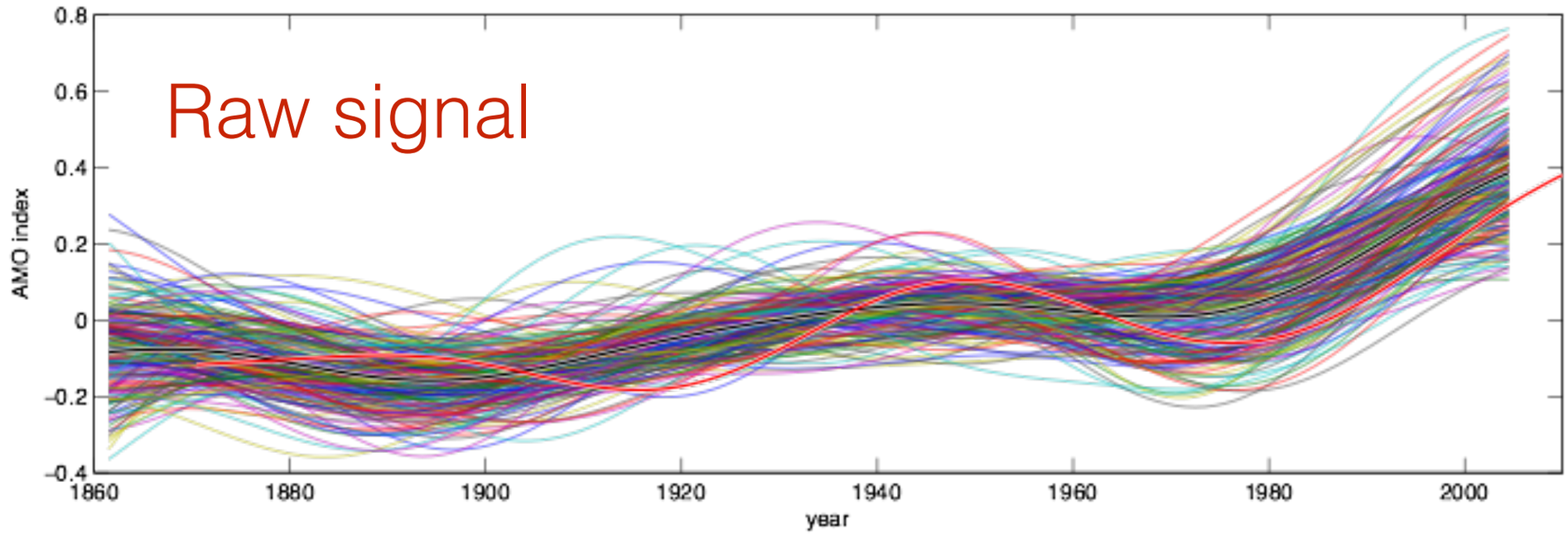
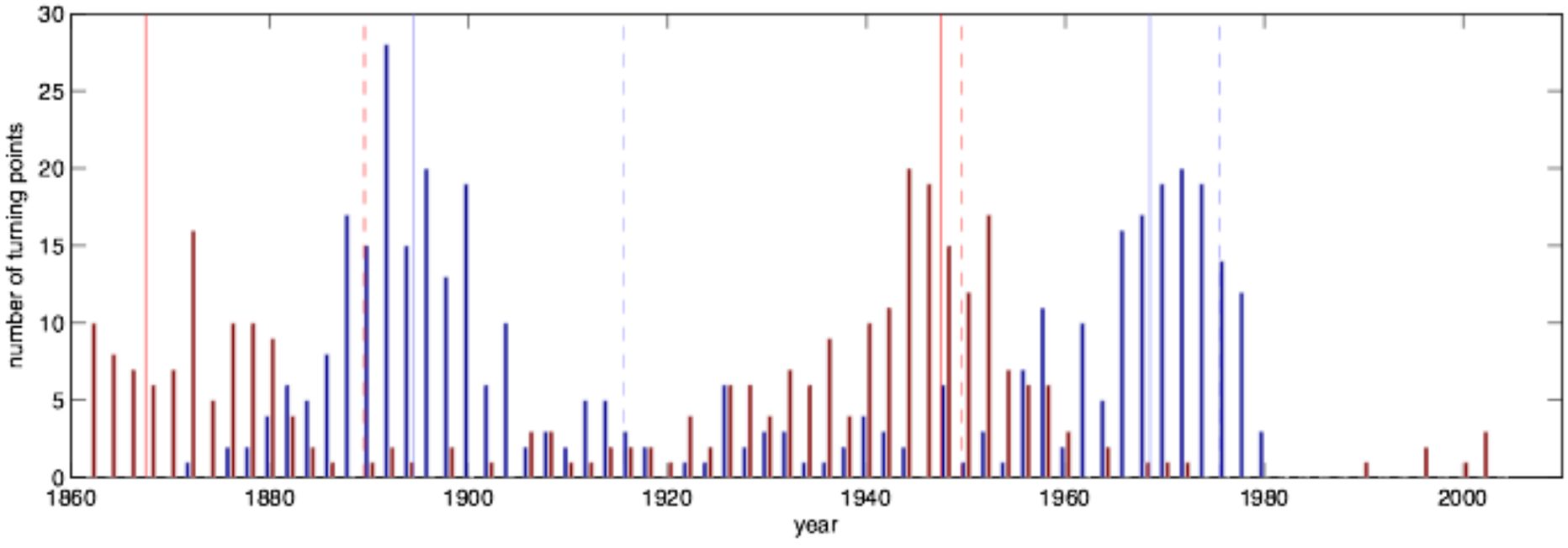
Separating internal variability from the forced signal

Leela Frankcombe

Matthew England, Michael Mann and Byron Steinman

Biases introduced by incorrect removal of forced signal





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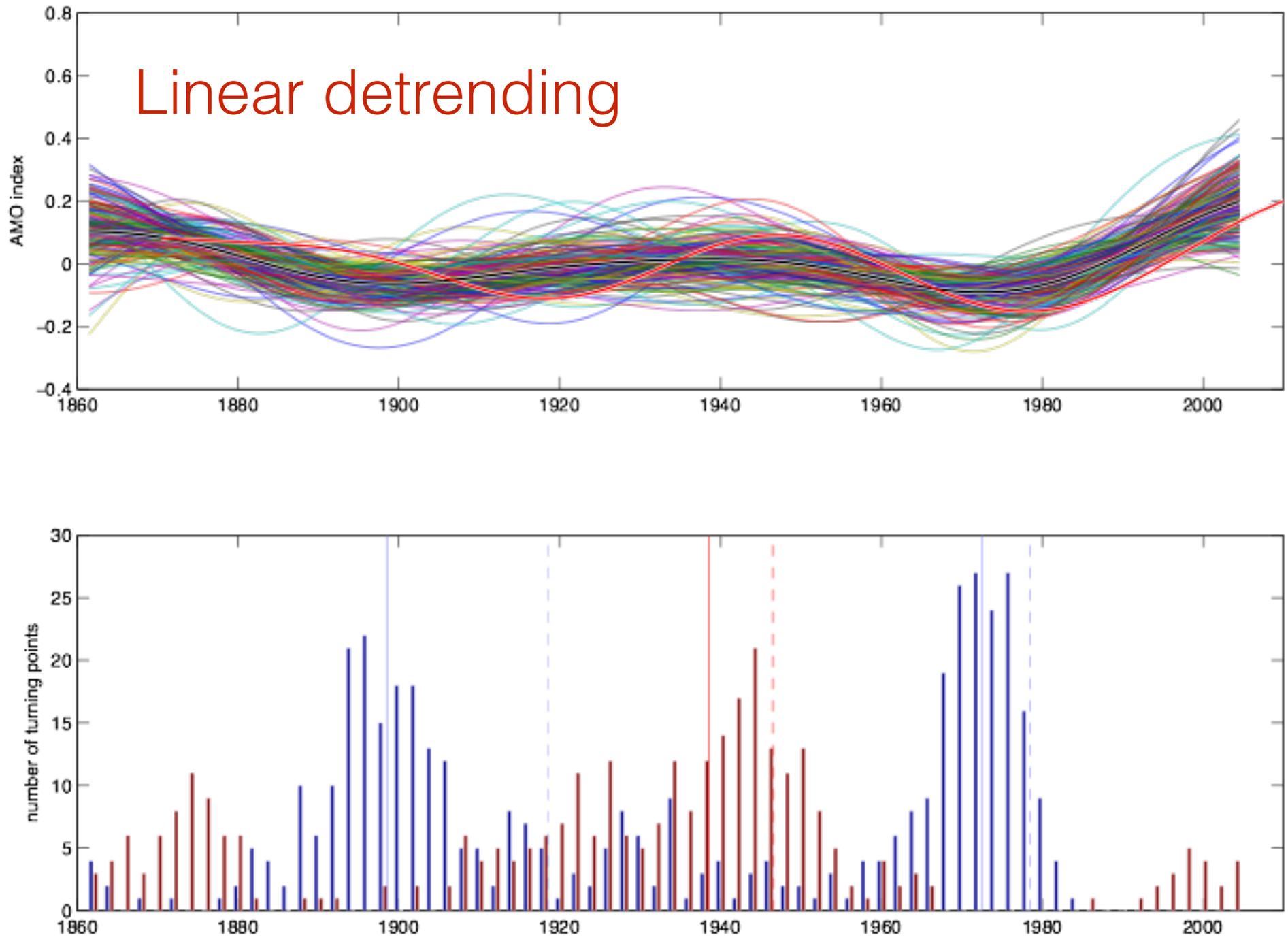

