CONSTRAINED CMIP6 FUTURE CLIMATE PROJECTIONS OVER THE EURO-MEDITERRANEAN REGION BASED ON A CIRCULATION PATTERNS APPROACH

MATÍAS OLMO

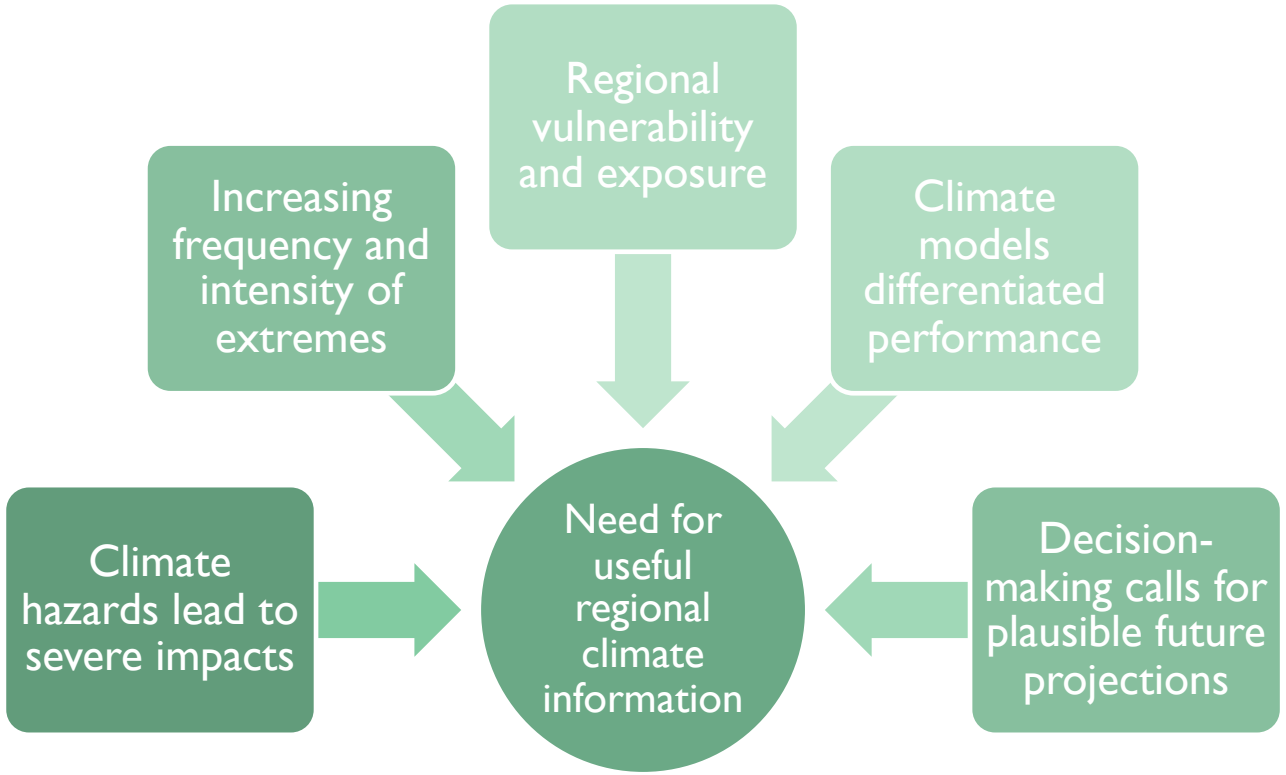
ÁNGEL MUÑOZ, DIEGO CAMPOS, PEP COS, ALBERT SORET, FRANCISCO DOBLAS-REYES

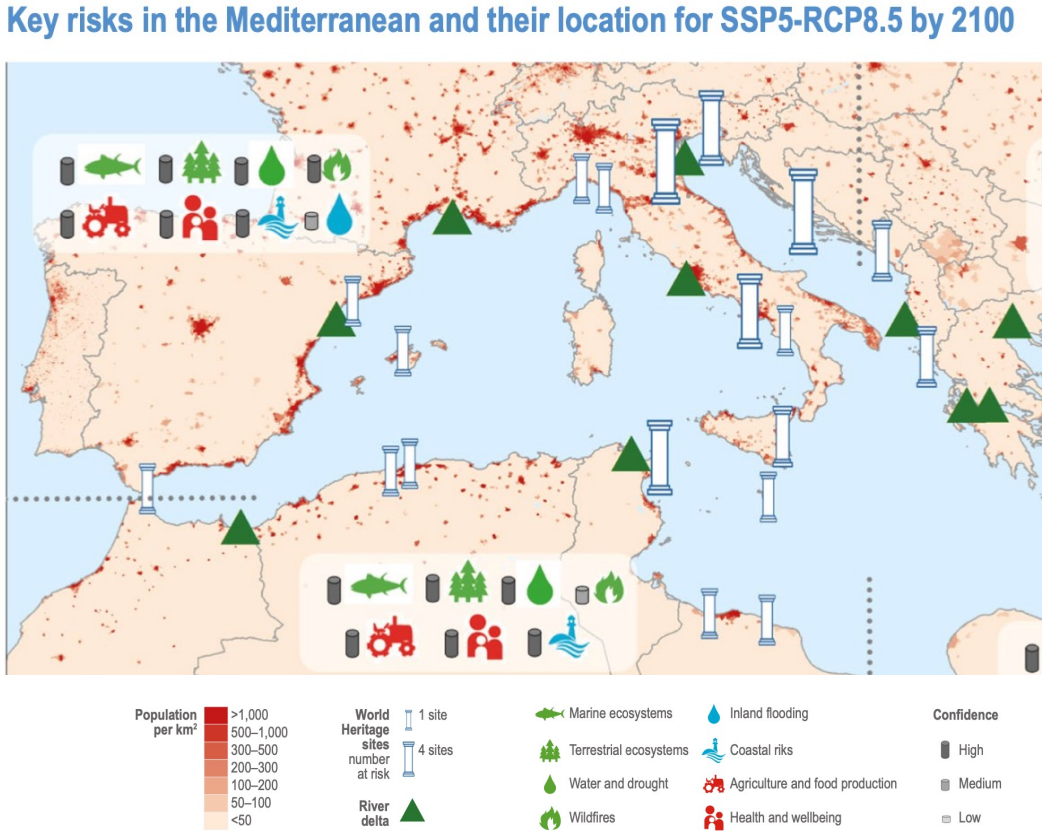
CLIMATE SERVICES TEAM – EARTH SCIENCES DEPARTMENT - BSC

15th International Meeting on Statistical Climatology

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

MOTIVATION



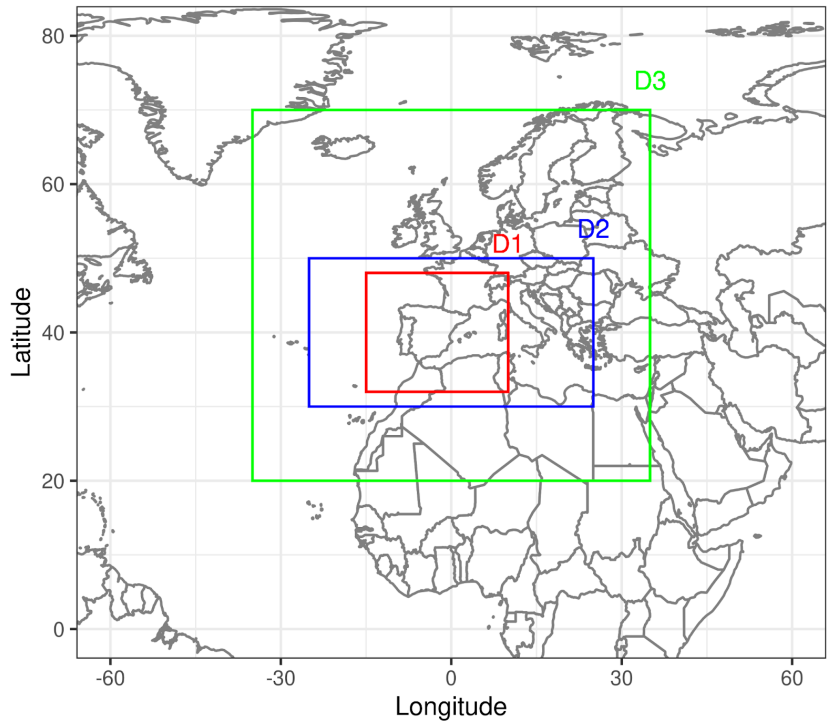


IPCC AR6 WGII, CCP4 Mediterranean Region.

OBJECTIVE

