Extremes of maximum temperatures over Iberia from ENSEMBLES regional projections

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1. MOTIVATION

- The study of extreme temperatures and heat waves is an active research topic with huge socioeconomic impacts (see Easterling et al 2000 and references therein). Climate change has the potential to alter the prevalence and severity of extremes giving rise to more severe impacts with unpredictable consequences.
- In the present work we estimate changes of **maximum temperatures over Iberia** using tow state-of-the-art **regional climate models** from the EU-funded project **ENSEMBLES**. Extremes are expressed in terms of **return values** derived from a **time-dependent generalized extreme value (GEV) model** for monthly maxima. The study focuses on the end of the 20th century (1961-2000) used as a calibration/validation period, and analyzes the changes projected for the period 2061-2100 considering the A1B scenario.

2. DATA

We use monthly maximum daily temperature over the Iberian Peninsula from observations (**Spain02** and **EOBS**) and two regional models from the EU-ENSEMBLES project (**KNMI** and **SMHI**):

- **Spain02** and **EOBS** gridded data at 20 and 25 Km respectively from 1961 to 2000 (See Herrera et al 2012 and Haylock et al 2008 for more details).
- **ERA-40** and **20C3M** based simulations from 1961 to 2000 and **A1B scenario** based simulations from 2061 to 2100.

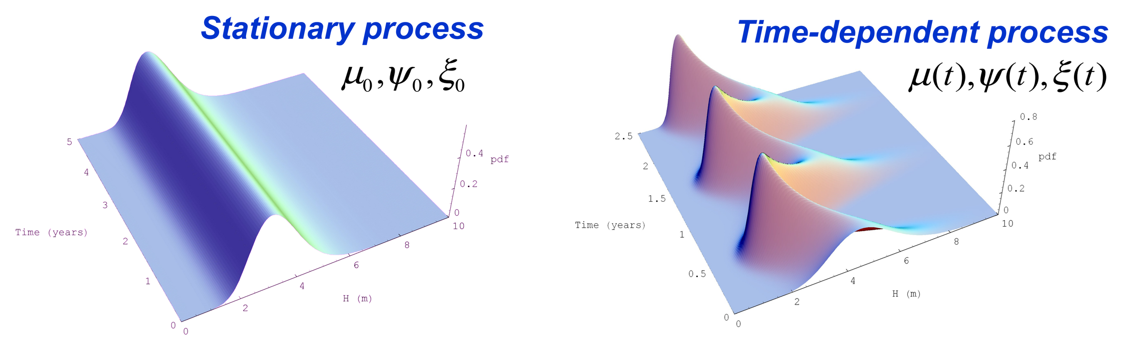
Regional climate models are used as dynamical downscaling tools to provide simulations on smaller scales than those represented for global climate models.

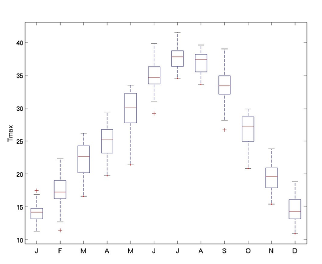
3. TIME-DEPENDENT GEV

Generalized Extreme Value distribution, GEV:

$$F(x,\mu,\psi,\xi) = \begin{cases} exp[-exp(-\frac{x-\mu}{\psi})] & \xi = 0 \\ exp[-(1+\xi\frac{x-\mu}{\psi})^{-(1/\xi)}] & \xi \neq 0 \end{cases}$$

being μ, ψ and ξ the location, scale and shape parameters respectively.





Monthly maximum temperature data shows the effects of seasonality both in the mean and in the variability.

We consider a parameterization for the location, scale and shape parameters using harmonic functions.

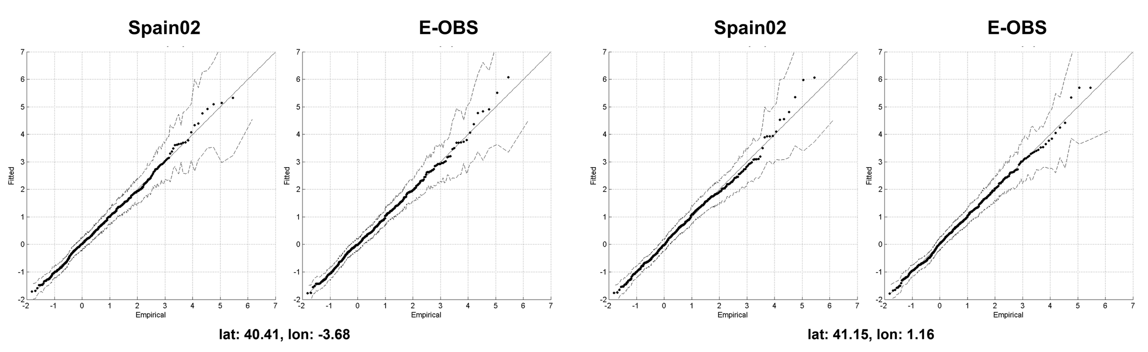
Parameterization: (See Frias et al 2012 and Minguez et al 2010 for more details)

