ISA

2024-2025

Uso e Gestão do Território e da Água

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U LISBOA | UNIVERSIDADE DE LISBOA

INSTITUTO SUPERIOR DE AGRONOMIA

1 MOTIVAÇÃO

EXTREME EVENTS UNDER CLIMATE CHANGE CONDITIONS

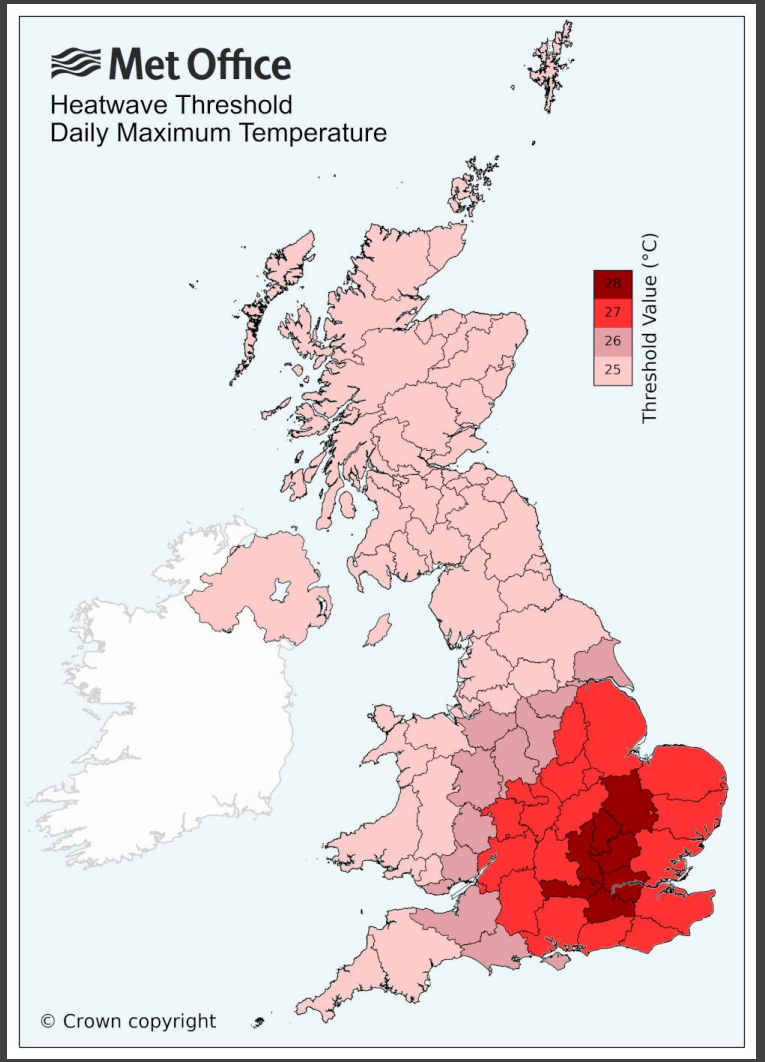
- Perigos naturais recordes ocorrem regularmente em todo o mundo, levando a uma variedade de impactos
- Desde 1970, houve mais de 11000 desastres relatados (2 milhões de mortes e US$ 3,64 trilhões em perdas)
- As secas e as ondas de calor estão incluídas no top 4 das catástrofes em termos de perdas humanas, com impactos desiguais em todo o mundo e uma elevada probabilidade de que as pressões climáticas antropogénicas aumentem a desigualdade económica entre os países

À medida que o aquecimento global progride, a probabilidade de ocorrência de grandes secas e Ondas de calor também aumenta

2 O que é uma onda de calor?

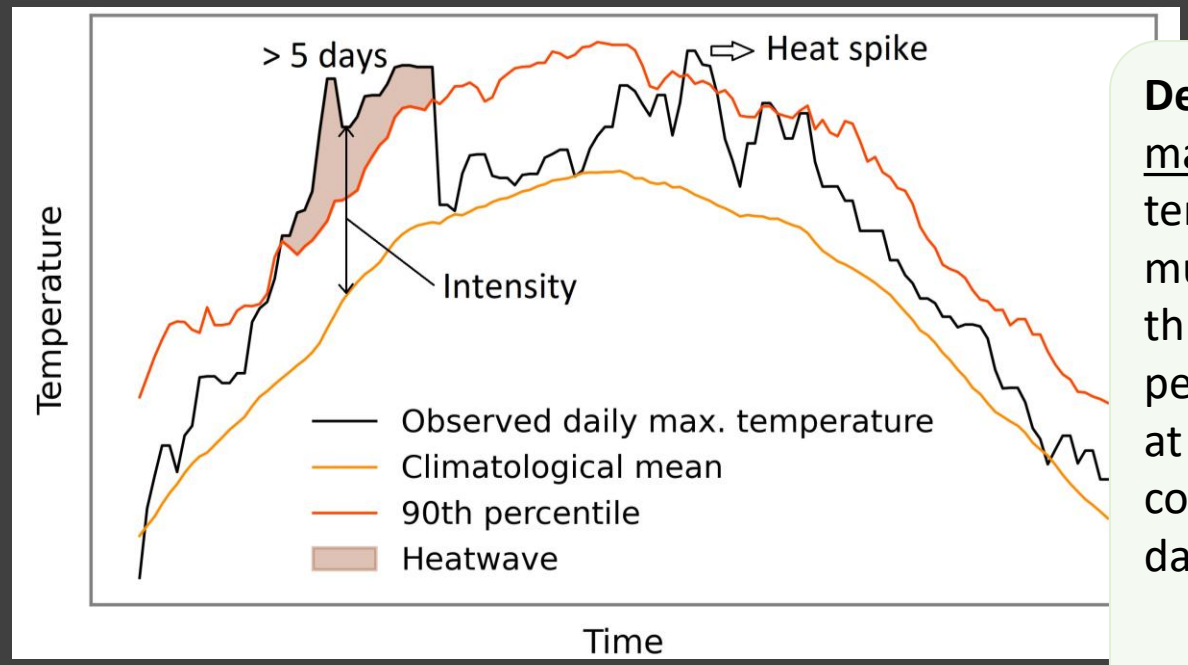
- Uma onda de calor é um período prolongado de tempo quente em relação às condições esperadas da área nessa época do ano, que pode ser acompanhado por alta humidade.

- Um limiar de onda de calor no Reino Unido é atingido quando um local regista um período de pelo menos três dias consecutivos com temperaturas máximas diárias que atingem ou excedem o limiar de temperatura da vaga de calor. O limiar varia consoante o condado do Reino Unido, ver o mapa do limiar de temperatura do Reino Unido abaixo.

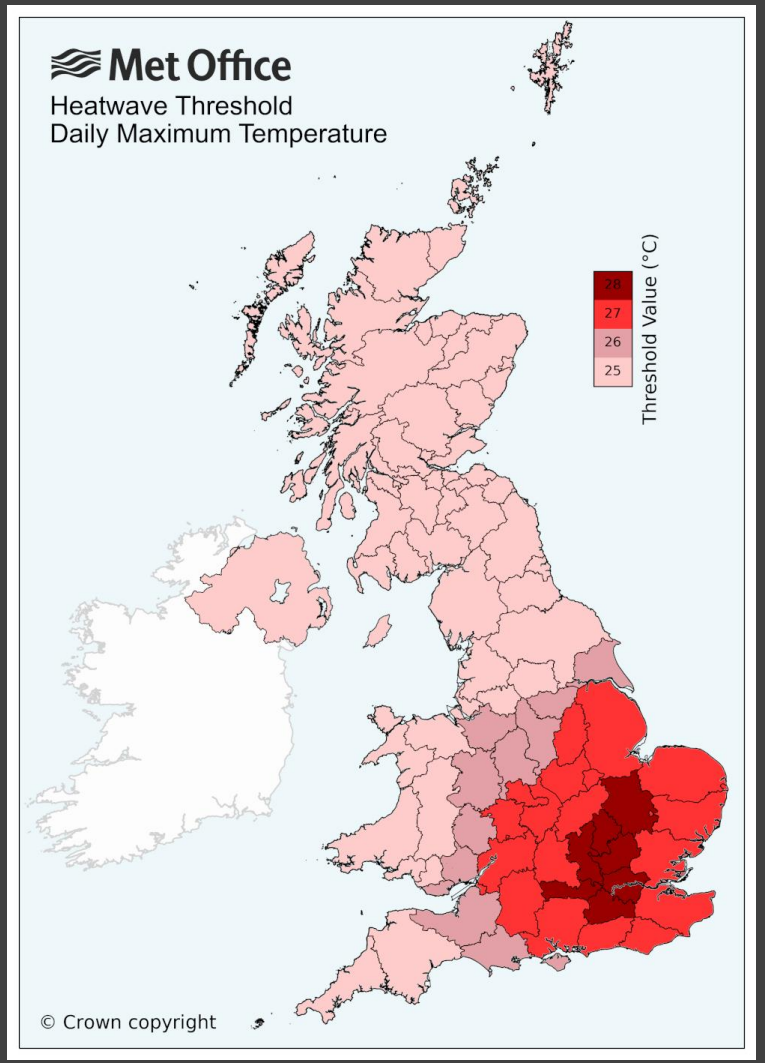


2 O que é uma onda de calor?

- Qual o problema de se usar thresholds?

