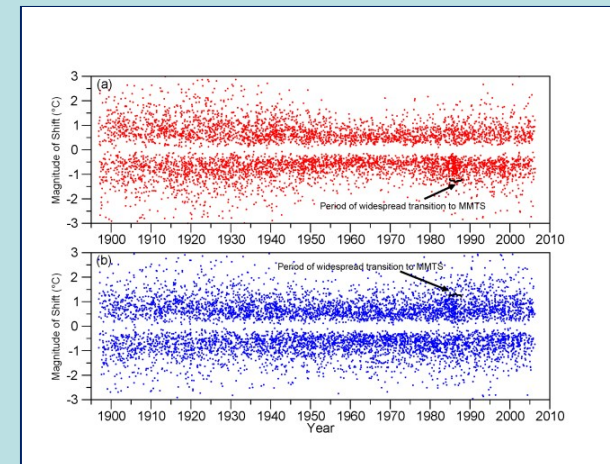
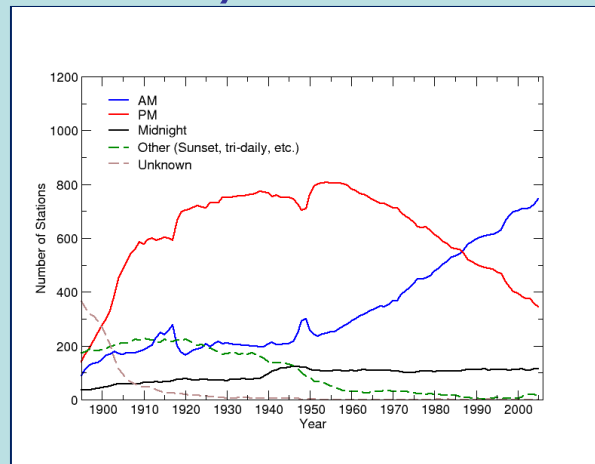
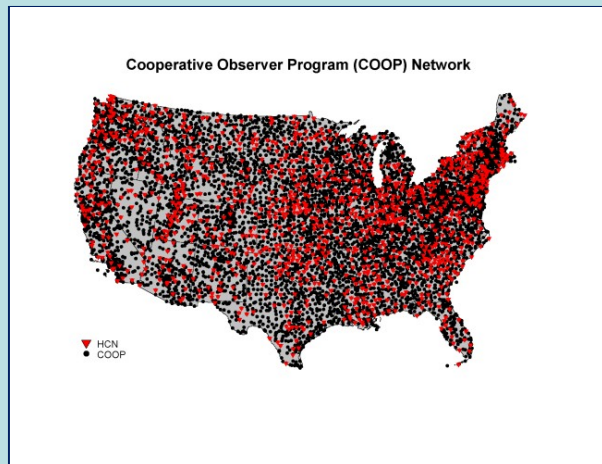


Structural uncertainty in the U.S. Historical Climatology Network temperature records:

*Benchmarking the performance of pairwise
homogenization of surface temperatures in the United
States*

Matthew Menne, Claude Williams & Peter Thorne
NOAA/National Climatic Data Center
Asheville, North Carolina



Outline

- Motivation
- Nature of experiment
- Results
- Conclusion

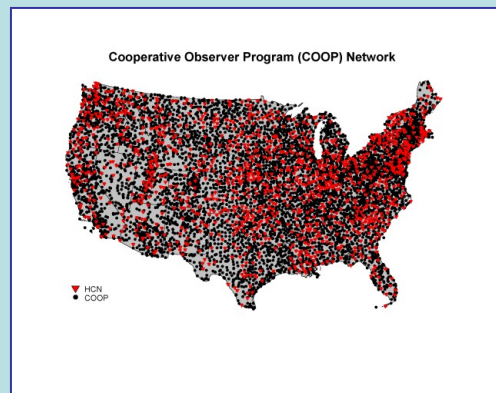
Motivation

Homogenization

- Requires multiple steps and decisions
 - What kind of breakpoint test?
 - Minimum segment lengths, significance level, use metadata?
 - How to compare stations?
 - How many comparisons? How to group stations (Distance? Correlation?)
 - How to compute the adjustment?
 - Mean break size, median?
- How sensitive are results to these decisions
- What are the “active” controls in the algorithm?

The Experiments

- Create analogs by sampling GCM model output over CONUS (from WCRP's multi-model dataset [CMIP3; *Meehl et al.*, 2007]).
 - Use data mask to replicate distribution and periods of record for U.S. Coop and USHCN sub-network (7200 and 1218 stations)
- Add noise term to series to approximate covariance between temperature stations
- Add random and clustered breaks to the analog series



Nature of the breaks

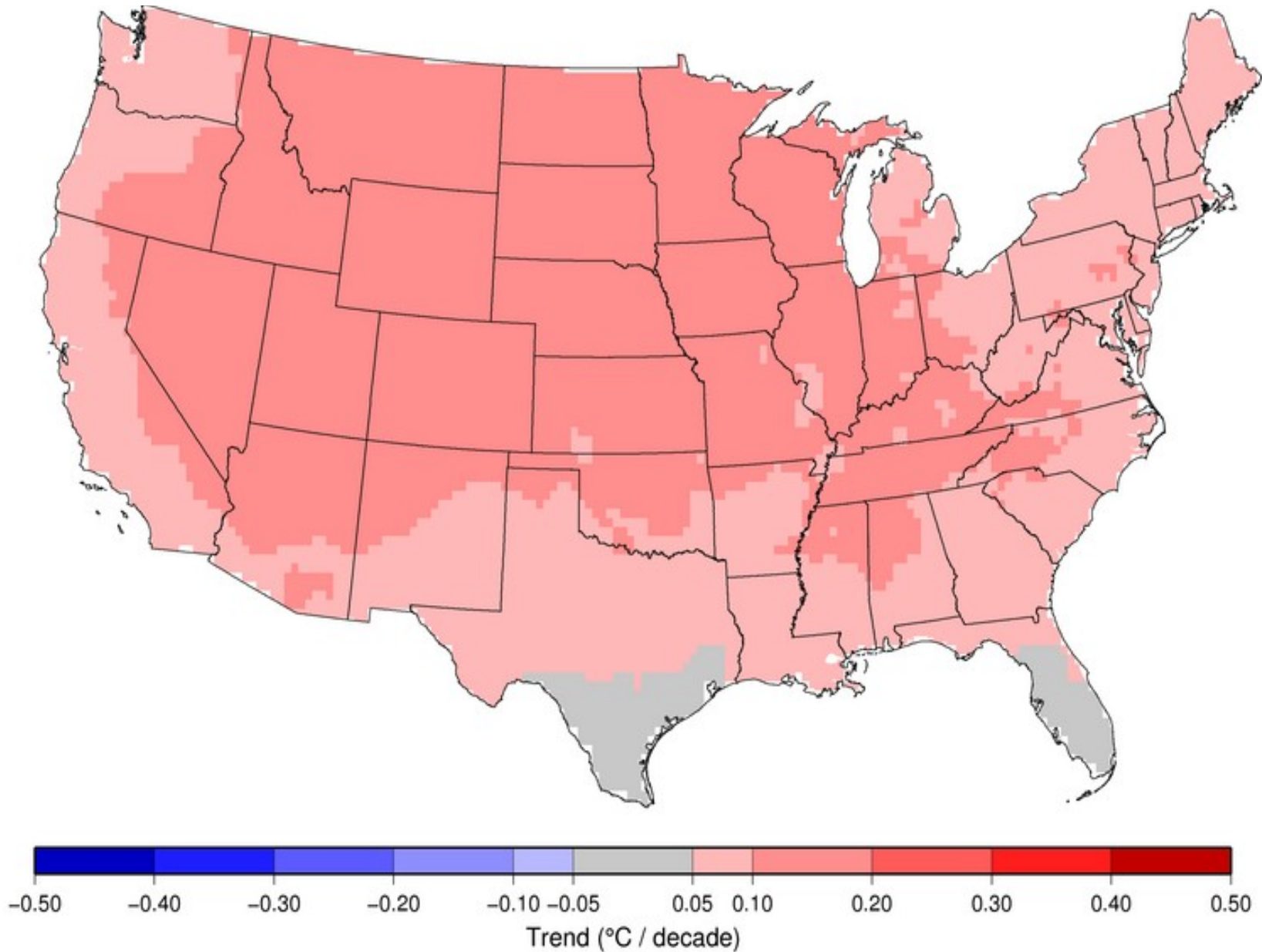
- **Control run – “Perfect Data”**
 - **World 8**
- **“Big breaks, perfect metadata”**
 - **World5**
- **“Mixed break sizes, some clustering”**
 - **World7**
- **“Clustering and sign bias” family**
 - **World1, World2, World3, World4**
- **“Very many mainly small breaks”**
 - **World 6**

Pairwise Algorithm

- Identified about 17 semi-objective components in the Menne and Williams (2009) pairwise homogenization algorithm (PHA)
- Assigned two, three or four reasonable values for each
- Randomly selected from these permitted values for each parameter
- Compiled 100 randomized versions of the PHA, each of which was used to homogenize all analog worlds