- Design a process-based evaluation framework for CMIP6 GCMs based on atmospheric circulation patterns (CPs) for climate diagnosis and performance ranking to get improved understanding of future projections.

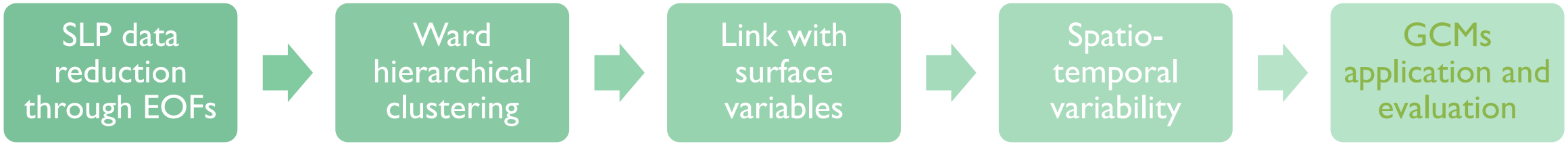
ECMWF ERA5 DAILY DATA (REFERENCE)
30 CMIP6 GCMS 1950-2014 + 2070-2100



Domains selected for the CPs.

- Atmospheric circulation domains
  - Mean sea level pressure (SLP)
  - Geopotential Height (Z) at 500 hPa
  - Zonal and meridional winds at 850 hPa
- Surface variables (historical)
  - Precipitation (PR)
  - Maximum temperature (TX)
  - Minimum temperature (TN)
- Extreme indices (SSP585 vs. historical)
  - ETCCDI indices, such as: TNn, TXx, TN90p, TX90p and RX1day.