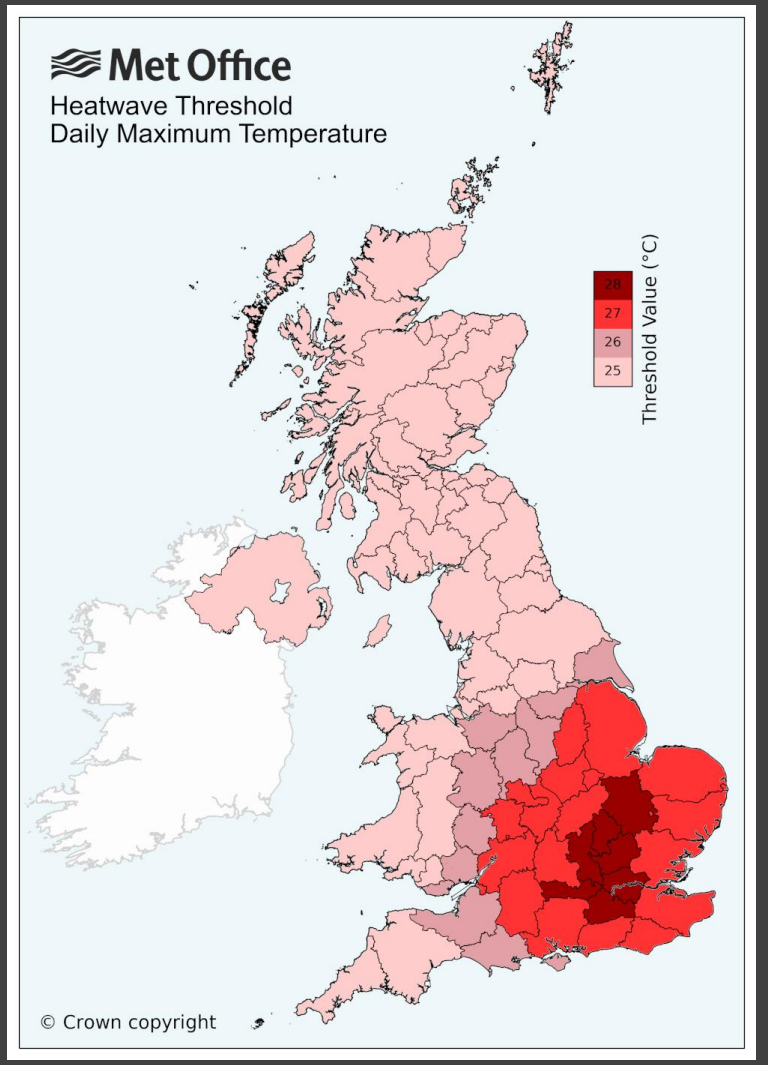


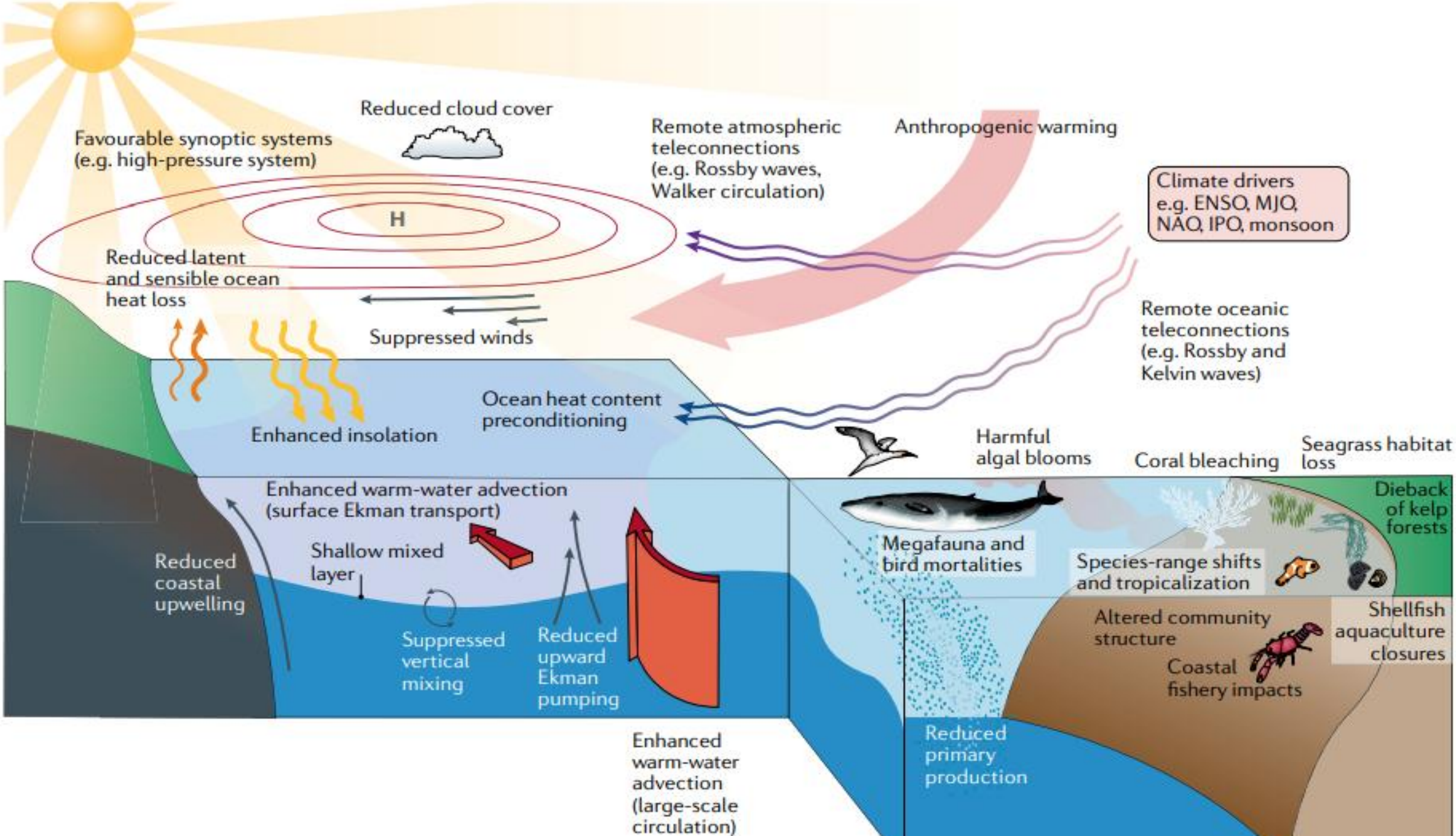
Definition: Daily <u>maximum</u> temperature must exceed the threshold (90th percentile) for at least 5 consecutive days.



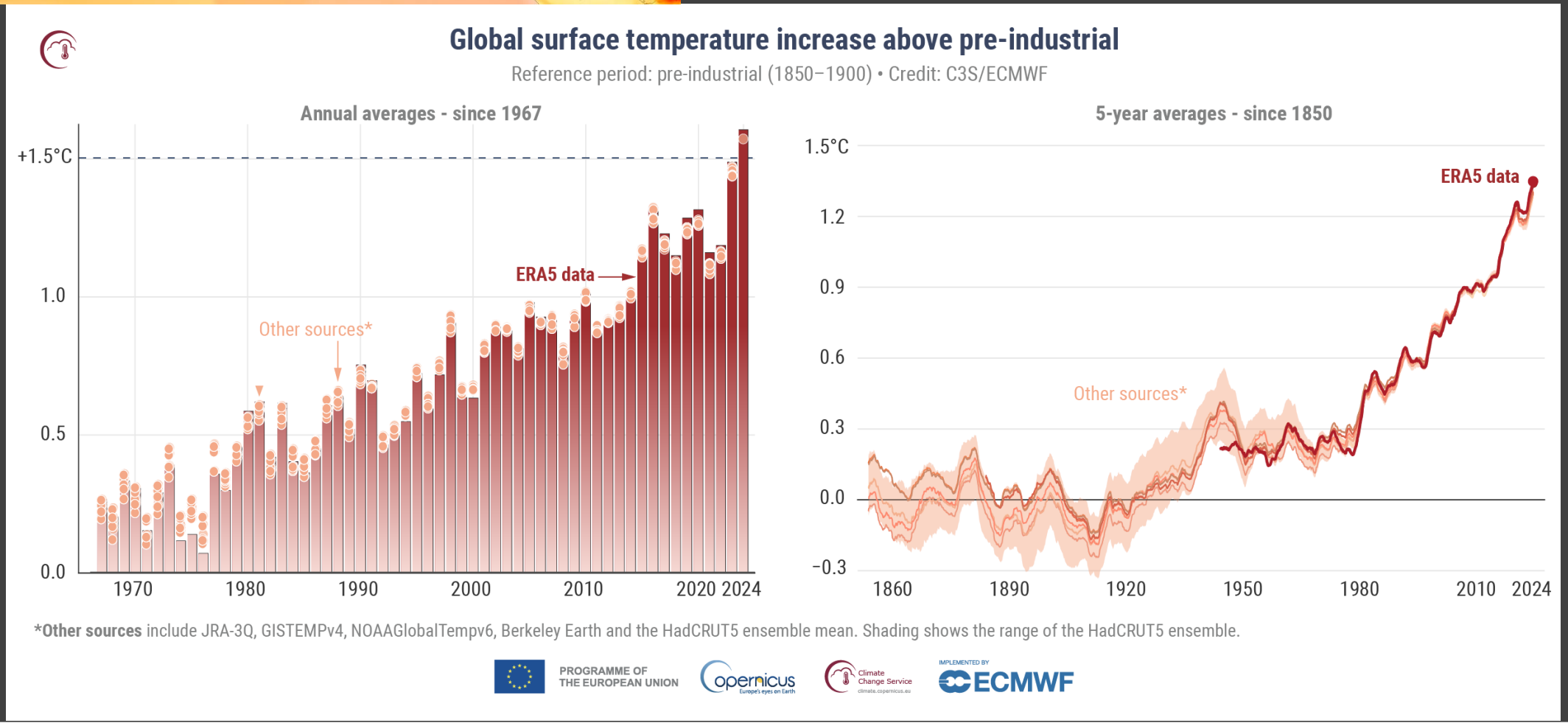
2 O que é uma onda de calor?

- As ondas de calor são mais comuns no verão, quando as alta pressões se desenvolvem ficando estáveis numa área. Os sistemas de alta pressão são lentos e podem persistir sobre uma área por um período prolongado de tempo, como dias ou semanas. Isso pode permitir que altas pressões se desenvolvam, resultando em tempo seco e persistente.




Favourable synoptic systems
(e.g. high-pressure system)
Reduced cloud cover
H
Reduced latent
and sensible ocean
heat loss
Suppressed winds
Remote atmospheric
teleconnections
(e.g. Rossby waves,
Walker circulation)
Anthropogenic warming
Climate drivers
e.g. ENSO, MJO,
NAO, IPO, monsoon
Remote oceanic
teleconnections
(e.g. Rossby and
Kelvin waves)
Enhanced insolation
Ocean heat content
preconditioning
Harmful
algal blooms
Coral bleaching
Seagrass habitat
loss
Dieback
of kelp
forests
Enhanced warm-water advection
(surface Ekman transport)
Shallow mixed
layer
Reduced
coastal
upwelling
Suppressed
vertical
mixing
Reduced
upward
Ekman
pumping
Megafauna and
bird mortalities
Species-range shifts
and tropicalization
Altered community
structure
Coastal
fishery impacts
Shellfish
aquaculture
closures
Enhanced
warm-water
advection
(large-scale
circulation)
Reduced
primary
production

2 O que é uma onda de calor?



2 O que é uma seca?

A Organização Meteorológica Mundial (OMM) define a **seca** como um período prolongado de escassez de precipitação, caracterizando-se por ser um fenómeno de início lento no ciclo climático natural que pode ocorrer em qualquer parte do mundo

2 O que é uma seca?

A OMM reconhece diferentes tipos de seca, incluindo:

- **Seca meteorológica**: ocorre quando há uma redução significativa na precipitação em relação aos valores normais de uma região.
- **Seca agrícola**: associada à insuficiência de humidade no solo para atender às necessidades das culturas, afetando a produção agrícola.
- **Seca hidrológica**: relacionada à diminuição dos níveis de água em rios, reservatórios e aquíferos, resultando em escassez hídrica para diversos usos.
- **Seca socioeconómica**: ocorre quando a escassez de água afeta negativamente a produção de bens e serviços, impactando a economia e a sociedade.

Essas definições destacam a complexidade da seca e seus impactos variados nos sistemas naturais e humanos.

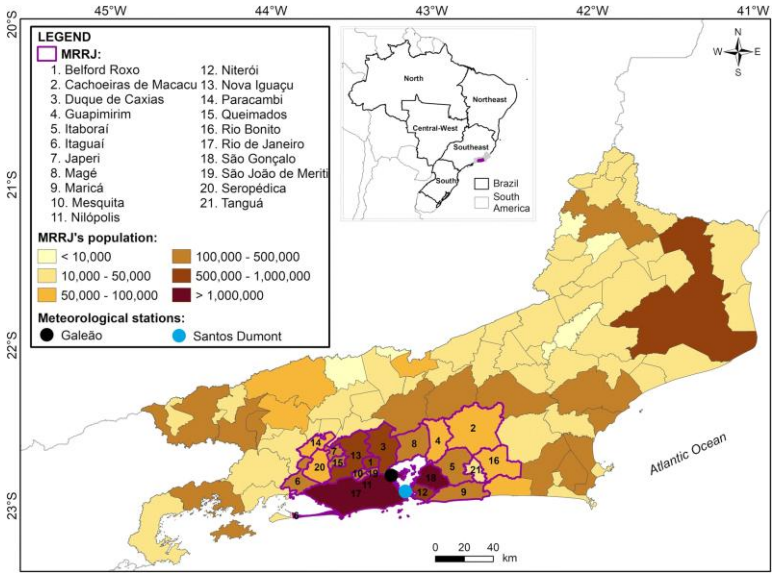
Daily summer mortality vs Tmax, Tmean and EHF (2000–2015)

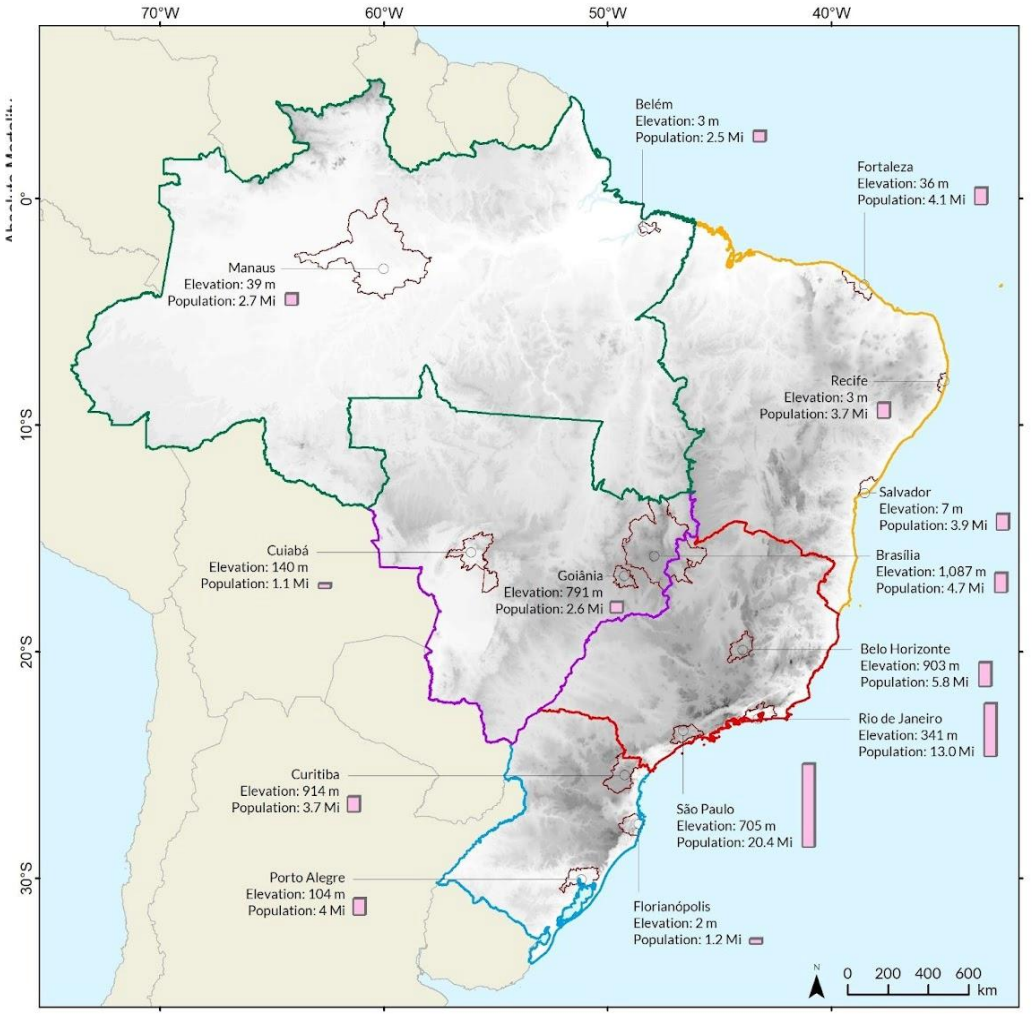
International Journal of Biometeorology
https://doi.org/10.1007/s00484-020-01908-x

