

Global Warming 2002

Climate Record 1: Instrument Records

March 27, 2002

April 22, 2002

Today

- Move to the past - now getting to Geology
- Consider the construction of a global temperature curve
- For two reasons
 - See the results - global surface temperatures have increased 0.4 to 0.8° c in last 150 years
 - See how efforts were made to reduce the unknowns with this

Concept of Error

- Fundamental Issue in Science
 - How to be sure of something?
- Any measurement has some noise
 - System variability
 - Instrument
- Adding several measurement or different kinds of measurements has some noise
- Signal / Noise Ratio
- Must have $S/N > 1$

How to Reduce Error

- Take Better Measurements
 - Change Proxy - New Techniques
- Take More Measurements
 - More and more being added all the time
 - But at some point only adding detail
- For Time Series - Smooth the data

Getting a Curve

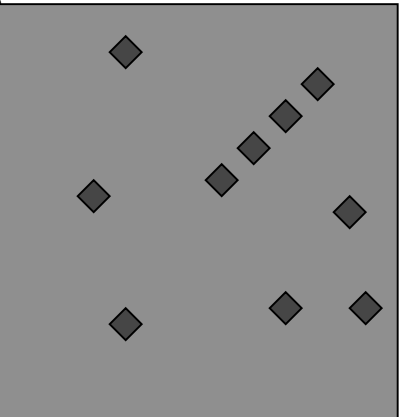
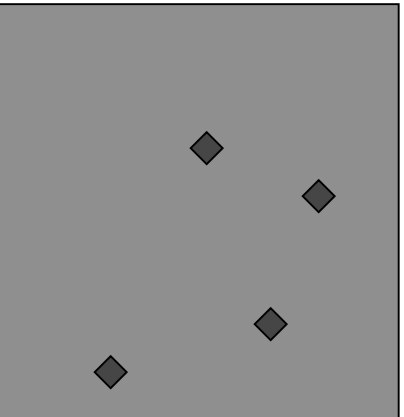
- Start with all weather stations
- Consider the daily temperature
 - Take maximum and minimum get sum / 2
- Consider the yearly temperature
 - Sum up all the daily values
- Consider a baseline - 1961-1990
- Is it really that simple?

Three Examples

- Land Average - Heat Island Effect
- Land vs. Sea
- Surface vs. Upper Atmosphere

Station Density

- What to do here?



