Assessment of extreme temperature percentiles by means of Regional Climate Models

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1. Introduction

The study of extreme events has become of great interest in recent years due to their direct impact on society. Extremes can be evaluated in a simple way by deriving extreme indicators, which are usually based on statistics on the tail of the probability distribution, i.e. on **percentiles**.

We test the ability of regional climate models (**RCMs**) in representing high (low) percentiles of **maximum** (**minimum**) **temperature** and assign their biases to deficiencies in the mean and variability of their probability distribution. We also 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.

We analyze the RCMs of the **ENSEMBLES** (EU-funded) and **ESCENA** (strategic action of Plan Nacional de I+D+i funded by the Spanish government) projects, in the Iberian Peninsula (IP).

2. Data and Methodology

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

Table 1: *Labels, acronyms and institutions for the RCMs used. ESCENA project models are shaded.*

- **Present:** The **dynamical downscaling methods** are first tested in present climate with quasi-perfect boundary conditions (**reanalysis**) in order to know to what extent these approaches properly reproduce the observed percentiles. We consider for the comparison the new, public, gridded dataset developed for continental Spain and Balearic Islands with 0.2º resolution (**Spain02**; Herrera et al. 2012). The common period for all models is 1989-2000, since ENSEMBLES models are nested to ERA-40 (1961-2000) and ESCENA models to ERA-Interim reanalysis (1989-2008). The **comparison** among the different models is obtained in terms of the **biases** of the seasonal percentiles. Biases correction regarding to the model mean and standard deviation are also presented.

- **Future**: We analyze the effect of nesting the RCMs to different Global Circulation Models (**GCMs**) on the A1B scenario. The study focuses on the end of the 20th century (1971–2000, 20C3M experiment), used as a control period, and assesses the changes projected for the period 2021–2050 considering the **A1B emission scenario**.

