Solar Forcing and Climate - Multi-resolution Analysis

Solar Variation

http://en.wikipedia.org/wiki/Solar_variation

The Sun and Climate **http://pubs.usgs.gov/fs/fs-0095-00/fs-0095-00.pdf**

Many geologic records of climatic and environmental change based on various proxy variables exhibit **distinct cyclicities that have been attributed to extraterrestrial forcing**. ... Another terrestrial observation was that the Maunder Minimum coincided with the coldest part of the Little Ice Age.

http://commons.wikimedia.org/wiki/File:Carbon-14_with_activity_labels.png

http://www.radiocarbon.org/IntCal04%20files/intcal04.14c

Read Carbon 14 Atmospheric Concentration Data

\# CAL BP, 14C age, Error, Delta 14C, Sigma,
YR BP ,YR BP, per mil , per mil

$C14 := READPRN(\text{"Atmospheric C14 Concentration.TXT"})$ $Yr := C14^{\langle 0 \rangle} + 40$

$SSSmooth := ksmooth\left(reverse(Yr), reverse\left(C14^{\langle 3 \rangle}\right), 2000\right)$

$Detrend := reverse\left(C14^{\langle 3 \rangle}\right) - SSSmooth$

$SSCycle := ksmooth(reverse(Yr), Detrend, 1000)$ $Yr_{SS} := 2010 - Yr$

Read Sunspot Data

YEAR MON SSN DEV

$SSpots := READPRN(\text{"SunSpot Monthly Averages.txt"})$ $NumSS := SSpots^{\langle 2 \rangle}$

$YrDec := -\left(SSpots^{\langle 0 \rangle} + \frac{SSpots^{\langle 1 \rangle} - 1}{12} - 2010\right)$ $SSpotYrly := READPRN(\text{"SSpotYrly.dat"})$

$SSSmth := ksmooth(-YrDec, NumSS, 20)$ $YrDec := SSpots^{\langle 0 \rangle} + \frac{SSpots^{\langle 1 \rangle} - 1}{12}$

Solar Influences Data Analysis Center - SIDC

http://www.sidc.be/sunspot-data/

YrMon, Year_Decimal, Monthly, Monthly Smoothed Sunspot Number, 1749 to 2010

$SSN := READPRN(\text{"monthssn.dat"})$

NGDC - Group Sunspot Numbers (Doug Hoyt re-evaluation) 1610-1995

http://www.ngdc.noaa.gov/stp/SOLAR/ftpsunspotnumber.html#hoyt - 4bb. monthrg.dat

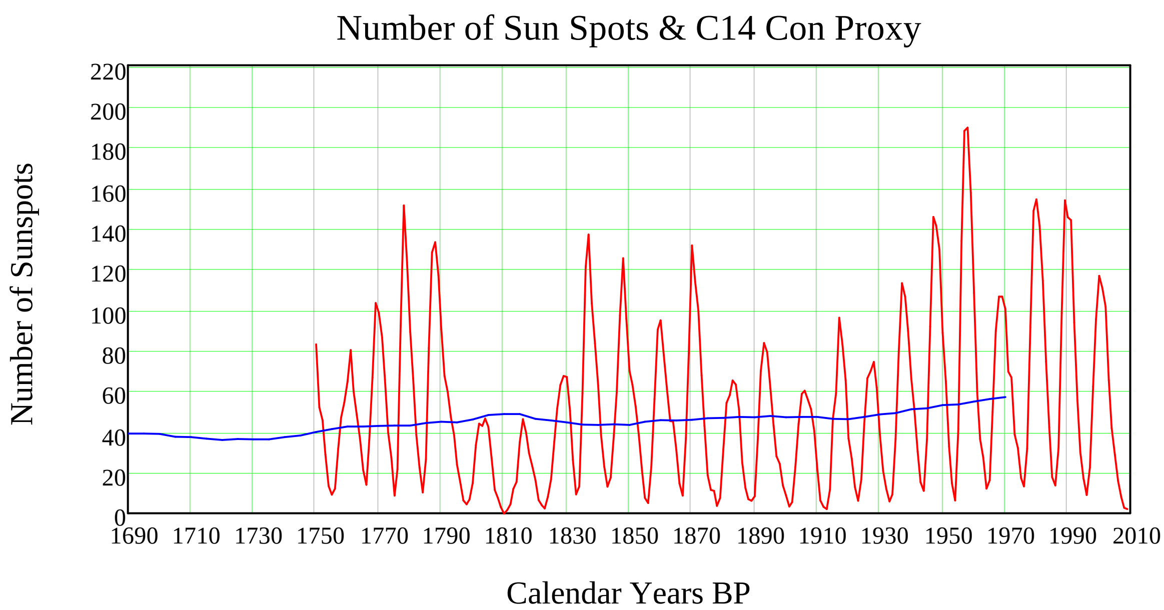
$SSN\_Hoyt := READPRN(\text{"Grp SSN-monthrg-1610-1995.dat"})$