April 22, 2002

□ Spatial

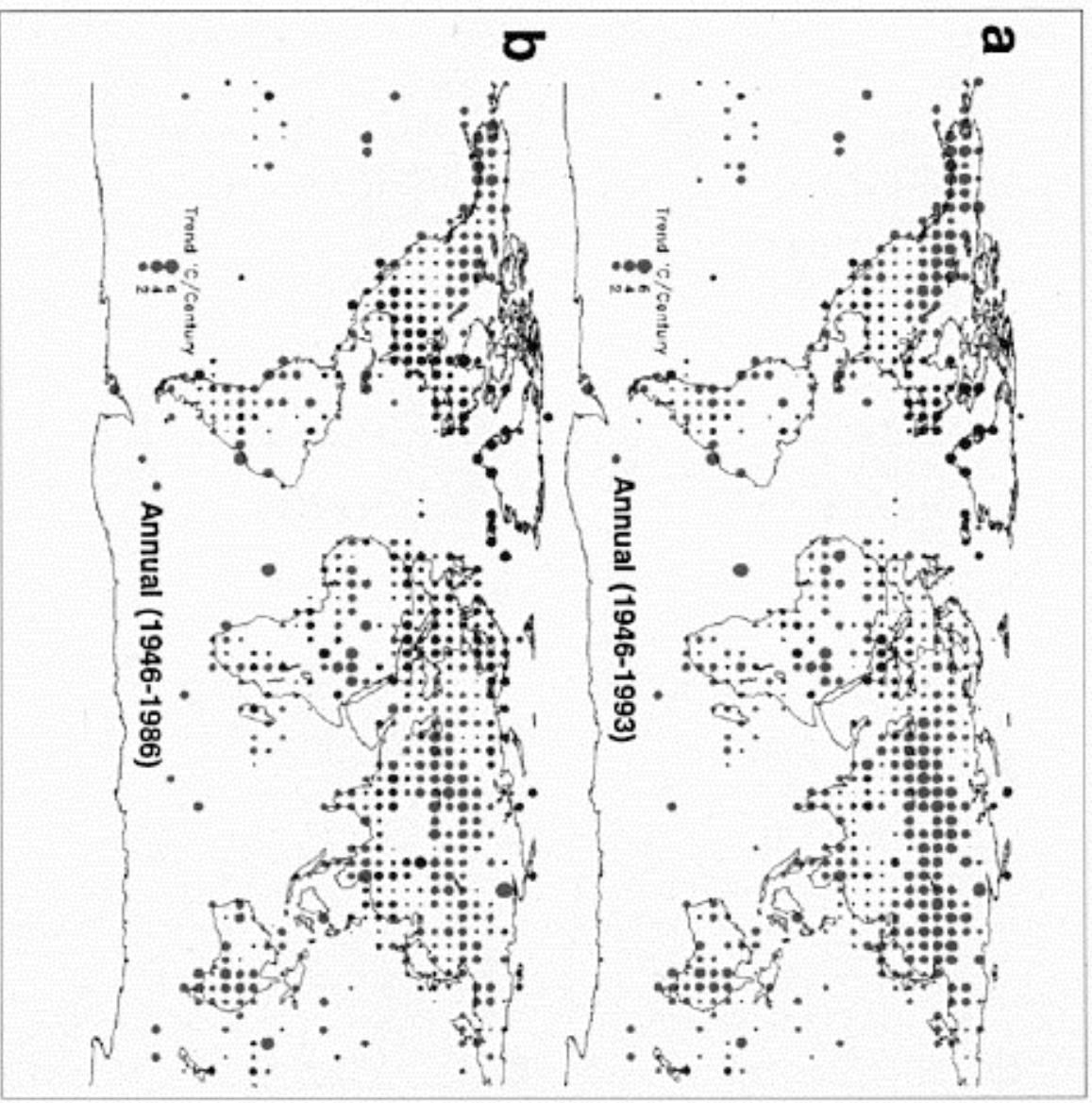
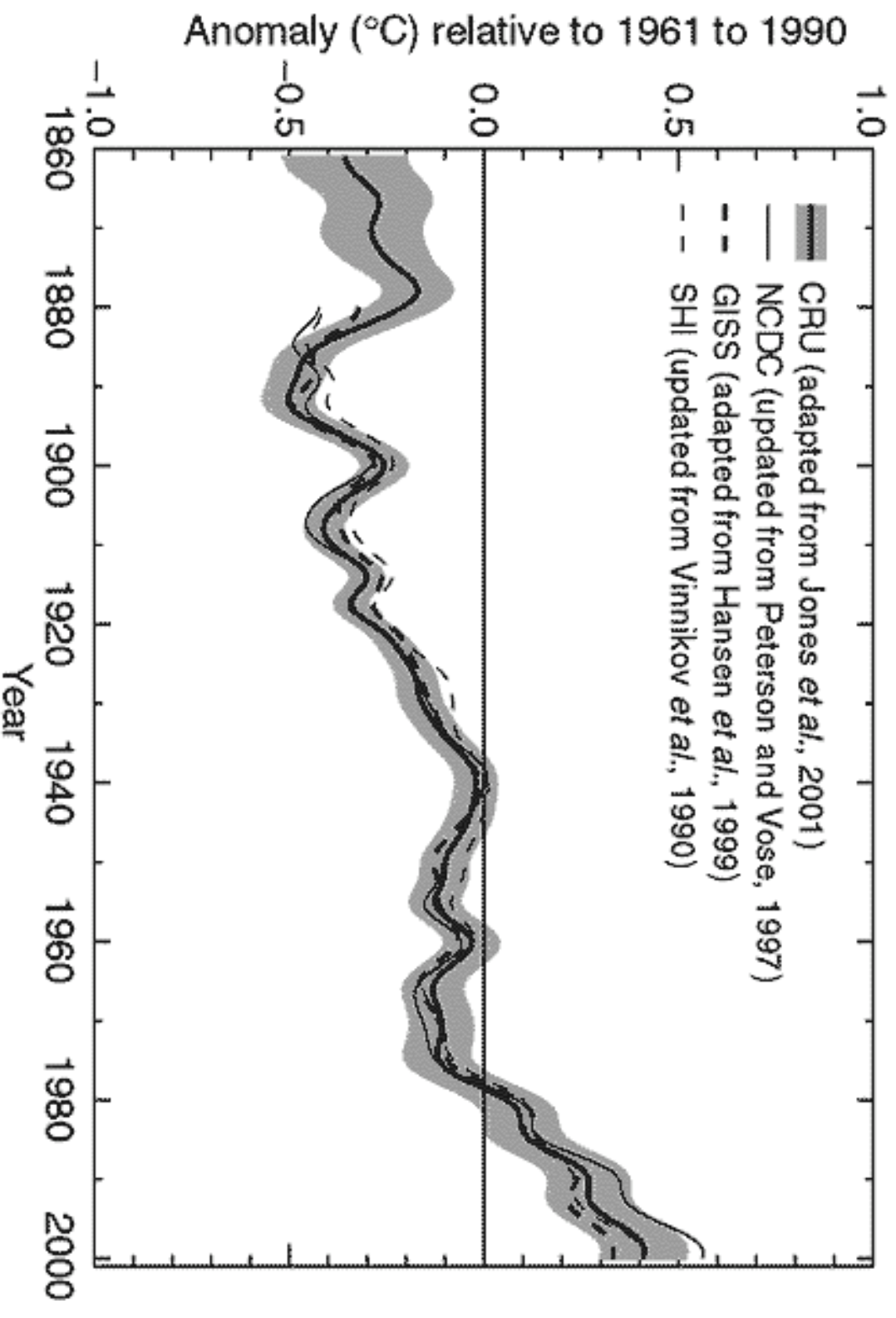


Plate 19.1 Linear temperature trends represented by the circle within each 5° x 5° land-based grid cell: (a) annual 1946–1993, (b) annual 1946–1986. Red circles represent positive trends; blue circles negative trends; and size of dot represents magnitude of trend.

