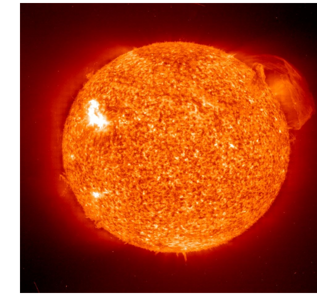
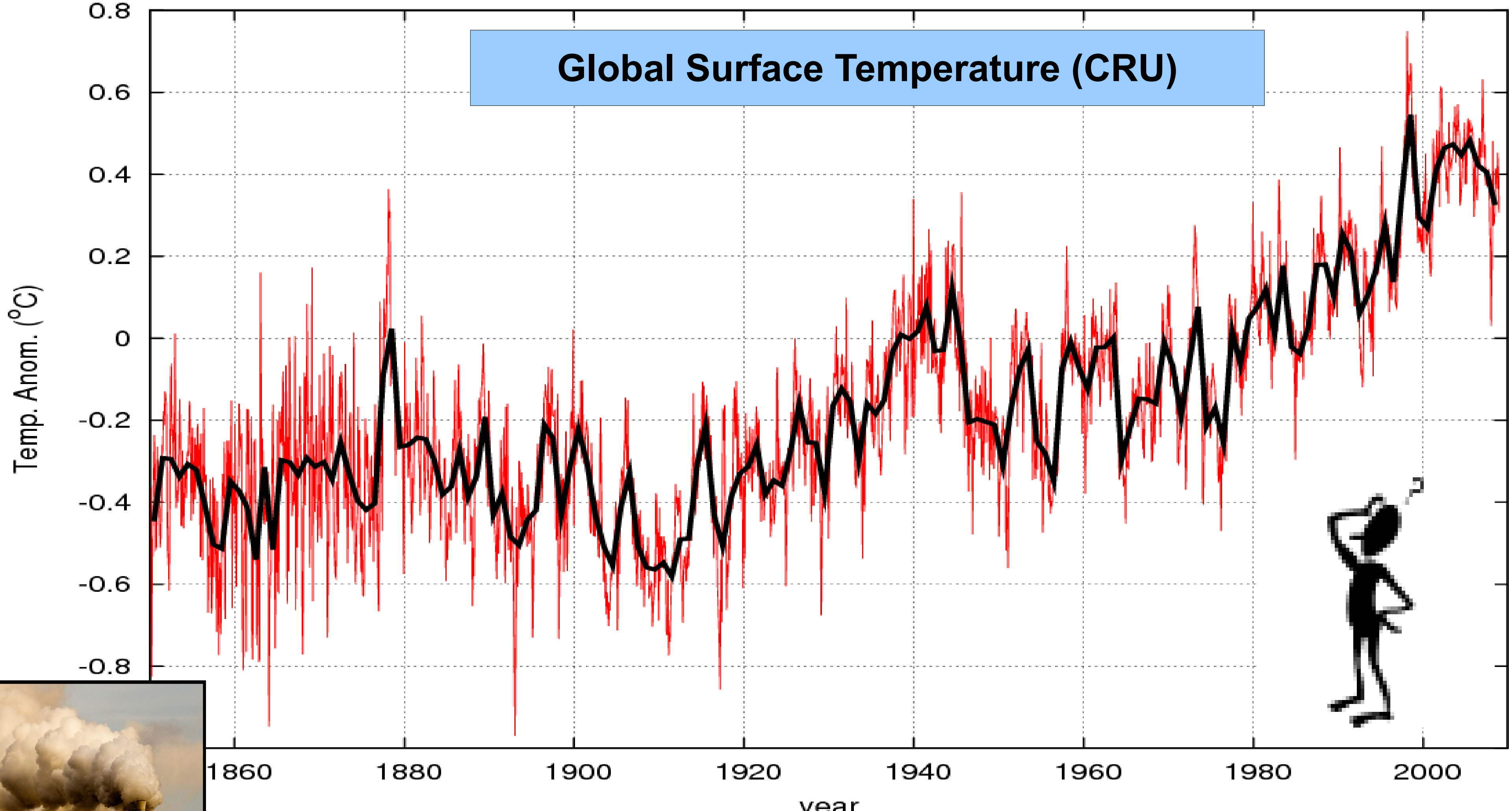
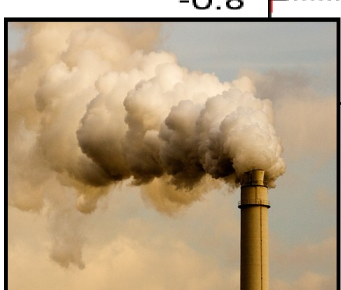
Climate Change and Its Causes: A Discussion about Some Key Issues

Nicola Scafetta, Duke University



At the Environmental Protection Agency, Feb/26/2009





Disclaimer (added by EPA)

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- **Climate Network and Topology ?**

The IPCC climate “structure” overestimates the human contribution to climate change.

- **Total Solar Irradiance ?**

The TSI likely increased from 1980 to 2002 contrary to the IPCC assumptions.
Evidences that the ACRIM TSI composite is more accurate than the PMOD are presented.

- **Global Temperatures ?**

The Hockey Stick temperature by Mann has likely misled the GW debate. More recent paleoclimate temperature reconstructions present a much larger pre-industrial variability which better agrees with historical records.

- **Climate Models ?**

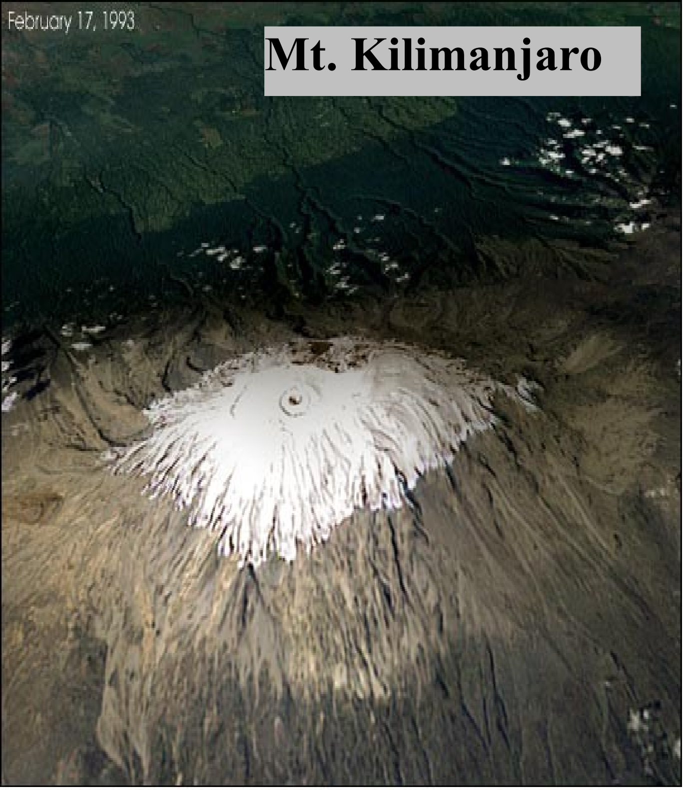
IPCC climate models fail to reproduce the climate variability before 1960 and greatly disagree with the empirical studies evaluating the 11-year solar signature on climate.
Limitations of the multi-linear regression climate models are discussed.

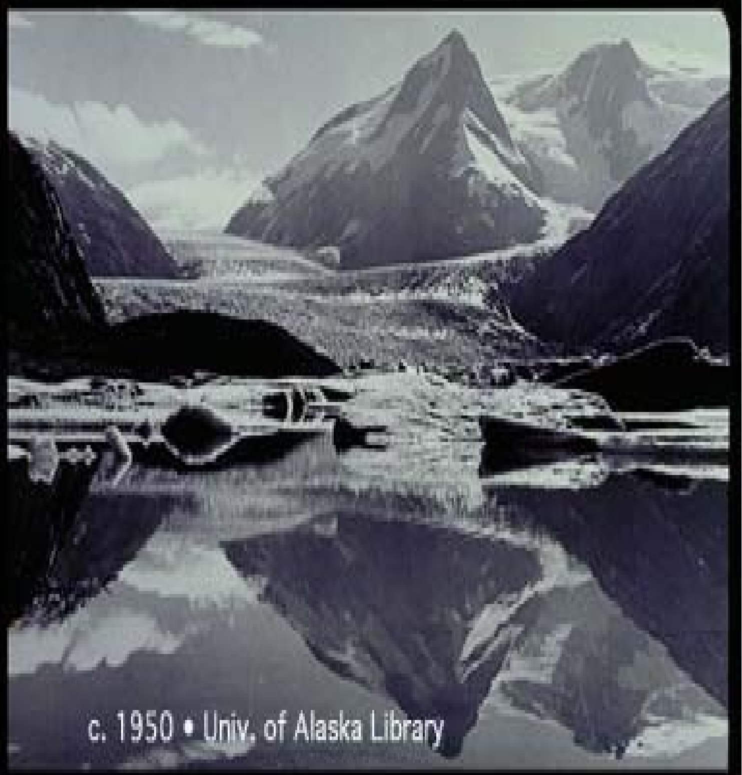
- **Missing Feedbacks and/or Climate Forcings ?**

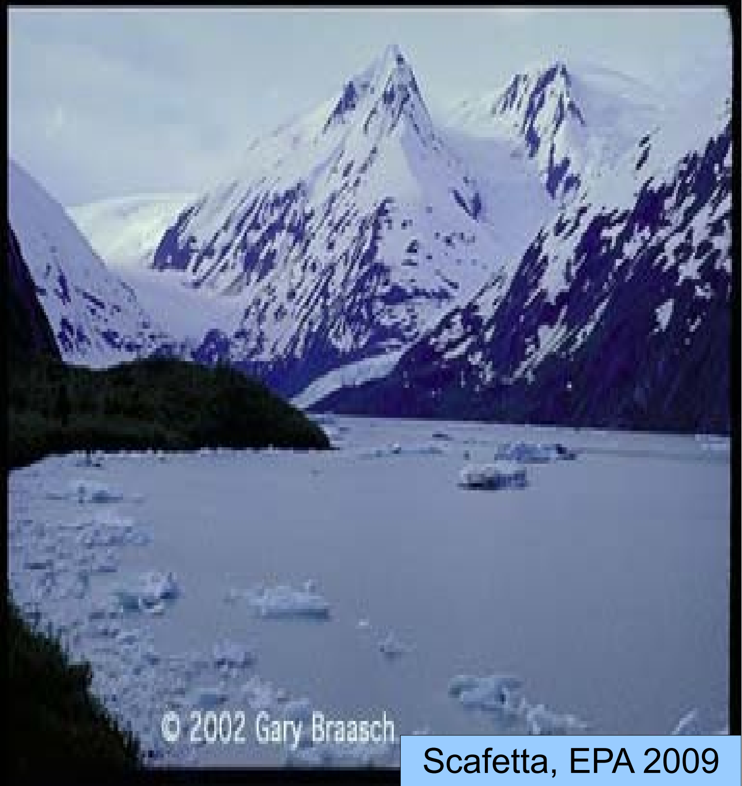
A phenomenological climate model studied to overcome the limitations of the current science is presented. The model well predicts centuries of climate change.

- **Future: Warming or Imminent Cooling ?**

A forecast of climate change based on the solar system planetary motion is presented.
The model appears to reconstruct with great accuracy the observed climate change since 1850 and predicts a cooling until 2030-2040. The physical mechanisms are unknown.







Scafetta, EPA 2009

IPCC 2007
interpretation of the climate network

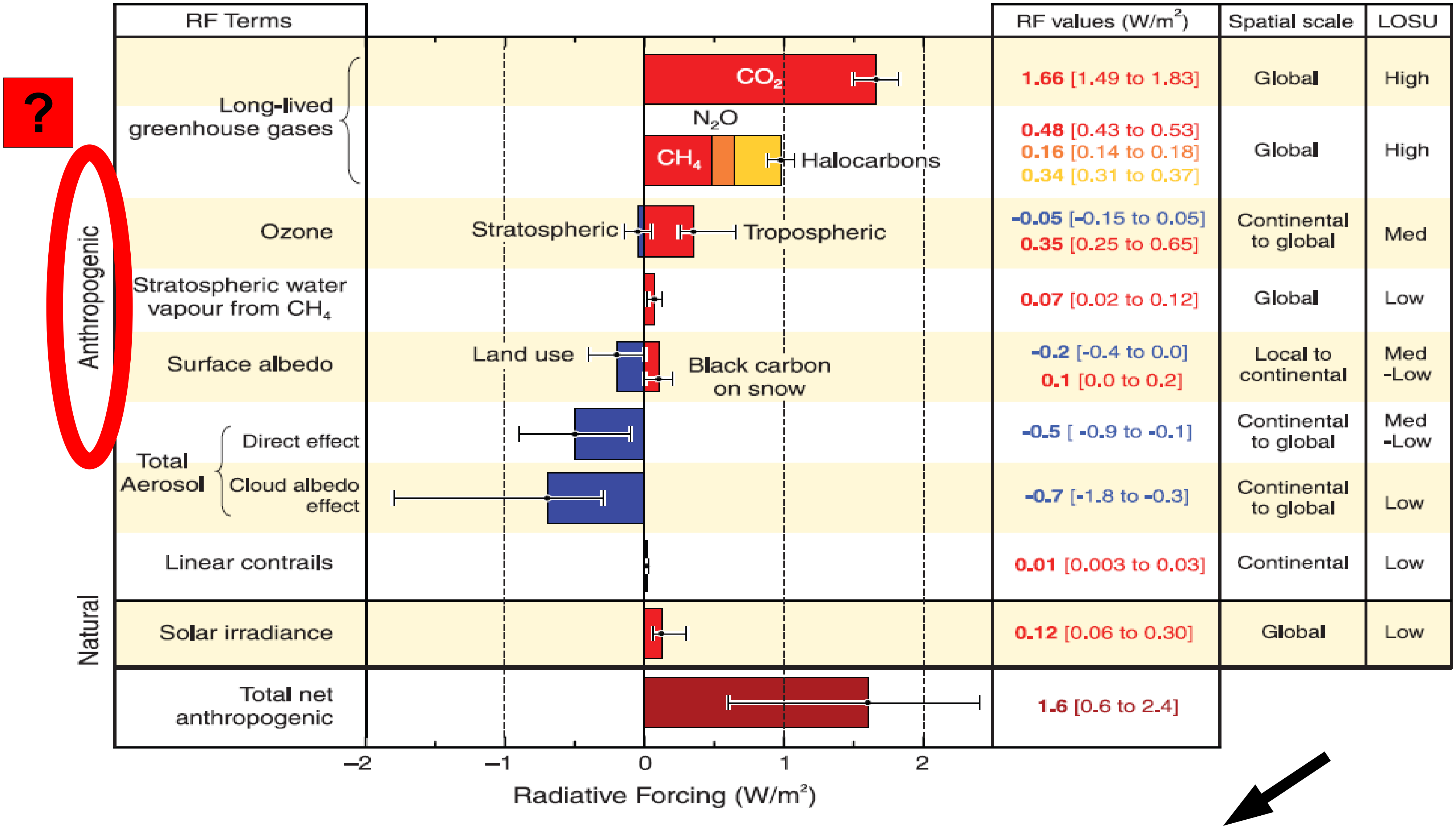
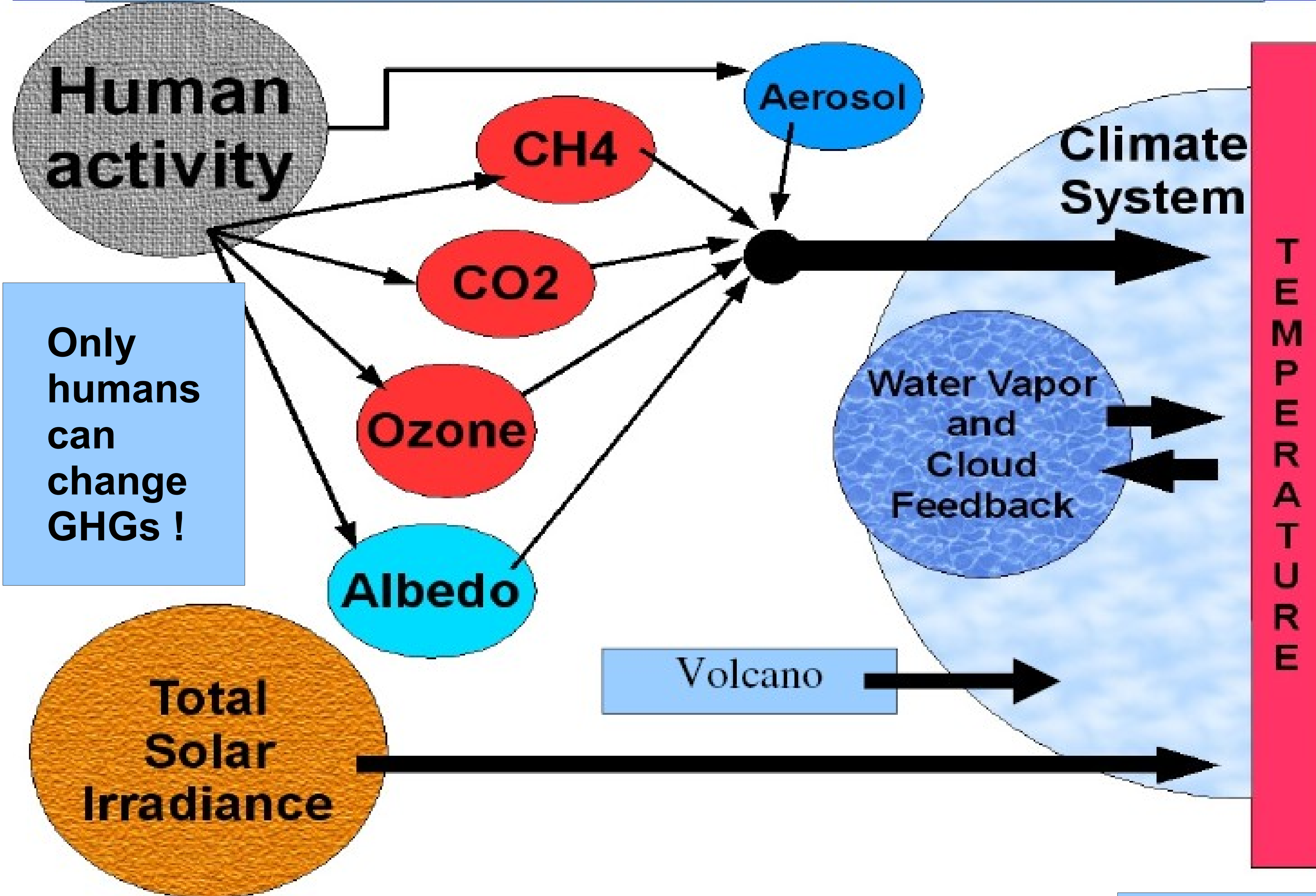


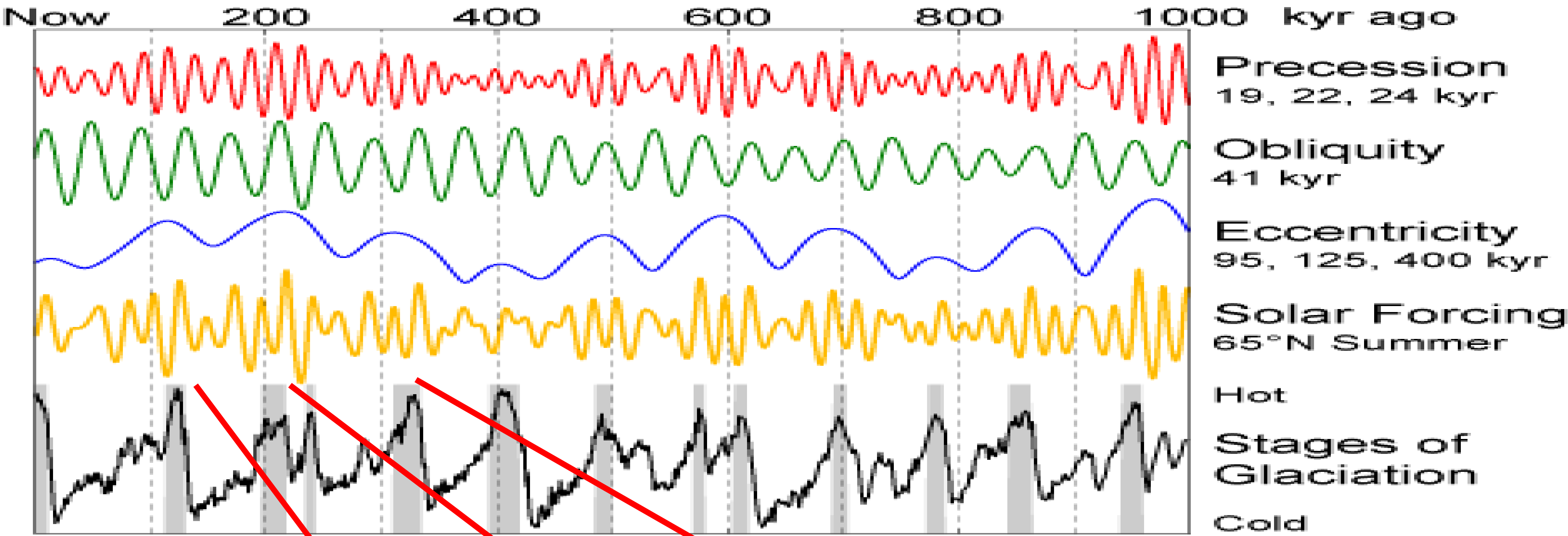
Figure 2.4. *Global average radiative forcing (RF) in 2005 (best estimates and 5 to 95% uncertainty ranges) with respect to 1750 for CO_2, CH_4, N_2O and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). Aerosols from explosive volcanic eruptions contribute an additional episodic cooling term for a few years following an eruption. The range for linear contrails does not include other possible effects of aviation on cloudiness. {WGI Figure SPM.2}*

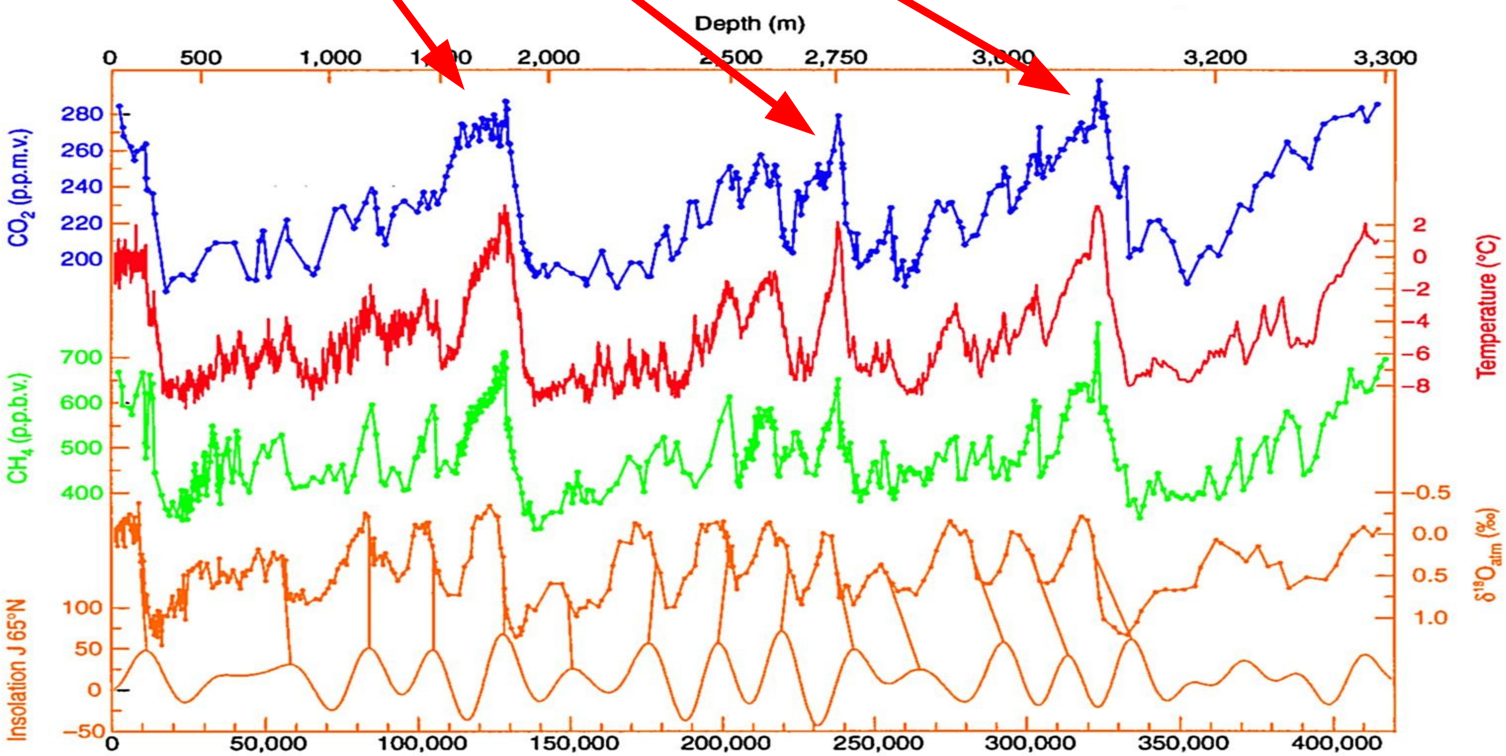
Scafetta, EPA 2009

Topology of the climate system according to the IPCC models



Scafetta, EPA 2009





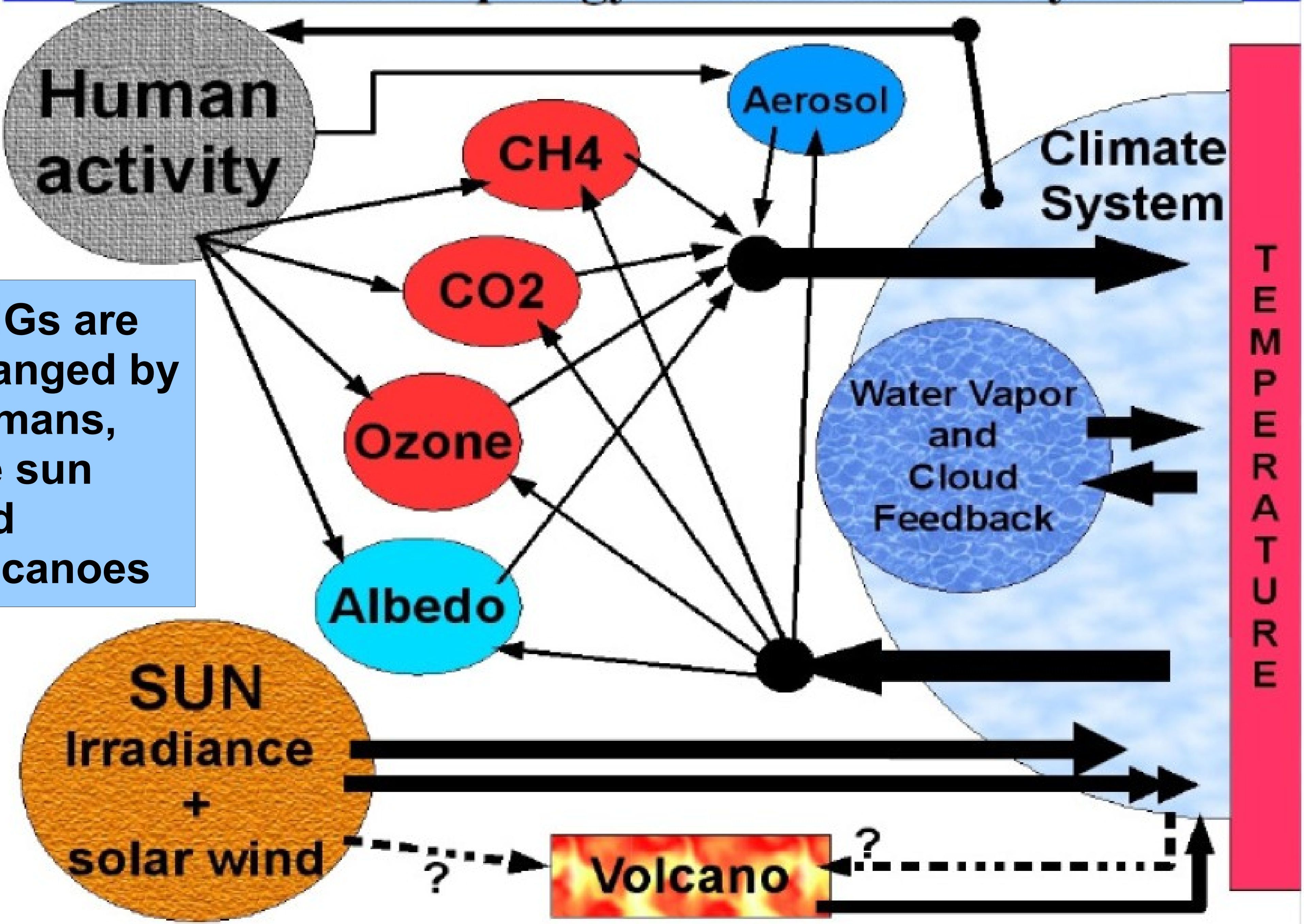
ice core data from Vostok, Antarctica

Glacial epochs & Milankovitch cycles

prove that there are several natural GHG feedback mechanisms!

Scafetta, EPA 2009

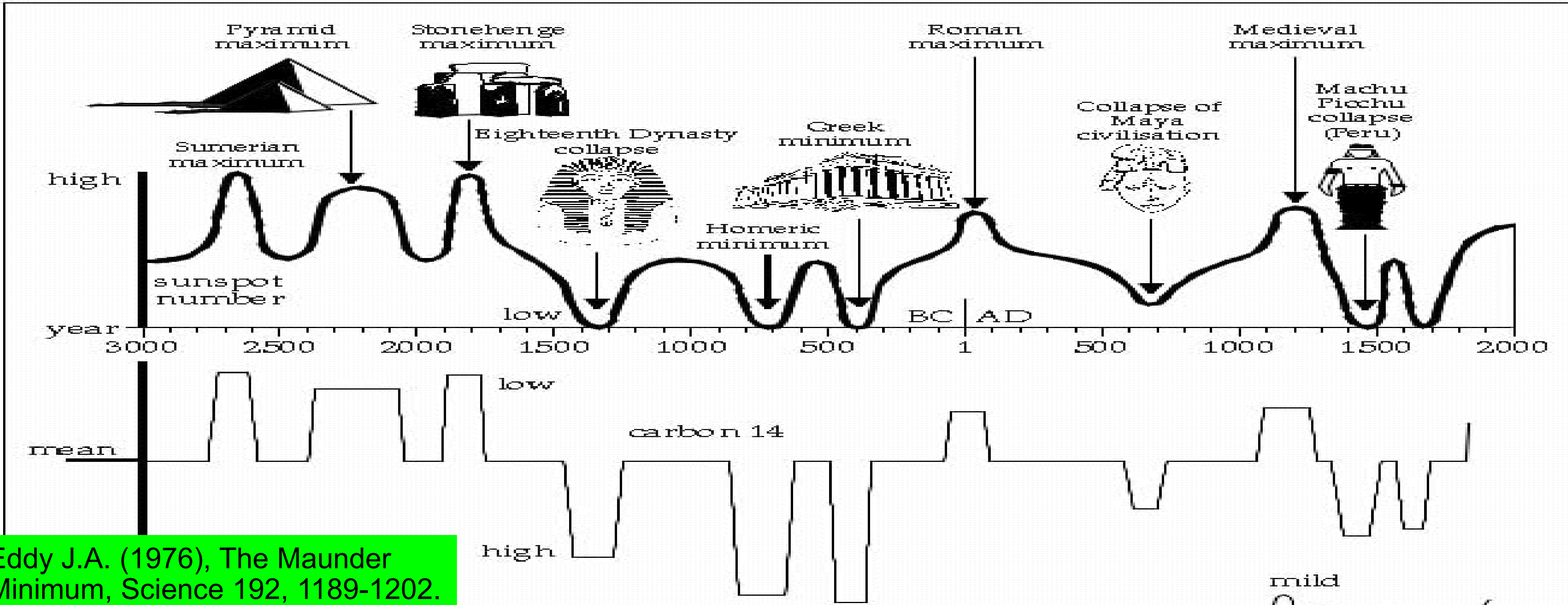
A Realistic Topology of the Climate System



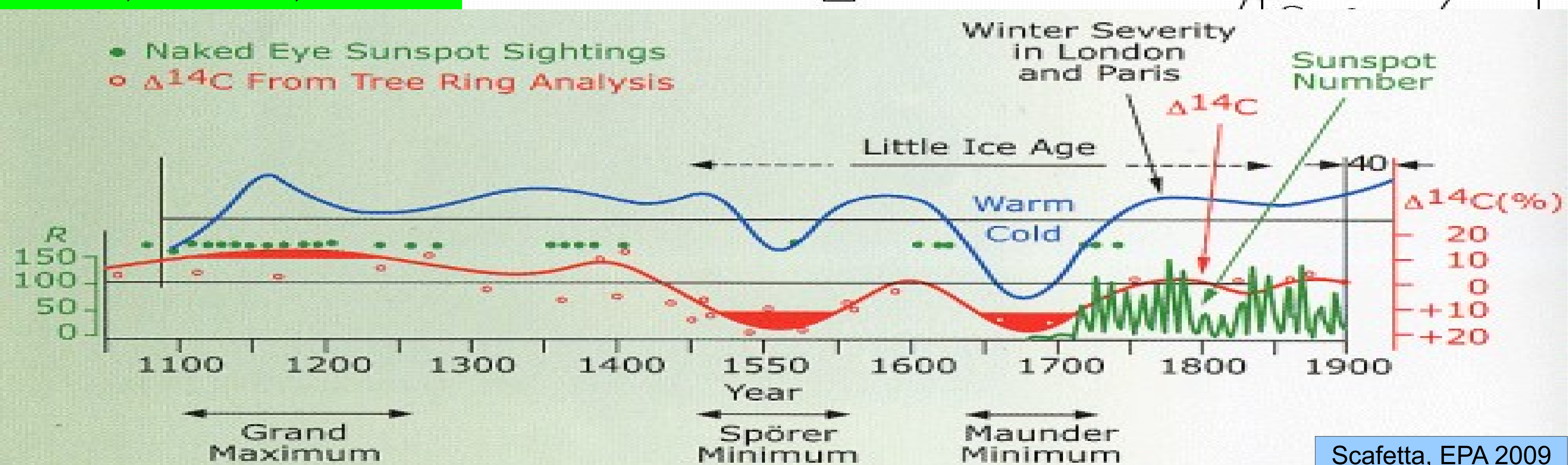
GHGs are changed by humans, the sun and volcanoes

Scafetta, EPA 2009

Secular correlation between solar and climate records

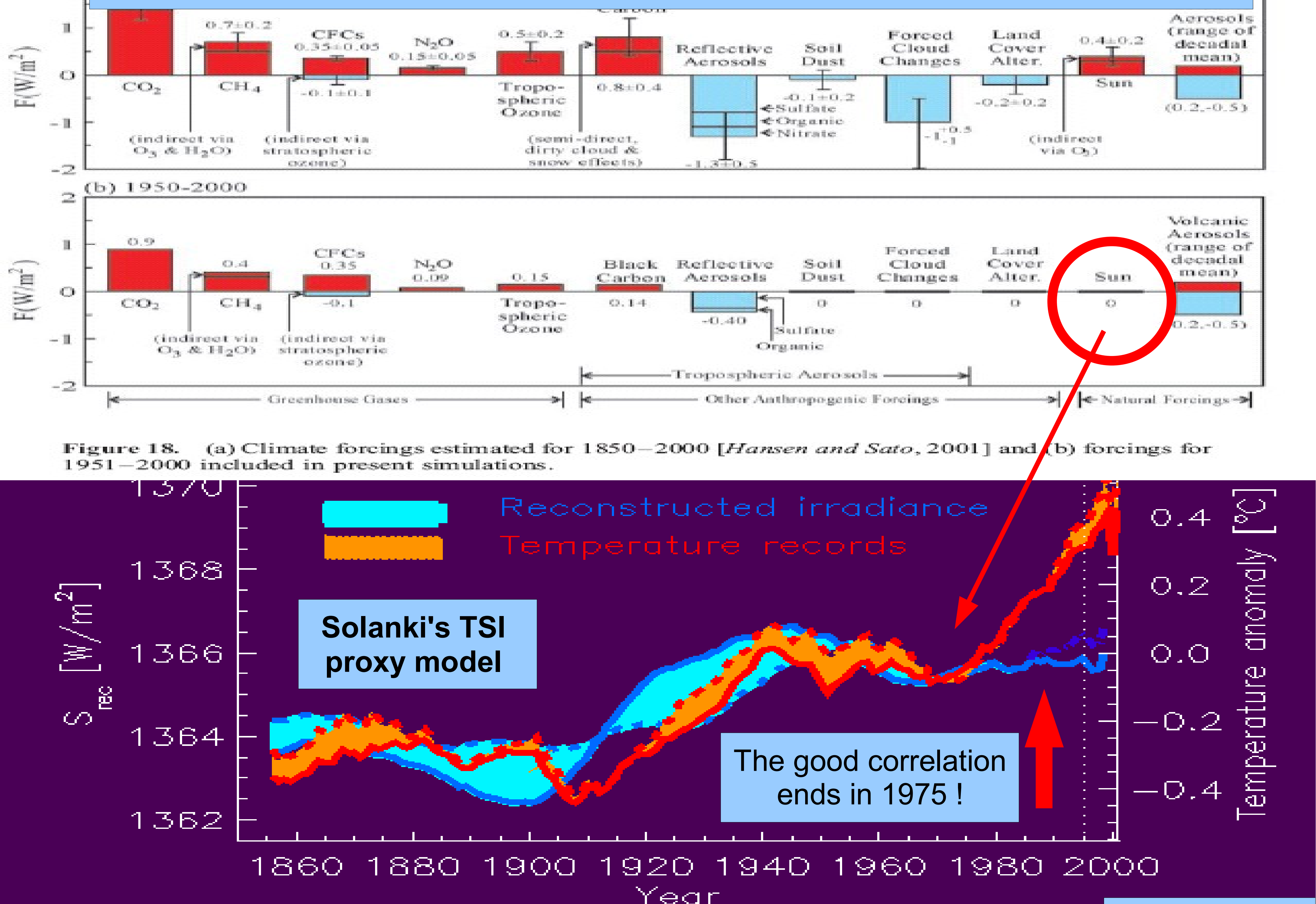


Eddy J.A. (1976), The Maunder Minimum, Science 192, 1189-1202.



