

## ***Interactive comment on “The early Eocene equable climate problem revisited” by M. Huber and R. Caballero***

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Review of: Title: The early Eocene equable climate problem revisited Author(s): M. Huber and R. Caballero MS No.: cp-2010-106

### GENERAL COMMENTS

In "The early Eocene equable climate problem revisited", Huber and Caballero do exactly as their title indicates, they revisit a paleoclimate conundrum of great longevity. Neither the topic nor the broad methodologies employed are, therefore, novel. The paper does, however, represent a significant step forward in regards to investigations of Early Eocene greenhouse climates and, from this perspective, deep-time paleoclimate investigations in general. As the authors outline, the past decade has seen a growing

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body of data suggesting that early constraints on Eocene greenhouse climates (e.g. tropical SST values and the "cool tropics" paradox) were incorrect. The consequent re-casting and re-constraining of the problems in question has obviated a number of those problems and, to some extent, simplified the study and understanding of the Eocene greenhouse. Recent years have seen the investigative focus shifting from attempting to explain physically "unexpected" climate conditions to quantifying and refining our understanding of climate system function in a much warmer world. In this context, Huber and Caballero's compilation and synthesis of proxy climate data and recent model simulations of the Early Eocene provides a logical, focused embarkation point for a new decade of research into this fascinating time period and, as such, is an important advance in the field. Furthermore, their robust, systematic, and logical approach to errors in proxy climate data, paleoelevation, paleolocation, and model simulation is robust and applicable to other, deep-time climate investigations where such errors are also persistent and unavoidable.

As such, I have no major problems with either the manuscript or the science within and recommend that it be published subsequent to minor revision.

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### SPECIFIC COMMENTS

p. 250

L 20 - 23: It should be clarified that it is Eocene tropical OCEAN temperatures that constrained this. Terrestrial records, as the authors later note, are in short supply.

p. 253

L 5 - 7: This sentence appears to refer to a tropical Middle Eocene data point that the author's reference later, but the sentence is awkward and/or missing a clause and neither the data nor the source are clear.

p. 255

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L 6: Bottom water temperatures previously cited as 10°C from the same reference. Value should be consistent throughout.

L 8: It should be clarified that the 'regions and seasons' are expected to be cold at present, not in the Early Eocene.

L 18: "Based on these considerations" appears to refer to the preceding paragraph, but the preceding paragraph does not offer clear, compelling reasons for excluding summer temperatures from the analysis, though it does present some important considerations re. novel environments. Either this sentence or the preceding paragraph should be expanded/clarified to better justify excluding summer temperatures. This is particularly true as the "equable climate" of the Early Eocene is not simply characterized by warm winter temperatures, but rather by a reduction in overall seasonality (as the authors note on p. 254 L 1 - 3). As it stands, by excluding analysis of the summer season, the authors limit their ability to address the entire equable climate problem and this is probably the biggest shortcoming of the work. Expansion here to better highlight limited constraints on maximum summer surface temperatures and, thus, the true extent of "reduced seasonality" would help to address this shortcoming.

p. 256

L 12 - 16: CMM temperatures are derived from CLAMP, analyses which were specifically excluded from MAT estimates in favor of LMA analyses. How does the selection of two different methodologies as the temperature basis influence comparisons?

p. 260

L 6: Please provide a reference for the "important high latitude feedback in CAM3"

p. 267

L 23: "more challenging" should be struck as it is largely subjective and arguably inaccurate. The historical problem that the authors note, and have worked on, where one was required to warm high latitudes and continental interiors while actively cooling

C81

the tropics was likely "more challenging" than the current framework, which the authors outline and work within here. This is supported by the fact that the equable world with cool tropics was never successfully simulated, while a warm tropical, equable world has been much more successfully simulated in this study.

p. 268

L 4 - 7: It should be noted here that, while improvements in both paleotopographic reconstructions and paleovegetation distributions are necessary and possible, many proxy data may represent the confluence of "infinitely" finite boundary conditions and, as such, discrepancies between time-slice representations of either topography or vegetation based on spatially-limited datasets and proxy data are unavoidable. This is, in fact, more likely the norm than a situation that can ultimately be resolved via further data collection – we simply do not have global coverage of Early Eocene strata, let alone paleoelevation, temperature etc. proxies. I would like to see, particularly in regards to paleotopography and paleotemperature, some discussion here of the likelihood for persistent errors or mismatch and the utility (which I believe to be high) of the author's systematic approach to addressing this (e.g. as outlined in section 3.1.3)

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#### TECHNICAL COMMENTS

The Early Eocene is a recognized, "official" time interval and "Early" should be capitalized throughout the manuscript where it refers to the Eocene. The same is true for "Middle"

p.244

L4 - 5: Here and elsewhere in the manuscript the ordering of references (e.g. chronological, alphabetical etc.) should be consistent and in accordance with journal style.