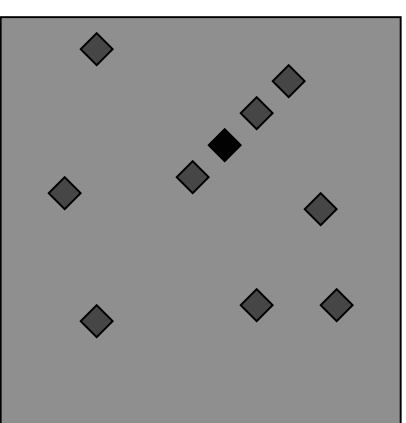
Time Series to show trend

(b) Globe



One question Urban Heat Island

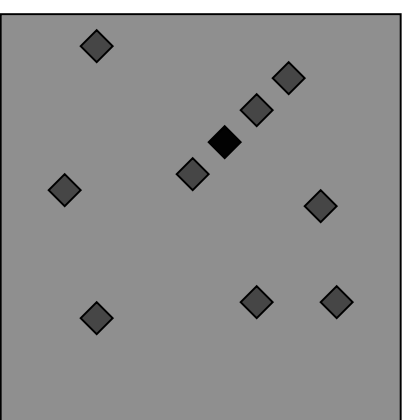
- Man-made structures have different heat capacity than natural topography
- So if weather station near these reflect urban build up not “natural trend”



Estimate Uncertainty

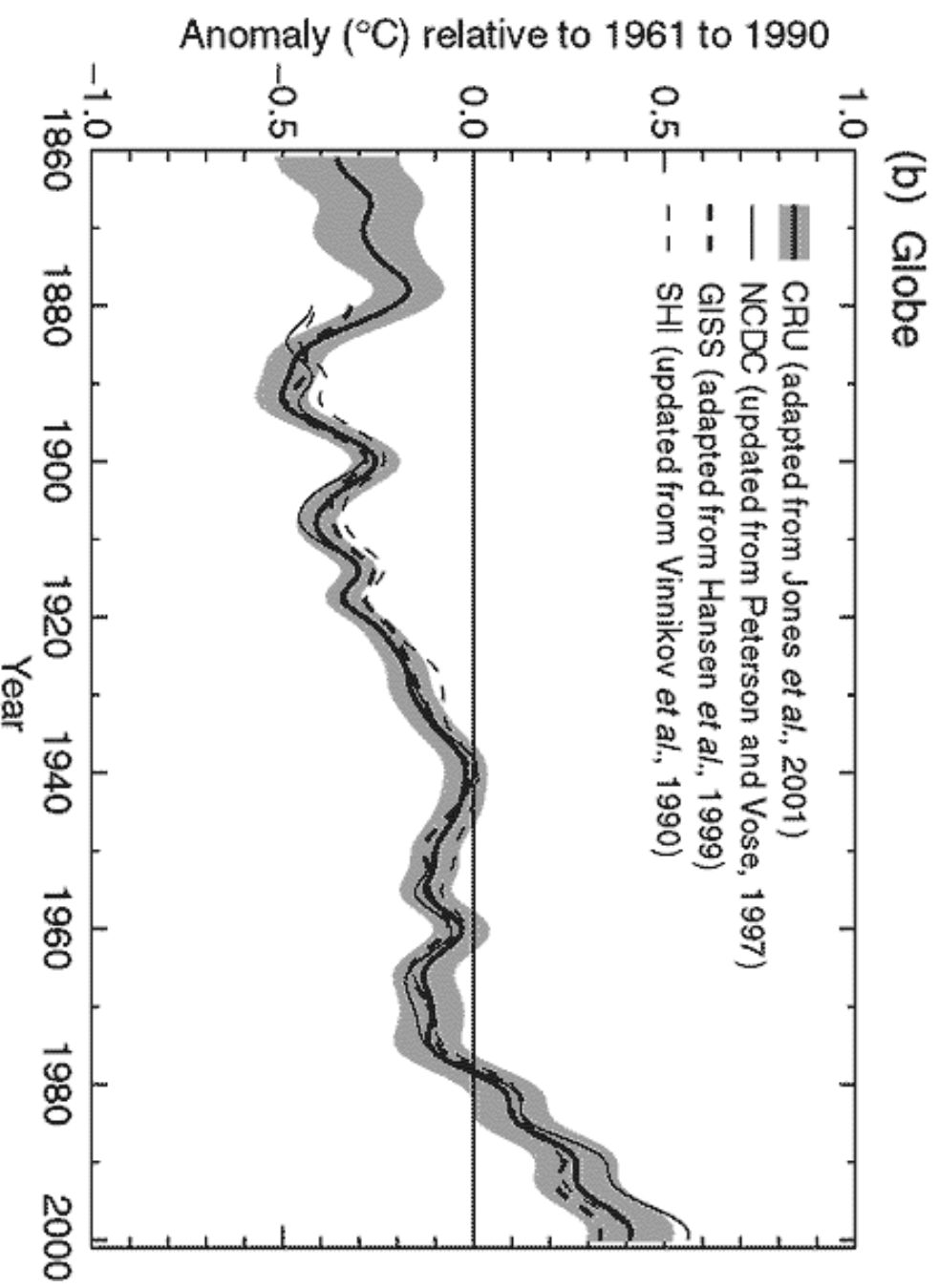
- If larger than signal then - work to reduce
- If small than signal then - move on
- Signal vs. Noise
- Main trend vs. underlying variations
 - resulting from erratic system behavior or measurement issues

How?



