Solar Radiation Management and Comparative Climate Justice
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Solar radiation management (SRM)—i.e., any climate engineering technique that would reduce the fraction of incoming solar radiation absorbed by the planet—is a very interesting subject for distributive justice, or the type of justice that concerns how benefits and burdens should be apportioned among various parties. On the one hand, SRM techniques carry risks of substantial injustice to present and future parties, and ethicists interested in climate engineering have tended to focus on these possible injustices. On the other hand, SRM has the potential to manage current and impending injustices due to anthropogenic climate change, including risks of unjust harm to the global poor. This points to the possibility that, for all its potential ethical problems, a climate policy involving deployment of some SRM technique might perform better than other available options in securing distributively just (or minimizing distributively unjust) outcomes, at least in certain future contexts.

In line with Christopher Preston's argument in the introduction to this volume, I argue here that, although it is helpful to identify potential injustices associated with SRM, it is also crucial both to evaluate how SRM compares to other available options and to consider empirical conditions under which deployment might occur. In arguing for this view, I rely on a distinction between two types of question: (1) whether SRM would produce just or unjust outcomes in some case and (2) whether it would be just to deploy SRM in that same case. The former question pertains to whether some distribution of benefits and burdens is morally good or bad, whereas the latter pertains to whether some action or policy is morally permissible, impermissible, or obligatory. Although related, these two uses of justice do not come to the same thing. It may be that some climate policy involving SRM carries risks of substantial distributive injustice and yet is permissible or even obligatory. This is because, as I argue, considering what would be just to do should be comparative, taking into consideration both empirical conditions and the morally valuable and disvaluable features of alternative climate policies. To put this in a more intuitive manner, rightness and goodness can come apart—sometimes the right course of action produces bad outcomes. I will return to this distinction in greater detail below.

I consider a prima facie case that some climate policies involving SRM could come out well on such a comparative perspective, given that a commitment to dangerous climate change due to past emissions may limit the effectiveness of policies relying on mitigation and adaptation alone. The Paris Agreement reached at COP 21 notwithstanding, insufficient progress on cutting global emissions makes it plausible to expect that, at some point in the future, all available climate policies will exhibit substantial inadequacies when it comes to securing just outcomes. In such cases, the morally disvaluable features of SRM might not be decisive in counting against the permissibility of deployment. In one sense of the term, we might think of this as a "lesser of two evils" argument, for my claim is that SRM, despite serious problems, could be morally permissible in cases in which it compares favorably to all the alternatives. However, although not technically incorrect, using this language of "lesser evils" potentially invites misunderstanding.

Usually, "lesser of two evils" arguments are broadly consequentialist in nature, claiming that some policy is to be favored despite serious costs or harms, and this because its ratio of benefits to costs or harms is better than the ratios of the alternatives. My argument is quite different, because it does not involve merely weighing up the aggregate costs and benefits of various climate policies. Instead, my focus is on the *distributions* of such costs (or burdens) and benefits, and I argue that some policy involving SRM can be a just thing to do if its distribution of burdens and benefits is better than that of any alternative policy. In order to avoid the false impression that my argument hinges on aggregate costs and benefits, I will forego using "lesser of two evils" language.

Distributive Justice and Climate Change

Anthropogenic climate change raises important questions of distributive justice, because climate change will involve substantial benefits and burdens, as will any policy meant to deal with it. Importantly, these benefits and burdens will be differentially distributed on each policy, with some parties enjoying a greater share of benefits or suffering a greater share of burdens. Moreover, specific distributions will vary depending on what responses are adopted. Potential climate-related burdens are driven by many factors: an increased frequency of extreme weather events, sea-level rise, the spread of disease to new regions, and so on. Potential benefits of various climate policies include curbing these burdens and perhaps avoiding them altogether. This could be achieved through mitigation of greenhouse gas emissions, adaptation to changing climatic conditions, climate engineering through either carbon dioxide removal (CDR) or SRM techniques, or some combination of these responses.

