Global Temperature Trends

Update 2011

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Questions

- Is the apparent warming trend statistically significant?

- Has the trend changed (perhaps reversed in late 1990s)?

Background

- Work first done in mid 2008

- Reported in Garnaut Review 2008

- Update early 2011, with 3 more years annual data

- Reported in Garnaut Update 2011

Data

- Three sources:

    - Climatic Research Unit, University of East Anglia, and the Hadley Centre of the UK Met Office
      (from 1850, deviations from average 1961-1990)

    - National Climatic Data Center of the US Department of Commerce
      (from 1880, deviations from average 1901-2000)

    - Goddard Institute for Space Studies at NASA
      (from 1880, deviations from average 1851-1990).

- Annual averages

- Temperature anomalies

- Land + ocean.

Hadley-CRU
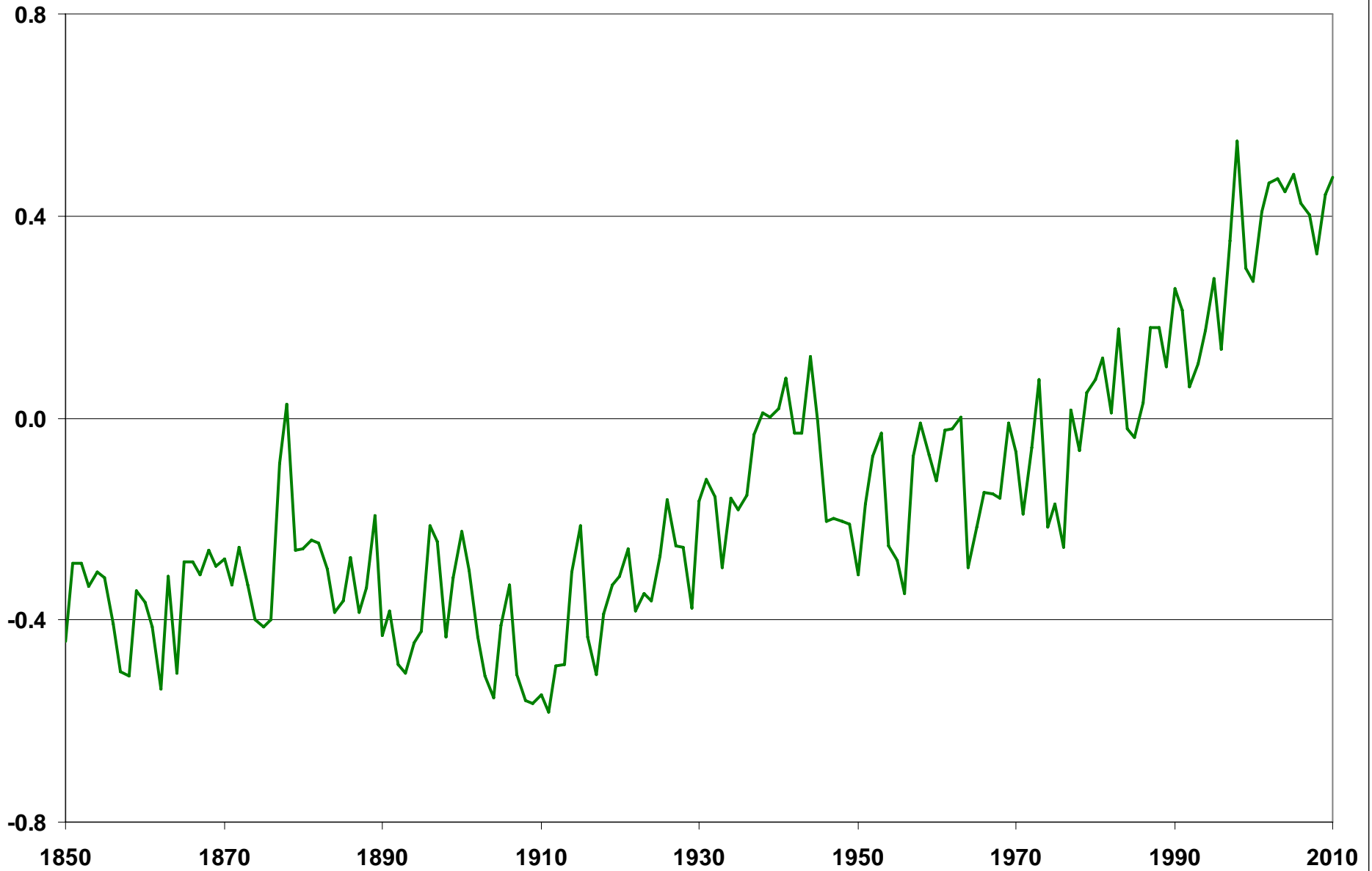
What is a warming trend?

