NOAA-NIST Meeting on Calibration for Climate Quality Time Series

Comparing MSU T2 Time Series with Ground-based Measurements

Bert W. Rust
Math. and Comp. Sci. Div.
NIST (Formerly NBS)
Gaithersburg, MD

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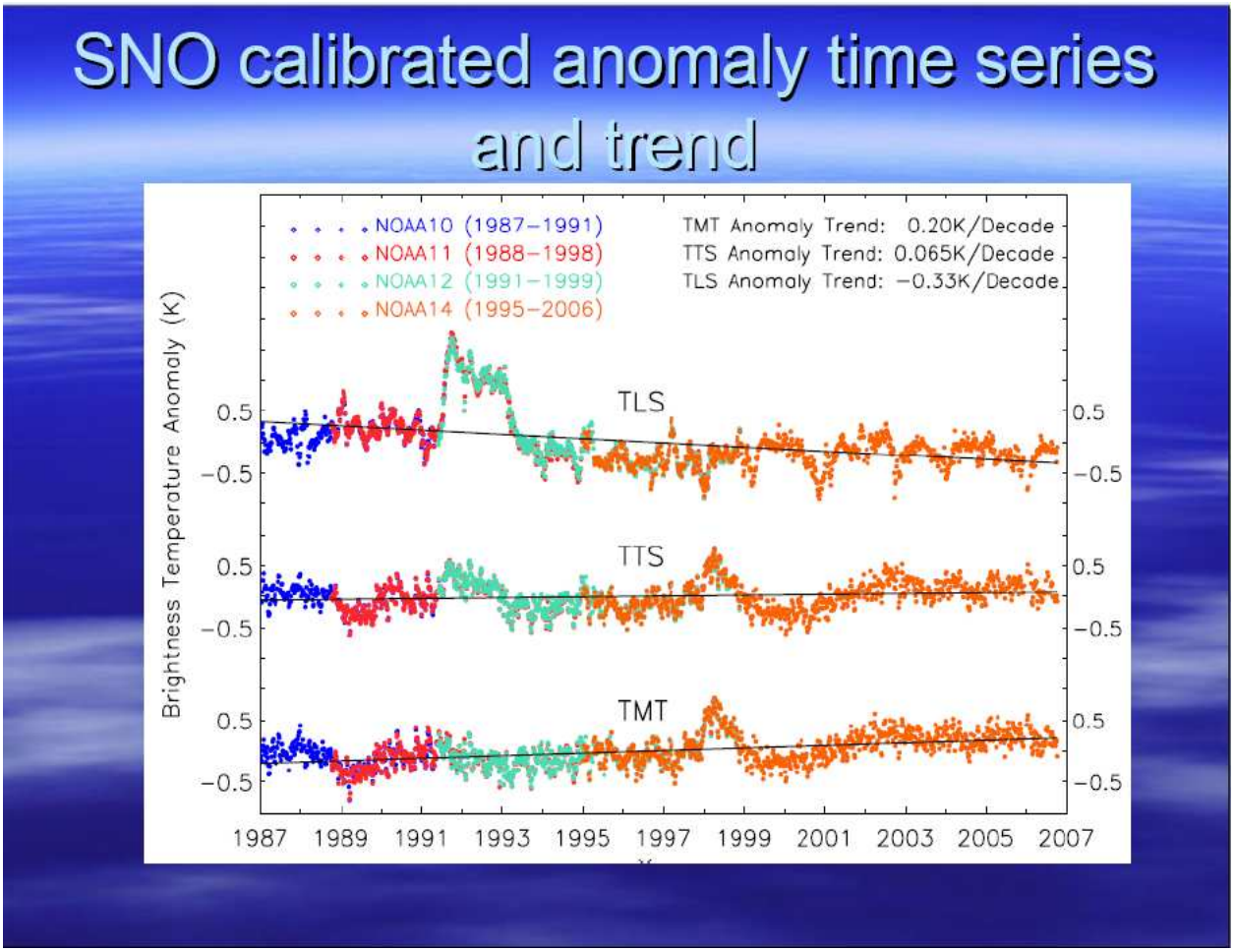
NOAA Science Center, Room 707
5200 Auth Road
Camp Springs, MD 20746

Slide No. 34 from

MSU Intercalibration for Climate Research Using Simultaneous Nadir Overpasses

Presented by Cheng-Zhi Zou

at NIST, September 19, 2007



This paper presents evidence that:

- The $T2$ time series contains the same signal as the two leading surface temperature records,

- The random scatter about that signal is greater for the $T2$ record than for the surface temperature records,

- The signal in all of these records contains significant departures from a simple straight line,

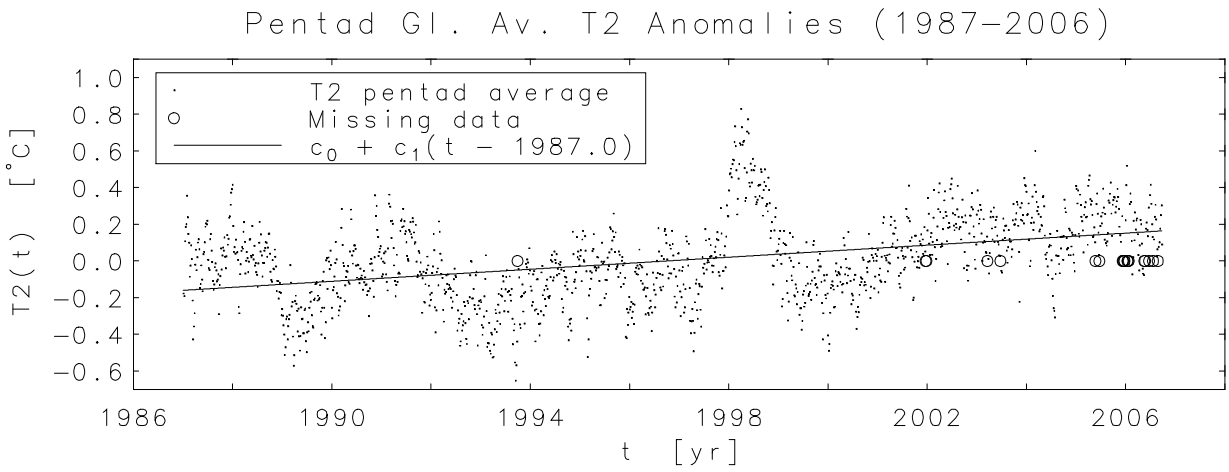
- One important component of those departures can be attributed to the El Nino cycle.

