How Strongly Does the Sun Influence the Global Climate?

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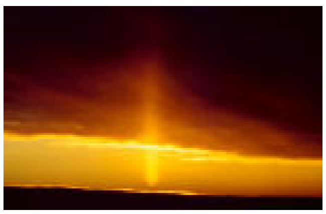

Studies at the Max Planck Institute for Solar System Research reveal: solar activity affects the climate but plays only a minor role in the current global warming

Since the middle of the last century, the Sun is in a phase of unusually high activity, as indicated by frequent occurrences of sunspots, gas eruptions, and radiation storms. Researchers at the Max Planck Institute for Solar System Research (MPS) in Katlenburg-Lindau (Germany) and at the University of Oulu (Finland) have come to this conclusion after they have succeeded in reconstructing the solar activity based on the sunspot frequency since 850 AD. To this end, they have combined historical sunspot records with measurements of the frequency of radioactive isotopes in ice cores from Greenland and the Antarctic. As the scientists have reported in the renowned scientific journal, Physical Review Letters, since 1940 the mean sunspot number is higher than it has ever been in the last thousand years and two and a half times higher than the long term average.

The temporal variation in the solar activity displays a similarity to that of the mean temperature of the Earth. These scientific results therefore bring the influence of the Sun on the terrestrial climate, and in particular its contribution to the global warming of the 20th century, into the forefront of current interest. However, researchers at the MPS have shown that the Sun can be responsible for, at most, only a small part of the warming over the last 20-30 years. They took the measured and calculated variations in the solar brightness over the last 150 years and compared them to the temperature of the Earth. Although the changes in the two values tend to follow each other for roughly the first 120 years, the Earth's temperature has risen dramatically in the last 30 years while the solar brightness has not appreciably increased in this time.

Astronomers have regularly observed sunspots since the invention of the telescope in the early 17th century. These are areas on the surface of the Sun where energy flow from the interior is reduced due to the strong magnetic fields that they exhibit. As a result, these regions cool by about 1500° and thus appear relatively darker than their surroundings at 5800°. The number of sunspots varies over an 11-year activity period, which in turn is subject to longer term variations. For example, in the second half of the 17th century, there were hardly any sunspots at all.

The German-Finnish research team has now applied a new method to obtain insight into the development of the sunspot number from before the beginning of direct records. In addition, these experts have analyzed measured abundances of beryllium-10 in ice cores from Greenland and the Antarctic. This radioactive isotope is created when energetic particles in cosmic rays enter the Earth's atmosphere and split atomic nuclei of nitrogen and oxygen. Beryllium-10 (half-life 1.6 million years) is a product of this decay process, which is then washed out of the atmosphere by precipitation and then deposited in layers in the polar ice

fields. Since the cosmic rays are partially deflected by the solar magnetic field filling interplanetary space, the production rate of Beryllium-10 in the atmosphere varies with the strength of this magnetic field, which in turn is associated with the number of sunspots.
A comparison of the Beryllium-10 data with the historical records of sunspot numbers reveals a high degree of correlation. Thus it was possible for the researchers to test and calibrate this new reconstruction method. The solar research team has managed, for the first time, to substantiate with consistent physical models every link in the complex chain, from the isotope abundance in the ice back to the sunspot number. This includes the creation of Beryllium-10 by cosmic rays, the modulation of the cosmic rays by the interplanetary magnetic field, and finally the relationship between the solar magnetic field and the number of sunspots. In this way it was possible for the scientists to obtain, for the first time, a reliable, quantitative determination of the sunspot numbers even for times before direct measurements were made.

These data show clearly that the Sun is in a state of unusually high activity, for about the last 60 years. The time interval for which this statement can be made has been tripled by these new investigations, for now the reconstructed sunspot numbers extend back to 850 AD. Another period of enhanced solar activity, but with substantially fewer sunspots than now, occurred in the Middle Ages from 1100 to 1250. At that time, a warm period reigned over the Earth, as the Vikings established flourishing settlements in Greenland.
The Sun affects the climate through several physical processes: For one thing, the total radiation, particularly that in the ultraviolet range, varies with solar activity. When many sunspots are visible, the Sun is somewhat brighter than in "quiet" times and radiates considerably more in the ultraviolet. On the other hand, the cosmic ray intensity entering the Earth’s atmosphere varies opposite to the solar activity, since the cosmic ray particles are deflected by the Sun’s magnetic field to a greater or lesser degree. According to a much discussed model proposed by Danish

researchers, the ions produced by cosmic rays act as condensation nuclei for larger suspension particles and thus contribute to cloud formation. With increased solar activity (and stronger magnetic fields), the cosmic ray intensity decreases, and with it the amount of cloud coverage, resulting in a rise of temperatures on the Earth. Conversely, a reduction in solar activity produces lower temperatures.

Two scientists from the MPI for Solar System Research have calculated for the last 150 years the Sun’s main parameters affecting climate, using current measurements and the newest models: the total radiation, the ultraviolet output, and the Sun’s magnetic field (which modulates the cosmic ray intensity). They come to the conclusion that the variations on the Sun run parallel to climate changes for most of that time, indicating that the Sun has indeed influenced the climate in the past. Just how large this influence is, is subject to further investigation. However, it is also clear that since about 1980, while the total solar radiation, its ultraviolet component, and the cosmic ray intensity all exhibit the 11-year solar periodicity, there has otherwise been no significant increase in their values. In contrast, the Earth has warmed up considerably within this time period. This means that the Sun is not the cause of the present global warming.

These findings bring the question as to what is the connection between variations in solar activity and the terrestrial climate into the focal point of current research. The influence of the Sun on the Earth is seen increasingly as one cause of the observed global warming since 1900, along with the emission of the greenhouse gas, carbon dioxide, from the combustion of coal, gas, and oil. "Just how large this role is, must still be investigated, since, according to our latest knowledge on the variations of the solar magnetic field, the significant increase in the Earth’s temperature since 1980 is indeed to be ascribed to the greenhouse effect caused by carbon dioxide," says Prof. Sami K. Solanki, solar physicist and director at the Max Planck Institute for Solar System Research.

Original work:

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Source: Max Planck Society