

Geoengineering from space: the final frontier for planetary-scale climate manipulation?

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*This update on solar geoengineering in space summarises the latest developments on the [Geoengineering Monitor Map](#), highlighting new trends for civil society and climate justice movements to follow in their efforts to oppose geoengineering globally. This update is Part Two of a four-part series on solar geoengineering, where we cover Solar Radiation Management projects at all distances between the Earth and the Sun: from the Earth's surface, through the clouds, into the stratosphere, and into outer space. It was researched and written by **Anja Chalmin**, and published with the support of the Geoengineering Monitor team.*

Critical developments covered in this update:

- An increasing number of research projects are underway that aim to develop the concept of using sun shades or shields in space to reduce incoming solar radiation as a climate change mitigation strategy.
- All of the space-based geoengineering approaches currently on the table would involve astronomical costs and fuel consumption in particular, meaning that development of and control over the technologies would lie with only a handful of countries.
- The UK's Advanced Research and Innovation Agency (ARIA) has awarded funding to two space-based geoengineering projects, one examining the feasibility of a space mission to test space-based solar reflectors, and the other designing and modeling six different space reflector approaches.
- Israeli researchers claim that they are ready to build a full-scale space shade the size of Argentina, and plan to build and launch a prototype within three years.
- Numerous other proposals are being developed, such as using bubbles and dust clouds as space shades, tethering shade structures to asteroids, and constructing a space elevator to pump carbon dioxide out of the atmosphere.

Unpredictable results, exorbitant costs: Geoengineering from space is still a long way off

Space-based geoengineering aims to control incoming solar radiation in order to reduce the impacts of climate change. All space-based proposals involve blocking or reflecting incoming solar radiation by building a structure between the Sun and Earth. The proposals range from dust clouds made of lunar or asteroid material, to sunshades or reflectors stationed in space, to large mirrors mounted on satellites. Space-based geoengineering modelling suggests that reducing incoming solar radiation by around 2% would counteract the warming effects of doubling

atmospheric CO₂ levels.

Although structures near Earth are considered more cost-effective, they are viewed with greater skepticism. There is a risk of collisions with satellites and space debris. Furthermore, they would cast a visible shadow that could negatively affect photosynthesis and living beings. Therefore, most proposals aim to position a structure at the Lagrange point (L1), which is approximately 1.5 million kilometers from Earth, where the gravitational forces of the Earth and the Sun virtually cancel each other out. However, the impact of space-based sunshades on Earth's surface temperatures would still be unpredictable, even when positioned at L1.

Space-based geoengineering would also be extremely costly. Launching one kilogram of payload into low Earth orbit costs about US\$1,500–2,000, and the cost increases significantly for higher orbits and beyond. Even with optimistic launch costs of US\$50 per kilogram, the estimated cost of a solar sail designed to reduce incoming solar radiation by 1% is US\$5–10 trillion. This geoengineering approach would therefore be too expensive for all but a few countries to afford.

One of the primary costs involved would be fuel, and according to NASA, a rocket weighing 2.5 million kilograms requires 2 million liters of liquid propellant at launch to overcome Earth's gravity. Building a space structure could entail several million launches, given that the amount of payload that can be carried per launch is extremely small compared to what is needed for a sunshade. This means that the required rocket launches would incur exorbitant costs and contribute to worsening the climate crisis. Disrupting incoming radiation levels on a planetary scale would also be fraught with considerable risks and uncertainties, for example with regard to the consequences for ecosystems, precipitation patterns and agricultural yields. There are also concerns that a space shade could trigger military conflicts, creating insurmountable governance challenges. And as with all solar radiation management proposals, space-based geoengineering does not address the root causes of climate change, meaning that greenhouse gas concentrations in the atmosphere would continue to increase regardless.

The Advanced Research and Innovation Agency (ARIA) grants funding for space-based geoengineering projects, UK

ARIA's £57 million "Climate Cooling" research programme is funding research into a number of geoengineering technologies, including space-based schemes, solar geoengineering in the lower atmosphere such as a Marine Cloud Brightening project and Stratospheric Aerosol Injections.

