**Evidence that cosmic rays seed clouds**

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[Clouds and sunlight over the Indian Ocean](http://images.iop.org/objects/phw/news/15/5/20/clouds.jpg)

By firing a particle beam into a cloud chamber, physicists in Denmark and the UK have shown how cosmic rays could stimulate the formation of water droplets in the Earth's atmosphere. The researchers say this is the best experimental evidence yet that the Sun influences the climate by altering the intensity of the cosmic-ray flux reaching the Earth's surface.

The now conventional view on global warming, as stated by the Intergovernmental Panel on Climate Change, is that most of the warming recorded in the past 50 years has been caused by emissions of manmade greenhouse gases. But some scientists argue that the Sun might have a significant influence on changes to the Earth's climate, pointing out that in centuries past there has been a close correlation between global temperatures and solar activity.

However, changes to the Sun's brightness are believed to have altered temperatures on Earth by no more than a few hundredths of a degree in the last 150 years. Researchers have therefore been investigating ways that the Sun could indirectly modify the Earth's climate, and one hypothesis, put forward by Henrik Svensmark of the National Space Institute in Copenhagen, posits a link between solar activity and cosmic-ray flux.

According to Svensmark, cosmic rays seed low-lying clouds that reflect some of the Sun's radiation back into space, and the number of cosmic rays reaching the Earth is dependent on the strength of the solar magnetic field. When this magnetic field is stronger (as evidenced by larger numbers of sunspots), more of the rays are deflected, fewer clouds are formed and so the Earth heats up; whereas when the field is weaker, the Earth cools down.

**Building clouds**

The latest experiment provides evidence for a major component of this theory – how ionization enhances cloud formation. To be converted into droplets and form clouds, water vapour in the Earth's atmosphere needs some kind of surface on which to condense, and this is usually provided by tiny solid or liquid particles already present in the atmosphere, including aircraft emissions. Svensmark's theory suggests that cosmic rays can enhance this process by ionizing molecules in the atmosphere that then draw molecules of water vapour to them until the aggregate is large enough to act as a condensing surface.

To reproduce this process in the lab, Svensmark and his colleagues filled a 0.05 m3 stainless-steel vessel with a mixture of gases representing an idealized atmosphere – oxygen and nitrogen plus trace amounts of water vapour, sulphur dioxide and ozone. They then shone ultraviolet light into the vessel in order to generate the sulphuric-acid molecules around which water molecules could aggregate, and irradiated the mixture with a beam of 580 MeV electrons supplied by the University of Aarhus's ASTRID storage ring.

By removing samples from the vessel and counting the number of gas clusters that measured at least 3 nm across, the researchers found that the beam led to a significant increase in the rate at which clusters were produced. They say that the electrons, like cosmic rays in the real atmosphere, are ionizing molecules in the air and so cause water molecules to stick together. Furthermore, the researchers found that this effect also took place when they used a radioactive sodium source, which produces gamma rays, and as such claim that similar measurements in the future will not require expensive accelerators.

Team member Jens Olaf Pepke Pedersen of the National Space Institute at the Danish Technical University explains that to prove the link between cosmic rays and cloud formation, the experiment will need to be carried out for longer in a bigger vessel. This would determine whether the clusters grow to about 100 nm, at which point they would be large enough to act as cloud-condensing nuclei. He says that the chamber being used in the CLOUD experiment at CERN, which has a volume of some 26 m3, might be large enough.

**Clouded science**

According to Pedersen, if it can be shown that the clusters reach the scale of micrometres, Svensmark's hypothesis will have been proven. Then, he explains, it would be a question of finding out the significance of the effect. "There is so much that is not known about cloud formation, so it is possible that it could be an important component of global warming," he says.

However, there are problems with the cosmic-ray hypothesis. One is that although there was a clear correlation between global temperatures and the intensity of cosmic rays reaching the Earth's surface (as measured by neutron counters) prior to 1970, that correlation has broken down over the last 40 years. Another problem is that a claimed correlation between cosmic rays and global low cloud cover – as revealed in satellite observations – that was put forward by Svensmark to support his theory has been questioned by a number of researchers, who have found that the correlation only holds over specific regions of time and space.

Indeed, Chris Folland, a climate researcher at the UK's Met Office, says it is not clear to what extent cosmic rays could really enhance cloud formation, given the vast numbers of naturally occurring particulates within the atmosphere that could act as cloud-condensing nuclei. He also says that even if there is a noticeable effect on cloudiness, this effect could be either positive or negative, arguing that cosmic rays might be expected to have a larger affect on higher-altitude clouds, which tend to warm the planet by preventing radiation from escaping into space. "Low-level clouds generally cool the surface climate, but it’s not clear why they should be preferentially affected by cosmic rays," he adds, "given that there is some effect on overall cloudiness."

The research has been published in *Geophysical Research Letters*.

**About the author**

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