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Related Variations of Solar Energy Flux and the CO_2 Content in the Earth Atmosphere

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Abstract

The aim of this work is to present a series of arguments against the widely accepted interpretation that the present heating of the Earth atmosphere is due to the increase of the CO_2 molecule abundance in it, which results in an increase of the greenhouse effect. The CO_2 abundance variation is supposed to be largely due to human activities, like thermal power plants for production of electricity, cars, planes, and many industries. First, we briefly present the observational data that are used to support this dominant point of view. We agree that an apparent correlation does exist between the CO_2 abundance and the atmospheric temperature, but it is wrongly interpreted. We suggest that it is the variations of solar energy reaching the Earth that produces changes of temperature, and in parallel this increase in temperature produces additional CO_2 content in the atmosphere. Our arguments are based on an analysis of the history of the sunspot's activity along approximately the last 10 centuries and on the correlation of this solar activity with the temperature on Earth. Motivated by the long-term analysis of Solar activity that we performed, a model is proposed to explain the surprising constancy of the time interval of 11 years between successive maximums of sunspots. The model is based on the interaction between Jupiter and the external layers of the Sun. In the conclusion section, a few possible actions to keep the temperature of the atmosphere within an adequate range are commented.

Keywords

Global Warming, History of Sunspot Numbers, Connection Sunspots Warming on Earth, CO_2 Produced by Warming, Means to Mitigate Temperature, Sunspots Induced by Jupiter, Tides on Solar Surface

1. Introduction

There is a widespread belief that the present steady increase of temperature on

Earth is due to the increase of the abundance of CO_2 molecules in the atmosphere, which produces a greenhouse effect. The generally accepted CO_2 based theory relies on two sets of data, 1) the temperature increases on the Earth (**Figure 1**), and 2) the CO_2 concentration increase in the atmosphere (**Figure 2**, from the NOAO Global Monitoring Observatory). The data shown in both figures come from well-known research centers.

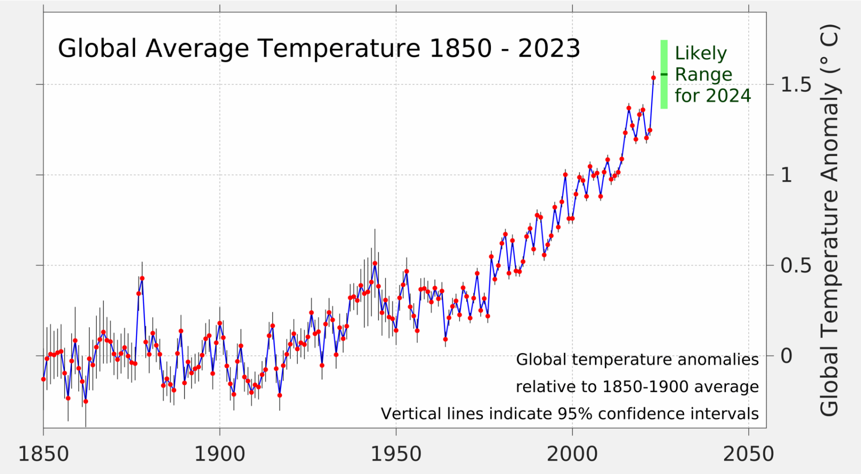


Figure 1. The variation of the surface temperature of the Earth, from years 1850 to 1923. (taken from https://berkeleyearth.org/global-temperature-report-for-2023/ [1]). The scale of the ordinate axis is adjusted by subtracting from each measurement a same value equal to the average temperature in the period 1850 to 1900. This provides a convenient scale for the plot.

