Historical and modern marine surface temperatures: improved analyses and estimation of uncertainties.

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Themes

- Boulder Workshop Feb 2002
- Creation of improved analyses: better coverage, new climatologies, flexible gridding system
- Sources of uncertainty in marine temperature analyses: biases and their treatment, sampling/measurement errors
- Global marine temperature anomaly series based on I-COADS

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Boulder Workshop Feb 2002

- **Specify and improve sea surface temperature (SST) data and analysis accuracies and errors (including bias estimates)**
- **Specify and improve night-time marine air temperature (NMAT) data and analysis accuracies and errors (including bias estimates)**
- **Specify accuracy and improve analyses of sea ice**

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Creation of improved analyses

- **Better data coverage**

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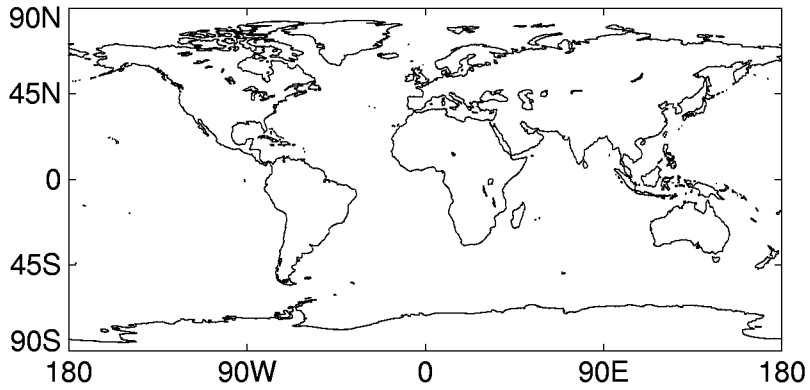
Improved data coverage:

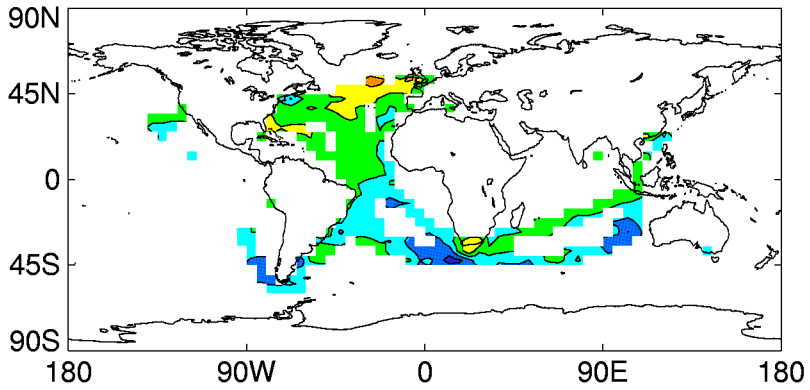
Decadal avg. SST anomaly (relative to 1961-90)

Min 1 month/season, 4 seasons/year, 5 yrs/decade

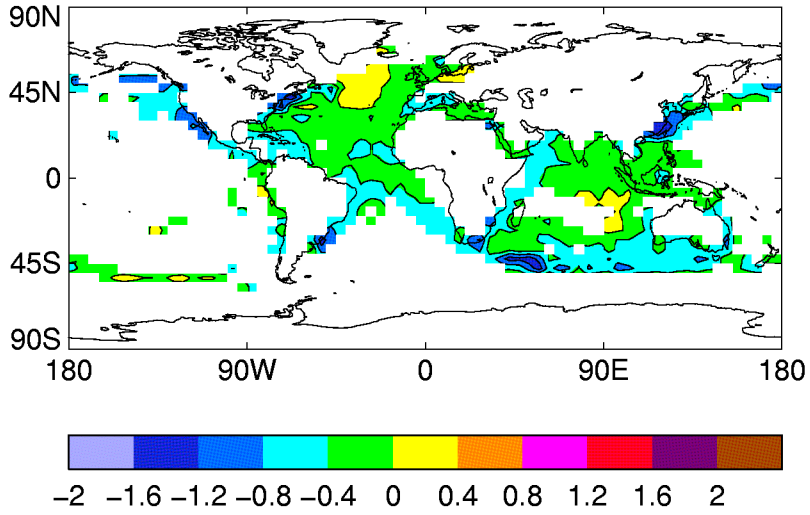
1850-59 MOHSST6D



HadSST2 1850-59



1910-19



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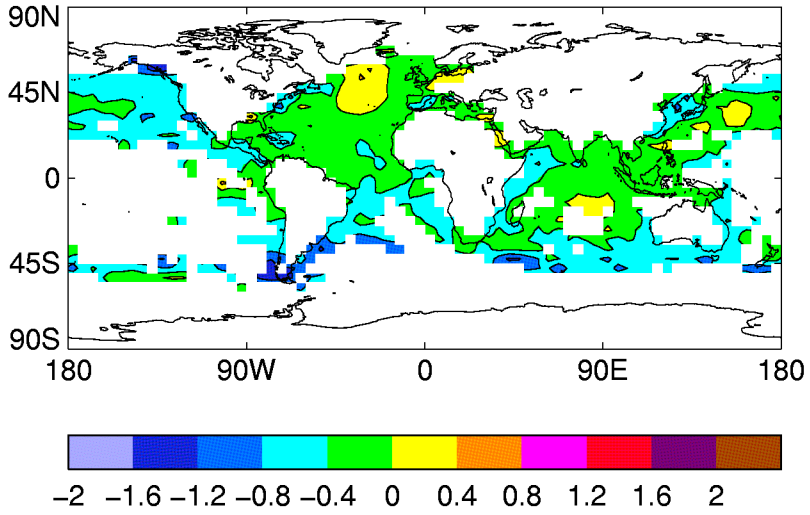

Creation of improved analyses

- **Better data coverage**
- **Took opportunity of improved input data to revamp our marine data processing system:**
  - **Flexible gridding**

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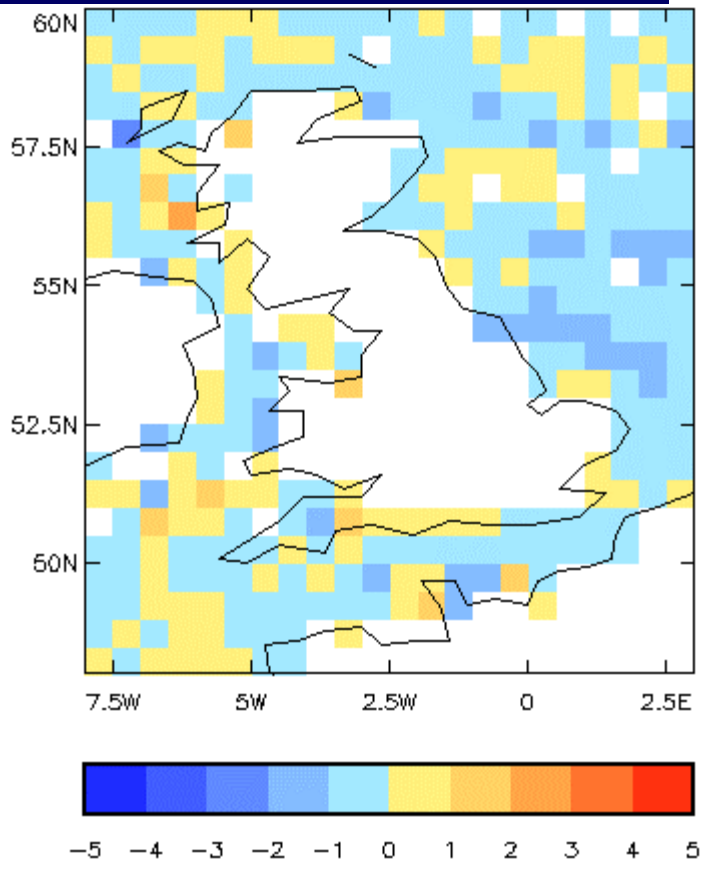
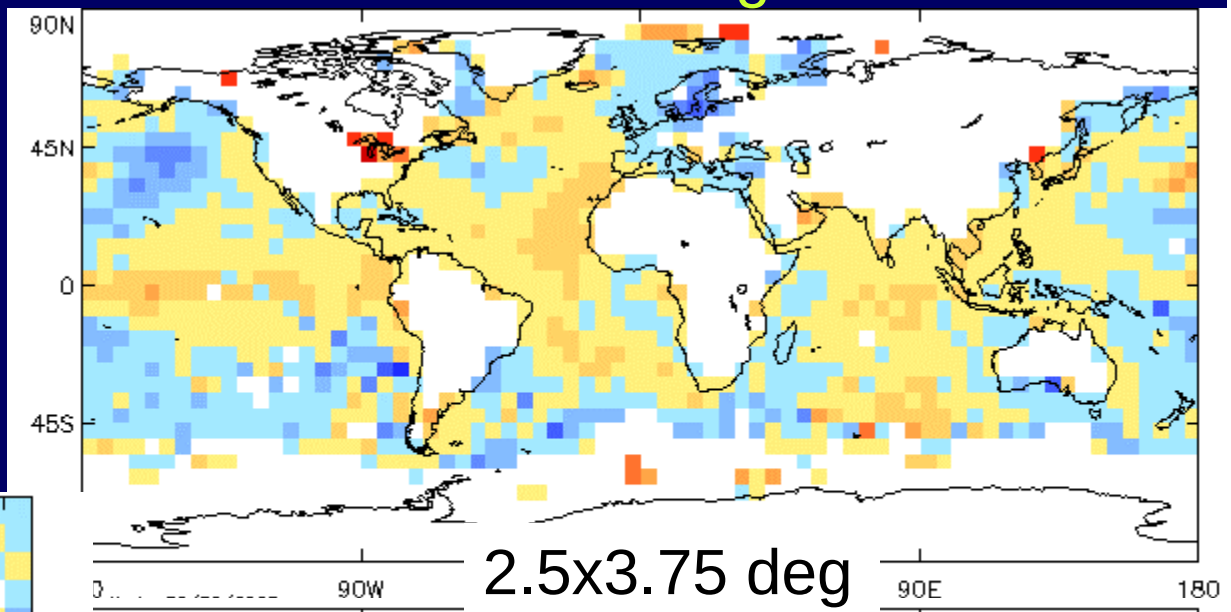
Flexible gridding: SST anomalies (rel to 1961-90): August 1996

