Title: Iberia01: A new gridded dataset of daily precipitation and temperatures over Iberia
Author(s): Sixto Herrera et al.
MS No.: essd-2019-95
MS Type: Data description paper
Iteration: Revised Submission

Dear Editor,

We are submitting a revised version of the above mentioned manuscript. We are confident that we have satisfactorily addressed all reviewers' comments and that the revised manuscript will meet the high quality standards of ESSD. Please find below the point-by-point responses to the reviewers' comments and the new manuscript with (and without) tracked changes. We hope the revised manuscript is now acceptable for publication in *Earth System Science Data*. All authors agree on the current form of the manuscript.

Dr. Sixto Herrera, on behalf of the authors.

Anonymous Referee #1:
Received and published: 19 July 2019

Review of "Iberia01: A new gridded dataset of daily precipitation and temperatures over Iberia"
This paper presents a gridded climatological data product for the Iberian peninsula called "Iberia01" which appears to be a revision of a previous data product called "Spain02", using the same station network and interpolation methods, except including "orography" (elevation?) as covariate in the thin-plate spline step. Iberia01 is compared against a standard (E-OBS), finding more or less similar predictions except in some specific locations for specific climate variables. For precipitation it is found that the higher-resolution Iberia01 predictions show more small-scale variation than the coarse E-OBS product, at least in the case of a specific major precipitation event. The construction and integrity of the dataset appear to be well-done overall, although much of the methods refer to a previously published paper by the same authors. The figures are well-done as well. As a presentation of a new dataset, I think this paper should suffice (with some major revisions, clarifications, etc), although it is not clear whether any of the techniques or analyses are particularly novel.

Interactive comment on ***Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2019-95, 2019.***

specific lines referenced as (pg:line)

Response: We thank the reviewer for the comments and the time devoted to our paper. Please, see below our point-by-point responses and the changes highlighted as tracked changes in the new version of the manuscript.

Major Issues:

Reviewer's Comment: *None of the links (p11: 4-6) to the data worked for me. The first sent me to a generic landing page in Portuguese. The second sent me to a site where the data was embargoed and required a login account. The third sent an error message. I assume based on the R code that the third access point requires authentication with Santander and requests via a specialized R function. The AEMET link (pg 10) sent me to another landing page where it was unclear how to find the dataset. Either way, I could not access the data.*

Response: We thank the referee for pointing out this comment. In the original manuscript we included several alternative potential access points for the dataset (corresponding to the webs and services of the different institutions involved in the work). In the revised version we leave just one of them, the DIGITAL.CSIC service for open science, which was embargoed at the time of revision of the original manuscript. The embargo was established to prevent the use of the dataset before the publication of this reference paper. The embargo has now expired and the data is now freely available at the provided link. Moreover, we have included also some metadata information on the stations used which is also available at the link.
Alternatively, a service for remote access is provided via the Santander Climate Data Service (CDS), which requires a (free online) registration (a link to a page with instructions is provided in the paper).
The section now reads:

> *"All the datasets used in this work are publicly available. On the one hand, the Iberia01 dataset is publicly available through the DIGITAL.CSIC open science service (Herrera et al., 2019, DOI: http://dx.doi.org/10.20350/digitalCSIC/8641). Moreover, a THREDDS remote access to this dataset is available from the Santander Climate Data Service, via the User Data Gateway (instructions at http://meteo.unican.es/udg-wiki). On the other hand, the E-OBS v17 dataset is remotely available through the KNMI's THREDDS server http://opendap.knmi.nl/knmi/thredds/e-obs/e-obs-catalog.html and the ensemble version E-OBS v17e is available through the Copernicus' Climate Change Service http://surfobs. climate.copernicus.eu.*

The R code needed to partially reproduce the results of this paper (for the remotely accessible datasets Iberia01 and E-OBS v17) is publicly available at https://github.com/SantanderMetGroup/notebooks, building on the remote data services above described and on the climate4R R framework (Iturbide et al., 2019)."

Reviewer's Comment: *The authors state that the E-OBS dataset is taken as a benchmark (4:7) but later claim that the dataset is biased for key variables (6:22). It is not clear in the methods how this assessment is made or quantified.*

Response: The E-OBS dataset was used as benchmark in the manuscript because it is considered the reference dataset at European scale in many studies (it has more than 1490 citations in Scopus as by August 2019). However, as discussed in the introduction of the paper, at national or regional scale E-OBS presents some known biases, mainly in regions with complex orography and/or with low stations' density. Therefore, besides the comparison plots shown in Figure 2, we wanted to include some quantitative assessment of the differences. However, we agree with the referee that that no information is provided on how the assessments on 6:22-24 were obtained:

"*E-OBS underestimates mean precipitation by 15 - 20% (mean relative bias, for E-OBSv17 - v17e, respectively), particularly in the Central System range of the Iberian Peninsula, and 50-year return values by 42 - 47% (mean relative bias),"*

These values were directly calculated from the spatial mean values of the different indices shown in the different panels in Figure 2 (e.g. a mean value of 1.6mm for E-OBS v17 and 1.9mm for the Stations, resulting in ~15% relative difference). However, we agree that in the original manuscript these results were difficult to follow.

In the revised version we have clarified this, extending the analysis to take into account the different nature of the gridded (Iberia01 and E-OBS) and point-based (station) datasets shown in Figure 2. Therefore, besides calculating (and showing in the different panels) the spatial mean values of the gridded datasets, we included a second value comparable with the result for the stations, averaging over the number of stations considering the value of nearest gridbox to the local station. This provides a fair estimate of the biases of the gridded products, when compared with the original station-based one. A table with different statistics computed following this approach was included in the responses to the interactive reviewers' comments (see below). However, in the revised manuscript we have decided to keep the analysis as simple as possible and included only the spatial mean values (both over the whole grid, or over the stations' corresponding gridboxes) in the different panels of Figure 2, together with a proper explanation of these numbers included in the figure caption:

"Climatology (mean) of the different temperature (top) and precipitation (bottom) indices defined in Table 1, from the stations (local values), Iberia01 (0.1◦ resolution), E-OBS v17 (0.2◦) and E-OBS v17e (0.1◦), in rows. For the ensemble E-OBS version (v17e), the climatology of daily standard deviations of the ensemble values is also shown (characterizing E-OBS observational uncertainty). The numbers shown in each panel correspond to the spatial mean values, calculated for gridded datasets averaging over all gridboxes (top, in italics) or over the gridboxes nearest to the stations (bottom), to provide a fair comparison with the station mean values in the top panels (in particular these numbers are used to assess the biases of the different gridded datasets)."

The procedure followed to assess the different biases (based on Figure 2 information) are now clearly described in the revised manuscript.

Iberia01	tas	RV50Yt	pr	RV50Yp	RR1
MAE	0.5404	1.6162	0.2888	20.1838	11.2783
BIAS	-0.2099	-1.3145	0.0881	-17.8175	11.2763
RMSE	0.8902	2.9837	0.5651	28.1075	13.6863
Correlation	0.9422	0.7319	0.8496	0.8623	0.4304
E-OBS v17	**tas**	**RV50Yt**	**pr**	**RV50Yp**	**RR1**
MAE	0.8212	2.6219	0.4288	42.4205	10.0718
BIAS	-0.2603	-2.1310	-0.2703	-42.2184	9.9931
RMSE	1.1530	3.9377	0.7510	54.2519	12.5221
Correlation	0.8931	0.5403	0.7508	0.5891	0.4297
E-OBS v17e	**tas**	**RV50Yt**	**pr**	**RV50Yp**	**RR1**
MAE	0.8260	2.6720	0.4357	46.9555	11.4778
BIAS	-0.3341	-2.3033	-0.3021	-46.7663	11.4641
RMSE	1.1811	4.0530	0.7600	58.0514	13.7543
Correlation	0.9047	0.5365	0.7560	0.5659	0.4374

Table 1: *Comparison between the spatial pattern of the different gridded datasets against the observations for the indices considered [not included in the revised manuscript, only some of the results].*

Reviewer's Comment: *It would be nice to provide some ideas explaining the specific deviations (e.g. along the coast) between Iberia01 and E-OBS in the discussion.*

Response: We have included in the conclusions and discussion section a paragraph discussing this point and pointing out to possible reasons for the observed differences between both datasets:

> "Note that the complex orography and the influence of both the Atlantic Ocean and the Mediterranean Sea modulate the precipitation over the Iberian Peninsula, leading to particular regimes, as the cold drop in the east coast, that a continental adjustment of the interpolation model is not able to reproduce, particularly when a low-dense observational network is considered. In this sense, the large increase of rain gauges considered in Iberia01, when compared with E-OBS, give rise to a much improved precipitation rendering. In the case of temperature, although the observational network considered is similar in both cases, the pattern tends to be more orographic in E-OBS v17 due to the continental adjustment of the interpolation method that overrates this component avoiding regional behaviors. In addition, the contribution of the observational network considered in France also has a clear effect on the interpolated value over the Pyrenees and the northeast of the Iberian Peninsula."

