



Met Office
Hadley Centre

All historical SST analyses are wrong*,
probably even this one

John Kennedy

MARCDAT-III, 3rd May 2011, Frascati, Italy

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The good news

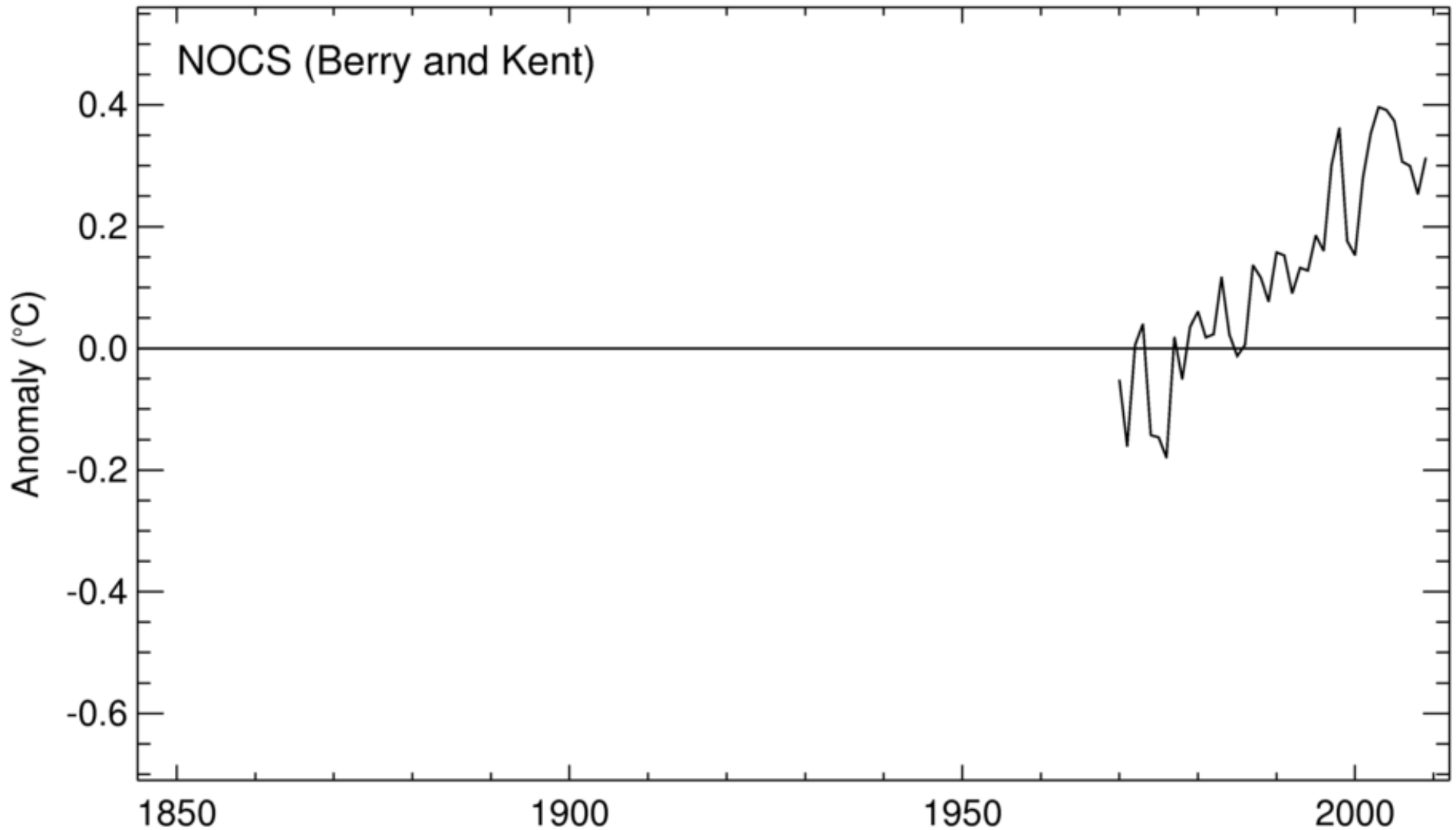
They're not very wrong

We can do something about it



Sea surface temperatures

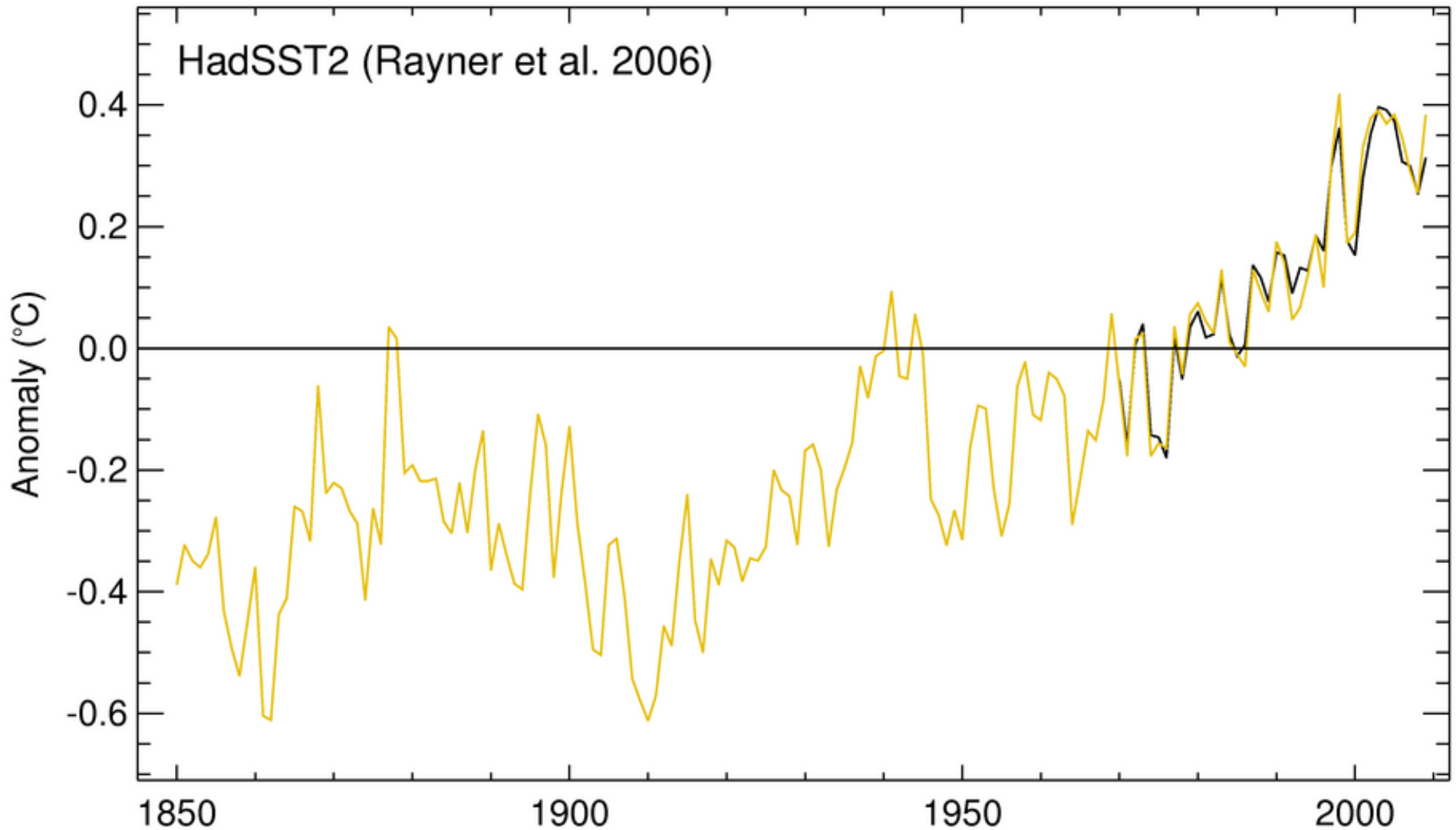
x1





Sea surface temperatures

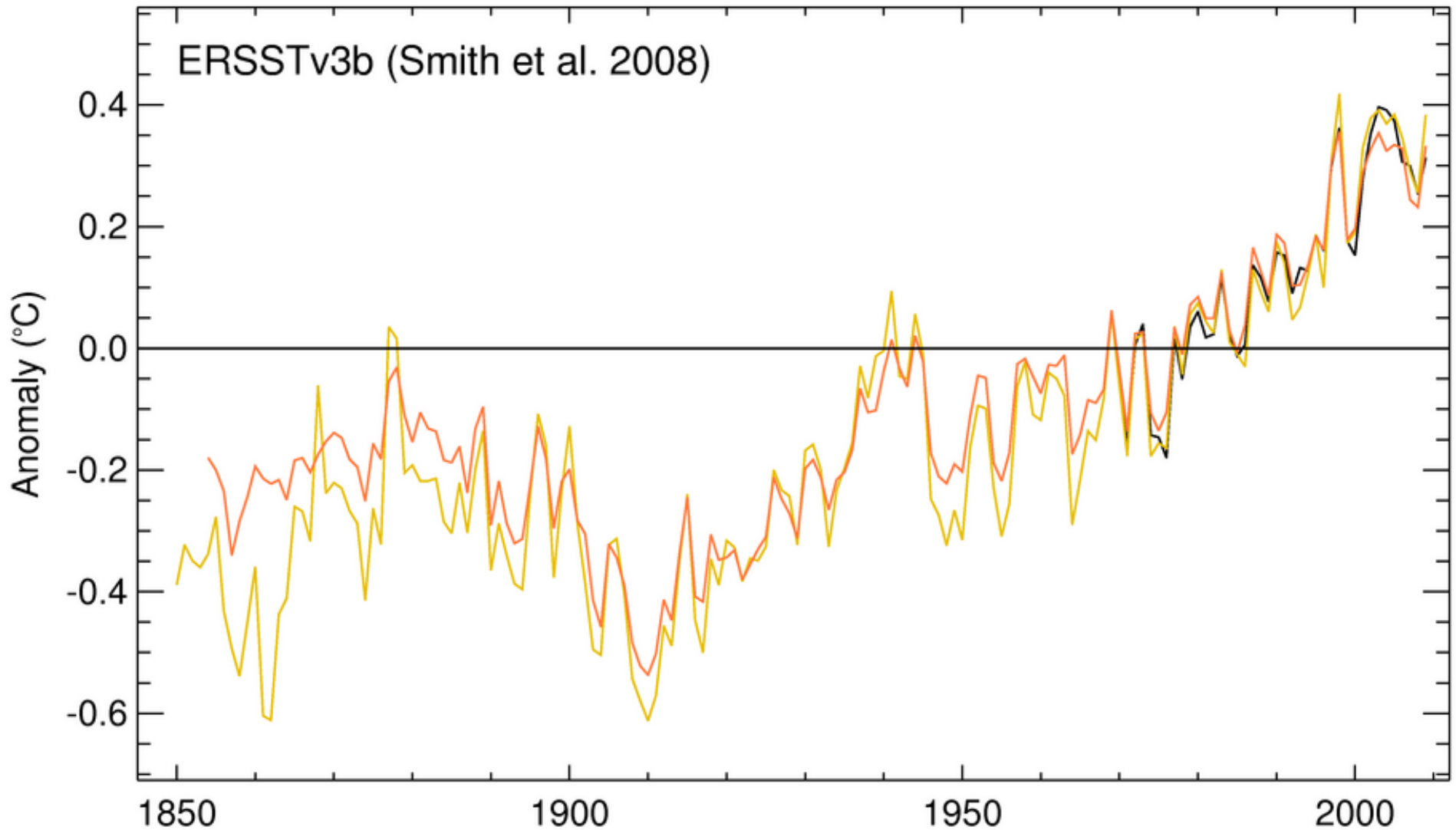
x2





Sea surface temperatures

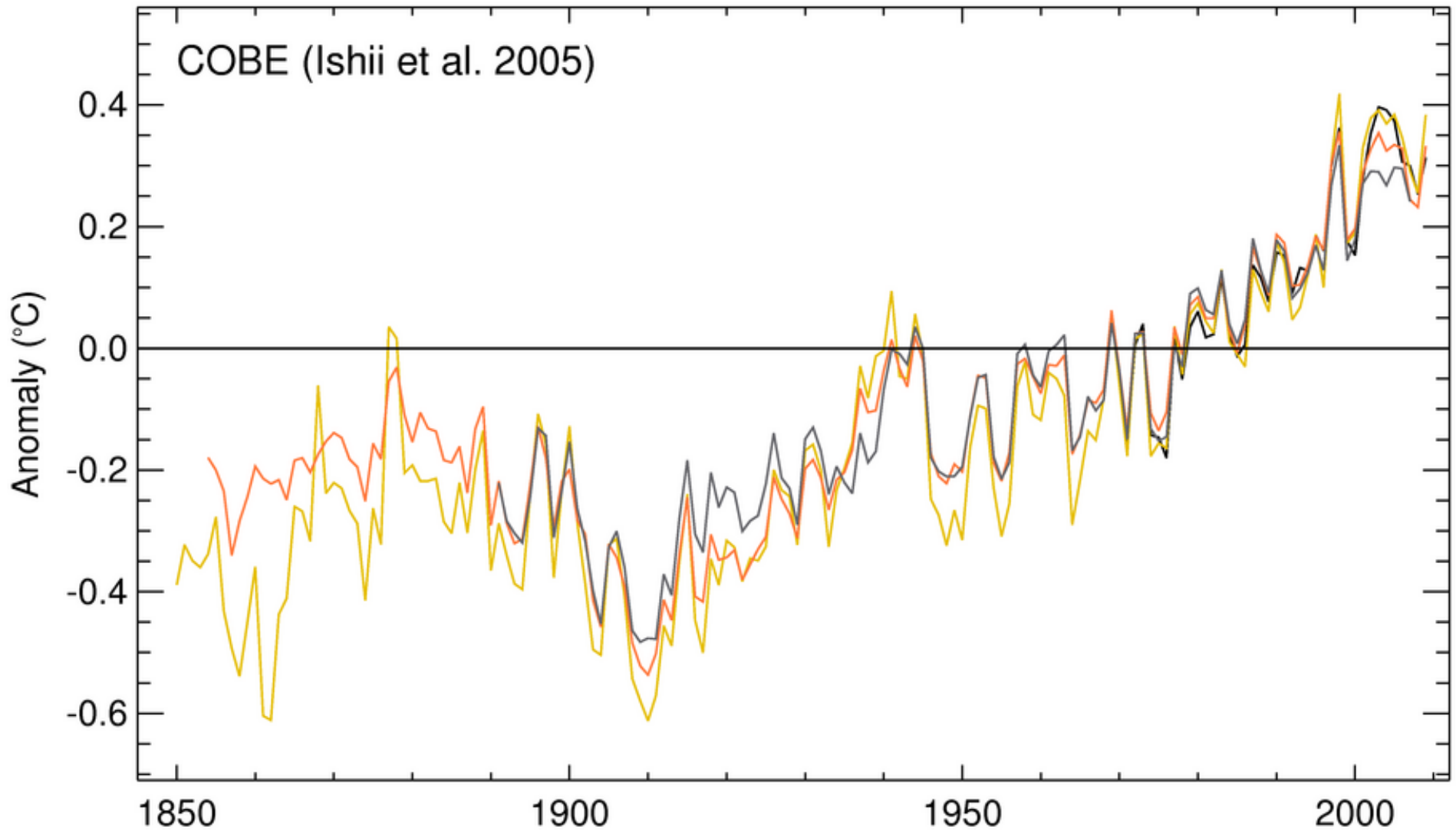
x3





Sea surface temperatures

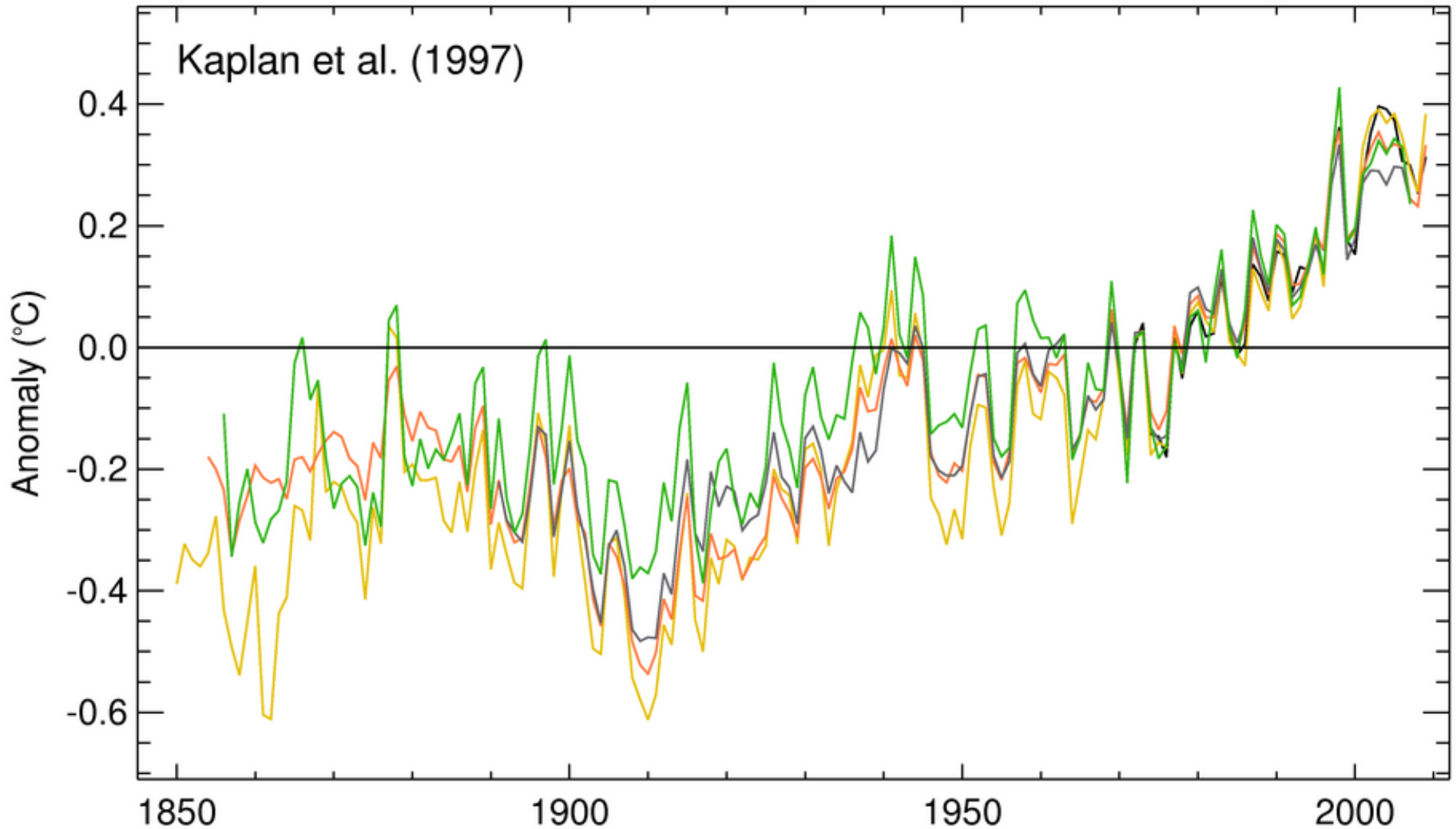
x4





Sea surface temperatures

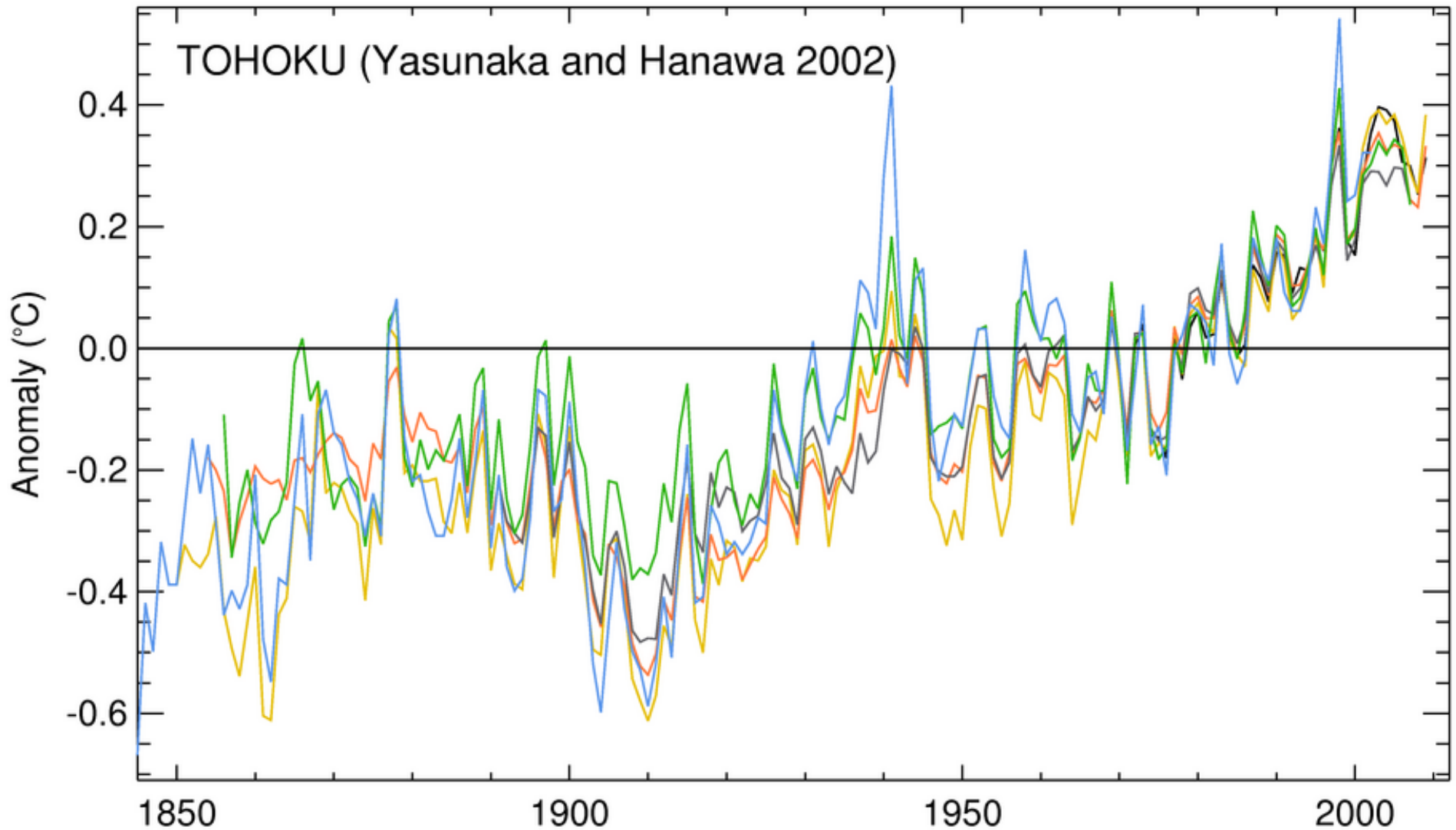
x5





