

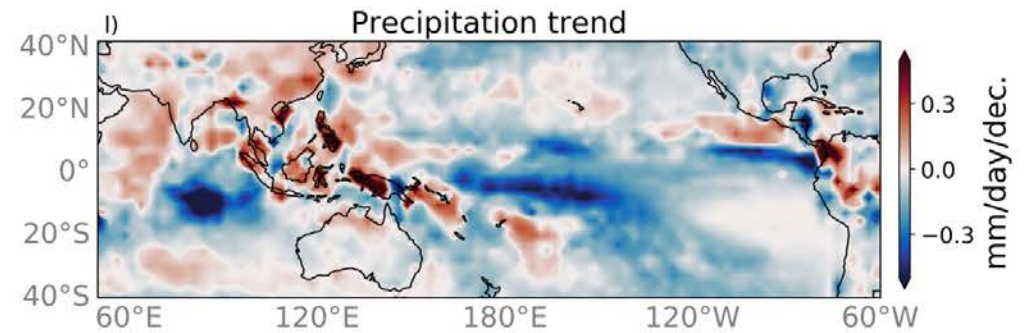
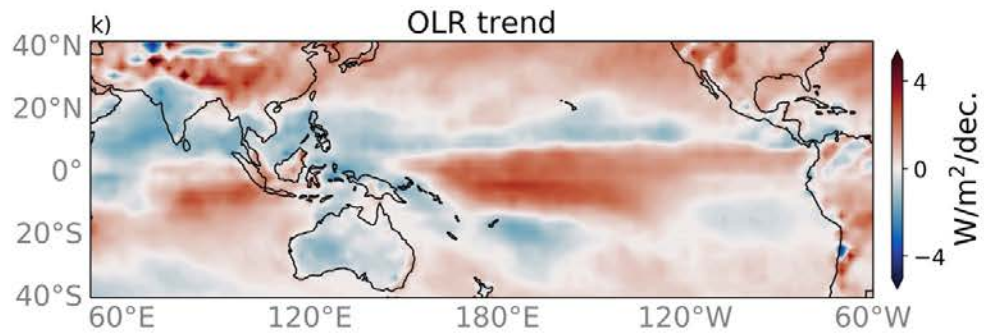
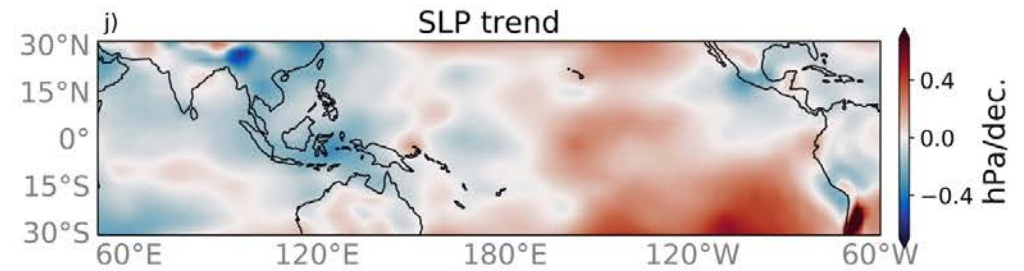
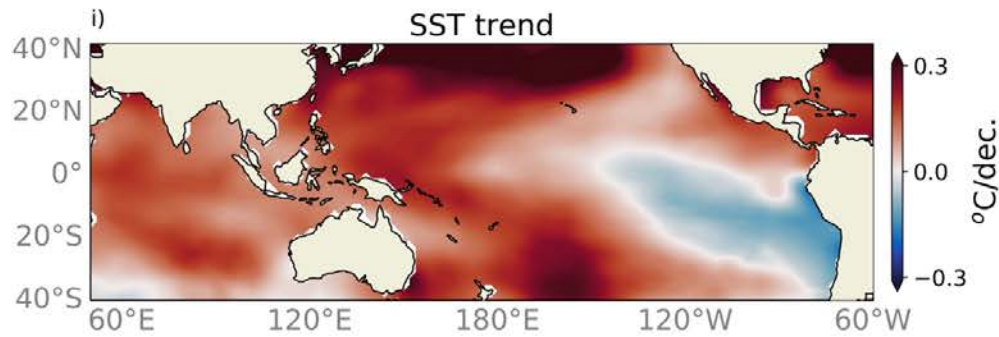
Separating the forced response in the tropical Pacific from natural variability

Ulla K. Heede, Ph.D.

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Collaborators: Alexey Fedorov, Kris Karnauskas, Nathan Lenssen, Clara Deser