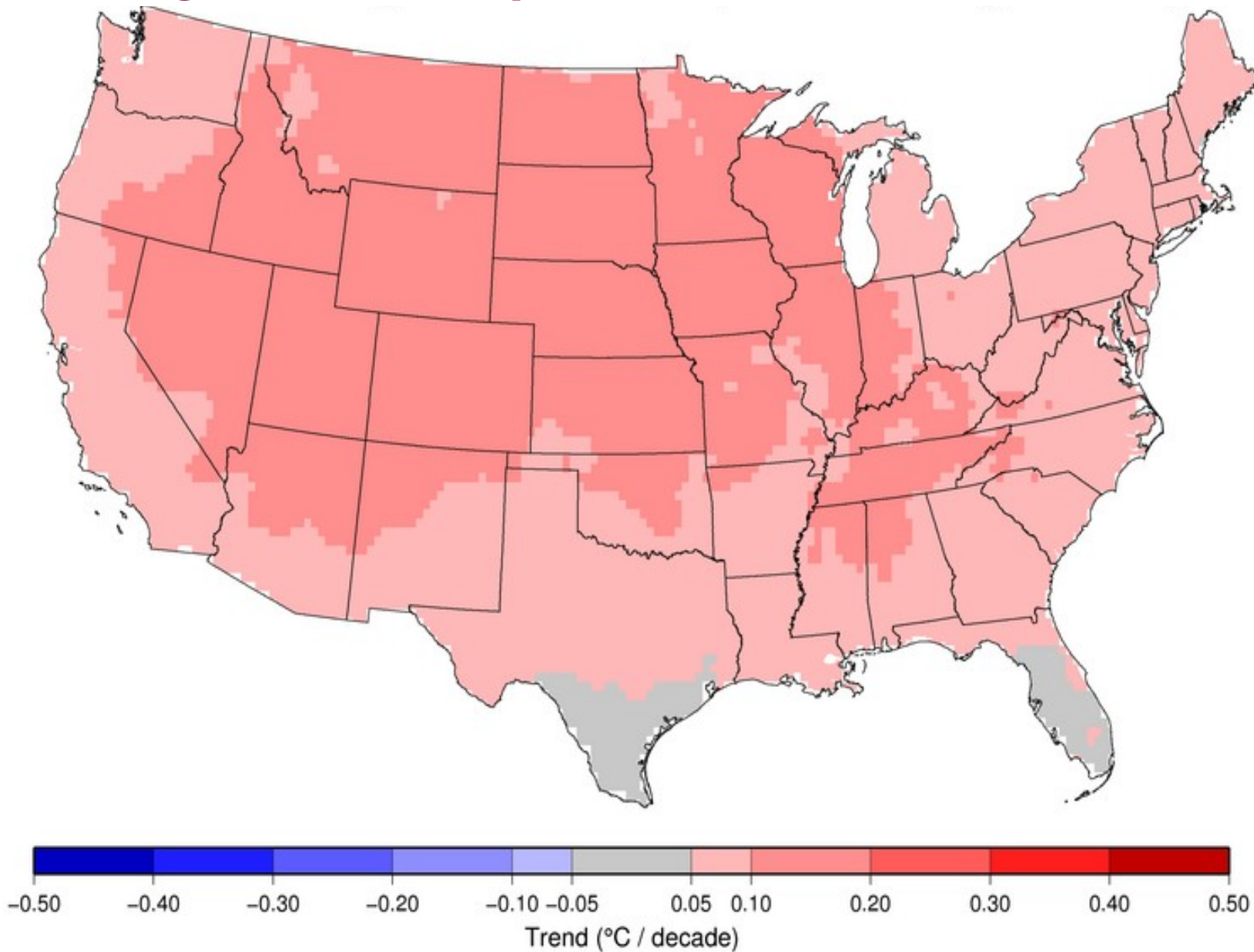
Results using the analogs

Analog World 8 (Perfect Data) True Temperature Trends

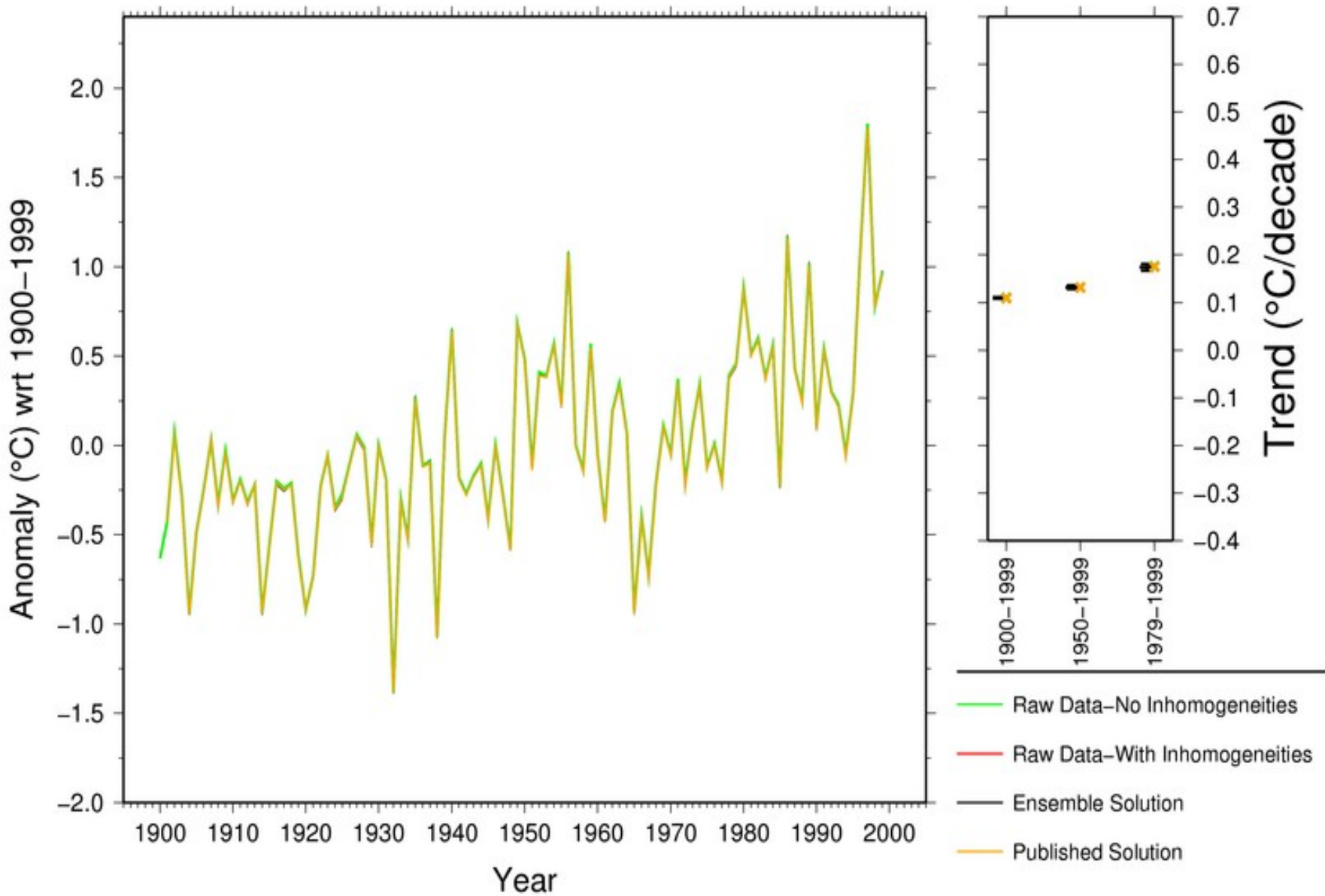


Analog World 8 (Perfect Data)

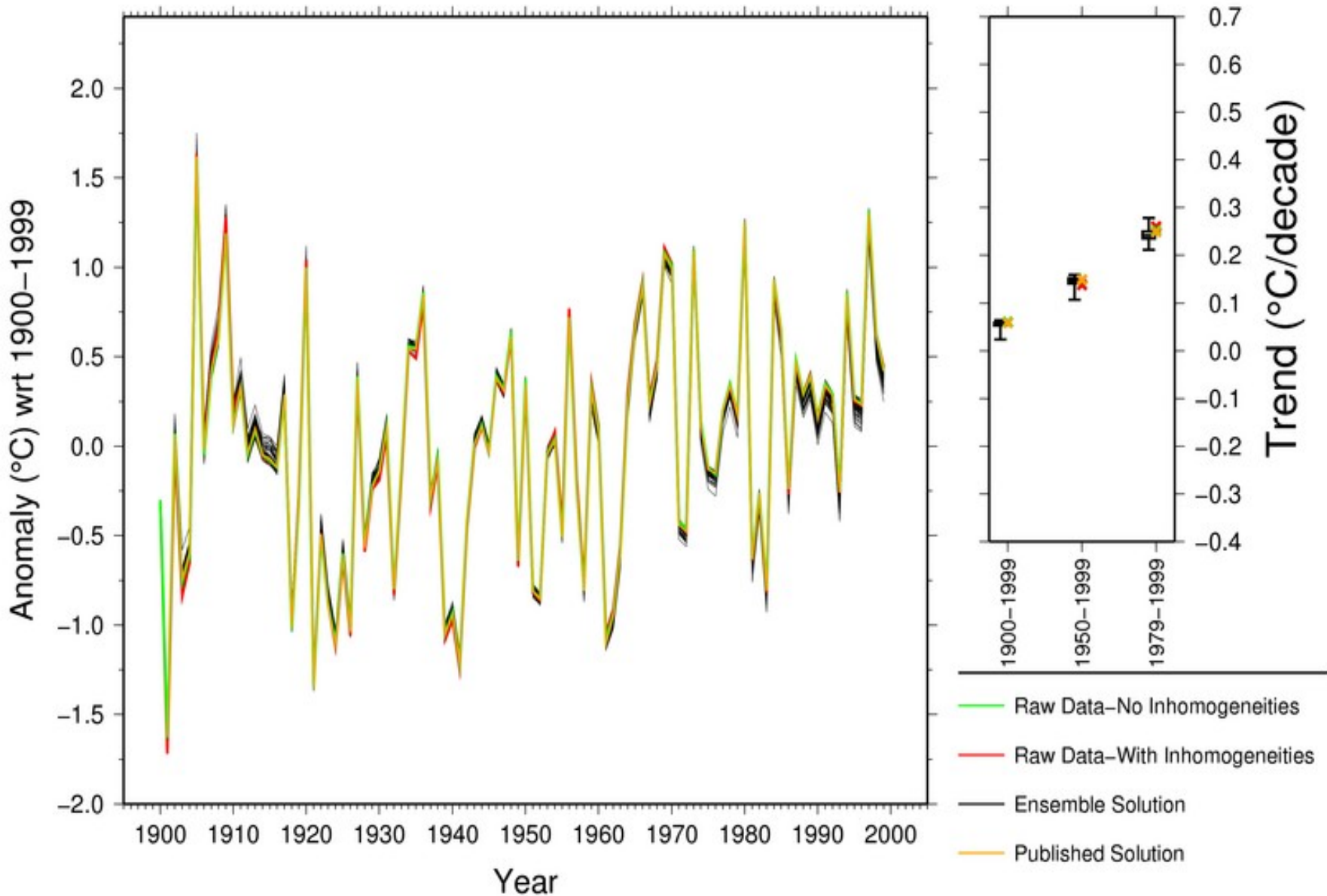
Homogenized Temperature Trends (Published Version)



