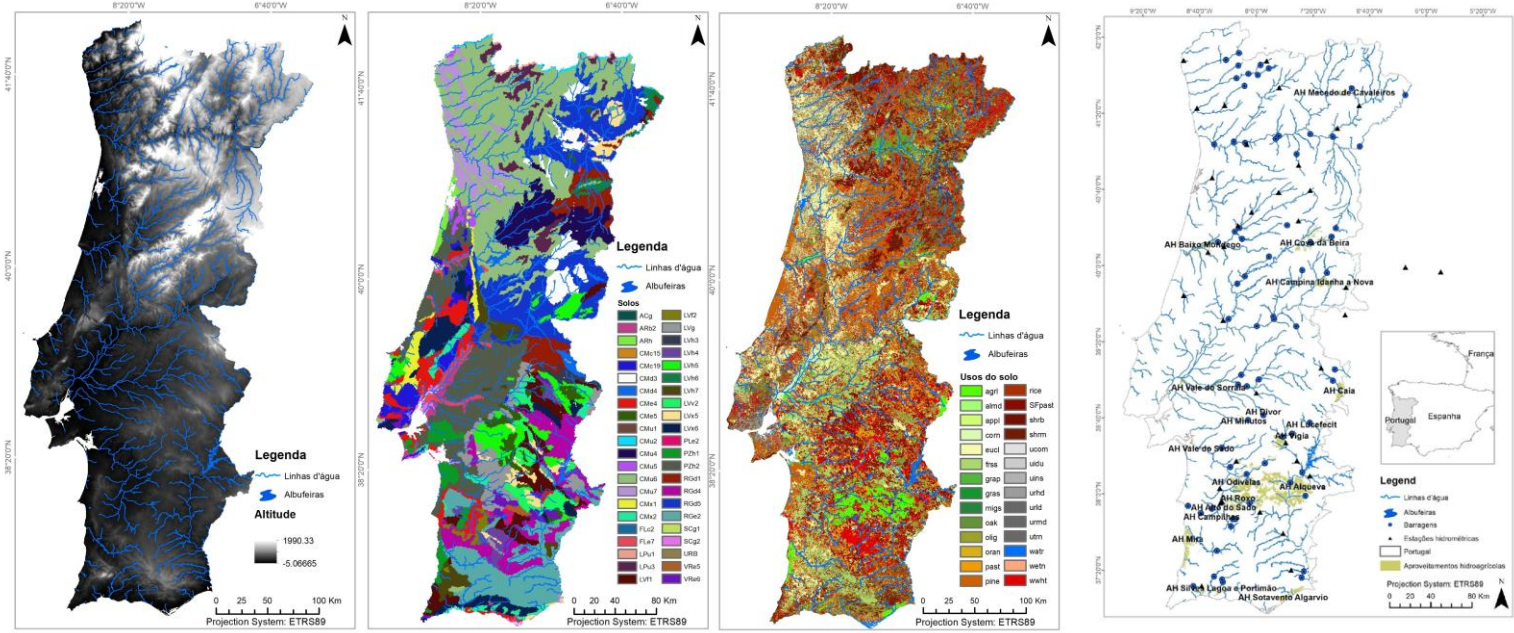
Modelling Sectoral Impacts | Water Resources and Agroforestry

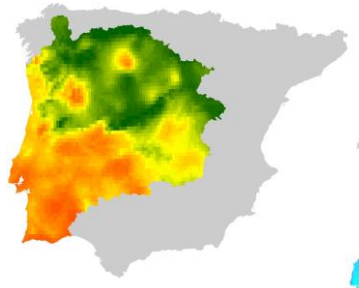
Ciências ULisboa

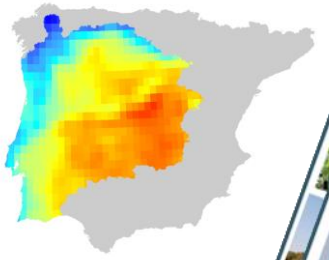
Modelling System SWAT+ and EPIC

Input data

- **Digital Terrain Model**
  - EU-DEM
  - Water Stream (DQA)
  - Water bodies (DQA)
- **Soil types**
- **Land use**
  - Crops
  - Dams
  - Irrigation perimeters
- **Climate data**
  - Observations (Ibéria 01)
  - Reanalysis (ERA5)
  - Climate Projections (EURO-CORDEX)







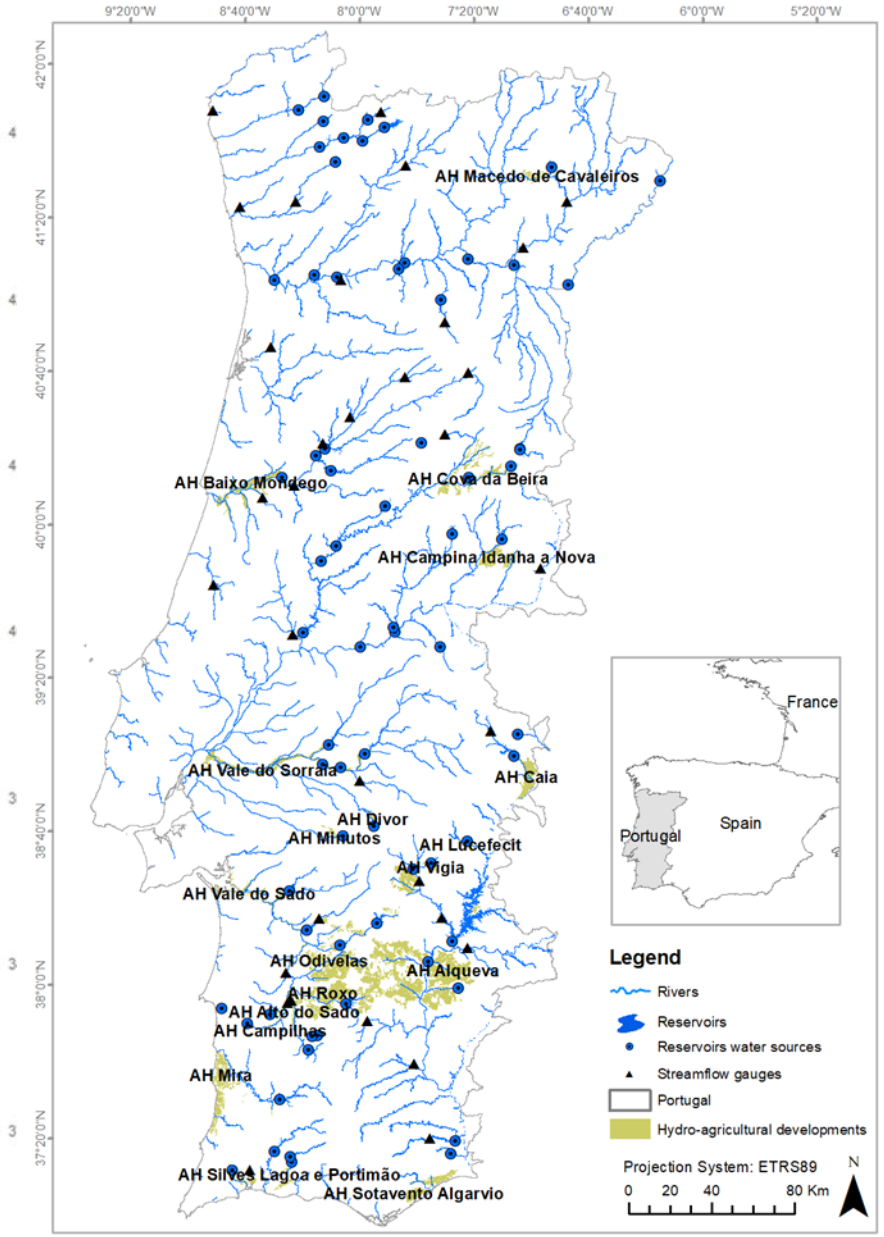
Soil & Water Assessment Tool (SWAT) is a river basin scale model

EPIC plant growth model

Modelling adaptation measures and their effect on hydrological balance

Modelling Sectoral Impacts | Water Resources and Agroforestry

SWAT+ EPIC MODELLING SYSTEM

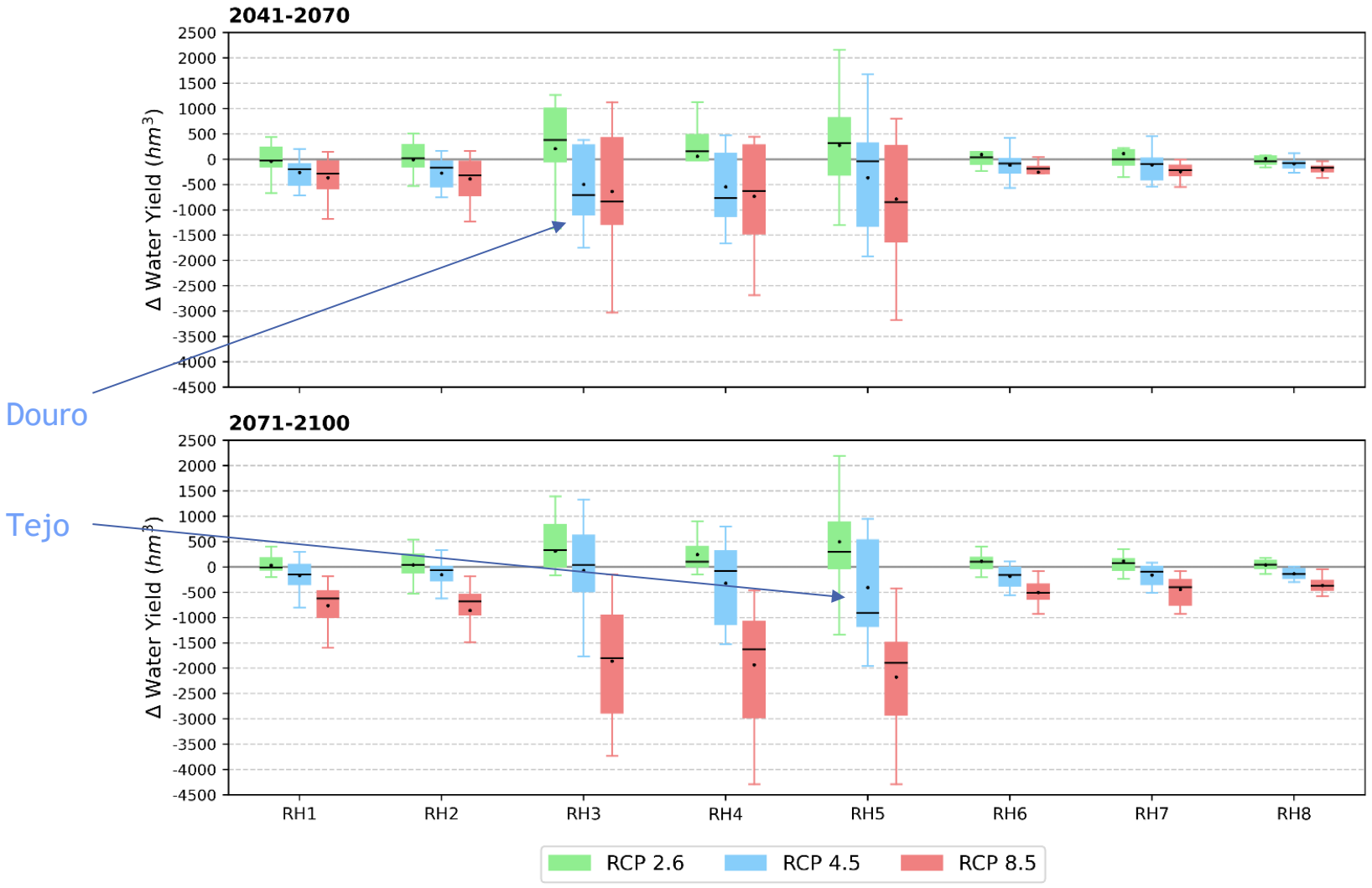


N	Aproveitamento Hidroagrícola	Bacia Hidrográfica	Origem da água (Albufeiras)
1	Macedo de Cavaleiros	Douro	Azibo
2	Cova da Beira	Douro	Sabugal
2	Cova da Beira	Tejo	Meimoa
3	Divor	Tejo	Divor
4	Vale do Sorraia	Tejo	Maranhão
4	Vale do Sorraia	Tejo	Montargil
5	Minutos	Tejo	Minutos
6	Idanha-a-Nova	Tejo	Idanha
7	Baixo Mondego	Mondego	Mondego
8	Campilhas e Alto Sado	Sado	Monte da Rocha
8	Campilhas e Alto Sado	Sado	Fonte Serne
8	Campilhas e Alto Sado	Sado	Campilhas
8	Campilhas e Alto Sado	Sado	Monte Gato
8	Campilhas e Alto Sado	Sado	Monte Migueis[9]
9	Mira	Mira	Santa Clara
10	Odivelas	Sado	Odivelas
11	Roxo	Sado	Roxo
12	Vale do Sado	Sado	Pêgo do Altar
12	Vale do Sado	Sado	Vale do Gaio
13	Alqueva (EFMA)	Guadiana	Alqueva
14	Caia	Guadiana	Caia
15	Lucefecit	Guadiana	Lucefecit
16	Sotavento Algarvio	Guadiana	Beliche
16	Sotavento Algarvio	Guadiana	Odeleite
17	Vigia	Guadiana	Vigia
18	Alvor	Odeáxere	Bravura
19	Silves Lagoa e Portimão	Arade	Arade
19	Silves Lagoa e Portimão	Arade	Funcho

