UC contribution to INDECIS D6.2:

Report on the datasets inter-comparisons with regard to selected ECVs and INDECIS-ISD

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Summary

The state-of-the art regional climate simulations provided by the EURO-CORDEX simulations for Europe have been evaluated using the reference EOBS observations and considering temperature and precipitation (see e.g. Kotlarski *et al.* 2014), confirming the ability of RCMs to capture the basic features of the European climate, including its variability in space and time, and also identifying several prominent deficiencies, such as a generalized cold and wet bias for most models and subregions. Among the different gaps in our current knowledge of the possible reasons for both common and model-specific bias characteristics, lies the effect of uncertainties in the observational reference and its effect on the validation results.

While the E-OBS gridded dataset provides a pan-European reference for model assessment and a good temporal coverage, it also poses strong limitations for a proper validation at regional to local scales, due to the relative sparseness of the station network used in the interpolation procedure across sizeable areas of Europe, for instance over the Iberian Peninsula (Herrera et al., 2012).

UC contribution evaluates daily precipitation and minimum and maximum temperature of eight ERA-Interim-driven (control) simulations of EURO-CORDEX over the Iberian Peninsula (IP), with a special focus on observational uncertainty. This study will take advantage of the recently developed high-resolution dataset Iberia01 (Herrera *et al.* 2019), that can be used as an alternative evaluation reference in addition to E-OBSv19 (Haylock *et al.* 2008), thus providing an opportunity for a new EURO-CORDEX evaluation effort. We expect this contribution to clarify an often overlooked, yet critical aspect of climate indices evaluation in terms of observational uncertainty.

Data and Methods

Data

The ECVs assessed are minimum (Tmin) and maximum temperature (Tmax) and precipitation (Pr). In addition, four climate indices from the INDECIS-ISD inventory (INDECIS-D42), relevant for impact analysis, are further evaluated. Table 1 summarizes the considered INDECIS-ISD and primary ECVs.

Index Code	Index Name	Description	Units	ECV
TN	Tropical nights	Number of days with Tmin >20°C	Days	Tmin
SU	Summer days	Number of days with Tmax >25°C	Days	Tmax
RR1	Wet day frequency	Number of of days with Pr ≥ 1 mm	Days	Pr
SDII	Simple precipitation intensity index	Mean wet-day precipitation	mm/day	Pr

Table 1. Description of considered INDECIS-ISD.

The observational datasets considered for evaluation are Iberia01 (Herrera *et al.* 2019) and E-OBSv19 (Haylock *et al.* 2008). Both are available at a regular 0.10ºx0.10º grid (approximately 10x10km) and cover the period of the RCM simulations (1989-2008). The list of EURO-CORDEX simulations is presented in Table 2. All the considered RCMs are integrated at horizontal resolution of 0.11ºx0.11º (approximately 12x12km) on regular rotated grids. E-OBS and the RCMs have been interpolated onto the Iberia01 grid for the sake of comparison, by means of nearest neighbour interpolation.

Daily data for the three ECVs from the two observational datasets and the EURO-CORDEX RCMs were retrieved from the data services provided by University of Cantabria Meteorology Group (UCMG), built on a THREDDS Data Server (TDS) by means of the user authorization web application User Data Getaway - Thredds Access Portal (UDG-TAP). Data retrieval, further postprocessing and indices calculation were performed with the *climate4R* bundle for climate data analysis and processing (Iturbide *et al.* 2019). The selected indices (Table 1) were calculated annually and the multi-year (20 years) mean is used as the final index. An example on data retrieval and subsequent calculations is shown in the Appendix, for the sake of reproducibility of the results.

RCM Code	RCM Description	Modelling center
ALADIN53	CNRM-ALADIN53 v1	Météo-France/C. National de Recherches Météorologiques
CCLM4-8-17	CLMcom-CCLM4-8-17 v1	Climate Limited-area Modelling Community
HIRHAM5	DMI-HIRHAM5 v1	Danish Meteorological Inst.
RACMO22E	KNMI-RACMO22E v1	Royal Netherlands Meteorological Inst.
RCA4	SMHI-RCA4 v1	Swedish Meteorological and Hydrological Inst.
RegCM4-2	DHMZ-RegCM4-2 v1	Meteorological and Hydrological Service of Croatia
REMO2009	MPI-CSC-REMO2009 v1	Max Planck Inst. - Climate Service Center
WRF331F	IPSL-INERIS-WRF331F v1	Inst. Pierre-Simon Laplace

Table 2. ERA-Interim-driven EURO-CORDEX simulations considered.

Evaluation

As described in INDECIS D61, several metrics such as mean differences (biases), Taylor diagrams and trend analyses are preferred for datasets intercomparison. Here the comparison relies on mean annual biases and Taylor diagrams, since the period of analysis is limited for trends calculation.
Our evaluation consists first of a comparison of the three ECVs in the two observational datasets and, secondly, a comparison in terms of the subset of INDECIS-ISD, considering the two observational datasets and the RCMs. All the evaluation metrics are obtained using Iberia010 as reference.

