



PROJECTIONS OF POPULATION EXPOSURE TO  
HOT AND DRY EVENTS IN THE END OF THE  
21ST CENTURY ON THE IBERIAN PENINSULA

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## Iberian Peninsula



# THE QUESTION

What is the projected population exposure to droughts and warm months in the IP?

- Historical vs End-of-the-Century
- RCP4.5 vs RCP8.5
- Which regions are more affected?
- What is contributing more?

Climate  
Change

Population  
Change

Interaction  
between them

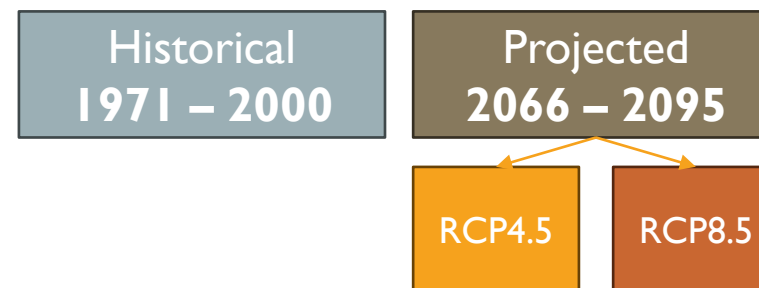


# DATA AND METHODS

**Table 1** – EURO-CORDEX RCMs used in this study, along with the responsible institute and the forcing GCMs. **The 13 simulations have historical, RCP4.5, and RCP8.5 scenarios.**

RCM	Institute	GCM	Reference
CCLM4-8-17	CLM	EC-Earth	Rockel et al., 2008
ALADIN63	CNRM	CNRM-CM5	Colin et al., 2010
HIRHAM5	DMI	EC-Earth HadGem2-ES	Christensen et al., 2007
REMO2015	GERICS	NorESM1-M	Jacob et al., 2012
RACMO22E	KNMI	CNRM-CM5 EC-Earth HadGem2-ES	Van Meijgaard et al., 2008
REMO2009	MPI	MPI-ESM-LR	Jacob et al., 2014
RCA4	SMHI	EC-Earth HadGem2-ES MPI-ESM-LR NorESM1-M	Strandberg et al., 2014

- 13 RCM simulations



- Daily total precipitation (P).
- Daily 2-m maximum and minimum temperatures (T).
- EURO-CORDEX simulations have undergone extensive evaluation to assess their ability to accurately represent current climate conditions in Europe and the IP.
- Added value of using EURO-CORDEX T and P.



# DATA AND METHODS

**Table 1** – EURO-CORDEX RCMs used in this study, along with the responsible institute and the forcing GCMs. **The 13 simulations have historical, RCP2.6, RCP4.5, and RCP8.5 scenarios.**

RCM	Institute	GCM	Reference
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## Multi-model Ensemble