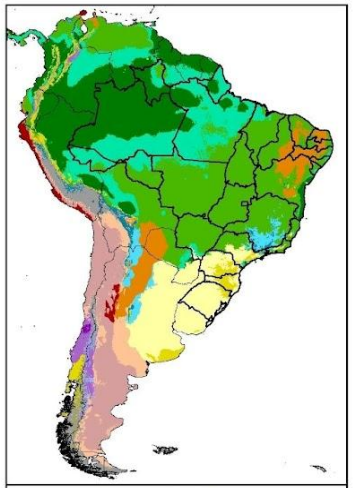
ORIGINAL PAPER

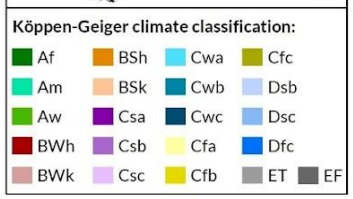
Heat-related mortality at the beginning of the twenty-first century in Rio de Janeiro, Brazil

João L. Geirinhas [1,2] · Ana Russo [1,2] · Renata Libonati [1,2,3,4] · Ricardo M. Trigo [1,2,3] · Lucas C. O. Castro [2,3] · Leonardo F. Peres [2,3] · Mônica de Avelar F. M. Magalhães [2,5] · Baltazar Nunes [2,6,7]









Meteorological stations
Metropolitan regions (MR)
MR 2020 population

Macroregions
North
Northeast
Central-West
Southeast
South

Elevation (m)
2956
1478
1

IMPACTOS 3
SAÚDE

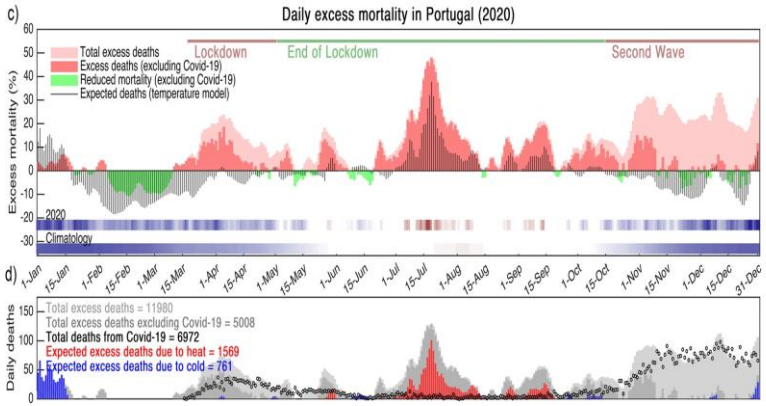
Statistical analysis and modelling of PED Fernando da Fonseca 2010-2017 (Admissions) using societal and meteorological variables

International Journal of Biometeorology (2022) 66:457–468
https://doi.org/10.1007/s00484-021-02192-z

ORIGINAL PAPER

Heat-related mortality amplified during the COVID-19 pandemic

Pedro M. Sousa[1,2] · Ricardo M. Trigo[2,3] · Ana Russo[2] · João L. Geirinhas[2] · Ana Rodrigues[4] · Susana Silva[4] · Ana Torres[4]



Analyses the influence of temperature in mortality during COVID using the EHF (Excess Heat Factor) index

Pediatric Emergency Care
Dedicated to the Care of the Ill or Injured Child
Articles & Issues · Collections · For Authors · Journal Info · CME

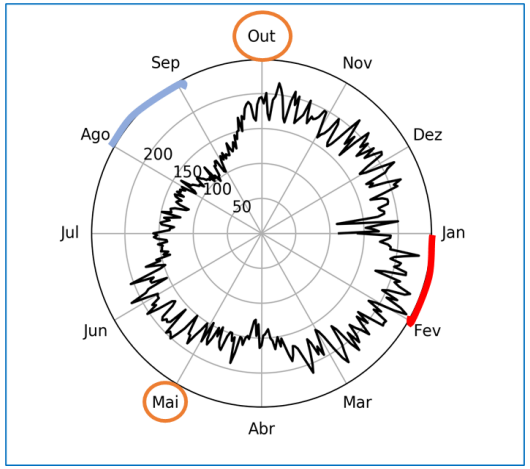
ORIGINAL ARTICLES

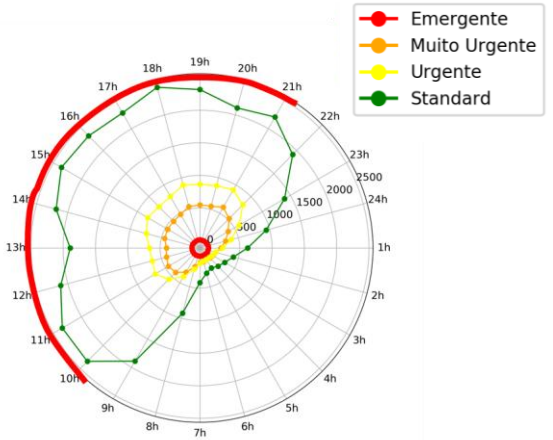
The Dynamics of Patient Visits to a Public Hospital Pediatric Emergency Department
A Time-Series Model

Almeida, Helena Seabra MD*; Sousa, Margarida†; Mascarenhas, Inês*; Russo, Ana‡; Barrento, Manuel§; Mendes, Manuel‖; Nogueira, Paulo¶; Trigo, Ricardo‡

Author Information

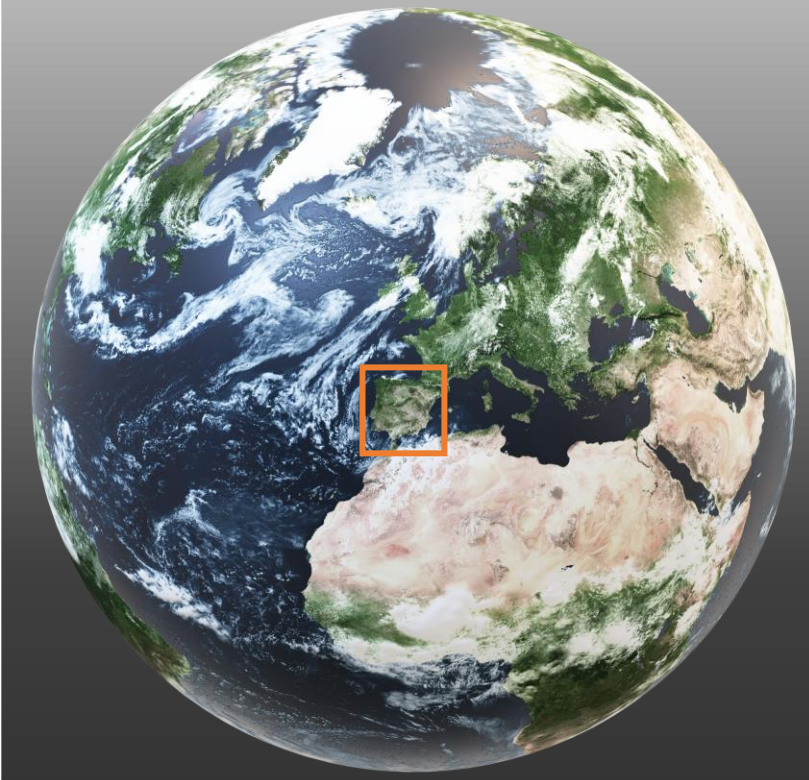
Pediatric Emergency Care 38(1):p e240-e245, January 2022. | *DOI:* 10.1097/PEC.0000000000002235





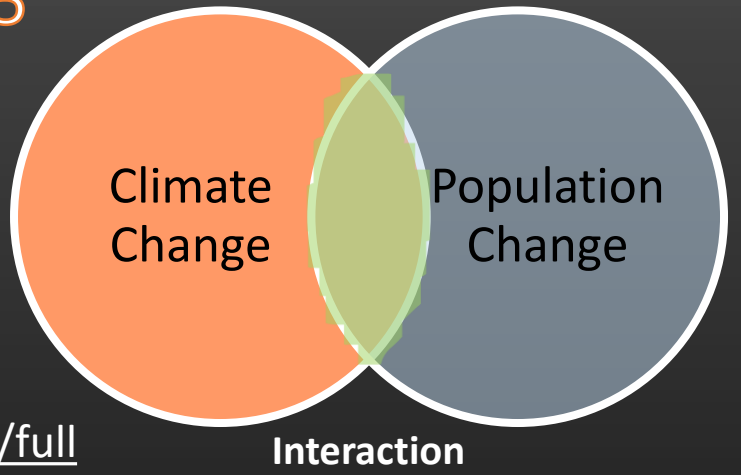
IMPACTOS 3

POPULAÇÃO



Qual é a exposição projetada da população às secas durante o PI?

- Níveis históricos de aquecimento global (GWL) de 1,5˚ e 2˚ C e final do século
- Seca extrema, severa e moderada
- RCP2.6, RCP4.5 e RCP8.5
- O que contribui mais?



LEITURA RECOMENDADA

https://iopscience.iop.org/article/10.1088/1748-9326/ad975d

https://www.frontiersin.org/journals/climate/articles/10.3389/fclim.2025.1519880/full

ENVIRONMENTAL RESEARCH
LETTERS

LETTER • OPEN ACCESS

Increased population exposure to extreme droughts in Iberia due to 0.5 °C additional anthropogenic warming

Ana Russo*, Virgílio A Bento, Andreia F S Ribeiro, Daniela C A Lima, João A M Careto, Pedro M M Soares, Renata Libonati, Ricardo M Trigo and Célia M Gouveia

Published 7 January 2025 • © 2025 The Author(s). Published by IOP Publishing Ltd

Environmental Research Letters, Volume 20, Number 1

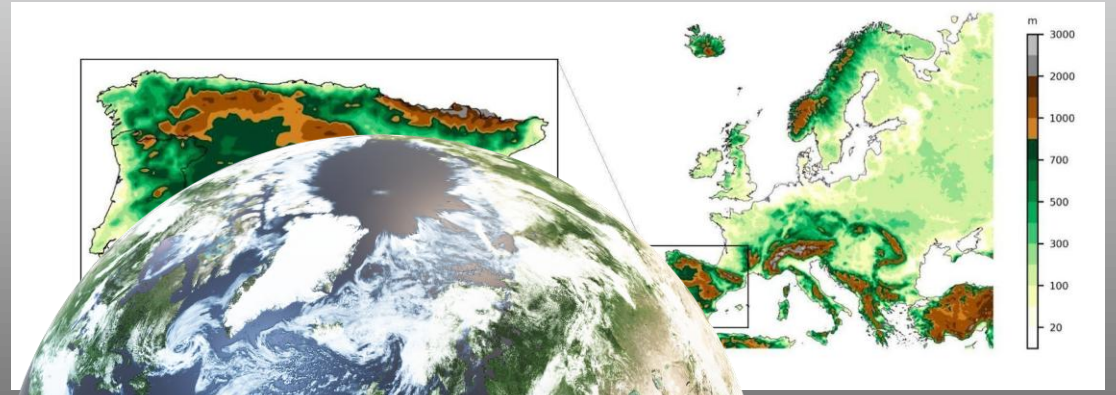
Focus on Human-Earth System Interactions under Climate Change

Citation Ana Russo *et al* 2025 *Environ. Res. Lett.* **20** 014075

DOI 10.1088/1748-9326/ad975d

DATA AND METHODS

EURO-CORDEX



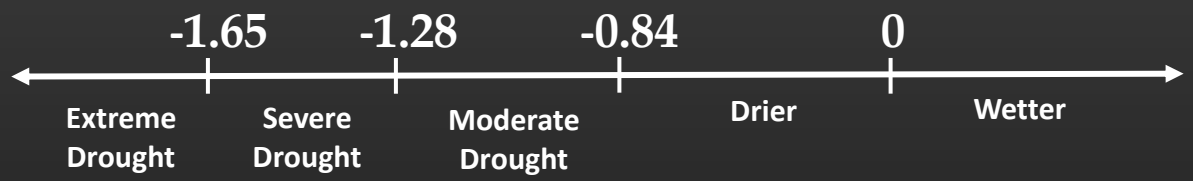
		GWL1.5	GWL2.0
		029	2043
		029	2043
		019	2035
		2019	2035
		2019	2035
		2019	2035
		2024	2037
KN		2024	2037
SMHI		2024	2037
MPI	REMO2009-MPI-ESM-LR (r1)	2016	2032
SMHI	RCA4-MPI-ESM-LR	2016	2032
GERICS	REMO2015-NCC-NorESM1-M	2033	2048
SMHI	RCA4-NCC-NorESM1-M	2033	2048

Weighted multi-variable multi-model ensemble

- Horizontal resolution: 0.11° from CMIP5
- Historical period: 1971 to 2000
- Future: 2011 to 2100
- RCP2.6, RCP4.5, RCP8.5
- Daily total precipitation
- 2-metre maximum and minimum daily temperatures

DROUGHTS

Computation of **SPI** and **SPEI**
(3-, 6-, 12-months)
Hargreaves equation
Gamma and log-logistic distribution functions
L-moment method and gaussian kernel function



(Agnew et al., 2000)

DATA AND METHODS

Population

- Population data for Portugal and Spain
  - The World Bank (before 2011)
  - Eurostat statistics
  - Eurostat EUROPOP2019

Aggregated population

	Year							
	1985	2016	2019	2025	2030	2035	2040	2080
Population (million)	48.5	56.8	57.2	58.5	58.8	59.1	59.2	54.5

