The Need for Governance of Climate Geoengineering

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Sooner rather than later, policymakers around the world will need to confront an uncomfortable reality: that despite the best efforts of national governments and thousands of mayors and other civic leaders, we can no longer contain global average temperatures to below 1.5–2 degrees Celsius above preindustrial levels through mitigation of carbon emissions alone. It is widely acknowledged that even if the world stopped all emissions today, there would still be a rise in global temperatures to a level that would stay for hundreds of years (the lifetime of the carbon dioxide already in the atmosphere) before temperatures began to drop, thus constituting a temperature "overshoot." For many experts the question is no longer whether the world can keep the temperature rise below the goals stipulated in the Paris Agreement, but by how much will the world miss that target and how long will the overshoot last.

The acknowledgement of this temperature overshoot—alongside a growing appreciation of its devastating impact on people's lives, the global economy, and the environment—may mark a new inflection point in our efforts to manage the risks of climate change.[1] When you add to this the U.S. president's announcement in June 2017 that the nation would withdraw from the Paris Agreement, it comes as no surprise that a growing number of scientists are thinking about additional approaches to managing the risks of an overshoot. Perhaps most dramatically, we have seen a resurgent interest in a field that once resided at the fringes of science or on the pages of sci-fi novels, but which is now being taken quite seriously in academic circles: geoengineering.

As this interest develops, it is becoming more likely that a group of countries or cities or even one or more wealthy individuals might decide to deploy geoengineering technologies during the coming decades. We need to be ready for any such eventuality; and being ready means considering a host of pressing questions. How

Ethics & International Affairs, 31, no. 4 (2017), pp. 419–430.

doi:10.1017/S0892679417000405

would we govern such actors? Who assesses the balance of risks and rewards when deploying geoengineering technologies? What safeguards and what compensation mechanisms need to be built in? If we start deliberately altering global temperatures, who controls the global thermostat?

It was to address these questions that the Carnegie Climate Geoengineering Governance Initiative was born: to bring the profoundly complex issues of geoengineering governance and ethics to a much wider audience.[2] We are potentially at the dawn of an age of geoengineering. It is time for policymakers to start discussing whether geoengineering is to go forward and, if so, how.

What is Geoengineering?

While definitions vary, geoengineering (also called climate engineering) is the deliberate, large-scale human intervention in the Earth's climate system to reduce the risks of climate change. As of now there are two different types of intervention: one, the removal of carbon dioxide from the air; the other, the reflection of heat back into space, also known as "solar radiation management"—or SRM for short. Both technologies are in their infancy. Carbon dioxide removal is seeing its first real-world applications, while solar engineering does not yet exist beyond computer models. Each faces a unique and heady mix of political, ethical, and scientific concerns. Neither represents an alternative to radically reducing greenhouse gas emissions or to adapting to the impact of climate change. But a growing number of scientists argue they are necessary tools to deal with what is coming, and that we can no longer afford to ignore them.

Carbon Dioxide Removal

Carbon dioxide removal technologies were considered to be indispensable for staying below the 2-degrees target in most scenarios of the 2013 Fifth Assessment Report of the Intergovernmental Panel on Climate Change, which referred to these as "negative emissions technologies." The methods range from the large-scale planting of biomass (which would be used to generate power in conjunction with carbon capture and storage) to artificial devices that capture carbon dioxide directly from the air. The problem with relying on these technologies as laid out in the 2013 Assessment Report is that, in reality, no carbon dioxide removal technique is close to being deployable at sufficient scale, or at a price point that is feasible for keeping below the Paris temperature goals. Moreover, most approaches entail land-use and other trade-offs—some very significant—with other high-priority development goals, such as food security.

Solar Radiation Management

Such technology does not yet exist beyond the lab, but some scientists say it potentially offers a faster, practical, and cost-effective route to lowering temperatures, and could help in managing an overshoot period. The broad concept behind this technology is based on the albedo effect, a term that describes how the ice caps reflect a significant amount of solar radiation back into space. (This is one reason why the melting of arctic ice is so worrying: less ice means less albedo effect, leading to higher temperatures, leading to even less ice, resulting in a spiraling cycle.)[3]

Some early ideas such as painting all the world's roofs white or deploying giant space mirrors have not taken hold, but one suggestion—that of spraying aerosols into the stratosphere—is gaining traction. This technique tries to mimic the natural process of volcanic eruption. A few months after the 1991 eruption of Mount Pinatubo in the Philippines, for example, global temperatures dropped by about a half degree Celsius, and stayed there for about a year. In much the same way, a controlled limited introduction of aerosols into the stratosphere could reduce what climate scientists call "radiative forcing" and thus allow the planet to cool.

