# Evaluating atmospheric simulations of the Last Glacial Maximum using oxygen isotopes in ice cores and speleothems

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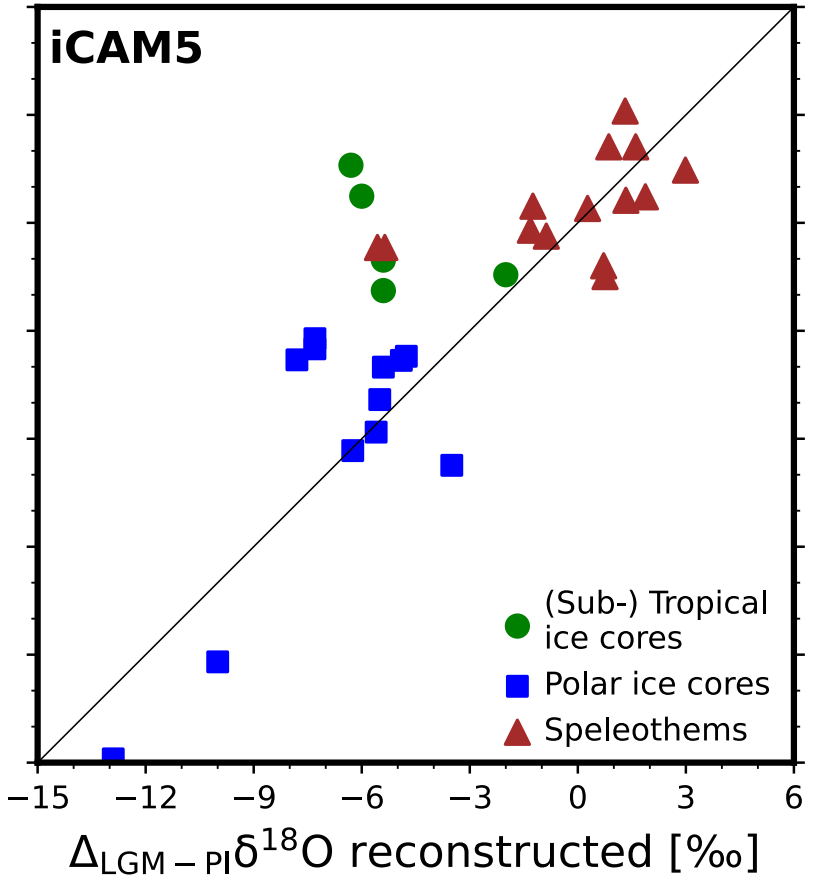
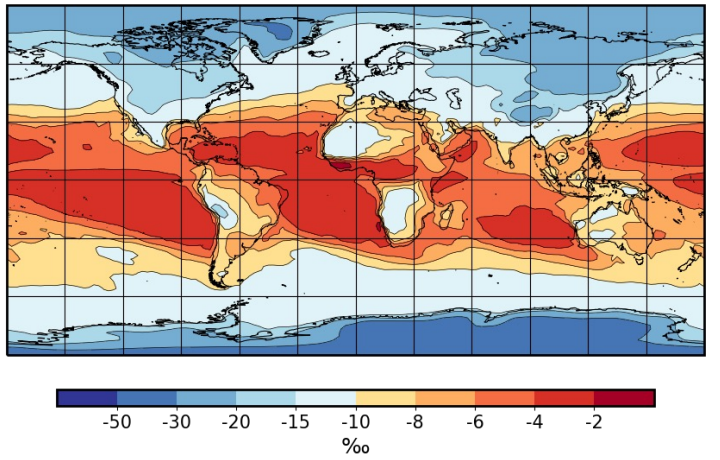
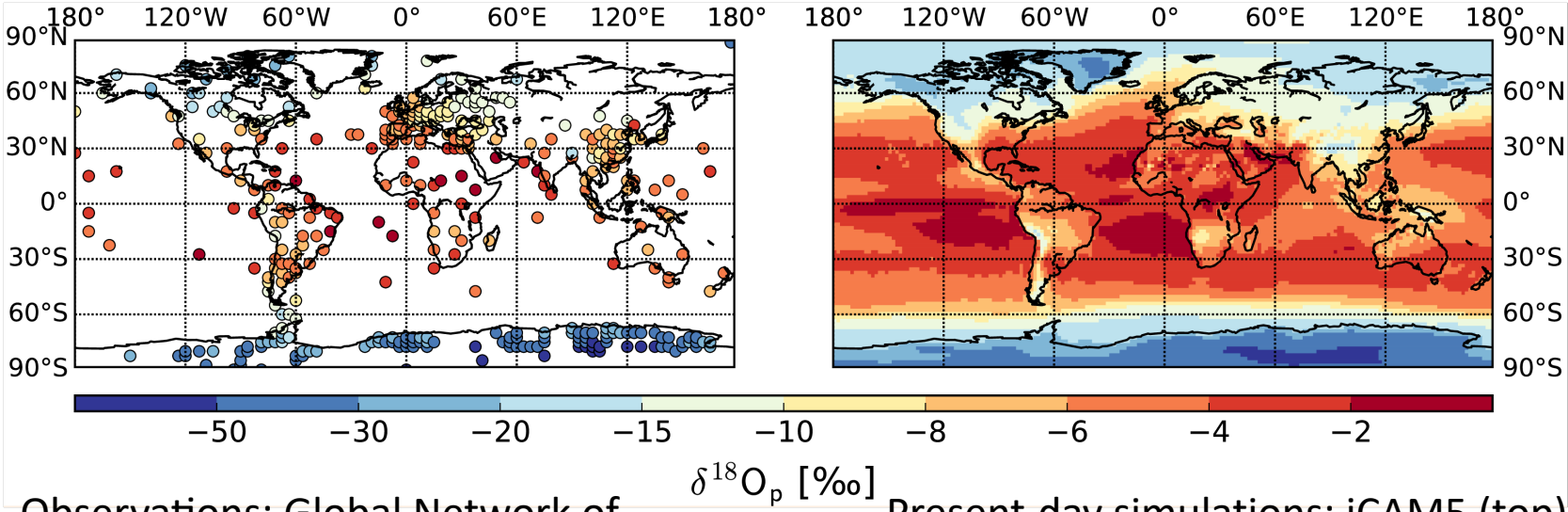


