The Panglossian politics of the geoclique[1]

Catriona McKinnon

Department of Politics, University of Exeter

c.mckinnon@exeter.ac.uk

Abstract

Solar radiation management (SRM) – a form of geoengineering – creates a risk of 'termination shock'. If SRM were to be stopped abruptly then temperatures could rise very rapidly with catastrophic impacts. Two prominent geoengineering researchers have recently argued that the risk of termination shock could be minimised through the adoption of 'relatively simple' policies. This paper shows their arguments to be premised on heroically optimistic assumptions about the prospects for global cooperation and sustained trust in an SRM deployment scenario. The paper argues that worst case scenarios are the right place to start in thinking about the governance of SRM.

Key words: solar radiation management, termination shock, worst case scenarios, geoengineering governance, precautionary action.

[1] I am very grateful to Steve Gardiner and an anonymous reviewer for their constructive comments on this paper.

1. Introduction

Solar radiation (SRM) techniques propose to mask global warming by reflecting sunlight away from the Earth. The most developed SRM research programmes focus on one of the following methods.[2] Marine Cloud Brightening (MCB) involves increasing the reflectivity of marine clouds by spraying very fine droplets of sea water into them on a continuous basis. This could require fleets of ships continuously at sea with nozzles pointed upwards, spraying continuously. A research group at the University of Washington is working towards the outdoor experiments to test parts of the technology.[3] Stratospheric aerosol injection (SAI) involves spraying tiny reflective particles – sulfur, or nano-engineered particles – into the stratosphere in order to reflect solar radiation away. This could be done by large tethered balloons or by drones continuously circling the Earth. A research group at Harvard will undertake a small scale outdoor experiment in the next couple of years, probably over New Mexico.[4]

---

[2] SRM methods that have not generated serious interest from research scientists include placing mirrors in space, painting roof tops white, and genetically engineering crops to increase the reflectivity of their surfaces.

[3] See The Marine Cloud Brightening Project: www.mcbproject.org. Accessed 5 February 2019. Thomas Ackerman leads on this project.

[4] The experiment is called SCoPEx: https://projects.iq.harvard.edu/keutschgroup/scopex. Accessed 5 February 2019. David Keith used to lead on this project, which is now led by Frank Keutsch.

In 2006 Paul Crutzen published a paper that made solar radiation management (SRM) a respectable topic for enquiry by the scientific community (Crutzen 2006). Since then, there has been an increase in the interest paid to SRM by natural scientists, the media, and scholars concerned to assess not only the social and economic costs and benefits of the technologies but also the ethical worries and governance challenges SRM throws up (Callies 2019; Gardiner 2010; Gardiner and Fragnière 2018; Heyward 2015; Hourdequin 2019; McKinnon 2018; Morrow 2014; Chhetri et al. 2018; Preston 2012, 2016; Smith 2014; Whyte 2019). One of the most abiding of these worries relates the possibility of a potentially catastrophic 'termination shock' if SRM were to be stopped abruptly. If deployment were to be suspended by, for example, war, sabotage, or natural disaster then global average temperatures would be likely to rise very quickly to pre-deployment levels (Jones *et al.* 2013). Some studies suggest a similar, although less pronounced, effect on precipitation (Keller *et al.* 2014, Zhang *et al.* 2015). These effects would be damaging to people in the future both as a result of the impacts of the temperature rises (and other changes) previously masked by deployment, but also because of the speed at which these impacts would occur (Goes *et al.* 2011, Svoboda *et al.* 2011, Reynolds *et al.* 2016). In a termination shock, climate impacts that would have taken decades or longer to materialise as a result of cumulative emissions would happen much more quickly, causing great damage to people affected by the shock (Baum *et al.* 2013, MacMartin *et al.* 2014, Keith and MacMartin 2015).

In a recent issue of *Earth's Future*, Andy Parker and Peter Irvine argue that a handful of 'relatively simple policies' could minimise the risk of termination shock as a result of the abrupt cessation of SRM deployment (Parker and Irvine 2018a). They argue that these risks have been overstated because it is likely that there would be a time lag of a few months between abrupt cessation of SRM and the rapid temperature rises of a termination shock. The lag could allow for resumption of deployment and so avert the shock.

