Observational constraints on the contribution of internal variability to recent climate trends

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with Andy Poppick, Etienne Dunn-Sigouin, and Clara Deser

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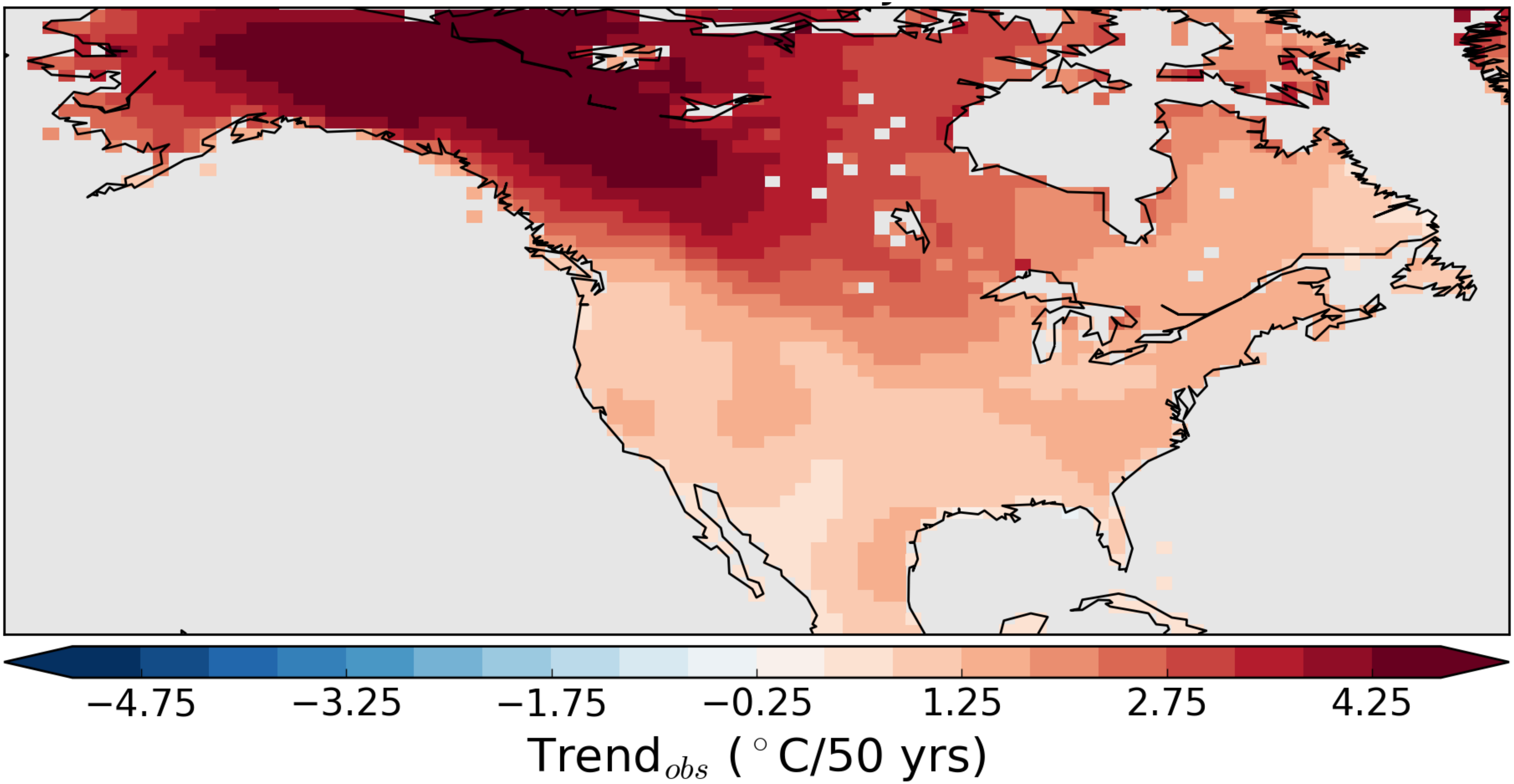
Carleton College
LAMONT-DOHERTY EARTH OBSERVATORY
THE EARTH INSTITUTE AT COLUMBIA UNIVERSITY
NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Observed DJF temperature trend, 1966-2015



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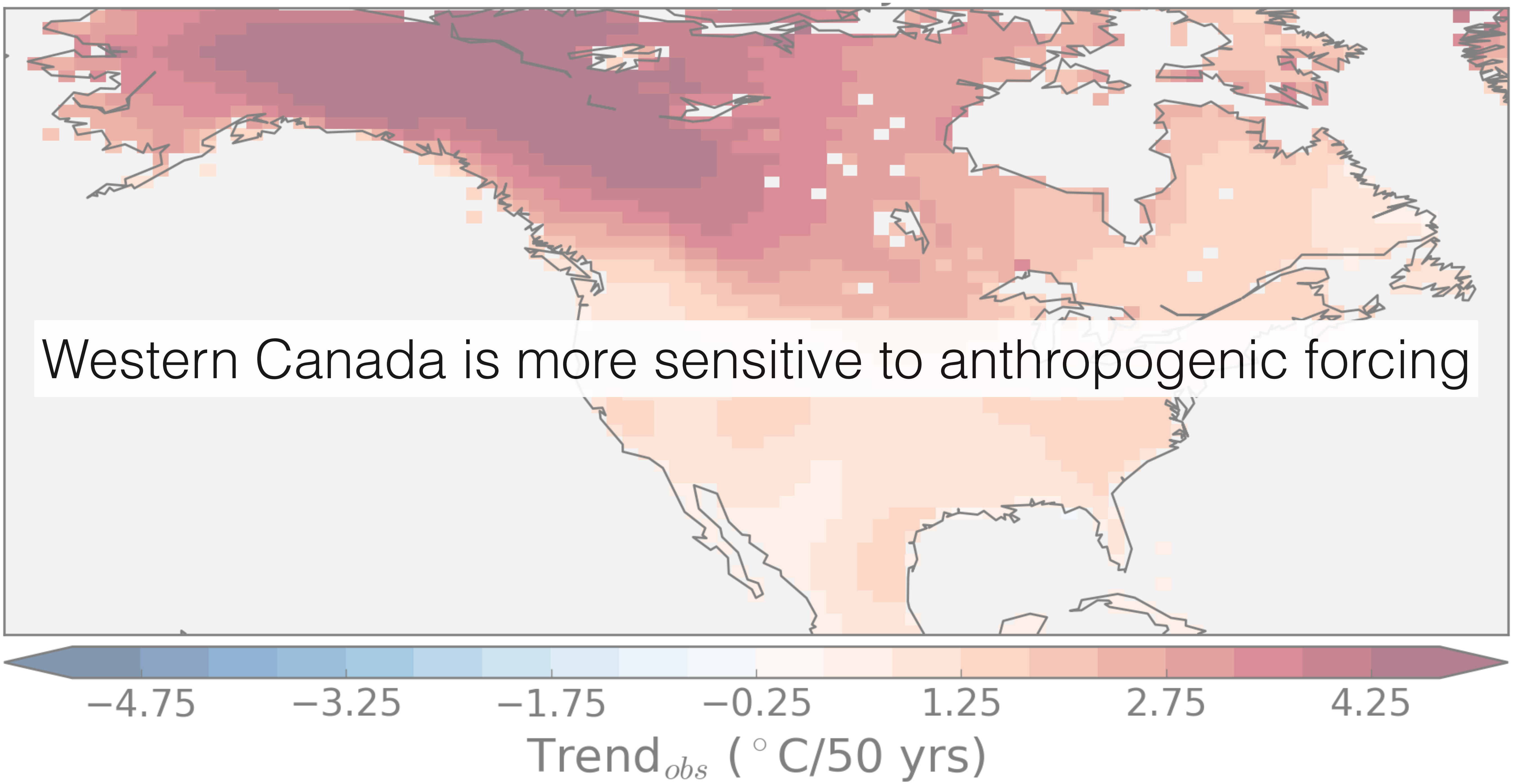

