

# Northern Hemisphere temperature to precipitation relationships during the last Glacial from pollen records and climate simulations

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▷ Anna Sommani, ▷ Nils Weitzel, and ▷ Kira Rehfeld

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▷ Palaeoclimate dynamics and variability, Institute of Environmental Physics, Heidelberg University

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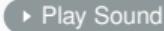
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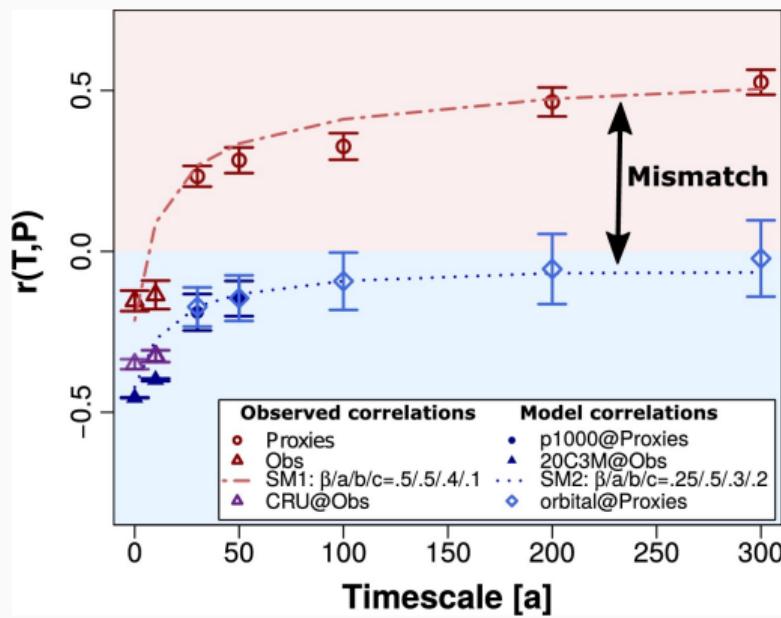
A quick summary of **central questions** of our research:

1. How are temperature and precipitation linked to each other in terms of correlation and variability?
  2. How does the temperature-precipitation relationship differ between proxy reconstructions and simulations?
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Few words about this document:

- ▷ White triangle indicates clickable contents.
-  Play Sound Indicates a short audio explanation embedded in the pdf (supported by Okular, but not by the default browser pdf readers or Preview).
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# Temp-Prec relationship in climate models differs from observations



- Many climate models have difficulties in simulating seasonal rainfall and its variability.
- Proxy reconstructions in Asia [Rehfeld and Laepple, 2016] and Europe [Ljungqvist et al., 2019], show a positive centennial-timescale correlation between temperature and precipitation.
- On the contrary, CMIP5/PMIP3 climate model simulations, show a small negative centennial-timescale correlation for Asia.

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Figure from [Rehfeld and Laepple, 2016]

# Does higher temperature mean more precipitation globally?

## Thermodynamics consideration:

- Saturation water vapor pressure  $e_s \propto e^{0.067 T^\circ[C]}$
- Higher temperature  $\Rightarrow$  more water holding capacity of the atmosphere  $\Rightarrow$  **more precipitation globally?**

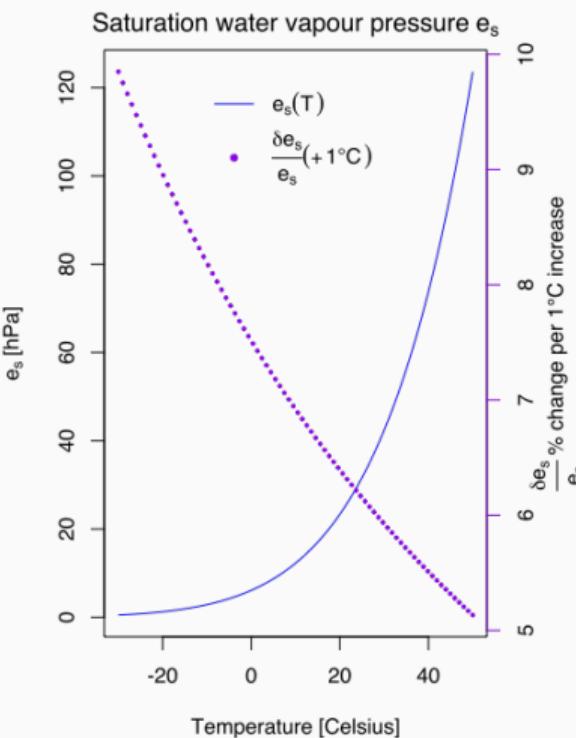
## Our approach:

- Reconstruct temperature and precipitation from four high resolution pollen records at mid-latitudes in the Northern Hemisphere.
- Focus on the last Glacial period, characterized by colder temperature than the Holocene as well as pronounced millennial-scale climate fluctuations in the Northern Hemisphere.

