We first would like to thank the reviewer for his comments which will help to improve our manuscript.

Substantive Comments

1. As mentioned by reviewer #1, additional information on how temperature perturbations are applied to the ERA-Interim forcing are necessary to better understand the results. Were the temperatures increased only at the surface or at each MAR atmospheric vertical level? This should be clearly mentioned. Section 2.1 should also explicitly state how many atmospheric vertical levels are used in these simulations.

As explained in the responds to reviewer #1, more details will be given in the sentence p3, line 5-6. We suggest then to reformulate our sentence *"Then, we performed sensitivity experiments in which ERA-Interim atmospheric temperatures were increased by respectively +1 °C, +1.5 °C and +2 °C at the MAR atmospheric lateral boundaries (hereafter referred to as warmer reanalysis)."*
to
"Then, we performed sensitivity experiments in which ERA-Interim atmospheric temperatures were increased by respectively +1 °C, +1.5 °C and +2 °C at each of the 24 vertical sigma level of the MAR atmospheric lateral boundaries (hereafter referred to as warmer reanalysis)."

2. Section 2.1 should also briefly discuss how the snow pack was initialized for the different sensitivity experiments. Is the initial state of the snow pack similar for each sensitivity experiment (MAR forced by ERA-Interim and GCM scenarios)?

The reference simulations have been initialized with snowpacks from previous MAR simulations (forced by ERA and by the 3 GCMs) and started in 1970 to give time to MAR to be independent of the initial snow condition. To remove the dependence of the snowpack initialization in the ERA-Interim forced sensitivity experiments, we have started these simulations in 1970 with warmer ERA-40.

3. In Section 2.2.2, the authors should explain in more detail why these three specific GCMs were selected. The authors should also clarify why the 20-yr periods experiencing +1, +1.5 and +2 °C are sometimes very different for the three GCMs, i.e. especially for CanESM2.

As explain p3 l 21-22, the three selected GCMs are the best representing the general circulation at 500 hPa (impacting he precipitation amount and pattern simulated by MAR) and the JJA (June-July-August) temperature at 700 hPa (impacted the melt amount simulated by MAR) over Greenland compared to ERA-Interim over 1980 – 1999.We refer to Fettweis et al. (2013) for more details in this choice of GCMs

The 20-yr periods experiencing +1, +1.5 and +2 °C are very different following the used GCM because there is offset in the warming projected by each GCM: For instance, CanESM2 projects a faster warming notably due to the melting of the Arctic sea ice with respect to the other GCMs. Again, this is also well shown and discussed in Fettweis et al. (2013).

4. At P5 L3-5, the authors state that capturing the circulation change results in a massive runoff increase "nearly two times higher" relative to the reference period. This is an interesting result that is not further discussed. The authors should consider discussing the potential mechanisms driving this significant runoff increase. See also the corresponding point comment at P7 L4-6.

See point comment at P7 L4-6.

Point Comments

P1 L4: Add “North” before “Atlantic”.
L8: For consistency, replace “forced with” by “forced by”. This comment holds for the whole manuscript.
L23: The authors could add: “[…] snow grain metamorphism and further decreasing surface albedo […]”.

Ok, thanks. All of these will be taken into account in the revised version of our paper.

P2 L1: The authors could add: “[…] in summer leads to longer exposure of bare ice at the GrIS margins […]”.

OK, thanks.

L4-7: The authors certainly mean that as GCMs fail to capture the current circulation change, the resulting recent melt increase modeled by RCMs forced by GCM “historical climate” is underestimated compared to observations. Could the authors clarify this and reformulate?

GCMs do not simulate any circulation change for both the historical scenario (prior to 2006) and RCPs scenarios, so that the melt increase observed since the 2000’s is underestimated when RCM’s are forced by these GCM as Fettweis et al. (2013a) showed that 70% of the recent melt increase is explained by the NAO shift. We therefore propose to reformulate L4-7 (p2):

“*Such an amplification in surface melt is well represented by Regional Climate Models (RCMs) when they are forced by reanalysis (Ettema et al., 2009; Fettweis et al., 2011, 2017; Noël et al., 2015, 2018). However, as General Circulation Models (GCMs) do not presently predict any circulation changes (Belleflamme et al., 2012; Fettweis et al., 2013b), the melt increase currently observed is underestimated when RCMs are forced by GCM scenarios (e.g., Fettweis et al., 2011, 2013b; Rae et al., 2012).*”

to

“Such an amplification in surface melt is well represented by Regional Climate Models (RCMs) when they are forced by reanalysis which capture the current circulation change (Ettema et al., 2009; Fettweis et al., 2011, 2017; Noël et al., 2015, 2018). However, as General Circulation Models (GCMs) do not presently predict any circulation changes (Belleflamme et al., 2012; Fettweis et al., 2013b), the melt increase currently observed is underestimated when RCMs are forced by GCM scenarios starting from 2000’s (e.g., Fettweis et al., 2011, 2013b; Rae et al., 2012).”