Equal weights to all models? **NO**

Weighted multi-model multi-variable ensemble? **YES**

$$ENS = \sum_{m=1}^M V_m (0.5w_{p_m} + 0.25w_{tx_m} + 0.25w_{tn_m})$$

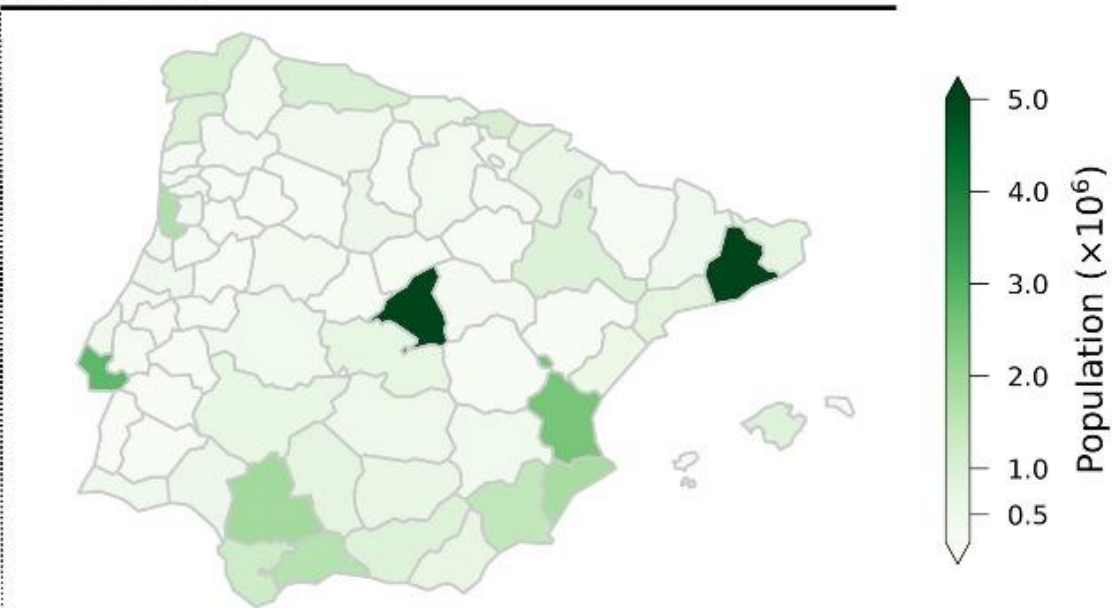


Lima et al., 2023

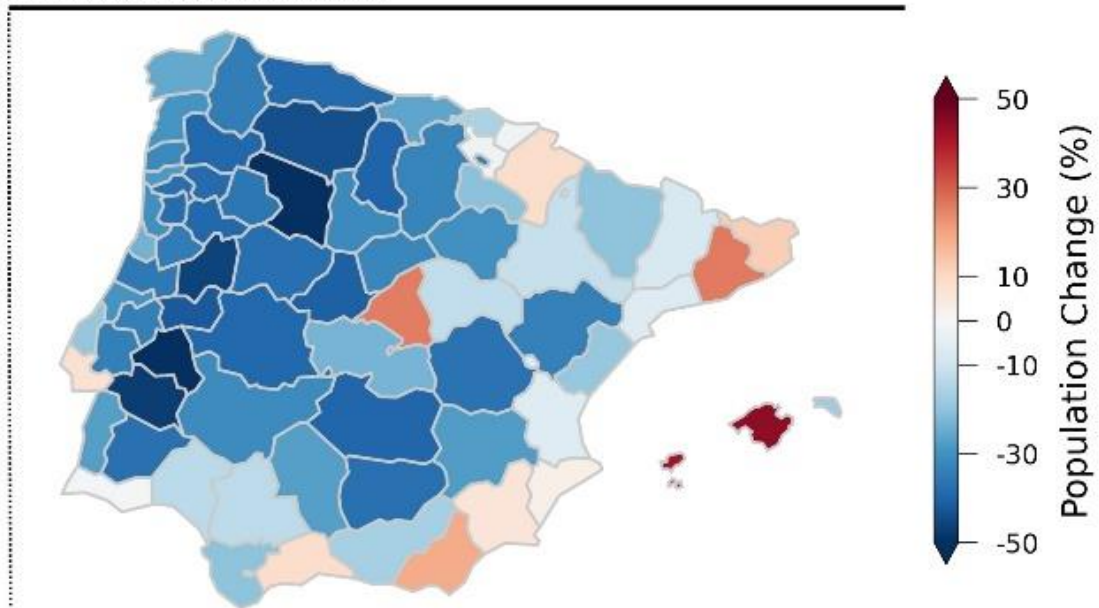


# DATA AND METHODS

a) 2019



b) 2080 – 2019



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

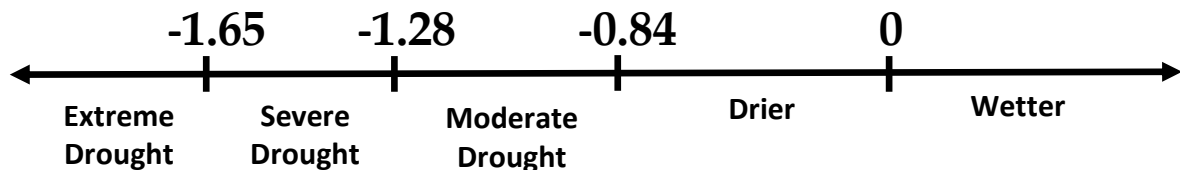


# DATA AND METHODS

## Drought

## Warm Month

Computation of SPEI  
(12-months)  
Hargreaves equation  
Log-logistic distribution function  
L-moment method and gaussian kernel function