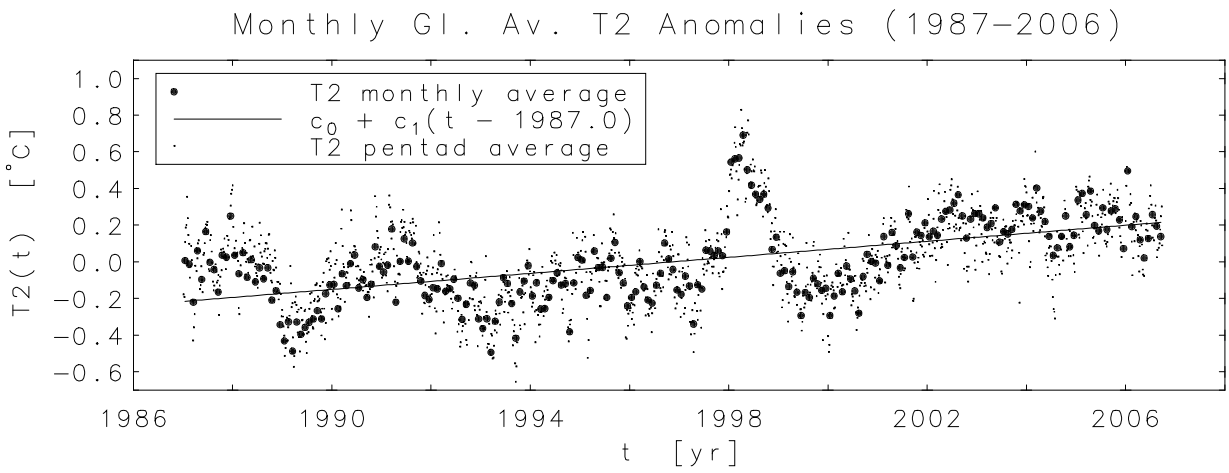
http://www.orbit.nesdis.noaa.gov/smcd/emb/mscat/mscatmain.htm

pentad data: tabulated on 144 X 72 X 1442 grid

area weighted averages: 19 missing values

$\widehat{c}_1 = 0.0164 \pm .0010$ $[^{\circ}C/yr]$





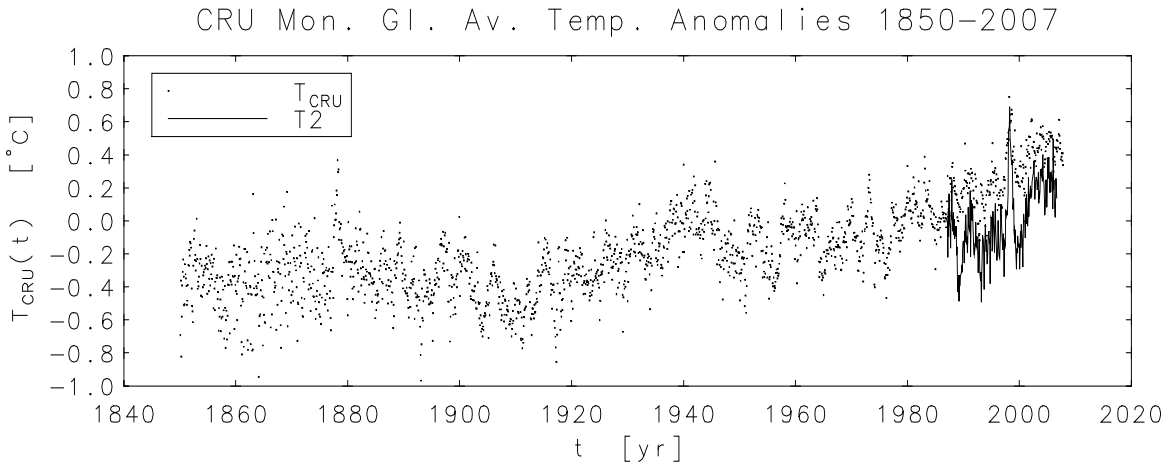
monthly data: tabulated on 144 X 72 X 237 grid

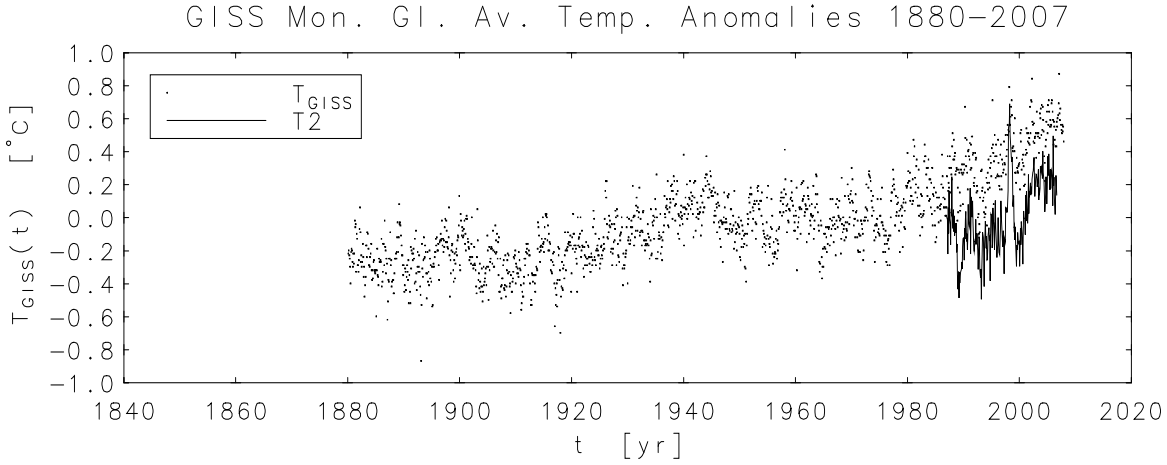
area weighted averages: no missing values

$\widehat{c}_1 = 0.0219 \pm .0020$ $[^{\circ}C/yr]$

CRU: Climatic Research Unit

http://www.cru.uea.ac.uk/cru/data/temperature/hadcrut3gl.txt





GISS: Goddard Institute for Space Studies

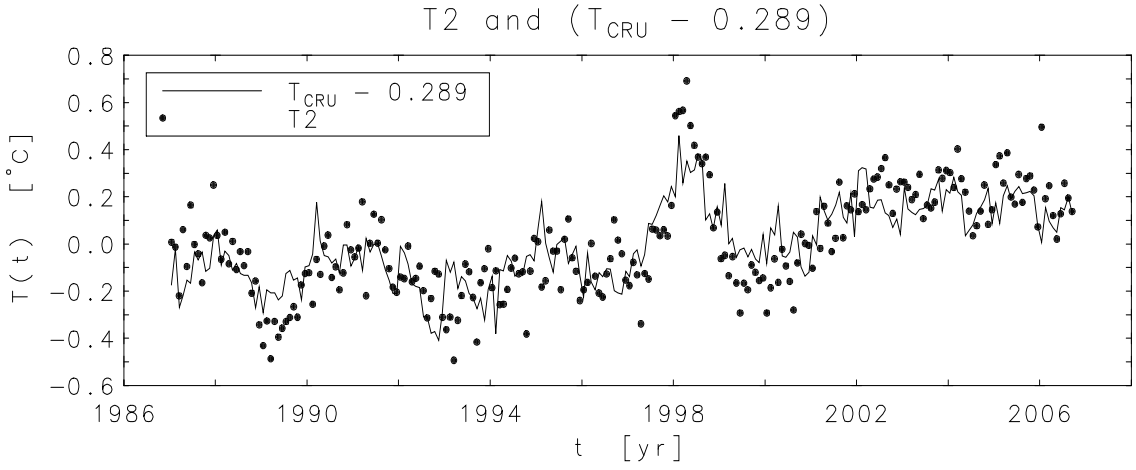
http://data.giss.nasa.gov/gistemp/tabledata/GLB.Ts+dSST.txt

