CLIMATE CHANGE DURING GEOLOGICAL AND RECENT TIMES

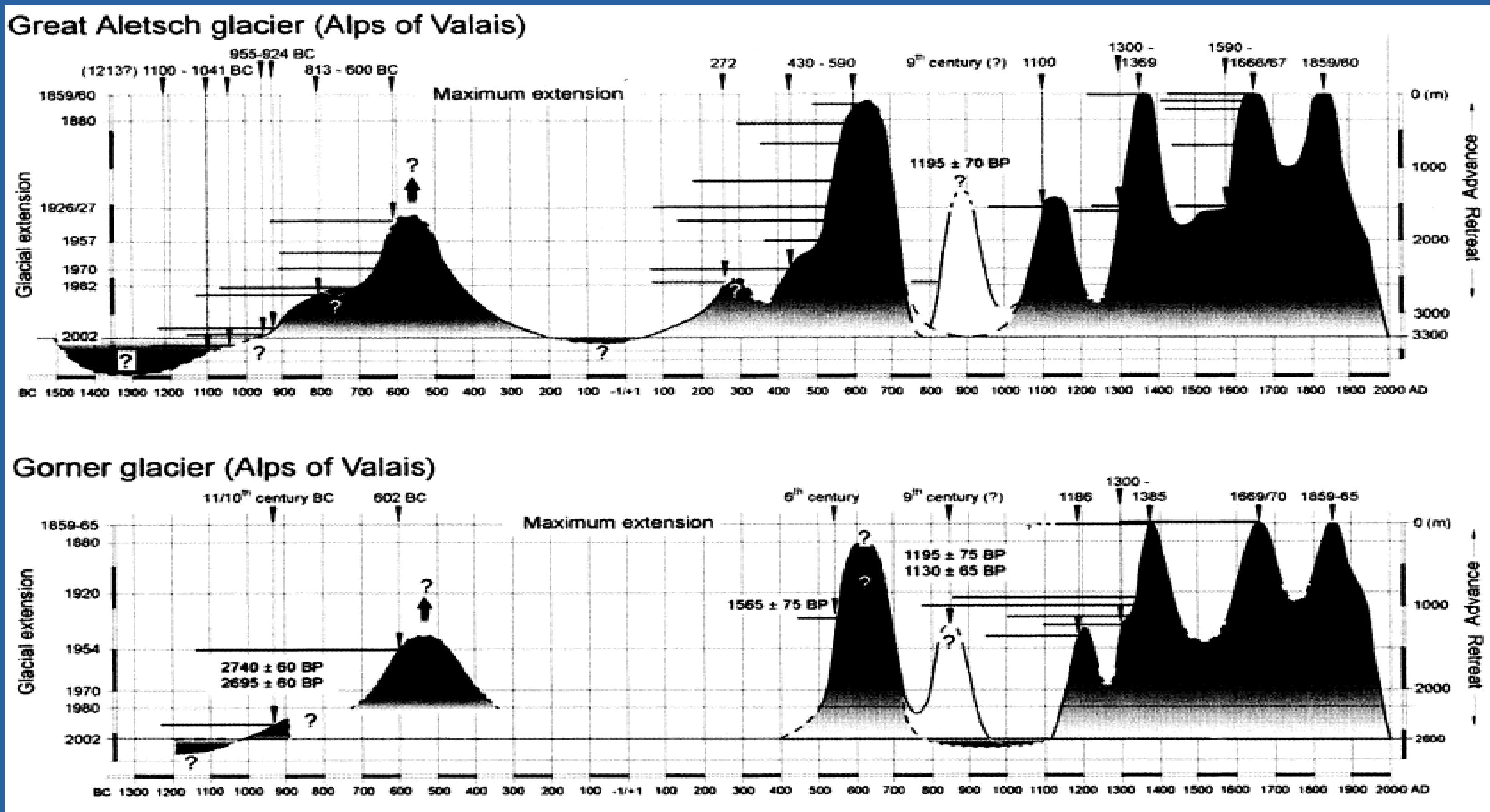
any thing new or déjà vu?

Causes, Speculations and IPCC Postulates

Prof. Peter A. Ziegler, Dr. h.c.

March 2011, updated December 2011

Glaciers always waxed and waned, even without anthropogenic CO_2 emissions

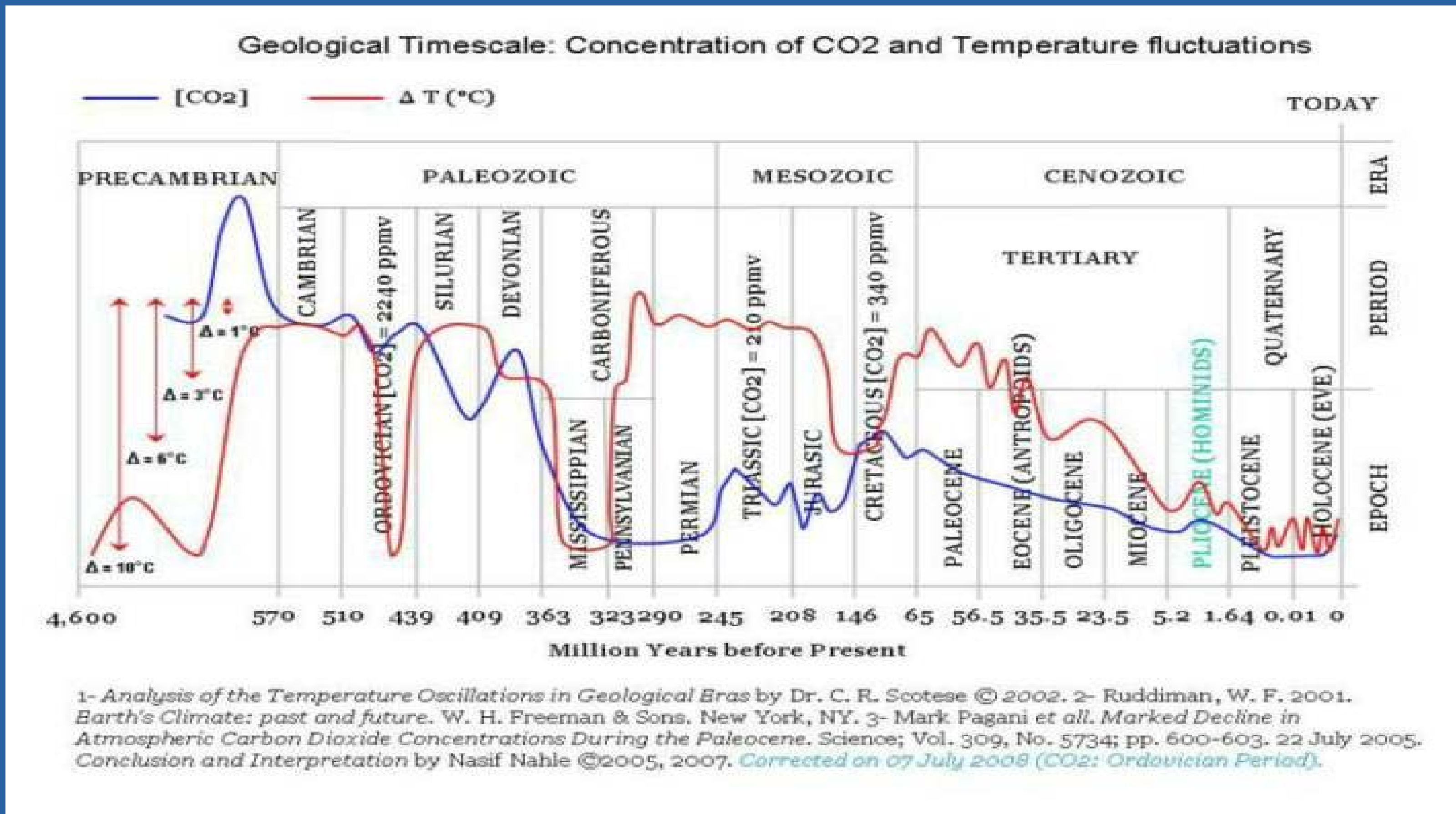


Source of diagram: Holzhauser et al., 2005

During the Roman (400 BC - 400 AC) and Medieval (700-1300) Warm Times Alpine glaciers had retreated further than at present. They advanced again during 400-700 and the Little Ice Age (1300-1850). Our climate has never been stable and has always changed, even without human CO_2 emissions.

Is there something special about Global Warming during industrial times, as advocated by IPCC ?

During the last 570 million years the Earth's climate has undergone major changes with temperatures and atmospheric CO_2 concentrations reaching at times much higher values than at present



Source of diagram: Nahle, 2005, updated 2008.

Temperatures and atmospheric CO_2 concentrations given for Phanerozoic times (the last 570 million years) were reconstructed from proxies, such as sedimentologic and palaeontologic data and the $^{16}O/^{18}O$ isotope ratio.

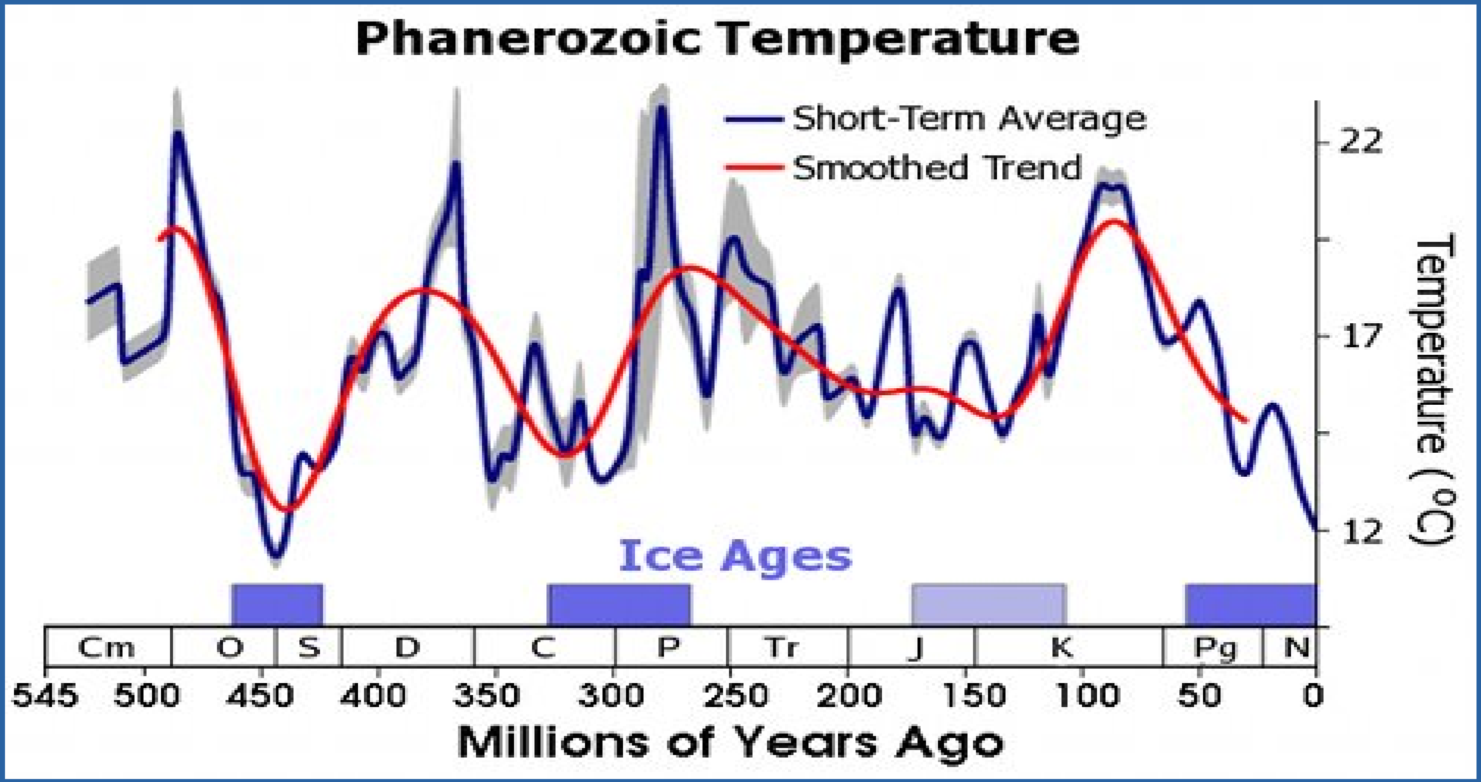
Oxygen Isotope Ratio $^{16}O/^{18}O$ is a Temperature Proxy

- Oxygen occurs as ^{16}O, ^{17}O, and ^{18}O. The most abundant is ^{16}O, with a small percentage of ^{18}O and an even smaller one of ^{17}O. Isotope analyses address in a sample the ratio of ^{18}O to ^{16}O.

- As ^{18}O is two neutrons heavier than ^{16}O, more energy is required to vaporize $H_2{}^{18}O$ than $H_2{}^{16}O$. During evaporation residual liquids become $H_2{}^{18}O$ enriched. When water vapor condenses $H_2{}^{18}O$ is preferentially precipitated, leaving progressively more $H_2{}^{16}O$-rich water vapor. As temperatures decrease, this distillation process causes precipitation to have lower $^{18}O/^{16}O$ ratios. The $^{18}O/^{16}O$ ratio provides a record of ancient water temperatures, and as such is a temperature proxy.

- Oxygen isotope ratios obtained from carbonates and organic matter, as well as from air inclusions in salt and ice cores, provide a temperature proxy at geological time scales. Changes in isotope ratios are interpreted in terms of water temperature change. A one per mil change in $^{18}O/^{16}O$ represents a temperature change of about 4 ^{0}C.

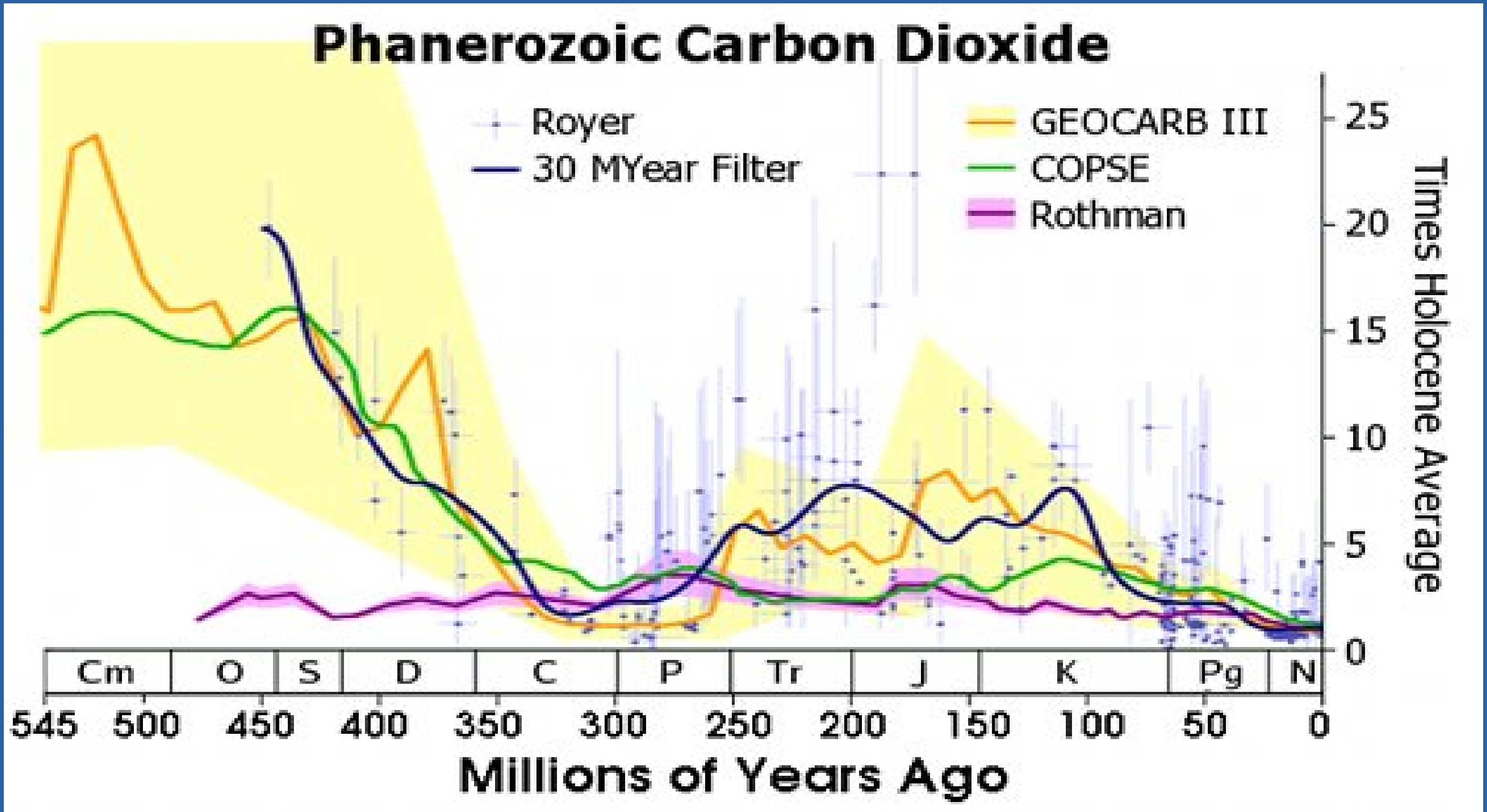
Temperature record based on Oxygen Isotope Ratio $^{16}O/^{18}O$



Source of diagram: Veizer et al., 2000 (updated online 2004)

During the last 545 Million years the Earth‘s climate shifted repeatedly between ice-house and green-house conditions. We live in an interglacial period of the Neogene ice-house.

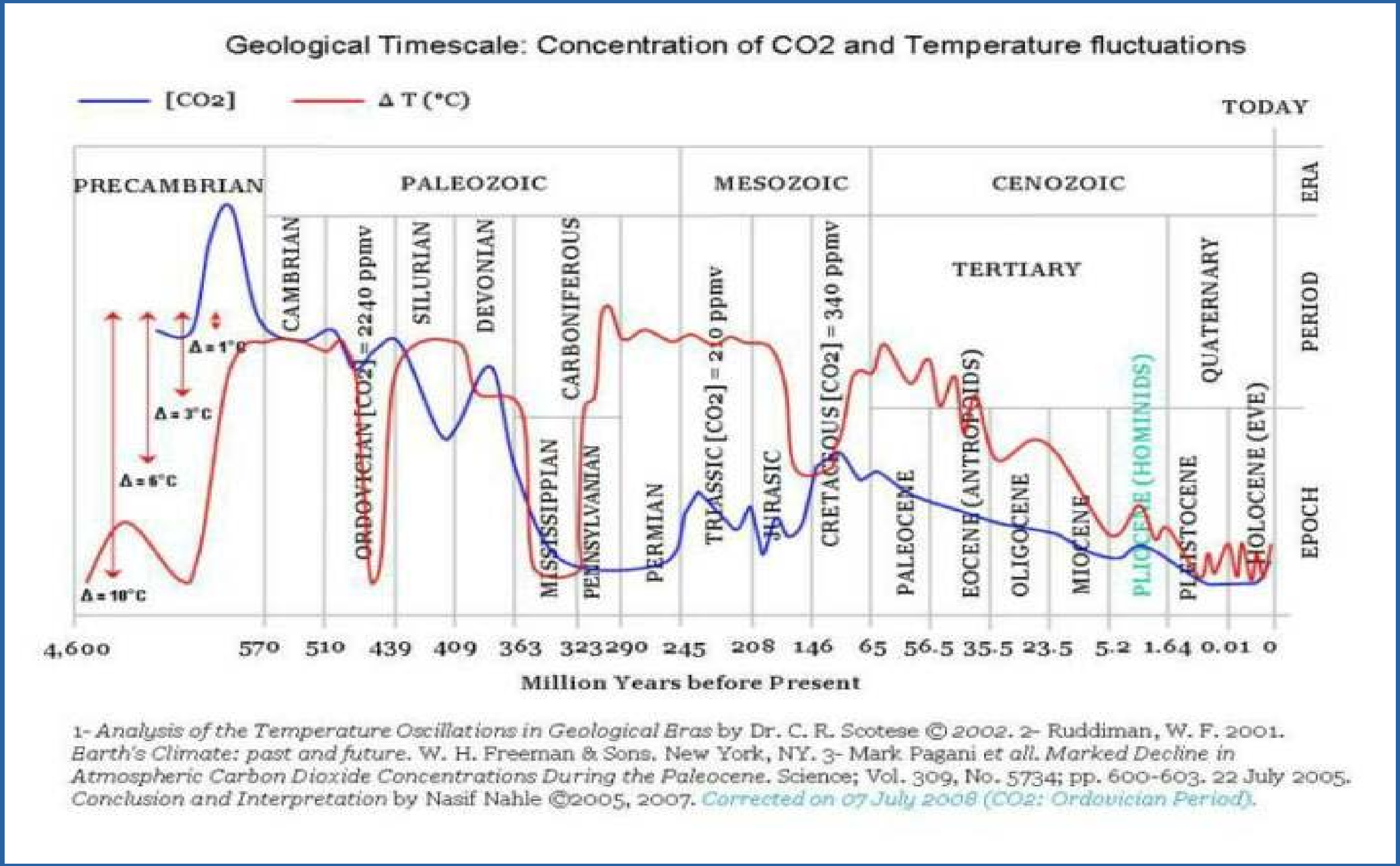
Temperatures changed in geological times in response to natural processes. These processes are still active at present and influence our climate.



Source of Diagram: Berner & Kothalva, 2002

Reconstructions of atmospheric CO_2 concentrations through time are based on the analysis of multiple proxies, as summarized by Berner& Kothalva (2002). Estimates are consistent across methods but the amplitude of CO_2 concentration changes varies between methods.

During Phanerozoic times atmospheric CO_2 concentrations varied widely. At times they were more that 20 times higher than at present. Our atmosphere is CO_2 starved.

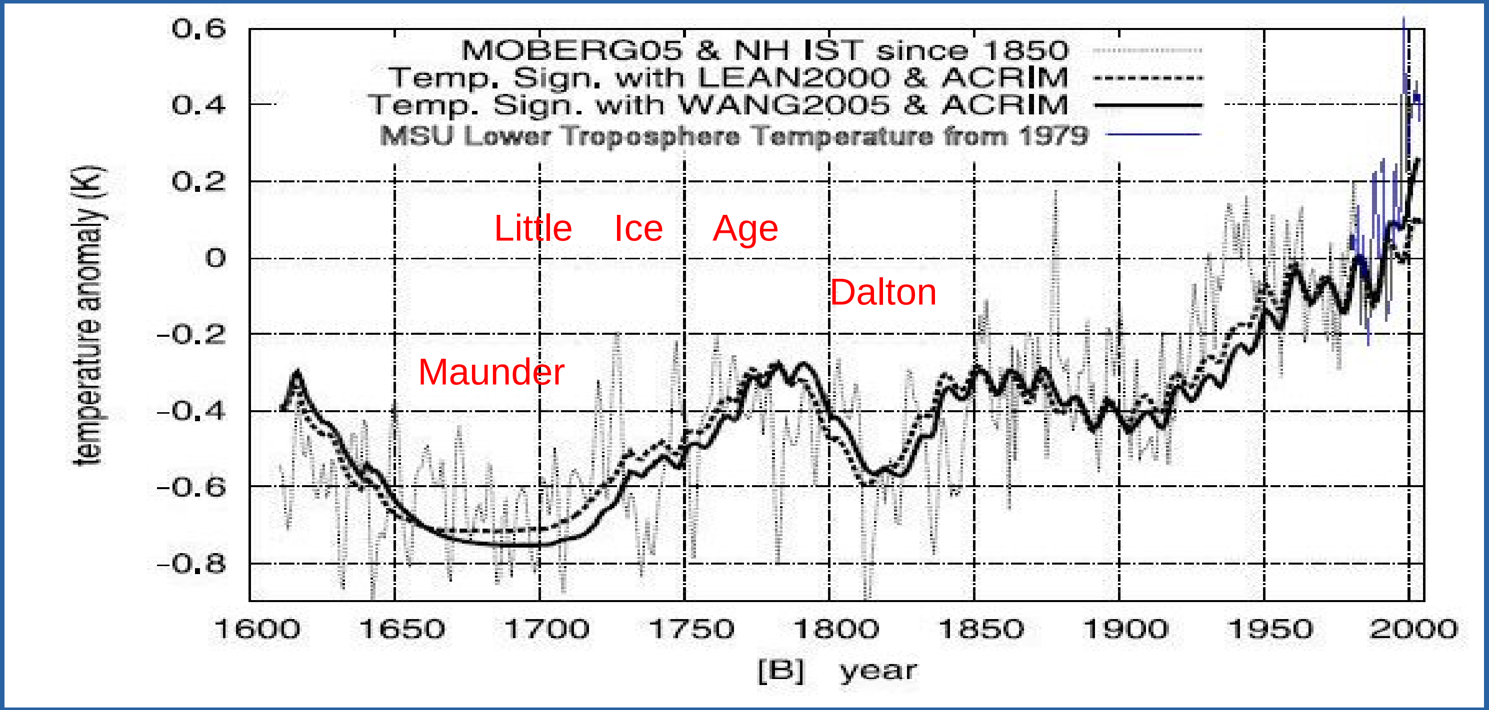


Source of diagram: Nahle, 2005, updated 2008

Taking proxy-derived data and their inherent uncertainties at face value, there is a poor correlation between average atmospheric CO_2 concentrations and temperature fluctuations during Phanerozoic times.

Amongst different factors influencing the Earth's climate (e.g. solar activity, orbital changes, continent distribution), CO_2 does not appear to be a dominant forcing (Veizer et al., 2000; Shaviv & Veizer, 2003; Royer, 2006; Soon, 2007).