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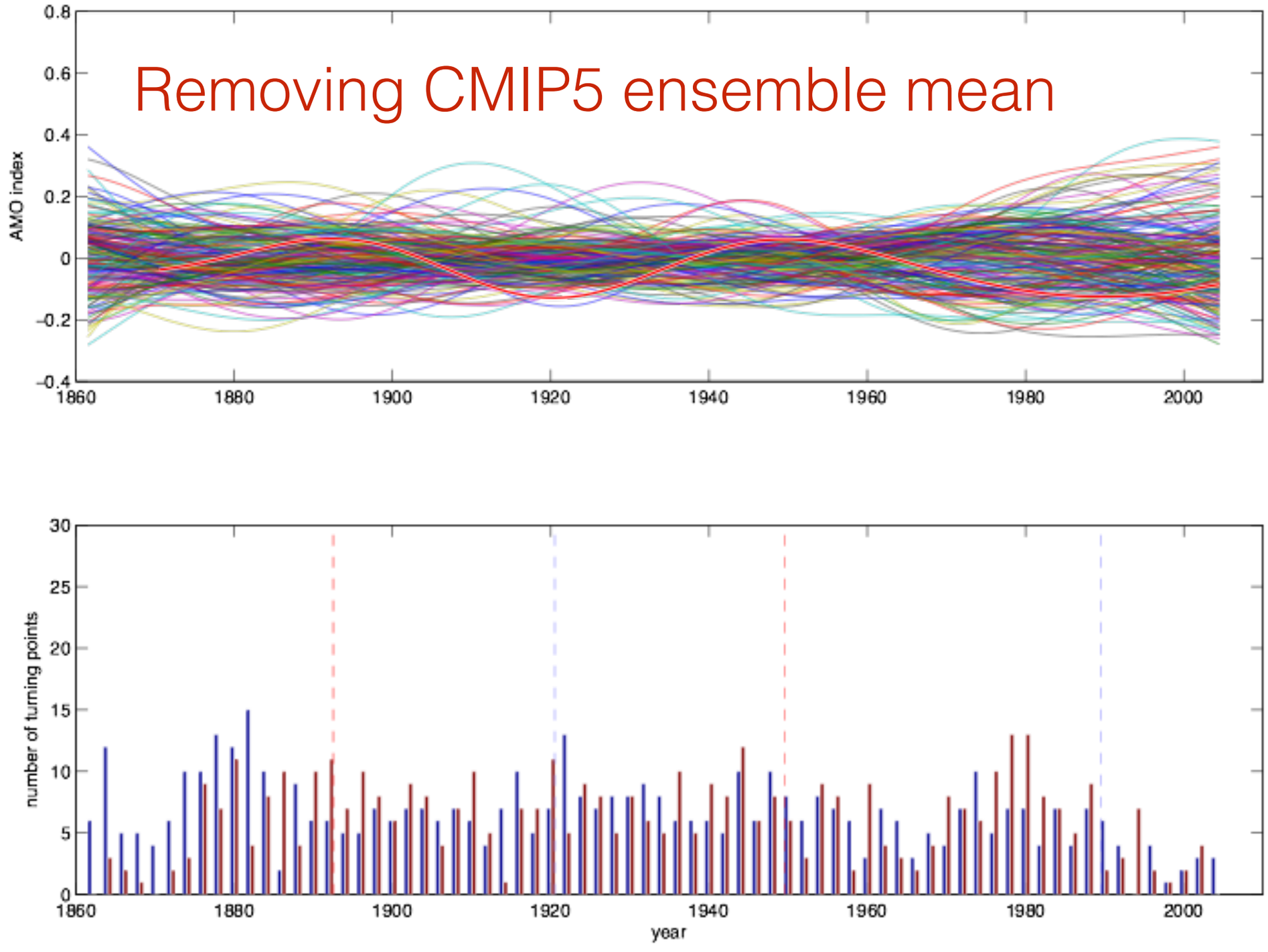
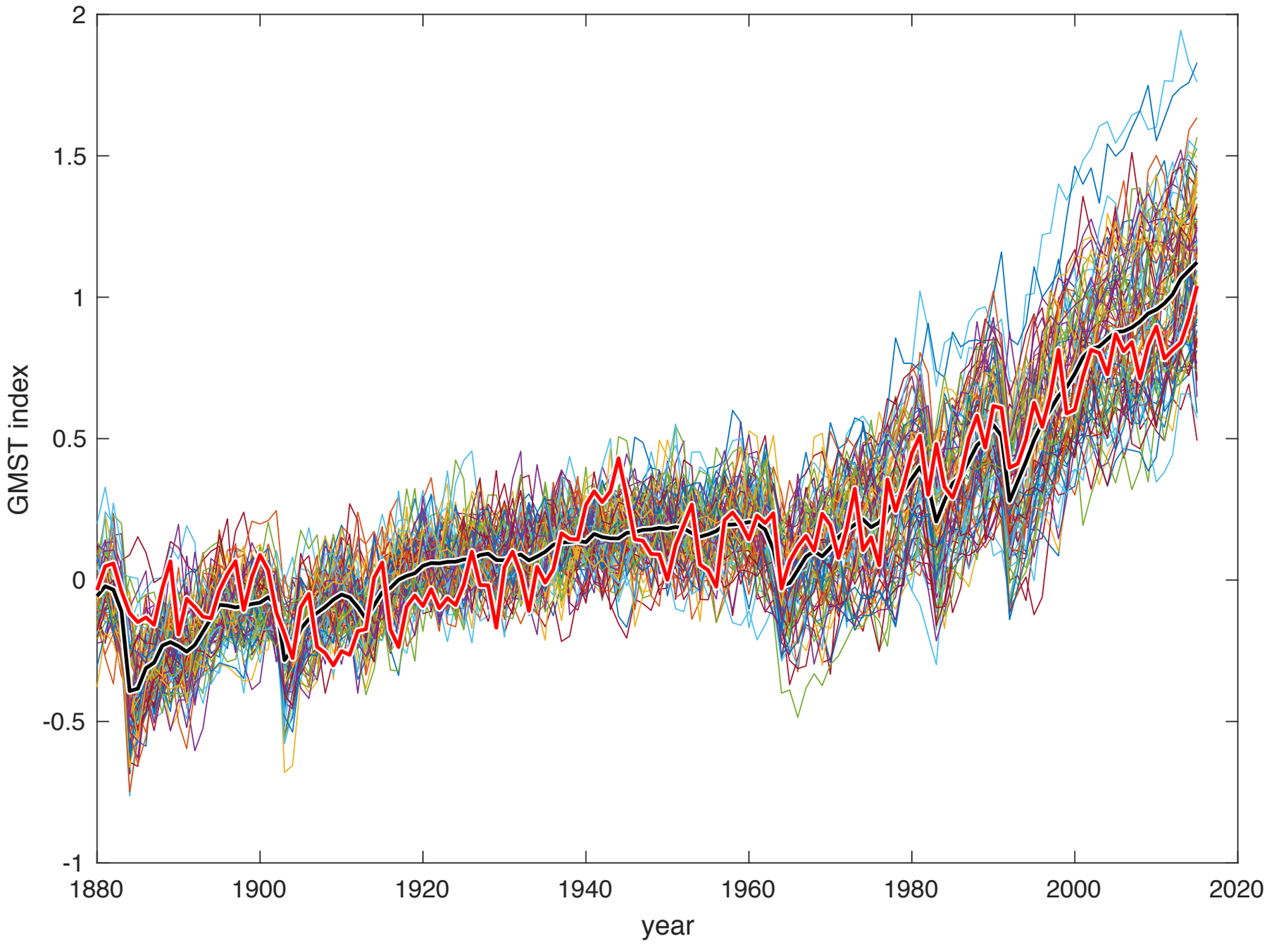
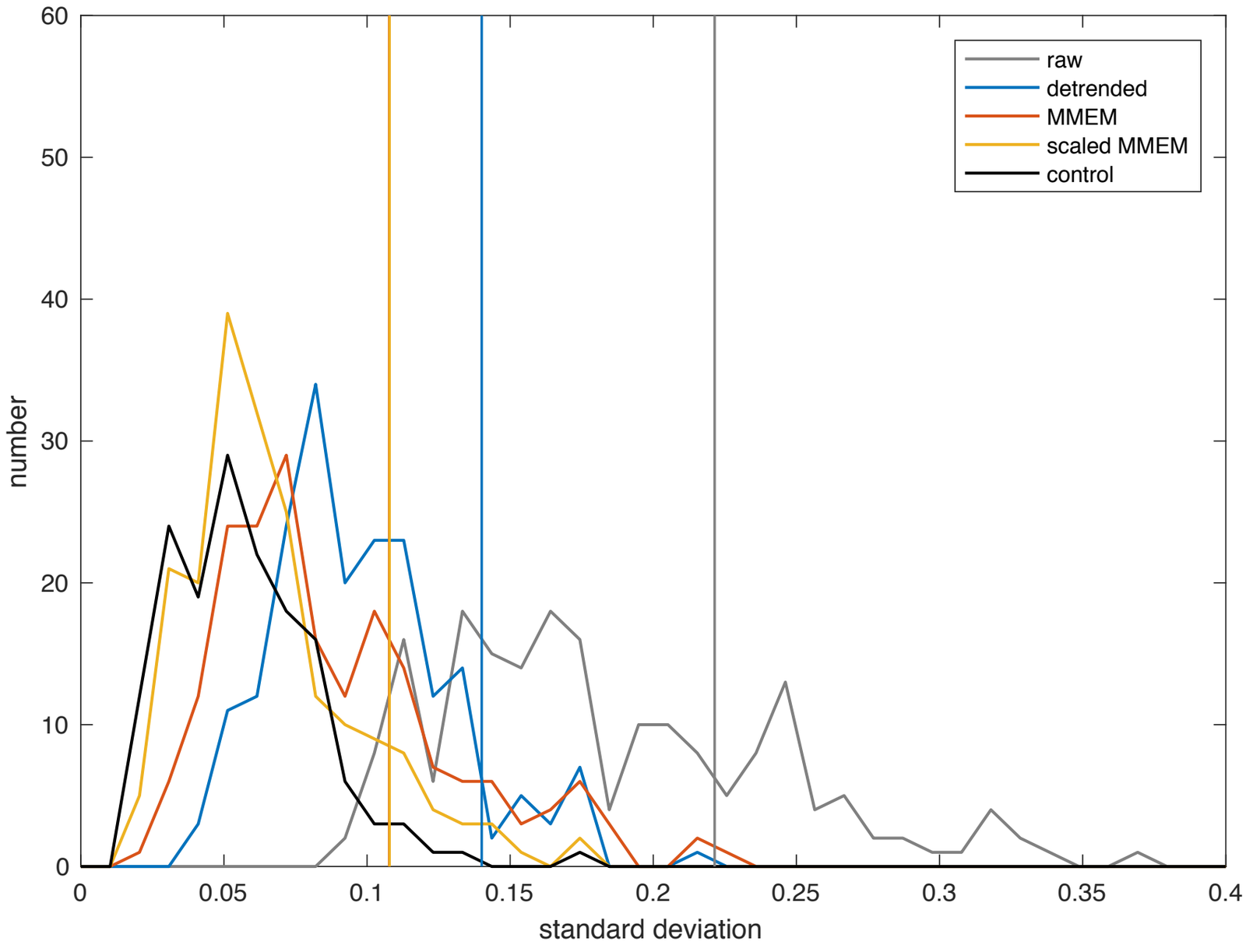


