# Response to RC2 comments on the submitted paper *Reconciling the surface temperature–surface mass balance relationship in models and ice cores in Antarctica over the last two centuries*

We thank the reviewer for their constructive comments. We have responded to all of them and will modify the paper accordingly. Our point-by-point answers follow.

Please note that review comments are in grey italics while our answers are not. Changes/additions to the original manuscript are indicated in blue.

# Answers to RC2

*In this article the authors investigate the relationship between the surface mass balance (SMB), surface air temperature (SAT) and d18O in models and ice cores. They analyze output of four GCM models and one regional climate model of which the GCMs are aware of isotopes. The dataset of ice cores consists of about 50 ice cores. They report a strong positive correlation between modelled SMB and SAT as well as d18O and SMB, which is in agreement with previous studies. However, there are regions where the relationships break for which the authors investigate reasons. Mainly they find a dependence on the prevailing winds that can strongly affect the relationship by e.g. leeside warming due to Föhn winds or adiabatic warming of the falling katabatic winds along the coast. Additionally, they report that the correlations found in ice cores are much lower than in the model and discuss reasons for this discrepancy. Overall, this is a very interesting study, which I recommend for publication in The Cryosphere. Before publishing, some major and a number of minor points should be clarified/improved as listed below.*

***Major***
***(1) Correlation testing*** *The authors present a number of correlation maps. When conducting a high number of significance tests on a gridded map, this increases the number of false rejection of the null hypothesis, (e.g. Wilks 2016). There are correction methods for this issue (e.g. Benjamin and Hochberg, 1995), which the authors should apply in their study.*
*Benjamini, Y. and Hochberg, Y.: Controlling The False Discovery Rate – A Practical And Powerful Approach To Multiple Testing, J. Roy. Stat. Soc. Ser. B, 57, 289–300, 1995.*
*Wilks, D. S.: "The Stippling Shows Statistically Significant Grid Points": How Research Results are Routinely Overstated and Overinterpreted, and What to Do about It, B. Am. Meteorol. Soc., 97, 2263–2273, https://doi.org/10.1175/bams-d-15-00267.1, 2016.*
**Answer:** Thank you for bringing these papers to our attention. We will test the FDR method to our correlations and modify the text and figures where necessary and describe this method in the manuscript, citing these two papers as references.

***(2) Gridding of ice core data*** *The authors describe their method to analyze the ice core data on a grid. They mention that it is important to have enough ice cores per grid cell, however, the information about how many ice core measurements used per gridded value is missing (a figure or table in the supplementary material could do the job). First, they present gridded ice core results at 108 km x 108 km and 216 km x 216 km. Finally, they analyze results where they analyze results for different resolution between 108 km x 108 km and 684 km x 648 km (Fig. 9) where they only take into account grid cells with five or more ice cores. Based on figure 9, this criteria is not fulfilled for 108 km x 108 km. Thus, I wonder how many ice cores are available in the 108 km x 108 km and 216 km x 216 km grid cells. Does the analysis presented for 108 km x 108 km and 216 km x 216 km actually remove the general noise? For how many locations do these grid cells take into account more than one or two ice cores? This needs to be clearly stated as it will have a strong impact on the analysis.*
**Answer:** Fig. 8 presents the gridded ice core results at the 216 km x 216 km resolution only (for both the SMB-SAT correlation and the SMB-$\delta^{18}$O correlation). We only describe the results obtained for the gridding at the 108x108 km resolution in the text, stating that "both the SMB-SAT and the SMB-$\delta^{18}$O correlations remain at 0.09 and 0.13 respectively". Aggregation at this resolution does not improve our results, which is why we do not show it. We will add "(not shown here)" to that effect to be as clear as possible.
When setting a minimum threshold 1 ice core per grid point, the correlation values are much more noisy (see Fig. 3 at the end of this document; note that if Fig. 3 is added to the supplement, it will of course

modified in the same way that Fig. 9 will be modified). However, if we look at the average calculated for both the individual ice core and the aggregate ice cores (”average of individual” and ”average of aggregated”, i.e. the dark orange and dark blue dots), the same slightly increasing trend in correlation strength is observed. But of course, there is a lot more ”noise” in the individual signals, seen from the widely varying correlation values. In the manuscript, we propose to keep using the same two panels for Fig. 9, but doubling them, with the extra two panels providing information on the number of ice cores per dot.
Fig. 9 shows the comparison, for a specific scaling of the RACMO27 grid cells, between the average of the ice core correlations in that augmented grid cell versus the average of the RACMO27 correlation over the augmented grid cell. We propose to, on the model side, also calculate the average in the augmented grid cell of only the original RACMO27 grid cells that contained ice cores (see Fig. 4 for a sketch). We will therefore be able to show a direct comparison between the ice cores and the RACMO grid cell correlations.

*(3) **Figure 9** Figure 9 needs strong improvement. In the caption it is stated that the size of the colored dots is a function of the number of ice cores aggregated. There is need for a legend giving information about the actual number of ice cores for the different dot sizes. The dots for the model in the legend are far too small (black and gray dots). The dots in the legend could all have the same size.*
**Answer:** We agree that this figure is too dense and should be clarified. We propose to make all dots the same size, and to double each panel: each of the existing panels will have a first panel where the dots show the correlation values, and a second panel where the dots show the number of ice cores used per dot. In addition, the dots for the model will be made the same size as that of the ice cores, and we will modify the legend accordingly.

