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Interactive comment on "Unprecedented atmospheric conditions (1948–2019) drive the 2019 exceptional melting season over the Greenland ice sheet" *by* Marco Tedesco and Xavier Fettweis

Anonymous Referee #2

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The authors show that summer 2019 was an exceptional melt season for Greenland, with record or near-record values in runoff, snowfall, and SMB. They find that summer 2019 was characterized by persistent anticyclonic conditions and melting was enhanced by melt-albedo feedback and warm air advection. Comparing 2019 to the extreme melt season of 2012, they show that although the two years have similar values of runoff and SMB, these exceptional conditions were driven by different atmospheric circulation patterns.

This study provides valuable insights into this latest Greenland melt season within the

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Discussion paper

context of long-term trends. Overall, the analysis is thorough and well done, and the manuscript is well written.

— Main Comments —

In the SOM analysis, I'm concerned that the persistency of atmospheric patterns is defined somewhat arbitrarily and the exceptional persistency of 2019 may be overstated. In lines 246-249, 257-259, and Fig. 14c, the cumulative number of days for the top 5 most frequent classes of 2019 is compared to to the cumulative number of days of these same classes in other years and is found to be much higher. But this seems to be an inevitable result by construction, since the top 5 classes vary from year to year, so we're comparing 2019's top 5 classes to lesser ranked classes in other years. If these 5 classes were all adjacent on the SOM map, and represented some broader category of circulation pattern, then I could see how grouping them together is physically meaningful for comparison across years. But in this case, the grouping seems artificial and perhaps not a very robust approach to comparing across years.

For example, in Fig. 14c, the cumulative number of days for the 5 classes appears to be approximately 25 in 2012, much lower than the 55 days for these classes in 2019. However, we can see from Fig. 14b that 2012 had high persistency in atmospheric patterns as well, just with different classes than those in 2019. From Fig. 14b, I estimate the cumulative number of days for 2012's top 5 classes is approximately 47, which is pretty close in magnitude to the 55 days for 2019's top 5 classes. Thus, I would conclude that both 2012 and 2019 probably had high persistency, contrary to the analysis presented here.

If you were to repeat the analysis but instead compute the cumulative number of days for each year based on the top 5 classes in that specific year, then how do the results change? Is the persistency of atmospheric conditions in 2019 as exceptional as stated? It would be interesting to see if both 2012 and 2019 stand out as exceptional in this approach.

— Minor Comments —

L21-22 “the total number of days with the most frequent atmospheric pattern that characterized the summer of 2019 was 5 standard deviations above the 1981 – 2010 mean”: This seems misleading, since the number of days referred to here is the cumulative total for the top 5 most frequent patterns of 2019, not the single most frequent pattern.

L102-103 “When looking at the different summer months separately, the MI values in 2019 ranked 5th in June, 7th in July and 9th in August (Fig. 2b)”: Fig. 2b only shows summer averages, not monthly values, so perhaps the reference to it should be removed?

L109-110 “was also responsible for the cumulative 3-day melt event”: Perhaps change “the cumulative. . .” to “a cumulative. . .”, because this 3-day melt event hasn’t been previously introduced. It would also be helpful to mention the specific dates of this event.

L112-118: Is this analysis of air mass trajectories all from the current study and details are not shown here? In particular regarding the 2012 summer, it’s not clear if the discussion is summarizing earlier studies which should be cited here, or if it’s referring to current analysis.

L167-168: The switch to positive albedo anomalies is confusing here, since the rest of the discussion centers around negative albedo anomalies. Also, looks like a typo here “In June, only 23%... was 23%.”

L188-189: The text refers to “geopotential height anomalies”, but the values listed (5567 m, etc.) seem to be actual geopotential heights, rather than anomalies.

L197 “high pressure system centered near Summit over the whole 2019 summer (Fig. 5a)”: I think Fig. 10b should be referenced here, rather than Fig. 5a.

L198: I think Fig. 5e should be referenced here, rather than Fig. 5d.

L205-206: Should the area integrated anomalies be reported in units of W rather than W/m2?

L218 “We classify the daily 500 hPa GPH”: Should specify that it’s the GPH anomalies that are being classified.

L220-221: This description of the training phase with “existing SOM nodes” seems a bit off. The SOM nodes are defined in an iterative process during training – they don’t exist prior to training.

L218-221: Were the input data fields weighted to account for grid cell area variation at high latitudes (for example, as in Mioduszewski et al. 2016)?

L229-230: Can you explain in more detail how the 4x7 SOM shape was selected? Were any sensitivity tests performed to determine the impact of SOM size / aspect ratio and analyze error metrics?

L263 “frequency and occurrence of the atmosphere”: What does this mean?

— Figures —

Figure 1b: The colour scheme is inconsistent with Fig. 1a, Fig. 3a, and Fig. 5a, which all use red for more melting days and blue for fewer melting days. I recommend reversing the colour scheme in Fig. 1b to be consistent with the others.

Figure 2b: The caption describes the blue line as “Summer-averaged melt extent”, but this is not a summer-averaged quantity, is it? It looks like the blue line shows, for each summer, the overall area subject to at least one day of melting.

Figure 5: Captions for subplots (b)-(e) are mixed up (i.e., (b) is snowfall anomaly but caption says 2m temperature, etc.). It would also be helpful to add a bit more horizontal space between subplots, so that there is some space between the colour bar labels and the y-axis of the right-adjacent subplot.

Figure 9: The annotation reads “Melt extent reaches ∼97%”, whereas the main text

reports this value as 96%.

Figure 10a: In the caption “Anomaly of the JJA 2019 averaged geopotential height anomalies”, extra “anomaly” should be removed.

Figure 11: Typo in the y-axis label: “yStandardized”.

Figure 13: The subplots are very tiny. Can these be enlarged? Also, 3-4 decimal places in the average geopotential heights seems excessive - they could be rounded to 0 or 1 decimal place in these annotations.

Figure 14c: Caption and y-axis label describe this data as anomalies in the cumulative number of melting days, but the values shown aren’t anomalies. Also, are they the cumulative number of melting days, or just cumulative number of days (melting or not)?

— Typographic Corrections —

Punctuation / spacing typos:

- L45 “i.e. ,Kohonen”

- L76 “.eg. Fettweis”

- L77 “2011); .”

- L90 “2015 ,2018;”

L115 “relative cold” ==> “relatively cold”

L259-260 “Despite similar in terms of runoff and SMB” ==> “Despite being similar. . .”

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