Draft: Paleo perspectives on pattern effects over inter-decadal time scales

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May 11th, 2022

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"It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so." *Mark Twain*

Overview

1. Uncertainties and biases in inter-decadal SST variations during the instrumental period
    a. Decoupling of land-ocean temperatures prior to 1940
    b. Rapid early 20th Century SST warming
    c. Discrepancies between coastal land and sea temperatures
2. Uncertainties in inter-decadal and longer SST variations over the Common Era
    a. How large was the Little Ice Age?
    b. Was the Little Ice Age spatially coherent?
    c. Do simulations produce sufficient internal SST variability?

How well do we know SST trends over the instrumental era?

Possible artifacts of data biases in the recent global surface warming hiatus

26 JUNE 2015 • VOL 348 ISSUE 6242

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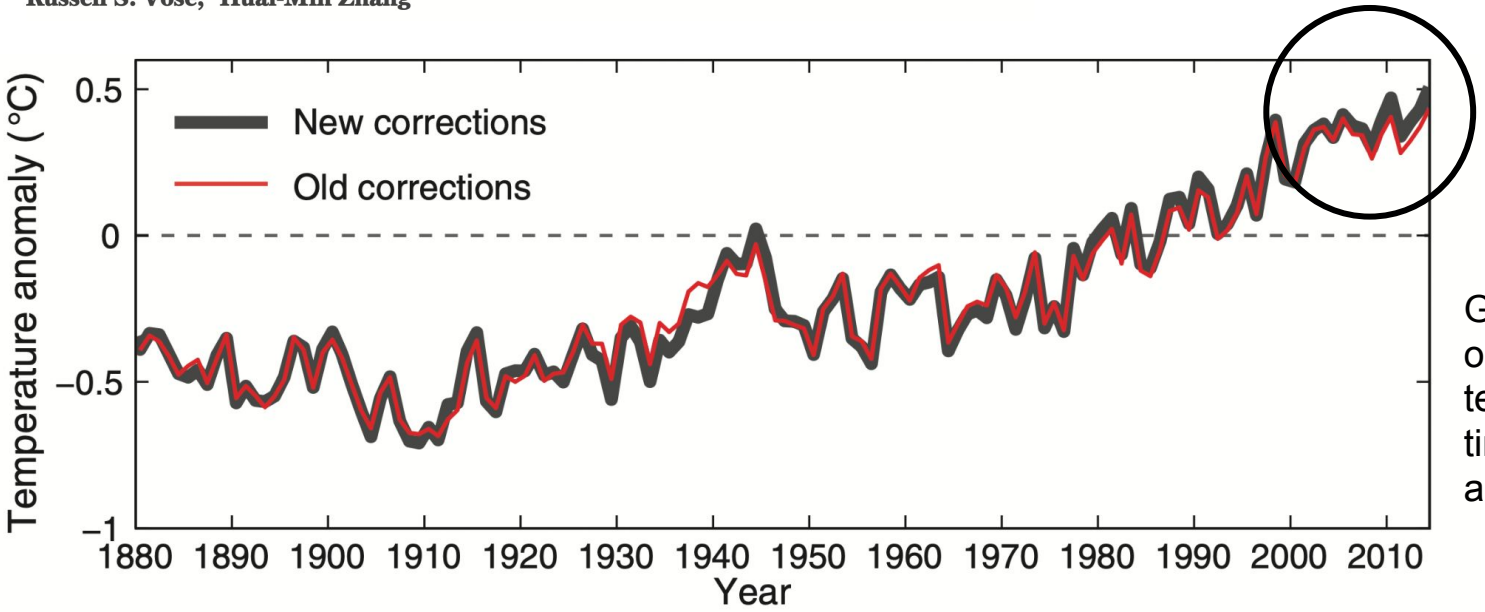

Global (land and ocean) surface temperature anomaly time series with new analysis, old analysis

How well do we know SST trends over the instrumental era?

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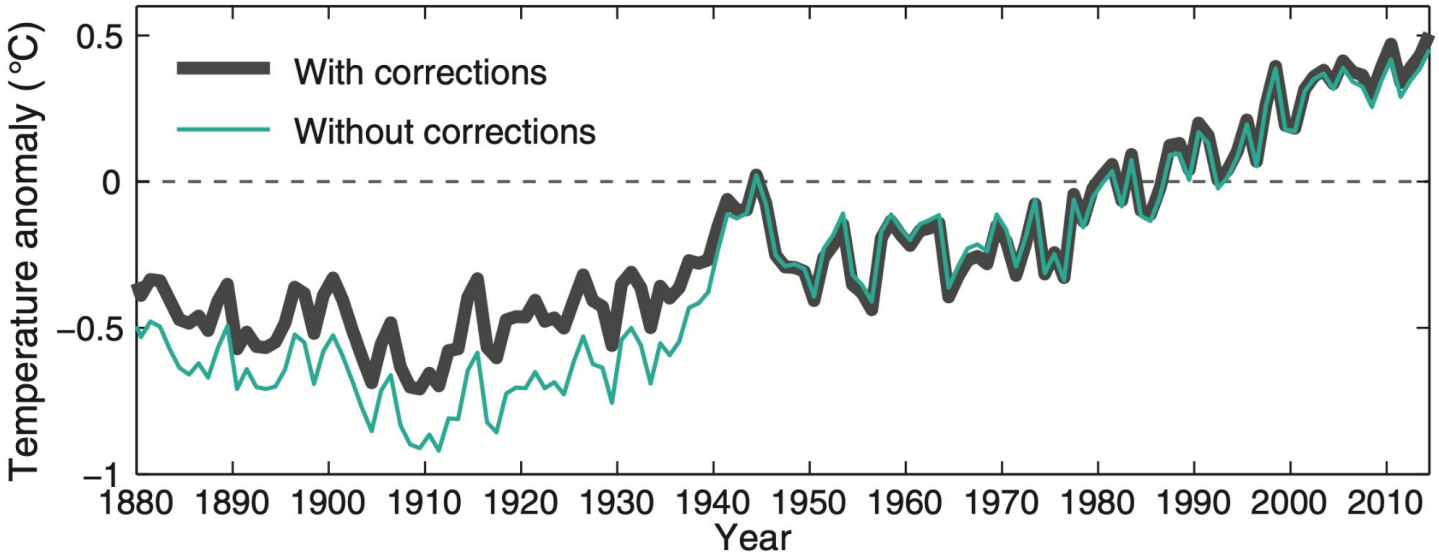
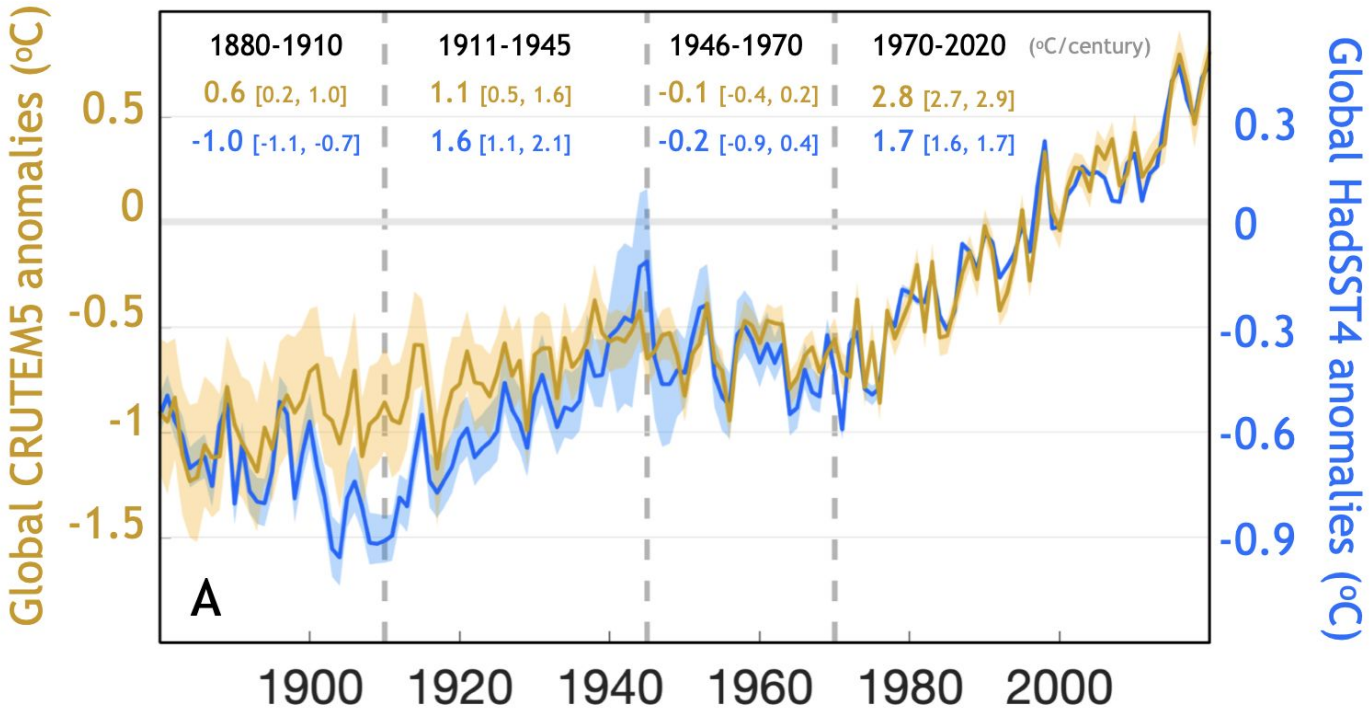


