Changes in climate extremes at distinct warming levels in coupled and AMIP experiments

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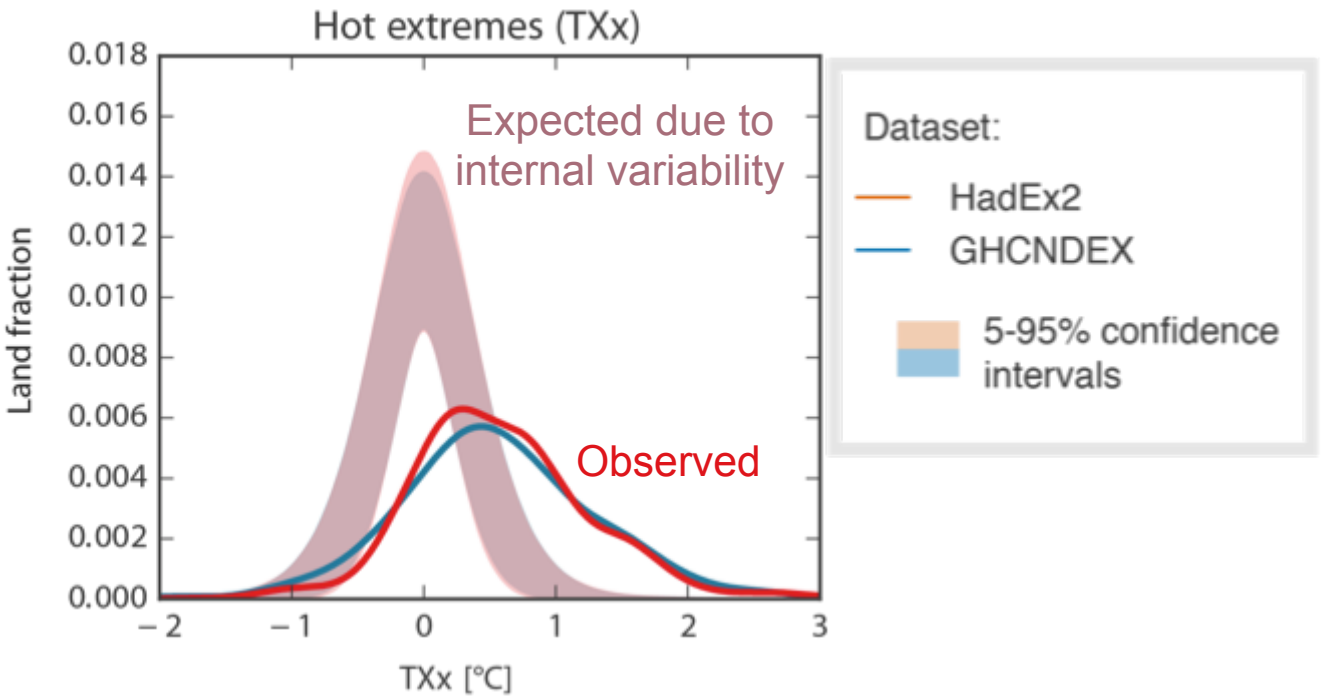
COMMENTARY:

In the observational record half a degree matters

Carl-Friedrich Schleussner, Peter Pfleiderer and Erich M. Fischer

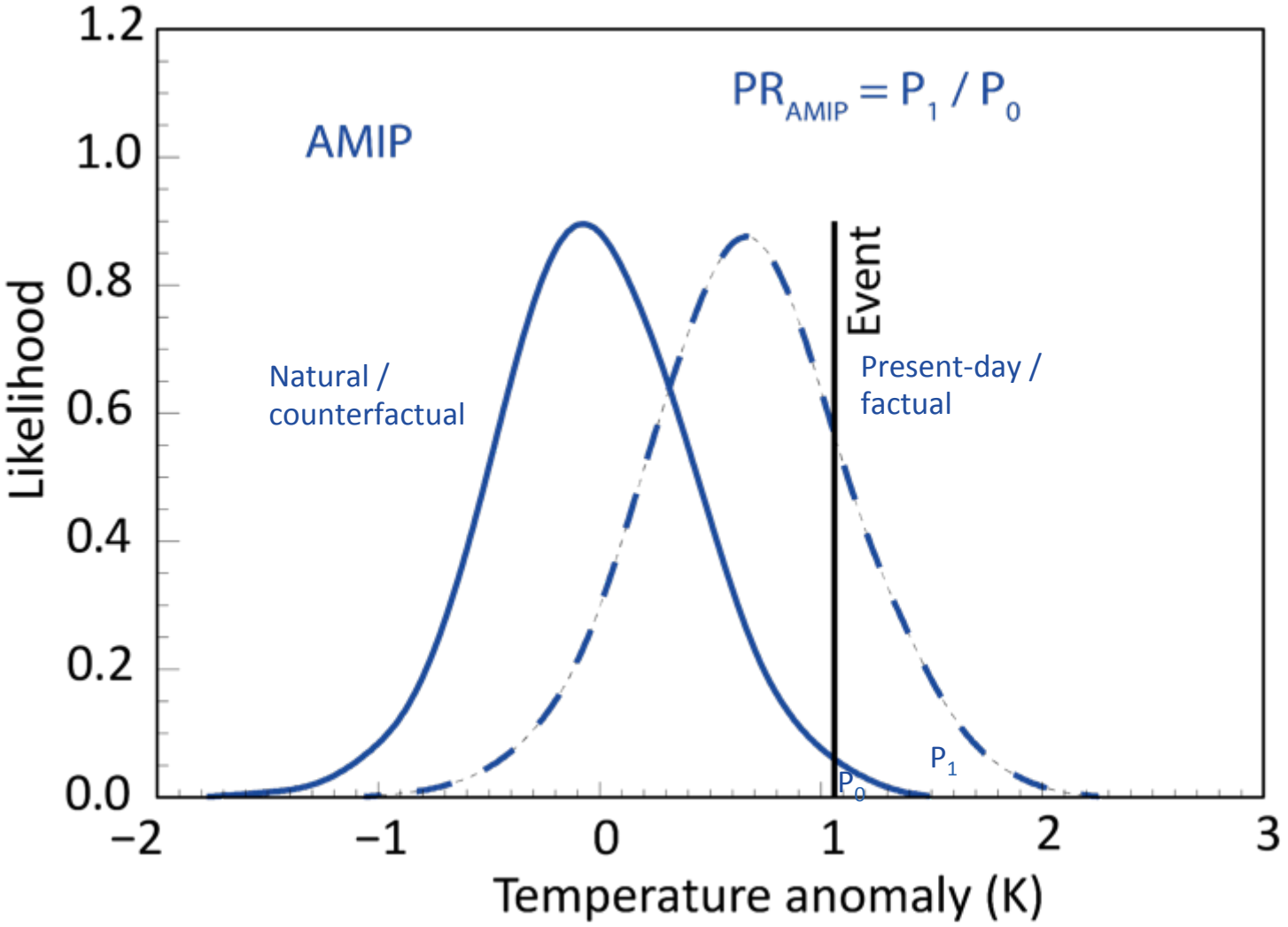
Discriminating the climate impacts of half-degree warming increments is high on the post-Paris science agenda. Here we argue that evidence from the observational record provides useful guidance for such assessments.



Schleussner, Pfleiderer and Fischer 2017, *Nature CC*

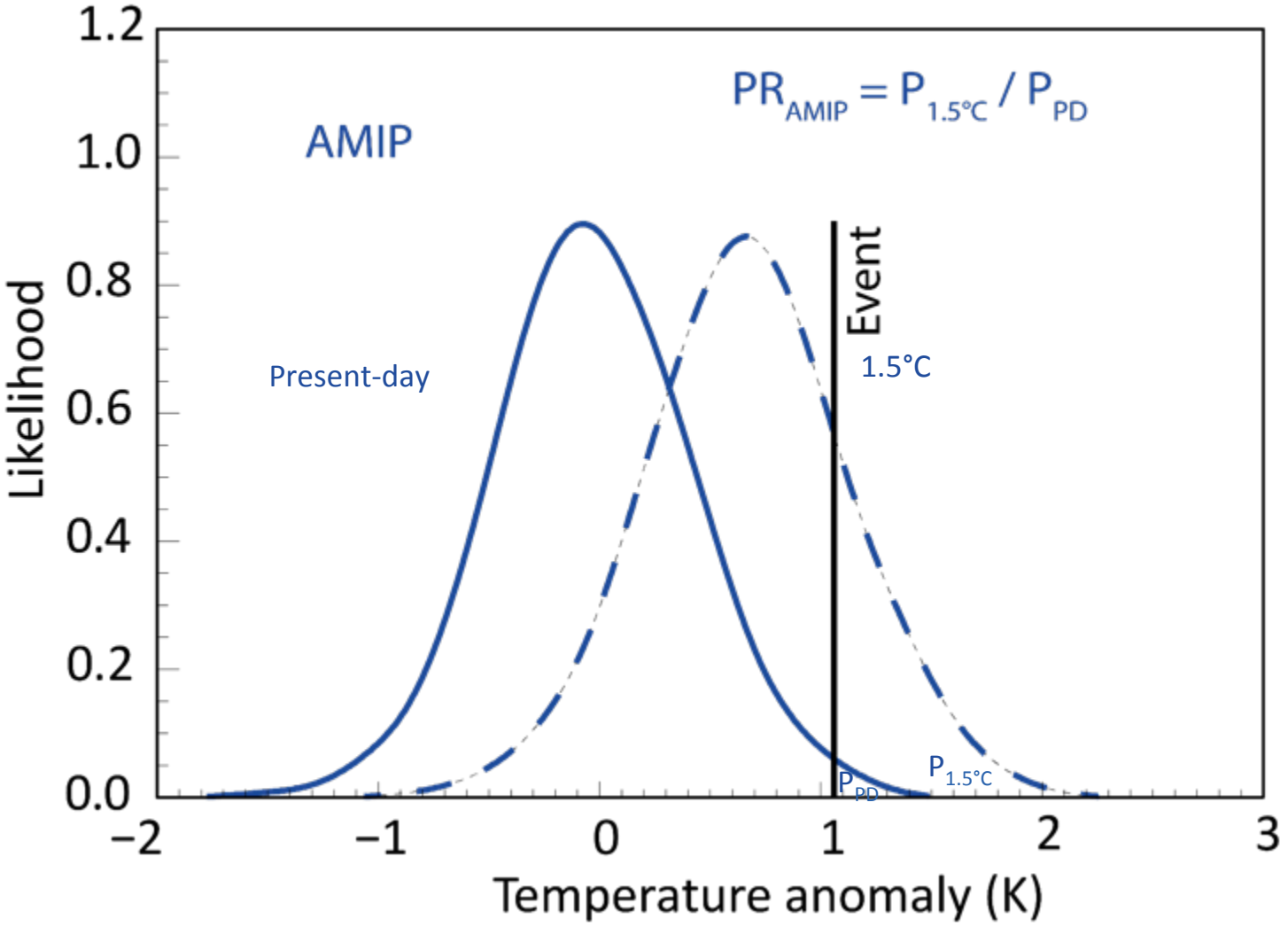
How does ocean coupling affect probability ratio?

