To reviewer 2

The authors have run LIG simulations with three different versions of MIRCO model, the climate change between the LIG and PI are compared with proxy data. They show that all three models have produced expected warming in summer correspond to the imposed orbital forcing. Among the three models, only one model that is coupled with a dynamical vegetation model, is able to reproduce the annual warming over the northern high latitudes. And they conclude that vegetation feedback is necessary for reproducing the comparable warming showing in proxy data. The paper is an overall evaluation on simulated LIG climate by MIRCO, it is a good documentation for the LIG simulations from this specific model. The authors may consider the following comments and improve the manuscript.

We greatly appreciate that you agreed to review this paper and we thank you for your positive comments. We revised our manuscript following your and another reviewer's comments. Please find following response to specific comments.

1. The models are presented in a clear hierarchy, from an AOGCM, to a AOGCM coupled with LPJ vegetation and finally an earth system model with more physical processes are included. The results are obviously not following the complexity of the model components, instead it turned out the version OAGCM+LPJ version is the one that better agree with temperature reconstruction. Besides concluding that vegetation feedback play important role to simulate LIG climate, the authors should discuss more why the other components such as biogeochemistry over the land and in the ocean do not contribute much to the expected LIG warming. Does it imply these components are not important or these components do not work well in LIG climate?

In all experiments, GHG values are fixed to specific values in all models including MIROC-ES2L along PMIP4 protocol. It means that land and ocean ecosystem do not affect on atmospheric GHGs. The different GHGs between PI and 127k may cause slight difference on LAI through difference of photosynthesis, but it is negligible. We add explanation of fixed GHG treatment in the experimental settings.

2. For the major conclusion, the important contribution from vegetation feedback to reproduce the warming over land and northern high latitudes, the authors did not present the relevant feedbacks. Is it due to the change in the albedo, or LAI, or evaporations? According to the results from ESM, it seems LAI does not contribute much. It is not clear which physical processes are associated to LAI, if these processes do not contribute to the warming, does it mean they are not important at all or they are not well represented in this model? More discussions on these key questions would provide

useful information on how to improve the model.

This comment is related to comments 4 and 6. We explain the feedback processes focusing on the surface energy balance by referring previous studies (Laîné et al. 2015 and Yoshimori and Suzuki 2019). To explain the effect of biogeophysical feedback on surface temperature, we will add figures focusing on change in albedo. This figure also helps explanations to the reviewer's comments 4 and 6. In MIROC4m-LPJ, not only LAI increase but also vegetation height reduces snow amount in MAM -> reduction of albedo larger than that of due to vegetation change in MAM -> larger ice reduction in the Arctic Ocean in summer -> heat stored in Arctic Ocean -> stored heat is emitted in SON. We plan to add discussion on changes in surface energy flux components and/or related variables over the largely warmed land region."

3. The presentation on the results are lack of the motivation, each section simply starts with showing the figures on temperature, precipitation, sea-ice and vegetation and did not mention why do authors show these results. We may understand that simulated temperature can be compared with proxy data and tell us if the warming in certain regions are well reproduced. What do the resulted precipitation and sea ice imply? It would be helpful that author can provide a few motivation sentences for their results presentation.

In the present study, we clarify how vegetation feedback affects on the LIG climate, throughout different processes in different seasons. Precipitation change is important to understand vegetation distribution and its feedback. Sea ice change is also an essential ingredient of warming amplification.

4. For the sea-ice, the authors may aim to show that sea-ice feedback is contributing to the high-latitude warming. In this case it is better to use the sea-ice extent instead of thickness, which can better explain the sea-ice-albedo feedback. It would be helpful to add some discussion on sea-ice feedback, instead of only showing the differences in sea-ice.

Sea ice figures will be replaced to sea ice extent (with observed value, suggested by reviewer #1). We will add explanations on the interseasonal effect of sea ice feedback referring previous feedback studies (Laîné et al. 2015, Yoshimori and Suzuki 2019) which also answers to comment 2 and 6. We plan to add discussion on changes in surface energy flux components and/or related variables over the Arctic ocean region.

5. For the model-data comparison, the temperature reconstructions from two datasets are used, but no any comments on the uncertainty of each datasets. I suggest the authors provide some information on the data uncertainties in order to gain fair evaluation for the model results

We explain Turney and Jones (2010) indicate the maximum change during the whole LIG and not

directly comparable to 127k model result. However, sign and pattern is worth comparing with model result since number of data site is very small in newer transient-based reconstructions (Capron et al., Hoffman et al. 2017).

6. Fig1 shows much less insolation in SON in northern high latitudes, but in all three models simulated warm Arctic in surface air temperature in fig4, especially a strong warming in MIROC4m-LPJ version. Authors should mention this in the text and give some explanations.
The explanation is related to the reply to reviewer's comment 2 and 4. Due to an intra-seasonal feedback, sea ice change in summer causes warming in SON in spite of less insolation in the Arctic Ocean in the LIG. We will add detailed explanation in discussion part.

7. L129, "We also compare model annual SST..", should be "We also compare modelled annual SST...".
Corrected.

8. Line 150, this section is talking about the precipitation and it is strange to end with a sentence with vegetation distribution in Sahara. Consider to remove. It is more appropriate to mention it as in L193-194, so called "green Sahara" needs the reference, and specify how green it is? Do the proxy data indicate any specific vegetation type development in Sahara, and within how large area?
This part is removed as suggested. We referred Larrasoaña et al. (2013) as reference of Green Sahara in the LIG. This research estimated the expansion of vegetation in the LIG from correspondent wetness in the LIG.

9. L161, "...on the eastern coast of Geendland", I observed the northern part of Greenland in figure 13. In fig13, it doesn't make sense that warm LIG climate produces more sea-ice than PI in March (fig1 shows more insolation in MAM in northern high latitudes), any explanation?
Modified to "northern part of Greenland". The difference of sea-ice shows reduction in the major part of the Arctic Ocean in all three models, though small increase occurs in coastal region. As same as comment 4, we plan to add explanations based on surface energy fluxes.

10. L171-172, ".... as well as NH", this is confusing and suggest to rephrase.
Modified to "similar to".

Figures:
1. In Fig3, the Greenland ice-sheet distribution in ES2l looks different from others, any explanation?
MIROC-ES2L applies a new definition of land-sea mask than that of MIROC4m. The distribution of prescribed vegetation is also re-defined from newer satellite data set than MIROC4m. These

explanations are added to the model section.

2. Fig5, though it shows Greenland, would be helpful to have the lat-lon labels.

To be corrected.

3. Fig6 and Fig7, it is difficult to distinguish the dark red and dark blue for proxy data, for example those over the Greenland, suggest to change the colour bar for a clear distinguish.

Figures 6 and 7 are corrected along both reviewer's comments.