

Carbon Emissions, Stratospheric Aerosol Injection, and Unintended Harms

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The ambitious targets for limiting global temperature increases agreed upon at the United Nations Climate Change Conference in Paris in 2015 leave many questions unanswered. The “ambition gap” between what has been promised and what is currently on track to be delivered has left atmospheric scientists scratching their heads about how the temperature increases that appear to be in store can actually be avoided. While there was much talk in Paris about “negative emissions” technologies that would decrease atmospheric greenhouse gas concentrations while maintaining an adequate energy supply to the world’s increasingly voracious markets, considerable skepticism remains about both the readiness and effectiveness of these technologies.¹

In light of this skepticism, some climate engineers continue to argue for research into what many people regard as the alarming prospect of intentional solar radiation management.² These proposed climate management techniques typically would seek to reduce global temperatures by masking a portion of the shortwave solar radiation that is allowed to pass through Earth’s atmosphere.³ Unsurprisingly, given the audacious nature of the whole idea of a global sunshade, considerable barriers exist to the acceptance of their use. In order for these proposals to gain widespread support, there is not only the need to reduce the technical and scientific uncertainty surrounding their potential consequences but also a need to dramatically reduce the social and ethical doubts they create.⁴

Though scientists are exploring a range of options that can be classified as solar radiation management techniques, the one that has received the most sustained attention is stratospheric aerosol injection (SAI), which seeks to mimic the effect of a volcanic eruption by sending reflective aerosols into the stratosphere. Even before the Dutch Nobel Prize-winning atmospheric scientist Paul Crutzen had

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put the contemporary discussion of SAI on the map,⁵ a number of climate ethicists had zeroed in on the key question of a moral difference between deliberately engineering the climate using technological means and the existing phenomenon of human-caused climate warming. More than a decade and a half ago, David Keith argued in the article “The Earth is Not Yet an Artifact” that there is an important difference between intentionally using a technology to shape an environment and accidentally affecting an environment as a side effect of other activities.⁶ The former amounts to engineering an artifact, the latter is simply making a mess. From a number of perspectives, Keith insisted, “intent matters.”⁷

While Earth’s climate has been significantly altered in recent centuries by anthropogenic emissions,⁸ in no morally meaningful sense have those alterations ever been intentional. To be sure, for decades the scientific community has understood the relationship between greenhouse gas emissions and the warming of Earth’s atmosphere. Despite the fact that this knowledge has become mainstream—by now most people are well aware of the connection between man-made emissions and the fact that fifteen of the sixteen hottest years since record-keeping began have occurred in the twenty-first century—no one is arguing that industrial society ever *planned* to heat up (or cool down) the Earth. Deliberate stratospheric aerosol injection would change all this, as it would mark the first time that humans attempted to change the global climate purposefully. The prospect of such action brings with it a large number of new ethical considerations. One of the most challenging of these revolves around the possibility that SAI might create a range of unintended harms, including potentially disruptive changes in precipitation in different parts of the globe.⁹

While SAI would presumably not be undertaken without a broad consensus that there is a very high probability that it would lead to greater benefits than harms overall, even its most enthusiastic advocates concede that the effects of SAI on precipitation patterns are likely to be somewhat uneven and unpredictable. Generally, those looking at this issue anticipate that a small minority of the world’s population are likely to bear unanticipated harms from its deployment.¹⁰ As is often the case when deploying a major new technology, in trying to solve one problem, a new one can inadvertently be created.

The question explored in this article is not whether SAI is likely to cause an overall reduction in harms compared to a scenario in which global warming is allowed to proceed without climate engineering. That is an empirical question only answerable through a complicated projection of scenarios and extensive modeling. As complex as it is, the satisfactory resolution of this question is nevertheless the

sine qua non of any credible argument for climate engineering. The current article imagines a future scenario in which this question has been satisfactorily answered and the climate engineer is acting both with relative certainty about overall net positive outcomes of SAI deployment and with benevolent intentions. It then investigates the moral costs of climate engineering's unintended harms.

