We first would like to thank the reviewer #1 for his constructive comments which will help to improve our manuscript.

General comments

1. At several instances, the authors acknowledge that a horizontal resolution of 50 km is inadequate to accurately resolve orographic--forced and local precipitation at the AIS rough margins and over the Antarctic Peninsula (AP): e.g. P7 L17--18, P9 L2--4, P11 L10--13. Although the authors are fair on this point, and justify the use of a coarse spatial resolution as a tradeoff between manageable computational time and the number of simulation carried out, while still resolving the AIS SMB reasonably well (see Fig. 2), they fail at estimating the associated biases and uncertainties. This is an important concern as most SMB anomalies are found in marginal (steep) regions where the authors suggest potentially large resolution--driven precipitation biases.

   To address this issue, the authors should present a 2D comparison between the 50 km reference run (this study) and the state--of--the--art 35 km run (Agosta et al., 2018), both forced by ERA--Interim (1979--2015). This would highlight the spatial distribution of precipitation/SMB biases and point out where large uncertainties, in both the reference run and sensitivity experiments, are likely to be found. This additional analysis would help the reader interpreting the significance of the SMB anomalies obtained in the sensitivity experiments; in other words, whether these SMB anomalies are larger/smaller than the local difference between the two MAR runs at 50 km and 35 km resolution.

2. As for comparison, the authors should also consider including a second scatterplot in Fig. 2 for the 35 km run, and list the associated statistics. Integrated values and uncertainty (standard deviation) derived from the 35 km run should also be listed in Table 1.

3. An additional Section 6 “Limitations” could discuss in more detail differences in SMB between the 50 km and 35 km simulations as well as related model limitations, i.e. unresolved or not well resolved foehn effect and orographic--enhancement affecting precipitation e.g. over the AP.

(Response to general comments 1 to 3)
As highlighted by the reviewer, the influence of the resolution is not discussed in our paper even if we use a coarser spatial resolution than the previous study using MAR (Agosta *et al.*, 2018). However, we think that discussing the sensitivity of the Antarctic simulated SMB to the (spatial) resolution used in the model is beyond the scope of this study. Furthermore, our methods for comparing the modeled and observed SMB will not enable a fair comparison between the statistics for 50km and 35km simulations as the number of pixels used for the comparison differs and becomes very small for the 35km resolution grid if our criterion of observations (P7L8) by pixel is kept (i.e, more than one observation by pixel).

Since the sensitivity of the Antarctic SMB to the horizontal resolution is an interesting matter of debate and still an unanswered question, we plan to tackle this specific topic in a brief communication that will be soon submitted to TCD (Kittel *et al.*, in preparation) rather than including this in a supplementary section of the current paper.

To address the reviewer’s comment about uncertainties of our results, we propose to present in supplementary materials the following 2D comparison between our 50 km reference simulations (MAR50 hereafter) and the Agosta *et al.* (2018)’s 35 km results (MAR35 hereafter) and a map illustrating the biases of MAR forced by ERA-Interim at 50 km compared to the SMB observations.