METHODS AND WORKFLOW



Sensitivity to:
-Domain size
-Number of clusters
-Input data

Anomalies estimation
Correlation analysis

Cross-time scale evaluation of CPs variability

-ErrorCycle
-DISO
MODEL RANKING AND SUBSETTING

METHODS: EVALUATION METRICS

- ErrorCycle

Percentage of difference in the daily frequency of each CP.

$$Error_{CP} = \frac{\sum_{i=1}^{D} \left| fERA5_{CP}i - fGCM_{CP}i \right|}{D.fERA5_{CP}i}$$

Olmo et al. 2022
Agudelo et al. 2023

- Distance between Indices of Simulation and Observation (DISO)

Summary of a Taylor Diagram.

$$r = \frac{\sum_{k=0}^{n}(a_i - \bar{a})(b_i - \bar{b})}{\sqrt{\sum_{k=0}^{n}(a_i - \bar{a})^2}\sqrt{\sum_{k=0}^{n}(b_i - \bar{b})^2}},$$

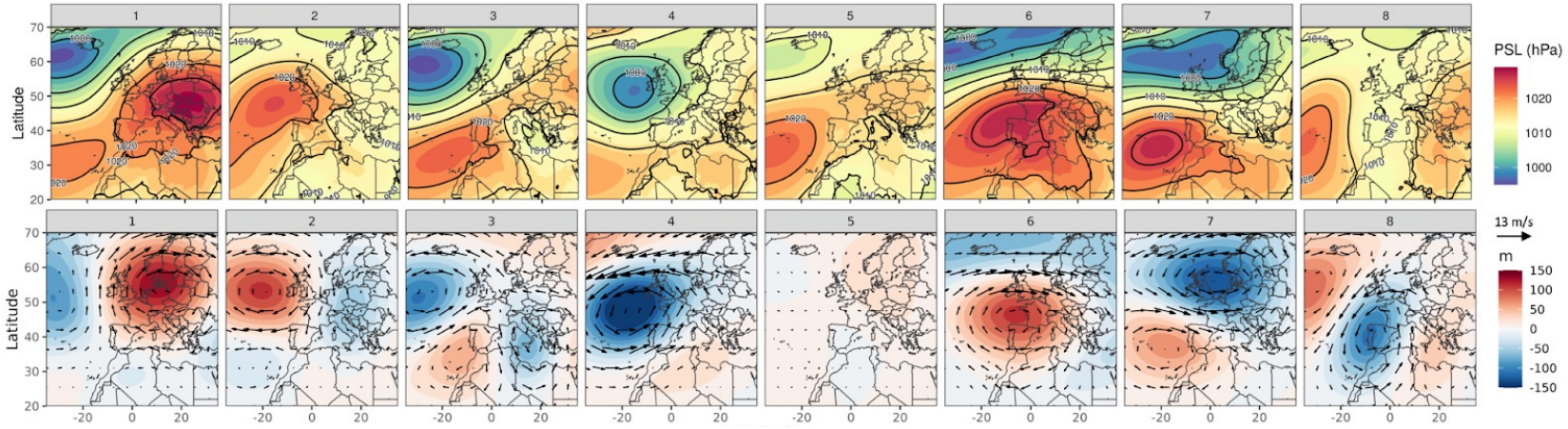
$$\mathrm{AE} = \frac{1}{n}\sum_{k=0}^{n}(b_i - a_i),$$

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{k=0}^{n}(b_i - a_i)^2},$$

$$DISO = \sqrt{(r-1)^2 + NAE^2 + NRMSE^2}$$

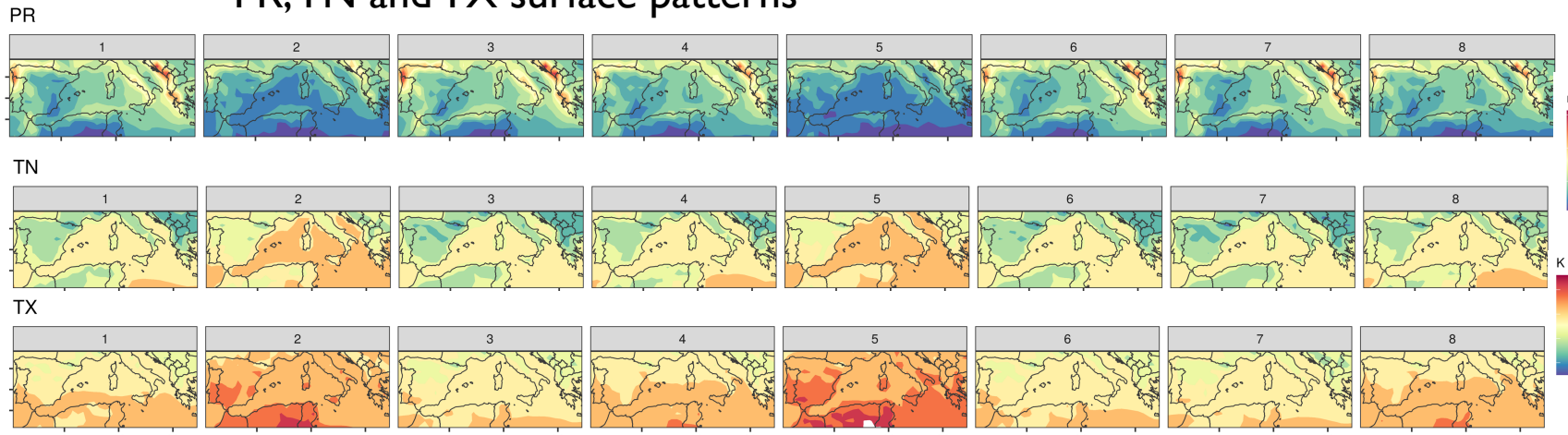
DISO mean = weighted mean of PR, TN and TX DISO

