MECHANISMS OF CLIMATE CHANGE

NATURAL CAUSES AND IPCC POSTULATE

THE GEOLOGICAL AND RECENT RECORD

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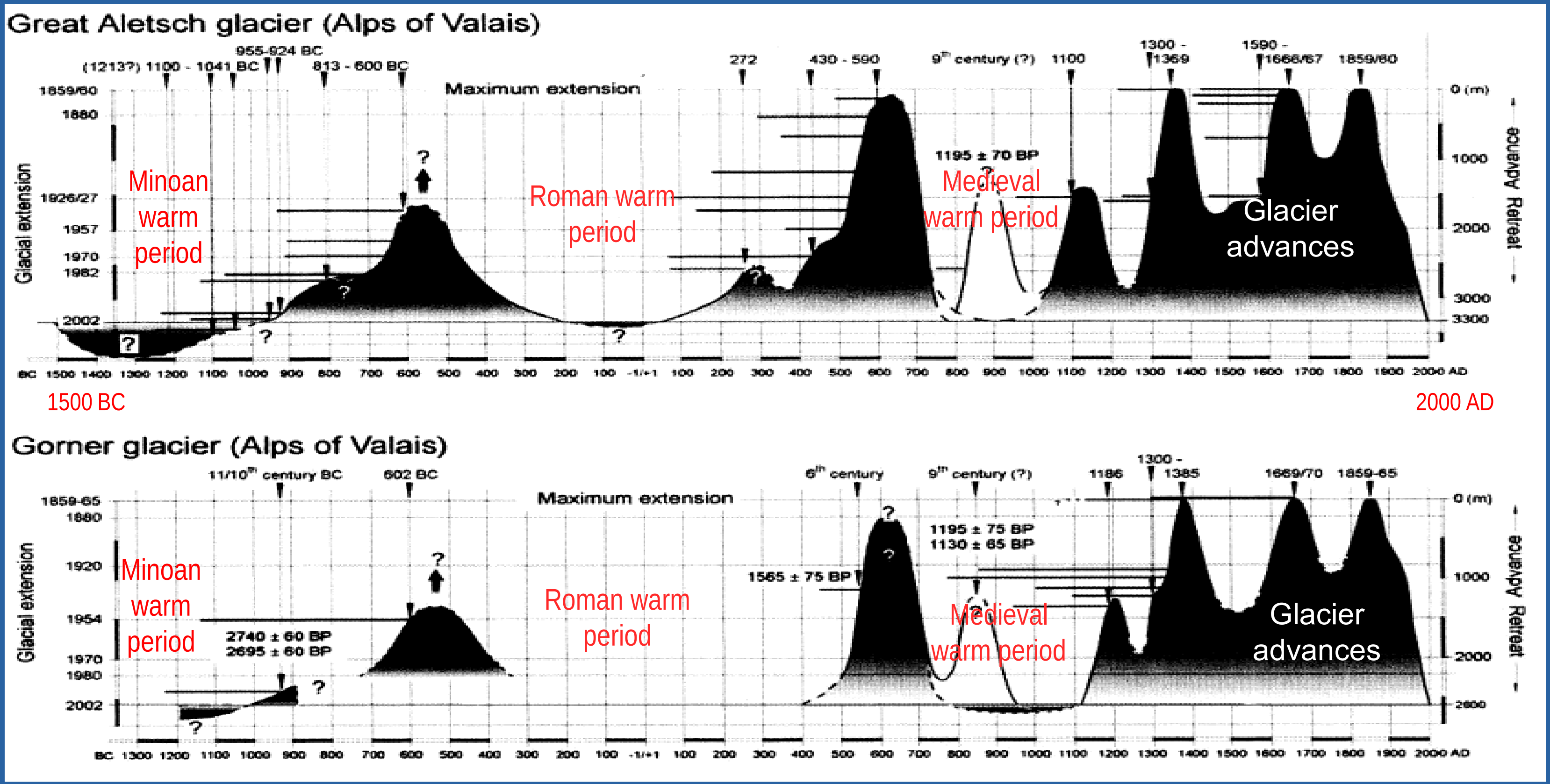
February, 2013

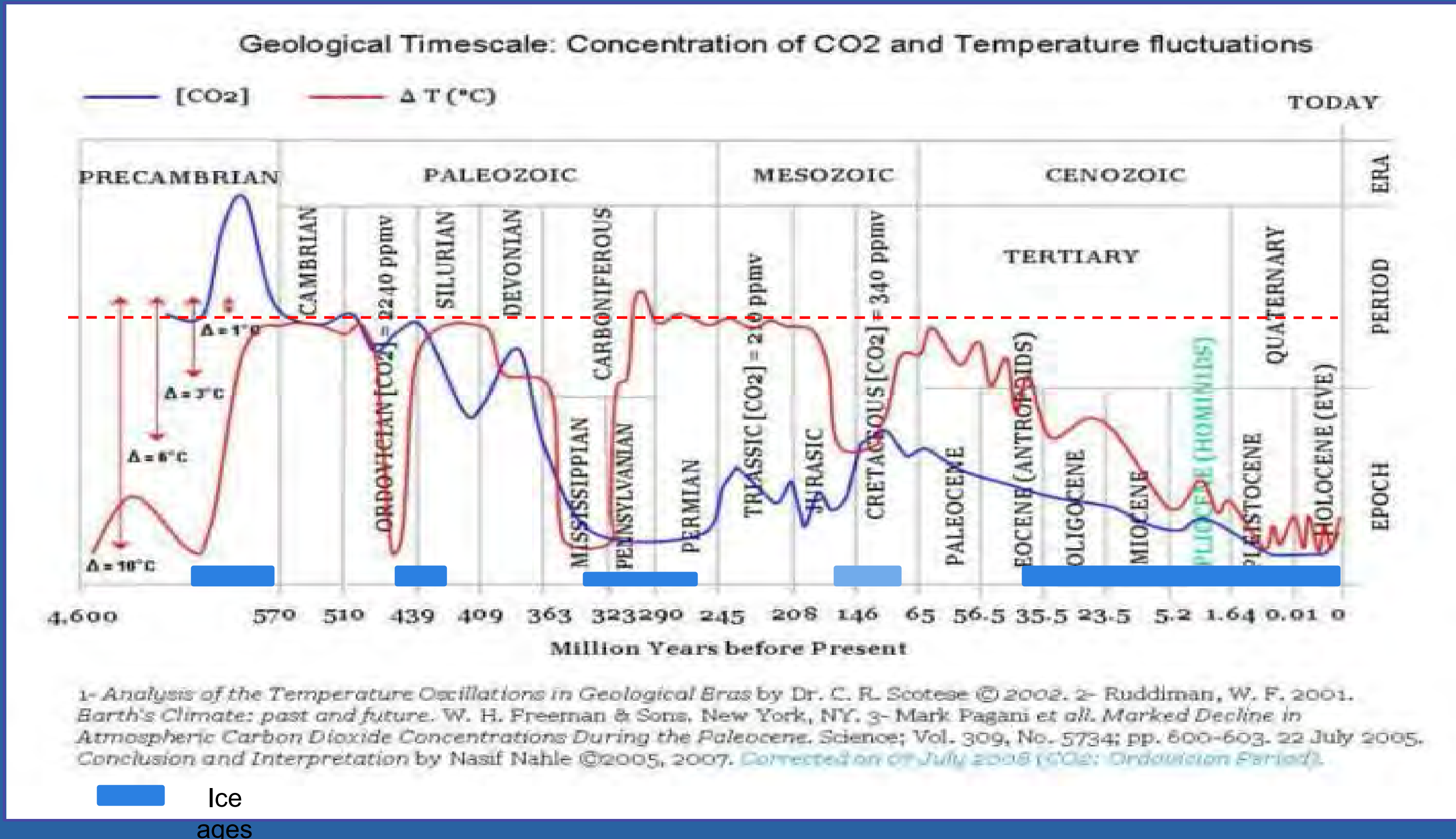
Do CO_2 emissions cause Global Warming, as advocated by IPCC ?



Source of diagram: Holzhauseret al., 2005

Alpine Glaciers always waxed and waned, even without anthropogenic CO_2 emissions.

Our climate was never stable. The present warm period is one in a sequence.



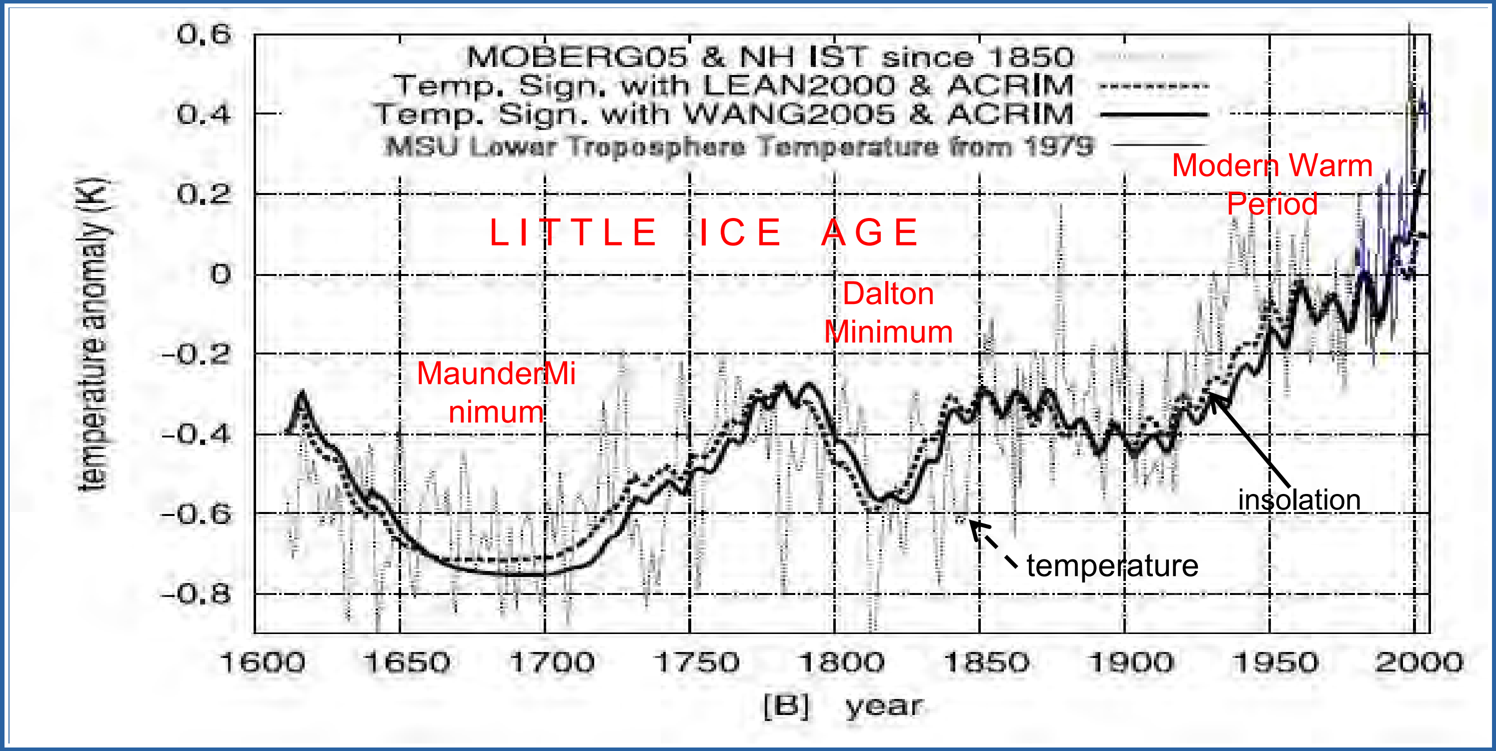
Source of diagram: Nahle, 2005, updated 2008

During geological times the Earth's climate underwent major changes, repeatedly shifting from green-house to ice-house and back. Temperatures varied by up to 10^{0}C while at times atmospheric CO_2 concentrations reached over 2200 ppm (presently 390 ppm)

Temperatures and CO_2 concentrations as derived from proxy data do not correlate

Climate changed in response to natural processes that are active also at present, including variations in solar activity and the galactic cosmic ray flux and ocean current oscillations

400 years Northern Hemisphere temperature versus solar activity

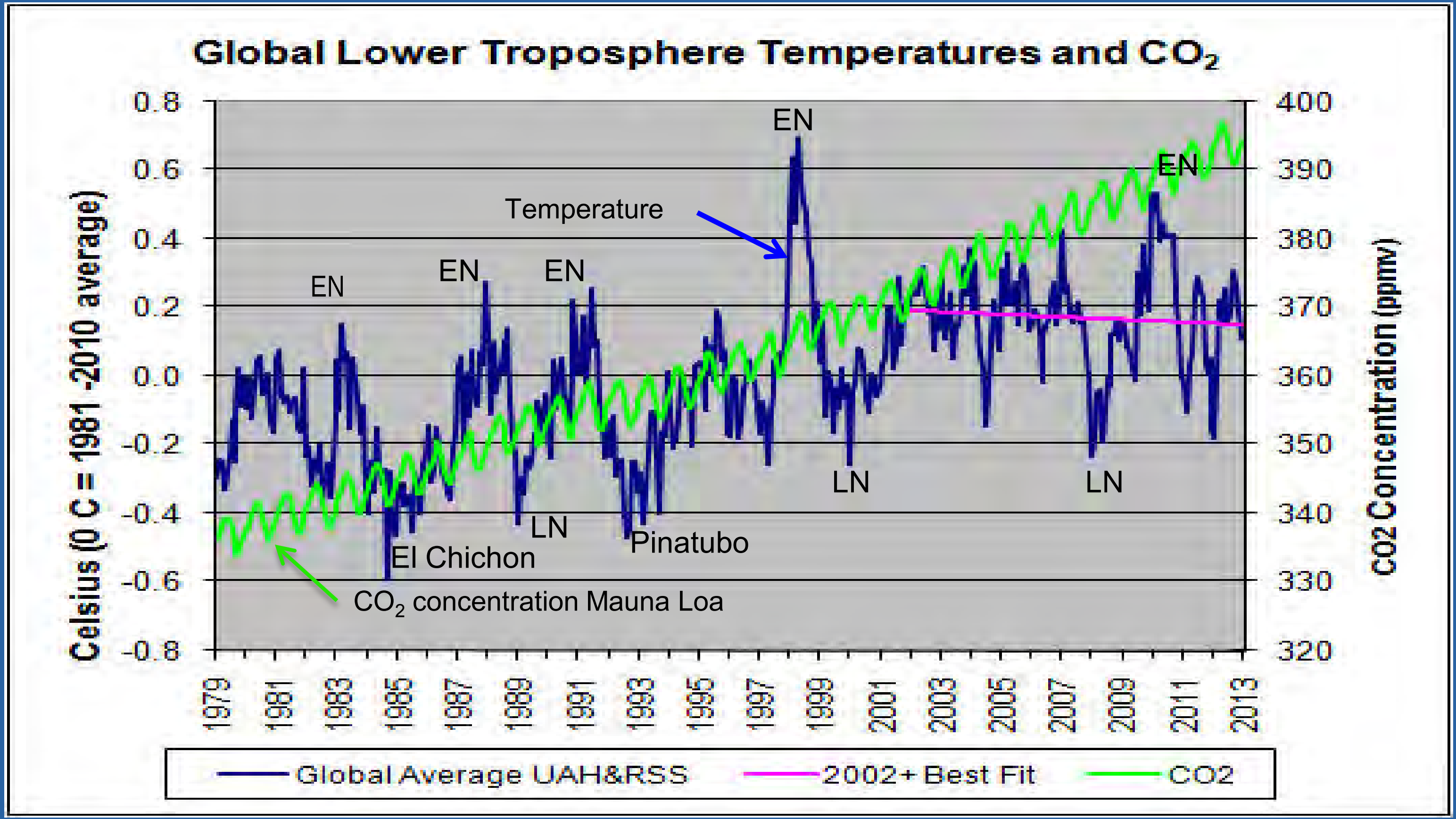


Source of diagram: http://www.friendsofscience.org/, modified after Scafetta& West (2007) to include satellite temperature data.

Smoothed heavy curves: variations in insolation based on the Sun's spectral irradiance and magnetic field up to 1980 and on satellite data thereafter

Serrated stippled thin curve: temperatures derived from proxy records up to 1850, instrumental surface temperature data up to 1980 and satellite data thereafter

changes in solar activity and temperature correlate closely



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

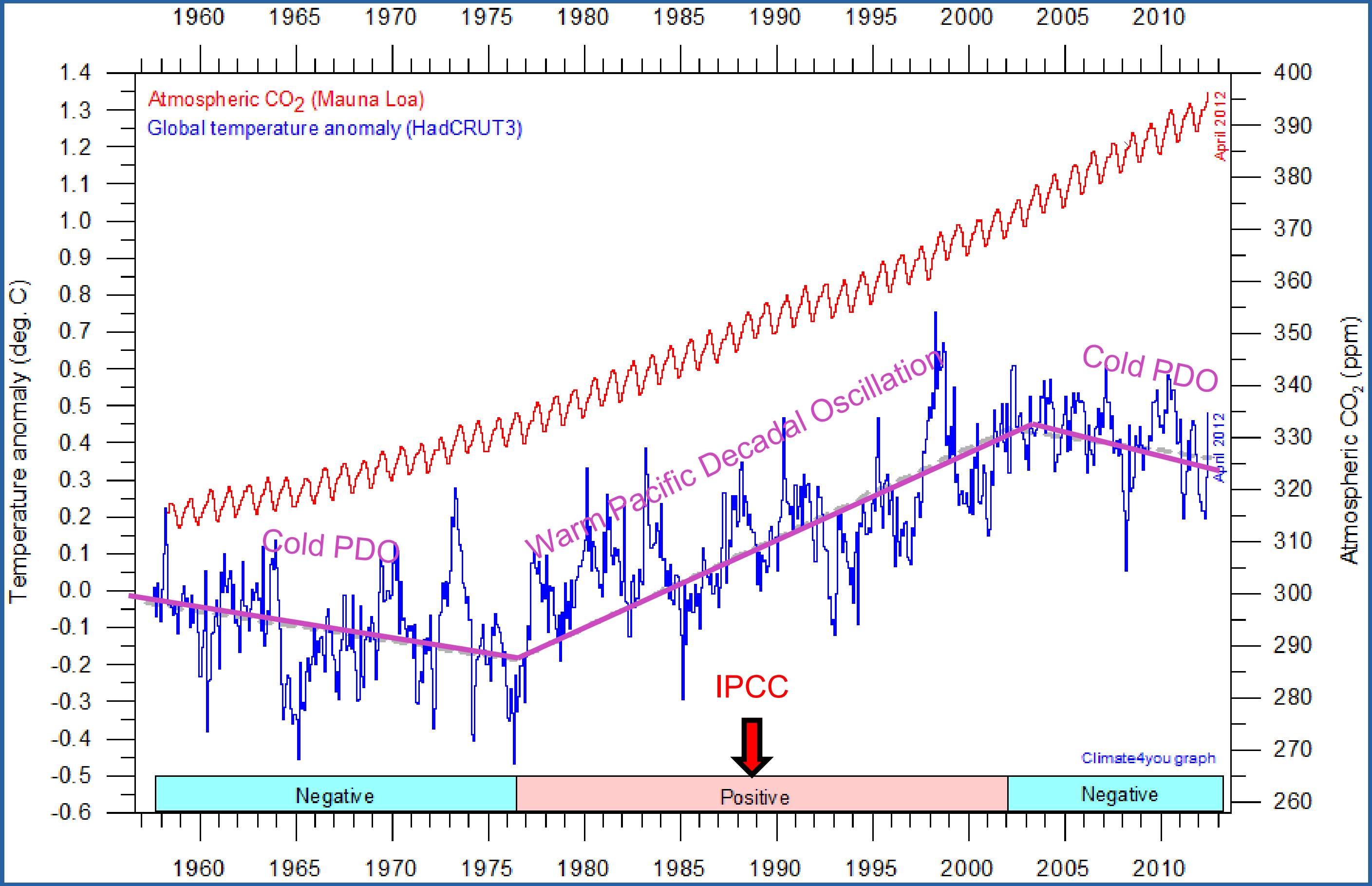
Whereas atmospheric CO_2 concentrations rose continuously during the last 33 years, lower troposphere temperatures increased cyclically until 2002 and then leveled out.

Positive temperature spikes reflect strong El Ninõs (EN), negative ones strong by La Ninas (LN) that relate to changes in atmospheric and ocean currents but not to Global Warming

The negative temperature spikes of 1984 and 1992 relate to volcanic eruptions

the temperature changes and rising atmospheric CO_2 concentrations of the last 33 years are at odds with the rapid Global Warming Concept of IPCC

Since 1958 global surface air temperature and atmospheric CO_2 concentrations do not always correlate while there is a striking correlation between the Pacific Decadal Oscillation and temperature.

