



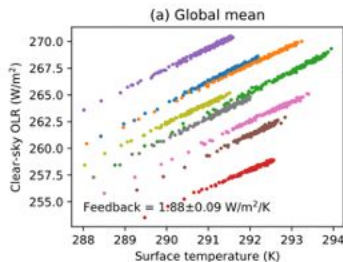
THE PATTERN EFFECT IN THE HISTORICAL RECORD

<panel discussion>

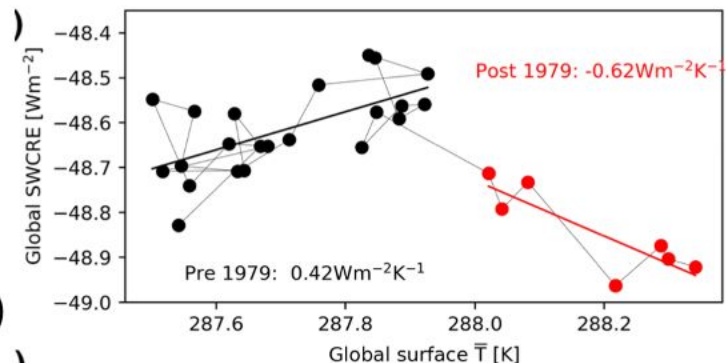


OLR = f([T]) -> functional relation between mean surface temperature and all components of the climate state vector. **Bold!** (Surprisingly ok!)

For CO₂/H₂O gas phase ok
(Zhang/Jeevanjee/Fueglistaler; GRL, 2021)



Clouds? With historical SSTs (Fueglistaler & Silvers, JGR, 2021)



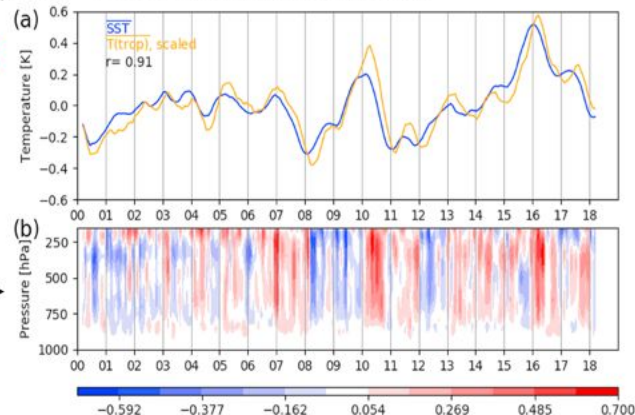
Coupled ocean-atmosphere GCMs show **monotonic** time-varying “sensitivity” (-> ocean, heat uptake).

Q: Is what we see with historical period SSTs the same as in coupled GCMs?

Patterns: How many?

Fueglistaler 2019: **Case for 2 modes:** Mean, and difference between Tropical mean and SSTs in atmospheric deep convective regions.

Atm. T **departure from moist adiabatic scaling** with mean SST



[See also Ceppi & Fueglistaler, 2021; Hogikyan/Resplandy/Fueglistaler 2022]

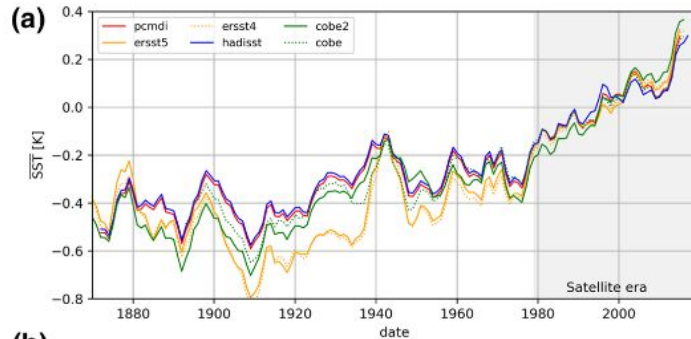


2 Modes: mean and “convective SST minus mean” (SST#; or: variance, width of PDF).

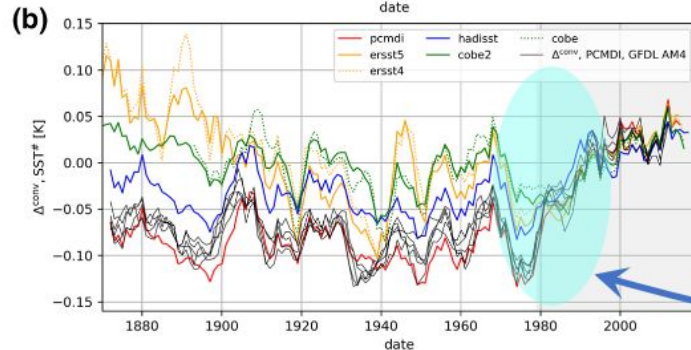
-> Very tropic-centric view of the world, explains AMIP historical global cloud radiative effect surprisingly well.

-> Reduced **dimensionality to 2 parameters** -> timeseries. “Peculiar Trajectory” (Fueglistaler & Silvers, 2021)

Colors: Different “observed” SSTs

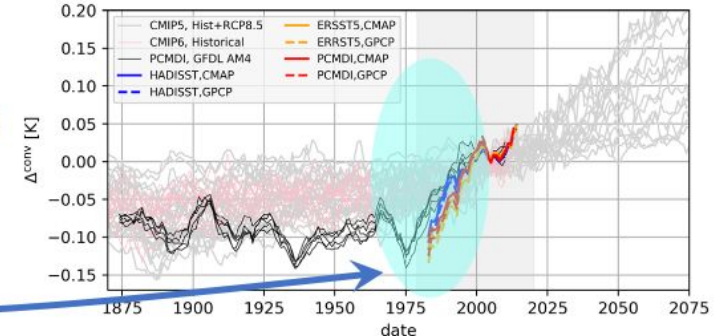
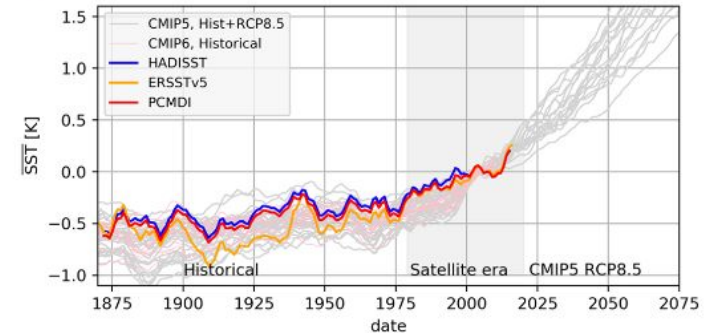


