Combined estimates of uncertainties in gridded marine temperature fields due to measurement errors and under-sampling of variability

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Outline

- **Illustration of the issue**
- **Modelling the effect: splitting grid box variability into "real" and "spurious" parts**
- **Resultant fields and time series of sampling/measurement error**

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Sampling and measurement error

- **Gridded observational data fields contain several sources of uncertainty. Two such are:**
  - **measurement error (the inaccuracy of an individual measurement) and**
  - **sampling error (the inability of a finite number of observations to capture the full variability of the quantity measured over the area of a grid-box).**
- **The error in an average of a finite number of observations of a variable is a combination of these**

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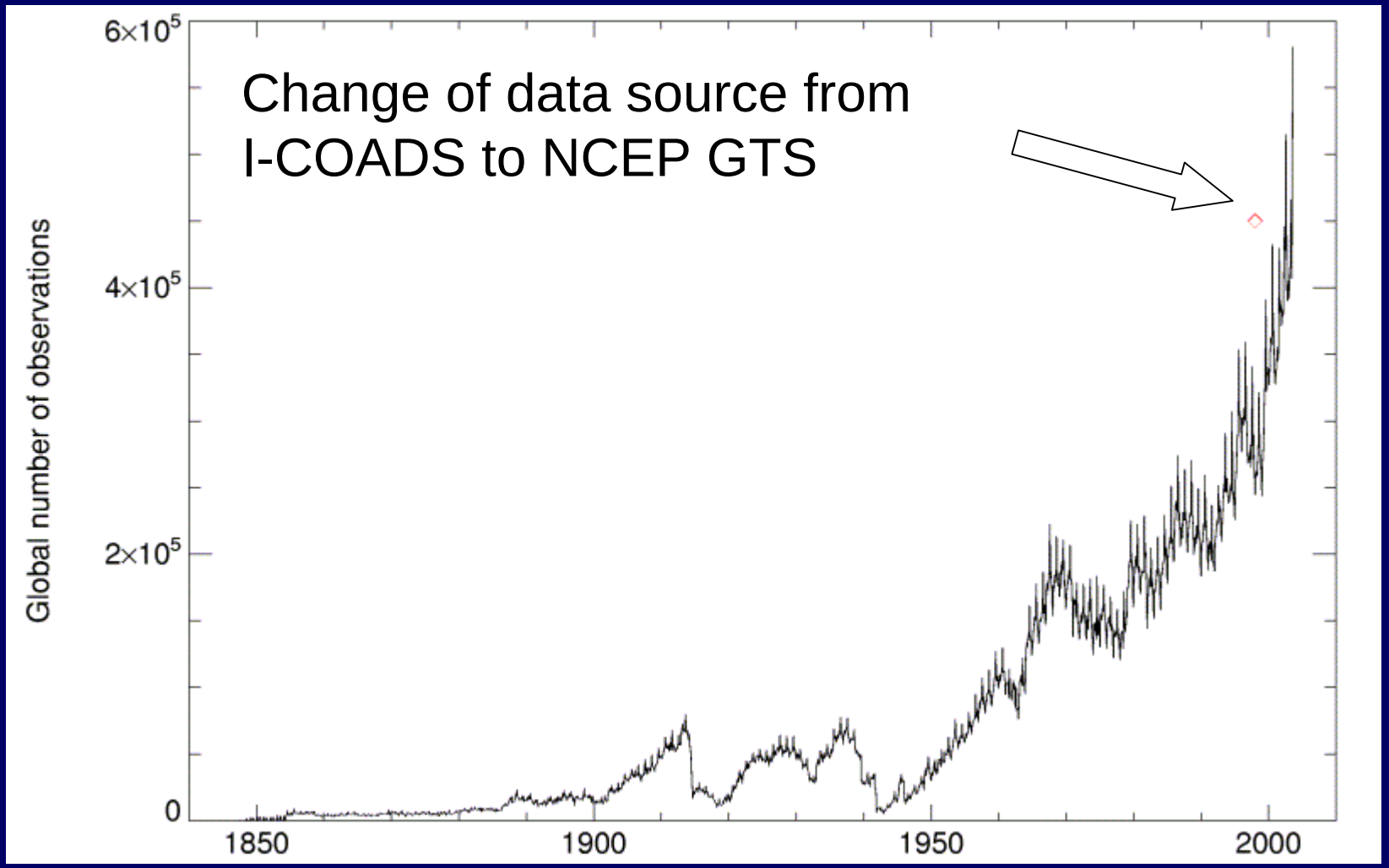
Number of observations is variable