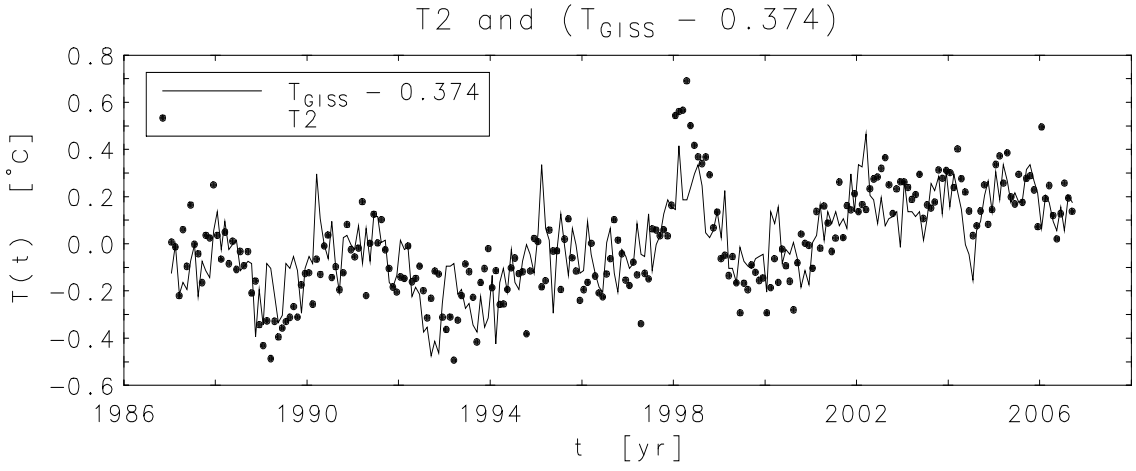
$$T(t_i) \equiv \left[\begin{array}{c} \text{Temp. ``anomaly''} \\ \text{for year } t_i \end{array} \right]$$

$$\equiv \left[\begin{array}{c} \text{Av. Temp.} \\ \text{in year } t_i \end{array} \right] - \left[\begin{array}{c} \text{Reference} \\ \text{Temperature} \end{array} \right]$$

CRU: Climatic Research Unit

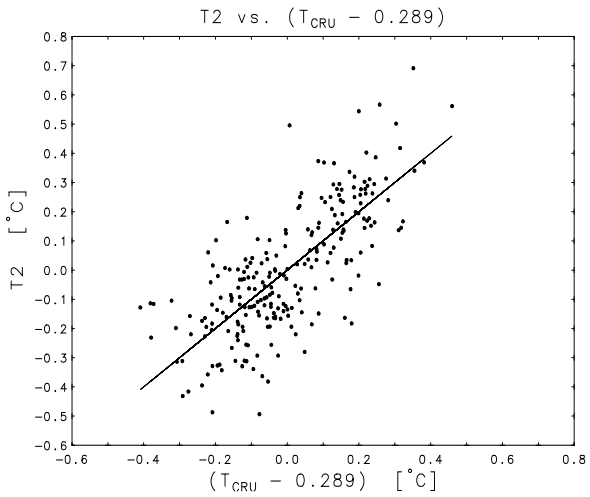
$$\left[\begin{array}{c}\text{Reference}\\ \text{Temperature}\end{array}\right] = \left[\begin{array}{c}\text{Av. Temperature}\\ \text{for 1961-1990}\end{array}\right]$$

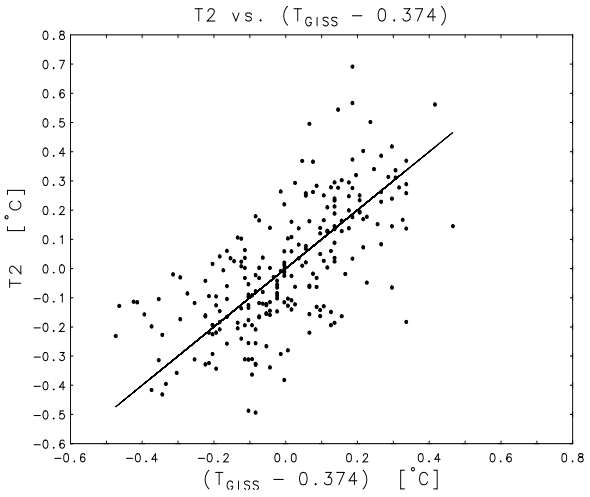


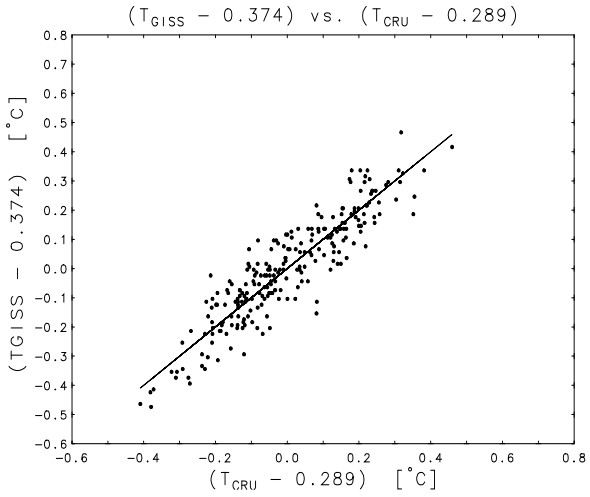


GISS: Goddard Institute for Space Studies

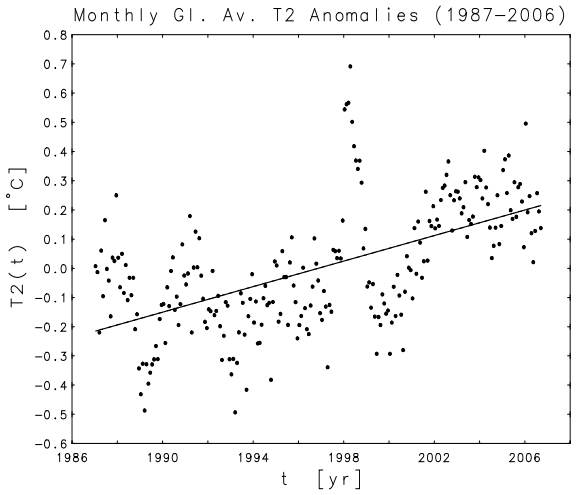
$$\left[\begin{array}{c}\text{Reference}\\ \text{Temperature}\end{array}\right] = \left[\begin{array}{c}\text{Av. Temperature}\\ \text{for 1951-1980}\end{array}\right]$$