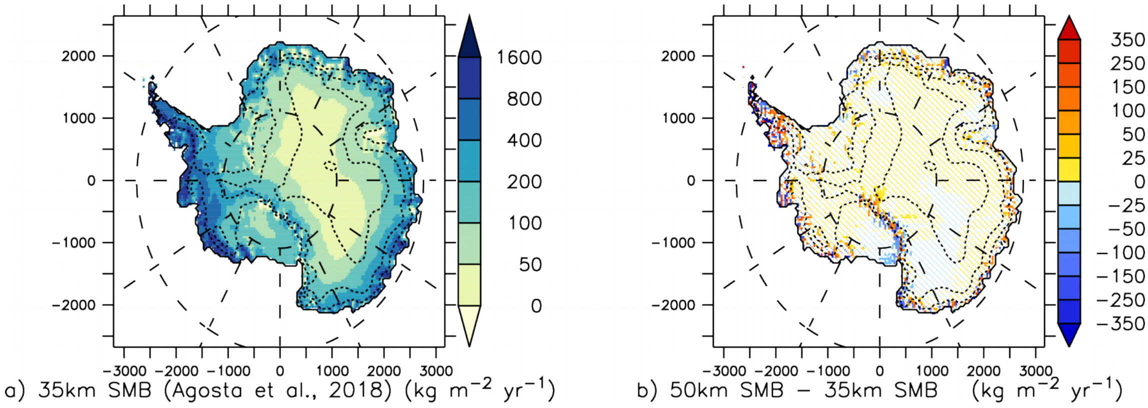

Figure 1. a: Mean SMB simulated by MAR over 1979 – 2015 from Agosta et al.(2018). b: Comparison between the MAR SMB at a 35 km resolution from Agosta et al. (2018) and the MAR SMB at a 50 km resolution (this study). Units are kg m^{-2} yr^{-1}. Non-significant anomalies (i.e., lower than the interannual variability) are hatched.

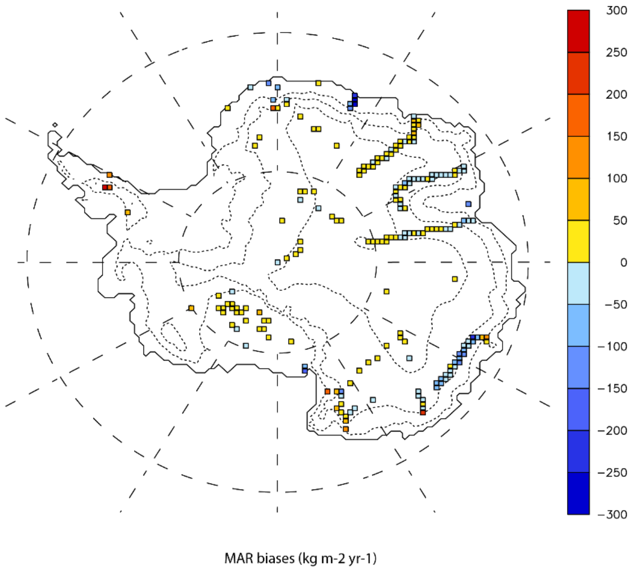

Figure 2. Comparison between MAR SMB and observed SMB from the GLACIOCLIM-SAMBA database (Favier et al., 2013) for 1950 – 2015. Units are kg m^{-2} yr^{-1}.

Figure 1 illustrates the SMB anomaly between MAR50 and MAR35. The largest anomalies are found over the Antarctic Peninsula and areas with a high orography spatial variability such as the Transantarctic Mountains. The significant anomalies are however smaller than the significant SMB anomalies due to changes in SSC from our study (except for the nearest pixels to the ocean where the MAR50 and MAR35 ice masks differ). Furthermore, they are mainly smaller than the SMB anomalies between MAR35 and RACMO2 presented in Agosta et al. (2018). Finally, it should also be noted that MAR50 biases compared to the observations are smaller than the SMB anomalies due to SSC changes (Fig. 2).

Besides adding Figure 1 and Figure 2 in supplementary materials, we also propose to modify the Section 3 "Evaluation against SMB observations" with a spatial analysis of MAR50 biases compared to the SMB observations as follows:

P7L11-18 *The high value of the correlation coefficient (r=0.93) between observed and modelled SMB values shows that MAR correctly represents the Antarctic SMB spatial variability at 50 km resolution over the 1979 – 2015 period (Fig. 2). Except over the Dronning Maud Land, the margins of the Amery ice shelf and a transect in the Wilkes Land, MAR overestimates the SMB (locally up to a factor of 5, Fig. S2).*

As also shown by Franco et al. (2012) over the Greenland ice sheet, these biases could partially arise from the coarse resolution used here (50 km) which induces a topography smoothed at the ice sheet margins.

This leads to an unsatisfactory representation of the topographic barrier effect allowing the precipitation systems modelled by MAR to penetrate too far inland.