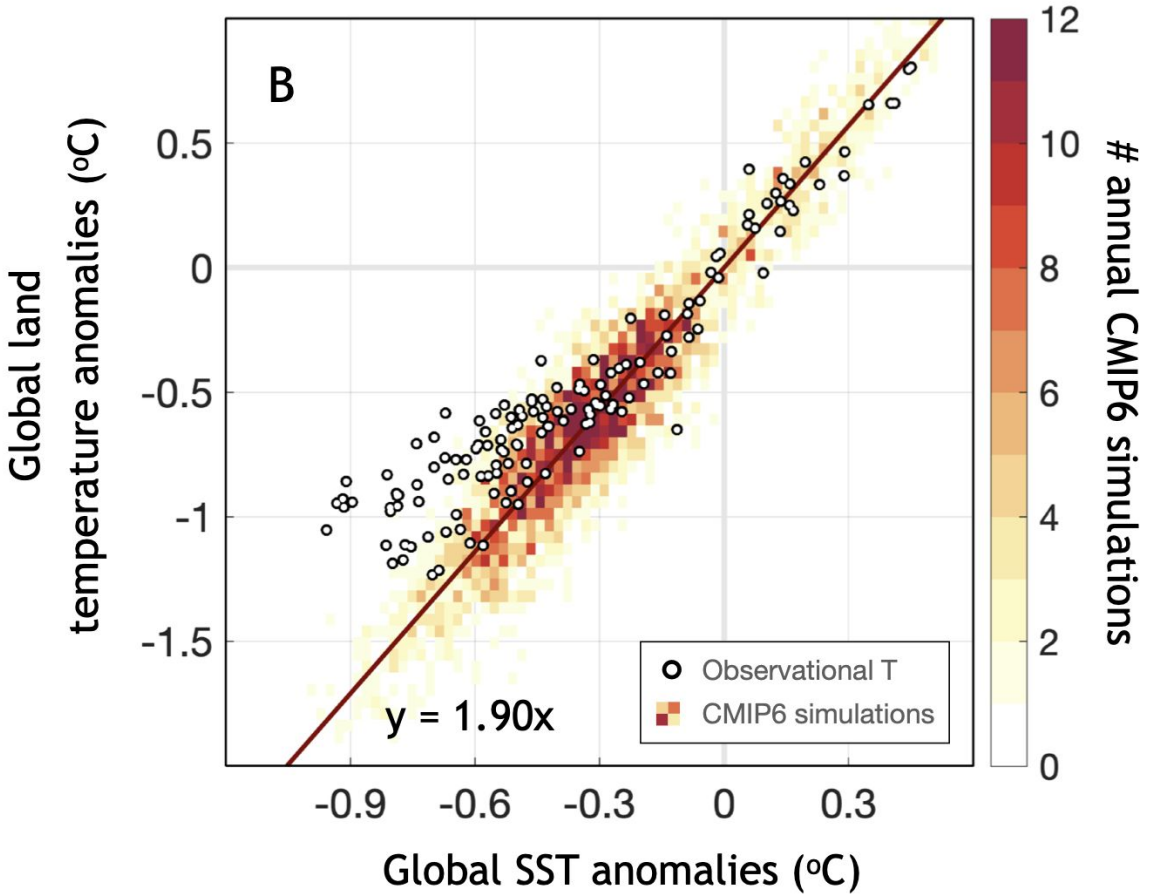
Global (land and ocean) surface temperature anomaly time series with and without corrections.

Global ocean and land temperature decouple prior to the 1940s



(Duo Chan et al., in prep.)

Global ocean and land temperature decouple prior to the 1940s



Observational land-ocean temperature decoupling is inconsistent with CMIP6 simulations.

(Duo Chan et al., in prep.)