Note on bias correction

In order to do the intercomparison exercise on a common ground, bias correction is required due to the different systematic model biases. Furthermore, bias correction is needed in order to properly calculate the absolute threshold-based indices proposed. To this aim, a simple scaling approach is used, considering additive/multiplicative factors for temperature/precipitation. The corrections are performed at a monthly scale and Iberia01 is used as reference.
After this simple bias adjustment, systematic biases on mean ECVs are removed, but some biases related to errors in higher moments of the distribution and, thus, in the climate indices, might still remain. For this reason, evaluation results of the RCMs are only presented for the subset of

INDECIS-ISD. The reader is referred to previous literature to assess the overall performance of the RCMs in terms of temperature and precipitation (e.g. Kotlarski *et al.* 2014 for the whole continent; Casanueva *et al.* 2016 and Herrera *et al.* 2016 for continental Spain).

Results

Comparison of ECVs

Large differences arise in the spatial pattern and intensity of daily mean precipitation as represented by Iberia01 and E-OBS (Fig.1), with much lower values and a smoother spatial pattern for the latter. Higher daily precipitation values in northwestern Iberia as well as in mountainous chains are depicted for Iberia01. With regard to daily maximum and minimum temperatures (Fig.2), both observational datasets show a clear orographic pattern. Higher temperatures are found in Iberia01 than in E-OBS, which also extend to larger areas, especially in southwestern Iberia.

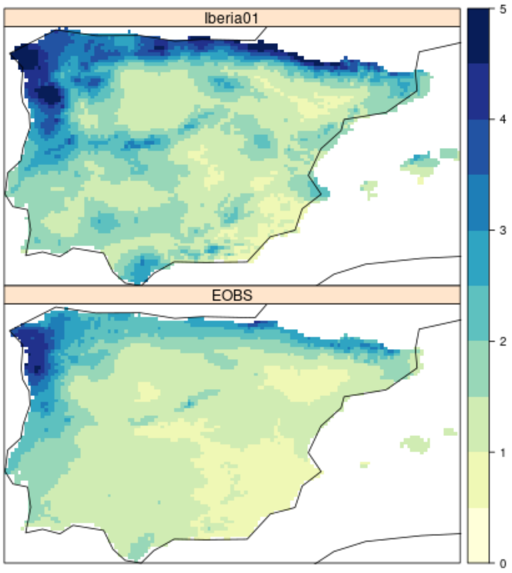

Fig. 1. Daily mean precipitation (mm/day), as represented by Iberia01 and EOBS.

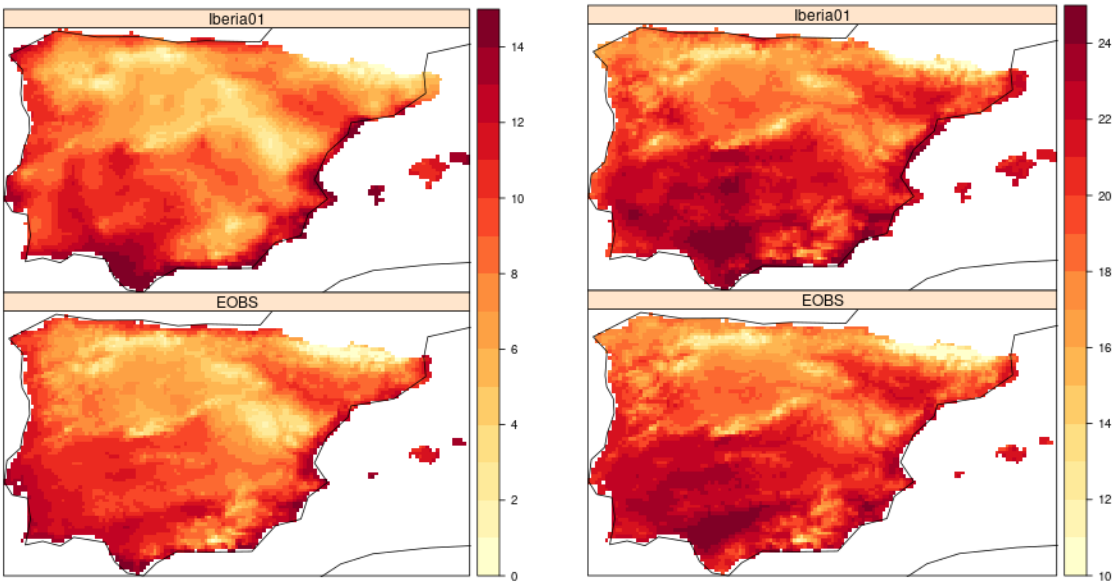

Fig. 2. Daily minimum (left) and maximum (right) temperature (ºC), as represented by Iberia01 and EOBS.

Comparison of climate indices

RR1

Comparison results for Iberia01 and E-OBS in terms of RR1 are aligned with those for daily mean precipitation, with a much smoother spatial pattern for the latter (Fig.3). Higher wet-day frequencies in northern Portugal and in the main mountainous chains cannot be found in E-OBS.

