Could space dust help protect the Earth from climate change?

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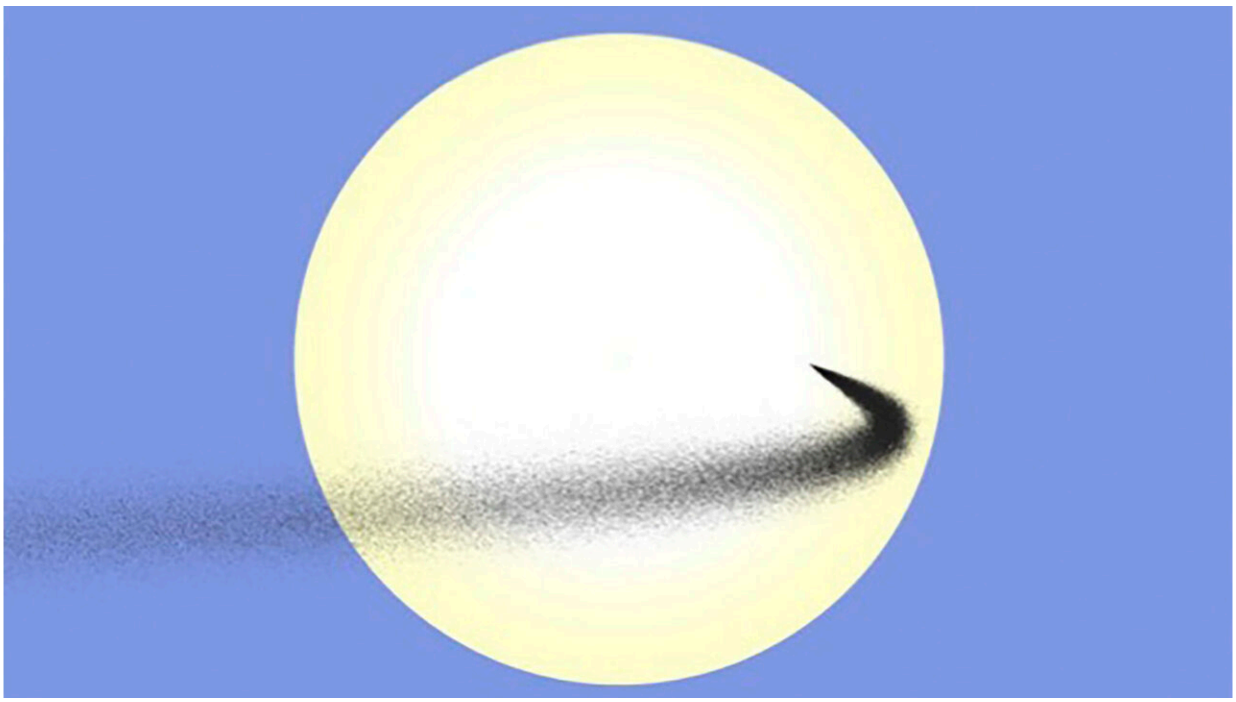

Simulated stream of dust launched between Earth and the sun. This dust cloud is shown as it crosses the disk of the sun, viewed from Earth. Streams like this one, including those launched from the moon's surface, can act as a temporary sunshade. Credit: Ben Bromley/University of Utah

On a cold winter day, the warmth of the sun is welcome. Yet as humanity emits more greenhouse gases, the Earth's atmosphere traps more and more of the sun's energy, which steadily increases the Earth's temperature. One strategy for reversing this trend is to intercept a fraction of sunlight before it reaches our planet.

For decades, scientists have considered using screens or other objects to block just enough of the sun's radiation—between 1 or 2 percent—to mitigate the effects of global warming. Now, a new study led by scientists at the Center for Astrophysics, Harvard & Smithsonian and the University of Utah explores the potential of using dust to shield sunlight.

The paper, published today in the journal *PLOS Climate*, describes different properties of dust particles, quantities of dust and the orbits that would be best suited for shading Earth. The team found that launching dust from Earth to a way station at the "Lagrange Point" between Earth and the sun would be most effective but would require an astronomical cost and effort.

