Universitat de les Illes Balears

Grup de Meteorologia

Statistical Downscaling of EURO-CORDEX climate change scenarios: Projections of droughts, heavy precipitation, heat waves and cold spells
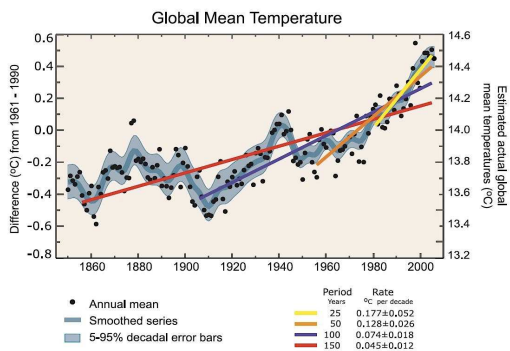
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1. Motivations and objectives

Climate change: current evidences

Global Mean Temperature

- Global mean surface air temperature has risen by about 0.74ºC (1906-2005)
- 11 of the 12 warmest years on record have occurred in the past 12 years
- Important regional variations
- Redistribution of rainfall and other variables

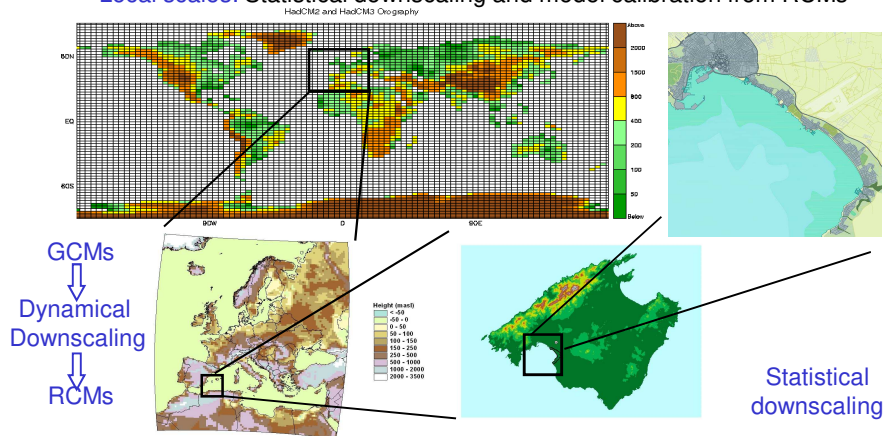## Extreme weather events

Summary for Policymakers (IPCC)

- ⬇ cold days and nights (99%)
- ⬆ hot days and nights (99%)
- ⬆ frequent and/or intense heavy rainfall events (90%)   Longer and/or more intense droughts (66%)
- ⬆ hurricane activity (50%) (western north pacific and north atlantic)

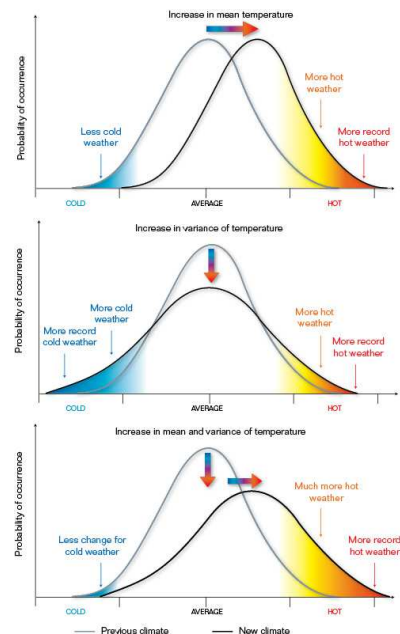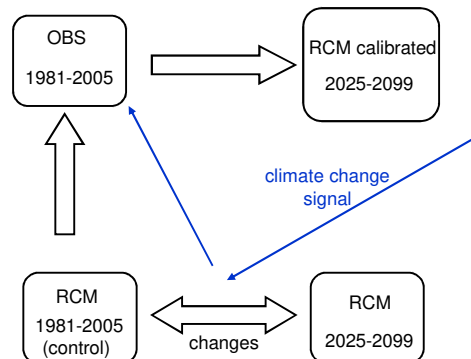# Tools for exploring climate change impacts

