

Response to Reviewer

Reviewer: The authors Gadde and van de Berg improved their manuscript entitled “Contribution of blowing snow sublimation to the surface mass balance of Antarctica” after implementing the comments from both reviewers. The authors shortened many parts in the manuscript which makes the text more precise and easier to read and follow. Overall, I would like to see a short discussion and the author’s thoughts on future model developments and how to further improve the representation of blowing snow sublimation and surface sublimation in future model versions.

We thank the reviewer for spending time on reviewing our manuscript. Below we explain the changes to the manuscript. While this manuscript was under review, RACMO2.4 was under development and we refer to [1] for the most recent model updates. In RACMO2.4 no further improvement on blowing snow sublimation or surface sublimation is implemented. In the current version of the blowing snow model, the snow properties such as dendricity and helicity are assumed to be constant ($d = 0.5$ and $s = 0.5$). The variance in the observational data is not captured accurately by the model due to the aforementioned simplification, it will be a major model improvement to fix this simplification. In addition, blowing snow model is not coupled with the radiation model, and as such the effect of blowing snow on radiative transfer is not considered, which will be looked into in the future. Finally, we intend to improve the surface snow density and wind packing, as we have observed that the poor representation of the temporal and spatial variability of the surface snow density is giving the largest uncertainties and model deviations in the modelled firn densification and firn air content.

Reviewer: After considering the minor comments below, I am suggesting this manuscript for publication in The Cryosphere.

The abstract is quite detailed and long which is fine if all information is relevant. I am wondering, however, if this part could be shortened and more precise on the main findings of the paper. In line 3, you write “among other things”. What do you mean by that?

Response: We agree and we have shortened the length of the abstract. By ‘among other things’ we meant the other major changes we introduced to streamline the coupling of blowing snow, which is explained in section 2.3. We have removed the phrase for clarity.

L. 62: speed winds \rightarrow wind speeds

Fixed in the revised manuscript.

L. 253: Please guide the reader and describe the mismatch between blowing snow form Rp3 compared to the observations. It might be obvious for you, but I would prefer to read more description than “It is evident from the figure...”.

Fixed in the revised manuscript. We have explained how the peaks are not captured properly with Rp3 and also the trends of windspeed vs blowing snow fluxes are not following the expected trend.

L. 263: Are you going to analyse the seasonal difference with the CALIPSO data later in the manuscript? Then please refer to the respective part of the manuscript.

We only qualitatively compare the seasonal variation of blowing snow frequency with the CALIPSO data and as such we did not mention this in L.263 where we discuss blowing snow flux magnitude.

Table 1: From the caption, it is not clear to me what the two numbers in each cell mean. Please provide a precise table caption.

We have added the caption in revised manuscript. The first table presents the blowing snow events as simulated by RpNew and Rp3, respectively. The second table presents high blowing snow flux events calculated as $Q_T > 0.05 \text{ kg m}^{-2} \text{ s}^{-1}$.

L. 352 and Figure 6: Please indicate what data you are showing here (RpNew or Rp3).

We are referring to RpNew, we will mention this in the revised manuscript.

L. 362f.: Please be more specific when saying ‘qualitatively similar’. Can you provide any numbers or figures for that? Currently, the reader has to entirely trust you that there is a similarity between your model runs and the CRYOWRF simulations.

We have added a description to this. Gerber et al. (2023) [2] report a zone of strongest blowing snow along the coast of East Antarctica with highest values of blowing snow frequency slightly inland. Zones with reduced blowing snow are found over the Amery ice shelf, toward the western Queen Maud land. RpNew shows similar qualitative trends.

L. 412: can you quantify the contribution of blowing snow sublimation to the total sublimation in winter?

For RpNew blowing snow sublimation contributes 108 Gt during winter out of the total sublimation of 175 Gt yr⁻¹. This amounts to 62% of the total blowing snow sublimation.

- L. 427: What could be a reason why CRYOWRF does not show a negative surface sublimation? Can you elaborate on this?

Unfortunately, we do not know the reason why CRYOWRF does not show the negative surface sublimation, and such an analysis is out of the scope of current study. As CRYOWRF is one of the few models with blowing snow parameterization applicable to entire continent (aside from MAR), future inter-comparisons with long-term simulations are necessary to obtain conclusive answers to model differences.

Table 2b: how do you compare RpNew values from 2000-2012 with CRYOWRF from 2010-2020? How representative is this comparison? You mention in l. 449 and 450 that RACMO does not vary much in the decades between 2000 and 2020. I am wondering what is then driving the inter-annual variability in the model if there is no difference between the decade from 2000 to 2010 and the decade from 2010 to 2020.

In our previous reply to the reviewer’s comments we mentioned that the inter-annual variability in the blowing snow sublimation from RACMO does not vary much in the decades between 2000–2020. Therefore, we could compare the blowing snow sublimation; we did not mention that SMB or precipitation does not vary between 2000–2010 and 2010–2020. There is a large inter-annual variability in precipitation (see Figure 2 from our previous reply).

L. 460: are you sure that sublimation is the largest ablation term compared to runoff and ice melt considering the entire Antarctic ice sheet?

Yes, we are sure. See, for example, van Wessem et al. (2018) [3], Table 2. Sublimation exceeds melt, and all snow melt water refreezes in the snowpack – so it does not contribute to actual mass loss (thus ablation) term.

References

- [1] Christiaan T van Dalum, Willem Jan van de Berg, Srinidhi N Gadde, Maurice van Tiggelen, Tijmen van der Drift, Erik van Meijgaard, Lambertus H van Ulft, and Michiel R van den Broeke. First results of the polar regional climate model racmo2. 4. *EGUsphere*, 2024:1–36, 2024.
- [2] Franziska Gerber, Varun Sharma, and Michael Lehning. Cryowrf—model evaluation and the effect of blowing snow on the antarctic surface mass balance. *Journal of Geophysical Research: Atmospheres*, 128(12):e2022JD037744, 2023.
- [3] M. J. van Wessem, W. J. van de Berg, P. Y. Brice Noël, E. van Meijgaard, C. Amory, G. Birnbaum, C. L. Jakobs, K. Krüger, J. T. M. Lenaerts, S. Lhermitte, et al. Modelling the climate and surface

mass balance of polar ice sheets using racmo2-part 2: Antarctica (1979–2016). *The Cryosphere*, 12(4):1479–1498, 2018.