Reduced Solar Activity Disguises Global Temperature Rise

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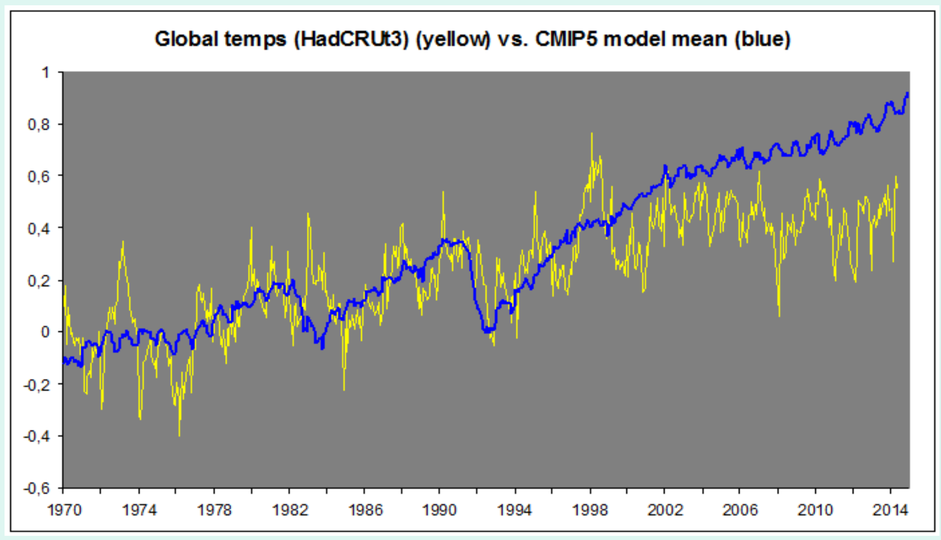
Introduction. The alarming rise in global temperatures from about 1975 to 2000 gave much concern around possible serious future climate changes that could result from the increasing levels of carbon dioxide, methane and other Greenhouse gasses in our atmosphere. However, the strong rise in global temperatures faded after year 2000 and was replaced by a rather steady level or even small decreases in the global temperatures from around 2001 to present (2014). The question is now whether the present fading of the temperature rise is related to the concurrent decrease in solar activity scaled, for instance, by the sunspot numbers. Scientists have linked past climate changes to solar activity. The so-called “Little Ice Age” in the 17’th century was linked to the Maunder minimum in solar activity. In author’s earlier analysis a quantitative assessment was made of the relation between solar activity represented by the cycle-average sunspot numbers and the terrestrial climate represented by the global temperatures averaged over the same interval length but delayed by 3 years. The solar activity is now at the lowest level seen in the past 100 years. If solar activity starts increasing then the global temperatures may rise even steeper than seen over the past three decades.

Figure 1 below illustrates the basis for presentation. The blue line displays the temperature development according to a CMIP5 model while the yellow curve shows the measured global temperatures according to the HadCRUT3 data. The two temperature data sets track each other nicely up to year ~2000. Thereafter the model temperatures continue their rise while the real temperatures, against expectations , attain a rather constant level.

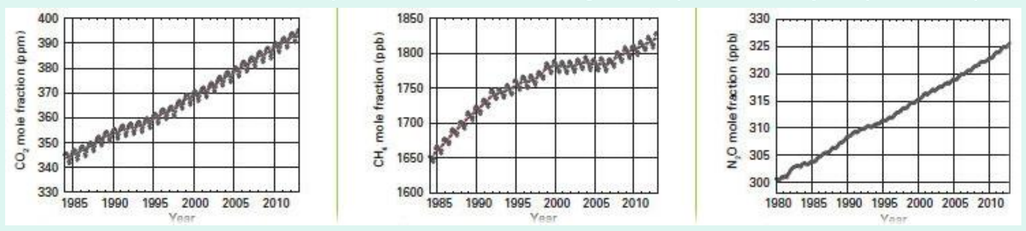
Fig.1



The quite marked increase ín the global temperatures between ~1975 and 2000 have often been associated with the concurrent increases in Greenhouse gasses, notably Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O). However, the concentrations of these gasses have continued to rise steadily also after year 2000 as seen in Figure 2 below and that development does not agree with the levelling-off in the global temperatures after ~year 2000.