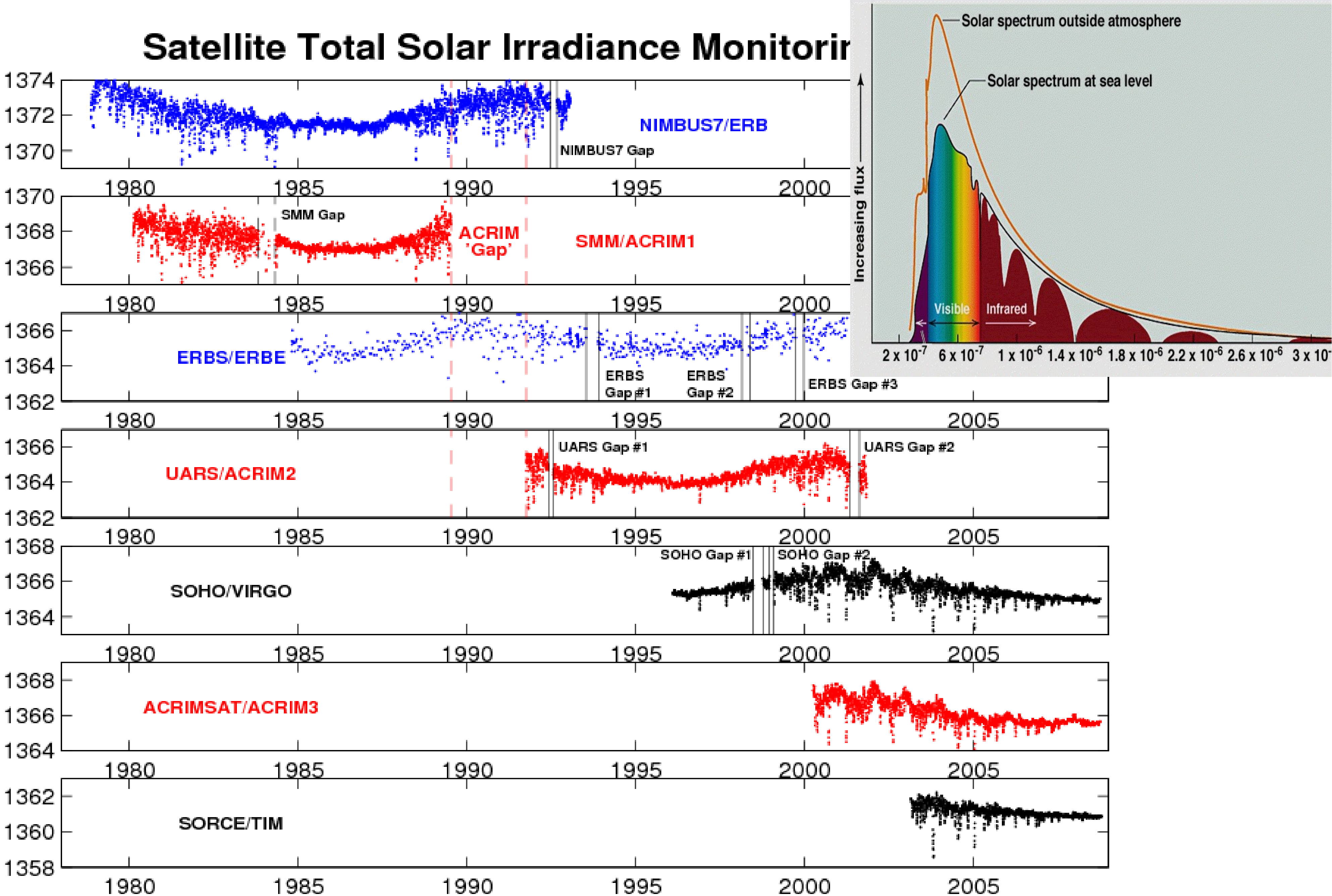
Scafetta, EPA 2009

IPCC 2001-7: Sun and climate are no longer correlated since 1975 (?)



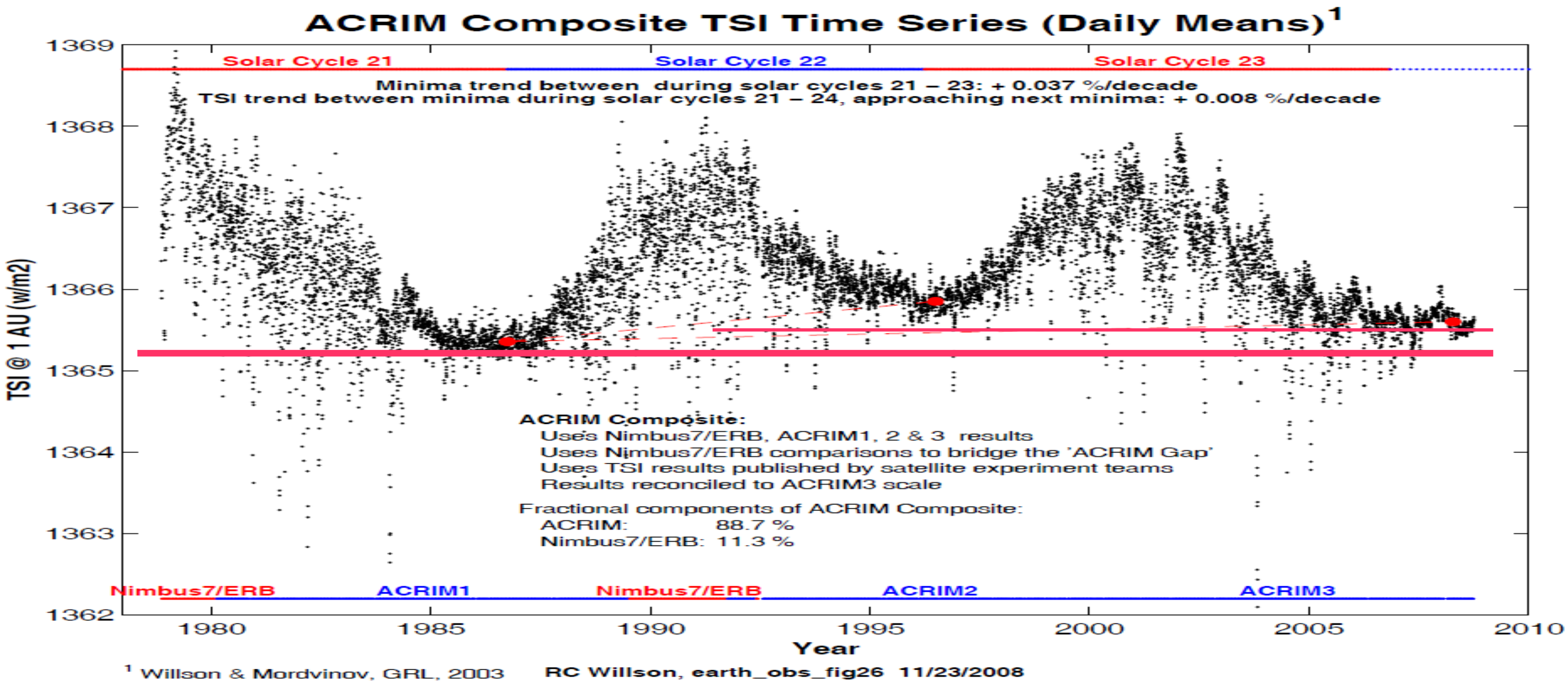
Scafetta, EPA 2009

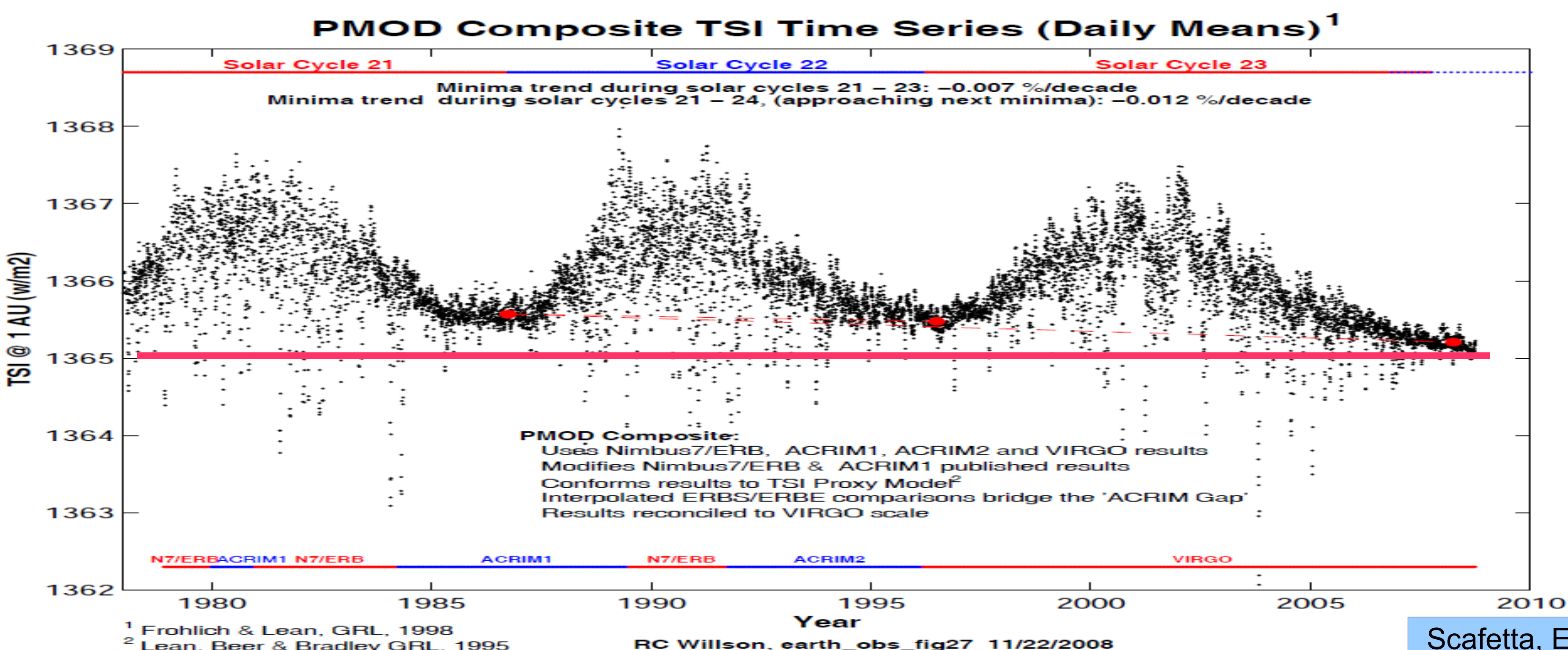
Did the TSI increase or remain constant after 1980?
THE ACRIM - PMOD CONTROVERSY - solved



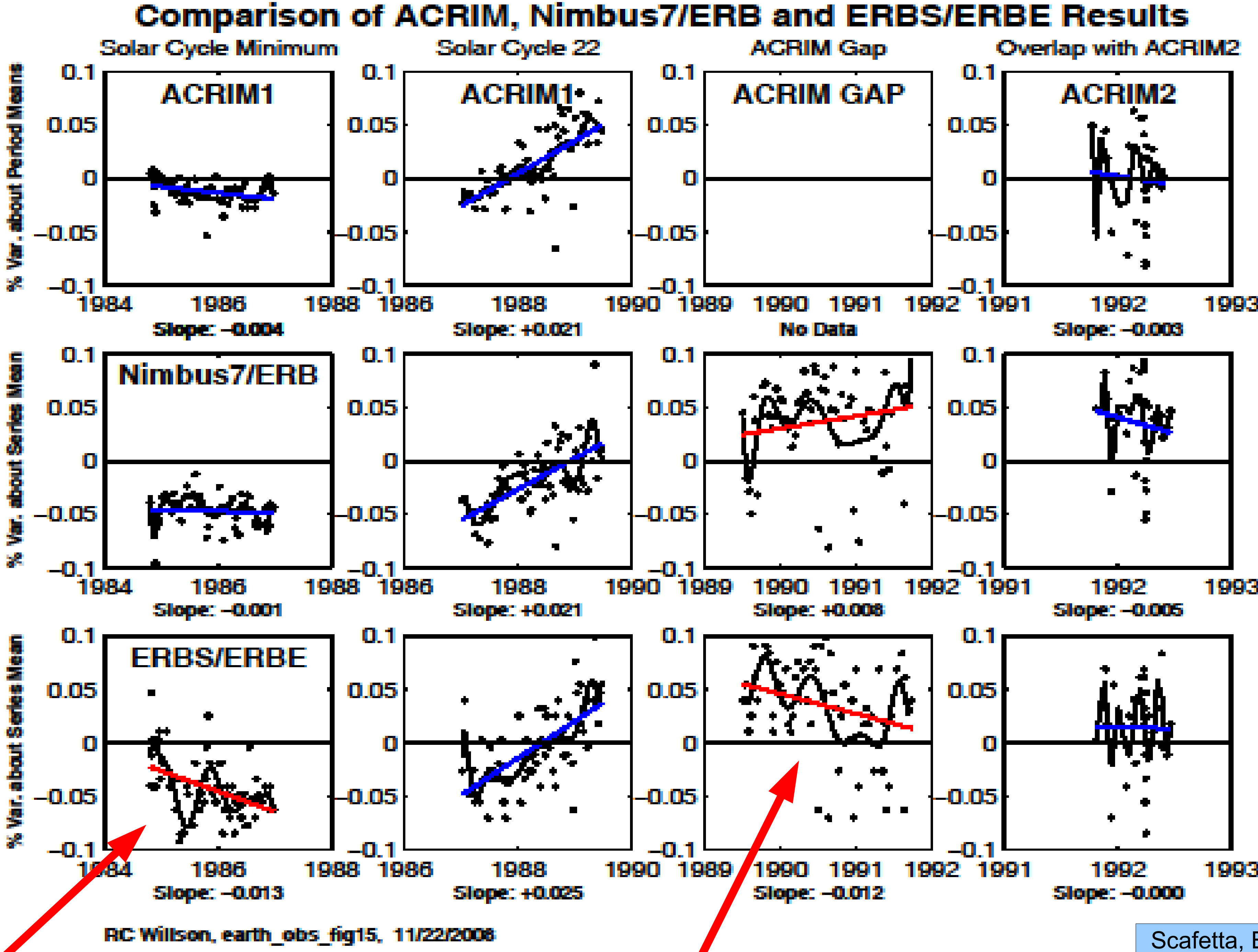
Nicola Scafetta and Richard Willson, “ACRIM-gap and Total Solar Irradiance (TSI) trend issue resolved using a surface magnetic flux TSI proxy model”, in press Geophysical Research Letter (2009) .

Scafetta, EPA 2009





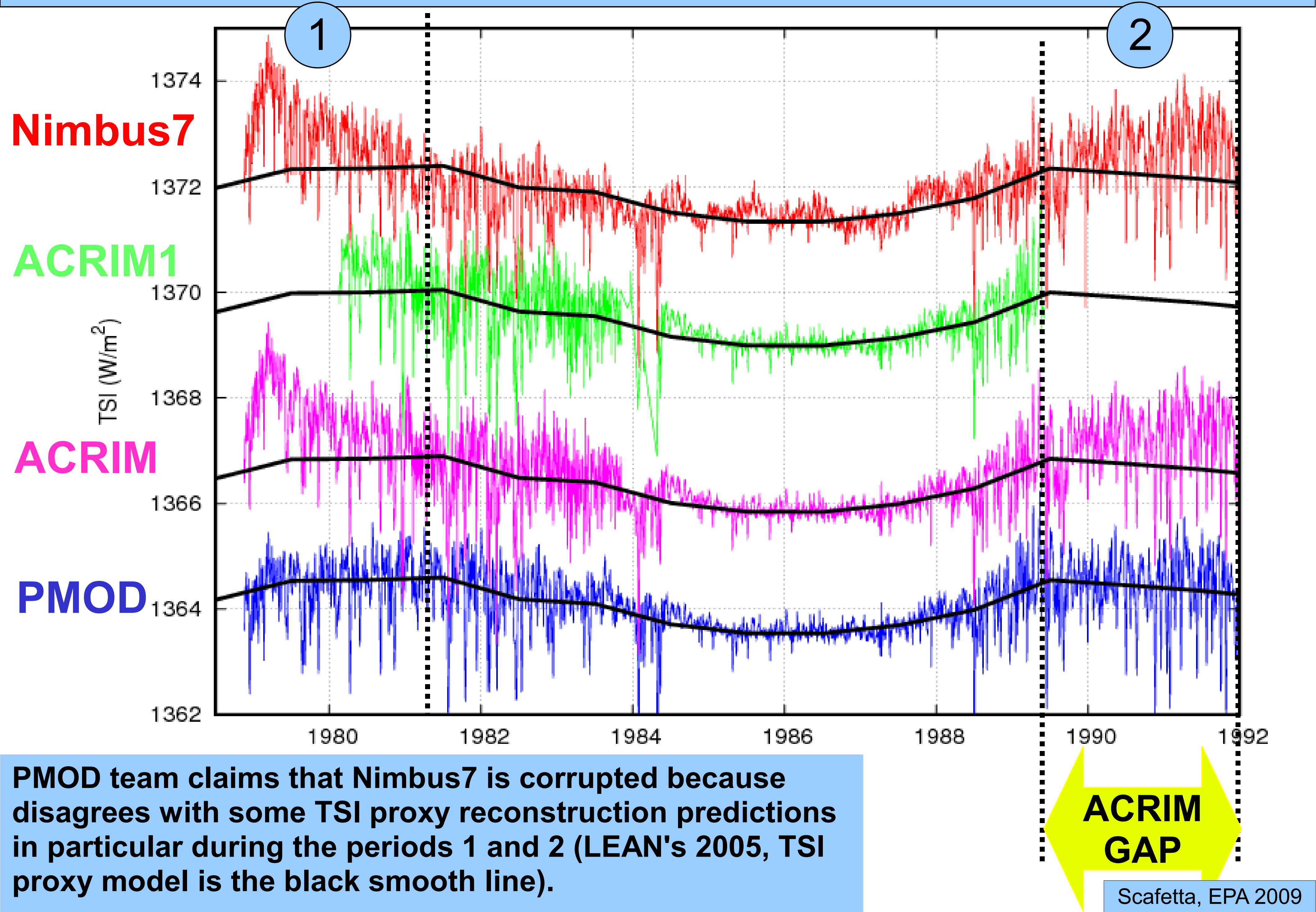
Scafetta, EPA 2009



Scafetta, EPA 2009

ACRIM team claims that ERBS/ERBE degraded during the ACRIM-gap because during this time ERBS sensors were experiencing the large high frequency solar irradiance for the first time. ERBS also clearly degraded in 1984-1986 when its mission started.

Comparison among TSI Data, Composites and a Proxy reconstruction

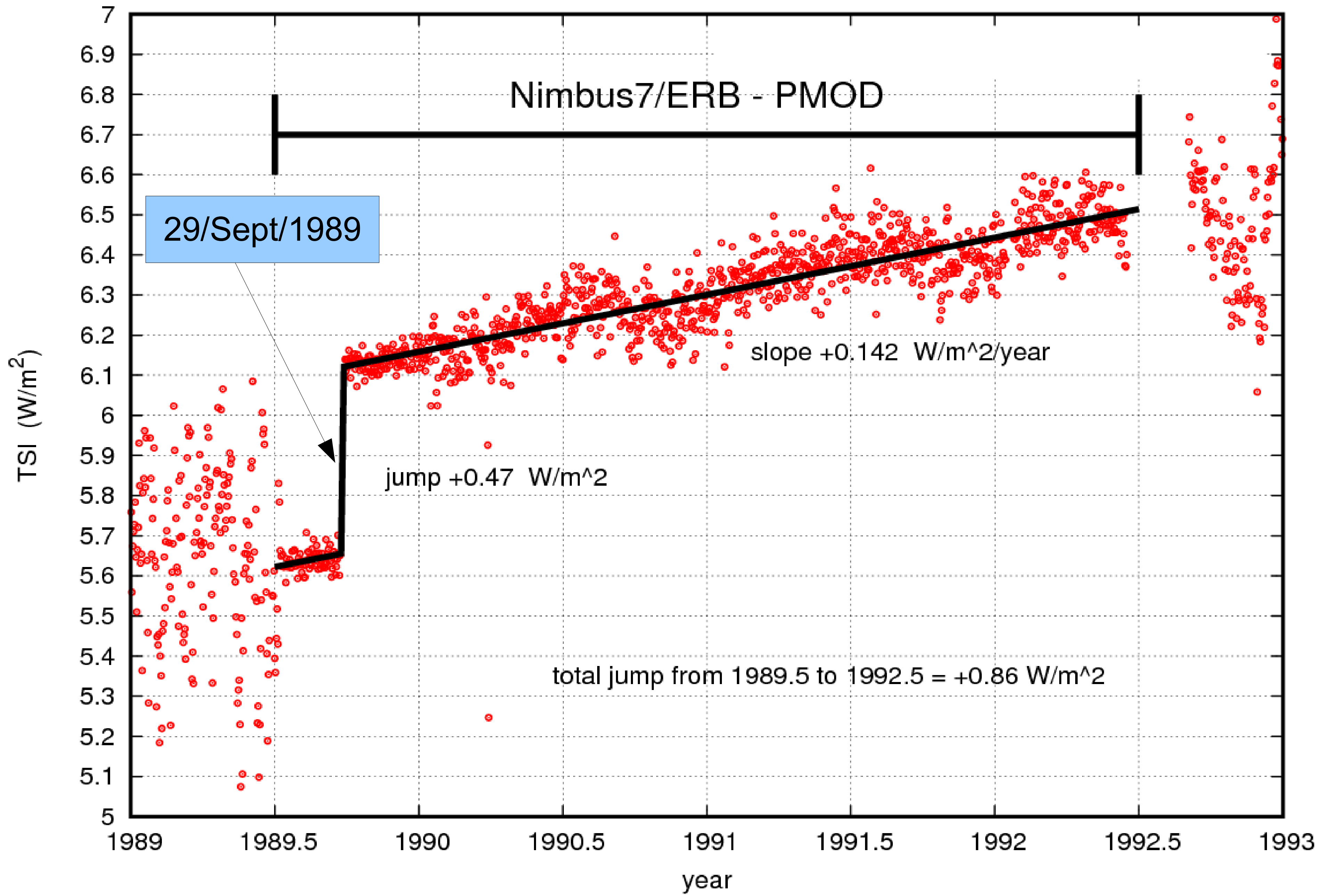


PMOD team claims that Nimbus7 is corrupted because disagrees with some TSI proxy reconstruction predictions in particular during the periods 1 and 2 (LEAN's 2005, TSI proxy model is the black smooth line).

Scafetta, EPA 2009

PMOD correction of Nimbus7 during the ACRIM GAP

PMOD shifts down Nimbus7 record by 0.86 W/m^2 during the ACRIM-gap



Scafetta, EPA 2009

The TSI experimental teams disagree with PMOD

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E-mail: rwillson@acrim.com

September 16, 2008

Dear. Dr. Scafetta:

Regarding Frohlich's PMOD TSI composite:

1. Frohlich made unauthorized and incorrect adjustments to the SMM/ACRIM1 and UARS/ACRIM2 TSI results. In the case of ACRIM1 he arbitrarily miss-applied the degradation correction published by the ACRIM1 Science team for the SMM 'spin mode' (1981 – 1984) to the 1980 results. He did this without any detailed knowledge of the ACRIM1 instrument or on-orbit performance, original analysis or consultation with the ACRIM1 team. His intent was clearly to revise the solar cycle 21 TSI to agree with Judith Lean's TSI proxy model.
2. Frohlich chose the ERBS/ERBE database to 'bridge' the ACRIM gap when it was clearly inferior to the Nimbus7/ERB gap data. His justification was based on hypothetical 'upward steps' in the Nimbus7/ERB results ('glitches' in Frohlich's words) that no other researchers, including both the original PI (Hickey) and the final science team (Hoyt and Kyle) believe exist. As with ACRIM1 above, Frohlich had no detailed knowledge of the Nimbus7/ERB instrument and made no original analysis or computations. The only obvious purpose appears to be to obtain a TSI composite that agreed with the predictions of Lean's TSI proxy model.
3. The TSI proxy models, such as Lean's, are not competitive in accuracy or precision with even the worst satellite TSI observations. To 'adjust' satellite data to agree with such models is incompatible with the scientific method.
4. The PMOD TSI composite panders to those who promote anthropogenic causes as the principal component of global warming, despite mounting evidence to the contrary. They cite its lack of significant TSI trending as evidence of relatively insignificant solar climate forcing during the past 30 years.

Sincerely,

Dr. Richard C. Willson

September 16, 2008

Douglas Hoyt
dhoyt@toast.net

Dear Dr. Scafetta:

Concerning the supposed increase in Nimbus7 sensitivity at the end of September 1989 and other matters as proposed by Frohlich's PMOD TSI composite:

1. There is no known physical change in the electrically calibrated Nimbus7 radiometer or its electronics that could have caused it to become more sensitive. At least neither Lee Kyle nor I could never imagine how such a thing could happen and no one else has ever come up with a physical theory for the instrument that could cause it to become more sensitive.

2. The Nimbus7 radiometer was calibrated electrically every 12 days. The calibrations before and after the September shutdown gave no indication of any change in the sensitivity of the radiometer. Thus, when Bob Lee of the ERBS team originally claimed there was a change in Nimbus7 sensitivity, we examined the issue and concluded there was no internal evidence in the Nimbus7 records to warrant the correction that he was proposing. Since the result was a null one, no publication was thought necessary.

3. Thus, Frohlich's PMOD TSI composite is not consistent with the internal data or physics of the Nimbus7 cavity radiometer.

4. The correction of the Nimbus7 TSI values for 1979-1980 proposed by Frohlich is also puzzling. The raw data was run through the same algorithm for these early years and the subsequent years and there is no justification for Frohlich's adjustment in my opinion.

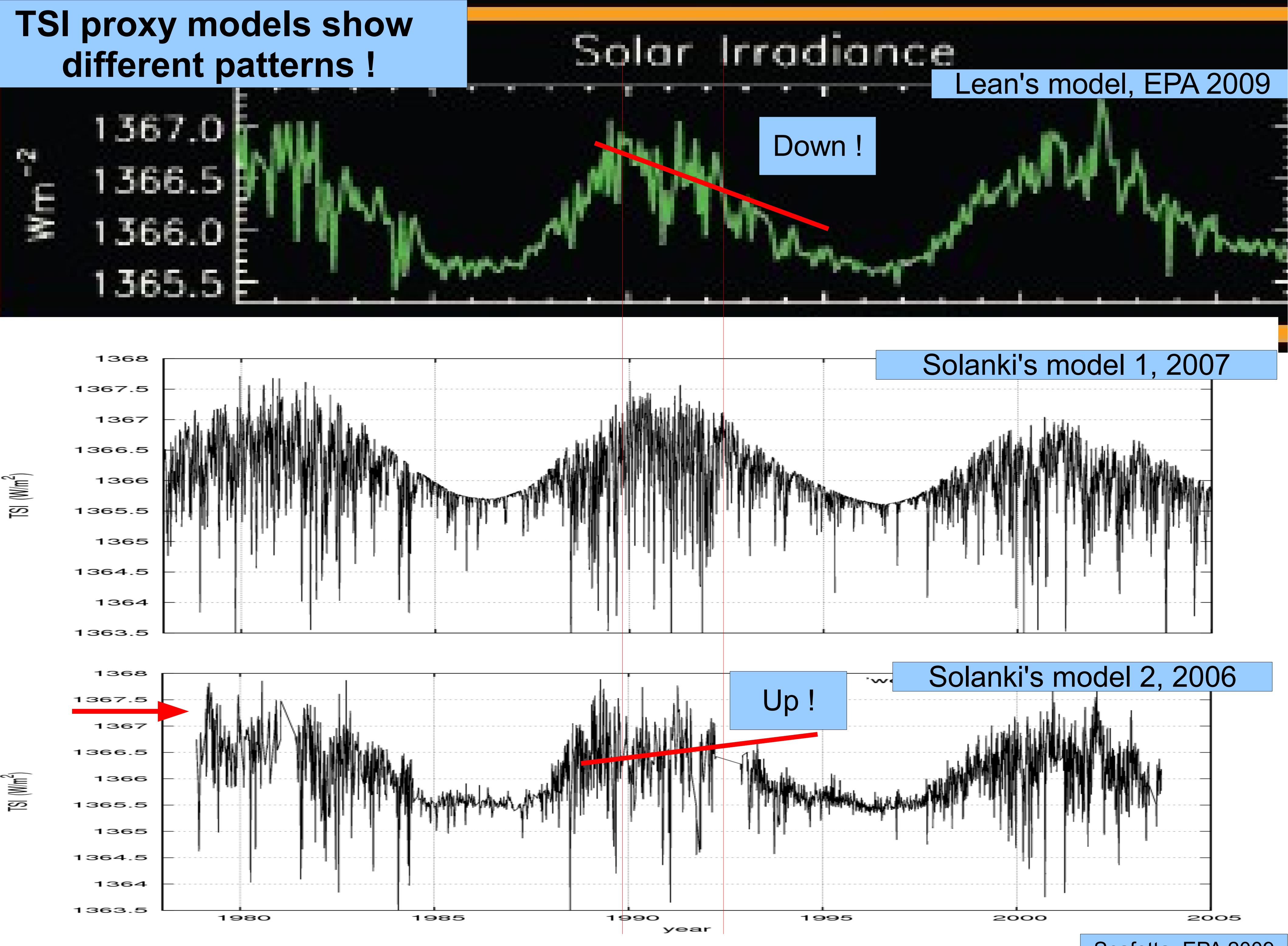
Sincerely,

Douglas Hoyt

The above statement is included in Scafetta and Willson, GRL 2009 Supporting Material

Scafetta, EPA 2009

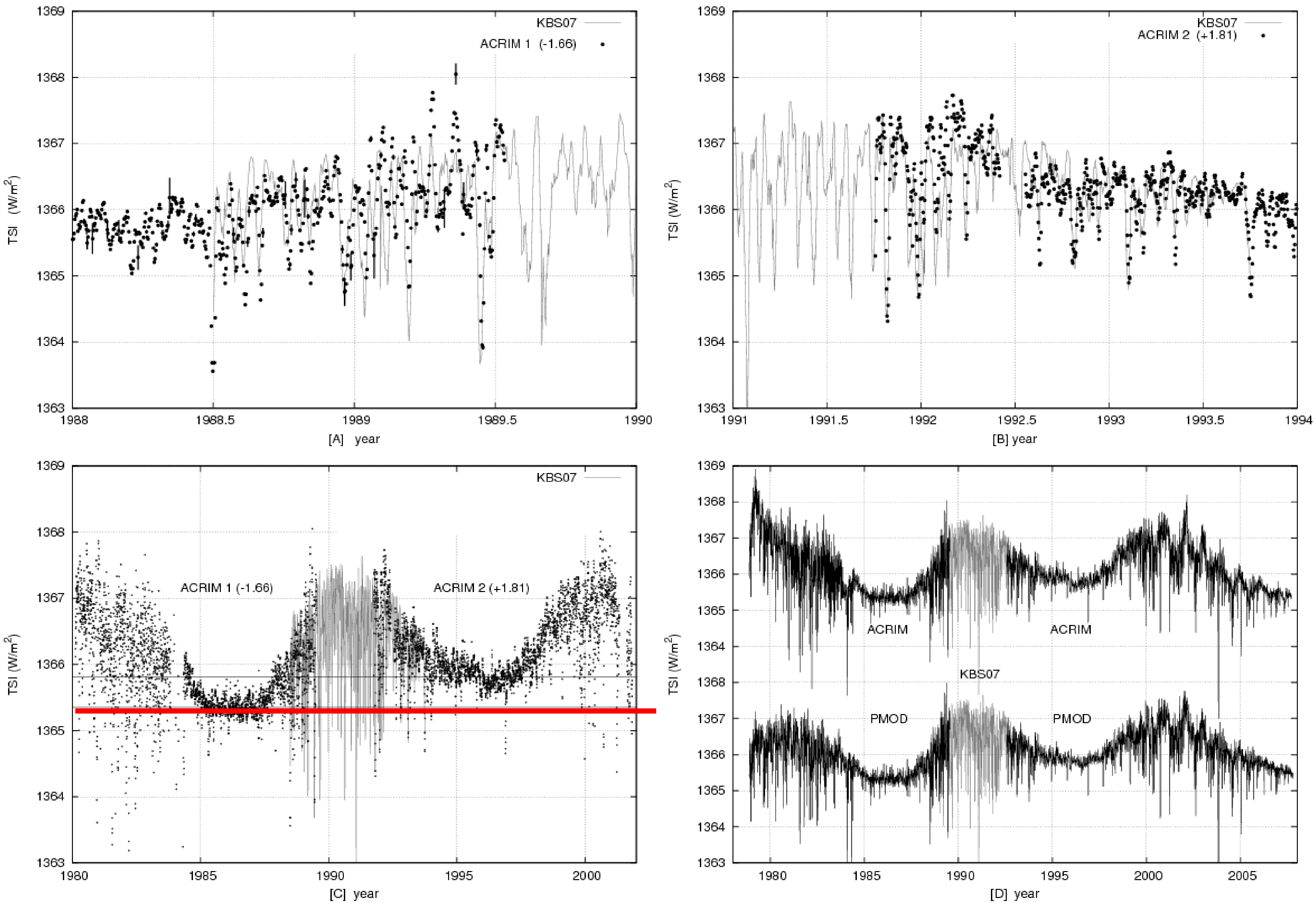
TSI proxy models show different patterns !



Scafetta, EPA 2009

Mixed mode TSI composite ACRIM and KBS07 TSI proxy model

Scafetta N. and R. C. Willson, 2009, ACRIM-gap and TSI trend issue resolved using a surface magnetic flux TSI proxy model, in press on GRL
Krivova N. A., L. Balmaceda, and S. K. Solanki, 2007, Reconstruction of solar total irradiance since 1700 from the surface magnetic flux: Astronomy and Astrophysics, v. 467, p. 335-346.



