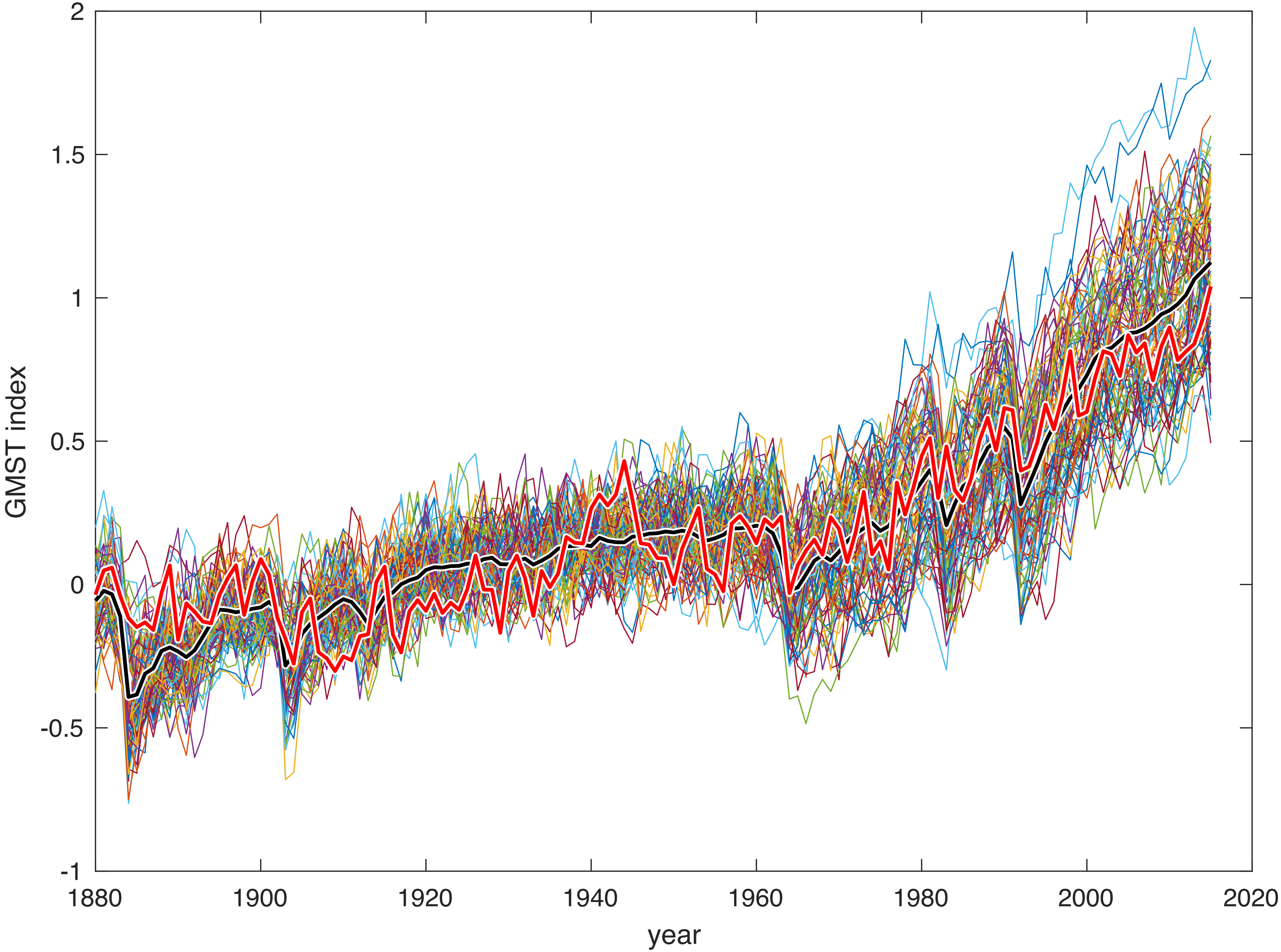
On the Choice of Method for Estimating the Forced Signal in the Presence of Internal Variability

Leela Frankcombe

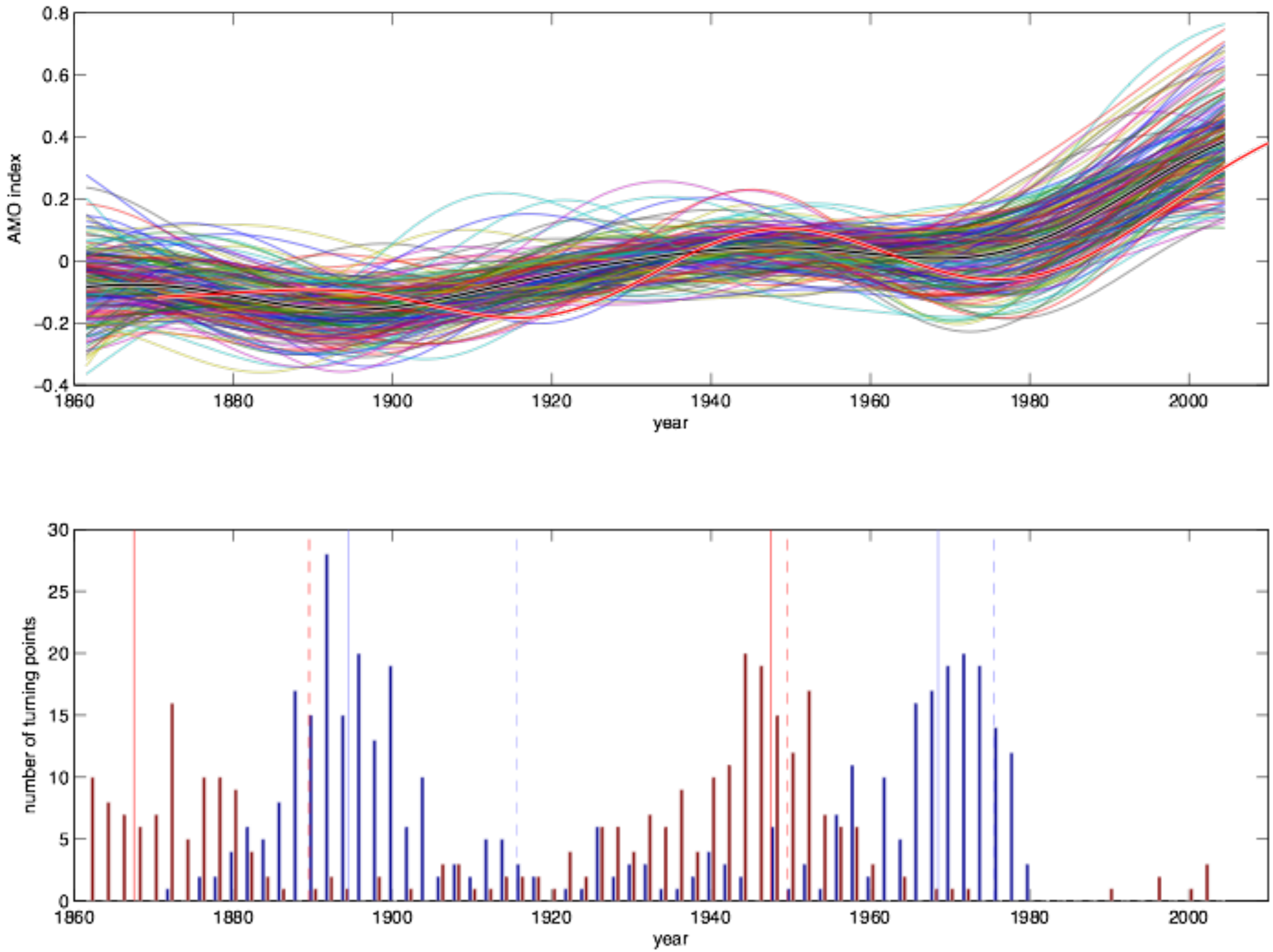
Matthew England, Jules Kajtar, Michael Mann and Byron Steinman



2
1.5
1
0.5
0
-0.5
-1
1880
1900
1920
1940
1960
1980
2000
2020
GMST index
year

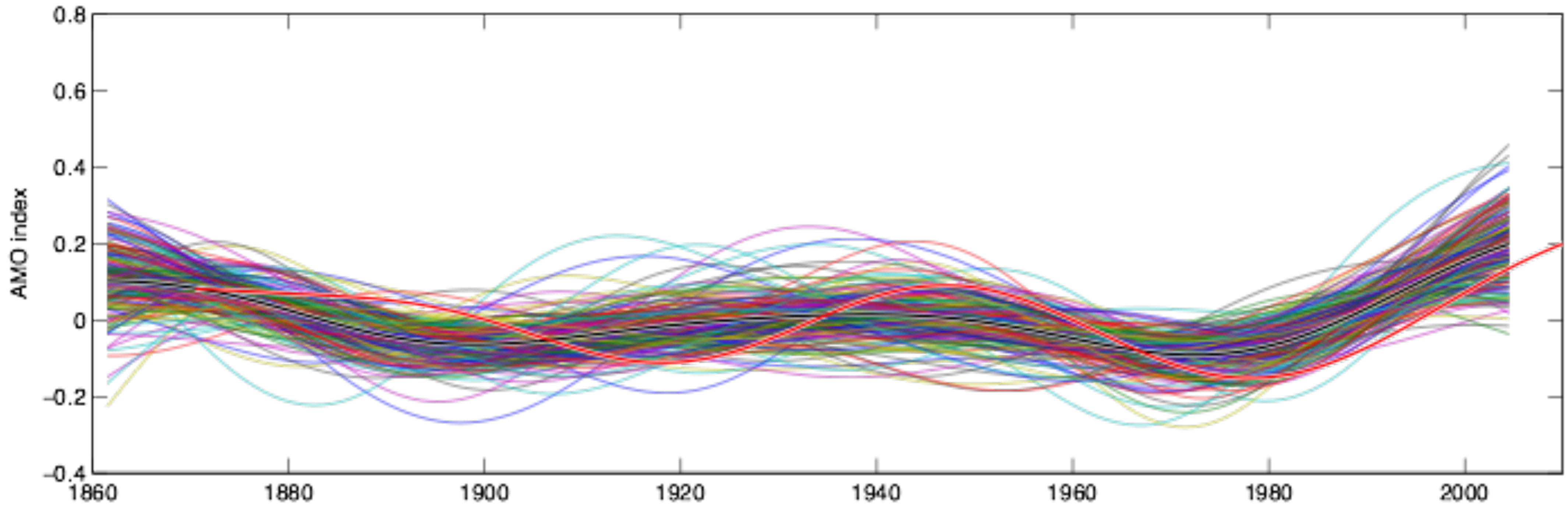
Biases introduced by incorrect removal of forced signal

