Large effect of Solar activity on Earth's energy budget

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Cosmic ray showers in the atmosphere may be important for cloud formation. Credit: Credit: DTU Space

This is the result of a new study by researchers from DTU Space at the Technical University of Denmark (DTU) and of The Hebrew University of Jerusalem, who have traced the consequences of eruptions on the Sun

on clouds and Earth's energy balance.

"We tested cosmic ray effects on the atmosphere for about two weeks. When solar explosions reduce the cosmic ray flux reaching Earth, they temporarily reduce the production of small aerosols. The aerosols are molecular clusters in the air that normally grow to seed the water droplets of low-level clouds. This, in turn, reduces the cloud cover, which is known to affect climate," says senior researcher. Henrik Svensmark, lead author of the study published in *Nature*'s *Scientific Reports*.

The breakthrough is that the effect on the Earth's energy budget has been quantified directly using detailed satellite observations from the CERES instrument on NASA's Terra and Aqua satellites. The observation is that Earth absorbs almost 2 W/m^2 extra energy within 4 to 6 days of the cosmic-ray minimum.

This research, in which Jacob Svensmark, Martin Bødker Enghoff, and Nir Shaviv participated, connects observable variations in clouds and Earth's energy budget to Danish laboratory experiments and theory. It shows how cosmic rays help make the all-important aerosols and accelerate their growth to cloud condensation nuclei.

Previous research by the team predicted that the effects should be most noticeable in low altitude liquid clouds over the oceans is confirmed with the new study. Spatial maps verify that the dominating net radiative forcing changes are from low liquid clouds over the pristine seas.

"We now have simultaneous observations of decreases cosmic rays, aerosols, clouds, and the energy budget, which is quite amazing," adds professor Nir Shaviv.

"The solar effects in this study are too short-lived to have a lasting effect

on the climate. They do, however, dramatize the cosmic ray-cloud mechanism that works more patiently on longer time scales. The hope is that this result will help rethink the long-term effect of solar activity and cosmic rays on climate," Says Henrik Svensmark.

More information: Henrik Svensmark et al, Atmospheric ionization and cloud radiative forcing, *Scientific Reports* (2021). DOI: 10.1038/s41598-021-99033-1

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