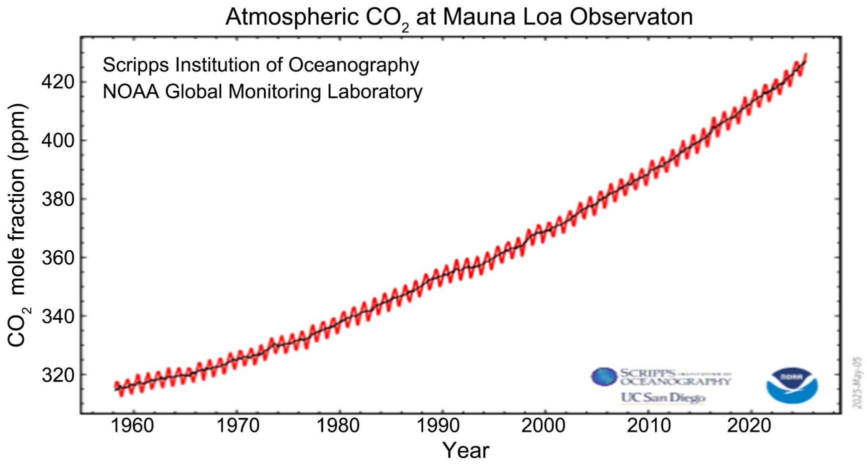


Figure 2. Variation of the concentration of CO_2 in the Earth atmosphere (data collected at Mauna Loa in Hawaii by the INOAAO Global Monitoring Laboratory).

In the period 1970 to 2024, a simultaneous growth of the two quantities occurred. This fact is the origin of the concern of the population and of a series of national or international initiatives to fight CO_2 emission. However, simultaneous growth does not necessarily mean that the content of CO_2 in the atmosphere is the main responsible for the heating. It can be the other way around, which is that, the heating by the Sun induces an increase of the CO_2 abundance. And also, there are processes that increase the abundance of CO_2 that do not depend on activities of humanity.

In this paper, we claim that the variations of the energy emitted by the Sun are the main cause of the temperature variations on Earth, and that a deep understanding of the sunspots is necessary to reach more predictability of the warm events.

2. The Need to Consider the Sunspots

A first superficial analysis of **Figure 1** and **Figure 2** tells that what is observed is not a strong correlation. The temperature is rising smoothly following a curve without irregularities, while the CO_2 abundance curve presents some maxima and minima. In the years 1940 to 1980, the temperature was about constant or even slightly decreasing while the CO_2 content of the atmosphere was growing.

It is also interesting to note that during the economic crisis associated with the COVID pandemic, in 2020-2022, air flights, use of cars, and many industries stopped. This did not produce any change in the slope of the rate of growth of CO_2 content of the atmosphere. These minor facts put under suspicion the idea that the excess heating is due to CO_2. It is not rare in scientific research, for instance, in medicine and economy, that interpretations of results are wrong, due to inversion of cause and effect.

The observations of the sunspots bring arguments in favor of the postulation, that the variations of the temperature of the atmosphere are not due to CO_2 abundance content. A detailed historical review of the discovery of the sunspots, and the history of a major cold period, the Maunder Minimum, and of another shorter one, the Dalton minimum, is presented in Appendix A. The results of this historical review are given in **Figure 3**.

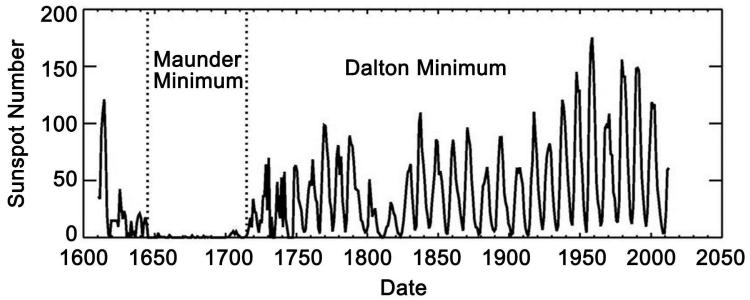


Figure 3. Successive maxima of the sunspots numbers for the period 1600 to 2010 (Hataway, D.H., 2010) [2].

These results should already be sufficient to demonstrate that there is a correlation between sunspot numbers and temperatures. It is, however, desirable to extend the study to a longer period. The fact that the number of sunspots has not been counted in epochs prior to 1600 could be a limitation.

Fortunately, scientific progress has provided a solution to the lack of sunspots counts before 1600. This advance comes from the analysis of the concentric rings inside trunks of old trees. The rings (see **Figure 4**) are due to the seasonal changes in weather conditions throughout the years. In cold climates, the growth of trees almost stops during winter and reaches a maximum during the summer. The trees grow in diameter and in number of rings. In several forests in Europe and in USA, it is possible to find tall trees (sequoias, oaks and others) that are around a thousand years old.

Figure 4. Example of a transversal cut of a tree, with concentric rings.

