

Evaluating a method for reconstruction of global, zonal and regional mean temperatures from sparse proxy data

Maximilian May, Nils Weitzel, Lukas Jonkers, Kira Rehfeld

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Sea-surface temperature (SST) proxies in 60°N/S region

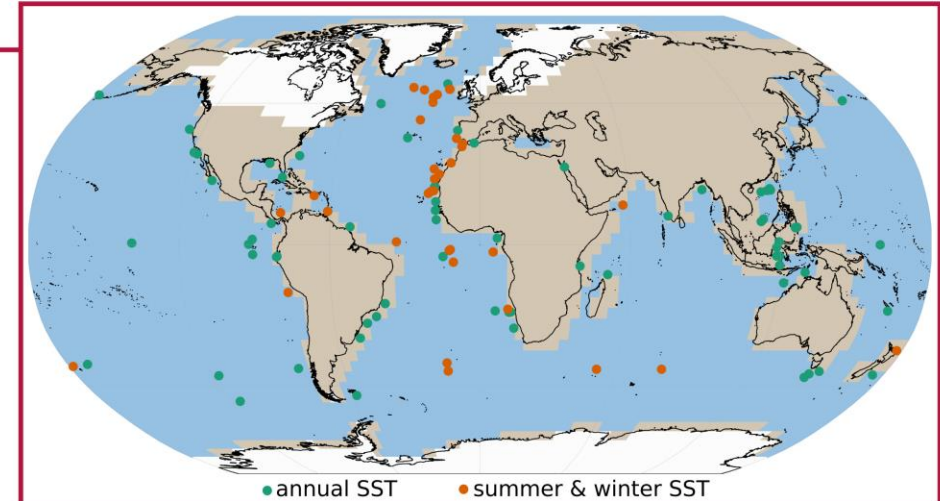
Key steps (adopted from [2]):

- 1) Interpolation to uniform time axis
- 2) Zonal normalization
- 3) Regional average ensembles
- 4) Linear scaling to account for polar regions

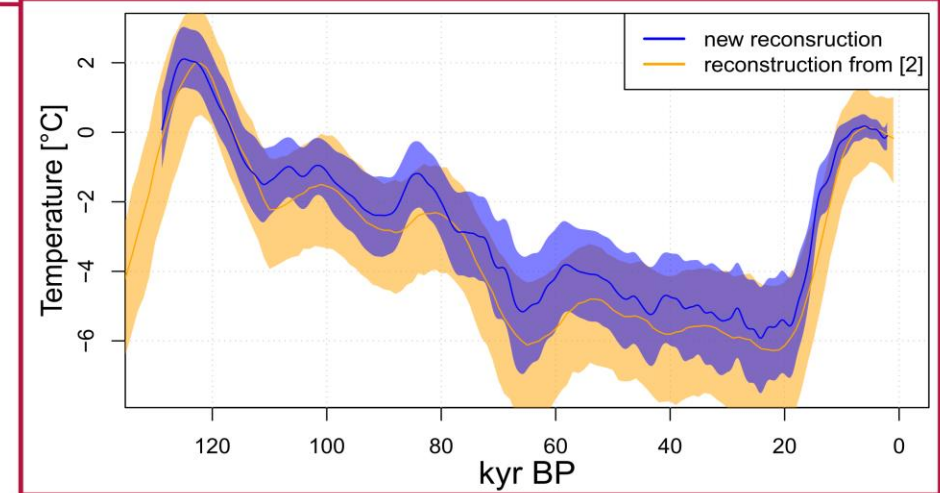
Global, hemispherical, zonal or regional mean temperature

Conclusions:

- From real proxy data:
 - Results consistent with previous data
 - Cannot resolve centennial-scale variability
- From pseudo proxy data:
 - Orbital and millennial timescale consistent with model data
 - More precise results with better spatial coverage



Data synthesis: [1]



[1] L. Jonkers et al. (2020), ESSD, DOI: 10.5194/essd-12-1053-2020

[2] C. Snyder (2016), Nature, DOI: 10.1038/nature19798

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1 Motivation

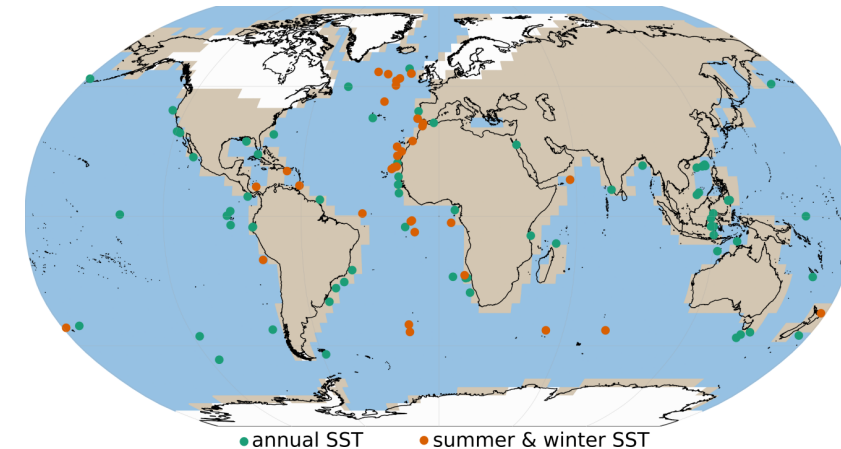
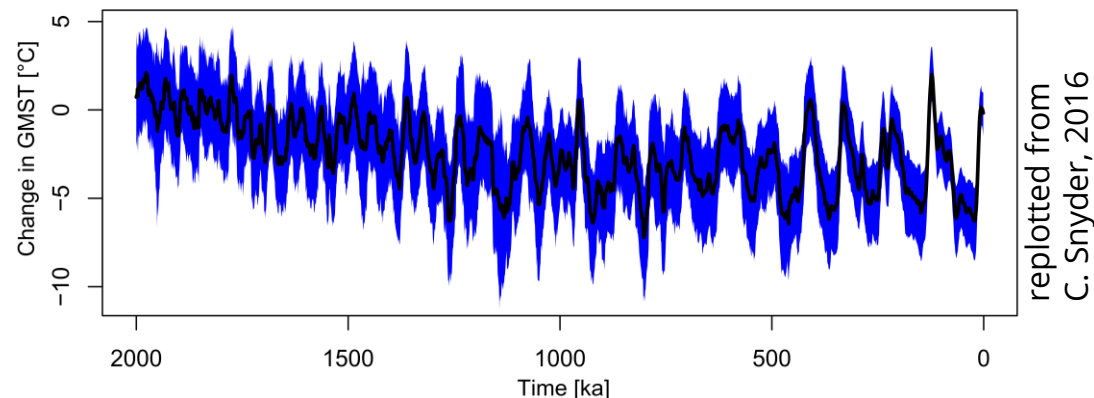
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1 Motivation

