The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC1
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# Comment on tc-2021-150

Anonymous Referee #1

Referee comment on "Relating snowfall observations to Greenland ice sheet mass changes: an atmospheric circulation perspective" by Michael R. Gallagher et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-150-RC1, 2021

## General Comments

The paper of Gallagher and colleagues touches upon an important aspect of the Greenland Ice Sheet (GrIS) mass balance variability. They provide a relationship between daily snowfall variability and atmospheric circulation, and advance from previous studies by linking the estimated mass contribution of snowfall to the GrIS mass balance for each classified circulation pattern. In doing so, Gallagher and colleagues are able to provide an estimate for mass accumulation versus ablation components, with a main interest in the active southerly pattern, that is a valuable step forward. Gallagher and colleagues use a novel approach to create the daily snowfall variability maps, but I do recommend that they elaborate and specify their method section in this regard, and possibly provide code, to the benefit of research reproducibility. Other minor comments that might be addressed are included below. Based on these comments I think the paper is well suited to merit publication in TC.

## Specific comments

Abstract L. 15-18: I would argue that the mass values stated here, which stem from Fig.6, do not represent the "good overall agreement" between GRACE and CloudSat, which is implied here, due to the "relatively weak statistical correspondence" of Fig.6 (L. 365). Maybe the wording could be revised, or maybe values from either Fig.5 or Fig.7a could be included to argue the agreement between GRACE and CloudSat, as is done in the manuscript (see L. 372; L. 470).

Section 3.1: could you elaborate which different clustering algorithms have been tested and what the different performances and outcomes were? What where the differences in internal cluster variance, were there strong differences in the resulting identified regions, etc? How robust do you expect the clustering of the regions in Fig.1 is.

Figure 1: I suggest to add the 2km elevation line in Fig.1c

Section 3.2: Please introduce the naming convention of the nodes as represented henceforth in the manuscript, [a,1] to [e,4], with briefly stating which nodes are considered 'southerly patterns, 'northerly' and 'zonal'/'easterly' etc. to prevent confusion later. For example, southerly patterns are described to be those "surrounding node [c,1]" which then later seems to be [b,1], [c,1], [d,1] based on Fig.7, thus only the horizontally adjacent nodes; but for zonal patterns "around node [c,3]", also [b,2] is included (diagonally adjacent). It can be difficult to infer which nodes have been considered by the authors when describing effects of a certain circulation pattern.

Section 3.2: Why does the SOM algorithm need SLP anomalies as input rather than SLP fields (L. 280)?

Section 4.1: It could be interesting to mention the impact of negative snowfall anomalies, e.g. node [a,3]; when do they occur and what would that implicate?

Section 4.2.1: I think I am misinterpreting something in the discussion about dynamic mass loss. L. 328 states a bound on dynamic mass loss of 10 to 30 *Gt/year*, but as this is read from Fig.5 this should be 30 *Gt/month*? But if that is the case, the comparison to the estimated dynamic loss of 50 Gt/*year* from literature (L. 336) is no longer 'realistic to the first order'. Could you please check and/or clarify the units presented in this part?

Figure 5-6-7: I suggest to add a bin count to the top histogram and/or mention the total number of points used for the regression, which is relevant as it changes for each of the figures. Furthermore, can you comment on why Fig.3 shows that patterns [b,1] [c,1] and [d,1] occur most often in 'melt' months but that the regression in Fig.6 and Fig.7 seem to have more 'non-melt' months data samples? Is the (top) histogram overlapping melt & non-melt bars or stacking them?

Section 4.2.2. It is mentioned (L. 363) that not all months are included in the regression of Fig.6. Could you specify which months that are and why not all months from the GRACE observations are utilized?

Acknowledgements: I feel the paper could benefit from more information in regards to reproducibility. Used packages are mentioned here, but maybe code could be made available as well?

**Technical corrections**

L. 5: the term 'daily maps' gives the wrong impression of the type of map. I'd recommend stating "maps of the daily spatial variability…", as is done elsewhere in the manuscript (L. 479)

L. 9: 'is contributes' to 'contibuting'

L. 42: 'surface mass balance' should be 'mass balance', I think

L. 102: replace comma after 'accumulation' to be after 'region'

L. 108: unnecessary apostrophe at "time series'".

L. 162: define abbreviation of SLP here instead of L. 165

L. 306: I think pattern [e,2] is meant instead of [e,1] (corresponding to 0.5 Gt snowfall)

L. 376; L. 378; L. 380; L. 384: gigatonnes to Gt for consistency with rest of manuscript

L. 378; L. 380: the use of 'additional' in 'additional occurrence' is somewhat confusing, and not consistent with elsewhere (e.g., L. 356 and others); I suggest to remove it

L. 462: "dependent *on*"

L. 468: "Because of the novel nature combined methodologies presented in this paper…": What is meant with 'novel nature'? Possibly revise the start of this sentence?

L. 471: mass values are switched from what is stated previously: "Every ***1.0 Gt*** observed by CloudSat corresponds with GRACE mass increase of ***1.19 Gt***"

L. 472; L. 476: ‘overestimated’ should be ‘**underestimated’** in agreement with said mass value switch. This has also been stated as 'underestimated' previously in section 2.1, L. 73-76 and section 4.2.1 L. 315-320.

Figure 2: add the node naming conventions [a,1] to [e,4] to the figure similar as in Fig.3

Figure 3: I’d suggest using the same coloring convention for (non)-melt months as used in Fig.5-7

Figure 8: add the node naming conventions [a,1] to [e,4] to the figure similar as in Fig.3