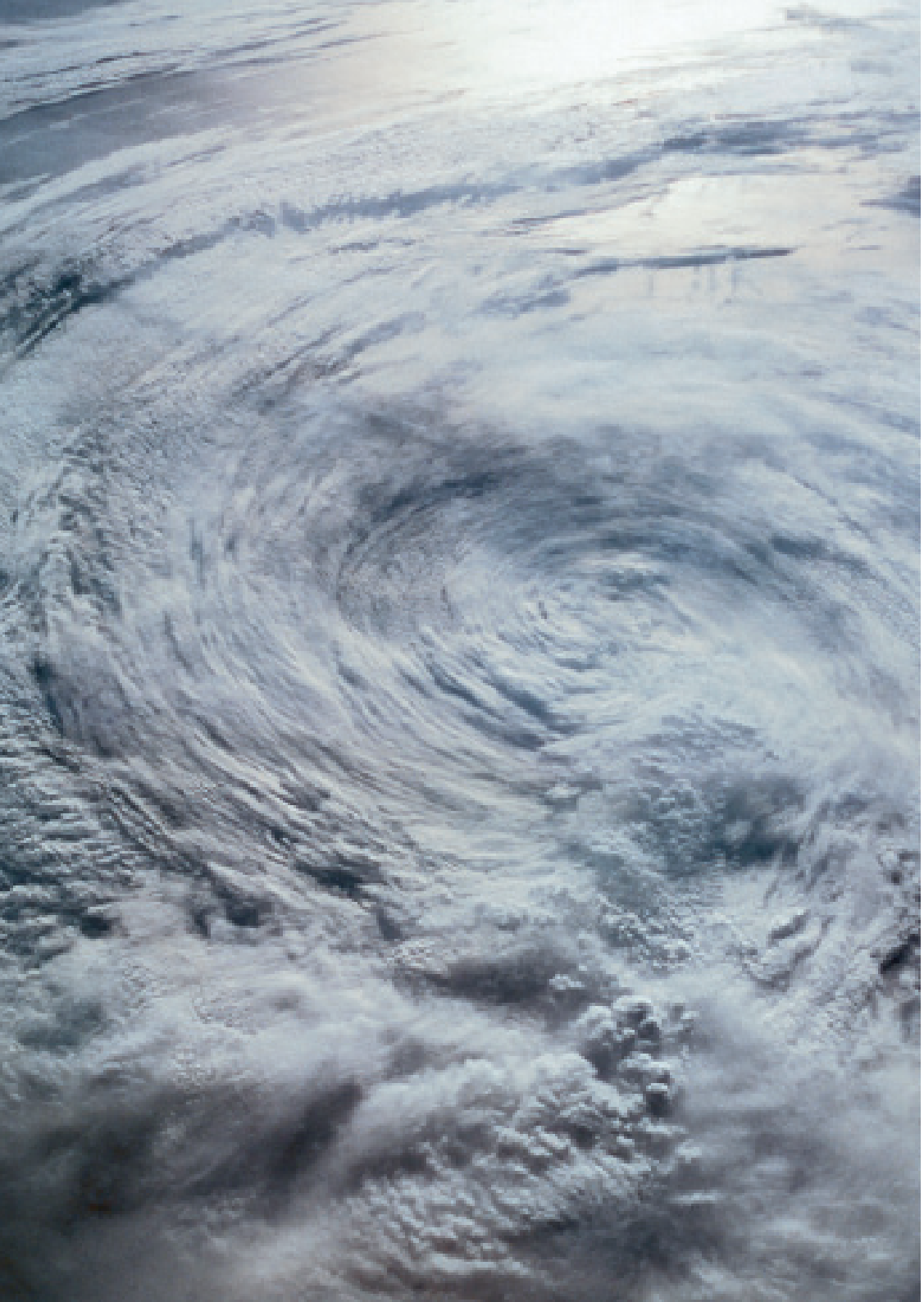

CHAPTER 4

Will solar geoengineering help us manage the risks of climate change?

by David Keith and Andy Parker

In 1896, the Swedish scientist Svante Arrhenius was the first to publish a quantitative estimate of how much the world would warm if industrial activities increased the concentrations of carbon dioxide in the atmosphere. His estimate was roughly the same as that generated today by climate models running on the world latest supercomputers. Yet Arrhenius was not troubled by industrial pollution as we are today. Instead he speculated about a virtuous circle in which warming caused by the carbon accumulating from burning coal would warm the world, spreading the limits of agriculture northward and so help to feed a growing population.

