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Interactive comment on "Reconstruction of the Greenland Ice Sheet surface mass balance and the spatiotemporal distribution of freshwater runoff from Greenland to surrounding seas" *by* Sebastian H. Mernild et al.

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Anonymous Referee #2

Interactive comment on "Reconstruction of the Greenland Ice Sheet surface mass balance and the spatiotemporal distribution of freshwater runoff from Greenland to surrounding seas" by Sebastian H. Mernild et al.

Received and published: 14 January 2018 I fully agree with review #1 that this paper can not be accepted in the present state for publication in TC due to the lack of

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a robust validation of the presented results. In addition, except Section 4.2 which is a bit interesting, the scientific interest of this paper is very poor and clearly not innovative (e.g. Section 4.1 which is just a confirmation of previous studies)! The mean 1979-2014 SMB over GrIS, the 2012 melt record year and the recent increase of runoff (and corresponding refreeze capacity decrease) in link with changes in AMO and NAO have already been shown and discussed in many papers like the ones from Hanna, Fettweis, Noel, Wilson, : : :. Finally, the studied period is limited to 2014 while ERA-Interim is available until Oct 2017! The results seem to be a bit outdated. Authors: In the papers mentioned by the reviewer the spatiotemporal distribution of individual catchment runoff from Greenland have not been studied, and linked to AMO and NAO. This is main scientific novelty of this study. SnowModel/HydroFlow is unique for simulation of the spatiotemporal distribution from each individual catchment, which no other model can do at present. This is important if we want to understand and link the terrestrial runoff freshwater from Greenland to ocean dynamic models, suspended sediment fluxes or biogeochemical/nutrient fluxes. The EOF analyzes and it potential freshwater runoff link to other scientific communities is of high interest and innovative, for better understanding how the terrestrial environment links to the marine environment. Here, we present 35-years (1979-2014) for spatiotemporal distribution of freshwater runoff from Greenland (understanding the distribution from a statistical perspective – an EOF perspective), and in that perspective adding three more years is not significant.

Line 132-133: The interest of this new version of the SnowModel in respect to the results of Mernild and Liston (2012) should be shown and discussed with validation data. Authors: The text was rewritten and parts were erased. Please see our responses to the comments by Reviewer #1.

Line 251: What do you mean by “acceptable results” ? Authors: This is now explained.

Line 338-343: only a 2D validation with MAR results should be useful here. A comparison at the scale of the ice sheet is not enough ? Why is there a such underestimation in respect to MAR ? In each area? MAR is not the true and a comparison

with the Bales et al. (2001, 2009, : : :) ice cores measurements should be useful here. Authors: An evaluation against other model outputs is not the most optimal way of doing evaluations. We evaluated our simulations against independent GrIS observations (see our answers to Reviewer #1). The simulations were evaluated in detail against observations from the GrIS Kangerlussuaq catchment, from where we have the most detailed long-term observations on air temperature, SMB, location of ELA, and catchment outlet river runoff available. This evaluation has been included in Section 2.3, and can further be found in the recent published paper by Mernild et al. (2018), doi.org/10.1080/15230430.2017.1415856. For further see above.

Line 316-318: SnowMOdel generally agrees with : : : It is not a validation! What do you mean by "generally agrees" ? A validation with the PROMICE SMB data set is absolutely needed. Authors: We agree that validation is important, which is already highlighted in the text (See Section 2.3), and why we several times in previous GrIS studies have verified SnowModel GrIS simulations against independent observations, to highlight the (in)accuracy of our simulations. The present SnowModel ERA-I GrIS simulations (using the same DEM) was validated against observations from the Kangerlussuaq catchment, SW Greenland, against observations from AWS and SMB from the K-transect and catchment outlet runoff (Mernild et al. 2018).