(Agnew et al., 2000)

- **NHD** is defined as the count of days at each grid point where the maximum temperature exceeds the 90<sup>th</sup> percentile threshold;
- A **warm month** is considered if the NHD is larger than the 90<sup>th</sup> percentile of the NHD in the historical period (this is performed on a grid-point basis).



# DATA AND METHODS

## Population Exposure to Hot and Dry Events

Population exposure to HDEs  $\longrightarrow$   $E = \frac{\sum_{i=1}^{30} \text{HDE}_i \times P}{30}$

Change in Population exposure to HDEs  $\longrightarrow$   $\delta E = \frac{E_{\text{fut}} - E_{\text{hist}}}{E_{\text{hist}}} \times 100$

$\Delta E = \underbrace{\text{HDE}_H \times \Delta P}_{\Psi_{\text{pop}}} + \underbrace{P_H \times \Delta \text{HDE}}_{\Psi_{\text{clim}}} + \underbrace{\Delta P \times \Delta \text{HDE}}_{\Psi_{\text{int}}}$

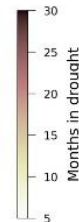
Exposure Change depends on population change, Climate change, and the interaction between them

# PROJECTED CHANGES: DROUGHT

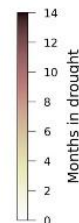
## Drought SPEI-12

a) Historical (1971 – 2000)

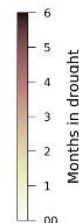
Moderate



Severe



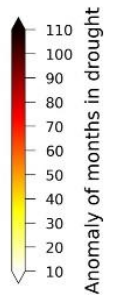
Extreme



b) RCP 4.5 (2066 – 2095)



c) RCP 8.5 (2066 – 2095)

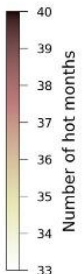
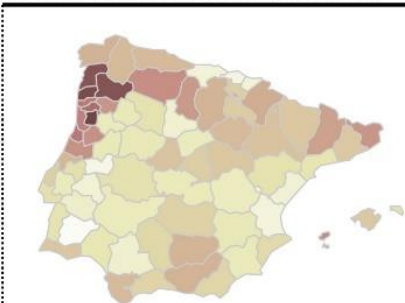




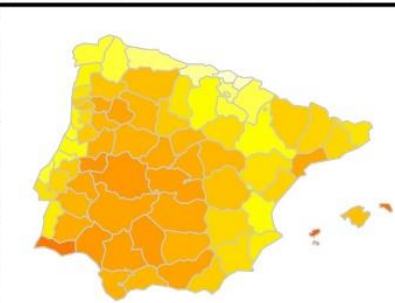
# PROJECTED CHANGES: WARM MONTHS

## Warm months

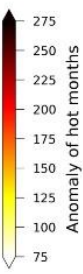
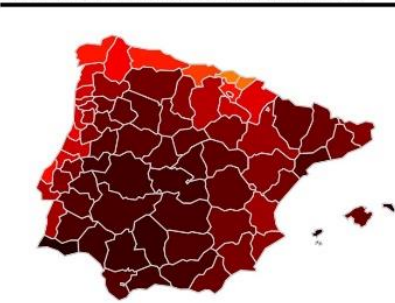
a) Historical (1971 – 2000)



b) RCP 4.5 (2066 – 2095)



c) RCP 8.5 (2066 – 2095)



