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Interactive comment on "The Eocene-Oligocene transition: a review of marine and terrestrial proxy data, models and model-data comparisons" *by* David K. Hutchinson et al.

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We thank the reviewer for their positive feedback and constructive comments on the manuscript. Here we outline our proposed response to each comment in blue text.

Kind Regards,
David Hutchinson

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Discussion paper

General Comments

This manuscript, entitled “The Eocene-Oligocene transition: a review of marine and terrestrial proxy data, models and model-data comparisons” by Hutchinson et al., is an outstanding review paper worthy of publication in Climate of the Past. This paper makes large strides and provides a comprehensive update to Eocene-Oligocene research as much has been done since the 2007 review of Coxall and Pearson. The authors take a methodical approach, first addressing terminology and a framework for the Eocene-Oligocene, then boundary conditions such as paleogeographic reconstructions, paleoceanography, and constraints on glaciation. Next, the authors move to a comprehensive review of marine and terrestrial paleoclimate and pCO2 reconstructions, mechanistic modeling studies of paleogeographic, CO2 and temperature changes. Finally, and most importantly, the authors end the paper with a metaanalysis of the factors affecting paleoenvironmental changes during the E-O transition and conclude that CO2 decrease likely served as the primary driver of cooling and Antarctic glaciation. As this manuscript is very well written, I do not have large structural comments.

Thank you for the positive overall assessment.

Instead, I include my few specific comments along with line-by-line technical corrections below.

Specific Comments and Technical Corrections

Lines 111 and 125: This is just one example of “Fig.” vs “Figure.” Be consistent throughout.

All instances have been changed to “Figure”.

Lines 111 and 123: Again, just an example: I think it may help to structure these paragraphs in a way that really highlights these key terms such as EOGM and EOIS. This reorganization could help readers not as familiar with key E-O events as this is a review intended for a broad audience.

We have re-organised these paragraphs to set out the terms more clearly.

Figure 1. Along with the comment above, perhaps it would help to differentiate old/existing terms with your new preferred framework. Possibly a different colored font for existing terms e.g. Step 1 vs your new proposed terms e.g. EOIS.

We have now highlighted the EOIS term in blue text, since it is a new term that we define in this manuscript. All other terms in the Figure are defined previously and left in black text. We have also added a new Table 1 listing and defining terms and differentiating old/existing terms in an easily accessible form.

Line 199. Isotope

This has been fixed.

Lines 202 to 205. Possibly one more sentence to explain the mammalian phenomenon

We have added an extra sentence and minor edits to explain the mammalian evolutionary turnover.

Figure 3 caption. UK37 formatting.

This formatting has been corrected.

Line 527. Possibly one additional sentence to discuss the d18Osw ice volume assumption and its robustness

This sentence has been re-ordered to come after the discussion of inter-basin similarity (previously Lines 531-533), and added a further comment on the assumption's limitations.

Line 645: Revise "multiple evidence"

This is now "multiple lines of evidence".

Line 657: UK37 formatting

This has been fixed.

Section 5.2. Possibly a short discussion of challenges with leaf proxies (e.g. preservation bias, sampling bias) would supplement the existing discussion of challenges with chronology in terrestrial records in general.

We have added a short paragraph on the challenges of leaf proxy estimates of CO2.

Line 920: The CCD was introduced on line 421 and should be abbreviated there.

We have used to the abbreviation here.

Lines 927-930: This sentence is very jargony and should be revised (and probably split into 3 or so sentences). At the very least, “glacio-eustatic sea level-led shelf-to-basin fractionation” and “C12-enriched carbon capacitors” should be explained.