We draw a simple lesson from Arrhenius: understanding of the basic science linking CO_2 and climate change has remained remarkably constant while the social context of this obstinate fact has changed hugely over the century.

In this chapter, we speculate about the future of solar geoengineering – also called solar radiation management or SRM.

Solar geoengineering looks likely to overshadow nuclear energy and shale gas as the most controversial issue in climate politics

SRM is a proposal for cooling the planet by reflecting sunlight away from the earth (of which more below), and it looks likely to overshadow nuclear energy and shale gas as the most controversial issue in climate politics. Here we look out to the year 2035 and, to make our discussion concrete, we assume that someone will deploy solar geoengineering that year. We make an (unrealistic) assumption that scientific understanding of SRM will remain identical to today. This assumption allows us to concentrate on how political ideology and geopolitics might influence the development of geoengineering. We want to show how the very same act of deployment could have greatly different implications, depending on who does it and how.

The risks and opportunities of solar geoengineering

The basic facts of climate change are painfully simple. From the telegraph and railroad to the smartphone and jet airliner, fossil energy – coal, gas and oil – has energized the rise of industrial civilization. Use of fossil fuels has involved the transfer of carbon from deep underground to the atmosphere, where it lingers for centuries and drives global warming.

The only way to stop the long-term rise of carbon dioxide concentrations is to stop adding carbon to the atmosphere. This means bringing emissions to zero, which in turn requires transformation of our systems of transportation, energy production and agriculture. This transformation is entirely possible. The world's failure to restrain emissions is not a forced choice, but rather a collective decision to extract the maximum benefits of cheap energy today while passing along the risky consequences of our actions to future generations. In our view, the failure to act represents an acute moral failure on the part of those in the best position to act: the world's richest and most powerful.

Even if humanity eliminated carbon emissions tomorrow, the planet would continue warming for decades and would remain warmer for thousands of years. This leaves us with a rather disagreeable reality: should we wish to stop global warming before emissions cuts take effect – and at the current rate of decarbonization, that could be many, many decades – then solar geoengineering is our only option. It is in this context that Eli Kintisch, author of one of the first books on geoengineering, described it as "a bad idea whose time has come".

The basic science is simple and well understood. Large volcanic eruptions can blast millions of tons of sulphur into the upper atmosphere (stratosphere). Tiny sulphate particles (also known as aerosols) remain in the stratosphere for a year or two and reflect away a small amount of sunlight, which cools the planet. The last time this happened was the eruption of Mount Pinatubo in the Philippines in 1991, which caused global temperatures to drop by about half a degree C for a year.

Even if humanity eliminated carbon emissions tomorrow, the planet would continue warming for decades

Faced with a warming planet, increasing CO_2 emissions and stalled climate talks, scientists are asking if it might be possible to add aerosols to the stratosphere to slow down global warming. And if so, what the effects (both desirable and undesirable) might be.

1965

the year in which solar geoengineering was first discussed in US politics

Solar geoengineering is in fact not a new idea. When the threat of climate change was first brought to the attention of then US President Lyndon Johnson in 1965, his advisers proposed blocking out a small amount of sunlight as a possible solution. For decades the topic remained a taboo amongst climate scientists, who feared that even researching and discussing the idea could prove a dangerous distraction from the need to reduce carbon emissions. In the last decade, however, fueled by concerns over how best to minimize the risks of the climate change we are already facing, geoengineering has moved from the margins to the mainstream and is now being seriously researched.