# In this study, we used version 5 of the isotope-enabled Community Atmosphere Model (iCAM5).

NCAR iCAM5 (Nusbaumer et al., 2017) at medium resolution (1.9° x 2.5°, 30 vertical levels)




For comparison purposes, we will use ECHAM6-wiso (Werner et al., 2016) at medium resolution (T63, ~1.875° x 1.875°, 30 vertical levels).



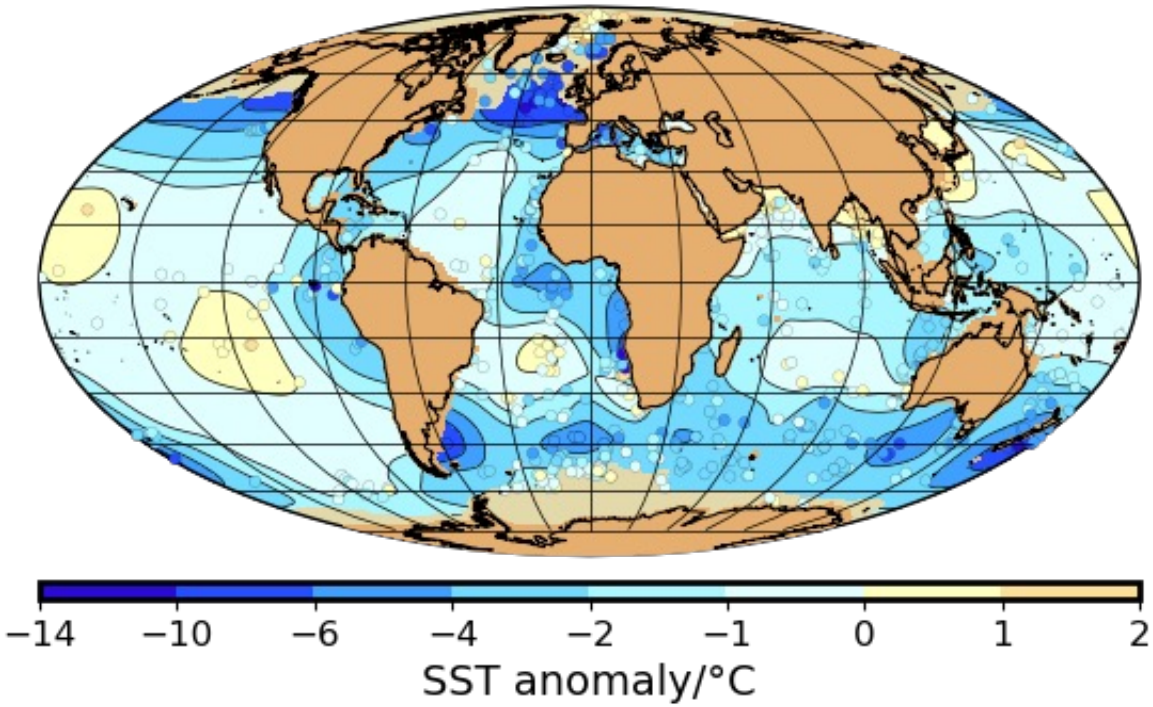

Observations: Global Network of Isotopes in Precipitation (GNIP)