A type of analysis of the tree rings, which gives the best results was made by independent researchers, who collected samples of the wood in each ring of big trees, and submitted the samples to mass spectrometer accelerators. This permitted determining the relative amount of C_{13} to C_{12} carbon isotopes (**Figure 5**). Surprisingly, the C_{13} to C_{12} isotopes ratios in the rings of trees follow very closely the variations of the sunspot numbers (Brehm *et al.*, 2021) [3].

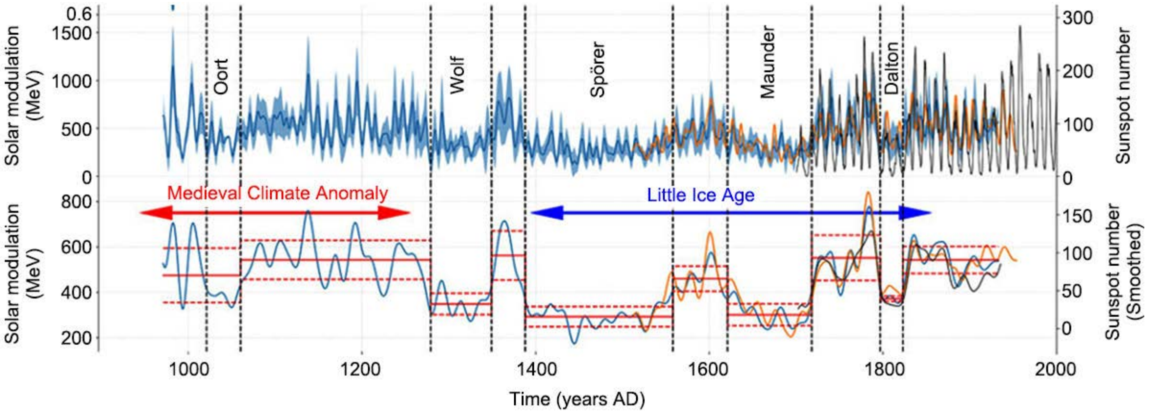


Figure 5. This figure, in the upper part, shows the sunspot activity with successive maxima, with total time coverage of one millennium (about years 980 to 2000), in blue color. This result comes from the analysis, the C13 to C12 abundance ratio. Part of the period covered by carbon isotope analysis coincides with the period in which direct star counts were available (in red, superimposed on the blue curve, to demonstrate the close agreement of the two methods). Since the number of sunspots and C13/C12 are in different units, a normalization factor has been applied to C13/C12. to match the blue curves to the red one during the epoch in which both were available. The curve of the lower part of the figure is the same data of the upper part, however, it has been smoothed, so that the 11 years cycles do not appear, which makes it easier to see the slower variations (part of a figure by Brehm *et al.*, 2021 [3]).

It is encouraging to see that a single normalization factor produced a good match of the two series of data (direct counts and C_{13}/C_{12} over the period of overlap). This means that we can consider the C_{13}/C_{12} ratio to be reliable to represent the number of spots before 1600 AC. Historical reports of temperatures in Europe in the past thousand years tell us that there was a long period of warm climate, from about 1100 to 1280, called the Medieval Warm Period (MWP). This epoch can be seen in **Figure 5** to have a generally high temperature level, with some fluctuations. On several occasions in that period, there were two harvests of cereals in a year. Then, the temperature became lower at the end of the MWP, and in 1300, in the Wolf minimum, the temperature is reported to have been extremely cold. **Figure 5** tells us that 1300 indeed corresponds to a minimum of sunspot activity.

Considering the number of coincidences that have already been listed above, not only of precise years for extreme cases, but also on duration of long-term tendencies, and the absence of anti-coincidences, no one can reject the conclusion that the sunspots activity has an influence on the temperature on the Earth (at least, in Europe). The temperature events that are mentioned from medieval eras or more recent ones can be found in texts written by historians (like Teodoneau, E., 2016 [4]), and there are no contradictions between historians. It must be noted that historical texts commented on here are limited to European ones.