Fig.2

Concentrations in the atmosphere of Greenhouse gasses (WMO Yearly Report 2013).



Carbon Dioxide (CO_2) Methane (CH_4) Nitrous Oxide (N_2O)

Looking for an explanation of the levelling-off in the global temperatures despite the steady increase in amounts of Greenhouse gasses the declining Solar activity may be taken into account. In Fig. 3 the Solar activity represented by the sunspot number (ssn) has been plotted along with the concurrent global temperature anomaly (deviation from average level through 1961-1990) derived from the HadCRUT4 combined sea surface/land surface temperature data series. It is clear from Fig. 3 that the average Solar activity has declined markedly in the recent years.

Fig.3

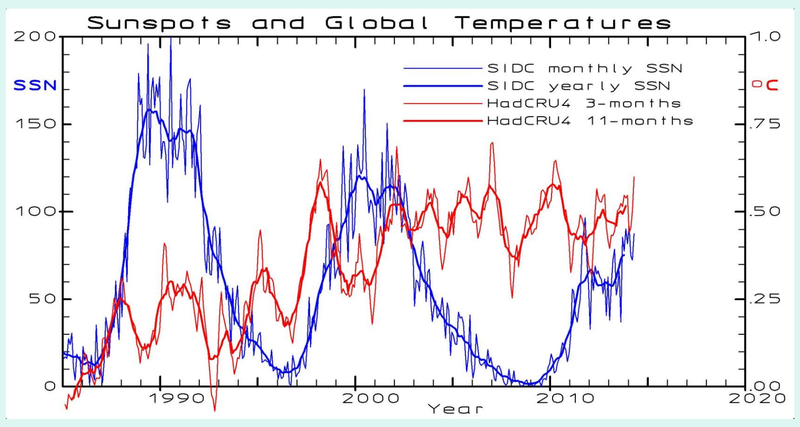
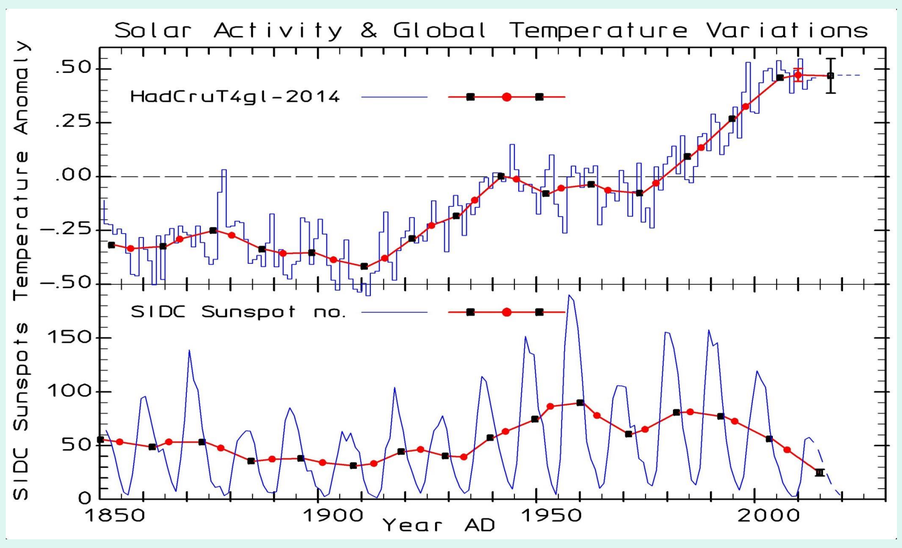


