Assessment of extreme temperature percentiles by means of Regional Climate Models

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Thanks to:

S. Herrera
J. Fernández
M.D. Frías
J.M. Gutiérrez

Outline

1. Motivation
2. Objectives
3. Data
4. Methods
5. Results
    - 5.1. Present
    - 5.2. Future
6. Conclusions

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Motivation

Extreme indicators are widely used for quantifying extreme events.

Some of them are based on **percentiles** (i.e. Tn10p (cold nights), Tx90p (warm days), …).

Changes in observed cold nights and warm days in the Iberian Peninsula (IP) have been analysed in Rodriguez-Puebla et al. 2010: **increase of warm days and decrease of cold nights** in 1950-2006.

Motivation

Many studies have validated RCMs with observations, considering mean variables.

Kjellstrom et al. (2007) and Suklitsch et al. (2011) validated the highest/lowest percentiles in maximum/minimum temperature.

According to Kjellstrom et al. (2007), **biases generally increase towards the tails of the probability distributions**, since they are larger in the $95^{th}/5^{th}$ percentiles than the corresponding biases in the median.

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Objectives

- To test the ability of regional climate models (RCM) in high (low) percentiles of maximum (minimum) temperature and assign their biases to deficiencies in the mean and variability of their probability distribution.

- To address the role of the forcing Global Circulation Model (GCM) and the RCM in the climate change signal in the percentiles under a future emissions scenario.

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Regional Climate Models

Label	Model	Acronym	Institution
1	RCA3	C4I	Community Climate Change Consortium for Ireland
2	ALADIN	CNRM	Centre National de Recherches Meteorologiques
3	HIRHAM	DMI	Danish Meteorological Institute
4	CLM	ETHZ	Swiss Institute of Technology
5a	HadRM3 Q0	HC	UK Met Office
5b	HadRM3 Q3	HC	UK Met Office
5c	HadRM3 Q16	HC	UK Met Office
6	RegCM	ICTP	Abdus Salam International Centre for Theoretical Physics
7	RACMO	KNMI	Koninklijk Nederlands Meteorologisch Instituut
8	HIRHAM	METNO	The Norwegian Meteorological Institute
9	REMO	MPI	Max Planck Institute for Meteorology
10	RCA	SMHI	Swedish Meteorological and Hydrological Institute
11	PROMES	UCLM	Universidad de Castilla la Mancha
12a	WRF-A	UC	Universidad de Cantabria
12b	WRF-B	UC	Universidad de Cantabria
13	MM5	UMU	Universidad de Murcia
14	REMO	UAHE	Universidad de Alcalá de Henares
15	PROMES	UCLM	Universidad de Castilla la Mancha

ENSEMBLES Project

Reanalysis: ERA-40
Simulation period: 1961-**2000**

ESCENA Project

Reanalysis: ERA-Interim
Simulation period: **1989**-2008

Data

Present time:

Observations: Spain02 (Herrera et al., 2012): a new, public, gridded dataset for continental Spain and Balearic Islands with 0.2º resolution (1950-2008).

Future scenarios:

Control { 1971-2000 ; 20C3M experiment }

Future { 2021-2050 ; A1B scenario }

GCMs: ECHAM5, ARPEGE, HADCM3-Q0, HADCM3-Q3, HADCM3-Q16.

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Methods

- **Present time:**

Bias for the 95th percentile of Tmax and 5th percentile of Tmin

Reference: Spain02

Bias correction:

- Seasonal mean correction in RCM data

$$x_i^{m\prime} = \left(x_i^{m} - \overline{x_{s(i)}^{m}}\right) + \overline{x_{s(i)}^{o}}$$

- Seasonal standard deviation correction in RCM data

$$x_i^{m\prime\prime} = \frac{x_i^{m} - \overline{x_{s(i)}^{m}}}{S_{s(i)}^{m}} S_{s(i)}^{o} + \overline{x_{s(i)}^{o}}$$

x_i= data for a day i
m= model
o= observed
s(i)= season of a day i
S= stardard deviation

- **Future scenario:**

Differences in percentiles: between 2021-2050 (A1B scenario) and 1971-2000 (20C3M).