***Minor***
***General:***
*Avoid “see Figure...”, ”shown on Fig...” just reference the figures. For the figures add a space after Fig., i.e. Fig.1 → Fig. 1*
**Answer:** We have applied your suggestions.

*Avoid spoken language, i.e. try to reduce the number of non-informative sentences, e.g. “Let us first focus on the link between wind redistribution and SAT.” (P.8, L228) or “To explain this, we have to first describe average conditions.” (P.8, L247) or “Now that we have a better understanding from the models let us look at...” (P.10, L.398). These are some examples but there are more in the text.*
**Answer:** We have reworded some of these: P8L228 has become ”We will first examine[...]”; P8L247 has become ”During average weather conditions in coastal areas,[...]; P10L398 has become ”We will next examine in-situ measurements of SMB, SAT and $\delta^{18}$O.”. As we modify the manuscript in the next phase, we will pay attention to any further sentences such as these.

***P.2, L24:*** *sea-level rise → SLR*
**Answer:** We have opted to explicitly write ”sea level rise” every time as it it is the only place in the manuscript that we mention sea level rise.

***P.2, L35:*** *temperature → heat*
**Answer:** Replaced.

***P.2, L34-36:*** *The first sentence leaves the reader wondering where the air comes from. Consider reformulation of the two sentences.*

**Answer:** The first two sentences have been reworded as follows: ”Large-scale atmospheric circulation (100s of km) strongly controls SMB in Antarctica. This large-scale atmospheric circulation embeds synoptic-scale cyclones that collect heat and moisture from further north, including the Southern Ocean, which they can release onto the AIS[...]”

***P.2, L45:*** *twice mentioned the increased SAT. Is it a positive feedback, i.e. increasing SAT → increased snowfall → increase in SAT? If yes, consider reformulation, if no remove one of the increased SAT.*
**Answer:** We thank the reviewer for noticing this confusing formulation. Also taking reviewer #1's comment, this paragraph has been changed as follows: ”In addition, based on the Clausius-Clapeyron relationship, the increasing mid and upper troposphere temperature due to climate change implies that the air can include more moisture before saturation, and therefore snowfall is increased (Frieler et al., 2015). If this predicted increase in SMB is linked to increasing temperatures in the 21st century, it will be interesting to see if SMB and SAT are linked in the past too, since an increase in SAT and tropospheric air temperature are strongly correlated. In this case, SMB records over time will be a helpful tool to constrain past climates.”

***P.3, L80:*** *at → as*
**Answer:** Changed.

***P.3, L85:*** *(Dalaiden et al., 2019) → Dalaiden et al. (2019)*
**Answer:** Changed. Also, note that the Dalaiden et al. (2019) The Cryosphere Discussions paper has now been published in The Cryosphere and all references have been changed to Dalaiden et al. (2020), here and in the manuscript.

***P.3, L87:*** *Here, for the second time you define the local scale. Redefine one*
**Answer:** We have chosen to remove the definition of local scale earlier (*'We will refer to this wind-based redistribution as the "local scale"'*) and keep it defined here P3L87 as that is spatial scale that we use in the whole manuscript.

***P.4, L91-95:*** *Add "?" to the questions*
**Answer:** Added.

***P.4, L107:*** *"(with the additional fourth made available recently, . . .)" Mention which model is new.*
**Answer:** This is now mentioned explicitly: ”with the additional fourth made available recently, iCESM1, ”

***P.4, L108:*** *Add the reference of Brady et al., 2019 as not all the models are described in Dalaiden et al., 2020.*
**Answer:** Added, as well as Stevenson et al. (2019).

***P4. L114:*** *"by a sea surface temperatures..." → "by sea surface temperatures"*
**Answer:** Modified.

***P.5, L120-121:*** *The authors use a different number of ensemble members for the different iGCMS. By averaging over several ensemble members variability is lost. It would be interesting to know how this affects the results, please discuss.*
**Answer:** We are sorry that the wording of this sentence was confusing. What we did was: (1) we calcu-

lated the correlation of the two variables (SMB-SAT or SMB-$\delta^{18}$O) for every grid point for each model member (3 members for iCESM1 and 7 members for iHadCM3). (2) We calculated the mean of the correlation values obtained per grid point over all the model members that belong to iCESM1 or iHadCM3 to get the mean SMB-SAT and SMB-$\delta^{18}$O correlation for each model. (3) We interpolated then all four iGCM correlation results (ensemble means for iCESM1 and iHadCM3, ECHAM5-MPI/OM and ECHAM5-wiso correlation results) onto the RACMO27 grid, for both the SMB-SAT annual correlations and the SMB-$\delta^{18}$O 5-yearly correlations. (4) We then calculated the mean over all four iGCMs to get the resulting iGCM plots shown in Fig.1. The sentence has now been changed to: "As the iCESM1 and iHadCM3 ensembles include three and seven simulations, respectively (each has slightly different initial conditions), we first calculate the correlation of the two variables (SMB-SAT or SMB-$\delta^{18}$O) for every grid point for each ensemble member (3 for iCESM1 and 7 for iHadCM3). Then we obtain the mean of the correlation values per grid point over each ensemble of simulations for both iCESM1 or iHadCM3. These ensemble means can then be compared to the correlations calculated for ECHAM5-MPI/OM and ECHAM5-wiso."