The team proposes moondust as an alternative, arguing that lunar dust launched from the moon could be a low-cost and effective way to shade the Earth.

"It is amazing to contemplate how moon dust—which took over four billion years to generate—might help slow the rise in the Earth's temperature, a problem that took us less than 300 years to produce," says study co-author Scott Kenyon of the Center for Astrophysics.

The team of astronomers applied a technique used to study planet formation around distant stars—their usual research focus—to the lunar dust concept. Planet formation is a messy process that kicks up astronomical dust, which forms rings around host stars. These rings intercept light from the central star and re-radiate it in a way that can be detected.

"That was the seed of the idea; if we took a small amount of material and put it on a special orbit between the Earth and the sun and broke it up, we could block out a lot of sunlight with a little amount of mass," says Ben Bromley, professor of physics and astronomy at the University of Utah and lead author for the study.

Casting a shadow

According to the team, a sunshield's overall effectiveness would depend on its ability to sustain an orbit that casts a shadow on Earth. Sameer Khan, Utah undergraduate student and study co-author, led the initial exploration into which orbits could hold dust in position long enough to provide adequate shading.

"Because we know the positions and masses of the major celestial bodies in our solar system, we can simply use the laws of gravity to track the position of a simulated sunshield over time for several different orbits," says Khan.

Two scenarios were promising. In the first scenario, the authors positioned a space station platform at the L1 Lagrange point, the closest point between Earth and the sun where the gravitational forces are balanced. Objects at Lagrange points tend to stay along a path between the two celestial bodies, which is why the James Webb Space Telescope (JWST) is located at L2, a Lagrange point on the opposite side of the Earth.

In computer simulations, the researchers shot particles from the platform to the L1 orbit, including the position of Earth, the sun, the moon, and other solar system planets, and tracked where the particles scattered. The authors found that when launched precisely, the dust would follow a path between Earth and the sun, effectively creating shade, at least for a while. The dust was easily blown off course by the solar winds, radiation, and gravity within the solar system. The team concludes that any L1 space station platform would need to create an endless supply of new dust batches to blast into orbit every few days after the initial spray dissipates.

"It was rather difficult to get the shield to stay at L1 long enough to cast a meaningful shadow. This shouldn't come as a surprise, though, since L1 is an unstable equilibrium point," Khan says. "Even the slightest deviation in the sunshield's orbit can cause it to rapidly drift out of place, so our simulations had to be extremely precise."

In the second scenario, the authors shot lunar dust from a platform on the surface of the moon towards the sun. They found that the inherent properties of lunar dust were just right to effectively work as a sunshield. The simulations tested how lunar dust scattered along various courses until they found excellent trajectories aimed toward L1 that served as an effective sunshield.

The results were welcome news, the team says, because much less energy is needed to launch dust from the moon than Earth. This is important because the amount of dust required for a solar shield is large, comparable to the output of a big mining operation here on Earth.

Kenyon says, "It is astounding that the Sun, Earth, and Moon are in just the right configuration to enable this kind of climate mitigation strategy."

Just a moonshot?

The authors stress that their new study only explores the potential impact of this strategy, rather than evaluate whether these scenarios are logistically feasible.

"We aren't experts in climate change, or the rocket science needed to move mass from one place to the other. We're just exploring different kinds of dust on a variety of orbits to see how effective this approach might be. We do not want to miss a game changer for such a critical problem," says Bromley.

One of the biggest logistical challenges—replenishing dust streams every few days—also has an advantage. The sun's radiation naturally disperses the dust particles throughout the solar system, meaning the sunshield is temporary and particles do not fall onto Earth. The authors assure that their approach would not create a permanently cold, uninhabitable planet, as in the science fiction story, "Snowpiercer."

More information: Dust as a solar shield, *PLOS Climate* (2023). DOI: 10.1371/journal.pclm.0000133 , journals.plos.org/climate/arti … journal.pclm.0000133

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