While this may seem like a Herculean endeavor, models suggest that a relatively small injection of aerosols, via aircraft or balloon, could have the desired global effect. Early cost studies also point to a relatively moderate price tag of $5–10 billion a year, negligible compared to the potential trillions required to decarbonize the global economy or to the cost of damage caused by rising temperatures. At the same time, those costs would not replace but merely supplement the broader price tag of mitigation and adaptation, so they cannot be seen as a simple trade-off. Research into solar engineering is actively taking place through computer modeling and laboratory experiments; and a few, small-scale outdoor in situ experiments are in development.

In March 2017 a group of Harvard scientists gained significant media attention for their plans to fly a balloon twenty kilometers high to explore the physics and chemistry of introducing tiny particles into the stratosphere. They would then compare these results to current models. The researchers stressed that this was "not a test" of planetary cooling: "The amount of material we would release is tiny compared to everyday activities. Our material of choice for the first flight?

Frozen water."[4] Nonetheless, the announcement caused some consternation. The idea that humankind may be embarking upon an era of global climate control is for many a terrifying prospect, with too many unknowns and potential risks. On the other hand, the effect of unchecked global temperature rise might bring even greater risks. Getting the balance right, and communicating that to a wider audience, will be among the most difficult tasks facing policymakers in the decades ahead.

Risks and Moral Hazard

A foretaste of popular concern can be found all over the Internet in the form of "chemtrailers" and other conspiracy theorists. While many of their claims are easily disproven, their ideas have moved increasingly into the mainstream. This should serve as a canary in the coal mine for the likely scale of unease at the deployment of geoengineering technologies, especially when ill understood. A number of mainstream civil society organizations are now taking a closer look at the risks, and ringing alarm bells. In a briefing note for civil society, the Ottawa-based ETC Group warns that "interventions could go awry because of mechanical failure, human error, incomplete knowledge and climate data, unpredictable synergic effects, natural phenomena (like volcanic eruptions, earthquakes, tsunamis), transboundary impacts, change in political regime, or funding failures, among others."[5]

Concerns were similarly expressed by some leading climate scientists at an April 2017 TED Talk in Vancouver. NASA's Kate Marvel was reported to have likened geoengineering to going to a doctor who says, "You have a fever, I know exactly why you have a fever, and we're not going to treat that. We're going to give you ibuprofen, and also your nose is going to fall off."[6]

Even the most ardent supporters of geoengineering acknowledge the risks inherent in these technologies. But they and others point out that the uncertainty goes both ways. There are also risks in *not* using a technology that could provide many potential benefits and help mitigate the worst effects of climate change. The challenge for policymakers, therefore, is to assess the risks of developing—and possibly deploying—geoengineering technologies against those of not deploying them.

Further complicating matters, carbon dioxide removal and solar engineering each bring their own set of challenges to the table. For example, to bring global emissions to net zero using just bioenergy with carbon capture and storage (a form of carbon dioxide removal known as BECCS) would require planting a land area potentially one to two times the size of India.[7] Land of that size devoted to energy crops—up to a quarter of global agricultural land, wherever it may be—would put severe pressures on global food production and would greatly affect biodiversity.[8] It would also require enormous amounts of water, fertilizer, and pesticide. Meanwhile, solar engineering techniques only address the symptoms of climate change (for example, increased temperature), and not the cause. Nor do they address the problem of ocean acidification, as they do not directly affect the atmospheric concentration of carbon dioxide.

If the world continues to add greenhouse gases to the atmosphere, or fails to reduce them fast enough, solar engineering brings with it a number of additional risks. For example, a "termination risk" arises because aerosols last only a limited amount of time in the stratosphere. In contrast, atmospheric carbon dioxide—the major cause of rising temperatures—takes centuries to dissipate. This means that to maintain a global cooling effect, aerosols or other chemicals used in solar engineering would require constant reapplication, and potentially in ever-increasing concentrations if greenhouse gases continue to grow. If solar engineering were to be terminated before global emissions were reduced to zero, and before greenhouse gas concentrations were substantially reduced, the earth could experience a sudden and catastrophic global temperature rise. In practice, any large-scale use of solar engineering would likely condemn future generations to continue with it for hundreds of years. Solar engineering would also lead to a shift in the quantity and quality of light reaching Earth's surface, with complex effects on plant life, and there would likely be a reduction in the global hydrologic cycle—that is, the rate at which water evaporates, condenses, and precipitates as rainfall.

