State-dependency of temperature variability in transient simulations of the last Deglaciation from models of varying complexity

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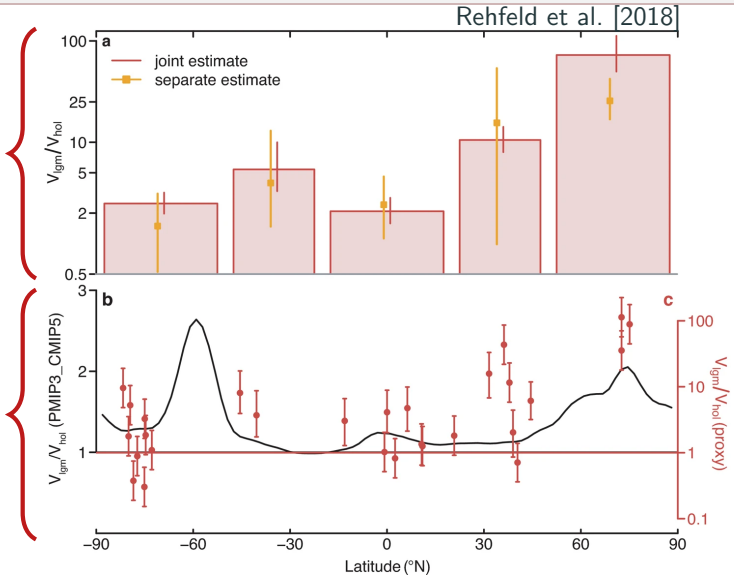
CL1.2

Models & proxies disagree on variability change since the Last Glacial Maximum

Proxies:
up to 100 times more variability during LGM than Holocene

Models:
only up to 3 times more variability



Transient simulations from models of varying complexity

Spatial resolutions:

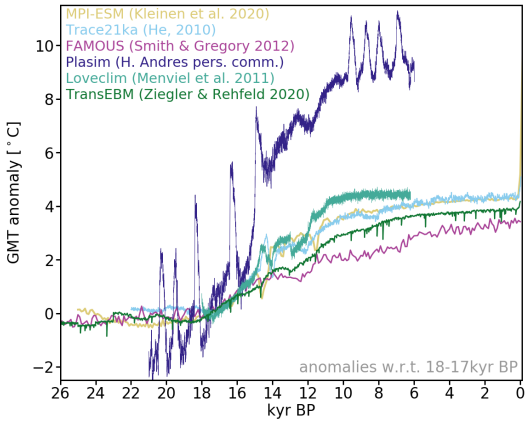
- T42: Plasim, TransEBM
- T31: MPI-ESM, Trace21ka
- T21: Loveclim
- $7.50^\circ \times 4.87^\circ$: FAMOUS

Temporal resolutions:

- 1 yr: Plasim, Loveclim, TransEBM
- 10 yrs: Trace21ka
- 100 yrs: MPI-ESM, FAMOUS

Global mean temperature:

- most simulations: 3-5°C increase since LGM
- exception: Plasim produces unforced fluctuations (related to tuning)



TransEBM forcings: CO_2: Köhler et al. [2017], orbital: Berger [1978], meltwater: assimilated based on sea surface temperatures from Jonkers et al. [2020], ice: Argus et al. [2014] & Peltier et al. [2015], volcanic: Schindlbeck-Belo, Kutterolf & Toohey, pers. comm., solar: surrogate data based on Steinhilber et al. [2009]
Models: MPI-ESM Kleinen et al. [2020], FAMOUS: Smith et al. [2008], Trace21ka: He [2010], Plasim: Andres (pers. comm.), Loveclim: Menviel et al. [2011], TransEBM: Ziegler and Rehfeld [2020]

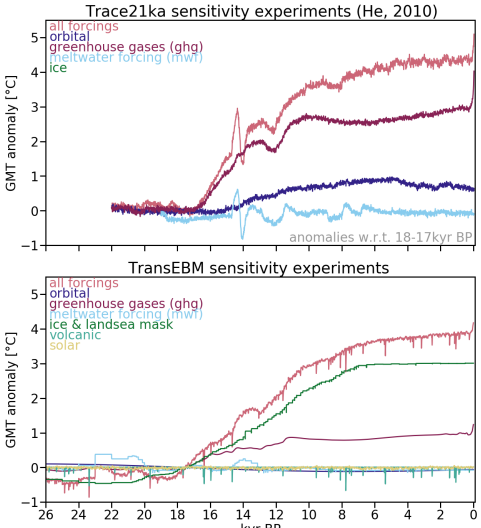
Sensitity experiments: Trace21ka & TransEBM

Trace21ka

- all produce trend in GMT except meltwater forcing
- greenhouse gases produce largest temperature response