Parker’s and Irvine’s paper matters not only because of what they argue, but also because of who they are. Irvine and Parker both have notable pedigrees in the SRM research community. Irvine is a member of the *The Keith Group* at Harvard, led by David Keith, who has been ‘the face’ of SRM scientific research to date.[5] Parker was a Policy Advisor for the Royal Society’s influential Report ‘Geoengineering the Climate’ (The Royal Society 2009) and is Project Director for the Solar Radiation Management Governance Initiative.[6] Irvine and Parker have both co-authored with world leaders in the SRM research community. They are key rising stars in what Eli Kintisch has called the ‘Geoclique’ (Kintisch 2010), and they have form in shaping the debate as it has developed in recent years.

In their paper, Parker and Irvine offer a number of reflections on the risks of termination shock under different scenarios. For example, they argue that SRM with a cooling effect of less than 0.1 degree Celsius would not cause a significant shock (Parker and Irvine 2018a) and that termination shock under SAI could be avoided if deployment were phased out at a rate of fifty years per degree Celsius of cooling (Parker and Irvine 2018a). They also argue that instantaneous cessation of SRM would not cause instantaneous termination shock. Instead, there would be several years of (what they call) a ‘buffer period’ before any appreciable global temperature rise. This warming could be avoided if deployment were to be

[5] See https://keith.seas.harvard.edu/home. Accessed 5 February 2019.

[6] The SRMGI is an NGO-driven project that aims to expand the global conversation around the governance of SRM research. See http://www.srmgi.org/. Accessed 5 February 2019.

resumed within a few weeks (for Marine Cloud Brightening) or a few months (for SAI) (Parker and Irvine 2018a).

What I shall focus on here are Parker's and Irvine's suggestions of how SRM deployment could be governed to minimise the risks of termination shock. They argue that global deployment of SRM could be designed and coordinated in ways that would significantly reduce the risk, and that catastrophic risk anyway only attaches to the largest scale deployments. If they are right, then worries about termination shock provide greater impetus to focus on questions of how to govern any deployment, rather than reasons to turn away from SRM as a response to worsening climate change. Given that we might be on the cusp of an era in which SRM research enters the mainstream of climate policy responses, policymakers' perceptions of the landscape of risk created by SRM are important. An argument by two rising stars in the Geoclique that termination shock can be dealt with via 'relatively simple policies' (Parker and Irvine 2018a) could mean that the dangers of termination shock are not properly factored in to decision making around SRM research programmes, and any ultimate deployment. If – as I shall claim - their arguments are premised on a Panglossian view of world politics that we have good reasons to reject, their suggestions could encourage humanity to sleepwalk into a future dangerous deployment scenario (McKinnon 2018).

I shall start by focusing on their claims that the risk of termination shock as a result of forced cessation of SRM at regional scales can be lessened – or even minimised - by a geographical distribution of backup deployment infrastructure, combined with adequate defences for that infrastructure (Parker and Irvine 2018a). I shall argue that there are serious tensions in their arguments which are all related to their background conception of political decision-making as never wantonly irrational, reckless, or morally corrupt. We know enough about the short-sighted, self-serving, and wilfully morally myopic, reasoning of political leaders in the face of global environmental catastrophe to design governance of SRM that avoids the Panglossian conception of political decision making assumed by Parker and Irvine. They tell us that, 'it is not possible to reach useful policy conclusions based on the analysis of worst-case scenarios' (Parker and Irvine 2018 10) *Pace* Parker and Irvine, I shall argue that analysis of worst case scenarios is exactly the right place to start for reaching policy conclusions about whether we should stimulate research into SRM now, and whether we should deploy this form of climate engineering in the future.