L21-27: This paragraph should better be moved to Section 2.1. Section 2.2 could start at L27: “We performed two sets […]”.

OK, thanks.

Information about the number of atmospheric vertical levels and initialization of the snow pack could be briefly discussed in Section 2.1, see also substantive comments.

See Substantive Comment 1 for the number of atmospheric vertical levels (i.e, 24 levels) and Substantive Comment 2 for the initialization of the snowpack.

P3 Sections 2.2.1 and 2.2.2 could be titled "ERA-Interim forcing" and "GCM forcing", respectively.

OK, thanks.

L18: How are temperature in the free atmosphere estimated at 850-700 hPa when these pressure levels cross the surface topography of the GrIS interior?

If the topography is higher than the altitude of the level pressure, the pixel is not taken into account for the average temperature.

P4 L25-28: I do not fully understand the analogy between SMB anomalies in Noël et al. (2014) and the present study. Could the authors clarify and reformulate?
I also suggest: "These differences at the ice sheet margins are similar to SMB anomalies found […], who obtained insignificant impact […]".

Although we made the analogy between forcing MAR by reanalyses warmer by 1, 1.5 and 2°C over the 1980-1999 period and by GCMs over a climate warmer by 1, 1.5 and 2°C compared to their reference climate over 1980-1999, experiments based on warmer reanalyses differ from corresponding experiments based on GCM because sea surface conditions (SSC, namely SIC and SST) remains unchanged in the warmer reanalysis forced sensitivity experiments but correspond to a warmer climate in the GCM forced simulations. SSC in MARera+x are thus representative of a colder ocean (more SIC and less SST) than the SSC from MARnor, MARcan and MARmir experiments. On the other hand, Noël *et al*. (2014) evaluated the influence of warmer SSC on the Greenland SMB by increasing (resp. decreasing) SST (resp. SIC) of ERA-Interim. Differences at the ice sheet margins (Fig. 1) are similar to the SMB anomalies found by Nöel *et al* (2014). We therefore assume that weak anomalies between MARera+x and MARmir (or MARnor or MARcan) result from the SSC unchanged in MARera+x.

We will modify L25-28:

"However, these differences on the ice sheet margins correspond to the same anomalies found by Noël et al. (2014) who evaluated the (not significant) impact of warmer SSC on the current SMB. Therefore, we can reasonably assume that these differences in anomalies mainly result from SSC not modified in experiments based on warmer reanalysis compared to GCM-forced simulations using future SSC."

to

"These weak differences are caused by the sea surface conditions (SSC) which were not modified in experiments based on warmer reanalyses while the GCM-forced simulations use future SSC and corresponds to what found by Noël et al. (2014) who showed that same unsignificant anomalies warmer SSC."

P5 L5: I understand: "The SMB anomaly in MARera2k+1 […] more negative than the warmer reanalysis over the reference period (MARera+1, resp. MARera+2) and the corresponding GCM-forced future experiments (Table 2)", could the authors clarify?

The SMB anomaly MARera2k+1 (resp. MARera2k+1.5) is significantly more negative than warmer reanalysis experiments and GCM-forced future experiments relative to a climate warmer by +1.5 °C (resp. +2 °C).

L6-7: Could the authors consider: "This suggests that capturing the recent circulation change simulated by warmer reanalysis in GCM-forced experiments would enhance the projected SMB decrease." Then at L9: "This is illustrated […] of +2 °C over 2000-2016 (Fig. 2b), i.e. including the recent circulation change, compared to the reference circulation over […]".

OK, thanks.

P6 L9: I read 3.7 W/m² in Table 2. The authors certainly mean "~4W/m2".

OK, thanks.

L9-11: The second part of this sentence is poorly written (i.e. after as well as), could the authors reformulate?

We will rewrite

"However both simulations forced by warmer reanalysis suggest a SWD decrease as well as in GCM-forced simulations with a warmer climate as a result of an increased cloud cover (Franco et al., 2013)."

to

"However both simulations forced by warmer reanalysis as well as in GCM-forced simulations with a warmer climate suggest a SWD decrease as a result of an increased cloud cover (Franco et al.,2013)"

P7 L1: Table 2 shows that absorbed SWD is more than two times higher for 2000-2016 compared to the reference period. I suggest: "is more than two times".

OK, thanks.

L4-6: As mentioned in the substantive comments, this is an interesting result which is unexploited. The authors should briefly elaborate on how increased melt lead to enhanced runoff, the authors could refer to Machguth et al. (2016).

