

Reply to the reviewers' comments: A continental reconstruction of hydroclimatic variability in South America during the past 2000 years (egusphere-2024-545)

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Summary of changes

We thank the second reviewer for their constructive comments, which will help in improving the quality of our manuscript.

In response to their suggestions we plan to

- reorder and reorganize the appendix and the supplement figures in order of appearance in the main manuscript
- include figure AF12a into the main manuscript and remove figure AF5-AF9 altogether
- and revise the text throughout the manuscript to clarify statements

A detailed response to the helpful remarks of the referee is given below.

1 Reply to the second reviewer

The original report is cited in italics, our reply is written in blue color. Sections describing specific adjustments that we will make are marked in bold.

This manuscript presents a new Common Era climate reconstruction of South America, generated via paleo data assimilation. The authors include speleothems in their methodology, a largely unused archive in paleo data reconstructions. The manuscript provides a detailed description of their DA methods, validation methods, and clearly discuss the methodological limitations. They use their climate reconstructions to examine climatological anomalies through time and compare their findings to existing DA products.

This manuscript was incredibly thorough and presents an exciting new advancement in the use of speleothem records in paleodata assimilation. I think the authors hit a good

balance between interpreting their reconstruction and an honest discussion of the limitations/uncertainties. From my understanding of DA, the methodology and science seems sound, and I believe the manuscript is nearly ready for publication. I focus my few comments here on organization and readability.

We thank the reviewer for this positive assessment.

Appendix organization: In my opinion, I think the Appendices are out of order (e.g. appendix D is reference before appendix C). This makes navigating through the very lengthy supplemental information a bit challenging. I would recommend reordering the appendices as follows (A, D, C, B). I ran into a similar issue with the supplemental figures within Appendix A. There were several times where figures were referenced out of order (e.g. AF9 and 10 were referenced before AF 5-8).

Thank you for pointing this out. We agree with the reviewer, that the Appendices are out of order and need to be in line with order of appearance in the main text. Therefore we will reorder and reorganize the Appendices, but will slightly deviate from the order suggested by the reviewer (D,C,B,A):

- **D** The data tables of the employed proxy records will be mentioned first. We will also include the additional figure for the proxy record distribution (currently AF1) in that section. The former section A will become a section that includes only additional figures concerning the results.
- **C** This section will be changed into an Appendix Section for the Methodology. It will include the algorithm sketch (currently AF 2), a new sketch for the multi-time scale approach which was suggested by Reviewer 1 and the derivation of the SNR based proxy record error.
- **B** The validation of the reconstruction with instrumental data appears before the actual results in the main text.
- **A** for the additional figures of the results section.
- The Appendix names will be renamed to match the alphabetical order.

After the adjustment of the appendices, we will check the order of appearances of figures in the main text. We think that the reorganization of the appendices, for instance only including figures regarding the results in appendix A (new appendix D), will make the

order of appearance less confusing.

Supplemental figures: The number of supplemental figures in Appendix A makes the manuscript a bit cumbersome to read. I also find that the authors extensively discuss many of their supplemental figures in the text. This makes me wonder whether some should be moved to the main text? While I acknowledge that this may make the flow a bit less elegant, I think it would help guide the reader as the manuscript touches on quite a few different topics. I will not recommend any specific changes here and leave this decision up to the authors.

Thank you for appreciating our supplement figures and for leaving us the freedom to redesign the importance. We will move figure AF12, which shows the prior model dependency of the reconstruction, but only the precipitation part (a), into the main text. We consider the prior dependency of the precipitation reconstruction an important aspect of our study which should be highlighted more, as also Reviewer 1 has pronounced interest about this topic. We hope that the reorganization of the appendix will also help in making the appendix less cumbersome to read.

Detailed Comments

Line 65 – Missing some detail on the drivers of speleothem $d18O$. E.g. are there any studies specific to South America that should be cited here? What about upstream rainout, cloud effects. Etc... Dansgaard is a good reference, but some additional works should be cited here.

Thank you. We will be more specific to South America and change the section as follows:

”Speleothems are geological cave formations created by accumulating layers of calcium carbonates transported by seepage water. Among the many climate proxies archived in speleothems, the ratio between heavy and light oxygen isotopes ($\delta^{18}O$) as saved in accumulating layers of calcium carbonate reflects the isotopic composition of the precipitation above a cave and, thus, records hydroclimatic changes (Bradley, 2015). The $\delta^{18}O$ signatures of precipitation are sensitive to air temperature, precipitation amount changes, and the geographical location in terms of altitude, latitude, and distance from the coast (Dansgaard, 1964). **For South America, in particular the SASM influenced region, the rainfall amount during the monsoon season is a primary driver on the $\delta^{18}O$ signatures of precipitation (Vuille et al., 2003; Moquet et al., 2016)**”

Line 75 – topic sentence is a bit confusing – perhaps say ‘are excluded’ instead of ‘may be excluded’

Thank you for pointing this out. ‘may be excluded’ was used to indicate that the insights from speleothem proxy based studies of South American climate during the CE

could be missing in climate field reconstructions if not conveyed by other types of proxy records from South America. We will change the sentence as follows to make it clearer.

”...**It is not clear, if existing climate field reconstructions include these insights into South American Hydroclimate variability during the CE due to the limited integration of speleothem records. ...**”

Line 399 – Unless I missed it, I couldn't find the definition of the Southern Cone

Thank you for pointing this our. We will add a short definition, where it is first mentioned in line 167 as follows:

”...Regions lacking archive sites for proxy records can be found in the northern part of South America, namely Colombia, the Guianas and the north western states of Brazil. Additionally, the western part of the Southern Cone, **the cone-shaped area of South America south of the Tropic of Capricorn ($\sim 23.4^{\circ}\text{S}$)**, lacks proxy records. However, the South American Drought Atlas has demonstrated that tree ring records from the central and southern Andes can be skillfully used to reconstruct the hydroclimate of that region....”

References

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- Dansgaard, W.: Stable Isotopes in Precipitation, *Tellus*, 16, 436–468, <https://doi.org/10.1111/j.2153-3490.1964.tb00181.x>, 1964.
- Moquet, J. S., Cruz, F. W., Novello, V. F., Strikis, N. M., Deininger, M., Karmann, I., Santos, R. V., Millo, C., Apaestegui, J., Guyot, J. L., Siffedine, A., Vuille, M., Cheng, H., Edwards, R. L., and Santini, W.: Calibration of Speleothem $\delta 18\text{O}$ Records against Hydroclimate Instrumental Records in Central Brazil, *Global and Planetary Change*, 139, 151–164, <https://doi.org/10.1016/j.gloplacha.2016.02.001>, 2016.
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