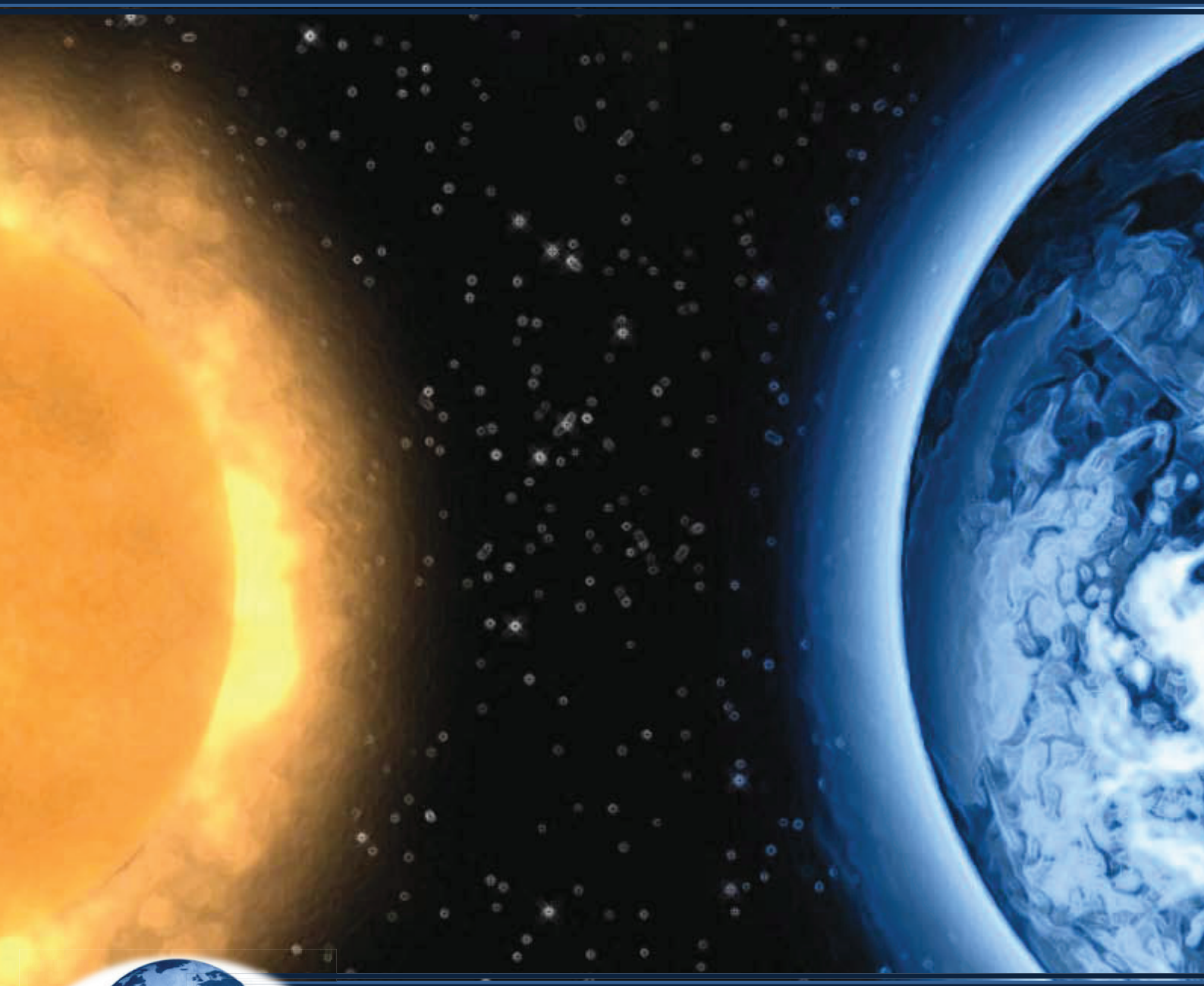
Climate Change and Its Causes

A Discussion About Some Key Issues

by Nicola Scafetta



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A Discussion About Some Key Issues

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Abstract

This article discusses the limits of the Anthropogenic Global Warming Theory advocated by the Intergovernmental Panel on Climate Change. A phenomenological theory of climate change based on the physical properties of the data themselves is proposed. At least 60% of the warming of the Earth observed since 1970 appears to be induced by natural cycles which are present in the solar system. A climatic stabilization or cooling until 2030-2040 is forecast by the phenomenological model.

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This work is made of

- An translation into English of the paper:
  Scafetta N., "Climate Change and Its causes: A Discussion about Some Key Issues," *La Chimica e l'Industria* **1**, p. 70-75 (2010);
- Several additional supporting notes are added to the paper;
- An extended appendix section part is added to cover several thematic issues to support particular topics addressed in the main paper.

This work covers most topics presented by Scafetta at a seminar at the U.S. Environmental Protection Agency, DC USA, February 26, 2009. A video of the seminar is here:
http://yosemite.epa.gov/ee/epa/eed.nsf/vwpsw/360796B06E48EA048525760100598 2A1#video

The Italian version of the original paper can be downloaded (with possible journal restrictions) from
http://www.soc.chim.it/files/chimind/pdf/2010/2010_1_70.pdf

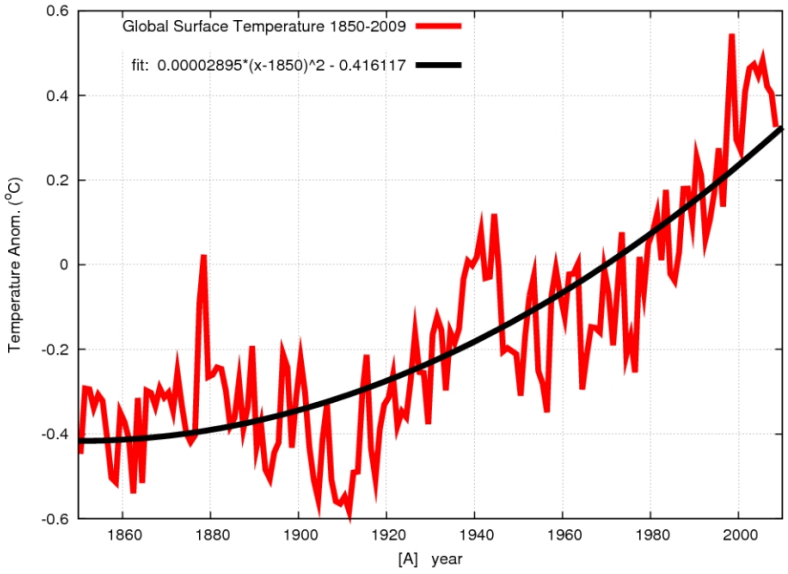

Figure 1: Global surface temperature (land and sea) HadCRUT3 (red) and its quadratic fit (black). [Climatic Research Unit, http://www.cru.uea.ac.uk/].

1. Introduction

Since 1900 the global surface temperature of the Earth has risen by about 0.8 ^oC (Figure 1), and since the 70s by about 0.5 ^oC. This temperature increase occurred during a significant atmospheric concentration increase of some greenhouse gases, especially CO_2 and CH_4, which is known to be mainly due to human emissions. According to the *Anthropogenic Global Warming Theory* (AGWT) humans have caused more than 90% of global warming since 1900 and virtually 100% of the global warming since 1970 (Appendix A). The AGWT is currently advocated by the *Intergovernmental Panel on Climate Change* (IPCC) [1], which is the leading body for the assessment of climate change established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). Many scientists believe that further emissions of greenhouse gases could endanger humanity [2].

However, not everyone shares the IPCC's views [3].[1] More than 30,000 scientists in America (including 9,029 PhDs) have recently signed a petition stating that those claims are extreme, that the climate system is more complex than what is now known, several

[1]The AGWT advocates claim that there exists a *scientific consensus* that supports the AGWT. However, a *scientific consensus* does not have any scientific value when it is contradicted by data. It is perfectly legitimate to discuss the topic of manmade global warming and closely scrutinize the IPCC's claims. Given the extreme complexity of the climate system and the overwhelming evidence that climate has always changed, the AGWT advocates' claim that the science is *settled* is premature in the extreme.

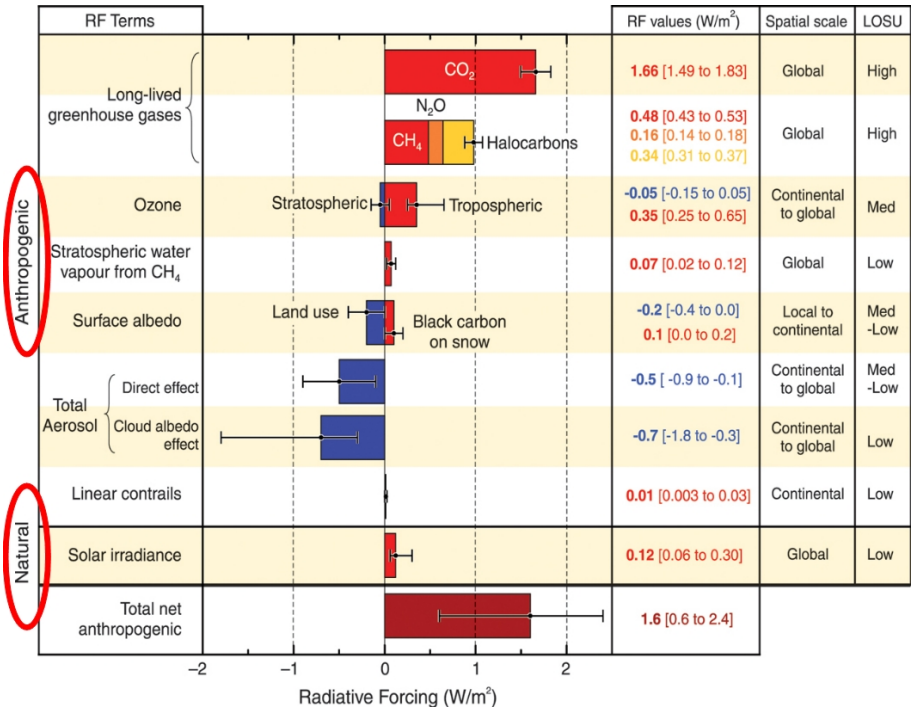

Figure 2: List of radiative forcings held responsible for the global warming since 1750 and used in the models adopted by the IPCC. The figure is adapted from the *IPCC Climate Change 2007: Synthesis Report*. These forcings are used as inputs of the climate models used by the IPCC to support the AGWT. The table suggests that the total net anthropogenic forcing since 1750 has been 13.3 times larger than the natural forcing. However, labeling on the left of the table, *anthropogenic* and *natural*, is misleading because it would imply that only human activity can change the chemistry of the atmosphere, which is non physical.

mechanisms are not yet included in the climate models considered by the IPCC and that this issue should be treated with some caution because incorrect environmental policies could also cause extensive damage [3]. This article briefly summarizes some of the reasons, mostly derived from my own research, why the science behind the IPCC's claim is questionable.[2]

[2]On November 19, 2009 a *climategate* story erupted on the web. This story is seriously undermining the credibility of the AGWT and of its advocates. Thousands of e-mails and other documents were disseminated via the internet through the hacking of a server used by the Climatic Research Unit (CRU) of the University of East Anglia in Norwich, England. These e-mails have been interpreted by some as suggesting serious scientific misconduct and even conspiracy by leading climate scientists and IPCC authors who have strongly advocated AGWT. These emails apparently suggest: 1) manipulation of temperature data; 2) prevention of a proper scientific disclosure of data and methodologies; 3) attempts to discredit scientists critical of the AGWT also by means of internet articles such as those at http://www.realclimate.org (several of these realclimate.org articles are quite shallow and suspiciously inaccurate); 4) attempts to bias Wikipedia articles in favor of the AGWT; 5) and much more seriously, attempts to control which papers appear in the peer reviewed literature and in the climate assessments in such a way to bias the scientific community in favor of the AGWT. Others, however, believe that the contents of those emails have been maliciously misinterpreted by the so-called *skeptics*. A detailed analysis of these emails can be found in: 1) J. P. Costella (2010), *Climategate analysis*, SPPI reprint series, (http://scienceandpublicpolicy.org/reprint/climategate_analysis.html); 2) S. Mosher and T. W. Fuller (2010), *Climategate: The Crutape Letters*, CreateSpace publisher; 3) See also United States Senate Report 'Consensus' Exposed: The CRU Controversy, http://epw.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=7db3fbd8-f1b4-4fdf-bd15-12b7df1a0b63

2. The IPCC's pro-anthropogenic warming bias

First, it should be noted that the IPCC mission states:

> *"The IPCC reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of human-induced climate change."*

The above statement implies that the IPCC may provide a colored reading of the scientific literature by stressing those studies that would better justify its own political mission, which evidently focuses on *human-induced* climate change.[3]

Indeed, the existence of an anthropogenic bias appears evident in Figure 2 that shows the complete list of the radiative forcings, which, as the IPCC claims, have caused the global climate warming observed since 1750. This figure divides the climatic forcings into two groups: one group includes only the total solar irradiance and is labeled *natural*, the other group comprises the rest and is labeled *anthropogenic*. Thus, the IPCC claims that 100% of the increase of the CO_2 and CH_4 atmospheric concentrations observed since 1750 and the change of all other climate components, except for the total solar irradiance, are *anthropogenic*. These labels do suggest that without humans the chemical concentrations of the atmosphere and a number of other climatic parameters would remain rigorously unchanged despite a change of the solar energetic input!

This claim is non physical because as the solar activity increases, climate warms, and this causes a net increase of atmospheric CO_2 and CH_4 concentration. During warming the ability of the ocean to absorb these gases from the atmosphere decreases because of Henry's law and other mechanisms. A warming would also increase the natural production of atmospheric CO_2 and CH_4 on the land due to the acceleration of the fermentation of organic material, outgassing of (permafrost) soils and other mechanisms [3,4]. The existence of CO_2 and CH_4 feedback mechanisms are evident in the large CO_2 and CH_4 cycles observed during the ice ages (which were caused by the astronomical cycles of Milankovich) when

[3]Further evidence of the IPCC's anthropogenic and political bias was discovered in January 2010: the IPCC's claim that Himalayan glaciers will disappear by 2035 was based on magazine interviews, not on peer-reviewed scientific research which is contrary to the IPCC's own policy. Dr. Lal admitted that this physically impossible event was highlighted in the IPCC report just to put political pressure on world leaders (http://www.dailymail.co.uk/news/article-1245636/Glacier-scientists-says-knew-data-verified.html). Curiously, NASA anticipated the Himalayan glacier melting to 2030 (http://wattsupwiththat.com/2010/01/23/nasa-climate-page-suckered-by-ipcc-deletes-a-moved-up-glacier-melting-date-reference/). Other significant errors and non peer-reviewed material in the IPCC have been uncovered such as: Endanger 40 percent of Amazon rainforests; Melt mountain ice in the Alps, Andes, and Africa; Deplete water resources for 4.5 billion people by 2085, neglecting to mention that global warming could also increase water resources for as many as 6 billion people; Slash crop production by 50 percent in North Africa by 2020. http://epw.senate.gov/public/index.cfm?FuseAction=Files.View&FileStore_id=9cc0e46e-56be-4728-9099-92dbda199bfc

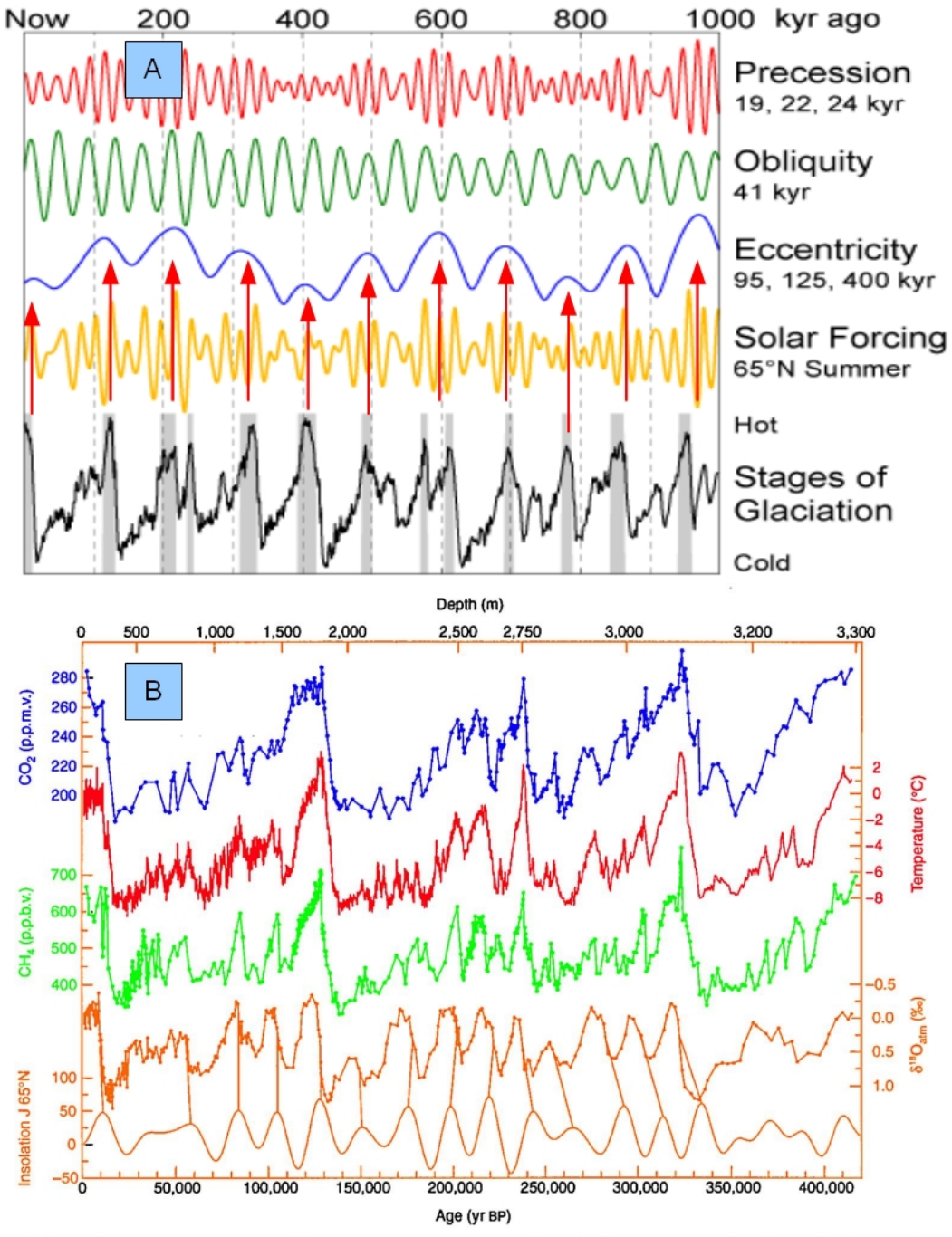

Figure 3: Cycles of CO_2 and CH_4 that time-lag (with a delay of about 800 years) the temperature cycles observed during the Ice Ages. These glacial cycles were likely induced by the modulation of the solar input into the Earth's system through the Milankovich cycles, which are orbital perturbations of the Earth such as the precession, obliquity and eccentricity. For example, notice the good correspondence between the 100.000 year temperature cycles with the eccentricity, as highlighted in the figure. The figure is adapted from Wikipedia' articles: [A] *Milankovitch cycles*; [B] *Vostok Station*.

no human industrial activity existed, see Figure 3.

For example, even assuming that the IPCC's forcing estimates in Figure 2 are correct, if only 10% of the total increase in greenhouse gases since 1750 has been due to the observed increase of solar activity during the same period, the IPCC, with its labels, has inflated the anthropogenic contribution by 20% and underestimated the solar contribution by 300%.[4] This can be easily extrapolated from the numbers depicted in Figure 2. It is evident that if the climatic forcings are labeled as *anthropogenic*, the presumed consequences, namely climate changes, would also be *anthropogenic*. This, however, is circular logic.

3. The climate sensitivity uncertainty to CO_2 increase

A second fundamental issue concerns how much global warming can be induced by an increase of CO_2 (or CH_4) atmospheric concentration. Indeed, this estimate is extremely uncertain. Also the radiative forcing associated with aerosols is extremely uncertain, as Figure 2 shows.

The IPCC acknowledges that if the atmospheric concentration of CO_2 doubles the global average temperature could rise between 1.5 and 4.5 ^oC at equilibrium. The variability of climate sensitivity to CO_2 is shown in Figure 4, which demonstrates an even wider sensitivity temperature range [5]. If greenhouse gases such as CO_2 are the major causes of global warming, a climate sensitivity to CO_2 increase with a minimum error of 50% (together with the extreme aerosol forcing uncertainty) can only raise strong doubts about the scientific robustness of the IPCC's climate change interpretation. This error is so large because it is not well known how to model the major climate feedback mechanisms, i.e., water vapor and clouds.

Indeed, the AGWT advocates acknowledge that the current models on which the claims of the IPCC are based are significantly incomplete. Rockstrom and 28 other scientists [2], who strongly promote the AGWT, have confirmed this fact by recently stating:

[4] A recent study (using CO_2 ice core reconstructions) found a CO_2 feedback rate of 1.7-21.4 ppmv CO_2 increase per ^oC, while other theoretical and empirical studies found a larger value (Frank D. C. *et al.* (2010), Ensemble reconstruction constraints on the global carbon cycle sensitivity to climate, *Nature* **463**, 527-530). However, a comparison between global temperature from 1860 and atmospheric CO_2 measurements by direct chemical analysis (not by ice core sample reconstruction) shows an atmospheric CO_2 concentration curve, with a maximum in 1942, which correlates relatively well with the temperature record; both curves present a maximum in 1940-1945 (Appendix B). This result would indicate the existence of strong CO_2 feedback mechanisms, which would imply that the observed CO_2 concentration increase during the last decades is highly related to some carbon cycle feedback mechanism in response to the increased solar input during this same period. It appears that it is climate change that alters the atmospheric CO_2 concentration, rather than vice versa. [E.-G. Beck (2007), 180 Years of atmospheric CO_2 Gas Analysis by Chemical Methods, *Energy & Environment* **18**, 259-282. http://www.biomind.de/realCO2/realCO2-1.htm]

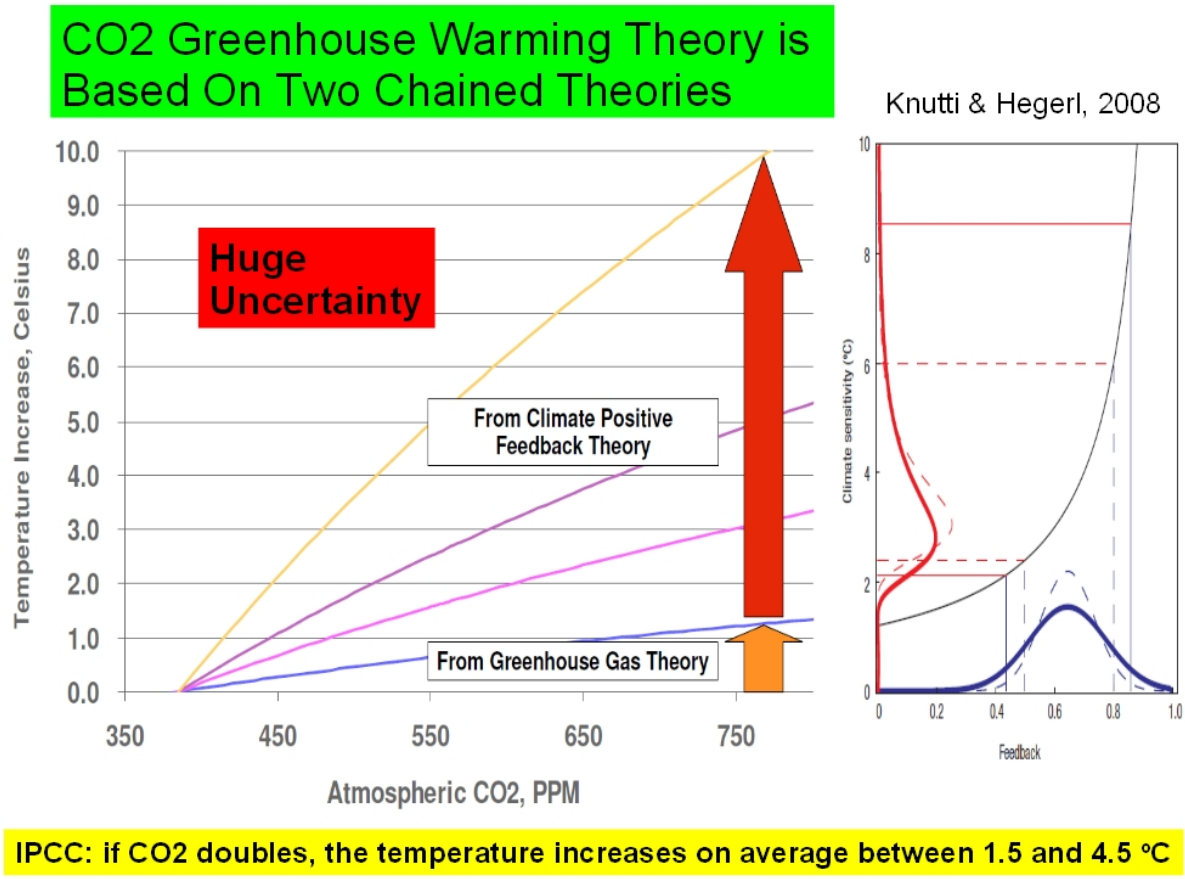

Figure 4: Climate sensitivity to CO_2 doubling in function of the feedbacks (from Knutti and Hegerl [5]). Note the large uncertainty: a CO_2 doubling may cause a global warming from 1 ^oC to 10 ^oC at equilibrium. The figure on the left explains why there exists such a large error. The GHG warming theory is based on two independent chained theories. The first theory focuses on the warming effect of a given GHG such as CO_2 as it can be experimentally tested. This first theory predicts that a CO_2 doubling causes a global warming of about 1 ^oC. The second theory, the *climate positive feedback theory*, attempts to calculate the overall climatic effect of a CO_2 increase by assuming an enhanced warming effect due to secondary triggering of other climatic components. For example, it is supposed that an increase of CO_2 causes an increase in water vapor concentration. Because H_2O too is a GHG, the overall warming induced by an increase of CO_2 would be due to the direct CO_2 warming plus the indirect warming induced by the water vapor feedback responding to the CO_2 increase. The problem with the climate positive feedback theory is that it cannot be directly tested in a lab experiment. Climate modelers evaluate the climate sensitivity to CO_2 increase in their *climate models*, not in nature. Thus, the numerical value of this fundamental climatic component is not experimentally measured but it is theoretical evaluated with computer climate models that create virtual climate systems. It is evident that different climate models predict a different climate sensitivity to CO_2, which gives rise to the huge uncertainty seen in the figure. Moreover, if the climate models are missing important mechanisms, it is evident that their predicted climate sensitivity to CO_2 changes may be extremely different from the true values. The left figure is partially adapted from "Catastrophe Denied: A Critique of Catastrophic Man-Made Global Warming Theory" by Warren Meyer, Phoenix Climate Lecture, November 10 (2009) http://www.climate-skeptic.com/phoenix

"Most models suggest that a doubling in atmospheric CO_2 concentration will lead to a global temperature rise of about 3 ^oC (with a probable uncertainty range of 2-4.5 ^oC) once the climate has regained equilibrium. But these models do not include long-term reinforcing feedback processes that further warm the climate,... If these slow feedbacks are included, doubling CO_2 levels gives an eventual temperature increase of 6 ^oC (with a probable uncertainty range of 4-8 ^oC)."