Northern Hemisphere Temperatures versus Solar Activity

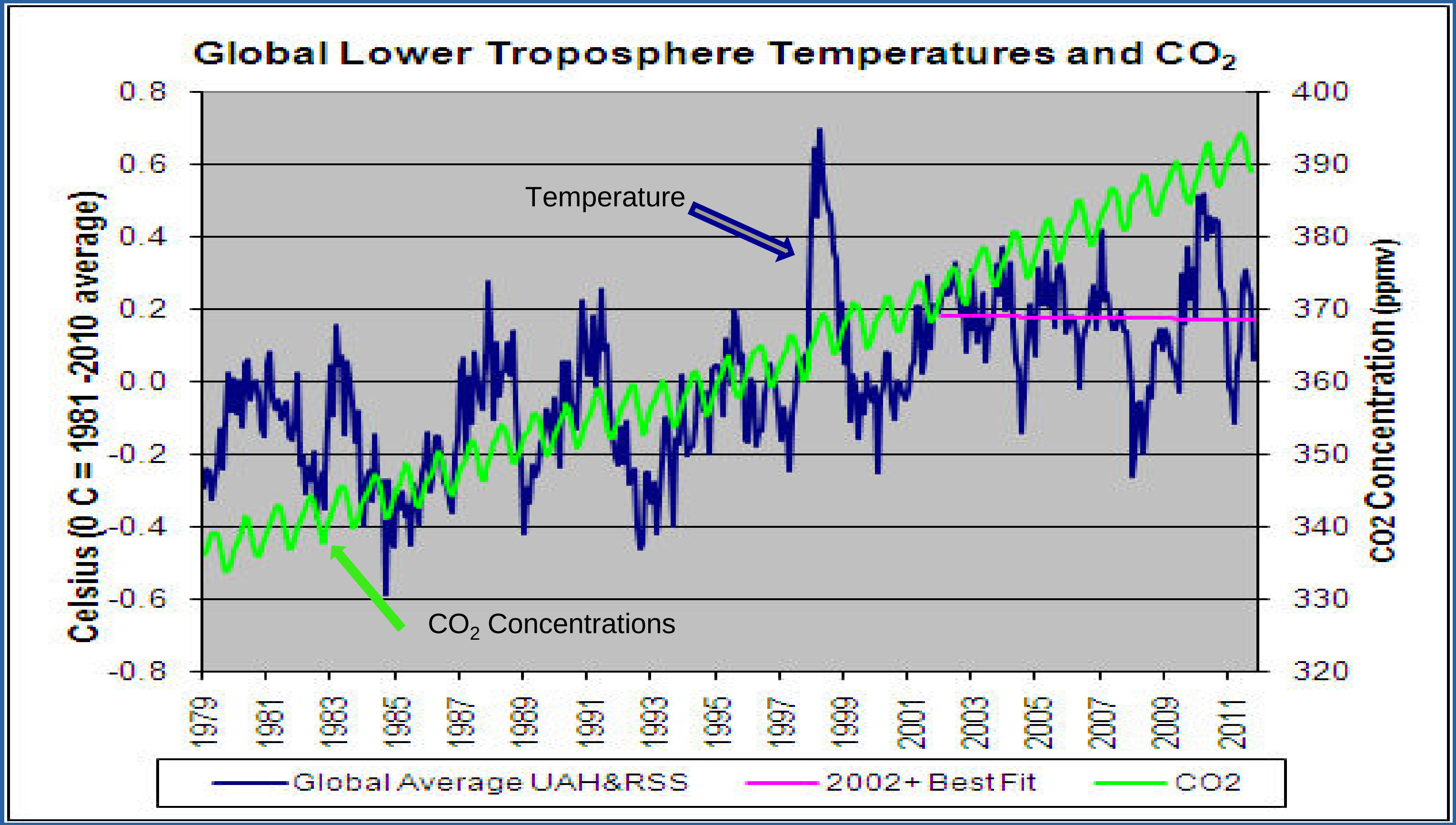


Source of diagram: http://www.friendsofscience.org/, modified after Scafetta & West (2007) to include satellite temperature data.

The smoothed heavy curves give insolation reconstructions by Lean (2000) and Wang (2005) that are based on the evolution of the Sun's spectral irradiance, respectively the Sun's magnetic field and irradiance up to 1980 and on ACRIM satellite data thereafter.

Northern Hemisphere temperatures given in the background were derived from proxy records up to about 1850, from instrumental surface temperature data for 1850 to about 1980 and thereafter from MSU satellite data.

A close correlation between solar activity and temperature is indicated



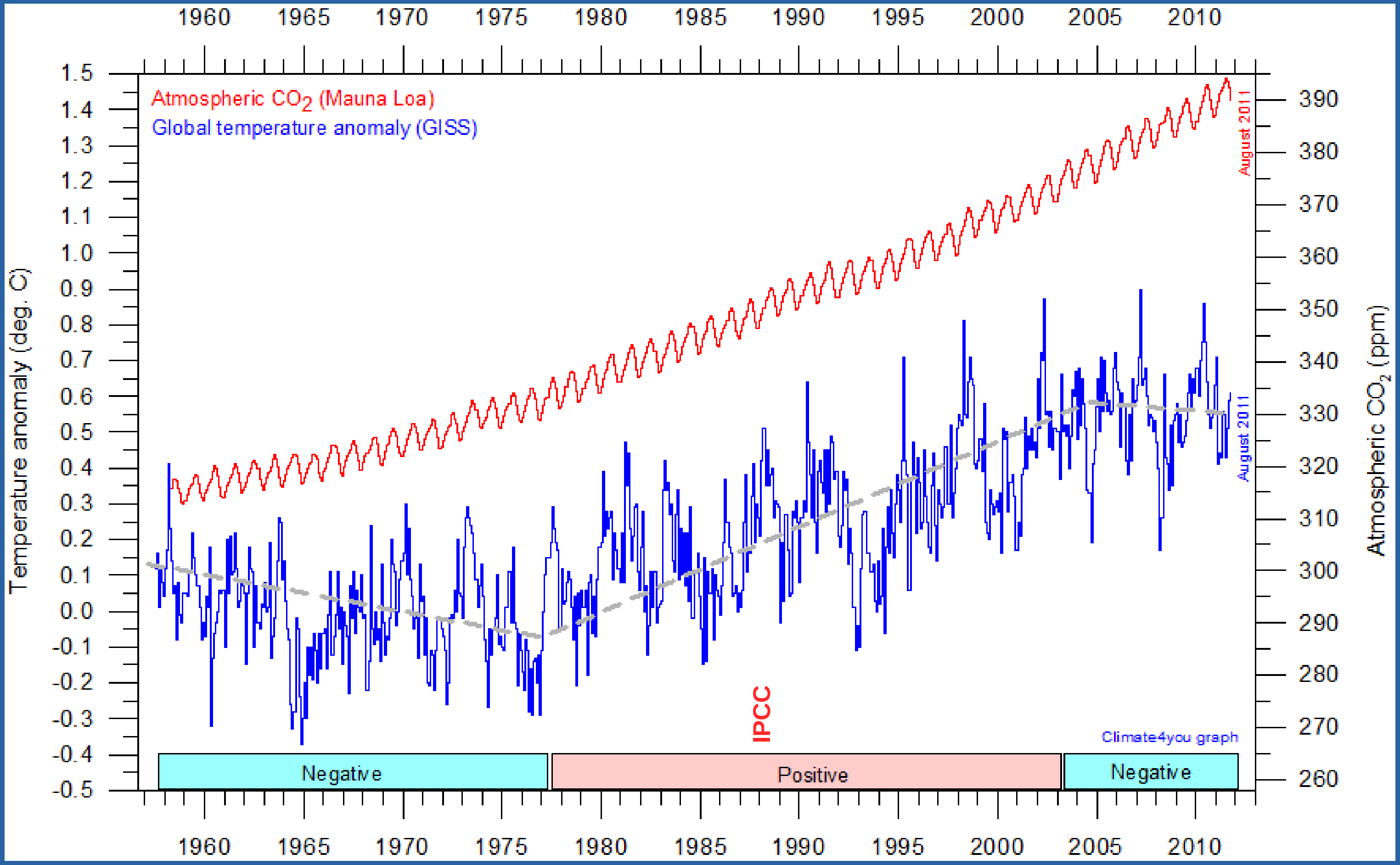
Source of diagram: http://www.friendsofscience.org/

Global lower troposphere temperatures rose cyclically until 2002. From then on onward temperature trends leveled out and start to decrease.

The positive temperature spikes of 1998 and 2010 were caused by strong El Ninos, which are not related to Global Warming, the negative spikes of 1984 and 1992 relate to the El Chichon and Pinatubo volcanic eruptions.

During the last 32 years rising atmospheric CO_2 concentrations and temperature changes do not correlate and thus contradict the IPCC rapid Global Warming concept.

Since 1958 there is only a partial correlation between Global Troposphere Temperatures and atmospheric CO_2 concentrations

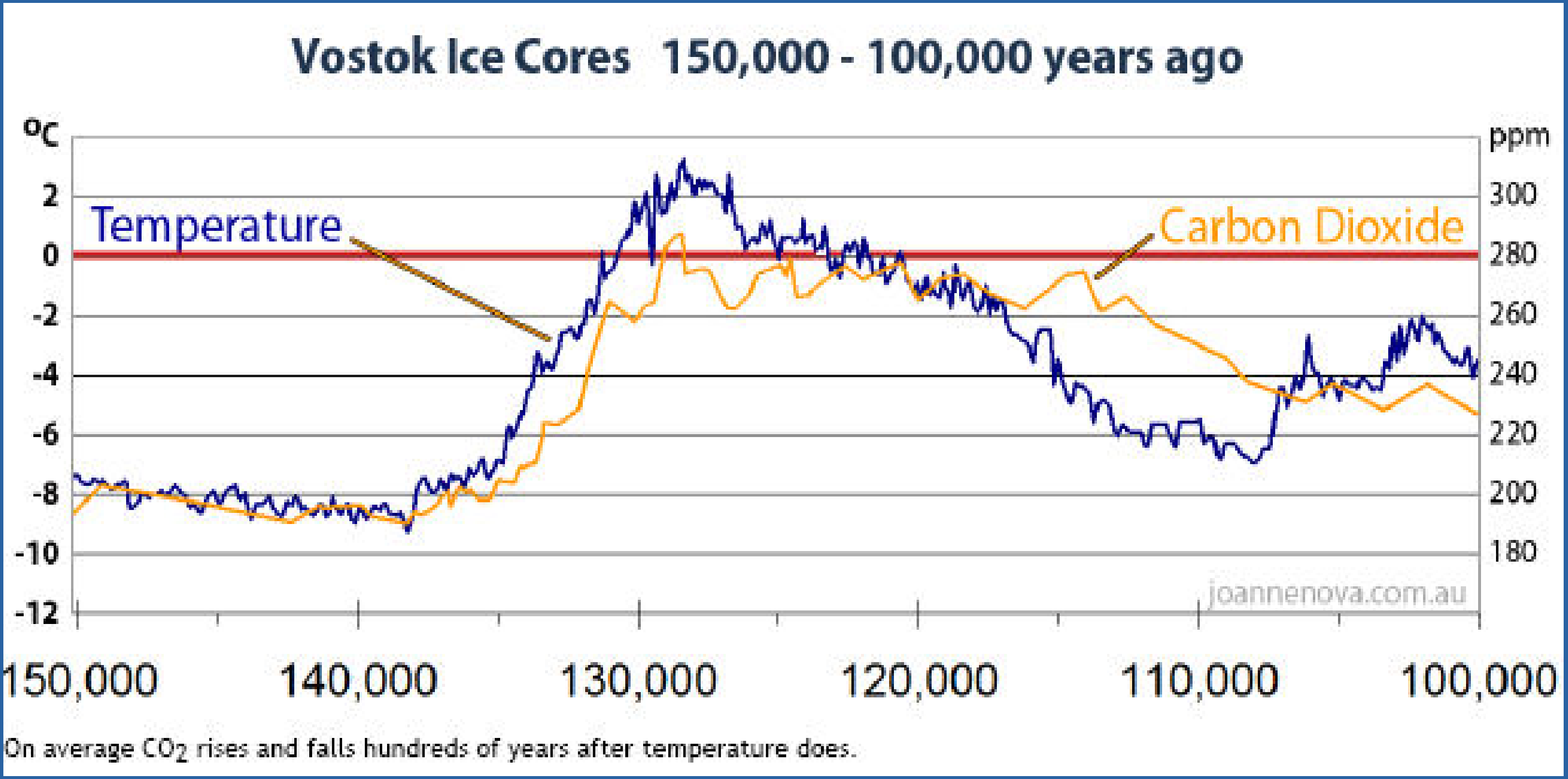


Source of diagram: Climate4you Greenhouse Gases

Similar to the GISS temperature curve, the NCDC, HadCRUT3, RSS MSU and UAH MSU curves show the same temperature relationship to atmospheric CO_2 concentrations

Note the 1988 start-up of IPCC and the Anthropogenic Global Warming Scare

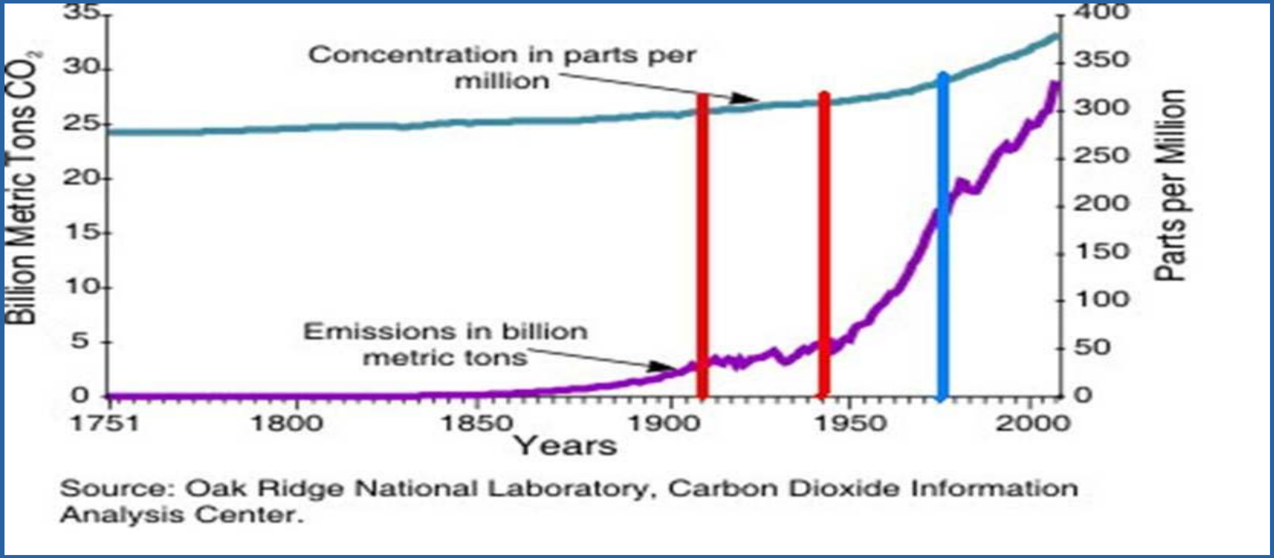
Ice-cores show that in the past temperatures rose and fell hundreds of years before atmospheric CO_2 concentrations rose and fell (Mudelsee, 2001; Caillon et al., 2003; White, 2009)



Source of diagram: http://joannenova.com.au/global-warming/ice-core-graph/

Warming is not forced by CO_2. Solar warming forces CO_2 degassing of the oceans that are an immense CO_2 reservoir

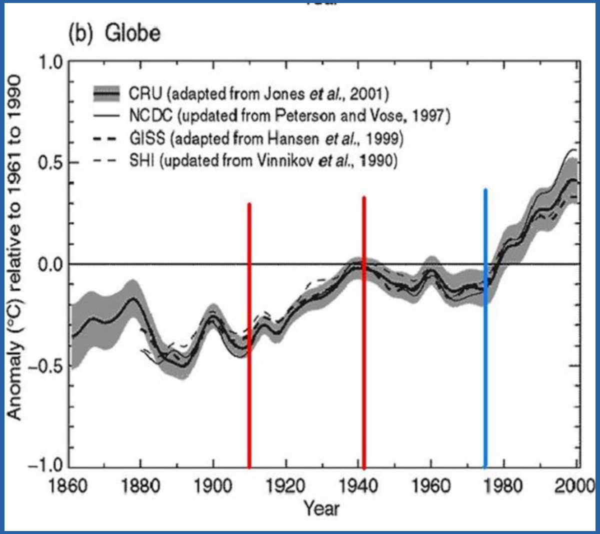
Atmospheric CO_2 concentrations, anthropogenic CO_2 emissions and 200 years of industrial Global Warming



Atmospheric CO_2 concentrations increased already prior to the increase in fossil fuel consumption starting around 1835. The 20th century atmospheric CO_2 concentration increase is probably not exclusively related to fossil fuel emissions.

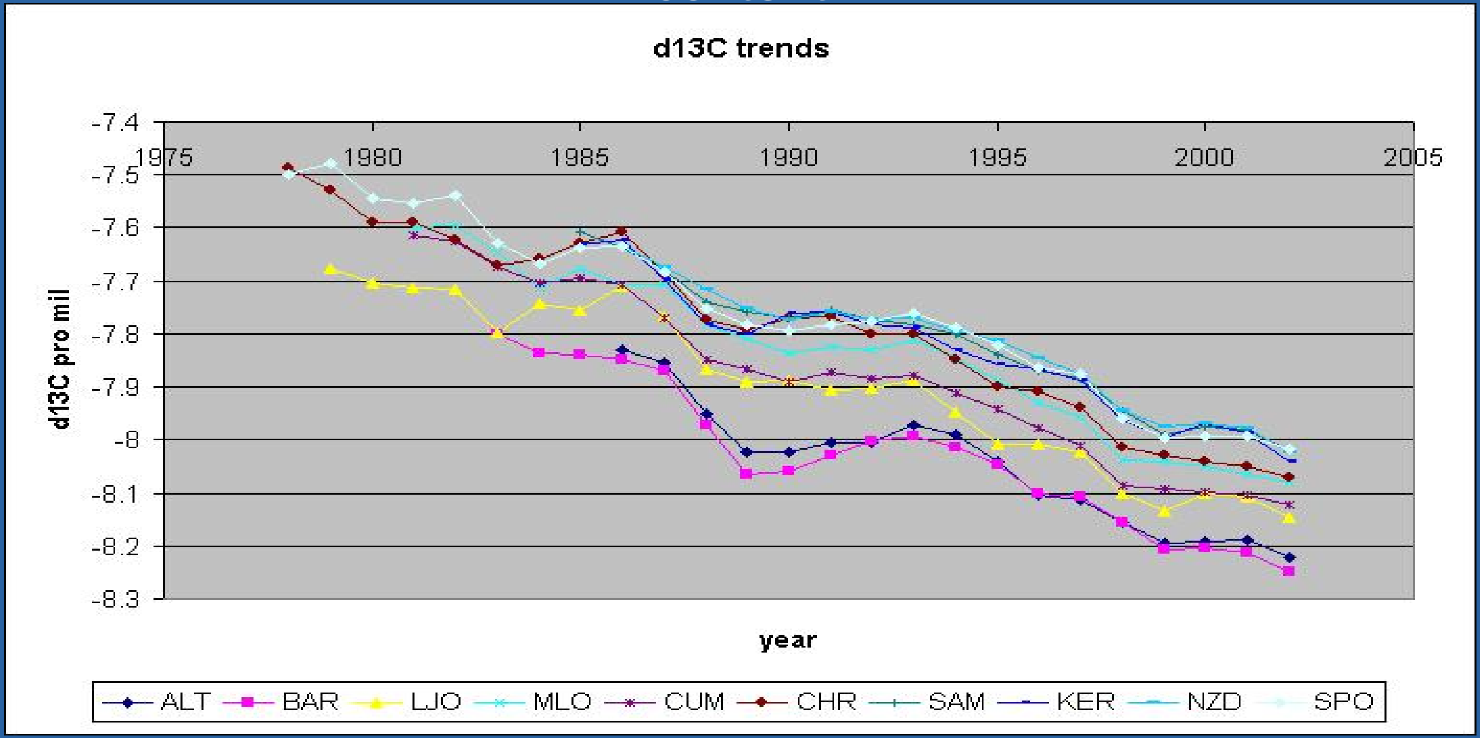
20th century warming started in 1910 and ended in 1942 (between red vertical bars). During this phase of rapid global warming atmospheric CO_2 concentrations and CO_2 emissions increased slowly from 3.5 Gt/yr in 1910 to 4.0 Gt/yr by 1942.

From 1942 to 1975 (between red and blue bars) the world cooled while CO_2 emissions increased 5-fold and the rise in atmospheric CO_2 concentration accelerated.



Global warming correlates with a slight increase in CO_2 emissions but global cooling correlates with a dramatic increase in CO_2 emissions from 4.0 Gt/yr in 1942 to 20.0 Gt/yr by 1975 at the end of the cooling phase.

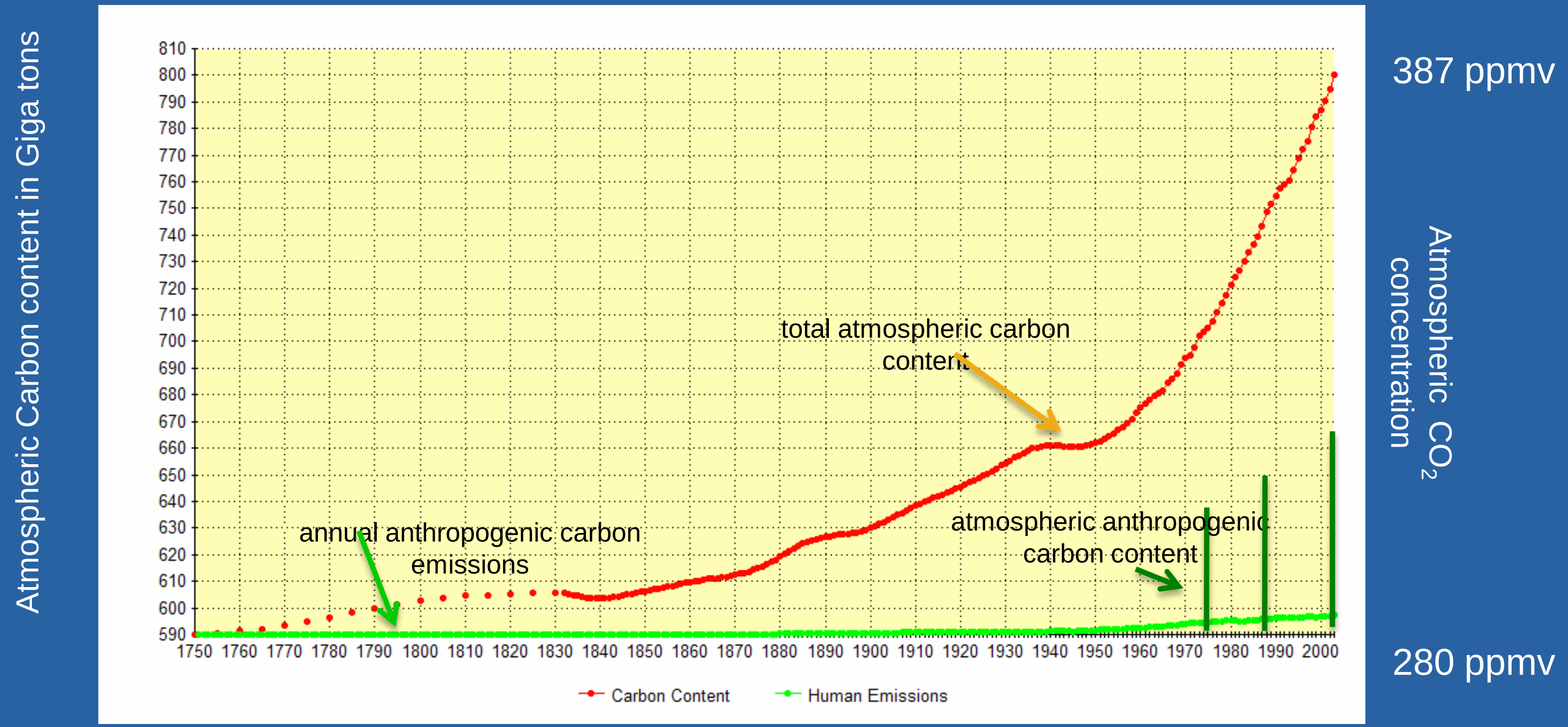
$\delta^{13}C$ measurements and atmospheric anthropogenic CO_2 content



Source of graph: Atmospheric Carbon Dioxide and Carbon Isotope Records at CDIAC.
ALT: Alert; BAR: Barrow; LJO; La Jolla; MLO: Mauna Loa; CUM; Cape Kumukahi; CHR: Christmas Island; SAM: Samoa;
KER: Kermadec Island; NZD: New Zealand (Baring Head); SPO=: South Pole.

Natural CO_2 is characterized by $\delta^{13}C$ of -6.37 per mill (VPDB standard) while CO_2 derived from burning fossil fuels has a $\delta^{13}C$ of -24 per mill. Estimates of the volume of anthropogenic CO_2 mixed into the atmosphere are based on atmospheric CO_2 concentration and $\delta^{13}C$ determinations . On the other hand, as $\delta^{13}C$ variations are seasonal and reflect temperature difference between sources and sinks, they may be a natural phenomenon (Haynie, 2010).

What is the Airborne Fraction of Anthropogenic CO_2?