At first blush, it seems that the intentional nature of climate engineering would engender enhanced responsibility for its negative consequences compared to the negative consequences of anthropogenic climate change. The well-documented consequences of the latter include crop stress, the increasing prevalence of certain diseases, sea-level rise, saltwater inundation into freshwater supplies, increased risk of wildfire, and dwindling seasonal water supplies from reduced snowmelt. Yet despite this long list of significant harms, anthropogenic climate change remains an accident of atmospheric chemistry. Climate engineering, on the other hand, would be an optional path deliberately chosen. As such, responsibility for its consequences would seem to be elevated.

What follows is a comparative investigation that pits one set of unintended harms against another. The question of interest here is how moral culpability—that is, the amount of blame that can be assigned to a given agent—for any unintended harms from the deployment of a complicated global technology such as SAI would stack up against culpability for the unintended harms already being caused by carbon emissions. In other words, is the gut reaction presented above actually correct? The argument is addressed to those who might quite reasonably and intuitively assume that culpability for climate engineering—given its deliberate nature—will automatically exceed culpability for carbon emissions. If scientists can show that climate engineering with stratospheric aerosols can bring temperatures nearer to preindustrial conditions than they would be without it (as some multi-model assessments appear to do),¹¹ then I argue it is not enough simply to point out that there will be unforeseen harms from such interventions. It is necessary to show that the harms that might be associated with climate engineering are either particularly severe or particularly culpable, relative to the existing harms of climate change. The next section looks at why this latter assumption about increased moral culpability initially seems so reasonable.

INTENTION AND RESPONSIBILITY

To think about why SAI might create new burdens of responsibility, it helps to start by dividing anthropogenic impacts on the atmosphere into three different

phases of human history. The first was a phase of *negligible impacts*. In this period, the human population was so small and technologies so primitive (and local) that the anthropogenic impact on the climate was virtually nonexistent. During the second phase—which some scholars argue began as early as 8,000 years ago with the clearing of forested land and the planting of certain crops,¹² while others say as late as 1850 with the increasing use of fossil fuels—impacts started to mount, but the reality of anthropogenic warming remained unknown. Thus, in this phase the impacts occurring were *unknown* and certainly *unintentional* since it would hardly have seemed credible that efforts to increase human well-being through farming and early industry might create global-scale changes in climate. In the third phase, which began in earnest around the latter part of the twentieth century, climate impacts were still *unintentional* but they increasingly became *known*.¹³ As the mechanisms of climate warming began to be understood and the climate effects of fossil-fuel burning more accurately documented, it became increasingly hard to disown responsibility for climate change. By the 1990s some nations had even begun to respond to the moral burden associated with these changes. The burden, however, was always mitigated by the fact that the impacts were the unintended side effects of activities that were directed—at least in large part—at successfully creating morally significant social benefits, such as reductions in poverty and increases in standards of living.

Should SAI be deployed, it would introduce a fourth phase of climate disruption, one in which for the first time climate impacts would be both *intentional* and *known*. As Keith implied in his article, SAI would result in a global climate that, by virtue of including some element of intentional design, would in some meaningful sense become artifactual. I have made a similar argument elsewhere, noting that “[S]olar R[adiation] M[anagement], in some powerful sense, begins the era of global artificing.”¹⁴ In this fourth phase, it seems intuitive that the responsibility humans would assume for the climate they had intentionally created would surpass anything that had come before. The action is consciously designed, after all, to make a difference to global temperatures. Attempts to change the climate that create harmful climate impacts would therefore seem *prima facie* to be more blameworthy than attempts to lift people out of poverty or create happier lives that inadvertently create similar negative effects.

There are sound reasons to think that intention increases the moral burden associated with an action. In both law and ethics, acting with intention typically makes a significant difference. In law, the different degrees of culpability between

murder, voluntary manslaughter, and involuntary manslaughter reflect the importance of intent when apportioning responsibility. Insanity defenses rely on the distinction between intended acts and acts where the agent could not in any meaningful sense be thought to have intended that harm. Similarly, on the grounds that their *intentionality* is compromised, perpetrators acting out of necessity, under duress, or under other types of psychological pressure or malady are generally thought to have lesser degrees of culpability for their actions than those acting freely and competently.

