

## ***Interactive comment on “Glacial–interglacial shifts in global and regional precipitation $\delta^{18}\text{O}$ ” by S. Jasechko et al.***

**S. Jasechko et al.**

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### **Re: C283: 'Review', Reviewer 1**

We thank Reviewer 1 for commenting on our manuscript and for their pointing out potential usefulness of the data compiled in this study. We will take the following steps to improve our manuscript:

**Jasechko et al. present a compilation of 88 sets of d18O isotope data. By bringing a large range of dated groundwater measurements together with speleothem and ice core data, they provide a global picture of the difference in d18O between the ice age (19,500 to 50,000 years ago) and the late Holocene (0 to 5000 years ago). This new compilation should prove a valuable resource for both iso-**

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topic modellers and observationalists. The paper is generally well structured and well written. It presents a convincing global and regional picture of the isotopic change. However the extended descriptions of the isotopic data can read more like an figure caption than a scientific investigation. Generally, there is a lack of physical explanations provided, more particularly , there is no meaningful use of the model results in helping the authors interpret/understand the compiled d18O measurements. To help alleviate this problem, Figures S1, S2, and S3 should be moved into the main text – and equivalent model plots to Figure S1b should also be provided. This would enable the authors to provide more by way of model-data interpretation. We thank the reviewer for their suggestions and we will move the supplemental figures into the revised main text. We agree that further model-data inter-comparison would benefit from diagnosing model intricacies, focusing on regions where inter-model and model-observation precipitation isotope compositions diverge. The primary contribution of this study is the exploration in the spatial patterns of isotopic change from the latter half of the last glacial time period to the late-Holocene. Future climate model work could use these synthesized records to further diagnose global and regional model performance, focusing on regions where most models diverge from the measured  $\Delta^{18}\text{O}$ late-glacial values. We add the figures previously shown in the Supplement to the main text.

**Finally, since the data compilation is the main point of the work, the data could usefully also be put into a more accessible form. Alongside Table S3, S4, and S5, a text or excel file, with these table info and also uncertainties (wherever possible) would be useful.** We thank the reviewer for their comment and agree that there may be scientists who would benefit from such a data repository. We will include an excel spreadsheet in our revised submission.

**Terminology: The ‘ice age’ tends to be a rather loosely defined term. The authors could usefully switch to using the ‘latter half of the last glacial period’. And define this as an average from 19,500 to 50,000 years ago. ‘Ice age’ is currently**

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**used throughout the text and figures.** We agree that we analyse isotope data spanning the latter half of the last glacial time period. However, this description is rather lengthy and leads to longer sentences that may complicate our efforts to communicate the findings of this study. We revise our manuscript to instead refer to “late-glacial” and explicitly state how we use this terminology by adding the following text: *“For brevity, we refer herein to the time period representing the latter half of the last glacial period ( 20,000 to 50,000 years before present) as the late-glacial (e.g.,  $\delta 18\text{O}_{\text{late glacial}}$ ).”*

**The current title could be more precise, given that it does not really deal with glacial-interglacial shifts (plural). Perhaps could be replaced with something like: “Global and regional  $\delta 18\text{O}$  in precipitation during the latter half of the last glacial period”.** We revise the manuscript title to convey our examining only the most recent glacial-interglacial shift: *“Late-glacial to late-Holocene shifts in global precipitation  $\delta 18\text{O}$ ”*

**‘In general, these models were the versions submitted to the CMIP5 archive and participating in PMIP3’. If three of the five model simulations are not from CMIP5-PMIP3 this sentence should be revised/removed, since ‘in general’ is not accurate.** We revise the manuscript to convey model participation in the CMIP5-PMIP3 inter-comparisons: *“GISSE2-R was submitted to the CMIP5 archive and participated in PMIP3. LMDZ4 was submitted to the CMIP3 archive. ECHAM5 and CAM3iso did not participate in CMIP5, while IsoGSM uses different boundary conditions than proposed for CMIP5 (Yoshimura et al., 2008).”*

**P840 L8, and all other similar instances: ‘reconstructed’. It would seem more accurate to use the term ‘measured’. Reconstructed is usually used when inferring a quantity from a measurement e.g. reconstructed temperature (from  $\delta 18\text{O}$ ). In this case these  $\delta 18\text{O}$  values seem to be measured quantities.** We agree with the reviewer’s comment to use “measured” rather than “reconstructed” and make this change throughout the manuscript.

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**subsection 3.1 It would be useful to include a brief analysis/discussion of inter-archive differences here, i.e. do speleothem measurements show the same pattern as groundwater measurements?** There are limited locations where both speleothem and groundwater archives covering similar time spans exist in close proximity. We have added a new paragraph to section 3.1 comparing measured  $\Delta^{18}\text{O}$  late-glacial values obtained from different types of proxy records located near to one another in China, Israel and Turkey.