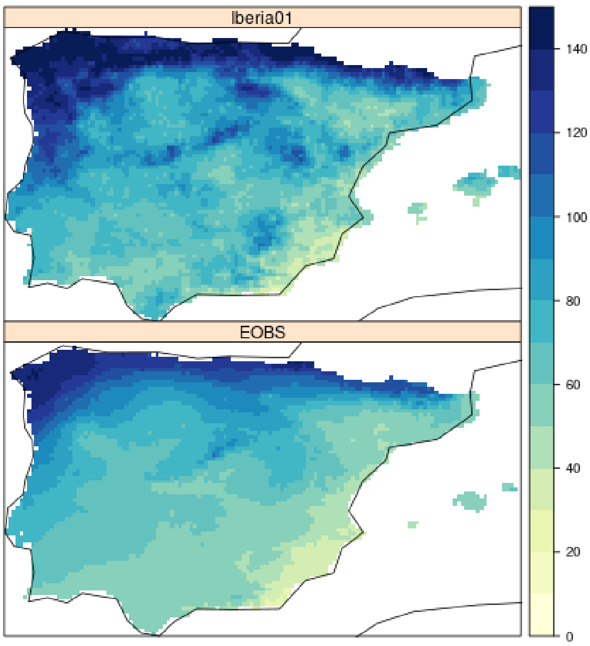

Fig. 3. RR1 (days) as represented by Iberia01 and EOBS.

RCMs can largely represent RR1 spatial pattern (Fig.4, left) although important biases of different sign arise (Fig.4, right). Bear in mind that the simple scaling used as a first order bias correction does not correct for the wet-day frequency. RegCM stands out showing a clear overestimation of the wet-day frequency, with more than 100 days/year in large parts of Iberia. ALADIN, RACMO and RCA present also a positive bias in the north and northeast of the Peninsula. An underestimation of the wet-day frequency is evident for CCLM and HIRHAM in large parts of Iberia, especially in the areas where the highest RR1 is observed. Biases in REMO and WRF depict the smallest biases, with an underestimation of RR1 at high elevations.

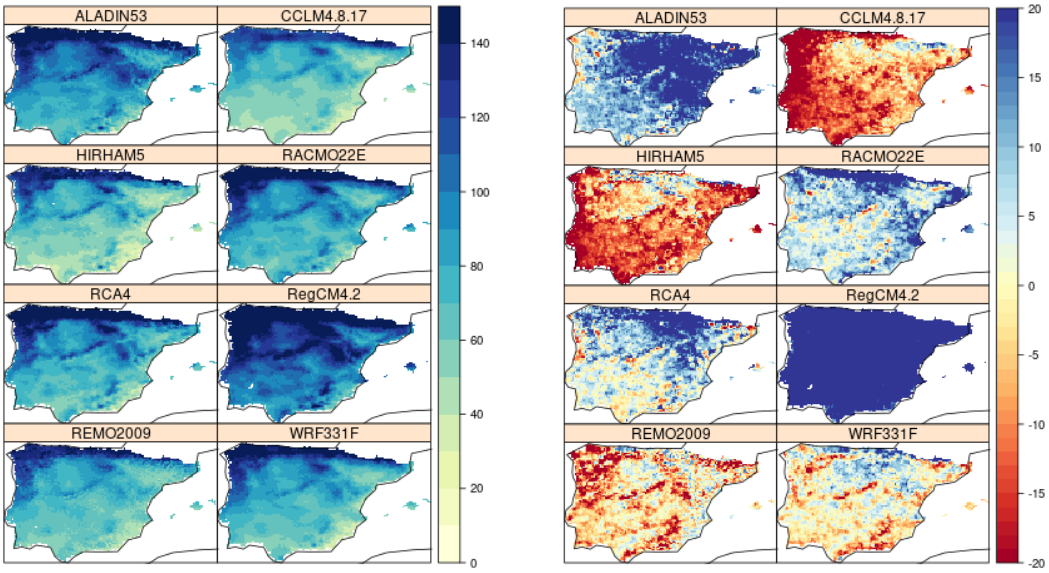

Fig.4. RR1 (days) as represented by the EURO-CORDEX RCMs (left) and biases (in days) with respect to Iberia01 (right).

Figure 5 shows a rather good agreement with the spatial pattern as represented by Iberia01, with correlations above 0.9, root mean squared differences below 0.5 and standard deviation less than ±0.125 of the observed counterpart. Results for E-OBS are indistinguishable from the RCMs.