total number in monthly HadSST2, 1840 - August 2003



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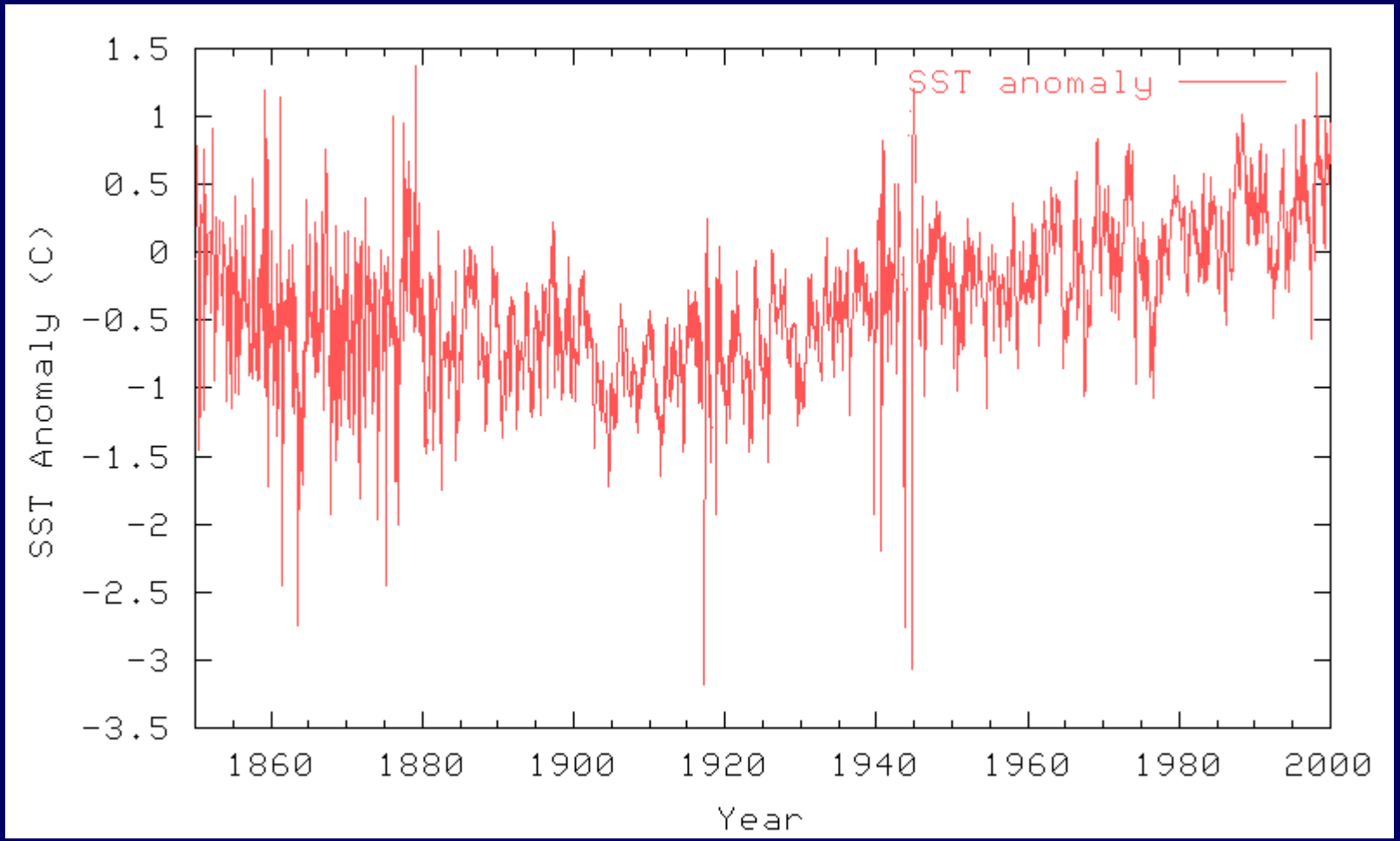
This leads to heteroskedasticity in a monthly bias-corrected grid box SST time series (e.g. for box [30-35W,0-5S])



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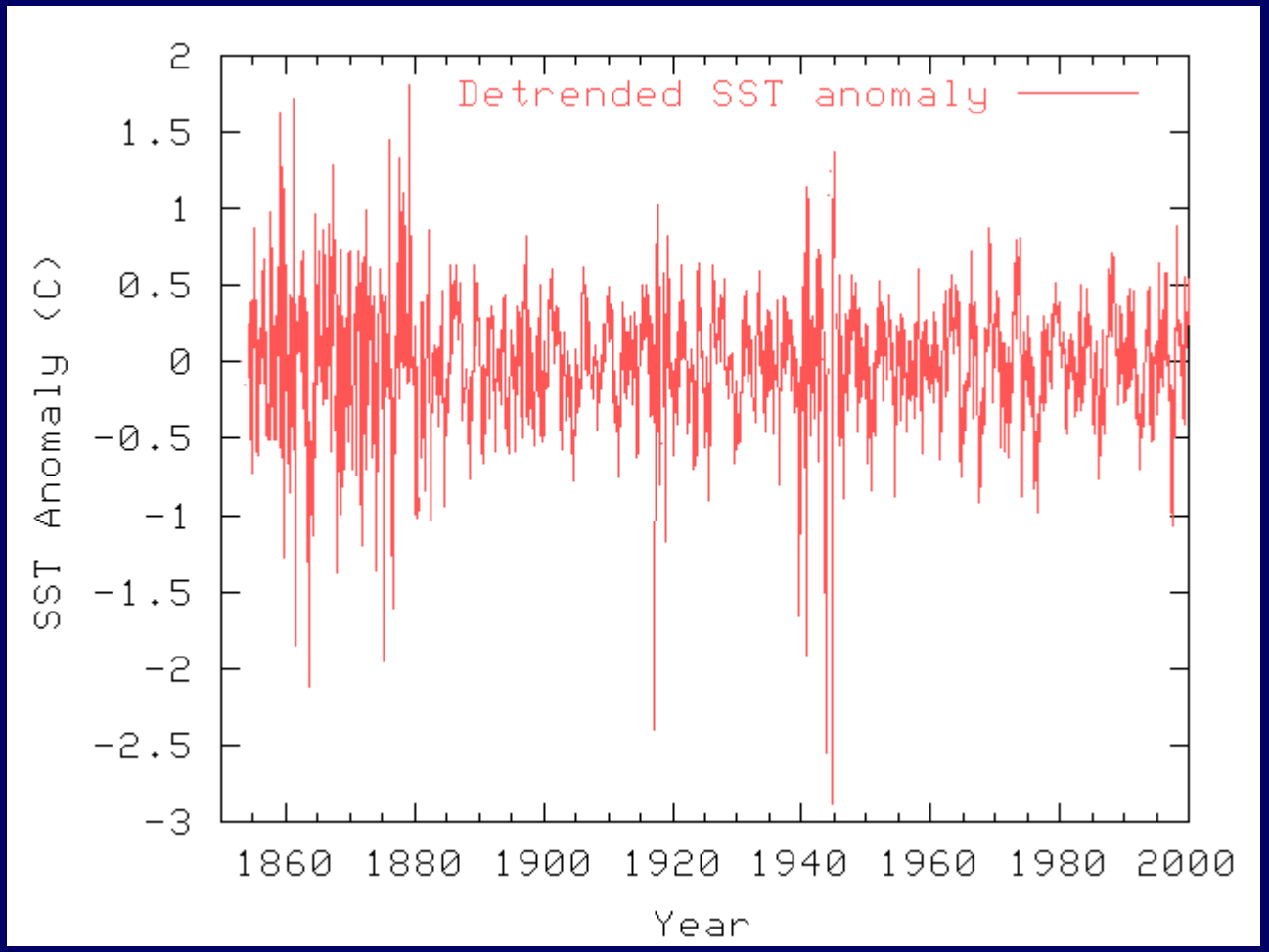
(e.g. for box [30-35W,0-5S])



