## Answer to Referee #1

In the present study the authors investigate the influence of the Greenland ice sheet on Greenlands surface climate during the Eemian interglacial. A comprehensive climate model is forced by different realizations of the Greenland ice sheet. The results show a significant impact of the topography on the surface air temperature despite a correction for the different elevations. Local changes of the energy budget appear to be the dominant mechanism while anomalous advection due to changes of the large scale dynamics is less important. For winter, the sensible heat flux is most affected due to surface wind anomalies controlled by the slope of the ice sheet. For summer, temperature anomalies are related to changes in surface albedo. The results suggest that a substantial part of the Eemian warming signal in Greenland proxy data may be attributed to local forcing due to changes in topography.

Paleoclimate reconstructions from proxy data are an important source of information in climate science. In particular the Greenland ice sheet provides an extensive archive of valuable data. However, to interpret these data correctly and to draw significant conclusions uncertainties need to be assessed and the data need to be linked to the underlying processes. Here, sensitivity studies based on model simulations can be of substantial help. For Greenland, the relatively pure knowledge of its paleo-topography introduces a high degree of uncertainty. In addition, the role of Greenlands topography for the local climate and the large scale atmospheric dynamics is still not completely understood.

The present study is a valuable and substantial contribution. It is clearly written and well structured. Overall, it provides sufficient new information to warrant publication in Climate of the Past. I only have three points the authors may consider to further improve the paper:

We kindly thank the referee for the encouraging feedback and the constructive comments on how to improve the paper. The three points are all addressed and answered below.

1) Most changes found in this study are related to changes in the planetary boundary layer. However, it is well known that there are large uncertainties in representing boundary layer physics in GCMs, in particular for stable stratification which is the case here (e.g. Holtslag et al. 2013). The authors may discuss/note this issue.

This is a valid comment and we acknowledge that the model's representation of the boundary layer is likely an important source of uncertainty for the results of this study.

Within revised conclusions:
„The simulated temperature response to changes in the GrIS topography shows particularly local characteristics during the winter season when the shape of the GrIS determines which areas are (relatively) warmed by the SHF in the katabatic wind zones in contrast to areas which experience little turbulence and are marked by strong cooling. However, these results strongly depend on processes within the stable boundary layer, and leading to some uncertainty in representing the amplitude of these SAT anomalies as they are sensitive to the details of the boundary layer formulation (Holtslag et al., 2013).“

We further specify the used atmospheric boundary parameterization scheme within the model description part in Section 2.

P6688,L11:
"As this study focuses on Greenland's surface climate, processes occurring within the atmospheric boundary layer and concerning the (partially) snow-covered land surface are of importance. For the former, the atmospheric model (CAM4) uses the non-local atmospheric boundary layer parameterization by Holtslag and Boville (1993). A detailed description is given in Neale et al. (2010)."

2) Figure 8 may be completed by the flux for snow melt.

The CCSM4 model provides a ground heat flux field which describes "heat flux into soil/snow including snow melt". The respective annual cycles at Camp Century (CC) and pNEEM are shown in Fig. A1. Two results can be drawn from Fig. A1: namely a receding ice sheet at CC (e.g. EEMr1 or EEMr2) leads to an increase in the ground heat flux in June at the expense of July which likely means that snow melts earlier compared to EEMpd. Further, at pNEEM we find that the strong warming in EEMr2 (mainly due to the local decrease in surface elevation) leads to a slight increase in summer ground heat flux which is likely a snow melt signal as an increase in snow melt amount (mm water equivalent) is also simulated by the land model component (not shown).

However, as we can not explicitly quantify the detached energy flux anomalies of snow melt we prefer not to include this figure within the manuscript but rather describe it in the text (P6704, L23).

3) In section 2.4 (page 6693) the authors state that in the present day simulation the implemented Greenland ice sheet is ’rather too flat’ compared to the real world. In the sensitivity studies, however, it appears that the prescribed perturbations are directly taken from the ice sheet model output without any scaling. Questions: How large is the difference to the real world in the present day setup? Does this means, that the effect of the reduced ice sheet is somewhat overestimated in the simulations? And, wouldn’t it be more appropriate to use scaled ice sheet anomalies?

