Science, Technology Assessment, and Analytics

SCIENCE & TECH SPOTLIGHT:

SOLAR GEOENGINEERING

GAO-26-108837, March 2026

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WHY THIS MATTERS

Solar geoengineering seeks to cool Earth's temperature by reflecting incoming sunlight back into space, but effects on the environment and public health are uncertain. Several private companies are beginning to develop and use these methods, raising concerns about the lack of oversight.

KEY TAKEAWAYS

- Solar geoengineering methods might mitigate Earth's rising temperatures, but effects are highly uncertain.
- More research and field testing of solar geoengineering methods would improve understanding of effects.
- Limited understanding of outcomes may heighten geopolitical risks and complicate governance.

THE TECHNOLOGY

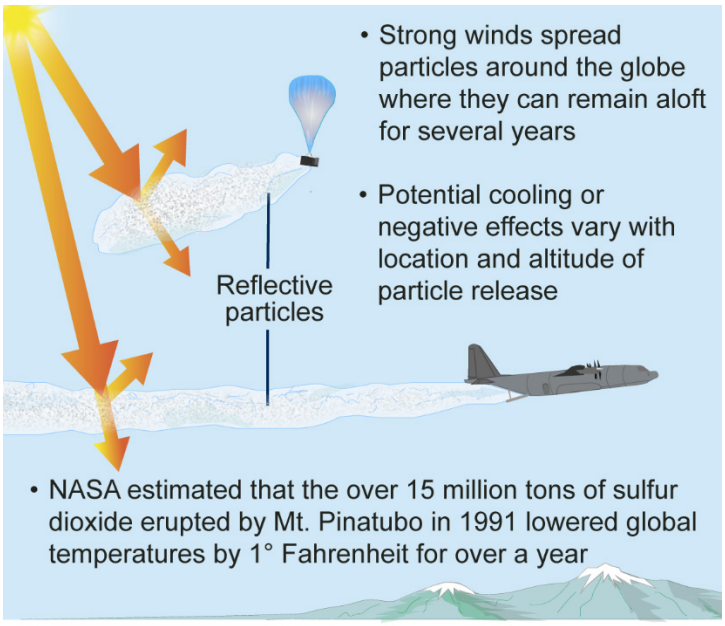
What is it? Solar geoengineering, also referred to as solar radiation modification, includes several proposed methods to reflect sunlight back into space. These methods could create a cooling effect on Earth's climate and reduce the effect of temperature increases from greenhouse gas emissions. A range of technologies are being explored for use in space, in the atmosphere, and through land surface modifications.

How does it work? Two atmospheric methods of solar geoengineering are generally considered the most feasible and cost effective. The first, stratospheric aerosol injection, adds aerosols—small particles or gases such as sulfur dioxide—high above Earth in the stratosphere using balloons or aircraft (see figure). This method attempts to cool the Earth at a global scale. It mimics the temporary cooling effect of some major volcanic eruptions.

The second method, marine cloud brightening, injects sea salt aerosols into low clouds over the ocean, aiming to cool the water, reefs, and coasts at a regional scale. This effect is similar to the "ship tracks" created when ship exhaust unintentionally increases the reflectivity of clouds along their routes.

Injected aerosols from both methods are removed from the atmosphere by natural processes. Solar geoengineering would therefore require a long-term commitment of regular applications of aerosols to maintain cooling effects.

Figure 1. Stratospheric Aerosol Injection



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How mature is it? The scientific concepts underlying solar geoengineering have been understood for decades. Potential deployment strategies have been demonstrated largely through computer models, laboratory experiments, and case studies. Additional research and field testing are needed to better understand key aspects of the methods, including how aerosols change over time and interact with clouds.

The technological capabilities needed to deploy aerosols at scales large enough to significantly change atmospheric reflectivity are also immature. Researchers have conducted just a few outdoor experiments, including a marine cloud brightening test in Australia. Other experiments, including one in the U.S., have been cancelled due to public concerns about safety or the ethics of solar geoengineering use.

At least two startup companies have received private funding in recent years to pursue stratospheric aerosol injection. One company has delivered sulfur dioxide gas to the stratosphere with balloons since 2022. In 2025, a second company reported it had received $75 million to develop and test technologies for aircraft-based aerosol deployment.

POTENTIAL OPPORTUNITIES

- **Mitigate rising global temperatures.** Conducting solar geoengineering research now may help identify scenarios in which the risks of geoengineering would be less than the effects of rising global temperatures.
- **Reduce regional temperatures.** Beneficial uses may also include dampening a local heat wave or protecting heat-sensitive ecosystems like the Great Barrier Reef.

CHALLENGES

- **Unknown consequences.** Potentially harmful effects on human health and the environment from solar geoengineering use have been identified but are poorly understood. These include increased air pollution, damage to the ozone layer, and changes in rain or snowfall patterns. There may be other detrimental effects still unidentified.
- **Geopolitical risks.** The effects of solar geoengineering are almost certain to cross state or international boundaries, creating risks of geopolitical disputes or conflicts.
- **Lack of governance.** There is no international consensus on how to regulate use of or coordinate research on solar geoengineering. In the U.S., several statutes apply to solar geoengineering, but federal oversight is limited. Some U.S. states, however, have already enacted bans on solar geoengineering activities, and how intrastate effects would be addressed is unclear.
- **Public opinion**. Several studies suggest that most U.S. survey respondents view solar geoengineering research negatively. In the U.S., a lack of transparency and public engagement has been reported as a reason why an outdoor experiment was cancelled.

POLICY CONTEXT AND QUESTIONS

- What information is needed to inform public policy discussions about the use of solar geoengineering, such as the effects and ethical implications, and how might policymakers facilitate its collection?
- What domestic or international coordination could help reduce geopolitical risks resulting from possible solar geoengineering deployment?

SELECTED GAO WORK

Weather Modification: NOAA Should Strengthen Oversight to Ensure Reliable Information, GAO-26-108013.

Climate Engineering: Technical status, future directions, and potential responses, GAO-11-71.

SELECTED REFERENCE

National Academies of Sciences, Engineering, and Medicine, *Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance* (Washington, DC: The National Academies Press, 2021). https://doi.org/10.17226/25762.

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