Reviewer's Comment: *The assessment of resolution for the convective rain event is unsatisfying. First, why do the authors present the 20 km product (v17) and not the 10 km product (v17e) for E-OBS, which seems like a much better comparison?*

Response: *Following the referee's comment we have updated the figure including the high-resolution version of E-OBS (~10 km) but, as can be seen in the following figure, the conclusions have not changed.*

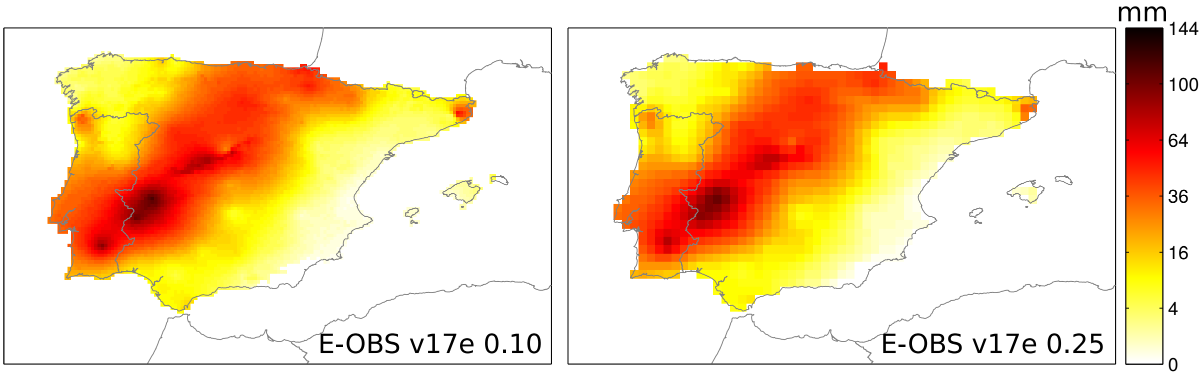


Figure: *Comparison between both resolutions of the E-OBS v17e dataset.*

Reviewer's Comment: *Second, the authors claim that the difference in resolution for Iberia01 10 vs 3 km resolution does not matter, but this is not quantitatively examined or explained in any way. Are the authors using gestalt, I assume?*

Response: *Although some further analysis was included in the responses of the interactive comments, we found this whole analysis unsatisfying (in agreement with the referee) and we have downgraded this topic in the revised manuscript to a simple illustrative example. Therefore, we have removed Sec. 2.5 (effective resolution) and included this discussion in the section describing the gridding method (and the different resolutions of the intermediate and final products). The objective of this example is to provide a simple example illustrating graphically the effective resolution of the different products.*

Reviewer's Comment: *There are numerous grammatical errors, run-on sentences and awkward phrasings throughout. I have noted some below, but not all. The writing is good in terms of logic, but needs a careful proofread (possibly by a native English speaker) before it is publishable.*

Response: We have revised the text carefully to eliminate grammatical errors and to rephrase awkward sentences.

Reviewer's Comment: *The methods frequently refer to Herrera 2011, 2012. However, more brief descriptions of these methods would be helpful, such as the QC protocols.*

Response: We have extended the description of the quality control procedure in the new version of the manuscript. In addition, two files with metadata information for each of the stations (geospatial information, start/end year, missing data for the whole period, number of years with less than 10% of missing data) have been included in the dataset one for precipitation and another for temperature. These files are available from the same DOI http://dx.doi.org/10.20350/digitalCSIC/8641 and provide detailed information on the characteristics of the observational networks used to build the gridded dataset.

> *"To keep consistency with previous datasets, the final network was obtained applying the same quality control used to build Spain02 (see Herrera, 2011, Herrera et al. 2012, for a detailed description), which requires stations with at least 15 (40) years in the period 1951-2015 with less than 10% yearly missing precipitation (temperature) data. The resulting observational network includes 3486 and 275 stations for precipitation and temperature, respectively, as shown in Figure 1(a-b). Note that detailed metadata for each station, including geographical and data availability information, is provided as part of the dataset in the same repository."*

Minor Issues:

Where did the 'orography' dataset come from? Isn't this just elevation?

Response: We have just considered elevation, given by the Global Digital Elevation Model (GTOPO30) which provides gridded 30 arc seconds (~1 km) elevation worldwide. We have changed 'orography' by elevation accordingly in several parts of the manuscript.

The R code (pg 11, line 10) Seems to only calculate and visualize climatologies but doesn't actually do any direct comparisons.

Response: We have rewritten and simplified the notebook provided with the paper. Now it computes the differences of the datasets and allows to easily calculate further indices to extend the analysis provided in the paper. We have included a comment on this in the "code and data availabililty" section:

> *"The R code needed to partially reproduce the results of this paper (for the remotely accessible datasets Iberia01 and E-OBS v17) is publicly available at https://github.com/SantanderMetGroup/notebooks, building on the remote data services above described and on the climate4R R framework (Iturbide et al., 2019)."*

(6:10) How exactly?

***Response:** We have downgraded the topic of effective resolution in the revised manuscript to a simple illustrative example (see previous comments).*

paragraph (6:29ff) move to methods

Response: We have modified the manuscript accordingly and included this paragraph at the end of the section "E-OBS Gridded Datasets (v17 and v17e)".

(6:30): "can be considered a realization of" seems like an awkward way to phrase it. Why not 'differs significantly from'?

Response: We have modified the sentence accordingly.

(7:2) "thus questioning" – Move interpretations like this to the discussion and flesh them out. I would tend to disagree with this statement as stands.

***Response:** We have modified the sentence accordingly.*

Technical issues:

Please remove "In order" from all sentences beginning with "In order to", as this is redundant.

***Response:** We have modified the manuscript accordingly.*

(1:9) Run on sentence

***Response:** We have rewritten the sentence.*

(1:11) omit "As a result"

***Response:** We have modified the sentence accordingly.*

(1:15) rephrase

Response: *The paragraph has been reformulated.*

(2:6) expands -> includes

Response: *We have modified the sentence accordingly.*

(2:11-12) reference for this assertion?

Response: We have included the citation's number of E-OBS in Scopus (1491 citations). In addition, we have modified the sentence to better clarify its meaning:

> *"With more than 1490 citations in Scopus (as by August 2019), this is the most used climate reference for European climate studies."*

(2:14) omit 'the'

Response: We have modified the sentence accordingly.

(2:19) 'smooths' awkward term here

Response: We have rewritten the sentence accordingly: "..., a reduction in the density of stations decreases the variability of both precipitation and temperature with large implications in the representation of extremes."

(3:6) include 'and' between citations

Response: We have modified the sentence accordingly.

(3:15) Run on sentences

Response: We have modified the sentence.

(3:20) Is this really the first? Seems like there are others, referenced in the same sentence (PT02)

Response: *The Iberia01 dataset is the first gridded dataset built ad hoc for the Iberian Peninsula. The previous IB02 was a dataset of opportunity created by joining two datasets (PT02 and Spain02). We have clarified this in the introduction:*

> "...for continental Portugal using more than 400 stations (PT02). Both datasets had consistent grids (with 0.2º resolution) and time periods (1950-2003) and were combined to build a gridded precipitation dataset of opportunity for the Iberian peninsula (IB02). However, this is not an homogeneous product for the Iberian peninsula due to the discrepancies existing between the two datasets near the borders, particularly in the northern mountain"

(4:8) Replace 'first dataset', 'this one' etc with specific title of each. Confusing

Response: We have modified the sentence accordingly.

(5:10) "temperature was built"

Response: We have modified the sentence accordingly.

(6:6) Run on sentence

Response: *We have modified the sentence accordingly.*

(6:13) How were clims aggregated?

Response: The climatologies have been obtained averaging the annual values of the indices (tas, pr and RR1). In the case of the 50-years return value the index is representative of all the period, so it is its own climatological value. This has been clarified in the caption of table 2.

(6:14) "the main differences being"

Response: *We have modified the sentence accordingly.*

(6:29) "we used"

Response: We have modified the sentence accordingly.

(9:7) on -> of

Response: We have modified the sentence accordingly.

(9:28) and (9:30) – these sentences are both difficult to understand.

Response: The conclusions have been substantially modified in the revised version.

Anonymous Referee #2:
Received and published: 7 August 2019

Review of "Iberia01: A new gridded dataset of daily precipitation and temperatures over Iberia"

The authors present an extensive, long-term dataset of temperature and precipitation in Iberia, based on a combination and extension of datasets from Spain and Portugal. While it is not dramatically new from previous data compilations by the senior author and his colleagues, they do introduce higher resolution and some new analysis. For instance, having elevation as a covariate in the interpolation procedure is a valuable improvement.