- Global mean surface temperature (GMST) as fundamental measure for climate evolution
- There is no widely accepted method to calculate GMST from sparse proxy data
- Marine sediment records are the most abundant archive for continuous temperature reconstructions
- Recently:
 - Approach by C. Snyder, 2016: reconstruction of GMST for last 2 Myr from sea-surface temperature (SST) proxies
 - PalMod 130k marine palaeoclimate data synthesis with common age model and rich metadata by L. Jonkers et al., 2020



We extend and generalize the approach by C. Snyder, 2016 to make it applicable to any set of SST proxies and test it on the PalMod marine palaeoclimate data synthesis, as well as pseudo proxies.

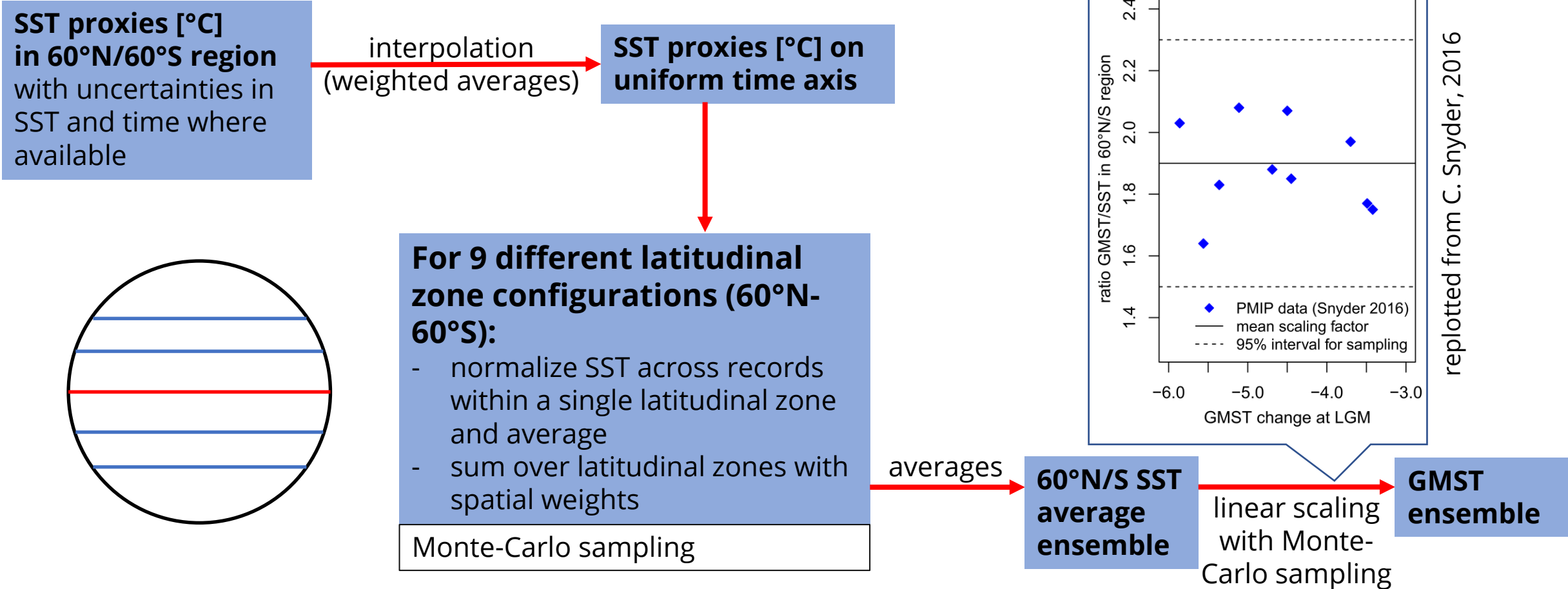
2 Details of the reconstruction method

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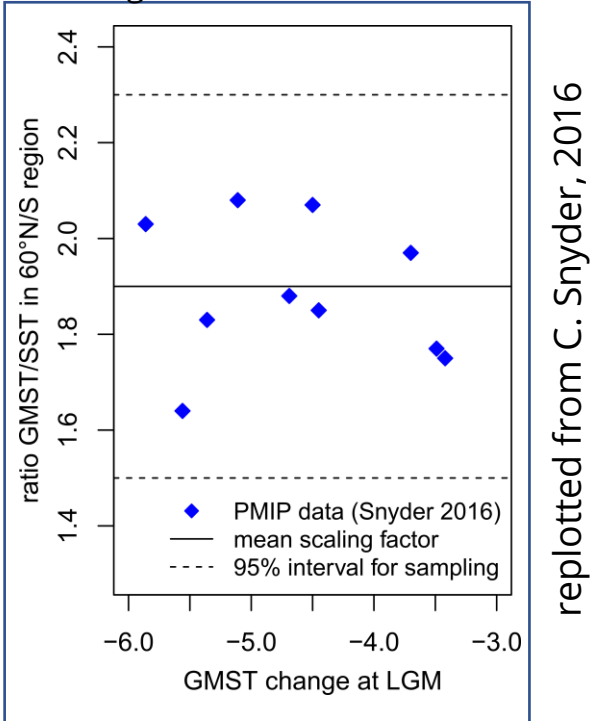
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2.1 Details of the reconstruction method for global or hemispherical mean surface temperature