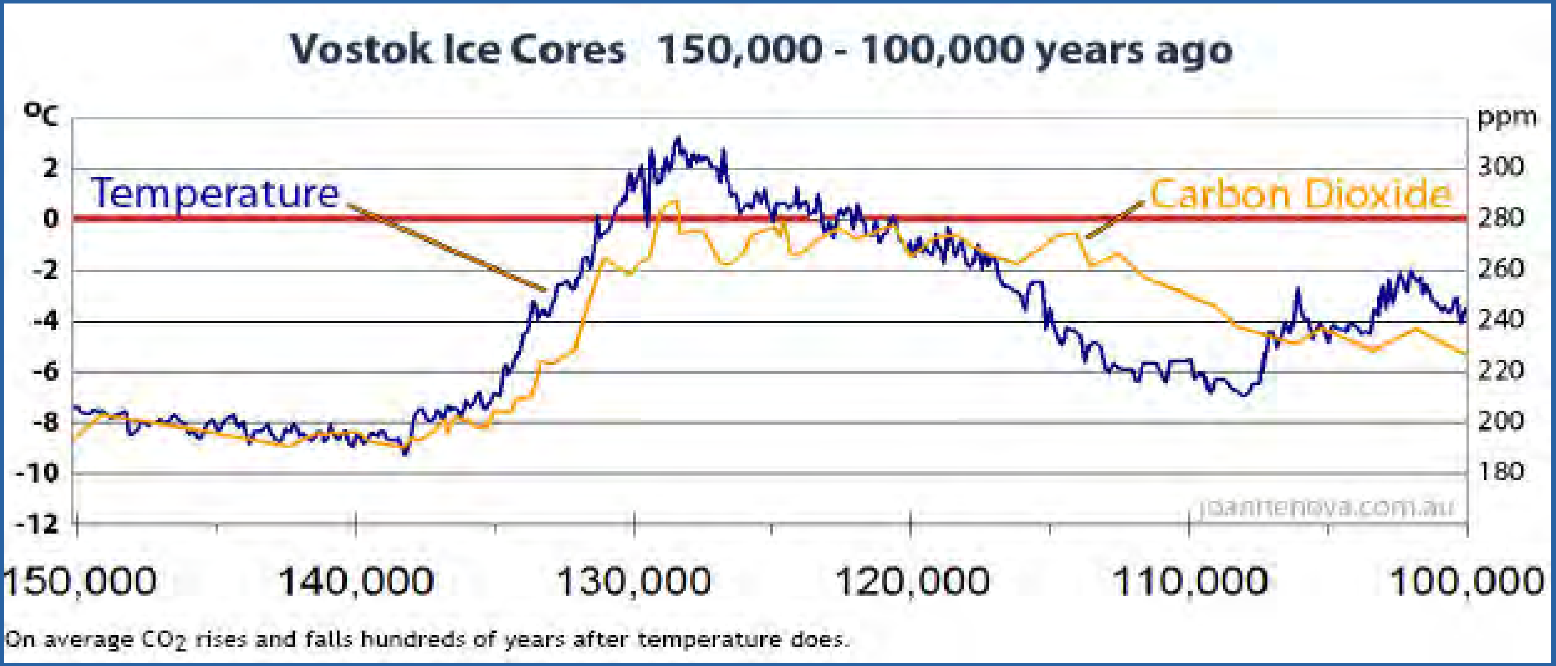


Source of diagram: Climate4you Greenhouse Gases

The NCDC, GISS, RSS MSU and UAH MSU temperature curves show the same temperature/ atmospheric CO_2 concentration relationship as the HadCrut3 curve given in this diagram

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

Ice core data show that Ice Age temperatures rose and fell hundreds of years before atmospheric CO_2 concentrations rose and fell



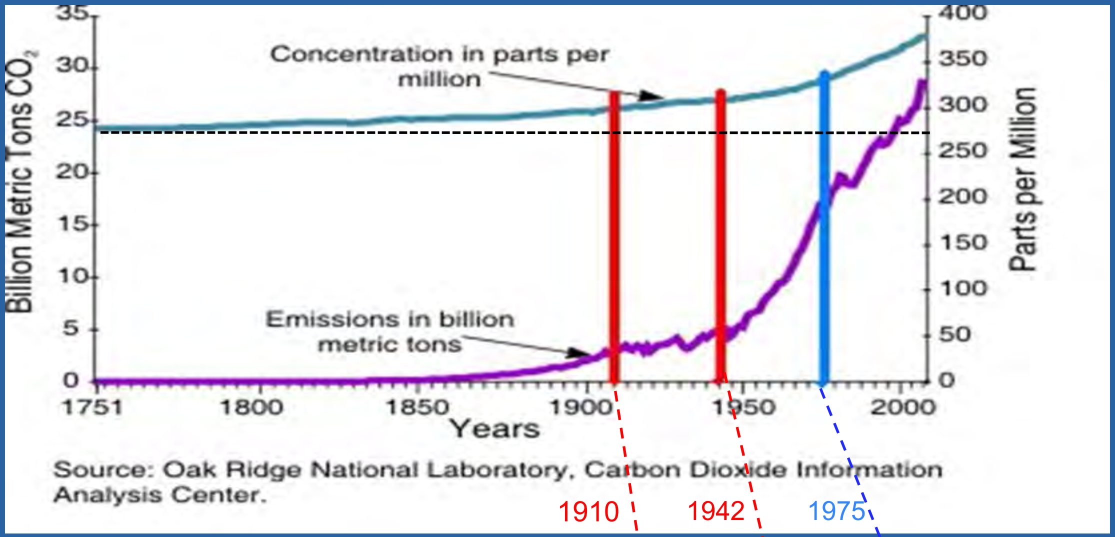
Source of diagram: http://joannenova.com.au/global-warming/ice-core-graph/

The oceans are an immense reservoir of CO_2 that releases/absorbs large volumes of CO_2 into/from the atmosphere in response to slow warming/cooling of the oceans in response to variations in solar irradiance

The thermal inertia of the oceans accounts for the observed delay between changes in global surface temperatures and atmospheric CO_2 concentrations

Temperature forces atmospheric CO_2 concentrations and not vice-versa

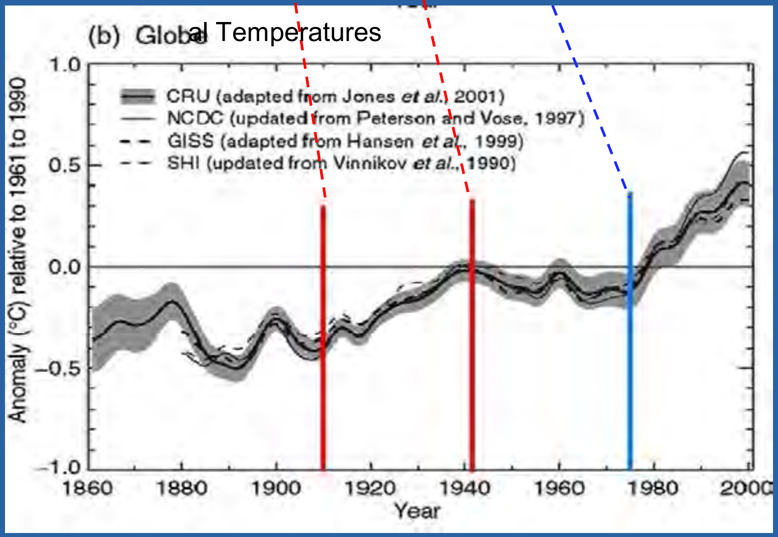
During industrial Global Warming atmospheric CO_2 concentrations, anthropogenic emissions and temperature do not correlate



Atmospheric CO_2 concentrations rose already prior to the increase in fossil fuel consumption around 1835. Temperature variations and the slow rise of CO_2 concentrations before 1910 can hardly be attributed to fossil fuel emissions. Between 1910 and 1942 the World warmed rapidly while atmospheric CO_2 concentrations gradually rose and CO_2 emissions increased slowly from 3.5 to 4.0 Gt/yr.

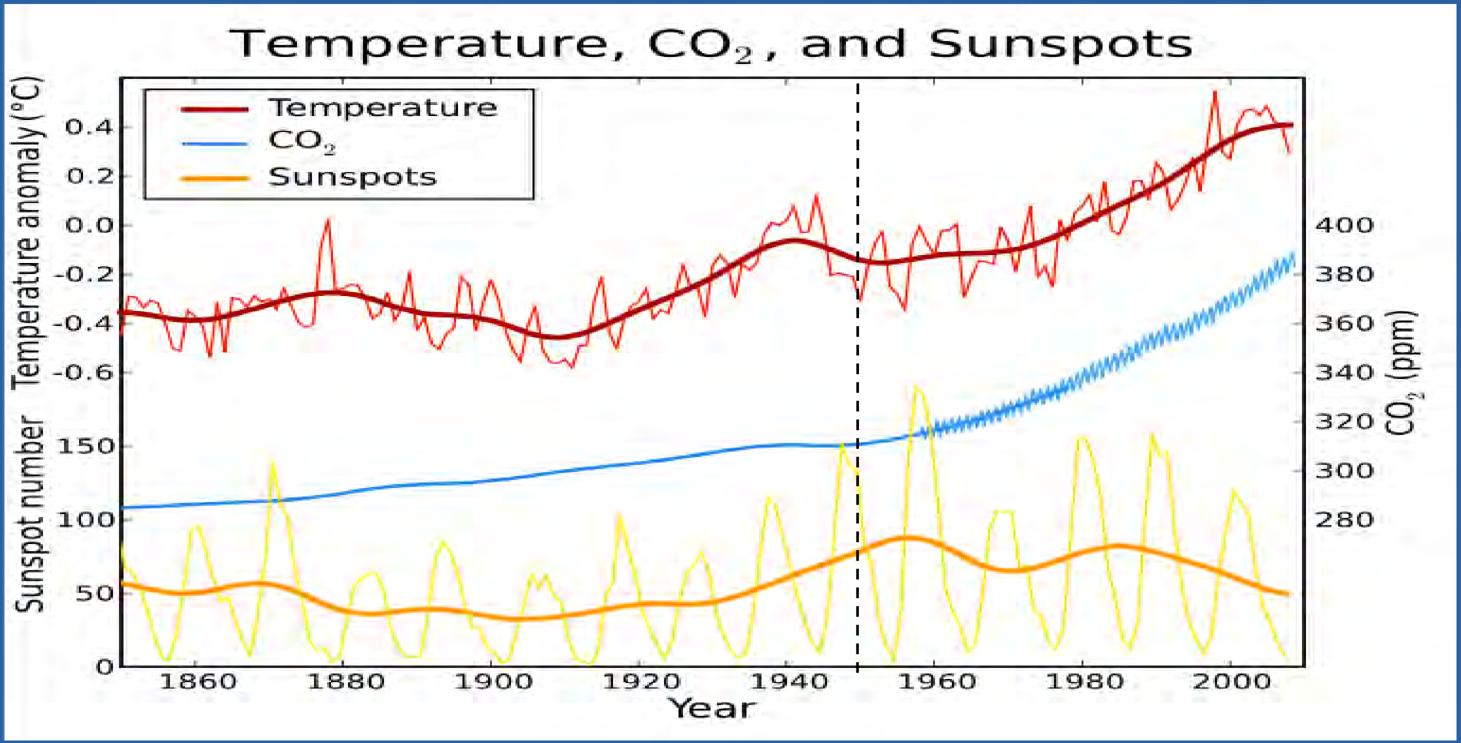
During the negative PDO of 1942 to 1977 the World cooled, CO_2 emissions increased 5-fold while atmospheric CO_2 concentration accelerated sharply.

During the positive PDO of 1977 to 2000 temperatures, CO_2 emissions and atmospheric CO_2 concentrations rose rapidly.



Source of diagram: IPCC AR-4, 2007

Early Global Warming coincided with a slight increase in CO_2 emissions, while Global Cooling was paralleled by a dramatic increase in CO_2 emissions from 4.0 Gt/yr in 1942 to 20.0 Gt/yr in 1975.



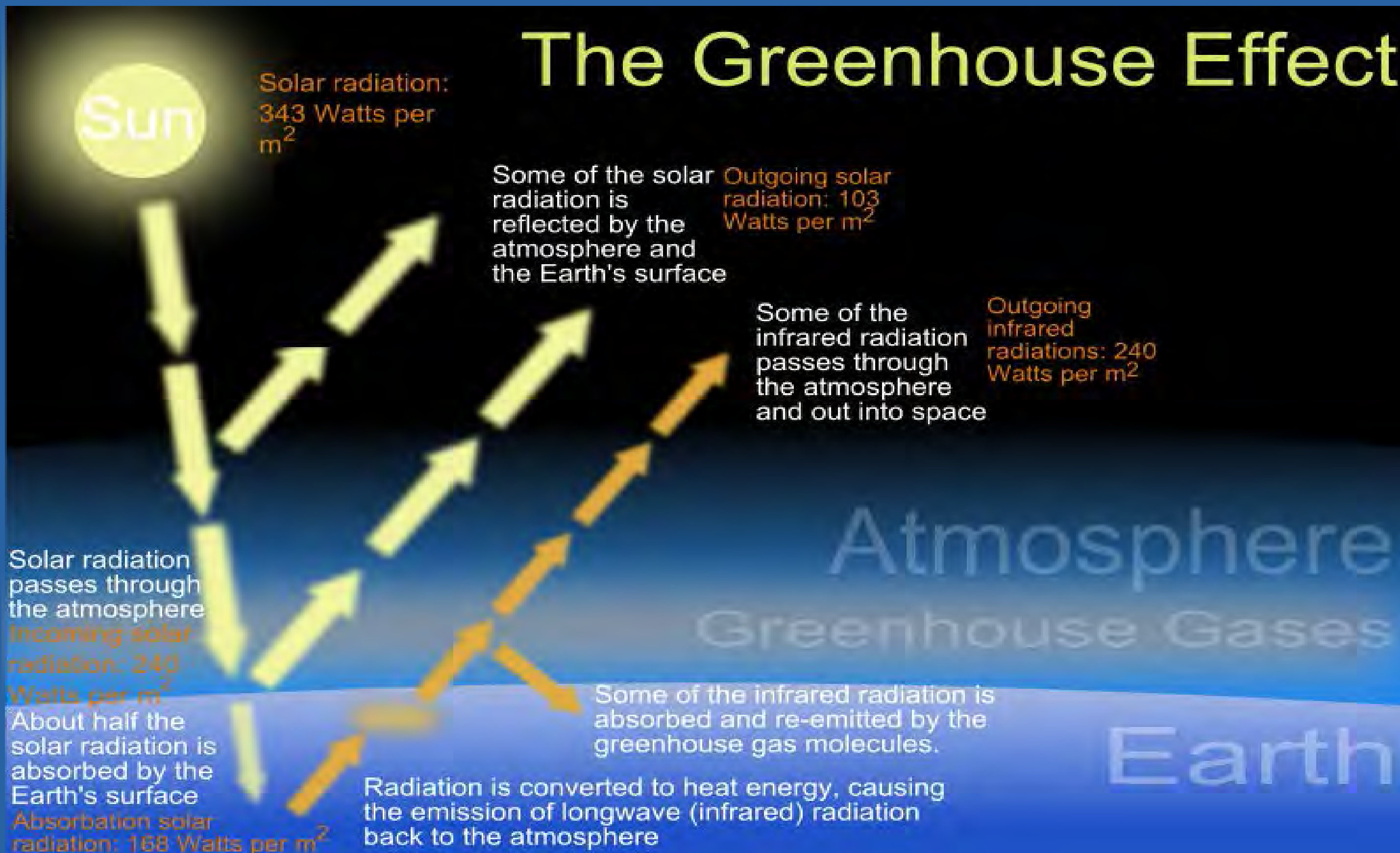
Source of diagram: L. McInnes, 2007. In: Wikipedia: Solar Variations
Thick lines for temperature and sunspots: 25 year moving average smoothing of raw data.

During the last 150 years atmospheric CO_2 concentrations rose during a period of cyclically increasing temperatures and solar activity that came to an end in the 1990s

The steady increase in atmospheric CO_2 concentrations and temperatures since the 1950s is attributed by IPCC to the Greenhouse Effect of anthropogenic CO_2 emissions, despite the fact that prior to 1950 the temperature and CO_2 curves do not correlate

This questions the validity of the Anthropogenic Global Warming Concept

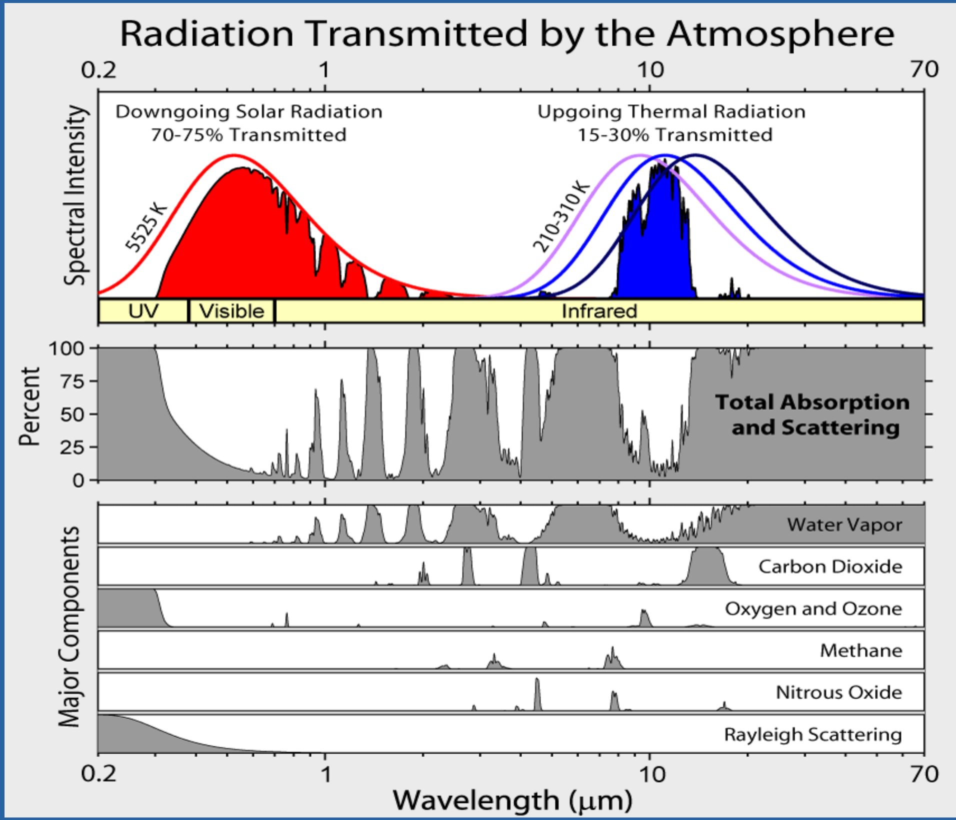
The Greenhouse Concept is a blatant misnomer
a greenhouse traps heat by suppressing convection



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)



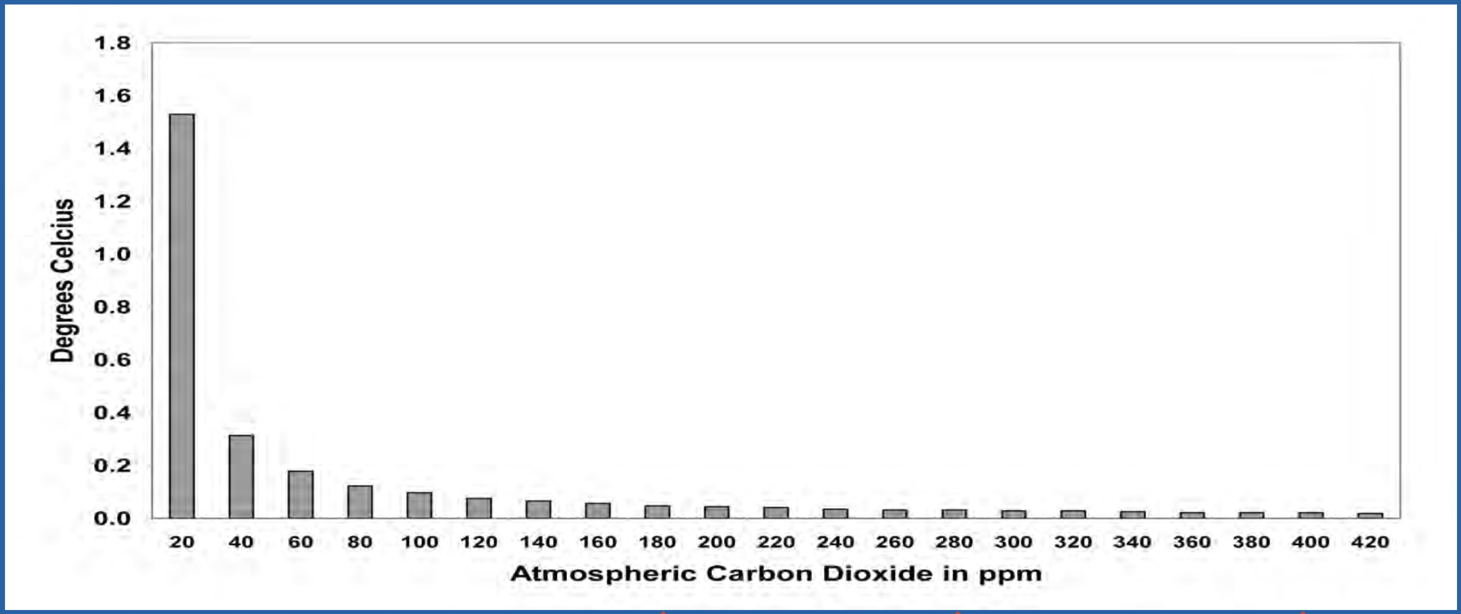
Absorption of the reflected ultraviolet, visible and infrared radiation by the different GHG of the atmosphere.
Absorption saturation: 100% absorption of the respective wavelength (Peixoto& Oort, 1992)

- Water vapor and clouds cause 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%.
- Only part of the infra-red 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 infra-red radiation that is absorbed by the GHG molecules is re-emitted by them, partly back towards the Earth
- GHG retain heat from the day to the night and redistribute energy within the atmosphere
- There is already sufficient CO_2 in the atmosphere to saturate most of the principal CO_2 infra-red 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

With increasing atmospheric CO_2 concentrations the warming effect of CO_2 decreases logarithmically



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

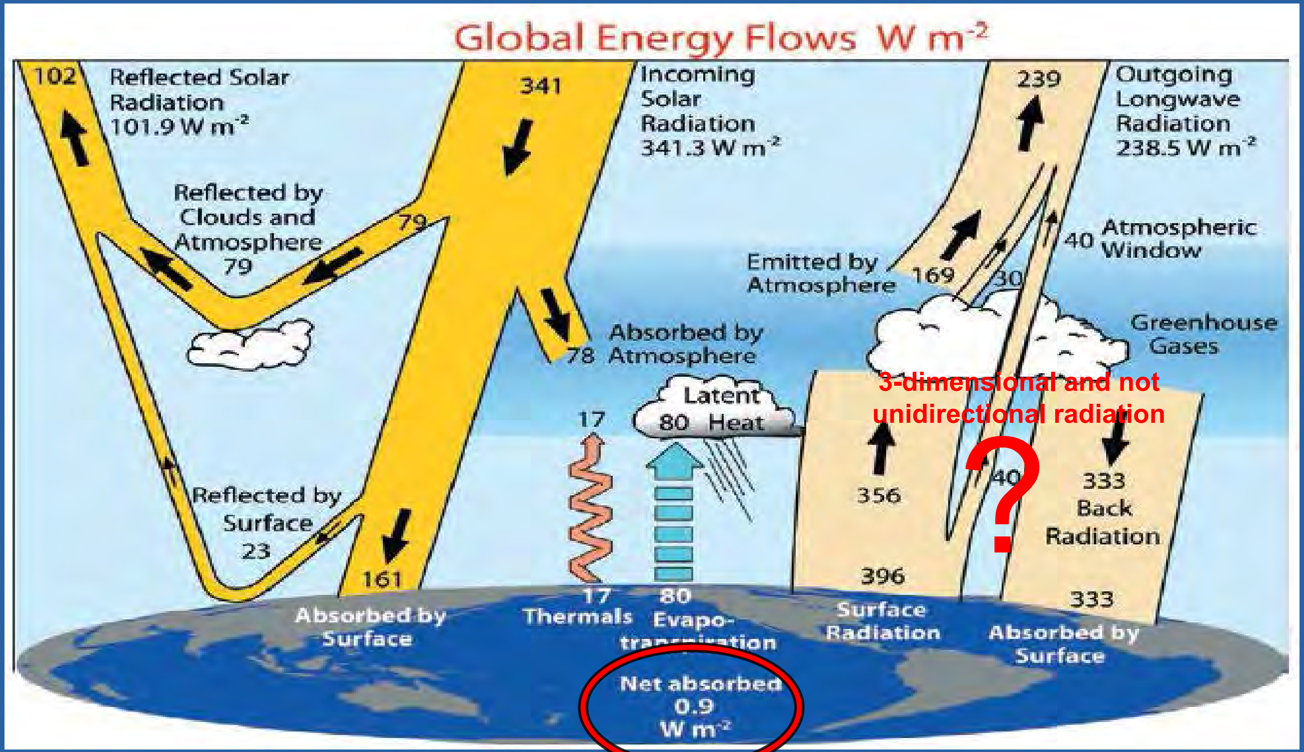
Temperature increase for successive 20 ppm increments of atmospheric CO_2 concentrations up to 420 ppm (MODTRANS; Archibald, 2007)

The temperature effect of the first 20 ppm of CO_2 is far greater than of the next 400 ppm.