Moving 6-yr average removed

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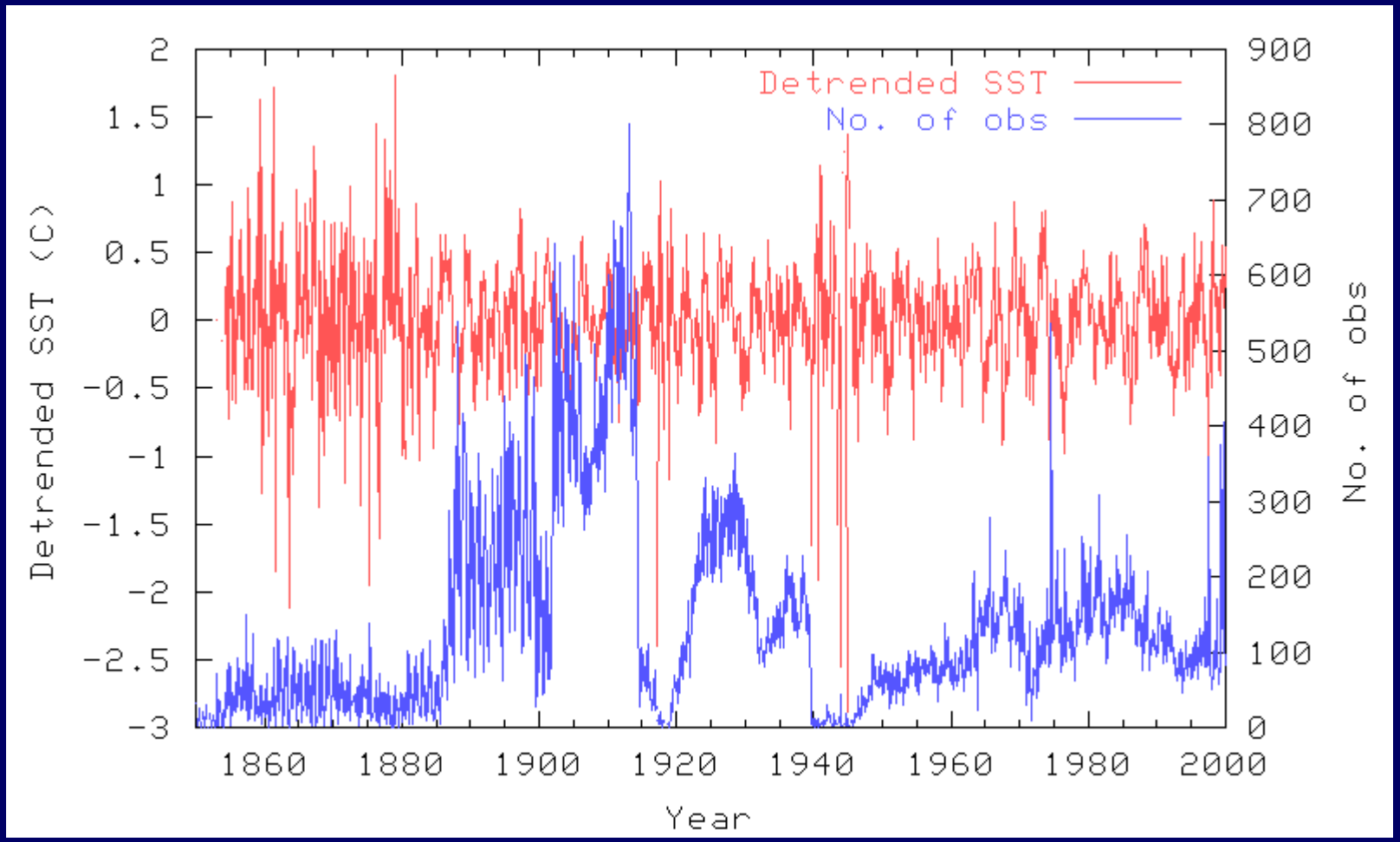
It is easy to see the correlation between variability and number of observations (e.g. for box [30-35W,0-5S])



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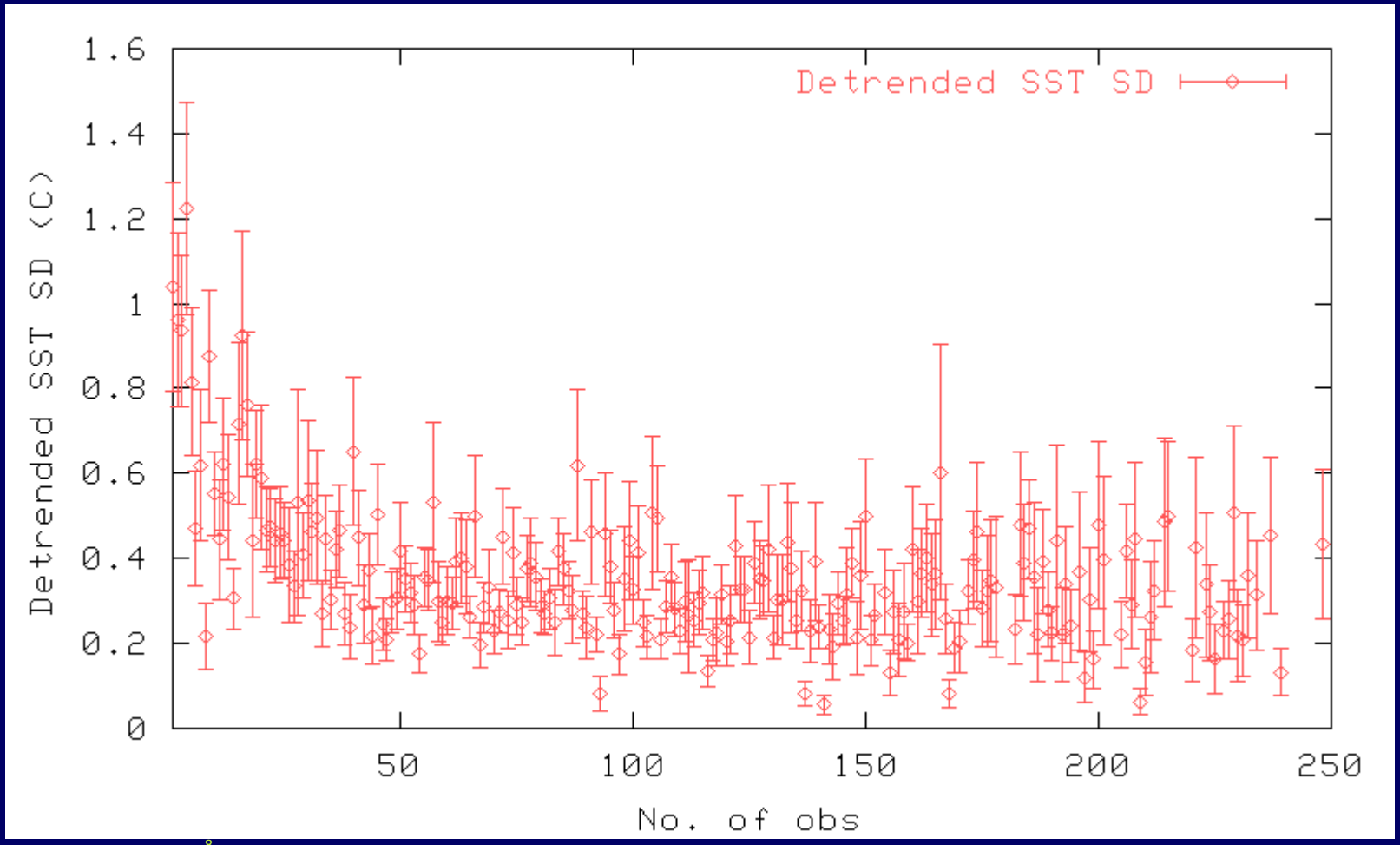