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Results

The area of study is the Iberian Peninsula

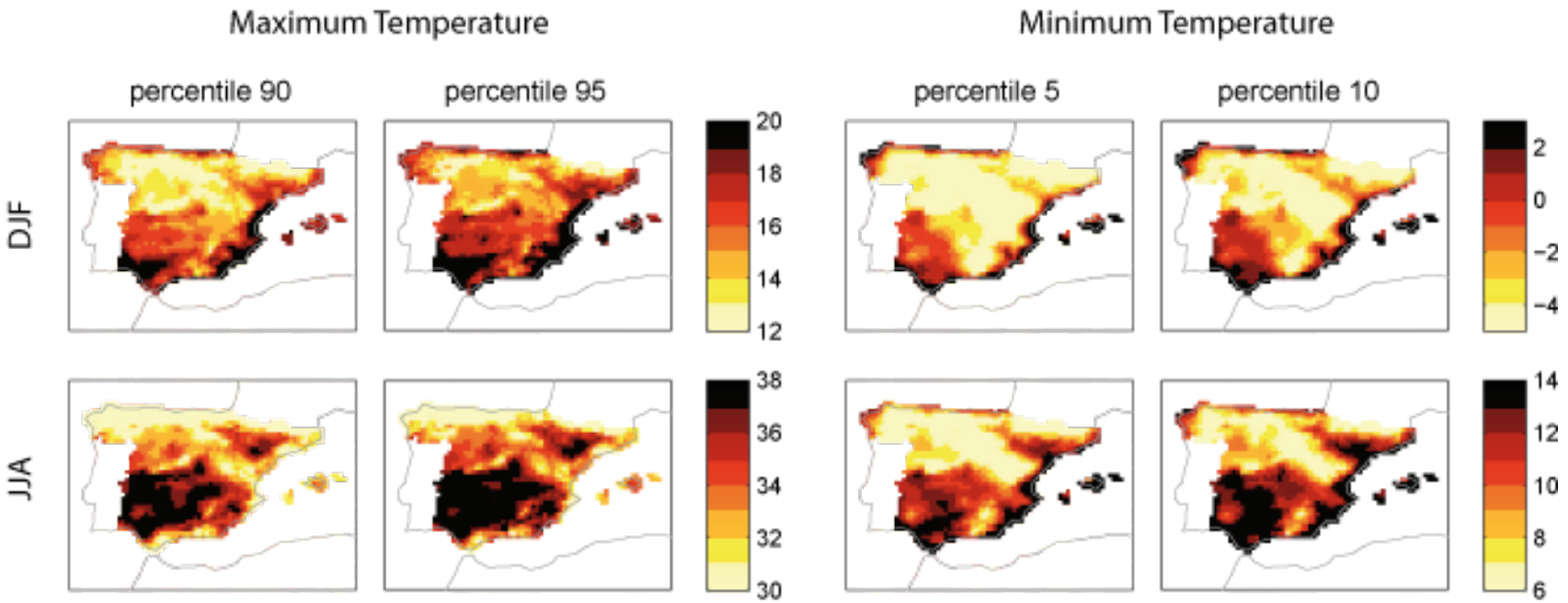
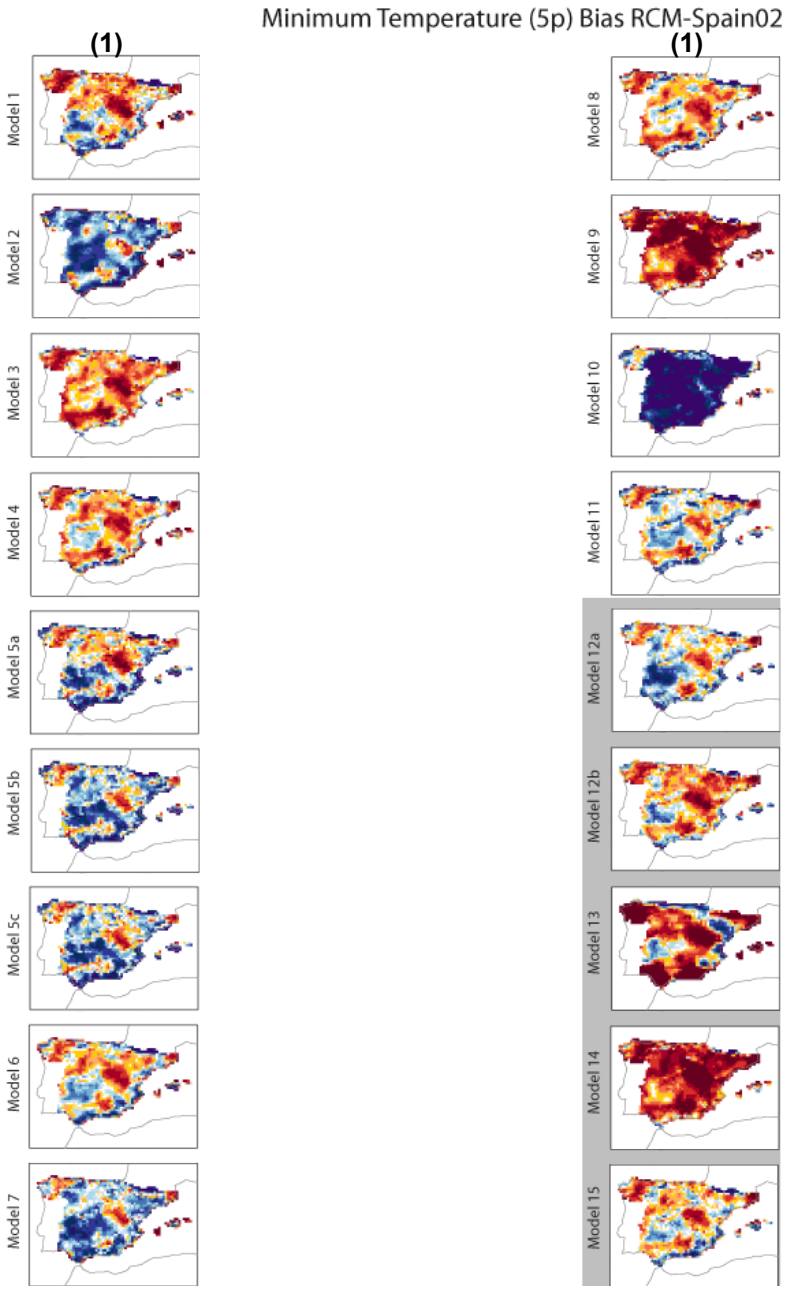


Fig.1: *Extreme percentiles for maximum (90th and 95th) and minimum (5th and 10th) temperature in winter and summer.*

Results are presented for the $5p_{Tmin}$ and the $95p_{Tmax}$

Results: Present



Label	Model	Label	Model
1	RCA3-C4I	8	HIRHAM-METNO
2	ALADIN	9	REMO-MPI
3	HIRHAM-DMI	10	RCA-SMHI
4	CLM	11	PROMES
5a	HadRM3 Q0	12a	WRF-A
5b	HadRM3 Q3	12b	WRF-B
5c	HadRM3 Q16	13	MM5
6	RegCM	14	REMO-UAHE
7	RACMO	15	PROMES

Fig.2: *Spatial bias distribution (ºC) for the* $5p_{Tmin}$ *in winter with respect to Spain02.*
(1) Bias without doing any correction to the model.

