

The Cryosphere Discuss., referee comment RC1  
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## Comment on tc-2021-69

Anonymous Referee #1

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Referee comment on "Downscaled surface mass balance in Antarctica: impacts of subsurface processes and large-scale atmospheric circulation" by Nicolaj Hansen et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-69-RC1>, 2021

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This is a well-written manuscript on an important topic, attempting to better understand how firn and snow pack processes affect surface mass balance in Antarctica through a modelling approach. The results are validated against observational data, though it is limited across the region of interest. I would recommend that it be accepted after minor corrections, most of these are little more than typographical in nature.

However I do have a small number of general comments.

First, the manuscript and the reader's ability to understand and assess the data in them, would be improved if some more attention was given to the figures' presentation. Much of this can be summarised as a making a better choice of colour scales and markers. In particular figures 1 and 4 rely on colour scales that do not steadily increase in their darkness, but instead jump around somewhat. This makes assessing more negative and more positive values difficult. Following on from this I would suggest the authors ensure the colours used for the Fixed, Dyn03, and Dyn15 results are consistent across figures (and ideally different from the colours used in the diverging scales). Likewise improvements can be made in the maps in figures 3 and 4: a clearer indication of the zoomed areas, which will be aided by a better choice of background colour and non-biased colour scales. Throughout the figures I recommend that the authors use larger text and labels and better and more consistent labelling of subfigures.

Second, and more scientifically interesting, is the question of resolution. Much effort has gone into considering different layer schemes and how mass is transferred between them down to a scale of 0.065 m w eq. In the horizontal direction however the resolution is 12.5km. Clearly there are computational demands that limit this resolution, but it does raise a question: namely, given that some features that indicate or result from localised melt and mass loss can be of this same length scale or less, how is this handled in the model? Is it simple averaging per pixel? Is a higher resolution used in some geographic areas? Or are the smallest of these features simply not seen / modelled?

A final general point: given that the manuscript focuses on firn and surface processes for which surface radiation fluxes are important, the treatment of the albedo seems a little simplistic. Perhaps the authors could expand on this. I understand that computationally it is probably hard to go beyond a broadband albedo, but are the values stated extremes, or

are they allocated for each class of surface i.e. all fresh snow is designated as having an albedo of 0.85, or is this dependent on grain size, density etc?

I think adding some comments on both the horizontal resolution point and some further details of how albedo is treated in the model would assist the reader with a general glaciology background, but who is less-versed in the details of such models.

Some more specific points follow, most typographical and minor, but also addressing of how to improve the presentation of the figures.

l29 "as such might" -> "due to their role in"

l57 "Acknowledging that the in-situ observations might be challenged judging the performance of the SMB model" -> "Acknowledging that it might be challenging to judge the performance of the SMB model against in-situ observations"

l71-72 Regarding "The SAM is an atmospheric phenomenon..." this seems to be a more introductory descriptive sentence and better placed a few lines earlier when the SAM is introduced

l88 Are these values for short-wave albedos? If so, add "shortwave" for clarity.

l89-90 "Specific, for the HIRHAM5 Antarctic simulations, was that we used the Antarctic domain defined in the Coordinated Regional Climate Downscaling Experiment" ->

"Specifically (or finally), for the HIRHAM5 Antarctic simulations, we used the Antarctic domain defined in the Coordinated Regional Climate Downscaling Experiment"

l90 12.5km resolution. This comparable size to small features often related to negative SMB: melt ponds, some glacier streams, blue ice areas. How are these handled?

l100 "Despite the forcing is based on 6 hourly ..." -> "Despite the forcing being based on 6 hourly...". Also could the forcing be interpolated to 1 hr time steps, or alternatively what would the impact be of simulating the subsurface at the 6 hourly interval of the forcing?

l101 "... model is following the ..." -> "... model follows the ..."

l122 "... which is fixed ..." -> "... which are fixed ..." OR "... the number of which are fixed ..."

l120-136 How is the bottom boundary handled? Or equivalently, how is the remainder of the mass between the lowest layer and the base of the icesheet handled?

l157 Diagnosed snow depth? What does diagnosed refer to here?

Table 1 "Fist snow then ice" -> "First snow then ice", I think?

Fig 1: The colour scale here is a little strange in the left hand panel referred to as (a) in the caption. Specifically it does not steadily get darker with a single hue, but changes part way through. This gives some bias and odd visual affects and probably makes it harder for those with colour blindness. I would suggest that the authors convert to using a standard diverging colour scheme such as Cynthia Brewer's Red-Blue scheme that can be found here: [colorbrewer2.org](http://colorbrewer2.org)

Also please check journal guidelines for placement of caption labels (a) and (b); in their current location, they were less obvious than placed outside top-left for example.

Fig 2: Would recommend consistent labelling of sub-figures. Here they are capitals, the last figure was lower case and the placement has changed between figures. They are referred in the text as lowercase. Also I would suggest adding a legend entry for precipitation, and choosing more distinct symbols for the TotAIS and GAIS cases.

l217 Given the importance of albedo in driving subsurface processes I wonder if it is possible to use a more refined scheme here. The single broadband value for snow / bare ice mentioned earlier appears crude compared to the detail given in the handling of layers for example. Would a density-based albedo be an option, even if broadband? If this is the case, this should be clarified.

Table 3: which units are being quoted? I guess kgm<sup>-3</sup>, but it should be stated.

l230: "Statistical comparison of mean difference and one standard deviation between the firn cores and the modelled densities, for the three simulations are given in Table 3." -> "A statistical comparison of the mean difference and one standard deviation between the firn cores and the modelled densities are given in Table 3 for the three simulations."

Fig 3: The choice of colours here has the potential to confuse when red and blue are used in previous and later maps to signify high and low deviations. The choice of colours for the AIS and iceshelves does not help. If a light blue were used for the Southern Ocean, a light grey could be used for iceshelves leaving the GAIS white, making the markers clearer, and allowing a better and wider choice of colours, for example purple and green to remove any ambiguity.

Fig 4: Again, this could be clearer. It is very hard to discern the zoomed in areas on the larger maps. A thicker line is needed to indicate these to the reader. The colour scale has the same issue as in figure 1. Again, I would recommend using a standard and well-tested red-blue diverging scale. Changing the colouration of the underlying map as in Fig 3 would also help the clarity of these figures.

Fig 5: The labels and other text needs to be made larger so that it is legible to the reader. Again labelling of the subfigures needs improving and to be made consistent. Here, the issue is that the labels (a) and (b) lie closer to the panels that are, in fact, (c) and (d)

l271 "the agreement becomes smaller" -> "the agreement becomes worse".

Fig 6: It appears that most of the points are from Dyn15 here, but I suspect it is a case of overplotting. I would suggest using different symbols so that it is clear when markers overlay one another and when they do not. Also why have the colours used for the different simulations changed? Earlier they were red, blue and green, now red, blue and yellow. It would make interpretation of the data easier if they were made consistent between figures, and better still if different colours than used for the diverging colour markers in Fig 1 and 4.

Fig 7: Larger text would be helpful here

Fig 8: I find the narrow bars confusing in this figure. Could standard uncertainty markers be used instead? Why do the means for the three simulations fall outside of the 5-95 percentile range so often? Perhaps some more explanation is needed in the caption.