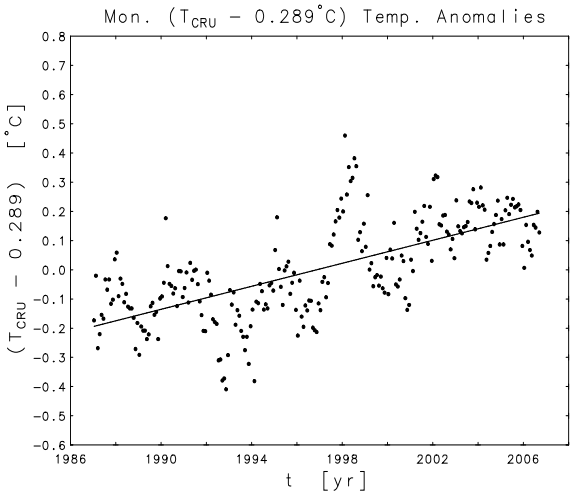

T2 vs. (T_CRU − 0.289)
T2 [°C]
(T_CRU − 0.289) [°C]

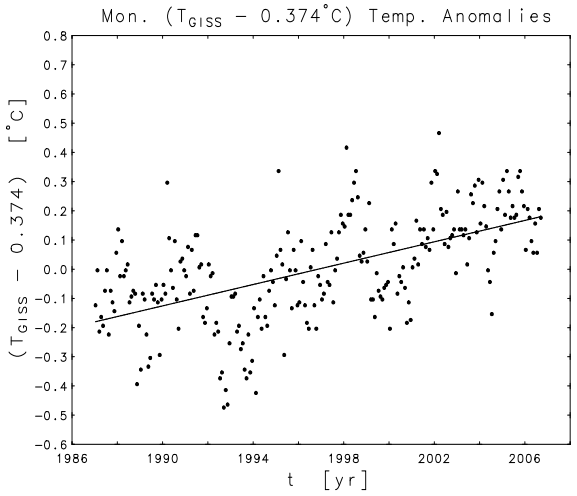

T2 vs. (T_GISS − 0.374)
T2 [°C]
(T_GISS − 0.374) [°C]

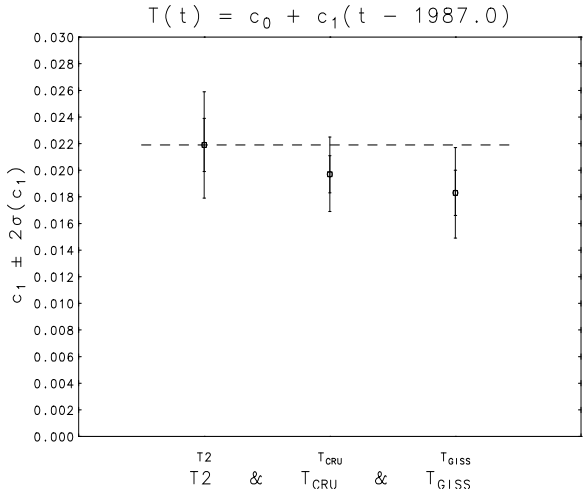

(T_GISS − 0.374) vs. (T_CRU − 0.289)
(TGISS − 0.374) [°C]
(T_CRU − 0.289) [°C]

$$T(t) = c_0 + c_1(t - 1987.0)$$







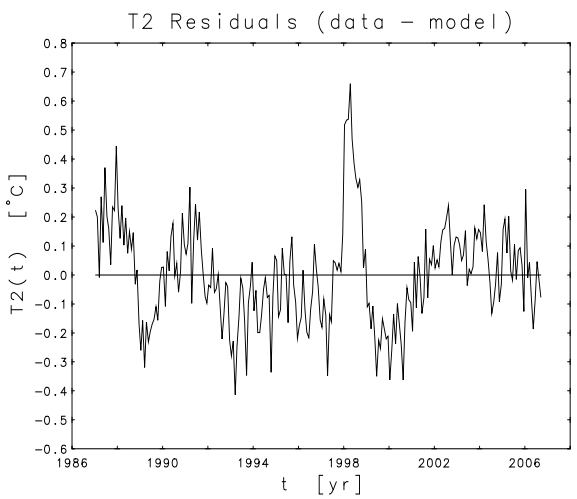


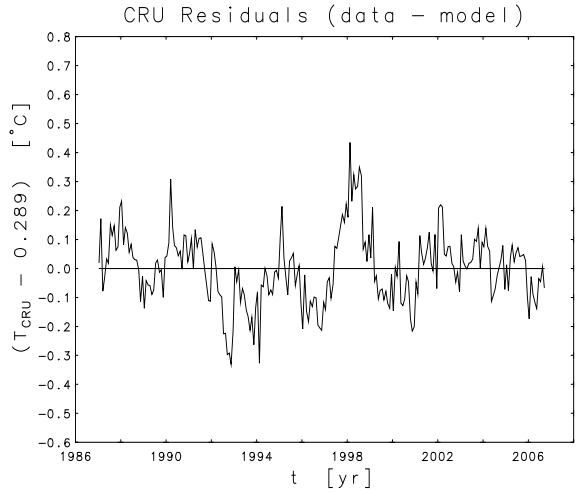
$$T2: \quad \hat{c}_1 = 0.0219 \pm .0020\ ^\circ C/yr$$

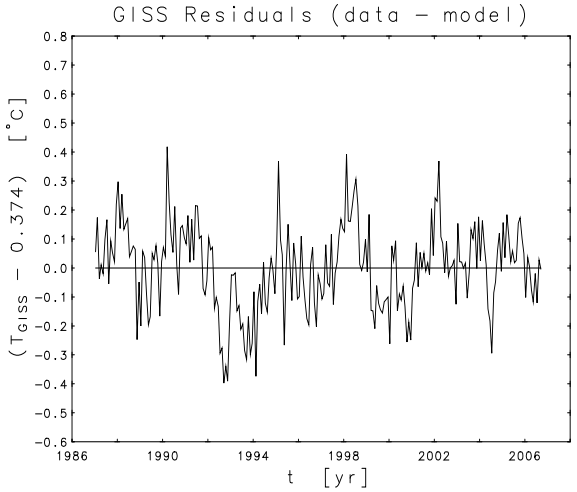
$$(T_{CRU} - 0.289^\circ C): \quad \hat{c}_1 = 0.0197 \pm .0014\ ^\circ C/yr$$

