Last Glacial to present-day variability of surface climate from oxygen isotope signatures in speleothems and model simulations

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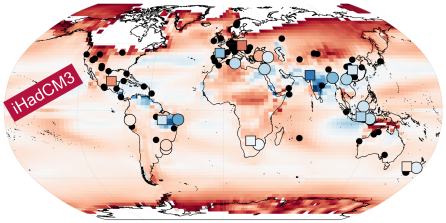
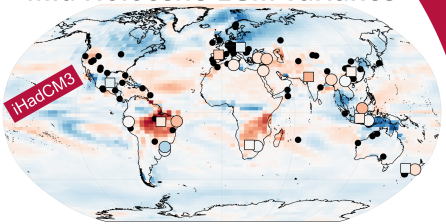
Mid Holocene-LGM mean



Mid Holocene-LGM variance



Separate: 134 records in 9 cluster; 27 for LGM (~21±0.5ky), 107 for MH (~6±0.5ky),

Joint: 16 individual records spanning the period of 21.5ky-6ky BP

Key Message

reasonable good agreement between sim. and speleos:

- speleos show greater changes than simulated
- state-dependency of simulated and recorded $\delta^{18}O$ variability

Display Material: precipitation, ECHAM5, ...

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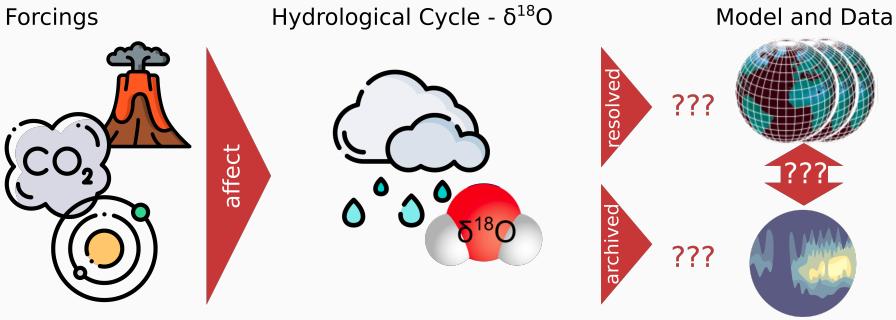
SISALv2: Comas-Bru et al. 2020

Model Data Comparison: GCMs vs. Speleothems

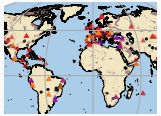


In past, present and future, the hydrologic response to radiative forcing changes is far less understood and more uncertain than thermal changes.

How are these changes resolved in paleoclimate simulations AND how are they archived in speleothems?

Water molecule Sakurambo, Wiki Commons, Public domain, Volcano: https://www.flaticon.com/authors/smashicons, Orbit, CO2, cave: https://www.flaticon.com/, Models: modified from Rehfeld,2019

Fast Summary

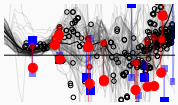


We compare isotopic signature changes in a large global speleothem database...

→ **SISALv2** from Comas-Bru et al. 2020 Earth System Science Data

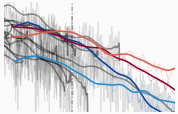
... to iHadCM3 and ECHAM5 PI, MH and LGM isotope enabled simulations.

→ **iHadCM3** as in Tindall et al. 2009, **ECHAM5** as in Werner et al. 2011, 2016



We see reasonable agreement between GCMs and speleothems...

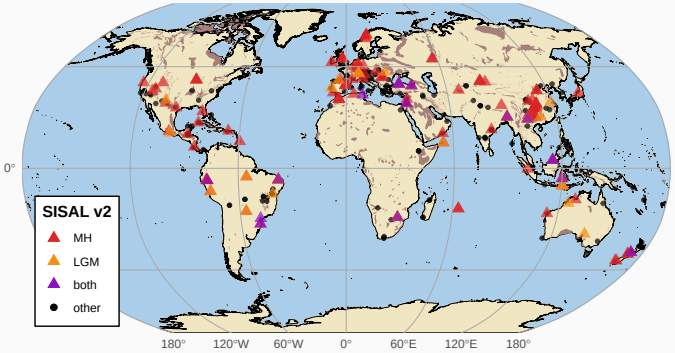
→ Total recorded changes in mean and variance higher than simulated



... and visible state dependency of variance.

