

Accounting for Pacific climate variability increases projected global warming

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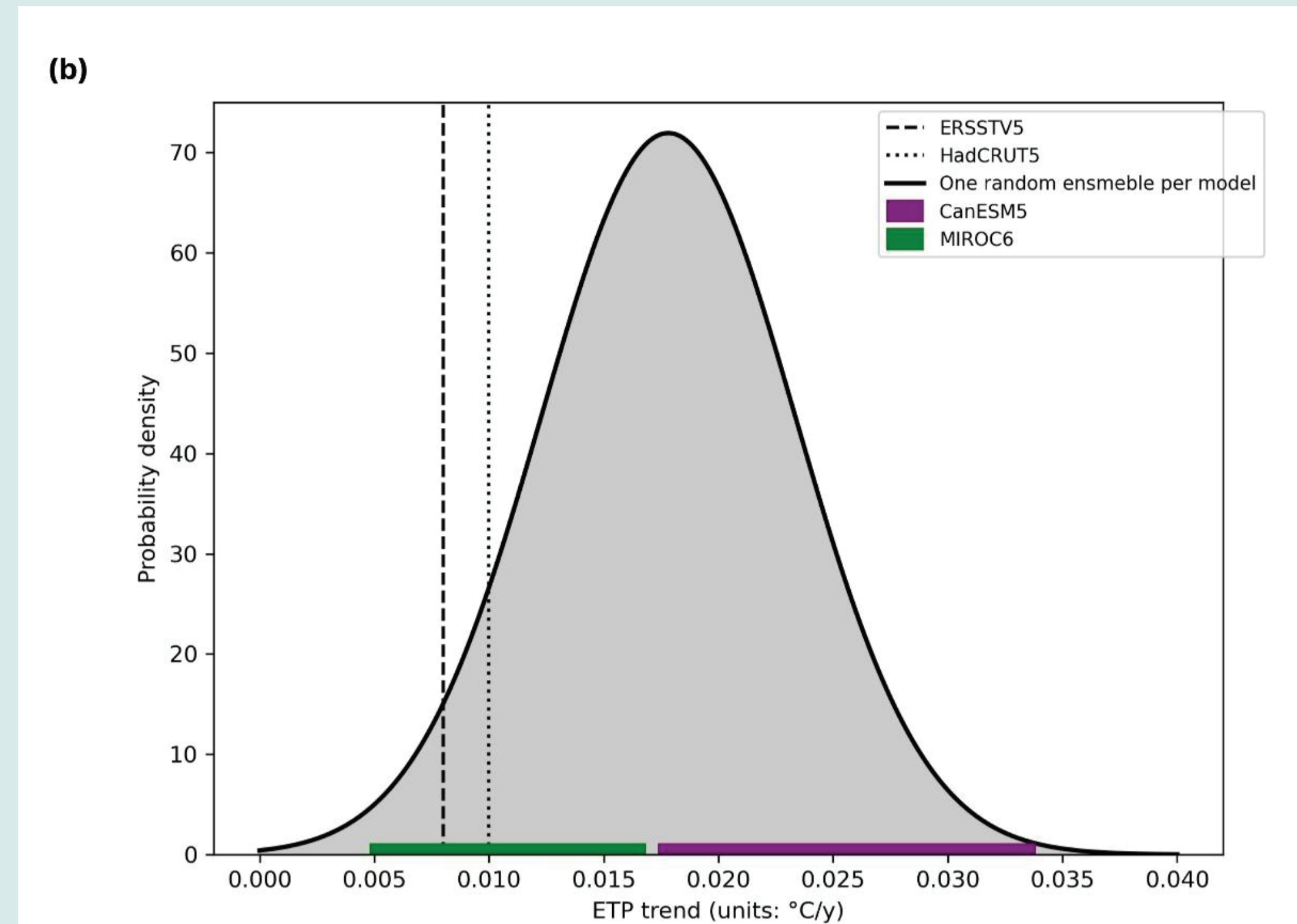
Motivation