GAST and SST (60°N-60°S) for LGM and pre-industrial state from PMIP models
→ scaling factor with standard deviation



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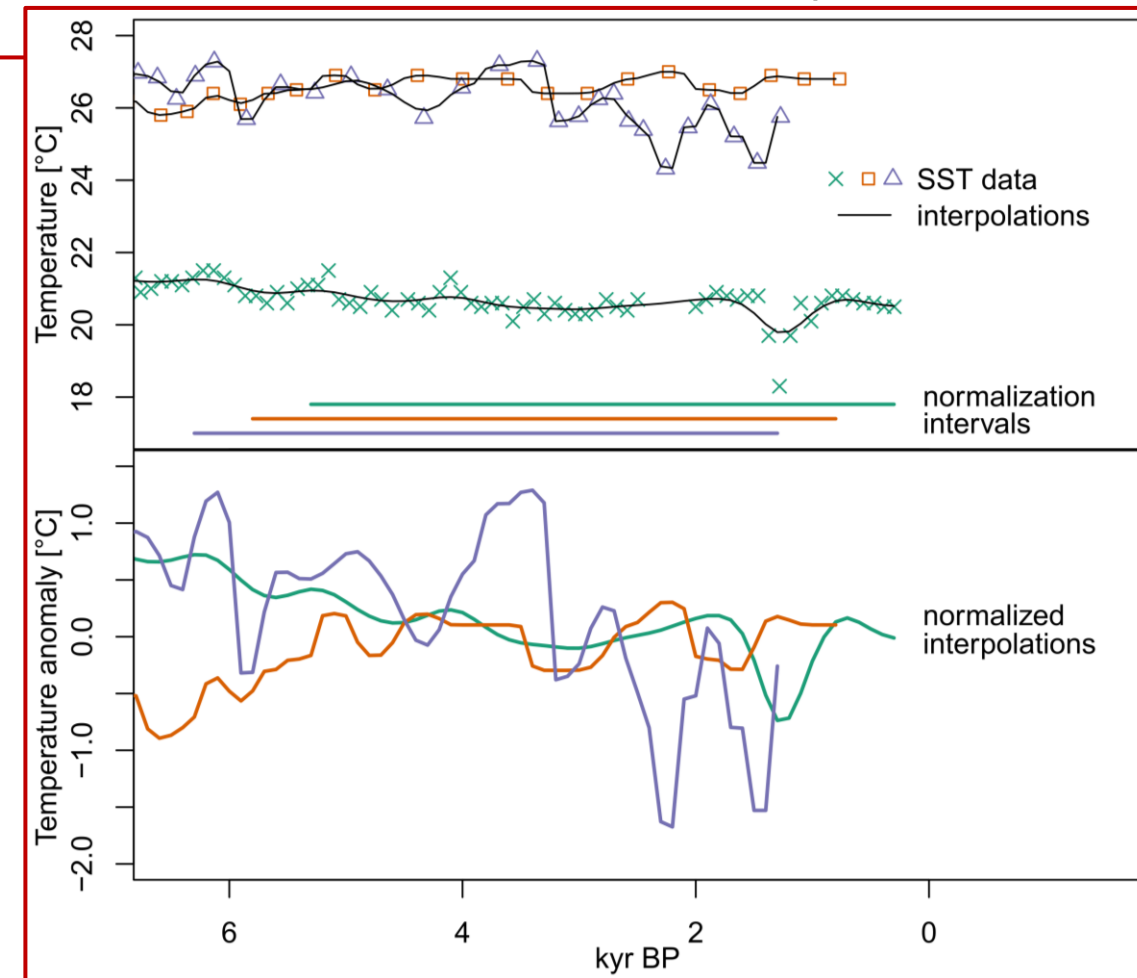
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2.2 Modifications added to the algorithm from Snyder, 2016:

- Zonal iterative normalization
 - For each zone:
 - Sort records by age of their most recent datapoint
 - For first record: add offset such that its mean temperature in the last 5 kyr is 0°C
 - For each following record: add offset such that the mean of its most recent 5 kyr equals the mean of the already calibrated ensemble in the same period
- Applicability for hemispheres
- Applicability for homogeneous regions (without subdividing into zones and scaling factor)
- Adjustable sampling parameters
- Adjustable scaling factor

normalization example:



3 Temperature reconstructions from marine proxies

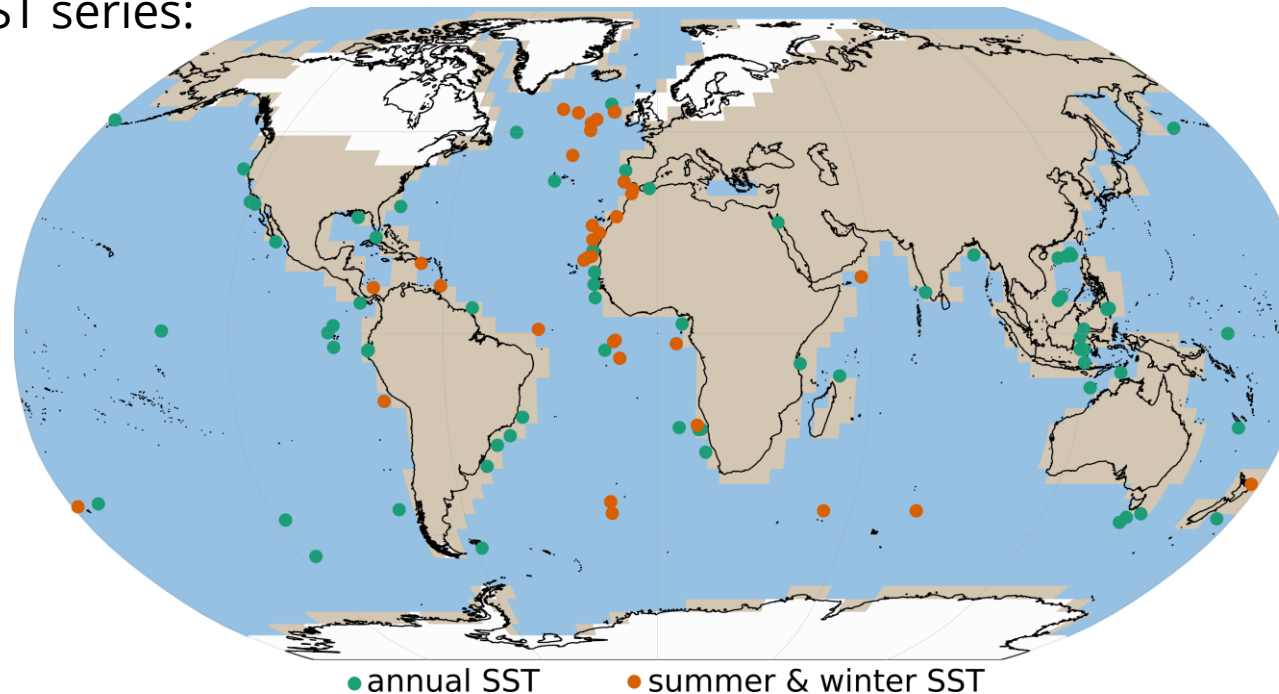
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3.1 The PalMod 130k marine palaeoclimate data synthesis

- Multi-parameter synthesis containing time series spanning 0 to 130 ka
- Version V1_1_0 (beta): 248 SST series from 132 sites with rich metadata and updated consistent age models
- Proxy types: foraminifera Mg/Ca ratio, UK37, assemblages and TEX86
- We use records of annual SST and averages of summer and winter SST series between 60°N and 60°S
→ Results in 160 SST series:



Original extensive description of the data synthesis:
L. Jonkers et al., 2020

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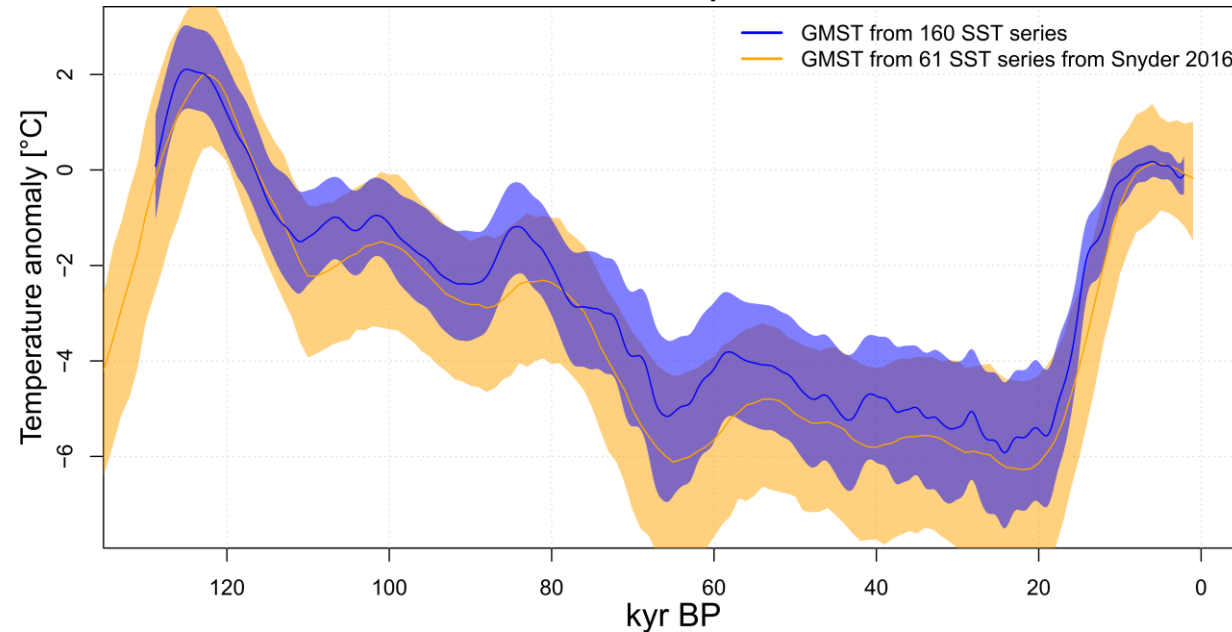
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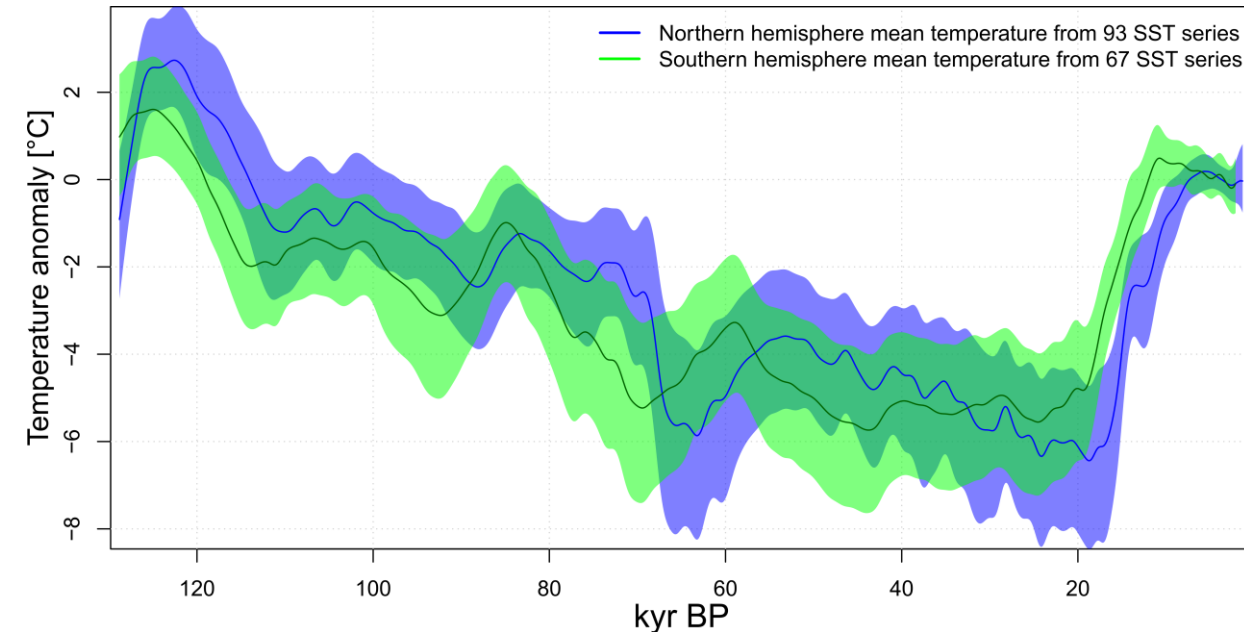
3.2 Results for marine proxies

a) Global mean surface temperature:



- Slightly warmer than previous result, higher temporal resolution
- Timing of events differs due to new age model and resolution

b) Hemispherical mean surface temperature:



- Larger millennial-scale variability in Northern Hemisphere
- Northern Hemisphere lagging Southern Hemisphere in orbital-scale changes