Rockstrom *et al.* [2] gave a quite alarmist interpretation to their acknowledgment that current climate models are missing important feedback mechanisms. However, such alarmism is baseless.[5] In fact, if missing feedback mechanisms were added to the current climate models, the corrected models would predict a much greater warming than the 0.8 ^oC observed during the last century. Thus, these models would severely fail to reproduce the warming of 0.8 ^oC observed in the temperature data. If the current IPCC climate models do not contain many feedback mechanisms that amplify the effect of a climate radiative forcing, the logical conclusion would be that the climate sensitivity to atmospheric CO_2 concentration is currently significantly overestimated by those models, while the effect of the solar input is severely underestimated.

4. The climatic meaning of Mann's *Hockey Stick* temperature graph

Let us clarify the issue from a historical perspective. In 1998 and 1999 Mann *et al.* [6] published the first reconstruction of global temperature over the last 1000 years. This paleoclimatic temperature reconstruction is known as the *Hockey Stick* (Figure 5). This graph suggests that before 1900 the temperature of the planet was almost constant and since 1900 an abnormal warming has occurred. From the Medieval Warm Period (1000-1300) and the Little Ice Age (1500-1750) this reconstruction predicts a cooling of less than 0.2 ^oC. This graph surprised many, including historians and geologists who have consistently argued that the early centuries of the millennium were quite warm (the Medieval Warm Period) while the period from 1500 to 1800 was quite cold (the Little Ice Age).[6]

[5] Rockstrom *et al.* [2] have implicitly acknowledged that the IPCC climate models are essentially flawed. This objectively undermines the IPCC's claims because its claims are based on the same climate models that the AGWT advocates acknowledge to be severely incomplete. Evidently, Rockstrom et al.'s claim that *future* climate models will necessarily confirm and greatly stress the AGWT cannot be considered as a *fact*. Indeed, it cannot be ruled out that, on the contrary, *future* climate models will discredit the AGWT by modeling new climate mechanisms that current models lack.

[6] This larger climate variability was clearly acknowledged by the IPCC in 1990. It was also consistent with the world climate history after AD 1,000 according to ground borehole evidence in a paper published in 1997 (Huang S. H. N. Pollack and P. Y. Shen (1997), Late Quaternary Temperature Changes Seen in Worldwide Continental Heat Flow Measurements, *Geophysical Research Letters* **24**, 1947-1950.)

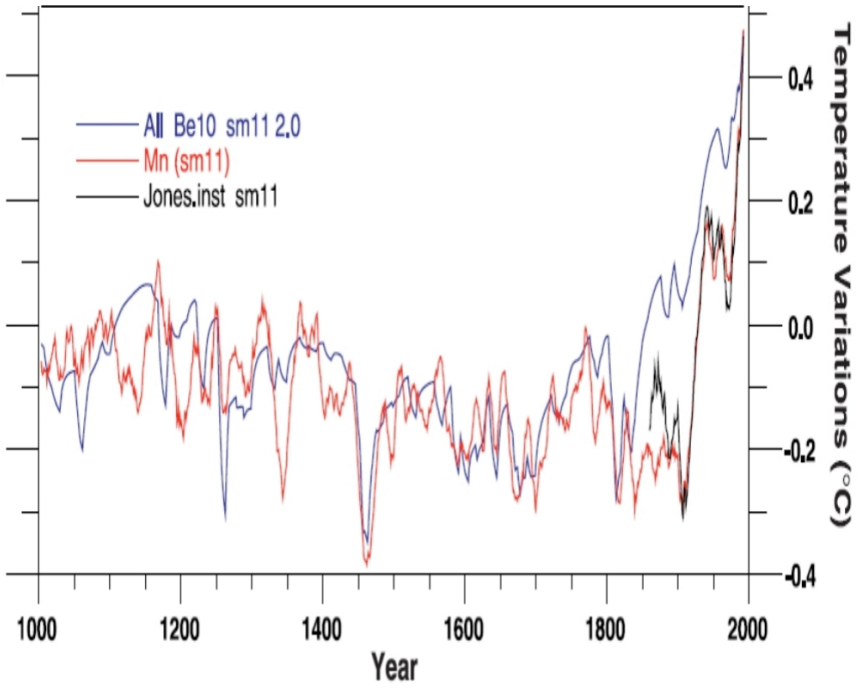

Figure 5: (Red) Mann's *Hockey Stick* [6]. (Blue) Output response of Crowley's linear upwelling/diffusion energy balance model using all forcing terms (solar, volcano, CO_2 and aerosol) [7]. Instrumental temperature data (black). Note the *very good agreement* between the model and temperature reconstruction that is claimed by Crowley in his article. Note that from the Medieval Warm Period (1000-1300) to the Little Ice Age (1500-1750) both the model response and Mann's temperature reconstruction show a cooling of about 0.2 ^oC.

The *Hockey Stick* temperature graph was considered the only global temperature reconstruction available at the time and it required a scientific interpretation. Several scientific groups, for example Crowley [7], used energy balance models and concluded that the *Hockey Stick* implied that the climate is almost insensitive to solar changes and the *anomalous* warming observed since 1900 has been almost entirely anthropogenic. In fact, only the (CO_2 and CH_4) GHG forcing function (as deduced from ice core reconstructions) presents a shape that resembles that of a hockey stick. Crowley concluded his article, which shows a good correlation between his climate model and the *Hockey Stick*, with this statement:

> *"The very good agreement between models and data in the pre-anthropogenic interval also enhances confidence in the overall ability of climate models to simulate temperature variability on the largest scales."* (See Figure 5)

Crowley's statement reveals the subtle link that exists between the *Hockey Stick* and the *confidence* in the sufficient accuracy of the climate models used to claim that the global warming observed since 1900 was almost entirely anthropogenically induced. This interpretation was strongly endorsed by the IPCC in 2001, was popularized by Al Gore in his documentary *The Inconvenient Truth*, where the *Hockey Stick* plays a predominant role, and was almost completely implicitly proposed again by the IPCC in 2007. It is important

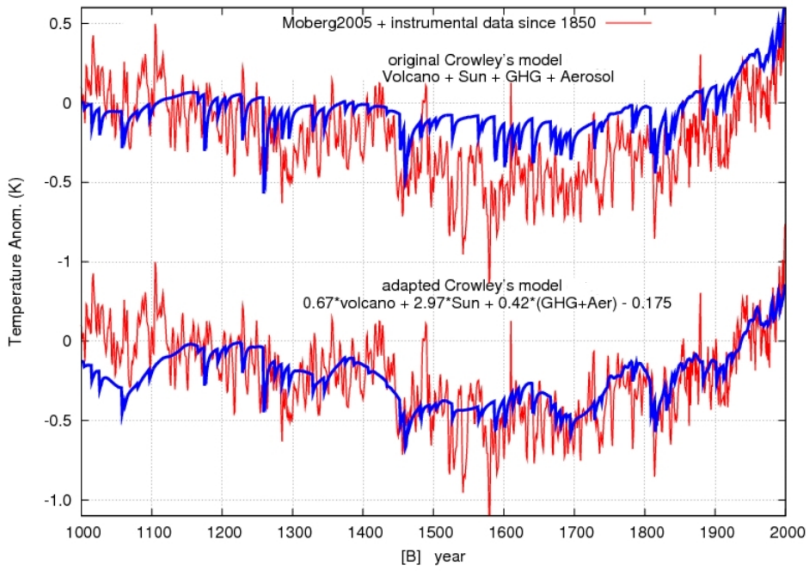

Figure 6: Top: Moberg's temperature (red) [8]. Crowley's model (blue) [7] which is also shown in Figure 5. Bottom: In blue Crowley's model once adapted to reproduce the temperature of Moberg *et al.* (2005) that shows a 0.6 ^oC cooling from MWP and LIA. Note that the solar contribution must be amplified by a factor of 3 while the GHG+aerosol contribution, which is commonly labeled as *anthropogenic*, must be reduced to a factor of 0.4.

to note that the IPCC's AGWT is based on the interpretation of climate models, such as Hansen's GISS models [20], developed before 2004/5 which appear to be compatible with the *Hockey Stick* temperature graph (see also Appendix H).[7]

5. The climatic meaning of recent paleoclimatic temperature reconstructions

The dates are important because since 2004/2005 the *Hockey Stick* has been mathematically and physically questioned.[8] An additional open issue is whether the tree rings used by

[7]For example, the GISS GCM are compared and found relatively compatible with Mann's *Hockey Stick* temperature graph in Shindell D.T., G.A. Schmidt, R.L. Miller, and M.E. Mann, (2003), Volcanic and solar forcing of climate change during the preindustrial era. *J. Climate* **16**, 4094-4107. A compatibility with the *Hockey Stick* temperature graph is also easily visible in the energy balance model (EBM) simulations in Foukal P., C. Fröhlich, H. Spruit, T. M. L. Wigley (2006), Variations in solar luminosity and their effect on the Earth's climate, *Nature* **443**, 161-166. In this paper it is clear that the EBM model simulations predict a cooling between the Medieval Warm Period (1000-1300) and the Little Ice Age (1500-1800) of less than 0.2 ^oC as shown by Mann's *Hockey Stick*.

[8]The problems with Mann's original *Hockey Stick* temperature graph were first exposed by McIntyre and McKitrick (2005), The M&M Critique of the MBH98 Northern Hemisphere Climate Index: Update and Implications, *Energy and Environment* **16(1)**, 69-100. It was shown than Mann's algorithm could produce hockey stick shapes even with a set of red noise sequences. Note that recently Mann has updated his reconstruction and acknowledged that the preindustrial temperature varied more than previously claimed in his works (Mann M. E., *et al.* (2008), Proxy-based reconstructions of hemispheric and global surface temperature variations over the past two millennia, *Proc Natl Acad Sci USA* **105**, 13252-13257). However, McIntyre and McKitrick have claimed that also this latest Mann's update presents significant mathematical errors including some records that would be improperly used

Mann are able to accurately reconstruct the temperature changes, especially over long time scales. Indeed, tree growth does not depend on temperature alone but on other factors too, such as rain patterns and biological adaptation. These multiple factors may introduce non-linear relationships and a certain degree of randomness in the data. This may reduce the amplitude of multidecadal and secular oscillations found in the proxy models, in particular when these proxy records are statistically calibrated against the instrumental temperature records, which are only available for the period after 1850, and combined for obtaining a world average.

Alternative paleoclimatic reconstructions, which do not use tree rings, have been proposed [8-10]. These proxy temperature reconstructions suggest a significant pre-industrial climate variability. From the Medieval Warm Period (1000-1300) and the Little Ice Age (1500-1750) these reconstructions show a cooling of at least 0.6 ^oC, three times larger than the *Hockey Stick*. Figure 6 shows that if Crowley's energy balance model is compared against Moberg's paleoclimatic temperature reconstruction [8], Crowley's *very good agreement* between the model and the data vanishes. If Crowley's model is recalibrated to reconstruct Moberg's temperature, it is easy to calculate that the solar effect must be amplified by a factor of 3 and the anthropogenic effect (GHG + Aerosol) should be multiplied by 0.4. Thus, if Moberg's temperature is accurate, in 2000 the anthropogenic contribution to global warming was overestimated by 250% because of the *Hockey Stick*.

Indeed, the *Hockey Stick* temperature graph does not have any historical credibility because between 1000 and 1400, the Vikings had farms and villages on the coast of Greenland, which would suggest an even milder climate than today, while the following period, from 1400 to 1800, is known as the Little Ice Age. The medieval warm and the following cold period were not only Western and European phenomena but are also evident in Chinese historical documents [11]. Numerous interdisciplinary studies reporting data from several regions of the world (see the Medieval Warm Period Project[9]) clearly indicate a significant change in pre-industrial climate which seems to be better reproduced by more recent paleoclimatic global temperature reconstructions [8-10] which do not show a hockey stick shape.[10] See Appendixes C-H for further details about climate data at multiple time scales.

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with the axes upside down by Mann's algorithm because these records are severely compromised by agricultural impact during the last century, e.g., Korttajarvi sediments from Tiljander data. Therefore, these data could not be used for reconstructing the past temperature because they could not be properly calibrated against the instrumental temperature record. (McIntyre S. and R. R. McKitrick (2009) Proxy Inconsistency and Other Problems in Millennial Paleoclimate Reconstructions. *Proc Natl Acad Sci USA 106*, E10.). See an extended comment by McIntyre here: http://climateaudit.org/2009/10/14/upside-side-down-mann-and-the-peerreviewedliterature/. Also interesting is the following comment by Eschenbach: http://climateaudit.org/2008/11/23/cant-see-the-signal-for-the-trees/

[9] *http://www.CO_2science.org/data/mwp/mwpp.php*

[10] A nice summary about the findings of numerous studies published before and after Mann's original work in 1998 and 1999 that

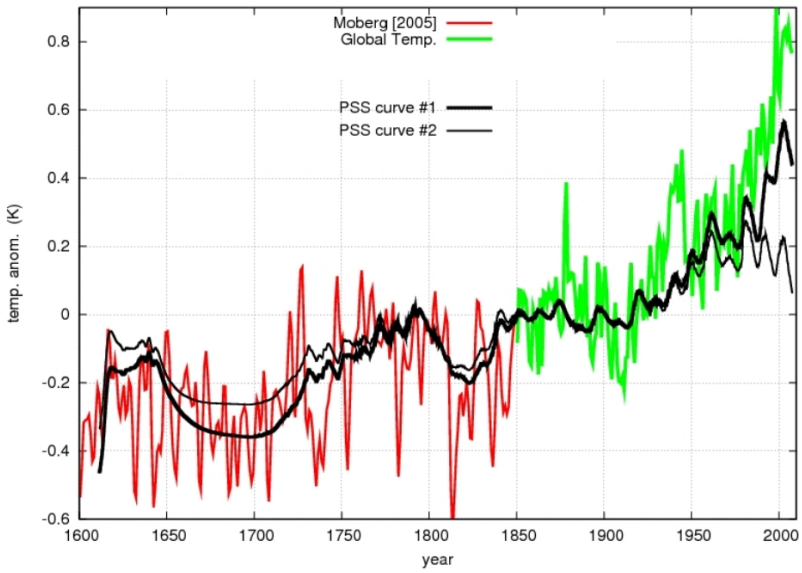

Figure 7: Reconstruction of global surface temperatures over the last 400 years (red and green). In black there is the solar signature on climate as estimated by the empirical model [12]. If since 1980 the TSI satellite composite A in figure 8 (PSS # 1) is used most of the warming observed during the last decades is solar induced. If the TSI satellite composite C in figure 8 (PSS # 2) is used the good correlation between temperature and solar signature abruptly stops in 1980. (Appendix I)

6. The phenomenological solar signature since 1600

It is possible to use a phenomenological model to interpret climate change [12]. This model can simulate a typical energy balance model to interpret the global surface temperature. However, here the climate sensitivity to solar variations and the thermodynamic characteristic relaxation times are empirically determined in the temperature patterns during the last decades. A secular total solar irradiance reconstruction is used as input of the model as a proxy for the total solar activity. The model can be used to reconstruct the solar signature on climate for the past centuries and it is possible to compare this signature against the paleoclimatic temperature reconstructions. Figure 7 shows this result: the temperature signature induced by solar changes as predicted by the phenomenological model well reproduces 400 years of climate change as reconstructed by Moberg *et al.* [8].

The advantage of the phenomenological approach over that implemented in the traditional climate models, which can be described as analytic engineering, is that the phenomenological approach attempts to measure the climate sensitivity to solar changes through

strongly question the validity of the *Hockey Stick* temperature graph can be found in *Heaven and Earth, Global Warming the Missing Science*, chapter 2 'History,' by Ian Plimer, Taylor Trade (2009). Apparently, the IPCC's choice in 2001 to strongly highlight Mann's *Hockey Stick* temperature graph, despite extensive published literature pointing toward a large preindustrial climate variability, can be interpreted as a further evidence of the IPCC's *pro-anthropogenic* warming bias, as discussed in Section 2.

the empirical determination of a kind of *response function*. This methodology would take into account all mechanisms involved in the process, although the individual microscopic mechanisms are not explicitly modeled. It is essentially analogous to the method used by an electric engineer to study the electric response properties of an unknown circuit closed inside a box by carefully comparing the patterns of the input and the output signals. The phenomenological approach is essentially a holistic approach [11] that emphasizes the importance of studying a complex macroscopic system by directly analyzing the properties of the whole because of the complex interdependence of its parts rather than analyzing it by separating it into parts.

On the contrary, the traditional analytic climate model approach attempts to simulate climate by dividing the climate system into its smallest possible or discernible elements and uses their elemental physical properties alone to interpret the macroscopic system. The limitation of the latter approach is that only those mechanisms and the physical couplings among them that are currently well known can be modeled. All unknown mechanisms and physical couplings remain excluded in an analytic model. Therefore, the analytic modularization may fail to properly model and interpret climate change because it just creates a *virtual* climate system that may have nothing to do with reality. The risk is *scientific reductionism*, that is, compensating the current *ignorance* about the true climatic mechanisms by mistakenly stressing a few of them, such as the anthropogenic GHG and aerosol forcings, in such a way to reproduce some warming trend during a restricted period of time. However, for not mistaking the physics of a complex phenomenon a model should be able to reproduce the data oscillations at multiple time scales. In science, the holistic approach complements the traditional analytical approach. When the two methodologies are appropriately used together, they are considered the most efficient way for studying complex systems. Essentially, the phenomenological approach acknowledges that understanding climate is an *inverse-problem* that risks to be *ill-posed* in the analytic approach.

For example, the IPCC [1, p. 674] reports that the 11-year solar cycle produces a temperature cycle on the global surface temperature of about 0.1 ^oC that is easy to observe [12]. However, current climate models predict an average solar signature cycle which is three times smaller, approximately 0.035 ^oC [12] (for example, Crowley's model [7] predicts a cycle of about 0.02 ^oC). It is obvious that the current climate models are oversimplified. They are poorly modeling the solar-climate link mechanisms and, therefore, mistaking the real magnitude of the solar effects on climate (Appendix J).

[11] The term *holistic science* is used as a category encompassing a number of scientific research fields. These are multidisciplinary, are concerned with the behavior of complex systems, and recognize feedback within systems as a crucial element for understanding their behavior. http://en.wikipedia.org/wiki/Holism_in_science

In fact, the IPCC models assume that the sun can influence climate *only* through total solar irradiance variation, that is used only as a radiative forcing. However, there are additional chemical mechanisms that are stimulated by specific frequencies of the solar radiation (for example, UV alters ozone, which is a greenhouse gas, and light stimulates photosynthesis which influences the biosphere) and there is an additional modulation of clouds, which alters the albedo, that is due to the solar modulation of cosmic ray flux [13,14].[12] All these alternative solar-climate link mechanisms are absent in the current climate models because the climate modelers do not know how to model them and the computers are not sufficiently fast to simulate them. The phenomenological model would automatically include all these mechanisms because the climate sensitivity to solar changes is directly, that is phenomenologically, estimated by the magnitude of the temperature patterns that can be recognized as correlated to and, therefore, likely induced by solar changes.

7. The ACRIM vs. PMOD satellite total solar irradiance controversy

Some discrepancy between the temperature reconstruction and the solar signature on climate as seen in Figures 6 and 7 may also be due to errors in the temperature as well as in the solar proxy records. Figure 7 shows two possible empirical solar signatures on climate after 1980. This uncertainty is due to an uncertainty about the behavior of the total solar irradiance. The climate models adopted by the IPCC have used total solar irradiance (TSI) proxy models that claim that total solar irradiance has remained constant since 1980. However, the satellite experimental groups (ACRIM and Nimbus7), which have measured the total solar irradiance since 1978, claim that TSI increased from 1980 to 2000 like the temperature [15].[13]

[12] A solar induced low cloud cover modulation can greatly affect climate by greatly enhancing the climatic solar impact because of the potential magnitude of the resulting radiative forcing. This is evident from the fact that cloudy days are significantly cooler than sunny days. In fact, if clouds were absent the solar radiative forcing warming the Earth's surface would increase by about 30 W/m^2. This value is far larger than the sum of all IPCC anthropogenic forcings in 250 years shown in Figure 2. Thus, even a small solar modulation of cloud cover can have a significant impact on climate change. Clouds can also respond quite fast to cosmic ray flux variations and, therefore, they may link some temperature fluctuations to the solar intermittency. Finally, a cosmic-ray cloud climate link has been suggested to explain the warm and ice periods of the Phanerozoic during the last 600 million years. In fact, the climate oscillations correlate with the cosmic ray flux variations much better than with the CO_2 atmospheric concentration records. In the latter case, most of the cosmic ray flux variation is claimed to be due to the changing galactic environment of the solar system, as it crosses the spiral arms of the Milky Way (Shaviv, N. J. (2003), The spiral structure of the Milky Way, cosmic rays, and ice age epochs on Earth, *New Astronomy* **8**, 3977; Svensmark H. (2007), Cosmoclimatology: a new theory emerges, *Astronomy & Geophysics* **48** 1, 18-24; Kirkby J. (2009), Cosmic rays and climate, CERN Colloquium, http://indico.cern.ch/getFile.py/access?resId=0&materialId= slides&confId=52576)

[13] Although it is not possible to verify the accuracy of all satellite measurements, to claim that the TSI proxy models must necessarily be correct is scientifically unsound. TSI proxy models, by definition, are based on the unproven assumptions that a given set of solar related measurements (such as sunspot number records, a few ground based spectral line width records, ^{14}C and ^{10}Be cosmogenic isotope production and others) can reconstruct TSI. However, TSI proxy models significantly differ from each other and, evidently, this undermines the claim that they are accurate. Thus, although TSI proxy models are useful, they cannot be used to question the accuracy of actual TSI satellite measurements without valid physical reasons. Some of the more popular TSI proxy models were produced by Lean *et al.*, Solanki *et al.* and Hoyt and Schatten.

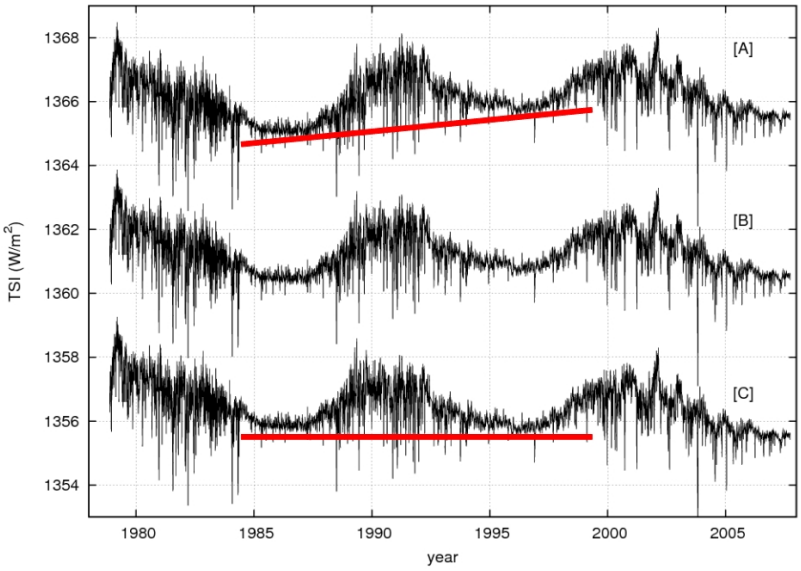

Figure 8: Possible reconstructions of the total solar irradiance using satellite data [12]. The reconstruction 'A' uses the Nimbus7/ERB dataset to fill the ACRIM-gap from 1989.5 to 1991.75; the reconstruction 'C' uses the ERBE/ERBs dataset to adjust the annual trend of the Nimbus7/ERB dataset and uses this altered record to fill the ACRIM-gap from 1989.5 to 1991.75; the reconstruction 'C' is jus the average between the two. The level difference between the minimum in 1986 and 1996 is approximately $0.3 \pm 0.4 W/m^2$. ACRIM is between 'A' and 'B'; PMOD is similar to 'C'. The red curves indicate the trend between the 1986 and 1996 solar minima.

However, another group, the PMOD in Switzerland, claimed that the TSI satellite data obtained and published by the above two experimental groups had to be corrected.[14] By doing so, Fröhlich obtained a TSI satellite composite that does not show any upward trend from 1980 to 2000 [16]. It is important to notice that the experimental groups have always rejected the corrections of their own TSI data proposed by PMOD as arbitrary [15].[15]

[14]During the ACRIM-gap (1989.5-1992.5) Fröhlich [16] altered the Nimbus7/ERB results to make them compatible with the ERBE/ERBS results. The Nimbus7 record was shifted downward by 0.86 W/m^2. This shift consisted of: (1) a step function change of about 0.47 W/m^2 which is used to correct a hypothetical sudden change of the sensitivity of the Nimbus7's sensors following a shutdown claimed to have occurred on 09/29/1989; (2) a linear drift of 0.142 Wm^{-2}/yr from October 1989 through middle 1992 which is supposed to correct an hypothetical gradual sensitivity increase of the same satellite sensors. However, during the ACRIM-gap ERBE/ERBS sensors were expected to degrade due to a decrease in their cavity paint absorbency which occurs during the first exposure of these kind of sensors to high solar maximum UV radiation. So, the experimental teams claim that Fröhlich's alteration of the published Nimbus7/ERB data, to force them to agree with the lower quality ERBE/ERBS results, is unjustified.