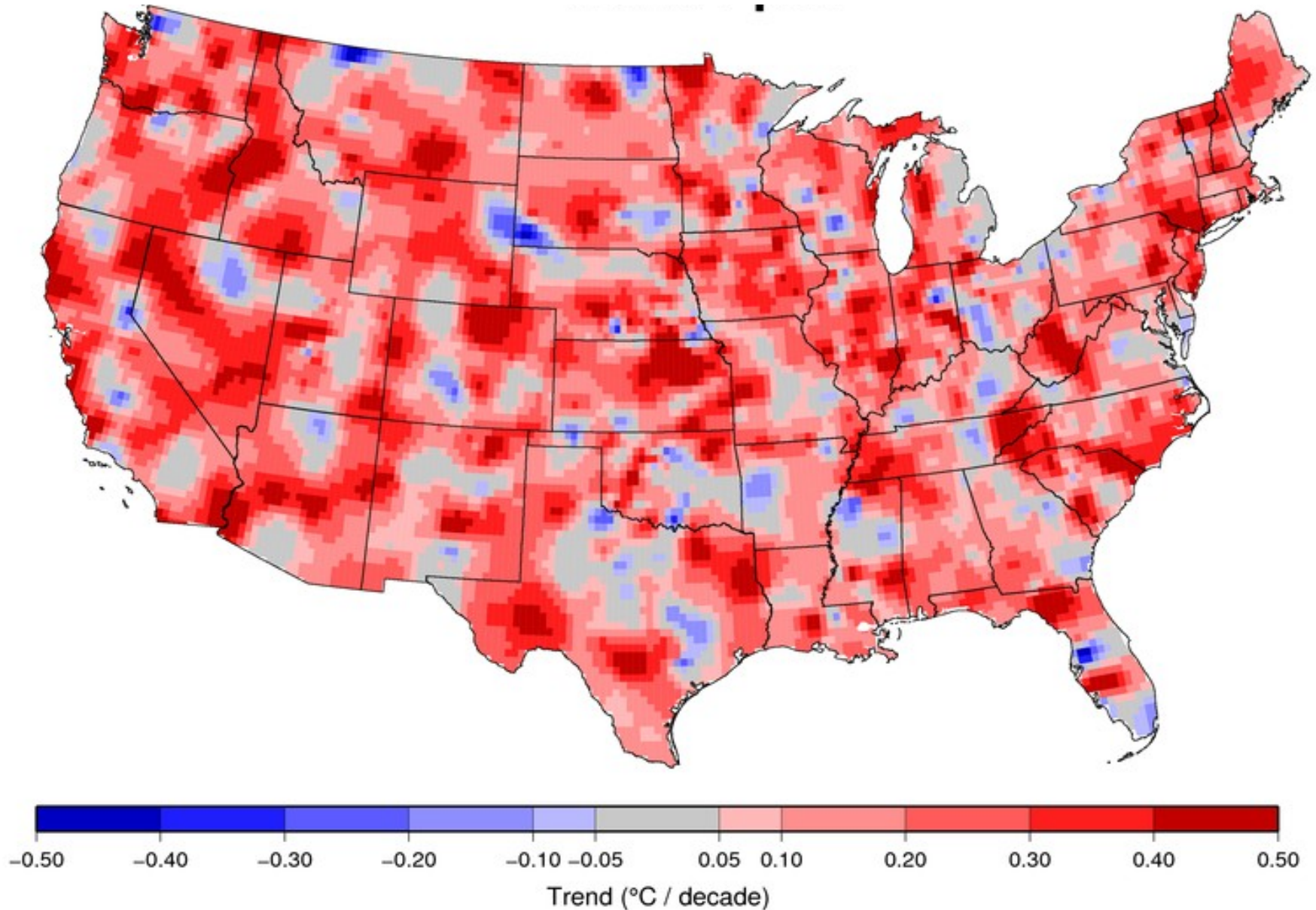
Perfect Data



Perfect Metadata – No Sign Bias

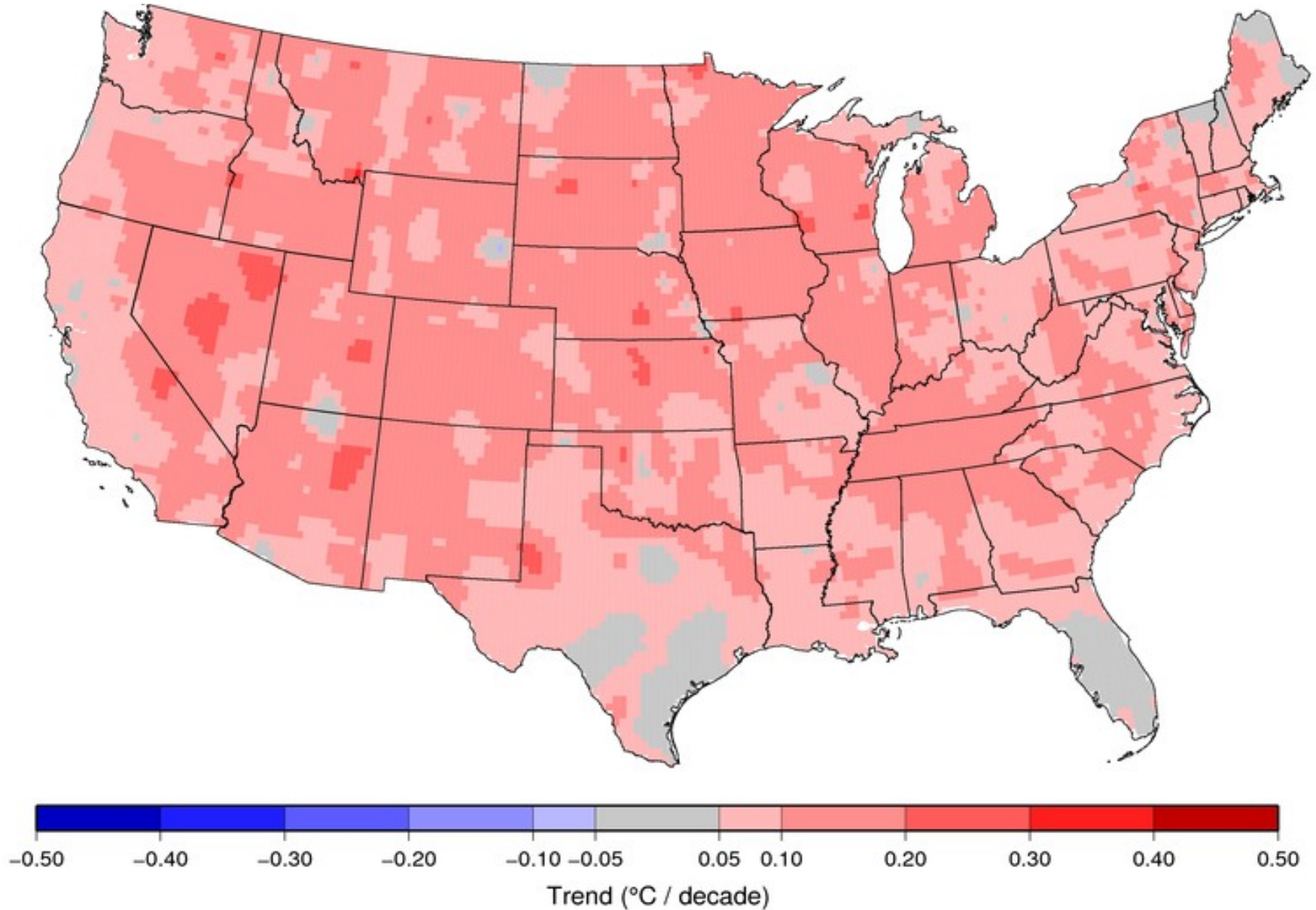


Uncorrected Temperature Trends Analog World 1 (clustering and sign bias)



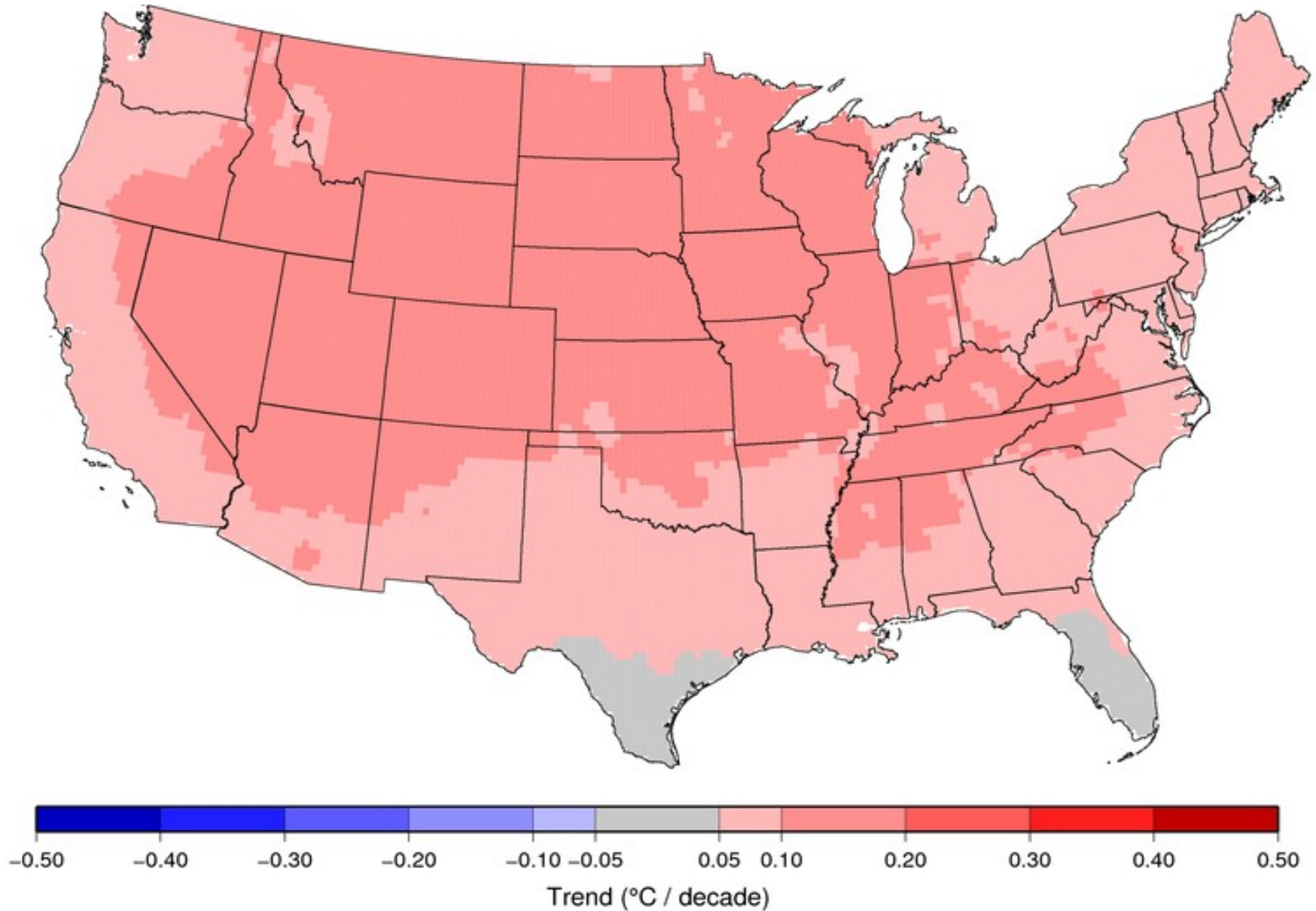
Bias-corrected Temperature Trends (Published Ver.)