$$(T_{GISS} - 0.374^\circ C): \quad \hat{c}_1 = 0.0183 \pm .0017\ ^\circ C/yr$$

Residuals: $T_i - T(t_i)$





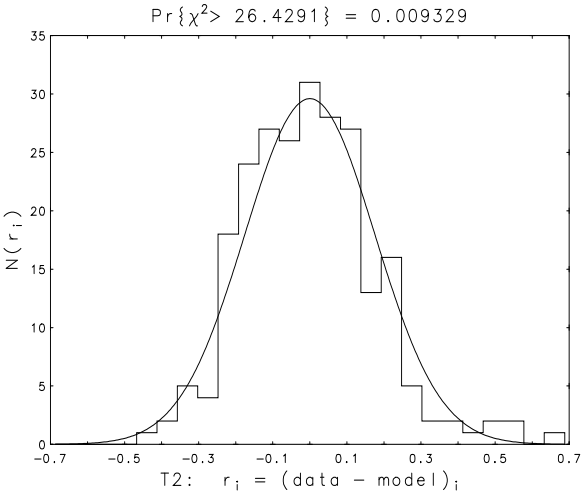


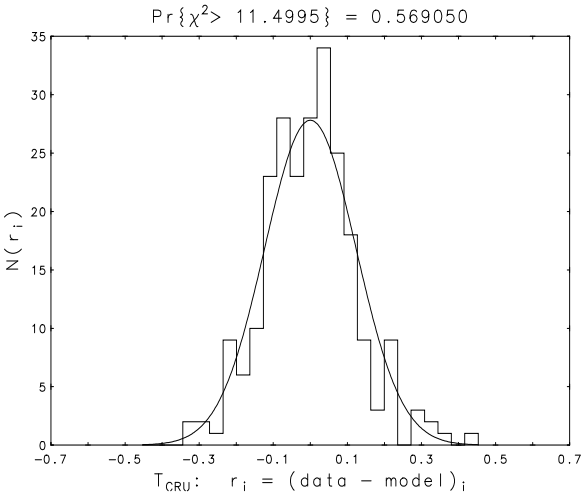
$T2$: $SSR = 7.2895$

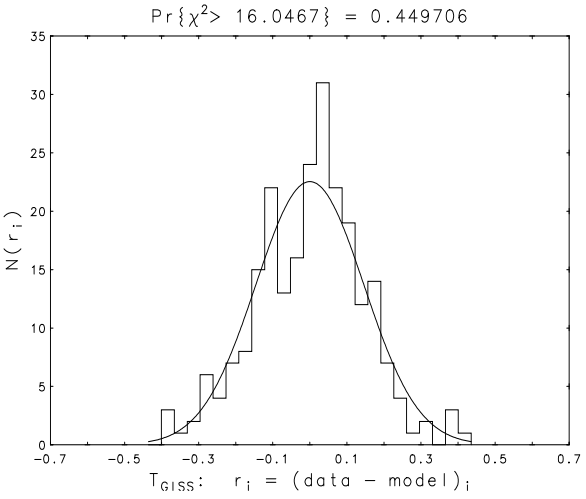
$(T_{CRU} - 0.289°C)$: $SSR = 3.5842$

$(T_{GISS} - 0.374°C)$: $SSR = 5.0395$

Residual Distributions

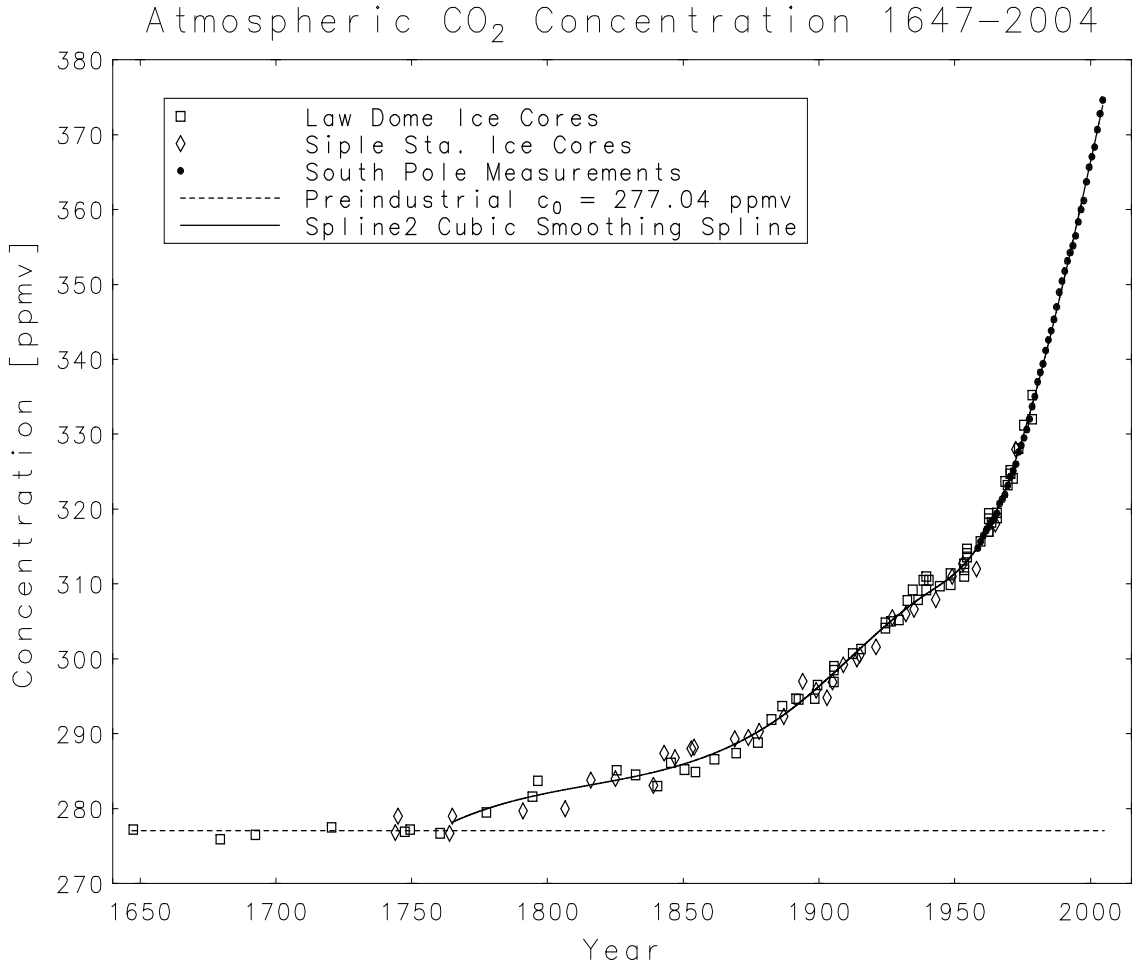






spline2: Optimal regression spline fit

Thijsse and Rust, *Computing in Science & Engineering*, **10** (Jan/Feb 2008) pp. 49-59.