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August–Roche–Magnus formula:

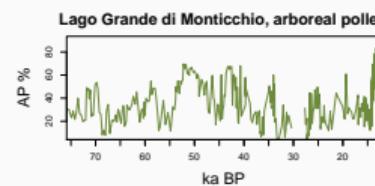
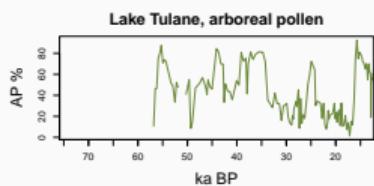
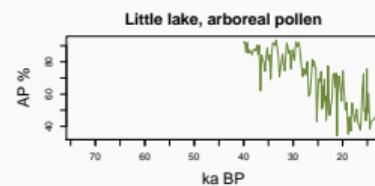
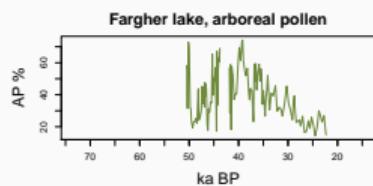
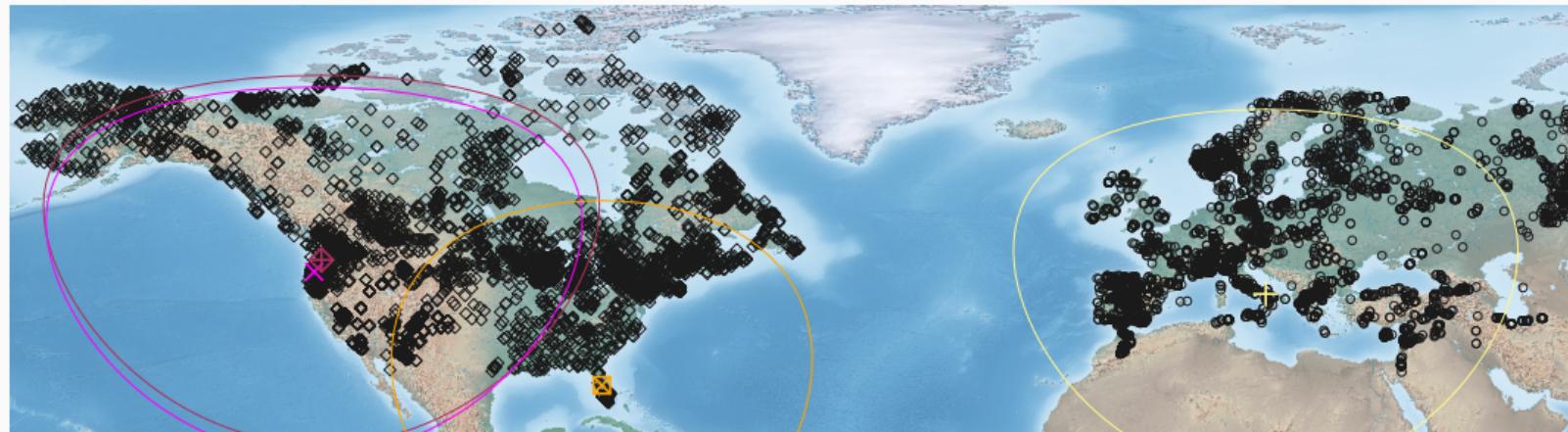


# Fossil pollen data and arboreal pollen (AP) percentages

- ◆ Fagher Lake
- ✖ Little Lake
- ▣ Lake Tulane
- ✚ Lago Grande di Monticchio

- 3000km from Fagher Lake
- 3000km from Little Lake
- 3000km from Lake Tulane
- 3000km from Lago Grande di Monticchio

- ◇ NAMPD samples (North American Modern Pollen Database)
- EMPD samples (European Modern Pollen Database)