The total industrial atmospheric CO_2 increase caused a temperature rise of ±0.10°C

CO_2 concentrations may rise from 380 ppm in 2007 to 420 ppm in 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 an additional temperature rise of about 0.16°C .

IPCC overestimates the CO_2 temperature forcing by assuming unrealistic positive feedbacks from a concomitant water vapor and cloud increase



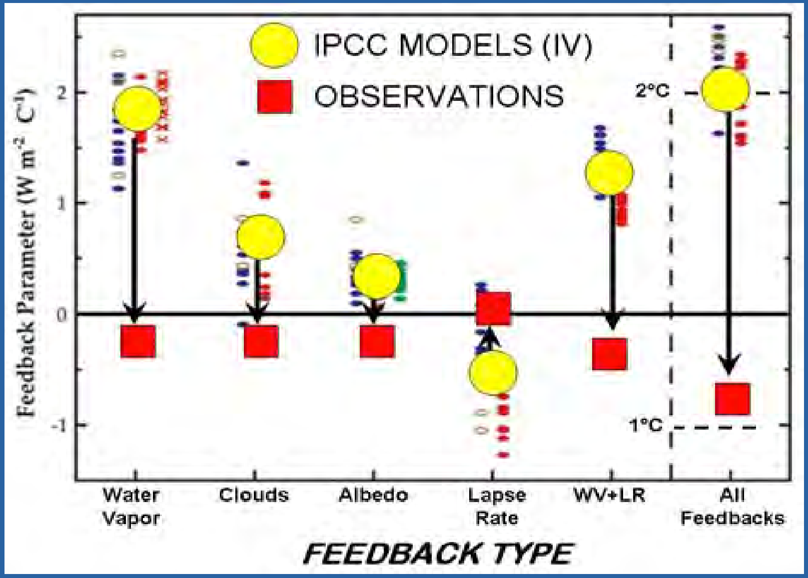
Source of diagrams: IPCC AR-4, 2007; Trenberth et al., 2009

In 2011 K.E. Trenberth still shows the Earth as warming by 0.9 Wm^{-2}/yr despite Solar irradiance having decreased during the last 10 years and wonders:

Were has global Warming from increased GHG gone?

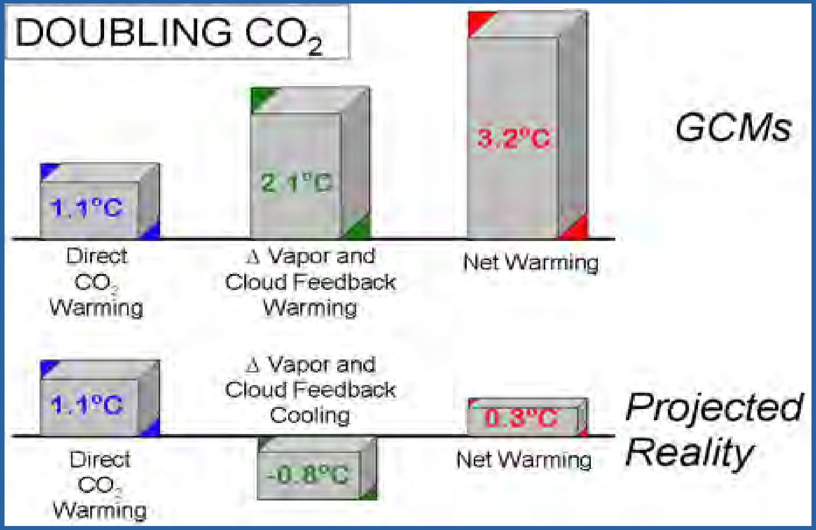
The magnitude of the radiative electro-magnetic flux portrayed as ascending from the surface to high cloud levels and returning to surface is controversial. The model neglects latitudinal changes in solar irradiance and pole-ward convective heat transfer.

IPCC's Global Circulation Models postulate for a CO_2 doubling that water cycle-related feedbacks strongly amplify solar radiative climate forcing



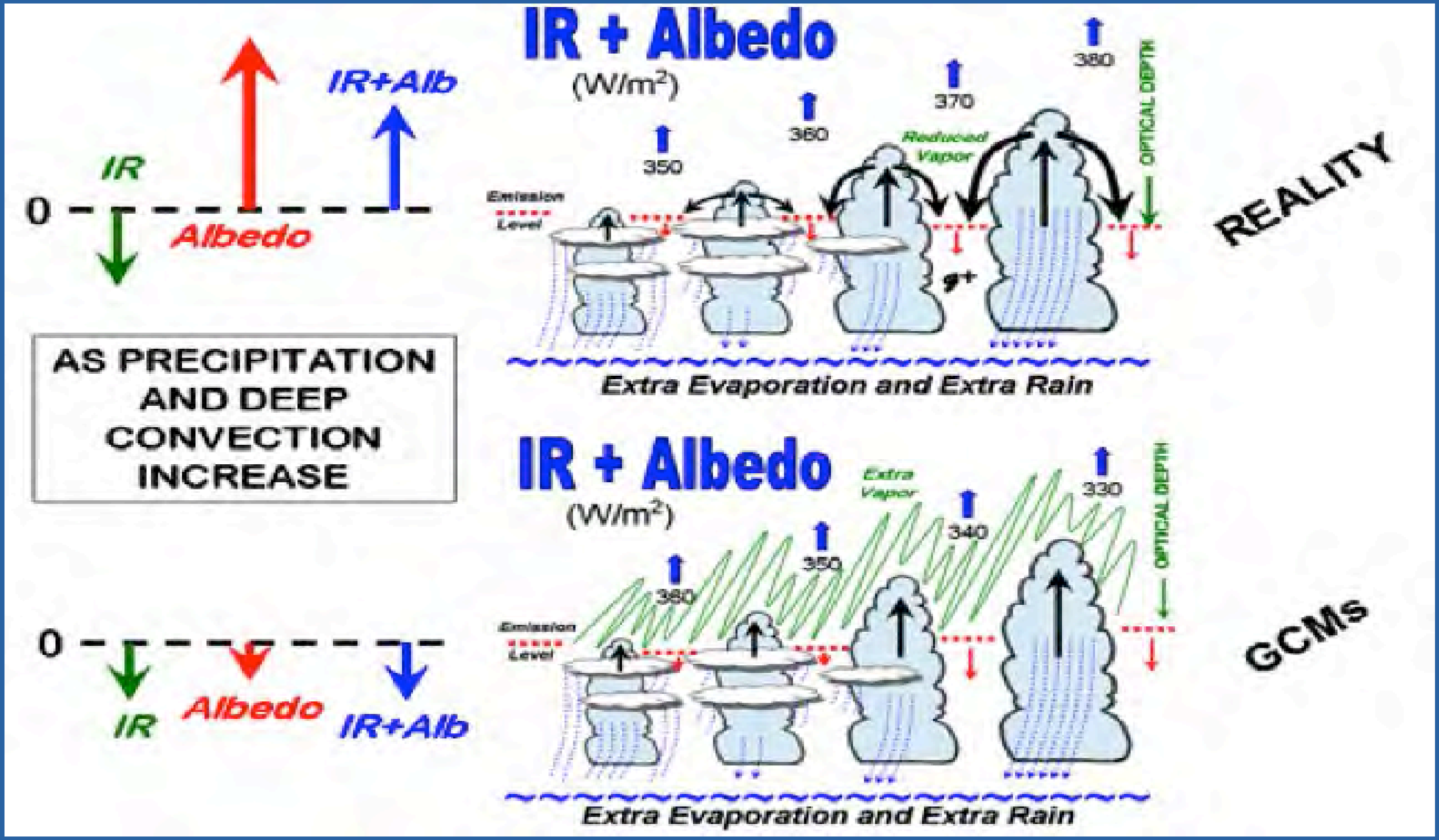
- magnitude of feedback by different processes according to GCMs (yellow circle)
- magnitude of feedback by different processes based on observations (red square)
- results of individual GCM runs (dash)

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



GCMs assume that doubling of the atmospheric CO_2 concentration from a pre-industrial level of 280 ppm will cause by outgoing IR blockage 1.1°C warming that is amplified by associated water-vapor related IR blockage, giving rise to a positive feedback of 2.1°C, resulting in a net temperature increase of 3.2°C.

Observations show, however, that the combined water vapor, clouds and Albedo feedback is with -0.8°C clearly negative and thus reduces the postulated net CO_2 warming effect to 0.3°C



Source of diagram: Gray & Schwartz, 2011

GCMs (Global Circulation Models): upper troposphere temperature und humidity increase, cloud-induced Albedo decreases, outgoing infra red radiation decreases -warming effect

REALITY (observations): upper troposphere temperatures and humidity decrease while cloud-induced Albedo and outgoing infra red (IR) radiation increase - cooling effect

Warming of the Lower Troposphere, associated with rising CO_2 levels, stimulates convection and Upper Troposphere cooling and IR emission to space

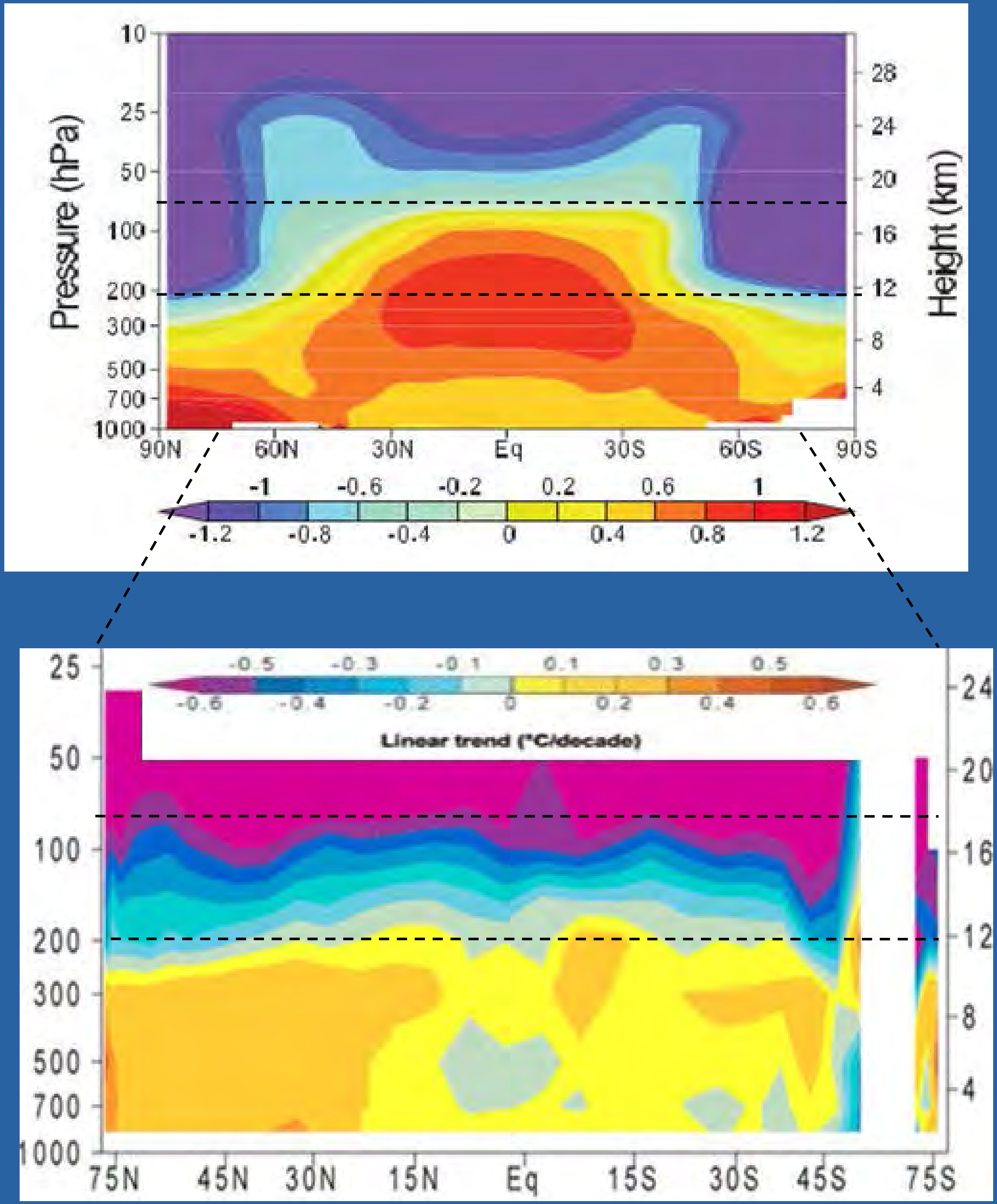
IPCC's missing equatorial Hot-Spot

Source of diagrams: D. Evans, 2010

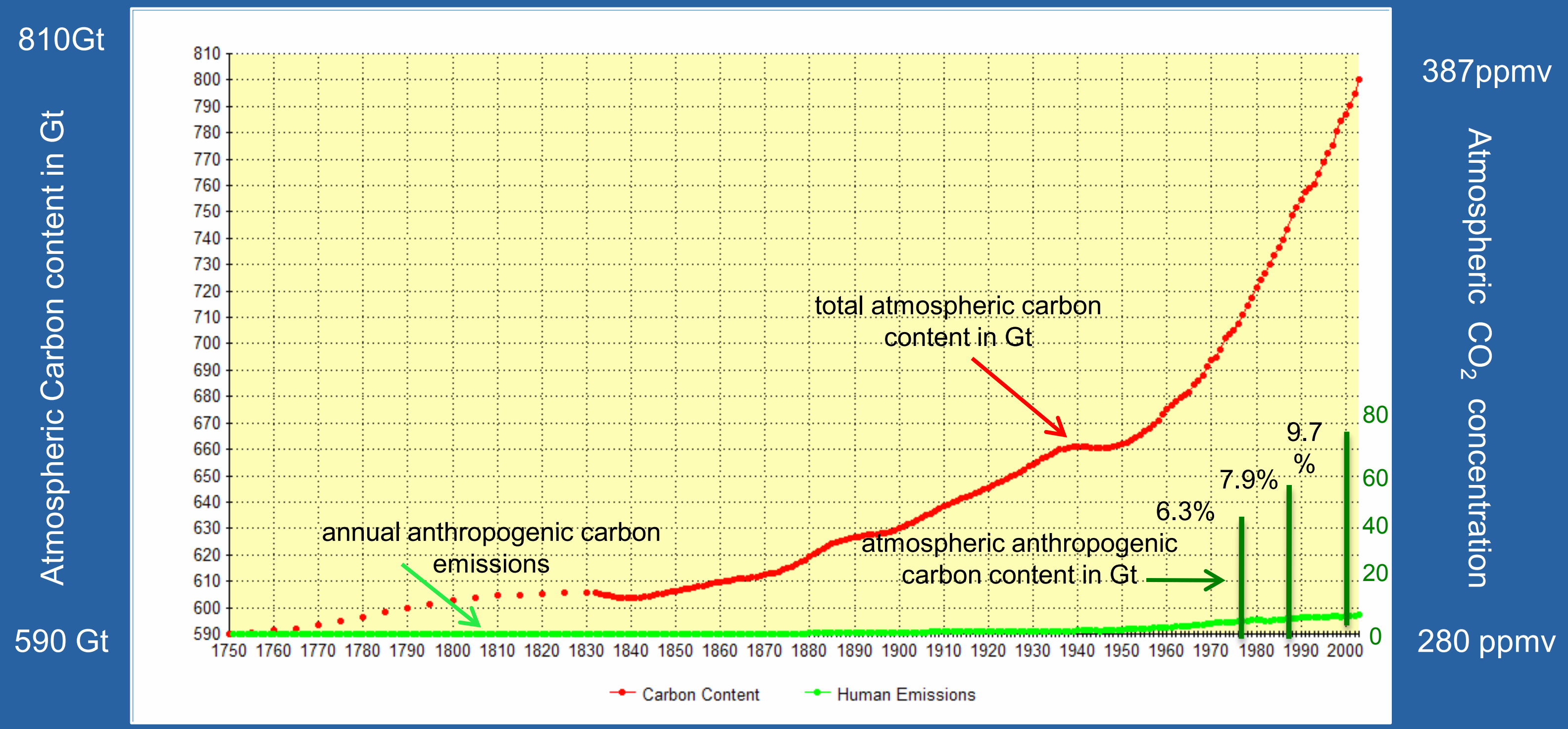
IPCC's Global Circulation Models (AR4 chapter 9, 2007) predict that warming causes in the upper troposphere of the tropics the development of a distinct pattern of enhanced warming - a "hot-spot" (see red blob in upper diagram)

The lower diagram shows the results of weather balloon radiosonde data. There is no evidence for such a "hot spot". If it were there, it would have been readily detected.

IPCC'sGCMs are based on unrealistic assumptions. The troposphere cannot store energy. Increasing atmospheric CO_2 concentrations cause only a very small temperature increase that hardly enhances the hydrologic cycle..



The atmosphere contains 0.0394% of CO_2 one tenth of which is attributed to anthropogenic emissions



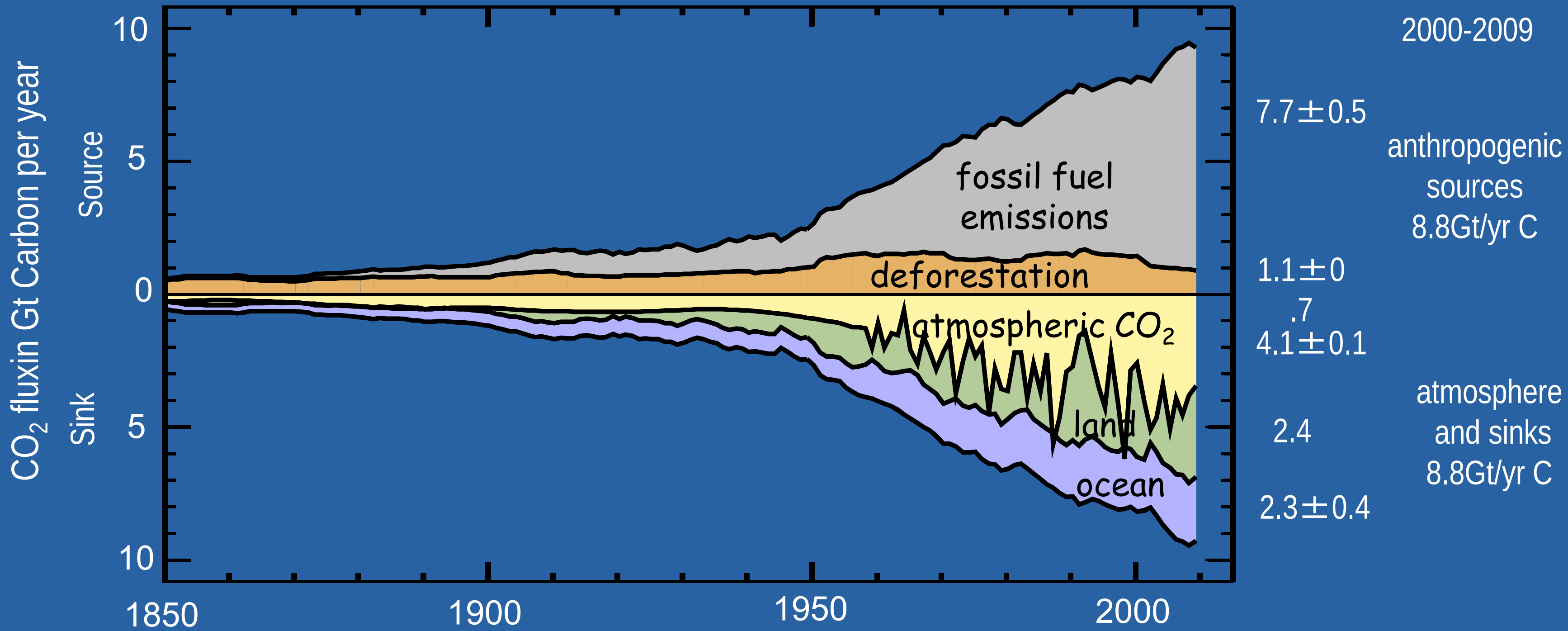
Source of diagram: modified after Siddons &D˙Aleo, 2007.
based on Carbon Dioxide Analysis Center http://cdiac.ornl.gov/trends/co2/contents.htm

Between 1750 and 2009 atmospheric CO_2 concentrations increased from 280 to 387 ppmv, reflecting a Carbon content increase of about 210 Gt (red curve), while anthropogenic emissions had increased by 2002 to 8.3 Gt Carbon/year (light green curve, 10 Gt steps).