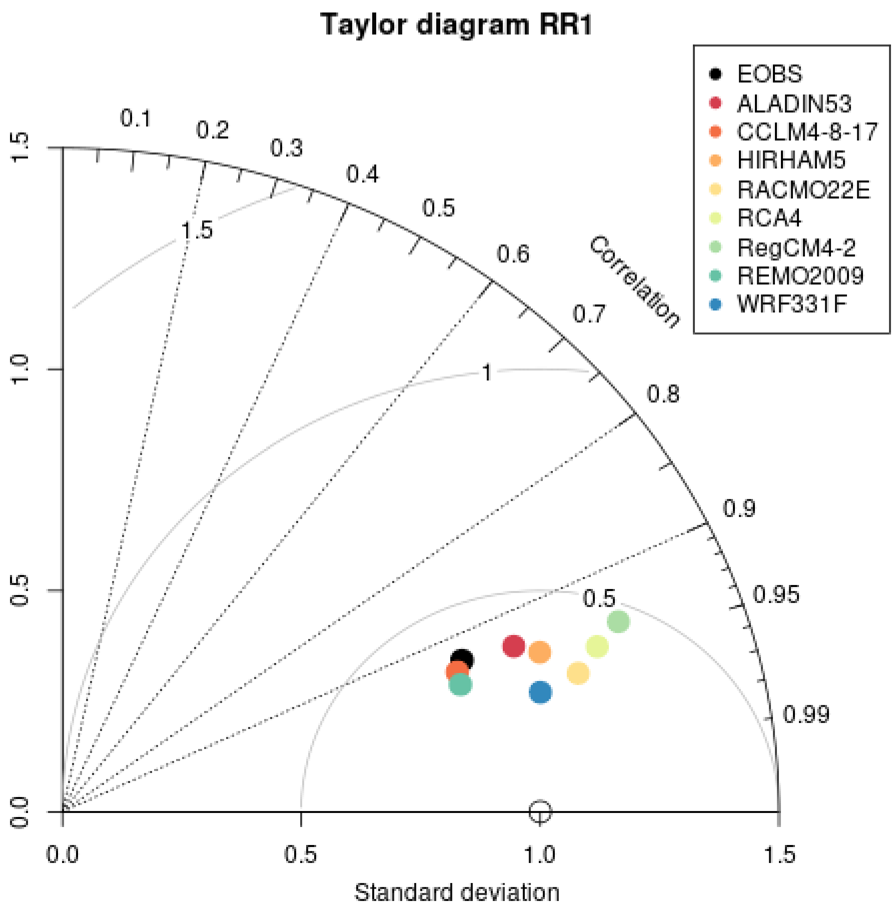

Fig. 5. Taylor diagram of the spatial pattern of RR1 (Iberia01 is used as reference).

SDII

As expected, a much smoother pattern is found for E-OBS compared to Iberia01 for SDII (Fig.6). High values in southwestern Iberia and the Mediterranean cannot be found for E-OBS.

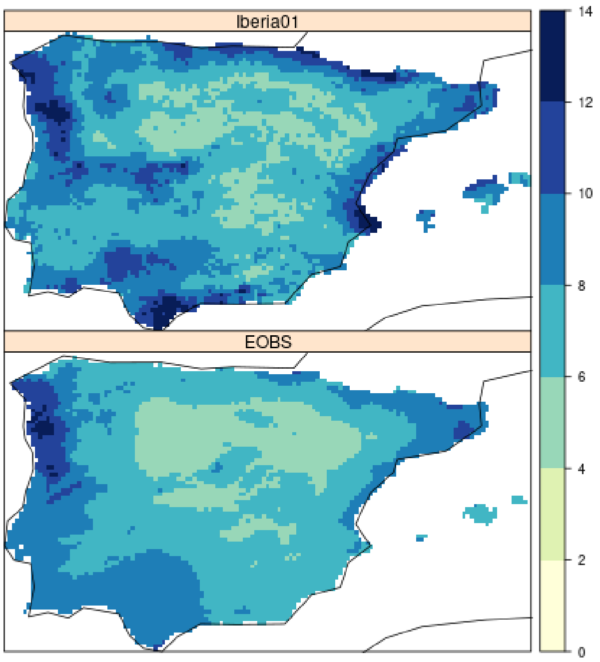

Fig. 6. As Fig. 3, for SDII (mm/day).

Important biases of more than 3mm/day are found in large parts of Iberia for RegCM (Fig.7), for which the wet-day frequency is largely overestimated (Fig.4). Wetter conditions are simulated by CCLM and HIRHAM (Fig.7), especially in western and southern Iberia, where they depicted an overestimation of RR1 (Fig.4). These results highlight the need of analyzing the two components of precipitation (namely frequency and amount) separately, since their biases can compensate. Results for RR1 and SDII go hand in hand and biases depend on the wet-day threshold considered for their calculation, herein 1mm (Casanueva *et al.* 2016). For the other RCMs biases up to ±2mm/day can be found (Fig.7).

