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Interactive comment on "SEMIC: an efficient surface energy and mass balance model applied to the Greenland ice sheet" *by* Mario Krapp et al.

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This paper presents a new simple energy balance snow model (called SEMIC) in the aim of simulating the GrIS SMB for forcing ice sheet models. The parameters of this model are calibrated with outputs of the regional climate model MARv2 forced by CanESM2 (RCP85). This paper is well written, fits well with TC and deserves to be published after some revisions. The physics used in SEMIC are well explained and justified. The model calibration by minimising the cost function (Figs 6 and 7) is original and statistically more robust than a simple inter-comparison. Finally, the open source mind of the authors needs to be highlighted.

However, before publication in TC, several major issues should be resolved or at least discussed:

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1. Reference to MAR in the text

After a quick read of this paper, it appears that SEMIC is comparable to MAR !! (e.g. abstract line 7; conclusion: line 9). But claiming this, is lie to the readers because SEMIC is comparable in fact to the snow model used in MAR (daily MAR atmospheric outputs were used to force SEMIC). The MAR snow model, based on the CROCUS snow model and called SISVAT, uses exactly the same input (precip, temperature, radiative flux, humidity, wind, surface pressure) than SEMIC. The only difference between SEMIC and SISVAT is the forcing time step (150s in SISVAT vs daily in SEMIC). Therefore, it is normal for example that the interannual/daily variability is very well correlated with the MAR outputs as the variability of the snowpack is mainly driven by the near-surface atmosphere variability and precipitation.

- First, all the inter-comparisons of Surf Temp. and SMB components with MAR must refer to SISVAT (used in the MAR model) and not to MAR!

E.g. : pg 10 line 19: "The Taylor diagram in Fig. 7 summarises the performance of SEMIC compared to MAR and its multi-layer snowpack model" MUST BE "The Taylor diagram in Fig. 7 summarises the performance of SEMIC compared to the multi-layer snowpack model used in MAR". The meaning of the corrected sentence is fully different.

- Secondly, SEMIC does not allow to take into account the atmosphere-snowpack interactions. But, as it is forced by MAR, theses feedbacks (and notably the albedo feedback) are taken into account here. This should be mentioned in the manuscript.

- Thirdly, it is true that MAR is very slow in respect to SEMIC but it is not due to its snow model which is fully parallelized (taking about 5 % of its computing time) but it is due to the physical atmospheric downscaling. As next step, it will be a lot of more interesting to compare SEMIC forced directly by CanESM2 vs SISVAT-MAR forced by CanESM2 but it is clearly out of scope of this paper. Such comparison has been made

by Geyer et al. (TCD, 2013) using CROCUS as snow model. They showed well that the biggest issue is not the snow model but the downscaling of the atmospheric fields (e.g. precipitation). This should be mentioned in the manuscript. Finally, the SISVAT snow model as well as the raw CROCUS snow model can be run in stand alone mode like SEMIC. Therefore, this shows well that this paper is well SEMIC vs CROCUS and not SEMIC vs MAR.

Geyer, M., Salas Y Melia, D., Brun, E., and Dumont, M.: The Greenland ice sheet: modelling the surface mass balance from GCM output with a new statistical downscaling technique, The Cryosphere Discuss., 7, 3163-3207, doi:10.5194/tcd-7-3163-2013, 2013.

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2. Calibration with MAR outputs only

- Firstly, while this model is very fast, I am a bit surprised that the calibration was only made over three years (2098-2100). I understand the aim of being able to simulate extreme values. But 3 yrs is very short and a validation (as Figure 7) over both 10 yrs periods (2090-2100 and 1990-2000) will be more robust. As nothing is linear, using current climate (which is the only climate we know well) can be also useful. If it is not a big job for the authors, I will like to see the sensitivity of the extreme values of the parameters from Table 1 over these both periods.

- Secondly, I am also surprised that the sensitivity of the bare ice albedo value is not tested. In MAR, this one is the more sensible parameters (as explained in Fettweis et al., 2016). As SEMIC underestimates melt in respect to MAR, lower values of bare ice albedo can reduce this bias.

Fettweis, X., Box, J. E., Agosta, C., Amory, C., Kittel, C., and Gallée, H.: Reconstructions of the 1900–2015 Greenland ice sheet surface mass balance using the regional climate MAR model, The Cryosphere Discuss., doi:10.5194/tc-2016-268, in review,

2016.

- Thirdly, the parameters of SEMIC are calibrated with MAR outputs only. But MAR is not the true!! and as shown in Fettweis et al. (2016), MARv2 (used here) overestimates the melt in respect to MARv3.5.2. A calibration/validation over current climate using the SMB PROMICE data set will be more robust. Outputs of MAR forced by NCEP1 or ERA can be used as forcing for this. It is clear that current climate is not future climate but the melt rate of the recent summers is already significant. I don't ask to recalibrate SEMIC over current climate using the SMB PROMICE data set but this issue should be at least mentioned in the manuscript. I can provide daily outputs of MARv3.5.2 forced by CanESM2 (rcp85) to check the sensitivity of the calibration to the used MAR version.

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3. Cumulated SMB change.

SEMIC was built to force an ice sheet model but an ice sheet model is not sensitive to the daily variability and in a less extent to the interannual variability of SMB. It is mainly sensitive to the cumulated SMB changes. When we are looking on Fig 8, SEMIC seems to diverge from MAR after 2050. What are the total cumulated differences in 2100? For me, the calibration should be made to have the same cumulated SMB changes over 2000-2100 than MAR and not to have good results over 2098-2100 only. Due to error compensations, having a too high/too low SMB several years in respect to MAR is not a problem for an ice sheet model which will give the same results at the end than if it will be forced by MAR. The best will be to calibrate SEMIC over current climate when we have other estimations of cumulated SMB changes than MAR (van den broeke et al., TC, 2016).

Minor remarks:

- Fig 2: the SMB zones shown in Fig 2 were only valid over the 1990's (based on Zwally and Giovineto, JGR, 2002) and were formerly used in MARv2 to initialise the snow model. These boundaries are already no more relevant for current climate of the 2000's. This issue should be mentioned in the manuscript.

Fig3: MAR/ERA-40 must be SISVAT/CanESM2. It should be interesting to show the differences over current climate (in supplementary material) when MAR is forced by reanalysis. This error in the legends means that such a comparison has already been done.

Fig. 5: not useful => supplementary material.

Fig. 8: showing an equivalent of Fig 4 with cumulated values will be more useful.

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