# *The Sun, the Moon, and the Planets:*

# *The Astronomical Origins of Climate Change on Earth*

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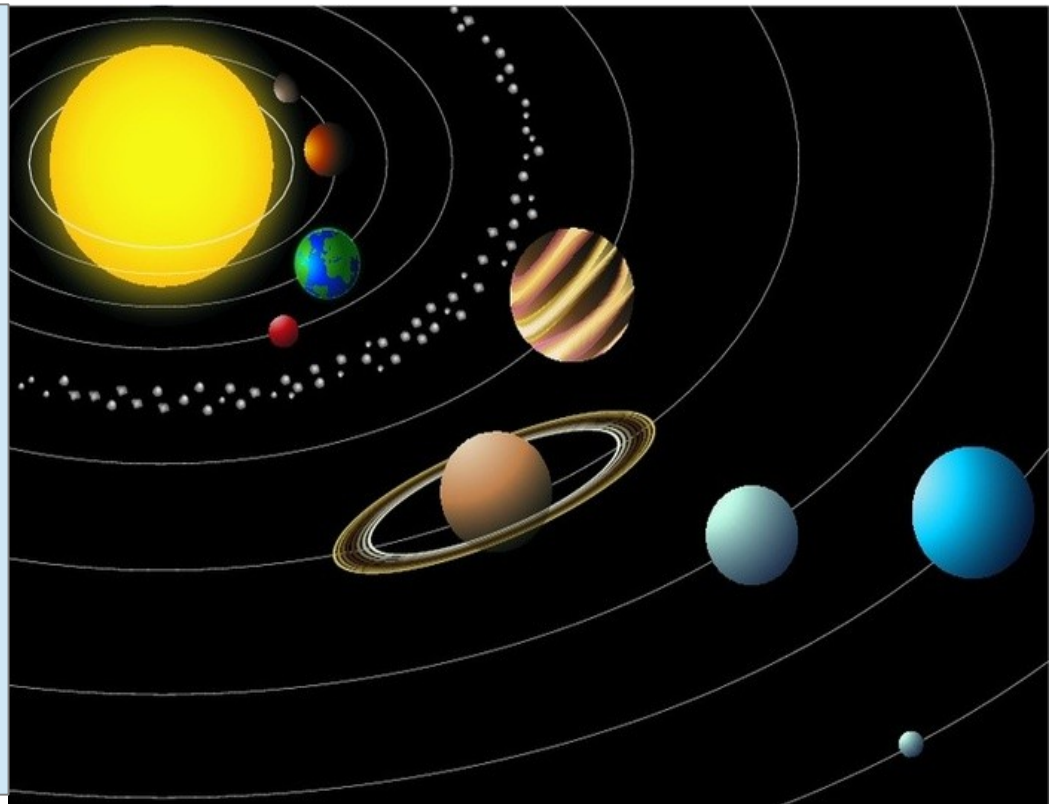
**ACRIM &**
**Duke University**

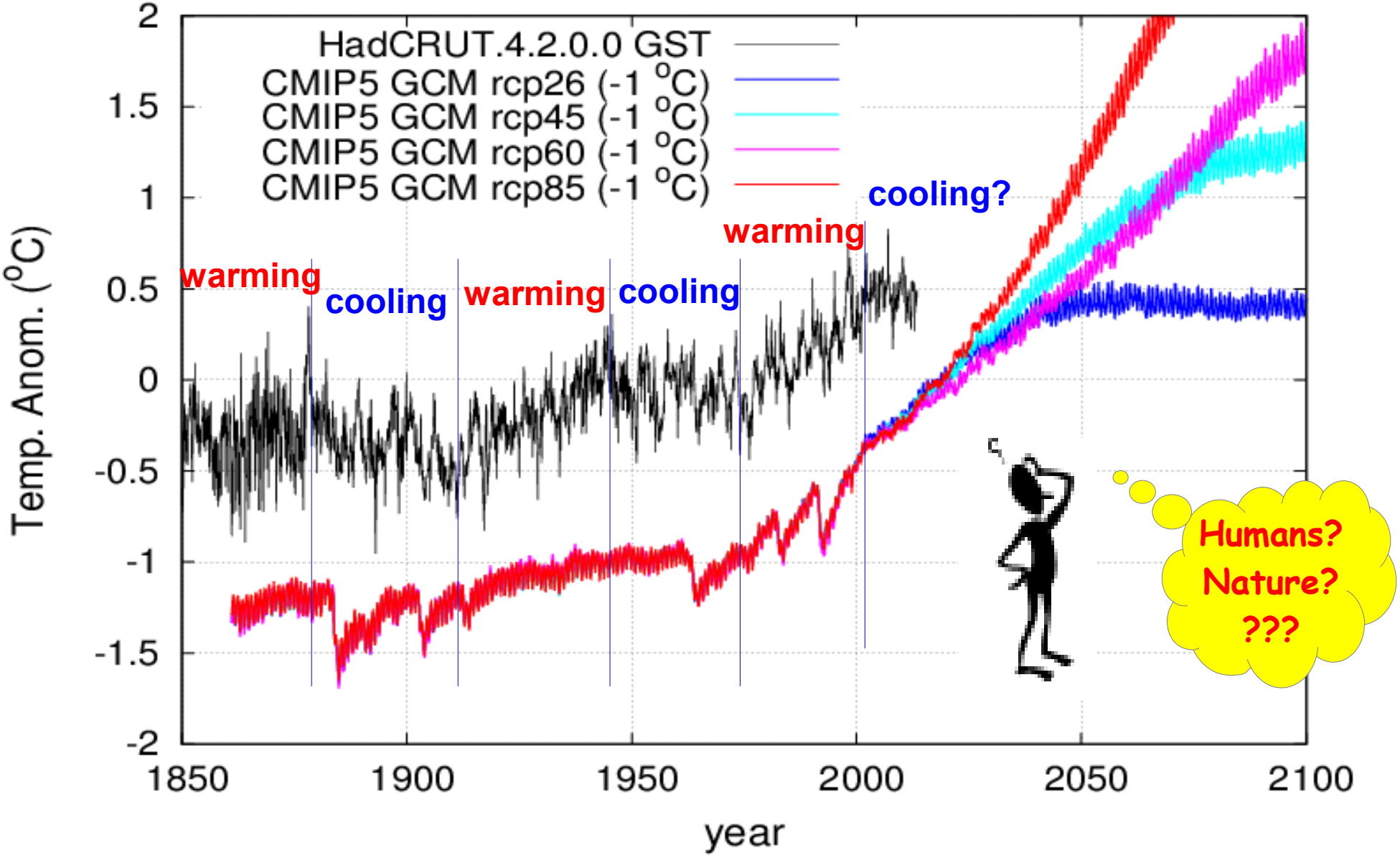
**Raleigh, 18 November, 2013**

## We are living in a solar system

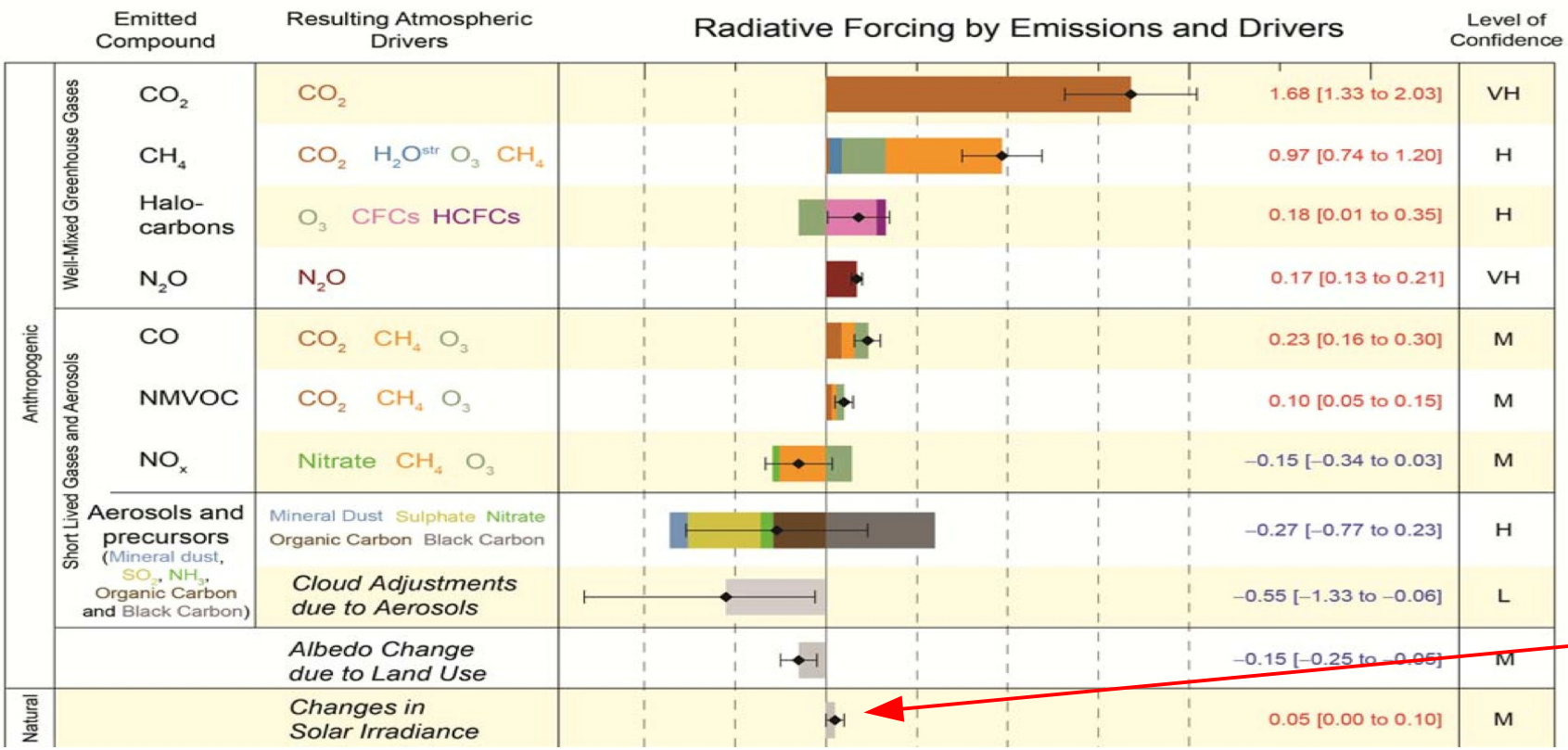
- The solar system oscillates because of planetary motion
- The Sun is likely synchronized to them
- The Earth's climate system oscillates with the same oscillations by synchronizing to them



# Global Surface Temperature (CRU) versus the CMIP5 (IPCC AR5) GCMs



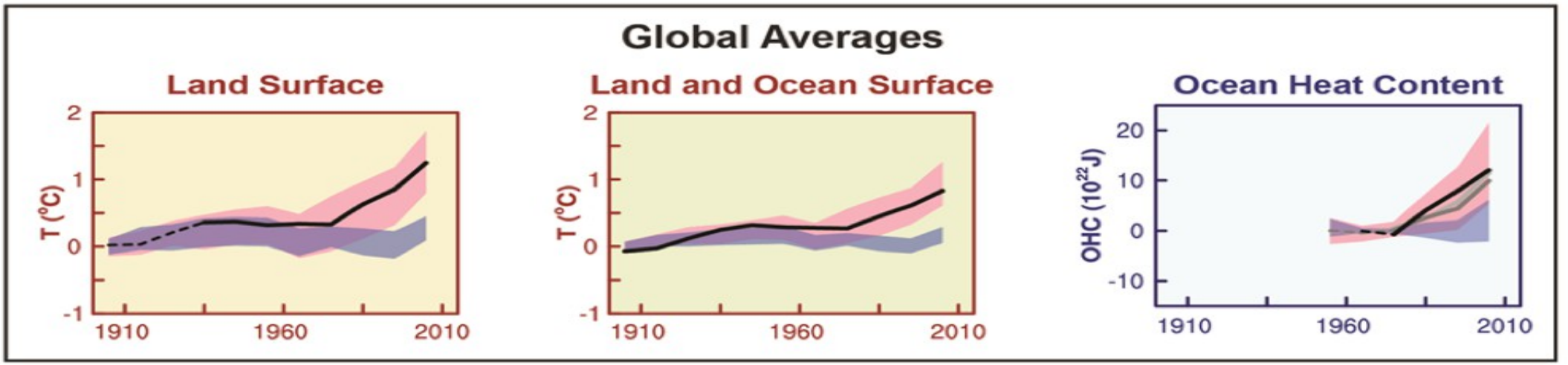
# The anthropogenic global warming theory



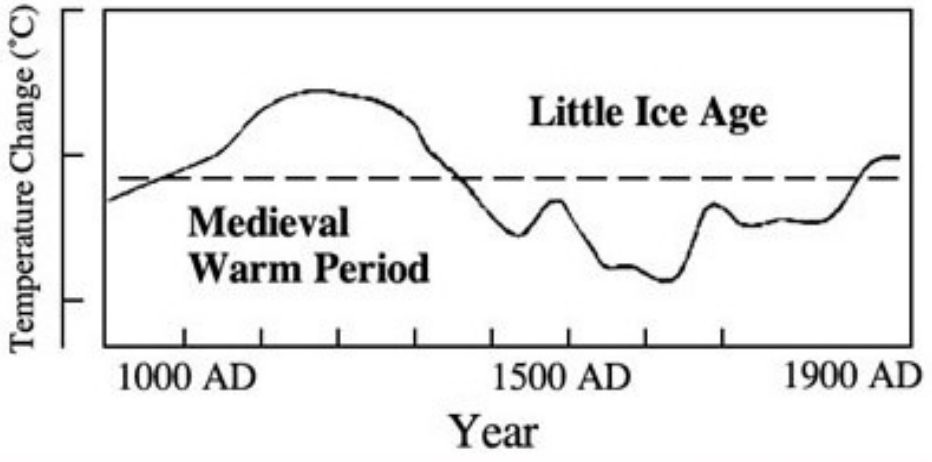

**CMIP5 GCM Forcings:**

**IPCC AR5, 2013**

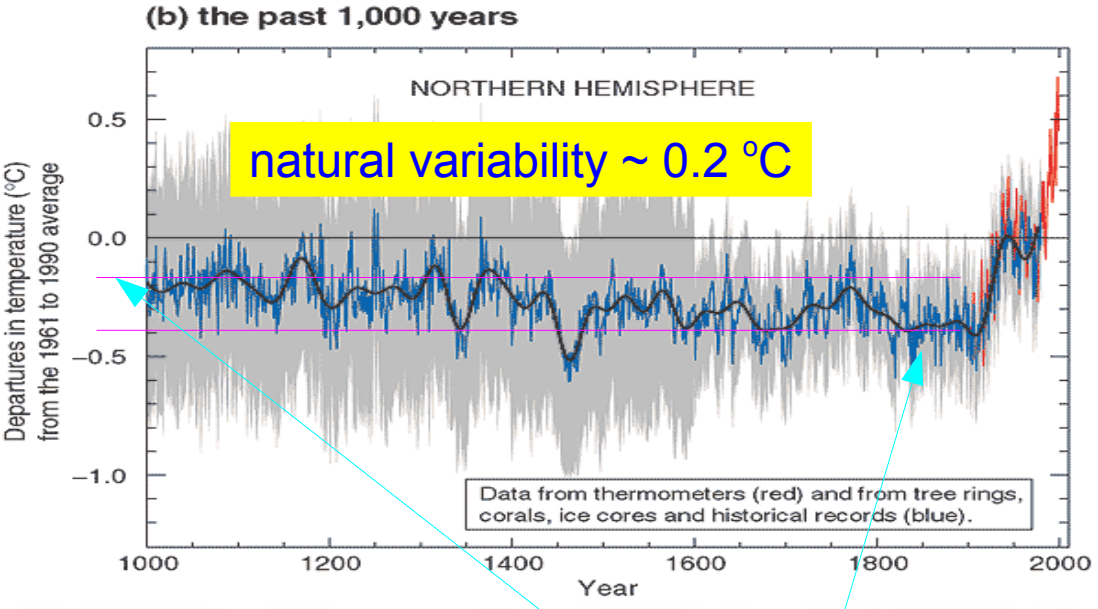
**The Sun does not Matter.**



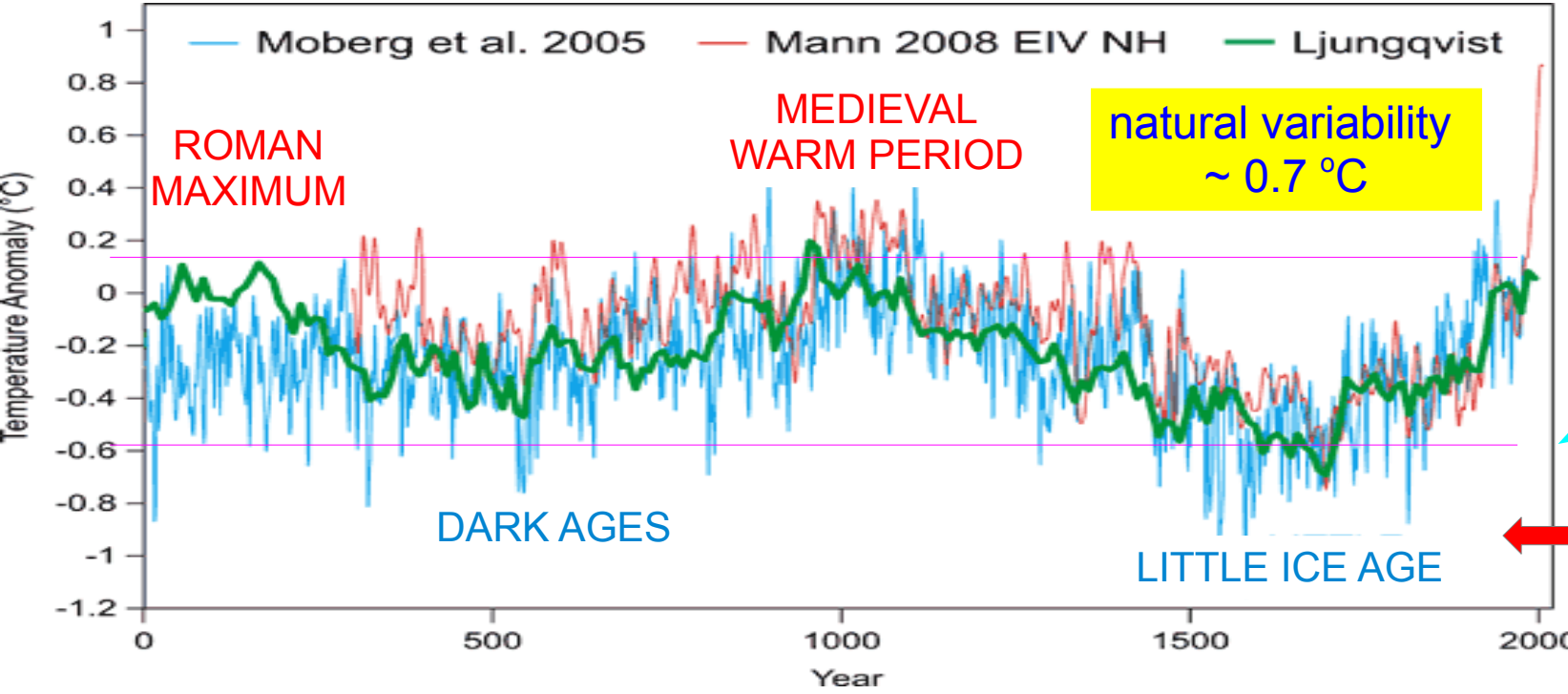
# 1999 Mann's failed “Hockey Stick” AGW evidence