While incremental, this is a valuable dataset that can be used in a wide range of applications. I don't know of a network of observations this extensive, dense, and long-running anywhere in the world. While it is a shame to see the number of observations degrade in recent years, this is a valuable dataset that can be used for either weather or climate analyses. I can certainly see the value of this dataset as a test of the CORDEX high-resolution simulations. The paper is well-written: clear and concise. I recommend publication with minor revisions.

Interactive comment on Earth Syst. Sci. ***Data Discuss., https://doi.org/10.5194/essd-2019-95, 2019.***

Response: We thank the reviewer for the comments and the time devoted to our paper. Please, see below our point-by-point responses and the changes highlighted as tracked changes in the new version of the manuscript.

Minor errors or clarifications:

p.2,l.5, "higher longitudinal and latitudinal resolution", I think?

Response: We have changed "longitudinal" by "spatial".

p.2,l.14, should be "has been analyzed"

Response: We have modified the sentence accordingly.

Figure 1 caption, "ised" should be "used"

Response: We have modified the sentence accordingly.

Table 1, RV50Yt - shouldn't this be the maximum daily 2-m air temperature?

Response: To obtain the 50-years return values we consider the annual maximum of the corresponding variable, in our case daily precipitation and 2-meters daily mean temperature as is reflected in Table 1. The annual maximum of 2-meters daily maximum temperature can be also considered but we have not analyzed this variable in the paper.

p.6,l.8,"southwest to the northeast"

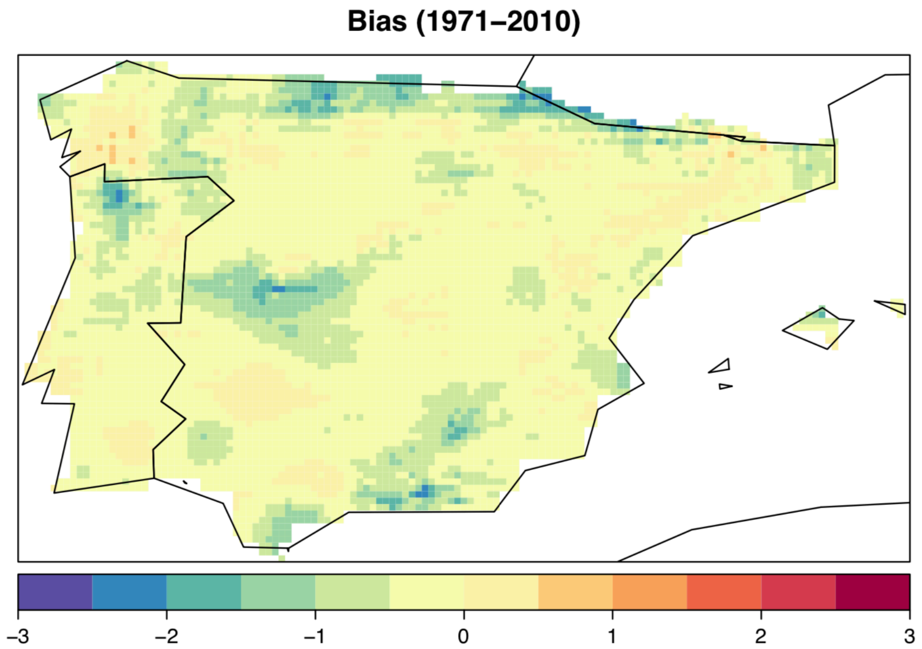
***Response:** We have modified the sentence accordingly.*

p.6,l.14, "with" the main differences being...

***Response:** We have modified the sentence accordingly.*

Discussion of Figure 2. It is hard to discern the differences. Difference maps would help to illustrate the main differences of interest between the datasets.

Response: Calculating and showing differences for maps of different nature (stations vs. gridded) and resolutions would involve regridding and would make difficult to interpret the obtained results. Therefore, we have opted to keep the same maps and 1) provide further intercomparisson analysis as detailed below and 2) provide the code required for reproducibility in a user-friendly notebook (described in the "code and data availabililty" section) which allows to easily compute the differences, giving flexibility for the different regridding options (when needed). Now that the notebook computes the differences of the datasets and allows to easily calculate further indices to extend the analysis provided in the paper. The figure below is included in the notebook and shows the differences between Iberia01 and E-OBS v17 (regridded to the Iberia01 grid).



Regarding the additional intercomparisson analysis, besides the spatial means of the different products shown in the original manuscript, we have extended the analysis to take into account the different nature of the gridded (Iberia01 and E-OBS) and point-based (station) datasets shown in Figure 2. Therefore, for the gridded datasets, we include now a second value comparable with the result for the stations, averaging over the number of stations considering the value of nearest gridbox to the local station. This provides a fair estimate of the biases of the gridded products, when compared with the original station-based one. A table with different statistics computed following this approach was included in the responses to the interactive reviewers' comments (see below). However, in the revised manuscript we have decided to keep the analysis as simple as possible and included only the spatial mean values (both over the whole grid, or over the stations' corresponding gridboxes) in the different panels of Figure 2, together with a proper explanation of these numbers included in the figure caption.

Iberia01	tas	RV50Yt	pr	RV50Yp	RR1
MAE	0.5404	1.6162	0.2888	20.1838	11.2783
BIAS	-0.2099	-1.3145	0.0881	-17.8175	11.2763
RMSE	0.8902	2.9837	0.5651	28.1075	13.6863

Iberia01	**tas**	**RV50Yt**	**pr**	**RV50Yp**	**RR1**
Correlation	0.9422	0.7319	0.8496	0.8623	0.4304
E-OBS v17	**tas**	**RV50Yt**	**pr**	**RV50Yp**	**RR1**
MAE	0.8212	2.6219	0.4288	42.4205	10.0718
BIAS	-0.2603	-2.1310	-0.2703	-42.2184	9.9931
RMSE	1.1530	3.9377	0.7510	54.2519	12.5221
Correlation	0.8931	0.5403	0.7508	0.5891	0.4297
E-OBS v17e	**tas**	**RV50Yt**	**pr**	**RV50Yp**	**RR1**
MAE	0.8260	2.6720	0.4357	46.9555	11.4778
BIAS	-0.3341	-2.3033	-0.3021	-46.7663	11.4641
RMSE	1.1811	4.0530	0.7600	58.0514	13.7543
Correlation	0.9047	0.5365	0.7560	0.5659	0.4374

Table 1: *Comparison between the spatial pattern of the different gridded datasets against the observations for the indices considered [not included in the revised manuscript, only some of the results].*

p.6,l.24, "all datasets show a clear overestimation" - why do you think this is? I don't understand why this would be for wet-day frequency, as it seems that this should come in a straightforward way from the dataset. How does interpolation or modelling introduce too many wet-days?

Response: Note that each grid point is obtained, in some way, as the spatial average of the surrounding stations. As a result, for each day if it has rained in one of the surrounding stations the interpolated value would be low but large enough to be considered as wet-day.

It would be interesting to see mean precipitation here as well, for each dataset.

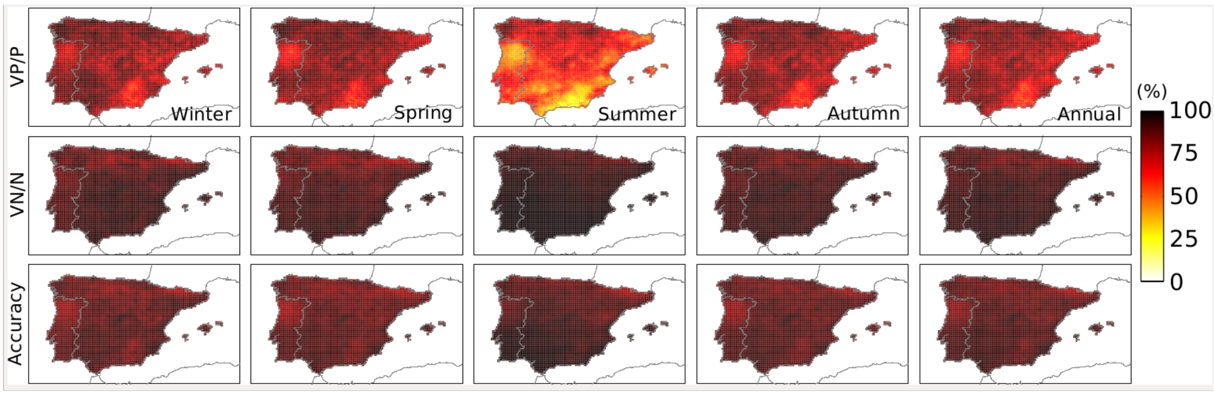
Response: We are not sure what the referee is referring to as this index is included in Figure 2.

p.9, conclusions - the authors frequently refer to Iberia02, but that is the next paper isn't it? Up to here and in the title this is presenting Iberia01.