- GCMs → RCMs

    -Regional scales: Dynamical downscaling. Regional Climate Models (RCMs)

    -Local scales: Statistical downscaling and model calibration from RCMs

GCMs
⇓
Dynamical Downscaling
⇓
RCMs

Statistical downscaling

Statistical downscaling of RCM outputs

OBS 1981-2005 ⟹ RCM calibrated 2025-2099

climate change signal

RCM 1981-2005 (control) ⟷ changes ⟷ RCM 2025-2099

Statistical downscaling of RCM outputs:
Quantile-Quantile adjustment *(Amengual et al. 2012)*

$$p_i = o_i + g\overline{\Delta} + f\Delta_i',$$

$$\Delta_i = s_{\mathrm{fi}} - s_{\mathrm{ci}}$$

$$\overline{\Delta} = \frac{\sum_{i=1}^{N}\Delta_i}{N} = \frac{\sum_{i=1}^{N}(s_{\mathrm{fi}} - s_{\mathrm{ci}})}{N} = \overline{S_f} - \overline{S_c}$$

$$\Delta_i' = \Delta_i - \overline{\Delta} \qquad g = \frac{\left(\sum_{i=1}^{N} o_i\right)\big/N}{\left(\sum_{i=1}^{N} s_{\mathrm{ci}}\right)\big/N} = \frac{\overline{O}}{\overline{S_c}}$$

$$f = \frac{\sigma_O}{\sigma_{S_c}} = \frac{\mathrm{IQR}|_O}{\mathrm{IQR}|_{S_c}}. \qquad\qquad f = \frac{\sigma_{O'i}}{\sigma_{S_c'i}}$$

Global   **Local**

Downscaling method

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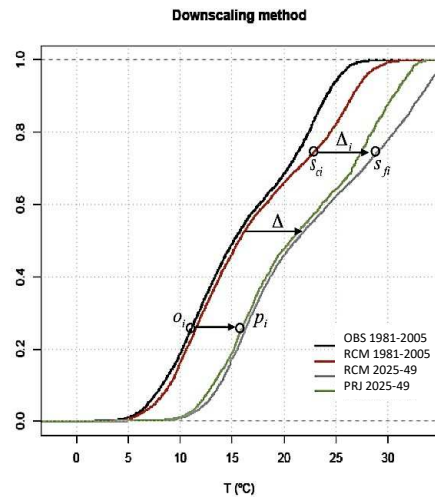
2. Database and methodology

E-OBS gridded dataset (25 km)   **EURO-CORDEX (12,5 km)**

Future regional scenarios
rcp4.5 and **rcp8.5**
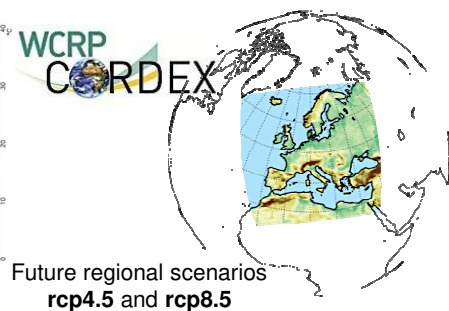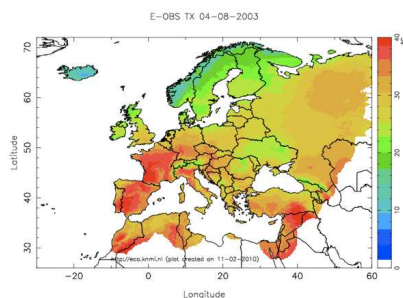
Validation task

Evaluation of raw and calibrated data compared against observations for the 1956-1980 interval. Control period (1981-2005)

Climate change projections

Compute changes in calibrated CDFs between a 25-year past (i.e. control/observed; 1981-2005) and successive 25-year RCM time-slices (2021-2045; 2046-2070; **2071-2095**)

