RC2: 'Comment on egusphere-2024-3483', Anonymous Referee #2, 17 Jan 2025

The study by Moore et al. compilated global hydroclimate proxies for the 8.2ka event in the tropics and subtropics and compared them with the hosing simulation by the state-of-the-art isotope enabled CESM.

Major novelties:

1. They developed an updated compilation of high-resolution, continuous, well-dated proxy datasets. This is important to the broad paleoclimate community.
2. They introduced the use of the Abrupt Change Toolkit in R (actR) for event detection, which better accounts for age model uncertainties in proxy records. As a result, they quantified the starting, ending, and duration of the 8.2ka event.
3. They revealed a more complex, regionally specific hydroclimate response pattern rather than a simple hemispheric dipole in the 8.2ka event.

However, the paper lacks depth in discussing the source of model-data differences, regional hydroclimate mechanisms, and the responses and of δ18Op, making it feel dry due to excessive qualitative descriptions of proxy and modeling results. In my opinion, it could be published in climate of the past, but a list of concerns should be addressed.

We appreciate your feedback. While a detailed analysis of the mechanisms of the hydroclimate changes in the model is outside the scope of this study, we have performed a decomposition of the isotopic signals in the model and included further discussion of the regional hydroclimate changes in the model, the possible underlying mechanisms, and how they compare with other climate model simulations and proxy data, as detailed below. We hope these additions add depth to our analysis and discussion.

Major concerns:

1. Condense the proxy and model results description while enhancing analysis of model-data differences. Focus on presenting actR results primarily, with MM results moved to supplementary materials for greater conciseness. This paper's unique contribution lies in the detailed regional data-model comparison, but thoughtful discussions lack. For instance, the δ18Op responses in East Asia during the 8.2ka event exhibit an east-west dipole pattern, contrasting with the uniform enriched isotopic signal seen in the Heinrich events. Despite similar hosing experiments, it is intriguing to explore why such discrepancies exist between these events.

Thank you for this helpful suggestion. We have moved many of the MM results to the Supplemental Material for conciseness. We have also enhanced the discussion of the regional δ^{18}Op responses in the model and elaborated on comparing these features to the proxy records. Regarding the east-west dipole pattern in East Asia, we now point out two other modeling studies that have demonstrated a large zonal asymmetry in the δ^{18}Op response in this region under meltwater forcing: Lewis et al. (2010) and Pausata et al. (2011). In Lewis et al. (2010), the response of δ^{18}Op to a simulated Heinrich event in GISS ModelE-R changes sign between inland China and the North Pacific, with a pattern very similar to our simulation of the 8.2 ka event, while in Pausata et al. (2011) the simulated response to a Heinrich event in CCSM3 includes a large enrichment signal over South and East Asia and no change over the North Atlantic. We have added a discussion comparing these model results to the text as follows:

"Similarly large zonal asymmetry in the precipitation δ^{18}O response to meltwater forcing between China and the North Atlantic was identified in the Heinrich simulations of Lewis et al. (2010) and Pausata et al. (2011). In fact, the simulated pattern in precipitation δ^{18}O from iCESM under 8.2ka meltwater forcing is remarkably similar to the response in GISS ModelE-R under Heinrich forcing from Lewis et al. (2010), including in South and East Asia, NE Brazil, and the Caribbean/central America, indicating a robust model response in precipitation δ^{18}O to meltwater forcing. The only regions where this inter-model agreement breaks down is tropical/subtropical Africa and Antarctica."

2. The data-model comparisons are necessarily quantitative rather than qualitative, particularly for speleothem δ18Op records. Otherwise, why use the isotope-enabled model? It would be beneficial to understand if changes in δ18Op are caused by the water isotope or precipitation seasonality.

Thank you very much for this suggestion. We have added a decomposition of the changes in amount-weighted precipitation $\delta^{18}O$ using the decomposition method performed in Liu and Battisti (2015) in order to assess whether the changes are due to changes in the monthly isotopic composition of precipitation or changes in the seasonality of precipitation (i.e., changes in the amount of monthly precipitation). To this end, we have added Figs. 11-14 to the manuscript, showing the decomposition in precipitation $\delta^{18}O$ for each of the target regions.