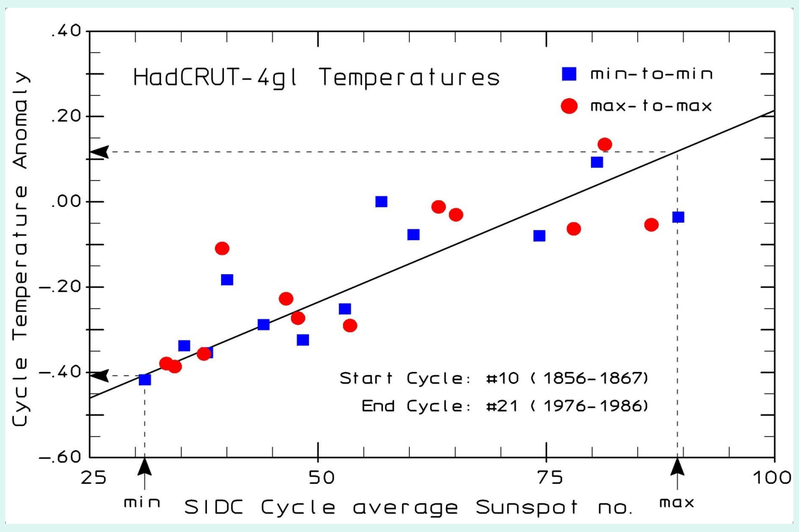
Figure 4 below presents through 1850 to 2014 the HadCRUT4 global temperatures in the upper panel while the solar activity scaled by the SIDC sunspot number is displayed in the lower field for comparison. The squares and round dots at the sunspot data mark averages through solar min-to-min and max-to-max intervals, respectively. In this figure it is evident that the global temperatures level off after ~ year 2000 contrary to the steep rise bebetween ~1975 and 2000.

Fig.4



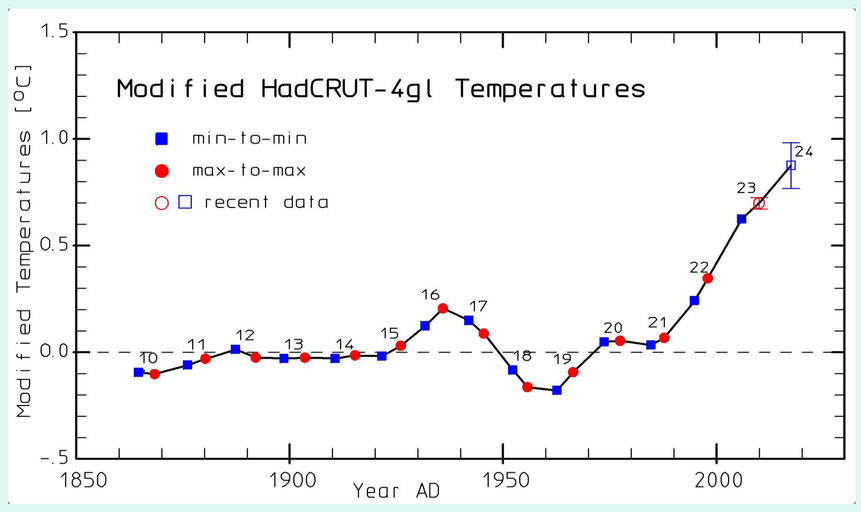
The best correlation between solar activity represented by the sunspot numbers averaged over a full cycle and the global temperatures averaged over the same length of time, but delayed, is found by a displacement of the interval by ~3 years. The figure below presents the results of temperature anomaly plotted against sunspot number for cycle #10 (1856-1887) through cycle #21 (1976-1986). Like in Fig. 4, the squares represent averages from min-to-min while the dots present the max-to-max intervals in solar activity. The regression line shown in the figure has the slope 0.009 ºC/ssn.

Fig.5



Results. Using the 0.009 ºC/ssn relation enables us to calculate the global temperatures as they would have been without the contributions from solar activity represented by the sunspot numbers. The so reduced temperatures are presented in Fig. 6 below. The symbols have the same meaning as in the former figures and solar cycle numbers have been added. The dotted horizontal line represents the average level for cycle #10 through #21. Note the rather flat development in the modified temperatures up to cycle #21 and the steep rise thereafter. Specifically it should be noted that the recent development for cycle #23 through #24 now shows a continued steady rise in agreement with the steady rise in Greenhouse gas abundances presented in the diagrams in Fig. 2.

