

Clim. Past Discuss., referee comment RC2
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Comment on cp-2022-6

Anonymous Referee #2

Referee comment on "South American Summer Monsoon variability over the last millennium in paleoclimate records and isotope-enabled climate models" by Rebecca Orrison et al., *Clim. Past Discuss.*, <https://doi.org/10.5194/cp-2022-6-RC2>, 2022

General comments

The paper does a nice job of integrating longer-term proxy records and Earth system models, but links between recent observational datasets of modern water isotopes in precipitation (e.g., Aron et al., 2021; Fiorella et al., 2015; Guy et al., 2019; Vimeux et al., 2005, 2011) and water vapor (e.g., Galewsky & Samuels-Crow, 2015; Samuels-Crow et al., 2014) are not well established. Many of these authors came to similar conclusions regarding the relationship between water stable isotope ratios over South America and convection, and a few sentences to a few paragraphs incorporating these observations I think would help strengthen your conclusions. There are several areas in this manuscript where such a comparison would be relevant, but L. 486-488 stands out in particular.

On a related note, the authors indicate multiple times that precipitation isotope ratios are strongly related to rainout (e.g., L. 25, 368-370, 492). This may well be true, but the analysis presented doesn't establish this. Given the complexity in convective systems, there may well be additional factors that are also quite important. I would suggest revising these sections to be a bit more circumspect about the dominance of rainout in the region. Another approach would be to better establish links between rainout and precipitation isotope ratios using a more quantitative approach (e.g., Aron et al., 2021; Fiorella et al., 2021; Konecky et al., 2019; Sodemann et al., 2008; Sodemann & Stohl, 2013).

This paper would also benefit for a more detailed explanation of the MCEOF approach, how the number of EOFs to present have been chosen, etc., as the description of these methods is quite brief. For example, the authors seemed to have selected the first two EOFs based on guidelines from North et al. (1982), but then note that these two EOFs only explain ~30-35% of the variance (and less in the pseudoproxy experiment), meaning there remains a lot of unexplained variations. This could also be discussed a bit more. (For example, one potential source of this unexplained variance is ENSO, but ENSO is treated extremely briefly in this manuscript – once in the introduction, and then re-enters

unexpectedly in the conclusions) – of course there are other potential mechanisms of variation, but I think this manuscript would benefit from additional analysis/discussion regarding the explained vs. unexplained sources of variation.

Specific Comments

L. 74-76: Various processes in convection (e.g., raindrop evaporation, interaction with unsaturated downdrafts, entrainment of mid-troposphere vapor, etc.) can promote deviations in isotope ratios that would be expected from Rayleigh distillation. More details on these processes and their impact on isotope ratios are provided by: (Lee & Fung, 2008; Moore et al., 2014; Risi et al., 2008).

L. 144: was the annual resolution in these records determined by U/Th dating? Or by other methods? Not my area of expertise with respect to this paper, but I was surprised that U/Th dating could be so precise.

L. 225-226: It would be worth specifying which version and configuration of the iCESM this refers to, since this bias is not constant throughout different versions of iCAM/iCESM. For example, compare simulations in Brady et al. (2019) (fully coupled iCESM1) to Nusbaumer et al. (2017) (iCAM5/iCLM4) and Fiorella et al. (2021)(iCAM6/land bucket scheme).

L. 439-441: It may be worth noting here the impact a 2° grid may have on the ability of a model to resolve complex topography.

L. 451-453: Perhaps the models are incorrect here, but another possibility is that this is subgrid variability that cannot be resolved.

Technical Corrections

L. 142-3: I would suggest providing links here for both data sources for consistency.

L. 334 – “EOF” should be “EOF2” here I think?

Figures:

- Figure 3 is really hard to read. Could it be made significantly larger?
- Consistency with labeling the proxy sites – these sites are labeled in Fig. 2 and 4, but not Fig. 3 and 5. These plots might be easier to read if these sites were labeled in Fig. 1 (since this allows you the most room), but perhaps omitted in Fig. 2 and 4.

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