Researchers show new Ice Age may begin by 2030

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In this 1677 painting by Abraham Hondius, "The Frozen Thames, looking Eastwards towards Old London Bridge," people are shown enjoying themselves on the ice. Credit: Museum of London

The arrival of intense cold similar to the weather that raged during the

"Little Ice Age", which froze the world during the 17th century and in the beginning of the 18th century, is expected in the years 2030 to 2040. These conclusions were presented by Prof. V. Zharkova (Northumbria University) during the National Astronomy Meeting in Llandudno in Wales by an international group of scientists, which also includes Dr. Helen Popova of the Skobeltsyn Institute of Nuclear Physics and of the Faculty of Physics of the Lomonosov Moscow State University, professor Simon Shepherd of Bradford University (UK) and Dr Sergei Zharkov of Hull University (UK).

It is known that the Sun has its own magnetic field, the amplitude and spatial configuration of which vary with time. The formation and decay of strong magnetic fields in the solar atmosphere results in changes of electromagnetic radiation from the Sun, of the intensity of plasma flows coming from the Sun, and the number of sunspots on the Sun's surface. The study of changes in the number of sunspots reveals an 11-year cyclic structure that affects the Earth's environment, as the analysis of carbon-14, beryllium-10 and other isotopes in glaciers and in trees showed.

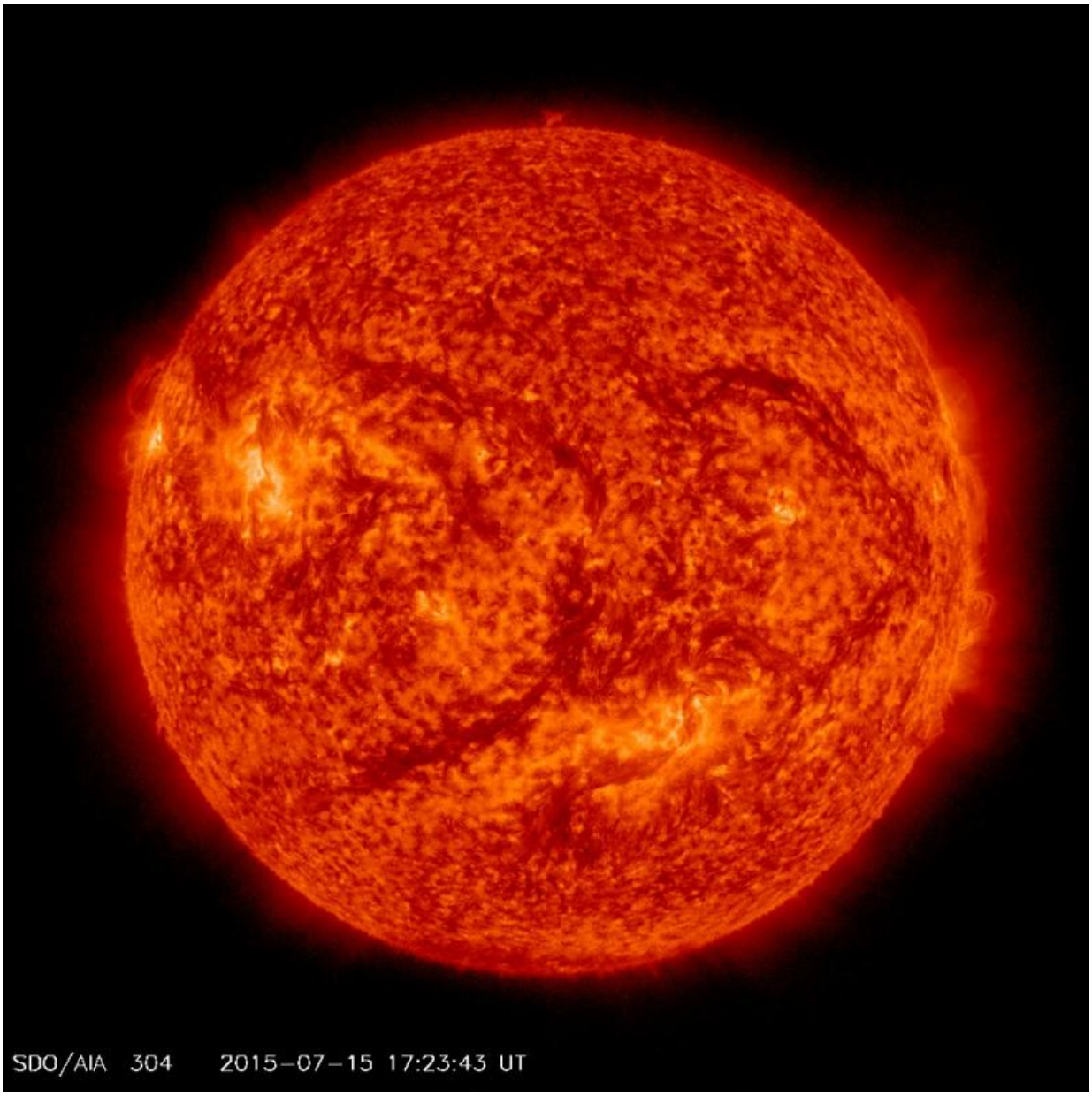
There are several cycles with different periods and properties; the 11-year cycle and the 90-year cycle are the best known of them. The 11-year cycle appears as a cyclical reduction in sunspots every 11 years. Its 90-year variation is associated with periodic reduction in the number of spots in the 11-year cycle from 50 percent to 25 percent. But in the 17th century, there was a prolonged period of solar activity called the Maunder minimum, which lasted roughly from 1645 to 1700. During this period, there were only about 50 sunspots instead of the usual 40 to 50 thousand sunspots. Analysis of solar radiation showed that its maxima and minima almost coincide with the maxima and minima in the number of spots.