Scafetta, EPA 2009

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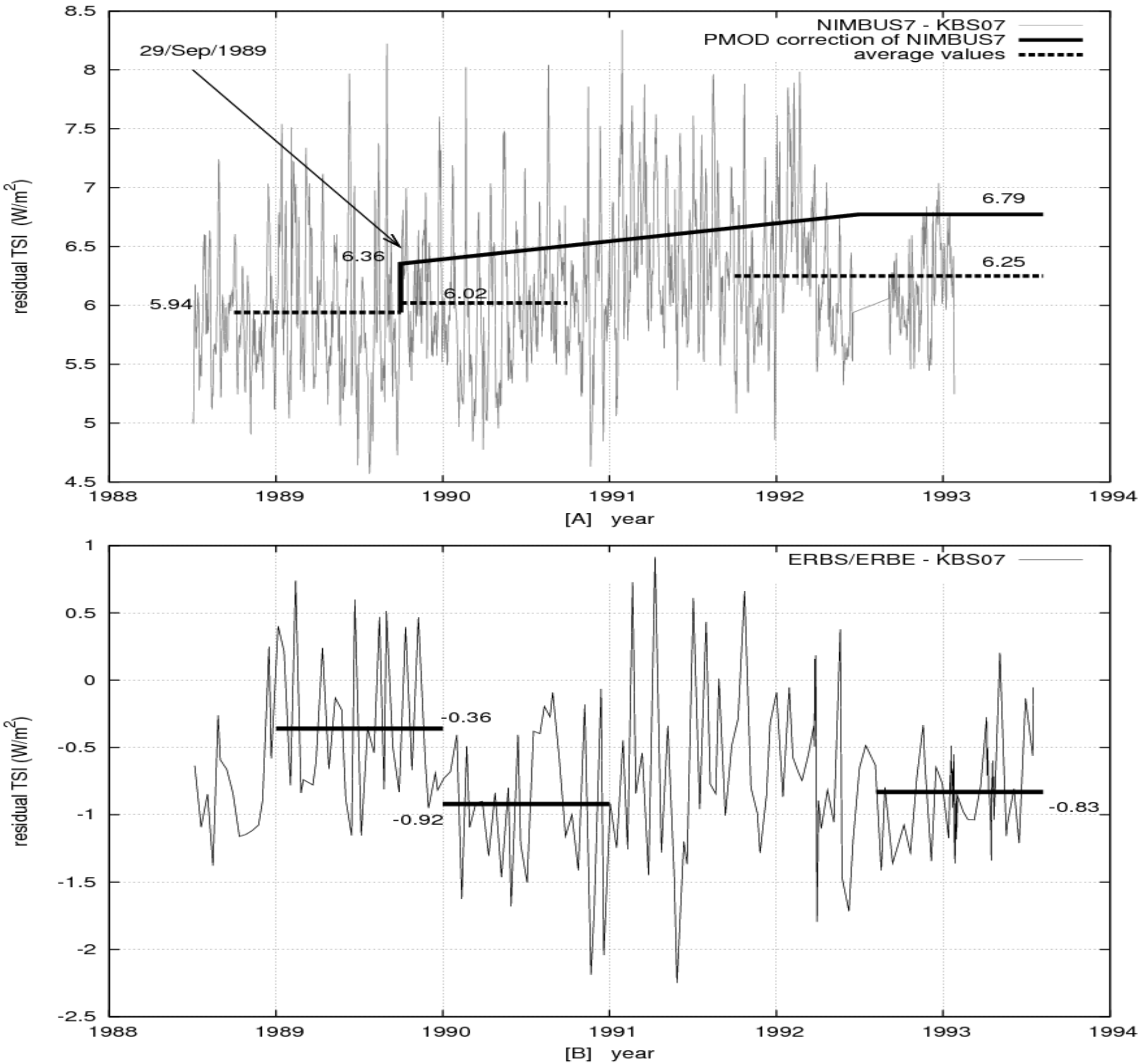
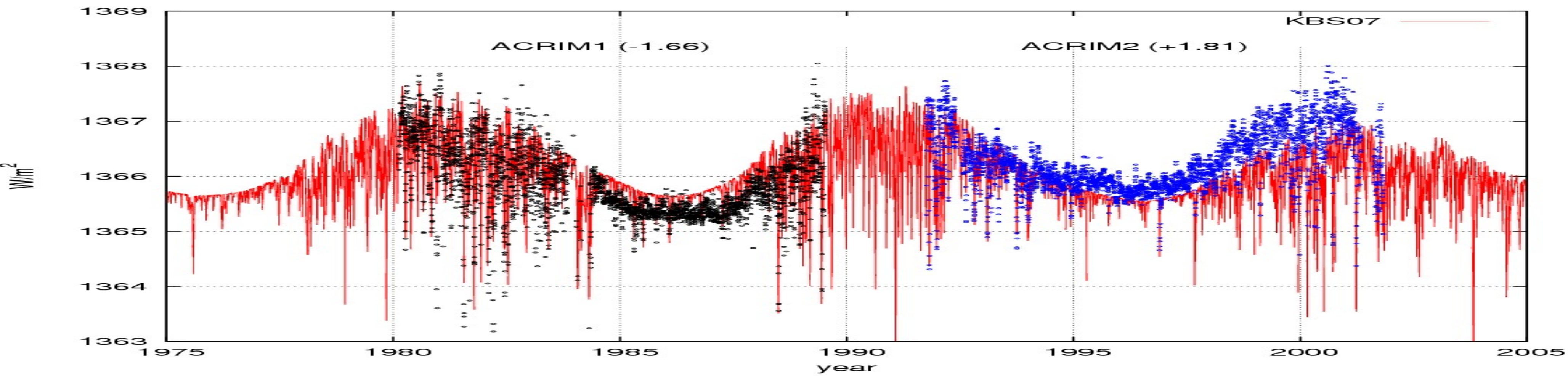
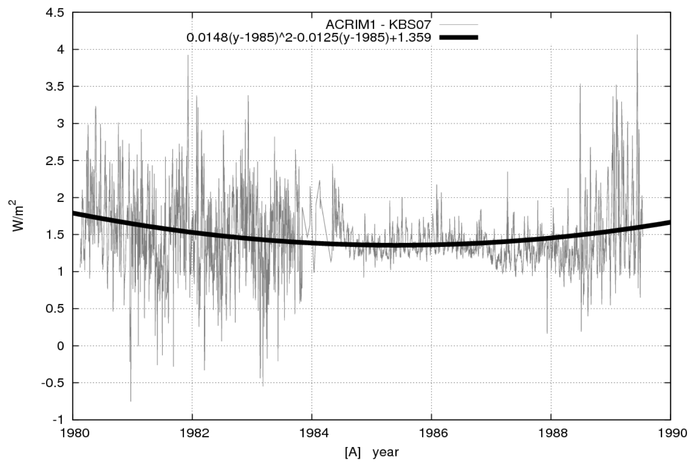


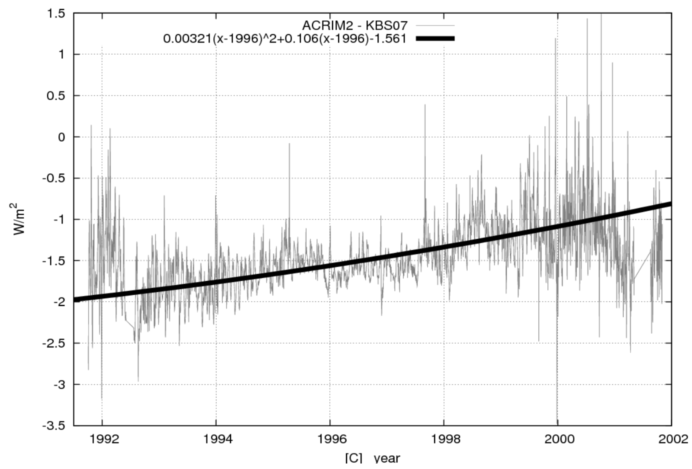
KBS07 TSI proxy model contradicts PMOD corrections of Nimbus7 and confirms ACRIM claims of a significant degradation of ERBS during the ACRIM-gap

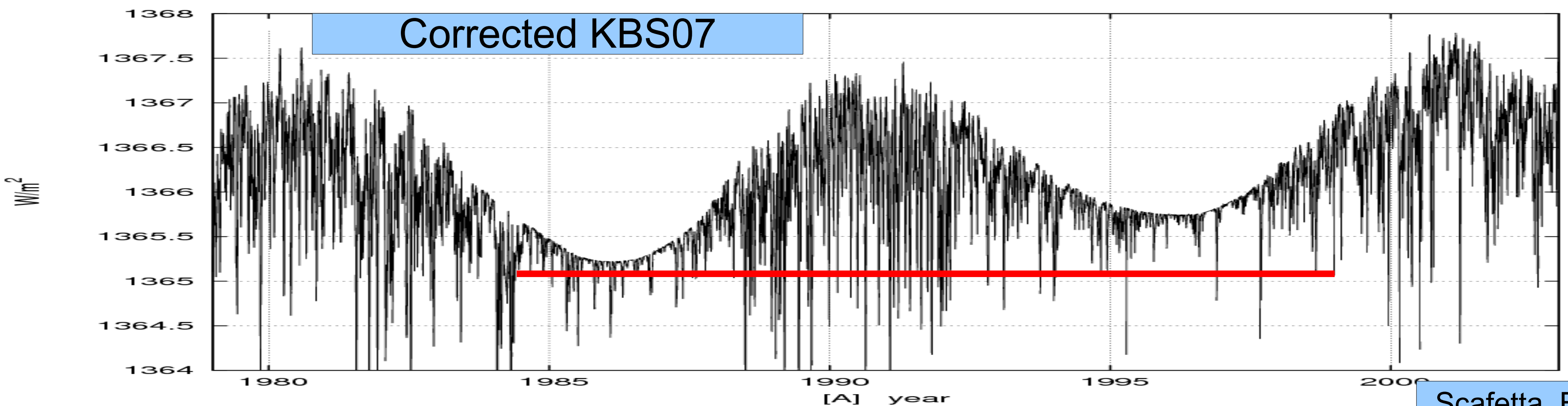
Scafetta, EPA 2009



After adjusting KBS07 outside the ACRIM-gap, it appears as ACRIM composite.



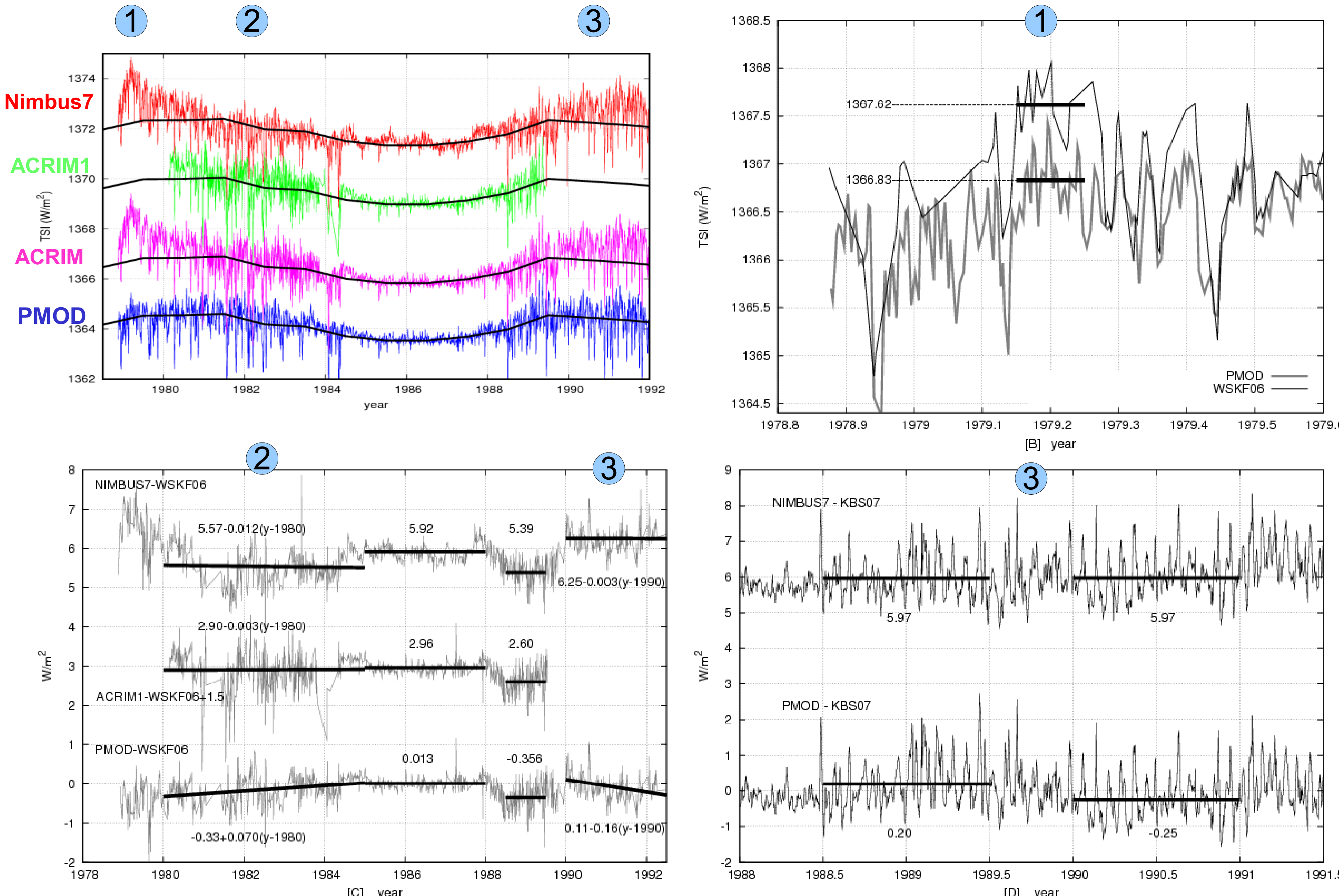




Scafetta, EPA 2009

Incompatibility between PMOD composite and WSKF06 TSI proxy model

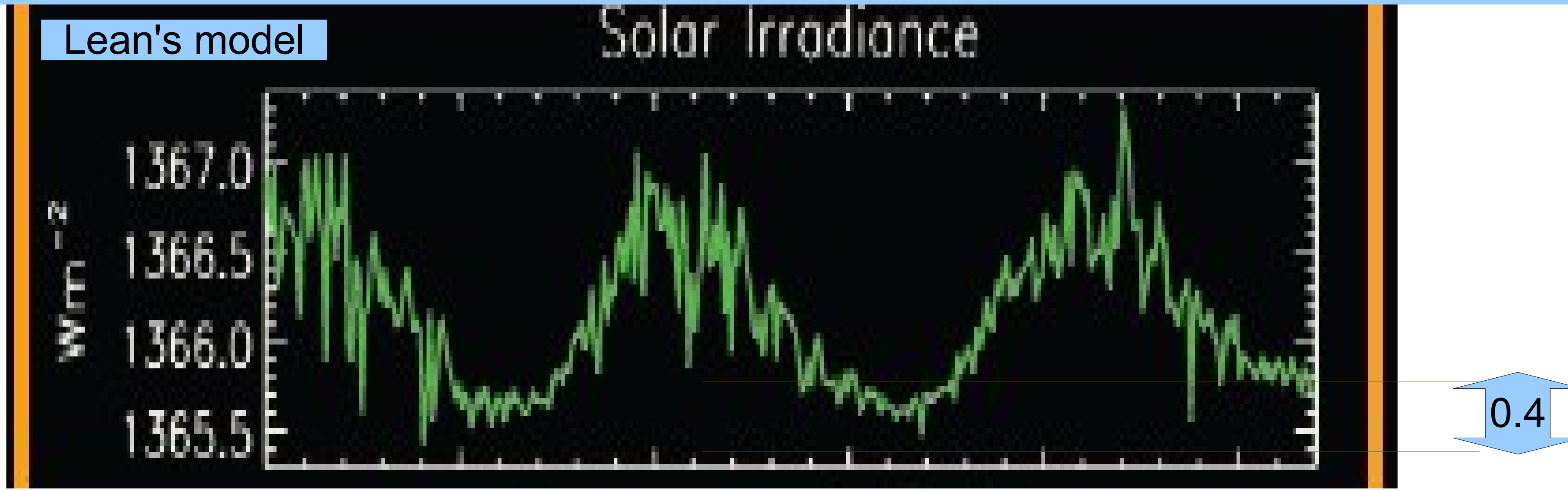
Scafetta N., "**1978-1993 TSI satellite trend issues resolved using a surface magnetic field TSI proxy model" AGU Fall Meeting, San Francisco, 2008.**
Wenzler T., S. K. Solanki, N. A. Krivova, and C. Frohlich (2006), Reconstruction of solar irradiance variations in cycles 21-23 based on surface magnetic fields, Astr. and Astrophys, 460, 583-595.

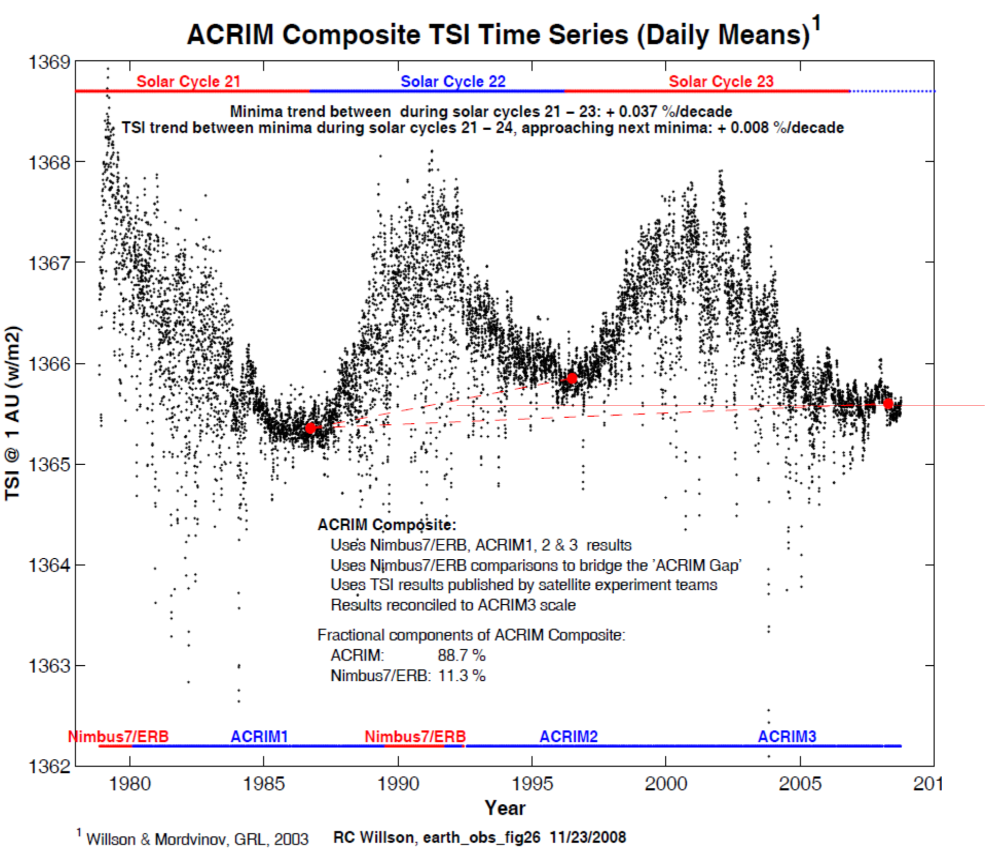


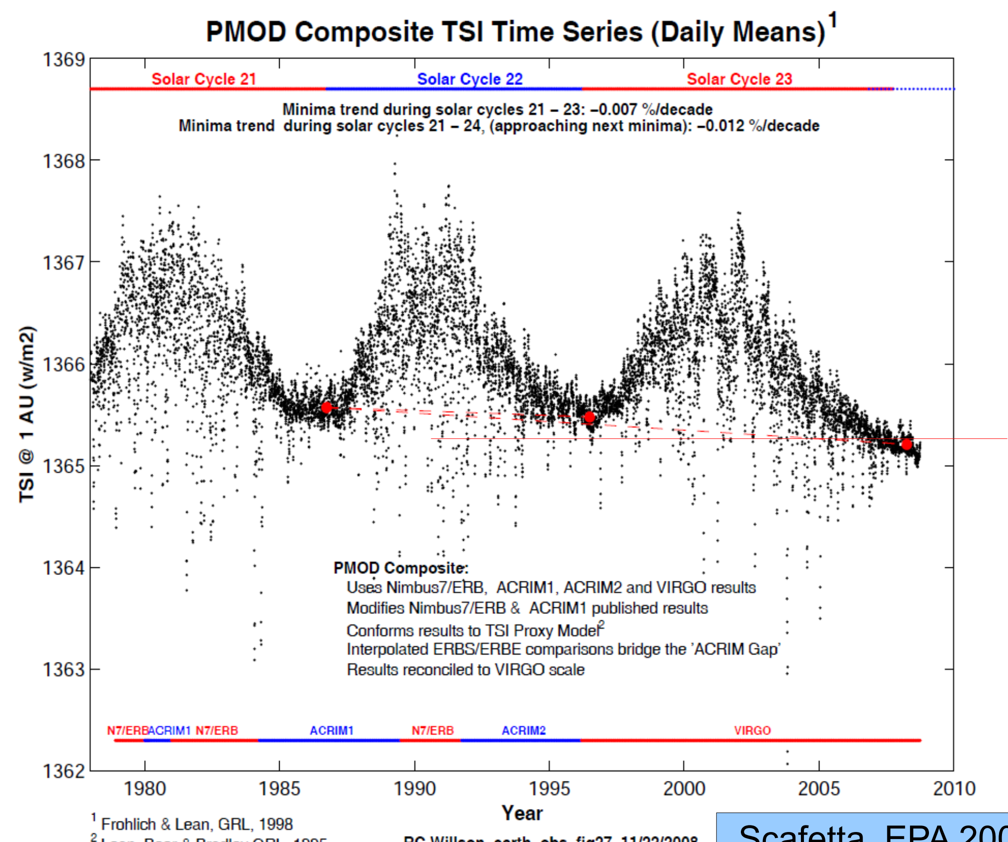
Scafetta, EPA 2009

Incompatibility between the 1995-2007 TSI composites and Lean's TSI proxy model

Scafetta N., **EPA, presentation February 2009.**
From Judith Lean, presentation at the EPA meeting January 2009

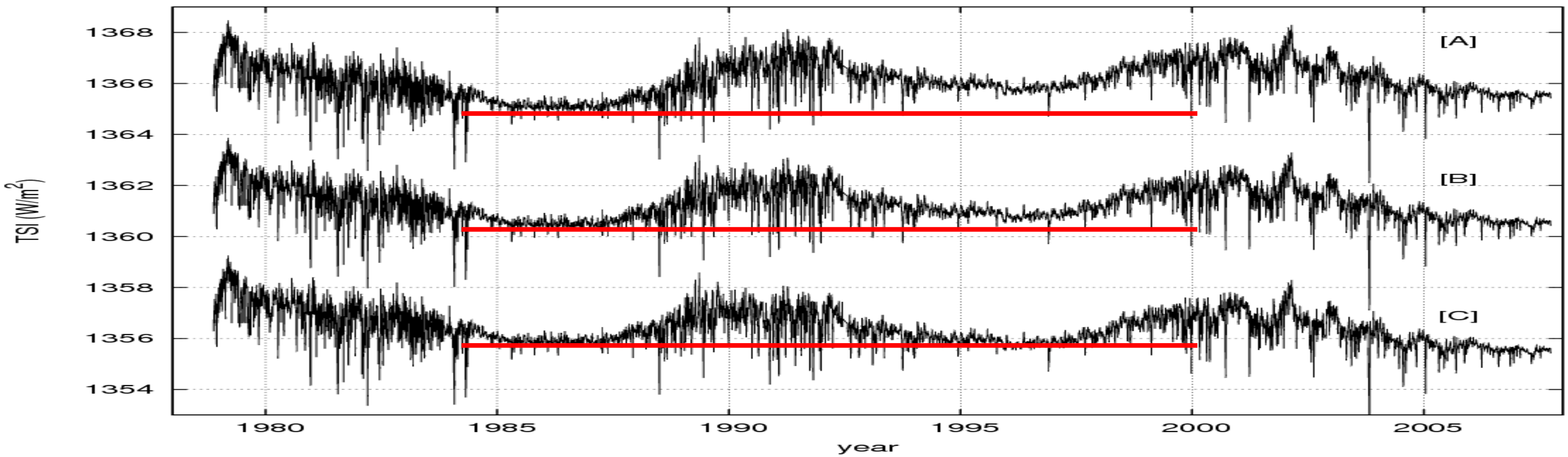


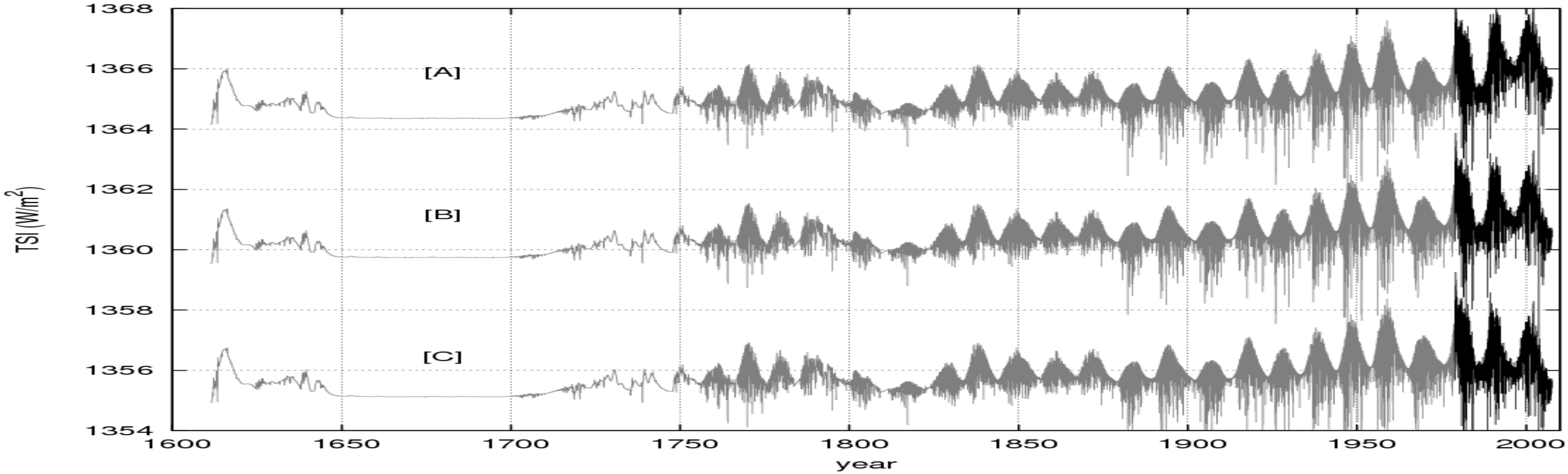




Scafetta, EPA 2009

KBS07 TSI proxy model is corrected since 1980 with three possible TSI composites compatible with [A] Nimbus7, [C] ERBS, [B] average.
The TSI during the last decades has been the largest in four centuries
[Scafetta, 2009 in press, GSA Special Paper on Global Climate Change]



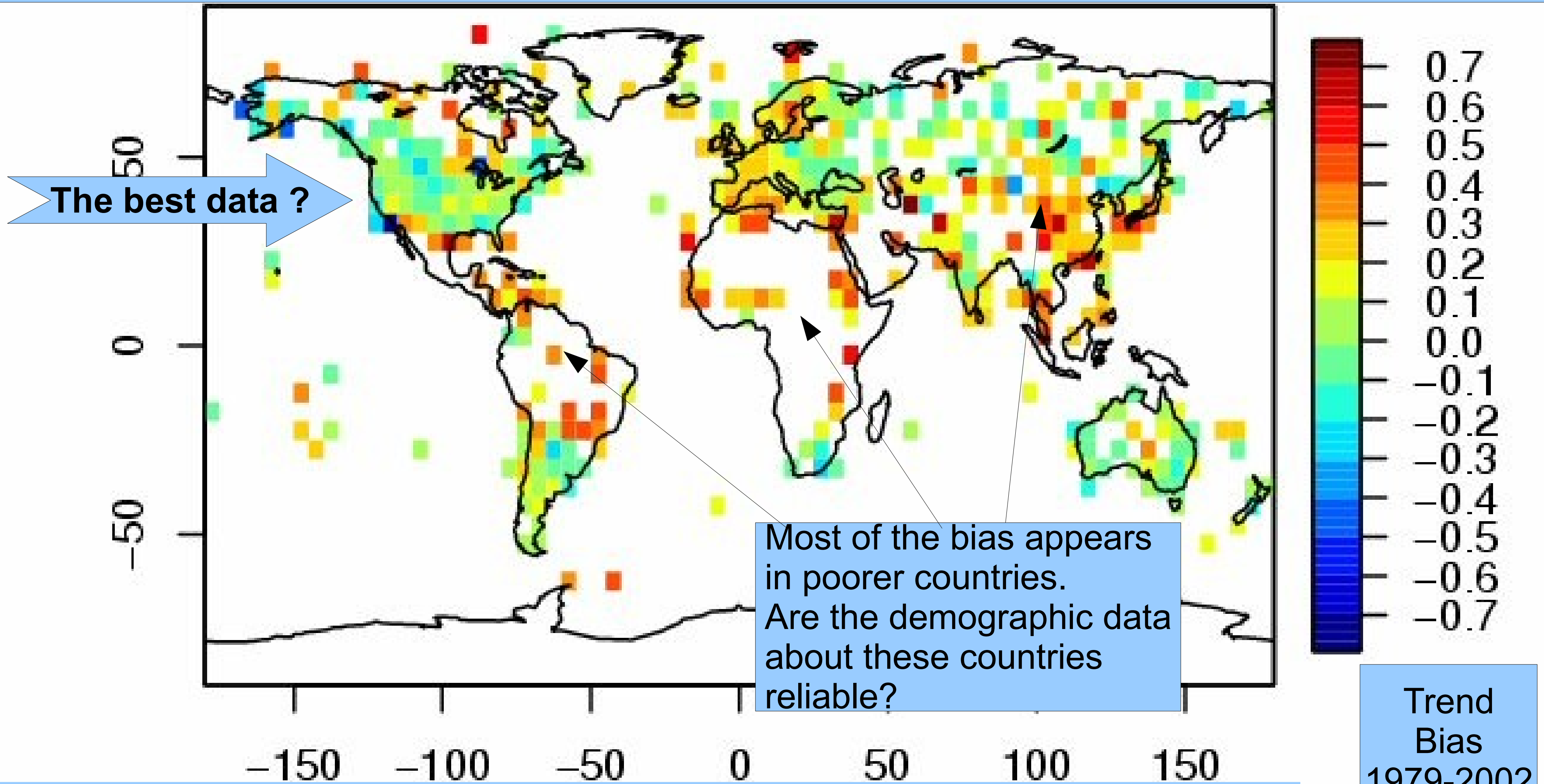


Scafetta, EPA 2009

Can we trust the global surface temperature record?

Some studies suggest that a significant part of the global warming is due to still uncorrected urban heat island problems
Is about half of the global warming trend on the land since 1980 spurious?

R. McKitrick and P. Michaels, Quantifying the influence of anthropogenic surface processes and inhomogeneities on gridded global climate data, December 2007, Journal of Geophysical Research, Volume 112.



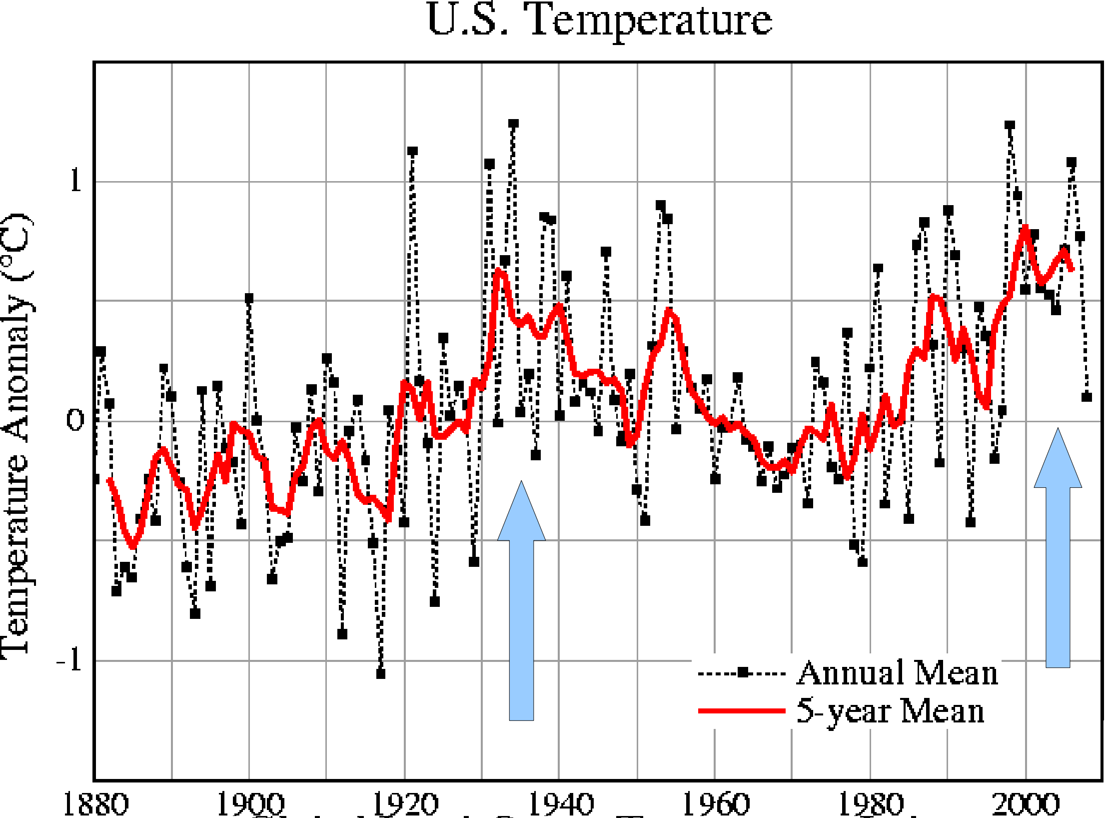
Differences between observed and adjusted warming trends around the world. A value of, say, 0.1–0.2 means that the observed trend in that cell was between 0.1 and 0.2°C/decade higher than the adjusted trend.

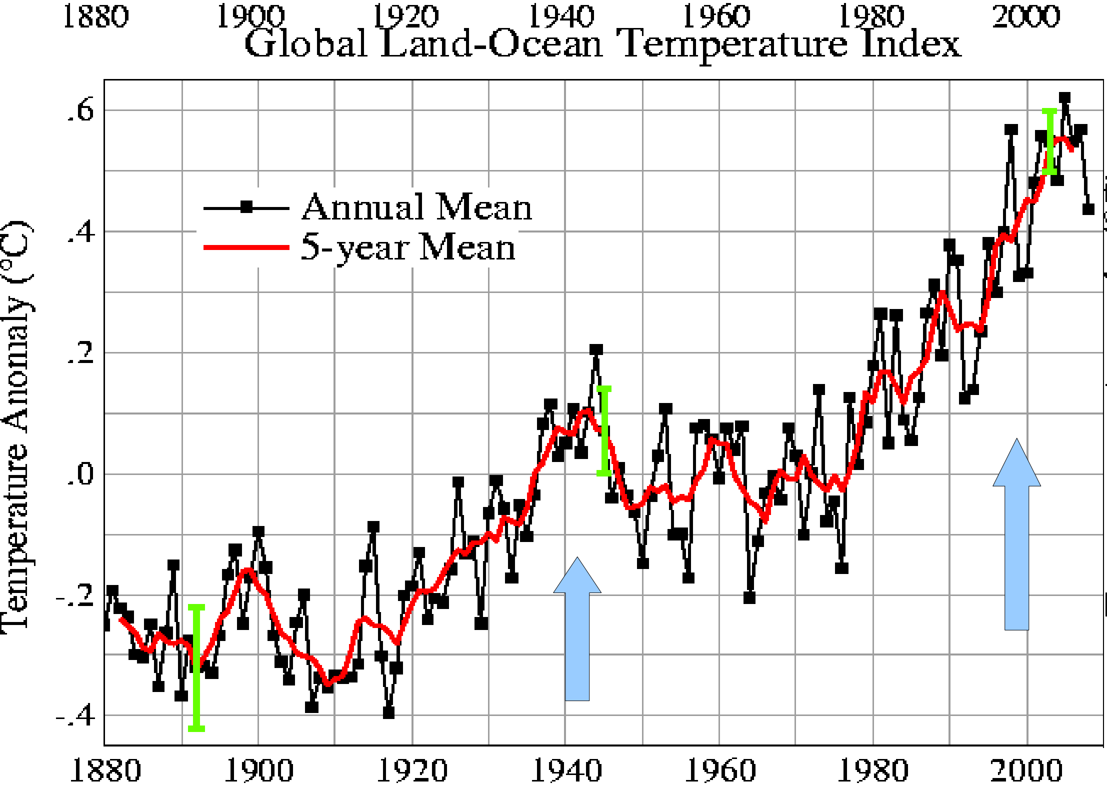
Scafetta, EPA 2009

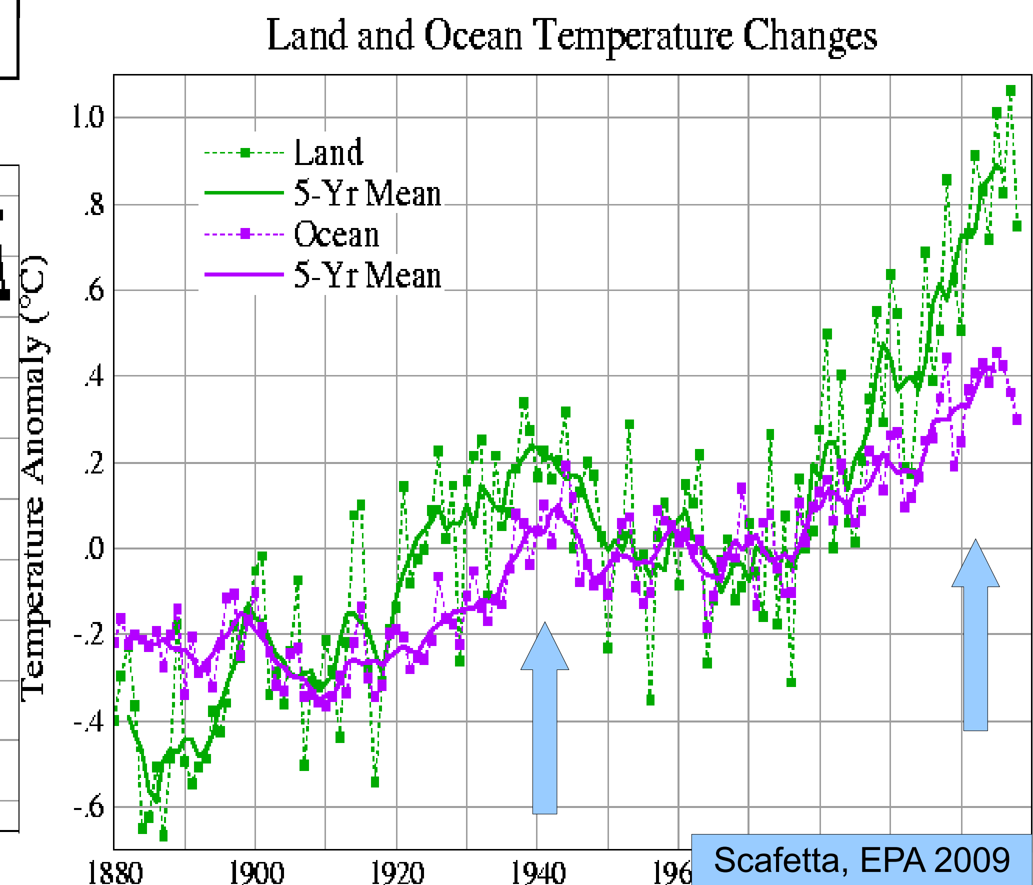
GISS Surface Temperature Analysis

US temp. record suggests that the current warming period is similar to the warming in the 30s!

Did the 20th century have two warming periods?