[15]On September 16, 2008, Douglas Hoyt (PI of the Nimbus7/ERB experiment which is fundamental for resolving the ACRIM-gap problem, and whose data have been altered to construct the PMOD TSI satellite composite) sent me the following statement that was published in Ref. [15]: "Concerning the supposed increase in Nimbus7 sensitivity at the end of September 1989 and other matters as proposed by Fröhlich'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

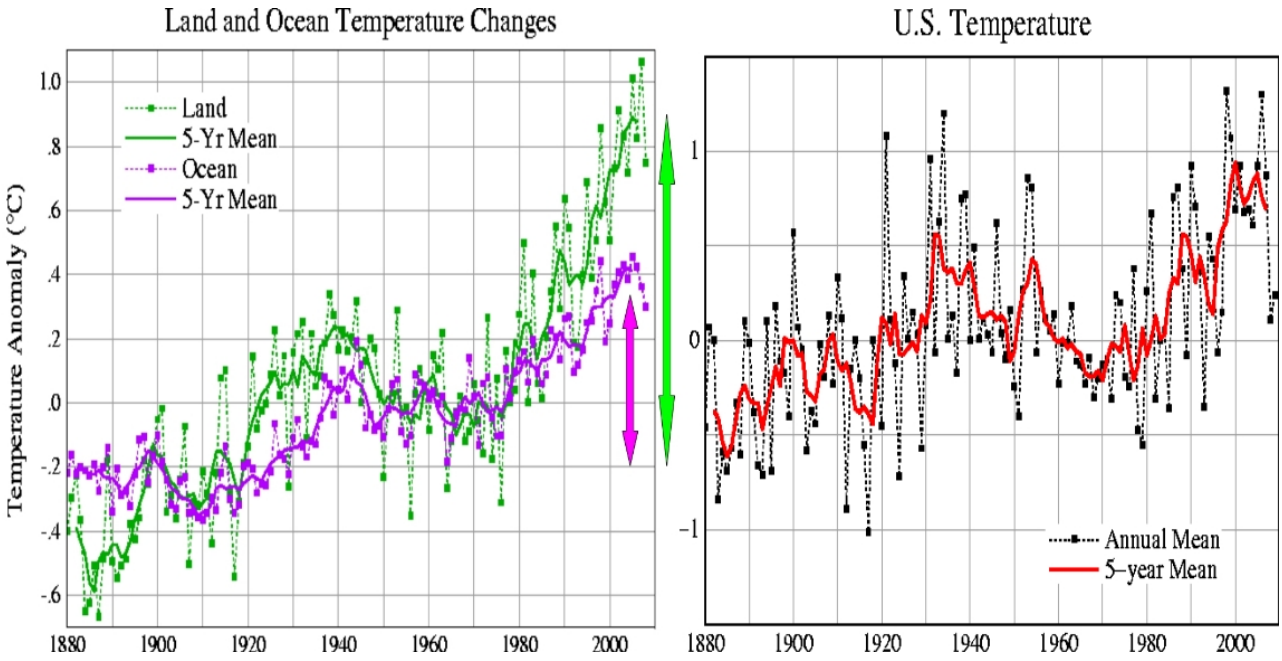

Figure 9: **Left:** Global surface temperature records of the ocean and the land. Note the significant difference observed between the two records since 1970. The land apparently warmed at a double rate than the ocean. **Right:** Global surface temperature record relative to the United States of America. Note that this record highlights the existence of a large 60-70 year cycle and shows a smaller upward secular trend. (GISTEMP: http://data.giss.nasa.gov/gistemp/)

By preferring the PMOD total solar irradiance satellite composite to the ACRIM one the IPCC message was that the global warming observed since 1980 could not be naturally interpreted and, therefore, it had to be 100% anthropogenic. Figure 8 shows three alternative reconstructions of the total solar irradiance using satellite measurements since 1978. The IPCC has adopted a reconstruction similar to C, which is compatible with PMOD's claim. However, the figure clearly indicates that the latter composite shows the lowest 1986-1996 decadal trend but, as the figure suggests, total solar irradiance could very likely have increased from 1980 to 2000 (See also Appendixes K-N).

8. Problems with the global surface temperature record

Once again it is the uncertainty in the data that makes it difficult to correctly interpret climate change. Even the global warming of about 0.8 ^oC since 1900 may be uncertain. In fact, during this period the land warmed by about 1.1 ^oC, while the oceans warmed by about 0.6 ^oC (Figure 9). This difference appears to be too significant to be explained only by the

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, Fröhlich'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 Fröhlich 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 Fröhlich's adjustment in my opinion."

different thermal inertia between the ocean and the land regions. It could be partially due to an underestimation of the urban heat island effect by at least 10-20% [17], to land use changes or perhaps to the fact that several meteorological stations located in cold regions were closed after 1960.[16] The US temperature record present a smaller warming trend since 1880 than the global temperature records. Given the better quality of this record, this finding may suggest that part of the reported global warming may be spurious. If the warming trend has been overestimated (or if it was partially due to land use changes), the effect of CO_2 and CH_4 on climate change has to be reduced for this reason as well (Appendix O-P).

9. A large 60 year cycle in the temperature record

A reasonable alternative is to extract any relevant physical information from the temperature fluctuations. It has been observed that several multi-secular climatic and oceanic records present large cycles with periods of about 50-70 years with an average of 60 years [18].[17] Figure 10 shows the global temperature record detrended of its quadratic upward trend [19] depicted in Figure 1. This sequence has been filtered of its fast fluctuations (by applying a six year moving average smooth algorithm) and it has been plotted against itself with a time-lag of about 60 years. The figure clearly suggests the existence of an almost perfect cyclical correspondence between the periods 1880-1940 and 1940-2000. The peak in 1880 repeats in 1940 and again in 2000. The smaller peak in 1900 repeats in 1960. This 60-odd year oscillation cannot be associated with any known anthropogenic phenomenon [19]. (See also Appendixes Q and R).

On the contrary, Figure 11 shows the global temperature as reproduced by a typical climate model such as the GISS ModelE [20], one of the major climate models adopted by the IPCC 2007. The failure of the model to reproduce the 60 year cycle is evident from the

[16]The surface temperature data present several problems that may have skewed the data so as to overstate the observed warming trend both regionally and globally. For example, it has been observed that there is a significant divergence between ground temperature measurements and satellite global temperature measurements (Klotzbach P. J. *et al.* (2009), An alternative explanation for differential temperature trends at the surface and in the lower troposphere, *J. Geophys. Res.* **114,** D21102.) Possible causes may be: 1) More than three-quarters of the 6,000 stations that apparently existed in the 60s were discontinued during the last decades; 2) Higher-altitude, higher-latitude, and rural locations, all of which had a tendency to be cooler, have been tendentiously removed; 3) Contamination by urbanization, changes in land use, improper siting, and inadequately-calibrated instrument upgrades further overstates warming; 4) Cherry-picking of observing sites combined with interpolation to vacant data grids may have further stressed heat-island bias; 5) Satellite temperature monitoring findings are increasingly diverging from the station-based constructions in a manner consistent with evidence of a warm bias in the surface temperature record. For an overview on this issue see J. D'Aleo J. and A. Watts (2010), *Surface Temperature Records: Policy Driven Deception?*, SPPI original paper (http://scienceandpublicpolicy.org/images/stories/papers/originals/surface_temp.pdf)

[17]Climatic records that present a dominant cycle at about 60 year period include ice core sample, pine tree samples, sardine and anchovy sediment core samples, global surface temperature records, atmospheric circulation index, length of the day index, etc.

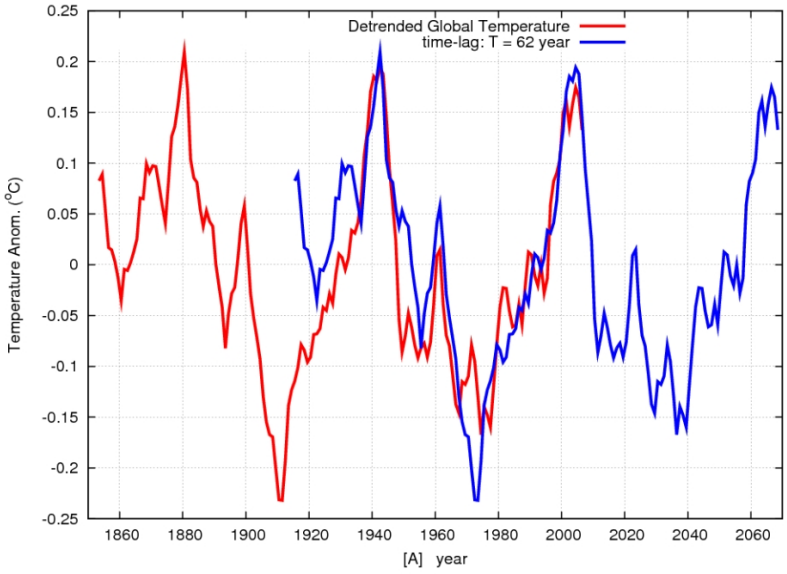

Figure 10: The 60 year cycle modulation of the temperature [19]. (Red) global temperature detrended of its quadratic upward trend which is shown in Figure 1. (Blue) the same record time-lag shifted of about 60 years. Note the perfect symmetry between the periods 1880-1940 and 1940-2000 that excludes the fact that these cycles could have had an anthropogenic origin. Even a smaller peak in 1900 repeats in 1960. This overwhelming clear finding, by alone, contradicts the AGWT and the IPCC's claim that 100% of the warming observed from 1970 to 2000 is anthropogenic.

figure. Indeed, all IPCC climate models have the same failing.[18]

The existence of a natural 60 year cycle with a total (min-to-max) amplitude of at least 0.3 ^oC, as Figure 10 shows, implies that at least 60% of the 0.5 ^oC warming observed since 1970 is due to this cycle. Considering that longer natural cycle can be present and that solar activity was stronger during the second half of the 20^{th} century than during the its first half [12], the natural contribution to the warming since 1970 may have been even larger than 60%. Human emissions can have contributed at most the remaining 40%, or less, of the warming observed since 1970 (if no overestimation of the global warming is assumed as Section 8 would suggest), not the 100% as claimed by the IPCC. This 60 year cycle has just entered into its cooling phase and this will likely cause a climate cooling, not a warming,

[18]The other IPCC model scenario runs also fail to reproduce this 60-year cycle. These climate model simulations can be downloaded from the IPCC Data Archive at Lawrence Livermore National Laboratory (http://climexp.knmi.nl/selectfield_co2.cgi?someone@somewhere). However, this is not the only shortcoming of the climate models adopted by the IPCC. These models have predicted an increase in the warming trend with altitude in the tropic troposphere due to anthropogenic GHG emissions, but balloon and satellite temperature observations have shown a significant disagreement with the model predictions. (Douglass D. H., J. R. Christy, B. D. Pearson and S. F. Singer (2007), A comparison of tropical temperature trends with model predictions, *Intl. J. Climatology*, DOI: 10.1002/joc.1651). A list of comparison of model predictions with actual observations and the incompatibility between the two was prepared by Douglas Hoyt: Greenhouse Warming Scorecard Updated 4/2/2006 (http://www.warwickhughes.com/hoyt/climate-change.htm)

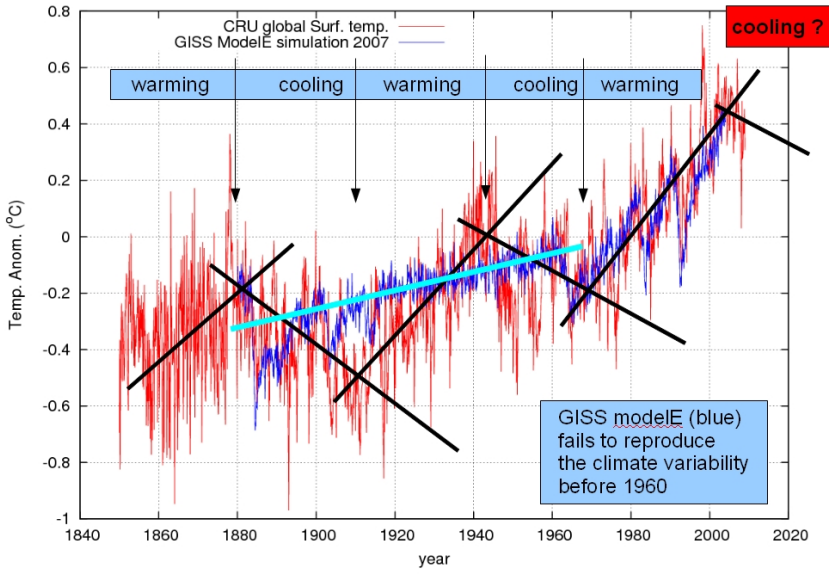

Figure 11: Global temperature (red) against the temperature prediction of the GISS ModelE [20] adopted by the IPCC. The temperature shows a clear cycle of about 60 years which herein is emphasized by black segments. This 60 year cycle has been explicitly shown in Figure 10. This cycle is clearly not reproduced by the climate model simulation [19]. The climate simulation clearly crosses from 1880 to 1970 the black segments instead of reproducing the 60 year modulation of the temperature.

until 2030-40, as Figure 10 would suggest.[19]

The latter result is quantitatively consistent with the results depicted in Figures 6-8 that suggest a significant change in pre-industrial climate, in contrast to the *Hockey Stick*, and that solar activity has increased from 1980 to 2000 as Willson of the ACRIM team claims in contrast to PMOD Fröhlich's claim. In fact, they are consistent with a reduction of the anthropogenic contribution by 250% as calculated above in Figures 6 and 7. The independent results depicted in Figures 6, 7 and 10 are consistent with each other and would imply that if the CO_2 atmosphere concentration doubles, the temperature could rise between 1.0 and 1.5 ^oC, which is significantly less than the IPCC's estimate of 1.5-4.5 ^oC.

This result clearly indicates that the possible impacts that anthropogenic GHGs can have on global climate change should be greatly diminished. Consequently, the IPCC's claims about imminent and catastrophic consequences that human emissions are causing and will cause, are unsubstantiated: these claims should be greatly moderated. The existence of a large 60-year natural cycle in the global temperature essentially points toward the conclusion that nature, not human activity, rules the climate.

[19]There is strong observational evidence that the ocean has been cooling since 2003 (Loehl C. (2009), Cooling of the global

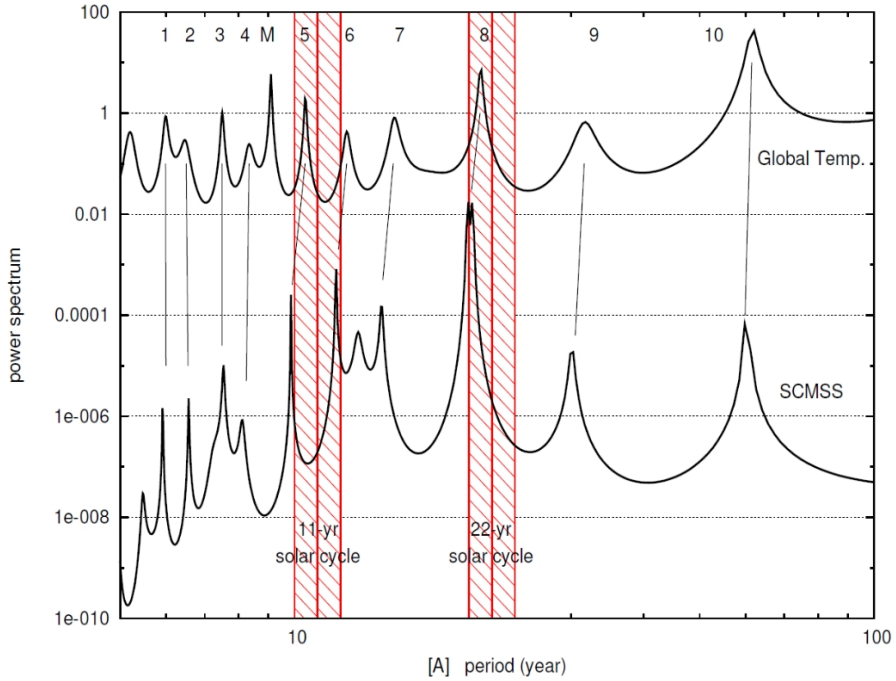

Figure 12: Spectral analysis of the global temperature from 1850 to 2009 (above), and of the speed of the center of mass of the solar system SCMSS (below) [19]. Cycles 5 and 8 are also close to the 11 ± 1 and 22 ± 2 year solar cycles. The M cycle in the spectrum of the temperature at about 9 year is absent in the SCMSS record. However, it corresponds to a lunar cycle (Appendix Q-W).

10. Astronomical origin of the climate oscillations

If the temperature is characterized by natural periodic cycles the only reasonable explanation is that the climate system is modulated by astronomical cycles. Natural cycles known with certainty are the 11 (Schwabe) and 22 (Hale) year solar cycles, the cycles of the planets and luni-solar nodal cycles [19]. Jupiter has an orbital period of 11.87 years while Saturn has an orbital period of 29.4 years. These periods predict three other major cycles which are associated with Jupiter and Saturn: about 10 years, the opposition of two planets; about 20 years, their synodic cycle; and about 60 years, the repetition of the combined orbits of the two planets. The major lunar cycles are about 18.6 and 8.85 years.

Figure 12 shows a spectral analysis of the global surface temperature and of a record that depends on the orbits of planets (the speed of the sun relative to the center of mass of the solar system [19]). The two records have almost the same cycles. The temperature record contains the cycles of the planets combined with the two solar cycles of 11 and 22 years and a lunar cycle at about 9.1 years.[20] (See also Appendixes Q-V).

ocean since 2003, *Energy & Environment* **20**, No. 1&2, 101-104).

[20]The temperature cycle 'M' shown in Figure 12 appears to be exactly at 9.1 ± 0.1 years. This period is exactly between the period of the recession of the line of lunar apsides, about 8.85 years, and half of the period of precession of the solar-luni nodes, about 9.3 years.

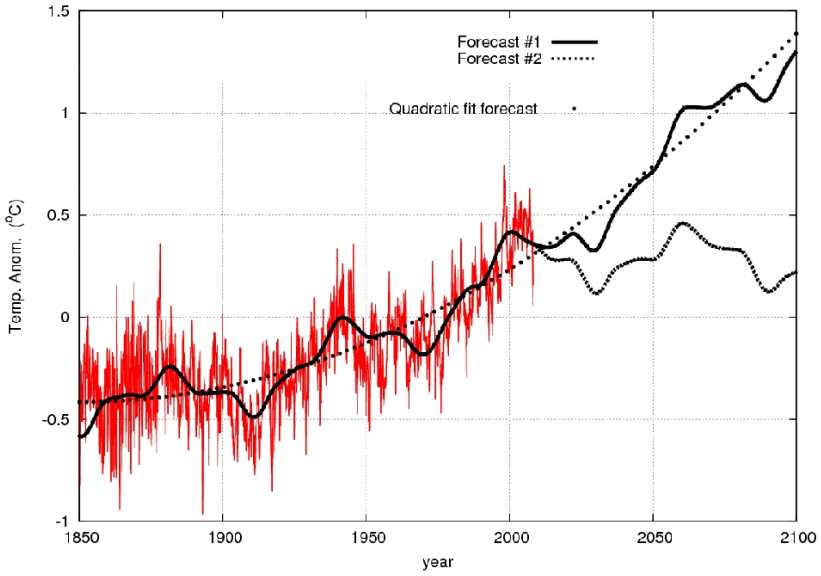

Figure 13: Global temperatures (red) and the reconstruction of temperature using only the 20 and 60 year planetary cycles (in black). The dashed curve indicates simply the quadratic trend of the temperature [19].

These cycles can be used to reconstruct the fluctuations of the temperature [19]. For example, it is possible to adopt a model using only the major 20 and 60 year cycles plus a quadratic trend of the temperature and the reconstruction of Figure 13 is obtained. Other natural cycles associated with the Sun are evident in Figures 6 and 7. The model reconstructs with great accuracy the temperature oscillations since 1850. It suggests that until 2030-2040 the temperature may remain stable if the upward trend in temperature observed from 1850 to 2009 continues in the near future[21] or the global temperature cools if the trend of the secular solar activity decreases, as other independent considerations would suggest.

For example, an imminent relatively long period of low solar activity may be predicted on the basis that the latest solar cycle (cycle #23) lasted from 1996 to 2009, and its length was about 13 years instead of the traditional 11 years. The only known solar cycle of comparable length (after the Maunder Minimum) occurred just at the beginning of the Dalton solar minimum (cycle #4, 1784-1797) that lasted from about 1790 to 1830. The solar Dalton minimum induced a little ice age that lasted 30-40 years as shown in Figure 7. Therefore, it is possible that the Sun is entering into a multi-decade period of low activity, which could produce cooling of the climate. (Appendix W).

[21]Note that a quadratic trend function supposes a warming acceleration. Even in this situation Figure 13 would suggest that by 2100 the temperature will increase no more than 1 ^oC above the actual values. This estimate is significantly lower than the IPCC estimates (their figure SPM.5) that have projected a warming from 1 to 6 ^oC according to different GHG emission scenarios.

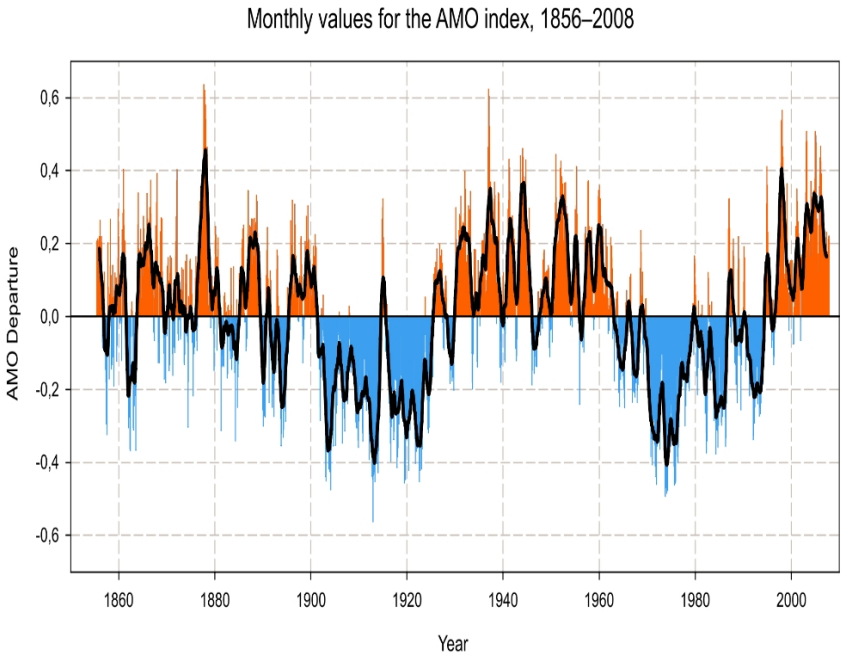

Figure 14: Monthly value of the Atlantic Multidecadal Oscillation (AMO) index. Note the evident 60-year cycle. The figure is adapted from Wikipedia at the voices: *Atlantic Multidecadal Oscillation*.

The physical mechanisms involved in the process are likely numerous. The gravitational forces of the planets can partially modulate the solar activity. For example, it was noted that the alignment of Venus, Earth and Jupiter presents cycles of approximately 11 years that are in phase with the 11-year solar cycles [21] and multi secular reconstructions of solar activity reveal 60-year cycles associated with the combined orbit of Jupiter and Saturn and other longer cycles [22]. Solar changes could modulate climate change through various physical and chemical processes as explained in Section 6, which are currently not included in the models, as explained in Section 6.

There is also the possibility that the Earth's orbital parameters are directly modulated by the gravitational forces of Jupiter, Saturn and the Moon, and the Sun's magnetic force in such a way that the length of day is modulated and/or other planetary parameters are altered. For example, the rotation of the Earth on its axis shows 60-year cycles that anticipate those of the temperature by a few years [18, 23]. Variations in the Earth's rotation and tides caused by the lunar cycles can drive ocean oscillations, which in turn may alter the climate [19]. For example, the Atlantic Multidecadal Oscillation (AMO) and the Pacific Decadal Oscillation (PDO) present clear 60-year cycles and other faster cycles, see Figures 14 and 15. None of these mechanisms are included in the models adopted by the IPCC.

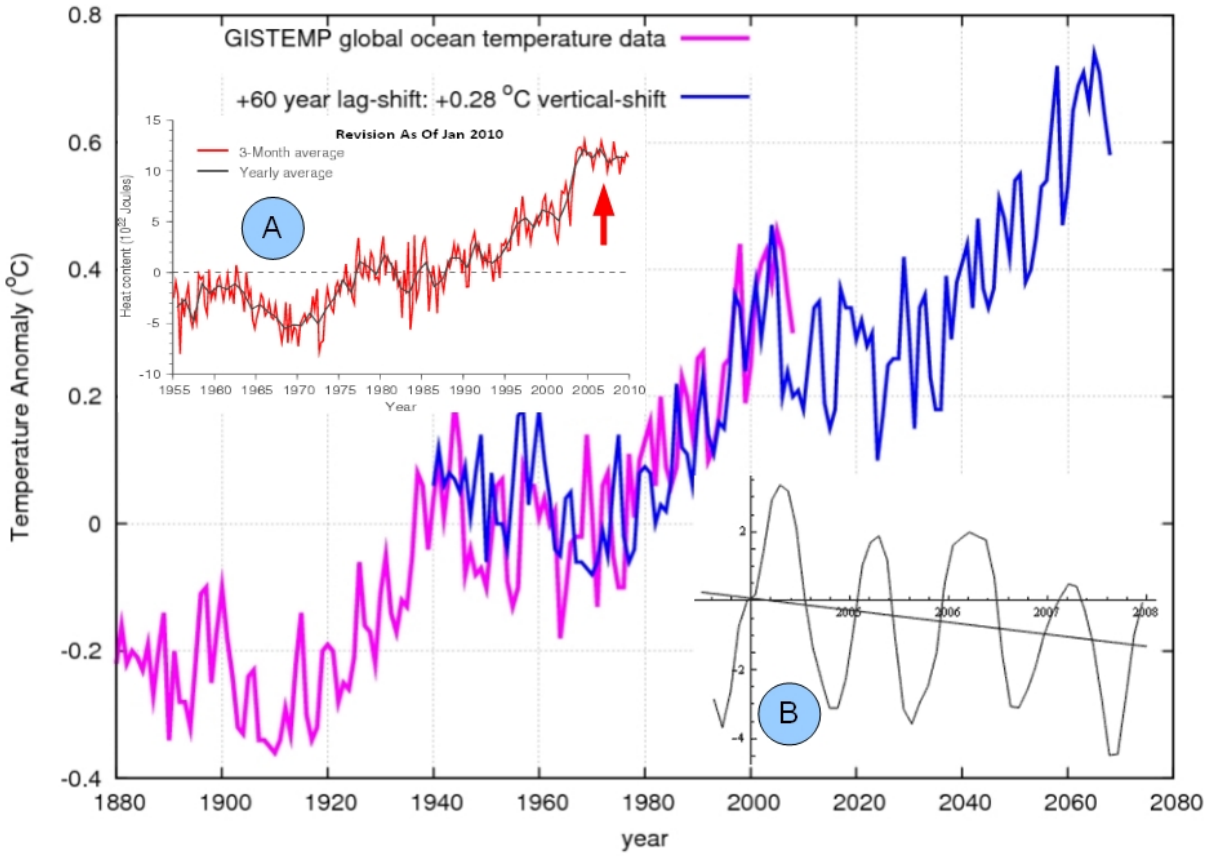

Figure 15: GISTEMP global surface ocean temperature record (shown also in Figure 9) plotted against itself with a 60 year lag shift and a vertical translation. The figure clearly indicates an almost perfect matching between the 1880-1940 and 1940-2000 periods. This further proves the existence of a 60-year natural cycle driving climate change. In particular, note the almost perfect correspondence between the warming trends during the 1910-1940 and 1970-2000 periods. The upward trend during the former period (1910-1940) appears even slightly higher than the upward trend during the latter period (1970-2000) suggesting a warming deceleration. This finding strongly contradicts the IPCC's claim that 100% of the warming observed since 1970 can only be explained with anthropogenic emissions. The figure also suggests a slight ocean cooling until 2030-2040, as does the climate-planetary model of Figure 13, which started in 2002-2003. The upward trend between the first and second half of the last century correlates well with the increased solar activity occurring between the first and second half of the 20^{th} century, as indicated by all solar models (see Ref. [12] and Figure 7). If the upward warming trend observed since 1880 continues the ocean will not likely warm more than 0.5 ^oC by 2100.

