

Responses to Reviewers' comments

We are grateful for the careful review and valuable feedback provided by the referees. Below, we have provided our point-by-point responses to each of the reviewers' comments and detail the associated revisions made to the manuscript. Comments from the referees are marked in *italics*, and our responses are in **blue font**. Revisions made to the manuscript are highlighted in **yellow** for your convenience. We hope that the revision addresses the referees' concerns.

Reviewer 1

Comment 1: *The work titled "The Effects of Orbital Forcing on the East Asian Summer Monsoon for the Past 450 kyr" is intriguing. The authors have adeptly reviewed previous research progress and provided a detailed and clear explanation of the research methodology in this paper. However, the section discussing their own research findings appears to be rather weak, lacking a comprehensive showcase of the work's novel discoveries. Substantial revisions are necessary to better highlight the new contributions of the study.*

Response to comment 1: We appreciate the reviewer's constructive feedback. We believe the novelty of our study lies in demonstrating the varying impact of solar radiation variability on the East Asian monsoon across different regions. Particularly noteworthy is the discovery that summer precipitation patterns in Japan and China exhibit distinct responses, each governed by different atmospheric circulation mechanisms—the reinforced North Pacific High and sub-high, respectively. However, based on your suggestions in Comment 1 and Comment 9, we revised sections 3 and 4 to underscore the novelty of this study. Additionally, in response to Reviewer 2's suggestion, we included simulation results beyond summer precipitation and incorporated additional proxy data for comparison. We have included simulated annual precipitation and summer temperature, which was compared with insolation, simulated summer precipitation, and proxies (speleothem $\delta^{18}\text{O}$, ^{10}Be , and pollen records). Furthermore, we have extended the model-proxy comparison in CLP and JP by incorporating several other proxies that offer access to variabilities in annual mean temperature (CLP), winter monsoon (CLP), and annual temperature range (JP). These revisions have altered the data presented in Fig. 2; additionally, we have added Fig. 4 and Fig. 5, as well as a supplemented discussion on model validation and proxy-data comparison.

Comment 2: *The term "calculate and calculation" in the given sentence (Abstract) is not accurate; it should be replaced with "simulated" or "simulation." Please check similar issue thorough the manuscript.*

Response to comment 2: The text was revised per your suggestion.

Comment 3: *The initial segment of the abstract is well-structured; however, the latter part, starting from "The calculated change in summer precipitation is dominated by a 20-kyr precession cycle over China, highly consistent with cave $d18O$ records in southeast China," becomes overly generalized. The author delves into various aspects, addressing the periodicity of simulated East Asian Summer Monsoon (EASM) precipitation in connection with forcing cycles. Subsequently, a correlation analysis is presented to establish the relationship between EASM precipitation intensity and solar radiation forcing. This deviates somewhat from the conventional approach of enhancing mechanistic understanding through numerical simulations. Therefore, in this section, I recommend that the author enrich the paper by incorporating more explanations related to climate dynamics.*

Response to comment 3: We thank the referee for the constructive comment. Reviewer 2 also suggested rewriting the abstract. Accordingly, we have reworked the latter portion of the abstract. Specifically, we revised the structure and wording to highlight the simulation outcomes: the influence of solar radiation on summer precipitation across each East Asian monsoon region (SEC, CLP, and JP). Additionally, the description of correlation analyses was removed from the abstract. Subsequently, we delved into the underlying causes of simulated EASM variability from a climate dynamics perspective.

Comment 4: *The Introduction section lacks a recent review of the advancements in the comparison of data and models in East Asian paleomonsoonal dynamics.*

Sun, Y., H. Wu, G. Ramstein, B. Liu, Y. Zhao, L. Z. X. Li, X. Y. Yuan, W. C. Zhang, L. J. Li, L. W. Zou, T. J. Zhou. *Revisiting the Physical Mechanisms of East Asian Summer Monsoon Precipitation Changes During the Mid-Holocene: A Data–model Comparison*. *Climate Dynamics* 60, 1009–1022 (2023). <https://doi.org/10.1007/s00382-022-06359-1>.

