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Global Warming: CO2 vs Sun

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1. Introduction

It is an undoubted fact, within the scientific community, that the global temperature has increased by about 0.7°C over the last century, a figure that is considered disproportionally large. With the whole world being alarmed, the scientific community has assumed the task to explain this warming phenomenon. This has resulted in the formation of basically two schools of thought with two opposing theories.

The first theory (the most popular one) claims that the prime guilty for the recent temperature increase is the release of greenhouse gases – mainly Carbon Dioxide (CO2) – coming mostly from the burning of fossil fuels, the clearing of land and the manufacture of cement. Due to these anthropogenic activities the concentration of CO2 has increased by about 35% from its 'pre-industrial' values, with all the resulting consequences.

There are though other factors – besides the greenhouse gases – that affect the global temperature, like changes in solar activity, cloud cover, ocean circulation and others. Therefore, the 'second' theory claims that it is the Sun's activity that has caused the recent warming that, *incidentally* in this theory, is considered to be in the generally expected limits of the physical temperature variation throughout the aeons. One assumption on how the Sun is affecting the climate is that the magnetic field and the solar wind modulate the amount of high energy cosmic radiation that the earth receives. This in turn affects the low altitude cloud cover and the amount of water vapor in the atmosphere and thus regulates the climate. (It must be noted that water vapor is considered as the main greenhouse gas.)

In the sequel both of the above-mentioned theories are examined and conclusions about their soundness are drawn. Firstly (section 2), an analysis in past time of the temperature of the Earth is presented, showing that today's temperatures are not in any way extraordinary, unnatural or exceptional, contrary to what many scientists claim. In fact, on large time scale today's temperatures agree with what was expected for this geologic period, while on a small time scale the higher temperatures observed are the result of a natural recovery of the planet from the global coldness of the Little Ice age.

In section 3, the view of the Intergovernmental Panel on Climate Change (IPCC) on the effect of the accumulation of the CO2 in the atmosphere is presented. Then, in section 4 the CO2 accumulation effect during the past is examined on large and small time scales. Note that Florides & Christodoulides (2009) using three independent sets of data (collected from ice-cores and Chemistry) presented a specific regression analysis and concluded that forecasts about the correlation between CO2-concentration and temperature rely heavily on the choice of data used, making it very doubtful if such a correlation exists or even, if

existing, whether it leads to a gentle or any global warming at all. A further analysis of existing data suggested that CO2-change is not a negative factor for the environment. In fact it was shown that biological activity has generally benefited from the CO2-increase, while the CO2-change history has affected the physiology of plants. Moreover, here, an extensive analysis based on data from physical observations is presented.
Section 5 is concerned with the Sun. The Sun radiation varies in amount with respect to time and affects accordingly the environment of the earth. The factors that affect the Sun radiation reaching the earth on long time scales are physical and are mainly due to the so-called Milankovitch cycles. It is also shown that the Sun's activity is another major factor. At the present time during the course of the solar cycle, the total energy output of the sun changes by only 0.1%. On the other hand, the ultraviolet radiation from the sun can change by several percent but the largest changes, however, occur in the intensity of the solar wind and interplanetary magnetic field. Finally, it is claimed that cosmic rays could provide the mechanism by which changes in solar activity affect the climate. We close with our concluding statements in section 6.

2. A matter of time scale

In this section time series of mean global temperatures are presented to examine the presence of any unusual ongoing global warming.
In Fig. 1 we present the observation datasets (variance adjusted, version CRUTE3Vgl) for the last decade's combined land and marine temperature anomalies on a 5°×5° grid-box basis, as published by the Met Office Hadley Centre (2010). A slight downward trend can be observed with a mean anomaly of about 0.45°C.

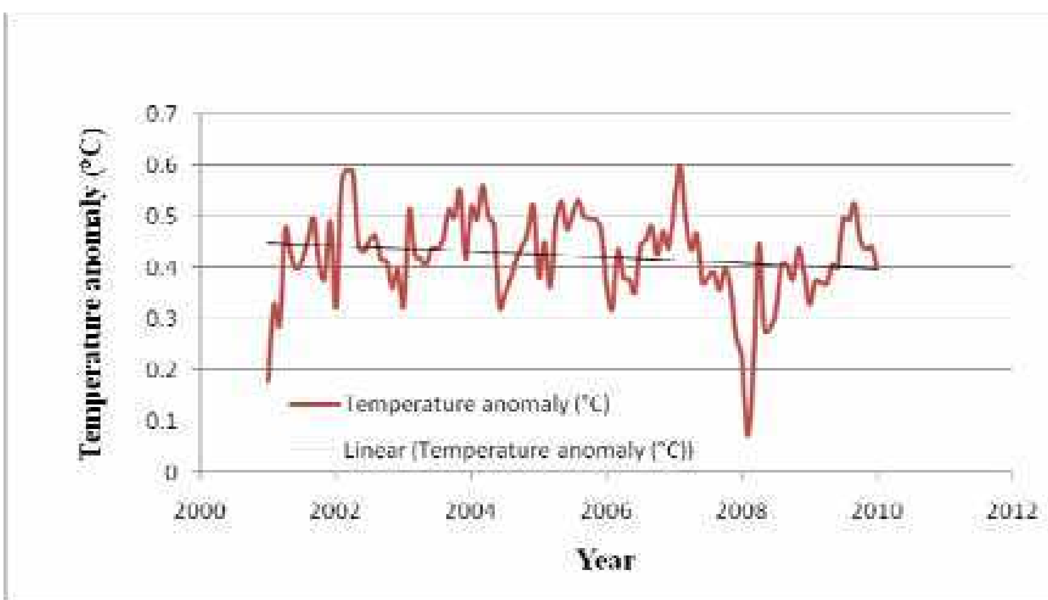

Fig. 1. Global temperature anomaly from 2001 to 2010 showing a slight downward trend.

For a longer period in time the Met Office Hadley Centre data-set shows a slightly negative temperature slope between 1850 and 1915, a positive slope between 1916 and 1943, a slightly negative slope between 1944 and 1968 and a positive slope between 1969 and 2000 (see Fig. 2). In all there is an increase in the global temperature between 1850 and today of about 0.8°C. Note that year 1850 signals the beginning of systematic recordings of temperatures.

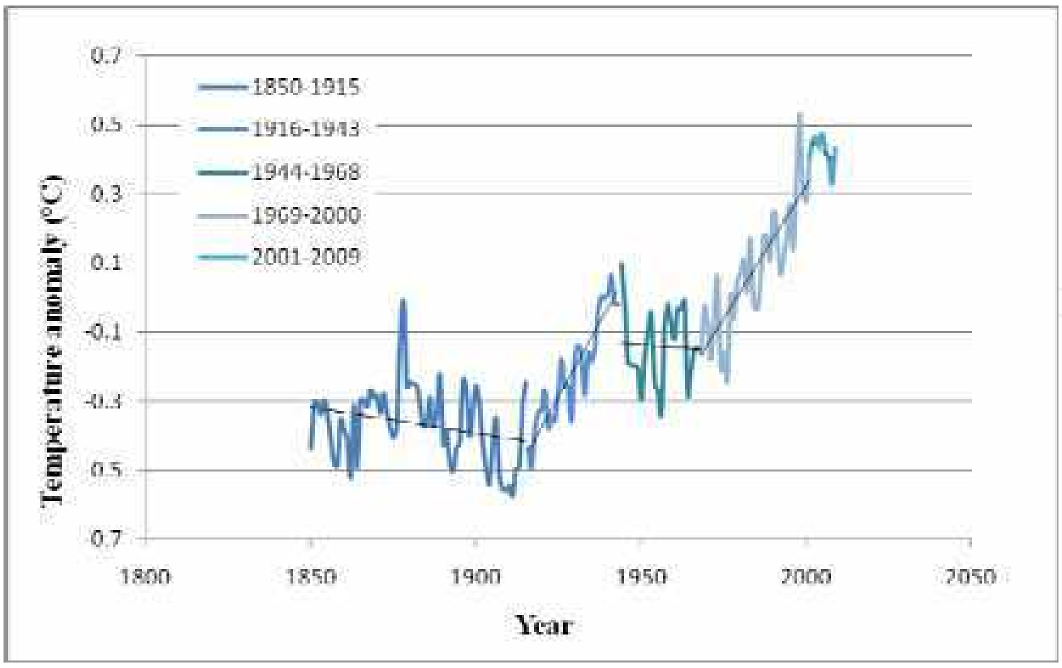

Fig. 2. Global temperature anomaly since 1850 exhibiting differing trends.

Still, a 150 year-span is not sufficient to convincingly answer the question of how temperature varies with time. It is unavoidable that only indirect methods can give insight to this matter. Such methods include extracting temperature information from tree rings, measuring borehole temperatures, the use of pollen and/or diatoms, measuring cave layer thickness, obtaining speleotherm data, collecting stalagmite oxygen isotope data, obtaining $\delta^{18}O/Mg/Ca$ data and so forth. As expected, the methods are not perfect and assessment of the data requires great knowledge of all possible affecting factors.

One such series of data, studying pre-1850 temperatures, has been used by the Intergovernmental Panel on Climate Change (IPCC) of the United Nations in their Fourth Assessment Report (2007a, p. 467). Their graph, reproduced here in Fig. 3, shows the various

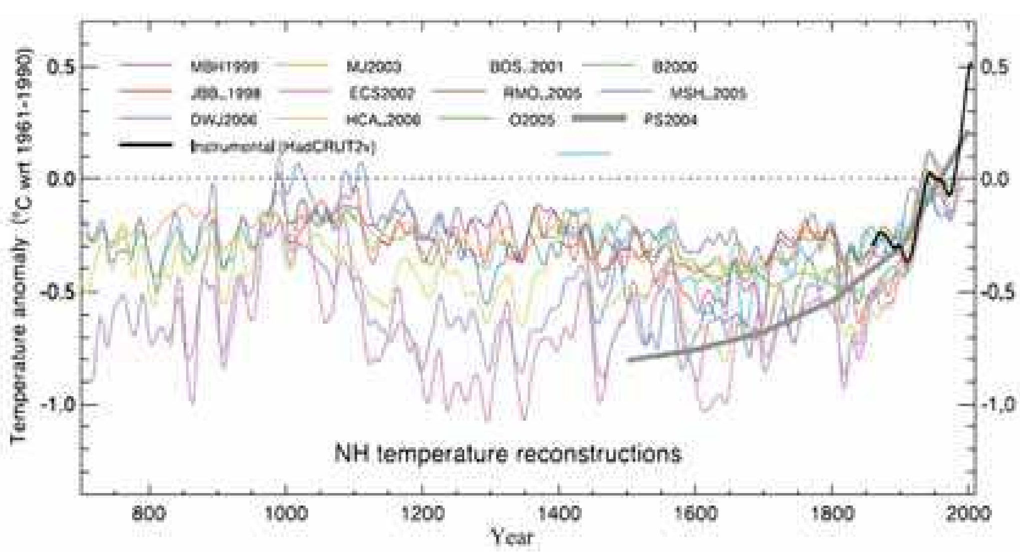

Fig. 3. IPCC's (2007) instrumental and proxy climate data of the variations in average large-scale surface temperatures over the last 1300 years for the North hemisphere.

instrumental and proxy climate data of the variations in average large-scale surface temperatures over the last 1300 years for the North hemisphere. Fig. 3 clearly shows that the warming experienced in the last decades of the 20th century is prominent and it had never been surpassed during the studied time period.
The temperature graphs presented by the IPCC (especially the "hockey stick" reconstruction of Mann et al., 1999) have been severely criticized (see for example Soon & Baliunas, 2003; McIntyre & McKitrick, 2003; the National Academy of Sciences (NAS) Report, 2006; the Wegman Report, 2006; McIntyre, 2008). It has been independently ascertained that Mann's PC method produces unreal "hockey-stick" shapes. It is worth inspecting McIntyre & McKitrick's (2010) reconstruction of the MBH98 data series of Fig. 3. After a critical analysis of the data the reconstruction presents high early 15th century values, as shown in Fig. 4. In recent years there have been numerous publications examining and updating old proxy data and improving the statistical methods for extracting more reliable results for the past temperature variation. Two such studies are presented below.

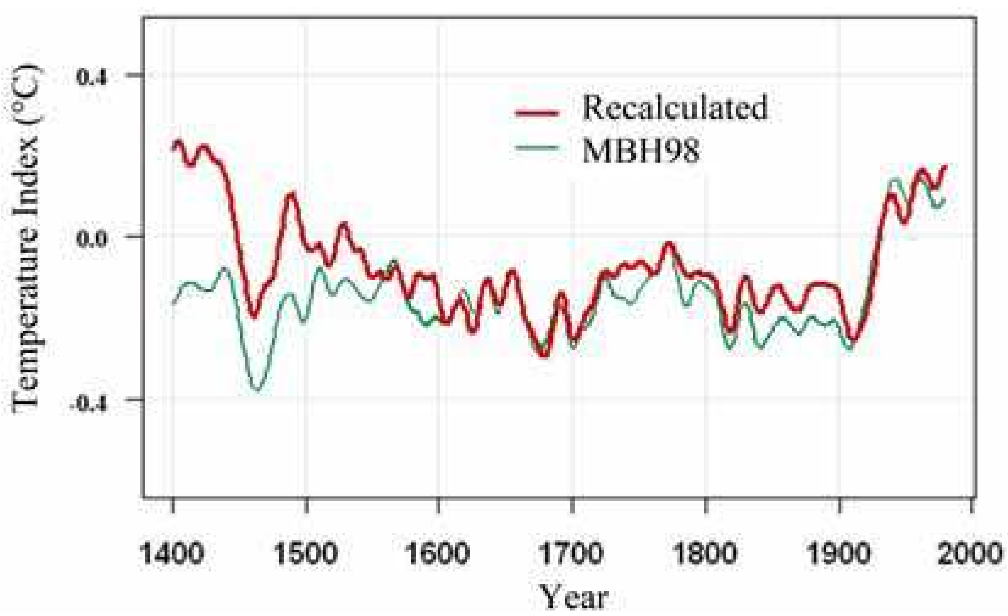

Fig. 4. McIntyre and McKitrick's (2010) reconstruction of the MBH98 data series.

(a) Grudd (2008) presented updated tree-ring width (TRW) and maximum density (MXD) from Tornetrask in northern Sweden, covering the period AD 500-2004. This reconstruction is compared with two previously published temperature reconstructions based on tree-ring data from Tornetrask (Fig. 5). The red curve is from Briffa et al. (1992) based on TRW and MXD. These data subsequently found their way in various other multiproxy reconstructions. The hatched curve is from Grudd et al. (2002) and is based on TRW. The three reconstructions were equally smoothed with a 100-year spline filter and have AD 1951-1970 as a common base period. Fig. 5 also shows the Grudd (2008) revised Tornetrask MXD low frequency reconstruction of April-August temperatures (blue curve), with a 95% confidence interval (grey shading). Grudd mentions that the updated data enable a much improved reconstruction of summer temperature for the last 1500 years in northern Fennoscandia and concludes that the late-twentieth century is not exceptionally warm in the updated Tornetrask record. On decadal-to-century timescales, periods around AD 750, 1000, 1400 and 1750 were all equally warm, or warmer. The warmest summers in this reconstruction occur in a 200-year period centered on AD 1000. A "Medieval Warm Period" is supported by other paleoclimate evidence from northern Fennoscandia, although the new tree-ring evidence from Tornetrask suggests that this period was much warmer than previously recognized.

(b) - Loehle & McCulloch (2008) presented a reconstruction using data that largely excluded tree-ring records to investigate the possible effect of proxy type on reconstruction outcome (Fig. 6). Again confidence intervals were computed for more robust evaluation of the results.

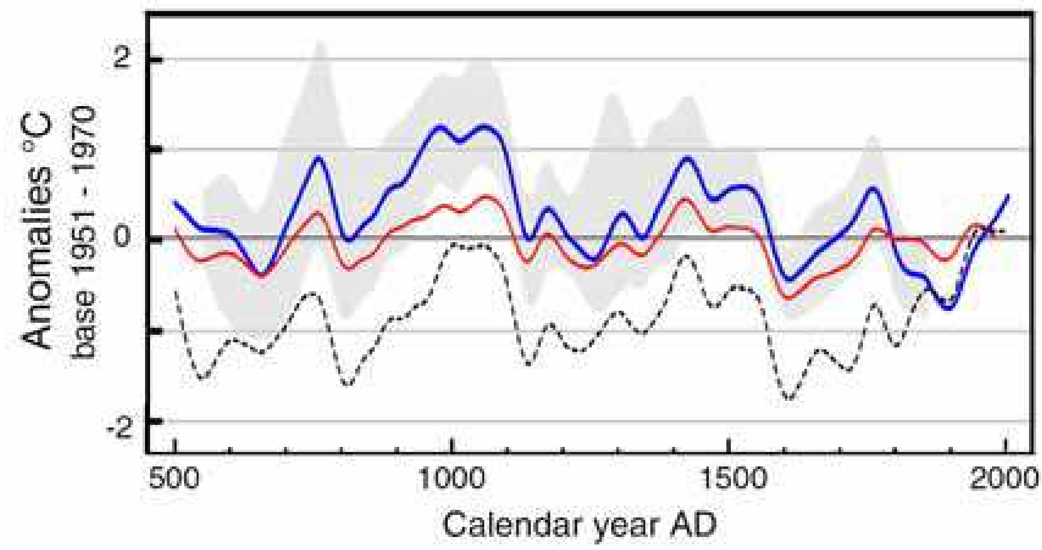

Fig. 5. Reconstructions by Grudd (2008) (blue curve) with a 95% confidence interval (grey shading) compared to Briffa et al. (1992) (red curve) and Grudd et al. (2002) (hatched curve).