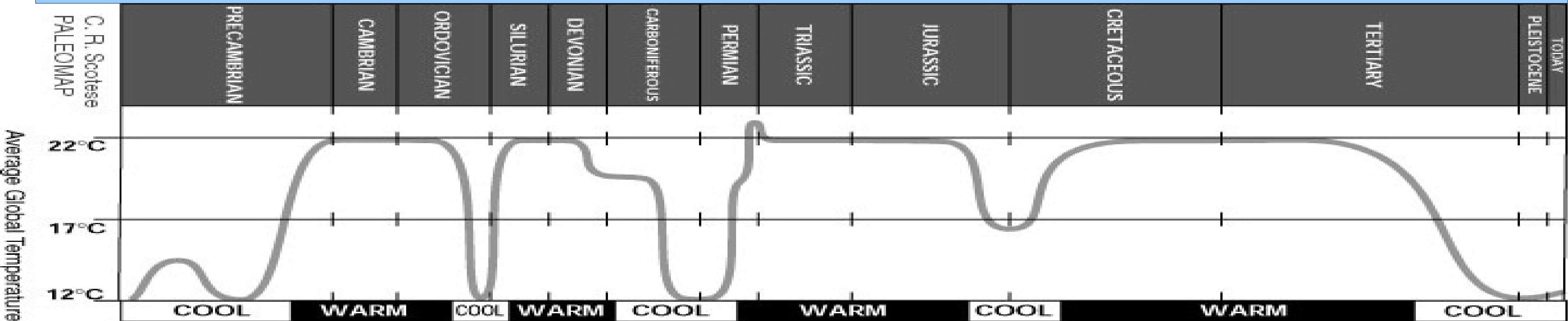


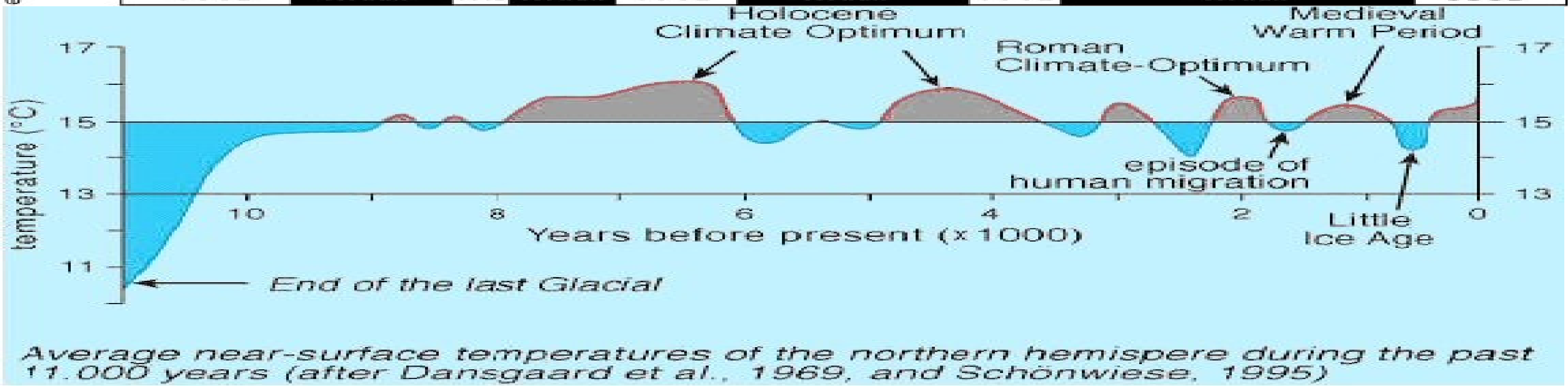


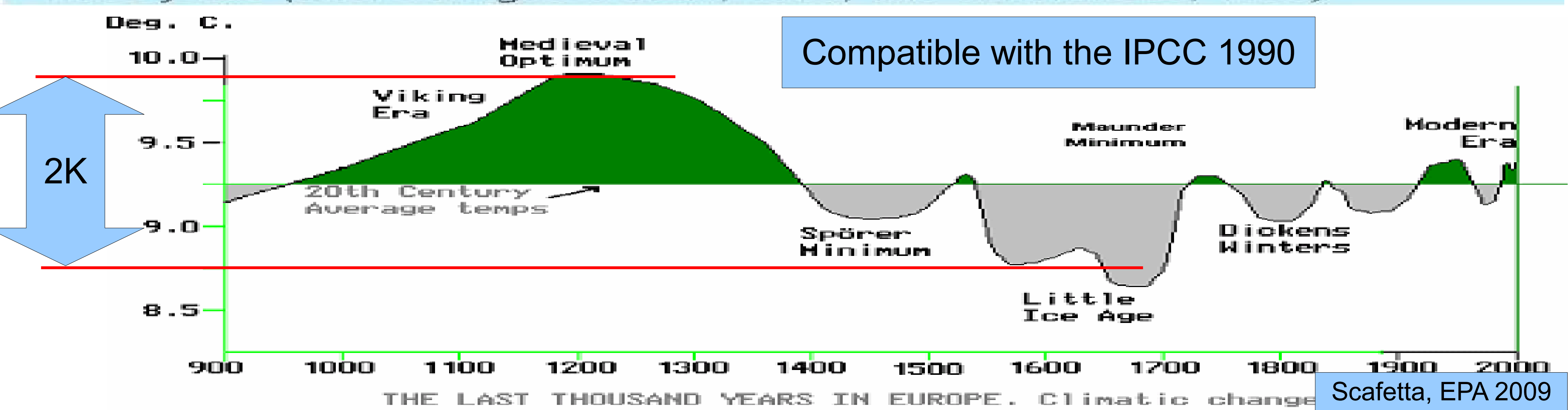


Scafetta, EPA 2009

Paleoclimate Global surface temperature of the Earth

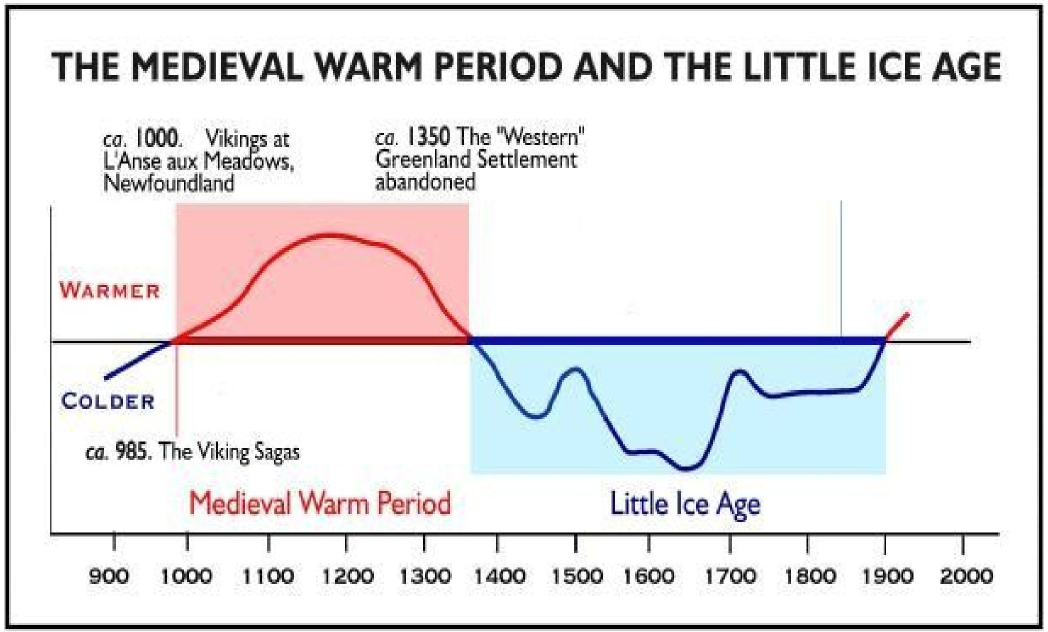






Scafetta, EPA 2009

Vikings' Greenland today (no trees) and (likely) yesterday



Scafetta, EPA 2009

The Little Ice Age in Europe:

A time of severe cold and great hardship, when the Thames froze regularly and alpine glaciers grew deep into the valleys. The latter is greatly illustrated by painters of Dutch school, showing winter scenes, ice-covered canals, figures skating and sledging.

WMO

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
Working Group I: The Physical Basis of Climate Change

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uncertainties are large. Such studies also help to explain episodes during the climate of the last millennium. For example, several modelling studies suggest that volcanic activity has a dominant role in explaining the cold conditions that prevailed from 1675 to 1715 (Andronova et al., 2007; Yoshimori et al., 2005). In contrast, Rind et al. (2004) estimate from model simulations that the cooling relative to today was primarily associated with reduced greenhouse gas forcing, with a substantial contribution from solar forcing.

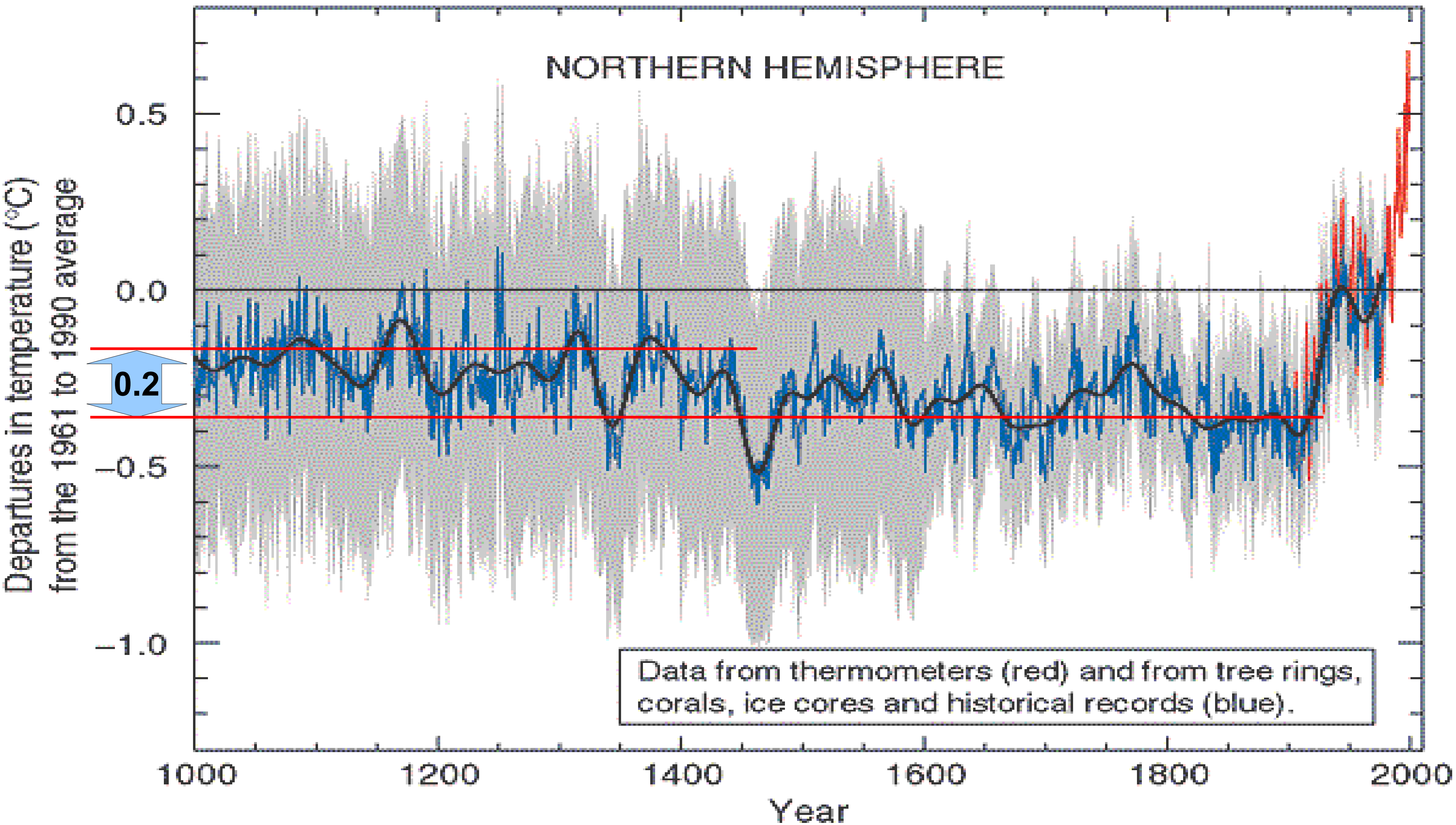
682

?

IPCC 2007

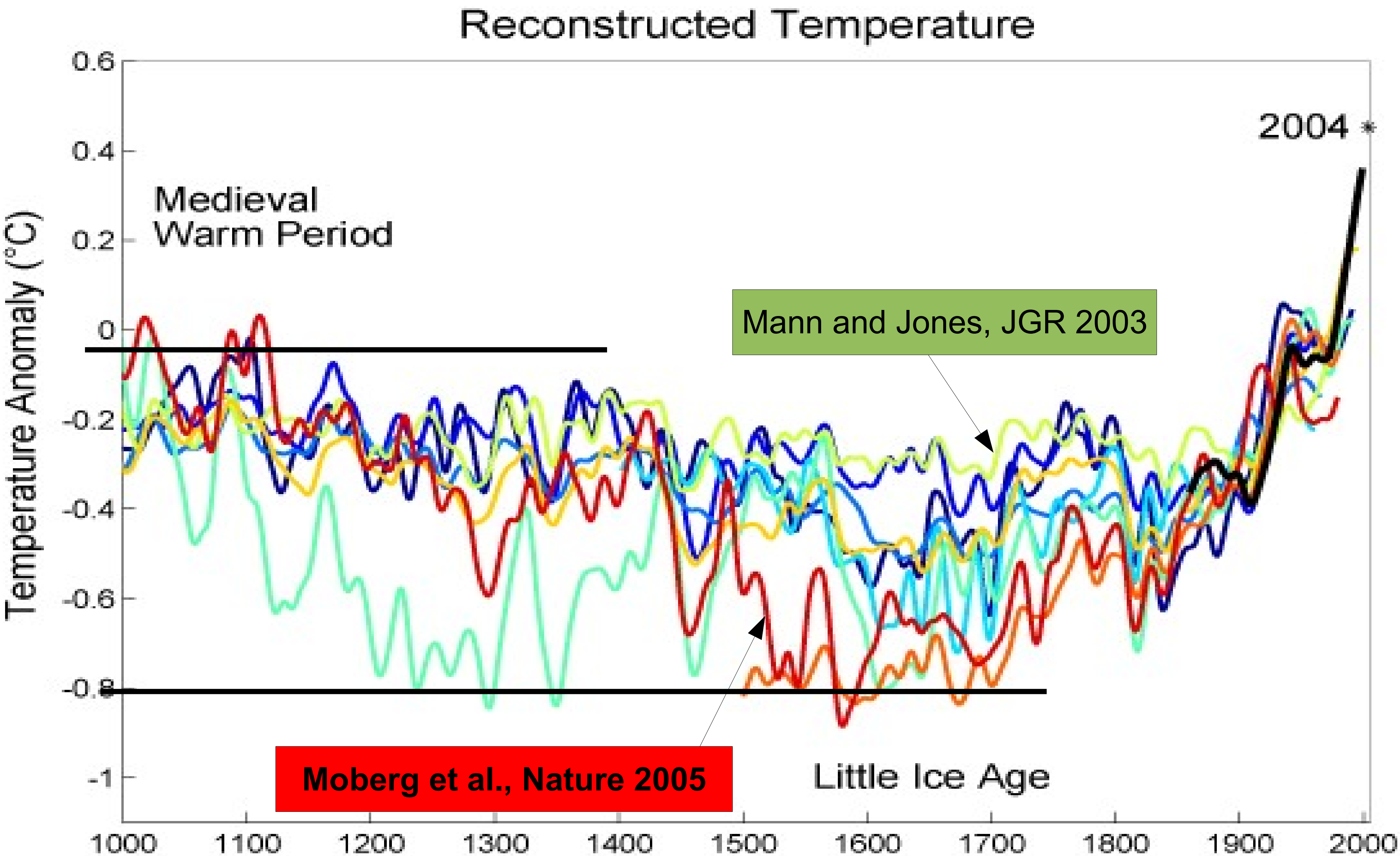
Scafetta, EPA 2009

The “Hockey Stick” temperature (Mann, Bradley, Hughes 1998).
This record surprised the scientific community because the preindustrial climate (<1900) varies 5-10 times **less** than what was previously expected!

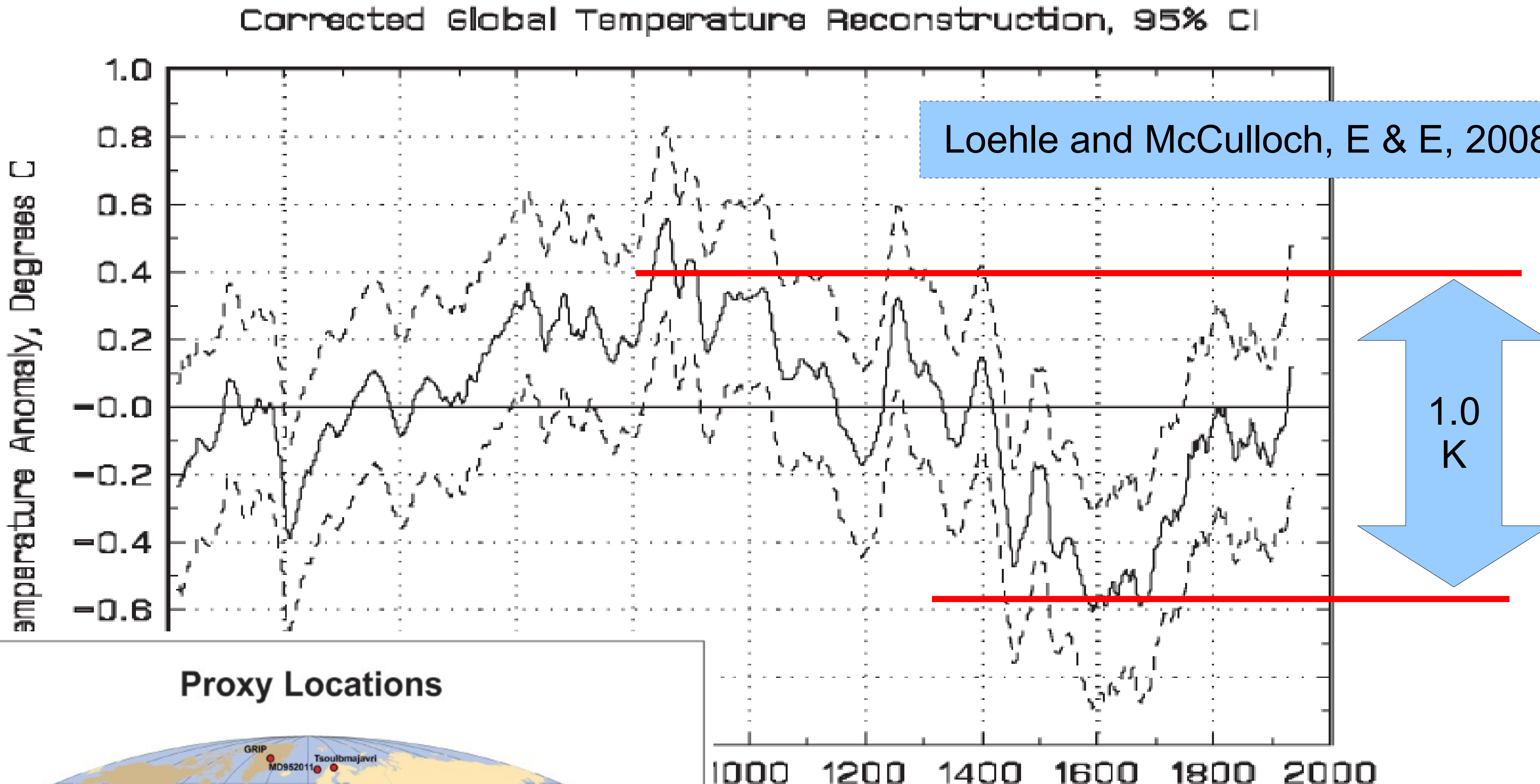


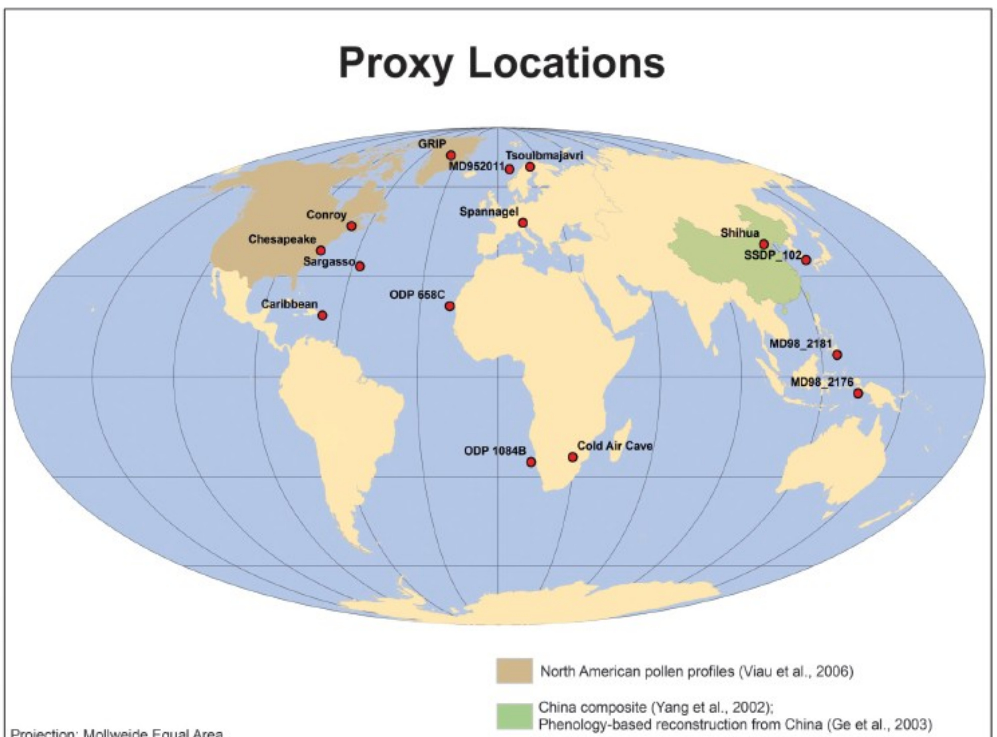
Scafetta, EPA 2009

Since 2004 several new paleoclimate temperature reconstructions were proposed. Some of them show a very large pre-industrial variability which better agrees with the *pre-Mann* understanding of climate change !



Scafetta, EPA 2009





Both Loehle (2008) and Moberg (2005) reconstructions show a large preindustrial variability because tree ring records are <u>NOT</u> used for the secular reconstruction!

Tree growth may be characterized by non-linear behavior that reduces their secular variability. (biological adaptation and water dependency)

Scafetta, EPA 2009

Where IPCC 2001 and 2007 were

1) Total solar irradiance did not change since 1950.
2) Pre-industrial climate (<1900) did not change much (less than 0.2 K).
3) A global anomalous warming was observed since 1900 that rose since 1980.
4) Anthropogenic GHG emission increased monotonically since 1900 and rose since 1950.

Implication: Humans are causing the anomalous warming observed during the last decades

Where we are now

1) Total solar irradiance likely rose between 1970s and 2000.
2) Pre-industrial climate significantly changed (as much as 1.0 K from MWP to LIA).
3) Two apparently similar warming periods are observed during the first (1910-1940) and second half (1970-2000) of the 20th century.
4) Anthropogenic GHG emission increased monotonically since 1900 and rose since 1950.

Expectation: A significant fraction of the warming observed during the last decades is natural (sun or something else).

How climate is modeled

Energy Balance Models and General Circulation Models

All known climate mechanisms are included. All unknown climate mechanisms are ignored.
A set of known climate forcings (TSI, GHG, Aerosol, etc) are used as inputs.

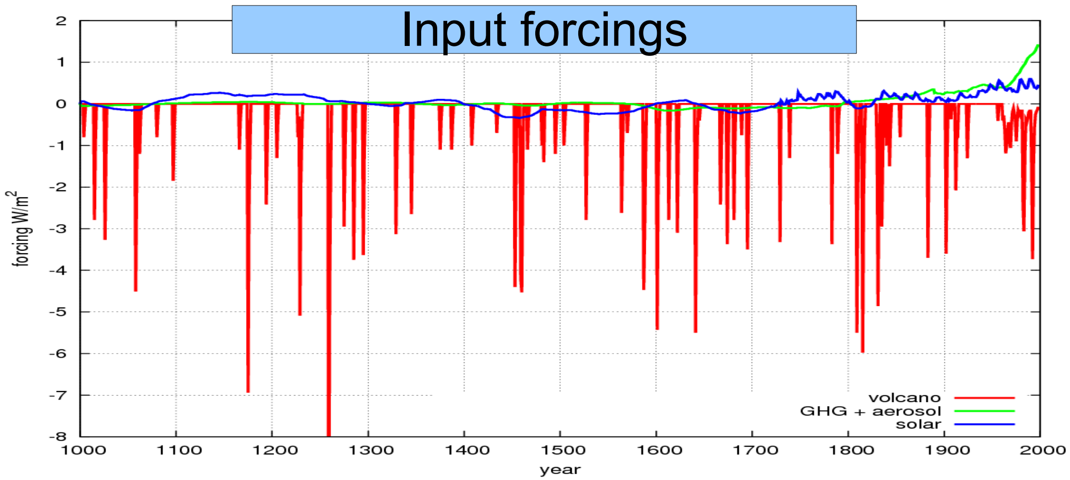
Multilinear Regression Analysis of the temperature

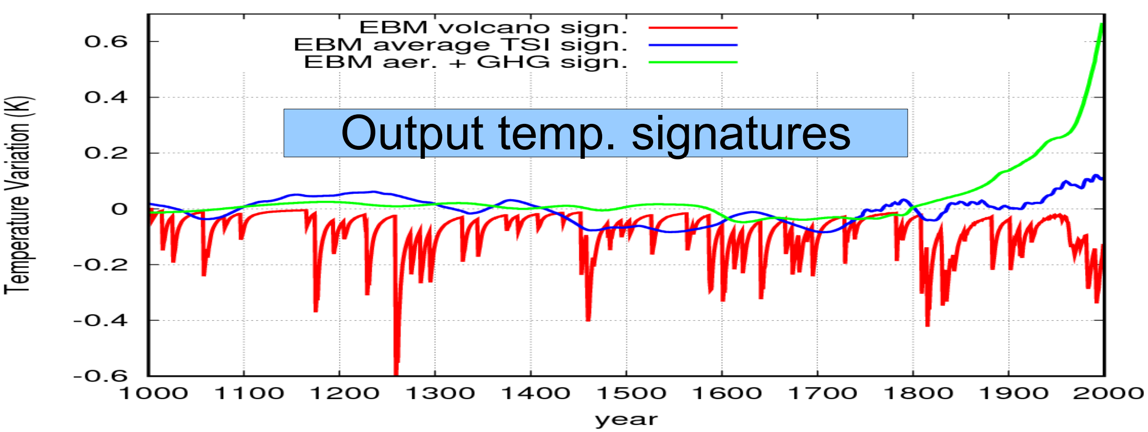
A set of forcings is processed by an energy balance climate model that is used to generate waveforms that are assumed to be **independent** and **proportional** to the fingerprint of each forcing on the temperature.

Phenomenological Model (my proposal)

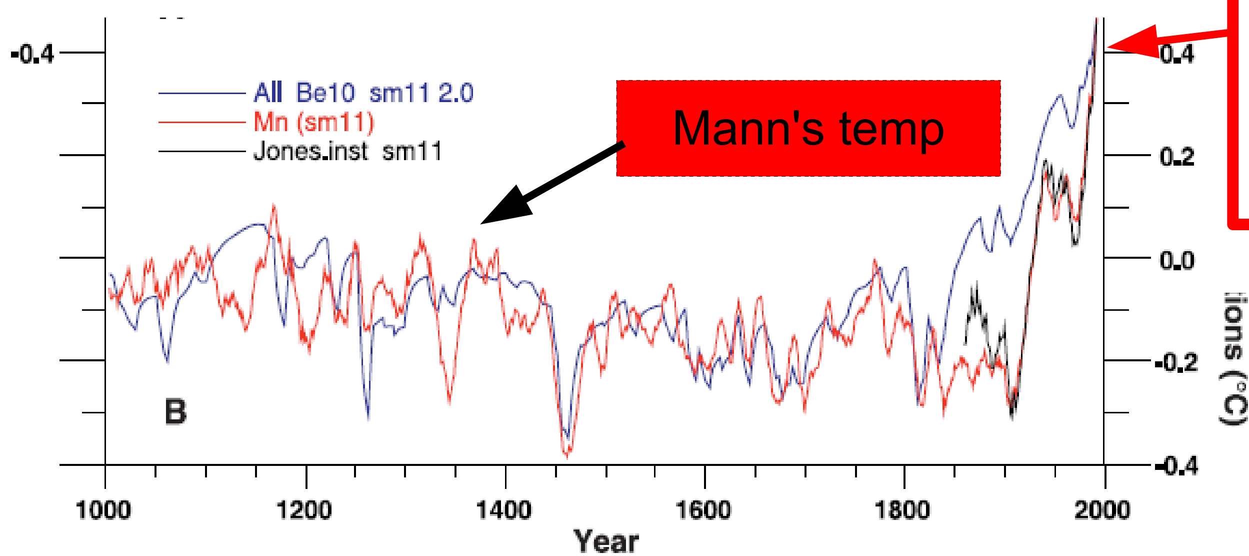
The solar signature on climate is directly constructed by using empirical findings where they are more certain, and some general properties of climate which are empirically evaluated.

Energy balance model simulation



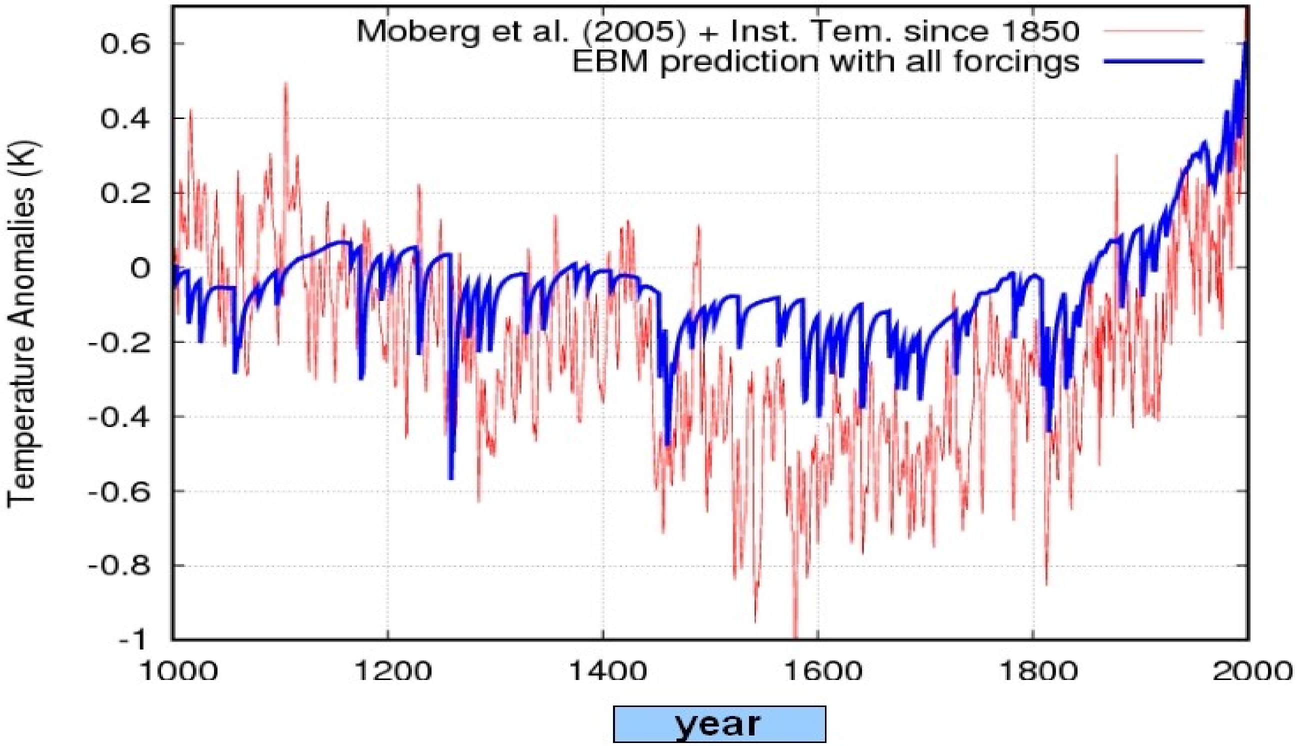


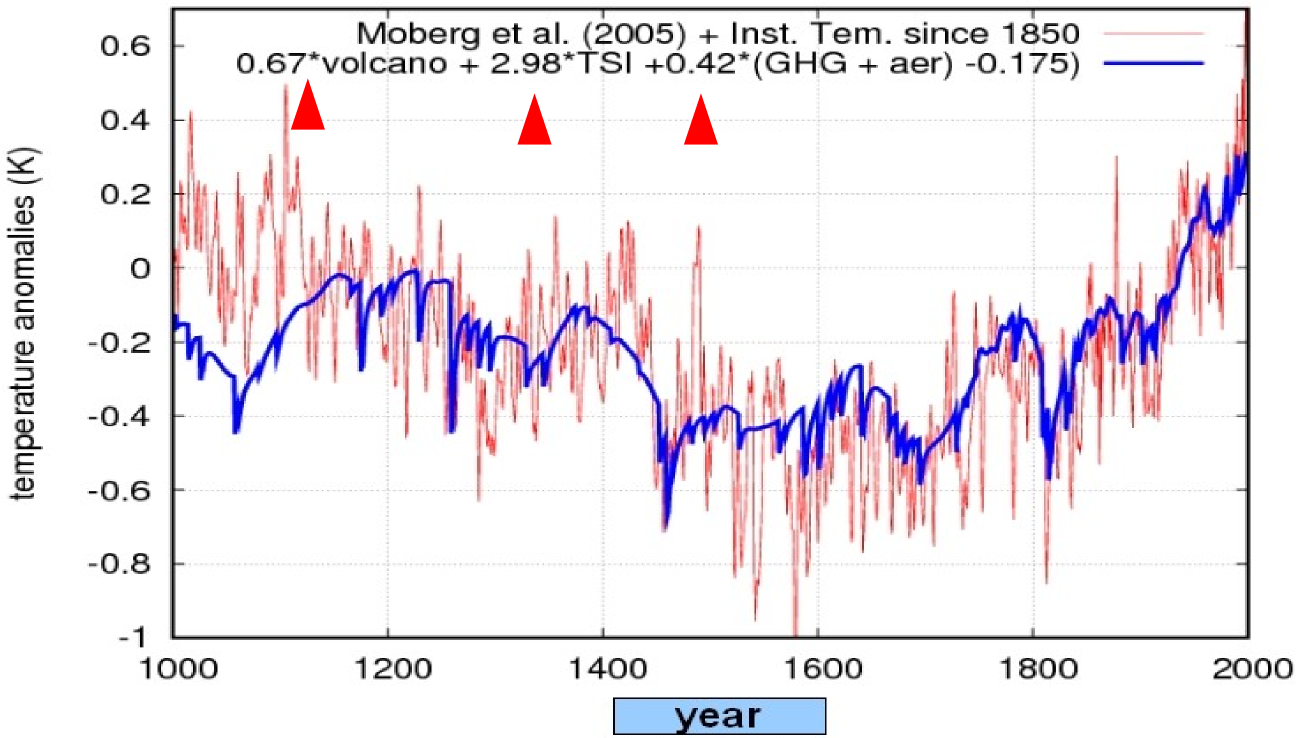
burning, and mineral dust. Although regional climate change is almost certainly influenced by these complex dynamic and thermodynamic feedbacks, the striking agreement seen in this study between simple model calculations and observations indicates that on the largest scale, temperature responds almost linearly to the estimated changes in radiative forcing. The very good agreement between models and data in the preanthropogenic interval also enhances confidence in the overall ability of climate models to simulate temperature variability on the largest scales.



