

# Sensitivity of isotopes in the hydrological cycle to simulated vs. reconstructed Last Glacial Maximum surface conditions

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# Methods

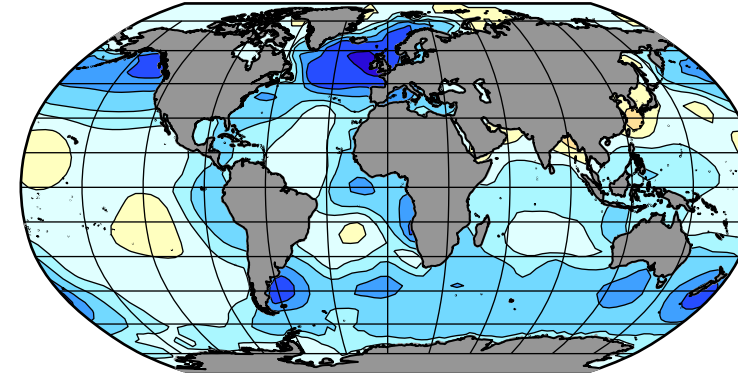
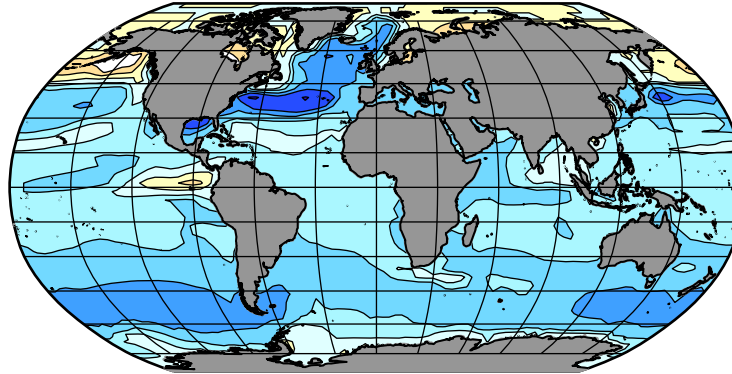
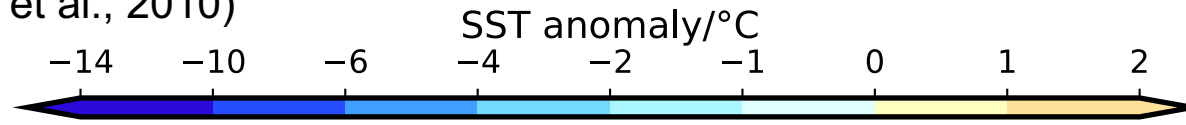
- Models
  - two different atmosphere-only general circulation models including water isotopes in the hydrological cycle (NCAR iCAM3 and MPI ECHAM6-wiso)
- Forcing data
  - PMIP-type insolation, ice-sheet height/extend and greenhouse gas concentrations for pre-industrial (PI) and Last Glacial Maximum (LGM) conditions
  - two different data sets for sea-surface temperature and sea-ice concentration
    - **simulated** using a coupled atmosphere-ocean general circulation model (CCSM3, Merkel et al. 2010)
    - **reconstructed** based on MARGO (2009) and recent estimates of LGM sea-ice extent (GLOMAP, under review for Climate of the Past, <https://doi.org/10.5194/cp-2019-154>)
- Data for comparison
  - oxygen isotope ratios  $\delta^{18}\text{O}$  from ice cores and speleothems

# Results

Simulated sea-surface conditions  
derived from CCSM3 (Merkel et al., 2010)  
larger global cooling  
more zonal structure

Reconstructed sea-surface conditions  
based on MARGO (2009)  
stronger polar cooling  
large zonal gradients

