Responses to RC2 on manuscript EGUSPHERE-2023-166

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1 Reviewer comment 2

The manuscript compares temperature, precipitation, and snow values of the European Alps from several reanalysis and climate modeling products with remote sensing and in-situ data of the last few decades. The authors focused their extensive analysis on 4 large sub-regions and on three elevation band between 600 and 2400 m. The results show that the agreement varies widely and depends mainly on the data set or variable considered. Such analyses are an important base for many scientific investigations since more and more applications rely on such spatially gridded long-term datasets. Moreover, the study provides a very valuable overview on the strength and weaknesses of the currently available observation datasets and gridded modelling products.

The structure of the paper is clear, the text mostly concise and follows a obvious thread. The methods and results are nicely presented. Despite the many acronyms the study is relatively easy to read. Except for one major point, there are only minor issue listed below. Therefore, I suggest accepting the manuscript as soon as the following points, have been addressed :

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We thank Reviewer 2 for his/her useful comments that have lead to an improved revised manuscript.

1.1 Major comment

1.1.1 The determination of SCD, SOD and SMOD is fully dependent on complete time series. According to 2.3.1 you still allowed 20% of less of missing data in the in-situ snow depth data set. How many of the used time series were affected by such gaps and how were the above snow cover related variables determined in such cases ? What was the procedure, if two or more periods of the same length were detected ?

As mentioned in the manuscript section 2.3.1, most of the missing values are temporally located during summer, where no snow is present. During this period, for some stations neither manual measurements nor a filling of the time series were performed. We did not check manually the temporal location of each missing values for each of the time series, but it is highly unlikely, given that we used quality-checked and gapfilled products from Matiu et al. (2021), that missing values are found during the snow season.

In order to address this point, we provide in the following a short sensitivity study to investigate the impact of using a more restrictive threshold.

For this, we removed stations that have more than 5% missing values for the entire year, allowing us to identify at which elevations the stations with 5% to 20% missing values are located. In total 74 stations were identified. Out of them, only 3 were located above 1800m.

To ensure that these series, despite their percentage of missing values (lying between 5% to 20%) provide realistic values of snow cover duration, we compare the distribution of the mean snow cover duration over the 2000-2015 period for stations that have less than 20% missing values with stations that have between 5% and 20% missing values, which we show on Figure 1. Figure 1ab show the impacts of using different thresholds on the snow cover duration distribution. We see that the blue points on Figure 1a, showing between 5 to 20% missing values, are mostly in the quantile range 25-75. Figure 1b shows the distribution of the SCD for two thresholds of missing values : 5% and 20%. As no significant differences can be observed when setting a more restrictive threshold values for the missing values, we choose to keep the initial threshold value of 20% missing values to maximize the number of observations included in the analysis.

