

On the thief in the night:

A Movement Primer on

Solar Geoengineering

About Climate Vanguard

Climate Vanguard is a youth-led organisation empowering the youth climate movement through radical political education.

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Introduction

At 1.2°C heating above pre-industrial levels, the catastrophic impacts of climate breakdown are plain to see. In 2021, wildfires wiped out an entire town in Canada.¹ In 2022, a third of Pakistan was submerged by unprecedented monsoons.² And in 2023, a fifth consecutive failed rainy season in Somalia left millions in acute food insecurity.³ But this is just the beginning. The world is set to cross 1.5°C by 2032, 2°C by 2052, and 2.9°C by 2100.⁴

Climate collapse has done little to sway the ruling classes' feverish accumulation drive. In 2022, investors pumped \$499 billion into upstream oil and gas development (the largest year-on-year increase in history), despite the IEA warning in 2021 that new oil and gas is incompatible with the 1.5°C guard-rail.⁵ Over the next 16 years, the world's largest fossil fuel companies are planning to invest \$1.5 trillion in new oil and gas.⁶ The hotter it gets, the more capital invests in the inferno.

To remedy the existential contradiction between capital accumulation and a habitable planet, ruling classes have a growing interest in solar geoengineering – an umbrella term referring to technologies aimed at limiting global heating by reflecting sunlight back to space, limiting the amount of heat that reaches the Earth's surface.⁷ These hypothetical technologies vary in their approach, including deploying large space mirrors and increasing the reflectivity of clouds by spraying them with salt water droplets (see *Figure 1*). Among the range of solar geoengineering technologies, stratospheric aerosol injection (SAI) stands out as the most prominent. For this reason, SAI will be the focus of this report. However, many of the warnings made in this paper are equally applicable to other solar geoengineering technologies.

Although SAI deployment would have grave socio-ecological consequences for our collective future, movement organisers do not have a clear understanding of these risks, nor do they have a critical awareness of its growing sway amongst the ruling classes (see *Box 1*).

As such, this is a necessary and timely movement primer, which aims to increase literacy on what SAI is, explain why SAI is emerging as a technology of interest for the ruling classes, and explore organising strategy for engaging with accelerated SAI development and possible future deployment.

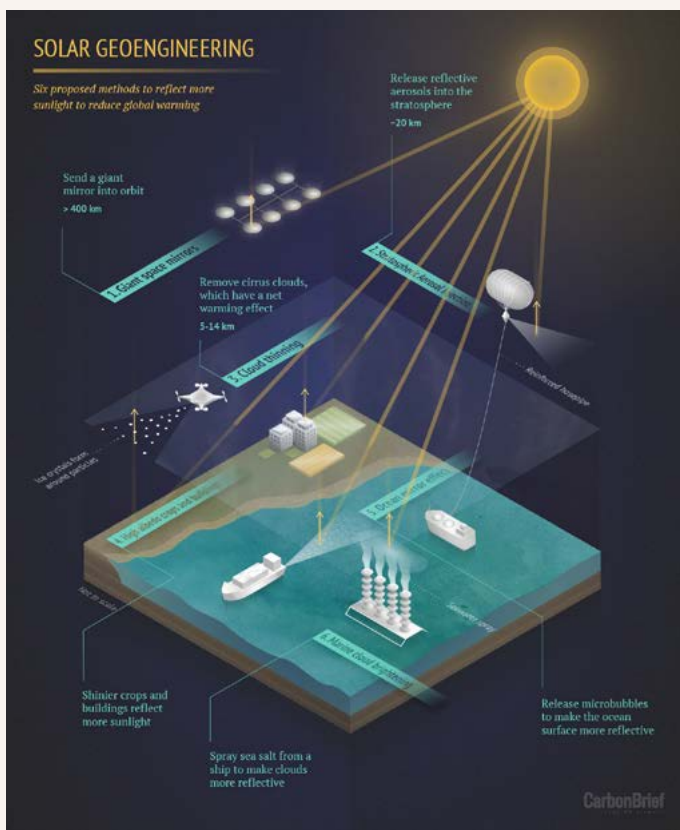


Figure 1: Illustration showing six different solar geoengineering approaches. Space mirrors are depicted in type 1 and marine cloud brightening is depicted in type 6. SAI is depicted in type 2. Source: Adapted from Carbon Brief (2018).

Box 1: Organisers' Awareness of Stratospheric Aerosol Injection

From November 2023 to February 2024, Climate Vanguard used an online survey to poll 73 climate justice organisers from 24 countries. The survey gauged organisers' awareness of SAI, their experiences in SAI-related campaigns, as well as their stance on SAI research, potential deployment, and governance.

While nearly 80% of the respondents were aware of SAI, many demonstrated a limited understanding of the science behind SAI and its potential risks.^a Even so, over half did, in fact, answer that they were opposed to SAI deployment as a climate solution (only two individuals were strongly in favour).

However, this dominant position has not translated into action. Only 20% of respondents had ever discussed SAI within their organisation and only 5 of the 73 organisers had ever participated in a campaign related to SAI.

^a It should be recognised that the proportion of respondents who were aware of SAI is likely much higher than is the case in the wider climate movement, and indeed, among the general public. Our results are subject to self-selection bias whereby those who did not know about SAI were less likely to voluntarily respond to a survey on the topic.

The report is laid out as follows:

- ➔ Section 1, *Sun Dimming*, explains what SAI is and how it works.
- ➔ Section 2, *The Aerocene*, explores the ecological impacts of potential SAI deployment.
- ➔ Section 3, *Capitalist Chronicles*, offers a political-economic analysis of SAI's rise in prominence, detailing its relationship to capital accumulation and ruling class interests.
- ➔ Section 4, *Battle Plans*, ventures into movement strategy, making the case that further SAI research and SAI institutionalisation should be resisted by popular movements.