NGDC-Table of smoothed monthly sunspot numbers 1700-present

Year, SNN-Jan to SNN-Dec

$SSNSm\_Hoyt := READPRN(\text{"SmoothMonthMeanHoyt-1749-2009.txt"})$ $\quad R := rows(SSNSm\_Hoyt)$

$r := 0..R-1 \qquad SSH_r := \sum_{m=1}^{12} \left(SSNSm\_Hoyt_{r,m} \cdot \frac{1}{12} \right) \qquad Year_H := SSNSm\_Hoyt^{\langle 0 \rangle}$



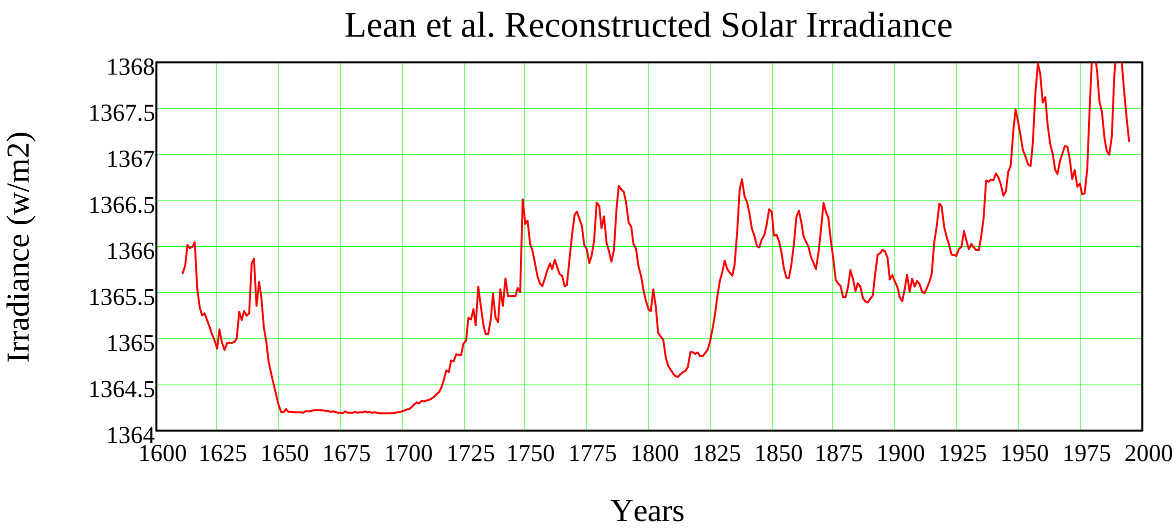
<u>Fill in Missing Data with Averages</u>

$z(x) := if(x \le 0, 0, x)$

$$Fill(Y) := \left| \begin{array}{l} \text{for } n \in 0..rows(Y)-1 \\ \quad Y_n \leftarrow \left(Y_{z(n-1)} + Y_{z(n-2)}\right) \cdot \frac{1}{2} \ \text{ if } Y_{z(n)} < 0 \\ Y \end{array} \right.$$