**IPCC's depiction of the Medieval Warm Period from their 1995 Report**




**IPCC's depiction (from Mann) of the MWP as seen in their 2001 Report**

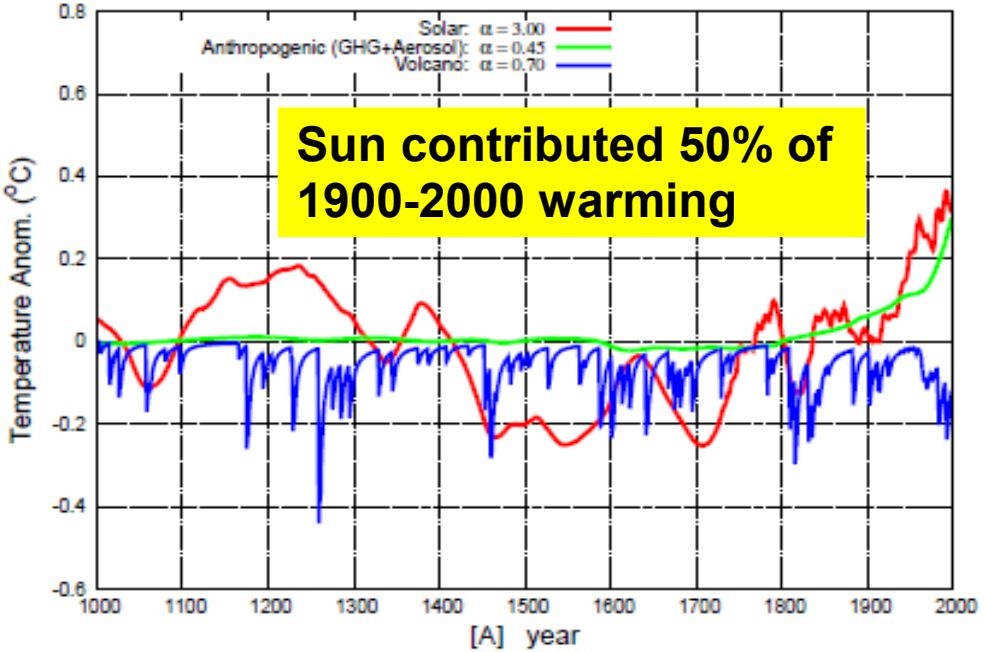


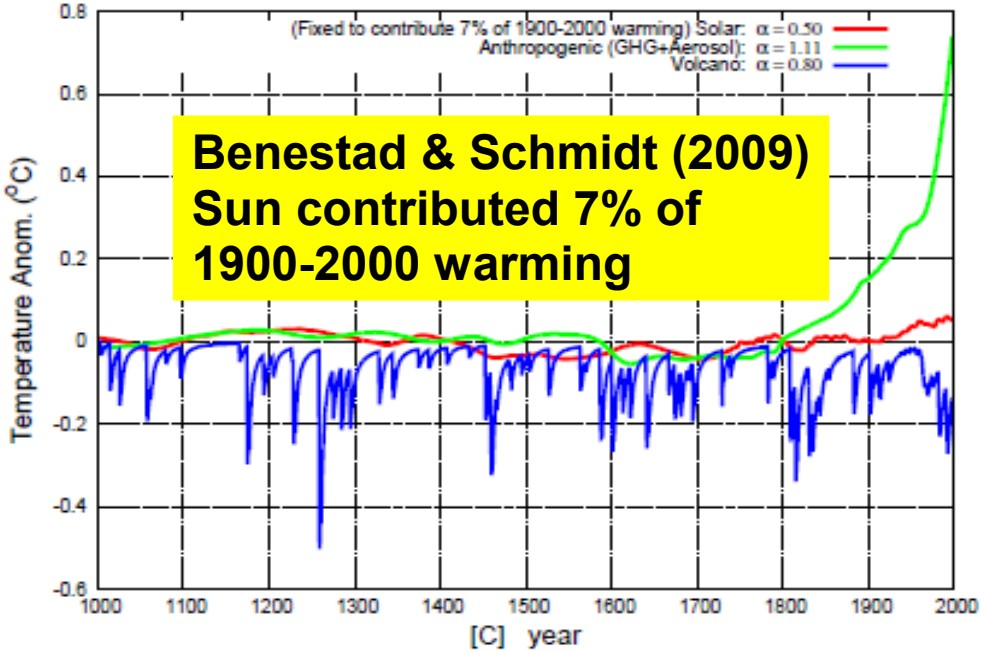

**~ 0.2 °C**

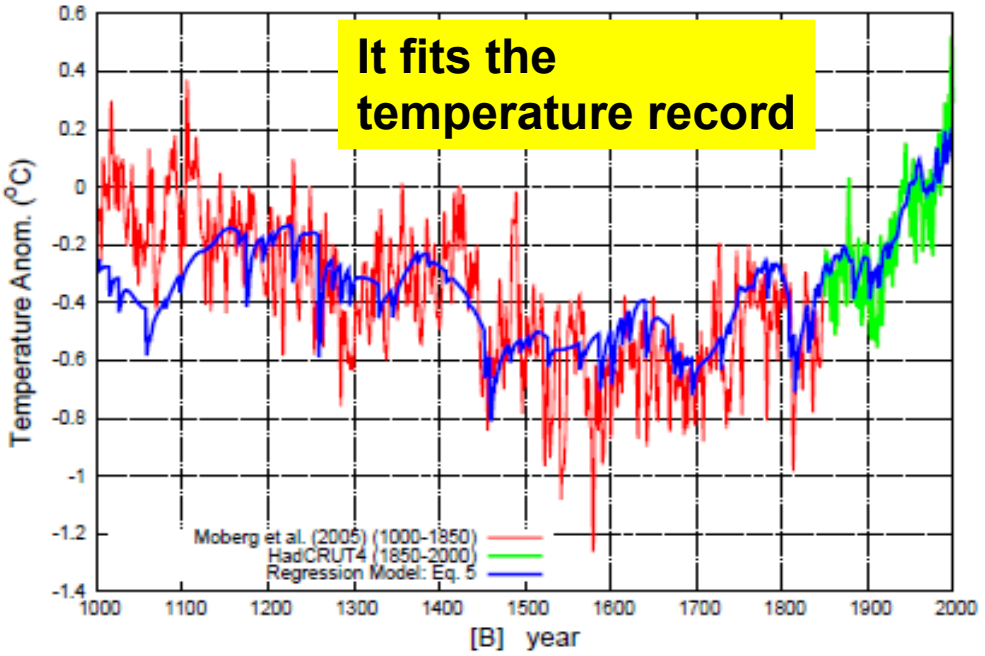
**~ 0.7 °C**

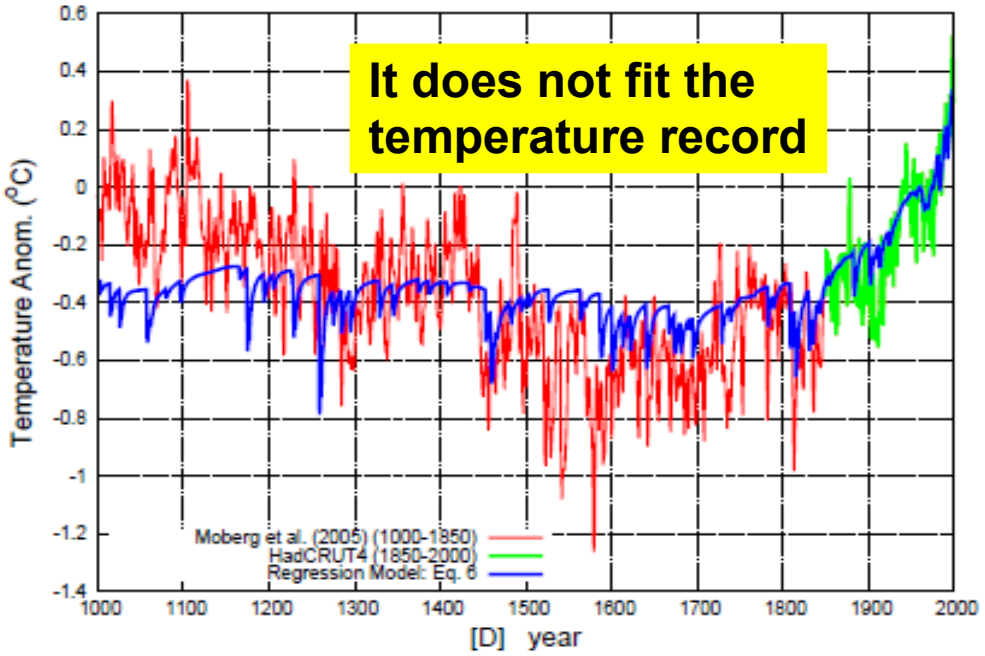
Modern GST reconstructions

Discussion on common errors in analyzing sea level accelerations, solar trends and global warming. N. Scafetta. Pattern Recognition in Physics, 1, 37–57 (2013).



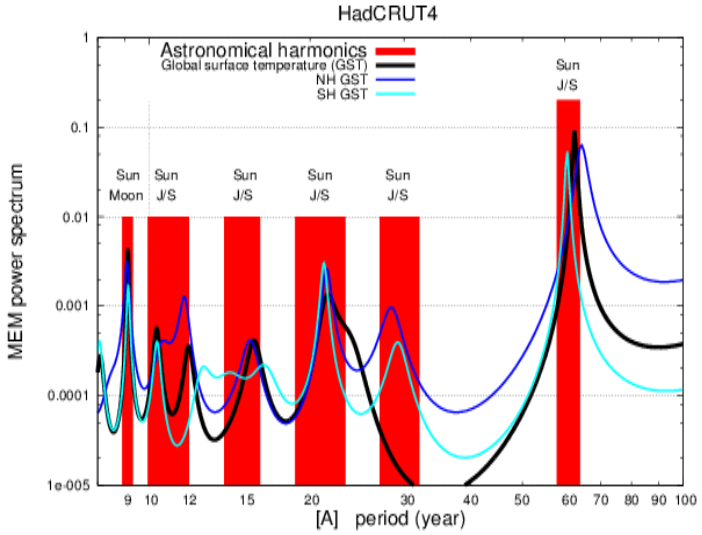



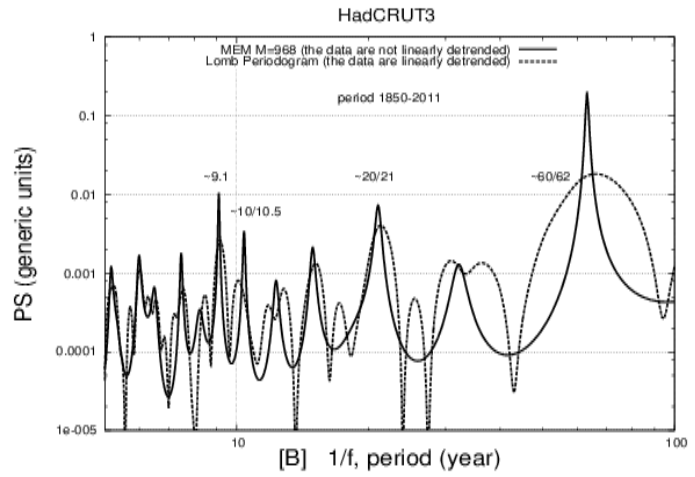



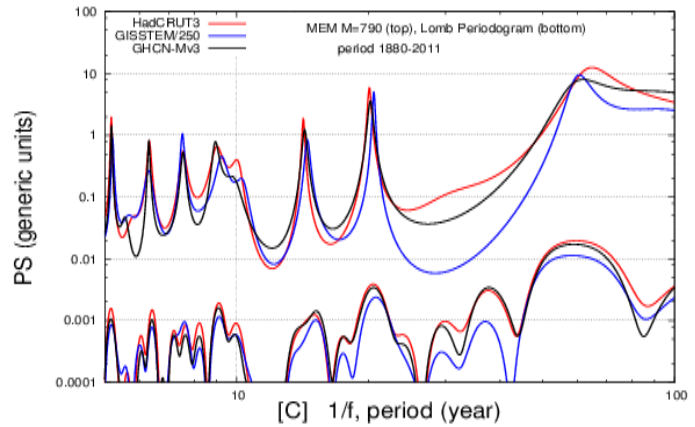



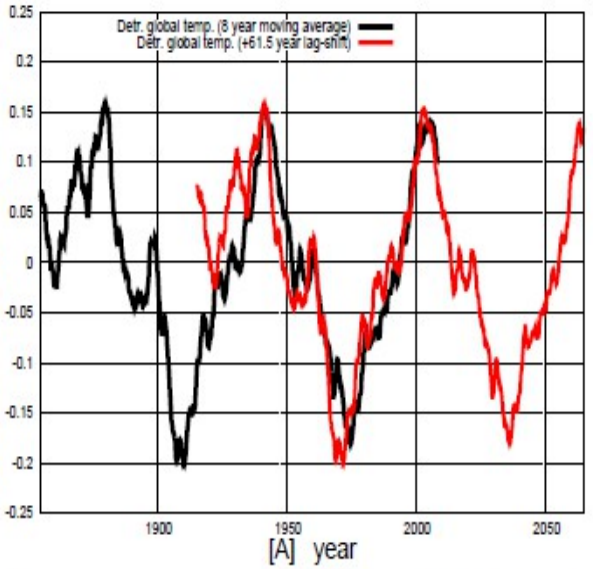
# Harmonic analysis of the global surface temperature records:

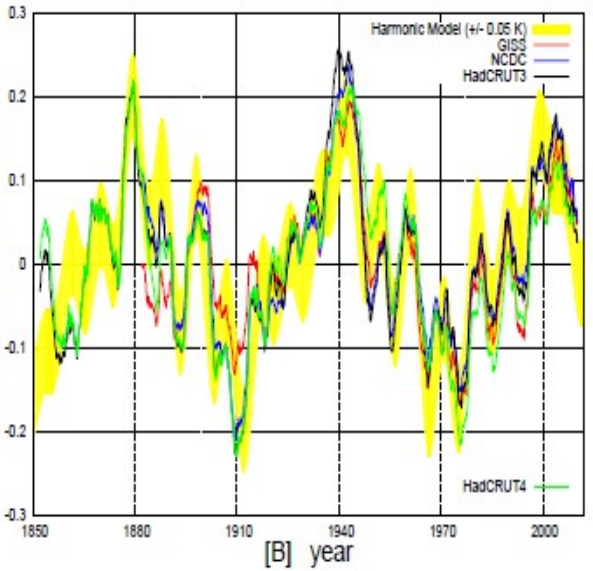
## ~9.1, ~10.5, ~20, ~60 year oscillations

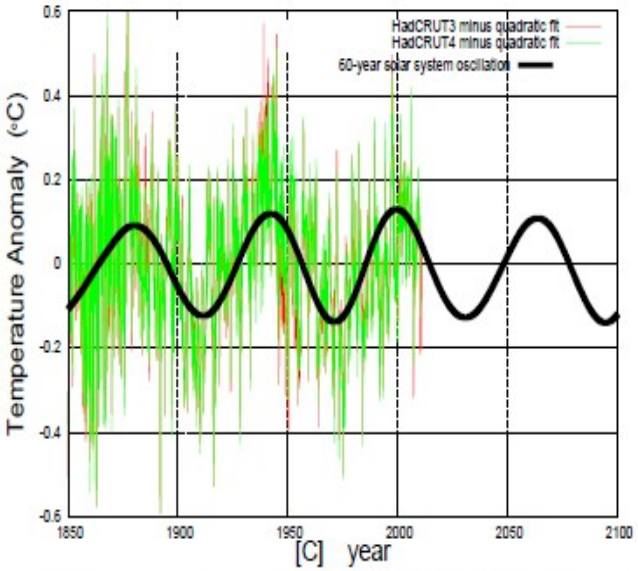


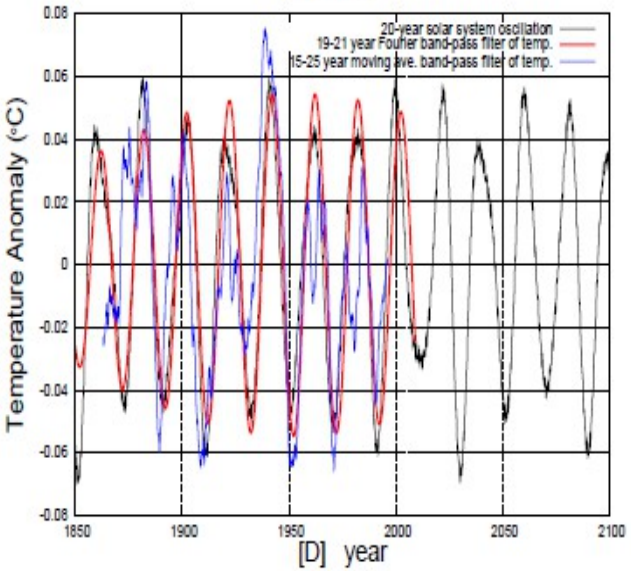



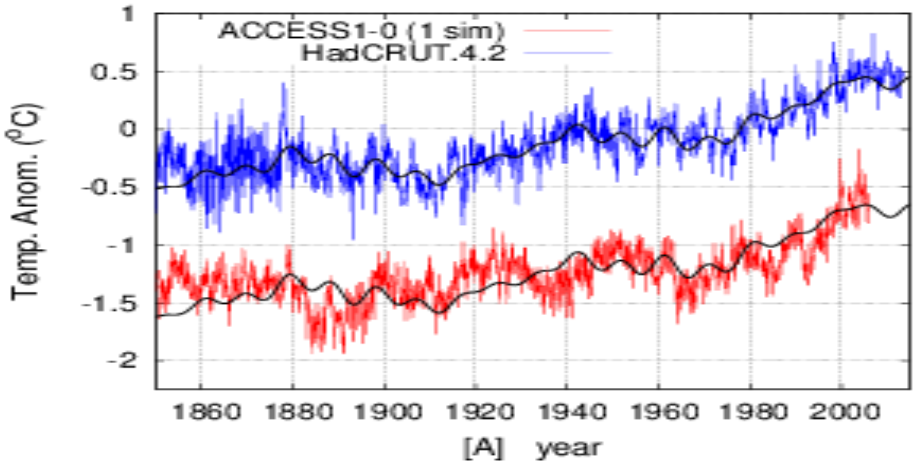



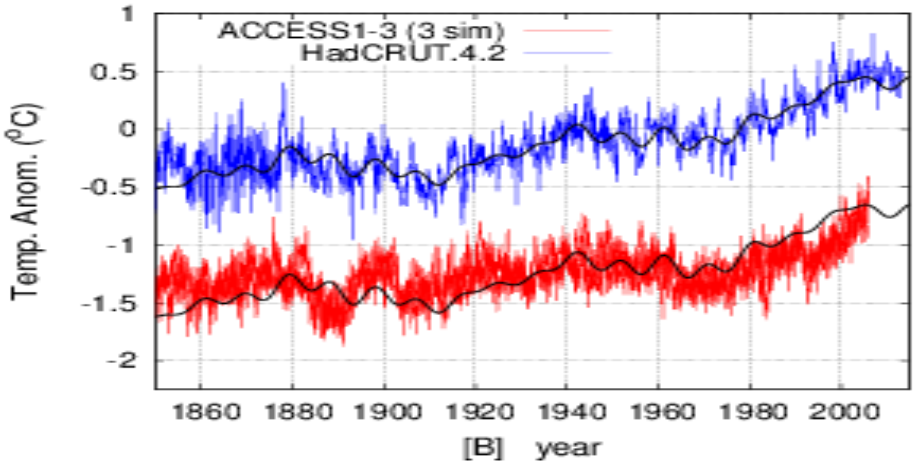



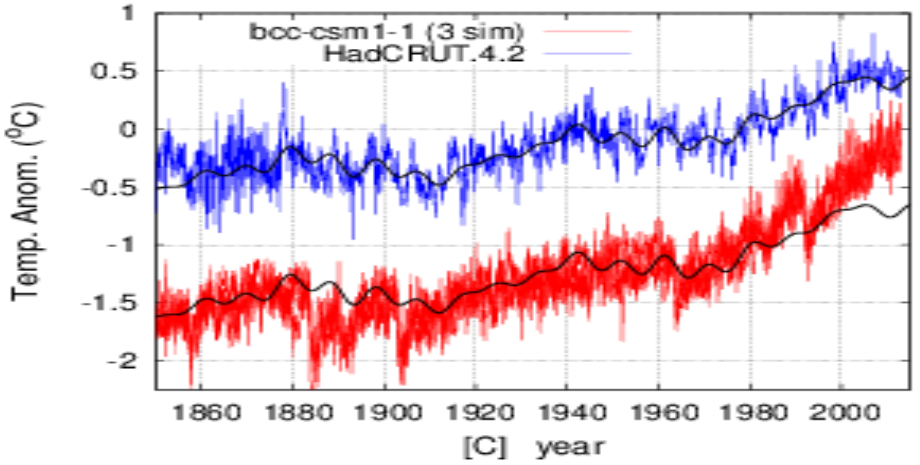



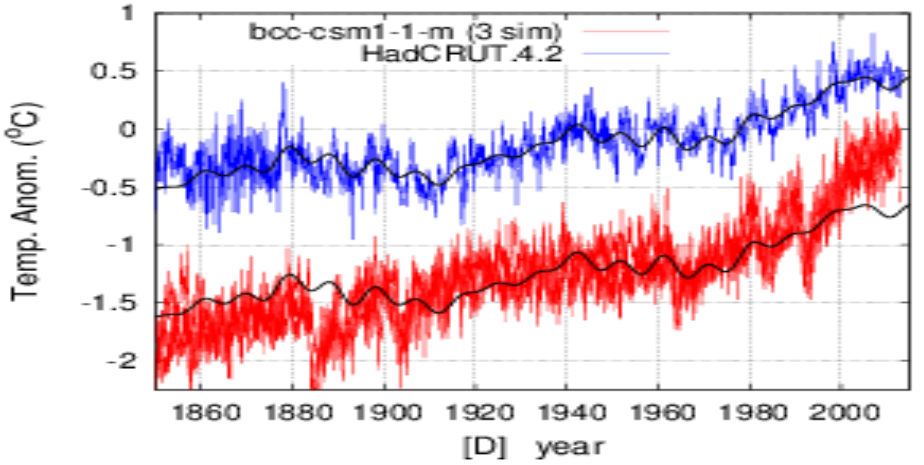



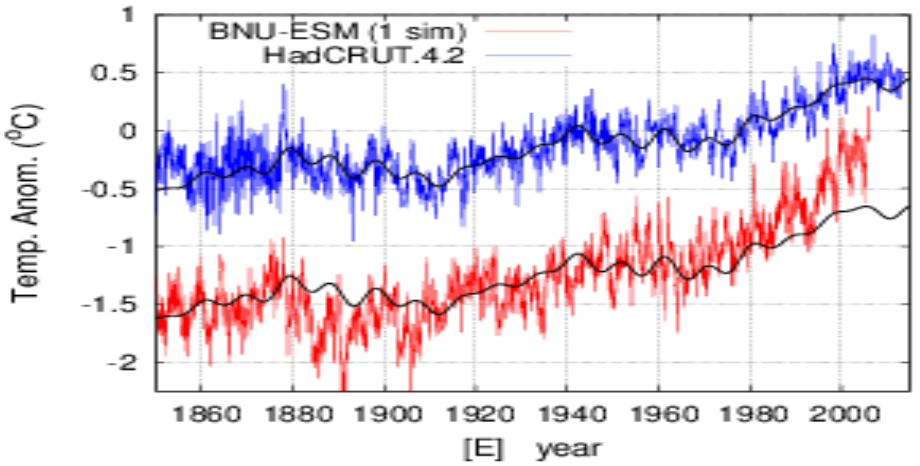
# Comparison between the CMIP5 GCMs (IPCC AR5) versus Global Surface Temperature

