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Impact Of Solar Activities On Climate: A Study

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Abstract
The sun is the source of the energy that drives the biological and physical processes in the world around us and in the atmosphere it warms air which drives our weather. The rate of energy coming from the sun changes slightly day to day. Over many millennia in the Earth-Sun orbital relationship can change the geographical distribution of the sun's energy over the Earth's surface. It is found that changes in solar output might affect our climate both directly, by changing the rate of solar heating of the Earth and atmosphere, and indirectly, by changing cloud forming processes. Solar influence has been a significant driver of global temperature change over several decades. We found that the sunspot activities are more responsible to increase the temperature of the climate.
Keywords: *Climate, Sunspot, Global temperature, Solar irradiance.*

1- INTRODUCTION

Over the millions of years the change in solar intensity is a critical factor influencing climate (e.g., ice ages). However, changes in solar heating rate over the last century cannot account for the magnitude and distribution of the rise in global mean temperature during that time period and there is no convincing evidence for significant indirect influences on our climate due to twentieth century changes in solar output.

Sunspots are storms on the sun's surface that are marked by intense magnetic activity and play host to solar flares and hot gaseous ejections from the sun's corona. Scientists believe that the number of sun spots on the sun cycles, reaching a peak the so-called solar maximum every 11 years or so. Some studies indicate that sunspot activity overall has doubled in the last century. The apparent result down here on Earth is that the sun glows brighter by about 0.1 percent now than it did 100 years ago.

Solar wind consists of magnetized plasma flares and in some cases is linked to sunspots. It emanates from the sun and influences galactic rays that may in turn affect atmospheric phenomena on Earth, such as cloud cover. But scientists are the first to admit that they have a lot to learn about phenomena like sunspots and solar wind, some of which is visible to humans on Earth in the form of Aurora Borealis and other far flung interplanetary light shows.

Some skeptics of human-induced climate change blame global warming on natural variations in the sun's output due to sunspots and/or solar wind. They say it's no coincidence that an increase in sunspot activity and a run-up of global temperatures on Earth are happening concurrently, and view regulation of carbon emissions as folly with negative ramifications for our economy and tried-and-true energy infrastructure.