The $\delta^{13}C$ record of atmospheric CO_2 suggests that the airborne fraction of anthropogenic CO_2 had increased by 2002 to 78 Gt or 9.7% (vertical dark green bars, 10 Gt steps).

Since 1750 atmospheric CO_2 concentrations increased by about 35.5% of this about ⅓ is attributed to anthropogenic emissions and ⅔ to natural sources

According to models 40-45% of the annual anthropogenic CO_2 emissions accumulate in the atmosphere and 55-60% are taken up by oceanic and terrestrial plant sinks



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

Despite rising emissions, the airborne fraction of anthropogenic CO_2 probably increased since 1850 by less than10% and not by 37% as postulated by models

The atmospheric residence time of CO_2 is about 5 year and not 100 years as IPCC claims

About 20% of the atmospheric CO_2, representing 165 Gt C, are annually exchanged with oceanic and terrestrial plant sinks while annual anthropogenic emissions amount to 8.8 Gt C

$\delta^{13}C$ of atmospheric CO_2

- Natural Carbon has the two stable isotopes ^{12}C and ^{13}C and the radiogenic isotope ^{14}C. It generally consists to 98.987% of ^{12}C and 1.103% of ^{13}C plus traces of ^{14}C.
- The ratio $^{13}C/^{12}C$ is expressed as $\delta^{13}C$ ‰ relative to the standard VPDB carbonate which has a $\delta^{13}C$ of +0.11‰. Positive values indicate ^{13}C enrichment, negative ones ^{13}C depletion.
- Carbon isotopes are kinetically fractionated during the photosynthesis of terrestrial and marine plants and by bacteria, all favoring ^{12}C. Their biomass is ^{13}C depleted and depending on type and species has a $\delta^{13}C$ ranging between -10‰ and -30‰.
- Decaying terrestrial biomass releases CO_2 with an average $\delta^{13}C$ of about -26‰ while CO_2 derived from the burning of fossil fuels has a $\delta^{13}C$ of about -29‰ (range -20‰ to over -70‰).
- Decaying phytoplankton and fecal pellets sinking to depth are converted by bacteria to inorganic carbon, thus increasing the carbon content of the deep ocean layers and decreasing their $\delta^{13}C$ (biological pump).
- Equilibrium fractionation of carbon isotopes during the exchange of CO_2 between the atmosphere and oceans (solubility pump) depends mainly on pCO_2 and temperature differences between the two media. It is more efficient at the ocean-air transition (-12.2‰) than at the air-ocean transition (-2.4‰).
- As $^{13}CO_2$ has a lower vapor pressure than $^{12}CO_2$ it is slightly preferentially absorbed by water droplets of clouds and rain, which upon evaporation preferentially release $^{12}CO_2$.Cloud droplets freezing and evaporating in the upper troposphere probably decrease its $\delta^{13}C$.
- Atmospheric CO_2 has a $\delta^{13}C$ ranging from -7.8‰ to -8.6‰, presently averaging to 8.2‰. CO_2 released by the oceans has a $\delta^{13}C$ between +1.5‰ and -7‰.

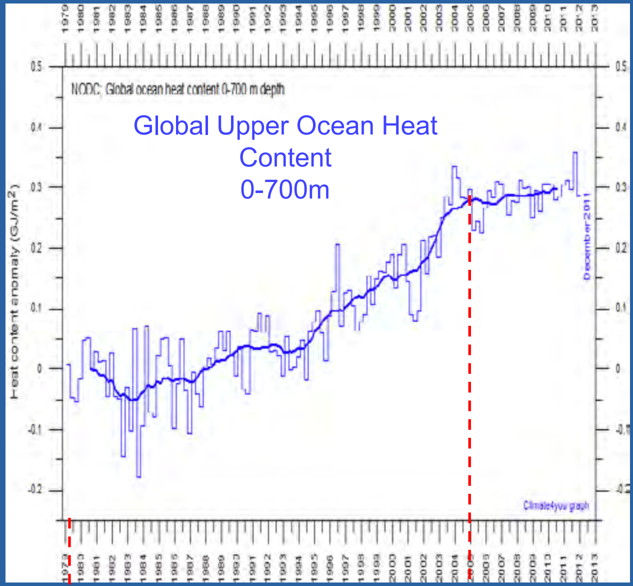
The Oceans, a giant CO_2 reservoir, contain about 39,000 Gt of dissolved C while atmospheric CO_2 represents 834 Gt C

source of diagrams: climate4you

CO_2 solubility in sea water is mainly pressure and temperature dependent; CO_2 isreleased upon decompression and/or warming

The CO_2 content oceanic surface layers is ± in temperature-dependent equilibrium with atmosphere CO_2 concentrations

Large volumes of Carbon are annually exchanged between the oceans and atmosphere. Carbon is also sequestered in sea floor sediments (coral reefs, pelagic limestones, organic shales)

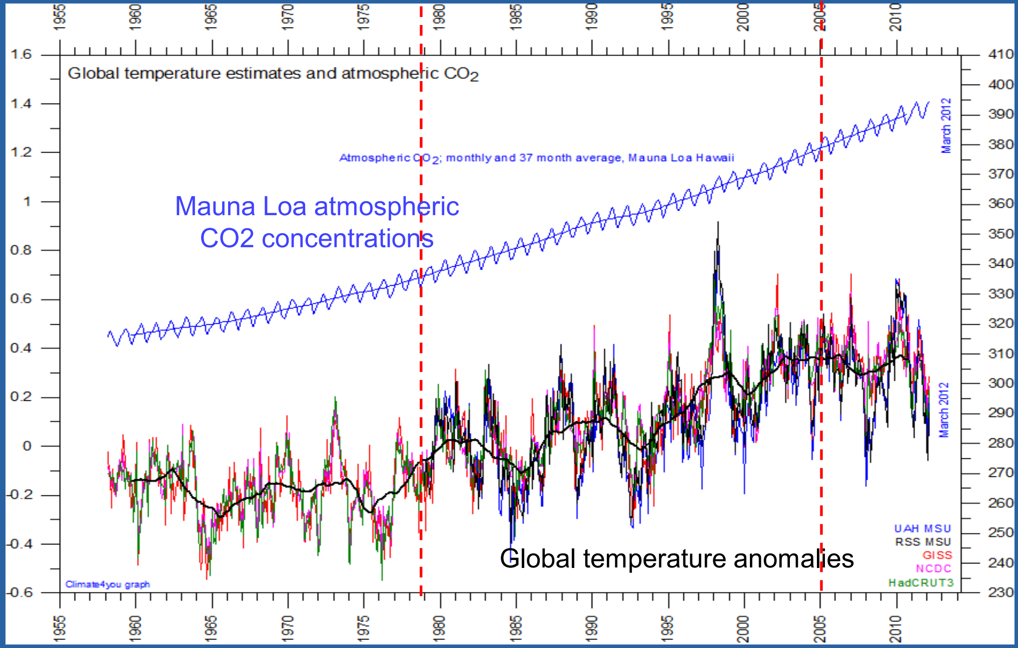


Solar SW radiation is absorbed in the upper 100 m of the oceans, warming them and causing their CO_2 out-gassing, and by warming of the lower troposphere enhanced evaporation and related cooling

IR radiation reflected back to Earth does not penetrate and warm the oceans but fosters evaporation and related cooling

The troposphere cannot warm the oceans

The North Atlantic Deep-Water current links the seas of the Arctic region, the main CO_2 sink, with the upwelling currents of the Southern Seas, the main CO_2 source



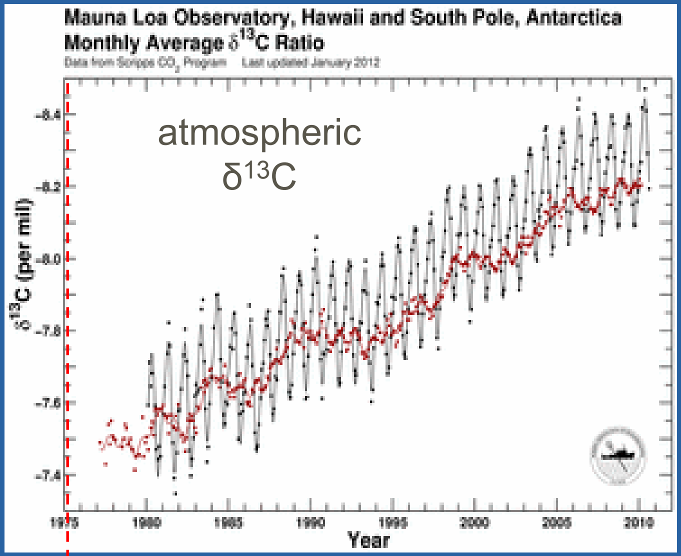
Natural CO_2 and δ^{13}C variations

Source of diagram: Scripps CO_2 Program, January 2012
black curves: Mauna Loa, red curves: South Pole

Variations in atmospheric CO_2 concentrations and δ^{13}C correlate closely and reflect temperature differences betweenoceanic and terrestrialCO_2 sources and sinks

ENSO- and PDO-type oscillations of ocean currents and sea surface pressure/temperature modulate at inter-annual and multi-decadal scales out-gassing of the Southern Ocean CO_2 source

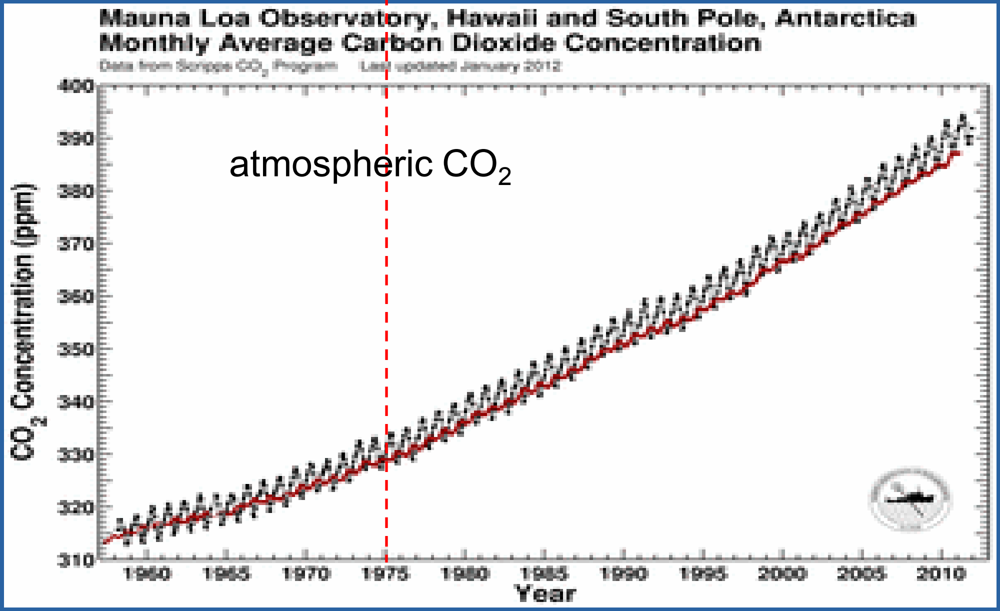
inverted scale

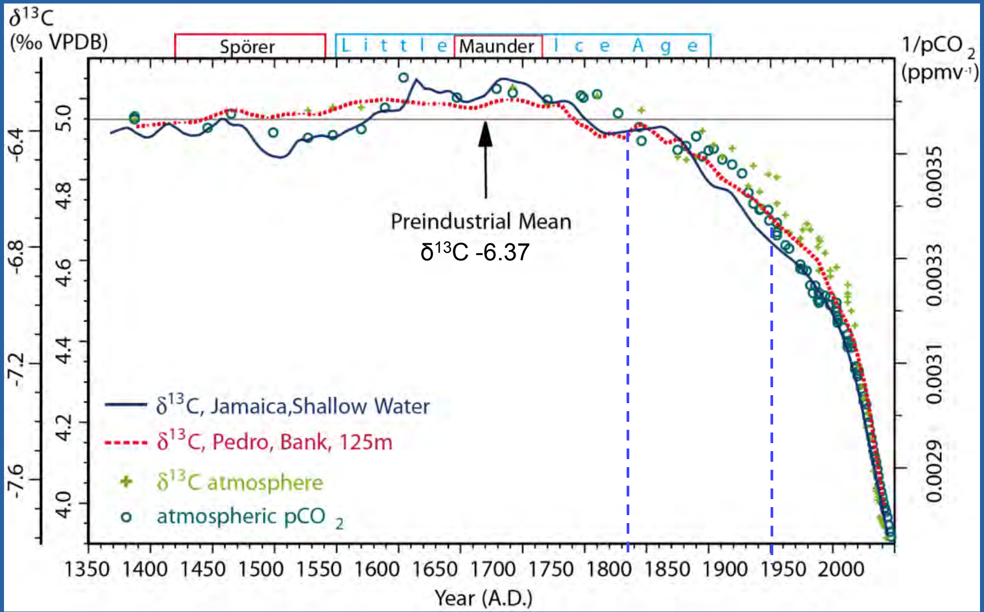


The efficiency of the northern oceanic CO_2 sinks is modulated at seasonal and multi-decadal scales by sea-ice cover and the temperature of sea water

The pronounced seasonal variations in atmospheric CO_2 concentration of the Northern Hemisphere apparently involve only the ^{13}C depleted fraction

Variations in solar irradiance control ocean temperatures, ocean circulation patterns and long-term variations in atmospheric CO_2 content and δ^{13}C





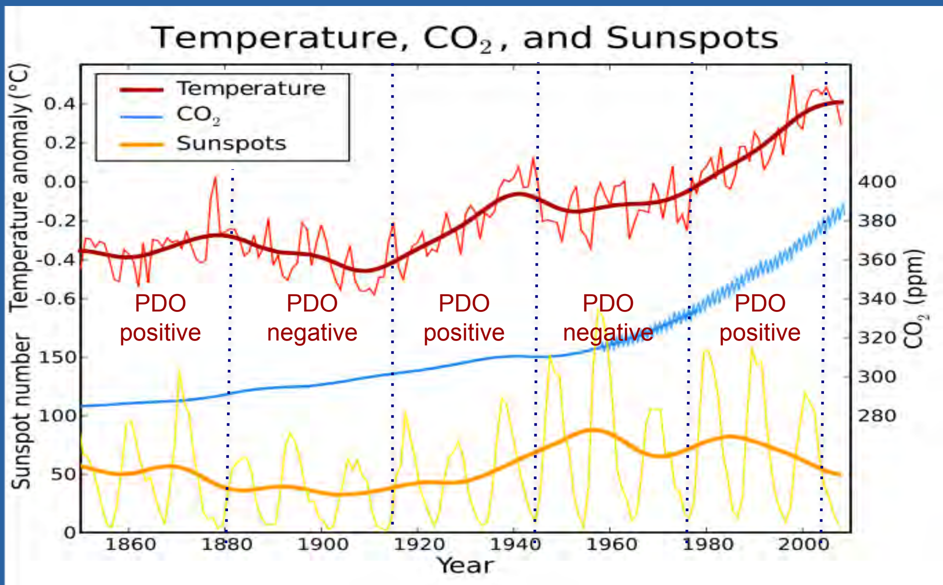
Atmospheric δ^{13}C is dominated by naturally depleted CO_2

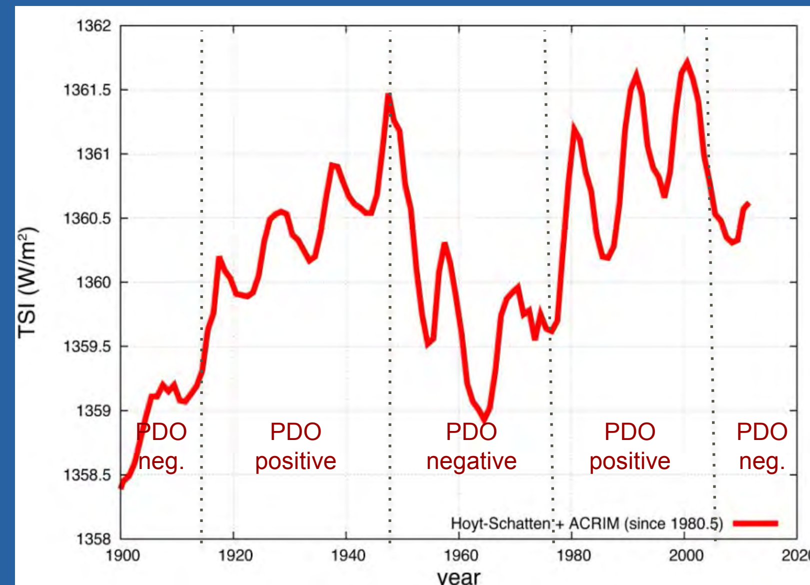
Source of diagram: Böhm et al., 2002

Since the Maunder Minimum atmospheric CO_2 concentrations increased from 280 to 390 ppm while δ^{13}C declined from -6.3 to -8.20, accelerating with the beginning of fossil fuel consumption in the 1830s and in response to the rapid increase in fossil fuel consumption in the 1950s. Does δ^{13}C clearly reflect the anthropogenic emissions?

- Atmospheric δ^{13}C decreased with increasing temperatures, evaporation and atmospheric CO_2 concentration that stimulated the efficiency of the atmosphere-ocean gas exchange, the terrestrial and marine biosphere and the release of CO_2 from stored terrestrial biomass.
- Inter-hemispheric atmospheric CO_2 concentration and δ^{13}C gradients are too small to result from anthropogenic emissions and thus speak for very efficient CO_2 sources in the tropical Southern Oceans and for equally efficient circum-Arctic oceanic and biogenic CO_2 sinks.
- The δ^{13}C of atmospheric CO_2 gives a measure of the airborne fraction of ^{13}C depleted CO_2 that originates from large natural sources as well as from anthropogenic emissions.
- δ^{13}C-based and mass balance calculations suggest that about 30% of the current atmospheric CO_2 are isotopically depleted with more than ⅔ originating from natural marine and biogenic sources and less than ⅓ from anthropogenic emissions.

Global Warming and the Pacific Decadal - Atlantic Multidecadal Oscillations (PDO-AMO)





Source of diagrams: Left: modified after Wikipedia Solar Variation Right: modified after Scafetta, 2013

Since 1850 global surface temperatures increased cyclically by about 0.8^{0}C with positive PDO phases corresponding to warming periods and negative ones to periods of cooling.

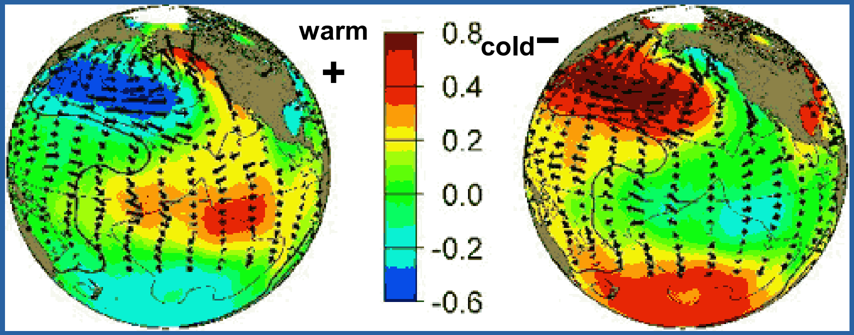
Solar activity increased cyclically until the mid-1990s. The Sunspot number correlates poorly with TSI, which was distinctly lower during negative PDO phases than during positive ones.

Steadily increasing atmospheric CO_2 concentrations reflect progressive out-gassing of the slowly warming oceans but do not reflect the PDO-related cooling phases.

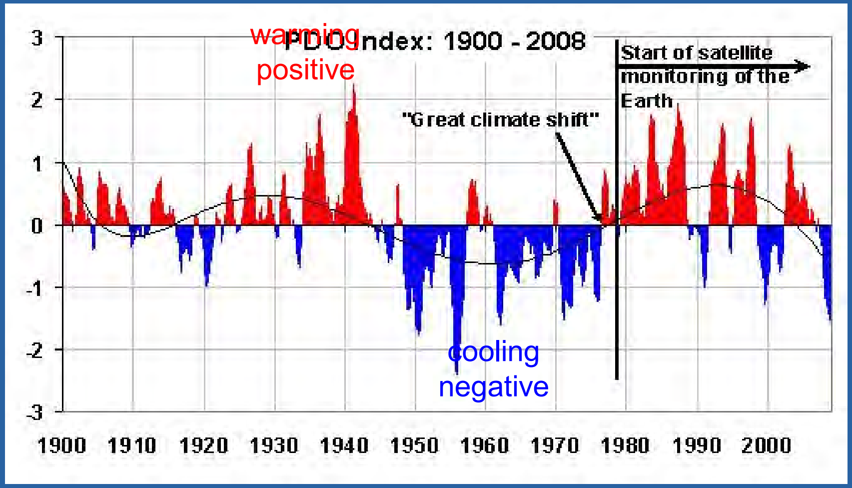
The 20th Century warming trend can be attributed to a centennial-scale increase in TSI causing slow warming and degassing of the oceans rather than to an increase in atmospheric CO_2 concentration.