Modelling Sectoral Impacts | Water Resources and Agroforestry

Ciências ULisboa

Anomalies in Water Yield (hm^3)

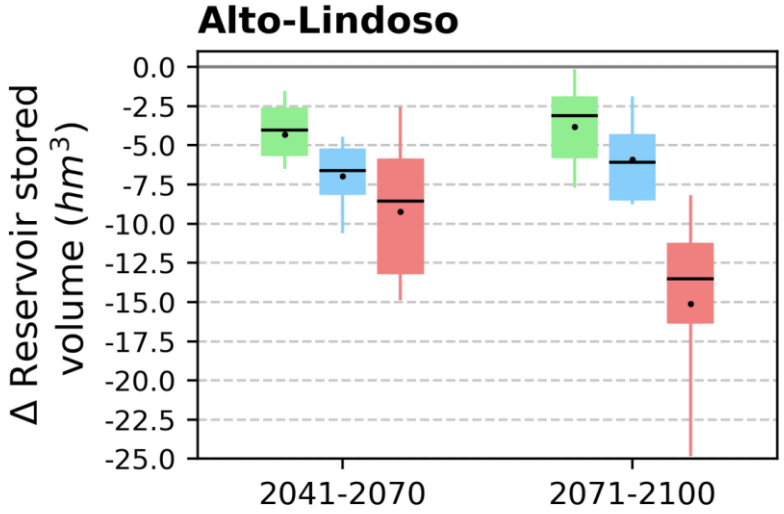


Losses in all RHs,except under RCP2.6 (Paris)

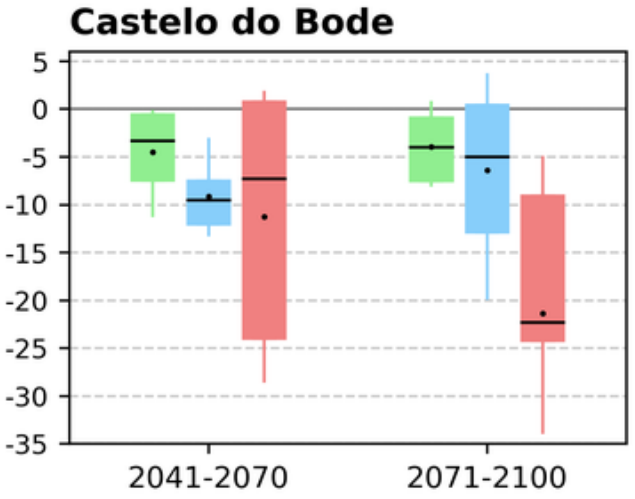
RH1 - Minho e Lima
RH2 - Cávado, Ave e Leça
RH3 – Douro
RH4 - Vouga, Mondego e Lis
RH5 - Tejo e Ribeiras do Oeste
RH6 – Sado e Mira
RH7 - Guadiana
RH8 - Ribeiras do Algarve

Modelling Sectoral Impacts | Water Resources and Agroforestry

Anomalies in Volume Storage (hm^3)

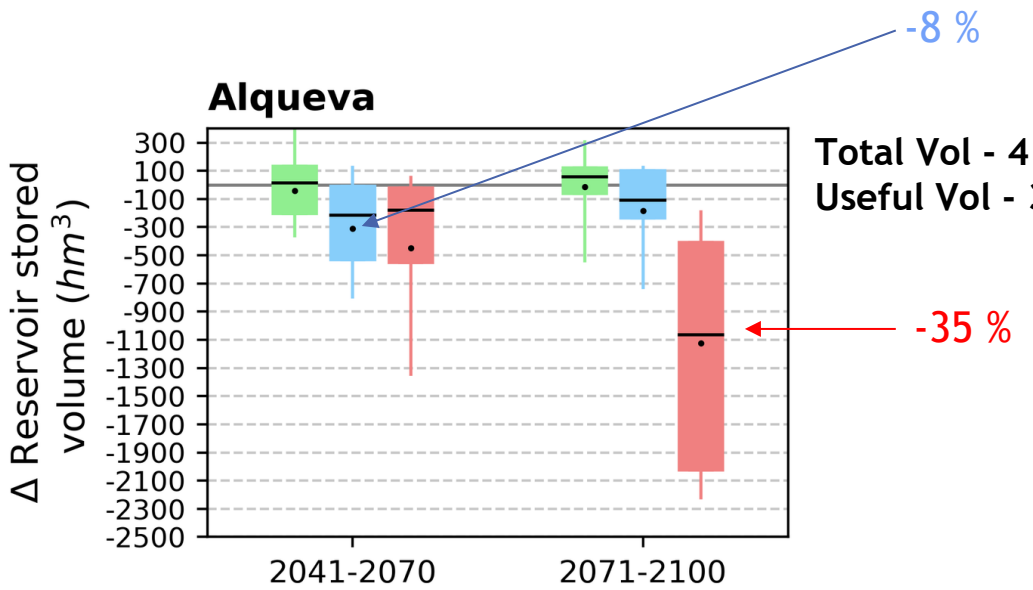


Total Vol - 390 hm^3
Useful Vol - 359 hm^3

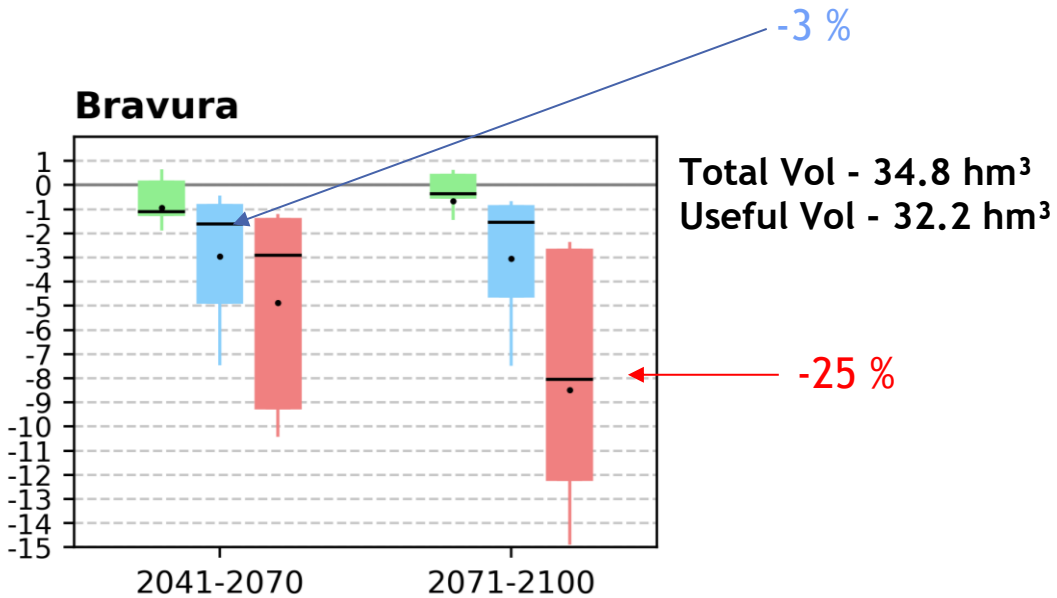


Total Vol - 1095 hm^3
Useful Vol - 900 hm^3

RCP 2.6
RCP 4.5
RCP 8.5



Total Vol - 4150 hm^3
Useful Vol - 3150 hm^3



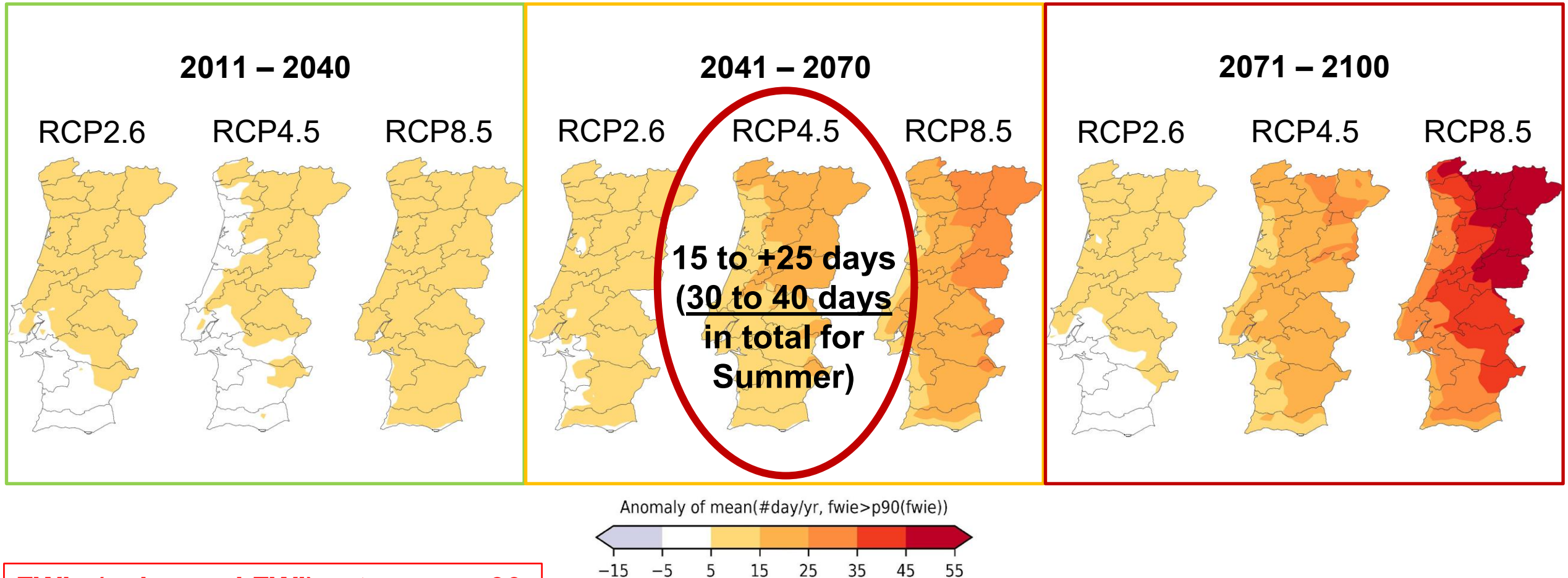
Total Vol - 34.8 hm^3
Useful Vol - 32.2 hm^3