GMST in models



- Errors due to different climate sensitivities of the models

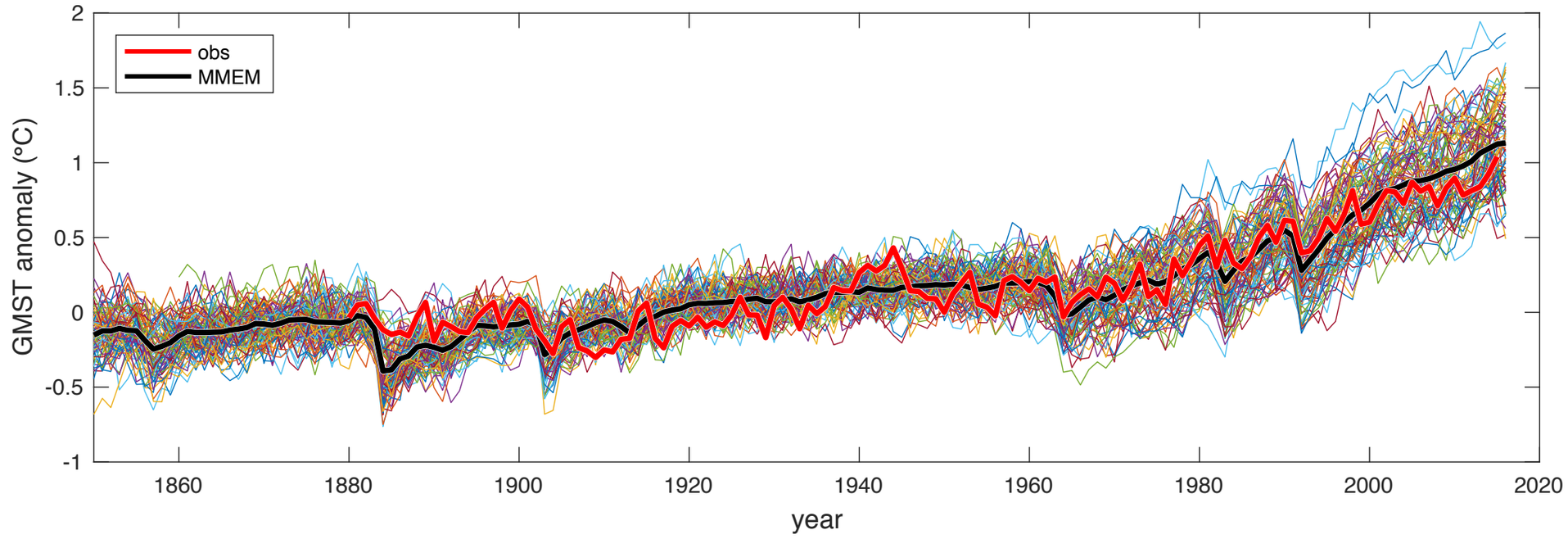
Methods for removing the forced signal

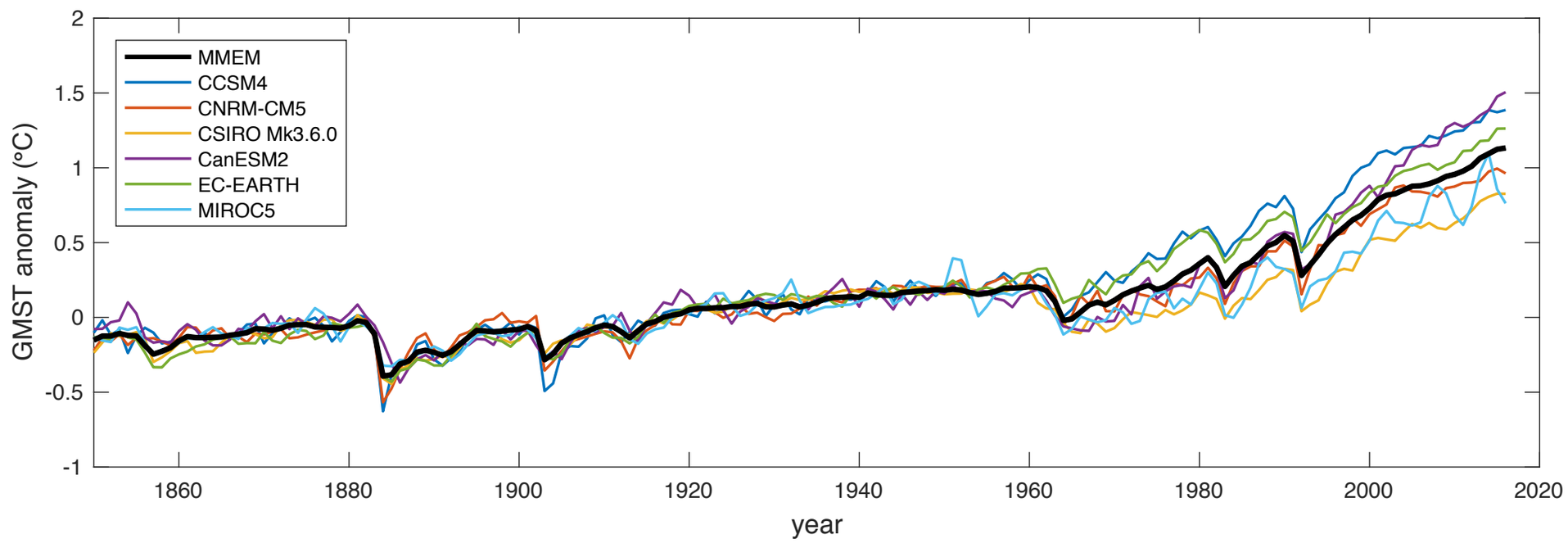


Frankcombe et al., J. Clim., 2015

- Scale and subtract the multimodel ensemble mean
- But…

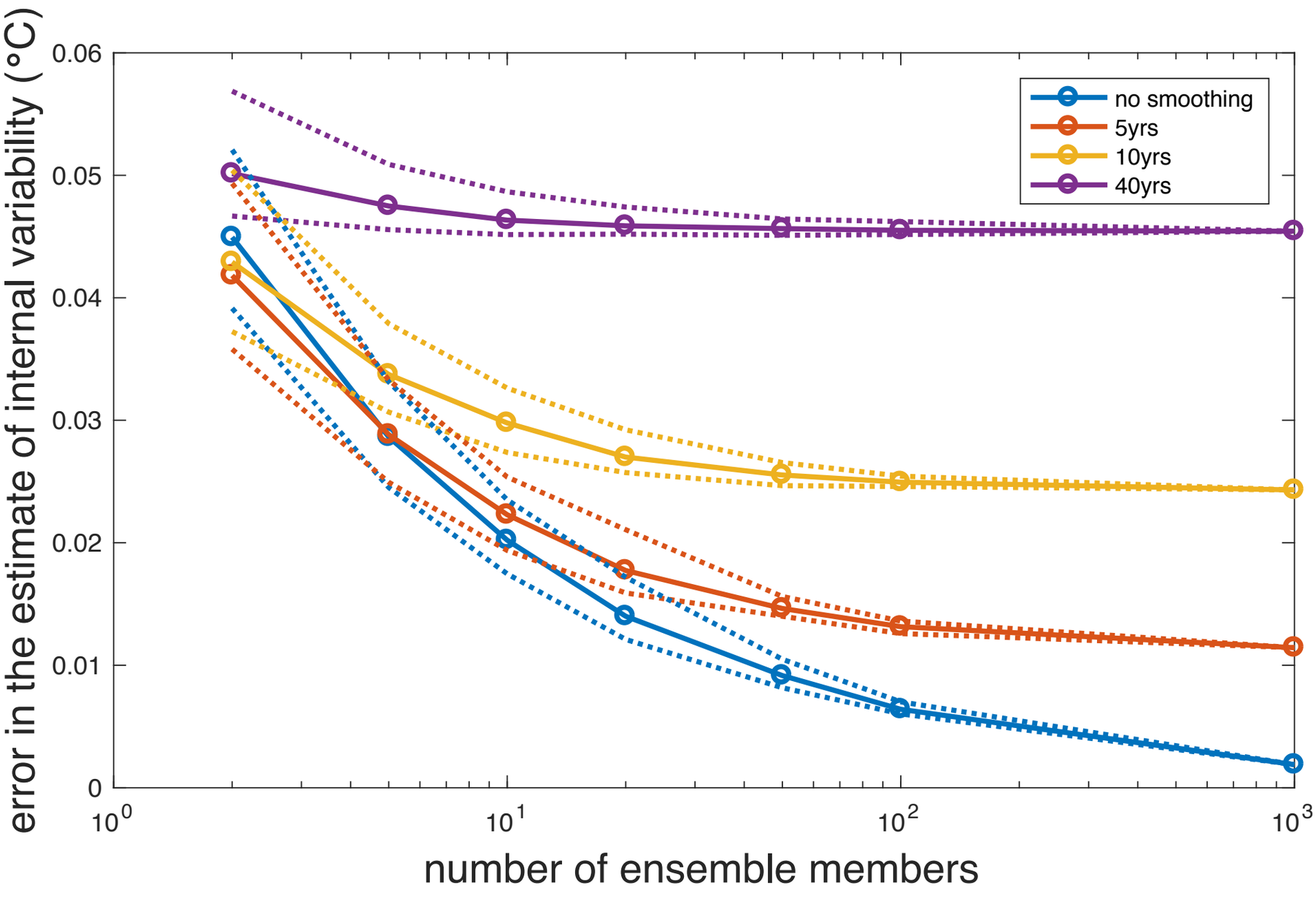
Using single model ensemble means





- How many ensemble members are required?

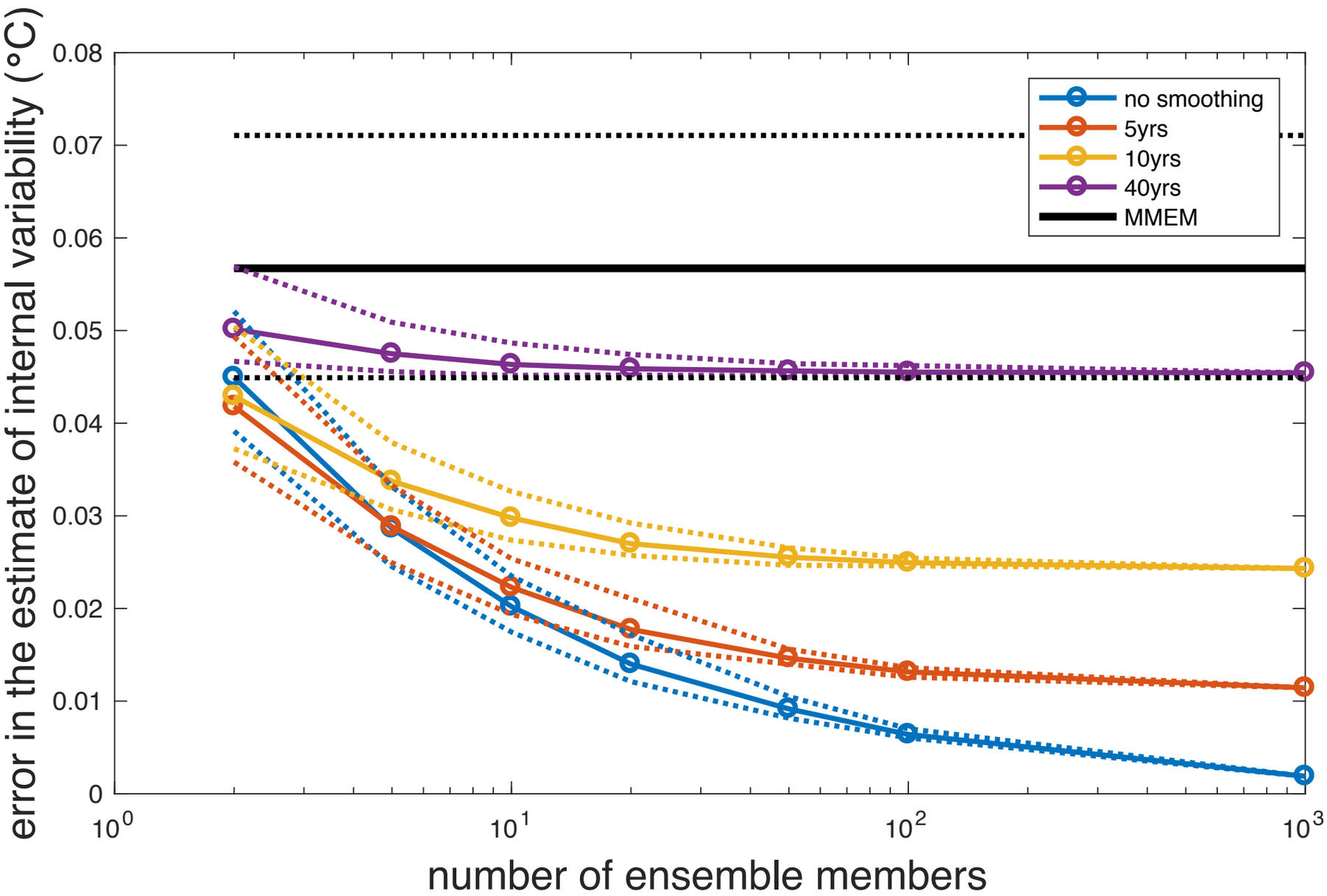
How many ensemble members?



Frankcombe et al., in prep.