Sea surface temperatures

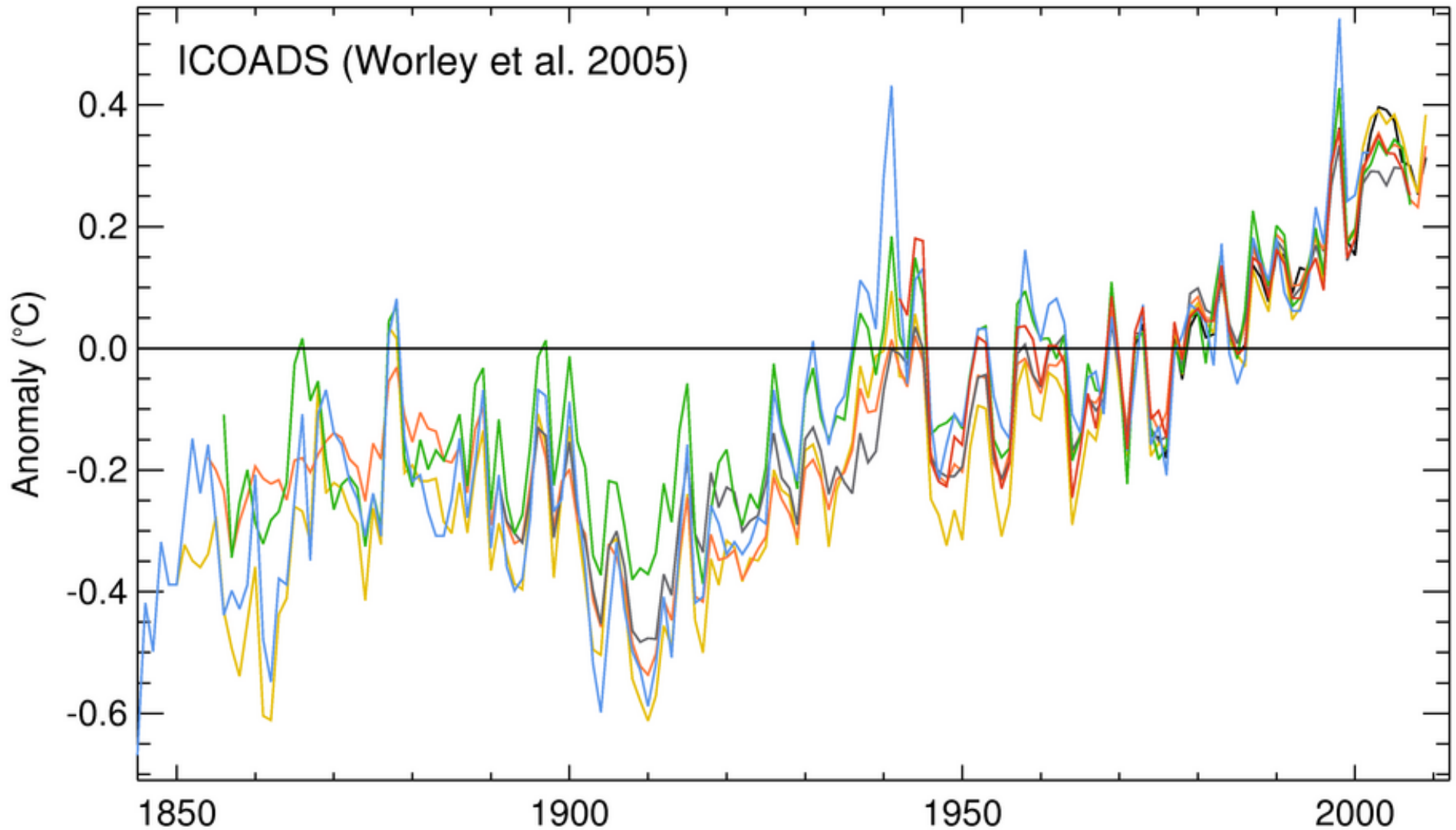
x6





Sea surface temperatures

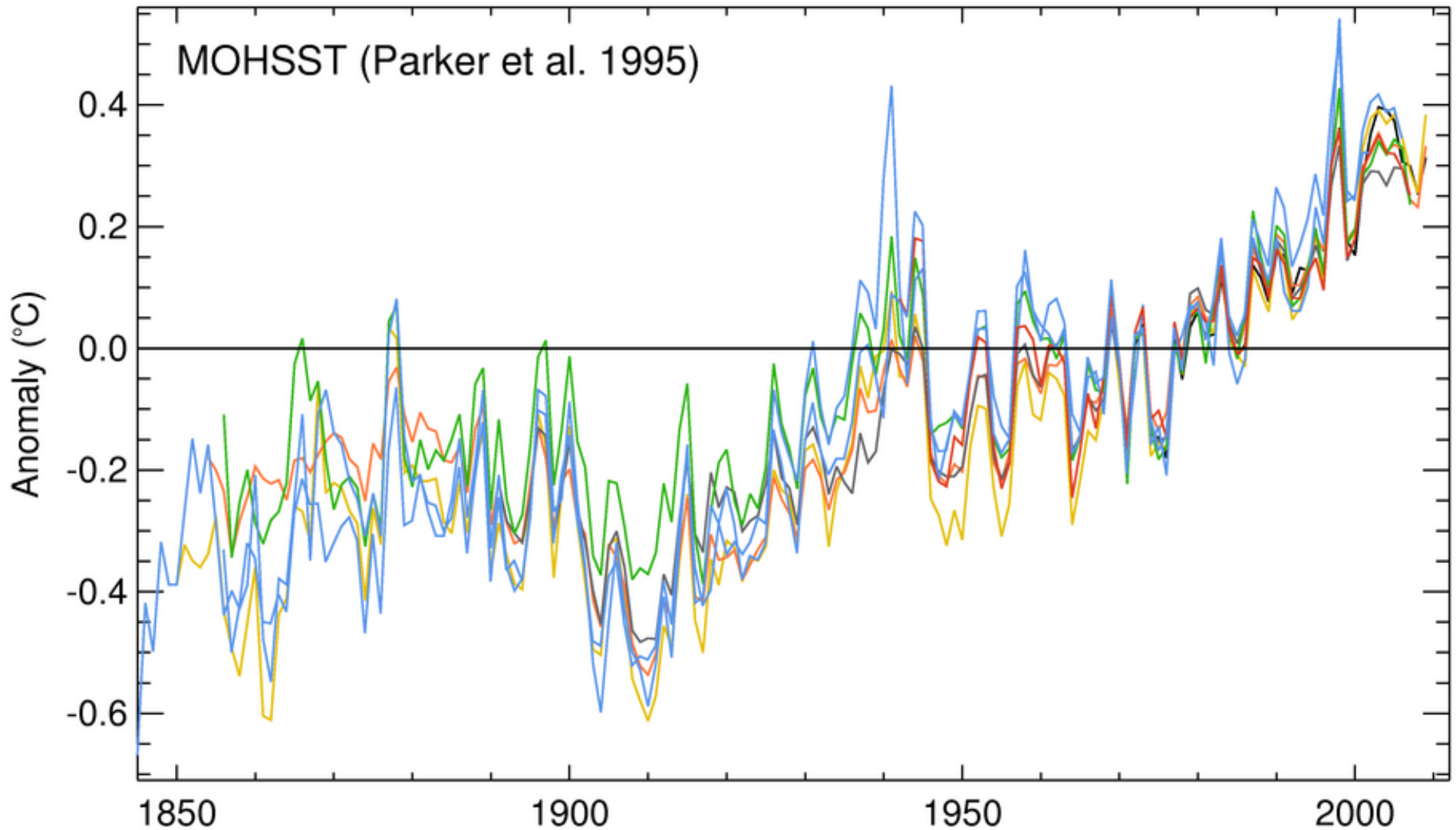
x7





Sea surface temperatures

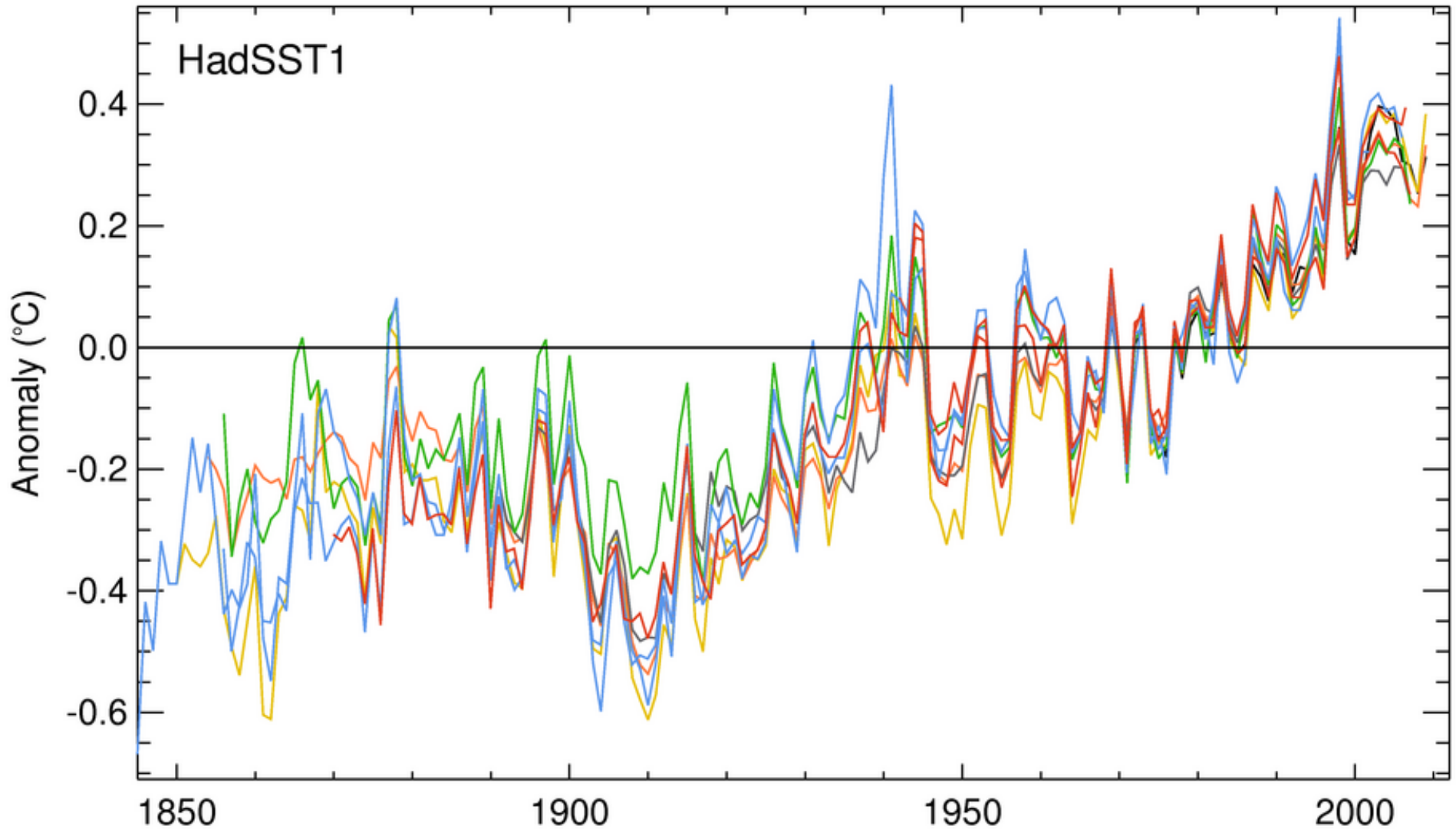
x8





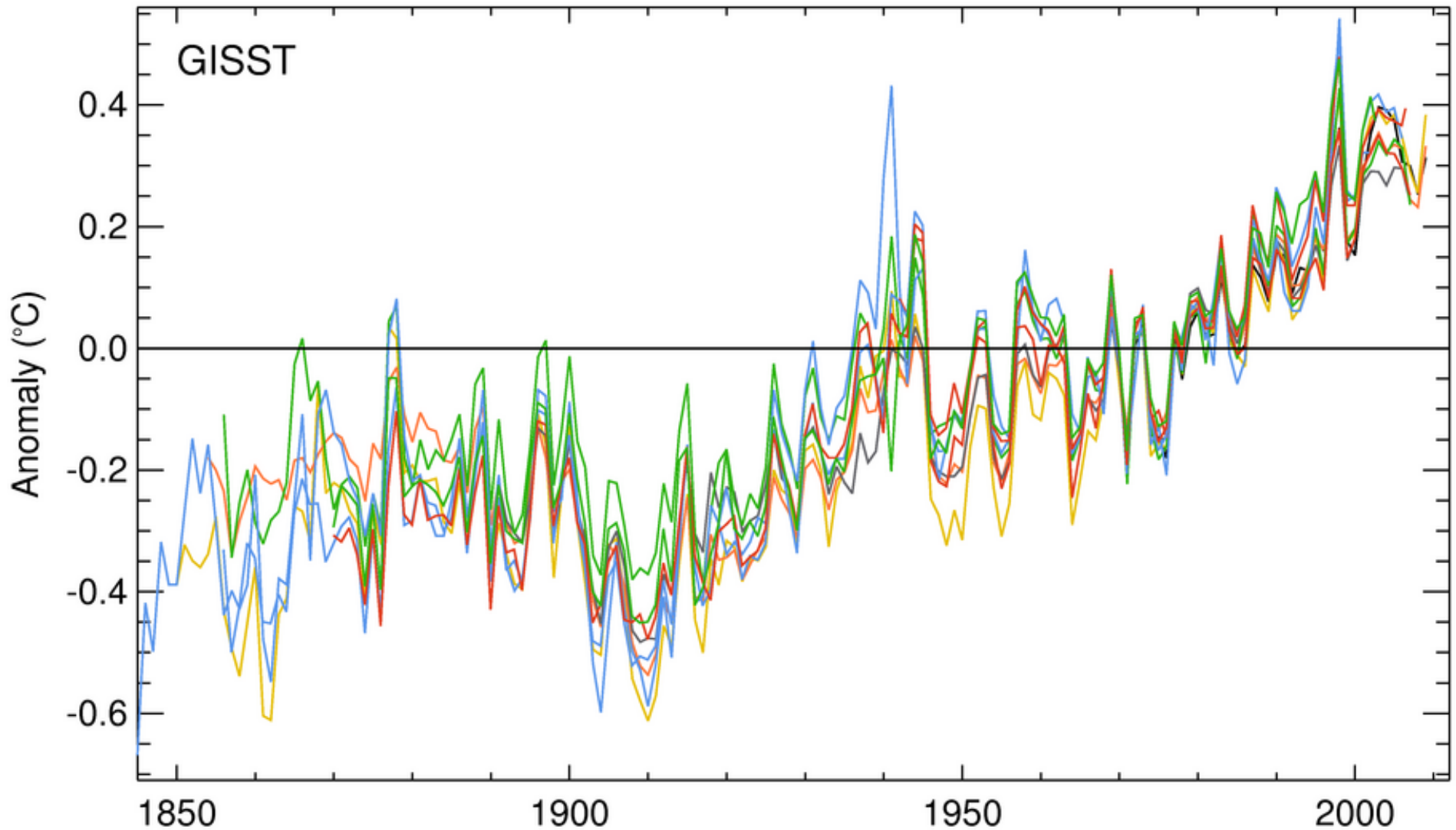
Sea surface temperatures

x9



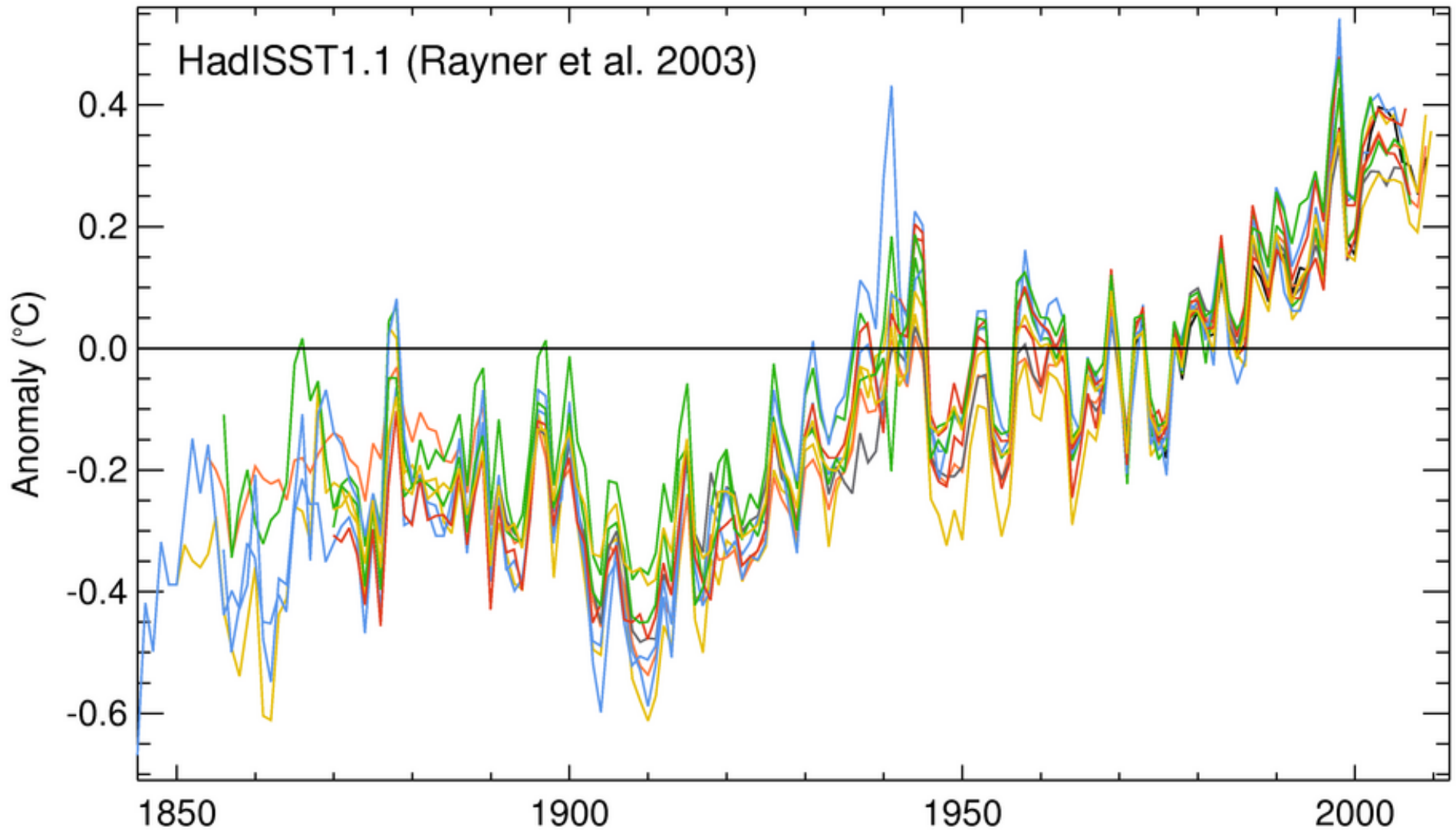


Sea surface temperatures x10



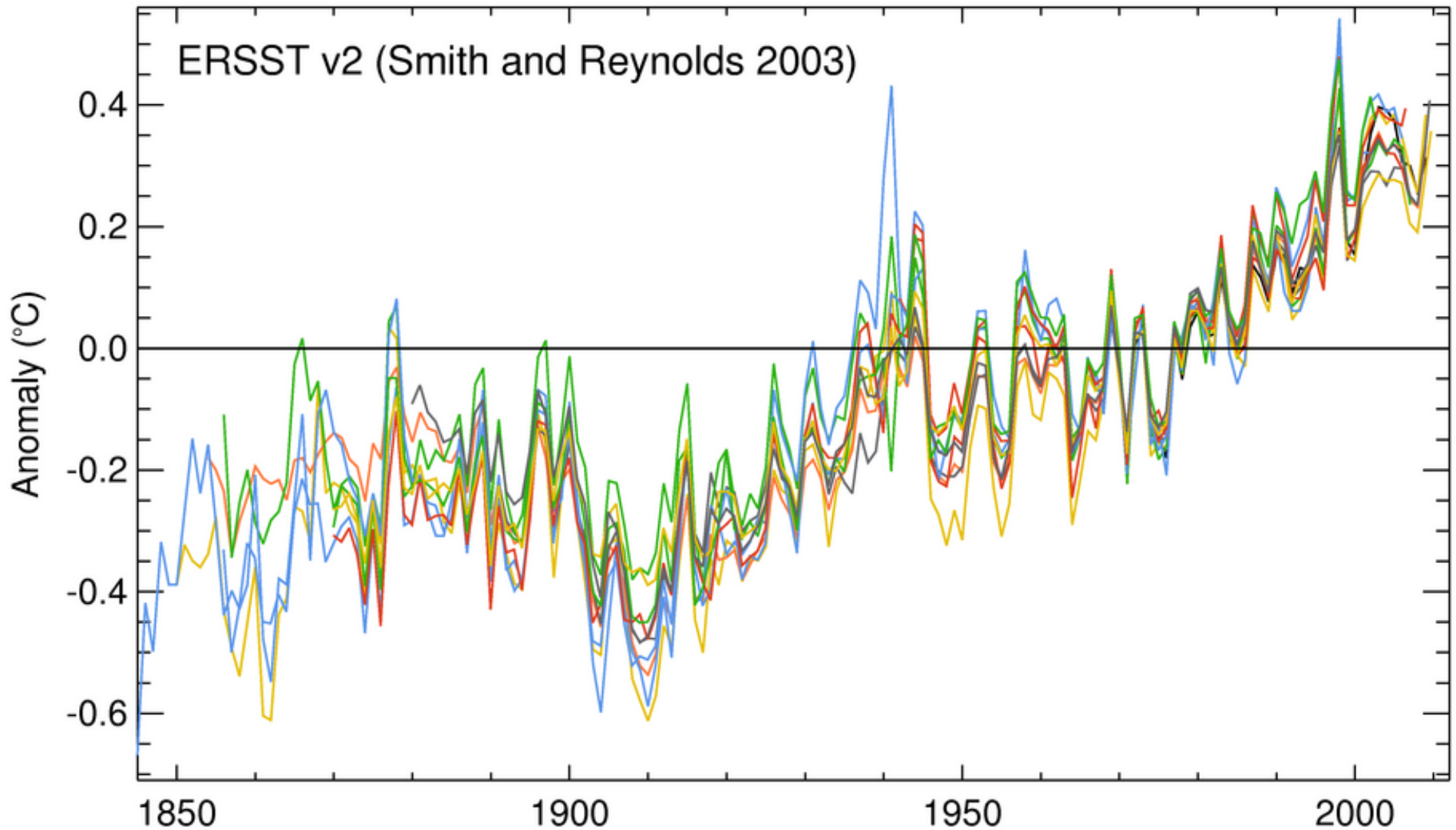
Sea surface temperatures

x11

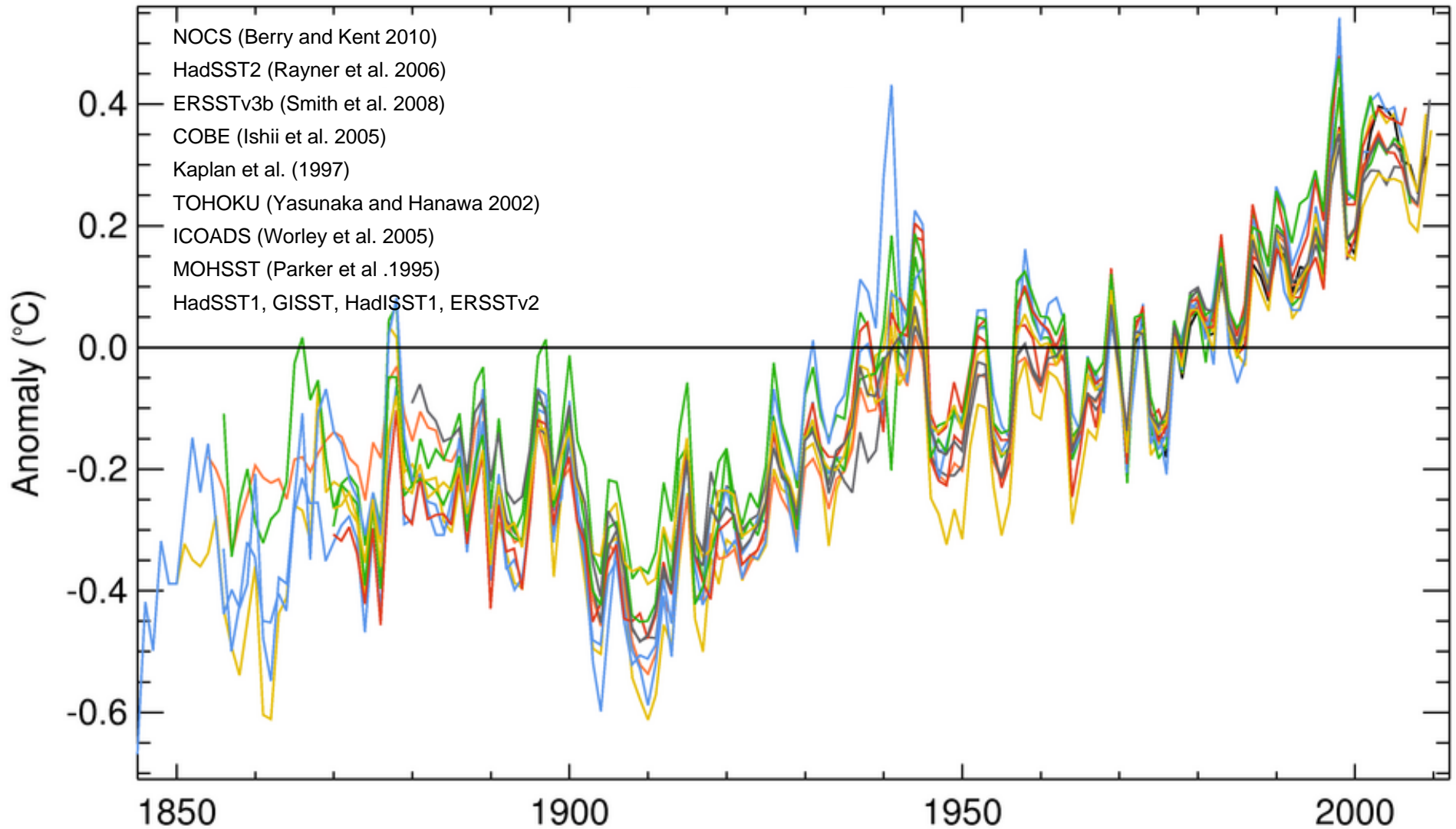




Sea surface temperatures x12



A dozen estimates show structural uncertainty



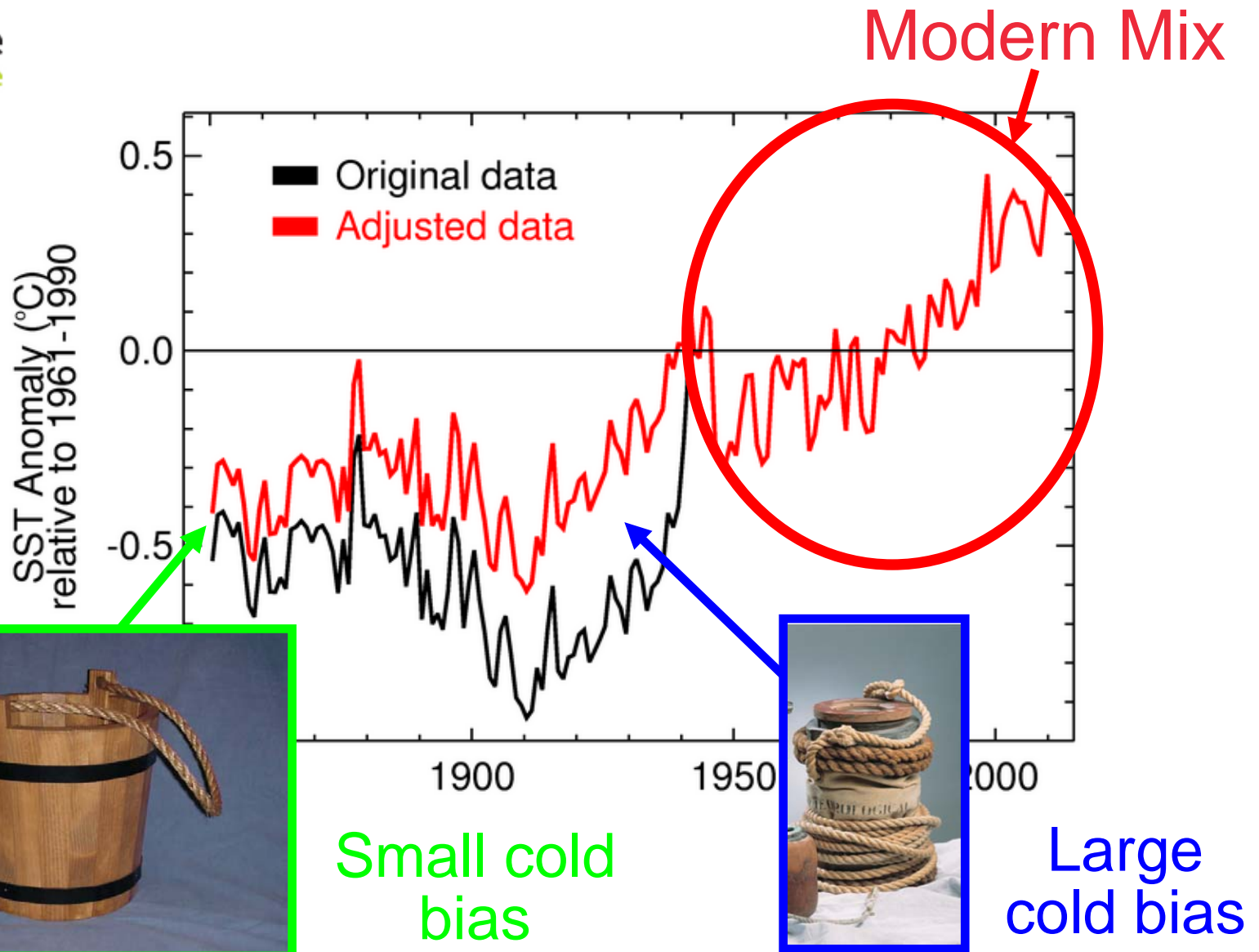


Differences show sensitivity to reasonable choices

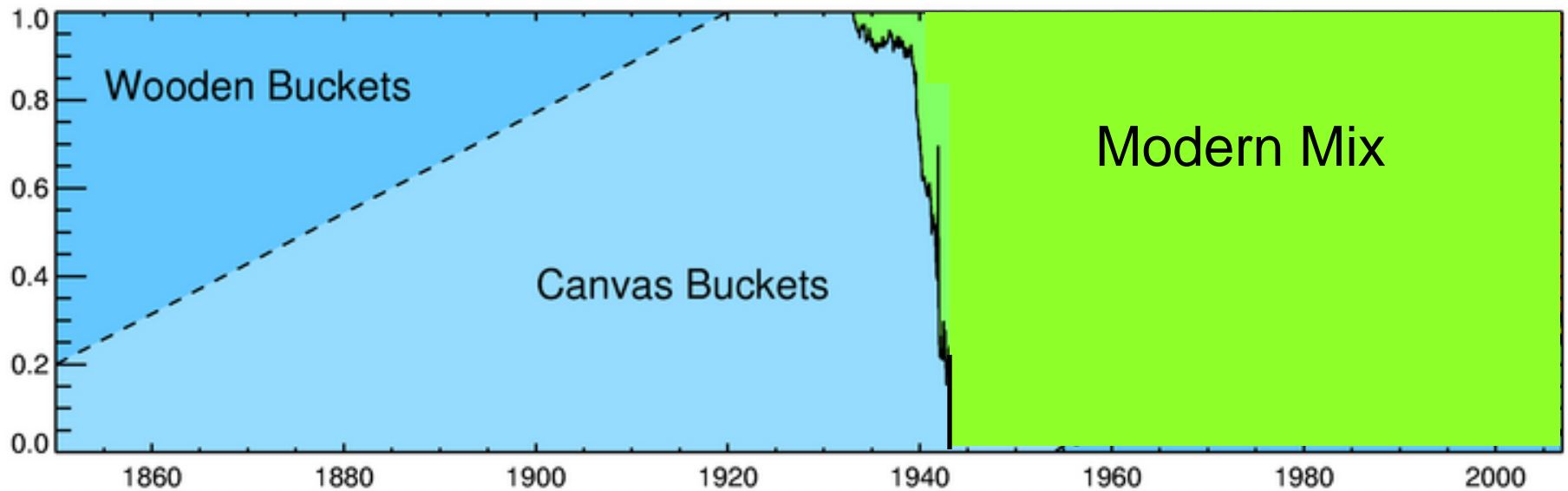
- Data selection