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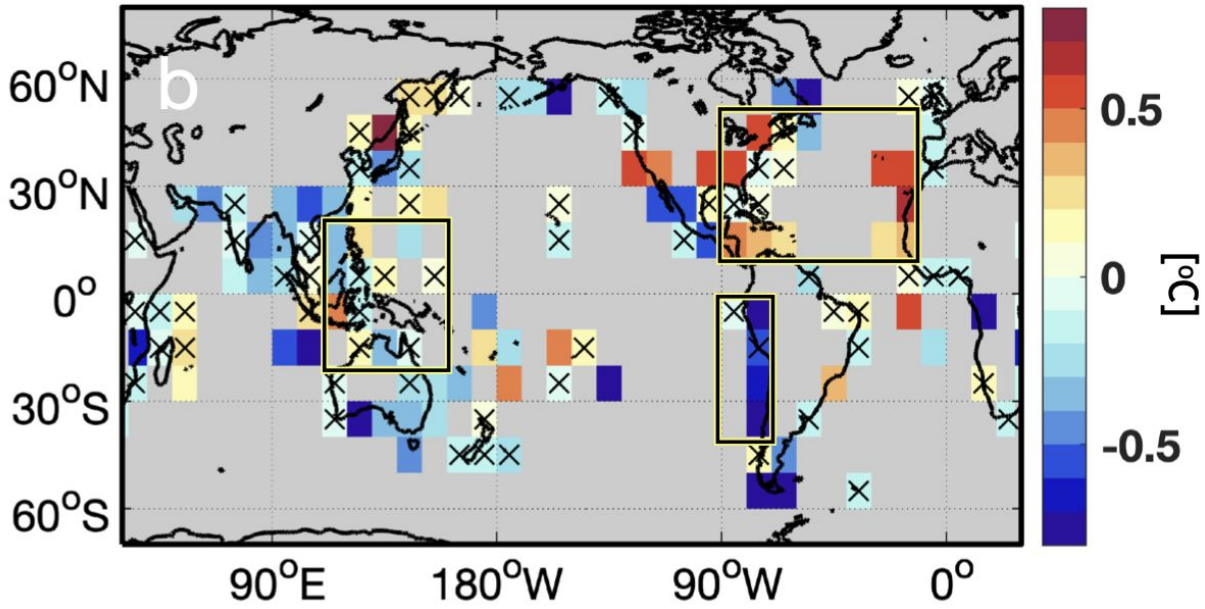
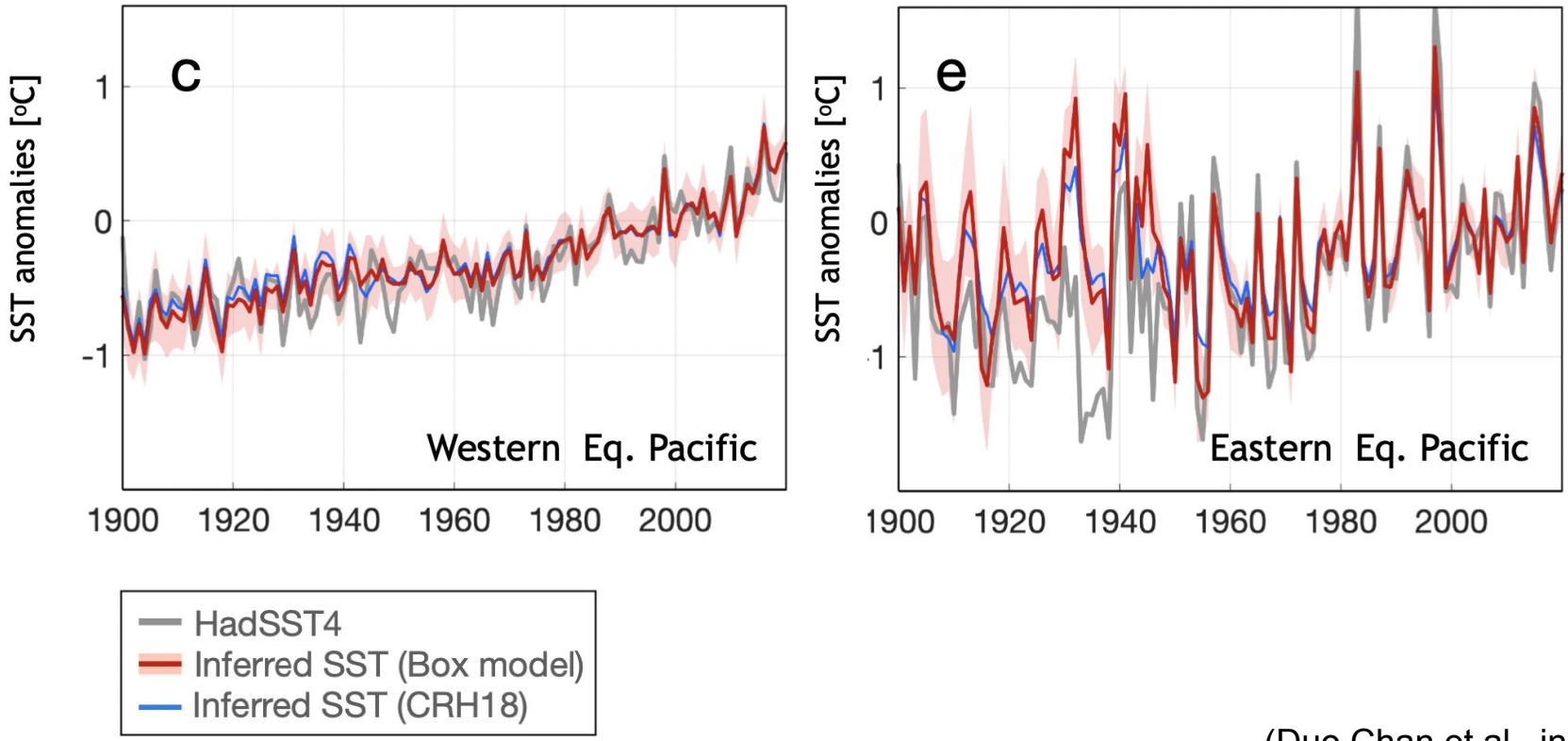


Pattern of SSTs minus those inferred from surface air temperature between 1920–1940 in coastal regions. The average bias accounts for the global land-ocean discrepancy but also indicates major regional differences.

(Duo Chan et al., in prep.)

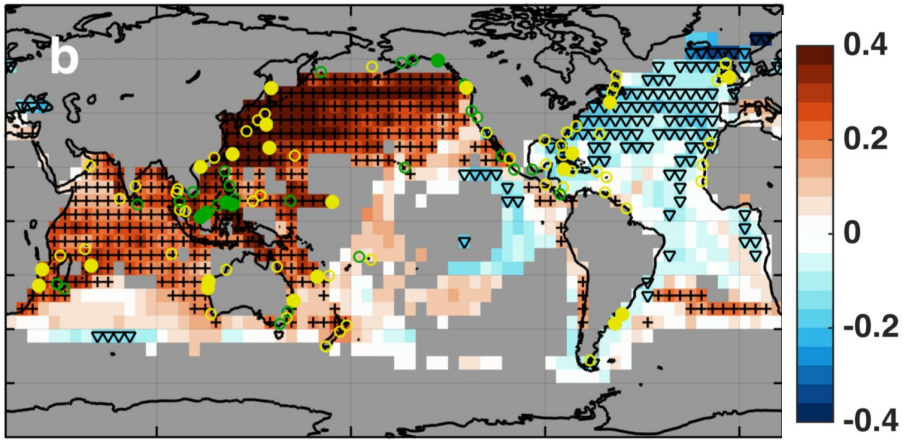
Global ocean and land temperature decouple prior to the 1940s



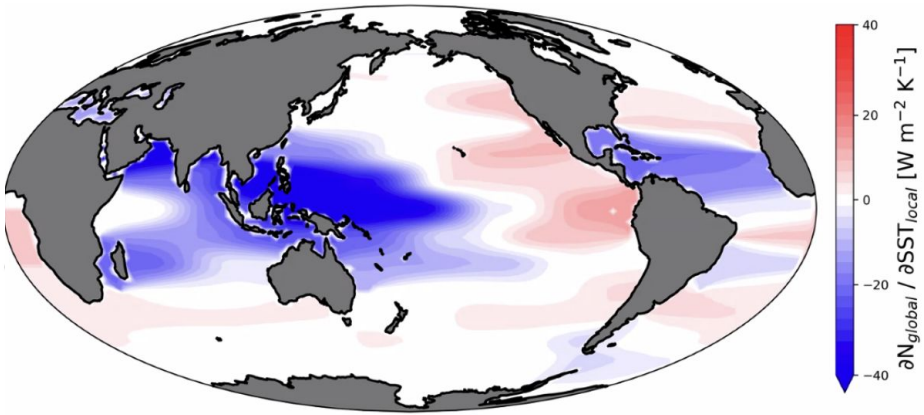
(Duo Chan et al., in prep.)