Figure 1. Record of Minimal Variation in Sun's Energy

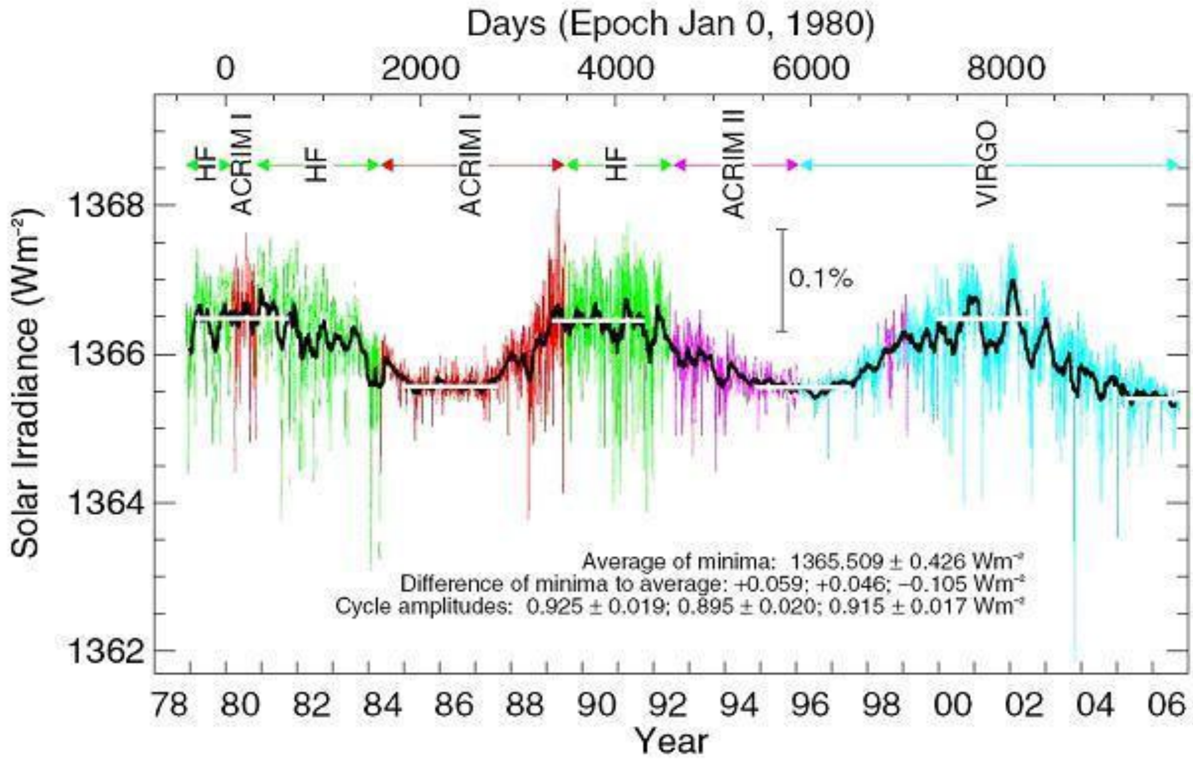


Figure 1. Two and a half solar cycles of Total Solar Irradiance (TSI), also called 'solar constant'. This composite, compiled by the VIRGO team at the Physikalisch-Meteorologisches Observatorium / World Radiation Center Davos, Switzerland, shows TSI as daily values plotted in different colors for the different originating experiments. The difference between the minima values is also indicated, together with amplitudes of the three cycles. Image courtesy of SOHO consortium a project of international cooperation between ESA and NASA.

2- THE SUN-CLIMATE CONNECTION

The rate at which energy from the sun reaches the top of Earth's atmosphere is denoted by the term "total solar irradiance" (or TSI). TSI fluctuates slightly from day to day and week to week. Superimposed on these rapid short-term fluctuations is a cycle related to sunspots in the outer layers of the Sun that lasts approximately every 11 years. The current TSI varies with season, time of day, and latitude. Yet it is thought that small changes in this relatively small amount of absorbed solar energy can make a difference to our climate. Might changes in the rate of solar absorption, called radiative forcing (RF), be influencing our climate today.

(1) Direct changes in climate due to solar output

The average increase in solar radiative forcing since 1750 is much smaller (~ 0.12 W m-2) than the increase in RF due to heat-trapping gases (~2.6 W m-2) over that same time period. [3] The slight increase in solar absorption is, moreover, more than offset by natural cooling. The twentieth century witnessed the eruption of major volcanoes— the most recent, Pinatubo, in 1991—that spewed tiny reflective particles into the atmosphere. Incoming energy from the sun that encountered these particles was reflected back into space. In other words, natural processes alone would have brought about slight late twentieth century cooling—not the warming we have experienced.

(2) Indirect changes in climate due to solar output

The variations of the rate of emission of solar radiation on the 11 year time scale, as well as the small long-term increase in TSI over the past few centuries, appear in some studies to be correlated with variations in cloud patterns. These changes in absorbed solar energy appear to be far too small to explain the major changes in our climate.

Two different hypotheses have been proposed to test whether solar radiation can explain climate change. The first relies on the fact that in both the 11 year cycle and, in the longer term, the changes in solar energy are highest at ultraviolet (short) wavelengths. The short wavelength radiation is particularly effective in modifying ozone concentrations in the level of the atmosphere above where typical weather occurs. According to this hypothesis, modifications in the ozone layer could in turn filter down to that level of the atmosphere where our weather is formed, potentially modifying clouds and temperatures there.

The second hypothesis relies on the fact that changes in solar activity also change the flow of small, charged, highly energetic particles that travel through the atmosphere toward Earth [1, 2]. These particles in turn create more ions (charged atoms or molecules) from air molecules in the atmosphere, and it has been suggested [3] that these ions might modify cloud formation, causing large changes in weather and temperatures below.