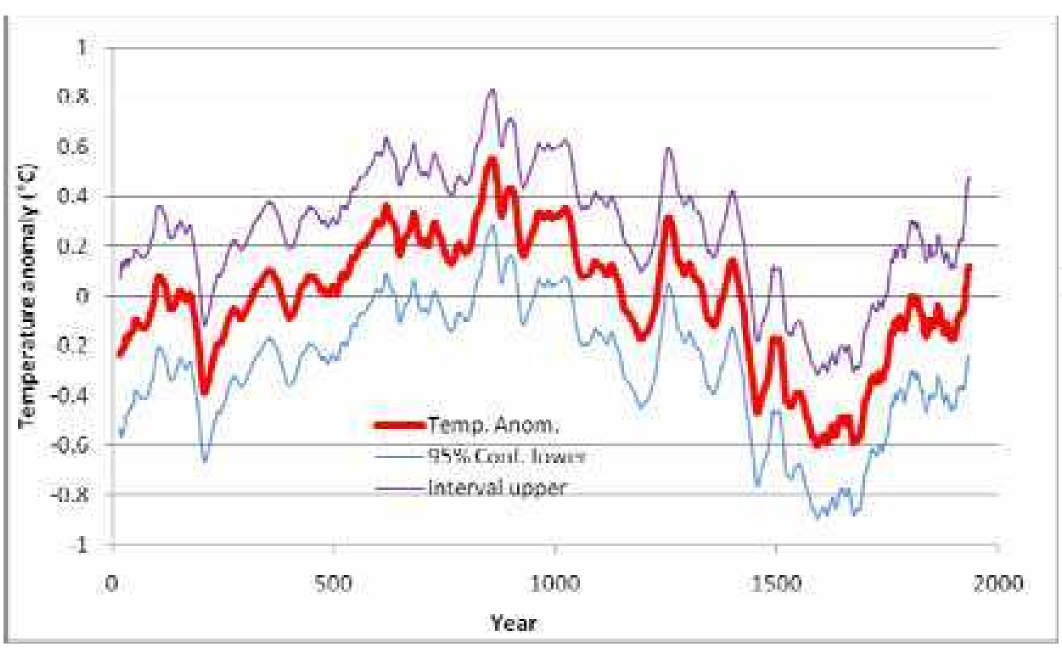

Fig. 6. Loehle & McCulloch (2008) temperature reconstruction.

The obtained data are for long series that had been previously calibrated and converted to temperature by their respective authors. All data that were used had at least 20 dates over

the 2000-year period. The final results were smoothed (29-year running mean), therefore peaks and troughs are damped compared to annual data. Thus it is not possible to compare recent annual data to this figure and ask about anomalous years or decades. The results continue to show the Medieval Warm Period (MWP) and the Little Ice Age (LIA) quite clearly. The 95% confidence intervals indicate that the MWP was significantly warmer than the bimillennial average during most of approximately 820-1040 AD. Likewise, the LIA was significantly cooler than the bimillennial average during most of approximately 1440-1740 AD. The peak value of the MWP is 0.526°C above the mean over the period (again as a 29-year mean, not annual, value). This is 0.412°C above the last reported value in 1935 (which includes data through 1949) of 0.114°C. The main significance of these results is the overall picture of the 2000 year pattern showing the MWP and LIA timing and curve shapes.
Finally, observing the temperature fluctuation on an even larger scale, we present the results derived from the European Project for Ice Coring in Antarctica (EPICA, 2010). EPICA is a multinational European project for deep ice core drilling. Its main objective is to obtain full documentation of the climatic and atmospheric record archived in Antarctic ice by drilling and analyzing two ice cores and comparing these with their Greenland counterparts. The site of Concordia Station, Dome C, was chosen to obtain the longest undisturbed chronicle of environmental change, in order to characterize climate variability over several glacial cycles. Drilling, reaching a depth of 3270.2 m, 5 m above bedrock, was completed in December 2004. Presenting the results of the project above, Jouzel et al. (2007) mention that a high-resolution deuterium profile is now available along the entire European Project for Ice Coring in Antarctica Dome C ice core, extending this climate record back to marine isotope stage 20.2, about 800000 years ago.
The general correspondence between Dansgaard-Oeschger events and their smoothed Antarctic counterparts for this Dome C record were assessed and revealed the presence of such features with similar amplitudes during previous glacial periods. It was suggested that the interplay between obliquity and precession accounts for the variable intensity of interglacial periods in ice core records. Fig. 7, presents the temperature variation ΔT for the

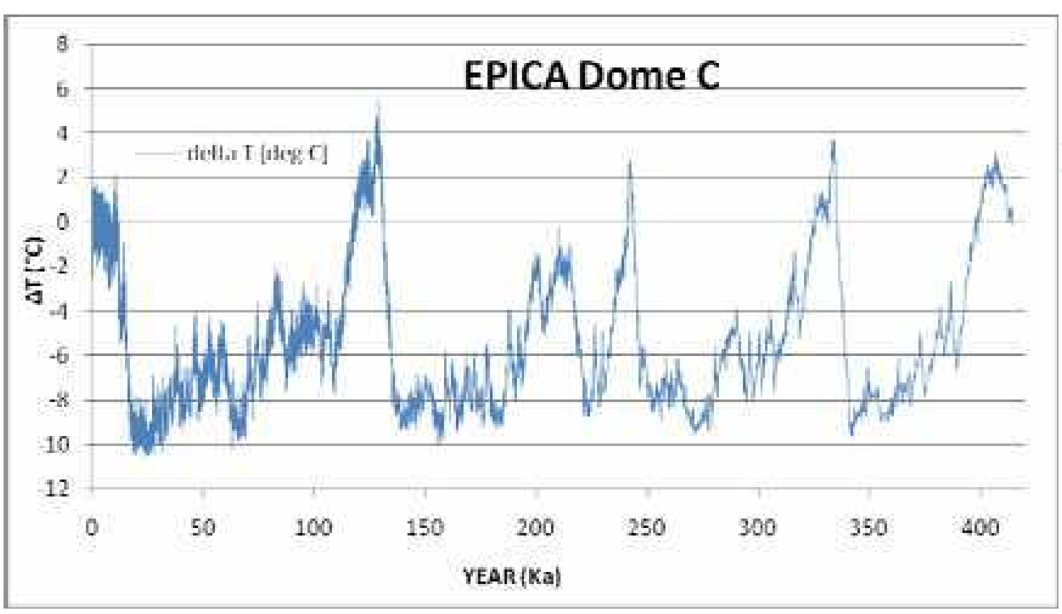

Fig. 7. Jouzel et al. (2007) EPICA reconstruction.

past 420000 years indicating that nowadays we are at a pick point (at about 1.5-2°C) and that the temperature was higher during all four previous recorded picks (128 ka at about 5°C, 242 ka at about 2.4°C, 333 ka at about 3.7°C and 405 ka at about 2.6°C).
We believe that the analysis presented above clearly shows that the mean environmental temperature of the planet has varied continuously through time and there is probably nothing unusual to last century's 0.7°C increase of temperature.

3. The greenhouse effect

According to IPCC (2007b, p. 144) the Sun powers the climate of the Earth, radiating energy at very short wavelengths. Roughly one-third of the solar energy that reaches the top of Earth's atmosphere is reflected directly back to space. The remaining two-thirds are absorbed by the surface and, to a lesser extent, by the atmosphere. The Earth balances the absorbed incoming energy, by radiating on average the same amount of energy back to space at much longer wavelengths primarily in the infrared part of the spectrum. Much of this emitted thermal radiation is absorbed by the atmosphere and clouds, and is reradiated back to Earth warming the surface of the planet. This is what is called the greenhouse effect.
The natural greenhouse effect makes life as we know it possible because without it the average temperature at the Earth's surface would be below the freezing point of water. However, as IPCC maintains, human activities, primarily the burning of fossil fuels and clearing of forests, have greatly intensified the natural greenhouse effect, causing global warming. The greenhouse effect comes from molecules that are complex and much less common, with water vapor being the most important greenhouse gas (GHG), and carbon dioxide (CO2) being the second-most important one.
In regions where there is water vapor in large amounts, adding a small additional amount of CO2 or water vapor has only a small direct impact on downward infrared radiation. However, in the cold and dry Polar Regions the effect of a small increase in CO2 or water vapor is much greater. The same is true for the cold and dry upper atmosphere where a small increase in water vapor has a greater influence on the greenhouse effect than the same change in water vapor would have near the surface. Adding more of a greenhouse gas, such as CO2, to the atmosphere intensifies the greenhouse effect, thus warming the Earth's climate.
The amount of warming depends on various feedback mechanisms. For example, as the atmosphere warms up due to rising levels of greenhouse gases, its concentration of water vapor increases, further intensifying the greenhouse effect. This in turn causes more warming, which causes an additional increase in water vapour in a self-reinforcing cycle. This water vapor feedback may be strong enough to approximately double the increase of the greenhouse effect due to the added CO2 alone.
IPCC (2007b, p. 121) reports that climate has changed in some defined statistical sense and assumes that the reason for that is anthropogenic forcing. As it states, traditional approaches with controlled experimentation with the Earth's climate system is not possible. Therefore, in order to establish the most likely causes for the detected change with some defined level of confidence, IPCC uses computer model simulations that demonstrate that the detected change is not consistent with alternative physically plausible explanations of recent climate change that exclude important anthropogenic forcing. The results of the computer simulations are that anthropogenic CO2 emissions to the atmosphere are the main reason for the observed warming and that doubling the amount of CO2 in the atmosphere will increase the temperature by about 1.5°C to 4.5°C. A similar result is mentioned in IPCC

(2007c, p. 749), where the equilibrium global mean warming for a doubling of atmospheric CO2, is likely to lie in the range 2°C to 4.5°C, with a most likely value of about 3°C.
In IPCC (1997, p. 11) the formula for calculating the radiative forcing for a CO2 doubling gives 4.0–4.5 W×m^{-2} before adjustment of stratospheric temperatures. Allowing for stratospheric adjustment reduces the forcing by about 0.5 W×m^{-2}, to 3.5–4.0 W×m^{-2}. If temperature were the only climatic variable to change in response to this radiative forcing, then the climate would have to warm by 1.2°C in order to restore radiative balance. The new formula for radiative forcing in W×m^{-2} is given as:

$$\Delta Q = 4.37 \frac{\ln C(t) - \ln C_0}{\ln 2} \quad (1)$$

where C(t) is today's CO2 concentration and C_0 the preindustrial level of 285 ppmv. As seen in Fig. 8, for the present CO2 concentration (385 ppmv) the warming calculated by the above-mentioned formula is 0.6°C, i.e. all the warming occurring from preindustrial era is allocated to the CO2 increase. Also, note that formula (1) above would give an increase of 1.2°C for the doubling of the CO2 concentration to 570 ppmv. In addition, the IPCC models consider a positive feedback because of this increase and depending on the model the final result is between 2°C and 4.5°C for a doubling of atmospheric CO2.

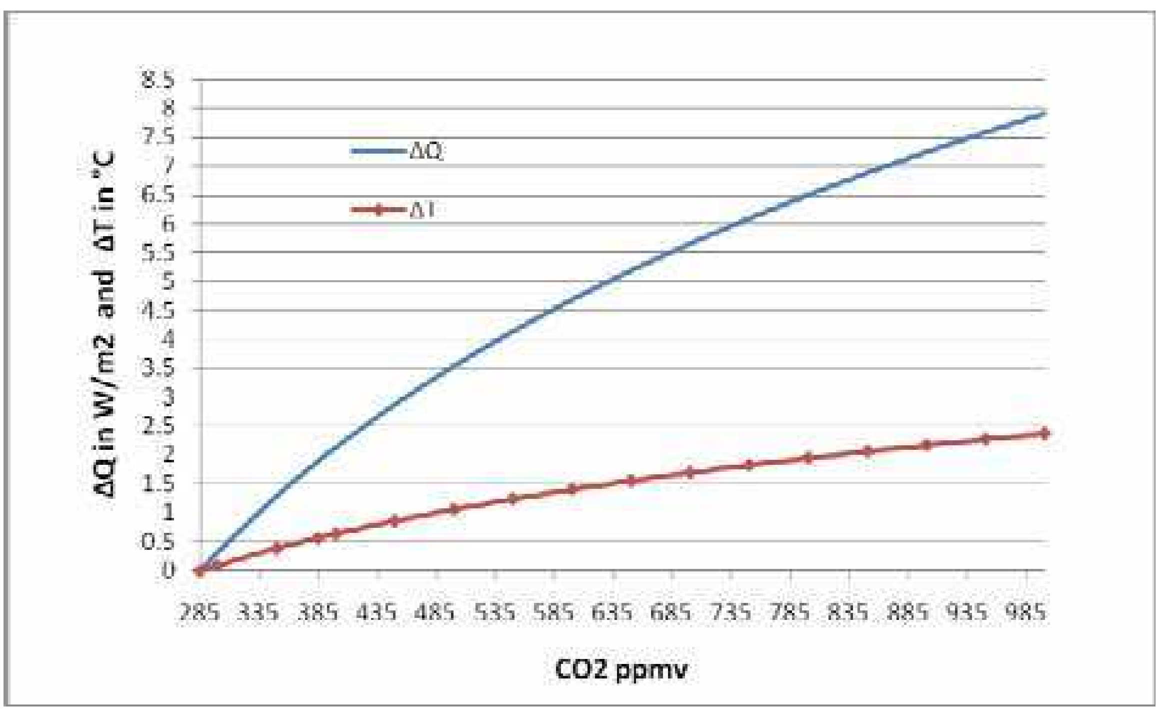

Fig. 8. Radiative forcing and caused warming in order to restore radiative balance evaluated by IPCC with no amplification considered.

As mentioned by the Committee on the Science of Climate Change-National Research Council (2001, p. 5), "the central value of 3°C is an amplification by a factor of 2.5 over the direct effect of 1.2°C. Well-documented climate changes during the history of Earth, especially the changes between the last major ice age (20000 years ago) and the current warm period, imply that the climate sensitivity is near the 3°C value. However, the true climate sensitivity remains uncertain, in part because it is difficult to model the effect of feedback. In particular, the magnitude and even the sign of the feedback can differ according to the composition, thickness, and altitude of the clouds, and some studies have suggested a lesser climate sensitivity." Also on p. 15 of the same book, it is stated that "climate models calculate outcomes after taking into account the great number of climate variables and the complex interactions inherent in the climate system. Their purpose is the creation of a synthetic reality but although they are the appropriate high-end tool for forecasting hypothetical climates in the years and centuries ahead, climate models are imperfect. Their simulation skill is limited by uncertainties in their formulation, the limited size of their calculations, and the difficulty of interpreting their answers that exhibit almost as much complexity as in nature."

4. How much of the global warming is caused by CO2?

4.1. Physical observations

Assuming that the above-mentioned theory of IPCC on CO2 concentration is correct, then one should expect a strong relation between CO2 concentration in the atmosphere and global temperature increase.

Plotting the CO2 concentration and temperature anomaly over the last 40 years (Fig. 9) one can observe that as from 2001 the relation that existed since 1969 has now deviated and although the CO2 concentration is still increasing as before, the temperature has slightly decreased.