- Systematic tendency to increase

- Obscured by variability, correlation, persistence

- Is the trend statistically significant?

- Persistence is a particular problem:

    - Trend is like a cycle with infinite period

   - Hard to distinguish persistence from trend with short data.

Information not used

- Climate science

- Theories of global warming/cooling

- Fossil or geological records, etc.

- "Expert" selections of particular data points or sub-periods.

Initial answer – simple linear trend

- Automated time series modeling around a linear trend:

    - Allows for variability and correlation.

- Technical details:

    - Initial AR model to whiten residuals

    - Automatic search over all AR and MA simplifications

    - Schwarz BIC for selection

    - Diagnostic tests for dynamics, normality and linearity.

- Findings:

    - Trend approx. 0.7 °C per century from 1880

    - Warming trend is highly statistically significant

    - But evidence of high persistence.

ncdc and linear trend
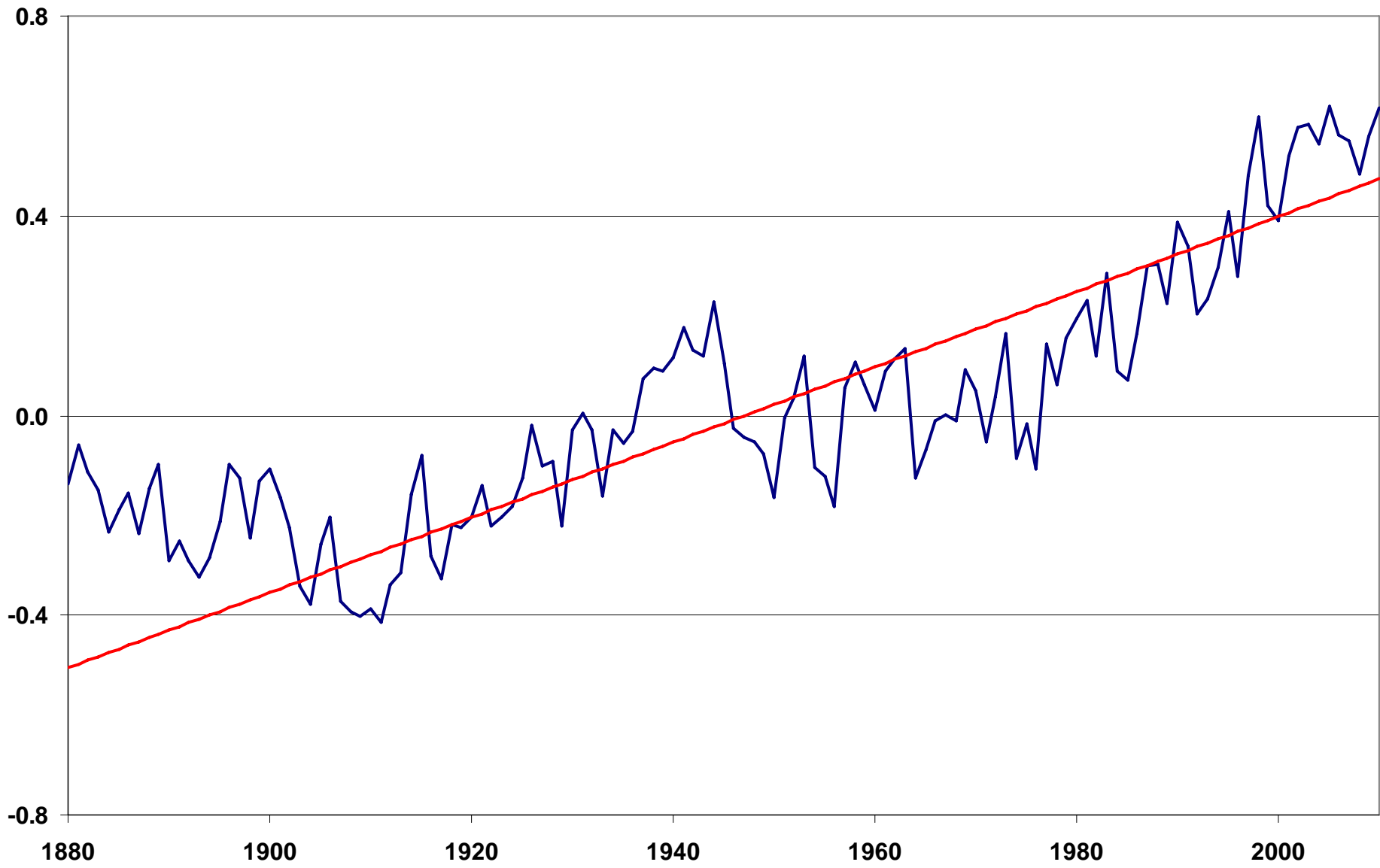
High persistence

- Seen in the wandering around the trend

- With high persistence, standard methods will:
    - Over state significance of trend
    - Under state the degree of persistence

- Find conflicting evidence on random walk component

- Adopt the extreme case (rw, unit root). Findings:
    - Trend is slightly less (0.6°C per century)
   - Warming is statistically significant

=> There is a warming trend.