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Fitting a relationship

- **How exactly does standard deviation (s.d.) vary with number of obs?**
- **Jones et al (1997), Yevjevich (1972) and Kagan (1966) relate the s.d. of a multi-site mean time series, *V*, to the average s.d. of the constituent observations via their number and their mean correlation:**

$$V^2 = v_i^2 \left[\frac{1+(n-1)\bar{r}}{n} \right]$$

- **We fit this relationship to the curve at each grid box**

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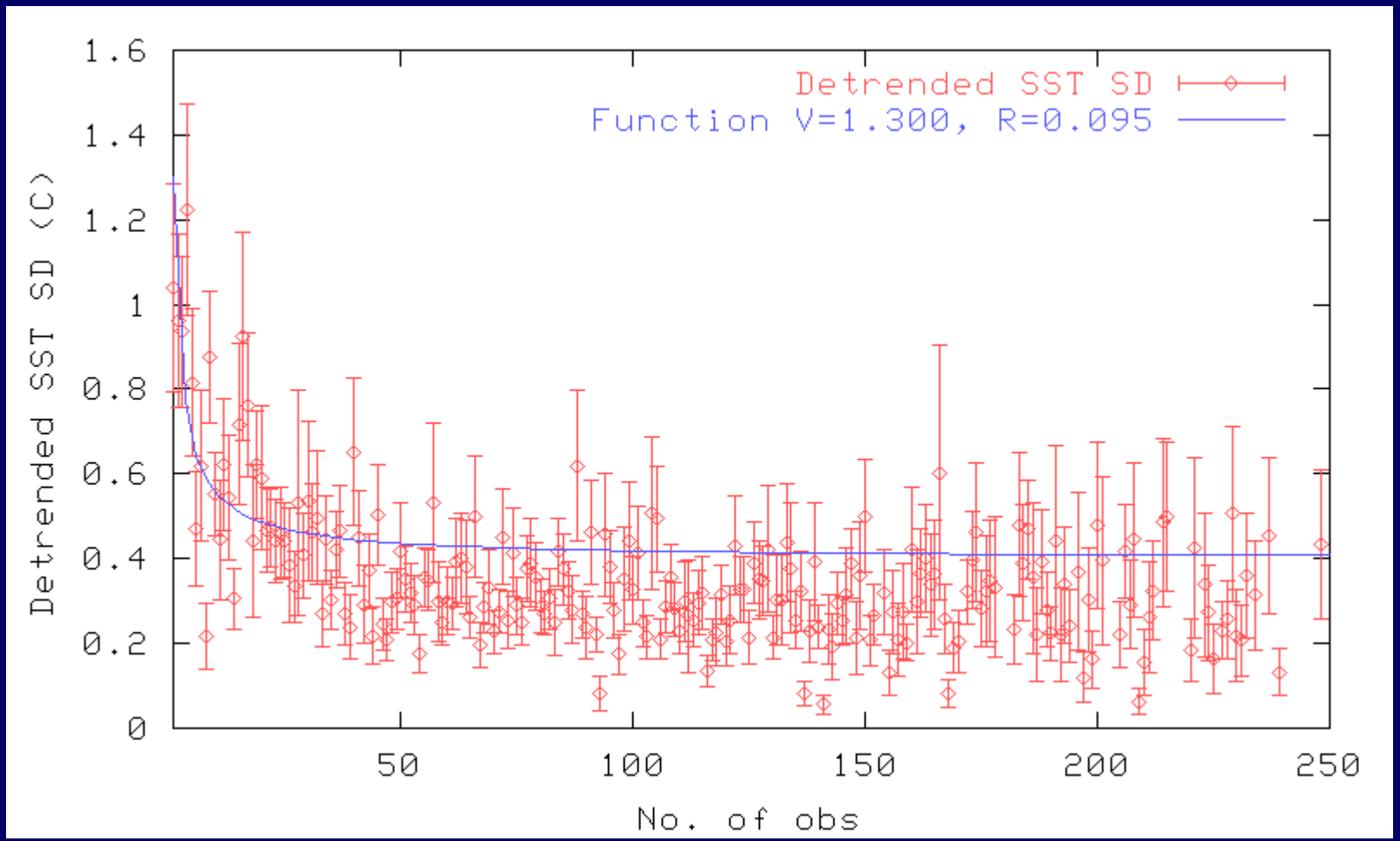
Fitting the formula to our test grid box [30-35W,0-5S]



