The intensity of sunlight over decades related to ultra-fine, man-made dirt particles

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The observatory in Potsdam measuring solar radiation. Credit: Deutscher Wetterdienst DWD

Based on the long-term Potsdam radiation time series, ETH Professor Martin Wild and his collaborators have shown that variations in the intensity of sunlight over decades are down to ultra-fine, man-made dirt particles in the atmosphere.

In the late 1980s and 1990s, researchers at ETH Zurich discovered the

first indications that the amount of sunlight reaching the Earth's surface had been steadily declining since the 1950s. The phenomenon was known as "global dimming." However, a reversal in this trend became discernible in the late 1980s. The atmosphere brightened again at many locations and surface solar radiation increased.

"In previous studies, we showed that the amount of sunlight that reaches the Earth's surface is not constant over many decades but instead varies substantially—a phenomenon known as global dimming and brightening," says ETH Professor Martin Wild of the Institute for Atmospheric and Climate Science.

Natural variations or air pollution?

Yet little is known about the reasons for these fluctuations, which have been observed for decades. One particularly controversial point is whether the fluctuations are caused by air pollution, with aerosols blocking the sunlight, or whether they are a result of natural variations in the climate system.

A number of scientists suspected that cloud cover may have changed over the years, absorbing the sun's rays more effectively during the dimming phase than during the brightening phase.

This is why Wild and colleagues from other research institutes analyzed measurements collected between 1947 and 2017 in the Potsdam radiation time series, which is renowned among climate researchers. The series offers one of the longest, most homogeneous, continuous measurements of solar radiation on the Earth's surface.

Dimming also occurred in cloud-free conditions

In this new study, they were able to show that rather than these fluctuations being due to natural changes in the cloud cover, they are instead generated by varying aerosols from human activity. The paper was published in the journal *Geophysical Research Letters*.

"In our analysis, we filtered out the effects of cloud cover to see whether these long-term fluctuations in solar radiation also occurred in cloud-free conditions," Wild explains. As it turned out, the decadal fluctuations in the sunlight received at the Earth's surface were apparent even when skies were clear.

The researchers identified aerosols entering the atmosphere due to air pollution as the major contributor to global dimming and brightening. "Although we'd already assumed as much, we'd been unable to prove it directly until now," he says.

Brightening after economic collapse

The fact that the transition from dimming to brightening coincided with the economic collapse of the former communist countries in the late 1980s supports the argument that these variations have a human cause. Moreover, around this time, many western industrialized nations introduced strict air pollution regulations, which improved air quality significantly and facilitated the transfer of the sunbeams through the atmosphere. Lastly, the atmosphere was recovering from the volcanic eruption of Mount Pinatubo, which had ejected vast amounts of aerosols into the air in 1991.

Wild and his colleagues had already ruled out fluctuations in solar activity in an earlier study. "The sun itself had only an infinitesimal, negligible effect, which in no way accounts for the magnitude of the intensity changes that had been observed over the years at the surface," Wild says.

Dimming reduced evaporation and precipitation

Surface solar radiation is a key parameter for climate issues. Not only does it govern the temperature, it also has a fundamental impact on the water cycle by regulating evaporation, which, in turn, governs cloud formation and affects precipitation. During the global dimming, less water evaporated from the Earth's surface, causing precipitation to decline worldwide.

Solar radiation also affects the cryosphere, i.e. glaciers, snow and ice. "Glacial retreat accelerated when the atmosphere began brightening again," Wild says, adding: "It's also becoming increasingly important for the solar industry to gain a better understanding of these fluctuations when it comes to planning new facilities."

Germany's National Meteorological Service, the Deutscher Wetterdienst, operates an observatory in Potsdam that has been measuring solar radiation since 1937. This means the station boasts one of the world's longest radiation time series. "I'm extremely grateful to have access to decades' worth of data; after all, it is only thanks to measurement series such as this that we're able to record and show changes in our environment and climate," Wild says, adding that this makes it imperative to support monitoring networks around the world for prolonged periods of time. Admittedly, this task isn't particularly spectacular, making it difficult to secure funding. "But if we want to understand climate change and clarify the impact of human activities, we need time series that go back far enough," he says. To this end, ETH maintains the Global Energy Balance Archive (GEBA), an unparalleled database of surface energy fluxes worldwide.

More information: Martin Wild et al. Evidence for Clear-sky Dimming and Brightening in Central Europe, *Geophysical Research Letters* (2021). DOI: 10.1029/2020GL092216

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