Results: Present

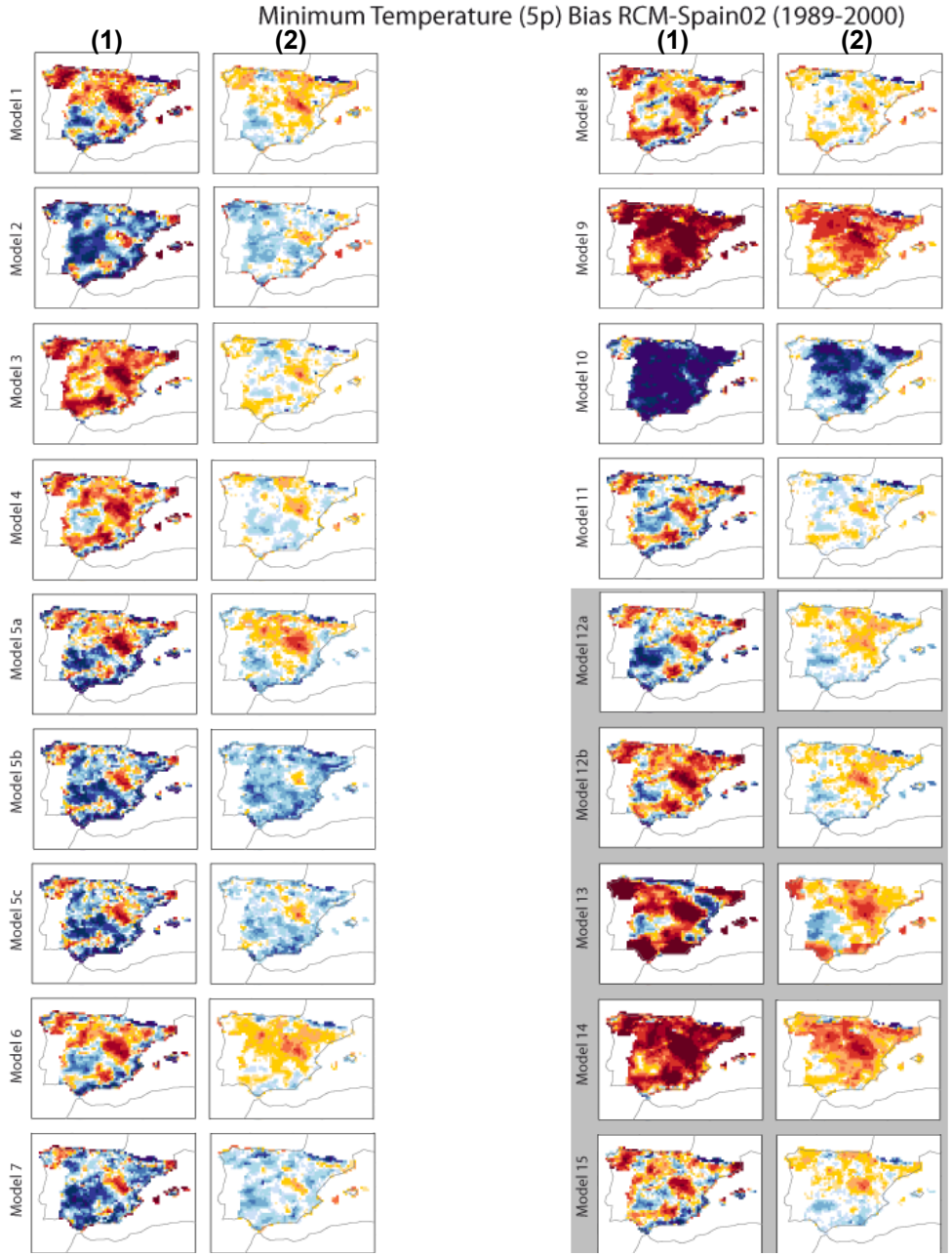


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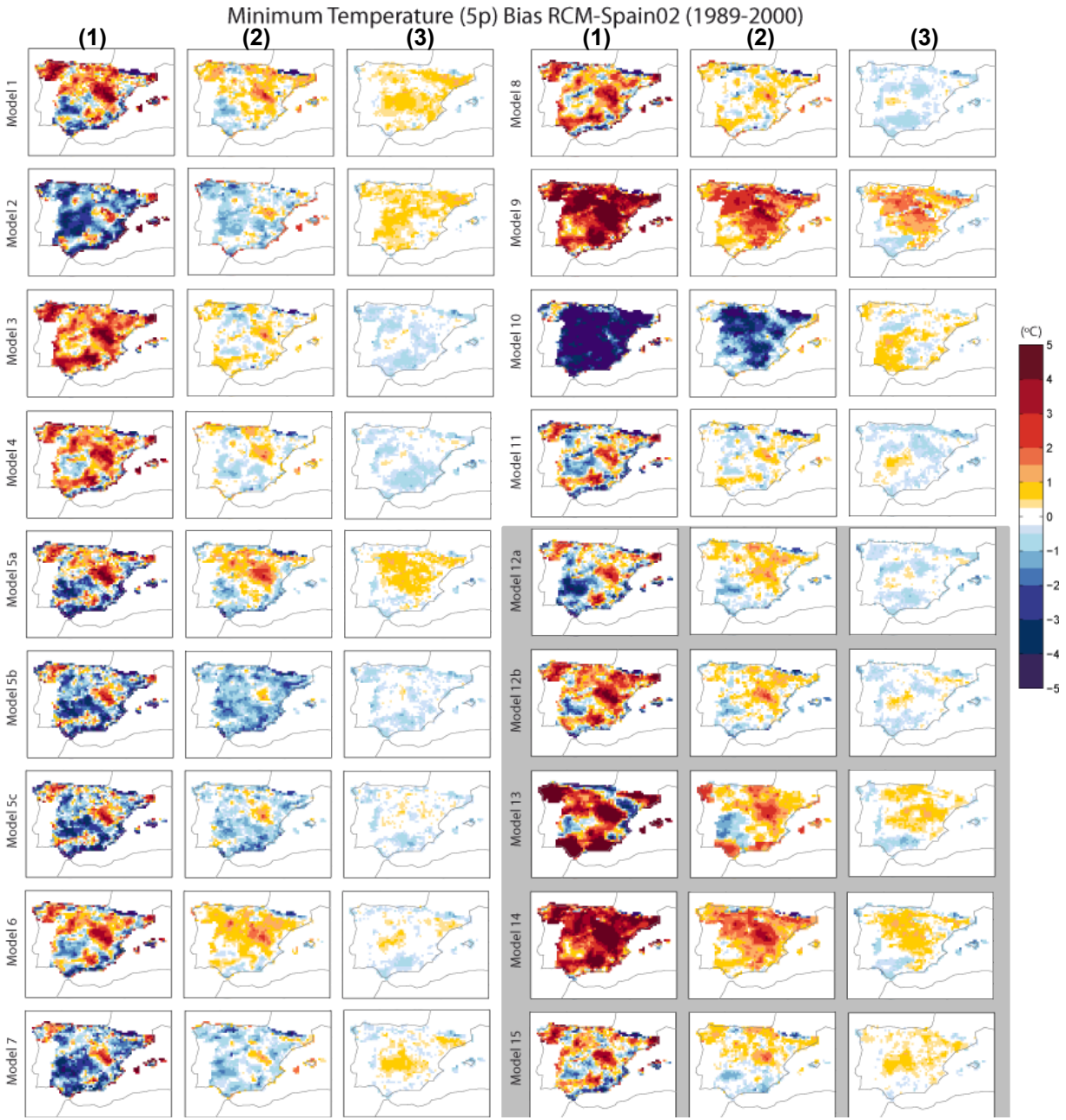
Fig.2: *Spatial bias distribution (ºC) for the $5p_{Tmin}$ in winter with respect to Spain02.*
(1) Bias without doing any correction to the model..
(2) Bias when the correction in the seasonal mean is done.