Anthropogenic climate change and climate policy are matters of justice because, unlike natural phenomena, they are driven by human activity, such as the emission of greenhouse gases and the deliberate policy choices made by human societies. Those who suffer a disproportionate measure of the burdens of climate change are victims of injustice, for they have been wronged due to the actions or inaction of others. Such injustice can include actions that merely put others at *risk* of suffering climate-related burdens, even if those risks are not realized. In his recent work on climate change justice, Darrel Moellendorf relies on the following reasonable principle: "If a person is especially vulnerable to very bad things happening due the actions and omission of others, that person has a prima facie claim to have the vulnerability reduced" (Moellendorf 2015, 182). The idea is that imposing such vulnerability on others is unjust and that the victims of this injustice have a legitimate claim against other parties (e.g., high emitters) to reduce or eliminate the amount of vulnerability that has been imposed on them. By contrast, a victim of mere misfortune (e.g., a genuinely natural disaster) does not have the same type of legitimate claim, because no one has wronged her by either causing or culpably allowing the burden she suffers. Moellendorf argues that justice therefore requires cutting emissions, as doing so decreases the vulnerability of various parties to climate-related burdens. At the same time, justice requires that emissions continue to some extent, as they are currently necessary for the pursuit of many goods, including reducing global poverty via relatively affordable fossil fuels. As Moellendorf notes, how emissions entitlements get distributed is itself a matter of justice. For example, distributive justice might favor differential emission entitlements, with less developed countries receiving larger entitlements than more developed countries, the latter of whom have already

benefited from substantial historical emissions and can more readily afford large-scale transitions to renewable sources of energy.

Justice as a Value and Justice as a Duty

Considerations of distributive justice can help us think about potential climate policies in at least two ways, corresponding to the two uses of justice I noted earlier, which I will refer to as axiological justice and deontic justice. First, consideration of distributive justice can highlight morally valuable and disvaluable features of such policies. This is what I call the "axiological" (from the Greek *axiā*, meaning value) use of distributive justice, for it identifies morally good and bad aspects of such policies. On this use, justice is treated as a moral value. Second, considerations of distributive justice can help us determine whether certain climate policies are permissible, impermissible, or obligatory. This is what I call the "deontic" (from the Greek *deon*, meaning duty) use of distributive justice. On this use, justice is treated as a moral obligation, and we may speak of duties of justice as distinct from other types of duty (e.g., duties of beneficence). These two uses of justice are not entirely separable. Whether some policy is morally permissible, for example, will depend in part on whether that policy delivers morally valuable or disvaluable distributions of burdens and benefits. Nonetheless, these two uses of justice are distinct. To see why, consider a policy that involves some distributive injustice. Axiologically, this injustice is a bad thing. Deontically, however, the policy could be permissible in some scenarios and impermissible in others, because it is plausible to suppose that the permissibility of this policy will hinge on how it compares to other available policies, and this will differ across scenarios. For instance, in some cases there might not be a feasible policy that avoids distributive injustice altogether, and so it might be permissible to adopt the policy in question despite its (morally disvaluable) distribution. On the other hand, there may be cases in which there are policy options for securing distributively just outcomes, and in such cases a policy involving some degree of distributive injustice would be impermissible.

This indicates that a purely axiological use of justice is not enough to determine whether some climate policy ought to be pursued. To answer that question, we also need to compare the distributions likely to be entailed by competing policies while acknowledging that some of these will be more feasible than others (technically, economically, and politically), and we should consider these policies as being pursued under conditions likely to hold in the future (Morrow and Svoboda 2016). While thinking about climate policy under idealized conditions might be useful for a variety of purposes, some policies might be infeasible or impossible to implement in the real world, such as extremely rapid emissions mitigation. As atmospheric greenhouse gas concentrations increase, we may lock ourselves into a future scenario in which some degree of distributive injustice is unavoidable, regardless of the policies pursued. In that case, it would be a mistake to suppose that any policy involving unjust distributions is impermissible, for that would entail that *no* policy is permissible in that context. Instead, in a bad situation like that envisioned, some policy may be unjust in the axiological sense while being just in the deontic sense, and the latter because that policy involves less axiological injustice than any other option. I will discuss potential examples of this below, particularly in the case of hybrid climate policies that include SRM.