In 2025, ARIA awarded funding to a project led by the University of Glasgow, UK, aiming to assess the technical feasibility of a space-based solar reflector. The project also involves researchers from Delft University of Technology in the Netherlands and AAC Clyde Space, a private space company headquartered in Sweden. Although the project itself will not carry out a space mission, it does examine the engineering challenges associated with carrying out a small-scale mission to test the feasibility of a space-based sunlight reflector. It will also provide insights into further research on this approach. Researchers at the University of Glasgow have previously explored and modelled a number of space-based geoengineering proposals, including placing a cloud of dust, captured near-Earth asteroids, and a large solar shield at L1.

ARIA has also awarded funding to a 15-month study to design and model six different space reflector approaches, led by the US-based Planetary Sunshade Foundation. Founded in 2021, the Foundation has proposed the installation of a sunshade at L1 which would take the form of a giant solar sail spanning one million square kilometers, which they claim would cool the planet by one degree. Their ARIA-funded project is being conducted in cooperation with researchers from Cornell University (USA), the University of Nottingham (UK), Ethos Space (a private space company in the United States with links to SpaceX), and NASA's Jet Propulsion Laboratory at the California Institute of Technology. The team, composed of space engineers and climate modelers, will simulate the potential climate impacts of six approaches, and then assess which warrant further study, based on factors such as their modelled efficiency, scalability and potential side effects.

Researchers plan to launch a prototype space shade, Israel

In 2024, a team of researchers from the Technion – Israel Institute of Technology Asher Space Research Institute, led by Yoram Rozen, launched the Cool Earth project, which involves demonstrating the feasibility of space-based geoengineering by building a prototype space shade and placing it at L1. The team claims to be ready to build a full-scale space shade stretching about 1 million square miles — an area the size of Argentina. This shade would consist of smaller shades arranged in a patchwork. According to the team, this could be achieved within three years. The Cool Earth team is currently seeking funding to use a small spacecraft to launch a prototype that would deploy the shade at L1, and they estimate that building the prototype will cost US\$10-20 million. The researchers have not yet publicly acknowledged risks such as solar storms or collisions with cosmic objects which would damage the space shades if fully deployed. One of the likely consequences of this would be to trigger a so-called termination shock. This would cause major impacts to ecosystems due to a sudden cessation of solar radiation management, followed by rapid temperature increases and changes in precipitation.



Sunrise/Sunset colors over icy landscape in Leknes, Norway. Photo by Emmeli M.

International team discusses space shade precursor mission, Italy

Scientists from the Politecnico di Torino in Italy, along with researchers from institutions in the UK, US, Sweden and Germany, have published a paper where they assess the technical and economic feasibility of a precursor mission to the installation of what they refer to as a Planetary Sunshade System (PSS) . A PSS is intended to reduce the quantity of solar radiation reaching Earth by means of a shield positioned in space, and the researchers envision that the system would comprise a large number of smaller spacecraft operating as a swarm that could potentially combine to form larger units. During the precursor mission, key PSS technologies would be tested and demonstrated, and the behaviour of materials would be observed, for example. The mission would comprise a 400-meter solar sail and a 12U-CubeSat, which is a cube-shaped satellite measuring approximately 20 x 20 x 30 centimeters and weighing a maximum of 24 kilograms. Initially, the spacecraft would enter geostationary orbit, approximately 35,800 kilometers above the Earth's equator, before reaching L1. The projected cost of the precursor mission has been estimated at US\$10 million, although it is not known if the researchers are actively seeking funding for this mission.

Proposal to tether a solar shield to a captured asteroid to reduce costs, USA

In 2023, István Szapudi, a researcher at the Institute for Astronomy at the University of Hawaii, published a proposal to reduce the cost of setting up a space-based solar shield. To ensure that a solar shield is held in place at L1, it must be sufficiently heavy. In order to save weight — and thus costs — when transporting the solar shield to L1, the proposal involves capturing an asteroid and anchoring it to the shield with tethers, thereby providing sufficient mass. According to the university, the biggest technological hurdle is the availability of sufficiently robust tethers. The shield would be pointed towards Earth and the counterweight towards the Sun. According to the university, this design would enable the use of lighter materials for the shield, with only 1% of the total weight

needing to come from Earth.