So far, there is no convincing evidence that either of these ideas adequately demonstrate a causal links between small changes in solar irradiance and the relatively large, measurable changes in Earth's surface temperature over the past century

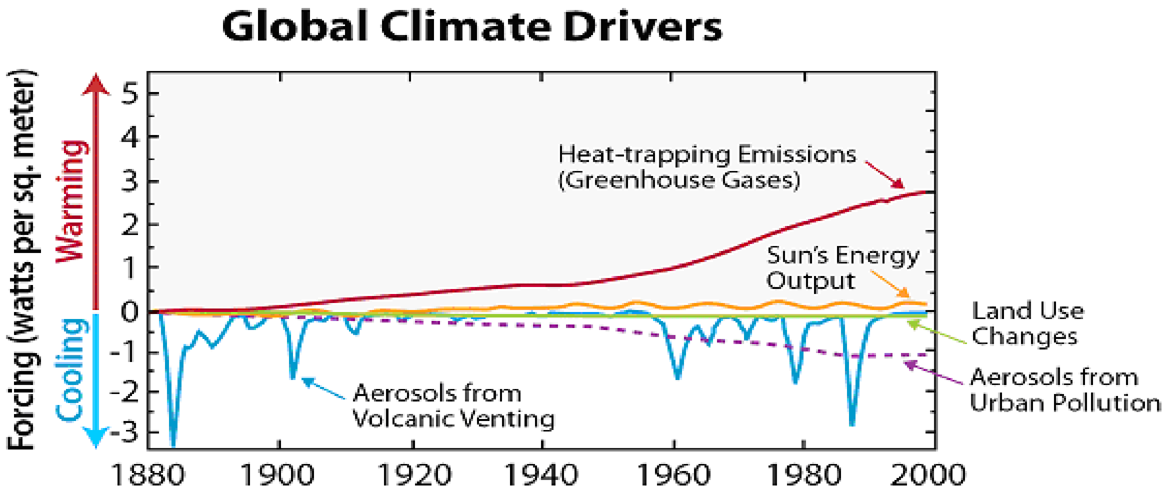
3- TWENTIETH CENTURY CLIMATE AND SOLAR VARIATIONS

The rate at which solar energy reaches the Earth's surface in any location depends on the season, time of day, cloudiness and the concentration of small aerosol particles in the atmosphere. During the late twentieth century, the average amount of solar energy reaching the surface decreased slightly due to atmospheric particles, particularly in urban locations, that reflect the sun's energy back into space. This pollution did not cause net global cooling because it was more than counteracted by the increasing concentrations of heat-trapping gases in the atmosphere.

In its Fourth Assessment Report [3], IPCC scientists evaluated simulations of twentieth century climate variables using a number of numerical models. They first assumed no increase in heat-trapping gases over this period, so that the temperatures calculated were those that would have been achieved if only solar variability, volcanic eruptions, and other natural climate drivers were included. The temperature results were similar to observed temperatures only for the first half of the century, but the models did not accurately show the general warming trend that has been recorded during the second half of the twentieth century. However, when the human-induced heat-trapping gases were included in the computer model, it accurately reproduced the observed warming during the twentieth century.

Thus, although fluctuations in the amount of solar energy reaching our atmosphere do influence our climate, the global warming trend of the past six decades cannot be attributed to changes in the sun (Figure 2).

Figure 2. Twentieth Century History of Climate Drivers



Heat-trapping emissions (greenhouse gases) far outweigh the effects of other drivers acting on Earth's climate. Source: Hansen et al. 2005, Figure adapted by Union of Concerned Scientists. [5]

4- CO_2, TEMPERATURE AND SUNSPOT ACTIVITY

Over the past 3 decades, terrestrial temperature has not correlated with sunspot trends. The top plot is of sunspots, while below is the global atmospheric temperature trend shown in figure-3. El Chichón and Pinatubo were volcanoes, while El Niño is part of ocean variability. The effect of greenhouse gas emissions is on top of those fluctuations.