At higher levels of temperature reduction, the models suggest that solar engineering would have increasingly diverse regional effects on weather and climate, with different costs and benefits over time. For some countries and communities the global benefits from lower temperatures might therefore come with high costs, such as drought or floods. Obviously, this would create stresses that would need to be dealt with. One can envisage a situation where some countries actively seek out solar engineering's predicted regional effects of increasing or lessening rainfall, despite the concerns of others. If a developing island state, for example, learns that solar engineering might lessen its risk of hurricanes, its people may feel aggrieved if the technology is *not* deployed due to the concerns of rich countries.

This raises important questions of relative power and economic influence. It also highlights the need to consider these technologies in the context of overall sustainable development efforts.

There is also the much-raised question of *moral hazard*. Many commentators fear that if humankind pursues geoengineering, it might provide grist to the mill of those arguing against a rapid reduction in greenhouse gas emissions. On the flip side, the serious prospect of a geoengineered future might spur other people to faster action in order to avoid it.

Governing the New Age of Geoengineering

Despite the risks of geoengineering, the reality of unchecked global warming may prove even more terrifying. Faced with rising sea levels and an increasingly adverse climate, one can easily imagine a handful of small countries, or a group of large coastal cities whose survival is threatened, joining forces with a billionaire philanthropist and deciding unilaterally to begin injecting aerosols into the stratosphere. This could take place despite incomplete knowledge about its effects, as well as its risks—known and unknown.

Faced with such "minilateral" action, we might easily imagine other countries adversely affected by solar engineering deciding to interdict it through military action. Thus, one thing could lead to another, resulting in an uncontrolled spiral of geopolitical and environmental fallout. While such a future is unlikely, it is plausible, and so we need to consider it seriously. In other words, the real question facing humanity might not be whether or not to go ahead with geoengineering technologies, but how to govern them when they inevitably arrive. This will require a high degree of knowledge about geoengineering technologies, and will entail a considerable amount of work to understand the risks. This is something no one group can do alone. The world as a whole needs to deal with this, involving all levels of society.

In mid-2016 I was approached by the V. Kann Rasmussen Foundation[9] with the idea of creating, under the aegis of the Carnegie Council for Ethics in International Affairs (the home of this journal), an international initiative to explore how geoengineering might be governed. I had previously served as the United Nations Assistant Secretary-General for climate change, and I have been working on climate change and sustainable development all my professional life. This was not the first initiative looking at climate engineering governance, but it did mark a change of pace. While geoengineering techniques had been considered as far back as the 1960s, for most of the subsequent decades their discussion was somewhat taboo.

Paul Crutzen broke that taboo in 2006 with an editorial in the journal *Climatic Change*.[10] Crutzen's words were prescient: "The very best would be if emissions of the greenhouse gases could be reduced so much that the stratospheric sulfur release experiment would not need to take place. Currently, this looks like a pious wish."[11] Since then, scholars have published hundreds of studies on solar engineering; and more recently a number of major organizations, including the U.S. National Research Council, have published major reports with recommendations about its governance. Hitherto, however, only a limited number of initiatives have been put into effect. For example, a 2010 decision of the Convention on Biological Diversity provided guidance to countries for considering conditions under which to undertake (or not) geoengineering activities;[12] and amendments to the London Convention/London Protocol (which deals with all issues related to putting waste and other materials into the oceans) addressed specific marine geoengineering processes, such as ocean fertilization, first as a nonbinding decision of the Conference of the Parties and later as binding amendments.[13] However, the fact remains that there is currently no comprehensive international framework for governing these emerging technologies.

To address this lacuna, it is imperative that there begin a global discussion of the operational feasibility of geoengineering and its governance requirements. And it is to this end that the Carnegie Climate Geoengineering Governance Initiative (C2G2) was created in January 2017 and publicly launched on February 16. From the outset, our philosophy has been clear: *We do not take sides or engage in advocacy for or against geoengineering*. Rather, we aim to bring together leading thinkers and policymakers to discuss the best way to govern geoengineering, should society decide to employ it.

