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Discussions

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Interactive comment on "Reconciling the surface temperature–surface mass balance relationship in models and ice cores in Antarctica over the last two centuries" *by* Marie G. P. Cavitte et al.

Anonymous Referee #2

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In this article the authors investigate the relationship between the surface mass balance (SMB), surface air temperature (SAT) and δ18O 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 δ18O 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.

(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.

(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.

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

- 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.

Specific:

P.2, L24: sea-level rise -> SLR

P.2, L35: temperature -> heat

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

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.

P.3, L80: at -> as

P.3, L85: (Dalaiden et al., 2019) -> Dalaiden et al. (2019)

P.3, L87: Here, for the second time you define the local scale. Redefine one or link them. Also, in the Results and discussion the "local scale" is only used once.

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

P.4, L107: "(with the additional fourth made available recently, ...)" Mention which model is new.

P.4, L108: Add the reference of Brady et al., 2019 as not all the models are described in Dalaiden et al., 2019.

P4. L114: "by a sea surface temperatures ... " -> "by sea surface temperatures"

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.

P.5, L121: Consider reformulations "we average over their ensemble of simulations to obtain mean representation of SMB, SAT and δ18O for each iGCM." -> "we retrieve the ensemble mean of SMB, SAT and δ18O for each iGCM."

P.5, L123: Mention the most important findings of the evaluation. What about the model that is not evaluated in Dalaiden et al., 2019?

P.5, L126: significative -> significant

P.5, L129-130: Explicitly give the number of years taken into account. Avoid "$\sim$" as the time periods are clearly defined.

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?

P.5, L132: Here and in the Figures 1, and S1-S4 you first mention δ18O-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.

P.5, L143: to studying -> to study

P.5, L147: remove "," before etc.

P.6, L158: Reformulate: "Ice cores record variations with depth of ice's δ18O."

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?

P.6, L177: Consider starting the results and discussion section with your results and discuss the comparison to other studies later.

P.6, L184: Figures S1 and S2 are about δ18O. 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.

P.7, L191: Avoid generalizing, as you only have two different resolutions and two different time periods (which are partially overlapping).

P.8, L223-224: How do the findings by Agosta et al. (2019) relate to your findings? Indicate the link more clearly.

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

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.

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)".

P.8, L231: "very positive" -> "strongly positive"

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.

P.8, L236: "this leeward side" -> "the leeward side"

P.8, L.239: "here" -> "in this area"

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.

P.8, L.244: Did you test whether the correlation is significantly less negative? Otherwise, avoid using significantly.

P.9, L.255: "... become weaker or increase". This is not clear, please clarify. Do you mean "become weaker or positive"?

P.9, L.256: "bottom panel" -> use a), b), ... for all the figure panels.

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, L.274) and AL (P.9, L.277).

P.9, L.271: "i.e." instead of "so"

P.9, L.272: Change "very positive" to "strongly positive"

P.9, L.277: Does the model confirm especially high precipitation in the Adélie Land?

P.9, L.282: The lines on Fig. 2 are not magenta but black dashed.

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.

P.10, L.290: RACMO05? (= RACMO5?)

P.10, L.295: Try to avoid generalization. Consider changing "all scales" to "all investigated scales".

P.10, L.310: Reference figures for iGCMs and RACMO.

P.11, L.318: ".. an important process, process that ..." -> "... an important process, i.e. a process that.." or "... an important process, that ..."

P.11, L.393: instead of "as discussed below" reference Section.

P.11, L.342ff: 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?

P.11, L.344: remove "outlined"

P.12, L.356: reference the 108x108 km results as "not shown"

P.12, L.366: "Results are shown in Fig. 9." No need for a whole sentence, just give reference as (Fig. 9).

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

P.12, L.375-376: Please clarify this sentence.

P.21, Fig.7: significantive -> significant

P.21, Fig.7: Maybe change "Large dots indicate..." 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.

Suppl., P.8, Fig S9: specify on which level wind speed and direction is shown.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-36, 2020.