$TSDF_{lean} := READPRN(\text{"lean1995data.txt"}) \qquad Yr_{lean} := TSDF_{lean}^{\langle 0 \rangle} \qquad TSD_{lean} := Fill\left(TSDF_{lean}^{\langle 1 \rangle}\right)$

$$\frac{\log\left(rows\left(Yr_{lean}\right)\right)}{\log(2)} = 8.589 \qquad 2^9 = 512$$



$R := \mathrm{rows}(TSD_{lean}) = 385$ $\quad rr := 0..R-1$ $\quad \Delta Yr := Yr_{lean} - Yr_{lean_0}$ $\quad \Delta Yr_{R-1} = 384$

$T_{run} := \frac{1.024}{2}$ $\quad \Delta T := .001$ $\quad thisWave := bl(6)$ $\quad TSD_{lean} := TSD_{lean} - 1366$

$thisWave := symmlet(10)$

$N := \frac{T_{run}}{\Delta T}$ $\quad i := 0..N-1$ $\quad x_i := \Delta T \cdot i$ $\quad N = 512$ $\quad Year_i := \frac{R}{N} \cdot i$

$CS := \mathrm{cspline}(\Delta Yr, TSD_{lean})$ $\quad y_i := \mathrm{interp}(CS, \Delta Yr, TSD_{lean}, Year_i)$

Fill in the end segment with the last TSI value

Fill y with the R TSI values

$ii := 0..1023$ $\quad Yrr_{ii} := \frac{\Delta Yr_{R-1}}{1024} \cdot ii$ $\quad CS := \mathrm{cspline}(\Delta Yr, TSD_{lean})$ $\quad yy_{ii} := \mathrm{interp}(CS, \Delta Yr, TSD_{lean}, Yrr_{ii})$

$y_i := \sin\left(4 \cdot \frac{Year_i}{100} + 1\right)$ $\quad WRITEPRN("Isolation\text{-}Lean\text{-}1024.txt") := yy + 2$

Maximum Scale of Dilation (How Large) Parameter, J

$MaxDWTLevel(y) = 9$ $\quad J := 6$ $\quad j := 0..J-1$

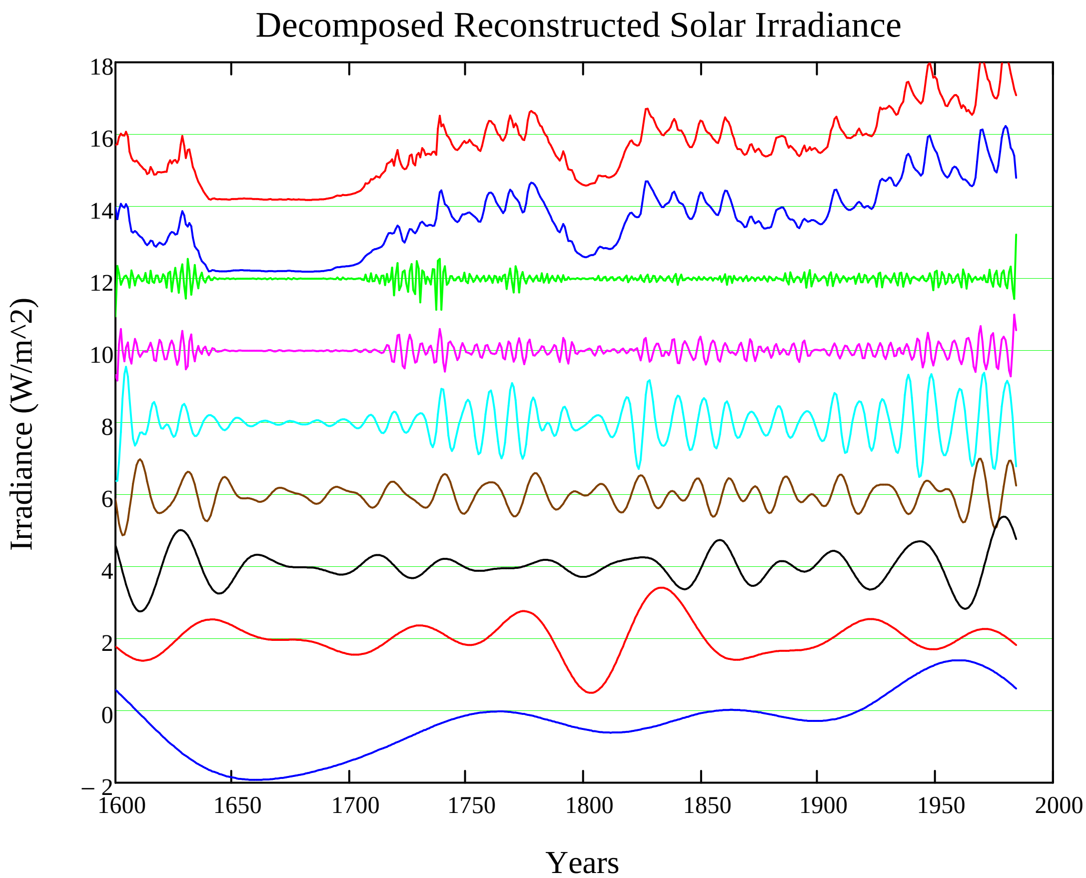
Compute the multiresolution decomposition:

$$
\text{mra}(v,J,\text{filter}) := \left|
\begin{array}{l}
w \leftarrow \text{dwt}(v,J,\text{filter}) \\
Z_{\text{rows}(v)-1} \leftarrow 0 \\
M^{\langle 0\rangle} \leftarrow \text{idwt}(\text{put\_smooth}(Z,J,\text{get\_smooth}(w,J)),J,\text{filter}) \\
\text{for } qj \in J..1 \\
\quad \left| \begin{array}{l}
Z_{\text{rows}(v)-1} \leftarrow 0 \\
M^{\langle J+1-qj\rangle} \leftarrow \text{idwt}(\text{put\_detail}(Z,qj,\text{get\_detail}(w,qj)),J,\text{filter})
\end{array} \right. \\
M^T
\end{array}
\right.
$$

$$M := \text{mra}(y,J,\text{thisWave}) \qquad Y_{wav_i} := \sum_{j=0}^{J-1} M_{j,i}$$

$$S6_i := M_{0,i} \quad D6_i := M_{1,i} \quad D5_i := M_{2,i} \quad D4_i := M_{3,i} \quad D3_i := M_{4,i} \quad D2_i := M_{5,i} \quad D1_i := M_{6,i}$$

The mra data structure is a matrix of (J+1) rows. Row 0 is the smooth component; the other J rows are the detailed components $D_J, ..., D_1$.



$TempMill7 := READPRN(\text{"Temp 7 Reconstructions-briffa.txt"})$ $rows(TempMill7) = 1 \times 10^{3}$