→ reflected both in calcite-$\delta^{18}O$ and simulated precipitation $\delta^{18}O$

Proxies: SISALv2 database $\delta^{18}O$ filtered for MH and LGM



Criteria: more than 2 datings and more than 10 $\delta^{18}O_{calcite}$ measurements within a 500y period during **M**id **H**olocene (6$\pm$0.5ky) and **L**ast **G**lacial **M**aximum (21$\pm$0.5ky)

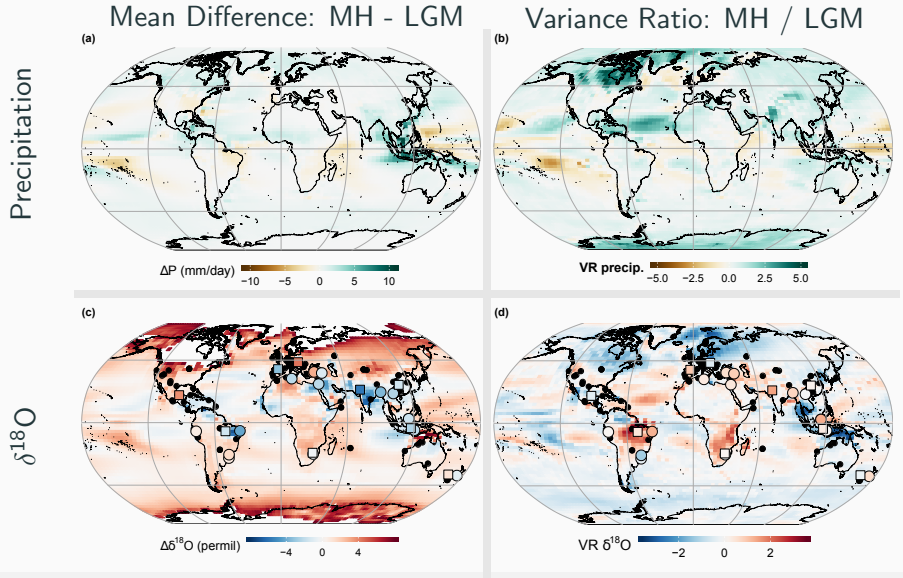
Distance based clustering: 1: N-America (21), 2: S-America (11), 3: Western Europe + N-Africa (16), 4: Eastern Europe (26), 5: S-Africa (3), 6: India + centr.-Asia (16), 7: E-Asia (20), 8: SE-Asia (15), 9: New Zealand (6)

Joint Ansatz: 16 individual records spanning the period of 21.5ky-6ky BP

Separate Ansatz: 134 records in 9 cluster; 27 for LGM (21$\pm$0.5ky), 107 for MH (6$\pm$0.5ky),

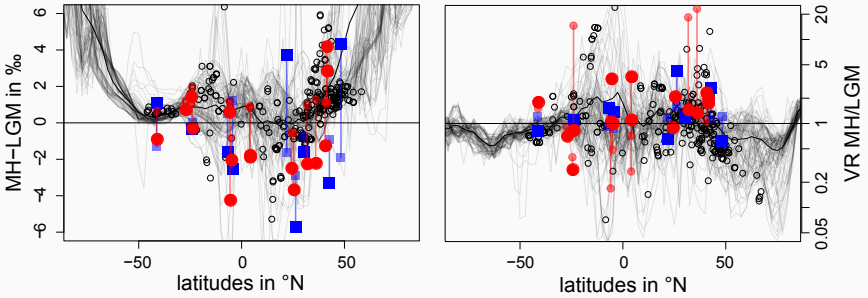
Karst data (brown) from Williams and Ford, Zeitschrift für Geomorphologie, 2006, **SISALv2 database:** Comas-Bru et al. 2020 Earth System Science Data.