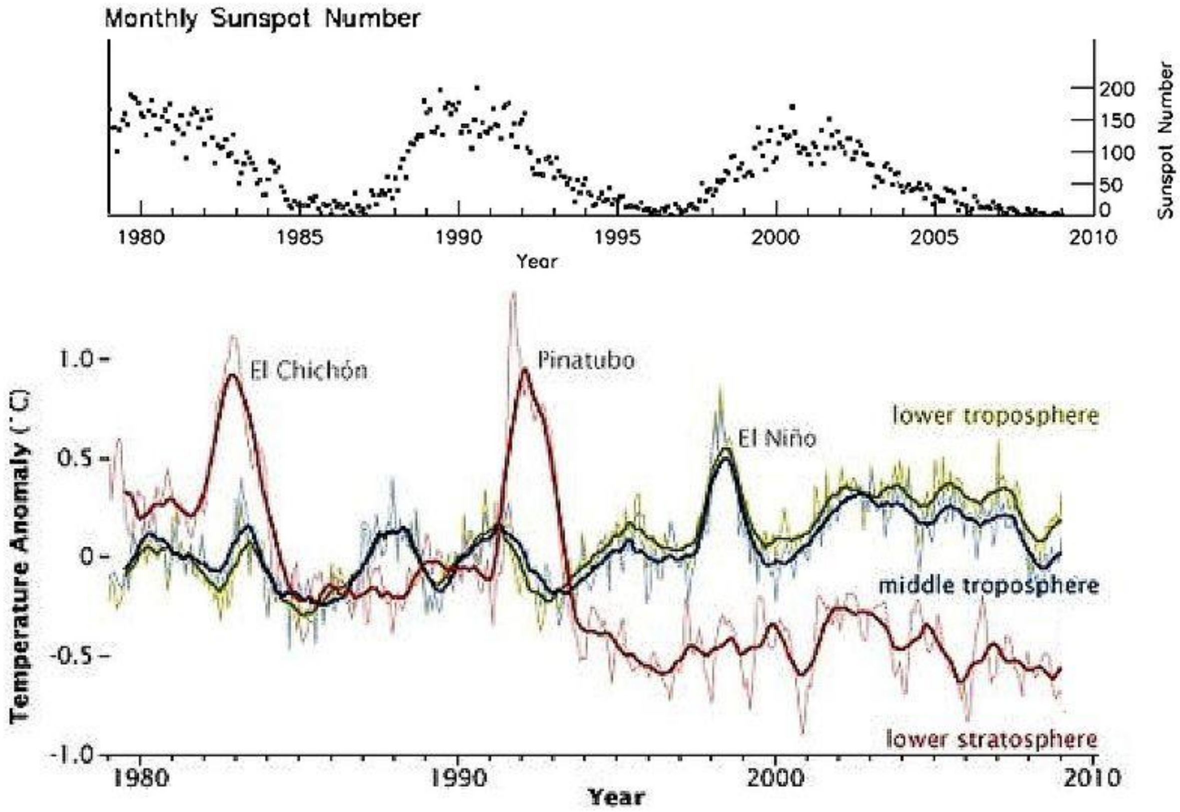


Figure-3. Sunspot number and temperature relation.

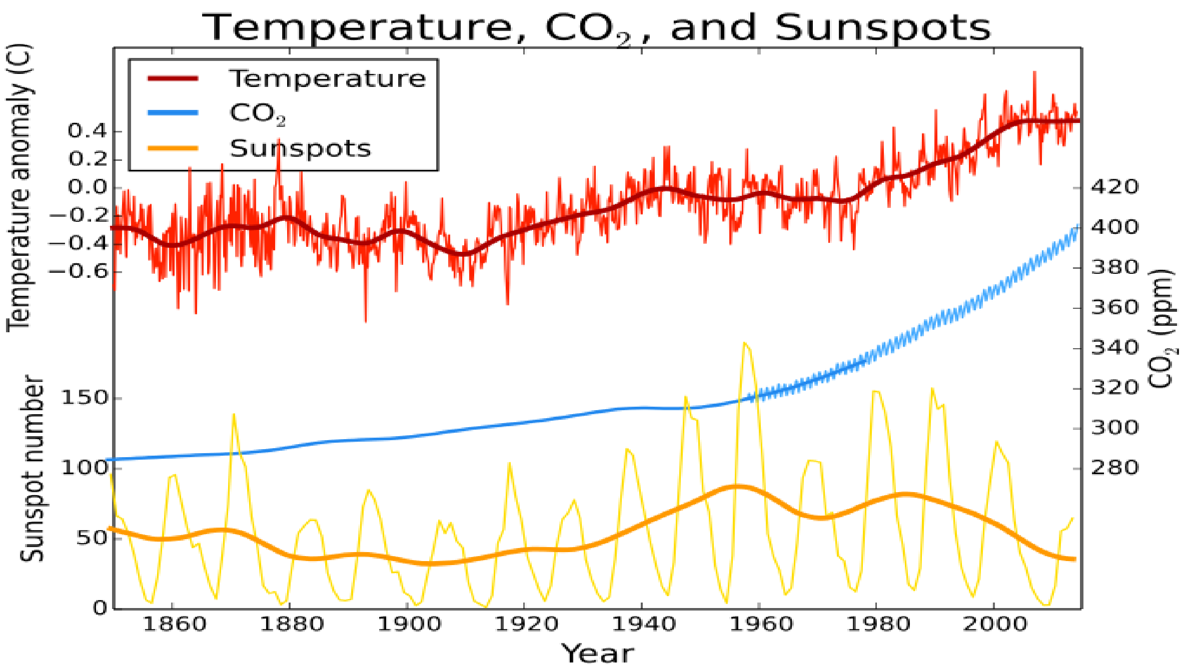


Figure-4. Global average temperature, atmospheric CO2, and sunspot activity since 1850. Thick lines for temperature and sunspots represent a 25 year moving average smoothing of the raw data.