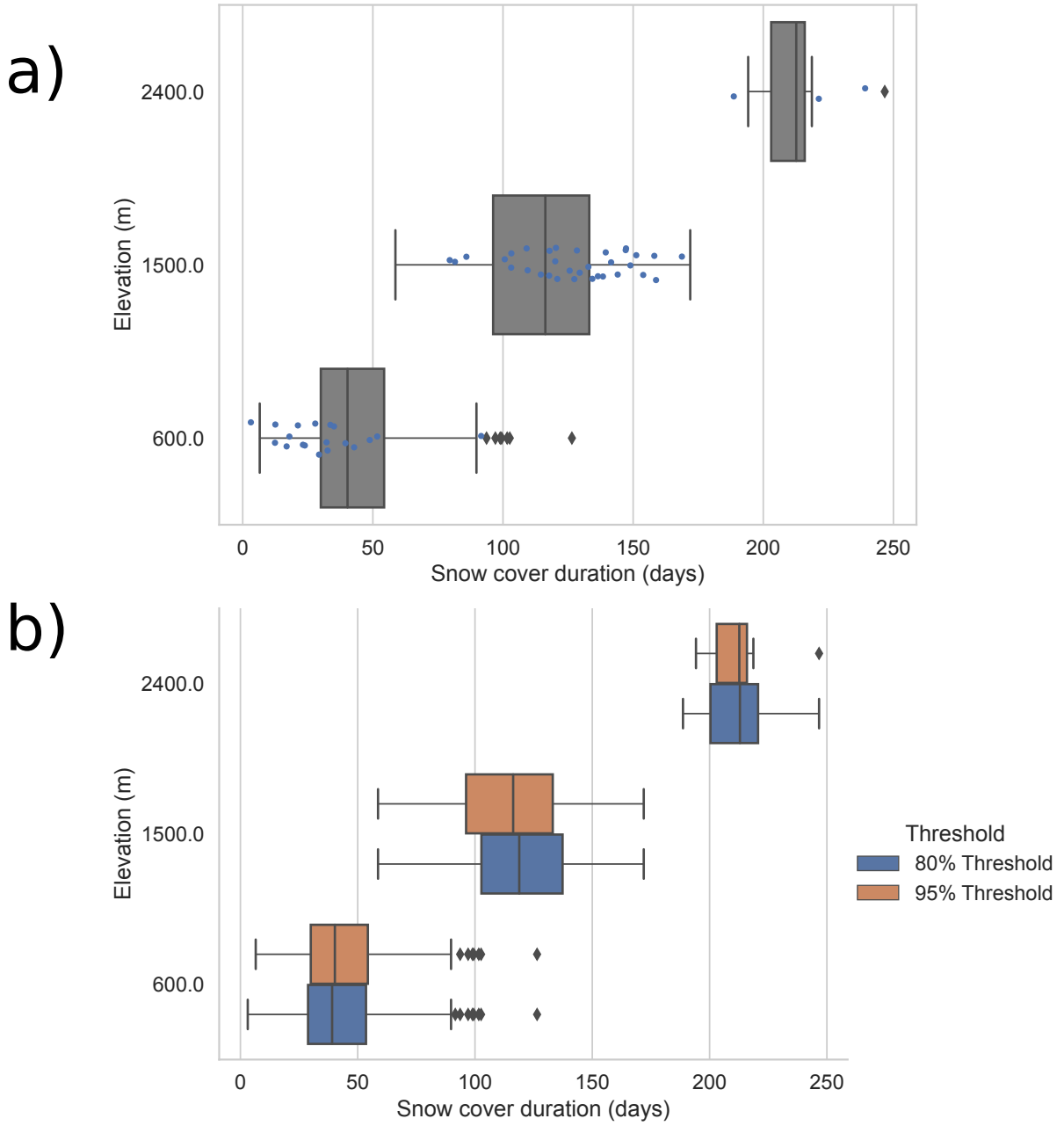

FIGURE 1 – a - Boxplot representing the distribution of the mean values of snow cover duration (SCD) for the 2000-2015 period using a threshold set at 20% missing values for three elevation bands (600 m ±150 m, 1500 m ±150 m, 2400 m ±150 m). Blue points are the mean values of SCD for the 2000-2015 period for stations that have 5% to 20% missing values. b - Blue boxplots represent the distribution of the mean values of SCD for the 2000-2015 period using a threshold set at 20% missing values for three elevation bands (600 m ±150 m, 1500 m ±150 m, 2400 m ±150 m) and orange boxplots for a threshold set at 5%.

Concerning the last part of the question, for the computation of the snow cover duration, missing values are considered as a 0 (absence of snow), and we are looking for the longest consecutive snowy period. If two or more period of the same length are detected, the first is chosen to determine the snow onset date (SOD) and the snow melt out date (SMOD).

1.2 Minor comments

1.2.1 L11 : Please add the information that the presented results are mainly valid for the November to April period.

Accodingly, we added L.9 : "..., mainly for the winter period (from November through April).".

1.2.2 L20 : Since such a sentence does not really provide any meaningful information, certainly not in the summary, delete it or be more specific.

We find valuable to introduce the main results of the section dedicated to the interannual variability and trends comparisons between the reference and the evaluated datasets, which mention that most of the datasets provides result consistent with past literature, which is the main "summarized" conclusion of this section.

1.2.3 L36 : Please provide reference for 5 days per decade

The reference for "5 days per decade" is (Hock et al., 2019), that we cited above and below.

1.2.4 L37 : Please provide an example for altering the magnitude of natural hazard in the winter season.

From the IPCC SROCC (Hock et al., 2019), we can mention snow avalanches, floods and landslides. Accordingly we added L.37 : "... such as snow avalanches, floods and landslides".

1.2.5 L94 : contrasting results twice ?

The manuscript was corrected accordingly.