Variations in solar activity dominate climate change. Variations in GHG concentration and composition (water vapor, CO_2) play a secondary role.

Pacific Decadal Oscillation



Source of diagram: http://jisao.washington.edu/pdo/



Source of diagram: Spencer (2012)

The driving mechanism of the PDO is probably of an astronomical-physical nature, involving interaction of planetary tidal forces with the Sun that affect its activity and motion, the Earth's rotation rate and, via Solar and Lunar tidal forces, the ocean current system.

Particularly in the North Pacific two different oceanic and atmospheric circulation patterns alternate with each other every 20-30 yrs with a cyclicity of about 60 yrs, controlling changes in areas of warm and cold surface waters.

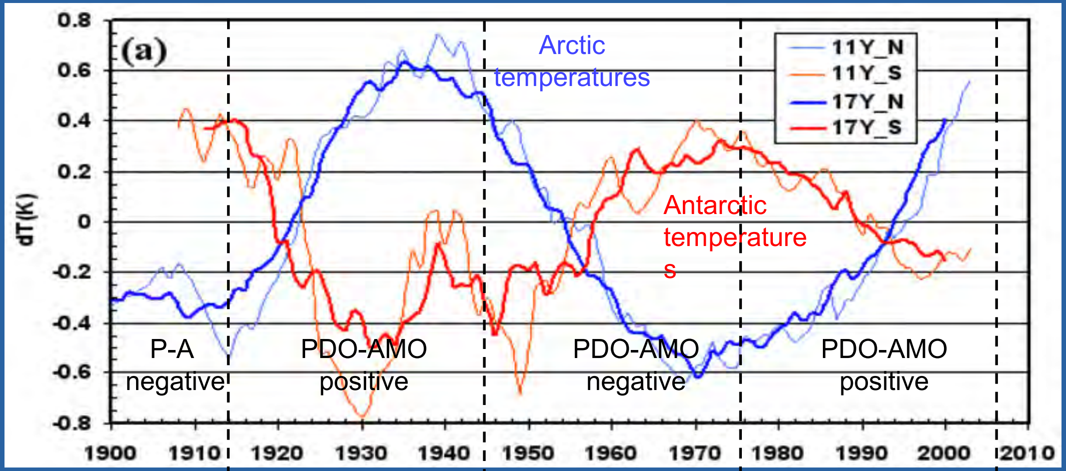
A clear relationship between the PDO and surface temperature indicates that during positive PDO phases the secular warming trend is enhanced by increased TSI while during negative PDO phases it is dampened up to a net cooling by decreased TSI.

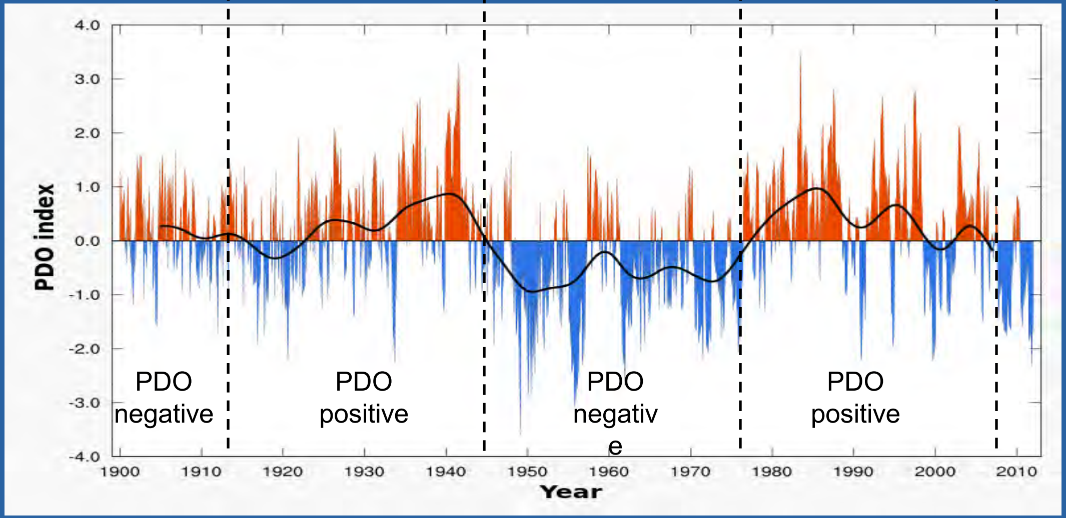
Modeling and satellite data show that the cloud cover of oceans decreases slightly during positive PDO phases but increases slightly during negative PDO phases. This affects the Earth's Albedo and by radiative forcing the climate (Spencer, 2008).

The PDO entered recently a new negative phase and thus contributes to the present decline of the average surface temperatures.

GCM neglect the PDO

The seesaw pattern of Arctic and Antarctic temperatures





Source of diagrams: top Chylek et al., 2010
bottom: http://en.wikipedia.org/wiki/File:PDO.svg

De-trended temperature series of the last 100 years document the anti-correlation of Arctic and Antarctic temperatures and the correlation of their phase changes with those of the PDO-AMO.

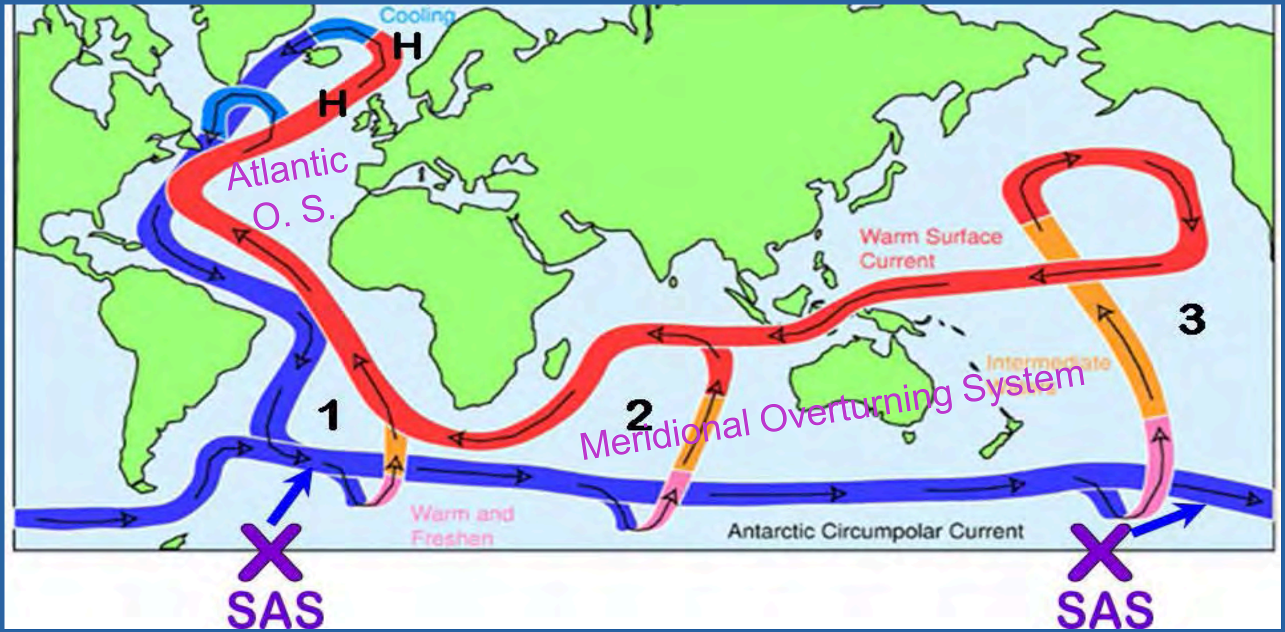
During the last century the Arctic warmed by 2^{0}C and the Antarctic by 1^{0}C, presumably in response to increasing solar activity rather than due to increasing atmospheric CO_2 concentrations.

Arctic and Antarctic temperature variations reflect oscillations of TSI and the global thermohaline ocean circulation system.

During positive PDO-AMO phases the Atlantic overturning system is more vigorous, warms W-Europe and the Arctic by exporting more heat from the Meridional overturning system, thus cooling the Antarctic.

During negative PDO-AMO phases the Atlantic overturning system is less vigorous, exports less heat from the Meridional over-turning system, thus warming the Antarctic and cooling W-Europe and the Arctic

Global Thermohaline Ocean Circulation (THC) and Climate



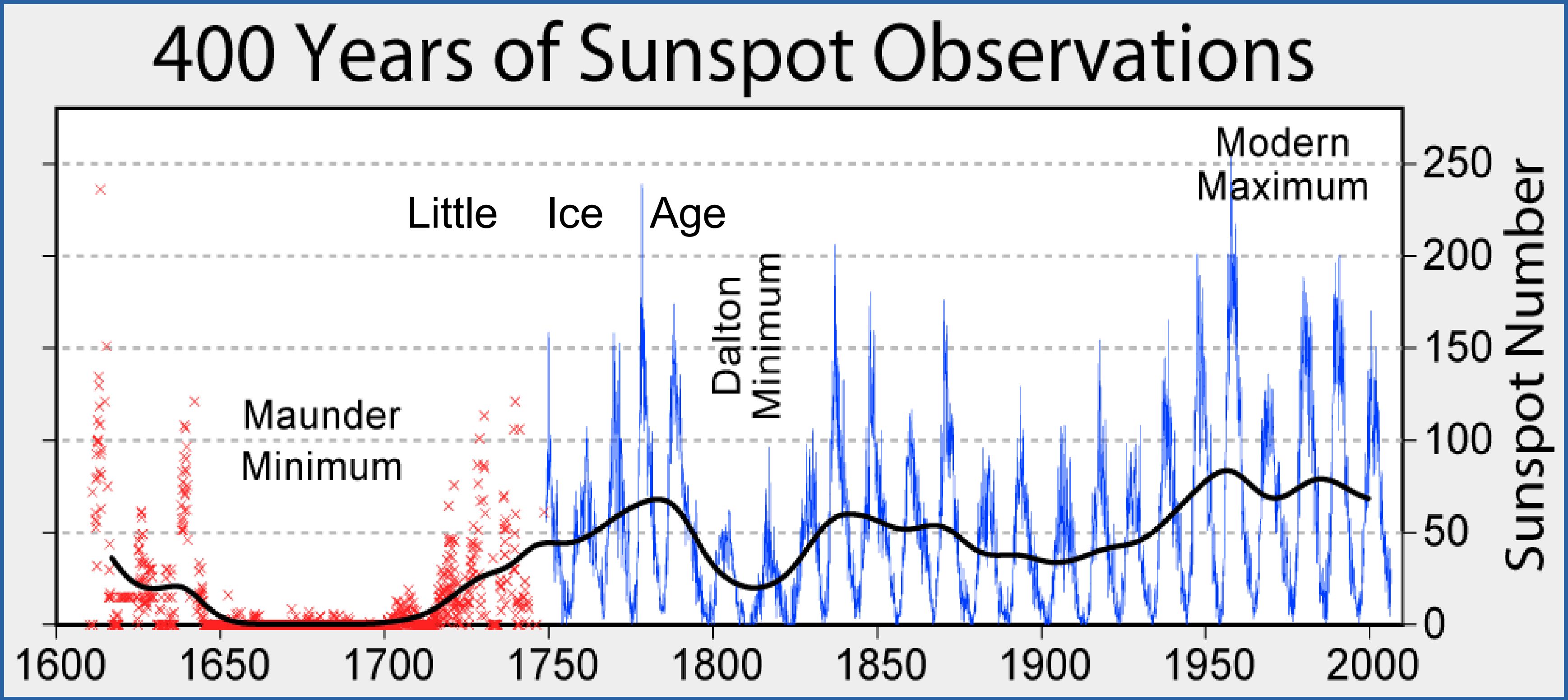
Source of diagram: Gray (2012), modified after Marshall & Plume (2008)
blue: deep, cold, high-salinity currents; red: shallow, warm, variable salinity currents
H: sinking cooled higher-salinity waters; SAS: sinking Antarctic cold waters

The oceans with their immense heat storage capacity dampen the climatic effects of changes in solar irradiance. The THC distributes heat from low to high latitudes.

The pattern of the THC is controlled by the distribution of the continents and oceans that changes at time scales of 10^6 yrs and by changes in solar irradiance due to orbital forcing (time scale 10^{4-5} yrs) and variations in solar activity (time scale 11 to 8000 yrs).

During periods of increased solar irradiance and warming, the Gulf Stream extends further northward, enhancing warming of the North Atlantic and Arctic seas.

With a periodicity of ± 30 yr the PDO-AMO overprints the modern secular warming.

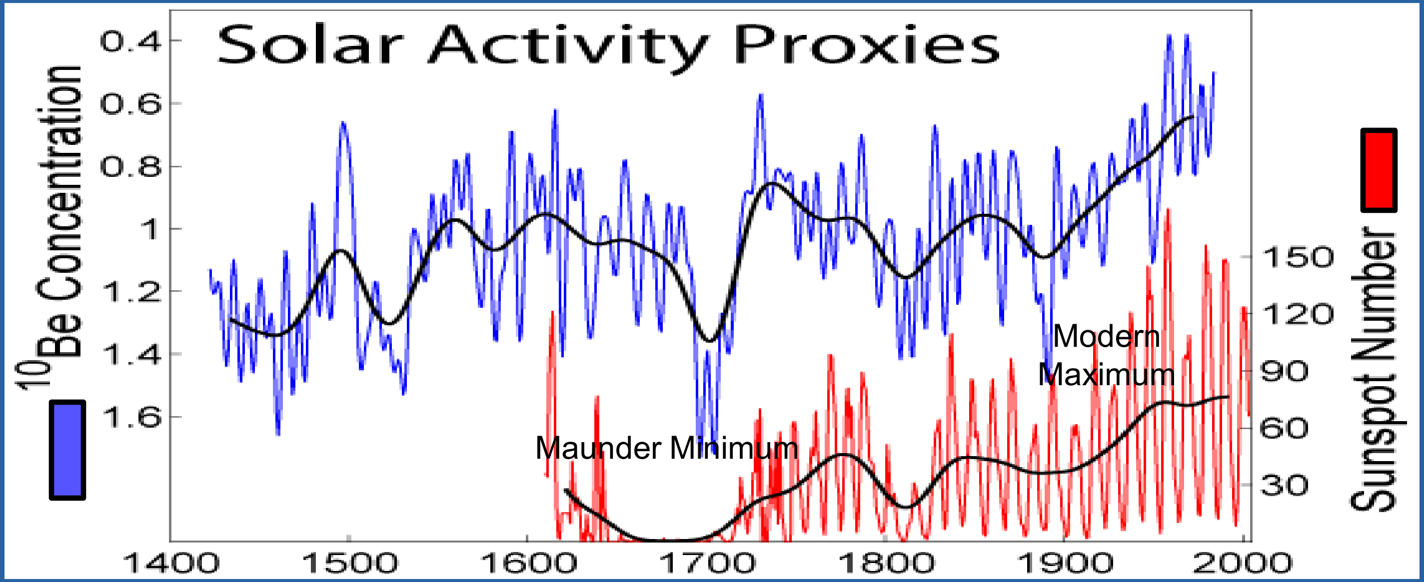


Source of diagram: Wikipedia File Sunspot Numbers.png, based on NOAA and Royal Observatory of Belgium, compiled by Hoyt &Schatten, 1999

Important variations in solar activity are documented for the last 400 years by the observed sunspot numbers and their eleven-year mean of the monthly average (heavy black line).

Low solar activity characterized the Maunder and less severe Dalton Minimum of the Little Ice Age. Solar activity peaked during the progressively warming Modern Maximum that started in 1924 and ended in 2008. The new epoch will be characterized by less intense solar activity and may even commence with a cool Dalton-type Minimum.

Proxies for past solar activity are provided by cosmogenic ^{10}Be (half-life ±1.36 Mio. yr) and ^{14}C (half-life ±5'730 yr)



Source of diagram: Wikipedia File Solar Activity Proxies.png
^{10}Be concentration: Beer et al. (1994). Sunspot frequency: Hoyt &Schatten (1999)

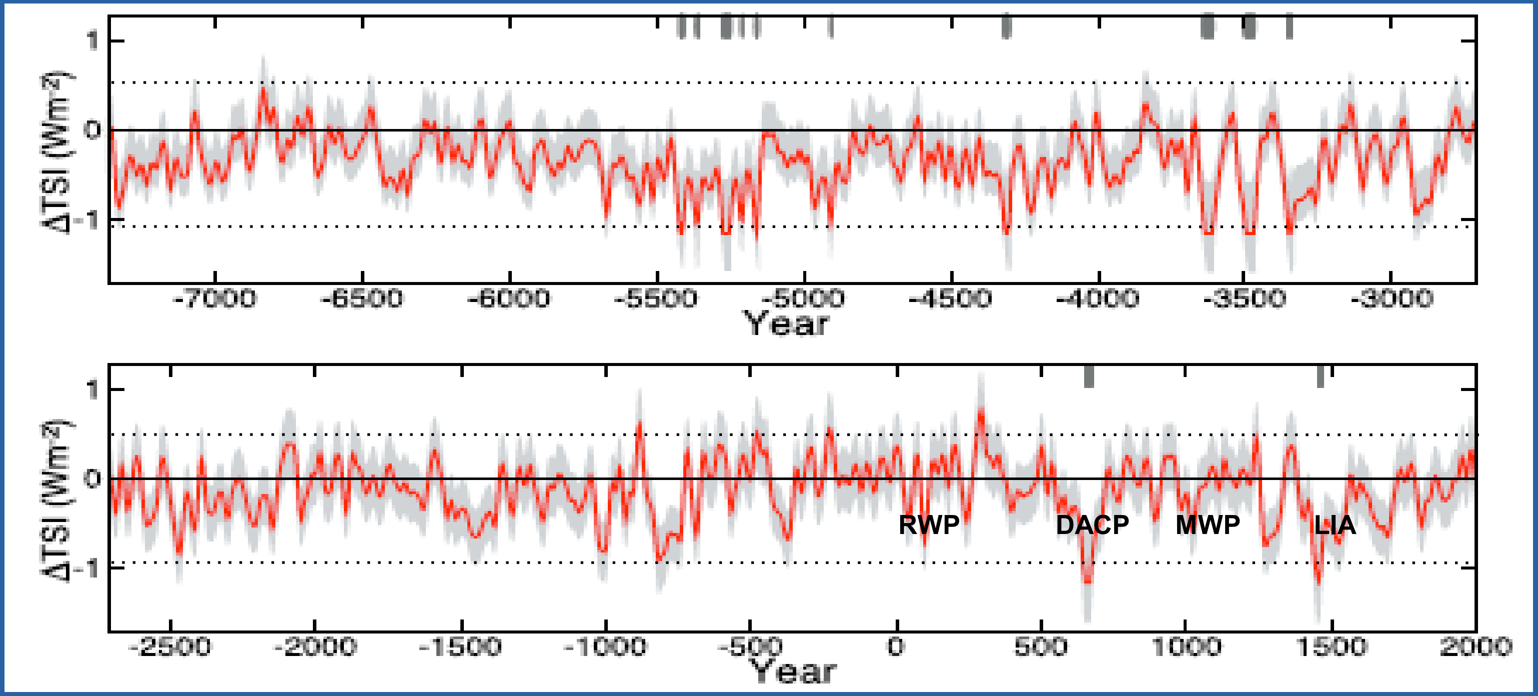
Cosmogenic ^{10}Be and ^{14}C are produced in the atmosphere by cosmic ray spallation of Oxygen and Nitrogen. ^{10}Be is stored in polar ice and deep sea sediments, ^{14}C in organic remains. The concentration of ^{10}Be and ^{14}C gives a measure of the cosmic ray flux

The magnetic field of the heliosphere and the solar wind, which together with the geomagnetic filed shield the Earth from galactic cosmic rays, vary with time and are lowest during periods of reduced solar activity (few sunspots).

Therefore, the flux of galactic cosmic rays reaching the Earth is lowest during periods of high solar activity and highest during periods of low solar activity.

Production of ^{10}Be and ^{14}C is inversely proportional to solar activity.