We have also added the following text to the Methods section:

"We decomposed the changes in amount-weighted precipitation δ^{18}O following Liu and Battisti (2015) in order to assess whether the changes are due to changes in the monthly isotopic composition of precipitation or changes in the seasonality of precipitation (i.e., changes in the amount of monthly precipitation). Noting that the difference in amount-weighted δ^{18}Op between the hosing and control simulation is:

$$\delta 18O_{P,\,hose} - \delta 18O_{P,\,ctrl} = \frac{\sum_j \delta 18O_{j,hose} P_{j,\,hose}}{\sum_j P_{j,\,hose}} - \frac{\sum_j \delta 18O_{j,ctrl} P_{j,ctrl}}{\sum_j P_{j,ctrl}}, \ (1)$$

the importance of changes in the seasonality of precipitation to the changes in δ^{18}Op is then given by: $\frac{\sum_j \delta 18O_{j,ctrl} P_{j,\,hose}}{\sum_j P_{j,\,hose}} - \frac{\sum_j \delta 18O_{j,ctrl} P_{j,ctrl}}{\sum_j P_{j,ctrl}}, \ (2)$

and the importance of changes in δ¹⁸O of precipitation to the changes in total δ¹⁸Op is given by:

$$\frac{\sum_j \delta 18O_{j,hose} P_{j,ctrl}}{\sum_j P_{j,ctrl}} - \frac{\sum_j \delta 18O_{j,ctrl} P_{j,ctrl}}{\sum_j P_{j,ctrl}}. \quad (3)$$

Note that Eqns (2) and (3) do not sum to the total changes in δ^{18}Op due to the nonlinearity in the definition of δ^{18}Op."

We also added the following text to the Discussion section:

"In East Asia, the change in amount-weighted precipitation δ^{18}O, including the east-west dipole pattern with isotopic depletion off the coast of China into the North Pacific and isotopic enrichment inland, is driven by the seasonal changes in precipitation δ^{18}O. Under meltwater forcing, precipitation δ^{18}O inland is more enriched throughout the year, particularly in the dry season from December to April. While precipitation δ^{18}O off the coast is more depleted throughout the year, particularly during the wet season from June to November. Consistent with previous studies on Heinrich events, these results suggest that the meltwater-induced enrichment in Chinese speleothem δ^{18}O records is not driven by changes in local precipitation and/or the EASM strength, but rather driven by changes in moisture source, circulation, and/or upstream rainout (Chiang et al., 2020; Pausata et al., 2011, Lewis et al., 2010). That the largest changes in precipitation δ^{18}O over China occur during the winter season seems to align with the results from Lewis et al. (2010), indicating that increased moisture provenance in the Bay of Bengal during winter yields enriched precipitation δ^{18}O over China during Heinrich events.

In NE South America and central America, the change in amount-weighted precipitation δ^{18}O is also dominated by the seasonal changes in precipitation δ^{18}O and not the seasonality of precipitation, however the mechanisms of the response seem to differ from those in East Asia. In NE Brazil, precipitation increases under meltwater forcing and becomes more isotopically depleted during the wet season from December to July. These changes are consistent with a Type-1 control on precipitation δ^{18}O (Lewis et al., 2010), wherein the local amount effect dominates the precipitation δ^{18}O response. In central America, the change in amount-weighted precipitation δ^{18}O is characterized by a distinct SW-NE dipole with isotopic enrichment in the northern tropical Pacific and over Panama and isotopic depletion over the Caribbean and the remainder of central America. This pattern is also driven by the seasonal changes in precipitation δ^{18}O under meltwater forcing. In the northern tropical Pacific, wet season precipitation is substantially weakened and isotopically enriched, consistent with a Type-1 site (Lewis et al., 2010), wherein the local amount effect dominates the precipitation δ^{18}O response. Past studies on the response to Heinrich events have shown that regional precipitation changes in NE Brazil and eastern Pacific are associated with a southward shift of the Atlantic and eastern Pacific ITCZs (Lewis et al., 2010; Roberts et al., 2020; Atwood et al., 2020). The precipitation δ^{18}O response over the Caribbean and central America is distinct from any of the above sites. In this region, the wet season precipitation decreases under hosing, essentially eliminating the wet season, however precipitation becomes substantially more isotopically *depleted throughout the year. This response is expected in association with the large surface cooling of the tropical Atlantic Ocean and the addition of isotopically depleted meltwater into the North Atlantic. Thus, the precipitation δ^{18}O response in this region would be classified as Type-5 according to the categorization of Lewis et al. (2010), with the mechanisms of precipitation δ^{18}O governed by processes outside of the local or nonlocal amount effect, moisture source, or seasonality of precipitation."*

