

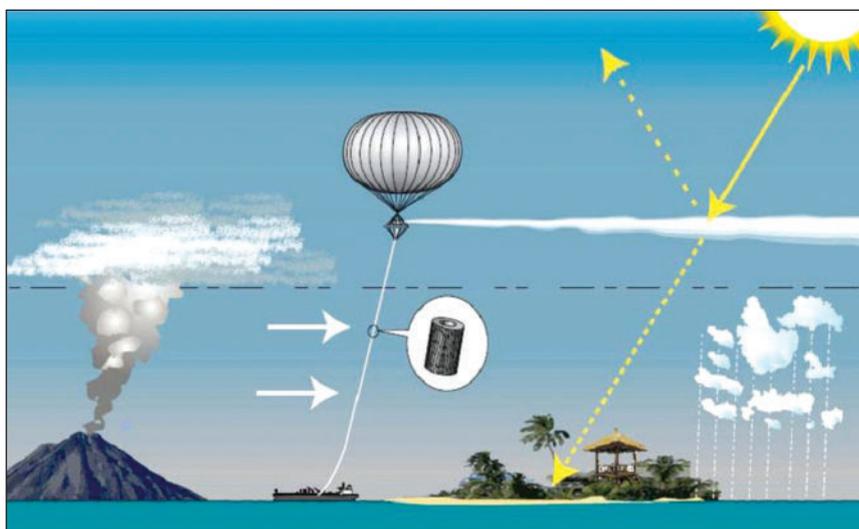
Stratospheric Aerosol Injection (SAI)

Description and purpose of the technology

Stratospheric Aerosol Injection (SAI) is a theoretical solar geoengineering proposal to spray large quantities of tiny reflective particles into the stratosphere, an upper layer of the Earth's atmosphere, in order to cool the planet by reflecting sunlight back into space. Proposals range from spraying reflective particles, such as sulphur dioxides, finely powdered salt or calcium carbonate, from aircraft, shooting particles from artillery guns, or using large hoses to reach the sky.

None of those solar geoengineering approaches address the underlying causes of climate change. Instead they aim to control the amount of incoming solar radiation by emulating the sulphur-rich dust cloud that remains in the atmosphere after large volcanic eruptions. In contrast to a volcanic outburst, SAI assumes continuous maintenance of the particle layers by regular injections.

SAI using sulphur dioxide is the most-studied option. Computer simulations suggest that this technique would likely cause droughts in Africa and Asia and estimate that the SAI could endanger the source of food and water for two billion people. Because of the unequal global impacts and its potential to be weaponized, solar geoengineering carries unsurmountable challenges for governance. Therefore, several hundred civil society organizations from around the world are calling for a multilateral ban on solar geoengineering.¹

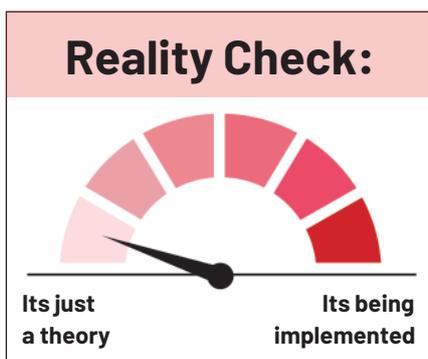


SAI using a tethered balloon, one way of geoengineering the climate
Illustration by Hugh Hunt / Wikipedia

Actors involved

Research on SAI is largely based on modelling, mostly conducted in the Northern hemisphere and at U.S. institutions, in particular Harvard University, and largely supported by fossil fuel (burning) industries, billionaires and other wealthy individuals, such as Bill Gates. The same sources of funding launched the Developing Country Impacts Modelling Analysis for Solar Radiation Management (DECIMALS) Fund, to appear as if the research on SAI has expanded to the Southern hemisphere, although it is only happening because of the grants from a Northern organization managed by a majority of geoengineering advocates. The U.S. government is the most important public funding source for financing research and modelling of SAI on global and regional scale since 2008.

Point of Intervention:



In 2019, the U.S. government allocated US\$ 4 million to the National Oceanic and Atmospheric Association (NOAA) to conduct research on solar geoengineering, SAI with sulphur dioxide is one of the approaches NOAA is going to explore. The only known SAI field experiment injected sulphate into the troposphere and was conducted by a Russian institution in 2009.²

SCoPEX: Stratospheric aerosol injection experiment

David Keith, based at Harvard University, is the foremost geoengineering advocate advancing solar geoengineering. He is an investor in the technology, has lobbied governments, and manages, along with Ken Caldeira, the Fund for Innovative Climate and Energy Research (FICER), a multimillion geoengineering fund provided by Bill Gates since 2007. He has also commissioned a study by an U.S. aerospace company that argued for the feasibility of large-scale deployment of solar geoengineering technologies. In early 2017, he launched Harvard's Solar Geoengineering Research Program, which aims to raise US\$ 20 million in funding from several billionaires and private foundations to execute the open-air experiment SCoPEX.³