Analog World 1

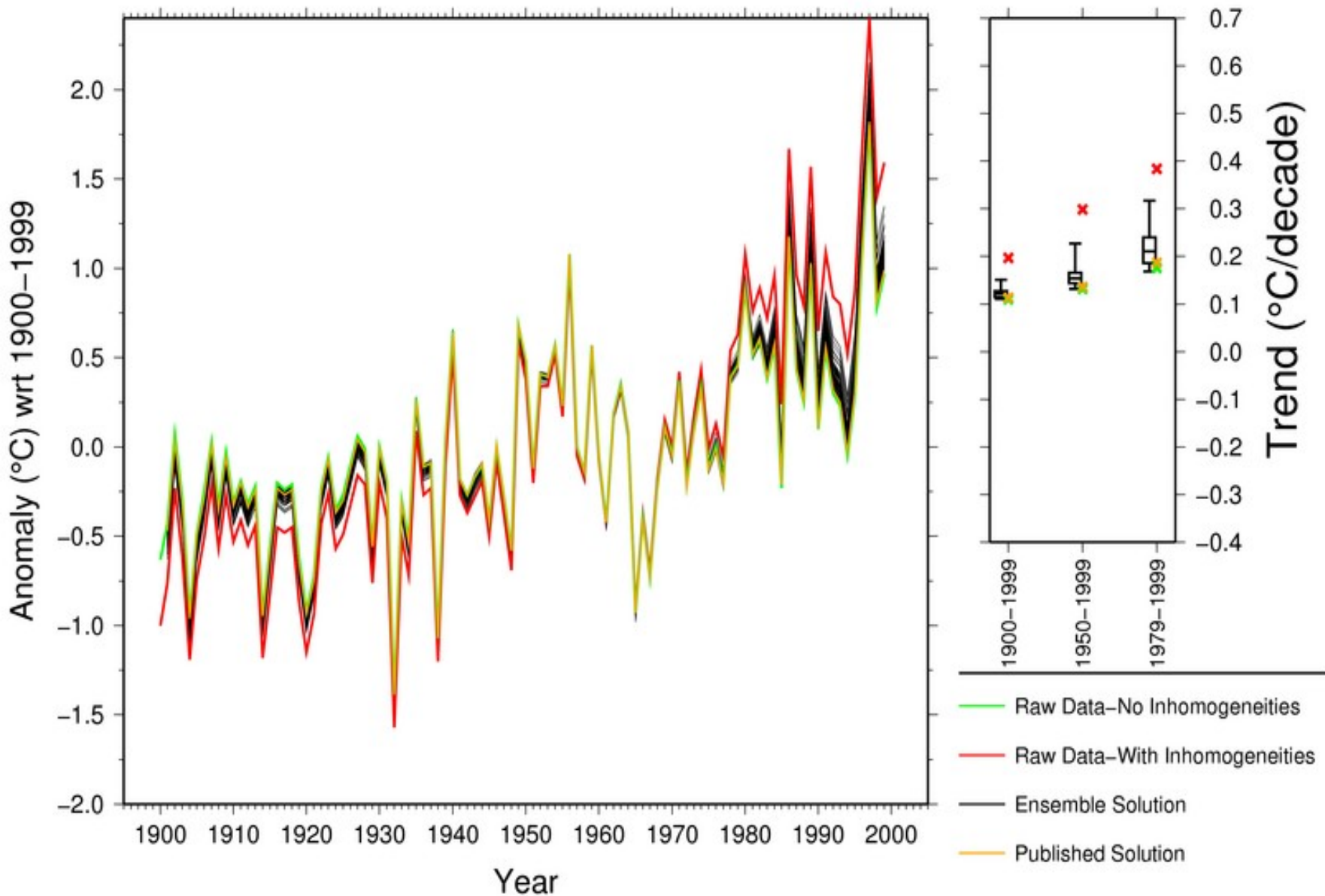


True Temperature Trends

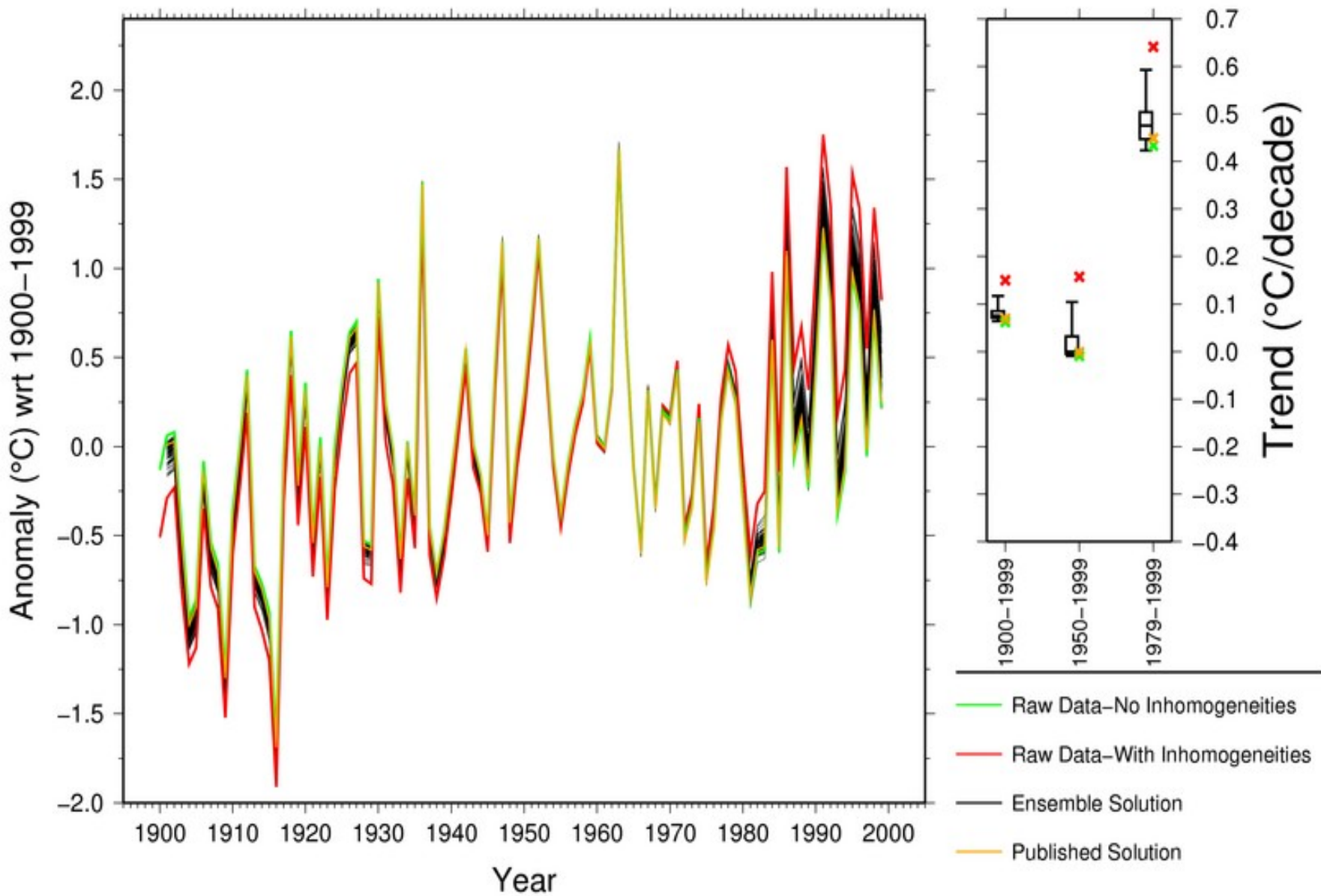
Analog World 1



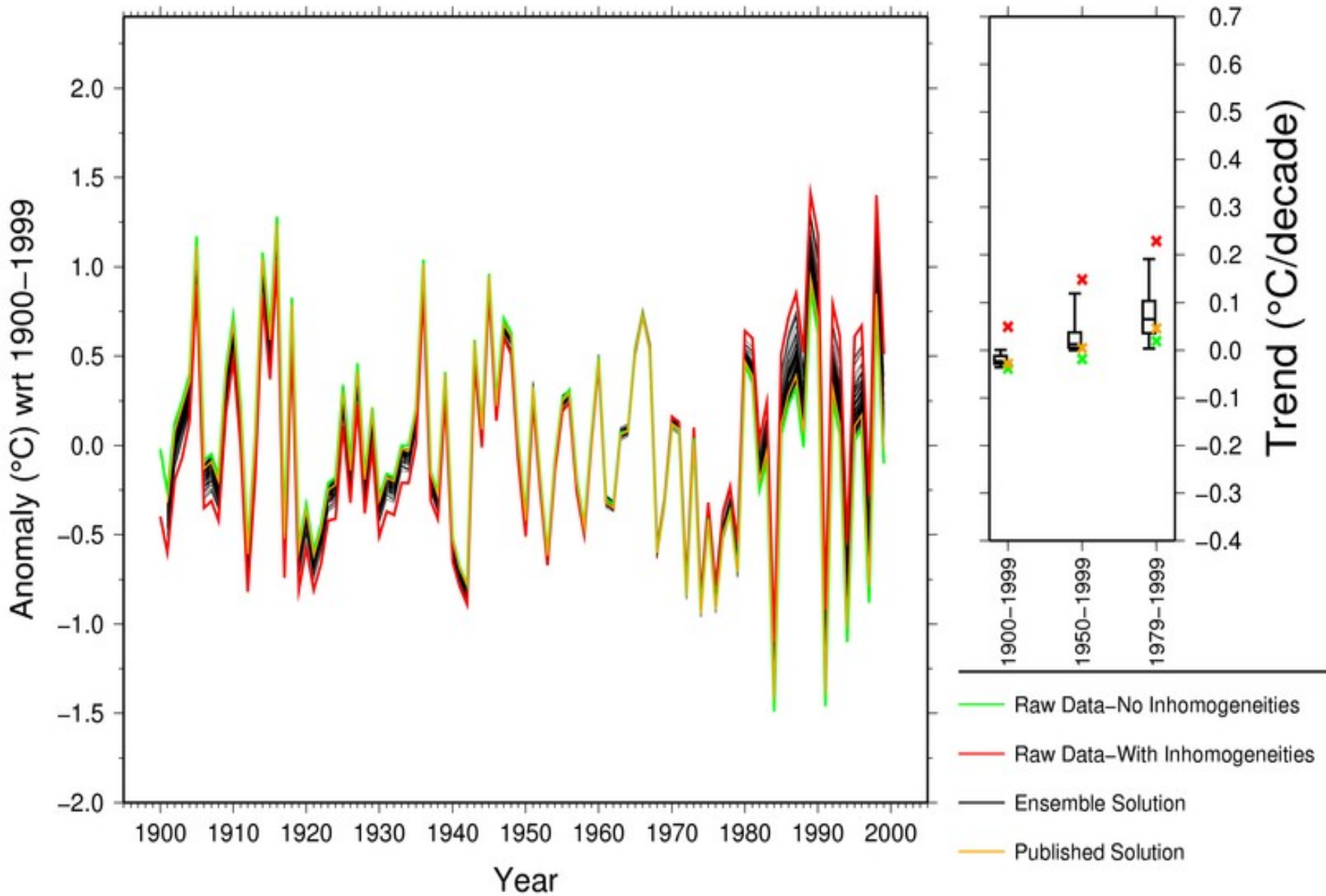
Clustering & Sign Bias–C20C1



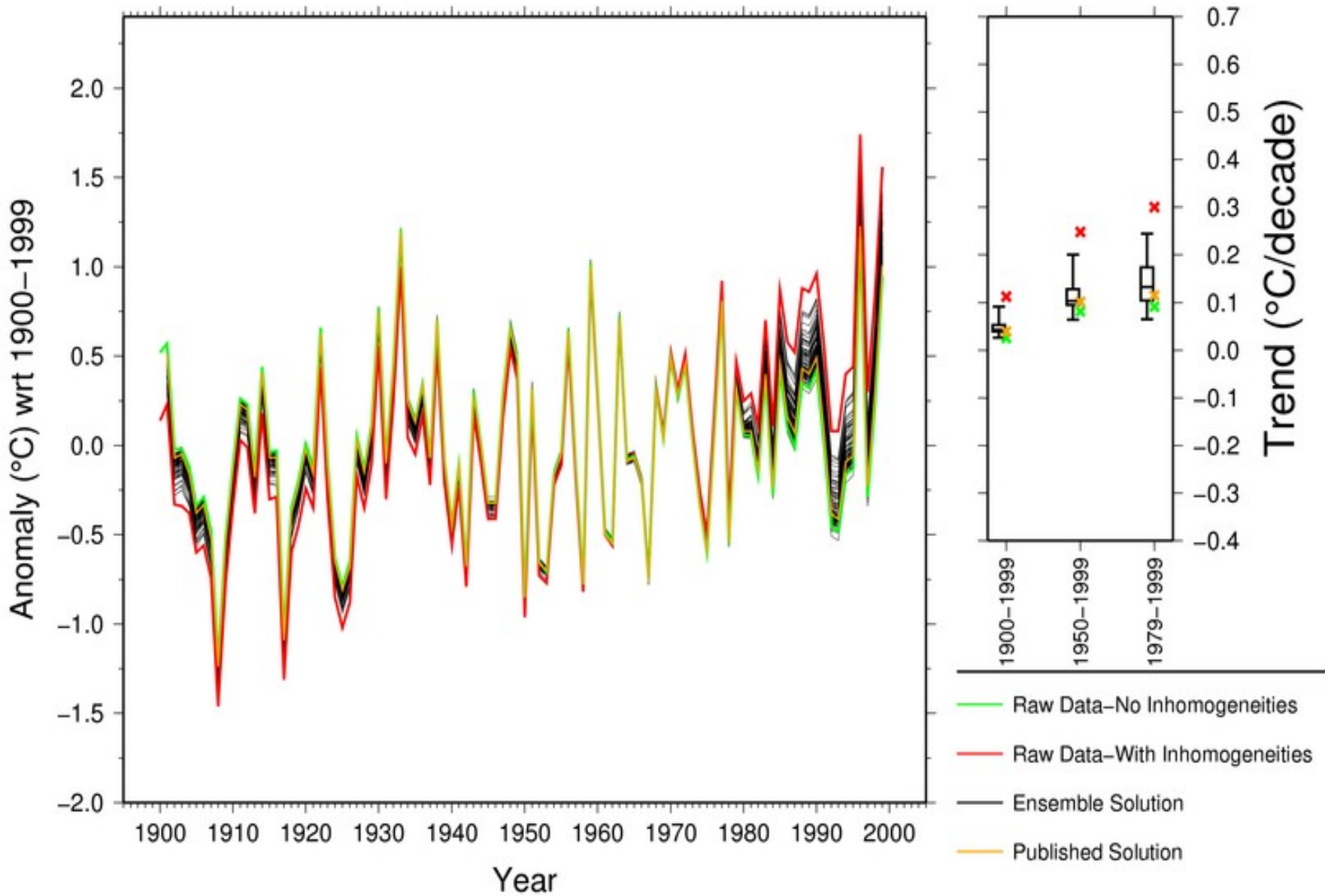
Clustering & Sign Bias–C20C2