Sun Dimming

SAI is a technology that involves injecting aerosol particles (e.g. sulphate aerosols) into the lower stratosphere to reflect sunlight, thereby blocking a proportion of solar radiation from reaching the Earth's surface.^{8,a} In effect, SAI would artificially “dim the sun” to reduce global temperatures.^{9,b}

The 1991 explosion of Mount Pinatubo is commonly proposed as a live demonstration of naturally occurring SAI. This mega eruption released 20 million tons of sulphate aerosols (from here on, sulphate) into the atmosphere, decreasing solar radiation and temporarily cooling the planet by 0.5°C.¹⁰ Modelled on this geophysical proxy, the science is “virtually certain” that SAI would reduce the global mean temperature within months of deployment.¹¹



Image 1: The eruption of Mount Pinatubo in 1991. Source: [Arlan Naeg, AFP](#).

In addition to being the only technology that guarantees immediate planetary cooling, SAI would be relatively easy to operate. While various imaginative schemes have been suggested, ranging from particle injection via artillery to balloon-lofted pipes, the most widely accepted and straightforward method is aerosol injection via aircraft.

This deployment method would entail a fleet of specially outfitted planes flying 20 kilometres above the Earth's surface, spraying sulphate around the

a Aerosols are small particles suspended in the atmosphere. They're usually too small for the human eye to perceive.

b Crucially, SAI does *not* address the actual source of global heating, i.e. the combustion of fossil fuels. It merely attempts to remedy the symptoms of climate breakdown.

globe.¹² To avoid a rebound in temperatures once the aerosols fall down to Earth – as was the case with the Mount Pinatubo eruption – this process would need to be continuous. In the case of a ‘limited deployment scenario’ that halves the rate of heating globally, the first 15 years of full-scale deployment would require 95 aircraft flying a combined 164 flights per day, releasing 1.5 million tons of sulphate into the stratosphere.¹³



Figure 2: Detailed illustration of how SAI works.
Source: Adapted from [United Nations Environmental Programme \(2023\)](#).

SAI deployment would also be cheap. Sulphur is abundant and some military planes already meet the specifications needed to fly at the required altitude, making the fuel for the planes – which is fossil of course – the most costly element.¹⁴ One study estimates that a global SAI operation would cost around \$30 billion annually, roughly the same amount spent on pet food in the United States.¹⁵ While it’s clear that such an operation would be a massive industrial undertaking, not least extracting huge quantities of sulphur from the Earth’s core, it appears a small price to pay for the promise of reversing the catastrophic effects from 200 years of CO₂ emissions.

However, a deeper look at the science tells a different story. In addition to the intended cooling effect, the models predict a series of unintended side effects from global SAI deployment.

Before reviewing these ecological impacts, it should be noted that SAI research is an immature field of study. First, in terms of quantity of research, there are only a few studies per SAI impact, whereas the scientific process of the Intergovernmental Panel on Climate Change (IPCC) entails hundreds of scientists drawing conclusions from thousands of peer-reviewed papers.¹⁶ Also, in terms of quality, SAI models do not use a standardised deployment scenario (i.e. they assume different quantities of sulphate to mask a discrete amount of heating), leading to irregular results.¹⁷

In addition to general immaturity, SAI research systematically underestimates the ecological side effects of deployment. Studying future developments in the climate system relies on mathematical models called Integrated Assessment Models (IAMs). IAMs, also used more generally in the field of climate science, are widely criticised for being overly conservative because they are influenced by a variety of human assumptions, which limits their capacity to account for “complexities, nonlinearities, non-convexities, tipping points, and uncertainties.”¹⁸

So, while the following section outlines the known ecological side effects of SAI deployment, the full scope of impacts are likely larger and more severe. Ultimately, these would only be revealed through large-scale SAI deployment.

The Aerocene

The risks of SAI deployment can be divided into two impact categories:

- ➔ **1. Substance impacts:**
Those resulting directly from the usage of sulphate
- ➔ **2. Ecological impacts:**
Those resulting from the global cooling process

Substance Impacts

The injection of sulphate into the stratosphere would lead to the reduction of ozone molecules, impairing the recovery of the ozone layer – ironically, one of the few achievements of international environmental governance.¹⁹ In turn,

depleted ozone would increase the amount of solar UV radiation hitting Earth, which is linked with increased rates of skin cancer.²⁰

Another public health risk of SAI deployment is air pollution. Injected sulphate would eventually fall back down to the surface, increasing fine particulate matter and degrading air quality.²¹ As the widespread combustion of coal shows, sulphate leads to increased rates of respiratory illnesses and mortality.²² Moreover, sulphate can be ‘deposited’ in the form of acid rain, leading to soil acidification and crop damage.²³

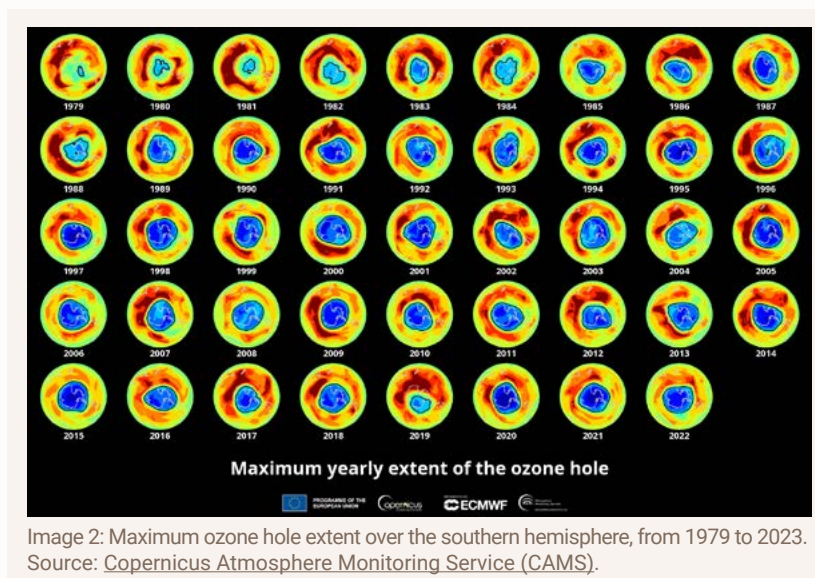


Image 2: Maximum ozone hole extent over the southern hemisphere, from 1979 to 2023. Source: Copernicus Atmosphere Monitoring Service (CAMS).