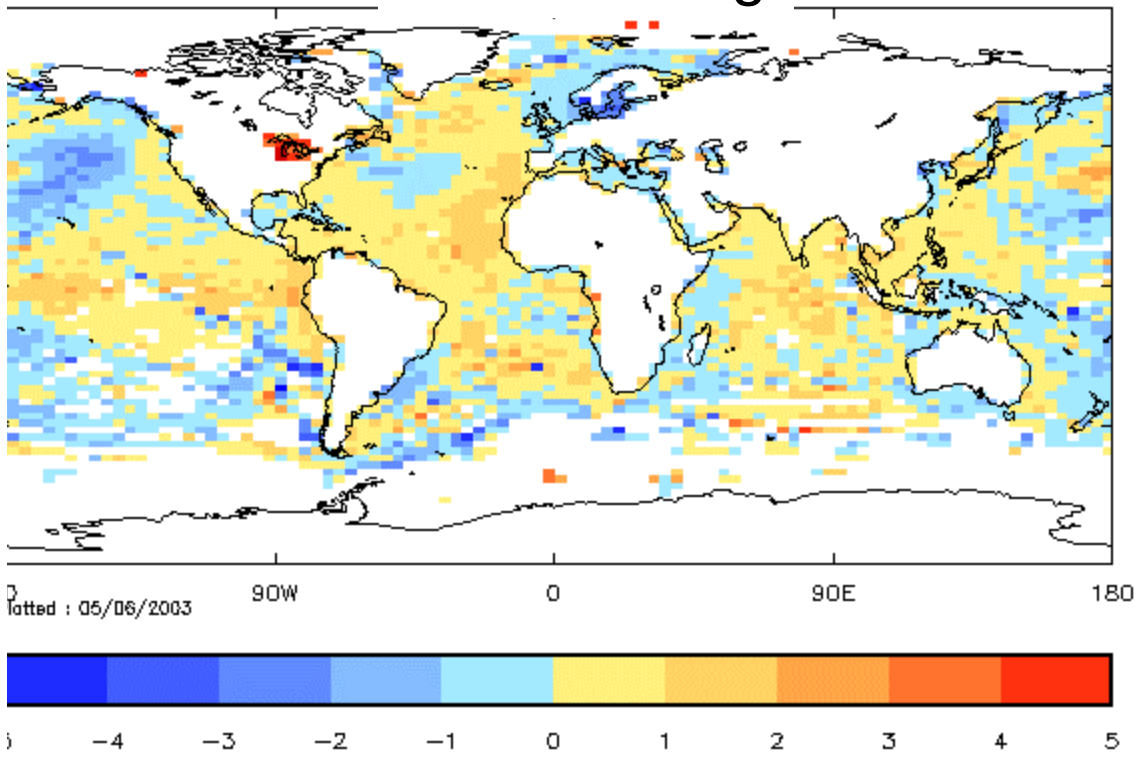
0.5x0.5 deg



5x5 deg



2.5x3.75 deg



Creation of improved analyses

- **Better data coverage**
- **Took opportunity of improved input data to revamp our marine data processing system:**
  - **Flexible gridding**
  - **New climatologies**

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New climatology

- **Applied broadly the same methods as before to create the monthly climatologies for 1961-90 from I-COADS data**
- **But, replaced the harmonic synthesis of pentad (5-day) climatologies from the monthlies with a conservative spline fitting method, ensuring that the mean of the pentad fields = the original monthly climatology (it did not before)**
- **Used a daily version linearly interpolated from the pentads in the QC of the I-COADS data**

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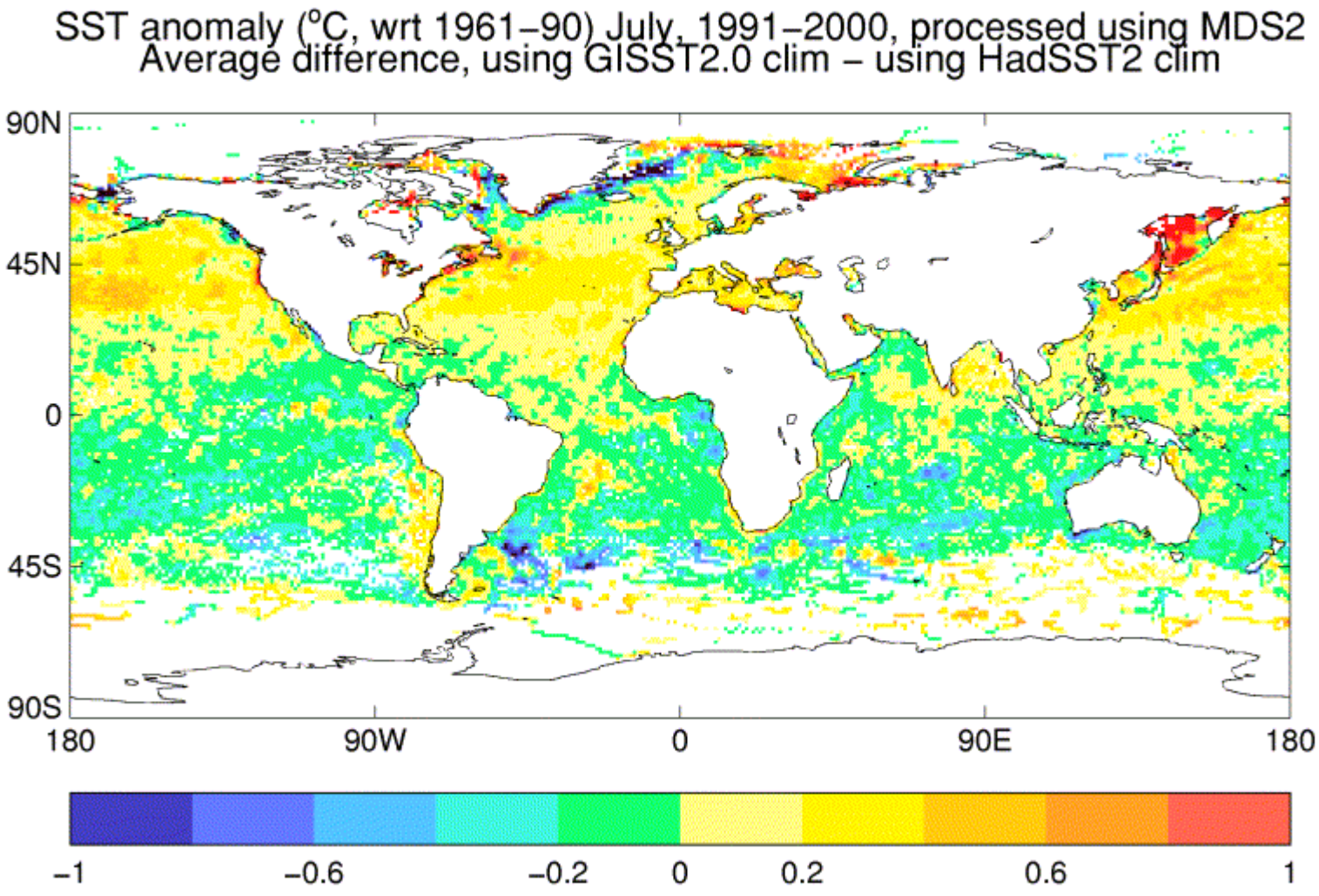
Effect of new climatology on SST analysis



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Sources of uncertainty in marine temperature analyses

- Incomplete geographical and temporal coverage of data
- Measurement and sampling errors
- Uncertainties in bias-corrections

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Uncertainties in box averages owing to measurement and sampling error

- **These will be unimportant in grid-boxes with many observations but large in those with few**
- **Variance of detrended grid box time series varies with number of observations**
- **Extrapolate this relationship back to one observation to get the sampling/measurement error and to infinity to get the correlated variance**
- **Use this to derive the sampling/measurement error for any number of observations**

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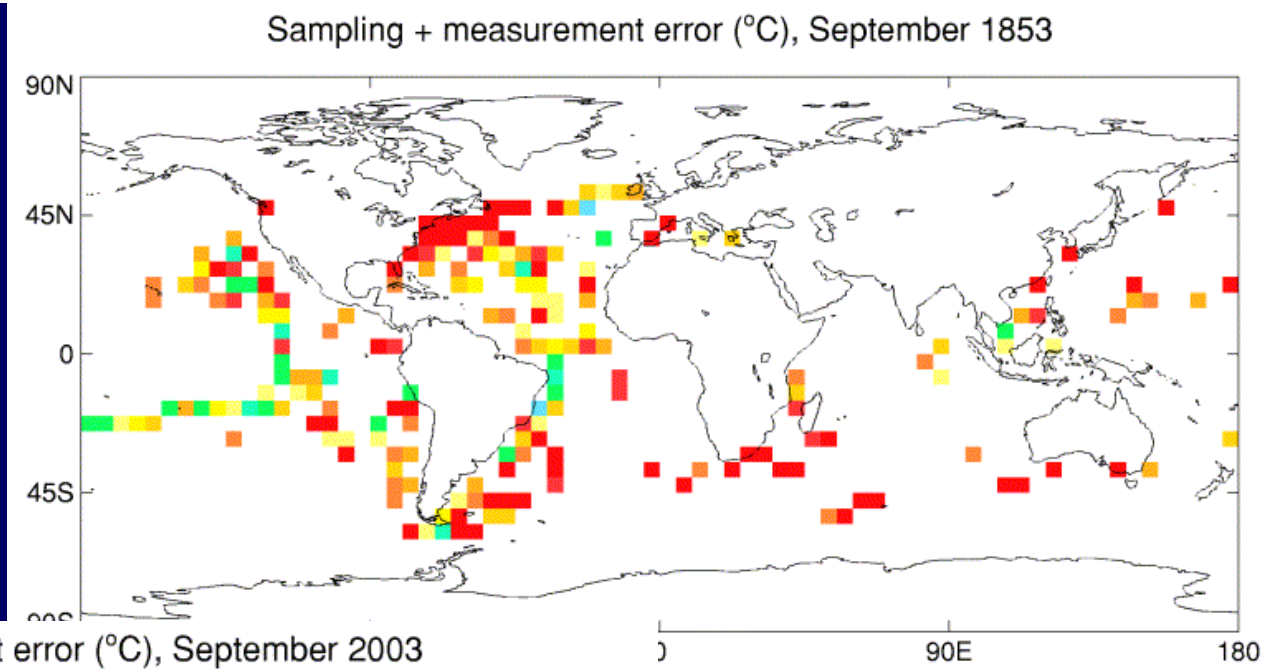
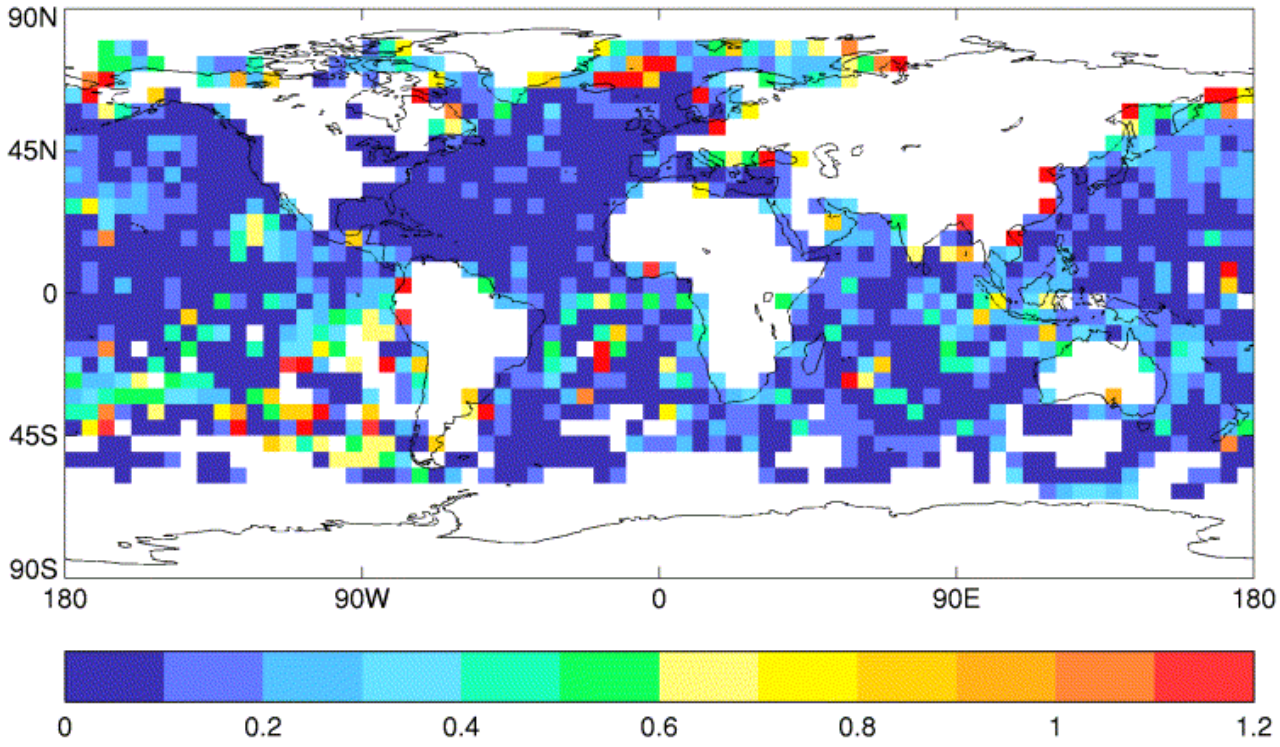
Examples of monthly measurement and sampling error





