Press Release

GEOMAR
Helmholtz-Zentrum für Ozeanforschung Kiel

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Sun Controlled Climate During Ice Ages
Irregularities of solar activity affected the climate 20,000 years ago

04th of September 2014 / Kiel. In a model study, researchers from the GEOMAR Helmholtz Centre for Ocean Research Kiel reconstructed the relationship between solar activity and climate during the last ice age. Their chemistry climate model contributed significantly to a study by the Swedish Lund University, which has now been published in Nature Geoscience.

A well-known behavior pattern of the sun is its irregular solar activity. The most prominent activity cycle of the sun is the eleven-year sunspot cycle, where sunspot maxima and minima alternate every eleven years. But there are also other known solar variations on different time scales. Sunspots are areas on the surface of the sun that appear dark because they emit sunlight with reduced luminosity. At the same time, high-energy radiation, especially in the UV range, leaves the sun. During sunspot minima, there are fewer sunspots and therefore less solar UV radiation arrives at the Earth. The opposite is true during solar maxima.

More solar radiation, especially in the UV range, during solar maximum leads to a warming of the stratosphere (between 15 and 50 km) in the tropics and to increased ozone production. This in turn, via complex interaction mechanisms, leads to circulation changes in the atmosphere which are also felt on the Earth's surface. The mechanisms of how such changes in solar activity affect the atmosphere, however, are still subject of ongoing research. In particular, there is speculation whether or not the sun spot minima are connected to cold, snowy winters, or if the currently lower solar activity might be responsible for the pause in global warming.

Scientists from Lund University (Sweden), in cooperation with the GEOMAR climate scientists Prof. Dr. Katja Matthes and Dr. Rémi Thiéblemont, have succeeded in reconstructing the solar activity back to the last ice age. The study was published in August in *Nature Geoscience*.

Ice cores from Greenland were used to gain insight into the solar activity at a time when Sweden and northern Germany were under a thick layer of ice. The analysis works in principle like for tree rings: The ice core reveals various layers that contain information on temperature and precipitation conditions. The radioactive molecules of beryllium and carbon play an important role because they occur in the atmosphere only when the magnetic field around the earth is too weak and too much cosmic radiation is allowed to pass through. Therefore, the presence of excessive radioactive beryllium and carbon in the ice core is indicative of a weak protective layer and thus low solar activity.

A combined analysis of ice cores and speleothems by scientists at Lund University allowed a reconstruction of solar activity back to the end of the last ice age. They showed that the eleven-year sunspot cycle also existed at that time and obviously represents a typical pattern of solar activity. "For the first time we were able to document a high-resolution record of solar activity," says Prof. Matthes. "Using our climate model, which includes the transfer of the solar signal from the stratosphere to the ground more accurately than other models, we were able to reconstruct the atmospheric circulation patterns typical for a sunspot minimum. We therefore gain information on

possible temperature and precipitation conditions over Greenland, which closely reflect the conditions at the end of the last ice age. The agreement is impressive and suggests that the mechanism underlying the effect of solar activity on climate at that time and today is very similar."

The results confirm the evidence from other studies that years with low solar activity might be associated with severe winters in the northern hemisphere. One example are the strong winters, coupled with severe snowfall and storms, which we experienced in northern Europe and North America in 2008 and 2010. Those years were also characterized by a sunspot minimum.

"The effect of solar activity on regional climate variability is very revealing. Estimates of future solar activity could lead to more accurate climate predictions within the next decades," explains Prof. Matthes.

Original publication:
Adolphi, F., R. Muscheler, A. Svensson, A. Aldahan, G. Possnert, J. Beer, J. Sjolte, S. Björck, K. Matthes, R. Thiéblemont (2014): Persistent link between solar activity and Greenland climate during the Last Glacial Maximum, *Nature Geoscience*, http://dx.doi.org/10.1038/NGEO2225

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