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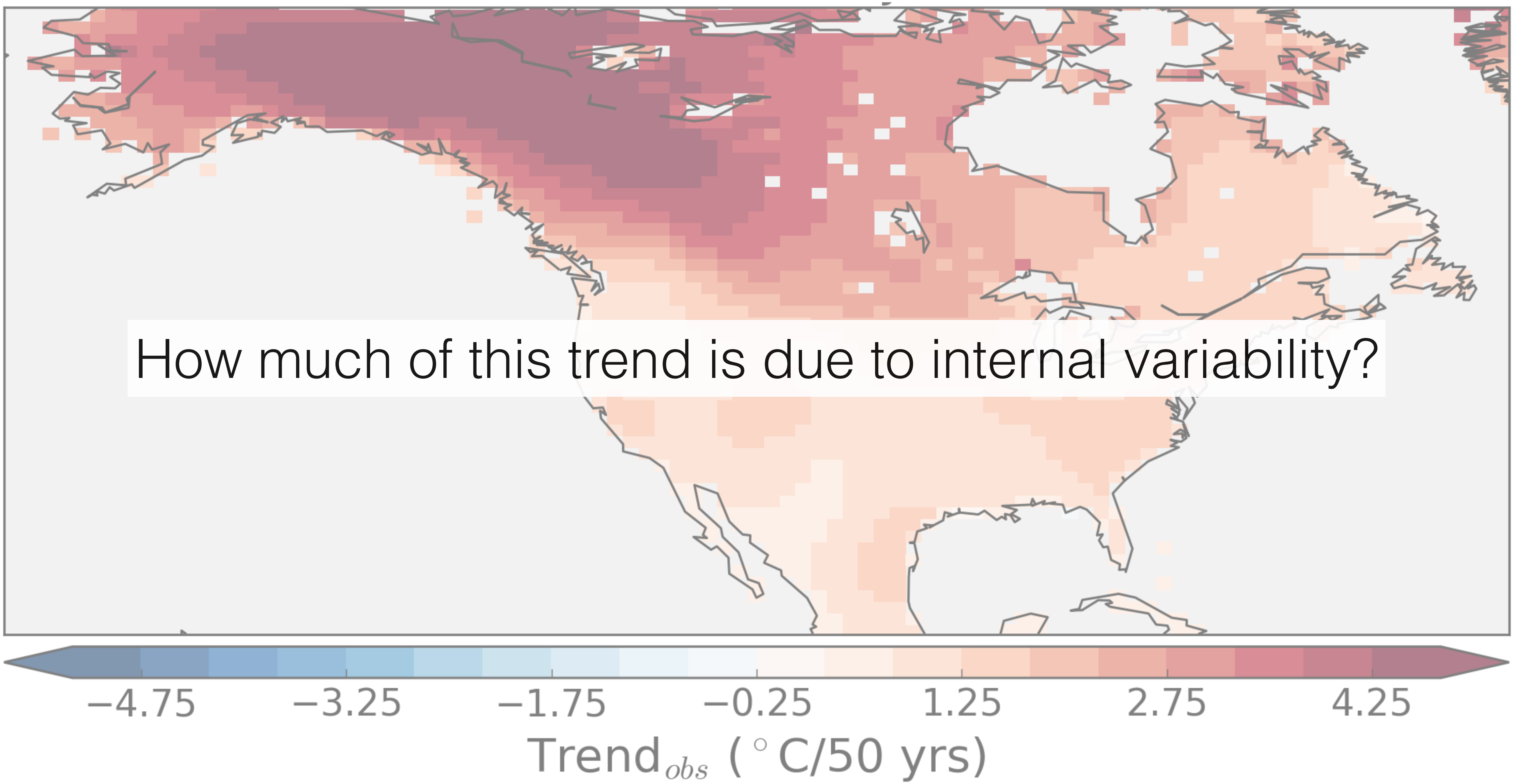
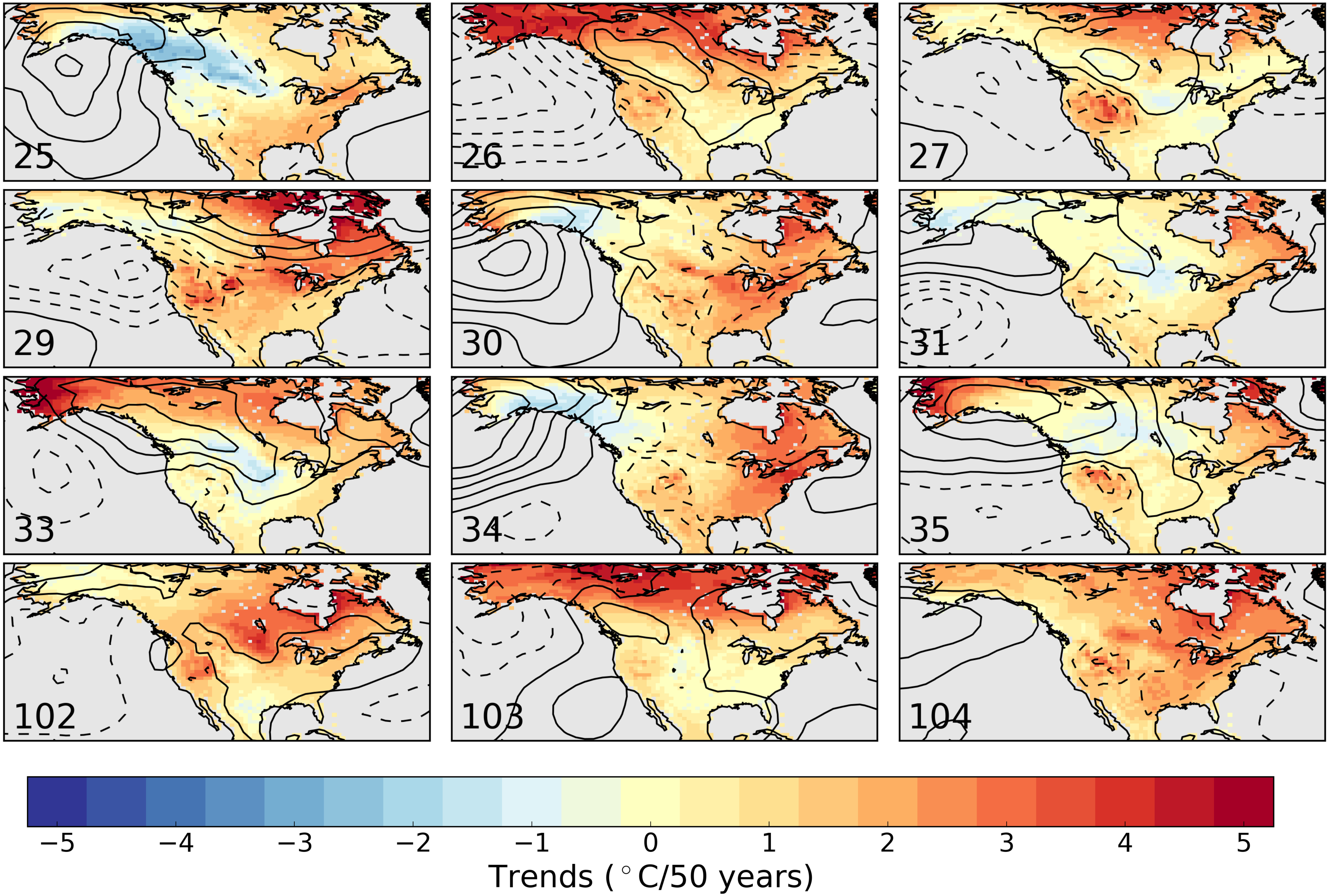
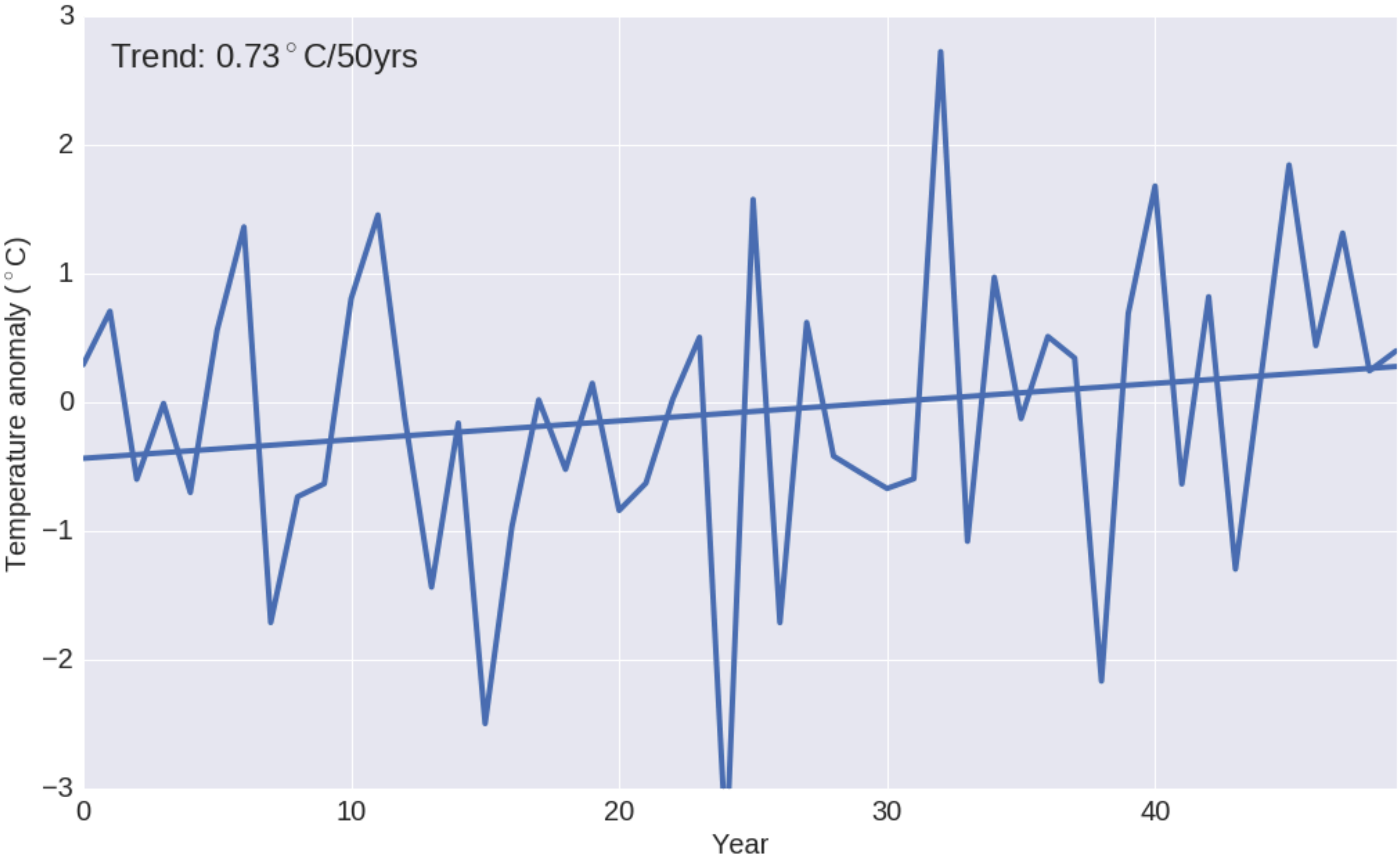
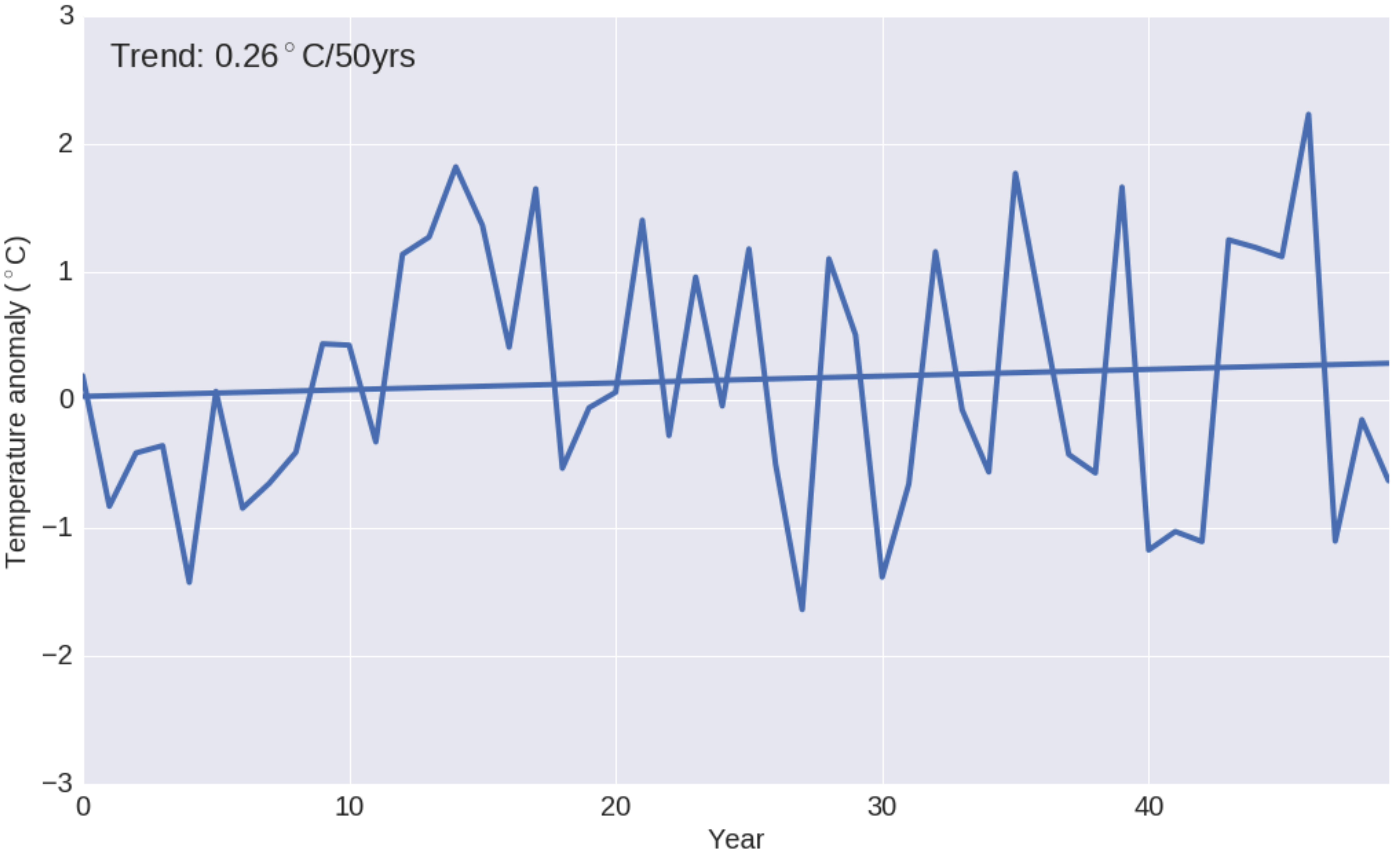


