The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2021-388

Anonymous Referee #1

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-RC1, 2022

Silva et al. examines the influence of the North Atlantic Oscillation (NAO), Greenland Blocking Index (GBI), and a cluster-aggregation of the aforementioned indices along with integrated water vapor (IWV) over the Greenland Ice Sheet (GrIS) on regional surface energy budget (SEB) changes, derived from the polar-adapted Regional Atmospheric Climate Model (i.e., RACMO2), between the 1959-1990 and 1991-2020 periods. In addition to deconstructing the GrIS-wide and regional SEB and thermodynamic variables (e.g., skin temperature, IWV, and near-surface specific humidity) by phase of these raw and clustered climate indices, the authors also correlate the accumulation and ablation zone rates of change associated with the indices' phases to each of these variables individually for winter and summer seasons. Mesoscale processes forcing SEB changes (e.g., loss of local sea ice increases in wind speeds due to strengthening surface pressure gradients) are also discussed in the context of results. Main conclusions include that GrIS surface warming is most pronounced during winter (following the strongest period of Arctic Amplification), but the associated magnitude and spatial pattern of temperature changes depend on the prevailing atmospheric pattern and presumably its frequency. Meanwhile, sensible heat flux increases in the summer ablation zone are found regardless of the atmospheric circulation pattern, further signaling the importance of mesoscale controls (e.g. katabatic wind strengthening due to land-sea temperature and pressure changes) on low-elevation melt.

The level of detail provided in linking the climate indices/oscillations to the SEB and thermodynamic variables is commendable and presents a more detailed picture of atmosphere-GrIS surface forcing than is typically presented in comparable studies. However, this amount of detail also presents challenges with regards to clearly distilling key results. As such, the main findings could be more clearly stated in the abstract and especially in the conclusions. If key takeaways and related points could be more clearly stated through the manuscript, this study could be a valuable addition to the literature.

My comments are provided by line number (LN) or specific figure below. While most are

minor in nature, the total number of comments may tilt the paper toward the category of major revision.

LN14: Do you mean clouds have become optically thinner? Please clarify.

LN43: Can you clarify what is intended and ultimately hypothesized by "tilt within large-scale structures may have an impact at different locations"? Work by Woollings et al. (2008) J. Climate and Hanna et al. (2018) Int. J. Climatol. has shown that that the setup of Greenland blocks tends to precede by a couple of days downstream positive North Atlantic SLP anomalies in the vicinity of the Icelandic Low (i.e., -NAO conditions). Perhaps referencing this work may help clarify the large-scale structural reference?

LN76: It would be good to emphasize around this point in the introduction the explicit goal and primary research questions of the study. These would help build upon some previously mentioned hypotheses (e.g., LN 74-75) by adding more structure and thus guidance for the reader toward analyses that lie ahead.

LN 117: List the flux terms units, W/m^2?

LN126-127: I think you could move this sentence (beginning with "Using the 62 years…") to L131 and explicitly list the sub-periods that were the result of equally dividing the total years in the dataset.

L155: Both the NAO and GBI indices should be defined here (e.g., domains, methods, papers defining such, etc). Moreover, both atmospheric indices are derived at z500, did you look at the surface NAO (i.e., Hurrell PCA or weather station-based NAO)? In this context, I recommend in the paper that you address why only z500 indices are used or why NAO from SLP data is not used. This discussion would seem appropriate since you are exploring through cluster analysis how co-varying characteristics of these atmospheric patterns (along with IWV) may impact GrIS surface conditions.

LN167-168: To clarify the sentence, I recommend substituting "predominant" with "prevailing" then remove "prevailing" in LN168.

LN172: The clustering approach could use more description. Why did you pick 3 clusters? Did you select these based on subjective or objective criteria? Are the results sensitive to the number of clusters selected and analyzed?

LN179: Be more specific on what data is shown in the Figure S3 scatterplots. This is very vague as currently written.

LN183: “The positive phase of NAG is connected…” Is this “connection” illustrated somewhere either graphically or statistically? This would be helpful to show the reader to see what +NAG entails.

Figure 2 caption: The last sentence is unclear. I suggest mentioning that data from 1991 onward is found to the right of the gray vertical line.

L192: Why show the 925 hPa height anomaly rather than SLP, a field typically used in defining surface pressure characteristics of the NAO.

L193: “vertical tilting structure” meaning what? Please clarify.

L199: Do you mean “winter” instead of “spring” is when the equator-to-pole air temperature contrast is maximized?

Figure 3: Should the colorbar label r_s(Seasonal ablation…) be r^2 as it is in the caption?

Figure 4: “The percentage of each NAG phase used...” can you please clarify what this means? As I interpret it, it sounds like some +/-NAG days were composited and some were not without explanation as to why since f0 and f- percentages do not sum to 100% (as in Fig 5).

LN253: Remove “configuration.” Also, since these surface temperature and radiative fields (i.e., Fig 5) increase regardless of atmospheric pattern, does that suggest that warming climate is the main culprit in driving these fluxes that impact SMB? What link is being made with adjacent marginal seas; they respond similarly to these fields as the GrIS?

LN 270-271: In comparing 1991-2020 against the reference period, do you mean “increased surface-based inversions…”

LN272-273: This sentence is confusing; the IWV increase over the northern GrIS is not related to local cloud water content? Please clarify. Is this shown in the analysis and if so, then where?

LN293: “high summer GBI values…” – where is this analysis shown?

LN 297: “crucial role of NAO advecting heat and moisture…” through storms/the storm track migrating poleward toward Greenland?

LN311-313: This sentence is a bit hard to follow. I recommend splitting it into two sentences.

LN315: To clarify, is the suggestion that the summer wind speed increase over northern GrIS is due to the near-complete summer melt of Baffin (particularly) ice cover, a typical feature of its annual cycle? Atmospheric circulation patterns can accelerate the melt, but their intensity and orientation could also presumably affect the onset of such summer wind increases.

LN 322-324: It would be a good idea to direct the reader to this figure or analysis within the paper.

LN382: Change “has” to “have”

Supplemental Material:

Figure S8: Label seasons at the top of the graphic as with Figure S7, etc.

Figures S12-14: I am confused what these graphics actually show and what the units on each concentric circle represent. Please clarify.