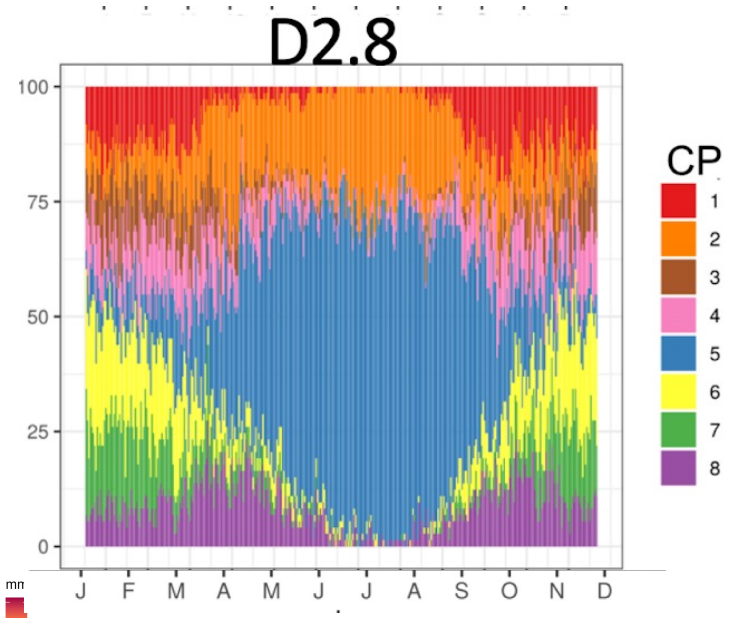
Hu et al. 2018
Liu et al. 2018



SLP spatial patterns; Z500 (shaded) and low-level winds (vectors)