2. 'Relatively simple' safeguards against forced termination shock: geographical dispersion and backup hardware

Parker and Irvine make three related suggestions of measures that could be taken to reduce the risk of termination as a result of forced disruption of deployment caused by destruction of, or damage to, the delivery infrastructure for SRM. The cases they have in mind are generated by political opposition – for example, terrorist attack – or regional collapse as a result of conflict, economic breakdown, or local natural disaster.[7] They claim that these

---

7 Parker and Irvine accept that a *global* catastrophic event fit to disrupt deployment would not be addressed by their 'relatively easy and cheap' measures. They reflect that 'global domestic product would … need to drop by over 90% before maintaining SRM would cost more than 1% of the collective post-catastrophe GDP of the world's top 20 economies' and thus that 'if spare deployment capacity were maintained, or could be brought online quickly, a catastrophe would have to be on a scale unprecedented in modern history to force

measures should be 'relatively simple' to achieve. I shall argue that this is true only given heroically optimistic and unsupported assumptions about the prospects for future political cooperation between states. Let me start with two interrelated suggestions they make:

> *Geographical Dispersion*: Geographical distribution of deployment infrastructure would enable continuation of deployment in the event of any part of the distributed infrastructure going down (5-6).

> *Backup Infrastructure*: 'Backup delivery hardware' kept by one state, or a group of states, would enable swift redeployment were the existing deployment infrastructure to be irreparably damaged (5-6).

---

termination shock' (p. 6). This strikes me as a non sequitur for at least two reasons. First, there are good reasons to worry that in the Anthropocene we could face a number of catastrophes unprecedented in human, let alone modern, history (see (Bostrom and Ćirković 2008). Second, the fact (if it is one) termination shock caused by a global catastrophe would have to reduce GDP by over 90% for redeployment to cost more than 1% of GDP is just one factor in assessing how likely states would be to redeploy. Looking at the lamentable failure to date of states to take measures to tackle climate change that they can easily afford tells against Parker and Irvine's assumption that the affordability of redeployment significantly increases the likelihood of redeployment. That states can afford to do the right thing is tangential to whether they are likely to do the right thing.

Taking *Geographical Dispersion* first, their claim is that the infrastructure for delivery of SRM should be distributed across many states and geographical locations so as to minimise the amount of disruption to deployment that could be caused by forced termination at any one place in the infrastructure. Far from being 'relatively simple', this proposal would require an unprecedented degree of cooperation and trust between all states in possession of delivery hardware. Furthermore, it is very likely that private companies will be involved in producing and maintaining deployment infrastructure. Interstate and corporate cooperation under Geographical Dispersion would have to be sustained across many decades, possibly across centuries, depending on (a) how quickly emissions could be brought down, (b) how quickly the atmospheric concentration of greenhouse gases could be reduced, and (c) how far disruption to deployment – by, for example, climate surprises - could be avoided.[8] This degree of sustained trust and cooperation between states and private companies is not impossible but it is certainly far from 'relatively simple' to achieve.

Furthermore – and more concerning - if efficiency and affordability requires that different parts of the delivery infrastructure performing different functions are to be located in different parts of the world, it is not obvious that geographical distribution would properly address the danger of termination shock. If drones are manufactured in China, nozzles are made in Russia, sulfur compounds are made in Iran, and monitoring systems are made in

---

[8] One oddity of Parker's and Irvine's classification of the possible driver events for termination shock is that they fail to register climate surprises as a driver that does not fit their schema. Disruption of deployment as a result of, for example, the speedy shutdown of the THC is something humanity could not control (and so looks like an external driver) and yet is caused by human choices (like an elective driver).

Canada, then the geographical dispersion of the overall infrastructure across these and other sites would do nothing at all to limit the danger of termination shock as a result of an earthquake in China, or terrorist attack in Canada.

Backup Infrastructure addresses circumstances in which deployment infrastructure is irreparably damaged.

> If any capable party, anywhere around the world, kept backup SRM delivery hardware, it could be redeployed to maintain the SRM cooling before temperatures started to rise rapidly … [i]f spare deployment capacity were maintained or numerous nations were capable of deployment, then the SRM system would be resilient against catastrophes that were confined to one country or region (Parker and Irvine 2018).

Their thought here is that if geographical dispersion of deployment capacity fails to prevent abrupt cessation of deployment, backup delivery hardware could be activated in what they call the 'buffer period' between abrupt cessation of deployment and the start of a termination shock. There are actually two ways in which this could happen (although Parker and Irvine do not make this distinction). The first way involves activation of the appropriate part of a 'shadow' deployment infrastructure that is also geographically dispersed, whereas the second way involves maintenance of backup hardware by one actor unilaterally, or by bilateral or minilateral cooperation between actors.