Ciências ULisboa

Fires

Modelling Sectoral Impacts | Fires

Anomaly in the number of days per year in extreme fire weather index

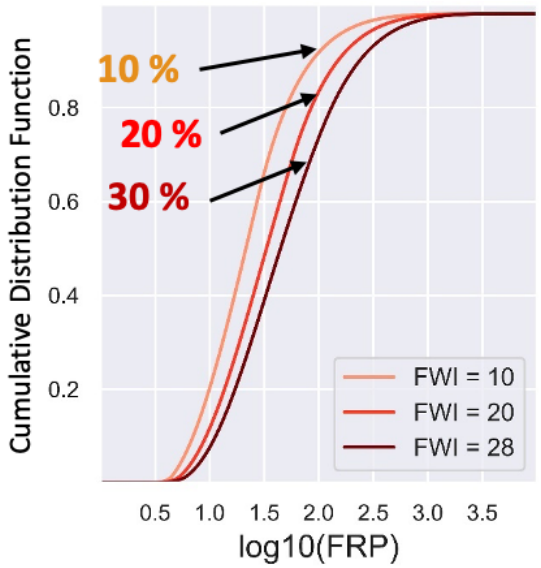


FWIe (enhanced FWI) extreme > p90

Historical period = **15 days on average**

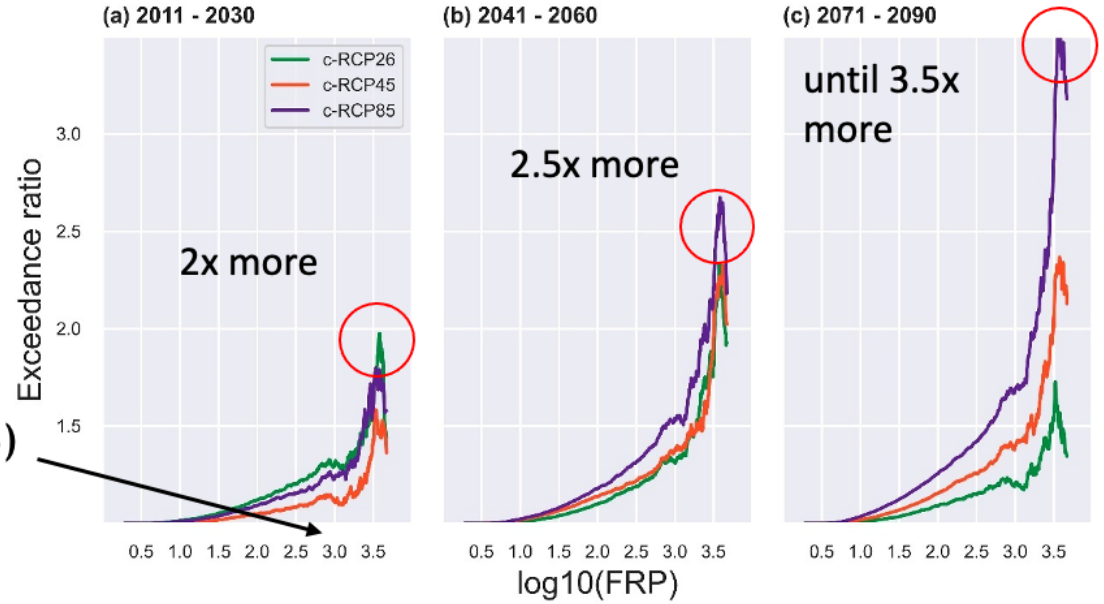
Bento et al. 2023

Modelling Sectoral Impacts | Fires

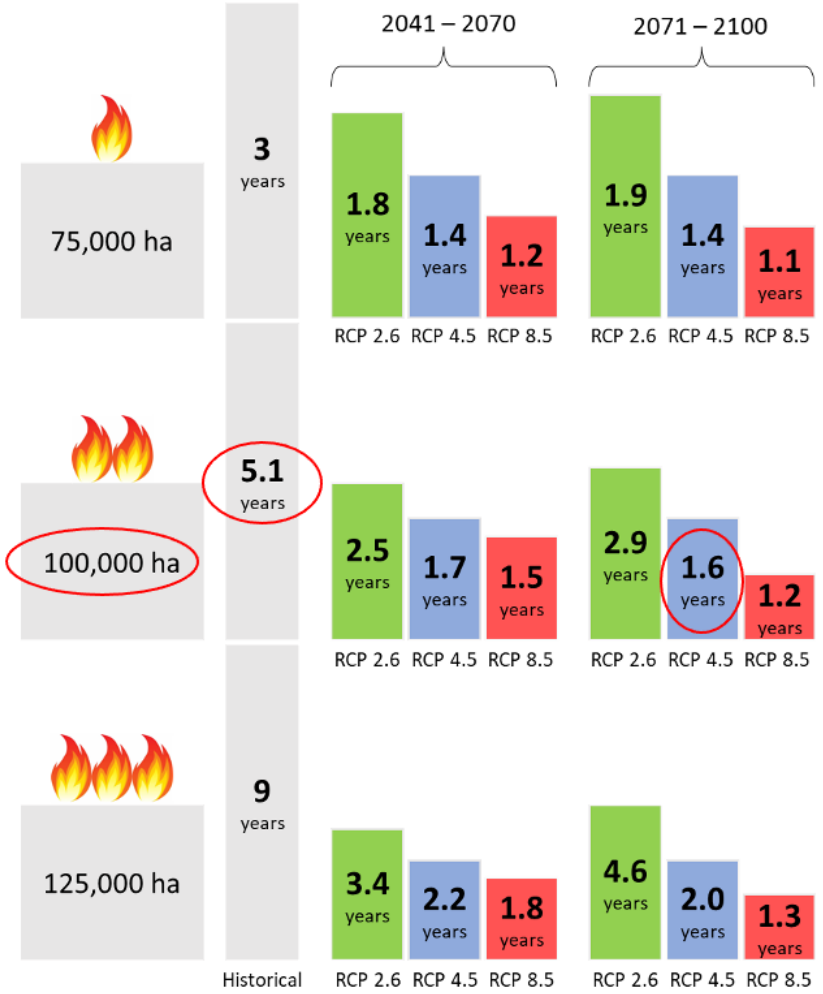


FRP - Fire Radiative Power

- The ignition hazard is not equivalent to the existence of a fire
- The model estimates the probability of ignition, and of FRP, based on the FWIe



Mega-Fires >1000MW
(log10(FRP) > 3)