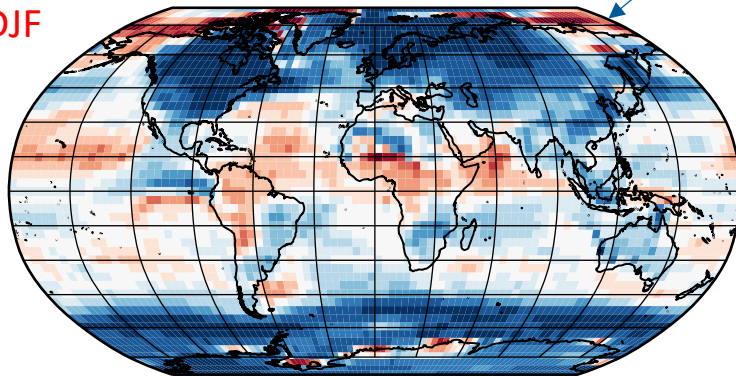
February



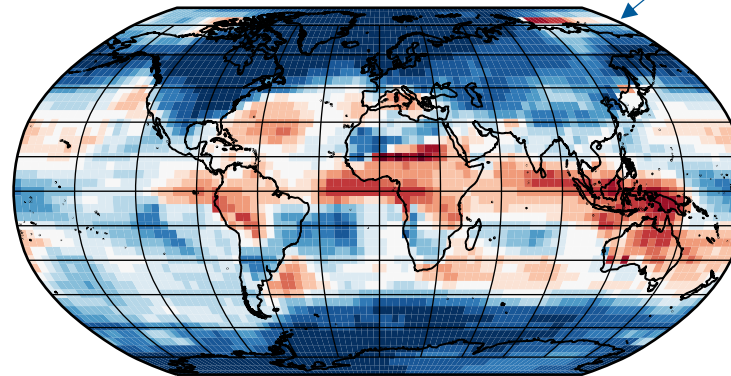
anomaly  
= LGM – pre-industrial

DJF

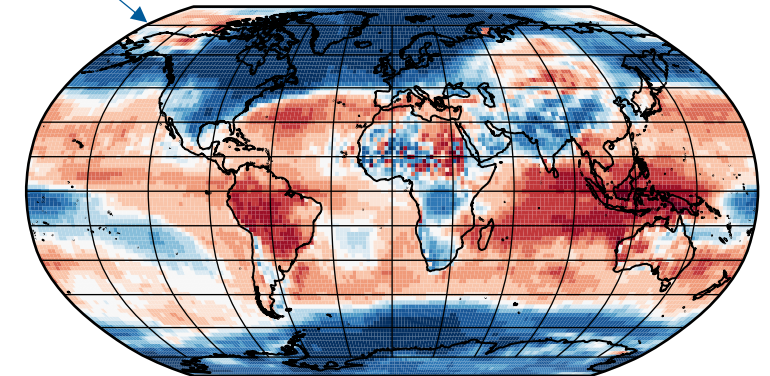
$\delta^{18}\text{O}$  in precipitation anomaly