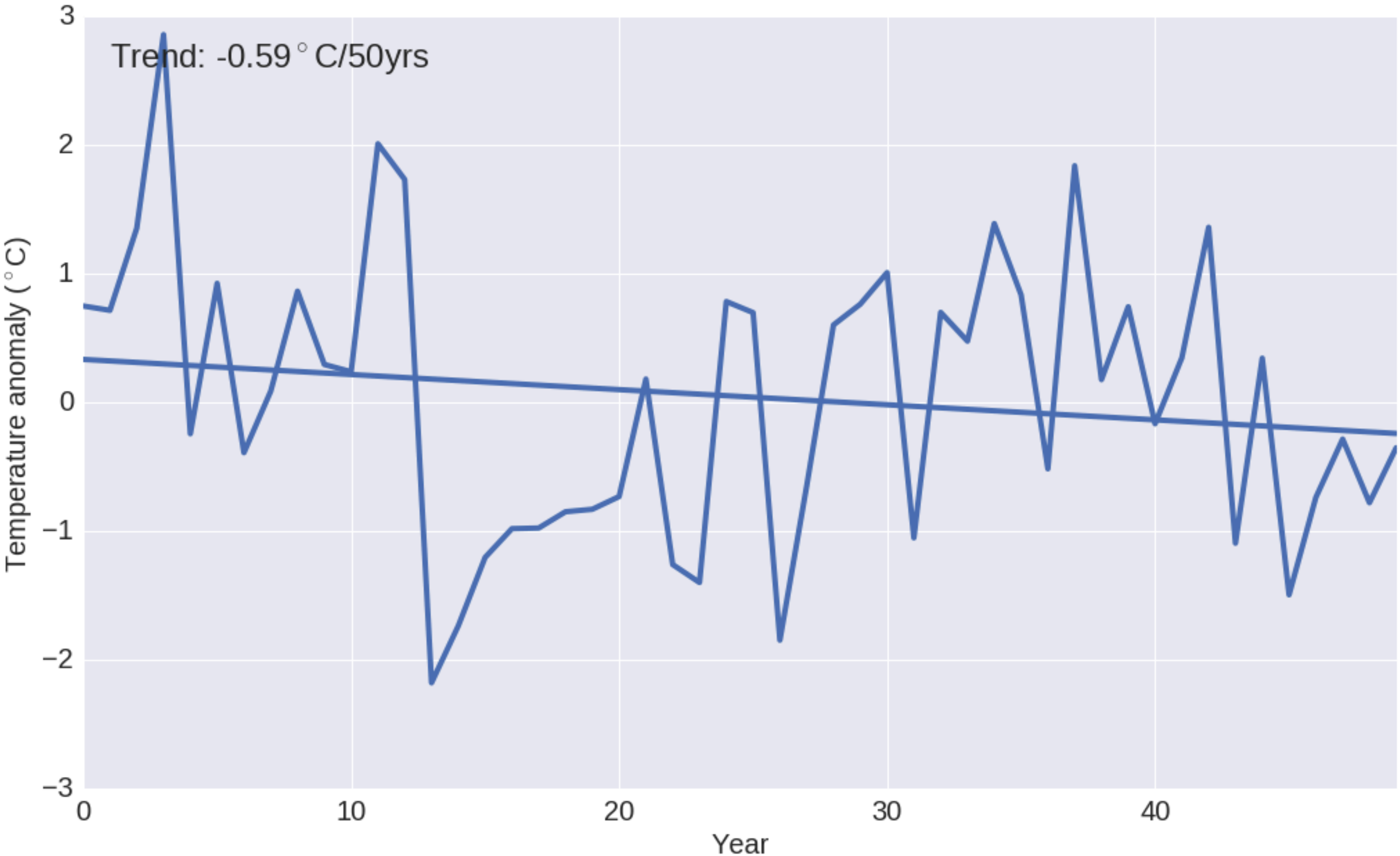
Large Ensemble shows influence of internal variability



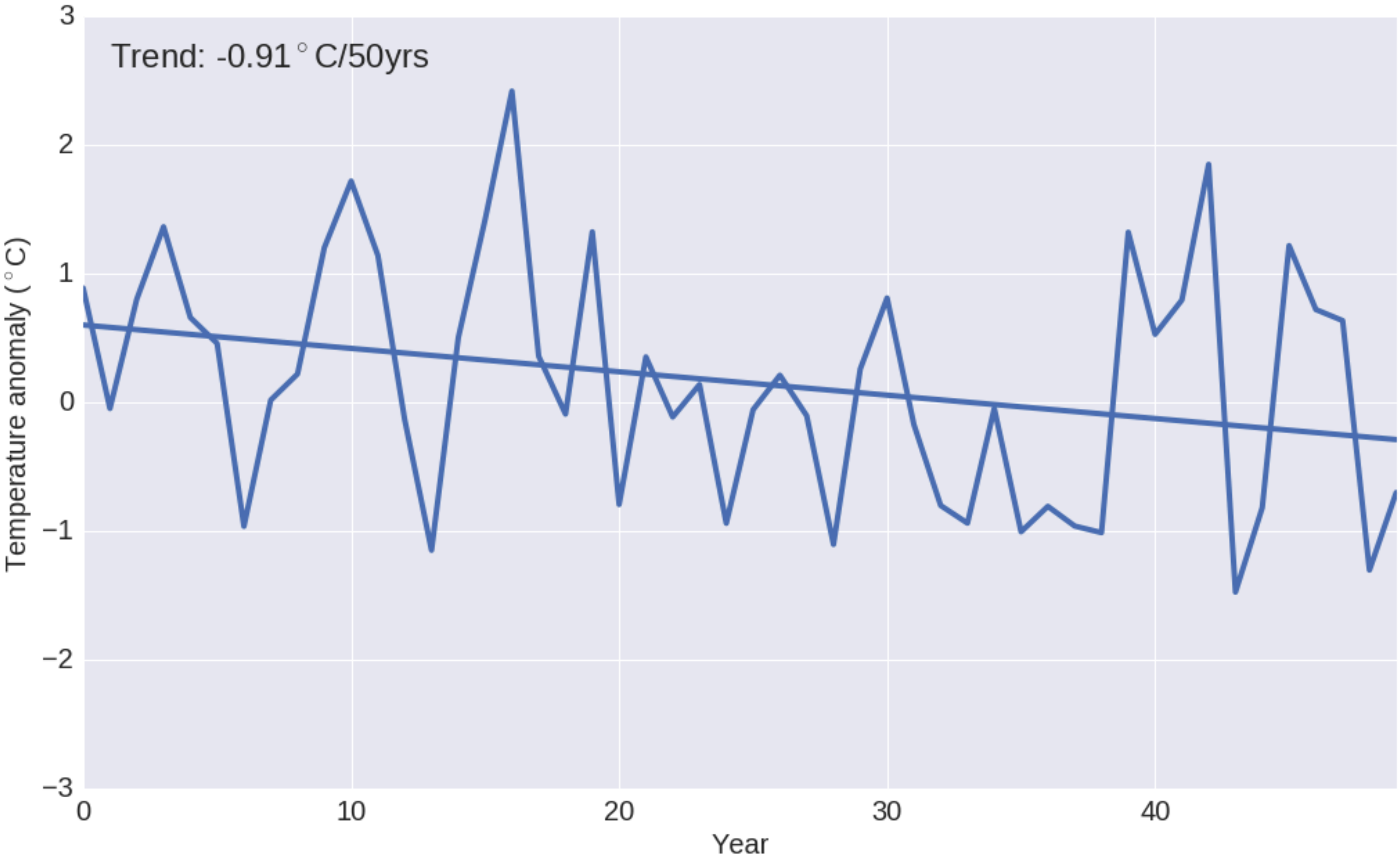

Trend: 0.73 °C/50yrs
Temperature anomaly (°C)
Year
3
2
1
0
−1
−2
−3
0
10
20
30
40