The ^{10}Be record of ice cores documents strong variations in solar activity during the last 10,000 years

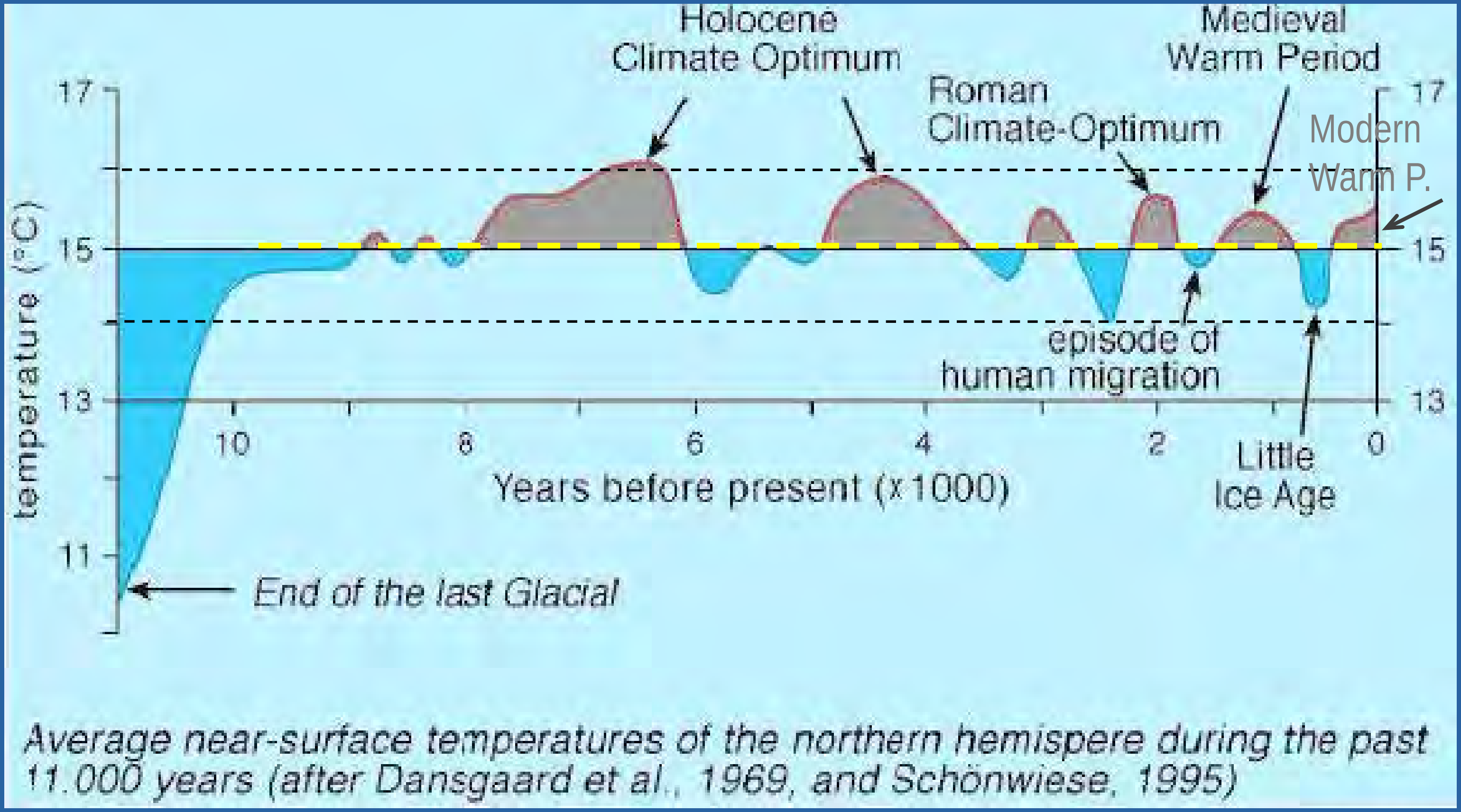


Source of diagram: Steinhilber et al.,2009

During the Holocene solar activity varied continuously with Grand Minima occurring repeatedly (see black ticks on upper margins of graph), involving TSI variations of at least 1.5 Wm^{-2} and possibly up to 6.8 Wm^{-2}, and related changes in the galactic cosmic ray flux

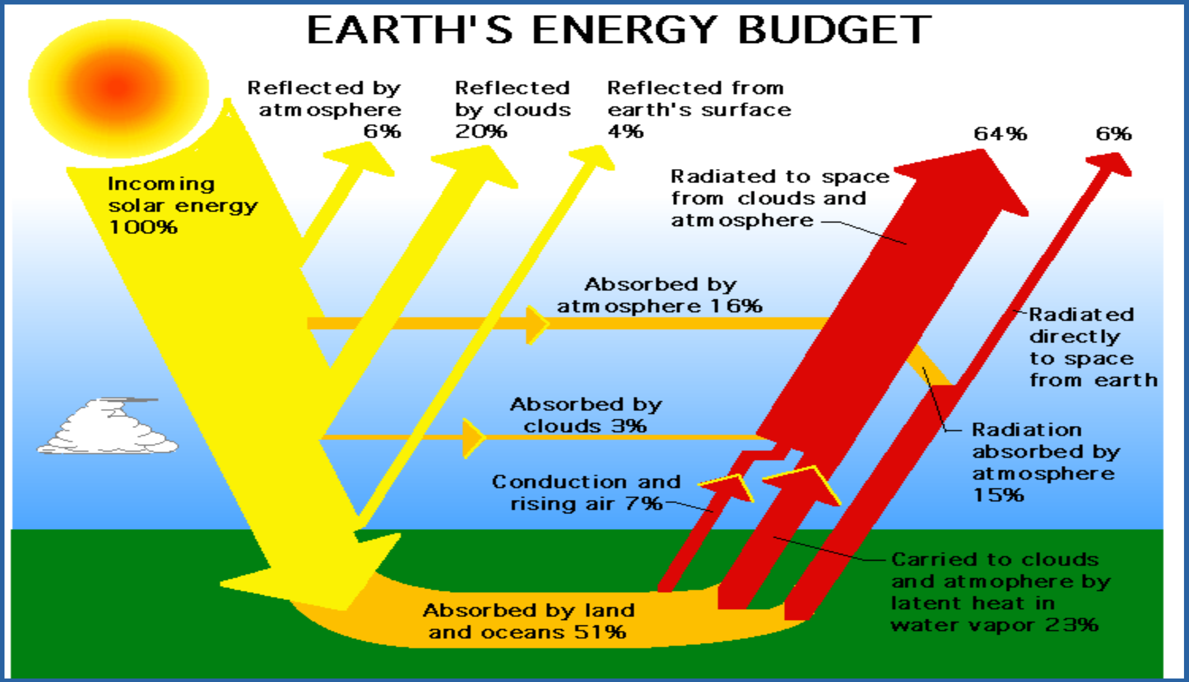
Variations in solar activity, combined with orbital forcing and volcanism, were the main forcing mechanisms of Holocene climate changes

Holocene climate changes based on Solar and Temperature Proxies



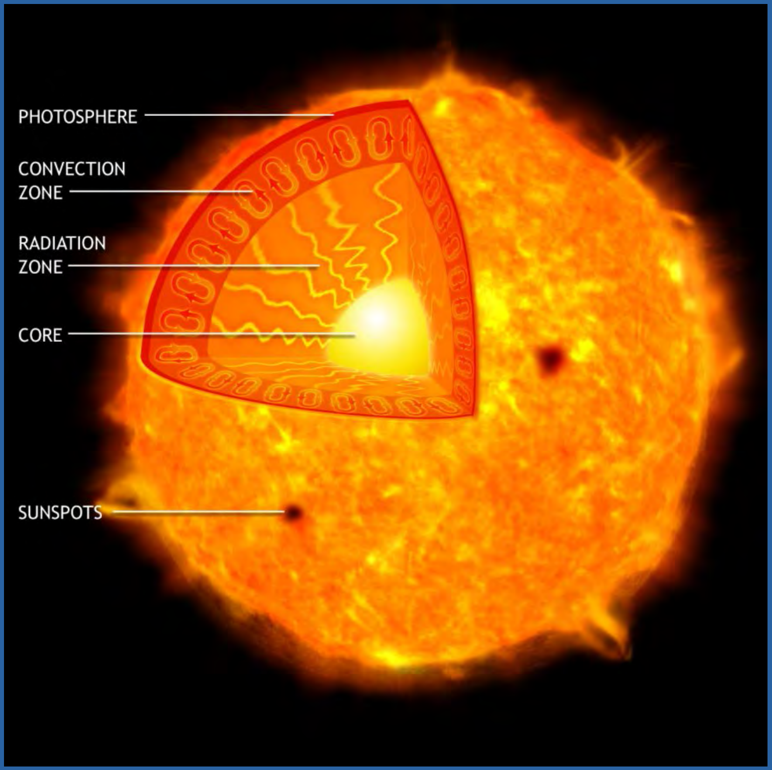
After we had come out of the last glaciation 11,000 years ago with a temperature rise of about 4.5^{0}C the climate of the Northern Hemisphere was never stable. Temperatures slowly declined by 1.14^{0}C and fluctuated up and down by about 1^{0}C around an average of about 15^{0}C

The Modern Warm Period is not an anomaly but one in a sequence reflecting astronomically-controlled solar oscillations



Source of diagram: http://science-edu.larc.nasa.gov/EDDOCS/images/Erb/components2.gif

- Variations in Total Solar Irradiance (TSI) involve changes in the power of SW radiation that is absorbed by the Earth and of the LW radiation that it emits back to space.
- The Earth's energy budget is generally in an unbalanced state, oscillates around a shifting equilibrium, and absorbs and emits variable amounts of energy.
- The inertia of the oceans, representing an immense thermal reservoir, accounts for a delay between long-term changes in incoming SW radiation and long-term changes in outgoing LW radiation.
- Whether the Planet gets colder or warmer depends on the balance between incoming SW and outgoing LW radiation. The troposphere cannot heat the oceans.



Source of diagram: Sharp, 2012

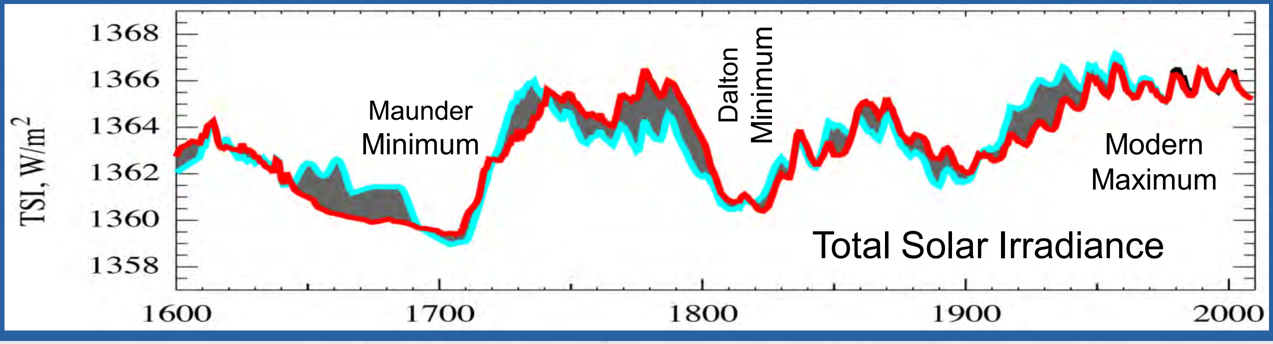
Solar activity is the primary driver of the Earth's climate

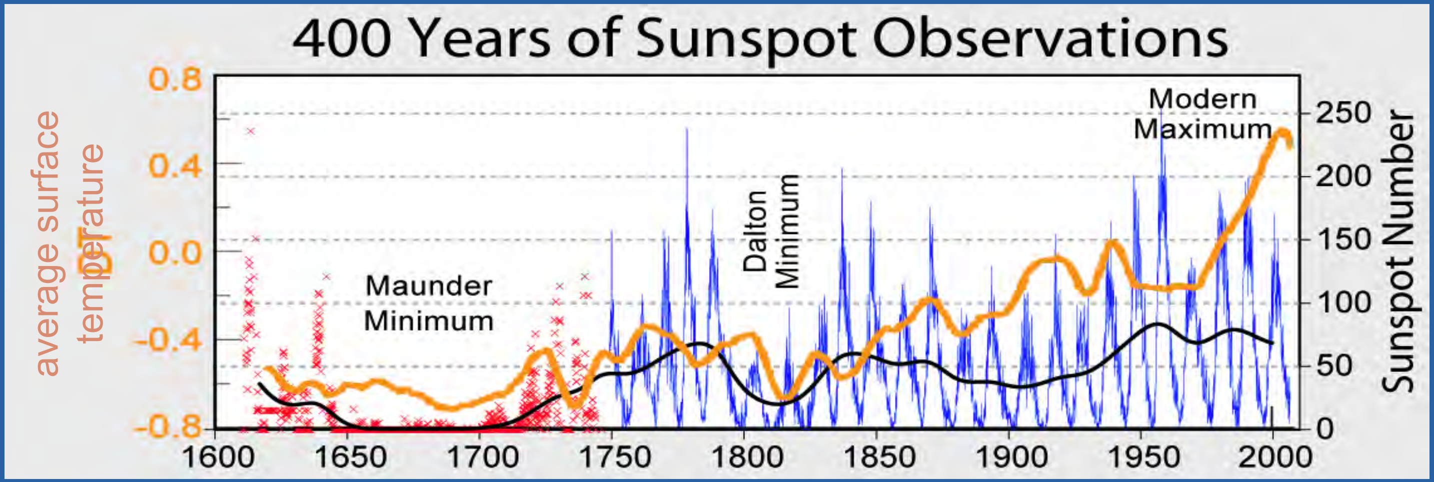
Empirical relationships demonstrate that variations in solar activity, involving a wide range of parameters, are governed at all time scales by tidal forces exerted by the solar planets on the nuclear active core of the Sun, which greatly amplifies the small tidal energy that is dissipated within it.

Direct Solar Climate Forcing is caused by changes in solar activity resulting in variations of the Total Solar Irradiance (TSI) and the Solar Spectral Irradiance (SSI). These underlie changes in the Earth's energy budget. TSI and the sunspot number do not correlate fully.

Indirect Solar Climate Forcing results from changes in solar activity or from solar tidal forces

- Variations in Solar UV radiation affect via stratospheric ozone production the temperature of the Stratosphere and thus its interaction with the Troposphere and tropospheric dynamics.
- Solar activity-related changes in the Open Solar Magnetic flux affect the Galactic Cosmic Ray flux, which influences the Earth's energy budget via global cloud cover and Albedo changes.
- Planetary tidal forces inducing abrupt motions of the Sun around the solar system barycenter affect the Earth's rotation rate, causing PDO-AMO-related changes in ocean current systems.





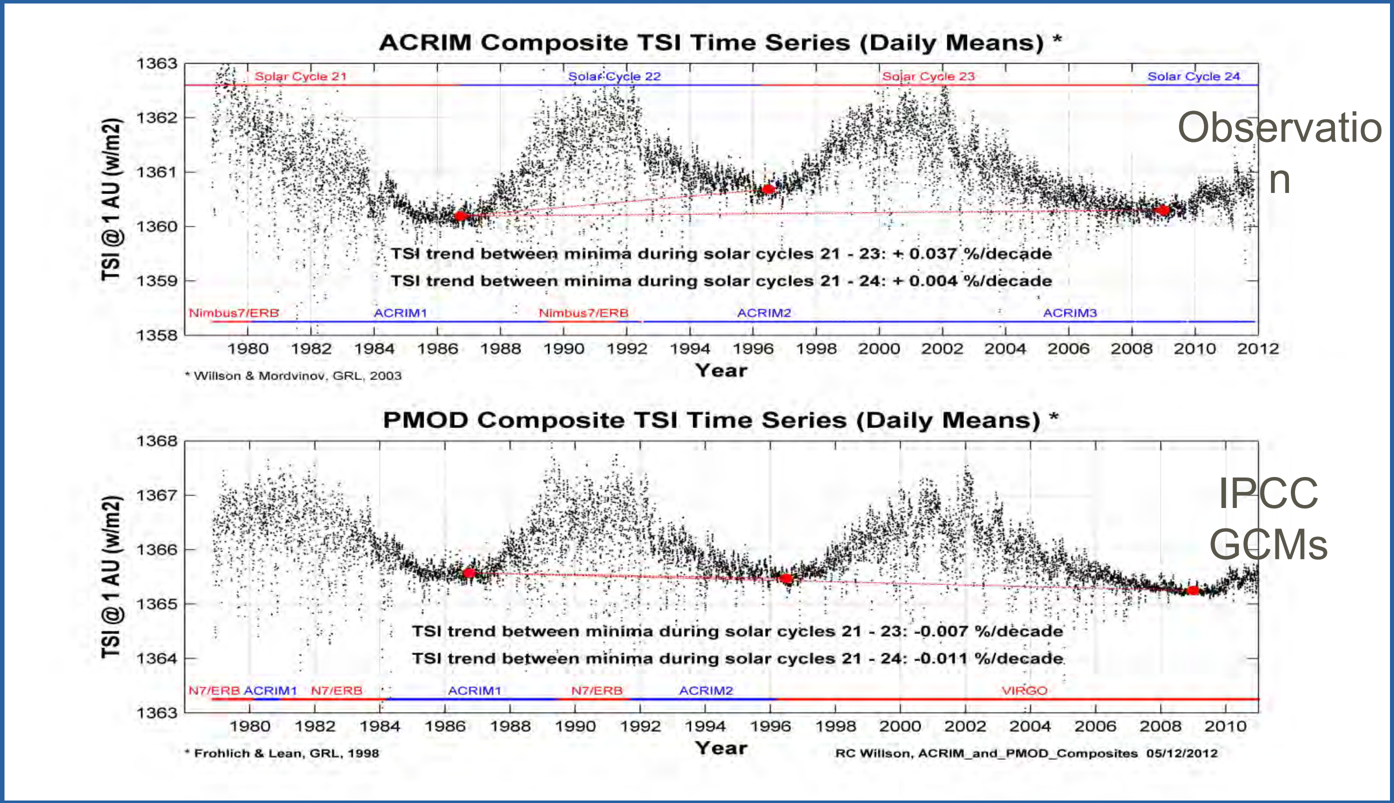
Source of diagrams: top: Shapiro et al., 2011; bottom: modified after Hoyt &Schatten, 1999 and de Jager et al., 2010

At centennial time-scales historical data document a clear correlation between solar activity and temperature (e.g. cold Maunder and Dalton Minima, warm Modern Grand Maximum)

Of the observed post-Maunder warming of about 1.2^{0}C only 40% can be attributed to direct solar forcing in response to cyclically increasing TSI.

Direct solar climate forcing is amplified by indirect solar forcing and feedback mechanisms, such as variations in solar UV radiation (ozone production and stratospheric temperature), the Galactic Cosmic Ray flux (cloud cover and Albedo) and soli-lunar tidal forces (PDO).

Direct solar forcing: 34 years of satellite TSI measurements



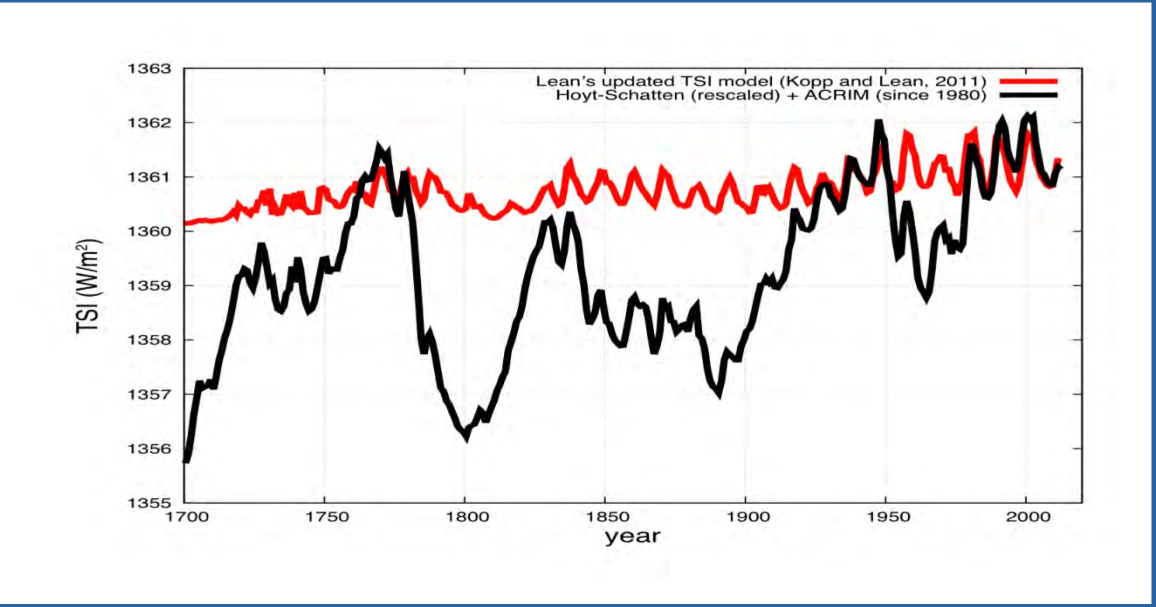
Source of diagram: Scafetta, 2013

The ACRIM composite is purely based on observed data and shows that TSI increased between 1987 and 1996 and decreased thereafter, akin to the global surface temperatures.

PMOD arbitrarily modified the observed data such that their composite conforms to the solar regression models of Lean, which shows a steady TSI decline since 1986.

GCMs used by the IPCC are based on the PMOD composite. As their solar forcing function is flawed they underestimate direct solar forcing.

Total Solar Irradiation reconstructions for the last 300 years



Source of diagram: Scafetta, 2013

Estimates of TSI fluctuations since the Maunder Minimum (1650-1700) are based on proxies, are still uncertain, both in amplitude and temporal pattern for lack of calibration with real data. Reconstructions vary considerably, depending on the proxies used.

