Clim. Past Discuss., 8, C3683–C3693, 2013
www.clim-past-discuss.net/8/C3683/2013/

Climate of the Past Discussions

Interactive comment on "Variations of oceanic oxygen isotopes at the present day and the LGM: equilibrium simulations with an oceanic general circulation model" *by* X. Xu et al.

X. Xu et al.

xu.xu@awi.de

Received and published: 29 April 2013

General Comments The referee asked for improving the organization, description of aspects, and language to make the manuscript more clarity.

We thank the anonymous referee for his/her comments. They are very helpful in improving our paper. We will work on improving the clarity of our manuscript in the revision. The following are point-by-point responses to the comments.

Special Comments 1. The referee asked for more contexts to clarify the motivation and the unique aspects of the current work.

For an improved presentation of the motivation and goals of our study, we have added one more paragraph in the introduction (2nd paragraph) to briefly describe the previous isotope modeling studies. Furthermore, we rearranged the third paragraph in the introduction to explain the different aspects of our work. Context is also added in this paragraph to contrast our study from previous isotope modelling studies.

2. 'Why is the model PD seawater d18O distribution not directly compared to the Global Seawater Oxygen-18 Database (Schmidt et al., 1999; LeGrande and Schmidt, 2006)? Calculating carbonate d18O via a paleotemperature equation in order to compare the PD model results against a Holocene planktic foraminiferal carbonate d18O dataset unnecessarily includes additional errors.'

The comparison with the Schmidt d18Ow database has been done in a previous study (Xu et al., 2012), which shows good agreement with the observations. Therefore in this study, we applied the paleotemperature equation to calculate carbonate d18Oc, and compared it with available late Holocene measurements to show the practicability of this method for later application on the LGM results. The reference to the d18Ow comparison has been added in the discussion section of the revised manuscript.

3. 'The overall organization of the study's results (all parts of section 3) has significant room for improvement. A more rational order would first present the PD and LGM physical characteristics of the ocean, then the PD and LGM d18Ow distributions, followed by model-data comparison for the PD and LGM (in order to show that the modeled PD and LGM are reasonable), then finally concluding the results section by describing the ISOPD simulation and differences between the runs. The simultaneous description of what is observed in the LGM, PD and ISOPD simulations together is currently quite confusing.'

We have changed the order of the presented results according to this comment. The Results chapter now comprises three sub-sections. Sub-section 3.1 ('Comparison of simulated LGM and PD ocean physical state') presents and compares the sea surface

temperature, sea ice cover, and the AMOC of the LGM and PD simulations. Distributions of d18Ow and d18Oc at PD and LGM, as well as the model-data comparison are shown in sub-section 3.2 ('Variations of d18Ow and d18Oc at PD and LGM'). The last sub-section 3.3 ('Sensitivity experiment') compares the ISOPD simulation with the LGM and PD results to explain the isotope variations due to the change of surface fluxes and ocean circulation.

4. 'Clarity in language can be improved throughout. I have included technical corrections below.'

We have tried to improve the clarity in language in the revised manuscript version.

5. 'Conducting one additional experiment in order to separate the contributions of surface fluxes vs circulation changes to seawater d18O variability does not constitute "sensitivity studies". Hence, the statement at line 18 that "Sensitivity studies are used to understand the factors giving rise to the variations of d18Ow during PD and LGM" should be revised, as should other references to sensitivity experiments.'

The last sentence in the introduction has been revised to 'a sensitivity study'. Other references to 'sensitivity experiments' have been changed, accordingly.

6. 'The COSMOS model should be described at its first use (pg 4889, L. 4) (instead of later at L. 24), and a brief but complete explanation of this model run added. For example, what LGM boundary conditions were utilized for the COSMOS simulation?'

For more clarity, we adjusted the second paragraph of sub-section 2.2. We moved the general description of the COSMOS Earth System Models after the first mentioning of it in this paragraph. The external forcing and boundary conditions for the COSMOS LGM simulation have been imposed according to the protocol of PMIP3, and the details are available at http://pmip3.lsce.ipsl.fr, which is now stated in the revised manuscript version.

7. 'Are the carbonate d18O values reported as part of the observational database

raw values, or are species-specific offsets taken into account and corrections applied? Please briefly describe what level of data processing has occurred to the utilized data (section 2.4 and the accompanying supplementary table).'

We have revised the d18Oc database for the LGM. The new version of the database consists of the average depth (18-21ky, or single value depending on the resolution of sediment core) of Pangaea data and the data read from past publications. Descriptions are included in the second paragraph of subsection 2.4. The details of the LGM database (core locations, average depth/years, d18Oc values and references) are listed in detail in the Tables S1-Table S4 of the Supplement.

8. 'Throughout the discussion section, the authors should relate their interpretations to specific figures - for example, more use of "(see Fig. X) "'

We have included more references to the specific figures in the revised text.

9. 'The final sentence in the conclusions is a bit of a surprise. Precisely how can isotope model simulations be used to validate models? Remove or clarify this conclusion.'

This sentence has been removed.

Technical corrections All technical corrections have been included in the revised manuscript accordingly.

Figures 1. The white line in Fig. 1b is very hard to see, while the red line is clearly visible. Make the white line thicker, and just as visible as the red line (and change the white line's color if necessary).

The white line has been plotted thicker in the revised Figure 1.

2. In the caption for Fig 2a, AMOC is Atlantic meridional overturning circulation (not ocean circ.), and it should be specified that the basin-wide zonal mean is mapped.

The text has been revised accordingly

3. Figures 6 and 8 should be combined.

The figures were rearranged due to the modification in the results chapter. In the revised version, we combined the PD and LGM d18Ow distributions in the Atlantic and Pacific sections in Figure 5.