3. The Nature of Sunspots and the Effect of Jupiter

The temporal analysis of the behavior of the sunspots and of the temperatures on the Earth made it clear the existence of a relation between them. Still, many readers will keep skeptic, because it does not seem logical to suppose that a few tiny dark spots on the surface of the Sun can produce such important disturbances on the Earth. The explanation of this apparent contradiction is that the human eyes are not good enough to reveal what is "behind" a sunspot. Our eyes are only able to detect light in a limited range of wavelength (around 400 to 700 nanometers). In this section, three images taken at different wavelengths are presented that reveal much larger sizes of active regions, compared to the visible sunspot part, and reveal the nature of their activity (**Figure 6**, **Figure 7(a)** and **Figure 7(b)**). For present purpose, these tree images are sufficient. The first image demonstrates that when the sunspots are not there (in an epoch of the minimum of the Solar cycle), all the remaining structures associated with the sunspots disappear. Consequently, the Solar wind also disappears.

It is beyond the scope of the present text to discuss the physics of the sunspots, not yet fully established. However, in a later section, a process that could stimulate the birth of sunspots is discussed.

The elongated structures of solar wind leaving the Sun are a starting point to understand why some regions of the Earth receive more excess of heat than others. The solar wind leaves the Sun divided into several beams. If one of these beams is directed towards the Earth, it will be captured by the magnetic field of the Van Allen Belts before penetrating the atmosphere of the Earth. This is the usual explanation for the boreal auroras.

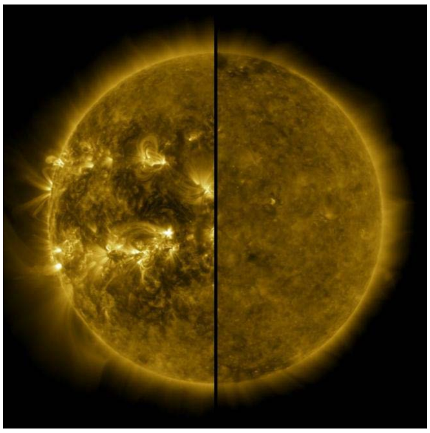
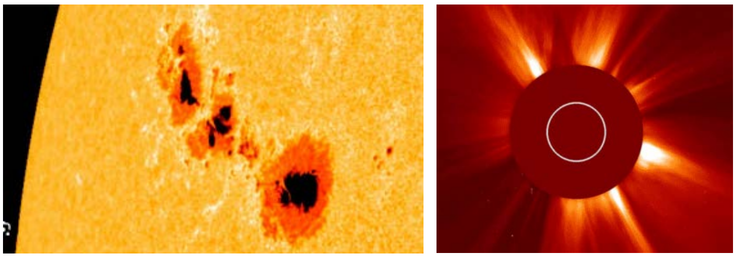


Figure 6. The image of the Sun, obtained in an extreme ultra-violet range of wavelengths, is divided into two halves, illustrating the Solar activity at two different times. On the left side, the Sun is shown during its maximum activity (or maximum spots numbers). The sunspots are, therefore, observable, on the left side. On the right side is the Sun at its minimum of activity, when there are no sunspots.



(a) (b)

Figure 7. (a) Three sunspots on the surface of the Sun. Note that the center is cold and appears in black, it is surrounded by hotter material (shown in orange color), and in a larger area, the white color indicates still hotter material. (b) The Sun itself is covered by a mask situated in the telescope to protect the equipment against excessive radiation (the brown disk). This allows the observation of elongated structures of the Solar wind leaving the Sun and reaching large distances (source: NASA Science).

The spacing in time between successive maximums of the number of sunspots is very regular, being 11.2 years, and this spacing (or period) has been maintained during so many years that even the cycles which reappeared after the Maunder minimum were in phase with the cycles that were observed just before that minimum. This regularity is surprising, since the interior of the Sun is known to host deep convection of matter, responsible for the transportation of energy from the interior to the surface. A convective ambience (as we know that it exists inside the Sun) would be turbulent and incompatible with regular oscillations. We are inclined, therefore, to look for interactions with another body situated outside the solar interior, to regulate the frequency. The nearest massive planet of the solar system is Jupiter, which has a period of 11.8 years, close to the sunspot period. This turns it an interesting candidate, which deserves some attention.