Taking the 'shadow infrastructure' version first, imagine that Germany has back up nozzles, the US maintains a fleet of backup drones, alternative sulfur compounds can be sourced in Australia, and replacement monitoring systems are kept up to date in Brazil. If one essential part of the original geographically dispersed infrastructure were to go down, the corresponding part of the shadow infrastructure would be activated. If drone manufacturing plants in China were destroyed, the US could step into the breach. Let me offer three reflections on the 'shadow infrastructure' rote to maintaining backup delivery infrastructure.

First, a 'shadow infrastructure' would amplify the problems of sustained trust and cooperation between states and private companies already mentioned: now we must not only assume cooperation with respect to primary deployment infrastructure, but also with respect to the shadow infrastructure. And the problems of cooperation are given an additional dimension of complexity. Not only would states maintaining the shadow infrastructure have to cooperate with one another, each state would also have to cooperate with whatever party is running the part of the deployment infrastructure that they are shadowing, so as to ensure their shadow components genuinely mirror the original. Without this, there would not be a guarantee that any part of the shadow infrastructure could replace its damaged counterpart in the event of forced termination.

Second, the shadow infrastructure suggestion would at least double the cost of deployment, which undermines one of the touted advantages of SRM as a tool to buy more time for mitigation, viz. that it is cheap.[9]

---

[9] For criticism of the claim that cheapness per se is an advantage consider Stephen Gardiner's comment: '[s]aying that SSI is cheap because it does not cost much to spray particles into the stratosphere is a little like saying "brain surgery is cheap" because it would not cost much for me to buy a scalpel and start cutting into your head. While true in one sense, the point is largely irrelevant. What we care about in the brain surgery case is much wider, such as what

Third, reliance on a shadow infrastructure as a last line of defence against potentially catastrophic termination shock should commit us to maintaining a shadow-shadow infrastructure. Given what is at stake, would we want to place all our hopes in just one layer of shadowing? If not, the problems of cooperation and cost already mentioned would balloon in ways that should alarm us.

Parker and Irvine do not envisage shadow infrastructure as the way in which to secure backup delivery hardware. Instead, as they state, they intend backup infrastructure to be maintained unilaterally, minilaterally or bilaterally by one or more capable parties, presumably including both states and private companies. Under this scenario, if deployment using geographically dispersed infrastructure were to be abruptly stopped, a capable party or club of parties could step into the breach and redeploy in the buffer period. If there were other parties – states or private companies – also in possession of deployment infrastructure through unilateral, bilateral or minilateral cooperation, then that would serve as backup to the now deployed backup, thus solving the shadow-shadow infrastructure problems mentioned above.

Parker and Irvine's suggestion that unilaterally, bilaterally or minilaterally maintained backup capability would be a good safeguard against the risk of termination shock in the event of a geographically dispersed delivery infrastructure going down rests, again, on a Panglossian vision of international politics. In fact, their proposal stands in serious tension with

---

the consequences of my digging will be, whether I am qualified, whether I have the right to do it, and what will happen if things go wrong. The same is true of climate engineering. To say that SSI is "cheap" is to ignore the most relevant "costs"' (Gardiner 2019, 31)

Geographical Dispersion because it would reintroduce the potentially catastrophic danger of abrupt cessation for which geographical dispersion was offered as a remedy. This is the case because it would incentivise a 'backup deployment infrastructure arms race' between states, private companies, and a mixture of these capable parties. Any party that is unilaterally (bilaterally, minilaterally) in possession of backup deployment hardware is in a position of immense global power, and all parties would know this. It has often been noted that unilateral, bilateral or minilateral control over SRM deployment technology itself would create a severe imbalance of power across states. That this imbalance could be echoed in governance structures enabling deployment has not been noticed, and would increase the risks of dangerous imbalances of power in a deployment scenario.

