Response to the comments of reviewer 2 for the manuscript "Impact of Greenland Ice Sheet Disintegration on Atmosphere and Ocean Disentangled"

by M. Andernach, M.-L. Kapsch and U. Mikolajewicz

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We would like to thank the reviewers for their time and effort in reviewing our manuscript and providing constructive feedback. Their valuable comments and advice will help us to improve the content and to enhance the quality of our manuscript. We have carefully considered the feedback provided by the reviewers and propose changes for the revision of our manuscript.

In the revised version of the manuscript we will focus on the following main aspects raised by the reviewers:

- Shortening the presentation of our results
- Reorganizing certain parts of the results
- Strengthening the ocean analysis by incorporating additional figures

We provide a detailed point-by-point reply to all comments below. The reviewers' comments are presented in regular font, the authors' replies in green font, and changes to the text in italic green font.

All authors have read and approved the suggested changes. We appreciate the opportunity to enhance our manuscript and are looking forward to your feedback.

Kind regards,

Malena Andernach, Marie-Luise Kapsch and Uwe Mikolajewicz

Response to reviewer 2

This paper presents sensitivity experiments of the global model MPI-ESM with or without the Greenland ice sheet. It is interesting to read, mainly well written and figures are nice. It then deserves to be published in ESD.

We are grateful for the overall positive feedback of our analysis of the impact of a disintegrated Greenland Ice Sheet (GrIS) on the atmosphere and ocean. We thank the reviewer for taking the time to review our manuscript and provide valuable suggestions to improve our manuscript.

However, some discussion about the usual atmospheric indexes (NAO, AO and GBI) and their seasonal variability is missing for me as it will help the readers to put in a larger context the atmospheric impacts of noGrIS. Moreover, the impact on the Jet Stream and its variability should be also discussed for me as it is the main driver of the atmospheric dynamics. As this paper is already too long, I suggest to split this paper into 2 papers with a partim 1 about the atmosphere and associated climate indexes and with a partim 2 about the ocean (including its feedback on the atmosphere).

Thank you very much for your ideas on improving our manuscript. As suggested, we computed the atmospheric indices NAO (Fig. 1) and GBI (Fig. 2). Recognizing that various definitions of the NAO can

yield different results (see Pokorná & Huth, 2015, https://link.springer.com/article/10.1007/s00704-014-1116-0), we applied three different methods to compute the NAO index: the difference of the normalized sea level pressure between Iceland and the Azores, an Empirical orthogonal function (EOF) and a principal component (PC) analysis. Further, we investigated the position of the Jet Stream over the North Atlantic region (Fig. 3). We found only small differences between the experiments that are not statistically significant. We assume that the horizontal resolution of our atmospheric model is not high enough to resolve such dynamics sufficiently. Therefore, we decided to not include the analysis of these indices and the Jet Stream to our manuscript.

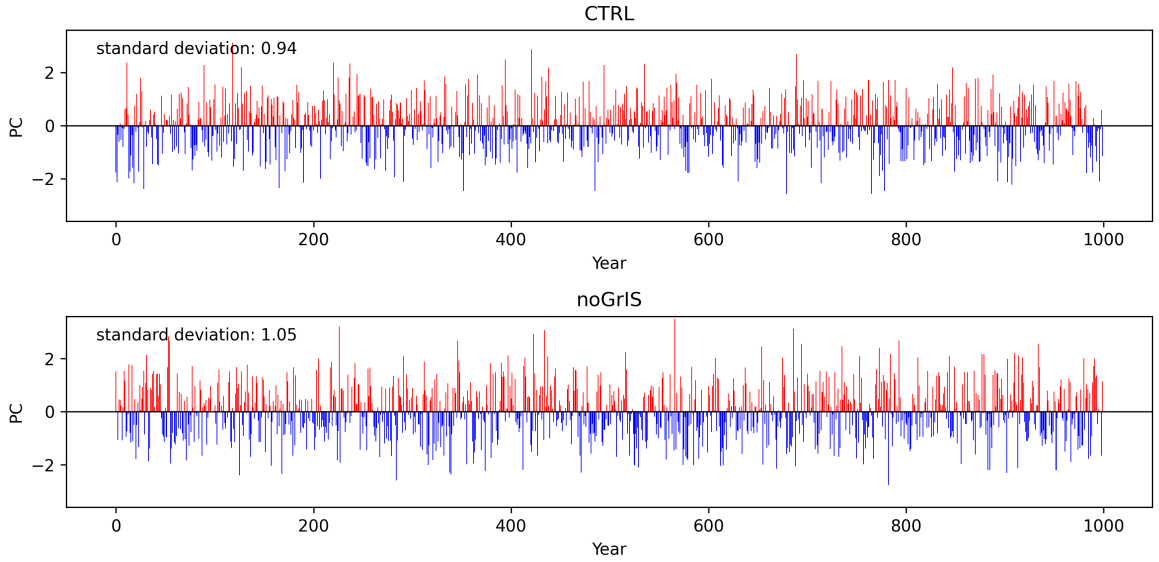

Figure 1: First (PC1) principal component time series associated with the leading EOF mode in sea-level pressure in DJF. The leading EOF modes explains 40% of the total variance.