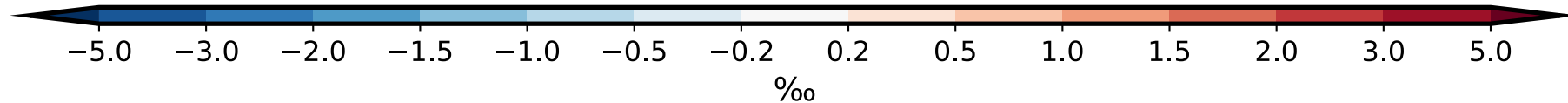
iCAM3



iCAM3



ECHAM6-wiso

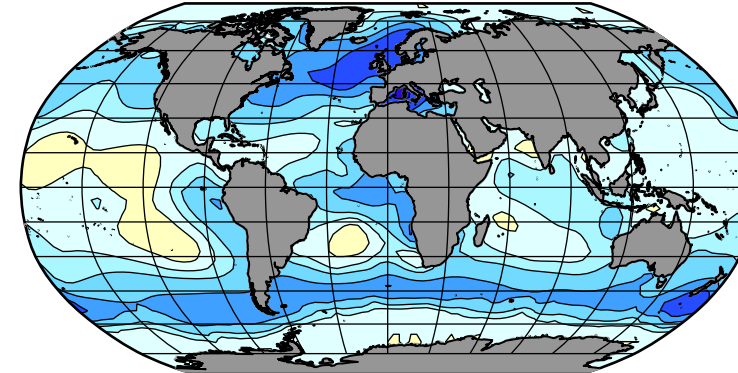
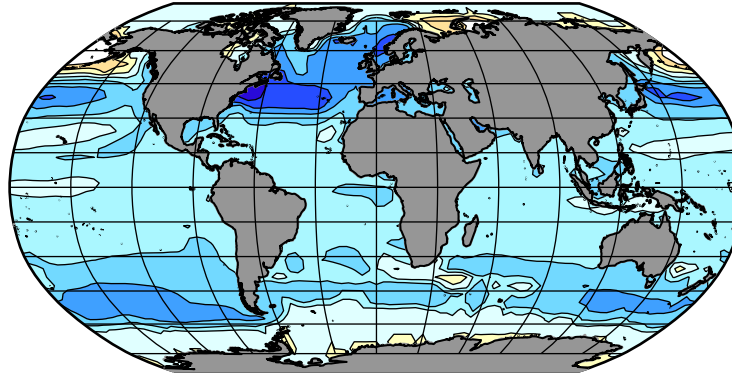
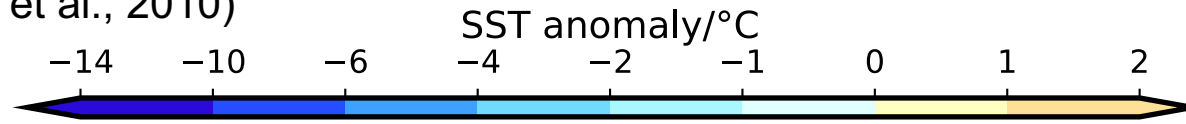


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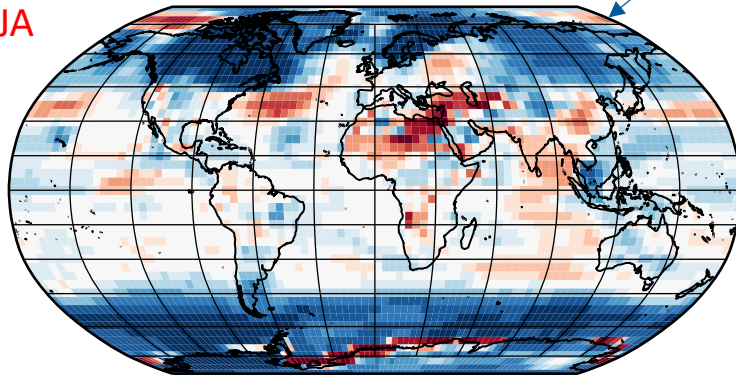
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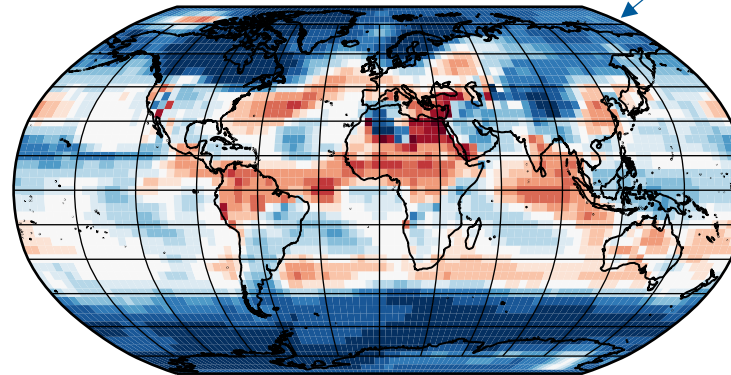
anomaly  
= LGM – pre-industrial

JJA

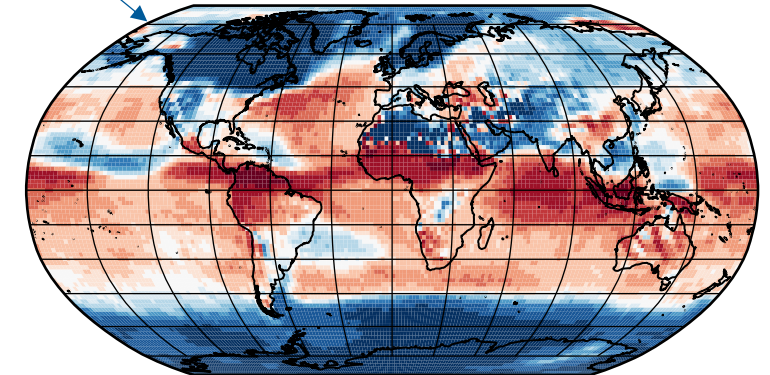
$\delta^{18}\text{O}$  in precipitation anomaly