4. Figures 7 and 9 should be combined.

The order of figures has been changed after we rearranged the results chapter. The comparison of the Atlantic and Pacific subsurface to bottom d18Ow composition between LGM and ISOPD, ISOPD and PD, as well as LGM and PD are combined in the revised Figure 12.

5. For Figures 5, 7, and 9 depicting seawater d18O anomalies between model simulations, the caption or the figure titles should indicate what process(es) or effect(s) the anomaly is mapping. For example, the LGM-PD shows the effect of both surface forcing and circulation/topography changes, while ISOPD-PD shows the effect of LGM circulation/topography changes, etc.

The figures were changed due to the applied text modifications of the Results chapter. The effects of the mapped anomaly (LGM-ISOPD: the effect of surface forcing; ISOPD-PD: the effect of circulation/topography changes; LGM-PD: the effect of both surface forcing and circulation/topography changes) are now mentioned in the captions of Figure 11 and Figure 12 (former Figure 5, 7, and 9).

6. For Figures 11, 12, 13, and 14, include the statistical error metrics (NRMSE values) in either the caption and/or within the figures.

In the revised manuscript, the NRMSE values were added in the captions of Figure 7, Figure 8, Figure 9, and Figure 10.

Please also note the supplement to this comment:
http://www.clim-past-discuss.net/8/C3683/2013/cpd-8-C3683-2013-supplement.pdf

Interactive comment on Clim. Past Discuss., 8, 4885, 2012.

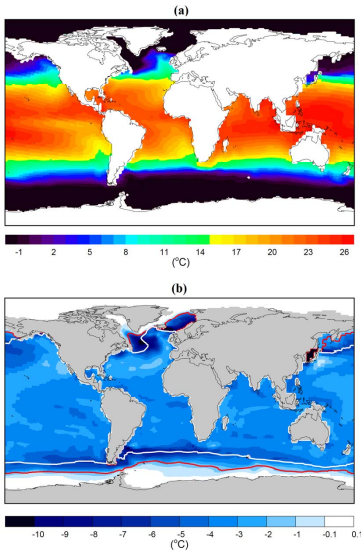

Figure 1 (a) Modelled annual mean sea surface temperature (°C) distribution at the LGM. (b) SST anomaly between LGM and PD simulations. Red line: 15% sea ice cover at PD; white line: 15% sea ice cover at LGM.

28

Fig. 1.

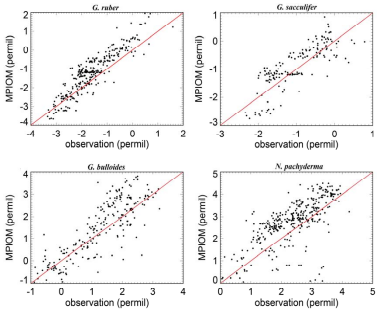

Figure 7 Comparison of observed $\delta^{18}O_c$ shown in the upper panel of Figure10 (averaged onto the MPIOM model grid) versus modelled surface $\delta^{18}O_c$ values for the present day climate (NRMSE: *G. rubber* 12.7%, *G. sacculifer* 14.8%, *G. bulloides* 15.0%, and *N. pachyderma* 20.9%). The 1:1 line is colored in red.

34

Fig. 2.

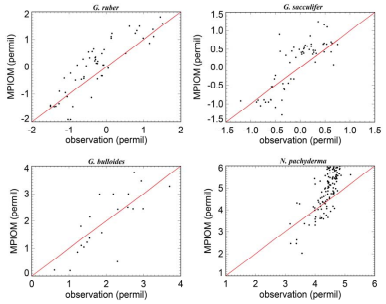

Figure 8 Comparison of observed $\delta^{18}O_c$ shown in the lower panel of Figure10 (averaged onto the MPIOM model grid) versus modelled surface $\delta^{18}O_c$ values for the LGM climate (NRMSE: *G. rubber* 15.2%, *G. sacculifer* 22.7%, *G. bulloides* 35.0%, and *N. pachyderma* 41.3%). The 1:1 line is colored in red.

Fig. 3.

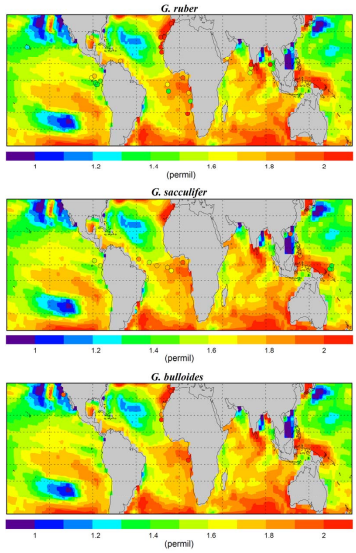

Figure 9 Modelled $\delta^{18}O_c$ differences between LGM and PD in tropical and subtropical surface waters. The circles show the LGM-PD differences from the observations (*G. rubber*, *G. sacculifer*, and *G. bulloides*) where both PD and LGM data exist (NRMSE: *G. rubber* 21.4%, *G. sacculifer* 30.3%, and *G. bulloides* 41.0%).

Fig. 4.

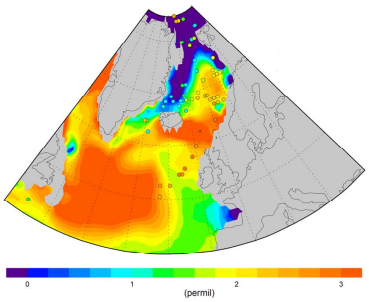

Figure 10 Modelled $\delta^{18}O_c$ differences between LGM and PD in the North Atlantic (north of 40°N). The circles show the LGM-PD differences from the reconstructions (*N. pachyderma*) where both PD and LGM measurements exist (NRMSE: *N. pachyderma* 24.8%).

Fig. 5.