***P.5, L121:*** *Consider reformulations "we average over their ensemble of simulations to obtain mean representation of SMB, SAT and $\delta^{18}O$ for each iGCM." → "we retrieve the ensemble mean of SMB, SAT and $\delta^{18}O$ for each iGCM."*
**Answer:** Same comment as above.

***P.5, L123:*** *Mention the most important findings of the evaluation. What about the model that is not evaluated in Dalaiden et al., 2019?*
**Answer:** Based on the comments of both reviews, we have chosen to re-do the evaluation provided by Dalaiden et al. (2020) for SMB for three of the iGCMs, and add iCESM1 to it, as well as evaluate the SAT and sea-level pressure (SLP) fields. SMB and SAT will be evaluated against RACMO27 and SLP will be evaluated against ERA-Interim (to provide sufficient northerly coverage), over the 1979–2000 AD time interval. We will further discuss the relevance of this evaluation in the manuscript in this section (P5).

***P.5, L126:*** *significative → significant*
**Answer:** Changed.

***P.5, L129-130:*** *Explicitly give the number of years taken into account. Avoid "∼" as the time periods are clearly defined.*
**Answer:** These have been changed to 130 years and 40 years.

***P.5, L130/P.5, L141:*** *Please clarify the choice of the time periods. You mention "...a shorter () timescale covering 1961-2000 AD for comparison to the RCM simulations and measured SAT." However, the RCM start in 1979. Why don't you take a time period that matches between the iGCMs and the RCM? I guess this would be 1979-2000?*
**Answer:** The reason for this is that we wanted to keep as many years as possible for correlating the climate variables (SMB, SAT and $\delta^{18}O$. RACMO covers 1979-2016 = 38 years). Truncating the iGCM data to start in 1979, would have meant we only had 22 years of data, which is very short to have meaningful correlation results. We thus prefer to have a similar length for all models. This is now specified at the end of this paragraph as: "We choose to use the 1961–2000 AD time interval instead of starting in 1979 AD as for the RCM simulation, so that all model simulations have a similar length (40 years and 38 years for the iGCMs and the RCM, respectively) and their correlation results are meaningful."

In addition, we have compared the SMB-SAT correlations over the 1961–2000 AD and the 1979–2000 AD time intervals and the correlation strengths are unchanged, although the correlations over the shorter 1979–2000 AD time interval lose in significance (more areas with $p > 0.1$, e.g. see iCESM1, shown at the end of this document in Fig. 5). For the SMB-$\delta^{18}$O correlations, the 1979–2000 AD interval is very short to calculate a 5-yearly correlation.

***P.5, L132:*** *Here and in the Figures 1, and S1-S4 you first mention $\delta^{18}$O-SMB followed by SMB-SAT. However, in the analysis you first analyze SMB-SAT. Flip the order in both the text (here) and the figures.*
**Answer:** We agree, and will flip the order in the text here and this will be taken into account when modifying Fig. 1 and 2 as described P9 of this review.

***P.5, L143:*** *to studying $\rightarrow$ to study*
**Answer:** Changed.

***P.5, L147:*** *remove "," before etc.*
**Answer:** Removed.

***P.6, L158:*** *Reformulate: "Ice cores record variations with depth of ice's $\delta^{18}$O."*
**Answer:** Reworded as: "Ice cores record variations of the $\delta^{18}$O of the ice with depth"

***P.6, L164-168:*** *How well does this temperature reconstruction method work? Why do you need to rely on this? Could you use SAT from reanalysis instead? Are there weather stations in the close proximity of the ice core locations? For locations where weather stations are available, how well does the SAT reconstruction method agree with the measurements? Could you present correlations of ice cores to station measurements for some locations?*
**Answer:** We use this SAT reconstruction as they are based on the only direct observations of temperatures from weather stations over the last 50 years. Prior to 1979, reanalysis data have well known biases (e.g. Bromwich et al., 2007). This SAT reconstruction uses 15 weather stations (many along the coast), based on which they produce estimates of monthly gridded mean temperature anomalies for the whole continent over 1958–2012 AD. They use a kriging technique, originally developed for the reconstruction of Antarctic snowfall (Monaghan et al. 2006), to then interpolate the data between the stations. We will provide a map of the station locations used in the reconstruction the supplementary material, and provide correlations of ice cores to station measurements for some locations where they are in close proximity.

***P.6, L177:*** *Consider starting the results and discussion section with your results and discuss the comparison to other studies later.*
**Answer:** We have moved this sentence that compares our results to those of Dalaiden et al (2020) towards the end of this section 3.1.1, reworded a little as: "Dalaiden et al (2020) have shown that the relationship between SMB and SAT is positive on the continental scale for each of their seven Antarctic regions, whether they used the GCMs or RACMO2.3 simulations. The simple concept that Antarctic precipitation originates mainly from lower latitudes, in the form of warm and wet air masses, explains the co-variance of SMB and SAT at the continental scale as shown by Dalaiden et al. (2020). This simple concept therefore also applies at the regional scale here."

***P.6, L184:*** *Figures S1 and S2 are about $\delta^{18}$O. Don't mention them here. I think only Fig. S3 is relevant to this section. Reorder the figures in the supplementary material and only mention the related ones.*
**Answer:** Based also on the other review, we will move part of the supplementary figures (SMB-SAT cor-

relation and SMB-$\delta^{18}$O over the 1871-2000 AD time interval) for each iGCM and the iGCM average to the main manuscript. But we will only refer them in the relevant sections of the manuscript, as suggested here.