Most research on distributive justice and SRM has relied on the axiological use of justice, usually highlighting potentially disvaluable features of SRM deployment, such as

disproportionately harming the global poor through precipitation change, shifting the costs and risks of SRM maintenance to future generations, or undermining the moral solidarity needed for a long-term solution to climate change (Hourdequin 2012; Svoboda et al. 2011; Tuana et al. 2012). This is an important exercise, but it is not sufficient to tell us whether it is permissible to deploy SRM. To address that issue, we also need to know how some SRM policy compares to other feasible options. Now some might think that certain SRM policies are simply impermissible in and of themselves, regardless of how they compare to other options. For example, perhaps something about SRM deployment necessarily entails moral wrong-doing, such as its dramatic interference with natural processes (Jamieson 1996). But taking this view can quickly lead us into implausible territory. Most serious proponents of researching and testing SRM see it as a potential means to reduce risk associated with greenhouse gas emissions. If it turns out that, all things considered, some SRM policy likely would alleviate such risk, and supposing it would do so to a greater extent than other options not involving SRM, it may be a mistake to view SRM as impermissible, even if it violates some important moral norm, and even if violating that norm is ordinarily wrong. The problem is that anthropogenic emissions could create a future situation in which *no* feasible course of action manages to comply with such norms. This would certainly be a regrettable situation, and one we ought to try avoiding if that is still possible. Unfortunately, we seem to be headed toward just such a scenario, and if we do find ourselves in that bad situation, the question remains: what should we do? In such a case, it is reasonable to compare the various alternatives and adopt the best (or least bad) option, using whatever standards are relevant—in the case of this paper, standards of distributive justice. At the very least, given a scenario in which all options are morally bad in some sense, we would have moral reason to prefer the best (or least bad) of those options (Svoboda 2012).

Now perhaps we should view the situation just described as constituting a genuine moral dilemma, or a scenario in which all available courses of action involve moral wrong-doing (Gardiner 2010). Such a view is attractive because it captures the tragic nature of the scenario, but it is unattractive because it arguably undermines our moral reasons for preferring some course of action (e.g., the least bad one) over others. In a *genuine* dilemma, all option are impermissible and ought not to be pursued, hence the inescapability of wrong-doing. For this reason, framing a future climate scenario as a genuine moral dilemma has the unfortunate side-effect of undermining moral action-guidance in such cases, including guidance on what concrete policies we ought to pursue (Svoboda 2015). Ethical theory is supposed to provide us with some guidance when it comes to thinking about how we ought to act, but it cannot do so in a genuine dilemma. While I lack space to argue explicitly for the view here, I think it sufficiently plausible to assume that, even in climate scenarios in which all courses of action carry moral disvalue and thus call for regret, there will be at least one course of action we are morally permitted to take, if only because that course is the last bad option available.

What Should We Compare?

I have suggested in the previous section that getting clear on whether SRM deployment is permissible in light of distributive justice requires comparing climate policies involving SRM to other options. This involves comparing the differential impacts of various policies insofar as they are relevant to the distributions of benefits and burdens. This requires us to think about what climate states are plausible to compare. Now one might question whether this is the most

relevant issue—shouldn't we focus on climate *policies* rather than states, given that we have more control over the former? The reason for focusing on climate states is that distributive justice concerns states of affairs, namely how benefits and burdens are shared among relevant parties. Some climate states will be more just (or less unjust) than others, depending on their respective distributions. The ultimate question of this paper is one of climate policy, and more specifically what types of policy are likely to minimize unjust outcomes, but we can't address that issue until we know something about the justice or injustice of the states of affairs those policies are likely to yield. I should note that, insofar as we are focused on states of affairs (rather than actions or policies), the relevant use of justice is axiological (rather than deontic.)