Finally, and worst, when Panglossian assumptions about the reasons for which states and private companies act are abandoned, it is apparent that in a backup deployment arms race there are powerful incentives for parties to deliberately damage existing geographically dispersed infrastructure and so become unilaterally (bilaterally, minilaterally) positioned with their hands on the global thermostat. And if there is more than one party (or club) with backup deployment hardware, that incentive remains even if the first party to unilaterally use their backup deployment hardware manages to avert termination shock by redeploying. If other parties have backup capability, there is the world to be gained by bringing down the backup infrastructure of competitors who were the quickest to redeploy after the failure of a geographically dispersed deployment programme.

Parker and Irvine present *Backup Infrastructure* as the inverse of 'mutually assured destruction', whereby freedom from nuclear strikes is supposed to be enhanced by nuclear proliferation and the balance of power it creates. Their 'unilateral (bilateral, minilateral) backup' scenario is supposed to be a case of 'mutually assured survival': freedom from termination shock is enhanced by proliferation of SRM delivery hardware and the global safety net this provides. But once we abandon heroically optimistic assumptions about the reasons for which states and corporations act, we can see that their proposal could easily create a greater risk of termination shock than the original scenario of geographically dispersed deployment infrastructure: the cure is worse than the disease.[10]

3. 'Relatively simple' safeguards against forced termination shock: adequate defences

The third suggestion Parker and Irvine make for guarding against force termination shock is this:

Adequate Defences: Delivery equipment should be protected with adequate defences, 'such as those that guard power plants or military bases' (p. 6).

Adequate Defences is supposed to address elective drivers of termination shock such as deliberate attacks on infrastructure. However, there are immediately noticeable differences between the defences in place for military bases and power plants, and those that would be

---

10 There are parallels here with Stephen Gardiner's argument SSI deployment could start a geoengineering arms race: states with a legitimate interest in self-defence could undertake their own SRM deployments if they are threatened by the unilateral deployment of a different state, or if they believe that a different form of geoengineering is better for them than the one to which they are reacting. This dynamic could lead to an SSI arms race (Gardiner 2013)

needed to provide adequate protection for SRM delivery infrastructure. Military bases and nuclear plants have a fixed geographical location, whereas SRM and MCB delivery infrastructure would have many mobile components, such as the drones delivering the sulfur particles to the stratosphere, or the ships spraying saline into marine clouds. In addition to providing adequate defences for these moving parts, all the manufacturing and production lines, distribution and supply chains, and product design and improvement intelligence, would require adequate defences. An additional layer of complexity is introduced once we recognise that many if not all of these functions would be very likely to be contracted out to private companies that would also require adequate defences for their operations across multiple sites.

Furthermore, we could only be sure that defences are adequate and reliable if they are regularly inspected by some body with the expertise, authority and legitimacy to do this. This, again, reveals Parker's and Irvine's extremely optimistic assumptions about cooperation, trust and transparency between states. If we avoid Panglossianism by assuming that levels of conflict and mistrust between states in the future will not significantly lessen, or disappear, then nothing about Parker and Irvine's recommendation on adequate defences for SRM infrastructure is 'relatively simple'.

One way to make the *Adequate Defences* challenge manageable would be to give just one state, or a small group of states, control over provision and inspection of adequate defences for delivery infrastructure, perhaps by sanctioning that state, or club of states', monopoly over production. Here, again, we see the fundamental tension in Parker's and Irvine's proposals. The conditions under which they would be effective are precisely conditions in which they would fail to minimise the danger of termination shock. Taking seriously states' desires for geopolitical dominance, their corrupt political leadership, and the profit motive of private corporations makes Parker's and Irvine's proposals a manifesto for unilateral or minilateral production, defence and deployment of SRM which increases the risk of termination shock.