- Quality control
- Gridding (or not)
- Interpolation (or not)
- Sea ice, lakes, odds and ends
- Averaging

- Bias adjustments to account for changing measurement methods

SST bias adjustments

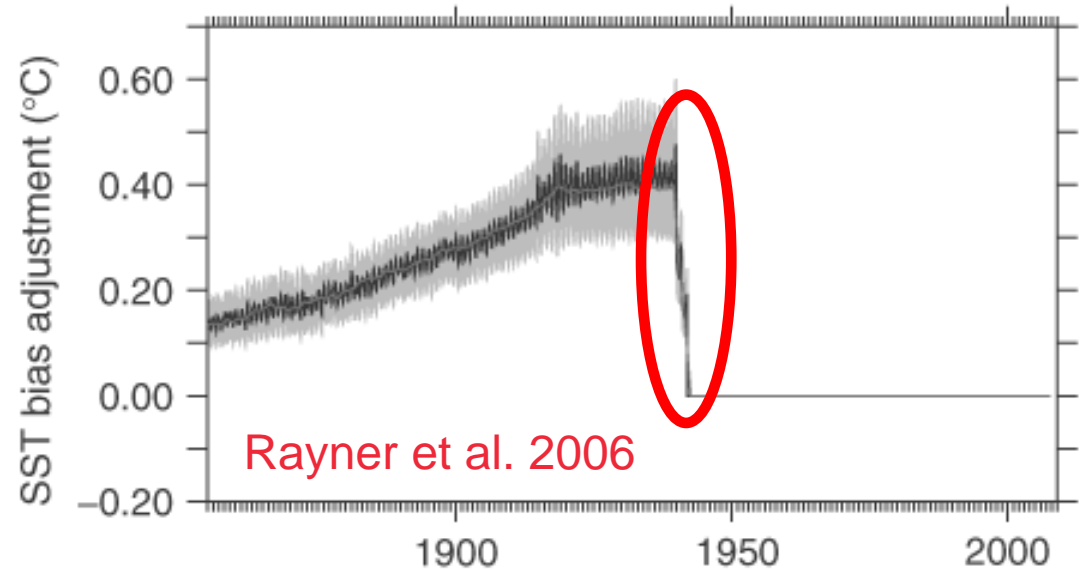


SST measurement methods changed through time

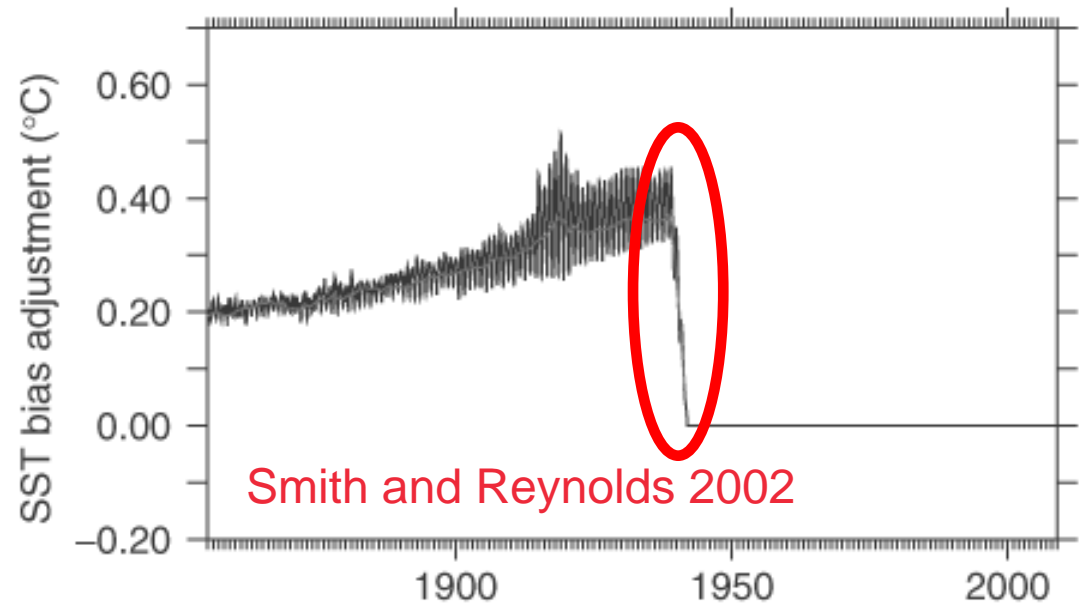


Bias adjustments currently applied to historical SST data

Images from Kent et al. (2010)
Effects of instrumentation changes on sea surface temperature measured in situ. WIREs climate change



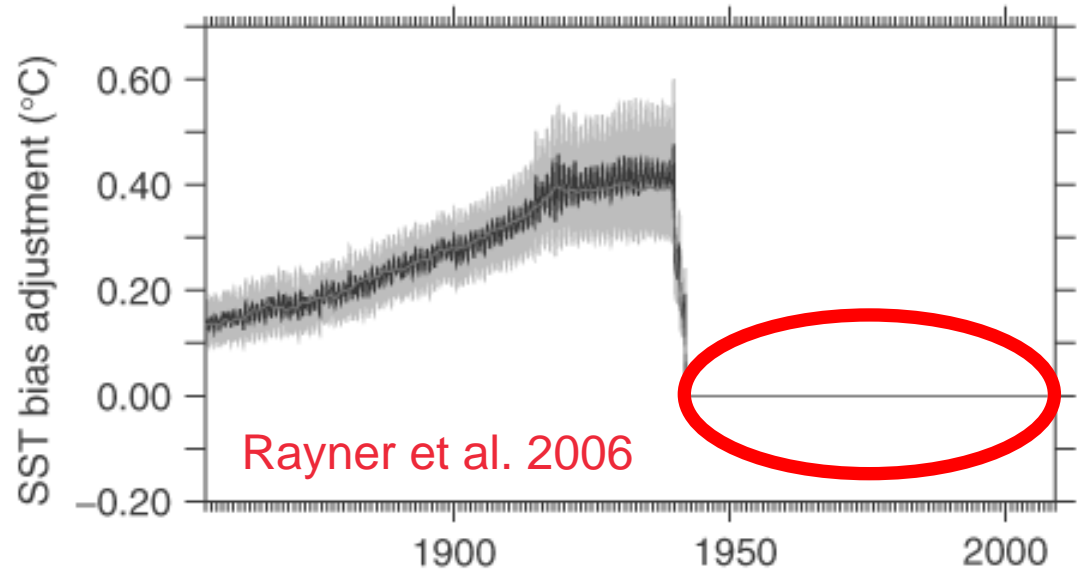
(a) Bias adjustment [5], global average where data present shading represents 95% confidence limits



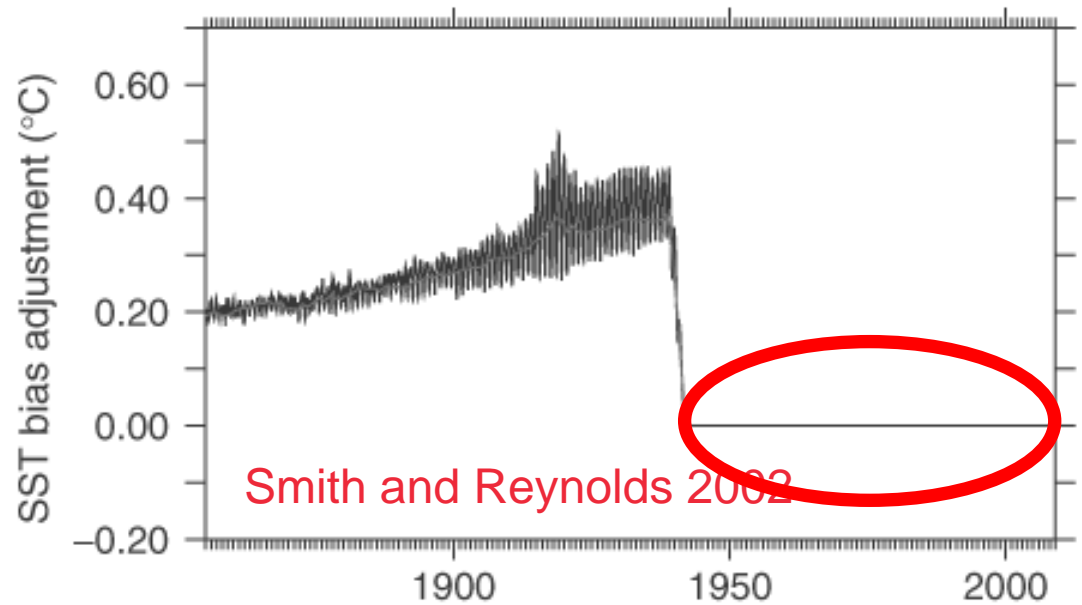