$40 million

estimated amount spent on research on solar geoengineering worldwide

Even though funding levels are still very low (probably less than $40 million has been spent on research around the world to date), there are research projects or programs in the US, China, Japan, India and various EU countries. Almost all research has so far taken place indoors, in studies and laboratories, rather than outdoors in the field. Geoengineering research is not only conducted in the areas of climate modeling and atmospheric chemistry but also in politics, law, philosophy and economics. In 2013, for the first time, there were more publications about solar geoengineering in the fields of social sciences than in physical sciences.

Calls are increasing to do more small-scale field experiments to better understand what the possible benefits and drawbacks might be, but so far most governments have been timid about investing in SRM research.

At this stage, engineers are arguing over how such deliberate cooling of temperatures might best be achieved, whether with planes or balloons spraying sulphates or perhaps a tailor-made nanoparticle. But it does seem possible to spray aerosols into the stratosphere, where they would circulate the planet and reflect away sunlight for a year or two. It also seems that this would be extremely cheap, with a projected price tag of a few billion dollars per year.

Solar geoengineering would be extremely cheap, with a projected price tag of a few billion dollars a year

Whether we could deploy SRM is one question, whether we should deploy it is something entirely different. Understanding the potential physical and socio-political consequences is a huge challenge.

Computer models of the potential climate impacts of SRM have produced some encouraging results. A growing body of research indicates that a world in which SRM were used would be much more palatable, because of lower average temperatures and less extreme rainfall pattern, than a world where SRM was not used.

It is certain that there would be some side effects: possibilities include delays in the regeneration of the ozone layer, hazier skies, and some areas with slightly worse weather than they would have had otherwise. But in general, our current understanding indicates that the drawbacks would be greatly outweighed by the benefit of reducing the impacts of climate change.

Politics will be as important as science

The potential socio-political consequences may, however, be more worrying than the physical effects. SRM would only ever mask the problem of global warming rather than treating its cause. It is not yet clear to what extent the idea of SRM might distract people from traditional action to fight climate change.

Some people also fear that, over time, irresistible political momentum might build for larger and larger research projects and possibly even deployment, regardless of what is learned from research results. On top of all of this, we must ask hard questions about the use of SRM. Who would get to decide about deployment, and how? How could liability and compensation schemes work to resolve claims for damages from people who believe that they have been harmed by climate engineering (from an extreme weather event, for example)? What would democratic decision-making look like for an inherently global technology?

Given all these risks and uncertainties, it is clear that SRM can never be the sole solution to climate change. Climate change is far too complex to be addressed by just one solution, either technical or social. But it would be a risky gamble to dismiss SRM out of hand. The earth will continue warming for decades (at the very least), and the world's most vulnerable people are already beginning to suffer the consequences. Climate change will have many consequences that we cannot avoid through adjustment and adaptation, for example the loss of Arctic ecosystems or low-lying lands that will be inundated by rising seas.

Solar geoengineering would only ever mask the problem of accumulating greenhouse gases rather than treating its cause

The large risks of climate change, plus the risks and uncertainties of solar geoengineering, place us in a risk/risk scenario. There are obvious risks from developing SRM (such as possible effects on weather patterns and ozone) but there are also significant risks from not developing it

(our vulnerability to the damaging consequences of climate change that are already emerging and to which we cannot adapt).

In this situation of uncertainty, it is hard to overstate the importance of the manner in which SRM is perceived, researched and developed.

Predictions about geoengineering – about any complex technology – are most probably doomed to ignominious failure. There are huge uncertainties, not only about the science, but also about the roiling morass of political power, social relations, beliefs, norms, hopes and fears in which the science is developing. This is not to say that projections are useless. Even if they turn out to be wrong, they are needed to fuel debate about the decisions that will shape the future.

At the Climate Engineering Conference 2014 (the largest conference yet held on the topic of geoengineering), writer Jamais Cascio pointed out that projections will probably be wrong, but that they can be wrong in a useful way. Where projections are based on sound analysis, even when proved comically wrong, they can encourage thought on the forces that might produce more or less desirable outcomes. The reader will judge whether the analysis here is sound, but we have tried to identify factors that could be influential in the use of SRM.