Mean



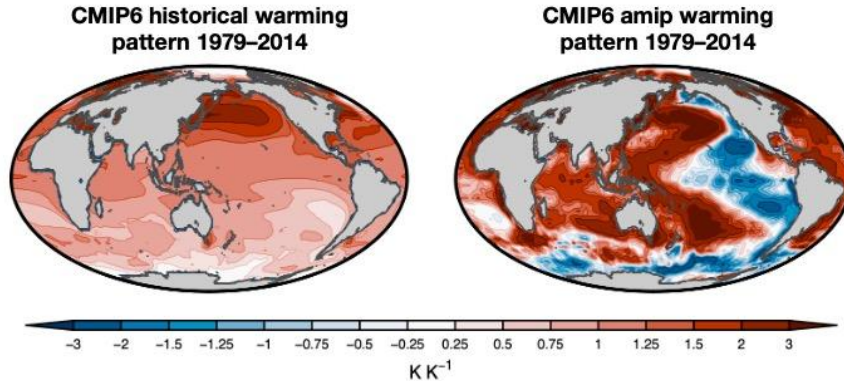
1. Large change at begin satellite period
2. Trend over historical period dubious.

Strong: Obs./AMIP <-> faded: Coupled GCMs



1) SST → Radiation

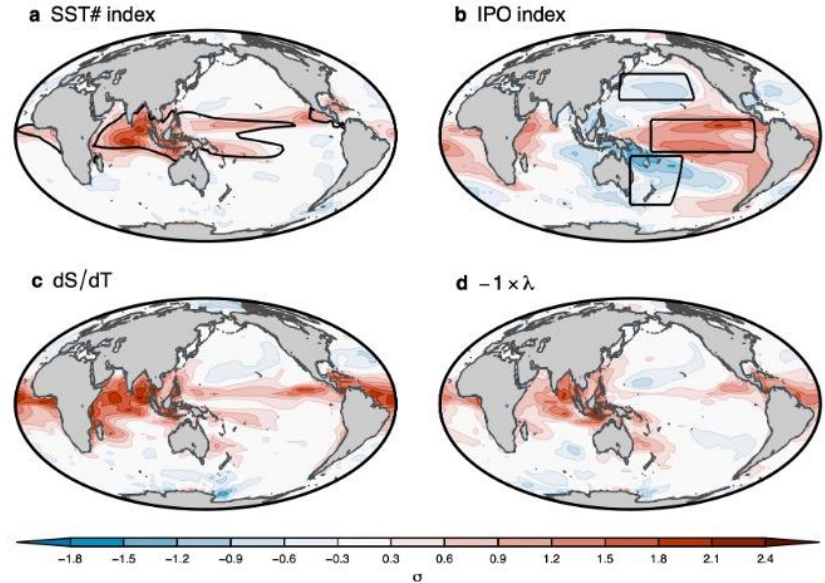
What modes of SST variability are relevant to the pattern effect?



The warm pool matters. The IPO is mostly radiatively neutral.

See also poster by Erik Schaffernicht

Regression onto CMIP6 historical warming patterns



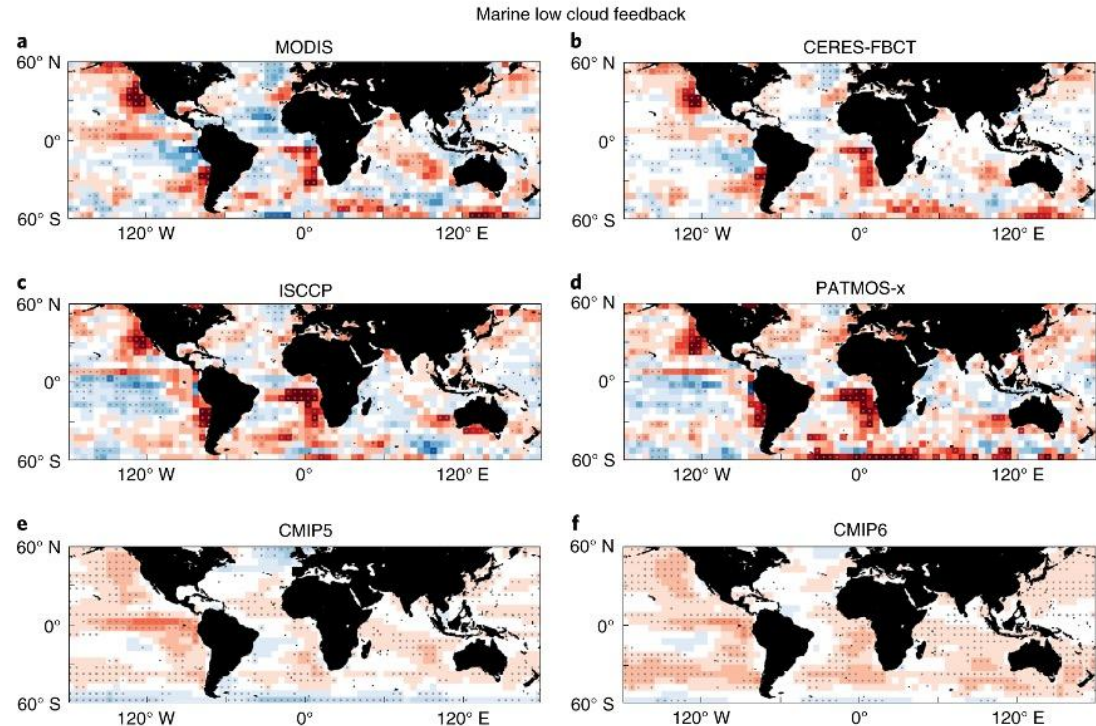
2) Radiation → SST

What are the implications of incorrect low-cloud feedbacks for coupled climate variability?