TransEBM

- ice produces largest temperature response
- followed by GHG



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Spectral analysis

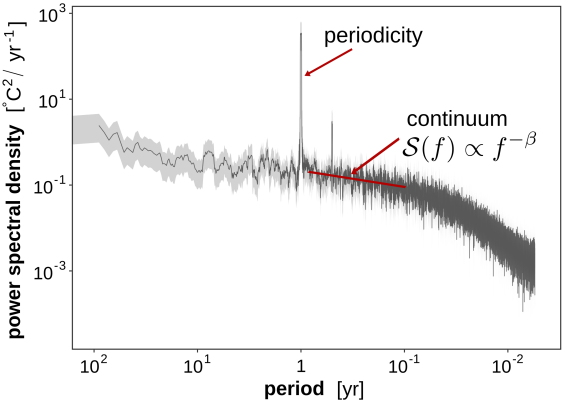
For a climate variable $X(t)$ which is a stationary, stochastic process

the **power spectral density** is given by $\mathcal{S}(f) = \mathcal{F}[\mathcal{R}(\tau)]$

that is the Fourier transform of the **autocovariance** $\mathcal{R}(\tau)$.

The spectrum then shows how variance changes as a function of time scales.

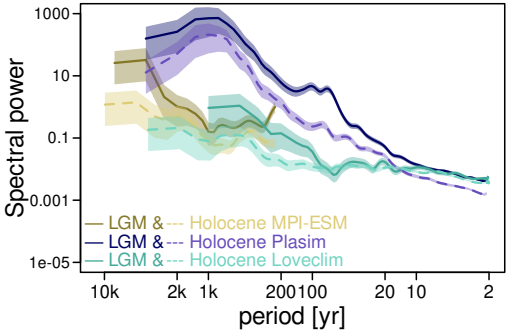
Here: multitaper method (Thomson,1982)



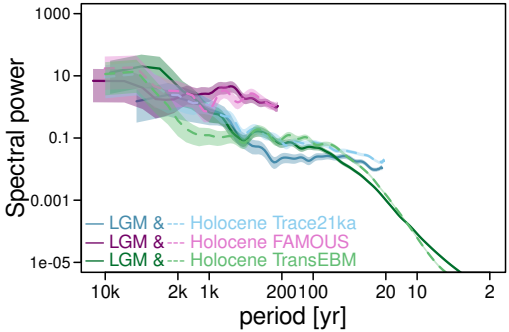
HadCET data from Parker et al. [1992] & Morice et al. [2012], Figure by B. Ellerhoff

Model response varies on centennial timescales and above

3 models show **higher LGM variability** compared to the Holocene

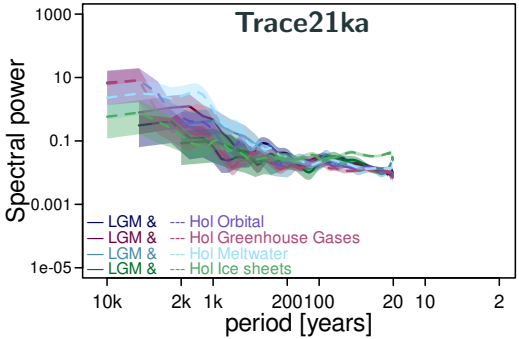


3 models show **similar** or **lower LGM variability**

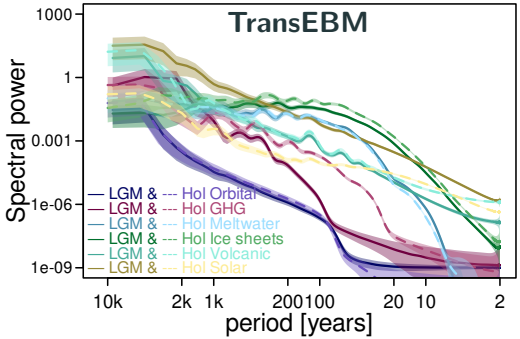


- generally: variability increases towards longer timescales & scale break around millennial scales
- exception: FAMOUS has a white spectrum
- Plasim: highest overall variability

Sensitivity to forcings of the variability change

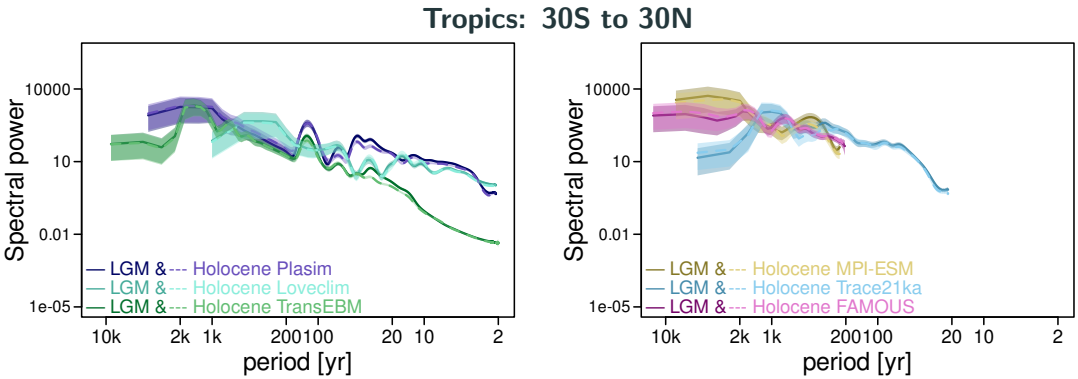


- smaller LGM variability on multi-millennial scales for orbital & GHG forcing
- similar variability in response to orbital & GHGs