Population exposure to drought

$$E = \frac{\sum_{i=1}^{30} drought_i \times P}{30}$$

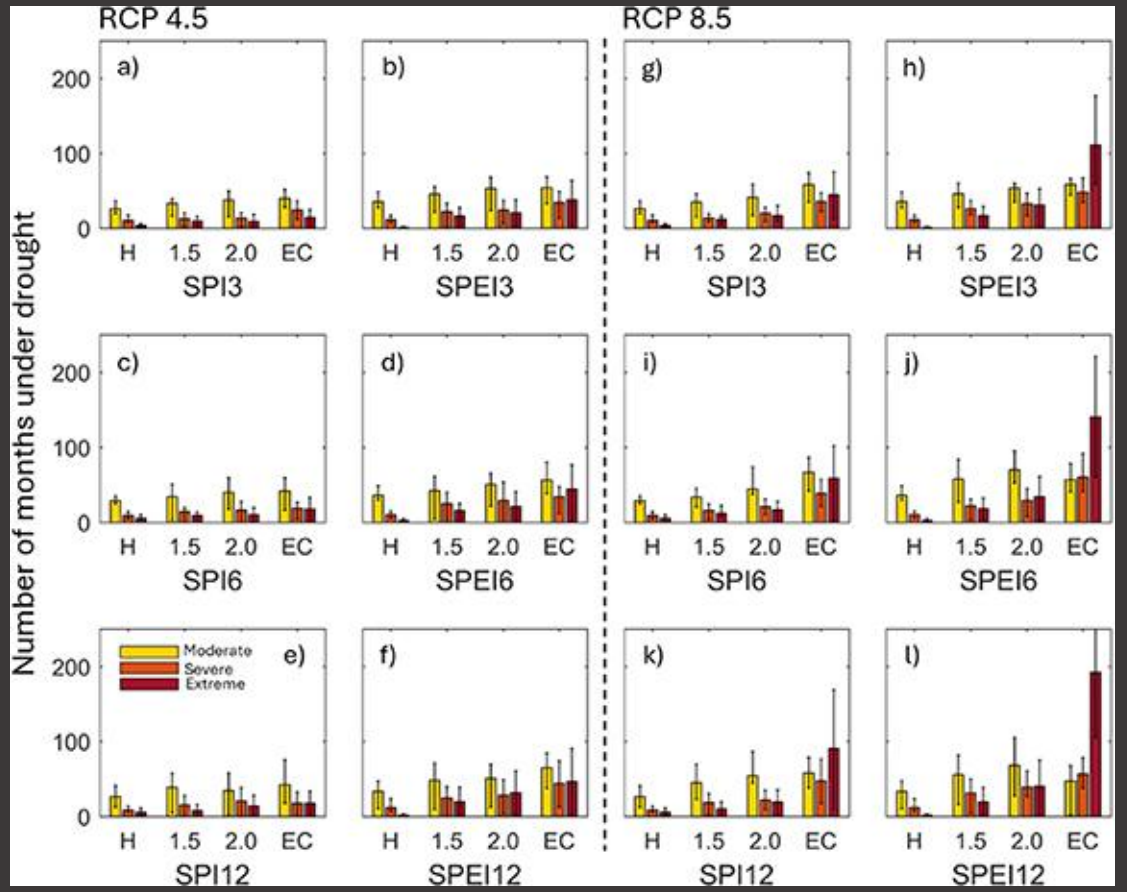
$$\delta E = \frac{E_{fut} - E_{hist}}{E_{hist}} \times 100$$

$$\Delta E = \underbrace{D_H \times \Delta P}_{\Psi_{pop}} + \underbrace{P_H \times \Delta D}_{\Psi_{clim}} + \underbrace{\Delta P \times \Delta D}_{\Psi int}$$

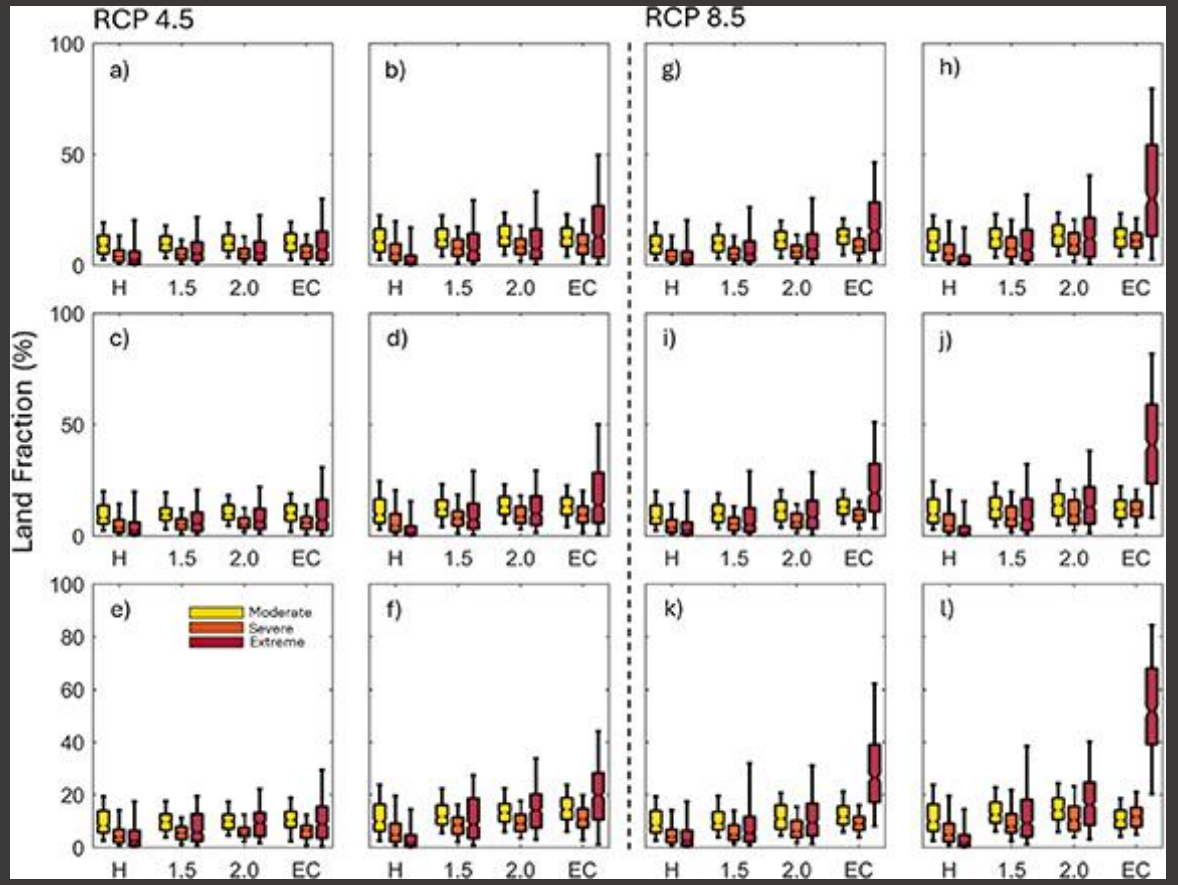
RESULTS

- Rise in the number of months under drought conditions with increasing GWL
- Substantial increase in the likelihood of more frequent and intense droughts
- Temperature's pivotal role

NUMBER OF MONTHS



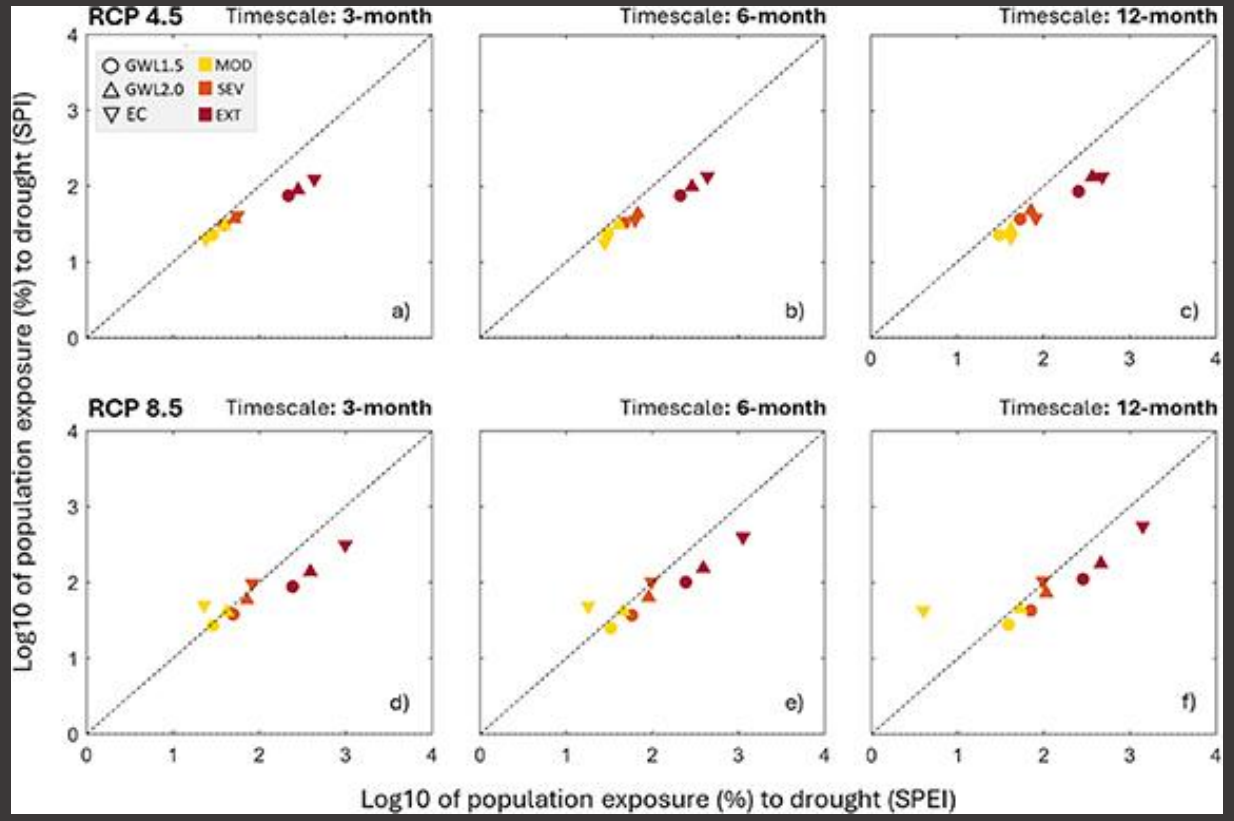
LAND FRACTION

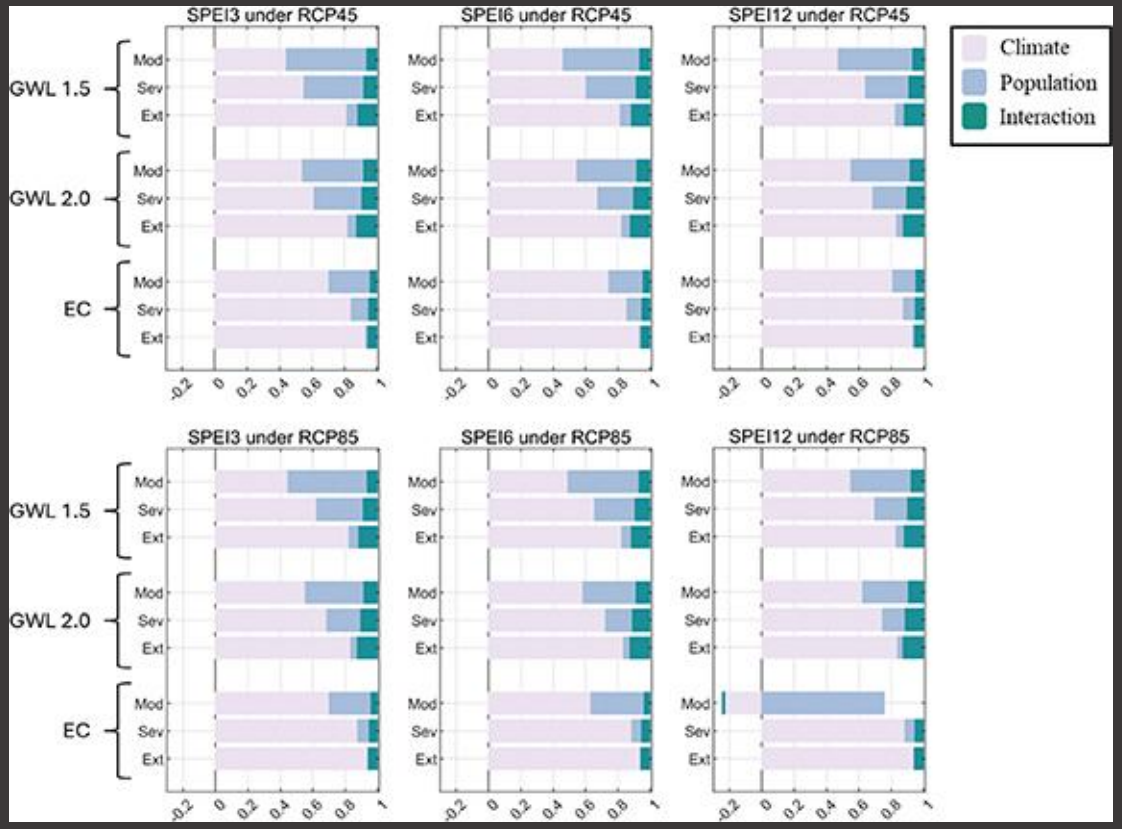


RESULTS

EXPOSURE

- Significant increase in population exposure to drought (RCP8.5 scenario and the GWL2.0)
- Climate change is the dominant factor





FINAL REMARKS

- Escalating impacts associated with drought in the IP under different warming scenarios
- Climate change is clearly the dominant factor contributing to increased drought exposure
- Emphasis on the NEED TO LIMIT GLOBAL WARMING BELOW 1.5 ºC to mitigate the adverse impacts on ecosystems and human populations
- The comprehensive assessment of drought conditions, considering both land fraction and population exposure, provides a robust foundation for informed decision-making and effective climate resilience strategies in the face of a changing climate

ATIVIDADE 2

1. Consulte o site da Organização Meteorológica Mundial (WMO)
   https://wmo.int/topics/extreme-weather

2. Identifique outro tipo de extremos

3. Escolha um dos extremos e recolha informação sobre esse tipo de extremo em geral e sobre eventos que tenham afetado Portugal ou outro país da Europa

   https://www.emdat.be/
   https://www.eea.europa.eu/en/topics/in-depth/extreme-weather-floods-droughts-and-heatwaves

4. Apresente as suas principais conclusões utilizando um ppt

And global warming on compound events?