PR, TN and TX surface patterns

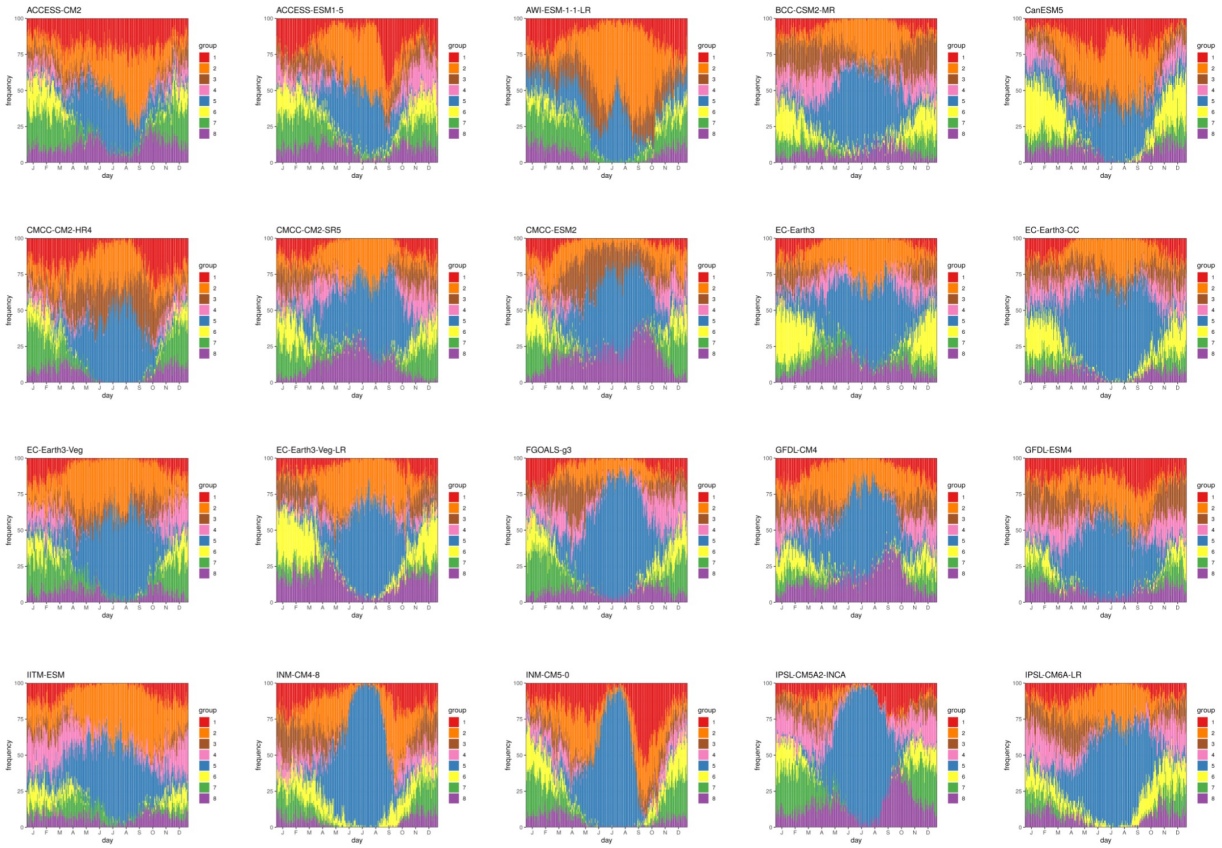


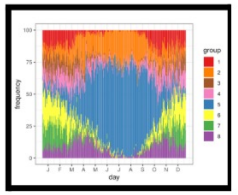


Annual cycles of CPs.

Olmo et al. 2024 JOC, under review.

OBSERVATIONAL REFERENCE: CP CIRCULATION AND SURFACE PATTERNS

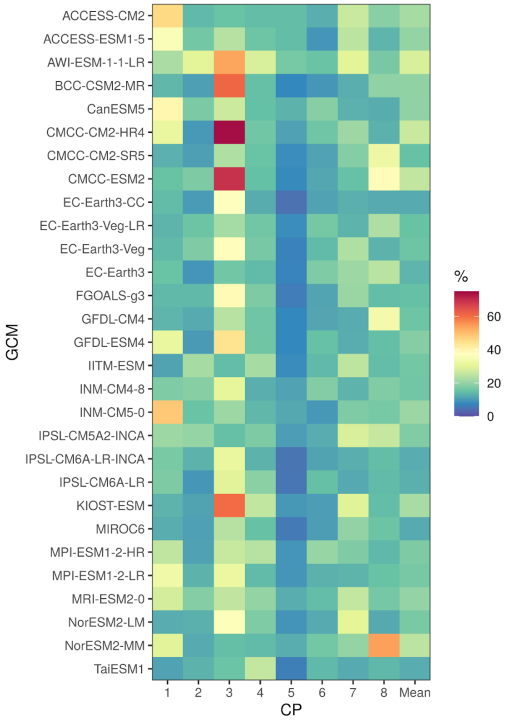




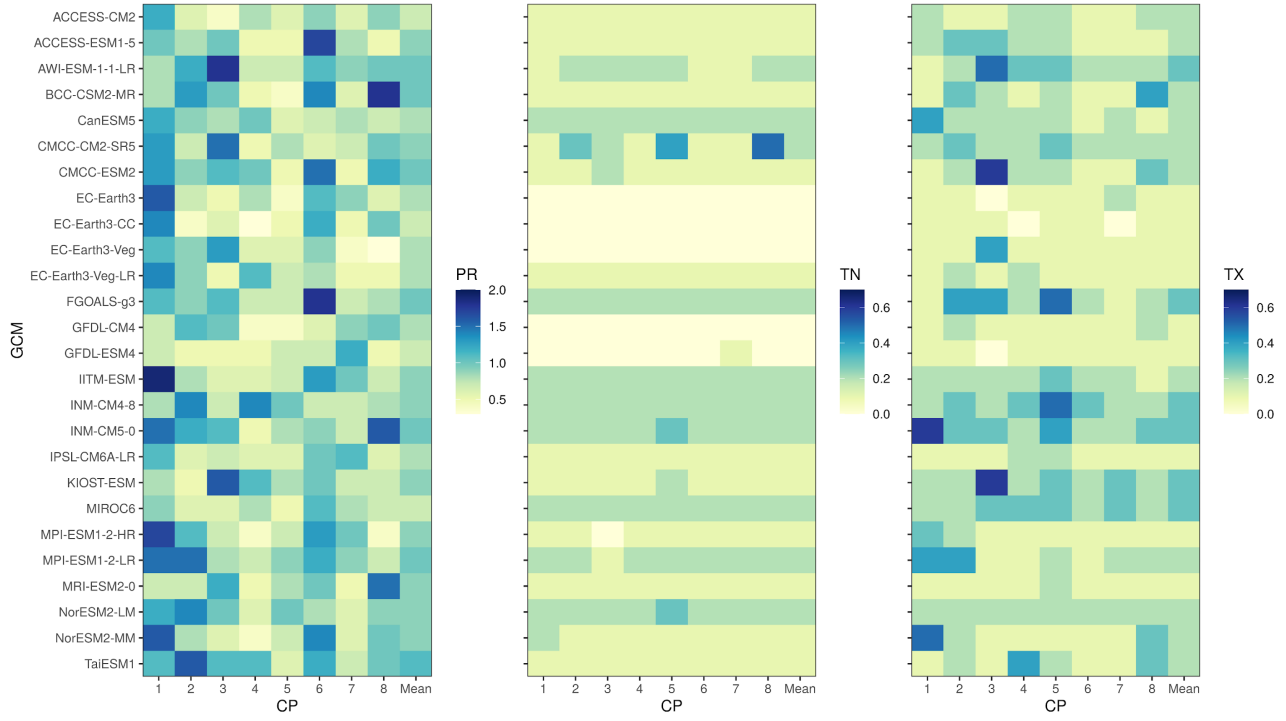
<- ERA5

Annual cycles of CPs by GCM.