It has been a remarkable journey. Anyone who spends any time thinking about geoengineering governance quickly realizes how mind-expanding a topic it is, touching on the essence of who we are as humans, and our relationship with the planet around us. With such a vibrant mix of technology, politics, risk management, economics, and philosophy, it can be difficult to know where to begin. One way to start is by framing a series of questions, such as those posed at the start of this article:

- In a geoengineered world, who controls the "global thermostat"? Who ensures that aerosol deployment is not manipulated to deliver regional gains/losses? Who decides to increase the global effect, given the risk of increased local or regional side effects? How should transborder and transgenerational ethical issues be addressed?
- How will governance frameworks withstand substantial geopolitical changes over the coming decades, and possibly centuries? How might such techniques be deployed without undermining the will to cut emissions (which will continue to be necessary no matter what)? How should decisions relating to the rate of starting, continuing, and stopping those techniques be governed?
- Can we build on existing international treaties and institutions, or do we need to develop new ones? Most immediately, how should further research on solar engineering be governed—especially given current plans to go beyond the laboratory and to start experiments in situ in the stratosphere?

We do not yet have the answers to these questions, but they anchor our thinking. And getting them right requires building in ethical considerations from the outset.

Taking an Ethical Approach to Geoengineering Governance

David Morrow, who studies the ethics and political philosophy of climate change, highlights three major areas of inquiry: justice, the precautionary principle, and humanity's relationship to nature. He then subdivides "justice" into three categories: distributive (which seeks to ensure that the benefits and costs of solar engineering are fairly shared); procedural (which tackles how decisions are made); and intergenerational (which addresses our responsibility to the future). On procedural justice, he noted during a recent C2G2 webinar that "arguably a decision to deploy solar geoengineering would be an unprecedented global social choice, and it is unclear whether our existing global governance institutions are morally adequate to the task."[14]

The precautionary principle is particularly tricky here, as it can cut both ways. While taking action involves many risks, not taking action might result in even more. As Morrow notes, geoengineering ethics is not about "some ideal situation in which rapid mitigation has prevented significant climate change," but, rather, one in which significant climate change is actually taking place.

Finally, there is the question of our relationship with the planet around us. Some would have us leave it well alone. But there is a growing understanding that we have entered a period in which humans are the primary agent of change (the Anthropocene), and that this forces us to rethink the traditional dichotomy between humankind and nature. Perhaps it is time to dispense with the concept of an unaffected Nature altogether.

These ideas have been around for a while, but they are growing in urgency. Bill McKibben argued against an artificial distinction as far back as 1989 in *The End of Nature*; and more recently we have seen the rising popularity of the philosopher Timothy Morton, who argues in *Ecology without Nature* that the chief stumbling block to environmental thinking is the image of nature itself.[15] For his part, Clive Hamilton warns in his new book, *Defiant Earth*, that we have entered the "bizarre situation in which we have become potent enough to change the course of the Earth yet seem unable to regulate ourselves."[16]As he puts it,

> Grasping the scale of what is happening requires making the cognitive leap to "Earth system thinking"—that is, conceiving of the Earth as a single, complex, dynamic system. It is one thing to accept that human influence has spread across the landscape, the oceans, and the atmosphere, but quite another to make the jump to understanding that human activities are disrupting the functioning of the Earth as a complex, dynamic, ever-evolving totality comprised of myriad interlocking processes.[17]

For many people, perhaps most, these questions by extension touch on humankind's relationship with one, or multiple, deities. These considerations impel us to broaden the debate. Currently, much of the discussion on climate geoengineering takes place in the research community and academia. These debates will clearly continue, and they will surely build up greater coherence over time. But as the scientific work reaches a point of real-world experiments and potential deployment, we must involve a far wider range of people—from governments, international organizations, and civic and faith groups, as well as from business, the media, and labor. In short, the debate needs to move from science to policy.

This will not be easy. The issues raised by geoengineering are at the cutting edge of technology and governance, and require an understanding of the nature of risk and uncertainty. As we build this community, we need to find ways to communicate the risks and benefits of geoengineering side by side, and to avoid the natural inclination to retreat into subject matter silos. Communicating risk may, in fact, ultimately prove our biggest challenge, given the difficulty even the most well-informed policymakers can face in understanding uncertainty. But it cannot be avoided. Solar radiation management has planetary-wide consequences, and discussion cannot be restricted to area experts alone. The research community has started to address these issues seriously, but the global policy community has not. It is time it did.