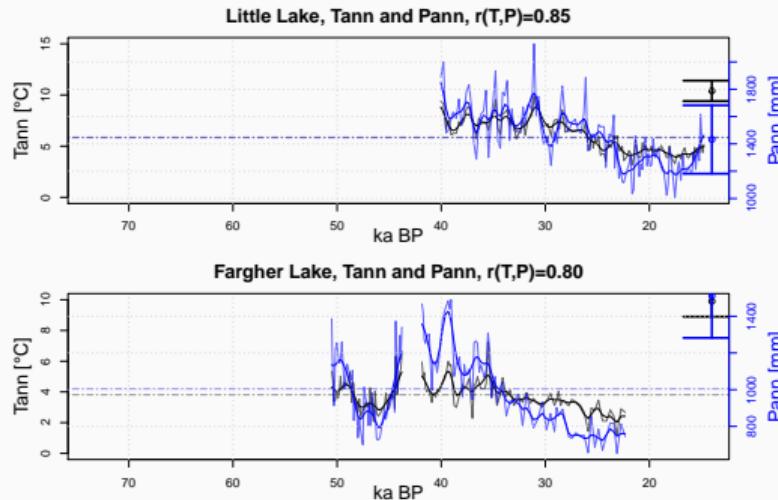
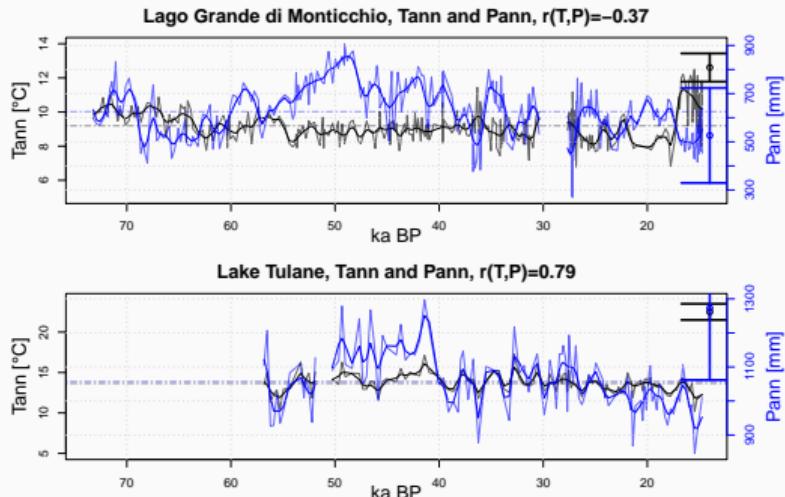


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04\_proxydata.mp3 (0:57)

[Goñi et al., 2017, Davis et al., 2020, Whitmore et al., 2005, Grigg and Whitlock, 2002, Grigg et al., 2001, Grimm et al., 1993, Allen et al., 1999]

# Preliminary results: Annual mean temperature (Tann) and precipitation (Pann)



Reconstruction method: WAPLS [ter Braak and Juggins, 1993] with two components.

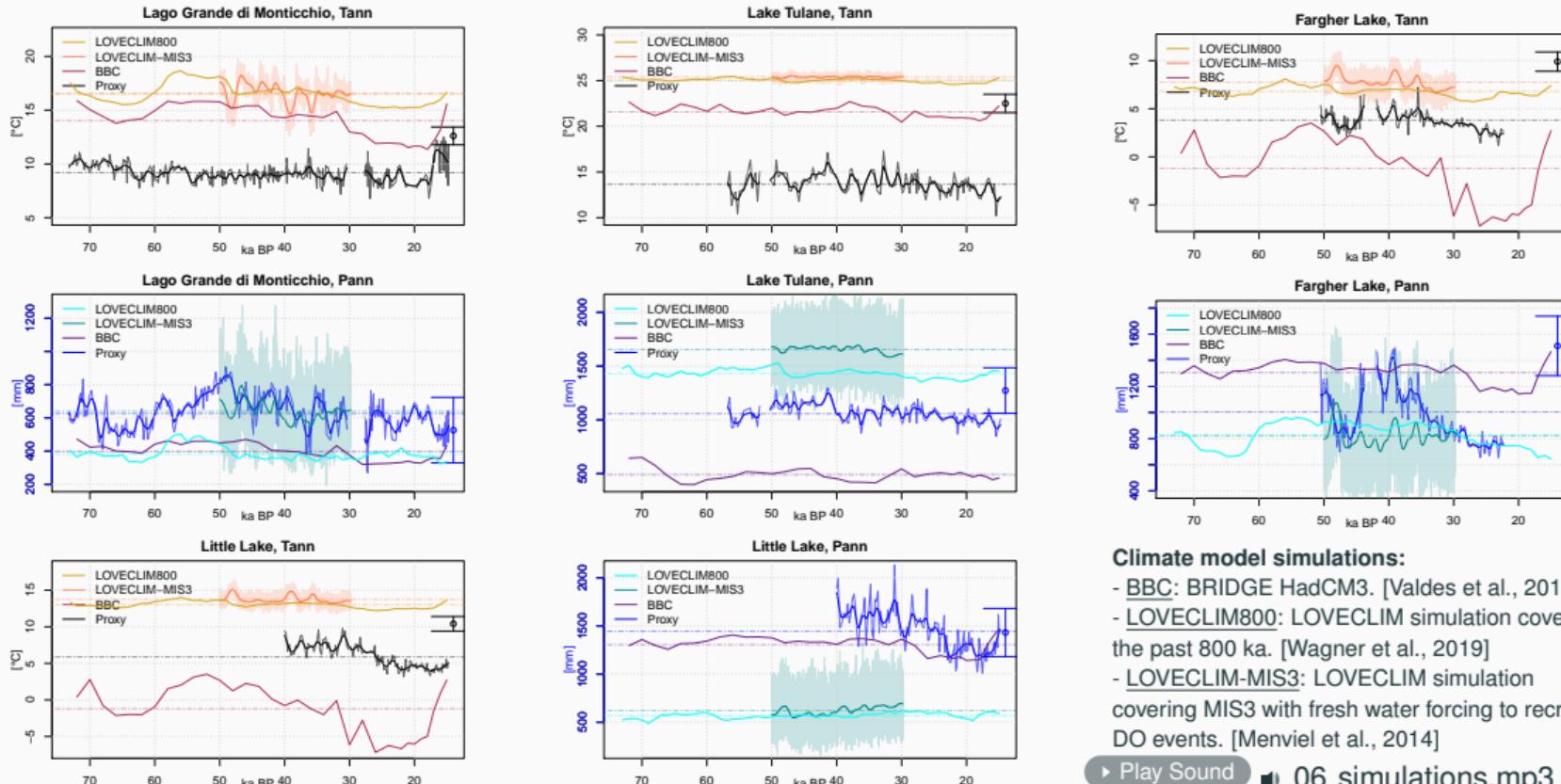
Training set given by the modern pollen samples within 3000km from the proxy site.

