Responses to Reviewer #2's comments

General comments:

This manuscript presents an interesting study of the Eurasian Ice Sheet, addressing a wide range of configurations towards the Last Glacial Maximum under different climate forcings and evaluating the mechanisms that might have triggered its deglaciation.

Overall, the manuscript presents a nice approach, using a palaeo-ice sheet to explore the impact of individual processes needed to account for the mechanisms involved in the growth and demise of EIS. My comments mainly concern the finding of the dominance of atmospheric processes over ocean processes for the EIS and its dependence on the parameters chosen. The following suggestions will contribute to strengthening the analysis and conclusions.

The authors are very grateful to Reviewer #2 for taking the time to write such helpful, thorough and constructive comments. All the comments have been taken into consideration in the revised manuscript. Our responses are written in blue, and excerpts from the manuscript are italicized. Line numbers refer to the revised manuscript.

Specific comments:

Result-dependence on the parameters chosen. The first filter to select the global circulation models that reproduce in a good manner the geometry of EIS are the positive degree day (PDD) factors, the precipitation correction with the temperature, and the lapse rate. A sensitivity analysis of those factors will clarify if the finding is robust.

Thank you for this feedback. To address this comment, we have performed new spin-up simulations (100 kyr under constant LGM climatic forcing) and new perturbation experiments of the atmospheric temperature and the oceanic conditions (Tadd = +1 °C and +5 °C; Kt= 10 $m°C^{-1}yr^{-1}$ and Kt = 50 $m°C^{-1}yr^{-1}$). We have also modified the standard values of the degree-day factors, the factor controlling the precipitation correction with temperature and the lapse rate. As the main conclusion of the paper is the prevailing effect of the atmospheric forcing over the oceanic forcing in the EIS retreat at the beginning of the last deglaciation, the new values of model parameters have been chosen as to reduce the relative importance of the atmospheric forcing. The list of the new sensitivity experiments is given in the new Table 4. These new experiments and the related conclusions are described in a new section in the revised manuscript (Section 4.4.1). The results are displayed in Figure 11. The analysis of these results leads to the following conclusion:

As such, this series of perturbed experiments shows that changing climate-related model parameters results in only small changes in the EIS ice volume loss compared to the standard configuration of the GRISLI ice-sheet model, and does not question the prevailing influence of the atmospheric forcing suggested by our reference sensitivity experiments.

A list of key parameters and the range of values that were tested should be included.

Besides Table 4 that is related to the new sensitivity experiments, we have also added two Tables (Table 2 and Table 3) that list the model parameters (and their value) and the physical parameterizations used in the GRISLI2.0 ice sheet model.

As mentioned before, the conclusions are highly dependent on the parameters. For instance, different PDD factors and calving rates might lead to a different sensitivity to the climate.

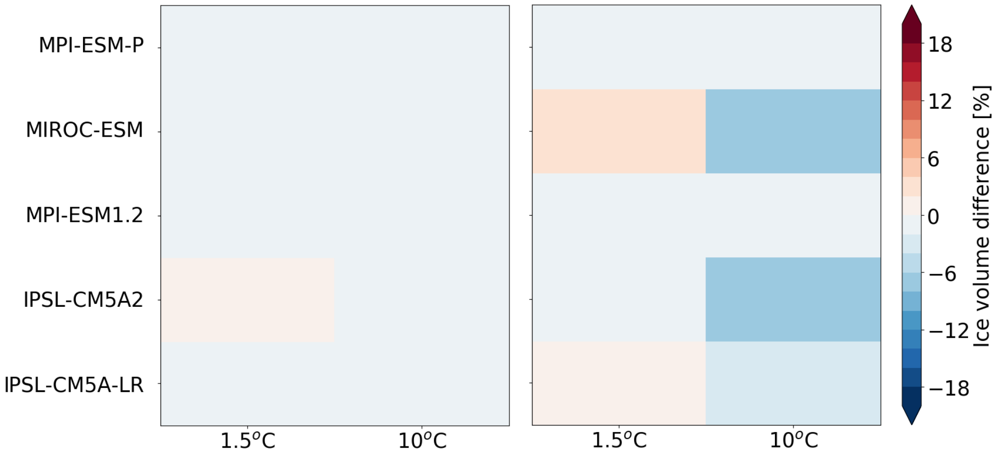
We have also changed the calving cut-on criterion (from 250 m to 50 m) with the objective of increasing the area covered by ice-shelves. This is described in Section 4.4.2 dedicated to changes in physical parameterizations:

Thinning of confined ice shelves through basal melting produce a weakening of the buttressing effect, implying an acceleration of the grounded ice streams and ultimately a substantial ice discharge in the ocean. This sequence of events was observed in the Antarctic Peninsula after the collapse of the Larsen B Ice Shelf in 2002 (Rignot et al., 2004; De Rydt et al., 2015). In our reference experiments, the ice shelf extent is small (Fig. 3). This likely explains why the EIS appears poorly sensitive to basal melting. In order to potentially increase the area of ice shelves, we reduced the calving criterion from 250 m to 50 m. This results in a slight increase of the ice shelf area at the LGM (Fig. SP12d) compared to the reference simulations (Fig 3). However, this increase did not result in a substantial change of the sensitivity of the EIS to basal melt and atmospheric temperature perturbations (Fig. 11g). This limitation is due to the topography, which does not allow for adequate confined ice shelf development, unlike the Antarctic, where the presence of bays (in Ross and Weddell Seas for example) allows the formation of confined ice shelves.

For better analysis and understanding of the reader, the multi-model mean of the ice thickness should be shown as a reference. → Done (see the new figure 3 in the revised manuscript)

Although the sensitivity experiments performed in this study cover a wide range of possible drivers (EXP1-5), experiments conducted to evaluate the impact of changing both oceanic forcing and the sea level could be performed.

This is a very interesting suggestion because sea-level rise can lead to changes in the geometry of both grounded ice sheet and ice shelves. In turn, changes in the EIS configuration could modify its sensitivity to oceanic conditions. Following this suggestion, we have performed additional experiments by combining a sea-level perturbation (+10 m with respect to -120 m) and an oceanic temperature perturbation (+1.5°C and +10°C). The results are displayed in the following figure:



Differences in ice volume loss (in %) between the experiments combining sea level and oceanic perturbations and the corresponding EXP3.2 experiments.

As shown in this figure, differences with the EXP3.2 experiments are negligible on time scales of 1000 years. On longer time scales, differences do not exceed 7% for only two GCM forcings. We commented these results in the revised manuscript at the end of Section 4.2.5 :

However, it should be noted that sea level rise can lead to changes in the geometry of the ice sheet and floating ice shelves. Therefore, these changes in the EIS configuration may influence its sensitivity to oceanic temperature perturbations. We tested this hypothesis by raising the sea level from -120 m to -110 m compared to the current level and by raising concomitantly the oceanic temperatures (+1.5°C and +10°C). Adding a sea level perturbation to the oceanic temperature perturbation does not drastically change the response of the ice sheet. Differences of 6 to 7 % in ice volume losses were only observed for the highest temperature perturbation (+10°C) after 10 000 years for only two GCM forcings (MIROC-ESM and IPSL-CM5A2), while the differences are negligible (lower than 2%) for smaller perturbations, shorter timescales and other GCM forcings (not shown).

Technical corrections:

L126: “Bmelt” instead of “bmelt” “done”

L515: “4-1” instead of “4_1” “done”