Responses to RC3 on manuscript EGUSPHERE-2023-166

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1 Reviewer comments 3

This is a very relevant study, which compares in a particularly comprehensive way data sets of winter temperature, winter precipitation, and snow depth (or the derived variable of snow cover duration) for the Alpine region. The data sets are on the one hand products derived from station data, satellite products, reanalysis data and climate simulations. Such a comprehensive and in-depth comparison is, to my knowledge, unique and of great value to the cryospheric research community but also well beyond. Since the Alps are characterized by a high density of measurements, satellite products, modeling studies, and investigations of spatiotemporal changes, the results can be considered as a benchmark of comparison between observational data and model results for mountain regions.

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We thank reviewer 3 for his/her comprehensive evaluation and positive appreciation of our work.

1.1 Title

I have only several minor comments or suggestions for improvement :

1.1.1 The title could be more concise. Actually, it is more a comparison of the data sets (as it is also written in the abstract) than an evaluation. I suggest also to make clear in the title that all climate variables studied have as reference the winter period (so also for precipitation). Also, instead of "snow cover information", one could use "snow depth information" to make clear that the study refers to the quantity "snow depth" as well as quantities derived from it.
Proposal for the title : "Comparison and analysis of winter temperature, winter precipitation and snow depth variables in the European Alps from multiple datasets".

We thank reviewer 3 for his/her suggestion regarding the title. We agree that it could be more concise, but we should not remove some informative words. Indeed, the proposal does not mention the temporality of the period studied "multi-decadal" and "past", which we find very useful and have decided to keep in the title.

The word "evaluation" refers to a comparison between simulated fields and reference fields. Most of our analyses in the article are comparisons where we take the observational datasets as references, even though we are aware of their own limitations and mention them. Nevertheless, it's not clear whether or not this word adds valuable information to the title, so we've decided to delete it.

Concerning the use of "snow cover information" instead of "snow depth information", we have decided to keep it, as it may be clearer to readers that snow depth is not the only snow variable being analyzed, but also the snow cover onset and melt-out dates and snow cover duration.

Accordingly, we propose a new title for the article, as a compromise between clarity, informativeness and size. Note that the title of the original manuscript was shorter, and has been extended following suggestions from reviewer 1.

"Multi-decadal analysis of past winter temperatures, precipitation and snow cover data in the European Alps from reanalyses, climate models and observational datasets".

1.2 Abstract

1.2.1 The data on trends in snow cover duration given in the abstract are altitude dependent (as will be shown later in the paper), so giving a range of variation rather than a fixed value would be more accurate and clearer to the reader.

We thank reviewer 3 for his/her remark, and rephrased part of the paragraph L.22 to 25 in order to include information about the elevational gradient of the trend :

"Based on these datasets, over the last 50 years (1968-2017) at a regional scale, the European Alps have experienced a winter warming of 0.3řC to 0.4řC per decade, stronger at lower elevation and a small reduction of winter precipitation, homogeneous with elevation. The decline of the winter snow depth and snow cover duration range from -7% to -15% per decade and from -5 days to -7 days per decade, respectively, both showing a larger decrease at low and intermediate elevation."

1.2.2 From the sentence "Reference datasets and some of the evaluated datasets provides past trends in line with current available literature" it remains unclear what is meant. Which datasets were evaluated ? (In this study or elsewhere).

Accordingly, we rephrased L21 of the abstract for clarity : "Nevertheless, many of the considered datasets in this study exhibit past trends in line with the current state of knowledge."

1.2.3 I find the altitude dependencies of the trends (elevation dependent climate change) for temperature, precipitation and snow sizes a relevant result and suggest to include it in the abstract as well.

We have taken this suggestion into account and suggest above a modification of the abstract.