Biases in trends between 1910–1943 partly map onto radiative responses

SST trends (°C/34 years)

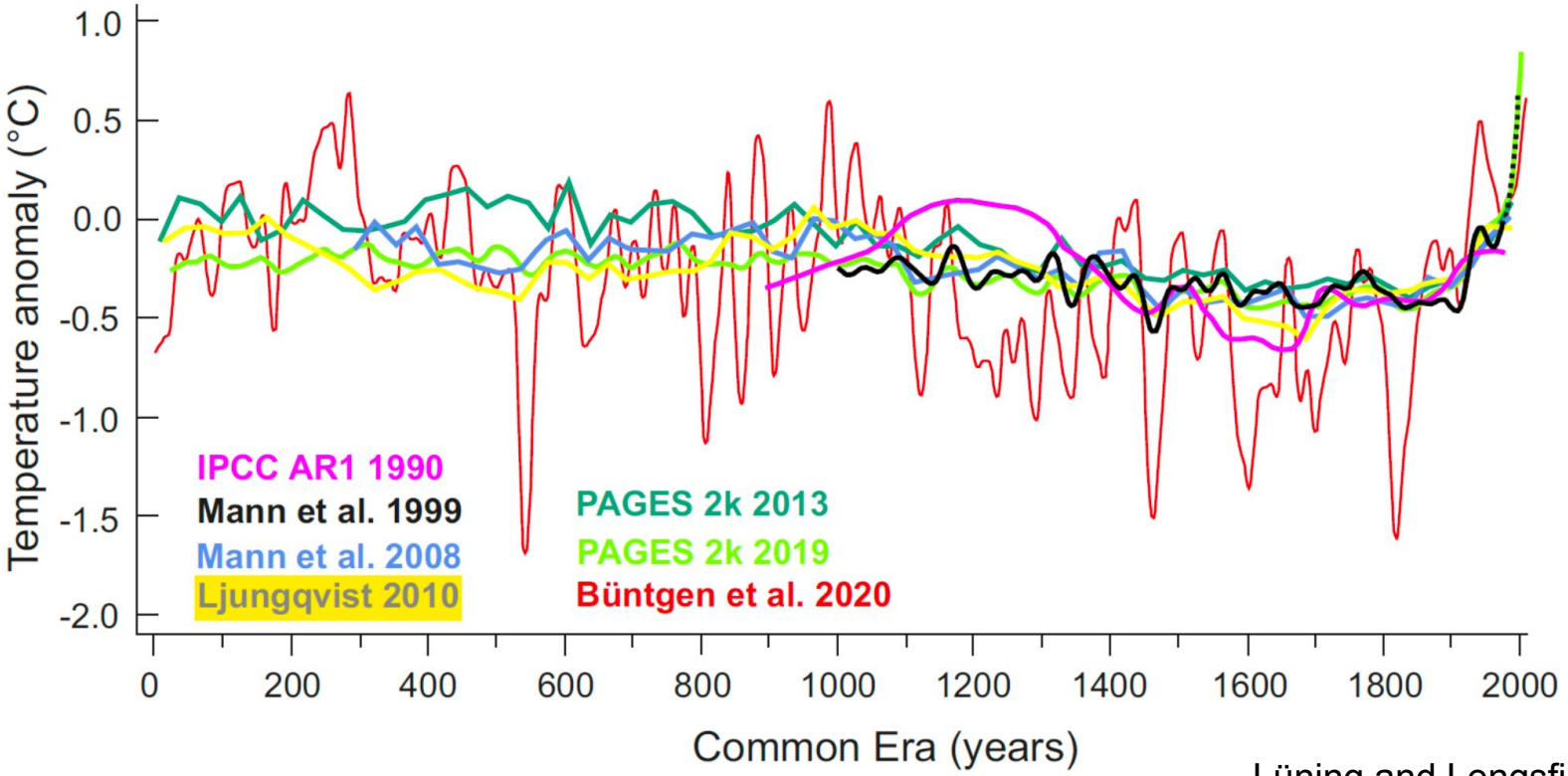


Global radiative response to local warming



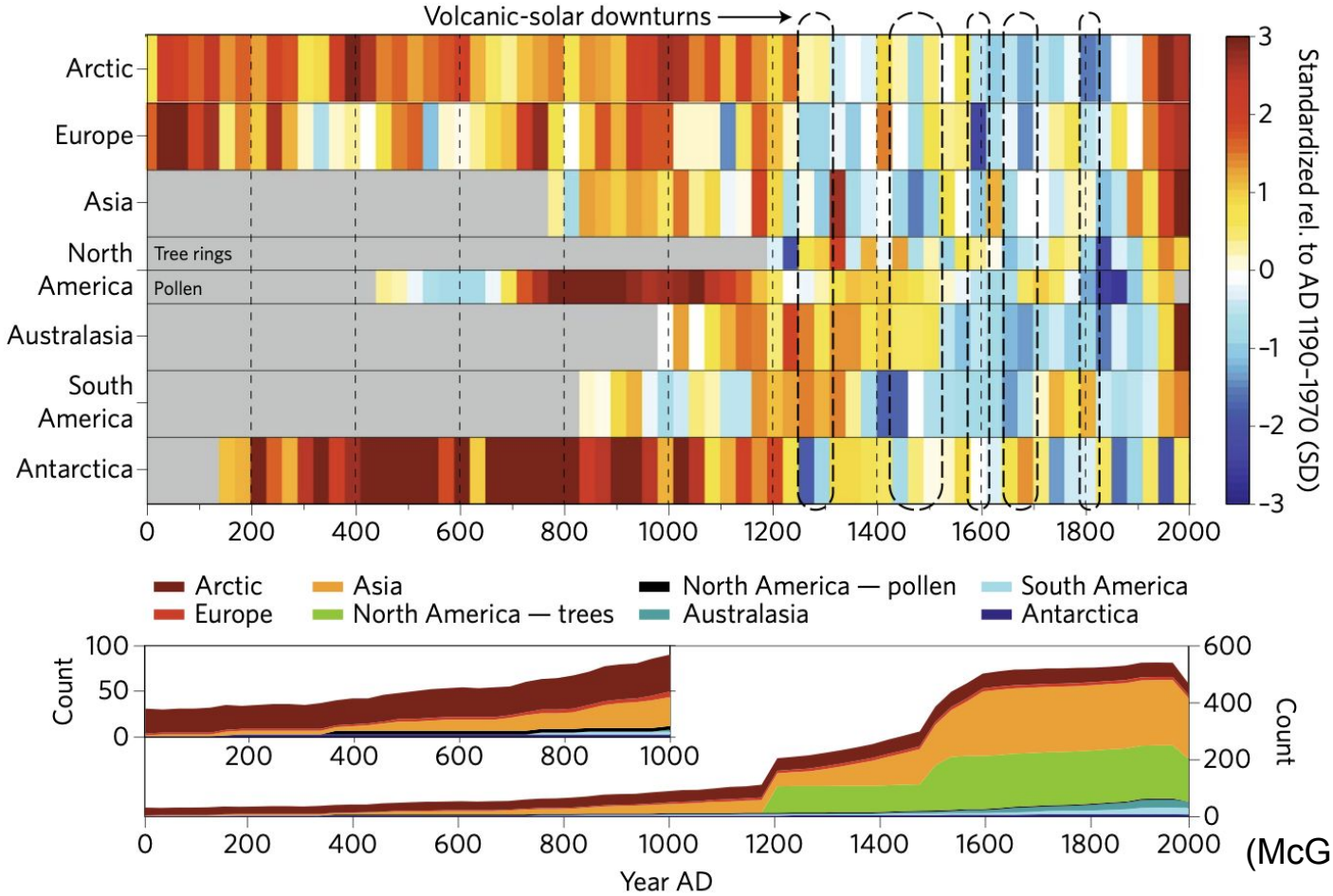
(Chan et al., 2019)