Sun, Y., H. Wu, M. Kageyama, G. Ramstein, L. Z. X. Li, N. Tan, Y. T. Lin, B. Liu, W. P. Zheng, W. C. Zhang, L. W. Zou, T. J. Zhou. 2021. *The contrasting effects of thermodynamic and dynamic processes on East Asian summer monsoon precipitation during the Last Glacial Maximum: a data-model comparison*. *Climate Dynamics*. 56, 1303–1316.

Sun, Y., G. Ramstein, L. Z. X. Li, C. Contoux, N. Tan, T. J. Zhou. 2018. *Quantifying East Asian summer monsoon dynamics in the ECP4.5 scenario with reference to the mid-Piacenzian warm period*. *Geophysical Research Letters*, 45: 12,523–12,533.

Response to comment 4: Thank you for providing these additional relevant articles, which have been incorporated into the introduction.

Comment 5: *I could not agree with the authors statements “Section 4 discusses the possible climate systems that drive EASM variability”. As we knew, orbital forcing via solar radiation changes can be attributed fundamental driver of climate changes, here the authors may discuss the possible climate systems associated with EASM variability.*

Response to comment 5: The phrasing has been revised accordingly.

Comment 6: *L86: “due to orbital forcing” needs to put behind the insolation changes*

Response to comment 6: The text has been revised per your suggestion.

Comment 7: *L131-135 should move to the method section somewhere.*

Response to comment 7: The text has been revised per your suggestion.

Comment 8: Title in section 3.1 is confusing, if I understand well the authors want to express “simulated.....”?

Response to comment 8: The text has been revised per your suggestion.

Comment 9: *I have additional comments on the organization of the results section. In fact, it is not necessary to divide Section 3 into two subsections. The authors intend to focus on one specific task in this section: the model-data comparison of East Asian Summer Monsoon (EASM) precipitation evolution for the last 450,000 years. The current version contains numerous citations, making it challenging for the reader and reviewer to discern the extent of the authors' new findings. Consolidating the section into a single subsection may help clarify the presentation and emphasize the novel contributions of the authors. Please rephrase these sections.*

Response to comment 9: As suggested, Section 3 has been presented as a single section rather than being divided into subsections and was modified to emphasize the study’s novelty.

Comment 10: *Figure.4-5-6 can be merged into one new Figure.*

Response to comment 10: The text has been revised per your suggestion.

Comment 11: *L427: please use SEC instead South East China, as the abbreviation has already appeared.*

Response to comment 11: The text has been revised per your suggestion.

Reviewer 2

Comment 1: *This paper presented new results about how orbital forcing influence the East Asian Summer Monsoon by a group of new time-slice simulations. The authors conducted an extensive review of previous research. But more discussion should be added regarding their own results. (1) They only presented summer precipitation changes. But for East Asian summer monsoon, annual precipitation and summer temperature could also be presented and compared with proxy records; (2) They only show three proxy records. More model-proxy comparison should be added.*

Response to comment 1: We appreciate this feedback. Recognizing the significance of enriching the context of our simulation outcomes, we have incorporated additional data and discussion. In response to the concerns raised, we made the following modifications to the revised manuscript:

- (1) Annual precipitation and summer temperature variability simulation results have been included for the three regions under investigation (SEC, CLP, and JP). The simulation results were compared with simulated summer precipitation and summer/annual precipitation proxies.
- (2) The dataset was expanded by incorporating several other proxies in CLP and JP that offer access to variabilities of annual mean temperature (CLP), winter monsoon (CLP), and annual temperature range (JP).

In response to Reviewer 1's suggestion, we also modified the structure of Section 3 and revised the associated text in Sections 3 and 4 to underscore the study's novelty. These revisions have altered the data presented in Fig. 2; additionally, we have added Fig. 4 and Fig. 5. We have also added a new discussion on model validation and proxy-data comparison based on the revised Fig. 2, Fig. 4, and Fig. 5.