April 22, 2002

Plot the
uncertainty
along with
the trend

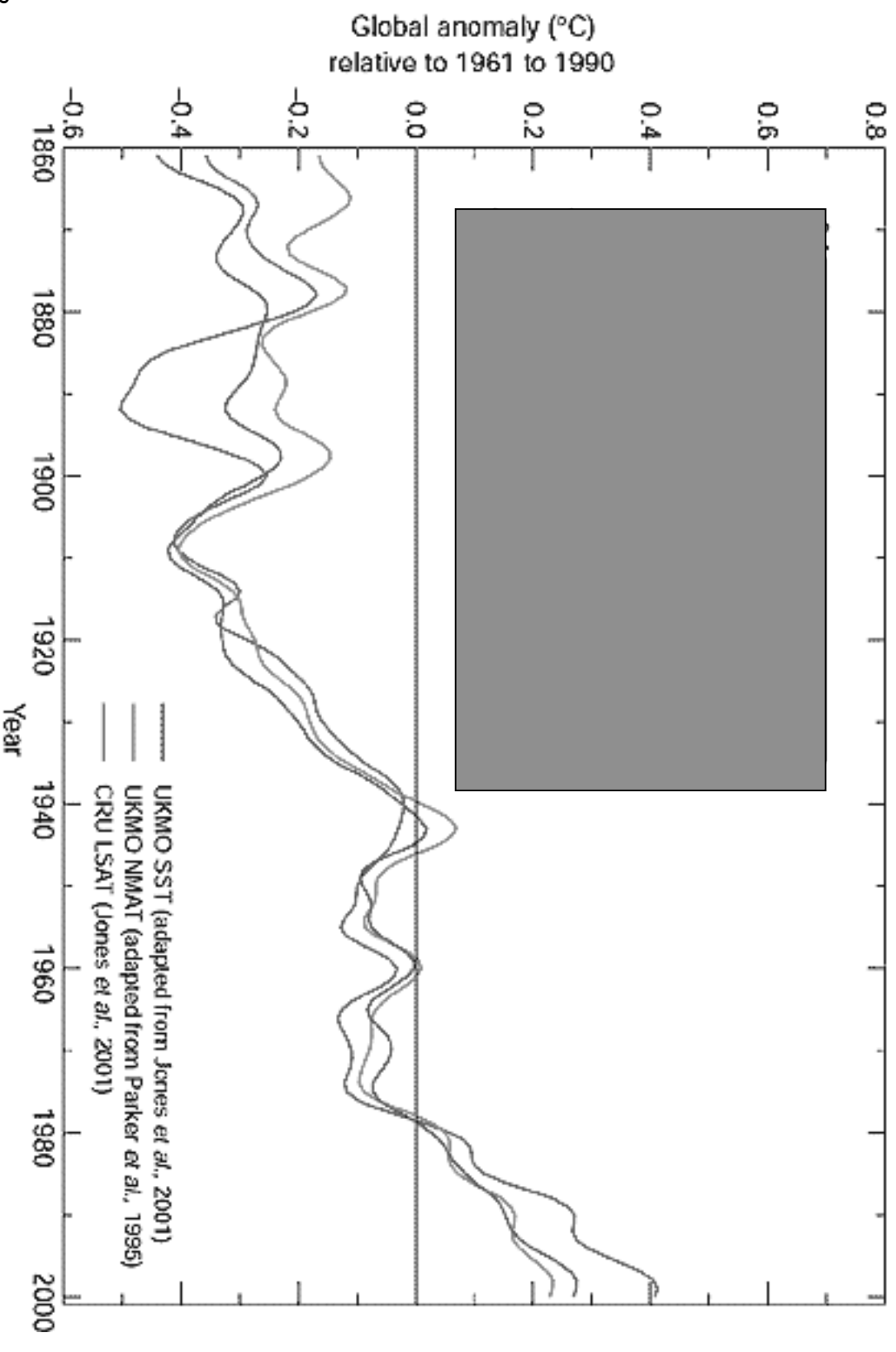


These results confirm the conclusions of Jones *et al.* (1990) and Easterling *et al.* (1997) that urban effects on 20th century globally and hemispherically averaged land air temperature time-series do not exceed about 0.05°C over the period 1900 to 1990...

Next

- But the world is 78% and very few stations there
- Ships move across - take measurements
 - Wood bucket
- Smooth by 21 point
- 3 estimates