(c) Bias adjustment [57], global average where data present

Bias adjustments currently applied to historical SST data

Images from Kent et al. (2010)
Effects of instrumentation changes on sea surface temperature measured in situ. WIREs climate change



(a) Bias adjustment [5], global average where data present shading represents 95% confidence limits



(c) Bias adjustment [57], global average where data present



Bias adjustments are needed after December 31 1941 if:

1. There are significant biases between measurement methods
2. The mix of measurement methods changes significantly over time.

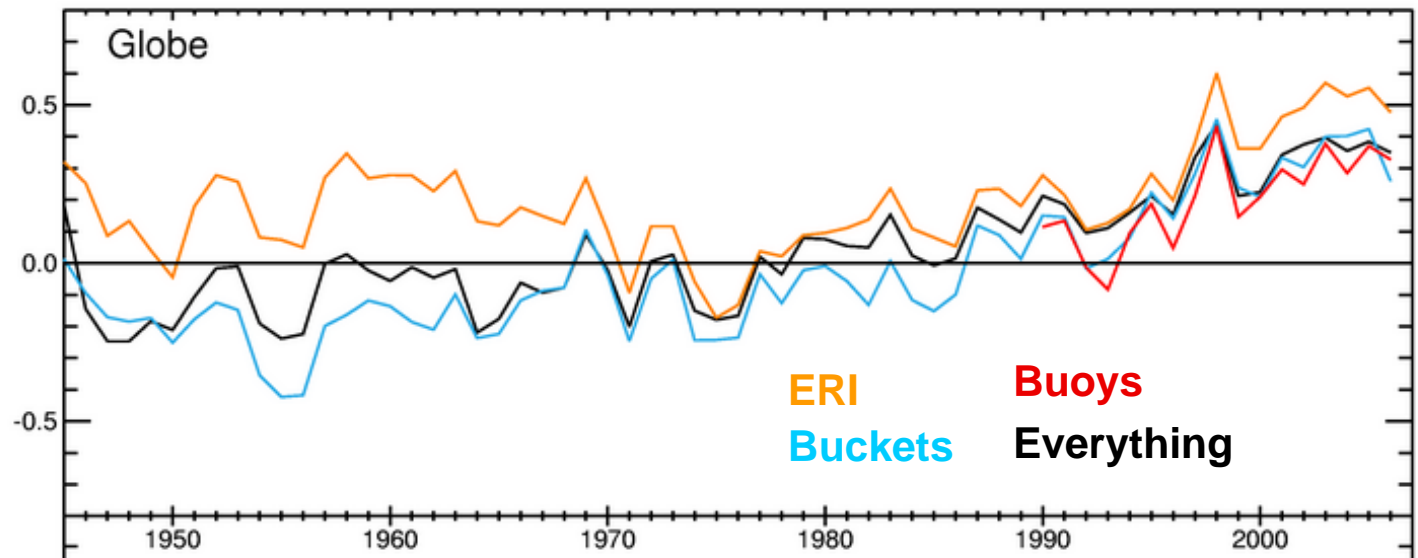


Metadata is king. How were measurements made?