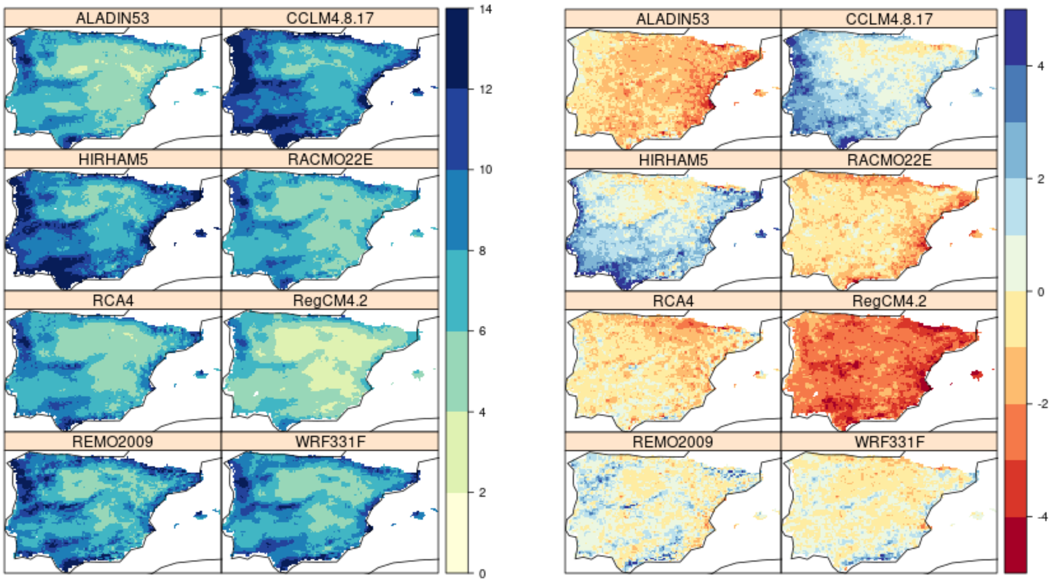

Fig.7. As Fig.4, for SDII (mm/day).

The spatial pattern of SDII (Fig.8) shows high correlations for all RCMs (approximately 0.9, but HIRHAM 0.85), whereas large differences in the observed standard deviation (almost +0.5 for HIRHAM and CCLM). Conversely, E-OBS underestimates the standard deviation of the spatial pattern and presents a spatial correlation of about 0.8.

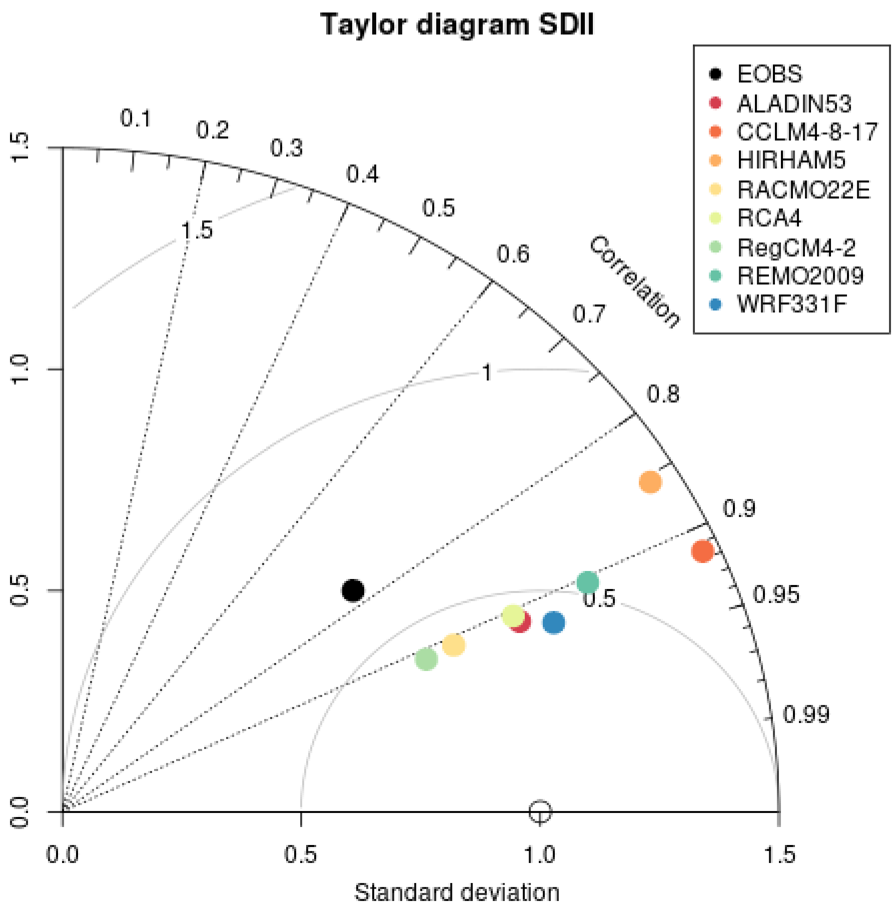

Fig. 8. As Fig. 5, for SDII.

TN

Tropical nights are considered to assess values on the upper tail of the Tmin distribution, which are projected to be more frequent in a warmer climate. High values are found in both observational datasets in the Mediterranean coast, whereas differences arise in southwestern Iberia (Fig.9). Iberia01 shows higher values in Cadiz, Extremadura and along the Guadalquivir River basin, whereas the highest values in E-OBS are shifted eastwards.