Col 6 has Data to 1987 (row 987) $t := 0..987$

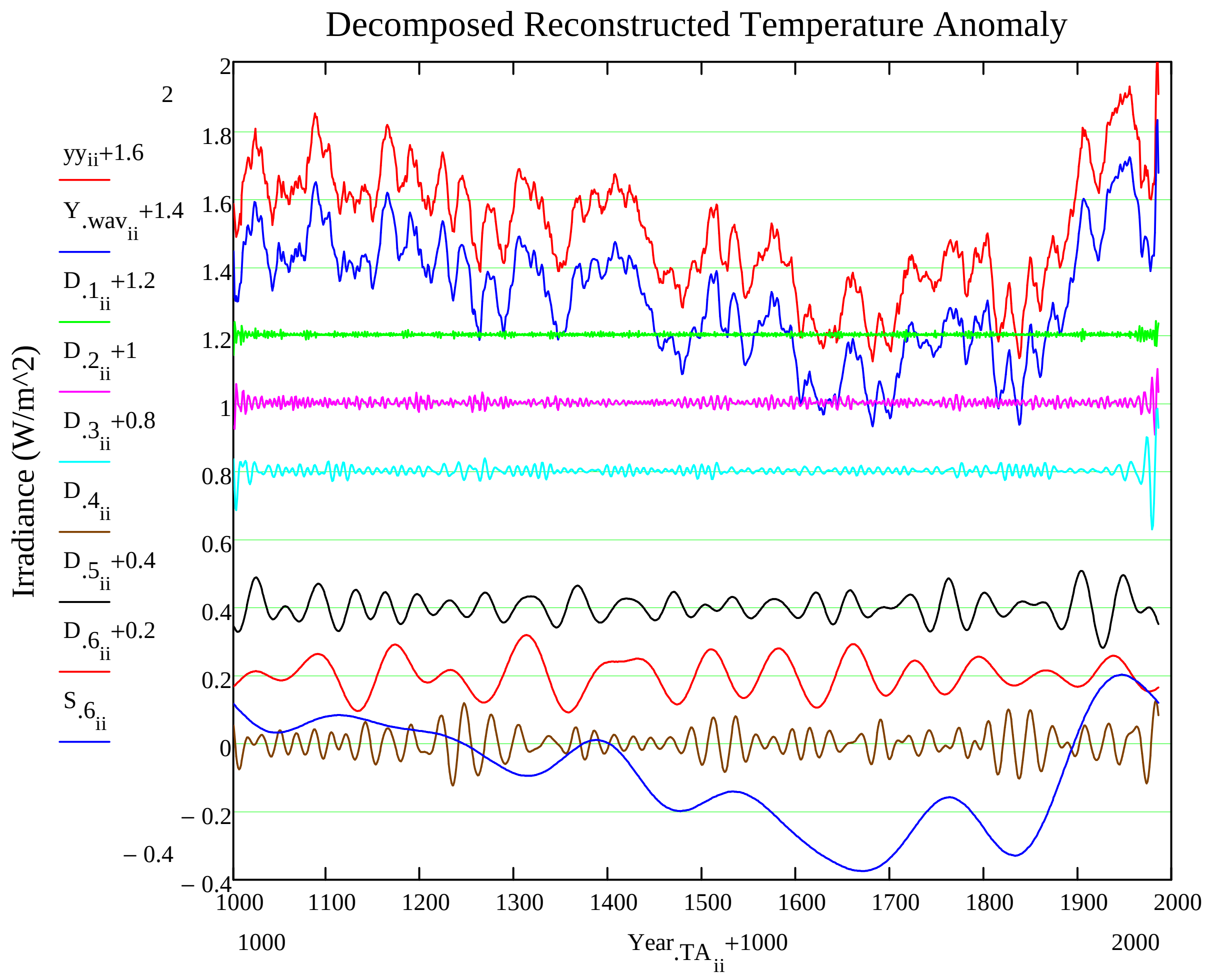
$Y987_t := TempMill7_{t,0} - 1000$ $T987_t := TempMill7_{t,6} + 0.2$ $Year_{TA_{ii}} := 987 \cdot \frac{ii}{1024}$

$CS := cspline(Y987, T987)$ $yy_{ii} := interp\left(CS, Y987, T987, Year_{TA_{ii}}\right)$

$MaxDWTLevel(yy) = 10$ $M := mra(yy, J, thisWave)$ $Y_{wav_{ii}} := \sum_{j=0}^{J-1} M_{j,ii}$

$S6_{ii} := M_{0,ii}$

$D6_{ii} := M_{1,ii}$ $D5_{ii} := M_{2,ii}$ $D4_{ii} := M_{3,ii}$ $D3_{ii} := M_{4,ii}$ $D2_{ii} := M_{5,ii}$ $D1_{ii} := M_{6,ii}$