Further, below is a list of the SnowModel GrIS studies, where SnowModel routines have been validated over time against independent observations:

Parameters used for validation Difference between simulations and observations Time period Reference Meteorological data from AWS located on GrIS (from GC-Net): - Air temperature - Wind speed - Relatively humidity - precipitation

0.2°C 0.2 m s-1 0.1 % 1.0 mm w.e. 1995-2005 Mernild et al. 2008

MAAT (from K-Transect) 0.2–0.5°C (Forcing and DEM are similar to this TCD study in review) 1979-2014 Mernild et al. 2018 End-of-Seacon satellite-derived surface melt extent Average 4 % and maximum distance of 160 km between modeled and satellite-

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derived melt and non-melt boundaries. 1995-2005 Mernild et al. 2008

End-of-season satellite-derived surface melt extent

Mean annual satellite-derived surface melt extent Average 40 $\pm$ 35 km and maximum âĄŞ160 km

0.4 $\times$ 105 km2 2010

1979-2010 Mernild et al. 2011 Melt-index Modeled results are consistent with observations 1995-2005 Mernild et al. 2008 Location of ELA Average 35 m a.s.l. and maximum 425 m a.s.l. 1995-2005 Mernild et al. 2008 Average meteorological data (the explained variance): - air temperature - wind speed - precipitation - relatively humidity

SWE depth

End-of-season satellite-derived surface melt extent

84-87% 49-55 % 49-69 % 48-63 %

1 %

Average 7.8 $\pm$ 5.1 and maximum 22 km 2000-2007 Mernild et al. 2011 SWE depth Mean ELA Daily ranked runoff (the explained variance) 1% 50 m in elevation 0.86-0.97 2009-2013 Mernild et al. 2015 GrIS SMB Mean annual difference between simulations and observations 0.17 $\pm$ 0.23 m w.e. (Forcing and DEM are similar to this TCD study in review) 1979-2014 Mernild et al. 2018

References: Mernild, S. H., Liston, G. E., Hiemstra C. A., and Steffen, K. 2008. Surface Melt Area and Water Balance Modeling on the Greenland Ice Sheet 1995–2005. Journal of Hydrometeorology, 9(6), 1191–1211.

Mernild, S. H., Liston, G. E., van As, D., Hasholt, B., and Yde, J. C. 2018. High-resolution ice sheet surface mass-balance and spatiotemporal runoff simulations: Kangerlussuaq, West Greenland. Arctic, Antarctic, and Alpine Research (Special Is-

sue), doi.org/10.1080/15230430.2017.1415856.

Mernild, S. H., Mote, T., and Liston, G. E. 2011. Greenland Ice Sheet surface melt extent and trends, 1960–2010. Journal of Glaciology, 57(204), 621–628.

Mernild, S. H., Holland, D. M., Holland, D., Rosing-Asvid, A., Yde, J. C., Liston, G. E., and Steffen, K. 2015. Freshwater flux and spatiotemporal simulated runoff variability into Ilulissat Icefjord, West Greenland, linked to salinity and temperature observations near tidewater glacier margins obtained using instrumented ringed seals. Journal of Physical Oceanography, 45(5), 1426–1445, doi: 10.1175/JPO-D-14-0217.1.

Fig 2: showing mean SMB without a validation or without a 2D comparison with other models (e.g. MAR or RACMO) is not interesting for me. Authors: We prefer comparing SnowModel simulations against observations rather than comparing the simulations against other model systems (see above). Comparisons between models may be flawed if both/all models are 'wrong' or biased but still produce similar results. Therefore, it is more comprehensive to use observations for comparison. However, to approach the reviewer's request for model comparisons, we used model simulations from other studies for evaluations in the Result and discussion.

Fig 3b: what is the interest of showing the 2 last figures? Authors: It is simply to highlight the spatial variability in refreezing and retention when using the standard 6-catchment division compared to our 3000+ catchment division. Studies use this simple division of six GrIS basins, but to give a more detailed and spatial catchment illustration of the refreezing and retention conditions we included these last two figures. This was one of the issues, among many, discussed at a Greenland Ice Sheet Retain Workshop, held in June 2016 at GEUS in Copenhagen, and which would be of interest for the community.

Fig5: these figures are not readable. Authors: Please see our response to Reviewer #1 regarding Figure 5.

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