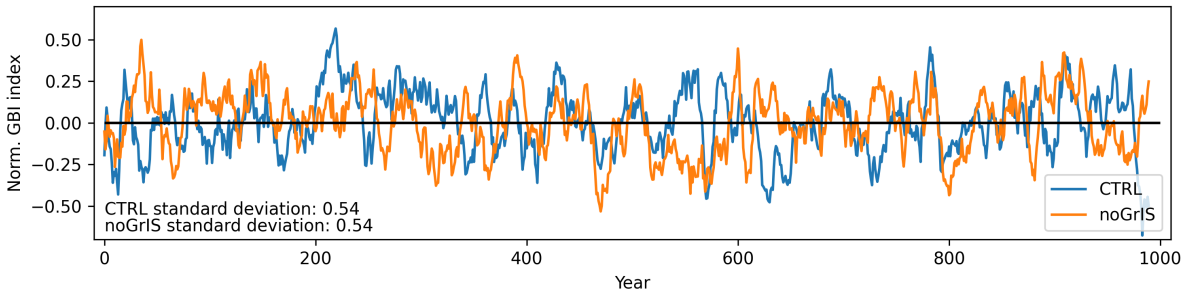

Figure 2: Time series of the GBI in DJF in CTRL and noGrIS using a 5-year running mean.

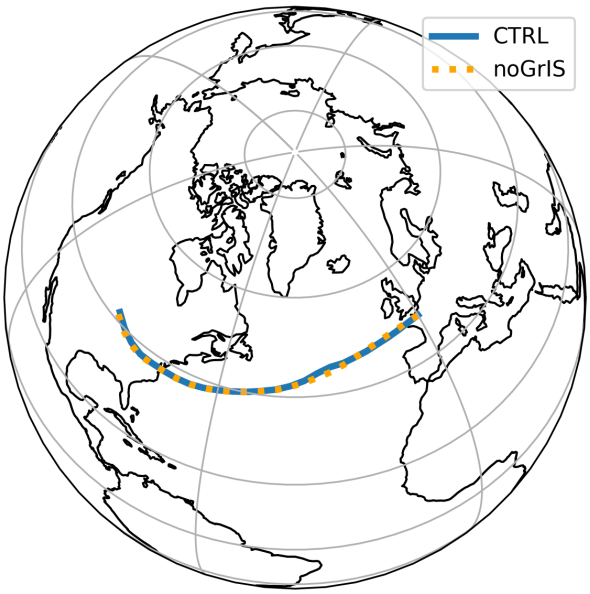

Figure 3: Mean location of the DJF Northern Hemisphere Jet Stream calculated from the last 1000 years of the simulations CTRL and noGrIS.

We agree that the manuscript is rather long. However, we believe that our manuscript is stronger when including the analysis of the atmosphere and the ocean in one single manuscript, as we found many interactions between the atmosphere and ocean in the climate with an absent GrIS. Additionally, the reader has to understand the changes in the atmosphere to be able to understand the oceanic response. As our focus is on the oceanic response, we decided to shorten the analysis of the atmospheric response and to keep both parts in one manuscript. We hope that this will overcome the concerns on the lengths of the manuscript by the reviewer.

Finally, the impact of noGRIS on the SMB is a bit out of context here and not enough scientifically robust with respect to other parts of this paper. This part should be leaved for another paper for me where a fully coupled ice sheet – atmosphere – ocean model should be used to evaluate this as a regrow of the ice sheet will impact the atmosphere which is not taken into here while discussed in depth in the other parts of this paper.

Thank you for your comment. We fully agree with your point regarding previous studies that have addressed the irreversibility of a GrIS disintegration. However, the simulation designs of those studies do not allow for a clear distinction between the contributions of the GrIS surface-elevation and property effect on the regrowth of the GrIS. Our study offers a significant advancement in this respect. Our findings reveal that regrowth in certain regions of Greenland is not only hindered by the reduced elevation but is also critically suppressed by surface-property effects, such as a lower surface albedo and higher surface temperatures. Further, we demonstrate that changes in the background climate decisively constrain the regrowth. Therefore, we believe this section advances our understanding of the potential consequences of a GrIS disintegration and its potential (ir)reversibility. We will revise the beginning of the section to clearly highlight the benefits and new insights provided by these experiments:

"[...] To investigate this matter, we ask the question: Could a new ice sheet form under the different climate conditions in noGrIS? *This is an important step towards a better understanding of how ice-sheet induced climate changes would impact a potential regrowth of the GrIS and whether the GrIS would be stable under the altered climate conditions. Thereby, our sensitivity experiments enable us to investigate the individual impacts of altered GrIS surface height or surface properties on a potential regrowth. Using a complex ESM for such analysis is hereby novel. This allows us to attribute the potential regrowth of the GrIS or its lack thereof to the two main effects that a disintegrated GrIS has on the climate.*"

Additionally, we will emphasize the distinct impacts of the GrIS surface-elevation and property effect throughout the analysis of this section.