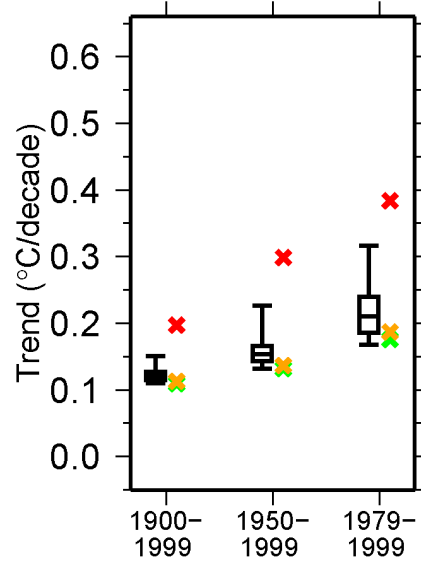
Clustering & Sign Bias-Control



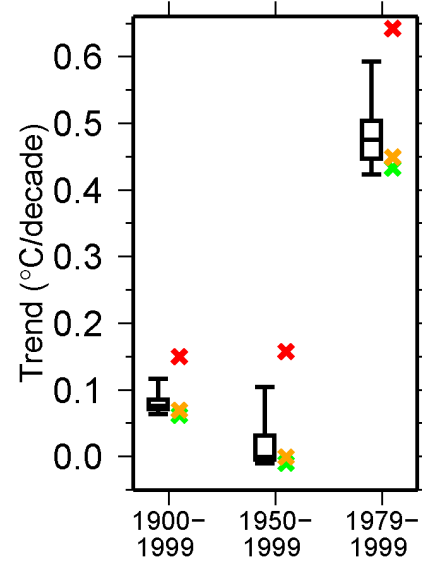
Clustering & Sign Bias–Committed



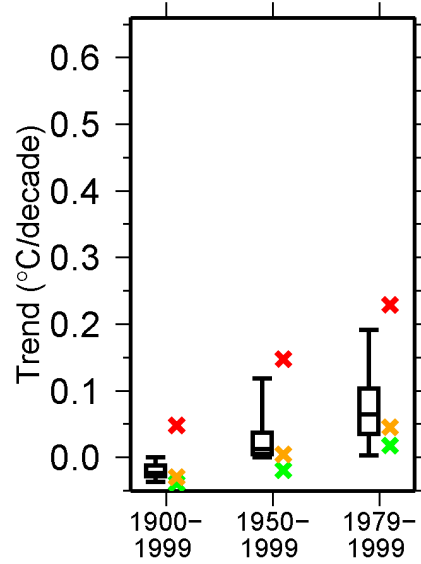
Clustering & Sign Bias-C20C1



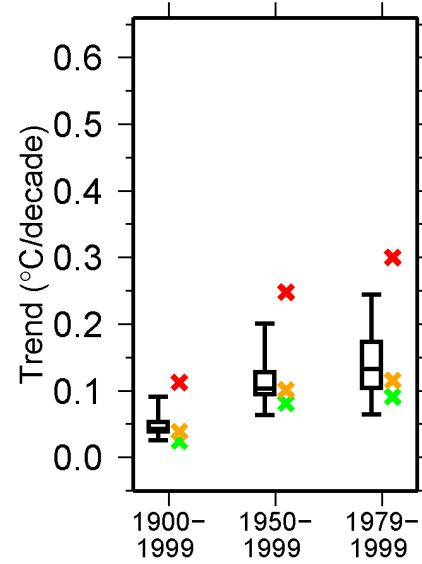
Clustering & Sign Bias-C20C2



Clustering & Sign Bias-Control