The difference in surface elevation comparing the CCSM4 present-day topography with the ETOPO1 observations (Amante and Eakins, 2009) reveals that the surface elevation in northern and central Greenland is generally underestimated by 100-300 m as also shown in the elevation transect (Fig. 9a in the manuscript). Moreover, large deviations appear in coastal areas where the complex topography can not be fully captured by the horizontal resolution of the model (0.9°x1.25°). In addition the model likely includes a smoothed GrIS topography to avoid numerical problems.

Hence, it is true that the reductions in terms of ice sheet height are rather overestimated. However for large parts of the ice sheet (with the exception of coastal regions) the differences are relatively small, so including scaled anomalies would not dramatically change the result. For example, the implemented surface elevation reduction at NEEM in EEMr1 (see Fig. 9a in manuscript) is 400 m that corresponds to 19% reduction of the EEMpd surface elevation (2100 m). When using the observed elevation (2350 m) as reference, the reduction of 400 m corresponds to a 17% decrease. Consequently, the error associated with the omitting of the scaling should be of minor importance compared to other uncertainties associated with the Eemian ice sheet configurations provided by the ice sheet models as the Eemian topographies are weakly constrained.

Nevertheless, we consider this as an important remark and we include a corresponding comment in the model description paragraph in order to make this point clear.

P6693 L17
“Besides, the implemented elevation changes are slightly overestimated with respect to ones simulated by the ice sheet models as they are added to the smoothed CCSM4 topography.“

**Figures**

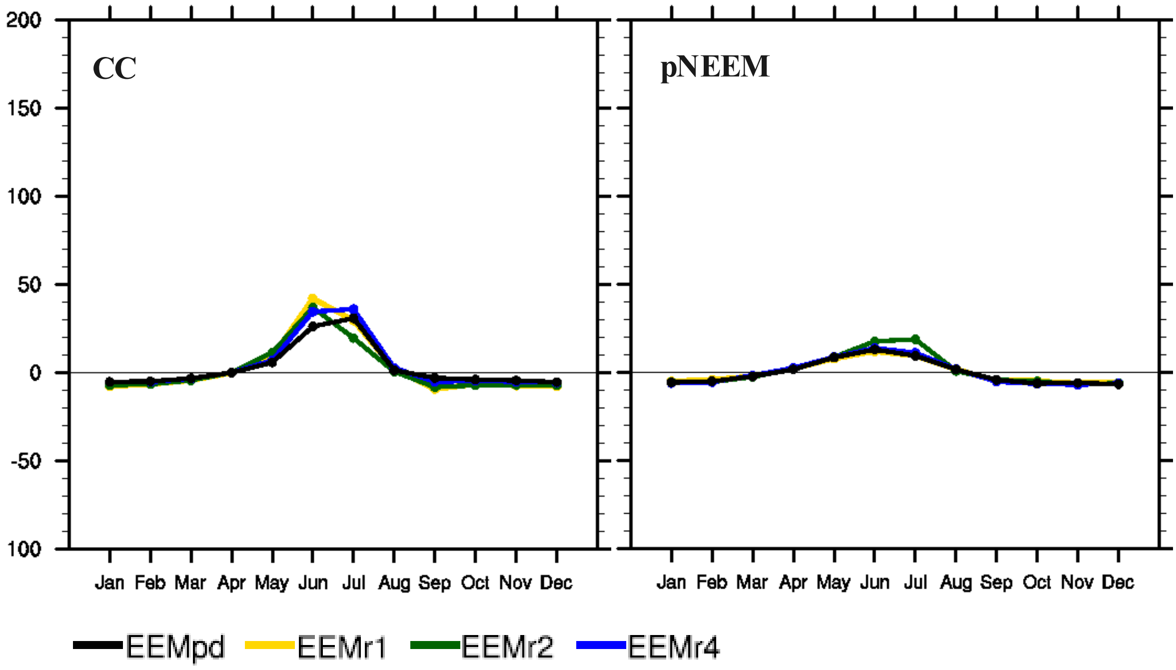


**Fig. A1:** Annual cycle of ground heat flux (including snow melt) [W/m$^2$] at Camp Century (CC, left) and pNEEM (right). The sign convention is positive into the soil/snow. .

**References**

Amante, C. and B. W. Eakins, ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis. *NOAA Technical Memorandum NESDIS NGDC-24,* 19 pp, March 2009