1.2.6 L105 : Missing clause !

The manuscript was corrected L. 105 : "[...] and find that the quality of the dataset for a given area is for a large part determined by the number of assimilated observations."

1.2.7 L106 : I do not understand this last sentence. Please rephrase.

It was due to a typing error, the manuscript was corrected accordingly L.105 : "... find that the quality of the dataset for a given area is for a large part determined by the number of assimilated observations.".

1.2.8 L159 : Please shortly mention, why only the 2000-2015 period was considered.

Indeed, in this section, the choice of the time period for each of the subsets was not explained. Accordingly, we modified and rephrased part of the paragraph L.151-161 : "In order to have the largest spatial coverage to compute monthly to seasonal mean snow depth over large regions, we keep all stations data that have at least 70% valid daily values over the November to April for the 1985-2015 period (see Figure 1b). Section 2 focuses on the snow cover seasonality, using the indicators SCD, SOD and SMOD computed using continuous daily values of snow depth over the winter period, and compare it to satellite observations from MODIS (record starting in 2000). Most of the missing values happen in summer (for most of the observation stations, no snow is present during this period). In this section, we keep stations with more than 80% of valid daily values over all year of the 2000-2015 period (see Figure 1c). Section 3 focuses on the interannual variability and trends. This requires the most homogeneous possible dataset along with a sufficiently long time period, so we only keep stations with more than 90% valid daily values over the winter months (November to April) of the 1968-2018 period (see Figure 1d)."

1.2.9 Fig.2 : Yellow color is hard to read. Id suggest adding (e.g. right of the color box) the final spatial and temporal resolution of each product.

Yellow color has been changed to a darker yellow, easier to read. Spatial and temporal resolution are already indicated within the squares representing each of the component of the products.

1.2.10 L302 : Please rephrase

Accordingly, part of the paragraph L.300-305 has been rephrased : "The agreement metrics used are skill scores based on the confusion matrices calculated using daily values of presence or absence of snow, considering in situ observations as the truth :

- True Positive Rate (TPR) corresponding to the proportion of number of points flagged as presence of snow in MODIS pixel and in the corresponding in situ station.
- True Negative Rate (TNR) corresponding to the proportion of number of points flagged as absence of snow in MODIS pixel and in the corresponding in situ station.

— Positive Predictive Value (PPV) or Precision is the proportion of number of points correctly flagged as presence of snow in MODIS pixel.
— Negative Predictive Value (NPV) is the proportion of number of points correctly flagged as absence of snow in MODIS pixel.
— Accuracy corresponding to the proportion of the total number of predictions that were correct (both presence and absence of snow).

"

Then, differences for the different thresholds between MODIS and stations observations for our three indicators (SCD, SOD, MOD) are quantified using mean absolute error (MAE) and mean error (ME) values."

1.2.11 L217 : You mention several NH snow analyses, but reference only one, which is about arctic snow only ?

We added an other reference (Decharme et al., 2016), that investigates the performance of the surface reanalysis over Eurasia.

1.2.12 L275 : Please shortly mention what the reference is.

Accordingly, we modified L.275 : "... compared to the DEM at 100 m".

1.2.13 L287 : Last section of what ?

"Last section" was not precise, we modified it L.287 : "Section 3.3".

1.2.14 Fig.3 : What is UE Alps ?

UE Alps incorrectly stood for European Alps, but it was unclear, so we replaced it by : "Whole Alps".

1.2.15 L355 :..there are not much differences in the results at the sub-regional scale. This contradicts the results of Matiu et al. (2021). Please explain.

When saying that there are not much differences in our results at the subregional scale, we refers to section 3.1 only, that adressed the differences between the evaluated datasets and the reference one concerning the mean characteristics of the snow cover. Matiu et al. (2021) show differences between subregions of the mean characteristics of the snow cover for its in situ observational dataset, which differs what we investigated in our study.

1.2.16 L369 : normalized mean error. In the same sentence you also use relative mean error ?

In the study, both terms refer to the use of normalized (by mean values) error metrics and expressed in pourcentage. Using both terms can be confusing, so we only keep the term "normalized" for the error metrics.

1.2.17 Fig.5 : I do not see circle markers ? Figure caption : Sub figures a,b,c labeled wrong order.

Circle markers are only associated with the black line (representing the observations), and are rather small to let visible other lines. The labeling was designed to be ordered from the top to the bottom and therefore is not in the wrong order. Nonetheless, according to the comment 2.2.24, we reversed this order in the revised manuscript.

