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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.

Anonymous Referee #2

Received and published: 10 December 2012

I. General Comments

The present study describes the simulation of seawater oxygen-isotope distributions at present day and LGM using the isotope-enabled OGCM MPIOM-wiso, surface forcing from ECHAM5-wiso (which in turn is informed by simulations using the COSMOS model), with sea level adjusted in the LGM. Model-data comparison is achieved by converting the modeled seawater isotope distributions to carbonate d18O, and comparing this to planktic foraminifera d18O measured in in the Holocene (MARGO dataset) and in the LGM. The differences in isotope distribution are examined between the PD and LGM simulations, and one additional experiment consisting of LGM conditions with PD

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surface isotope fluxes is conducted. By differencing the simulations, the authors aim to separate the contributions of surface isotopic forcing from that of ocean circulation changes in order to explain the observed LGM-PD seawater d18O changes.

I find that this study presents several novel advances and results, which the authors should be commended for. The goal of diagnosing the relative contributions of surface isotope fluxes and ocean circulation to LGM vs present day seawater d18O variability is well achieved. It is noteworthy that the change in sea level has been accounted for, thus producing a more realistic ocean circulation regime with respect to topography for the northern North Atlantic. The main problem with the current manuscript is that of clarity, and stems from a combination of mis-used language, several areas with poor organization, and/or insufficient description. The upside is that given sufficient attention, it should be rather straightforward to address this problem in the manuscript. Please also note that in order to provide a completely independent peer-review, I have not read the other referee's comments.

II. Specific Comments

1. The introduction does not do a good enough job of explaining why this analysis is being done and presenting the motivation. Context is needed in order to relate this study, its goals and its methods, to previous ocean isotope modeling efforts for PD and LGM. The paper would greatly benefit from this additional context, possibly with a compare/contrast of model set-up and results. For example, how does the current study extend our understanding of LGM vs PD ocean isotope characteristics from past modeling studies (i.e. in the GISS Model-E (Schmidt, 1998), HadCM3 (Tindall et al., 2009), UVic (Brennan et al., 2012), GENESIS-MOM (Zhou et al., 2008), C-GOLDSTEIN (Rohling et al., 2004), CCM3 (Delaygue et al., 2000), etc.? Please clearly define and emphasize the unique aspects of the current work from the outset.

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)?

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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.

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.

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

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.

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?

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).

8. Throughout the discussion section, the authors should relate their interpretations to

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specific figures - for example, more use of “(see Fig. X)”.

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.

III. Technical corrections

1. Changes in title: “Variations” to “Variation” and remove second instance of “the”: “Variation of oceanic oxygen isotopes at the present day and LGM: . . .”

2. Change all occurrences of “data is. . .” to “data are. . .”

3. P 4886, L 3: change first occurrence of “last glacial maximum” to “Last Glacial Maximum (LGM, 21000 yr ago)” and change all subsequent occurrences of “last glacial maximum” to “LGM”

4. P 4886, L 6: change “but the Northern” to “except for the northern” (and all occurrences of “Northern North Atlantic” to “northern North Atlantic).

5. P 4887, L 5: change “local variations of oxygen isotope in sea water” to “local sea water oxygen isotope variations”

6. P 4887, L 8: change “acquire” to “simulate” or “represent”

7. P 4889, L14: change “are” to “is”

8. P 4889, L18: expand AMIP and/or describe what constitutes “AMIP-conform”

9. P 4889, L 24: change to “model COSMOS-landveg (version r2413), developed . . .”

10. P 4889, L 26: “The model setup is identical to the Millennium project COSMOS-1.20 release (Jungclaus et al. 2010), but with the addition of a dynamic vegetation module (Brovkin et al., 2009). Paleoclimatological studies employing COSMOS with a comparable setup have been successfully applied to the Holocene. . .”

11. Change all occurrences of “G. rubber” to “G. ruber”

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12. P 4891, L 4 remove “then”, change “them” to “these”

13. P 4891 L 7 change “SST gradient pattern” to “SST gradients”

14. P 4891 L 15 change “the sea-ice extents reach” to “sea ice extends to”

15. P 4891 L 19-20 change “the increase in sea ice compactness” to “sea ice concentration increases”, remove “is”

16. P 4891 L20 add “a” before “noticeable”

17. P 4891 L 26 change “is in the characteristics of their upper cell” to “is found in the upper cell”

18. Change all occurrences of “antarctic bottom water” to “Antarctic Bottom Water”

19. P 4892 L 7-9 change to “under different ocean circulation and isotopic flux scenarios. First we evaluate the modelled sea surface zonal-mean isotopic composition.

20. P 4892 L 12 change “almost parallel” to “essentially equivalent”

21. P 4893 L 12 remove “one”

22. P 4893 L 24-25 change to “Increases (>1‰ are apparent in the d18O values of the Arctic Ocean and Baffin Bay.”

23. P 4896 L 24 change “upper” to “upward”

24. P 4897 L 1 change to “than at the 100m depth”

25. P 4897 L 8-9 change to “. . .reach +6‰ in the simulation for N. pachyderma, while the observations range. . .”

26. P 4898 – change the section title “Discussions” to “Discussion”

27. P 4898 L 10 change “sea surface temperature (SST)” to “SST” since it has already been defined (in Section 3.1)

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28. P 4898 L 12 remove “around”

29. P 4898 L 13 change to “Another important region of temperature decrease extends from the east of Iceland to the eastern Nordic Sea, and is comparable to paleoreconstructions”

30. P 4898 L 15 remove “in the”

31. P 4898 L 16 change to “indicated as a sea-ice free area in GLAMAP and recent recontructions. . .”

32. P 4898 L 18 replace “previous” with “LGM SST”, remove “during LGM”

33. P 4898 L 19 insert “and” before “our model results”

34. P 4898 L 20-23 change to “In the Southern Ocean, strong cooling . . . “ and “. . .increasing sea ice extent (Gersonde et al., 2005).”

35. P 4900 L 5-6 change to “. . . the variation of the vertical d18O distribution is mainly caused by the ocean circulation regime.”

36. P 4900 L 18 replace “glacial time” with “LGM”

37. P 4900 L 19 “agrees”

38. P 4900 L 21-22 change “upper shift of” to “bias in” and “a bit” to “slightly”

39. P 4900 L 23-24 “High d18Oc values. . . in the LGM eastern Nordic Sea, . . .”

40. P 4901 L1-3 Rewrite this sentence to increase clarity.

41. P 4901 L 11 change “for” to “of”

42. P 4901 L 18 change to “compensates for the effect. . .” and remove “distinct”

43. P 4901 L 19 change “for” to “in”

44. P 4901 L 25-26 change to “implies that all precipitation falling over Northern Hemi-

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sphere ice sheets will discharge into"

45. P 4902 L 5 change to "...the impacts of isotope fluxes and ocean circulation on the"

46. P4902 L 6 Rewrite this entire sentence beginning "Our modelled LGM..."

47. P 4902 L 9 change to "...situation, except in the northern North Atlantic."

48. P 4902 L 23 change "slightly" to "slight"

IV. 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).

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.

3. Figures 6 and 8 should be combined.

4. Figures 7 and 9 should be combined.

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.

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

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