The insert A shows the latest update (Jan/2010) of the Ocean Heat Content (OHC) data from the National Oceanographic Data Center (NODC) (http://www.nodc.noaa.gov/OC5/3M_HEAT_CONTENT/). This record shows a decrease of the ocean heat content since 2003. This record significantly differs from an earlier version, which showed a slight increase, published in Levitus *et al.* (2009), Global ocean heat content 1955-2008 in light of recently revealed instrumentation problems, *Geophys. Res. Lett.* **36**, L07608.

The insert B depicts ocean heat content as measured by Argo. Argo is a network of over 3000 floats scattered across the globe that measure temperature and salinity of the upper ocean. A cooling trend from 2003 to 2008 is found. Loehl C. (2009), Cooling of the global ocean since 2003, *Energy & Environment* **20**, No. 1&2, 101-104.

Both inserts are compatible with a forecast suggesting that ocean temperature will decrease until 2030-2040.

11. Conclusion

The analysis of several records suggests that the IPCC's claim that humanity is running an imminent danger because of anthropogenic CO_2 emissions[22] is based on climate models that are too simplistic. In fact, these models fail to reproduce the temperature patterns and the temperature oscillations at multiple time scales. (See also Appendixes H, J, X-Z). These models exclude several mechanisms that are likely to affect climate change related to natural temperature oscillations that have nothing to do with man. Indeed, these oscillations, such as a large 60 year cycle, appear to be synchronized with the oscillations of the solar system.

By ignoring these natural mechanisms, the IPCC, also through a questionable choice of data and labels as explained in Section 2, has greatly overestimated the effect of an anthropogenic forcing by a factor between 2 and 3 just to fit the observed global warming in particular from 1970 to 2000, as the climate model depicted in Figure 11 shows. However, a detailed climatic reconstruction suggests that the phenomenological model depicted in Figures 13 and 15 is more satisfactory and is likely to be more accurate in forecasting climate change during the next few decades, over which time the global surface temperature will likely remain steady or actually cool.[23]

[22]The AGWT advocates claim, by using climate model projections, that an increase in anthropogenic CO_2 concentration in the atmosphere will lead to ecological disasters, including wild swings in weather patterns, extended desertification, spread of hot-climate infectious diseases, greater risks of severe damaging weather phenomena such as Katrina-like hurricanes, melting of the glaciers in a few decades that, in turn, will leave hundreds of millions of people without fresh water, cause the extinction of polar bears and raise so much the ocean level that all coasts and their cities will be severely flood beginning, of course, with New York [Al Gore (2006), *An Inconvenient Truth,* documentary movie]. After that, an increase in anthropogenic CO_2 will reach the *tipping* point and activate a runaway greenhouse effect that will let the oceans boil away and, ultimately, transform the Earth into a Venus-like state (as James Hansen claimed during his AGU 2008 scientific talk (2008-12-17) "Climate Threat to the Planet"). All this AGWT apocalypticism is extensively rebutted in *Climate Change Reconsidered* [3] by using scientific research based on actual data. Al Gore's movie has been elegantly rebutted by Christopher Monckton of Brenchley in *"35 Inconvenient Truths: The errors in Al Gores movie"* SPPI (2007), http://scienceandpublicpolicy.org/monckton/goreerrors.html
Regarding the hypothetical *tipping* point and the runaway greenhouse effect that the Earth would be risking, it should be noted that the atmospheric CO_2 concentration was many times higher than today in almost all earlier geologic periods when no runaway greenhouse effect occurred (Hayden H. C. (2007), *A Primer on CO_2 and Climate*, Vales Lake Publishing, LLC.). For example, during the Jurassic period (150-200 million years ago) the CO_2 concentration was at least 5 times higher than today (about 2000 ppmv), and during the Cambrian period (500-550 million years ago) it was at least 10-15 times higher than today (4000-6000 ppmv). Interestingly, during the late Ordovician period (490-440 million years ago) the Earth experienced an extremely cold glacial period despite the fact that the CO_2 concentration was at least 10 times higher than today. In fact, most of the greenhouse effect that keeps the Earth warm is regulated by water vapor, not by CO_2. The water vapor concentration, together with the low cloud cover percentage, are not well understood yet but they are likely strongly influenced by the solar changes and cosmic rays. During the last few years there has been a tendency among the AGWT advocates to declare CO_2 to be a *pollutant*. This is a further serious mystification of the reality. For human health CO_2 is completely innocuous even at a concentration 10 times larger that the 0.036% (360 ppmv) actual atmospheric value. Moreover, CO_2 is as essential to life as oxygen and water. Carbon dioxide is the major food for plants, which in turn are food for animals, and of course for humans too. Indeed, an increase in atmospheric CO_2 concentration would lead to accelerated plant growth and, therefore, to increased food production [3]. In fact, in man-made greenhouses CO_2 is enriched at 2, 3 or 4 times the natural concentration (about 1000 ppmv) because this causes plants to grow faster and improves plant quality. Thus, an increase of atmospheric CO_2 concentration may also benefit humanity.

[23]Some of the strongest AGWT advocates are rapidly acknowledging that no significant global warming has been observed since

12. Bibliography

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at last 10 years contrary to the IPCC projections. Other factors, besides anthropogenic GHGs, are responsible of climate changes. In February 2010 Phil Jones, the ex director of the CRU center for climate change and the academic at the center of the *climategate*, has admitted that there has been no global warming since 1995. http://www.dailymail.co.uk/news/article-1250872/Climategate-U-turn-Astonishment-scientist-centre-global-warming-email-row-admits-data-organised.html
In 2009 Susan Solomon *et al.* (Irreversible climate change due to carbon dioxide emissions, PNAS **106** 1704-1709) predicted a large, imminent and irreversible warming since 2000 due to anthropogenic emissions. However, in January 2010 Solomon *et al.* (Contributions of stratospheric water vapor to decadal changes in the rate of global warming, *Science* 10.1126/science.1182488) acknowledged that stratospheric water vapor, not just anthropogenic CO_2 and CH_4, is an important climate driver of decadal global surface climate change that has largely contribute both to the warming observed from 1980-2000 (30%) and to the slight cooling observed after 2000 (25%). Stratospheric water vapor concentration can also be indirectly driven by UV solar irradiance variations through ozone modulation and its contribution would be included in the phenomenological model herein presented.

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Appendix A. The IPCC's anthropogenic global warming theory

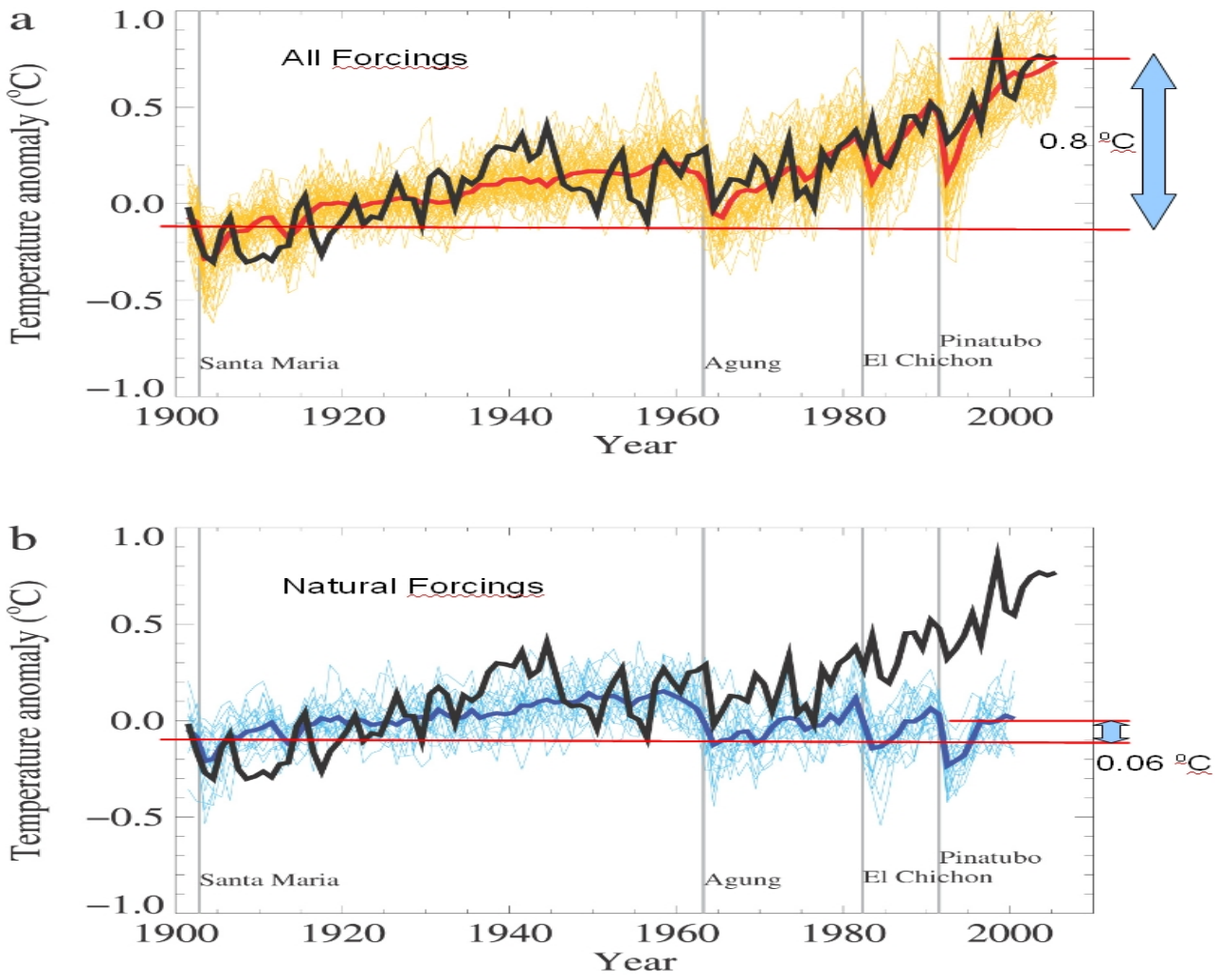
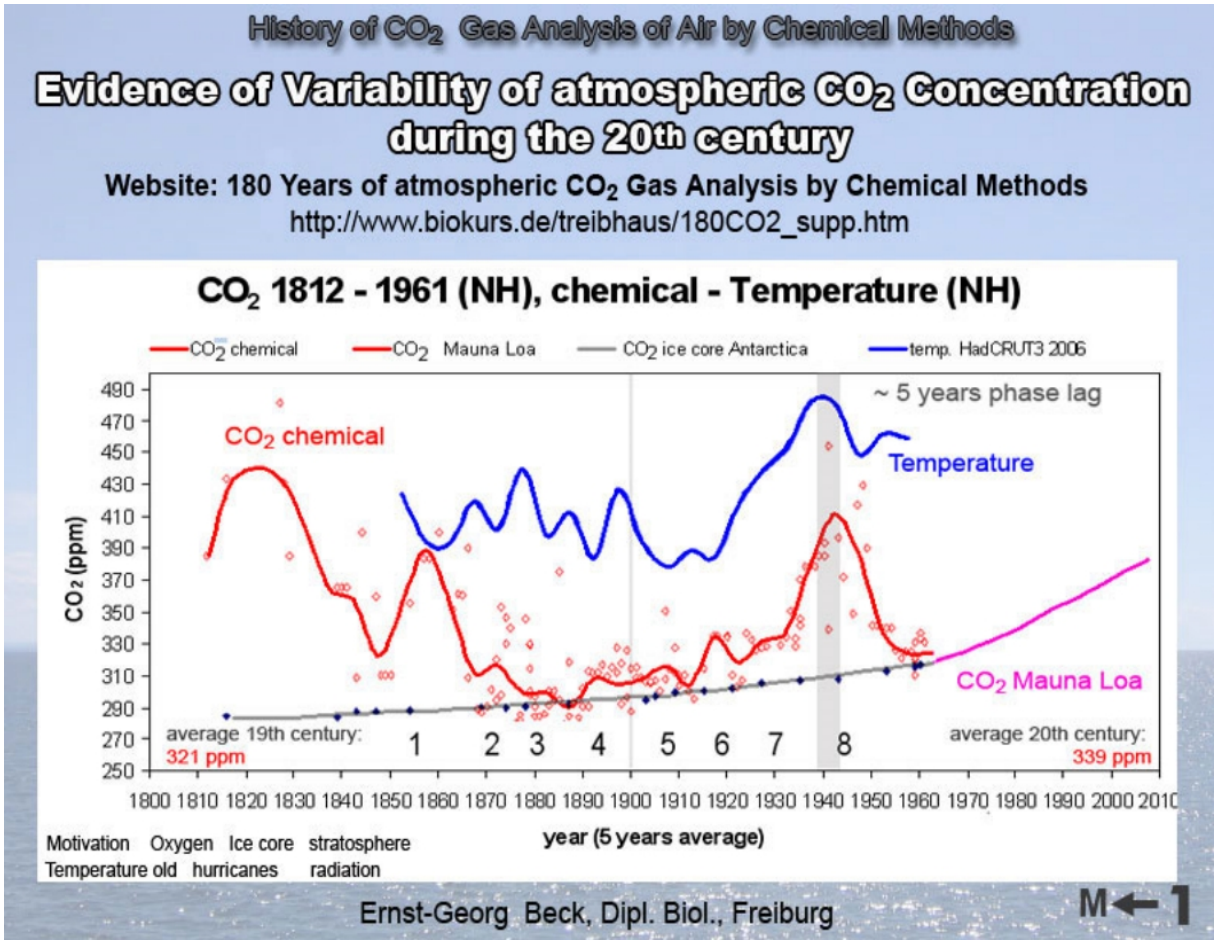


Figure 9.5 from the IPCC (AR4-WG1). The figure highlights the IPCC's anthropogenic global warming theory. The figures compare global mean surface temperature anomalies from observations (black) and general circulation model simulations forced with (a) both anthropogenic and natural forcings and (b) natural forcings only. By comparing the results depicted in the two figures it can be concluded that more than 90% ((0.8-0.06)/0.8 = 92.5%) of the observed global warming since 1900 and 100% of the warming since the 1970s has been anthropogenically induced, according the IPCC. The latter estimate derives from the fact that according figure (b) the natural forcings (solar and volcano) would have caused just a cooling since the 1970s. Note, however, that the model simulations (yellow) fail to reproduce the oscillations found in the data at multiple scales: they just appear to produce noisy fluctuations.

All data are shown as global mean temperature anomalies relative to the period 1901 to 1950, as observed (black, Hadley Centre/Climatic Research Unit gridded surface temperature data set (HadCRUT3); Brohan et al., 2006) and, in (a) as obtained from 58 simulations produced by 14 models with both anthropogenic and natural forcings. The multimodel ensemble mean is shown as a thick red curve and individual simulations are shown as thin yellow curves. Vertical grey lines indicate the timing of major volcanic events. The simulated global mean temperature anomalies in (b) are from 19 simulations produced by five models with natural forcings only. The multi-model ensemble mean is shown as a thick blue curve and individual simulations are shown as thin blue curves.

Appendix B. Chemical vs. Ice-Core CO_2 atmospheric concentration estimates



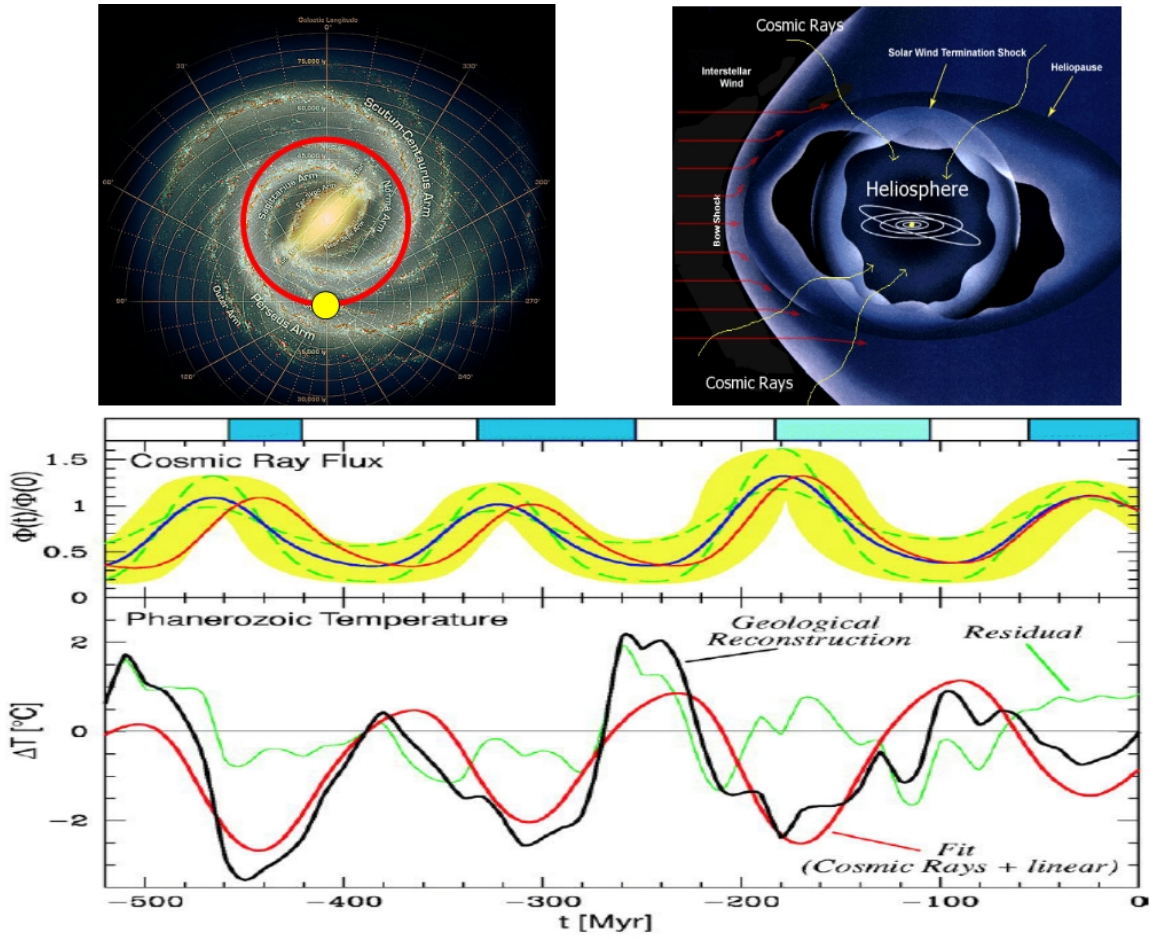
The figure highlights a strong discrepancy between the atmospheric CO_2 concentration as estimated by historical chemical measurements and ice core sample measurements.

More than 90,000 accurate chemical analyses of CO_2 in air since 1812 are summarized in the red curve. The historic chemical data reveal that changes in CO_2 track changes in temperature and, therefore, climate in contrast to the simple, monotonically increasing CO_2 trend depicted in the post-1990 literature on climate-change (which before 1960 is derived from ice core samples, gray curve). Since 1812, the CO_2 concentration in northern hemispheric air has fluctuated exhibiting three high level maxima around 1825, 1857 and 1942 the latter measuring more than 400 ppm. Between 1857 and 1958, the Pettenkofer process was the standard analytical method for determining atmospheric CO_2 levels, and usually achieved an accuracy better than 3%.

If the chemical CO_2 measurements are accurate, the climate models adopted by the IPCC are: 1) using an inappropriate CO_2 record for determining the CO_2 forcing because they use the CO_2 Mauna Loa record (pink) merged with the CO_2 ice core record (gray) which shows a kind of hockey stick shape; 2) overestimating the climate sensitivity to CO_2 changes because CO_2 atmosphere concentration tracks changes in temperature (there is a 5 year phase-lag), more than vice versa. The finding would also imply that ice core samples may not be fully trusted as accurate estimates of CO_2 atmospheric concentration because they would tend to greatly smooth such values.

Beck E.-G. (2007), 180 Years of atmospheric CO_2 Gas Analysis by Chemical Methods, *Energy & Environment* **18**, 259-282. http://www.biomind.de/realCO2/realCO2-1.htm

Appendix C. Milky Way's spiral arms, Cosmic Rays and the Phanerozoic temperature cycles

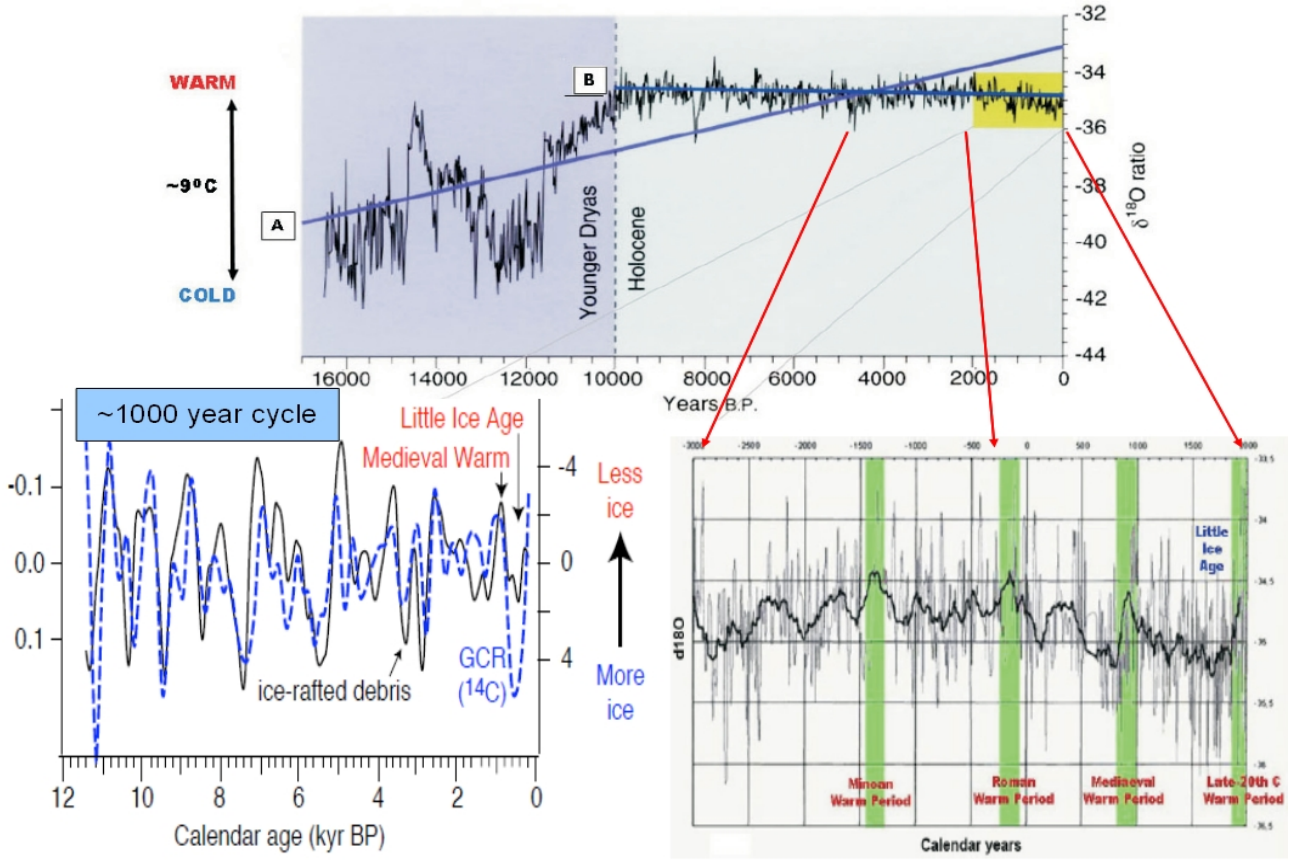


The figure illustrates the link between cosmic ray flux variation and the terrestrial climate during the last 550 million years.

The top left panel describes the orbit of the solar system through the galactic spiral arms. Top right panel illustrates the interaction between the cosmic rays, which come from outside the solar system, and the solar activity. Essentially, a changing of the solar activity varies the solar wind strength: a stronger wind reduces the flux of cosmic rays reaching Earth. Also a changing of the galactic environment of the solar system, as it travels through the Milky Way's spiral arms also likely results in a variation of the cosmic ray flux reaching the Earth. Cosmic rays ionize the atmosphere and this ionization partially modulate the low altitude cloud cover formation. Since low altitude clouds have a net cooling effect (their "whiteness" is more important than their "blanket" effect), increased cosmic ray flux implies a cooler climate.