$\overline{v_i^2}$=1.30

$\overline{r}$=0.095

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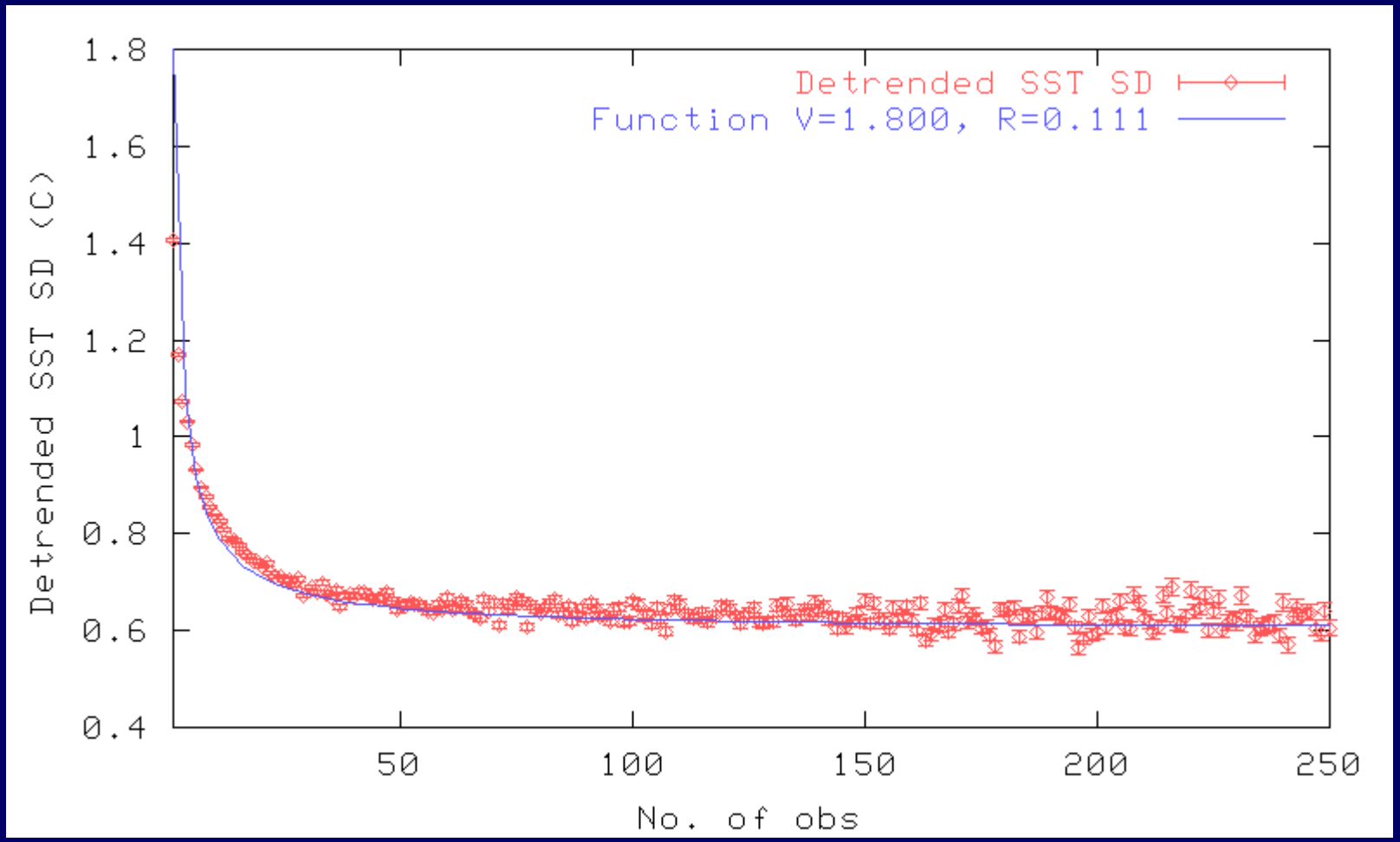
The fit is clearer if all data for the globe are used



$\overline{v_i^2}$=1.80

$\overline{r}$=0.11

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$v_i^2 = s^2 + m_i^2$

Partitioning the variance

- **The inter-month variance in each site time series comprises two parts:**
  - **variance common to the whole grid box, s^2**
  - **sub-grid-scale variability/measurement errors at the site, m_i^2**
- **Using $v_i^2 = s^2 + m_i^2$ and $r = \frac{s^2}{v_i^2}$, we solve for $\sqrt{m_i^2}$ and s**
- **Here s would be the rms error in the grid box average incurred if only one**

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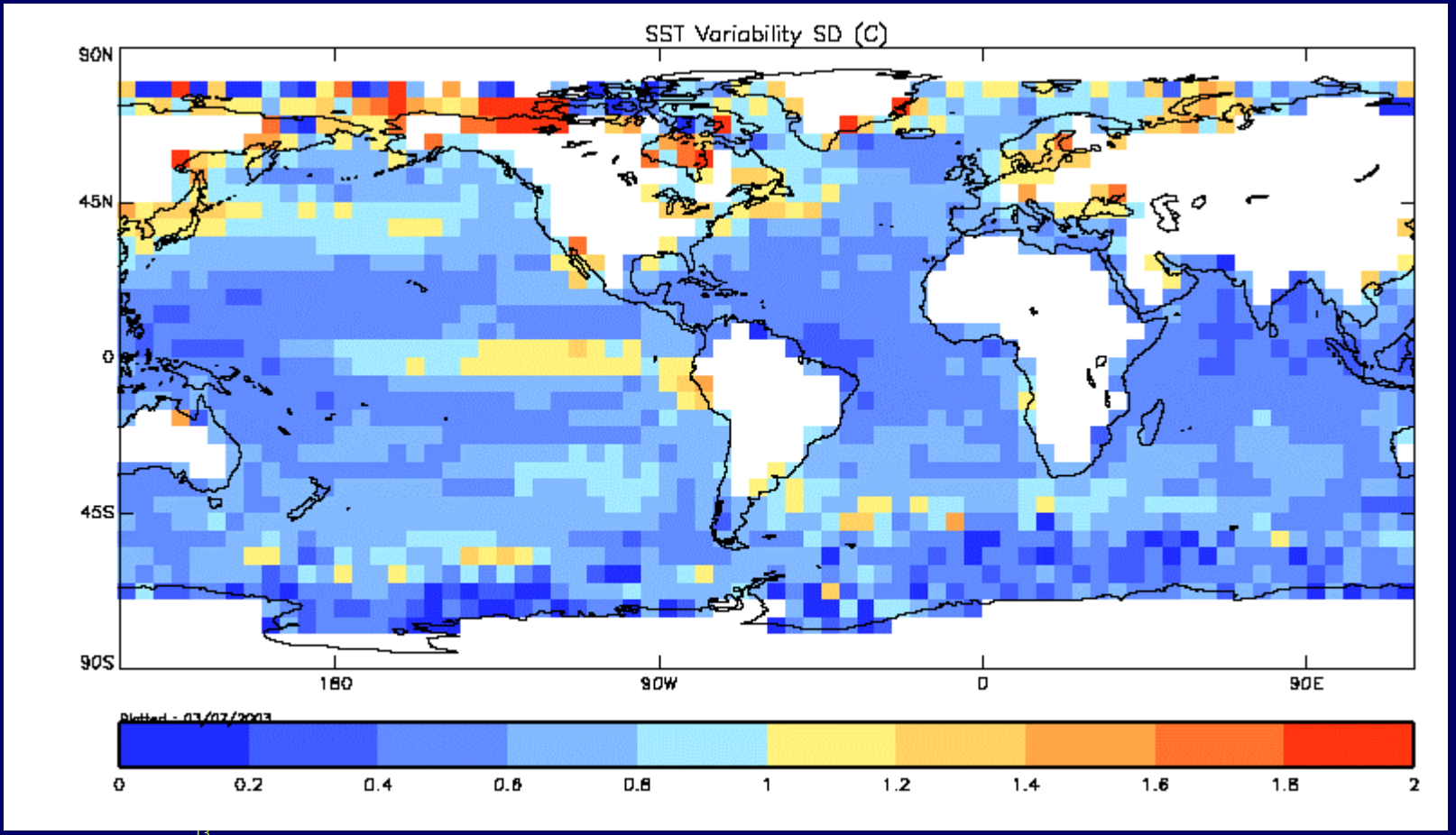
Grid-box-wide inter-month SST variability, *s*

standard deviation (°C)