The process of building a wider geoengineering governance community has already begun under the C2G2 Initiative. Many of our staff come from a United Nations and intergovernmental background, and we have already engaged with many governments, international organizations, and nongovernmental actors. These include treaty bodies such as the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity, as well as intergovernmental organizations such as UN Environment and the Intergovernmental Panel on Climate Change.

We are also engaging with numerous nonstate actors active in the climate and sustainable development space, including civil society organizations such as the WWF and the ETC Group as well as faith leaders, and we see significant potential for connecting with interfaith dialogues. To this end, we have been fortunate to attract a diverse and accomplished Advisory Group, consisting of advocates and critics, scientists, and civic leaders and diplomats—of all ages, and from all parts of the world.[18] Ultimately, we hope a large and diverse network of individuals will emerge across a range of institutions to drive the debate nationally and internationally.

Where We Go from Here

So what comes next? Early work suggests our first priority should be to ensure that research into geoengineering is properly governed, and that it is communicated effectively to a wider audience. There has already been some discussion and initial work on a code of conduct governing research into and the deployment of geoengineering. Important progress has been made here, yet we must maintain a delicate balance, as excess regulation could impede progress. We need to seek ways in which governance intelligently weighs the trade-offs between enabling research and regulating it.

There is also a clear sense that the world would gain from a broad agreement that large-scale solar engineering should not be deployed outside the lab before appropriate governance structures are in place, and before the risks and benefits are better known. How this would be put in place is an open question. Whichever way we go, we will keep stressing that under no scenario should solar engineering be adopted as an alternative to what we already know how to do. If it happens at all, it should be as a complementary approach to mitigation, adaptation, and greenhouse gas removal.

Finally, all these plans will need to take account of a rapidly shifting geopolitical context, such as the rise of populism in the West, China's ambitions to build a new global trade infrastructure, record-breaking migration flows, and declining confidence within some circles in international institutions. As history indicates, nothing is totally predictable. But if current predictions about our inability to address rising temperatures quickly enough turn out to be accurate, the global debate over the availability and feasibility of climate geoengineering is about to switch into high gear. If it does, we need to be ready for it.

NOTES

[1] Work has already begun on an Intergovernmental Panel on Climate Change special report on the impacts of global warming of 1.5 degrees Celcius above preindustrial levels, due for publication in 2018.

[2] The home of this project is the Carnegie Council for Ethics in International Affairs. Founded in 1914 by Andrew Carnegie, the Council is an independent nonpartisan institution that works to foster global conversations on ethical issues in the international arena. *Ethics & International Affairs*, the journal in which this essay appears, is the Council's flagship publication.

[3] For one example of the discussion of ethical concerns surrounding the implementation of solar radiation management, see Christopher J. Preston, "Carbon Emissions, Stratospheric Aerosol Injection, and Unintended Harms," *Ethics & International Affairs* 31, no. 4 (2017), pp. 479–493; Holly Lawford-Smith, "The Comparative Culpability of SAI and Ordinary Carbon Emissions," *Ethics & International Affairs* 31, no. 4 (2017), pp. 495–499; Sikina Jinnah and Douglas Bushey, "Bringing Politics into SAI," *Ethics & International Affairs* 31, no. 4 (2017), pp. 501–506; and Mike Hulme, "Calculating the Incalculable: Is SAI the Lesser of Two Evils?" *Ethics & International Affairs* 31, no. 4 (2017), pp. 507–512.

[4] David W. Keith and Gernot Wagner, "Fear of Solar Geoengineering is Healthy—But Don't Distort Our Research," *Guardian*, March 29, 2017, www.theguardian.com/environment/2017/mar/29/criticism-harvard-solar-geoengineering-research-distorted.

[5] ETC Group, "Climate Change, Smoke and Mirrors," May 2017, www.etcgroup.org/content/civil-society-briefing-geoengineering. As noted on their website, the ETC Group "works to address the socio-economic and ecological issues surrounding new technologies that could have an impact on the world's poorest and most vulnerable people."