Present-day simulations: iCAM5 (top) and ECHAM6-wiso (bottom)

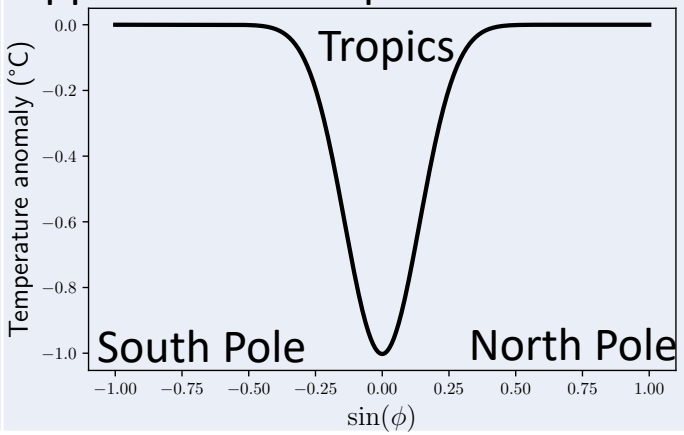
# Different efforts of combining model and data yield different results for mean tropical sea-surface temperature cooling.

| Reference | Mean/°C | Min/°C | Max/°C | Confi-dence |
|---|---|---|---|---|
| CLIMAP | -0.8 | | | |
| MARGO | -1.5 | -2.1 | -0.9 | |
| Annan and Hargreaves (2013, in prep.) | -1.6 | -2.3 | -0.9 | 95 % |
| Lea et al. (2004) | -2.8 | -3.5 | -2.1 | |
| Ballantyne et al. (2005) | -2.7 | -3.7 | -1.7 | |
| Leduc et al. (2017) – alkenones | -2.3 | -3.1 | -1.5 | |
| Leduc et al. (2017) – Mg/Ca | -2.4 | -3.2 | -1.4 | |
| Tierney et al. (assimilated) | -3.5 | -3.7 | -3.3 | 95 % |
| Tierney et al. (data only) | -2.5 | -2.8 | -2.2 | 95 % |

# We used two different sets of sea-surface boundary conditions, both based on the new “Glacial Ocean Map” (GLOMAP).

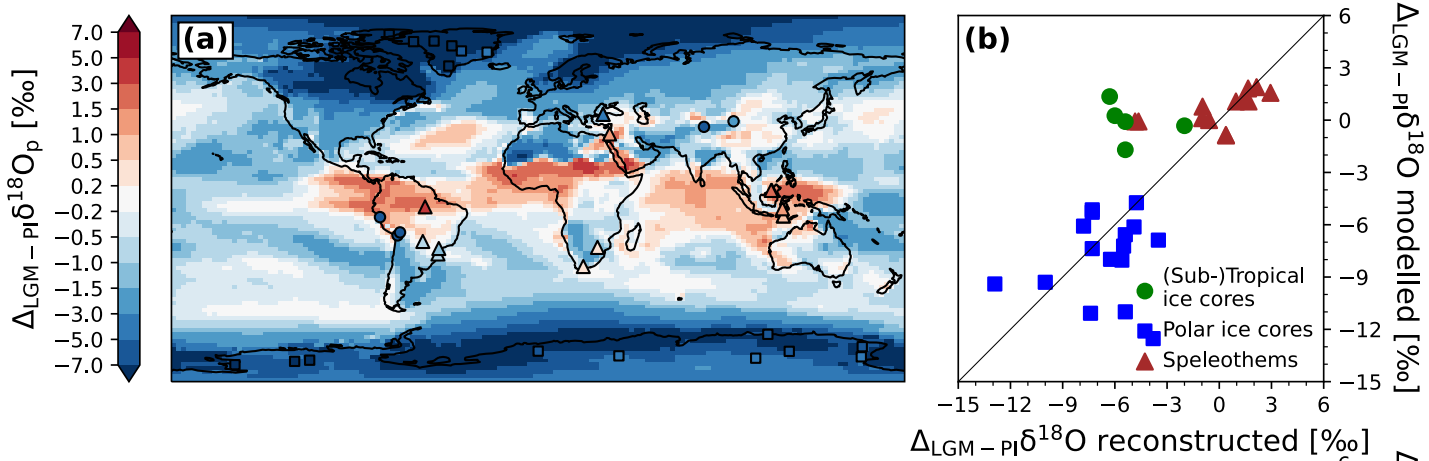



Temperature differences in °C between the Last Glacial Maximum and today for winter in the northern hemisphere (DJF). *Colored points:* locations of the 600 sediment cores included in the statistical analysis. *Yellow-brownish areas:* reconstructed sea-ice extent