- Caution: rw with no trend is not stability:
    - Not tendency to "normal".

Changes in trend

- Has the trend changed, (perhaps reversed since the hot year 1998)?

- Search for breaks in trend and test statistical significance, both with and without assuming rw

- Need to adjust apparent significance levels for search, otherwise a form of cherry-picking

- Findings:

    - Most notable break point is in mid-1970s

    - Next best candidate for a single break is 1909-1913

    - Only 1970s break is statistically significant

   - *Nothing* indicates a break around 1998.

ncdc and broken trend
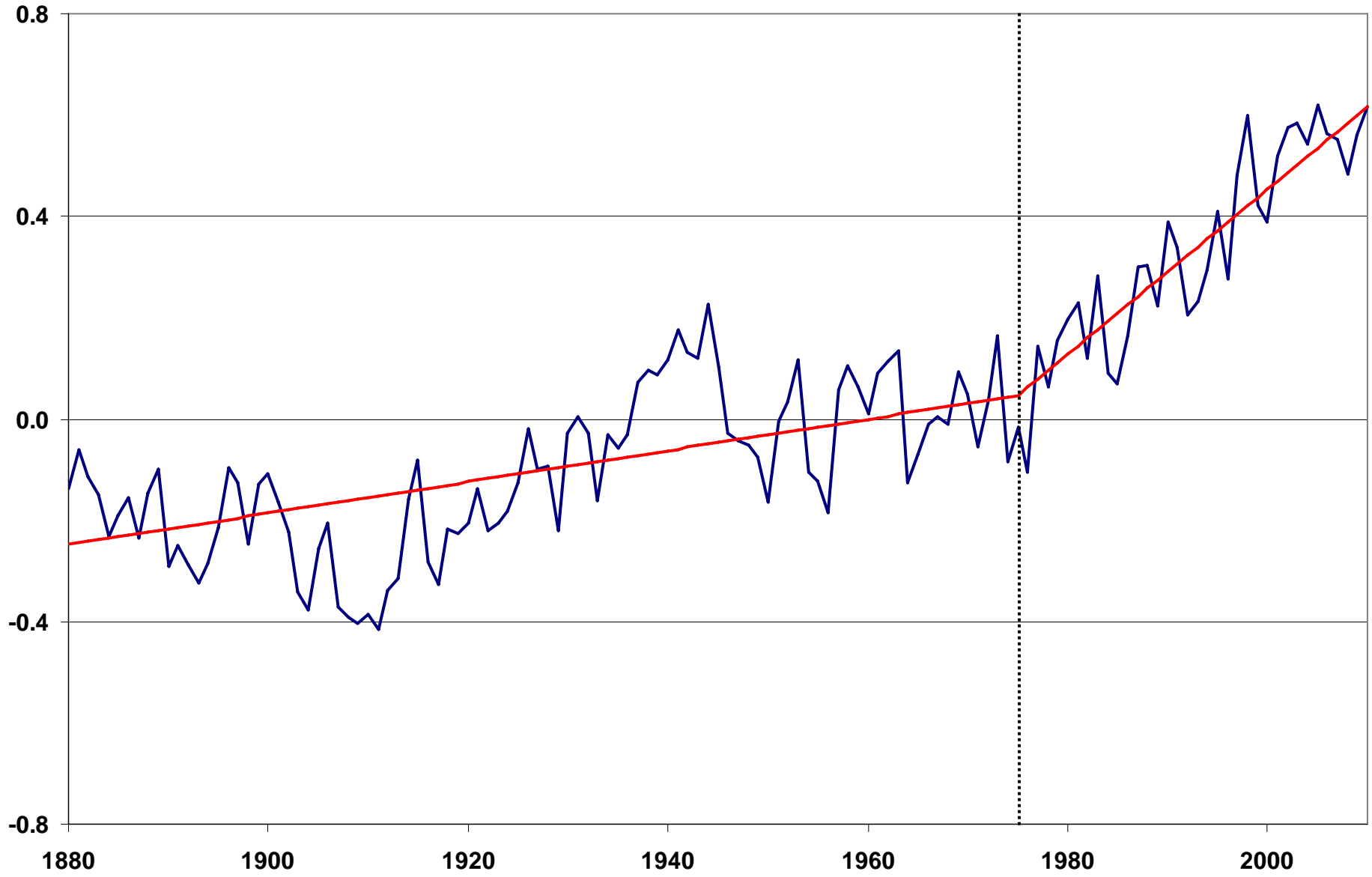
Alternative approach