P.7, L191: Avoid generalizing, as you only have two different resolutions and two different time periods (which are partially overlapping).
**Answer:** We have modified *"Whatever the temporal and spatial scale,* to: "For the temporal and spatial scales investigated," and moved it further down in the paragraph to link to the Dalaiden et al. (2020) study.

***P.8, L223-224:*** *How do the findings by Agosta et al. (2019) relate to your findings? Indicate the link more clearly.*
**Answer:** We have changed these lines to: "Agosta et al. (2019) also show the strong impact of surface topography (surface curvature in their case) - wind interactions on modelled SMB by examining the spatial link of time-averaged values. They observe that above a certain threshold, winds will affect SMB locally in pattern that matches that of drifting snow fluxes as modeled by RACMO2.3."

***P.8, L225:*** *"very positive", reformulate to "strongly positive" or "positive".*
**Answer:** Changed.

***P.8, L225:*** *"weaker-to-positive" this needs to be reformulated. What you refer to is a weaker-negative-to-positive correlation. This needs to be specified.*
**Answer:** *"weaker-to-positive"* has been changed to "weaker (less negative) or positive".

***P.8, L226:*** *"(outlined here with a magenta line)": Why using a magenta line (Figs. 4 and 5) and not the black dashed lines as in Fig. 2? Magenta lines are harder to see. Remove "here", i.e. "(outlined with a magenta line)".*
**Answer:** We chose to plot the lines in magenta because they were difficult to see due to the blue–white-red color scheme of the maps (versus red tones in Fig.2). "Here" is now removed.

***P.8, L231:*** *"very positive" $\rightarrow$ "strongly positive"*
**Answer:** Changed.

***P.8, L232:*** *To me it looks like the effect is not present over the whole range of the Trans-Antarctic Mountains, i.e. I can't see the effect for the eastern part of the mountain range. Please, clarify.*
**Answer:** This is due to the fact the Antarctic Peninsula is very thin and the eastern side if more difficult to see, especially since we do not show the ice shelf values. We will, depending on which is more visual, either increase the size of this figure panel (for MSWD-SAT and MSWD-SMB both), or provide a zoomed-in view of the AP (see Fig. 1 at the end of this document).

***P.8, L236:*** *"this leeward side" $\rightarrow$ "the leeward side"*
**Answer:** Changed.

***P.8, L.239:*** *"here" $\rightarrow$ "in this area"*
**Answer:** Changed.

***P.8, L.241:*** *Be specific about the difference between the low level westward winds and upper level winds*

*bringing the warm air masses from the north.*
**Answer:** The distinction between low level westward winds and upper level winds bringing heat and moisture from further north will be made in the revised manuscript, and we will use the opportunity to reorganize and clarify the discussion in this section.

***P.8, L.244:*** *Did you test whether the correlation is significantly less negative? Otherwise, avoid using significantly.*
**Answer:** We have removed ”significantly”, since we meant it more as ”visibly”.

***P.9, L.255:*** *“...become weaker or increase”. This is not clear, please clarify. Do you mean “become weaker or positive”?*
**Answer:** Yes, we meant ”become weaker or positive”, we have now changed it in the text.

***P.9, L.256:*** *“bottom panel” → use a), b),... for all the figure panels.*
**Answer:** This will be changed.

***P.9, L.268:*** *Instead of “marked on Fig. 2” use either “AE on Fig. 2” (or “marked as AE on Fig. 2”). Same for BG (P.9, L274) and AL (P.9, L.277).*
**Answer:** They have all been changed to: ’yy’ on Fig.xx.

***P.9, L.271:*** *“i.e.” instead of “so”*
**Answer:** Changed.

***P.9, L.272:*** *Change “very positive” to “strongly positive”*
**Answer:** Changed.

***P.9, L.277:*** *Does the model confirm especially high precipitation in the Adélie Land?*
**Answer:** Adélie Land is in a coastal regime and therefore show a high snowfall rate, above 500 mm w.e. yr$^{-1}$ and up to 2000 mm w.e. yr$^{-1}$. See Fig 2, top panel. We have modified this paragraph as follows: ”For example, Adélie Land (’AL’ on Fig. 2) displays high snowfall rates (above 500 mm w.e. yr−1 based on RACMO2.3 results), but is also known for its record-high katabatics (van den Broeke et al., 2002). This region does not display particularly weak MSWD-SMB or MSWD-SAT annual correlations in RACMO2.3 results.”

***P.9, L.282:*** *The lines on Fig. 2 are not magenta but black dashed.*
**Answer:** Thank you for spotting this, it has been changed.

***P.10, L.288:*** *“Perhaps here snowfall input from further north is so high that it dominates the SMB and SAT records.” Do the model results confirm this? The models might have the different components of the SMB to check this.*
**Answer:** This was a hypothesis but it is difficult to verify it in this case as we would need daily data to look into the local variability. So we prefer to simply remove this sentence and keep the description factual.

***P.10, L.290:*** *RACMO05? (= RACMO5?)*
**Answer:** Yes, it was a typo and has been corrected everywhere it appeared in the manuscript.

***P.10, L.295:*** *Try to avoid generalization. Consider changing "all scales" to "all investigated scales".*
**Answer:** We agree and have added "investigated" in that sentence.