Political scenarios for the use of solar geoengineering

As outlined above, there are great uncertainties in both the scientific and socio-political dimensions of SRM. To keep our analysis manageable, we assume that the science remains stuck and that SRM will work in line with our current understanding until 2035:

We need projections – even if wrong – to fuel debate about the decisions that will shape the future

- It would be cheap to deploy.
- It would generally reduce the impacts that global warming is set to have on temperatures and rainfall patterns in all regions of the world.
- There would be some side effects but these would be outweighed by the positive impacts.

It is worth restating with unambiguous clarity that SRM is highly unlikely to work exactly in this way. The taboos surrounding SRM research means that very little effort has been expended to improve the technology. As these taboos are lifted and the research community expands, new innovation will likely overturn our conception of SRM. But assumptions are necessary for manageable analysis.

Extrapolating from our assumptions about the science of SRM, our starting premise is that, in the year 2035, solar geoengineering will be deployed. The rationale is that at least one country will find the prospect of a cheap, instantaneous way of mitigating warming too much to resist. We use this basic premise to explore how political ideologies and geopolitics might influence the use of SRM.

The political history of climate change has shown the extent to which science can be distorted to suit pre-existing political ideology. This tendency has been particularly strong for right-wing commentators, think-tanks and publications that have a sorry track record of denying that climate change is happening or is man-made.

Geoengineering already appears to be following the same path. Sections of not only the right but also the left-wing political spectrum are seeking to contort the available evidence to match their beliefs. Ideology will shape our understanding and use of geoengineering. To understand how this might happen, we examine the topic's recent history and speculate about its future.

I The right-wing debate

Right-wing ideologues are already promoting geoengineering as a way of addressing climate change without emissions cuts

Right-wing ideologues, with a history of global warming skepticism, are already promoting geoengineering as a way of addressing climate change without emissions cuts. In the US, the Heartland Institute, a conservative Chicago think-tank, and the Republican politician Newt Gingrich, have already started promoting SRM as a possible climate solution, as has Madsen Pirie, President of the free-market Adam Smith Institute in the UK.

The argument is simple and seductive: why bother with the hassle and expense of decarbonizing the economy over decades while geoengineering would allow us to affect temperatures now?

The seamless switch from climate change denial to the embrace of geoengineering stems from a false skepticism about global warming. This skepticism was not born of genuine doubts about science. Rather, climate skeptics fear that the actions needed to deal with climate change present a threat to the agenda of small government and deregulation.

To think about geoengineering as a substitute for climate action is dangerous. We know that solar geoengineering would only mask the warming effects of increased greenhouse gas concentrations while doing nothing to address emissions. While it might be useful for reducing climate risk in the short term, SRM cannot be a complete solution to climate change.

If right-wing ideology dominates the development of geoengineering up until our projected deployment date in 2035, then SRM will have distracted attention from fighting climate change and dealing with its consequences. Such a distraction would increase environmental risk as the world would then have to use much more SRM and for longer in an effort to maintain the balance between cooling and warming effects, until such time as atmospheric carbon concentrations could finally be brought under control.

Moreover, if SRM is seen as a substitute for coordinated, meaningful emission cuts, the global climate policy landscape will be much more antagonistic. Trust between countries and governments will be low, and effective international cooperation on developing and using SRM will be very difficult. (Below we explain why international cooperation will be vital for the effective use of SRM.)

II The left-wing debate

As the right wing of the political spectrum has warmed to the idea of solar geoengineering, some on the left wing have moved into short-sighted, knee-jerk opposition. In part, this opposition is driven by the reasonable fear that right-wing ideologues might use the prospect of SRM to avoid climate change action. But some on the left are also frustrated that SRM threatens their view of climate change as a vehicle for other political goals, notably overhauling the way the global economy works.

At least some people on the left have supported traditional climate policy (such as carbon taxes or reducing consumption) because they hope that such measures could also be a direct challenge to the excesses of corporate capitalism. According to anti-capitalist author and activist Naomi Klein, climate change is "the best argument progressives ever had … to block harmful free trade deals". This may be so, and making the economic system more just is a goal that both authors of this chapter share. But climate change is first and foremost an immediate and growing threat to vulnerable people and nature. It would be dangerous to mislead people that useful action to reduce climate risk can only come from overhauling the global economic system.