The mass of Jupiter is 1.9×10^{27} kg and that of the Sun is 1.99×10^{30} kg, a difference of a factor 1000. Many astronomers will reject the possibility of measurable gravitational perturbation of the Sun by Jupiter, due to this enormous difference in mass. But, maybe, it is possible to proceed with this line of thought, by considering that the needed perturbation is not at the center of mass of the Sun, but only on a thin layer of gas of the solar atmosphere, in the boundary of the Sun. The perturbation must occur in the region of the closest approach of Jupiter, which is in the plane of the equator of the Sun. Galileo determined the rotation period of the sun, 28 days, by observing the sunspots. Later, it was discovered that the rotation period changes with the latitude, that is, the Sun presents differential rotation. The rotation period is 25.67 days at the equator and 33.40 days at 75 degrees of latitude.

Due to this rotation, the Sun has a larger radius at the equator, like the Earth. And, like the Earth, the Sun has a smaller equivalent gravitational force directed towards its center, in the region of the equator, due to the centrifugal force. Adopting the reasonable hypothesis that the form of interaction of Jupiter with the Sun is just to produce a pull on a thin layer of gas, this will be a short duration pull occurring during the closest approach. This gravitational attraction by Jupiter resembles, in some way, with the attraction of the Earth's sea water by the Moon, which is the explanation for the tides on the Earth. In both cases, we are thinking in terms of a thin layer of matter suffering the external attraction, and we get a periodic variation. So, let us think that there is a phenomenon of transport of matter along the surface of the Sun that we will call a tide. The center of the tide on the Earth is the place where the sea reaches the highest level of water, and on the Sun, it could be the local with a thicker amount of gas. We can also imagine that the local with a thicker amount of gas is the place where the sunspots can form, because the sunspots are structures with relatively large depths. Only minor sunspots could be formed, or survive, in locals where the tide has smaller amplitude. In this model, the sunspots would reach a maximum quantity every 11 years, in successive passages of Jupiter.

This is only a toy model, which does not enter in the full complex physics of the sunspots, but it could stimulate astronomers to consider models that consider the role of Jupiter and to look for additional correlations between sizes and shapes, positions and lifetimes of sunspots, which have not yet been fully explored. More attention could be given to measurements of the direction of the spin axis of the Sun (perpendicular to the plane of the equator), and, maybe, to establish a precession period of its spin axis, like we have for the Earth' spin axis. Jupiter's orbit is tilted by 6.09° to the Sun's equator (Wikipedia). The point of closer approach between Jupiter and the Sun is a point that moves on the surface of the Sun; the variations in the orientation of the spin axis may produce slow changes in the number of sunspots produced, and on the time separation of sunspots maxima. An attempt to propose more detailed calculations beyond the scope of this work.

4. Causes of the Increase of the Amount of CO_2 in Earth Atmosphere

Since we have proved that the heating of the atmosphere of Earth is due to the

Sun, we must consider another aspect of the discussion: what, then, produces changes in the CO_2 abundance present in the atmosphere? There are certainly other processes, besides the human activities, that produce CO_2. Some of these reasons are related to the increase of temperature caused by the Sun (heating produces CO_2).

One obvious example is the release of CO_2 by forest fires, which are more frequent when the temperature is high. Let us attempt to estimate the emission of CO_2 from forest fires. The weight of carbon contained in a tree is about 50% of the total weight of the tree. A fire can be described as the combination of carbon with the oxygen of the air, to form CO_2. To go further in estimating the effects of the fires, we are forced to go through uncertain values found in Wikipedia. The average weight of a tree is 1 ton, which means 0.5 ton of carbon, and the average density of trees in forests is about 10,000 per square kilometer. The mass of CO_2 is 3.6 times the mass of the pure carbon that formed it, (counting the mass of all the atoms). The largest errors in the estimate come from the next step: what is the number of forest fires and the area affected by them, on the Earth, in one year. Enormous wildfires are common in different states of USA (Washington, Oregon, Texas, Florida), and in other places: in Canada, Australia, Amazon Rainforest, in Siberia, Indonesia.

The European community and USA keep reports on the number of fires and their areas, which happen every year. However, of course, only big fires are recorded. It is impossible to record all the small fires, which are more frequent. We will not show any calculation, but our certainty is that there is much more emission by these processes than by human economic activities. The official number for the human activities is of the order of 40 billion tons of CO_2 released annually, largely due to the burning of fossil fuel. We can make the hypothesis that the total area of the fires per year is equivalent to the area of Australia (7.6 million km^2), that in a forest there are 10,000 trees per km^2, each representing 0.5 ton of carbon and so it could be stated that the fires of forests produce more CO_2 than the human activities. The quality of such estimates, however, is poor.