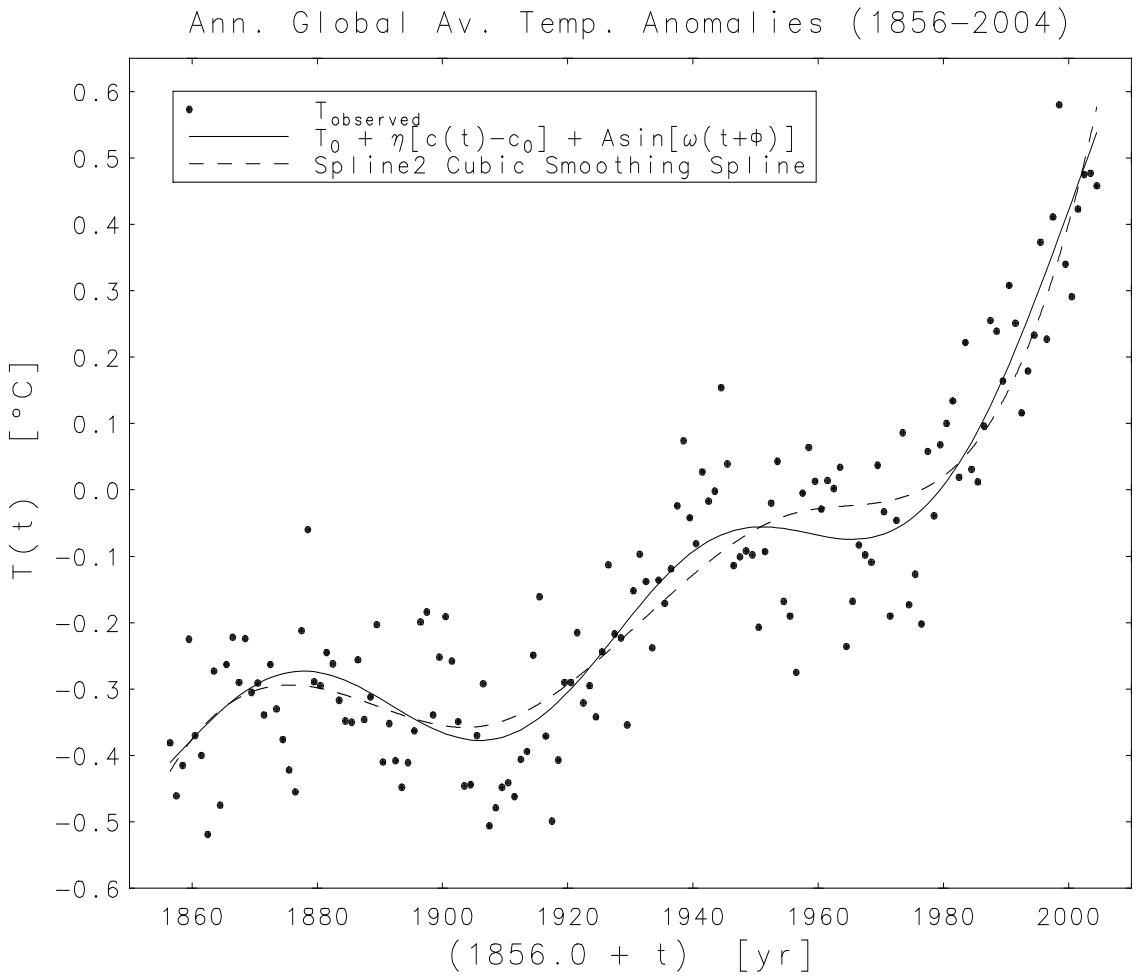
$c_i \equiv$ Atm. CO_2 conc. in year t_i

$c_0 \equiv$ Preindustral atm. CO_2 conc.

$= 277.04$ ppmv

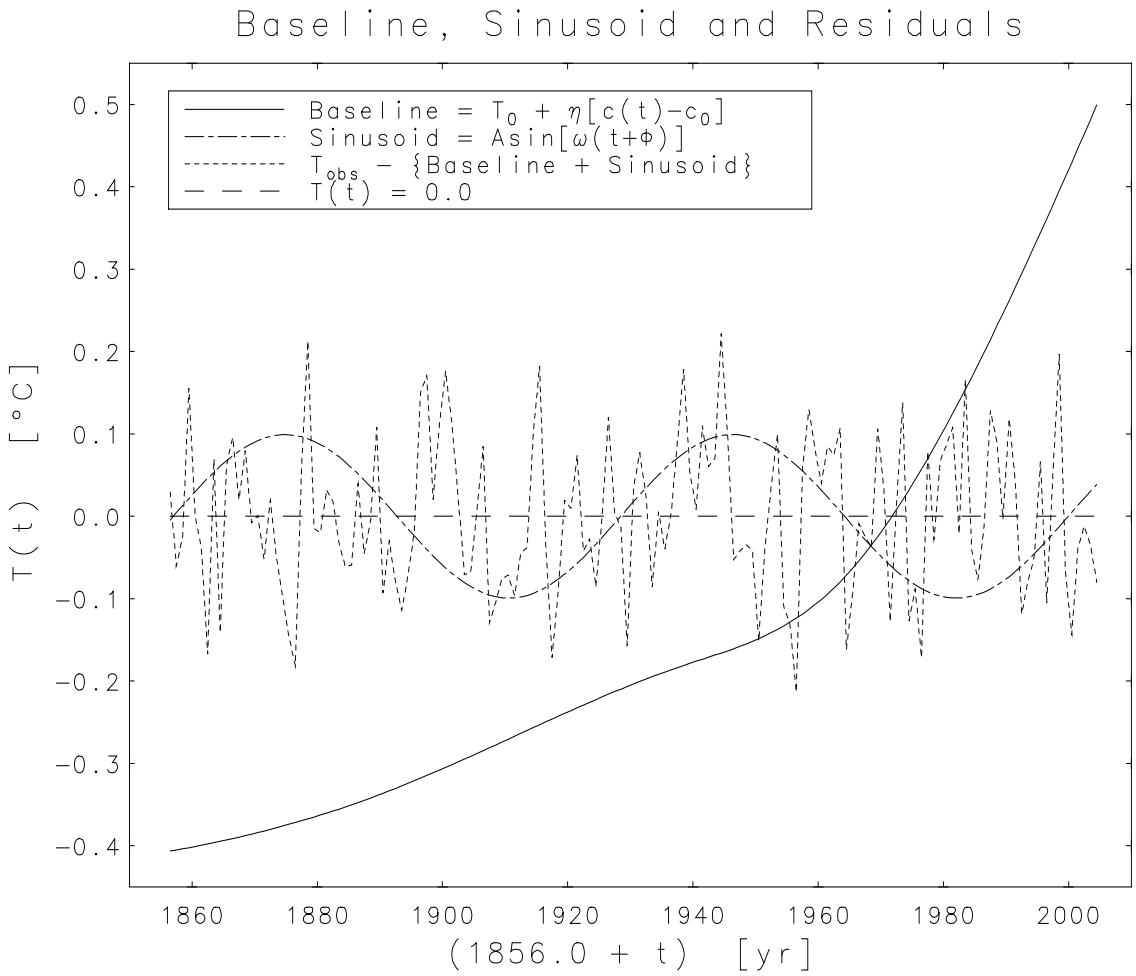
$c(t) \equiv$ *spline2* fit to the (t_i, c_i)

$$T(t) = T_0 + \eta\,[c(t) - c_0] + A \sin\left[\frac{2\pi}{\tau}(t + \phi)\right]$$



$$\begin{aligned}
\widehat{T}_0 &= -0.507 \pm .016 \ [^\circ\text{C}] \\
\widehat{\eta} &= 0.01039 \pm .00042 \ [^\circ\text{C/ppmv}] \\
\widehat{A} &= 0.099 \pm .012 \ [^\circ\text{C}] \\
\widehat{\tau} &= 71.5 \pm 2.2 \ [\text{yr}] \\
\widehat{\phi} &= -1.0 \pm 1.4 \ [\text{yr}]
\end{aligned}$$

