

## ***Interactive comment on “A model-data comparison of the Holocene global sea surface temperature evolution” by G. Lohmann et al.***

### **Anonymous Referee #2**

Received and published: 28 September 2012

Paleoclimate data can provide a useful test bed for evaluating climate model performance. Compilations of published data sets, based on the biological alkenone and Mg/Ca proxies, are identifying large-scale sea surface temperature (SST) trends for the mid-Holocene to present. However, climate model simulations for the same time interval, although showing similar tendencies to the data, fail to reproduce the magnitude of the trends. This manuscript investigates reasons for these data-model discrepancies. The manuscript results show that the discrepancies may be a function of changes in the season the organisms record their SST signal or a change in water depth in which the organisms live. Taking into account these seasonal and depth biases improves the correspondence between the data and models, however mismatches remain and the manuscript concludes that quantitative data-model comparison may not be possible.

This manuscript presents interesting new findings on resolving data-model differences, by considering additional ecological variables that may be the source of the differences. This approach is novel and the results of value to the paleoclimate community. Ultimately, the manuscript challenges those producing paleoclimate data to better understand what aspect of climate their proxies are recording, and equally challenges climate modelers to identify deficiencies in the models. The study design is logical and the results support the manuscript's conclusions. Overall I recommend publication, though with additional documentation of the data sets used for the comparison, and with improvements to the description of some of the methods. I have provided detailed comments below, which I hope will help guide the authors in further strengthen the manuscript.

## MAJOR POINTS

1) The proxy data sets used for the data model comparison are taken from the compilation of Leduc et al. 2010a and are presented in Figure 1 and 2.

a. Citations for proxy data sets. As far as I can tell the citations to the original papers reporting the data are not included in the bibliography. I feel these citations must be included to give credit to those who originally produced these data.

b. Reproduce the metadata table from Leduc et al. 2010a and include seasonality information. Better documenting of the underlying datasets will help the reader understand the possible biases in the data used for the comparisons. In addition, some data studies already acknowledge a seasonal and/or depth habitat bias for their data sets, e.g. Seki et al (2004) – autumn SST, Lea et al. 2003 warm season and/or annual SST. If, for example, a data set has a known seasonal bias then it should not be compared to the global mean model output as this is not a like-with-like comparison and may artificially reduce (or increase) the correlation coefficient. Alternatively, if a dataset has a reported seasonal bias, yet correlates best with model SST for a different season or the mean annual SST then this may give indications as to the origin of the data-model

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discrepancies. In addition to documenting any recorded seasonalities in a metadata table, I would like to see the discussion on this point expanded (e.g. additional discussion at the end of section 4.1, page 1019 and section 4.2, page 1019 on particular records examined in this paper that report a seasonal or depth habitat bias).

c. Aliasing. The minimum requirement for data set inclusion in the data-model comparison is 10 values per 6000 years. However, looking at Figure 1 and 2, most records with this number of values show large variability over the 6000 years (e.g. PC17 (which seems to have only 7 values?), ODP 1002C). These variations may be real, may be the result of one or two spurious measurements, or may be aliasing the real trend. I suggest using 15 values per 6000 years (400 year resolution or better; still arbitrary) or a statistical measure of the significance of the trend.

2) More information on the red data points in Figure 4. Related to my comments above, which are the data sets with the greater than 2degC difference from the models? Are these data sets from the same region or is there a site-specific reason why they are offset? I would like to see these points discussed further in the discussion section.

3) Additional explanation of the time shifting and depth shifting. In general it is hard to understand exactly what has been done with the time shifting and depth shifting experiments. I suggest additional explanation on the methodology here (e.g. does a time shift of 10-20 days mean that a seasonal correlation originally centered on JJA is now centered on JAS or MJJ? Staying with the example for summer, is the time shifting applied to the middle Holocene and the present day remains at JJA?). Specific areas that would benefit from additional explanation include:

- a. Page 1016, line 7-8.
- b. Page 1022, lines 21-29: What is meant by a 'higher time shift'?

#### MINOR POINTS

1) The manuscript considers ecological factors to resolve data-model discrepancies

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and it would be useful to see this reflected in the title.