- **ICOADS**
 - Recruiting Country
 - Measurement method
 - Data source ID
- **WMO Publication 47**
 - Ship name or call sign
 - Recruiting Country
 - Measurement method
- **Observer instructions**
- **Scientific literature**

Large relative biases between different methods of measurement

RAW





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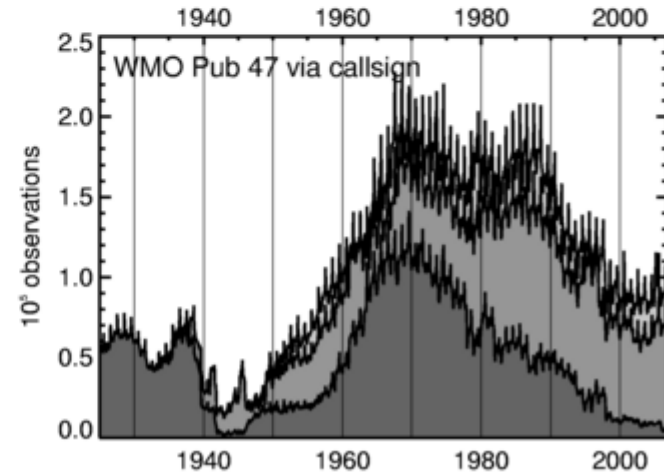
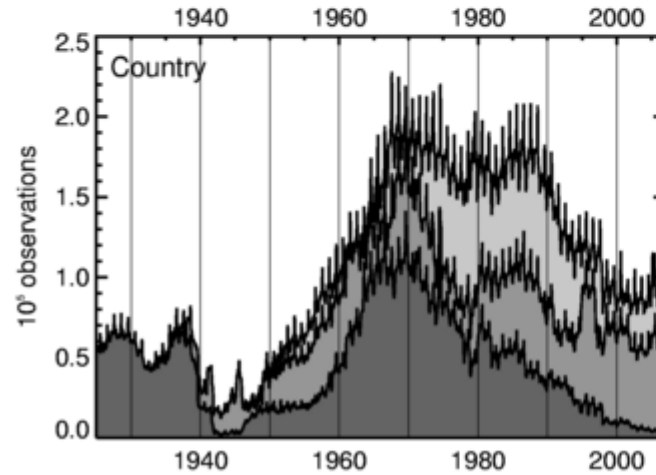
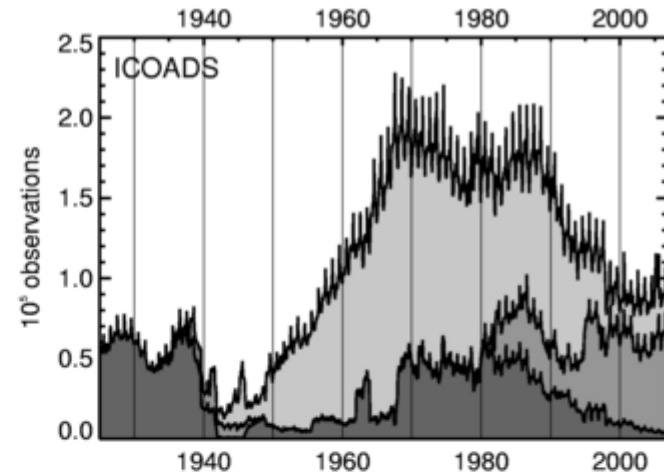
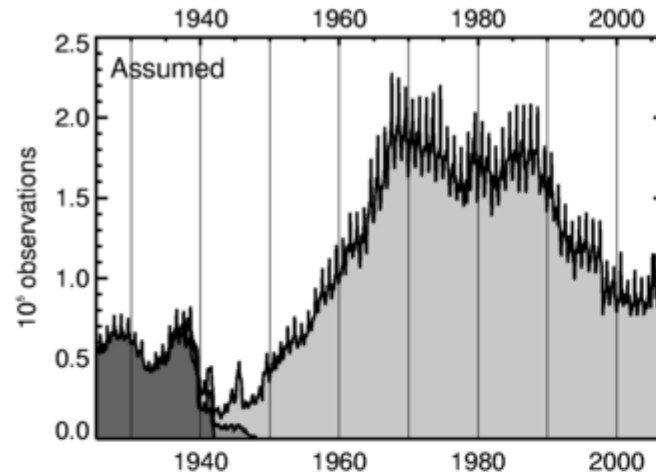


Assigning measurement methods

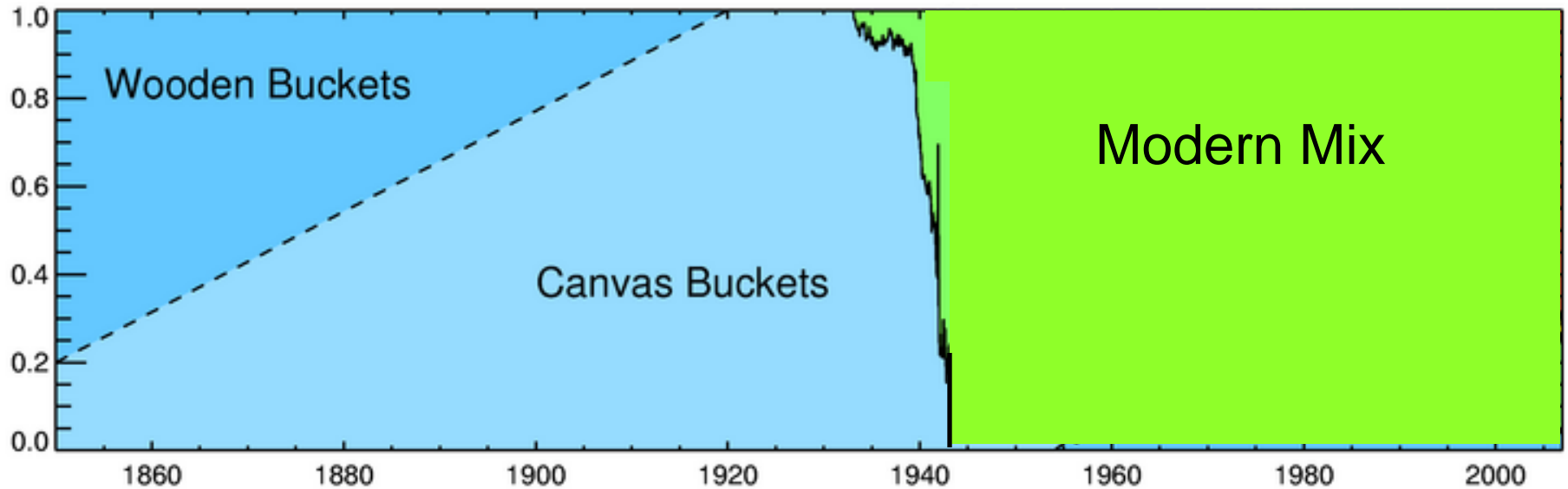
?

ERI



BUCKET



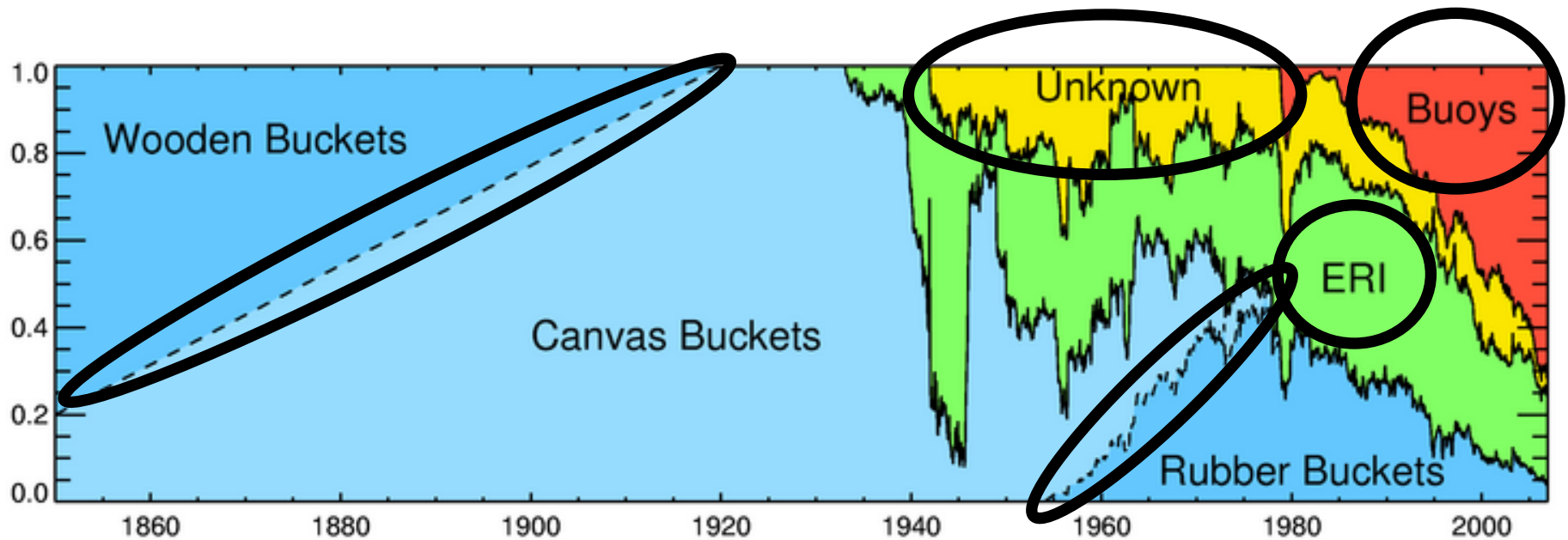
SST measurement methods changed through time



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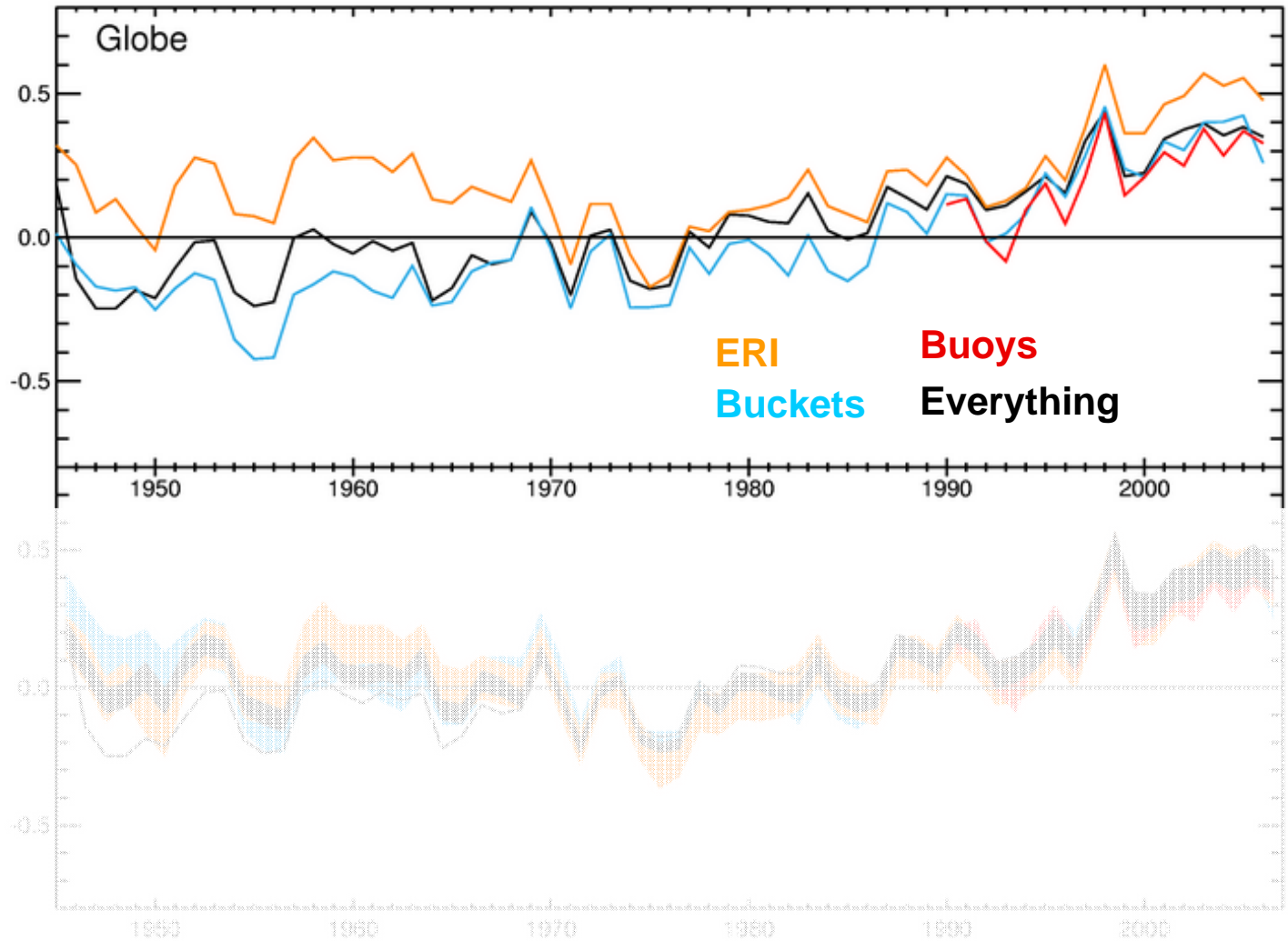
Uncertainties in bias assessment