Results: Present



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(1) Bias without doing any correction to the model..
(2) Bias when the correction in the seasonal mean is done.
(3) Bias when the second order correction is done.

Results: Present

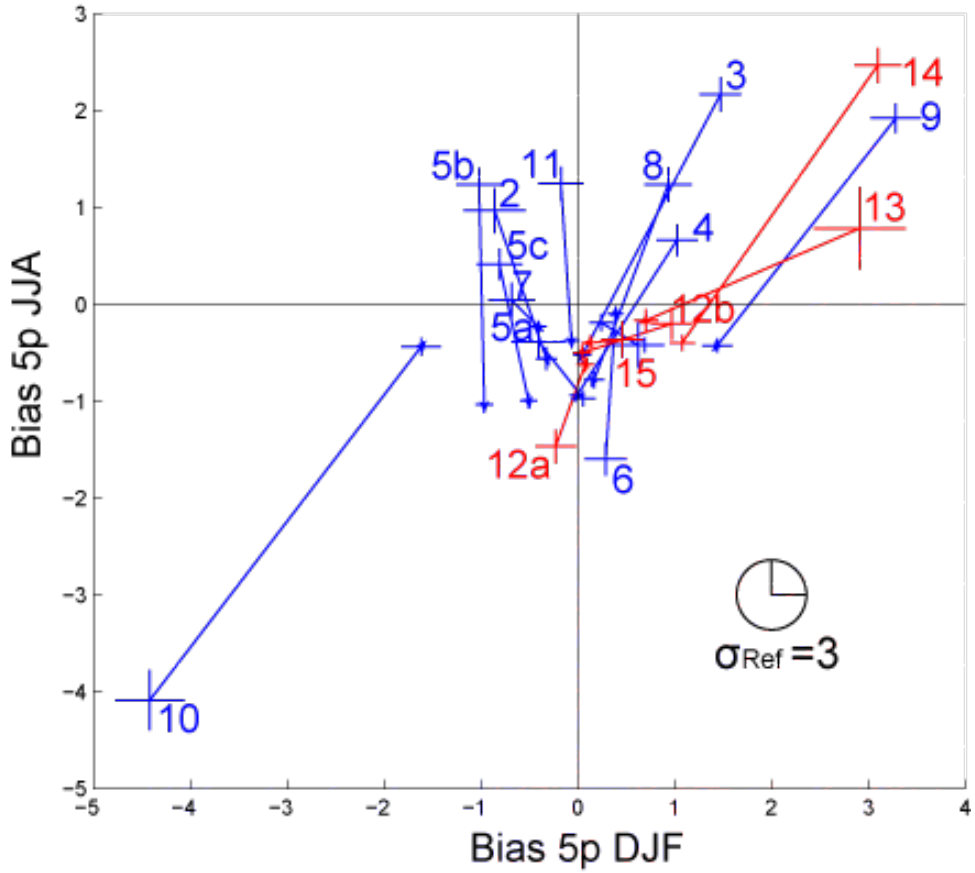

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Fig. 3: *Spatially averaged bias over the IP (ºC) of the $5p_{Tmin}$ with respect to Spain02. The line graph's origin (where the lines are labelled) represents the bias without doing any correction for winter (X axis) and summer (Y axis). The end of each line represent the bias when the correction in the seasonal mean is done. Blue lines for ENSEMBLES and red for ESCENA RCMs. Crosses indicate the standard deviation of the bias through the IP in winter (X axis) and summer (Y axis). σ is rescaled between 0 and 0.5, and the value σ_{ref} =3 is indicated as a reference.*