Disparate, albeit plausible, global temperature reconstructions over the Common Era



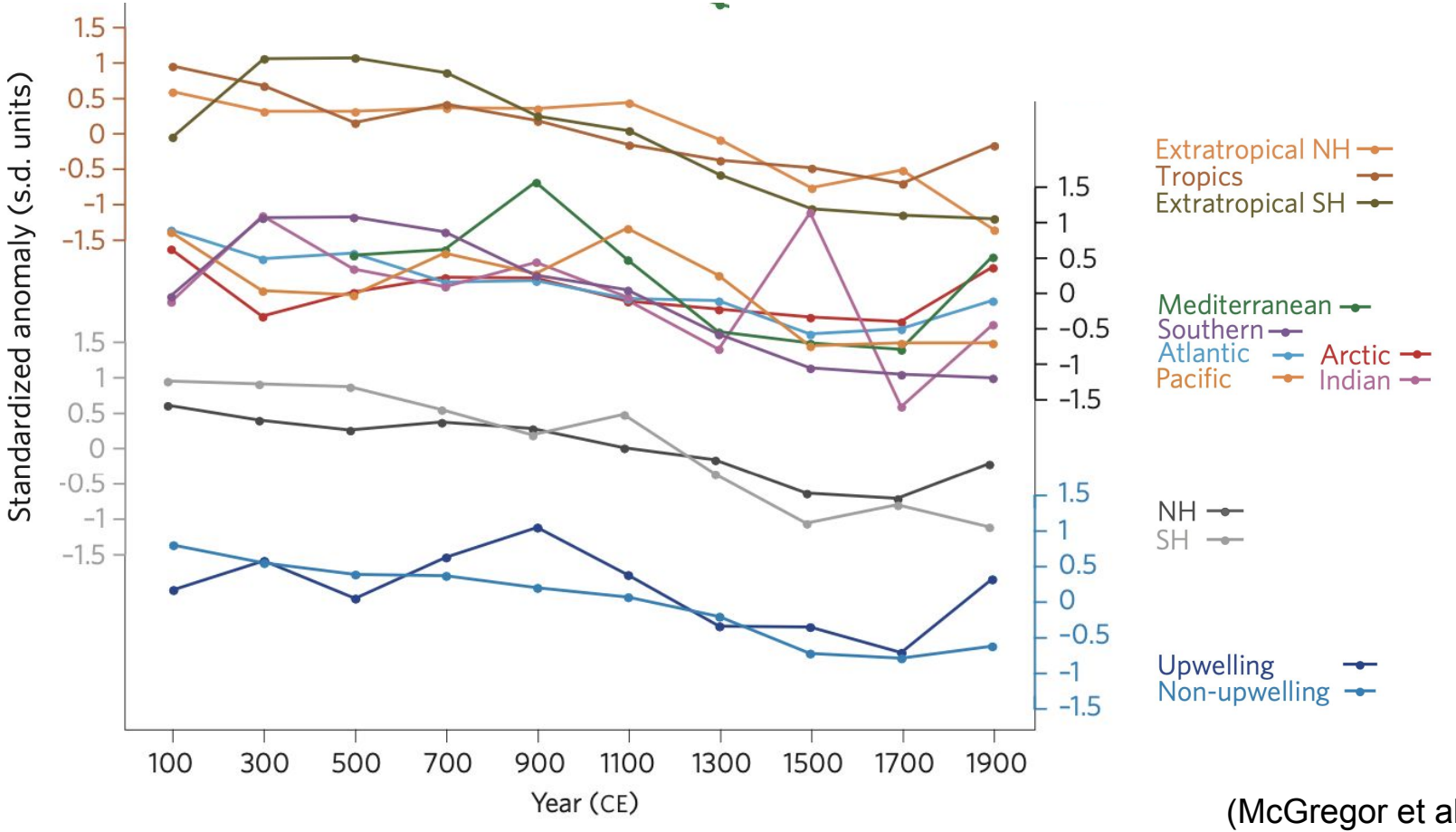
Lüning and Lengsfield (2022)

Evidence for a globally coherent Little Ice Age (PAGES2k, continental)



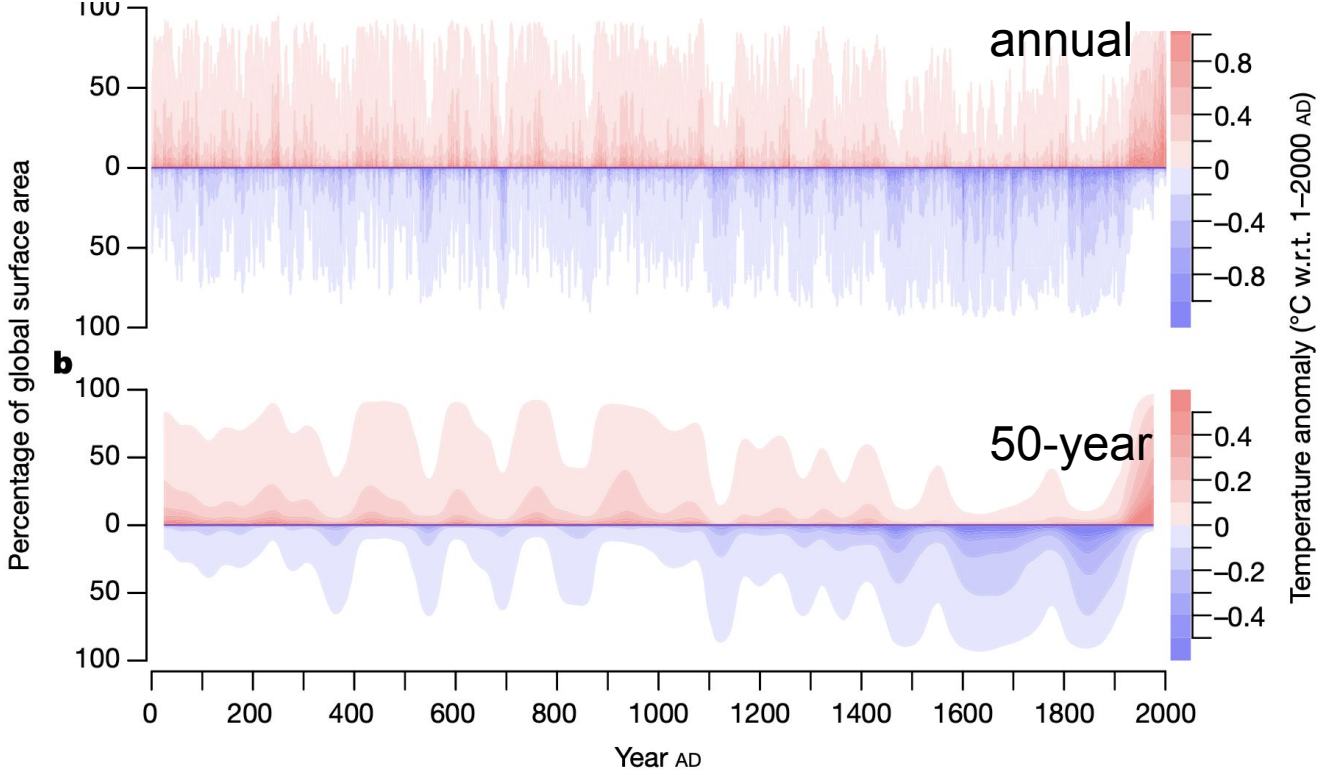
(McGregor et al, 2018)