Public health impacts will get worse the longer SAI deployment lasts. More sulphate leads to coagulation, where molecules clump together to form blobs.²⁴ Of course, these blobs are heavier than individual molecules, making them fall faster.²⁵ Coagulation therefore sets into motion a vicious cycle in which sulphate falls from the sky more quickly, necessitating an increased sulphate payload, leading to more coagulation, more pollution, and so on and so forth.

Ecological Impacts

In popular discourse, SAI is framed as a kind of global air conditioner that restores a comfortable temperature to Earth. The appeal hinges on the concept of restoration, i.e. the idea that SAI can bring us back to a planetary goldilock zone where human civilisation once thrived. This represents the principal mischaracterisation of SAI: it would not restore

pre-industrial planetary conditions, but rather launch the Earth into an entirely new geological state, one with no-analogue in human history.²⁶

Understanding this requires a more nuanced depiction of SAI deployment. Effective SAI deployment would lead to an equal distribution of sulphate around the globe.²⁷ However, solar radiation does not hit all areas of Earth in equal doses: more in the tropics than the poles, more in the summer than the winter, and none at night.²⁸ In other words, an *equal* atmospheric distribution of sulphate is reflecting an *unequal* amount of solar radiation.²⁹ This means that SAI would lead to the relative “overcooling” of the sun-bathed tropics and “undercooling” of the night-filled poles.³⁰ The temperature gradient prevailing between the tropics and poles drives global weather systems.^{31,c} A flatlining of this gradient would cause serious disruption.³²



Image 3: A white sky of the type that would be a permanent reality after global SAI deployment.

A particularly distressing example is precipitation. Greenhouse gases trap heat, amplifying the hydrological cycle and the intensity of rainfall.³³ Sulphate, in contrast, would reflect sunlight and cool the planet, starving the hydrological cycle of solar energy.³⁴ However, SAI would not simply reverse global heating’s amplification of the hydrological cycle. Rather, it would “overcompensate” in the other direction, leading to a disproportionate reduction in precipitation.^{35,d} Summer monsoons in Africa and Asia, upon which billions of people depend for their food security, would be critically weakened.³⁶

c Climate breakdown is already leading to temperature gradient flatlining between the equator and poles. This is due to the albedo effect, whereby melting ice and snow accelerates heating. Research suggests that SAI would be unable to ‘override’ this albedo effect, accelerating flatlining and subsequent weather disruption (Malm 2022).

d Both Da-Alla et al. (2020) and Abiodun et al. (2021) use a model where SAI is deployed to the extent that it maintains 2020 temperatures under a RCP8.5 Representative Concentration Pathway (RCP) heating scenario. RCP8.5 is a “high-end scenario” under which temperatures would rise by more than 5°C by the end of the century (Visioni et al. 2020).

SAI's diffusion of incoming solar radiation would have additional negative side effects. First, any gains made from global cooling (i.e. the prevention of agricultural losses due to global heating) in the cultivation of maize, soy, rice, and wheat would be offset by scattered sunlight.³⁷ Similarly, SAI would reduce the output of concentrated solar power – one of the most effective ways to produce renewable energy at scale.³⁸ Thirdly, and perhaps the most psychologically damaging, SAI would colour the sky a *permanent white*. In the words of Naomi Klein, “we would have a roof, not a sky – a milky, geoengineered ceiling gazing down on a dying, acidified sea.”³⁹

However, these impacts, disastrous in their own right, pale in comparison to the ultimate risk of SAI deployment: termination shock. Termination shock occurs when SAI is abruptly ended, which, absent large-scale decarbonisation and carbon removal, leads to the rapid release of previously masked global heating. Depending on the accumulation of greenhouse gas emissions, termination shock could lead to a temperature increase of 0.5° C/year to 4° C/decade – a heating curve with “no precedent in the geological history of the climate.”⁴⁰ Such a rate of heating would eclipse the speed limits of life, leading to mass species extinction.⁴¹

Termination shock could be caused by an assortment of circumstances: sabotage, war, pandemic, financial collapse, natural disaster (made more likely by SAI's own ecological impacts), revolution, or a strike along the SAI supply chains (certainly this merits a new category of the labour aristocracy).⁴² In a world increasingly characterised by sharpened contradictions within the capitalist world system, the list of potential disruptions to SAI deployment seem more than just possible, but probable.

Even in the ideal circumstance of uninterrupted SAI deployment where CO₂ levels are returned to the ‘safe’ level of 350 parts per million, the phase out of SAI would throw the planet out of its previous geoengineered state – by no means a smooth transition.⁴³ Therefore, even in some hypothetical where an assortment of eco-socialist regimes remove hundreds of parts per million of CO₂ from the atmosphere through democratic international planning and oversee some phase out of SAI without cooking the planet, the underlying truth remains: there is no return from the Aerocene.^e

e Aerocone is derived from the words “aerosol” and “anthropocene,” the latter being a popular expression for an (unofficial) geological epoch dominated by anthropos (Greek for human).

Capitalist Chronicles

We can only understand the rise of SAI if we understand its relationship to capitalism. The first two subsections analyse capitalism's usage of fossil fuels, while the following two unpack how SAI provides an escape from capitalism's contradictions.