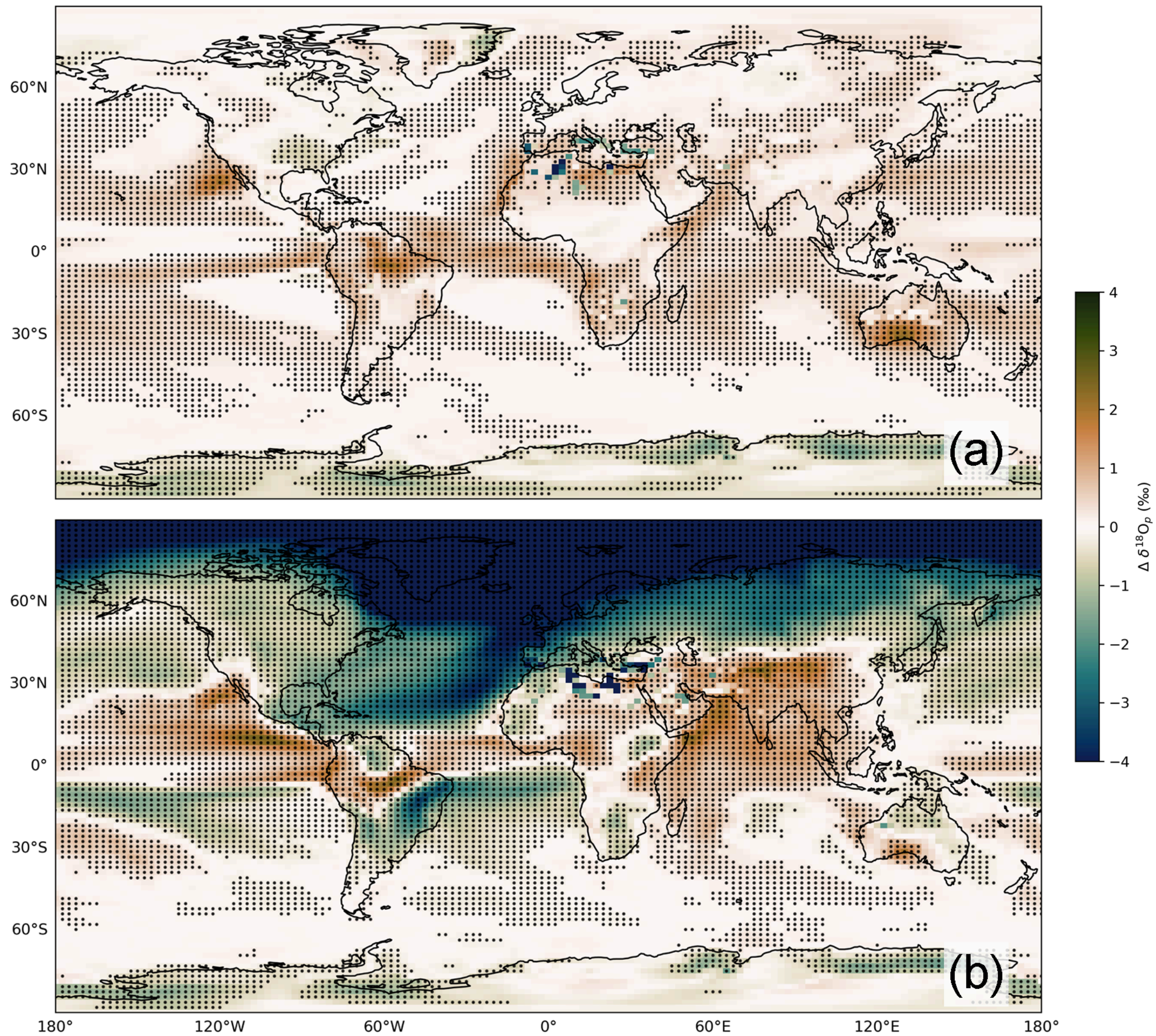

Figure 11. The contribution of (a) the changes in the seasonality of precipitation and (b) the monthly changes in $\delta^{18}O_p$ to the total change in mean annual amount-weighted $\delta^{18}O_p$ between the last 50 years of the "hose" and "ctrl" simulations. Stippling represents data plotted at the 95% confidence level ($p < 0.05$).