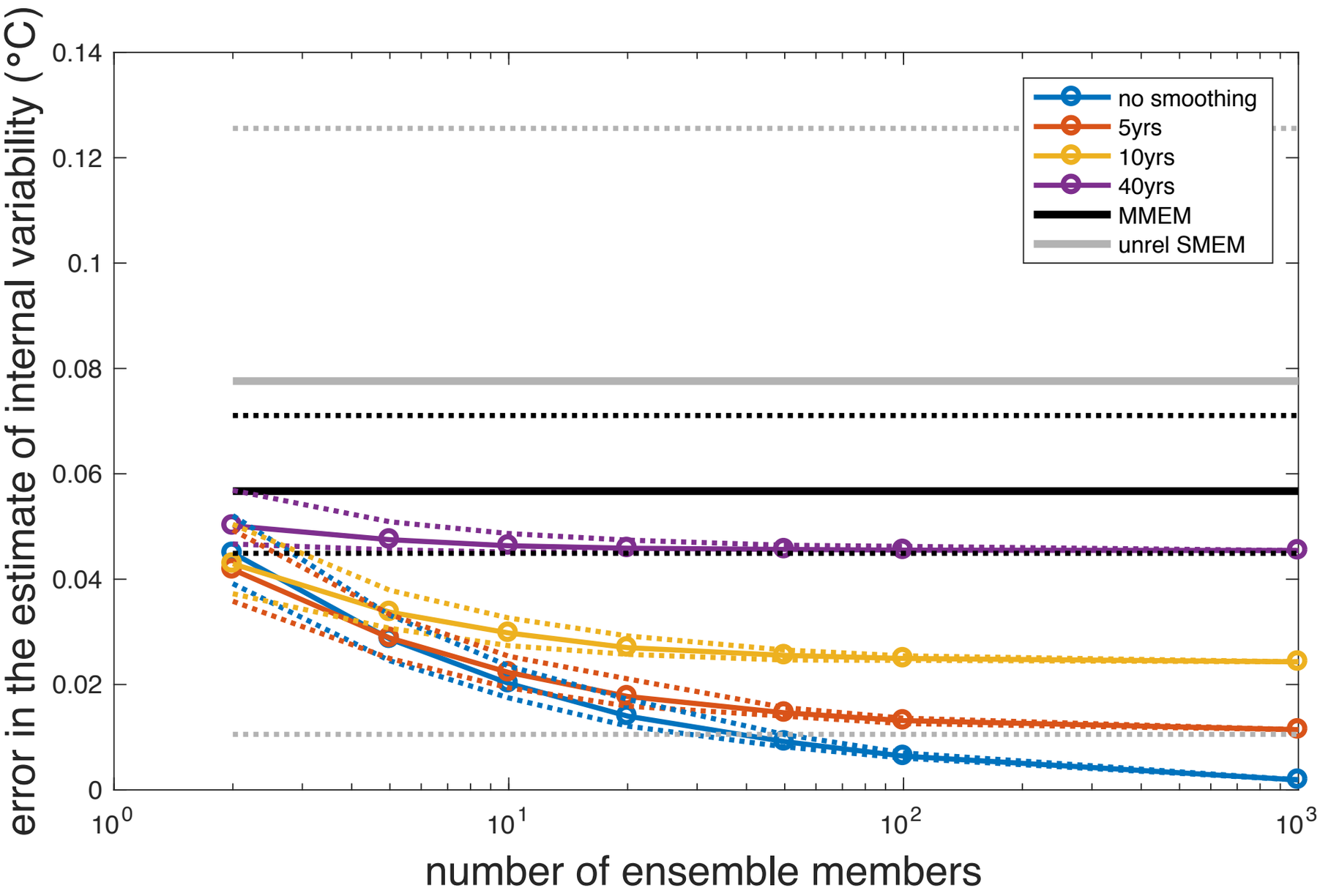
- Smoothing the ensemble mean is ineffective

How many ensemble members?



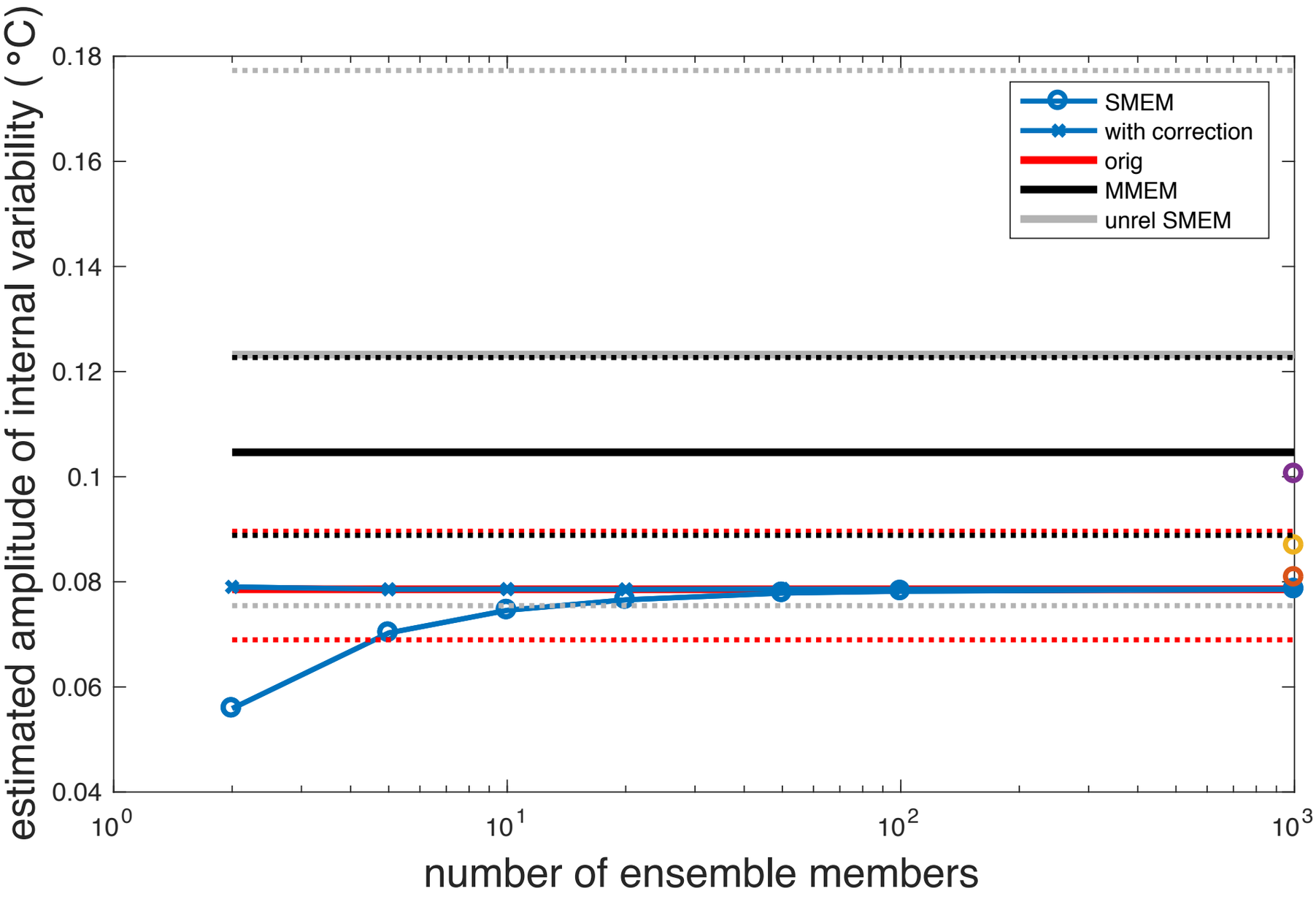
- Even two ensemble members can be more accurate than using the multi-model ensemble mean

How many ensemble members?



- Using the MMEM is better than using the wrong SMEM

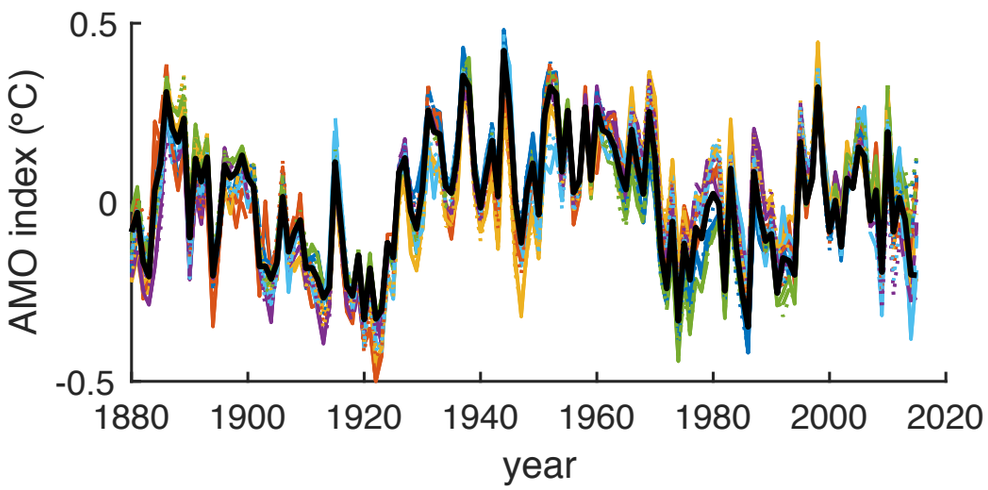
How many ensemble members?