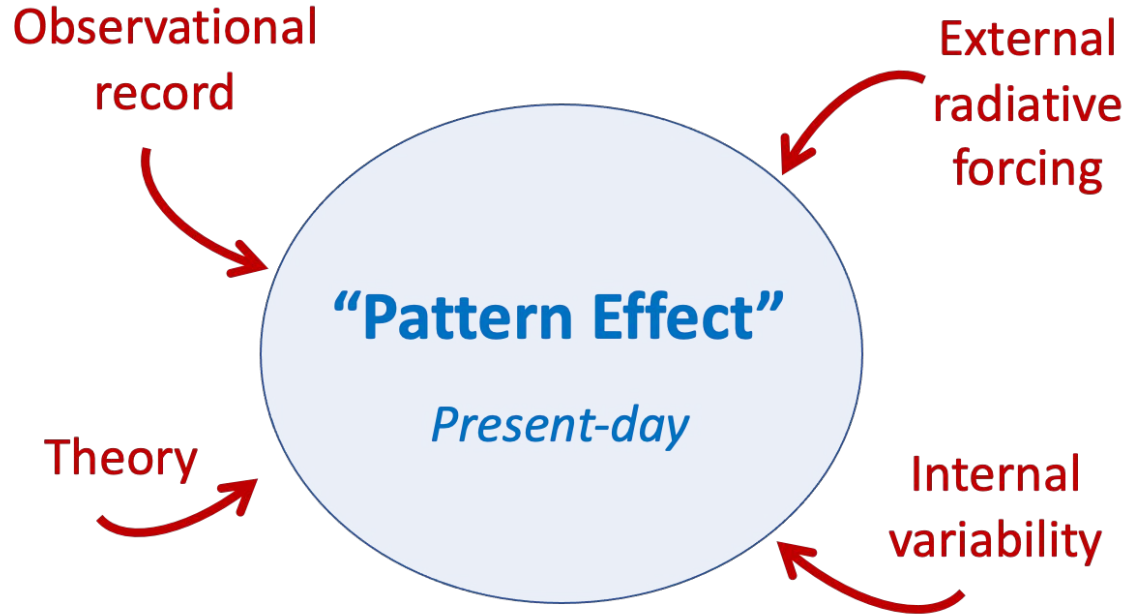
AOGCMs underestimate positive low cloud feedback in stratocumulus regions.

Likely important for coupled variability and teleconnection patterns.

Also for the forced response?



A Nexus for exposing myriad challenges in climate science



A Nexus for exposing myriad challenges in climate science

**Short, sparse,
inhomogenous.**

Discrepancies remain
even after 1979.
Need for proxy records to
expand our time horizon.

Observational
record

External
radiative
forcing

Theory

Internal
variability

“Pattern Effect”

Present-day



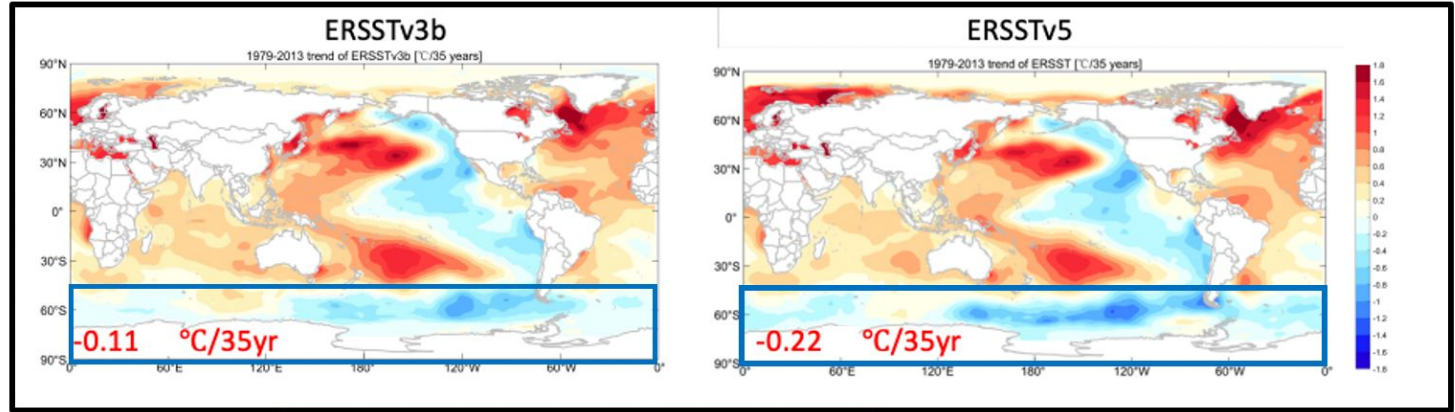
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SST Trends: 1979-2013

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Theory



Present-day

(courtesy of Sarah Kang)
Internal
variability



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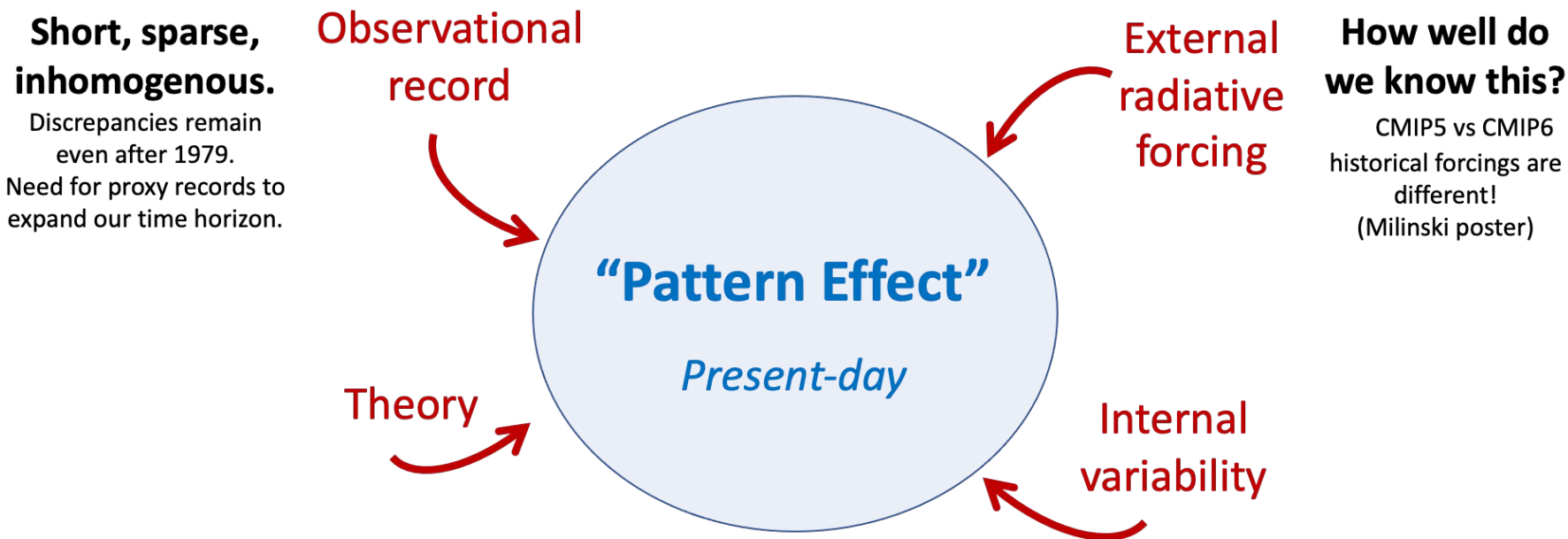
Present-day