CP ANNUAL CYCLE



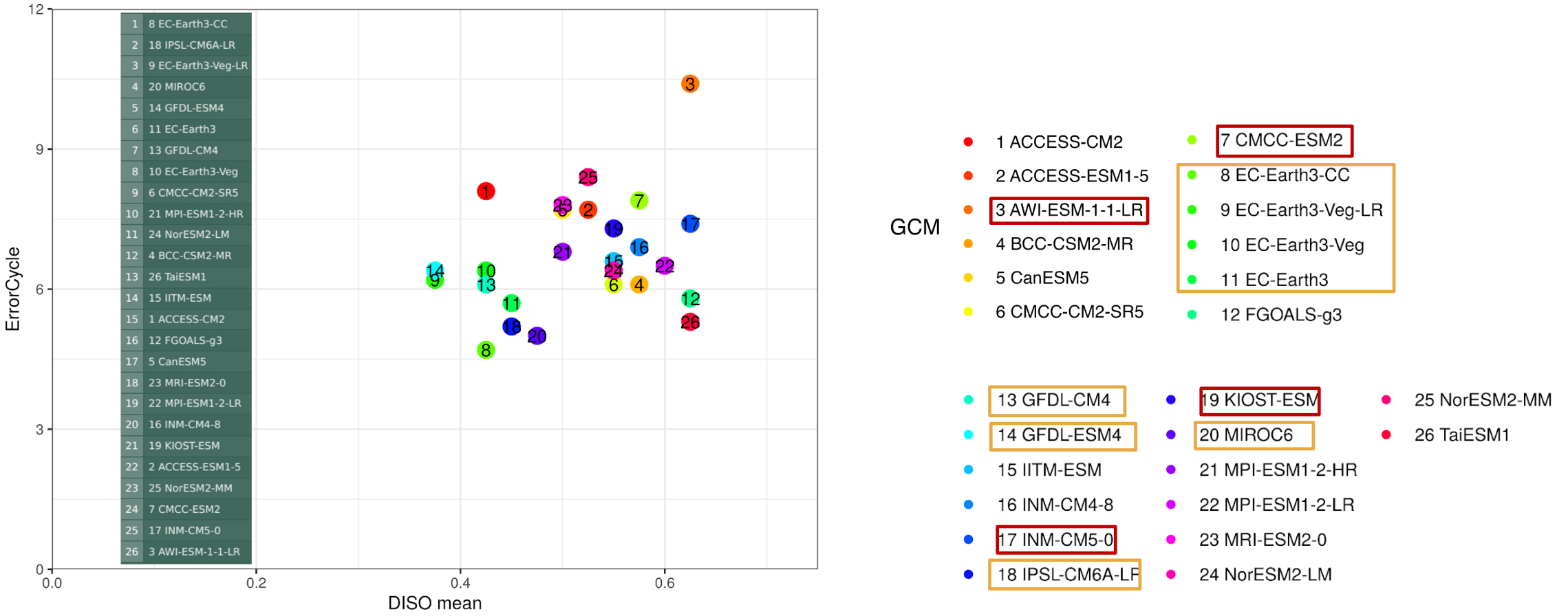
More difficulties in winter and transitional CPs (CP1, CP3, CP7).