Extreme hazards

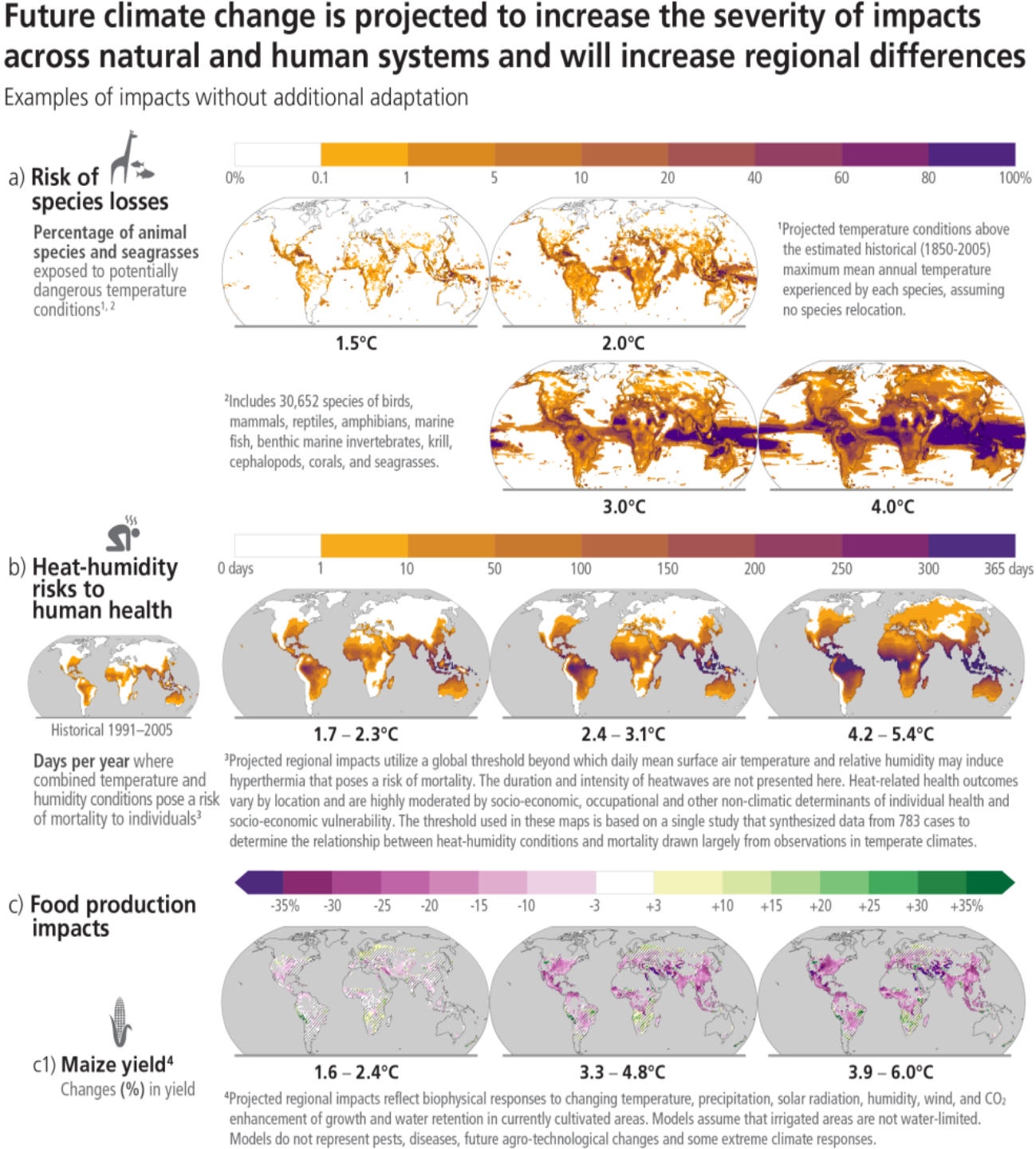
and their isolated or compounded impacts from a climate change perspective

The Current State of the Climate
IPCC 2023 – AR6

- It is unequivocal that **human influence has warmed the atmosphere, ocean and land.** Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred.

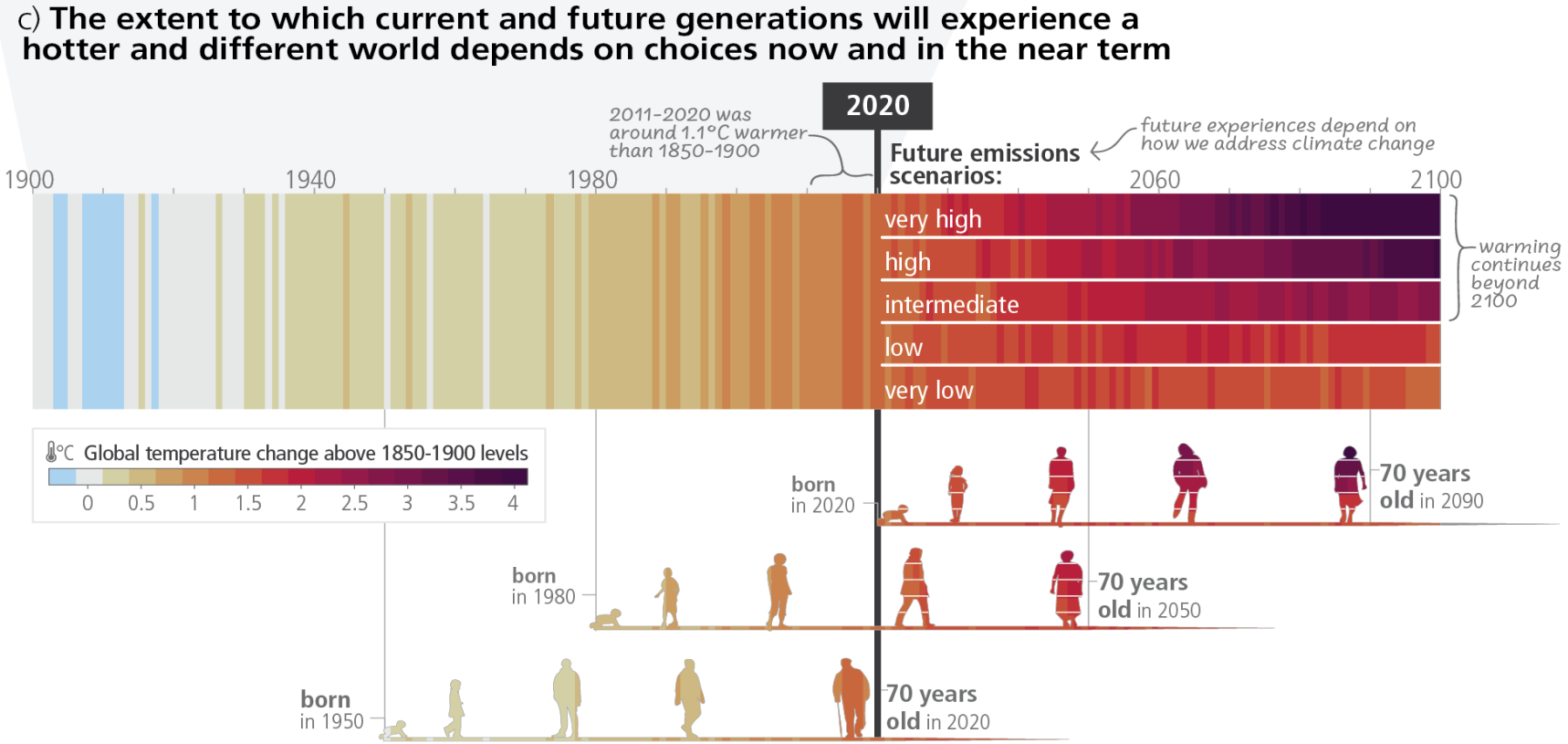
- **The scale of recent changes** across the climate system as a whole and the present state of many aspects of the climate system **are unprecedented** over many centuries to many thousands of years.

- **Human-induced climate change is already affecting many weather and climate extremes** in every region across the globe. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since the Fifth Assessment Report (AR5).



Adverse impacts from human-caused climate change will continue to intensify

The Current State of the Climate
IPCC 2023 – AR6



The generation born in 2020 will suffer far more than previous generations

It is unequivocal that **human influence has warmed the atmosphere, ocean and land**

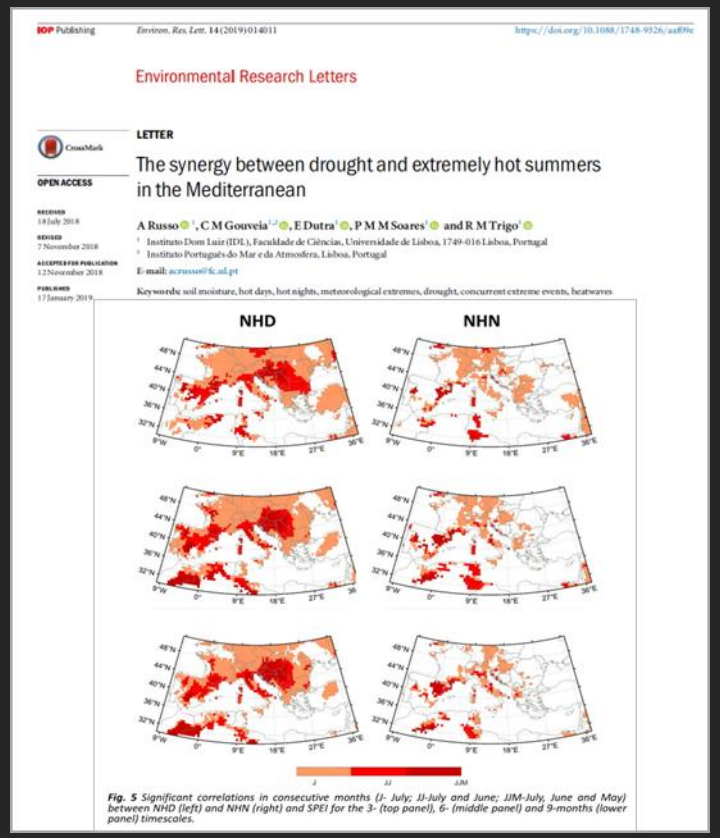
Conversations are like cherries; we never pick just one!

What about natural hazards?

2 | HAZARDS

SINGLE AND COMPOUND

Strong evidence that droughts and heatwaves are at times synergetic – COMPOUND EVENTS



IOP Publishing Environ. Res. Lett. 14 (2019) 014011 https://doi.org/10.1088/1748-9326/aaf0fe

Environmental Research Letters

LETTER

OPEN ACCESS

The synergy between drought and extremely hot summers in the Mediterranean

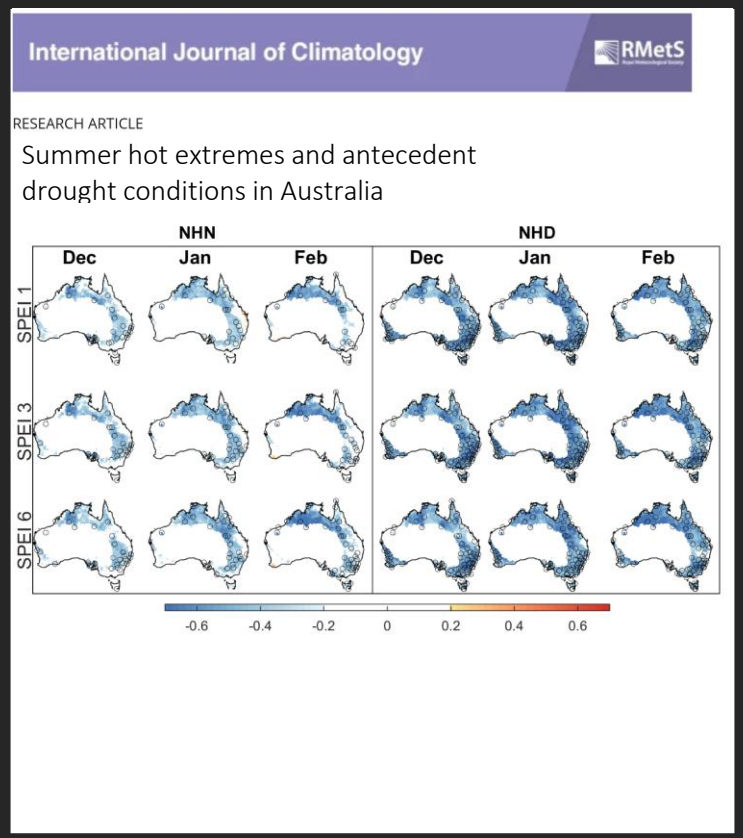
A Russo[1], C M Gouveia[1,2], E Dutra[1], P M M Soares[1] and R M Trigo[1]

[1] Instituto Dom Luiz (IDL), Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa, Portugal
[2] Instituto Português do Mar e da Atmosfera, Lisboa, Portugal

E-mail: acrusso@fc.ul.pt

Keywords: soil moisture, hot days, hot nights, meteorological extremes, drought, concurrent extreme events, heatwaves

Fig. 5 Significant correlations in consecutive months (J- July; JJ-July and June; JJM-July, June and May) between NHD (left) and NHN (right) and SPEI for the 3- (top panel), 6- (middle panel) and 9-months (lower panel) timescales.