Shaded areas are always 95% intervals

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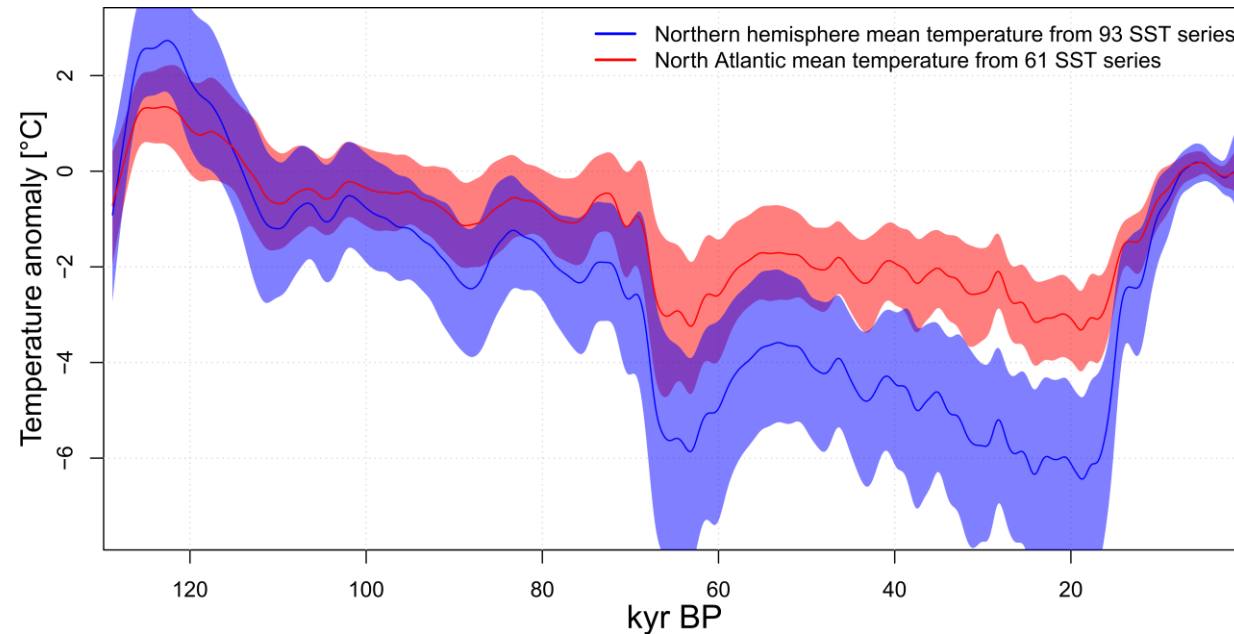
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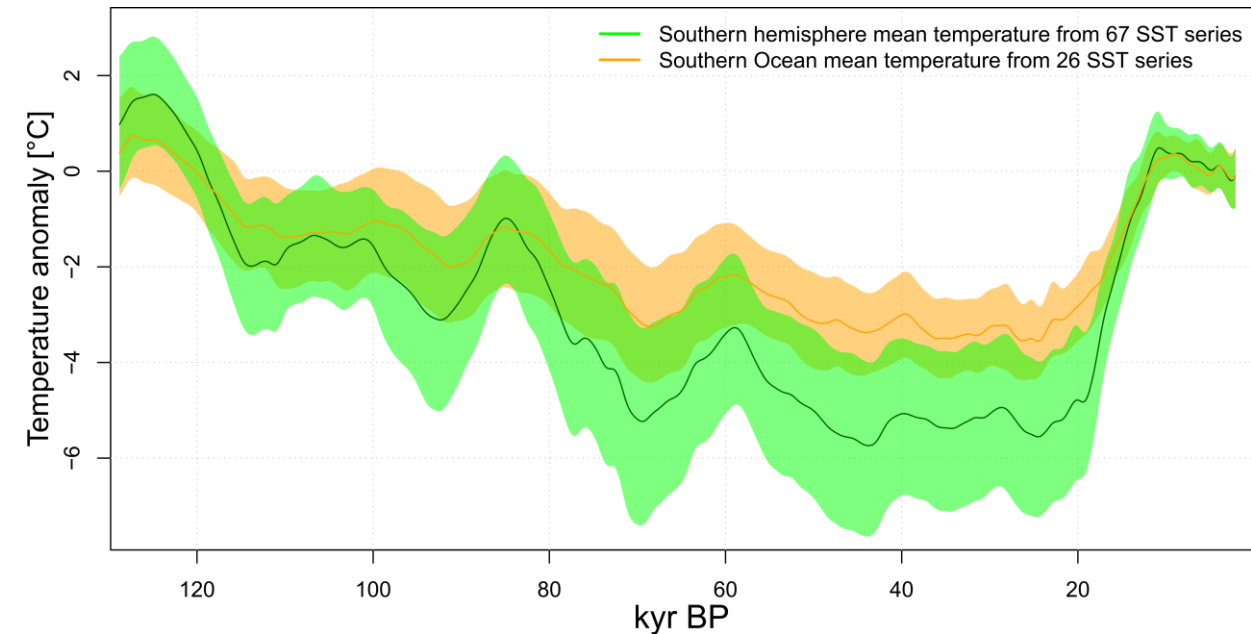
3.2 Results for marine proxies

c) North Atlantic:



- Strongly resembles Northern Hemisphere temperature
- At least in part due to distribution of data

d) Southern Ocean:



- Smaller variability than on whole Hemisphere

Shaded areas are always 95% intervals

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4 Temperature reconstructions from pseudo proxies

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4.1 Creating pseudo proxies from model data

- Construction of artificial proxy data from temperatures simulated by models
- Use of *sedproxy* R package (Dolman and Laepple, 2018):
 - Simulates sensor, archive and observation stage of proxy data creation process
 - Use of random marine proxy locations
 - Use real time series and uncertainties, accumulation rates, material and foraminifera species from PalMod130k marine synthesis
- Used models:
 - Famous (R.S. Smith et al., 2012)
 - TraCE-21k (Z. Liu et al., 2009)