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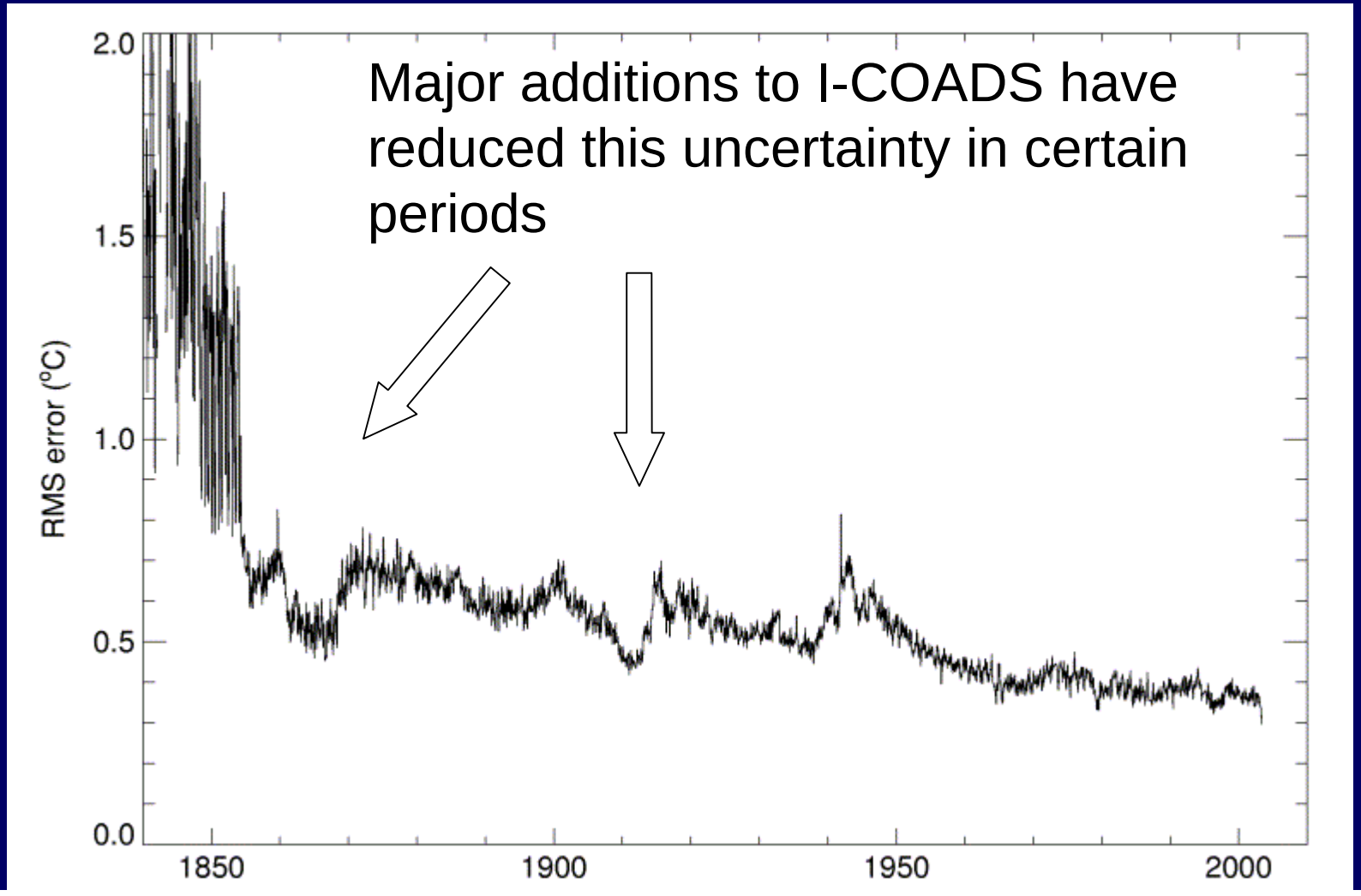
HadSST2 global rms sampling + measurement error (°C)

1840 - August 2003



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Biases in historical SSTs: buckets

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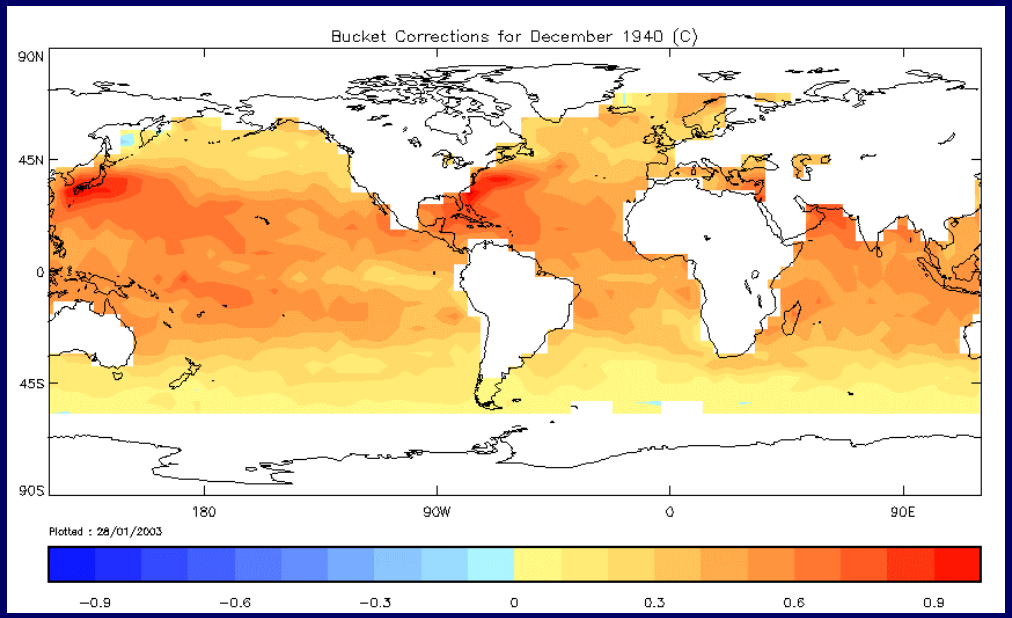
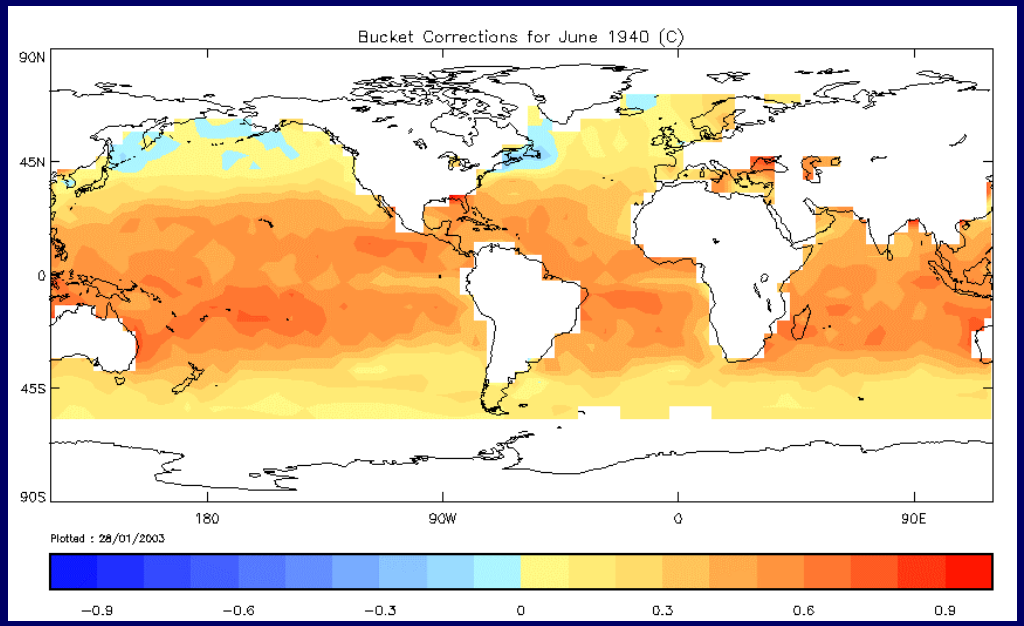
Biases in historical SSTs: Folland and Parker 1995