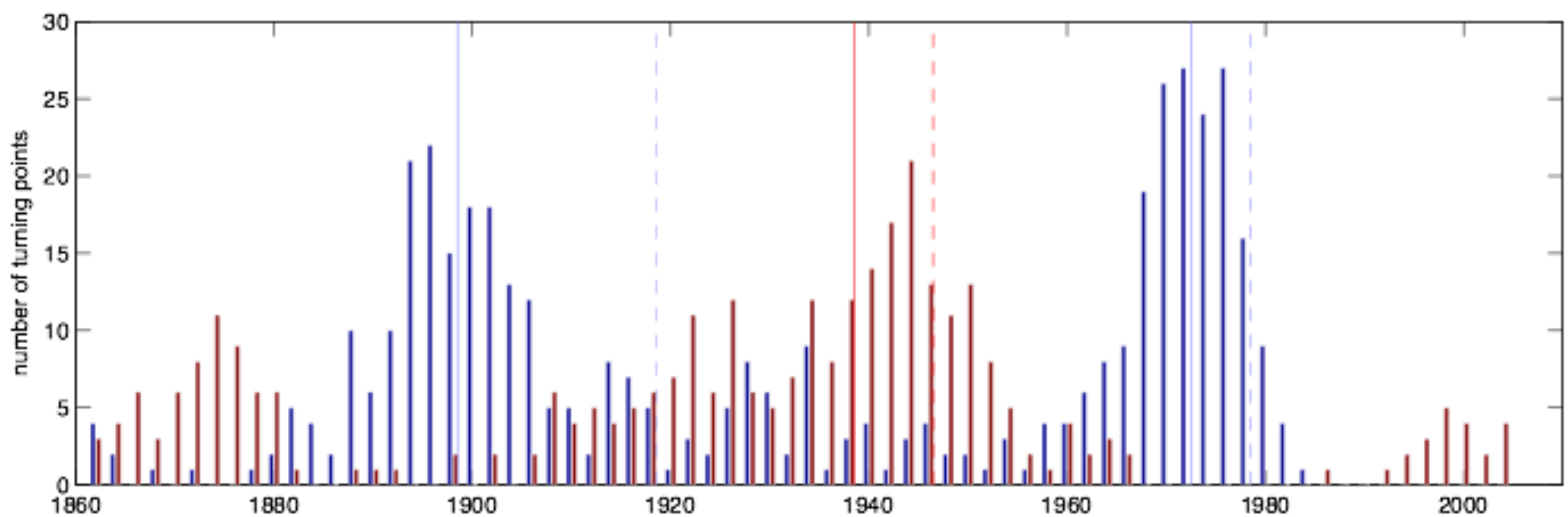
Raw signal



Biases introduced by incorrect removal of forced signal

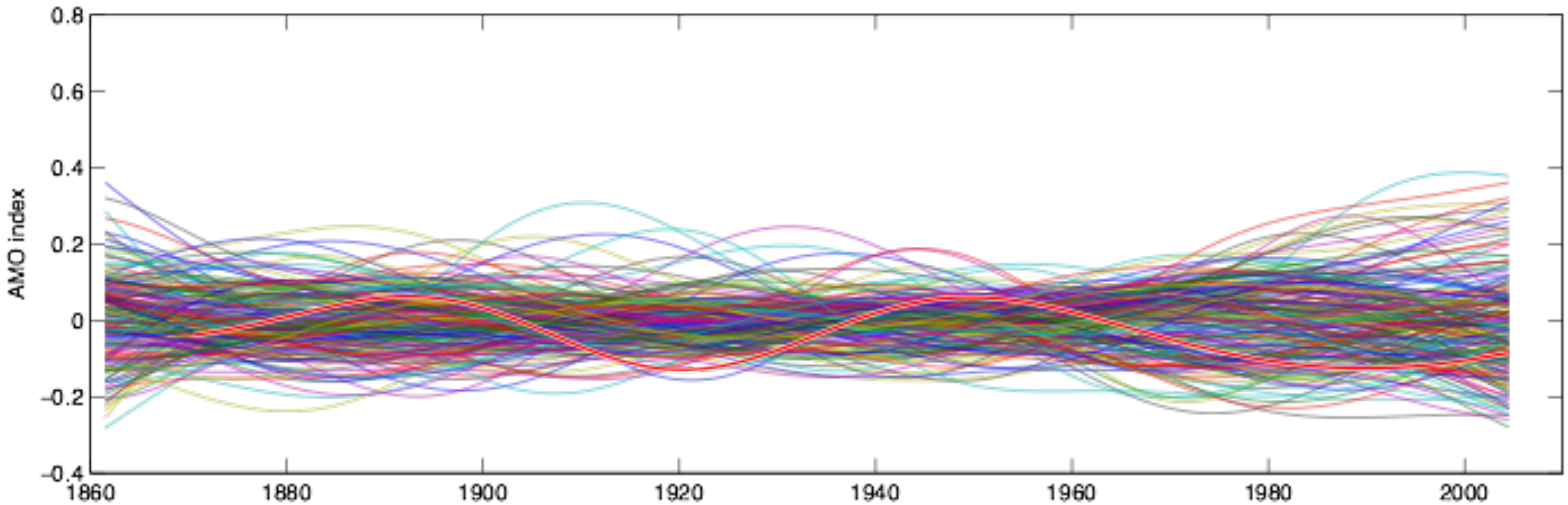
Linear detrending

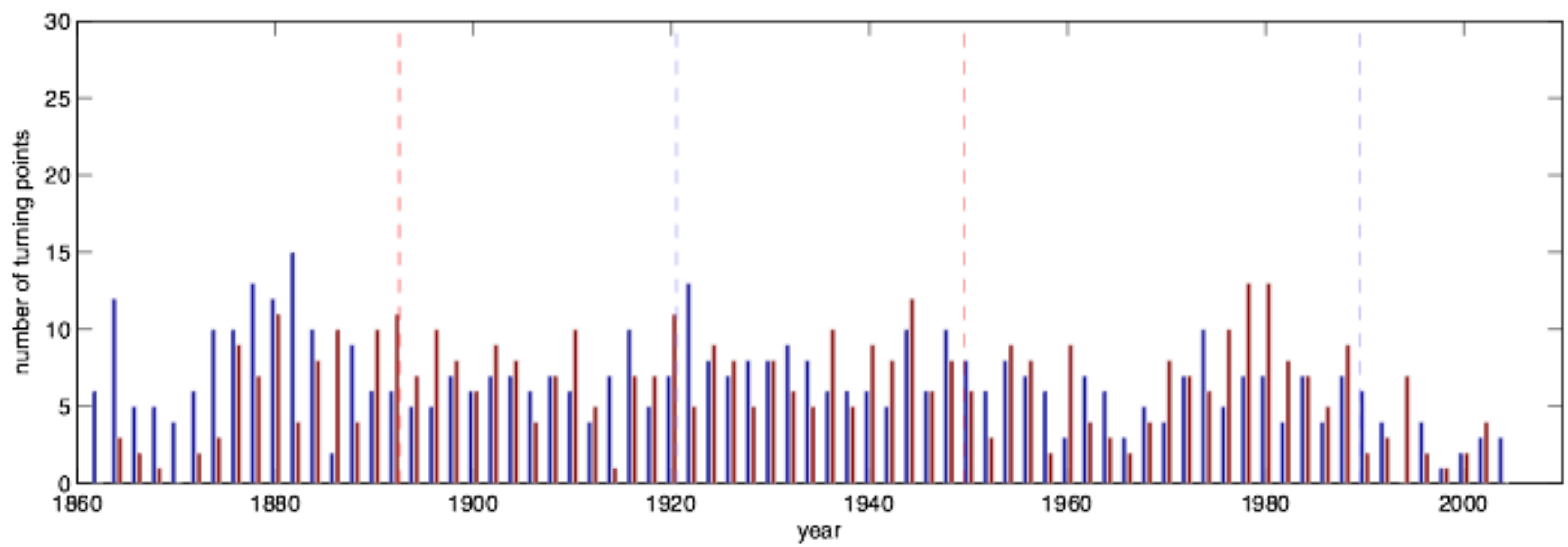




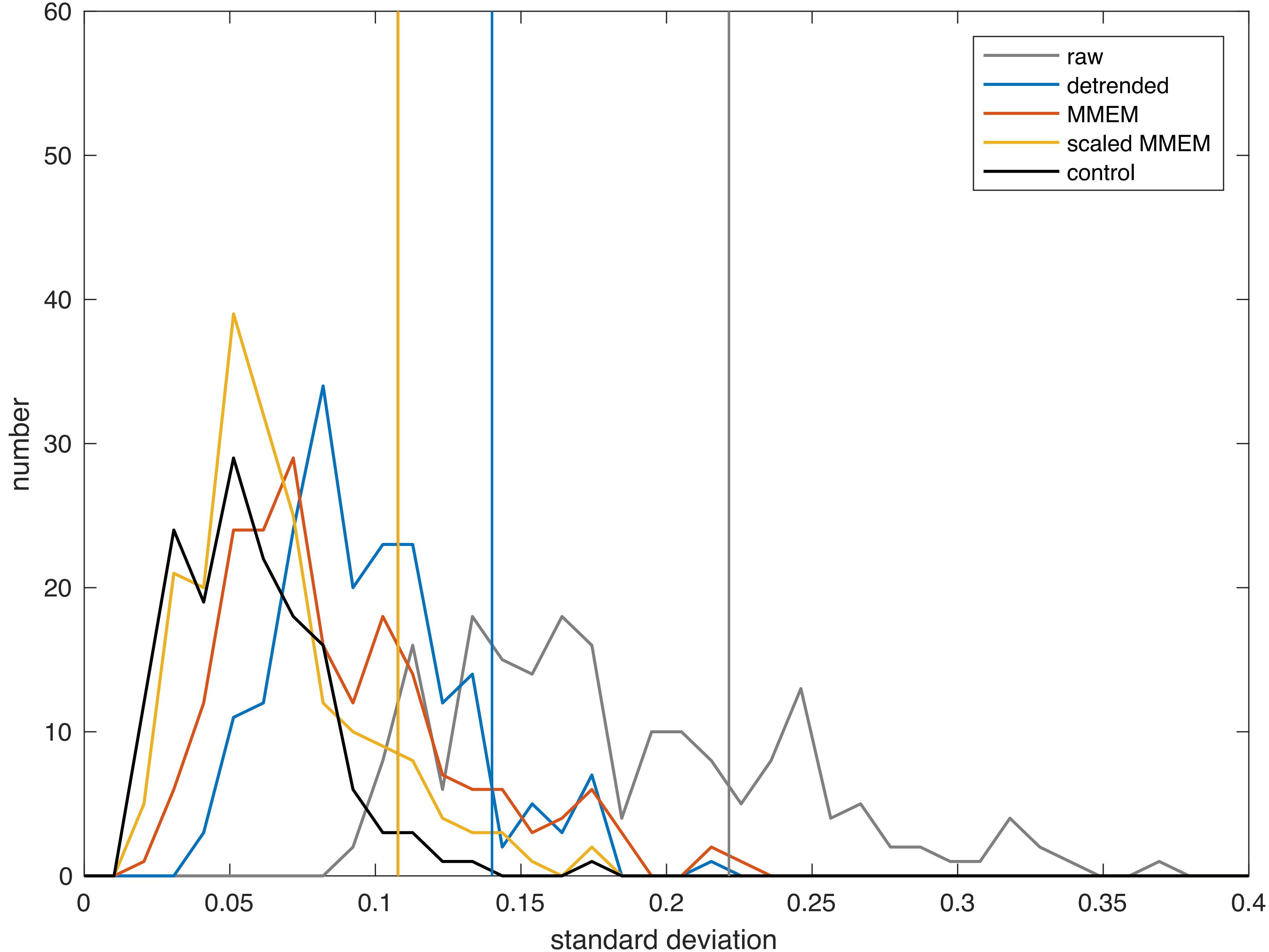
Biases introduced by incorrect removal of forced signal