Crowley, Science 289, 270-277 (2000)

Scafetta, EPA 2009





Crowley's 2000 model

against

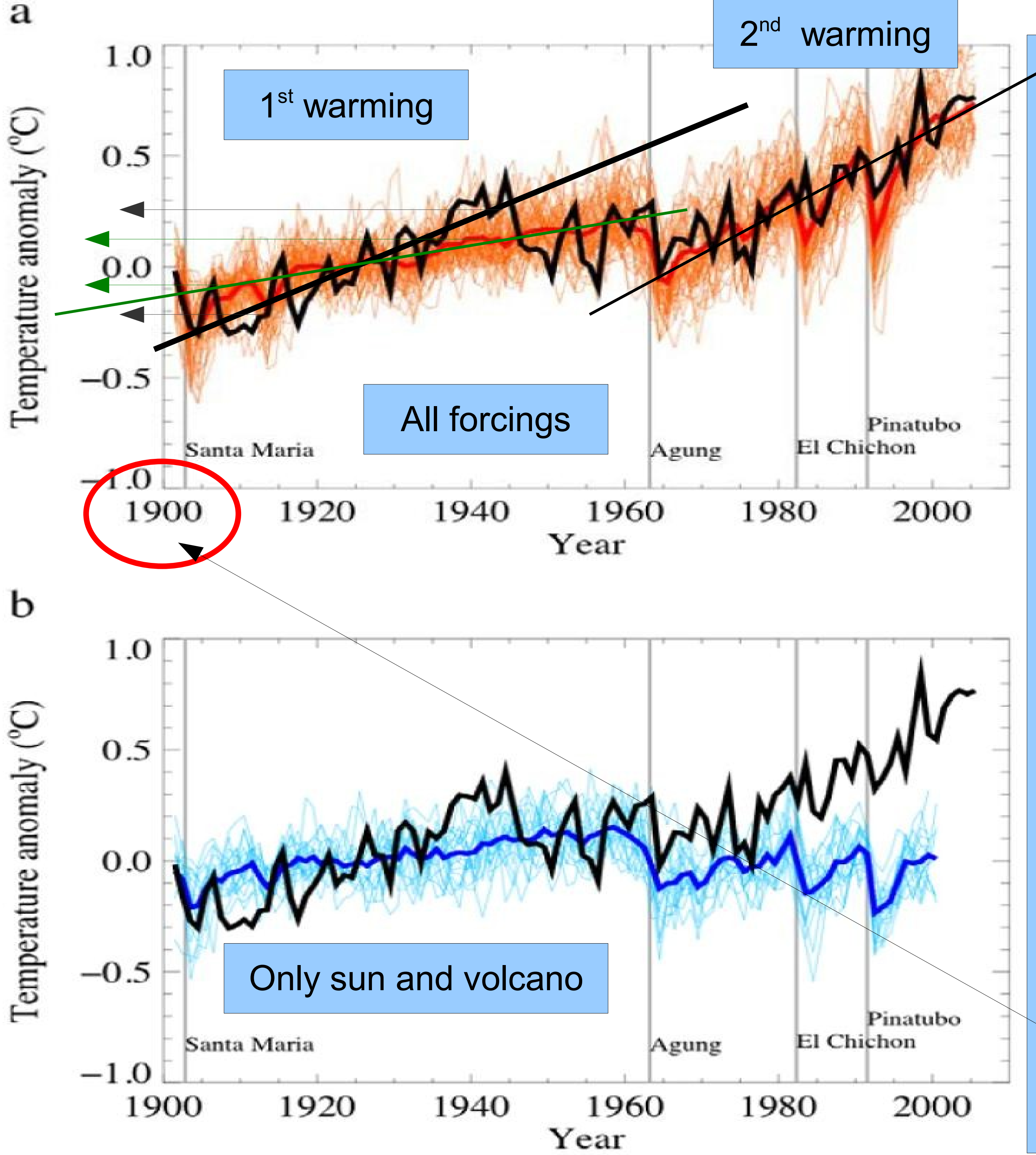
Moberg et al, (2005) reconstruction

Crowley's 2000 energy balance model fails to reconstruct Moberg's temperature.

This temperature record suggests that the model is seriously underestimating the solar effect on climate and overestimating the volcano and GHG effects.

Would global warming debate be different if Moberg published in 1998?

Scafetta, EPA 2009



Do the GCM simulations used by the IPCC 2007 fit the temp. data?

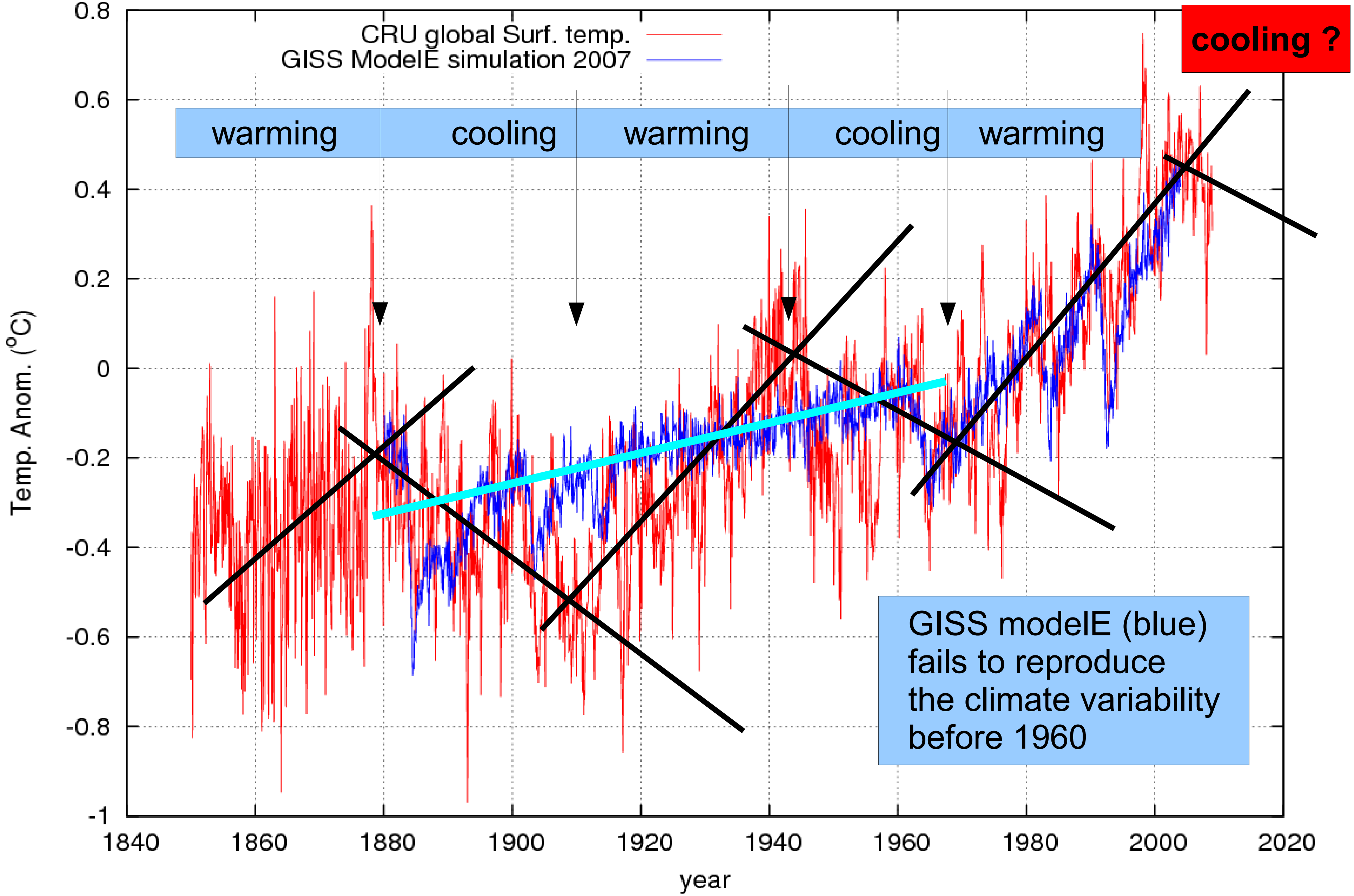
The simulation appears to reproduce the global surface temperature only after 1960.

The model fails to correctly reproduce the 1910-1945 warming: observed ~0.45K predicted ~0.20 K

Why didn't they show the data before 1900?

Scafetta, EPA 2009

Surf. Temp. Data – Model comparison



Hansen et al. "Climate simulations for 1880–2003 with GISS ModelE," Clim Dyn (2007) 29:661-696

Scafetta, EPA 2009

Are these IPCC 2007 theoretical projections reliable?

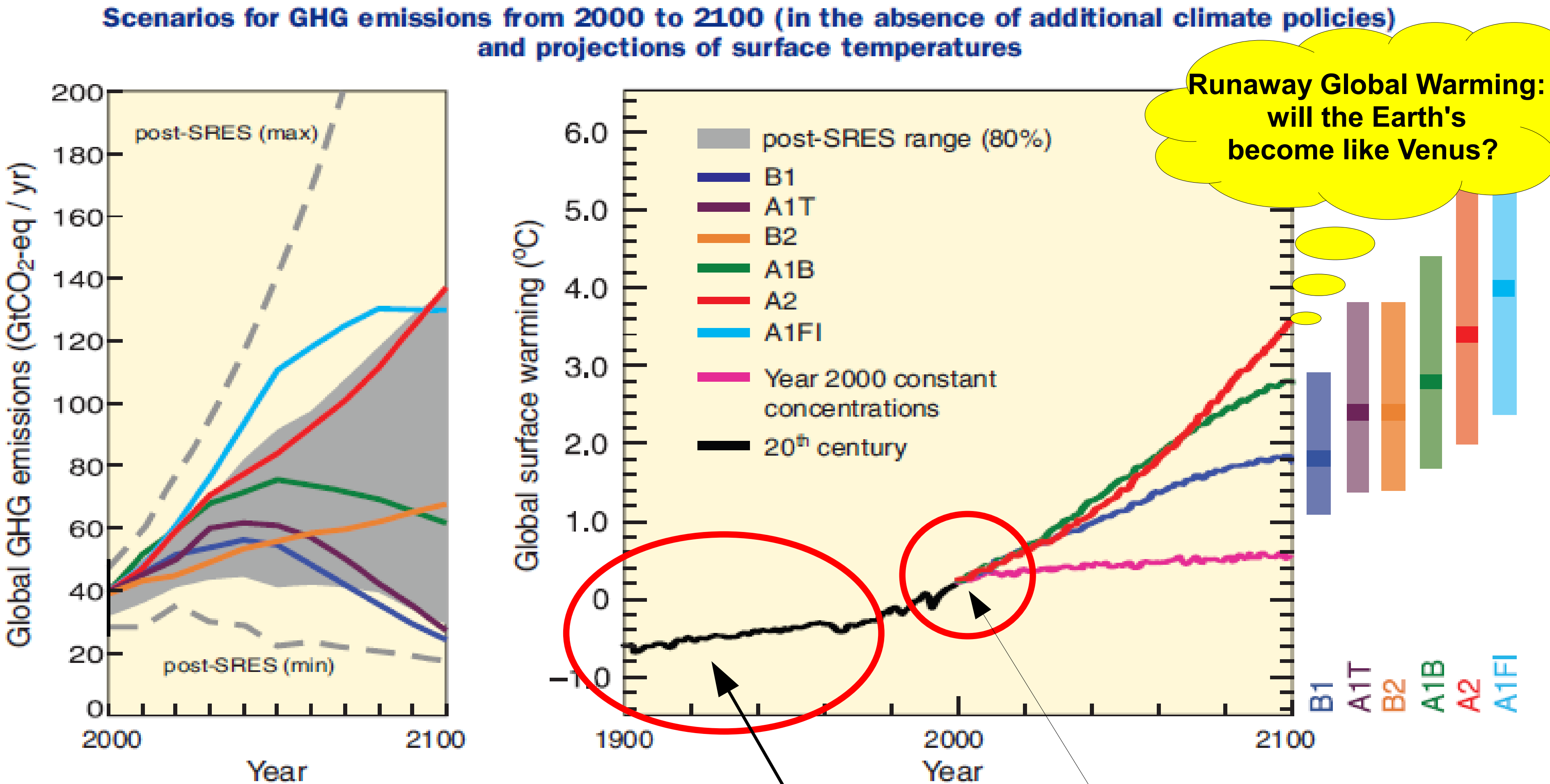


Figure SPM.5. Left Panel: *Global GHG emissions (in $GtCO_2$-eq) in the absence of climate policies: six illustrative SRES marker scenarios (coloured lines) and the 80th percentile range of recent scenarios published since SRES (post-SRES) (gray shaded area). Dashed lines show the full range of post-SRES scenarios. The emissions include CO_2, CH_4, N_2O and F-gases.* ***Right Panel:*** *Solid lines are multi-model global averages of surface warming for scenarios A2, A1B and B1, shown as continuations of the 20th-century simulations. These projections also take into account emissions of short-lived GHGs and aerosols. The pink line is not a scenario, but is for Atmosphere-Ocean General Circulation Model (AOGCM) simulations where atmospheric concentrations are held constant at year 2000 values. The bars at the right of the figure indicate the best estimate (solid line within each bar) and the likely range assessed for the six SRES marker scenarios at 2090-2099. All temperatures are relative to the period 1980-1999. {Figure*

Failure to reproduce the climate variability before 1960

Failure to reproduce the cooling after 2002

Scafetta, EPA 2009

R. Knutti, G. C. Hegerl, Nature Geoscience 1, 735 - 743 (26 Oct 2008), doi: 10.1038/ngeo337.

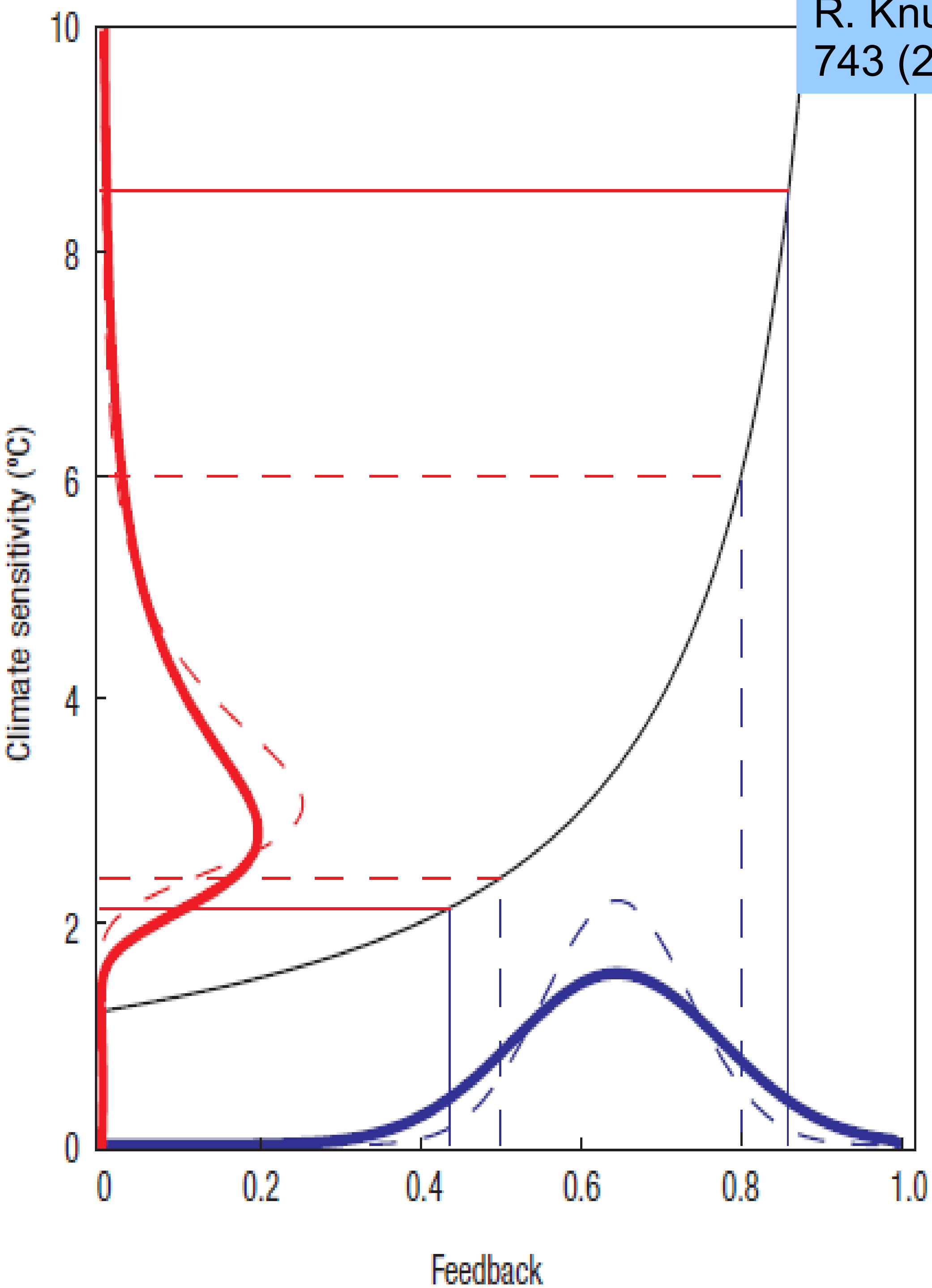


Figure 2 Relation between amplifying feedbacks *f* and climate sensitivity *S*. A truncated normal distribution with a mean of 0.65 and standard deviation of 0.13 for the feedback *f* (solid blue line) is assumed here for illustration. These values are typical for the current set of GCMs[8,33]. Because *f* is substantially positive and the relation between *f* and *S* is nonlinear (black line, equation (2)), this leads to a skewed distribution in *S* (solid red line) with the characteristic long tail seen in most studies. Horizontal and vertical lines mark 5–95% ranges. A decrease in the uncertainty of *f* by 30% (dashed blue line) decreases the range of *S*, but the skewness remains (dashed red line). The uncertainty in the tail of *S* depends not only on the uncertainty in *f* but also on the mean value of *f*. Note that the assumption of a linear feedback (equation (1)) is not valid for *f* near unity. Feedbacks of 1 or more would imply unphysical, catastrophic runaway effects. (Modified from ref. 8.)

There exists a very large uncertainty about the climate sensitivity to GHG forcing !

Doubling CO_2 may cause from 1.5 to 4.5 °C and more warming!

Feedbacks, such as clouds, are poorly understood!

Scafetta, EPA 2009

Multilinear regression analysis models

The basic idea is that traditional climate models are incomplete. The contribution of the forcings to climate change is statistically evaluated under minimal assumptions such as **linearity** and **mutual independence** of the climate forcings.

A

$$T(t) = \sum a_f T_f(t)$$

The temperature is assumed to be the linear superposition of the several waveforms functions "$T_f(t)$" that are the temperature fingerprint prototypes generated by a given forcing "f(t)".

The waveform functions are calculated with an energy balance model (EBM).

The coefficient "a_f" are the amplification factors:

If "$a_f=1$" then the EBM is fine!

(North, Hegerl etc.)

B

$$T(t) = \sum b_f f(t-l)$$

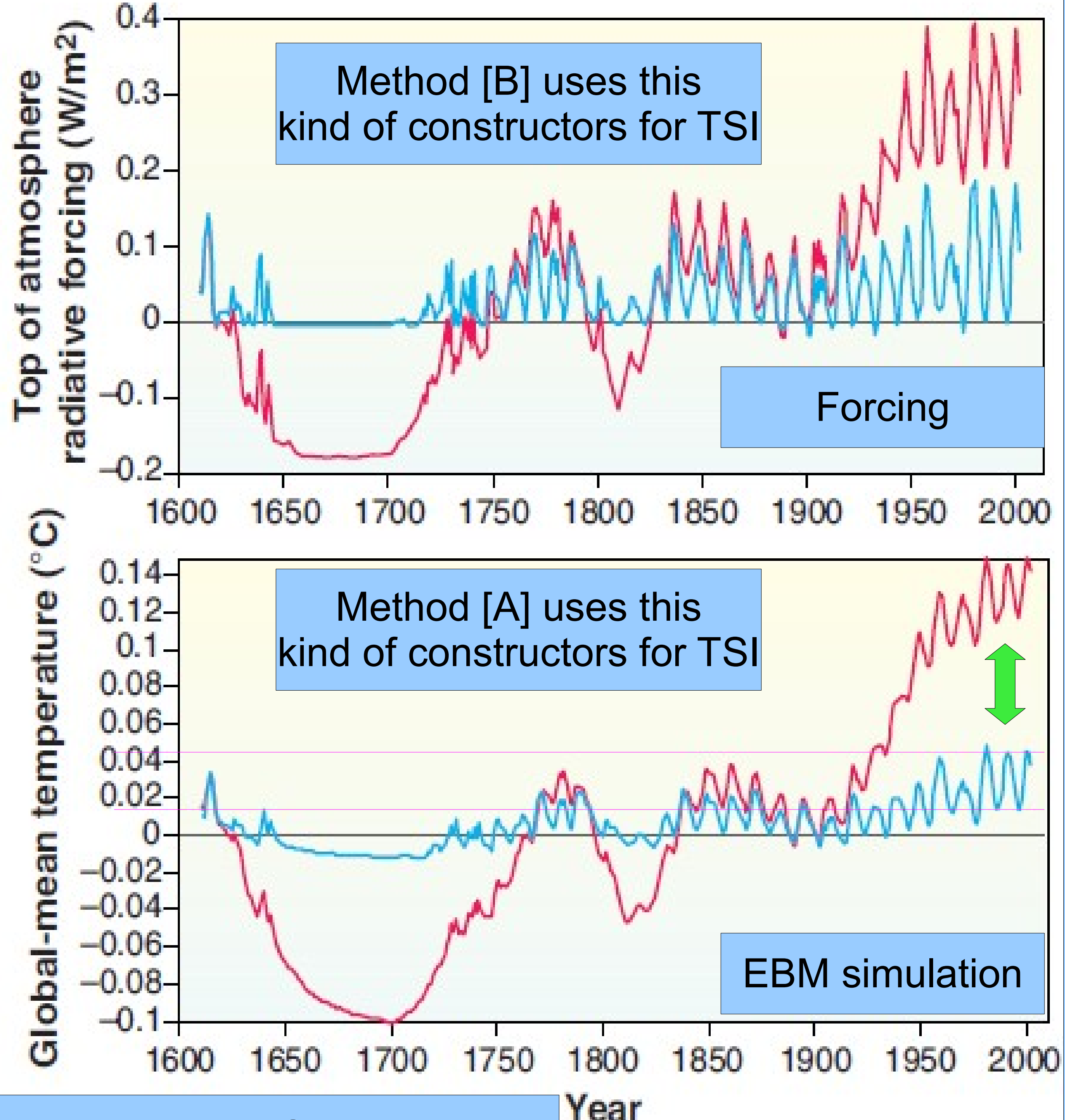
The temperature is assumed to be the linear superposition of the several forcing functions "f(t)" shifted with a time-lag "l" . This functions are assumed to be the temperature fingerprint prototypes of a given forcing "f(t)".

The coefficient "b_f" are the scaling factors.

(Lean, Douglass, Gleisner, etc.)

Scafetta, EPA 2009

Difference between MLRA method type [A] and method type [B]



EBM by Wigley, Science 2004

Methods A and B give quite different results because the constructor functions are very different.

Method A is more physical in principle because assumes that the climate system has a given heat capacity as predicted by the EBMs.

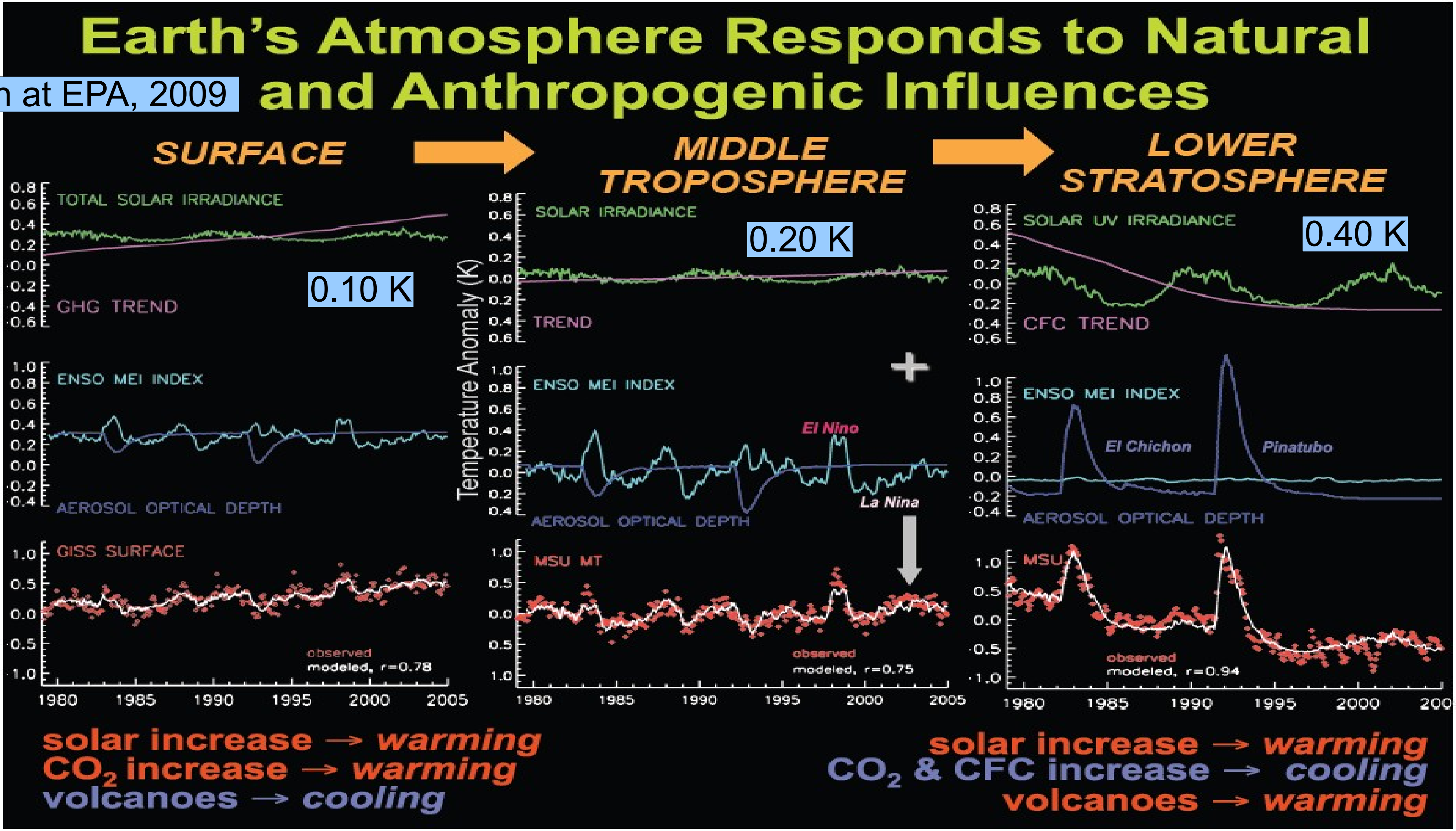
EBMs imply that the climate sensitivity to low frequency components is larger than the sensitivity to high frequency components. EBMs are required to analyze long records.

However, the two methods are quite equivalent if we are interested in just one frequency component such as the 11-year solar cycle. In this case B may be better because simpler on short scales!

Scafetta, EPA 2009

Multilinear regression analysis of temperature signatures since 1979-2005.

Lean at EPA, 2009



Lean uses method "B". These evaluations may be OK only if the TSI did not increased from 1980-2002, which is unlikely. The major error is that if TSI increased, the purple line that according to Lean represents the anthropogenic influence is including the TSI upward trend contribution! The 11-year solar signature amplitude (in the boxes) may be OK!

Scafetta, EPA 2009

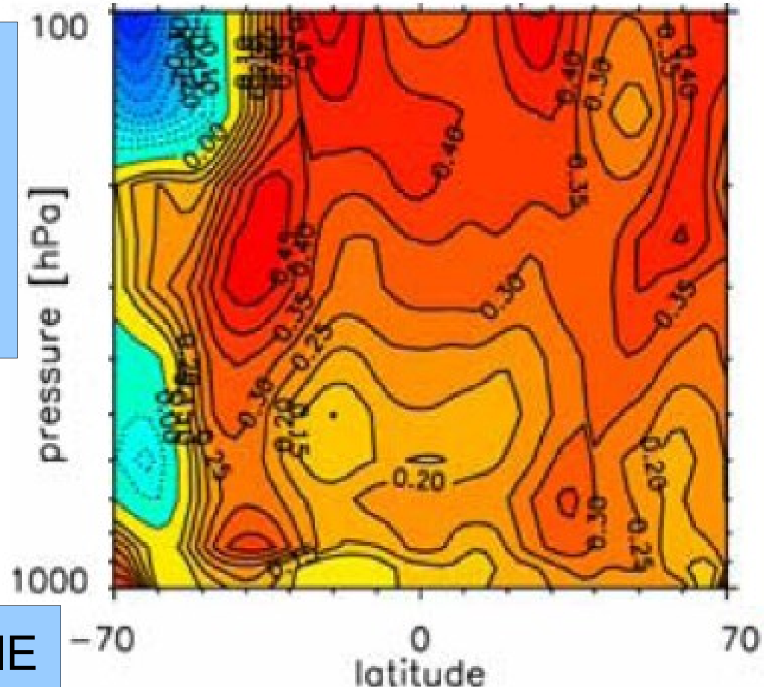
The 11-year cycle solar signature on climate

Comparison between the MLRA model [B] during the last decades and the theoretical prediction of the GISS ModelE in the troposphere and of an EBM in the surface.

The models severely underestimate the climate sensitivity to the 11-year solar cycle by a **large factor** between 3 and 8 !

The boxes on the side of the figures report the estimated max-min amplitude of the 11-year solar signature at different Altitudes from the surface to 16 Km.

Gleisner and Thejll, GRL 2003 MLRA Model [B]



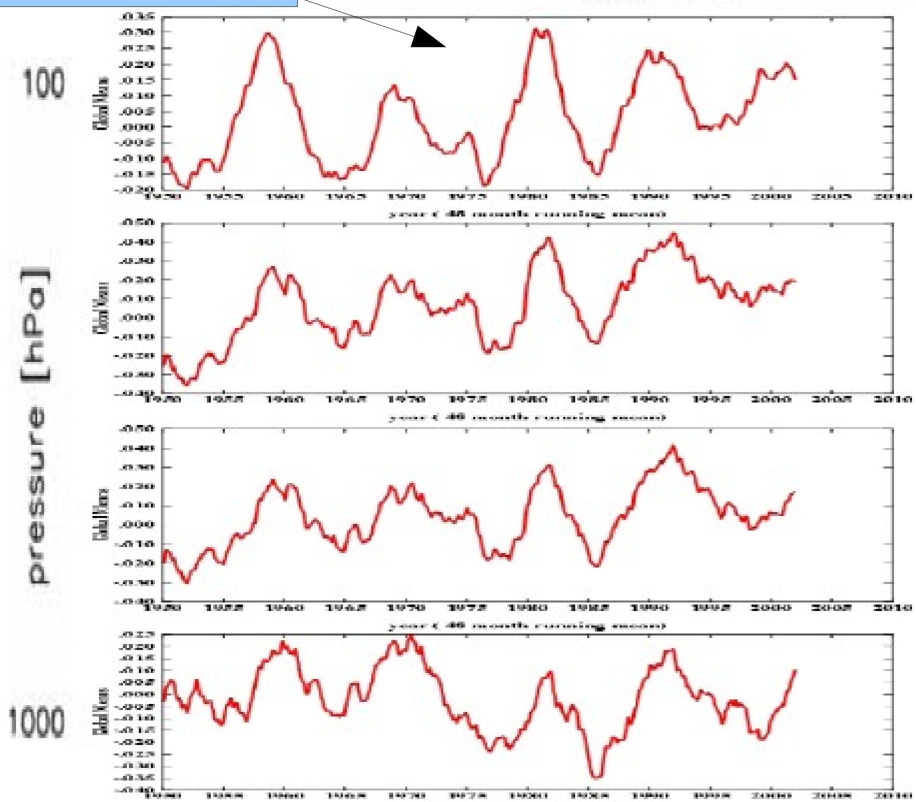
0.37K

0.32K

0.25K

0.15K

GISS ModelE



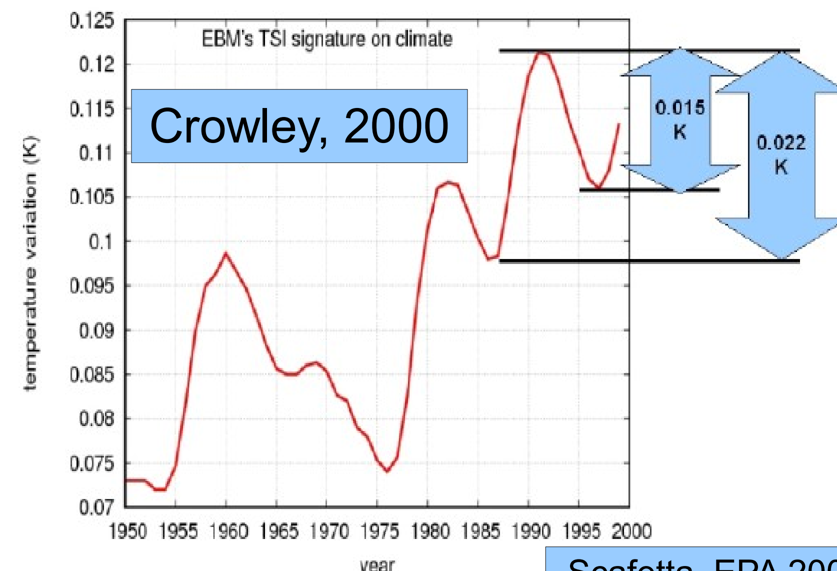
MSU C4 0.050K

MSU C3 0.045K

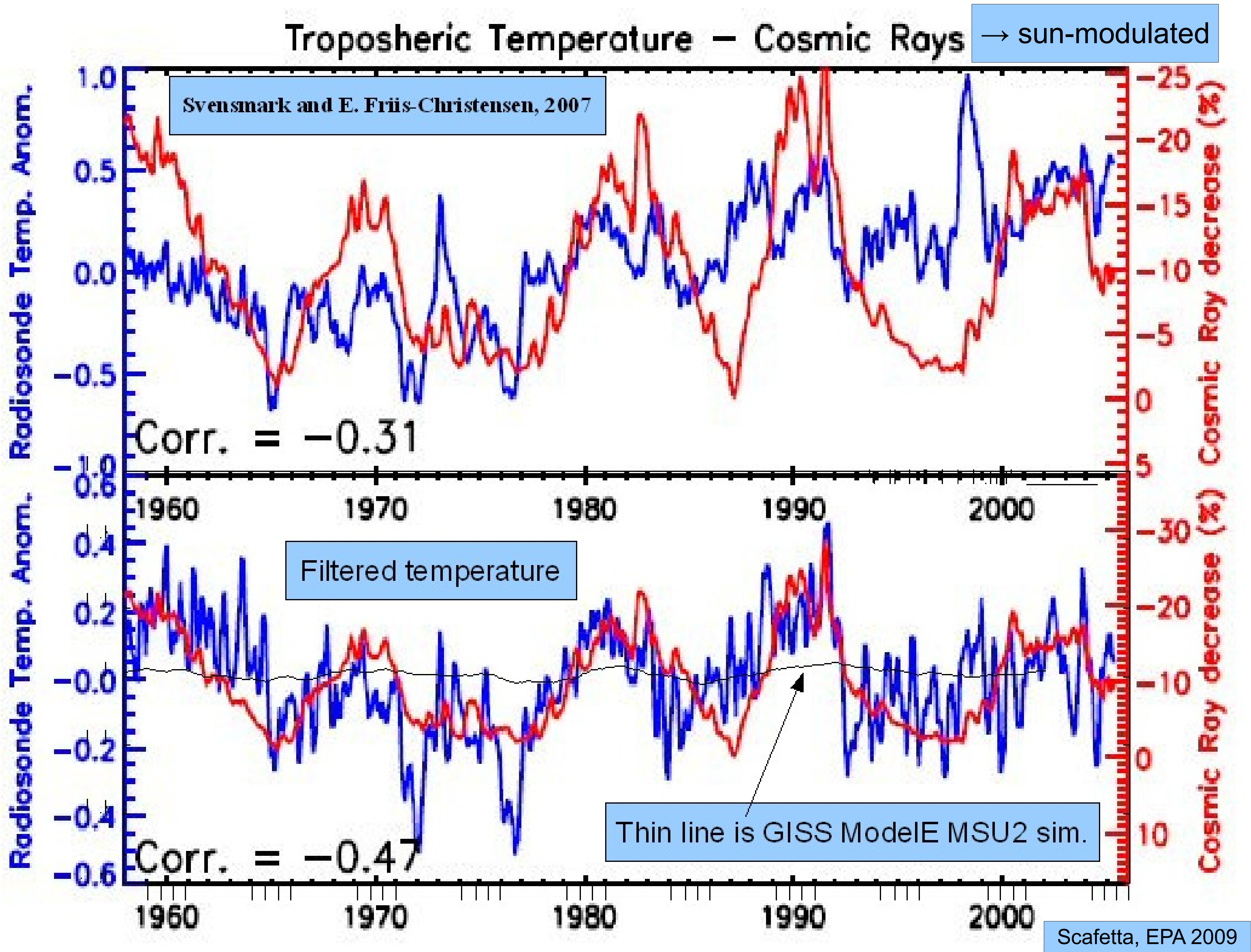
MSU C2 0.040K

Surface 0.035K

http://data.giss.nasa.gov/modelE/transient/Rc_jt.1.06.html



Scafetta, EPA 2009



Troposheric Temperature – Cosmic Rays
→ sun-modulated
Svensmark and E. Friis-Christensen, 2007
Radiosonde Temp. Anom.
Cosmic Ray decrease (%)
1.0
0.5
0.0
−0.5
−1.0
−25
−20
−15
−10
−5
0
5
Corr. = −0.31
1960
1970
1980
1990
2000
Filtered temperature
0.6
0.4
0.2
−0.0
−0.2
−0.4
−0.6
−30
−20
−10
0
10
Corr. = −0.47
Thin line is GISS ModelE MSU2 sim.
Scafetta, EPA 2009

CLIMATE RESPONSE to the 11-YEAR SOLAR CYCLE

IPCC 2007, page 674

et al., 1997). A number of independent analyses have identified tropospheric changes that appear to be associated with the solar cycle (van Loon and Shea, 2000; Gleisner and Thejll, 2003; Haigh, 2003; White et al., 2003; Coughlin and Tung, 2004; Labitzke, 2004; Crooks and Gray, 2005), suggesting an overall warmer and moister troposphere during solar maximum. The peak-to-trough amplitude of the response to the solar cycle globally is estimated to be approximately 0.1°C near the surface. Such variations over the 11-year solar cycle make it is necessary to use several decades of data in detection and attribution studies. The solar cycle also affects atmospheric ozone concentrations with possible impacts on temperatures and winds in the stratosphere, and has been hypothesised to influence clouds through cosmic rays (Section 2.7.1.3). Note that there is substantial uncertainty in the identification of

IPCC 2007 contradicts itself by on one side acknowledging the above empirical studies and on the other side using climate models whose predictions are contradicted by these same empirical studies !