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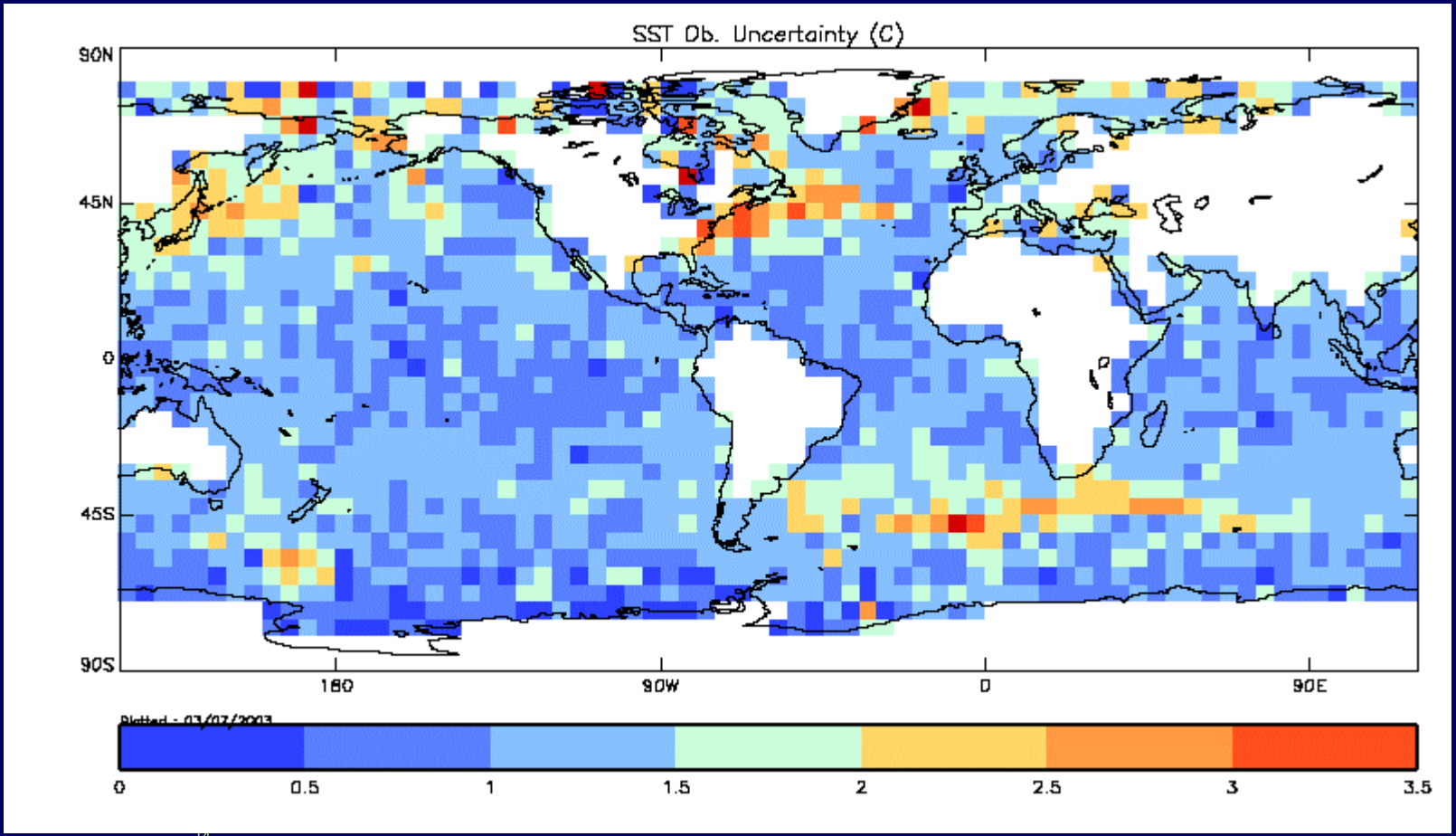
RMS sampling+measurement error if only one observation in monthly average (°C)



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Sampling + measurement errors for each month

- **Combining the rms error for one observation at each grid box with the number of observations used in each monthly grid-box average gives the combined uncertainty (1 s.e.) in the gridded average from measurement error and under-sampling**