Sedproxy: a forward model for sediment-archived climate proxies

Andrew M. Dolman and Thomas Laepple

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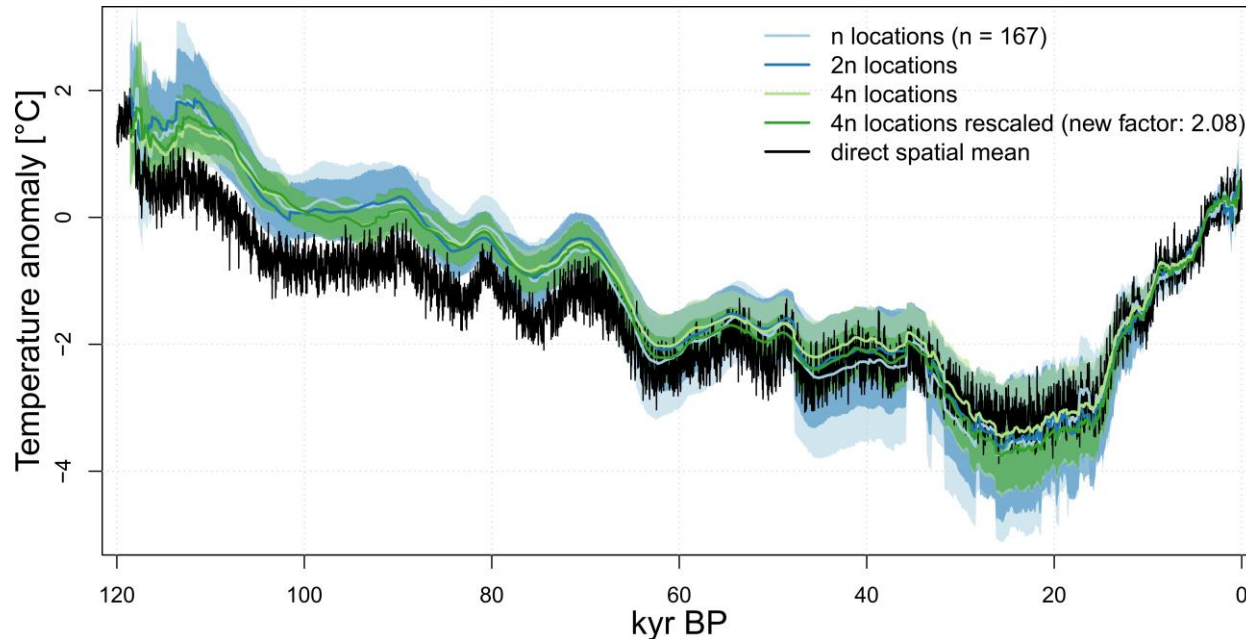
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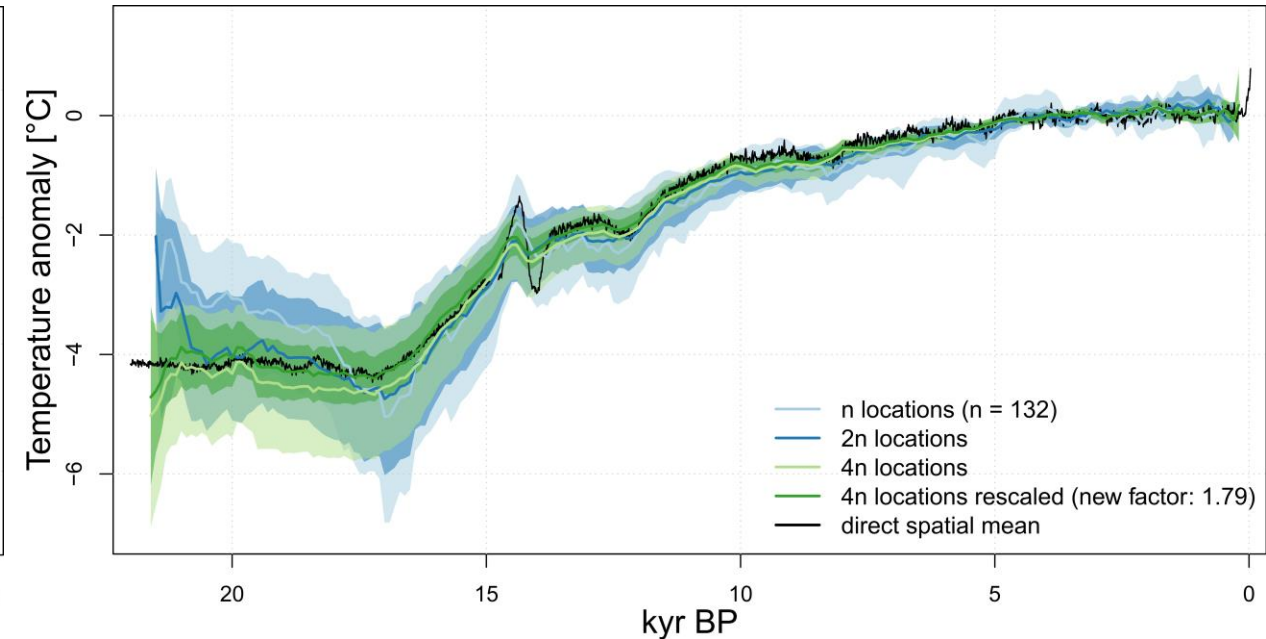
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4.2 Results for pseudo proxies

a) Famous



b) TraCE-21k:



- Apparent state-dependence of scaling factor
- Stronger agreement with model temperature and smaller uncertainties with better spatial coverage
- Limited ability of capturing centennial-scale variability