Future regional scenario rcp4.5 and **rcp8.5**
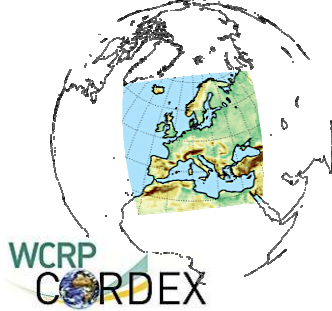
Driving GCM	RCM	Institute
CNRM-CM5-LR	CCLM4-8-17	CLMcom
EC-EARTH	CCLM4-8-17	CLMcom
HadGEM2-ES	CCLM4-8-17	CLMcom
MPI-ESM-LR	CCLM4-8-17	CLMcom
EC-EARTH	RACMO22E	KNMI
HadGEM2-ES	RACMO22E	KNMI
EC-EARTH	HIRHAM5	DMI
NorESM1-M	HIRHAM5	DMI
CNRM-CM5	ALADIN53	CNRM
CNRM-CM5	RCA4	SMHI
EC-EARTH	RCA4	SMHI
HadGEM2-ES	RCA4	SMHI
MPI-ESM-LR	RCA4	SMHI
IPSL-CM5A-MR	RCA4	SMHI

Extreme weather events

1. Heat Waves
2. Cold Spells
3. Heavy precipitation
4. Droughts

We characterize their attributes with the following parameters:

- Number of extreme events that occur in a given time interval
- Frequency: the number of days under extreme conditions in a given time interval
- Duration exceedance: the total number of consecutive days exceeding the duration threshold for all events in a given time interval. It accounts for the whole amount of excess days.
- Amplitude exceedance: the accumulated thermal stress exceedance for all the days under extreme conditions in a given time interval.

3. Results

3.1 Heat waves

- A spell lasting dth = 3 or more consecutive days with *daily maximum temperature* above 95th percentile of observed daily maximum temperature in summer.
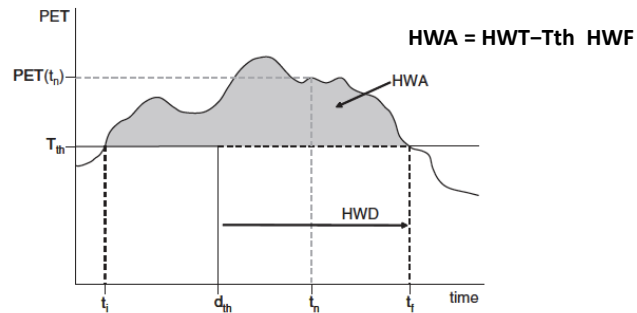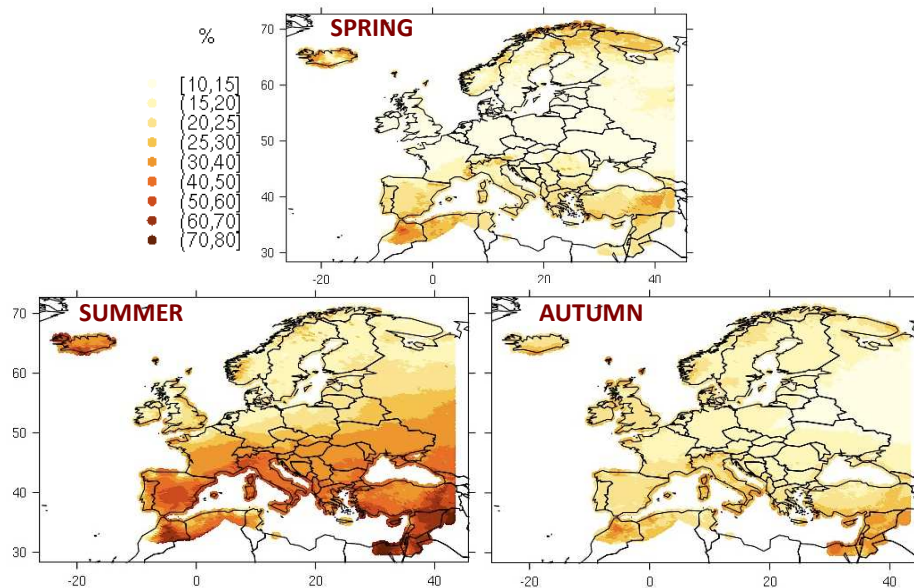