In about two years after a fire, most of forests that burned are growing again, and consuming CO_2 to produce trees. How to count this?

Another strong contributor to the balance of CO_2 content in the atmosphere is the immense area covered by the oceans. Most articles in the literature discussing the role of the oceans mention them as stabilizers of the climate on Earth. In laboratory measurements, if we increase the temperature of a volume of pure water which contains CO_2 solved in it (as all the normal water contains), you get a release of CO_2, since the maximum amount of CO_2 in water decreases with temperature. It would not be difficult to estimate the amount of CO_2 released by the oceans when there is a 0.1˚ increase in temperature in one year. An uncertainty is the depth of water to be considered. For a depth of 30 m, the amount of CO_2 produced is greater than the production of humanity. We will not present such results because there are other paths to be considered. CO_2 combines with plankton (specifically phytoplankton) and is part of the source of calcium carbonate ($CaCO_3$).

Several specialists (Woods Hole Oceanographic Institution) argue that the carbonate-rich products sink large depth of in the oceans. So, the role of the oceans is more to remove CO_2 from the atmosphere than to emit CO_2. The two CO_2 sources that we discussed are more examples of how useless it is to do calculations of this type.

There are huge quantities of CO_2 being exchanged in one direction and in the other. In a recent paper, M. Nishioka (2025) [5] states that during the warm epochs, there is an increase of the CO_2 emission due to an increase of soil respiration. This is another example of a process in which the CO_2 emission is a consequence of warming, not the reverse.

Any important cause of warming that is not due to CO_2 produced by the human activities should be taken into account to better understand the full problem. For instance, the volcanic activity of volcanoes situated under the water in the oceans is certainly important, but difficult to estimate.

So the only conclusion that can be reached is that the amounts of CO_2 that are processed in emission or in absorption by the natural phenomena are orders of magnitudes larger than the processes controlled by human activities. It is then derisory to make efforts to decrease the emissions produced by the activities of humanity. This will not change the point of equilibrium that exists presently between the natural phenomena.

5. Conclusions

We presented a view of the global changes of the climate, quite different from the one that is commonly adopted by the media in general. The Sun is passing at this moment a slightly warmer phase compared to previous decades. This situation must be recognized as being intrinsic to the Sun. The only reasonable expectation that we can have is that the Sun will come back to its average emission intensity in at most a few years. This conclusion is based on the study of the curves of variations of solar temperature for a quite long historical period. The hot weather at the present time is within the range of the maxima that happened in the past. Some authors declare that the present temperature is the highest of many thousands years, but there is no sufficient scientific basis to reach such conclusions; the only sufficiently precise methods to estimate the epoch and the intensity of heating events are the ones based on analyses of tree rings, which do not reach longer times than about a thousand years in the past.

Despite the reasonable arguments given above that the Sun will come back to the emission of energy of the past decades, many readers would like to have more long-term security. What can be said is that if such improbable high temperature events occur, humanity will have means to protect itself. A recommendation would be that instead of fighting the CO_2 content of the atmosphere, it would be better to spend public funds with more efficient solutions, going to the cause of the warming. There are a few solutions that can be recommended here. For instance, a solution is to decrease the amount of solar energy absorbed by the surface of the Earth, which is the same as increasing the amount of energy reflected to space. Without reflection, the solar heat is dissipated where it reaches the ground. As an example, the solution adopted by some cities, in the Middle East or in North Africa, is to paint all houses in white color. This is quite efficient, because the white color reflects a large fraction of the incoming energy. To better explain this concept, compare, for example, a white car and a black car exposed to the solar light. The black car will become much hotter than the white one. The black car will later re-irradiate, in the form of infrared radiation, the energy that it had previously absorbed, and will heat the objects and the air around it. It is the experience of people who painted their roofs white that the temperature inside the house decreased several degrees. A plan to decrease the temperature in a big city could include painting the roofs of the buildings, or the entire buildings, in white, and choosing a type of asphalt not totally black as usual, but with a clearer color. Many trees should be planted, preferably selecting trees which have better reflection coefficients for the short wavelength light. These initiatives would be sufficient to break the temperature increase. The life of human beings can also be made more comfortable by using underground areas. In a few modern cities, like Montreal in Canada, the population has many activities, like supermarkets and all types of commercial shops, below the ground. In some ways, too hot weather and too cool weather can be combated with similar solutions.