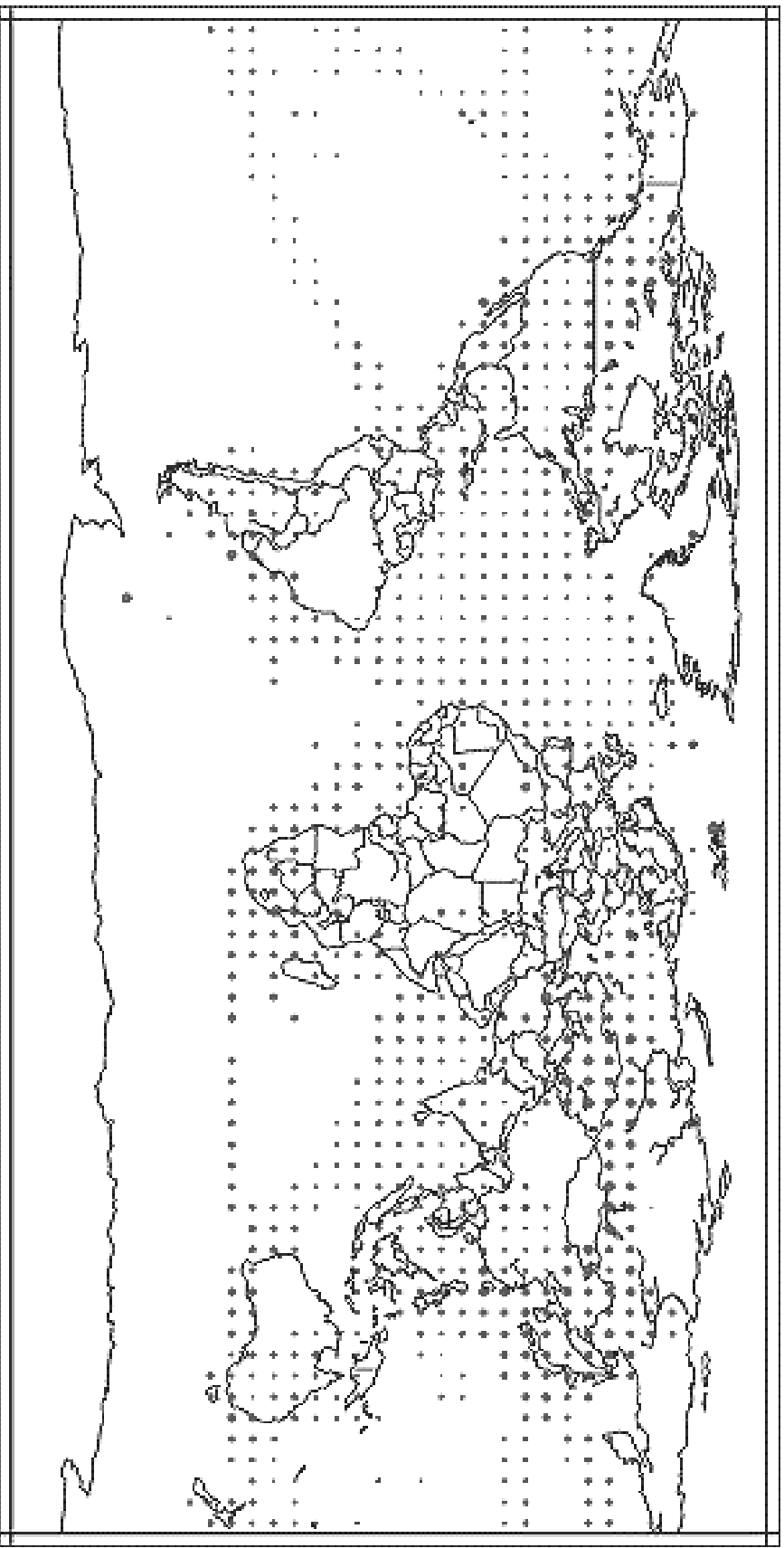
Sea Surface Temperature



April 22, 2002

Overall Grid Results

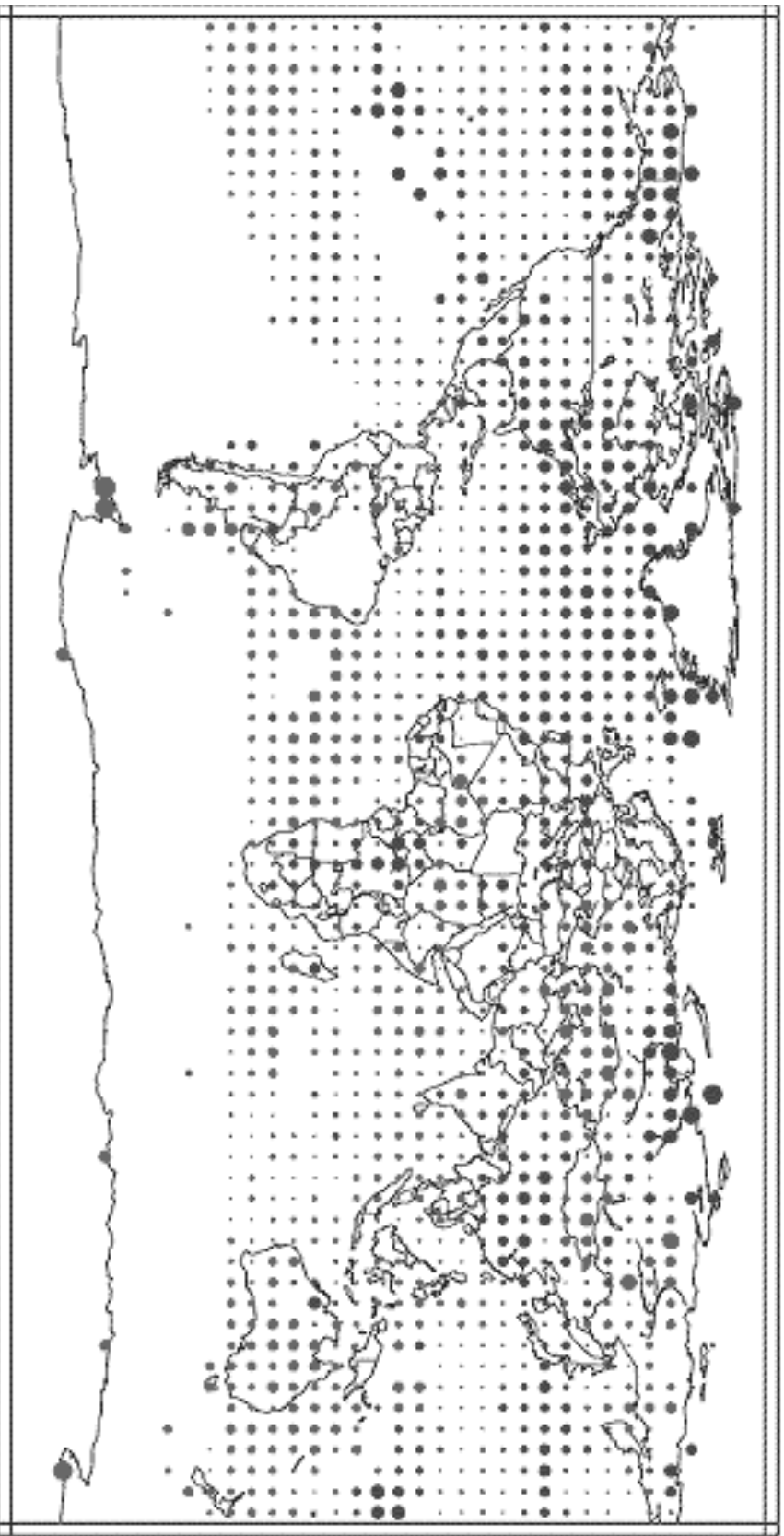
(a) Annual temperature trends, 1901 to 2000