There is a strong impact of pattern effect in the eastern tropical Pacific (ETP) on the global mean surface air temperature (GSAT) trend (Andrews et al. 2018; Dong et al. 2020; Gregory et al. 2020; Zhou et al. 2016, 2021; Forster et al. 2021)

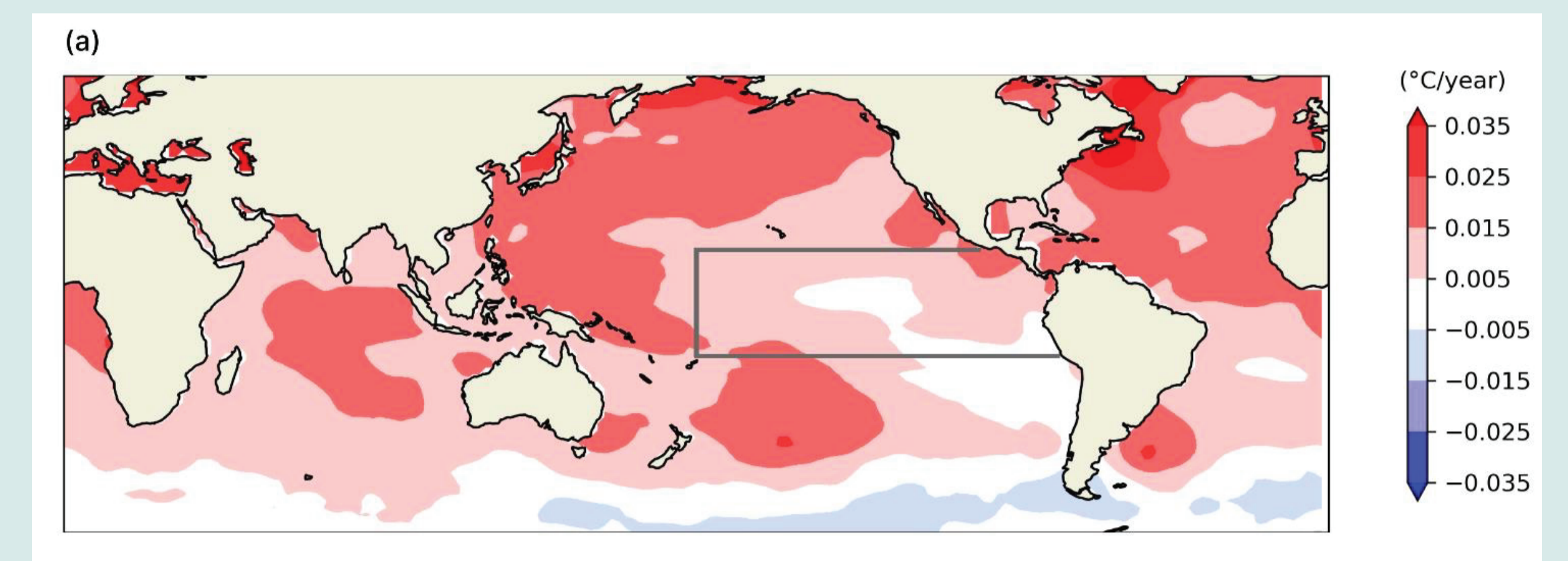
The observed and simulated pattern effect can be understood as internal variability which means recent observed trends in Eastern tropical Pacific SST are not expected to continue in the future (Forster et al. 2021; Watanabe et al. 2021)

Can we narrow the uncertainty in projected warming by constraining based on the observed GSAT trend with the pattern effect removed?