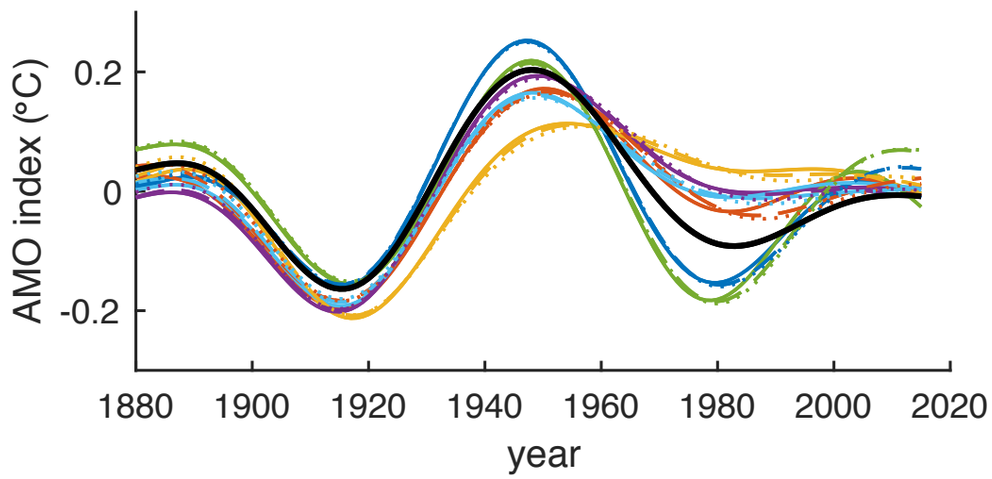


- Estimated amplitude can be corrected

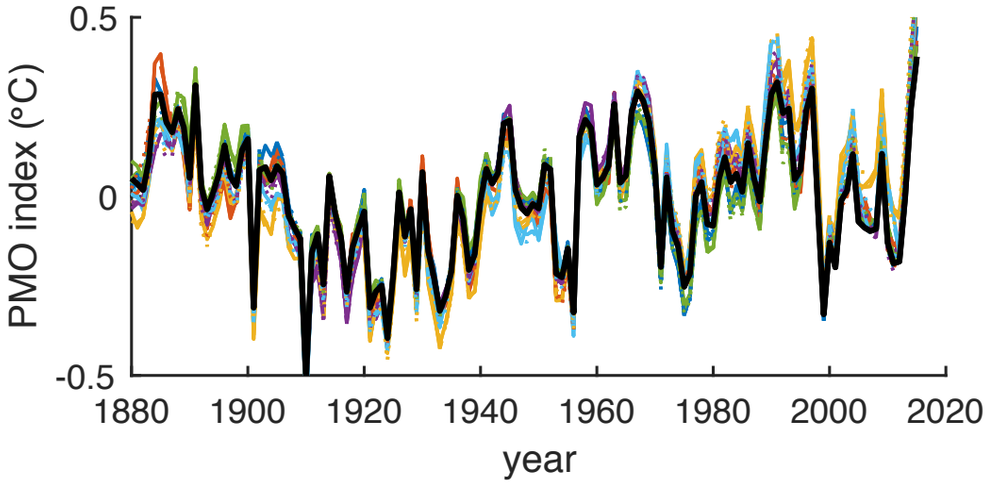
Multiple estimates of internal variability from observations