One of the explanations for this difference in culpability lies in the doctrine of double effect (DDE). In both law and in ethics, DDE has been used for centuries to maintain that it is morally worse to bring about a harmful state of affairs as an intended effect of one's action than it is to bring about the same harmful state of affairs as an unintended side effect of an action.¹⁵ With regard to the climate, SAI brings intentional change into the picture for the first time. As a result, one might expect that culpability for any harms that come from efforts to engineer the climate would be elevated. While not always necessary for blame, intent clearly adds something significant to the moral equation.¹⁶ The climate engineering ethics literature to date has made much of this increased moral burden.¹⁷ When Keith titled his provocative article "The Earth is Not Yet an Artifact," he was clearly implying that all this would change with SAI. Environmental writer Jason Mark has latched onto the moral (and psychological) weight that attends this change:

Once we take responsibility for managing the planet . . . our position in this place changes. . . . The new role will force upon us an existential anxiety. Because as soon as we are in control of the weather, we will always be fearful of letting our grip slip from the string that keeps the planet in a semblance of balance.¹⁸

Despite the apparent reasonableness of the initial assumption, when facing such moral opprobrium, a defender of SAI might quickly cry foul. The difference between intentional climate engineering and unintentional anthropogenic climate change may not be as relevant as it first appears. After all, *harms* from greenhouse gas emissions and potential *harms* from SAI are both still thoroughly unintentional. Just as no one planned to heat up the planet, so no one would plan to harm people in the course of cooling it down. Climate harms due to a benevolently directed SAI are no more intentional than climate harms due to anthropogenic warming.

This response bears some scrutiny. Does the unintentional nature of any harm caused by SAI mean that an agent initiating SAI is no more blameworthy for negative side effects than an agent causing greenhouse gas pollution? Could it really be no worse to harm people unintentionally through a planetary intervention as dramatic as SAI as it is to harm people unintentionally through carbon emissions? It should be noted at the outset that issues of agency will complicate the answers to these questions. There is a long-running debate in climate change ethics about the inconsequentiality of any one individual emitter's contribution to climate harm.¹⁹ There is now a newer debate about who would be the appropriate agent of climate engineering.²⁰ Culpability might vary depending on whether the agent of climate engineering was a poor nation acting in self-defense, a super-rich individual with heroic aspirations, a global body acting on some sort of global consensus, or a small coalition of high-emitting nations. To make the current inquiry manageable, let us assume for this investigation that the agent deploying SAI and the agent emitting carbon is the same.²¹ In this highly simplified scenario, the agent is assumed to be equally causally responsible for the relevant harms in each case.

Before going any further, however, it is also important to note that making progress on these questions will not help answer the question of whether SAI is at the end of the day morally legitimate.²² Such deliberation requires an entirely different set of arguments. It will, however, offer a comparison that shines a light on matters of culpability within climate ethics. One reason David Keith has suggested that it is important to take the discussion of SAI seriously is that it may have the potential to “shake up the stale politics of climate change and accelerate action.”²³ In this vein, it is illuminating to dig beneath the gut reactions and see where the ethical considerations lead.

THE DOCTRINE OF DOUBLE EFFECT AND THE CLIMATE

Since the comparison between moral culpability in carbon emissions and in SAI involves the *unintended* harms or side effects of actions directed toward a good end, the doctrine of double effect (DDE) plays a central role in the discussion. As it is normally understood, DDE insists on a meaningful distinction between “harm that is intended and harm that is merely foreseen and not intended.”²⁴

Any actor engaged in emitting fossil fuels or deploying SAI is engaging in actions that include both beneficial intended effects and harmful unintended

effects, and can in either case potentially utilize DDE to its advantage. Under the right conditions, DDE will shield an agent that is causally responsible for a bad effect from some (unspecified) portion of the blame.²⁵ A standard interpretation of the conditions required for DDE to provide such a shield is as follows:

- (a) The intended final end must be good.
- (b) The intended means to it must be morally acceptable.
- (c) The foreseen bad upshot must not itself be willed (that is, must not be in some sense intended).
- (d) The good end must be proportionate to the bad upshot (that is, must be important enough to justify the bad upshot).²⁶

As long as the climate engineer and the fossil-fuel emitter are able to meet the four conditions required by the doctrine, both types of unintended harm may involve diminished culpability relative to an intended harm.