Return period for burned areas

Centre RCP4.5

Ciências ULisboa

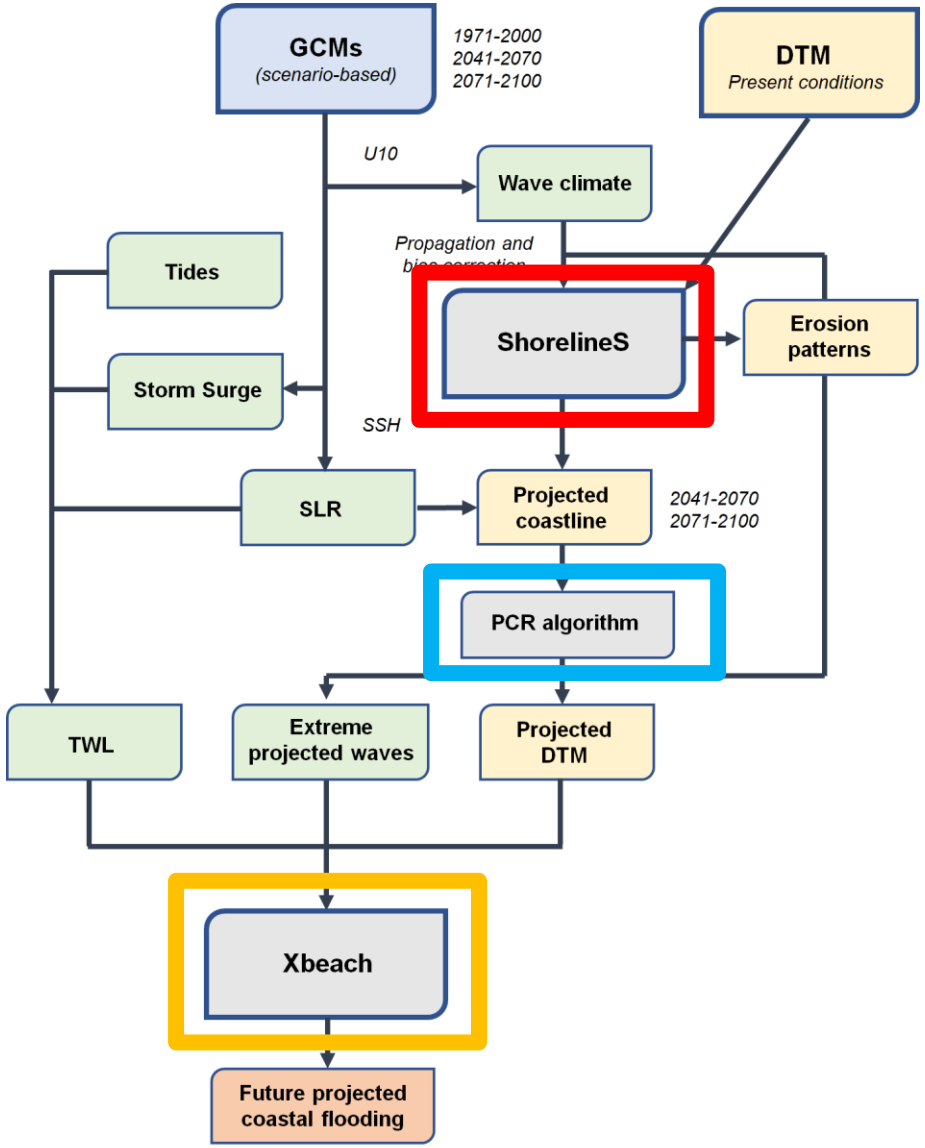
Coastal areas

Modelling Sectoral Impacts| Coastal areas

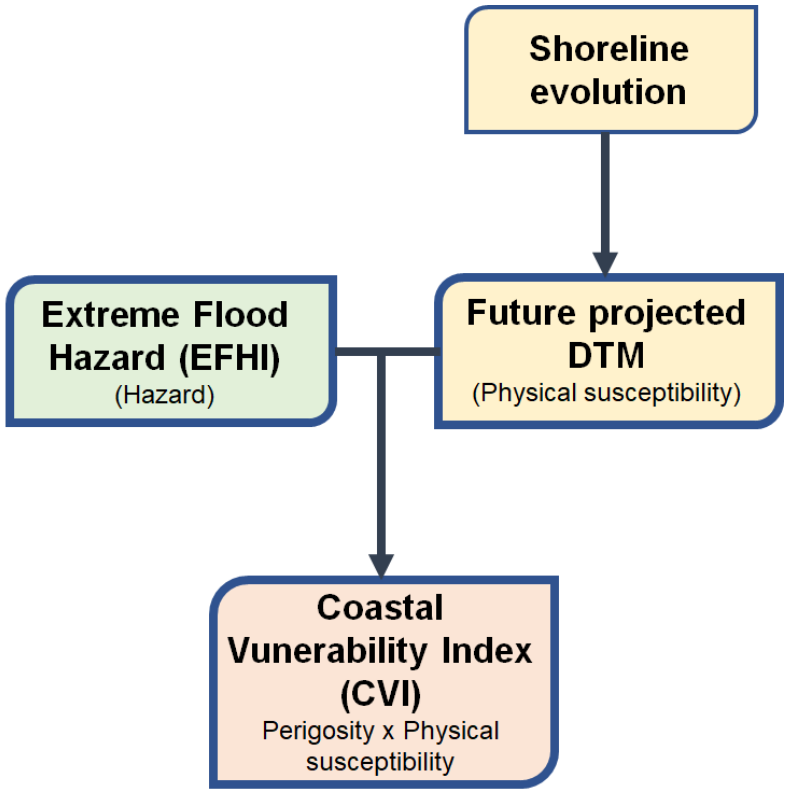
High resolution Dynamical Modelling

Local Sites & Calibration

- Ofir
- Costa Nova
- Cova Gala
- Costa da Caparica
- Praia de Faro



Parametric Modelling



Lemos et al. 2024

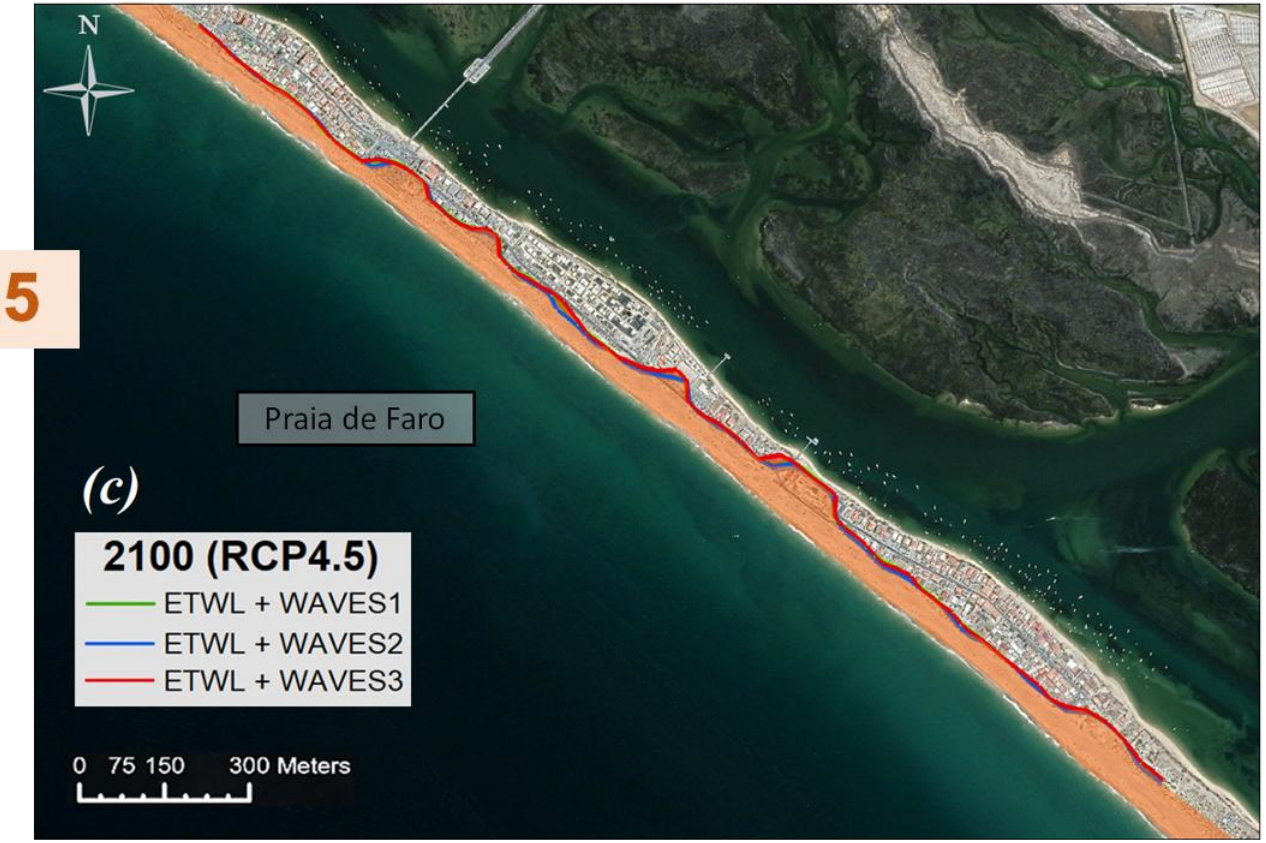
Modelling Sectoral Impacts| Coastal areas

ETWL – Extreme Total Water Level (return period 25 years) + Extreme waves events

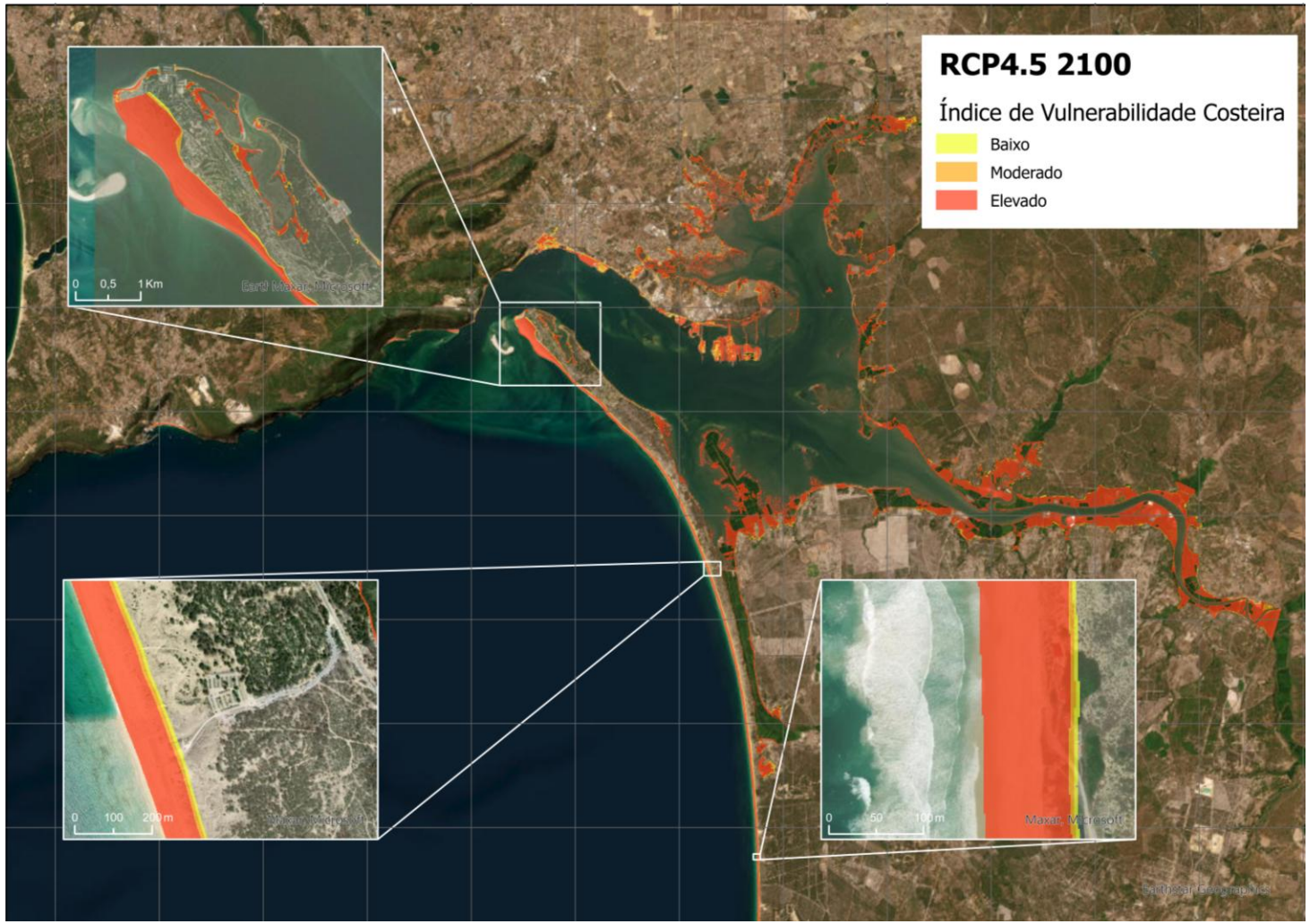
← **COSTA NOVA**
max spread Praia Velha ~400m
max spread Praia da Barra ~300m

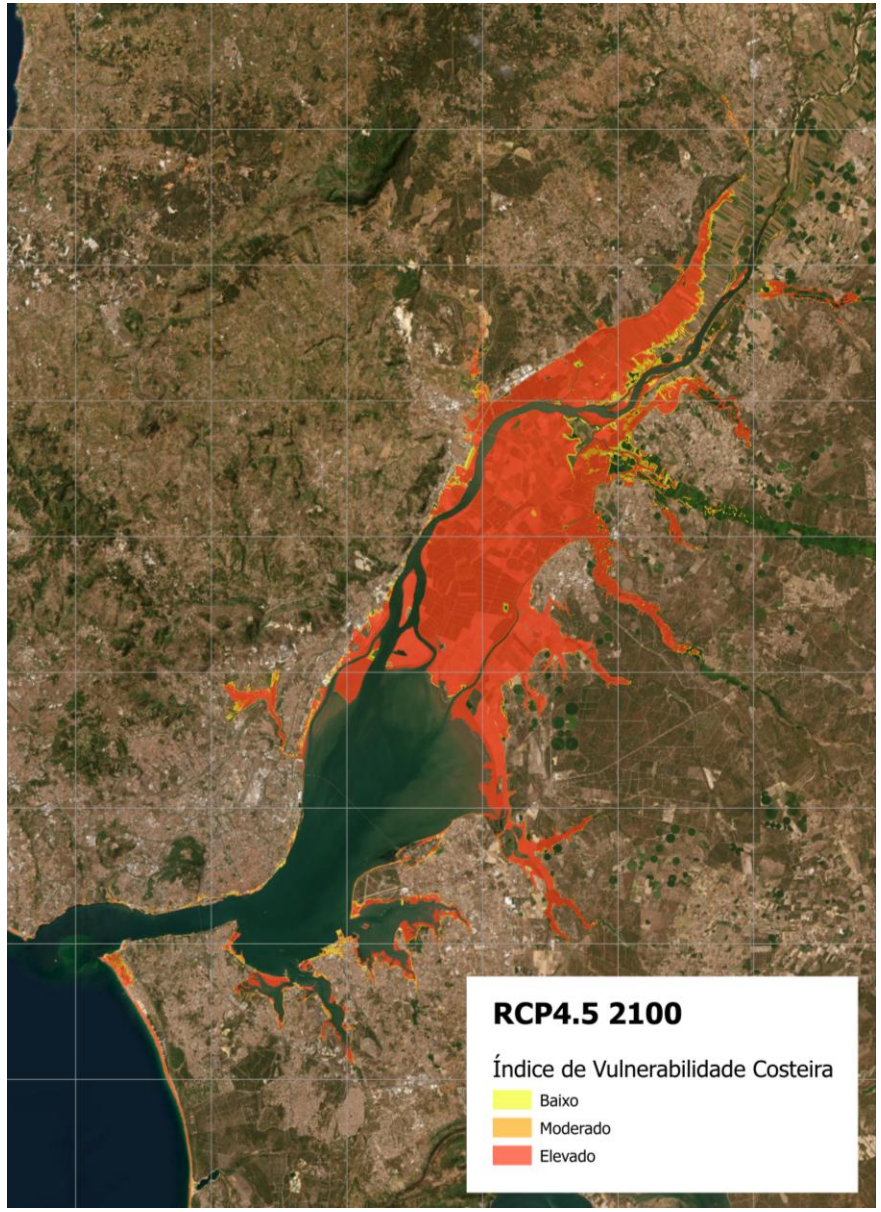
↓ **FARO BEACH**
climb the dune cord
break the island ~ 150 m

RCP4.5



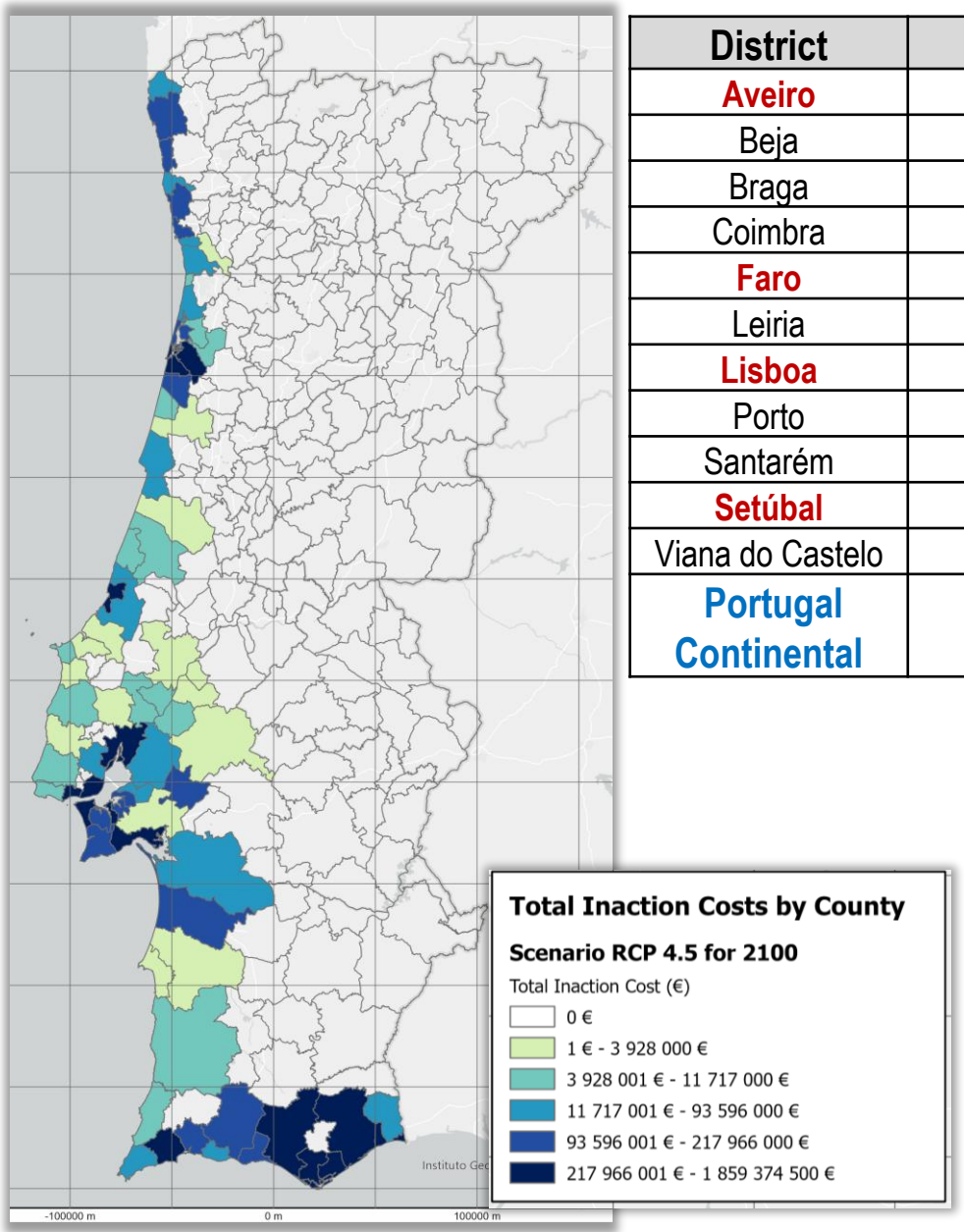
Modelling Sectoral Impacts| Coastal areas