1.2.4 Objective of the study as described in the introduction section :

It is stated (page 4/118-120) : The objective of the present study is to compare the performance of different datasets from different modelling strategies in the European Alps, in order to provide the best possible estimate of the state of the snow cover, and its first order drivers, wintertime near surface temperature and precipitation.
I recommend to rethink if this is really the main objective :
- best possible estimate of state of snow cover (and its first order drivers)
- comparison of the performance of different datasets from different modelling strategies
If the objective is really for best possible estimate then this aim should be more reflected in the conclusions. Moreover, comparison includes not only the modelling data. I guess, this is certainly already a special fine-tuning of the study, but it would strengthen the work once again.

We thank reviewer 3 for this comment. Indeed, the conclusion does not indicate specific datasets or even strategies for constructing datasets (i.e. from models and observations, using assimilation or not...) that would obtain better results than others. However, we aim to answer that some strategies have advantages when it comes to representing daily and/or seasonal values of variables, while others are more robust when it comes to reconstructing past trends and variability.

Concerning the comparison, the first objective of the study remains to characterize the robustness of each dataset evaluated in multiple aspects of the climatology, using observational or observation-based datasets as reference. Indeed, we are aware that these datasets also have their limitations, and the study can be seen as a cross-evaluation of the "evaluated" datasets and the "reference" datasets.

For clarity, we proposed to rephrase L.118-120 : "The objective of the present study is to compare the performance of different datasets from different modelling strategies in the European Alps, in order to better understand their different characteristics and assess how to provide the best possible estimate of the snow cover spatio-temporal variability and trends, and its first order drivers, wintertime near surface temperature and precipitation."

1.3 Data and methods

1.3.1 2.4.4 Time periods, statistics and trend analyses Please clarify in the formula for correlation what the "n" means.

Indeed, as the meaning of "n" is unclear, we have replaced it in the equation with "N", in reference to the sample size as indicated.

1.4 Conclusions

1.4.1 Another suggestion from my side concerns the Conclusions. My impression about this is that the paper does very nicely the comparison between the different datasets and also shows the spatiotemporal trends of the datasets for temperature, precipitation and different snow variables, but the conclusions from this are still somewhat open. I totally agree with the statement that none of the datasets outperforms the others. But ev. it could be interesting to contrast the detected differences between the data sets with the detected trends. This could be done either in a figure (however there is already an extremely high supply of figures and should not be enlarged) or purely textual, where the latter is probably easier to do.

We thank Reviewer 3 for this suggestions. Indeed, a more in-depth analysis linking the multiple aspects examined in the study for each of the datasets would be interesting. Nevertheless, we feel that at this stage, the manuscript is already well-furnished, if not too well-furnished, and we have therefore decided not to add any further analysis and leave this for further investigations.

1.5 Figures

1.5.1 Figure 1 caption : ... at 1km and contour of the Alpine Convention outline of the Alps and the four .

The captions have been corrected accordingly.

1.5.2 For Figures 7, 8, 9 14, A1, A2, A3 it would be helpful for the reader if the structure of the three altitude bands would be more emphasized in a graphic way. For some of the Figures, one could get the impression that the Y-axis is a continuous representation of the altitude (but defacto it is only an indication of the altitude bands).

We understand that the discontinuous y-axis containing numerous boxplots for each elevation band may be rather unusual for some readers, but we believe that the caption provides sufficiently detailed information to avoid any misunderstanding of the figure's meaning.

1.5.3 To some of the Figures the font size is already very small and it is not easy to read (but ev. It still meets the Copernicus requirements)

Upon acceptance of the manuscript we will interact with Copernicus, if need be, to adjust the figures where needed.

1.5.4 I recommend to improve the language quality by looking for repetition of words and some spelling errors as well as simplifying sentence order / improving readability. Example e.g. page 4 last paragraph : We investigate ... We take .... We also exploit .... By doing so, we aim ..

Manuscripts accepted for publication in Copernicus journals are usually edited by professionnal editors at the copy-editing stage, which will ensure than such issues are resolved