A broad range of simulated trend of SST patterns over tropical Pacific



- CMIP6 models show a broad range of SST trend over ETP ocean
- Most models' realizations cannot reproduce the observed pattern
- The SST pattern over the tropical Pacific ocean as the so-called pattern effect can exert a strong impact on GSAT change (Forster et al. 2021; Dong et al. 2020; Zhou et al. 2021)



Observed SST pattern in 1970-2022

Data

Model in use:
28 CMIP6 models

Projected variable: GSAT changes
Calculated as changes of 2081-2100
(SSP5-8.5) relative to 1995-2014

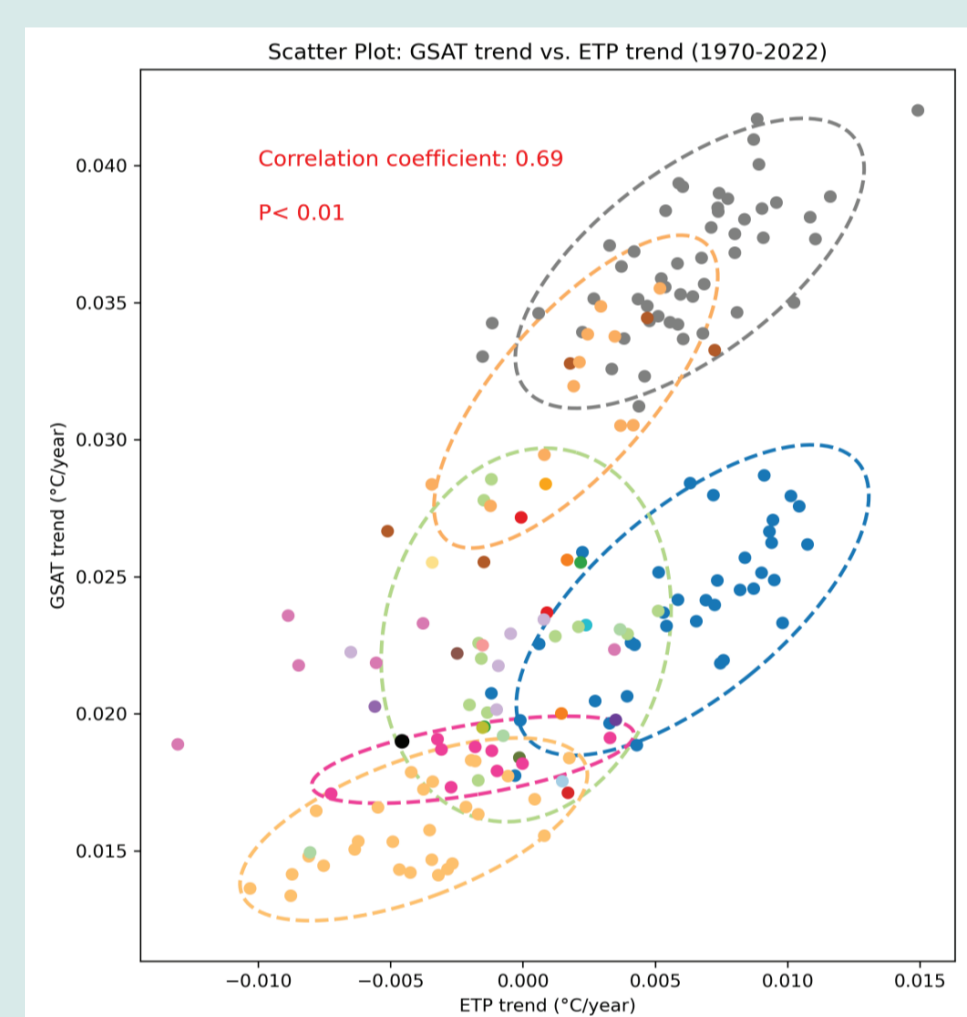
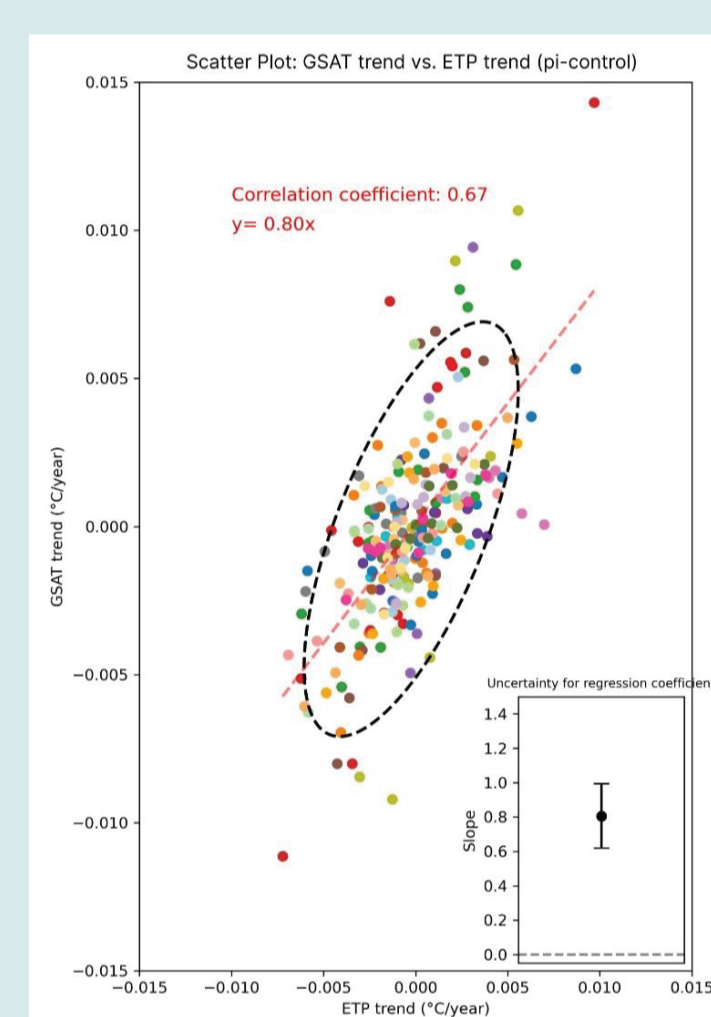
Constraint:
GSAT trend in 1970-2022
without ETP congruent variability