Response: We have corrected this error. In a first version, we decided to use Iberia02 to keep the coherence with the existing datasets, PT02 and Spain02, but we finally decided to use Iberia01 to make emphasis on the higher resolution.

p.9, ll.22-23 - I must misunderstand wet-days. I don't understand how the dry-days could be equivalent between datasets but the wet-days differ; I would have thought that wd = 365 - dd. This is likely just my deficiency, but others might also be confused here so some explanation would be good

Response: This comment was misleading since it referred to the coincidence (hit rates) of dry and wet days in the two datasets (E-OBS and Iberia01). This comment was based on the results from the figure below (not included in the paper) that shows the percentage of dry/wet days well identified by E-OBS, considering Iberia01 as the reference. In particular, the first row shows the ratio between the number of wet-days coincident in both Iberia01 and E-OBS (VP) and the number of wet-days of Iberia01 (P), and the second row the same information but for the dry-days. In this sense, the sum of both quantities should give the 100% of data. The whole conclusions section has been rewritten and simplified and the above discussion has been removed.



p.6,l.21, double negative - I think it should be "either" and "or"

Response: *We have modified the sentence accordingly.*

Iberia01: A new gridded dataset of daily precipitation and temperatures over Iberia

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Abstract. The present work ~~introduces~~ presents a new observational gridded dataset (referred to as Iberia01) for daily precipitation and temperatures produced using a dense network (thousands) of stations over the Iberian Peninsula ~~(referred to as Iberia01, Herrera et al. (2019a), DOI:), providing daily precipitation and temperatures~~ for the period 1971-2015 at 0.1° regular (and 0.11° ~~rotated CORDEX compliant~~CORDEX-compliant rotated) resolutions. ~~A comparison with both the standard and ensemble version of the~~ We analyze mean and extreme indices and compare the results with the E-OBS v17 dataset (using both the standard and ensemble versions, at 0.25° and 0.1° resolutions, respectively)~~is undertaken~~, in order to assess observational uncertainty in this region. ~~First, a standard comparison is performed for several weather indices , obtaining~~ We show that Iberia01 produces more realistic precipitation patterns than E-OBS for the mean and extreme indices considered, although both are comparable for temperatures. To assess the differences between ~~both datasets. Secondly~~these datasets, a new probabilistic intercomparison analysis ~~is introduced~~was performed, using the E-OBS ensemble (v17e) to characterize observational uncertainty and testing ~~the hypothesis that~~ whether Iberia01 ~~is a realization of the ensemble (i.e. it~~ falls within the observational uncertainty range provided by E-OBS~~). Finally,~~. In general, uncertainty values are large in all the territory, with the exception of a number of kernels where the uncertainty is small, corresponding to the stations used to build the ~~effective resolution of the auxiliar very high resolution grid (0.01°) built to obtain the area-average representativity of the final dataset, and thus the possibility to increase the resolution of the dataset by means of pure interpolation methods, is analyzed considering an extreme event of convective precipitation affecting the Iberian Peninsula.~~

~~As a result, we show that Iberia01 produces more realistic patterns than E-OBS v17 in the case of precipitation for all the indices considered, although both are comparable for temperatures. These differences are assessed using the probabilistic approach based on the E-OBS ensemble showing a quite homogeneous spatial pattern for precipitation(with less than 25% significantly~~ grid. For precipitation, significant differences —at a 10% level— ~~different days~~ between both datasets ~~) and~~ were found for less than 25% of days over the Iberian Peninsula. For temperature, a very inhomogeneous ~~pattern for temperatures~~spatial pattern was obtained, with either a small (in most of the regions) or large fraction of significantly different days~~. The great uncertainty of the precipitation given by E-OBS ensemble, in which the standard deviation of the ensemble has the same order~~

~~than the mean value, increases the significance of the results obtained for this variable reflecting the differences between both datasets.~~ , thus indicating sensible regions for observational uncertainty.

Iberia01 is publicly available (Herrera et al., 2019a, DOI: http://dx.doi.org/10.20350/digitalCSIC/8641).

KEY WORDS: *Observational uncertainty; extremes; gridded observations; kriging; thin plate splines; E-OBS*

1 Introduction

The availability of high resolution climate data together with an estimate of its uncertainty (observational uncertainty) is of paramount importance for climate studies, from global (Sun Qiaohong et al., 2018) to regional and local scales (Kidd et al., 2011). The first comprehensive gridded temperature dataset was obtained by Jones et al. (1982). This dataset only covered the Northern Hemisphere and produced monthly means at 5° latitude by 10° longitude grid. Later, this grid was extended to cover the entire globe, with a higher ~~longitudinal~~ spatial resolution (at 0.5° resolution, Jones et al., 1986a, b) and currently ~~expands~~ includes several variables covering Earth's land areas for 1901-2015 (CRU TS4.0, Harris et al., 2014; Trenberth et al., 2014). However, this kind of resolution is too coarse for regional analysis, which typically requires datasets with tens of kilometres spatial resolution and daily to sub-daily temporal data, in order to differentiate climatic sub-regions and extreme events. In Europe, ~~within the framework of the ENSEMBLES project, the~~ the first high resolution continental observational gridded dataset was produced within the framework of the ENSEMBLES project (E-OBS ~~) for daily~~ dataset), for daily precipitation and maximum, minimum and mean temperatures ~~, precipitation~~ (Klein Tank et al., 2002; Haylock et al., 2008; Klok and Klein Tank, 2009) and sea level pressure (van den Besselaar et al., 2011). ~~This is by far~~ With more than 1490 citations in Scopus (as by August 2019), this is the most used climate reference for European climate studies. Yet, in some regions, E-OBS relies on a sparse observational network which limits its ability to correctly represent not only mean values, but also the variance and extremes, particularly over complex topography (Klok and Klein Tank, 2009). The ~~influence of the station~~ Influence of stations density in the quality of gridded products ~~have~~ has been analyzed in the last decades by several authors: Rudolf et al. (1994) was able to significantly reduce the precipitation error, from a maximum of 40% to 20%, by doubling the number of stations within a 2.5° grid box; Prein and Gobiet (2017) found that in regions with sparse data the uncertainties associated to mean seasonal precipitation could reach 60%; Beguería et al. (2016) found that, in a high resolution observationally based gridded dataset, the density of the underlying observations determines its spatial variance and thus strongly influences climate variability; Hofstra et al. (2010) concluded that, by randomly changing the number of stations in each grid box, a reduction in the density of stations ~~smooths~~ decreases the variability of both precipitation and temperature with large implications in the representation of extremes. Moreover, large temporal differences in the number of stations within each grid box also adds another source of uncertainty since it can change trends of the time series (Hofstra et al., 2009; Frei, 2014; Beguería et al., 2016). Finally, in an analysis of the sources of uncertainty in observationally based gridded datasets, Herrera et al. (2019b), highlight that the station density represents the major variability factor, irrespective of the interpolation method. The authors analysed several grids for Spain (complex topography) and Poland (smooth topography) and concluded that the influence of station density is more pronounced in Spain than in Poland due to the large spatial variability and complex orography of the first.

The quality of the station observations is an additional source of observational uncertainty for gridded products. These uncertainties may be reduced by applying quality control procedures and homogenising the time series (Herrera et al., 2012). Precipitation time series also commonly suffer from undercatch associated to windy conditions, which usually results in underestimation of the correct precipitation rate (Frei et al., 2003). Yet in complex topography an increased uncertainty may be associated to the use of these types of corrections (Adam et al., 2006). The areal representativeness of a particular station also poses a challenge. Again, in regions with high terrain gradients, like mountains or coastal areas, surface temperatures are affected by local circulations like sea-breeze, up/down slope breeze associated to night-time radiative cooling in the valleys and to differentiated warming/cooling at sunrise/sunset of the slopes (Whiteman, 1982; Whiteman and McKee, 1982; Whiteman, 1990). Frei (2014) proposed a new interpolation method to tackle the latter, in which the thermal vertical profile of the station surrounding area is considered. Yet, Frei (2014) also acknowledges that the best way to reduce this type of uncertainty is through high station density.

Recently, several national high-resolution grids have been compiled for individual European countries from dense observation networks: SAFRAN analysis at 8km grid spacing covering France at an hourly timestep (Durand et al., 1993; Quintana-Seguí et al., 2008; Vidal et al., 2010), and its recently published extension for continental Spain and Balearic Islands (Quintana-Seguí et al., 2017); PTHBV, a 4km daily dataset for Sweden (Johansson, 2000; Johansson and Chen, 2003); the 5km resolution HYRAS for Germany (Rauthe et al., 2013; Frick et al., 2014); seNorge2 a daily dataset with an 1km resolution for Norway (Uboldi et al., 2008; Lussana et al., 2018); TabsD (MeteoSwiss, 2013a) and RhiresD (MeteoSwiss, 2013b) at 2km for Switzerland; CARPATCLIM a 0.1° grid covering parts of nine countries along the Carpathian Mountains (Lakatos et al., 2013) and a 0.11° grid for Poland (Herrera et al., 2019b).