In order to estimate the biases and the uncertainty related to our resolution, the reference SMB of this study was briefly compared to the SMB at 35 km resolution from Agosta et al. (2018) (Fig. S3). This comparison also shows an SMB overestimation in the reference run compared to SMB results at a higher resolution, although this overestimation appears to be non-significant. The largest anomalies can be found over the Antarctic Peninsula and areas with a high orography spatial variability such as the Transantarctic Mountains. The coarse 50 km resolution used here leads to artificially overestimated precipitation on the windward sides of orographic barriers. This is notably the case over the Filchner-Ronne and Ross ice shelves where the Amundsen Sea Low generates a return flow. However it should be noted that the SMB anomalies of our 50 km reference run compared to both 35 km results (Agosta et al. 2018) and observations are smaller than the SMB anomalies due to SSC perturbations presented in Section 4.

4. I would strongly advise to replace Fig. 3 by Fig. S2 in the main manuscript, as it displays inefficient to move back and forth to the supplementary material to visualize and compare results from experiments not shown in the main manuscript.

Thank you for the advice, we will replace Fig. 3 by Fig. S2.

Substantive Comments

Section 2.3.4: P5 L1-2: Here, I understand that monthly SSC (1979--2005) derived from CMIP5 ensemble average and two extreme members, as well as from ERA--Interim are interpolated to the MAR grid (50x50 km) using an inverse distance weighting method based on the four CMIP5 models/ERA--Interim cells nearest to the current MAR one. If so, please reformulate accordingly.

L5: This is confusing, are the authors calculating monthly mean SIC--SST from CMIP5/ERA--Interim for 1979--2005 (12 values) or an annual mean (1 value). I understand that monthly SIC and SST anomalies are used, please clarify.

We calculated monthly mean SIC and SST anomalies between CMIP5 and ERA-Interim so as to take into account open water areas when computing the monthly SST anomalies and to not introduce additional temperature biases: monthly SST anomalies were computed only if SIC from both CMIP5 ensemble average and ERA-Interim are less than 50%. Monthly values of SIC and SST anomalies are then averaged to obtain an annual anomaly value, supposed to represent a constant bias.

We suggest to reformulate P5 L1-5:

For that purpose, we have determined a perturbation whose magnitude is representative of the CMIP5 ensemble bias. Monthly SSC over 1979–2005 from all the CMIP5 models (using the historical scenario), as well as from ERA-Interim were interpolated on the MAR grid (50 km x50 km) using an inverse-distance weighted method based on the four CMIP5 models/ERA-Interim grid cells nearest to the current MAR one. We then computed the CMIP5 ensemble average from the interpolated CMIP5 monthly SSC. Firstly, to not introduce additional temperature biases, monthly SST anomalies between CMIP5 and ERA-Interim were computed only if the SIC from both the CMIP5 ensemble average and ERA-Interim are less than 50%. Secondly, we average the monthly anomalies to obtain a mean anomaly, supposed to represent a constant bias over time.

L6--10: Are the new 6--hourly SST--SIC calculated as the sum of 6--hourly ERA-- Interim (i.e. for a specific day of a certain month) and the corresponding monthly anomaly in SST--SIC from CMIP5 models? If so, please reformulate.

Yes, it is. We propose to reformulate P5l6-10 as follows:

New 6-hourly forcing SST are calculated as the sum of the 6 hourly ERA-Interim (i.e., for a specific day of a certain month) and the corresponding monthly anomaly in SST from CMIP5 ensemble average (Fig. 1b), hereafter referred to as SST(CMIP5) experiment. In the same way, we define SIC(CMIP5) experiments in which SIC anomalies (Fig. 1e) from the CMIP5 ensemble average are added to the 6-hourly ERA-Interim SIC.

P7 L17--18: This is an important caveat that should be addressed in an additional section "Limitations". A 2D map comparison between 50 km and 35 km simulations could help the reader understanding where large uncertainties are likely to be found at 50 km, see also general comments #1 and #3.
See our answer to General comments 1-3.