Removing CMIP5 ensemble mean

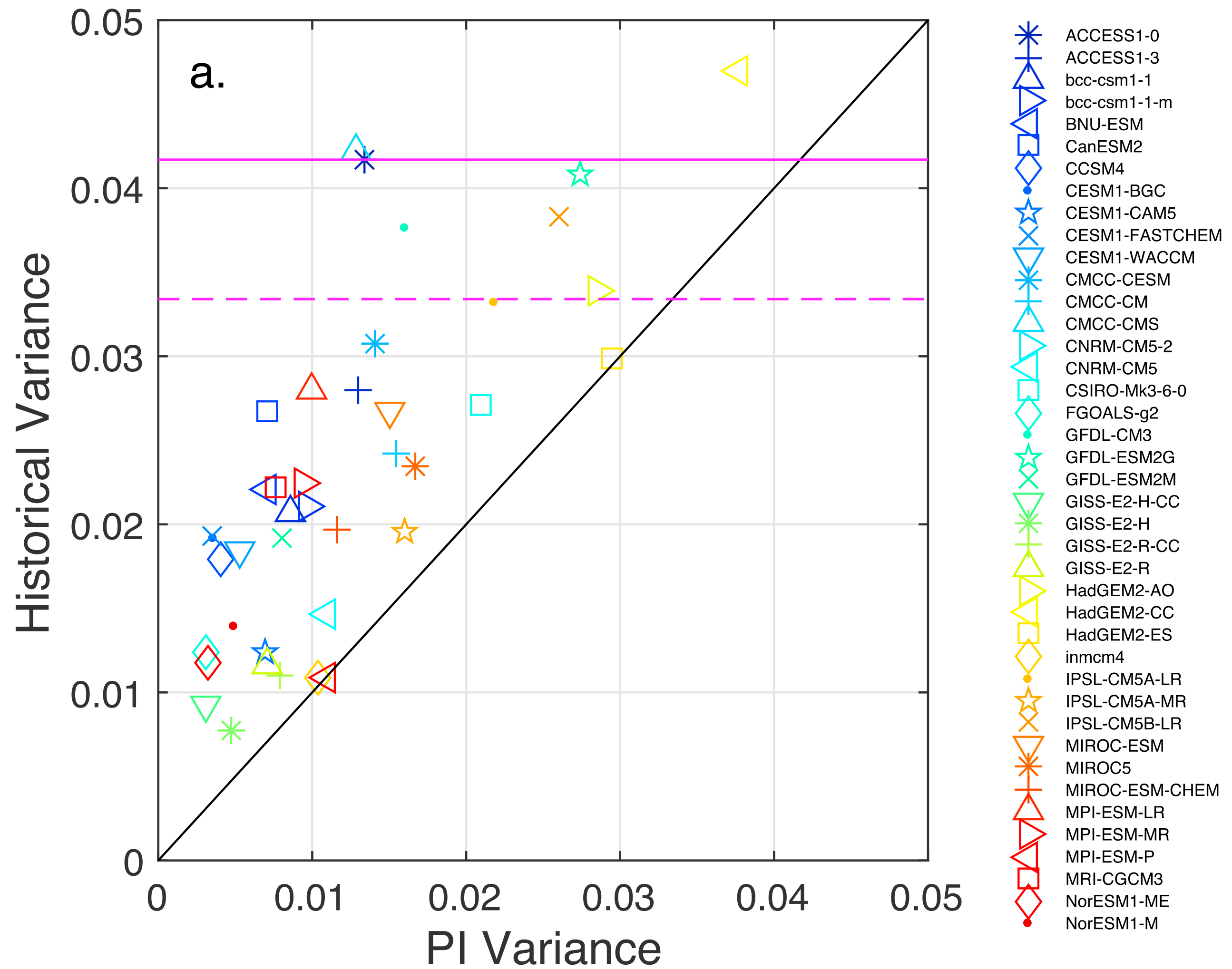




Scaling the MMEM



What could possibly go wrong?



Murphy et al., GRL, 2017
(used linear detrending)

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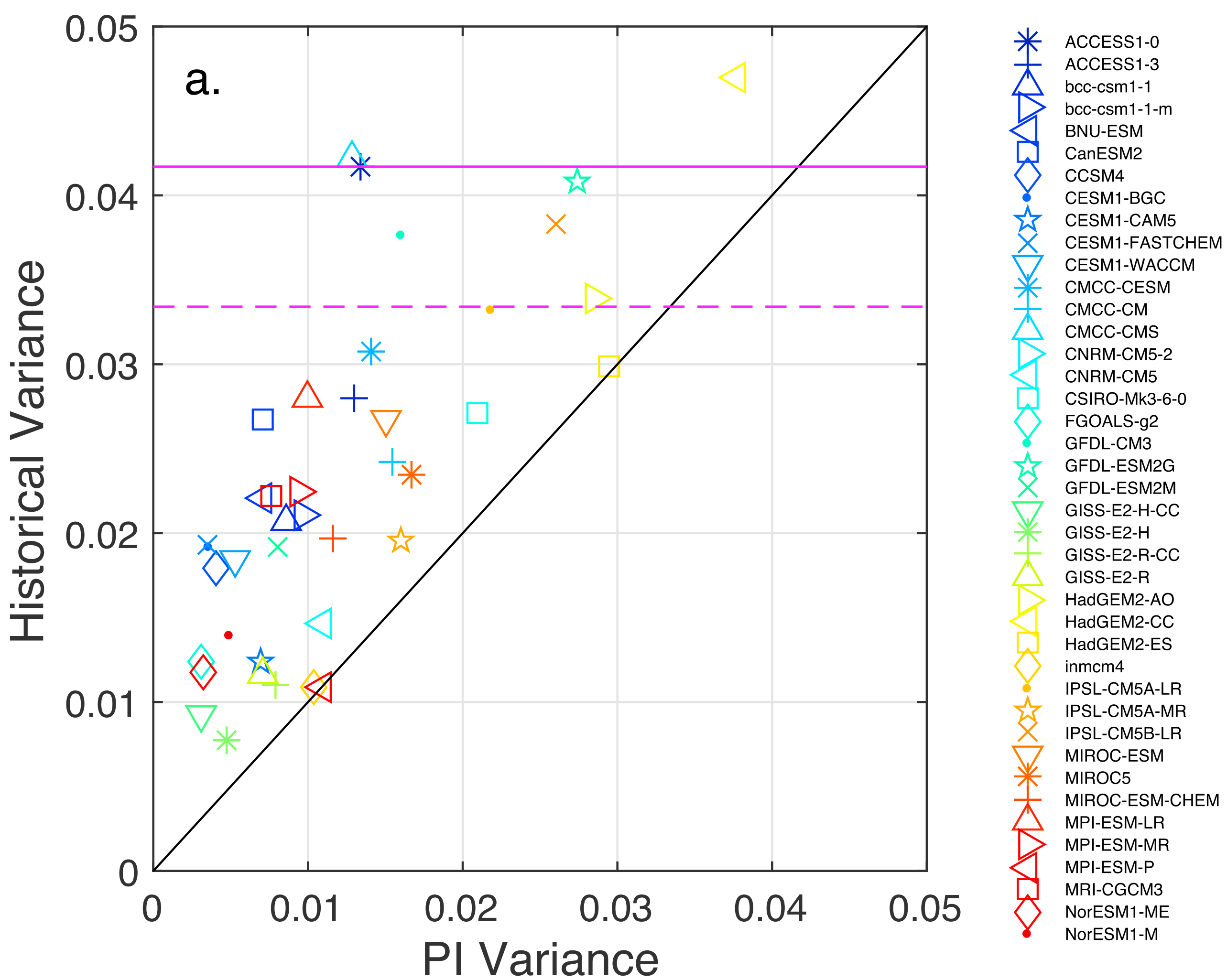
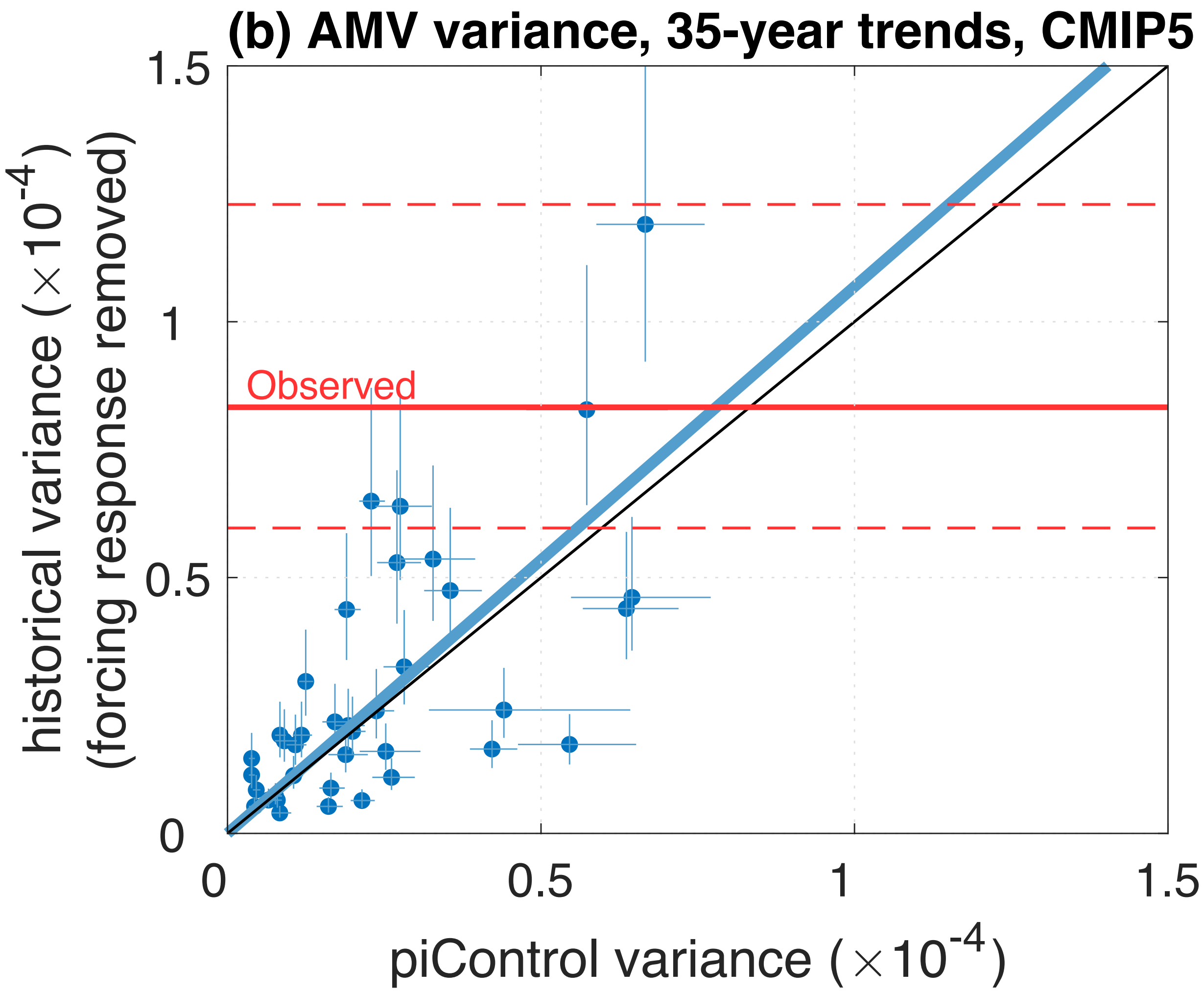


Murphy et al., GRL, 2017
(used linear detrending)