Shaded areas are always 95% intervals

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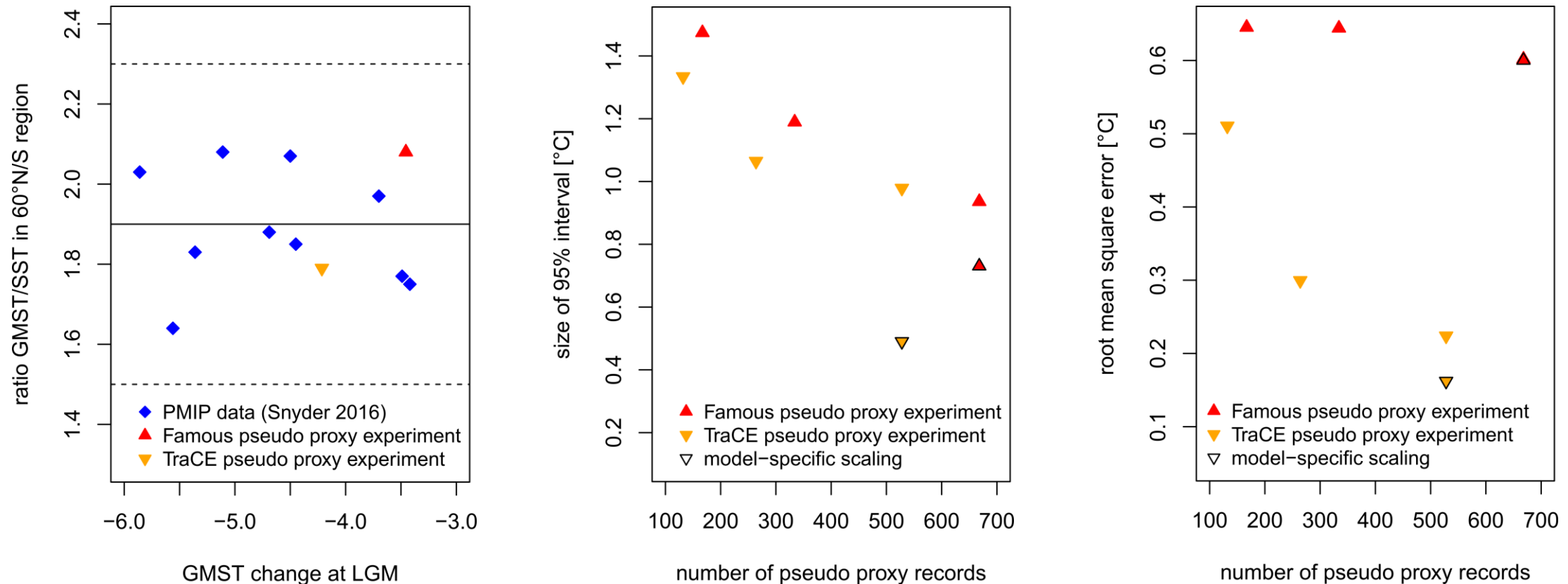
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4.2 Results for pseudo proxies



- Stronger restrictions on scaling factor depending on climate state and/or model desirable
- Larger abundance and more homogeneous spatial coverage of SST records desirable

5 Conclusions and Outlook

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Conclusions

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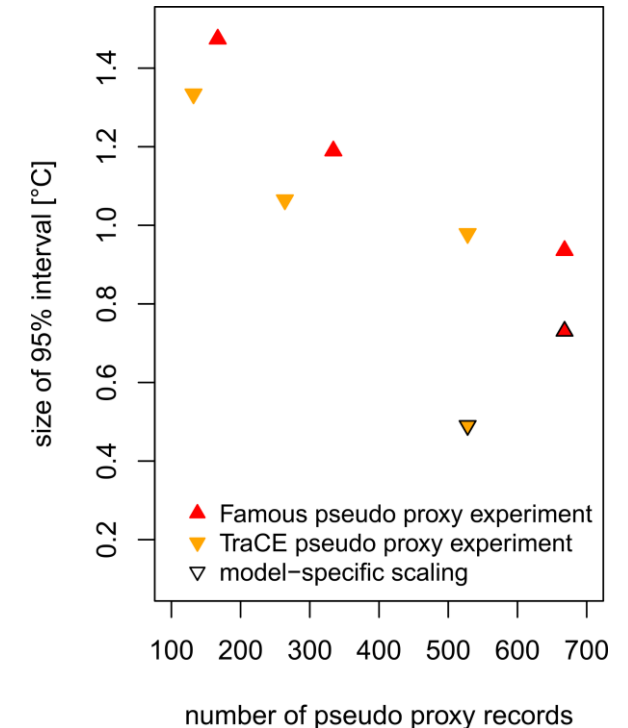
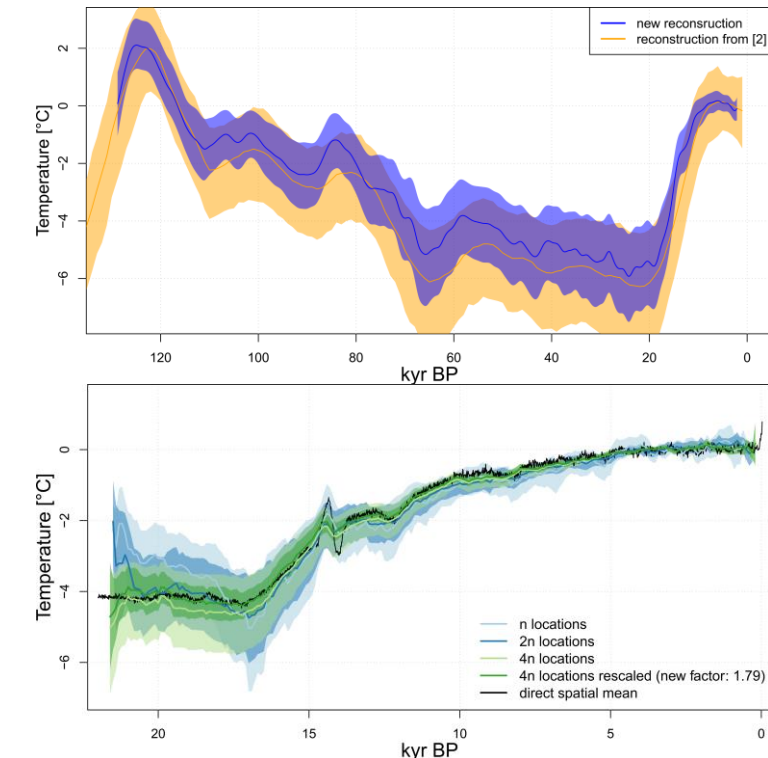
- Results consistent with previous data
- Cannot resolve centennial-scale variability

From pseudo proxy data:

- Orbital and millennial timescale consistent with model data
- More precise results with better spatial coverage

Outlook: Possible future extensions

- Inclusion of non-marine proxies
- State-dependent scaling factor
→ Dependence on ice sheet volume?



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