HWA = HWT−Tth HWF

Fig. 1. Graphical sketch of heat wave duration (HWD) and amplitude (HWA, gray shading) exceedances. T_{th} and d_{th} denote the thermal stress and duration thresholds, respectively.
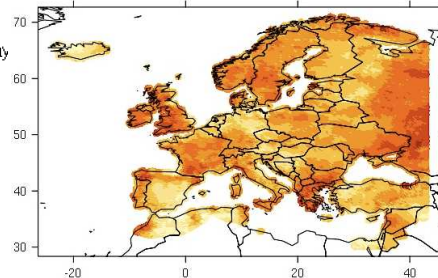

Events over P95 of daily maximum temperature

FUTURE CHANGE

HEAT WAVE AMPLITUDE

SUMMER

OBSERVED

Future change (multi-model mean)

Std (future change multi-model)
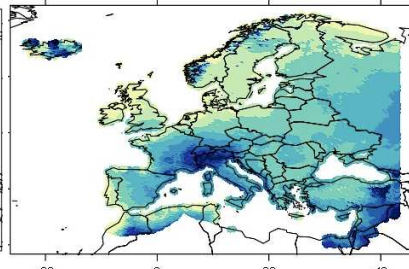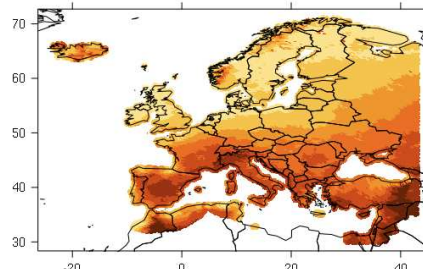
HEAT WAVE AMPLITUDE

Future change (multi-model mean)

Std (future change multi-model)

SPRING
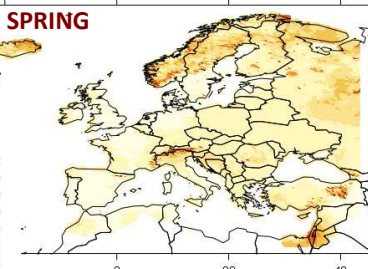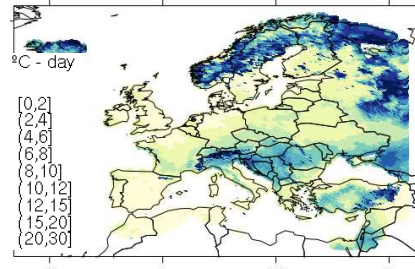
AUTUMN
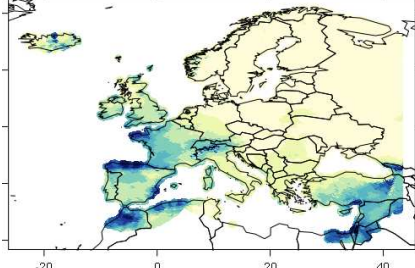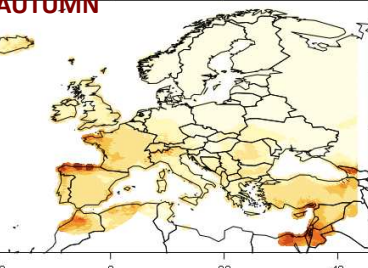
3. Results

3.2 Cold spells

- A spell lasting dth = 3 or more consecutive days with *daily minimum temperature* under 5th percentile of observed daily minimum temperature in winter.