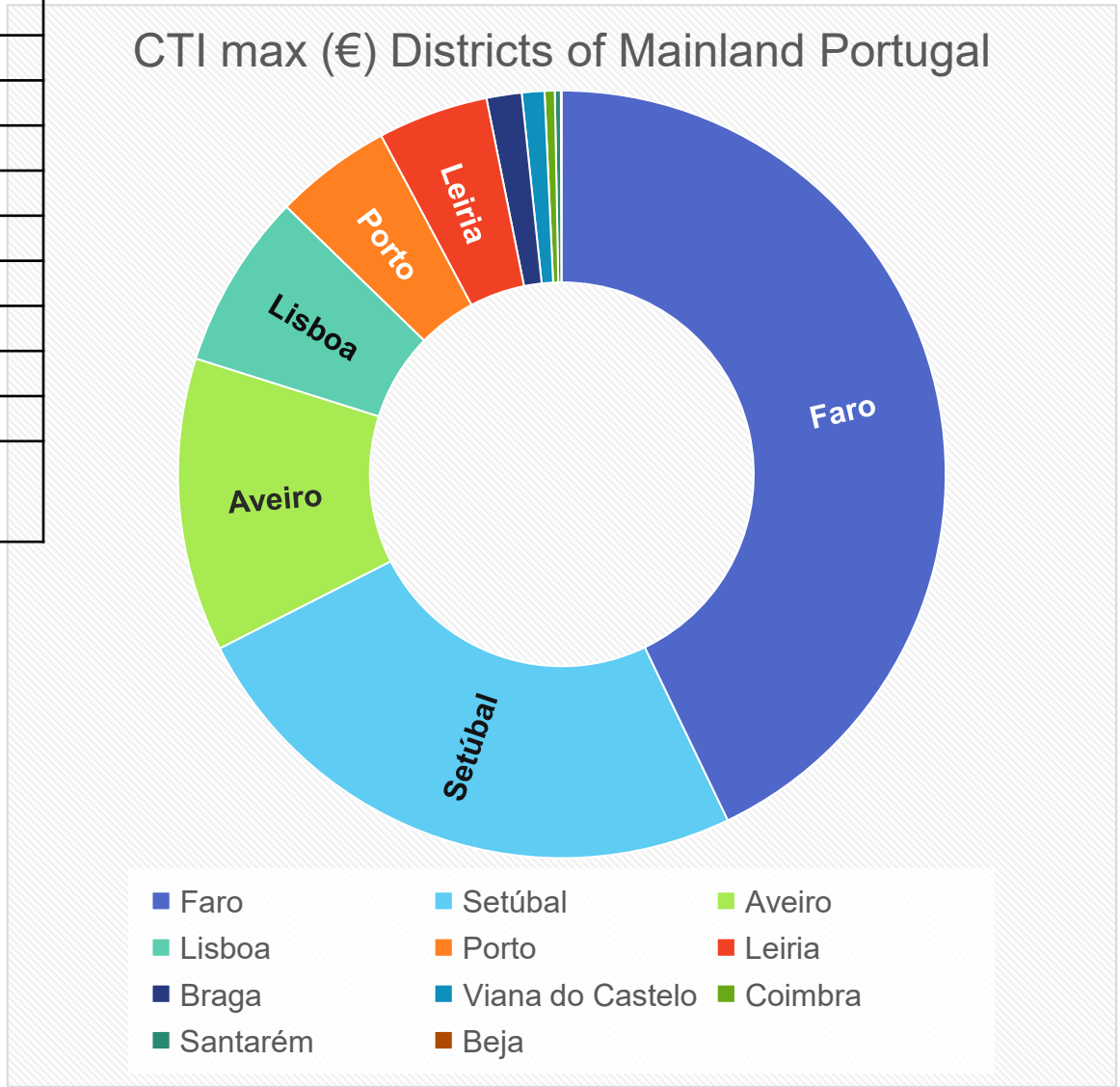


Inaction Costs
2100 (RCP4.5)

Modelling Sectoral Impacts| Coastal areas

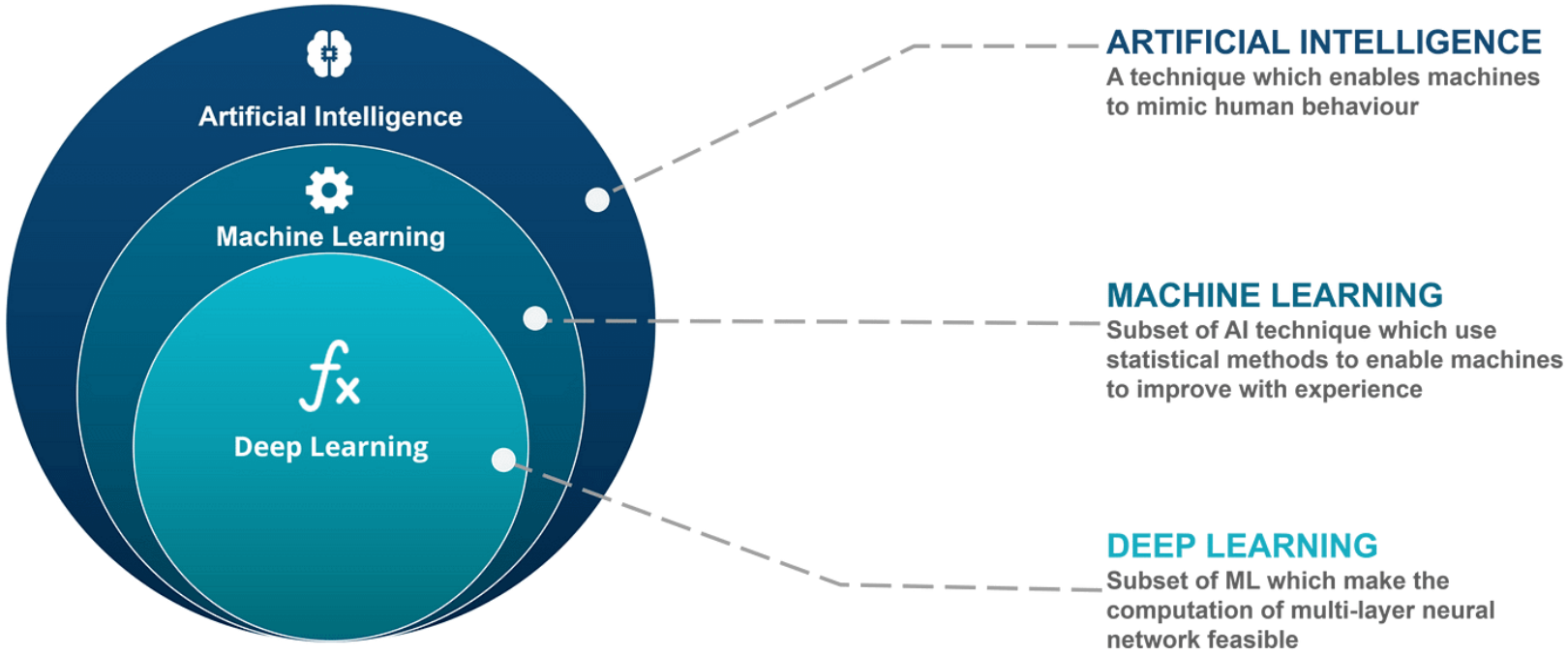


District	CTI max (M€)
Aveiro	**1 425.3**
Beja	4.2
Braga	218.0
Coimbra	55.4
Faro	**4 957.8**
Leiria	572.2
Lisboa	**1 099.0**
Porto	609.4
Santarém	62.8
Setúbal	**2 982.1**
Viana do Castelo	149.5
Portugal Continental	**12 135.7**



Global to local | Leveraging Climate Modelling and AI

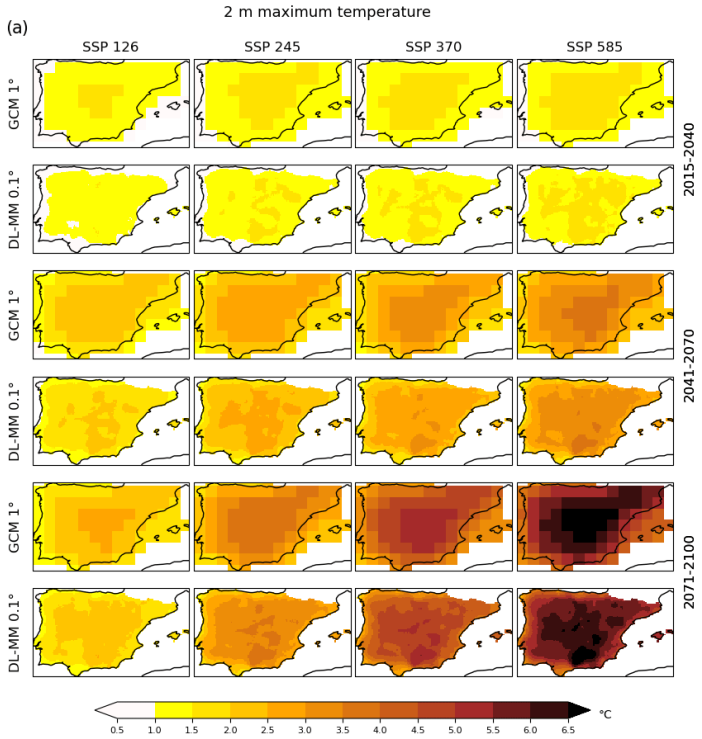
AI Machine Learning (ML) in Climate Sciences

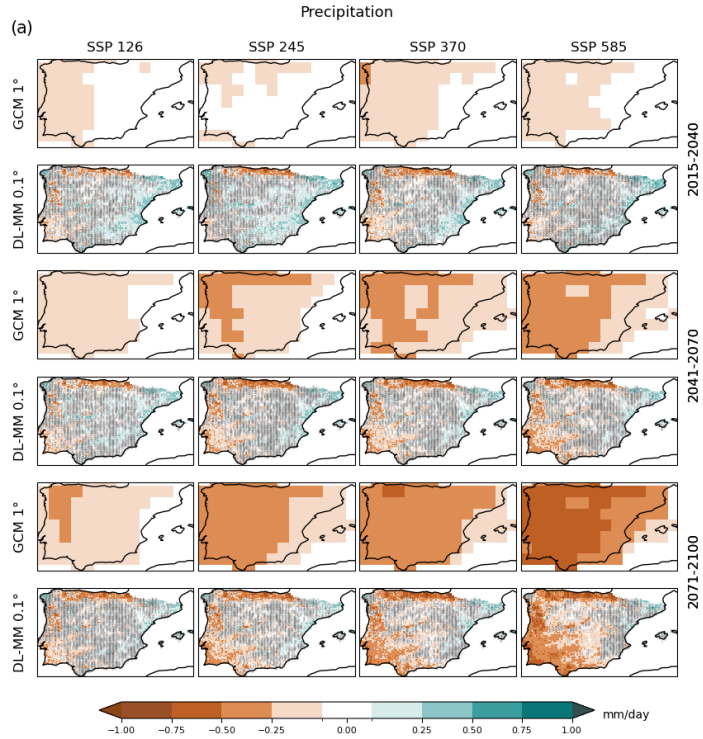


AI for Downscaling Regional Iberia – Deep Learning (DL)