1. Fossil Lovestory

Fossil fuels were first integrated into capitalist production in early-mid 19th century Britain.^{44,f} In this historical conjuncture, British industrial capitalists swapped water for coal-powered steam not because it was cheaper, but because it was more profitable.⁴⁵ We can observe the advantages of steam across space and time:

- ➔ **Spatial Advantage:** Water-power required capitalists to set-up production in the countryside, where they had access to the best waterways.⁴⁶ However, these rural areas lacked a large, disciplined workforce (i.e. one accustomed to wage-labour), strengthening the hand of workers who knew that they could not easily be replaced.⁴⁷ Unlike a river, which is fixed in place, coal could be cut and hauled to cities where labour was abundant, disciplined, and cheap, providing a crucial fix for capital.^{48,g}
- ➔ **Temporal Advantage:** Natural phenomena (e.g. ice, drought, flooding) impacted the regularity of river flow.⁴⁹ Initially, this was not as big a concern for the capitalists, as they could force their employees to work longer hours, making up for lost time once the flow returned.⁵⁰ However, the arbitrary extension of the working day was tactically disabled by the passing of the Ten Hour Bill in 1847 – the outcome of revolutionary working class struggle.⁵¹ Penned in by a set working day, coal could be used

f In this section, we are not offering an analysis of capitalism as a world system, which would require a deeper investigation of primitive accumulation and imperialism. Rather, we are analysing why a specific faction of capital latched onto fossil fuels in a unique historical conjuncture in order to evidence capitalism's laws of motion.

g Labour abundance leads to a downward pressure on wages because more people are competing for a given number of jobs. In effect, the capitalist can set lower wages because they know if someone is unhappy with the terms they can easily find someone who is.

to power machines at a steady rate, thereby increasing labour productivity and the realisation of profit.⁵²

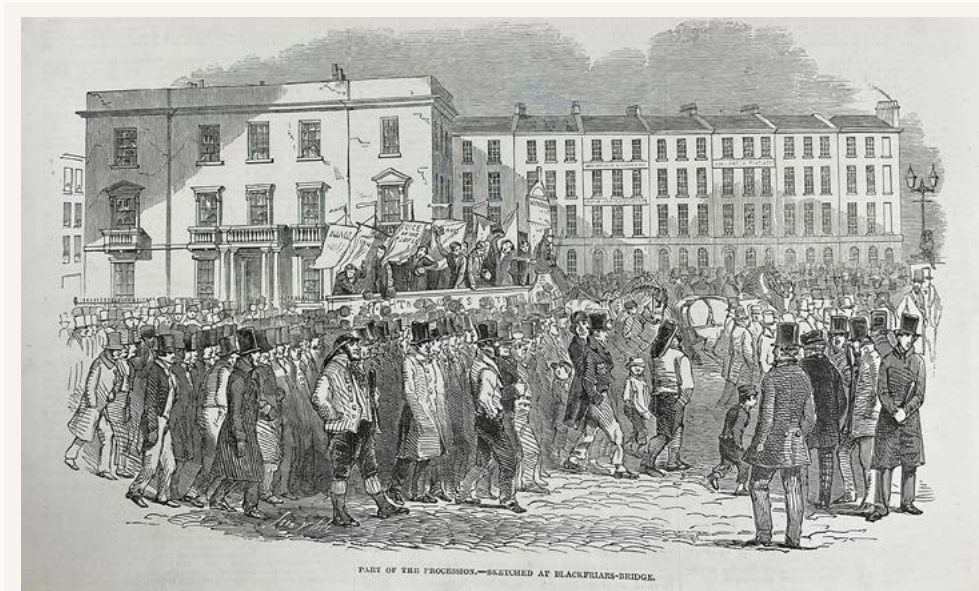


Image 4: English workers in the the 1842 uprising, also known as the Plug Plot Riots. This is the closest England has ever come to revolution, the threat of which ultimately forced Parliament to pass the Ten Hour Bill to appease the rebelling workers. Source: [The National Archives](#).

2. Eternal Romance

The spatio-temporal advantages of fossil fuels (from the vantage point of capital) are still observable in contemporary capitalism.

First, large renewable energy installations effectively shackle capital to a specific geographic location, impairing its ability to scour the globe for cheap labour.⁵³ Second, renewables remain prone to intermittency issues, posing problems for regular, on demand production.⁵⁴

Moreover, the actual production of fossil fuel power remains more profitable than renewable energy.⁵⁵ The cost structure of renewable energy projects tends to be front-loaded, with substantial initial investment required for infrastructure construction.⁵⁶ This contrasts with fossil fuels, where costs are more evenly distributed over time.⁵⁷ As a result, there is reluctance to invest in renewables due to the risks associated with recouping large upfront investments in a volatile market.⁵⁸

This is further complicated by the razor-thin margins of renewables, a product of the low-entry barriers to renewable energy production.⁵⁹

The power of the wind and sun can be harvested by all, while fossil fuel extraction is restricted by a limited number of access points, which are tightly controlled by drilling and mining rights.

It is little wonder then that only 2.5% of fossil fuel companies' capital expenditure goes to "clean energy technologies," while the other 97.5% goes to fossil fuel production.⁶⁰

3. Toxic Relationship

Capitalism's astronomical usage of fossil fuels is destroying the ecological basis for its own existence. More specifically, losses in labour productivity, the destruction of physical assets, and supply-chain complications resulting from fossil-fueled global heating are increasing the costs of production, eroding profit margins, and weakening capital's capacity to accumulate.⁶¹

Losses in labour productivity are especially illuminating. Hotter weather makes people work slower, decreasing economic output. In fact, a recent report by the International Labour Organization finds that global heating will lead to the loss of 2.2% of total working hours, equivalent to 80 million full-time jobs (losses are especially concentrated in Western Africa and South Asia).^{62,h}

But hot weather is not just a drag on labour productivity. It is also a deadly threat to workers, especially for those in outdoor sectors like transport, agriculture, and construction.⁶³ For example, in 2022, 24-year-old UPS Driver Esteban Chavez died during a Californian heatwave, only one year after 23-year-old Jose Cruz Rodriguez died from heatstroke in Waco, Texas.⁶⁴

UPS was ultimately forced to meet union members demands for increased heat protections, including the installation of air conditioning, heat shields, and additional fans in company vehicles.⁶⁵

^h However, the actual figure will be much higher, since the International Labour Organization projects productivity losses based on a 1.5°C end-of-century heating trajectory. Current national climate targets, which are entirely voluntary, would cause up to 2.9°C heating by 2100.