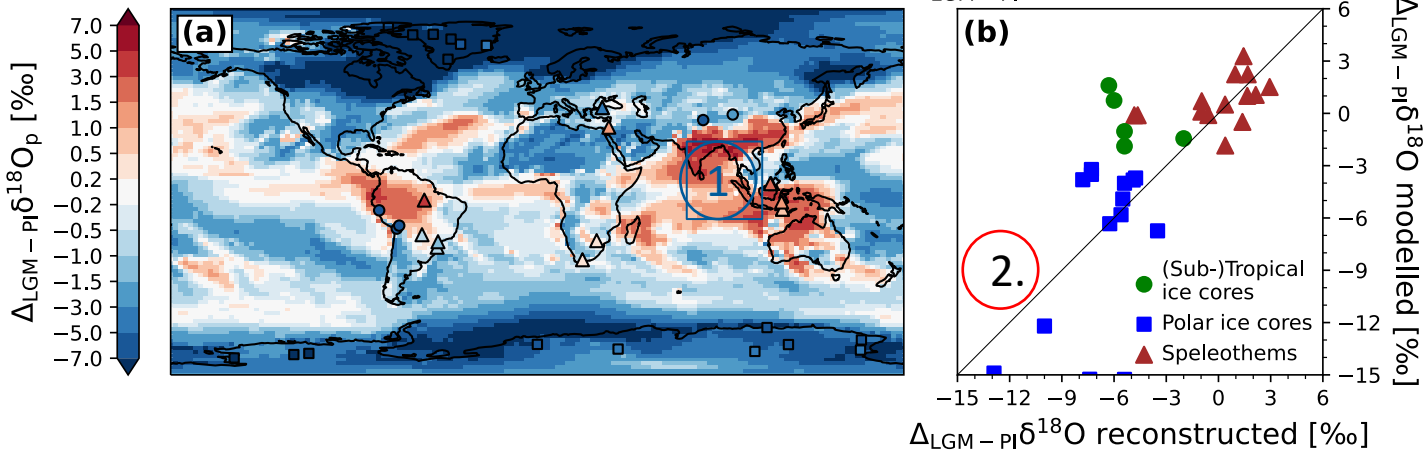
| Sensitivity experiment | Sea-surface boundary conditions |
|---|---|
| GLOMAP | Monthly climatology of near-sea-surface temperature anomaly and sea-ice extent during the LGM (Paul et al., 2021). |
| GLOMAP with additional tropical cooling | As above, but a Gaussian-shaped anomaly of up to 1°C was applied to the tropics.  |

# As a result, there were (1) a larger positive anomaly in south-east Asia and (2) only slightly smaller misfits over Greenland.

iCAM5 (2°) with reconstructed sea-surface conditions (GLOMAP, 30-a mean)




iCAM5 (2°) with reconstructed sea-surface conditions (GLOMAP with tropical anomaly, 15-a mean)