Past cosmic ray flux variations can be reconstructed with iron meteorite analysis. This record can be compared to the quantitative reconstructed tropical ocean temperature variations using isotope data from fossils over the Phanerozoic over the past 500 Million years. The reconstructed signal reveals an approximate 145 Myr periodicity, shown in the bottom panel. The notable fit implies that most of the temperature variations can be explained using the cosmic ray flux. Not a lot is left to be explained by other climate factors, including CO_2. This implies that cosmic rays are likely a dominant climate driver over the many million year time scale. (Shaviv, N. J. (2003), The spiral structure of the Milky Way, cosmic rays, and ice age epochs on Earth, *New Astronomy* **8**, 3977)

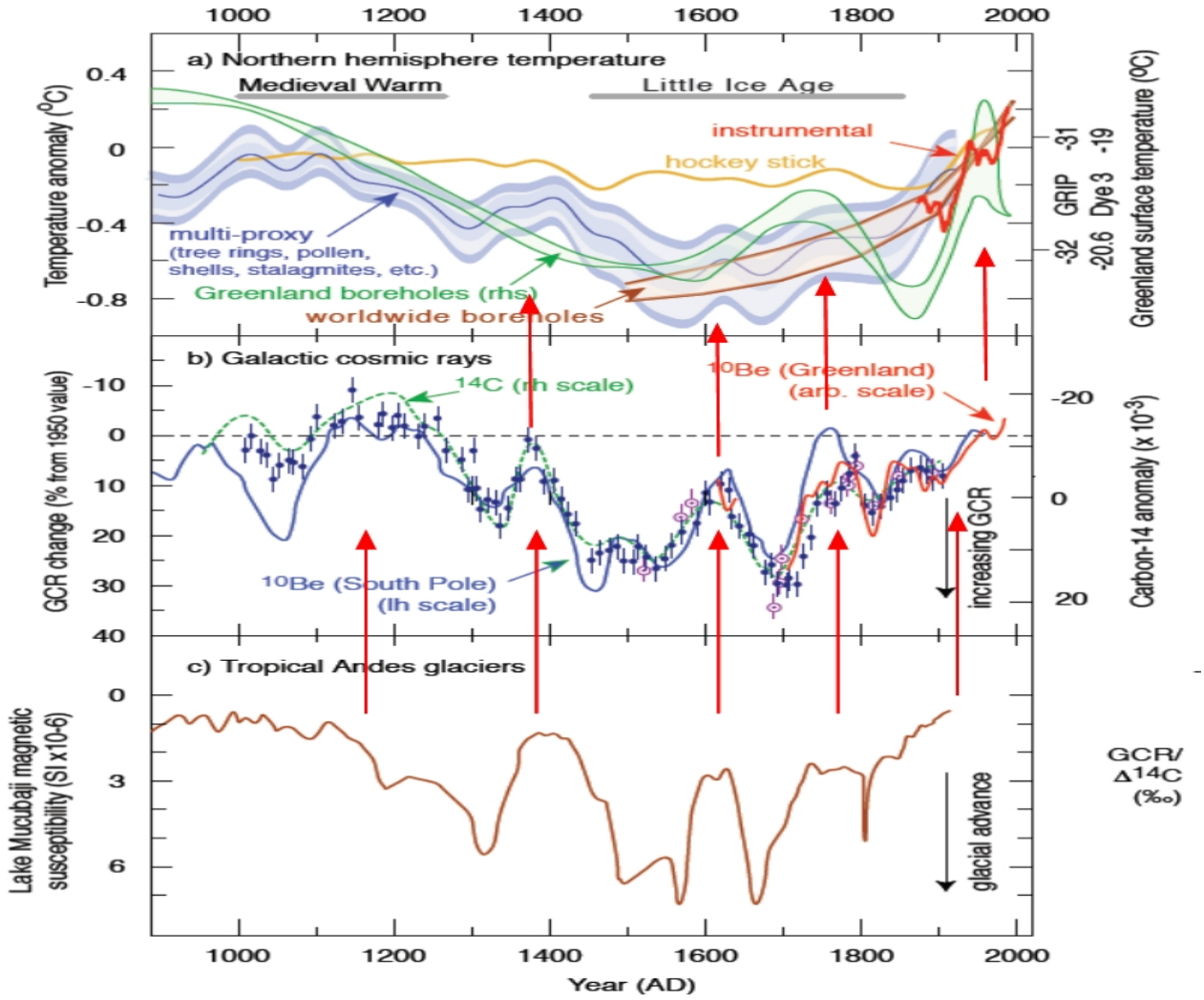
Appendix D. The Holocene cooling trend and the millennial-scale temperature cycles



Top: The figure shows the climatic cycling over the last 16,000 years as indicated by averaged 20-year oxygen isotope ratios from the GISP2 Greenland ice core (after NSIDC User Services), which can be used as a temperature proxy. The figure highlights a warming as the Earth moved out of the last glaciation period through the Younger Dryas period when an abrupt and large climate oscillation occurred, and a cooling during the Holocene period as the Earth approaches the next ice age following the Milankovitch cycles.

Bottom: The figure magnifies the last 12000 years. Evident large oscillations with cooling and warming periods are seen in the proxy temperature data. In particular there exists an approximate 1000 year large cycle whose maxima are in correspondence of the Minoan, Roman, Medieval and Modern warm periods, which are all historically known to have been quite warm. Indeed, the modern warm period does not appear to be particularly anomalous relative to the previous three warm periods. The data clearly suggest that the modern warm period is in large part the consequence of a large millenarian temperature cycle. The figure on the left shows the N. Atlantic ice rafted debris during the last 10 kyr (Holocene) vs. the cosmic ray flux (GCR) as measured by ^{14}C records, which is a proxy of the solar activity. The figure clearly shows that the Medieval Warm Period (MWP), the Little Ice Age (LIA) and the Modern Warm Period are merely the most recent of the millennial-scale temperature cycles occurred during the Holocene induced by this long and large solar cycle. Many studies have uncovered evidence of repeated climate oscillations of 2500, 1500, and 1000 years which are likely related to solar cycles: Kerr R. A. (2001), A Variable Sun Paces Millennial Climate, *Science* **294**, 1431-1433; Bond S. *et al.* (2001), Persistent Solar Influence on North Atlantic Climate During the Holocene, *Science* **294**, 2130-2136. (Data from : http://www.gisp2.sr.unh.edu/GISP2/; See Carter R. M. (2007), The Myth of Dangerous Human-Caused Climate Change, The AusIMM New Leaders Conference, http://www.schmanck.de/Carter.html)

Appendix E. The last 1000 years of global temperature, solar and ice cover data

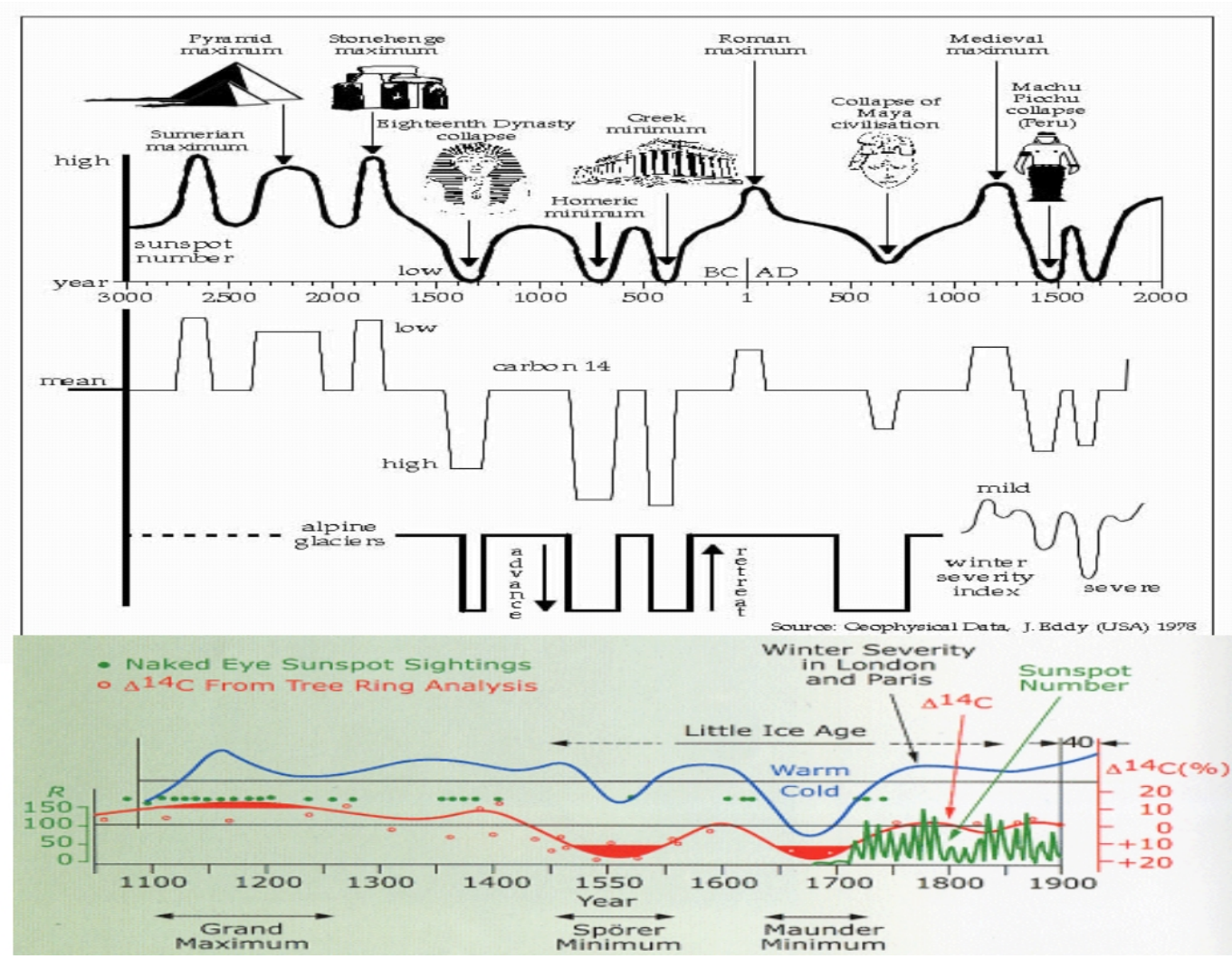


Top: The figure clearly highlights the difference between the *Hockey Stick* temperature graph by Mann [6] (yellow) and the temperature reconstruction by Moberg [8] (blue) and the temperature from the boreholes, for example Huang [9]. The *Hockey Stick* shows very little preindustrial variability and it is clearly at odds with the other temperature reconstructions. In fact, the other temperature reconstructions show a clear millenarian cycle with the Modern Warm Period that appears to be compatible with the Medieval Warm Period, and a Little Ice Age between the two warm periods. The large cyclical pattern presented by the latter temperature reconstructions is consistent with what can be inferred from historical events, while the *Hockey Stick* is incompatible with history.

Middle: Several records that are used as proxies for the solar activity. The millenarian cycle is evident and well correlates with the millenarian temperature cycle. The solar activity experienced a maximum during both the Medieval Warm Period and the Modern Warm Period, and a minimum during the Little Ice Age. Several shorter cycles of about 200 years in the solar activity agree with the observed temperature cycles.

Bottom: Extension of the tropical Andes glaciers in the Mucubaji valley. This record also clearly suggests a link between climate and solar activity. Moreover, it proves that the Medieval Warm Period and a Little Ice Age were not just Northern Atlantic phenomena, but world wide events. (Figure adapted from Kirkby J., Cosmic ray and climate, colloquium 2009).

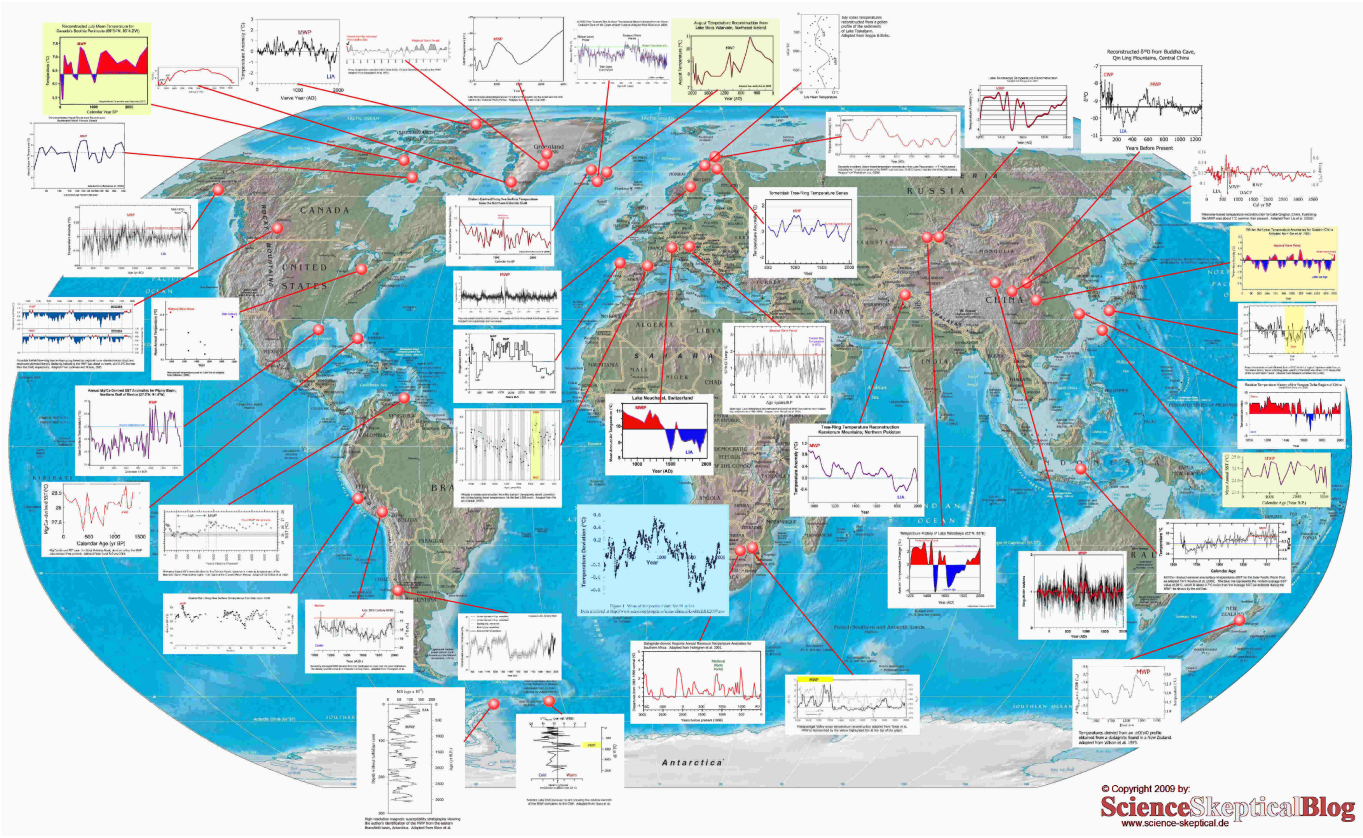
Appendix F. The solar dynamics fits 5000 years of human history



The figure shows that there exists a clear link between the solar variation, as estimated by the ^{14}C record, and the rise and fall of human civilizations. When solar activity is high, less cosmic rays reach the Earth and a lower production of ^{14}C occurs.

The figure suggests that during periods of higher solar activity, which correspond to warm periods, humanity greatly benefitted because of the warmer climate. Thus, entire civilizations could more easily prosper and develop. On the contrary, during cooler periods humanity suffered most, and some civilizations even collapsed. This presumably happened because during warm periods more food, on average, is produced. So, people are healthier and mortality decreases. The claim of the IPCC and of the supporters of the AGWT that humanity should fear a climate warming runs contrary to the human experience throughout history. It is not unreasonable to claim that the increased prosperity enjoyed by humanity during the last century has been partially caused by the observed warming, together with a scientific technological advancement, during the last century.

Appendix G. The Medieval Warm Period and the Little Ice Age - A global phenomenon



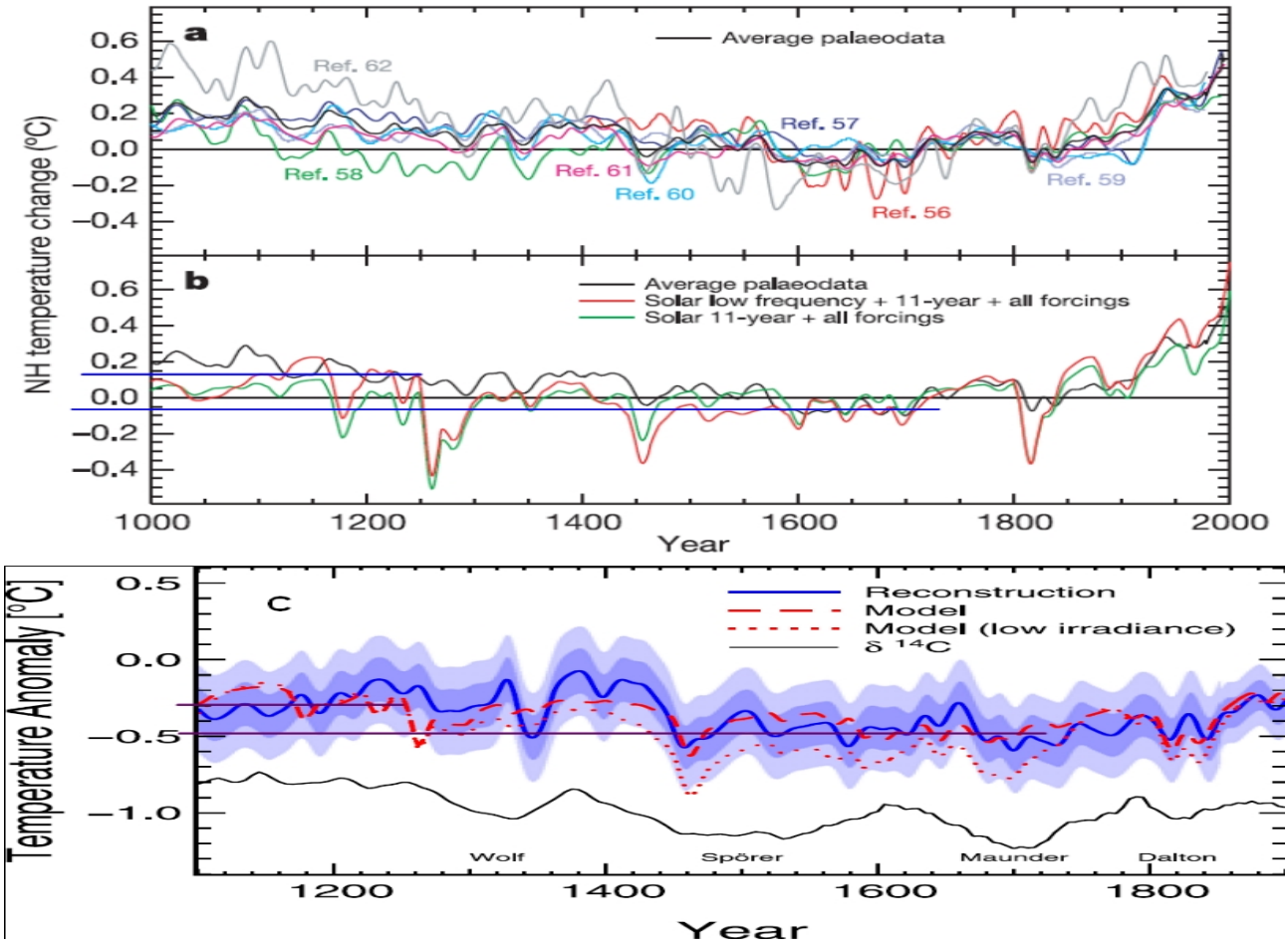
The Medieval Warm Period from 1000-1400 and the Little Ice Age from 1500 to 1800 were global phenomena. The figure shows paleoclimatic data from several regions of the Earth covering the last 1000-2000 years based on numerous peer-reviewed scientific papers. According these data the Medieval Warm Period was similar to the current warm period or even warmer. In the center of the figure is depicted the global surface temperature records as evaluated in Loehle and Mc Culloch [(2008), Correction to: A 2000-year global temperature reconstruction based on non-tree ring proxies. *Energy Environ.* **19**, 93-100].

The above figure is taken from a web-site
http://pages.science-skeptical.de/MWP/MedievalWarmPeriod1024x768.html

There exists an ongoing project called *Medieval Warm Period Project* at
http://www.co2science.org/data/mwp/mwpp.php

The *Medieval Warm Period Project* is an ongoing effort to document the magnitude and spatial and temporal distributions of a significant period of warmth that occurred approximately one thousand years ago. Its purpose is to ultimately determine whether the Medieval Warm Period: (1) was or was not global in extent; (2) was less warm than, as warm as, or even warmer than the Current Warm Period; (3) was longer or shorter than the Current Warm Period has been to date. This project has up-to-date collected data published by 805 individual scientists from 478 separate research institutions in 43 different countries. The current conclusion of these studies is that the Medieval Warm Period has been about 0.5 ^oC warmer than the Current Warm Period.

Appendix H. Compatibility between the AGWT climate models and the *Hockey Stick*



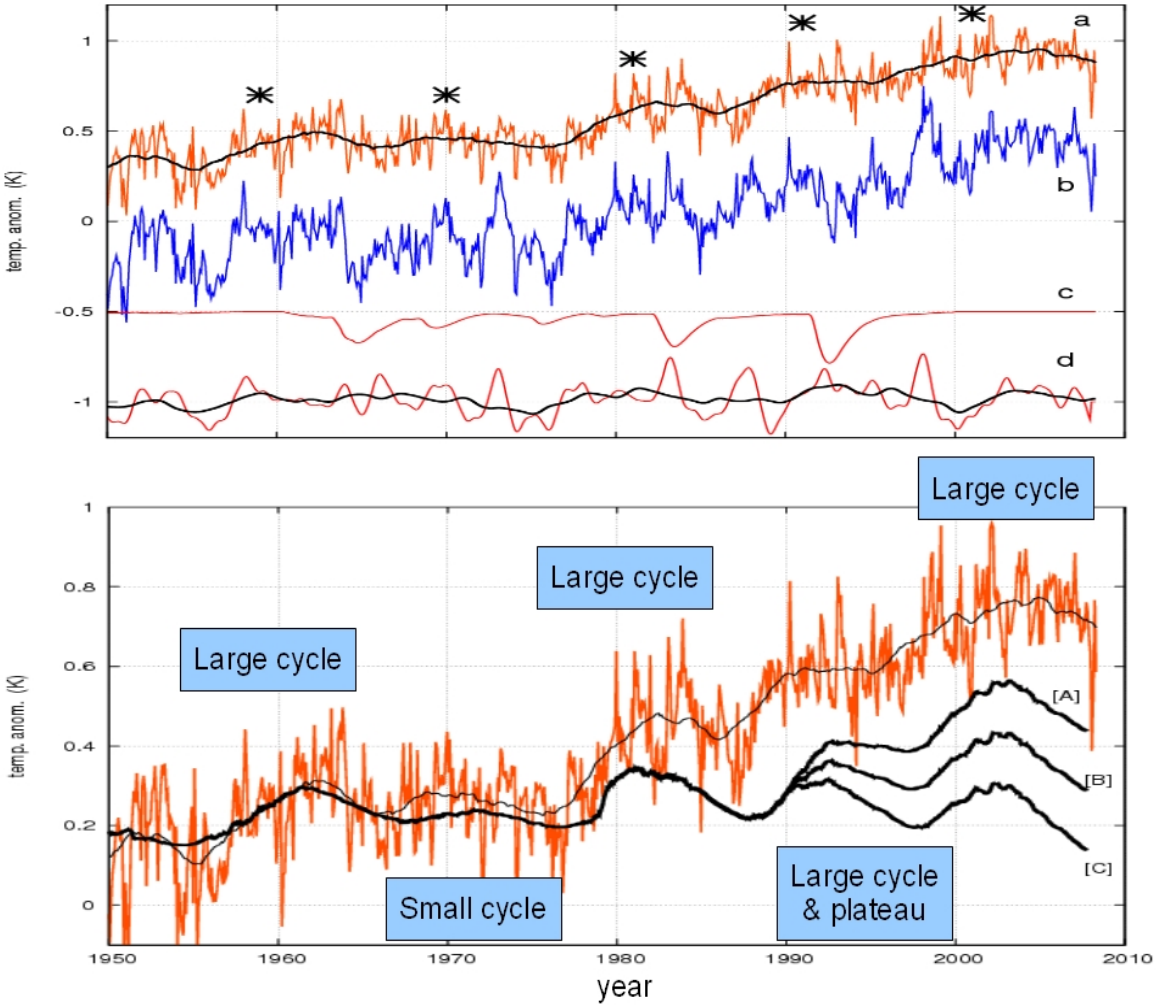
The figure highlights recent typical climate model simulations used to support AGWT. These models predict that from the Medieval Warm Period (1000-1300) to the Little Ice Age (1500-1750) a cooling of about 0.2 ^oC. This value is compatible only with the *Hockey Stick* temperature reconstructions such as those by Mann. Therefore, they are approximately equivalent to Crowley's model depicted in Figure 5. As Figure 6 would also imply, these recent models would fail to reproduce the 0.6 ^oC cooling from MWP to LIA observed in alternative paleoclimatic temperature reconstructions such as those by Moberg and other authors [8-10].

(a) Variations of Northern Hemisphere (NH) mean temperature over the past millennium as reconstructed in seven recent studies. # 62 is Moberg [8] while #56-61 were made before 2003 and are all *Hockey Stick* temperature reconstructions. All data are zeroed over 1601-1900.

(b) Comparison of the reconstructed Northern Hemisphere temperature for the past millennium with the modeled temperature changes including volcanic and anthropogenic forcing, with TSI forcing by solar cycle amplitude (green curve) and with additional low-frequency variations (red curve). Note that the volcano signal is clearly overestimated by the model. Figure from Foukal P., C. Fröhlich, H. Spruit, T. M. L. Wigley (2006), Variations in solar luminosity and their effect on the Earth's climate, *Nature 443*, 161-166.

(c) Comparison of global temperature reconstructions [Mann *et al.*, 2008, using the EIV HadCRUT3v land+ocean data-set] (blue line with shaded errors) and the model simulations with solar forcing corresponding to recent reconstructions of total solar irradiance (TSI, red dashed line) and lower TSI (red dotted line) for the time interval 1100-1900. Figure from Feulner G., and S. Rahmstorf (2010), On the Effect of a New Grand Minimum of Solar Activity on the Future Climate on Earth, *Geophys. Res. Lett.*, doi:10.1029/2010GL042710.