Kajtar et al., GRL, 2019

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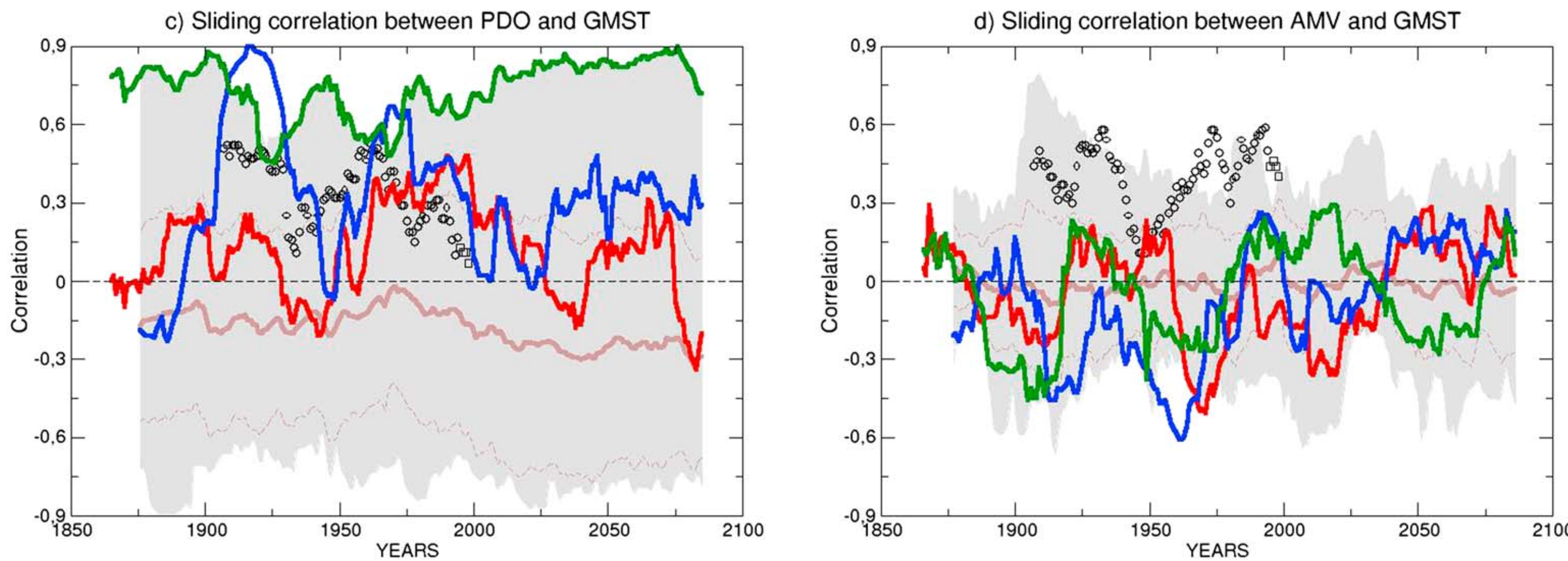

Douville et al., GRL, 2015 (subtracted each ensemble members' global mean SST)

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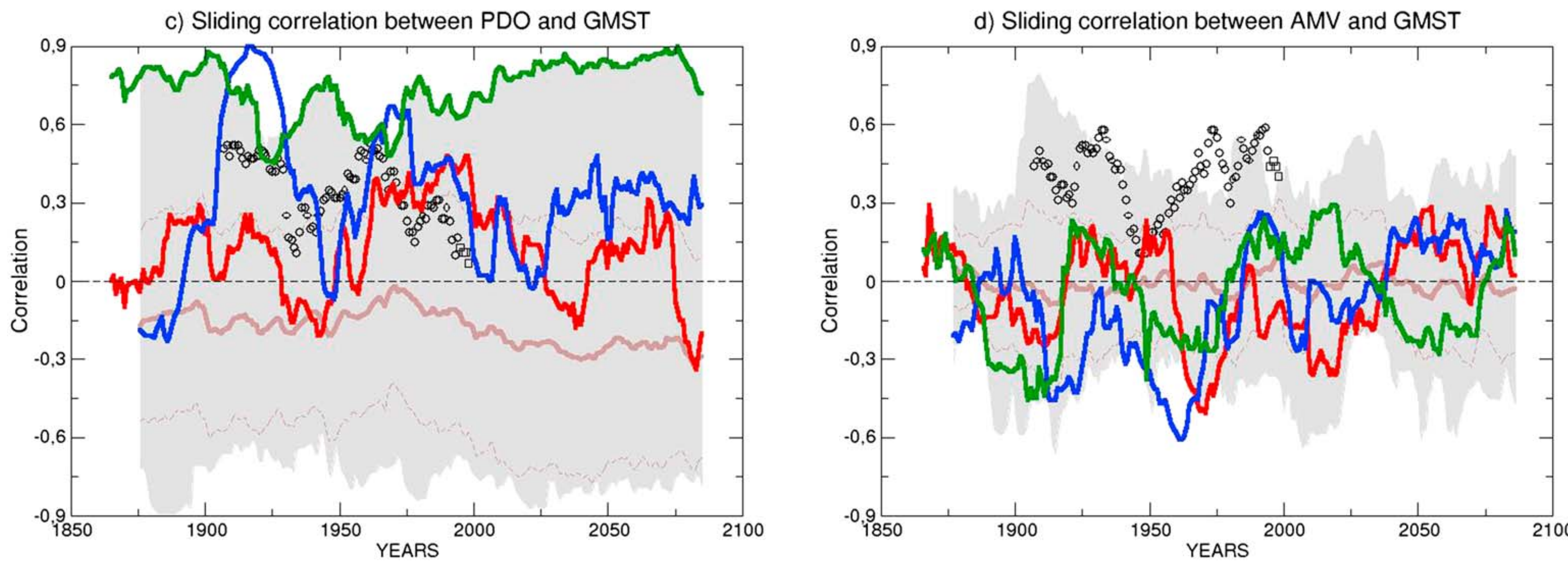

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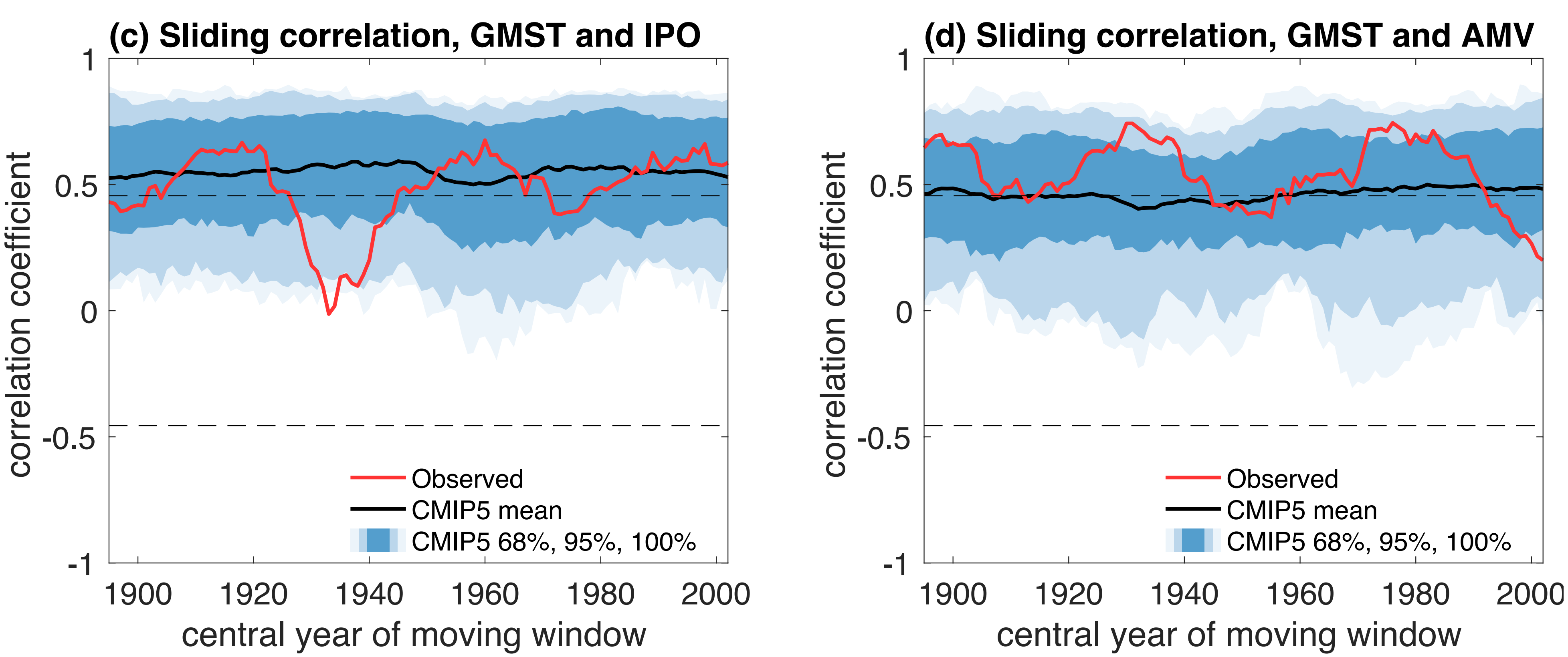
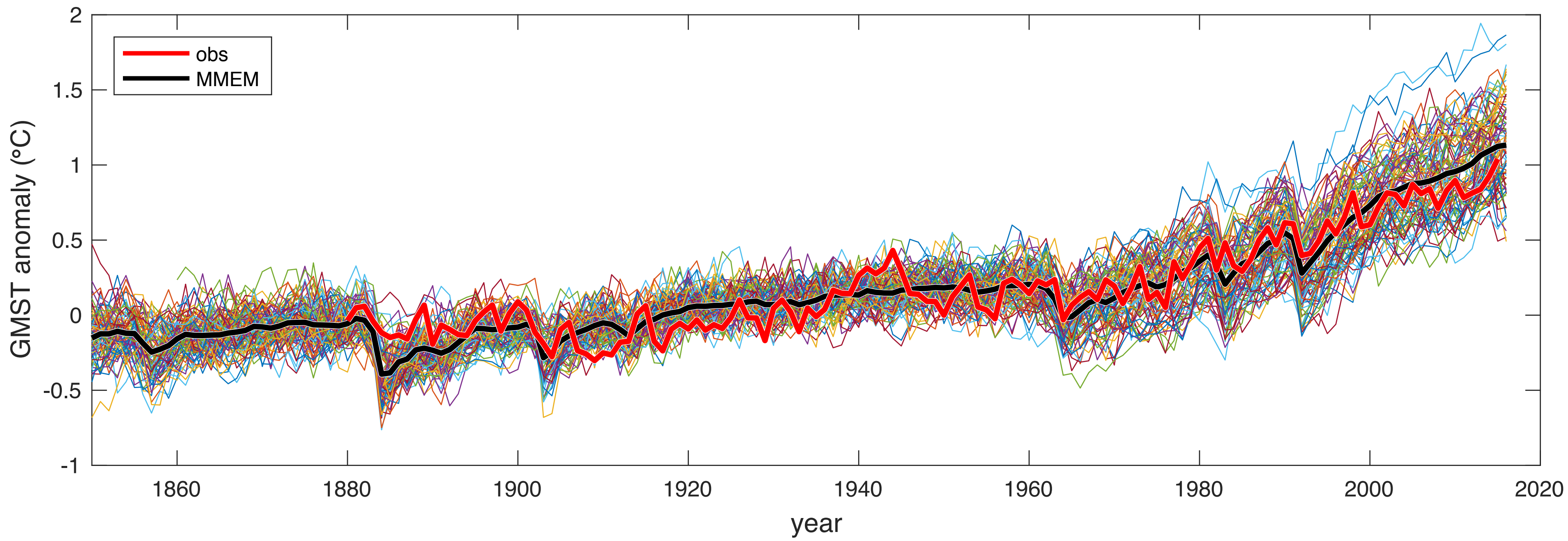
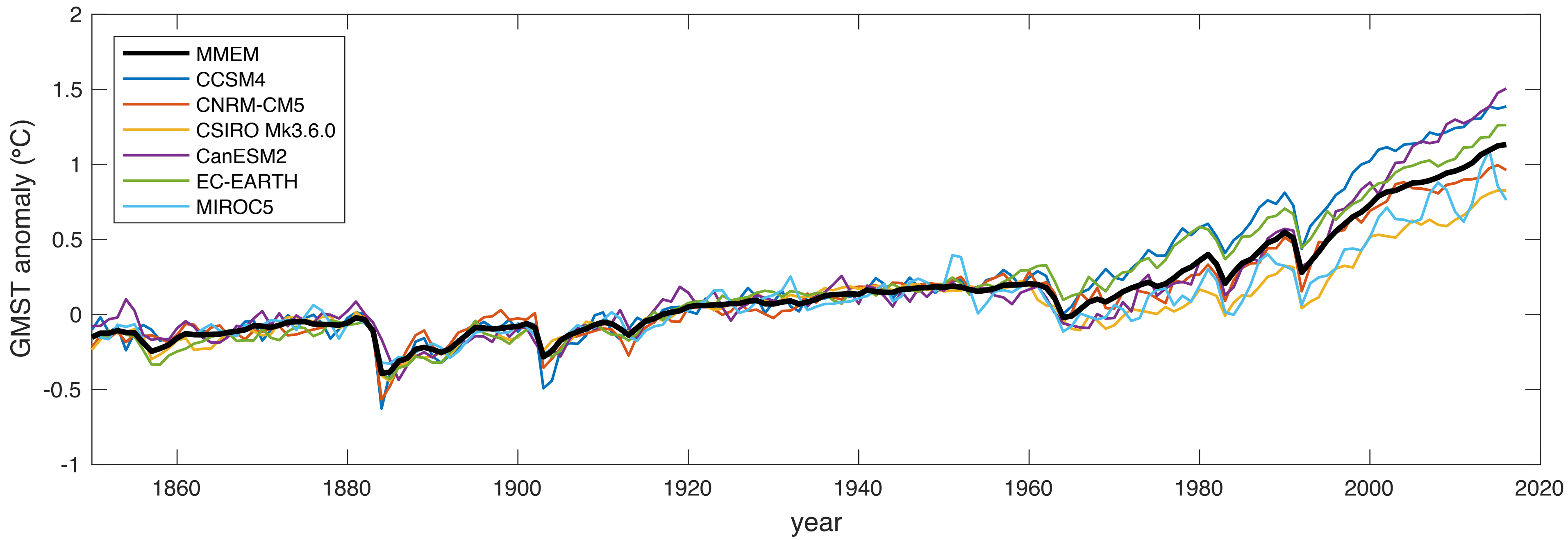