Results: Present

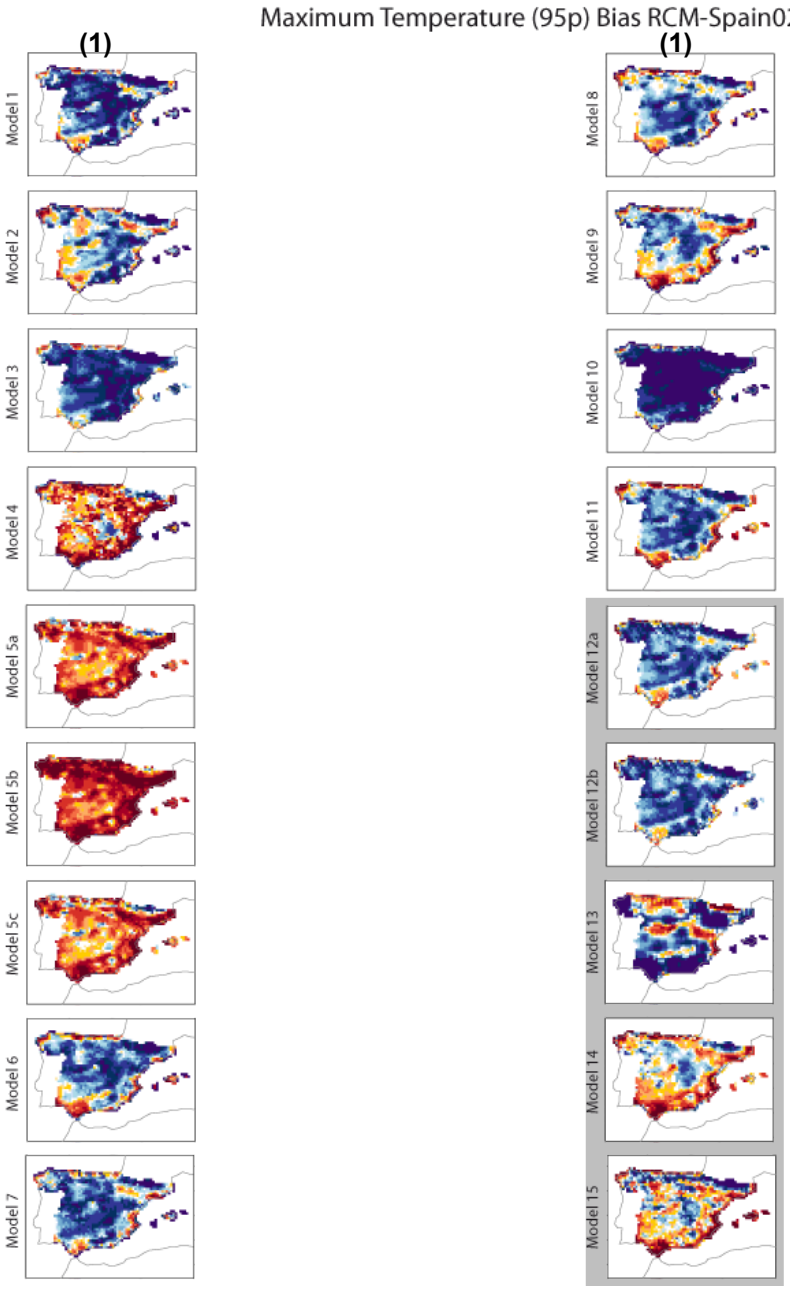

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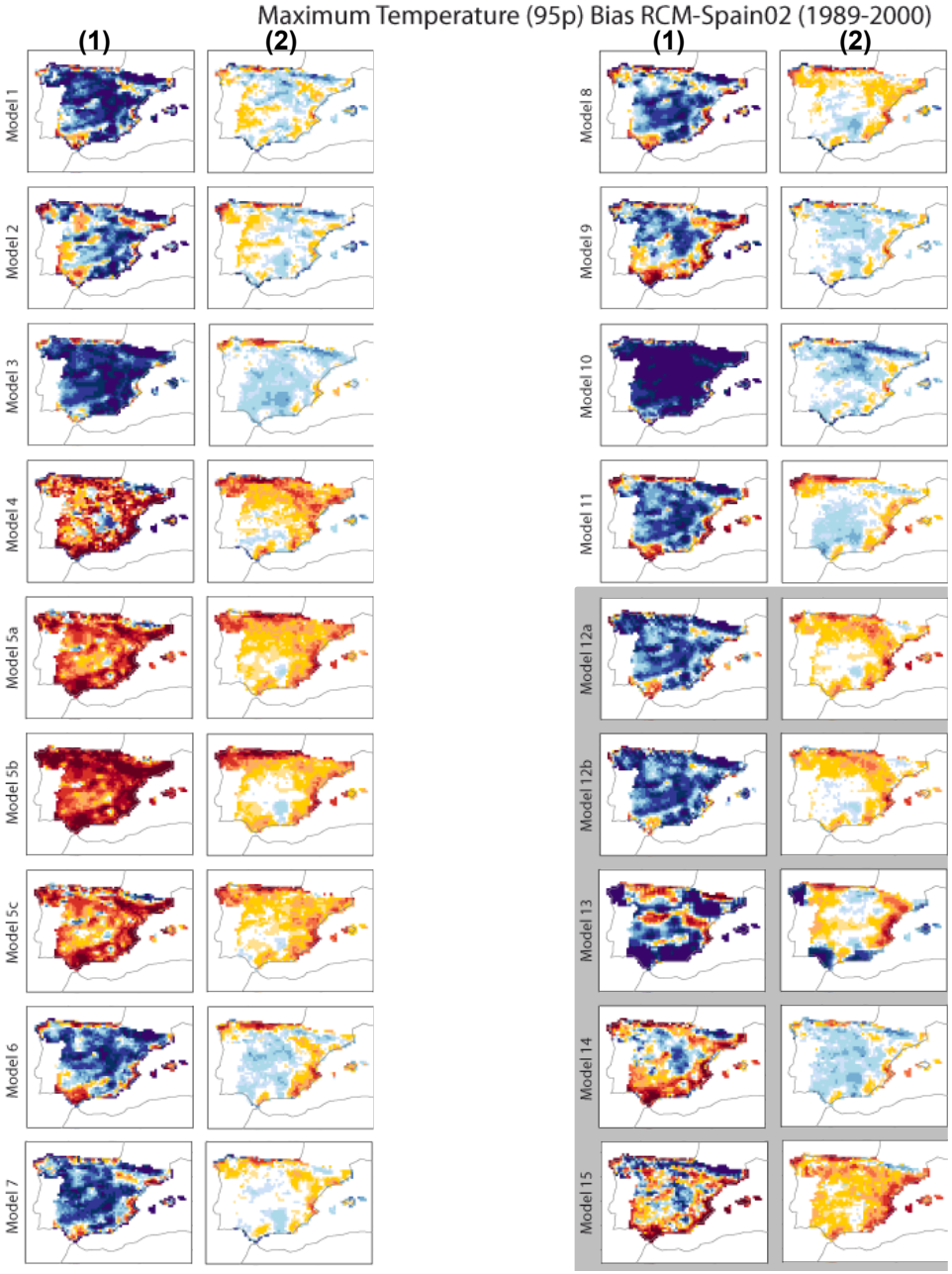
Fig.4: *Spatial bias distribution (ºC) for the $95p_{Tmax}$ in summer with respect to Spain02.*
(1) Bias without doing any correction to the model.