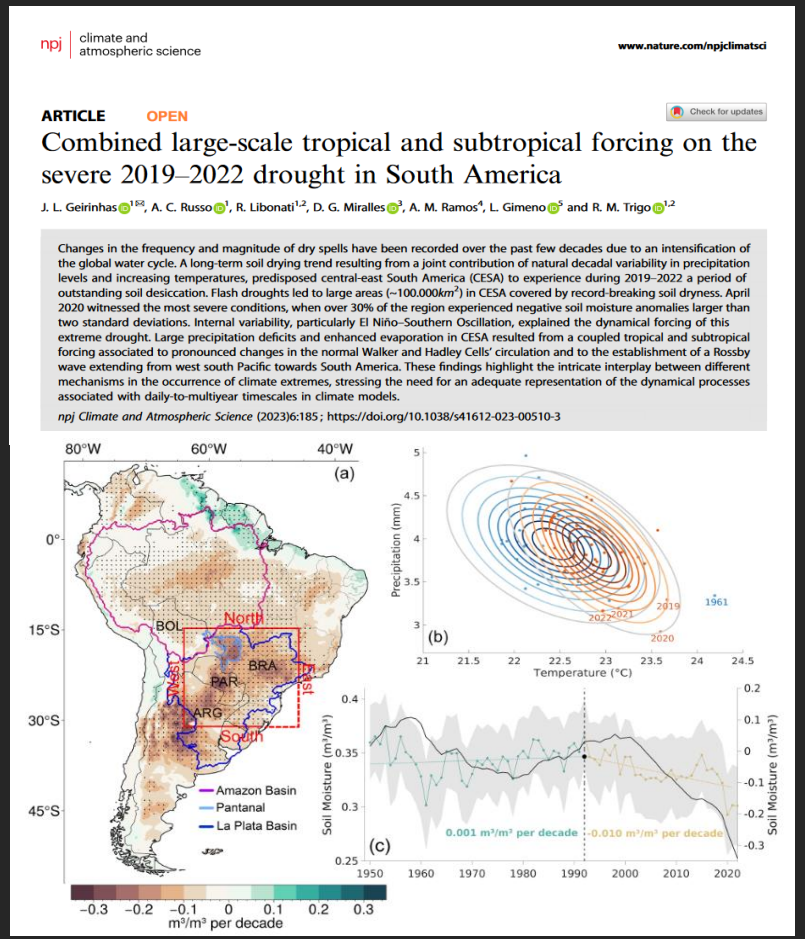


International Journal of Climatology

RMetS

RESEARCH ARTICLE

Summer hot extremes and antecedent drought conditions in Australia



npj climate and atmospheric science

www.nature.com/npjclimatsci

ARTICLE OPEN

Check for updates

Combined large-scale tropical and subtropical forcing on the severe 2019–2022 drought in South America

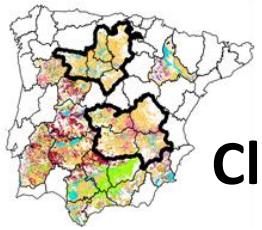
J. L. Geirinhas[1,2], A. C. Russo[1], R. Libonati[1,2], D. G. Miralles[3], A. M. Ramos[4], L. Gimeno[5] and R. M. Trigo[1,2]

Changes in the frequency and magnitude of dry spells have been recorded over the past few decades due to an intensification of the global water cycle. A long-term soil drying trend resulting from a joint contribution of natural decadal variability in precipitation levels and increasing temperatures, predisposed central-east South America (CESA) to experience during 2019–2022 a period of outstanding soil desiccation. Flash droughts led to large areas (~100.000km^2) in CESA covered by record-breaking soil dryness. April 2020 witnessed the most severe conditions, when over 30% of the region experienced negative soil moisture anomalies larger than two standard deviations. Internal variability, particularly El Niño–Southern Oscillation, explained the dynamical forcing of this extreme drought. Large precipitation deficits and enhanced evaporation in CESA resulted from a coupled tropical and subtropical forcing associated to pronounced changes in the normal Walker and Hadley Cells' circulation and to the establishment of a Rossby wave extending from west south Pacific towards South America. These findings highlight the intricate interplay between different mechanisms in the occurrence of climate extremes, stressing the need for an adequate representation of the dynamical processes associated with daily-to-multiyear timescales in climate models.

npj Climate and Atmospheric Science (2023)6:185 ; https://doi.org/10.1038/s41612-023-00510-3

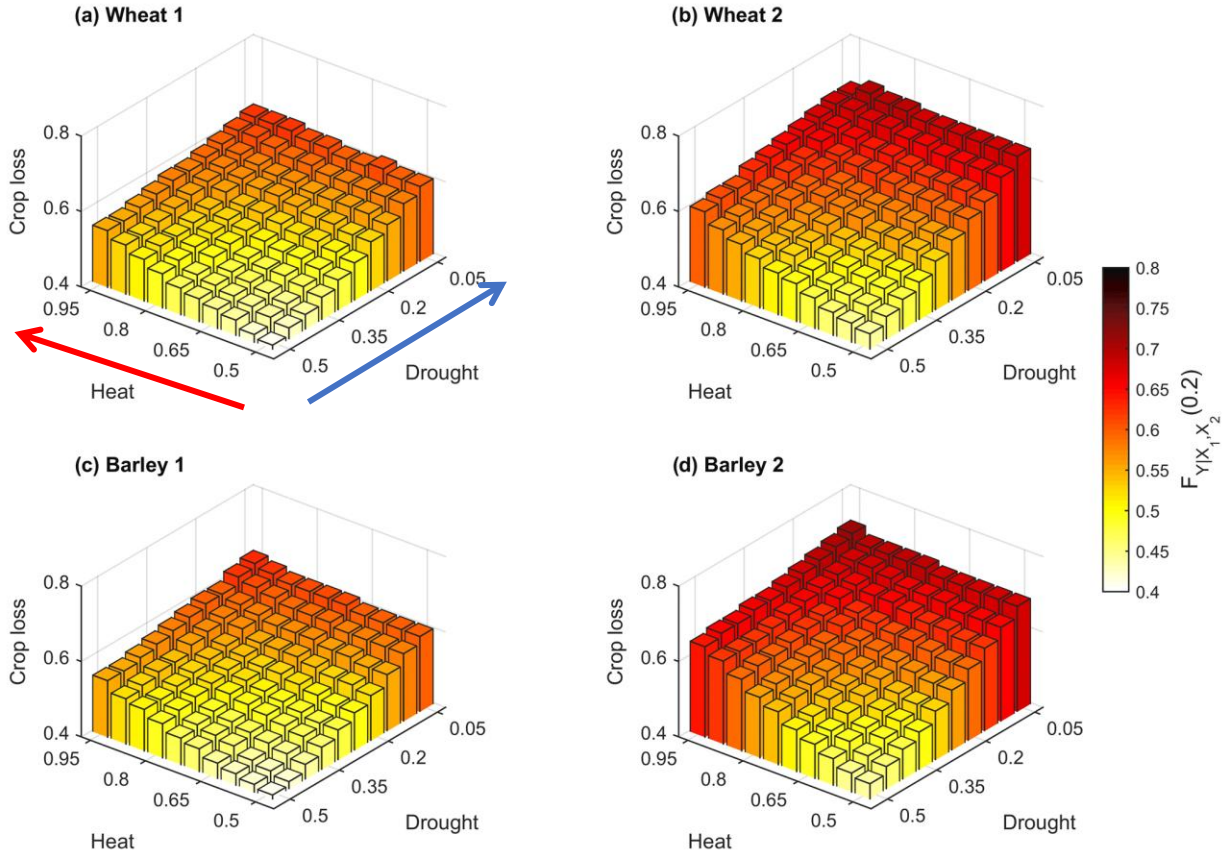
Wheat and barley t/ha

Threshold for crop failure
20th percentile



Cluster 1

Cluster 2



IMPACTS 3

CROP LOSSES

Agricultural Water Management
Volume 223, 20 August 2019, 105689
ELSEVIER

Copula-based agricultural drought risk of rainfed cropping systems

Andreia F.S. Ribeiro [a], Ana Russo [a], Célia M. Gouveia [a, b], Patrícia Páscoa [a]

Risk of crop failure due to compound dry and hot extremes estimated with nested copulas

Andreia Filipa Silva Ribeiro [1,2], Ana Russo [2], Célia Marina Gouveia [2,3], Patrícia Páscoa [2,3,4], and Jakob Zscheischler [1,5]

The probability of crop-loss increases with the severity of the compound hot and dry conditions

Drought plays the dominant role in crop-loss due to the compound event

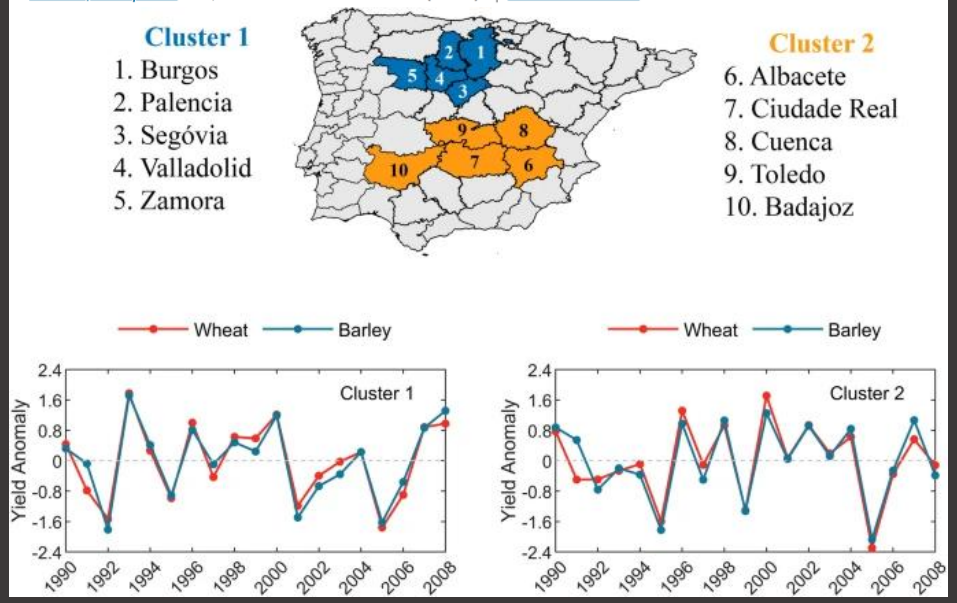
IMPACTS 3

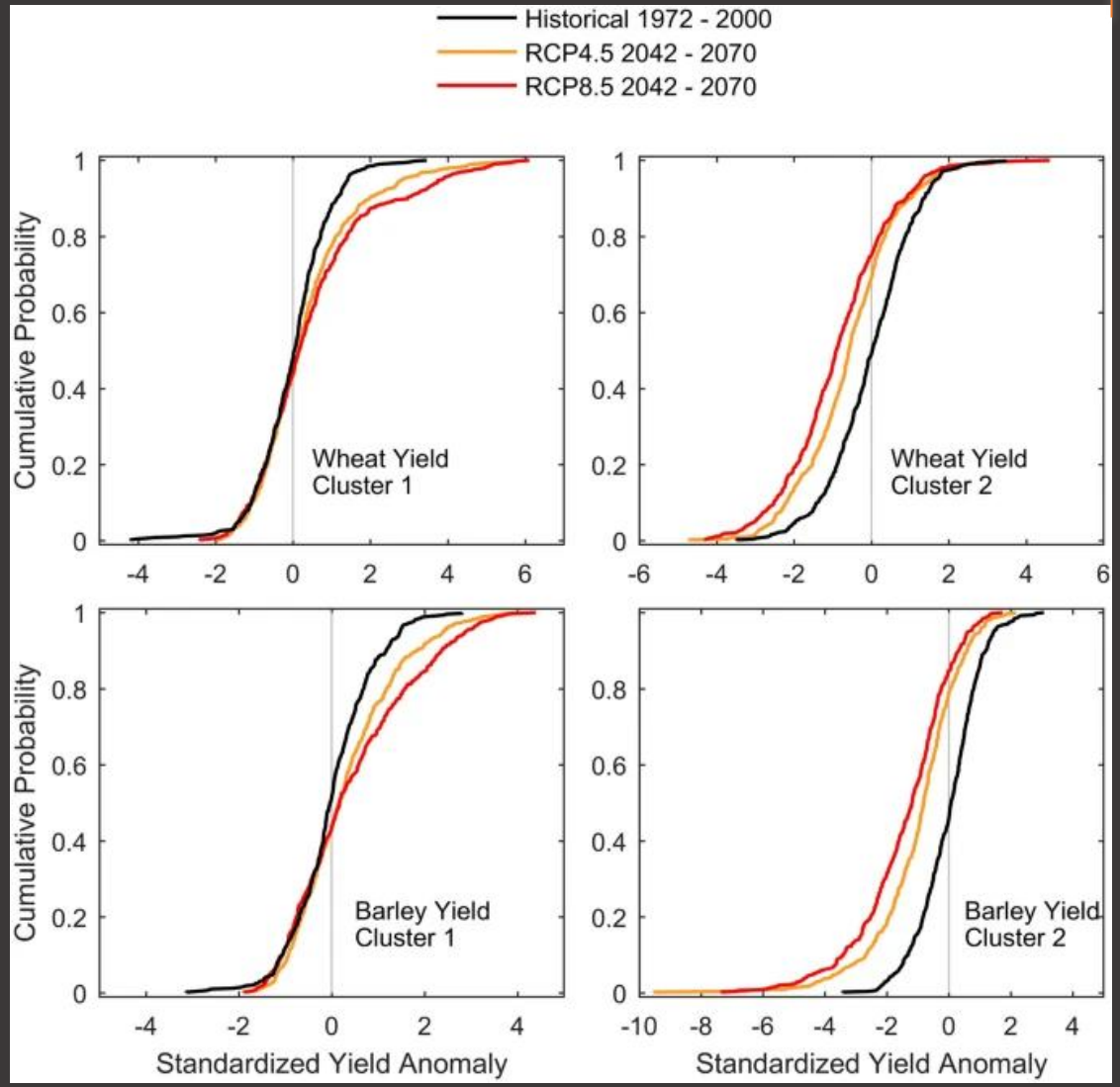
CROP LOSSES

The impact of climate change in wheat and barley yields in the Iberian Peninsula

Virgílio A. Bento, Andreia F. S. Ribeiro, Ana Russo, Célia M. Gouveia, Rita M. Cardoso & Pedro M. M. Soares