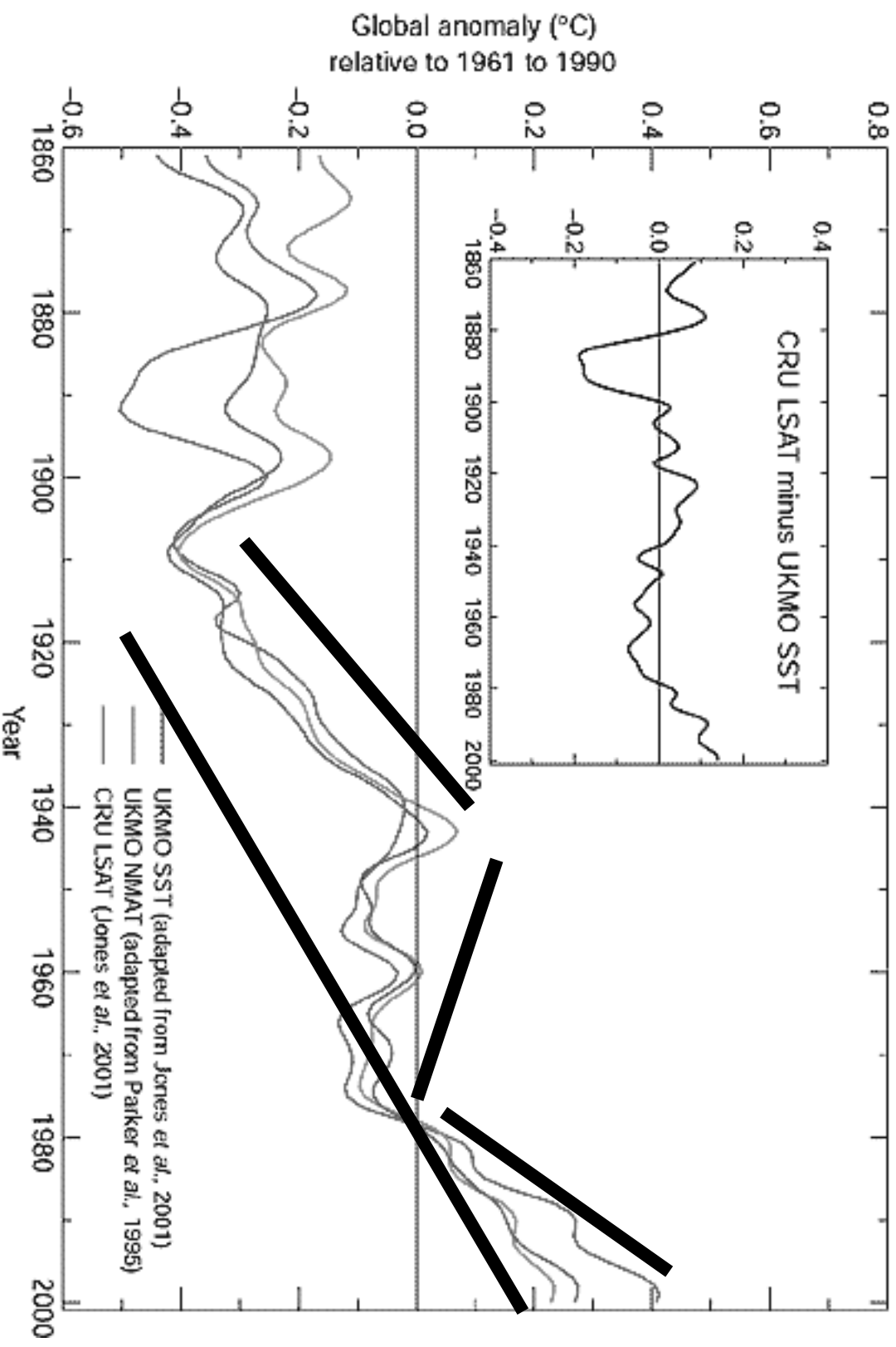
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At a Different Time