4. The bigger picture: worst case scenarios are where we should start

Parker and Irvine are right that the mere possibility of catastrophic harm as a result of termination shock does not provide policy guidance (Parker and Irvine 2018a) and that consideration must be given to the likelihood of termination shock in thinking about how to govern the development and potential deployment of this technology. However, they misinterpret the significance of the imperative to think more about the likelihood of termination shock, and they misconstrue the phenomena to which it applies. This explains in part, I think, why they proceed using Panglossian political assumptions. They understand the requirement to think about the likelihood of termination shock as applying only to the physical processes that could cause a termination shock were deployment to be interrupted. This is why, at the beginning of their paper, they focus on defending the claims that termination shock is scalar i.e. not all 'shocks' would cause substantial warming, termination shock could be avoided if SAI were phased out at a rate of fifty years per degree Celsius of cooling, and instantaneous cessation of SRM would not cause instantaneous termination shock. What they massively underestimate is the scale of the political, social and economic challenges to the proposals they make to address the non-physical causes of termination shock. This leads them to ignore entirely the question of whether, and under what conditions, their governance proposals could make termination shock more likely. It is also fit to encourage complacency about the difficulty of SRM governance which, in my view, creates a real danger that we will sleepwalk into being locked-in to deployment, and/or to research into the most dangerous form of SRM (McKinnon 2018).

My argument is not that we know that future social, political and economic conditions will be such that Parker's and Irvine's proposals could make termination shock more likely. Although we live in a deeply unjust world, these injustices - created by the action of states, corrupt political leaders, and the profit seeking behaviour of firms in a capitalist global economy - are not unalterable facts. I do not believe humanity is stuck with its present unjust hand. A world of cosmopolitan justice is a live option (Caney 2005). Capitalism does not have to be the future (Cohen 2009). Human beings – including political leaders – can and should be expected to act ethically and justly (Estlund 2011). We are deeply uncertain about the prospects for a more just future in which states and other actors resist the incentives that would be created by Parker's and Irvine's proposals, and which would increase the likelihood of termination shock. The fact – if it is one – that assessing the likelihood of termination shock as a result of physical processes is more nuanced than is often assumed provides only partial information for an overall assessment of the likelihood of termination shock. Understanding the full picture requires assessing how likely it is that the actors in charge of any future deployment will be willing and able to sustain transparent cooperation and maintain trust over a period of at least decades, perhaps longer. We are deeply uncertain about the prospects for this cooperation, and Parker and Irvine do not acknowledge this.

The core of the problem with Parker's and Irvine's approach is that they assume the incentives on states collectively to maintain SRM and avoid termination shock will generate the unprecedented levels of sustained interstate and cross-corporation trust, cooperation, and transparency necessary for their proposals to deliver on their promise of minimizing the risk of termination shock. They claim that they do not assume perfect rationality on the part of actors involved in deployment and that their minimal assumption is only that actors will avoid wanton irrationality in the face of disruption to deployment fit to cause a termination shock. One important thing to note here is that there has been a very strong – overwhelming - rationale for aggressive mitigation for the last few decades, and yet this has not moved states to act as they should and avert the climate crisis. Putting that to one side, if Parker and Irvine are right to assume no wanton irrationality from actors involved in SRM deployment, their ‘relatively simple’ proposals incentivize powerful states and corporations to minilateral implementation of the measures they contain. In a world of states with opposed interests and nefarious ambitions, the most instrumentally rational choice for a powerful state or corporation committed to minimizing the risk of termination shock is to band together with other powerful actors to produce, protect, and deploy SRM in the ways Parker and Irvine suggest. Actors that avoid wanton irrationality will seek the most efficient and reliable means to their ends. If those actors are themselves ethically questionable, or are hemmed in by structures of interaction that crowd out ethically required action, then the avoidance of wanton irrationality by these actors will not magically transform the ends of their action into those that serve the interests of the whole human community over time.

Where does this leave us? Underlying my criticisms of Parker and Irvine is the view that worst case scenarios are the right place to start in our political thinking about SRM. This is not because we know that worst case scenarios with respect to future actors in charge of deployment are more likely than best case scenarios. As I have been emphasizing, we do not know this. Rather, starting with worst case scenarios is required in thinking about termination shock because there is a powerful argument for taking a precautionary approach to such cases. When uncertainty about the consequences of a course of action is extensive and deep, when the costs of assuming more than we are entitled to given this uncertainty are catastrophic, and when these costs will fall on people separate to those making decisions under these assumptions, we are morally required not to make political decisions using these assumptions. Applied to the present case: we are not permitted to assume that states and private companies will cooperate with one another on terms of trust in order to build and sustain a system of governance for SRM deployment that realizes geographical dispersion, backup infrastructure, and adequate defences.