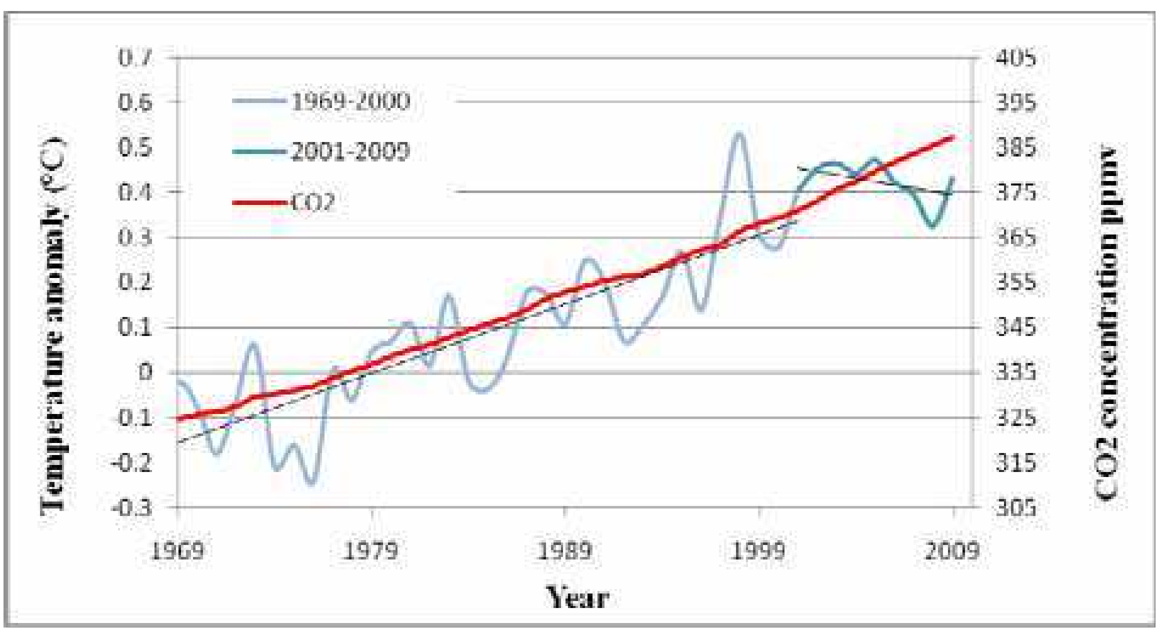

Fig. 9. Comparison of the CO2 trend with temperature from 1969 to 2009.
(Temperature data from: Met Office Hadley Centre, 2010. CO2 data from: Mauna Loa CO2 annual mean data, 2010).

As before (recall Fig. 2), plotting the temperature anomaly along with CO2 concentration since year 1850, one cannot avoid observing that from 1850 to 1915 there was an opposite trend with the temperature cooling, from 1916 to 1943 the trend reversed as the temperature was increasing at a high rate and again from 1944 to 1968 when the CO2 was accumulating at an increased rate the temperature was not increasing (see Fig. 10).

Let us now compare the temperature data and the CO2 variation during greater time spans in order to obtain a deeper insight on how the CO2-concentration change affects the temperature.

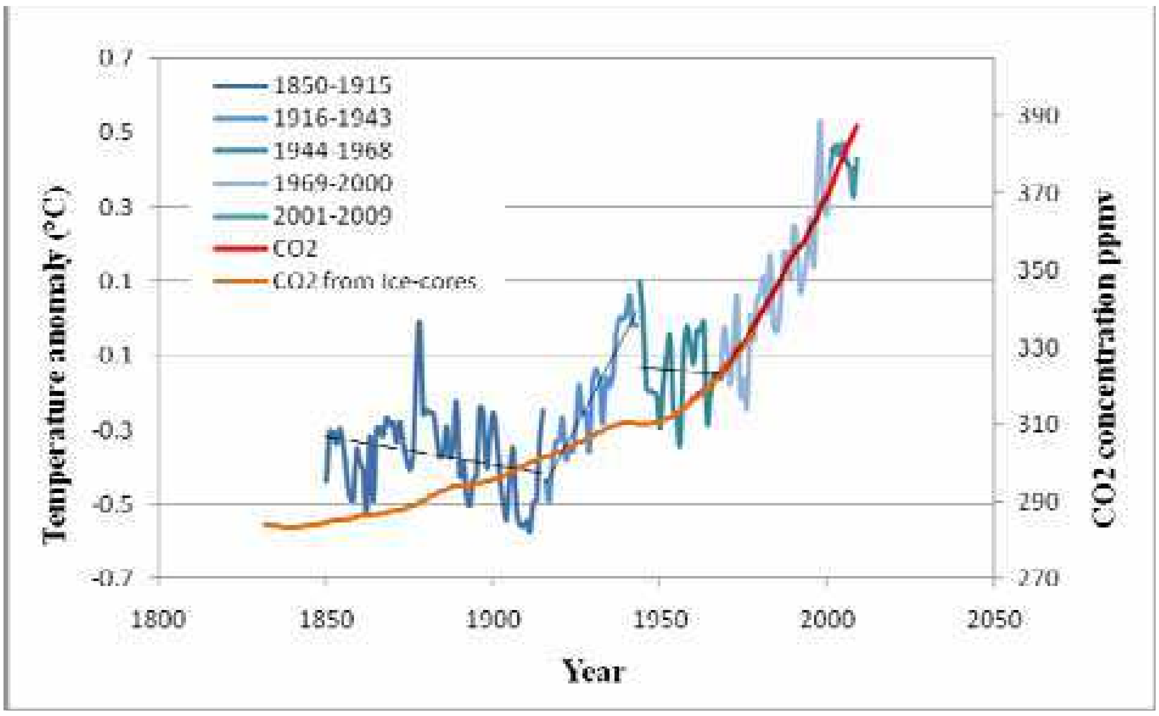

Fig. 10. Comparison of the CO2-concentration trend with temperature anomaly since 1850. (Temperature data from: Met Office Hadley Centre, 2010. CO2 data from: Mauna Loa CO2 annual mean data, 2010 and Historical CO2 record, 1998).

In Fig. 11 the temperature difference in Antarctica (as measured in ice cores by Jouzel et al., 2007) is compared to various CO2 concentrations: Petit et al. (1999) for the past 420000 years from the Vostok ice cores, Monnin et al. (2004) for the High resolution records of atmospheric CO2 concentration during the Holocene as obtained from the Dome Concordia and Dronning Maud Land ice cores, and others. It is clear (see circled points) that the temperature increase by natural causes precedes the CO2-concentration increase.

In fact, concentrating on the period between 400-650 thousand years before present (see Fig. 12) it is even clearer that very frequently CO2-concentration increase (blue circles) follows the temperature-increase that takes place many thousand years in advance (orange circles). Actually only in the era between 580-600 thousand years before now (red circles), did the CO2-rise precede the temperature-rise. The behavior described by Figs. 11 and 12 could possibly show that physical phenomena like the degassing/dilution of CO2 in the oceans, biological effects (plan growth and microbial activity) and so forth, may be the reason for the CO2 change following the temperature fluctuation and not the other way round.

Let us finally check how CO2-concentration has fluctuated throughout the Earth's history and draw conclusions about its correlation with the temperature over the geologic aeons. Palaeo-climatologists calculated palaeolevels of atmospheric CO2 using the GEOCARB III model (Berner & Kothavala, 2001). GEOCARB III models the carbon cycle on long time-scales (million years resolution) considering a variety of factors that are thought to affect the CO2 levels. The results are in general agreement with independent values calculated from the abundance of terrigenous sediments expressed as a mean value in 10 million year time-steps (Royer, 2004).

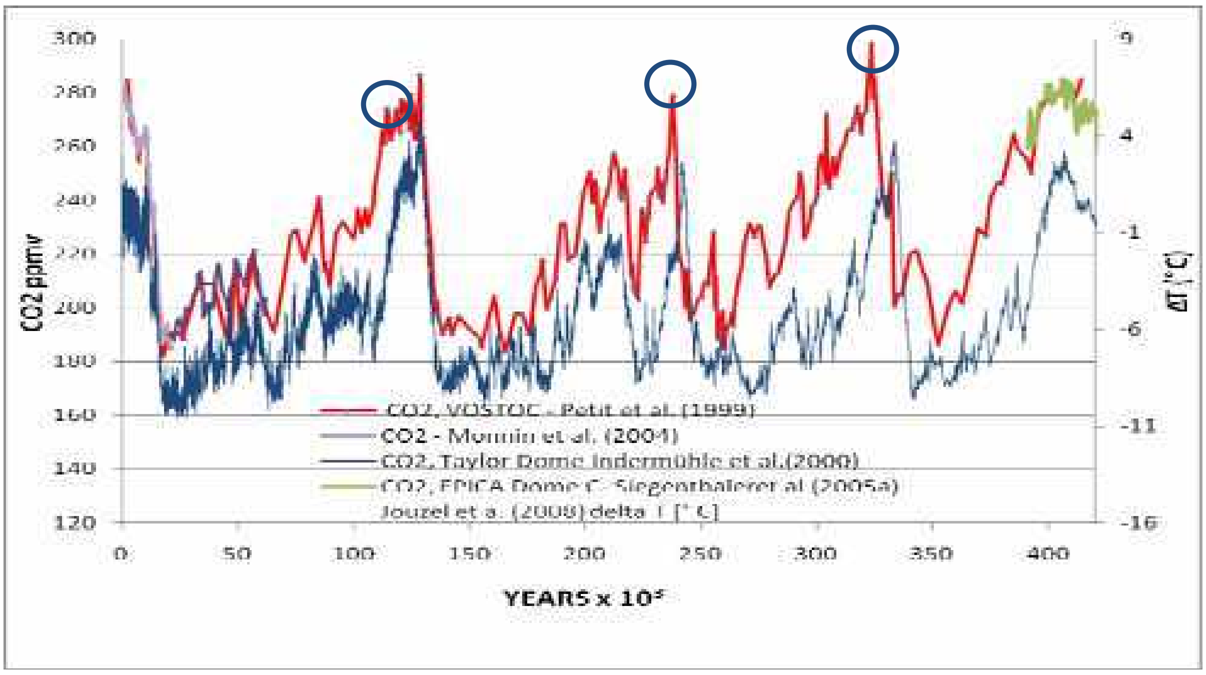

Fig. 11. Circled points indicate CO2-concentration increase following the temperature increase by natural causes.

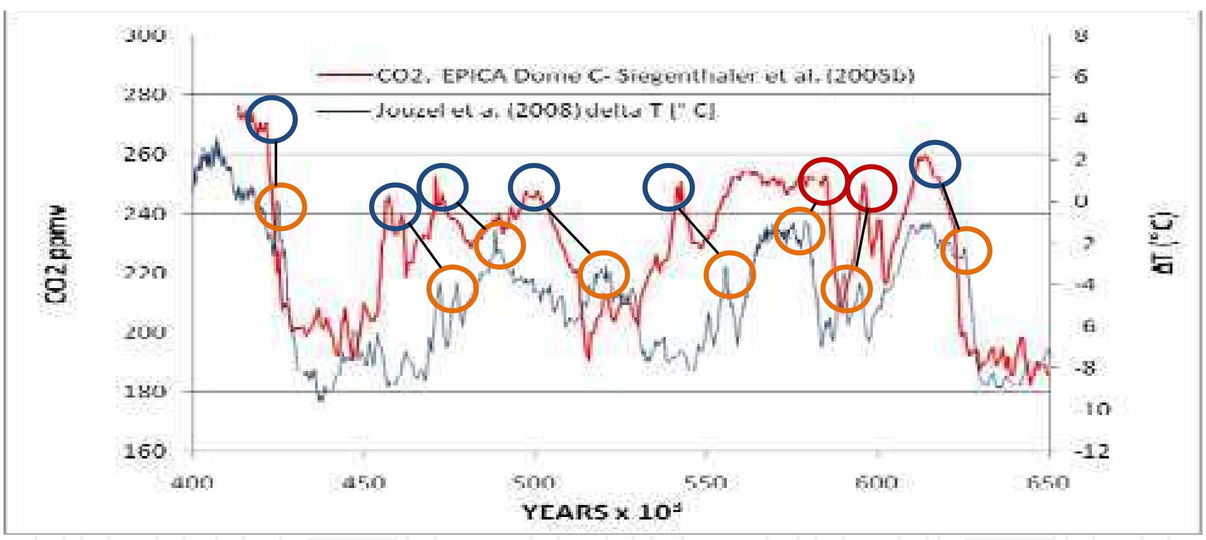

Fig. 12. CO2-concentration increase sometimes follows temperature-increase (blue circles) and sometimes precedes the temperature-rise (red circles).

As shown in Fig. 13A, CO2 levels were very high, about 20-26 times higher than at present, during the early Palaeozoic – about 550 million years ago (Ma). Then a large drop occurred during the Devonian (417–354 Ma) and Carboniferous (354–290 Ma), followed by a considerable increase during the early Mesozoic (248–170 Ma). Finally, a gradual decrease occurred during the late Mesozoic (170–65 Ma) and the Cainozoic (65 Ma to present). In Fig. 13B, C and D the range of global temperature through the last 500 million years is reconstructed. Figure 13B presents the intervals of glacial (dark color) and cool climates (dashed lines). Figure 13C shows the estimated temperatures, drawn to time-scale, from mapped data that can determine the past climate of the Earth (Scotese, 2008). These data include the distribution of ancient coals, desert deposits, tropical soils, salt deposits, glacial material, as well as the distribution of plants and animals that are sensitive to climate, such as alligators, palm trees and mangrove swamps. Figure 13D presents the temperature deviations relative to today from $\delta^{18}O$ records (solid line) and the temperature deviations corrected for *p*H (dashed line).

As indicated in Figure 13B, one of the highest levels of CO2-concentration (about 16 times higher than at present) occurred during a major ice-age about 450 Ma, indicating that it is not the CO2-concentration in the atmosphere that drives the temperature. The logical conclusion drawn from Fig. 13 is that the temperature of the Earth fluctuates continuously and the CO2-concentration is not a driving factor.

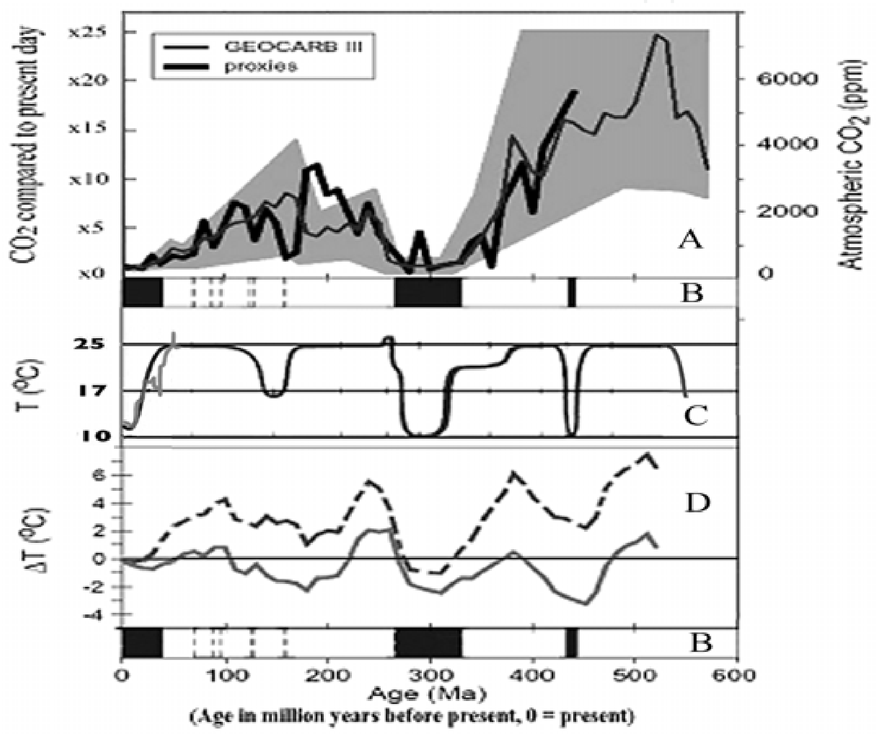

Fig. 13. (A) GEOCARB III model results with range in error shown for comparison with combined atmospheric CO2-concentration record as determined from multiple proxies in average values in 10 Ma time-steps, (redrawn from Royer, 2004). (B) Intervals of glacial (dark color) and cool climates (lighter color) (redrawn from Royer, 2004). (C) Estimated temperature drawn to time scale (Scotese, 2008). (D) Temperature deviations relative to today (solid line - Shaviv and Veizer, 2003) from the “10/50” $\delta^{18}O$ compilation presented in Veizer et al. (2000) and temperature deviations corrected for *p*H (dashed line) reconstructed in Royer (2004) and redrawn from Veizer et al. (2000).

4.2 Physical observations of glacier melting

Huss et al. (2008) determined the seasonal mass balance of four Alpine glaciers in the Swiss Alps (Grosser Aletschgletscher, Rhonegletscher, Griesgletscher and Silvrettagletscher) for the 142-year period 1865–2006. They report that the cumulative mass balance curves show similar behavior during the entire study period, the mass balances in the 1940s were more negative than those of 1998–2006 and the most negative mass balance year since the end of the Little Ice Age was 1947 and not the year 2003 despite its exceptional European summer heat wave. As correctly argued in the NIPCC (2009, p. 145) and shown on the redrawn Fig. 14, the most important observation is the fact that the rate of shrinkage has not accelerated over time, as evidenced by the long-term trend lines they have fit to the data. There is no compelling evidence that this 14-decade-long glacial decline has had anything to do with the air's CO2 concentration.