(c) Annual temperature trends, 1946 to 1975



Long term vs. Short Term

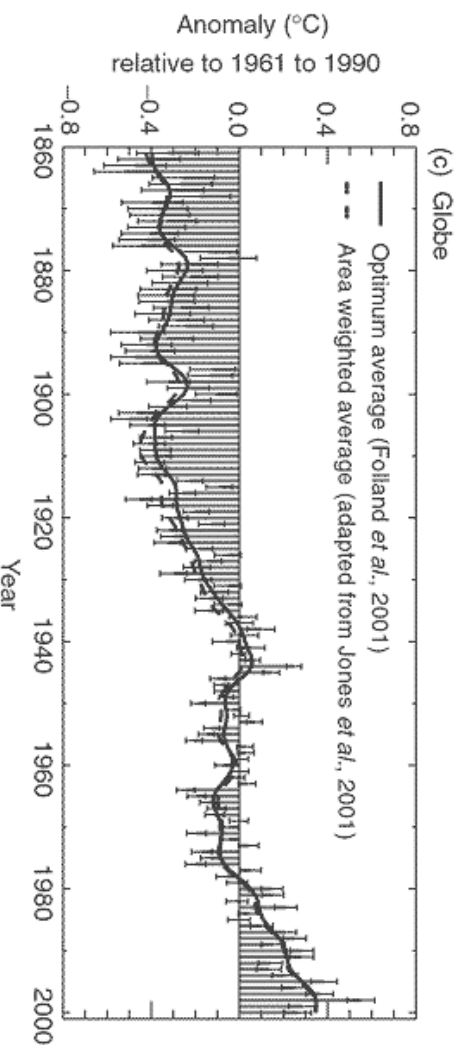
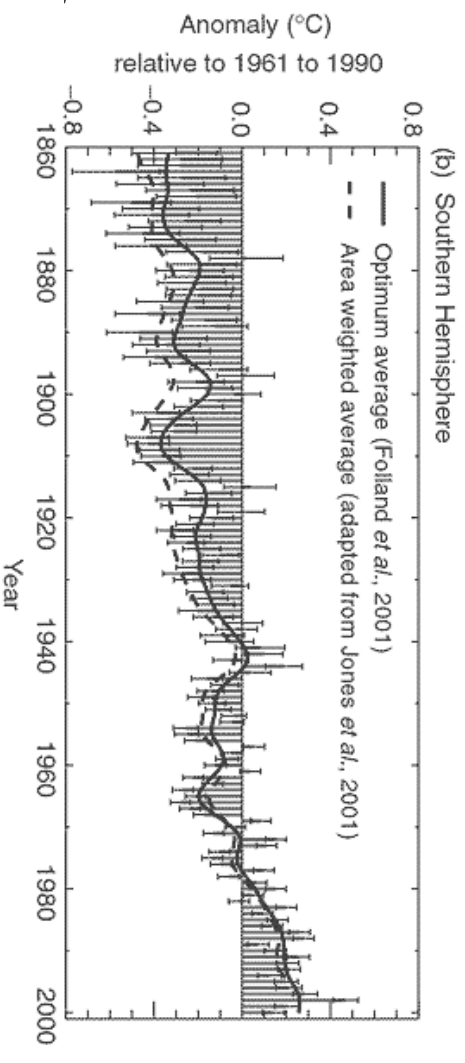
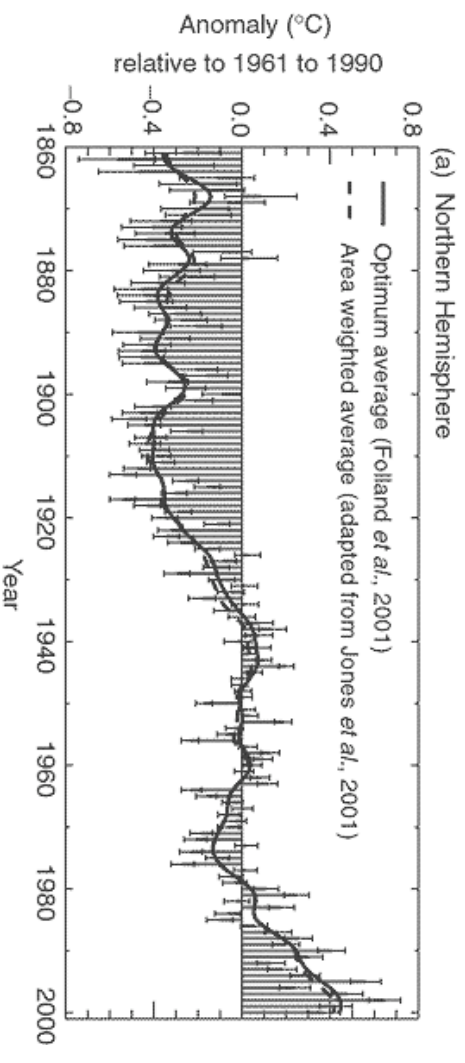