Appendix I. The 11-year solar cycle in the global surface temperature record

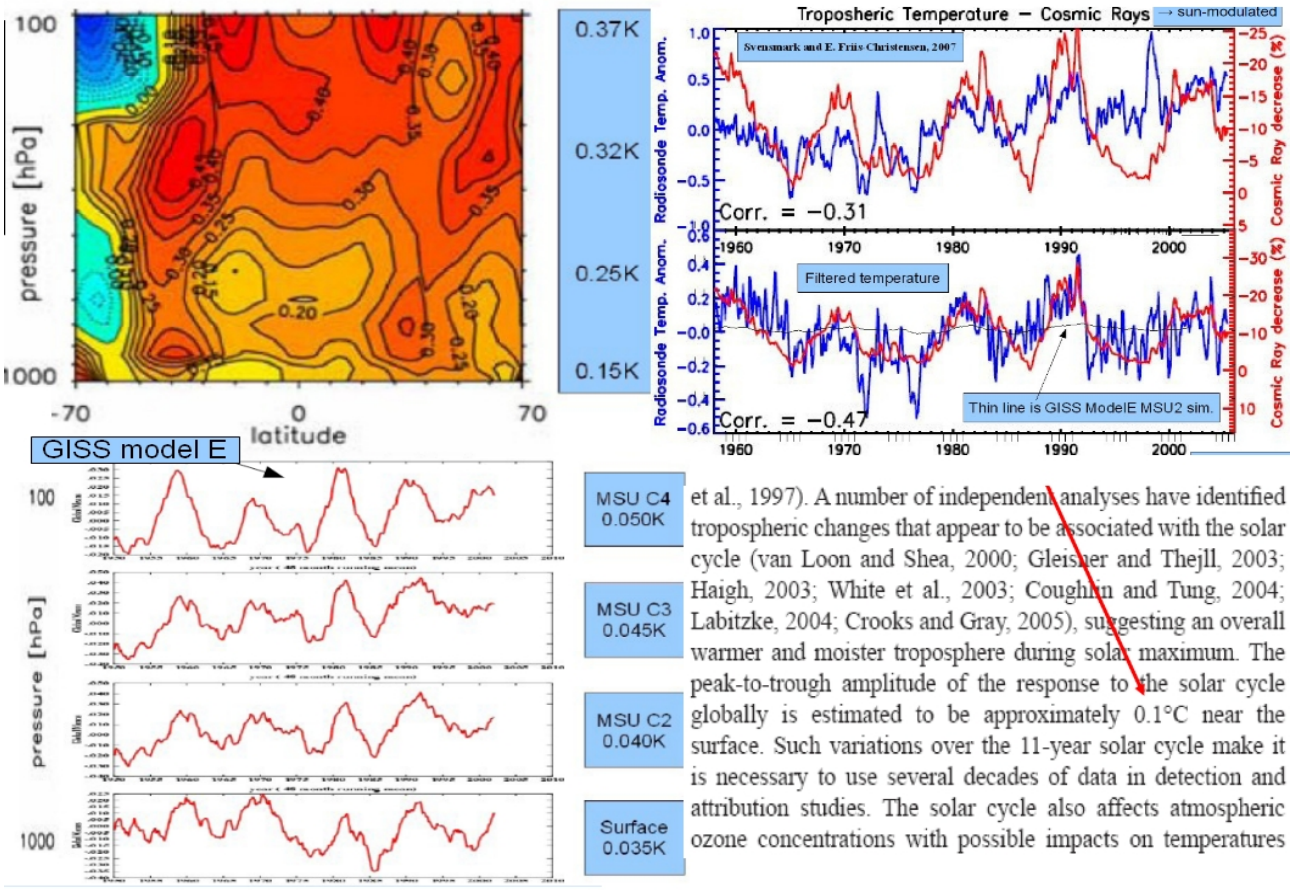


The figure shows a filtering of the global surface temperature that highlights its 11-year solar signature. The solar signature cycle has a (Min-to-Max) amplitude of about 0.1 ^oC. This signature is compared against the phenomenological model reconstructions [12]. The figures show temperature anomalies relative to the 18951905 average.

Top: Temperature components. The curve (b) is the original HadCRUT3 global surface temperature in Figure 1 (Brohan *et al.*,2006). The curve (c) is the empirical volcano signature on the global surface temperature. The thin curve (d) is the empirical ENSO signature on the global surface temperature; the thick curve is a four year moving average of the thin curve. The thin curve (a) is the surface temperature minus the volcano and ENSO signatures plus the thick smooth curve in (d); the thick orange smooth curve in (a) is a four year moving average of the thin curve (a). The curves are dislocated at 0.5 ^oC intervals for visual convenience. The * symbols indicate the position of the solar maxima.

Bottom: The filtered global surface temperature is compared against the phenomenological model reconstructions using since 1978 the three alternative total solar irradiance satellite composites shown in Figure 8. Note the good correspondence between the temperature cycles and the solar signature cycles.

Appendix J. The climate models underestimate the 11-year solar cycle signature



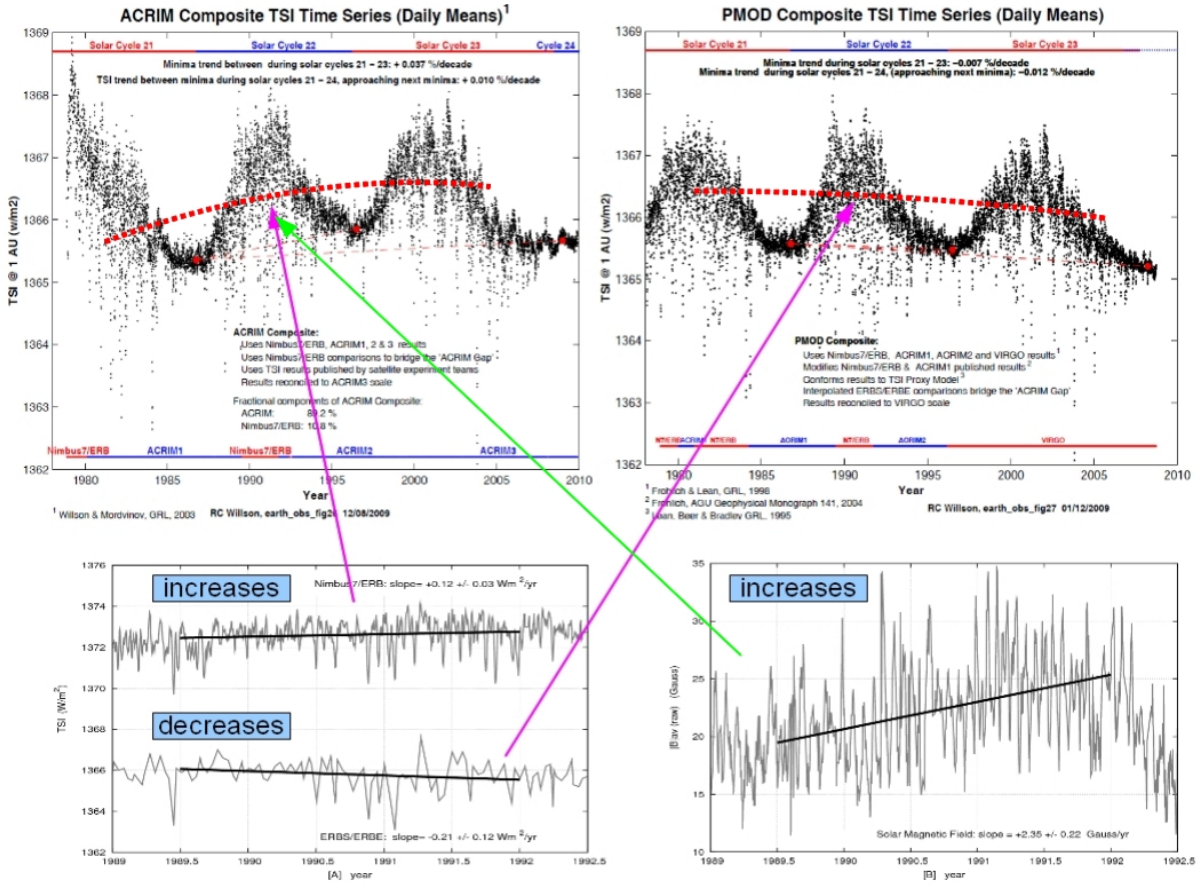
The figure highlights the severe disagreement between the climate model predictions and the empirical findings about the 11-year solar cycle signature in the temperature data. The climate models predict a signature from 3 to 8 times smaller than what empirically found in the data. The same problem occurs with all IPCC climate models and this suggests that these models are underestimating the solar effect on climate by a large factor.

Top: The figure shows the empirical 11-year solar cycle signature in the temperature data in function of the latitude and altitude. The Min-to-Max amplitude of this signature on average goes from about 0.1 ^oC on the surface to about 0.4 ^oC in the lower stratosphere. Left figure from Gleisner, H., and P. Thejll (2003), Patterns of tropospheric response to solar variability, *Geophys. Res. Lett. 30*, 1711, doi:10.1029/2003GL017129. Right figure from Svensmark H. and Friis-Christensen E. (2007), Reply to Lockwood and Frhlich - The persistent role of the Sun in climate forcing, Danish National Space Center Scientific Report 3/2007 http://www.spacecenter.dk/publications/scientific-report-series/Scient_No._3.pdf/view

Bottom right: The quote is from the IPCC 2007, page 674. This quote acknowledges some empirical findings about the 11-year solar cycle signature in the temperature data. In particular, it is acknowledged the fact that this cycle is globally estimated to be about 0.1 ^oC on the global surface temperature.

Bottom left: Theoretical 11-year solar cycle signature obtained with traditional general circulation climate models. In this case the outputs are from the GISS ModelE. The figure clearly shows that this climate model predicts a Min-to-Max amplitude for this signature to be on average from about 0.035 ^oC on the surface to about 0.05 ^oC in the lower stratosphere (MSU C4). This is from 3 to 8 times smaller than what is observed in the data. Data from http://data.giss.nasa.gov/modelE/transient/climsim.html, Hansen, J. *et al.* (2007), Climate simulations for 1880-2003 with GISS modelE, *Clim. Dyn.* **29**, 661-696.

Appendix K. The ACRIM-PMOD total solar irradiance satellite composite controversy



The ACRIM total solar irradiance satellite composite uses the Nimbus7/ERB data to bridge the ACRIM-gap (1989.5-1992). This group fees that it is superior to the ERBS/ERBE data [15]. The resulting ACRIM TSI composite shows a significant upward trend between successive minima during solar cycles 21-23 of about +0.5 W/m^2 because during this period Nimbus7/ERB database shows an increasing trend. On the contrary the PMOD TSI composite, which was first proposed by Fröhlich and Lean [1998] and later updated by Fröhlich [2006] [16], uses the ERBS/ERBE database to bridge the ACRIM gap. More specifically PMOD alters the Nimbus7/ERB database from 1989.5 to 1992.5 in such a way to reproduce the descending trend of ERBS/ERBE database.

However, ERBS/ERBE sensors were expected to degrade during the ACRIM-gap. This fact can be easily experimentally justified. In fact, it is experimentally known that TSI sensors experience a degradation during their first exposure to the enhanced UV flux of a solar maximum. ERBE/ERBS sensors did not self-calibrate to automatically correct the problem and from 1989 to 1992 they were experiencing for the first time a solar maximum. Indirectly, during the ACRIM-gap the solar magnetic field strength observed with 1 arc sec pixels and averaged over the full solar disk from the National Solar Observatory/Kitt Peak Data Archives (Bottom) (http://nsokp.nso.edu/dataarch.html) increased exactly as the Nimbus7/ERB record shows. This observation clearly supports a sufficient accuracy of the Nimbus7/ERB database, as Willson and Hoyt claim: see next Appendix.

TSI composite reconstructions can be downloaded from http://www.acrim.com/

Appendix L. Willson and Hoyt's statements about the ACRIM and Nimbus7 TSI published data

Dr. Richard C. Willson
Principal Investigator
ACRIM Experiments
12 Bahama Bend,
Coronado, CA, 92118
Phone: 619-407-7716
Fax: 619-365-9579
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

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.

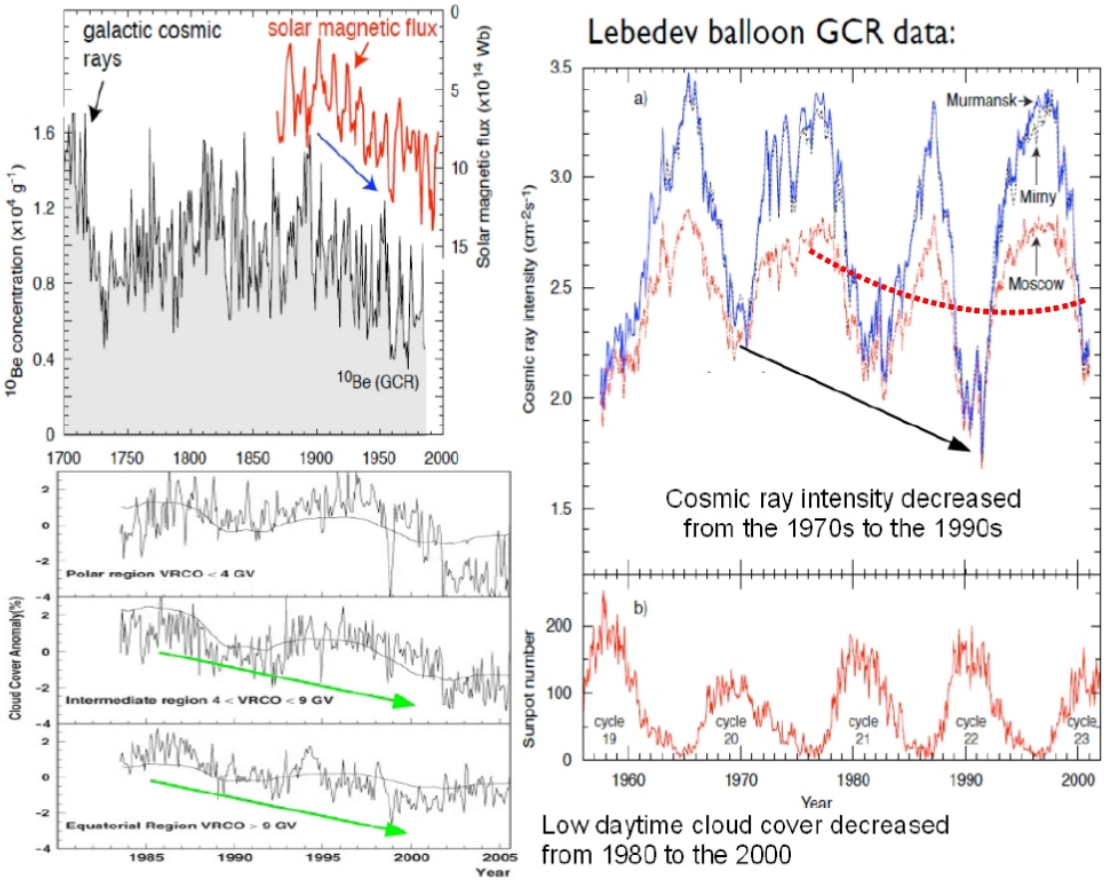
4. The correction of the Nimbus7 TSI values for 1979-1980 proposed by Frohlich is also puzzling. The raw data was run through the same algorithm for these early years and the subsequent years and there is no justification for Frohlich's adjustment in my opinion.

Sincerely,

Douglas Hoyt

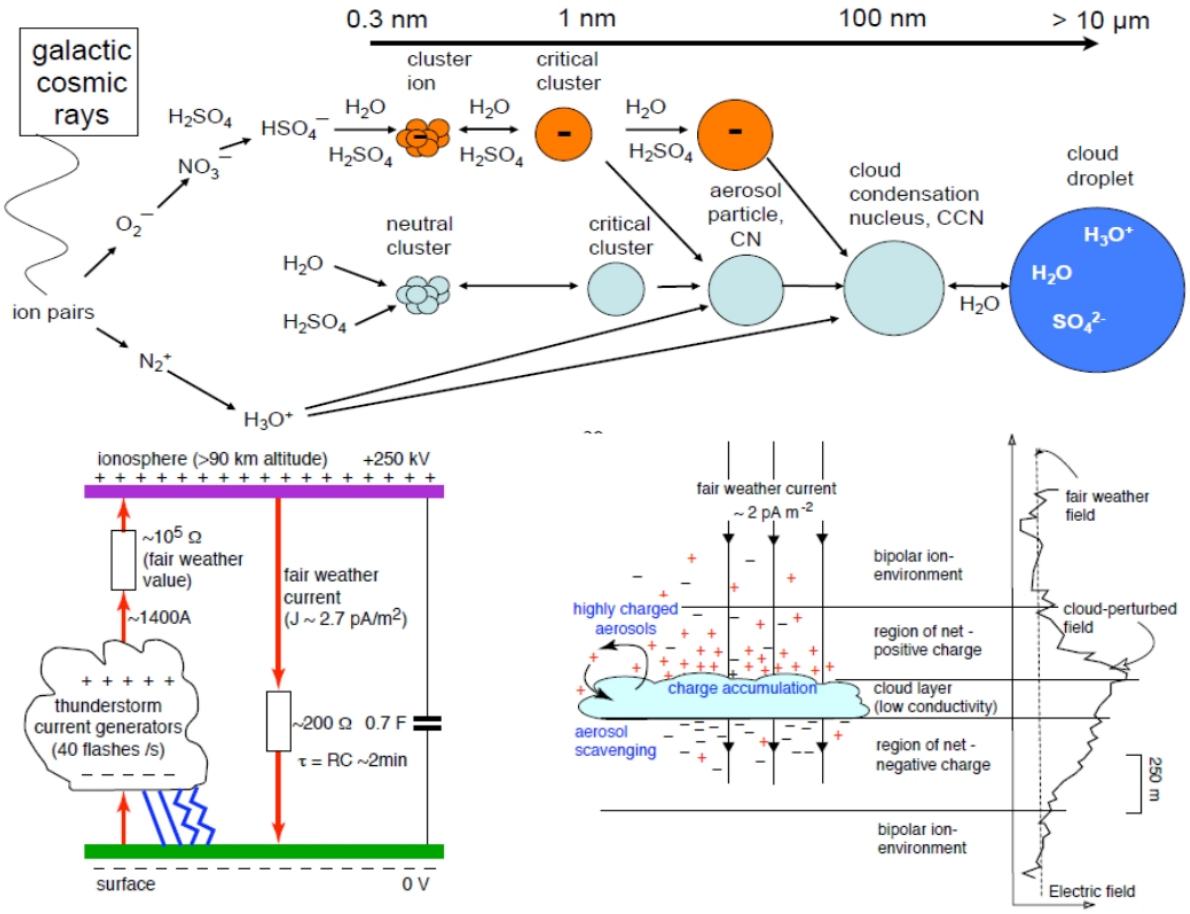
These are the statements given to me by Dr. Willson and Dr. Hoyt, who are the PIs of the ACRIM and Nimbus7/ERB total solar irradiance satellite experiments, respectively. In these statements these authors state that they do not believe that the corrections of the ACRIM and Nimbus7 TSI published records implemented by Fröhlich and Lean [16] for building the PMOD total solar irradiance satellite composite are accurate nor appropriate.

Appendix M. Cosmic ray flux, solar activity and low cloud cover positive feedback



It has been hypothesized that cosmic ray flux modulates low cloud cover [13,14]. When solar magnetic activity increases, cosmic ray flux decreases and ionize less the atmosphere. Consequently, fewer cloud condensation nuclei form, yielding less cloud cover. The albedo decreases, more solar irradiance reaches the Earth's surface and causes warming. Therefore, a solar modulation of the low cloud cover percentage would activate a powerful positive climatic feedback to solar changes. In fact, cloud cover variation can shield up to 30 W/m^2 of solar irradiance. Just a 5% modulation of the low cloud cover by the sun would have the same radiative forcing impact of the 1.6 W/m^2 IPCC net anthropogenic forcing since 1750 (see Figure 2). The figure shows: 1) Solar magnetic flux increased during the 20th century (the data are flipped for convenience) – this record well correlates with the increased average surface temperature of the globe during the last century; 2) cosmic rays flux decreased from the 1970s to the 1990s, this well correlates with the increased TSI activity as registered by ACRIM and with the global warming observed from 1970 to 2000; 3) The global low cloud cover percentage shows a clear 11-year solar modulation and decreases from 1984 to 2000 that fits with the observed warming during this period (data from ISCCP infrared data). So, during the 20th century solar activity may have greatly warmed the climate by reducing the global low cloud cover percentage. It should be observed that cloud formation does not depend only on cosmic ray flux. A increase of total solar irradiance warms water vapor molecules and would reduce the likelihood of their condensation to form cloud droplets. In fact, the decrease in global low cloud cover percentage from 1984 to 2000 is also in agreement with a TSI increase as shown by the ACRIM TSI satellite composite. Moreover, biosphere, for example phytoplankton, may produce aerosols that may favor cloud formation. [Cloud data from: Sloan T. et al. (2008), Testing the proposed causal link between cosmic rays and cloud cover, *Environ. Res. Lett.* **3** 024001]

Appendix N. Possible mechanisms linking cosmic ray flux and cloud cover formation



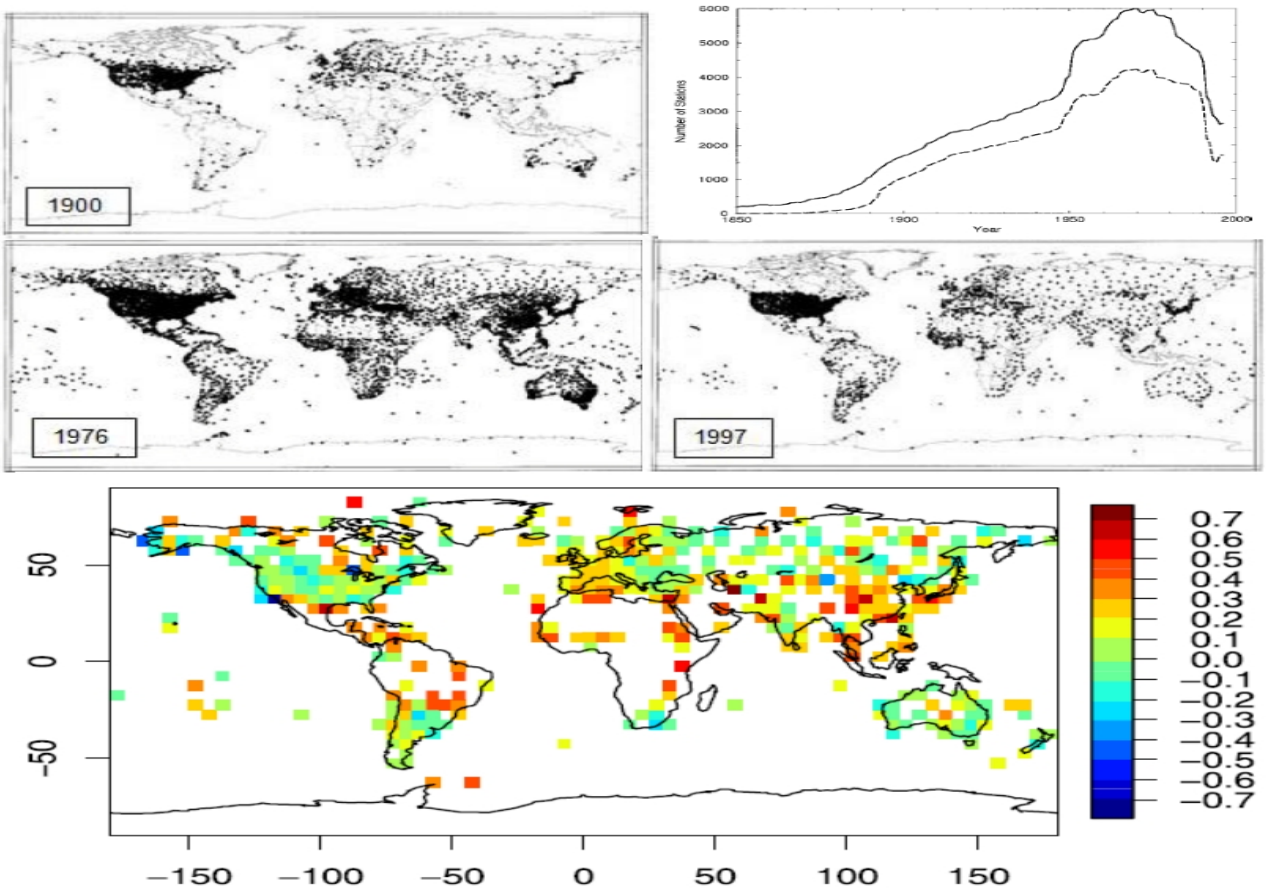
The figure highlights how cosmic ray flux, under natural conditions, can influence aerosol formation, clouds and, consequently, climate. Cosmic ray flux is modulated by the solar activity in such a way that higher solar activity implies a lower cosmic ray flux entering in the Earth's atmosphere. A solar modulation of the low cloud cover has the potentiality of inducing a large climatic positive feedback to solar changes. In fact, clouds cover 65% of the globe on average. They cause a net cooling of about 30 W/m^2 which is a forcing with a magnitude about 20 times larger than the net anthropogenic forcing estimated by the IPCC since 1750, which is 1.6 W/m^2 (see Figure 2). So, even a small 5-10% solar modulation of the low cloud cover can easily overcome any anthropogenic forcing.

Top: Galactic comic rays ionize the atmosphere and favor the formation of aerosol particles that serve as seeds of cloud formation. In fact, all cloud droplets form on aerosol seeds known as cloud condensation nuclei (CCN). Cloud properties are sensitive to number of droplets. More aerosols/CCN imply brighter clouds, with longer lifetimes.

Bottom: Global electric circuit. Cosmic rays ionize atmosphere and control Earth-ionosphere conductivity. Large aerosol charges at cloud boundaries imply unipolar space charge region and can be entrained inside clouds and may affect: Rate of aerosol accretion by cloud droplets; Ice particle formation; Atmospheric dynamics. The largest ionization is seen in the polar regions.

See references [13,14]. Figures adapted from Kirkby J. (2009), Cosmic rays and climate, CERN Colloquium, http://indico.cern.ch/getFile.py/access?resId=0&materialId=slides&confId=52576

Appendix O. A warming bias in the surface temperature records?

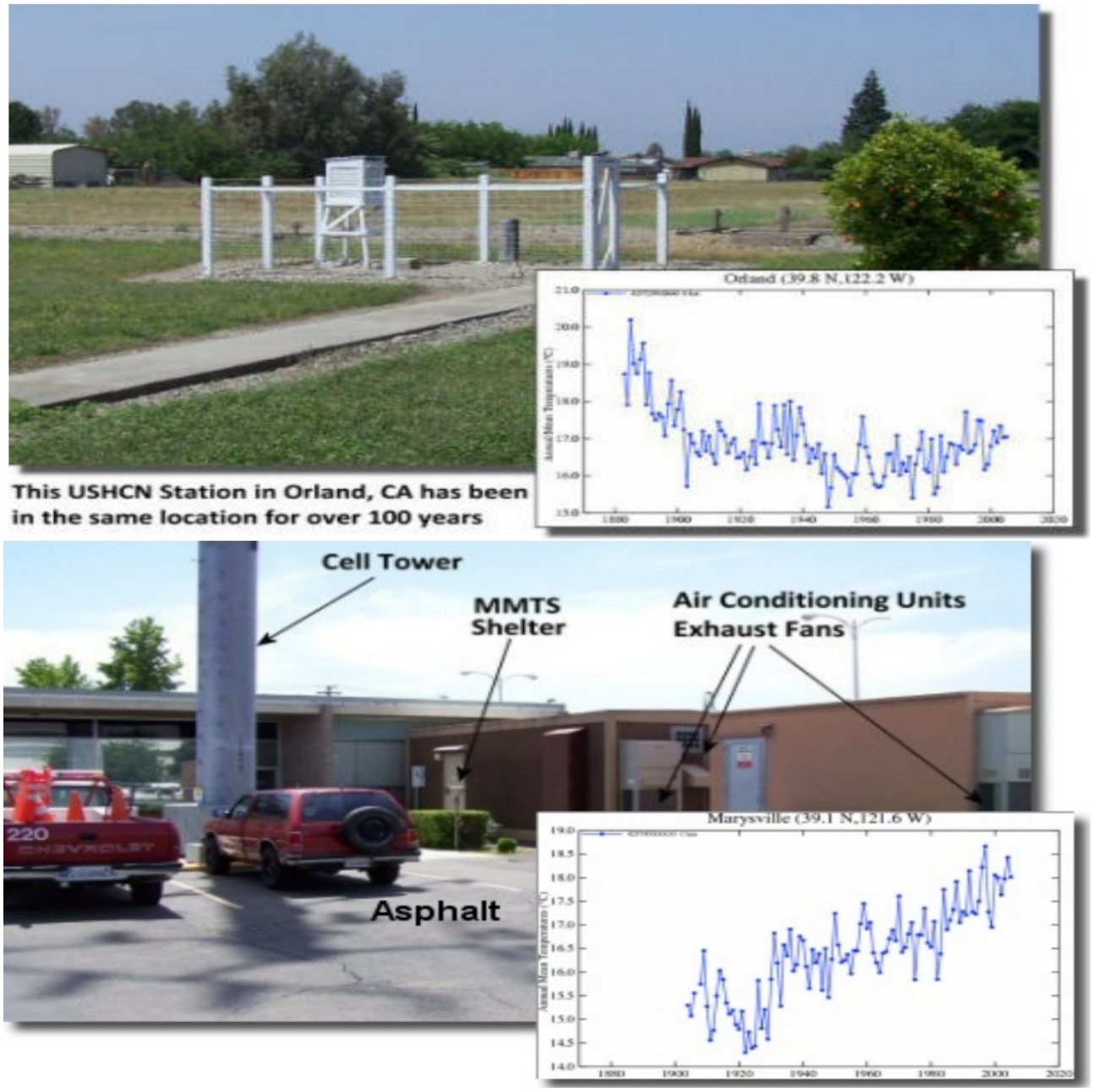


The figure highlights some problems that may have caused a warming bias in the global surface temperature record.