***P.10, L.310:*** *Reference figures for iGCMs and RACMO.*
**Answer:** The figures will be referenced accordingly, once Figs. 1 and 2 have been modified as described in an earlier review comment.

***P.11, L.318:*** *"...an important process, process that..." $\rightarrow$ "...an important process, i.e. a process that..." or "...an important process, that..."*
**Answer:** We have opted for "...an important process, i.e. a process that...", thank you.

***P.11, L.339:*** *instead of "as discussed below" reference Section.*
**Answer:** It's in the same section, so perhaps this phrasing is unnecessary. We have removed it.

***P.11, L.342:*** *You mention that the correlations of the cores with an inhomogeneous distribution over the continent are probably not representing the continental or even regional correlation. Then, you mention that the model shows mainly positive correlations where the ice cores are located. Did you consider calculating the correlation of the model only for grid cells for which ice core data exists? How does the comparison compare in this case? Could this result be used to underline the disagreement?*
**Answer:** We have not compared the correlation values between the ice cores and the model grid cells for which ice core data exist directly. We will make this comparison and add this information to Fig. 9 and the discussion. What Fig. 9 shows is: for each regular grid spacing, we retain grid cells that contain at least 5 or 10 ice cores. The correlation of the SMB and SAT time series of each of these ice cores is represented by the colored dots in the plot. For any grid cell that meets these ice core criteria (thus for any colored dot), we average the correlation values of the matching RACMO27 grid cell as for the ice cores (we calculate the individual mean and the aggregate value). So any colored dot representing ice core-based correlations has a matching gray dot representing model-based correlations (based on the RACMO27 simulation). The correlation strength difference between the ice core-based and model-based correlations is clearly visible. However, following earlier comments on this figure (see second comment of this review), Fig. 9 will be clarified and the text in the revised manuscript adapted accordingly. We could show this using a threshold of 1 ice core as stated before (see second comment of this review and Fig. 3 at the end of this document), but the fewer ice core records are averaged over, the weaker their mean correlation, and the larger the gap between the ice core-based correlations and the model-based correlation (the latter remains more or less constant). See also response to major comment = 2nd comment of this document.

***P.11, L.344:*** *remove "outlined"*
**Answer:** Removed.

***P.12, L.356:*** *reference the 108x108 km results as "not shown"*
**Answer:** We have added "not shown" after "[...] remain at 0.09 and 0.13 respectively".

***P.12, L.366:*** *"Results are shown in Fig. 9." No need for a whole sentence, just give reference as (Fig. 9).*
**Answer:** This has been changed to "(only three grid points contain at least five ice cores at the 648 x 648 km grid resolution, Fig. 9)".

***P.12, L.368:*** *"all spatial scales": Avoid generalization, i.e. "all investigated spatial scales"*

**Answer:** Modified.

***P.12, L.375-376:*** *Please clarify this sentence.*
**Answer:** We have reworded it to: ”Examining the ice core-based results, we note that increasing the number of ice core records that are initially averaged, results in a visible increase of the SMB-SAT annual correlation, but the trend is weak.”

***P.21, Fig.7:*** *significantive → significant*
**Answer:** Changed.

***P.21, Fig.7:*** *Maybe change “Large dots indicate...” to “Large gray encircled dots indicate...“*
**Answer:** This has been changed as suggested to ”Large gray encircled dots indicate [...]”.

***P.22, Fig.8:*** *Why don’t you show the standard deviation and percentage of $p<0.1$ on these graphs? What does the size of the dots display? Provide information in the caption and a legend for sizes.*
**Answer:** The standard deviation and percentage of $p<0.1$ will be added. The size of the dots displays the number of records averaged over, and we will therefore provide size information in the caption and legend as suggested.

***Suppl., P.8, Fig S9:*** *specify on which level wind speed and direction is shown.*
**Answer:** We have changed the caption to ”Mean 10 m wind speed[...]”.