Some technologies might help reduce the risks of global warming without changing the global economic system

Like some other contentious environmental technologies (such as carbon capture and storage and nuclear power), SRM may help reduce the risks of global warming without doing anything to change the global economic system. This is perhaps why it has met with some fierce opposition on the left.

Naomi Klein took an entire chapter of her recent book to oppose SRM, particularly by attacking the science and scientists with half-truths, cherry-picked facts and misleading insinuations. Some center-left politicians have also been skeptical, for example former US Vice President Al Gore, who has described solar geoengineering as "insane, utterly mad and delusional in the extreme". Left-wing critics are right to be wary of the potential risks of SRM, but are deeply cavalier to dismiss it outright, given the scale of the problem of climate change.

Some organizations have gone even further. ETC Group, an anti-technology pressure group, has campaigned aggressively against geoengineering science and scientists for years. It has pushed hard (but unsuccessfully) for a ban on "all geoengineering activities" at the United Nations Convention on Biological Diversity. The potential impact of more radical organizations should be a genuine concern for anyone who favors evidence-based and open public debate.

If research on SRM was stopped, the technology could still be deployed, but it might then be poorly controlled and more dangerous

If left-wing ideological opposition to SRM is successful at stopping, delaying or severely hampering research on SRM, the technology could still be deployed in 2035, but it might then be poorly controlled and more dangerous.

The basic characteristics of SRM mean that at least some people, probably some countries, will want to deploy the technology by 2035, if only out of desperation. Without proper research on SRM, the drive for its deployment might even be stronger since facts would not be available to counter blind, fear-fueled determination. But it would then be far less likely that the use of SRM would be widely agreed, carefully planned and well controlled.

III The political outlook

The more controversial and rigid elements of left and right will feed off each other, each seeking to polarize the debate. Such a debate will get the opponents of SRM into the news but it will undermine well-informed decision-making. The more that the right-wing "SRM is the solution to climate change" narrative prevails, the greater the risk that climate mitigation will be sidelined. Long-term climate risks would then increase. Equally, the greater the success of those on the left who oppose even research, the greater the chances that SRM will be sidelined, denying the most vulnerable a chance to temper short-term climate risk.

The geopolitics of geoengineering

Decisions over SRM will not be based simply on political battles within countries because (at least for the foreseeable future) decision-making powers over climate engineering are likely to be the preserve of nation states.

Academics have only recently started to think seriously about how the deployment of SRM could play out in our chaotic, multipolar international system, but theories are starting to emerge.

SRM would be very cheap to use, which could make it possible for a single state to deploy the technology unilaterally, without international coordination. The effects of SRM, however, would not stop at state boundaries.

If solar geoengineering was so cheap as to be an option for all, then the world might get an oversupply of cooling

It seems inescapable that some countries will want more SRM, some less, and others will want none at all. Harvard economist Marty Weitzman characterizes this as a "free driver" problem, in contrast to the classic "free rider" problem that bedevils efforts to cut CO_2 emissions. If the use of SRM was so cheap as to be an option open to all, then the state wanting the greatest degree of cooling might be the only one to get its wish, and all others might be "oversupplied" with cooling. This would be the exact opposite of the "undersupply" of emissions cuts in the fight against climate change (see chapter 1).

Other researchers have argued that it might be hard for an individual state to deploy SRM in the face of opposition from powerful neighbors. Nevertheless, a sufficiently strong coalition of countries might have the political clout to use SRM regardless of opposition from others. The members of this coalition might have an interest in keeping the group as small as possible to retain maximum influence over where to set the global thermostat.

The idea that individual countries could use solar geoengineering without further coordination initially looks alarming. But we think this risk is overblown. Powerful nations could probably use the traditional tools of statecraft to try to dissuade any one state that intended to deploy SRM on its own. But if research continues to show that SRM would be beneficial, it seems likely that big countries, too, would also want to play a role in deployment.

Many people may also think that traditional power relations will hold sway when it comes to the use of this technology, with the richest countries deploying SRM against the will of the developing world. It would certainly be understandable if developing countries were initially suspicious of the SRM, as the basic facts are fairly damning: this is a technology conceived in the global North to address a problem that was largely

created by the global North. The North has done little to address the problem it created and could try to sidestep its responsibilities altogether through use of the technology. In this light, skepticism from the South may seem inevitable.