Some measurement types
But we're going to look at types of when
Ship-buoy biases

Adjusting individual components of SST series

RAW

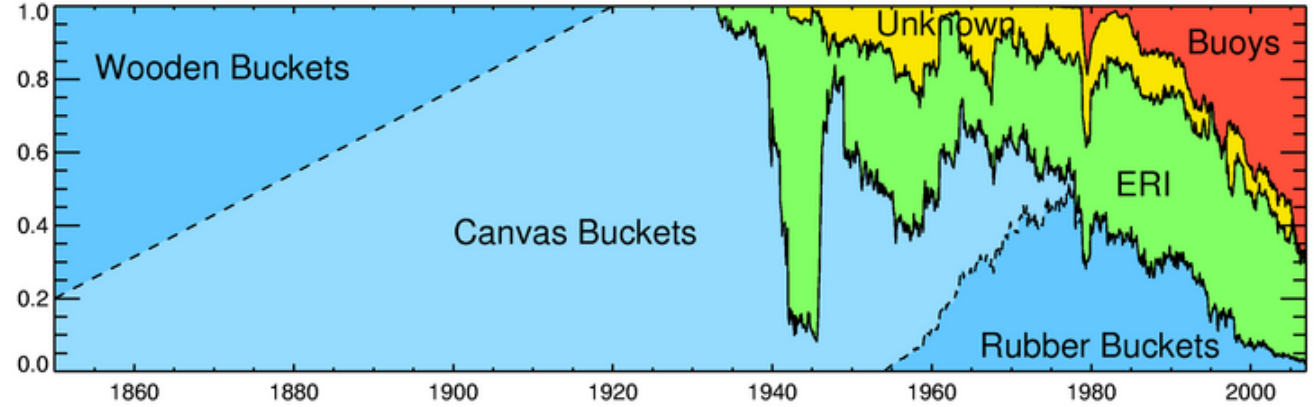




Contribution
(fraction) of
each
measurement
method



Fraction of Measurements from each Type in ICOADS



Monthly bias
adjustments
from 100
realisations



Global
average
annual SST
timeseries



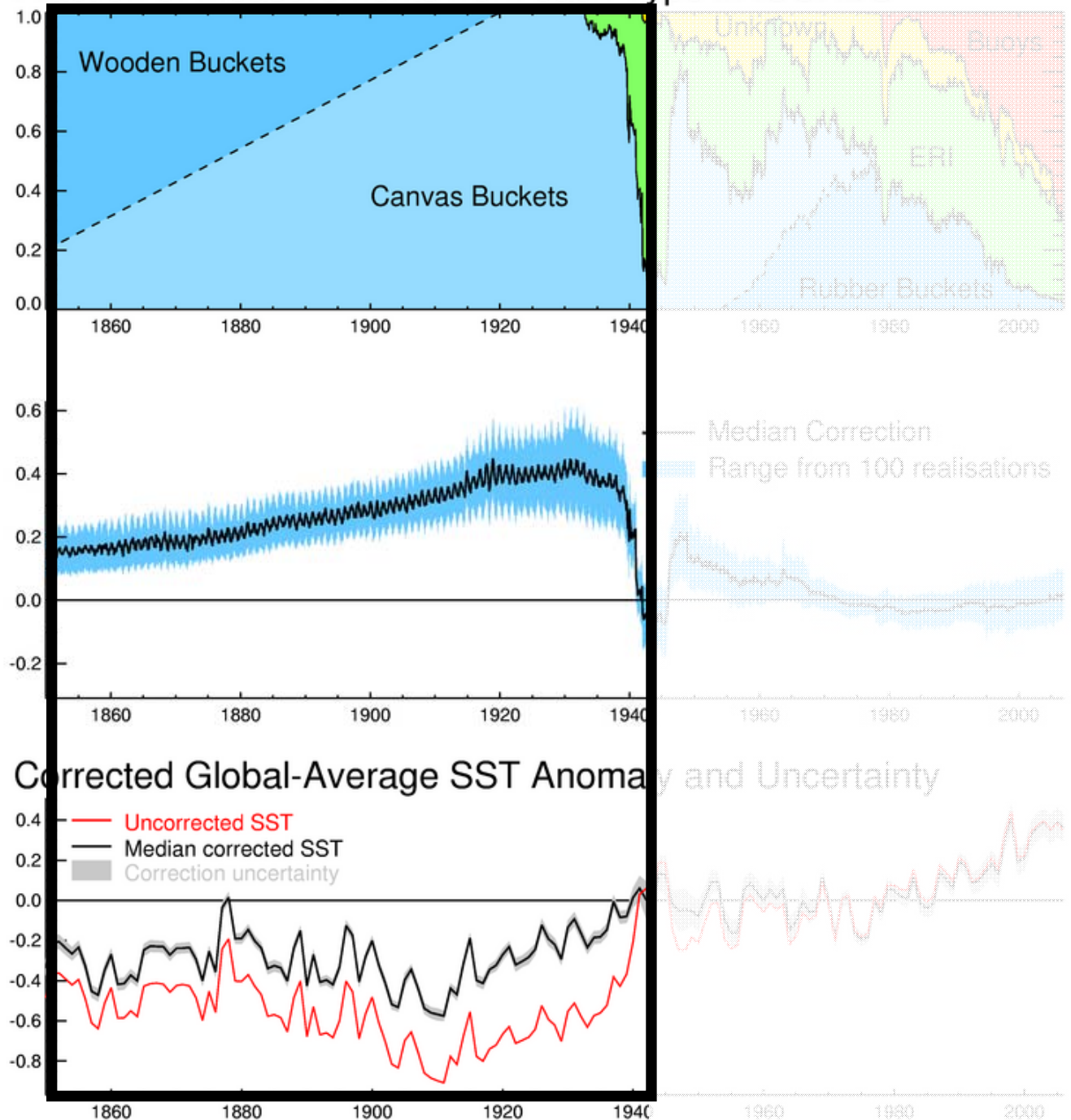


Contribution (fraction) of each measurement method

Monthly bias adjustments from 100 realisations

Global average annual SST timeseries

Fraction of Measurements from each Type in ICOADS



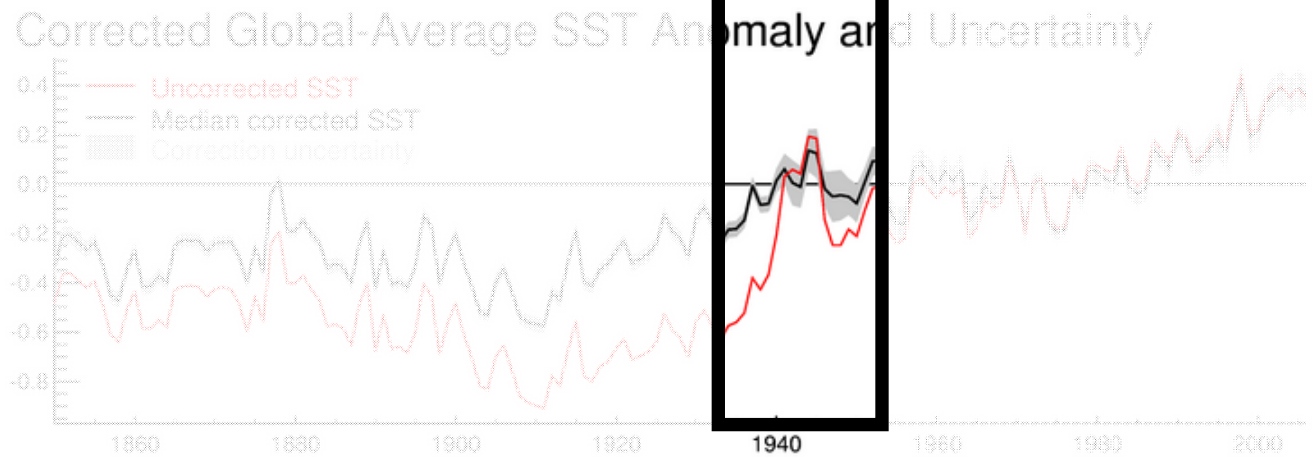
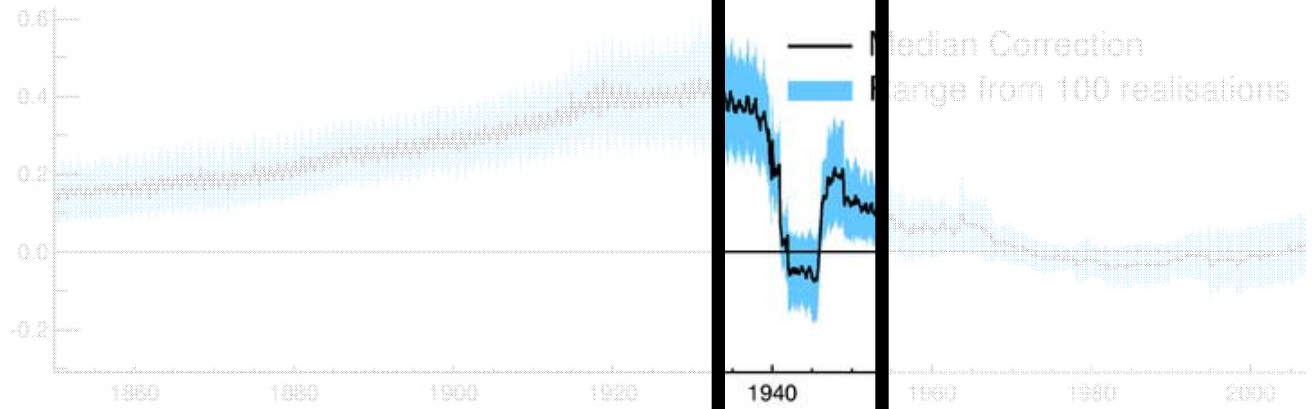
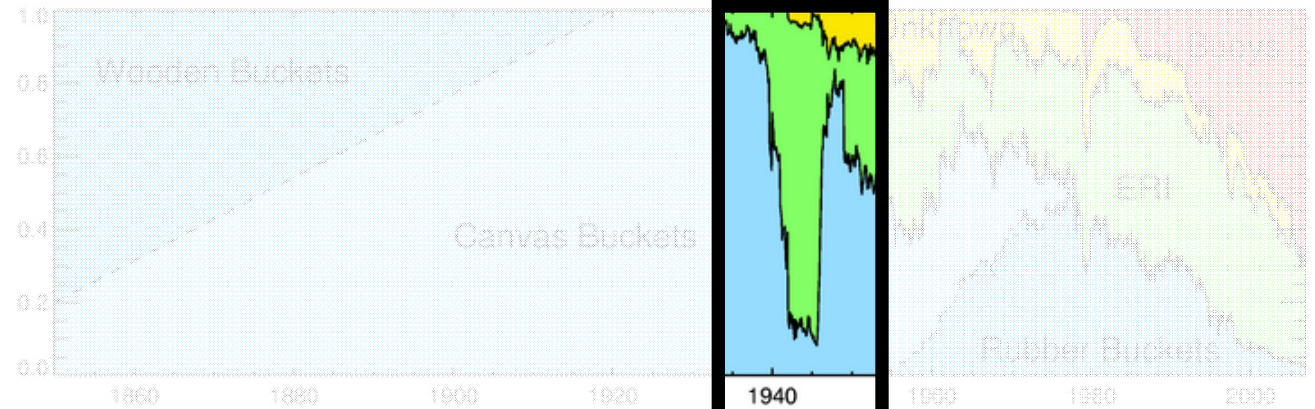


Contribution (fraction) of each measurement method

Monthly bias adjustments from 100 realisations

Global average annual SST timeseries

Fraction of Measurements from each Type in ICOADS



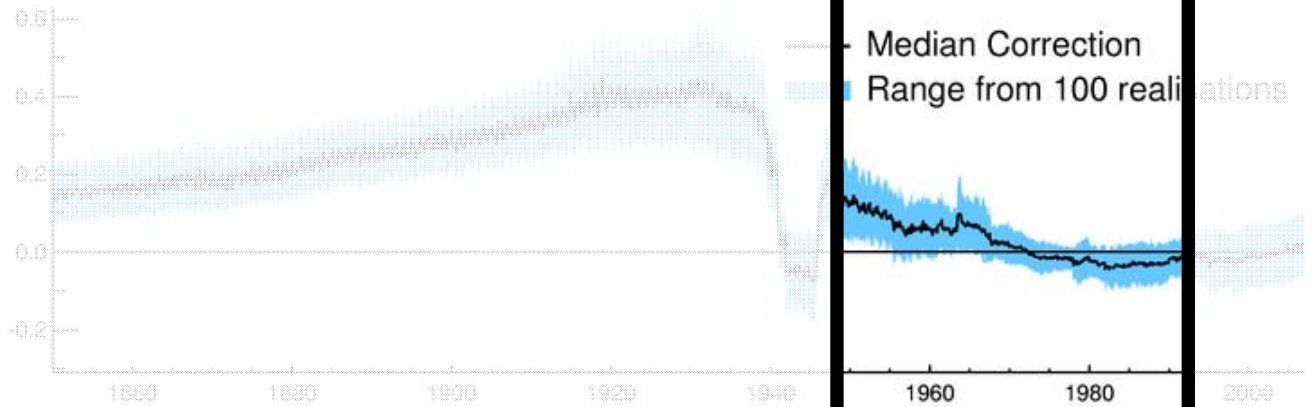
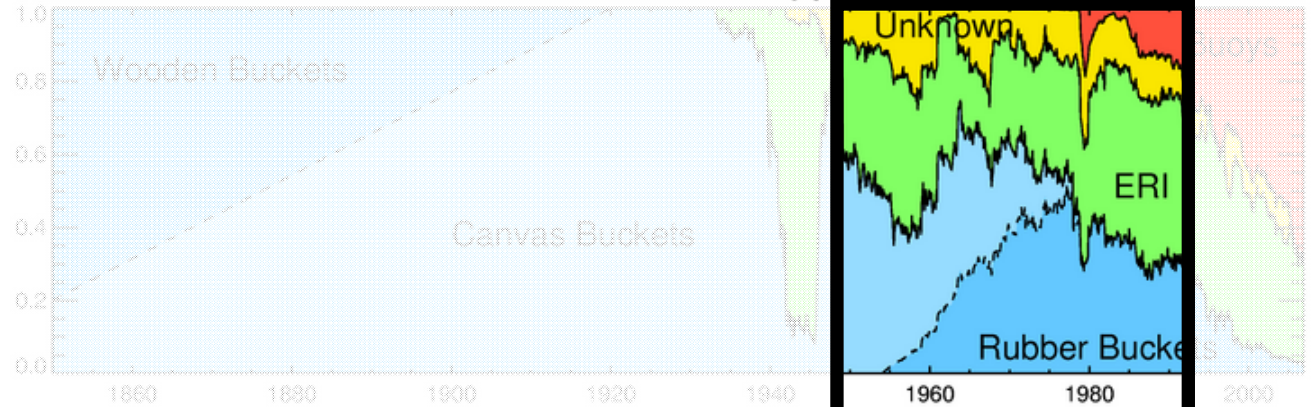


Contribution (fraction) of each measurement method

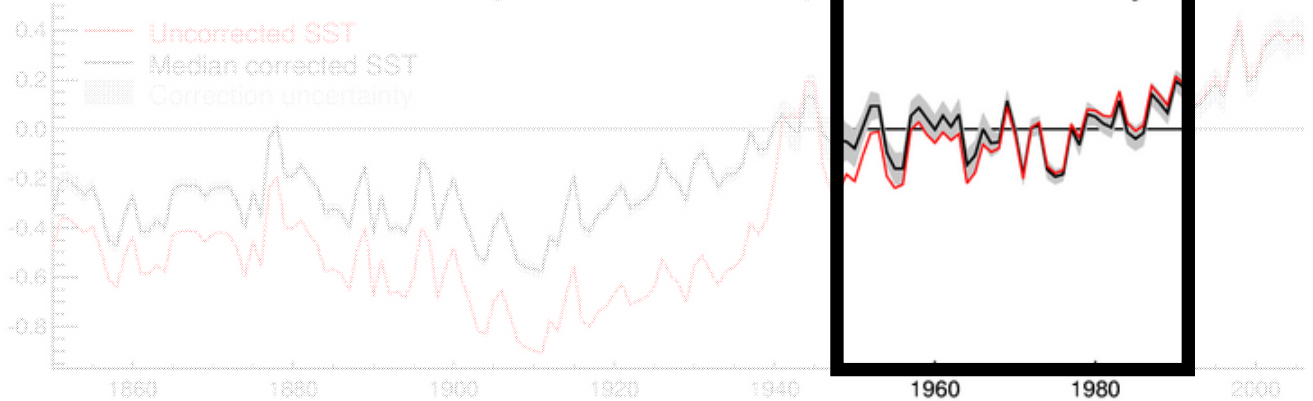
Monthly bias adjustments from 100 realisations

Global average annual SST timeseries

Fraction of Measurements from each Type in ICOADS



Corrected Global-Average SST Anomaly and Uncertainty



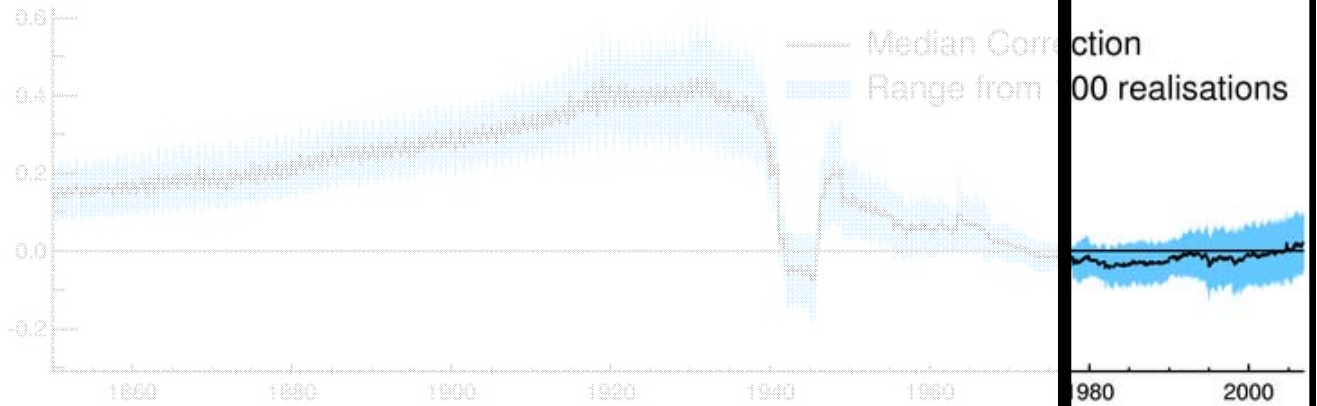
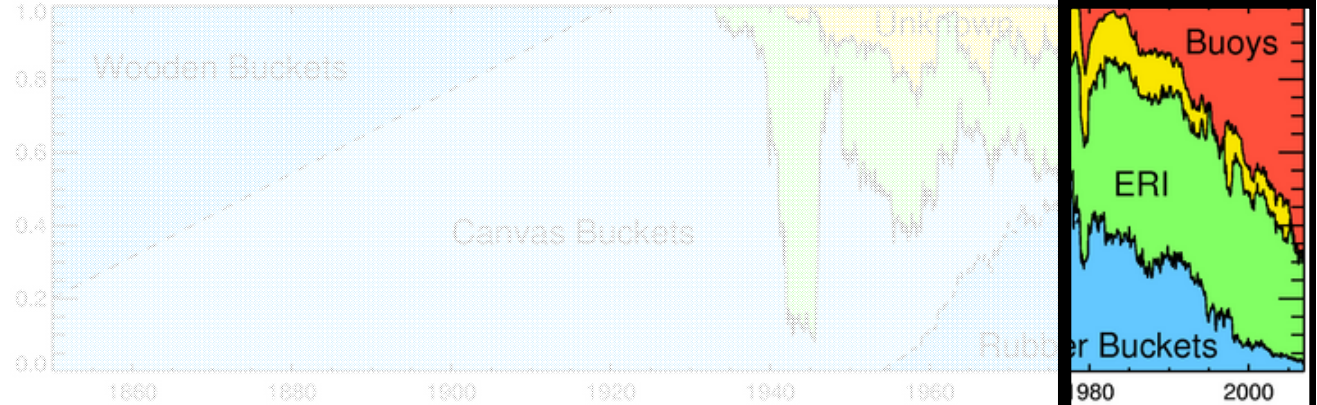


Contribution (fraction) of each measurement method

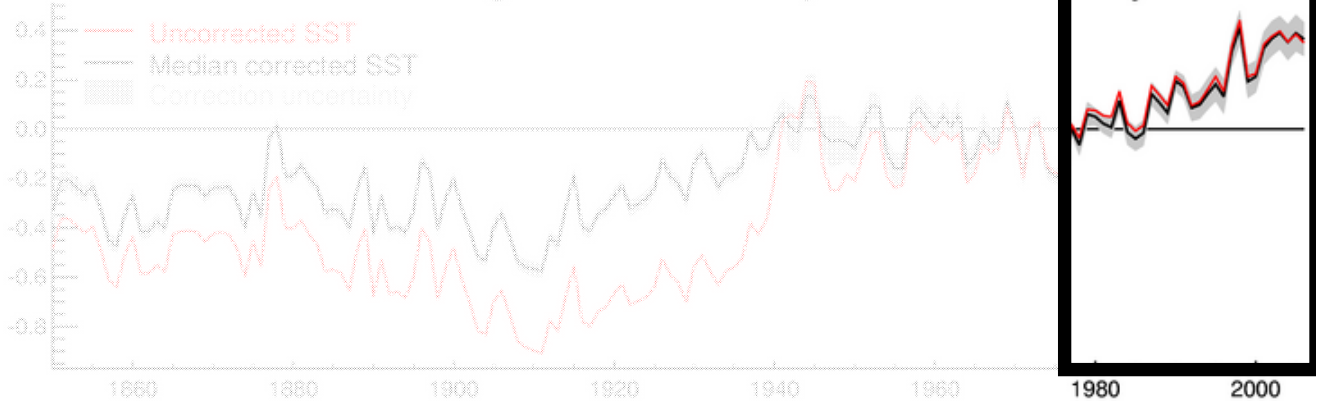
Monthly bias adjustments from 100 realisations