  ➢ Future events under P5 of daily observed minimum temperature in winter.
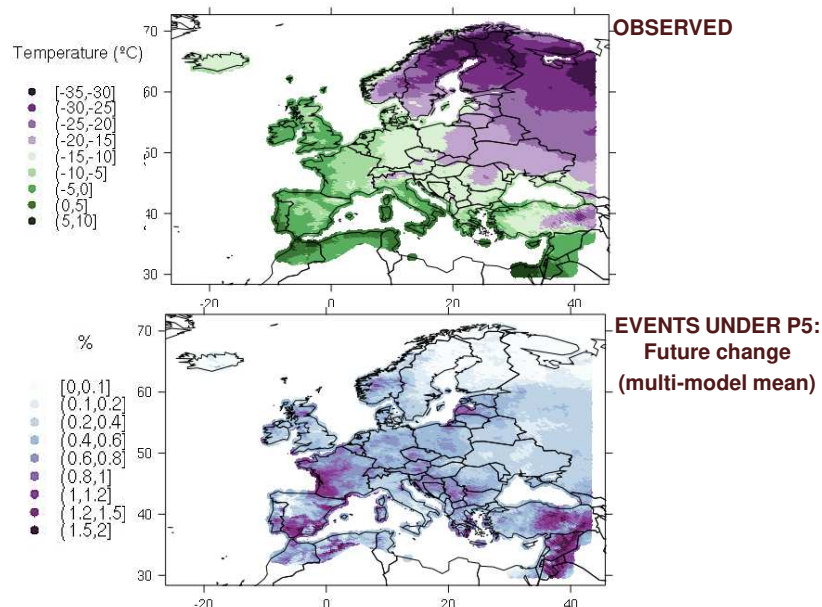
  ➢ Cold Spell Amplitude (CSA)
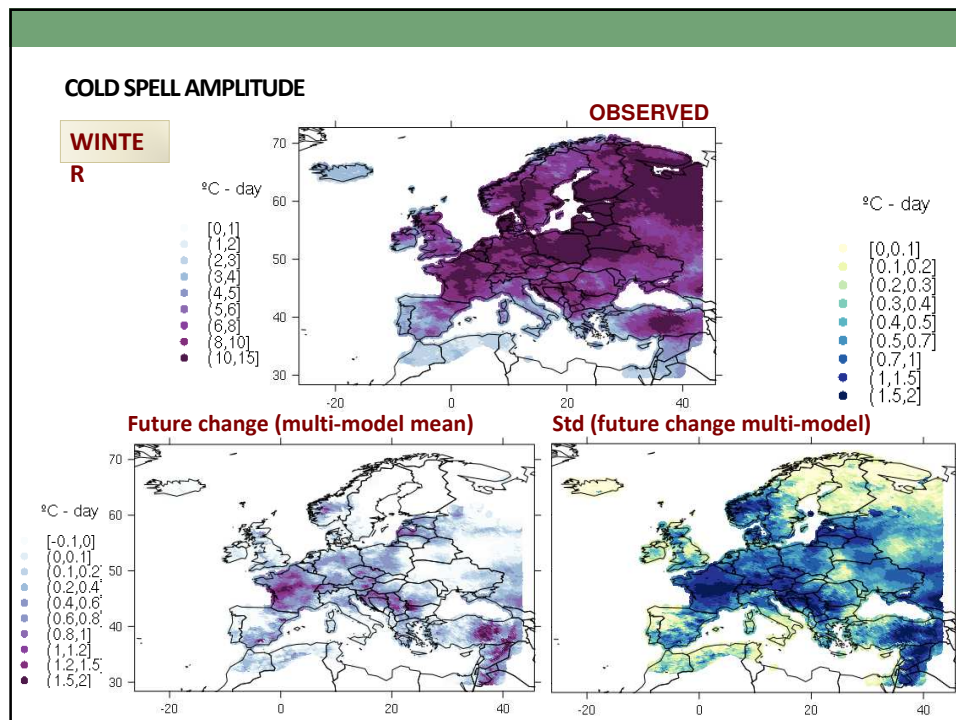
$$CSA = T_{th} \; CSF - CST$$

T_{th}: thermal stress
CSF: cold spell frequency
CST: integral of the minimum daily temperatures over the duration of each individual cold spell, and accumulated for all cold spells in a given time interval

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P5 of daily minimum temperature (WINTER)