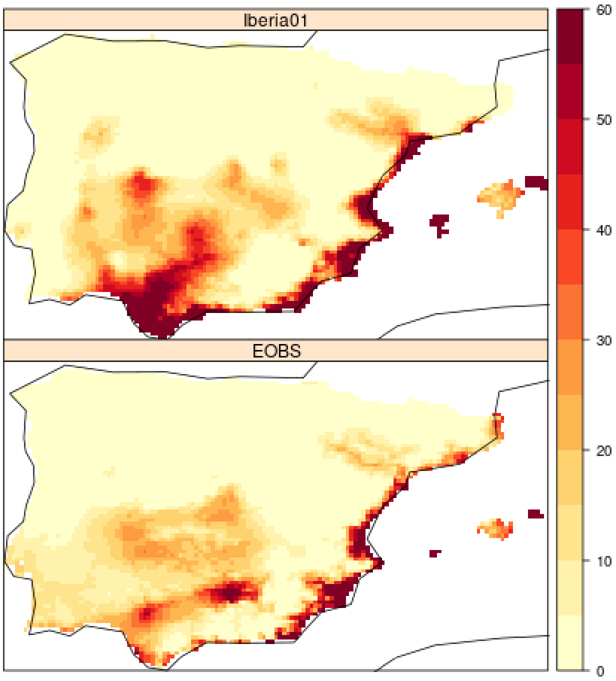

Fig. 9. As Fig.3, for TN (days).

RCMs are able to capture rather well the intensity of tropical nights (Fig.10), confirming that high percentiles are also fairly well adjusted only by shifting the mean distribution (Casanueva *et al.* 2013). The largest biases are found for CCLM in western Iberia (with an overestimation of more than 10 days) and Cadiz, where all models depict an underestimation. Bear in mind that TN presents large temporal variability and the multi-year average presented here is strongly driven by very extreme years (e.g. 2003).

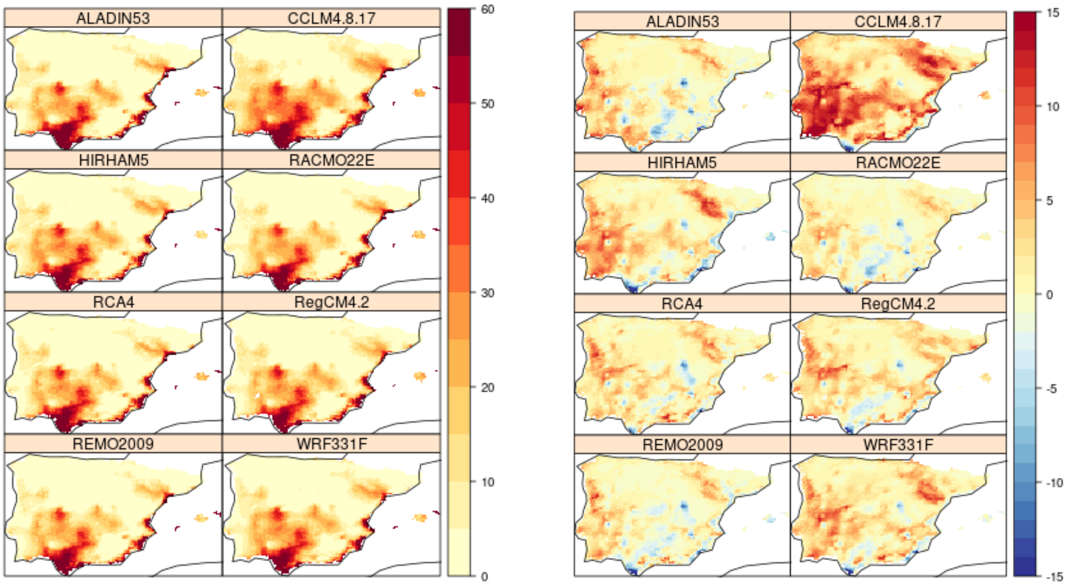

Fig. 10. As Fig.4, for TN (days).

The observed spatial pattern of TN (as represented by Iberia01) is well captured by all RCMs, with a small underestimation of the observed standard deviation (Fig.11). The largest differences in the spatial pattern are found with E-OBS, with correlation about 0.7 and -0.5 standard deviation with respect to Iberia01.