Image 5: UPS workers on strike. Source: Photo by Jeff Kowalsky, Bloomberg (left); @teamsters on X (right).

But it's not just UPS. Capital, especially in the Global North, where more labour regulation exists, must respond to the occupational risks of increasing temperatures. Some companies are now planning to change their work hours to night or early morning to take advantage of cooler temperatures.⁶⁶

This is striking. Wasn't it the British capitalists of the early 19th century who had to plan production around capricious weather patterns? Now the previous antidote – fossil fuels – are the cause of ecological volatility. How will capital respond this time?

4. Sulphate Therapy

Capital is presented with three options. First, it continues to extract, pump, and burn ever-more fossil fuels, destroying the ecological foundation upon which it depends. This is a path of self-annihilation.

Second, capital stops producing fossil fuels and initiates a global acceleration of renewable energy production. Not only does this go against its profit motive, but it would also expedite ecological collapse, leading to the same self-annihilatory outcome.ⁱ

This brings us to the third option: capital briefly escapes its own internal contradictions through a technological lifeboat. Clearly, this lifeboat is SAI. It is a cheap, effective method of global cooling that can restore the ambient temperature required for further capital accumulation.

ⁱ Decarbonising a growing capitalist economy would require huge amounts of copper, lead, zinc, aluminium, iron, and lithium, the extraction of which would destabilise ecosystems and exacerbate biodiversity loss (Hickel, 2019).



Image 6: The Loire river, the longest in France, running dry in summer 2022 amidst severe drought. Source: [Reuters](#).

As the crescendo of global heating gets louder and louder, so do the ruling classes' cries for dimming the sun.⁶⁷ In June 2023, the White House released a report that opens the way for a full-fledged research programme on solar geoengineering.⁶⁸ Soon after, it was the European Commission that called for an international effort to better understand solar geoengineering.⁶⁹ And, most recently, it is the ultra-wealthy European inlet of Switzerland proposing the creation of an expert UN advisory panel on solar geoengineering.⁷⁰

Sure, they're not saying 'it,' but their efforts at research and governance are the rhetorical equivalent of pouring the concrete and loading the planes. As the next section shows, it is this dual front for which movements must draw their battle plans.

Battle Plans

Combining the ecological side effects of SAI (outlined in Section 2) with the political-economic dynamics behind the rise of SAI (outlined in Section 3), it is clear that the current trajectory of SAI must be resisted by popular movements.

This section explores which stages of SAI development should be resisted, and how. First, the risks of researching SAI are explored, followed by the challenges of democratically governing SAI. In view of research risks and governance challenges, avenues for resisting both are then explored.

Front 1: Research

More research leads to more knowledge, which leads to rational decision-making and secular progress. This is a dominant theory in liberal society. On its face, it makes sense. If we understand something better, then we can make more informed decisions. It is also the exact logic that proponents of SAI rely on: more research on SAI will lead to a more accurate understanding of its risks, providing a robust knowledge-base from which policy-makers can make rational decisions on development, regulation, and deployment.^{71j}

But this is a mystification of how the real world works. Decisions are not made on a rational analysis of existing knowledge, but in accordance with the *irrational* imperatives of capitalism. The global response to climate breakdown provides a lucid example.

The IPCC has produced five exhaustive reports on the reality of anthropogenic climate change and the necessity for rapid decarbonisation. The thousands of peer-reviewed papers, reviewed by hundreds of the best climate scientists around the world, has not led to any meaningful climate action. In fact, more carbon has been emitted since the IPCC's first report published in 1990 than at any prior point in human history.⁷² Indeed, the very fact that SAI research is on the agenda – in and of itself a sign that climate research has not elicited requisite decarbonisation – discredits the claim that further SAI research will induce rational decision-making.⁷³

Crucially, it is not research, but the imperatives of capital that will determine the arc of SAI development. SAI won't be used to shave the peak off global heating pending some hypothetical decarbonisation programme, as SAI proponents like to suggest.⁷⁴ Instead, it will be deployed to restore the necessary climatic stability for capital accumulation without stopping the growing combustion of fossil fuels. No amount of extra research changes this reality, only political struggle can.

j SAI research consists of two research modes. First, and most common, are computer generated models, which attempt to predict the cooling effect and ecological impacts of varying levels of SAI deployment. Second, are field experiments, in which SAI is actually deployed on a small scale. Multiple field experiments have already been carried out, while others have been prevented from getting off the ground due to intense local resistance. From here on, "research" in the context of SAI, refers to both of these research modes.

In fact, additional research only strengthens the chances of deployment. This is known as a “slippery slope” effect, whereby an initial exploration into a hypothetical ‘solution’ accrues increasing legitimacy, with each cycle of research followed by governance assessments and international deliberation, incrementally building a discourse and framework for normalisation.⁷⁵

This is reinforced by the well-documented trend of researchers becoming an endogenous interest group for their area of study. For example, medical researchers often become advocates for treatments they have invested their entire career into, sometimes irrespective of potential harms.⁷⁶ This trend is already observable in the burgeoning field of SAI, where the co-founder of Harvard’s Solar Geoengineering Research Program, David Keith, has emerged as a leading public advocate.

We, therefore, are in a situation where SAI is subjected to the interests of capital accumulation and further fossil fuel combustion, *and* the process of simply researching SAI expedites its legitimisation. Combining these two elements, it is clear that there are huge risks associated with allowing further SAI research absent a robust governance structure that ensures just, democratic regulation of the technology.



Image 7: Make Sunsets releasing a balloon full of sulphur dioxide as part of a small-scale field experiment. Source: [Tech Startups](#).

Discussions with existing SAI researchers all but confirm this necessity. In an interview with Luke Iseman, the co-founder of SAI start-up Make Sunsets, he stated:

"If, with no strings attached, some oil company gave me 10 billion dollars and said 'quietly do deployment to half a degree Celsius,' I'd be lying if I were to say I wouldn't do it."