This part has been revised with improved explanations each process and simpler terms:

Carbon cycle box models suggest that the best fit to observations is achieved by a shift from shelf-to-basin carbonate fractionation (Armstrong McKay et al., 2016; Merico et al., 2008). In this interpretation of events, the fall in sea-level due to Antarctic glaciation (i) reduces the global flux of carbonate into shallow water (reef, bank and shelf) sediments; and (ii) exposes fresh, readily dissolved shelf carbonate sediments around the world to rapid subaerial weathering (Merico et al., 2008). The first of these two mechanisms drives the sustained CCD deepening from Eocene to Oligocene. The second mechanism drives a one-off dump of carbonate into the ocean that explains the initial transient overshoot behaviour (Zachos and Kump, 2005), and the transient increase in benthic δ^{13}C occurs because the shelf carbonate reservoir is enriched in ^{13}C relative to pelagic carbonate reservoir (Swart and Eberli, 2005; Swart, 2008; Merico et al., 2008; Armstrong McKay et al., 2016). If the isotopic fractionation between these two carbonate sediment reservoirs is modest, however, shelf-basin fractionation can only fully explain the transient increase in oceanic δ^{13}C if the one-off dump of weathered shelf carbonate is questionably large (Merico et al., 2008). In their follow up study, Armstrong McKay et al. (2016) considered this problem in detail and concluded that, unless shelf carbonates were substantially enriched in ^{13}C relative to pelagic carbonates (by $\sim$3‰), an additional process must also have contributed, with sequestration of ^{12}C-enriched carbon into carbon capacitors, and possibly increased ocean ventilation, offering the best fit to the paleorecords when combined with shelf basin fractionation.

Line 929: “C12-enriched” formatting

This term has been reformatted correctly.

Line 930: clathrates

This has been fixed.

Lines 931-935: These mechanisms require additional explanation and reduced jargon. Explain “labile and refractory components”

We now provide definitions of labile and refractory carbon and their relevance to the mechanisms discussed, as follows:

“They suggest several mechanisms are needed to explain the CCD change in addition to the shelf-basin fractionation hypothesis above: (i) perturbations to continental weathering and solute input to the deep ocean, or (ii) changes in the partition of organic carbon flux between labile (organic carbon that is readily available for oxidation and driving carbonate dissolution) and refractory (carbon that is more resistant to degradation and largely preserved and buried) components.”

Line 955: This description of GENIE is very similar to line 932

We have removed the duplicate explanation of cGENIE.

Line 968: Define SAT here and not in line 971.

This has been done.

Figure 7. This figure is perhaps the most important in the paper and possibly the hardest to interpret. At the very least, when finally published, these three panels should be much larger. Many of the other figures can be smaller. I found 7a particularly hard to interpret, but the coastlines and proxy-model comparisons in all three panels are a bit challenging to see.

We agree – in journal form this figure would have been hard to read. For the sake of clarity, we have removed the stippling, and changed the colouring of the coastlines to make them more visible. We have also removed the numbers written adjacent to the proxy locations, since they were difficult to read, and the proxy values are already presented in table form.

Line 1082: For UVic,

The comma has been added.

Line 1085: For FOAM,

The comma has been added.

Table 2 caption: This caption requires the statement as in Table 3 about the meaning of green highlighted cells

We have added the explanation of green highlighted cells.

Line 1164: This is the first of several instances where “CO2 forcing alone” is cited as the best fit. Perhaps I’m not understanding the skill score analysis, but in Table 3 it appears that the ensemble mean skill score of 0.326 is achieved with coefficients of 0.7, 0.06 and 0.26 for alpha, beta and gamma respectively. Wouldn’t this mean that

CO2 is the primary driver but that ice and paleogeography make modest contributions as well? If this is the case, the authors should clarify modify their interpretation to include these additional factors. If this is not the case, a quick mention of why this result indicates CO2 is the sole driver would be helpful.

We agree with the interpretation in this comment and have removed the references to "CO2 forcing alone". CO2 is the primary (but not the sole) driver according to our analysis and we have clarified this.

Figure 8 caption: 910 ppm, not 900 right?

Yes, this has been corrected.

Line 1217: Here,

The comma has been added.

Line 1229: There is therefore a ... :

The sentence has been completed.

References

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