Alongside other engineers and researchers, Keith has proposed a number of field experiments,⁴ including the "Stratospheric Controlled Perturbation Experiment" (SCoPEX). The explicit aim of this experiment is to acquire further data for modelling solar geoengineering and predicting larger-scale effects of SAI, by monitoring the reflective properties of injected particles and their impact on the surrounding atmosphere. The envisaged field test aims to disperse various particles of different chemicals, from a balloon into the stratosphere, at an altitude of 20 kilometres above the Earth. The balloon will be steered from ground and equipped with scientific instruments, including sensors for data collection.⁵

However, more than just a scientific experiment, this outdoor solar geoengineering experiment has been pointed to as a public relations exercise – a way of building acceptance for outdoor experiments, to pave the way for large-scale and longer experiments that ultimately would lead to large-scale deployment.⁶

// SAI would modify the Earth's radiative balance, and is also associated with significant potential risks and uncertainties, such as impacts on extreme weather events, ecosystems, rain patterns, agricultural yields, ozone chemistry, solar energy output, human health and many more. //

Other actors

There are large companies for whom "saving the world" – exclusively through some sort of techno-fix – is increasingly becoming a structural prerequisite for continuing their business, particularly when those companies depend heavily on fossil fuels. They try to shift policy norms so that previously unthinkable notions and activities – like solar geoengineering and other proposals – start to become more mainstream and acceptable.

ExxonMobil is one of those companies. The company's Senior Scientific Advisor, Dr. Haroon Kheshgi is the company's point person on geoengineering, recruited from the Lawrence Livermore National Laboratory.⁷ Through his efforts, ExxonMobil has influenced "independent" reports on geoengineering and has funded a report that advocates for carbon dioxide removal and solar geoengineering. Kheshgi has also been an author of several IPCC reports and has been denounced by civil society for this involvement. ExxonMobil's former CEO and former U.S. Secretary of State Rex Tillerson has described climate change as an "engineering problem" with "engineering solutions."⁸

Shell's chief lobbyist, David Hone, is evangelical about "negative emissions" and increasingly openly supports solar geoengineering.⁹ Steve Koonin, by then chief scientist at BP, led a project to determine hardware feasibility for solar geoengineering experiments.¹⁰



Volcanoes also inject aerosols into the stratosphere – and eruptions have been followed by terrible droughts and famine
Photo: R Clucas / Wikipedia

Boeing's Integrated Defense Systems Chief Scientist and Vice-President David Whelan (formerly of DARPA) is also active in geoengineering debates, claiming there is a small team at Boeing studying the issue. He has publicly mused about the technical feasibility of getting mega-tonnes of aerosol sulphates up to different stratospheric levels via aircraft or large cannons.¹¹

Impacts of the technology

As with all solar geoengineering technologies that only address global surface temperatures, dramatic perturbations in the climate system can be expected if SAI is deployed. SAI would modify the Earth's radiative balance, and is also associated with significant potential risks and uncertainties, such as impacts on extreme weather events, ecosystems, rain patterns, agricultural yields, ozone chemistry, solar energy output, human health and many more.¹² Early research into SAI from the UK's Met Office Hadley Centre found that SAI could lead to severe drought in the Sahel region of Africa. While researchers found that this could possibly be countered by injecting particles into the southern hemisphere's stratosphere instead, this would likely cause a failure of the rains in northeast Brazil.¹³

A recent modelling study simulating the climate effects of SAI found similar potential negative consequences. Injection in the northern hemisphere would lead to fewer hurricanes in the North Atlantic, which might be good news for the Caribbean, but it would likely create drought in Sub-Saharan Africa and parts of India. Injecting aerosol in the southern hemisphere wouldn't create drought, but it would create more hurricanes in the North Atlantic.¹⁴

Regional warming is also likely, based on the results of the Geoengineering Model Intercomparison Project published in 2014. It predicted that temperatures in the tropics would cool as a result of SAI, but higher latitudes would warm, with ice sheets and Arctic sea ice still declining, and extreme temperature anomalies also still increasing.

The so-called termination effect is another major risk: "If geoengineering were halted all at once, there would be rapid temperature and precipitation increases at 5–10 times the rates from gradual global warming."¹⁵ A scientific study published in *Nature* in 2018, showed that the shock caused by sudden termination of solar geoengineering would have grave impacts on biodiversity. This means that stopping SAI once it had started could be more dangerous than starting it in the first place. Ozone depletion is another important side effect of SAI.¹⁶

Studies on the impacts of SAI on public health are limited, but a recent analysis suggests that adverse public health impacts may be expected. Little is known about the toxicity of some aerosols that have been suggested, and there is no consensus on what acceptable levels for public exposure to these aerosols are. There are also very few means of evaluating potential public health impacts should SAI be deployed.¹⁷