OBSERVED

EVENTS UNDER P5: Future change (multi-model mean)
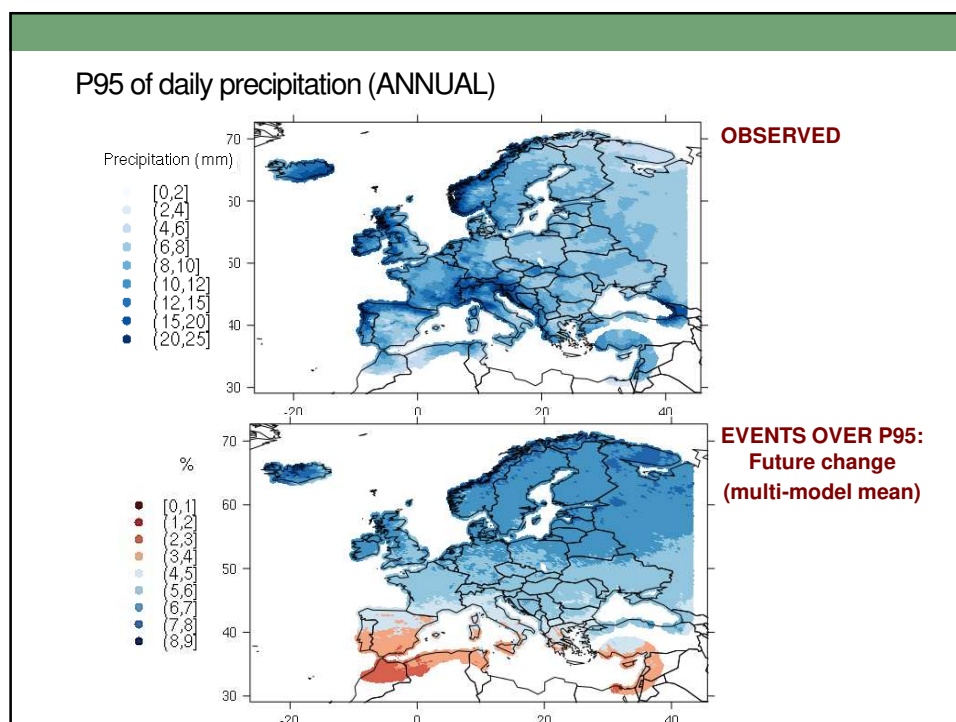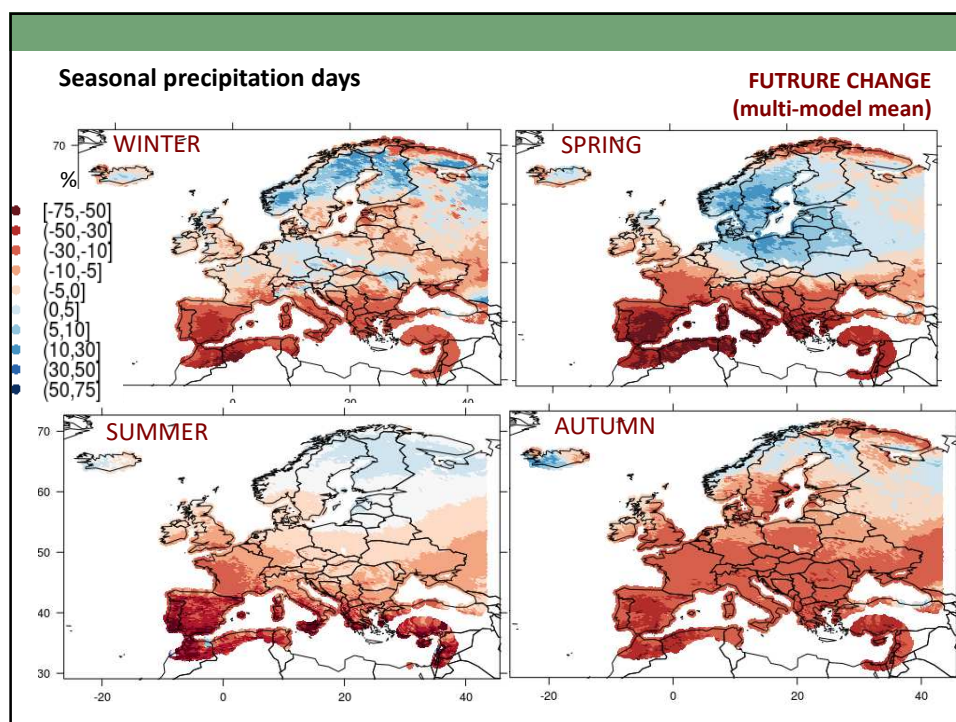
COLD SPELL AMPLITUDE

3. Results

3.3 Heavy precipitation

• A spell lasting dth = 2 or more consecutive days with *daily precipitation* >= 0.01 mm

➢ Future change in seasonal precipitation days.