Scafetta, EPA 2009

North, Wu and Stevens, "Detecting the 11-year solar cycle in surface temperature field," in AGU Geophysical Monography 141, 2004

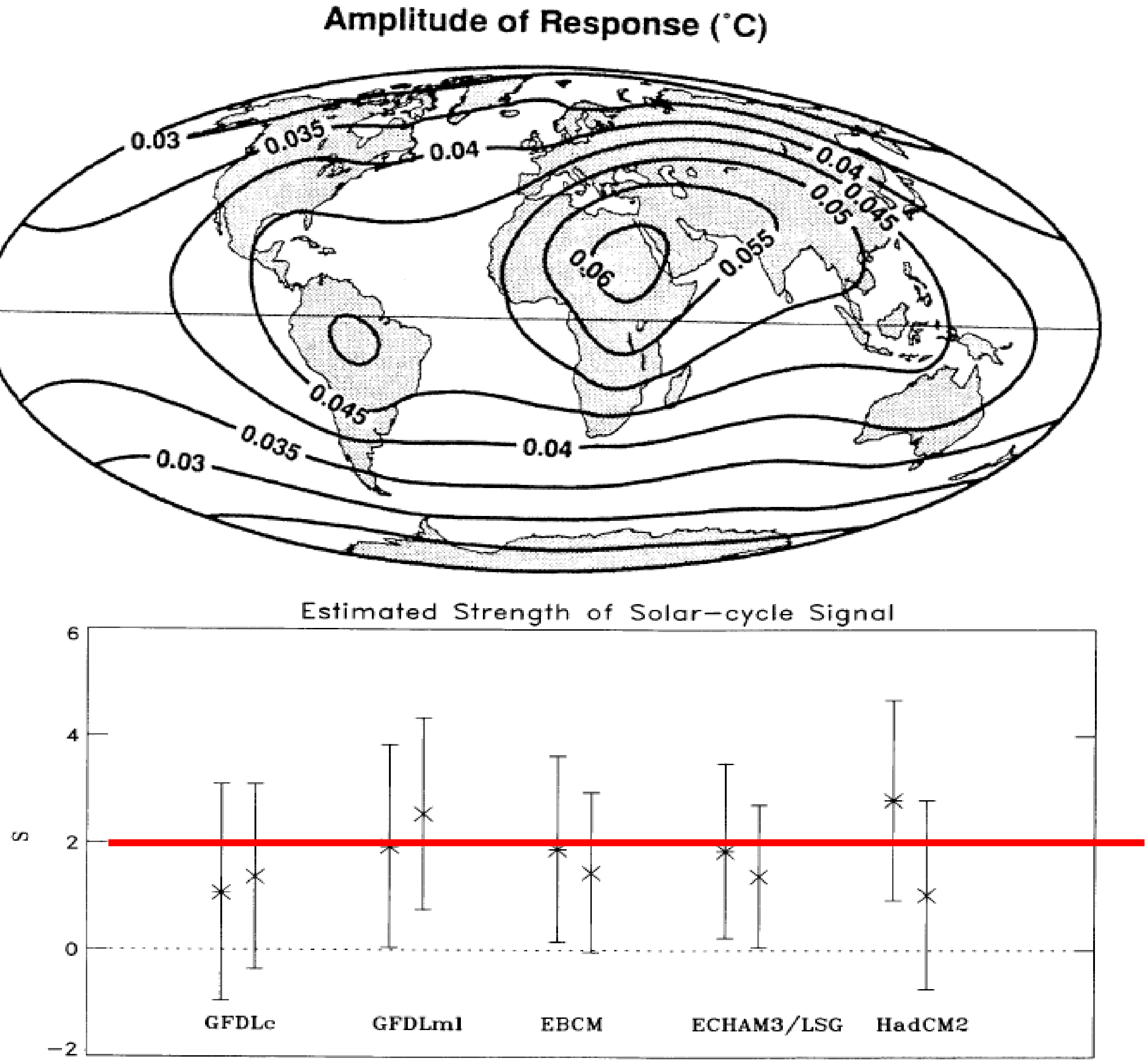


Figure 4. The estimated signal amplification factors for the solar signal using several different climate models for natural variability. For each climate model there are two configurations of sites. The error bars enclose the 90% confidence interval. The left-most point in the pairs of points represents data from 20 tropical stations, while the right-most represents data taken from 36 globally distributed stations.

In this paper MLRA method [A] is adopted which uses EBM for the obtaining the MLRA waveform functions.

The sun-spot record is used as a TSI proxy.

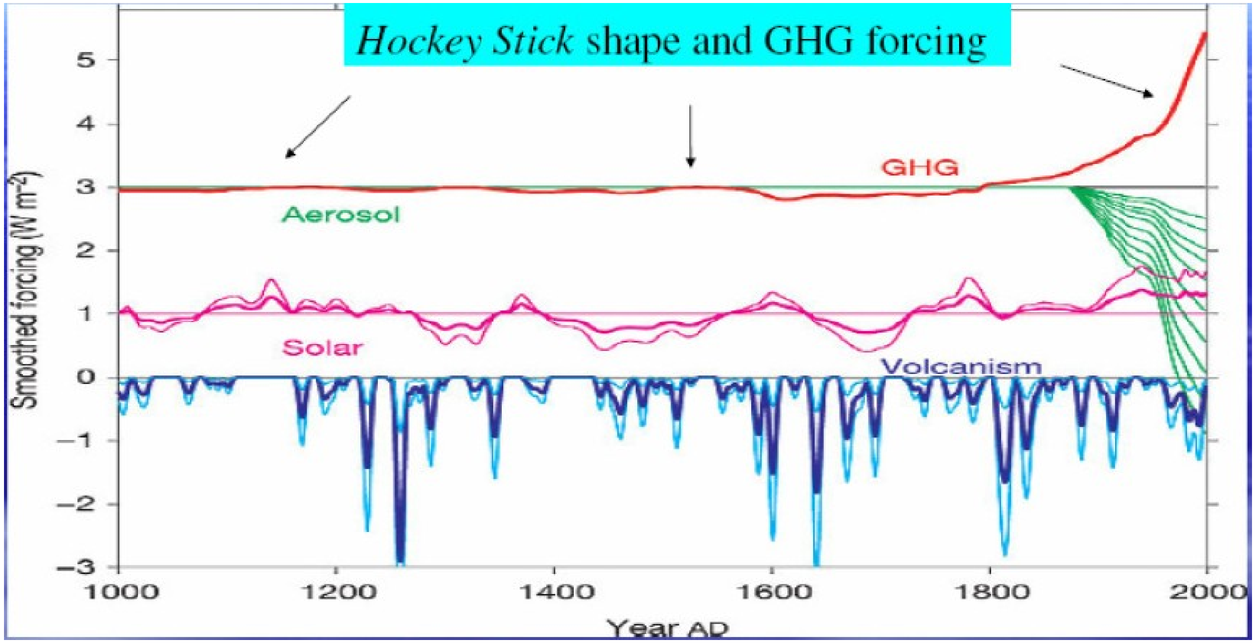
Top panel:
typical EBM prediction regarding the 11-year solar cycle signature

Bottom panel:
MLRA amplification factors found for several EBMs.

The amplification factor is about "2" indicating that the EBMs severely underestimate the climate sensitivity to solar forcing

Scafetta, EPA 2009

Hegerl G. C., Crowley T. J., Allen M., et al, (2007), Detection of human influence on a new, validated 1500-year temperature reconstruction, J. of Climate 20, 650-666.



This paper uses MLRA method [A] applied to long sequences.

The amplification factors relative to the solar component is severely suspicious because ranges from negative to large positive values.

MLRA is not appropriate because of the uncertainty in the secular data and the lack of independence between the forcings on this large scale.

Record analysis period represents the following:	Briffa et al. (2001) 1402–1940 20°–90°N land growing season	Esper et al. (2002) 1400–1960 20°–90°N land growing season	CH-blend 1270–1960 30°–90°N all annual	Moberg et al. (2005) 1270–1925 0°–90°N all annual	Moberg 1001–1925 0°–90°N all annual
Volcanic	Y (0.9)	Y (1.0)	Y (1.5)	Y (1.1)	Y(1.4)
Solar	N (−0.1)	N (−0.2)	N (0.5)	N (Y periods)	Y(2.2)
Ghg+aer	Y (1.1)	Y (1.9)	Y (1.0)	Y (1.3)*	N
20thc Ghg+aer	10%–99%	50%–100%	22%–52%	—	—
20thc volcanic	18%–50%	18%–51%	16%–39%	—	—
20thc solar	<22%	<15%	<16%	—	—
20thc internal	13%	2%	30%	—	—
Residual std	0.11 (57%)	0.17 (60%)	0.10 (70%)	0.13 (61%)	0.18 (52%)

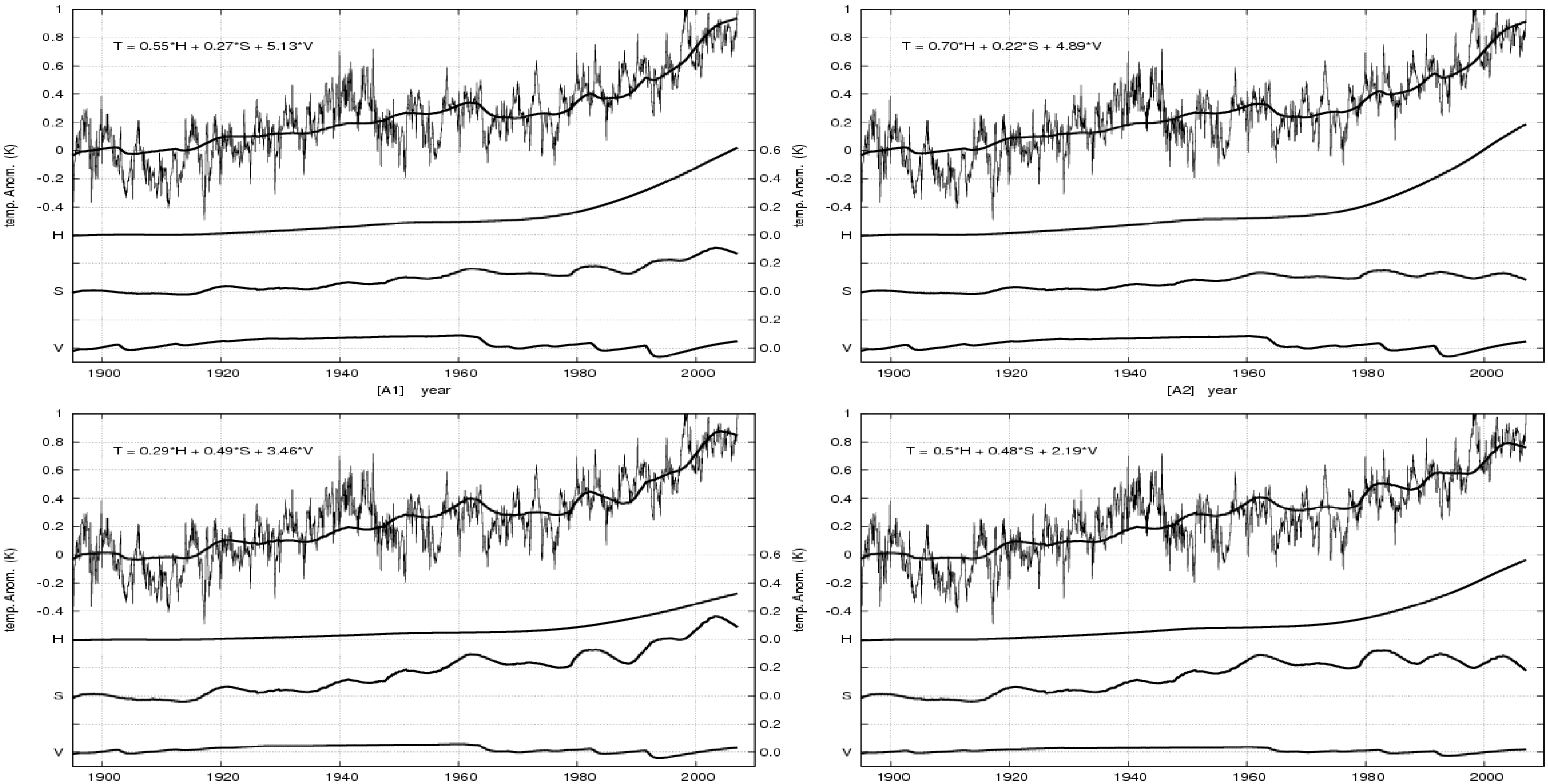
Lean J. L., and D. H. Rind (2008), How natural and anthropogenic influences alter global and regional surface temperatures: 1889 to 2006, Geophys. Res. Lett., (2008).

Lean and Rind use MLRA method [B] applied to the 1889-2006 temperature record. They find that the sun contributed less than 10% (0.07 K) of the observed warming (0.8 K) during the period.

Below it is my analysis of the same data using MLRA method [A] with a model similar to Crowley 2000 EBM with a relaxation time of 10 years and ACRIM and PMOD TSI record since 1979. The fit is quite good, as the figures show in particular in B1!

Figures A1 and A2 suggest that TSI contributed between 15% and 35%, but the 11-year solar cycle signature is about 0.05K. Figures B1 and B2 suggest that TSI contributed between 35% and 65%, by constraining the model to have the 11-year solar signature at 0.1K.

So, the result strongly depends on the adopted model!

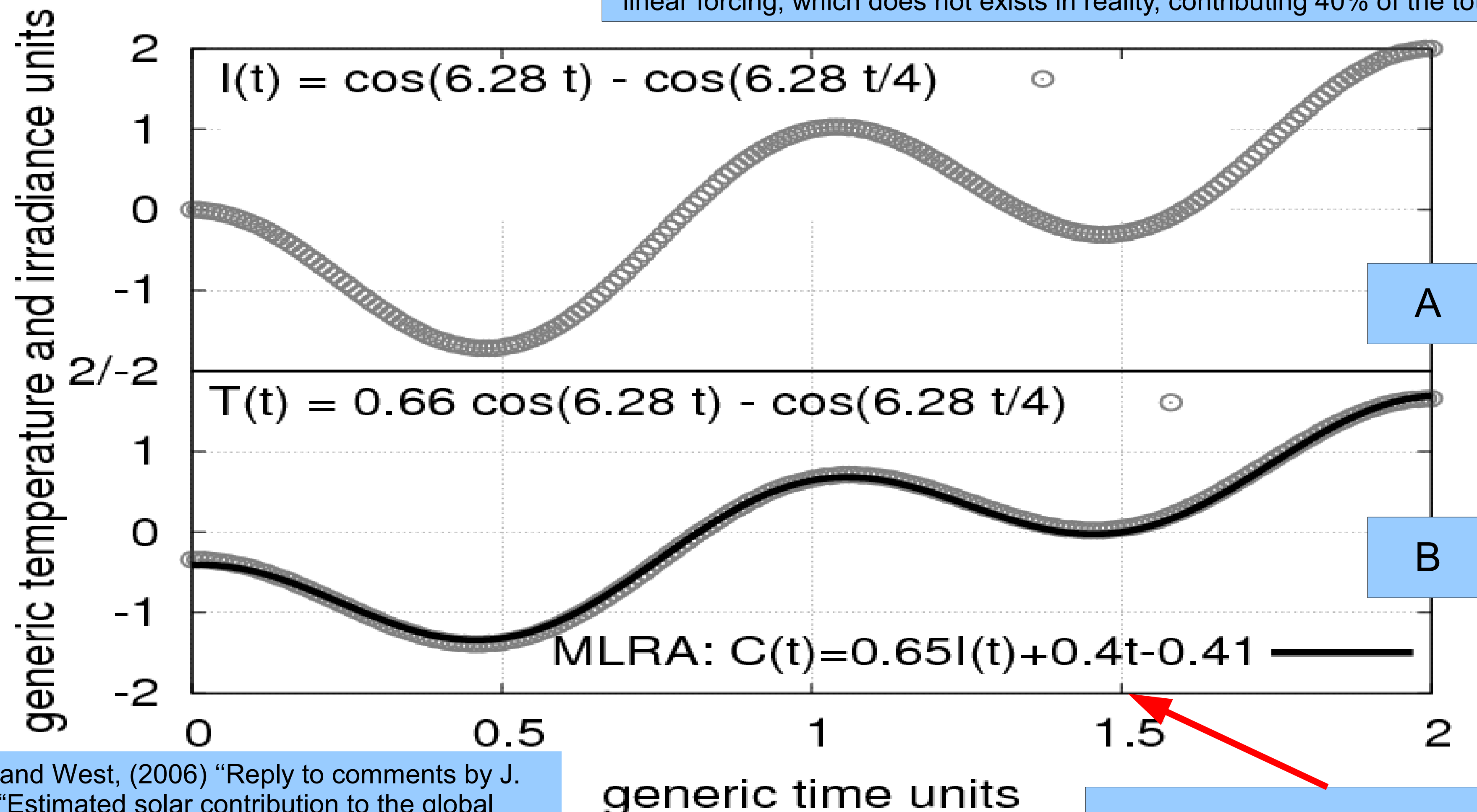


John von Neumann:
"Give me four parameters,
and I can fit an elephant.
Give me five,
and I can wiggle its trunk".

Limitations of Multilinear Regression Analysis

[A] Hypothetical TSI climate forcing (gray curve).
[B] Hypothetical climate response (gray curve) and
Lean's MLRA -like model reconstruction (black line).

MLRA may be extremely misleading if an erroneous physical model is adopted.
I show that a MLRA model similar to those adopted by Lean, where the temperature is assumed to be the linear superposition of the forcing plus a linear trend, artificially well correlates the output signal produced with an energy balance-like model that just dampens the high frequency component of the input forcing.
In this example the MLRA model suggests the presence of an additional upward linear forcing, which does not exists in reality, contributing 40% of the total increase.



Fake linear upward component

Scafetta and West, (2006) "Reply to comments by J. Lean on "Estimated solar contribution to the global surface warming using the ACRIM TSI satellite composite", Geophys. Res. Lett., 33

Where we are !

Traditional EBMs and GCMs fail:

a) to reconstruct the warming and cooling climate variability before 1960.
b) to reconstruct the 11-year solar signature on climate by a large factor.

Multilinear regression analysis models

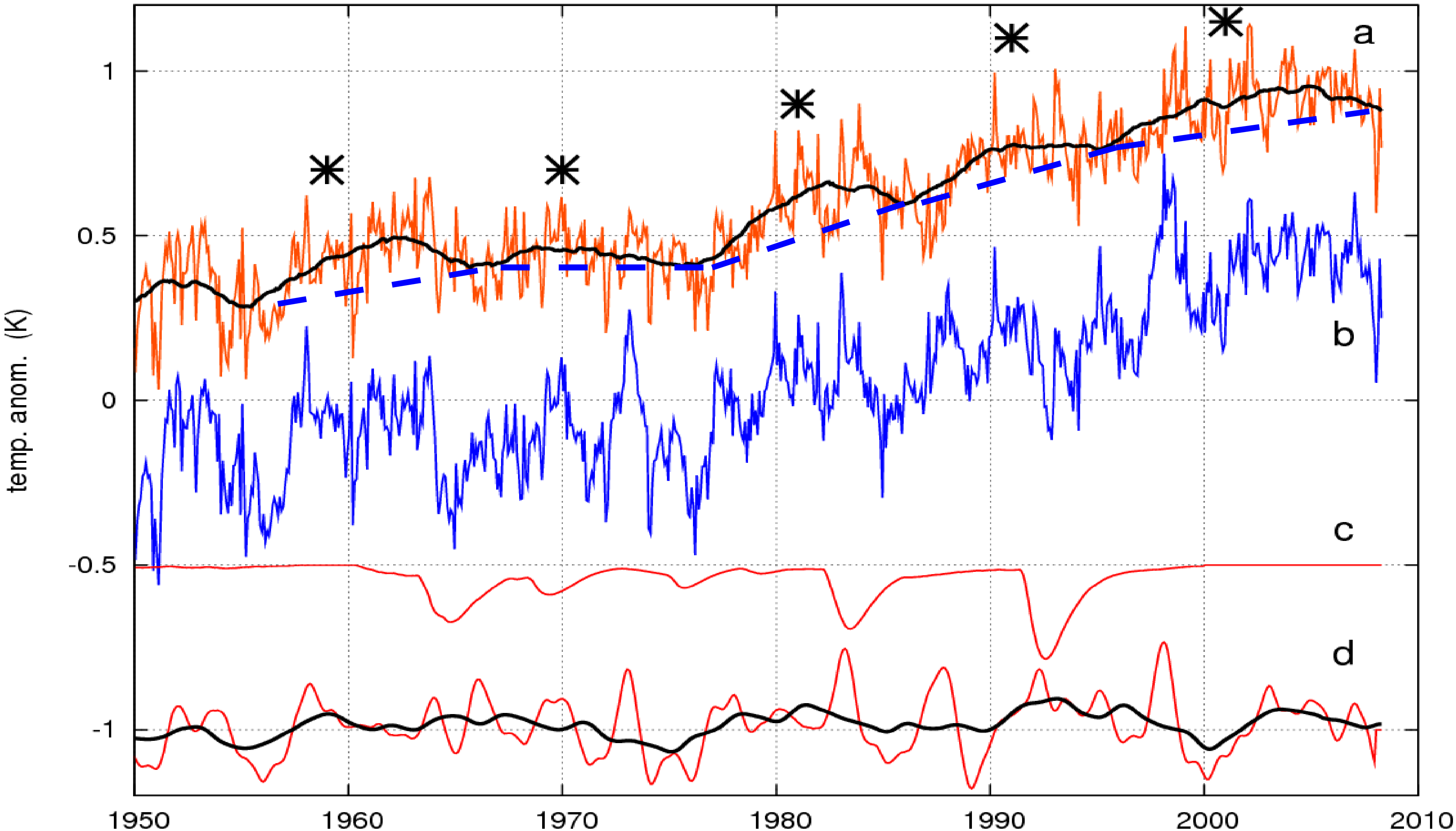
type [A]: are ambiguous because: 1) the EBMs are ambiguous; 2) they assume independence of the forcings, 3) the data on long time scales are severely uncertain.

type [B]: cannot be used for analyzing long time scales because unphysical. They are useful just for detecting the 11-year solar cycle signature on short records. On the global surface this cycle has a maximum-minimum amplitude of about 0.1 K.

My proposal: The Phenomenological model

The solar signature on climate is directly constructed by using empirical findings where they are more certain, and some general properties of climate which are empirically evaluated.

A close look at the temperature data

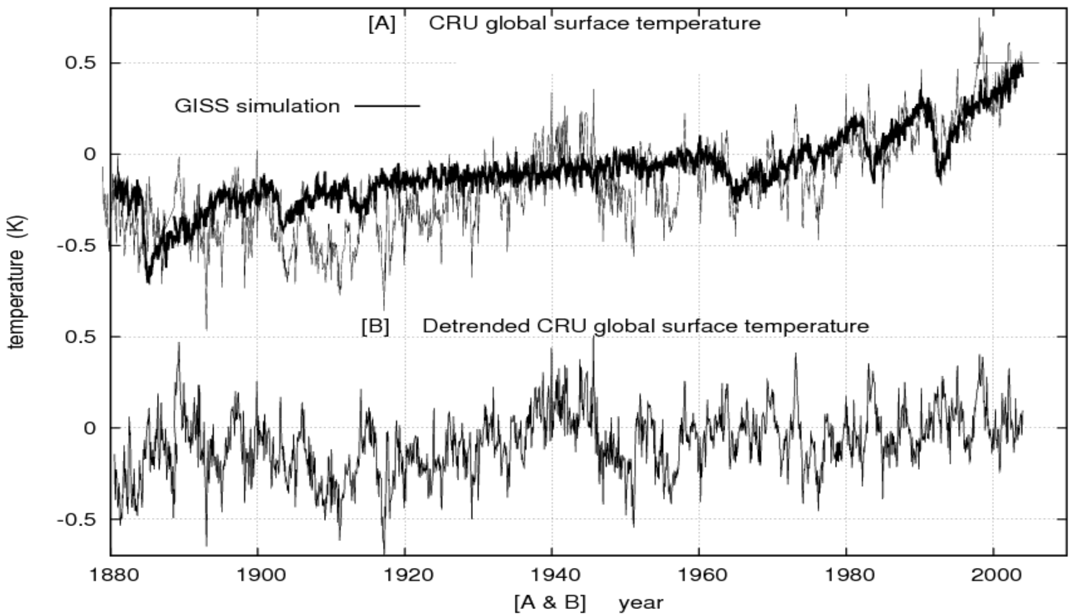


a) filtered global surface temperature data with the decadal modulation associated to solar cycle; b) global surface temperature data; c) volcano signature; d) E-Nino signature.
"*" solar maxima position; the ~0.1K solar cycle signature emerges clearly from the filtering.

Scafetta, EPA 2009

Measurements of the time constants of the climate system

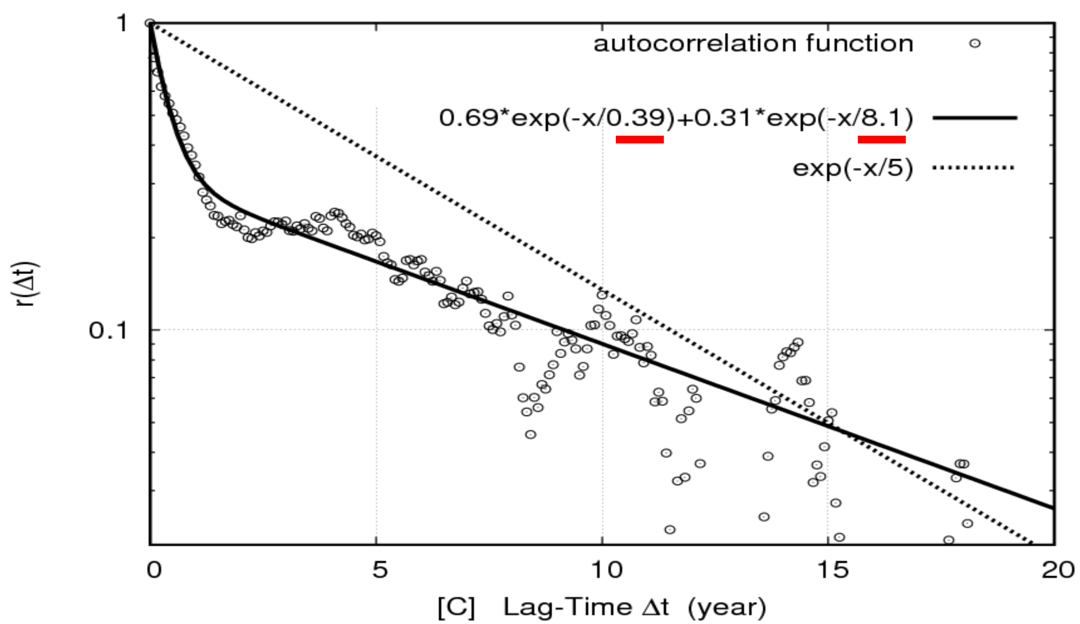
Scafetta, *Comment on "Heat capacity, time constant, and sensitivity of Earth's climate system" by S. E. Schwartz*, GRL (2008).

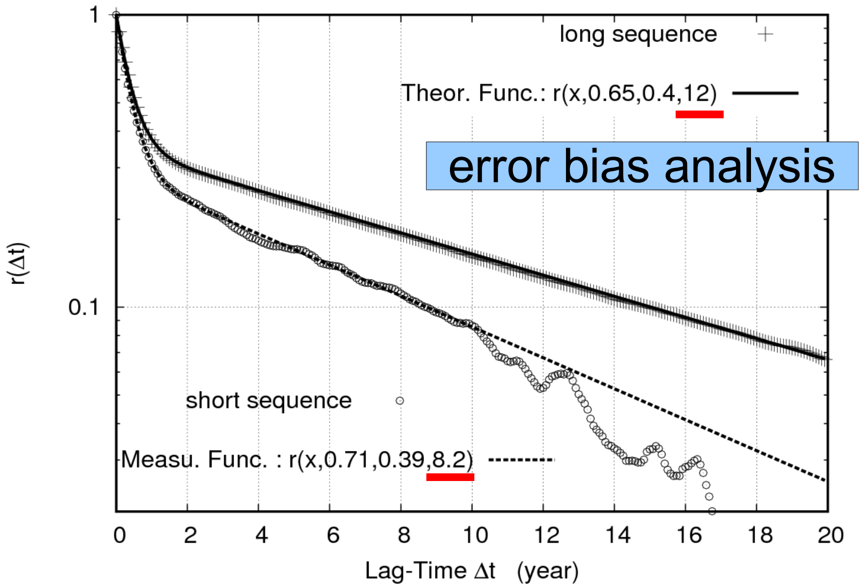


Analysis of the autocorrelation of the temperature fluctuation record based on autoregressive models AR(1) suggests that the climate system is characterized by two relaxation time constants indicating that climate is made of two subsystems with two different heat capacities.

$\tau_1 \sim 0.4$ year

$\tau_2 \sim 8$ or 12 +/- 3 year





Scafetta, EPA 2009

These papers suggest that climate is characterized by both short (less than 1 year) and long (decadal scale) characteristic times.

The detection of, albeit damped, solar cycle variations in the surface air temperature is consistent with recent studies that have given a smaller response time constant to solar variations; for example, Douglass & Clader (2002) and Douglass *et al.* (2004) have reported a response time of $\tau<1$ year to solar variations and Schwartz (2007) has obtained $\tau=5\pm1$ years for all forcings. These studies agree with a number of results implying short response times to (and rapid recovery from) a variety of rapid radiative changes (Taylor *et al.* 1997; Dickinson & Schaudt 1998; Lindzen & Giannitsis 1998; Santer *et al.* 2001; Alley *et al.* 2003; Wigley *et al.* 2005; Boer *et al.* 2007). These results are not, in most cases, incompatible with the longer response times (as found, for example, by Wetherald *et al.* 2001, Hansen *et al.* 2005, Meehl *et al.* 2005 and Wigley 2005) because the duration of the forcing in many cases is short and the response time of the system is not the same as for sustained forcing changes, such as that from increased well-mixed greenhouse gases, owing to a relative lack of penetration of the thermal signal into the oceans. Understanding the different time constants for

From: Lockwood M. (2008), Recent changes in solar output and the global mean surface temperature. III. Analysis of the contributions to global mean air surface temperature rise, Proc. R. Soc. A, 464,1-17

The phenomenological model assumes that the solar signature is made of the superposition of two signals produced by two basic thermodynamic models (TM) with the two found empirical characteristic time constants. (These models are simplified EBMs)

A simplified model with one time constant is discussed in Scafetta and West, JGR 2007.
The model herein discussed was presented by Scafetta at the AGU fall meeting 2008.

There is the need of evaluating the scaling factors k_1 and k_2

$$\Delta T_S(t) = \Delta T_{1S}(t) + \Delta T_{2S}(t),$$

TM 1

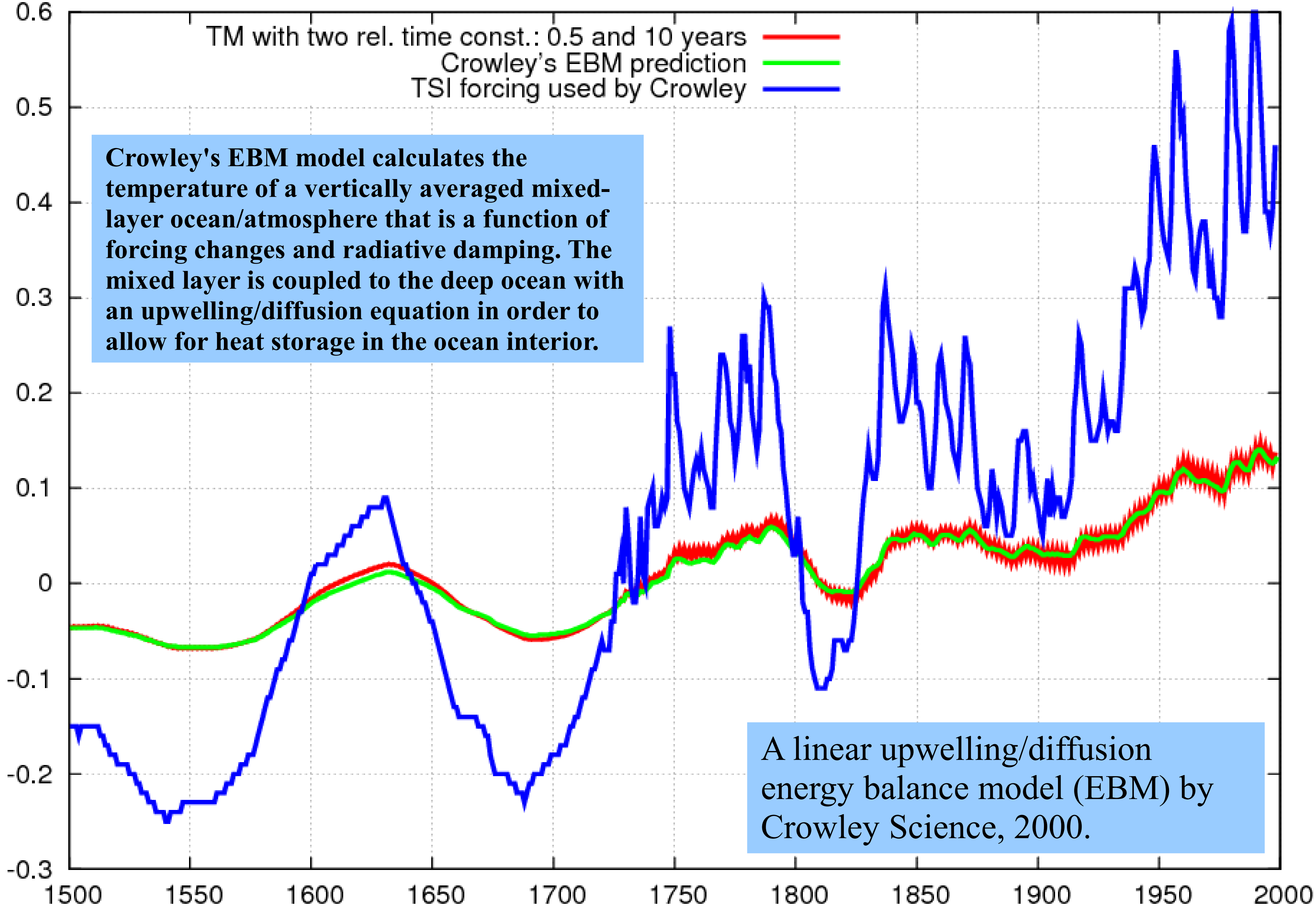
$$\frac{d\Delta T_{1S}(t)}{dt} = \frac{k_{1S}\,\Delta I(t) - \Delta T_{1S}(t)}{\tau_{1S}},$$

TM 2

$$\frac{d\Delta T_{2S}(t)}{dt} = \frac{k_{2S}\,\Delta I(t) - \Delta T_{2S}(t)}{\tau_{2S}}.$$

Scafetta, EPA 2009

The phenomenological model (red curve) I propose well simulates the performance of a typical EBM (green curve) when appropriate sensitivity coefficients are adopted.



Crowley's EBM model calculates the temperature of a vertically averaged mixed-layer ocean/atmosphere that is a function of forcing changes and radiative damping. The mixed layer is coupled to the deep ocean with an upwelling/diffusion equation in order to allow for heat storage in the ocean interior.

A linear upwelling/diffusion energy balance model (EBM) by Crowley Science, 2000.

Evaluation of k_1

We can assume that the processes characterized by a short characteristic time response do not alter drastically the physical properties of the climate system. Thus, on short times the albedo “a” and the additional feedback and climate functions “f” and “g” remain approximately constants.