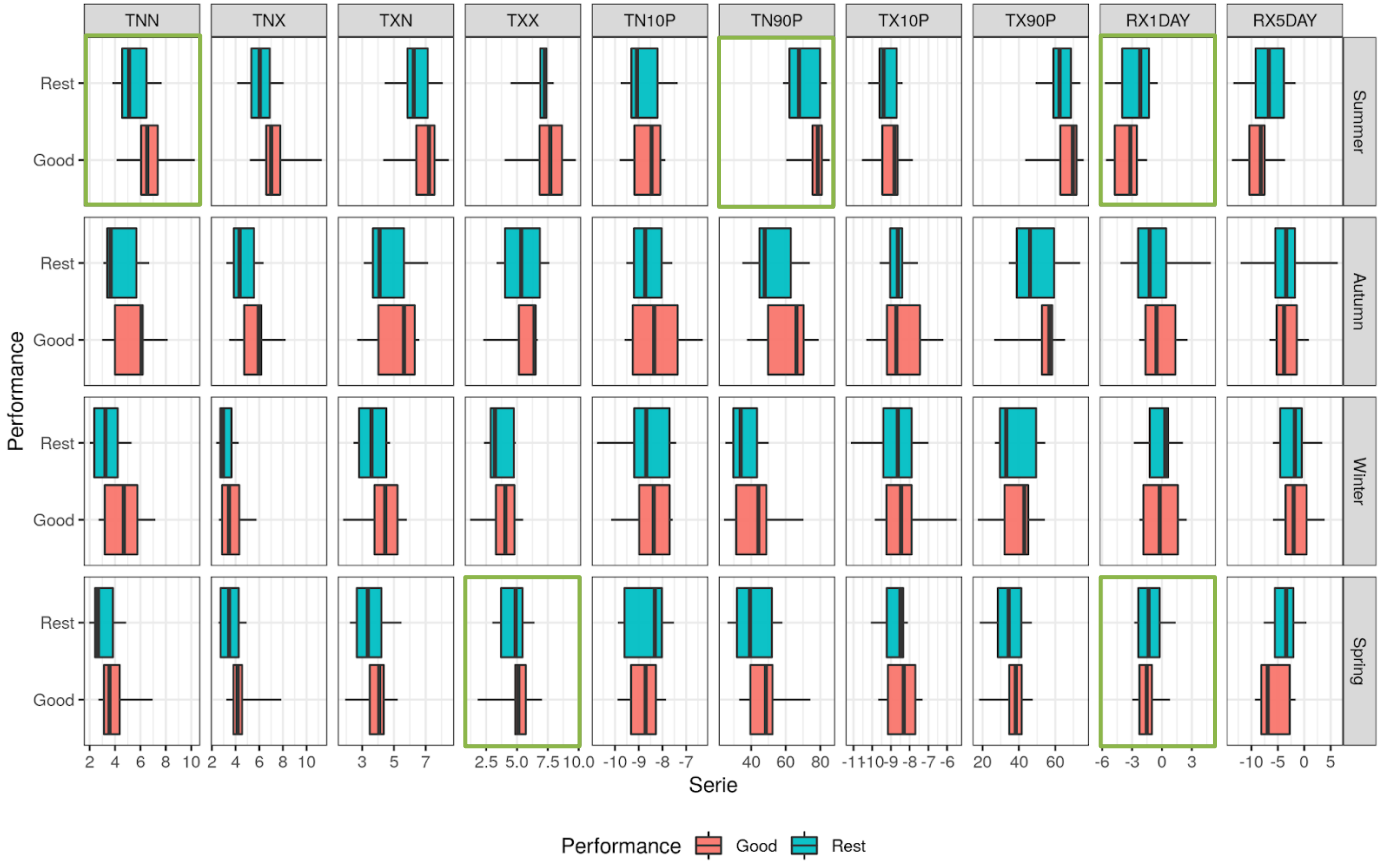
PR spatial patterns are more challenging to reproduce, particularly in the transition seasons.

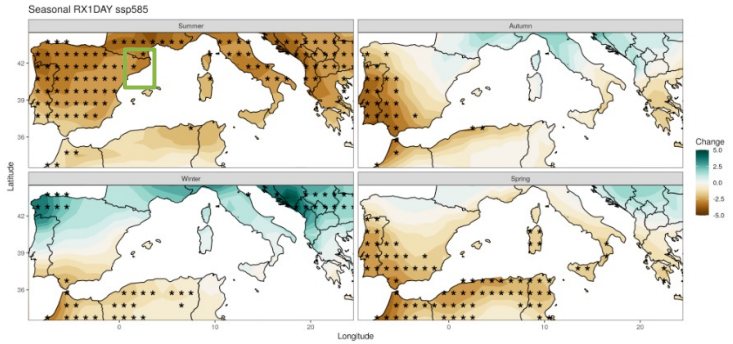
ERRORCYCLE

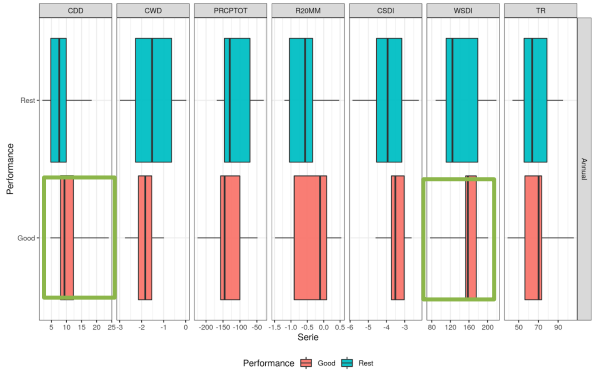
DISO



MODEL PERFORMANCE: ERRORCYCLE VS. DISO MEAN (PR, TN AND TX)







Best-performing GCMs often have similar delta changes.
The ensemble preserves GCMs with high climate sensitivity.