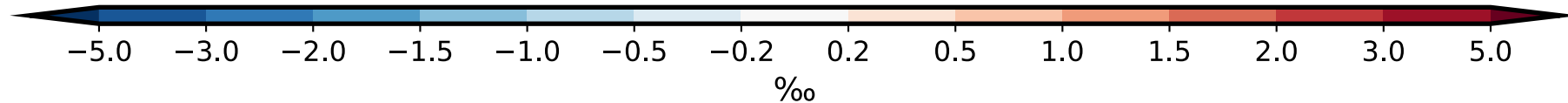
iCAM3



iCAM3



ECHAM6-wiso

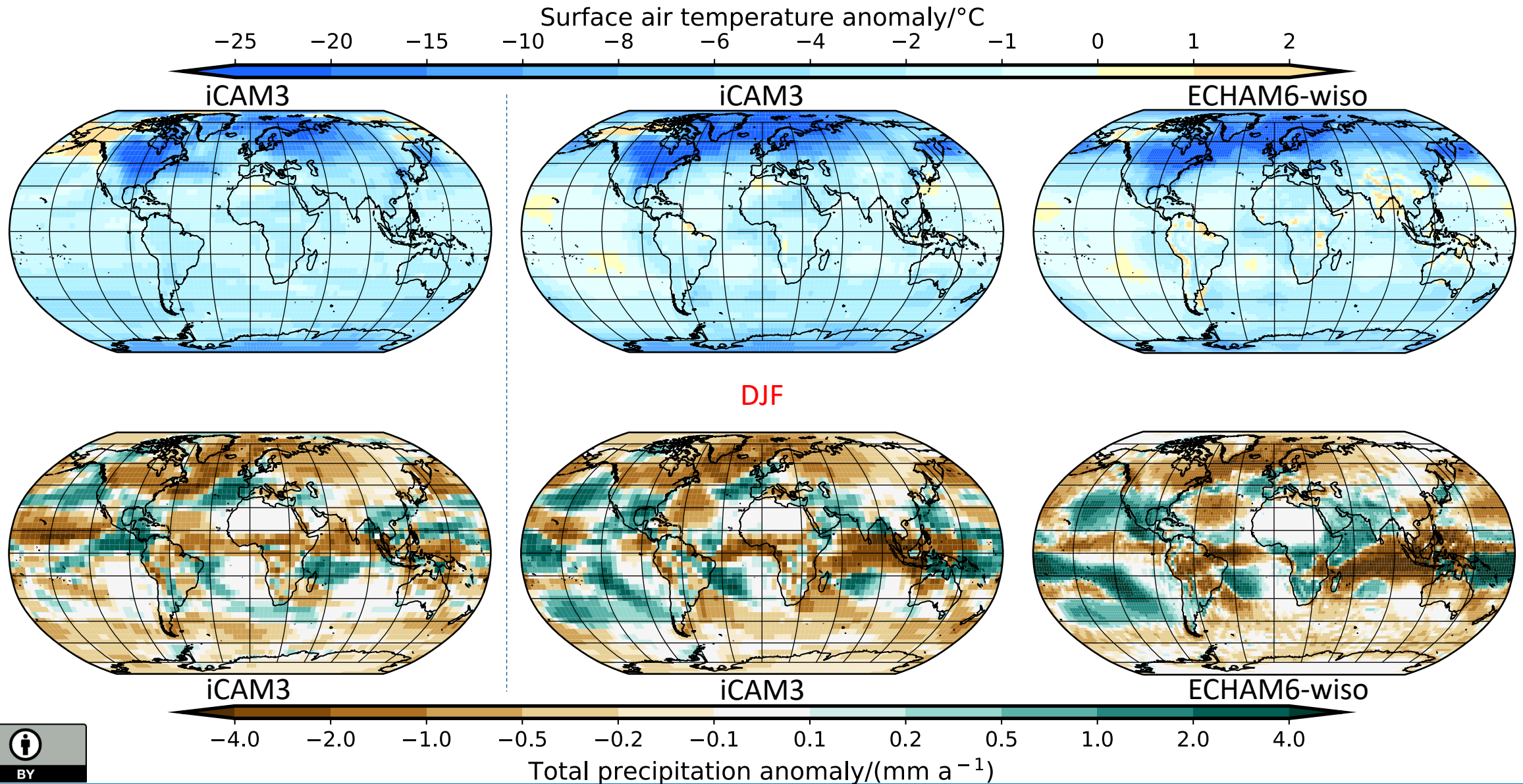