iHadCM3 MH-LGM: Reasonable model data agreement



Close-up on title slide

Zonal View: Speleothems record greater changes than iHadCM3



Lines and dots = Model data, zonal view for all longitudes and all SISAL speleothem sites

big, bright color = speleothem data

small, faint color = model data equivalents

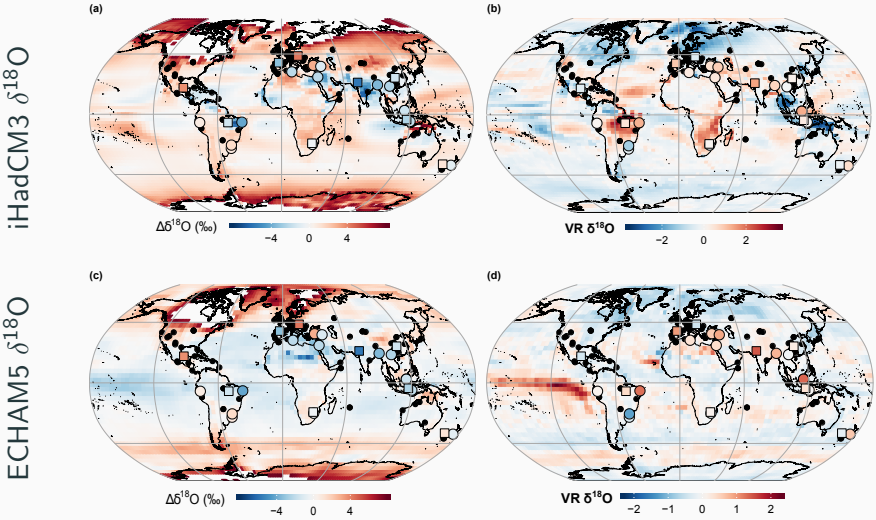
colored lines connecting corresponding speleothem and model data

Joint: Speleothems show $-1.44‰$ (CI:$-2.28‰, -0.52‰$) larger changes in mean δ^{18}O compared to simulated precipitation δ^{18}O. The speleothems show 1.59 (CI: $0.85, 2.42$) times higher variance changes.

Separate: Speleothems show $0.19‰$ (CI:$-1.61‰, 2.82‰$) similar changes as simulated. The speleothems show 1.34 (CI: $0.97, 1.77$) times higher variance changes.

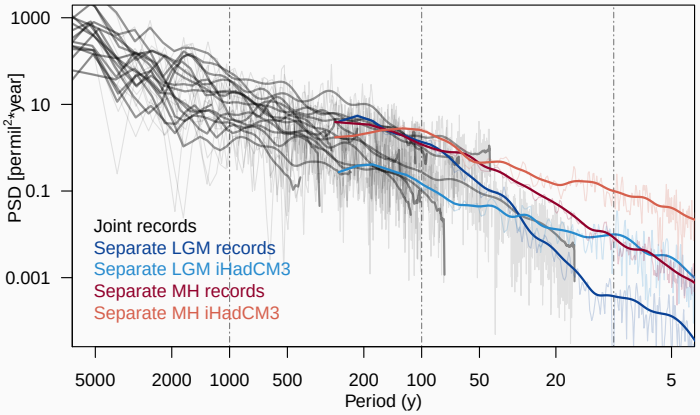
Confidence intervals are 90% and calculated via boot-strapping

Comparison between iHadCM3 MH-LGM and ECHAM5 PI-LGM



ECHAM5 PI and LGM data provided by Martin Werner

Variability analysis shows state dependency in iHadCM3 and speleothem $\delta^{18}O$



Mean spectra of simulated and recorded $\delta^{18}O$

State dependency visible in offsets between MH and LGM records for both the iHadCM3 model and the speleothems.

While the simulation shows similar slopes in both states, the slopes in the speleothems differ, resulting in an earlier cross-over between simulated and recorded spectra for the LGM than for the MH.

Mean spectra for irregular timeseries are computed by first equidistancing the time series, and then averaging over all available records. The simulated data at the cave location is first down-sampled to its corresponding record resolution following Buehler et al. 2020 CP discussion.

Conclusion & Outlook

Reasonable agreement between simulated iHadCM3 and recorded speleothem changes → promising start for further analysis

Further studies in prep: include time uncertainties and sensitivity tests → develop measure for agreement between model and data

Include runs without volcanic forcing → Better distinguish between background states

Summarize to extend to precipitation changes → more insight into low- to mid-latitude climate patterns

Icons from https://www.flaticon.com/de/autoren/freepik or modified from Rehfeld, 2019,

Acknowledgments

We are happy to receive your questions/comments via live chat or contact jbuehler@iup.uni-heidelberg.de

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