Point Comments

P1 **L10:** The authors refer to "warm SSC" or "cold SSC" several times across the manuscript. While it may sound obvious that warm (resp. cold) SSC represents combined low SIC and high SST (resp. high SIC and low SST), this should be explicitly stated in the manuscript, e.g. in Section 2.3.3 or more generally in Section 2.3.

Warm and cold SSC are explicitly stated in the manuscript P14,L5 (Section Conclusion). We will define warm (i.e., high SST and low SIC) and cold (i.e., low SST and high SIC) SSC by modifying the abstract (P1,L10) and the first reference to "warm" or "cold " SSC (P6,L5) according to

P1,L10 *Results show increased (resp. decreased) precipitation due to perturbations inducing warmer, i.e. higher SST and lower SIC (resp. colder, i.e. lower SST and higher SIC) SSC than ERA-Interim significantly altering the SMB of coastal areas, as precipitation is mainly related to cyclones that do not penetrate far into the continent*

And

P6,L5 *Following the same method, we perform combined experiments for two selected CMIP5 models, namely NorESM1-ME (Bentsen et al., 2012) and GISS-E2-H (Schmidt et al., 2014), respectively representative of a colder (i.e., lower SST and higher SIC) and warmer (i.e, higher SST and lower SIC) SSC than ERA-Interim as shown in (Agosta et al., 2015).*

P2 **L29--30:** What do the authors mean by "neither feedbacks involving sea ice and ocean"?
We suggest to delete this part of the sentence as it was redundant with the beginning *"This means that we do not consider feedbacks on the general circulation associated to sea ice removal (e.g., Bromwich et al., 1998; Krinner et al., 2014)"*

P3 **L18:** Could the authors briefly elaborate on the reasons why the drifting snow module is switched off?
Similarly to Agosta et al. (2018), we decided to switch off the drifting snow as the new version of this module is still under evaluation against satellite and ground-based observations over the whole Antarctic ice sheet. We suggest to add this reason in our manuscript P3L18:

Although MAR includes a drifting snow module (Gallée et al., 2001), this module has been switched off similarly to Agosta et al. (2018) as the new version of this module is still under evaluation against satellite and ground-based observations.

L25: Could the authors define OSTIA?
The Operational SST and Sea Ice Analysis (OSTIA) is a daily global SST analysis produced at a 0.05° resolution (Stark *et al*., 2007; Donlon *et al*., 2012). We suggest to change the text P3L25 as follows:

It is worth noting that ERA-Interim uses the SST and SIC values from ERA-40, which are based on monthly and weekly ocean forcing fields (Fiorino, 2004), until January 2002. Afterwards, a switch was made with the daily operational NCEP product and since 2009 with the Operational SST and Sea Ice Analysis (OSTIA). The latter is a daily global SST analysis product at a 0.05° resolution (Stark et al., 2007; Donlon et al., 2012)

L31: I guess the authors mean "[...] from a previous reference simulation", or is the initialization based on multiple simulations, please clarify.
Indeed, we use a snowpack from a previous reference simulation. Thank you for the correction.

P4 **L2:** Could the authors mention the original resolution of their DEM?
The original resolution of the DEM is 1km. We add it P4L2:
The Antarctic topography is based on the 1-km resolution DEM Bedmap2 from Fretwell et al. (2013).

P5 L7: I guess the authors mean (Fig. 1b). **L8:** (Fig. 1e).
Yes, thank you. (See our answer to the first point comment where we already corrected it).

P6 L3: Could the authors estimate by how many °C on average these two extreme CMIP5 members are "colder" or "warmer" than ERA--Interim.
The mean temperature anomaly as well as the mean SIC anomaly is listed in Table 1. We will specify it in our manuscript P6L3:

Table 1 compares SSC perturbations to the reference SSC for June-July-August (JJA) and December-January-February (DJF) SST and sea ice area (SIA). The mean SST and SIC anomalies of CMIP5 ensemble average, NorESM1-ME, and GISS-E2-H are also listed in Table 1.