4.1 SUNSPOT AND TEMPERATURE RECONSTRUCTIONS FROM PROXY DATA

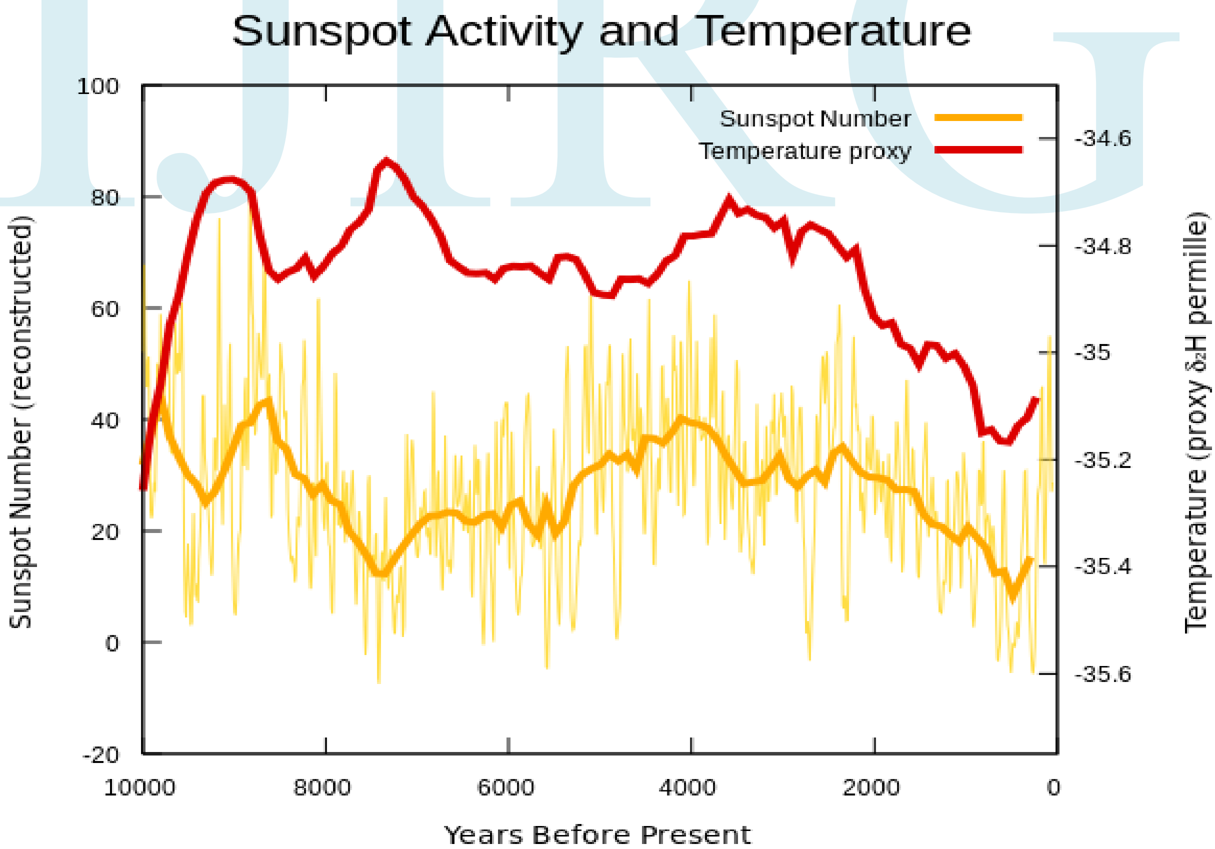


Figure-5. Sunspot versus temperature.