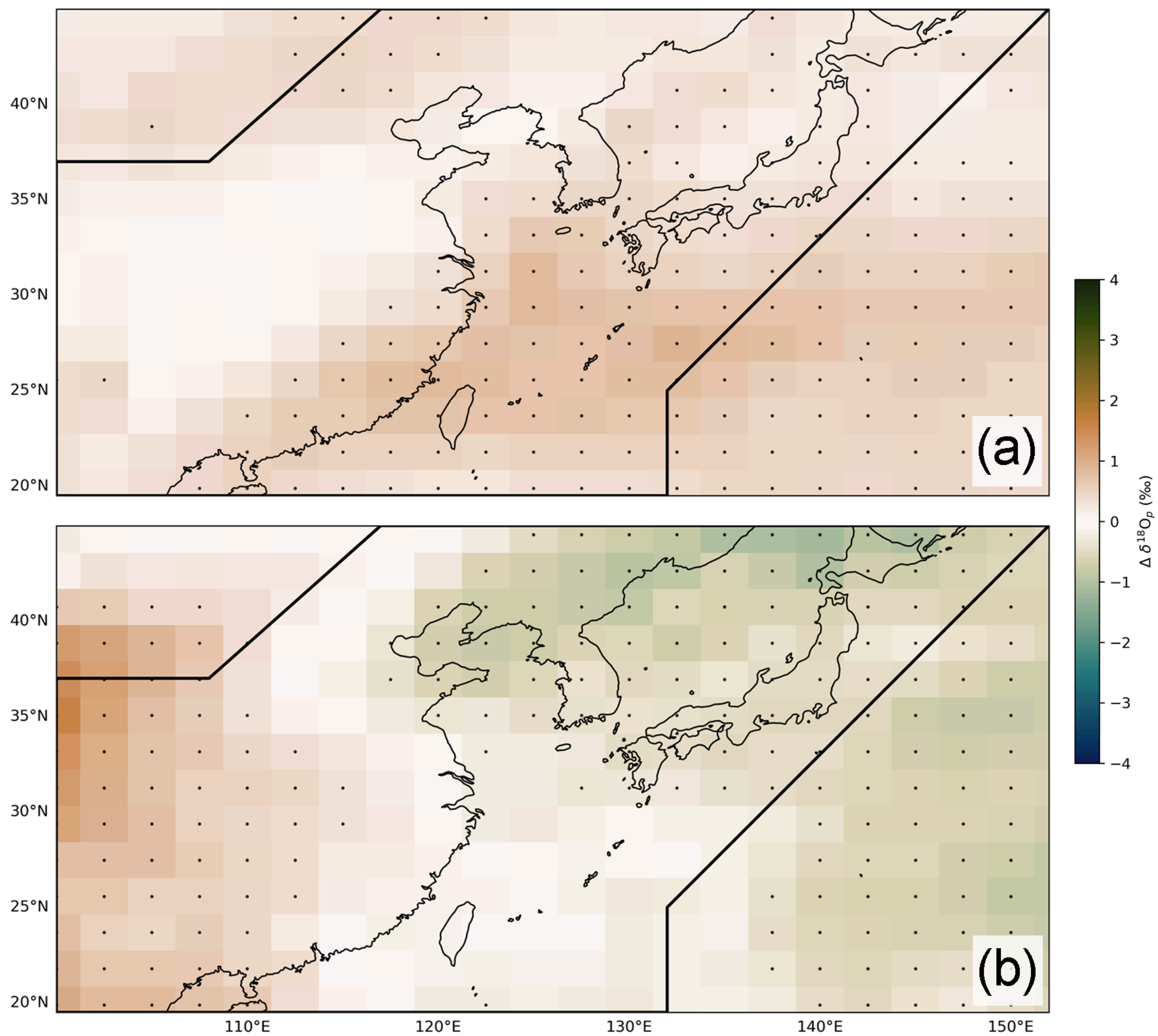

Figure 12. As in Fig. 11, but for East Asia. The unfilled black polygon represents the boundaries of the region defined by the IPCC.