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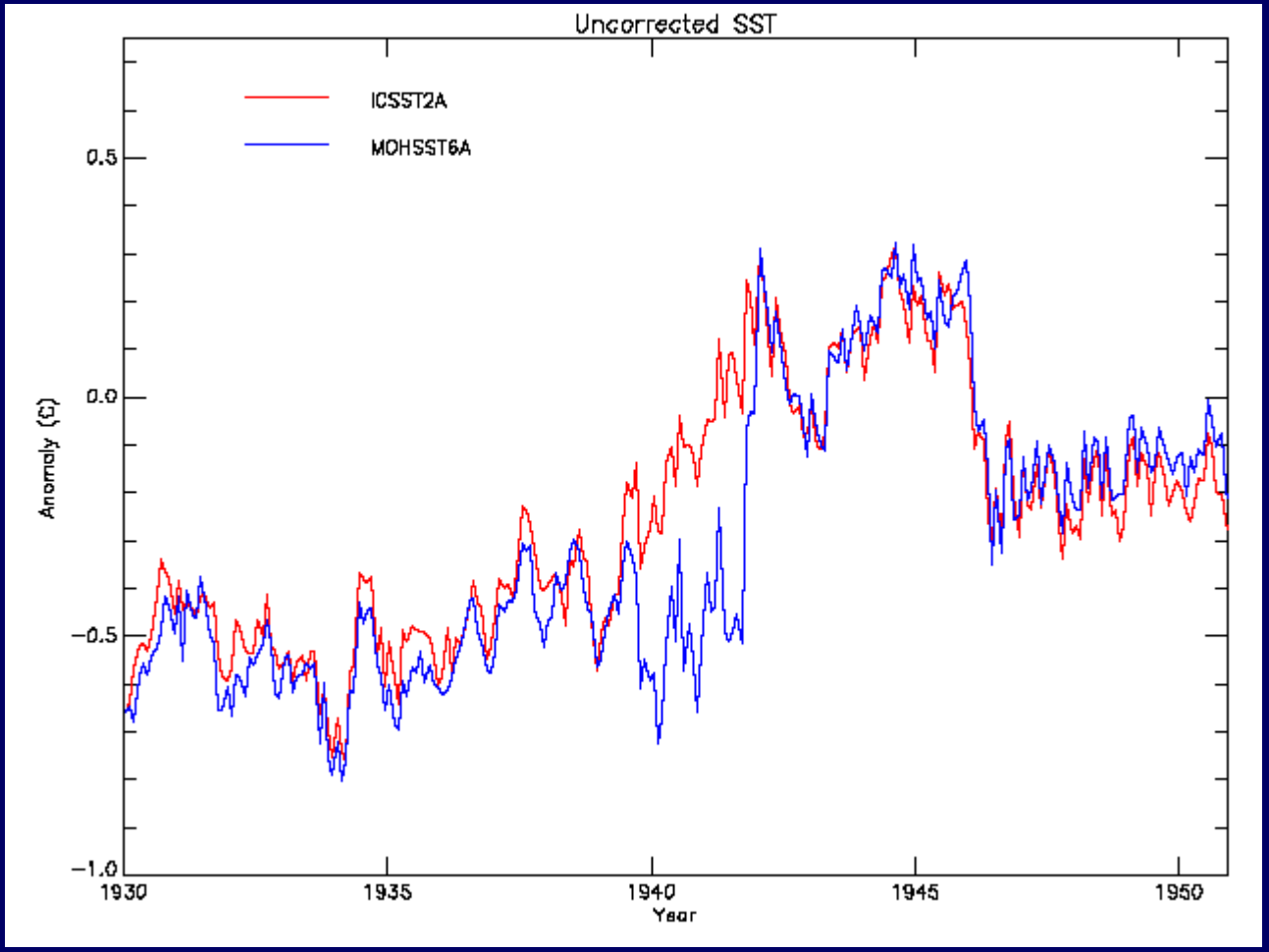
Uncorrected datasets in the period 1930-50



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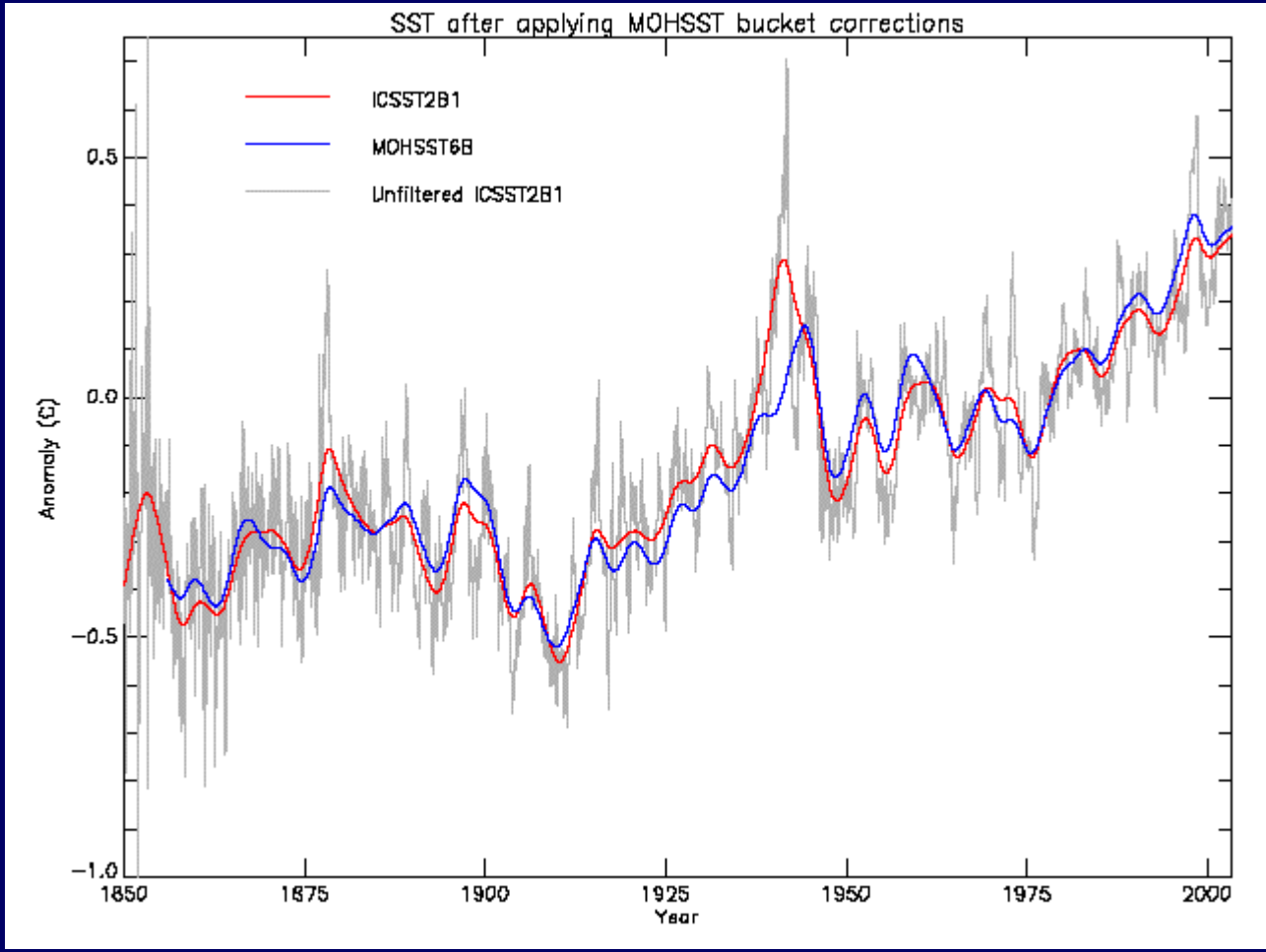
After applying MOHSST bucket corrections



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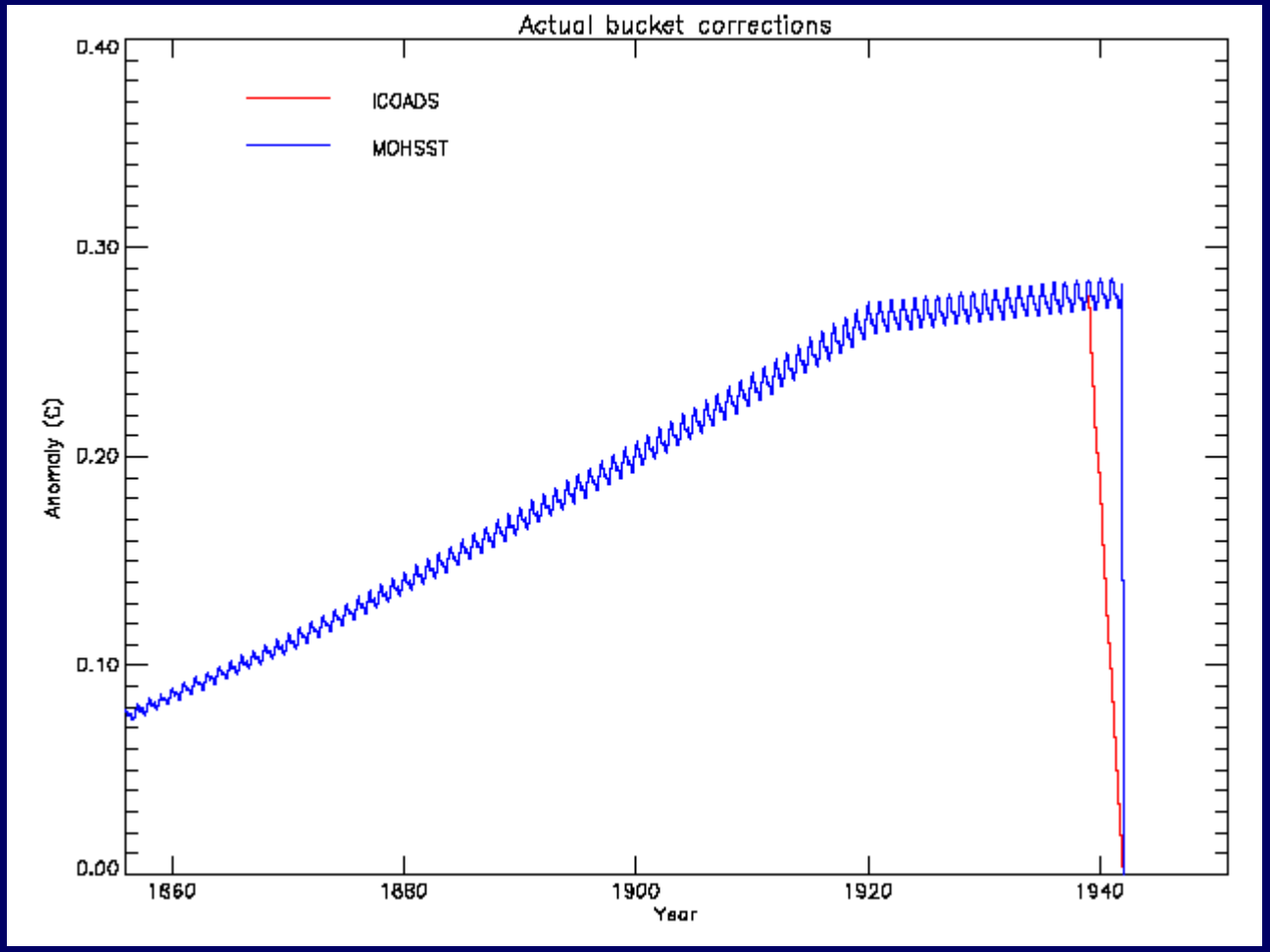
Bucket corrections, ICOADS & MOHSST