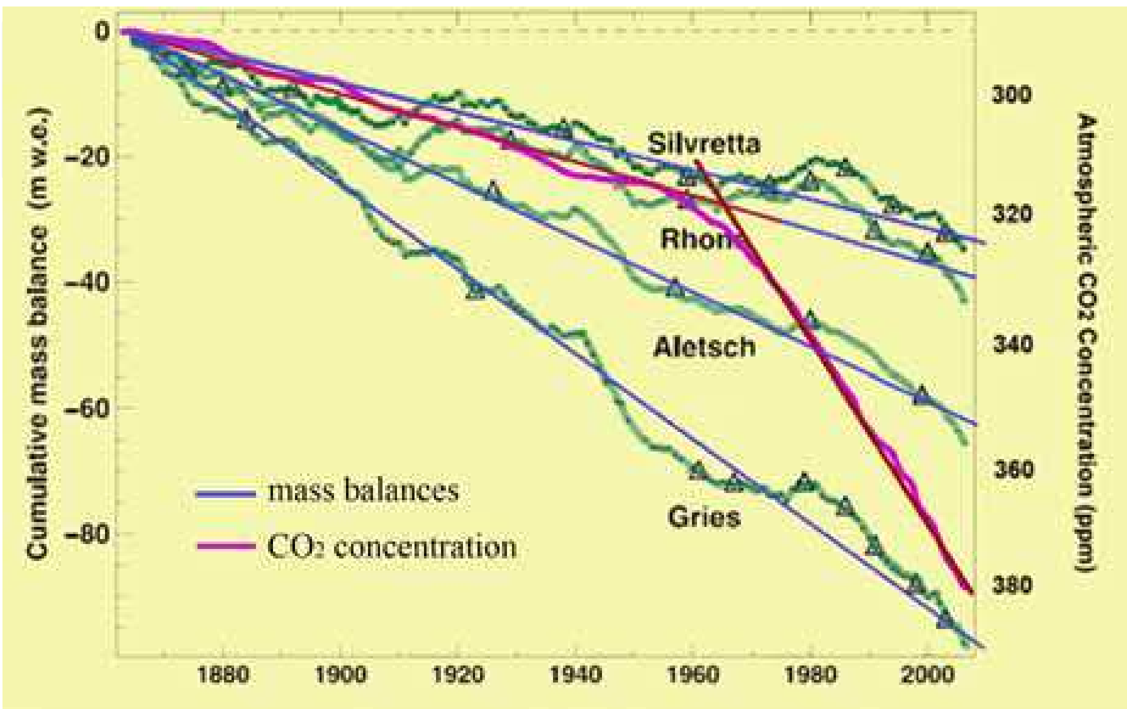

Fig. 14. Time series of the cumulative mass balances of the four Swiss Alps glaciers of Huss et al. (2008). CO2 increase in air concentration shows no inverse effect on their melting rate (redrawn from NIPCC, 2009).

As it is stressed, from 1950 to 1970 the rate-of-rise of the atmosphere's CO2 concentration increased by more than five-fold, yet there were no related increases in the long-term mass balance trends of the four glaciers. It is clear that the ice loss history of the glaciers was not unduly influenced by the increase in the rate-of-rise of the air's CO2 concentration that occurred between 1950 and 1970, and that their rate of shrinkage was also not materially altered by what the IPCC calls the unprecedented warming of the past few decades.
A similar argument to the one above can be applied to a worldwide study of 169 receding glaciers of Oerlemans (2005). Fig. 15 shows the composite average of up to 169 glaciers (the number varies in different time periods) indicating the pattern that is consistent for most glaciers. Exactly as in Fig. 14 for the four Alpine glaciers in the Swiss Alps, the recession of glaciers started long before anthropogenic CO2 levels rose, and naturally there is no indication that since 1970, when the anthropogenic CO2 began increasing at a higher rate, the recession rate of the glaciers has increased.

4.3. A chemist view: vibrational modes and emission spectra

According to Barrett (2005) greenhouse molecules absorb terrestrial radiation, which is emitted by the Earth's surface as a result of the warming effect of incoming solar radiation. Their absorption characteristics allow them to act in the retention of heat in the atmosphere

increasing the global mean temperature. The absorption characteristics of CO_2 depend on the form of the molecule, which is linear and symmetrical about the central carbon atom.
The three vibrational modes of the molecule and their fundamental wave numbers are the symmetric stretch at 1388 cm^{-1}, the antisymmetric stretch at 2349 cm^{-1}, and the bend at 677 cm^{-1}. The CO_2 spectrum is dominated by the bending vibration, centered at 667 cm^{-1}.
As calculated in Barrett (2005), the contributions to the absorption of the Earth's radiance by the first 100 meters of the atmosphere for the pre-industrial CO_2 concentration (285 ppmv) are 68.2% for the water vapor, 17% for CO_2, 1.2% for CH_4 and 0.5% for N_2O. These absorption values add up to 86.9%, which is significantly higher than the actual resulting combined value of 72.9%. This discrepancy occurs because there is considerable overlap between the spectral bands of water vapor and those of the other GHGs. If the concentration of CO_2 were to be doubled in the absence of the other GHGs, the increase in absorption would be 1.5%. But in the presence of the other GHGs the same doubling of CO_2's concentration would yield an increase in absorption of only 0.5%.

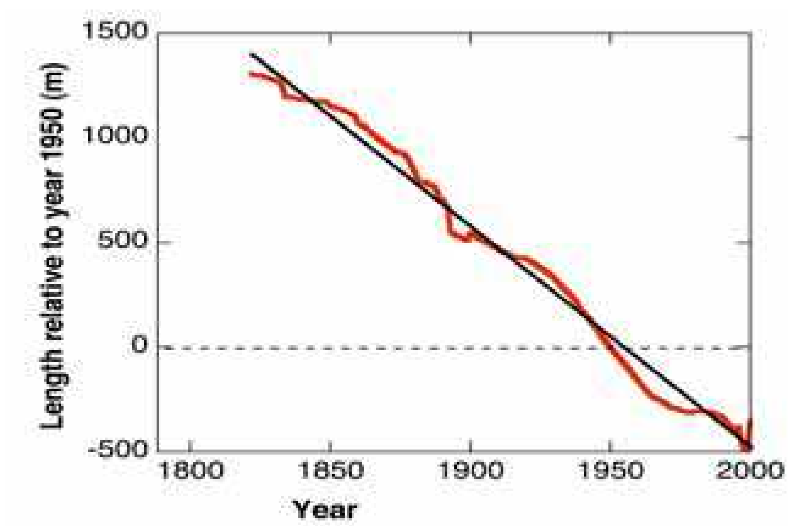

Fig. 15. Curve for the change in mean global glacier length. CO_2-increase in air concentration especially after 1970 shows no inverse effect on their melting rate (modified from Oerlemans, 2005).

As far as temperature-rise is concerned, Barrett & Bellamy (2010) explain that by using the MODTRAN program (which is a state of the art atmospheric transfer code used as a basic tool of research) they compute an increase of 1.5 K, resulting from doubling the pre-industrial CO_2 concentration.
The GHGs absorb 72.9% of the available radiance, leaving 27.1% of it to be transmitted, of which, 22.5% passes through the window, leaving a small amount of 4.6% to be transmitted by the other parts of the spectral range. For the doubled CO_2 case this small percentage decreases slightly to 4.1%. The above-mentioned small percentage transmissions (4.6 and 4.1%) are further reduced by 72.9% and 73.4% respectively, by the second layer of 100 m of the atmosphere so that only about 1%, in both cases, is transmitted to the region higher than 200 m.
Moreover Barrett (2005), states that the 19.6% of pre-industrial CO_2 contribution to the greenhouse effect are responsible for a 6.7 K temperature rise. Doubling of the CO_2 concentration will increase its contribution to 20.9% (which will, by simple analogy, correspond to a 0.44 K additional temperature rise), but at the same time the water vapor contribution will diminish from 78.5 to 77.1%.

To support his results Barrett presents an analysis of three emission spectra of the Earth as recorded by satellites (Fig. 16). As explained from 400–600 cm^{-1} the spectra consist of rotational transitions of water molecules, while the regions from 600–800 cm^{-1} are dominated by the main bending mode of CO2 and some combination bands that are of smaller intensity, together with some of the water rotation bands which overlap with the CO2 bands. Between 800 and 1300 cm^{-1} the spectra correspond to IR window regions with some ozone absorption and emission spectra at around 1043 cm^{-1}, which essentially demonstrate the temperature of the surface when compared to the Planck emission spectra that are incorporated into each spectrum. The Saharan surface temperature is around 320 K (spectrum a), that of the Mediterranean is around 285 K (spectrum b) and that of the Antarctica is around 210 K (spectrum c). Above 1300 cm^{-1}, the spectra consist of vibration-rotation bands of water molecules and the bending vibrations of methane and dinitrogen monoxide molecules.

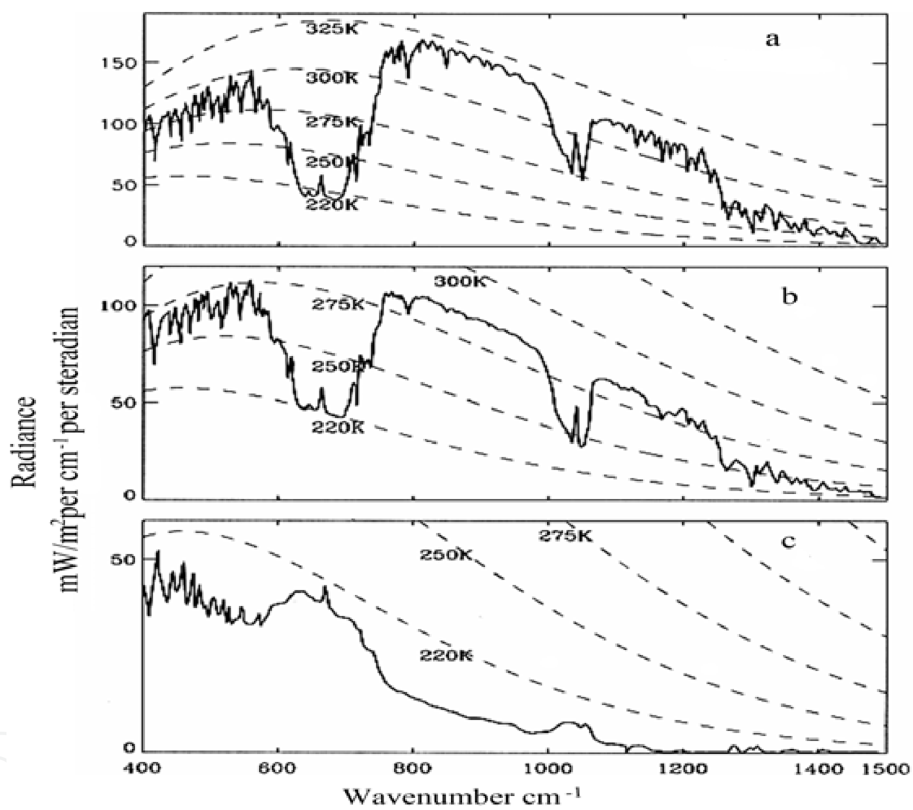

Fig. 16. Emission spectra of the Earth taken by the Nimbus 4 satellite. Spectrum (a) is measured over the Sahara Desert, spectrum (b) over the Mediterranean, and spectrum (c) over the Antarctic

The influence of CO2 can be seen from the Saharan and Mediterranean spectra as absorbing all of the radiation in the 600–800 cm^{-1} regions and emitting about 25% of it. The large absorption areas in the two spectra show how CO2 is an important GHG. Spectrum (c) shows that emission by CO2 in the Polar Regions is relatively more important and arises because of the low water vapor pressure. A detailed estimate of the effects of the GHGs from the analysis of spectra such as those shown in Fig. 16 indicates that CO2 provides about 7–8 K of global warming, in agreement with the conclusion yielding from a study of its absorption characteristics.

Fig. 16 shows that much of the CO_2 emission originates from the atmosphere at a temperature of about 218 K. This part of the atmosphere is at an altitude of about 15 km (tropopause) and is the dividing layer between the troposphere and the stratosphere. Emission from the CO_2 occurs at that level because the air is 'thin', as around 90% of the atmosphere is below that level. The doubling of CO_2 concentration will have as a result the widening of the wings of the saturated band where the additional absorption will occur. It is stressed though (Barrett & Bellamy, 2010) that this increase represents the instantaneous effects of CO_2 changes and it does not include the ameliorating effects of clouds, nor does it include the eventual global consequences of the instantaneous changes.

4.4 A Geophysicist view

The 1970 radiative spectrum from the Earth, measured by Nimbus 4 satellite through clear skies at several locations, clearly shows a deep 'notch' at the 4.77 micron wavelength band caused by the 325 ppmv atmospheric CO_2 concentration of the time (Fig. 16 & Fig. 17). The depth and width of this 'notch' demonstrate that over 90% of the Earth's thermal radiation from this wavelength band that could possibly be affected by CO_2, had already been affected at that concentration (of just 325ppmv). As Karmanovitch & Geoph (2009) mention, we now know that about three quarters of the Earth's 34 K total greenhouse effect is from clouds and only 10% of the effect is from CO_2. Ten per cent of 34 K is 3.4 K and this is exactly the total effect that has resulted from the observed notch in the spectrum from CO_2 as measured by the Nimbus 4 satellite. Since this 3.4 K effect results from 90% of the available energy within this wavelength band, the energy remaining in this band is only capable of adding another 10% to the 3.4 K greenhouse effect already in place. Regardless of how great the concentration of CO_2 in the atmosphere becomes, there is only 10% of the available energy left to capture and the possible additional effect from CO_2 increases is therefore limited to something in the order of just 0.34 K, which is nowhere near the 5–6 K predicted by Arrhenius (the first to provide a simplified expression, still used today, linking the CO_2 concentration to the temperature increase). This result alone clearly falsifies the equation and the numerical values used to determine the forcing parameter of the climate models that support the anthropogenic global warming (AGW) hypothesis of IPCC.
Recent measurements (Karmanovitch & Geoph, 2009) of the thermal radiation spectrum from Mars reveal a spectral notch that is virtually identical on both the 1970 Earth spectra with a 325ppmv (see Fig. 17). Mars has a very thin atmosphere consisting of 95% CO_2, virtually zero water vapor and 5% O_2, N_2 and Ar. So, CO_2 is essentially the only "GHG' with a concentration of 950000 ppmv, being 9 times that of the Earth's in absolute terms. Again, using the formula of the IPCC one should expect, for Mars, a spectral notch from CO_2 that represents an increase in forcing analogous to 9 times difference in CO_2, i.e. a value of 11.755 $W \times m^{-2}$. This is not at all the case, as shown if Fig. 17, indicating that there is virtually no effect increases in CO_2 beyond 325ppmv.

4.5 A planetary climatologist view: a comparison of the CO2 greenhouse effect on Mars, Earth and Venus

As Idso (1988) mentions, in two separate assessments of the magnitude of the CO_2 greenhouse effect, the U.S. National Research Council concluded that the likely consequence of a 300–600 ppmv doubling of the Earth's atmospheric CO_2 concentration would be a 3 ± 1.5 K increase in the planet's mean surface air temperature.

Idso (1988), presented a comparison for the CO2 greenhouse effect on Mars, Earth and Venus by plotting the CO2 warming and the CO2 atmospheric partial pressure on a log-log scale (Fig. 18). He concludes that considering the consistency of all empirical data, atmospheric CO2 fluctuations influence surface air temperature largely, independently of atmospheric moisture conditions, because water vapor is practically non-existent on Mars, is intermediate on Earth and large on Venus (in an absolute sense). Hence, the long-espoused claim of a many-fold amplification of direct CO2 effects by a positive water vapor feedback mechanism would appear to be rebuffed by the analysis. As a result, the final conclusion is that the scientific consensus on the strength of the CO2 greenhouse effect, as expressed in past reports of the U.S. National Research Council, is likely to be in error by nearly a full order of magnitude. Based on the comparative planetary climatology relationship of Fig. 18, a 300–600 ppmv doubling of Earth's atmospheric CO2 concentration should only warm the planet by about 0.4 K.

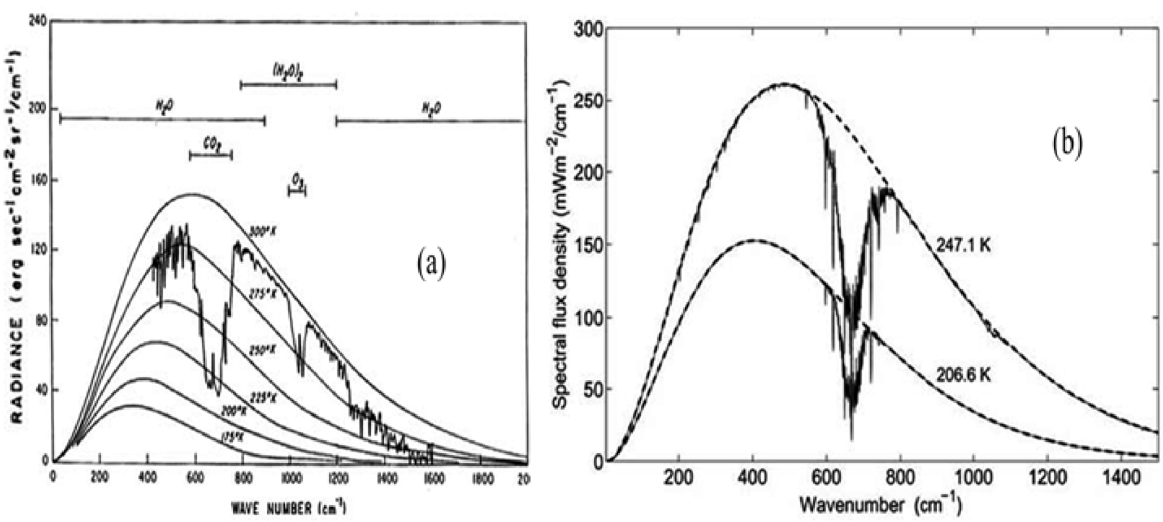

Fig. 17. Earth Thermal Radiative Spectrum (a) as measured by Nimbus 4 satellite in 1970, when the CO2 concentration was 325ppmv and Mars Thermal Radiative Spectrum (b) redrawn from Karmanovitch & Geoph, 2009.