Global average annual SST timeseries

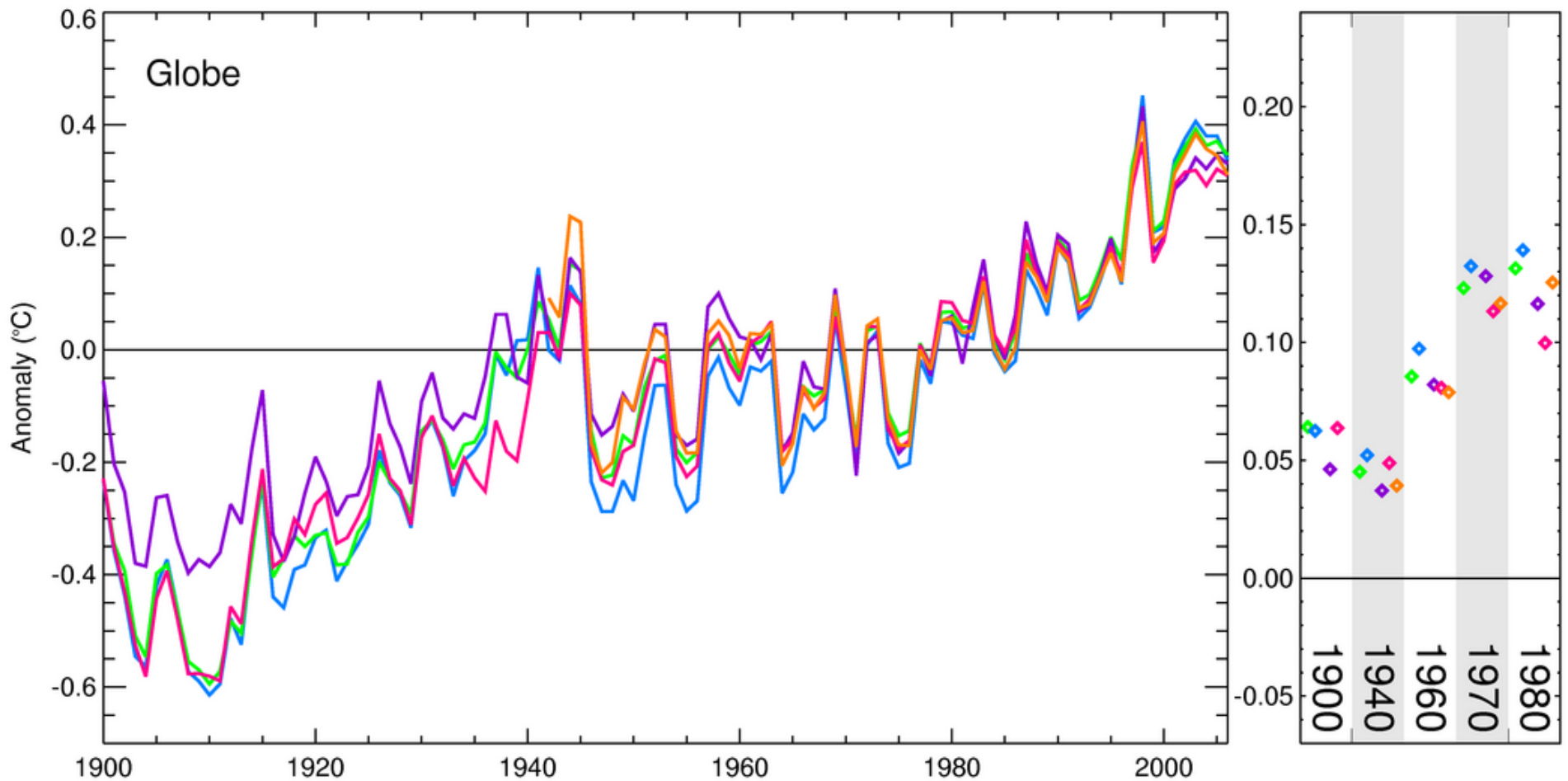
Fraction of Measurements from each Type in ICOADS



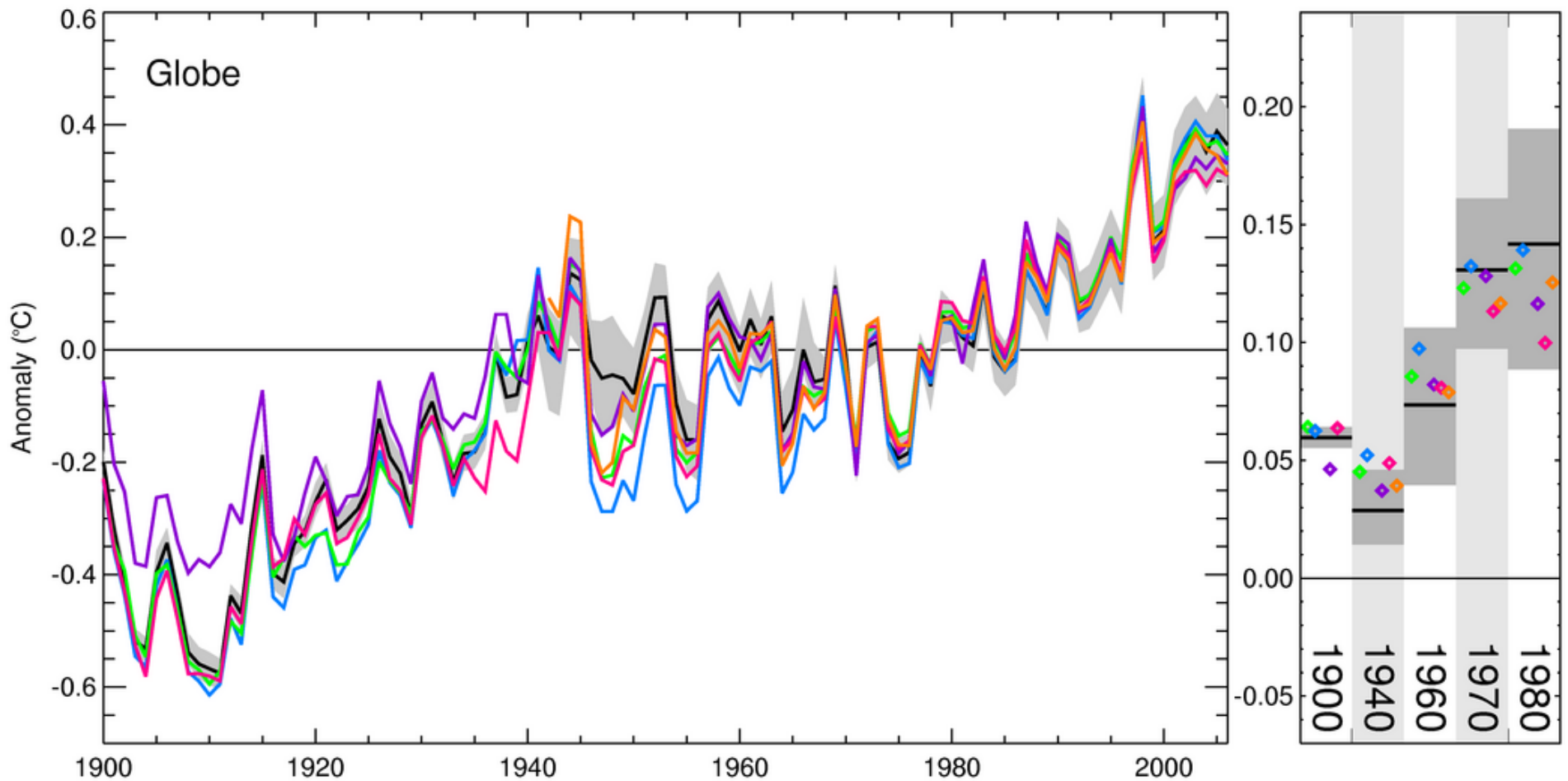
Corrected Global-Average SST Anomaly and Uncertainty



Structural uncertainty: Global average



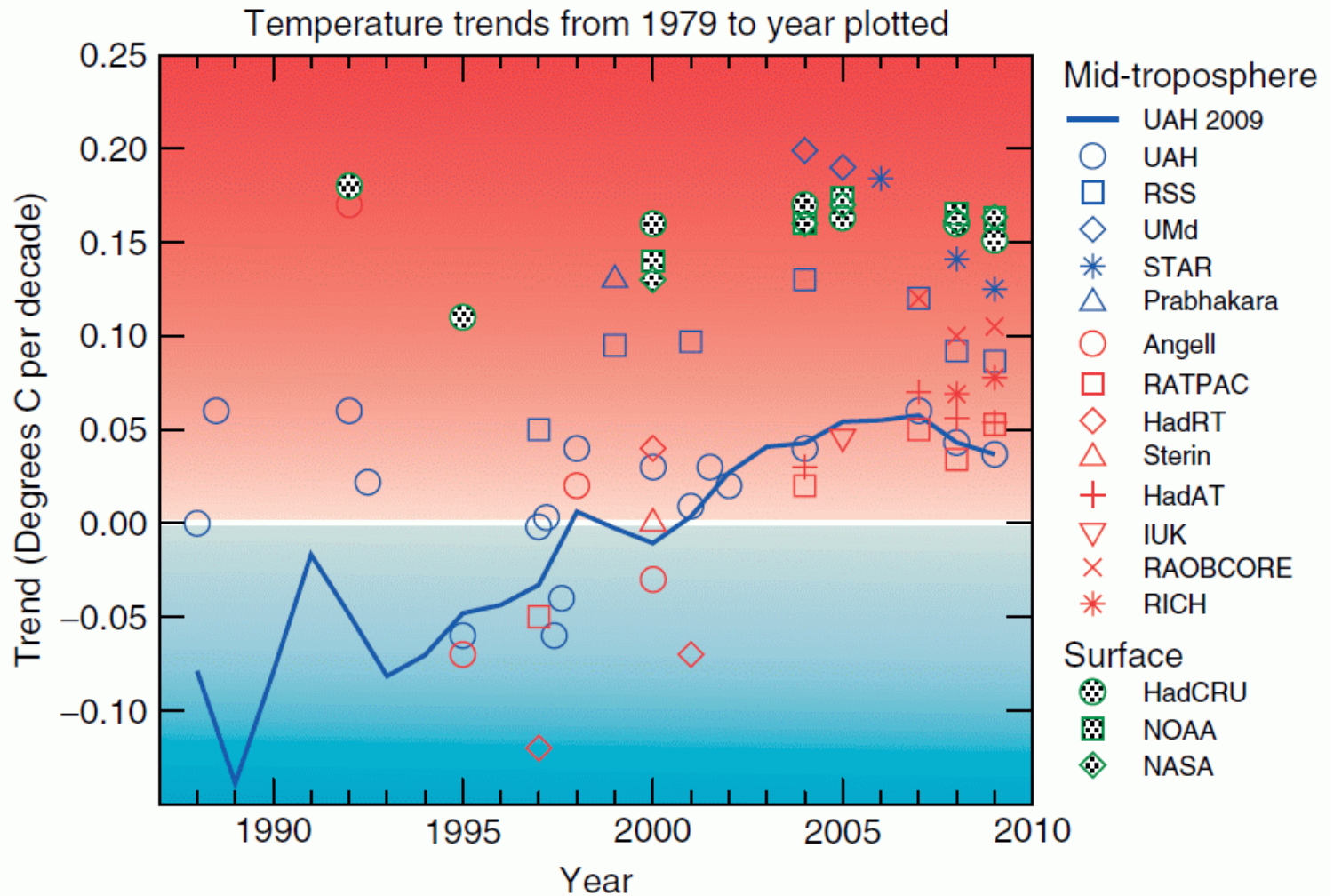
Structural vs bias uncertainty: Global average



Have we solved the problem of
biases after December 31st 1941?

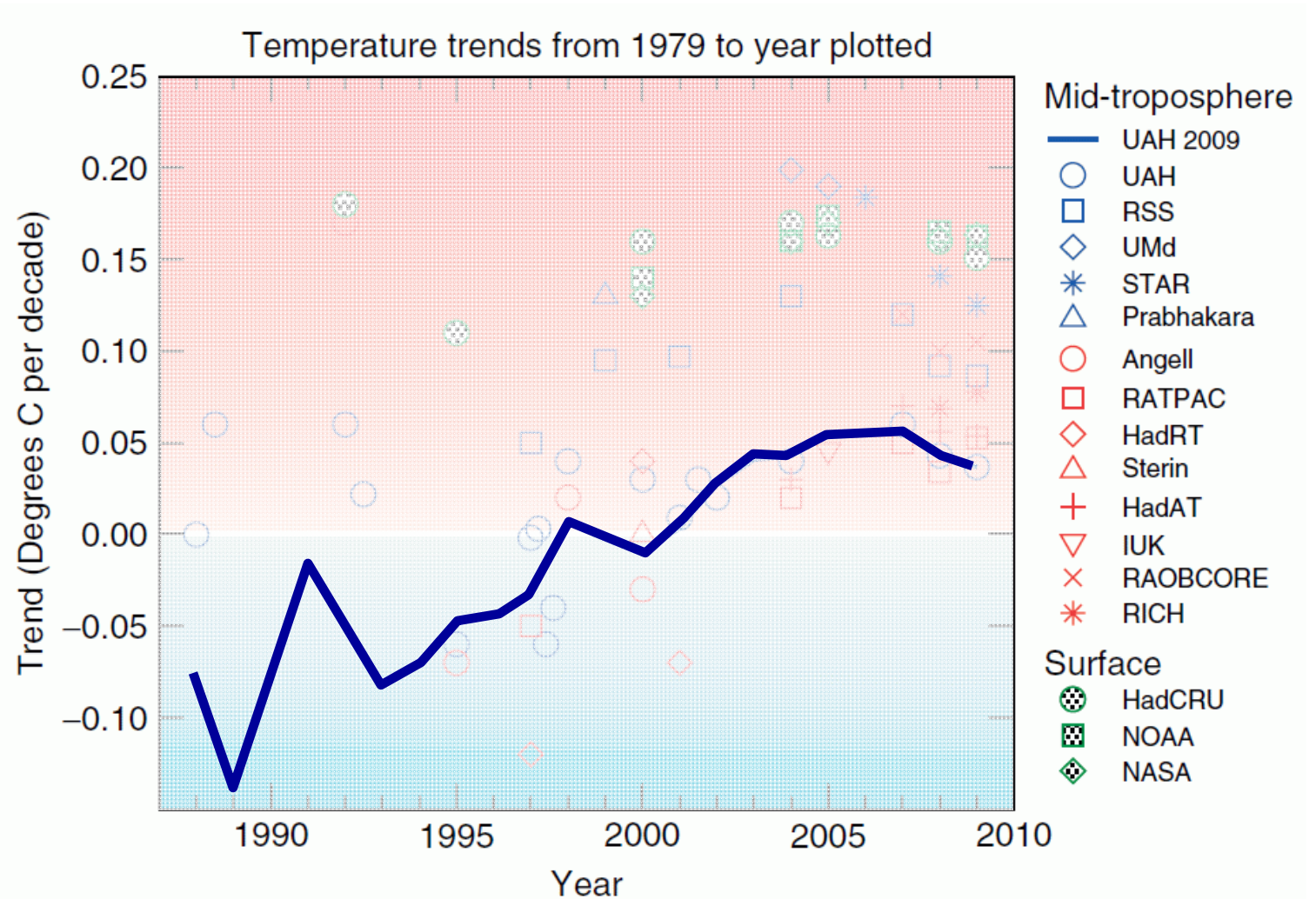
No, Probably Not

Tropospheric temperatures



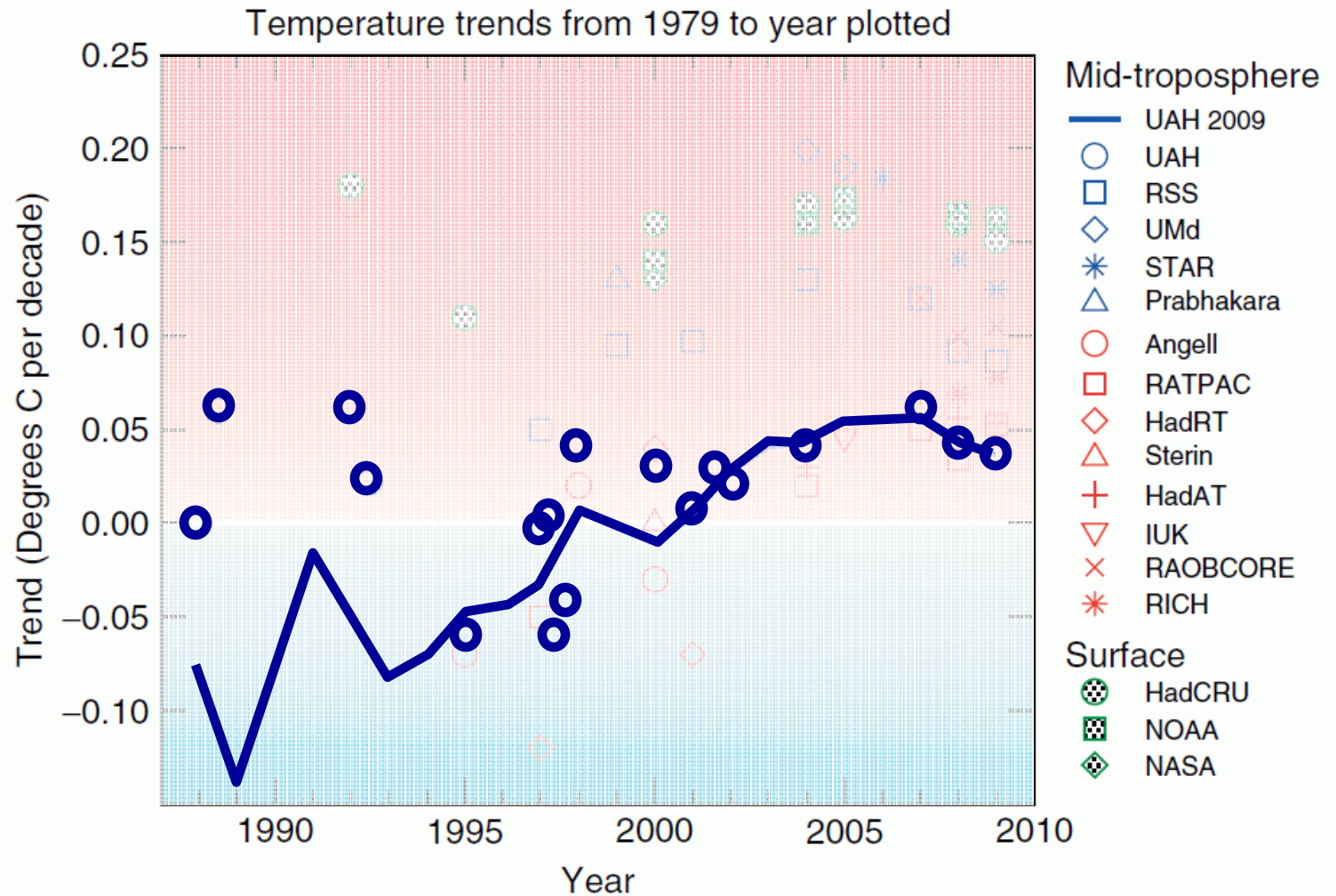
Thorne et al. 2010 in WIREs Climate Change