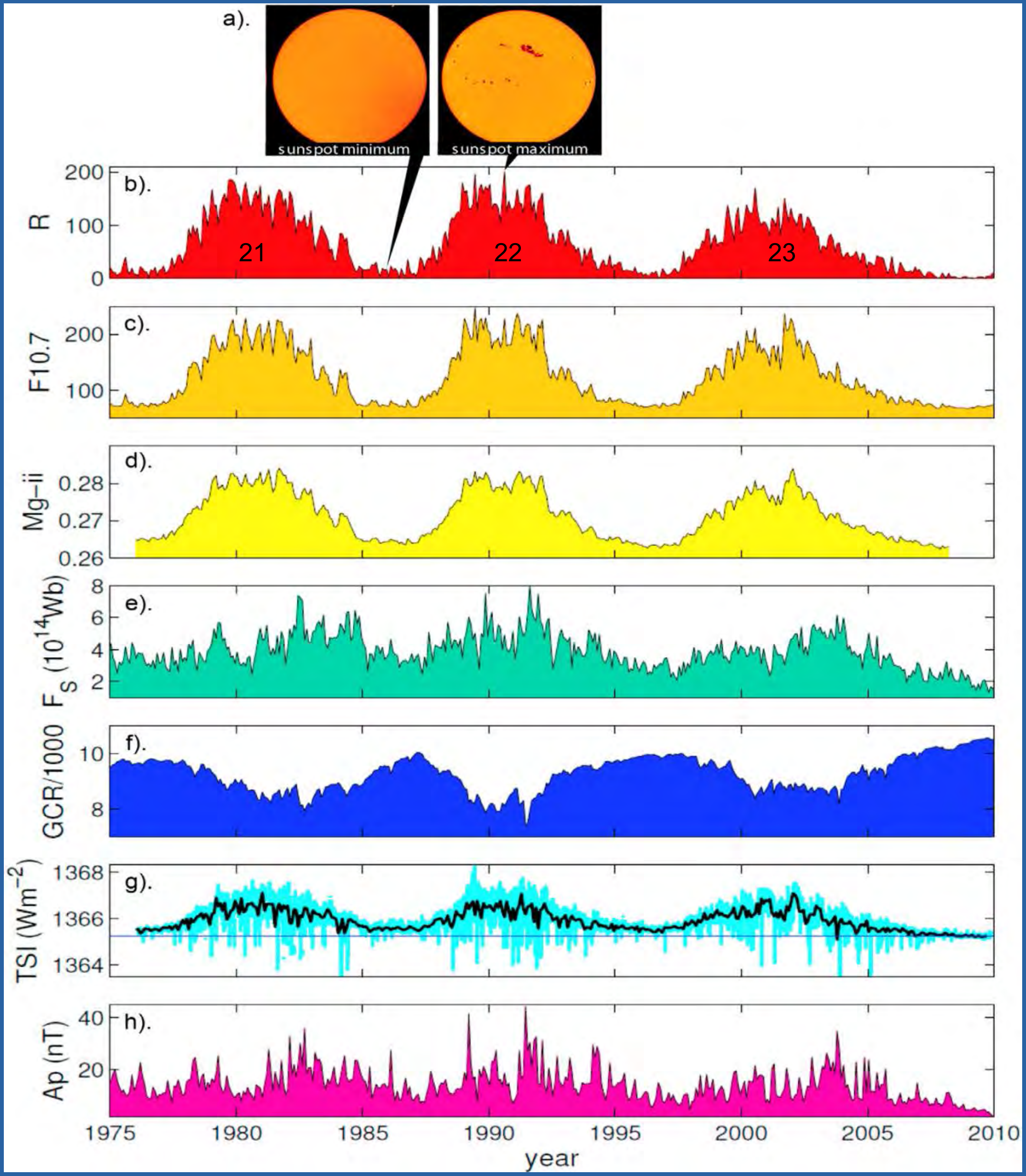
The Hoyt &Schatten + ACRIM reconstruction shows strong TSI variations and a total TSI increase of 6 Wm^{-2}, similar as the observed surface temperature record.

The Lean + PMOD reconstruction shows small TSI fluctuations and a total TSI increase of only 1.25Wm^{-2} that hardly reflect the observed surface temperature record.

IPCC adopted the Lean + PMOD reconstruction in support of its AGW concept

During and between Solar Cycles not only the sunspot number and TSI vary

Source of diagram: Gray et al., 2010



SUN

SUNSPOT NUMBER AMPLITUDE
and length of Schwabe Solar Cycles
(varies between 9 and 14 years)

SOLAR RADIO EMISSION FLUX

SOLAR UV IRRADIANCE
varies by up to 6% during Solar Cycles

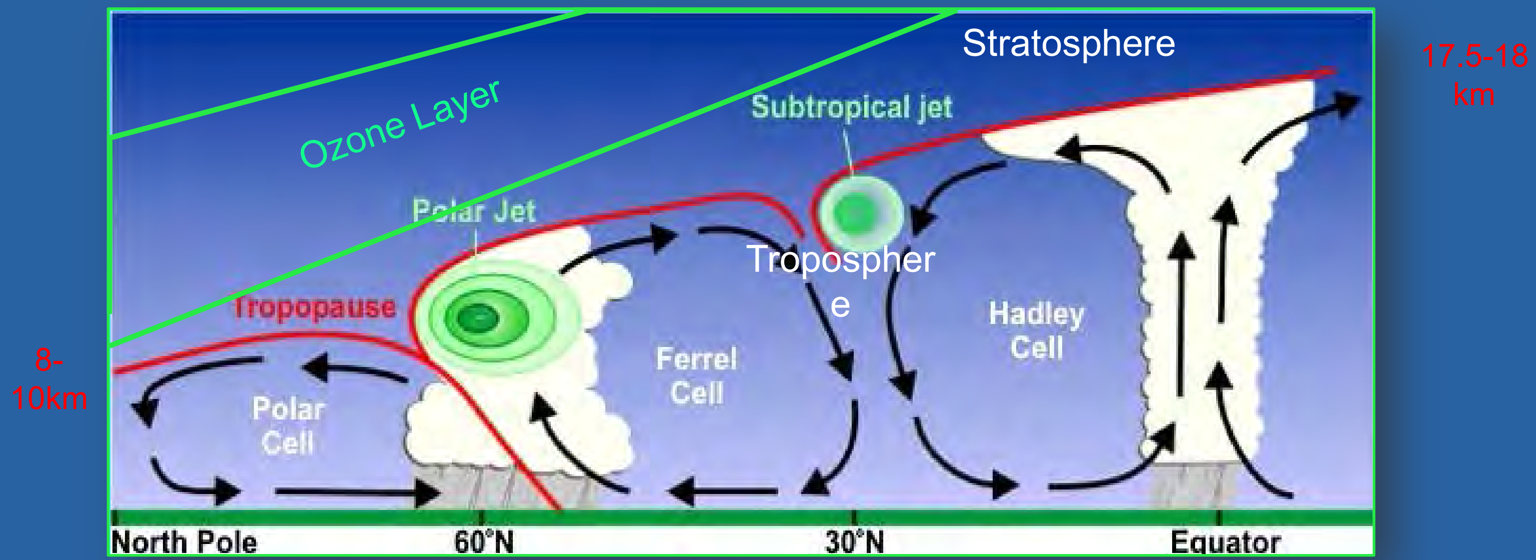
OPEN SOLAR MAGNETIC FLUX
Varies up to 70% during Solar Cycles

GALACTIC COSMIC RAY FLUX
varies up 20% during Solar Cycles

TOTAL SOLAR IRRADIANCE, normalized, variation during SC 0.9 Wm^{-2}, between SC 0.9–1.6 Wm^{-2} and up to 6.8 Wm^{-2}

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

Variations in Solar UV irradiance 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.

The temperature of the stratosphere is controlled by the intensity of UV radiation that varies by up to 6 % during solar cycles, with long-term variations probably being considerably larger.

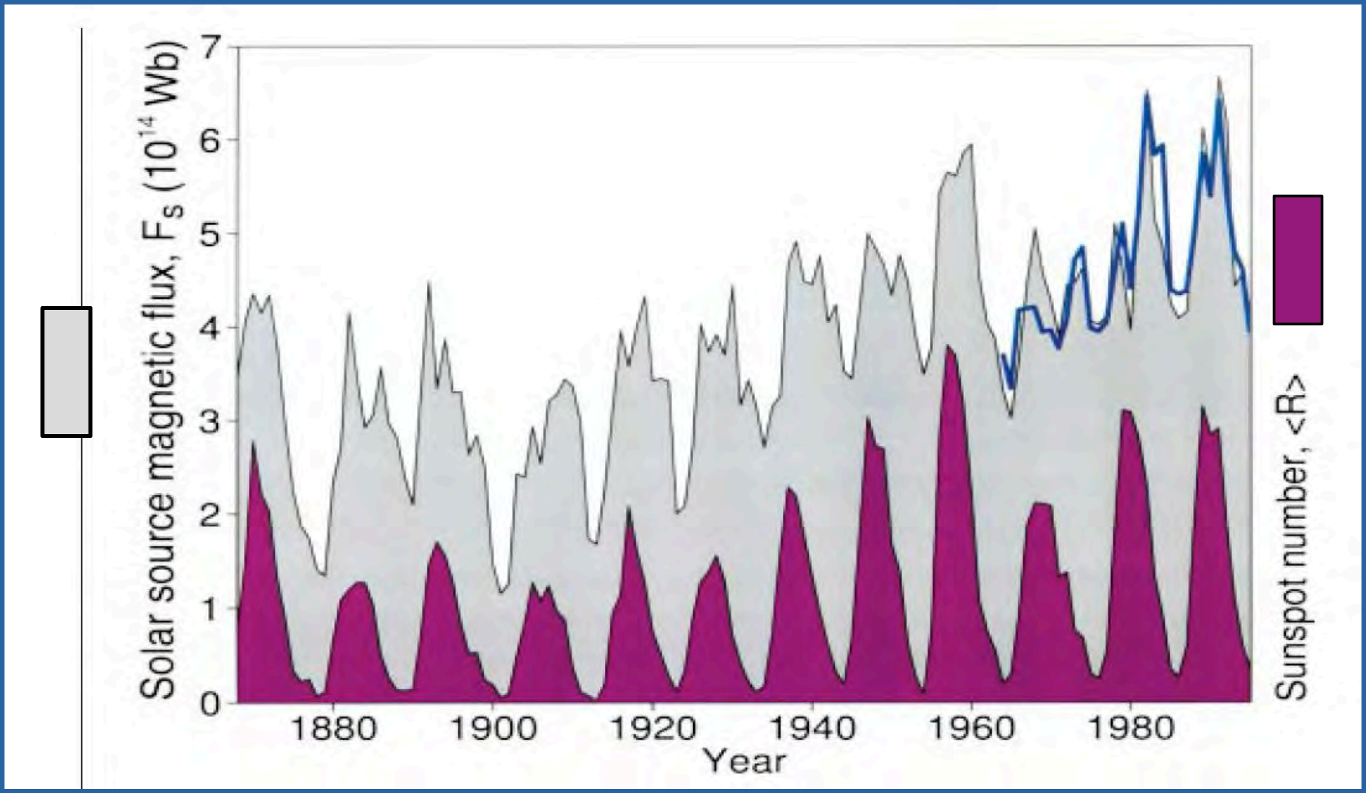
In the stable Stratosphere, slow Brewer-Dobson circulation transports warm, O_3-enriched air from the upper stratosphere at low latitudes towards the Poles and into the lower stratosphere.

The warm Stratosphere emits thermal infrared radiation towards the Troposphere.

The Troposphere and Stratosphere are dynamically coupled across the Tropopause (thermal inversion zone). At Jet Stream fronts, warmer stratospheric air is inserted into the colder upper Troposphere.

Solar-induced stratospheric ozone variations strongly influence the interaction of the Troposphere and Stratosphere and the dynamics of the Troposphere.

The Open Solar Magnetic flux and the Sunspot Number increased cyclically after the Little Ice, reaching a peak in the 1990s

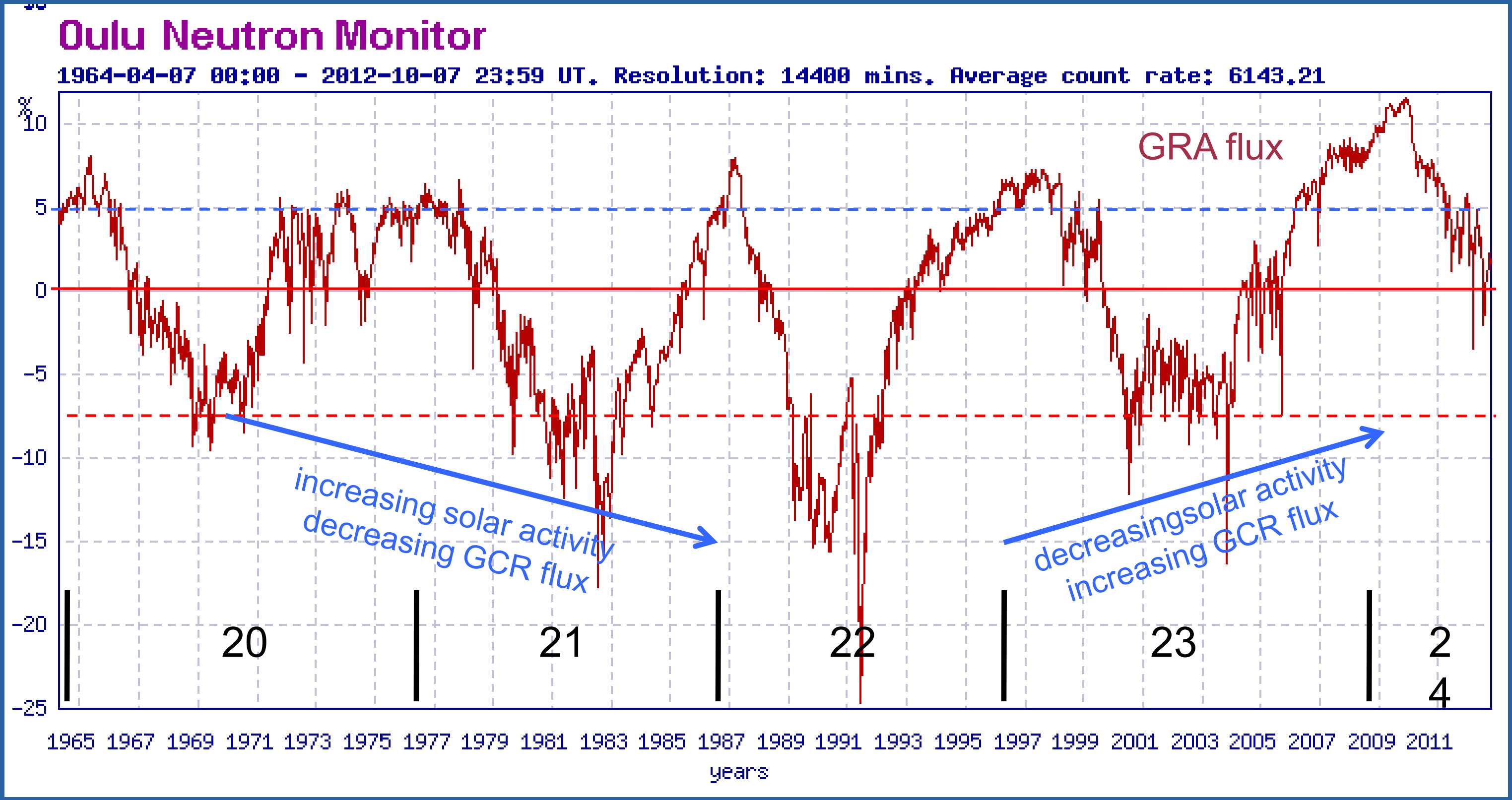


Source of diagram: Lockwood et al., 1999.

Measurements of the near-Earth interplanetary magnetic field show that between 1964 and the 1990s the total magnetic flux leaving the Sun increased by a factor of 1.4 with surrogate measurements indicating that it increased since the Little Ice Age by 350% while the Galactic Cosmic Ray flux decreased by about 50%

(Lockwood et al., 1999; Steinhilber et al., 2010; Beer et al., 1994).

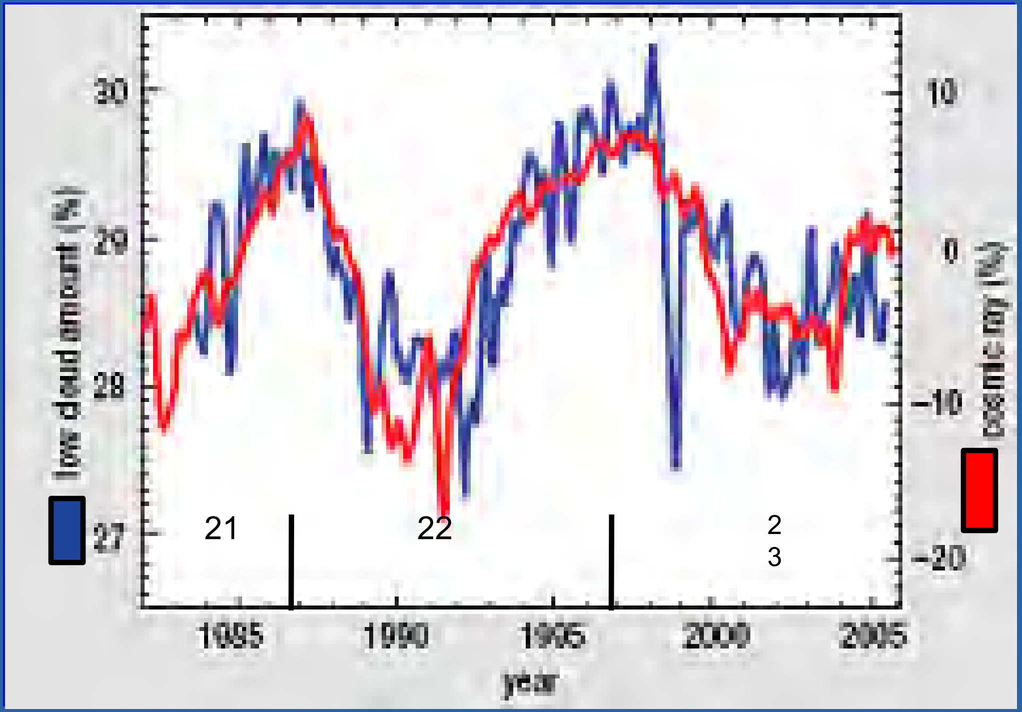
The Galactic Cosmic Ray (GCR) flux decreased during solar cycles 20 to 22 of increasing solar activity but increased during cycles 23 and 24 of decreasing solar activity



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

Until the 1990s Solar activity and temperatures increased cyclically whereas the GCR flux decreased cyclically. Thereafter, temperatures leveled out and the GCR flux increased again, as shown by the shallower and wider trough of the maroon curve during the peak of cycle 23 as compared to the peak of cycle 22 and itsdistinct culmination during the cycle 23/24 transition.

Observational and experimental data indicate that Galactic Cosmic Rays reaching the Earth influence the formation of Low Clouds

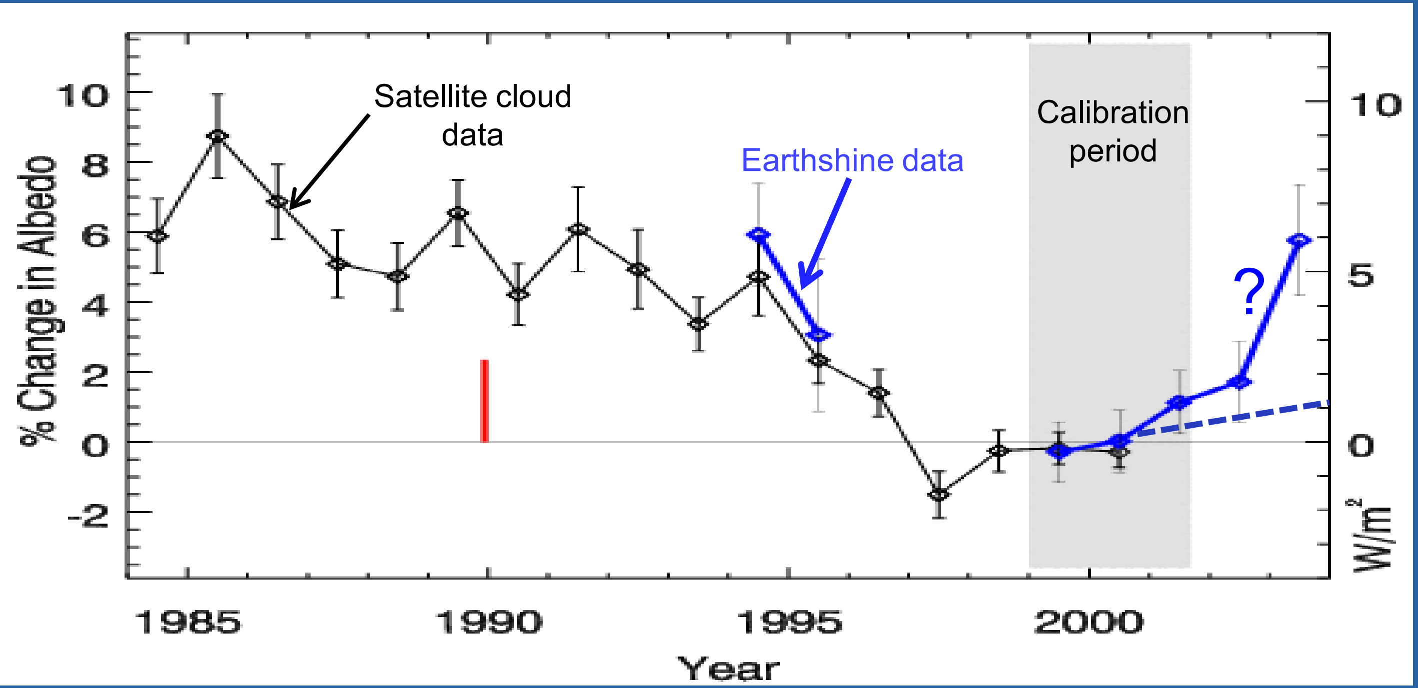


Variations in the GCR flux and global Low Cloud cover during Solar Cycles 21 to 23
Source of diagram: Svensmark, 2007.