$$\mu_t = \beta_0 + \sum_{i=1}^{3} [\beta_{2i-1}\cos(i2\pi t) + \beta_{2i}\sin(i2\pi t)]$$

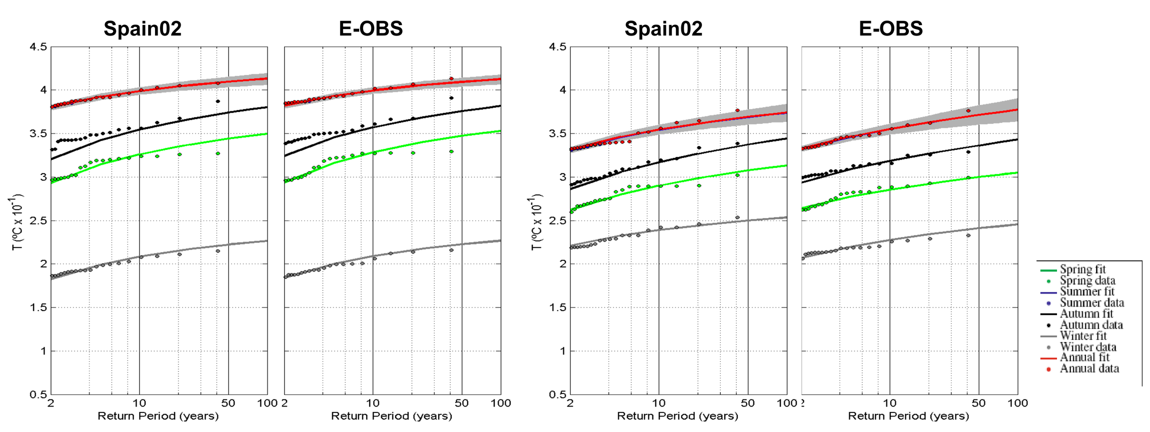
$$\log(\psi_t) = \alpha_0 + \sum_{i=1}^{3} [\alpha_{2i-1}\cos(i2\pi t) + \alpha_{2i}\sin(i2\pi t)]$$

$$\gamma_t = \gamma_0 + \gamma_1\cos(2\pi t) + \gamma_2\sin(2\pi t)$$

Goodness of fit Q-Q plots from the non-stationary GEV show very good diagnostics for both pseudo-observational datasets, with points close to the diagonal. Solid lines indicate 90% confidence intervals.



Return levels are represented for summer, autumn, winter, spring, and annual using the non-stationary approach.