**External
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**Internal
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**How well do
we know this?**

CMIP5 vs CMIP6
historical forcings are
different!
(Milinski poster)



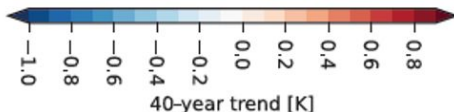
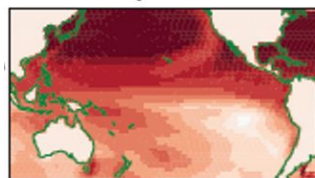
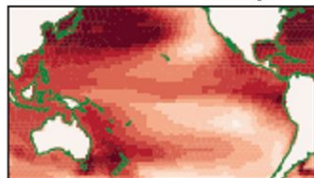
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1975-2014
Trends

CESM2 (10 members)
CMIP5 forcing

CESM2 (50 members)
CMIP6 forcing

Forced (ensemble mean)



40-year trend [K]

External
radiative
forcing

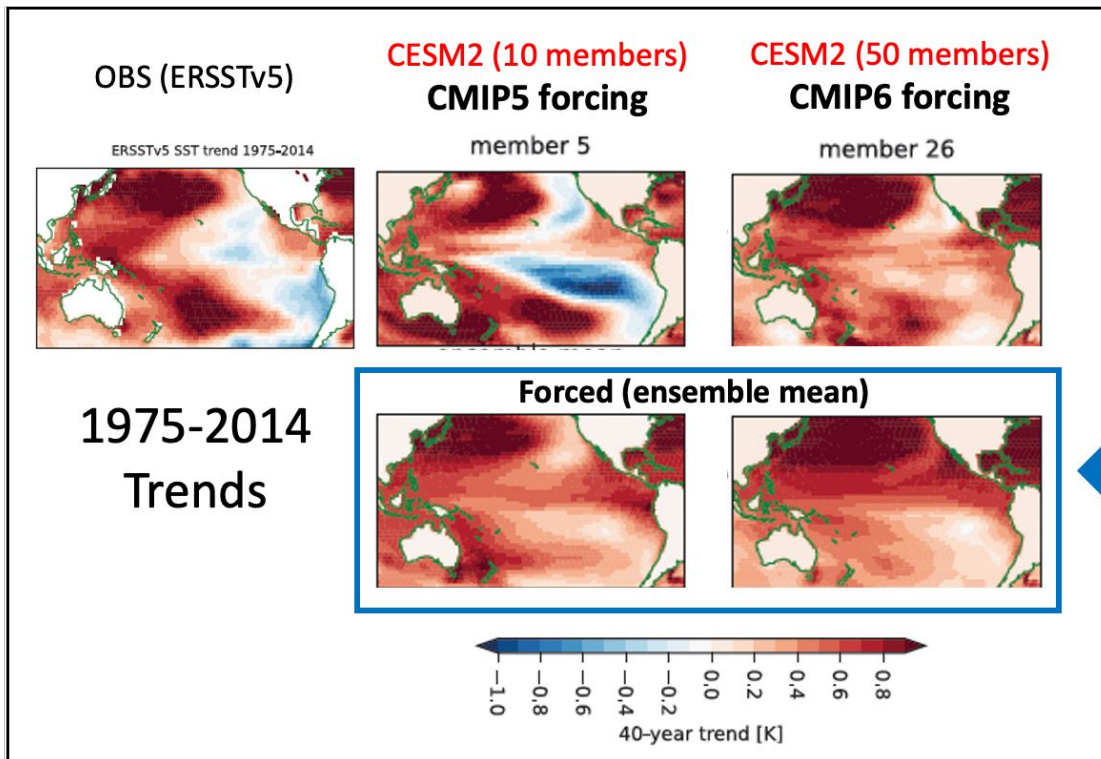
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(Milinski poster)

Internal
variability

Poster: Milinski and Deser

A Nexus for exposing myriad challenges in climate science



Poster: Milinski and Deser

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Observational record

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External radiative forcing

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(Milinski poster)

Internal variability

Need for model Large Ensembles.

But do models underestimate magnitudes, and are they missing / misrepresenting key physical processes (EUC, Antarctic meltwater, aerosol-cloud interactions)?