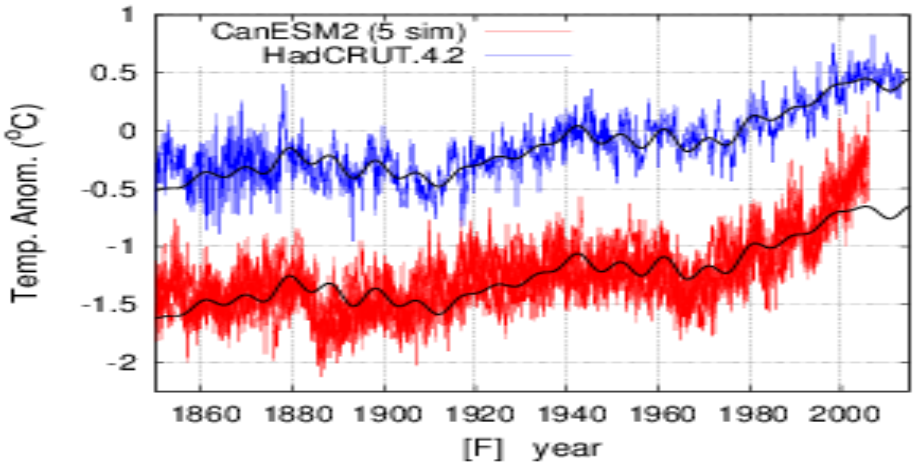


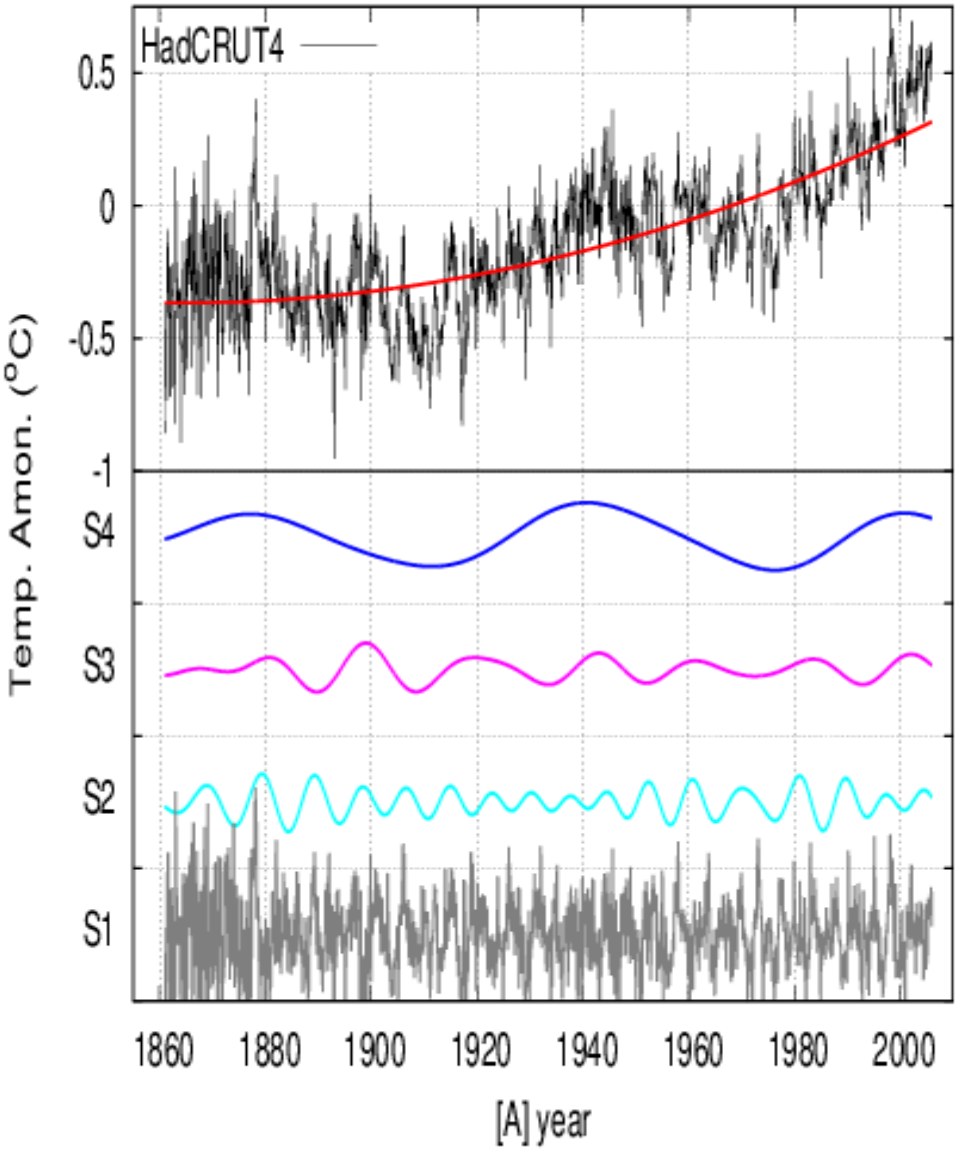



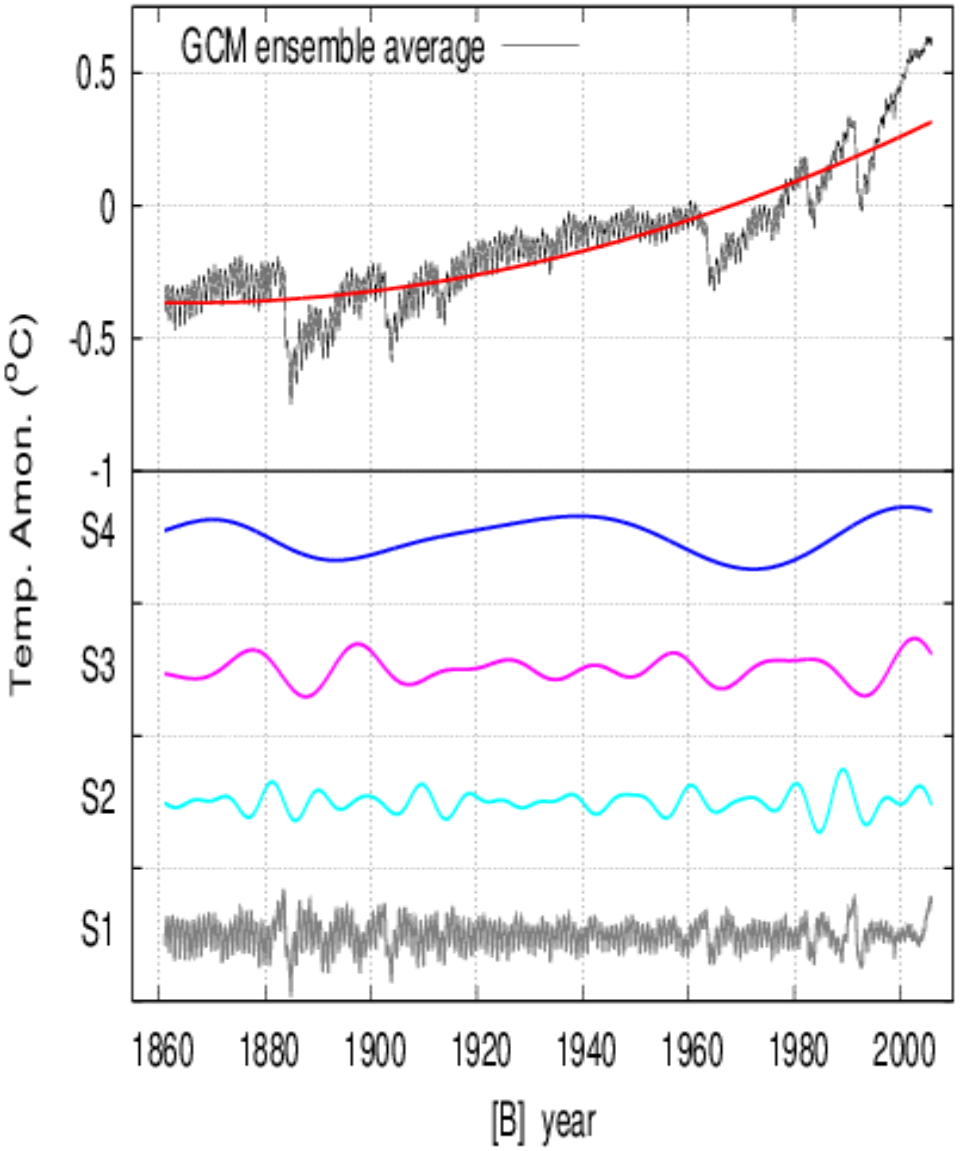



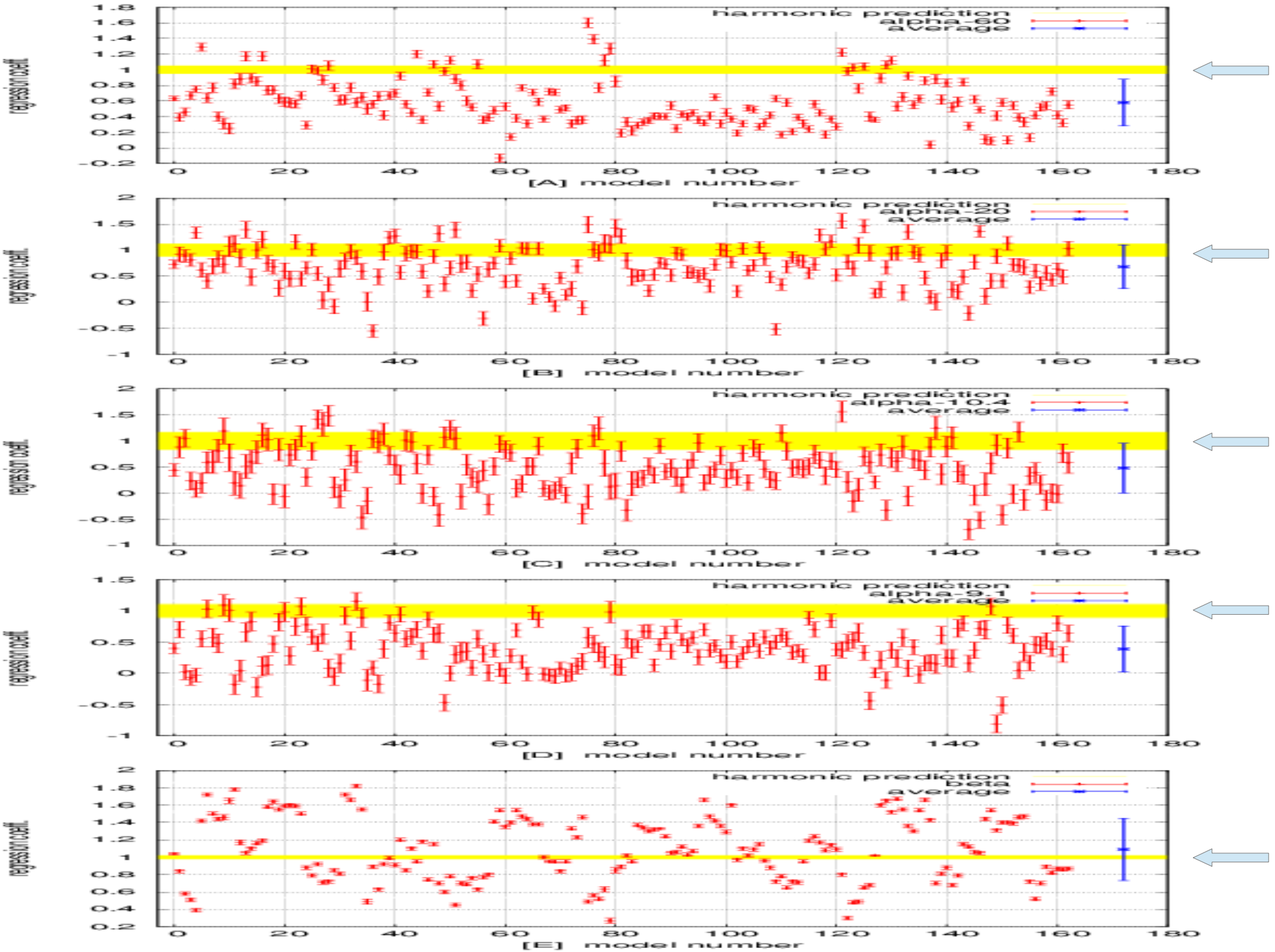



# Scale by Scale comparison between the global surface temperature versus the CMIP55 General Circulation Models



# How well the CMIP5 models get the temperature warming and cycles?



# Typical CMIP3/CMIP5 GCM failures

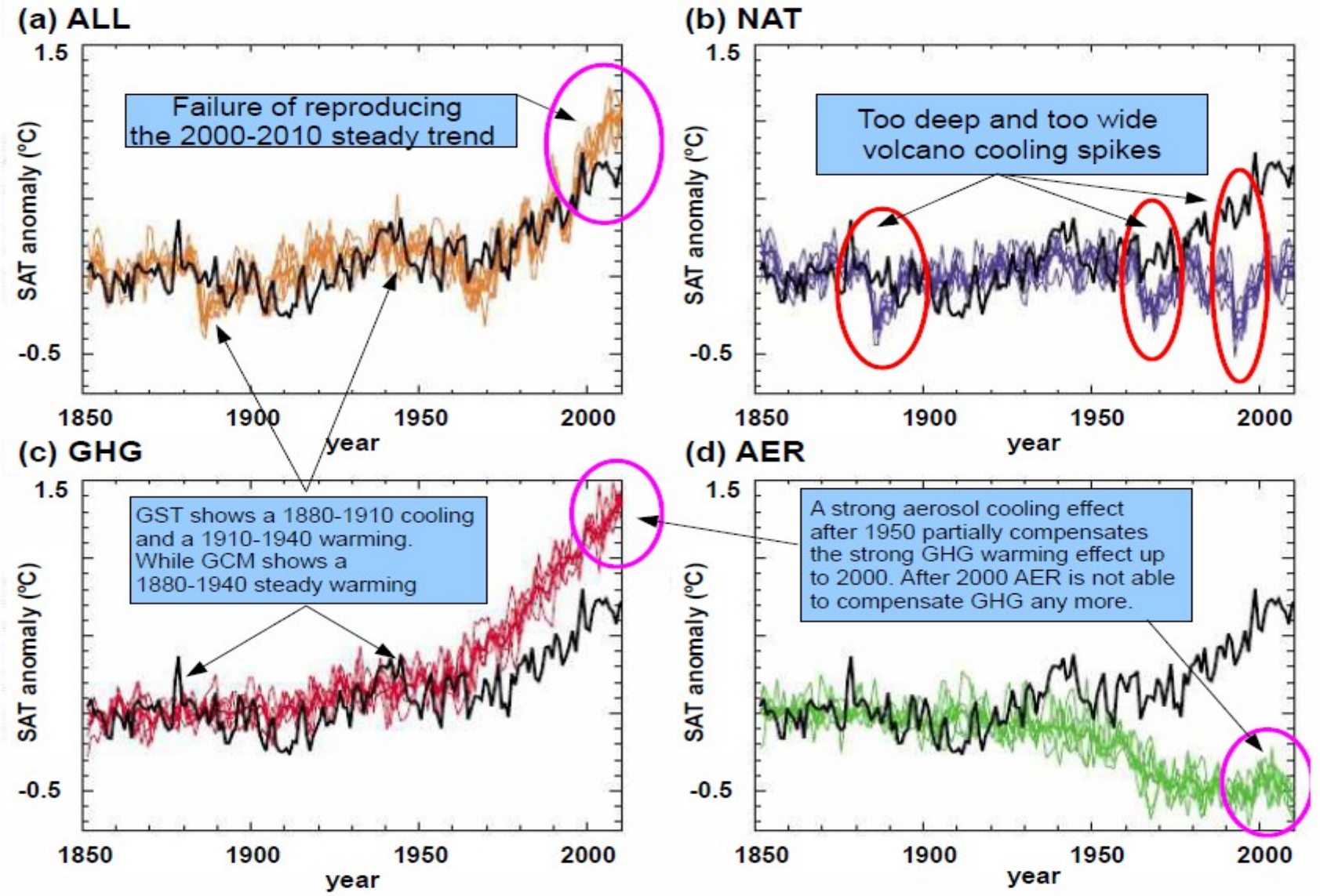
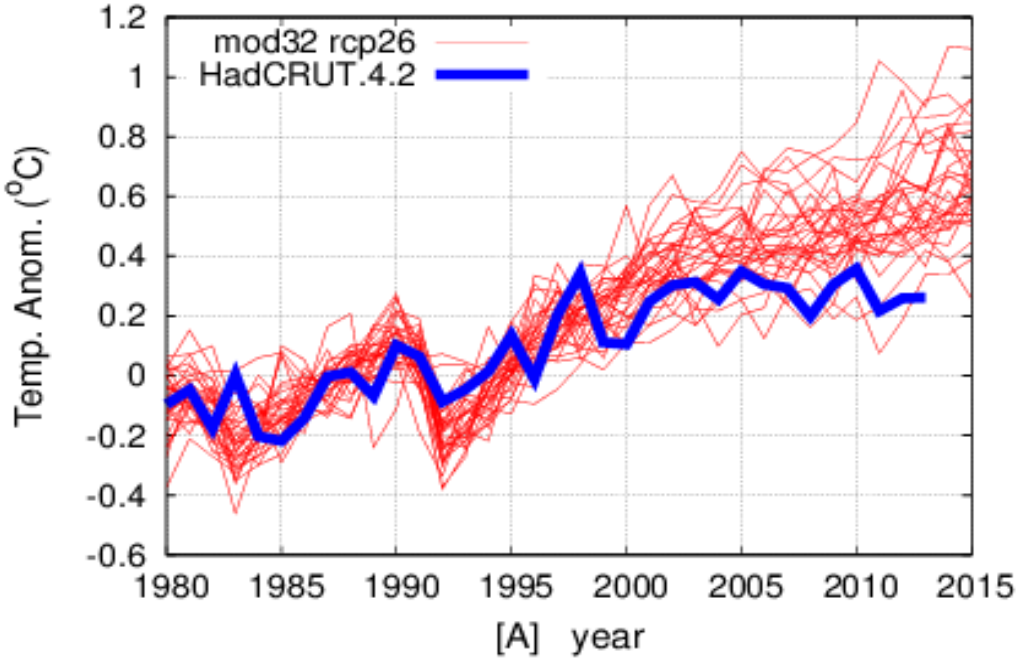
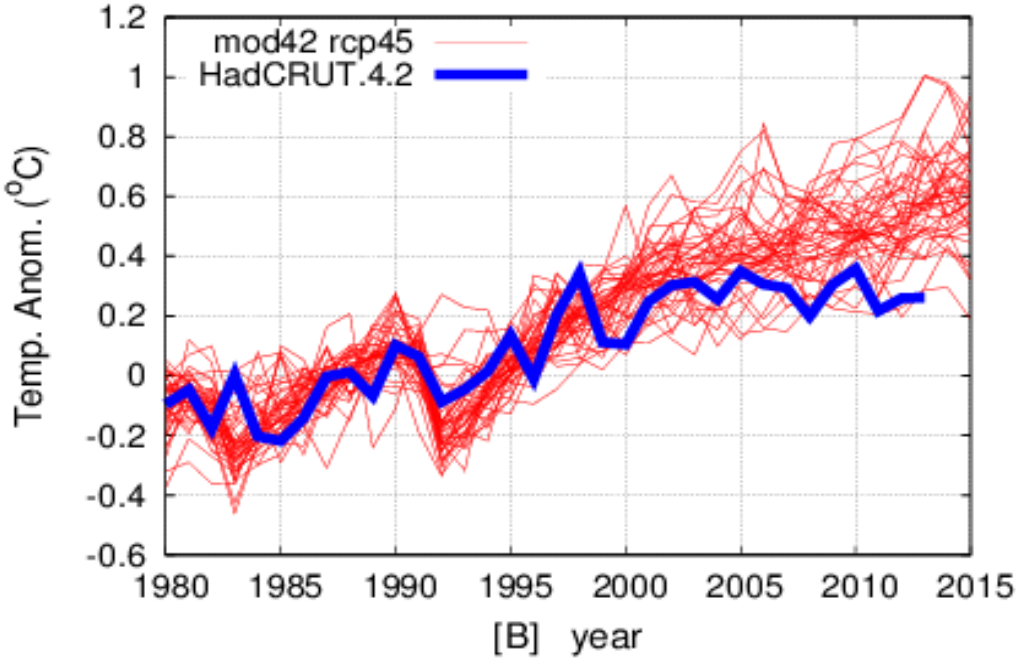
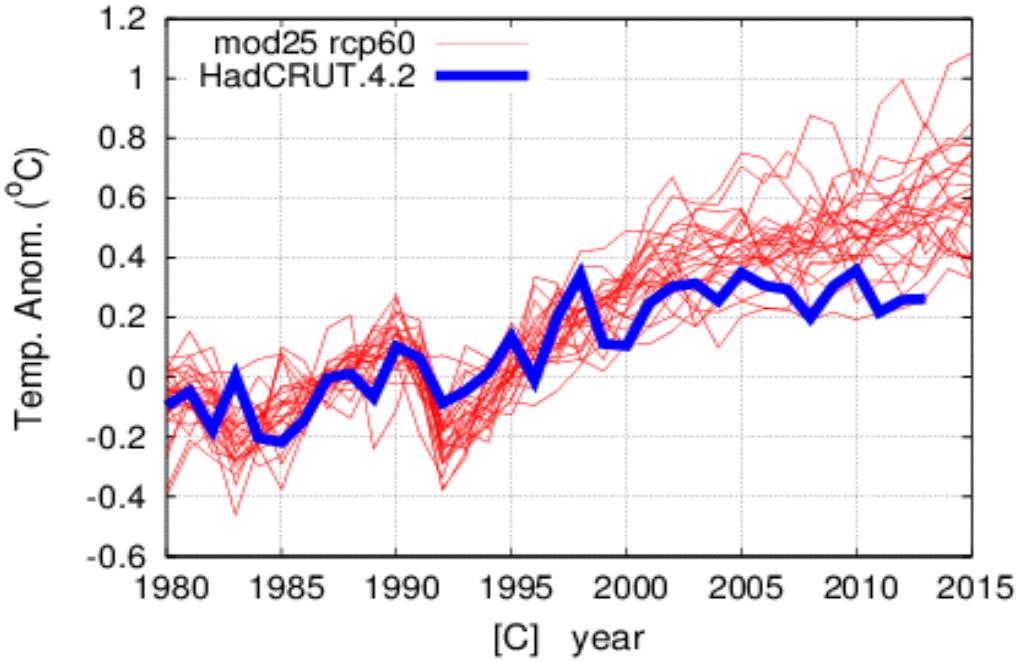


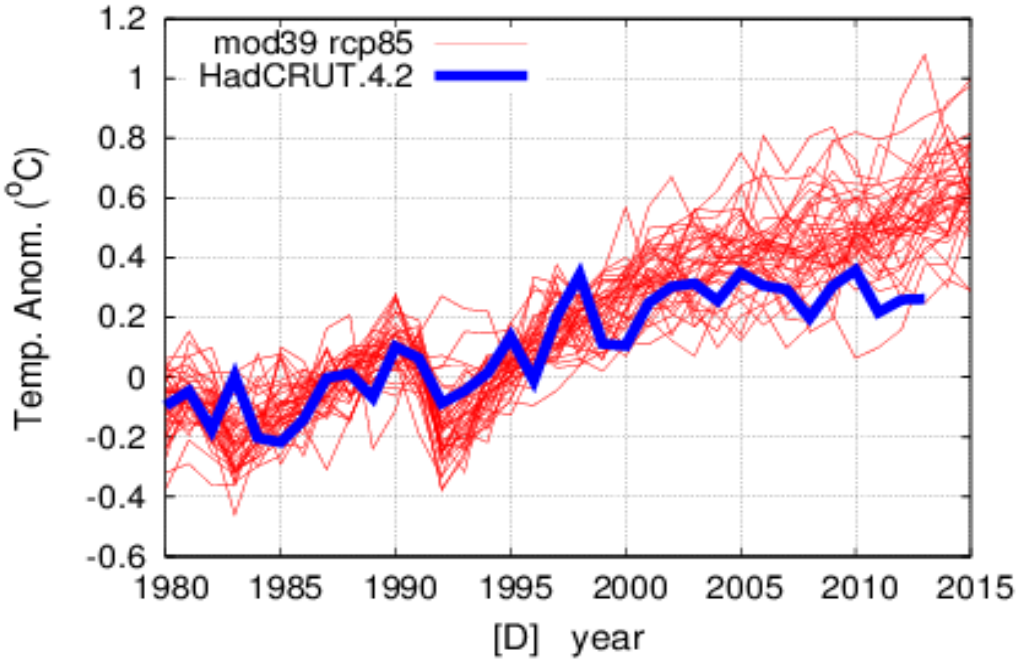

Figure 11: A reproduction of Figure 1 of Gillett et al. [88]. Comments in the diagrams highlight common problems inherent to all CMIP5 GCMs. Simulations were run with: (a) anthropogenic and natural forcings (ALL), (b) natural forcings only (NAT), (c) greenhouse gases only (GHG), and (d) aerosols only (AER).

# The CMIP5 models fail macroscopically to get the GST plateau after 2000

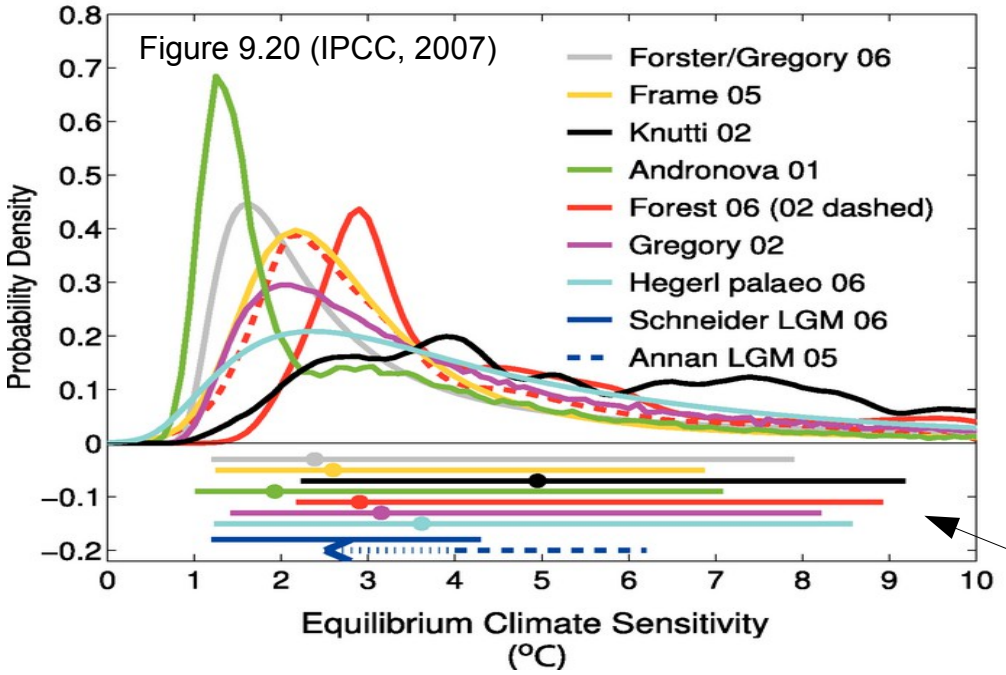


# Huge uncertainty in the Equilibrium Climate Sensitivity

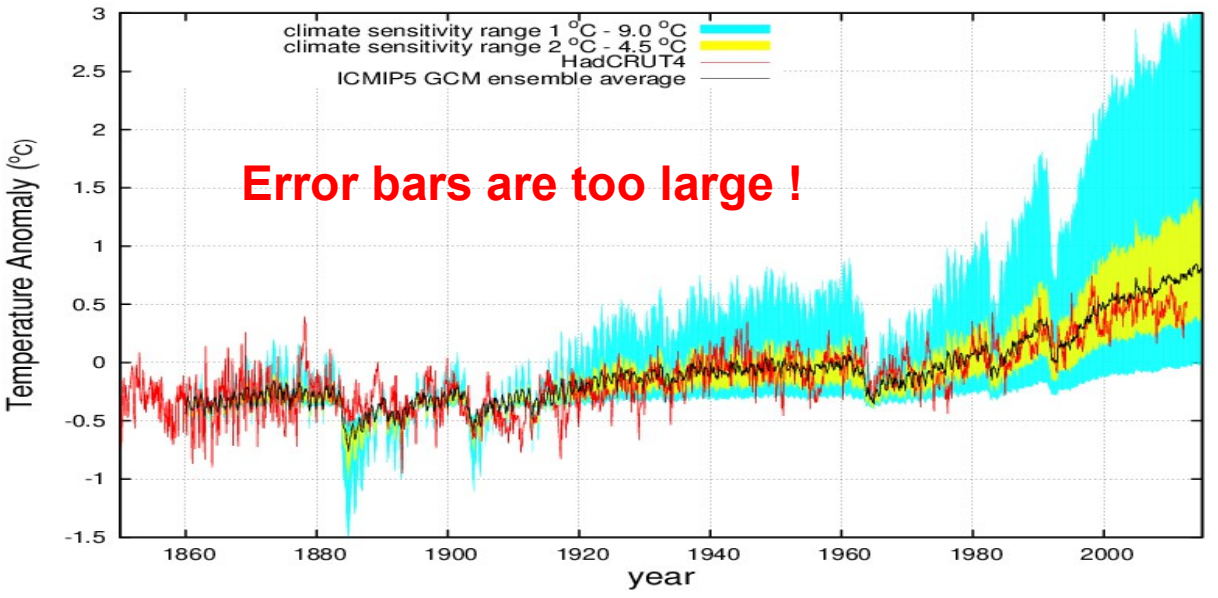



**The general circulation models (GCM) used by the IPCC claim that a doubling of $CO_2$ atmospheric concentration would increase the temperature by ~ 3 °C.**