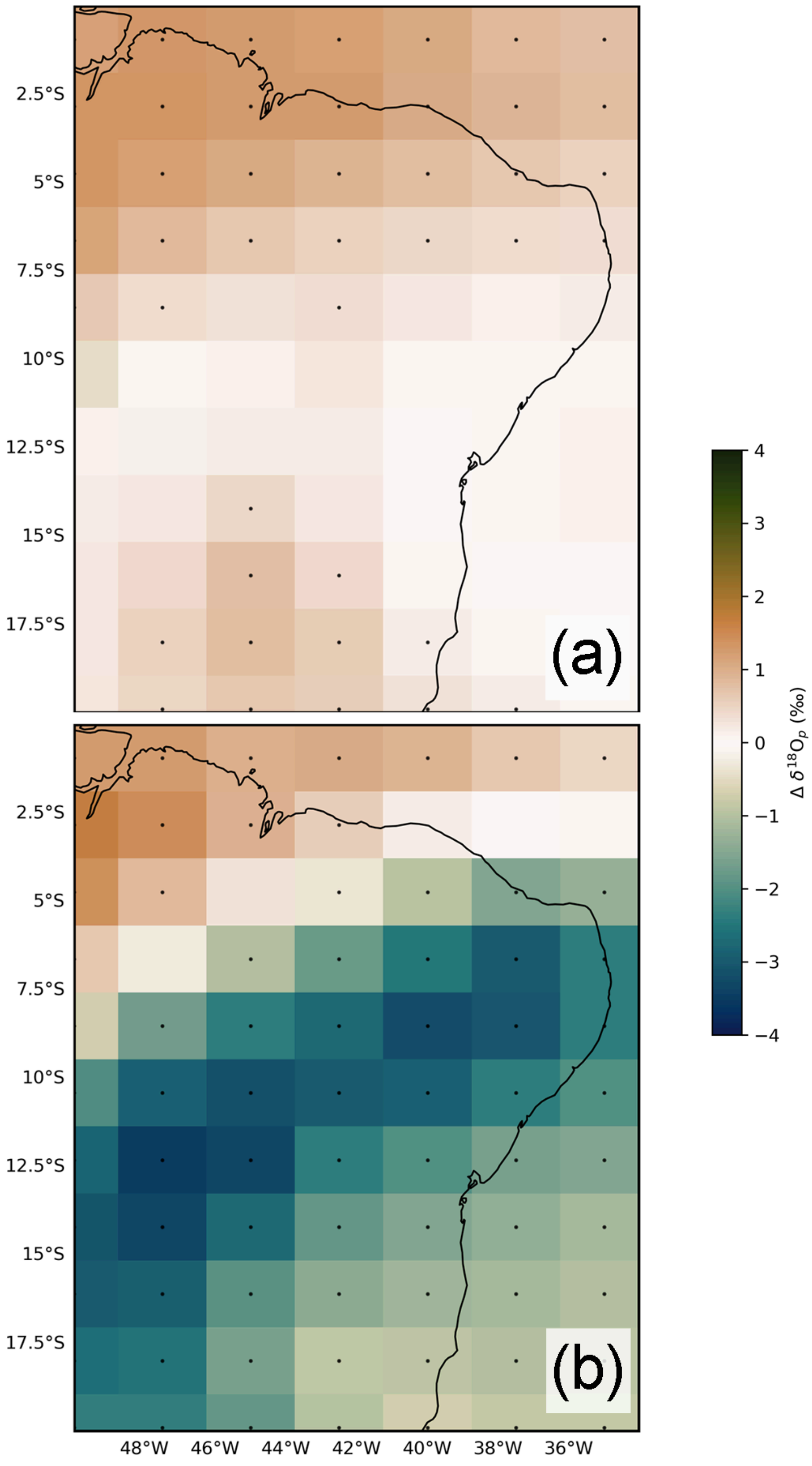

Figure 13. As in Fig. 11, but for Northeast South America.

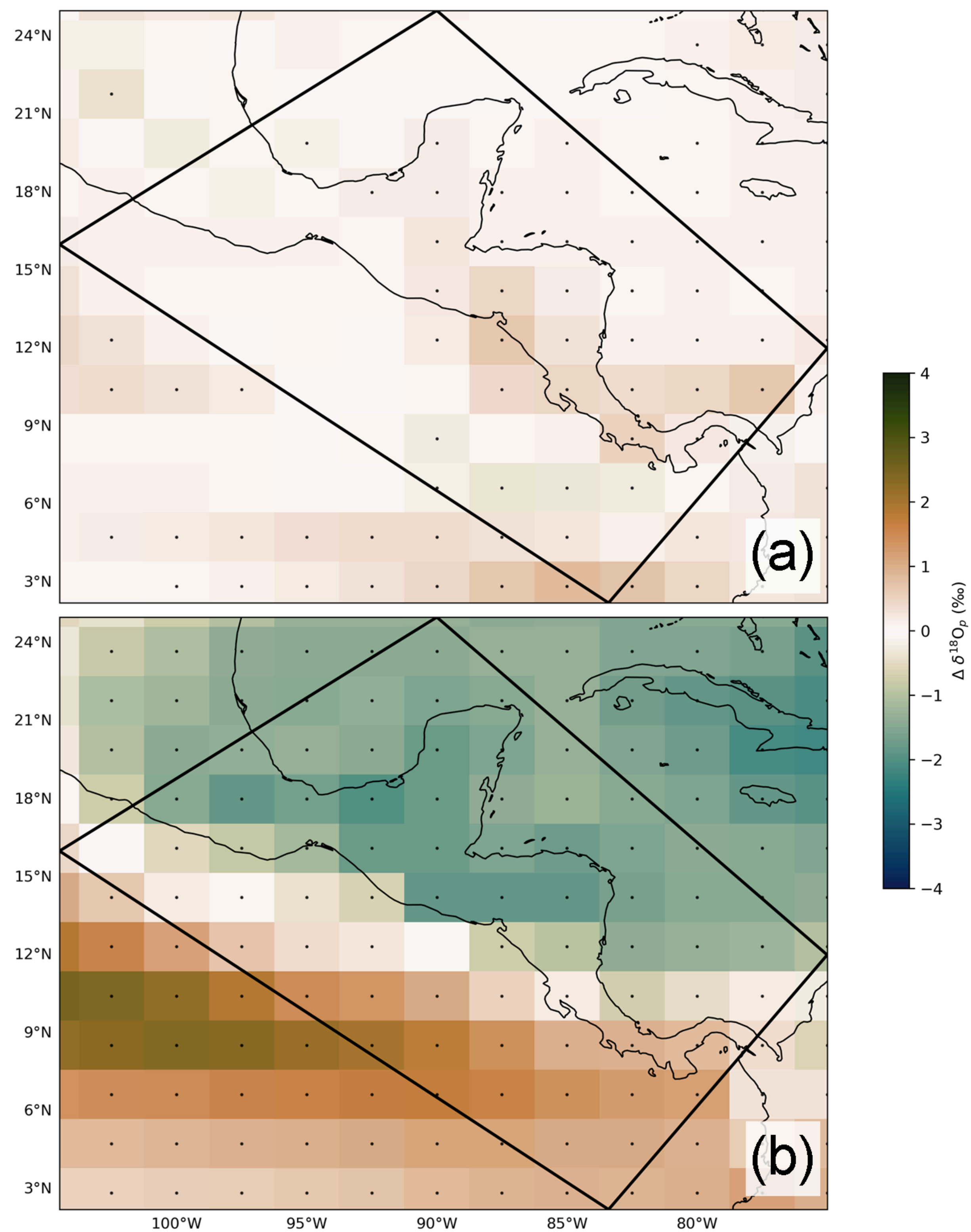

Figure 14. As in Fig. 11, but for Southern Central America.