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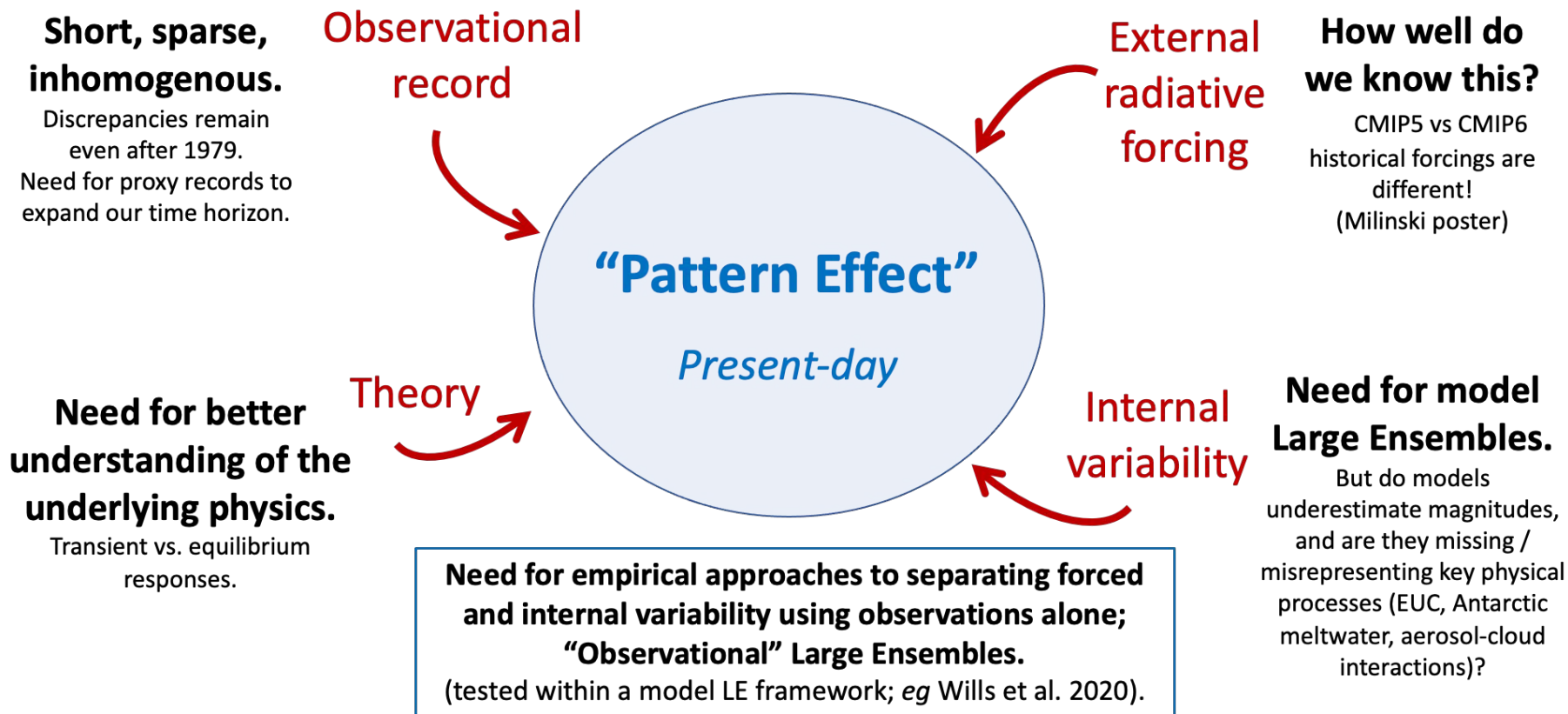
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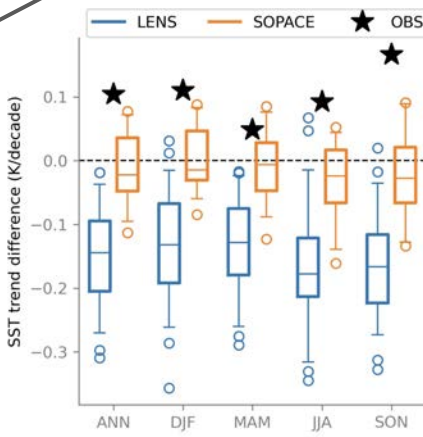
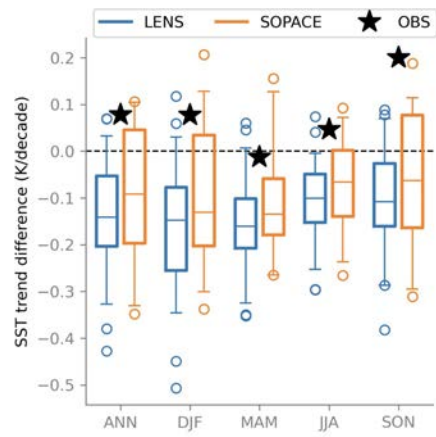
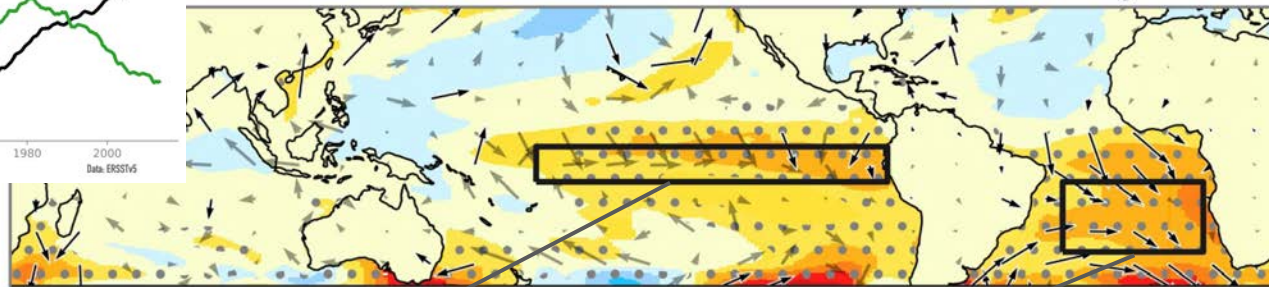
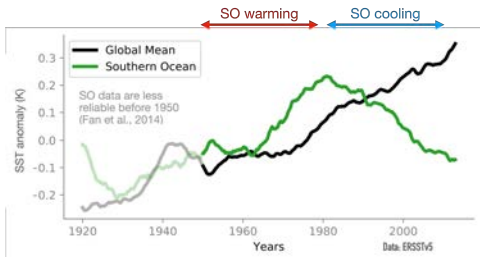
Need for empirical approaches to separating forced and internal variability using observations alone; “Observational” Large Ensembles.
(tested within a model LE framework; eg Wills et al. 2020).

A Nexus for exposing myriad challenges in climate science



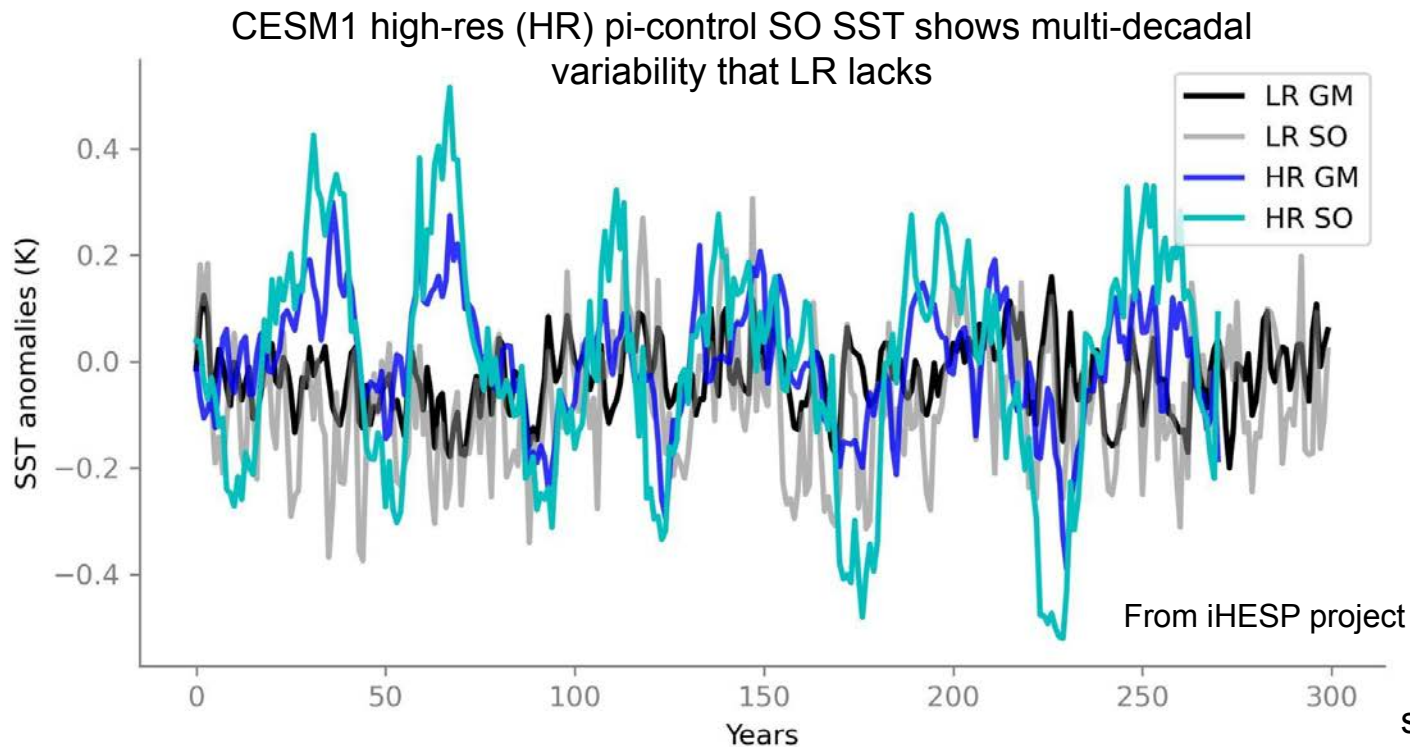
Q: How do “observed” Southern Ocean SST trends affect the tropical SST?