Allowing additional SAI research depends on an appropriate governance structure being in place. We now investigate the possibility of such a structure emerging.

Front 2: Governance

An appropriate governance structure would need to be universal, democratic, and enforceable. This section defines each principle before analysing it against the existing record of international environmental governance structures, which are commonly suggested by SAI proponents as evidence that an appropriate SAI governance structure can be developed.^k

UNIVERSAL

The characteristics of SAI make it amenable to unilateral deployment, particularly by rich countries. As such, all states must be party to the governance structure. This is to ensure that there is no opportunity for a single actor or a minority coalition to make such world-shaping decisions.

This requirement becomes particularly necessary considering that the heterogeneous effects of SAI would produce "winners and losers," creating an incentive for minority deployment by the 'winners' against the will of the 'losers.'^{98,a}

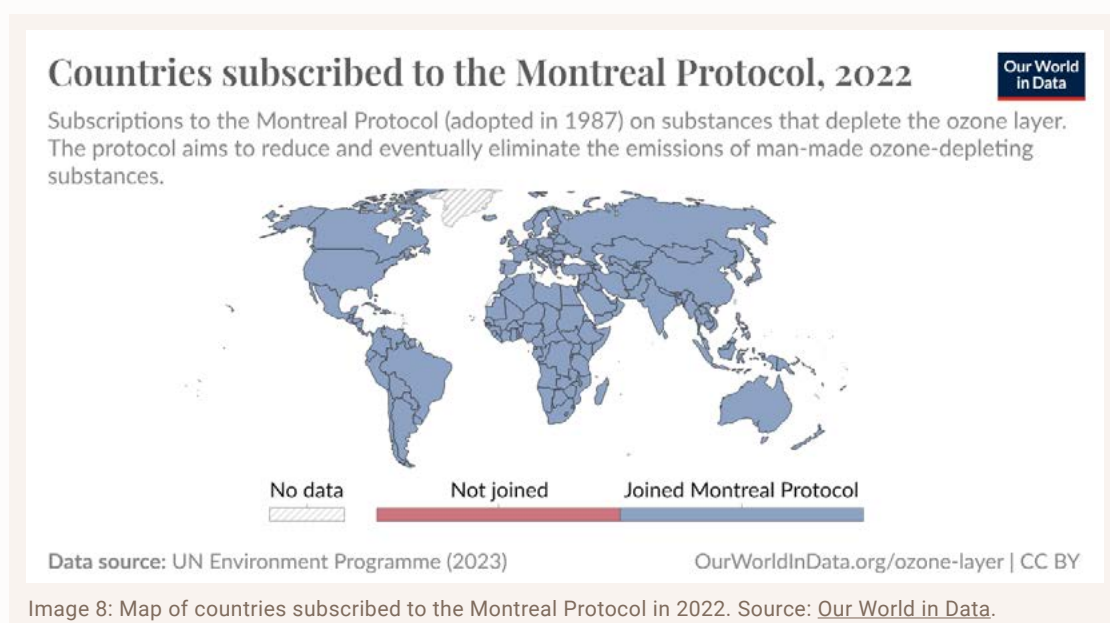
^a It should be noted that SAI proponents, disproportionately from the Global North, identify the possibility of unilateral deployment to be an *advantage* of solar geoengineering, as it can be deployed in an emergency "without broad international cooperation" (Reynolds, 2021). Existing enthusiasm for unilateral deployment reveals the imperative for a robust SAI global governance structure.

^k For example, the UNFCCC (see [Biermann et al.](#)), the UN General Assembly, and the Montreal Protocol (see [Silver Lining](#))

International climate agreements have a spotty record on universality. They have particularly, and not coincidentally, struggled to reign in the world's largest emitter: the US. The US never ratified the Kyoto Protocol, nor the Convention on Biodiversity, and also temporarily left the Paris Agreement under Donald Trump's presidency.

Only the Montreal Protocol received universal ratification. Indeed, it stands out as the first and only international environmental agreement to have 197 state signatories. However, the Montreal Protocol was unique in that it focused on the phase out of chlorofluorocarbons – an ozone-depleting chemical that was easily replaceable in production processes. This stands in stark contrast to climate change agreements, as fossil fuels cannot be easily replaced without disrupting capitalist production. Indeed, this helps explain the success of the Montreal Protocol and the relative failure of the Kyoto Protocol.

When it comes to regulating processes intimately involved with capital accumulation, it is only when the agreements are non-binding that the most powerful countries agree to join. In this way, under current political-economic arrangements, developing a universal SAI governance structure would be *conditional on* insufficient enforcement mechanisms – another necessary condition explored further below.



DEMOCRATIC

SAI governance needs to be democratic to the degree that the interests and voices of the global working class and oppressed – that is, the global majority – are represented. This is the most basic and crucial condition given the world-making effects of SAI deployment.

While a full review of democratic governance principles is beyond the scope of this report, such a structure must address three aspects. First, it must have mechanisms for evening out power asymmetries between states, which are characteristic of the imperialist world system. Second, it must meaningfully include the voices of stateless people, including Palestinian people, Sahrawi people, Kurdish people, and indigenous nations, among others. Third, it must have processes that are accessible and varied to welcome contributions from diverse knowledge systems and worldviews.

It is a recurring theme that the needs of the global majority are subordinated to interests of Northern governments and capital in international climate negotiations. This power asymmetry is why the 2011 People's Agreement of Cochabamba called for the Global North to commit at least 6% of annual GDP to climate finance for the South, and yet, Northern states only mustered a combined \$89 billion in climate finance in 2021 – 0.4% of the US' GDP that year.⁷⁷

Indeed, SAI proponents recognise that “the international system is undemocratic in sometimes contradictory ways.”⁷⁸ However, they deploy this in justification of pressing ahead with undemocratic SAI deployment, rhetorically asking, “is democracy everywhere not circumscribed by wealth and power?”⁷⁹ In so doing, they reveal their fundamental commitment to reproducing existing power imbalances instead of acknowledging and addressing the systemic drivers of climate breakdown. Ultimately, with international governance structures that don't address the material power imbalances between states and feign equal representation, “the force [of imperial powers] will decide.”⁸⁰

ENFORCEMENT

Any effective SAI governance structure needs appropriate enforcement mechanisms. Crucially, the strength of these mechanisms would need to be a historic first, strong enough to deter the most powerful nations from unilateral or minority coalition deployment.