There are many potential options for responding to climate change, all of which are likely to raise concerns about justice in the axiological sense. These include doing nothing (i.e., business-as-usual), various ways of mitigating anthropogenic emissions, adapting to changing climatic (and other environmental) conditions, and climate engineering (including both CDR and SRM). Yet it is very important to remember that, with the exception of doing nothing, we are not bound to favor just one of these responses. Hybrid policies would involve two or more of the just-mentioned policy types. We may think of a hybrid policy as a portfolio of responses meant to complement one another. Such policies probably include the most attractive options from a justice perspective, both axiologically and deontically. None of the policy types just enumerated is a cure-all for climate change. Even very ambitious mitigation would not address the climate change to which past emissions have already committed the planet. But as Gardiner and Frangiere argue in this volume, it would be a mistake to suppose that these various policies are independent and exclusive of one another. For instance, coupling ambitious mitigation with adaptation to the climate change to which are likely committed would be better from a justice perspective than mitigation alone, for the hybrid policy might offer helpful resources to those made more vulnerable by past emissions. There is also a reasonable case to be made for SRM if it is taken to be part of a hybrid policy. Many justice-related concerns about SRM lose much of their force when it is merely one part of a policy portfolio. I will turn now to considering the comparative merits and drawbacks of SRM in terms of distributive justice.

Managing climate risks

SRM has the potential to avert or ameliorate various risks of harm associated with climate change. For example, by curbing global warming, SRM could keep sea-level rise within certain bounds, reducing the harm that vulnerable coastal populations might otherwise experience. The same holds for reducing other risks of warming-driven harm, such as the spread of diseases to new regions or an increase in the occurrence of more severe weather events. Although normally a moral good, *merely* reducing risks of harm is not itself a matter of distributive justice. Yet because climate risks tend to be more damaging to those with few resources for responding to them, such risks have a tendency to be distributively unjust by increasing the vulnerability of the global poor (Moellendorf 2015). This is why reducing risks of the above-mentioned harms is a matter of justice. If some SRM policy could ameliorate certain climate risks, it is plausible to expect it also to ameliorate the distributive injustice that tends to accompany those risks. For example, less developed countries may have greater difficulty than more developed countries in responding to a severe storm surge. Because anthropogenic climate change will elevate risks of such harm to less developed countries, it will disproportionately burden parties within such countries, and this is plausibly viewed as an unjust burden. Insofar as SRM has the potential to reduce risks of this type, it has the potential to alleviate some of the

injustices associated with climate change. This is an axiological justice-based consideration in favor of SRM.

It is true that SRM carries risks of its own, such as precipitation change in certain regions (Ferraro, Highwood, and Charlton-Perez 2014), which might impact agricultural productivity in potentially harmful ways. If such impacts disproportionately burden less developed countries, then we have reason to view these impacts as unjust in the axiological sense. However, at least some of these risks could be lessened depending on how SRM is used. In the case of stratospheric aerosol injections, there is evidence that precipitation change would be responsive to both the latitude of deployment and the quantity of aerosols injected. For example, southern hemisphere deployment may carry a reduced risk of precipitation reduction in the Sahel compared to northern hemisphere deployment, and a smaller quantity of aerosols may have less impact on the hydrological cycle than a larger quantity (Haywood et al. 2013; Irvine, Ridgwell, and Lunt 2010).

Other justice-related concerns can be addressed to some degree by using SRM as only one part of a policy portfolio, along with long-term mitigation, adaptation, and even CDR (Keith 2013). For example, there is a worry that deploying SRM could be distributively unjust to future generations, for it imposes on them the so-called termination problem, namely that a sudden cessation of SRM could result in extremely rapid global warming as global average surface temperature "catches up" to the forcing of atmospheric greenhouse gases. But the concern is less acute if SRM is used only as a short-term complement to mitigation (and possibly to CDR as well). If atmospheric concentrations of greenhouse gases decrease over time, then SRM can be drawn back as well, eventually being phased out entirely. While SRM is in effect, various parties would be at some risk due to the termination problem, and this may be unjust in the axiological sense. All else being equal, however, it is much better than deploying SRM in perpetuity, that latter of which would put many more parties at risk of unjust harm. In other words, here some form of SRM might be deontically just even if it is axiologically unjust.