Kajtar et al., GRL, 2019

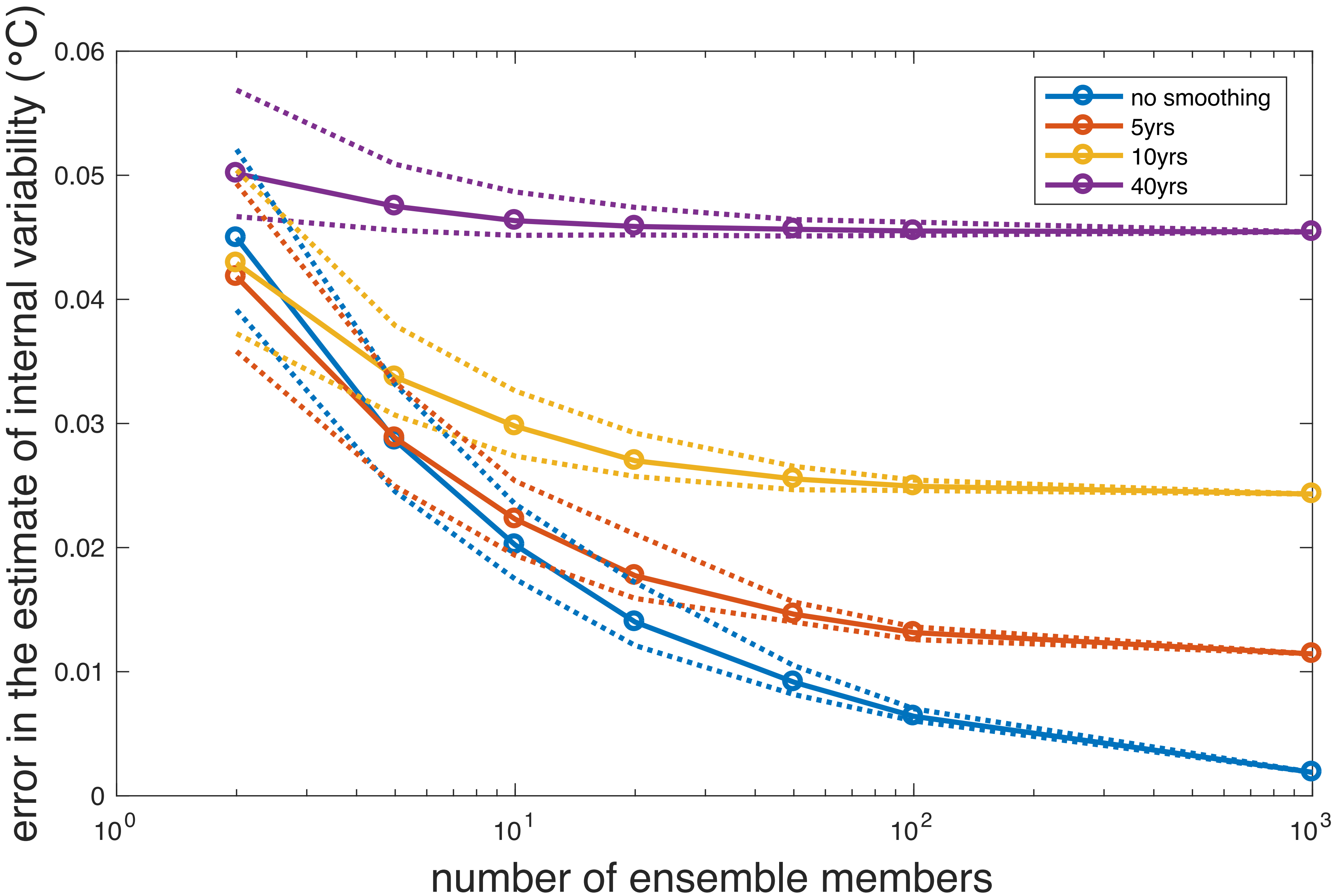
Using single model ensemble means





- How many ensemble members are required?

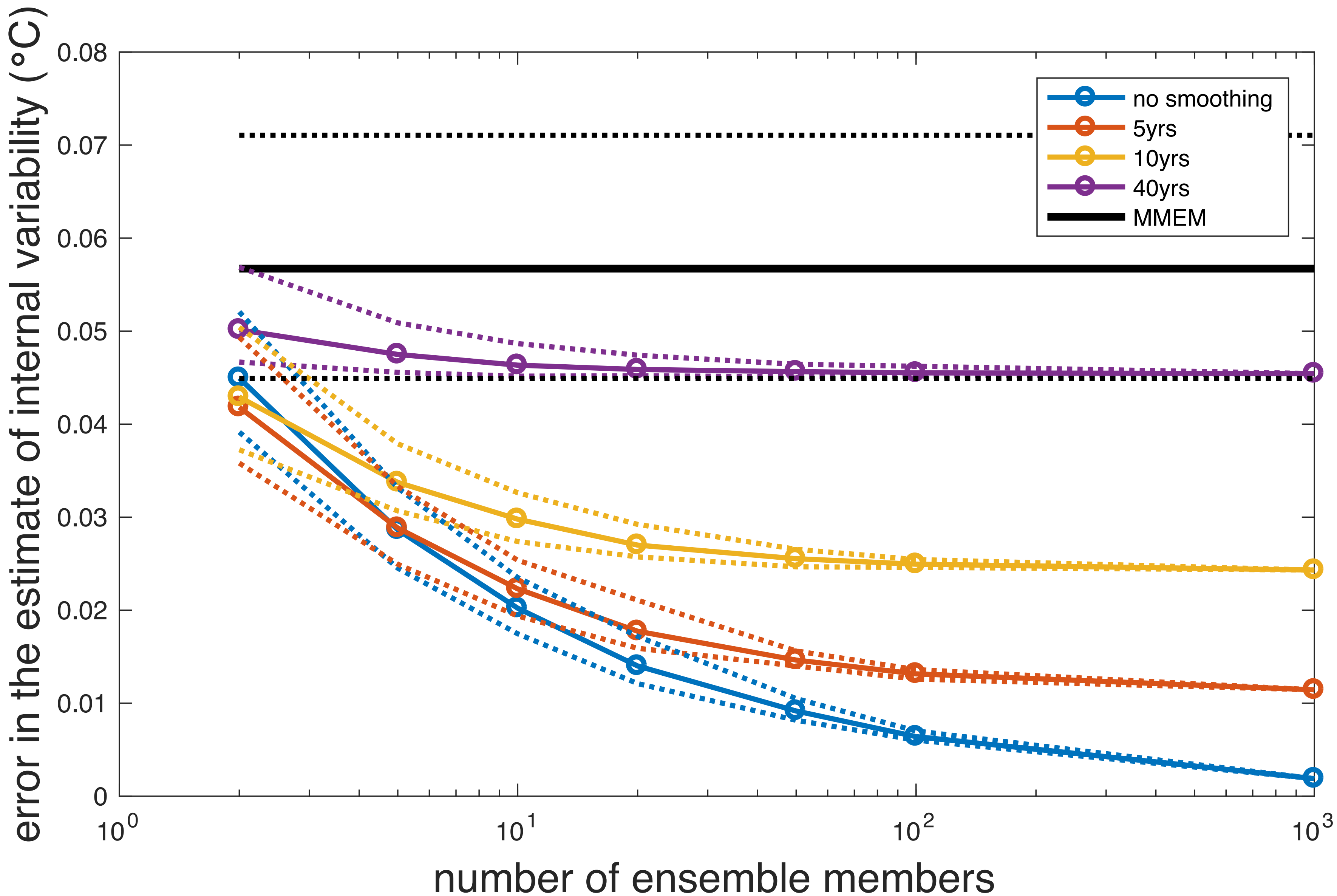
How many ensemble members?



- Smoothing the ensemble mean is ineffective

Frankcombe et al., J. Clim., 2015

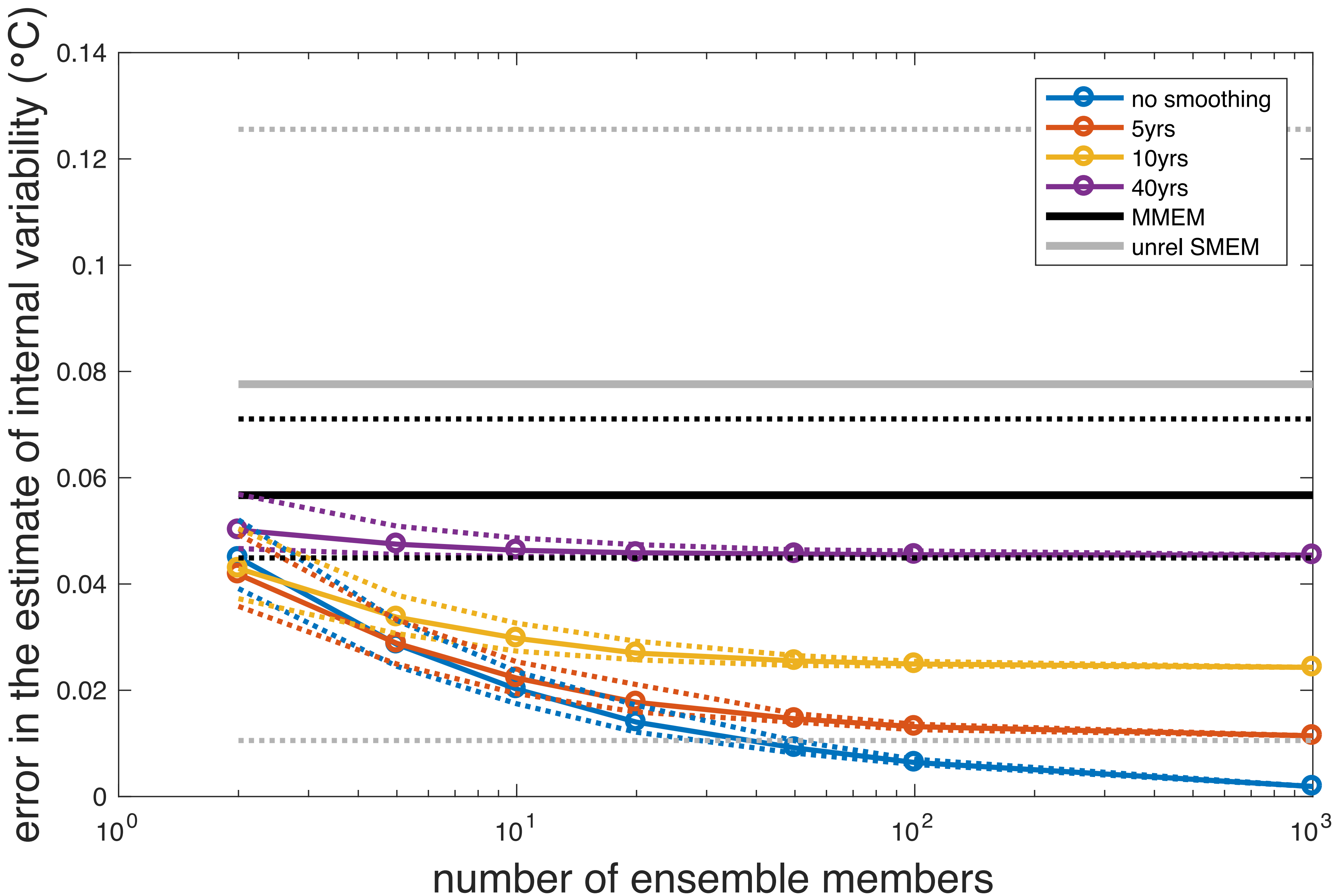
How many ensemble members?