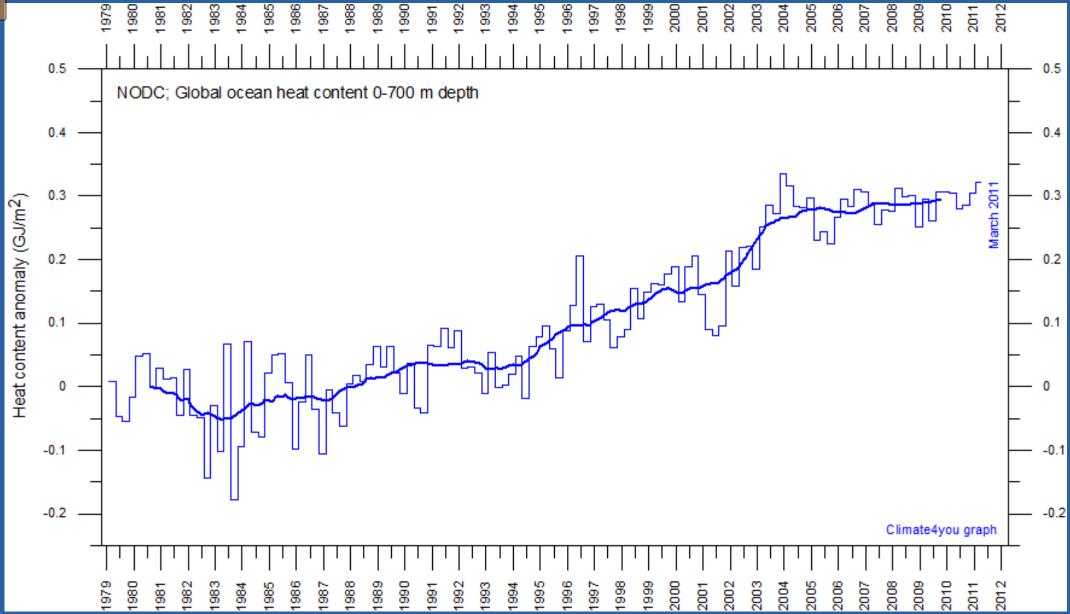


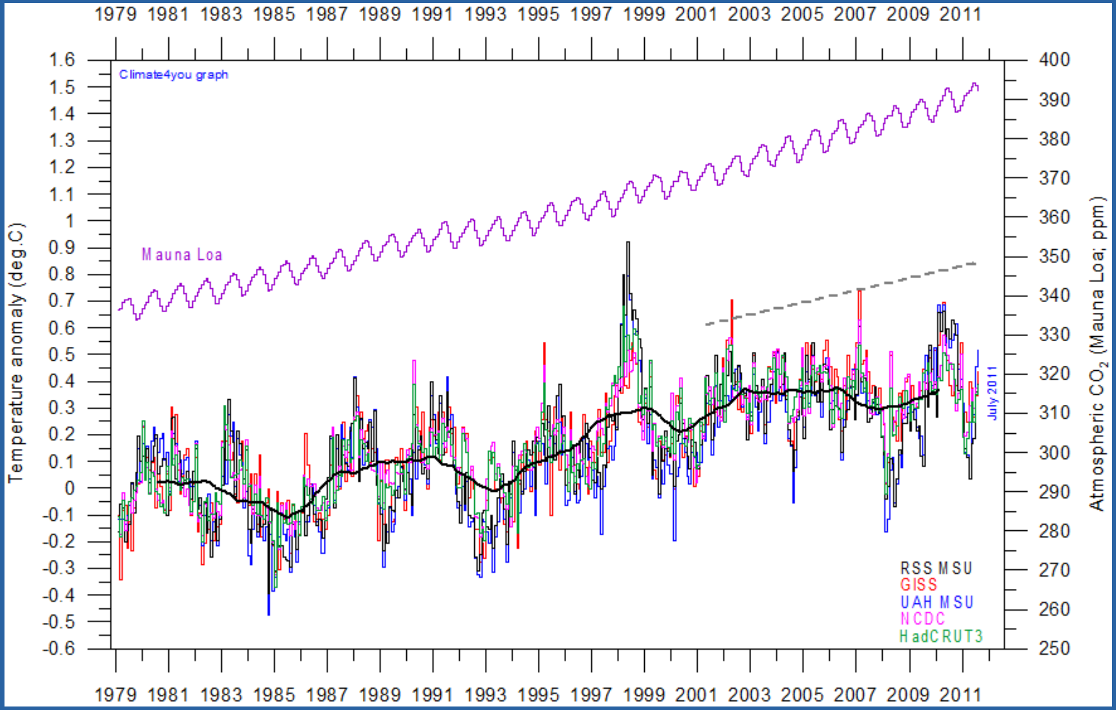
Source of diagram: modified after Siddons & D˙Aleo, 2007.
based on Carbon Dioxide Analysis Center http://cdiac.ornl.gov/trends/co2/contents.htm

Atmospheric CO_2 concentrations increased from 280 ppmv in 1750 to 387 ppmv in 2009, corresponding to an increase by about 332 Gt of Carbon (red curve), while annual anthropogenic CO_2 emissions increased by 2007 to about 8.3 Gt C/year (light green curve, scale 10 Gt steps)

According to the atmospheric CO_2 $\delta^{13}C$ record, the airborne fraction of anthropogenic CO_2 increased from 6.3% in 1978 to 9.7% in 2002 of the total atmospheric CO_2 content (vertical dark green bars, scale 10 Gt steps).

The $\delta^{13}C$ record may, however, not tell us the full story as annually large volumes of CO_2 are absorbed in and released again by natural sinks characterized by a lower $\delta^{13}C$ than the atmosphere.





Upper diagram:

Global Ocean Heat Content

(GJ/m^2, 0-700m depth)

Lower diagram:

Atmospheric CO_2 Content (ppm) and Troposphere Temperature anomalies (^0C)

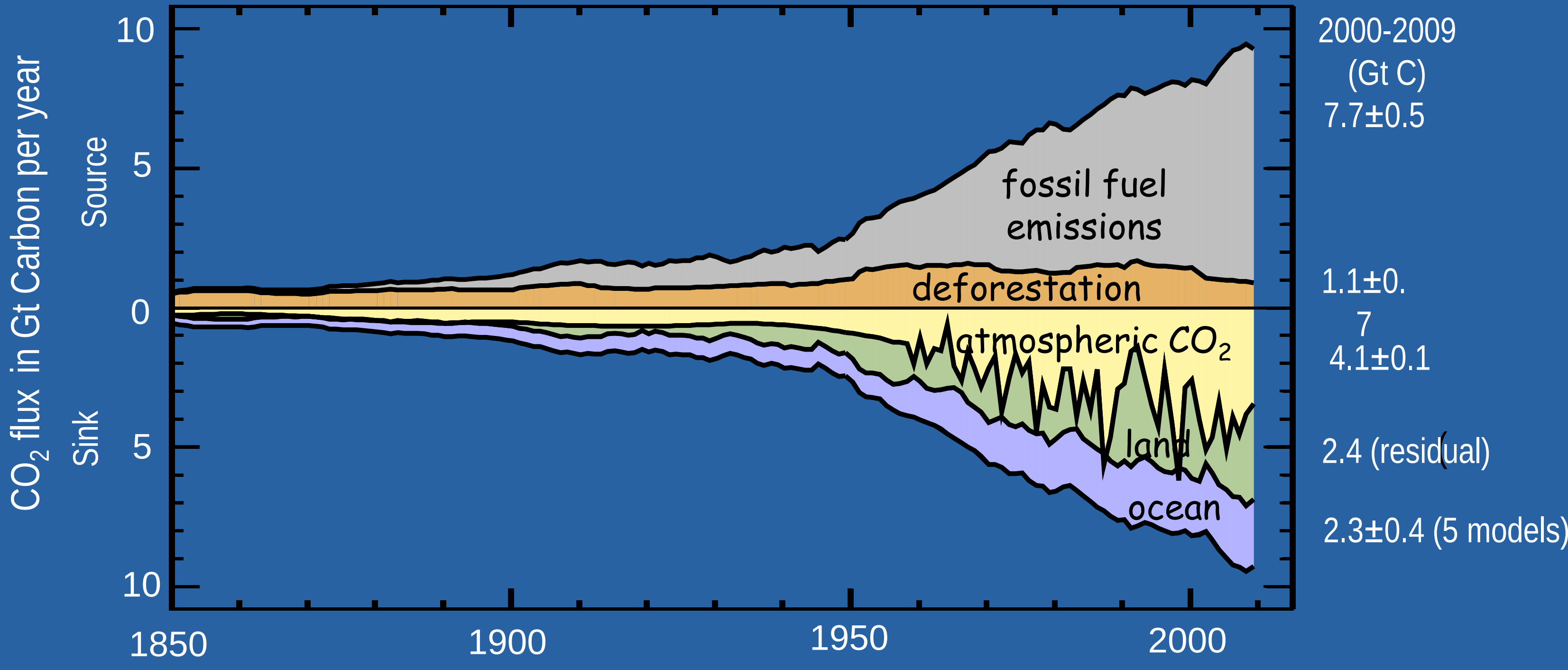
Time span 1979 and 2011

(source of diagrams: climate4you)

Solar SW radiation penetrates the oceans, is absorbed in their upper 100m causing warming of their surface layers and the lower atmosphere, increasing evaporation and cooling. LWIR radiation reflected back to Earth cannot penetrate and warm the oceans but enhances evaporation and cooling. **The oceanic surface layers are saturated with CO_2 and are in equilibrium with the atmospheric CO_2 concentration.**

The CO_2 content of the oceans is temperature and pressure dependent; upon warming and/or decompression CO_2 is released. The oceans have cyclically warmed and released CO_2 since the Little Ice Age. Their warming has now slowed down in unison with a leveling-off of temperatures.

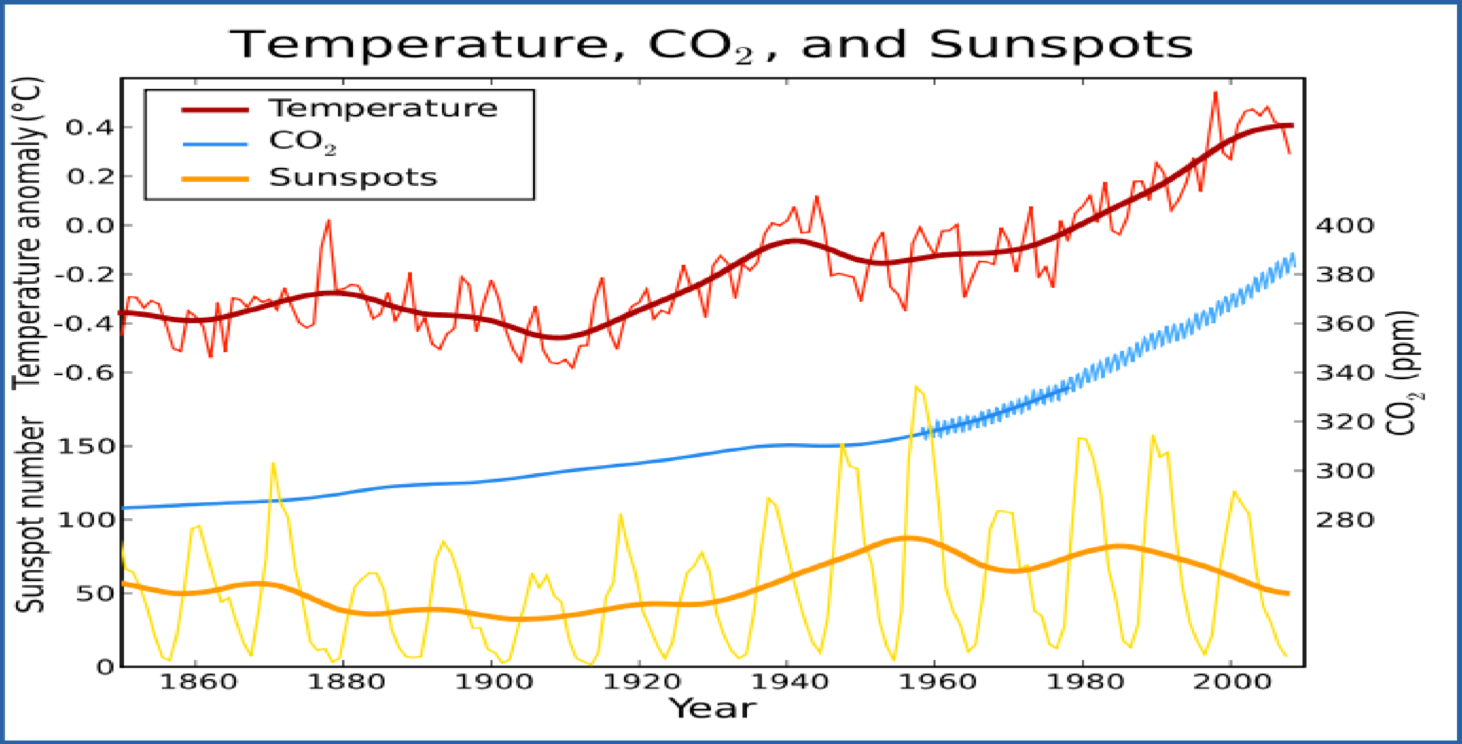
Model for Human Perturbation of the Global Carbon Budget



Global Carbon Project 2010; updated from Le Quéré et al. 2009; Canadell et al. 2007, PNAS

Models suggest that during the last 50 year 55-60% of the annual anthropogenic CO_2 emissions were taken up in terrestrial plant and oceanic sinks while the remaining 40-45% accumulated in the atmosphere (Quéré et al., 2009).

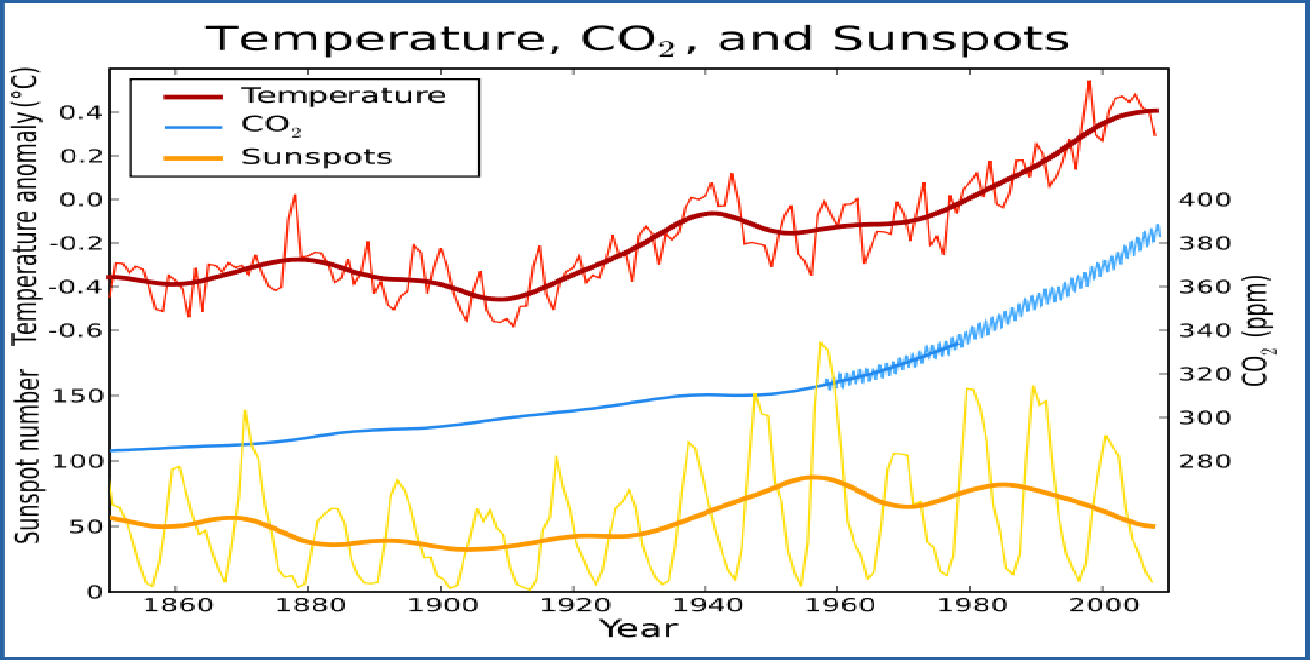
Is this realistic in terms of the short atmospheric residence time of CO_2?

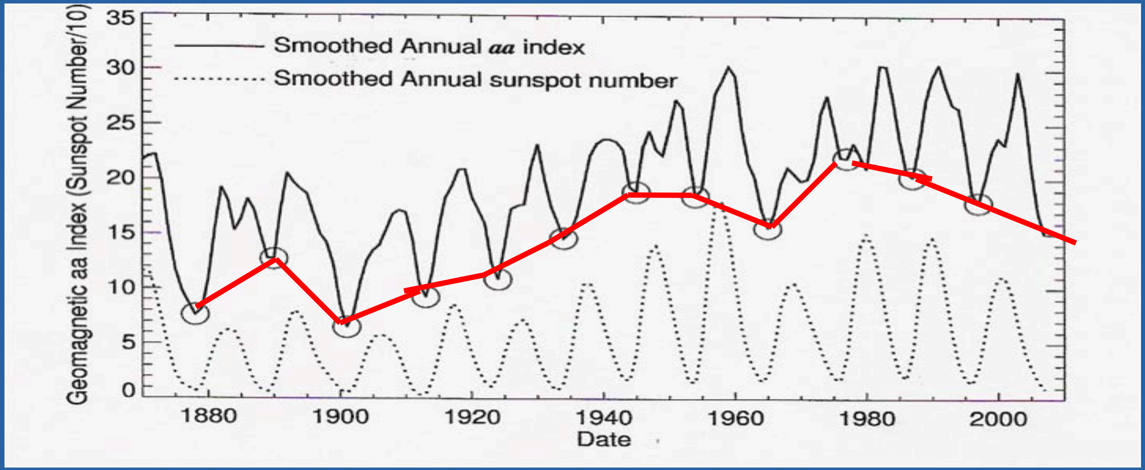


Source 0f diagram: L. McInnes, 2007. In: Wikipedia: Solar Variations
Thick lines for temperature and sunspots: 25 year moving average smoothing of raw data.

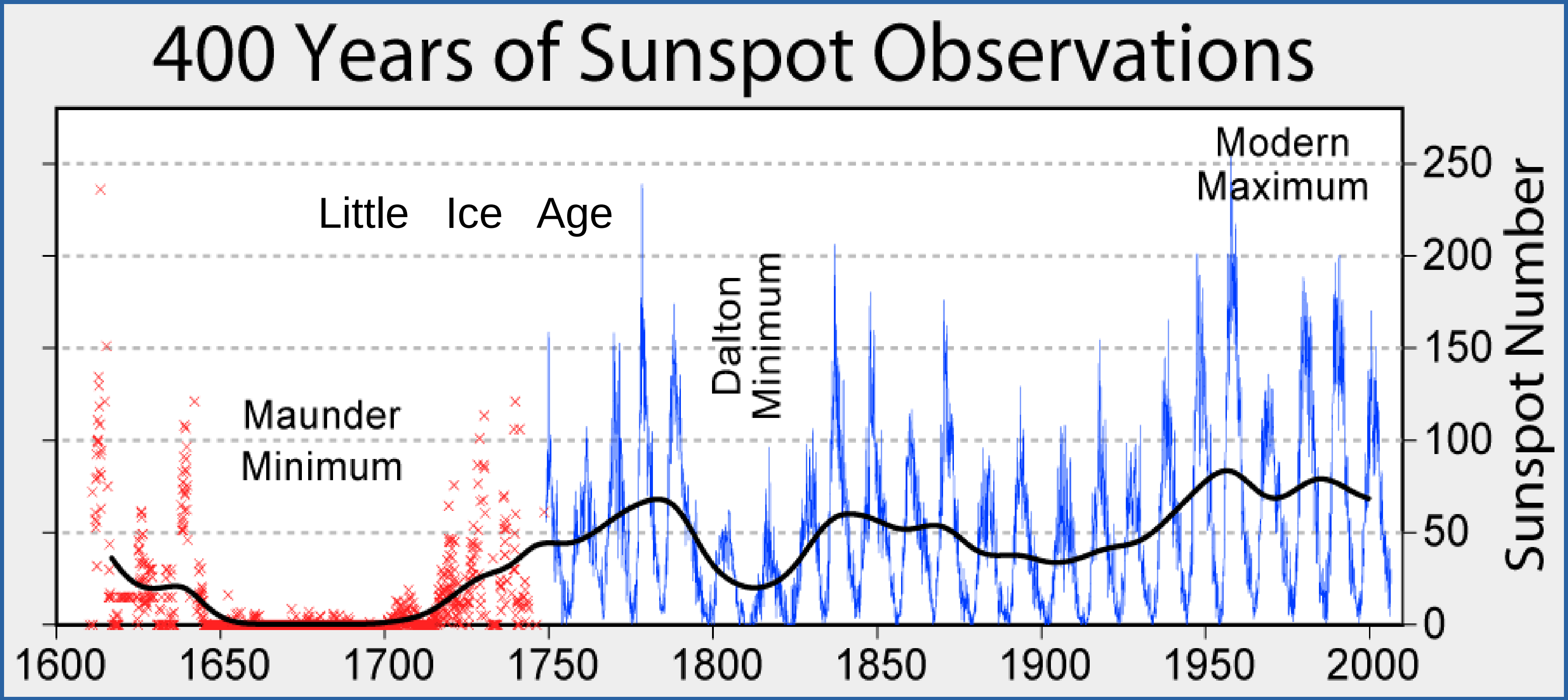
During the last 150 years temperatures and atmospheric CO_2 concentrations rose during a period of cyclically increasing solar activity that came to an end in the 1990s. The steady increase in atmospheric CO_2 concentrations reflects progressive degassing of the gradually warming oceans, combined with increasing anthropogenic emissions. A delay in the temperature response to solar activity decreasing since the 1990s is attributed to the great heat storage capacity of the oceans.
Solar variability is the dominant climate forcing, controlling sea surface and atmospheric temperatures. The greenhouse effect of CO_2 on climate is minor.

There is a convincing message between temperatures and solar cycle minimum values of the geomagnetic index aa that expresses solar activity





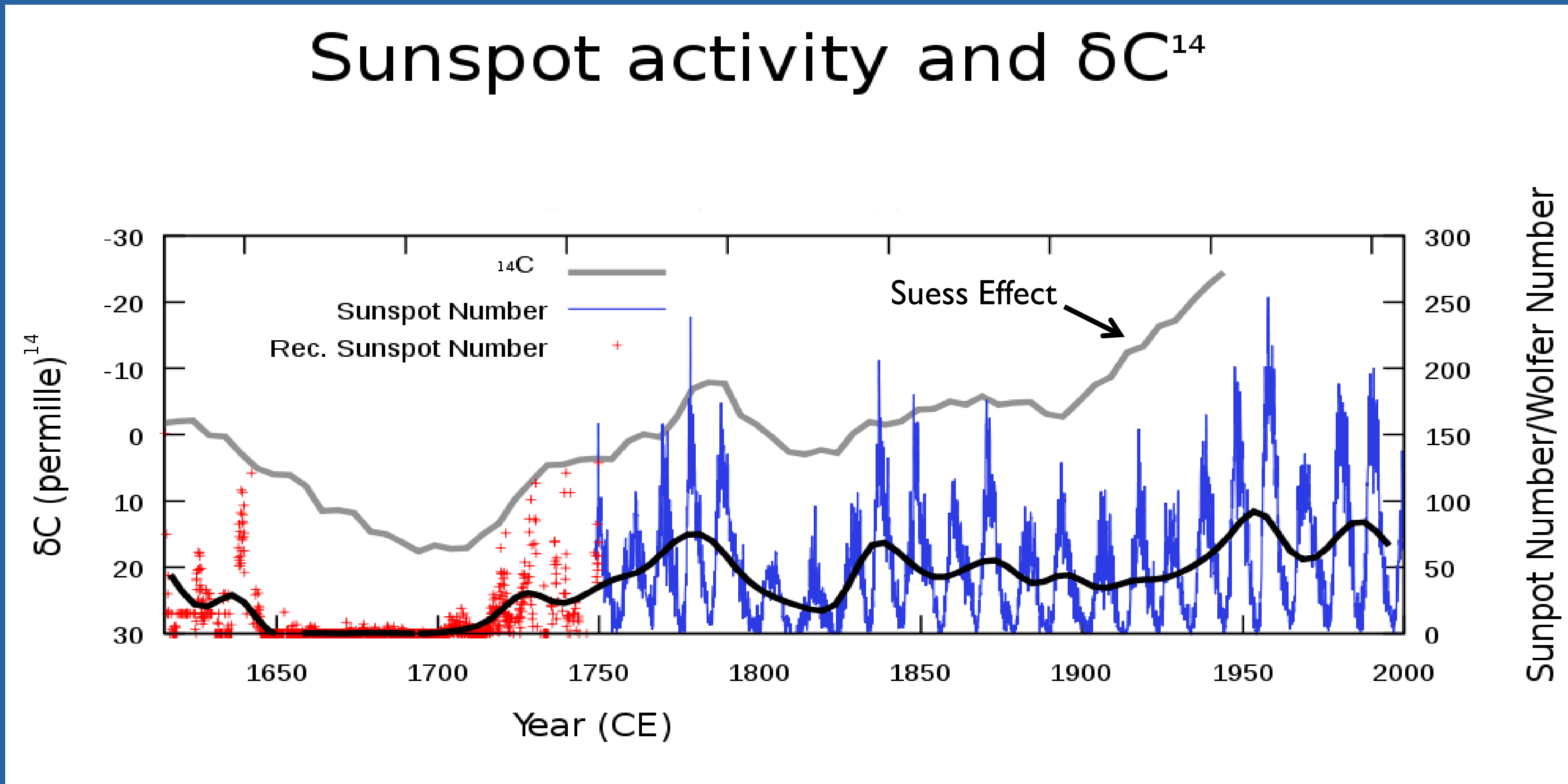
D.H. Hathaway & R.M. Wilson, 2006.



Source of diagram: Wikipedia File Sunspot Numbers.png, based on NOAA and Royal Observatory of Belgium, compiled by Hoyt & Schatten, 1999

Observed sunspot numbers and their eleven-year mean of the monthly average (heavy black line) reflect important variations in solar activity during the last 400 years. Low solar activity characterized the Maunder and less severe Dalton Minimum of the Little Ice Age. Solar activity increased during the progressively warming modern Maximum and began to decline again in the late 1990s, possibly heralding a new Maunder-type minimum in solar activity and related cooling.