Additionally Idso, (1998) in a worth noting review enumerates a number of analyses he performed on natural phenomena that reveal how the Earth's near-surface air temperature responds to surface radiative perturbations. All of these studies confirm that a 300–600 ppmv doubling of the atmospheric CO2 concentration could raise the planet's mean surface air temperature by only about 0.4 K. He even expresses doubts that even this modicum of warming will ever be realized, for it could be negated by a number of planetary cooling forces that are intensified by warmer temperatures and by the strengthening of biological processes that are enhanced by the same rise in atmospheric CO2 concentration that drives the warming. At the same time he is skeptical of the predictions of significant CO2-induced global warming that are being made by state-of-the-art climate models and believes that much more work on a wide variety of research fronts will be required to properly resolve the issue.

4.6 A view from a general science graduate

Archibald (2009), using the MODTRAN facility maintained by the University of Chicago, estimated the relationship between atmospheric CO2 concentration and increase in average global atmospheric temperature, concluding that anthropogenic warming is real but at the same time minute. Archibald used the temperature response, demonstrated by Idso (1998), of 0.1 K per W×m^{-2} as a base for his calculations. The effect of CO2 on temperature is logarithmic and thus climate sensitivity decreases with increasing concentration. The first 20 ppmv of CO2 has a greater temperature effect than the next 400 ppmv.

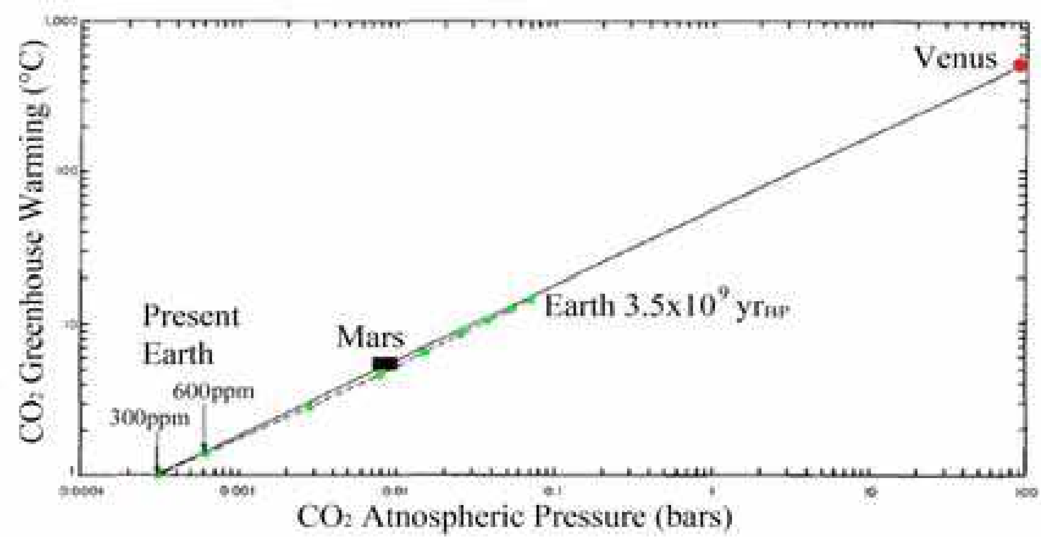

Fig. 18. A comparative planetary climatologist relationship for Mars, Earth and Venus based on the greenhouse warming of Mars and Venus, which are produced by their atmospheric partial pressures of CO2 (solid line). Also shown is the almost identical relationship derived from standard considerations related to the Earth's paleoclimatic record and the first early Sun paradox (dashed line) (redrawn from Idso, 1988).

The increase in atmospheric CO2 concentration from the pre-industrial level of 285 ppmv to the current level of 384 ppmv is calculated to have resulted in a 0.1 K rise in the atmospheric temperature. If the atmospheric CO2 level would increase to 600 ppmv, a further 0.3 K increase in temperature would be projected due to this factor (see Fig. 19).

In addition Archibald (2008), presents an interesting comparison of estimates of the effect that CO2 would have if its concentration in the atmosphere doubled from its pre-industrial level, and he concludes that the models of the IPCC apply an enormous amount of compounding water vapor feedback and, at their worst, the IPCC models take 1 K of heating and turn it into 6.4 K (see Fig. 20).

For Fig. 20 Archibald explains that:

a. The Stefan-Boltzmann figure of 1 K is based on the Stefan-Boltzmann equation without the application of feedbacks and as he comments everybody agrees with this figure when no feedbacks are involved.
b. Kininmonth estimates a 0.6 K and this is based on water vapor amplification but also includes the strong damping effect of surface evaporation.
c. Lindzen's estimation is based on water vapor and negative cloud feedback.
d. Idso derived an estimate of climate sensitivity from nature observations and Spencer used data from the Aqua satellite for his estimates and proved that these are very close to what happens in Nature.

In particular, what Spencer (2008) has done was to examine the satellite data in great detail, and then built the simplest model that can explain the observed behavior of the climate system whilst, as he explains, the currently popular practice is to build immensely complex and expensive climate models and then make only simple comparisons to satellite data. His main conclusion is that the net feedbacks in the real climate system are probably negative. A misinterpretation of cloud behavior has led climate modelers (of the IPCC) to build models in which cloud feedbacks are instead positive, which has led the models to predict too much global warming in response to anthropogenic greenhouse gas emissions.

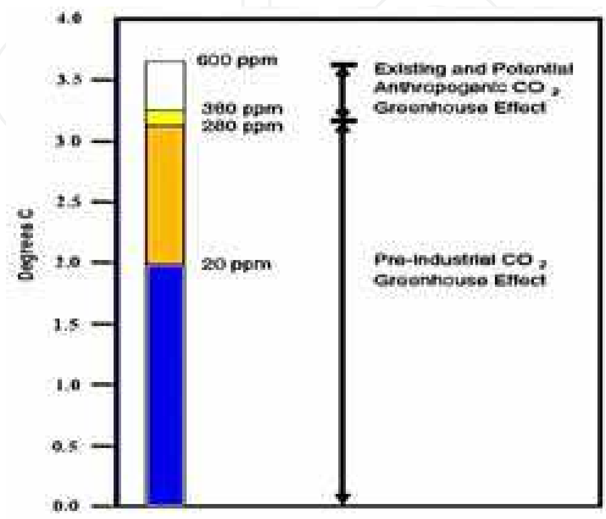

Fig. 19. Relative Contributions of Pre-Industrial and Anthropogenic CO2 (redrawn from Archibald, 2009).

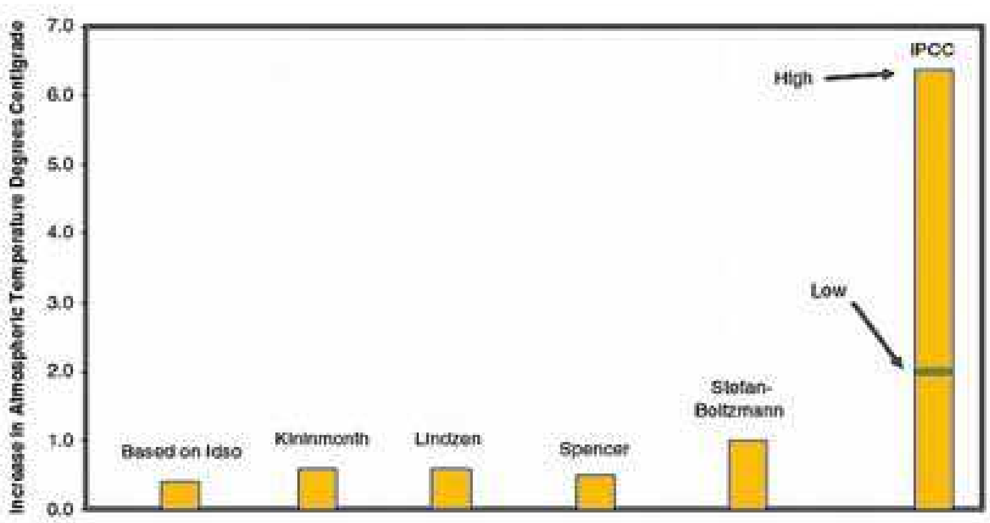

Fig. 20. Archibald's (2008) comparison of estimates for doubling the atmospheric CO2 from its pre-industrial level.

4.7 Unique fingerprint for anthropogenic warming

The concentration of water reduces very rapidly with altitude and therefore, the water contribution to the warming of the atmosphere is accordingly diminishing in comparison to that of CO2 as altitude increases. This is because the water vapor concentration is affected by temperature but CO2 concentration decreases only with the decreasing pressure. At sea level the mean molecular ratio of water vapor to CO2 is around 23, but at an altitude of 10 km the value is as low as 0.2. It would be expected that more CO2 would have a greater effect on atmospheric warming at higher altitudes (Barret, 2005), but this seems not to be occurring in spite of the predictions of most greenhouse computer models (GCMs).

All Climate models predict that, if GHG is driving climate change, i.e. if the current global warming is anthropogenic, there will be a unique fingerprint in the form of a warming trend increasing with altitude in the tropical troposphere (the region of the atmosphere up to about 15 km). Climate changes due to solar variability or other known natural factors do not produce this pattern and only sustained greenhouse warming does. While all greenhouse models show an increasing warming trend with altitude, especially at around 10 km at roughly two times the surface value, the temperature data from balloons give the opposite result showing no increasing warming, but rather a slight cooling with altitude in the tropical zone (compare Figs. 21 and 22). The Climate Change Science Program executive summary (CCSP, 2006) tried inexplicably to reconcile this difference, claiming agreement between observed and calculated patterns, the opposite of what the report itself documents. The obvious disagreement shown in the body of the report is dismissed by suggesting that there might be something wrong with both balloon and satellite data (NIPCC, 2009, p. 106).

The main conclusion of the CCSP Report (CCSP, 2006, p. 118) is that many factors – both natural and human-related – have probably contributed to the climate changes. Analyses of observations alone cannot provide definitive answers because of important uncertainties in

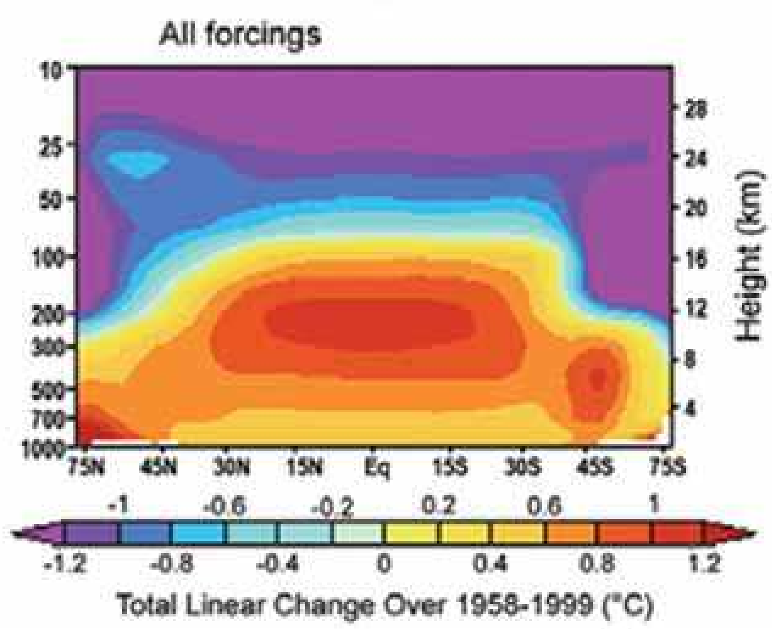

Fig. 21. Greenhouse-model-predicted mean atmospheric temperature change versus latitude and altitude for all forcings (CCSP, 2006, p. 25). The figure clearly shows the increased temperature trends in the tropical mid-troposphere (8–12 Km).

the observations and in the climate forcings that have affected them. Although computer models of the climate system are useful in studying cause-effect relationships, they, too, have limitations. Finally the Report notes that advancing our understanding of the causes of recent lapse-rate changes will best be achieved by comprehensive comparisons of observations, models, and theory – it is unlikely to arise from analysis of a single model or observational data set.

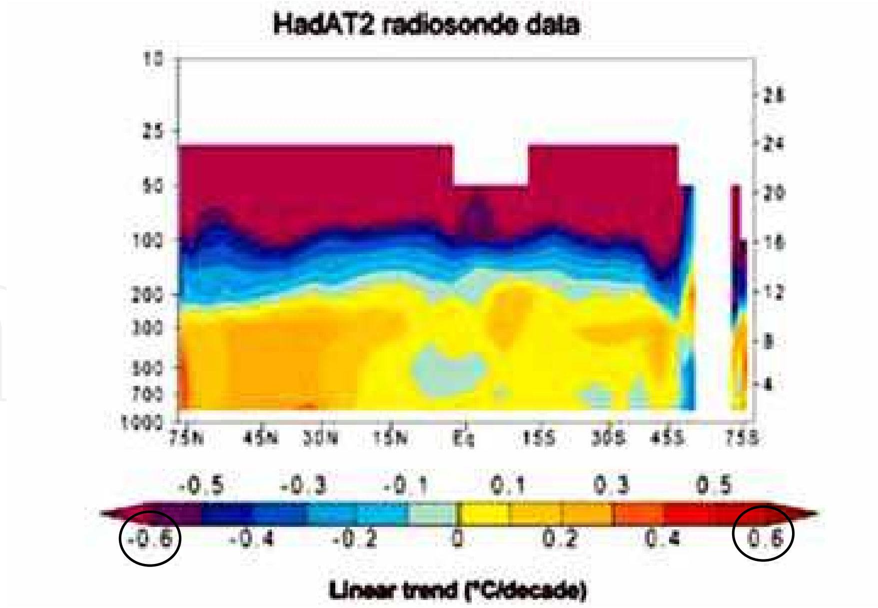

Fig. 22. Observed changes estimated with HadAT2 radiosonde data (CCSP, 2006, pp. 116). All temperature changes were calculated from monthly-mean data and are expressed as linear trends (in K/decade) over 1979 to 1999. Note that the colours used in this figure represent lower temperature increases when compared to figure 21 above.

4.8 A view from physics: the adiabatic theory of the greenhouse effect

As stressed by Sorokhtin et al. (2007), until recently a sound theory, using laws of Physics, for the greenhouse effect was lacking and all predictions were based on intuitive models using numerous poorly defined parameters. Their examination showed that at least 30 such parameters were contained in the models making the numerical solution of the problem incorrect. For this reason they devised a model based on well-established relationships among physical fields describing the mass and heat transfer in the atmosphere. Basic formulas describe, among others, the heat transfer in the atmosphere by radiation, the atmospheric pressure and air density change with elevation, the effect of the angle of the Earth's precession and the adiabatic process. For the adiabatic process the formula considers the partial pressures and specific heats of the gases forming the atmosphere, an adiabatic constant and corrective coefficients for the heating caused by water condensation in the wet atmosphere and for the absorption of infrared radiation by the atmosphere. The adiabatic constant and the heat coefficients are estimated using actual experimental data.

The convective heat transfer dominates in the troposphere (the lower and denser layer of the atmosphere, with pressures greater than 0.2 atm). When infrared radiation is absorbed by the GHGs, the radiation energy is transformed into oscillations of the gas molecules, heating the exposed volume of gaseous mixture. Then, further heat transfer can occur either due to diffusion or by convective transfer of expanded volumes of gas. Since the specific heat of air is very small, the rates of heat transfer by diffusion do not exceed several $cm \times s^{-1}$, whereas the rates of heat transfer by convection can reach many $m \times s^{-1}$. Analogous situation occurs upon heating of air as a result of water vapor condensation: the rates of convective transfer of heated volumes of air in the troposphere are many orders of magnitude higher than the rates of heat transfer by diffusion.

The adiabatic model was verified, with a precision of 0.1%, by comparing the results obtained for the temperature distribution in the troposphere of the Earth with the standard model used worldwide for the calibration of the aircraft gauges and which is based on experimental data. The model was additionally verified with a precision of 0.5–1.0% for elevations of up to 40 km, by comparing the results with the measured temperature distribution in the dense troposphere of Venus consisting mainly of CO2.