Observation:
HadCRUT5, Berkeley Earth, NOAA-
GlobalTempv5 and ERSST v5

Region

Following Kosaka and Xie (2013), the ETP is defined as the region in the Pacific east of the dateline and between 20° S and 20° N.

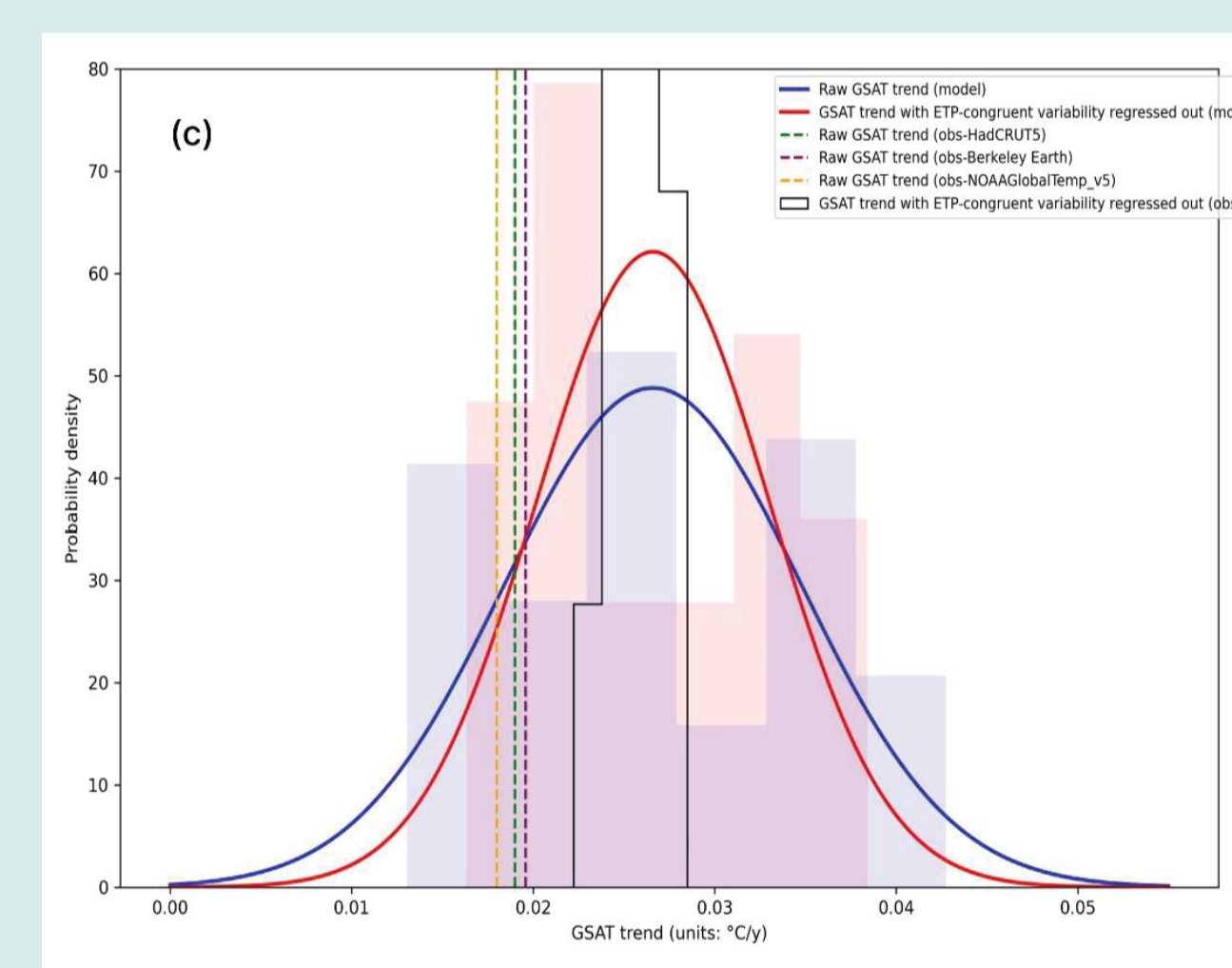
GSAT trend with the impact of unforced ETP congruent variability



Relationship between GSAT trend and ETP trend across all realizations

CMIP6 archive shows a tight correlation between GSAT trend and ETP trend. The variability of the GSAT trend is well correlated with the variability of the ETP trend [$r=0.67$, $p < 0.001$ in the preindustrial control; $r=0.66$, $p < 0.001$ over the 1850-1902 period; and $r=0.69$, $p < 0.001$ over the 1970-2022 period]

The contribution of unforced ETP internal variability to the GSAT trend can be removed by regression