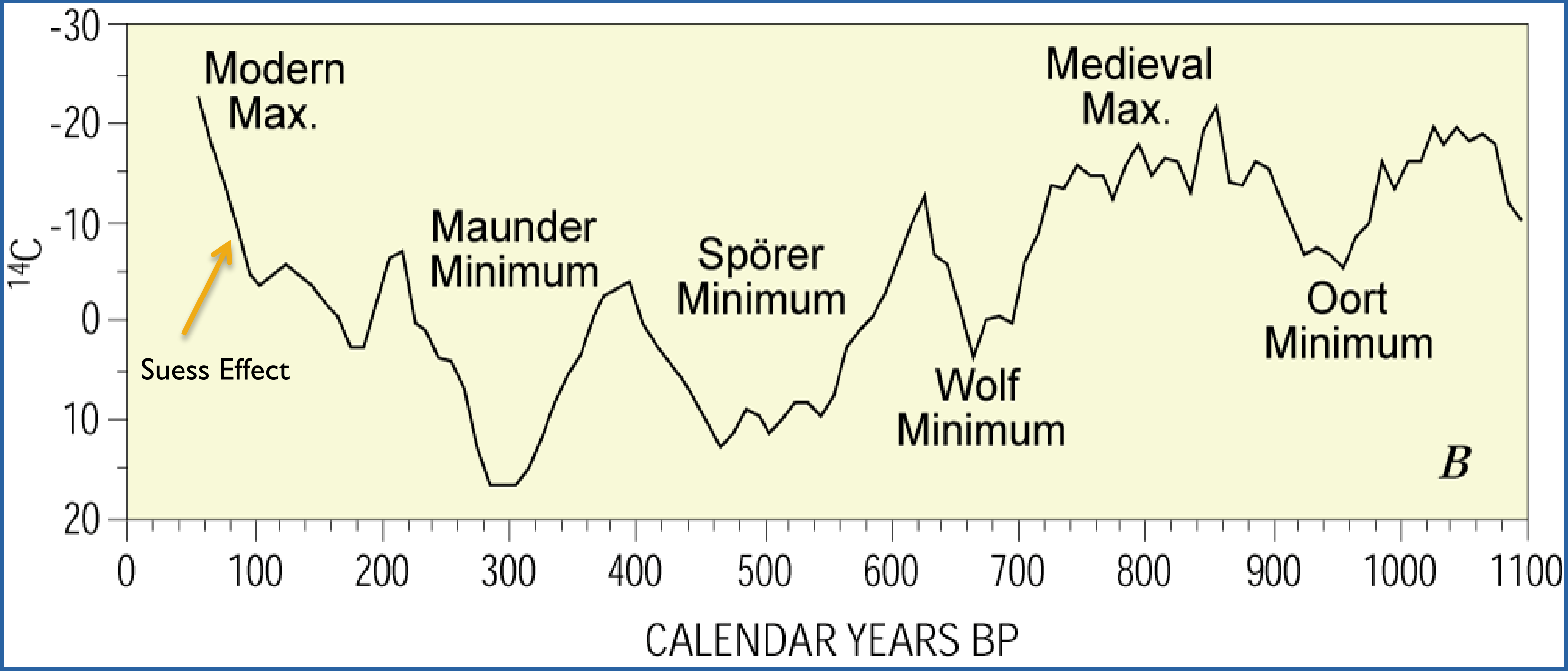
^{14}C with a half-life of ± 5730 years is a proxy for solar activity and correlates closely with the $^{18}O/^{16}O$ ratio, the temperature proxy



Source of diagram: L. McInnes, Wikimedia Commons File: Carbon-14-sunspot.svq

^{14}C is produced in the upper atmosphere through spallation of Nitrogen by neutrons coming from powerful galactic cosmic radiation that varies with the solar magnetic flux. The production of ^{14}C is inversely proportional to solar activity. During periods of high solar activity the magnetic field of the heliosphere and the solar wind increase, thus reducing the flux of galactic cosmic cays that reaches the Earth.

^{14}C reconstruction of historical climate

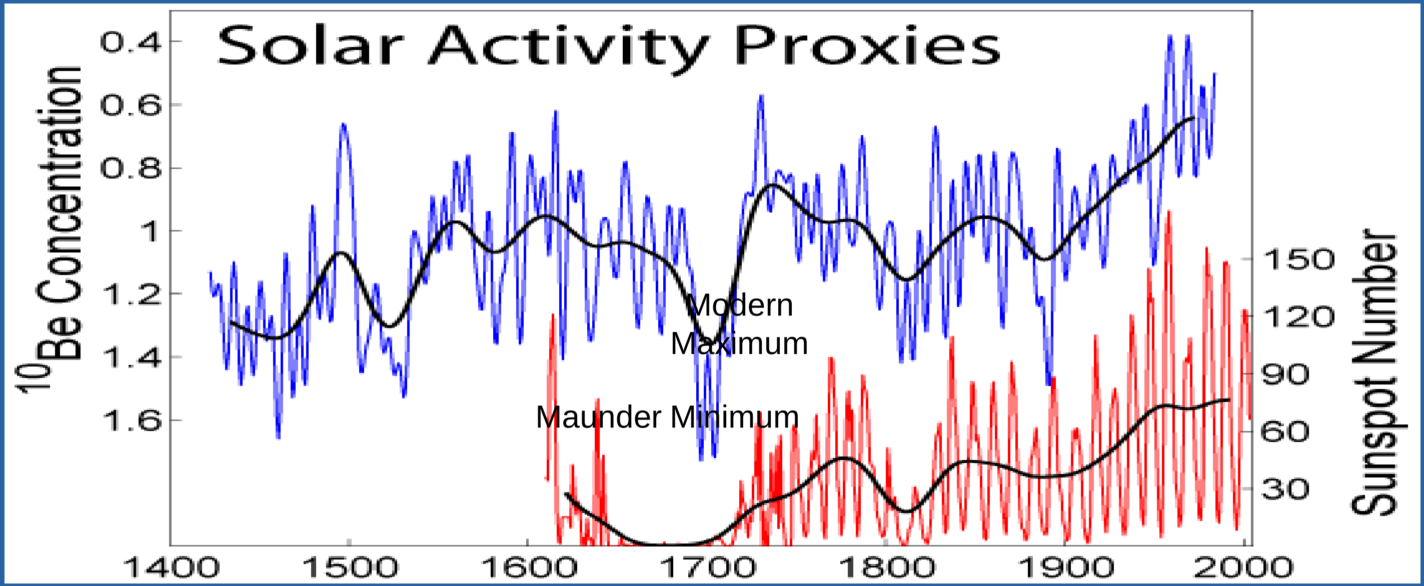


Source of diagram: Wikipedia File Solar Variations

This diagrams shows the ^{14}C record for the last 1100 years (note inverted scale) with solar activity events labeled after USGS. The ^{14}C record shows that solar activity varied continuously during the last 1100 years, forcing climate fluctuations such as the Maunder Minimum of the Little Ice Age and the Medieval and Modern Maxima with annual mean temperature differences of up to $1^{0}C$.

While in historic times humanity adapted to major climatic fluctuations, IPCC holds modern societies responsible for ongoing climate changes and claims that the climate can be engineered by controlling CO_2 emissions

Cosmogenic ^{10}Be with a half-life ± 1.36 million years provides an even longer-term proxy for solar activity



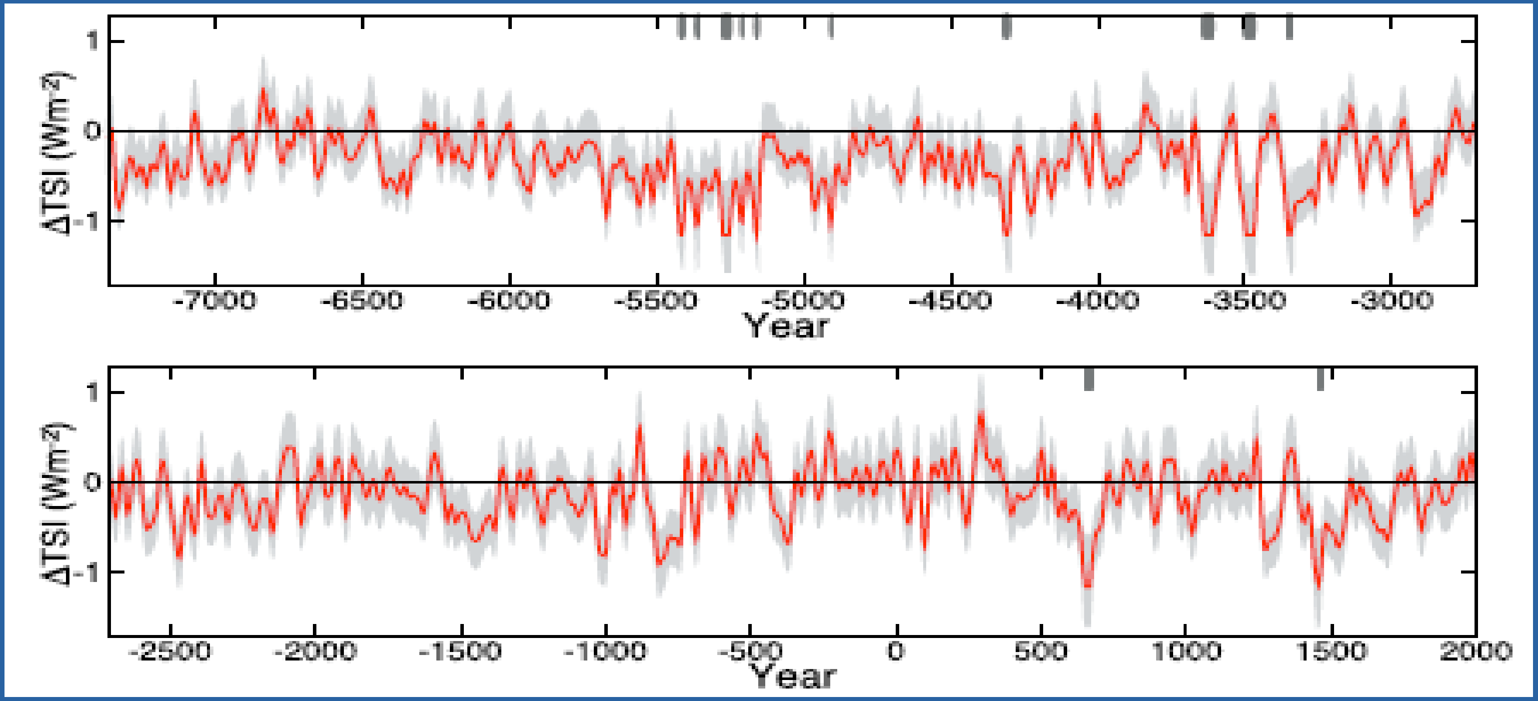
Source of diagram: Wikipedia File Solar Activity Proxies.png

Blue: ^{10}Be concentration, after Beer et al. (1994). Red: Sunspot frequency, after Hoyt & Schatten (1999)

Cosmogenic ^{10}Be is produced in the atmosphere by cosmic ray spallation of Oxygen and Nitrogen. ^{10}Be is stored in polar ice and deep sea sediments.

The magnetic field of the heliosphere and the solar wind, which together shield the Earth from galactic cosmic rays, vary with time and are lowest during periods of reduced solar activity (few sunspots). Correspondingly, the flux of galactic cosmic rays that reaches the Earth is lowest during periods of high solar activity and highest during periods of low solar activity. Production of ^{10}Be is therefore inversely proportional to solar activity.

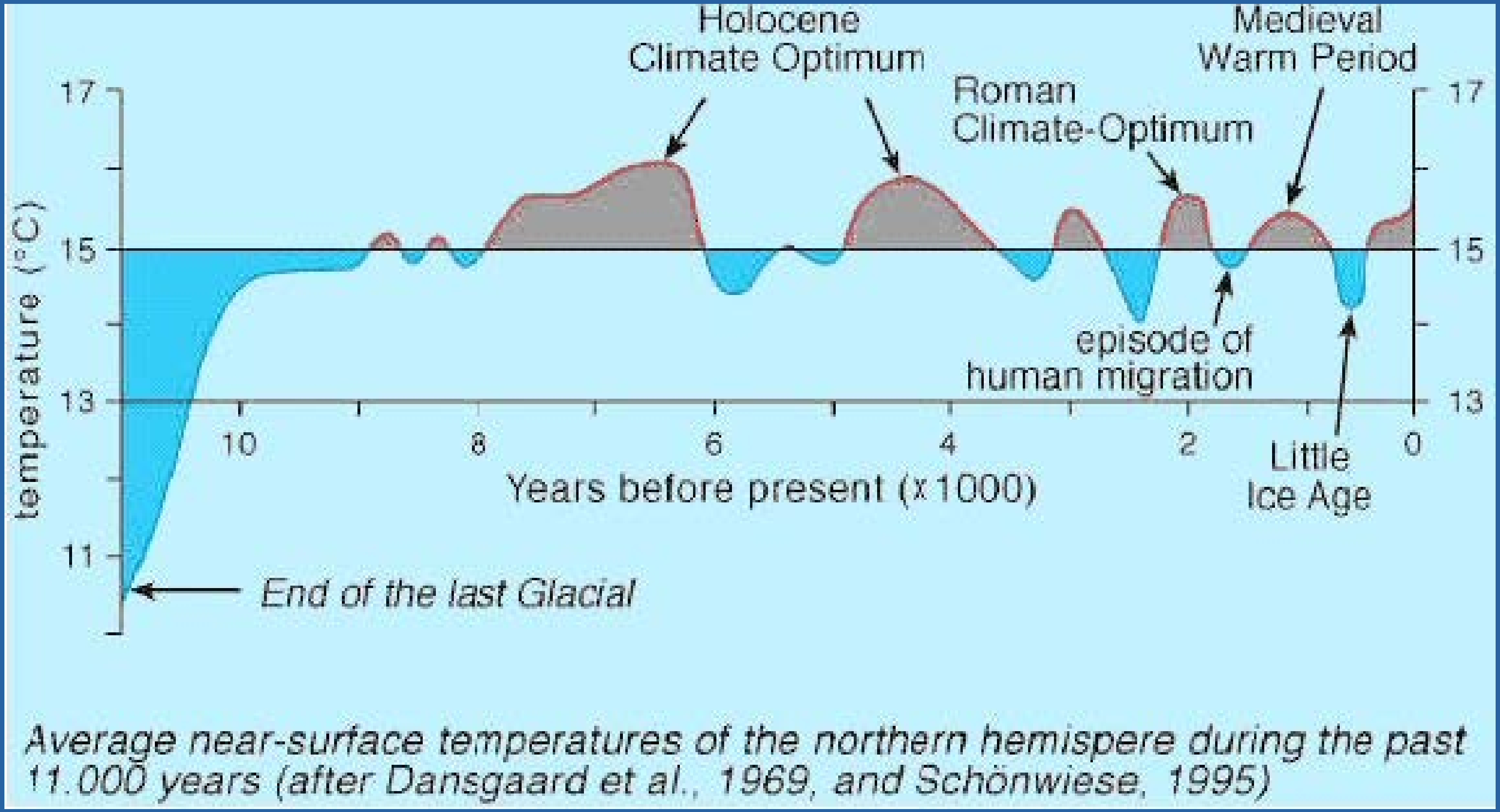
Holocene Variations in Solar Activity based on cosmogenic ^{10}Be measurements in ice cores



Source of diagram: Steinhilber et al., 2009

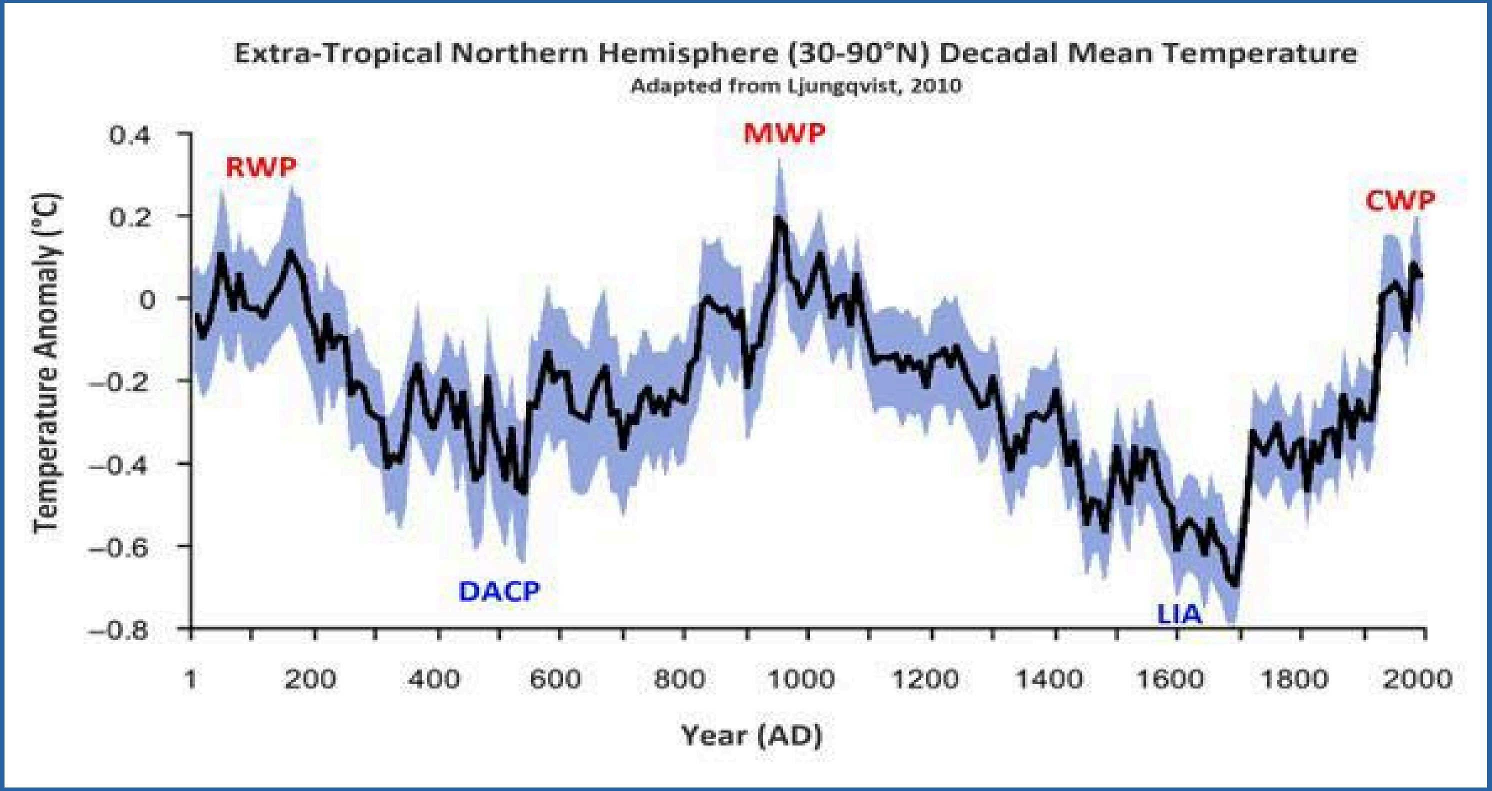
During the Holocene solar activity varied continuously with Grand Minima occurring repeatedly (black ticks on upper margins of graph). During this period TSI varied by as much as 2 Wm^{-2}. Combined with orbital forcing and volcanism, changes in solar activity were the main controlling mechanism of Holocene climate changes (Wanner et al., 2008).

Holocene climate changes



After we had come out of the last glaciation 11,000 years ago with a temperature rise of about 4.5^0C the climate of the Northern Hemisphere was never stable but changed repeatedly with temperatures fluctuating up and down by about 1^0C around an average of about 15^0C. In this context the current Warm Period is not an anomaly.

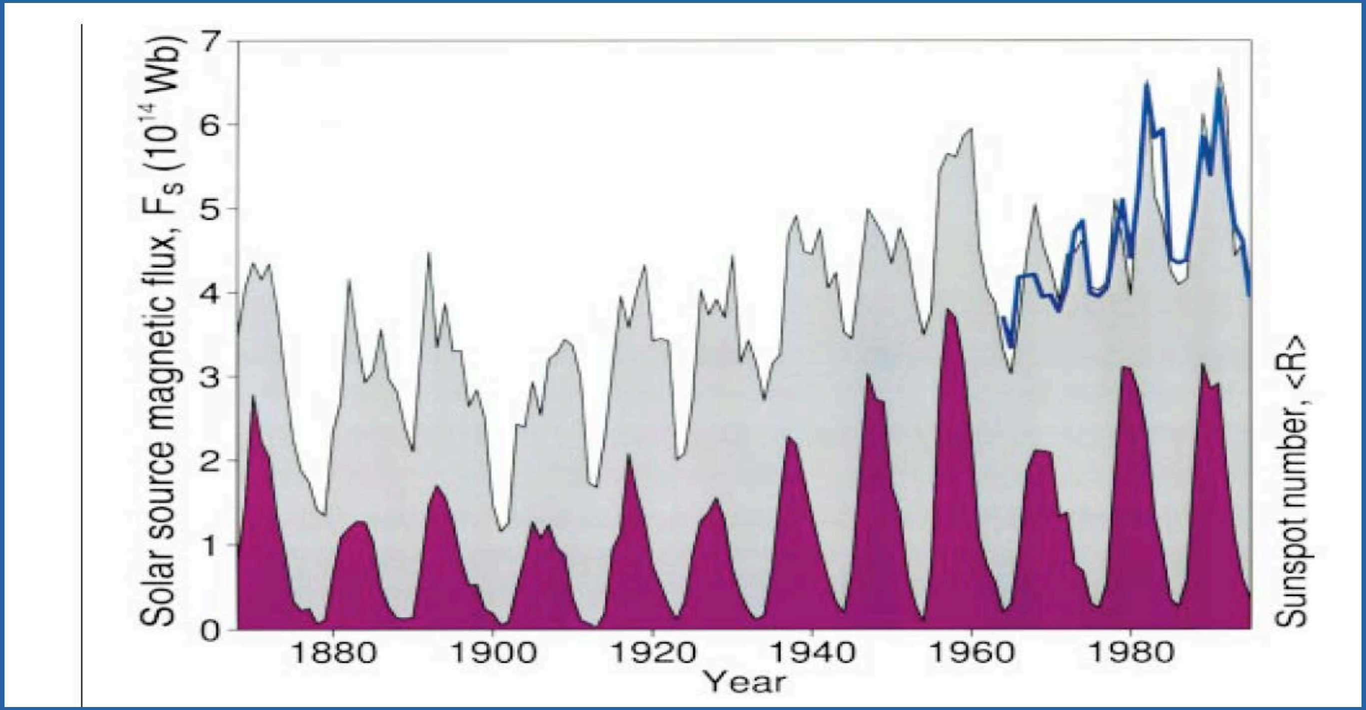
During the last 2000 years Northern Hemisphere average temperatures fluctuated by as much as 1^{0}C. The Medieval warm period and the Little Ice Age were global phenomena. Post Little Ice Age warming was mainly forced by increasing solar activity.



Source of diagram: Ljungqvist, 2010.

The Roman (RWP) and Medieval (MWP) warm periods were at least as warm as the current warm period (CWP). The Dark Age (DACP) and Little Ice Age (LIA) cold periods were times of poor harvests, famines, social unrest and migrations. Fluctuations in solar activity dominated the observed climate changes (see slide 19).

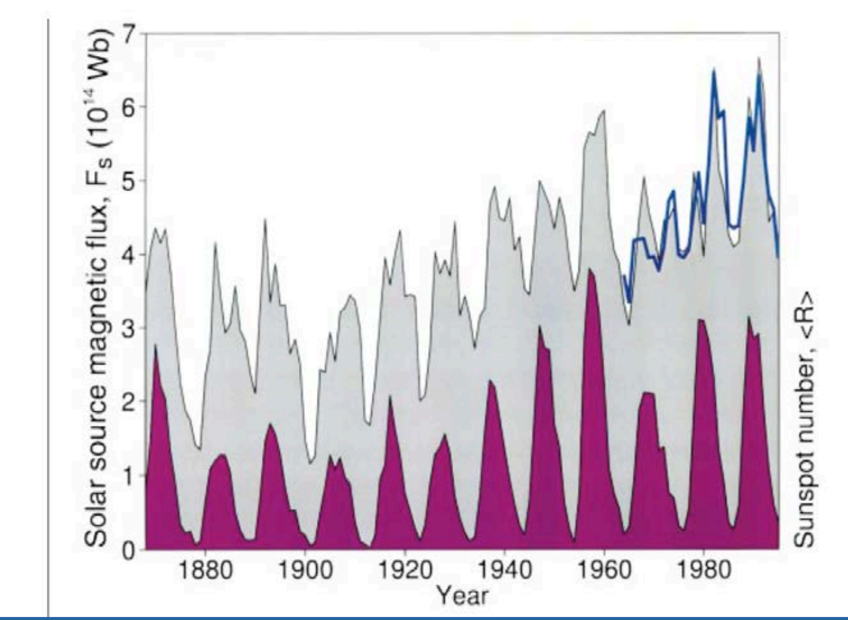
While we came out of the Little Ice Age the number of Sunspots and the Sun's coronal magnetic field doubled



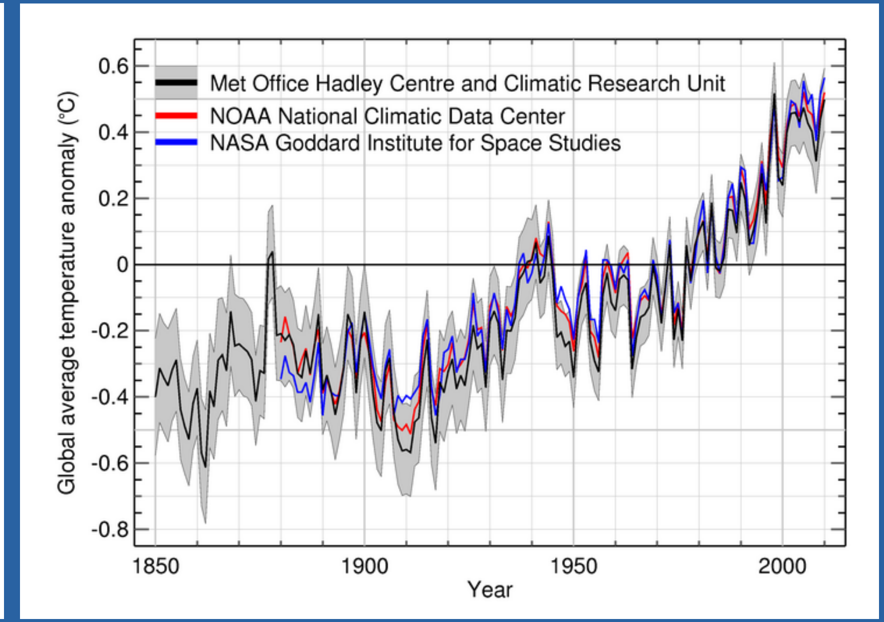
Source of diagram: Lockwood et al., 1999.