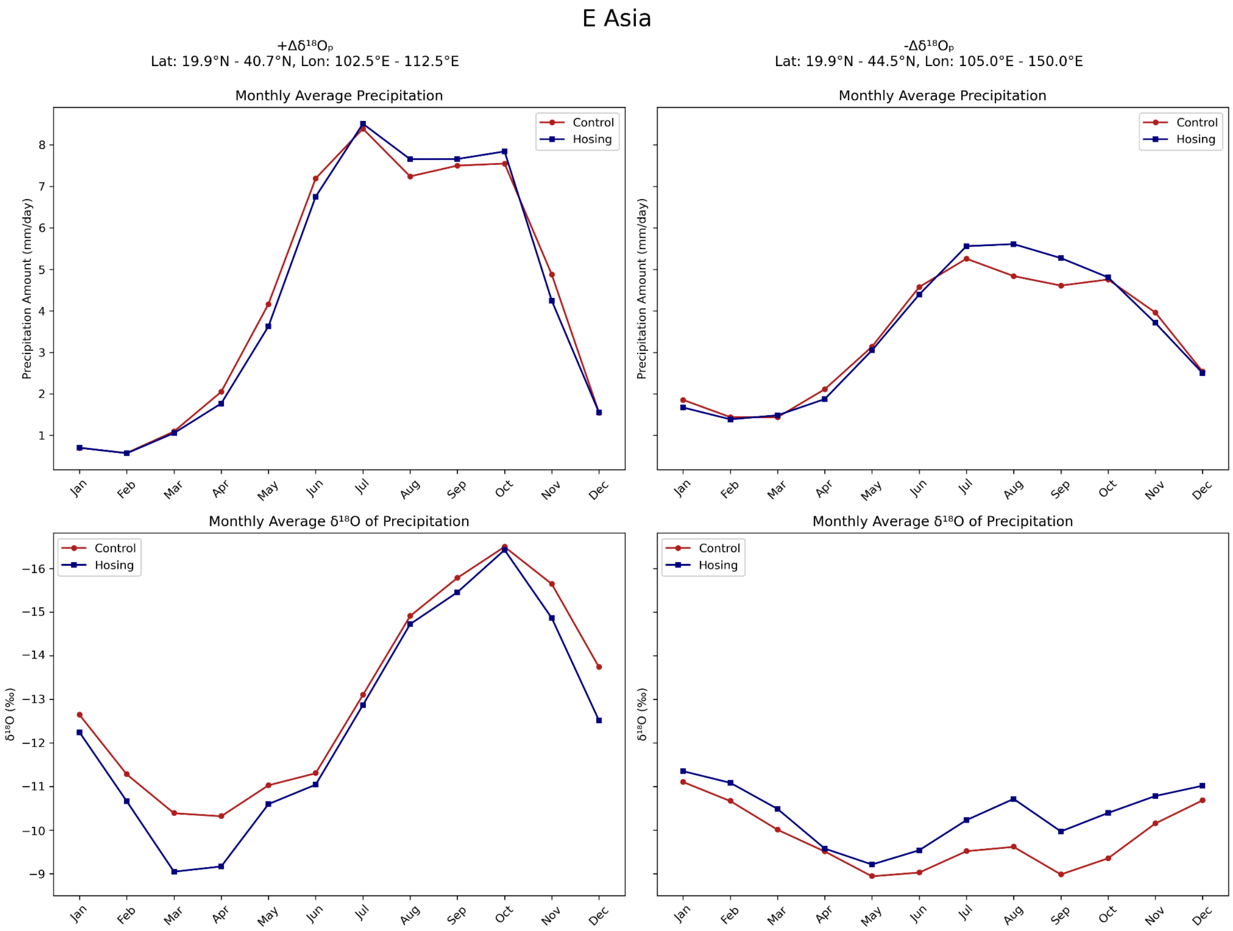

Figure 15. The area-weighted monthly average precipitation amount (top row) and precipitation $\delta^{18}O$ (not amount-weighted; bottom row) for the “ctrl” (red) and “hose” (blue) simulations. Data from the western subregion defined by the $+\Delta\delta^{18}Op$ anomaly in manuscript Fig. 4a are plotted in the left column. Data from the eastern subregion defined by the $-\Delta\delta^{18}Op$ anomaly are plotted on the right.