Results: Present



Label	Model	Label	Model
1	RCA3-C4I	8	HIRHAM-METNO
2	ALADIN	9	REMO-MPI
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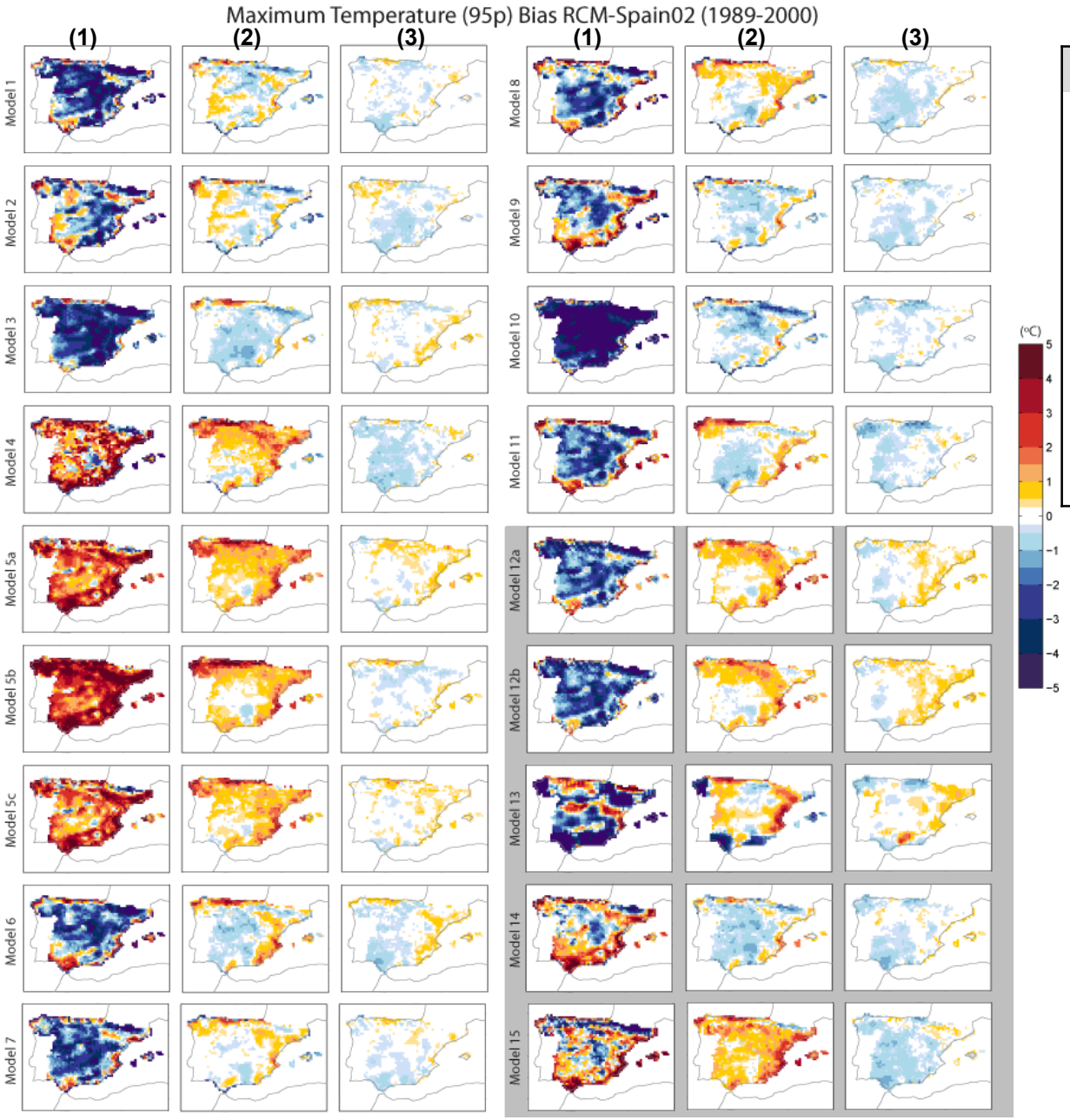
Fig.4: *Spatial bias distribution (ºC) for the $95p_{Tmax}$ in summer with respect to Spain02.*
(1) Bias without doing any correction to the model.
(2) Bias when the correction in the seasonal mean is done.

Results: Present



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(1) Bias without doing any correction to the model.

(2) Bias when the correction in the seasonal mean is done.

(3) Bias when the second order correction is done.