Lockwood et al. (1999) write: "Measurements of the near-Earth interplanetary magnetic field reveal that the total magnetic flux leaving the Sun has risen by a factor of 1.4 since 1964 with surrogate measurements indicating that it increased since 1901 by a factor of 2.3. This increase may be related to chaotic changes in the dynamo that generates the solar magnetic field. We do not yet know quantitatively how such changes influence the global environment".

During the last 150 years increasing Solar activity and doubling of the Sun's coronal magnetic field was accompanied by a distinct temperature increase



Source: Lockwood et al., 1999

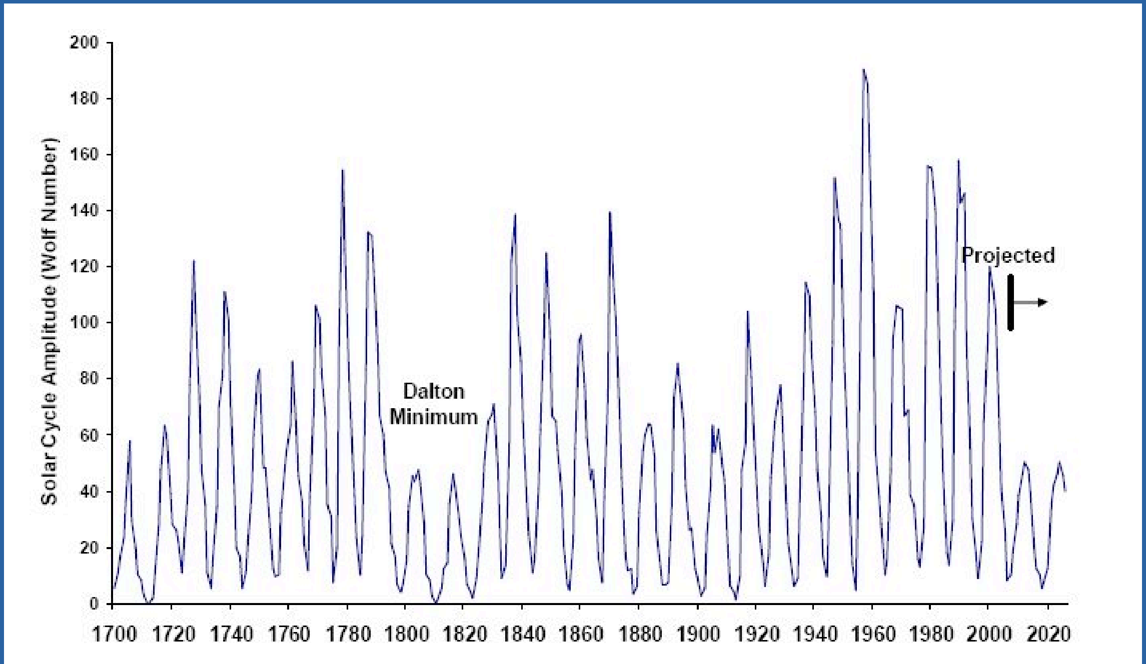


Source: World Meteorological Organization, 2011

Post-Little Ice Age cyclically increasing solar activity and related intensification of the heliospheric magnetic field was paralleled by a decrease in the galactic cosmic ray flux (see slide 20) and a reduction of the Earth's cloud cover.

These and related processes controlled the observed rise in global surface temperatures in which increasing atmospheric CO_2 concentrations played a subordinate role (see slide 17).

Current Solar activity heralds a new Maunder-type Minimum

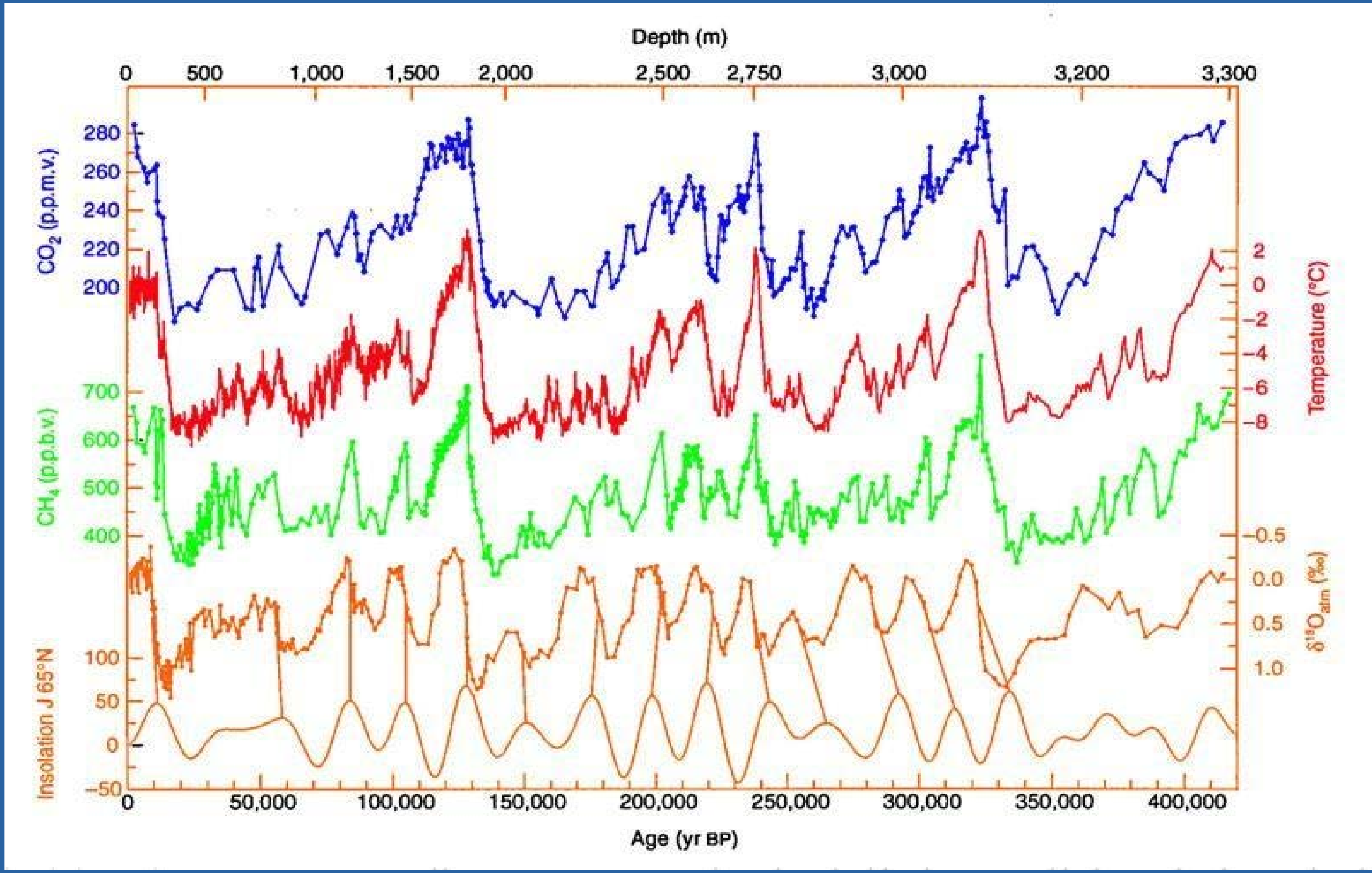


Source of diagram: Archibald, 2008

.

The Sun’s activity is presently going through a transition period (2000 – 2013) that may be followed by a remarkably low Schwabe cycle preceding a forthcoming Dalton- or Maunder-type Minimum with a relative temperature decrease of at least 0.3 – 0.4 ^{0}C. The current state of the Sun compares to its state in 1620 prior to the onset of the Maunder Minimum (1645-1715) (Duhau & de Jager, 2010; de Jager et al., 2010).

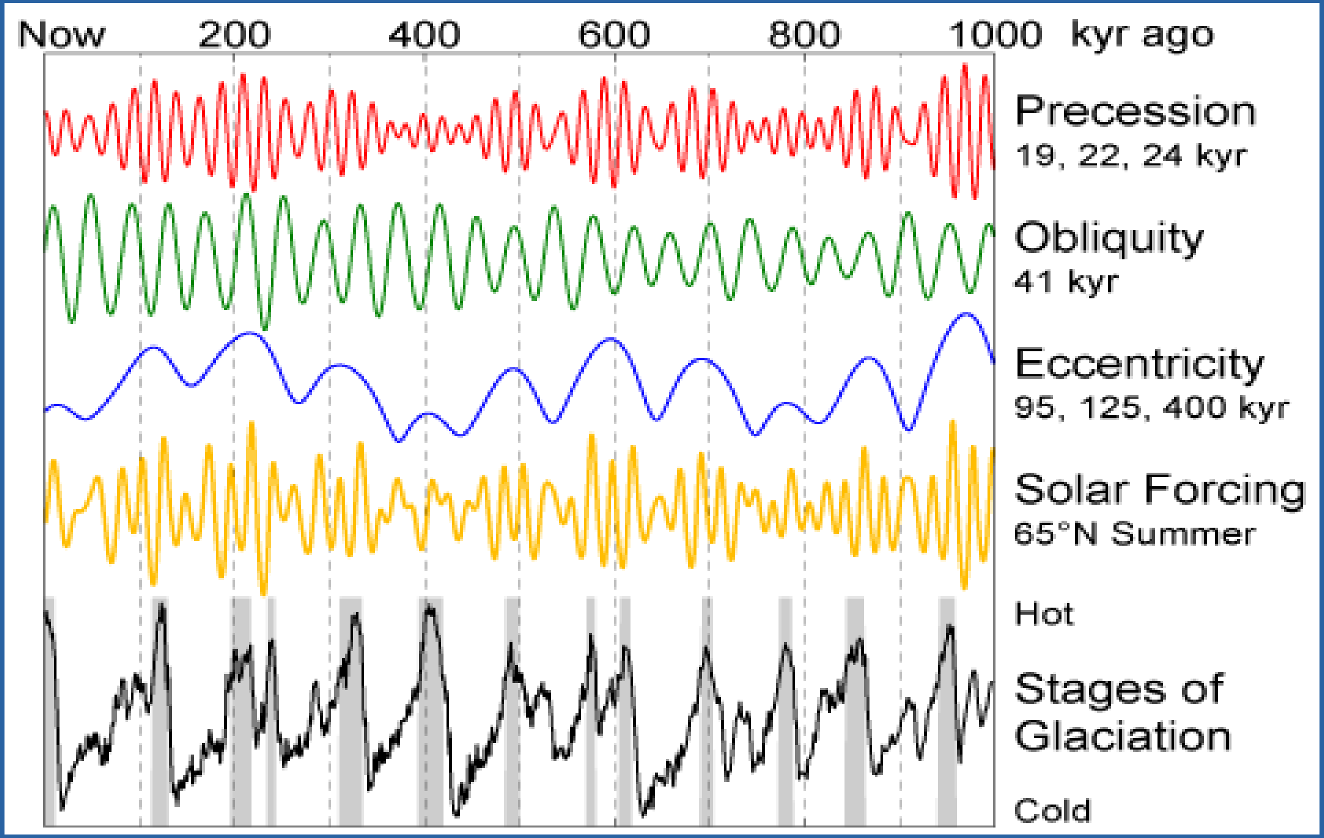
Ice core record of insolation, temperature and CO_2 variations (Vostok ice cores, Petit et al., 1999)



Source of diagram: Wikipedia File Vostok-ice-core-petit.png

The end of each Ice Age was driven by an orbital forced increase in insolation. Temperatures rose 800 to 1000 years prior to rising atmospheric CO_2 concentrations (see slide 11).

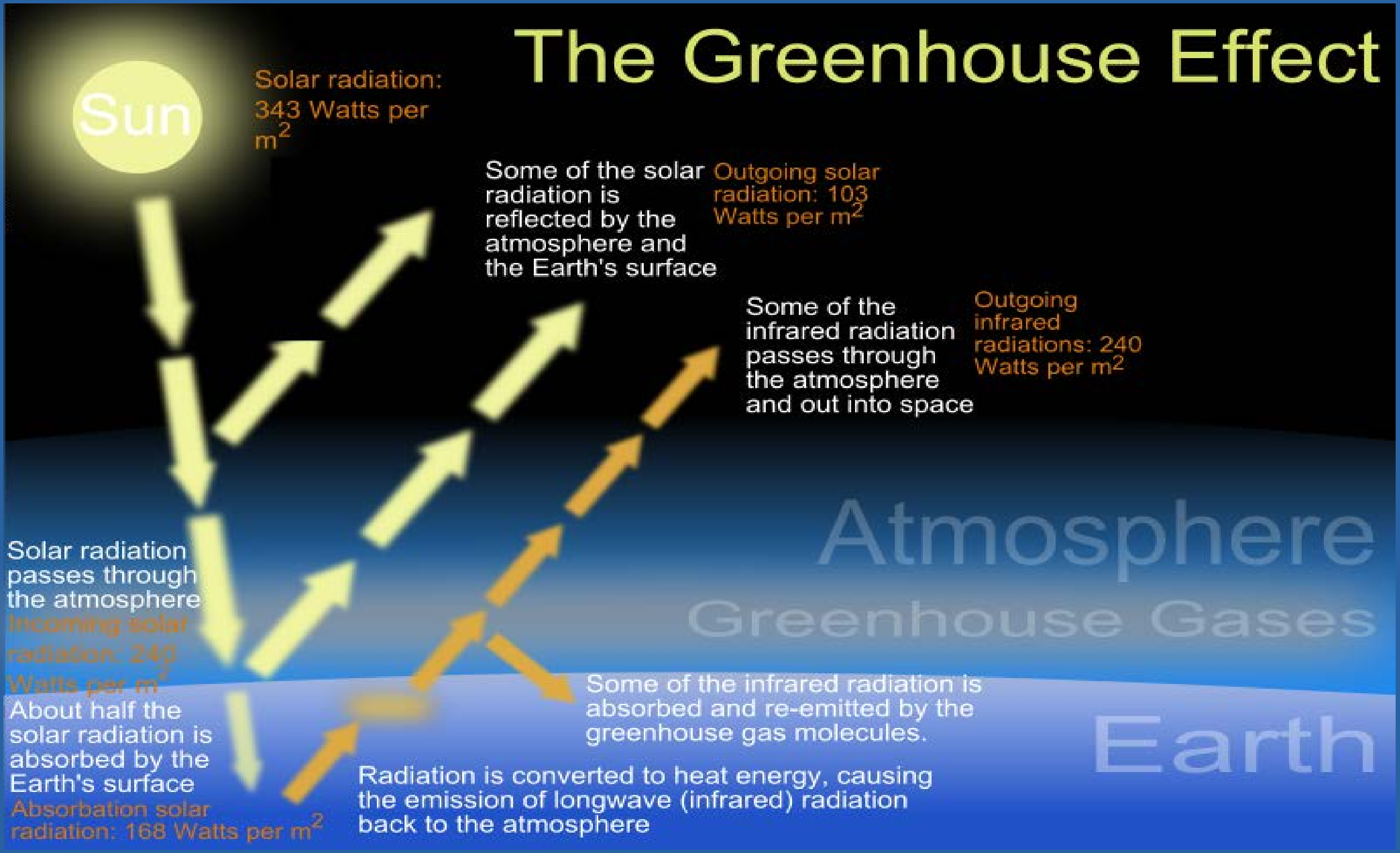
During the last one Million years climate changes were controlled by orbital forcing and solar variability but not by CO_2 forcing



Source of diagram: R.E. Rohde, Wikipedia article on Milankowitch Variations, 2010

There is growing evidence that among other forcings the Sun plays a significant role in climate change (Beer et al., 2009).

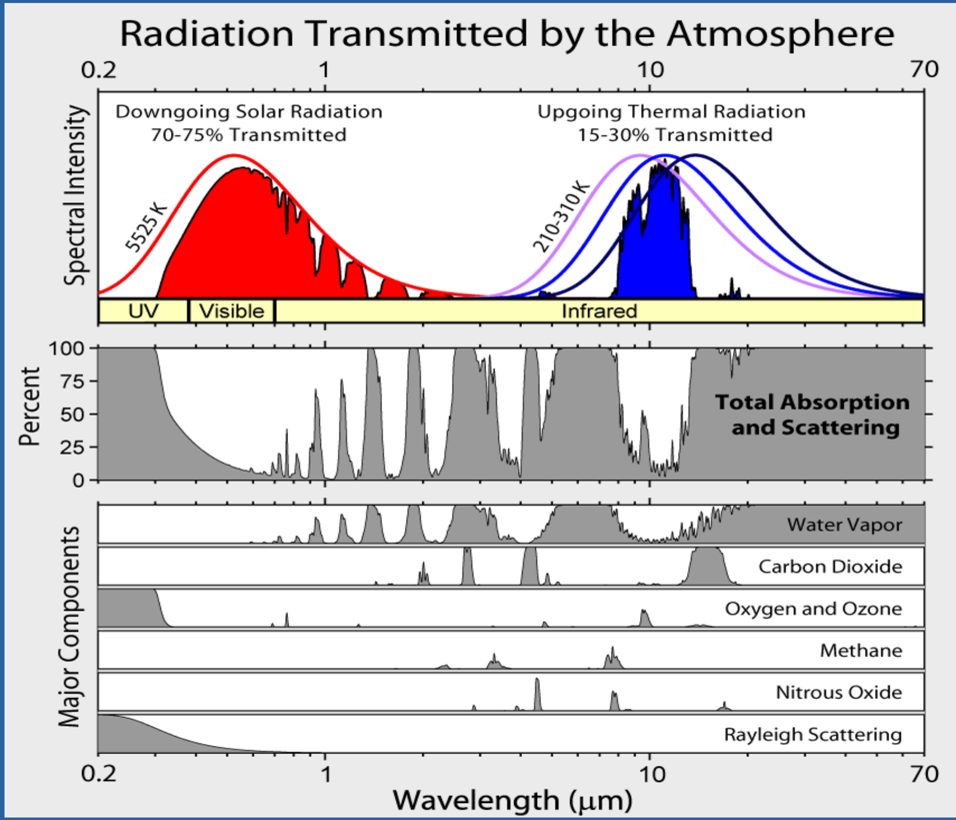
The Greenhouse analogue is a blatant misnomer as a greenhouse impedes convective circulation



Source: http://commons.wikimedia.org/wiki/File:The_green_house_effect.svg

The Earth is insulated from space by the atmosphere, which together with the hydrosphere maintains a degree of climate equilibrium by convective distribution of heat from low to high latitudes (air conditioner effect).

Greenhouse Gases (GHG)



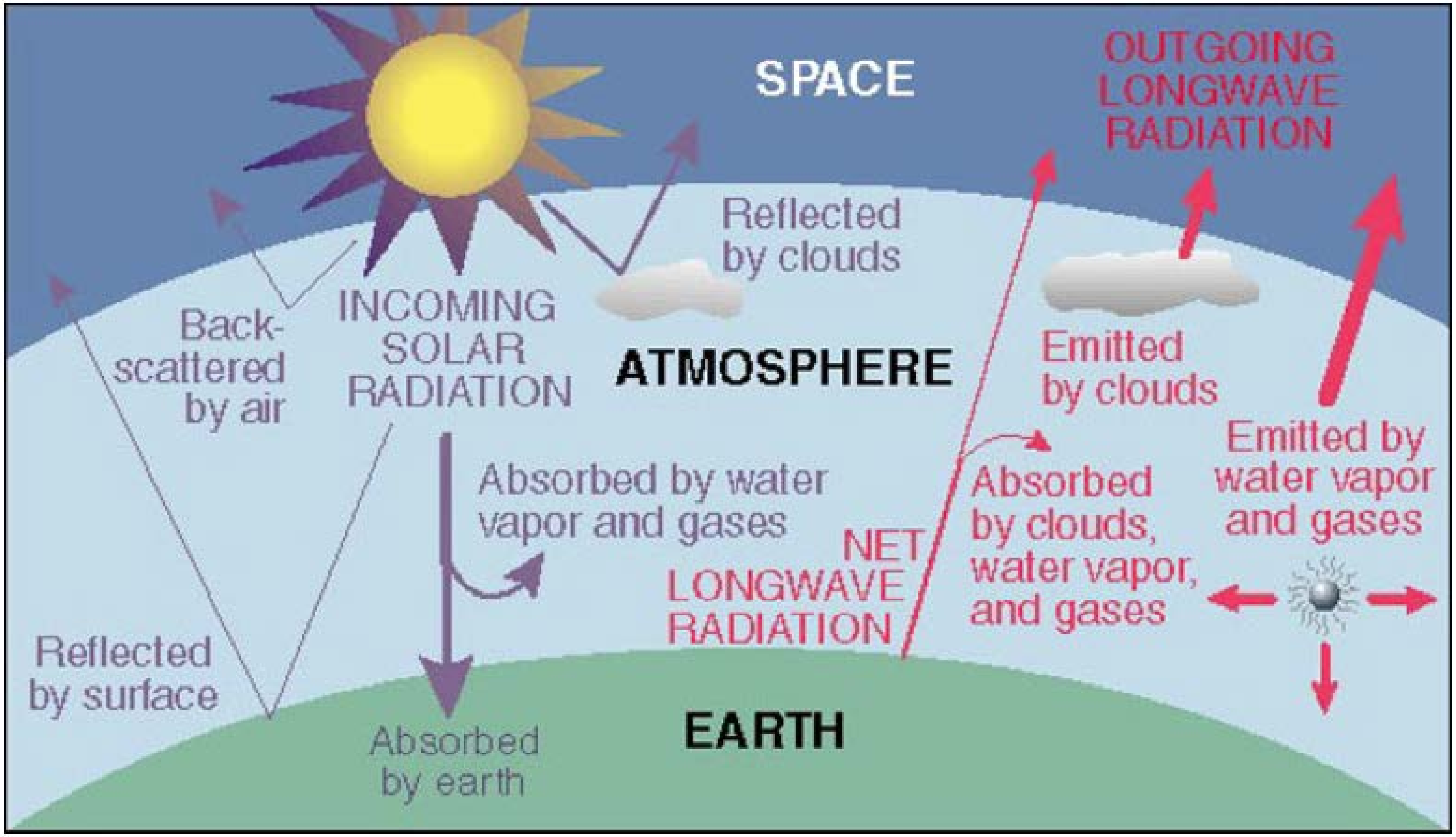
Absorption of the reflected ultraviolet, visible and infrared radiation by the different GHG of the atmosphere.
Absorption saturation: 100% absorption of the respective wavelength (Peixoto & Oort, 1992)

- Only part of the LWIR radiation reflected by the Earth's surface toward space is absorbed in the atmosphere by the so-called GHG. The rest is lost to space.
- Some of the absorbed LWIR radiation is re-emitted by the GHG molecules, partly toward Earth.
- GHG retain heat from the day to night and redistribute energy within the atmosphere.
- Water vapor and clouds cause up to 90-95% of the total greenhouse effect, CO_2 4.2-8.4% and Methane, Ozone, N_2O, CH_4, CFCs etc about 1.3%.
- There is already sufficient CO_2 in the atmosphere to absorb most of the LWIR radiation in the principal CO_2 absorption bands.

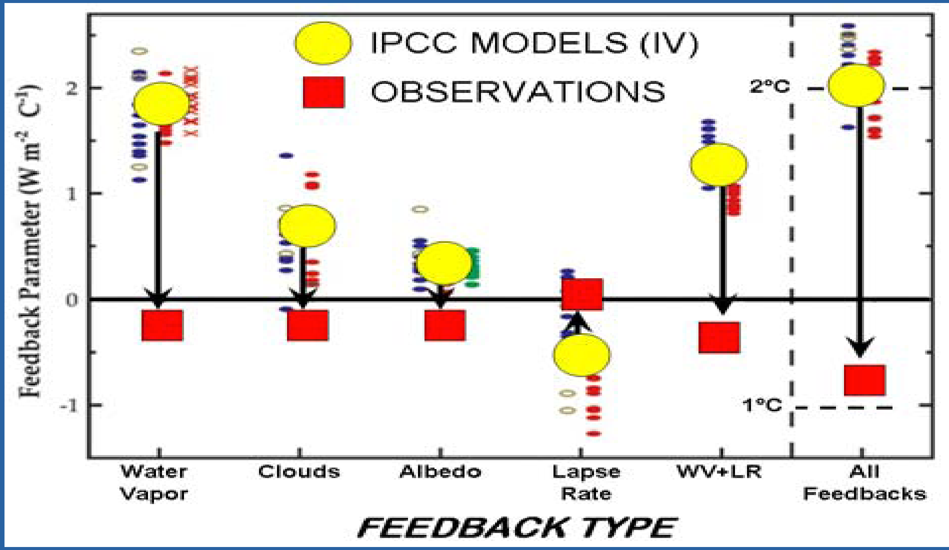
(T. Nelson: Cold Facts on Global Warming)

Source of diagram: Global Warming Art Project, Wikipedia, http://en.wikipedia.org/wiki/File:Atmospheric_Transmission.png

THE TOTAL GREENHOUSE EFFECT IS 34.5°C
CLOUDS AND WATER VAPOUR PROVIDE OVER 90% of the GREENHOUSE EFFECT



For a doubling of CO_2 IPCC models erroneously assume that radiative solar climate forcing is strongly amplified by water cycle related feedbacks



Basic principle: a warmer Earth radiates more energy back to space.

For every Wm-2 of solar radiative forcing the climate warms by only about 0.3 ^{0}C

Feedbacks modulate the Earth's radiative budget and thus its climate

In IPCC climate models, feedbacks amplify solar radiative forced warming by up to a factor of 2

Source of diagram: Gray & Schwartz, 2011, modified after Bony et al., 2006

WV - Water Vapor content of the lower atmosphere increases exponentially with increasing temperatures, but this has little effect on radiative cooling. Higher temperatures cause greater evaporation and precipitation, strong negative feedback. IPCC models ignore that with warming the humidity in the upper atmosphere decreases, exerting a negative feedback.

