1 General comments

This manuscript presents a Greenland Surface Mass Balance (SMB) product which was downscaled from 6km to 100m resolution using output from the regional climate model MAR and demonstrates that the downscaled dataset exhibits an predominantly better agreement with observations than the respective original MAR output at its native resolution (which is already at a very high resolution). To my knowledge the data product is unique in its extremely high resolution and Greenland wide coverage. The presented analysis convincingly demonstrates the improved quality of the SMB data and this work could be a valuable source for the community with respect to small scale applications. The manuscript is clearly structured and most parts are easy to understand, even though some sentences could possibly be decluttered and shortened (examples in the specific comments).

Nevertheless, being interested in downscaling approaches in general rather than in small scale applications, I have some major concerns which mostly concern the general approach.

2 Major comments

The downscaling approach will be most effective where the MAR topography and the 100m DEM strongly differ and where topographic gradients are large and are dominating the temperature distribution. Towards the coast and on high altitude plateaus the temperature and SMB distribution might be unrelated to elevation. Please provide a map of height difference between the 100m DEM and the native MAR orography, possibly in a supplement. Similarly, I propose to include the height at in situ location, and respective heights according to the DEM and MAR orography in table 1 and 2. Also a map of the topographic slope might be helpful.

It is not clearly stated, and it should be, where the here applied downscaling approach differs from the one in Noel et al. (2016). An indeed major difference is, that here SMB is downscaled directly (p. 6, l.23), while in Noel et al. (2016) only the SMB components melt, runoff and sublimation are downscaled while precipitation is interpolated and SMB and refreezing are recalculated from the downscaled components. I am not convinced that downscaling SMB in total is a similarly good choice and would be interested to see the correlation of SMB to elevation (similar to Fig.3 in Noel et al. (2016)). Furthermore it should be explained how grid points outside of the 6km ice mask are treated.

I also wonder how much information is actually gained from going to ever increasing resolution (e.g. when going from 6km to 1km to 100m). Is it possible to repeat the SMB downscaling for 1km and compare to stake measurements?

Where the correlation of a variable to elevation is weak, an elevation based downscaling will likely smooth the signal rather than adding finer structure (since regression parameters are interpolated). In these regions I would expect that simple interpolation to 100m resolution would produce better results. Therefore it would be interesting to see the same statistics for 6km-SMBs being interpolated to the precise stake location.

3 Specific comments

p. 1, l 21: „In the case of the downscaled MAR product“: unnecessary repetition. The formulation “in the case of” is heavily used in general and in some case it is redundant or makes the text a bit clumsy.
p. 1, ll. 23-24: slope and intercept are interchanged.
p. 1, l. 28: specify that this study was analyzing North and Central Greenland
p.2, l.14: maybe provide references for datasets which provide resolution of 100s of meters.
p.2, ll. 15-16: this is a bit elusive. Can you specify how understanding englacial systems or ocean interaction would benefit from higher degree of detail at the surface (given that mass is conserved with respect to the source data)?
p.3,l.12: is the TT variable 3-dimensional air temperature or near surface air temperature? Is it possible to specify the height

above surface?
p.4,l.1: typo, pint-> point
p.4,l.11: precise: values of near surface air temperature
p.4,l.24: . . . we use surface temperature fields from seven different. . .
p.5,l.13-14: It should be stated that this (I guess) is referring to pixels at the margins of the ice masks
p.6,l.20: specify what the physical constraints are in terms of temperature and SMB.
p.6,l.21: typo, constrains – constraints?
p.6,l.25: typo, slop->slope
section 3.2: I had a hard time reading this section. Maybe concentrate a bit more on what information this analysis provides and how to interpret it. Introduce scale brakes here.
p.8,l.5: what do you use for the comparison with the original MAR output? Is it nearest neighbor or do you interpolate to the station location or do you interpolate to 100m grid and then choose the nearest neighbor?
p.8,l.18: this is unclear to me. What are the sole pixels?
p.8,l.24: reword, maybe: the similarity in mean differences is not surprising. . .
p.9, ll.10-12: confusing sentence. Please rephrase.
p.9, ll.28-31: confusing, please rephrase. Maybe: Against our expection. . .
p.10, ll.31-33: It needs to be noted that Fettweis et al. (2020) also applied an elevation correction and interpolated to in stake location.

Figures: please check x and y labels for the maps (distance, longitude, latitude)
Fig. 2: m and q are not consistent with Eq. 1 (interchanged)
Fig. 3: check colorbar label
Fig. 8: it would be interesting to also show RMSE by topographic slope.

References

Fettweis, X., Hofer, S., Krebs-Kanzow, U., Amory, C., Aoki, T., Berends, C. J., Born, A., Box, J. E., Delhasse, A., Fujita, K., Gierz, P., Goelzer, H., Hanna, E., Hashimoto, A., Huybrechts, P., Kapsch, M.-L., King, M. D., Kittel, C., Lang, C., Langen, P. L., Lenaerts, J. T. M., Liston, G. E., Lohmann, G., Mernild, S. H., Mikolajewicz, U., Modali, K., Mottram, R. H., Niwano, M., Noël, B., Ryan, J. C., Smith, A., Streffing, J., Tedesco, M., van de Berg, W. J., van den Broeke, M., van de Wal, R. S. W., van Kampenhout, L., Wilton, D., Wouters, B., Ziemen, F., and Zolles, T.: GrSMBMIP: intercomparison of the modelled 1980–2012 surface mass balance over the Greenland Ice Sheet, The Cryosphere, 14, 3935–3958, https://doi.org/10.5194/tc-14-3935-2020, https://tc.copernicus.org/articles/14/3935/2020/, 2020.

Noel, B., van de Berg, W. J., Machguth, H., Lhermitte, S., Howat, I., Fettweis, X., and van den Broeke, M. R.: A daily, 1 km resolution data set of downscaled Greenland ice sheet surface mass balance (1958-2015), CRYOSPHERE, 10, 2361–2377, https://doi.org/10.5194/tc-10-2361-2016, 2016.