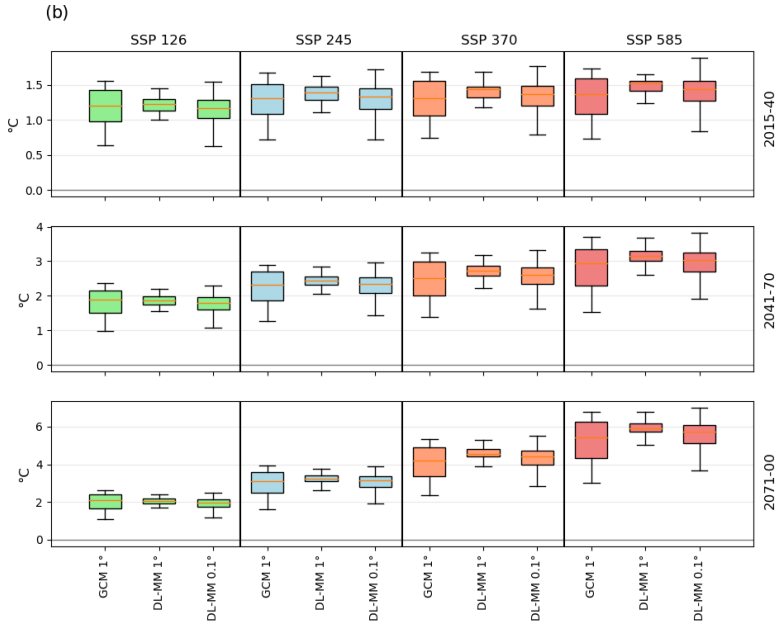
AI for Urban Climate - Deep Learning (DL), Machine Learning (ML, eXtreme Gradient Boosting)

DL for Iberia Future Projections

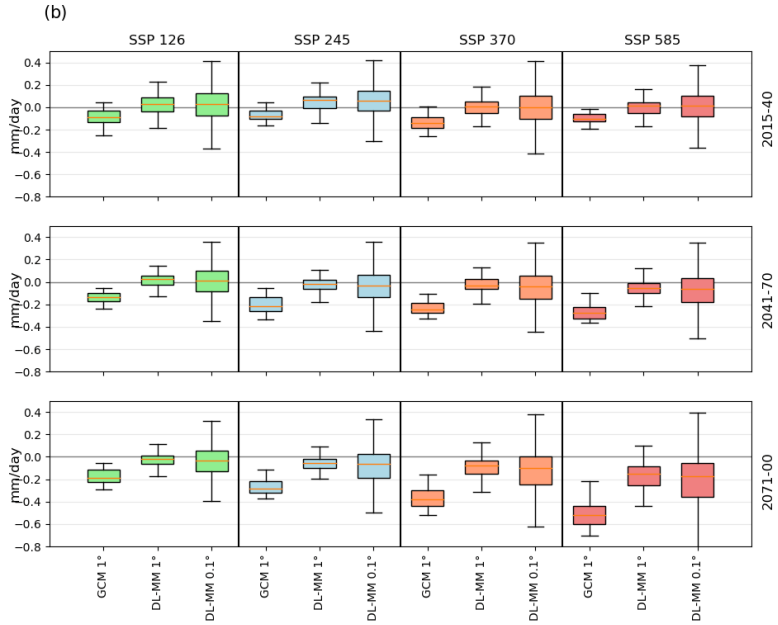




Tmax



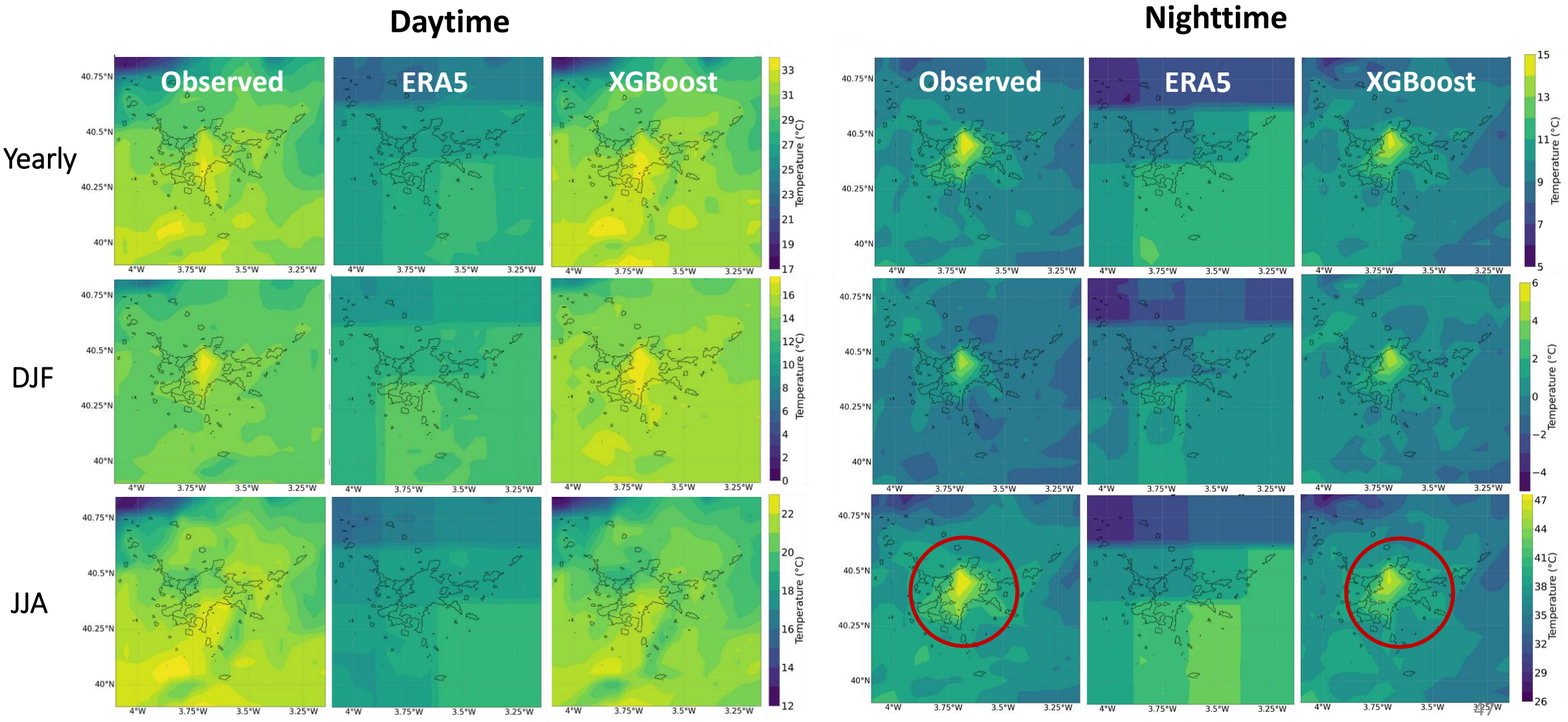
Precipitation



Soares et al., 2024

ML (XGBoost) for Urban Climate

Spatial characterization of Land Surface Temperature (2017-2022)



Bushenkova et al., 2024

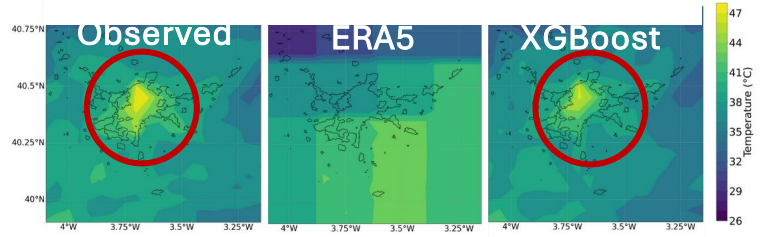
Urban Heat Island | Madrid and Paris | ML

Madrid | SUHI and UHI | Present Climate

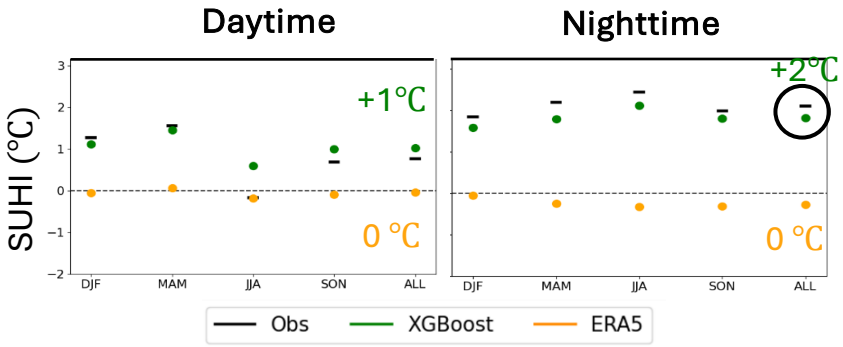
Land Surface Temperature (2017-2022)

Nighttime

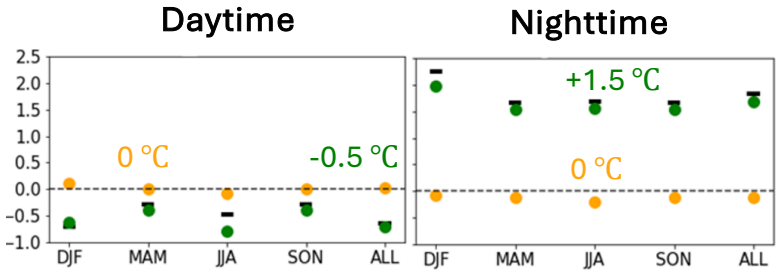
JJA



SUHI (2017-2022)

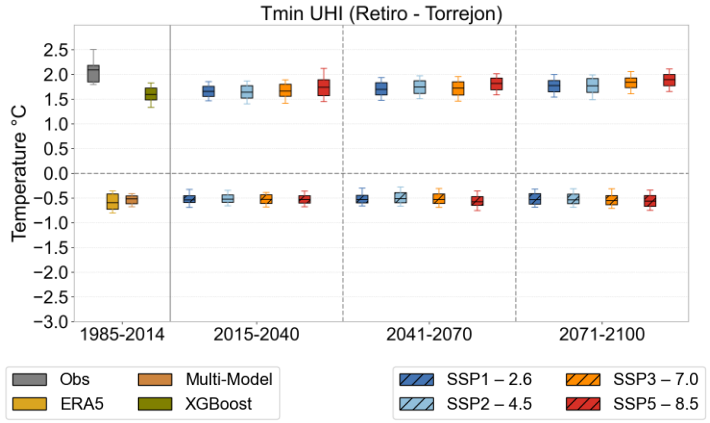


UHI (2016-2022)