A similar issue arises with ocean acidification, which is driven by increased concentrations of atmospheric carbon dioxide. A major drawback of SRM is that it would neither reduce nor curb carbon dioxide emissions and thus would allow ocean acidification to continue. This has the potential to create burdens for some parties—such as by damaging resources (e.g., coastal reefs and fisheries) on which coastal communities rely—while others benefit from SRM in the ways noted above. Once again, this problem can be ameliorated via some hybrid policy. Coupling SRM with mitigation and/or CDR could diminish the factors causing ocean acidification, and coupling SRM with certain adaptive measures could reduce the burden that ocean acidification would otherwise bring. On this point, such hybrids are likely to yield states of affairs that are (in the axiological sense) more distributively just than an SRM-only policy, as the former have the tools to ameliorate the unjust burdens created by ocean acidification. This gives us some reason to suspect that such hybrid policies may be more just (in the deontic sense) than an SRM-only policy.

An additional option for assuaging the axiological injustice of SRM is to offer compensation to those who are unjustly burdened (Heyward 2014). Although there are challenges to crafting an SRM compensation scheme that is itself just—such as properly attributing particular impacts to SRM rather than natural variability in the climate and determining what parties are morally responsible for paying such compensation (Svoboda and Irvine 2014)—this could go some distance in reducing the injustice of some distribution. I suggest this cautiously. Research on SRM compensation is just beginning, and so it is unclear

how much of a contribution such compensation could make to alleviating SRM-induced axiological injustice.

None of the foregoing is to say that any hybrid policy including SRM is likely to yield a perfectly just (in the axiological sense) state of affairs. Even if SRM is part of the best option, it will still bring burdens (e.g., risks of harm), and those burdens and any benefits might not be distributed as they ought to be. Moreover, the non-SRM components of a hybrid policy might also bring unjust burdens, such as the economic costs of mitigation or adaptation. Now whether such costs would be axiologically unjust depends in part on what parties would be paying them. I do not think it unjust for more developed countries who have greatly benefited from past emissions to pay such costs (e.g., by subsidizing renewable energy or financing adaptation in less developed countries), but the matter is otherwise if those burdens should fall to less developed countries. Unfortunately, it might be the case that no feasible climate policy (hybrid or otherwise) can fully avoid all such injustices. But now it should be clear why the axiological/deontic distinction is both crucial and helpful, for it provides a way to acknowledge the real moral disvalue of certain distributions but without undermining our ability to act when all available options carry such disvalue. On the one hand, we can recognize that some state of affairs likely to be brought about by some policy includes morally bad features, such as burdening some less developed country with the economic costs of mitigation. This is unjust in the axiological sense. On the other hand, we can simultaneously (and coherently) think that this same policy is morally permissible or even obligatory in light of our duties of justice, for it might be better (or less bad) from a justice perspective than the other options. In other words, pursuing some policy can be (deontically) just even if it is likely to carry some (axiological) injustice.

These examples indicate why, given a comparative approach to justice, it is important to consider the empirical conditions under which some climate policy is to be adopted, taking into account both how the policy in question is designed and how it is likely to play out in the actual world. The question is not whether SRM as such would be (deontically) just in some abstract sense. Rather, the question is whether some particular policy involving SRM would be (deontically) just given geophysical, political, and social facts about the actual world. A policy that includes SRM but seriously strives to reduce risks of unjust burdens *might* be deontically just in some set of circumstances even if other SRM policies would not be deontically just in those same circumstances (Svoboda 2016). How this turns out would depend on the axiological question of what distributions of burdens and benefits are likely to be delivered by feasible policies, which are partly constrained by the possibilities afforded by the empirical conditions that happen to hold.