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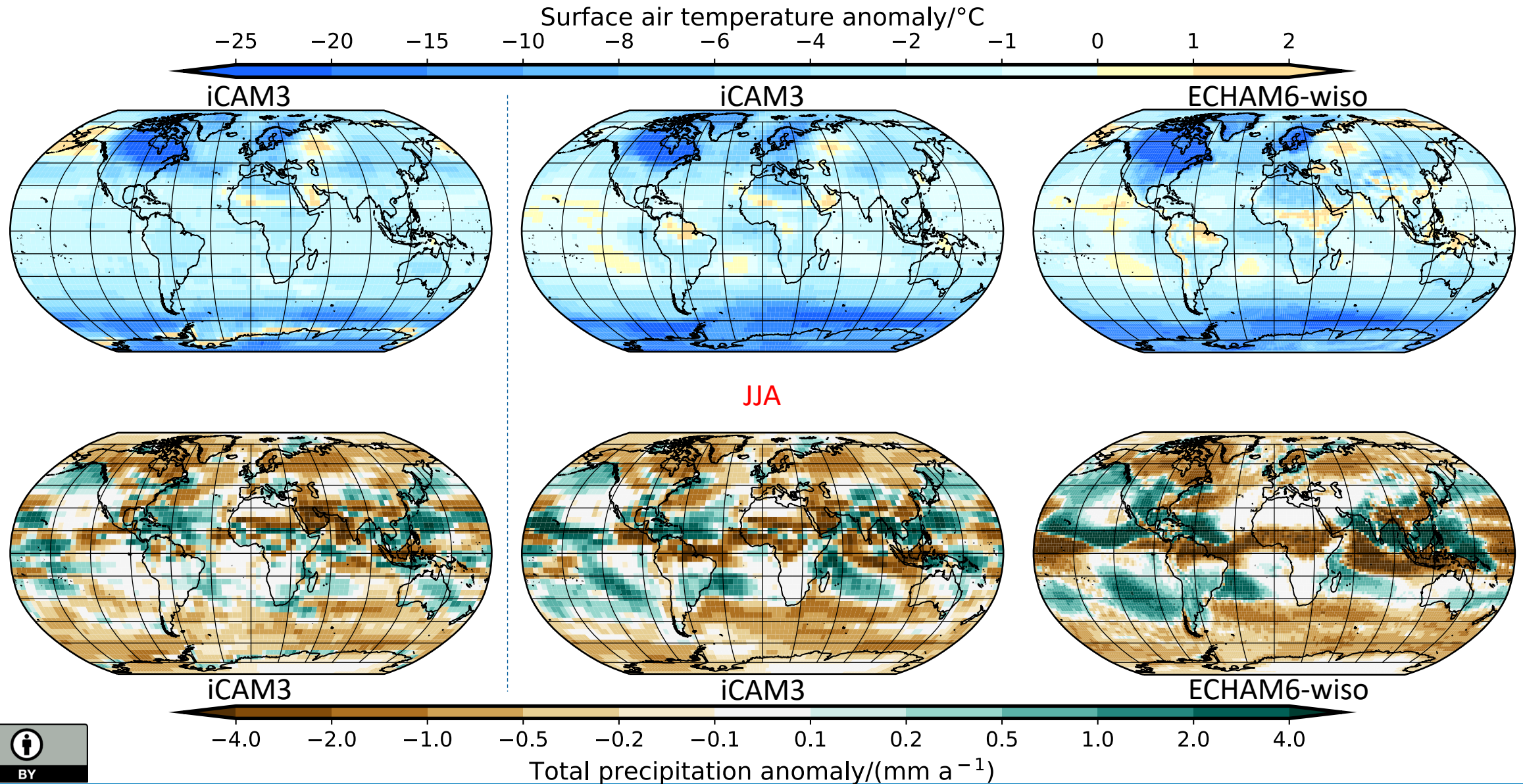
Results