Scientific Reports **11**, Article number: 15484 (2021) | Cite this article





- **Cluster 1**: positive future results (low losses and high productivity)
- **Cluster 2**: negative future results (higher losses and lower productivity)

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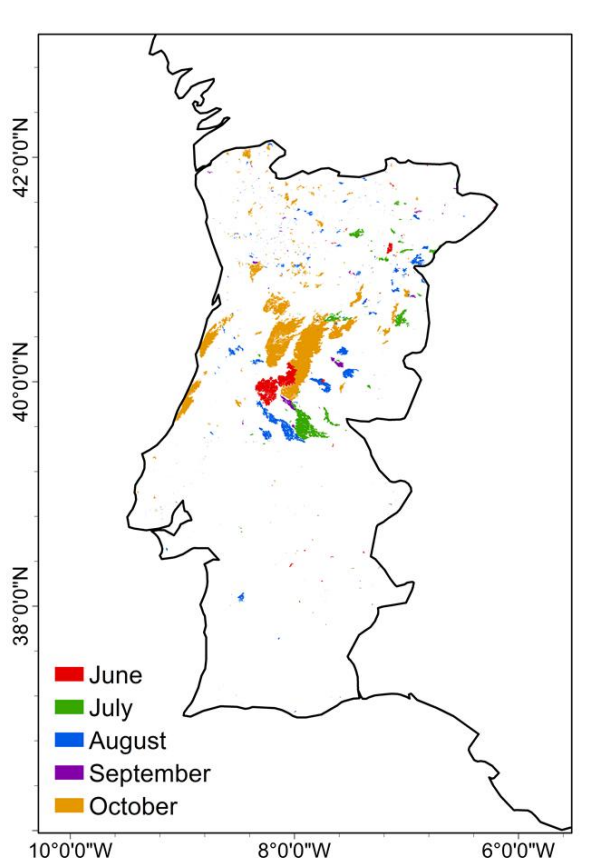
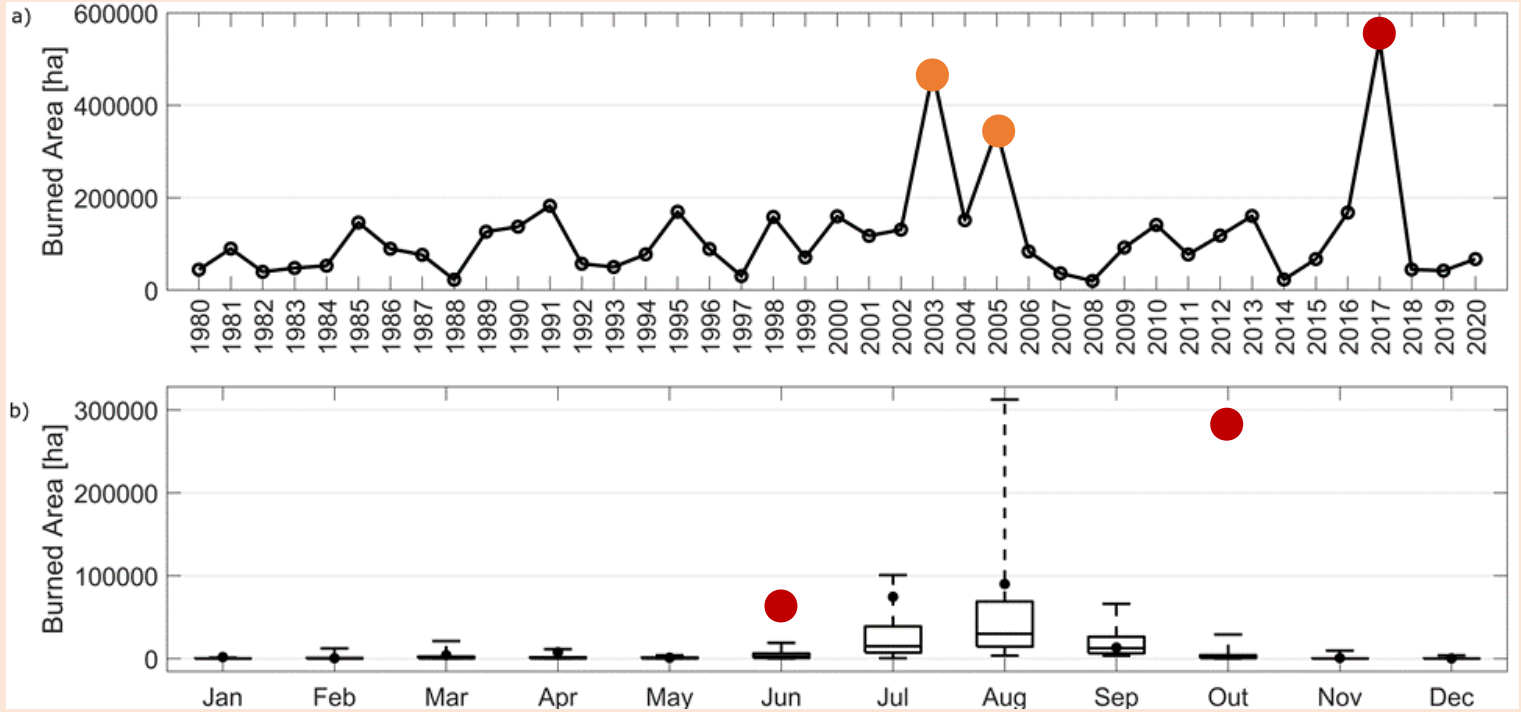
Article
The compound event that triggered the destructive fires of October 2017 in Portugal

IMPACTS 3

THE DESTRUCTIVE FIRES OF OCTOBER 2017 IN PORTUGAL



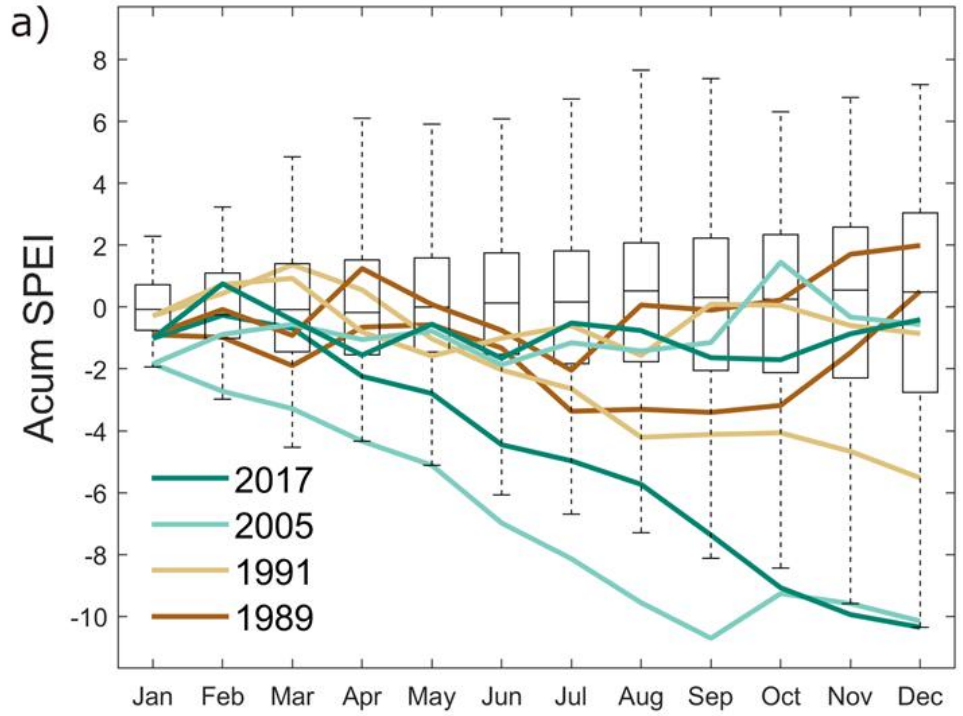
2017 monthly burned areas

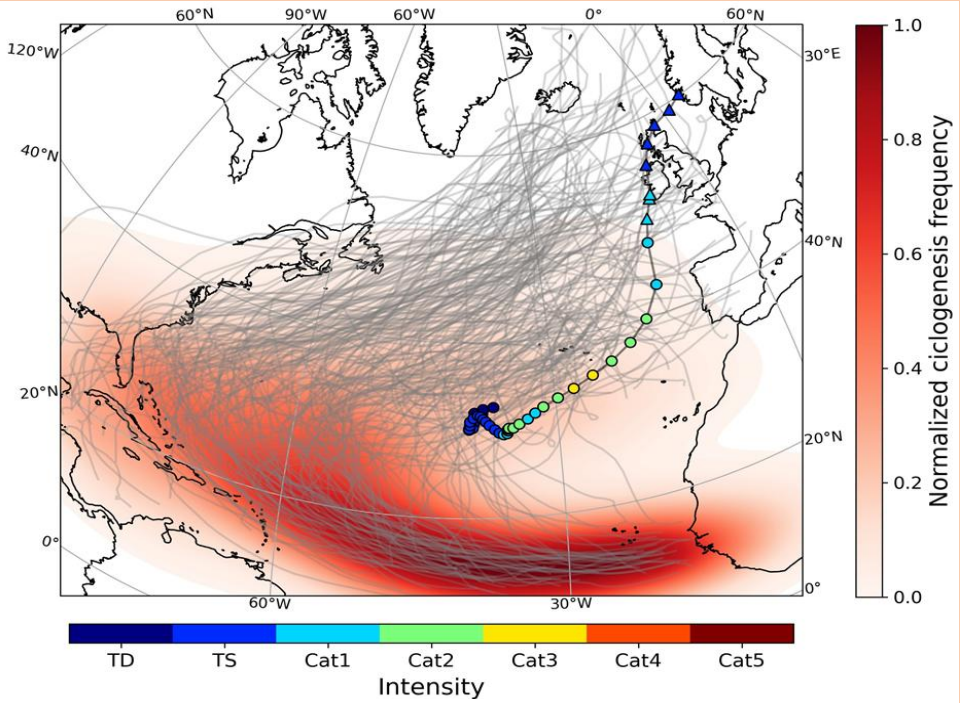


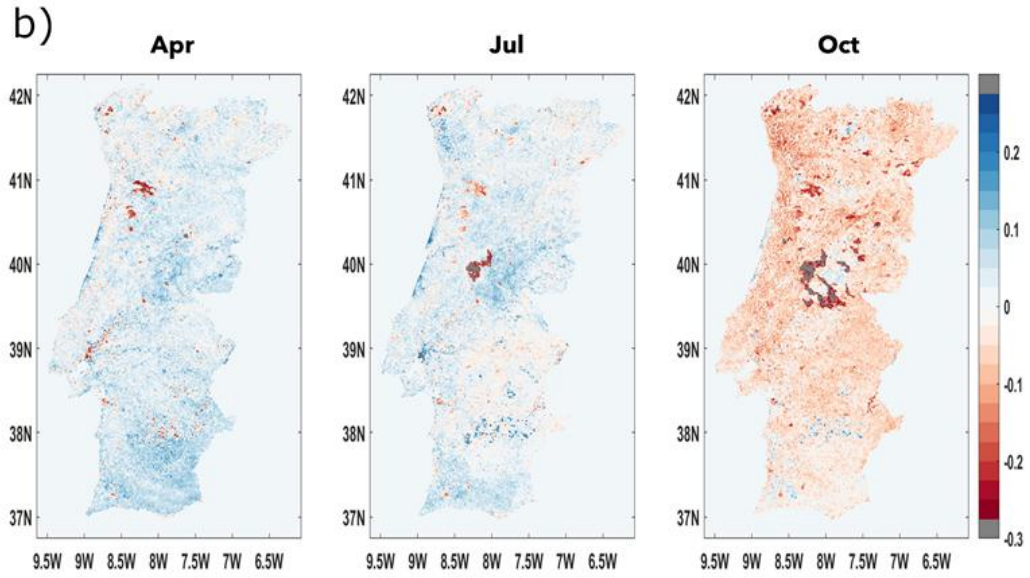
Annual and monthly accumulated burned areas

