

The Cryosphere Discuss., referee comment RC3
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Comment on tc-2021-388

Anonymous Referee #3

Referee comment on "The impact of climate oscillations on the surface energy budget over the Greenland Ice Sheet in a changing climate" by Tiago Silva et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-388-RC3>, 2022

General comments

In this study, the authors use a cluster analysis of NAO, GBI, and column water vapor to derive a "North Atlantic influence on Greenland" (NAG) index. RACMO2 output is then used to investigate atmospheric and cryospheric conditions across different NAG phases and their changes across a 1991 break point in summer surface mass loss. Results describe a large array of seasonal anomalies in atmospheric conditions and surface energy balance components across the NAG phases for each season during the pre- and post-1991 periods.

I found this paper difficult to follow due to the large number of figures and sub-panels within figures and the organization of the paper, as it lacks a clear statement of the research questions or summary of what important new information was learned in this study. I also agree with the editor that there is insufficient originality, at least with how the results are presented in current form. However, there do not appear to be any technical flaws in the methods employed, and I do think there is potential for some of the results to form a nice study if they are better organized. I encourage the authors to think about what they consider to be the most important and novel findings contained within their many analyses and distill these findings into a focused message for readers to take from the paper. As an example, the contrast between moistening in northern Greenland and drying / clearing in southern Greenland under +NAG conditions is an interesting finding. In addition to the specific comments and technical corrections below, I would recommend that the authors simplify the figures, and restructure the discussion so that a large part of the findings in the main paper are not describing figures found in the supplement.

Specific comments

Did the authors examine trends in the frequency of NAG phases, or did they only look at changes in atmospheric conditions over time during each NAG phase?

L18–45: The opening paragraph of the Introduction is quite long and does not provide a compelling introduction to the research topic that the authors investigate. I think it would make more sense to first introduce the problem of Greenland surface melt and its atmospheric drivers (the second paragraph), before moving on to the indices that are used to help quantify these atmospheric drivers (first paragraph).

L21: Liu and Barnes (2015) is a good reference on the relationship between Rossby wave breaking and poleward moisture transport in the vicinity of Greenland.

L29: I'm not sure it's correct to say that the NAO phase "explains most of the heat and moisture transported poleward". It's more accurate to say that the NAO phase affects the location and magnitude of poleward heat and moisture transport, and provide a reference on this.

L32: GBI simply quantifies the mean 500 hPa geopotential height over a Greenland-centered domain, as the authors state in the previous sentence. It does not directly quantify the strength and moisture transported over the Greenland domain although it is correlated with these quantities (see the Barrett et al. 2020 paper the authors already cite). See Wachowicz et al. 2020 for a more nuanced discussion of the GBI and comparison with other blocking metrics.

L120 and Figs. 5, S9–S11: It is not clear how the method of dividing the adjacent seas into four areas is actually used to assess potential sources of moisture. I am having trouble understanding what the numbers in the corners of Figs. 5 and S9–S11 (the "differences in composites between adjacent seas") represent.

L123: It should be stated explicitly at the beginning of section 2.3 that the reason for the break point detection is to form the basis for subsequent analyses of atmospheric and glaciological conditions before and after the break point. As it stands now, this section reads like it is reporting research findings, rather than describing a method that will be used to produce the results of the study.

L172–180: State up front that you are using a k-means clustering method (rather than first describing the method and naming it as k-means clustering at the end of the description).

L181: I don't think the "influence of the North Atlantic over Greenland" is an accurate description of what the NAG index produced by the cluster classification provides. Maybe describe as the "influence of regional climate" on Greenland instead. (The AMV index, which specifically quantifies oceanic conditions, is discussed in the Introduction and in L159 in the Data and Methods, but doesn't appear to be included as an input to the NAG index.)

L226, 232–236, 311–315, and 368–370: The authors should consider that the stronger wind speeds during the +NAG phase are not strictly katabatic but are enhanced by the interaction of a strengthened synoptic-scale pressure gradient with the Greenland ice sheet's orography. I would suspect this is especially true for the winter cases where the authors find that increased wind speeds and SHF occur during +NAG. Previous studies have described this synoptically-driven wind enhancement as the Greenland "barrier jet" or "plateau jet" – see e.g. Meesters 1994, van den Broeke and Gallée 1996, Moore et al. 2013, Mattingly et al. 2020.

L255, Figs. 4–6: I assume all the results in Figs. 4–6 (e.g. the increasing trend in TCWV in northern Greenland described in L255) are produced from RACMO2 data? If so this should be explicitly stated in the figure captions and the text.

L282–284: This statement about the seasonal preconditioning effect of skin temperature warming appears to contract the finding in L166–168 that there is no relevant time-lag response between seasonal GrIS surface mass fluxes and the predominant atmospheric circulation pattern prevailing in the preceding seasons.

L314: How would decreasing ice in neighboring seas contribute to an increase in summer wind speed? Please explain in more detail.

Technical corrections

L2: The word "fluxes" is not needed since "advection" already describes the horizontal flow of heat and moisture.

L2: surface mass balance of what? (state definitively that it's the SMB of the Greenland Ice Sheet)

L2: "pattern" --> "patterns"

L14: "optical" --> "optically"

L14–16: Run-on sentence. Consider splitting into two sentences.

L15: "shortwave radiation flux" should be "shortwave radiation" or "shortwave radiative flux"

L18: north of the *climatological location of* the jet stream

L63: "largest" --> "most intense"?

L91: ERA5 is the most recent reanalysis product from ECMWF (it's not an "earlier product")

L211: The abbreviation "ONAG" is used repeatedly from this point forward without previously being defined in the text. It appears to be defined in the caption for Figure 4, but its meaning should be explicitly stated in the text at first use.

L331: Delete the word "or" at the end of this line.

L335: Accumulation zone has been decreasing *in area*?

L337: Insert the word "zone" after "accumulation"

L366-367: "vertically distributed changes" --> "vertical distribution of changes"

References

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