Reply to the reviewers' comments: Investigating oxygen and carbon isotopic relationships in speleothem records over the last millennium using multiple isotope-enabled climate models (cp-2021-152)

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Summary of changes

We again thank the second reviewer for their comments and detailed reading. In response to the suggestions by the reviewer we

- added one sentence to the conclusion to clarify the interpretation of the conclusion,
- checked the reference format throughout the manuscript

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

Reply to the second reviewer

(Original report cited in italics)

Dear authors of the manuscript "Investigating stable oxygen and carbon isotopic variability in speleothem records over the last millennium using multiple isotope-enabled climate models", I appreciate for a substantial effort in revising this manuscript. The current version is easier to understand than before, especially two very interesting questions in the discussion section. However, I still worry about the main conclusion that the temperature is dominant driver. Thus, I suggest that the manuscript should be accepted for publication after minor revision.

Thank you for the second reviewing. We are pleased to read that our changes increased the readability of the manuscript.

Major comments:

1) How to understand the significant temporal correlation between simulated temperature to $\delta^{18}O_{speleo}$? If I am right, the temperature effect on the speleothem $\delta^{18}O$ record is very small. Moreover, the equations 1 and 2 include the annual mean modelled surface temperatures in the drip water equivalent, which would increase the influence of temperature on the simulated oxygen isotope records.

Thank you for the comment. For the correlation estimates between simulated variables and the isotope signal in speleothems in Figure 5, we make sure to always use the "raw" δ^{18}O measurements (denoted as $\delta^{18}O_{speleo}$) as given by the SISALv2 database and not the drip-water equivalents (denoted as $\delta^{18}O_{dweq}$) as described in equation (1) and (2). The higher number of speleothem entities that show significant correlation to temperature than to precipitation could be attributed to the more uniform response of modeled temperature to e.g. volcanic forcing between model ensemble runs compared to precipitation responses, which depend strongly on regional particularities. We have already highlighted this in the discussion section 5.2 (lines 5-16) on page 23.

2) There are some divergences need to be checked. e.g. in the conclusion, "temperature was driving $\delta^{18}O_{iw}$ variability in high latitudes and precipitation in low latitudes. At cave site locations in particular, which are mostly located in low- to mid-latitudes, models agreed more on temperature being the driving factor of SWI variability than on precipitation." This implies that the models show that the temperature is more important than precipitation in all latitudes. Right?

While large-scale hydroclimate patterns are well represented in general circulation models, they tend to struggle in realistically simulating regional hydroclimate particularities due to convection and cloud dynamic parameterizations. Hence, spatial and temporal consistency between models and proxy records has to be evaluated carefully (PAGESHydro2k-Consortium, 2017). A higher number of correlation estimates to temperature than to precipitation indicates a higher correlation to external forcing factors, as the temperature response to these forcings are more uniform (PAGESHydro2k-Consortium, 2017). Bühler et al. (2021) showed significant correlation between external volcanic forcing and simulated temperature but no significant correlation to precipitation for the iHadCM3 last millennium run, that is used in our multi-model ensemble. In our analysis on extreme synchronous events, volcanic forcing was detectable in $\delta^{18}O_{sim}$ on an annual basis but not on record resolution. To make it easier to interpret the results, we added the following explanation to our conclusion after the section that you cited (page 26, lines 23-24): "**However, temperature signatures in climate models are generally more uniform than those of precipitation, as these depend heavily on how models parameterize convection and cloud dynamics (PAGESHydro2k-Consortium, 2017).**" .

Specific Comment:

The format of the references should be checked. e.g. (Fohlmeister et al., 2017) studied..., and (PAGESHydro2k Consortium, 2017).

Thank you for the careful reading. We scanned the document and changed citation styles where necessary.

References

Bühler, J. C., Roesch, C., Kirschner, M., Sime, L., Holloway, M. D., and Rehfeld, K.: Comparison of the oxygen isotope signatures in speleothem records and iHadCM3 model simulations for the last millennium, Climate of the Past, 17, 985–1004, 2021.

PAGESHydro2k-Consortium: Comparing proxy and model estimates of hydroclimate variability and change over the Common Era, Climate of the Past, 13, 1851–1900, https://doi.org/10.5194/cp-13-1851-2017, 2017.