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Geoscientific Model Development Discussions

Interactive comment on "Simulating the mid-Holocene, Last Interglacial and mid-Pliocene climate with EC-Earth3-LR" *by* Qiong Zhang et al.

Qiong Zhang et al.

qiong.zhang@natgeo.su.se

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Thanks for the review comments, we have taken into account the suggestions and revised the manuscript accordingly. Below is our response to your comments.

1. As suggested, we have added more motivation and description on the three past warm periods in the introduction. We also included summary on simulated large-scale features by the PMIP4 models on mid-Holocene (Brierly, et al., 2020), lig127K (Otto-Bliesner et al., 2020) and mid-Pliocene (Haywood et al., 2020).

2. The core information for introducing a new albedo parameterization is to better represent the albedo-feedback by allowing the snow can fall and melt over the icesheet, instead of static in previous scheme. We now mention this core information in the

beginning of section 2.2.2.

3. Thanks, as suggested we now combine 4.1 and 4.2 into one section to describe the global features of temperature and precipitation. We also added a global change in precipitation.

4. Thanks for your carefully reading and observed this mistake. Indeed, it should be "stronger" Hadley circulation but not the "weaker" as stated in the manuscript. As shown in Figure 4b and 4c, the midHolocene and lig127k simulations show slight cooling in the SH compared to the tropics. This can induce a slightly stronger meridional temperature gradient and favor a stronger Hadley circulation in Figure 5a and c. This is corrected in the revised version.

5. In Figure 5, we have compared the PI climatology of vertical integrated zonal mass stream function (ZMS) (in contours) and the anomalous ZMS in all three warm periods (shading), they all exhibit positive anomalies west of the positive Centre in PI run, which is indicating the westward movement of the Walker circulation. The westward shift appears more evident in the lig127k and midPliocene than in the midHolocene simulation. We now provided the climatology for all the simulations in the supplement for a better comparison.

6. The sea ice extent defines a region as either "ice-covered" or "not ice-covered." In the model grid, for each grid cell, a threshold determines either the cell has ice or the cell has no ice. Here we apply a commonly used threshold 15% (such as used by National Snow and Ice Data Center NSIDC), meaning that if the model grid cell has greater than 15% ice concentration, the cell is "ice-covered." A threshold can also be as high as 30 percent. The sea ice edge is the 15% sea ice concentration isocline. We added our definition of sea ice and sea ice edge in the text.

Indeed, the mPlio-PI anomaly is smaller in August than in March, simply because the difference between the two simulations is smaller then. In August, the PI simulation has less than 10*10ˆ6 kmˆ2 of sea ice, while the mPlio simulation has 0. Therefore, the anomaly is smaller than $10*10^6$ km^2 in this month. On the contrary, in March the PI simulation has more sea ice (winter peak) and also a larger difference with the mPlio simulation, of almost $12*10^6$ km^2 more sea ice. Therefore, Figure 6 and 7 are consistent with each other."

7. Thanks for the comments. We collected the published SST reconstructions for all three warm periods and added a data-model comparison on SST in section 4.2.

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