CESM1 Southern Ocean pacemaker experiment shows that the most robust response is in the tropical Atlantic

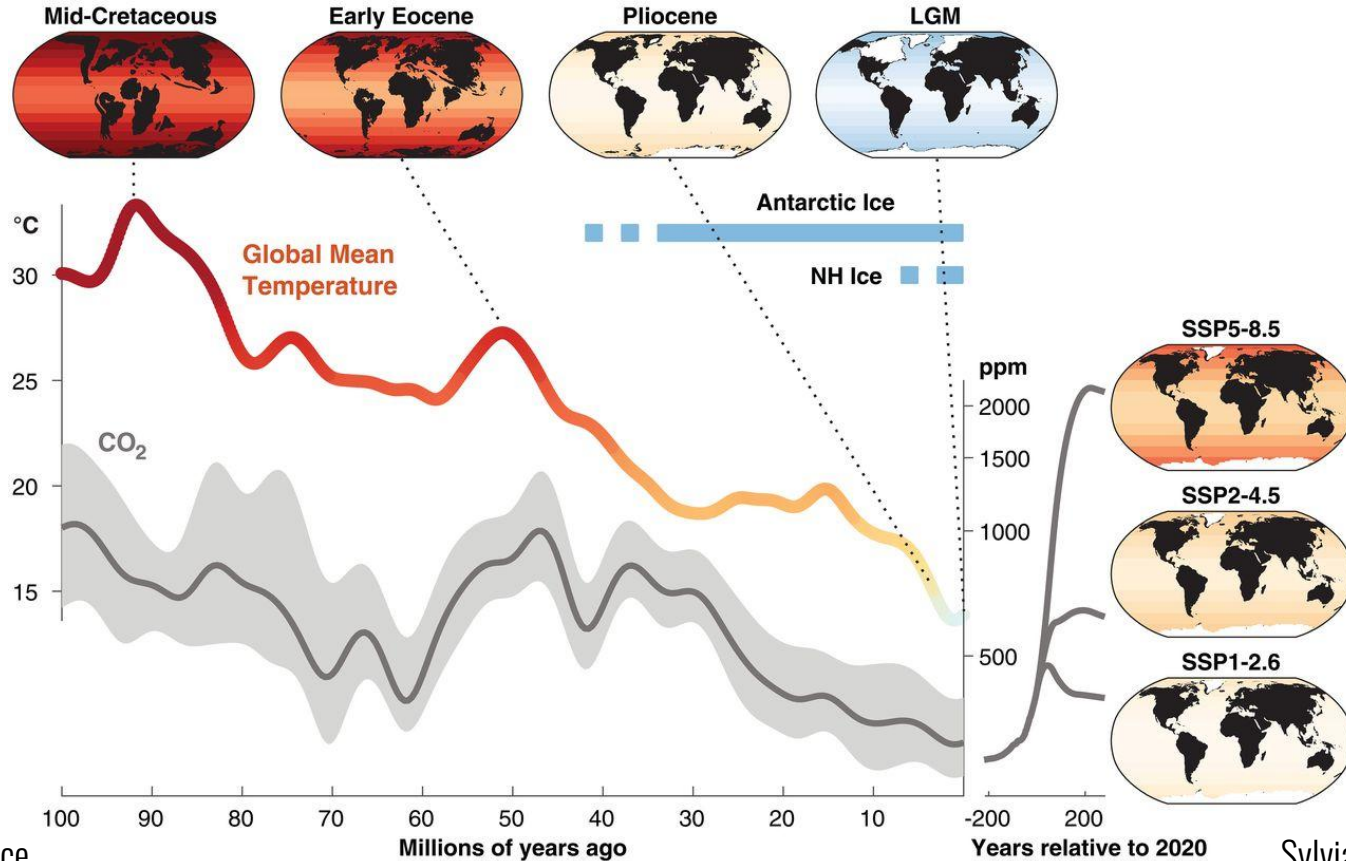


Q: What's the tropical Atlantic's role in the pattern effect?

Q: How is the pattern effect affected by model resolution (or by processes that are missing in current GCMs)?