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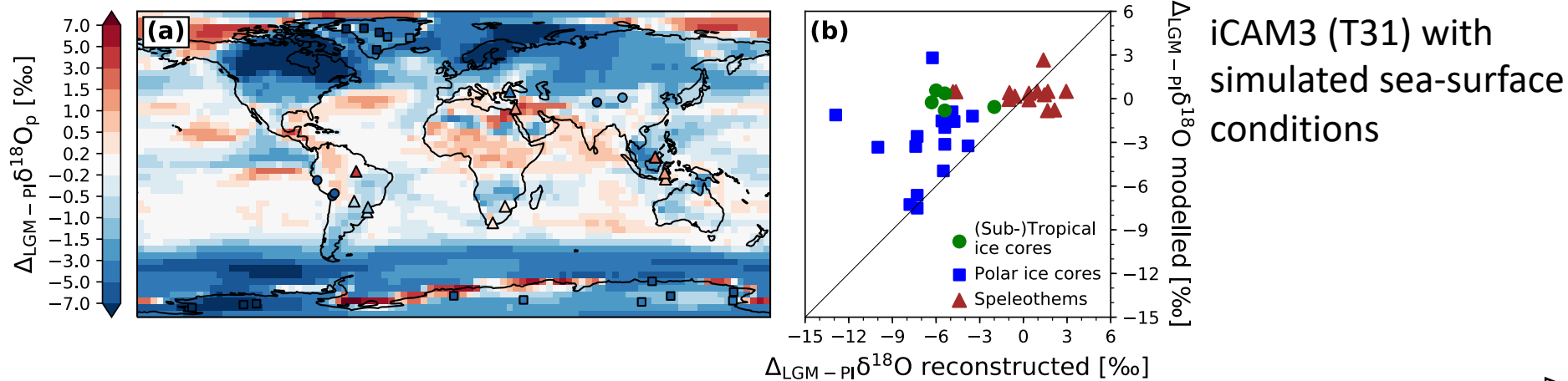
Reconstructed sea-surface conditions  
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Results