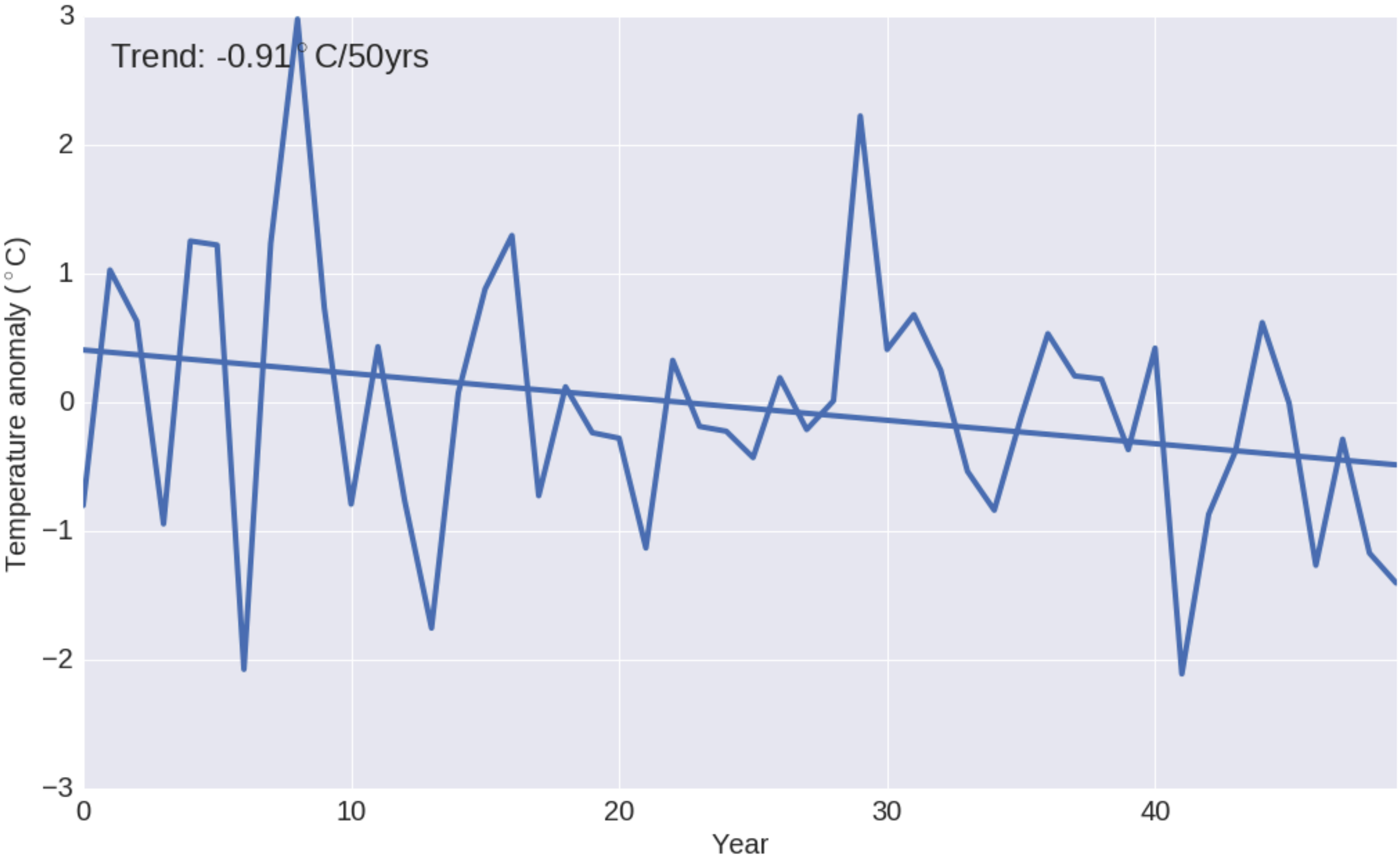


Trend: 0.26 ° C/50yrs
Temperature anomaly (° C)
Year
3
2
1
0
−1
−2
−3
0
10
20
30
40

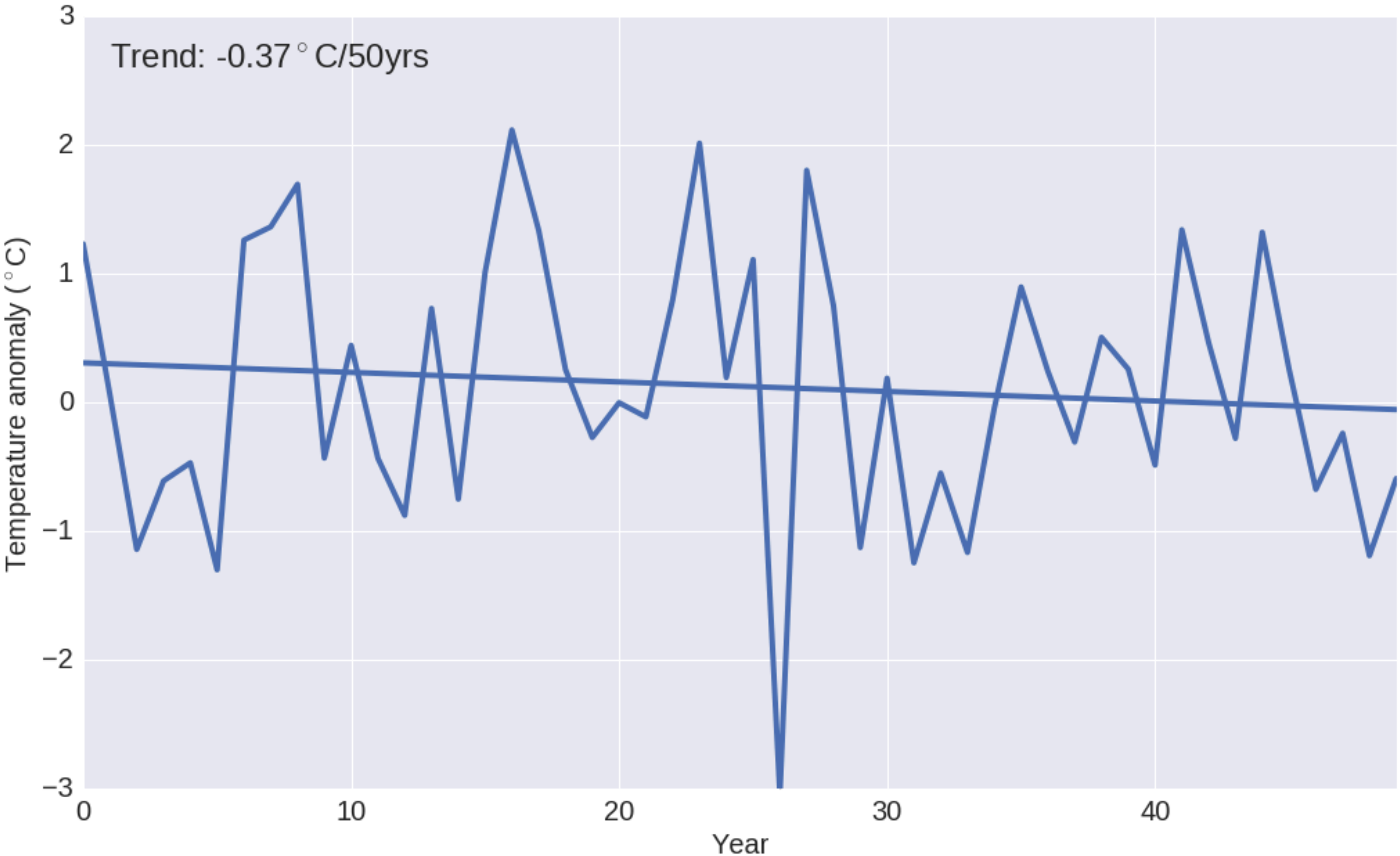


Trend: -0.59 °C/50yrs
Temperature anomaly (°C)
Year
3
2
1
0
−1
−2
−3
0
10
20
30
40


Trend: -0.91 ° C/50yrs
Temperature anomaly (° C)
3
2
1
0
−1
−2
−3
0
10
20
30
40
Year