The results of their analysis are the following:

a. Convection accounts for approximately 67% of the total amount of heat transfer from the Earth's surface to the troposphere, the condensation of water vapor for 25% and radiation accounts for only 8%. As the heat transfer in the troposphere occurs mostly by convection, accumulation of CO2 in the troposphere intensifies the convective processes of heat and mass transfer, because of the intense absorption of infrared radiation, and leads to subsequent cooling and not warming as believed.
b. If the nitrogen–oxygen atmosphere of the Earth was to be replaced by a CO2 atmosphere with the same pressure of 1 atm, then the average near-surface temperature would decrease by approximately 2.5 K and not increase as commonly assumed.
c. The opposite will happen by analogy if the CO2 atmosphere of Venus was to be replaced by a nitrogen–oxygen atmosphere at a pressure of 90.9 atm. The average near-surface temperature would increase from 462°C to 657°C. This is explained easily by observing how the results of the derived formulas are affected, considering that the molecular weight of CO2 is about 1.5 times greater and its specific heat 1.2 times smaller than those of the Earth’s air.
d. If the CO2 concentration in the atmosphere increases from 0.035% to its double value of 0.070%, the atmospheric pressure will increase slightly (by 0.00015 atm). Consequently the temperature at sea level will increase by about 0.01 K and the increase in temperature at an altitude of 10 km will be less than 0.03 K. These amounts are negligible compared to the natural temporal fluctuations of the global temperature.
e. In evaluating the above consequences of the doubling of the CO2, one has to consider the dissolution of CO2 in oceanic water and also that, together with carbon, a part of atmospheric oxygen is also transferred into carbonates. Therefore instead of a slight increase in the atmospheric pressure one should expect a slight decrease with a corresponding insignificant climate cooling.

4.9 The verdict on the effect of CO2 on climate change

To examine the increase in the greenhouse effect in recent years corresponding to the CO2 concentration increase in the atmosphere, Harries et al. (2001), analyzed the difference between the spectra of outgoing longwave radiation (OLR) obtained in 1970 by the IRIS satellite and in 1997 by the IMG satellite of the Japanese Space Agency. The data utilized over a 26-year period showed a number of differences in the land-masked and cloud-cleared data, which the authors attributed to changes in atmospheric concentrations of CH4, CO2, O3, CFC-11 and CFC-12. Hence, they concluded that their results provided direct experimental evidence for a significant increase in the earth’s greenhouse effect over the examined period.

In a related article Griggs & Harries (2007), observe the changes in the earth’s spectrally resolved outgoing longwave radiation (OLR), comparing the outgoing longwave spectra from the 1970 (IRIS) the 1997 (IMG) and the 2003 (AIRS) instruments. As they mention, in all three difference spectra, the brightness temperature difference in the atmospheric window between 800–1000 cm^{-1} is zero or slightly positive, indicating a warming of surface temperatures between the three time periods. Although these observations are within the limit of uncertainty due to noise, the positive anomaly in this region seems to increase. This is in agreement with the trend in sea surface temperatures. A negative brightness temperature difference is observed in the CO2 band at 720 cm^{-1} in the IMG–IRIS (1997–1970) and the AIRS–IRIS (2003–1970) difference spectra, indicating increasing CO2 concentrations, consistent with the Mauna Loa record. However, they note that this channel in the difference is also sensitive to temperature, and in the 2003–1997 difference, despite a growth in CO2 between these years, there is no signal at 720 cm^{-1}. As a key result of their analysis they state that "the CO2 band at 720 cm^{-1}, though asymmetric, nevertheless shows some interesting behavior, with strong negative brightness temperature difference features for 1997–1970 and 2003–1970: whereas, the 2003–1997 (a much shorter period, of course) shows a zero signature. Since we know independently that the CO2 concentration globally continued to rise between 1997 and 2003, we must conclude that the 2003–1997 result must be due to changes in temperature that compensate for the increase in CO2. This would mean a warming of the atmosphere at those heights that are the source of the emission in the center of this band. This is somewhat contrary to the general (small) cooling of the stratosphere at tropical latitudes."

Such a conclusion, however, does not provide direct experimental evidence for a significant increase in the Earth's total greenhouse effect. What the above-mentioned studies show is that for the cloud-free part of the atmosphere, there was a drop in outgoing radiation at the wavelength bands that greenhouse gases such as CO2 and methane (CH4) absorb energy. These results do not show the earth's climatic response to the inferred increase in radiative forcing and do not consider negative or positive feedback cycles.

Lindzen & Choi (2009), estimated climate feedbacks from fluctuations in the outgoing radiation budget from the Earth Radiation Budget Experiment (ERBE) nonscanner data in general and with all OLR wavelengths. For the entire tropics, the observed outgoing radiation fluxes increase with the increase in sea surface temperatures (SSTs). The observed behavior of radiation fluxes implies negative feedback processes associated with relatively low climate sensitivity. This is the opposite of the behavior of 11 atmospheric models forced by the same SSTs. Their conclusion is that the models display much higher climate sensitivity than is inferred from ERBE, though it is difficult to pin down such high sensitivities with any precision. Results also show that the feedback in ERBE is mostly from shortwave radiation while the feedback in the models is mostly from longwave radiation. Although such a test does not distinguish the mechanisms, this is important since the inconsistency of climate feedbacks constitutes a very fundamental problem in climate prediction.

Having in mind all the above it is doubtful if further increase in CO2 concentration will have any significant effect on the global temperature. IPCC is not sure at what extent the doubling of CO2 will affect the temperature (its guess is 2–4.5 K) and this is because the initial equation was derived empirically without any theoretical background. For this reason computer modelling, as used by IPCC, is merely a form of data curve fitting.

Our focus must now be turned to the main source of energy that drives the climate system, the radiation from the Sun. All meteorological phenomena are the results of this energy which is absorbed, transformed and redistributed on Earth. Therefore any phenomena observed in the climate change should be in a way related to this source.

IPCC (2007d), states that continuous monitoring of total solar irradiance now covers the last 28 years. The data show a well-established 11-year cycle in irradiance that varies by 0.08% from solar cycle minima to maxima, with no significant long-term trend. The primary

known cause of contemporary irradiance variability is the presence on the Sun's disk of sunspots and faculae. The estimated direct radiative forcing due to changes in the solar output since 1750 is +0.12 W×m^{-2}, which is less than half of the estimate given in the Third Assessment Report (TAR), with a low level of scientific understanding. While this leads to an elevation in the level of scientific understanding from very low in the TAR to low in this assessment, uncertainties remain large because of the lack of direct observations and incomplete understanding of solar variability mechanisms over long time scales.
The IPPC report then mentions that empirical associations have been reported between solar-modulated cosmic ray ionization of the atmosphere and global average low-level cloud cover, but evidence for a systematic indirect solar effect remains ambiguous. It has been suggested that galactic cosmic rays with sufficient energy to reach the troposphere could alter the population of cloud condensation nuclei and hence microphysical cloud properties (droplet number and concentration), inducing changes in cloud processes analogous to the indirect cloud albedo effect of tropospheric aerosols and thus causing an indirect solar forcing of climate. Studies have probed various correlations with clouds in particular regions or using limited cloud types or limited time periods; however, the cosmic ray time series does not appear to correspond to global total cloud cover after 1991 or to global low-level cloud cover after 1994. Together with the lack of a proven physical mechanism and the plausibility of other causal factors affecting changes in cloud cover, this makes the association between galactic cosmic ray-induced changes in aerosol and cloud formation controversial.

5. The Sun

The Sun is one of over 100 billion stars in the Milky Way Galaxy. It is by far the largest object in the solar system and it contains 99.8% of the total mass of the Solar System (Fig. 23).

5.1 Solar activity and energy output

Before studying the effect of the Sun on global warming we give a brief description of Sun's activity.
The Sun's magnetic field changes from a simple overall shape to an extremely distorted one in cycles (NASA - The Sun, 2007). The sun's magnetic fields rise through the convection zone and erupt through the photosphere into the chromosphere and corona. The eruptions lead to solar activity, which includes such phenomena as sunspots, flares, and coronal mass ejections.
Sunspots are dark, often roughly circular features on the solar surface. They form where denser bundles of magnetic field lines from the solar interior break through the surface. These are "cool" regions, only 3800 K (they look dark only by comparison to the surrounding regions). Sunspots can be very large, as much as 50000 km in diameter. The number of sunspots on the sun depends on the amount of distortion in the magnetic field.
The change in the number of sunspots, from a minimum to a maximum and back to a minimum, is known as the sunspot cycle. The average period of the sunspot cycle is about 11 years during which the activity varies from a solar minimum at the beginning of a sunspot cycle to a solar maximum about 5 years later. The number of sunspots that exist at a given time varies from none to approximately 250 individual sunspots and clusters of sunspots. At the end of a sunspot cycle, the magnetic field quickly reverses its polarity, from north to south, and loses most of its distortion. A change of polarity from one orientation to

the other and back again covers two successive sunspot cycles and is therefore about 22 years.

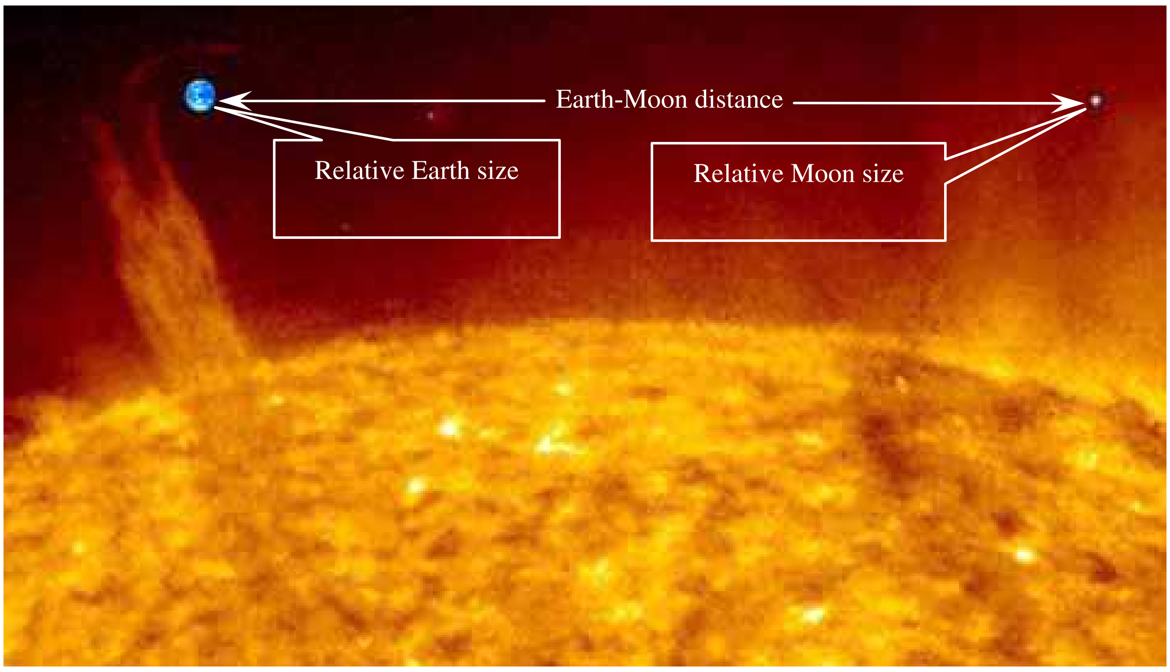

Fig. 23. Comparative sizes of the Sun, Earth, Moon and Earth-Moon distance. (Sun diameter: 1390000 km, Earth diameter: 12700 km, Moon diameter: 3474 km, Earth-Moon distance: 382500 km).

Flares are the most violent eruptions in the solar system. Coronal mass ejections, though less violent than flares, involve a tremendous mass (amount of matter). A single ejection can spew approximately 18 billion metric tons of matter into space.

The Sun emits electromagnetic radiation in the form of visible light, infrared radiation that we feel as heat, ultraviolet rays, microwaves, X-rays, gamma rays and so forth. This radiation can be thought of as waves of energy or as particle-like "packets" of energy, the so-called photons. The energy of an individual photon is related to its frequency. All forms of electromagnetic radiation travel through space at the speed of light (299792 $km \times s^{-1}$). At this rate, a photon emitted by the sun takes 8 minutes to reach the Earth that travels around the sun at an average distance of about 149600000 km.

The amount of electromagnetic radiation from the sun that reaches the top of the Earth's atmosphere is known as the solar constant. This amount is about 1370 $W \times m^{-2}$. Of this energy only about 40% reaches the Earth's surface. The atmosphere blocks some of the visible and infrared radiation, almost all the ultraviolet rays, and all the X-rays and gamma rays. Nearly all the radio energy reaches the Earth's surface.

The Sun also emits particle radiation, consisting mostly of protons and electrons comprising the solar wind. These particles come close to the Earth, but the Earth's magnetic field (Fig. 24) prevents them from reaching the surface. More intense ejections, known as solar cosmic rays, reach the Earth's atmosphere. Solar cosmic rays cannot reach the Earth's surface but they are extremely energetic, they collide with atoms at the top of the atmosphere and may cause major disturbances in the Earth's magnetic field disrupting electrical equipment and overloading power lines.

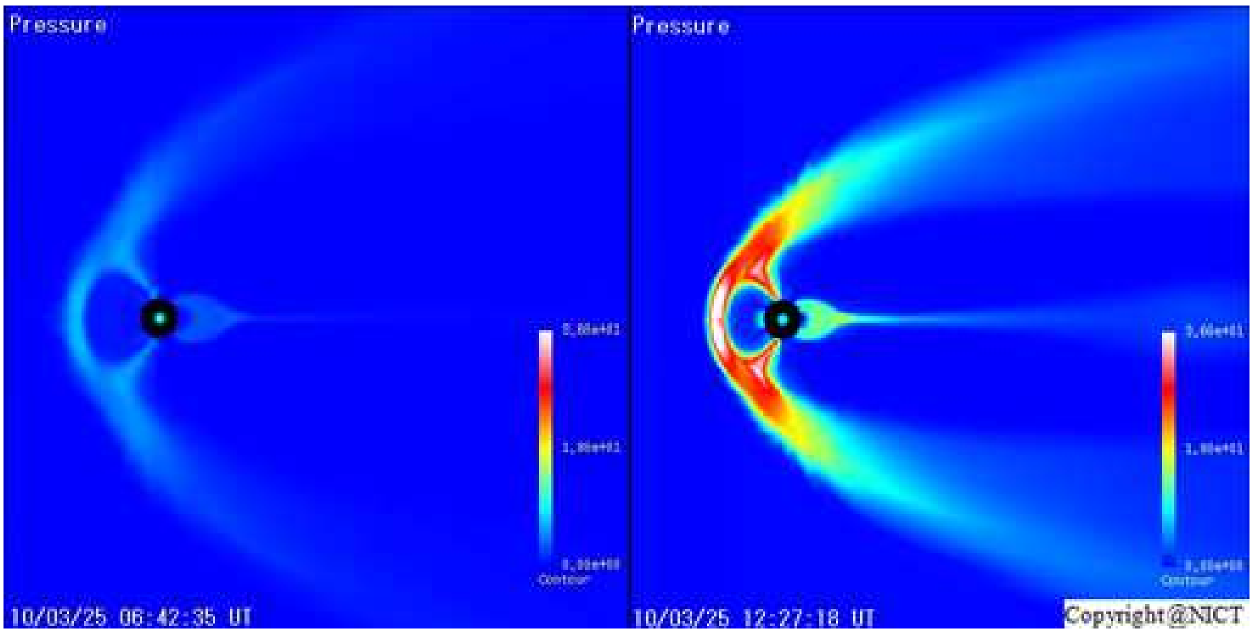

Fig. 24. Earth's magnetic field protects life from the solar wind (NICT, 2010).

5.2 Earth's orbit and variations in climate

Astronomers have linked the earth climate to various changes related with the earth orbit around the sun and the amount of energy that it receives. These orbital processes are thought to be the most significant drivers of ice ages according to the theory of Milankovitch, and such changes are (NASA-Milankovitch, 2007):

(a) The shape of the orbit (eccentricity) of the Earth around the Sun, which changes from a nearly perfect circle to an oval shape on a 90000–100000-year cycle. At present there is a 3% (5000000 km) difference between the closest approach (perihelion) in January and the furthest departure (aphelion) in July. This difference in distance causes about a 6% increase in the incoming solar radiation from July to January.

(b) The angle of the Earth's axis with respect to its orbital plane (axial obliquity). Today, the Earth's axis is tilted at 23.5°. This tilt varies between 22.1–24.5° during a 40000 years cycle causing warmer summers and colder winters when the tilt is greater.

(c) The orientation of the Earth's axis is slowly but continuously changing (precession), like a wobbling top, tracing out a conical shape in a cycle of approximately 26000 years. Changes in axial precession alter the dates of perihelion and aphelion, and therefore increase the seasonal differences in one hemisphere and decrease the seasonal differences in the other hemisphere.

The Milankovitch cycles were recently observed and confirmed in the Antarctica Dome C ice-core samples recording the climate variability over the past 800000 years (Jouzel et al., 2007).

