

## ***Interactive comment on “Palaeogeographic controls on climate and proxy interpretation” by D. J. Lunt et al.***

**Anonymous Referee #2**

Received and published: 15 February 2016

The study of Lunt et al. investigates the impact of paleogeography and the solar constant on climate during the period 150 to 35 Ma BP. One key conclusion of the study is that without changes in atmospheric CO<sub>2</sub>, the simulated climate remains relatively stable throughout the period. One explanation proposed is that there is a cancellation between solar and paleogeographic changes. The manuscript also includes an analysis of the migration of core locations through time, showing that locally paleogeography has a significant impact and that this should be accounted for when reconstructing past climate states.

The manuscript reads well and contributes with novel results, but depends on a large number of results only given in the supplementary material with a large number of cross-references. At the same time, there is a concern with the quality of the paleo-

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geographic reconstructions used as they are derived from a proprietary product, which is not documented in the manuscript, and therefore cannot be evaluated.

Given that the quality of the paleogeographic constraints can be documented, the study provides a valuable tool to guide scientists in their work to improve reconstructions of past climates.

### **MAJOR COMMENTS:**

1) One clear conclusion of the work as given by the abstract is that there is a cancellation of the opposing trends from solar and paleogeographic change. There is also a note on the implications for the interpretation of paleo proxy records. However, this does not provide a concise and complete summary of the work and the conclusions. A revised text would benefit from a clear account of the novel concepts provided by the research. Including the relative impact of changes in the boundary conditions, the impact of internal feedbacks such as albedo, clouds and water vapour, and the significance of the adjustment factor for the interpretation of proxy records.

2) The main focus of the study is the impact of paleogeography on climate. However, the reconstruction of the bathymetry and topography is not documented in the paper and there are no references to how this was made. Therefore, it is very hard to evaluate how the paleogeography used compares with observations or with previous studies. This issue needs to be addressed in a revised manuscript.

3) As indicated in the table describing each simulation, there is different smoothing applied to the paleogeography. It is not clear how this is done, and why the smoothing is applied differently for each experiment. Does this impact the results? In a revised manuscript the smoothing should be applied consistently across all stages, or if not possible given the computational expense, the impact of this procedure must be documented.

4) None of the runs are at equilibrium after 1422 years of integration, and there is a

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drift in the deep ocean of up to 2C/1000years. Even if the authors focus on the upper ocean climatologies in the analysis there is the potential for major reorganisations of the circulation and climate which are not detected yet. In a revised manuscript this possibility must be assessed (e.g. by extending a few runs). Note that many of the results are discussed in terms of changes in ocean overturning circulation and heat transport (both dependent on deep sea ocean state).

5) Calculating the back-trajectories for the ocean sediment core locations is of great value to the paleoceanographic community. However, the focus in the paper is on a comparison between inferred surface temperatures based on a relationship to benthic  $\delta^{18}O$ . To better make use of the back-trajectories the potential impact of "migrating" ocean sediment core locations on the benthic records should be considered. A key advancement in the field would be assessment of how much the global benthic  $\delta^{18}O$  record is affected by migration of the core sites?

#### SPECIFIC COMMENTS

page 5686: "direct tectonic" forcing needs to be defined - assume this refers to changes in the bathymetry/topography.

page 5690: ice caps are included on Antarctica in the latest two stages. There is no reference or documentation for the existence and configuration of these.

page 5690, line 20: remove "modelled" - misleading (CO<sub>2</sub> value is not modelled).

page 5693: is the TOA energy imbalance consistent with the drift of the model?

page 5693-4: it is stated that the simulations from 34Ma to 2Ma with varying CO<sub>2</sub> reproduce the first-order response seen in the data. This is not clear and should be further documented, including a description of the model setup, or relevant references where this is published.

page 5694: the authors lack long term temperature records to compare with their simulations of the CPE. Did they consider using the benthic  $\delta^{18}O$  records instead of SST?

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page 5695: to calculate the expected warming trend due to solar forcing alone the albedo is kept constant at 0.27. What is the albedo change in the different stages + what is its potential impact? Also, is it reasonable to assume a constant climate sensitivity? This needs to be assessed.

page 5697: it is stated that emissivity (in particular water vapour feedback) is more important than albedo in amplifying the changes due to paleogeography. This is a fundamental result of the study and should be discussed further. Note also that this dominance of emissivity over albedo is not clear from the examples choose in sections 3.3.1-3.3.3 (albedo impact ranges from 40 to 60%).

FIGURES: figure 1: most of the discussion of this figure relates to the estimated surface temperature record (e.g. page 5685) - would be best if the y-axis were exchanged to make references between temperature plot and axis easier to follow (c.f. figure 5).

figure 2: orange line is missing from figure, make it visible.

figure 8: add correlations to plots. Move b) to bottom line and homogenise the axis (global temperature as x-axis e.g.). Also use consistent description on axis and in caption (continental or land temperature). Mask change is not very clear - please change this to continental area and if possible use actual area. What is the unit of orography?

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Interactive comment on Clim. Past Discuss., 11, 5683, 2015.

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