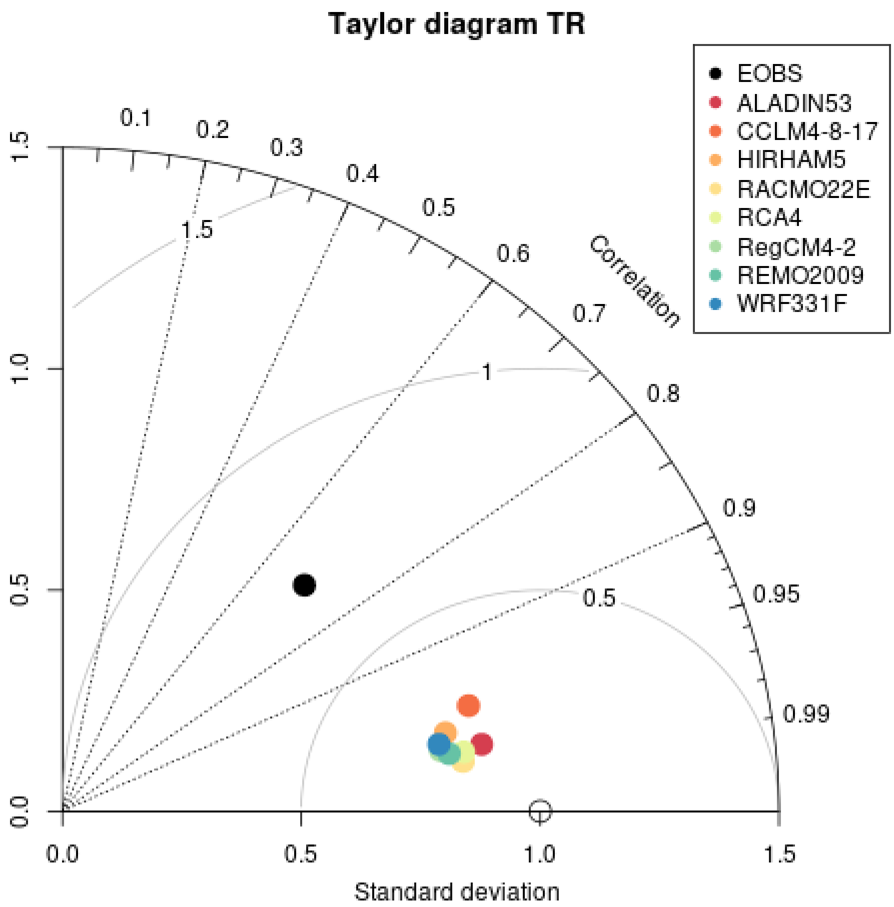

Fig. 11. As Fig. 5, for TN.

SU

A similar distribution of summer days is found for Iberia01 and E-OBS, with slightly more SU in the Ebro River basin and southern Spain for the former (Fig.12). Iberia01 also depicts about 80 summer days, on average, in some spots in the north, which are not found in E-OBS.

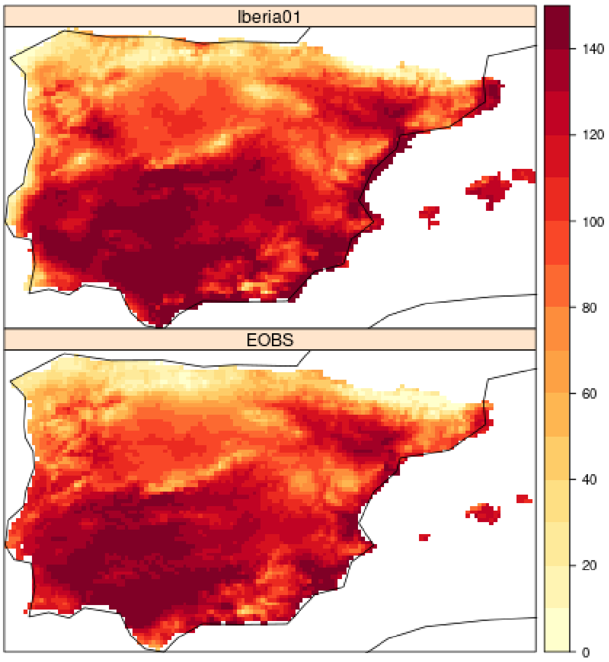

Fig. 12. As Fig.3, for SU (days).

The overall intensity of summer days is well represented by all RCMs, with biases less than ±5 days in southern Iberia and the Mediterranean (Fig.13). There are, however, some more important biases in the northern coast (up to +15 days), which extend in space for RegCM.

