Clim. Past Discuss.,
https://doi.org/10.5194/cp-2019-25-AC3, 2019

Climate of the Past Discussions

Interactive comment on "Evaluating model outputs using integrated global speleothem records of climate change since the last glacial" *by* Laia Comas-Bru et al.

Laia Comas-Bru et al.

l.comasbru@reading.ac.uk

Received and published: 25 April 2019

Reply to Anonymous Referee 3

The authors used different approaches to compare the speleothem records from the SISAL database with the simulated results of the ECHAM5-wiso model for present-day, MH and LGM. Based on their analyses, they propose a protocol for using speleothem isotopic data for model evaluation. The paper is well written and the analyses could be interesting for researchers working in related field. However, it seems to me that the paper could be improved by adding more in-depth discussions/analyses.

We thank the reviewer for their comments, but we feel they may not have fully understood the purpose of this paper. We try to clarify what we are doing in response to these comments: the reviewer comments are in normal script in black, our explanations in blue italics and additional text is given in normal script in blue.

I don't see very well what is the advancement made by this study as compared to the traditional approach for comparing the speleothem records with models. Maybe the authors should stress more why their approaches are better and what new can been discovered by their approaches that cannot be done by traditional approach.

Data-model comparisons using speleothem data are comparatively new, and have tended to focus on validation of new versions of isotope-enabled models. These comparisons have often overlooked important characteristics of, and/or uncertainties associated with, the speleothem records (see discussion lines 90-99). There is no agreed protocol for using speleothem data for model evaluation. The purpose of our paper was to identify issues that could affect data-model comparisons, drawing on the new SISAL database that has been explicitly constructed to facilitate such comparisons and the expertise of the speleothem experts who constructed this database. Thus we are not claiming that our approach is different from or better than a "traditional" approach – we are simply making it clear how speleothem data should and could be used. We can make this clearer by amplifying our description of the purpose of the paper (108-110) as follows:

In this paper, we examine a number of issues that need to be addressed in order to use speleothem data, most especially data from the SISAL database, for model evaluation in the palaeoclimate context and make recommendations about robust

approaches that should be used for model evaluation in CMIP6-PMIP4. We focus particularly on interpretation issues that could be overlooked in using the speleothem records and we show the strengths and limitations of different comparison techniques.

It is not very clear to me what is the final goal of the data-model comparison and what can be improved or learned after all the analyses. If the comparison is good, can we assume that the temperature and precipitation simulated by the model are correct and what is the uncertainty? What might be the reasons for the similarities and differences between model results and speleothem data? Can the results help to improve the model and/or experiment design and how?

As we explain in the introduction (lines 45-54), model evaluation using palaeoclimate data provides an out-of-sample test of model performance and is one component of the Palaeoclimate Modelling Intercomparison Project. Such evaluations help to provide confidence in the projections of future climates. Speleothems are a relatively new source of information for such evaluations and the purpose of our paper is to provide a robust framework to make such evaluations. We do not want to distract from this goal by discussing the generic purposes of data-model comparison in the Introduction to the paper, but we could certainly add a concluding paragraph discussing what can be learnt from such data-model comparisons as follows:

Comparisons with speleothem data can be seen as a complement to model evaluation using other types of palaeoenvironmental data and palaeoclimatic reconstructions (see e.g. MARGO Project Members, 2009; Harrison et al., 2014). They can be considered particularly useful because they provide insights into how well state-of-the-art models reproduce the hydrological cycle and atmospheric circulation patterns. The ability to reproduce past observations provides additional confidence in the ability of climate models to simulate large climate changes, such as those expected by the end of the

21st century (Braconnot et al., 2012; Schmidt et al., 2014). However, mismatches between model simulations and palaeo-observations are also useful because they can help to pinpoint issues that may need to be addressed in developing improved models or in better experimental protocols (Kageyama et al., 2018), providing that these mismatches do not arise because of misunderstanding or misinterpretation of the observations themselves. By providing a protocol for using speleothem data for data-model comparisons that accounts for uncertainties in the observations, we anticipate that at least such causes of data-model mismatches will be minimized.

The major uncertainties and biases of the ECHAM5-wiso model in simulating present day and past climates and the experiment design of the MH and LGM simulations, the reliability of the SST and sea ice simulated by the CCSM3 and their potential influence on the data-model comparison should be discussed.

We use outputs from the ECHAM-wiso model in order to illustrate potential approaches to data-model comparison. Our goal here is not to provide an in-depth evaluation of the quality of these simulations. The performance of the ECHAM-wiso model under modern day conditions has been extensively analysed (see e.g. Werner et al., 2011; Wackerbarth et al., 2012) and the MH and LGM simulations have also been published and discussed (Wackerbarth et al., 2012; Werner et al., 2018). In order to make it clear that our use of the model is illustrative, we will modify the final section of the introduction (line 113 onwards) to read:

We use an updated version of the SISAL database (SISALv1b: Atsawawaranunt et al., 2019) and simulations made with the ECHAM5-wiso isotope-enabled atmospheric circulation model (Werner et al., 2011) to explore the various issues in making data-model comparisons. The goal is not to evaluate the ECHAM5-wiso simulations but rather to use them to illustrate generic issues in data-model comparison with

speleothem isotopic data.

The simulations for MH and LGM are only 12 and 22 years. Are they long enough to allow the climate at different speleothem location reaching equilibrium? What is the initial state of these simulations? What might be the influence of using fixed ocean condition?

As we explain in the methods section (lines 128-154), these are atmosphere-only simulations forced with sea-surface temperatures and sea-ice cover from a pre-existing transient simulation. Thus, there is no spin-up necessary and the issue of equilibrium is irrelevant. If the purpose of this paper were to use the model simulations to explain speleothem records, then the lack of ocean coupling would mean that the simulations would be unsuitable for evaluating the degree to which long-term (multi-decadal) variability in the speleothem isotope record reflected internal unforced variability. But as our purpose in using the experiments is illustrative, then the short length of the simulations is not important. We hope that the modification to the introduction suggested above will help clarify the purpose of this paper.

Interactive comment on Clim. Past Discuss., https://doi.org/10.5194/cp-2019-25, 2019.