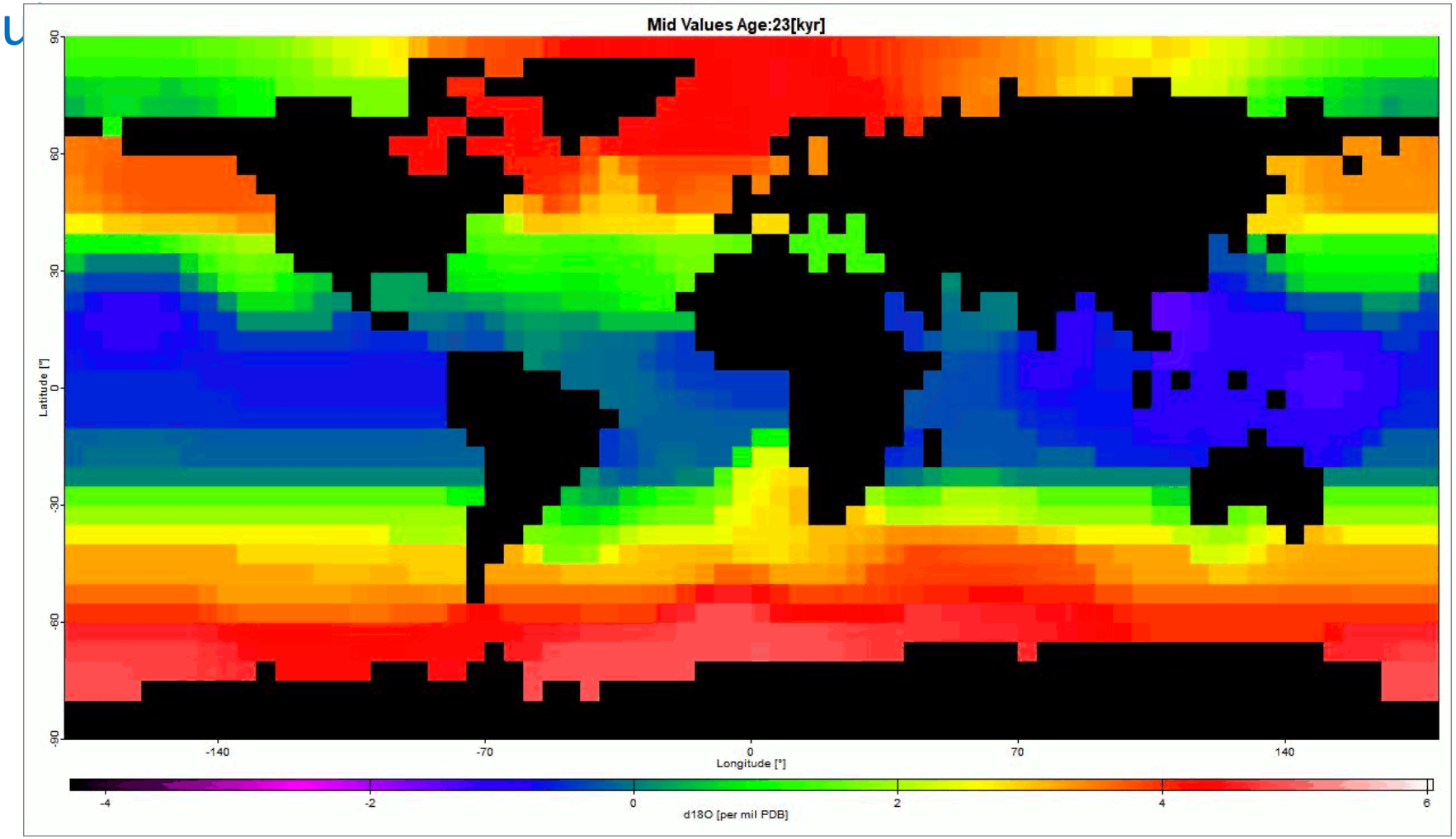
# The additional tropical cooling leads to an only slightly improved comparison with the Greenland and tropical ice-core.

| Experiment | Slope of regression line a | Coefficient of determination $R^2$ | Root-mean square error RMSE/‰ |
|---|---|---|---|
| iCAM5 – prescribed GLOMAP SBCs | 1.10 | 0.39 | 5.3 |
| iCAM5 – prescribed GLOMAP SBCs with tropical anomaly | 0.99 | 0.38 | 4.8 |

| Experiment | Greenland RMSE/‰ | Antarctic RMSE/‰ | Tropical RMSE/‰ | Speleothemes RMSE/‰ |
|---|---|---|---|---|
| iCAM5 – prescribed GLOMAP SBCs | 10.75 | 2.22 | 5.31 | 2.15 |
| iCAM5 – prescribed GLOMAP SBCs with tropical anomaly | 9.46 | 2.50 | 5.28 | 2.15 |

South-polar ice-core data: Vostok, Dome F, EDC, EDML, Taylor Dome, Talos, Byrd, Siple Dome, Law Dome, WDC
North-polar ice-core data: GRIP, NGRIP, NEEM, Camp Century, Dye 3, Renland, Agassiz
(Sub-) Tropical ice-core data from Risi et al. (2010), speleothem data from SISAL compilation (after Comas-Bru et al., 2019)

# Mulitza et al. provide a new World Atlas of late Quaternary Foraminiferal Oxygen and Carbon Isotope Ratios suitable for comparison to *transient* climate simu




Evolution of planktonic foraminiferal $\delta^{18}O_c$ over the past 23 ka in steps of 0.5 ka.

Mulitza et al. (ESSD, https://doi.org/10.5194/essd-2021-337, 2022), Fig. 3