Drought SPEI-12

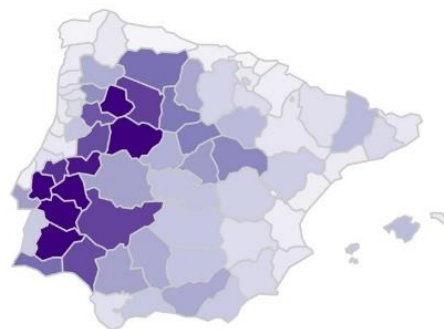
a) RCP 4.5 (2066 – 2095)

b) RCP 8.5 (2066 – 2095)

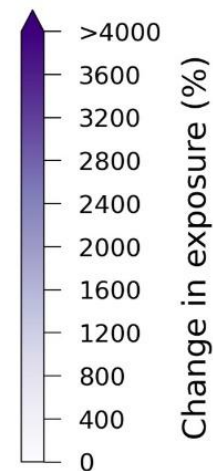
Moderate



Severe



Extreme



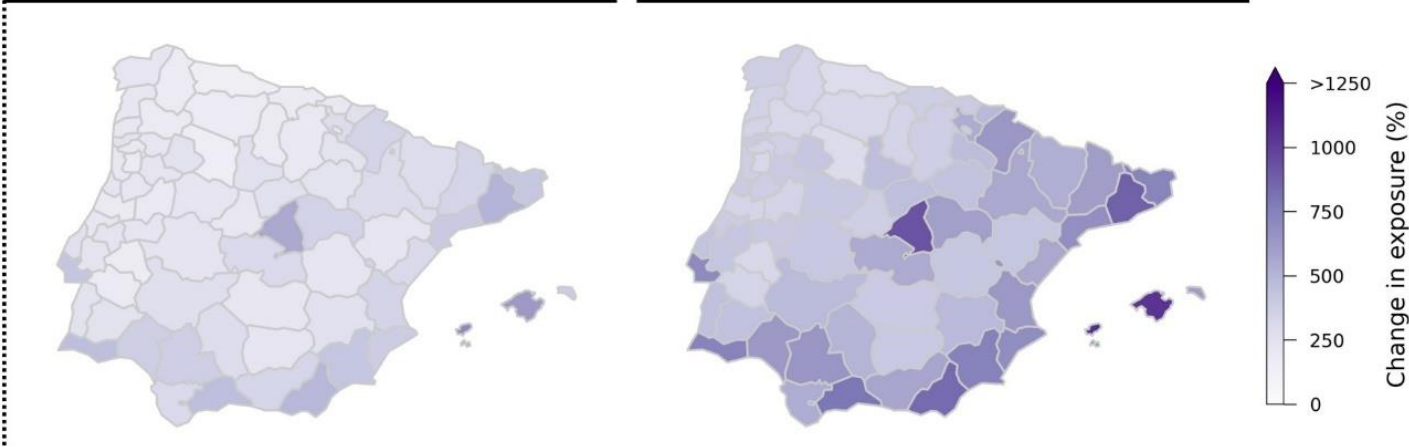
PROJECTED  
CHANGES:  
POP. EXPOSURE  
TO  
DROUGHT

PROJECTED  
CHANGES:  
POP. EXPOSURE  
TO  
WARM MONTHS

Warm months

a) RCP 4.5 (2066 – 2095)

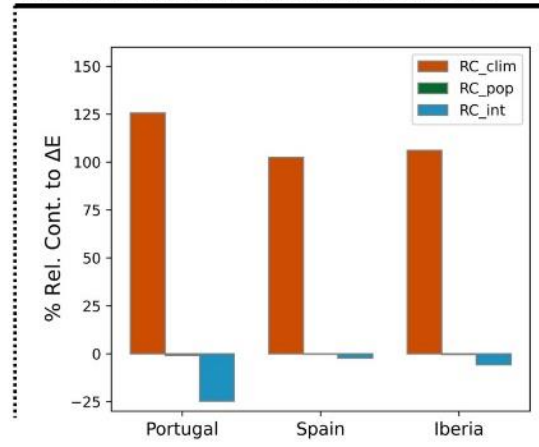
b) RCP 8.5 (2066 – 2095)