We believe, however, that developing countries will be the most likely to demand deployment of solar geoengineering. The worst impacts of climate change are expected to hit developing countries, which are often least able to cope with environmental change. If the science continues to indicate that SRM could relieve the worst effects of global warming, there will be pressure from the global South to use geoengineering. In addition, it is expected that the global economy will have doubled by the early 2030s, with the highest growth rates among developing countries and emerging economies. Where developed countries are not taking action on the climate, developing countries might feel both justified and empowered to start taking matters into their own hands.

Developing countries will be the most likely to demand deployment of solar geoengineering

The use of solar geoengineering – what happens next?

Even if SRM were used successfully to stop all planetary warming, there would still be storms, floods and droughts afterwards. After all, extreme weather was around long before humanity first put spark to tinder, tilled the earth or sent sulphate-laden jets to the stratosphere.

But current modeling studies suggest that SRM could improve temperatures and precipitation in almost all regions of the planet. Yet, even if the vast majority of areas enjoyed a more palatable climate, some people would suffer extreme weather events that they would not otherwise have experienced. The problem is that it would not be possible to say who would be affected and how with any degree of confidence.

People might question whether a major typhoon or heatwave was linked to solar geoengineering

These uncertainties will have a large effect on the public perception of solar geoengineering. Just as today people question whether a hurricane or drought was the result of global warming, people would wonder whether a major typhoon or heatwave was linked to use of solar geoengineering.

If ideological opposition to SRM severely hampers research, SRM may in future be deployed in a panicked or improvised manner, without international norms or governance institutions having been established. Alternatively if SRM is used to distract attention from the need to reduce emissions, deployment may take place without a solid, binding and verifiable agreement on cutting carbon emissions. In such an environment, the chances of international cooperation over, and trust in, geoengineering would be much diminished. Similarly, if developing countries are not empowered to take part in geoengineering discussions and research early on, and their opposition to SRM becomes entrenched, SRM deployment will lack legitimacy and opposition will be fierce.

Discussion of solar geoengineering tends to gravitate to the eye-catching technical details. Yet the who and the how matter as much as the what when it comes to the use of geoengineering. We have used unrealistic and rigid assumptions to accentuate some of the ways in which the same physical deployment of SRM could be cast in very different lights depending on the circumstances and the political forces shaping them.

The siren calls of ideologues on either side of the political spectrum must be resisted. No one yet knows enough to say that SRM should be used or should be rejected. Those who seek to prevent SRM research are taking an unnecessary gamble with the lives of the world's most vulnerable people. Those who say SRM obviates the need for tackling carbon emissions are taking a risk with the long-term health of the planet. Thankfully, there are plenty of people from diverse political backgrounds who recognize the large potential risks from the development of this technology, but also recognize the large risks from not developing it. These people are concerning themselves with the more pressing and practical questions of how research and development should be governed to ensure accountability, transparency and safety.

Those who seek to prevent SRM research are taking an unnecessary gamble with the lives of the world's most vulnerable people

It will be crucial to internationalize SRM research from an early stage. Establishment of cooperative research programs and shared governance standards can help create the conditions for international agreement, which will be necessary for large-scale research and deployment. Developing countries must be involved. People in the global South probably have the most to gain or to lose from solar geoengineering. But they also have the reasonable right to be suspicious of a technology being developed by the same rich countries that caused most of the climate change being experienced today, and who have done little to fulfil their responsibilities to decarbonize. It is therefore very important to secure their early participation – or active leadership – in research, governance and international discussions.

Finally, it is worth repeating that the science of SRM will most likely surprise us. Extrapolating from current understanding served our purpose here, but we do not expect the science to develop along a smooth trajectory. There are many surprises ahead in the social and natural sciences that cannot be guessed at this early stage. Only continued research will help us understand them. Such understanding will help us decide whether the use of solar geoengineering is indeed a bad idea whose time has come, or just a plain bad idea.

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