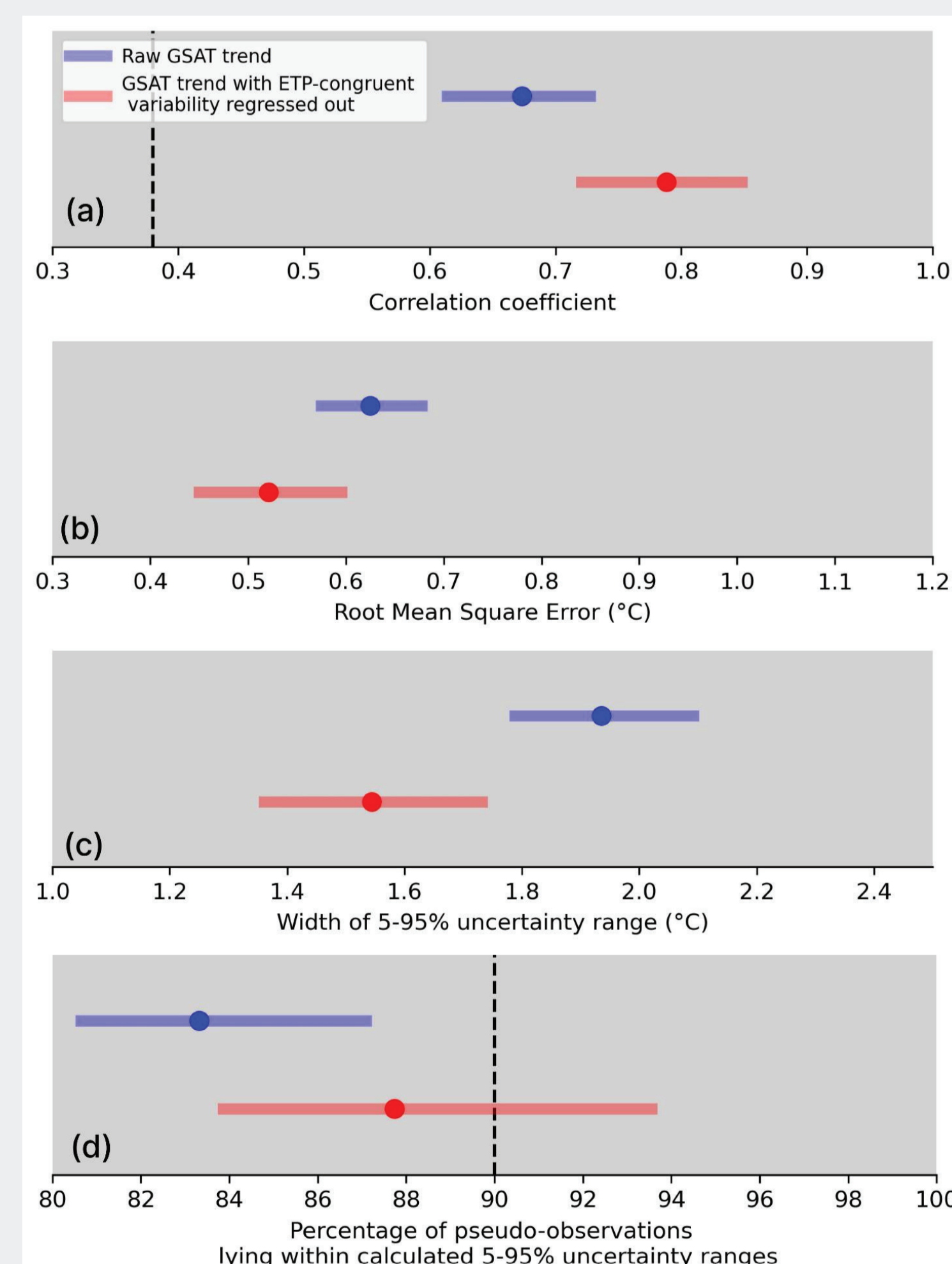


PDF of GSAT trend without ETP congruent variability

The observed GSAT trend with unforced ETP congruent variability removed approaches the median of the model simulations

The observed GSAT trend increases with removal of the cooling influence from the ETP SST pattern. The variance of the simulated GSAT trend is slightly reduced after removing unforced ETP internal variability.