Top: The figure shows a significant change in the number of temperature monitoring stations in time with a significant drop after 1990. More than 6000 stations were in the NOAA data base for the mid- 1970s, but just 1500 or less are used today. Many stations no longer included were mainly rural, at higher latitudes and altitudes. This tendency of eliminating cooler stations has likely introduced a warming bias in the global temperature reconstructions and has likely made any accurate assessment of warming problematic. There was a major disappearance of recording stations in the late 1980s to the early 1990s. The following figure compares the number of global stations in 1900, the 1970s and 1997, showing the increase and then a decrease. [Peterson T. C. and S. V. Vose (1997), An Overview of the Global Historical Climatology Network Temperature Database, *Bul. Ame. Met. Soc.* **78**, 2837-2849.]

Bottom: The figure shows that extraneous (nonclimatic) signals contaminate gridded temperature climate data. The patterns of contamination are detectable in both rich and poor countries and are relatively stronger in countries where real income is growing. The figure shows the differences between observed and adjusted temperature 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 ^oC decade higher than the adjusted trend. Using the regression model to filter the extraneous, nonclimatic effects would reduce the estimated 1980-2002 global average temperature warming trend over land by about half. [McKitrick, R. R., and P. J. Michaels (2007), Quantifying the influence of anthropogenic surface processes and inhomogeneities on gridded global climate data, *J. Geophys. Res.*, **112**, D24S09].

Appendix P. A underestimated Urban Heat Island effect?



The figure highlights typical problems that may have caused a warming bias in the global surface temperature record. Several photographs about US stations can be found in the web: http://surfacestations.org/

For a detailed discussion about the reliability of the temperature records see J. DAleo J. and A. Watts (2010), *Surface Temperature Records: Policy Driven Deception?*, SPPI original paper (http://scienceandpublicpolicy.org/images/stories/papers/originals/surface_temp.pdf)

Top: The figure shows a typical well maintained and well sited USHCN station. This USHCS station is in Orland, CA, and has been in the same location for over 100 years.

Bottom: The figure shows a typical not-so-well maintained or well sited USHCN station. This site is in Marysville, CA, and has been around for about the same amount of time of the above station. However, with time this station has been encroached upon by growth in a most serious way by micro-site effects as the figure shows. A significant spurious warming of several degree Celsius is observed in this record.

Appendix Q. A 60 year cycle in multisecular climate records

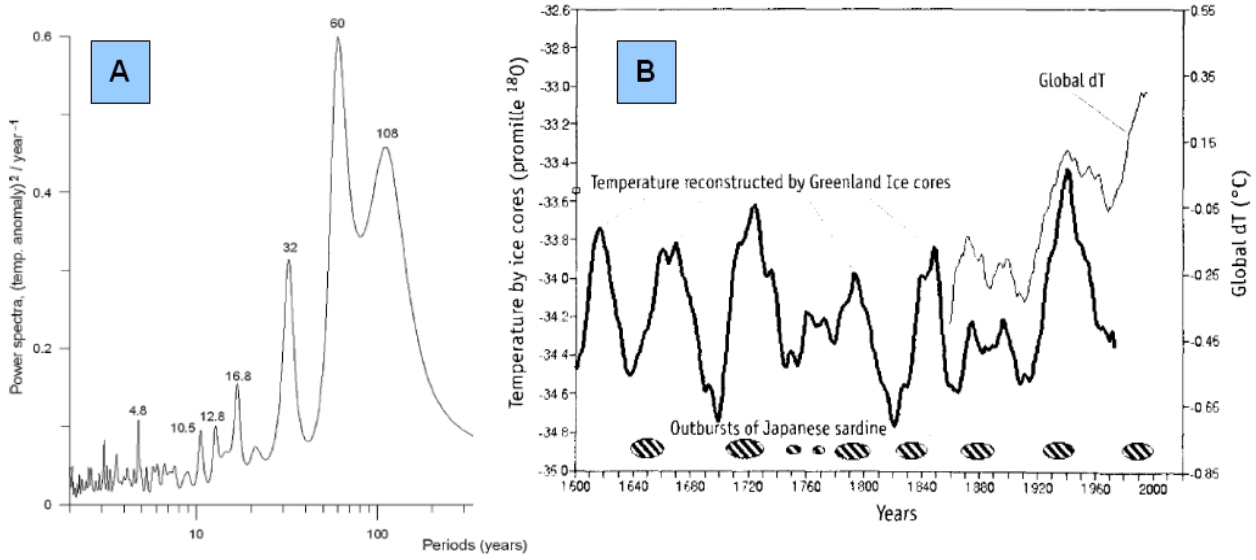


Table I. Predominant periods of climatic fluctuations within the range of 20–100 years according to all data available.

Time series	Series length, years	Predominant peak, years	Secondary maxima, years
Ice core samples	1420 (552–1973)	54	32
Arctic pine tree	1480 (500–1980)	60	32
California bristlecone pine tree	1500 (479–1979)	76	32
California bristlecone pine tree	8000 (–6000–1979)	55.4	20-35
Sardine (sediment core samples)	1730 (270–1970)	57 and 76	56, 33
Anchovy (sediment core samples)	1730 (270–1970)	57	72, 99
Global dT	140 (1861–2001)	55	18.0

(A) Spectrum of periodical temperature fluctuations for 1400 years by the Arctic pine tree (Pinus silvestris) growth rings (logarithmic X-axis) which clearly shows a strong 60-year cycle. **(B)** Cyclic temperature fluctuations and outbursts of Japanese sardine over the last 400 years (1640-1880) from the data derived from Japanese chronicles and the commercial statistics available beginning in the period of 1920-1998, which also show 50-60 year fluctuations that are synchronous with the fluctuations of climatic indices and historically confirms them. The bold line is temperature reconstructed by Greenland ice cores (13-year smoothing), the thin line is the Global dT, ellipses show sardine outbursts.

The table in the figure shows that several multisecular climate proxy records do present an approximate 55-60 year cycle that may be linked to the combined gravitational field of Jupiter and Saturn whose combined orbit is about 58-60 year as explained in the text. Numerous other climatic, geological and historical records with similar properties of the above are shown in the book and papers by Klyashtorin and Lyubushin [18]. [Figure adapted from Klyashtorin L.B. and Lyubushin, A.A. (2007). *Cyclic Climate Changes and Fish Productivity*. Moscow, VNIRO Publishing.
http://alexeylyubushin.narod.ru/Climate_Changes_and_Fish_Productivity.pdf]

Appendix R. A 60 year cycle in solar, geological, climate and fishery records

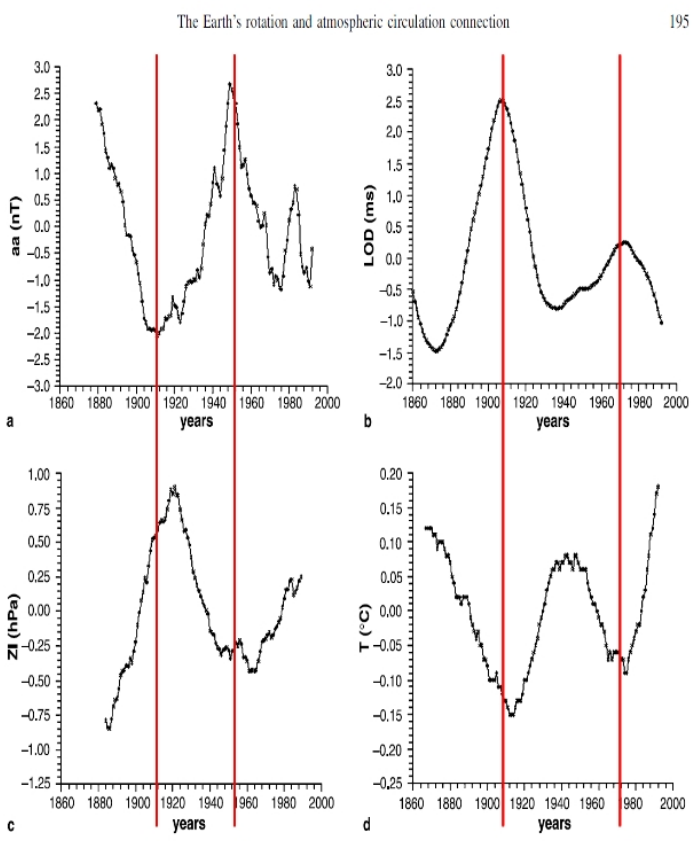


Fig. 1. Time plots of annual values, detrended and smoothed according to the 23-yr running mean, of: a) geomagnetic activity *aa*; b) length of day *LOD*; c) Northern hemisphere zonal circulation index *ZI*; d) Northern hemisphere surface air temperature anomalies *T*

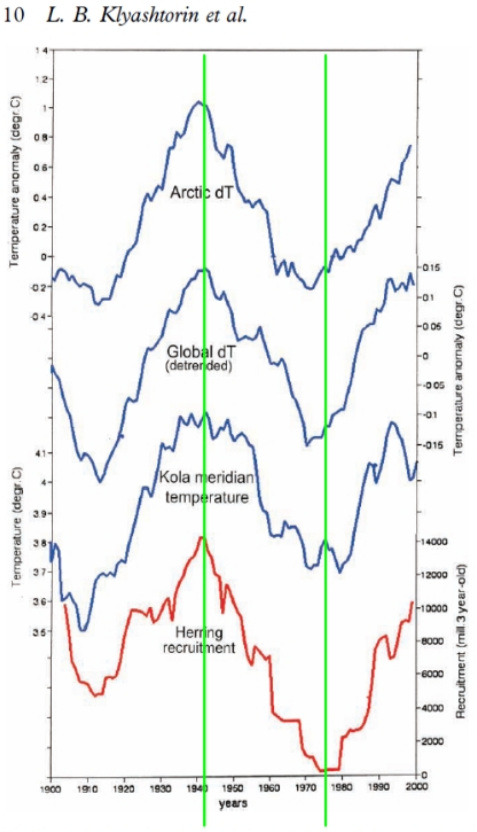


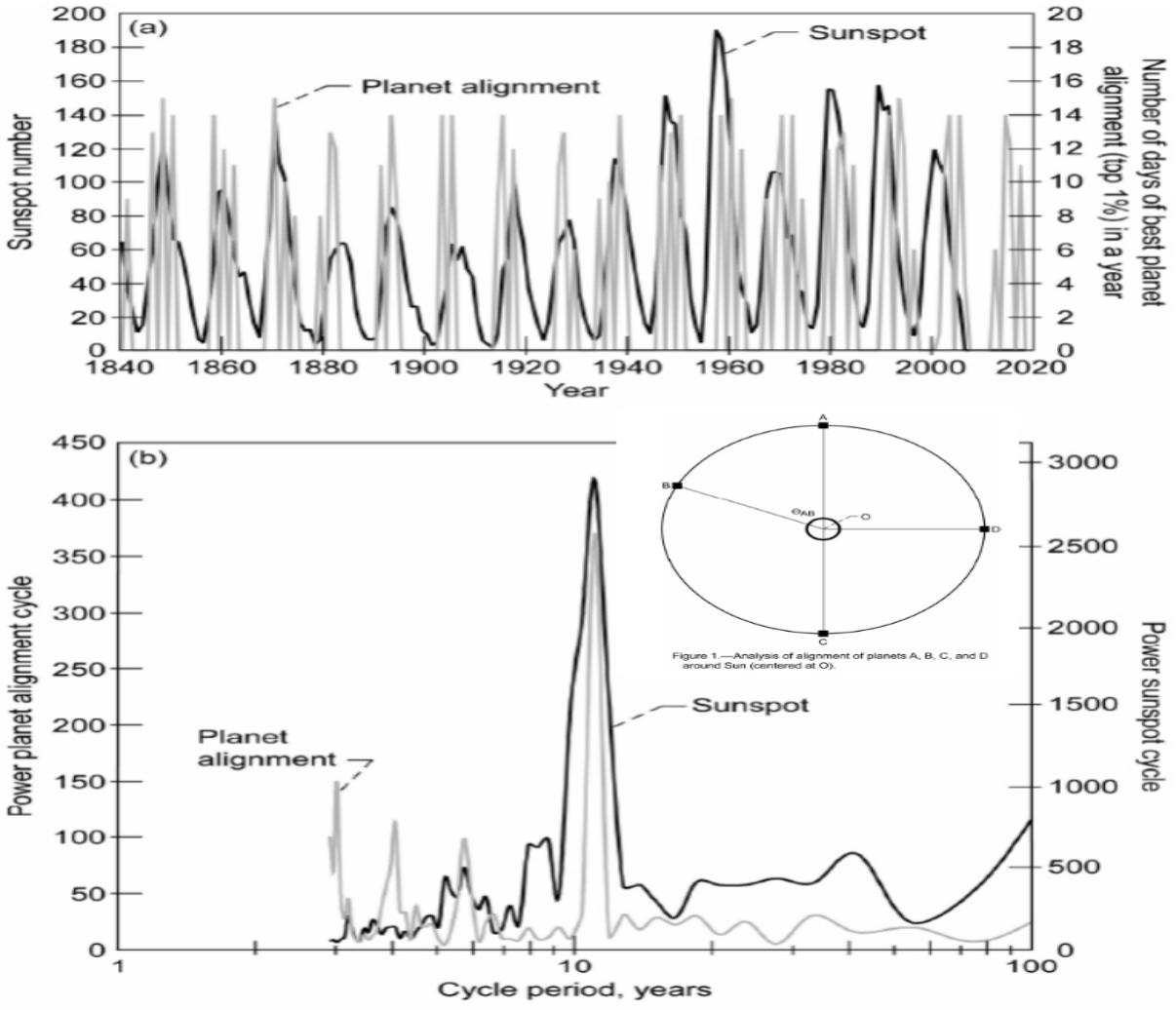
Figure 8. Comparative dynamics of Global dT (detrended), Arctic dT, Kola meridian 0–200-m mean water column temperature and spawning stock biomass of Atlantic spring-spawning herring for the period 1900–2000.

Left: The figure shows four plots of annual values, detrended and smoothed according to the 23-yr running mean, of: a) geomagnetic activity, aa; b) length of day, that is the variation of the duration of the days usually called LOD; c) Northern hemisphere zonal circulation index ZI; d) Northern hemisphere surface air temperature anomalies T. All these records clearly show approximate 60 year cycles which are in phase with each other. Fundamental it is the correlation between the geomagnetic activity that is controlled by the solar magnetic activity with other terrestrial records. The gain and phase factor analysis suggests that geomagnetic activity influences T through LOD and successively through ZI. (Figure from Mazzarella A. (2007), The 60-year solar modulation of global air temperature: the Earth's rotation and atmospheric circulation connection, *Theoretical and Applied Climatology* **88** #3-4, 193-199)

Right: Comparative dynamics of global temperature anomaly (detrended), of the arctic temperature anomaly, Kola meridian 0-200- m mean water column temperature and spawning stock biomass of Atlantic spring-spawning herring for the period 1900-2000. The figure clearly established the 60 year cycle in multiple climate records which are indirectly confirmed by fish stock pattern. (Figure from Klyashtorin, L.B., V. Borisov, and A. Lyubushin (2009), Cyclic changes of climate and major commercial stocks of the Barents Sea, *Mar. Biol. Res.* **5**, 4-17.)

Note that all other records lags of a few years the geomagnetic activity oscillations suggesting that the solar variation is driving all other climatic, geological and biological records.

Appendix S. The 11-year solar cycle and the V-E-J planet alignment



(A) Annual average sunspots from 1840 to 2007 and number of most-aligned days (top 1 percent) each year for the three-planet system: Venus, Earth, and Jupiter.

(B) Fast Fourier transforms of number of sunspots and number of most-aligned days for the three-planet system.

Hung [21] found that from the daily position data of Venus, Earth, and Jupiter, an 11-year planet alignment cycle is observed to roughly match the sunspot cycle. This observation supports the hypothesis that the resonance and beat between the solar tide cycle and non-tidal solar activity cycle influences the sunspot cycle and its varying magnitudes. He also found that 25 of the 38 largest known solar flares were observed to start when one or more tide-producing planets (Mercury, Venus, Earth, and Jupiter) were either nearly above the event positions ($< 10^o$ longitude) or at the opposing side of the Sun. The probability for this to happen at random is 0.039 percent. This supports the hypothesis that the force or momentum balance (between the solar atmospheric pressure, the gravity field, and magnetic field) on plasma in the looping magnetic field lines in solar corona could be disturbed by planetary tides, and this could result in magnetic field reconnection, solar flares, and solar storms.

Appendix T. The 60 and 20 year cycles in the wobbling of the Sun around the CMSS

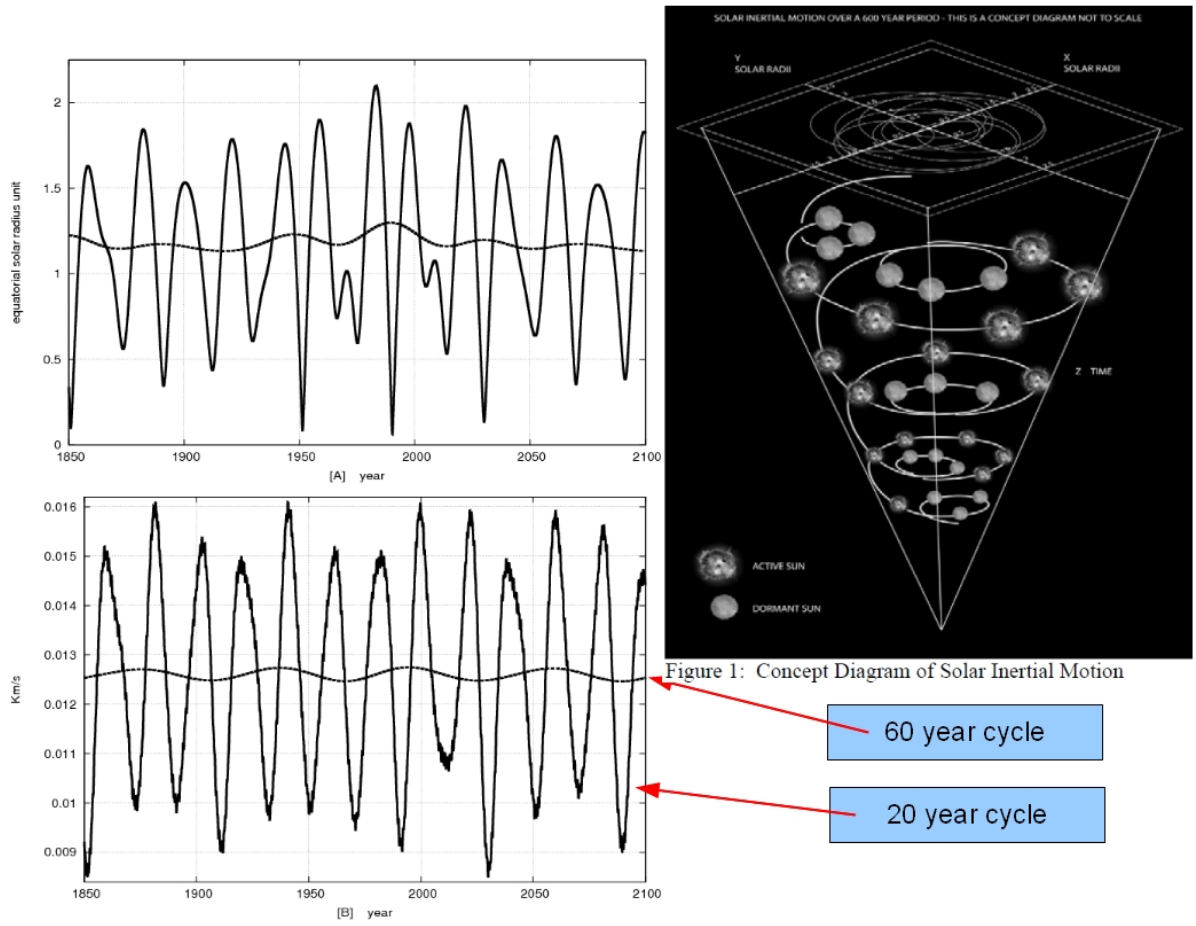
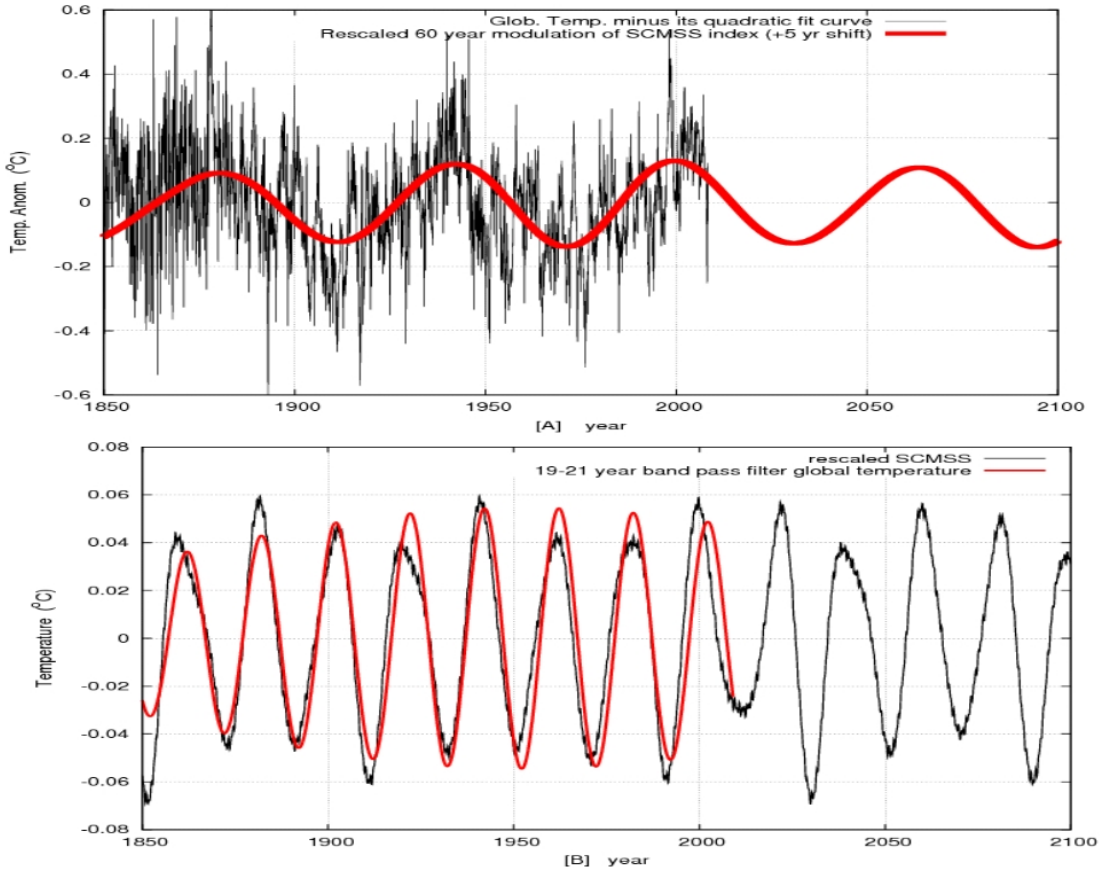


Figure 1: Concept Diagram of Solar Inertial Motion

The figure shows the wobbling of the Sun relative to the center of mass of the solar system (CMSS). The distance of the sun from CMSS and its speed are plotted. Large cycles with around 20 and 60 year periodicity which are due to the synodic period of Jupiter and Saturn and to the repetition of the two orbits, respectively, are evident. These curves are just proxies of the modulation of the gravitational and magnetic planetary forcings on the Sun.