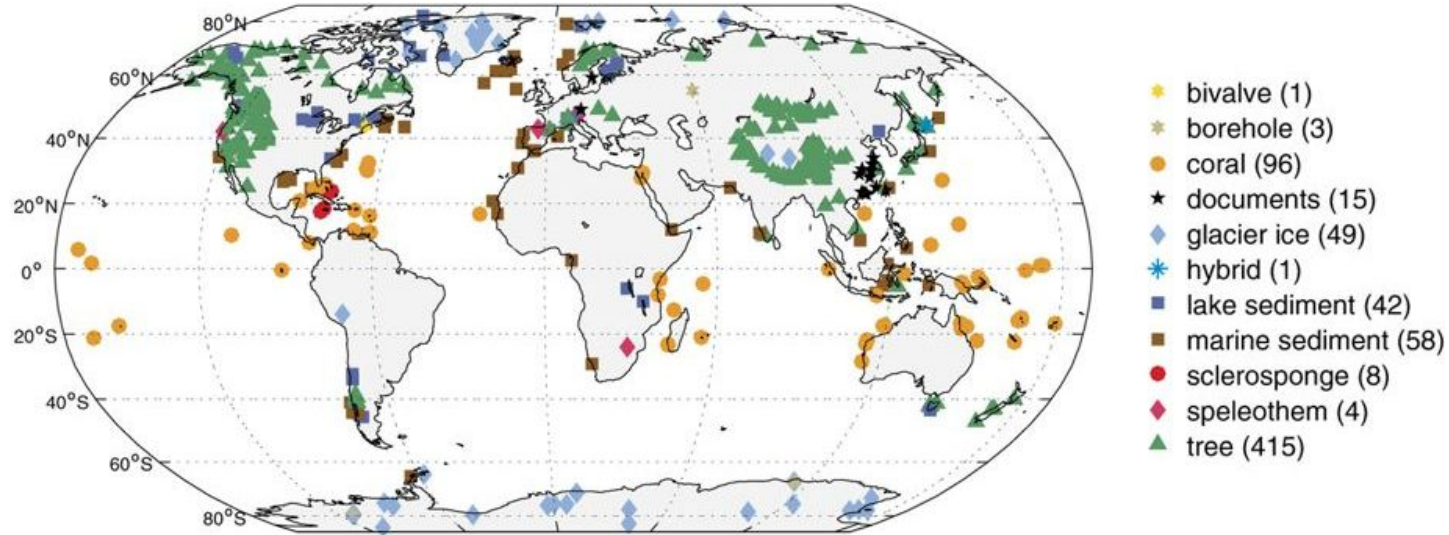
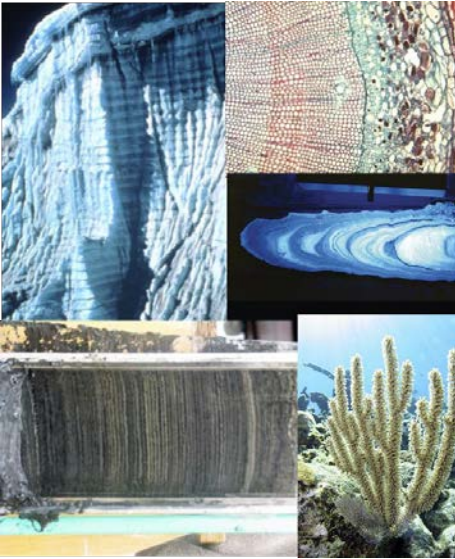


Long-Term and Paleoclimate Perspectives

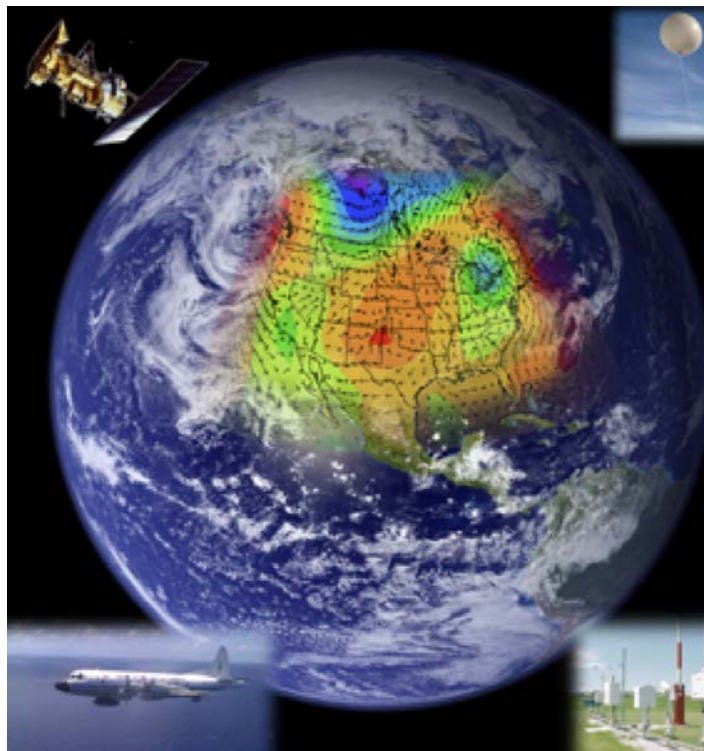


CONSTRAINTS ON THE PATTERN EFFECT:

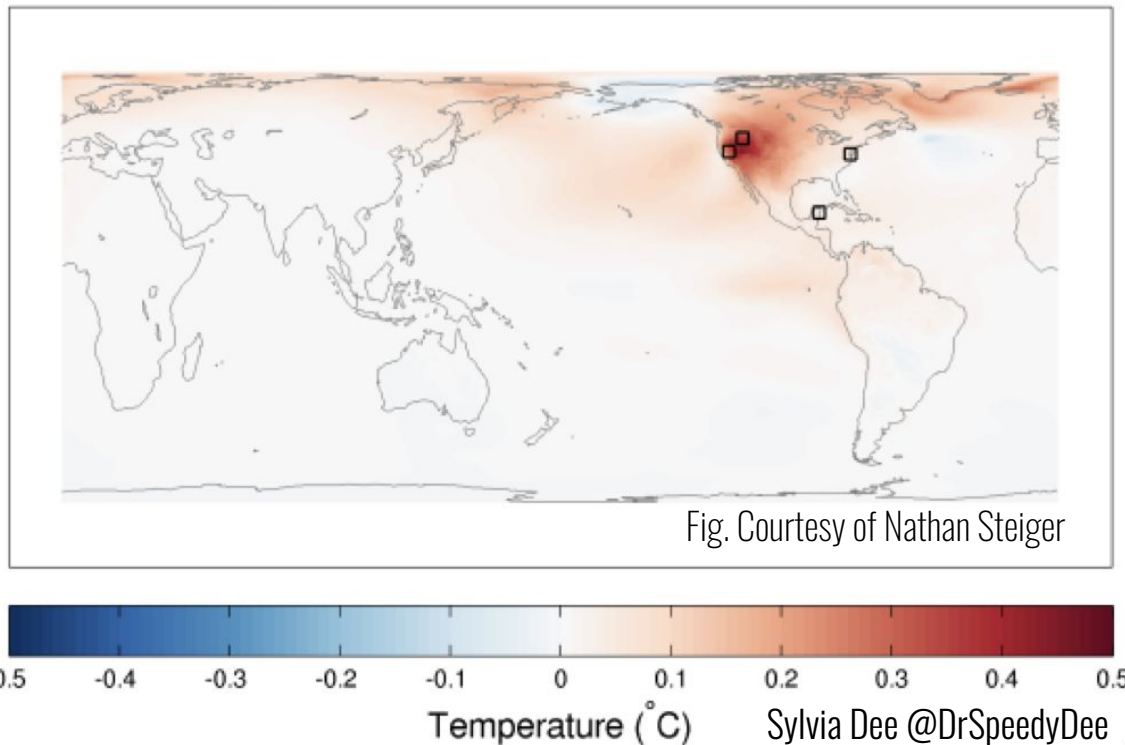
Individual and Networks of Paleoclimate Reconstructions