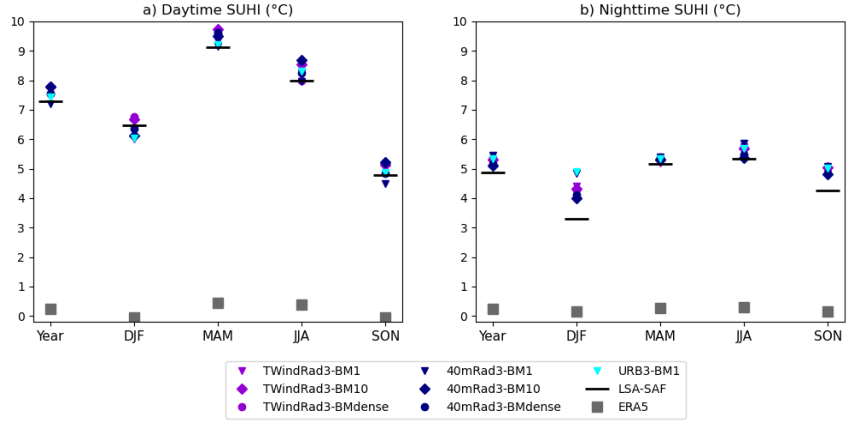
5 stations
1 urb
4 rur

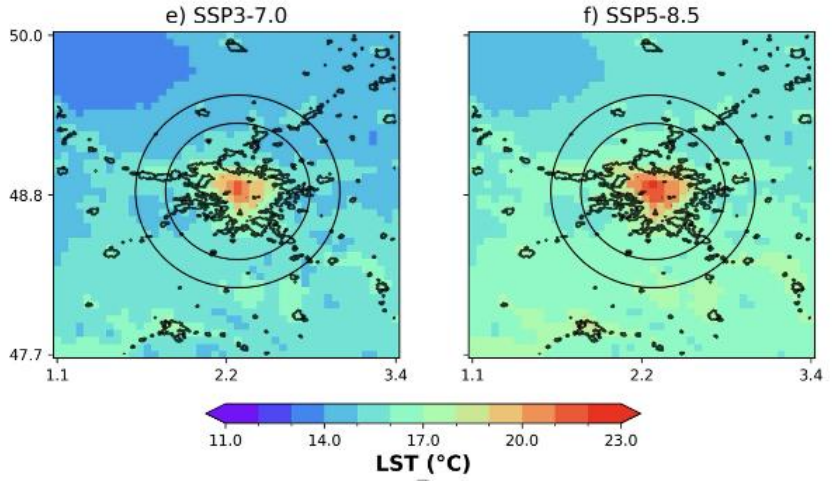
Madrid | UHI | Future Climate



UHI – Urban Heat Island effect
SUHI – Surface Urban Heat Island effect

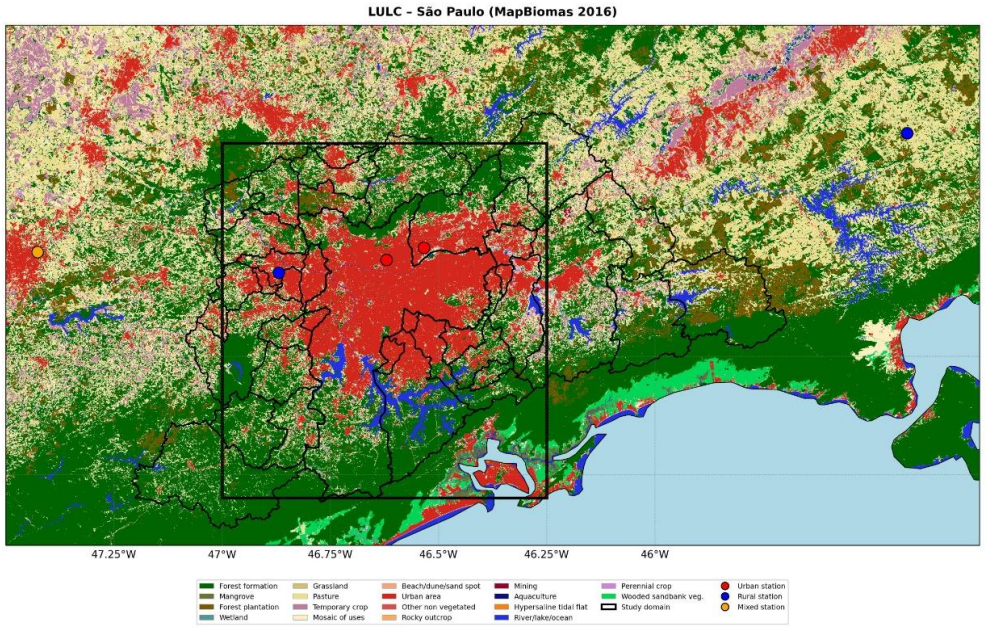
Paris SUHI | Present and Future Climate

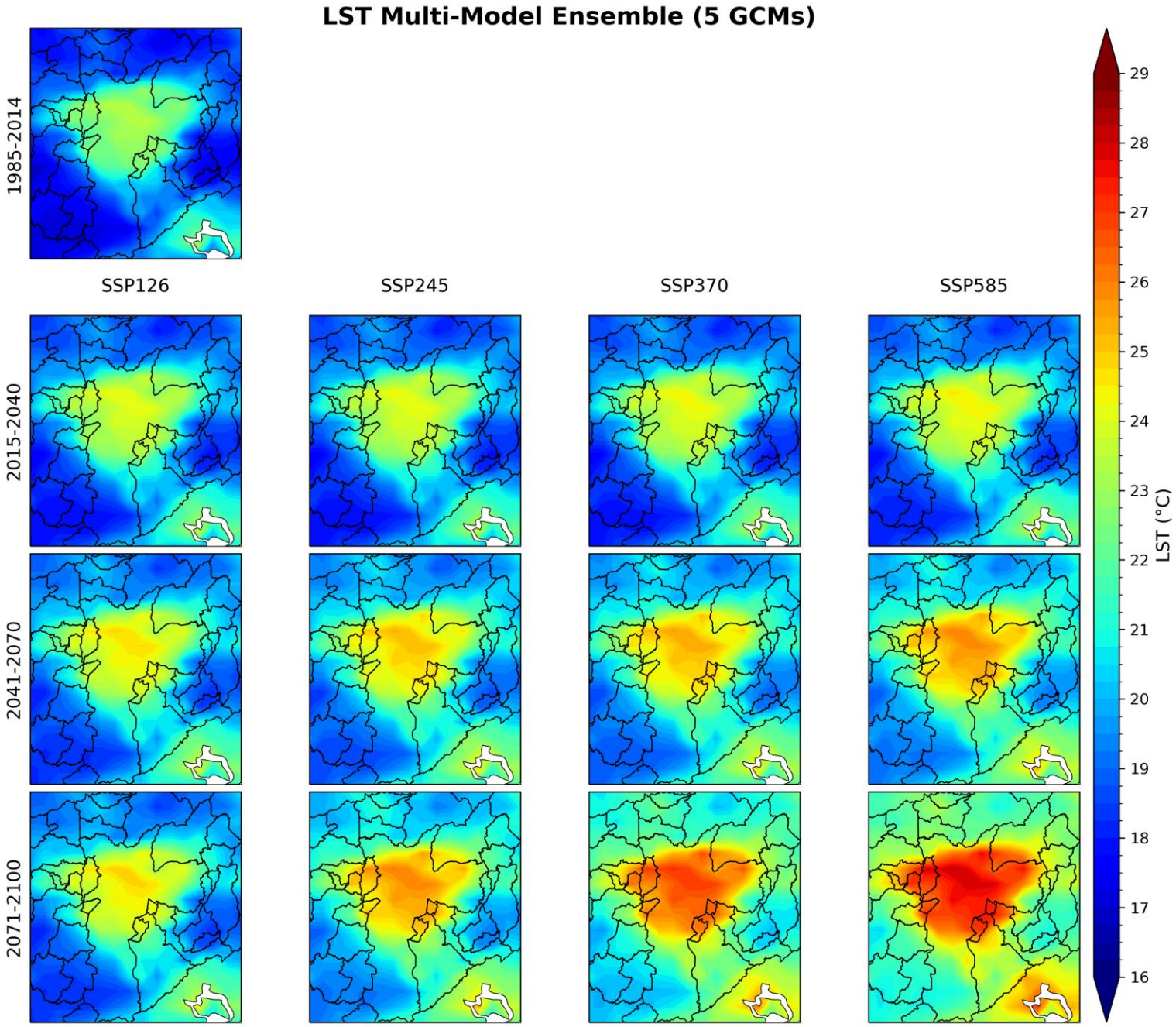




Johannsen et al., 2024; Bushenkova et al., 2024

Surface Urban Heat Island
São Paulo megacity | DL

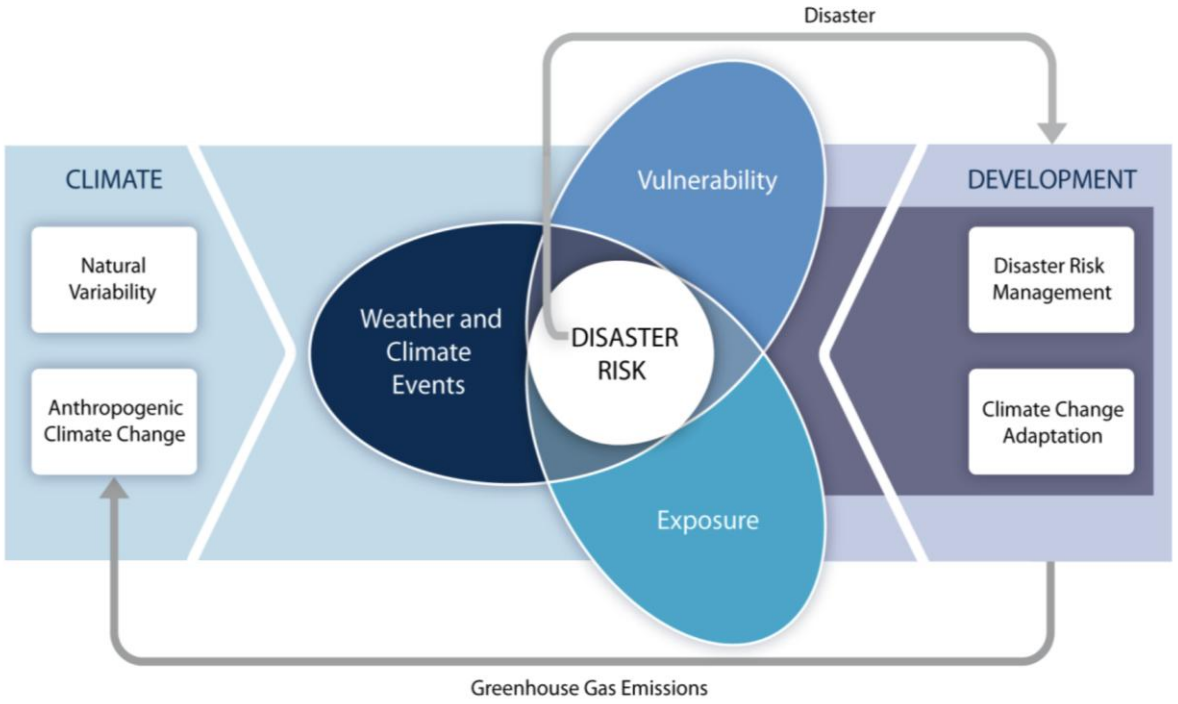




Bushenkova et al. 2026

Understanding Risk | Example of Heatwaves in Barcelos

Hazard (1 a 5) × **Exposure** (1 a 5) × **Vulnerability** (1 a 5) = **Risk** (1 a 125) ⟶ (1 a 5)



