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Climate of the Past
Discussions

Interactive comment on "Intensified Atlantic vs. weakened Pacific meridional overturning circulations in response to Tibetan Plateau uplift" *by* Baohuang Su et al.

Anonymous Referee #2

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This is a fairly straightforward and worthwhile study of how Tibetan uplift may have affected global climate. The authors describe a logical pair of GCM experiments to diagnose the role of the Tibetan Plateau (TP) as it could have influenced the climate during the Cenozoic, although these simulations do not account for changes in other boundary conditions such as CO2 and continental configuration. The paper does a good job of providing motivation for this study, noting that most attention to mountain uplift on climate has focused on atmospheric dynamics, rather than ocean circulation (especially in high latitudes). My overall impression of the paper is favorable and that it is worthy of publication, subject to several mostly minor issues explained below.

Major Comments:

1. Using a low-resolution GCM is probably necessary for the long simulations needed for this study, and the authors do a commendable job on page 12 of discussing possible limitations of the low resolution on their conclusions. However, the T31 version of CESM that is used in this paper is known to have significant climate biases, especially in high-latitude regions that are a main focus for this paper (including Arctic sea ice extent). For the global ocean, these biases include a long-term drift in volumetric temperature and salinity, as suggested in Figure 1c. Implications of these model biases on the results and conclusions of this study are warranted.

Minor Comments:

1. The text contains many minor grammatical errors involving the usage of articles (i. e., when to use "a" or "the" before a noun). A thorough proofreading should cure this problem.

2. For readers not familiar with the geologic history of Tibetan Plateau uplift, please cite upfront the timing of this evolution. Line 59 of the Introduction lists a vague mention of "Given the timing of TP uplift. . . ", but it does not specify when that occurred. Only in the Conclusions section are relevant dates revealed.

3. Lines 63-65: I'm not completely clear of the reasoning implied here. Are the authors saying that the required integration time of their model simulations is so long that it's impractical to test additional parameters besides topography? Please clarify.

4. Lines 113-114: Given the importance of AMOC in these results, it would help to elaborate on how the model compares with the observed strength. What is the best observational estimate, including the range? Also, how does the simulated 6 Sv strength of PMOC in the reference simulation compare with observations?

5. Figure 1: Very interesting how the strength of AMOC and PMOC flip almost exactly between the two experiments, such that one or the other is around 18 Sv in MTP and

NTP. Is that a coincidence, or does it reflect a meridional heat transport requirement that is met by either ocean basin in the two different climates?

6. Lines 132-134: Why does a warmer Tibet reduce the Eurasia-Pacific thermal contrast during summer? Figure 2a indicates a much warmer Tibetan region and an overall warmer Asian landmass. Likewise, the next paragraph describes an associated weaker monsoon circulation, but that also seems counterintuitive with a much warmer Tibet. For example, many studies show that excessive cold (warmth) resulting from abnormally high (low) snow cover on the plateau is associated with a weaker (stronger) summer monsoon.

7. Line 161: why use the term "on the other hand" when describing the role of increased sea ice coverage? That implies a contrast with the previous sentence, which reports an increase in freshwater flux over the Atlantic. Yet both expanded sea ice extent and greater freshwater flux cause a lower surface density and thus favor a weakened AMOC.

8. Line 260: Which hypothesis is being referred to here—the one about the MOC being determined by large mountains or the one about asymmetric continental extents and basin geometries between the Atlantic and Pacific basins?

9. Lines 274-276: Why would planetary cooling during the Cenozoic lead to a reduced equator-to-pole thermal gradient? Colder global climates usually have even larger cooling in polar regions, giving rise to the term "polar amplification".

10. Page 13: Good observational evidence for a stronger PMOC during the early Cenozoic to support the model results presented here.

11. Page 14 and elsewhere: The authors rightfully point out that they have only tested the direct role of Tibetan topography and therefore ignored possible coinciding influences of other boundary conditions, such as higher greenhouse gas concentrations that may be relevant for the actual paleoclimatic conditions resulting from Tibetan up-

lift. I recall a paper by Vavrus and Kutzbach (2002, GRL) that involved a similar modeling study, but it isolated the individual impacts of mountain uplift and higher CO2 on AMOC. That article might be relevant for the present study.

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