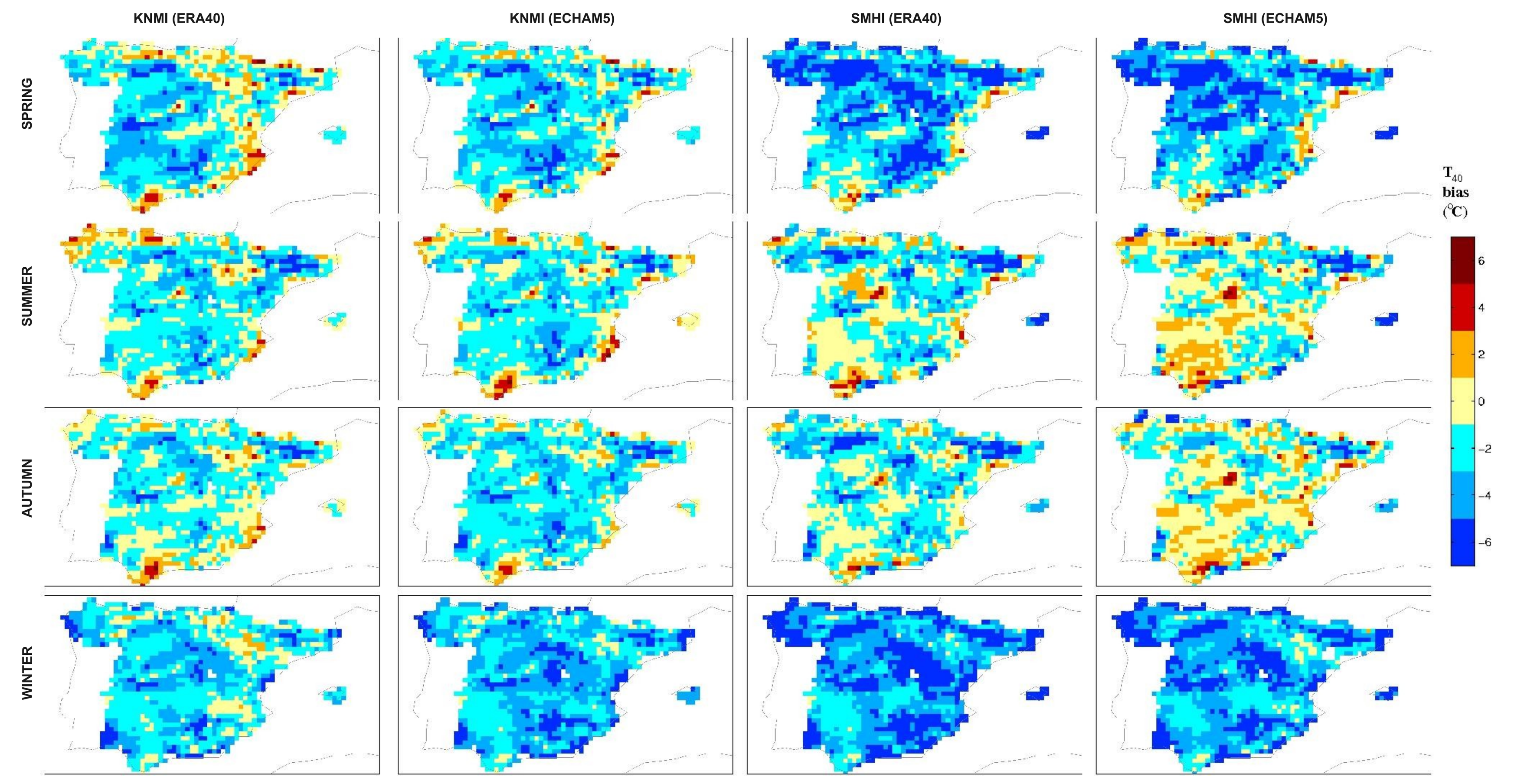


- Since the annual maxima occurs during the summer, annual aggregated quantiles (red) coincide with summer aggregated quantiles (blue) showing the consistency and coherency of the proposed model.

4. RESULTS

Extremes in the control period (1961-2000):

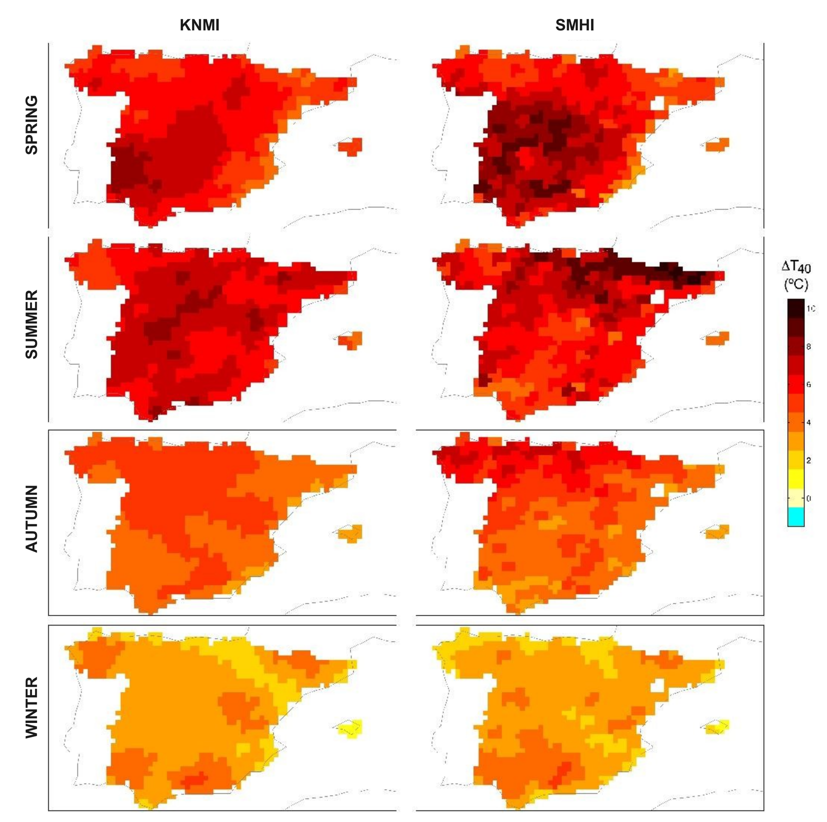
The performance of the regional models is evaluated in terms of the **anomalies for the 40-year return values** for each season of the calibration period with respect to the high-resolution gridded Spain02 dataset. The first two columns correspond to the KNMI model (ERA40 and ECHAM5-20c3m forcings, respectively) whereas the last two columns show the corresponding plots for the SMHI model.