Fonte: IPCC

5 Very high

4 High

3 Moderate

2 Low

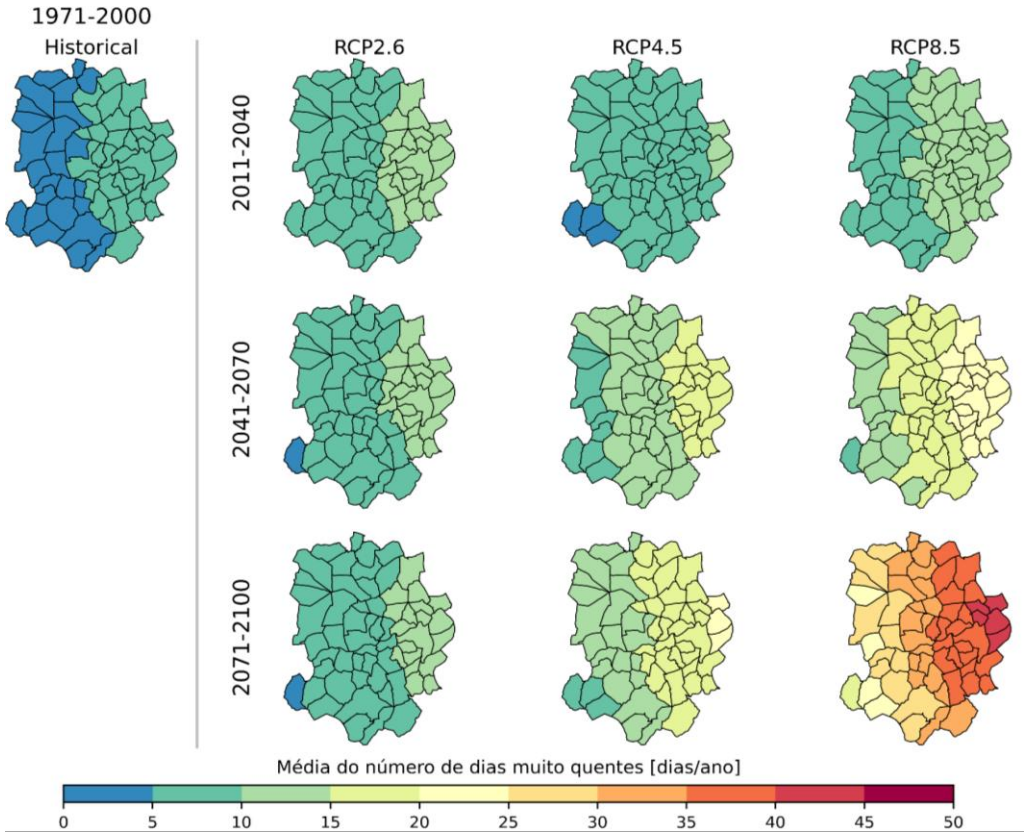
1 Very low

Understanding Risk | Hazard | Exposure

Exposure

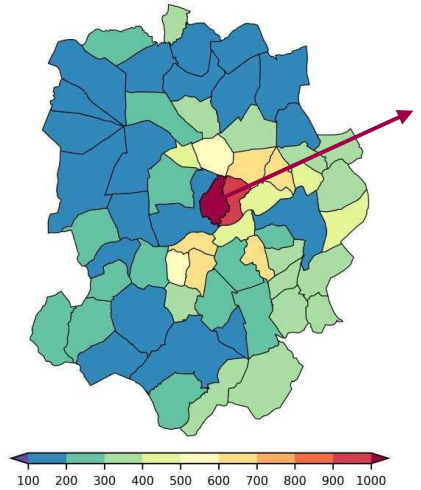
Hazard

Perigosidade - Exemplo de projeções climáticas



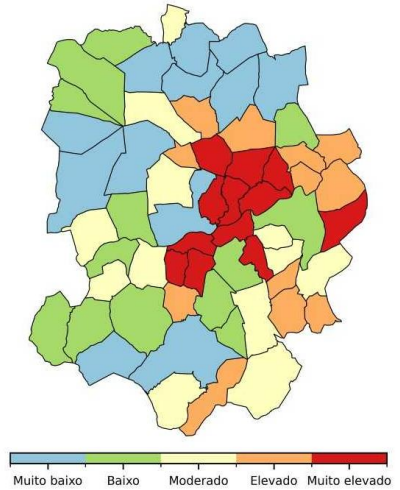
Exposição	Variável	Intervalos de classificação (classes)				
		1	2	3	4	5
Freguesias	Densidade populacional [%]	0 – 20	20 – 40	40 – 60	60 – 80	80 – 100
Infraestruturas críticas	Número total de ocupantes (trabalhadores, alunos, utentes, etc.) [%]	0 – 20	20 – 40	40 – 60	60 – 80	80 – 100
	Tipologia do edifício	Administrativo	–	Cultural	–	Social / Educativo

Densidade Populacional [$n^{o}\ hab/km^2$]



Arcozelo: 3732.56

Percentil Densidade Populacional



Understanding Risk | Vulnerability

Vulnerabilidade (classes)

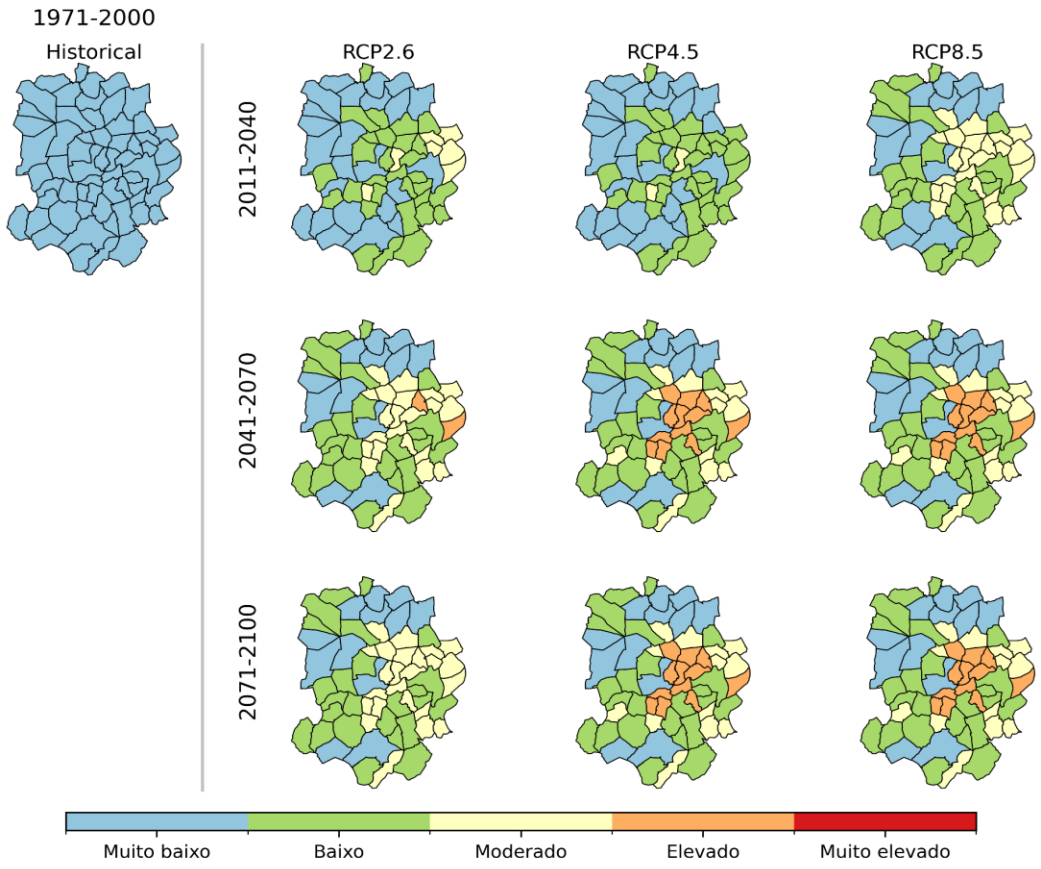
Freguesias

	Elemento vulnerável	Variável climática	Vulnerabilidade	Intervalos de classificação (classes)				
				1	2	3	4	5
Temperatura	Pessoas	OC	Faixas etárias	–	15 – 25 25 – 45	45 – 65	–	0 – 15 65+
	Pessoas	TxG35	Faixas etárias	–	15 – 25 25 – 45	45 – 65	–	0 – 15 65+
	Pessoas	TnG20	Faixas etárias	–	15 – 25 25 – 45	45 – 65	–	0 – 15 65+
	Pessoas	TnL0	Faixas etárias	–	15 – 25 25 – 45	45 – 65	–	0 – 15 65+
Precipitação	Pessoas	MaxPac5d	Altitude média	0 – 20	20 – 40	40 – 60	60 – 80	80 – 100
			Declive médio	0 – 20	20 – 40	40 – 60	60 – 80	80 – 100
	Pessoas	PacG50	Declive médio	0 – 20	20 – 40	40 – 60	60 – 80	80 – 100
			Percentagem de área urbana	0 – 10	10 – 20	20 – 30	30 – 40	40 – 100
Vento forte	Pessoas	MaxVh10	Percentagem de área urbana	0 – 10	10 – 20	20 – 30	30 – 40	40 – 100
Risco de incêndio	Pessoas	FWIGP90	Percentagem de área florestal e de matos	0 – 10	10 – 20	20 – 30	30 – 40	40 – 100
			Percentagem de área ardida (2001–2022)	0 – 10	10 – 20	20 – 30	30 – 40	40 – 100

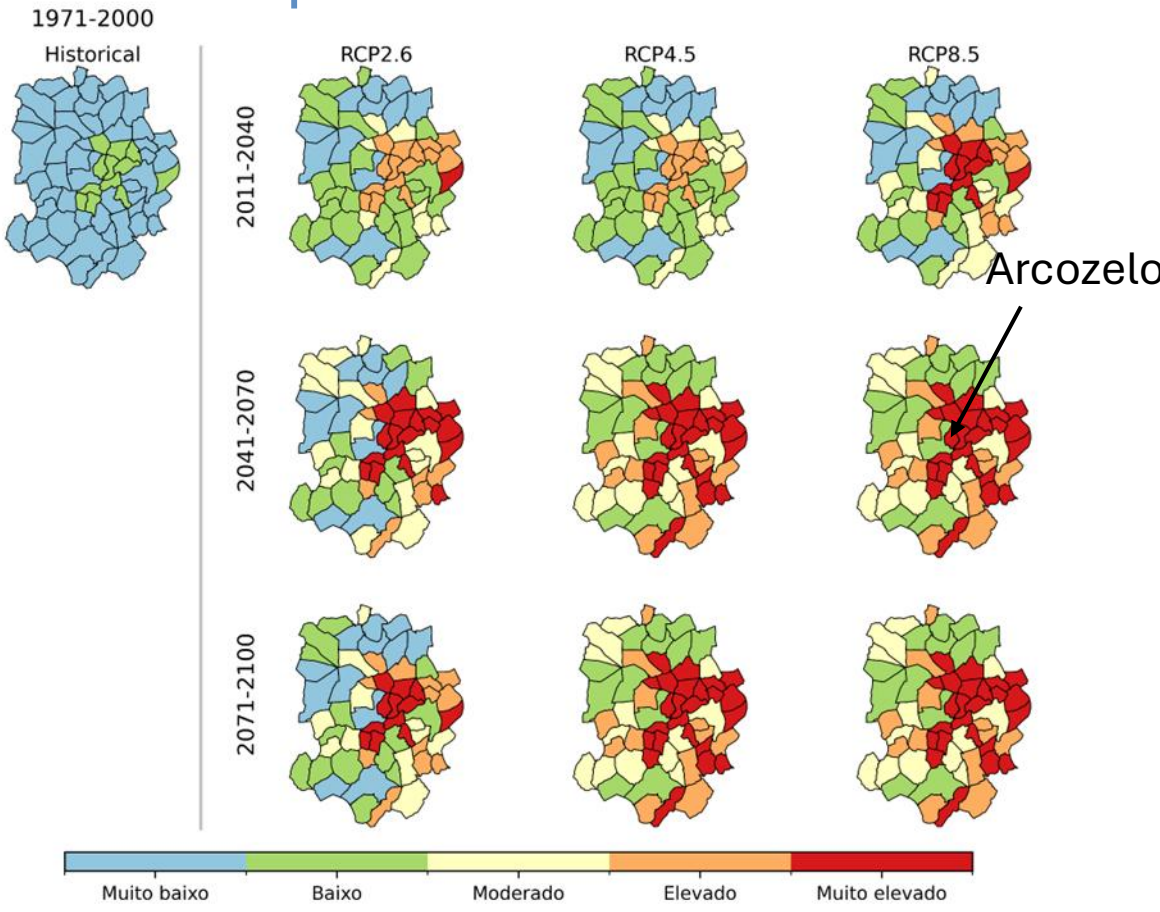
Understanding Risk | Temperature Extremes

Severidade das ondas de calor ⟶ Frequência x duração das ondas de calor

Todos os grupos etários



Grupos etários mais vulneráveis



Key messages

Climate change poses more than just a physical risk (hazard)

- Risks are dependent on level of exposure and vulnerability to hazards
- Governance needs to consider physical, transition and litigation risks

Governments, councils and businesses need to tackle climate risk without creating problems for the future (people and business)

There are co-benefits of tacking climate risk | Actions provide both adaptation and mitigation benefits.

From Risk to Action

- Climate Action Plans (CAPs) are investment roadmaps
- Align your strategy with high-resolution data and funding frameworks

Physics and AI as Your Climate Copilot - Combined Physics and AI models project local hazards and risk - allowing to optimize actions and decision-making

The Strategic Shift

Simulate. Adapt. Lead. That's the strategy behind resilient growth.

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INSTITUTO DOM LUIZ

Ciências ULisboa

Muito Obrigado

Pedro Matos Soares | pmsoares@fc.ul.pt | contact@phair-earth.com

phair-earth

Physics and AI for a Resilient Earth