Results: Present

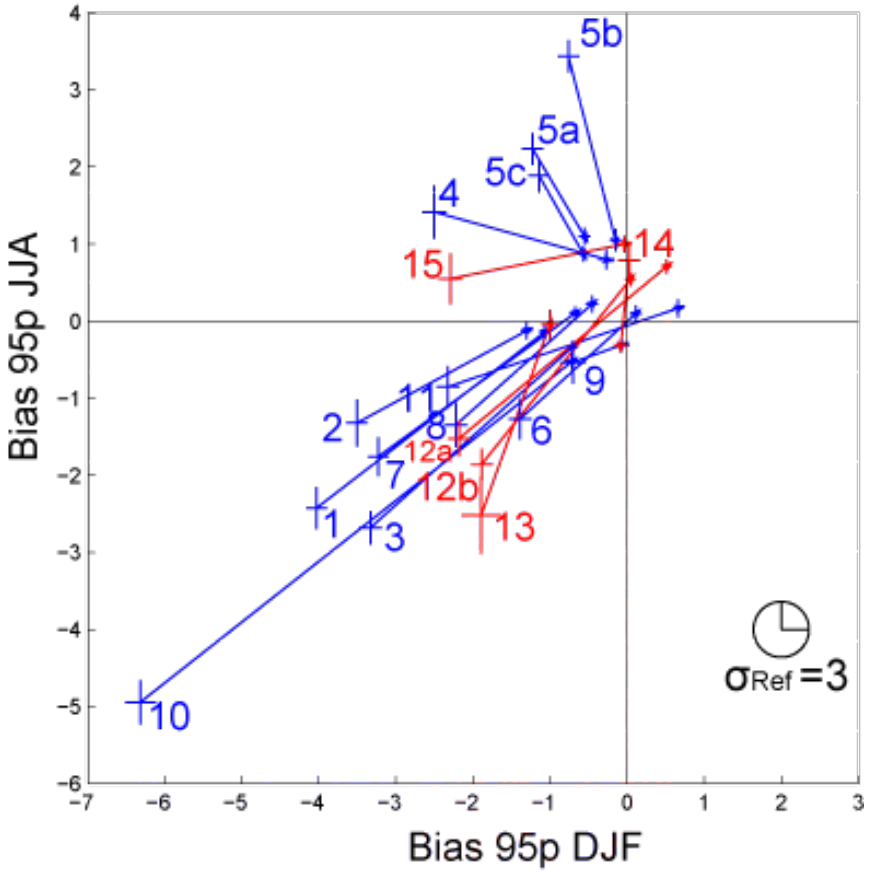

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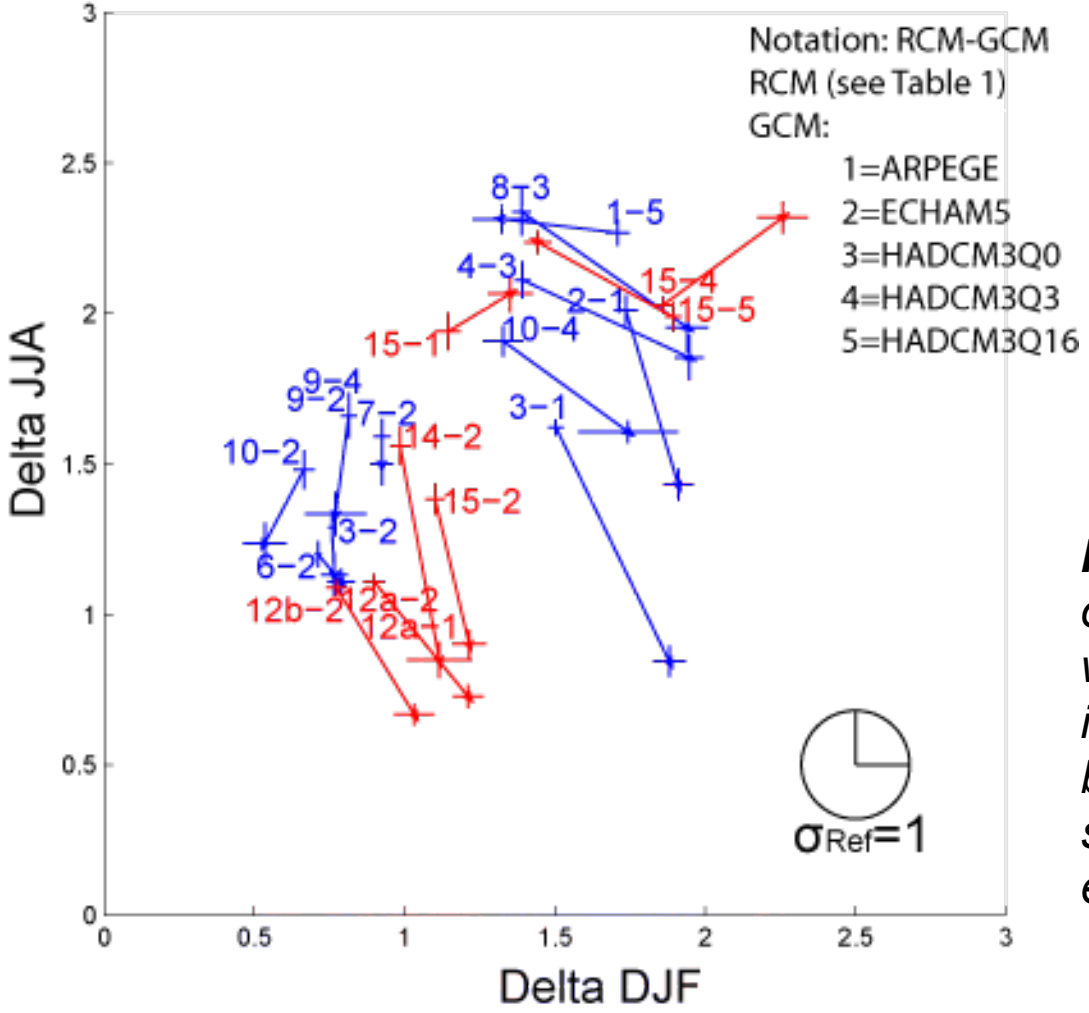
Fig. 5: *Spatially averaged bias over the IP (ºC) of the $95p_{Tmax}$ with respect to Spain02. The line graph's origin (where the lines are labelled) represents the bias without doing any correction for the winter predictions (X axis) and those for summer (Y axis). The end of each line represent the bias when the correction in the seasonal mean is done. Blue lines for ENSEMBLES and red for ESCENA RCMs. Crosses indicate the standard deviation of the bias through the IP in winter (X axis) and summer (Y axis). σ is rescaled between 0 and 0.5, and the value σ_{ref}=3 is indicated as a reference.*

Results: Future

Minimum Temperature



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6	RegCM	14	REMO-UAHE
7	RACMO	15	PROMES

Fig.6: *Spatially averaged increment over IP of Tmin and $5p_{Tmin}$. Values are presented for winter (X axis) and summer (Y axis). The increment is calculated as the difference between seasonal projections for A1B scenario (2021-2050) and 20C3M experiment (1971-2000).*

The line graph's origin (where the lines are labelled) represents the increment for Tmin in winter (X axis) and summer (Y axis). The end of each line represent the increment for the $5p_{Tmin}$. Crosses indicate σ over the IP.