1.2.18 Fig.6 : Please add units to the different column heads. Figure caption : What about the unit of the scores of temperature ?

Accordingly we added units to the column heads.

1.2.19 Fig.8 : Labels of x- and y-axis of right side figures are too small.

Accordingly, labels of Figure 8 were enlarged.

1.2.20 L453 : Please rephrase

Accordingly we rephrased L.453 : "Overall, most of the datasets provide winter precipitation rather close to the reference, excepted climate simulations CNRM-AROME and CNRM-ALADIN that strongly overestimate it at intermediate and high elevations."

1.2.21 L457 : could be nuanced ? Please rephrase

Accordingly, we rephrased L.457 : "However, the origin of the overestimation also identified for the other datasets during the winter period may be for a part due to LAPrec deficiencies."

1.2.22 L495 : consistent with boxplot ? Only if we assume that the negative whisker is caused by the low elevation pixels. Please explain.

The sentence was lacking clarity in its initial form, so we rephrased L494-495 : "For CNRM-AROME, the map on Figure **??**a seems to show an elevational pattern with a slight underestimation of the snow cover duration in valleys and an overestimation elsewhere. The boxplot Figure **??**b confirms it, revealing centered around 0 biases at low elevation, and a generalized overestimation above.".

1.2.23 Fig.9 : Caption : In order to compared.. ?

We rephrased part of the sentence in caption : "Note that MODIS products initially at 500 m horizontal resolution have been reggrided over each dataset grid using a first-order conservative method.". We decided to leave this sentence as a reminder of the methodology used to construct it.

1.2.24 L503 : ..underestimated in all datasets.. Where to see ? Fig.10 : The order of a,b,c (a for the lowest plot) is different from all the other figures, but I like it more.

According to this comment and the comment 1.1.4 from reviewer 1, we rephrased part of the text L.503 : "From Figure 10abc, the size of the errorbars provides information on the spatial variability of the SOD and the SMOD. Based on this information, we can conclude that it is underestimated in all datasets, except CNRM-AROME, but this may be partly related to a too small horizontal resolution in most of the datasets."

1.2.25 L537 : Solid line with circle markers should be part of the figure caption. What is the geographical mean value ?

Accordingly this part has been removed from the text. The "geographical mean value" stands for the mean value over the subregion. This expression has been modified for better clarity.

1.2.26 Fig.11 : What is the reason to show to markers ? The different markers can not be separated from each other. For comparability Id suggest to use the same axis scale for all four Taylor diagrams.

In our opinion, markers help to differenciate the different lines and identify the precise value associated with a specific date.

1.2.27 Fig. 12 : What is the reason for the large difference between the red and blue line for the second last year ?

It was an artifact that has been corrected in the revised manuscript.

1.2.28 L572 : lower

The manuscript have been corrected accordingly.

1.2.29 L582 : anomaly values

The manuscript have been corrected accordingly.

1.2.30 L599 : ..precipitation for the 1950-2020 period

We can not add it to the sentence, only the ERA5 dataset spans the 1950-2020 period, it would therefore be inaccurate.

1.2.31 L640 : over the last decade only ?

It was a typing error leading to the missing of the plural, we corrected it : "... over the last decades.".

1.2.32 Fig.15 : Winter (Nov-Apr) trend values

The manuscript has been corrected accordingly.

1.2.33 Fig.17 : What is the meaning of the two N-values for each dataset ? N-values are too small !

We thanks reviewer 2 for his/her remark, this is an oversight that has been corrected by adding in the caption of Fig 17 : " The N-number represents the number of trends detected as significant out of the total number of trends calculated.".

1.2.34 Fig.17 : Caption : winter (Nov-Apr) trend grid points included for three elevation bands (+/- 150 m) given on the y-axis.

We thanks reviewer 2 for his/her remark and corrected the caption accordingly.

Références

Decharme B, Brun E, Boone A, Delire C, LeăMoigne P, Morin S (2016) Impacts of snow and organic soils parameterization on northern Eurasian soil temperature profiles simulated by the ISBA land surface model. The Cryosphere 10(2) :853–877, DOI 10.5194/tc-10-853-2016

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