The observed Walker cell strengthening



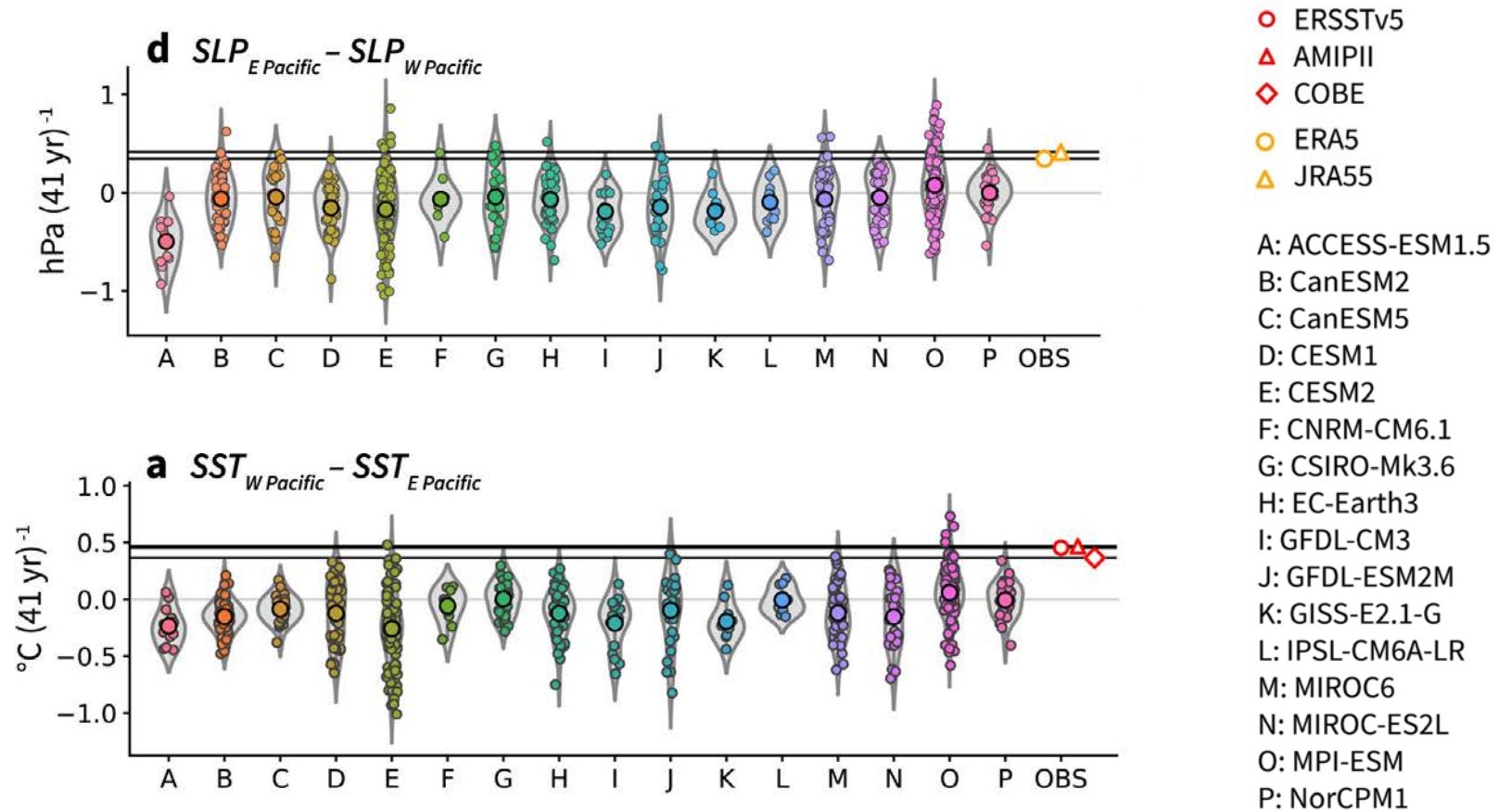
Drivers of Walker cell strengthening

- Pacific Decadal Oscillation/Interdecadal Oscillation (Watanabe et al., 2021, Wu et al. 2021)
- The ocean thermostat (Clement et al., 1996, Sun and Liu, 1997, Heede et al., 2020; 2021, Seager et al., 1997, 2019)
- Southern Ocean teleconnections (Dong et al., 2022, Hartman et al., 2022)
- Aerosols (Dong et al., 2014, Heede et al., 2021, Dittus et al., 2021)

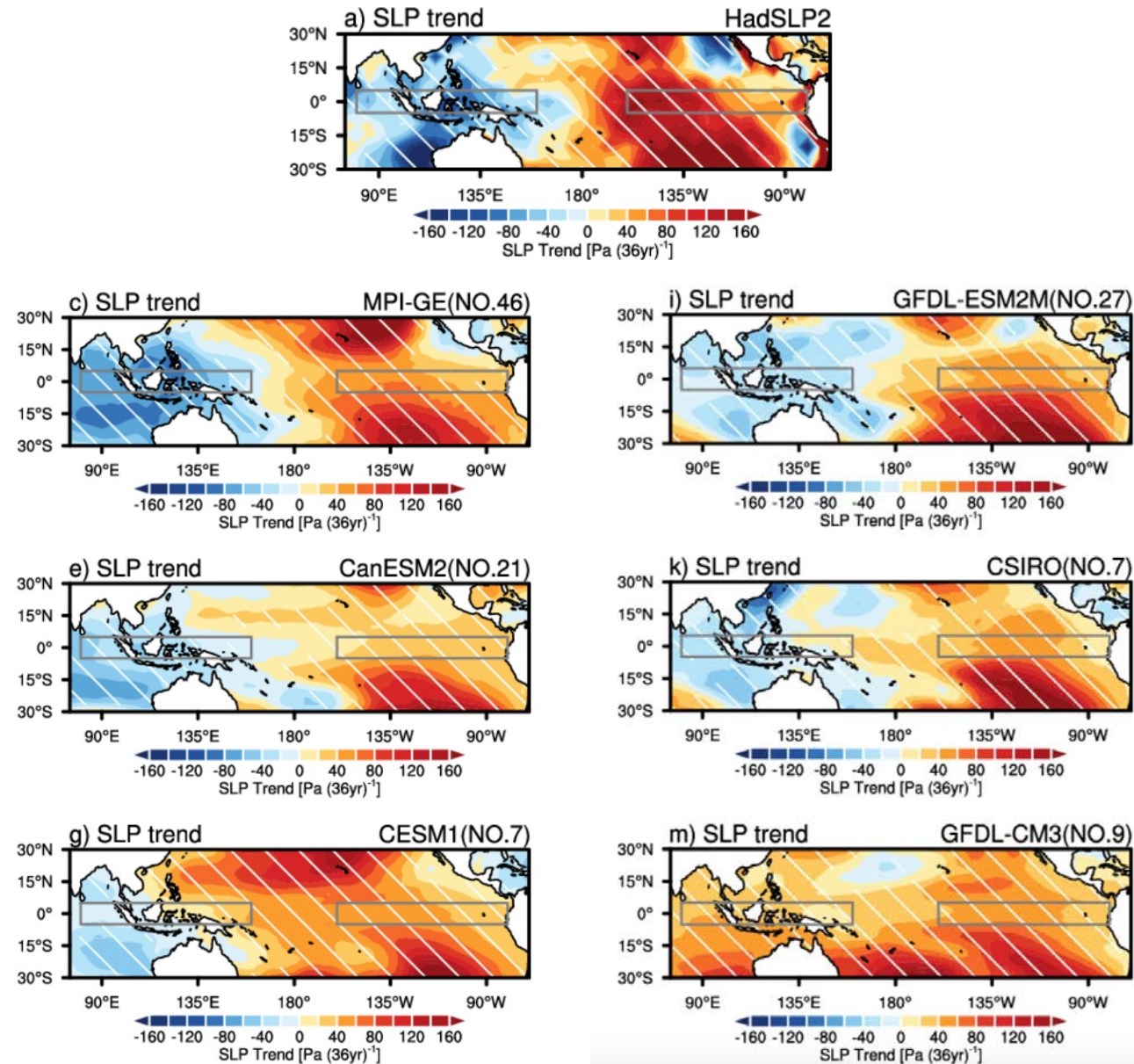
Is it natural variability?

A key question is: Does the observed trend falls within decadal variability in global climate models?