- larger LGM variability for solar forcing
- smaller LGM variability for GHG forcing on sub-millennial scales and below
- most forcings: similar variability for LGM & Holocene

Regional analysis: Tropics show no variability change from LGM to Holocene

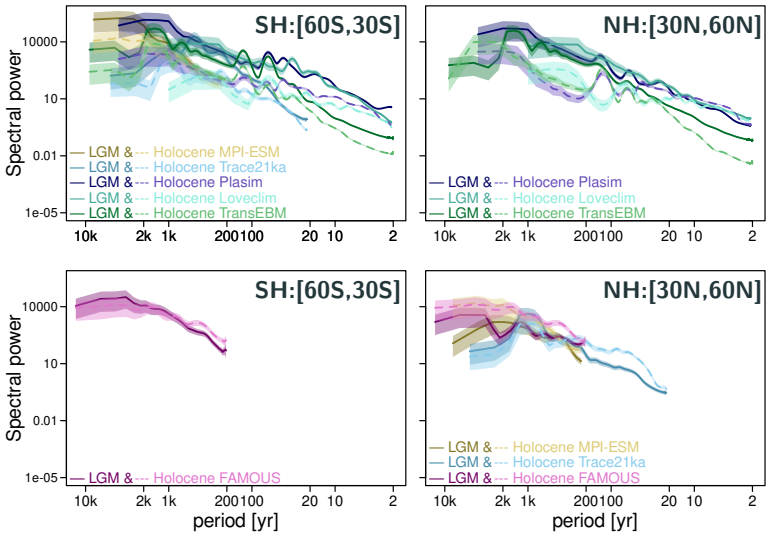


- variability during LGM & Holocene the same in all simulations (separated into two groups for better visibility)
- white spectra for most timescales
- some simulations show decreasing variability on longer timescales (i.e. TransEBM, Trace21ka)

Regional analysis: Responses vary in simulations & hemisphere in mid-latitudes

higher LGM variability in most simulations

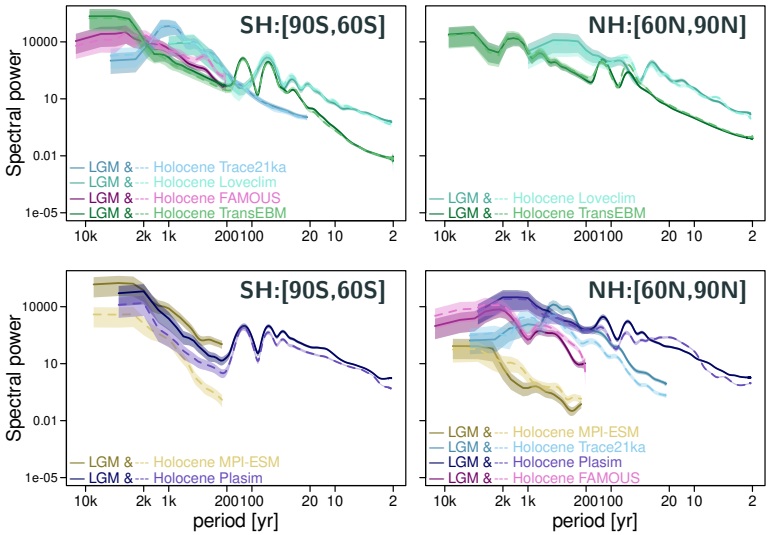
lower or similar LGM variability in some compared to the Holocene



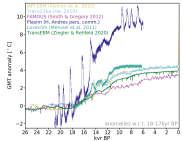
Regional analysis: Polar response depends on simulation & hemisphere

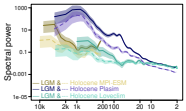
similar variability during LGM and Holocene

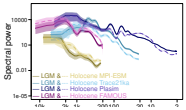
NH: mixed responses in remaining simulations; **SH: higher LGM** variability

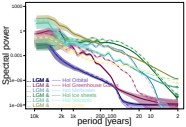


First conclusions: variability change since LGM differs between models









most transient simulations:
3 – 5° warming since LGM

model response w.r.t. variability varies, especially on longer timescales → **examine relation to resolution & parameterization**

as well as regionally, importance of forcings changes → **compare locally to proxies**

ice & meltwater: high influence across scales & periods
importance of forcings changes → **examine regional influence of forcings**

Thank you! If you have questions or feedback feel free to contact me.

Acknowledgements

We gratefully acknowledge funding by the German Research foundation (project no. 395588486) as well as the German Federal Ministry of Education and Research through the PalMod project (subproject no. 01LP1926C).

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