Existing climate governance structures are largely unenforceable, allowing countries to break pledges with impunity. For example, signatories of the 2015 Paris Agreement committed to “limiting global temperature increase to well below 2 degrees Celsius, while pursuing efforts to limit the increase to 1.5 degrees.” But current emissions reduction plans under the Paris Agreement, which are entirely voluntary and unenforceable, would lead to 2.5°C to 2.9°C heating.⁸¹

Universal, democratic, enforced governance: Capital's antithesis

It is no coincidence that there has never existed a governance model which appropriately fulfils the necessary conditions for SAI governance. Such a structure fundamentally contradicts the interests of the ruling classes. In the case of SAI, democratic participation and just deliberation would involve an interrogation of the atmospheric commons, including the colonisation of the atmosphere, the need for ecological reparations, and a general critique of global imperialism. SAI *requires a lack of participation* for it to be effectively deployed by the ruling classes as a fix to capitalogenic climate breakdown.

On this basis, it is clear that a governance structure, which includes the necessary degree of universalism, democracy, and enforcement mechanisms, is not possible in the capitalist world system. Absent such a governance structure, SAI becomes a form of “stratospheric imperialism.”⁸² Manipulation of the weather system to maintain existing patterns of accumulation, at the cost of uneven global impacts, assumes a ‘natural’ ownership of the climate by developed nations, which can only be understood as imperial domination of the atmosphere.

As such, movements should resist both the institutionalisation of SAI governance – which is necessarily inadequate and therefore extremely dangerous – and SAI research efforts, given the impossibility of appropriate governance structures under capitalism and imperialism.

We now explore examples of past resistance efforts from which important lessons can be learned for resisting SAI.

Resisting SAI

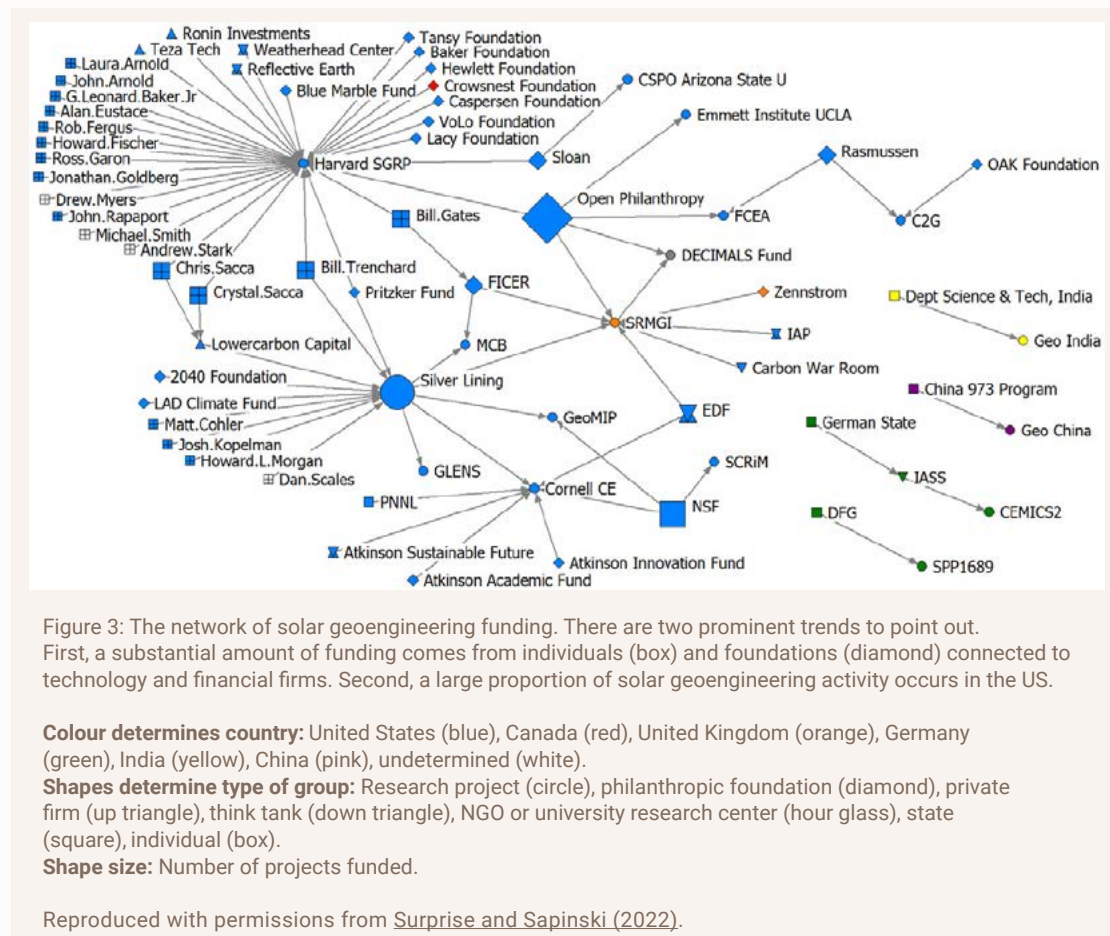
Below is a brief review of various case studies relevant to SAI resistance. Importantly, we do not propose a definitive strategy for movements to adopt; movement strategy and tactics can only emerge from a concrete analysis of concrete conditions. Rather, this should be read as an initial exploration into movement history, identifying examples which bear some lessons for potential SAI resistance.