Example 1: “Systematic bias in climate models”

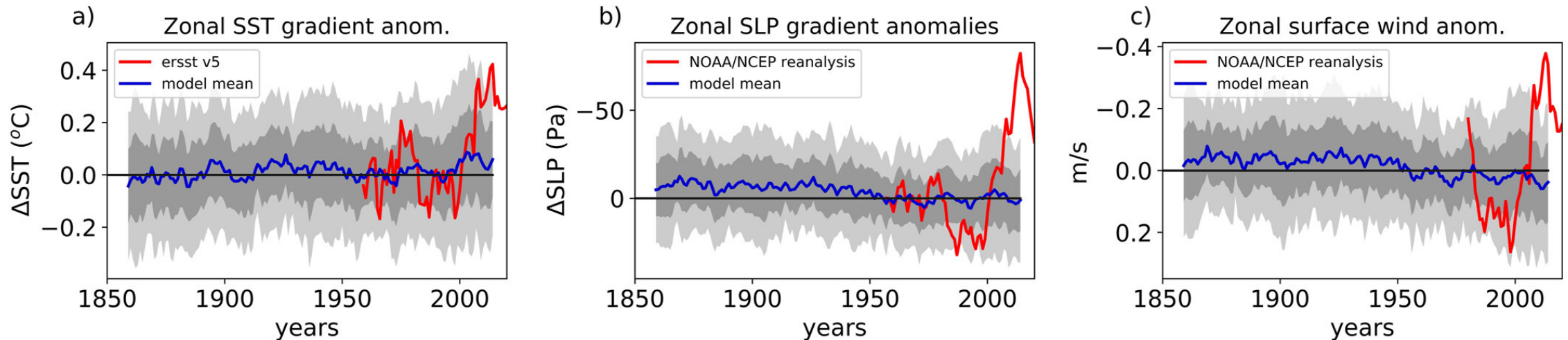


Example 2: “MPI LENS captures observed trend”



Metric and variable sensitivity

- We found that choice of metrics and variables matters for how to consider the observed trend with regards to CMIP6 models:



Is it natural variability?

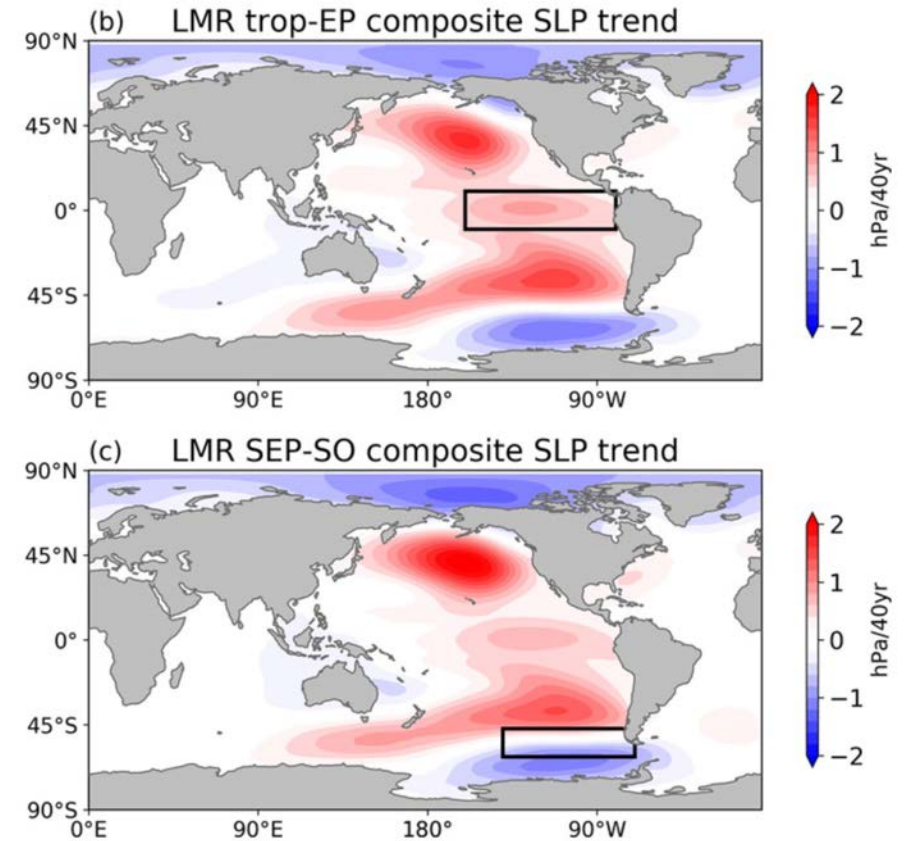
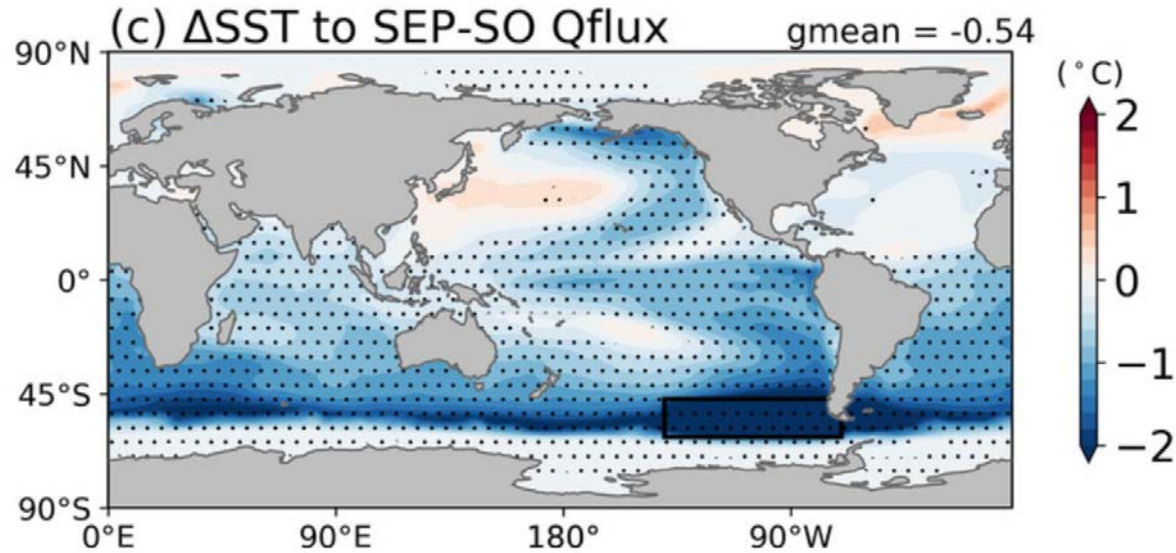
The jury is still out, but the observed trend can be considered an outlier

Next questions:

1. The real world has stronger decadal variability than climate models?
2. A forced response that isn't captured by climate models?