In the Iberian Peninsula, ~~Herrera (2011); Herrera et al. (2012)~~ Herrera (2011) and Herrera et al. (2012) built a precipitation regular grid for continental Spain and Balearic Islands based on 2756 stations (Spain02) following the methodology used in E-OBS. The same methodology was also applied by Belo-Pereira et al. (2011) for continental Portugal using more than 400 stations (PT02). Both ~~grids had a~~ datasets had consistent grids (with 0.2° resolution~~and a time span of~~) and time periods (1950-2003~~.~~) and were combined to build a gridded precipitation dataset of opportunity for the Iberian peninsula (IB02). However, this is not an homogeneous product for the Iberian peninsula due to the discrepancies existing between the two datasets near the borders, particularly in the northern mountains. Recently, Herrera et al. (2015) updated the Spanish grid including precipitation and temperatures (daily maximum, mean and minimum) and enhancing the spatial resolution to 0.1° (regular); moreover, they also provided results on a 0.11° rotated grid (CORDEX compliant) for the purpose of Regional Climate Model (RCM) evaluation. ~~While the gridding methodology in the PT02 was the same as in Herrera et al. (2012), some discrepancies between the two datasets occurred near the borders, particularly in the northern mountains. These problems could be solved building a joint grid, using observational station data from both countries. Furthermore, the 0.2° resolution of the Portuguese grid is too coarse for regional climate studies and the~~ The lack of temperature ~~grids also~~ for PT02 (and IB02) hinders a comprehensive analysis of the large ~~climate~~ inter-annual and spatial variability, characteristic of the Iberian climate (Esteban-Parra et al., 1998; Muñoz-Díaz and Rodrigo, 2004; Cardoso et al., 2013). These problems could be solved building an Iberian grid, using observational station data from both countries.

In this paper, we develop an Iberian wide daily regular grid at 0.1° resolution, for precipitation and temperatures (maximum, mean and minimum) as well as a 0.11° rotated grid (EURO-CORDEX compliant) suitable for model evaluation purposes. This grid is based on a high density network of stations across continental Portugal and Spain and Balearic Islands, with a reasonably stable number of stations for the period 1971-2015. This represents the first ~~precipitation and temperature gridded dataset for Iberia~~ gridded dataset of daily precipitation and temperatures for Iberia as a whole, and can be considered an update of the PT02 ~~dataset~~and IB02 datasets. Here, we also introduce the ~~orography~~ elevation as covariate in the interpolation process, which was missing in the initial PT02 and Spain02. The resulting dataset is compared against the most recent version of E-OBS (v17.0, referred to as v17), which includes a new ensemble version (v17e) to assess observational uncertainty and allows for a new probabilistic intercomparisson of these datasets.

The paper is structured as follows~~: First, in~~ . In Section 2 a description of the data and methods considered in this work is presented. ~~Secondly, the~~ The main results are described (Sec. 3). Finally, the main conclusions ~~and discussions grown~~ from the analysis are detailed in Section 4.

2 Data and Methods

2.1 Observation Network and Quality Control

The present work is based on a dense network of ~~3847 precipitation stations and over 380 temperature stations~~ thousands of stations from the Spanish ~~Agency of Meteorology~~ Meteorological Agency (AEMET), the Portuguese Institute for Sea and Atmosphere (IPMA) and the Portuguese Environmental Agency (APA). ~~The~~ To keep consistency with previous datasets, the final network was obtained applying the same quality control used to build *Spain02* ~~(see Herrera, 2011; Herrera et al., 2012, for a detailed description of the dataset and the corresponding quality contro~~ ~~obtaining the observational network~~ (see Herrera, 2011; Herrera et al., 2012, for a detailed description), which requires stations with at least 10 (40) years in the period 1951-2015 with less than 10% yearly missing precipitation (temperature) data. The resulting observational network includes 3486 and 275 stations for precipitation and temperature, respectively, as shown in Figure 1(a-b)~~, including 3481 and 276 stations for precipitation and temperature, respectively~~. Note that detailed metadata for each station, including geographical and data availability information, is provided as part of the dataset in the same repository. Figure 1(c) shows ~~that there is a~~ the data availability on a yearly basis, exhibiting a clear decline of the number of stations ~~with available data~~ in the last two decades, mainly for precipitation. Therefore, the resulting gridded product is not suitable for historical trend analysis, since biased results could be obtained as a result of the changing number of stations. Moreover, during the period 2009-2014 ~~the~~ there are very few precipitation stations in Portugal and, therefore, results should be interpreted with caution in this period. Therefore, we recommend using the reference climate period 1971-2000 for this dataset. Overall, the spatial distribution of the stations is quite homogeneous over the Iberian Peninsula with a good representation of the orographical gradients, specially for the case of precipitation (see the first column of Fig. 1). Therefore, the ~~orography~~ elevation was included as a covariate in the interpolation process (at a monthly scale) to model and reflect these gradients ~~.~~

(see Sec. 2.4).

2.2 E-OBS Gridded Datasets (v17 and v17e)

E-OBS (Haylock et al., 2008) is the reference gridded dataset of daily precipitation and temperatures in Europe and has been previously used to analyze the observational uncertainty in the context of the evaluation of regional climate models (see, e.g. Kotlarski et al., 2019). In this study, we use both the standard (v17, 0.2° resolution) and the ensemble ~~(v17e, 0.1° resolution Cornes et al., 2018)~~ (v17e, 0.1° resolution; Cornes et al., 20 of E-OBS v17 as benchmark for comparison purposes. In addition to the estimated daily value for each gridbox, the ensembles grid also provides a measure of daily uncertainty, characterized by the standard deviation of the ensemble. ~~The first dataset~~ E-OBS v17 is used for the sake of comparison with Iberia01 (see Fig. 2) and the ~~second one~~ E-OBS v17e (the ensemble) is used to assess the observational uncertainty provided by this dataset, ~~by testing~~ and test whether Iberia01 ~~could be considered a realization of~~ does not differ significantly from the ensemble (i.e. it falls within the observational uncertainty range) with a certain confidence (90%) day by day. For this purpose, the E-OBS ensemble ~~.~~

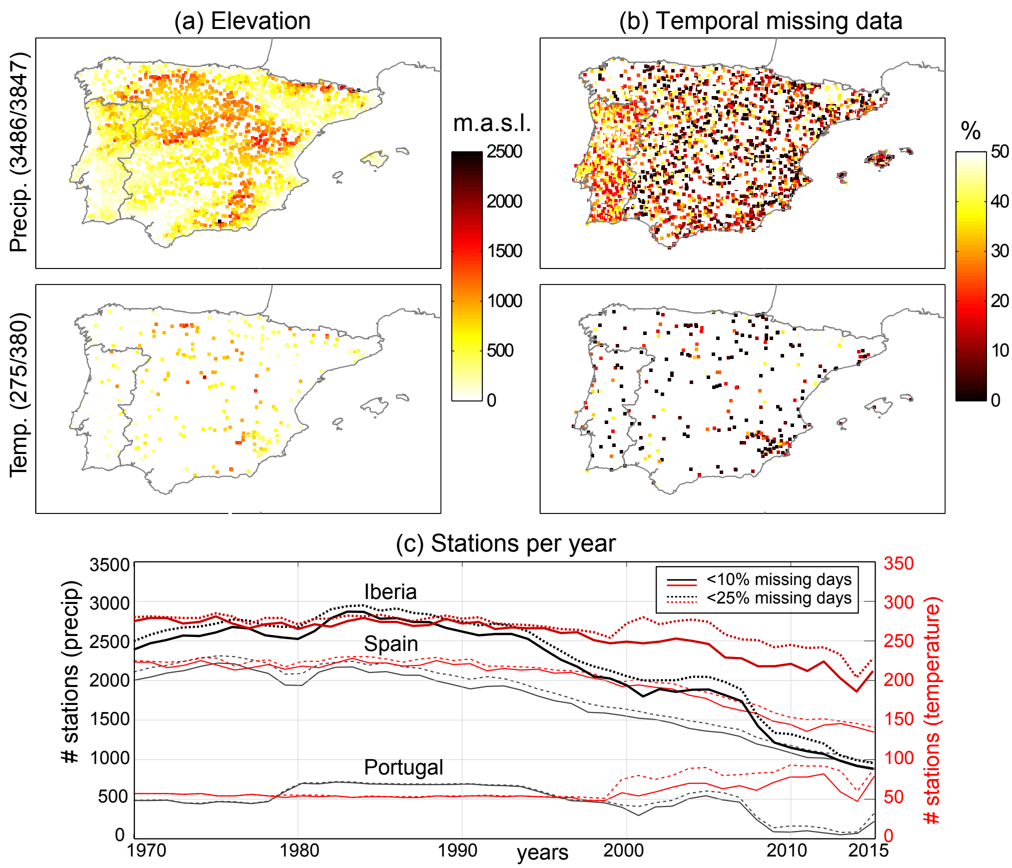

Figure 1. (a) ~~Orography~~ Elevation and (b) data availability (percentage of missing days) in the period 1971-2015 for precipitation (top) and temperature (bottom) for the observational networks considered for the interpolation. The numbers on the left of the figure reflect the initial and final number of stations ~~ised~~used, once the quality control is applied. (c) Number of stations ~~– considering~~ —considering the Iberian Peninsula, Spain or ~~Portugal –~~ Portugal— per year for different thresholds of annual missing data for precipitation (black) and temperature (red).

mean (μ) and spread (σ) are used to define a normal distribution $N(\mu,\sigma)$ characterizing observational uncertainty for each grid box and day, and the corresponding Iberia01 values are classified as either inside or outside (values outside the P5-P95 percentile range) the uncertainty range for each grid box and day. Note that outsider values indicate significant differences between both datasets (as characterized by the E-OBS ensemble).