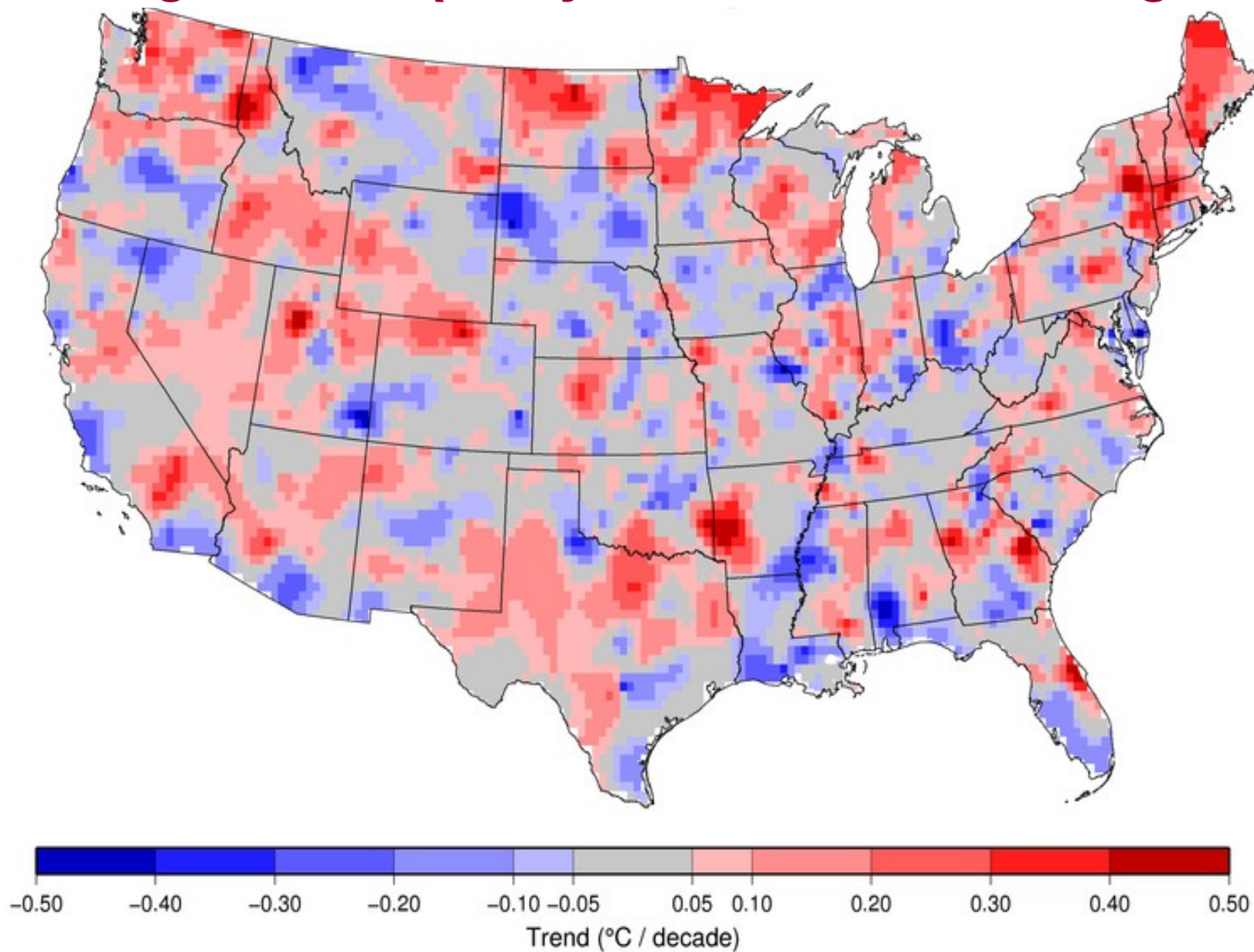


Clustering & Sign Bias-Committed



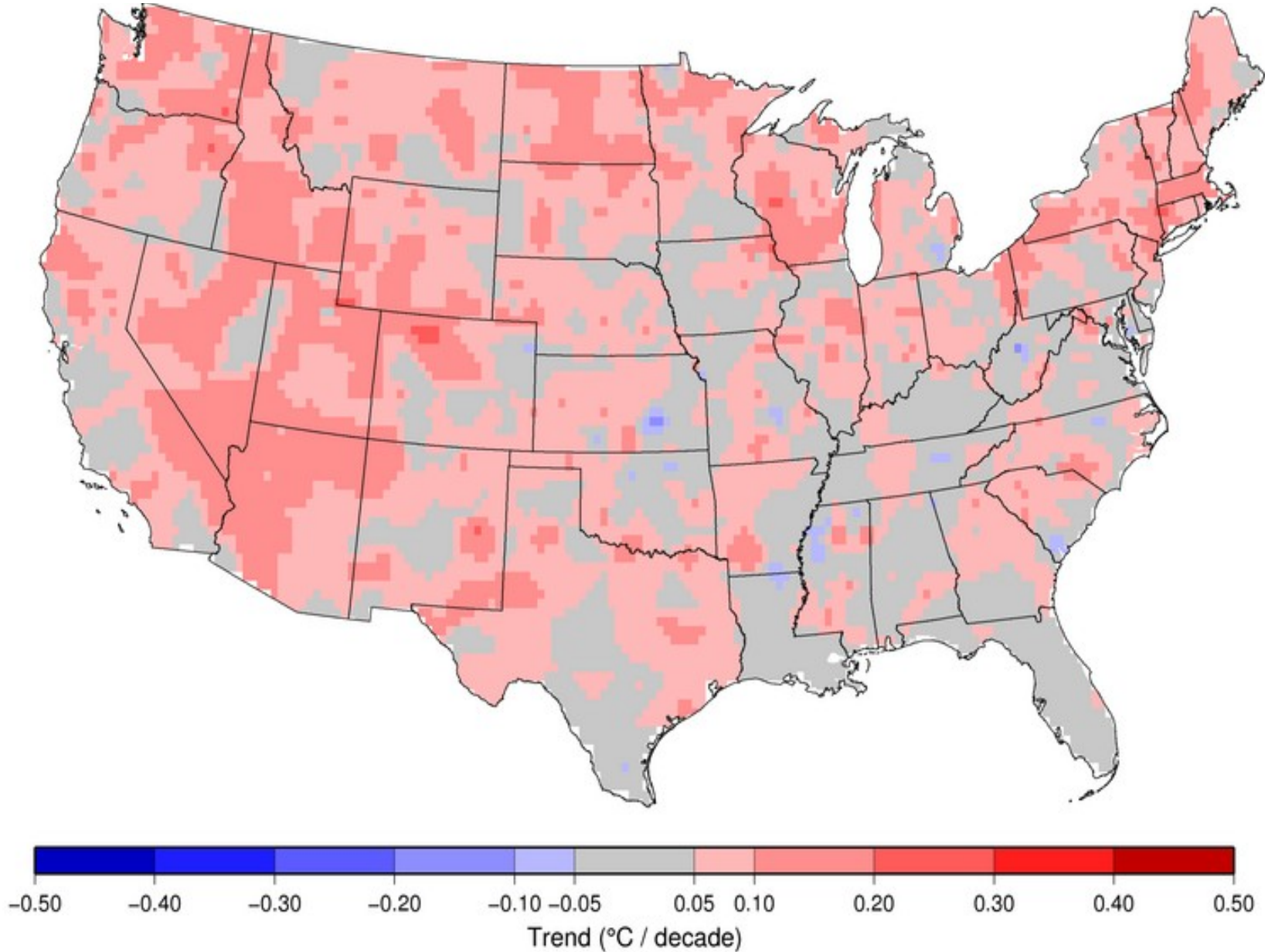
Uncorrected Temperature Trends

Analog World 6 (many small breaks with sign bias)

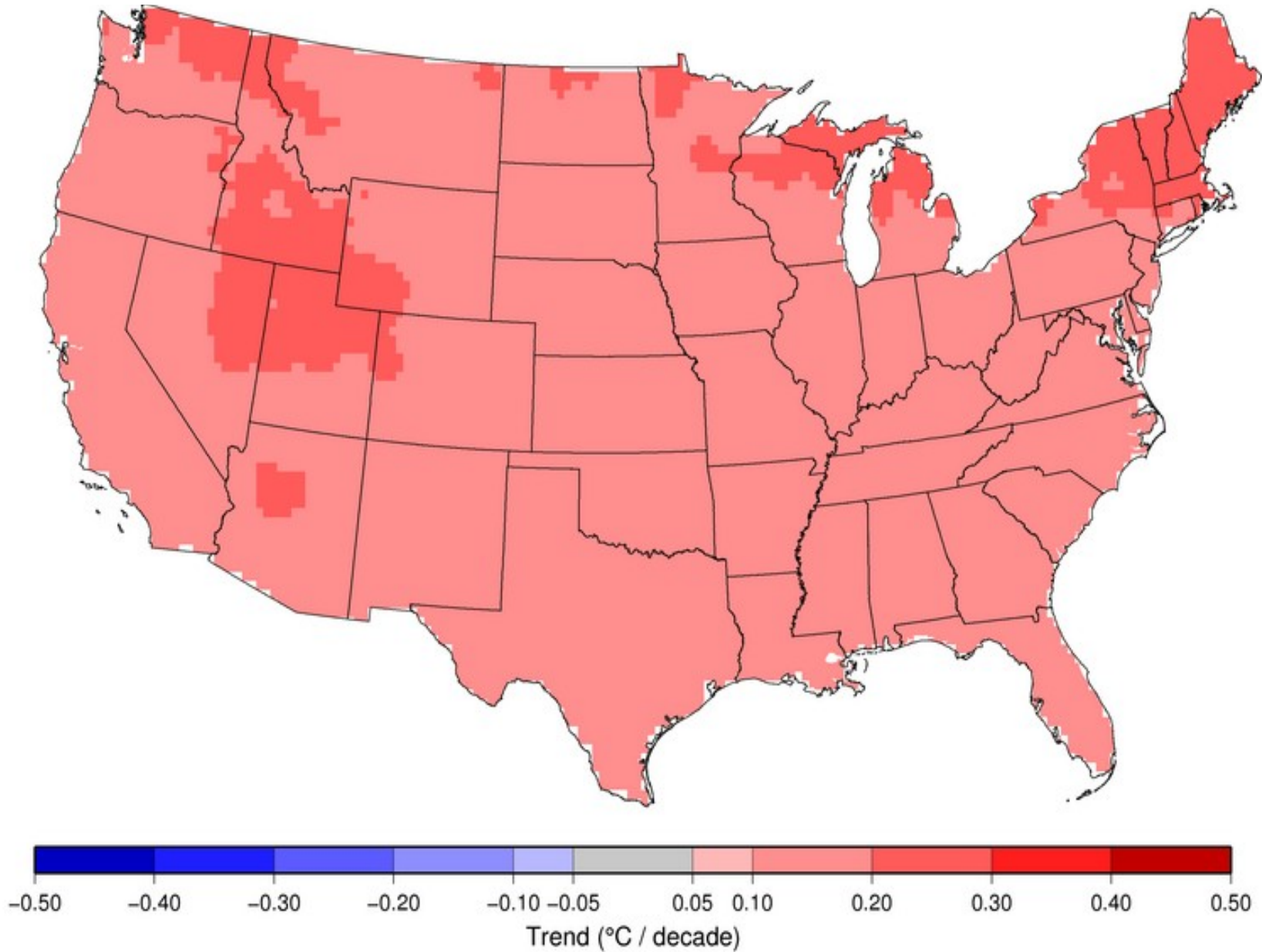


Bias-corrected Temperature Trends (Published Ver.)