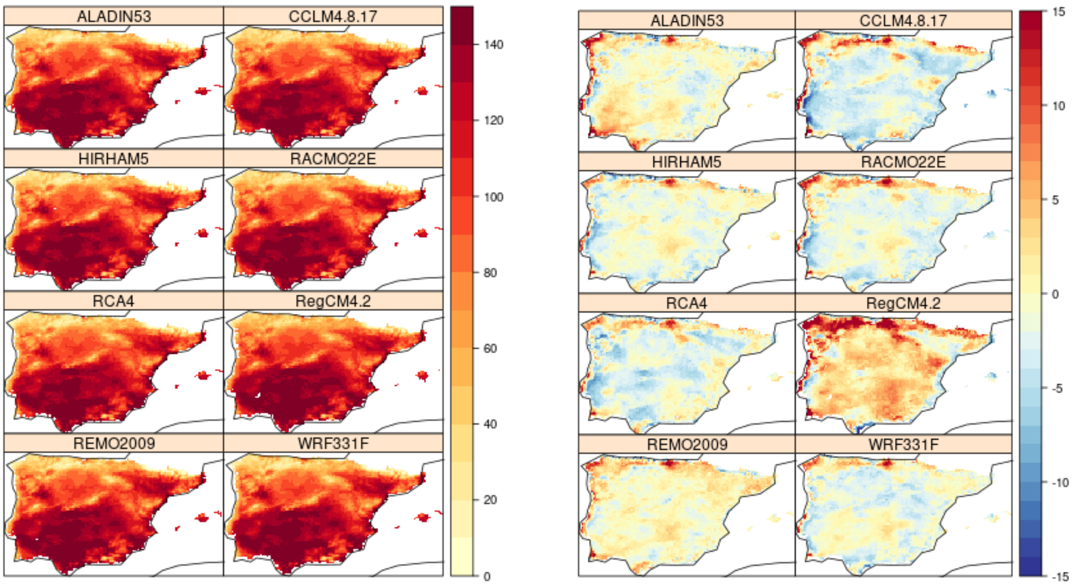

Fig. 13. As Fig.4, for SU (days).

The spatial pattern of SU is well represented by the RCMs, with high correlations and standard deviation close to the observed counterpart (Fig.14). E-OBS stands out again with lower correlation when compared to Iberia01 (still about 0.9).

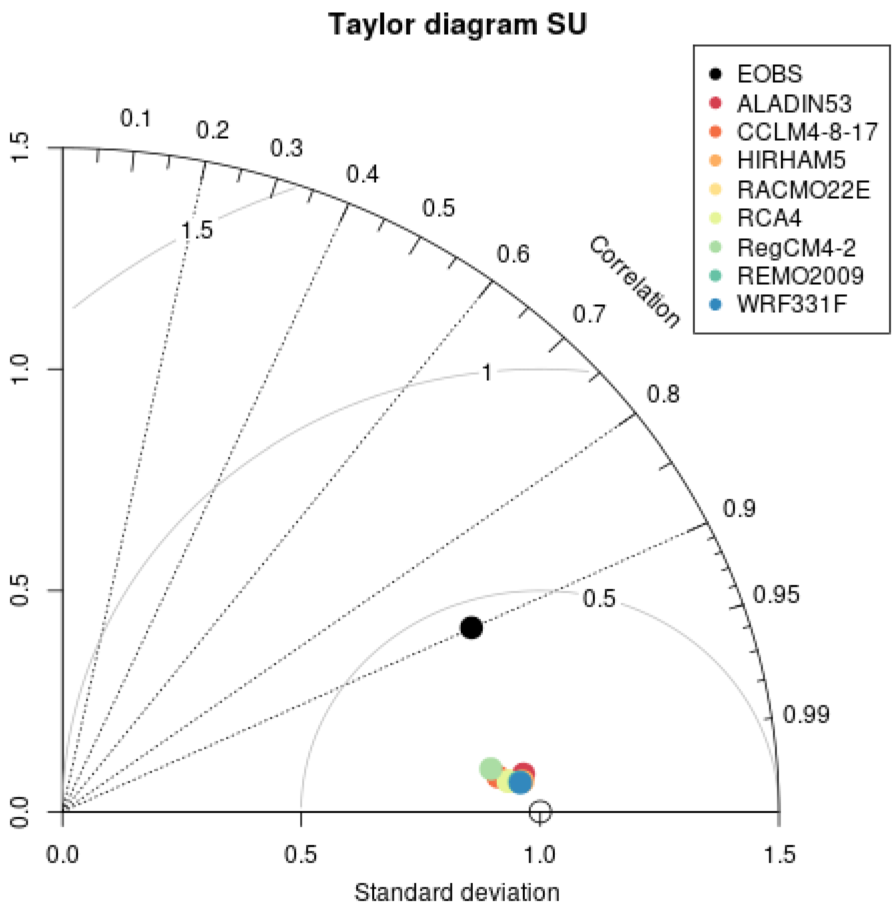

Fig. 14. As Fig. 5, for SU.

Conclusions and outlook

- There are clear differences between E-OBS and Iberia01 which have implications in RCM evaluation and bias correction. As it has been shown, the observed reference remains as a major factor of uncertainty for climate indices validation.
- E-OBS shows lower values and smoother spatial patterns for the three ECVs, mainly due to the less dense station network used to develop the dataset. The spatial pattern depicted by Iberia01 highlights the complex orography of the Iberian Peninsula, which is better represented by the RCM evaluation scenarios.
- After a simple scaling of the RCMs, they represent fairly well the observed spatial patterns of selected climate indices. However, E-OBS presents the largest differences to Iberia01 (note that RCMs are bias-corrected towards Iberia01, results might look different if E-OBS is used as reference).
- Mean biases in climate indices still remain in the precipitation-derived indices, mainly due to the chosen wet-day definition, whereas smaller biases are found in temperature-derived indices (in agreement with Casanueva *et. al* 2013).

- In any case, some sort of bias correction is needed in order to compute all the threshold-dependent climate indices considered, and this aspect is an important source of uncertainty to be further analysed in this WP.
- The use of observational regional datasets is recommended whenever possible due to their much better representation of local-scale features.

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