**However, today the equilibrium climate sensitivity is extremely uncertain.**
**The error bars span from 1 to 9 °C.**

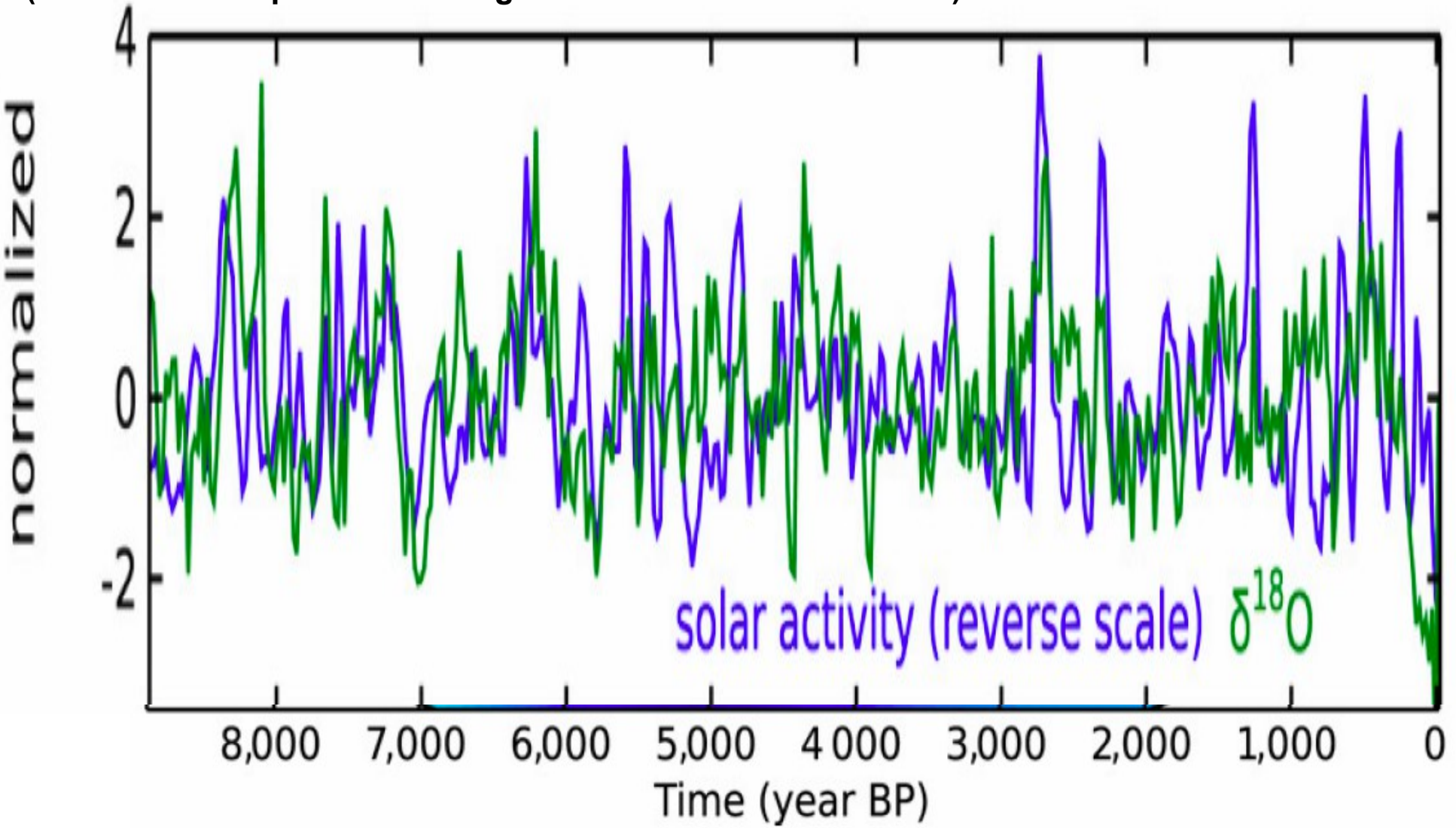
**It is not possible to determine whether missing and/or erroneous forcings regulate climate.**

Possible missing forcings:
- Gravitational
- Magnetic
- Chemical (cosmic ray, UV, etc.)
- Adopted TSI may be wrong



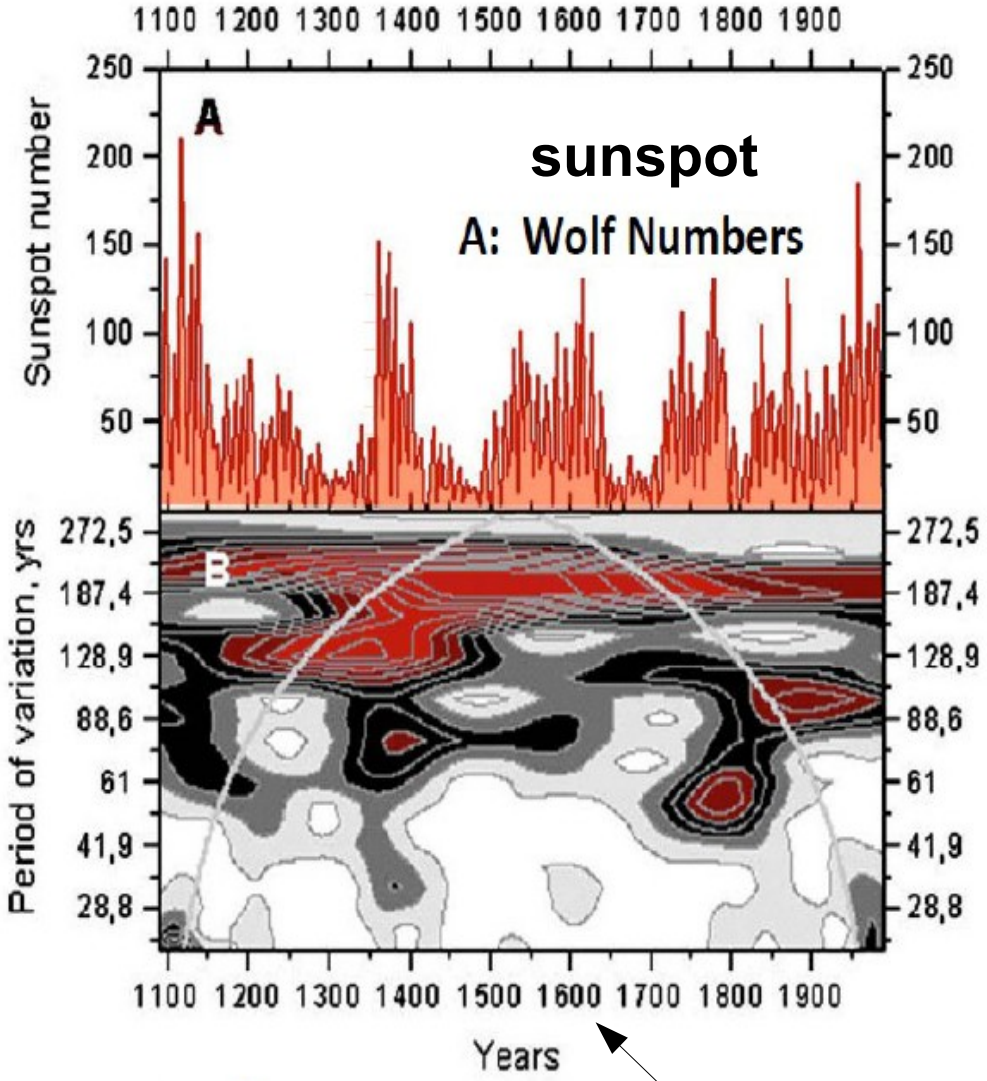
# Solar records and temperature records are synchronous throughout the Holocene

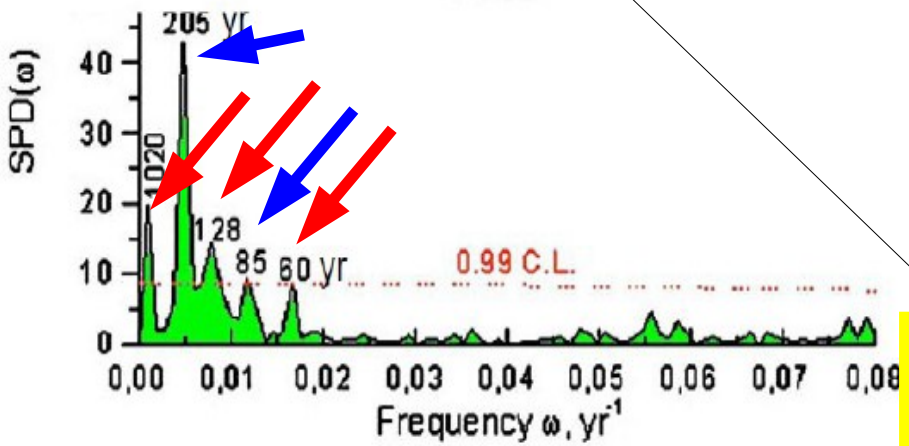
**Comparison of solar activity (total solar irradiance [TSI]) in blue and $\delta^{18}O$ from Dongge cave, China, in green representing changes of the Asian climate. Possibly the Asian monsoon (AM) (low $\delta^{18}O$ corresponds to strong AM monsoon and vice versa).**

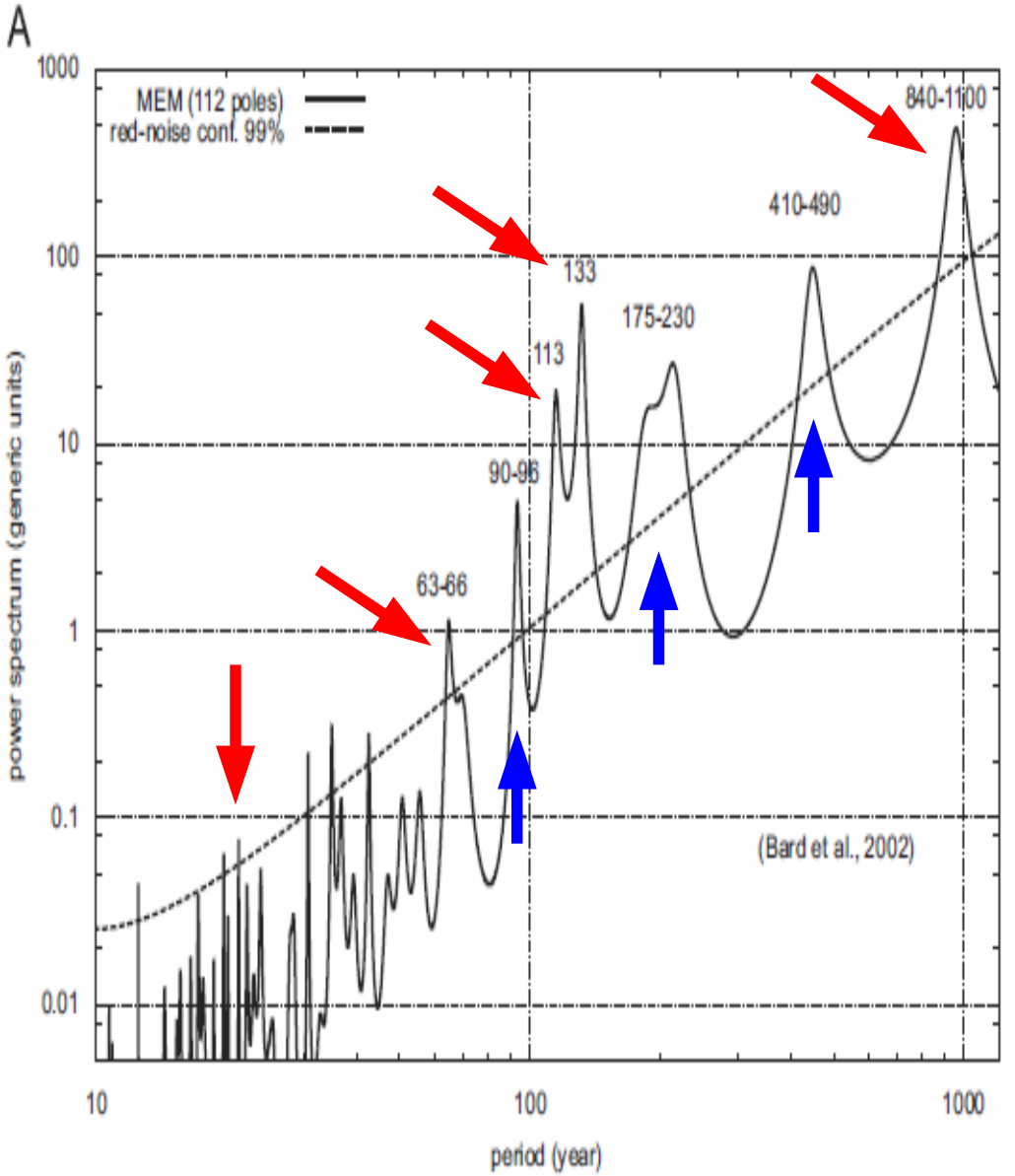



Steinhilber F et al. PNAS 2012;109:5967-5971

**Power spectrum evaluations of solar records: ~20, ~60, ~85, ~115, ~130, ~210, ~500 and ~1000 year cycles**

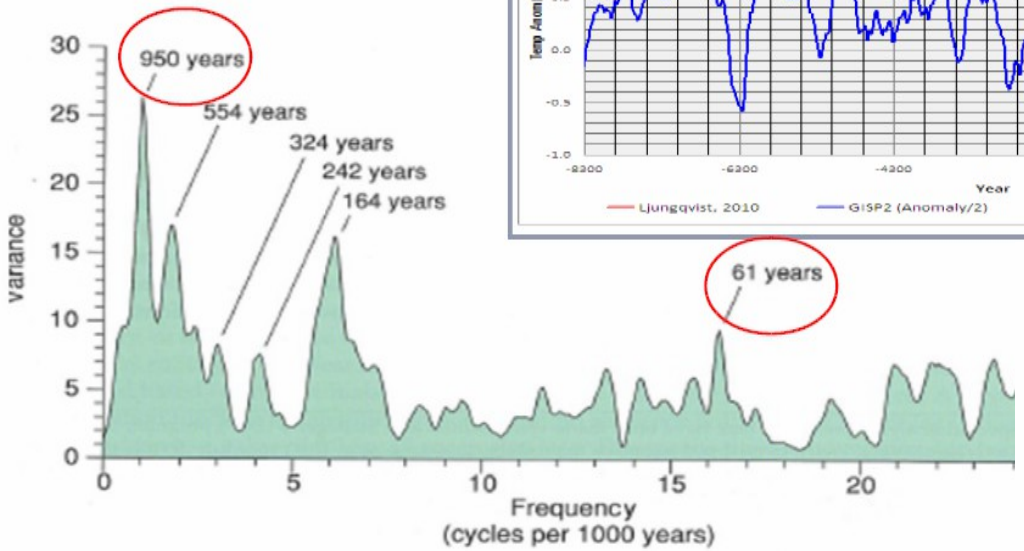



Ogurtsov, M.G., Y.A. Nagovitsyn, G.E. Kocharov, and H. Jungner (2002). Long-period cycles of the Sun's activity recorded in direct solar data and Solar Phys. 211, 371-394.

## A ~60-year cycle in Multi-millennial records



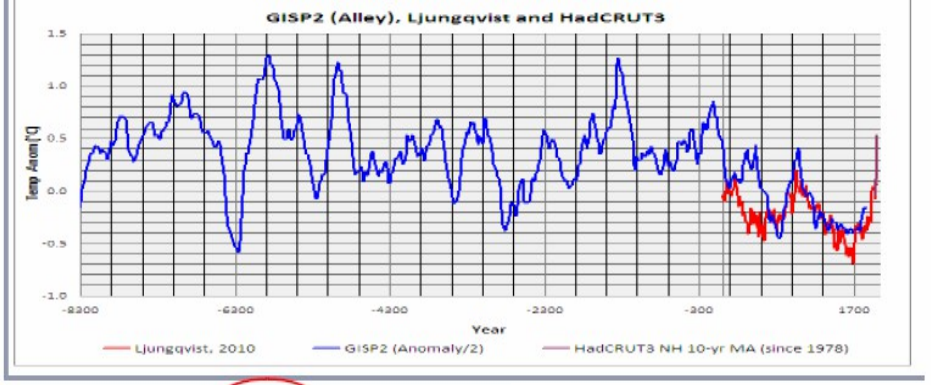
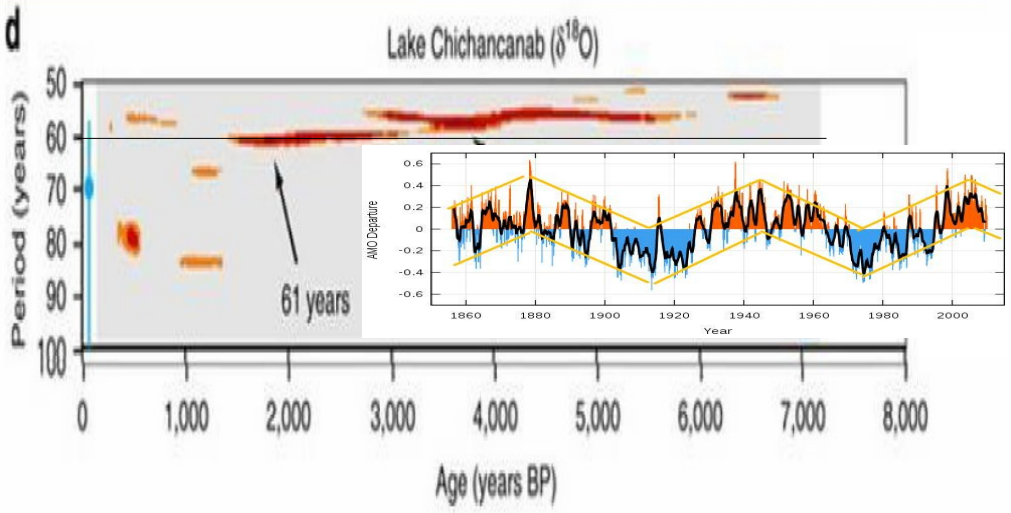




Figure 7 Power spectrum of 2-m average record of $\delta^{18}O$ ratios measured on the Holocene portion of the GISP2 ice core. Wavelengths, in years, of dominant peaks are labeled.

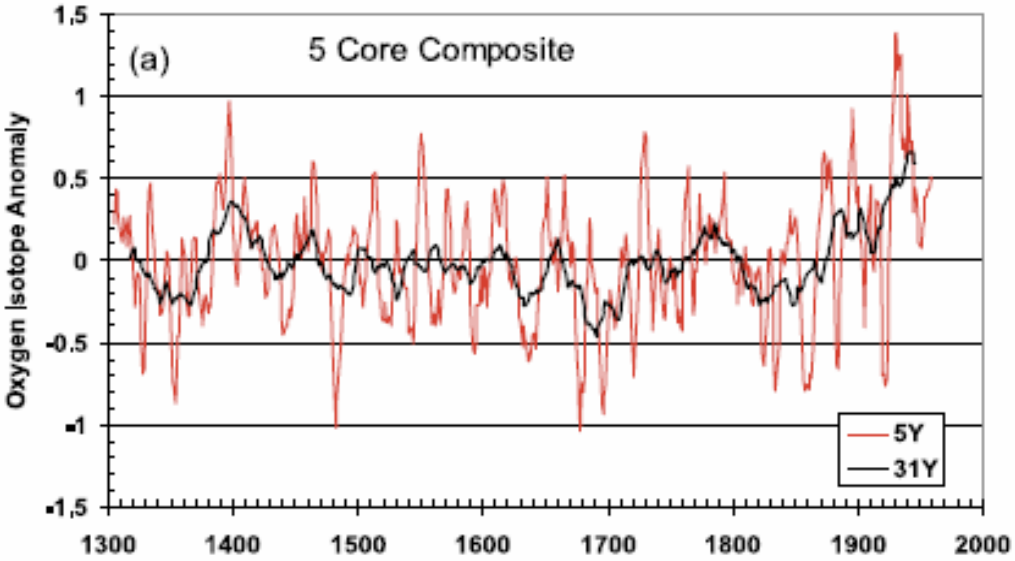
Davis, J. C., and G. Bohling, 2001. The Search for Patterns in Ice-Core Temperature Curves: in Geological Perspectives of Global Climate Change. Ed. Gerhard, L. C., E. H. William, et al.. Geological Perspectives of Global Climate Change 213-230.

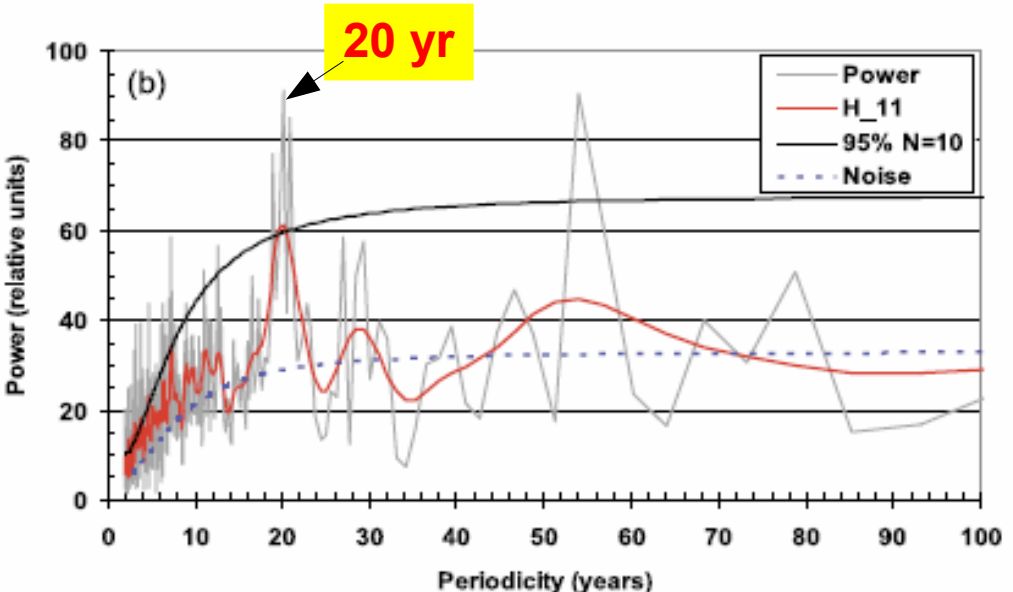
Knudsen et al., Tracking the Atlantic Multidecadal Oscillation through the last 8,000 years, Nature Communications, 2011.