Is it a forced response? (1/3)

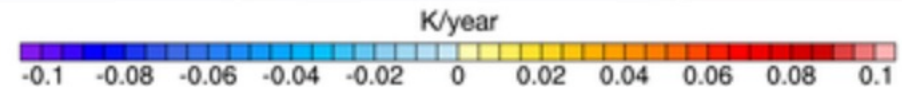
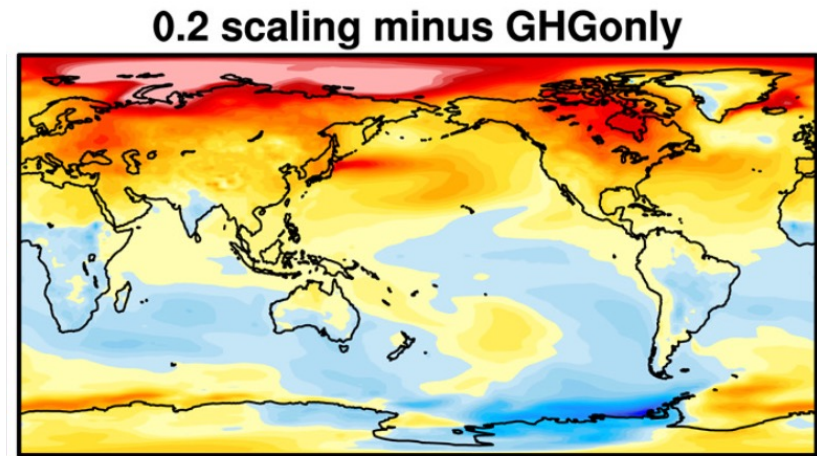
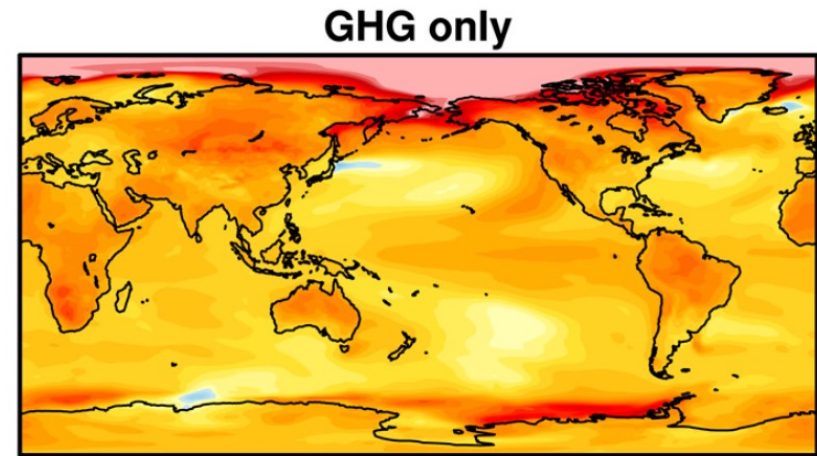
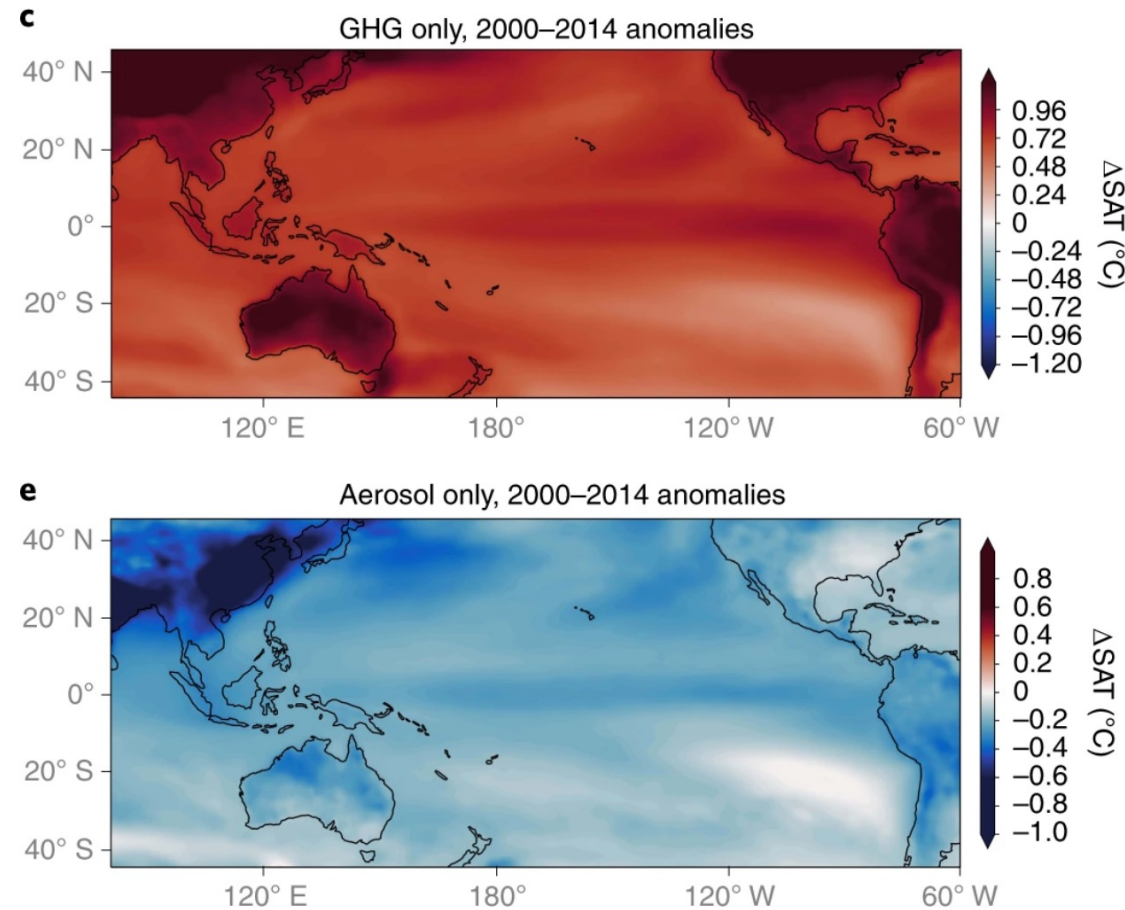
Hypothesis: Inaccurate winds over the southern ocean and/or lack Antarctica-SO interaction in CMIP models could explain tropical Pacific response due to teleconnection.