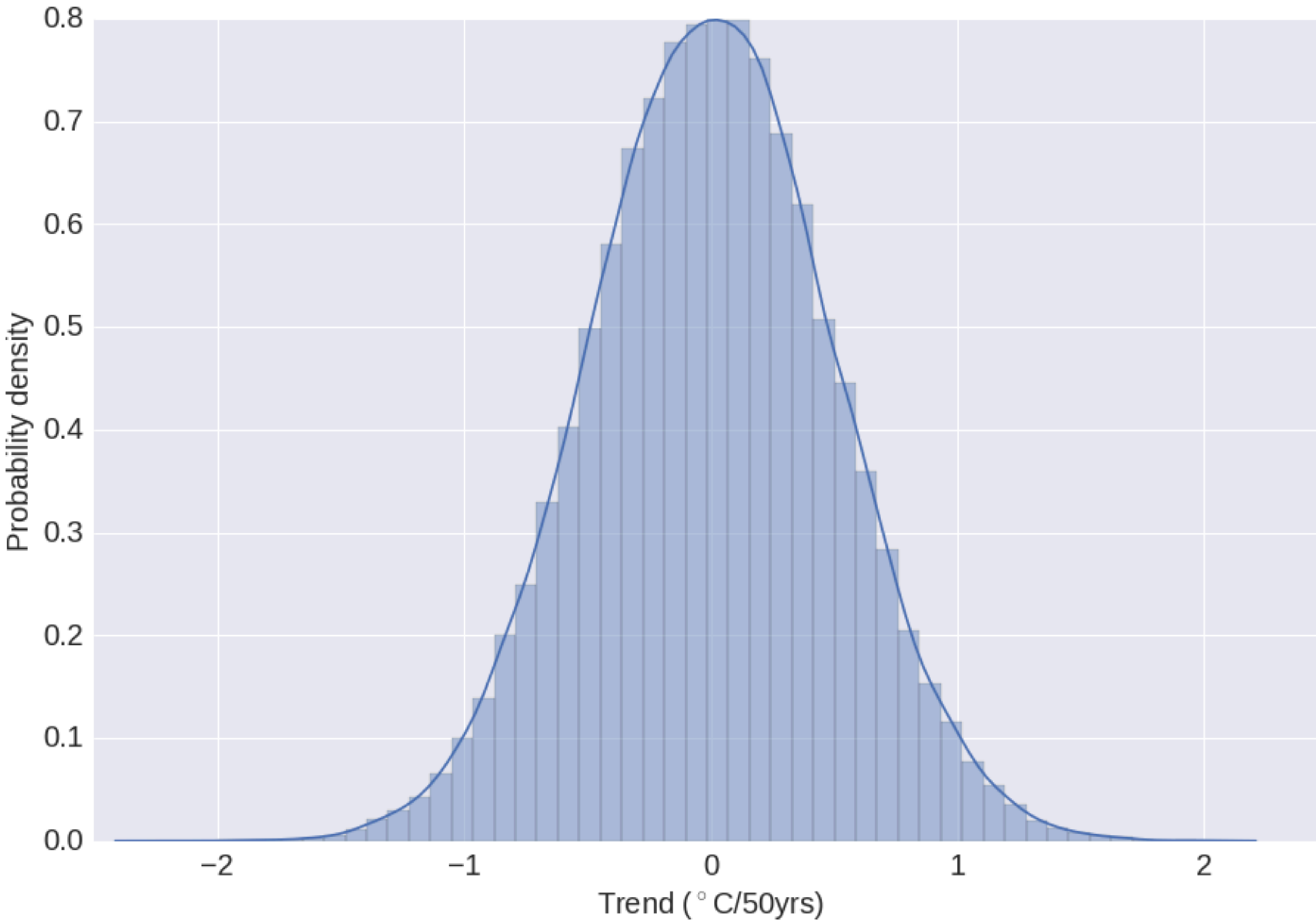


Trend: -0.91° C/50yrs
Temperature anomaly (° C)
Year
3
2
1
0
−1
−2
−3
0
10
20
30
40

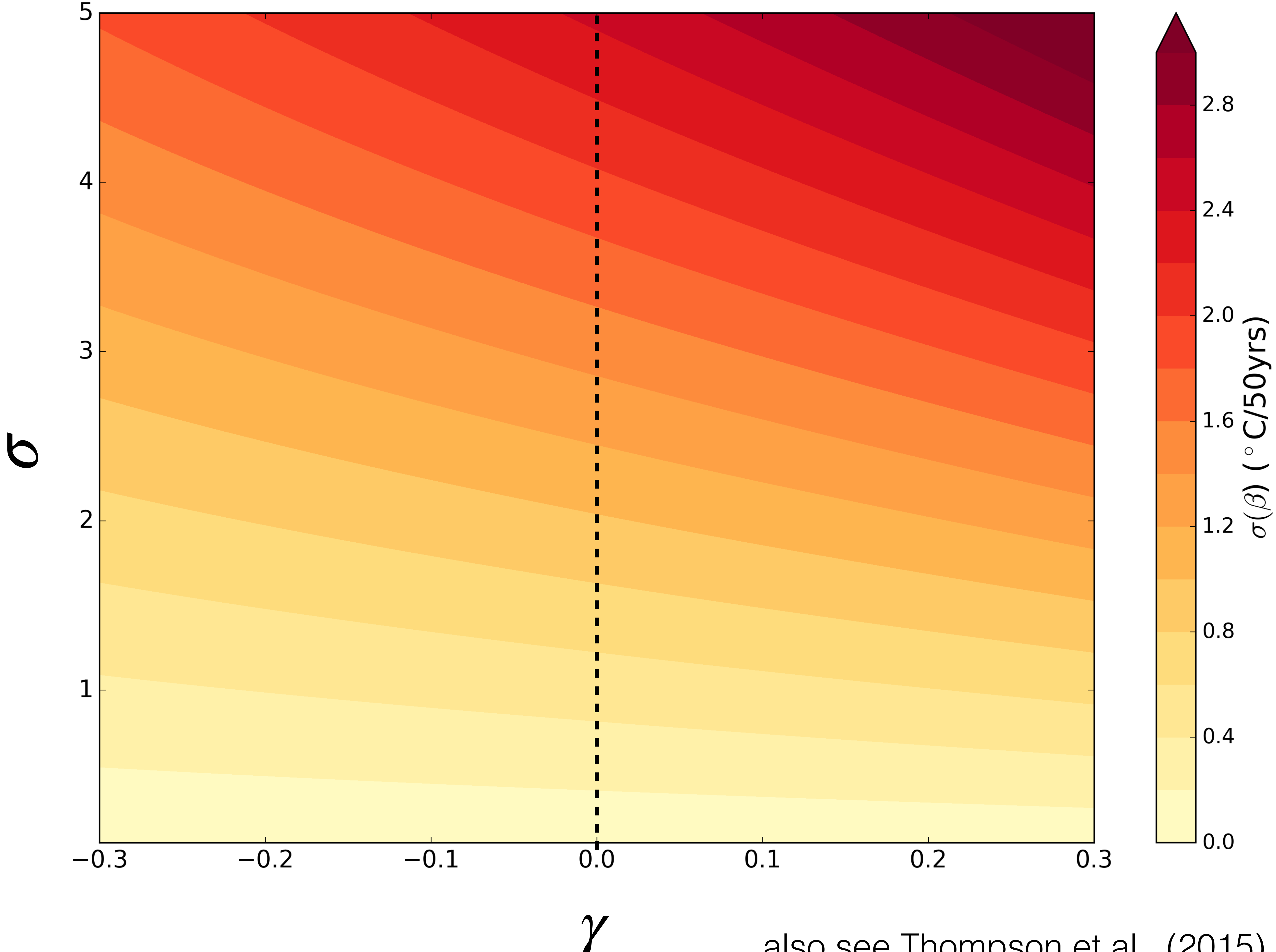


Trend: -0.37 °C/50yrs
3
2
1
0
−1
−2
−3
Temperature anomaly (°C)
0
10
20
30
40
Year

Distribution of trends from white noise



Variable 50-year trends from high-frequency noise



also see Thompson et al., (2015), *J Clim*

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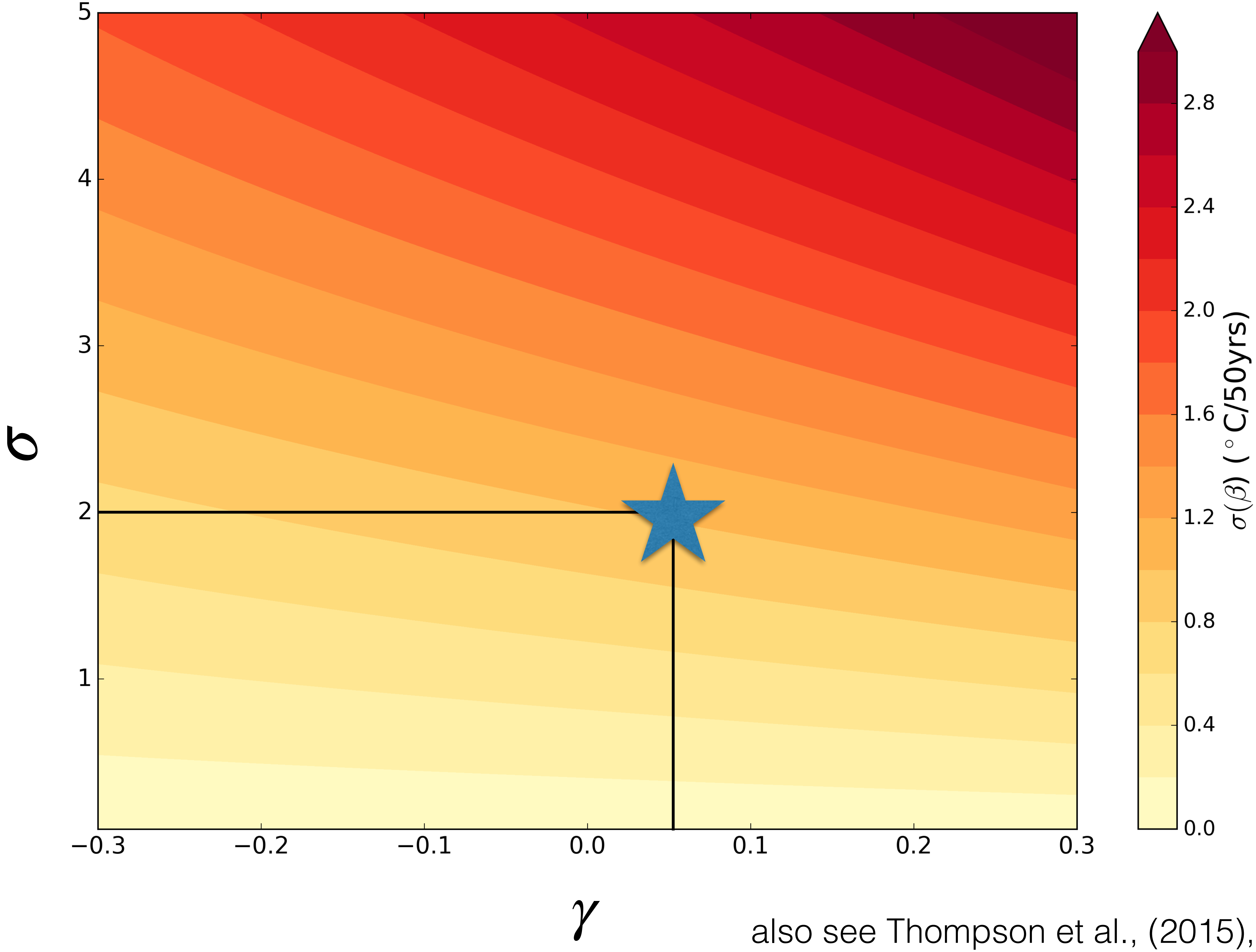