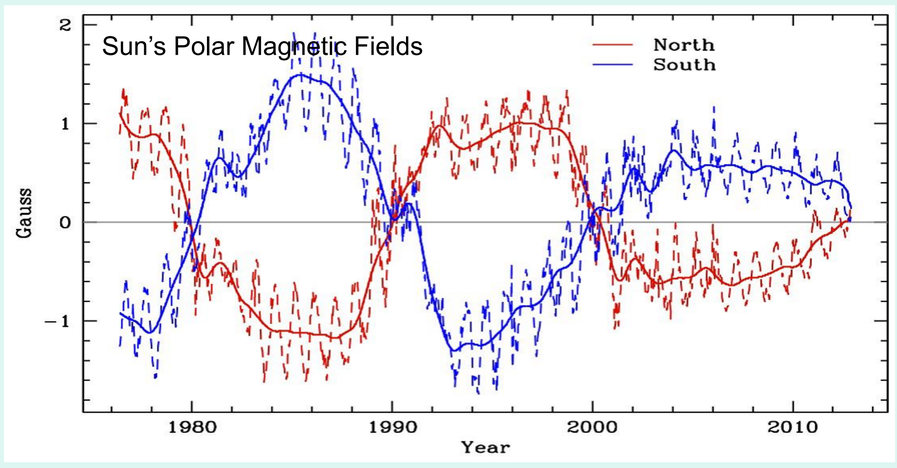
Fig.6



Discussions. How representative of Solar activity are the sunspot numbers? They represent the varying number of active regions at the Solar surface with strong local magnetic fields. These regions occasionally emit strong X-ray bursts and generate outburst of solar surface material and embedded magnetic fields in Coronal Mass Ejection (CME) events that may cause strong disturbances of the Earth’s Magnetosphere and Ionosphere.

Another indication of Solar activity with relations to the sunspots is the strength of the Sun’s polar magnetic fields. These fields shift polarity at the middle of the sunspot cycle (at sunspot maximum). The general level of the Sun’s polar magnetic fields have been decaying through the recent cycles as illustrated in Fig. 7 below in concordance with the average sunspot level .

Fig.7



Another issue in the discussions on the use of sunspot numbers is the recent examination of the validity of the derivation of sunspot numbers. It has been found (Cliver et al., 2013) that the SIDC sunspot numbers are around 18% too high since 1945. However, such a modification would not affect the presented results much.

A further point is the selection of the temperature data series. There are available series of temperature data for land surface and sea surface separately. However, using these series give much the same results and the combined sea surface/land surface HadCRUT series was considered to provide the most general representation of the Earth’s temperature level.

The most challenging question is how the interaction between Solar activity and Earth’s temperature level takes place. There are probably several channels (e.g., Engels et al., 2012; Gray et al., 2010; Mursula et al., 2013). The most straightforward mechanism would be a general increase in the total radiated solar energy during intervals of high levels of solar activity. Direct measurements in recent years indicate that this feature could be made responsible for just a fraction of the observed temperature changes.

Further candidates to explain the interaction are the strongly increased ultraviolet radiation and the reduced cosmic radiation (Svensmark and Friis-Christensen, 1997) during intervals of high solar activity. Both may in a complicated (height dependent) way change the ion abundances and also in the long run affect the chemical composition of the upper atmosphere with consequences for the cloud cover. Finally, an enhanced solar wind with strong embedded magnetic fields may cause disturbances comprising strong electric currents in the Earth’s upper atmosphere and secondary induced current in the ground.

Conclusions. The increasing emissions of Greenhouse gasses are the most likely cause of the recent global temperature increases during the last years of the past century and the most threathening cause of possible large future temperature increases (Global Warming). The solar activity could at most be made responsible for changes in the global temperatures of just a few tenths of a degree. However, the reduced contribution from the decreasing solar activity may disguise the ongoing temperature increases giving the impression of a ”stand still” in the Global Warming.
Taking the effects of the presently reduced solar activity into account indicate that the global temperatures are developing in concordance with the increasing emission of Greenhouse gasses.
The Global Warming is still ongoing!

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