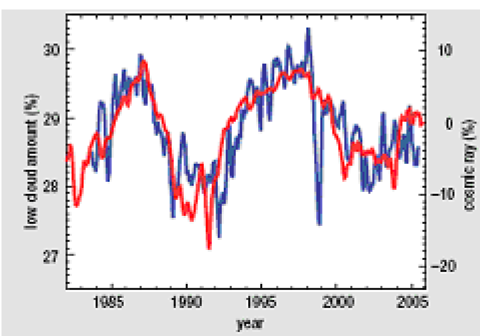
A brief summary of cosmoclimatology

Summary of a review article on cosmoclimatology by Henrik Svensmark, Danish National Space Center, published in Astronomy & Geophysics, February 2007.

In the article the leader of Sun-climate research at the Danish National Space Center, Henrik Svensmark, puts together the findings reported by him and his colleagues in a dozen scientific papers, to tell how the climate is governed by atomic particles coming from exploded stars. These cosmic rays help to make ordinary clouds. High levels of cosmic rays and cloudiness cool the world, while milder intervals like the warming in the 20th Century occur when cosmic rays and cloud cover diminish. Here are some of the salient points of the article:

A secure scientific base

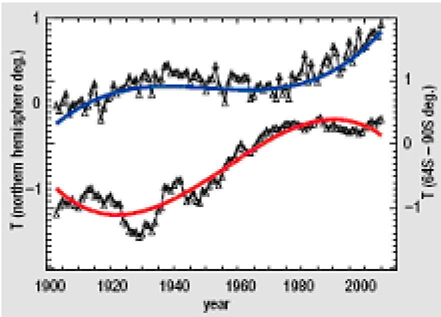


1. Red depicts cosmic-ray intensities and blue, the low-level cloudiness.

For more than 20 years, satellite records of low-altitude clouds have closely followed variations in cosmic rays (diagram 1). Just how cosmic rays take part in cloud-making appeared in the SKY experiment, conducted in the basement of the Danish National Space Center. Electrons set free in the air by passing cosmic rays help to assemble the building blocks for cloud condensation nuclei on which water vapour condenses to make clouds (note 1).

Note 1: See also DNSC press release 'Getting closer to the cosmic connection to climate,' 4 October 2006.

Evidence that the Earth's climate really responds to variations in cloud cover comes from Antarctica. When the rest of the world warms up, the southern continent tends to cool down, and vice versa (diagram 2). This contrary behaviour is predictable, because clouds have an unusual warming effect over Antarctica.



2. Upper curve shows temperature changes in the Northern Hemisphere, and the lower curve, changes in the Antarctic region.

Cosmic ray intensities – and therefore cloudiness – keep changing because the Sun's magnetic field varies in its ability to repel cosmic rays coming from the Galaxy, before they can reach the Earth. Radioactive carbon-14 and other unusual atoms made in the atmosphere by cosmic rays provide a record of how cosmic-ray intensities have varied in the past. They explain repeated alternations between cold and warm periods during the past 12,000 years. Whenever the Sun was feeble and cosmic-ray intensities were high, cold conditions ensued, most recently in the Little Ace Age that climaxed 300 years ago.

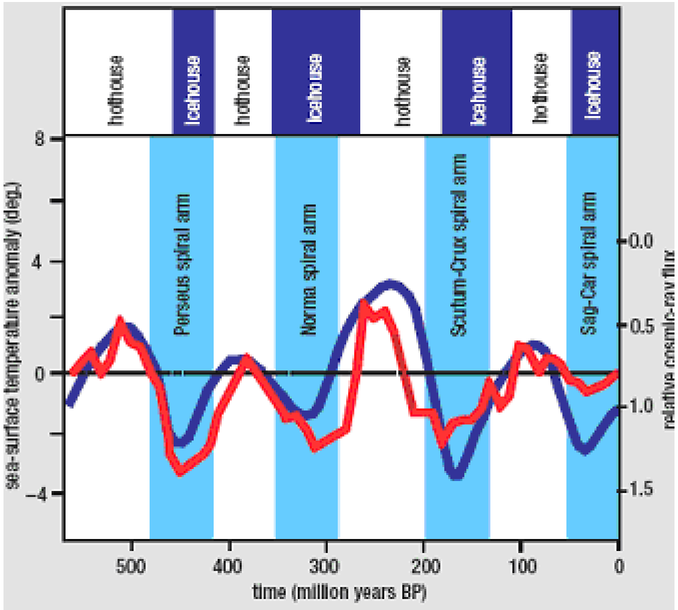
Events around 40,000 years ago posed a difficulty for the new theory. Cosmic rays intensified dramatically then, because the Earth's magnetic field weakened, but no perceptible cooling resulted. Calculations now show that the cosmic rays involved in cloud formation at low altitudes are produced by particles coming from the Galaxy with such high energy that the Earth's magnetism scarcely affects them.

'From this secure base,' Dr Svensmark writes in Astronomy & Geophysics, 'we can broaden the horizons of space and time to consider the relevance of cosmic rays to climate change since the Earth was young.'

Climate change during the Earth's history

On long timescales the intensity of cosmic rays varies more emphatically because the influx from the Galaxy changes. During the past 500 million years the Earth has passed through four 'hothouse' episodes, free of ice and with high sea levels, and four 'icehouse' episodes like the one we live in now, with ice-sheets, glaciers and relatively low sea levels.

Nir Shaviv of the Hebrew University in Jerusalem, together with Ján Veizer of the Ruhr University and the University of Ottawa, links these changes to the journey of the Sun and the Earth through the Milky Way Galaxy. They blame the icehouse episodes on encounters with bright spiral arms, where cosmic rays are most intense (diagram 3).



3. The red curve shows changes in tropical sea-surface temperatures over the past 500 million years. In the blue curve, drawn upside down to match, cosmic-rays intensities have varied according to our position relative to the Galaxy's spiral arms. After Shaviv and Veizer.

More frequent chilling events, every 34 million years or so, occur whenever the solar system passes through with the mid-plane of the Galaxy. Dr Svensmark has used the climate records to improve our knowledge of important astronomical details about the Milky Way (note 2).

Note 2: See also DNSC press release 'The microscopic hitchhiker's guide to the Galaxy,' 15 November 2006.

In Snowball Earth episodes around 700 and 2300 million years ago, even the Equator was icy. At those times the birth-rate of stars in the Galaxy was unusually high, which would have also meant a large number of exploding stars and intense cosmic rays. Earlier still, the theory of cosmic rays and clouds helps to explain why the Earth did not freeze solid when it was very young. The Sun was much fainter than it is now, but also more vigorous in repelling cosmic rays, so the Earth would not have had much cloud cover.

While calculating the changing influx since life began about 3.8 billion years ago, Dr Svensmark discovered a surprising connection between cosmic-ray intensities and a variability of the productivity of life (note3).

Note 3: See also DNSC press release 'The Milky Way shaped life on Earth.' 15 November 2006.

Near the end of his review Dr Svensmark writes: 'The past 10 years have seen the reconnaissance of a new area of research by a small number of investigators. The multidisciplinary nature of cosmoclimatology is both a challenge and an opportunity for many lines of inquiry.' Even the search for alien life is affected, because it should now take into account of the need for the right magnetic environment, if life is to originate and survive on the planets of other stars.

Publication data

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