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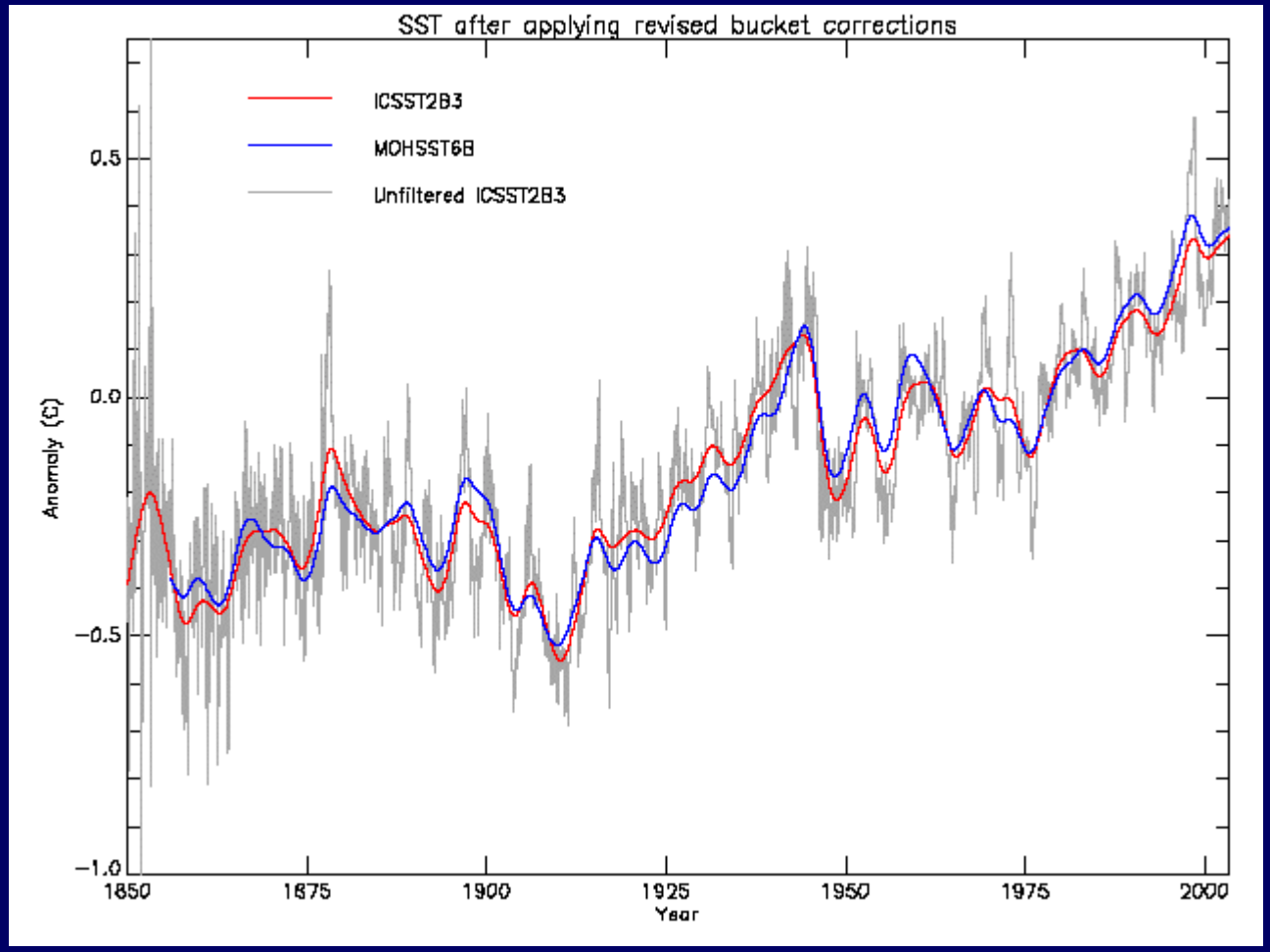
After applying revised bucket corrections



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Uncertainties in SST bucket corrections

- **Inputs to bucket corrections were varied within their likely limits**
- **Multiple realisations of the bucket corrections were generated**
- **Standard deviation of these at each grid box in each month gives the uncertainty in the correction (but ignores any possible bias)**

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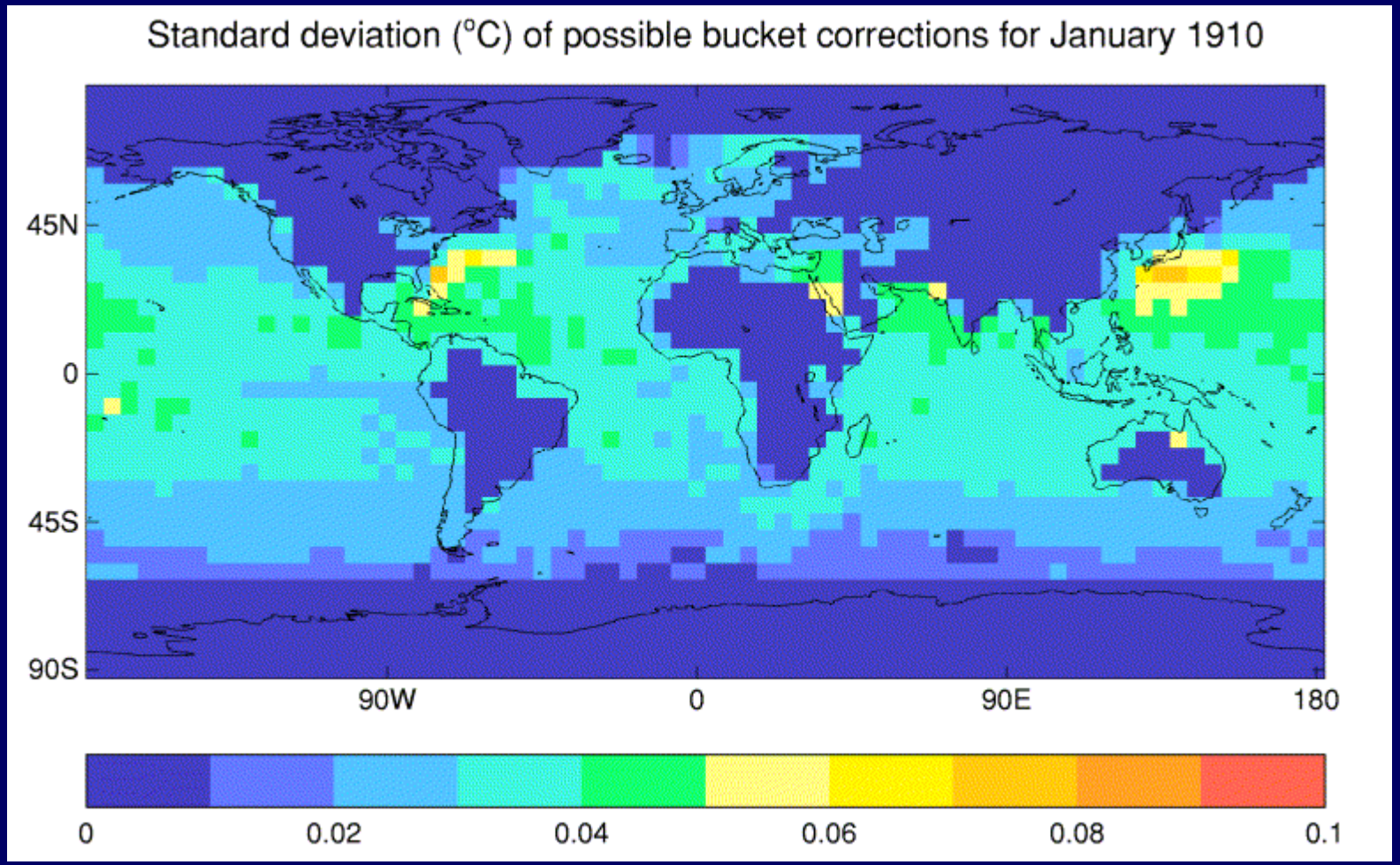
Uncertainties in bias corrections made to historical SSTs



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Biases and their uncertainties in air temperatures owing to variations in deck height

- Changes in deck heights were assessed through examination of log books and WMO-47
- This information combined with temperature lapse rates gives the size of the average bias in measured air temperatures in any year relative to a reference period.
- Our initial investigations show that the uncertainty in this correction is very small (negligible compared to other errors)

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Random errors and biases in modern marine temperatures (from Kent and Challenor)

Draft: To be submitted to the Journal of Atmospheric and Oceanic Technology

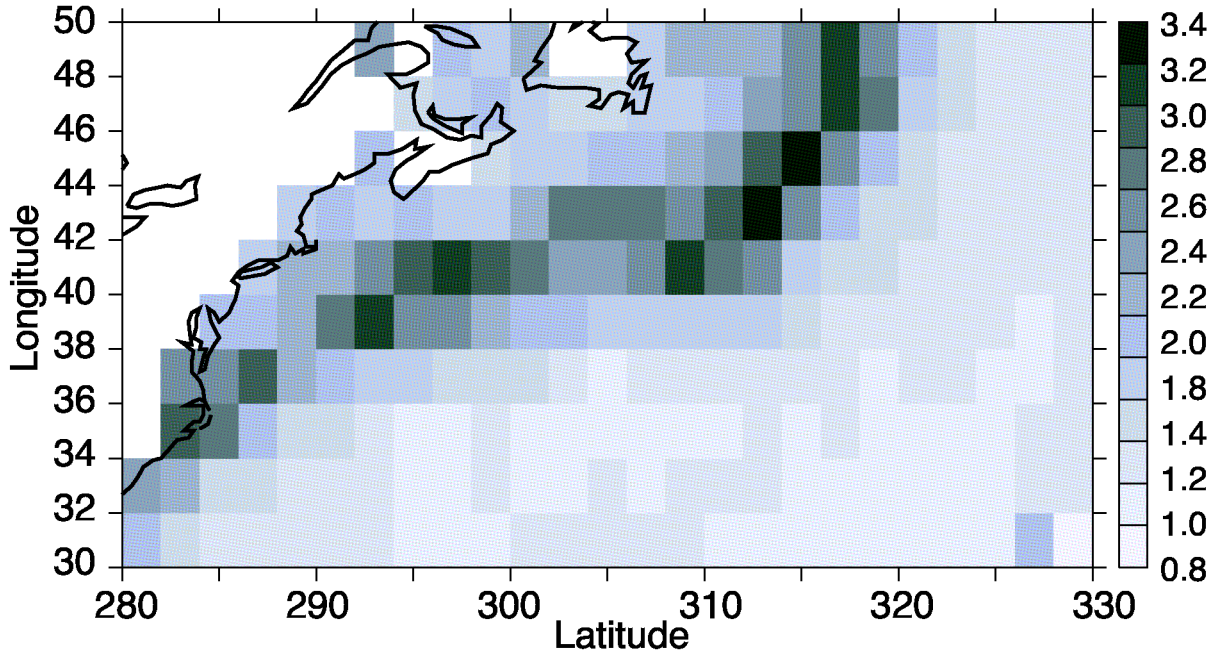

Figure 3 **SST random error estimates (°C) calculated as in Figure 5a but for 2° areas in the North Atlantic.**