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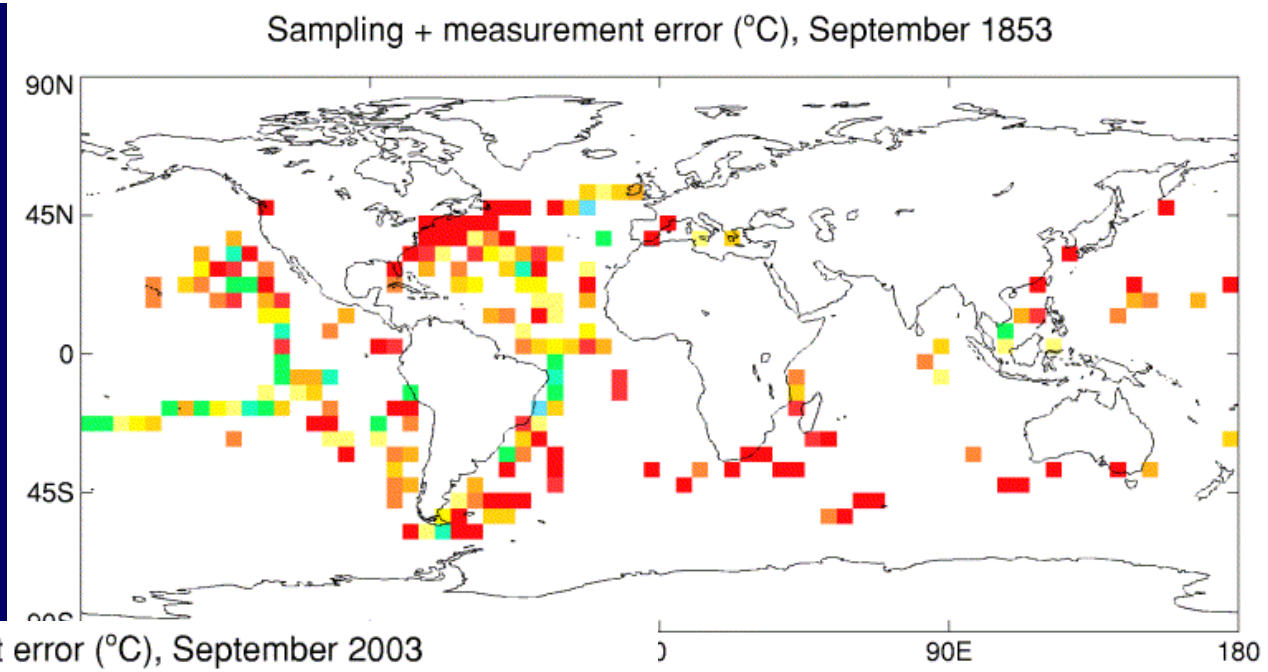
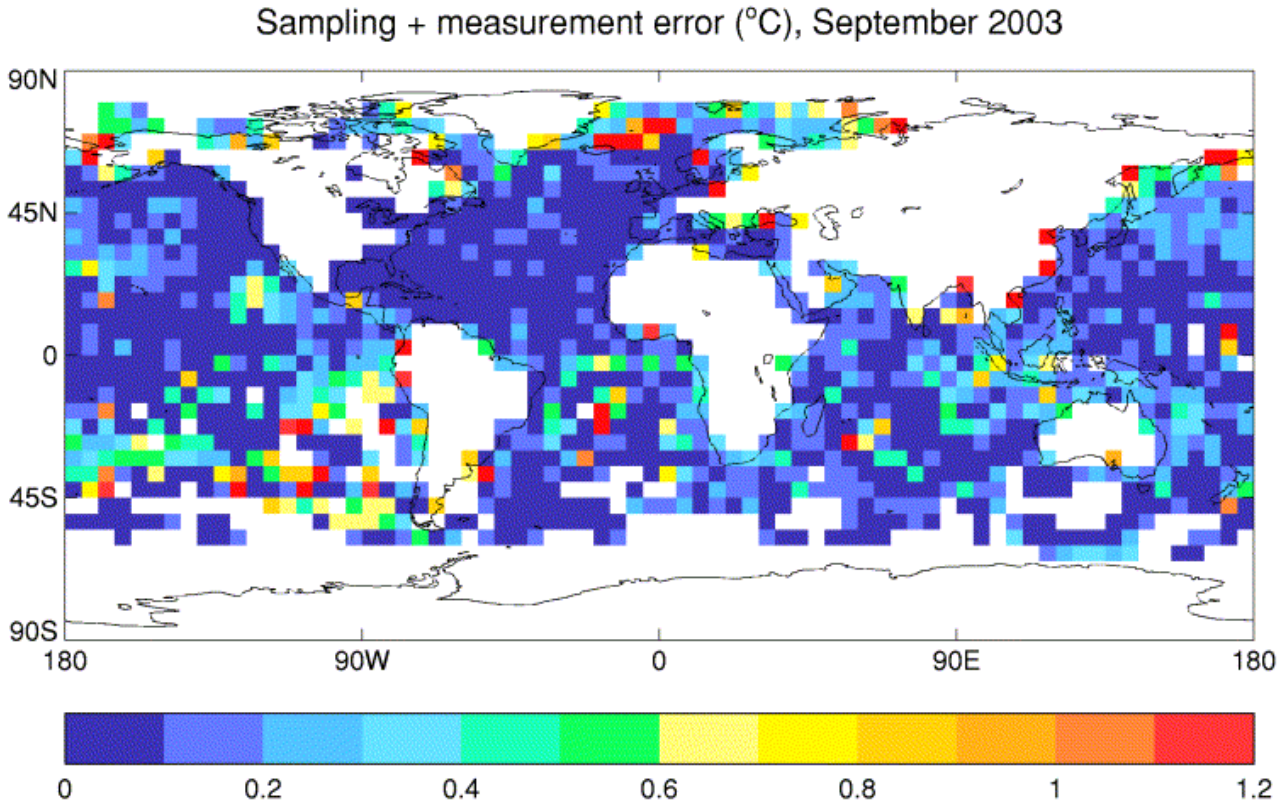
Examples of monthly measurement and sampling error