Evidence for a globally coherent Little Ice Age (PAGES2k, oceans)



(McGregor et al., 2015)

No evidence for globally coherent warm and cold periods over the preindustrial Common Era (PAGES2K, ocean and land)



(Neukom et al., 2019b)

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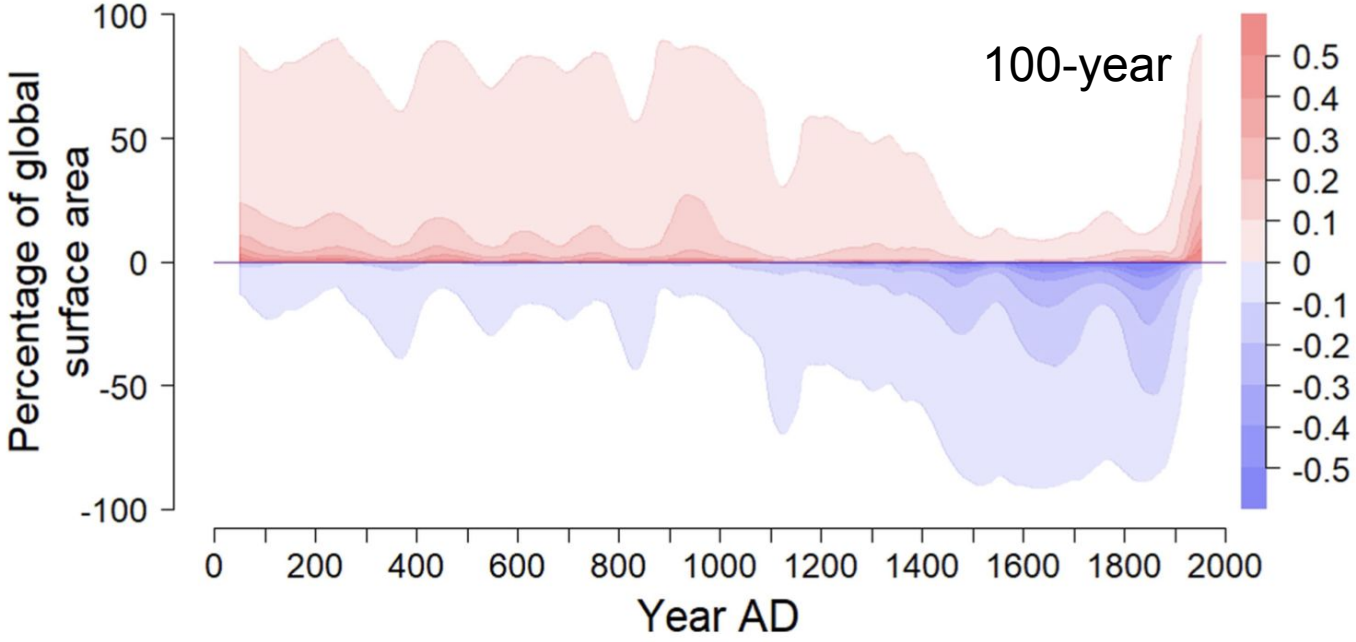
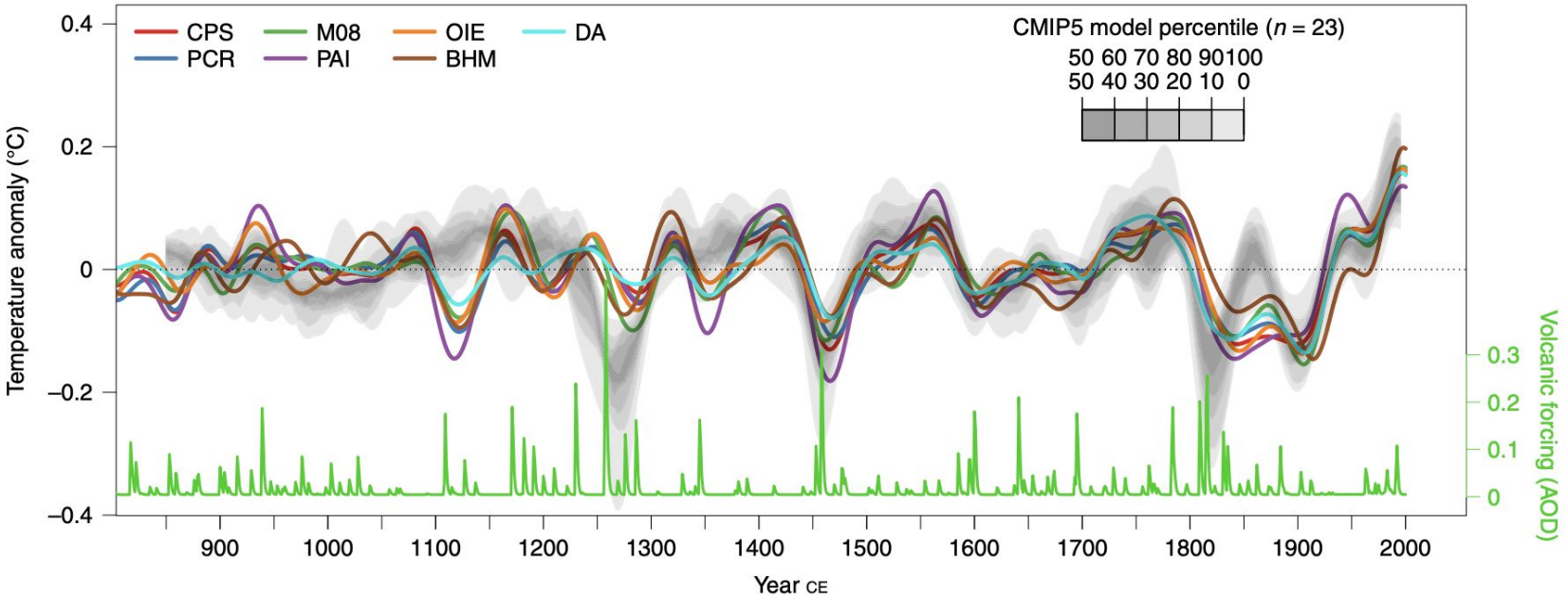


This results suggests that there is a frequency-wavelength relationship that defines anomalies during the Little Ice Age.