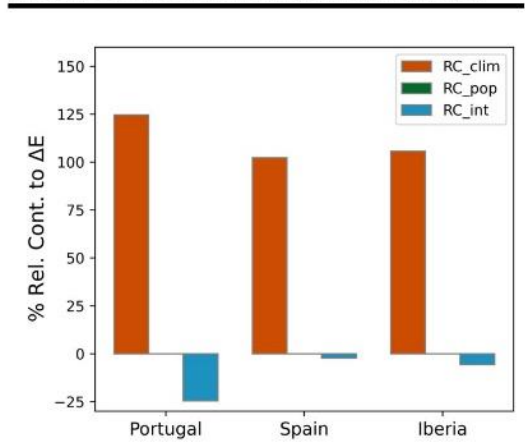
# PROJECTED CHANGES: POP. EXPOSURE TO DROUGHT (RELATIVE CONTRIBUTION)

SPEI-12  
Severe drought

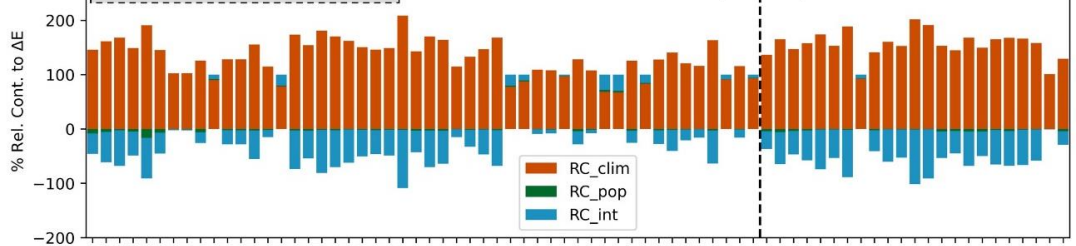
a) RCP 4.5 (2066 – 2095)



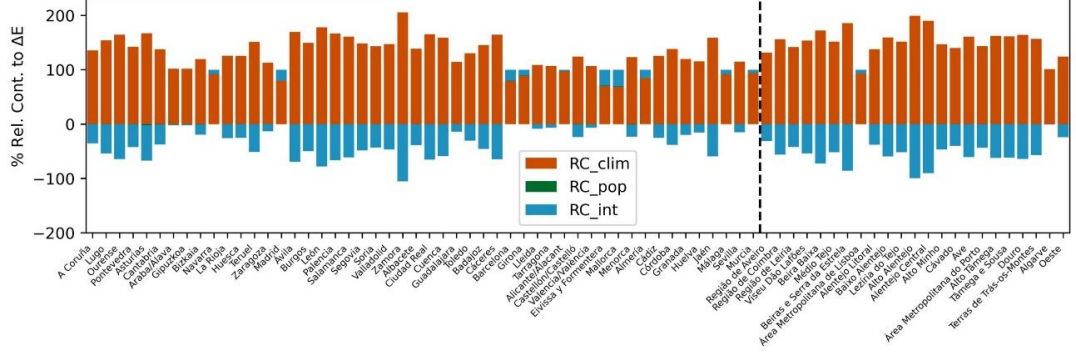
b) RCP 8.5 (2066 – 2095)



c) RCP 4.5 (2066 – 2095)



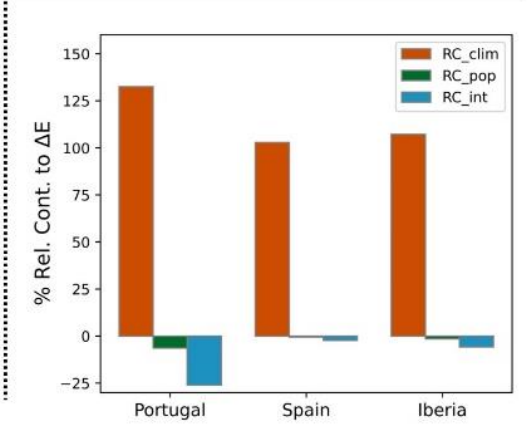
d) RCP 8.5 (2066 – 2095)