By differentiating the energy equation I get:

$$\frac{1-a}{4} I * f * g = s T^4$$

$$k_1 = \frac{dT}{dI} = \frac{T}{4I}$$

$$k_1 = 0.053\, K / Wm^{-2}$$

Evaluation of k_2

This coefficient is determined by assuming that the total 11-year solar signature on climate produced by the superposition of the two signals has a maximun-minimum amplitude of about 0.1 K on the surface, as empirically found.
I found:

$$k_2 = 0.28\, K / Wm^{-2}$$

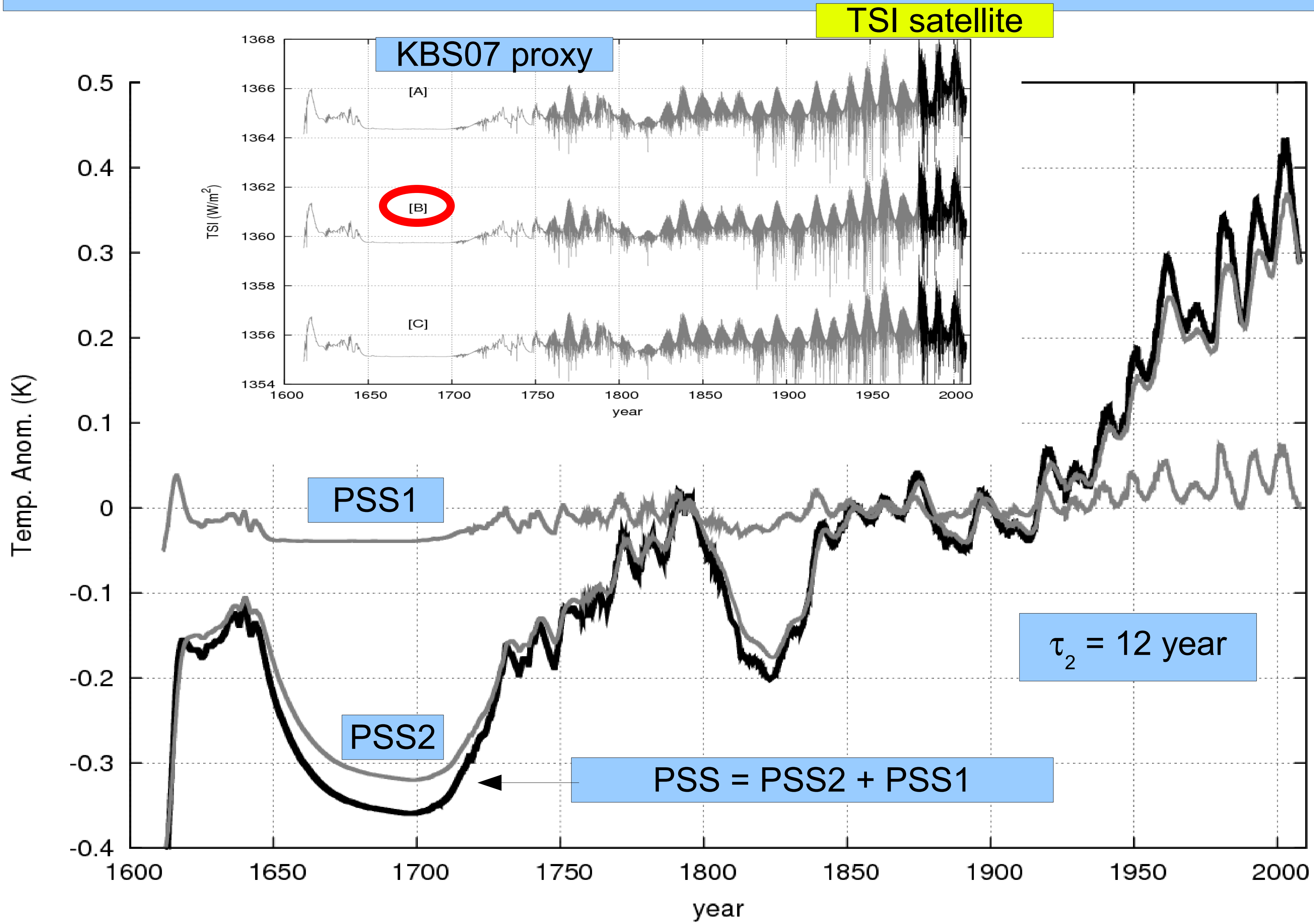
For τ_2 = 8 year

$$k_2 = 0.41\, K / Wm^{-2}$$

For τ_2 = 12 year

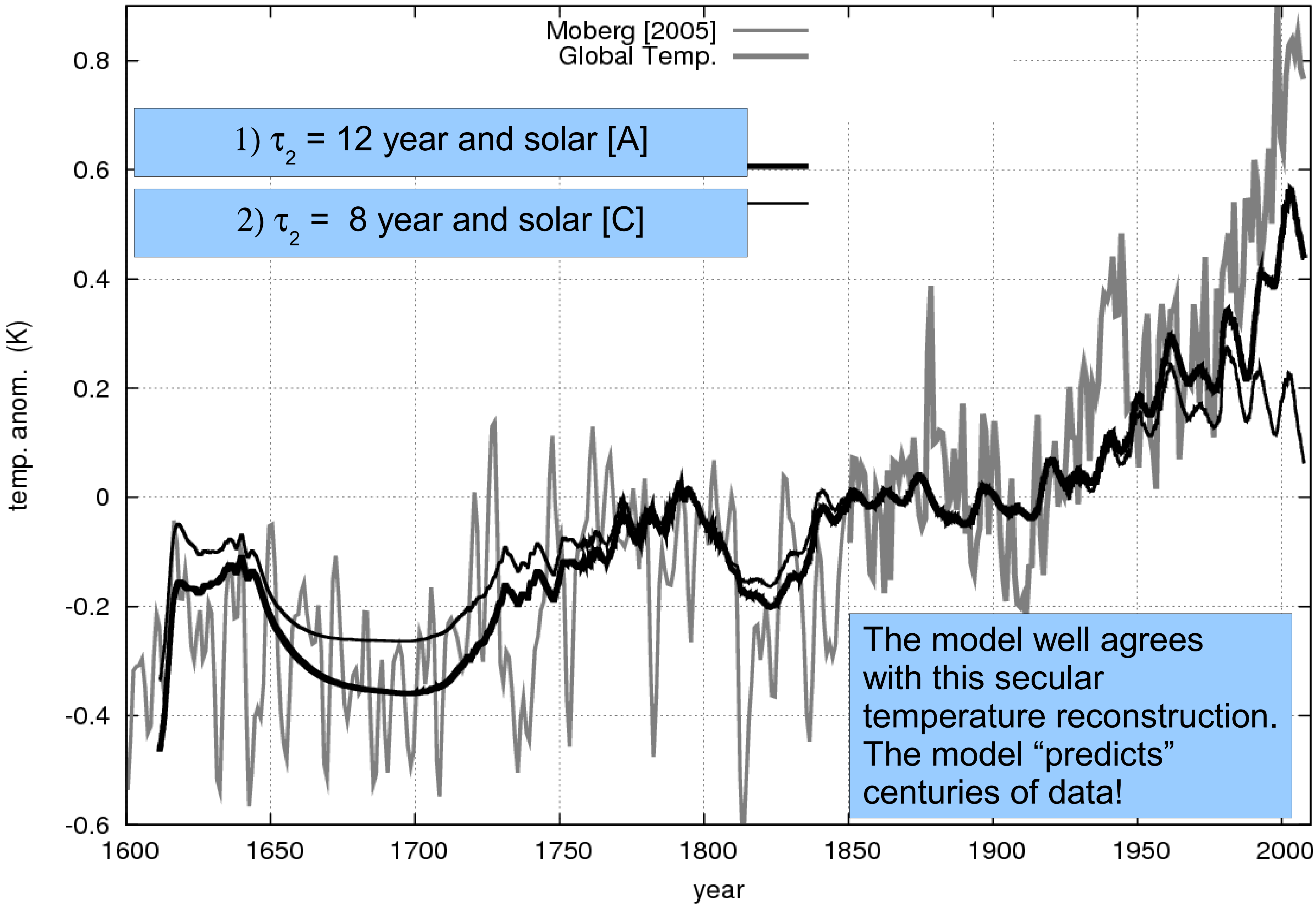
Scafetta, EPA 2009

The phenomenological solar signatures, as predicted by the model



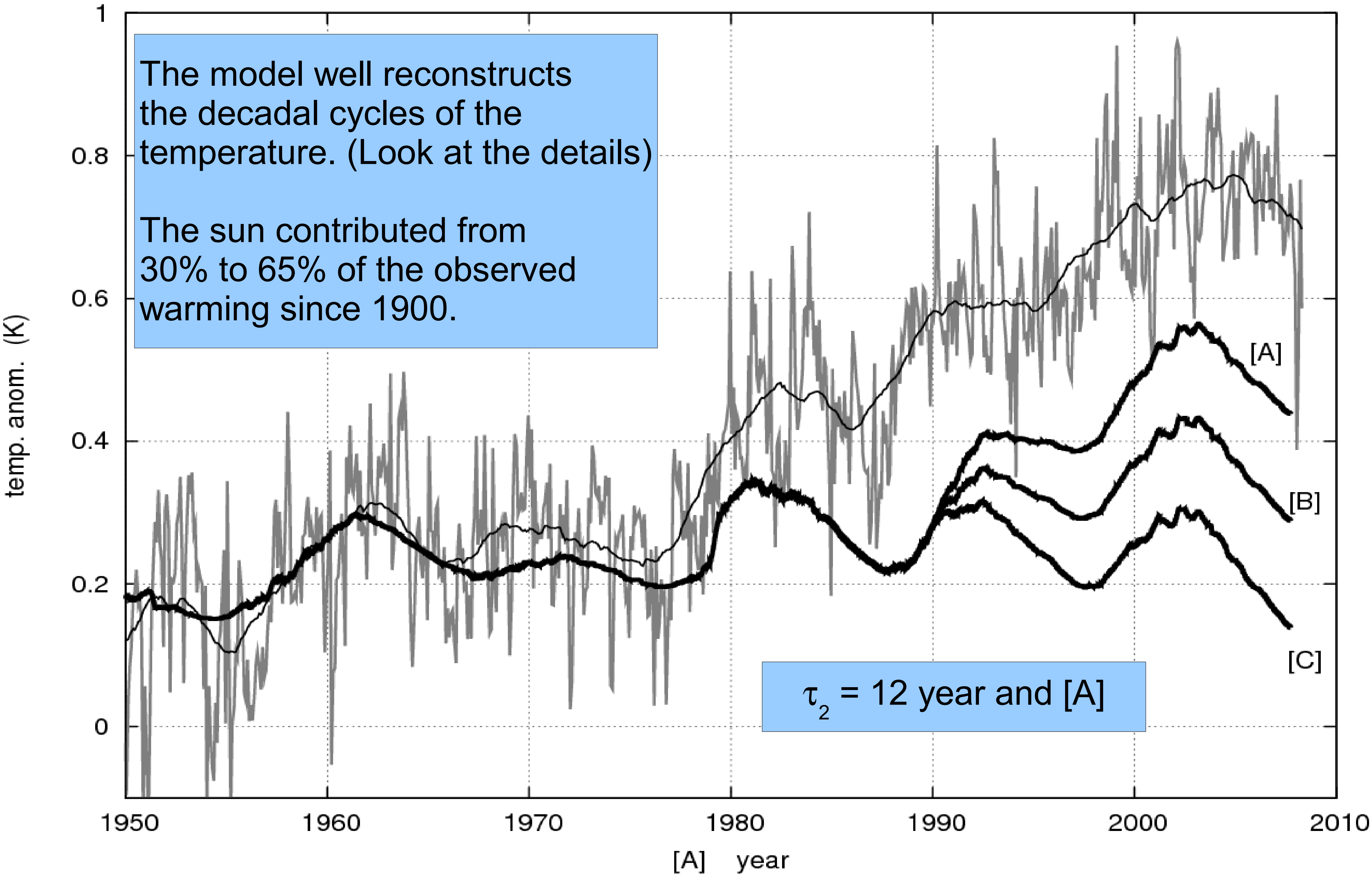
Scafetta, EPA 2009

The phenomenological solar signature as predicted by the model



Scafetta, EPA 2009

The phenomenological solar signature as predicted by the model against the "filtered" global surface temperature



The model well reconstructs the decadal cycles of the temperature. (Look at the details)

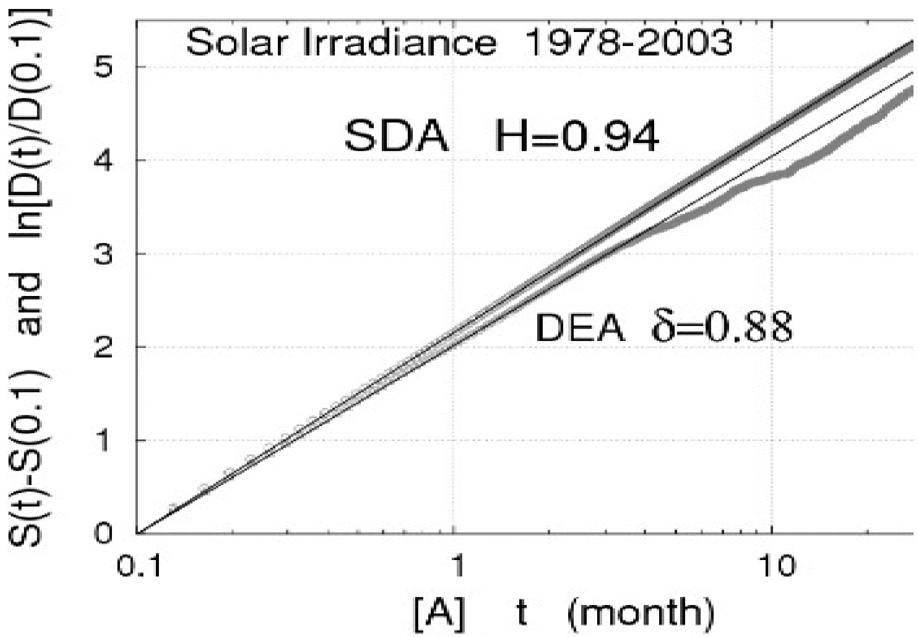
The sun contributed from 30% to 65% of the observed warming since 1900.

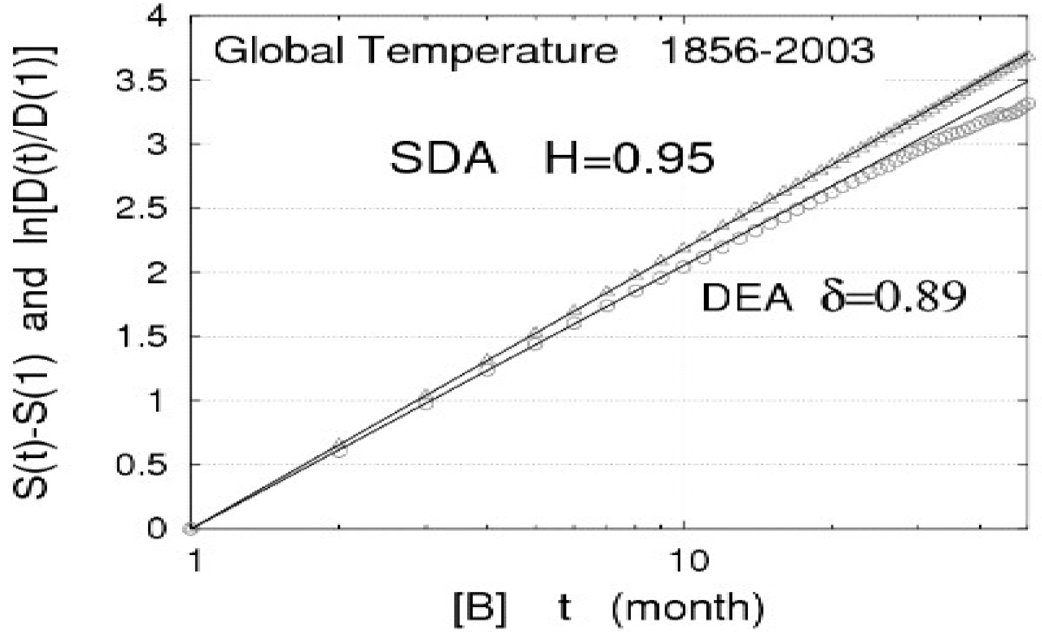
τ_2 = 12 year and [A]

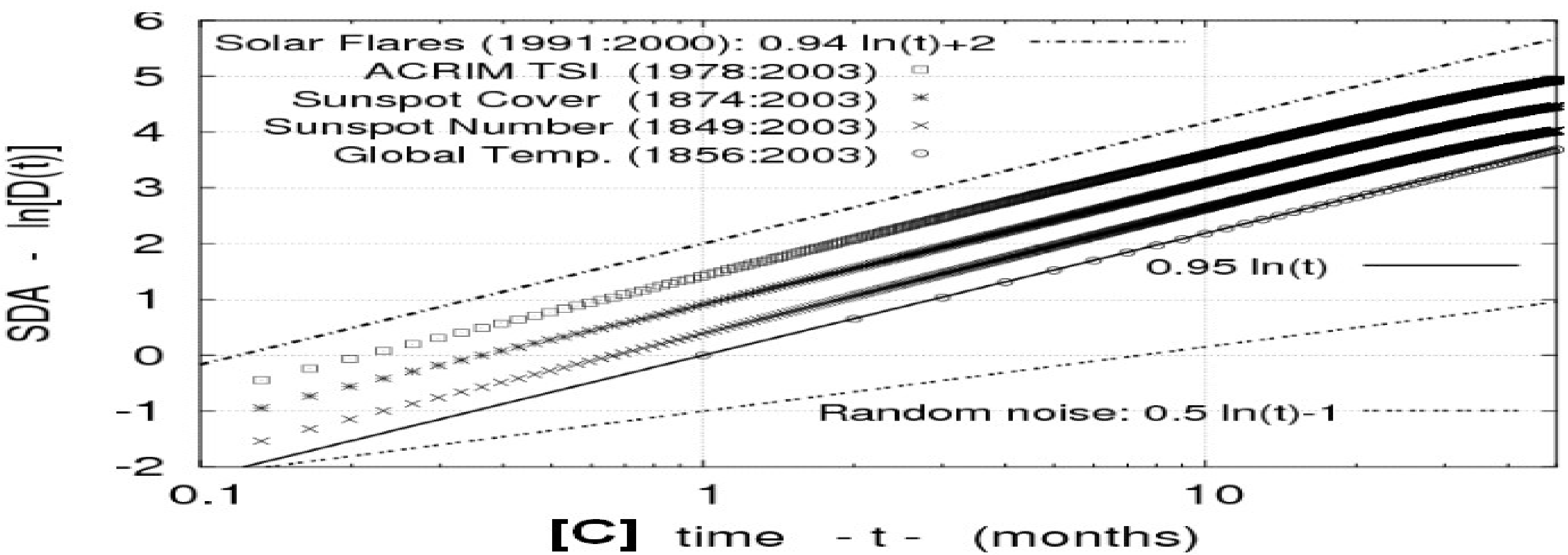
Scafetta, EPA 2009

Are the fast fluctuations of the temperature linked to the solar intermittent irradiance?
An analysis based on fractal exponents and Levy anomalous diffusion statistics.

Scafetta and West, “Solar Flare Intermittency and the Earth's Temperature Anomalies,” Phys. Rev. Lett. 90, 248701 (2003).
Scafetta and West, “Multiscaling comparative analysis of time series and geophysical phenomena,” Complexity 10(4) 51-56 (2005).





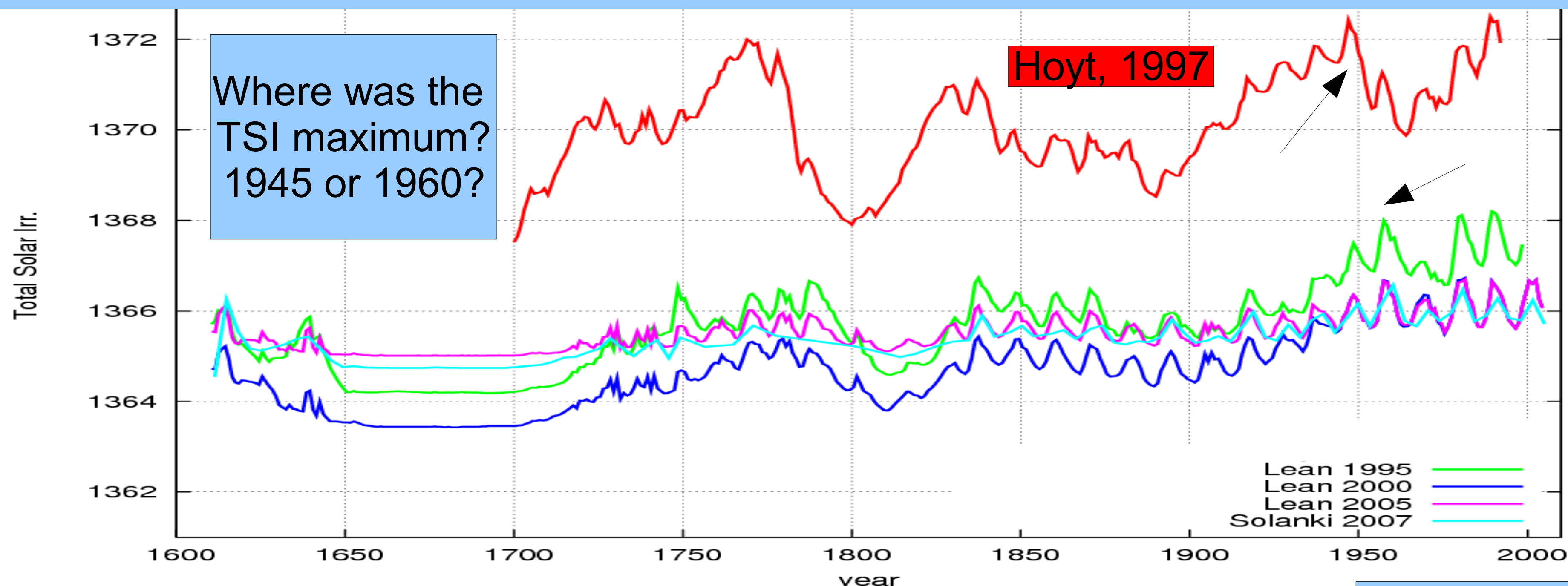


The phenomenological model predicts quite well centuries of climate change data as well as many decadal details as seen during the last 50 years. The climate is quite sensitive to solar changes.

However, the model does not appear to reproduce well the warming during 1910-1945.

A possible explanation is that the used TSI proxy model record is not accurate enough. This is likely because we have seen that these TSI models may fail to reproduce the observed decadal trends in TSI.

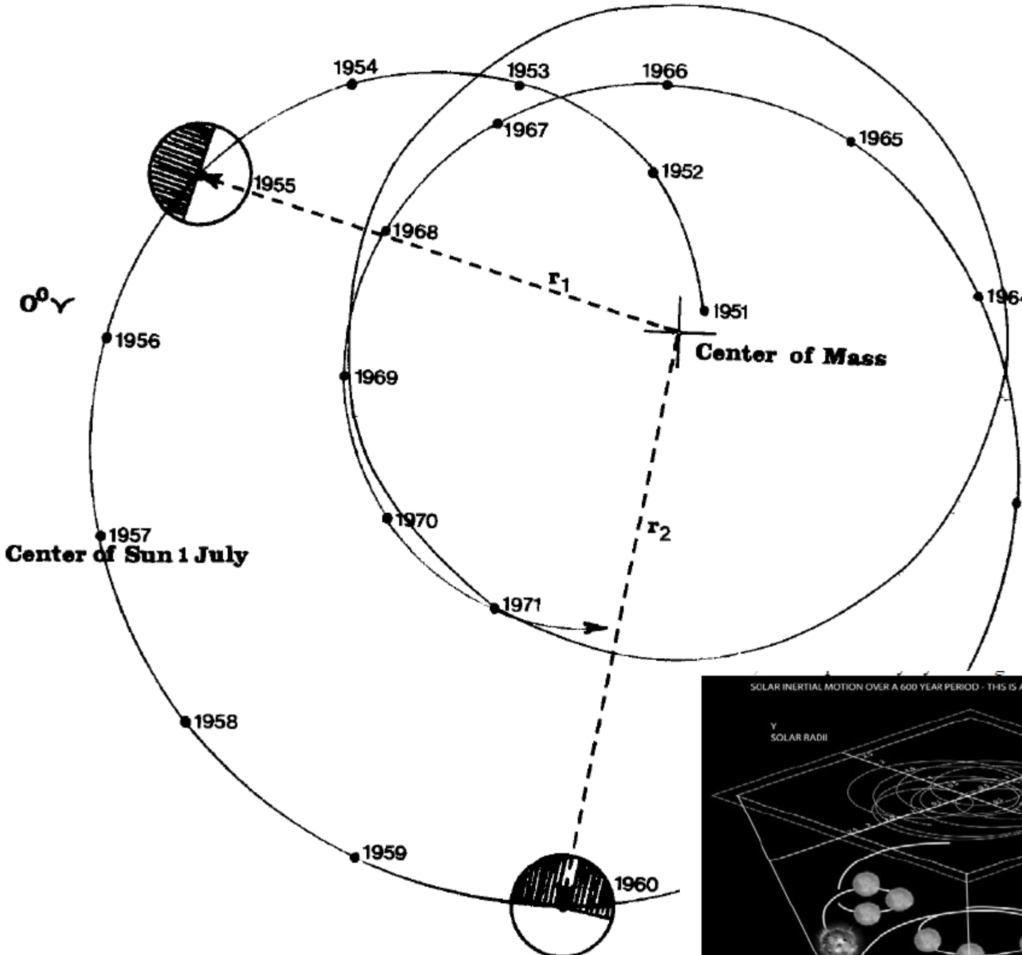
Indeed, the TSI proxy models greatly vary, as the figure shows. Which TSI may be correct? Or is there a missing climate forcing?

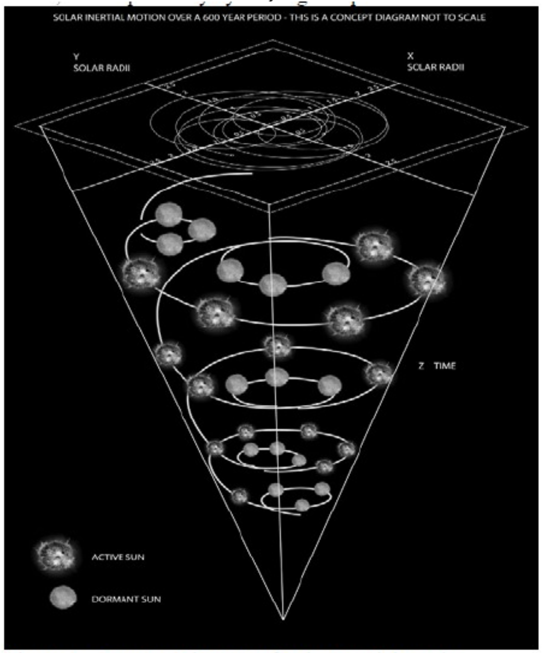


Scafetta, EPA 2009

Attempting a forecast of climate change:
An astronomical gravitational forcing for the Sun and the Earth?

Presented by Scafetta, at AGU fall meeting 2008





Jose, 1965;
Fairbridge and Shirley, 1987;
Landscheidt, 1988, 1999;
Charvatova and Stvrevstik, 2004;
Wilson et al., 2008

Wobbling of the Sun around the center of mass of the solar system.

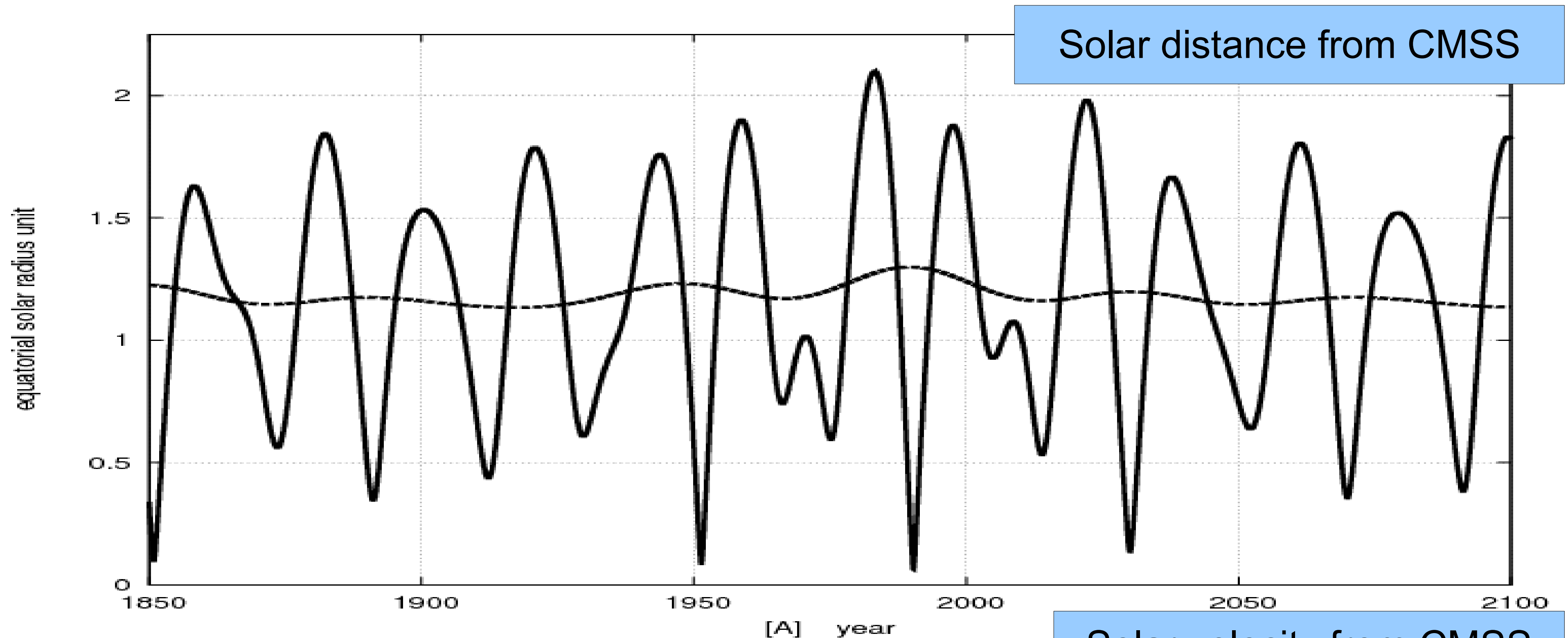
The Sun wobbles because of the gravitational attraction of the other planets of the solar system.

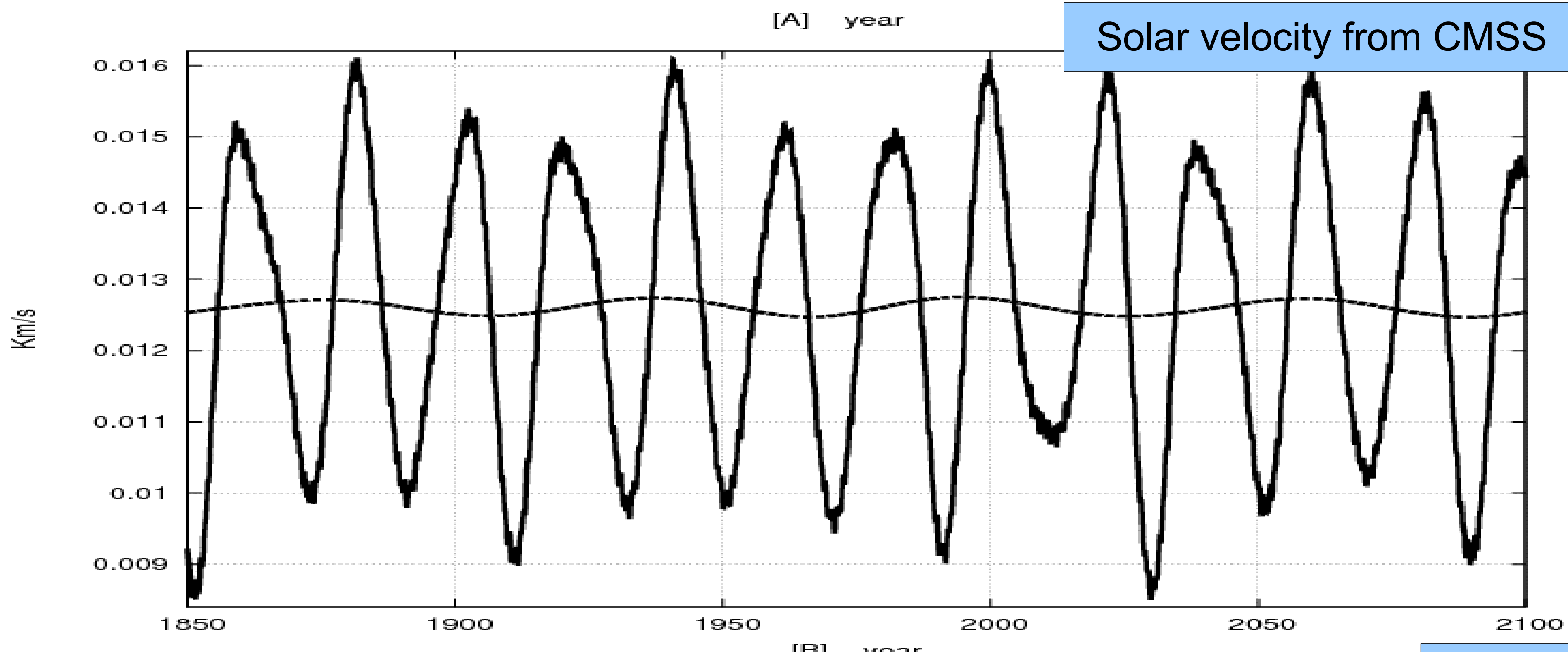
In particular because of the Jovian planets: Jupiter, Saturn, Uranus and Neptune.

This generates a tidal force and torque on the sun and on the Earth.

Is this forcing partially shaping solar activity and/or the Earth's climate?

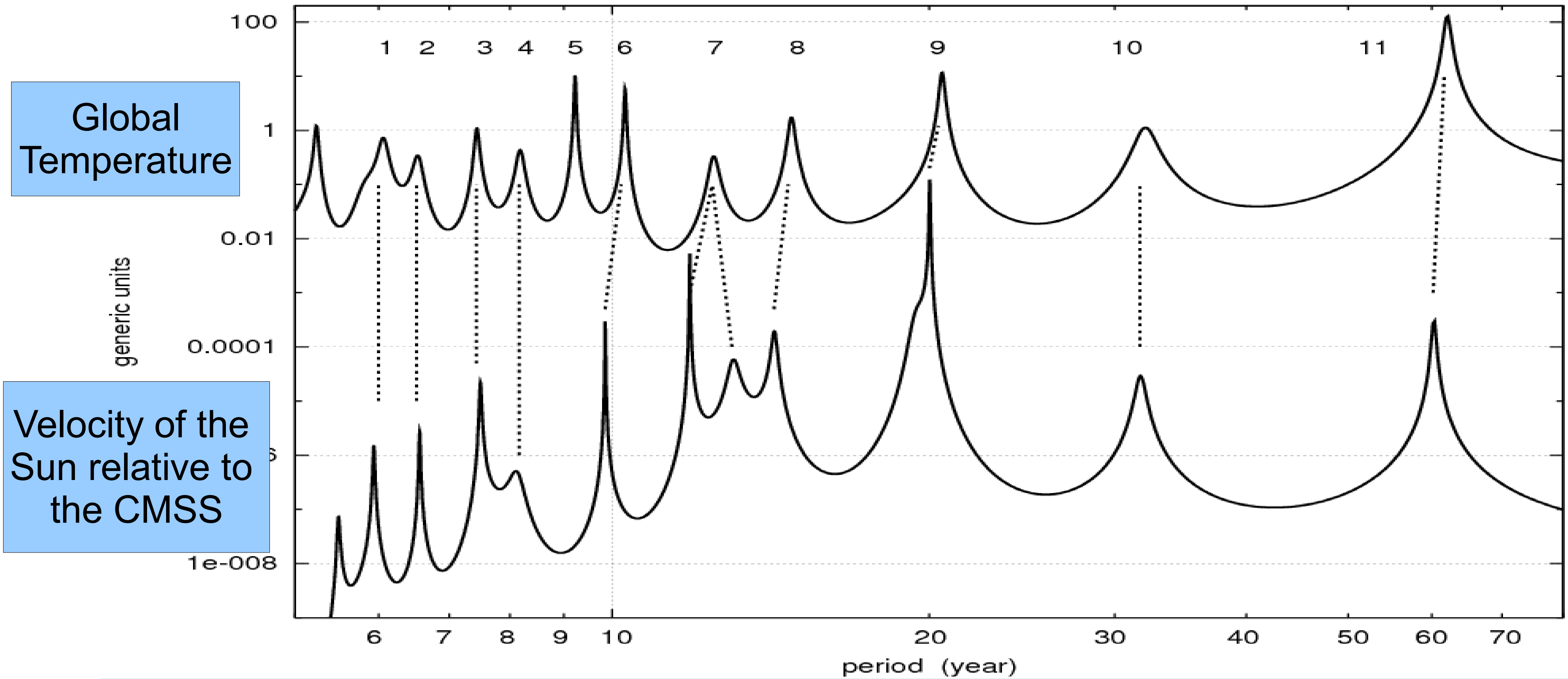
Scafetta, EPA 2009





Scafetta, EPA 2009

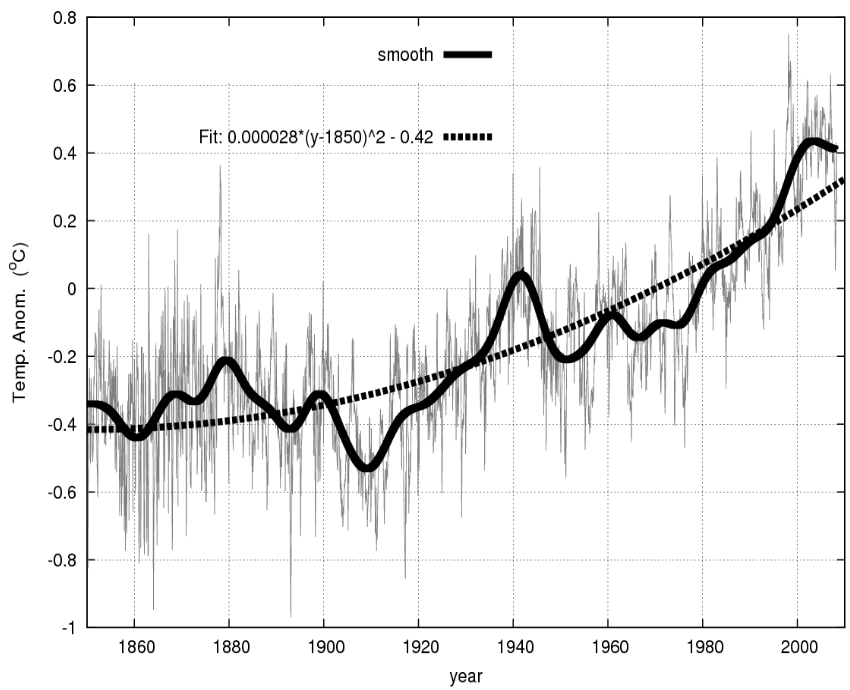
CMSS-Climate Power Spectrum Comparison

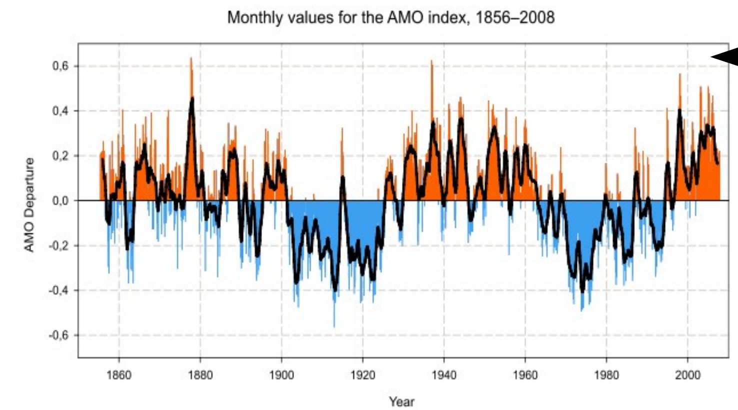


Maximum entropy spectral estimates (with 1000 poles) of the global surface temperature (top) and of the velocity of the Sun relative to CMSS (bottom) in function of the period calculated with monthly data since 1860.