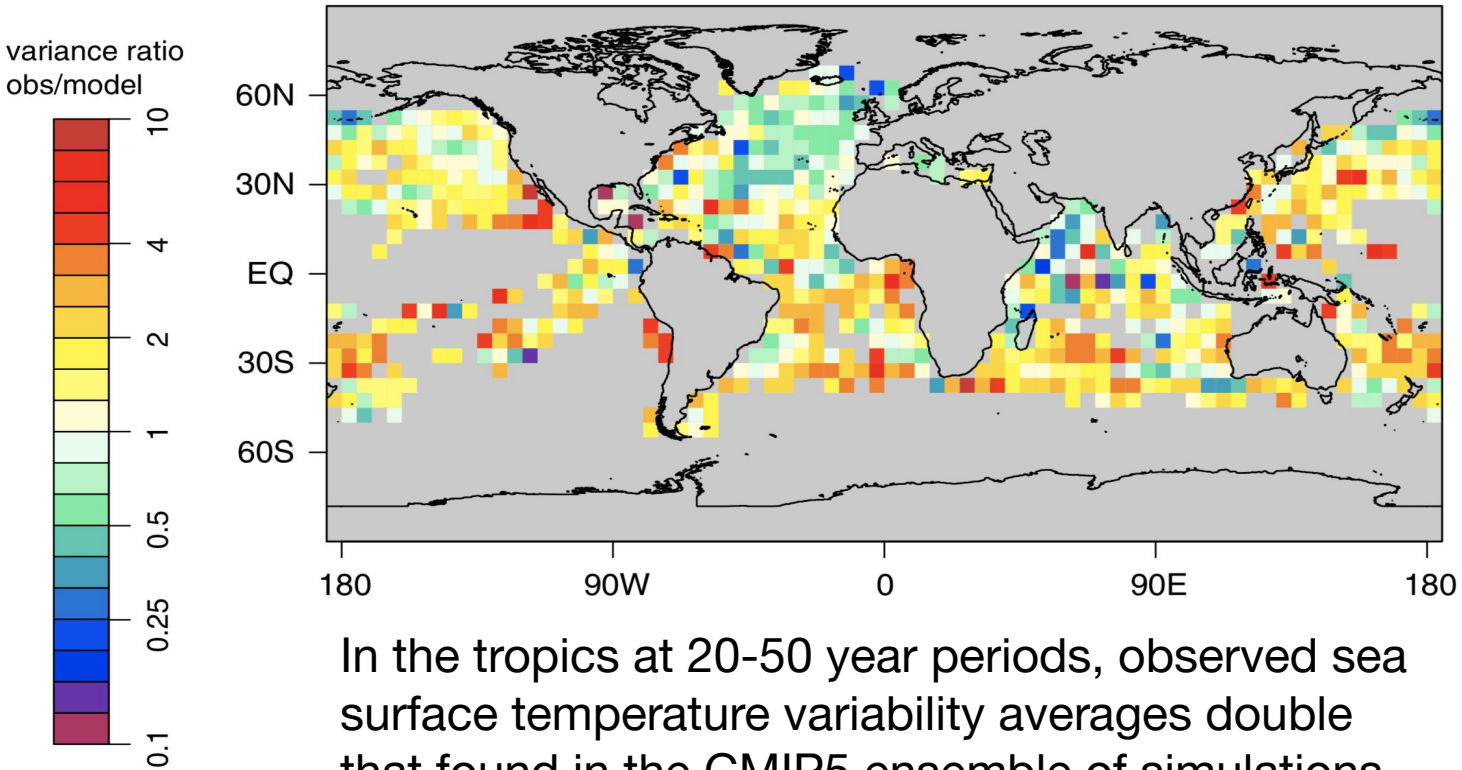
(Neukom et al., 2019b)

Only temperature reconstructions with low temperature variance are consistent with simulations, but note discrepancies at 1100 and 1250 CE



(Neukom et al., 2019)

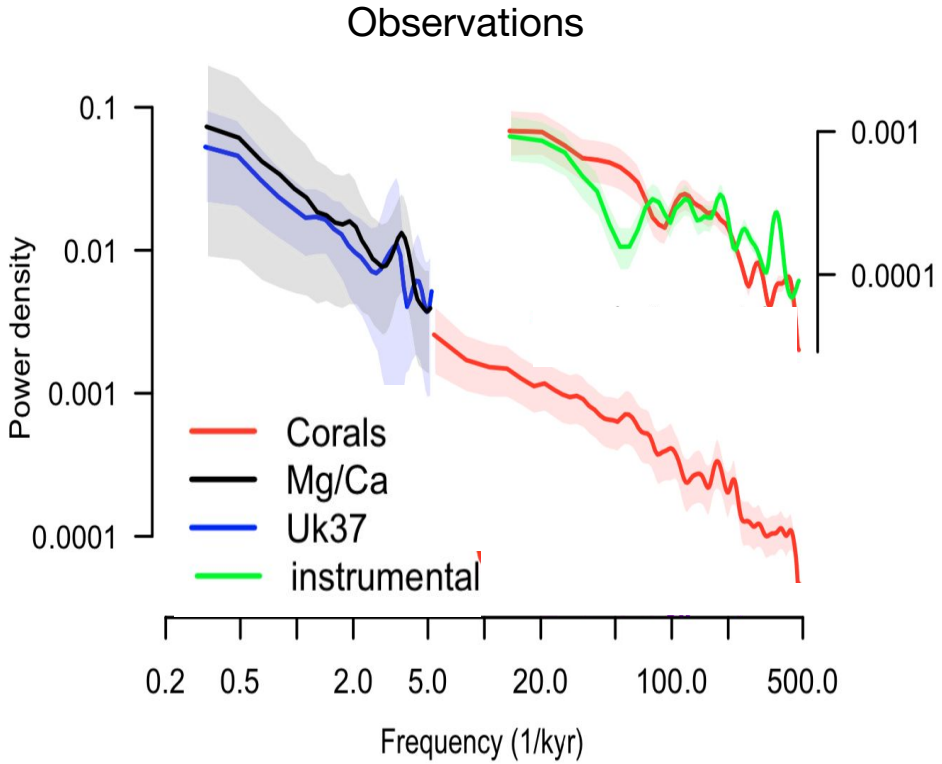
Evidence for models not producing sufficient SST variability at inter-decadal time scales.