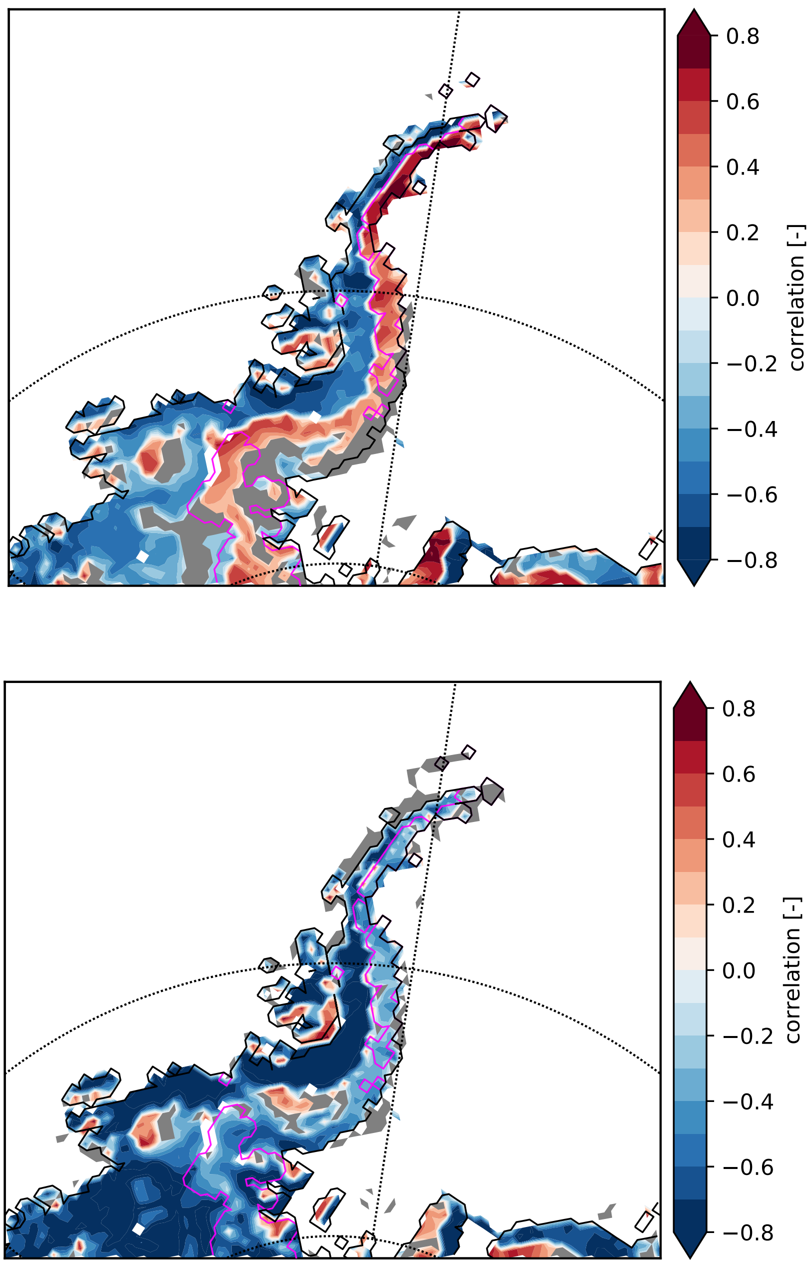


Figure 1: Zoom-in on the AP region: correlation between MSWD and (top) SAT and (bottom) SMB for the AIS calculated from RACMO27 simulations over 1979–2016 AD. Magenta lines outline the areas with a weak SMB-SAT correlation from Fig.2 in the main manuscript.