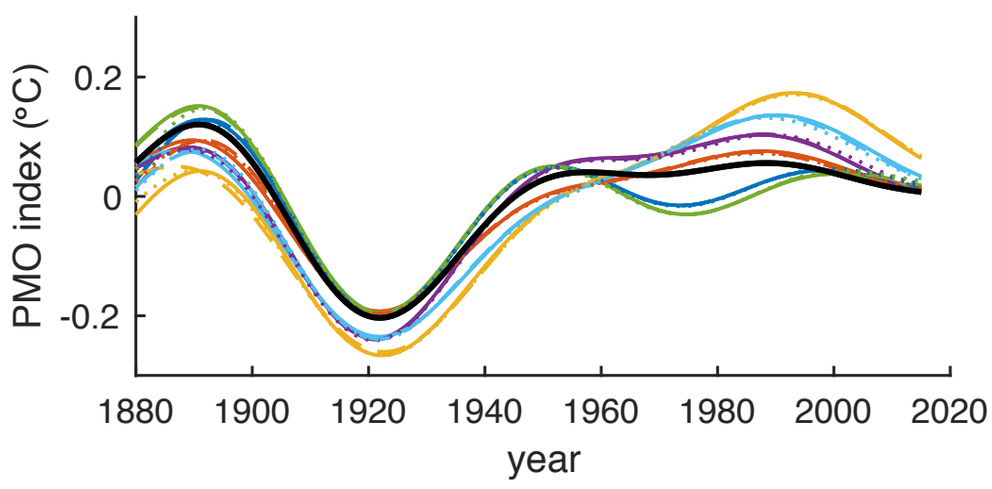
AMO



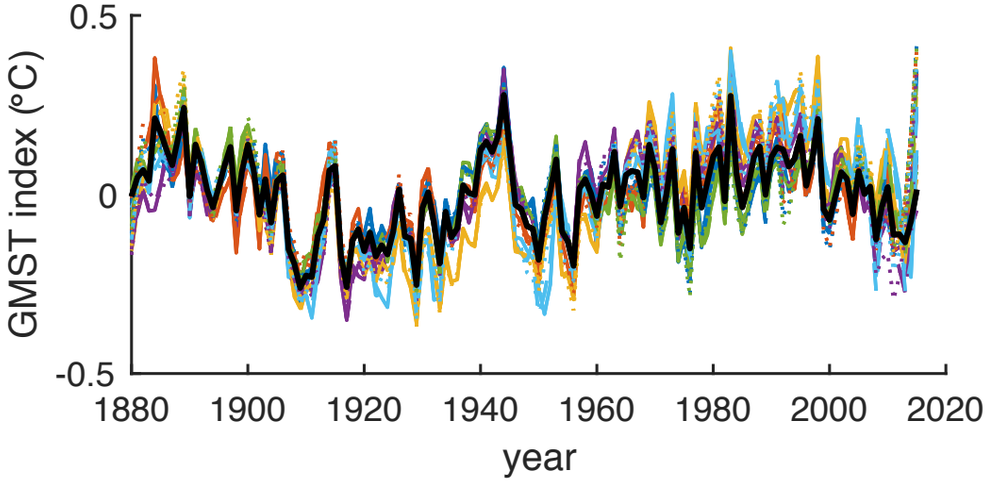


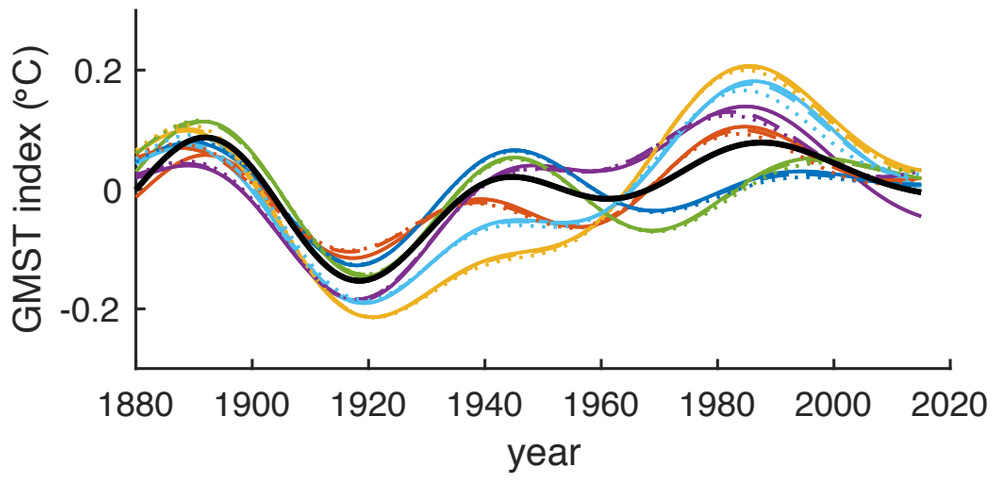
PMO



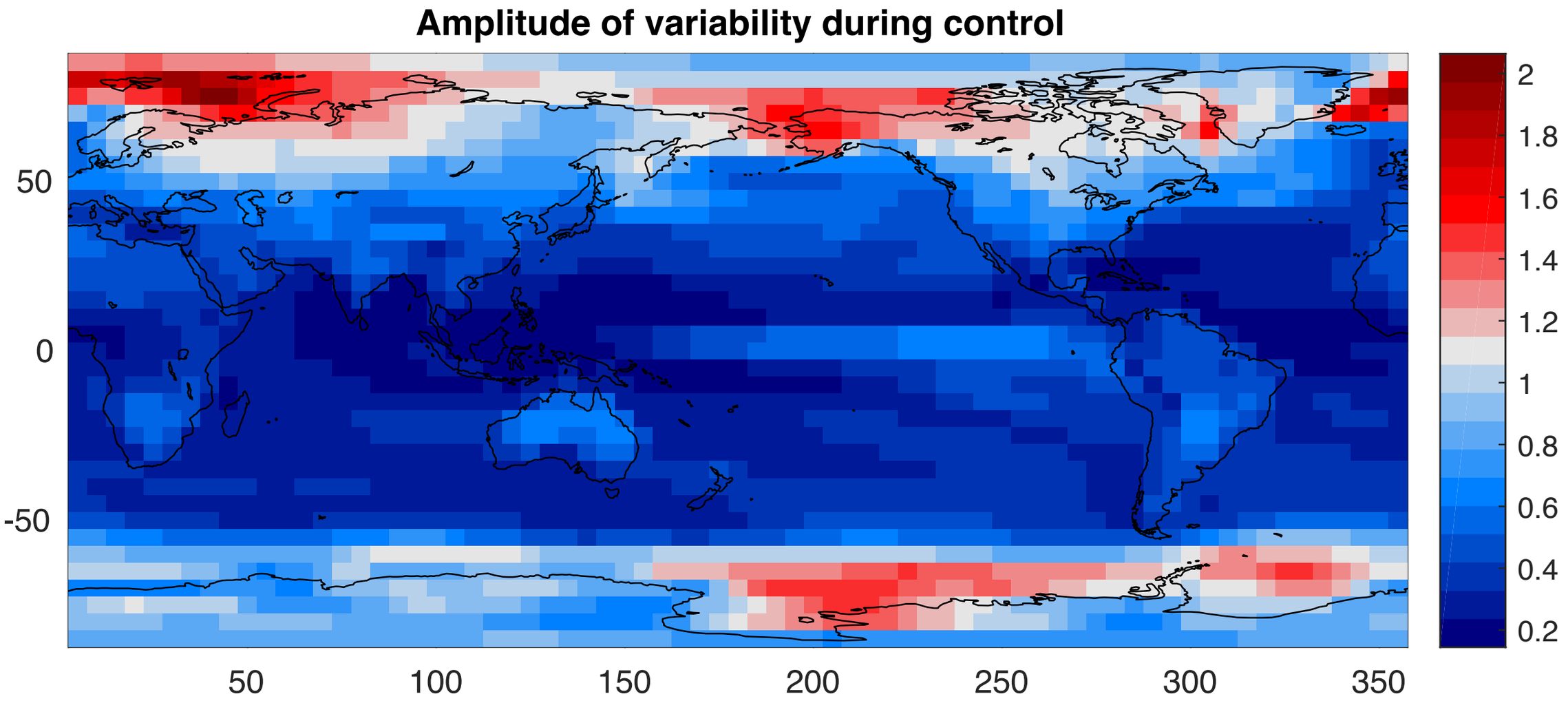


GMST





Future changes in amplitude of internal variability