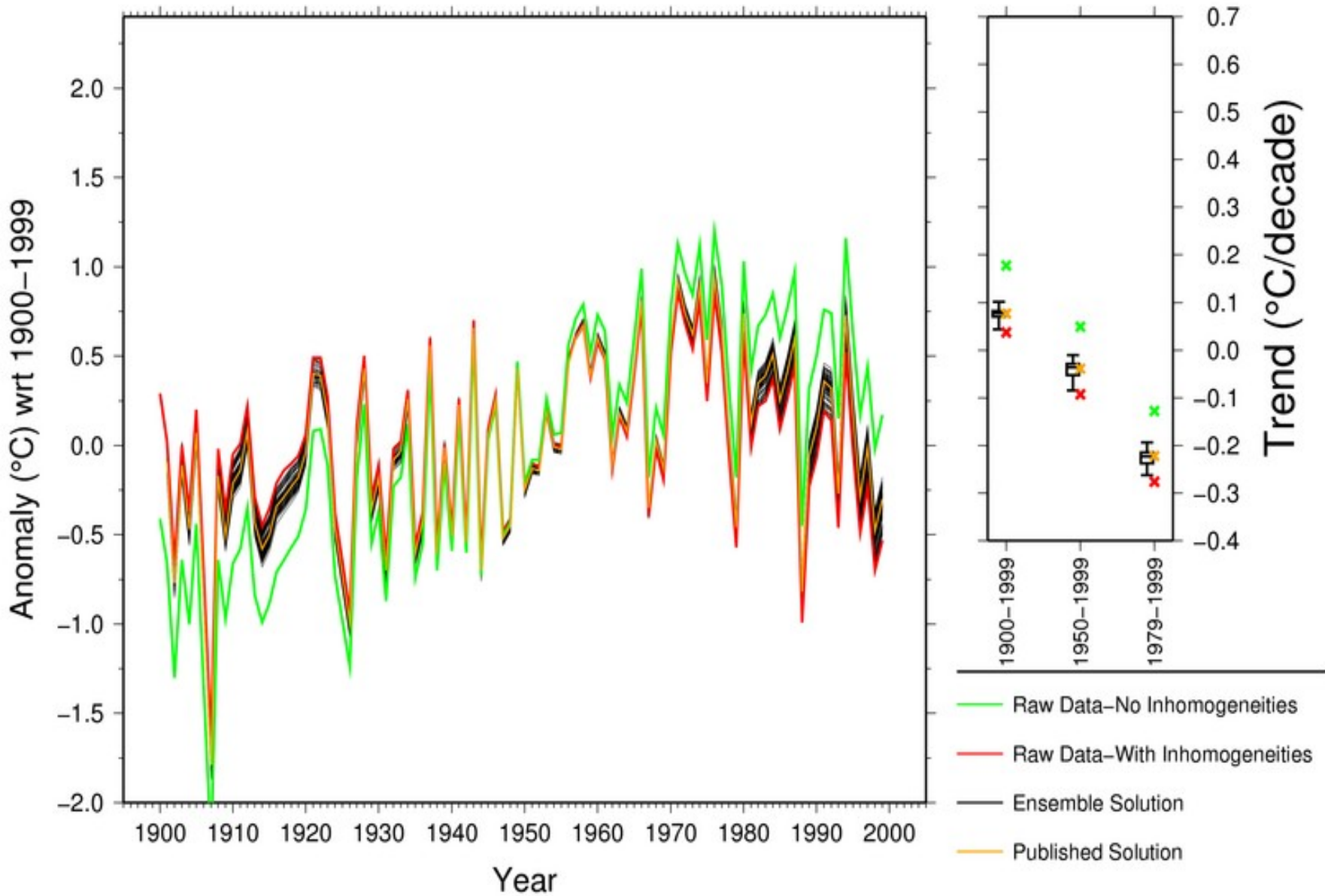
Analog World 6



True Temperature Trends Analog World 6



Many, Many Small Breaks with Sign Bias

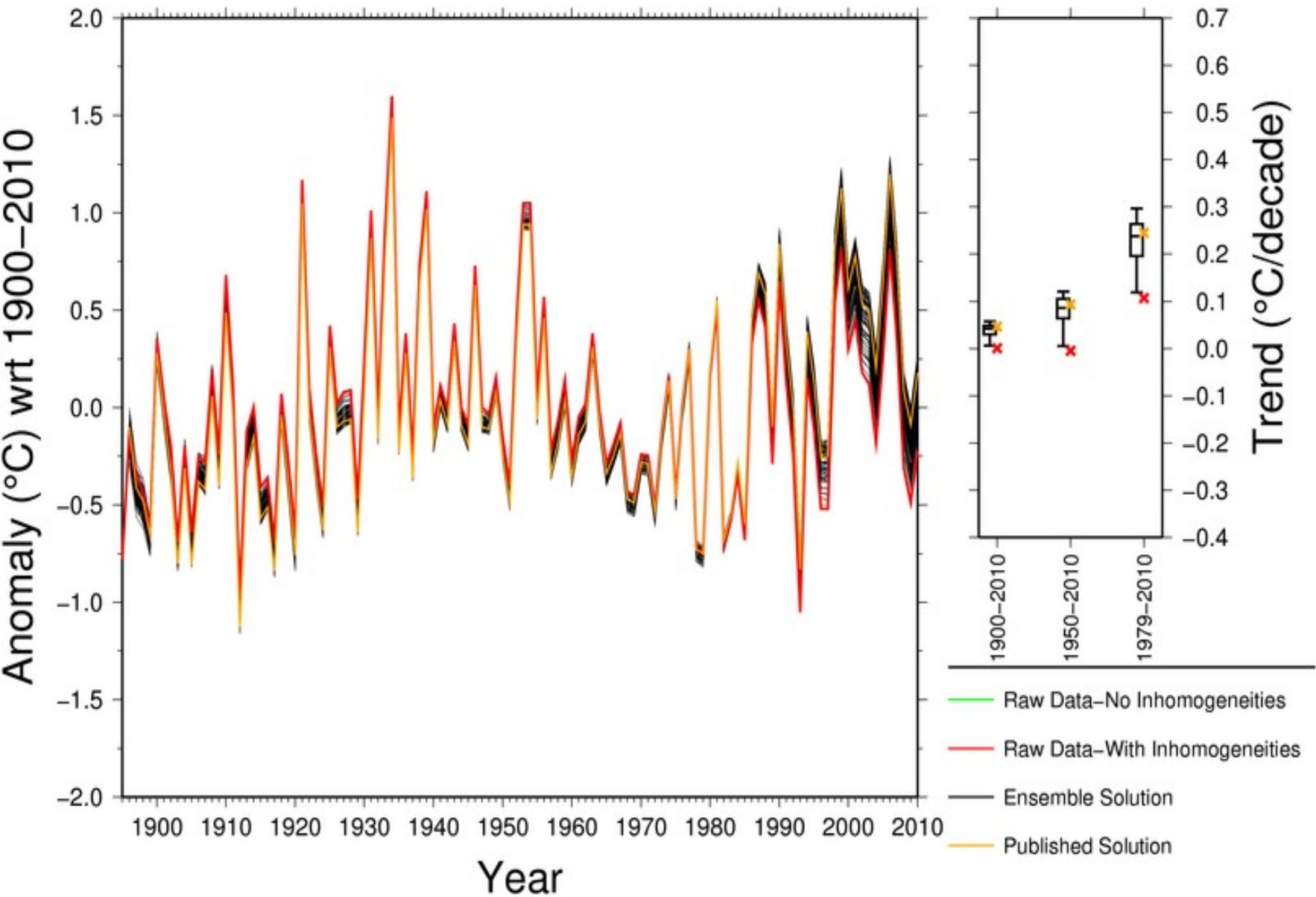


Conclusions

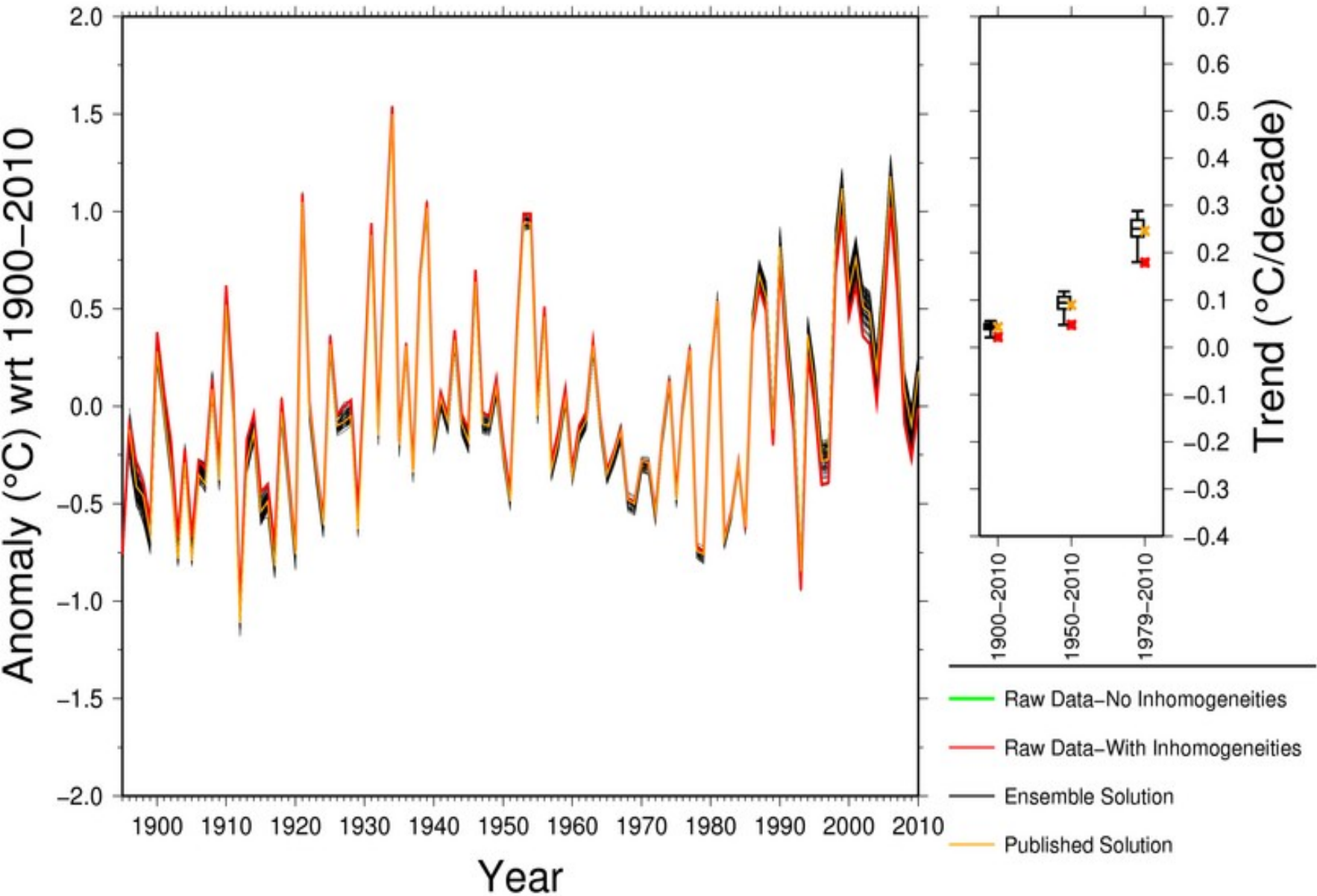
- For seeded errors with no sign bias, the randomized versions of the algorithm produced results tightly clustered around the true trend.
- In the case of perfect metadata, the randomized algorithms yield results that are unbiased and clustered around the truth.
- For errors with a sign bias, all versions moved the trend in the correct direction though generally not far enough
- The default version of the algorithm was one of the top performers in recovering the true trend except in the case of the “very many breaks with sign bias” analog.