Classical event attribution setup



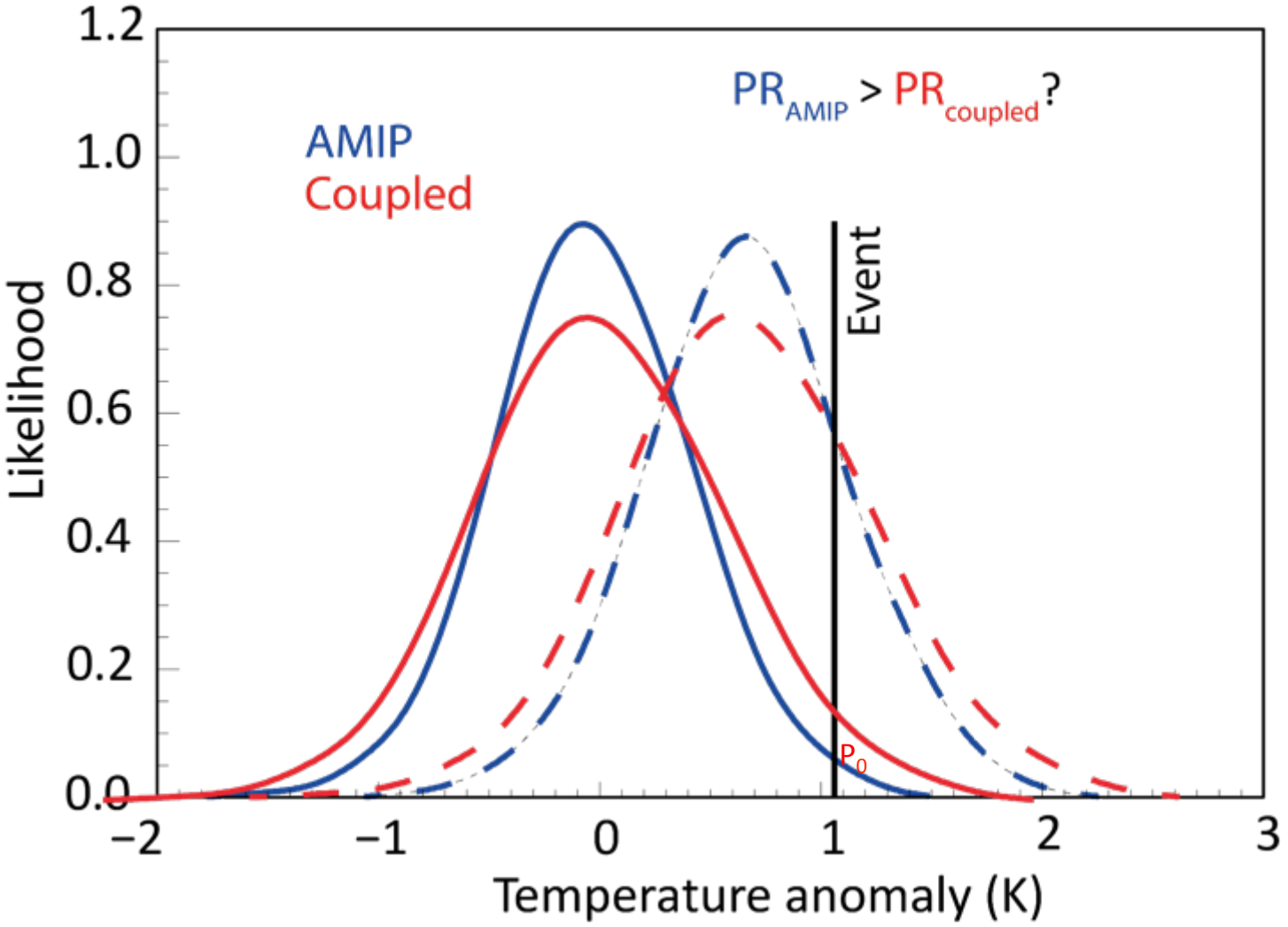
How does ocean coupling affect probability ratio?

AMIP experiment to assess warming targets



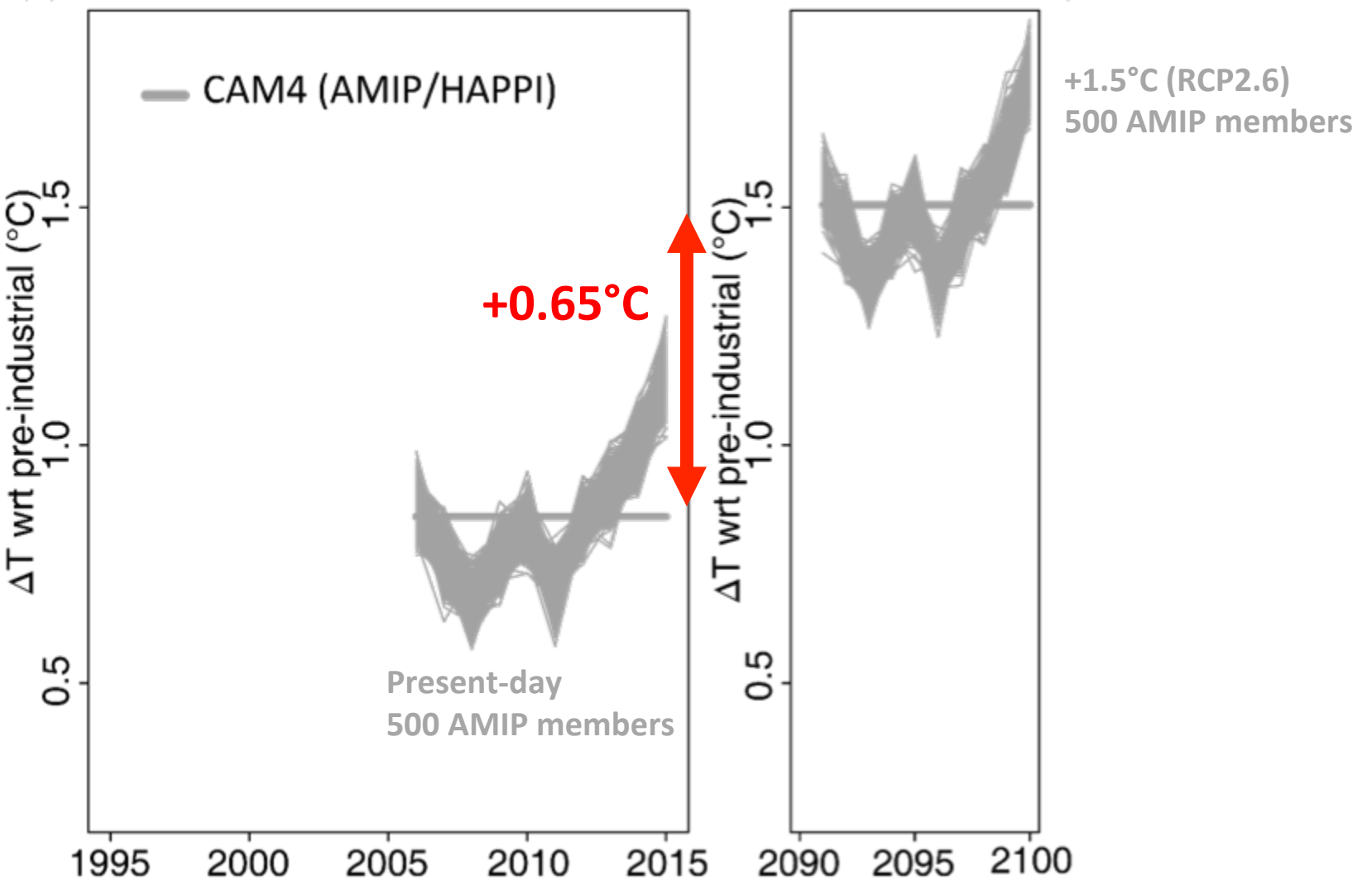
Are probability ratios biased high?