The GCR flux anti-correlates with TSI and the Open Solar Magnetic flux that, combined with the geomagnetic field shields the Earth from GCR. The smaller TSI, the greater the GCR flux, the more clouds and cooling, and vice-versa. GCR-related cloud changes amplify TSI-related climate changes by reducing the Solar SW radiation reaching the surface and by reflecting it back to space (Albedo)

This indirect solar climate forcing mechanism is still hotly disputed

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



Source of diagram: Pallé, 2009

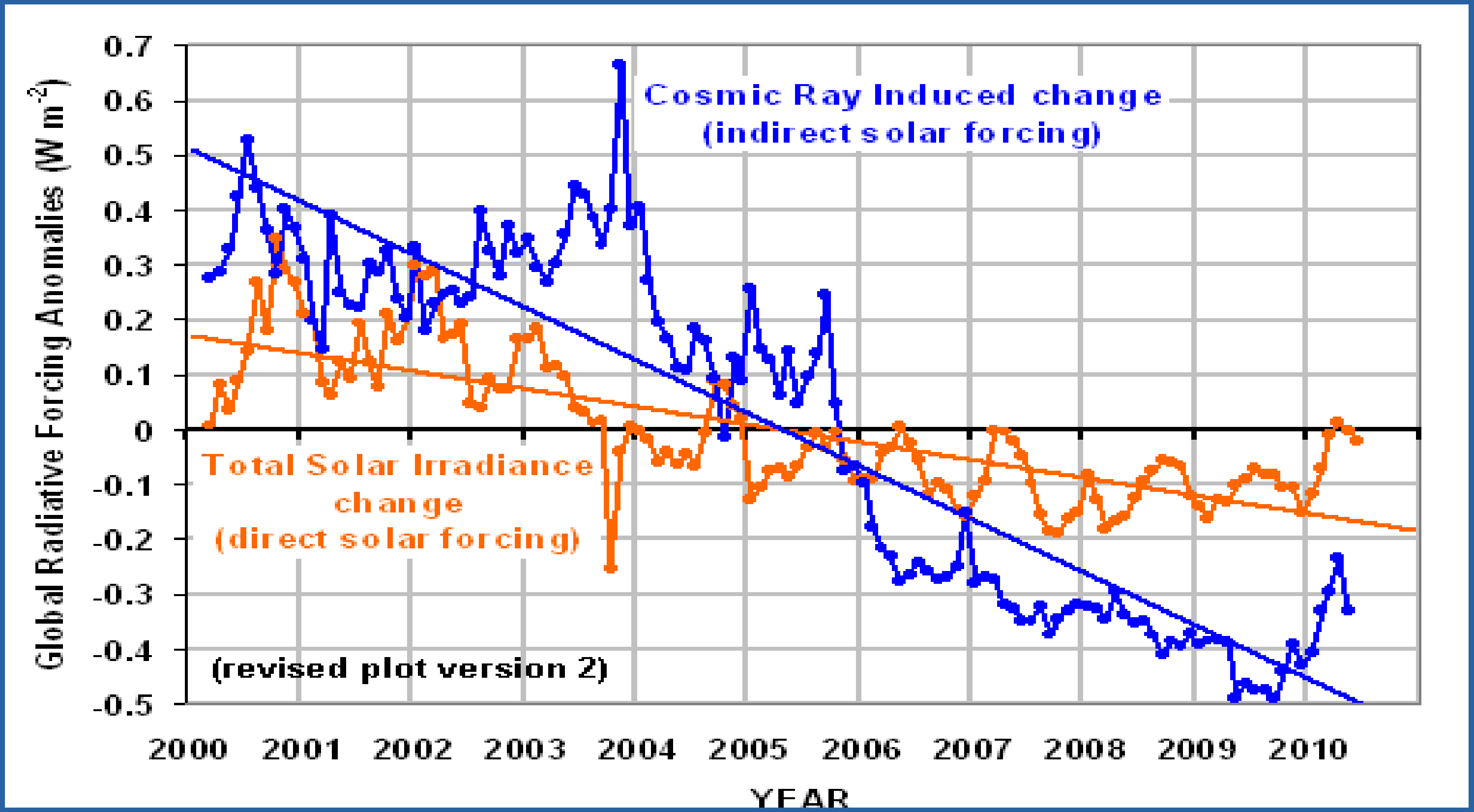
Between 1985 and 1997 the Earth's Albedo decreased during a period of strong solar activity, a decreasing GCR flux and a 5% decline in cloud cover.

During this period the up to 10 Wm^{-2} cloud-driven change in the Earth's radiation budget exceeded the 2.4 Wm^{-2} forcing attributed by IPCC (2001) to the entire industrial anthropogenic greenhouse gas impact (red bar).

The post-2000 Albedo increase was accompanied by gradually decreasing solar activity, an increasing GCRflux and a 1.5% increase in cloud cover.

IPCC climate models do not incorporate such large Albedo variability

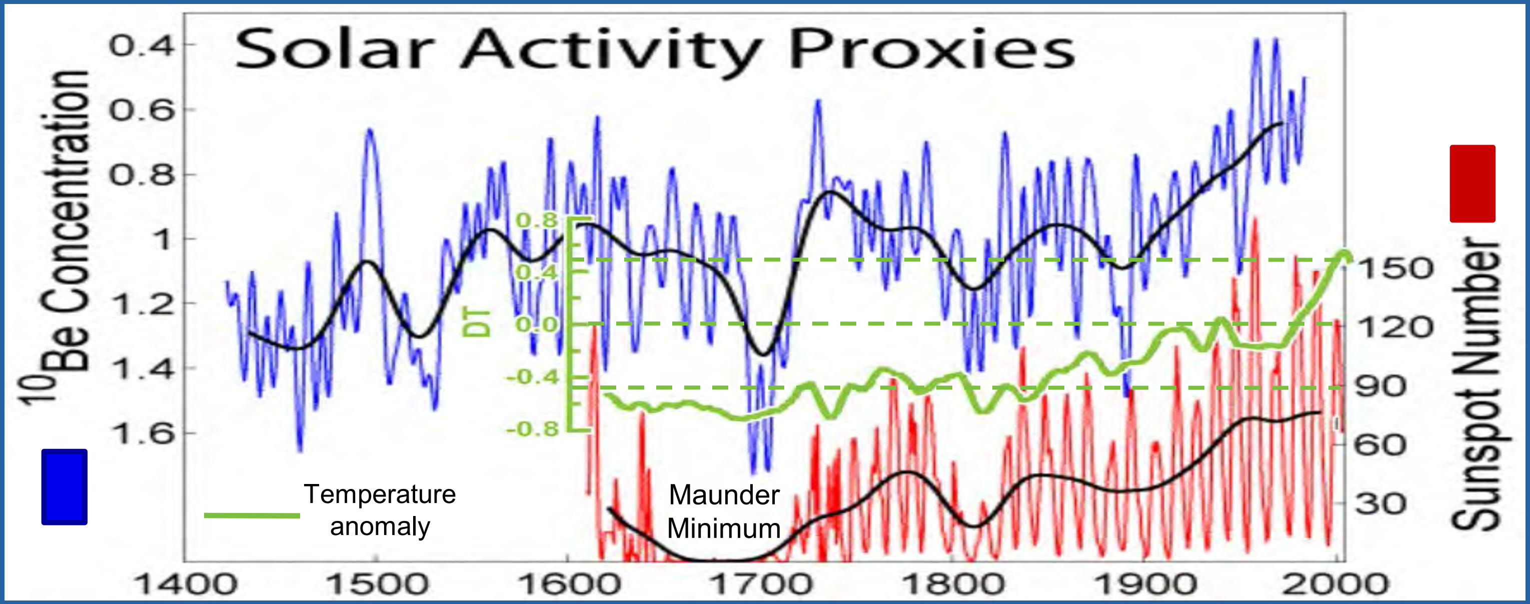
Cooling between 2000 and 2010 involved a slight decrease in TSI and an increase in the Cosmic Ray Flux and cloud cover



Source of diagram: Roy W. Spencer, 2011.

Cosmic Ray-related indirect radiative solar climate forcing appears to be 2.6 times greater than TSI-related direct solar forcing. During the solar cycle 23/24 transition combined direct and indirect solar climate forcing may be 3.8 times greater than commonly assumed by climate scientists.

Galactic Cosmic Ray Flux and Post-Maunder Minimum Warming



Source of diagram: Wikipedia File Solar Activity. ^{10}Be concentration after Beer et al. (1994), Sunspot Number after Hoyt &Schatten (1999), temperature anomaly after de Jager et al. (2010). Black lines: 25 year moving average.

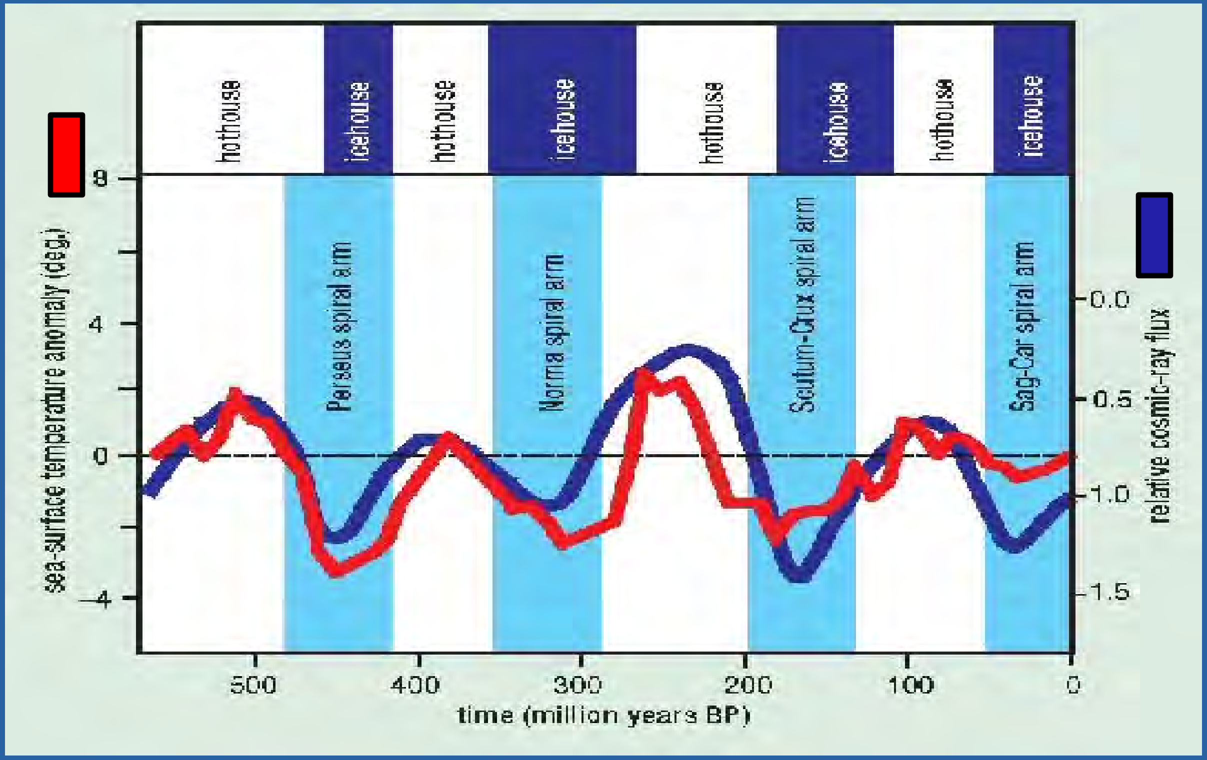
Sunspot Numbers show that after the Maunder Minimum solar activity increased cyclically and peaked after a TSI increase of at least 1.25 Wm^{-2} in the 1990s at 1366.5 Wm^{-2}(Krivova et al., 2010; Gray et al., 2010).

The solar open magnetic field, which together with the geomagnetic field modulates the CGR flux reaching the Earth, correlates closely with TSI. The observed concentration of the cosmogenic isotopes ^{10}Be and ^{44}Ti anti-correlates with TSI (Beer et al., 2000).

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

40% of the about 0.5 ^{0}C warming between1715 and 1970 is accounted by direct solar forcing, the remainder by indirect solar forcing in which the GCR flux plays an important role.

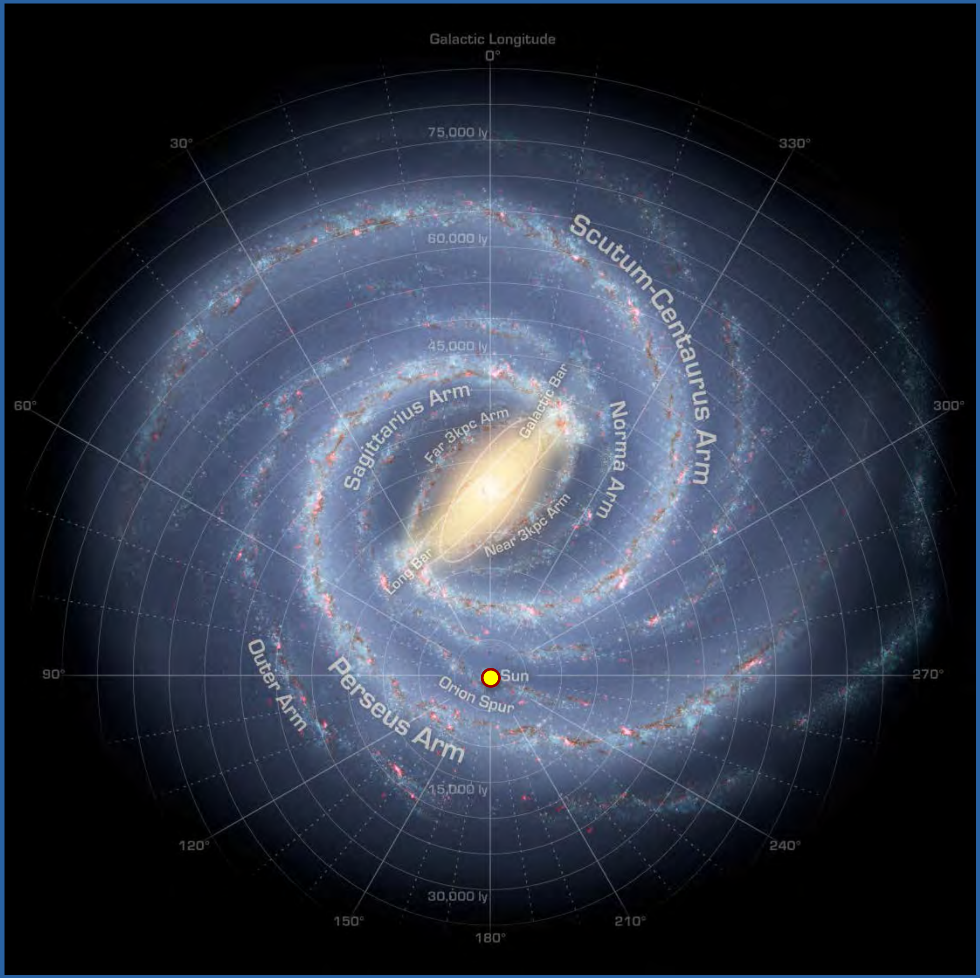
During Phanerozoic times major variations in the GCR flux controlled repeated changes between greenhouse and icehouse climates



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

As the Solar System drifted during Phanerozoic times through the four spiral arms of the Milky Way galaxy the intensity of the GCR flux varied significantly, controlling repeated transitions from greenhouse to icehouse conditions and back. These involved tropical sea-surface temperatures fluctuations of several ^{0}C, which do not correlate with changes in atmospheric CO_2 concentrations (Shaviv&Veizer 2003; Veizer, 2005).

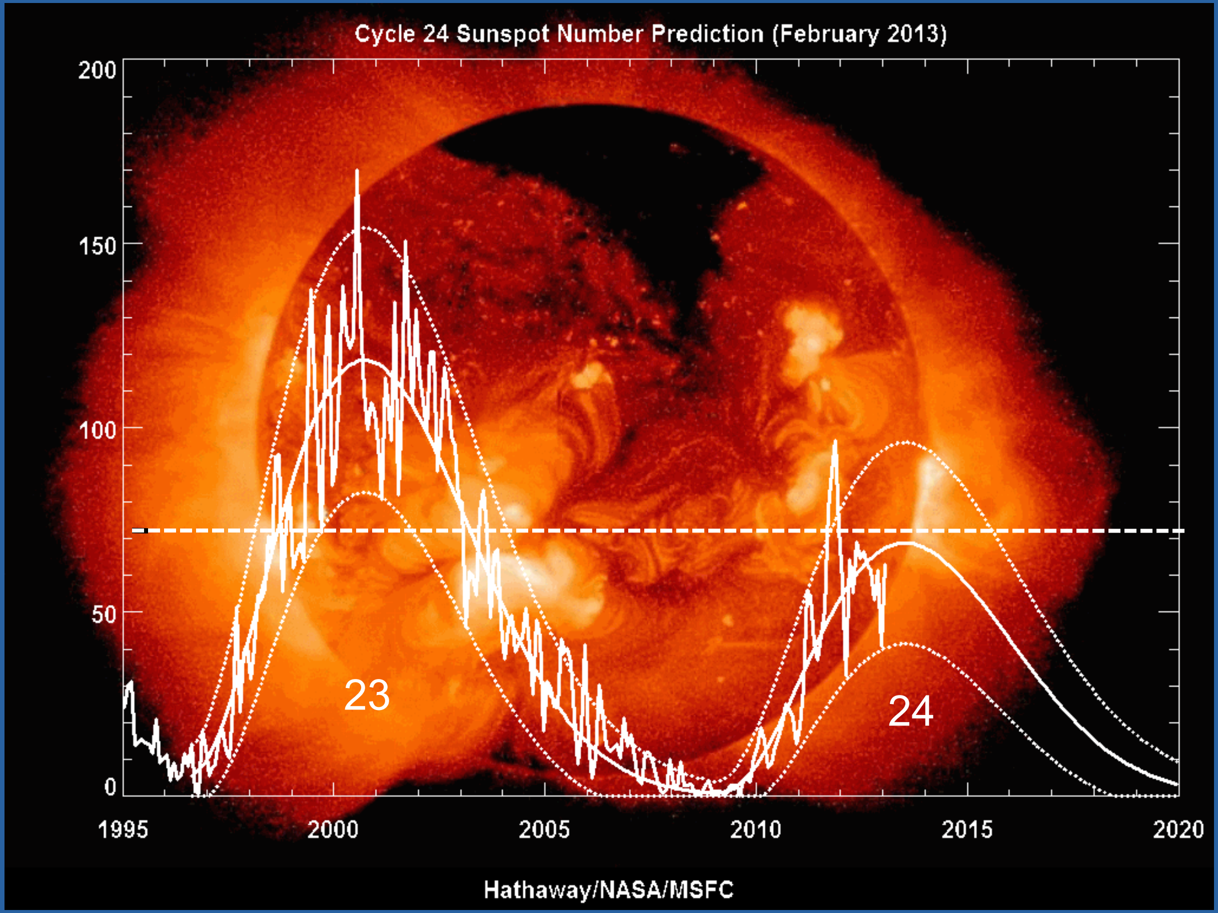
The Sun with its Planets, combined with the Galactic Cosmic Ray flux drive the Earth's climate and not CO_2 as professed by IPCC



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

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

What does the Sun hold in store for the climate of coming decades?



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

Solar cycle 24 is predicted to culminate in Fall 2013 at a smoothed sunspot number of ±69. Cycle 23 culminated in January 2000 at a smoothed sunspot number of ±120

The 20th Century Solar Grand Maximum of general warming that started in 1924 and ended 2008 will be followed by an episode of lower solar activity and notable cooling

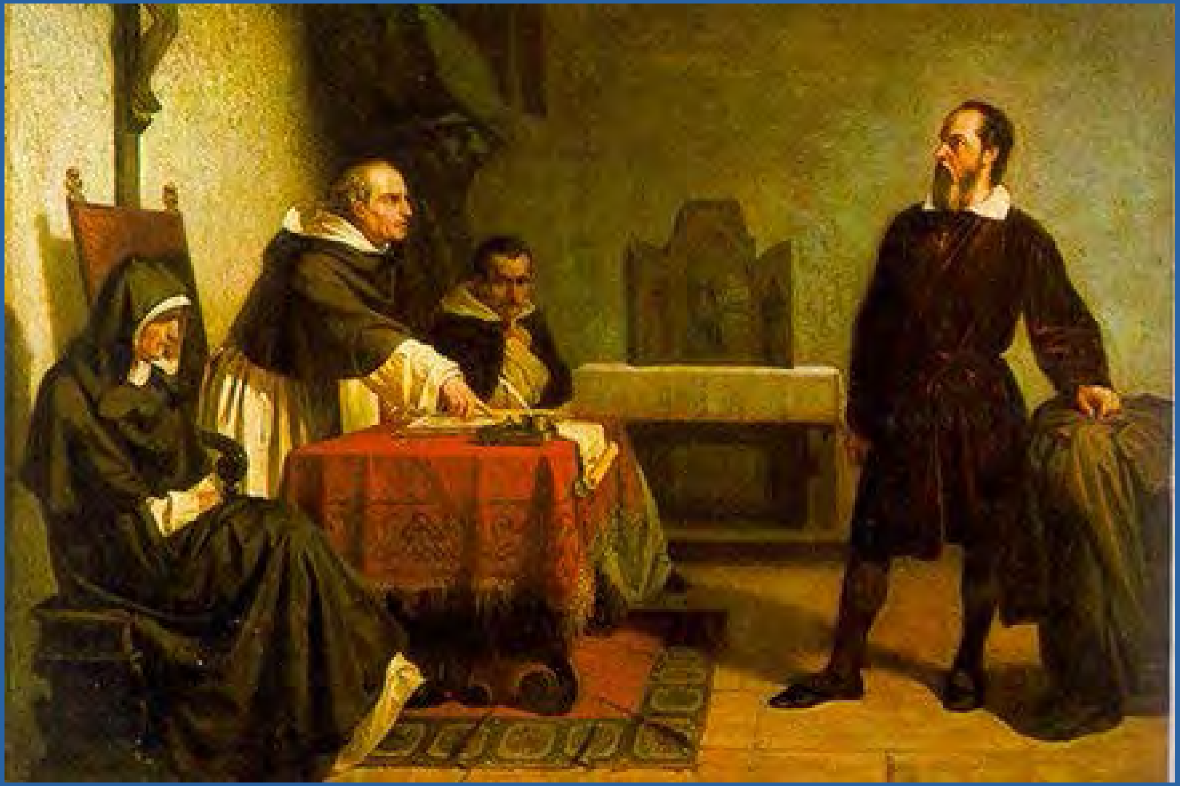
CONCLUSIONS

- Climate change during industrial times can be fully explained by natural processes
- During the last 550 Million years major natural climate changes involved large fluctuations in temperature and atmospheric CO_2 concentrations
- Apart from orbital forcing and the distribution of continents and oceans, variations 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
- There is overwhelming evidence that Temperature forces the Carbon Cycle and not vice-versa, as postulated by IPCC
- IPCC underestimates the effects of direct and indirect solar climate forcing but overestimates 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 and is therefore challenged

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 Climate Change (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 Anthropogenic Global Warming but by energy shortages. Fossil energy is still available in large quantities but at rising prices. Nuclear and renewable energy become ever more important, but not due to Global Warming

Galileo Galilei was condemned for opposing the consensus of the Church 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 Global Warming will ultimately face the same fate as the Church