The orbit of Jupiter is about 12 (11.86) years and the orbit of Saturn is about 30 (29.4) years. So, from here one obtains the following major planetary periods: about 10 years, the opposition of Jupiter and Saturn; about 12 years the period of Jupiter; about 20 years the synodic period of Jupiter and Saturn; about 30 years the period of Saturn; about 60 years the repetition of the combines orbit of the two planets which occurs every 60 years. Other planetary cycles are present and related to the orbits of Uranus (84 years), Neptune (164.8 years) and their orbital combinations. For example, the synodic period of: Jupiter and Neptune is 12.8; Jupiter and Uranus is 13.8; Saturn and Neptune is 35.8 years; Saturn and Uranus is 45.2 years; Uranus and Neptune is 171.3 years. Some cycle can have a millenarian scale such as the repetition of the combined synodic periods of Jupiter and Saturn and of Uranus and Neptune has approximate periods of about 1200 and 2000 years. Note the 60 and 20 year cycles are quite in phase with the cycles observed in the temperature records.
(Right figure of the wobbling sun is from Mackey R. (2007), Rhodes Fairbridge and the idea that the solar system regulates the Earths climate, *J. of Coastal Research* **50**, 955-968,
http://www.griffith.edu.au/conference/ics2007/pdf/ICS176.pdf)

Appendix U. The 60 and 20 year cycles in global surface temperature and in the CMSS

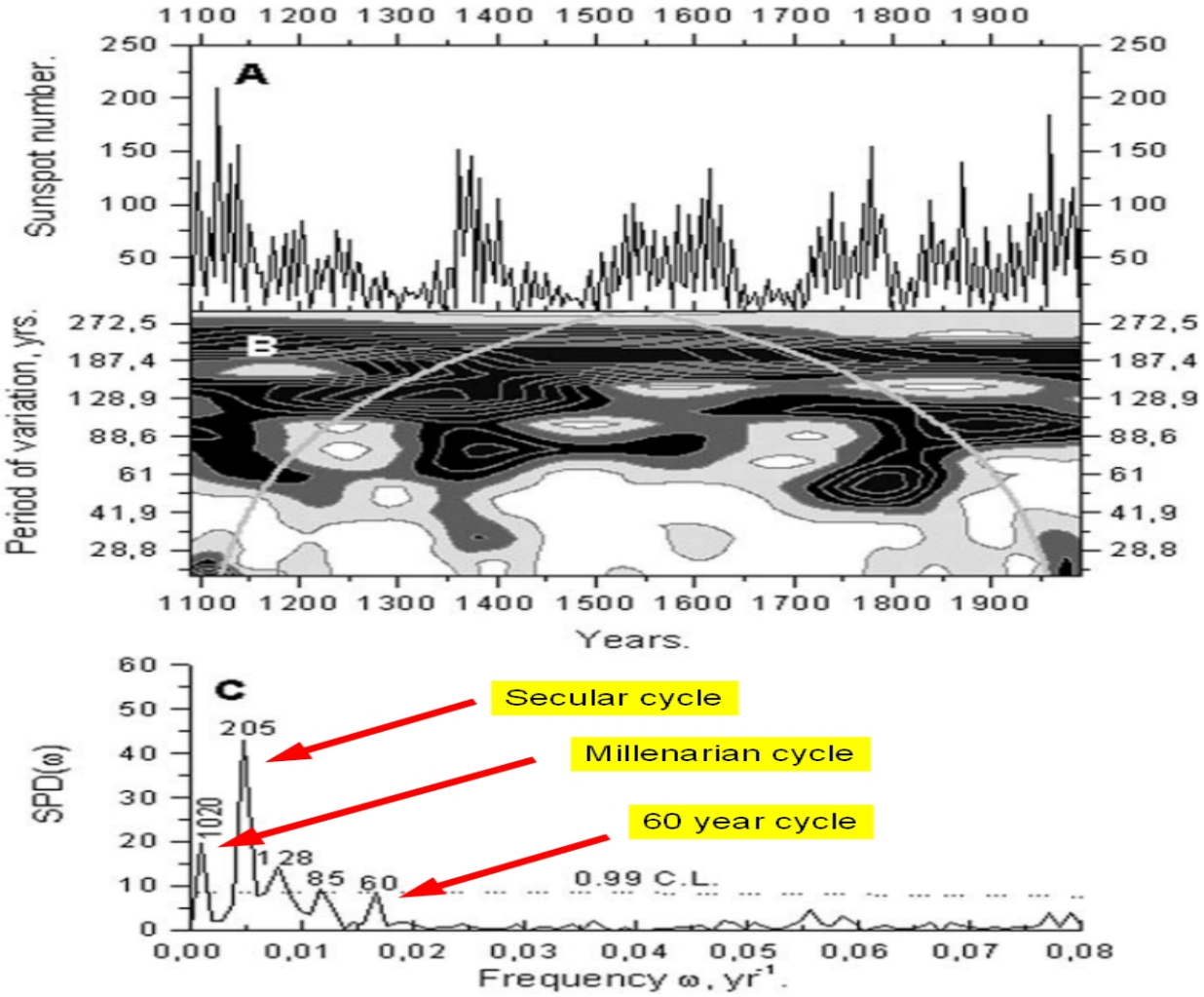


Top: The figure shows the global surface temperature (black) detrended of its quadratic fit function as done in Figure 1. The data are plotted against the 60 year modulation of the speed of the sun relative to the center of mass of the solar system (red) shown in Appendix T. The 60 year modulation of SCMSS has been time-shifted by +5 years.

Bottom: The figure shows the global surface temperature (black) filtered within its two decadal oscillation. The temperature modulation is plotted against the SCMSS (red) shown in Appendix T. No time-shift has been applied.

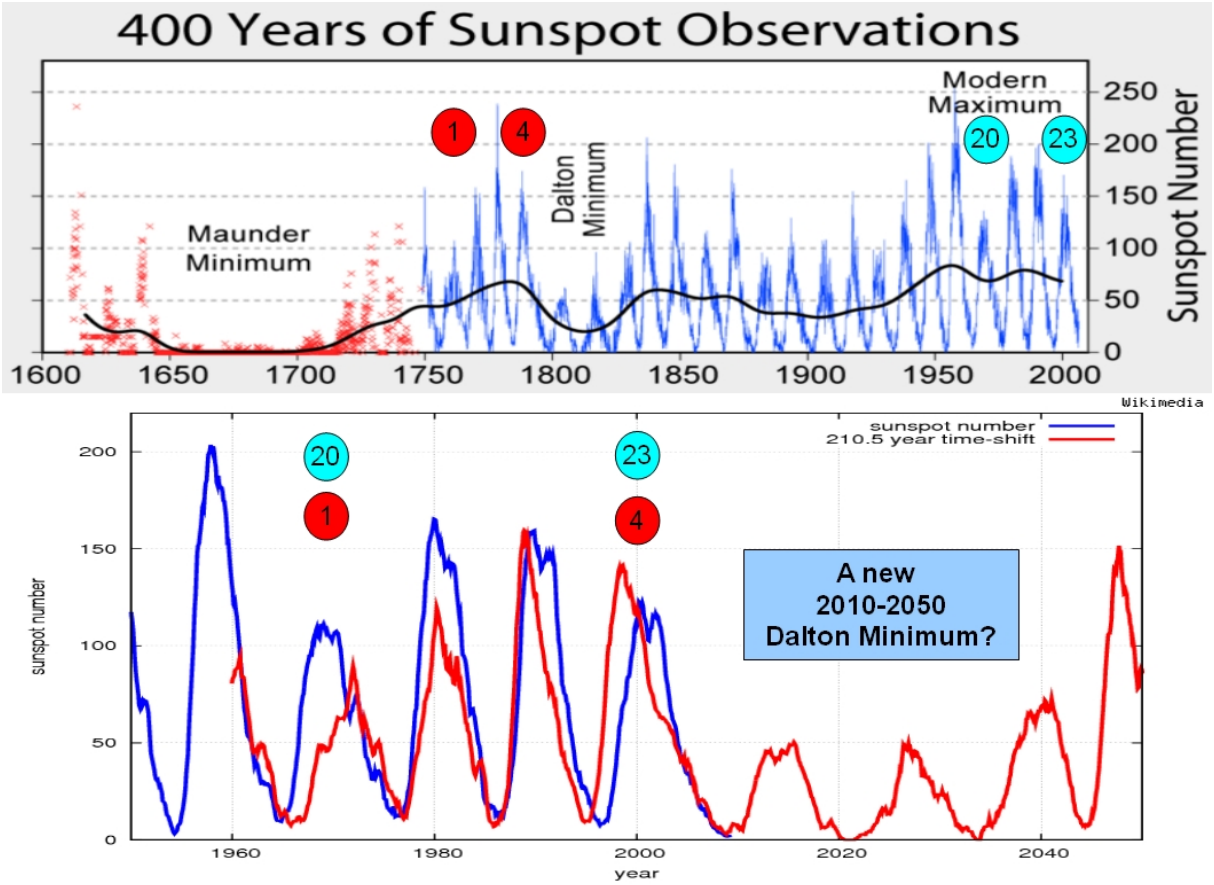
The figures suggest that the 60 and 20 year modulation of the SCMSS can be used for forecasting these global surface temperature oscillations and has been used to reproduce the forecast modulation curves in Figure 13.

Appendix V. **A 60 year cycle in multisecular solar records**



(A) Sunspot Wolf numbers reconstruction. After 1700 A.D. direct Zürich data are used. **(B)** Local wavelet (Morlet basis) spectrum of Wolf numbers reconstruction. White domains local wavelet power < 0.2, black domains local wavelet power > 1.0 (0.99 c.l.). **(C)** Fourier spectrum of Wolf numbers reconstruction. Dotted line: 0.99 c.l. (red noise factor 0.3). Solar records contain 60 years, 85 years and other longer cycles. The 60 year cycle appears linked to Jupiter and Saturn, Uranus has a period of 84 years and the second periodicity may be mostly linked to it in conjunction with Jupiter (note that the period of Jupiter is 12 years and that 7*12=84 which is the period of Uranus) and, probably partially with Saturn. The cycles in this sunspot record seem to wax and wane. This behavior is common for complex dynamical systems that are externally forced by quasi periodic inputs with relatively close periods such as, for example, 60 and 84 years. This behavior may indicate chaotic fluctuation around limit cycles, phase catastrophes, frequency beats and, of course, errors in the data. In addition to the Gleissberg frequency band solar cycles which covers the frequency bands of 50-80 years and 90-140 years, the figure also shows a millenarian cycle and a bi-secular cycle within the Suess frequency band (160-260 year) that are seen in the climate records as well (See Appendix E). The finding does not imply that all solar indexes must have exactly the same wavelet frequency temporal patterns, but all of them should present a similar set of frequencies that characterize the input forcing that may be linked to the orbit of the planets. Figure adapted from Ogurtsov *et al.* [2002, Long-period cycles of the suns activity recorded in direct solar data and proxies, *Solar Phys.* **211**, 371-394].

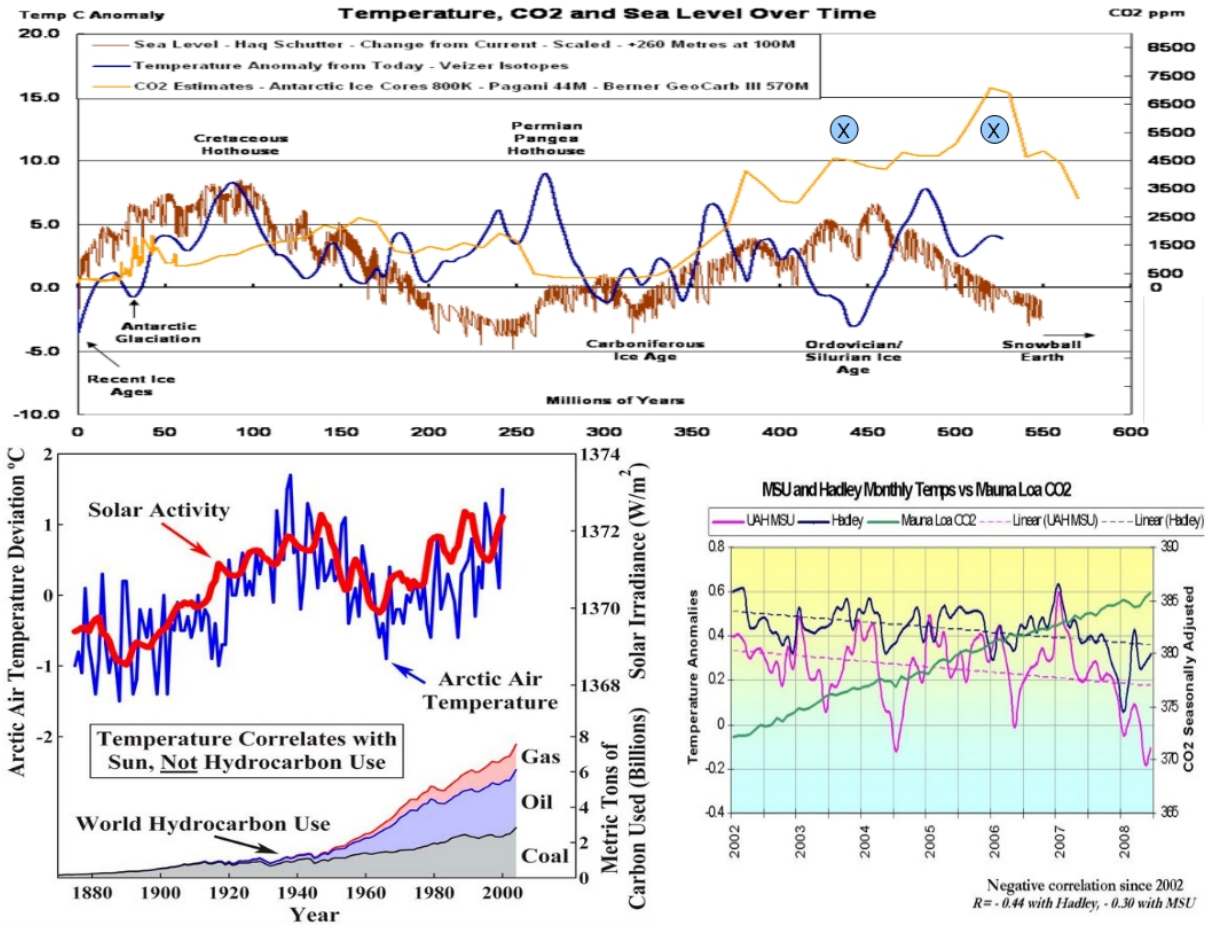
Appendix W. The bi-secular solar cycle: Is a 2010-2050 little ice age imminent?



Top: The figure shows the sunspot record. Data from Appendix E and V suggest that there exists a large bi-secular solar cycle with period roughly between 160 and 260 years, which corresponds to the Suess frequency band. See the figures and Table 1 in Ogurtsov *et al.* [2002, Long-period cycles of the suns activity recorded in direct solar data and proxies, *Solar Phys.* **211**, 371-394]. These cycles are responsible for the little Ice Age periods seen in the climate during the last millennium. The latest little ice age on the Earth occurred during the solar Dalton Minimum lasting from about 1790 to 1830.

Bottom: Solar cycles #1, 2, 3 and 4 are compared with the solar cycles #20, 21, 22 and 23. The two sequences are separated by about 210 years. The figure suggest a repeating pattern. There is an increase during the cycles #1, 2 and 3 followed by a decrease in cycle #4 that repeats for the cycles #20, 21, 22 and 23. Also the length of cycle # 4 almost corresponds to the length of cycle #23, which was about 13 years. If the bi-secular solar cycle repeats, a new solar minimum lasting a few decades should be expected. This new low solar activity cycle may induce a further cooling of the climate during the first half of the 21st century.

Appendix X. Temperature records do not correlate to CO_2 records



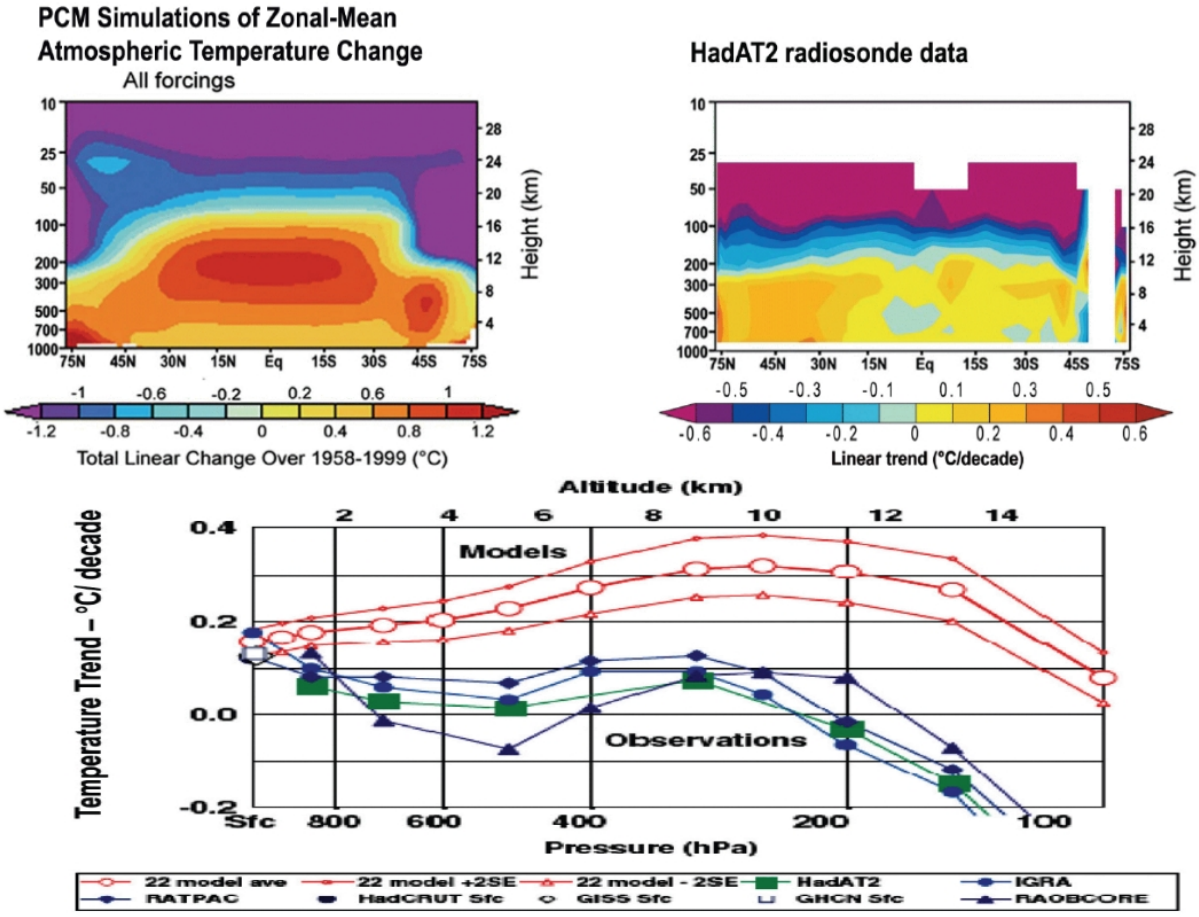
Top panel: Historically, there has been much more CO_2 in our atmosphere than exists today. During the Jurassic Period (200 Mya), average CO_2 concentrations were about 1800 ppm or about 4.7 times higher than the current value (about 390 ppm). The highest concentrations of CO_2 during the Paleozoic Era occurred during the Cambrian Period, nearly 7000 ppm. This is about 18 times higher than today. The Carboniferous Period and the Ordovician Period were the only geological periods during the Paleozoic Era when global temperatures were as low as they are today. Curiously the Late Ordovician Period (450 Mya) was also an Ice Age while at the same time CO_2 concentration was nearly 12 times higher, about 4400 ppm, than the current value. According to the anthropogenic greenhouse theory, the Earth had to be exceedingly hot. Instead, global temperatures were much cooler than today.

Bottom left panel: the arctic air temperature is compare against a total solar irradiance proxy reconstruction (Hoyt and Schatten (1997), *The Role of the Sun in Climate Change*) and against the world hydrocarbon use. Evidently, the temperature fits the solar record, which shows a similar modulation, much more than the anthropogenic forcing that increases monotonically. [Soon W.-H. (2009), Solar Arctic-Mediated Climate Variation on Multidecadal to Centennial Timescales: Empirical Evidence, Mechanistic Explanation, and Testable Consequences, *Physical Geography* **30**, 144-184.]

Bottom right panel: Monthly global temperature records are compared to the atmospheric CO_2 concentration record since 2002. It is evident that the temperature decreased slightly while the atmospheric CO_2 concentration monotonically increased.

All figures clearly show that the Earth's temperature in modulated by several factors besides atmospheric CO_2 concentration. Solar cycles and other natural astronomical events appear to play a dominant role.

Appendix Y. The CO_2 fingerprint: Climate model predictions and observations disagree



Climate models predict that, if GHGs are driving climate change, there will be a unique fingerprint in the form of a warming trend increasing with altitude in the tropical troposphere. However, this fingerprint is not found in the data. This fact additionally questions the accuracy of the IPCC climate models and their capacity of correctly interpret climate change.

Top left: Greenhouse-model-predicted temperature trends versus latitude and altitude; this is figure 1.3F from the US Climate Change Science Program (CCSP) 2006, p. 25.

Top right: Observed radiosonde temperature data trends by the Hadley Center versus latitude and altitude; this is figure 5.7E from CCSP 2006, p. 116. Notice the absence of increased temperature trends in the tropical mid-troposphere. Karl, T.R., S.J. Hassol, C.D. Miller, and W.L. Murray (eds.) 2006. *Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences. A report by the Climate Change Science Program and Subcommittee on Global Change Research*, http://www.climatescience.gov/Library/sap/sap1-1/finalreport/sap1-1-final-all.pdf

Bottom: Disparity between models and temperature data trends (in degrees C/decade) versus altitude in the tropics. Models show an increase in the warming trend with altitude, but balloon and satellite observations do not. Douglass, D.H., J.R. Christy, B.D. Pearson, and S.F. Singer (2007). A comparison of tropical temperature trends with model predictions. *Intl J. Climatology*. DOI:10.1002/joc.1651.

Appendix Z. The 2007 IPCC climate model projections. Can we trust them?

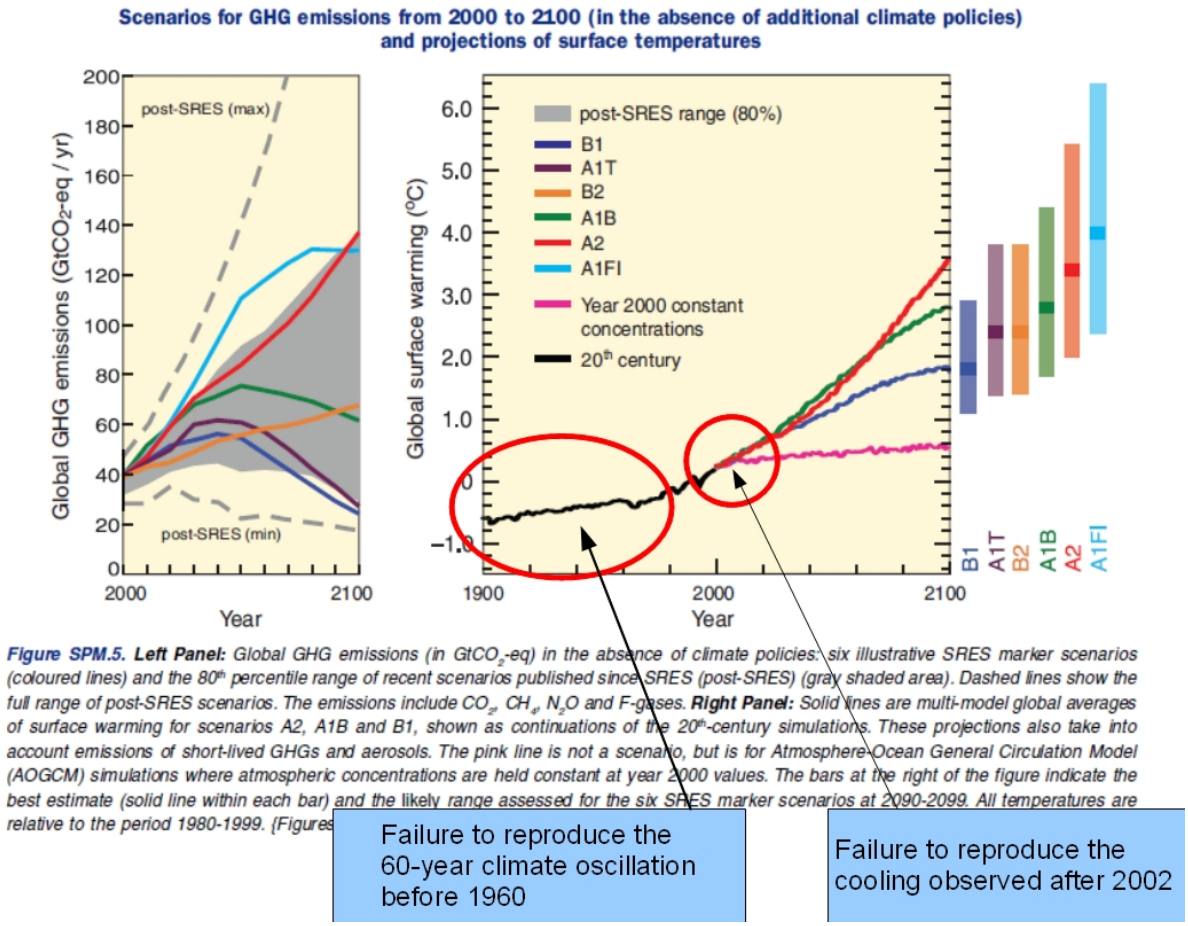


Figure SPM.5. ***Left Panel:*** *Global GHG emissions (in $GtCO_2$-eq) in the absence of climate policies: six illustrative SRES marker scenarios (coloured lines) and the 80th percentile range of recent scenarios published since SRES (post-SRES) (gray shaded area). Dashed lines show the full range of 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. {Figures*

The figure shows the climate model simulations and projections proposed by the IPCC 2007. The scientific method is based on four simple steps: 1) obtain some data about a given phenomenon, ie, a global surface temperature time series; 2) develop a theoretical model to explain the observed data; c) verify that the model actually reproduces the obtained data; 4) check that the model does correctly predict future data. If the last two steps fail, change the model and repeat the process. In the case of the climate models used by the IPCC it appears that the last two steps are poorly implemented. The models do not seem to reproduce the large 60 year cycle that is observed in the past temperature data. For example, the above simulation clearly fails to reproduce the 0.4 ^oC warming observed from 1910 to 1940, and the projections have failed to reproduce the slight cooling observed from 1940 to 1970 and since 2002 despite the fact that the anthropogenic GHG has increased, as projected. Indeed, these climate models appear to have been calibrated in such a way that the increase in anthropogenic GHGs observed since 1970 plus anthropogenic aerosol could reproduce, in the model simulations, the observed warming trend from 1970 to 2000. The calibration process takes advantage of the large uncertainty related to the anthropogenic forcing of climate. However, once calibrated to reproduce the 1970-2000 warming in this way, these models fail to reproduce the 1910-1940 warming which is very similar to the 1970-2000 warming. During this period anthropogenic forcing increased very little and, for the opposite reason, they fail to reproduce the cooling observed from 1940 to 1970 and since 2002, during which anthropogenic GHGs greatly increased. Consequently, the IPCC models are either incomplete or erroneous.

Nicola Scafetta graduated from the Universita' di Pisa (Italy) in Physics in 1997 and from the University of North Texas with a Ph. D. in physics in 2001. From 2002 to 2005 he was a research associate and since 2005 a research scientist at the department of physics at Duke University. His interest is in theoretical and applied statistics and nonlinear models of complex processes including solar-climate physics and climate change. He has taught Astronomy at Duke University, and several undergraduate and graduate physics courses at the University of North Carolina in Greensboro, at the University of North Carolina in Chapel Hill and at Elon University. He is currently associated and a co-investigator of the Active Cavity Radiometer Irradiance Monitor (ACRIM). He has over 48 peer-review scientific publications of various kinds. He is a contributor author of *"Climate Change Reconsidered: The Report of the Nongovernmental International Panel on Climate Change (NIPCC)"* editors S. Fred Singer and Craig Idso, The Heartland Institute, 2009. He is the author with Bruce J. West of *Disrupted Networks: From Physics to Climate Change*, World Scientific Publishing Company, 2010. He has organized several scientific international conference sessions focusing on solar variation and climate change for the American Geophysical Union.

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