AMIP vs. fully coupled experiments



Experimental setup (AMIP)

Half a degree Additional warming (HAPPI) experiment



Experimental setup (coupled)

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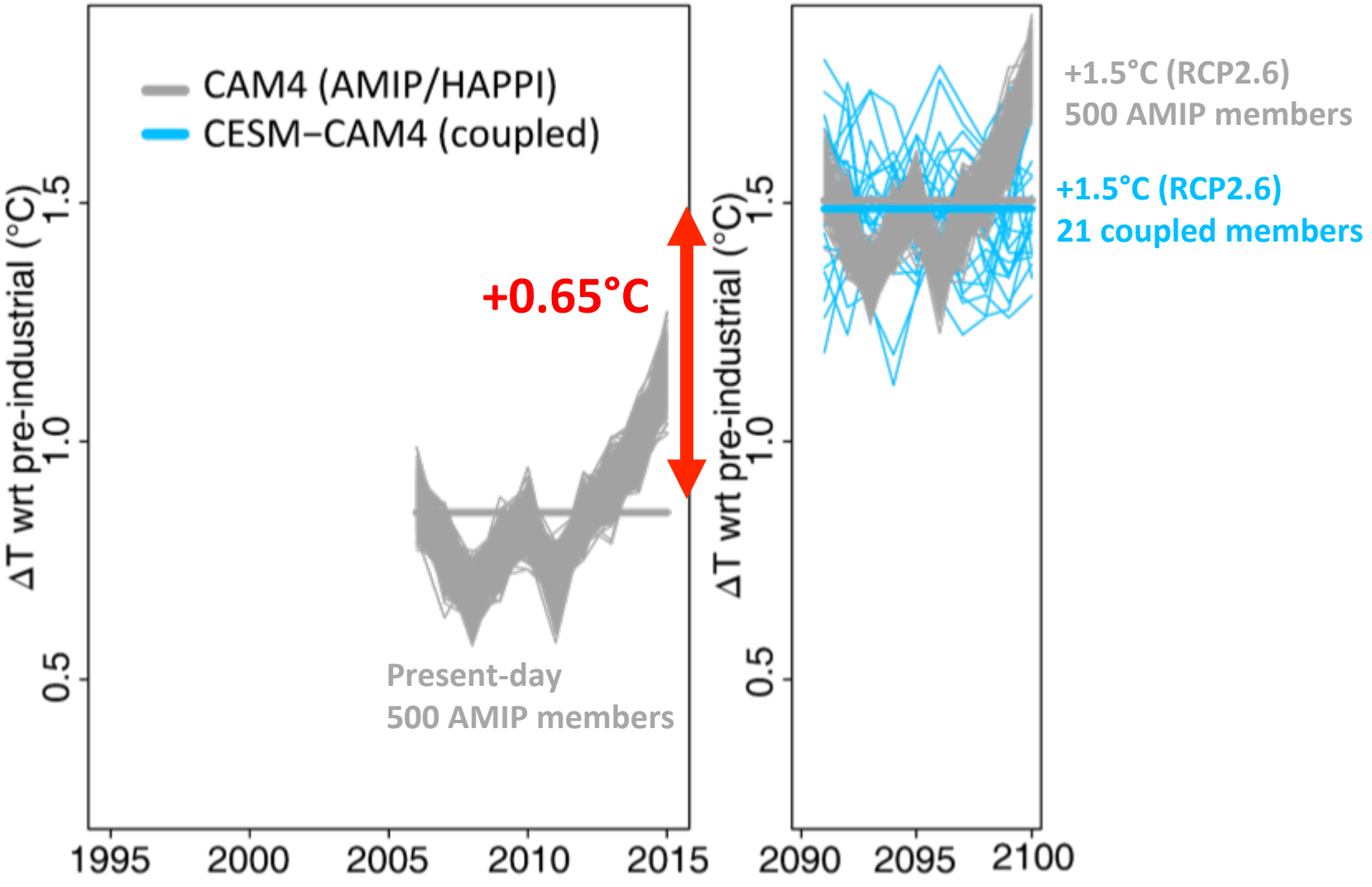
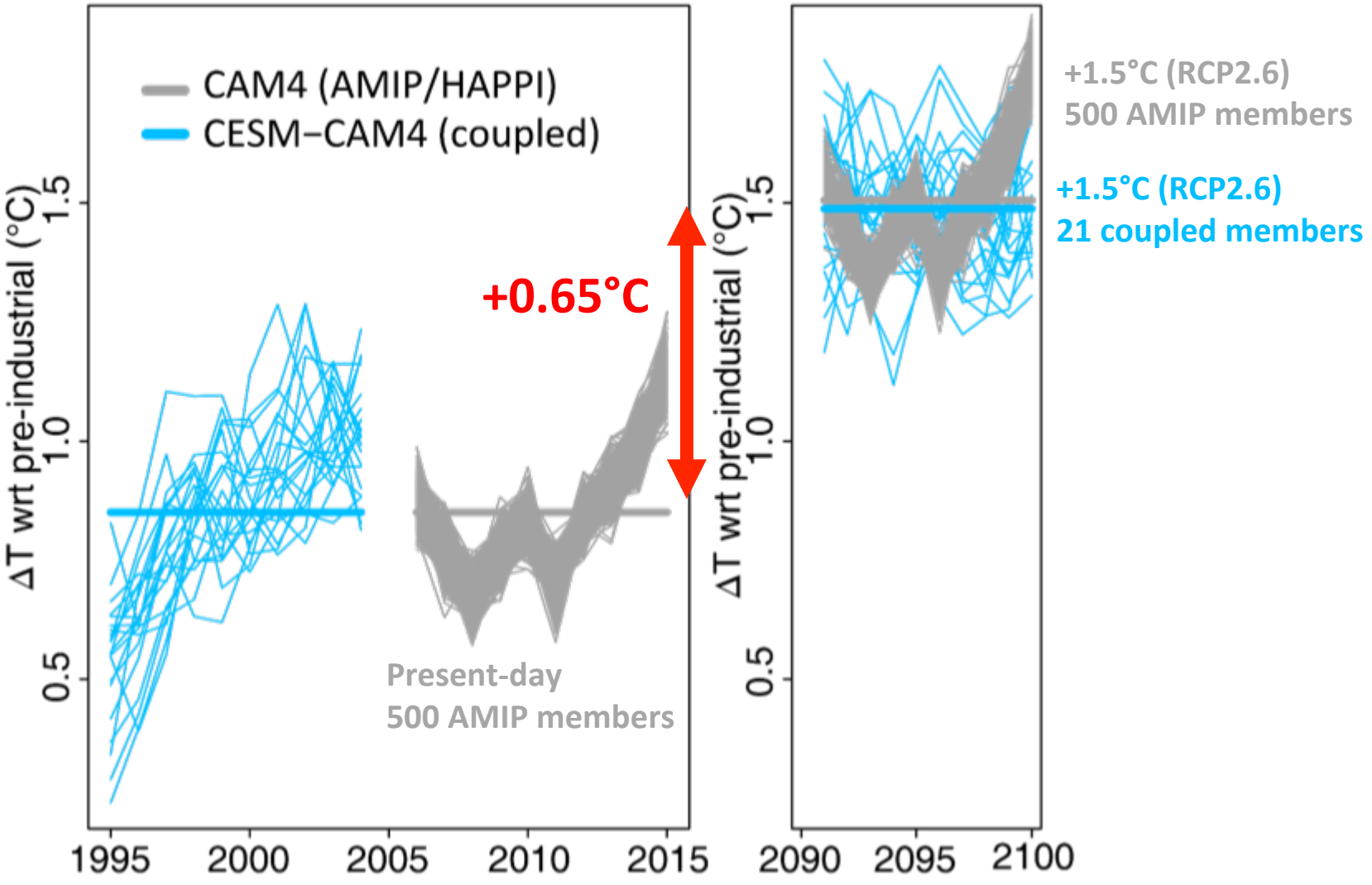


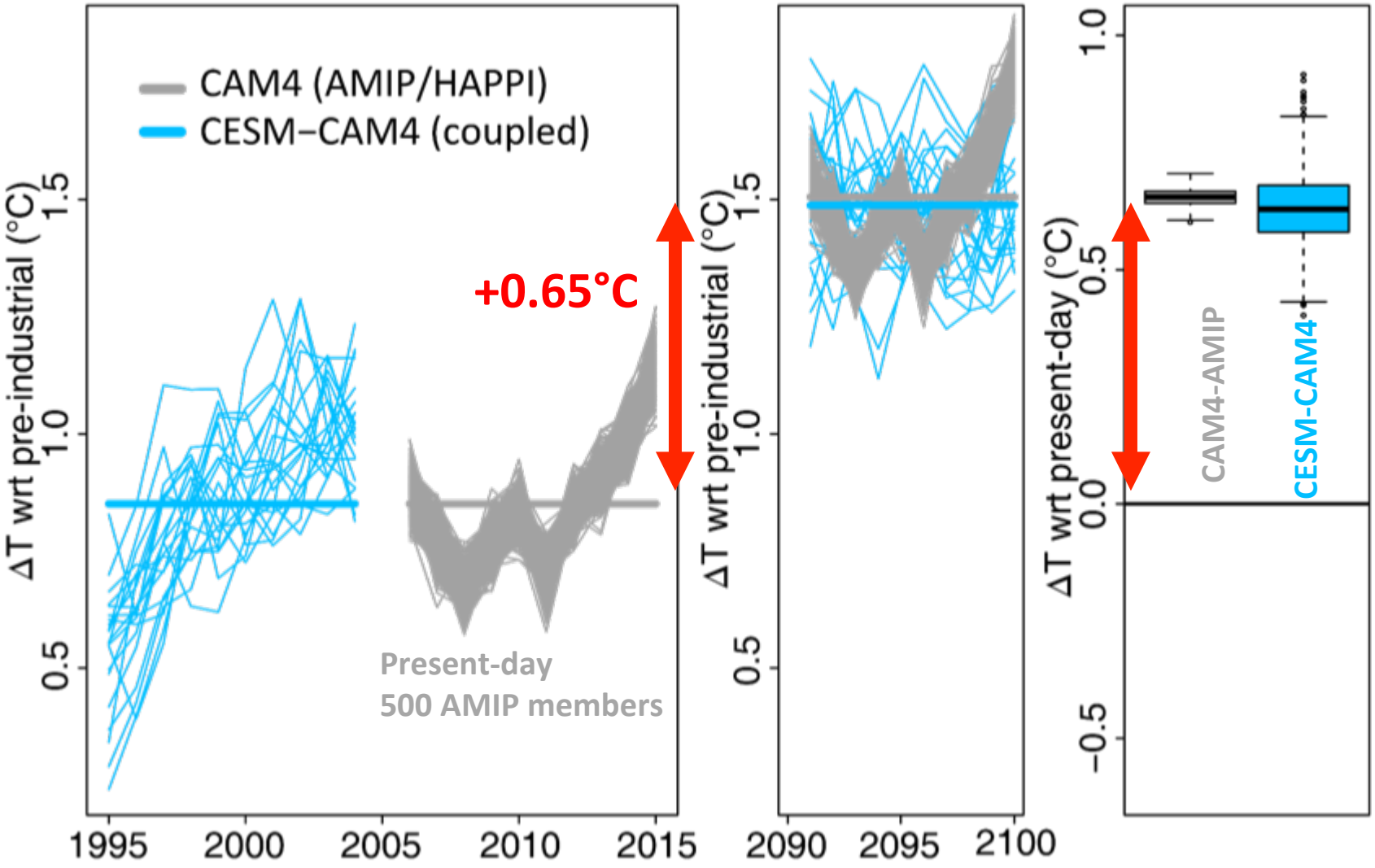
Experimental setup (coupled)