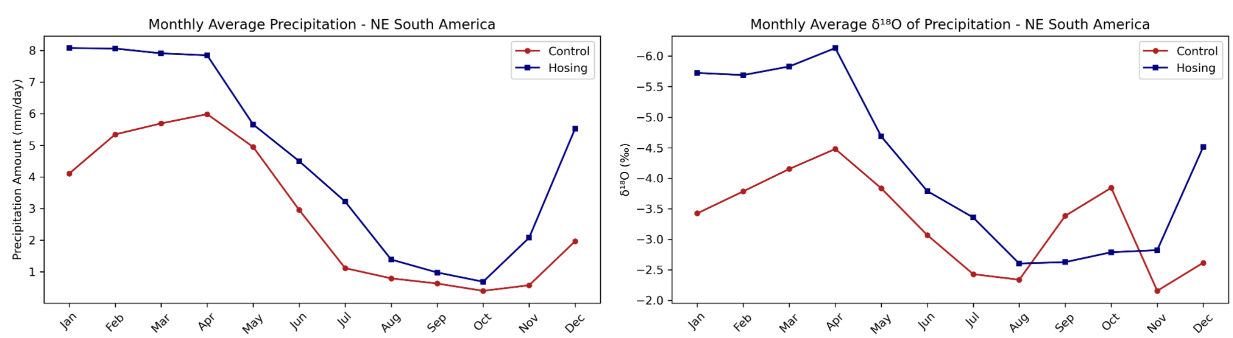

Figure 16. As in Fig. 15, but averaged over all of Northeast South America.