DELTA CHANGES OF FUTURE EXTREMES: THE CASE OF CATALONIA (NE SPAIN) 2070-2100 SSP585

MAIN CONCLUSIONS

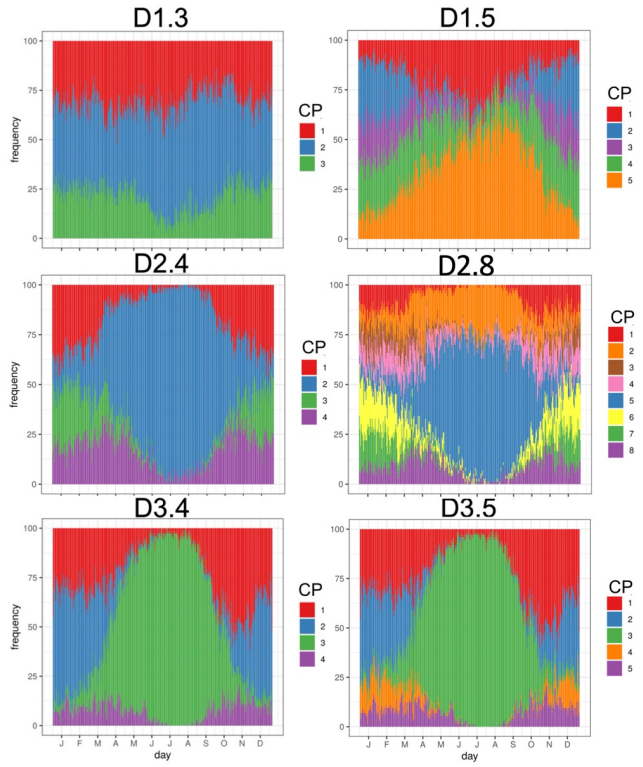
- The classification of CPs can discriminate synoptic and surface structures with clear seasonal behaviour.
- CMIP6 GCMs have different performances in terms of spatio-temporal variability.
- This is a flexible framework for process-based model ranking and filtering of climate projections.
- Larger delta changes are typically identified in the best-performing GCMs.

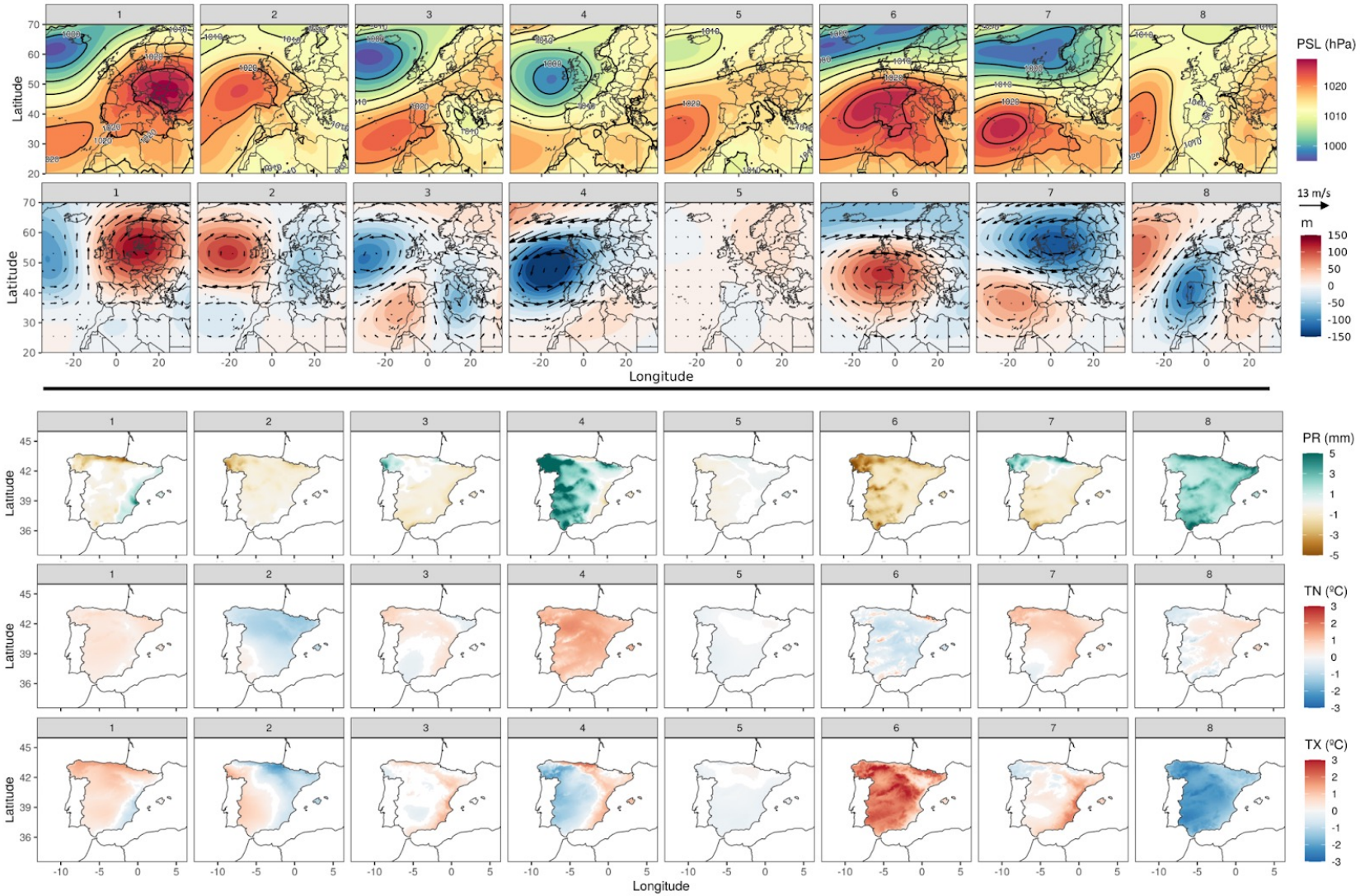
THANKS!

MATIAS.OLMO@BSC.ES

Barcelona
Supercomputing
Center
Centro Nacional de Supercomputación

EXTRA SLIDE I





EXTRA SLIDE II