In the current study, published in three peer-reviewed papers, the

researchers analyzed a total background magnetic field from full disk magnetograms for three cycles of solar activity (21-23) by applying the so-called "principal component analysis", which reduces the data dimensionality and noise and identifies waves with the largest contribution to the observational data. This method can be compared with the decomposition of white light on the rainbow prism revealing waves of different frequencies. As a result, the researchers developed a new method of analysis, which helped to uncover that the sun's magnetic waves are generated in pairs, with the main pair covering 40 percent of variance of the data (Zharkova et al, 2012, *MNRAS*). The principal component pair is responsible for the variations of a dipole field of the sun, which is changing its polarity from pole to pole during 11 year solar activity.

The magnetic waves travel to the Northern hemisphere (odd cycles) or to Southern hemisphere (even cycles), with the phase shift between the waves increasing with a cycle number. The waves interact with each other in the hemisphere where they have maximum (Northern for odd cycles and Southern for even ones). These two components are assumed to originate in two different layers in the solar interior (inner and outer) with close, but not equal, frequencies and a variable phase shift (Popova et al, 2013, *AnnGeo*).

The scientists derived the analytical formula describing the evolution of these two waves and calculated the summary curve linked to the variations of sunspot numbers, the original proxy of solar activity when using the modulus of the summary curve (Shepherd et al, 2014, *ApJ*). By using this formula, the scientists made the prediction of magnetic activity in cycle 24, which gave 97% accuracy in comparison with the principal components derived from the observations.



This image of the sun was taken by NASA Solar Dynamics Observations mission on July 15, 2015, at a wavelength of 304 Angstroms. Credit: NASA Solar Dynamics Observations

Inspired by this success, the authors extended the prediction of these two magnetic waves to the next two cycle 25 and 26 and discovered that the

waves become fully separated into the opposite hemispheres in cycle 26 and thus have little chance of interacting and producing sunspot numbers. This will lead to a sharp decline in solar activity during the years from 2030 to 2040, comparable with the conditions that existed during the previous Maunder minimum in the XVII century, when there were only about 50 to 70 sunspots observed instead of the usual 40 to 50 thousand.

The new reduction of the solar activity will lead to reduction of the solar irradiance by $3W/m^2$, according to Lean (1997). This previously resulted in significant cooling of Earth and very severe winters and cold summers. "Several studies have shown that the Maunder Minimum coincided with the coldest phase of global cooling, which was called 'the Little Ice Age.' During this period, there were very cold winters in Europe and North America. In the days of the Maunder minimum, the water in the river Thames and the Danube River froze, the Moscow River was covered by ice every six months, snow lay on some plains year round, and Greenland was covered by glaciers," says Dr. Helen Popova, who developed a unique physical-mathematical model of the evolution of the magnetic activity of the sun and used it to derive the patterns of occurrence of global minima of solar activity and gave them a physical interpretation.

If a similar reduction is observed during the upcoming Maunder minimum, this can lead to a similar cooling of the Earth's atmosphere. According to Dr Helen Popova, if the existing theories about the impact of solar activity on the climate are true, then this minimum will lead to a significant cooling, similar to the one that occurred during the Maunder minimum.

However, only time will tell (within the next 5 to 15 years) if this will happen.

"Given that our future minimum will last for at least three solar cycles, which is about 30 years, it is possible, that the lowering of the temperature will not be as deep as during the Maunder minimum. But we will have to examine it in detail. We keep in touch with climatologists from different countries. We plan to work in this direction," Popova said.

The notion that solar activity affects the climate appeared long ago. It is known, for example, that a change in the total quantity of the electromagnetic radiation by only 1 percent can result in a noticeable change in the temperature distribution and air flow all over the Earth. Ultraviolet rays cause photochemical effects, which lead to the formation of ozone at an altitude of 30 to 40 km. The flow of ultraviolet rays increases sharply during chromospheric flares from the sun. Ozone, which absorbs the sun's rays well enough, is being heated, and it affects the air currents in the lower layers of the atmosphere and, consequently, the weather. Powerful emission of corpuscles, which can reach the Earth's surface, arise periodically during high solar activity. They can move in complex trajectories, causing aurorae, geomagnetic storms and disturbances of radio communication.

By increasing the flow of particles in the lower atmospheric layers, air flows of meridional direction enhance warm currents from the south with an even greater energy rush in the high latitudes and cold currents, carrying Arctic air deeper southward. In addition, the solar activity affects the intensity of fluxes of galactic cosmic rays. The minimum activity streams become more intense, which also affects the chemical processes in the Earth's atmosphere

The study of deuterium in the Antarctic showed that there were five global warmings and four Ice Ages during the past 400 thousand years. An increase in the volcanic activity comes after the Ice Age and it leads to greenhouse gas emissions. The magnetic field of the Sun grows, which

means that the flux of cosmic rays decreases, increasing the number of clouds and leading to the warming again. Next comes the reverse process, when the magnetic field of the sun decreases and the intensity of cosmic ray rises, reducing the clouds and making the atmosphere cool again. This process comes with some delay.

Dr Helen Popova responds cautiously, while speaking about the human influence on climate.

"There is no strong evidence that global warming is caused by human activity. The study of deuterium in the Antarctic shows that there were five global warmings and four Ice Ages during the past 400 thousand years. People first appeared on the Earth about 60 thousand years ago. However, even if human activities influence the climate, we can say that the sun with the new minimum gives humanity more time or a second chance to reduce their industrial emissions and to prepare for the sun's return to normal activity, Popova summarized.

Provided by Lomonosov Moscow State University

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