I. Resisting SAI Modelling

Resisting SAI modelling should primarily be focused on established, well-funded research programmes. While this would include government research programmes, existing examples, like Harvard’s Solar Geoengineering Research Program, indicate that universities will be key hubs for such research efforts. Accordingly, the large number of student-led campaigns trying to cut ties between university research and fossil fuel companies as well as arms manufacturers provide useful examples.

In these campaigns, activities range from raising awareness on campus to engaging staff and direct action, including sit-ins, walk outs, occupations, and testing and assignment strikes. Recently, students at Cambridge University forced the university to place a temporary moratorium on all donations from fossil fuel companies, pending a review of the university’s donation policy.⁸³

A common thread between these campaigns is that they strategically target the *fundors* supporting university research programmes, a strategy that SAI resistance efforts would likely need to replicate (see *Figure 3* for a map of SAI funders).



In the recent student uprising for Palestinian liberation, student campaigns have also won a number of victories which demonstrate how students can mobilise their institutions towards campaign objectives. For example, at Swansea University, students have won a commitment from management to divest £5 million from Barclays bank, while students in Spain have forced 76 universities to cut ties with Israeli universities found to be 'complicit' in the genocide.^{84,1} These examples bear relevance for potential SAI resistance efforts aiming to keep SAI research and funding off campus.

II. Resisting SAI Field Testing

SAI resistance itself provides the best model for future resistance against SAI field testing, as there has already been a successful case.

¹ Barclays bank provides billions in loans to companies that manufacture weapons for Israel.

In June 2021, Harvard’s Keutsch Group, operating in connection with the Harvard Solar Geoengineering Research Program, attempted to conduct an SAI field experiment called the Stratospheric Controlled Perturbation Experiment (SCoPEX).⁸⁵ SCoPEX was set to launch in Kiruna, Sweden which is the territory of the Saami people. When the Saami Council learned of the planned experiment, not from the Keutsch Group and not from the Swedish government, but from their “international network of indigenous brothers and sisters,” they mounted a fierce resistance campaign.



Image 9: The Saami Council at the 10th Ministerial Meeting of the Arctic Council.
Source: [Geoengineering Monitor](#). Arctic Council Secretariat, Linnea Nordström.

The campaign consisted of several letters sent to the SCoPEX advisory committee, Swedish ministries, and Swedish Space Corporation. Other groups, including the Swedish Society for Nature Conservation, Friends of the Earth, and Greenpeace, also helped amplify the Saami Council’s position and triangulate resistance to the experiment.⁸⁶ Ultimately, Keutsch Group cancelled SCoPEX and suspended further field tests in Sweden.

In addition to Saami resistance, other efforts opposing SAI field experiments are well underway, such as the Hands Off Mother Earth! Manifesto, demanding an immediate stop to “all planned outdoor geoengineering experiments,” the Hands Off Mother Earth! Alliance – a cross-movement monitoring network – and the Mexican government’s January 2023 ban on SAI field experiments.⁸⁷

While these examples provide a strong foundation for future resistance to SAI field experiments, as climate breakdown accelerates and puts increased pressure on capital accumulation, the ruling classes' drive to deploy SAI will also grow. As such, resistance efforts will need to escalate in lockstep.

Here, one movement from history stands out in particular: the Luddites. Active in 19th century England, the Luddites were a movement of textile-workers resisting the introduction of new power looms. The Luddites are often characterised as technophobic, "short-sighted peasants who just wanted to put a stop to progress itself."⁸⁸ However, as described by Gavin Mueller, "their revolt was not against machines in themselves, but against the industrial society that threatened their established ways of life, and of which machines were the chief weapon."⁸⁹



Image 10: The leader of the Luddites, Ned Ludd.

The Luddites used a range of methods from sending threatening letters to cotton capitalists to sabotaging the new machinery.⁹⁰ Both in terms of motivation and tactical militancy, direct links can be made between the Luddites and possible future resistance to SAI deployment.

III. Resisting SAI Institutionalisation

Similarly to resistance efforts against SAI field testing, pushback against the institutionalisation of SAI governance is already underway. In 2022, over 60 scientists, academics, and climate experts issued a call for an International Non-Use Agreement on Solar-Geoengineering. The proposed Non-Use Agreement contains five key elements: (1) no public funding, (2) no outdoor experiments, (3) no patents, (4) no deployment, and (5) *no support in international institutions*. The open letter calling for a Non-Use Agreement currently has over 500 signatories from prominent academics around the world.

Should efforts to operationalise an international SAI governance structure escalate, so too must resistance. In recent history, the 1999 protest against the World Trade Organisation (WTO) offers the most relevant parallel.

In opposition to the WTO's neoliberal trade agenda, 50,000 people mobilised on the streets of Seattle (US), bringing together a diverse coalition of union leaders, anti-capitalist organisers, and environmental activists. Making use of a range of tactics from blockading key intersections to surrounding hotels where delegates were staying, the protesters successfully shut down the conference's opening ceremony, the talks collapsed, and the WTO left Seattle without a mandate.



Image 11: Environmental activists dressed up as turtles during the 1999 WTO protest in Seattle.
Source: [Northwest Labor Press](#).

It should be noted that the anti-globalisation movement, of which the 1999 Seattle protest was a key moment, ultimately failed. In the case of SAI, the stakes are so high that failure is not an option. So, let these historical examples provide a lesson from which we can build a resistance that is too big, too coordinated, and too organised to fail.

Conclusion

As climate breakdown accelerates, so will the ruling classes' scramble for an emergency fix. There is such a fix lurking in the wings, making its steady advances like a thief under the cover of a fire-blighted sky: SAI.

SAI must be resisted now, when it remains confined to esoteric research and loose calls for institutionalisation. Because when gleaming sulphate jets are unveiled to claps from planetary arsonists turned atmospheric saviourists, it will be too late.

The call from this report is not to divert attention away from organising against the systemic drivers of socio-ecological collapse: capitalism and imperialism. Instead, our movements must understand that SAI is yet another front in the struggle for global anti-imperialist eco-socialism.

Liberation awaits under a blazing blue sky.



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