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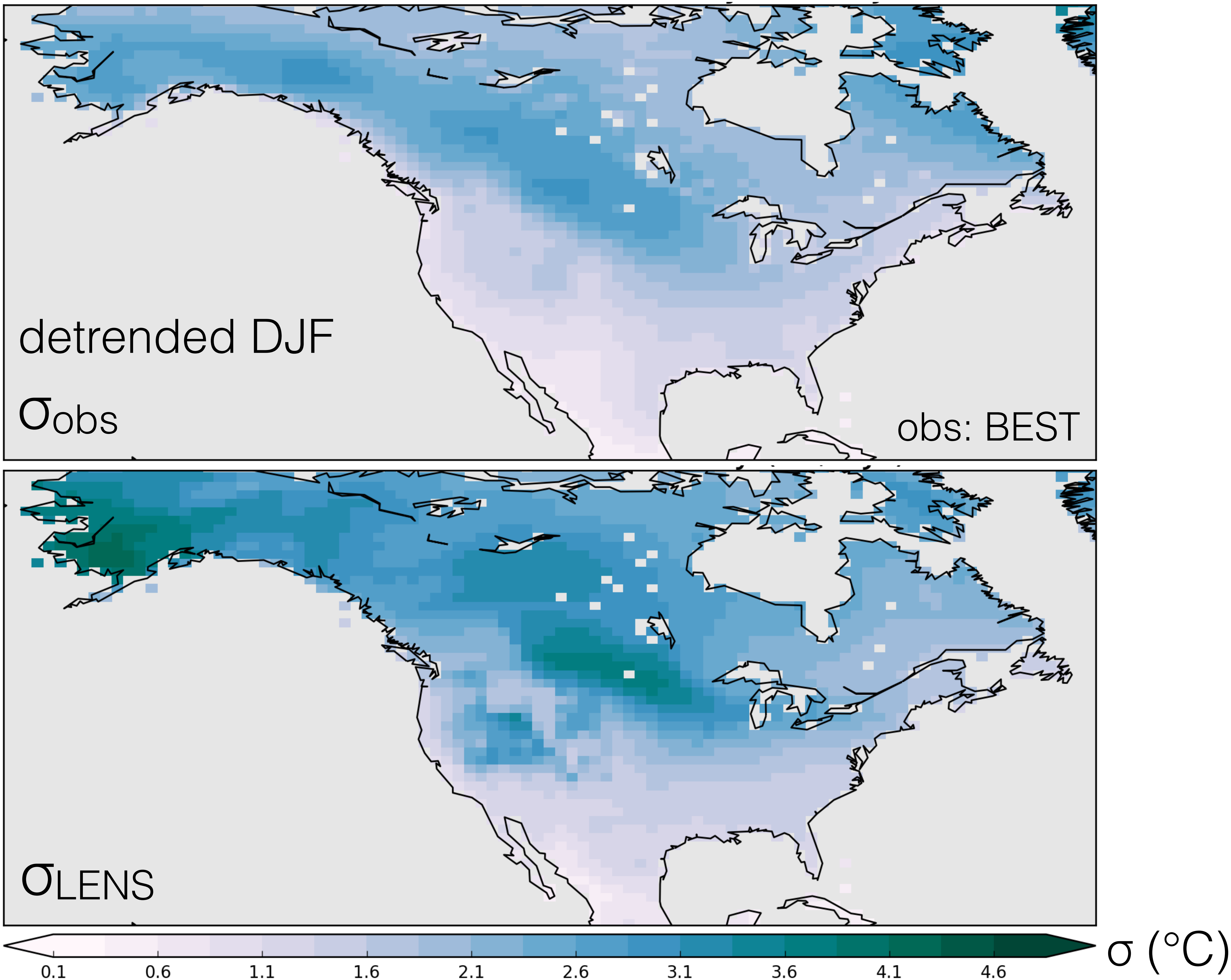
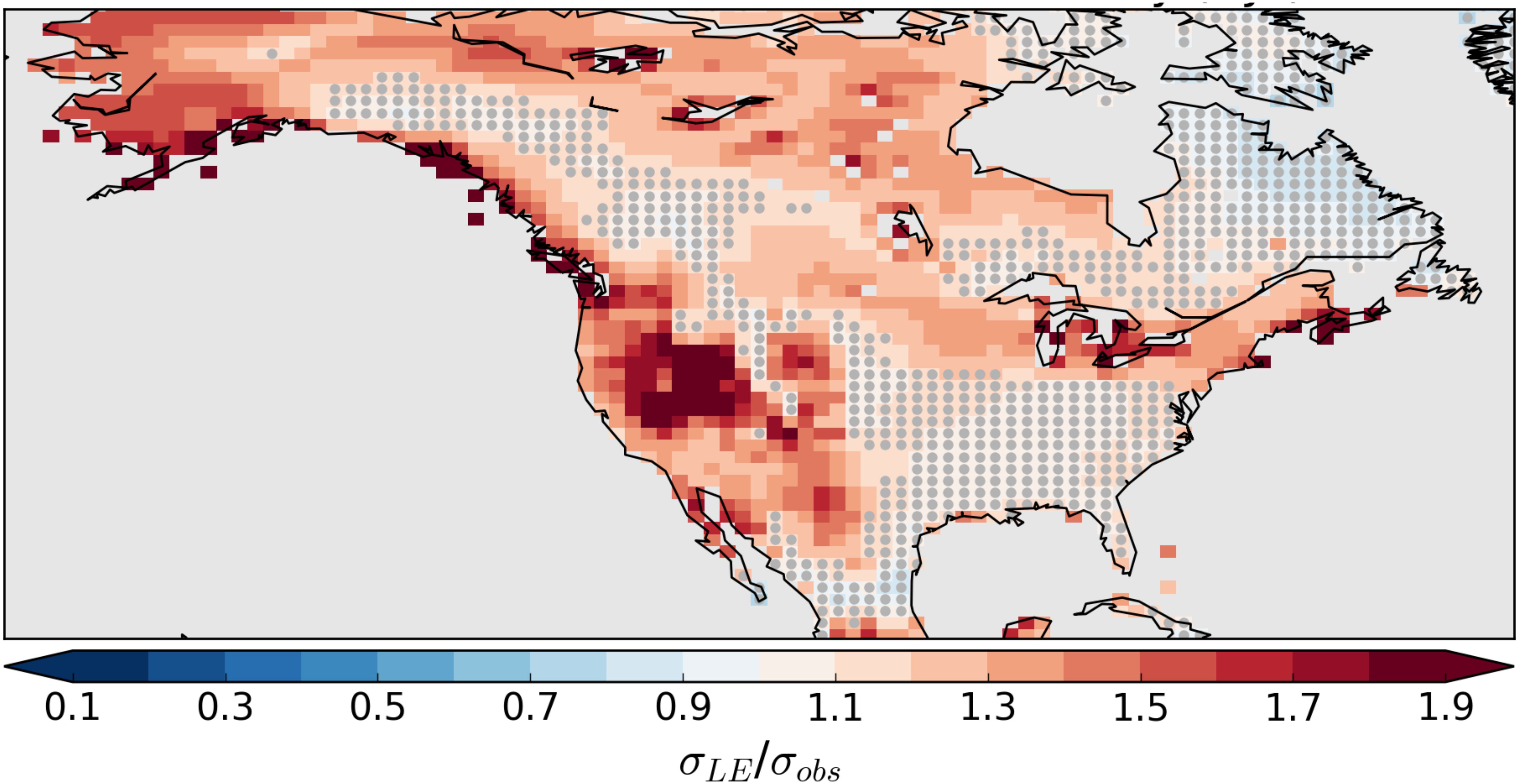