Massachusetts Institute of Technology lab tests a space shield made of bubbles , USA

The Senseable City Lab at the Massachusetts Institute of Technology (MIT) is exploring a space-based geoengineering approach involving bubbles, which would be positioned at L1. The approach was inspired by the work of Roger Angel at the University of Arizona, who proposed creating a cloud of trillions of small aircraft at L1 to shade the Earth from space. MIT sought a more lightweight solution with lower costs. The bubbles would be manufactured directly in space at L1 and have already been tested in outer space conditions in MIT laboratories. They would be produced from a compressed molten liquid solution, although MIT assumes that the spheres will be destroyed by space debris and would therefore not be durable.

Removing greenhouse gases from the atmosphere using a space elevator, Portugal

The concept of a space elevator has been around since the 19th century. In 2019, the International Academy of Astronautics published a report evaluating the current state of the technology, and concluded that building such an elevator was feasible. According to the International Space Elevator Consortium (ISEC), all components of the space elevator can be manufactured using existing technologies, except for the cable. This cable would need to reach geostationary orbit and would require a material strong and light enough to support its own weight and the payload. Three potential materials are currently being tested: carbon nanotubes, hexagonal boron nitride and single-crystal graphene. ISEC believes that graphene is the most promising material, and the Microsoft Corporation is one of ISEC's main sponsors.

In 2023, Orfeu Bertolami, a scientist from the Department of Physics and Astronomy at the University of Porto's Faculty of Sciences in Portugal, developed the idea by examining the feasibility of using a space elevator to dump greenhouse gases into space. The basic concept involves placing a satellite in Earth's orbit and lowering a cable or tube to its surface. Materials could be transported into space on this cable or inside the tube, eliminating the need for rockets. To prevent the CO₂ from falling back to Earth due to its gravity, the tube's end must be positioned at a sufficient altitude; that is, the satellite must be placed in geostationary orbit, around 35,800 kilometers above the Earth's equator. In 2024, Bertolami and Clovis Jacinto de Matos of the European Space Agency proposed collecting the CO₂ emitted by the space elevator and placing it in reflective or transparent containers. The idea is to reflect or filter incoming solar radiation through these containers, aiming to reduce the amount of solar radiation in the Earth's atmosphere. These containers could be made from materials used in the aerospace industry, and could be connected and transported to locations such as the poles to provide cooling by creating shade. The authors suggest L1 or the geostationary orbit as possible locations for the containers.

Reducing incoming sunlight using lunar dust, USA

Researchers from the Department of Physics and Astronomy at the University of Utah have proposed using lunar dust to cool the Earth's climate by scattering sunlight. They estimate that around 10 million tonnes of lunar dust would be needed to achieve a significant effect on the climate. The dust would be collected on the Moon and propelled towards Earth using an electromagnetic cannon. However, the researchers acknowledge that the large quantity of dust required poses a problem, as it would likely need replacing every few days to maintain the desired effect.

Using giant airships to unfurl a sunshade, UK

Martin Morrey founded the UK-based company SkyScroll in 2023 with the aim of further developing and

commercialising his patented high-altitude airship invention. This unmanned, gas-filled airship is designed to operate at an altitude of around 20 kilometers. SkyScroll is described by the company as a flying sunshade consisting of a flat envelope, similar to a horizontal sail, supported by two cylindrical airships. The airships rotate, causing the envelope to unfurl and inflate with lifting gas. SkyScroll is designed to shade an area of up to two square kilometers on Earth's surface, and the envelope is fitted with an albedo coating to reflect incoming sunlight. The company plans to deploy SkyScroll over regions such as the Arctic, in the hope of slowing ice melting or encouraging refreezing. It is currently seeking investors and partners to develop a prototype.