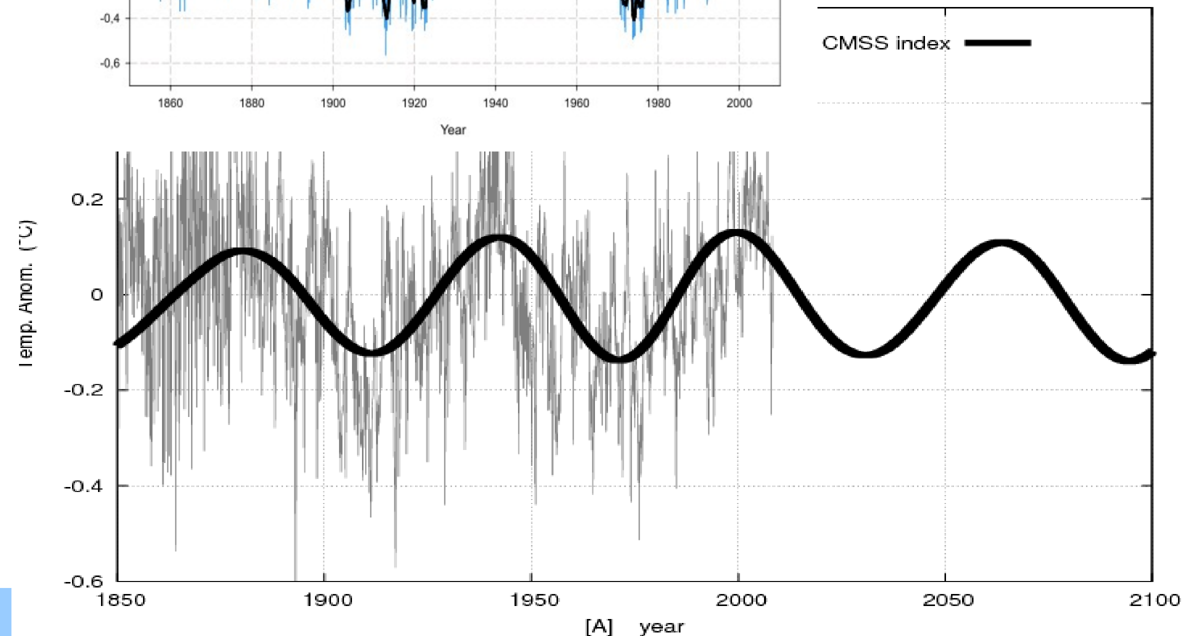
Cycle #7 refers mostly to the orbital period of Jupiter, which is 11.86 years; Cycle #9 refers mostly to the synodic period of Jupiter and Saturn, which is about 19.86 years; Cycle #10 refers mostly to the orbital period of Saturn, which is 29.42 years; Cycle #11 is about twice the orbital period of Saturn and five times that of Jupiter and is close to the third higher harmonic of the 178.7 solar cycle periodicity.

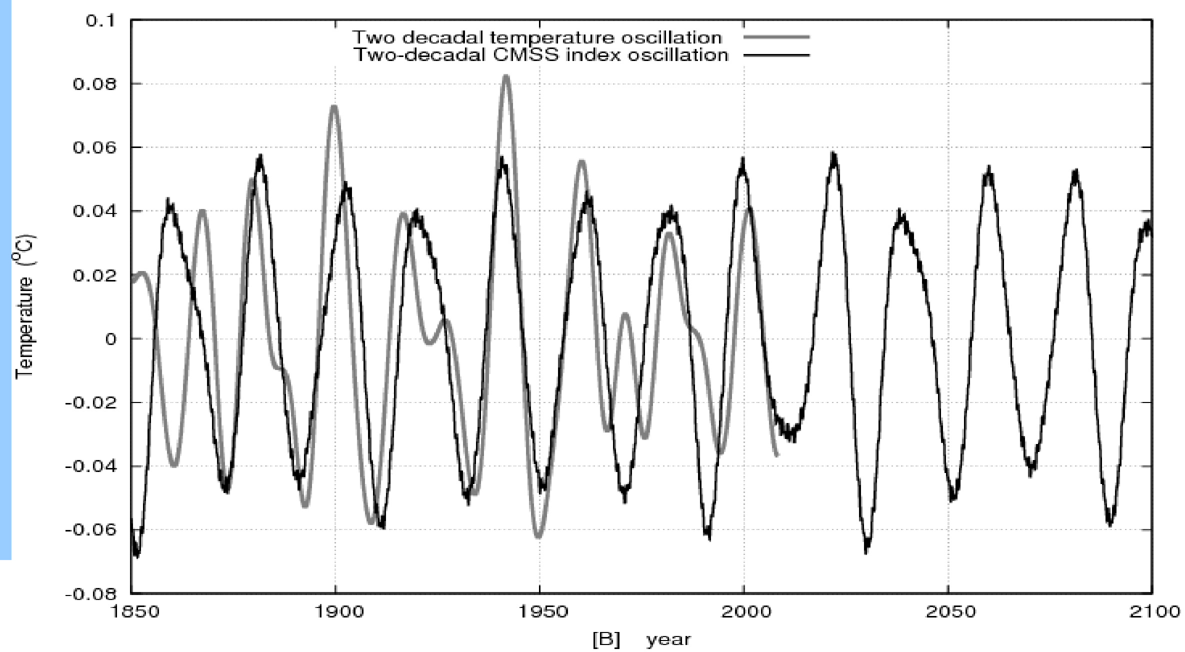
Scafetta, EPA 2009





60-year cycle Atlantic Multidecadal Oscillation

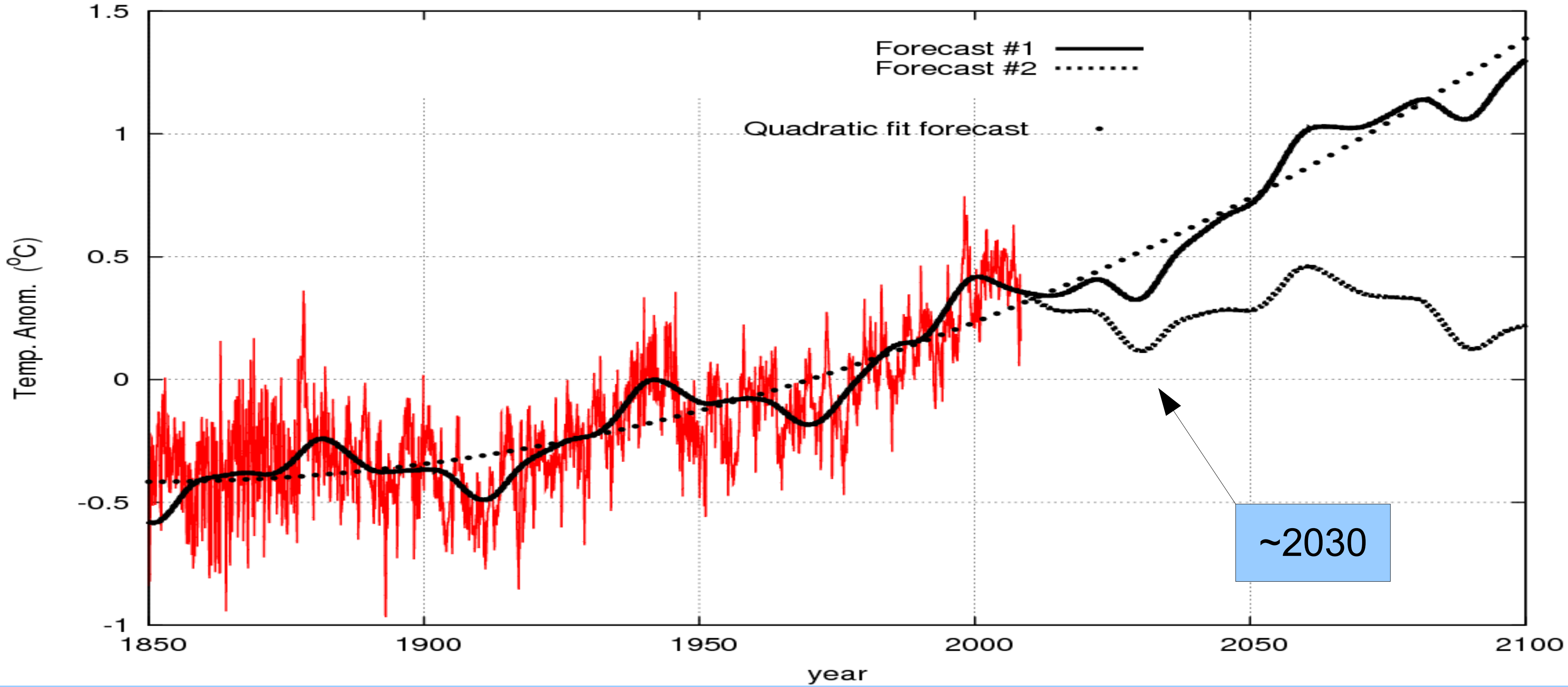




[A] Global surface temperature detrended of its quadratic fit plotted against the rescaled 60-year modulation of the velocity of the CMSS: the solar index is lag-shifted by +5 years.

[B] The 20-year oscillation of the climate (grey) plotted against the rescaled velocity (black) of the CMSS detrended of its six decade modulation: no lag-time is applied.

Scafetta, EPA 2009



Models of the global climate from 1850 to 2100 based on the reconstruction of the climate multidecadal variability based on the velocity of the Sun relative to the CMSS.

Forecast n. 1 is obtained by overlapping the two solid solar index curves shown previously and the quadratic fit of the global temperature indicated by the dotted curve. Forecast n. 2 assumes a constant trend after 2008. Note that all alternating periods of warming and cooling since 1860 are very well reconstructed by the model. The forecasts indicate that climate may cool until the 2030s. At the end of the 21st century the climate may warm at most by 1 °C relative to today temperature if the quadratic fit forecast holds.

The model suggests that climate is modulated by large 60, 30, 20 and 10 year natural cycles that combined have an amplitude of about 0.40-0.45 °C on the 60 year cycle. This explains the 1910-1945 warming and implies that about 70% of the observed warming from 1975 to 2002 was part of this natural climate cycle during its warm phase.

Scafetta, EPA 2009

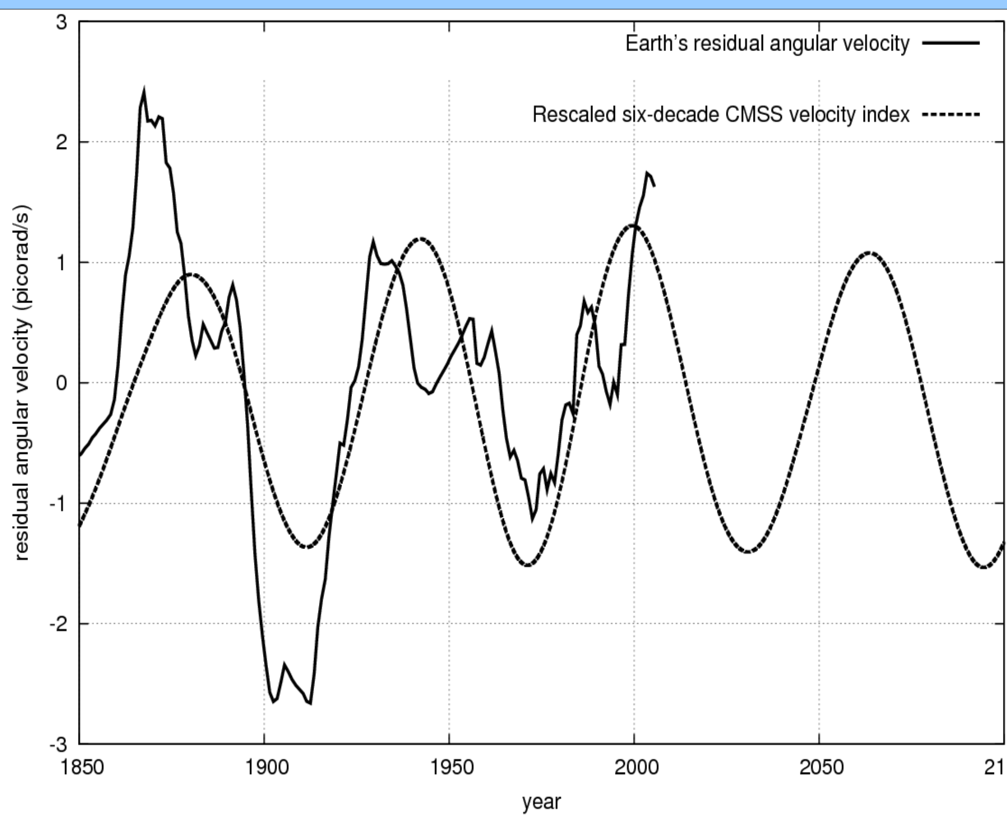
Two still “unproven” hypotheses:

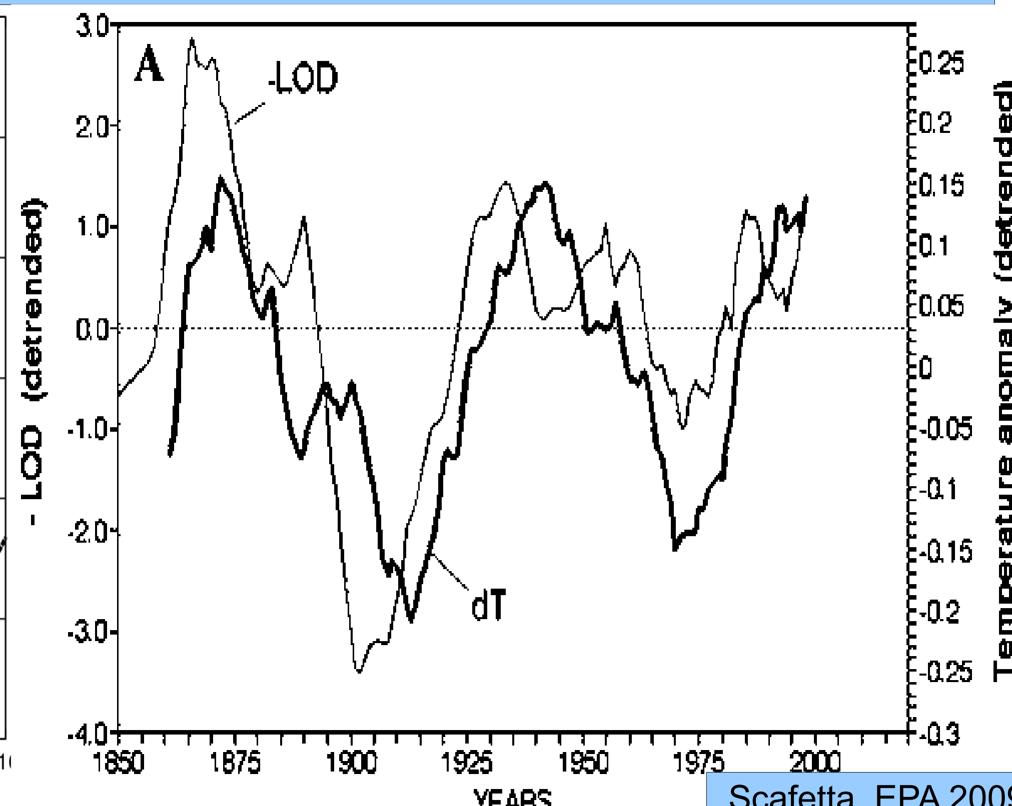
a) The movement of the planets partially modulates solar activity that then modulates climate. This hypothesis requires that current TSI proxy models are imperfect.

b) The movements of the planets drives a change in the Earth's Length Of the Day and the variation of the LOD constitutes a missing climate forcing that significantly contribute to climate change by altering the ocean and atmospheric currents, for example.

The figures below compare the LOD with the 60 year modulation of the solar velocity around the CMSS. Also, the LOD anticipates the change in global temperature by a 4-5 years.

Klyashtorin, L.B. (2001) Climate change and long-term fluctuations of commercial catches: the possibility of forecasting.” FAO Fisheries Technical Paper 410. See also: Mazzarella, *The Open Atmospheric Science Journal,* 2008, *2,* 181-184





Scafetta, EPA 2009

Conclusion

Current climate models, such as those adopted by the IPCC, appear to fail to reproduce large details found in the data on all temporal scales.

These details appear to be linked to solar variability.

Thus, climate models are severely underestimating by a large factor the solar effect on climate change on both short and long time scales.

A phenomenological model has been presented. It was shown to predict centuries of past climate change and suggests that up to 65% the observed warming since 1900 was directly or indirectly induced by the sun according to current TSI proxy models.

Climate may be significantly modulated also by an additional forcing that may be directly or indirectly linked to the movement of the planets that may affect the solar activity and/or the Earth.

A cooling is expected until 2030 – 2040 because of a 60 year cycle.

APPENDIX

General properties of the climate sensitivity function Z(ω) of an EBM

PERIOD →	5-years	10-years	20-years	40-years	80-years	160-years
AMPLITUDE						
0.5 K/Wm^{-2}	0.15	0.23	0.33	0.46	0.59	0.71
1 K/Wm^{-2}	0.08	0.13	0.19	0.28	0.39	0.52
2 K/Wm^{-2}	0.04	0.07	0.11	0.17	0.26	0.38
4 K/Wm^{-2}	0.02	0.04	0.06	0.1	0.17	0.28

General energy balance models predict that the climate sensitivity to a cyclical forcing, with a given period and amplitude, increases with the period and decreases with the amplitude. This is mostly due to general out of equilibrium thermodynamic effects and to the damping effect of the ocean thermal inertia.

Wigley, T. M. L. (1988), The climate of the past 10,000 years and the role of the Sun, pp. 368 209– 224, Springer, New York.

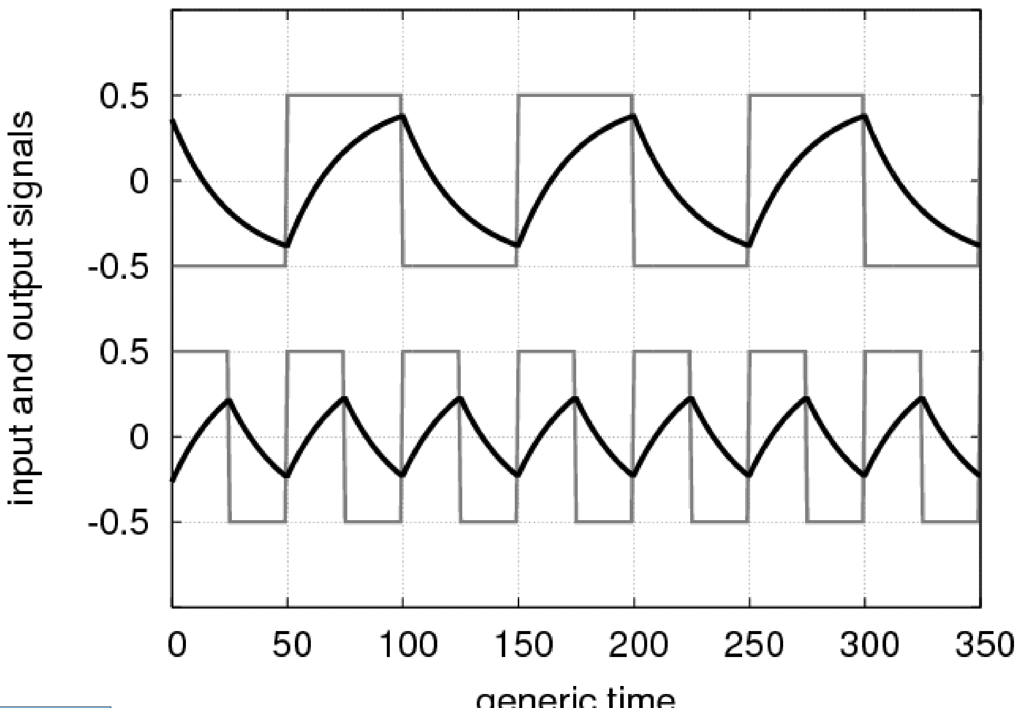
A phenomenological and simple sun-climate thermodynamic/relaxation model: A first order EBM

$$\frac{d\Delta T(t)}{dt} = \frac{c\Delta I(t) - \Delta T(t)}{\tau}$$

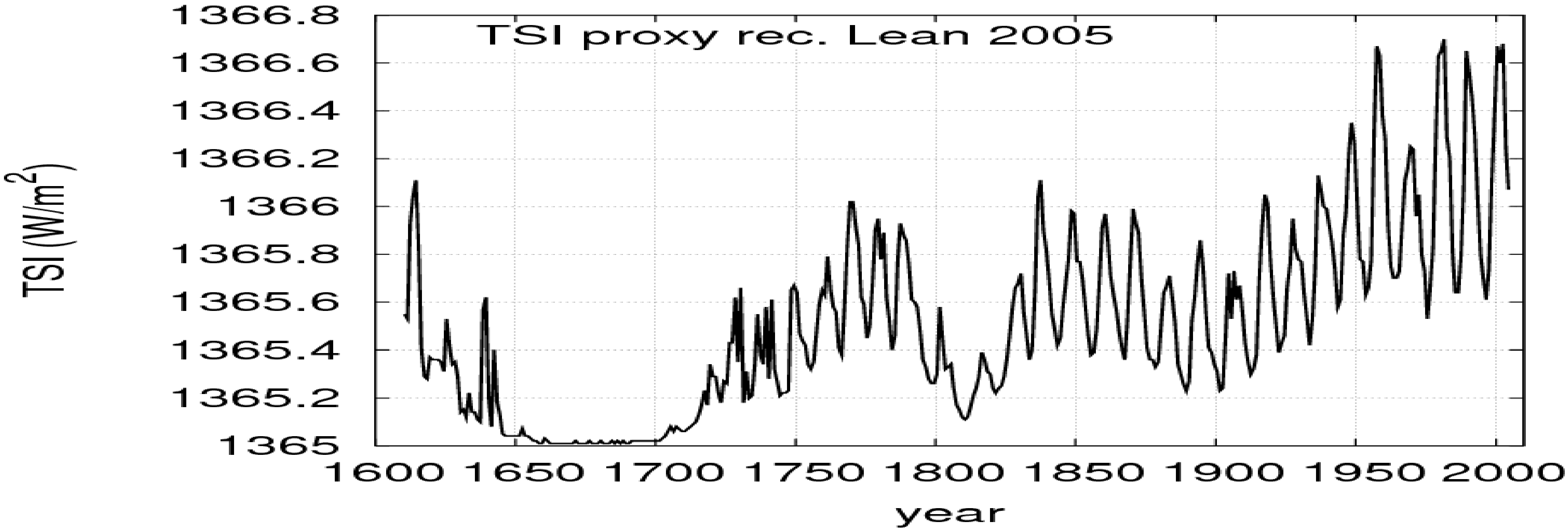
c = conversion constant

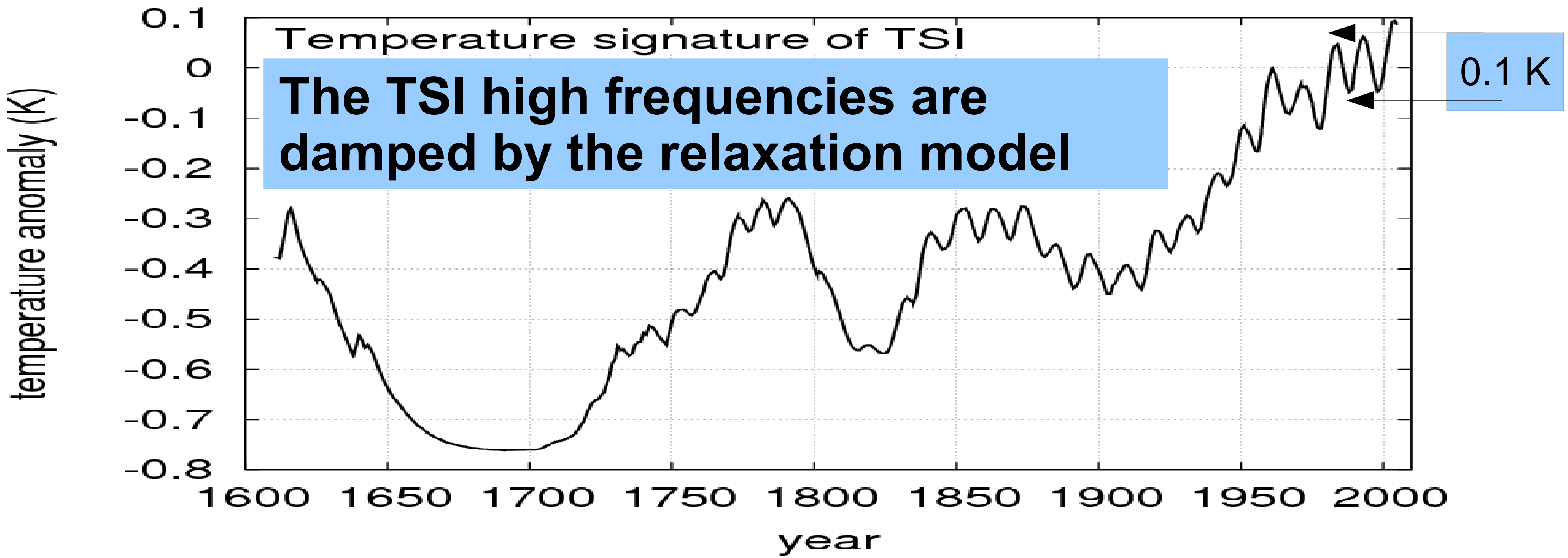
τ = relaxation time

High frequencies are reduced because of the thermal inertia

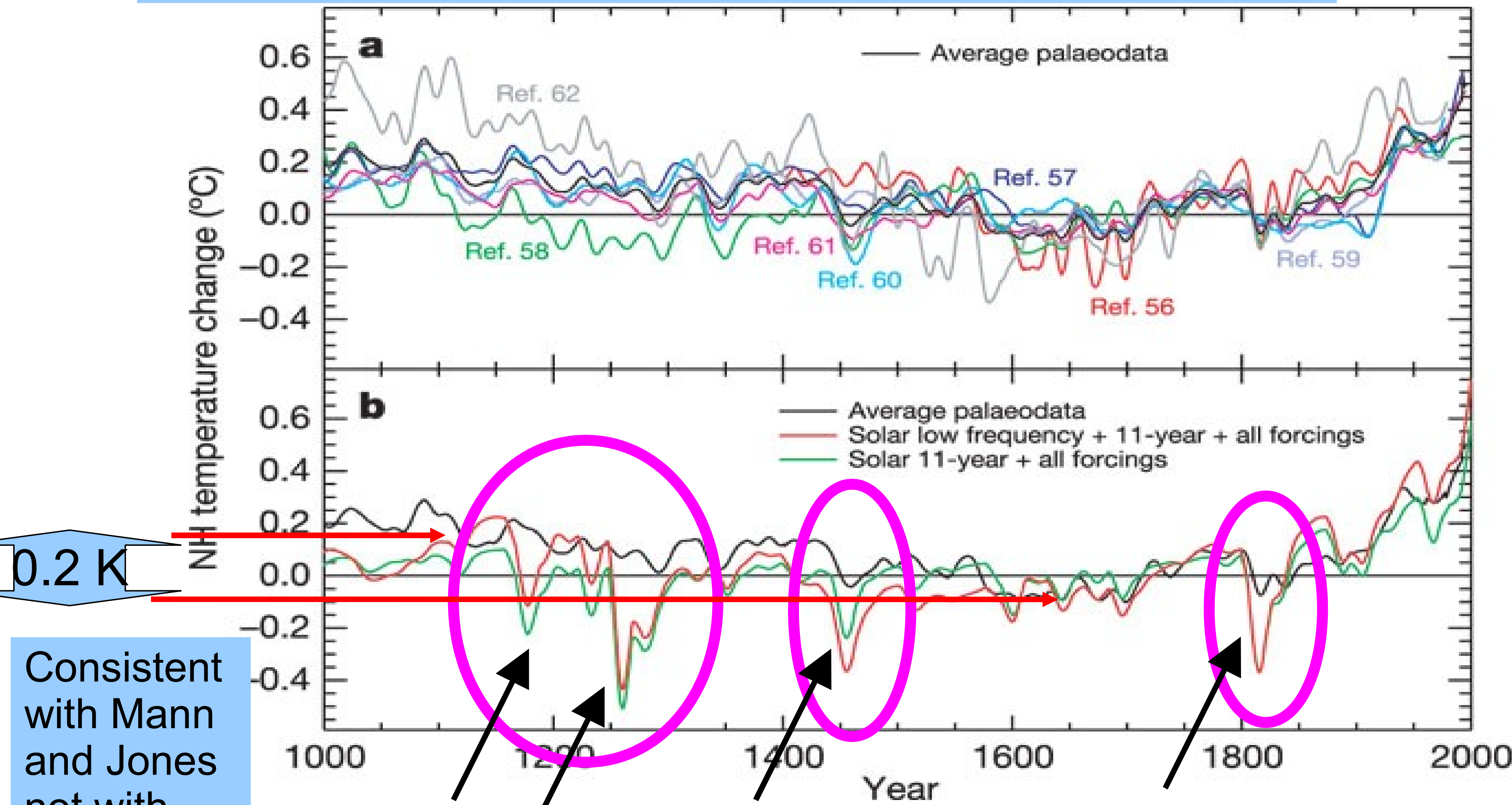


Scafetta and West, JGR 2007.


TSI proxy rec. Lean 2005
TSI (W/m2)
1366.8
1366.6
1366.4
1366.2
1366
1365.8
1365.6
1365.4
1365.2
1365
1600 1650 1700 1750 1800 1850 1900 1950 2000
year


Temperature signature of TSI
The TSI high frequencies are damped by the relaxation model
0.1 K
temperature anomaly (K)
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
1600 1650 1700 1750 1800 1850 1900 1950 2000
year

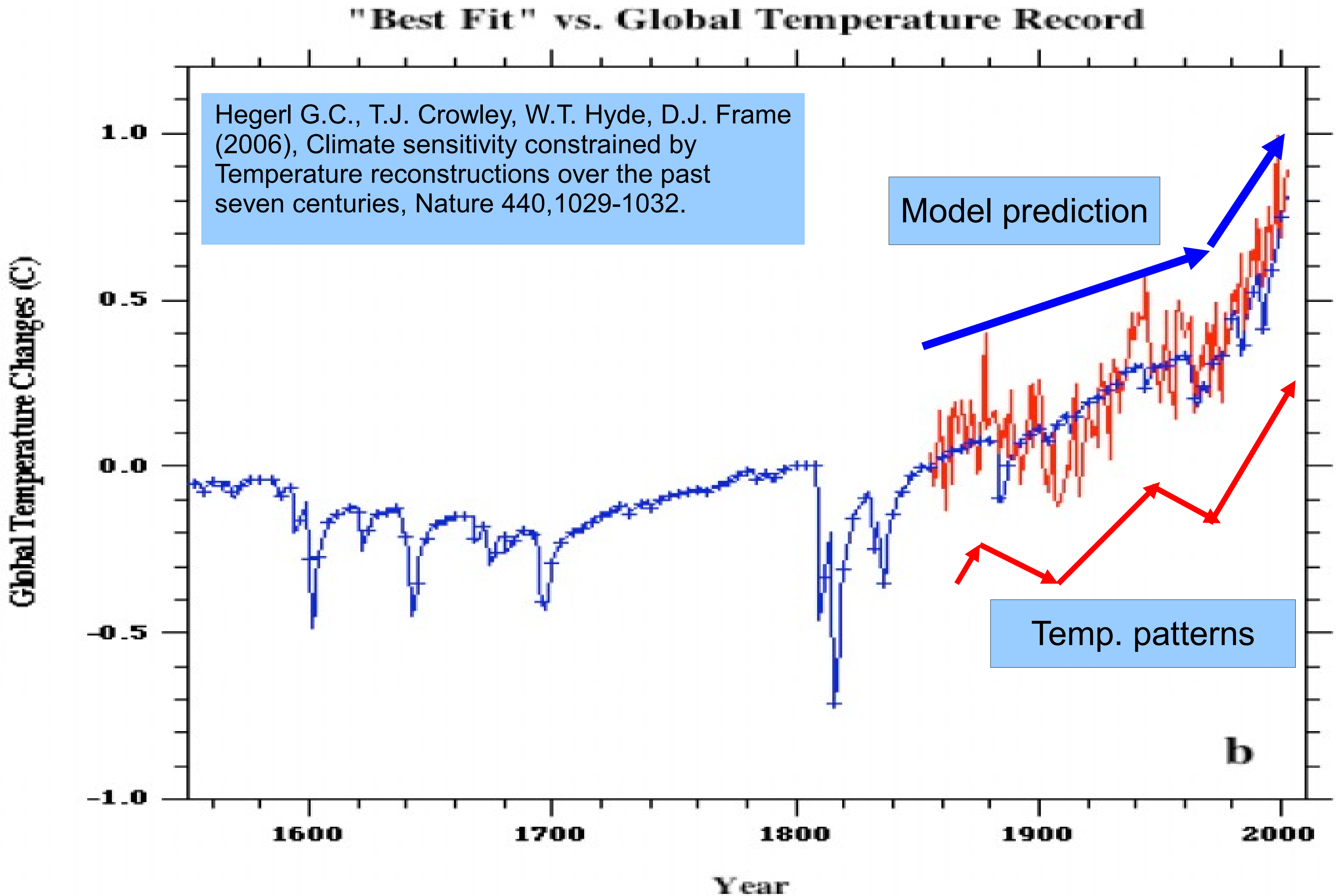
ENERGY BALANCE MODEL SIMULATIONS



Consistent with Mann and Jones not with Moberg

Volcano signals are too large and deep. The model is likely overestimating the volcano effects on climate

Foukal P., C. Frohlich, H. Spruit, T. M. L. Wigley (2006), Variations in solar luminosity and their effect on the Earth's climate, Nature 443, 161-166.



The model fails to reproduce the temperature variability before 1960 as the GISS ModelE fails to do (see slide 36)

Some papers on solar inertial motion and the Earth's length of the day oscillation

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Charvatova I. and J. Strestik (2004), Periodicities between 6 and 16 years in surface air temperature in possible relation to solar inertial motion, J. of Atm. and Solar-Terr. Phys. 66, 219-227.

Fairbridge R. W. and J. H. Shirley (1987), Prolonged minima and the 179-yr cycle of the solar inertial motion, Solar Physics 110, 191-220.

Klyashtorin, L.B. (2001) Climate change and long-term fluctuations of commercial catches: the possibility of forecasting. FAO Fisheries Technical Paper No. 410 Rome, FAO.

Jose P.D. (1965), Suns motion and Sunspots, Astronomical Journal 70, 193-200.

Landscheidt T. (1988), Solar rotation, impulses of the torque in Sun's motion, and climate change, Climatic Change 12, 265-295.

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Mackey R., (2007), Rhodes Fairbridge and the idea that the solar system regulates the Earth’s climate, Journal of Coastal Research 50, 955 - 968.

Mazzarella A. (2008), Solar Forcing of Changes in Atmospheric Circulation, Earth's Rotation and Climate, The Open Atmospheric Science Journal, 2, 181-184.

Wilson I. R. G., B. D. Carter, and I. A. Waite (2008), Does a spin-orbit coupling between the sun and the jovian planets govern the solar cycle?, Pub. of the Astr. Soc. of Astralia 25, 85-93.

Some papers about my research on climate change

Nicola Scafetta and Richard Willson, “ACRIM-gap and Total Solar Irradiance (TSI) trend issue resolved using a surface magnetic flux TSI proxy model”, in press Geophysical Research Letter (2009) .

Nicola Scafetta, "Total solar irradiance satellite composites and their phenomenological effect on climate," In press on a special volume for the Geological Society of America. (2009).

Nicola Scafetta, Can the solar system planetary motion be used to forecast the multidecadal variability of climate?, invited presentation at the AGU Fall Meeting, San Francisco (2008).

Nicola Scafetta, Analysis of the total solar irradiance composites and their contribution to global mean air surface temperature rise, AGU Fall Meeting, San Francisco (2008).

Nicola Scafetta, "Comment on ``Heat capacity, time constant, and sensitivity of Earth's climate system' by Schwartz." J. Geophys. Res. 113, D15104 (2008). doi:10.1029/2007JD009586.

Erik Kabela and Nicola Scafetta, “Solar Effect and Climate Change,” Bulletin of the American Meteorological Society, 89, 34-35 (2008).

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Nicola Scafetta, and Bruce J. West, “Phenomenological reconstructions of the solar signature in the NH surface temperature records since 1600.” J. Geophys. Res., 112, D24S03, doi:10.1029/2007JD008437 (2007).

Nicola Scafetta and Bruce J. West , “Phenomenological solar signature in 400 years of reconstructed Northern Hemisphere temperature record,” Geophys. Res. Lett., 33, doi:10.1029/2006GL027142. (2006).

Nicola Scafetta and Bruce J. West, ‘‘Reply to comments by J. Lean on “Estimated solar contribution to the global surface warming using the ACRIM TSI satellite composite”, Geophys. Res. Lett., 33, doi:10.1029/2006GL025668. (2006).

Nicola Scafetta and Bruce J. West, “Phenomenological solar contribution to the 1900-2000 global surface warming,” Geophys. Res. Lett., 33, L05708, doi:10.1029/2005GL025539 (2006).

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