3. Results

3.1. Present climate

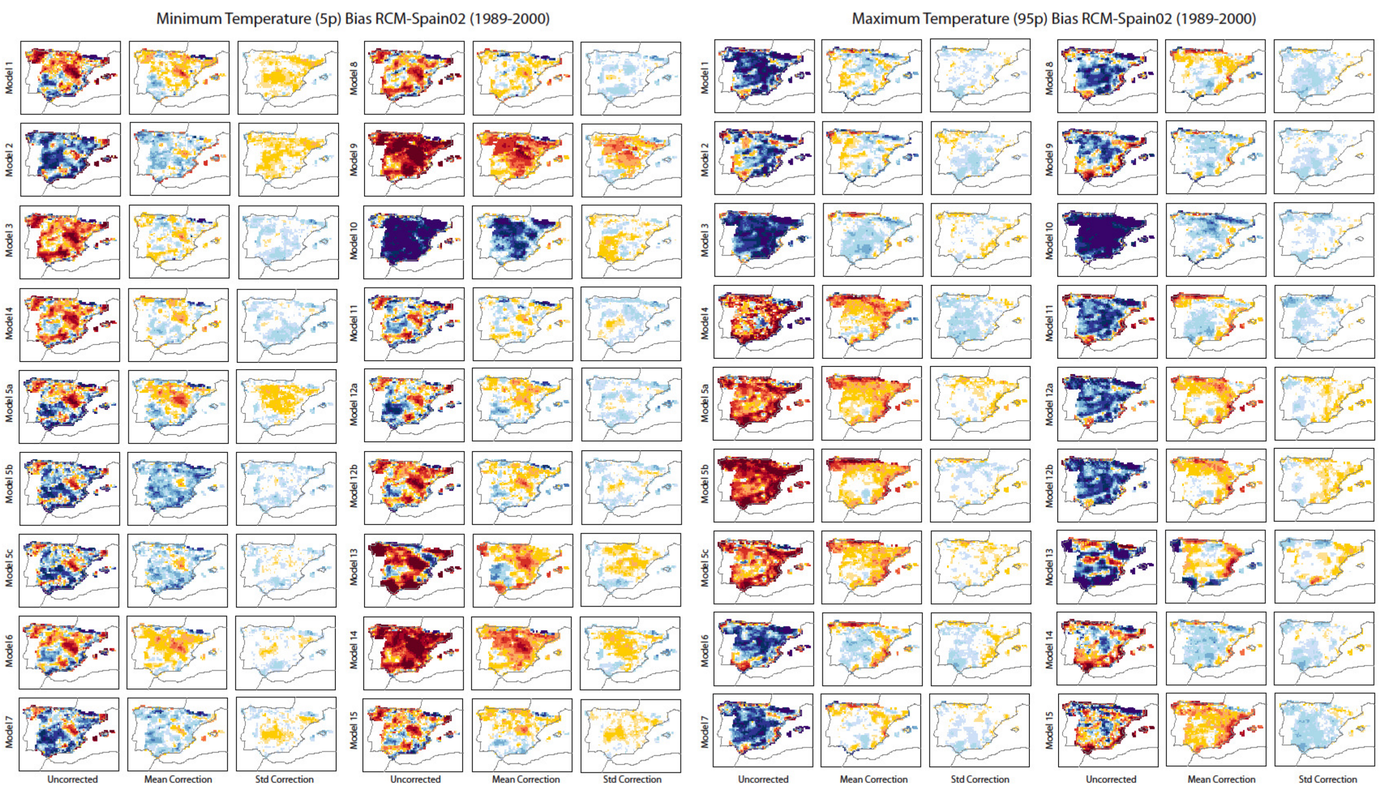


Fig.1: *Spatial bias distribution (in ºC) for the 5th percentile of winter minimum temperature (left panel) and for the 95th percentile of summer maximum temperature (right panel), with respect to Spain02. The first column of each panel represents the bias without doing any correction to the model. Second column represents the bias when the correction in the seasonal mean is done. Third column represents the bias when the second order correction is done. Each RCM is labelled as in Table 1.*

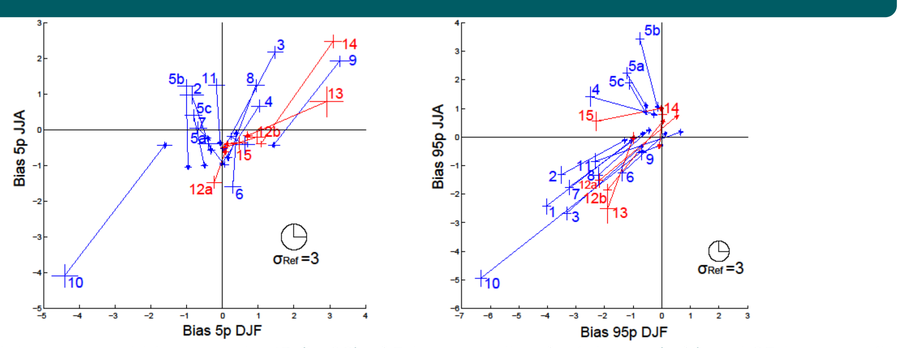
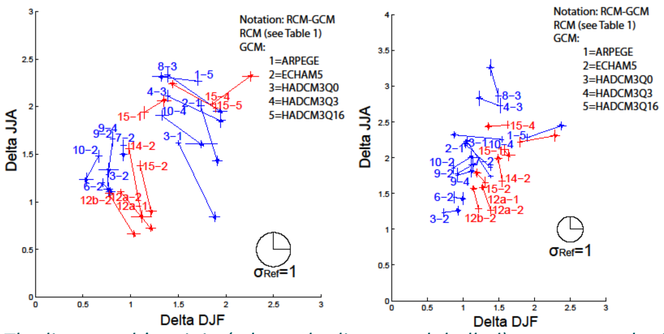


Fig. 2: *Spatially averaged bias over the IP (in ºC) of 5th percentile of minimum (left) and 95th percentile of maximum temperature (right) with respect to Spain02. The line graph's origin (where the lines are labelled) represents the bias without doing any correction for the winter predictions (X axis) 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.*

3.2. Future climate

Fig.3: *Spatially averaged increment over IP of minimum temperature and its 5th percentile (left) and maximum temperature and its 95th percentile (right). 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 minimum (left) and maximum (right) in winter (X axis) and summer (Y axis). The end of each line represent the increment for the 5th percentile of minimum (left) and 95th percentile (right) for maximum temperature. Crosses indicate σ over the IP, as in Fig.2.

4. Conclusions

- Each RCM presents different bias pattern (mainly cold or warm bias). The highest biases correspond to REMO-MPI, REMO-UAHE (warm) and RCA-SMHI (cold) for the 5th percentile of minimum temperature. For the 95th percentile of maximum temperature, the RCA3-C4I, HIRHAM-DMI and RCA-SMHI show the coldest bias and the HADRM3_Q3 the warmest. (See Fig.1)
- For all the RCMs, the bias is considerably reduced in winter and summer when the seasonal mean of the model is corrected. The model spread over the IP is reduced with this correction. (See Fig.2)
- PROMES and REMO are analized 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 to the same GCM usually present the same increment in future time.
- The increments are larger in the 5th percentile (of minimum temperature) in winter and in the 95th percentile (of maximum temperature) in summer.

REFERENCES: Herrera, S., Gutierrez, J., Ancell, R., Pons, M., Frias, M., and Fernandez, J. (2012): Development and Analysis of a 50 year high-resolution daily gridded precipitation dataset over Spain (Spain02). *International Journal of Climatology 32:74-85* DOI: 10.1002/joc.2256.

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