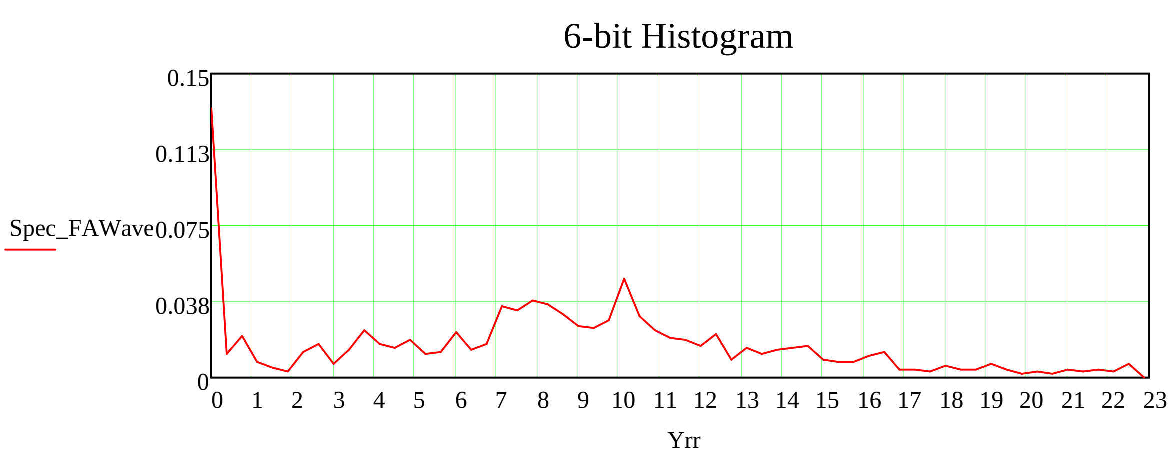


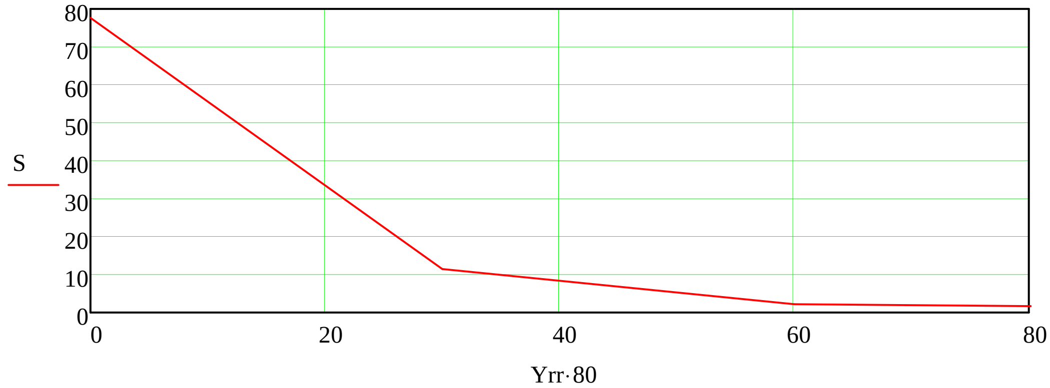
Spectral Analysis

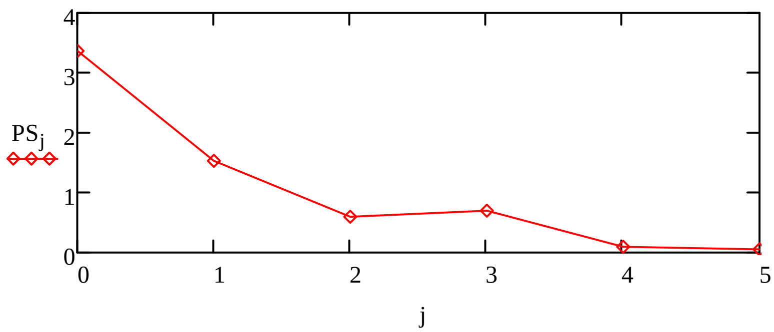
Years

$S := \text{pspectrum}(y, 5, 0.1)$ $\text{rows}(y) = 512$ $N = 512$

$\text{Spec\_FAWave} := \text{READPRN}(\text{"Spectrum-Iso-Lean-1024.TXT"})$ $PS_j := \sum_{r=0}^{N-2} \left(M_{j,r}\right)^2$




S
Yrr·80
0
10
20
30
40
50
60
70
80
0
20
40
60
80


PS_j
j
0
1
2
3
4
0
1
2
3
4
5