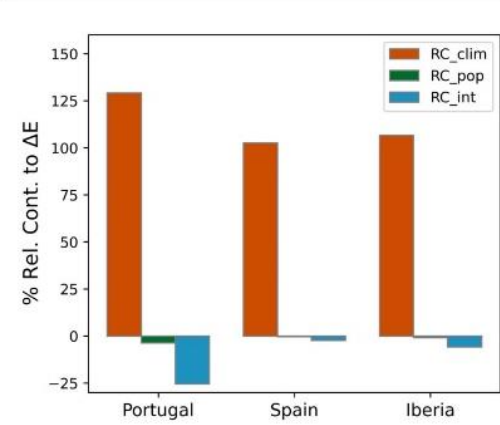
# PROJECTED CHANGES: POP. EXPOSURE TO WARM MONTHS (RELATIVE CONTRIBUTION)

Warm months

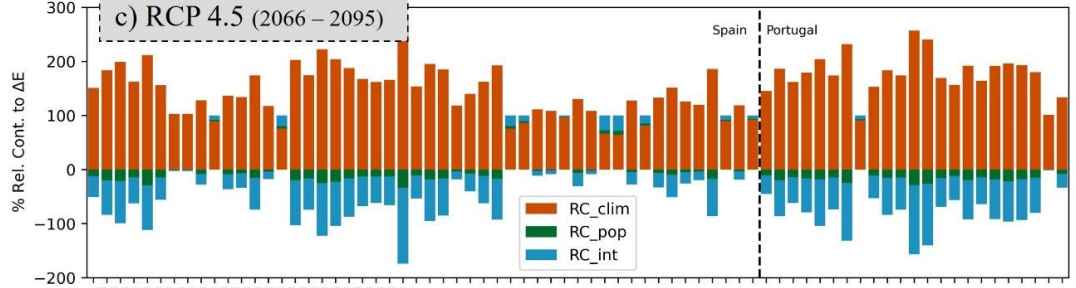
a) RCP 4.5 (2066 – 2095)



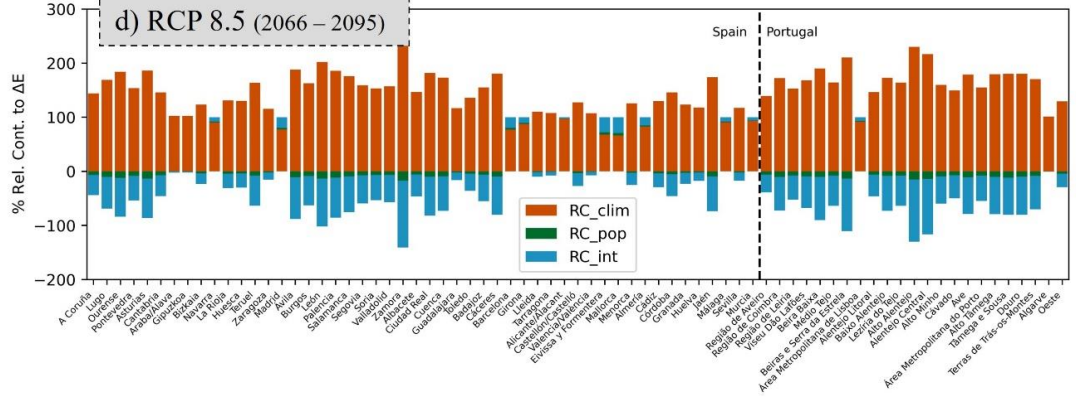
b) RCP 8.5 (2066 – 2095)



c) RCP 4.5 (2066 – 2095)



d) RCP 8.5 (2066 – 2095)





## MAIN CONCLUSIONS



- Although **population decreases**, the **exposure to HDEs will increase** due to more frequent, intense, and geographically extensive droughts and warm months.
- This may be exceptionally relevant since **most population will be concentrated in the largest cities** of Iberia.
- However, the intensity of exposure is rather different **depending on the scenario that is selected**.

# Thank you

To contact me:



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