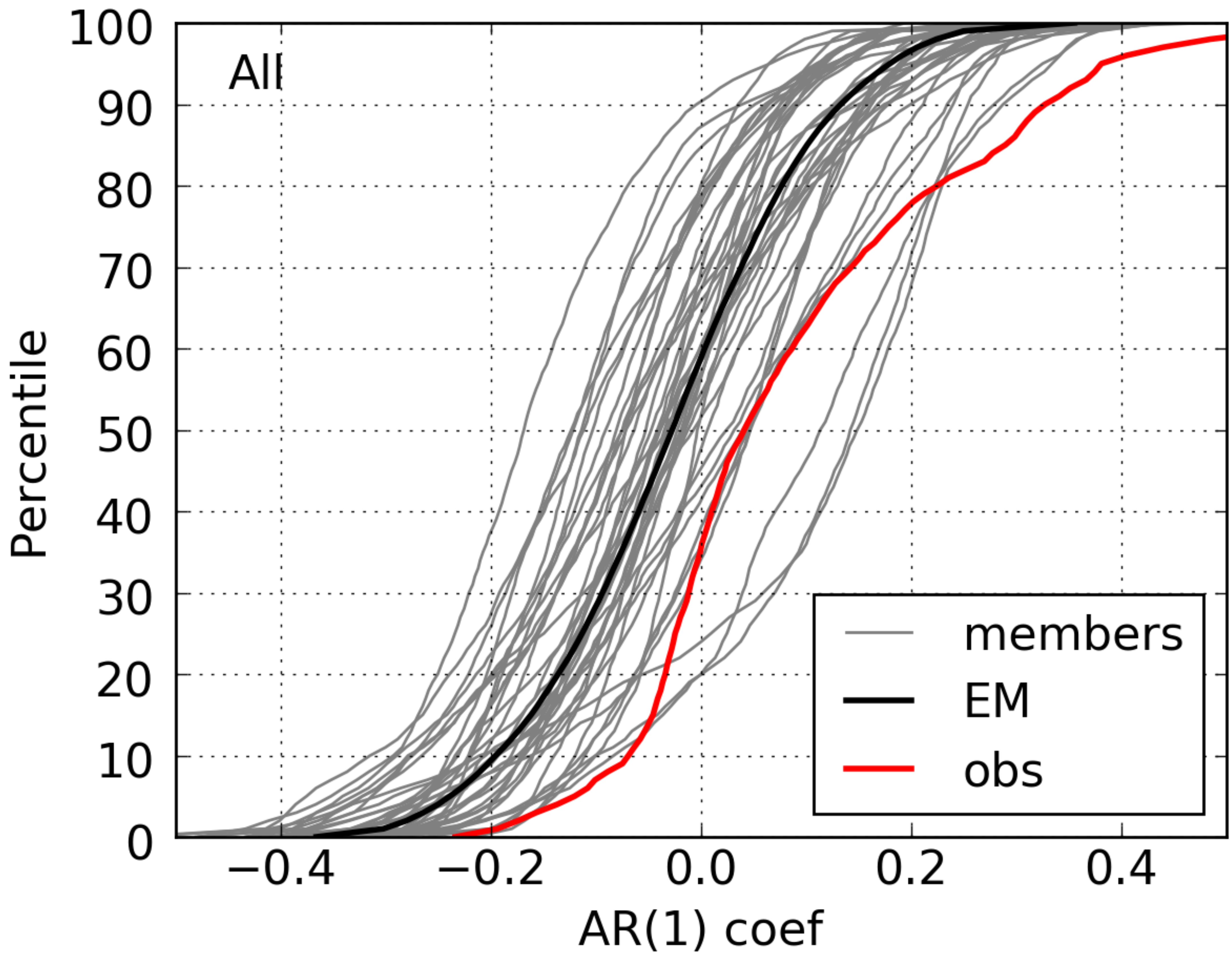
detrended DJF
σobs
obs: BEST
σLENS
0.1
0.6
1.1
1.6
2.1
2.6
3.1
3.6
4.1
4.6
σ (°C)

Observations tend to be less variable than LENS



Stippling: not significant

Observations tend to be more autocorrelated than LENS



How does this behavior map on to variability in trends?

Approach: create a synthetic ensemble

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- resample the full spatial field of the residuals using a block size of two years
- add resampled residuals back to original trend, and recalculate the trend

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Assumption: 2 year blocks of DJF temperature are interchangeable after accounting for the trend

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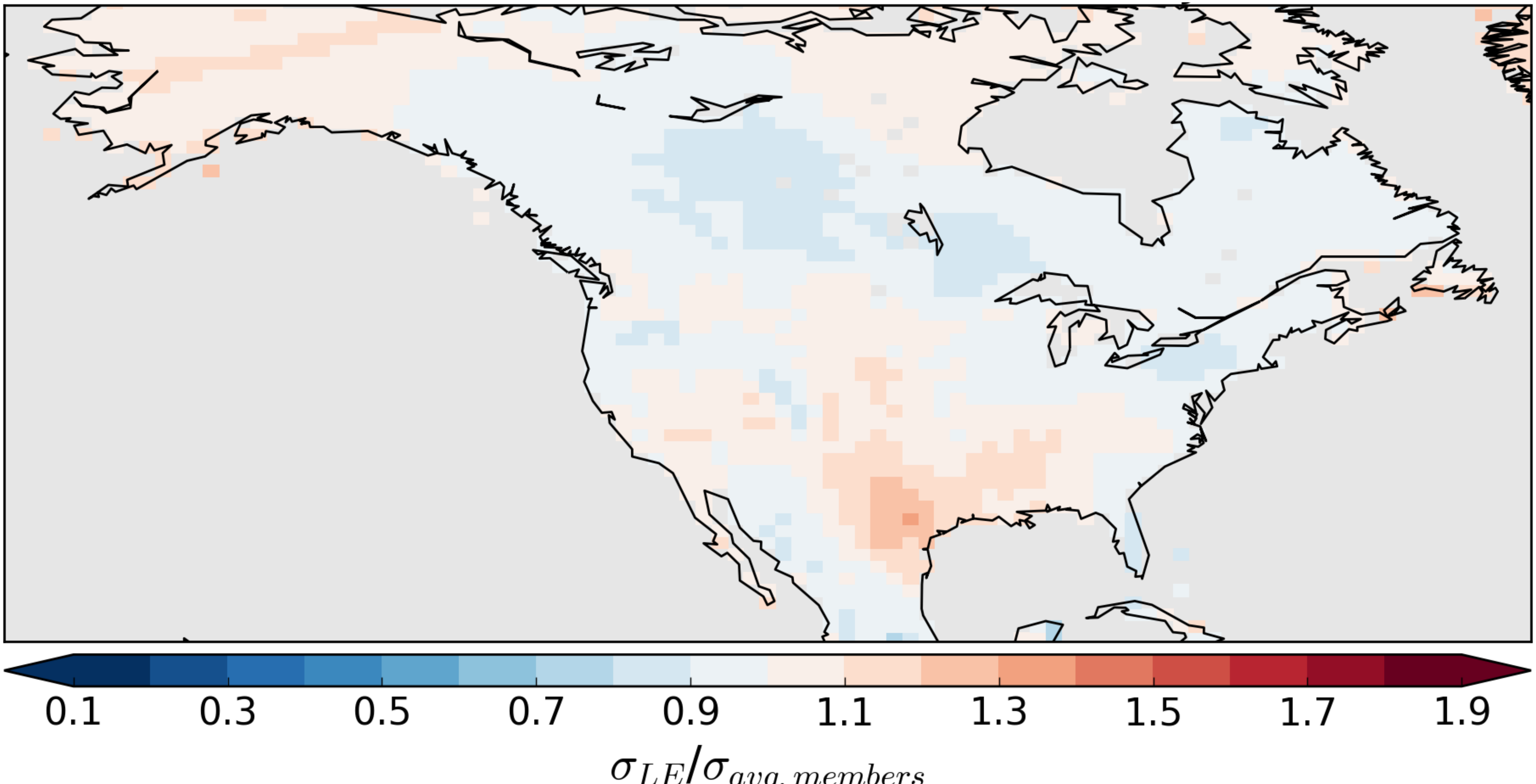
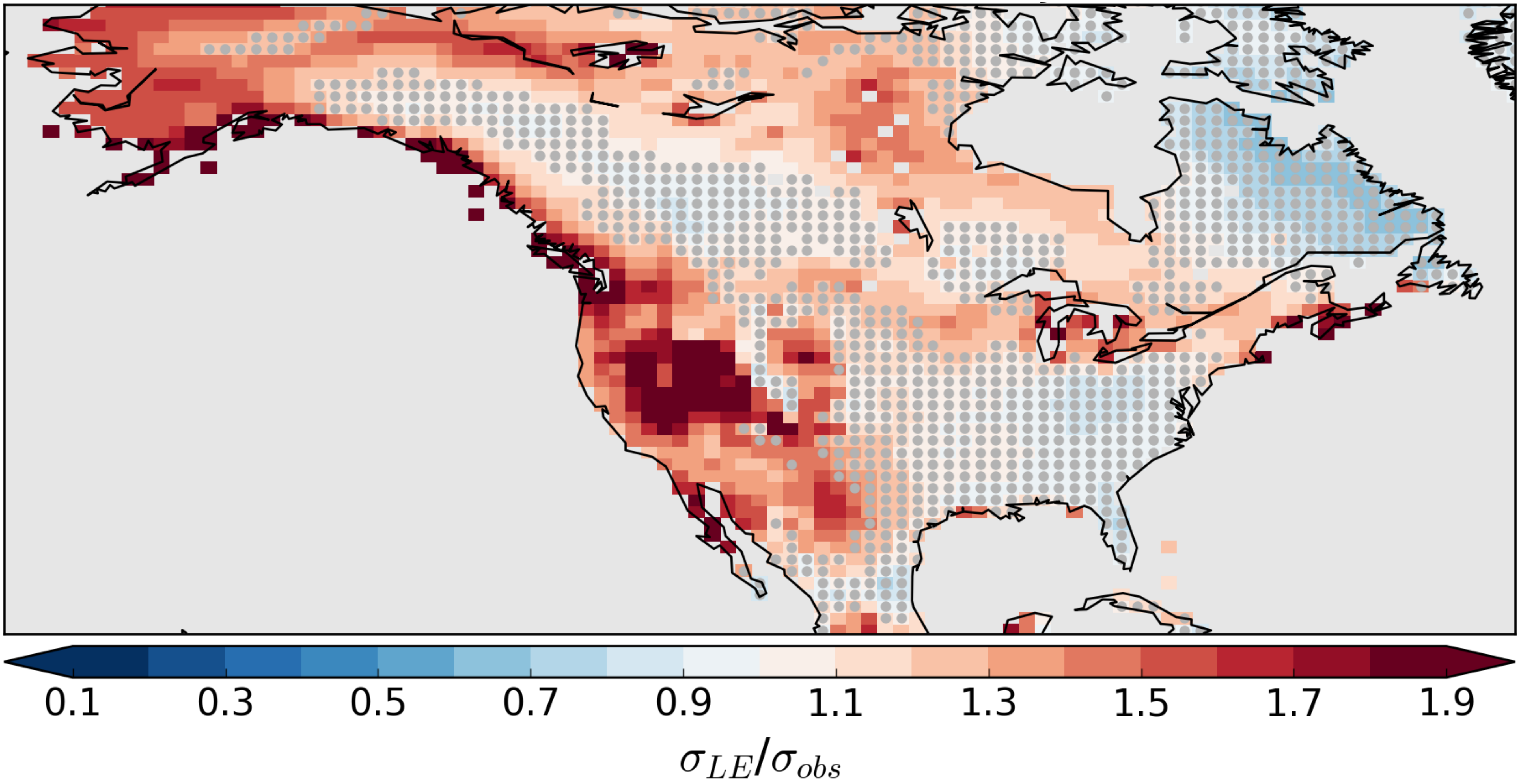
Evaluation: repeat exercise treating all members of the Large Ensemble as the observations.