CONSTRAINTS ON THE PATTERN EFFECT: Paleoclimate Data Assimilation Reconstructions



Change in ensemble mean: 4 proxies

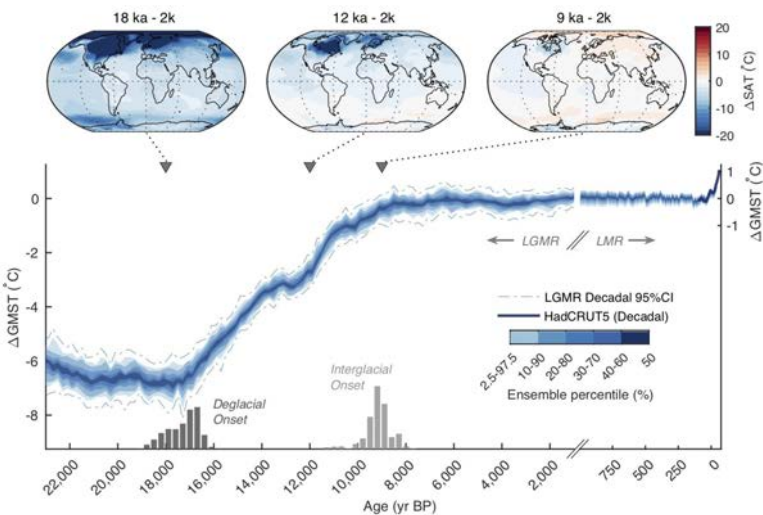


CONSTRAINTS ON THE PATTERN EFFECT: Paleoclimate (Data Assimilation) Reconstructions

New Paleoclimate Data Assimilation products provide a larger sample size

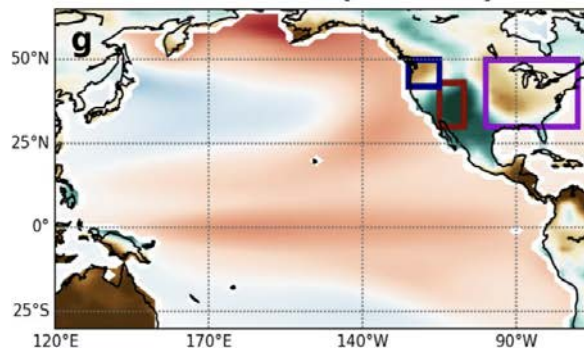
LMR: Last Millennium Reanalysis (Hakim et al., 2016), PHYDA: Paleo Hydrodynamics Data Assimilation product (Steiger et al., 2018)

COLD (LGM) 🧊



Osman et al., 2021

MEDIUM (LM) 😎



(Sea Surface) Temperature
Precipitation, Geopotential Height
Palmer Drought-Severity Index

HOT (EOCENE) 🥵

A new view of the Eocene greenhouse world from paleoclimate data assimilation

Show affiliations

Tierney, J. E.; Zhu, J.; King, J.; Li, M.; Malevich, S. B.; Poulsen, C. J.; Ridgwell, A.; Hakim, G. J.; Tardif, R.; Kump, L. R.

The Eocene, as the most recent greenhouse world, offers valuable lessons about how the climate system behaves under high levels of CO₂ (ca. 1000 ppm). However, our understanding of Eocene climate dynamics is fundamentally limited by uncertain, and spatially and temporally restricted, paleoclimate data. Conversely, climate model

Luo & Dee et al., 2022

CONSTRAINTS ON THE PATTERN EFFECT: Paleoclimate

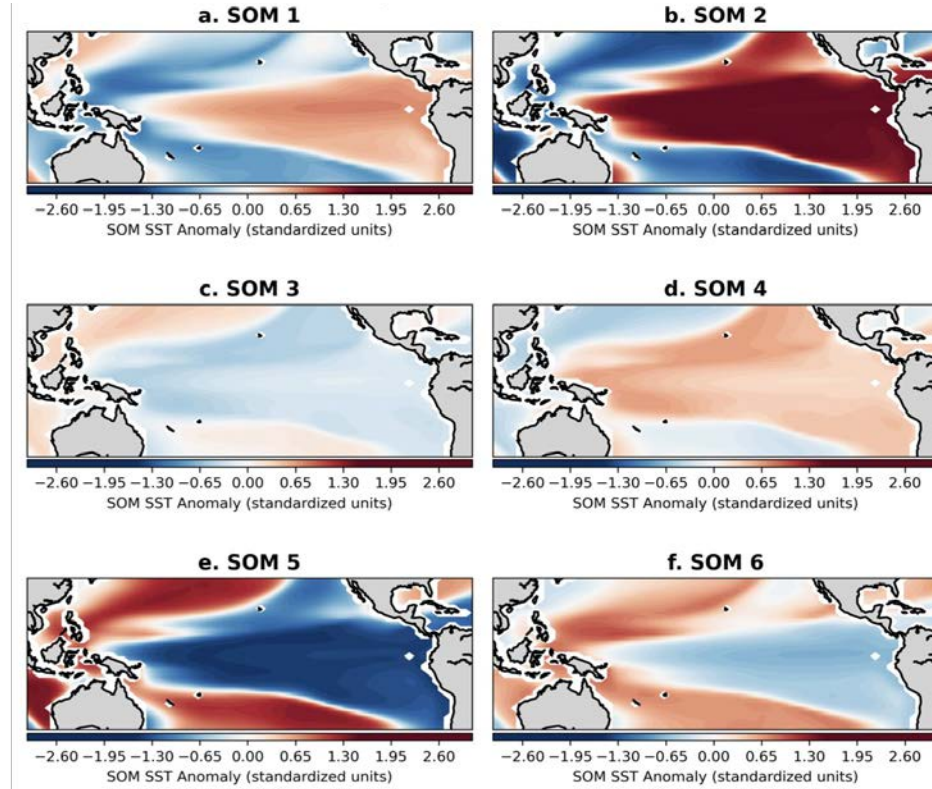


Ulla's talk: "How can we address the model differences?"
We can use paleoclimate data.

DISCUSSION Q1: What are the best methods for extracting information on the pattern effect from the paleoclimate record?

Issues: sparse data in space and time; time scale of DA products; model priors in DA

DISCUSSION Q2: Wish list for the paleoclimate modeling/data-model comparison community?



DISCUSSION:

THE PATTERN EFFECT IN THE HISTORICAL RECORD