➢ Future events over P95 of daily annual observed precipitation.
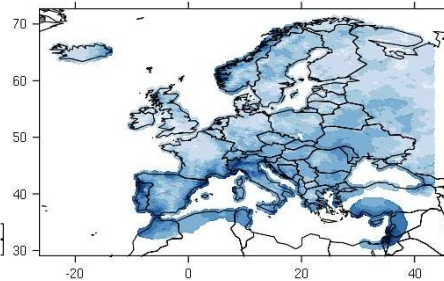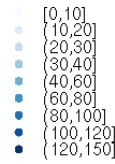
➢ Heavy Precipitation Amplitude (HPA)
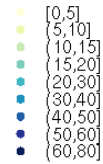
HPA = HPT - Tth HPF

Seasonal precipitation days

FUTRURE CHANGE
(multi-model mean)

WINTER · SPRING · SUMMER · AUTUMN

P95 of daily precipitation (ANNUAL)

OBSERVED

EVENTS OVER P95:
Future change
(multi-model mean)

HEAVY PRECIPITATION AMPLITUDE

ANNUAL

OBSERVED

mm - day

[0,10]
(10,20]
(20,30]
(30,40]
(40,60]
(60,80]
(80,100]
(100,120]
(120,150]

mm - day

[0,5]
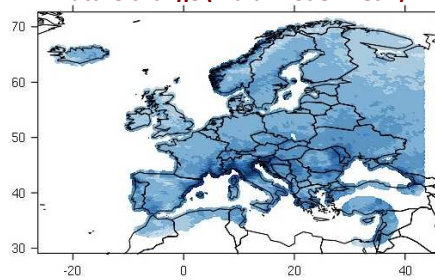(5,10]
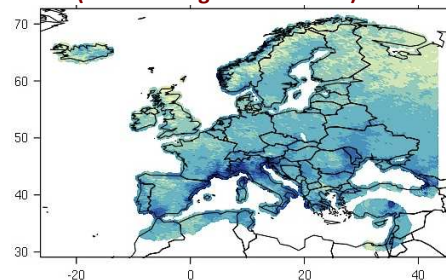(10,15]
(15,20]
(20,30]
(30,40]
(40,50]
(50,60]
(60,80]

Future change (multi-model mean)   Std (future change multi-model)

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3. Results

3.3 Droughts

- A spell lasting dth = 3 or more consecutive days with *daily precipitation* <= 0.1 mm

➢ P95 of observed annual drought duration

➢ Number of future events with a duration over P95 of observed drought duration

NUMBER OF DROUGHTS

ANNUAL

P95 of observed drought duration

OBSERVED

Future (multi-model mean)

NUMBER OF DROUGHTS

ANNUAL

P95 of observed drought duration

Future change (multi-model mean)