- Consider analyst 30, 40, 50 years ago, who believes in random walk but not a warming trend

  - Cannot reject these assumptions

- Would the recent temperatures be a surprise?

- Forecast confidence bands are wide, because of the wandering allowed by the rw component and the long 30-50 year forecast horizons

- Find that most of the last 10 years of data lie above even these wide confidence bounds

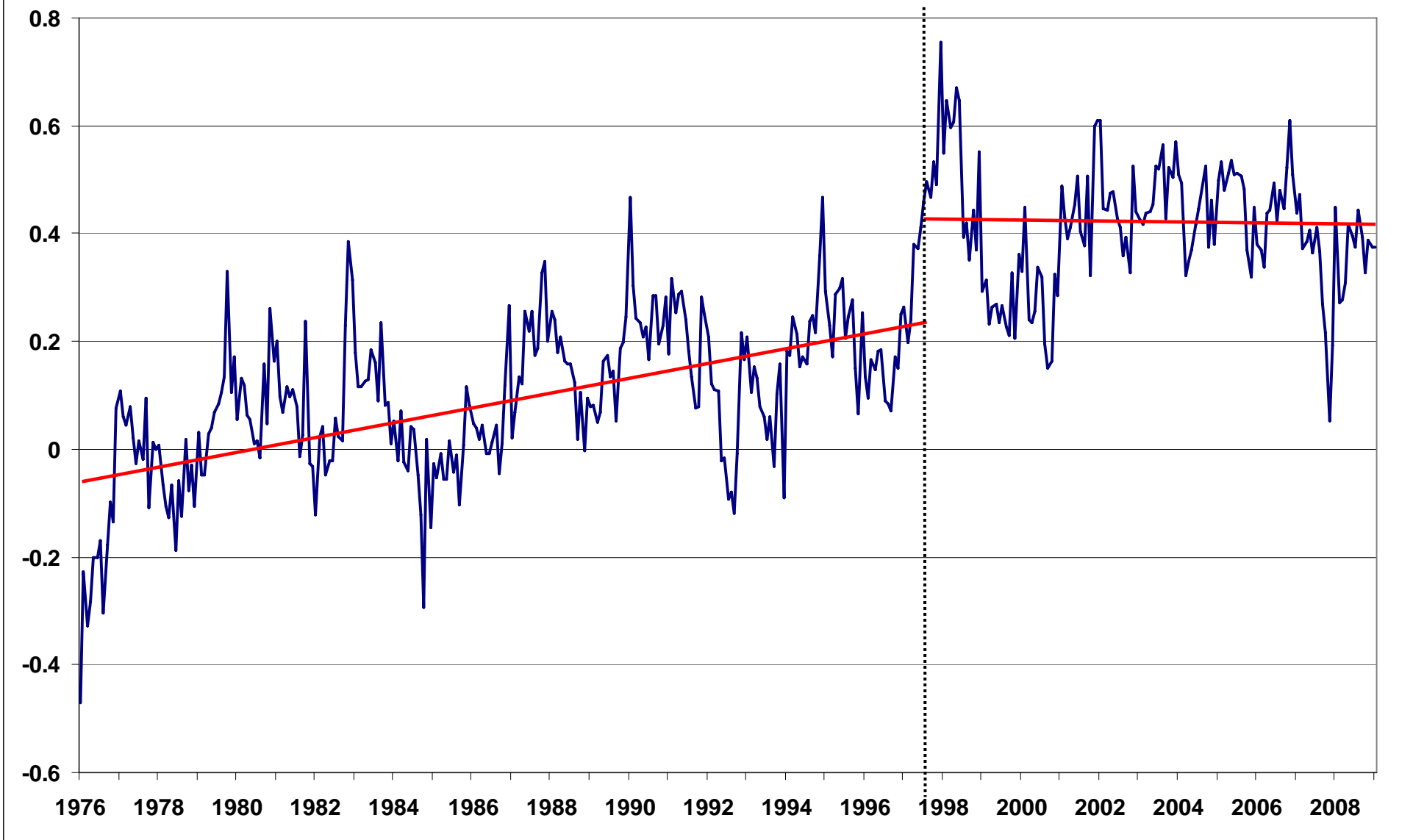=> There is a warming trend. No indication of trend reversal.