Tropospheric temperatures



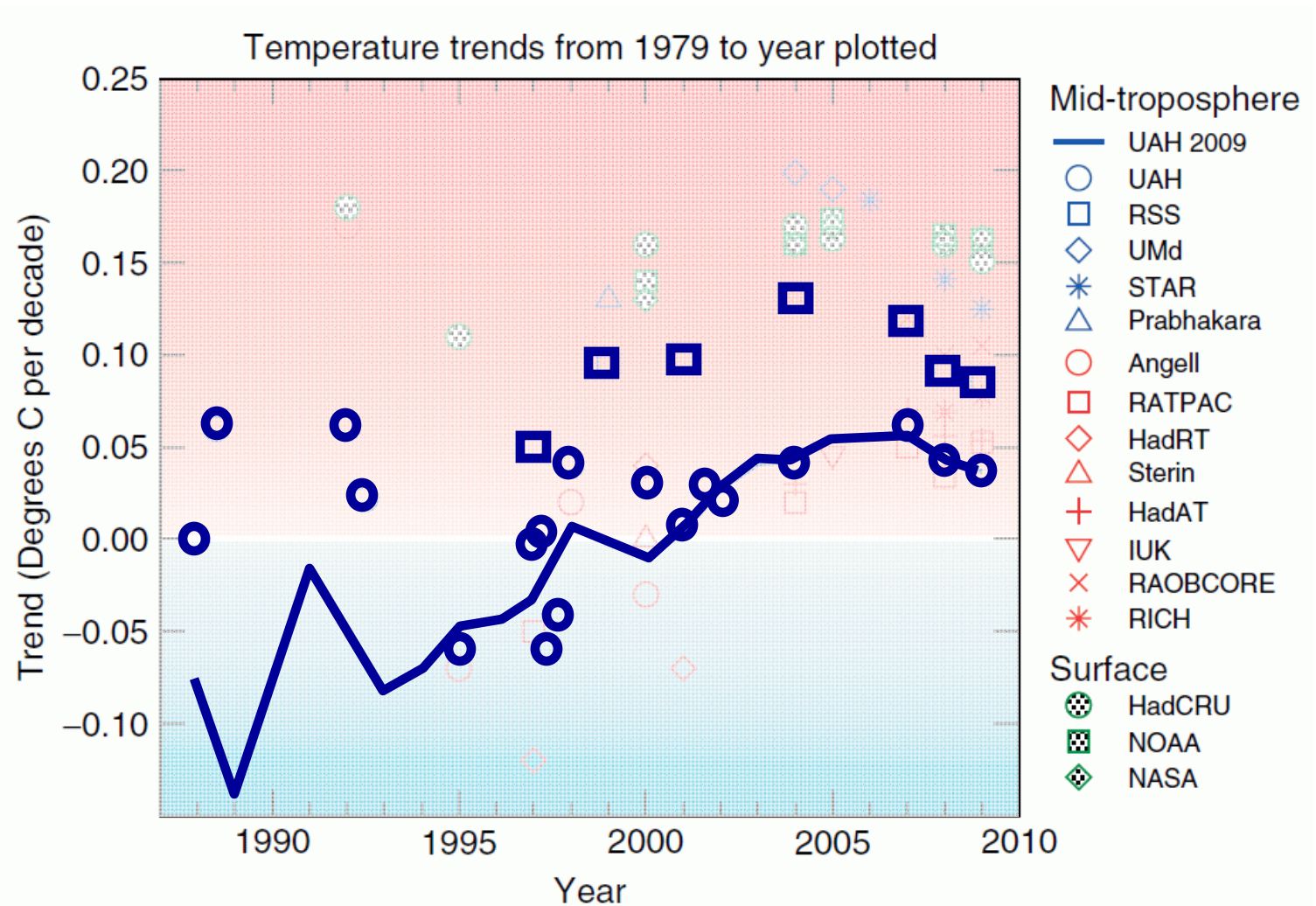
Thorne et al. 2010 in WIREs Climate Change

Tropospheric temperatures



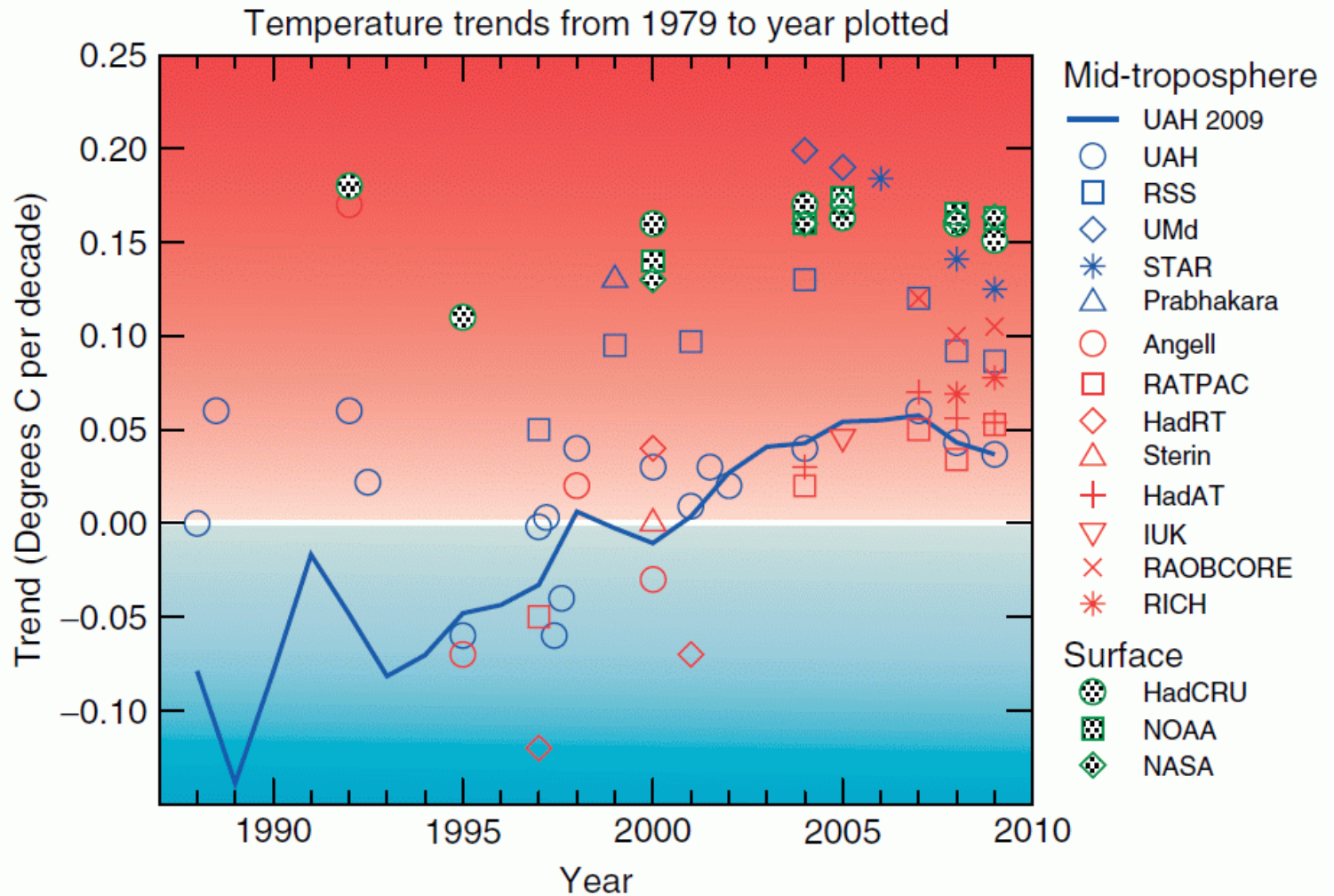
Thorne et al. 2010 in WIREs Climate Change

Tropospheric temperatures



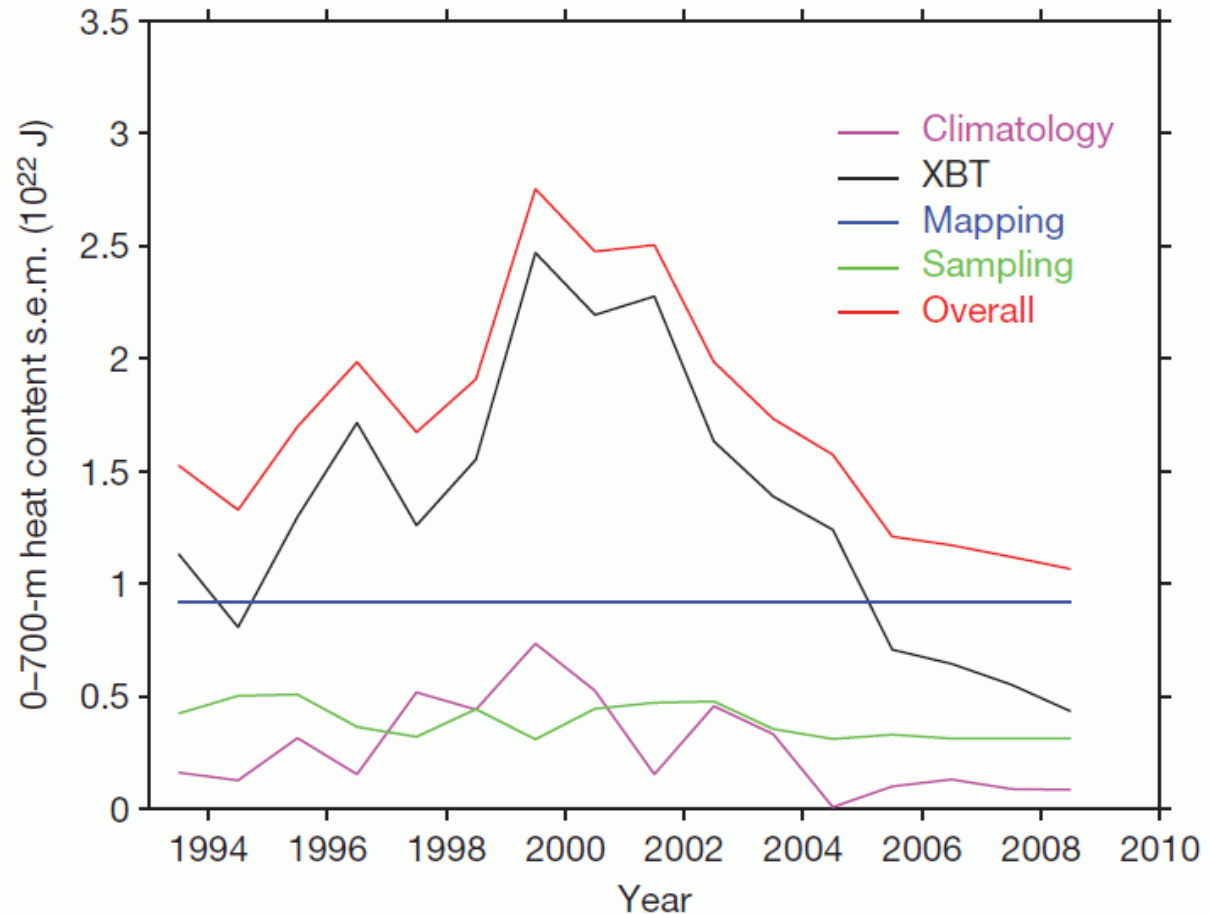
Thorne et al. 2010 in WIREs Climate Change

Tropospheric temperatures



Thorne et al. 2010 in WIRES Climate Change

Subsurface Ocean Temperatures



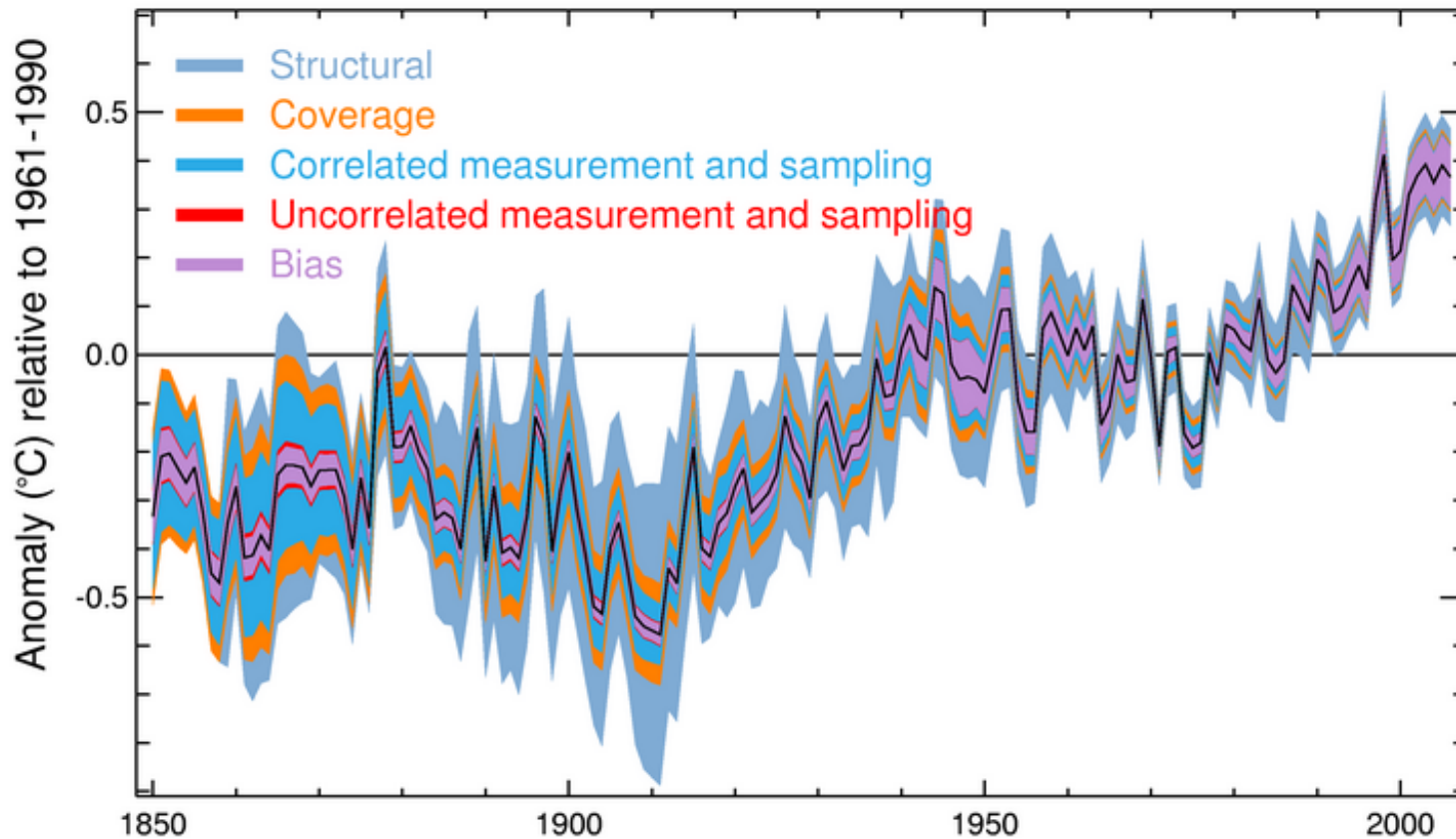
Lyman et al. (2010) Robust warming of the global upper ocean. Nature



Multiple refined estimates over time

- **Helped to define what the important contributions to inhomogeneity are**
- **Where the greatest uncertainties lie**
- **Give some idea of the remaining structural uncertainty**

SST – how large are the overall uncertainties?



There is likely to be some double-counting of uncertainties between the structural component and a number of others



Summary

- There are biases throughout the SST record
- These are not currently corrected in SST data sets
- We have made preliminary estimates of the biases from 1850-2006
- But uncertainties are still only partly quantified.

Multiple new and independent
estimates of historical SST
biases are needed



Met Office
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Questions and answers