This figure shows the reconstructed sunspot activity and reconstructed temperature over the last 10000 years. This figure was produced by Leland McInnes using gnuplot and Inkscape

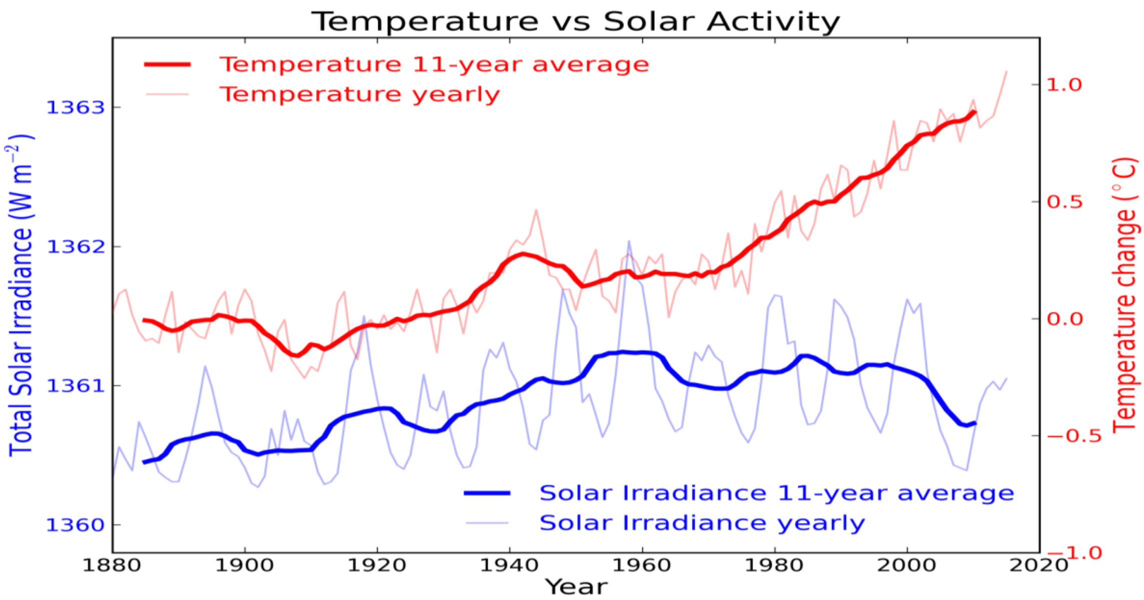


Figure 6: Annual global temperature change (thin light red) with 11 year moving average of temperature (thick dark red). Temperature from NASA GISS. Annual Total Solar Irradiance (thin light blue) with 11 year moving average of TSI (thick dark blue). TSI from 1880 to 1978 from Krivova et al 2007. TSI from 1979 to 2015 from PMOD (see the PMOD index page for data updates).

From this figure, the trend in global temperature compared to changes in the amount of solar energy that hits the Earth. The sun's energy fluctuates on a cycle that's about 11 years long. The energy changes by about 0.1% on each cycle. If the Earth's temperature was controlled mainly by the sun, then it should have cooled between 2000 and 2008.