2.3 Weather Indices

~~In order to~~ To analyze the mean and extreme regimes of precipitation and temperature we use the indicators shown in Table 1. In particular, the 50-year return value for each grid-box was used to characterize the extreme regimes (for the period 1971-2015) obtained by adjusting a Generalized Extreme Value (GEV) distribution to the series of annual maximum of daily values (see Herrera et al., 2015, for a detailed description). In the case of precipitation, both wet-day frequency and rainfall intensity have been considered to properly characterize the mean regime.

Table 1. Precipitation and temperature indices used in this study.

ID	*Indicator*	*Units*
pr	Mean daily precipitation amount	mm/day
RR1	Wet-day ($pr > 1mm$) frequency	%
RV50Yp	50-years return value of daily precipitation	mm/day
tas	Mean daily ~~2-meters~~ 2-meter air temperature	deg. Celsius
RV50Yt	50-years return value of the mean daily ~~2-meters~~ 2-meter air temperature	deg. Celsius

2.4 Gridding Method

The Iberia01 daily gridded dataset for precipitation and temperatures was ~~build~~ built using the previously described observational network and applying the area-averaged 3-dimensional (AA-3D) interpolation method described in previous studies (Herrera, 2011; Herrera et al., 2012, 2015). This interpolation method is an area-averaged method based on ordinary kriging (OK; Krige, 1951; Matheron, 1962) and 3-dimensional thin plate splines (3D-TPS; Craven and Wahba, 1979; Wahba, 1990; Hutchinson, 1998a, b) in a two-step process:

- first, the 3D-TPS is applied to the monthly value considering the ~~orography as covariable~~elevation given by the Global Digital Elevation Model (GTOPO30, see section on code and data availability) as covariate;
- second, the daily anomaly is interpolated by applying OK;
- as a result, both the daily anomaly and monthly value are combined to obtain the interpolated daily values

~~In order to~~ To ensure the area-averaged representativity of the final values, the initial interpolation is done over an auxiliary 0.01° resolution grid and, then, the interpolated results are upscaled (averaged) to the target resolutions, in our case a regular version of 0.10° spatial resolution ($10km$ approx.) and a rotated version matching the grids considered in the EURO-CORDEX project (0.11° and 0.44°). In this work we only describe for simplicity the regular version of 0.10° spatial resolution, although the other datasets are also provided (these datasets will be used in a future paper to evaluate the performance of EURO-CORDEX models over Iberia).

2.5 ~~Effective Resolution~~

Taking into account the two-step interpolation procedure followed to develop the area-average representative gridded dataset, a natural doubt surges about the possible application of the auxiliary very-high resolution grid (1 km) to build a grid at a resolution higher than 10 km. For instance, the new RCM convective permitting simulations performed in the framework of the CORDEX Flagship Pilot Studies (FPS) reach a resolution of $2-3$ km and, thus, high resolution grids are needed for the evaluation of these projects (Giorgi et al., 2009; Jacob et al., 2014). ~~In order to test this possibility,~~ Some previous works warn against the development of high-resolution grids with few (or none) stations per gridbox (Herrera et al., 2019b). Therefore, we limited the resolution of Iberia01 to 0.10° and do not provide higher resolution intermediate products. As an illustrative example ~~is considered:~~ to illustrate the effective resolution of the datasets, we consider a convective high-resolution extreme precipitation event ~~affecting the Iberian Peninsula~~ occurred on 4-5 November 1997, and characterized by heavy precipitation over most of the Iberian Peninsula~~, in particular crossing the Peninsula from the southwestern to the northeastern~~. This event had great socioeconomic impacts in Portugal (Ramos and Reis, 2002) and Spain (Lorente et al., 2008), and was ranked as the second greatest extreme precipitation event of the Iberian Peninsula (Ramos et al., 2015). We use this event as an illustrative case study ~~in order to analyze the potential benefits provided by a~~ the effective resolution of a potential 3 km gridded version of Iberia01, as compared with the standard 10 km resolution.

3 Results

Figure 2 shows the climatologies (mean annual values) of the indices shown in Table 1 for ~~Iberia02~~ Iberia01 (0.1°) and E-OBS (v17, 0.2° and v17e, 0.1°). The three datasets provide similar results in the case of temperature, ~~being~~ with the main differences being located in the South, around the Guadalquivir and Guadiana basins, where the maximum values are attained. In addition, the ~~uncertainty climatology~~ climatology of observational uncertainty (calculated as the temporal mean of the daily standard deviations of the ensemble values) is also provided for the ensemble version of E-OBS, showing a value around 2.5° in all the territory, with the exception of a number of kernels where the uncertainty is very small, corresponding to the stations used to build the E-OBS grid. Note that the ~~uncertainty climatology~~ observational uncertainty pattern is different in Spain and Portugal, with more clear kernels in the first case; this could be due to the different temporal coverage of both networks, with an increase of uncertainty due to days with no observation. Therefore, the uncertainty conveys relevant information on the station network used to build the grid.

In the case of precipitation, E-OBS ~~is not able to~~ cannot reproduce neither the mean spatial pattern (pr) nor the intensity of the 50-year return value (RV50Yp). E-OBS underestimates mean precipitation by 15~~-20~~% (mean relative bias, for E-OBSv17 ~~-~~and v17e, ~~respectively~~as obtained from the spatial mean numbers in Figure 2), particularly in the Central System range of the Iberian Peninsula, and 50-year return values by ~~42~~ 40 - ~~47~~44% (mean relative bias, for E-OBSv17 - v17e, respectively), with some very high biases in some Southern and Mediterranean regions. The case of wet-day frequency is different, since all datasets show a clear overestimation, with Iberia01 showing a more orographic pattern than E-OBS. In this case, the higher resolution of E-OBS v17e provides further spatial detail as compared to the standard v17 one, which is not evident for precipitation intensity. Moreover, the ~~uncertainty (temporal mean of the daily standard deviations of the ensemble values)~~ E-OBS observational uncertainty is of similar magnitude to the mean value (also with kernels of small uncertainty corresponding to stations) reflecting a large uncertainty for ~~to~~ this variable.

~~In order to quantitatively assess the differences between these two datasets, we use the "observational uncertainty" provided by the E-OBS v17e ensemble and test whether Iberia01 can be considered a realization of this ensemble (i.e. within the observational uncertainty range) with a certain confidence (90%) day by day. For this purpose, the E-OBS ensemble mean (μ) and spread (σ) are used to define a normal distribution $N(\mu, \sigma)$ characterizing observational uncertainty for each grid box and day, and the corresponding Iberia01 values are classified as either inside or outside (values outside the P5-P95 percentile range) the uncertainty range for each grid box and day. Note that outsider values indicate significant differences between both datasets (as characterized by the E-OBS ensemble).~~ Figure 3 shows the percentage of significantly different days for each gridbox, variable and season. For precipitation (first row), only Iberia01 wet-days were used in order to minimize the effect of the different wet-day frequencies. The differences for this variable exhibit a homogeneous spatial pattern over the Peninsula with values around 10% in general; this is due to the large uncertainty of the daily E-OBS ensemble spread (see Fig. 2)~~thus questioning the practical utility of this measure of uncertainty for this variable~~. Regarding the temperatures, most of the spatial pattern presents values close to zero, reflecting the similarity between both datasets for these variables. However, some local differences are found particularly for the mean (second row) and maximum (third row) temperatures, with the greatest values reached in the Pyrenean and Central ranges and the south coast of the Iberian Peninsula, in agreement with the differences shown in Figure 2. In this case, the ensemble uncertainty is in agreement with the differences between these two datasets found in Figure 2.