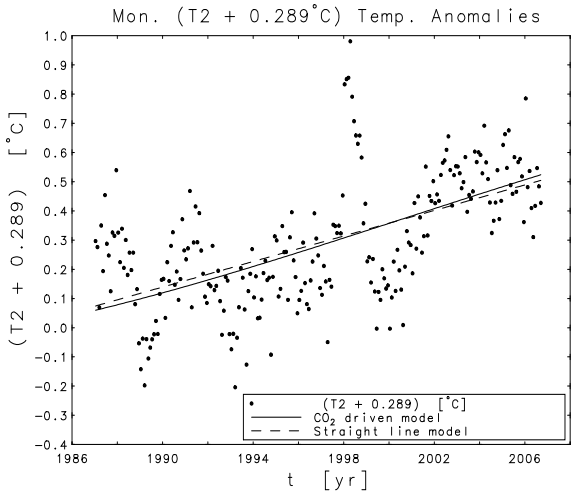
Components of Variance in the Temperature Record

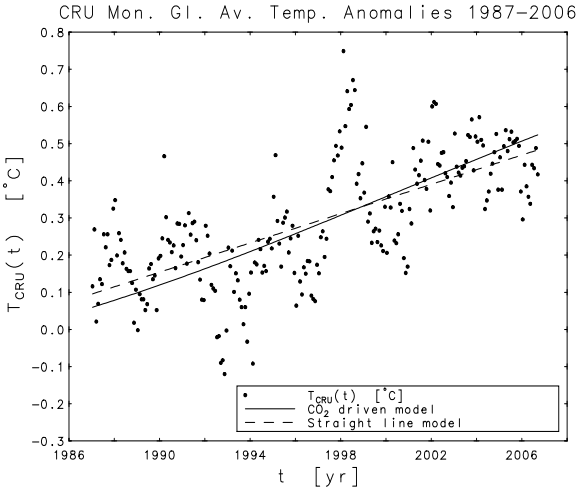


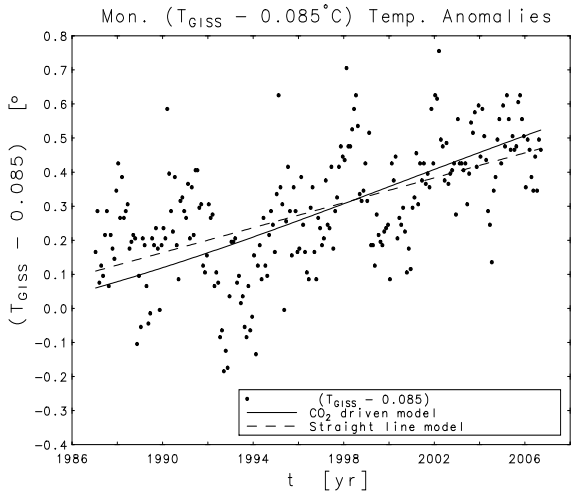
- Atmosphere warmed by 0.9°C in 1856-2004.
- Warming linearly proportional to increase in $c(t)$.
- **The warming is accelerating!**

$$T(t) = T_0 + \eta\,[c(t) - c_0] + A \sin\left[\frac{2\pi}{\tau}(t+\phi)\right]$$

$$T(t) = c_0 + c_1 t$$



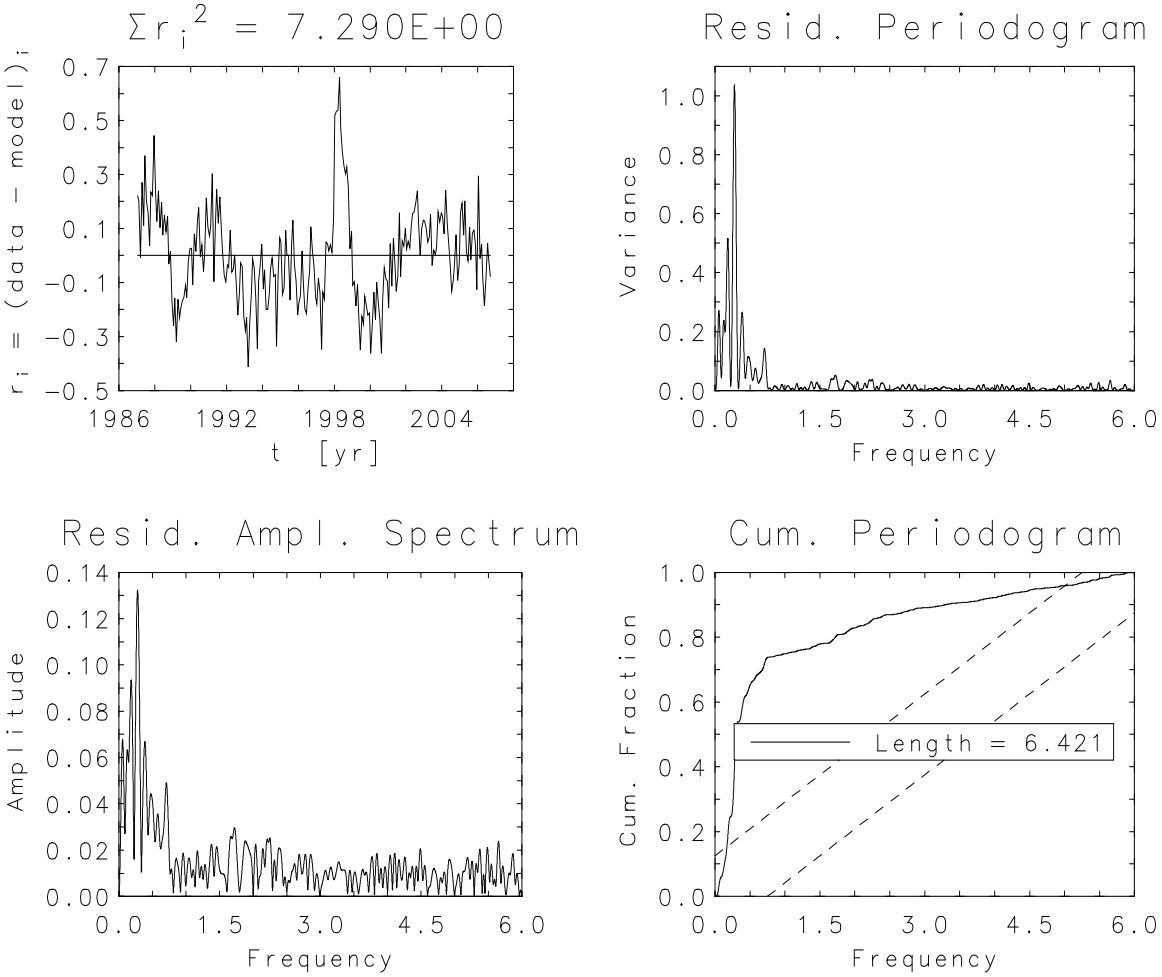




SSR	$T2$	T_{CRU}	T_{GISS}
CO_2-driven Model	7.228	3.682	5.228
Straight Line Model	7.290	3.584	5.039