Performance of GAT trend as a constraint



Imperfect model test results

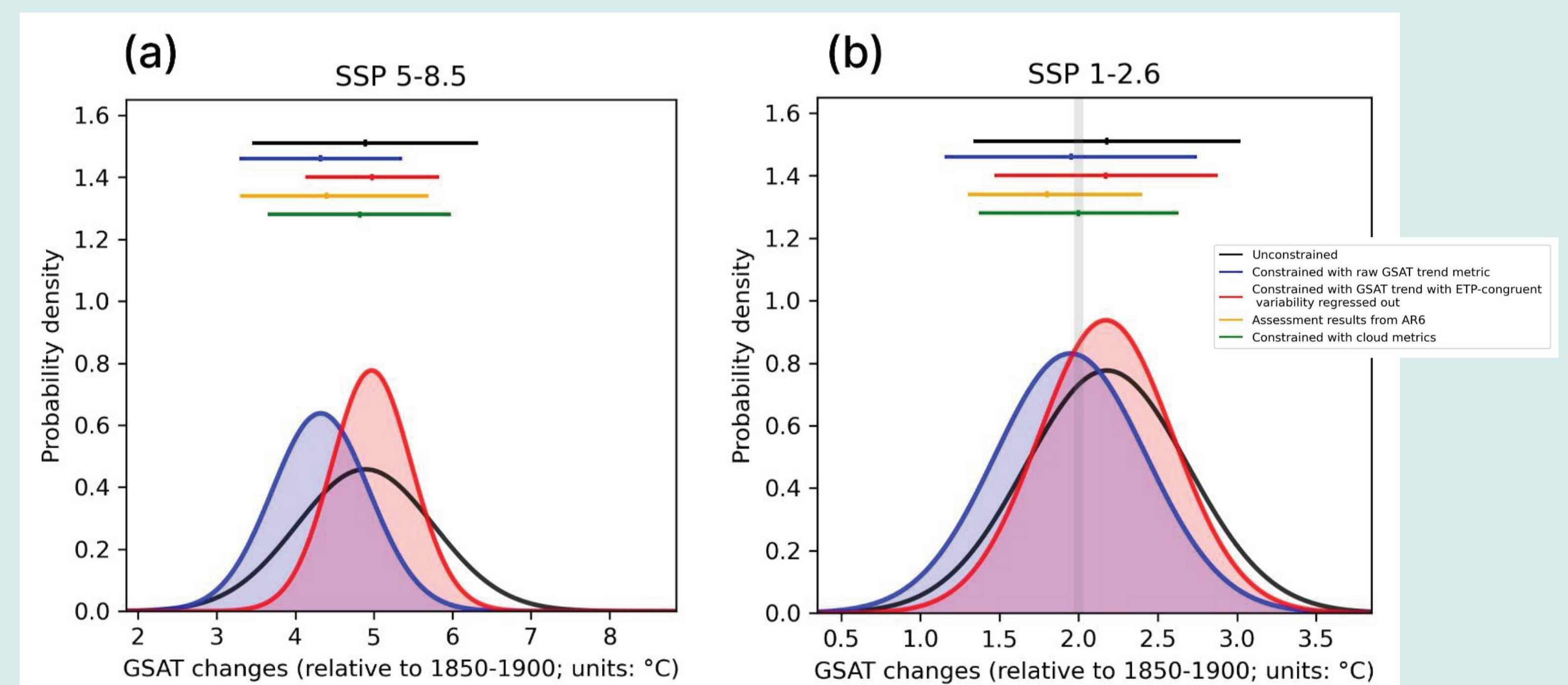
Projections constrained using the GSAT trend with ETP-congruent variability removed result in more accurate mean projections relative to pseudo-observations and a narrower constrained 5-95% uncertainty range compared to projections obtained by applying the raw GSAT trend as the predictor.

We find no evidence of overconfidence in our constrained projections, because around 90% percent of pseudo-observations lie in the constrained 90% uncertainty ranges resulting from both predictors

Observationally constrained future GSAT changes

Performance of GAT trend as a constraint

PDFs of constrained and unconstrained GSAT changes in 2081-2100 relative to 1850-1900



The GSAT trend metric with ETP congruent variability removed results in a larger mean and higher 5-95% range than the raw GSAT trend metric. Constrained warming is likely ($P > 66\%$) to exceed 2°C under SSP 1-2.6 scenario

Summary & Conclusions

Projections constrained using observed GSAT warming can be improved by removing ETP congruent variability first

Stronger constrained projected warming is obtained when we remove the pattern effect in both observations and model realizations [it is more consistent with other global-scale constraints (Liang et al. 2022)]

Key Reference

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Questions, Comments?

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