ncdc and forecasts from 1960
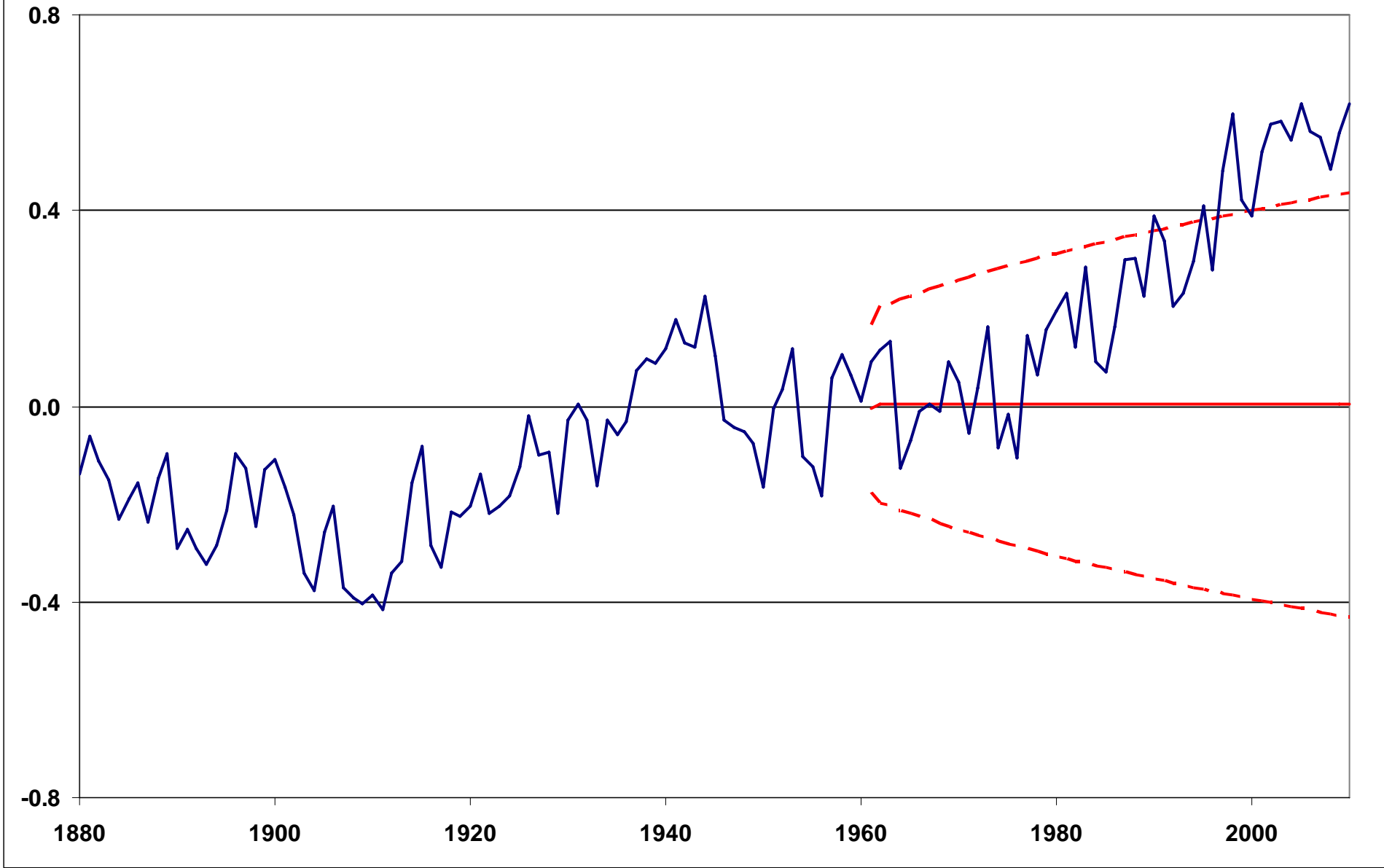
How to find that warming stopped in 1998

- Use Hadley-CRU data

- Use monthly data from mid-1970s

- Allow break in trend *and level*

  - Ignore the level shift as a one-off

- Ignore correlation when assessing significance

- Ignore cherry picking when assessing significance

- Find a break in 1997/1998

  - Large and significant if you choose data and period wisely and you ignore corrections to statistical significance

=> Conclude warming ceased in 1998.

HadCRU3GL monthly: broken trend and level

ncdc and trend break in 1998