Results: Future

MaximumTemperature

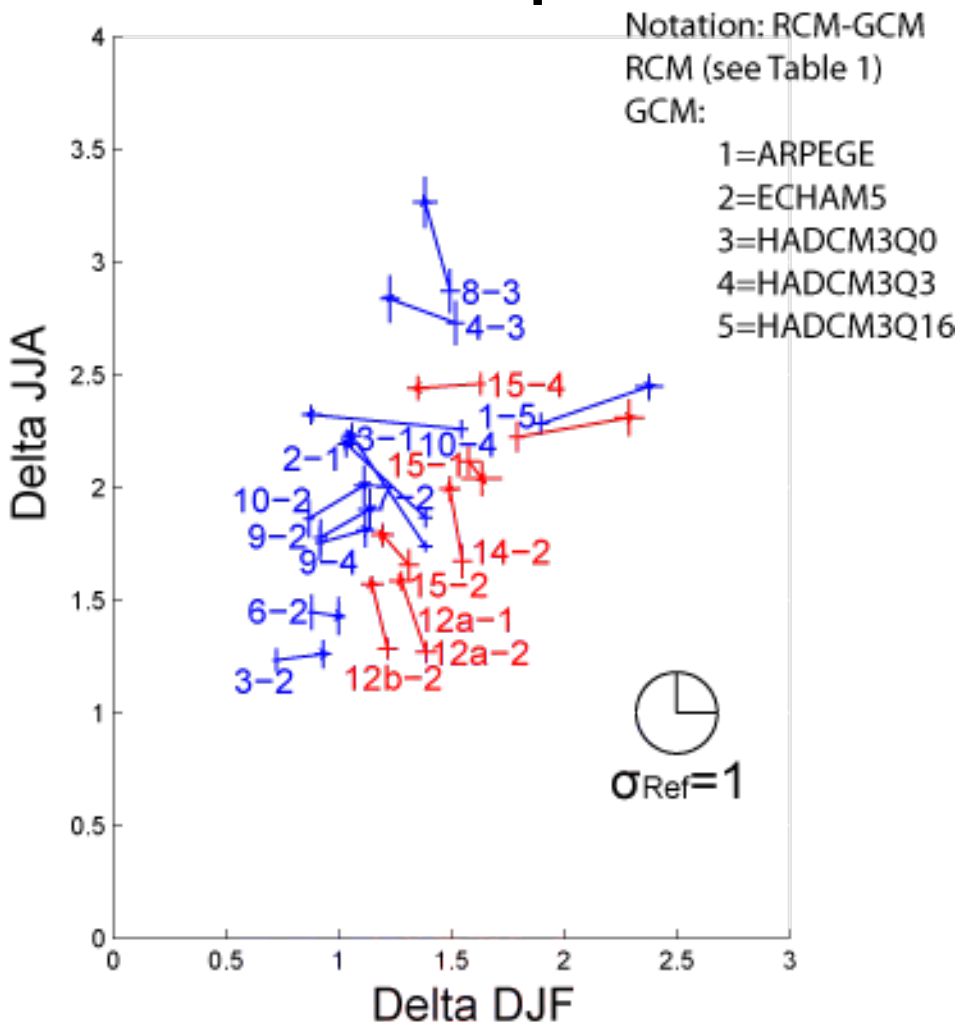

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Fig.7: *Spatially averaged increment over IP of Tmax and $95p_{Tmax}$. Values are presented for winter (X axis) and summer (Y axis). The increment is calculated as the difference between seasonal projections for A1B scenario (2021-2050) and 20C3M experiment (1971-2000).*

The line graph's origin (where the lines are labelled) represents the increment for Tmax in winter (X axis) and summer (Y axis). The end of each line represent the increment for the $95p_{Tmax}$. Crosses indicate σ over the IP.

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Conclusions

- ✓ Each RCM presents a different bias pattern in $5p_{Tmin}/95p_{Tmax}$ (mainly cold or warm bias).
- ✓ The highest biases are not associated to a specific model, they depend on the variable and the percentile considered.
- ✓ For all the RCMs, the bias in $5p_{Tmin}/95p_{Tmax}$ is considerably reduced in winter and summer when the bias in the mean is corrected. The model spread over the IP is reduced with this correction.

Conclusions

- ✓ PROMES and REMO are analyzed with both reanalysis (ERA-40 and ERA-Interim). We find similar biases when the seasonal mean is corrected, being even smaller with ERA-Interim.
- ✓ Different RCMs nested into the same GCM usually present similar increments in future projections.
- ✓ Increments are larger in the $5p_{Tmin}$ in winter and in the $95p_{Tmax}$ in summer than those in the mean variables.

On-going work

Compare these results with those for statistical downscaling methods.

Evaluate the weaknesses and stregths of different downscaling methods with regard to percentiles.

Acknowledgements

- Data providers:

  DMI repository for the ENSEMBLES Project
  The Universities involved in ESCENA Project.

  AEMET and UC for the data provided for this work (Spain02).

- Research projects

  EXTREMBLES (CGL2010-21869), CORWES (CGL2010-22158-C02) and ESCENA (200800050084265) from the Spanish Ministry of Science and Innovation.

  CLIM-RUN from the 7th European FP.

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Thank you!

Poster Session: panel nº 12

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