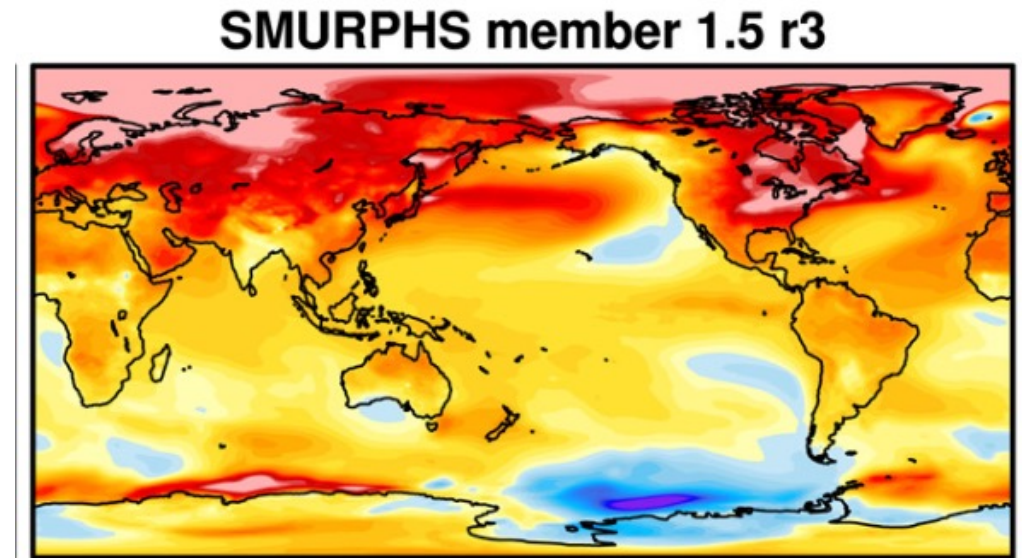
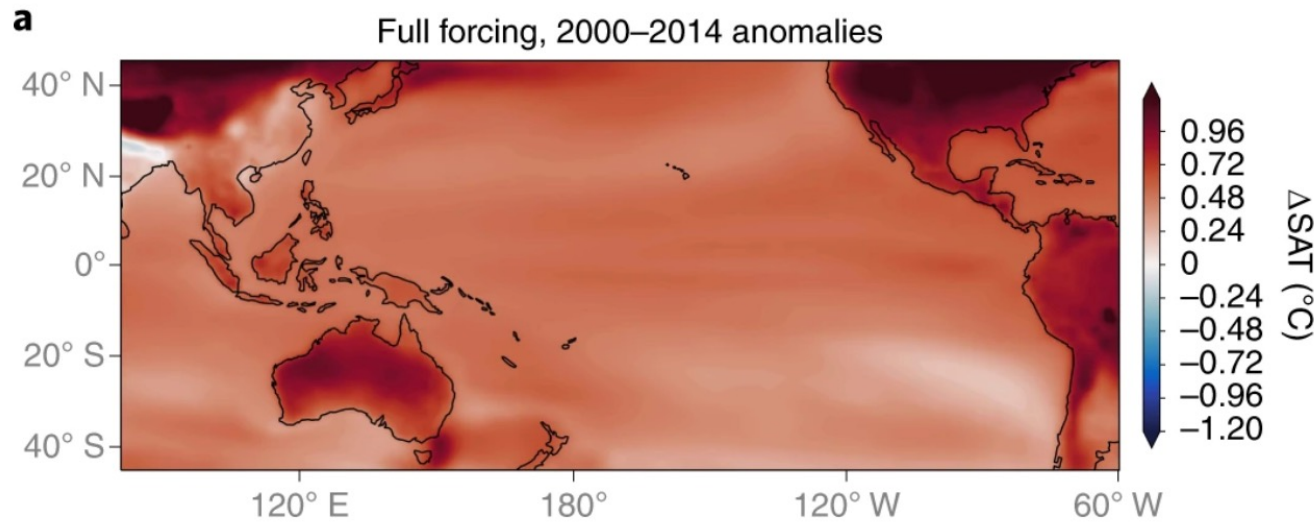
Two-way teleconnection makes cause-effect difficult

Is it a forced response? (2/3)

Hypothesis: Aerosols (inaccurately represented in CMIP models) may have counter-acted the GHG warming pattern in the historical record

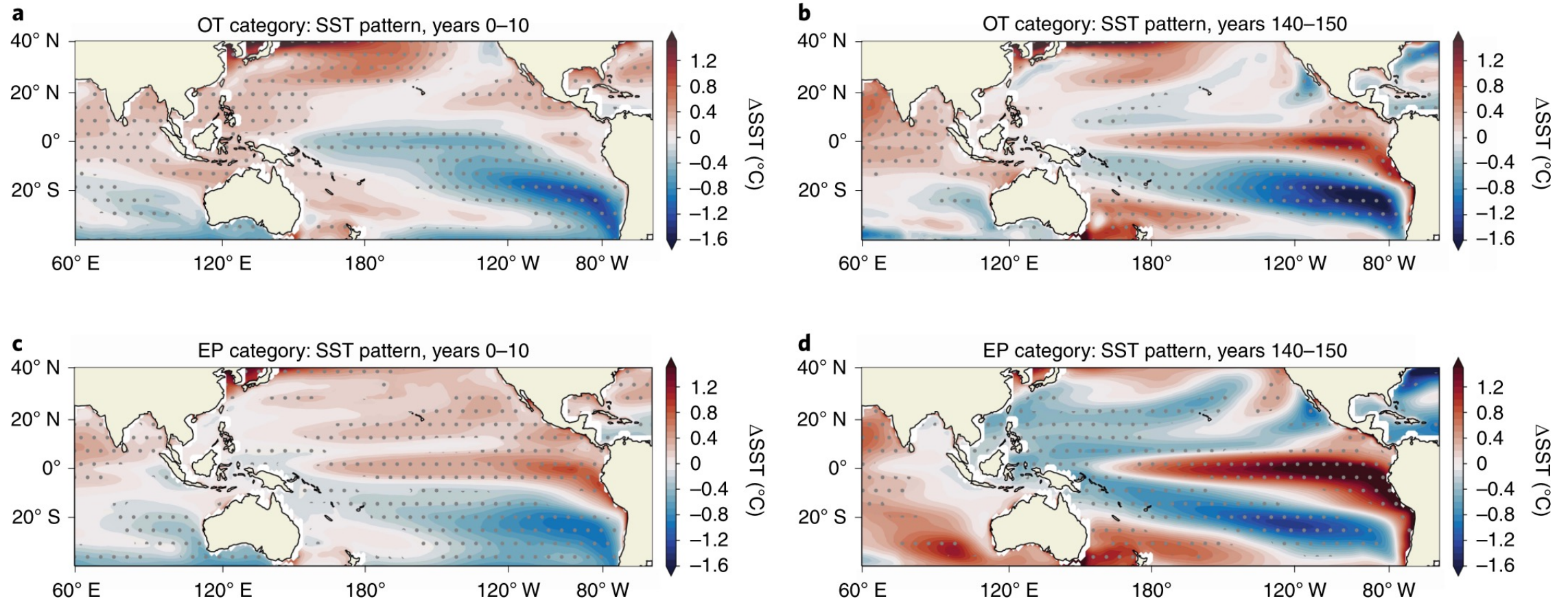


GHGs overwhelm aerosol effect in historical simulations



Is it a forced response? (3/3)

Hypothesis: Pacific response may be a transient response to GHG-emissions, which is too weak in CMIP models



Is it a forced response? (3/3)

Hypothesis: Pacific response may be a transient response to GHG-emissions, which is too weak in CMIP models

An idea: let's remove the SST pattern associated with the PDO using regression of the observed SST trend onto the PDO pattern