Exacerbates global power imbalances

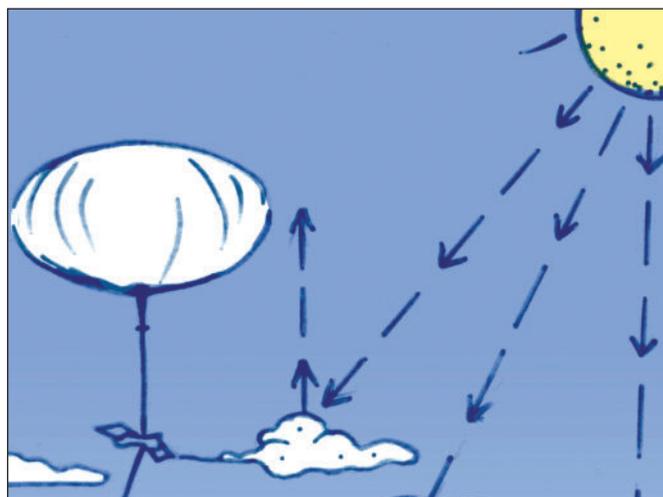
The prospect of controlling global temperatures raises serious questions of power and justice: if solar geoengineering functions, who gets to control the Earth's thermostat and adjust the climate for their own interests? Who will make the decision to deploy if such drastic measures are considered technically feasible, and whose interests will be left out?

The risk for weaponization of SAI is considerable. The premise of controlling the weather originated with military strategies, which led to the signing of the international Environmental Modification Convention (ENMOD). Military leaders in the United States and other countries have pondered the possibilities of weaponized weather manipulation for decades. If the explicit aim of a technology is to “combat climate change,” it doesn’t guarantee its use will be limited only to that application. Historian James Fleming argues that if anybody can control the Earth’s thermostat, this can and will be used for military purposes. Even before hostile use, any state or actor claiming to be able to alter global weather patterns will hold a powerful geopolitical bargaining chip with which to threaten and bully. The concept to establish capacities for counter-geoengineering was established in view of the aforementioned risks and means another step towards militarization.¹⁸

Solar geoengineering is the perfect excuse for inaction on climate change

Solar geoengineering, and geoengineering more broadly, is a “perfect excuse” for climate change deniers, industries and governments seeking to avoid the political costs of carbon reductions and to continue business as usual. For those looking to stall meaningful climate action, the active development of geoengineering tools and experiments will be presented as a preferred pathway to address climate change and be used as an argument to ease restrictions on high carbon emitting industries. This line of argument was already put forward by conservative think tanks in the United States such as the American Enterprise Institute.

Furthermore, once solar geoengineering is deployed, sudden interruption would cause a termination effect, raising temperatures rapidly, creating a situation worse than it was before its deployment. Therefore, solar geoengineering will create dependency and captive markets.¹⁹



One geoengineering technology, Stratospheric Aerosol Injection, proposes spraying particles into the upper atmosphere to block sunlight.

Governance of solar geoengineering could be impossible

There is a de facto moratorium on climate-related geoengineering under the Convention on Biological Diversity that clearly articulates the need for a global transparent regulatory mechanism for governance before experimentation is considered. 196 countries agree to require a global mechanism because they recognize that the potential impacts and side effects of geoengineering will be unfairly distributed.

Since solar geoengineering could be a tool to control the Earth’s thermostat for those who have legal, economic and technological resources, any step towards realizing those capabilities must be agreed through consensus by all members of the UN.

Another key problem is that if all governments could effectively agree on such a complex issue with so many social, economic, environmental and intergenerational aspects at play, including how and who will carry the cost and burden of the negative impacts, and if countries had the capacity to implement the necessary agreed climate measures that demand persistence and coherence over several decades or even centuries, we wouldn’t have climate change in the first place, because they could have agreed on clear and binding rules to stop excess emissions. Even the Paris Agreement, which seems a miraculous convergence of political will, only lasted a few months after entering into force before the largest historical GHG-emitting country declared it won’t respect it.

The failure to manage fair and effective international climate governance is a clear argument against moving ahead with geoengineering and particularly solar geoengineering, which is more deeply unfair and complex and for which there are poor prospects for establishing the fully democratic, multilateral, legally binding and century-long agreement needed for minimally fair governance. Without such a mechanism, once the tools are developed it will be extremely difficult – or impossible – to stop powerful governments from using it, for their convenience and/or against other countries. Therefore, the most appropriate governance for solar geoengineering is a ban.

Reality check

SAI is seen as a quick way of geoengineering the climate. Although outdoor experiments have been successfully opposed in several cases, limiting research to computer modelling (though one aerosol injection field experiment in the troposphere has taken place in Russia²⁰), there is a constant push by a few actors to normalize this kind of research and experiments, which could lead to the technology being developed quickly. SCoPEX is the most high-profile experiment that has been put forward on solar geoengineering.

Further reading

For more information on SAI, SCoPEX and solar geoengineering governance see

SCoPEX:

<http://www.geoengineeringmonitor.org/2019/08/open-letter-scopex/>

The Big Bad Fix:

<http://www.geoengineeringmonitor.org/2017/12/3087/>

Fuel to Fire:

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Why the SDGs Require a Governance Debate Based on Precaution, Rights and Fairness:

<http://sdg.iisd.org/commentary/guest-articles/geoengineering-at-unea-4-why-the-sdgs-require-a-governance-debate-based-on-precaution-rights-and-fairness/>

Endnotes

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