The strong urbanization of the last decades, with the expansion of big cities and construction of many roads with dark asphalt, could be one of the factors that increased the temperature in a few countries.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix

Detailed history of the Sunspots discovery, and the Maunder minimum

In 1610, the famous physicist Galileu reported for the first time the discovery of sunspots made with an astronomical telescope he had built, which led to many discoveries. Some observations were made 2 years before, with previous versions of telescopes. On the Sun, he noticed the presence of small dark spots, now known as sunspots. He himself, as well as some followers, began to observe frequently the spots (note that it is harmful to the human eyes to observe the Sun with a telescope without the protection of a filter; this is probably the reason why Galileo went blind some years later). Galileo noticed that the spots all moved in the same direction and then determined the period of rotation of the Sun around its axis, which he found to be 28 days. He also noticed that some spots disappeared, and some others appeared. Counting the number of sunspots that were present on the solar disk on different days, he and his assistants found that this number increases and then decreases slowly and continuously in a kind of cycle, going from zero sunspots at the minimum to about 2 dozens at the maximum, then going back to the minimum, and starting another cycle.

After a few decades of observations of the sunspots, an extraordinary phenomenon occurred. The sunspots practically disappeared completely around 1645, and remained absent for a long time, only returning around 1715. They returned gradually, following a cycle of several years, as before, with a greater number of sunspots in each successive cycle. Only then was it possible to establish that the cycle of the number of sunspots, from one maximum to the next, has a duration of 11 years and does not depend on the amplitude. The important fact is that the number of sunspots vary, but the duration of the cycle remains constant. The English scientist Maunder who lived from 1851 to 1929, was one of the first to study systematically the irregularities of solar cycles. He identified the total interval of the years 1645 to 1715 as an epoch during which the number of spots was extremely small; this epoch is now called the Maunder Minimum (name given by J.A. Eddy, 1976 [6]). In his investigations, Maunder chose arbitrarily a time interval of 28 years (from 1672 to 1699), near the middle of the Maunder minimum, to perform a more detailed investigation of sunspots numbers. Fewer than 50 spots appeared during this entire interval of time, whereas in the same number of years in normal times, between 40,000 and 50,000 sunspots would have appeared. But still, the sunspots maximums did not disappear completely even in this sample of time chosen in the middle of the Maunder period.

The sunspots numbers as a function of time since 1610 are shown in the main text, in **Figure 3**.

During the Maunder period, the temperature was extremely cold in Europe. This period is also often called the Little Ice Age. In London, the river Thames froze in several winters and made it possible to hold fairs on the river, as the layer of ice was around 25 cm thick. These fares were called “Frost Fairs”. The first great Frost Fair took place in 1608, with barbers, shoemakers, fruit sellers, pubs, etc., having their activities on the ice of the river. That year was just before the announcement of the discovery of the sunspots by Galileo, but the number of sunspots was already small, slowly reaching the Maunder minimum. The second great Frost Fair on the Thames took place in the winter of 1683-1684, with many sporting activities and competitions, including football, in addition to trading activities.

The year 1709, near the end of the Maunder period, was the most terribly cold of all, the coldest recorded in 500 years in France. Thousands of people died, due to poverty and hunger. Even in the Palace of Versailles, a somewhat protected place, several nobles of the court died. The wine froze in King's Louis XIV's glass on the dinner table.

The last great Frost Fair on the River Thames took place in 1814. This date is not within the Maunder period, but another minimum of sunspots can be seen in **Figure 3**, called the Dalton minimum. In this period, very low temperatures occurred. In 1820, a very rigorous winter occurred from England to Italy, and all the major rivers of Europe froze (Sena, Saone, Rhine, Danube, Garonne, Thames, Arno, Venice lagoon). Researchers say that for more than a century such a rigorous and long winter had not been seen [4].

The Dalton minimum constitutes an example of association of small sunspots numbers and very cold temperatures, independent of the Maunder minimum.