5- SOLAR RADIATION AT THE TOP OF OUR ATMOSPHERE, AND GLOBAL TEMPERATURE

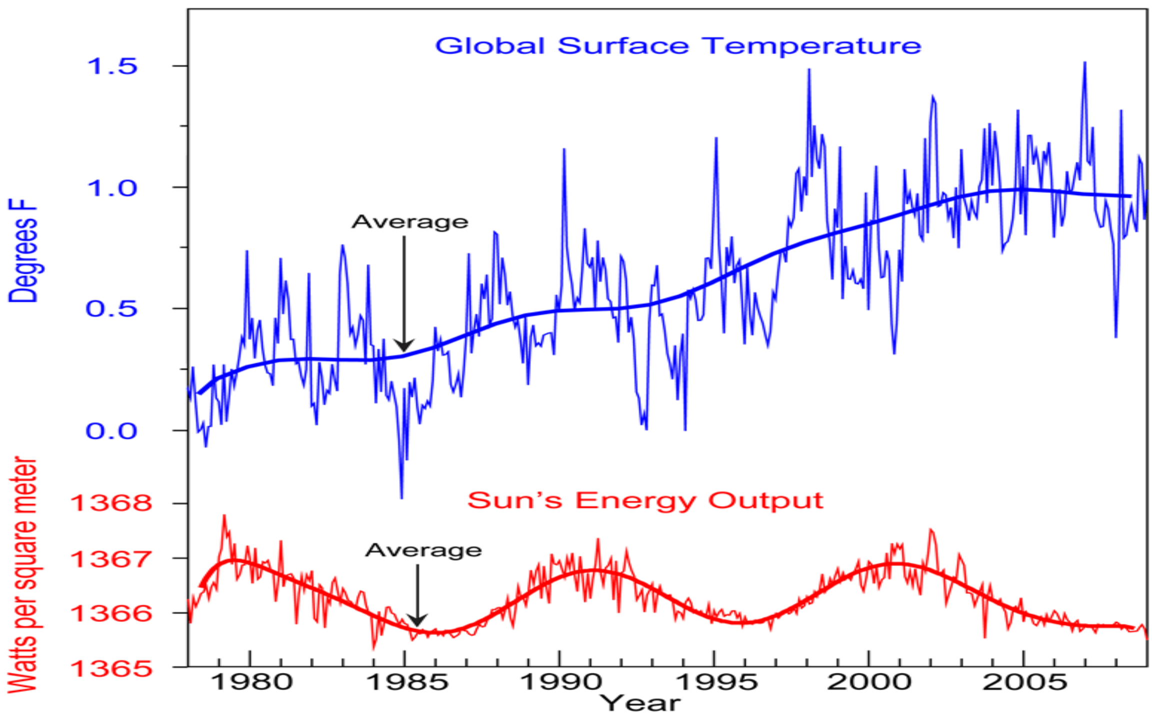


Figure-7 Solar irradiance and global temperature.

This graph shows global surface temperature (top, blue) and the Sun's energy received at the top of Earth's atmosphere (red, bottom). Data covers the years 1978 to 2009. From the cited public-domain source (NOAA, 2011): "The amount of solar energy received at the top of our atmosphere has followed its natural 11-year cycle of small ups and downs, but with no net increase. Over the same period, global temperature has risen markedly. This indicates that it is extremely unlikely that solar influence has been a significant driver of global temperature change over several decades."

6- SOLAR FORCING 1850–2050 USED IN A NASA GISS CLIMATE MODEL. RECENT VARIATION PATTERN USED AFTER 2000

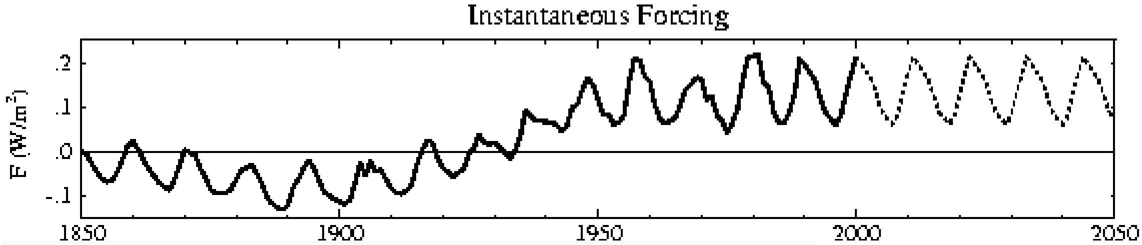


Figure-8 Solar forcing used in NASA GISS SI2000 simulations

7- Discussion

Changes in solar activity between maxima and minima of the 11-year solar cycle during the last three solar cycles only amount to a change of ~0.07 W m^{-2} in direct radiative forcing at the Earth's surface, which is small compared to the estimated effect of a doubling of atmospheric CO2 concentrations (~3.7 W m^{-2}). Several feedback mechanisms have been proposed to explain how the small-scale changes in TSI can have an effect on climate, including an increase in stratospheric ozone concentrations as a result of increased UV-radiation during a solar maximum. The 20th-century Grand Maximum of solar activity probably has come to an end [9,10,11] and relatively low solar activity is predicted for the next few decades. Model simulations by Feulner & Rahmstorf (2010) suggest that the effects of a new grand minimum of solar activity will lead to a decrease in global mean temperatures of only 0.1 ℃. This is a comparatively minor number compared to the 3.7–4.5 ℃ temperature increase that is expected to result from the increased emission of greenhouse gasses [13]. Similar results are obtained by Jones et al. (2012), who predict a decrease in warming of 0.06–0.1 ℃ as a result of decreased solar activity in the 21st century.

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