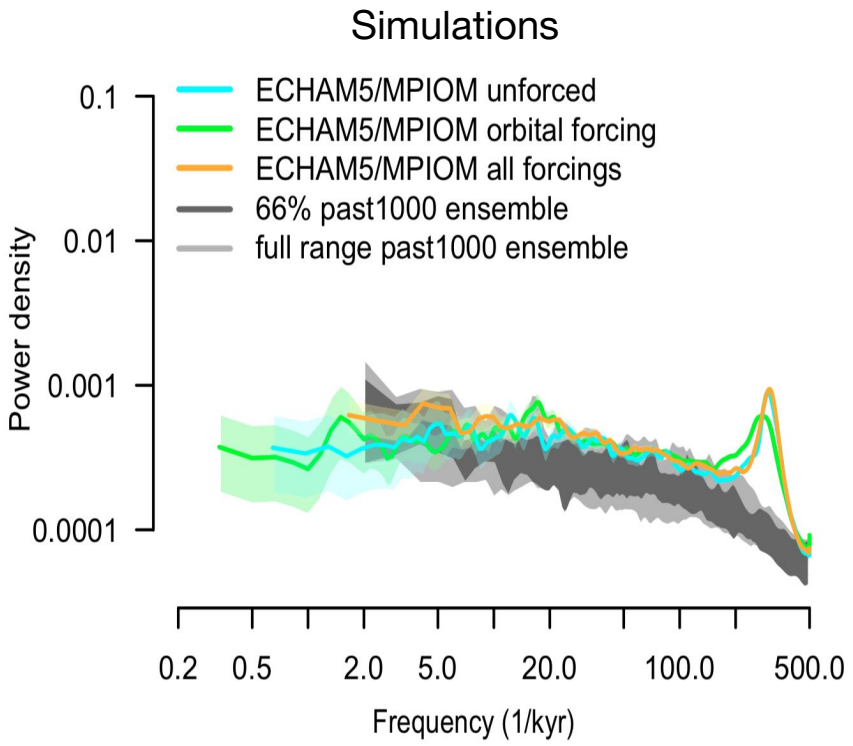


In the tropics at 20-50 year periods, observed sea surface temperature variability averages double that found in the CMIP5 ensemble of simulations.

(Laepple and Huybers, 2014)

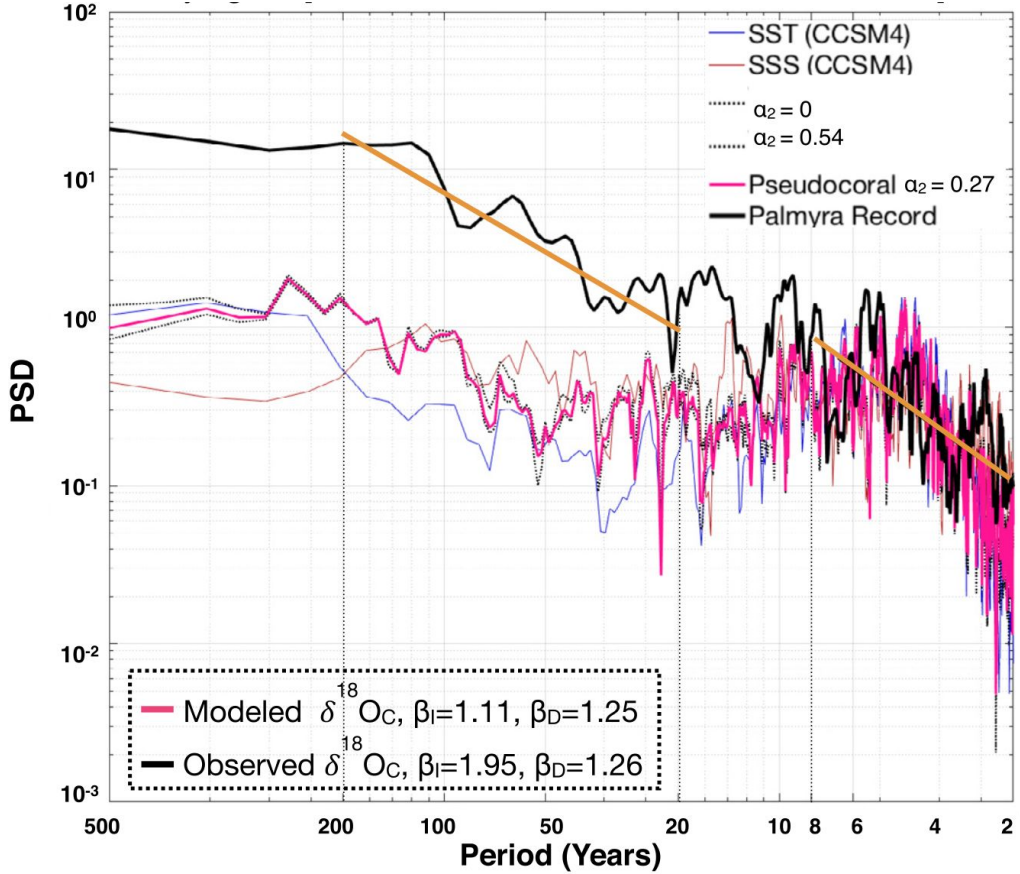
Evidence for models not producing sufficient SST variability at centennial and longer time scales.





(Laepple and Huybers, 2014)

Evidence for models not producing sufficient SST variability at centennial and longer time scales.



"We find that current proxy system models (PSMs) can help resolve model-data discrepancies on interannual to decadal timescales, but cannot account for the mismatch in variance on multi-decadal to centennial timescales."

(Dee et al., 2017)

Conclusions / further questions

1. Evidence suggests that errors in bucket bias corrections led to several effects:
   a. Land-ocean temperature decoupling prior to the 1940s,
   b. Too rapid early 20th Century SST warming,
   c. Discrepancies between coastal land and sea temperatures.
2. Simulations and reconstructions of global average temperature are consistent over the Common Era, if examining the recent reconstruction having the smallest amplitude.
3. The Little Ice Age is observed to be coherent at centennial time scales, implying that it also exists globally at shorter timescales.
4. Proxy SST indicators suggest that climate simulations produce insufficient regional SST variability.

Notes

1. Topic falls somewhere between that of Chris Karnauskas (SST Pattern Evolution in the Instrumental Record of the 20th Century) and Natalie Burls (Paleo Perspectives on the Pattern Effect on deep-time scales).

2. I'm unaware of papers using paleoclimate records to examine the pattern effect at decadal timescales, but there are some important overlaps and first order questions. Forced vs. Unforced — how do patterns arise and how come about. If you know the patterns, what implies about the energetics but the reverse. See paper by Rob Wills — high latitude modes versus tropical.

3. What doe the paleo-record actually say about interdecadal variability in terms of magnitude and frequency scaling, persistence (e.g., Laepple …);

4. If a proxy is something that is functionally related to the quantity of direct interest, i.e., x=f(p), then SST measurements prior to the 1960s are proxies by virtue of needing to be adjusted cooler for ERI and warmer for buckets. Moreover, these mean offsets are regionally and temporally variable, hence influencing patterns.
    a. Pattern offsets can be corrected (Chan et al. etc.)
    b. Mean offsets are harder but potentially also first order relative to land temperatures (Cowtan et al. etc.)

Notes

1. Ultimately the coupled evolution of the climate system needs to be understood. Just as there is a radiative response to SST patterns, there are also wind and buoyancy responses to SST patterns that will influence the evolution of subsequent SST patterns.

2. Is the radiative-SST evolution deterministic?

3. One reason to study the radiative response to SST patterns, in particular, is that we have relatively longer records of SSTs than radiative response. Given historical SSTs, is it possible to infer the radiative response and better constrain historical and future values of lambda?