0.65°C warming in coupled and AMIP runs



AMIP experiments

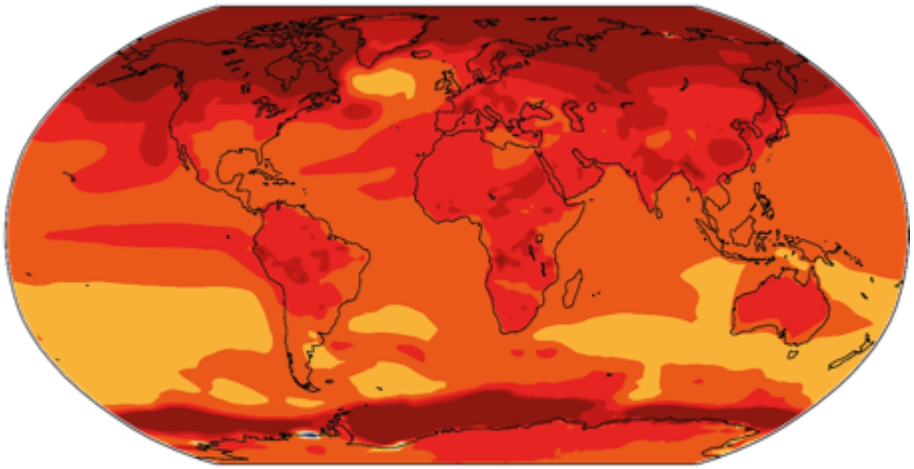
0.65°C warming in coupled and AMIP runs

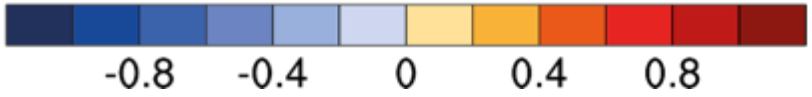


Forced response consistent

Annual mean temperature change 1.5°C vs present-day

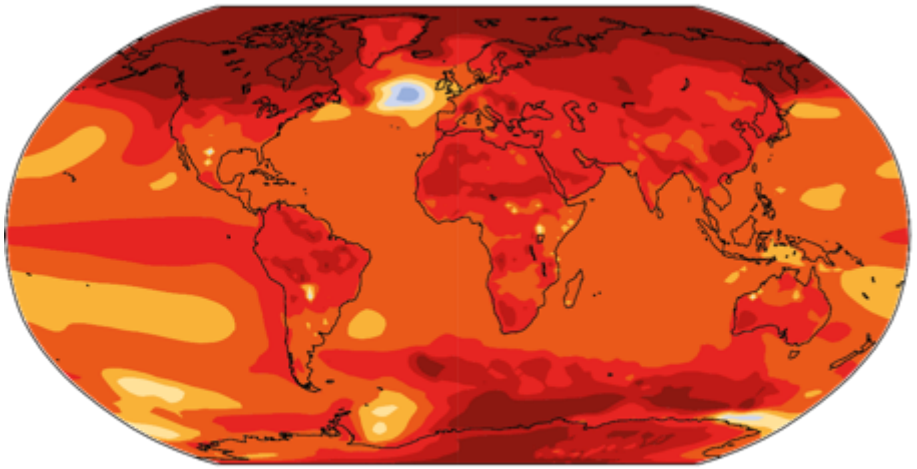
CAM4 (AMIP/HAPPI)

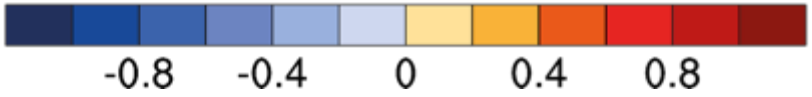




Global mean
+0.65°C

CESM-CAM4 (coupled)

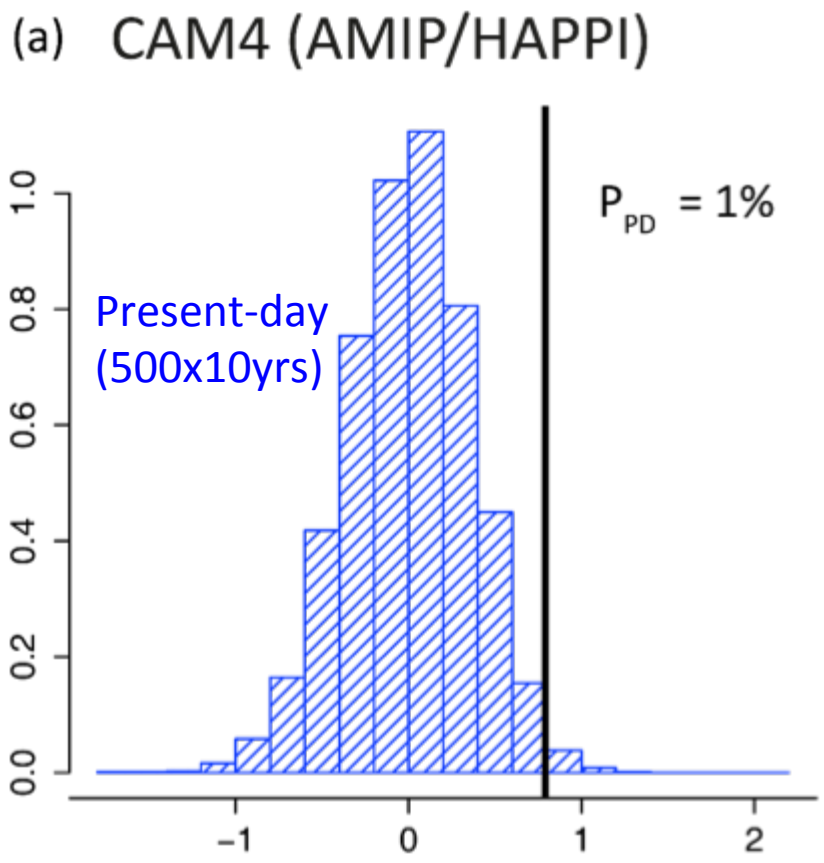




Global mean
+0.64°C

Probability ratio in HAPPI

Annual mean temperatures over Europe



Probability ratio in HAPPI

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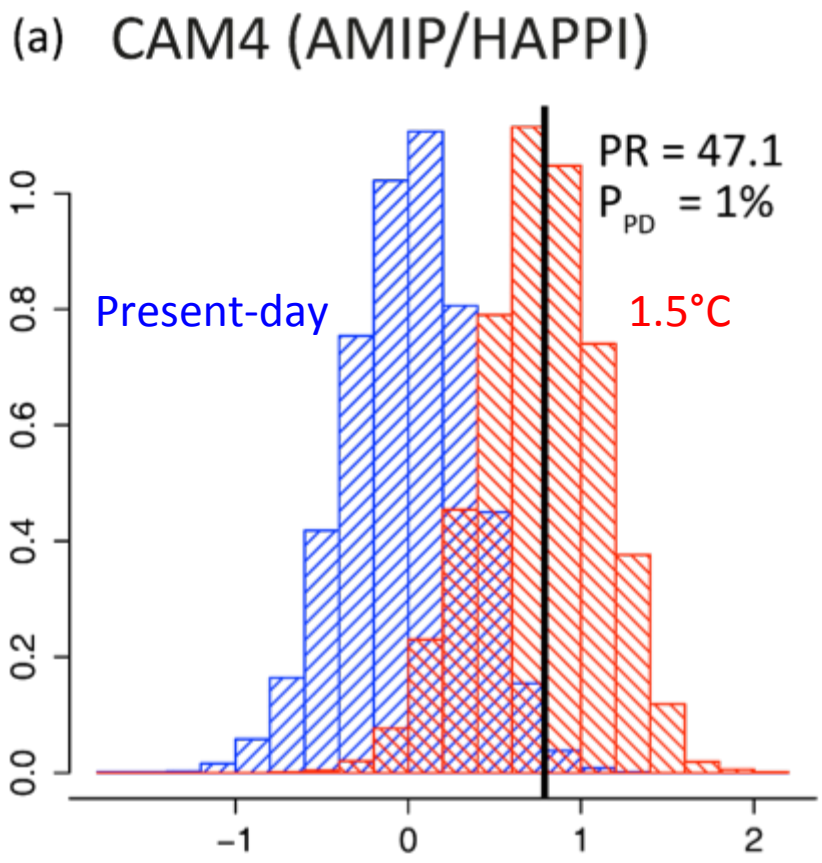
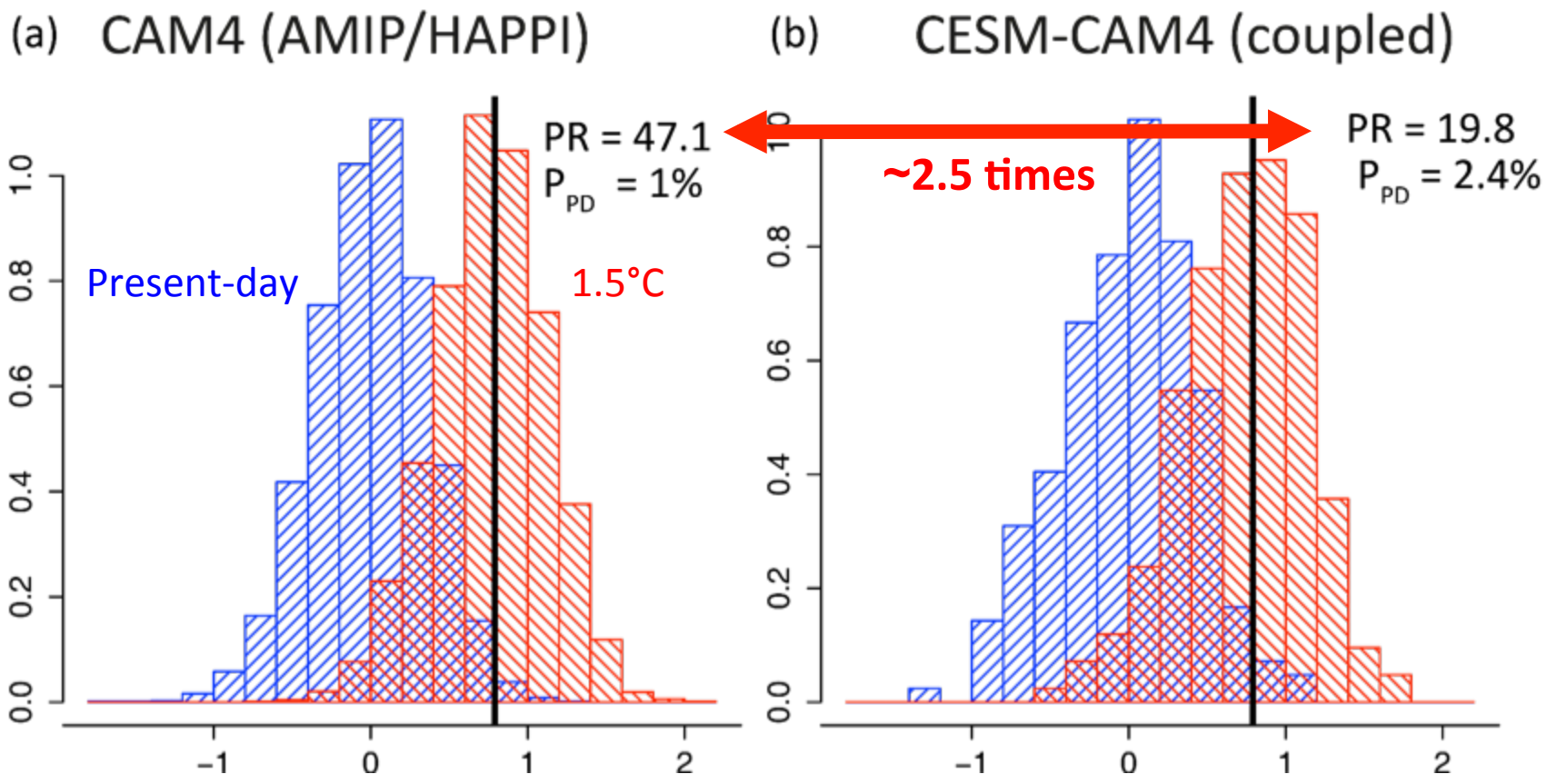