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Random errors and biases in modern marine temperatures (from Kent and Challenor)

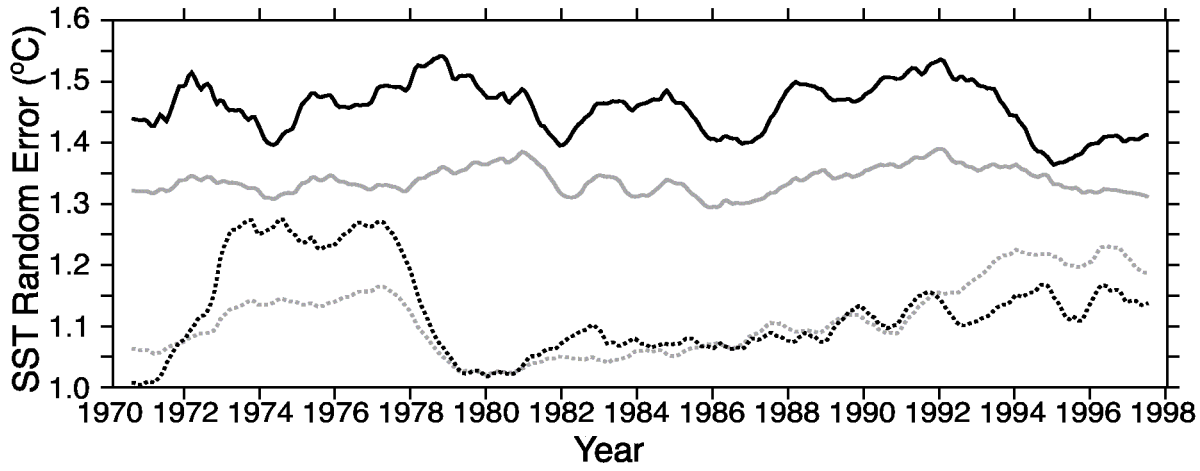

Figure 7 Time series of bucket and engine intake random errors as in Figure 4 with a 12-month running mean filter. Solid lines are random errors from the engine intake SST and dotted lines random errors for the bucket SST. Estimates weighted by the number of observations are shown by the dark lines and those by ocean area as the grey lines.

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Random errors and biases in modern marine temperatures (from Kent and Taylor)

To be submitted to the Journal of Atmospheric and Oceanic Technology *Draft*

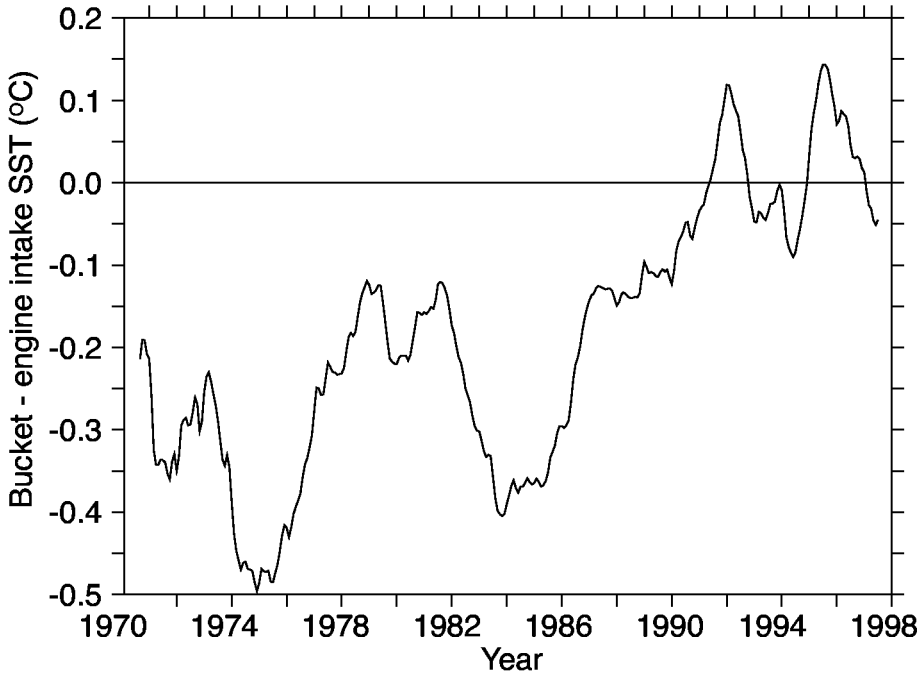

Figure 6a **Annual mean difference between Bucket and Engine Intake SST (C) averaged over the North Atlantic between 20°N to 50°N and 80°W to 0°W. Averages have been calculated for all 10° areas and months where there were at least 10 observations made using each method and smoothed with a 12-month running mean filter.**

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Random errors and biases in modern marine temperatures (from Kent and Taylor)

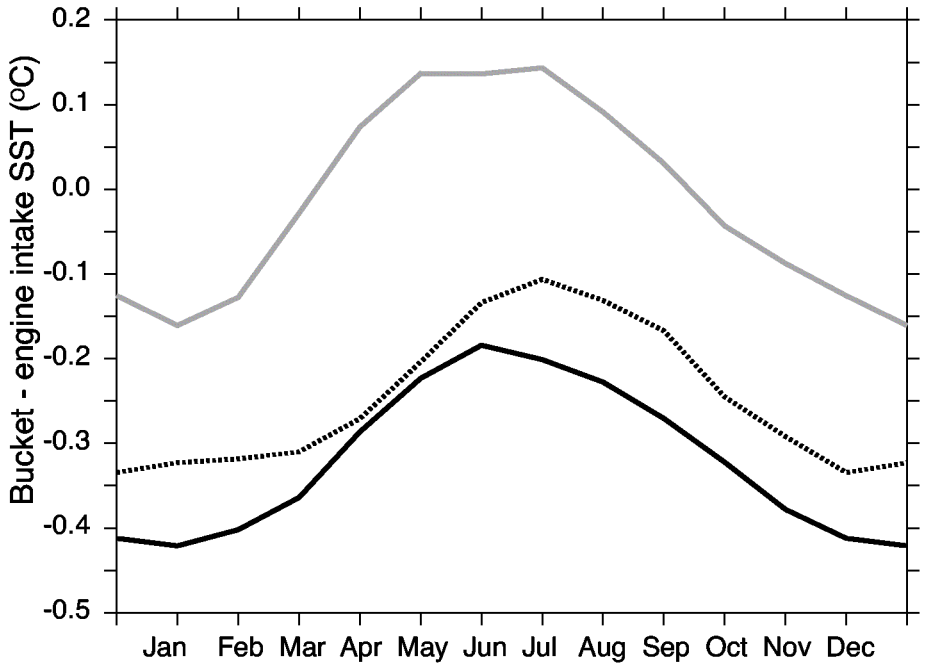

Figure 6b **Annual cycle of difference between Bucket and Engine Intake SST (C) for the same data as Figure 6a. The dark line shows the average annual cycle for the 1970s, the dotted line for the 1980s and the light line for 1990 to 1997.**

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Potential improvements in estimating biases

- New modern climatology after application of bias-adjustments to modern data
- Re-estimation of annual cycles in historical temperature anomalies
- Consider homogenising annual cycles of air-sea temperature difference anomalies instead of SST anomalies

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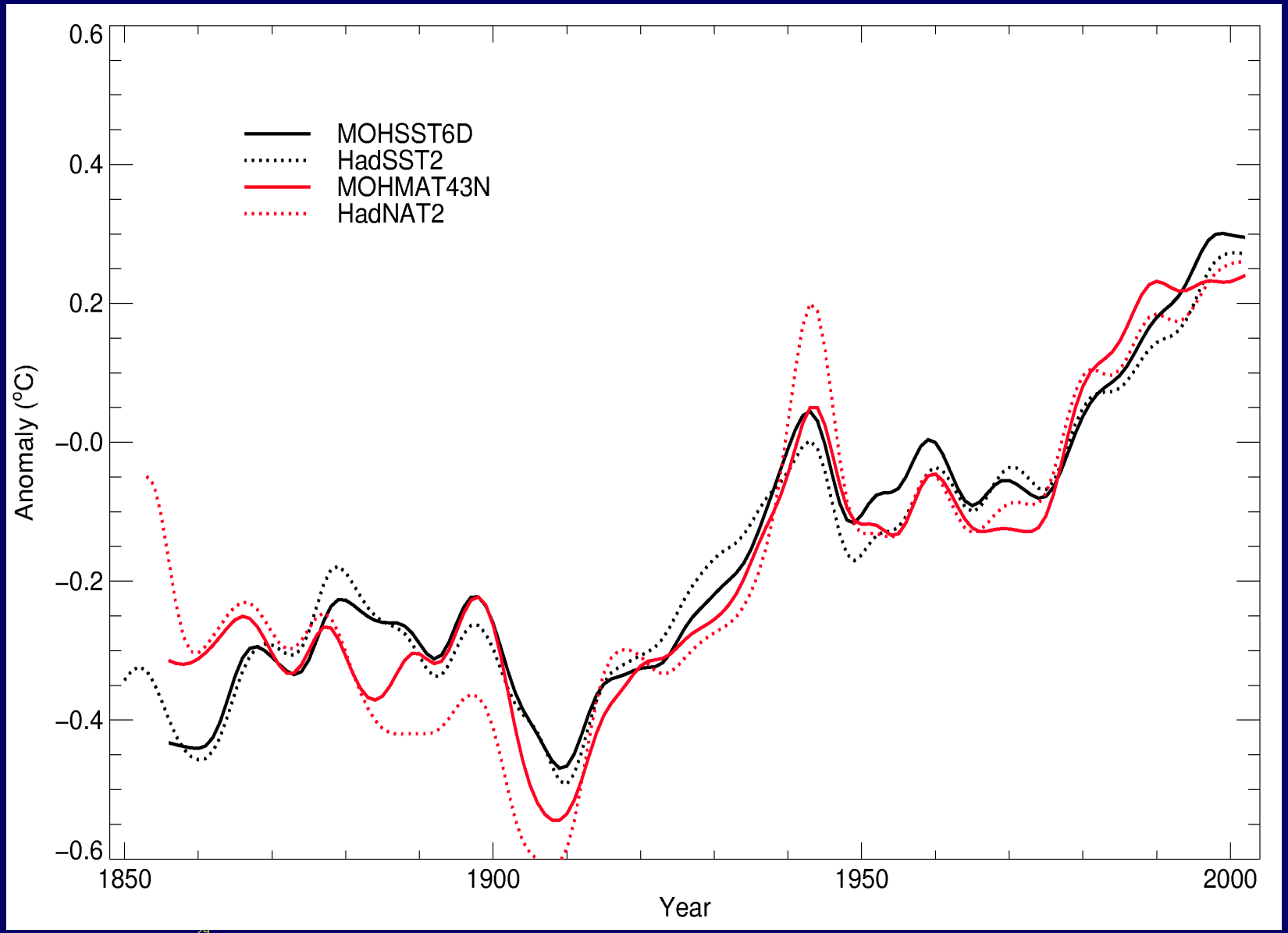
Global marine temperature anomaly series. Curves zeroed 1961-90