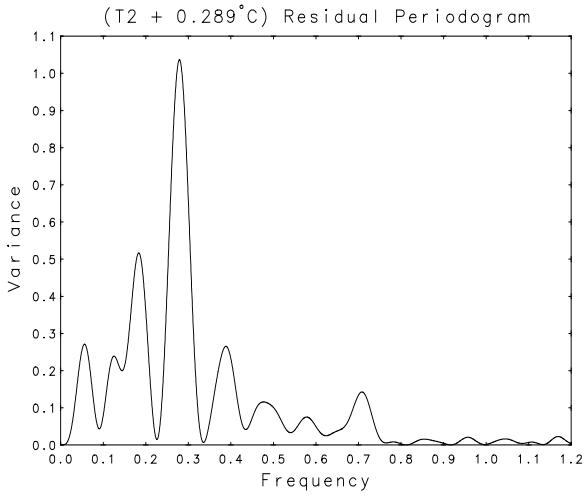
Fourier Analysis of T2 Residuals

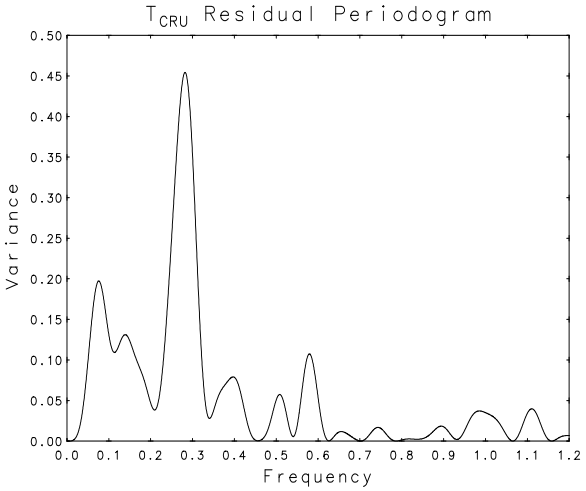
$$T2(t) = c_0 + c_1 t$$

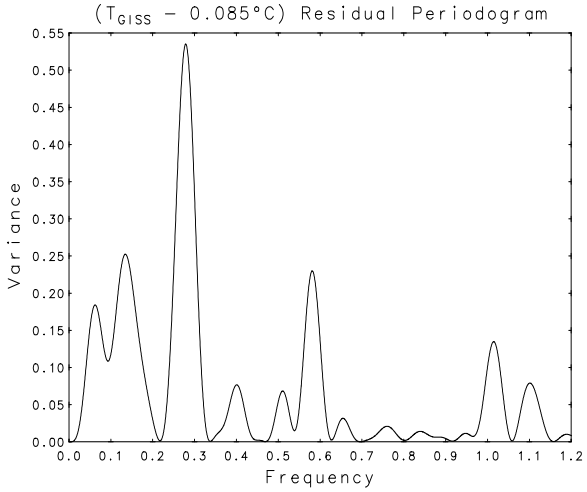


For largest peak in variance (power) spectrum,

Freq. $= 0.279\ \mathrm{yr}^{-1}$ Period $= 3.58\ \mathrm{yr} = 43.0\ \mathrm{mo}$.





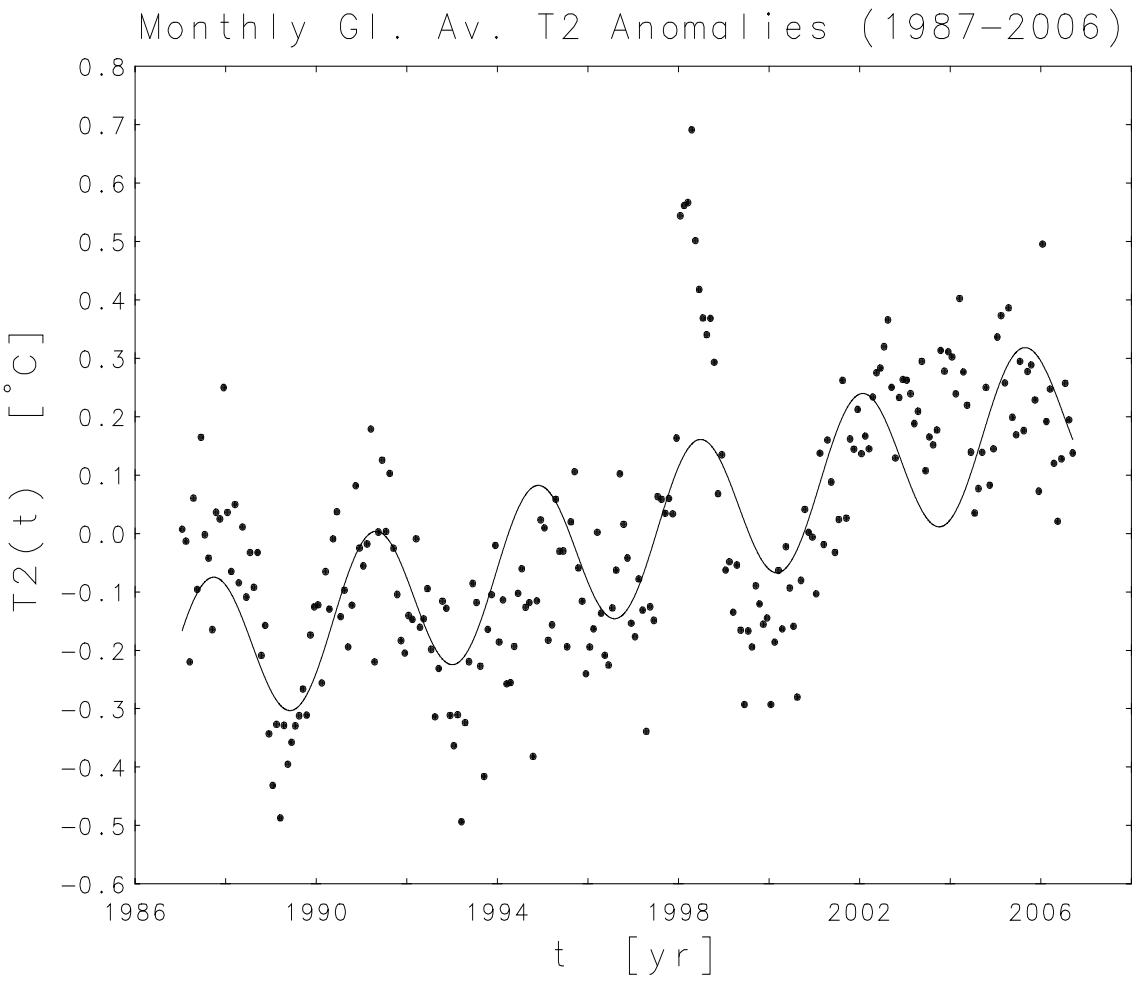


For $T2$, V_{max} at Period $= 3.58\,yr = 43.0\,mo$

For T_{CRU}, V_{max} at Period $= 3.55\,yr = 42.6\,mo$

For T_{GISS}, V_{max} at Period $= 3.58\,yr = 43.0\,mo$

$$T2(t) = c_0 + c_1 t + A \sin\left[\frac{2\pi}{43.0}(t+\phi)\right]$$



$\hat{c}_0 = 0.0219 \pm .0017\ ^\circ C$ $\hat{A} = 0.133 \pm .014\ ^\circ C$