Probability ratio can differ dramatically

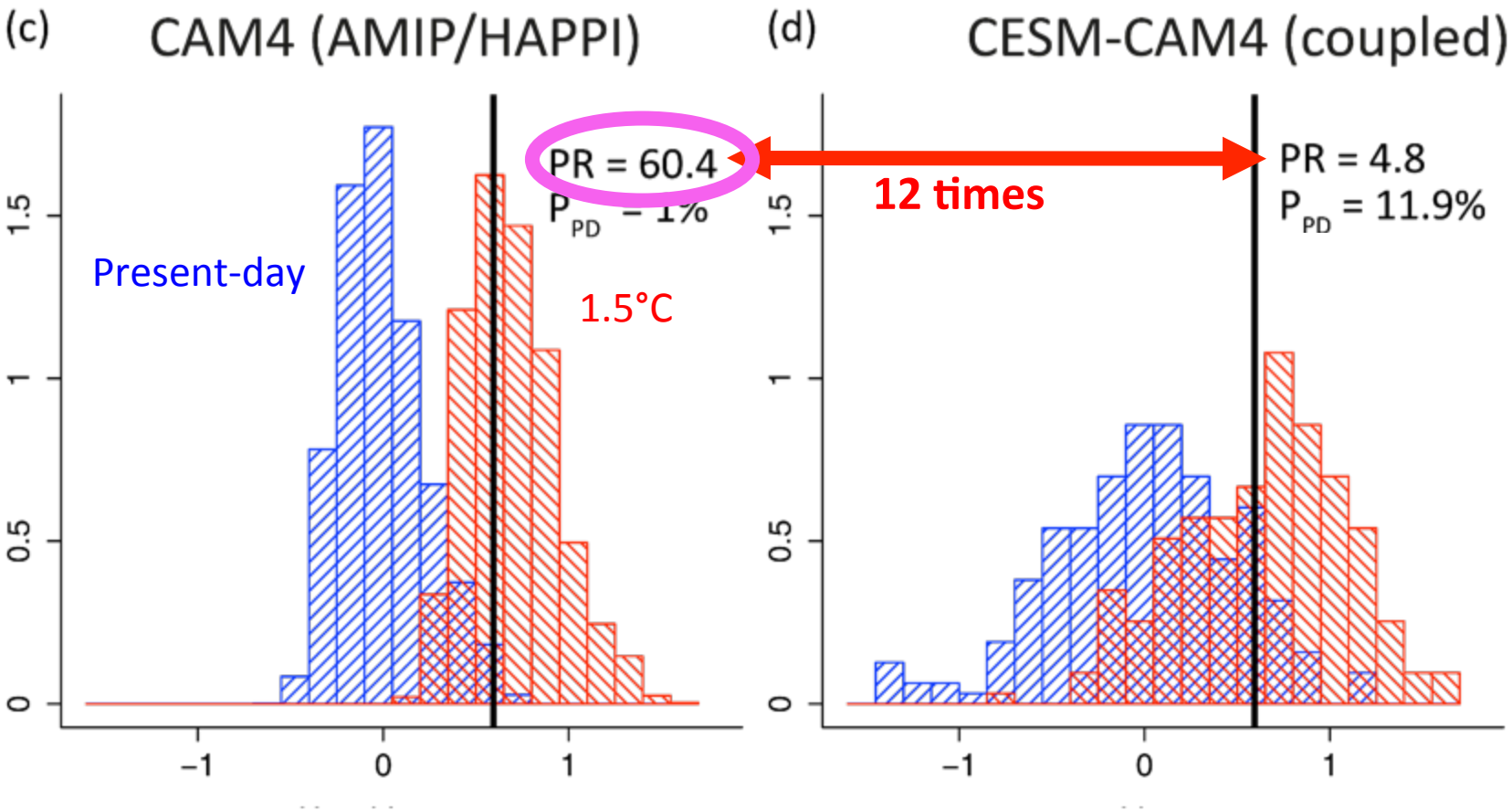
Annual mean temperatures over Europe



$P_{0,\ AMIP} < P_{0,\ coupled}$

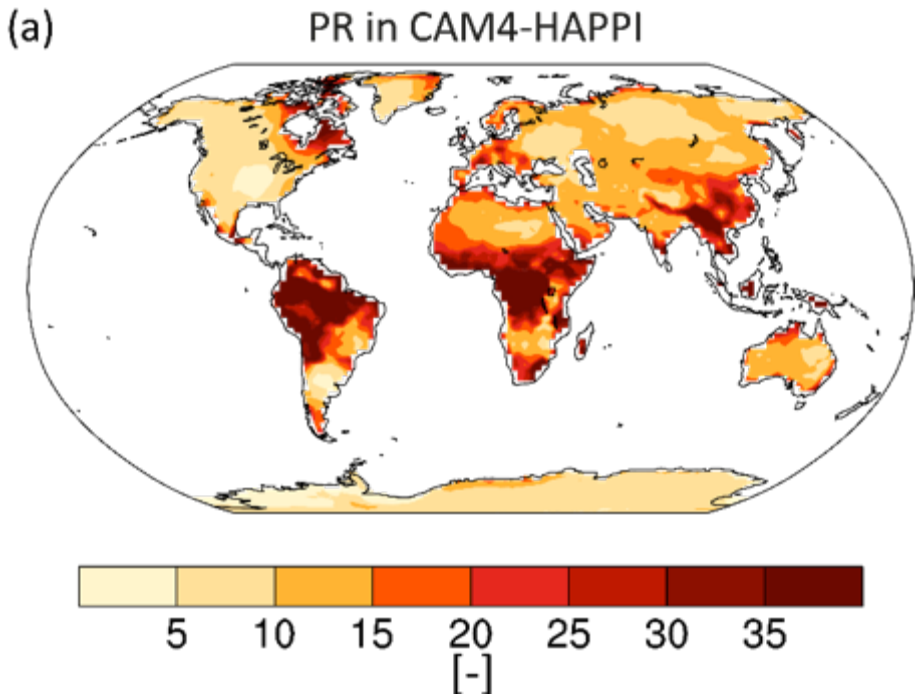
Dramatic differences over tropics

East African annual mean temperatures



Testing for same event magnitude