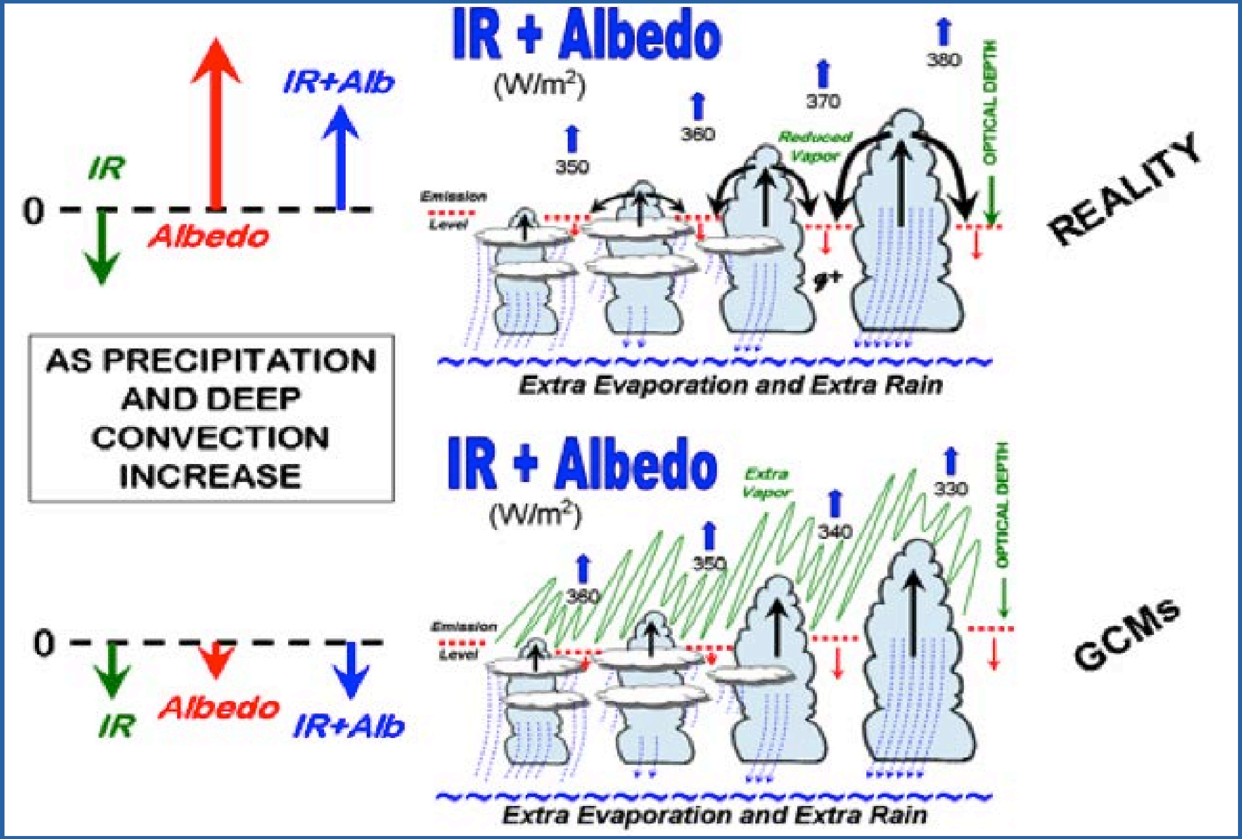
C - Clouds oppose radiative cooling but enhance albedo: positive feedback in IPCC models while satellite data indicates a negative feedback.

A - Albedo: with increasing temperatures, melting of snow and sea ice decreases the amount of SW radiation that is reflected back to space: positive feedback, if cloud albedo is disregarded

LR - Lapse Rate (troposphere temperature decrease rate with height): a warmer troposphere emits more LW radiation to space: negative feedback in IPCC models, in observations neutral

WV+LR - WV and LR feedbacks are anti-correlative coupled, partly compensating each other

All - All represents the sum of all feedback types: in IPCC models strongly positive feedback, while observational data indicate a clearly negative feedback.

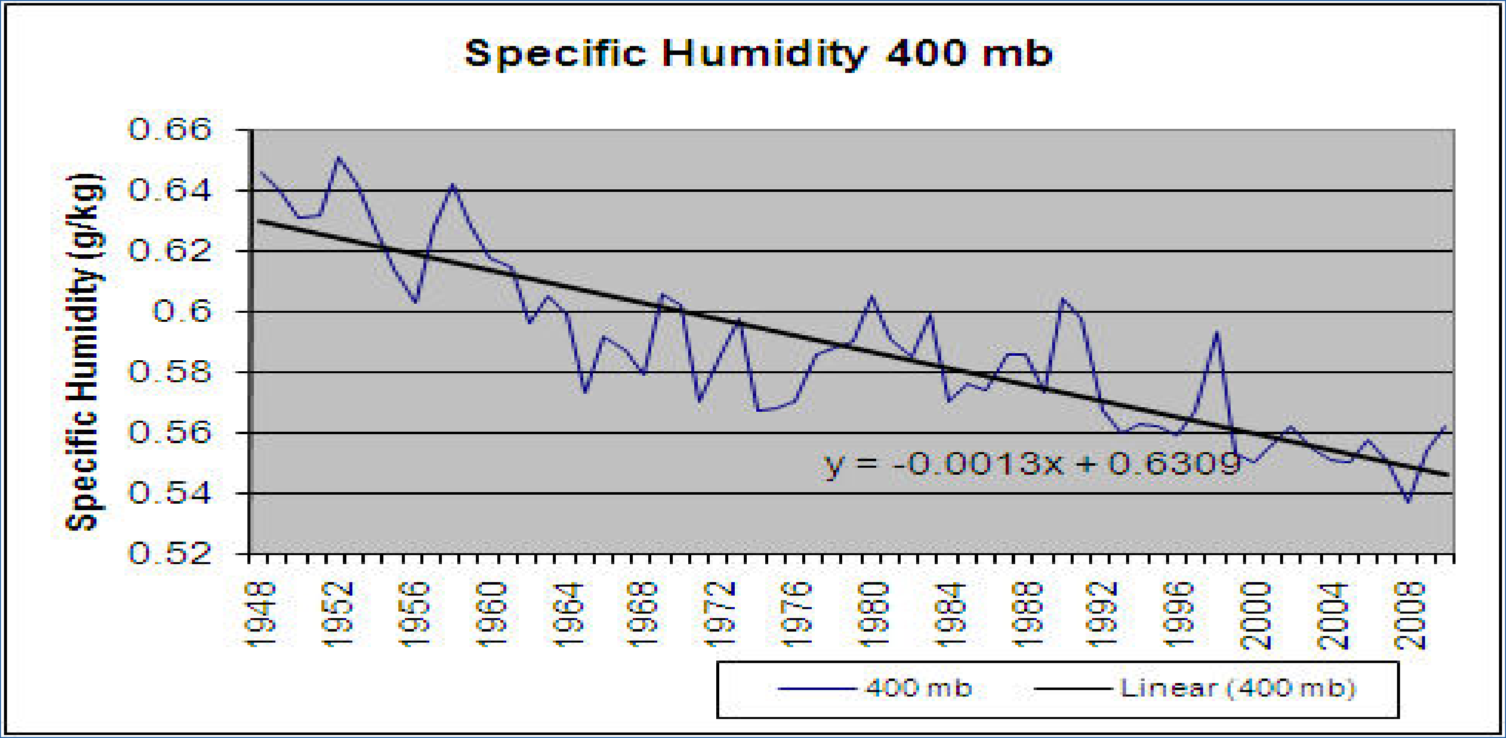


Source of diagram: Gray & Schwartz, 2011

With warming evaporation, convection and precipitation increase. This leads to decreasing humidity in the upper troposphere (see slide 34 and 36) and to an increase in cloud-induced Albedo. In contrast to the IPCC Global Circulation Models (GCMs), the cooling effect of increased Albedo is much stronger than the cloud-induced reduction of outgoing infra red (IR) radiation.

Net effect: CO_2 doubling will cause only 0.3^0C warming and not 3.2^0C as postulated by IPCC.

Out-going LW radiation increases with declining upper troposphere humidity



Source of diagram: NOAA Earth System Research Laboratory
http://www.cdc.noaa.gov/cgi-bin/data/timeseries/timeseries1.pl

The water vapor content (humidity) of the upper troposphere (above about 8 km and pressures of 400 mbar) declined by 13% between 1948 and 2010 (best fit line).

This resulted from an increase in upper troposphere temperatures and CO_2 concentrations and offsets increasing lower troposphere humidity and CO_2 concentrations.

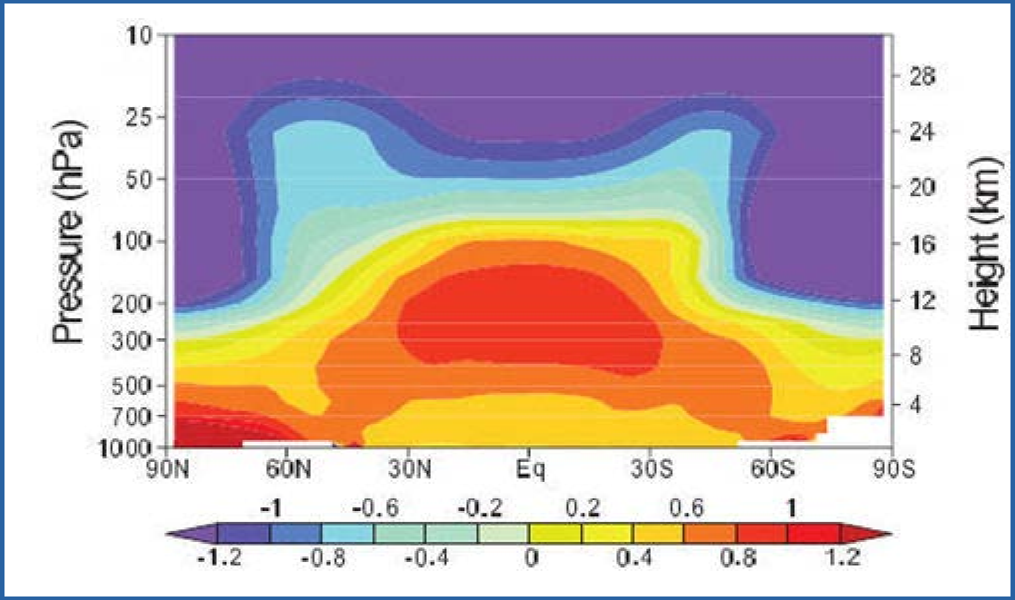
An upper troposphere humidity change has a 40 times greater effect on LWIR radiation going out to space than the same change in the lower troposphere.
A uniform 3% change in humidity has the same effect as a 100% change in CO_2.

The Missing Hot-Spot

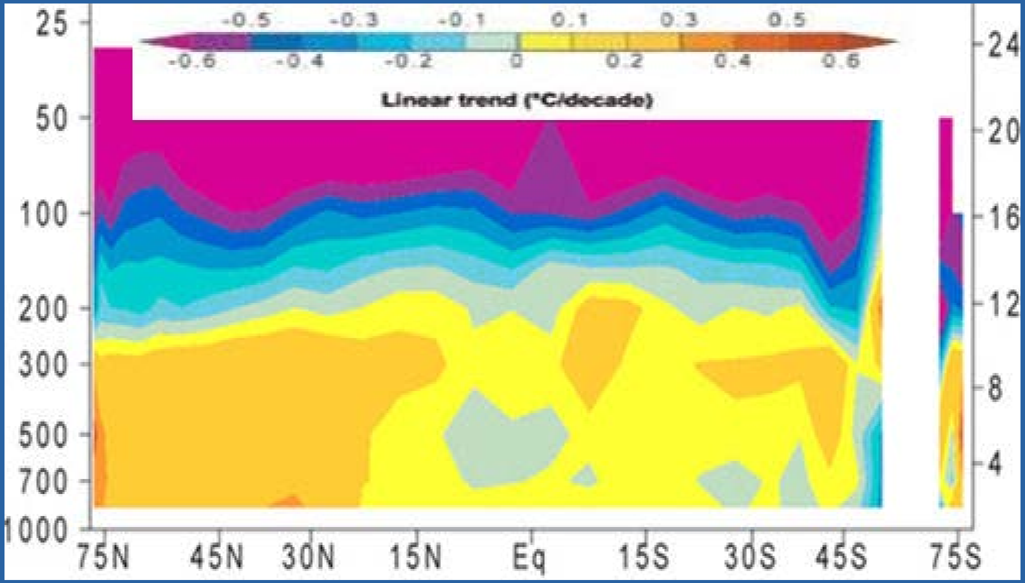
after

Dr. David Evans, 2010

IPCC climate models (2007, AR-4 chapter 9) predict over the tropics a distinctive pattern of warming - a “hot-spot” - of enhanced warming in the upper troposphere, as shown by the large red blob in the upper diagram.



The lower diagram shows the results of weather balloon radio-sonde data. There is no evidence of such a "hot spot" pattern. If it were there, it would have been readily detected. The IPCC climate models are not applicable as they assume that in the tropics the humidity of the upper troposphere increases with CO_2 forced warming whereas humidity decreases with increasing CO_2 and temperatures (see slide 36).



The net cloud feedback is negative and not positive as postulated by IPCC

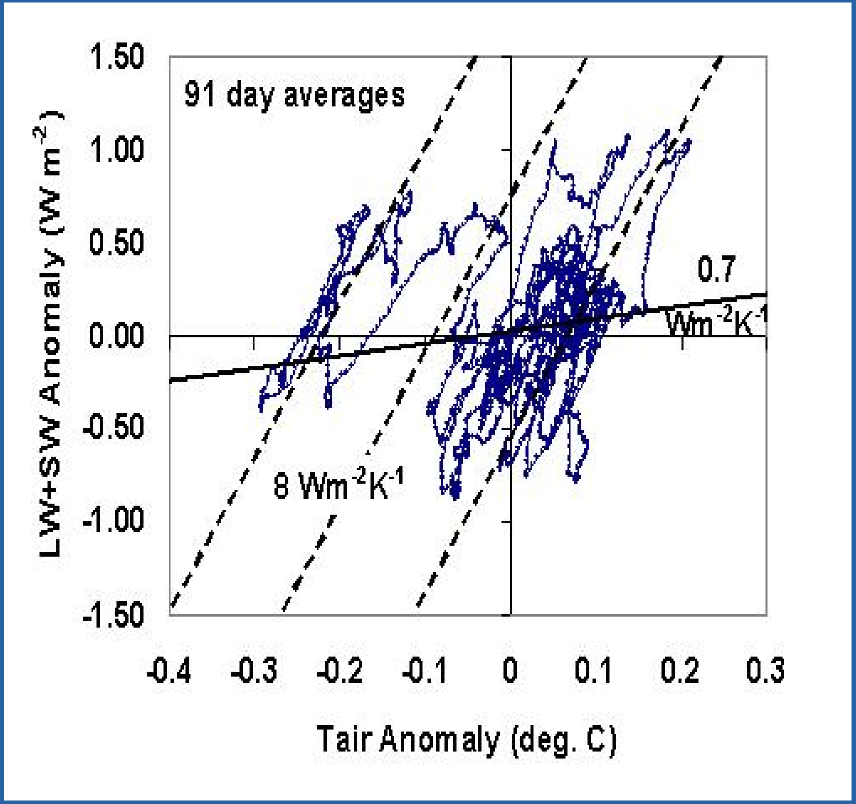
IPCC GCMs assume that with increasing temperatures the cloud cover decreases, and by letting in more Sun, causes further warming. This is a positive cloud feedback.

However, increasing temperatures do cause more evaporation and clouds and increased LW radiation going out to space, which offsets the initial temperature increase. This is a negative cloud feedback that contrasts with GCMs assumptions.

Spencer (2008) separated in satellite data the cloud feedback and solar radiative forcing signals, corresponding in the diagram to the right to linear striations and spiral lines, respectively.

The linear striations relate to discrete negative cloud feedback events (cooling due to strong energy loss to space). These are superimposed on a background of spiral lines that relate to slowly varying radiative forced changes in ocean heating, probably involving natural cloud cover fluctuations.

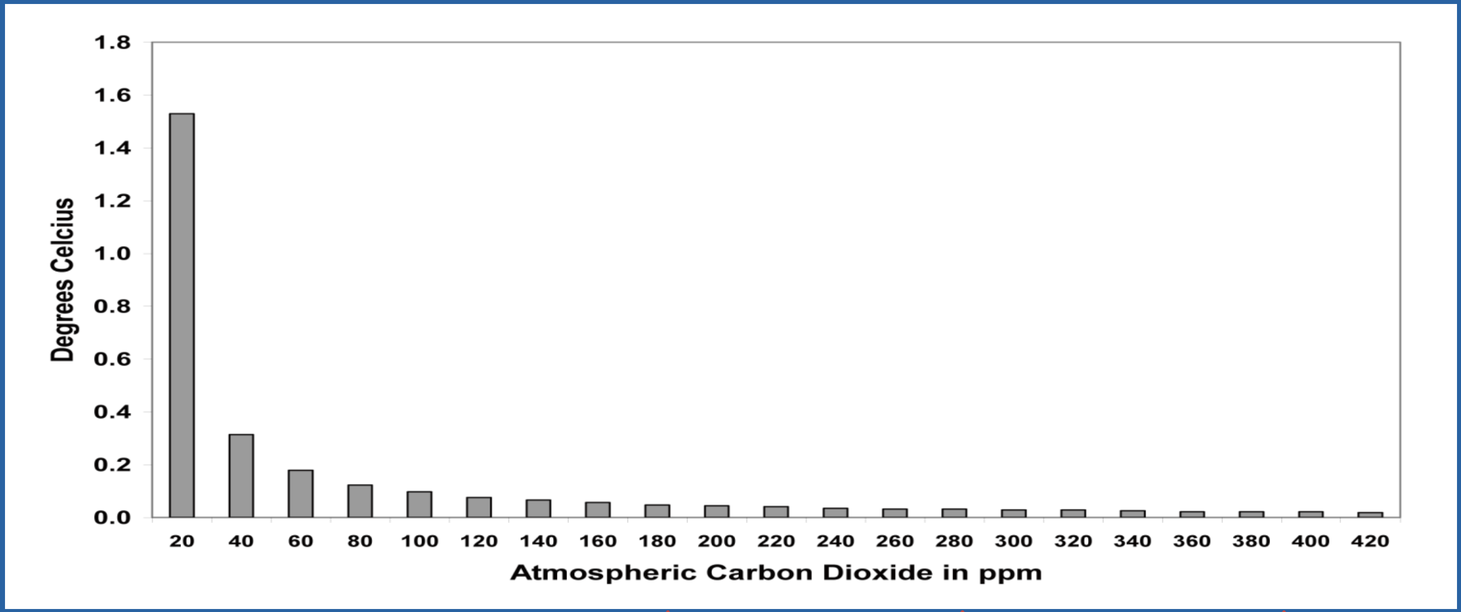
The dashed lines show a strongly negative cloud feedback of 8 $W^{-2}/^{0}C$. A fit of all data, including the spiral forcing signal, as used in GCMs, gives an erroneous positive cloud feedback interpretation of 0.7 $Wm^{-2}/^{0}C$ (solid heavy line). Correspondingly, GCMs forecast too much global warming and related climate change**.**



Source of diagram: Spencer (2008)

Phase space plot of Earth radiation energy balance versus sea surface temperature based on Terra CERES total radiative flux versus NOAA-15 AMSU troposphere temperature variations above the global oceans between March 2000 and August 2007.

Warming effect of increasing atmospheric CO_2 concentrations



CO_2 concentrations: Glacial 180 ppm pre-industrial 280 ppm present 390 ppm

Temperature increase calculated for successive 20 ppm increments of atmospheric CO_2 content up to 420 ppm (MODTRANS; Archibald, 2007)

The effect of CO_2 on temperature is logarithmic. Its climate sensitivity decreases with increasing concentrations. The first 20 ppm of CO_2 have a far greater temperature effect than the next 400 ppm. Over the last 30 years, the annual atmospheric CO_2 increase averaged 1.7 ppm. From the 2007 level of 380 ppm, CO_2 concentrations may rise to 420 ppm by 2030. The related 40 ppm increase reduces radiation to space by 0.4 Watts/m^2, equating to a temperature increase of 0.04°C. Increasing CO_2 concentrations to 620 ppm by 2150 would result in a further 0.16°C temperature increase. The total industrial atmospheric CO_2 increase caused a temperature increase of 0.10°C.

Water vapor is the primary GHG

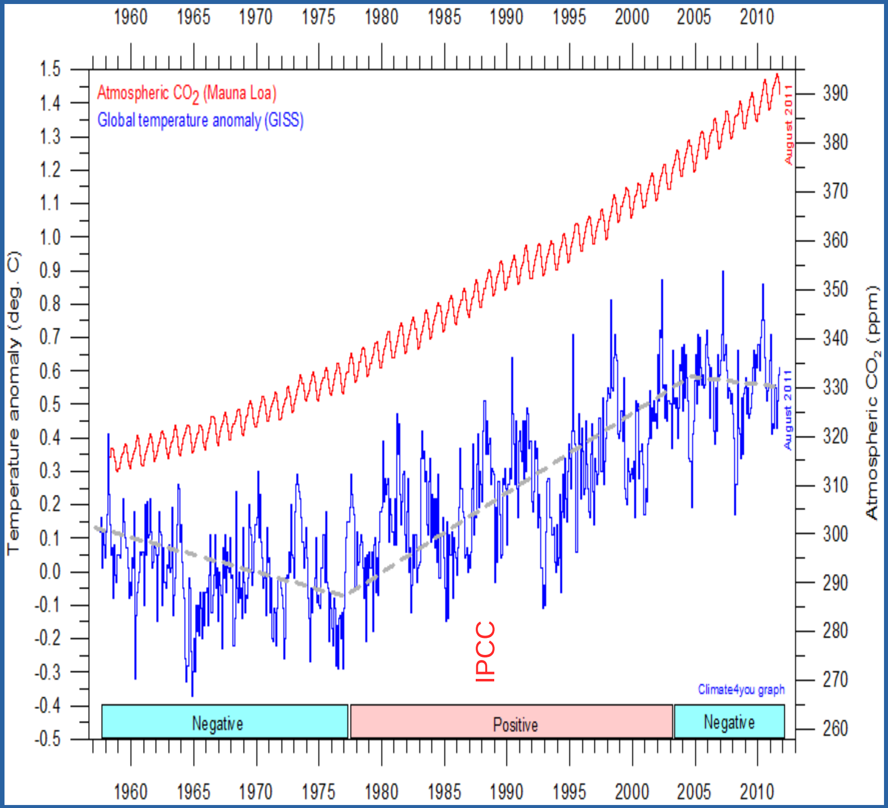
- With increasing insolation atmospheric temperatures rise and evaporation rates increase (strongly negative feedback). With warming and increasing CO_2 concentrations the amount of water vapor increases in the lower troposphere up to the cloud layer while it decreases above the cloud layer. The total amount of greenhouse gases, as measured by its absorption capacity (optical depth), has not increased over the last 60 years. The upper troposphere has become dryer, maintaining a maximum rate of radiative cooling owing to CO_2 replacing an equivalent amount of water vapor. (Miskolczi 2007, 2010).

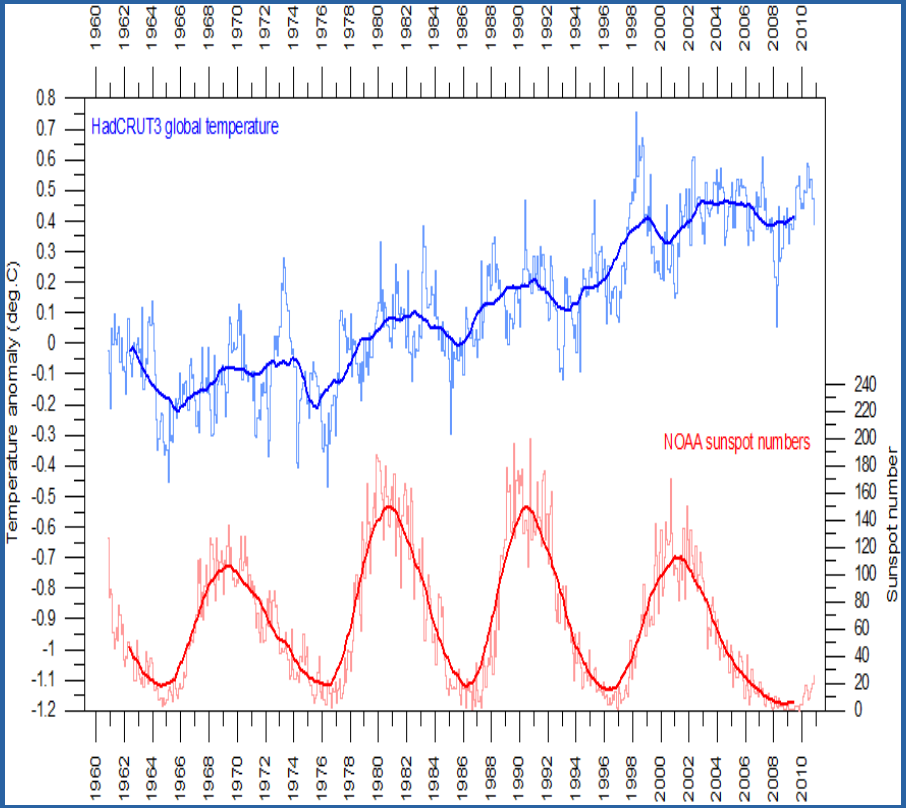
- CO_2 is a trace GHG. Its effect on temperature forcing decreases logarithmically with increasing atmospheric concentrations. At present most LWIR radiation is already absorbed in the principal CO_2 absorption bands. Future increases in CO_2 concentrations will have only a minor temperature effect, including related water cycle feedbacks (Archibald, 2007).

- The carbon cycle rides piggyback on the water cycle. For every unit of CO_2 sequestered by plants from the atmosphere almost 1000 units of water must be lifted from the soil to the leaf canopy and evaporated back into the air. The underlying huge energy source is the Sun (Veizer, 2005).

- Solar energy drives the water cycle, generating a warmer and wetter climate, which invigorates the biological carbon cycle and the release of CO_2 by the slowly warming oceans. More insolation, more temperature, more CO_2 in the atmosphere (Veizer, 2005).