L4--5: I guess the authors mean: (Fig. 1a,d) and (Fig. 1c,f.)
Yes, Thanks. We modify P6L4-5 accordingly:
These experiments are hereafter called SST/SIC(NorESM1-ME) (Fig. 1a,d) and 5 SST/SIC(GISS-E2-H) (Fig. 1c,f).

P7 L4: Could the authors mention how many measurements were discarded from the evaluation?
The original SMB data base from Favier *et al.* (2013) contains 3236 observations among which, as indicated p7,L3, 206 observations do not fit our selection criterions (i.e, covering more than 8 years if the observations interval is not included in the period 1979-2015).
P9 L2-7: Modeling limitations in the AP could be discussed in an additional "Limitations" section, see general comment #3.
As we have dedicated a full paper to the influence of the resolutions and strengthened the discussion on the biases related to resolution (see answer to General comments 1-3), we think that an additional "Limitations" section for discussing only the limitations over the AP is not necessary anymore.

P10 L11--12: Do the authors mean that the SMB from SIC(CMIP5) does not significantly differ from the reference, both spatially and integrated over the whole AIS? If so, please reformulate.
Yes, it is. We reformulate P10-L11-12:
Finally, the mean SMB from SIC(CMIP5) does not significantly differ from the reference SMB, both spatially (Fig. 3j) and integrated over the whole AIS (Table 2.)

L16: "SST+2/SIC--3", same at **L27**.
Thanks.
L19--20: I do not see snowfall decreasing over the AP in the supplementary figures, this rather seems to occur in the surrounding ocean. Please clarify.
The significant decrease in snowfall that we described "over the AP" only occurs over the Larsen C and George VI ice shelves. We will clarify it by changing P10 L19-20:

Moreover, snowfall significantly decreases over Larsen C and George VI ice shelves (both located in the AP) but is largely compensated by rainfall refreezing into the snowpak.

L32: The authors certainly mean (Fig. 1f).
Yes, corrected thank you.

L32--33: "SST/SIC(CMIP5) suggests", what do the authors mean by "as SIC and SST anomalies [...] around the mean"? Please, clarify.
We mean that the CMIP5 average anomalies for both SIC and SST are weak in our experiment as CMIP5 models are more or less equally distributed (warm or cold SSC anomalies) around the ERA-Interim SSC, even if the mean CMIP5 SSC are slightly warmer (lower SIC and higher SST) than ERA-Interim (see Table 1). We suggest to modify P10 L32-33 by:

SST/SIC(CMIP5) suggests a non-significant positive anomaly for both integrated and spatial SMB (Fig. 3k) as the mean SIC and SST anomalies in CMIP5 models do not significantly differ to the ERA-Interim

SSC (Table 1, Fig. 1b,e). CMIP5 models anomalies are more or less equally distributed (warm or cold SSC anomalies) around the ERA-Interim SSC, even if the mean CMIP5 SSC are slightly warmer than ERA-Interim explaining the non-significant positive SMB anomaly.

P11 L7--9: I am not sure to understand the links between unchanged inland temperature, coastal precipitation enhancement and downward (katabatic?) winds. Could the authors reformulate this sentence?

We suggest to reformulate P11 L7-15 as follows

These results suggest that precipitation can be formed further inland depending on the properties of air masses. In agreement with Gallée (1996), our hypothesis is that colder and drier air masses in cold ocean experiments are not sufficiently loaded with moisture to enable saturation and then snowfall over the margins. The decrease in moisture is likely to be larger than the decrease in the maximal moisture content in the atmosphere associated to lower temperatures. This leads to a larger amount of remaining humidity that can be advected further inland (Fig. 4b,d and S10b,d) where saturation occurs because of the lower temperatures. On the opposite, the additional humidity in warm ocean experiments results in air masses that reach saturation faster (the increase in humidity overcompensates the increase in the maximal moisture content) and thus generating precipitation over the ice sheet slopes. MAR also simulates significantly higher upper air temperature over the central part of the ice sheet (Fig. S11c,e and Fig S12c,e) that, combined with the lower remaining humidity, (Fig. 4C,e and S10c,e) limit snowfall.