- In general, the RCMs show lower T40 return values than those from the Spain02, especially in winter and for the SMHI model.
- Both models exhibit the same characteristic regional bias pattern (with small differences) for the two different global forcing conditions (reanalysis from ERA40 or control simulations from ECHAM5), so the inter-RCM changes in the bias pattern with respect to Spain02 are larger than the inter-GCM variability in the resulting patterns.

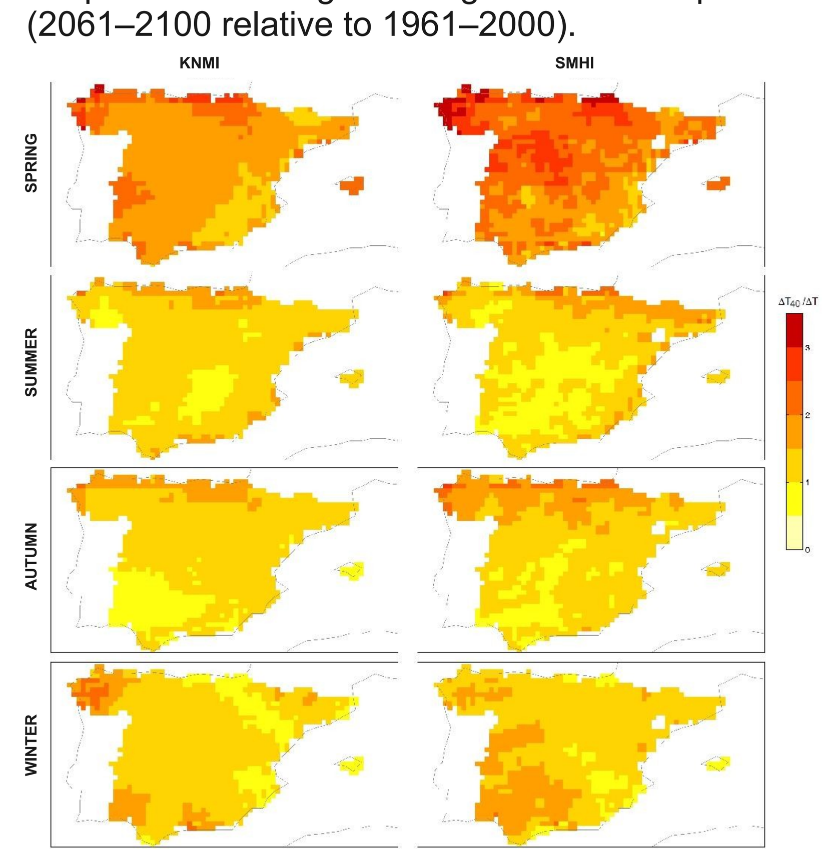
Future changes in temperature extremes (2061-2100):

Climate change increments for 40-year return values in 2061-2100 relative to 1961-2000 for the regional models:



- Simulations for the future (2061-2100) show an increase of maximum temperature extremes all over the Iberian Peninsula, with higher values in Spring and Summer.
- The response to increase green house gases, as projected by the A1B scenario, is consistent for both RCMs.

Climate change increments for the 40-year return levels, but expressed as a multiple of the mean temperature change during the same period (2061–2100 relative to 1961–2000).



- Extreme increments (e.g. 40-year return values) will be two times higher than those for the mean seasonal temperatures, particularly during Spring.

5. CONCLUSIONS

- The non-stationary behaviour of monthly maximum temperature over the Iberian Peninsula is adequately modelled by the proposed time-dependent GEV model.
- Regional climate models show lower T40 return values than those from the Spain02 data.
- Simulations for the future (2061-2100) show an increase of maximum temperature extremes all over the region, especially in Spring and Summer.
- Extreme increments will be higher than those for the mean seasonal temperatures.

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