PR for local 99th percentile



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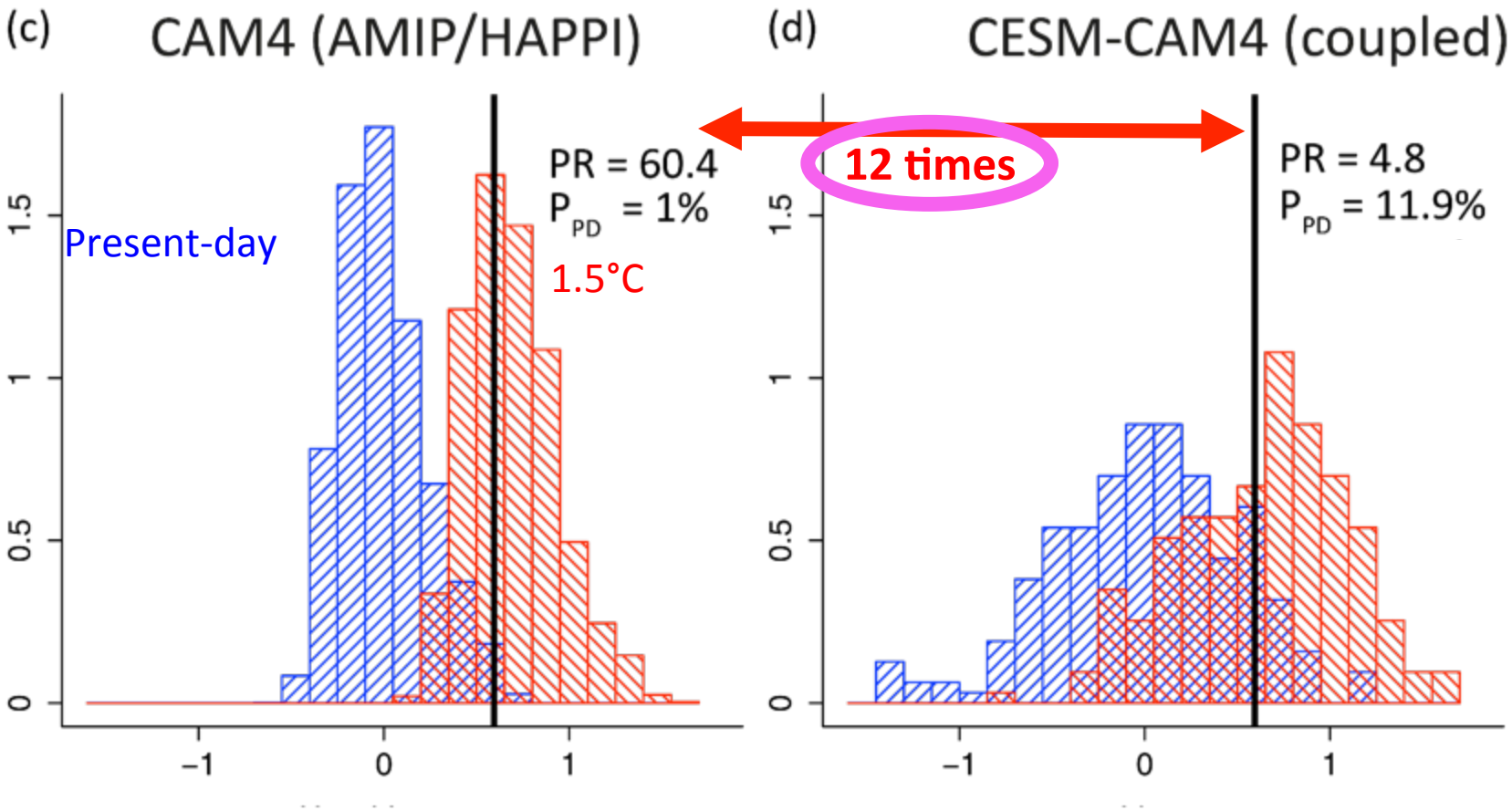
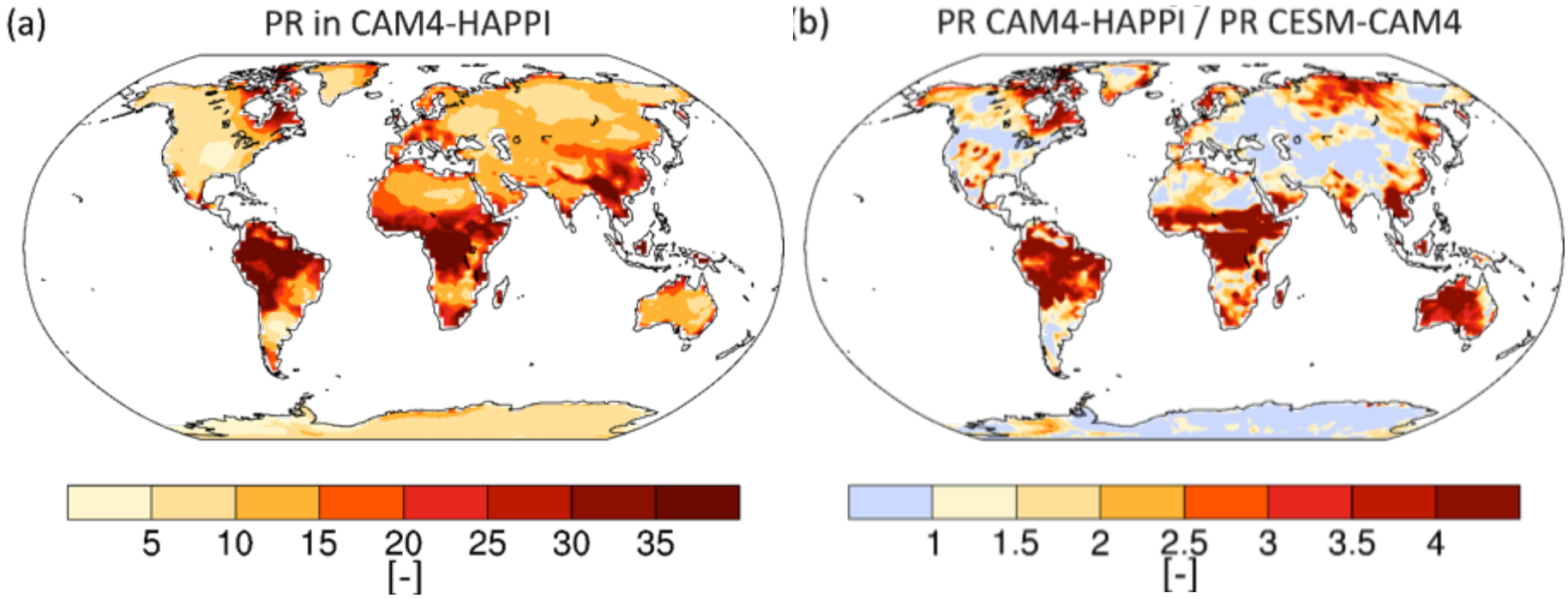


PR more than doubles over tropics

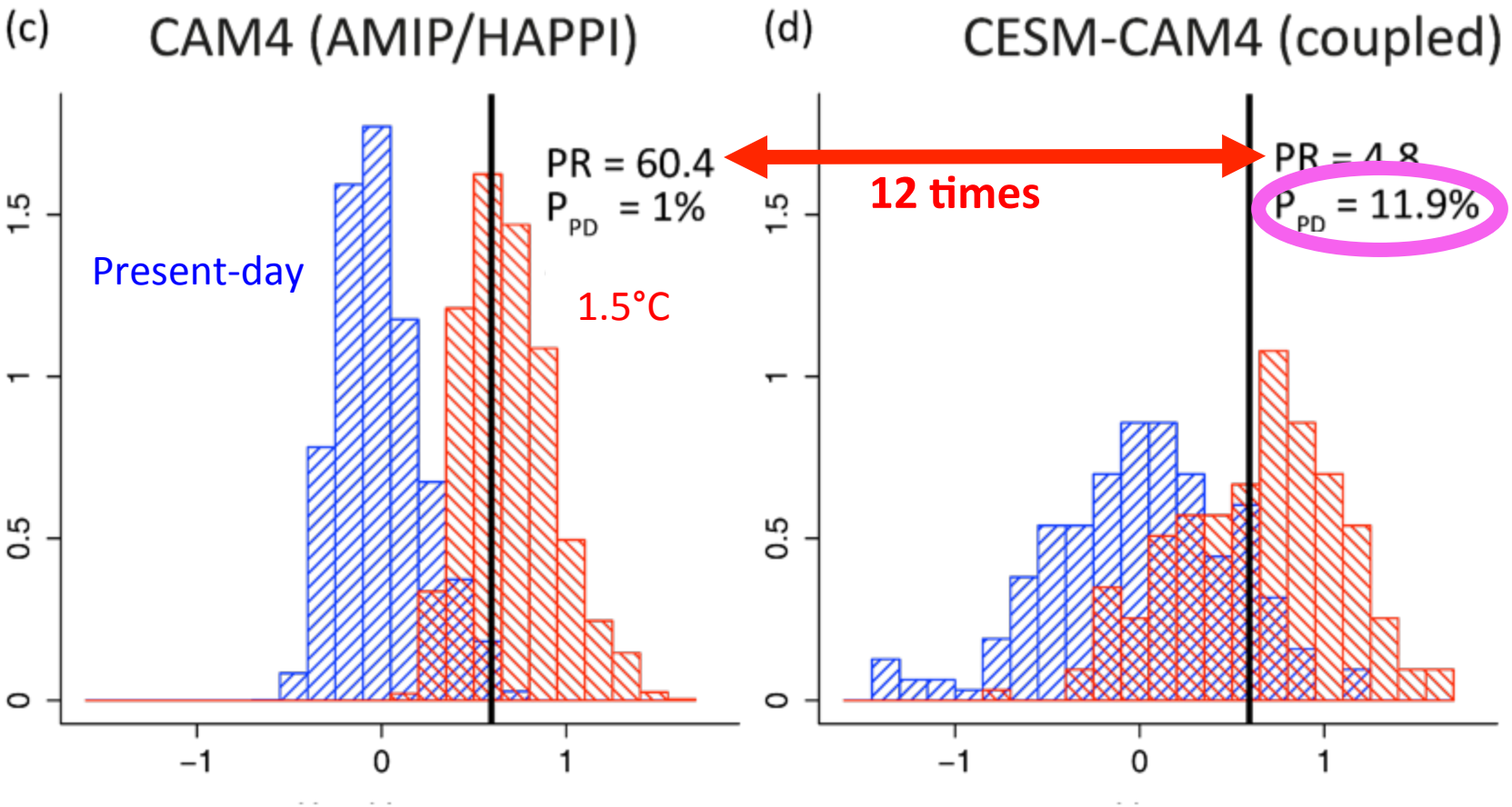
PR for same anomaly HAPPI-CAM4 vs. CESM-CAM4