Decomposition of the observed SST pattern into

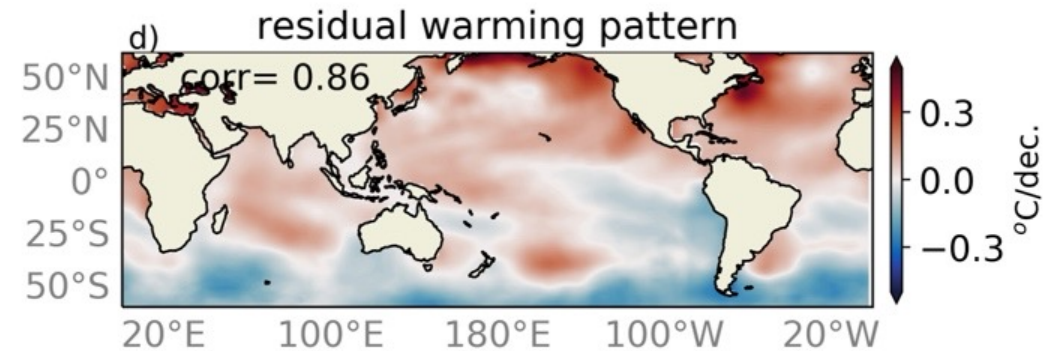
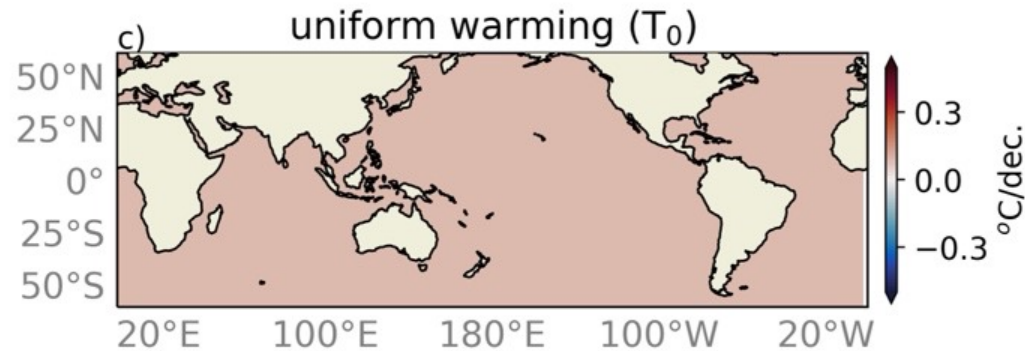
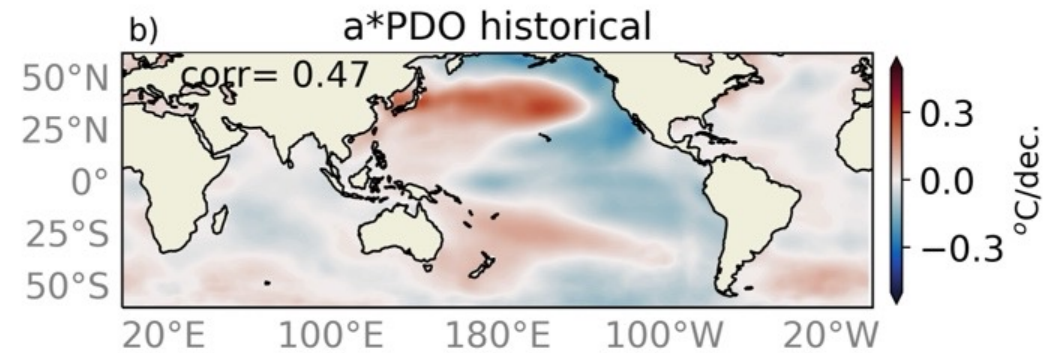
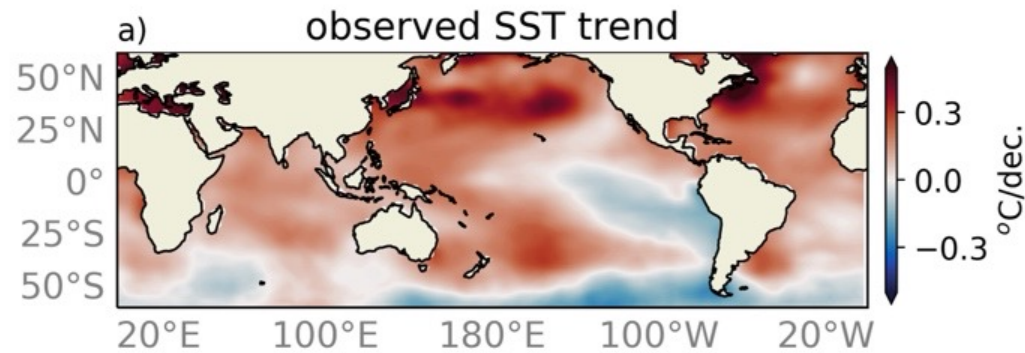
- the PDO pattern
- a uniform warming pattern
- a residual pattern

What are the characteristics of the residual pattern?