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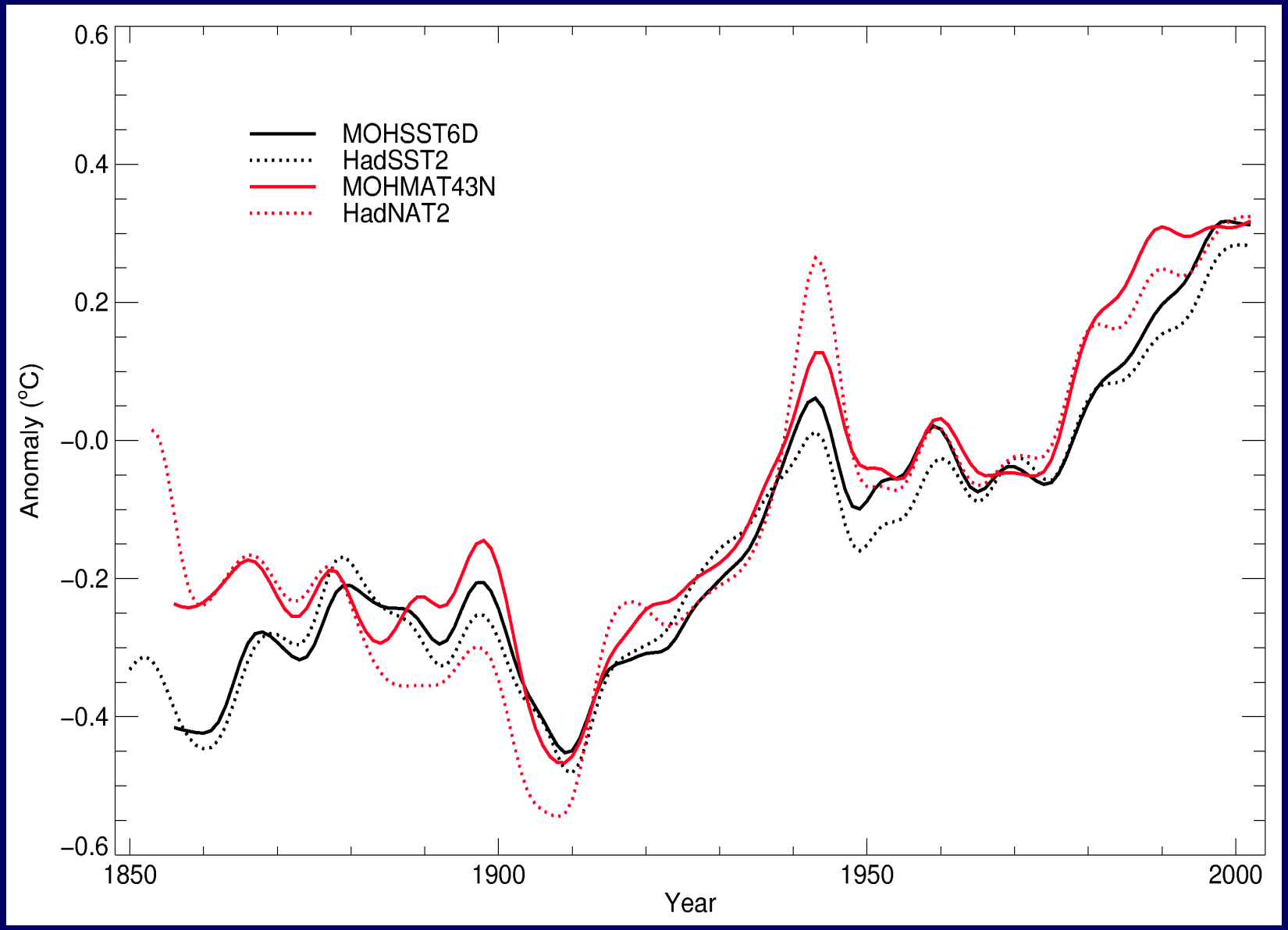
Global marine temperature anomaly series.
Curves not zeroed 1961-90



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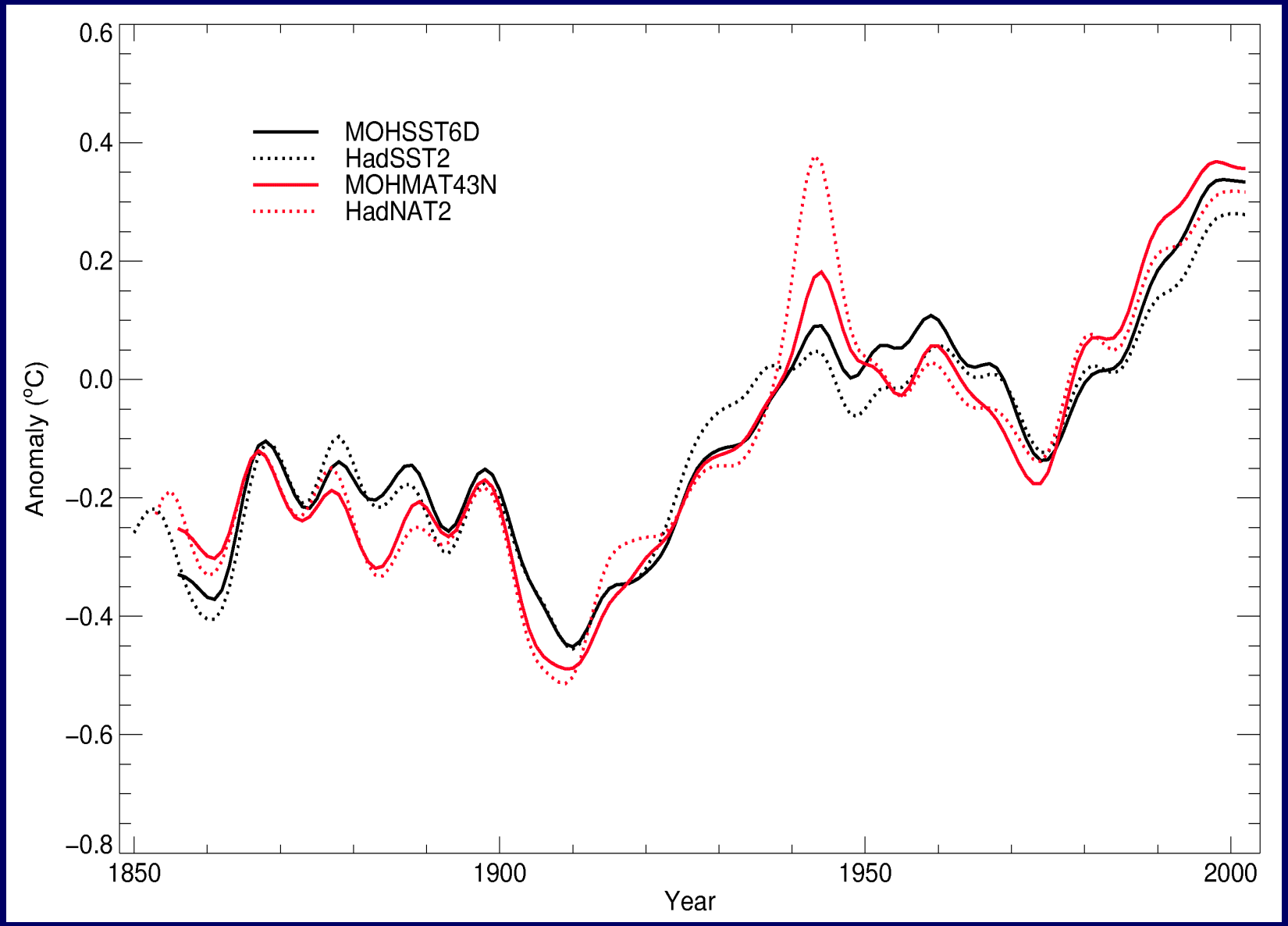
N. Hem. marine temperature anomaly series.
Curves zeroed 1961-90