Difference due to coupling largest over tropics and high latitudes

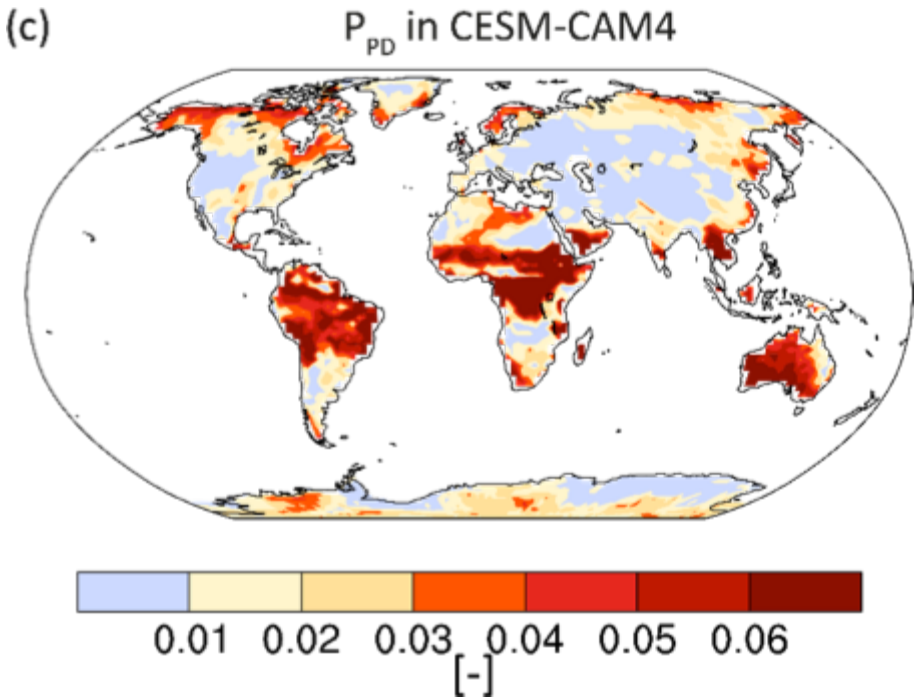
Dramatic differences over tropics

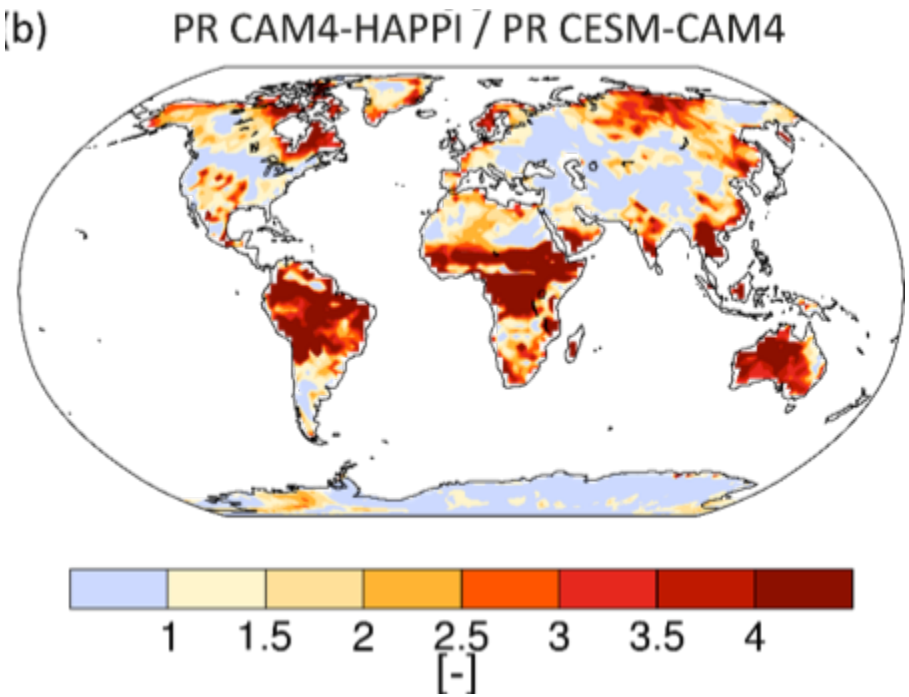
East African annual mean temperatures



Present-day variability explains difference

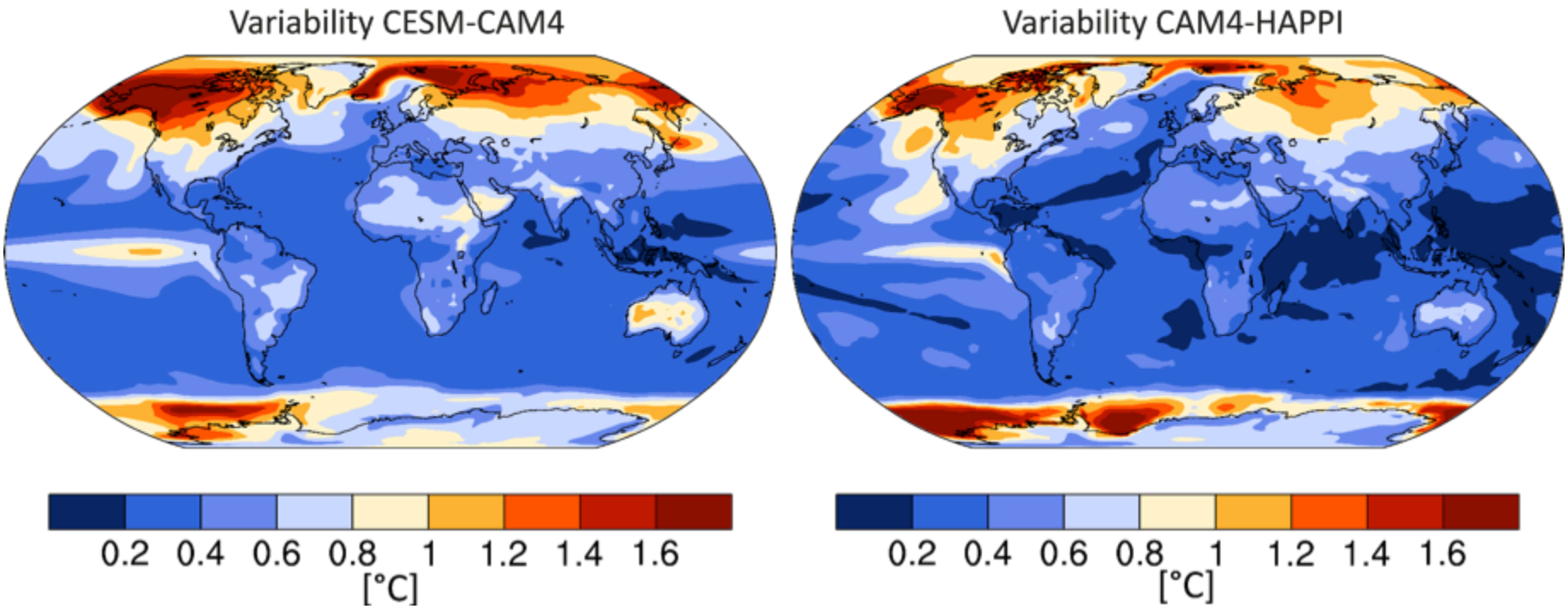
PR for same anomaly HAPPI-CAM4 vs. CESM-CAM4





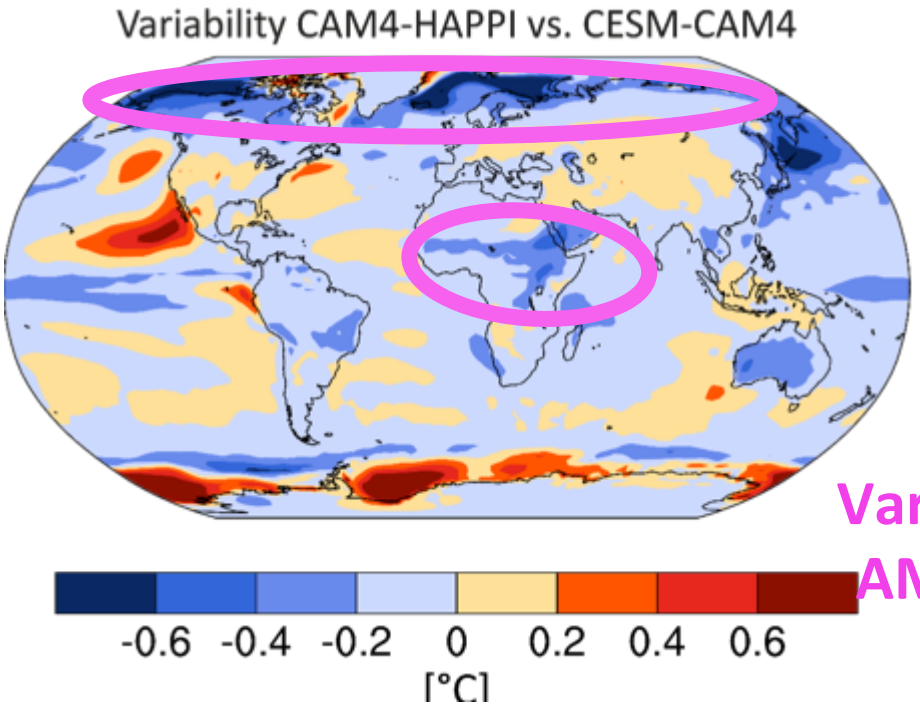
Getting the present-day variability right is essential

