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Climate of the Past Discussions

Interactive comment on "Eemian Greenland Surface Mass Balance strongly sensitive to SMB model choice" *by* Andreas Plach et al.

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This study is focused on understanding the challenges and sources of uncertainty of simulating the surface mass balance (SMB) of the Eemian interglacial period. Steady-state time slice simulations are performed for the Eemian and the present day, with global and regionally downscaled climatic forcing applied to several combinations of SMB models. The manuscript does a good job of describing many aspects of Eemian smb modeling that are often overlooked (seasonal changes in climate, sea-ice extent, lapse rate validation). The review of past Eemian sea-level contribution estimates is also well done, even if it is only part of the motivation for the current work rather than the main focus. I think that the paper should be published after minor revisions, explained below.

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Discussion paper

This is an excellent time-slice study with a good experimental design and thorough analysis. However, it is missing any insight into the role of feedbacks in transient coupled experiments where the ice-sheet topography could evolve. This could arguably be as important as the inherent bias that a particular smb model imposes, or even more so – see Robinson and Goelzer (2014), for example. I suggest adding some discussion of this point (note that this is a different point than that of the last paragraph on Page 18, and the first paragraph of Page 19 is more focused on whether a given time slice is realistic).

While I found the analysis very thorough, it was difficult to agree with the overall conclusions reached by the authors. For example, I disagree with this sentence from the abstract: "We suggest that future Eemian climate model inter-comparison studies are combined with different SMB models to quantify Eemian SMB uncertainty estimates." To me this is a strange conclusion to make, or perhaps I don't understand the phrasing clearly. Should we believe PDD is providing added information to an energy balance model? This also comes up in the last paragraph of the Discussion. The authors seem to conclude that all SMB models are needed, because emissivity of the atmosphere is uncertain. This is a strong conclusion, but here nothing was done with emissivity. Further, wouldn't a more prudent conclusion be that deeply uncertain parameters in complex models should include sensitivity experiments (parameter perturbation) rather than simply reverting to simpler models known to lack important processes?

Along those lines, I think it would have been quite interesting to see if using different parameter values (for example changing the emissivity of the atmosphere), it would be possible to bracket the MAR-SEB results on both sides with MAR-BESSI (SMB at 130ka showing negative and positive anomalies). That would go a long way towards showing that lower complexity smb models can be useful, but several simulations may be necessary to sample the uncertainty. [This is only a suggestion, not a requirement for publication.]

Generally, the manuscript could use a revision for English usage as well. Some mis-

takes are highlighted below. Particularly, I noticed the article “the” missing in many instances.

== Minor comments =====

Page 1, line 2: Eemian interglacial => Eemian interglacial period

Page 1, line 5: “introduces uncertainties” sounds a bit strange, consider rephrasing.

Page 1, line 10: the calculation of insolation should be straightforward – do you mean shortwave radiation at the surface?

Page 1, line 12: simulated climate => simulated climate,

Page 2, line 1: Past interglacials => Past interglacial periods [Generally this should be changed throughout, as “interglacial” is only and adjective.]

Page 2, line 7: pre-industrial => pre-industrial period

Page 4, line 30: surface air temperature => near-surface air temperature [?]

Page 4, line 34: “The only process it neglects” <= This is a strong statement, consider rephrasing.

Page 5, table 1: Units of PDD factors should be “mm/K/day”

Page 6, line 15: linearly => bilinearly [?]

Page 6, line 7: This 30 years => These 30 years

Page 8, Fig. 1: Lighter colors in the lower boxes would make this figure easier to read.

Page 10, line 13: “with an adapted PDD scheme” <= the ITM equation used by Robinson et al. (2011) and Calov et al. (2015) is not a PDD scheme, it is a “linearized energy-balance” scheme (originally published by Pollard, 1980).

Page 13, line 35: are we using => we use

Page 14, line 20: refreeze => refreezing [Change everywhere it appears as a noun.]

Page 15, line 6: “warmer/cooler at 125/130 ka” <= Consider reversing the time order here for consistency with elsewhere.

Page 15, line 7: I think Arctic warming and amplification are not synonymous, consider revising here somewhat for clarity.

Page 15, line 13: During early Eemian => During the early Eemian

Page 15, line 18: Sea ice are => Sea ice is

Page 18, first paragraph: This seems more like Discussion than Results.

== References =====

Robinson, A. and Goelzer, H.: The importance of insolation changes for paleo ice sheet modeling, The Cryosphere, 8, 1419-1428, https://doi.org/10.5194/tc-8-1419-2014, 2014.

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