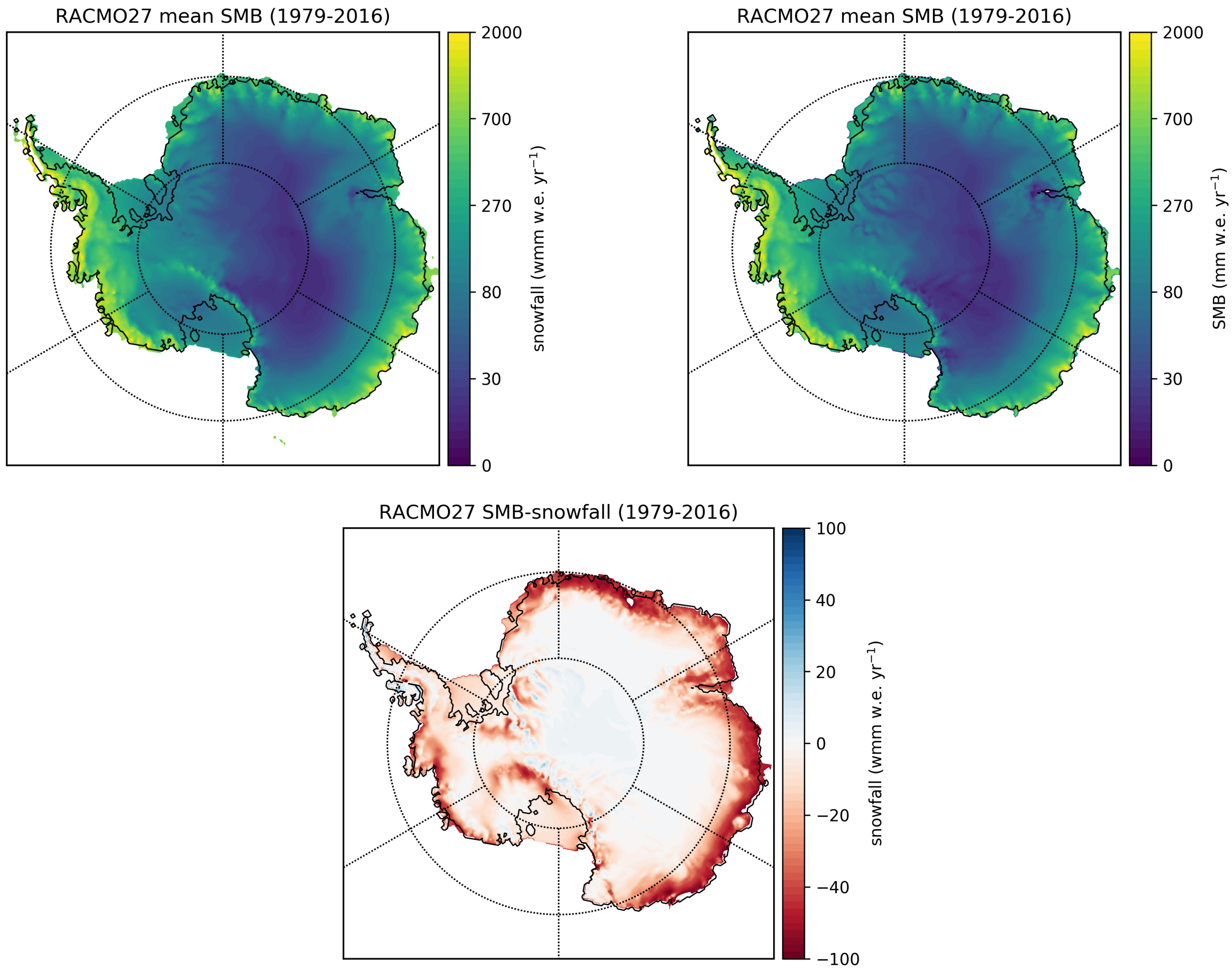


Figure 2: (top left) snowfall in mm w.e. yr$^{-1}$ vs (top right) SMB in mmm w.e. yr$^{-1}$, (bottom) difference between SMB and snowfall in mm w.e. yr$^{-1}$, mean RACMO27 simulation over 1979–2016 AD.

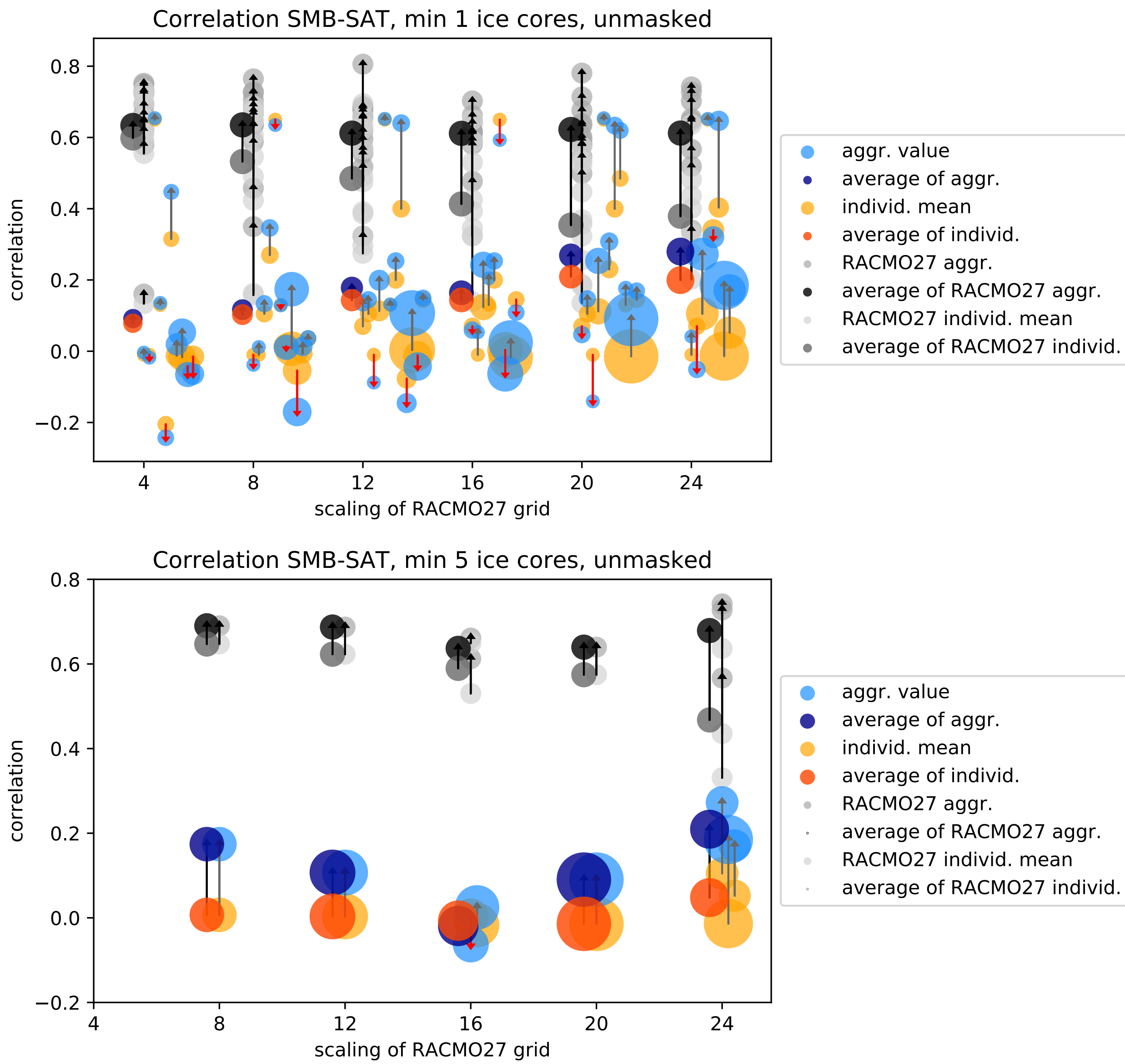


Figure 3: SMB-SAT annual correlation as a function of grid spacing for the aggregated records versus mean of the individual annual correlations for the ice cores (blues and yellows, respectively) and RACMO27 simulations (in dark and light grey, respectively). The size of the colored dots is a function of the number of ice cores aggregated for that grid point. Only grid points with at least (top) one and (bottom) five ice cores are kept. Annual correlations are over the 1958–2010 AD time interval.