**~20 yr and ~60 yr cycles in multisecular and multi-millennial climate records**

Chylek, P., C. K. Folland, H. A. Dijkstra, G. Lesins, and M. K. Dubey (2011), Ice-core data evidence for a prominent near 20 year time-scale of the Atlantic Multidecadal Oscillation, Geophys. Res. Lett., 38, L13704



# Monsoon rainfall cycles as depicted in ancient Sanskrit texts

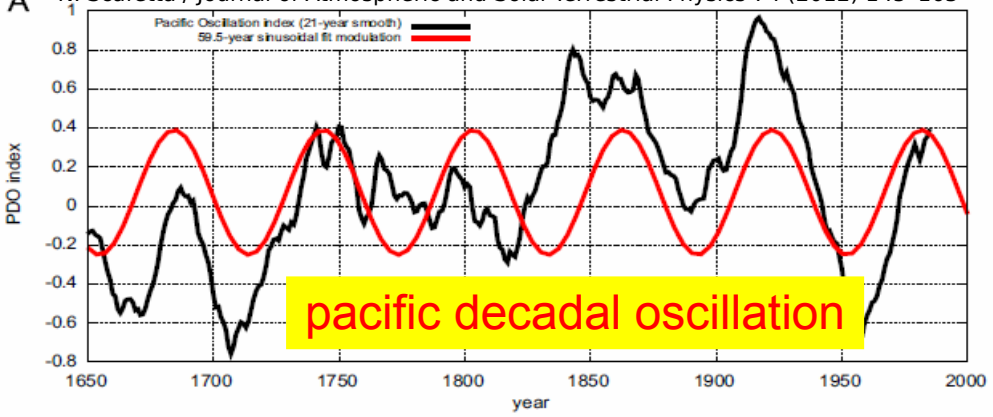
*R. N. Iyengar*

## The Brihaspati - Jupiter 60-year cycle in the climate

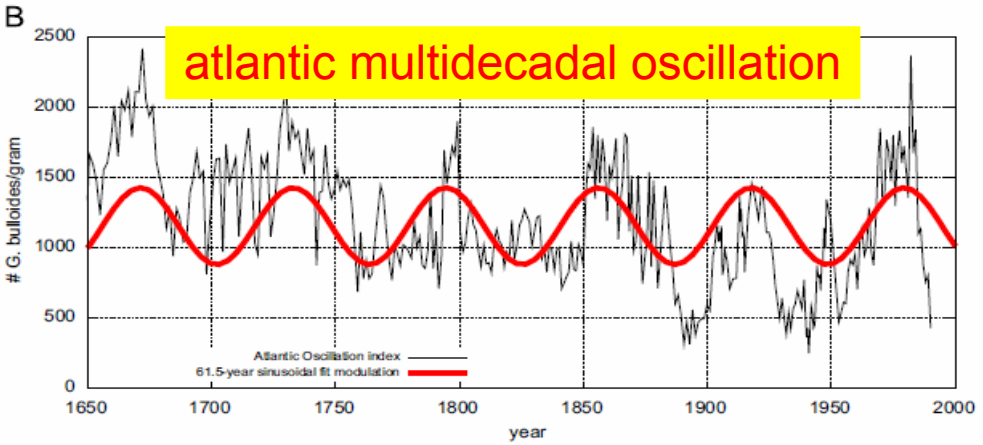
*Year to year variation of Indian monsoon rainfall is described qualitatively in some ancient Sanskrit texts. Interestingly, these are cyclic with periods of 3, 5, 7, 18 and 60 years. Time series analysis of actual seasonal rainfall data shows that at very near the abov visibility portent stated in the Arthaśāstra appears t the rainfall.*

N. Scafetta / Journal of Atmospheric and Solar-Terrestrial Physics 74 (2012) 145–163

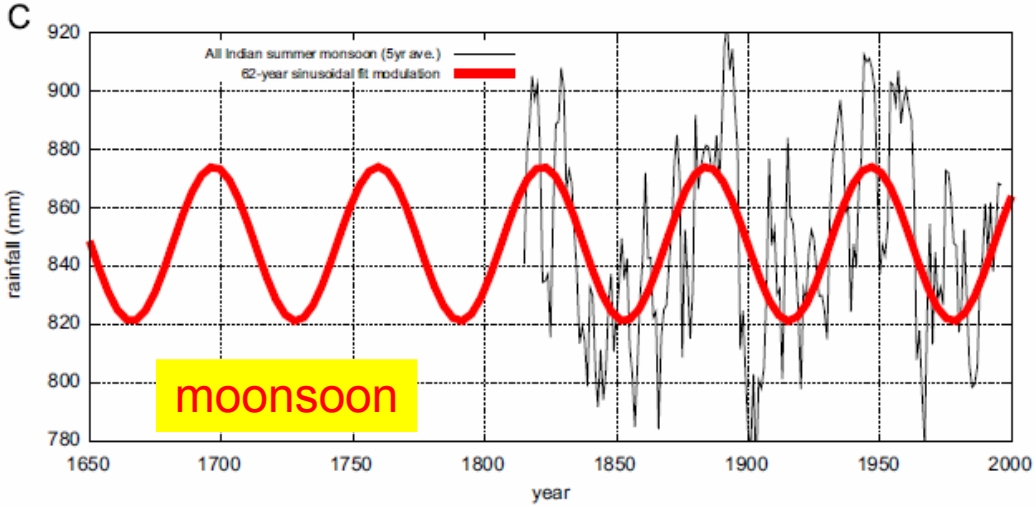
A

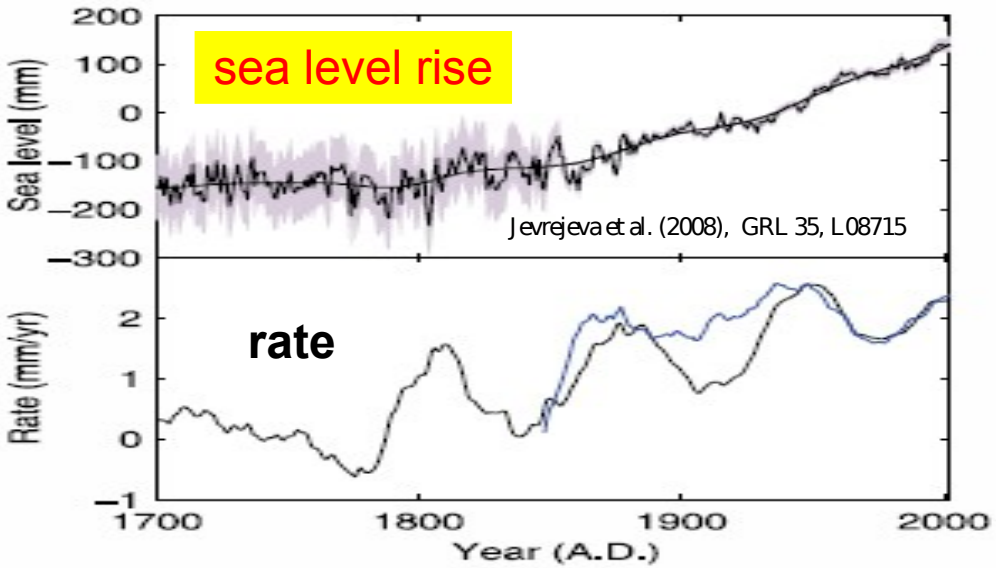



B

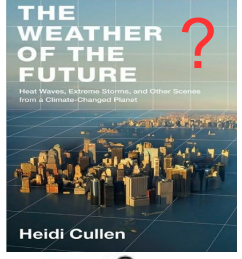



C



Scafetta N., 2013. Discussion on common errors in analyzing sea level accelerations, solar trends and global warming. Pattern Recognition in Physics, 1, 37–57. DOI: 10.5194/prp-1-37-2013



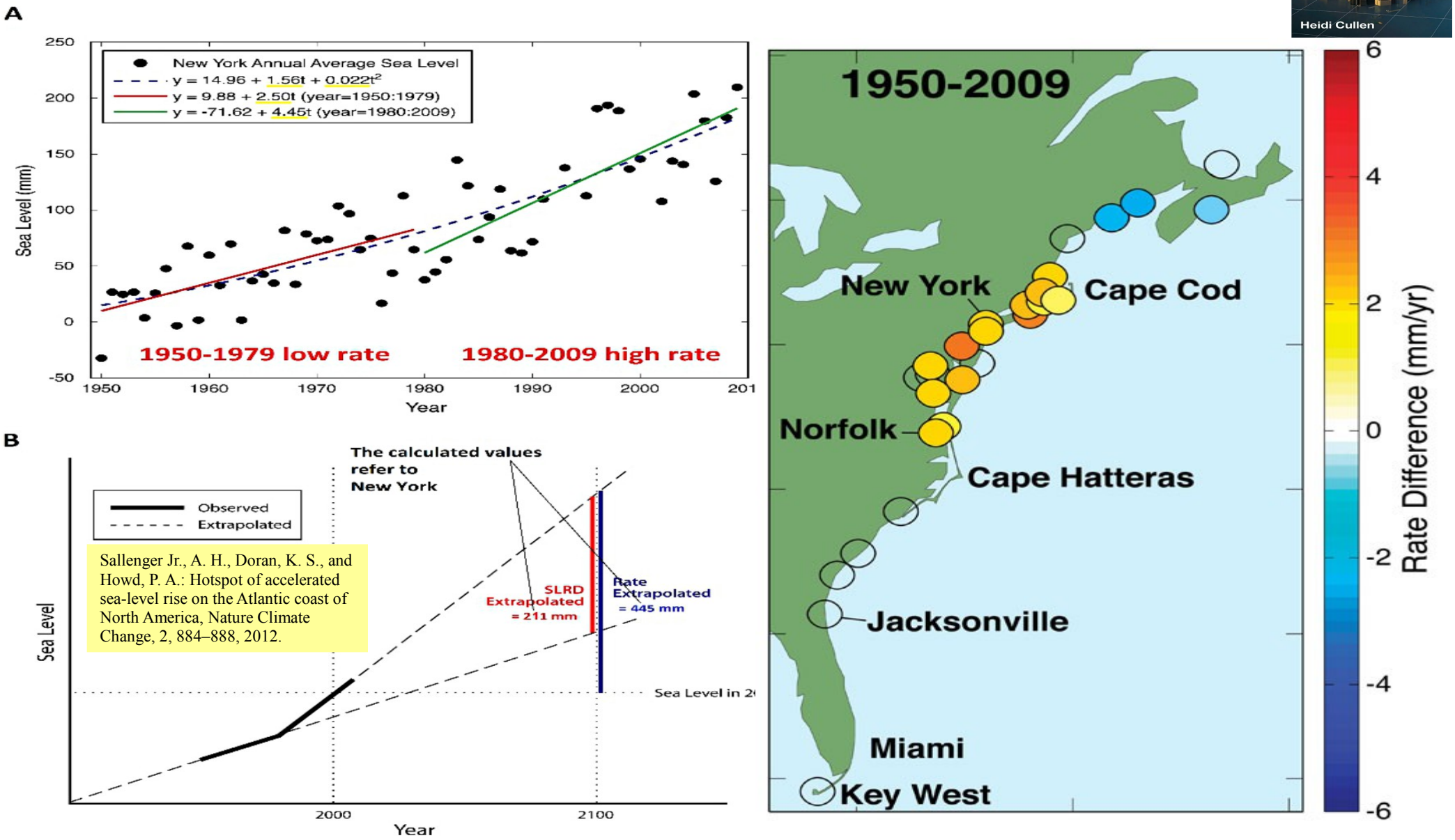
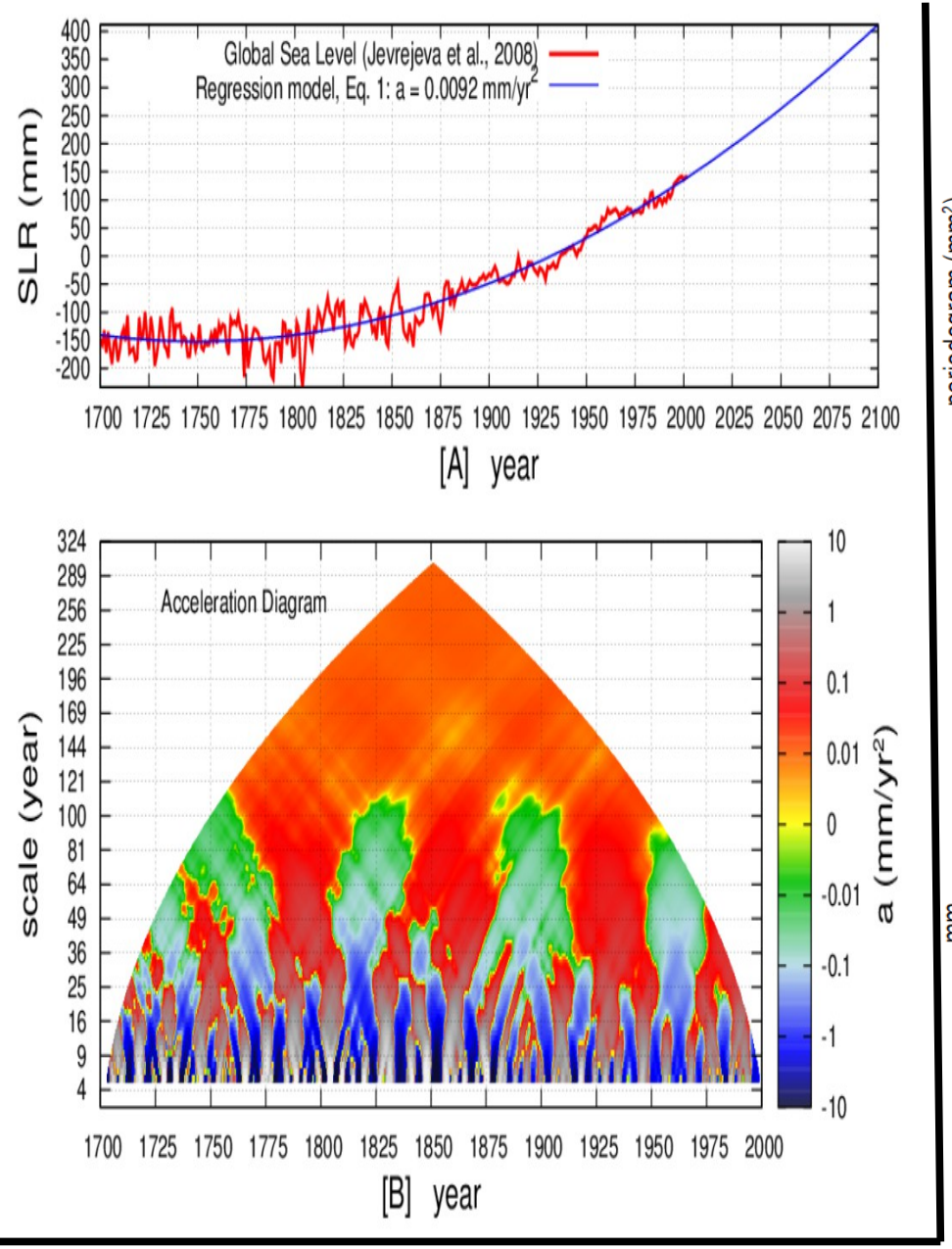




**Figure 1.** Reproduction and comments of Sallenger Jr. et al.'s (2012) figures S7 and S8. **(A)** Sea level record in New York as interpreted in Sallenger Jr. et al.'s (2012) figures S7 in their supplementary file. **(B)** Predicted sea level rate difference between the two half-window series (SLRD) for the 21st century as interpreted in Sallenger Jr. et al.'s (2012) figures S8 in their supplementary file.



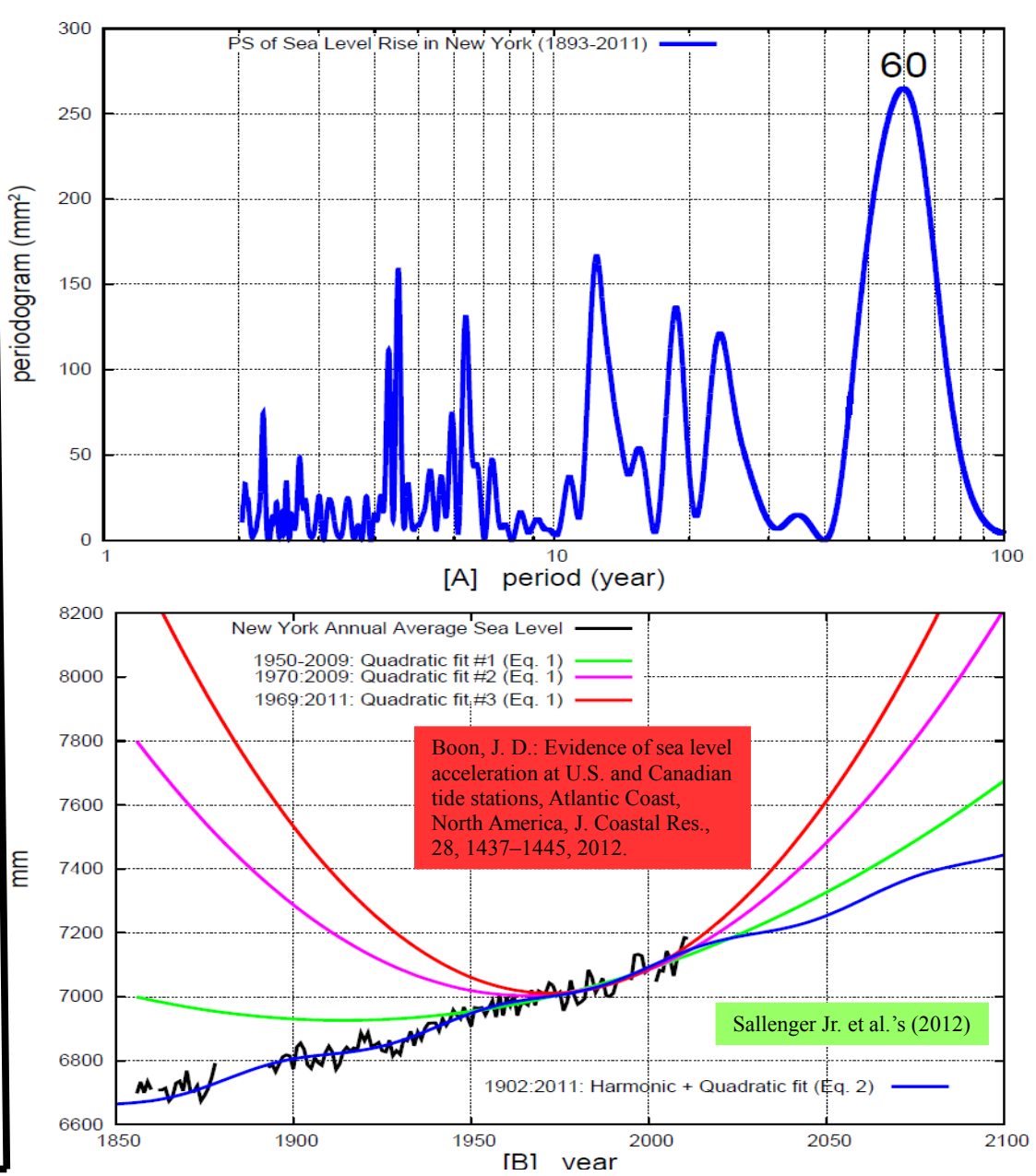
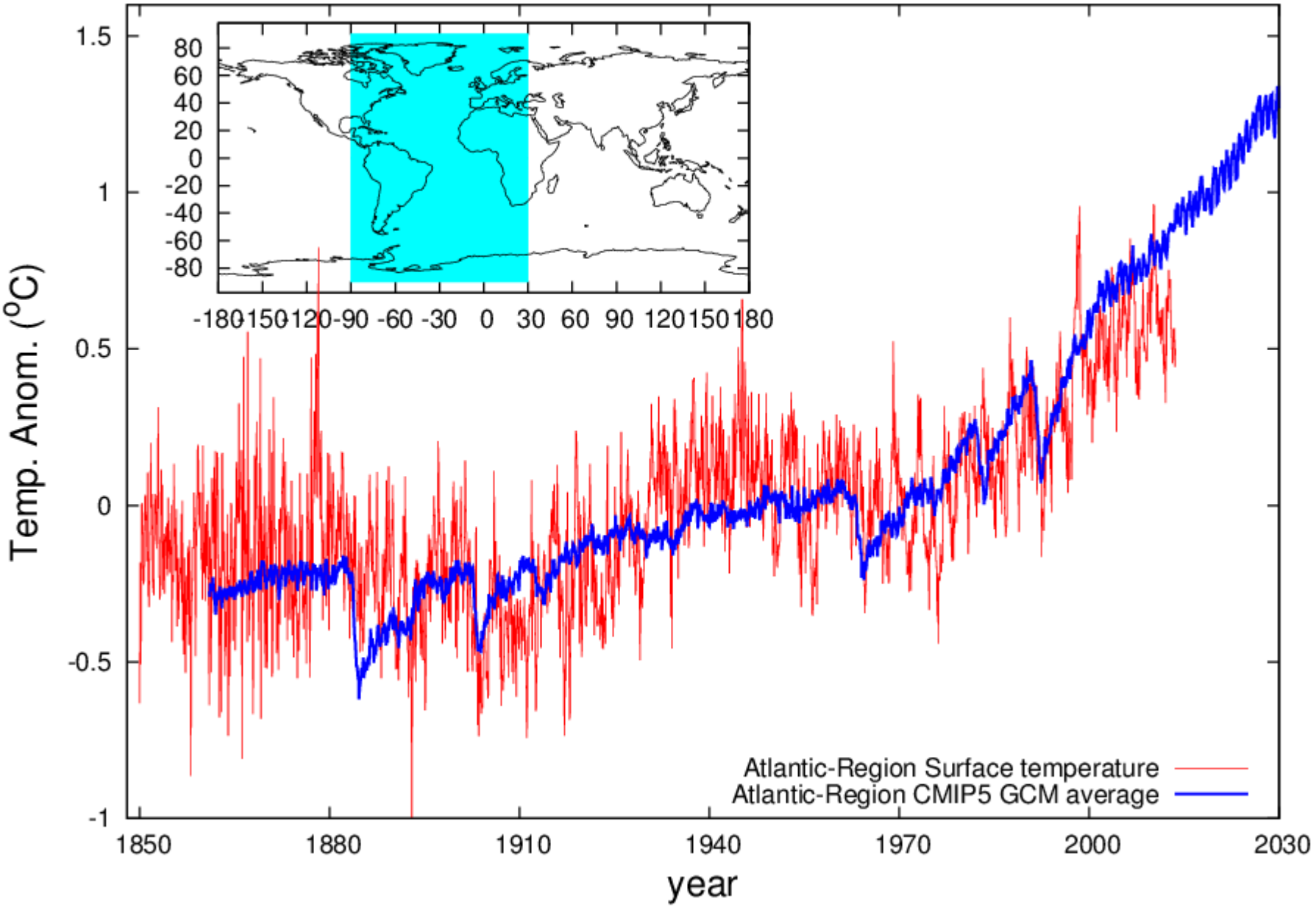




**Figure 3.** **(A)** Periodogram of the tide gauge record for New York City (1893–2011) that highlights a dominant quasi 60 yr oscillation. The data are linearly detrended before applying the periodogram algorithm for improved stability at lower frequencies. **(B)** Sea level record for New York City (black) fitted with Eq. (2) (blue) from 1902 to 2011, and with the Eq. (1) from 1950 to 2009 (green), from 1970 to 2009 (purple) and from 1969 to 2011 (red). Projections #1 and #2 use Sallenger Jr. et al.'s (2012) method, projection #3 uses Boon's (2012) method. The blue model agrees far better with the data since 1856 and likely produces the most realistic projection for the 21st century; see also Scafetta (2013) for additional details.

# Comparison between Atlantic-Region GST versus CMIP5 GCM prediction



# Preliminary Summary

- **The origin of many climatic oscillations have been found in astronomical cycles.**
- **The IPCC uses specific GCMs to infer that natural variability induced by the Sun is very small and explains only a few percent of the warming observed from 1850 to 2012.**
- **The IPCC GCM predicted natural variability is approximately compatible with the pre-industrial natural variability observed Mann's 1999 Hockey Stick temperature graph.**
- **Mann's Hockey Stick is contradicted by more recent pre-industrial temperature reconstructions showing a far greater past natural temperature variability, which questions the IPCC GCMs.**
- **Quasi 10, 20, 60 and 1000 yr cycles are easily visible in the data.**

**May these and other oscillations have an astronomical origin?**

# The “consensus” ancient theory of Ptolemy and Kepler of a lunar/planetary modulation of the climate system

**TETRABIBLOS (2nd century A.D.)**

“A very few considerations would make it apparent to all that a certain power emanating from the eternal ethereal substance is dispersed through and permeates the whole region about the earth...”

“For the **sun**, together with the ambient, is always in same way affecting everything on the earth...”