**P842, L842 It is unlikely that the  $\delta^{18}\text{O}$  simulation differences are primarily due to differences in ocean  $\delta^{18}\text{O}$ . Most of the differences are instead likely to be due to differences in the simulated climates: e.g. humidity, temperature, precipitation etc. This should be described and discussed in 3.2.** Inter-model differences in simulated seawater  $\delta^{18}\text{O}$  values may impact simulated precipitation  $\delta^{18}\text{O}$  (LeGrande and Schmidt, 2006). We agree with the reviewer that most of the inter-model differences are likely due to differences in simulations of physical processes between the latter half of the last glacial period and the late-Holocene. We update the manuscript to point out that inter-model differences in simulated seawater  $\delta^{18}\text{O}$  are likely of lesser importance than simulated atmospheric processes. We add: *“different seawater  $\delta^{18}\text{O}$  specifications cannot account for all inter-model differences in simulated  $\Delta^{18}\text{O}$  late-glacial values.”*

LeGrande, A. N., and Schmidt, G. A.: Global gridded data set of the oxygen isotopic composition in seawater, *Geophys. Res. Lett.*, 33, L12604, 2006.

**It seems odd to show the glacial-to-modern changes in land temperature S1 from reconstructed temperatures, without any similar discussion/plots of the model results. See also ‘general comments’ above.** We show a recently published map of temperature changes from the last glacial maximum to pre-industrial temperature change published (Annan and Hargreaves, 2013). We do not show individual atmospheric temperatures simulated by each model, instead providing references to publications describing the individual models for readers interested in examining inter-model

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differences in simulated hydro-climates.

Annan, J. D., and Hargreaves, J. C.: A new global reconstruction of temperature changes at the Last Glacial Maximum. *Clim. Past*, 9, 367–376, 2013.

**P843 “Simulated precipitation d18O values either show little change (0.1 ‰ or show increases of up to 1.5 ‰ when modern spatial heterogeneous of surface ocean d18O values are included (LeGrande and Schmidt, 2006).” This is confusing – should it not be one or the other?** We reword to clarify how homogenous versus heterogeneous simulated seawater  $\delta^{18}\text{O}$  impacts land precipitation  $\delta^{18}\text{O}$ : *“Including surface ocean  $\delta^{18}\text{O}$  heterogeneities in model simulations impacts land precipitation  $\delta^{18}\text{O}$  by up to 1.5 ‰ relative to simulations with homogenous seawater  $\delta^{18}\text{O}$  (LeGrande and Schmidt, 2006).”*

**P846 L10-11 “mechanisms driving this extra-tropical/tropical difference remain elusive and can be examined through future inter-model or model-reconstruction comparative studies.” Not a very useful statement – suggest removing it.** We remove this statement from the revised manuscript.

**P849, L19 ‘during the Pleistocene’ – rather non-specific!** We revise all cases to: *“during the late-glacial”*

**P850, L2, ‘subglacial recharge’ – clarify please.** We reference previous publications describing subglacial recharge. We reword “subglacial recharge” to *“groundwater recharge that took place beneath the Laurentide ice sheet.”*

**P852, L12 “Differences in simulated precipitation isotope composition changes amongst the models might be linked to different parameterizations of seawater d18O, glacial topography and convective rainfall, however, this hypothesis requires further testing.” These would seem to be three hypotheses.** We revise to *“these hypotheses”*

**The abstract should also be tightened up.** The abstract has been revised.

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**Figure 1** There are a lot of odd straight lines in my printed version of F1 – could these be removed? We will inquire with journal typesetters to avoid the lines showing up on the current version of Figure 1.

**Figure 2** It would be helpful if different colours were used for the groundwater versus the cave (speleothem?) measurements. Speleothem records are now displayed in green.

**Figure 3** This figure is much too small to be able to see anything. Perhaps it could be spread over two or three pages. We will request that the multi-model precipitation isotope composition figure be displayed in large format in the revised manuscript. We will also submit the figure in vector format so that readers who are interested in specific model outputs will be able to zoom in to regions of interest without sacrificing image resolution.

**S1, S2, and S3** would seem better off in the main text, accompanied by a new figure showing modelled temperature (and precipitation?) anomalies too. We move current figures S1-S3 into the main text. We also revise the regional maps to show  $\Delta^{18}\text{O}$ late-glacial values as text to complement the colour scale.

**P845 L17-18 i.e. or e.g. – consistency.** We revise the manuscript for consistency of “i.e.,” and “e.g.,”

**Supporting Information; Supplement; Supplementary Information – not used consistent throughout text.** We revise to “Supplement.”

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Interactive comment on Clim. Past Discuss., 11, 831, 2015.

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