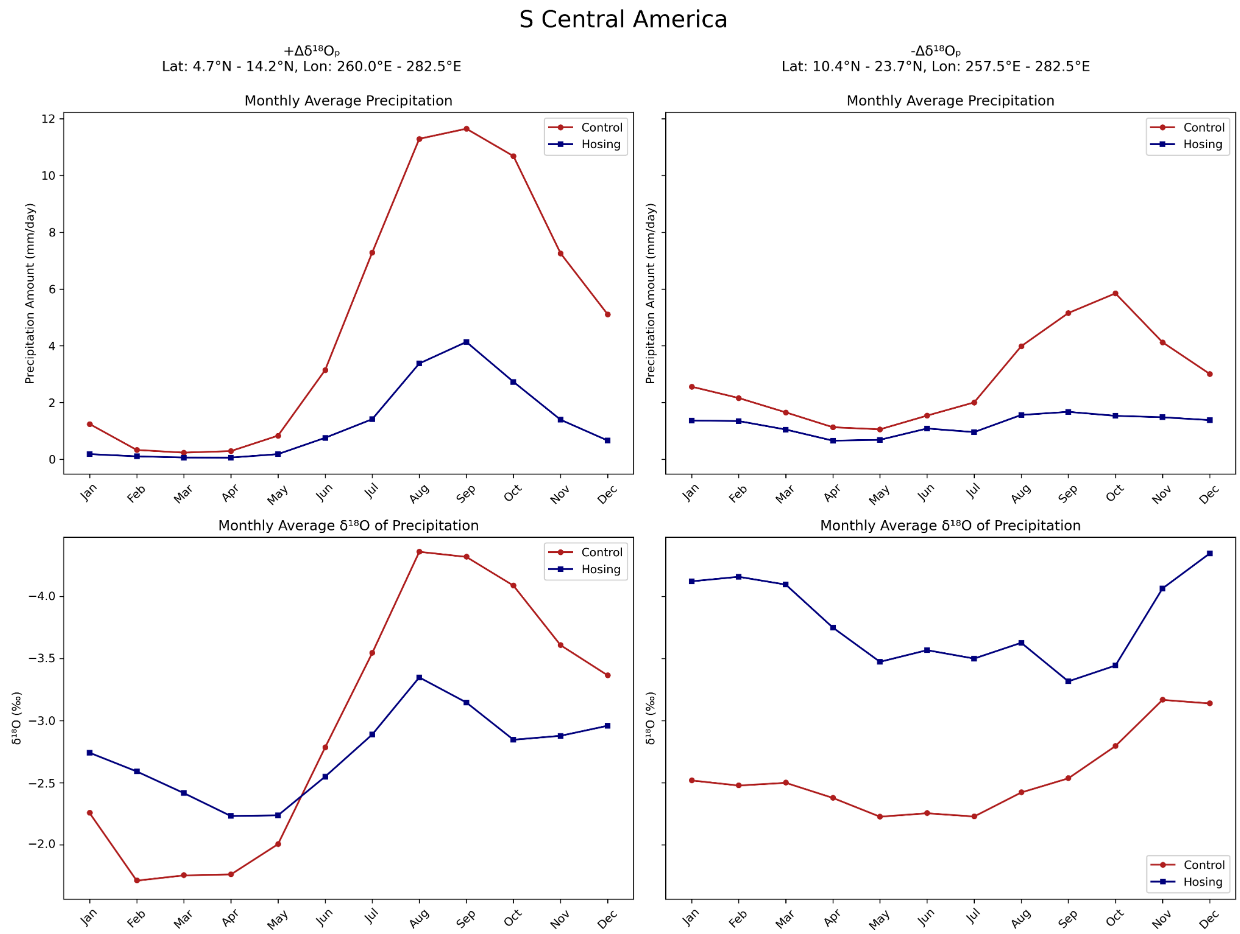

Figure 17. As in Fig. 15, but for Southern Central America. Data from the southern subregion defined by the $+\Delta\delta^{18}Op$ anomaly in manuscript Fig. 6a are plotted in the left column, while data from the northern subregion defined by the $-\Delta\delta^{18}Op$ anomaly in Fig. 6a are plotted in the right column.

Minor:

Line 6: "event detention methods" should be "event detection methods"
Thank you for finding this. It has been corrected.

Line11: "decadal to multi-centennial timescales" should be: "decadal-to-multi-centennial timescales"
Thank you for the correction.

Line 33: “strong strong” should be “strong”
Thank you for finding this. It has been corrected.

Line 253: add "A total of 61"
The final compilation of records used in our analysis of the amplitude, timing, and duration of the 8.2ka event includes only 30 records. As stated in Lines 234-239:

"The approximate start, end, and duration of hydroclimate anomalies associated with the 8.2ka event were calculated for all records in our compilation in which events of the same sign were detected in both our modified MM and actR event detection methods. This was done to provide a more robust reconstruction of the hydroclimate response to the 8.2ka Event than that which either method would achieve alone. ***This final set of records comprises 30 of the 61 records (49%) in our compilation. The remaining 31 records in our compilation displayed a lack of agreement in the sign or presence of an event and are thus excluded from further analysis.****"*

To avoid confusion, we have reworded Lines 253-254 to state:

"In the final set of 30 records (that agree on the sign of the event between the MM and ActR methods), drier and/or isotopically enriched events were detected in 13 of those 30 records, including six records from East Asia..."

Fig. 3. The shading should be difference between control and hosing, right? The caption is confusing.
Thank you for bringing this to our attention. We have clarified this in the caption for Fig. 9 as follows:

Summary of the 8.2ka Events detected using our actR method for the paleoclimate records included in this study. Records with drier and/or isotopically enriched events are shown in brown, records with wetter and/or isotopically depleted events are shown in green, and records in which no event was detected are shown in white. Stippling indicates that a "significant" event was detected in a given record by actR with event "start" and "end" times within the 7.9-8.3ka interval at the $p < 0.05$ significance level. Slashed hatching indicates the presence of a "tentative" hydroclimate anomaly, with either a "significant" event detected outside of the 7.9-8.3ka window (between 7.7-8.5ka) or an event within that window where $0.1 > p \geq 0.05$. Symbol size is scaled by $250\ln(1+|z|)$, calculated from the per-record mean and standard deviation over the 7ka-10ka interval. ***Symbols are mapped over the simulated anomalous (a) amount-weighted oxygen isotopic composition of precipitation, (b) precipitation amount, (c) and effective moisture, calculated from difference between the last 50 years of the iCESM "hose" and "ctrl" experiments****, at the 95% confidence level ($p < 0.05$).*

Fig 5. No color bar
Thank you for finding this. It has been corrected (see Fig. 10 above).

References

Atwood, A. R., Donohoe, A., Battisti, D. S., Liu, X., and Pausata, F. S. R.: Robust Longitudinally Variable Responses of the ITCZ to a Myriad of Climate Forcings, Geophysical Research Letters, 47, e2020GL088833, https://doi.org/10.1029/2020GL088833, 2020.

Chiang, J. C. H., Herman, M. J., Yoshimura, K., and Fung, I. Y.: Enriched East Asian oxygen isotope of precipitation indicates reduced summer seasonality in regional climate and westerlies, Proc. Natl. Acad. Sci. U.S.A., 117, 14745–14750, https://doi.org/10.1073/pnas.1922602117, 2020.

Lewis, S. C., LeGrande, A. N., Kelley, M., and Schmidt, G. A.: Water vapour source impacts on oxygen isotope variability in tropical precipitation during Heinrich events, Clim. Past, 6, 325–343, https://doi.org/10.5194/cp-6-325-2010, 2010.

Pausata, F. S. R., Battisti, D. S., Nisancioglu, K. H., and Bitz, C. M.: Chinese stalagmite δ18O controlled by changes in the Indian monsoon during a simulated Heinrich event, Nature Geosci, 4, 474–480, https://doi.org/10.1038/ngeo1169, 2011.

Roberts, W. H. G. and Hopcroft, P. O.: Controls on the Tropical Response to Abrupt Climate Changes, Geophys. Res. Lett., 47, https://doi.org/10.1029/2020GL087518, 2020.