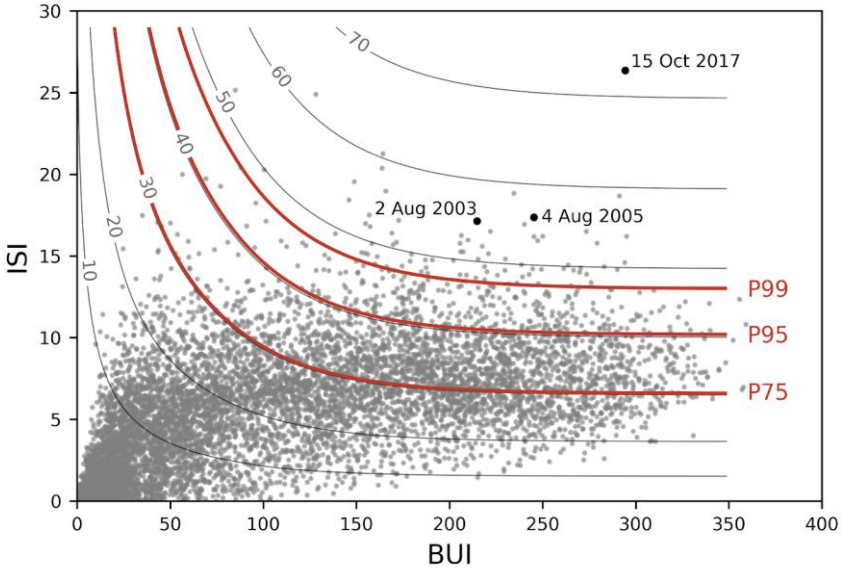
- The wildfires caused 55 deaths (51 PT, 4 SP), and dozens injured
- More than half of the 2017 burn area occurred in these two days

NDVI anomalies









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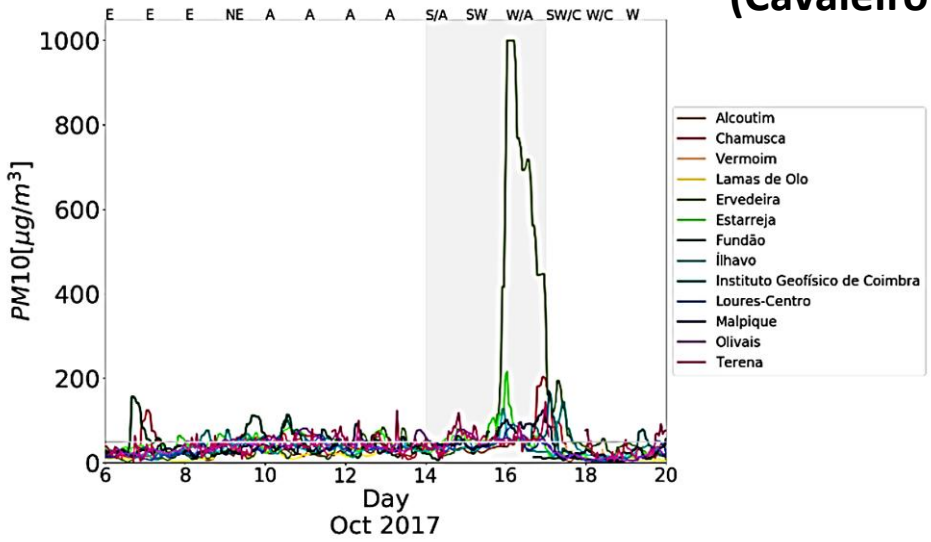
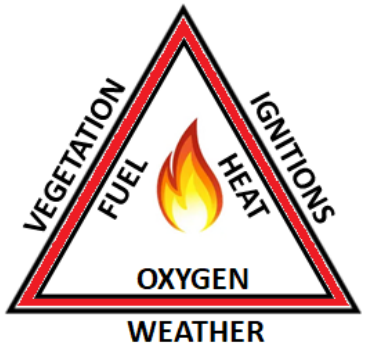
IMPACTS 3

THE DESTRUCTIVE FIRES OF OCTOBER 2017 IN PORTUGAL

(Cavaleiro et al., 2021)





Long-term Drought → Vegetation stress

Hurricane Ophelia

Fire Ignitions

→ Wildfires → Socio-economic and ecological impacts

- **Human Losses**
- **Burned Infrastructures**
- **Poor Air Quality**

4

Global Compound Events

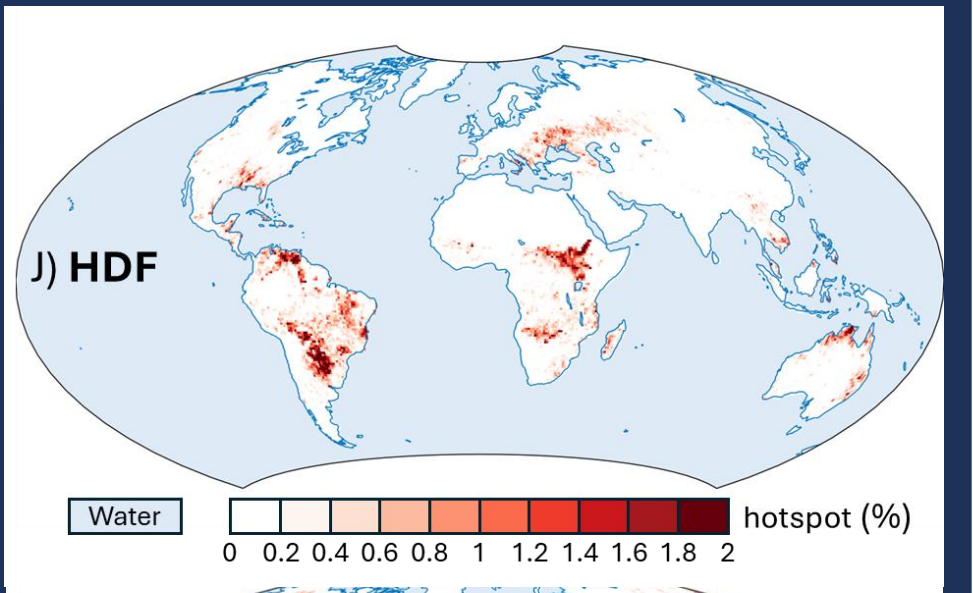
Hot and dry

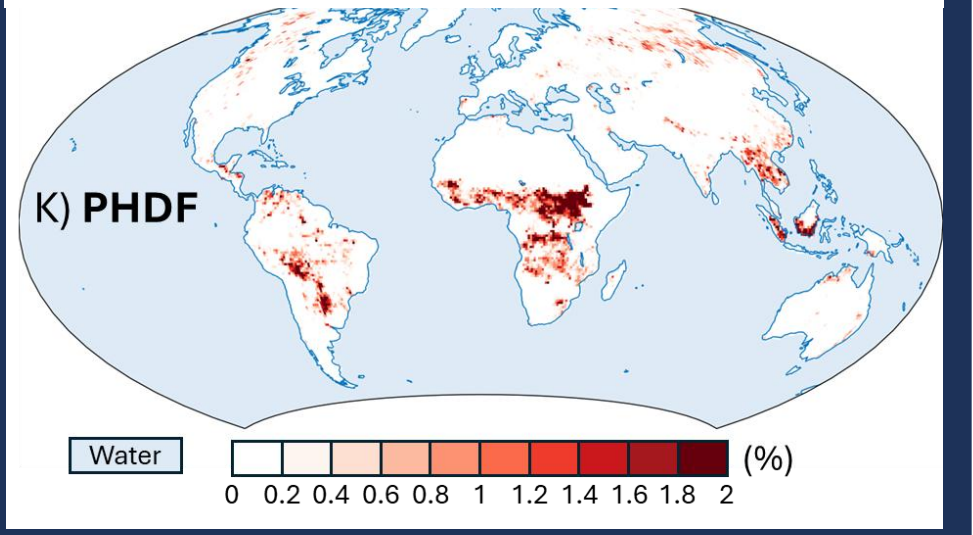
\+

Air Quality

Hotspots?

Where are these more common?

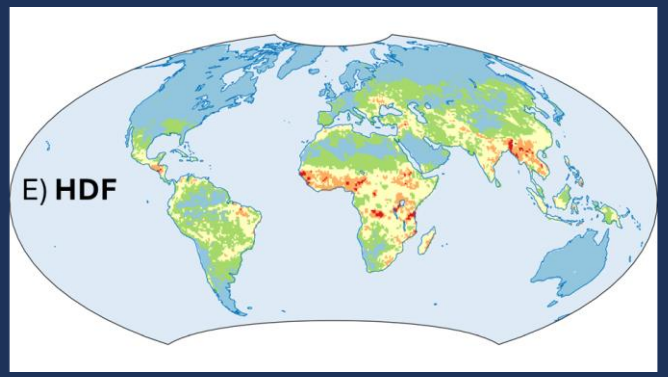


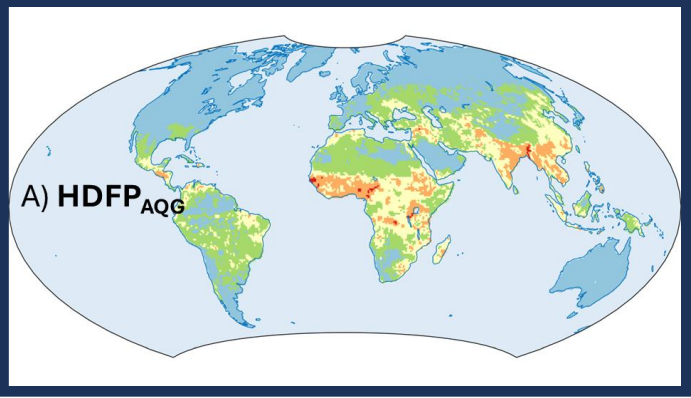


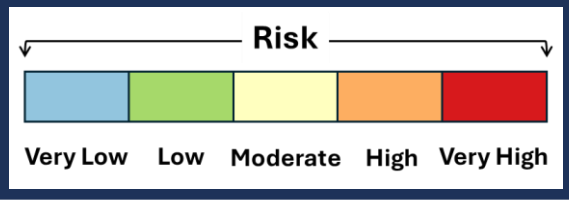
Risk?

Where are populations more at risk?

Vulnerability + Exposure + Hazard







Atividade

Mind Map de Eventos Compostos

Objetivo: Explorar a interação entre eventos compostos (como secas e ondas de calor) e seus impactos socioeconômicos e ambientais, utilizando mapas mentais para representar as conexões e implicações.

Tarefa

1. Escolha de Eventos Compostos:

- Identificar dois tipos de eventos compostos mencionados na aula, como secas combinadas com ondas de calor.

- Analisar as características de cada evento e como eles interagem para intensificar os impactos.

2. Mapeamento dos Impactos:

- Utilizando um software de mind mapping (como Coggle ou MindMeister), criar um mapa mental que inclua:

- Nó Central: Nome do evento composto (por exemplo, 'Seca + Onda de Calor').

- Nós Secundários: Impactos principais (como saúde, agricultura, recursos hídricos).

- Nós Terciários: Exemplos concretos de eventos ocorridos e seus desdobramentos.

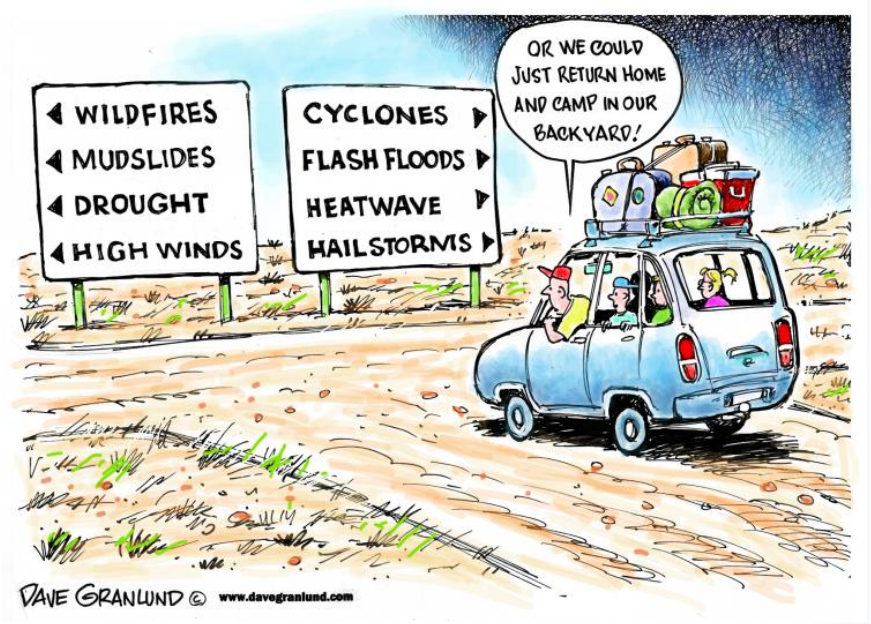
- Conexões: Como um evento potencializa o outro e quais medidas de mitigação podem ser implementadas.

3. Análise Crítica:

- Escrever um breve texto explicativo que acompanhe o mind map, destacando os principais fatores de interação e as estratégias de adaptação mais relevantes.

Produtos Finais

1. Mapa mental digital ilustrando a complexidade dos eventos compostos.
2. Texto de síntese com uma análise crítica das interações e impactos.



BOM TRABALHO!

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