It should be noted that it does not follow from the use of DDE that there will be *no culpability* for the unintended side effects. There is a difference between a version of DDE that is absolute and a version that is relative. In an absolute version, the unintended harms may be completely free of culpability. In a relative version, the unintended harms may simply be less culpable than if they had been intended. For the sake of avoiding setting a higher bar for DDE than I am prepared to defend, let us assume the relative version. We should still lament the unintended harms in both cases. Victims of side effects of both anthropogenic carbon emissions and SAI may also still have substantial negative rights not to be harmed.²⁷ Harming someone even without intention can be callous and reckless. But accepting the relevance of DDE in these cases does suggest that there is less culpability than one might originally think; and, consequently, the act may, depending upon other circumstances, be less culpable or potentially even permissible.

A well-meaning carbon polluter intends the good of creating increases in wealth and wellbeing and so meets condition (a). There does not appear to be anything inherently wrong with burning fossil fuels (condition b). The carbon polluter in no way intends to subject people to the side effects of climate warming (condition c). Only condition (d), the requirement that the good end must be proportionate to the bad upshot, is questionable, and this question has become sharper only as the climate harms from fossil-fuel burning have become better known.

Nevertheless, even with those harms better known, arguments for continued carbon pollution to reduce poverty make it possible to offer a plausible defense

of (d) in certain contexts involving extreme poverty.²⁸ In such contexts, one could argue that increases in wellbeing made possible by fossil fuels might still be significant enough to outweigh the foreseen climate harms. In these cases, well-meaning carbon polluters can use DDE to partially shield themselves from moral culpability for some of the unintended harms they have caused.

Conditions (a), (c), and (d) are arguably also met by a hypothetical benevolent climate engineer. The intended final end is to reduce some of the harms of anthropogenic warming (a). The negative side effects—including reduced (or shifting) precipitation—are clearly not themselves willed (c). For (d) we return to the assumption laid out in the first section, that for the purposes of this argument we have assumed that the climate engineer has overwhelming evidence that the benefits of the deployment will outweigh the harms. Based on this assumption, condition (d) can also be met.²⁹ The good end (reduced impacts of climate warming for most of the globe) is proportionate to the bad upshot (suffering due to reduced precipitation for some unlucky populations).³⁰

Condition (b) is perhaps the most controversial with regard to SAI. Several authors have in fact suggested that there is something inherently different (and wrong) about intervening in and intentionally managing the global climate.³¹ No case for or against condition (b) will be made here. But if it is deemed legitimate to use advanced technical means to solve intransigent social problems, then SAI could likewise plausibly pass all the central conditions required for DDE to apply.³² Thus, under these conditions we see that an argument can be made with both carbon pollution and SAI that any resulting unintended harms are to some extent shielded by DDE. As long as SAI is not inherently wrong (condition b), any comparable harms created as foreseen but unintended side effects may put the agent-as-benevolent climate engineer in no worse a moral position than the agent-as-poverty-reducing carbon polluter.

FURTHER MITIGATING CULPABILITY WITH SAI

An even more interesting observation is that the agent acting as a benevolent climate engineer arguably bears even less responsibility for the harms caused by his or her action than when the same agent knowingly emits greenhouse gases. This conclusion can be reached by adding several additional considerations to the way that DDE can shield an agent causing unintentional harms.