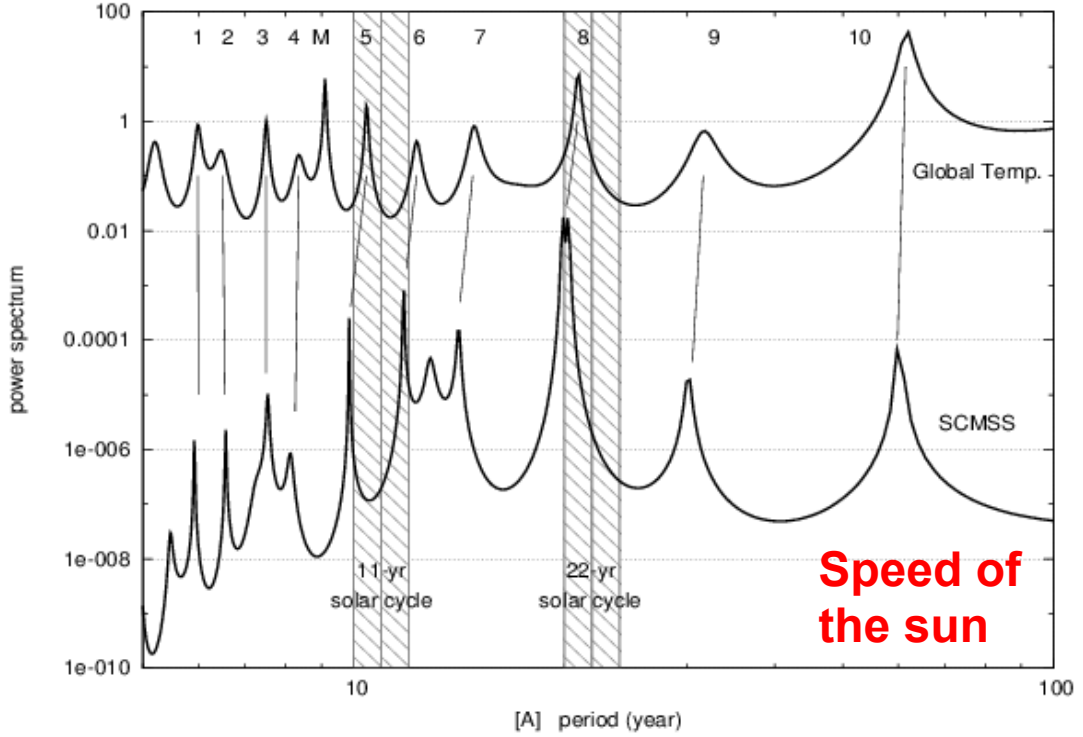
“The **moon**, too, as the heavenly body nearest the earth, bestows her effluence ….”

“Moreover, the passages of the fixed stars and the **planets** through the sky ... bring about many complicated changes.”

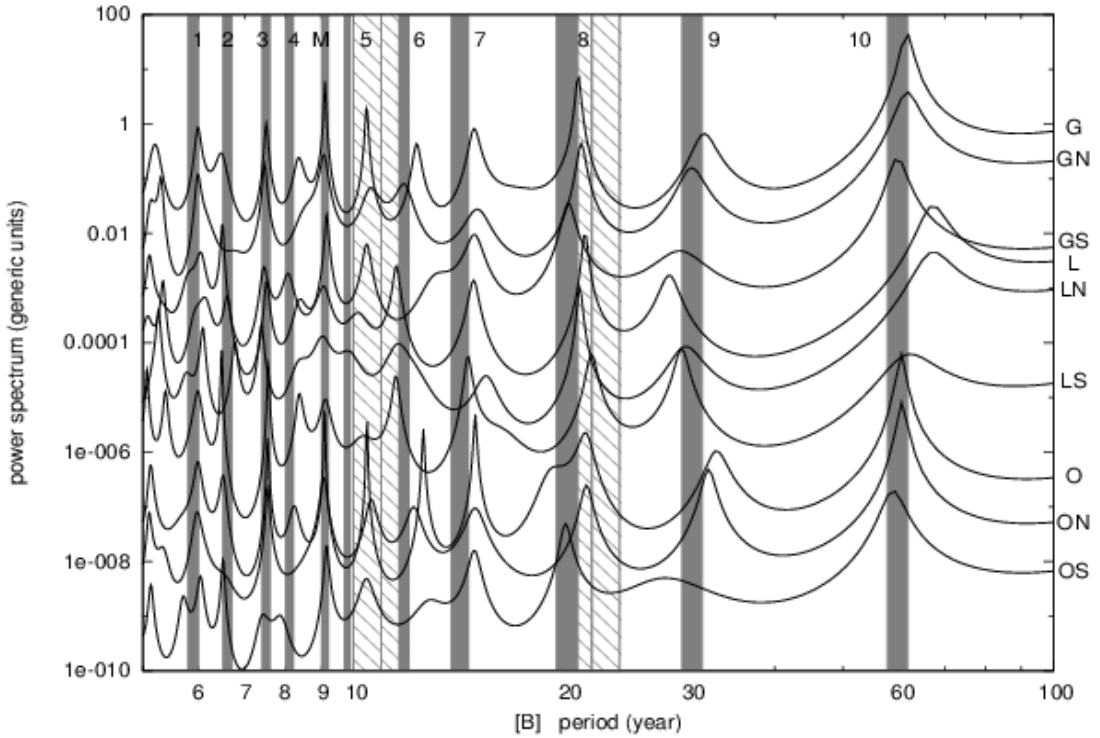
Stonehenge Astronomical Observatory

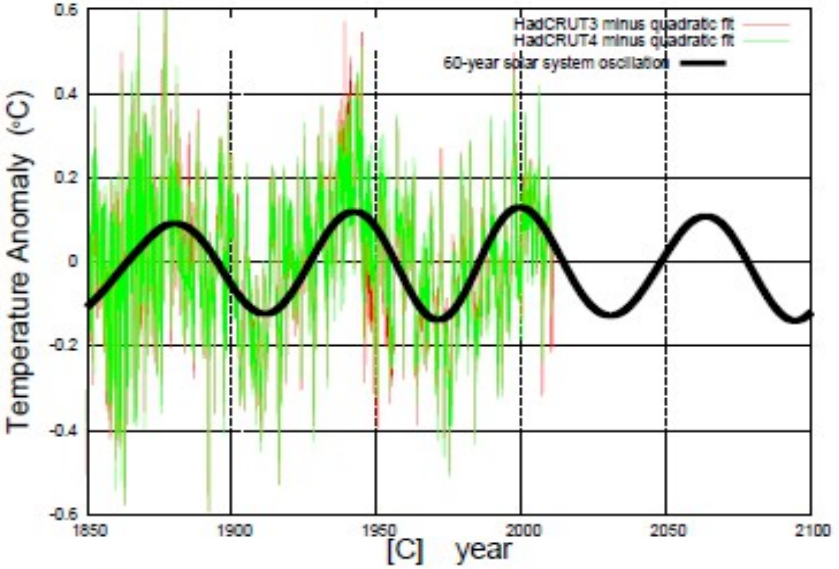
# Harmonic analysis of the global Surface temperature records:

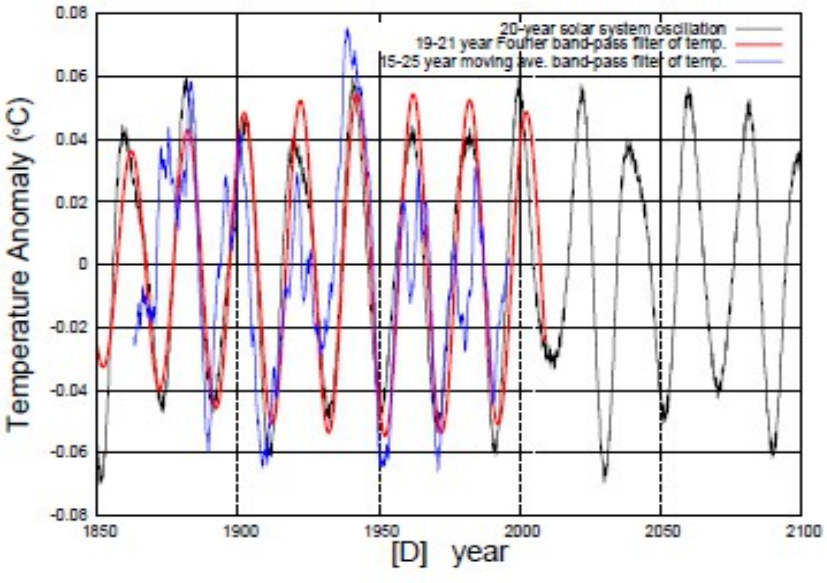
## ~9.1, ~10.5, ~20, ~60 year oscillations



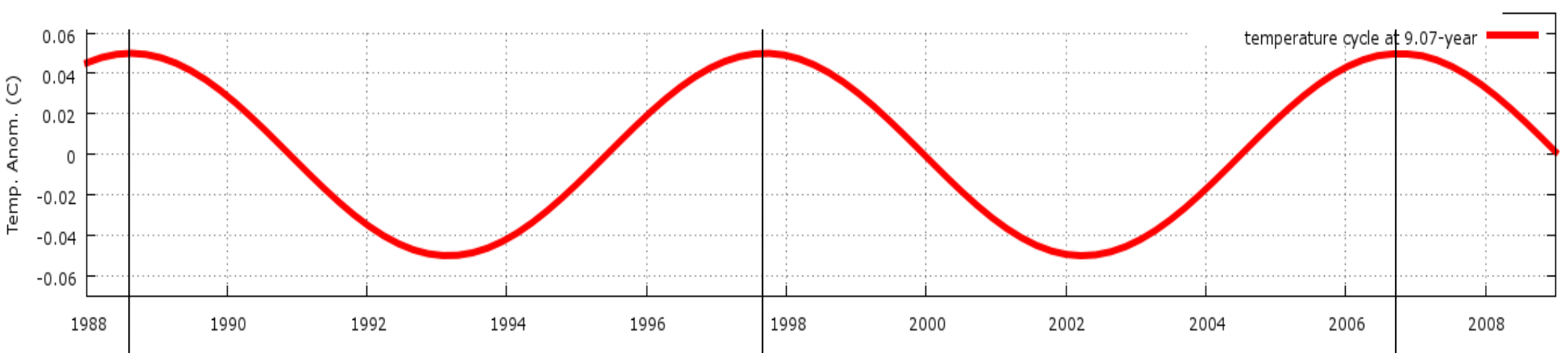

Speed of the sun



# The 9.07-year Temperature Cycle is very likely induced by a soli-lunar tidal cycle




~9-year cycle

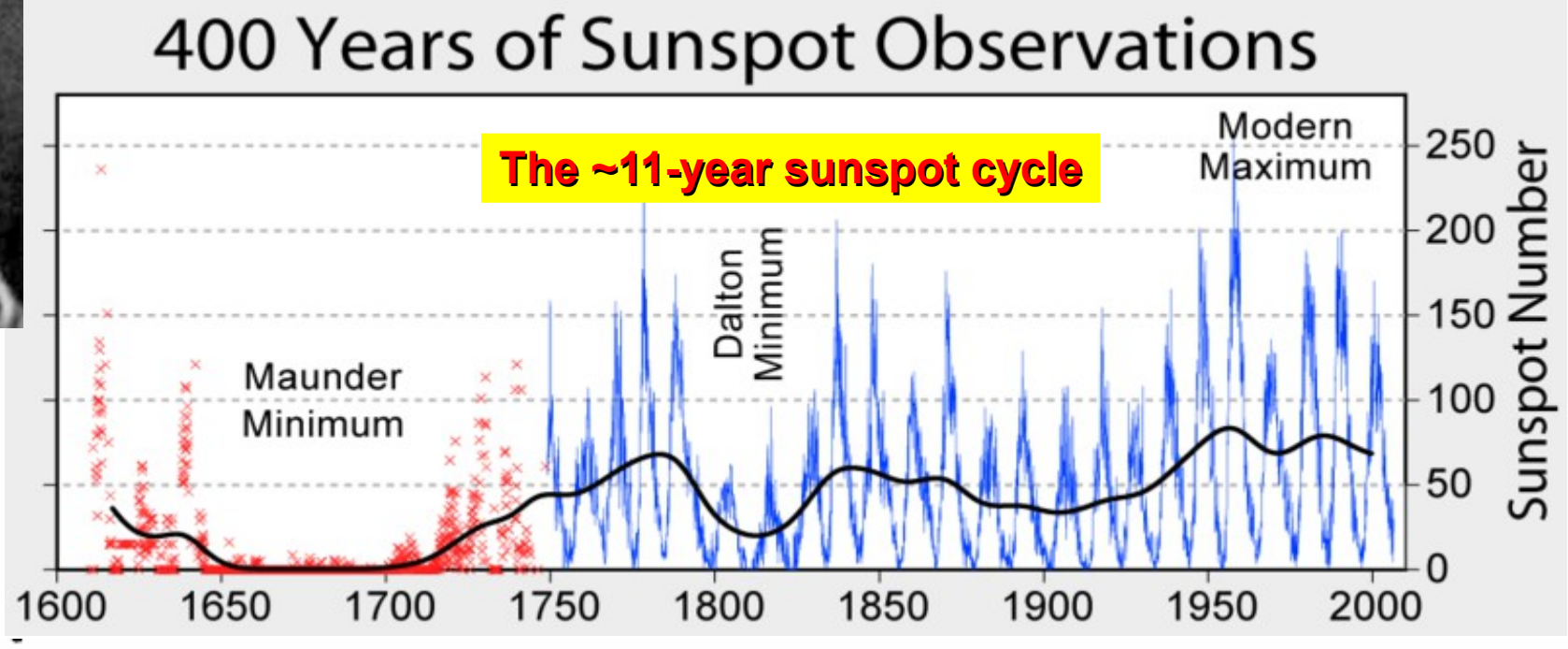
~9-year cycle

| Solar Eclipses | | | Lunar Eclipses | | |
|---|---|---|---|---|---|
| 1988 | Mar | 18 | 1988 | Mar | 3 |
| 1988 | Sep | 11 | 1988 | Aug | 27 |
| 1989 | Mar | 7 | 1989 | Feb | 20 |
| 1989 | Aug | 31 | 1989 | Aug | 17 |
| 1990 | Jan | 26 | 1990 | Feb | 9 |
| 1990 | Jul | 22 | 1990 | Aug | 6 |
| 1991 | Jan | 15 | 1991 | Jan | 30 |
| 1991 | Jul | 11 | 1991 | Jun | 27 |
| | | | 1991 | Jul | 26 |
| 1992 | Jan | 4 | 1991 | Dec | 21 |
| 1992 | Jun | 30 | 1992 | Jun | 15 |
| 1992 | Dec | 24 | 1992 | Dec | 9 |
| 1993 | May | 21 | 1993 | Jun | 4 |
| 1993 | Nov | 13 | 1993 | Nov | 29 |
| 1994 | May | 10 | 1994 | May | 25 |
| 1994 | Nov | 3 | 1994 | Nov | 18 |
| 1995 | Apr | 29 | 1995 | Apr | 15 |
| 1995 | Oct | 24 | 1995 | Oct | 8 |
| 1996 | Apr | 17 | 1996 | Apr | 4 |
| 1996 | Oct | 12 | 1996 | Sep | 27 |
| 1997 | Mar | 9 | 1997 | Mar | 24 |
| 1997 | Sep | 2 | 1997 | Sep | 16 |
| 1998 | Feb | 26 | 1998 | Mar | 13 |
| 1998 | Aug | 22 | 1998 | Aug | 8 |
| | | | 1998 | Sep | 6 |
| 1999 | Feb | 16 | 1999 | Jan | 31 |
| 1999 | Aug | 11 | 1999 | Jul | 28 |
| 2000 | Feb | 5 | 2000 | Jan | 21 |
| 2000 | Jul | 1 | 2000 | Jul | 16 |
| 2000 | Jul | 31 | | | |
| 2000 | Dec | 25 | 2001 | Jan | 9 |
| 2001 | Jun | 21 | 2001 | Jul | 5 |
| 2001 | Dec | 14 | 2001 | Dec | 30 |
| 2002 | Jun | 10 | 2002 | May | 26 |
| | | | 2002 | Jun | 24 |
| 2002 | Dec | 4 | 2002 | Nov | 20 |
| 2003 | May | 31 | 2003 | May | 16 |
| 2003 | Nov | 23 | 2003 | Nov | 9 |
| 2004 | Apr | 19 | 2004 | May | 4 |
| 2004 | Oct | 14 | 2004 | Oct | 28 |
| 2005 | Apr | 8 | 2005 | Apr | 24 |
| 2005 | Oct | 3 | 2005 | Oct | 17 |
| 2006 | Mar | 29 | 2006 | Mar | 14 |
| 2006 | Sep | 22 | 2006 | Sep | 7 |
| 2007 | Mar | 19 | 2007 | Mar | 3 |
| 2007 | Sep | 11 | 2007 | Aug | 28 |
| 2008 | Feb | 7 | 2008 | Feb | 21 |
| 2008 | Aug | 1 | 2008 | Aug | 16 |
| 2009 | Jan | 26 | 2009 | Feb | 9 |

# The theory of a planetary modulation of solar activity

*Extract of a Letter from Prof. R. Wolf, of Zurich, to Mr. Carrington, dated Jan. 12, 1859.*

(*Translation.*)




the same planets, the conclusion seems to be inevitable, that my conjecture that the variations of spot-frequency depend on the influences of *Venus, Earth, Jupiter, and Saturn,* will not prove to be wholly unfounded. The preponderating planet

# The inconvenient truth

- **Current climate science claims that astronomical forcings have a very small influence on the Earth's climate**

  **However, the synchronicity between solar and climate records remains unexplained and the ultimate origin of multiple climate oscillations remains mysterious as well.**

- **Current Solar science claims that the Sun is an isolared system regulated by an internal solar dynamo**

  **However, current solar dynamo models fail to explain**

  **1) 11-year solar cycle**
  **2) 60-120 yr cycles (Gleissberg solar cycles)**
  **3) 150-250 yr cycle (de Vries solar cycles)**
  **4) 800-1100 yr cycle (Eddy solar cycles)**
  **5) etc.....**

# The 11-year sunspot cycle is made of three frequencies

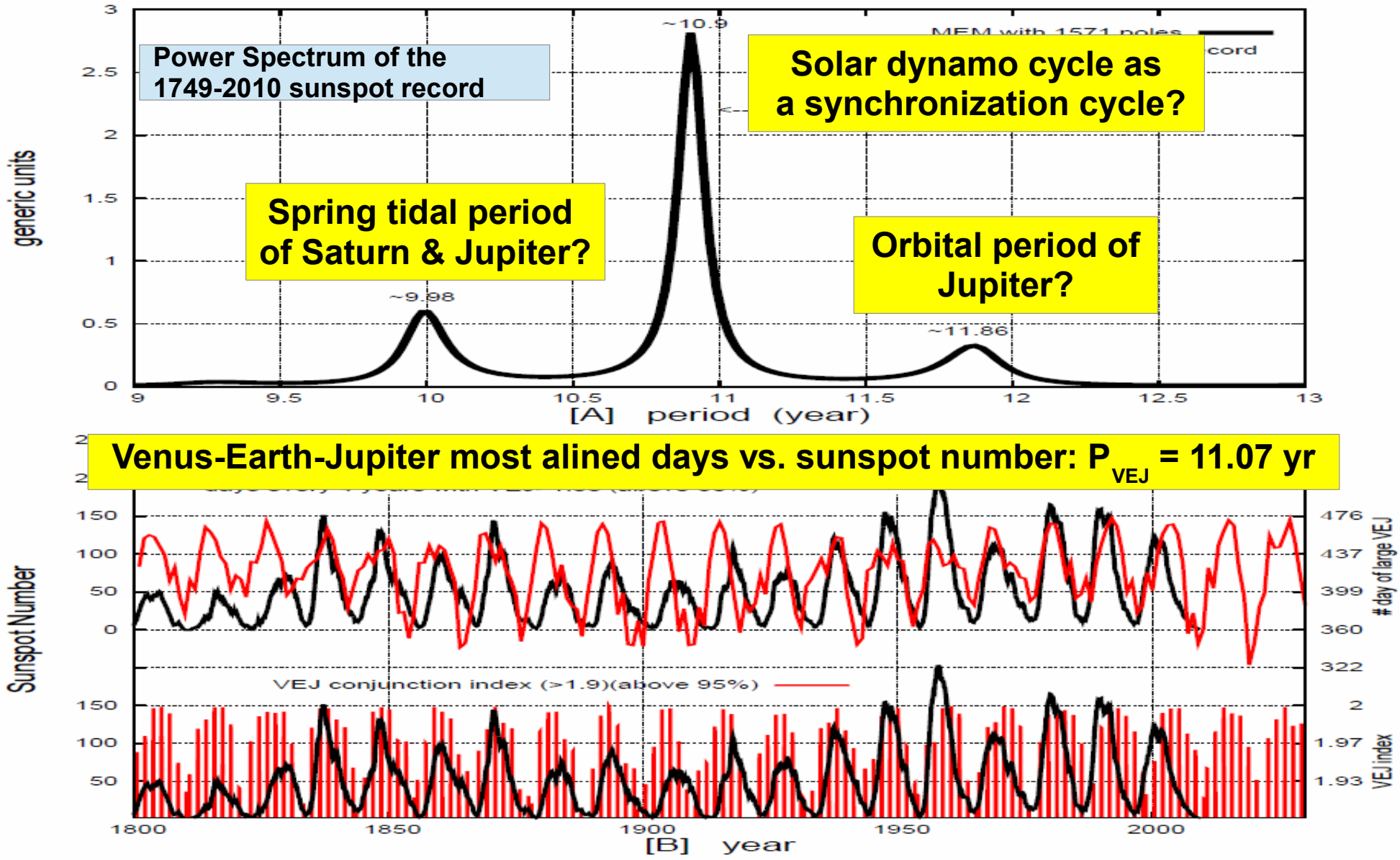
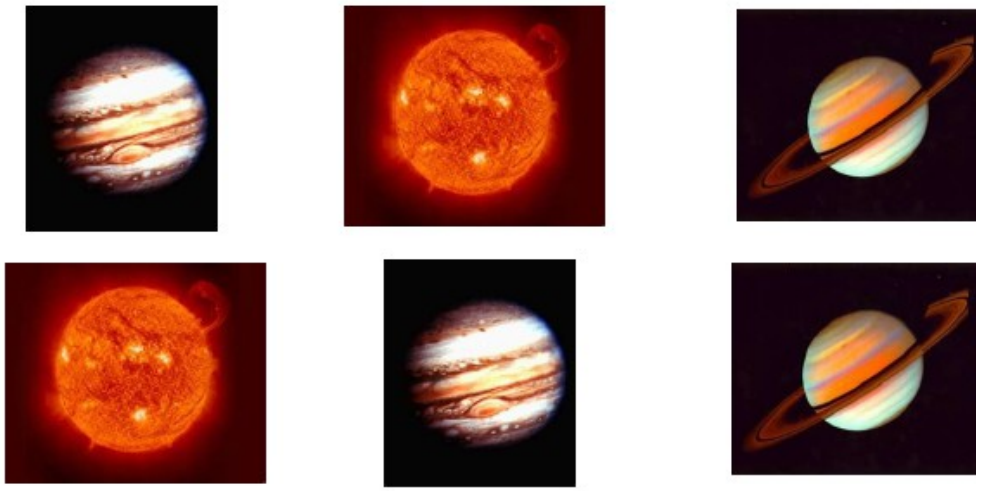
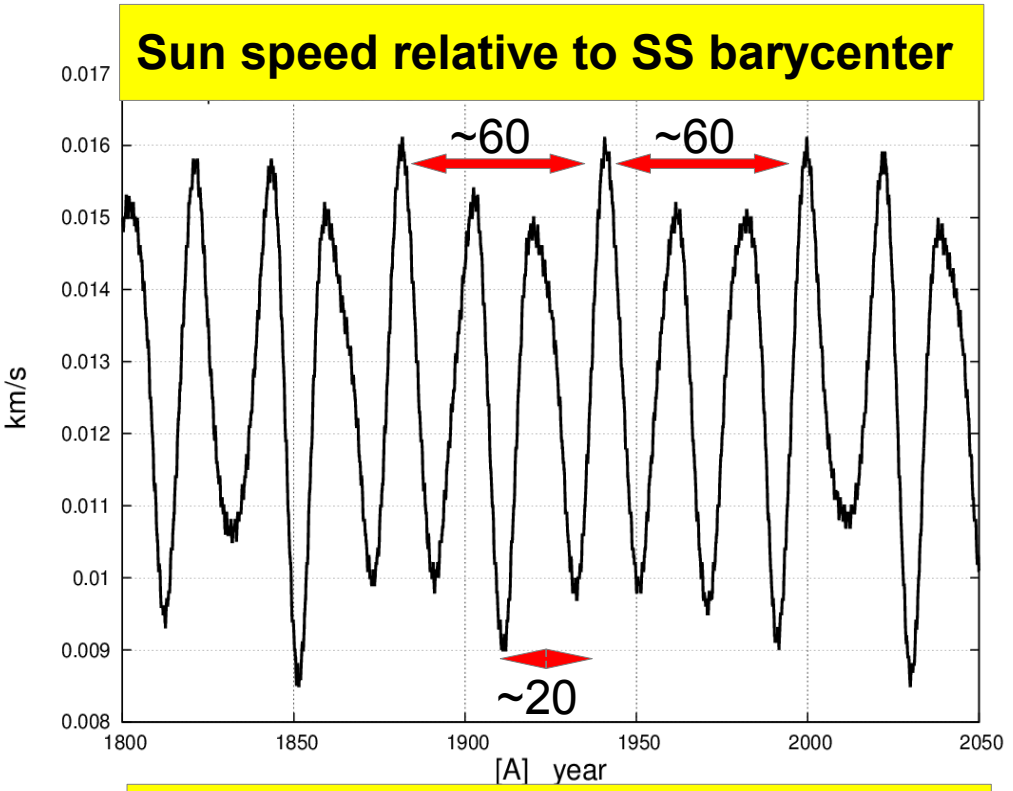


