

**Characteristics and dynamics of extreme winters in the Barents Sea in a changing climate**

Response to the reviewers' comments by Katharina Hartmuth, Heini Wernli, and Lukas Papritz

We thank all reviewers again for their helpful comments. We address each comment point by point below. The reviewers' comments are given in blue and our responses in black.

Please note, that we always refer to the lines in the updated, revised manuscript (document without track changes). We supplement this document with a latexdiff-pdf showing changes since the last version of the manuscript.

**Reviewer 1**

Overall, the manuscript has been improved from its previous version and the authors have taken suggestions, such as streamlining the narrative and shortening some sections, and generated a better article. It is clear that a lot of work has gone into this iteration of the work and I have only a few very minor comments, mainly technical, after which I recommend publication.

Minor:

L24: Aren't trends in summer and autumn sea ice expected to be largest?

Thank you for this remark. We realized there is some repetition here anyways, which is why we shortened and combined this sentence with the previous one:

"Global climate models project continuing large changes in Arctic sea ice extent and surface conditions in the coming century (...), with the prospect of an ice-free Arctic during September within a few decades (...)."

L150: What are P mode and S mode and why use one rather than the other?

We added this remark about the used PCA mode following the comment of reviewer 3 (please see comment and our reply). Following Richman (1986), the PCA mode differs depending on the definition of the component score matrix and, more precisely, which parameters are chosen as variables and fixed entity. In our case, we combine a variety of parameters for a fixed area which refers to P-mode as opposed to S-mode, where one would combine a number of different gridpoints/regions for a fixed field. That we use P-mode in our study follows by design of our method that is based on the combination of multiple surface parameters in a fixed region.

L194: It might be a good idea to add a few words here on potential issues with precip in ERA5, perhaps particularly in a remote region like the Barents Sea, which would be less constrained by observations, which could be biasing the ERA5 dependence on precip for extremes.

We added the following sentence in L194: "Note however that due to the remoteness of the study area the accuracy of ERA5 precipitation fields is potentially limited."

L282-284: I do not understand what issue is being pointed out here. The conclusions are repetitive, this section could still be somewhat shortened.

Here we point out that the amount of values contributing to the climatology (that is used to calculate seasonal anomalies in weather system frequencies) is not the same for each grid point and, in particular, decreases with increasing distance to BS, as the climatology is obtained as the mean of all cyclone/anticyclone/CAO masks overlapping with the enlarged BS region. This is important to consider when interpreting the results as an anomaly that occurs at a large distance to BS could be based on a less "robust" climatology compared to an anomaly within BS.

Technical:

L1: a trend in a decline would be something like the second derivative of sea ice area with respect to time, when I think the authors mean to imply large negative trends or large declines rather than large trends in the decline.

Changed to "...is experiencing large declines in sea ice and increasing surface temperatures...".

L2 remove comma after time.

Changed as suggested.

L43: still discussed, it has been shown -> a topic of debate/it has been argued

Changed as suggested.

L81 - 82: add comma after Further and extremes, and -> as well as

Changed as suggested.

L89: To make this sentence clearer, I'd recommend inverting it: In a warmer climate, is there a change in the relative importance....

Changed as suggested.

L278: remove comma after winter, if -> whether

Changed as suggested.

L298 (& L375, possibly elsewhere): favors -> favours

As we consistently use American English throughout the entire manuscript, we will keep “favor” and not change it towards “favour”.

L355 correlate -> correlates

Changed as suggested.

L388: remove comma after indicates

Changed as suggested.

L463: ‘and by the surface’ -> and drive the atmosphere?

Changed sentence to “can be either driven by the atmosphere or driving the atmosphere.”

L477-479: run-on-sentence

Thank you for this remark, subdivided into two sentences in the updated manuscript.

### **Reviewer 3**

Thanks for the authors’ effort in addressing my questions and shortening the manuscript by putting some materials in the supplementary. I recommend publication in WCD subject to minor revisions.

The substructure (L266-271 for S2000 and L366-370 for S2100) should be discussed after the synoptic weather systems are introduced (Figures 3 and 5 respectively)

Thank you for this suggestion. However, we think that mentioning the substructure before the respective sections is an important motivation for the analysis of the weather system anomalies (see L269-273). Further, there is no mention of weather systems at all in L366-370 (only surface parameters which are discussed in exactly this section) and, thus, moving this paragraph to the end of section 5.2 would result in confusion.

L409: “which combined yield” → “which combinedly yield”

Changed as suggested.

L600: “resulting in comparatively small changes in sea ice variability in a warmer climate” → Does this contradict the sea ice edge retreat in S2100?

No, this statement does not contradict the sea ice edge retreat in S2100. What we want to emphasize here is that in this study we are analyzing a sub-region in the Arctic which - despite the overall strong sea ice retreat - is already mostly ice-free in the present-day climate. As we show in the study, it is still strongly affected by the sea ice retreat, particularly in its surrounding regions. However, as the region itself shows a comparatively small change in its sea ice cover, changes in the variables governing atmospheric variability in a warmer climate are relatively small compared to regions that experience a much larger loss in sea ice cover.

[L239: It is good to mention again the direction of surface energy fluxes](#)

Added “a positive  $ES^*$  (i.e., net energy flux into the surface)”.

## References

Richman, M. B.: Rotation of principal components, *Int. J. Climatol.*, 6, 293-335, 1986, <https://doi.org/10.1002/joc.3370060305>