We have calculated same anomalies than runoff for the production of meltwater (ME):

Anomaly	Temperature increase (°C)	MARera+x	MARera2k+x	Mean 3 models
Annual mean SMB (Gt)	+0	0	**-205**	
	+1	-84	**-326**	-118
	+1,5	-146	**-408**	-164
	+2	**-206**	**-492**	**-197**
Annual mean RU (Gt)	+0	0	**211**	
	+1	**142**	**393**	**141**
	+1,5	**236**	**508**	**215**
	+2	**328**	**626**	**283**
Annual mean ME (Gt)	+0°C	**0**	**195**	
	+1°C	**133**	**352**	**135**
	+1,5°C	**210**	**440**	**203**
	+2°C	**291**	**534**	**261**

And we suggest to modify the flowing sentences by adding some details (in blue) in paragraph starting P5 L12 and ending P6 L13:

“As runoff (RU) and snowfall (SF) mainly drive the GrIS SMB (Box et al., 2004), we discuss in the following the anomalies relative to these two components only. Like for SMB anomalies, RU and SF anomalies are computed as differences between the corresponding mean value for a given experiment and the mean value for the reference period using the unaltered large-scale forcing (Table 2). Even though non-significant, an increase in SF is observed for all experiments associated with temperature rising in response to a higher air capacity for holding water vapor (Fettweis et al., 2013a). Moreover, mean RU anomalies increase with the temperature rising in all warming experiments, most significantly for the experiments using warmer reanalysis over 2000 – 2016 when the circulation change has occurred. It can thus be concluded that runoff is mainly responsible for the SMB discrepancies between the different sensitivity experiments in a warmer climate. Melt (ME) is also amplifying as RU with the circulation change. However, RU anomalies are systematically higher than ME anomalies which means RU increase more than ME. It can be explain by two factors (Machguth et al., 2016): (1) there is less pore place available for meltwater storage in warmer firn and, (2) bare ice area (in the ablation zone) is larger in warmer climate, so there is less meltwater storage which amplifies the runoff increase. The future decrease of the ice sheet meltwater capacity retention was notably shown by Van Angelen et al. (2013).

Due to the enhanced positive melt-albedo feedback since the 2000's, SWD absorbed by the surface is two times higher in simulations with warmer reanalysis over 2000 – 2016 than over the reference period. Due to a lower albedo, the surface absorbs more energy, amplifying the melt increase which further decreases the albedo, potentially reaccelerating melting in addition to a decrease of the ice sheet capacity to refreeze meltwater. This positive feedback triggered by more frequent anticyclonic summer situations over Greenland causes a runoff increase nearly two times higher in simulations over 2000 – 2016 than in the simulations over the reference period, i.e. before the circulation change.”

L31: Following my previous comment, melt is not a direct component of SMB. It is the runoff increase that drives the decrease in SMB.

We will rewrite :
“*As a result, the melt increase is enhanced and is responsible for the higher decrease in SMB.*”

to

“*As a result, the runoff increase is enhanced and is responsible for the higher decrease in SMB.*”

Figures and Tables

Table1: For consistency, replace 1± 0.39 by 1.00 ± 0.39 in the second row of the second column.
Table2: The authors should consider to explicitly mention MARera and MARera2k instead of/in addition to ERA-Interim in column 3 and 4.
Figure1: To improve readability, could the hatches be displayed in a darker color e.g. grey?
Figure2: As this figure also shows anomalies, a red-to-blue color scale centered on 0 should be used.As for Figure1, hatches could also be displayed in grey for better visibility.
Appendix A1 and A2: For consistency, replace “forced with” by “forced by”. The same applies to the two similar tables in the Supplementary Material.

Ok, thanks. All of these will be taken into account in the revised version of our paper.

References

Fettweis, X., Franco, B., Tedesco, M., van Angelen, J. H., Lenaerts, J. T. M., van den Broeke, M. R., and Gallée, H.: Estimating Greenland ice sheet surface mass balance contribution to future sea level rise using the regional atmospheric climate model MAR, The Cryosphere, 7, 469–489, https://doi.org/10.5194/tc-7-469-2013, 2013a.

Machguth, H., Macferrin, M., Van As, D., Box, J. E., Charalampidis, C., Colgan, W., … Van De Wal, R. S. W. (2016). Greenland meltwater storage in firn limited by near-surface ice formation. Nature Climate Change, 6(4), 390–393. https://doi.org/10.1038/nclimate2899

Van Angelen, J. H., Lenaerts, J. T. M., Van Den Broeke, M. R., Fettweis, X., & Van Meijgaard, E. (2013). Rapid loss of firn pore space accelerates 21st century Greenland mass loss. Geophysical Research Letters, 40(10), 2109–2113. https://doi.org/10.1002/grl.50490