Interactive comment on "A daily, 1-km resolution dataset of downscaled Greenland ice sheet surface mass balance (1958–2015)" *by* Brice Noël et al.

Anonymous Referee #2

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Review of "A daily, 1-km resolution dataset of downscaled Greenland ice sheet surface mass balance (1958-2015)" by Noël et al., published in *The Cryosphere Discussions*.

Review Summary:

This manuscript presents a newly developed downscaled version of the RACMO regional climate/SMB model. The downscaling procedure applies a statistical elevation correction using the GIMP DEM, a correction leading to increased runoff via lower-than-modeled and higher resolution MODIS albedo, and a bias correction to account for RACMO's apparent systematic underestimation of precipitation in the GrIS accumulation zone. The resulting 1-km downscaling of RACMO2.3 shows a notably improved agreement with in situ observations. In particular, the authors highlight better repre-

sentation of marginal GrIS regions, where complex topography and steep elevation gradients result in large SMB gradients that are poorly resolved in the native 11-km RACMO. Given that RACMO is widely used in the glaciological community, the improved and higher resolution version presented in this paper will certainly be of wide interest.

Below are comments that pertain mostly to the presentation of the material, as opposed to the downscaling methods employed. Overall, I believe the authors need to do a better job at describing the methods and presenting the results in their figures. Finally, I would suggest that the authors consider including more information (perhaps in a new section) on where the new dataset really shows promise for understanding the SMB variability and physical/climatic processes affecting the GrIS. Improved overall agreement with observations is shown (Fig 6), as well as improvements along some transects (Fig 7), and then the authors show some example regions while noting the effects of downscaling. However, the reader is largely left to decipher where the "old" RACMO still works, where the downscaling does a more realistic job, and areas where the SMB is still uncertain (and why). Given the wide use of RACMO, understanding a bit more where these uncertainties lie would be very helpful for the community, while also making for a much stronger manuscript.

Specific comments:

Abstract:

You reference the elevation correction almost exclusively here (except for the last sentence), but the albedo correction in particular, and accumulation zone precipitation bias correction to a smaller degree, are also important to improving agreement with the observations. I would add reference to these other two important steps in the abstract.

Figure 4a and text near line 160:

The method for calculating the regression slope (b11km) using the adjacent grid cells

is clear: i.e., using a maximum of the 8 adjacent grid cells with different elevations and SMB components to generate a linear regression. This figure (and the text), however is somewhat confusing at first because it looks like a separate regression (the blue line, seemingly labeled a11km) is being generated using only the single blue "current grid-cell" point. After studying this figure, my interpretation is that the blue line is simply applying the (red) regression slope (b11km, red line) and the blue point's x and y values to estimate the intercept, a11km. At first glance, this is not apparent.

I would suggest revising this figure to make it more clear. Perhaps you could make the blue line a different color (e.g., green), make it dotted, and only extending from the blue "current grid-cell" point to the y-axis, and have an arrow pointing toward this intercept point, labeled a11km. This would make it look less of a separate regression, and more clear that you're just calculating the intercept using the local regression slope (b) and only the central grid cell elevation (x) and SMB component value (y). Perhaps you could also indicate this by showing the formula a11km = y – b11km * x on the figure.

I would also suggest including a legend to label the red points "adjacent grid cell**s**" and blue point "current/central grid point".

Also, you should probably only show 6 adjacent grid cells, as this is what you end up using.

A perhaps bigger question I have about the method is why not just use the intercept value obtained from the first linear regression of the current grid cell and its adjacent cells?

Lines 165-168:

The method step here is unclear. Are you enlarging the native 11-km grid to match the larger spatial extent of the 1-km grid? Can you indicate how often this was used? Is this just at the lateral margins of the ice sheet?

Lines 207-210:

Why not apply this correction to all grid cells? Certainly for some grid cells, this would provide enough additional energy to generate melt (i.e., in non-melt cells), and for other cells, sufficient additional melt to generate runoff in cells where melt doesn't already exceed refreezing. It seems to me that this extra SW absorption may be important not just for cells that already have runoff, but the whole GrIS SEB and snowpack temperatures as well through both increased SW absorption and latent heat release upon refreezing in areas that melt.

Line 248:

Could it also be possible that this is due to only selectively applying the correction to cells already experiencing runoff?

Lines 273-274 / Figure 6a,b:

A more minor point: I calculate a 16.25% decrease in the RMSE, not 18%. On line 279, I calculate a 81.25% decrease in bias, not 88%.

Line 291/Figure 8:

Text here refers to SMB v0.2, but figure states it shows SMB v1.0. Which is it? And you state you applied the bias correction to places where SMBv1.0 > 0 mmWE/yr, but to get SMBv1.0, was it not necessary to first calculate PRv1.0? This seems circular to me.

Figures 9-12:

Can you add the names of these areas from table 1 in the respective figure captions? This would facilitate interpretation and cross reference between figure 1, table 1, sections 5.1-5.5, and these figures. Also, I found myself constantly needing to refer to the caption to interpret the panels. This became more problematic with figures 10-12 as I had to refer back to figure 9's caption. Please add some basic identifiers/titles to each panel.

Panels k and l also incorporate the SMB bias correction, right? This is not clear from the caption, but it is suggested in the text (lines 330-331). Please also specify in the caption.

Lines 334-335:

A systematic overestimation of bare ice albedo is difficult to see here given the different grid sizes. Can you show a plot of the albedo bias as you've done for elevation in panel e of figure 9?

Lines 351-352:

Should these figure references to runoff be Fig 10 g and k (not h and l)?

Line 360:

Similar to above, should these references to increased melt refer to the runoff plots (g and k) rather than SMB (where differences are less perceptible)? Same for line 374.

Lines 414-416:

This affects the entire GrIS, right? Perhaps change "high latitudes" to specify GrIS margins.

Lines 417-418:

I assume the underestimation of bare ice albedo prior to 2000 is because the MODIS time period used of 2000-2015 was one of very high melt, right? If so, you should explicitly state this. This leads me to a second point on the use of the MCD43A3 dataset. It is known that the MODIS Terra sensor has degraded, giving too strong of an albedo decrease for Greenland. The MCD43A3 data are affected since they incorporate both Terra and Aqua observations (e.g., Polashenski et al., 2015, GRL, and others). I would suggest at least acknowledging this as a limitation in this section.

Technical corrections:

9: "confined glaciated areas" is a bit unclear, could you reword this somehow?

163: change erratic to erroneous

179: remove comma

181: Specifying that you are estimating b11km would be helpful here.

187: remove "are"

191: specify "native resolution" or 11-km when referring to RACMO2.3 here.

281: specify Figure 11a for yellow dot.

288-290: Please add reference and better explain how this seasonality is different than that of other sites, e.g., Nordbogletscher, which is in a similar region that presumably experiences similar SMB seasonality.

Figure 7 caption: make reference to Figure 1 for locations.

356: remove "the" in "larger the glaciated"

385: Fix reference to Figure 12 i and j.

386: Fix reference to Figure 12 h and l.