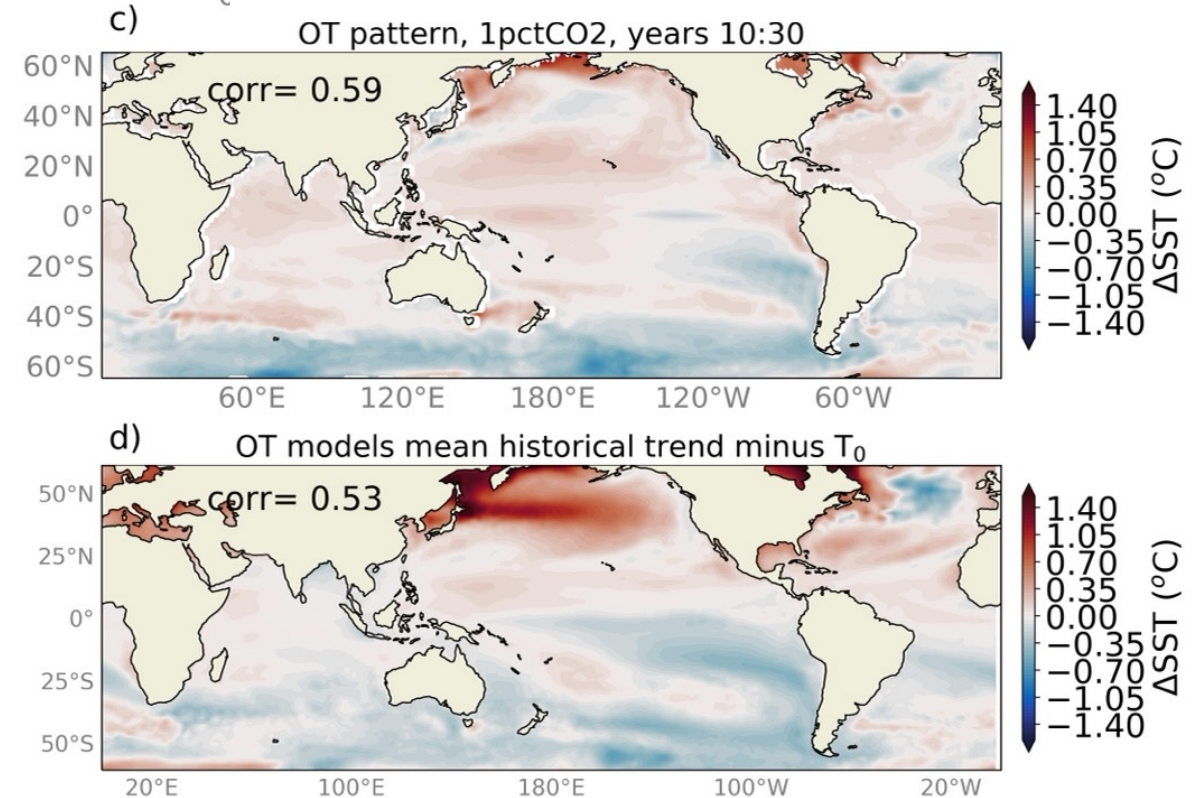
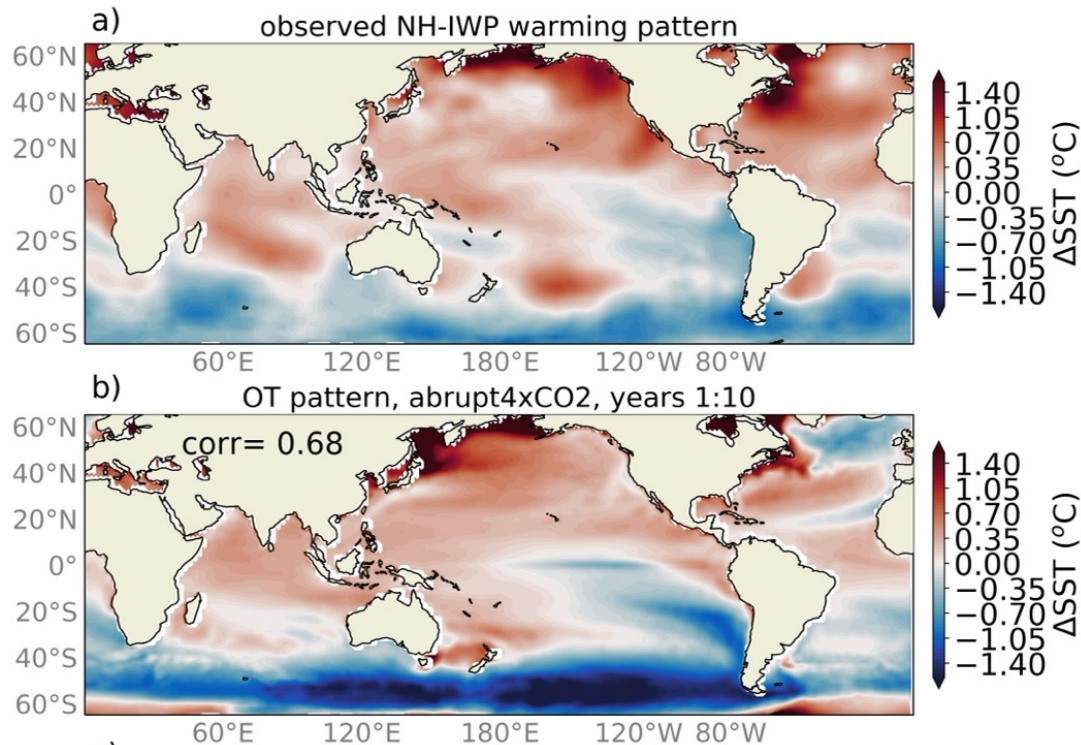
$$Trends_{lat,lon} = T_0 + a \cdot PDO_{lat,lon} + residual_{lat,lon}$$

Separating the forced response from the PDO

$$Trends_{lat,lon} = T_0 + a \cdot PDO_{lat,lon} + residual_{lat,lon}$$



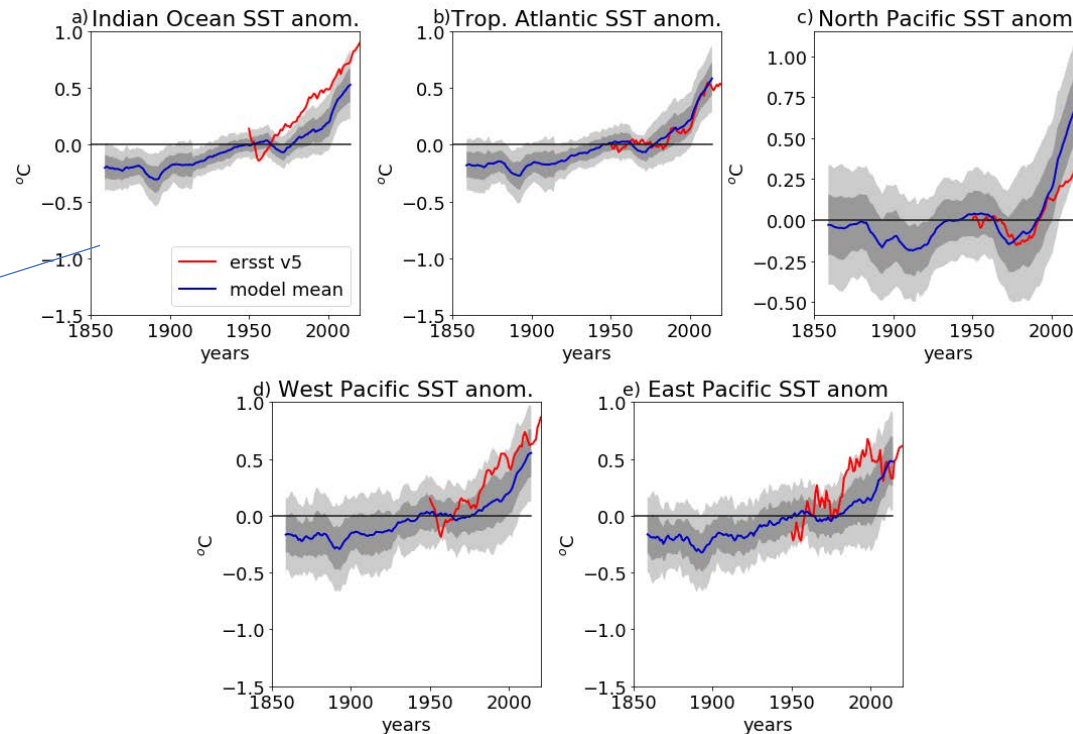
Similarities between the transient ocean thermostat pattern and the residual pattern



Is it a GHG transient response?

Observed SST trend looks remarkably similar to the transient ocean-thermostat like response in some climate models.