Buying time

By managing some climate risks and slowing planetary warming, SRM also has the potential to "buy time" for achieving justice-relevant objectives. First, SRM might allow time for emissions mitigation (Wigley 2006). Even in the wake of the Paris Agreement at COP 21, it seems unlikely that sufficiently ambitious mitigation will occur quickly enough to avert dangerous climate change. SRM could be used to delay various (unjust) emissions-driven impacts, reducing the vulnerability of those under climate risk, while the world transitions to renewable sources of energy. Second, SRM could buy time for development that could greatly benefit the global poor. It should not be controversial to note that global economic benefits and burdens are not currently distributed in a just fashion, as wealth is concentrated in relatively few hands. This injustice could be alleviated to some degree through economic development, but this

likely involves substantially increasing energy consumption in less developed countries. A large-scale transition to renewable energy in the very near term does not currently appear feasible (technically, politically, or economically) in less developed countries, so such development requires increasing consumption of (relatively affordable) fossil fuels and their attendant emissions in order to combat energy poverty (see Keith and Horton in this volume). Assuming that SRM would indeed be effective at managing much climate risk, increased reliance of fossil fuels in less developed countries could be less harmful than it would be without SRM, all else being equal. Depending on how it is used, coupling SRM with a short-term increase in emissions concentrated in less developed countries could be better from a distributive justice perspective than pursuing mitigation alone (Morrow and Svoboda 2016). Of course, there is a limit to how long this can go on without becoming a drain on distributive justice. Eventually, the unjust burdens of both growing emissions and SRM might outstrip the just benefits of poverty reduction and economic development. Nonetheless, pursued for a limited duration, SRM might offer a way for some countries to develop in the near-term before transitioning to renewable energy on a large scale.

SRM might also be used to buy time for adaptation and CDR. Obviously, large-scale adaptation cannot be achieved immediately, especially if it requires massive infrastructure projects. Planning, financing, and implementing such adaptation projects take time. Financing adaptation is of course a major issue for less developed countries, some of which may lack the funds to pursue robust adaptation while also meeting the basic human needs of their citizens. By slowing the rate of warming, SRM could allow more time for such countries to secure necessary financing, as well as to plan and to implement specific adaptation measures. Delaying some climate impacts an extra decade or two could make a substantial difference in some cases, allowing time for substantial adaptation and thus reducing the unjust burdens that come into play.

Likewise, short-term SRM could also allow more time for research, development, and deployment of CDR techniques. A major problem with CDR at present is its high cost (National Research Council 2015). Although the following is somewhat speculative, further research might yield cost-effective (or at any rate, less costly) CDR methods. It is possible that, with the extra time bought by temporary SRM, relatively affordable CDR techniques could be developed for large-scale use. Moreover, temporary SRM could also buy time for extensive implementation of CDR, effectively delaying some of the impacts of climate change while CDR is brought to scale. Without such extra time, unjust burdens might arise before CDR has any chance of averting them by drawing a significant amount of carbon dioxide out of the atmosphere. However, there are major concerns about CDR in general. Aside from high costs, there are also justice considerations about land use, such as using arable land for bioenergy with carbon capture and storage (BECCS), potentially driving up the cost of food or displacing vulnerable populations (Morrow and Svoboda 2016). It is important to note that I am not advocating any particular use of CDR here. My claim is only that SRM has the justice-relevant merit of potentially buying time for other measures. The climate policy that fares best in terms of axiological justice may or may not include a CDR component. That matter will hinge not just on features of the CDR technique(s) in question, but also on the relevant empirical conditions and the features of other potential climate policies that are feasible under those conditions.

Conclusion

I have argued in this chapter that, although it may impose distributive injustice, certain uses of SRM might nonetheless be distributively just. This may sound odd at first, but it becomes plausible if we distinguish axiological justice from deontic justice. SRM could have the morally disvaluable outcome of increasing the vulnerability of some parties to climate-related burdens, yet on the whole a policy involving SRM might be more just (or less unjust) than the alternatives, given SRM's potential to manage climate risk and buy time for mitigation, development, adaptation, and possibly CDR. Accordingly, SRM might be permissible in light of our duties of justice, despite its potential to bring unjust burdens to some parties. To be clear, I am not advocating SRM deployment, but it is time for ethicists to begin broadening their consideration of SRM, attending not just to its potential ethical problems but also to its potential ethical merits.

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