(see also our response to R#2)

L10-13: This discussion should be moved to a new section "Limitations".

We suggest to move this discussion in the section "Results" (see our answer to general comments 1-3)

L29--31: Please reformulate this sentence "present--climate [...] 21st century", it reads better at **L18--19 of P14**.

We will reformulate P11 L29-31 by:

[...]Our sensitivity tests with warmer (CMIP5-based) oceans reveal SMB anomalies over the current climate in the lower range of the SMB increase projected for the end of the 21st century

Stylistic suggestions

Thank you for all the stylistic suggestions. We will take them into account in the revised version of our manuscript.

P1 L2: [...] boundary forcing fields prescribed by reanalyses [...]. **L7:** Altering is rather negative, and suggests that data have been deteriorated. I would suggest: "by modifying the ERA--Interim SSC". **L10:** Replace "altering" by "affecting". **L17:** "exchange of gas". **L18:** Remove "behaviour"; "impacts" or "affects" instead of "alters". **L19:** "[...] water vapour loading of air masses, potentially [...]". **L20:** Remove "as the Antarctic" and insert "that" after "(SMB)". **L23:** The authors could consider reformulating as follows: "[...] have experienced a significant increase since the 1970s (e.g. Massonnet et al., 2013), highly contrasting with the dramatic decline reported in the Arctic Ocean [...]".
P2 L9: Maybe "[...] and increased precipitation [...]". **L13:** I suggest: "[...] (e.g. Weatherly, 2014), with simplified physics resulting [...]". **L14:** I suggest: "[...] (RCMs) forced by former and less reliable reanalyses (e.g. ERA--15 in Bromwich et al., 2007) over short periods [...]". **L24:** "[...] with the 'Modèle Atmosphérique Régional' (MAR) for the period 1979--2015. This allows partitioning [...]". **L27--31:** I suggest: "[...], this study only discusses the direct [...]. This means that no feedback on the [...] removal is considered [...] Krinner et al. 2014). Only direct impacts on [...] components are accounted for. Note that the general [...]". **L34:** Replace "altered" by "perturbed".
P3 L7: Maybe "The effect of sea spray on [...]". **L10:** I suggest: "[...] sub--modules, that simulate energy and [...]". **L15:** Remove "Consequently,". **L16:** I suggest: "[...] and open--ocean fractions". **L21:** "forced by". **L27:** "[...] evolve as a function of accumulated snowfall and surface [...]". **L29:** "we start". **L33:** "[...] moisture source for precipitation over the AIS [...]".
P4 L1: Maybe "selected" instead of "chosen". **L2:** "extending 6 km above". **L5:** "[...] SMB to SSC perturbations is limited to the [...] SIC anomalies within the MAR [...]". **L9--10:** "perturbed" instead of "modified". **L13--16:** "for ice--free pixels", "converted into full ice--covered pixels if the SST drops [...] (-- 2°C). For an SST [...] SIC value is set to [...]". **L18:** Maybe "at the interface between [...]". **L22:** "[...]

and maintain SST of sea ice--covered pixels [...]". **L25:** "in sea ice extent associated". **L29:** Replace "present climate" by "present--day" or "contemporary".

P5 **L9:** "[...] anomalies into the original [...] enables to account for constant [...]".

P6 **L9:** "perturbed" instead of "altered". **L10:** I suggest: "SST and/or SIA anomalies for JJA and DJF periods are 1.5 times as large as CMIP5 mean [...]". **L14:** "brief" instead of "short". **L14:** This is rather negative, I would suggest: "to highlight the impact of using a coarser horizontal resolution on SMB representation". **L15:** Remove "the one described".