April 22, 2002

Put It Together

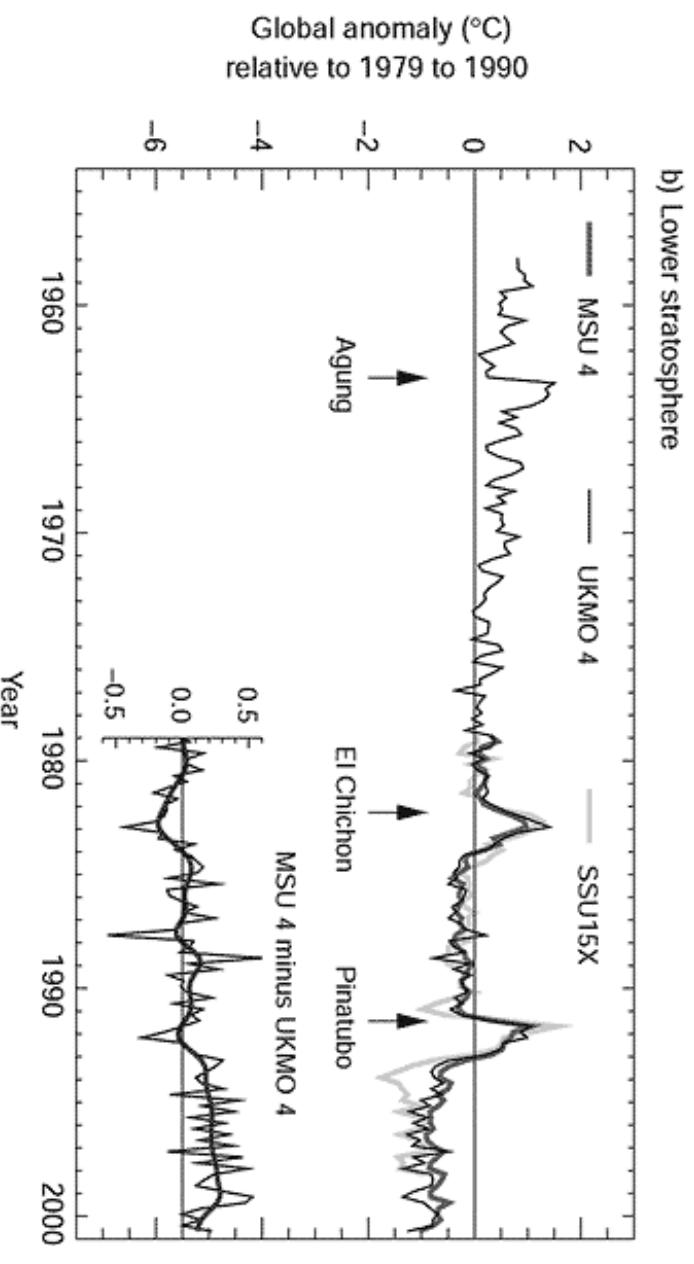
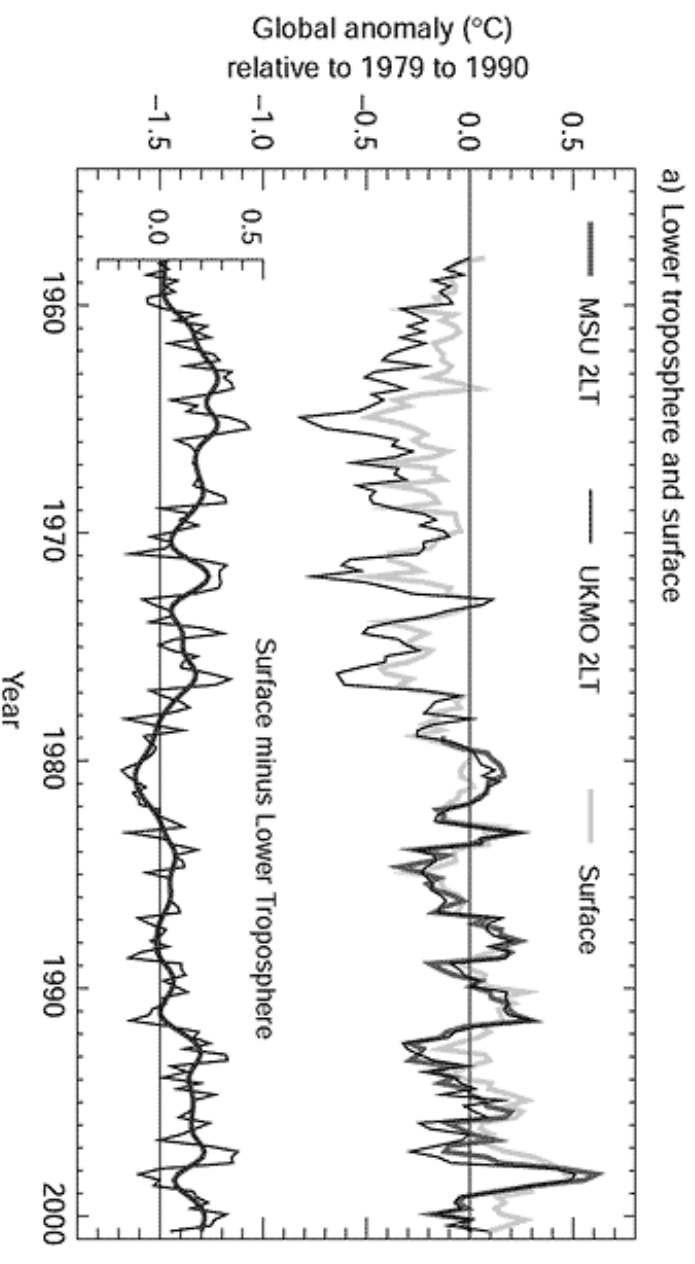
That all these different approaches/ combined data sets show very similar patterns

A strong argument they are real



Next Issue

- Take remote emissions
- Excellent spatial coverage
- Much shorter temporal coverage
- Tracks behavior above the surface



Less Warming

- This is about 0.12°C/decade less than the rate of temperature increase near the surface since 1979. About half of this difference in warming rate is very likely to be due to the combination of differences in spatial coverage and the real physical affects of volcanoes and ENSO (Santer et al., 2000), see also Chapter 12. The remaining difference remains unexplained, but is likely to be real.

Wrap Up

- Global surface temperatures have increased between 0.4 and 0.8°C since the late 19th century, but most of this increase has occurred in two distinct periods, 1910 to 1945 and since 1976.
- However, there is some disagreement between warming rates in the various land and ocean-based data sets in the 1990s, though all agree on appreciable warming.
- Near surface and higher elevation needs more work
- Bottom line Scientific assessment that we have warmed up.