Std (future change multi-model)
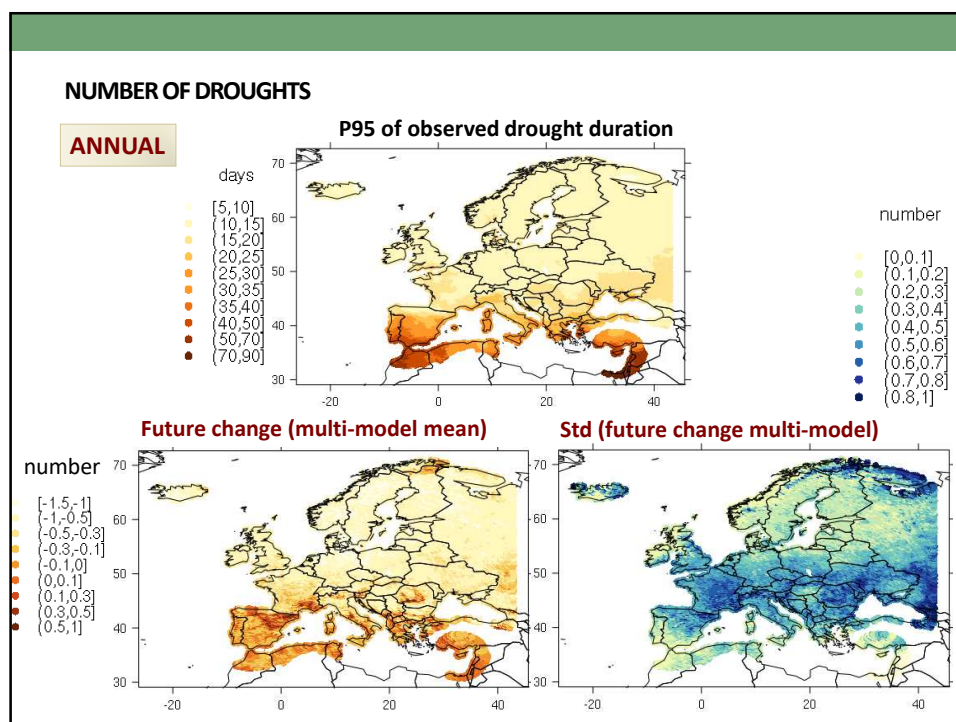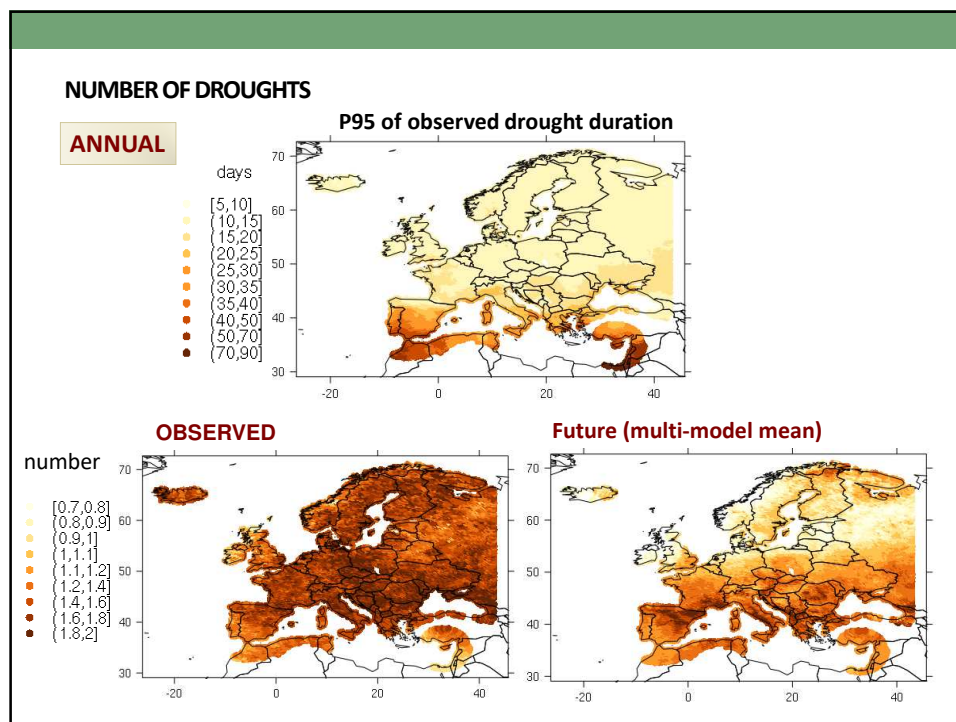
Aknowledegments:

CGL201452199-R (AEI/FEDER, UE)

FPI-CAIB (Conselleria d'Innovació, Recerca i Turisme del Govern de les Illes Balears and the Fons Social Europeu)