- Even two ensemble members can be more accurate than using the multi-model ensemble mean

Frankcombe et al., J. Clim., 2015

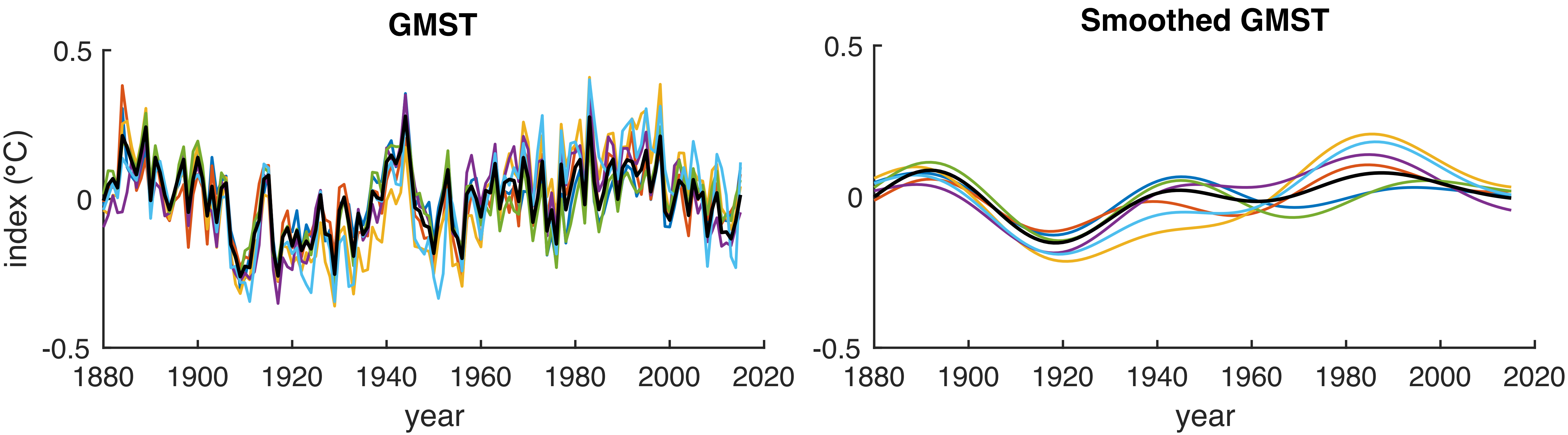
How many ensemble members?



- Using the MMEM is better than using the wrong SMEM

Frankcombe et al., J. Clim., 2015

Multiple estimates of internal variability from observations



Frankcombe et al., J. Clim., 2015

Conclusions so far…

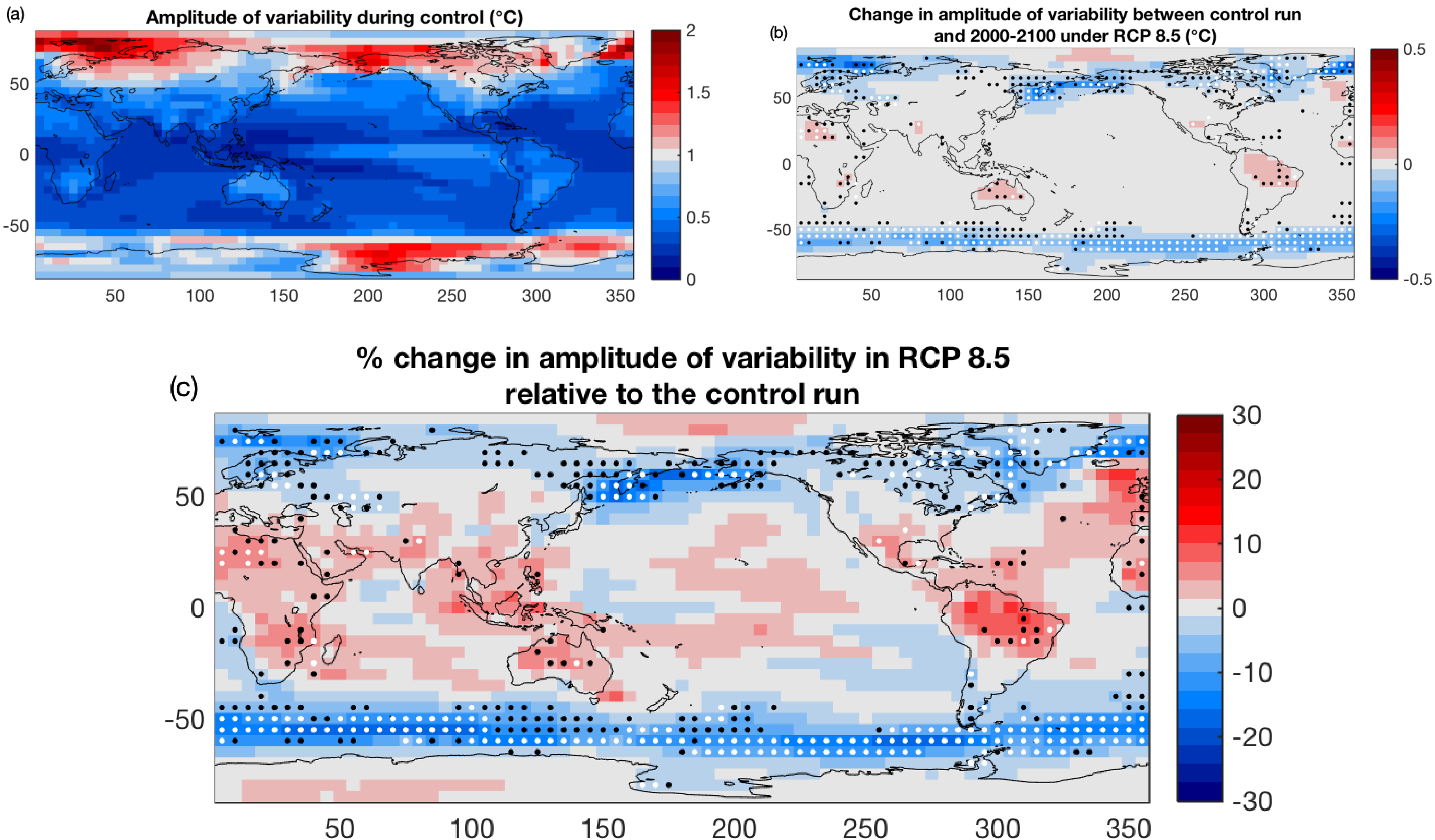
- Using an unsuitable method to remove the forced trend can result in large biases in estimates of internal variability.

- Useful single model ensemble means can be constructed with surprisingly few ensemble members.

- The (scaled) multi-model ensemble mean is still the best estimate for observations.

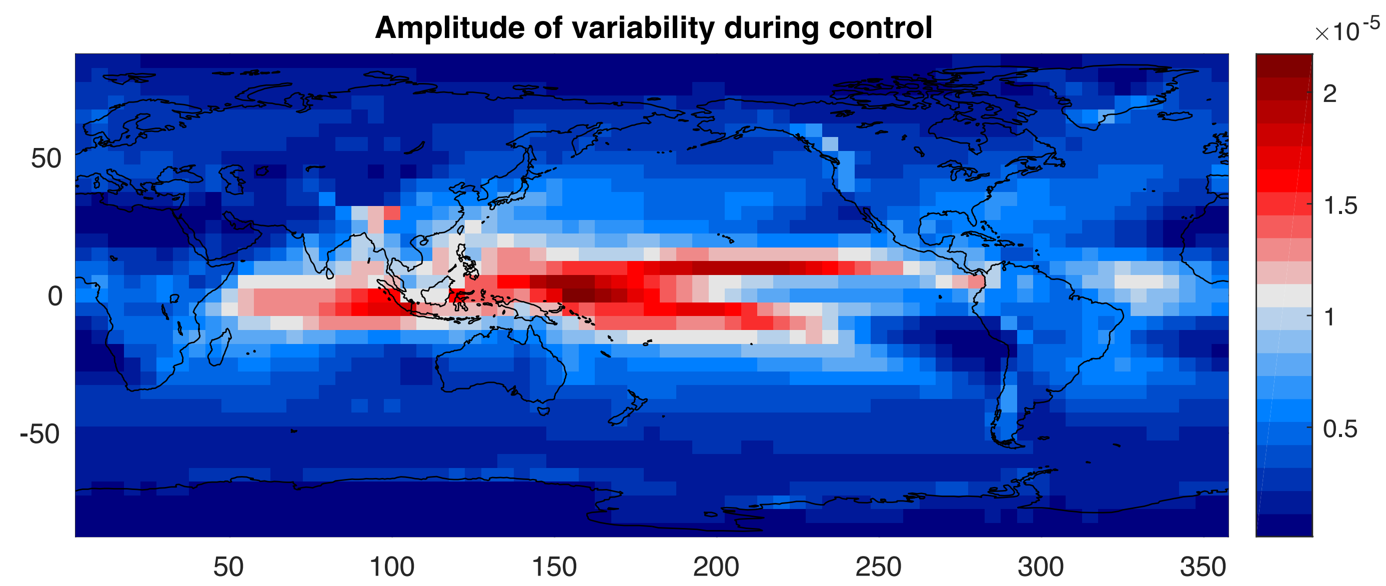
- **What about spatial patterns of variability?**