~~In order to explore the possibility to increase the resolution of the Iberia01 grid~~Finally, we consider an illustrative extreme event occurred the 4-5 November 1997 ~~and~~ to illustrate the effective resolution of the different datasets (including potentially new higher resolution products). To this aim, compare the resulting values of the 0.1° grid with a higher resolution 0.03° one developed using the auxiliary 0.01° grid generated in the interpolation process. Figure 4 ~~shows~~ show the results obtained for the extreme event indicating that an increment of the Iberia01 resolution beyond 10 km has no clear impact in the effective resolution of the precipitation pattern. In particular, in spite of the ~~clear~~ apparent improvement of both versions of Iberia01 w.r.t. E-OBS ~~v17 for all the parameters considered~~v17e, there are only slight differences between both versions of Iberia01 when compared with observations.

~~Note that the interpolation method, independently on the target resolution, is calibrated to reproduce the spatial dependence of the mean field of the target variable, which is usually greater than the grid resolution (1° approximately in this case). Therefore, the effective resolution of purely interpolated gridded products is limited by this spatial value, which define the size of the kernels used for the interpolation process. As a result, in order to properly evaluate the convecting permitting CORDEX simulations, other approaches like regional reanalysis (e.g. Häggmark et al., 2000) or methods combining interpolation and analysis as the proposed by Quintana-Seguí et al. (2017) and Peral et al. (2017), among others, should be used.~~

4 Conclusions and Discussion

In this work a new gridded dataset for the Iberian Peninsula and the Balearic Islands based on a quality-controlled and dense station network has been described and compared with E-OBS v17, considering both the standard and the ensemble version of this product, to reflect and analyze the observational uncertainty related with both datasets.

~~On the one hand, Iberia02 is~~ It is shown that Iberia01 is able to reproduce the spatial pattern and intensity of both the mean and extreme regimes of precipitation and temperature, in terms of the weather indices defined in Table 1, including extreme events as the ~~one~~ illustrative case study occurred the 4-5 November 1997 shown in the Figure 4. ~~For the weather indices considered~~However, E-OBS v17 tends to underestimate the extremes and soften the spatial pattern of precipitation, in agreement with ~~other~~ previous studies (Herrera et al., 2012). ~~It is however more similar to Iberia02 in~~ In the case of temperature~~indices,~~, both datasets exhibit similar spatial patterns with the main differences appearing in the Guadalquivir and Guadiana basins, and the Pyrenean range. ~~In addition, although both datasets seem to reproduce more or less the same dry-days (see Figure 2) large differences appear when wet-days are considered, with E-OBS v17 identifying less than the 70% of the observed wet-days all around the Peninsula and falling up to the 40% in Summer.~~

~~On the other hand, considering the~~ We have also used the ensemble version of E-OBS, E-OBS v17e ~~, an experimental framework to evaluate the observational uncertaintyhas been defined, analizing if Iberia02 falls inside the ensemble given by E-OBS v17 and, then, if it could be considered a realization of the ensemble~~to define observational uncertainty, and analyzed whether Iberia01 does differ significantly from the ensemble (i.e. it falls outside the observational uncertainty range). In this case, we conclude that both datasets ~~could be used indistinctly. First, note that the spread of the ensemble for precipitation has the same order of~~ are significantly different. In general, uncertainty values are large in all Iberia, with the exception of a number of kernels where the uncertainty is small, corresponding to the stations used to build the E-OBS grid. For precipitation, significant differences —at a 10% level— between both datasets were found for less than 25% of days over the Iberian Peninsula. For temperature, a very inhomogeneous spatial pattern was obtained, with either a small (in most of the ~~mean~~

~~value reflecting a large uncertainty for this variable in contrast to the one obtained for temperatures. In the case of precipitation the percentage of outliers for~~ regions) or large fraction of significantly different days, thus indicating sensible regions for observational uncertainty.

The complex orography and the influence of both the Atlantic Ocean and the ~~wet-days ranges between 5% and 25% along the Peninsula whilst for temperatures most of the area show values less than 5%, with the regions identified previously (Guadalquivir basin, Pyrenees, etc.) presenting the greatest percentages with values larger than $50\% - 60\%$. These results are in agreement with the quantile distribution, with the temperature centered around the median, with some underestimation/overestimation in the case of the minimum/maximun temperatures, and the precipitation showing a clear overestimation of the quantiles that increases dramatically when only wet-days are considered. In summary, although in most of the domain the temperatures given by Iberia02 are included within the ensemble defined by~~ Mediterranean Sea modulate the precipitation over the Iberian Peninsula. This leads to particular regimes, as the cold drop in the east coast, that a continental adjustment of the interpolation model is not able to reproduce, particularly when a low-dense observational network is considered. In this sense, the large increase of rain gauges considered in Iberia01, when compared with E-OBS~~v17e, there are several regions with significant differences that should be considered/treated with caution. Moreover, in~~ , give rise to a much improved precipitation rendering. In the case of temperature, although the observational network considered is similar in both cases, the pattern tends to be more orographic in E-OBS v17 due to the continental adjustment of the interpolation method that overrates this component avoiding regional behaviors. In addition, the ~~case of precipitation both datasets present significant differences that should be taken into account~~contribution of the observational network considered in France also has a clear effect on the interpolated value over the Pyrenees and the northeast of the Iberian Peninsula.

Note that the interpolation method, independently of the target resolution, is calibrated to reproduce the spatial dependence of the mean field of the target variable, which is usually greater than the grid resolution (1° approximately in this case). Therefore, the effective resolution of purely interpolated gridded products is limited by this spatial value, which define the size of the kernels used for the interpolation process. As a result, in order to properly evaluate the convecting permitting CORDEX simulations, other approaches like regional reanalysis (e.g. Häggmark et al., 2000) or methods combining interpolation and analysis as the proposed by Quintana-Seguí et al. (2017) and Peral et al. (2017), among others, should be used.

~~The Iberia01 dataset (Herrera et al., 2019a, DOI: http://dx.doi.org/10.20350/digitalCSIC/8641) is publicly available through the climate services portals of: IPMA: AEMET:~~