Precession is caused by the deviation of the Earth's mass distribution from the spherical symmetry and is mainly due to the non-uniformity of the Earth's crust in its continental and oceanic regions and also in the possible heterogeneity in the mantle density. According to Sorokhtin et al. (2007), the attraction of the Earth by the Moon and the Sun plays a leading role in the reduction of the precession angle. In their work to estimate the climatic temperature deviations due to the above-mentioned attraction effect they also considered the main harmonic components of the Milankovitch cycles giving rise to a temperature deviation of about ± 3%. Their work could be used for forecasting the climatic changes in the future considering a best fit of theoretical to experimental data. Such a fit is presented in Fig. 25 where one observes that there were slow periods of climatic cooling of about 8–10°C which lasted approximately 100000–120000 years. After the formation of thick ice covers, a rapid warming – by the same 8–10°C – occurred degrading the glaciers completely in a few thousand years. Their forecast is that in the future we should expect a significant cooling.

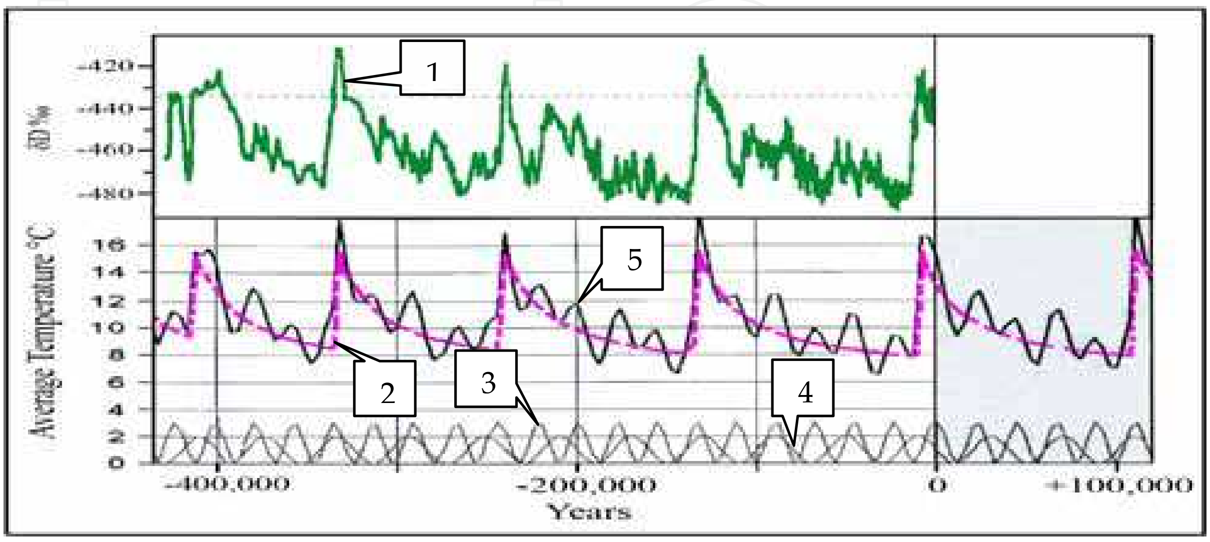

Fig. 25. Temperature deviations with respect to time presenting the combined effect of the attraction of the Earth by the Moon and the Sun and the main harmonic components of the Milankovitch cycles compared to the Vostok isotope temperature measurements (redrawn from Sorokhtin et al., 2007). (1) Vostok isotope temperature measurements, (2) Earth temperature change due to the attraction of the Earth by the Moon and the Sun, (3)–(4) Temperature change due to the main harmonic components of the Milankovitch cycles, (5) Resulting temperature change.

Undoubtedly, as argued above, solar variability plays an important role in global climate change. The total average solar energy flux currently reaching the Earth's surface is S_0 = 1.75×1014 kW and is determined by the so-called solar constant which is 1.37 kW×m^{-2}. The total heat flux through the Earth's surface due to energy generated in the mantle and the crust is approximately 0.0257% of the total Earth's solar irradiation. Additionally, the world total energy production is estimated to be about 0.0077% of the total solar irradiation reaching the Earth's body. Therefore it can easily be estimated that the solar radiation supplies more than 99.95% of total energy driving the world climate (Khilyuk & Chilingar, 2006).

The effect of solar irradiation on global atmospheric temperature can be evaluated using the adiabatic model of the heat transfer in the Earth's atmosphere (Sorokhtin et al., 2007). For a rough estimate of the global atmospheric temperature change ΔT at sea level, attributed to the natural variations in insolation S, the formula is:

$$\Delta T = 288[(S/S_0)^{1/4} - 1] \qquad (2)$$

and as they have calculated a 1% increase in the current solar radiation reaching the Earth's body translates directly into approximately 0.86 K increase in the Earth's global temperature.

To examine how the total solar irradiance (TSI) variation affects the climate, we use the reconstruction of Steinhilber et al. (2009), based on the relationship between TSI and the open solar magnetic field obtained from the cosmogenic radionuclide 10Be measured in ice cores. As shown in Fig. 26 a relation may exist but it is obvious that other factors are affecting the climate as well. One can observe that TSI reached an absolute maximum in about 1990, whereas the absolute maximum for temperature occurred with a time-lag of about +10 years. Over the 10 next years, while the temperature has remained essentially constant, the TSI has continued dropping. It would, therefore, be physically highly unlikely that there would be no temperature drop in the succeeding years.

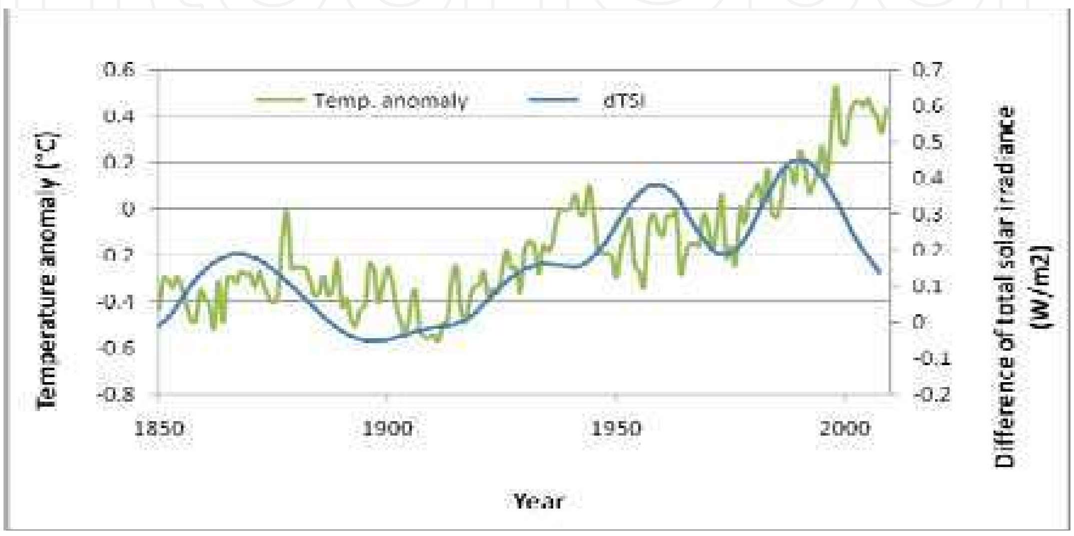

Fig. 26. Total solar irradiance variation (Steinhilber et al., 2009) and adjusted variance (HadCRUT3gv) taken from the Met Office Hadley Centre (2010).

A different solar parameter showing long-term changes is the length of the cycle. This parameter is known to vary with solar activity so that high activity implies short solar cycles whereas long solar cycles imply low activity levels of the Sun. Gleissberg demonstrated that the variation occurs in a systematic manner with a long-term periodicity of 80 to 90 years, known after his name as the Gleissberg period (Friis-Christensen & Lassen, 1991). Friis-Christensen and Lassen, (1991) showed that there is a close inverse relationship between sunspot cycle length and Northern Hemisphere land temperatures over the 1860–1985 period (Fig. 27).

5.3 Simultaneous warming of other planets in our solar system

Of course if the cause for global warming was solar irradiation then it would be expected that this cause should affect other planets of the solar system in the same manner.

It is accepted by NASA that Mars has warmed up by about 0.5 K since the 1970s. The climate change is so rapid that the red planet could lose its southern ice cap in the coming years. This is similar to the warming experienced on Earth over approximately the same period. If there is no life on Mars, as it is presently assumed, it means that rapid change in climate could be a natural phenomenon and essentially not anthropogenic.

A theory trying to explain the warming of Mars claims that variations in radiation and temperature across the surface of the red planet are generating strong winds caused by widespread changes in some areas which have become darker since 1970 (Fenton et al., 2007).

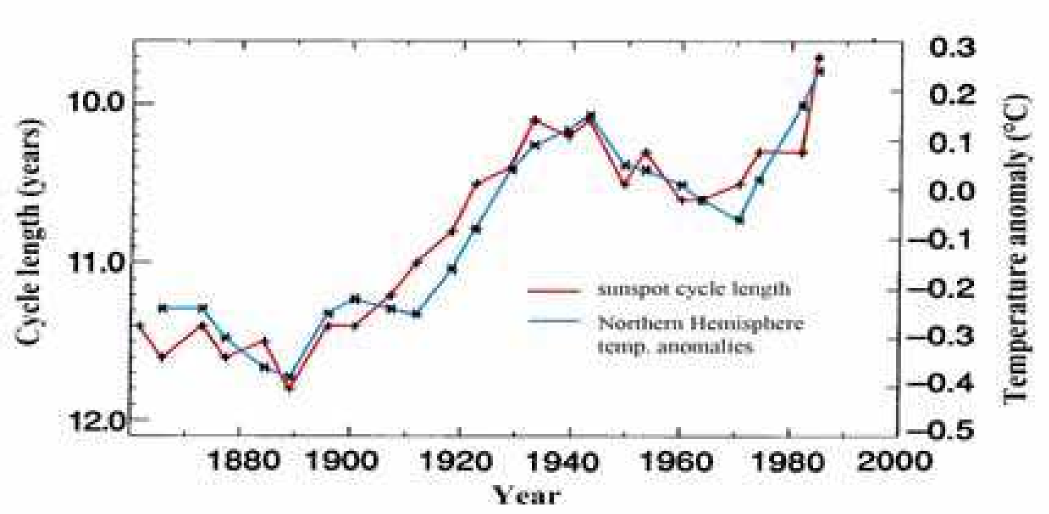

Fig. 27. Variation of the sunspot cycle length compared with the Northern Hemisphere temperature anomalies (modified from Friis-Christensen & Lassen, 1991).

The main gas in Pluto's atmosphere is nitrogen, and Pluto has nitrogen ice on its surface that can evaporate into the atmosphere when it gets warmer, causing an increase in surface pressure (MIT, 2002). Observations using eight telescopes made by Elliot et al. (2003), proved that the average surface temperature of the nitrogen ice on Pluto has increased slightly less than 2°C over a period of 14 years (1988–2002). The results have surprised the observers, who thought that Pluto's atmosphere may be cooling because now Pluto is orbiting away from the sun, being at its closest in 1989. Pluto's atmospheric temperature varies between around –235°C and –170°C, depending on the altitude above the surface.

Long-term, over half a century, photometric measurements of Neptune show variations of brightness. The detailed variations may partially be explain by seasonal change in Neptune's atmosphere but also the possibility of solar-driven changes, i.e. changes incurred by innate solar variability perhaps coupled with changing seasonal insolation may be considered as well. As Hammel & Lockwood (2007) point out the striking similarity of the temporal patterns of variation of Neptune's brightness and the Earth's temperature anomaly should not be ignored simply because of low formal statistical significance. If changing brightnesses and temperatures of two different planets are correlated, then some planetary climate changes may be due to variations in the solar system environment.

Based on the observed changes of temperature on other planets, one can conclude that it is possible that the main reason for these changes are variations in the electromagnetic solar environment that may trigger secondary processes affecting the temperature. Seasonal changes due to changes in orbit, internally generated heat or unknown mechanisms cannot be excluded neither.

5.4 A solar forcing scenario

As Solanki et al. (2004) mention, the level of solar activity during the past 70 years is exceptional, and the previous period of equally high activity occurred more than 8000 years ago (Fig. 28). The sunspot number covering the past 11400 years was reconstructed based on dendrochronologically dated radiocarbon concentrations averaged in 10-year intervals. Solanki et al. (2004) find that during the past 11400 years the Sun spent only about 10% of time at a similarly high level of magnetic activity and almost all of the earlier high-activity

periods were shorter than the present episode. They conclude that the Sun may have contributed to the unusual climate change during the 20th century although it is unlikely to have been the dominant cause. The big question until recently of a solar forcing scenario for climate change has been that the Sun's energy output through the sunspot cycle varies only by about 0.1%. This energy output variability is insufficient on its own, to cause the 0.6 K increase in global temperature observed through the 20th century.
Considering that the level of solar activity now is exceptional the response of the water vapor amplification must be re-examined especially since water vapor is the most dominant GHG with uncertain contribution in the range of 55–95% and since before present there was no anthropogenic CO2 to upset the balance.

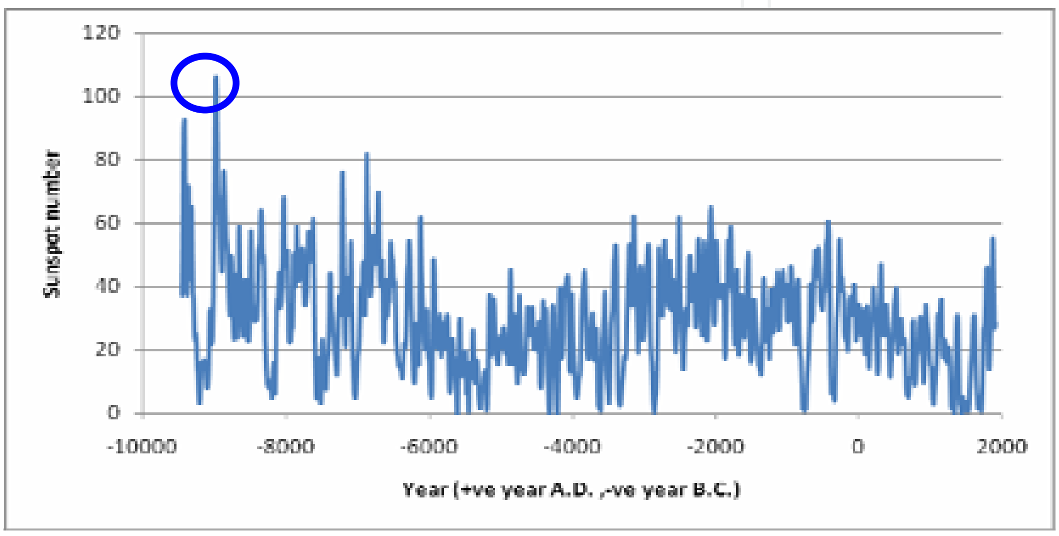

Fig. 28. Sunspot number (Solanki et al. 2004).

Time dependent experiments produce a global mean warming of 0.2–0.5 K in response to the estimated 0.7 W×m^{-2} change of solar radiative forcing from the Maunder Minimum to the present. However, the spatial response pattern of surface air temperature to an increase in solar forcing was found to be quite similar to that in response to increases in GHG forcing (IPCC, 2001).
Most of the Sun's heat is deposited into the tropics of the Earth with small variation of solar heating throughout the year. The amount of solar heating of the polar latitudes varies greatly, with the polar latitudes receiving much solar energy in summer, whilst in winter they receive no solar heat at all. As a result, in the winter hemisphere, the difference in solar heating between the equator and the pole is very large. This causes the large-scale circulation patterns observed in the atmosphere. The difference in solar heating between day and night also drives the strong diurnal cycle of surface temperature over land.
On the other hand, clouds block much of the solar radiation and reflect it back to space before it reaches the Earth. The more plentiful and thicker the clouds are, the cooler the Earth is. At the same time, clouds also block the emission of heat to space from the Earth acting like GHGs. The altitude of clouds changes the amount of thermal infrared blocking. Because temperature decreases with altitude, high clouds are colder and more effective in absorbing the surface emitted heat in the atmosphere, whilst they emit very little to space. Therefore clouds can either cool or warm the planet depending on the area of the Earth they cover, their thickness, and their altitude. Also the effectiveness of clouds depends on their

structure. The climate is so sensitive to clouds that present models of global climate can vary in their global warming predictions by more than a factor of 3, depending on how clouds are modeled (Goddard Space Flight Center, 1999).

5.5 Cosmic rays

During the 1990s Svensmark H. and Friis-Christensen E., presented a new astronomical cause for climate change, that of the cosmic ray hypothesis. Cosmic radiation originates from all luminous objects in the universe and it comprises primary particles with very high energy (mainly protons, 92%, and alpha particles, 6%). When the ray particles reach the Earth they cause ionization in the upper layers of the atmosphere. The particles loose energy colliding with other particles in the atmosphere and many of the lower energy particles are absorbed by the atmosphere on their way down to the surface. Magnetic fields deflect these rays and since the solar wind expands the magnetic field of the Sun, the Earth is shielded more from the incoming cosmic rays. Solar wind increases in strength with sunspot activity. According to the cosmic ray hypothesis, periods with low solar activity would allow more cosmic radiation to reach the earth, more clouds (low clouds) would be formed and finally a lower global mean temperature would result, and vice versa.