Bars: one standard deviation of the modern climatology of annual mean temperature (Tann, via ▷ Climate Explorer) and total precipitation (Pann, from ▷ CRU CL v. 2.0 [New et al., 2002]).

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05\_reconstructions.mp3 (0:57)

# Comparison of simulations and preliminary reconstructions



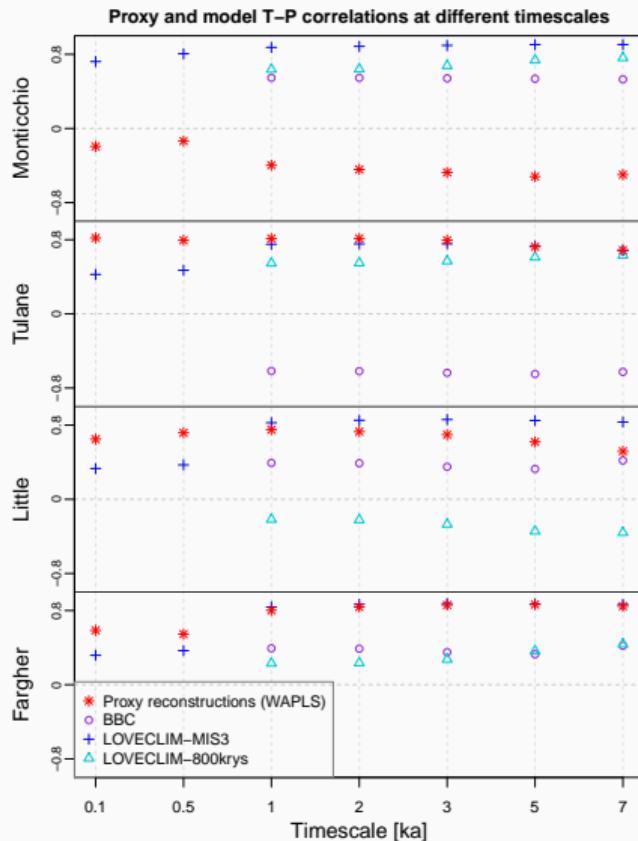
## Climate model simulations:

- BBC: BRIDGE HadCM3. [Valdes et al., 2017]
- LOVECLIM800: LOVECLIM simulation covering the past 800 ka. [Wagner et al., 2019]
- LOVECLIM-MIS3: LOVECLIM simulation covering MIS3 with fresh water forcing to recreate DO events. [Menkveld et al., 2014]

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# Overall correlations and Outlook



**Figure:** timescale-dependent correlation in proxy reconstructions and climate model simulations during marine isotope stage 2-3-4.

Both proxy and model timeseries were bandpass filtered and analyzed using timescale dependent Gaussian kernel correlation [Rehfeld and Kurths, 2014]. The timescale values correspond to the low frequency filter used  $f_{\text{low}} = 1/\text{timescale}$ . The high frequency filter used is  $1/10^3 \text{a}$  for the centennial timescales and  $1/10^4 \text{a}$  for the millennial timescales.

## Conclusions and Outlook

- Temperature to precipitation correlations differ between the sites, and models.
- Overall low precipitation in preliminary reconstructions, with large precipitation variability.
- Further testing of the reconstructions required.

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07\_correlations.mp3 (0:58)

## Acknowledgments

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Thanks for your attention!

We'd be happy to receive your questions/comments and to discuss related topics with you: ▷ live chat ▷ email

We would also like to warmly thank:

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