Results using real data

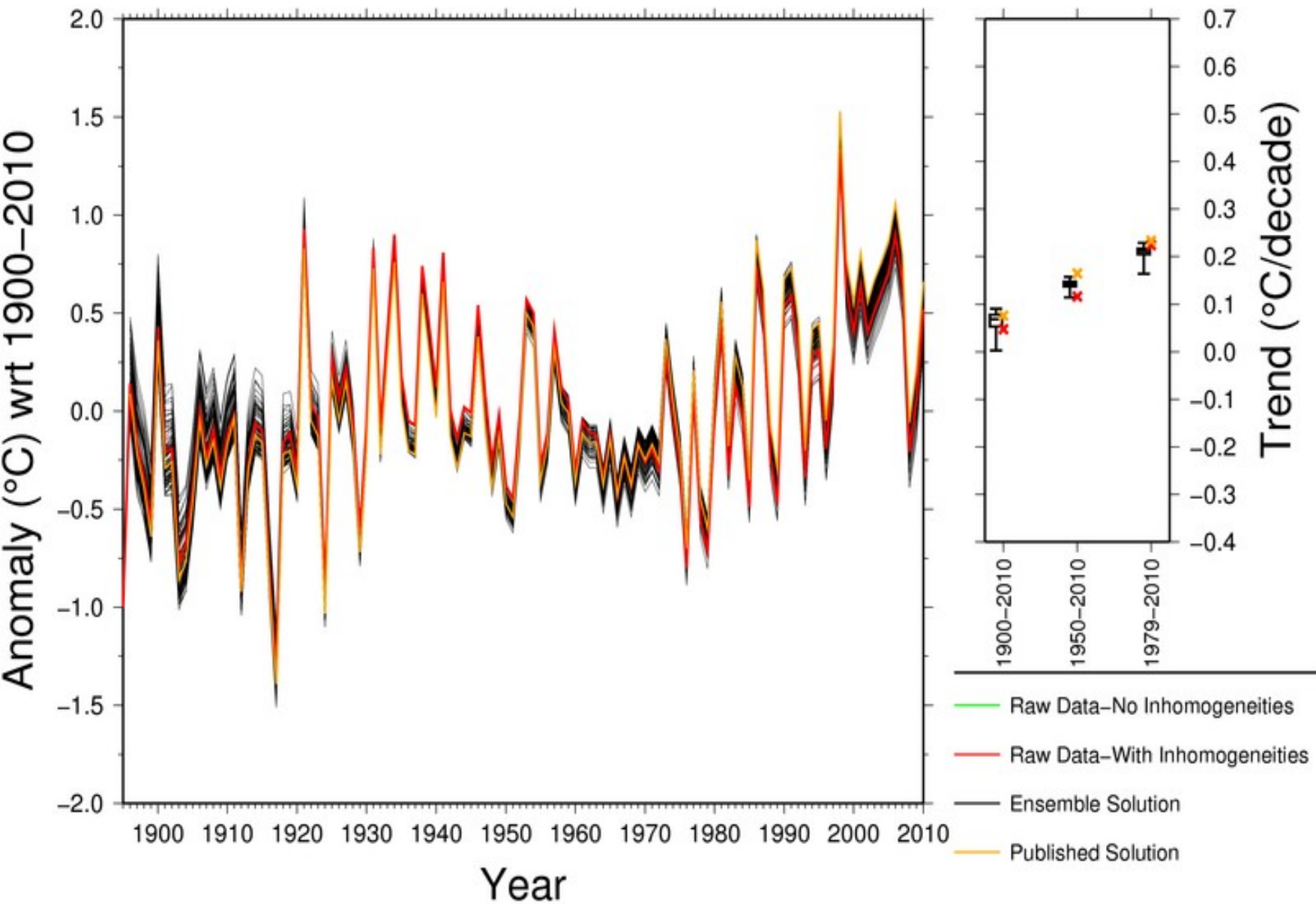
TMAX – Raw Input



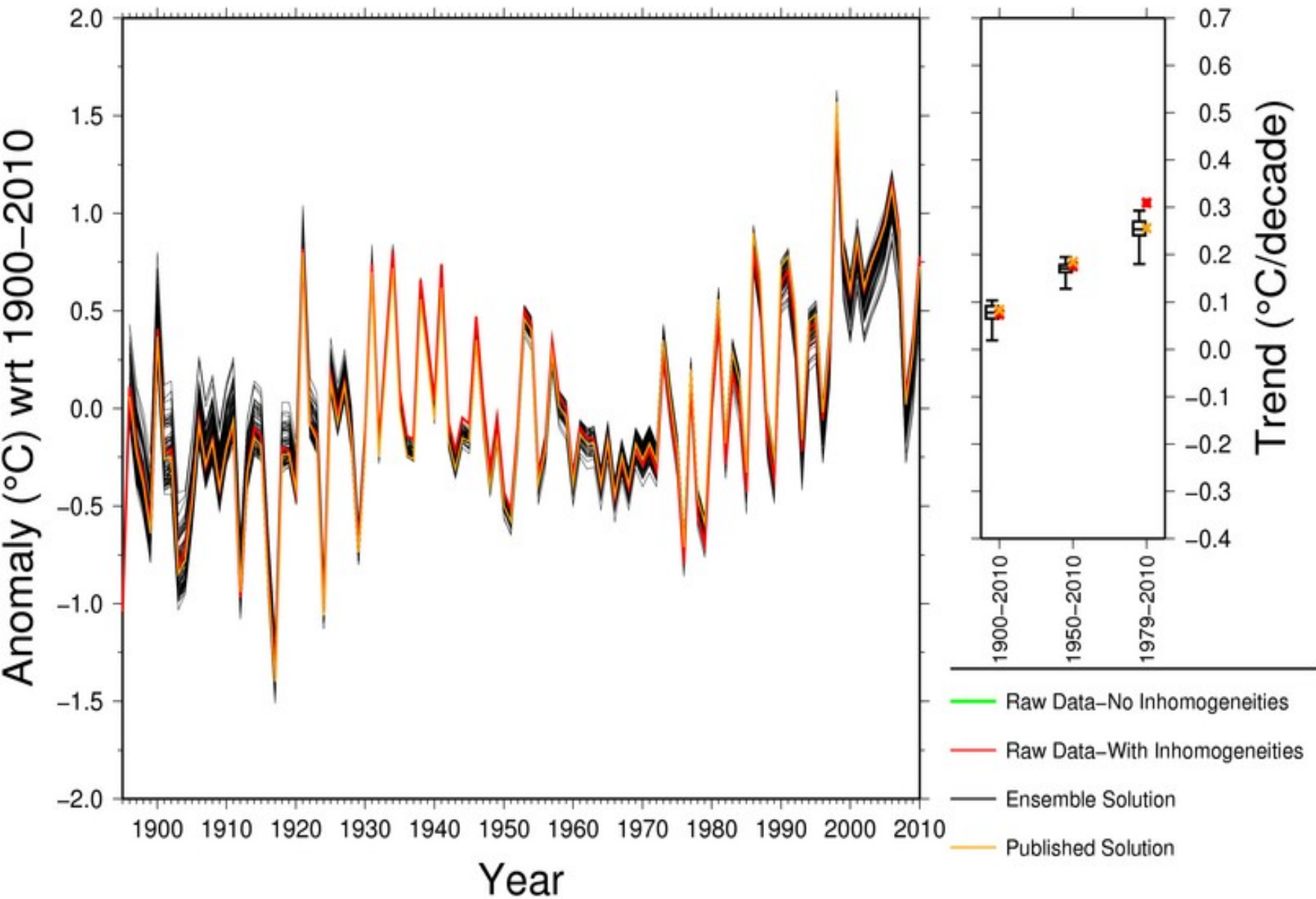
TMAX – TOB Adjusted Input



TMIN – Raw Input



TMIN - TOB Adjusted Input



Conclusions

- The raw maximum temperature record for the contiguous states has pervasive artifacts that have a negative bias
 - The collective bias is the sum of time of observation change effects after 1950 and the transition to electronic thermistors that began in the 1980s.
 - Trend uncertainty envelop does not include the raw data
- For minimum temperatures, there are competing biases caused by changes in observation time and instrument type.
 - Time of observation bias dominates period since 1950 and instrument change dominates period since 1979.
 - Raw minimum temperature within the envelop of trend uncertainty, except (perhaps) since 1979.

Conclusions

- Next up,
 - Use the active parameters and good settings to produce more “equiprobable” solutions
 - Add truly independent efforts