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N. Hem. marine temperature anomaly series.
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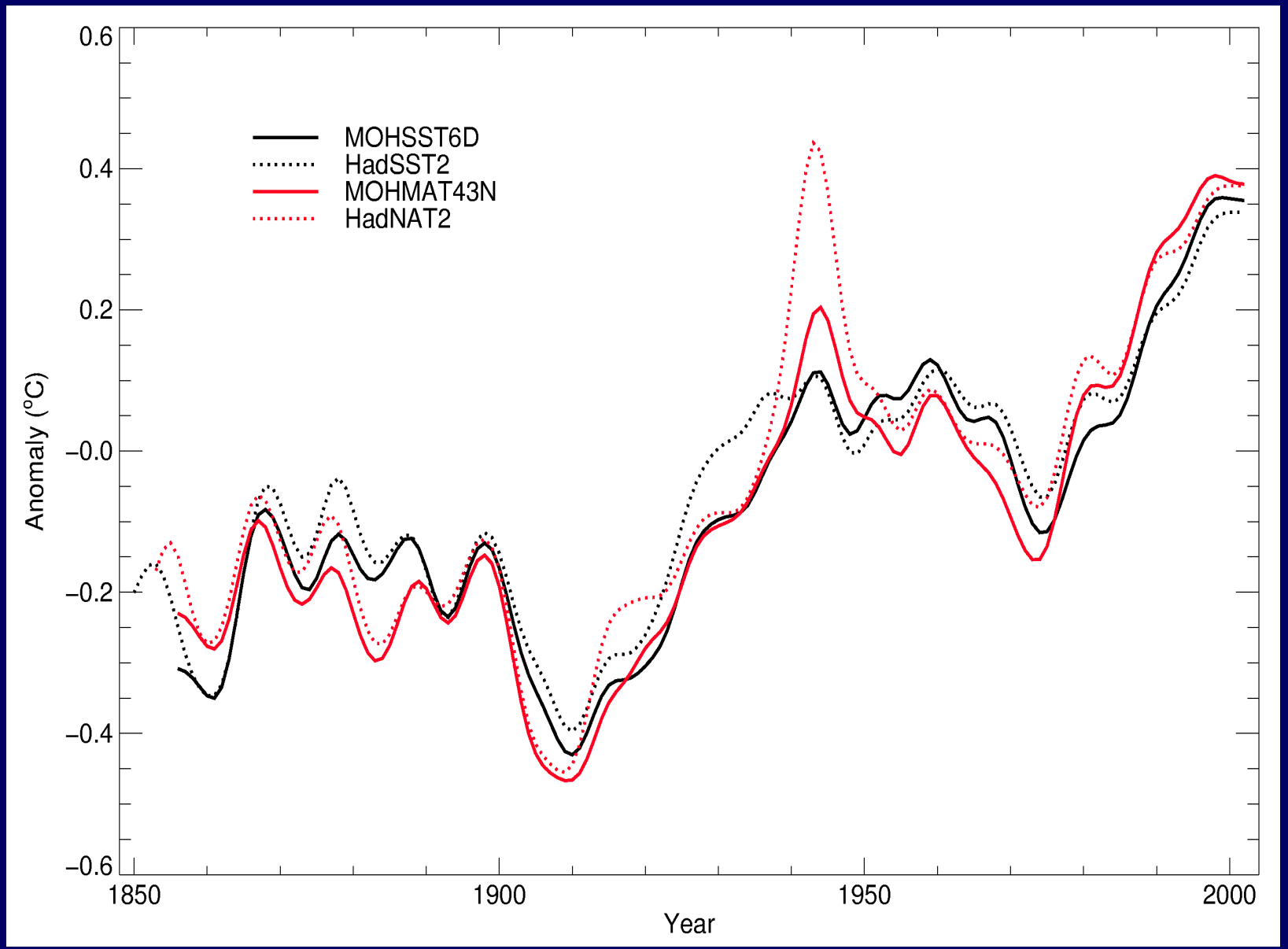

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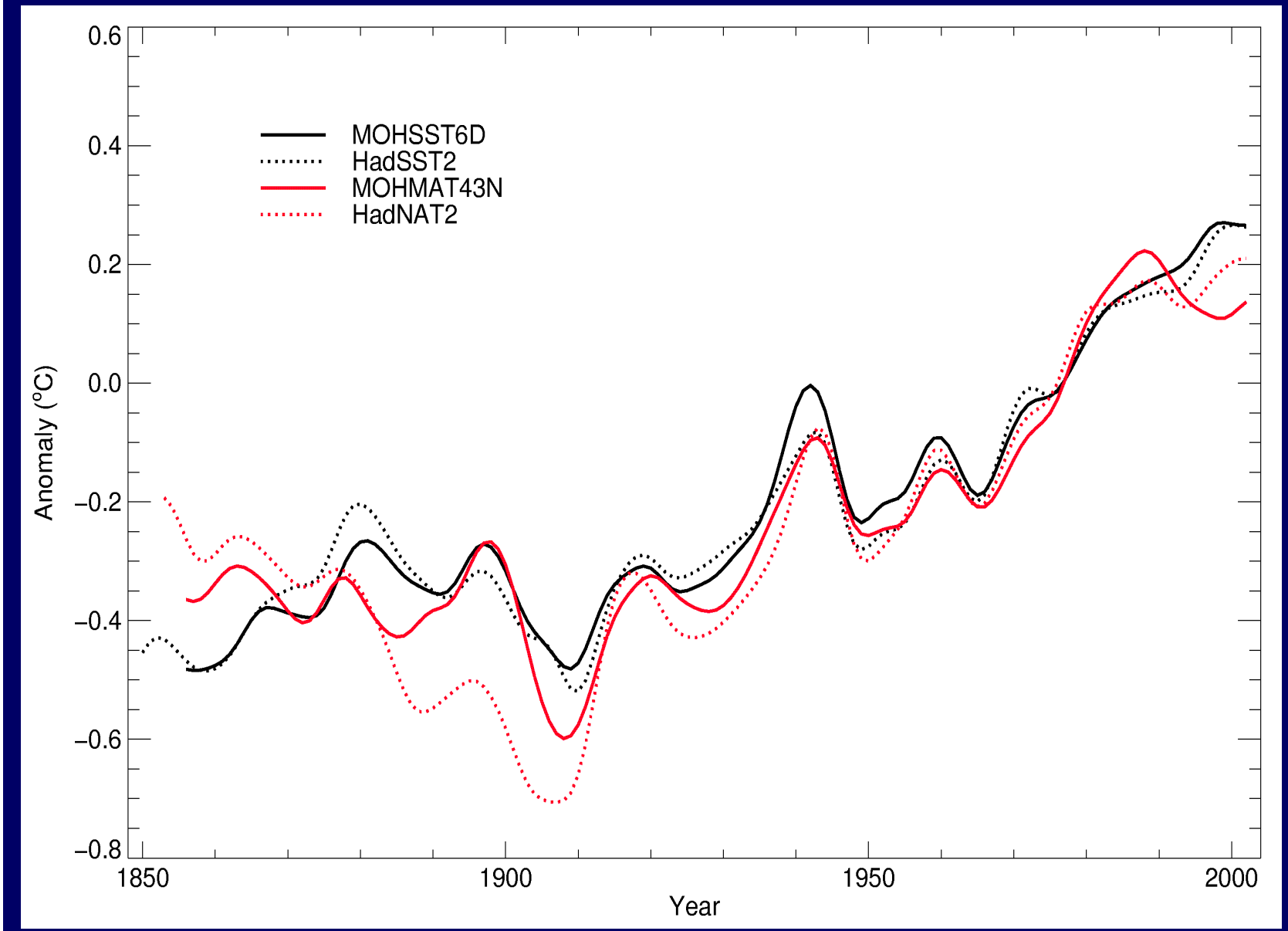
S. Hem. marine temperature anomaly series. Curves zeroed 1961-90



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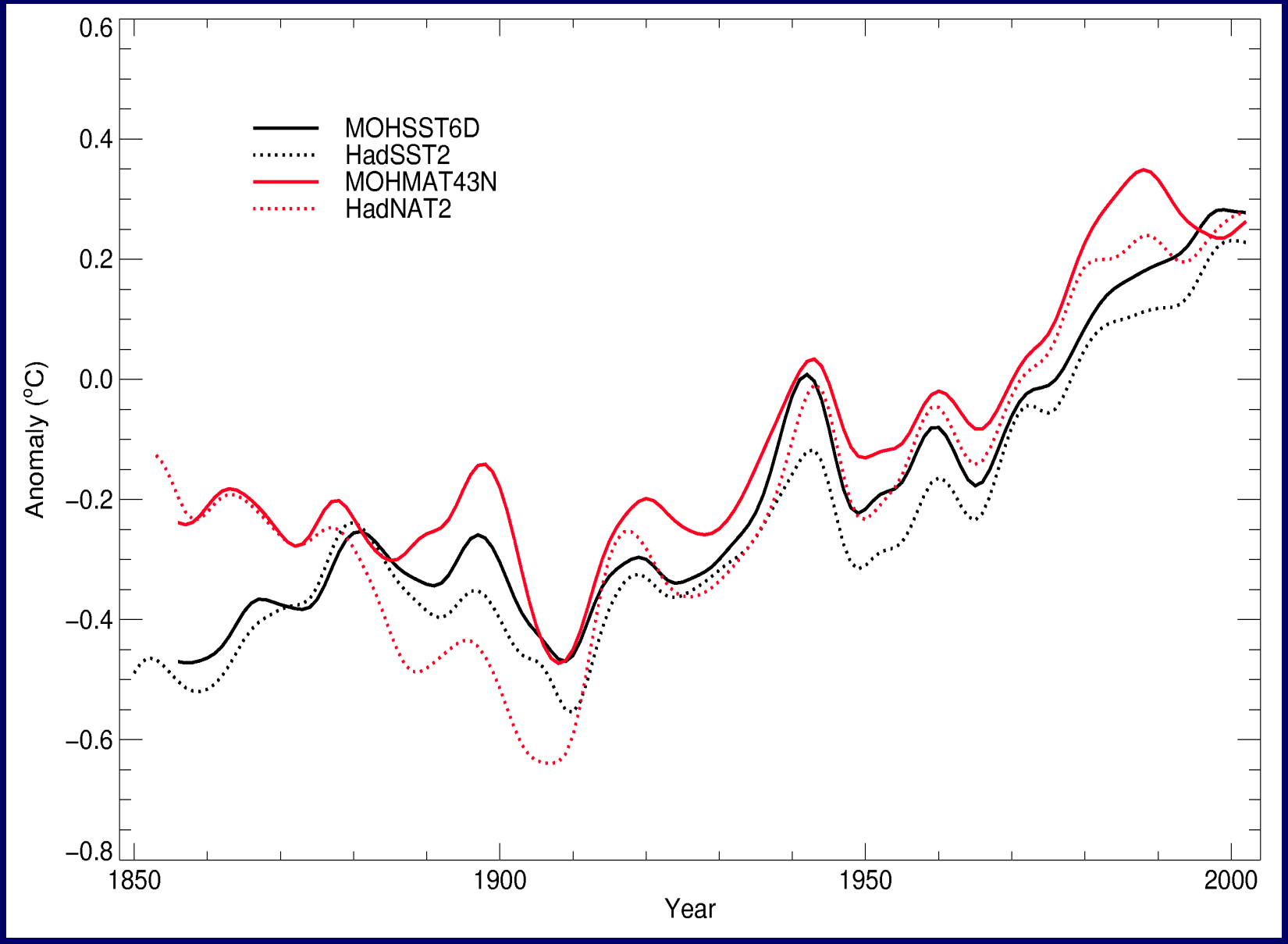
S. Hem. marine temperature anomaly series. Curves not zeroed 1961-90



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Conclusions

- **I-COADS is undergirding major improvements in estimation of marine climatic variations and their uncertainties.**

- **There is potential for further improvement by:**
  - **Digitisation and incorporation of millions more data 1850-1930**
  - **Refinement of bias corrections to pre-1942 data**
  - **Application of bias-corrections to recent data**
  - **Blending with unbiased infrared and microwave satellite SST**
  - ***With care*, ocean reanalysis for recent years**

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