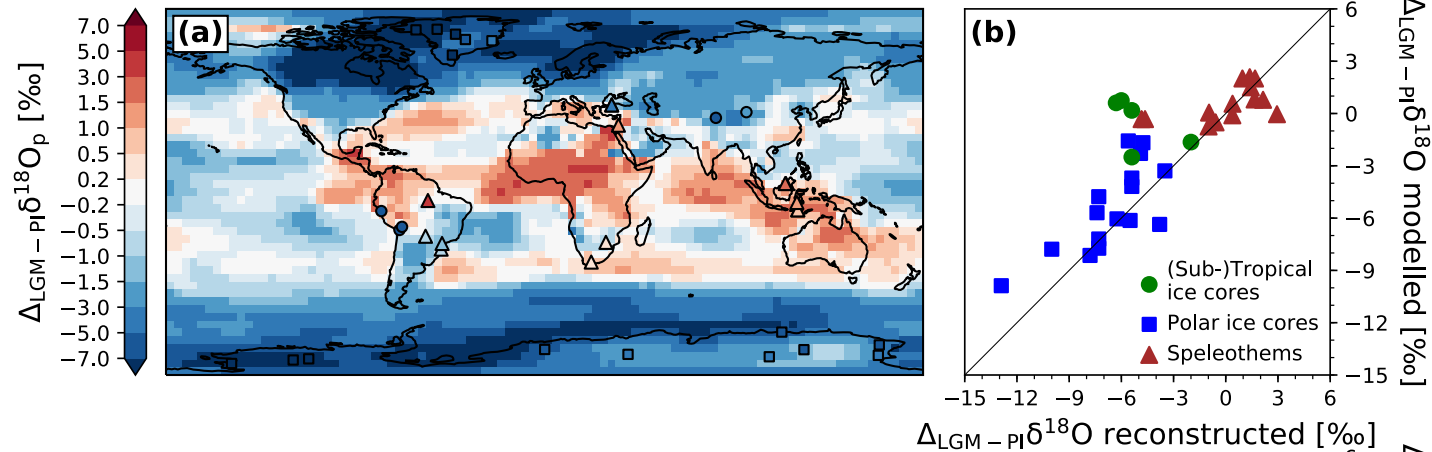




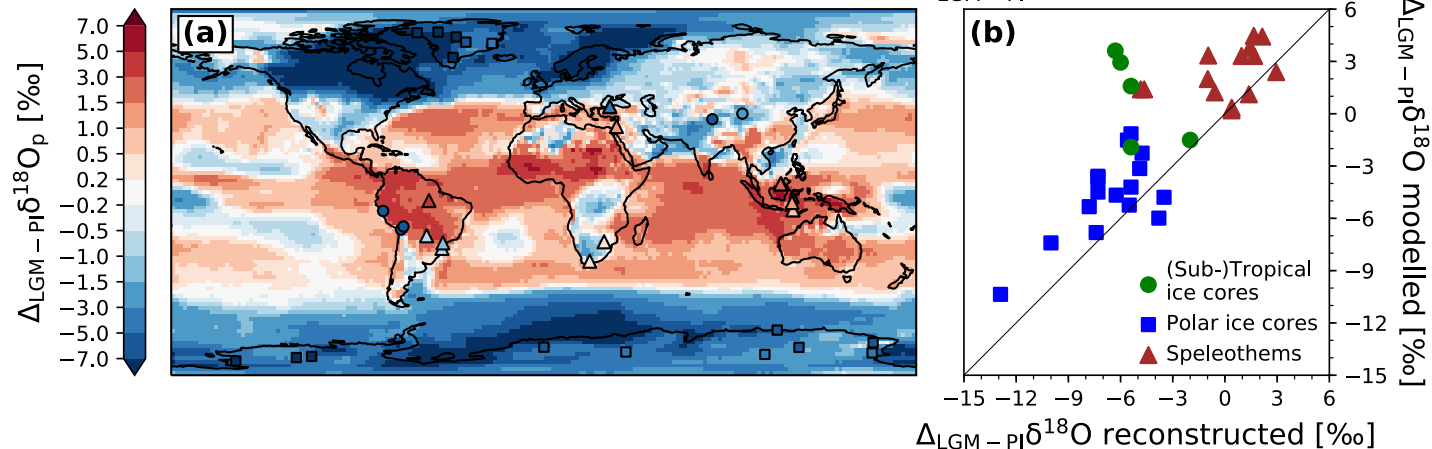
# Data-model comparison



iCAM3 (T31) with  
reconstructed sea-  
surface conditions



ECHAM6-wiso (T63) with  
reconstructed sea-  
surface conditions



Experiment	Coefficient of determination $R^2$	Root-mean square error RMSE/‰
iCAM3 with simulated anomalies	0.26	4.1
iCAM3 with reconstructed anomalies	0.64	2.7
ECHAM6-wiso with reconstructed anomalies	0.59	3.7

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 (converted after Comas-Bru et al., 2019)

Reconstructed sea-surface conditions:

Paul et al., A global climatology of the ocean surface during the Last Glacial Maximum mapped on a regular grid (GLOMAP), under review for Climate of the Past, <https://doi.org/10.5194/cp-2019-154>



# Conclusions

- The model-data fit for both models (iCAM3 and ECHAM6-wiso) forced by reconstructed sea-surface conditions (LGM SST anomalies and sea-ice concentrations) is comparably good.
- The model-data fit is much better for forcing one of the two models (iCAM3) with reconstructed as compared to simulated LGM sea-surface conditions.