The first consideration has to do with the relative certainty of the harms. Even though it is likely that a few populations will be made worse off by a benevolent SAI than they would have been otherwise, there remains considerable uncertainty about whether and to whom this will happen, and to what extent.³³ The feared consequences are all uncertain potential harms alongside the predicted benefits. In contrast, the harms created by those contributing to climate change through greenhouse gas emissions are relatively certain, both in terms of the character of the impacts and in terms of the populations that will bear—or are already bearing—the brunt of them.³⁴ While the harms in both cases remain unintended, the certainty of the harms in anthropogenic warming seems to be considerably greater than the certainty of the harms in SAI, in part because we are already seeing them. Advocates of SAI research Joshua Horton and David Keith have suggested that learning more about how to adjust SAI deployment parameters—such as how much reflectant to use, where to deploy it, for how long, etc.—may even enable the tailoring of the inevitable harms away from those populations that can least bear them.³⁵ If this were the case, the ability to “aim” the harms of SAI away from the world’s most powerless might accordingly reduce the moral culpability of the benevolent climate engineer for any harm that might be caused.

The uncertainty of the unintended harms is not the only consideration falling in favor of the benevolent climate engineer over the knowing carbon polluter. As discussed earlier, necessity or certain types of duress or psychological pressure can be used in situations to discount the moral significance of intentional action in law. A perpetrator committing a crime under threat of harm if they fail to act is usually thought to be less culpable than a perpetrator acting freely and clearly of his/her own settled volition. It is reasonable to think that this diminished culpability also carries over to the unintended side effects of an action taken under duress.

The common framing of climate engineering as a necessary “lesser of two evils” suggests that it might indeed be viewed as an activity performed under duress. While Stephen Gardiner and Augustin Fragnière rightly point out that extreme caution should be taken over framing SAI in this way due to the moral corruption such a framing can encourage, SAI is unlikely to be deployed as a first best option.³⁶ If it were the case that the global community knew that mitigation and adaptation efforts were not going to be enough—which is the only context in which some proponents of SAI claim that they advocate it³⁷—then this type of duress could potentially diminish the culpability for any unintended harms that might result from SAI deployment. An extension of this line of thinking is that the goods the benevolent

climate engineer is trying to achieve, including the avoidance of considerable suffering and death due to climate warming in the poorer parts of the globe,³⁸ arguably are often more urgent than the goods that continued fossil-fuel consumption supplies. While the strongest case for the continued emission of greenhouse gases applies to the cases where the emissions directly contribute to the reduction of poverty and its associated harms, it is clear that in many countries only a limited percentage of carbon emissions serve this purpose. When the burning of fossil fuels results in what Henry Shue calls “luxury” rather than “subsistence” emissions, then the protection provided by DDE is likely to diminish.³⁹

The above considerations all lead to a somewhat surprising result. Looking at SAI through the lens of DDE, we can conclude that, even if the deployer of SAI holds an elevated responsibility for the state of any future climate due to the intentional nature of their action, that agent may not be any more morally culpable for the unintended harms that might result than is the carbon polluter. In fact, as I have suggested, there are reasons to suspect that such an agent might actually bear less responsibility for any comparable unintended harms of SAI than those of carbon pollution. This is a conclusion that gets stronger the more a nation’s emissions are caused by luxury rather than by subsistence demands.

In the light of what would appear to be a counterintuitive conclusion, it is important to note again that this does not make any of these unintended harms morally permissible. The version of DDE being employed here does not erase all culpability. It only provides a certain amount of shielding. There might still be principled reasons why a particular set of side effects are morally prohibited. As a consequence, the relative shielding from culpability that DDE can provide is in no respects an argument in favor of SAI deployment. It does mean, however, that the sort of cover provided by DDE to the agent-as-carbon-polluter—one behind which most people in rich countries arguably shelter to some degree in their daily activities—is also available, and *perhaps even more available*, to the agent-as-climate-engineer. If this is true, then harming people unintentionally through climate engineering could be less culpable than harming people unintentionally through fossil-fuel emissions. As Keith suggested, consideration of the ethics of SAI may indeed “shake up” how to think about climate change.⁴⁰

PUSHING BACK

Those who are intuitively opposed to SAI still have plenty of arguments at their disposal to push back against this surprising consequence of the application of