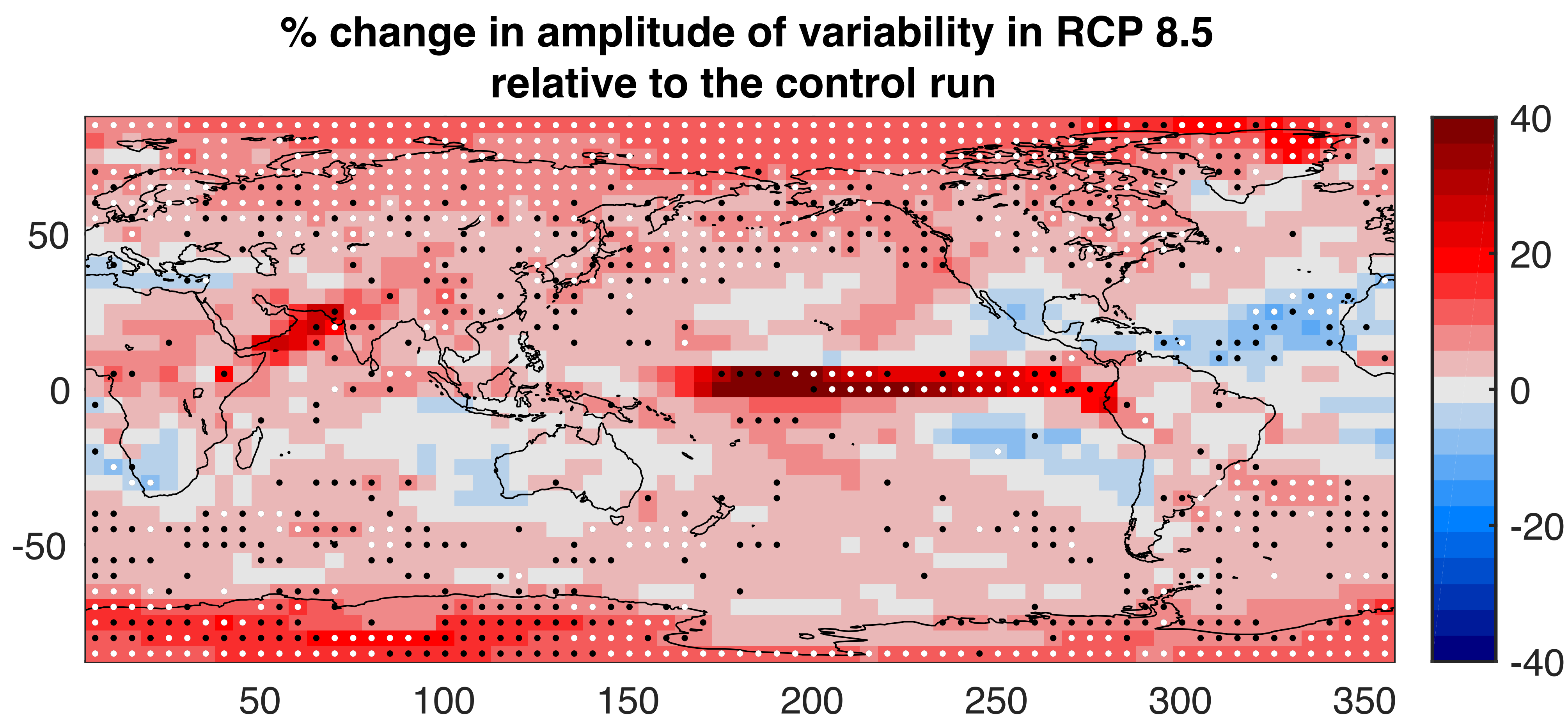
SAT



Frankcombe et al., J. Clim., 2018

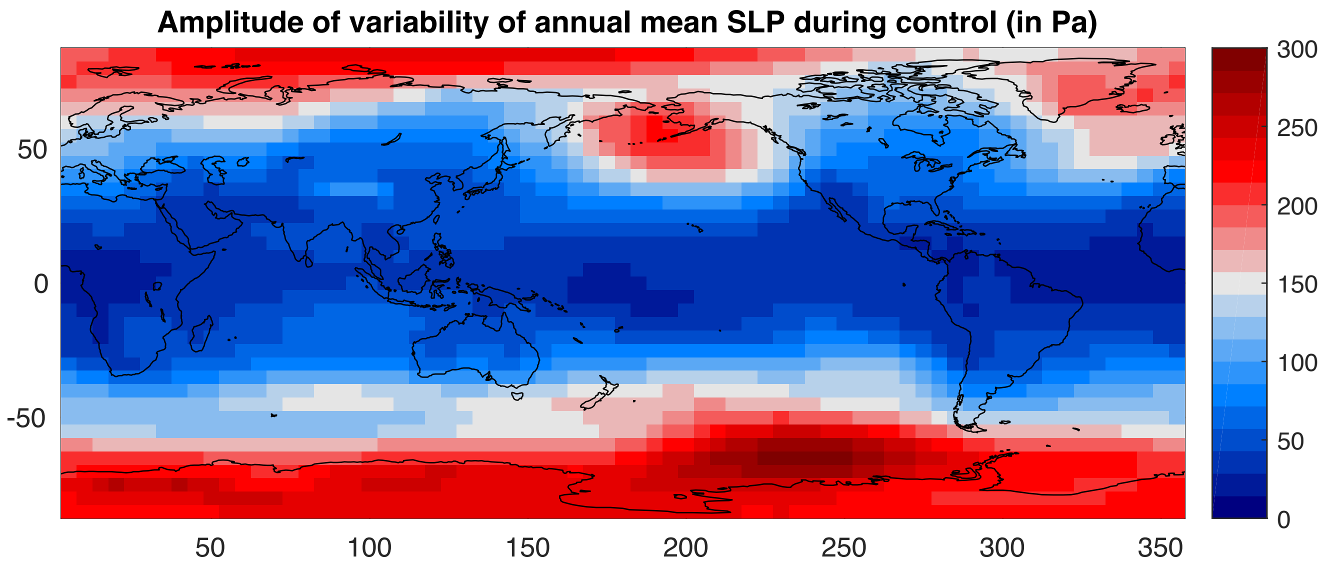
Precipitation





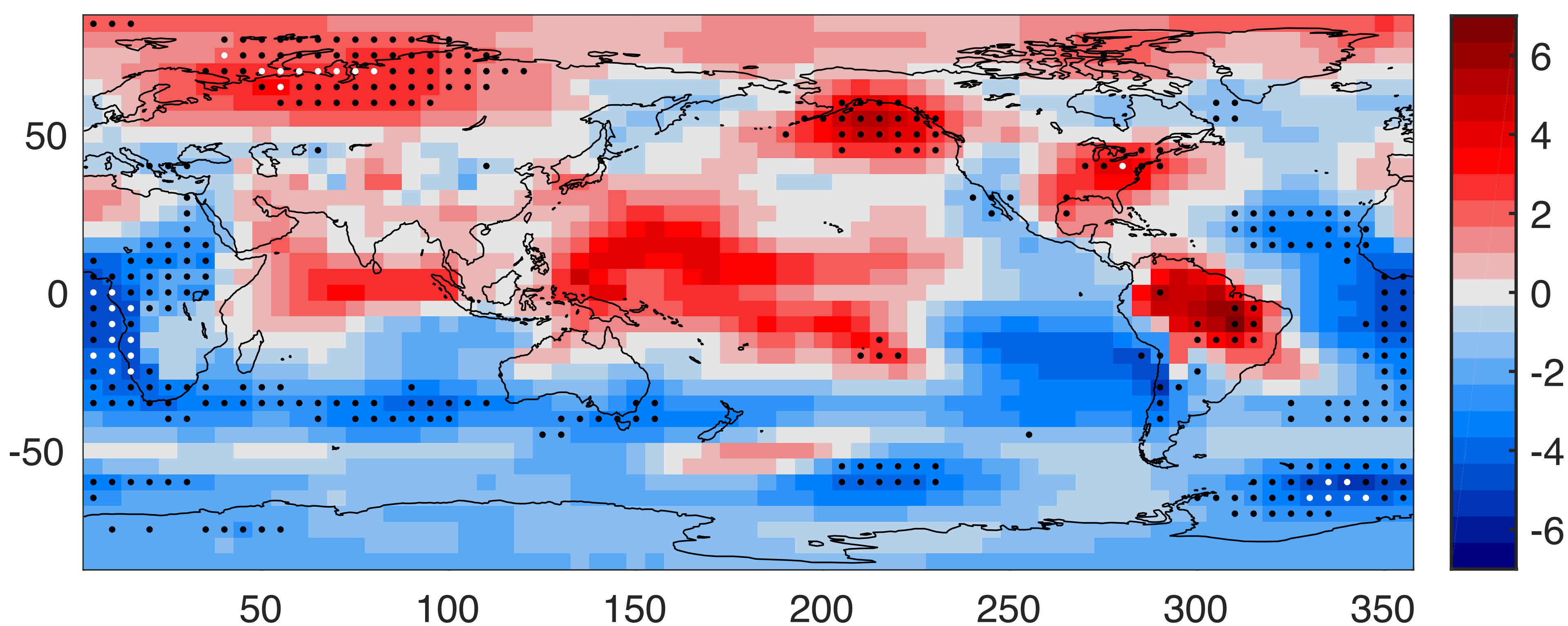
Frankcombe et al., J. Clim., 2018

SLP



Barnes and Polvani (2013):

- Jet variability is a function of jet latitude, with jets closer to the equator exhibiting more meridional shifting.
- In the SH and NA, jets shift poleward in future climates.
- Opposite in the NP.



Frankcombe et al., J. Clim., 2018

Changing spatial variability

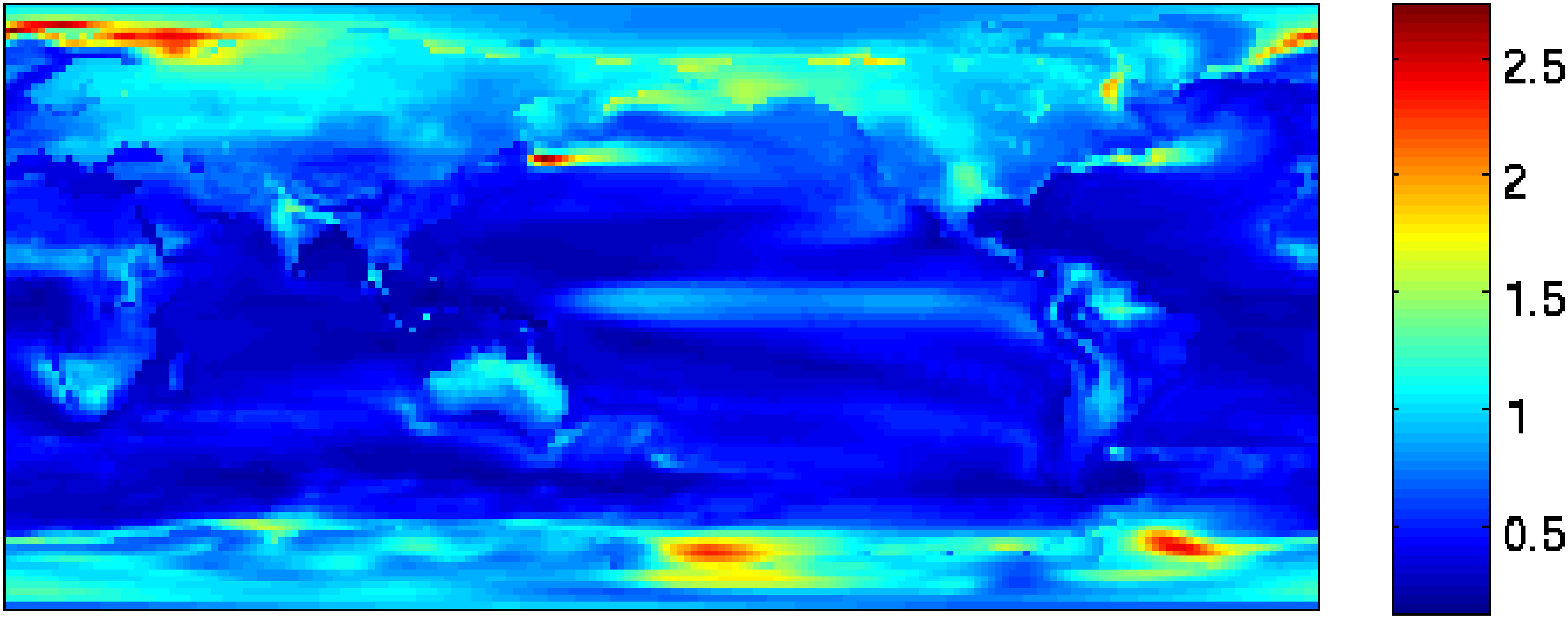
- Internal variability of SAT is projected to decrease along sea ice edges and increase over land at low latitudes.