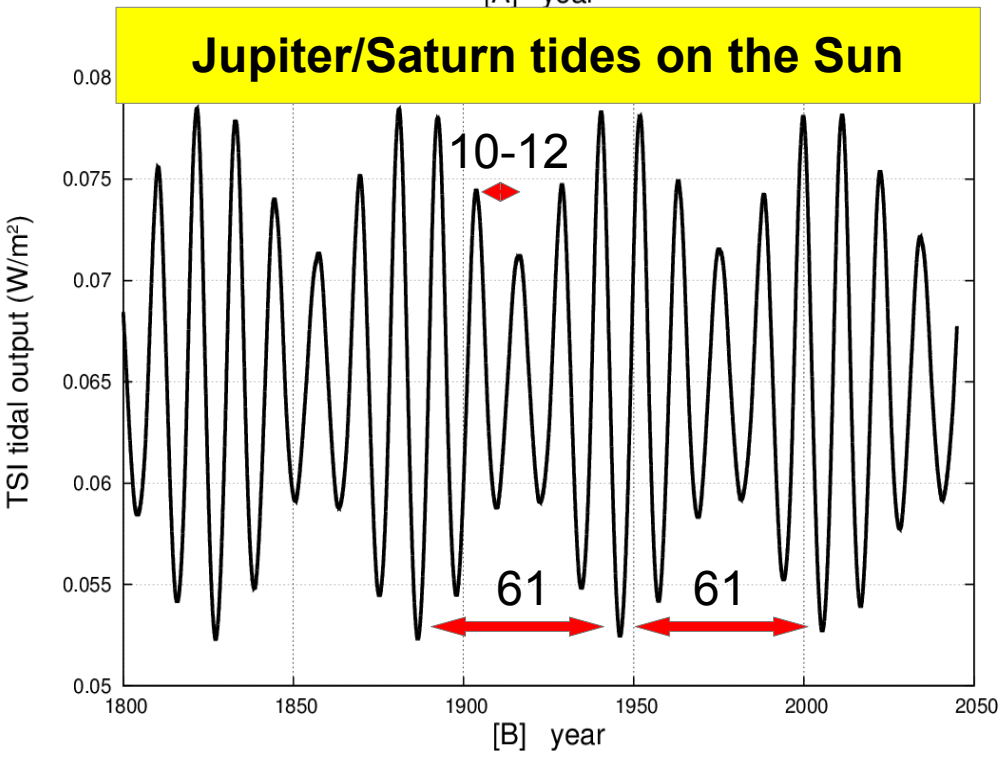

Figure 12: [A] Power spectrum of the sunspot record from 1749 to 2010 highlighting three peaks within the Schwabe frequency band (period 9-13 years) including the two major tides of Jupiter and Saturn. [B] Comparison between the sunspot record (black) and a particular tidal pattern configuration (red) made using Venus, Earth and Jupiter that reproduces on average the solar cycle length of 11.08 yr.

# Jupiter & Saturn

- ~10-12 year cycle
- ~20 year cycle
- ~61 year cycle





$$h_1(t) = 0.83 \cos\left(2\pi \frac{t-2000.475}{9.929656}\right), \quad (10)$$

Jupiter/Saturn spring tide

$$h_2(t) = 1.0 \cos\left(2\pi \frac{t-2002.364}{10.87}\right), \quad (11)$$

Solar Dynamo cycle

$$h_3(t) = 0.55 \cos\left(2\pi \frac{t-1999.381}{11.862242}\right), \quad (12)$$

Jupiter tide

**Beat Cycles**

$$b_{12}(t) = 0.60 \cos\left(2\pi \frac{t-1980.528}{114.783}\right), \quad (15)$$

beat

$P_{Ju-Sa}$ & $P_{Sc}$

$$b_{13}(t) = 0.40 \cos\left(2\pi \frac{t-2067.044}{60.9484}\right), \quad (16)$$

beat

$P_{Ju}$ & $P_{Ju-Sa}$

$$b_{23}(t) = 0.45 \cos\left(2\pi \frac{t-2035.043}{129.951}\right), \quad (17)$$

beat

$P_{Sc}$ & $P_{Ju}$

$$g_m(t) = A \cos\left(2\pi \frac{t-2059.686}{983.401}\right) + B. \quad (19)$$

beat modulator

$P_{Ju-Sa}$ & $P_{Sc}$ & $P_{Ju}$

## Appendix A. Model equations and supplementary data

Here we summarize the functions used for constructing the planetary/solar harmonic model in generic relative units.

The three basic proposed harmonics are

$$h_1(t) = 0.83 \cos\left(2\pi \frac{t-2000.475}{9.929656}\right), \quad (10)$$

Jupiter/Saturn spring tide

$$h_2(t) = 1.0 \cos\left(2\pi \frac{t-2002.364}{10.87}\right), \quad (11)$$

Solar Dynamo cycle

$$h_3(t) = 0.55 \cos\left(2\pi \frac{t-1999.381}{11.862242}\right), \quad (12)$$

Jupiter tide

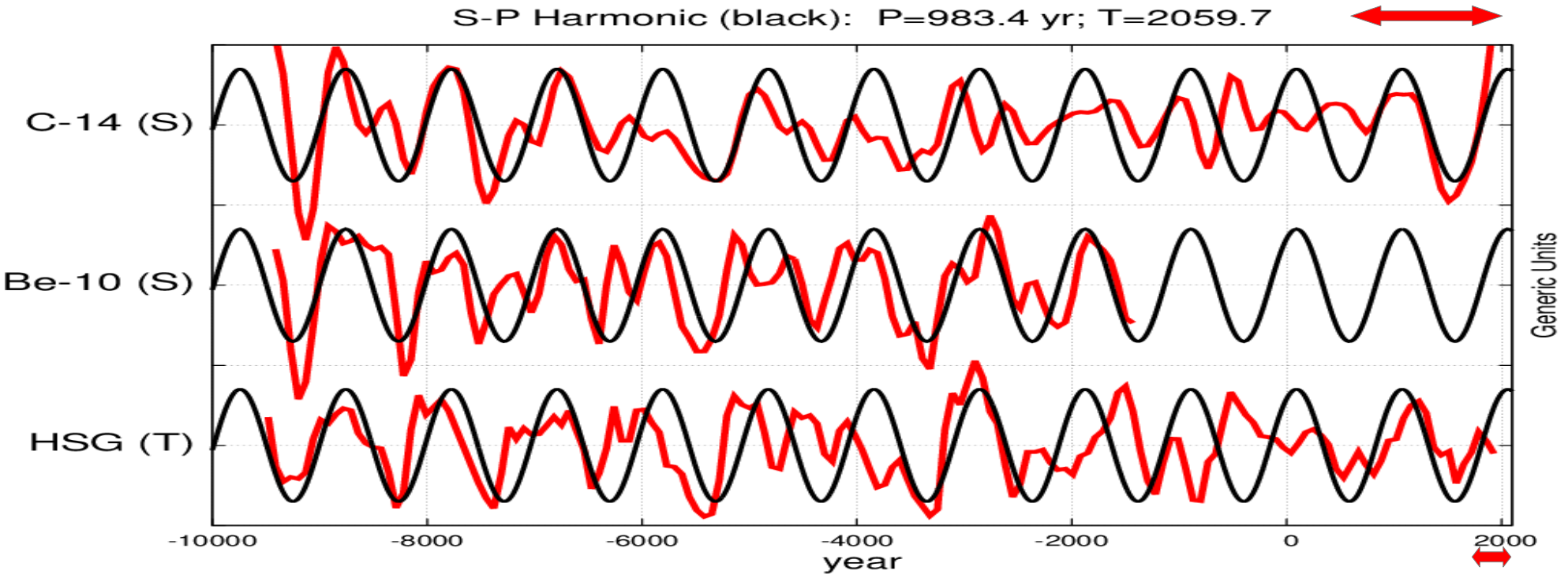
$$h_{123}(t) = h_1(t) + h_2(t) + h_3(t), \quad (13)$$

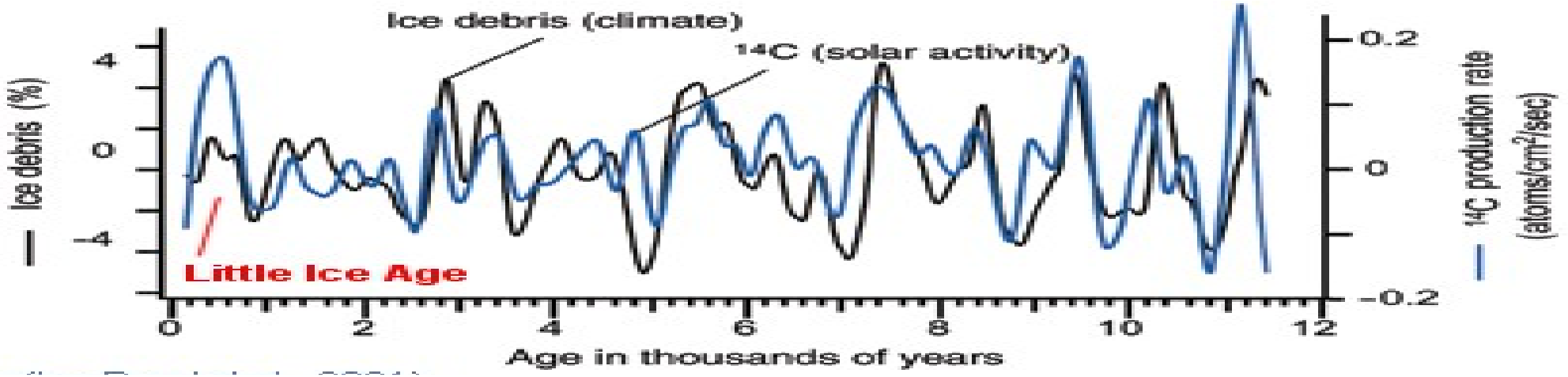
$$f_{123}(t) = \begin{cases} h_{123}(t) & \text{if } h_{123}(t) \geq 0, \\ 0 & \text{if } h_{123}(t) < 0, \end{cases} \quad (14)$$

$$g_m(t) = A \cos\left(2\pi \frac{t-2059.686}{983.401}\right) + B. \quad (19)$$

$$F_{123}(t) = g_m(t) * f_{123}(t)$$

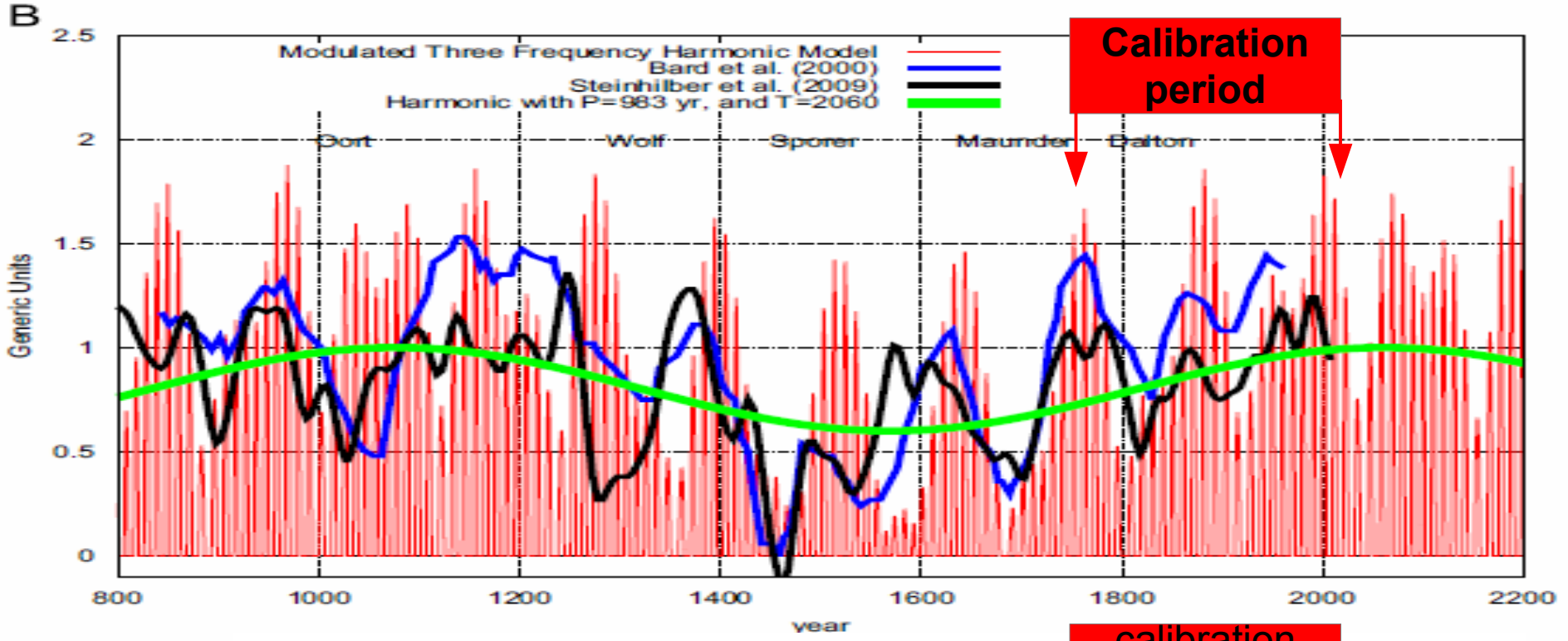
# Three-frequency solar model for solar and millennial climate cyclical variation throughout the Holocene (~983 yr cycle)



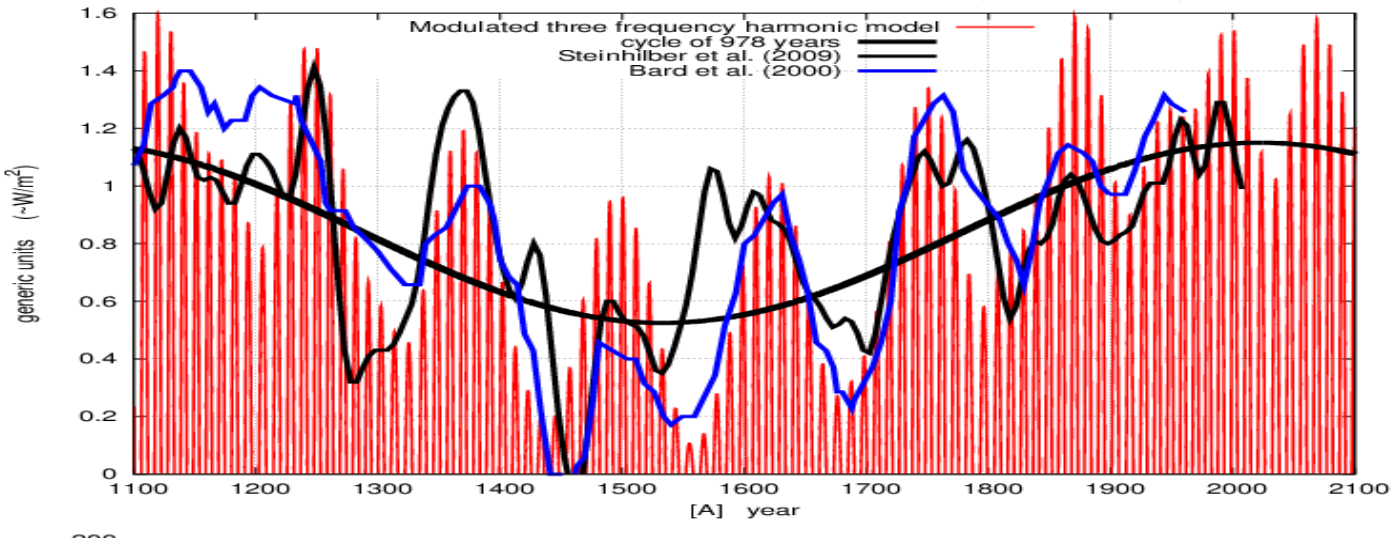

G. Bond, S. Hoffmann, R. Lotti-Bond, J. Beer, R. Muscheler, M. Evans, B. Kromer, W. Showers, I. Hajdes, G. Bonani, Persistent Solar Influence on North Atlantic Climate During the Holocene, Science (Nov, 2001)
R. Kerr, A variable sun paces millennial climate, Science, Vol. 294, p. 1442-1443, (Nov, 2001)