Since 1960 surface temperatures did not rise at the same rate as atmospheric CO_2 concentrations whilst solar activity and temperature fluctuations correlate

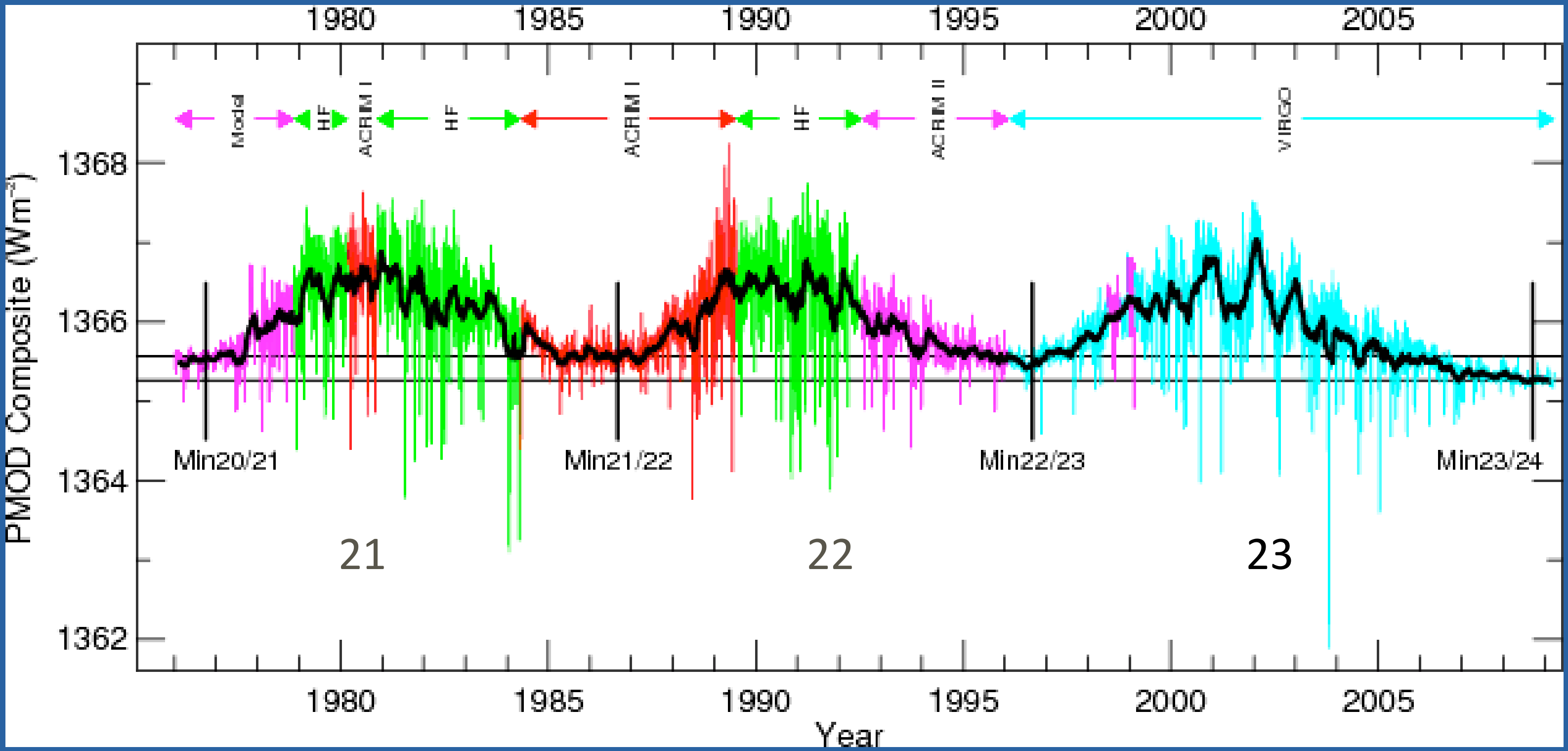




Source of diagrams: O. Humlum, 2011, Climate4you

Despite continuously rising atmospheric CO_2 concentrations surface temperatures have remained stable since 2002 and began to decline with decreasing solar activity.
The CO_2 climate forcing potential is highly overrated by IPCC.

TSI variations during Solar Cycles 21 to 23



Source of diagram: Fröhlich, 2009

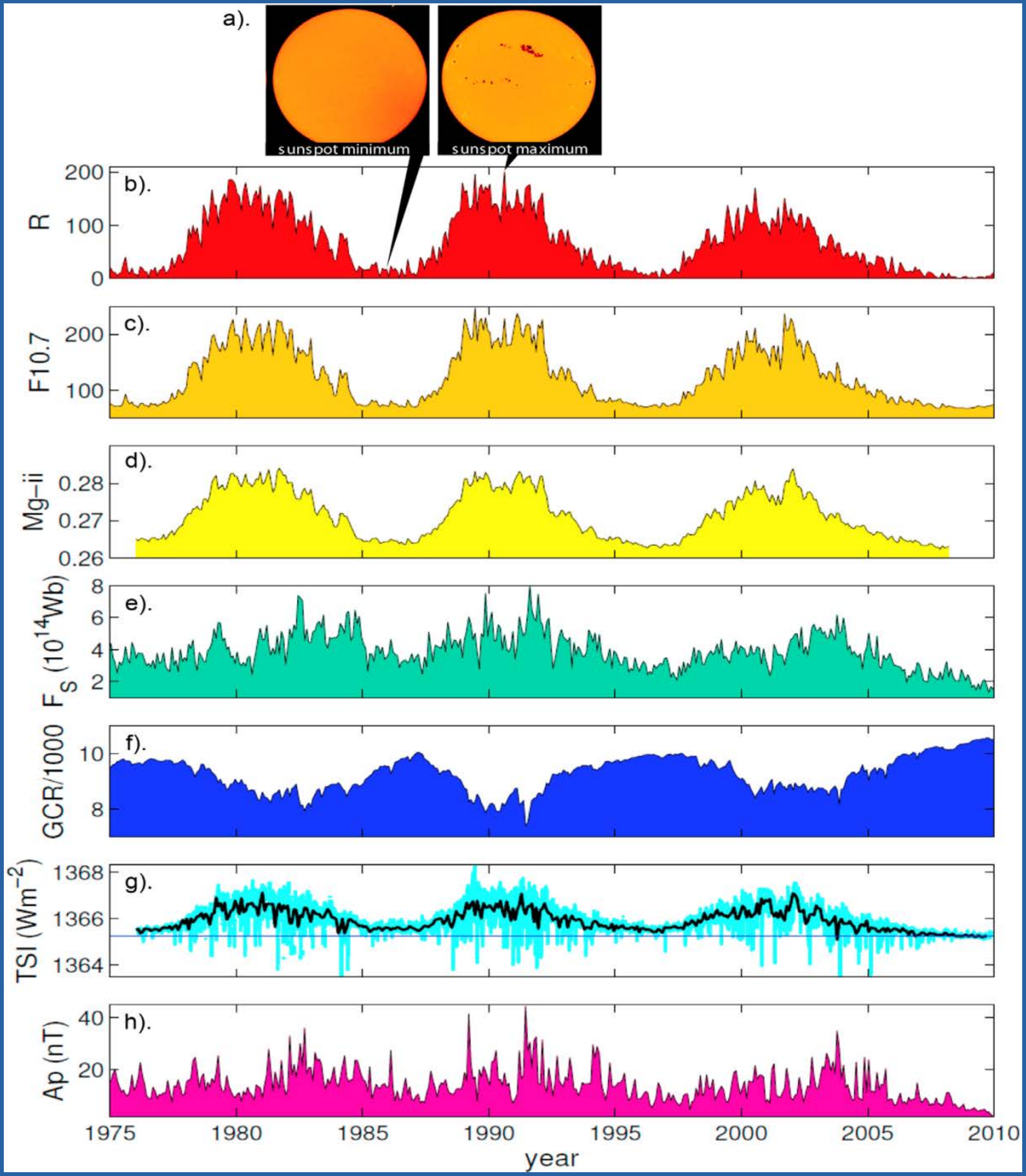
The horizontal black lines mark the solar minimum TSI values of 1986/7 and 1996/7, andof 2008/9, respectively.

The value of the 2008/9 minimum is 0.22 Wm−2 lower thanthat ofthe previouslows and 25% lower in terms of the mean cycle amplitude (Fröhlich, 2009).

With a duration of 12.5 year cycle 23 was the longest since 1823. Long cycles are historically followed by cycles of less intense TSI, implying cooling during cycle 24 (Carter, 2010; see also slide 44).

During Solar Cycles not only the Sunspot number and TSI vary

source of diagram: Gray et al., 2010



SUN

SUNSPOT NUMBER AMPLITUDE
duration of Solar Cycle

SOLAR RADIO EMISSION FLUX

SOLAR UV IRRADIATION
varies up to 6% during Solar Cycles

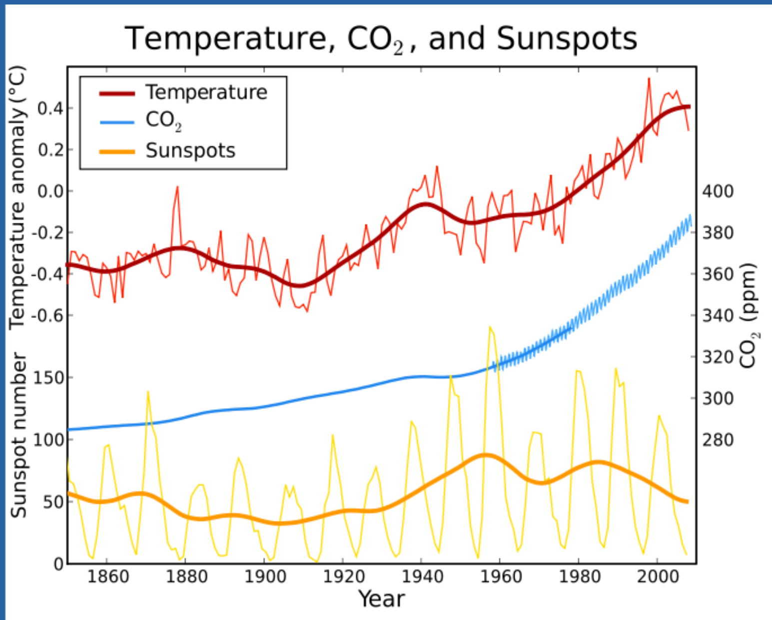
OPEN SOLAR MAGNETIC FLUX
Solar Wind

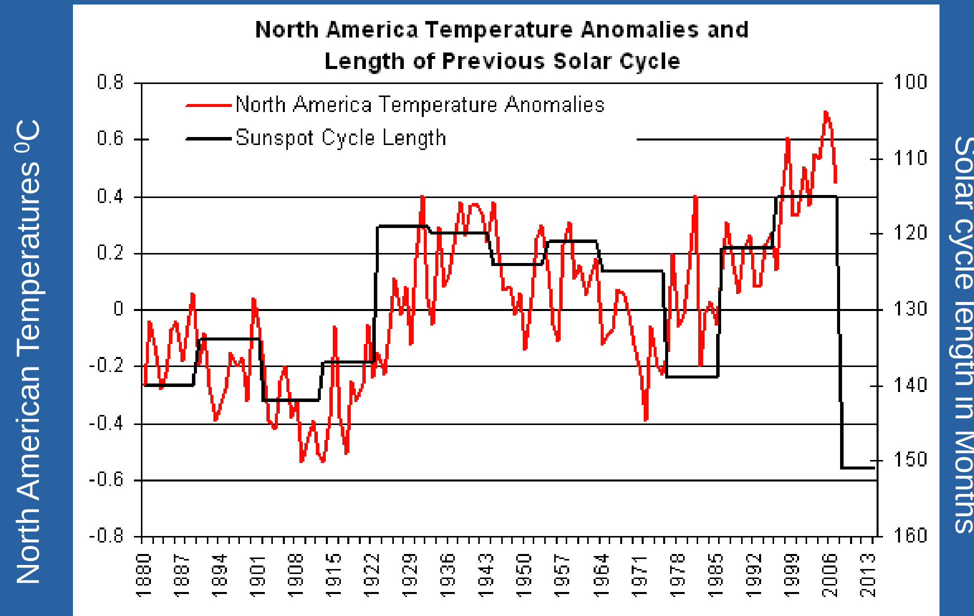
GALACTIC COSMIC RAY FLUX , modulated by Solar Wind, varies up 20% during SC

TOTAL SOLAR IRRADIATION, normalized, varies 0.09% during Solar Cycles

GEOMAGNETIC Ap INDEX
Earth magnetic field variations
proxy for Solar Energetic Particle Flux

Longer-term Temperature, Sunspot activity, Solar Cycle length and CO_2 changes



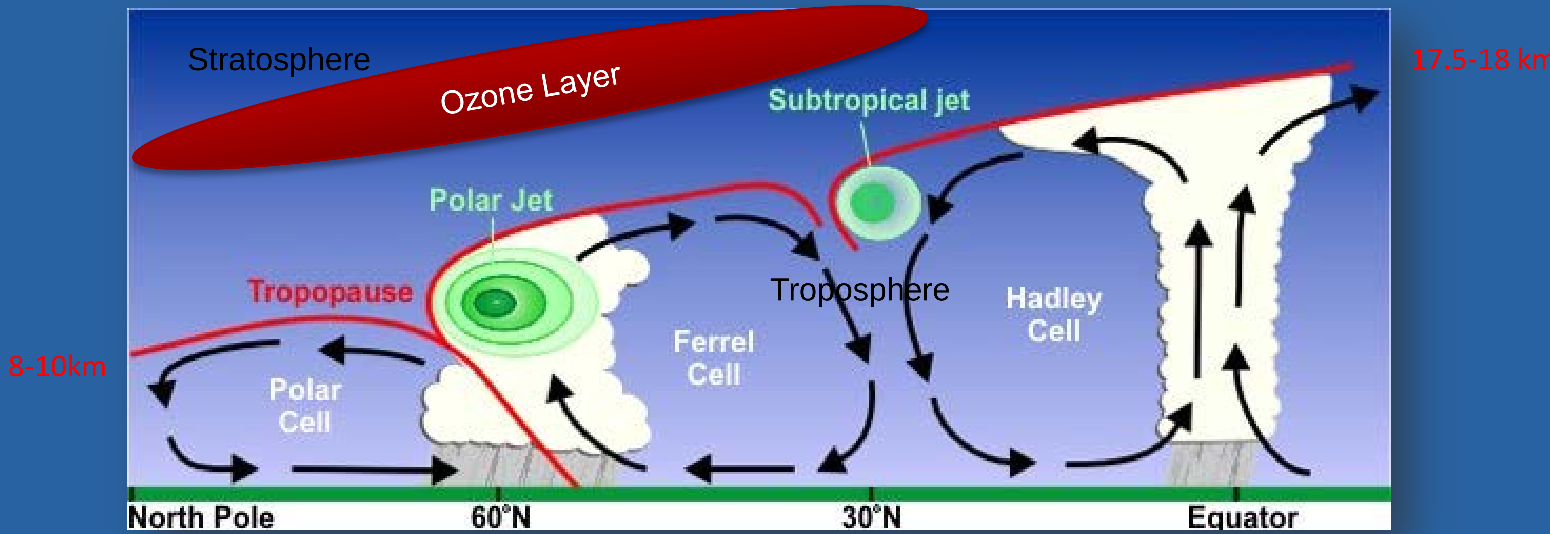


Source of diagram to the right: Stephen Strum, Frontier Weather Inc.

Long solar cycles peak at low sunspot numbers (50-70), short ones at high numbers (120-200). TSI is slightly higher during periods of high sunspot activity than during periods of low activity. Weak and long cycles lead to cooling, strong and short ones to warming.

Cycle 24 will provide key data on the solar impact on global climate and on the effect of anthropogenic CO_2 emissions. As CO_2 levels rose during times of increasing solar activity, assessment of their respective impact on the climate system left room for tendentious interpretations. With solar activity decreasing during cycle 24, the solar and CO_2 impacts on climate will become more apparent, resolving disputes between IPCC and Skeptics.

Variations in Solar UV irradiation can affect the Tropospheric climate



Source of diagram: http://en.wikipedia.org/wiki/Jet_stream

Solar UV radiation is partly absorbed in the stratospheric Ozone layer (2-8 ppm Ozone content), maintaining it and warming the Stratosphere from -60 C^0 at its base to near 0 C^0 at its top.

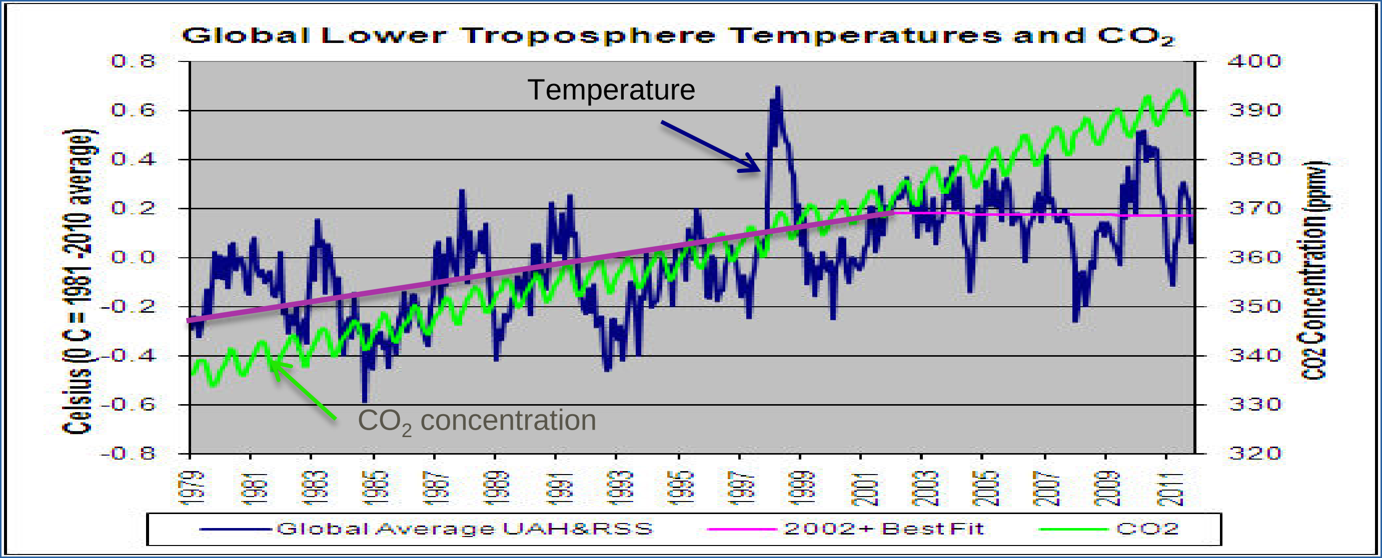
In the stable Stratosphere, slow Brewer-Dobson circulation transports warm and O_3-enriched air from low latitudes towards the Poles and downward in the Stratosphere.

During solar cycles, UV radiation varies by up to 6 %. The temperature of the Stratosphere varies with the intensity of UV radiation that essentially varies with the intensity of solar activity.

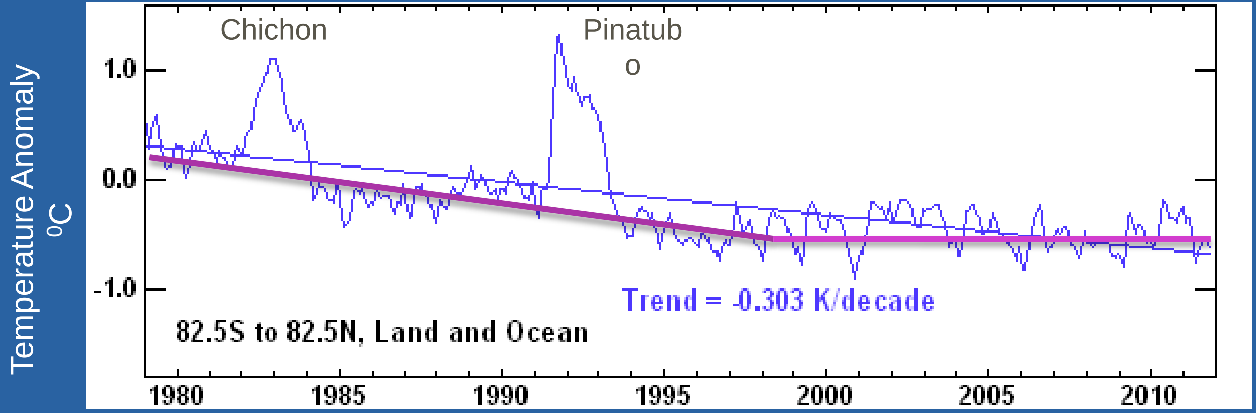
The intensity of Troposphere convection, distributing heat from low latitudes toward Polar regions, depends on sea surface temperatures that are controlled by the TSI.

The Troposphere and Stratosphere are coupled across the Tropopause (thermal inversion zone at 8-18 km above sea level). At Jet Stream fronts, operating at the Tropopause, warm stratospheric air is inserted into the much colder upper Troposphere, warming it, thus influencing the climate. The degree of Troposphere/Stratosphere interaction depends on their thermal energy potential.

IPCC 's Global Circulation Models do not take into account Troposphere/Stratosphere coupling.

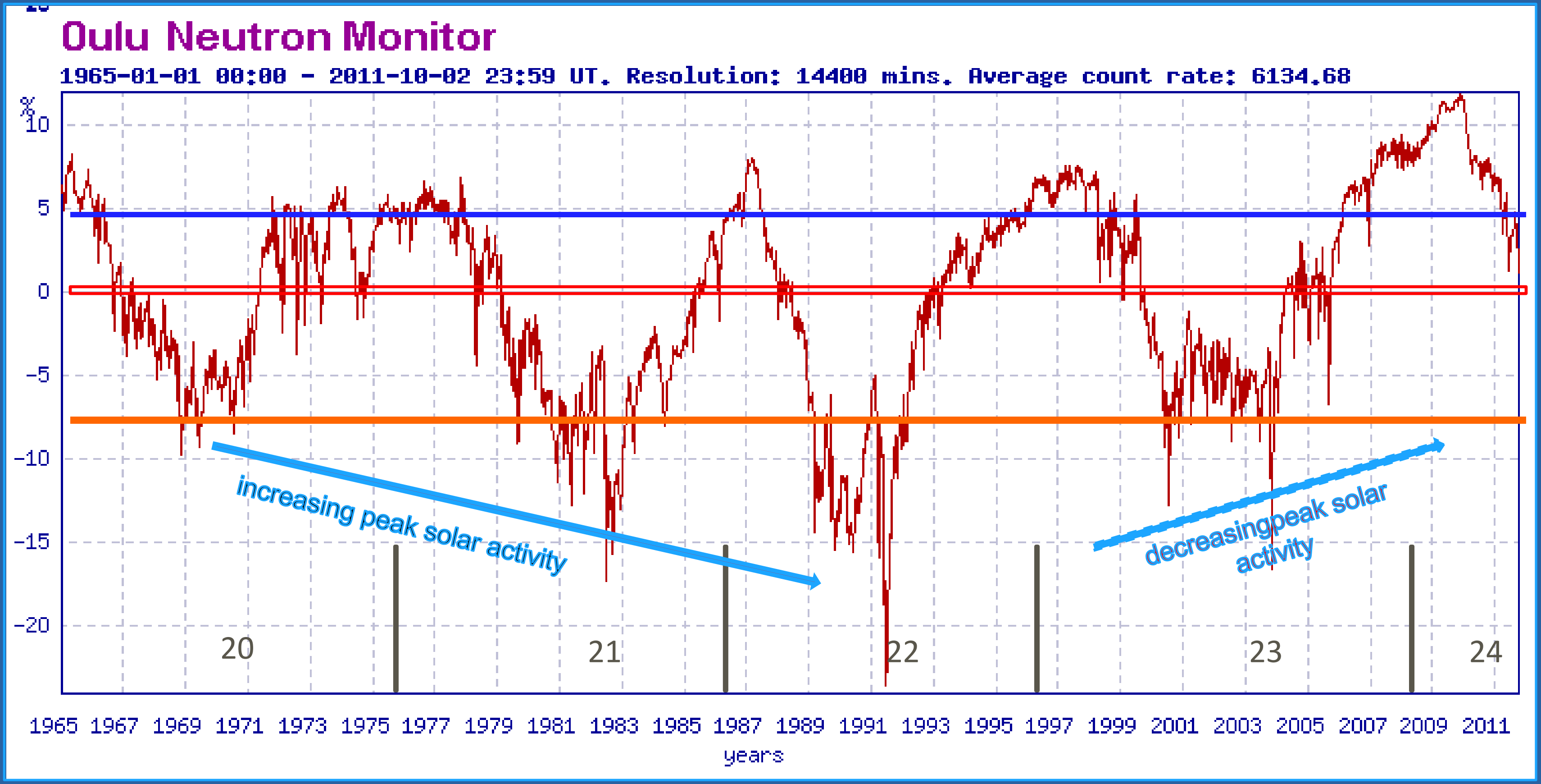


Global Lower Stratosphere Temperatures (source:http://www.ssmi.com/msu/msu_data_description.html)



Up to the late 1990s Solar activity increased while the GCR flux decreased, causing Lower Troposphere temperature to increase and Lower Stratosphere temperature to decrease. Subsequently Solar activity began to decreased while the GCR flux increased, stabilizing Lower Troposphere and Lower Stratosphere temperatures.