[6] Ariel Schwartz, "'You Terrify Me': TED Speakers Duke It Out over a Plan to Release Massive Amounts of Chalk into the Atmosphere," *Business Insider*, April 26, 2017, uk.businessinsider.com/ted-talk-speakers-geoengineering-2017-4.

[7] Oliver Geden, "Policy: Climate Advisers Must Maintain Integrity," *Nature*, May 6, 2015, www.nature.com/news/policy-climate-advisers-must-maintain-integrity-1.17468.

[8] See Carbon Brief, "In-Depth: Experts Assess the Feasibility of 'Negative Emissions,'"April 12, 2016, www.carbonbrief.org/in-depth-experts-assess-the-feasibility-of-negative-emissions.

[9] Villum Kann Rasmussen was a Danish entrepreneur who created the Velux roof window. VKRF was created in 1991 to strengthen environmental research. According to its website it has funded a number of climate engineering governance projects "since there currently is no systematic, coherent set of international legal governance frameworks in place." Further, "we need to know more about climate engineering, if only to discover what is and is not possible, and we need to be careful that investigation in this space is not driven solely by the interests of individual investors, scientists, or non-transparent governments." See www.vkrf.org/content/what-we-fund.

[10] David Morrow, "International Governance of Climate Engineering, A Survey of Reports on Climate Engineering, 2009–2015," Forum for Climate Engineering Assessment Working Paper Series, June 2017, ceassessment.org/wp-content/uploads/2017/06/Morrow-WPS001.pdf.

[11] Paul J Crutzen, "Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?" *Climatic Change* 77 (2006), pp. 211–19.

[12] Decision X/33, "Biodiversity and Climate Change," adopted by the Convention on Biological Diversity at its Tenth Meeting, Nagoya, Japan, October 29, 2010 (UNEP/CBD/COP/DEC/X/33).

[13] In April 2013, Australia, Nigeria, and the Republic of Korea submitted a proposal to amend the London Protocol to regulate placement of matter for ocean fertilization and other marine geoengineering activities. International Maritime Organization, "Ocean Fertilization under the LC/LP," 2017, www.imo.org/en/OurWork/Environment/LCLP/EmergingIssues/geoengineering/OceanFertilizationDocumentRepository/OceanFertilization/Pages/default.aspx.

[14] See Carnegie Council for Ethics in International Affairs, "A Briefing and Discussion on Solar Geoengineering: Science, Ethics, and Governance," May 16, 2017, www.carnegiecouncil.org/studio/multimedia/a-briefing-and-discussion-on-solar-geoengineering-science-ethics-and-governance.

[15] Bill McKibben, *The End of Nature* (New York: Random House, 1989); Timothy Morton, *Ecology without Nature: Rethinking Environmental Aesthetics* (Cambridge, Mass.: Harvard University Press, 2007).

[16] Clive Hamilton, *Defiant Earth: The Fate of Humans in the Anthropocene* (Cambridge, U.K.: Polity Press, 2017).

[17] Ibid., p. viii.

[18] See the Carnegie Council for Ethics in International Affairs website, "C2G2 Advisory Group," www.carnegiecouncil.org/programs/ccgg/advisory-group.

Abstract: Keeping global temperature rise to within 1.5–2 degrees Celsius above preindustrial levels is looking increasingly unlikely through mitigation alone. While increased adaptation to inevitable climate impacts will be necessary, a new realism is creeping into the climate debate. A growing number of scientists are proposing geoengineering technologies to deal with the expected shortfall, both through carbon dioxide removal and possibly through solar radiation management. But both approaches bring risks and pose significant governance challenges, and would likely affect different communities in different ways. As geoengineering moves mainstream, it is time to put governance at the heart of future discussion, and to broaden the debate from academia to governments, treaty bodies, faith groups, and civic organizations.

The Carnegie Climate Geoengineering Governance Initiative is a major new effort to catalyze this conversation, bringing together players from a wide range of social, geographical, and professional backgrounds. It argues that policymakers need to take an ethical risk management approach, informed by continued research. How should transborder and transgenerational ethical issues be addressed? How will governance frameworks withstand geopolitical change? Can we build on existing international treaties and institutions, or do we need new ones? And most immediately, how should further research on solar engineering be governed—given current plans to start experiments in the stratosphere? In a geoengineered world, who controls the "global thermostat"?

Keywords: geoengineering, climate change, solar radiation management, carbon dioxide removal, governance, Paris Accord, mitigation