# Three-frequency solar harmonic model vs. $^{10}$Be and $^{14}$C solar proxy reconstructions

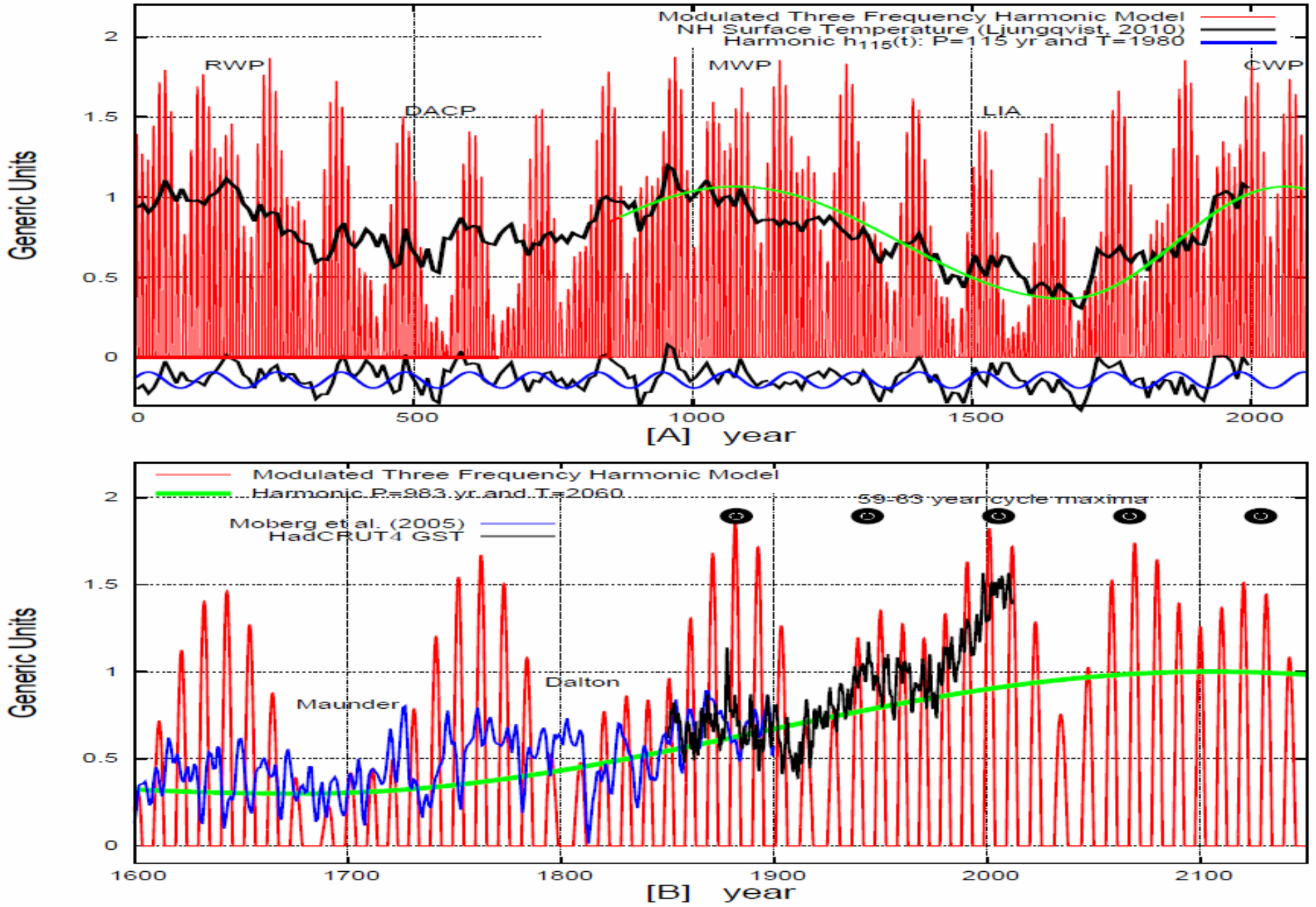



calibration

Same model with very small corrections

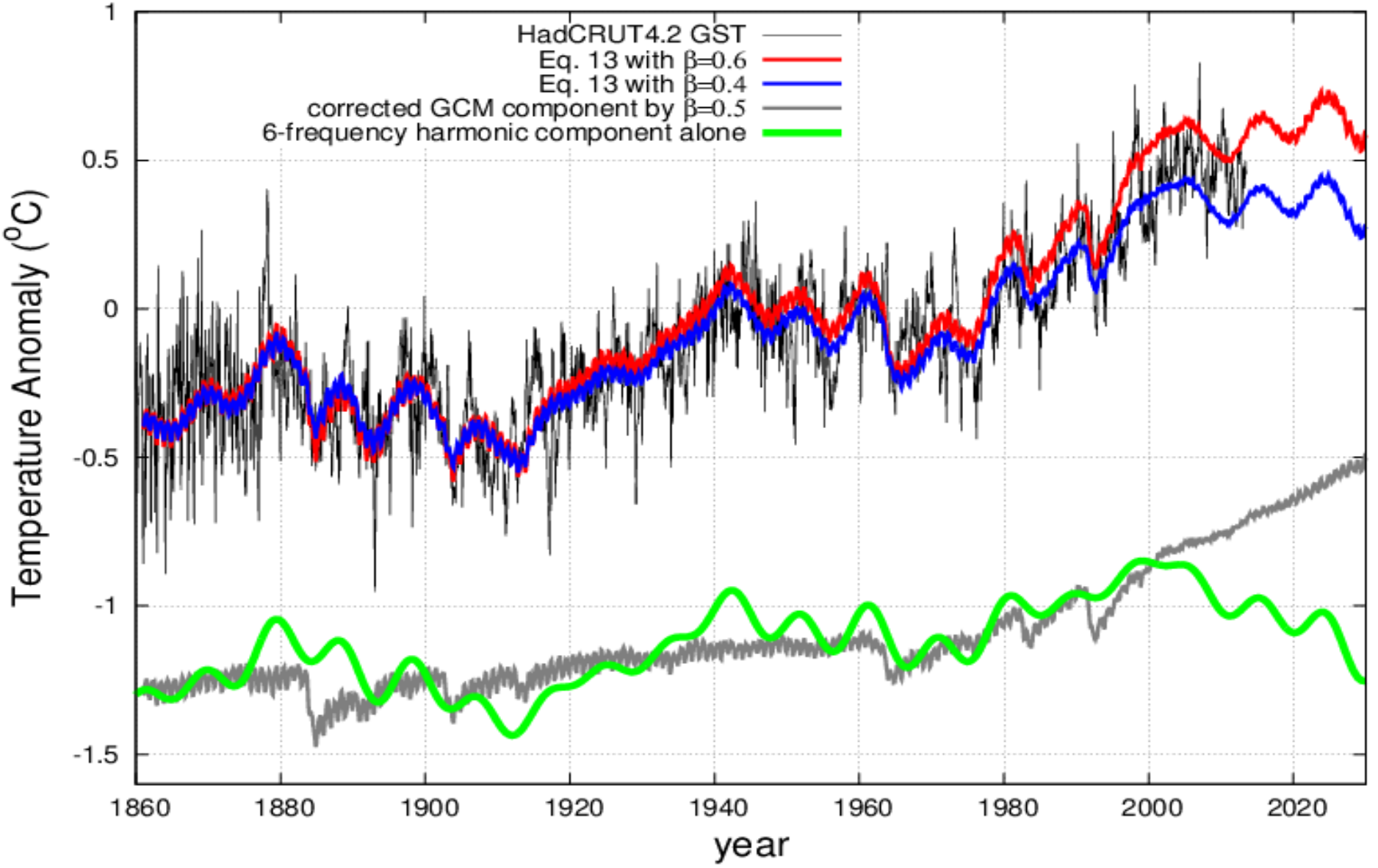


# Three-frequency solar harmonic model vs. temperature reconstructions (~61 yr, ~115 yr, ~980 yr cycles)



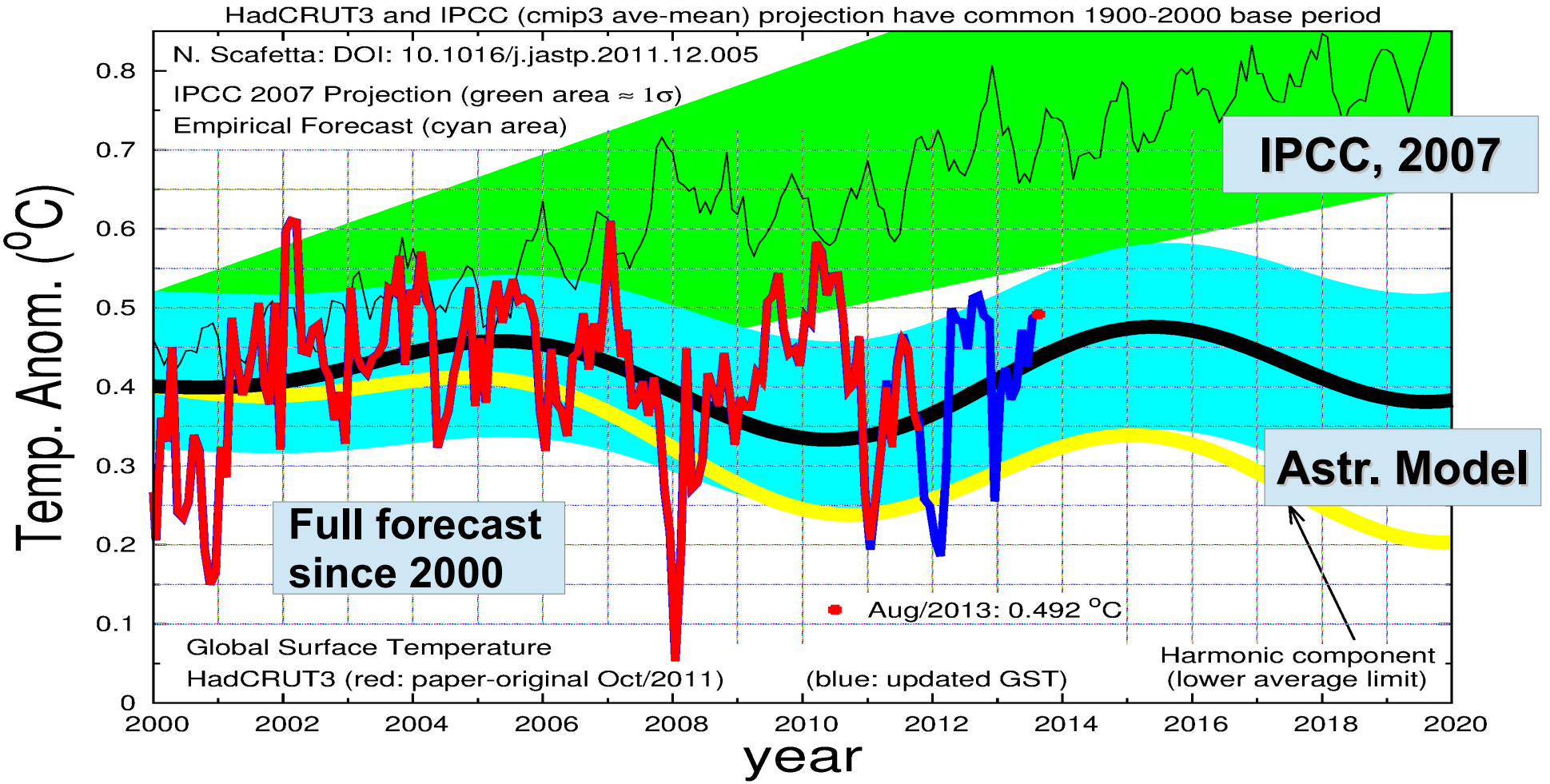
**Six-frequency astronomical model + corrected GHG-Aerosol-Volcano**

$$H(t) = h_{983}(t) + h_{115}(t) + h_{60}(t) + h_{20}(t) + h_{10.4}(t) + h_{9.1}(t) + \beta * m(t) + const,$$



# Astronomical Climate model forecast vs. CMIP3 GCM (IPCC 2007)

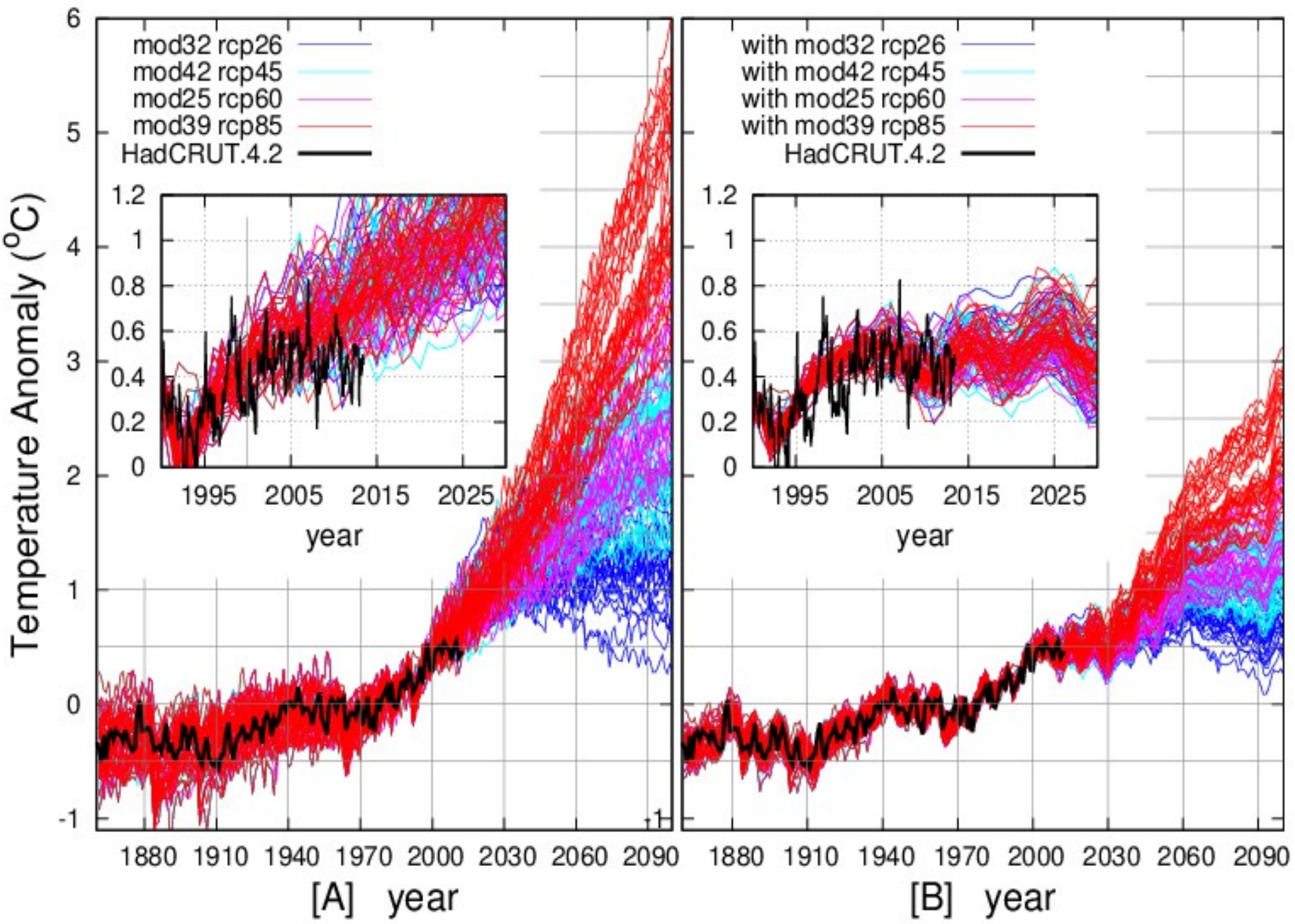
Visit http://people.duke.edu/~ns2002/




Global surface temperature (HadCRUT3): original global surface temperature record **(red)** published in Scafetta JASTP 2012b; and updated global surface temperature **(blue)**.

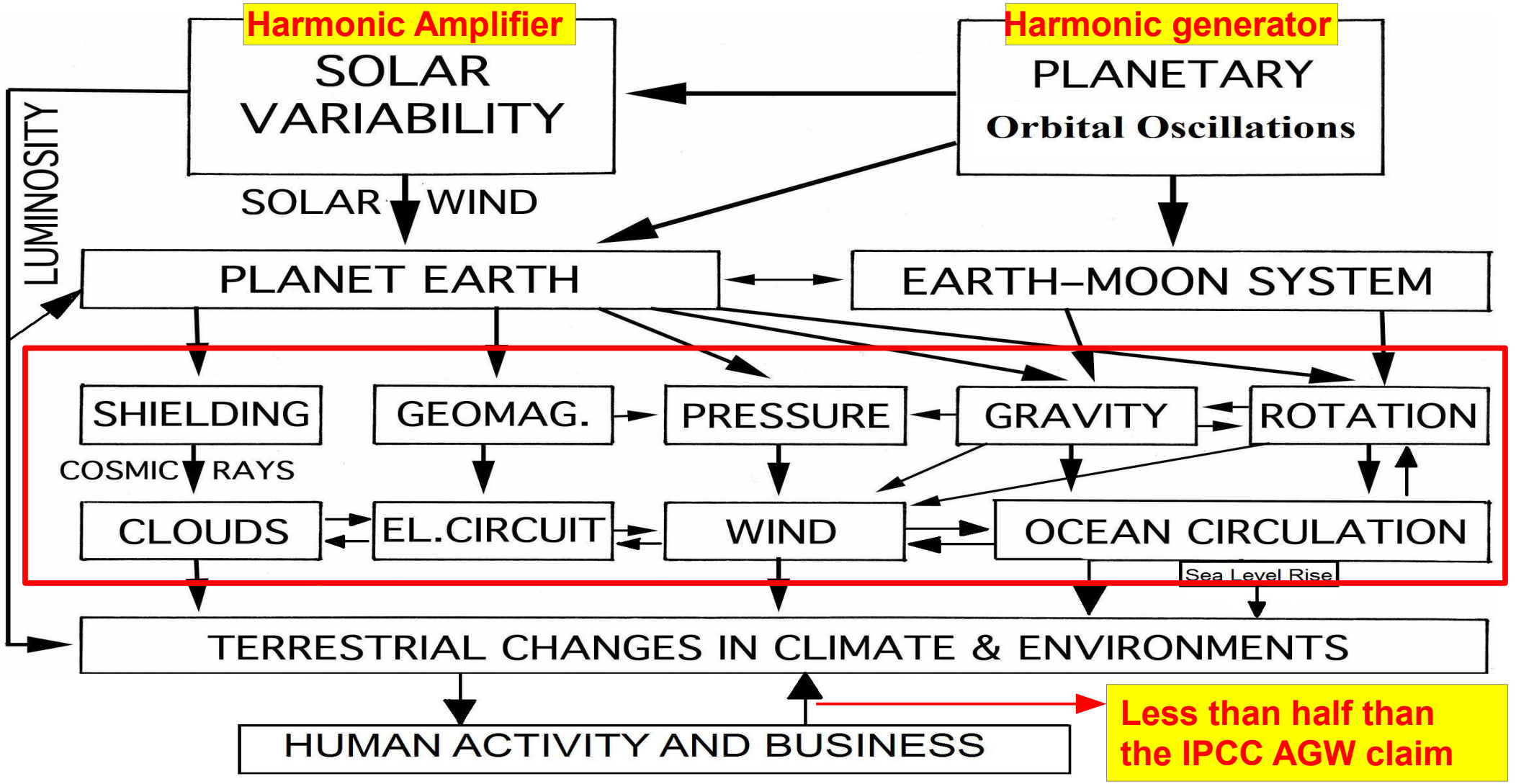
The **back** curve within the **cyan area** is the full astronomical harmonic model forecast since 2000 that clearly outperforms the IPCC general circulation model projections **(green area)**.

The yellow curve is the harmonic component alone without the anthropogenic component.


IPCC 2013
ALL CMIP5 Models
6-frequency + anthropogenic
SOLAR-ASTRONOMICAL MODEL
mod32 rcp26
mod42 rcp45
mod25 rcp60
mod39 rcp85
HadCRUT.4.2
with mod32 rcp26
with mod42 rcp45
with mod25 rcp60
with mod39 rcp85
HadCRUT.4.2
Temperature Anomaly (°C)
year
[A] year
[B] year

# Conclusion

After N.-A. Morner




- Solar and climate dynamics are coupled and synchronized with astronomical harmonics
- The Sun likely works as a strong amplifier of the gravitational oscillations of the solar system
- Solar/Lunar tidal (multi-)decadal harmonics are present in the climate system
- Current climate general circulation models (CMIP3 and CMIP5 GCMs) are seriously flawed.
- Natural cyclical variability has contributed at least 50% of the 20th century warming
- Climate sensitivity varies from about 1 ºC and 2 ºC with median about 1.5 ºC

## References: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# Luminosity production associated to tidal energy dissipated in the Sun

Equation to convert gravitational energy released by the tides into luminosity anomaly

$$I_P(t) = \frac{3\,G\,R_S^5}{2\,Q\,\Delta t}\int_0^1 K(\chi)\,\chi^4\rho(\chi)\,d\chi\,.$$

K($\chi$) is the amplification function

$$\int_{\theta=0}^{\pi}\int_{\phi=0}^{2\pi}\left|\sum_{p=1}^{8} m_p\frac{\cos^2(\alpha p_{,t})-\frac{1}{3}}{R_{Sp}^3(t)} - m_p\frac{\cos^2(\alpha p_{,t-\Delta t})-\frac{1}{3}}{R_{Sp}^3(t-\Delta t)}\right|\sin(\theta)\,d\theta d\phi,$$

$$\frac{L}{L_S}\approx\left(\frac{M}{M_S}\right)^4\approx 1+\frac{4\Delta M}{M_S},$$

rewriting it

$$L(t)\approx L_S+4L_S\frac{\dot{U}_{tidal}(t)}{\dot{U}_{Sun}}=L_S+A\cdot\dot{U}_{tidal}(t),$$

**Solar luminosity $L_S = 4\times10^{26}$ W**

amplification factor used in K($\chi$)

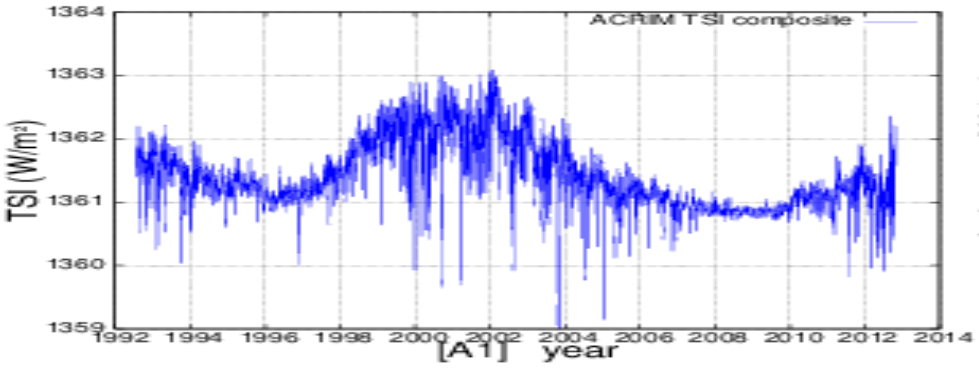
$$\dot{U}_{Sun}=-\dot{U}_{fusion}=\frac{1}{2}G\int_0^{R_S} m_S(r)\frac{d\dot{m}(r)}{dr}\frac{1}{r}\,dr=3.6\times10^{20}W,$$

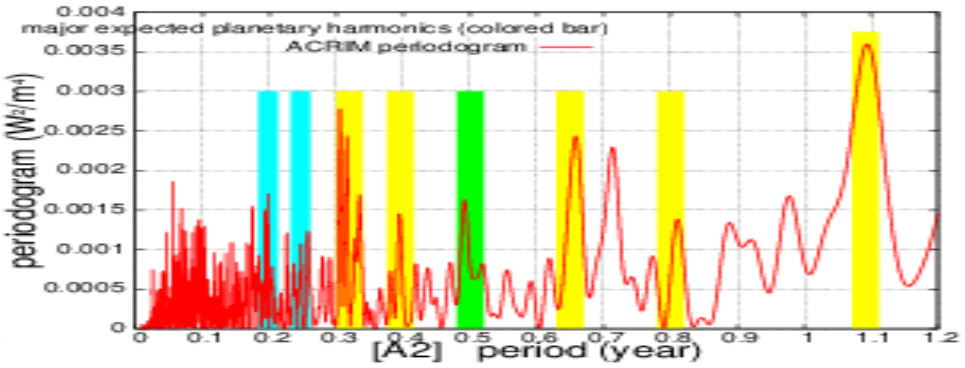
$$A=\frac{4L_S}{\dot{U}_{Sun}}\approx 4.25\times10^6.$$

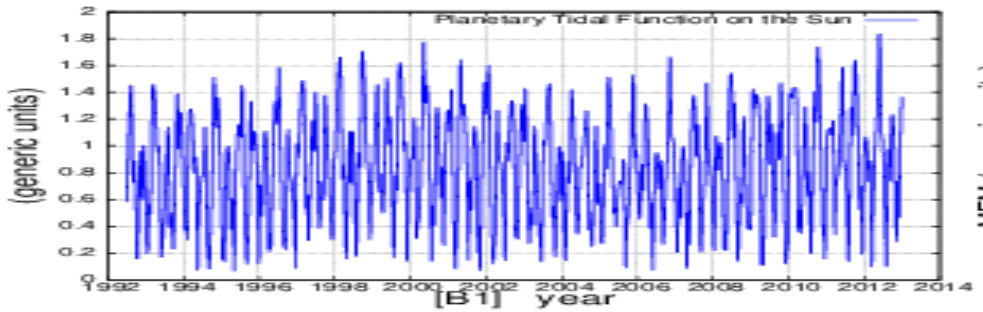
$$\frac{d\dot{m}(r)}{dr}=\frac{1}{c^2}\frac{dL(r)}{dr},$$

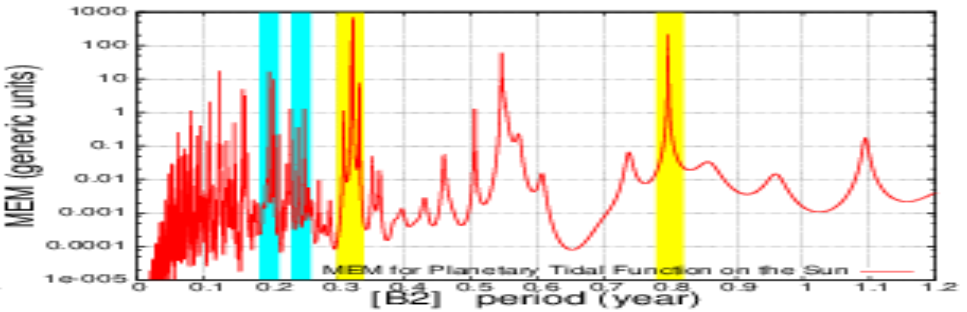
# Empirical evidences for a planetary modulation of total solar irradiance and the TSI signature of the 1.09-year Earth-Jupiter conjunction cycle.

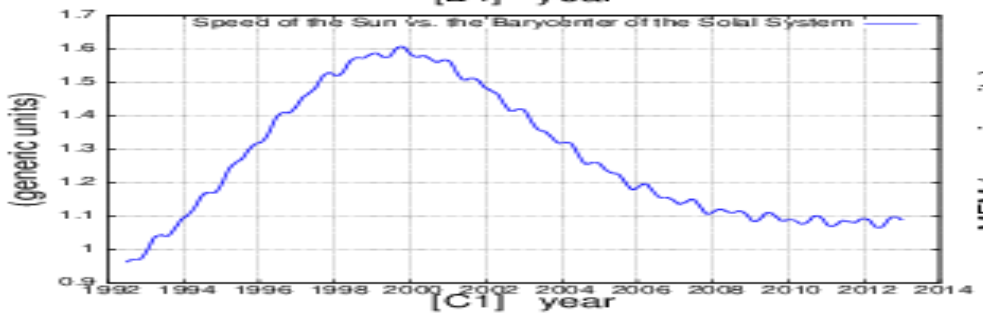
Scafetta N., and R. C. Willson, Astrophysics and Space Science (2013).

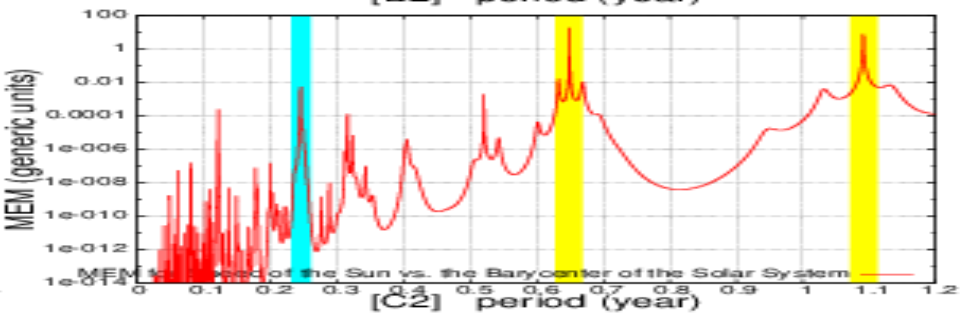


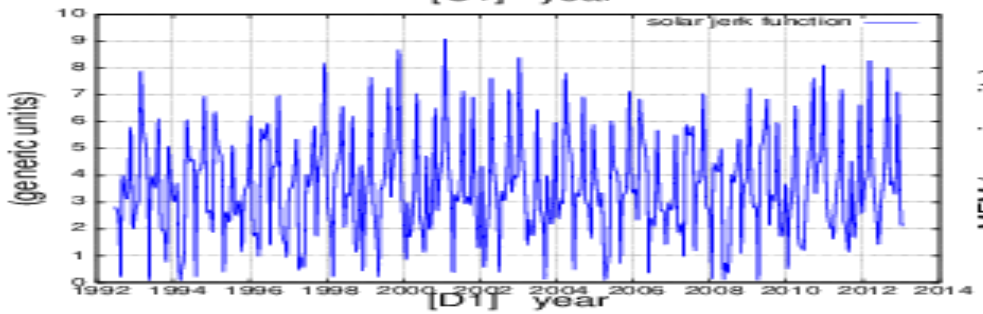



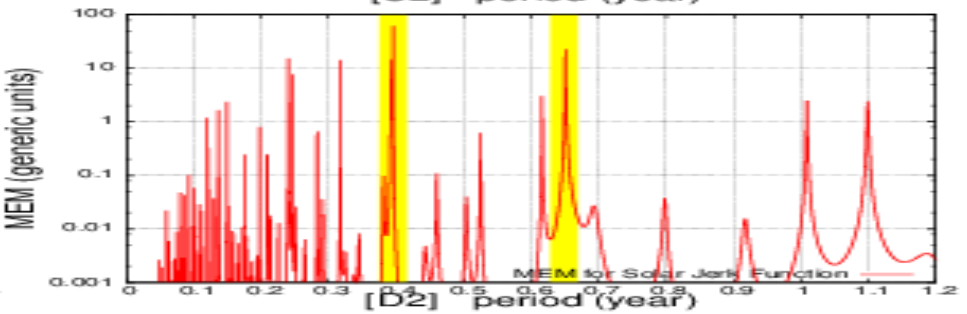



# Planetary harmonics in the historical Hungarian aurora record (1523–1960). Scafetta N., and R. C. Willson, 2013. Planetary and Space Science 78, 38-44 (2013)