P7 **L1:** Replace "by" by "using". **L2:** "observations collected prior to our study period". **L3:** "for the same period.". **L6:** Add "the" before "observation locations". **L7:** I suggest: "(Agosta et al., 2012), unresolved at 50 km [...]". **L8:** Replace "consequently" by "i.e." or by "or". **L13:** "noted" instead of "noticed". **L16:** "significantly smoothed topography".

P9 **L1:** "enhanced" instead of "stronger". **L7:** "This allows locating". **L12:** For consistency, "interannual variability". **L14:** "The warmer ocean leads to [...] of similar magnitude as [...] converting snowfall into rainfall." **L16:** "[...] higher temperature also causes [...] SST+4 relative to the reference simulation (Fig. S7a--l)." **L18--20:** "[...] sublimation are larger in SST+4 (Fig. S6a) because [...] temperature, increased precipitation dominates and the SMB anomaly is significantly positive (Fig. 3a and Table 2)." **L22:** "ocean surface and reduce the water vapour". **L26:** "Over the plateau, larger deposition combined with snowfall [...] than for the reference run.". **L28--29:** "[...] colder ocean as lower SST also decrease the near--surface air temperature [...]". **L31:** "revealing similar patterns as in SST+2 (Fig. S2m) although non--significant [...]".

P10 **L1:** "smaller" instead of "lower". **L5--7:** "[...] decrease in precipitation is observed over the new ice--covered ocean [...] act as an insulator [...] 2--m air temperature by 10°C". **L9:** Maybe "pronounced" instead of "strong"; "[...] SIC--6/SIC+6). This is likely due to the smaller magnitude [...] SIC--3 compared to the magnitude of SIC extension [...]". **L23:** "show similar anomalies as". **L24:** "larger anomalies [...] Besides, the sensitivity of AIS SMB to SSC is non--linear".

P11 **L2:** Maybe "marginal" instead of "external". **L14--15:** I suggest: "opposite pattern: drier air masses have to rise up higher [...] so that precipitation is generated further inland.". **L22:** "affect" instead of "modify". **L23:** "three times as large". **L29:** "perturbed SSC".

P13 **L1:** "are by far smaller". **L2:** Maybe "showing" instead of "with potential"; the authors could consider "[...] SMB anomalies do not significantly differ from observed SMB". **L4:** Replace "assess" by "evaluate". **L7:** Replace "driven" by "forced".

P14 **L2:** Replace "altering" by "perturbing" and move "unchanged" to the end of the sentence. **L3:** "The first set consists of [...]". **L8:** "(resp. decreased) precipitation due to warmer (resp. colder) [...]". **L12:** Maybe "leads to earlier/faster saturation as they rise [...]". **L15:** I suggest: "However, comparing modelled SMB from sensitivity experiments with observations shows no significant difference, suggesting [...]". **L18:** "with warmer (CMIP5--based) SSC reveal that SMB [...] climate stand in the lower". **L20:** Remove "as demonstrated in this study". **L21:** "using potentially biased SSC as forcing". **L22:** Replace "produce new" by "carry out future".

Figures and Tables

Table 1: For the reference run, insert "0.00" or "--" to fill the blanks in the anomaly columns.

Ok, we will fill the blanks with "-" in our revised manuscript.

Table 2: Caption **L2**: "floating ice" instead of "not grounded ice".

We will modify accordingly the caption of Table2.

For comparison with the coarser resolution simulation, the authors should consider adding integrated numbers from the 35 km run discussed in Agosta et al. (2018). See also general comment #2.

See our response to general comment 1-3

Fig. 2: For comparison, the authors should consider including a second scatterplot showing outputs of the 35 km run.

See our response to general comment 1-3

Fig. 3: This figure could be replaced by Fig. S2. See also general comment #4.

Thank you for the suggestion, Fig 3 will be replaced by Fig S2

Fig. S6: Caption **L1**: "minus" instead of "mines".

Thank you for the correction