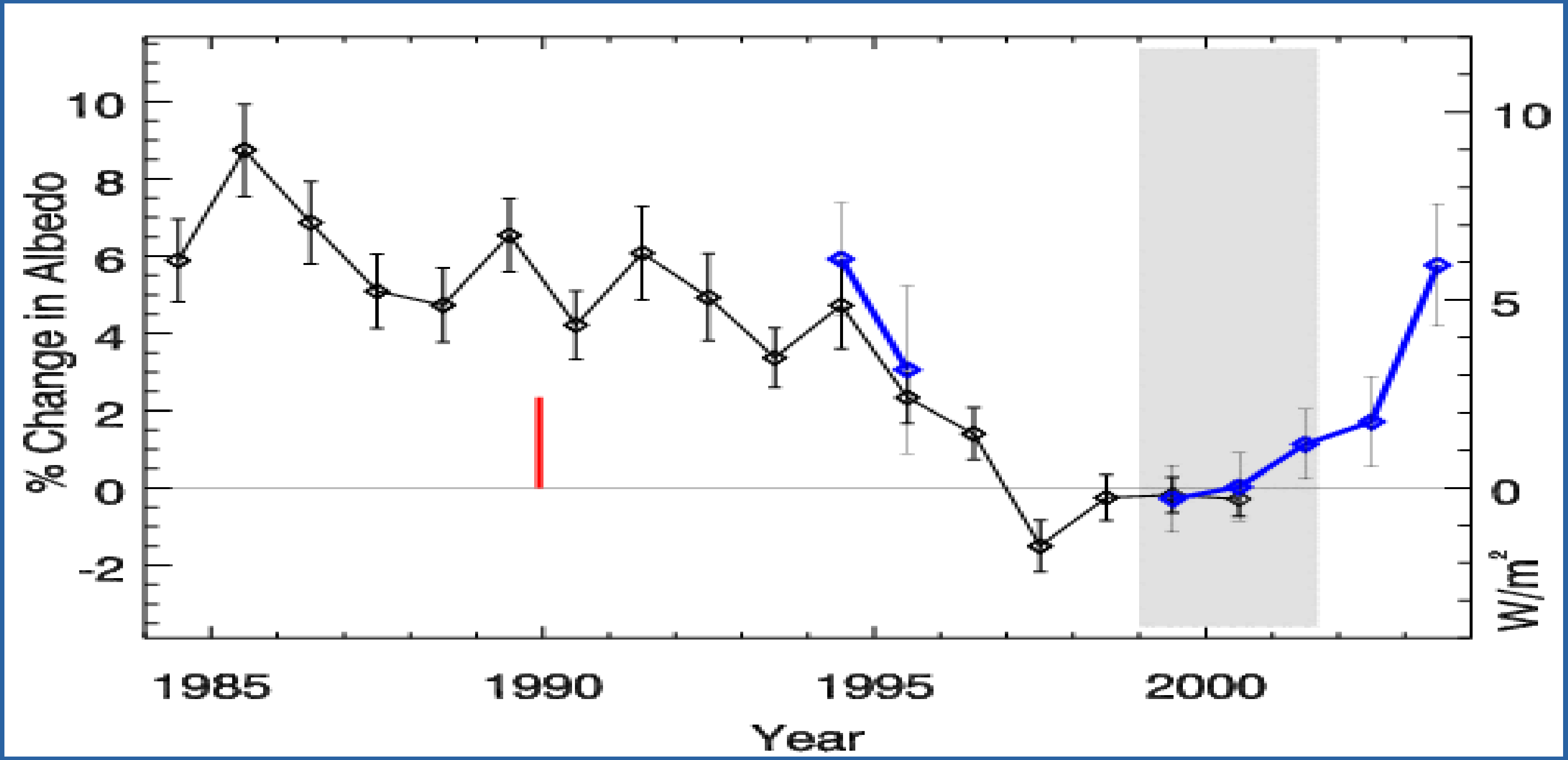
The Galactic Cosmic Ray (GCR) flux decreased during solar cycles 20 to 22 of increasing solar activity but increased again during cycles 23 and 24 of decreasing solar activity



Source of diagram: modified after Cosmic Ray Station, University of Oulu, Finland

Solar activity and temperatures increased cyclically since the Little Ice Age while the GCR flux decreased cyclically (see slides 18 and 22). Following the peak of solar activity in the 1990s, the GCR flux increased again, as evidenced by the shallower and wider trough of the maroon curve during the peak of cycle 23 and by its distinct culmination during the cycle 23/24 transition.

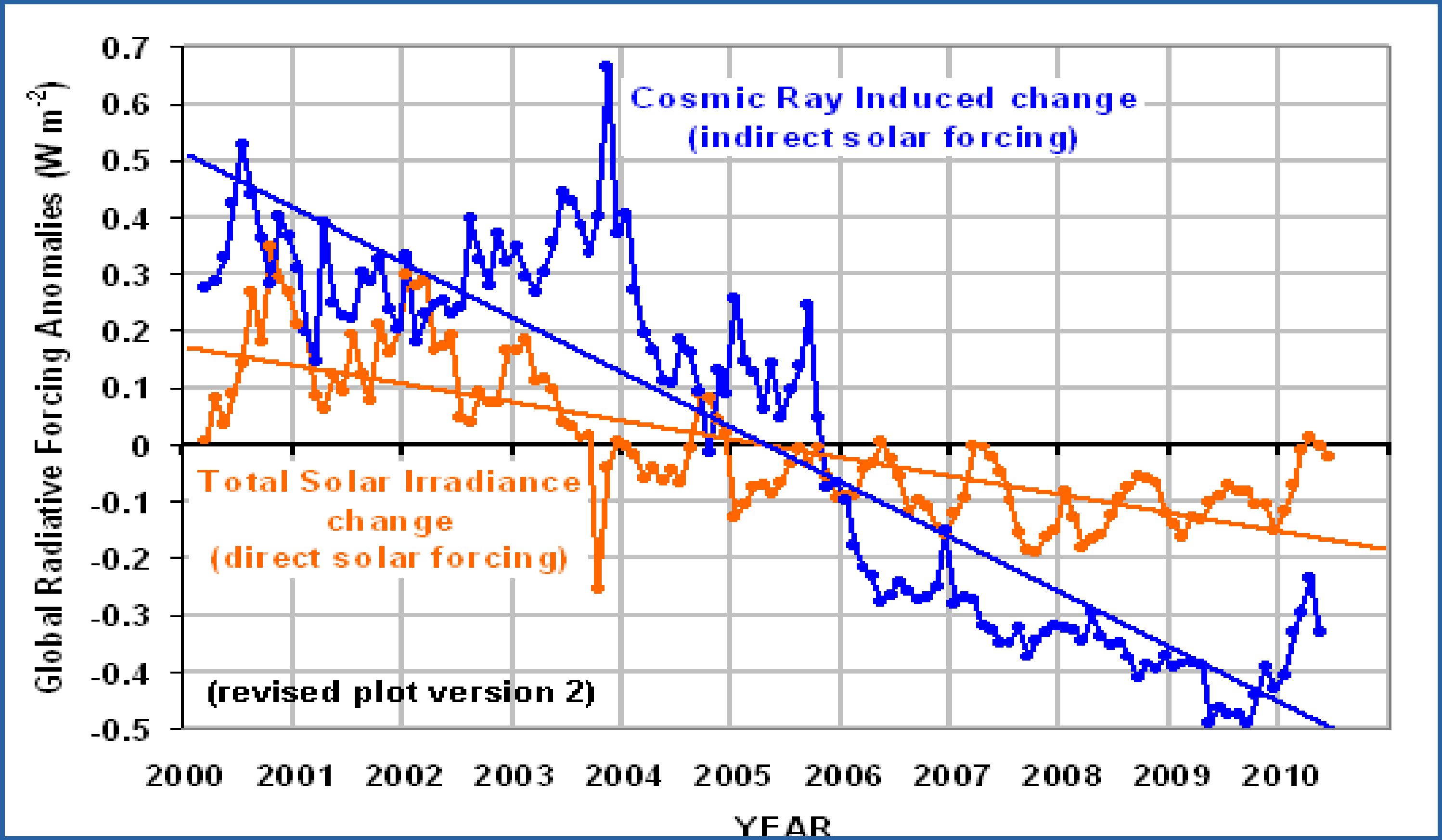
Solar activity, Galactic Cosmic Ray flux and Earth's Albedo



Source of diagram: Pallé, 2009

Decline of the albedo (cloudiness) between 1985 and 2000 is consistent with an increasing level of solar activity and a decline in cloud nucleation due to a diminished GCR flux. During this period, the up to 10 Wm^{-2} cloud-driven change in the Earth's radiation budget exceed considerably the 2.4 Wm^{-2} forcing attributed by IPCC (2001) to the entire post-Little Ice Age anthropogenic greenhouse impact (red bar). The post 2000 increase in albedo is compatible with gradually decreasing solar activity, an increasing GCR flux and cloud cover, and a decreasing water vapor content of the upper troposphere (slide 36).

During the years 2000 to 2010 radiative climate forcing involved decreasing Total Solar Irradiation and an increasing Cosmic Ray Flux, causing gradual cooling

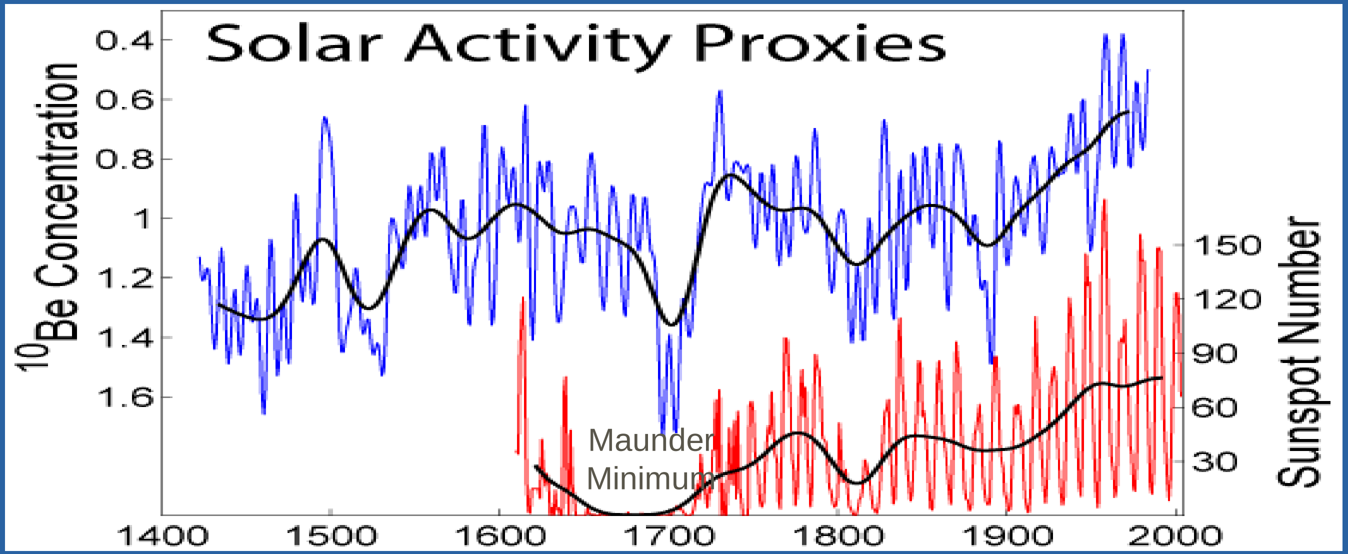


Source of diagram: Roy W. Spencer, 2011.

Cosmic Ray indirect radiative solar climate forcing appears to be 2.6 times greater than direct forcing by Total Solar Irradiation. During the solar cycle 23/24 transition solar climate forcing may be 3.8 times greater than commonly assumed by climate scientists.

Galactic Cosmic Ray (GCR) Flux and Post-Maunder Minimum Warming

x



Source of diagram: Wikipedia File Solar Activity. Blue: ^{10}Be concentration (Beer et al., 1994). Red: Sunspot frequency (Hoyt &Schatten, 1999). Black lines: 25 year moving average smoothing of raw data

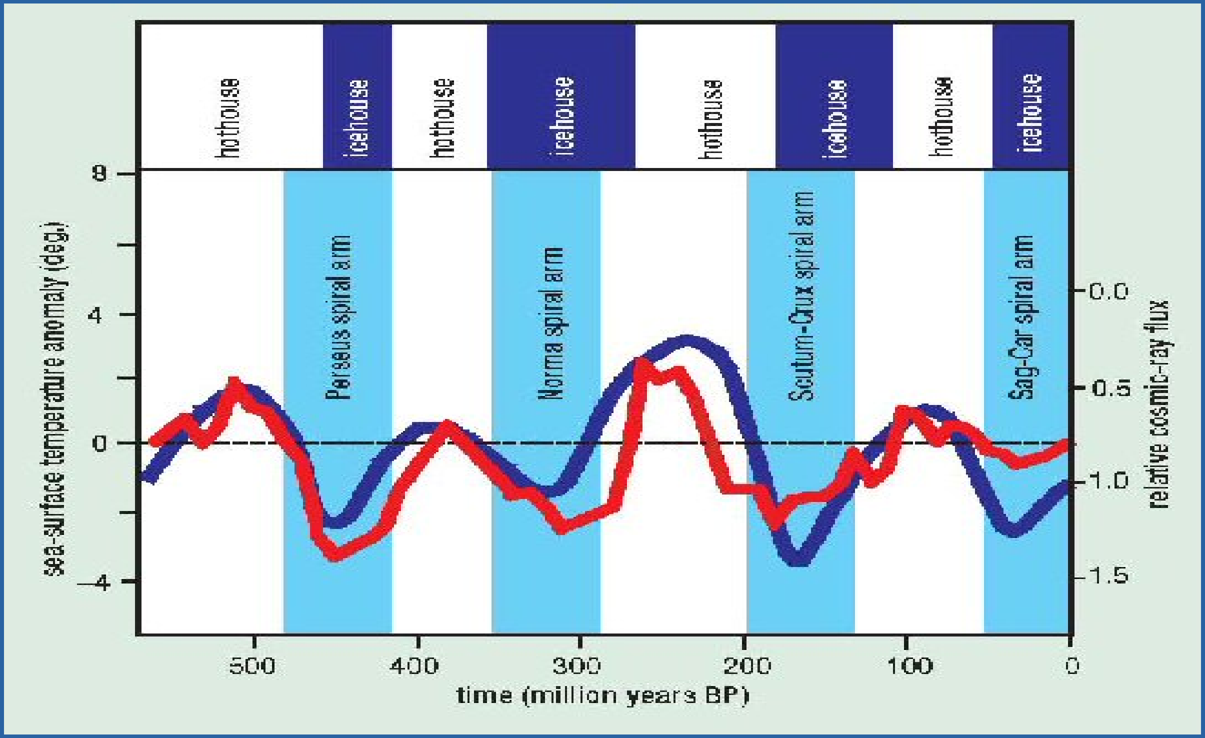
Sunspot Numbers show that after the Maunder Minimum solar activity increased cyclically and peaked after a TSI increase of 1.25 Wm^{-2} during the 1990s at TSI 1366.5 Wm^{-2}(Krivova et al., 2010; Gray et al., 2010).

TSI and the solar open magnetic field (Solar Wind) that modulates the CGR flux correlate closely. The concentration of the cosmogenic isotopes ^{10}Be and ^{44}Ti correlates inversely with TSI and the Solar Wind.

Since the Maunder Minimum the solar open magnetic field (Solar Wind) increased by about 350% (Steinhilber et al., 2010) while ^{10}Be data reflect an over 50% decrease of the GCR flux, reaching a low in the late 1990ies (Beer et al., 1994), and ^{44}Ti date indicate a 43% decrease of the GCR flux since 1770 (Taricco et al., 2006).

Solar variability accounts for 40% of the 0.5 ^{0}C warming from 1715 to 1970 (de Jager et al., 2010)
Cloud cover changes modulated by the GCR flux probably account for most of the remaining 60%

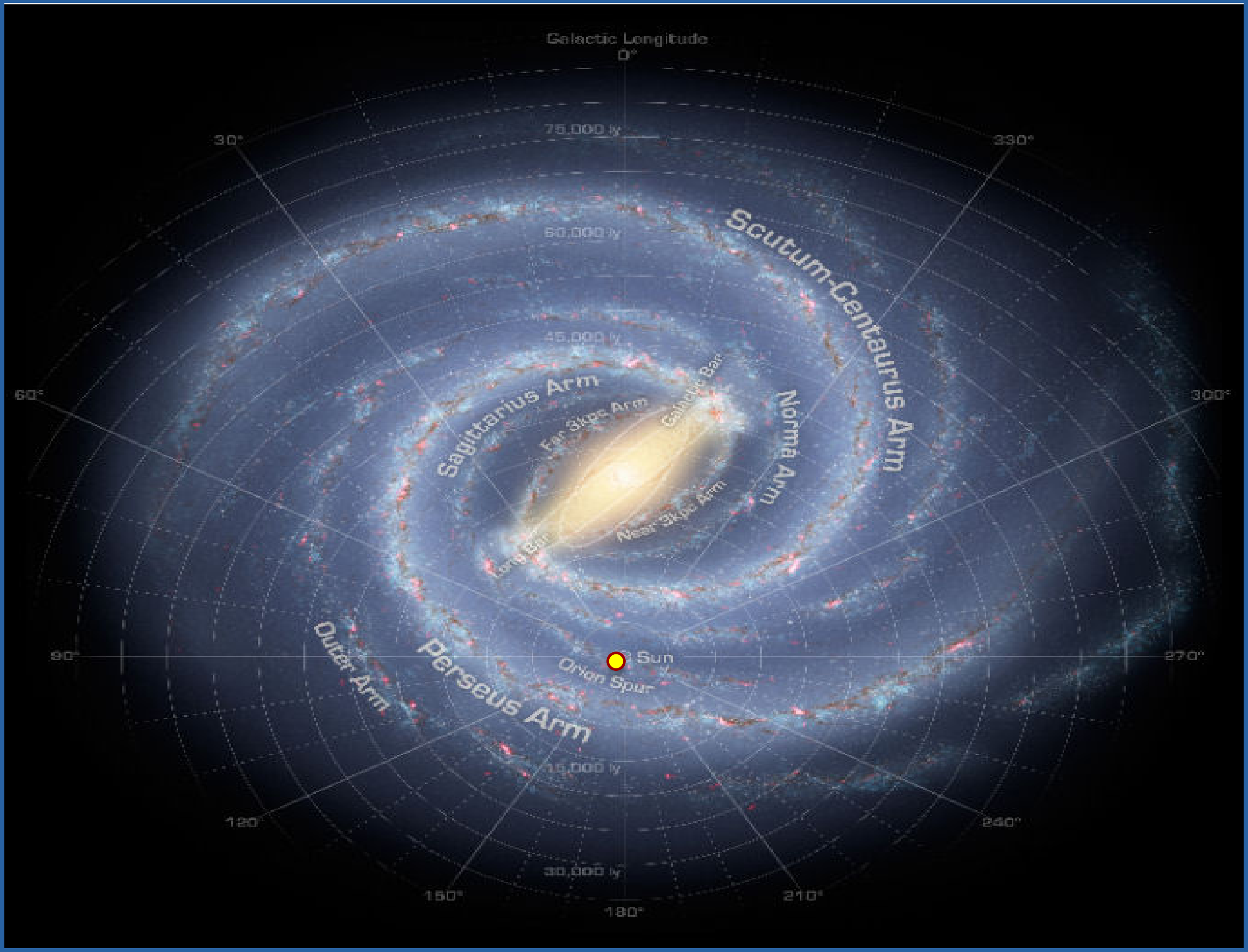
Major changes in the GCR flux probably controlled during Phanerozoic times repeated changes between greenhouse and icehouse climates



Source of diagram: DTU National Space Institute, Center for Sun-Climate Research
http://www.space.dtu.dk/English/Research/Research_divisions/Sun_Climate.aspx

While the Solar System migrated during Phanerozoic times through four spiral arms of the Milky Way galaxy, the intensity of the GCR flux varied significantly (blue curve), controlling transitions from greenhouse to icehouse conditions and back, involving changes in tropical sea-surface temperatures of several ^{0}C (red curve) (Shaviv and Veizer 2003). These temperature fluctuations cannot be attributed to changes in atmospheric CO_2 concentrations (see slide 7).

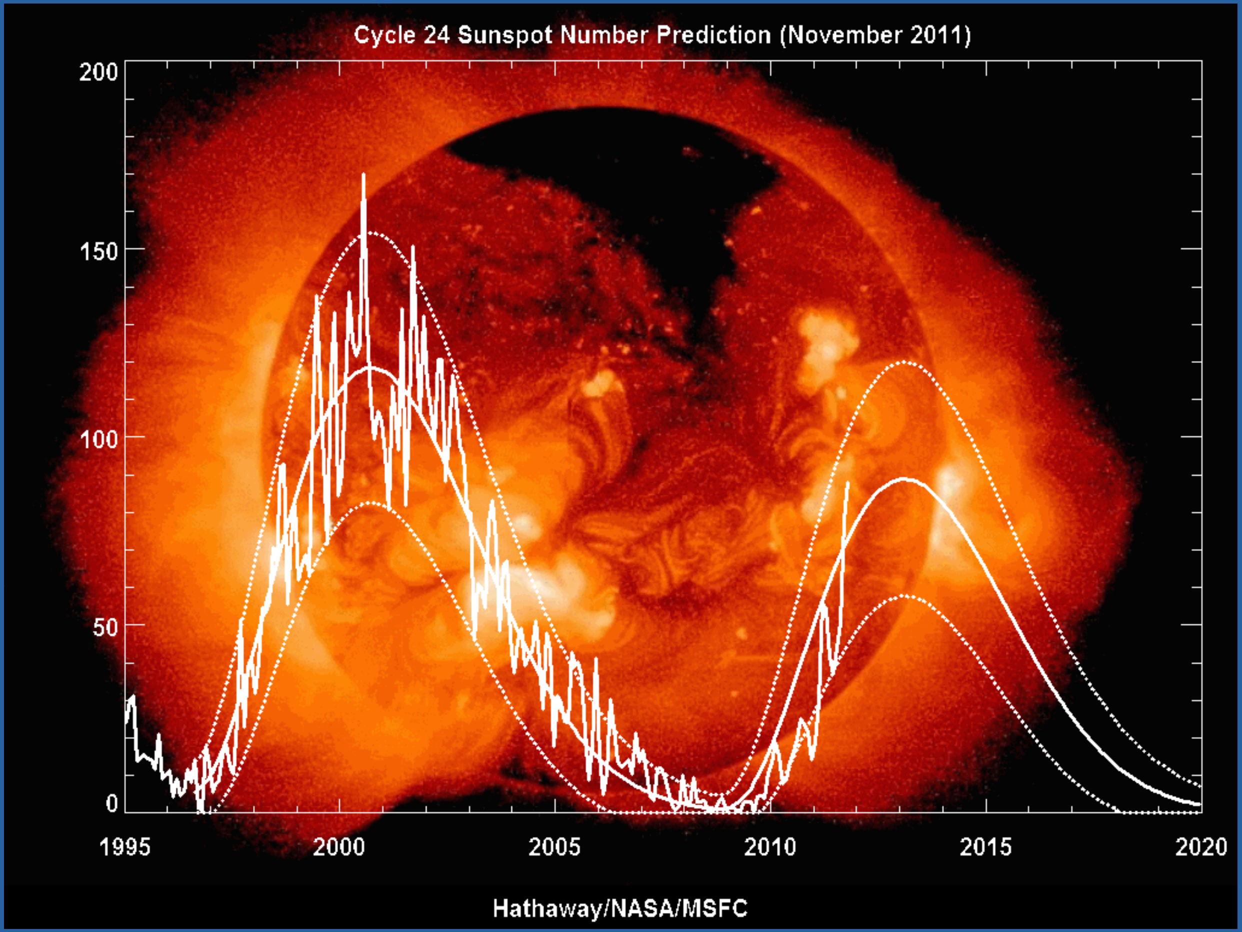
The Sun and the flux of Galactic Cosmic Rays are the main climate drivers and not CO_2 as professed by IPCC



Source of diagram: http://en.wikipedia.org/wiki/Milky_Way

Position of Solar System in the spiral arms of the Milky Way Galaxy

What holds the Sun in store for the climate of the coming decades?



Source of diagram: http://solarscience.msfc.nasa.gov/images/ssn_predict_l.gif

Solar cycle 24 is predicted to culminate in May 2013 at a smoothed sunspot number of ±89. Cycle 23 culminated in January 2000 at a smoothed sunspot number of ±120.

It looks like we are heading in the next four decades into a Maunder-type Solar Minimum with the Northern Hemisphere cooling by as much as 1^0C.

CONCLUSIONS

- There is nothing new despite rising atmospheric CO_2 levels. Industrial Times warming can be readily explained by natural processes.
- During the last 550 Million years major natural climate changes occurred, involving large temperature and atmospheric CO_2 fluctuations.
- Apart from orbital forcing and the distribution of continents and oceans, fluctuations in solar activity and the galactic cosmic ray flux controlled climate changes during the geological past and probably still do so.
- Despite rising atmospheric CO_2 concentrations we may experience during the coming decades a serious temperature decline akin to the Maunder Minimum due to decreasing solar activity and an increasing GCR flux.
- There is overwhelming evidence that Temperature forces the Carbon Cycle and not vice-a-versa, as postulated by IPCC.
- IPCC underestimates the effects of direct and indirect solar climate forcing while overestimating CO_2 forcing by assuming unrealistic positive temperature feedbacks from a concomitant water vapor and cloud increase
- The IPCC consensus on anthropogenic CO_2 emissions causing Global Warming cannot be reconciled with basic data

Socio-Economic Implications

- IPCC postulates on anthropogenic Global Warming are not only scientifically suspect and politically motivated, but are economically dangerous.
- There is social pressure to accept IPCC postulates. The press promulgates uncritically alarmist messages, blaming industrial nations for Global Warming.
- On the base of scientifically not substantiated concepts, governments, politicians, economists and businessmen are now concerned with climate control and ruinous emission mitigation and trading schemes.
- CO_2 is plant food and not a poison. The observed increase in atmospheric CO_2 concentration fosters plant growth, enhancing food production.
- At times of diminishing fossil energy resources, sequestering CO_2 in subsurface reservoirs is a waste of energy and financial resources as it does not influence the climate at all.
- Our way of living is not threatened by Global Warming caused by anthropogenic emissions. Although fossil energy is still available in large quantities, though at rising prices, development of renewable energy will become increasingly important, but not on account of Global Warming!

Galileo Galilei was condemned for opposing the Churches consensus on the Sun moving around the Earth.
Science proved Galileo right and the Church wrong!

“eppur si muove" (“and yet it moves")

The IPCC consensus on anthropogenic climate change is challenged by scientists at large and will ultimately face the same fate as the Church.