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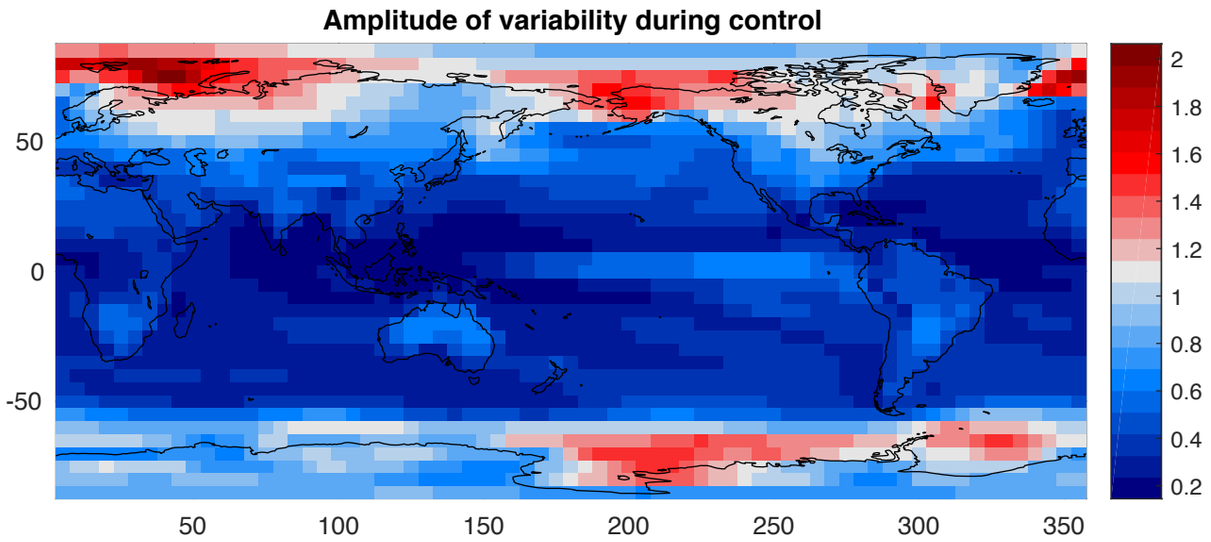
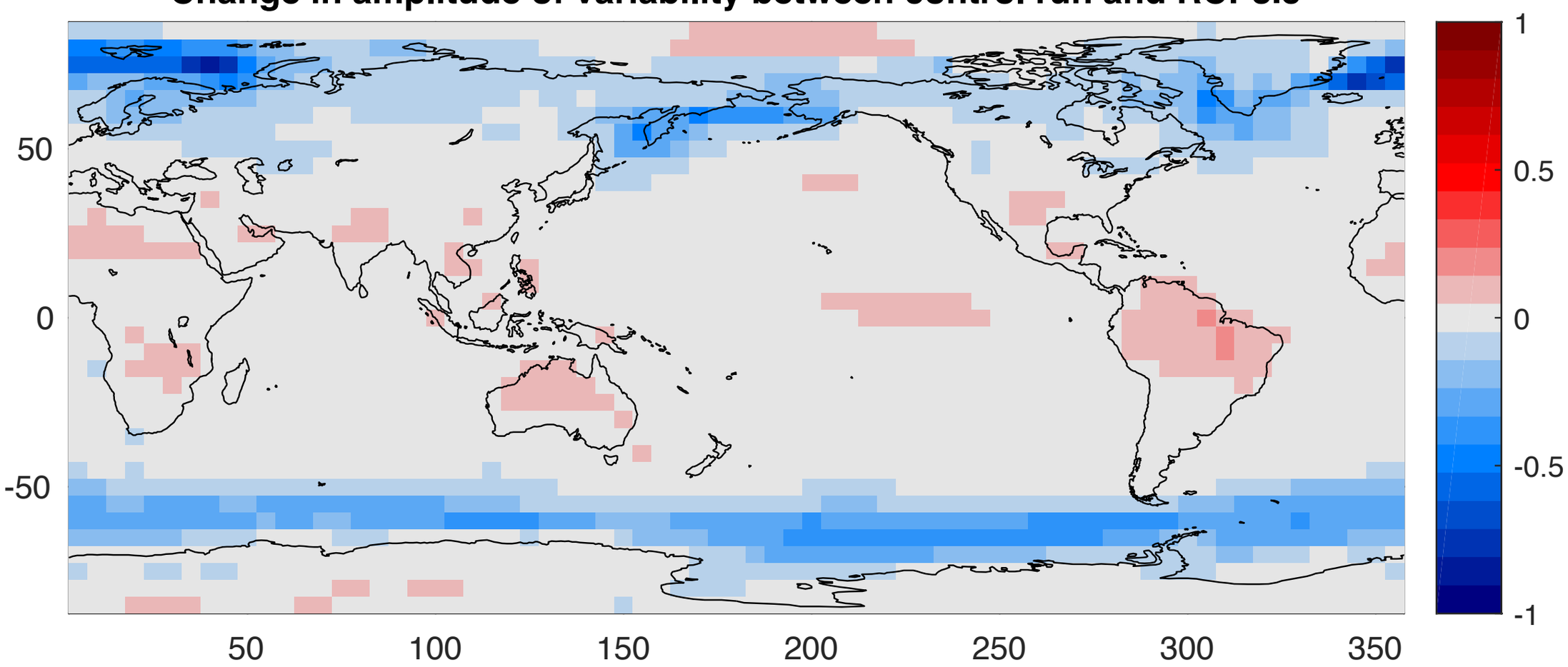
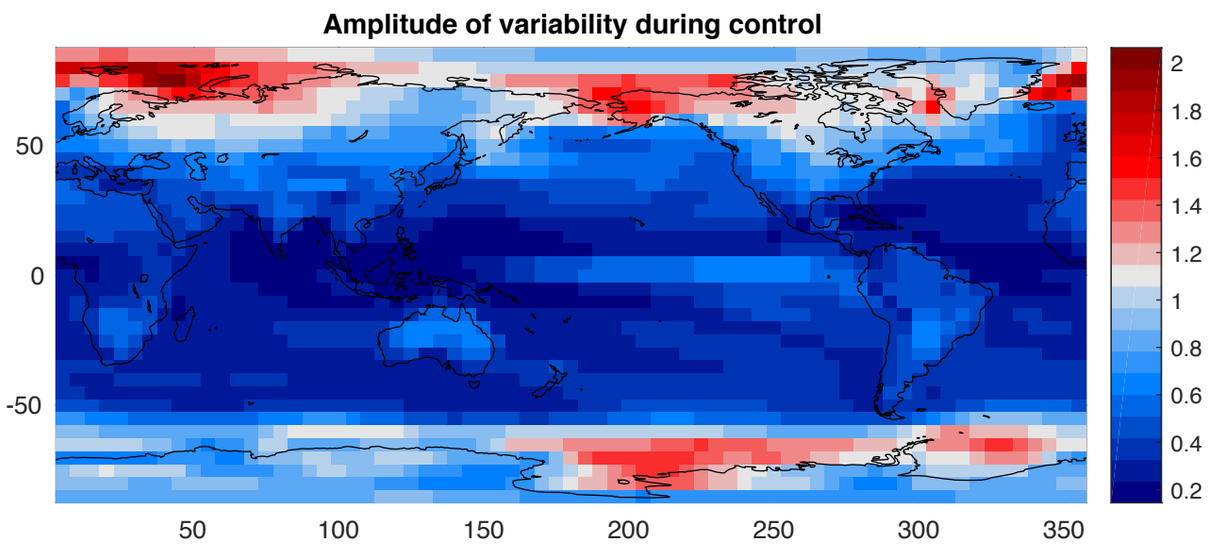
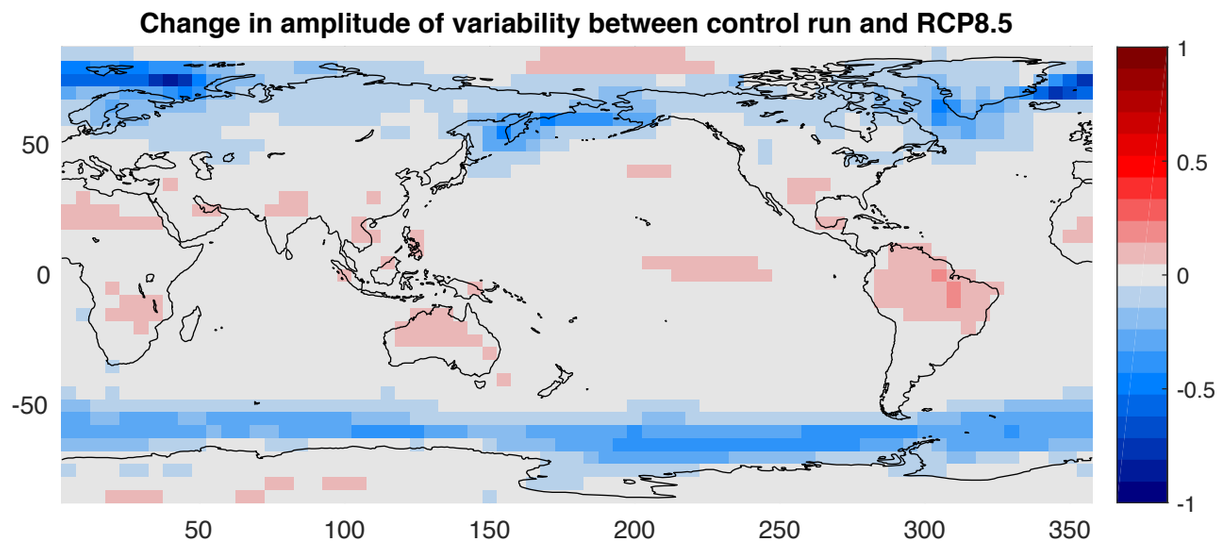