Interannual variability differs



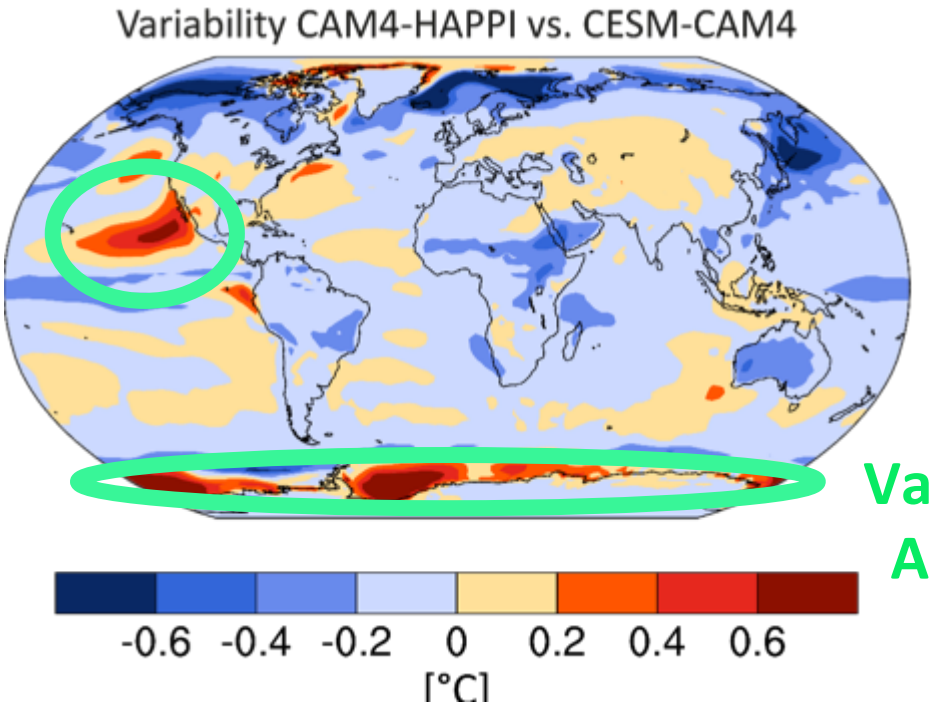
Variability not larger everywhere in coupled model

Variability is not always higher in coupled GCM



Variability lower in AMIP experiment

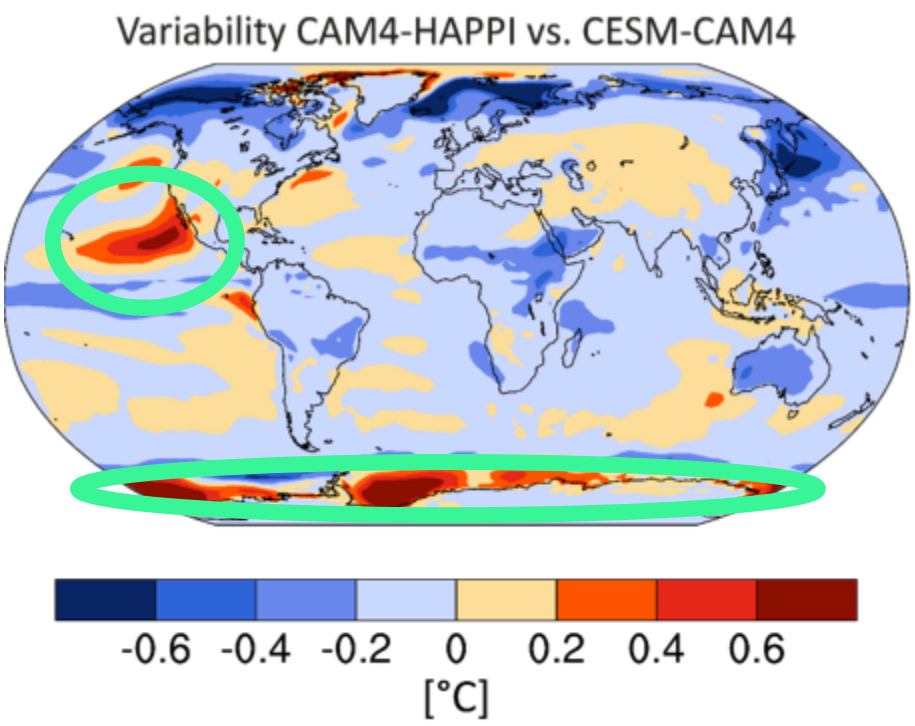
Variability is not always higher in coupled GCM

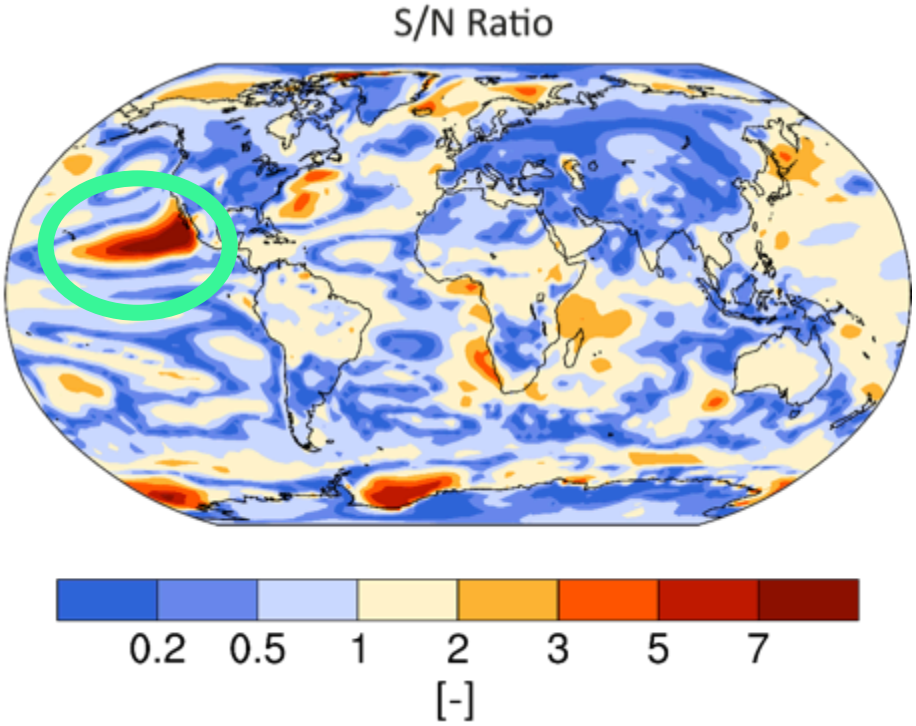


Variability higher in AMIP experiment

Is the variability difference systematic?

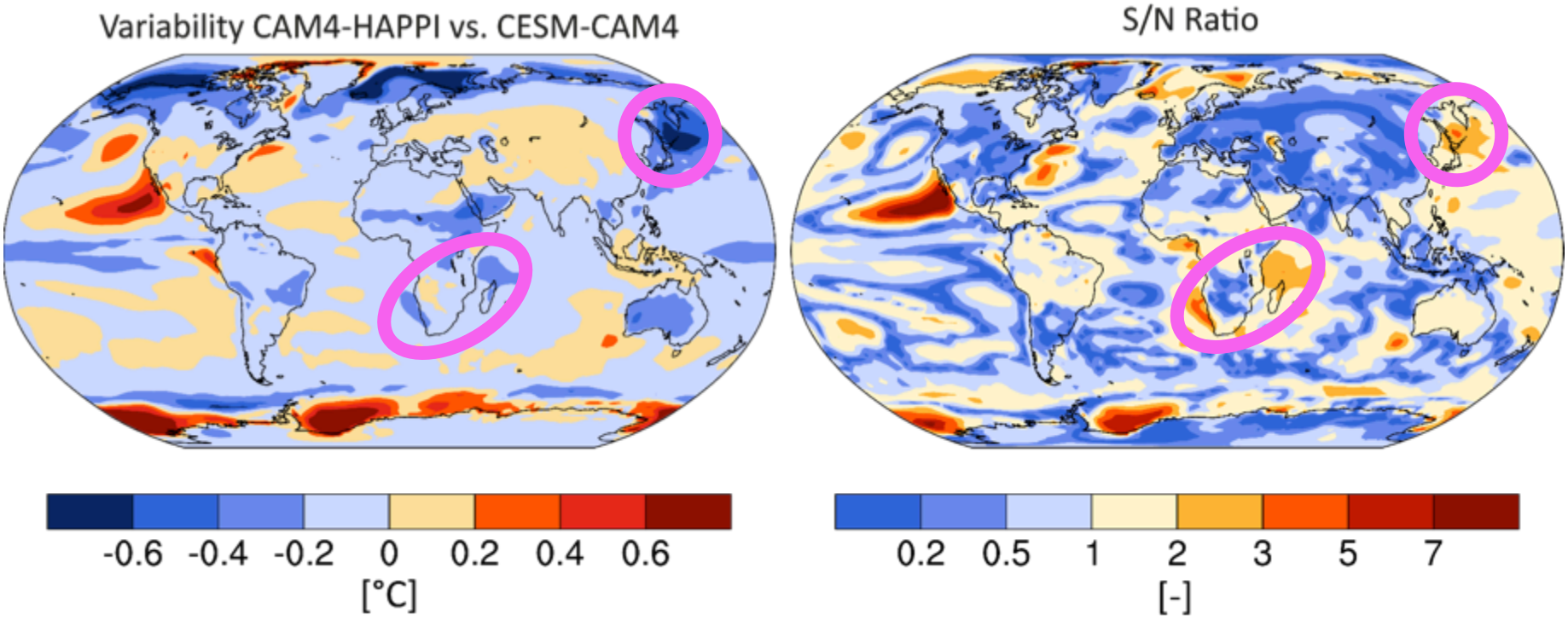
Systematic variability bias only over few regions





Systematically too low variability in coupled model

Present-day variability explains difference



Too high variability in coupled model

Conclusions

- Probability ratios tend to be higher in AMIP experiments
- Differences between coupled and AMIP experiments are largest for seasonal and annual means over tropics and high latitudes
- Small difference for daily extremes over mid-latitudes

Broader implications

- Getting the present-day variability right is essential for reliable probability ratios
- Gain of ensemble size (AMIP) goes at the expense of sampling ocean variability
- For AMIP projections there is a risk of biased and overconfident probability ratios