DDE. Here I will consider three such arguments. First, condition (b)—that there must be nothing inherently wrong with the means being used to pursue the intended effect—may prevent DDE from ever being employed in this context in the first place. Deontological arguments concerning appropriate respect for nature can be offered against SAI, at least on presumptive moral grounds.⁴¹ If it is determined that intentionally altering the climate in order to reduce warming temperatures is inherently wrong, then DDE cannot be used to reduce moral culpability for the foreseen negative side effects. Arguments pertaining to the hubris involved in SAI can also form an argument against condition (b).⁴² Alternatively, it might be suggested that the kinds of death that SAI might cause could be so horrible that they warrant prohibition on rule consequentialist grounds (though it is hard to see how those weather-related deaths could be worse than those that would occur through unintentional anthropogenic climate change).⁴³

Second, it might be suggested that the list of conditions for DDE employed above is not exhaustive enough. SAI may be determined not to be morally prohibited in principle (condition b) and its harms may be proportionate to the end (condition d), and yet those means may not be the least bad alternative for achieving the desired end. If the same end could be achieved by other morally acceptable means that were less bad than SAI (say, dramatic mitigation and adaptation efforts), then those less bad means should be chosen.⁴⁴ Many argue that indeed there are plenty of less bad means than SAI available today that should be employed first. To suggest otherwise, they say, plays into the “climate emergency” framing that can be viewed as part of a web of deceitful rhetoric surrounding SAI.⁴⁵ Thus, if the conditions for employing DDE are incomplete, it would not be clear that SAI could benefit from the shield it might offer.

Furthermore, even though this argument has assumed both (i) compelling evidence for a balance of good consequences of SAI over bad, and (ii) the benevolence of the climate engineering agent, it could be argued that neither of these conditions will ever be met. The science of predicting the effects of climate interventions is incomplete and the motives of would-be agents of climate engineering may always be inscrutable. There are plenty of reasons to think that these *sine qua non* requirements might be unattainable.⁴⁶

A third reason to think that any unintended harms from SAI may not be so forgivable is the so-called “closeness thesis” that can often negate DDE. The closeness thesis maintains that unintended consequences that are both foreseeable and close enough in type to the intended consequences might effectively count as

intended consequences. Philippa Foot puts it bluntly: “Anything very close to what we are literally aiming at counts as if part of our aim.”⁴⁷ In other words, the intended and unintended effects are almost identical. This thesis applies particularly in cases where the actor knows full well that the “unintended” effect *had* to happen in order for the intended effect to happen.⁴⁸

It could be argued that in the case of SAI the intended effect (a beneficial change in Earth’s climate) is close enough to the unintended effect (a harmful change in Earth’s climate) that the harmful change should also count as intended. In essence, the benefit and the harm are simply two parts of the same intended effect. This is not the case for the intended effects of fossil-fuel burning (increases in standards of living) and its unintended effects (anthropogenic warming). In that case, the two effects are different enough that they should not be considered morally linked to each other. If this reasoning holds, then the closeness of any harmful side effects of SAI to its intended effects could remove any degree of protection afforded by DDE.⁴⁹ The protection would remain in place, however, for the fossil-fuel polluter.

CONCLUSION

In its fifth assessment report in 2013–2014, the Intergovernmental Panel on Climate Change (IPCC) for the first time considered the feasibility of using climate engineering to push back against global warming. In 2017 a group at Harvard University announced their intention to conduct preliminary field-testing of how to reflect solar radiation using aerosols. With the IPCC due to produce a special report in 2018 on the aspirational target of 1.5 degrees Celsius for global temperature rise written into the Paris Agreement, it is likely that discussion of climate engineering will only increase in the coming years. The idea that SAI could be moving toward the mainstream of climate policy should be a wake-up call to everyone concerned about climate change.

Whether the increased level of discussion now taking place surrounding stratospheric aerosol injection causes people to focus more on carbon emissions out of a sense of heightened alarm or leads them to become complacent about emissions because of the prospect of an “easy” technical fix remains to be seen.⁵⁰ Either way, the unintended harms that SAI might cause are clearly a serious concern. But one lesson that could be drawn from the analysis presented here is that whatever the culpability for these harms might be, it may be no greater—and perhaps even less

—than the culpability held by those who continue to emit greenhouse gases when they are fully aware of their harmful consequences.