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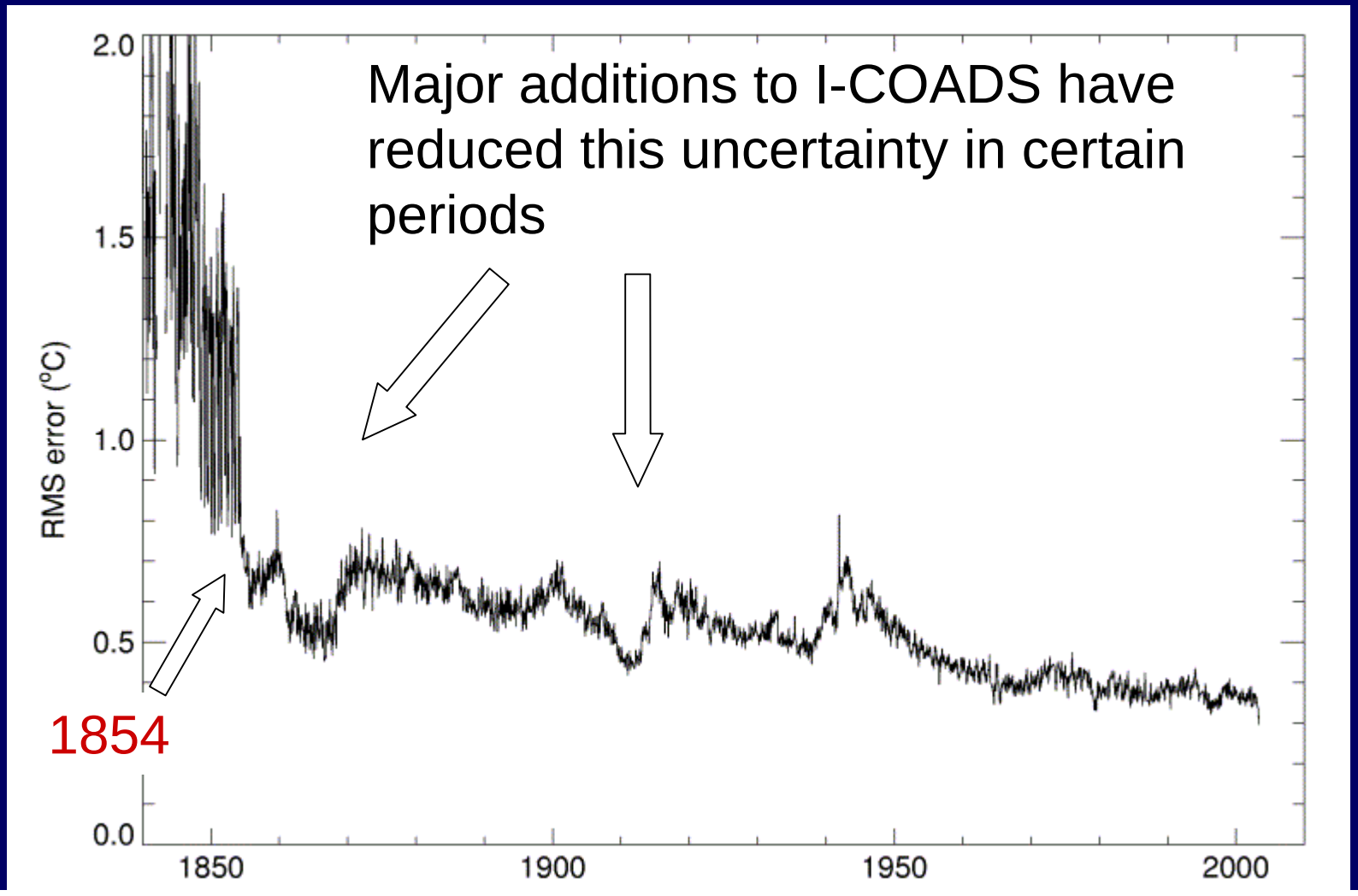
HadSST2 global rms sampling + measurement error (°C)

1840 - August 2003



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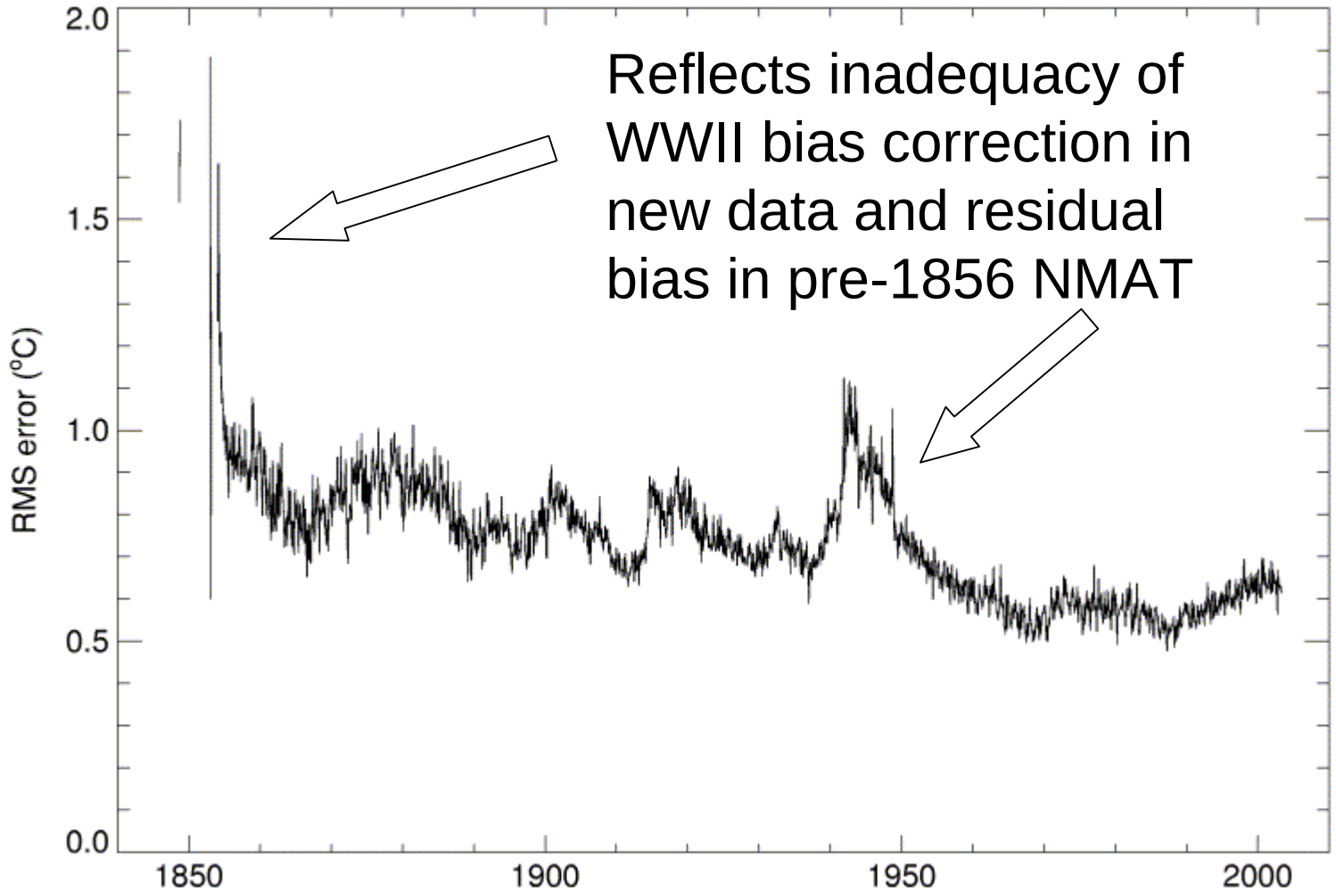

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Summary

- **Used relationship between detrended monthly gridded variance and the number and inter-correlation of constituent observations to infer "true" and "spurious" parts of grid box variance**
- **Dramatic reduction in this uncertainty is seen after the start of the coordination of the VOS following the 1853 Brussels Maritime Conference**
- **How does this relate to other uncertainties in the data? See next talk.**

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