Change in amplitude of variability between control run and RCP8.5

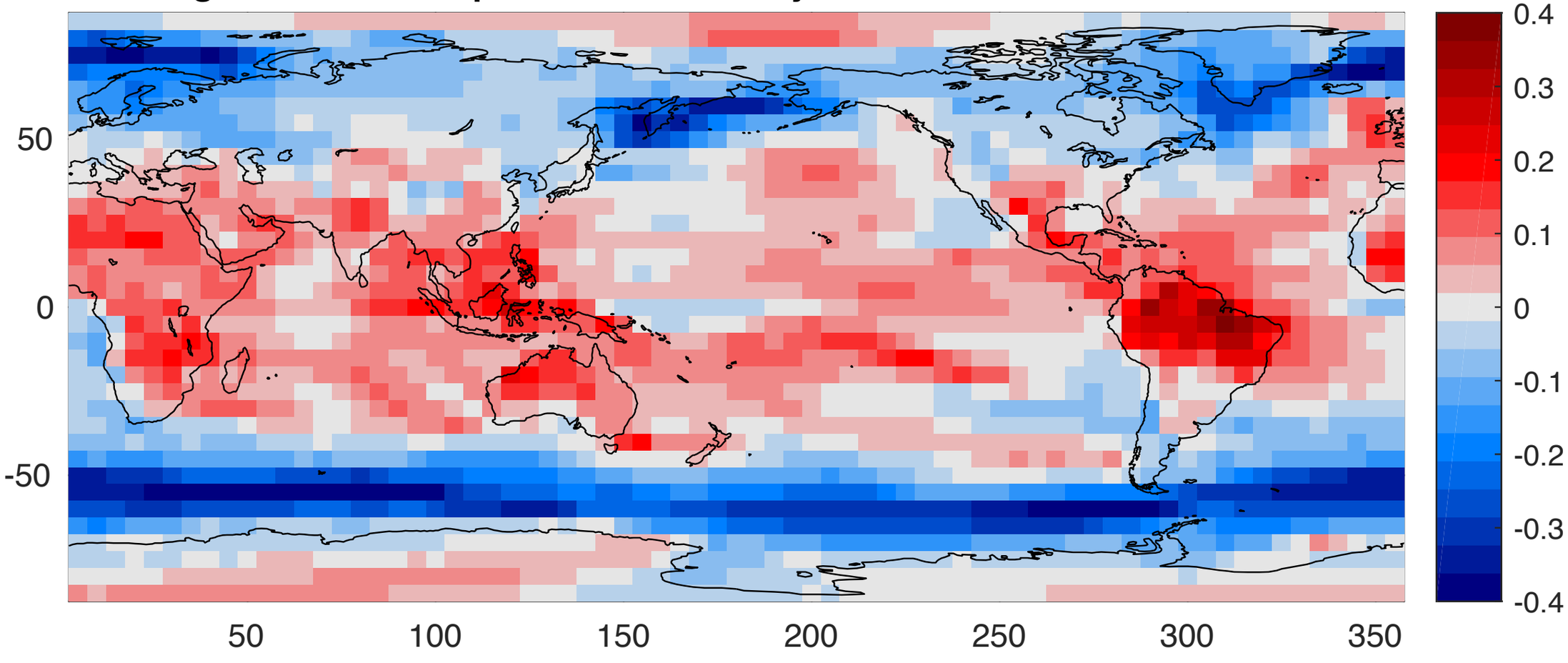


Future changes in amplitude of internal variability





Change in relative amplitude of variability between control run and RCP8.5



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

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

References

- Mann, Steinman and Miller (2014), On forced temperature changes, internal variability, and the AMO, *Geophysical Research Letters*, 10.1002/2014GL059233

- Steinman, Mann and Miller (2015), Atlantic and Pacific multidecadal oscillations and Northern Hemisphere temperatures, *Science*, 10.1126/science.1257856

- Frankcombe, England, Mann and Steinman (2015), Separating internal variability from the externally forced climate response, *Journal of Climate*, 10.1175/JCLI-D-15-0069.1

- Frankcombe, England, Mann and Steinman (2017), On the choice of ensemble mean for estimating the forced signal in the presence of natural variability, *in prep*