Even though this article is absolutely not intended as an endorsement of climate engineering, its conclusion will still be unwelcome for those who view climate engineering as unacceptable from any angle. After all, it has the appearance of diminishing the moral significance of climate engineering's unintended harms. In response, I would stress once again that this is a *comparative* conclusion; one that, read from another angle, is also consistent with the message of a great deal of climate politics. Even when considered alongside potential harms from climate engineering, the unintended harms caused by carbon emissions are a real and significant moral problem. Serious and rapid emissions reductions therefore remain the ultimate moral priority.

NOTES

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- ²⁰ Katharine L. Ricke, Juan B. Moreno-Cruz, and Ken Caldeira, "Strategic Incentives for Climate Geoengineering Coalitions to Exclude Broad Participation," *Environmental Research Letters* 8, no. 1 (2013), doi:10.1088/1748-9326/8/1/014021.
- ²¹ Perhaps this agent is some sort of globally representative body, or a particularly influential nation-state.
- ²² Previous papers I have published in this area suggest that I am skeptical about the technology. See, for example, Christopher J. Preston, "Re-Thinking the Unthinkable: Environmental Ethics and the Presumptive Argument against Geoengineering," *Environmental Values* 20, no. 4 (2011), pp. 457–79; and Christopher J. Preston, "Framing an Ethics of Climate Management for the Anthropocene," *Climatic Change* 130, no. 3 (2015), pp. 359–69.
- ²³ Keith, *A Case for Climate Engineering*, p. 135.
- ²⁴ Alison Hills, "Defending Double Effect," *Philosophical Studies: An International Journal for Philosophy in the Analytic Tradition* 116, no. 2 (2003), p. 133.
- ²⁵ Shielding from a portion of the blame does not, of course, entail that the action is now permissible.
- ²⁶ Warren S. Quinn, "Actions, Intentions, and Consequences: The Doctrine of Double Effect," *Philosophy and Public Affairs* 18, no. 4 (1989), p. 334, note 3.
- ²⁷ Quinn, "Actions, Intentions, and Consequences," p. 346.
- ²⁸ Alex Epstein, *The Moral Case for Fossil Fuels* (New York: Penguin, 2014).
- ²⁹ Meeting condition (d) clearly requires more precise climate modeling than is currently available and more confidence in the predictions of those models. It also requires surety about the benevolence of the motives of the climate engineering agent. All of these may admittedly be difficult to secure. See discussion below on "Pushing Back."
- ³⁰ Kravitz et al., "A Multi-Model Assessment of Regional Climate Disparities Caused by Solar Geoengineering"; and Horton and Keith, "Solar Geoengineering and Obligations to the Global Poor."
- ³¹ Clive Hamilton, *Earthmasters: The Dawn of the Age of Climate Engineering* (New Haven, Conn.: Yale University Press, 2013); Preston, "Re-Thinking the Unthinkable: Environmental Ethics and the Presumptive Argument Against Geoengineering"; and Forrest Clingerman and Kevin J. O'Brien, "Playing God: Why Religion Belongs in the Climate Engineering Debate," *Bulletin of the Atomic Scientists* 70, no. 3 (2014).
- ³² Alvin M. Weinberg and Lewis M. Branscomb, "Reflections on Big Science," *American Journal of Physics* 36, no. 1 (1968), pp. 65–66.
- ³³ Juan B. Moreno-Cruz, Katharine L. Ricke, and David W. Keith, "A Simple Model to Account for Regional Inequalities in the Effectiveness of Solar Radiation Management," *Climatic Change* 110, no. 3–4 (2012), pp. 649–68; Kravitz et al., "A Multi-Model Assessment of Regional Climate Disparities Caused by Solar Geoengineering"; and Ricke, Moreno-Cruz, and Caldeira, "Strategic Incentives for Climate Geoengineering Coalitions to Exclude Broad Participation."
- ³⁴ Alexander et al., "Summary for Policymakers," in *Climate Change 2013*.
- ³⁵ Horton and Keith, "Solar Geoengineering and Obligations to the Global Poor," p. 86.