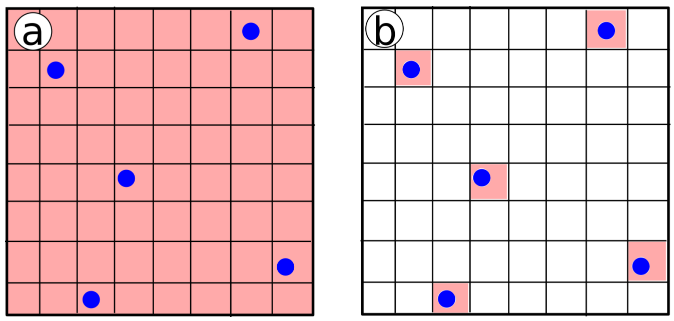


Figure 4: Sketch of the averaging of the model and ice core data for Fig. 9. Example for an averaging over grid cells in a square of 8 by 8 : the small cells represent the original RACMO27 grid cells, the blue dots the ice core locations, and the red coloring the RACMO27 grid cells used in the average. Sketch (a) is how we calculated the averages shown in Fig. 9: we compare the ice core average correlations (both average correlation and correlation of the averages) to the average RACMO27 correlation over the whole larger (red) grid cell (both average correlation and correlation of the averages as well). Sketch (b) is what we propose to look at for comparison: we compare the ice core average correlations to the average RACMO27 correlations using only the original RACMO27 grid cells that contain an ice core instead of the whole larger grid cell.

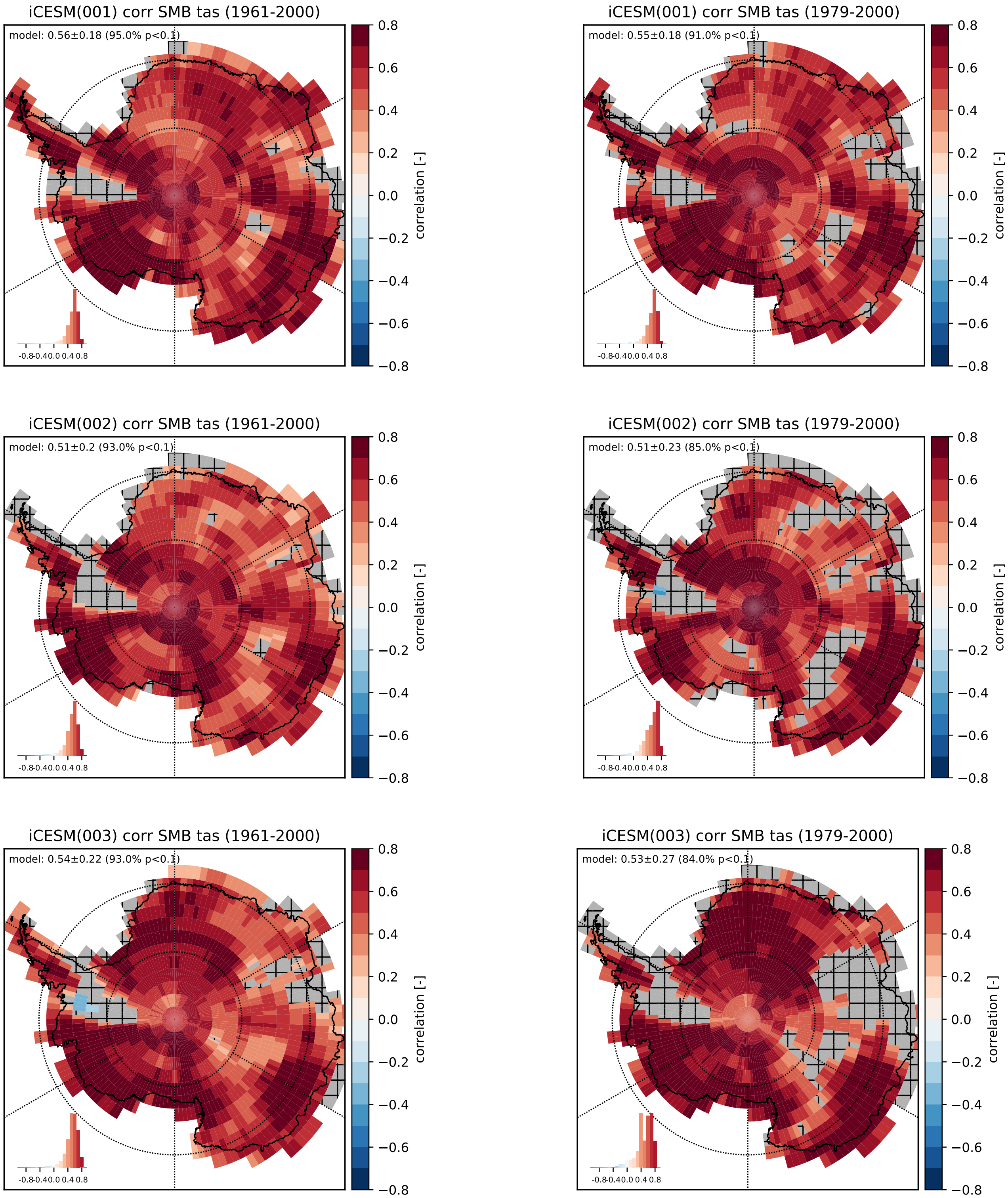


Figure 5: Annual correlation between SMB and SAT over (left) the 1961–2000 and (right) the 1979–2000 AD time intervals for each of the 3 iCESM1 simulations.