In examining the above-mentioned hypothesis the Danish National Space Center (DNSC, 2007), identified five external forcing parameters that are modulated by solar variability and have the potential to influence the Earth's lower atmosphere below 50 km. These are (a) the Total Solar Irradiance (TSI), (b) the Ultra-Violet (UV) component of solar radiation, (c) the direct input from the Solar Wind (SW), (d) the total Hemispheric Power Input (HPI) reflecting properties of precipitating particles within the magnetosphere, and (e) the Galactic Cosmic Rays (GCR). Their conclusion is that UV and GCR present a striking correlation with the global coverage of low clouds, over nearly two and a half solar cycles as shown in Fig. 29.

Currently, the National Space Institute of Denmark (DNSI, 2007) has been investigating the hypothesis that solar variability is linked to climate variability by a chain that involves the solar wind, cosmic rays and clouds. The reported variation of cloud cover was approximately 2% over the course of a sunspot cycle but simple estimates indicate that the resultant global warming could be comparable to that presently attributed to GHGs from the burning of fossil fuels.

Recent work has directed attention to a mechanism involving aerosol production and the effects on low clouds. This idea suggests that ions and radicals produced in the atmosphere by cosmic rays could influence aerosol production and thereby cloud properties. Cosmic rays ionize the atmosphere, and an experiment performed at DNSI has found that the production of aerosols in a sample atmosphere with condensable gases (such as sulphuric acid and water vapor) depends on the amount of ionization. Since aerosols work as precursors for the formation of cloud droplets, this is an indication that cosmic rays influence cloud formation.

As the National Space Institute of Denmark (2009) informs us, the European Organization for Nuclear Research, CERN, has currently been creating an atmospheric research facility at its Particle Physics laboratory. Called CLOUD, it will consist of a special cloud chamber exposed to pulses of high-energy particles from one of CERN's particle accelerators. Conditions prevailing the Earth's atmosphere will be recreated in CLOUD, and the incoming particles will simulate the action of cosmic rays. The main cloud chamber for the CLOUD facility is expected to begin operating in 2010.

Recently the Sun's magnetic activity unexpectedly declined and its surface is almost free of sunspots. Because of this, there is a concern that the Sun might now fall asleep in a deep minimum that may continue through the next years. During the period from 1650–1715 almost no sunspots were observed on the sun's surface. This extended absence of solar activity may have been partly responsible for the Little Ice Age in Europe and may reflect cyclic or irregular changes in the sun's output over hundreds of years. During that period, winters in Europe were longer and colder by about 1 K than they are today. A consequence of this phenomenon occurring will be the clarification of global warming causes.

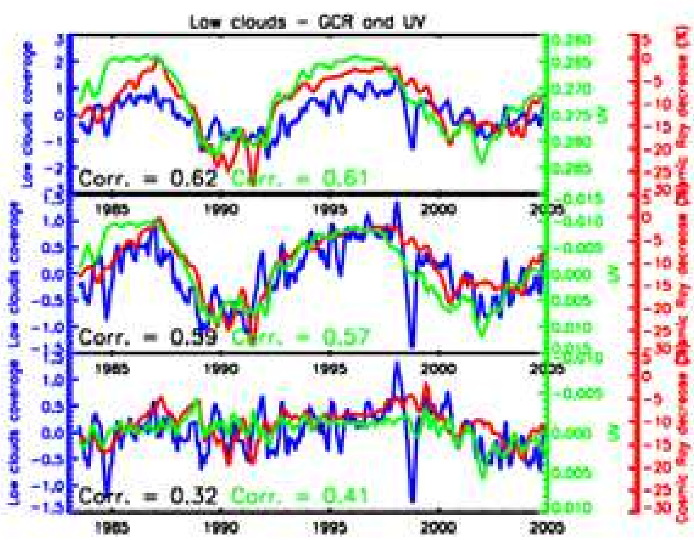

Fig. 29. Correlation between GCR (red) and UV (green) and coverage of low clouds (blue). ISCCP data for coverage of low altitude clouds after adjustment for their offset when compared with the independent data set of low cloud provided by the SSM/I microwave instrument aboard the DMSP satellites. From top: annual cycle removed, trend and internal modes removed, solar cycle removed (modified from DNSC, 2007).

Recently UK's National Centre for Atmospheric Science (NCAS) and the Science and Technology Facilities Council (STFC) (Osprey et al. 2009), showed that the number of high-energy cosmic-rays reaching a detector deep underground strongly matches temperature measurements in the upper atmosphere during short-term atmospheric (10-day) events. The effects were seen by correlating data from the underground detector used in a U.S.-led particle physics experiment called MINOS (managed by the U.S. Department of Energy's Fermi National Accelerator Laboratory) and temperatures from the European Center for Medium Range Weather Forecasts during the winter periods from 2003–2007.
As it was shown the relationship can be used to identify weather events that occur very abruptly in the stratosphere during the Northern Hemisphere winter. These events can have a significant effect on the severity of winters we experience, and also on the amount of ozone over the poles.
The cosmic-rays, known as muons are produced following the decay of other cosmic rays, known as mesons. Increasing the temperature of the atmosphere expands the atmosphere so that fewer mesons are destroyed on impact with air, leaving more to decay naturally to muons. Consequently, if temperature increases so does the number of muons detected. The relation for the winter period from 2006-2007 is shown in Fig. 30.

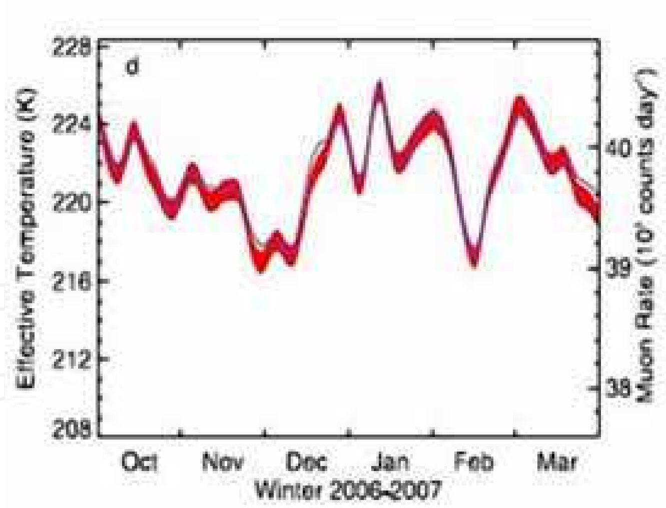

Fig. 30. Relationship between the cosmic-rays and stratospheric temperature for the winter of 2006–2007 (Osprey et al., 2009).

5.6 Palaeoclimate and cosmic-rays

The geological record of the past 550 million years shows variations between ice-free and glaciated climates. Since there were four alternations between "hothouse" and "icehouse" conditions during the Phanerozoic the greenhouse-warming theory could not account for these changes (Svensmark, 2007). Reconstructions of atmospheric CO2 show just two major peaks as shown in Fig. 13.

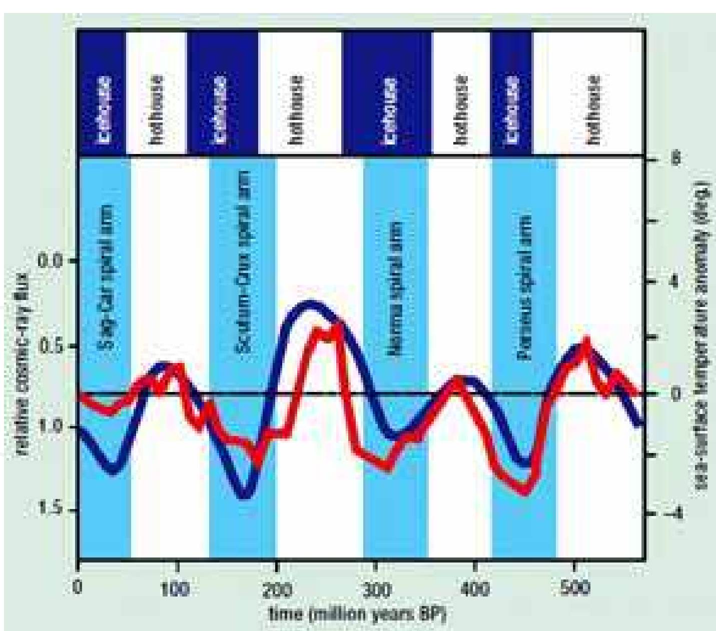

Fig. 31. Variations in tropical sea-surface temperatures corresponding to four encounters with spiral arms of the Milky Way and the resulting increases in the cosmic-ray flux (Redrawn from Svensmark, 2007 – after Shaviv and Veizer, 2003).

A more persuasive explanation comes from cosmoclimatology, which attributes the icehouse episodes to four encounters with spiral arms of the Milky Way, where explosive blue stars and cosmic rays are more concentrated. As Shaviv & Veizer (2003) showed, the relative motion of the spiral arm pattern of our galaxy with respect to the solar orbit around the galactic centre gave a good fit with the climatic record, in cycles of about 140 million years. The matches between spiral-arm encounters and icehouse episodes occurred during the Ordovician to Silurian Periods with the Perseus Arm, during the Carboniferous with the Norma Arm, the Jurassic to Early Cretaceous Periods with the Scutum-Crux Arm, the Miocene Epoch with the Sagittarius-Carina Arm leading almost immediately to the Orion Spur during the Pliocene to Pleistocene Epochs. This is demonstrated in Fig 31, where four switches from warm "hothouse" to cold "icehouse" conditions during the Phanerozoic are shown with respect to variations in tropical sea-surface temperatures (several degrees K).

5.7 A bold prediction

Archibald (2006), predicted weak solar maxima for solar cycles 24 and 25 and correlated the terrestrial climate response to solar cycles over the last 300 years. He also predicted a temperature decline of 1.5 K by 2020, equating to the experience of the Dalton Minimum from 1796–1820. In his 2009 paper he compares solar Cycles 4 and 23 aligned on the month of minimum. From this comparison it is apparent that solar cycles 22 and 23 are very similar to solar cycles 3 and 4, which preceded the Dalton Minimum, and assumes that the coming solar cycles will be similar to cycles 5 and 6 of the Dalton Minimum (see Fig. 32).

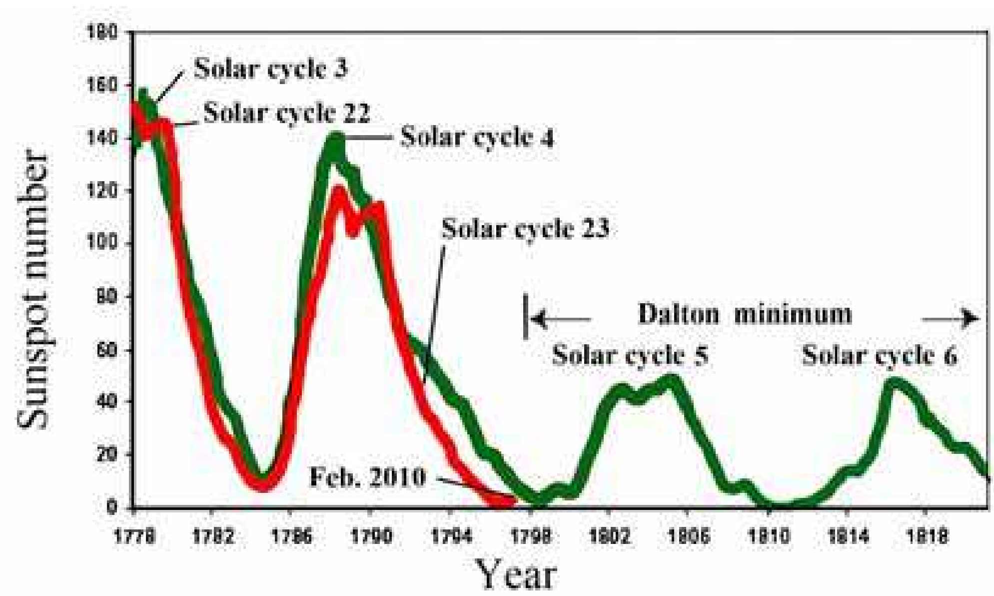

Fig. 32. Solar cycles 22 and 23 compared to solar cycles 3 and 4 (revised from Archibald, 2009).

Furthermore Archibald applied the methodology of Friis-Christensen and Lassen (1991), that demonstrated a relationship between solar cycle length (in one cycle) and annual-average temperature over the following solar cycle, to predict the annual average temperature of Hanover New Hampshire to be 2.2 K cooler during solar cycle 24 than it had been on average over solar cycle 23. His prediction in 2009, assumed that the solar minimum would be in July making solar cycle 23 over 13 years long, which in turn would mean that solar cycle 23 would be 3.2 years longer than solar cycle 22. His plot is presented in Fig. 33.

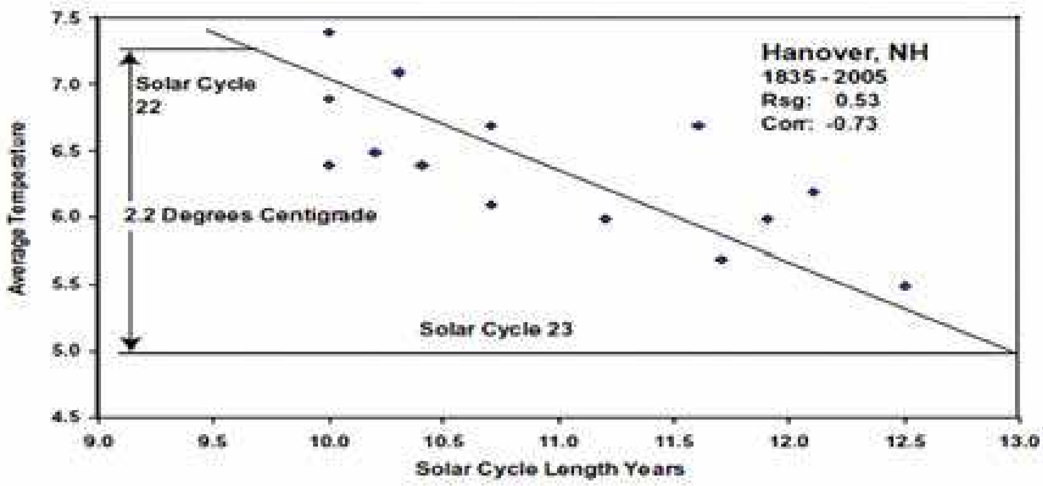

Fig. 33. Average temperature over the following solar cycle 24, for Hanover NH (modified from Archibald 2009).

6. Epilogue

The main conclusion drawn from this study is that contrary to what has become common place, there are mechanisms other than atmospheric CO2 concentration like the solar radiation and cosmic rays that may be largely responsible for the observed change in temperature. Besides, the phenomenon of global temperature rise is not only observed on this planet but it is also detected on other planets as well.

Anthropogenic CO2-concentration increase has contributed to global warming in a small part during the 20th century, but CO2 increase is in part a result of the temperature rise and various natural processes, like ocean changes in CO2 solubility. The procedure used by the IPCC may have mistaken a natural signal for an anthropogenic change because the spatial response pattern of surface air temperature to an increase in solar forcing is quite similar to that of the increase in GHG forcing.

Computer models have failed up to now to reproduce convincingly the observed climate changes. This is greatly due to the lack of implementation of any appropriate laws from Physics. Science does not really have a complete and total understanding of the functioning of the Earth's complex climate system, especially how any effects by or on water can be modeled. In our view, scientists involved in climate research will most likely not agree on a universal conclusion in the near future.

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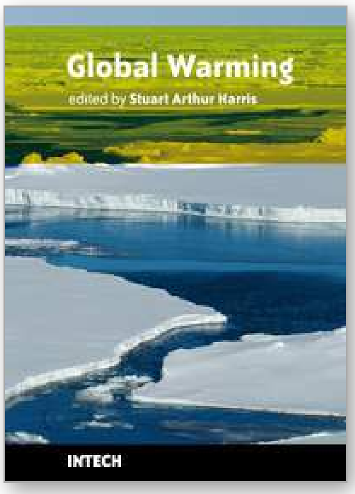

Global Warming

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This book is intended to introduce the reader to examples of the range of practical problems posed by "Global Warming". It includes 11 chapters split into 5 sections. Section 1 outlines the recent changes in the Indian Monsoon, the importance of greenhouse gases to life, and the relative importance of changes in solar radiation in causing the changes. Section 2 discusses the changes to natural hazards such as floods, retreating glaciers and potential sea level changes. Section 3 examines planning cities and transportation systems in the light of the changes, while section 4 looks at alternative energy sources. Section 5 estimates the changes to the carbon pool in the alpine meadows of the Qinghai-Tibet Plateau. The 11 authors come from 9 different countries, so the examples are taken from a truly international set of problems.