- Variability of precipitation will increase, particularly at high latitudes.

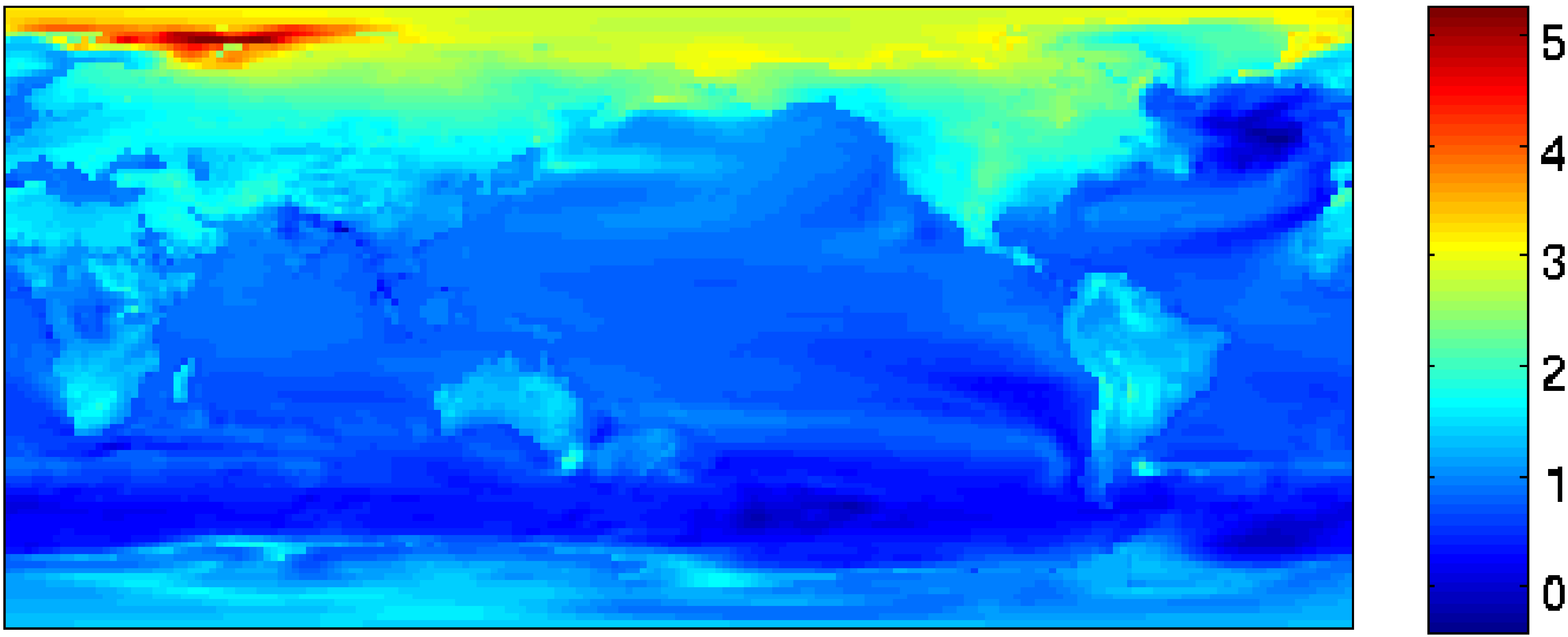
- SLP variability is projected to decrease in the Southern Hemisphere and the North Atlantic and increase in the North Pacific.

- **Can we learn anything from comparing local and global responses?**

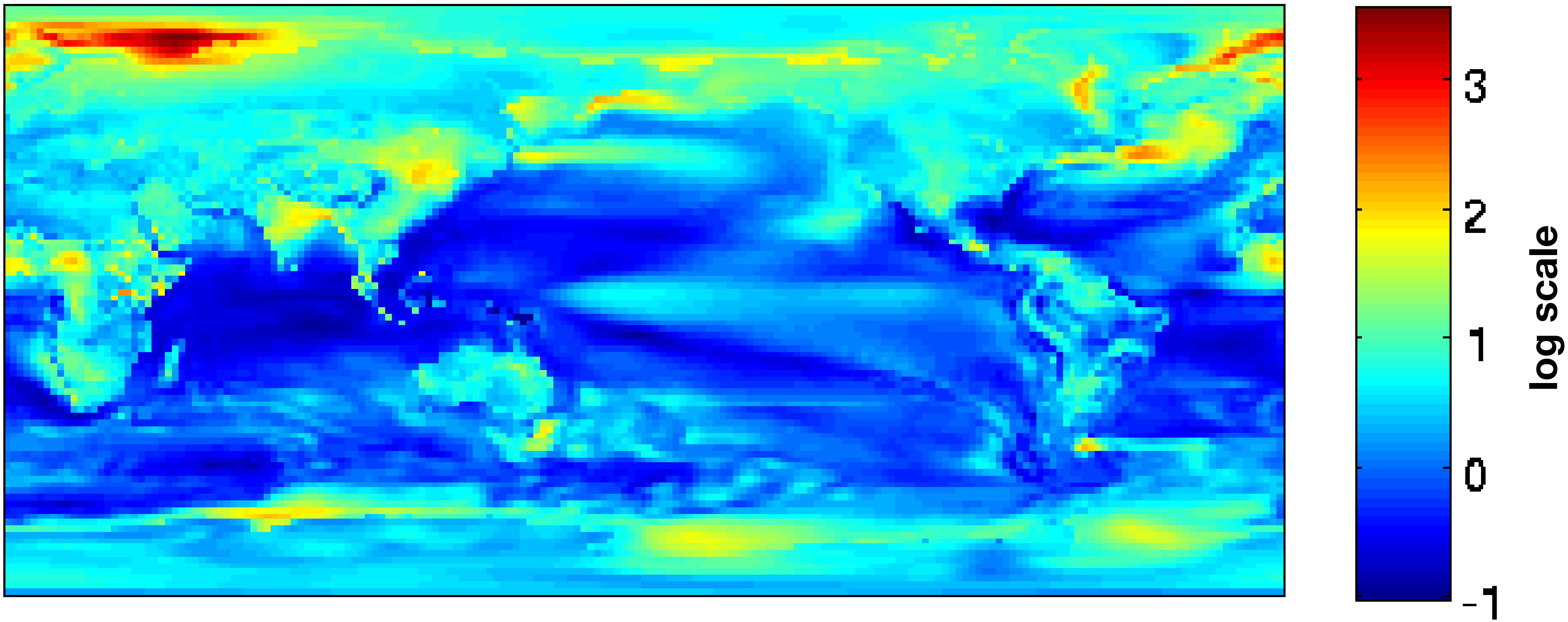
Amplitude of variability



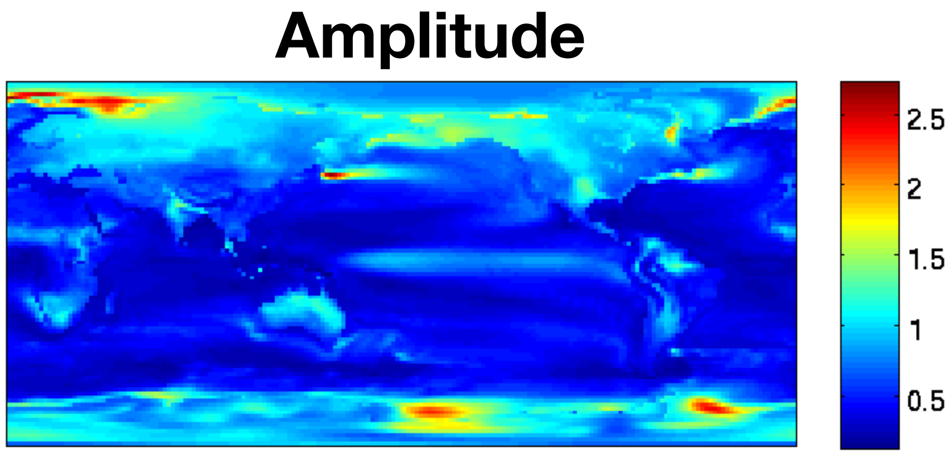
Spatial variation of scaling coefficient

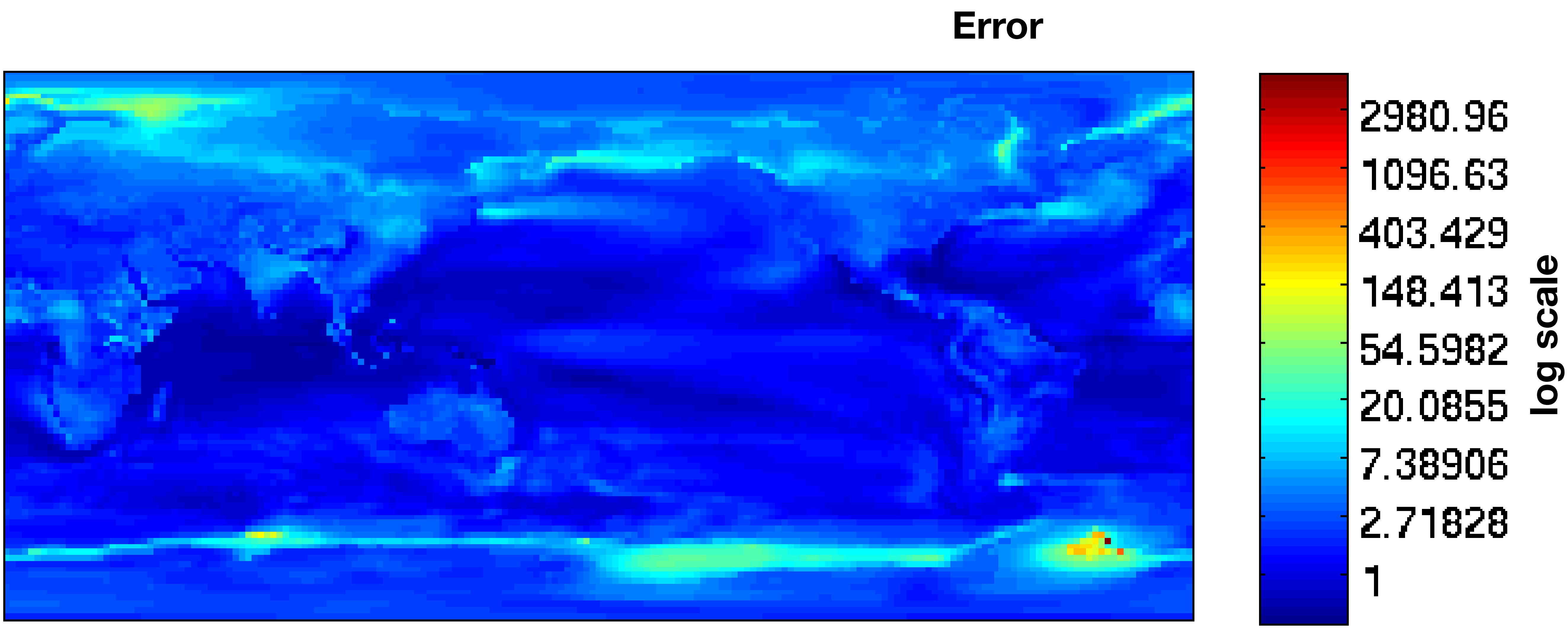


Error in local estimate of forced signal



Error in estimate of variability





Conclusions

- Using an unsuitable method to remove the forced trend can result in large biases in estimates of internal variability.
- Useful single model ensemble means can be constructed with surprisingly few ensemble members.
- The (scaled) multi-model ensemble mean is still the best estimate for observations.
- We can make predictions about future changes in variability, but only using models with a sufficient number of ensemble members.
- There are regions where the local forced signal differs considerably from the global mean (work in progress…).

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