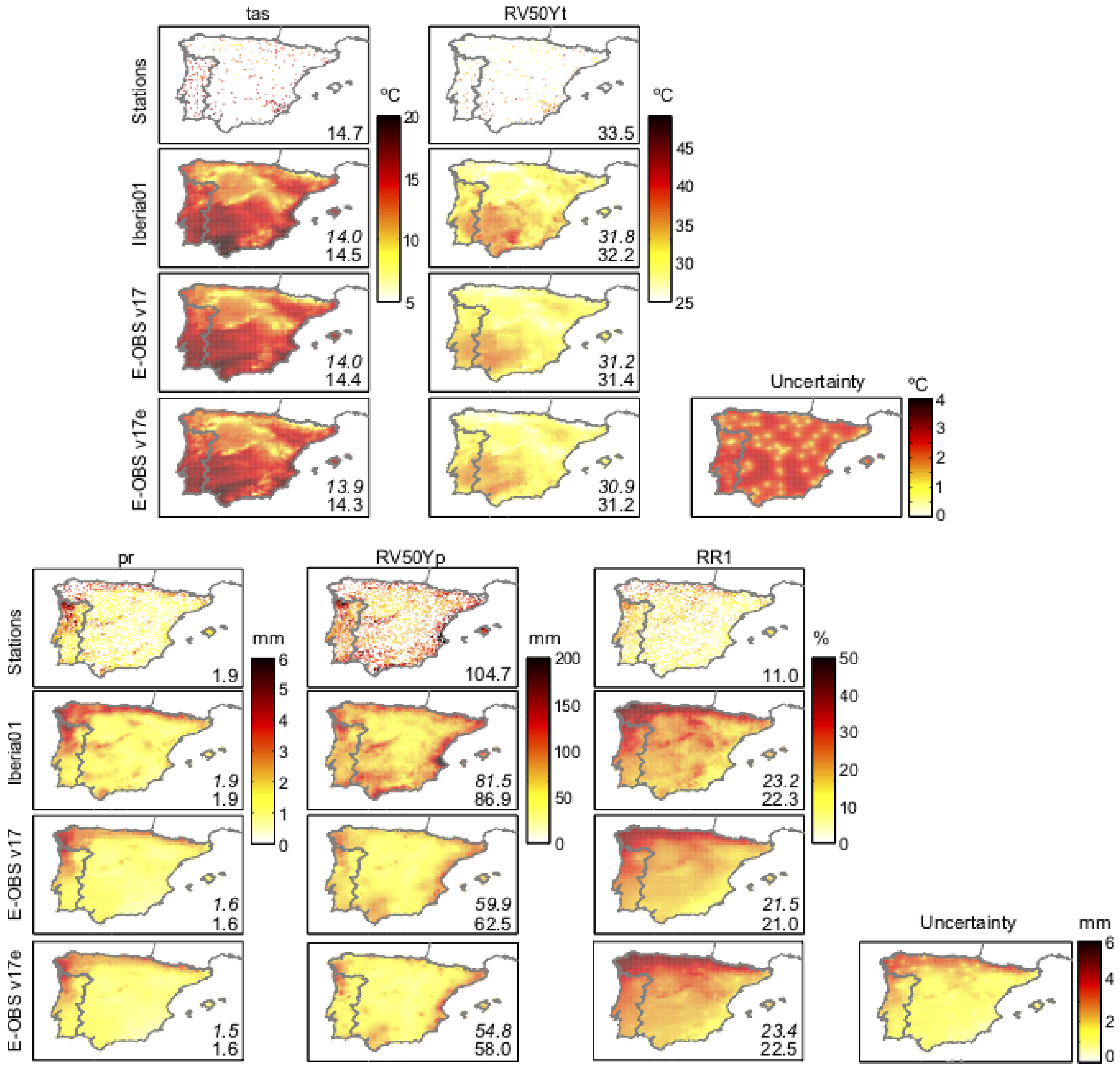

Figure 2. Climatology of the different temperature (top) and precipitation (bottom) indices defined in Table 1, from the stations (local values), Iberia01 (0.1° resolution), E-OBS v17 (0.2°) and E-OBS v17e (0.1°), in rows. The ~~mean~~ climatologies have been obtained averaging the annual values of the indices (tas, pr and RR1); in the case of the 50-years return value the index is representative of the whole period. For the ensemble E-OBS version (v17e), the climatology of daily standard ~~deviation has been included for~~ deviations of the ~~latest dataset~~ensemble values is also shown (characterizing E-OBS observational uncertainty). The numbers ~~show~~ shown in each panel correspond to the spatial mean values, calculated for gridded datasets averaging over all gridboxes (top, in italics) or over the gridboxes nearest to the stations (bottom), to provide a fair comparison with the station mean values in the top panels (in particular these numbers are used to assess the biases of ~~each map~~the different gridded datasets).

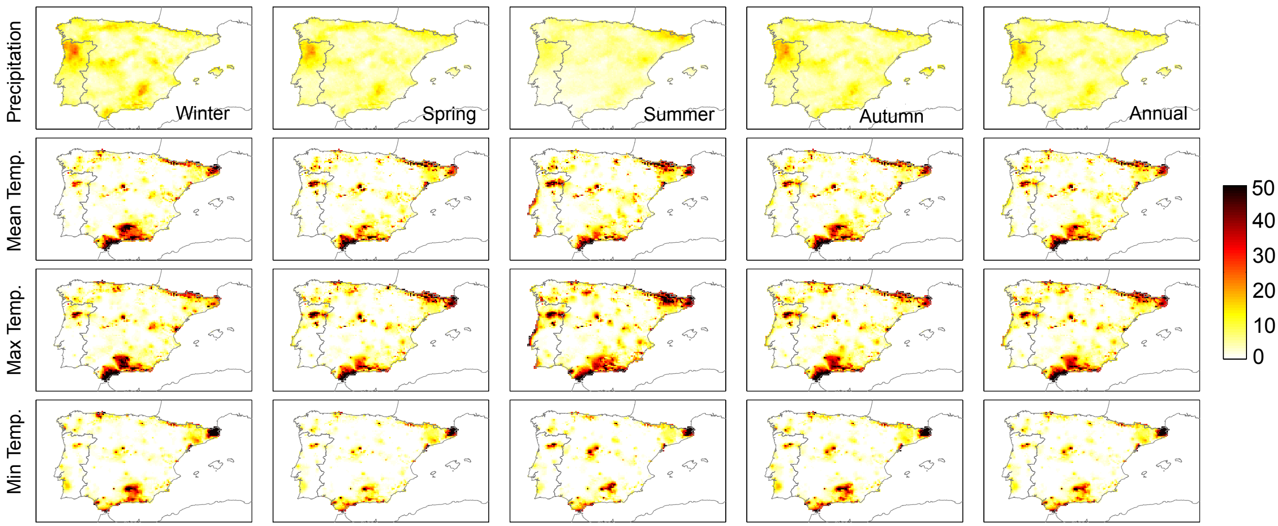

Figure 3. Percentage of significantly different days between Iberia01 and E-OBS v17e for each gridbox, variable and season, defined as the Iberia01 daily values outside the the $P5-P95$ percentile interval of the normal distribution given by the E-OBS ensemble, in the period 1970-2015 for wet-days (first row), and mean (second row), maximum (third row) and (fourth row) minimum temperatures.

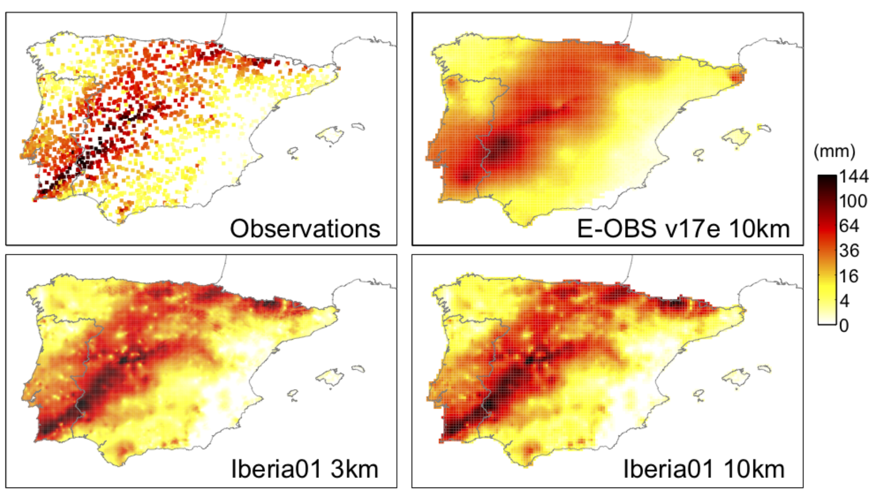

Figure 4. Daily precipitation of the 4-5 November 1997 observed and ~~given~~ represented by E-OBS ~~v17~~v17e and Iberia01 (10 km), and ~~a~~ higher resolution 3 km ~~and 10 km~~ version of ~~Iberia02~~Iberia01.

5 Code and data availability

All the datasets used in this work are publicly available. On the one hand, the Iberia01 dataset is publicly available through the DIGITAL.CSIC open science service (Herrera et al., 2019a, DOI: http://dx.doi.org/10.20350/digitalCSIC/8641). Moreover, a THREDDS remote access to this dataset is available from the Santander Climate Data Service, via the User Data Gateway (instructions at http://meteo.unican.es/udg-wiki). On the other hand, the E-OBS v17 dataset is remotely available through the KNMI's THREDDS server http://opendap.knmi.nl/knmi/thredds/e-obs/e-obs-catalog.html and the ensemble version E-OBS v17e is available through the Copernicus' Climate Change Service http://surfobs.climate.copernicus.eu. Elevation data is taken from the Global 30 Arc-Second Elevation (GTOPO30) DOI: 10.5066/F7DF6PQS.

The R code needed to partially reproduce the results of this paper (for the remotely accessible datasets Iberia01 and E-OBS v17) is publicly available at https://github.com/SantanderMetGroup/notebooks, building on the remote data services above described and on the `climate4R` R framework (Iturbide et al., 2019).

Author contributions. Herrera S., Gutiérrez J.M. and Soares P.M. conceived the study; Gutiérrez J.M., Soares P.M., Cardoso R.M., Espíritu-Santo F. and Viterbo P, obtained and processed the Spanish and Portuguese observational datasets; Herrera S. implemented the code to make the interpolation and the analysis, and built the dataset and figures of the paper; Herrera S., Soares P.M., Gutiérrez J.M. and Cardoso R.M. wrote the manuscript and all the authors revised the results.

Competing interests. The authors declare that there are not any competing interest.

Acknowledgement. This work was partially funded by the ~~Spanish Government~~ project MULTI-SDM (CGL2015-66583-R, MINECO/FEDER) from the Spanish R&D Programme~~(Exp. CGL2010-21869 and CGL2010-22158-C02).~~ . Pedro M.M. Soares and Rita M. Cardoso wish to acknowledge the SOLAR (PTDC/GEOMET/7078/2014) project and the funding by the project FCT UID/GEO/50019/2019 - Instituto Dom Luiz.

The authors are grateful to the Portuguese Institute for Sea and Atmosphere (IPMA)~~and~~ , the Portuguese Environmental Agency and the Spanish Meteorological Agency (AEMET) for providing the needed observational data. ~~The authors are also grateful to AEMET for providing the necessary data to do this work.~~ We acknowledge the E-OBS dataset from the EU-FP6 ~~project ENSEMBLES (http://ensembles-eu.metoffice.co~~ ~~and the data providers in the ECA&D project (http://www.ecad.eu). We acknowledge the E-OBS dataset from the EU-FP6 project UERRA (http://www.uerra.eu)~~ ENSEMBLES and UERRA projects and the Copernicus Climate Change Service, ~~and~~ as well as the data providers in the ECA&D project (https://www.ecad.eu).

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