Comment 2: *The abstract is a bit confusing and should be rewritten.*

Response to comment 2: The abstract was revised accordingly. Taking into consideration the feedback from both reviewers, we have rewritten the latter portion of the abstract to enrich the explanation from the standpoint of climate dynamics and accentuate the novel facets of this study.

Comment 3: *Line 18 'Calculated' should be 'Simulated'. Similar expressions throughout the text need to be modified.*

Response to comment 3: The text has been revised per your suggestion.

Comment 4: *Line 41 23 kyr periodicity should be 23-kyr periodicity. Similar expressions throughout the text need to be modified, e.g. line 43.*

Response to comment 4: The text has been revised per your suggestion.

Comment 5: *Line 34 Reference should be (An et al., 2015)*

Response to comment 5: The text has been revised per your suggestion.

Comment 6: *Line 46 Logic question. How does 'EASM varies in phase with orbital cycles' suggest 'the EASM is affected by changes in ice volume'? The author seems to confuse '100-kyr cycle' and 'eccentricity cycle'.*

Response to comment 6: In this sentence, we assumed that the eccentricity cycle is the underlying cause of the 100-kyr glacial–interglacial cycle (Lines 42–44 in the revised manuscript). In response to the comment raised, the text has been revised as follows to avoid confusion between the ‘100-kyr cycle’ that exists in ice volume, which can be a direct forcing factor for EASM, and the orbital ‘eccentricity cycle’:

“Geological records indicate that the EASM is affected by changes in insolation, ice volume, or both (e.g., Cheng et al., 2016; Clemens et al., 2018; G. Liu et al., 2020; Sun et al., 2006, 2015, 2019)” (Lines 46–47 in the revised manuscript)

The sentence “the EASM varies in phase with orbital cycles” was removed. As we address the periodicity of each geological record and corresponding possible climatic forcing in the subsequent text, removing this phrase will not alter the overall conclusions.

Comment 7: *Line 52 Rewrite the sentence.*

Response to comment 7: Thank you for the feedback. The sentence was rewritten accordingly.

Comment 8: *Line 61 Rewrite the sentence.*

Response to comment 8: Thank you for the feedback. The text was revised accordingly.

Comment 9: *Line 20 I do not agree that the results can come to the conclusion ... the importance of other forcing (e.g. ice sheet). Besides external forcings, the internal feedback should also be considered.*

Response to comment 9: We thank the referee for bringing this to our attention. It was not our intention to disregard the potential effects of internal feedback mechanisms. We acknowledge the significance of considering external forcing and internal feedback when interpreting geological records. The manuscript has been revised to reflect this.

Comment 10: *Line 97 This model comprises an atmospheric general circulation model (AGCM) and a global ocean general circulation model (OGCM). This sentence could be deleted because everyone knows that a coupled GCM consists of AGCM and OGCM.*

Reply to comment 10: The text has been revised per your suggestion.

Comment 11: *More introduction on the model should be added, e.g, if there is ice-sheet model.*

Response to comment 11: We have supplemented our description of the land model and sea ice simulation, specifically addressing the treatment of the ice sheet:

“The land component, incorporating vegetation effects, relies on the Simple Biosphere (SiB) model (Sellers et al., 1986; Sato et al., 1989). In this model, the ice sheet is treated analogously to vegetation. However, the dynamics of vegetation and the ice sheet are not integrated; adjustments in ice volume can be accommodated by modifying land vegetation and altitude, specified as boundary conditions. Sea ice compactness and thickness are forecasted utilising thermodynamics, horizontal advection, and diffusion principles.” (Lines 101–105 in the revised manuscript)

Comment 12: *Line 171 Why is the 100-kyr band from eccentricity? Why not ice volume?*

Response to comment 12: As clarified in our response to comment 6, this presupposes that the eccentricity cycle is responsible for the 100-kyr glacial–interglacial cycle. We have revised the text to avoid confusion between the eccentricity cycle and ice volume variability. (Line 189 in the revised manuscript)