L7: Strike "of these"

L16: Bracket "therefore" with commas

C82

p. 245

L 17 - 18: Strike "without recourse to novel mechanisms" and place a period after "forcing."

L 19: Insert comma after "In this paper"

p.246

L 11: Insert "than" between "values previously"

L 15: Insert comma after Sec. 2.2

p. 247

L 10: Strike comma after "dynamics"

L 19: paleoclimates is misspelled

p. 248

L 20: Provide a reference for the quantification of cold biases at 2 - 8°C. If it is one of the previous references, move it to the appropriate position after the temperature range.

p. 249

L 4: "suggest" should be "suggests"

p. 250

L 17: "produce" should be "produces"

L21: the end of the word "temperatures" from the previous line should not end in an "s"

p. 251

L 4: bracket "although not identical (Abbot et al., 2009a)" with commas

C83

L 6: period is orphaned from previous line.

p. 252

L 5: insert comma following "For these reasons"

L 16: insert comma following "In some cases"

L 20: Insert comma following "Consequently"

L 26 - 29: The sentence "Today, MAT above...100% entire margined" makes a good point but is awkward, in particular the phrase "are likely to be above that range" on line 28.

p. 253

L 24: should read "...or, worse, does not..."

p. 254

L 13 - 14: the clause "...required to the complementary information provided by these different proxies." is unclear

L 17: should read "...in the intermontane..."

L 21: should read "... were so warm that it is..."

L 26: "argue" should be "argues"

L 27 - 28: Better worded as "The important exceptions to this being inland Antarctica and high paleoelevations..."

p. 255

L 7: strike "which"

L 10: "More of concern," at the end of the line is awkward.

L 14: Should read "... such as is clearly..."

C84

L 20: Insert comma after "In this study"  
p. 256  
L5: Insert comma after "point by point"  
L8: reword "probably more likely"  
L 7 - 12: The entire section is awkward and difficult to follow and decipher  
L 12: Insert comma after "In this study"  
p. 257  
L 8: Replace "quantified" with "quantify"  
L 13: Here and elsewhere in the text (e.g. p. 258 L 15, p. 259 L23) in-line citations should have the author names moved outside of the parentheses.  
L 20: Insert comma after "available"  
p. 261  
L 2: insert comma after "these results"  
p. 265  
L 4: Strike "the" from "the intermontane"  
L 10: "in the at the" Pick one.  
L 14: Insert comma after "[E]arly Eocene in age"  
p. 267  
L 18: Last word should be "radiative"  
L 18 - 21: This section is awkward as the material immediately before (L 9 - 14) is referenced by the sentence immediately afterwards (L 22). This section should be

C85

moved or reworded so as not to break up the train of thought and flow of the paragraph.  
L 23: should read "...challenging than prior..."  
L 27: should read "...knowledge, for the first time."  
p. 268  
L 10: Insert comma after (2000)  
p. 269  
L 25: "as" should be "has"  
p. 270  
L 16 - 17: Suggest rewording to: "...as evidenced by the troubling model prediction of subtropical warmth at the upper limit of proxy error bars."  
p. 271  
L 3: Insert comma after "analysis"  
L 6: Strike "is" between "here" and "likely"  
L 8: Insert comma after (2010)  
L 9: Should be "studies' "  
L 15: Insert a comma after "Eocene"  
L 17: Strike "from these regions" as it is redundant with "in those areas" at the end of the sentence.  
p. 272  
L 12: Should read: "... spatial gradients derived from terrestrial..."  
L 13: Insert comma at end after "warmer"

C86

L 14: insert comma at end after "data"

L 17: Should read "...to resolve the remaining..."

L 20: Insert comma after "(...does not)"

L 22: Insert comma after "latitudes"

L 26: Suggest replacing "exclude" with "preclude"

Figure 1: The letters indicating the various panels are small and almost impossible to read (absolutely impossible in the case of panel C). While the images in panels a - e are reasonably clear, the information on panel f ( I assume a white contour overlay and numbers??) is unintelligible.

Figure 3: with the figure on 3 separate pages, the color bars should be repeated on each page.

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