Validation: can reproduce LENS variability



average across domain: 1.0

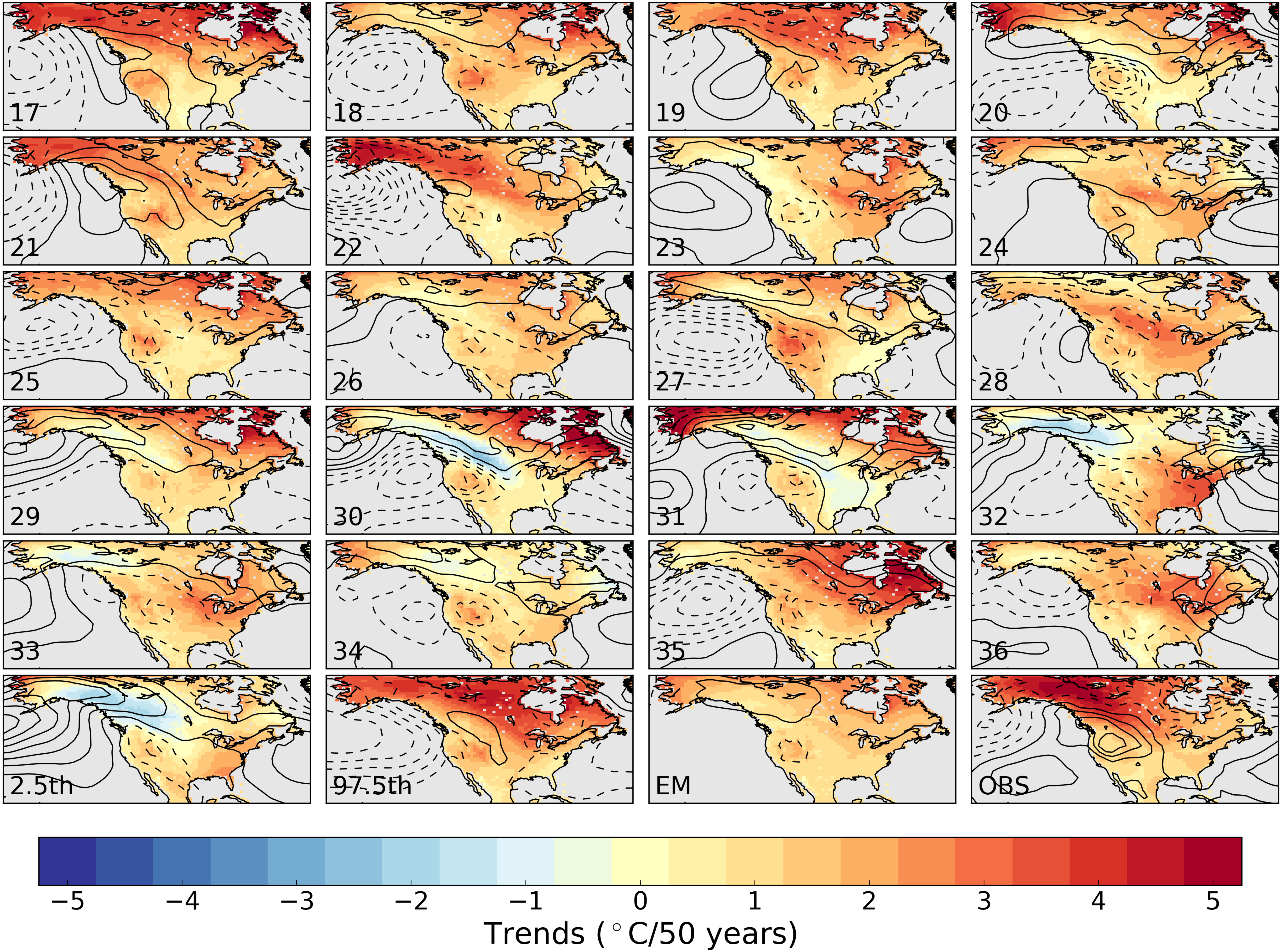
LENS overestimates trend uncertainty



Stippling: not significant

Observational Large Ensemble =

synthetic ensemble + ensemble mean from LENS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35
36
2.5th
97.5th
EM
OBS
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−4
−3
−2
−1
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1
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3
4
5
Trends (°C/50 years)

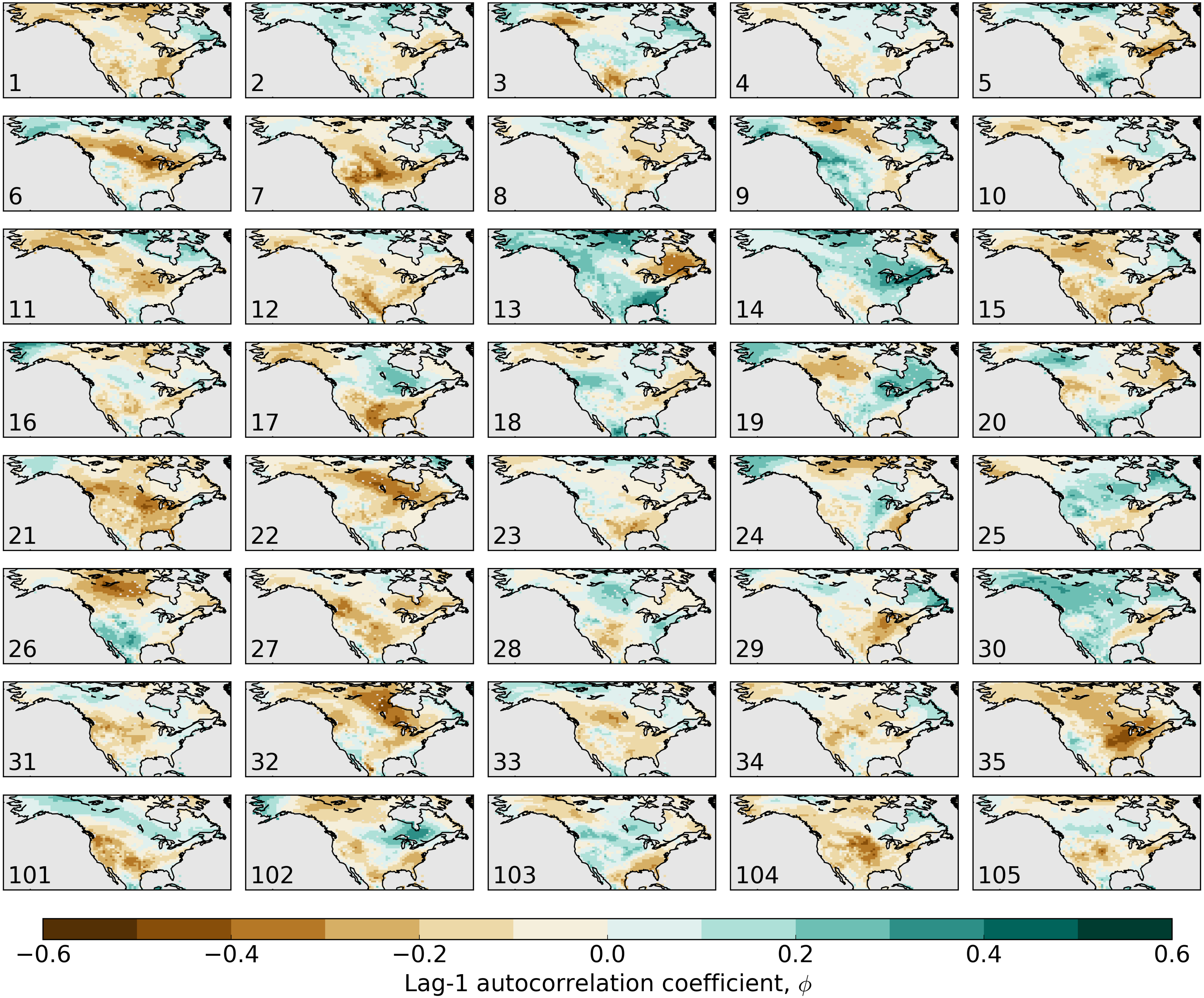
Take home points

Observed and modeled trends are a combination of natural variability and response to forcing

Variability in ‘long-term’ (e.g. 50 year) DJF temperature trends over North America primarily due to short-timescale variability

LENS tends to overestimate this variability, so overestimates the contribution of internal variability to trend uncertainty

By applying block bootstrapping to the observational record, we can make an ‘Observational Large Ensemble’ that has a covariance structure similar to the real world extras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34
35
101
102
103
104
105
−0.6
−0.4
−0.2
0.0
0.2
0.4
0.6
Lag-1 autocorrelation coefficient, ϕ