- ³⁶ Stephen M. Gardiner, "Is 'Arming the Future' with Geoengineering Really the Lesser Evil? Some Doubts about the Ethics of Intentionally Manipulating the Climate System," in Stephen M. Gardiner et al., eds., *Climate Ethics: Essential Readings* (New York: Oxford University Press, 2010), pp. 284–314; Stephen M. Gardiner, "The Desperation Argument for Geoengineering," *PS: Political Science & Politics* 46, no. 1 (2013), pp. 28–33; and Augustin Fragnière and Stephen M. Gardiner, "Why Geoengineering Is Not 'Plan B,'" in Preston, *Climate Justice and Geoengineering*, pp. 15–32.
- ³⁷ Crutzen, "Albedo Enhancement by Stratospheric Sulfur Injections"; and Keith, *A Case for Climate Engineering*.
- ³⁸ Keith, *A Case for Climate Engineering*; and Horton and Keith, "Solar Geoengineering and Obligations to the Global Poor."
- ³⁹ Henry Shue, "Subsistence Emissions and Luxury Emissions," *Law & Policy* 15, no. 1 (1993), pp. 39–60. If SAI were deployed as a technological mechanism for high-emitting countries to continue their profligate ways, then the protection provided by DDE for it would clearly be diminished.
- ⁴⁰ Keith, *A Case for Climate Engineering*, p. 135.
- ⁴¹ Dale Jamieson, "Ethics and Intentional Climate Change," *Climatic Change* 33, no. 3 (1996), pp. 323–36.
- ⁴² Hamilton, *Earthmasters*; and Clingerman and O'Brien, "Playing God: Why Religion Belongs in the Climate Engineering Debate."
- ⁴³ The frequently voiced consequentialist argument drawing on the danger of catastrophic, unforeseen harms caused by SAI would ultimately fall not under condition (b) but the proportionality requirements of condition (d).
- ⁴⁴ Alison McIntyre, "Doing Away with Double Effect," *Ethics* 111, no. 2 (2001), pp. 224–26. In some versions of DDE the bad consequences must not just be "less bad" but also "minimal."
- ⁴⁵ Fragnière and Gardiner, "Why Geoengineering is Not 'Plan B.'"
- ⁴⁶ Mike Hulme, *Can Science Fix Climate Change: A Case Against Climate Engineering* (Cambridge, U.K.: Polity, 2014).
- ⁴⁷ Philippa Foot, *Virtues and Vices and Other Essays in Moral Philosophy*, 1st ed. (Berkeley: University of California Press, 1978), p. 22.
- ⁴⁸ The case Foot discusses involves spelunkers in a flooding cave who blow up a person wedged in the escape route. Foot doubts those spelunkers can hide behind DDE by saying the plugged victim was killed "unintentionally" while the real intention was to open an escape route.
- ⁴⁹ David R. Morrow, "Starting a Flood to Stop a Fire? Some Moral Constraints on Solar Radiation Management," *Ethics, Policy & Environment* 17, no. 2 (2014), pp. 123–38.
- ⁵⁰ Christine Merk et al., "Exploring Public Perceptions of Stratospheric Sulfate Injection," *Climatic Change* 130, no. 2 (2015), pp. 299–312.

Abstract: In the rapidly expanding literature on the ethics of climate engineering, a lot has been made of the fact that stratospheric aerosol injection would for the first time create a world whose climate had been intentionally shaped by deliberate human decisions. Intention has always mattered in ethics. Due to the importance of intention in assigning culpability for harms, one might expect that the moral responsibility for any harms created during an attempt to reconstruct the global climate using stratospheric aerosols would be considerable. This article investigates such an expectation by making a comparison between the culpability for any unintended harms resulting from stratospheric aerosol injection and culpability for the unintended harms already taking place due to carbon emissions. To make this comparison, both types of unintended harms are viewed through the lens of the doctrine of double effect. The conclusion reached goes against what many might expect. The article closes by suggesting that a good way to read this surprising conclusion is that it points toward the continuing moral importance of prioritizing emission reductions.

Keywords: climate engineering, stratospheric aerosol injection, carbon emissions, unintended harms, doctrine of double effect