2) Some sentences seem overly long or poorly worded, to the point where in some cases I didn't fully understand what they were about. I suggest rewording for clarity:

- page 1009, lines 12-15
- page 1009, lines 26 to page 1010 lines 1-2
- page 1010, lines 6-11
- page 1025, lines 2-5
- page 1027, lines 3-4

3) Introduction – the third paragraph (beginning page 1007 “There have been several studies. . .”) reads more as a list of previous work related to Europe rather than how these studies reconciled data-model discrepancies. In addition, the paragraph covers only studies related to European climate, yet the manuscript presents global data-model comparisons. I suggest either reword and expand the paragraph to give a more global focus (e.g. include additional references such as Braconnot et al. Nature Climate Change 2012) or delete the paragraph.

4) Page 1012, lines 7-10: I suggest amending this sentence, since the habitat depth and seasonality are known for some of the proxy records, at least for the modern.

5) Page 1014, lines 24-26: I found this a little confusing – is the R value for Mg/Ca and model annual mean indicating a strong, though inverse, correlation? Perhaps an additional sentence or two of explanation would help.

6) Page 1015, lines 18-27: A couple of additional sentences on the importance of nitrate concentrations to coccolithophores would improve the clarity here.

7) Page 1015, line 21: should read ‘do’ not ‘does’.

8) Page 1016, line 5: I think ‘reduced’ would be a better word than ‘relaxed’.

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9) Page 1017, section 3.2: It strikes me that this section could come much earlier in the paper – the text could shift to just after that describing Figure 4. Figure 9 and Figure 10 could slot in right after figure 4. Co-locating the ECHO-G and PMIP simulations would up-front establish confidence in the ECHO-G model output and would justify the subsequent in-depth analysis using ECHO-G alone. As it stands section 3.2 seems a little out of place.

10) Page 1018, line 14: delete ‘and Mg/Ca’ as this sentence is about alkenone records only?

11) Page 1018, line 20: ‘considering’ could be read a couple of different ways in this sentence. I would suggest replacing with ‘taking into account’.

12) Page 1020, lines 1-2: Please explain what you mean by ‘the spatial patterns of these matches are featureless’.

13) Page 1021, lines 1-3: The sentence “Comparing the reconstructed Holocene temperature trends to the model levels of the upper 100m neither does remove much of the discrepancy between models and proxies.” would read better as “Comparing the reconstructed Holocene temperature trends to the model levels of the upper 100m does not remove the discrepancy between models and proxies.”

14) Page 1021, lines 3-6: I think this sentence is trying to say that the greatest number of records fit best with model trends for 10m and smaller proportions of Mg/Ca ratios fit best with trends for depths greater than 10m but the way it’s written at the moment it sounds that the 10m level has the lowest number of records that fit.

15) Page 1023, line 19: Remove the word ‘needed’.

16) Page 1024, line 24: Replace ‘for’ with ‘to’.

17) Page 1025, line 23: Replace ‘question’ with ‘invalidate’ or reword the sentence.

18) Page 1025, lines 23-25: Why would advection reduce the signal when propagating

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through different water masses?

19) Page 1026, lines 1-3: This sentence implies that none of the data sets used in this study were from frontal regions. Is this actually the case? If so, it would be better to state this explicitly.

20) Page 1027, line 2: Replace 'more identifiable' with 'more readily identified,'.

21) Page 1027, lines 25-26: Replace 'as much studied' with 'studied as much'.

22) Page 1028, line 15: Delete 'which'.

23) Page 1028, line 26: Insert 'of' (example of)

24) Page 1029, line 10: Replace 'to' with 'with'.

25) Page 1029, line 20: Replace 'of' with 'in'.

26) Page 1031, line 12 to page 1032, line 6: This paragraph strikes me as more of a discussion paragraph than a conclusions paragraph as it introduces new material. I suggest moving it to the discussion section.

27) Figure 1: The details on this figure were hard to read. Is it possible to enlarge the fonts slightly?

28) Figure 4: A descriptor for the black line is needed in the caption.

29) Figure 6a: I found it hard to distinguish the red colours indicating different depths. I suggest using more distinctive colours.

30) Figure 6b and c: Are the blue and red dots matched up? For example, between latitude 70-80 in Figure 6b, are the blue dots the nitrate concentration and then the red dots the depth of data-model best fit? It was a little confusing what was actually being shown in this plot and I suggest additional explanation in the caption.

31) Figure 7c: The caption needs to state what the diamonds and triangles represent.

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32) Figure 8: Perhaps this is a pdf glitch but some parts of Figure 8 appear to be cut off.

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