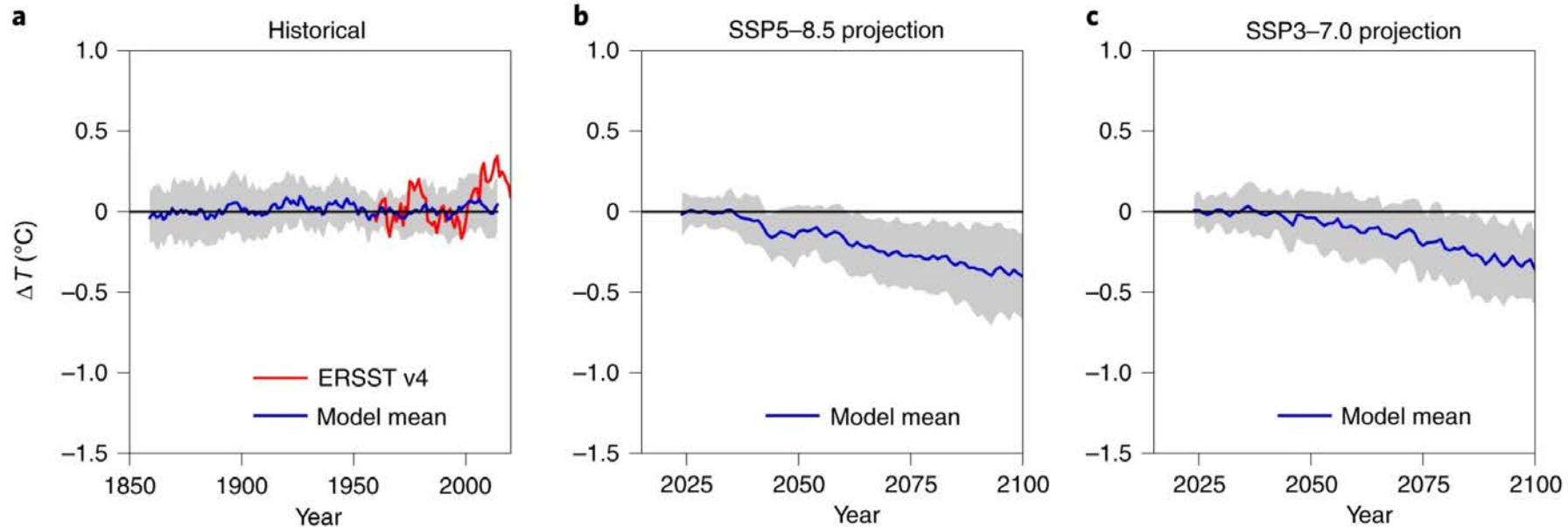
This leaves the question: Why isn't this pattern captured with realistic forcing?



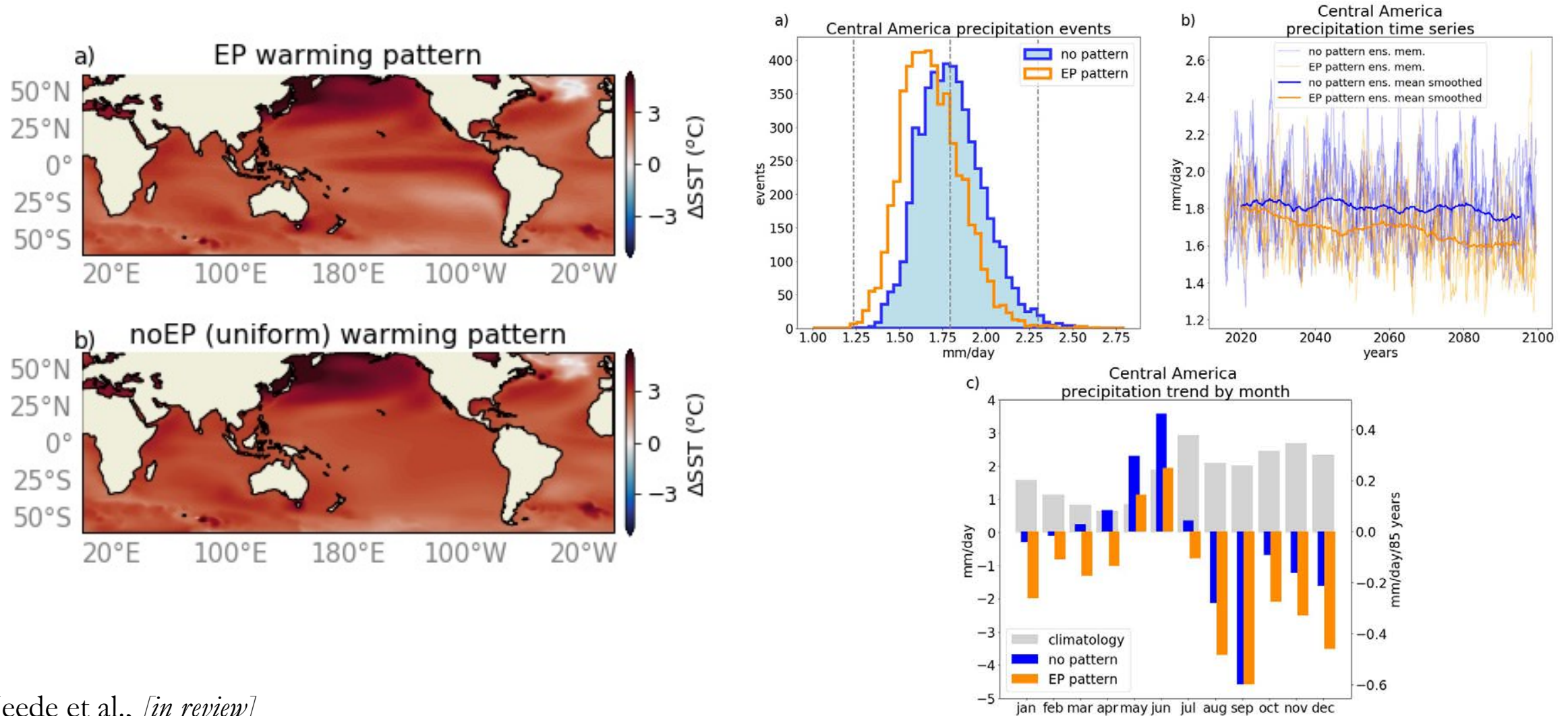
Indian ocean
warming
underestimated

The future projections for the tropical Pacific

According to models we should soon be able to see a weakened SST gradient in the tropical Pacific



The future of the tropical Pacific matters



Conclusions

- Observed trends in the tropical Pacific in the satellite era may be considered an outlier in the realm of large ensemble historical simulations
- Several mechanisms have been proposed to explain possible forced components of this trend
- With the PDO signal ‘subtracted’, the forced response resembles a transient Ocean-Thermostat type response to GHG-forcing
- The model-observation discrepancy introduces uncertainty in the future of the tropical Pacific, which matters for climate impacts