The bigger picture behind my objections to Parker's and Irvine's proposals is that they encourage political decision making that violates a moral requirement, given that deployment governed by the proposals has features that bring it within the scope of this precautionary approach. These features are described by Henry Shue as follows.[11]

> *Massive loss*: the magnitude of the possible losses [in the case] is massive;
> *Threshold likelihood*: the likelihood of the losses [in the case] is significant, even if no precise probability can be specified [for these losses], because the mechanism by which the losses would occur is well understood, and the conditions for the functioning of the mechanism are accumulating (Shue 2010).[12]

---

[11] Shue's account of the conditions for precautionary action is influenced by (Gardiner 2006). Other excellent recent treatments of precautionary approaches are (Steel 2014, Hartzell-Nichols 2017).

[12] Shue identifies an additional third feature not listed here, as follows: '(3) *non-excessive costs*: the costs of prevention are not excessive (a) in light of the magnitude of the possible

Everyone agrees that the magnitude of the losses involved in a termination shock would be massive, so let me focus instead on *threshold likelihood*. I have claimed that we are deeply uncertain of the political, social and economic future. It is possible that states and other actors in control of deployment could evolve in ways that make sustained trust and cooperation feasible, but it is also possible that the unjust status quo could continue, or even worsen. If we do not know the probabilities of these futures, how can we know whether they are above any threshold of probability? The right approach here is to make a distinction between exactitude in our judgements of the probability of uncertain outcomes and accuracy in our judgements about whether these outcomes are above some threshold of probability: judgements of the latter type can be well founded when judgements of the former type are not. Shue defends this method (Shue 2010, 2015): 'one can reasonably, and indeed ought to, ignore entirely questions of probability beyond a certain minimal level of likelihood'.

---

losses and (b) even considering other important demands on our resources'. (2010, p. 148). I shall take it to be straightforward that prevention costs are non-excessive in both the case of warming above 2C and the case of governance stimulating SRM research. In the climate case, the costs are those created by mitigation. In the SRM case, the costs are those created by not doing the research. Given the early-days state of research into SRM, these costs are almost entirely opportunity costs. Some SRM researchers make the case that this research could enable us to learn important things that would also benefit mitigation efforts, e.g. with respect to clouds. Granting this, if massive loss and threshold likelihood are satisfied in the case of governance stimulating SRM research, these opportunity costs are far from excessive, especially given that we may be able to learn these important things about clouds by other means.

Following Shue, the relevant question is not 'what is the likelihood of states and other actors cooperating with sustained trust and transparency in the future?'. Instead, the relevant questions are (a) 'are there well-understood political, social and economic mechanisms that could bring about termination shock when the proposals for governing deployment are implemented?', and (b) 'are the conditions for the functioning of these mechanisms accumulating?'. My argument in this paper relate to (a). I have claimed that once we abandon Panglossian assumptions about levels of trust that can be sustained between states, the motives of private corporations, and the integrity of political leaders, we have good reasons to believe that Parker's and Irvine's governance proposals would function as mechanisms that would exacerbate the risk the termination shock. The natural next step is to argue what would need to be changed in the global political, social and economic order so to make Parker's and Irvine's optimism warranted. Those who care about governance of SRM to avoid termination shock should focus on this question before dreaming about a relatively simple world in which we need no longer worry about the worst outcomes of deployment.

5. Conclusion

Getting serious about minimizing the ethically unacceptable dangers of termination shock requires much more than the superficial proposals made by Parker and Irvine. Parker and Irvine claim that '[i]t is not justifiable to draw insights about the risk of termination shock by reporting the magnitude of the worst possible impacts, while leaving aside consideration of the likelihood of events that could cause or prevent termination' (Parker and Irvine 2018a). Read in one way, this is exactly right. In deciding how to act now to govern SRM we must take account of the likelihood of events that could cause or prevent termination. My objections to Parker and Irvine have been that they are sanguine to the point of naivete about the prospects for friendly conditions under which their proposals could reduce the risk of termination shock. If conditions of sustained and trusting cooperation between states and corporations do not obtain, their proposals will in fact make termination more likely, given the incentives they would create for powerful and self-interested actors.

Although we have ample evidence from history that states and corporations often yield to the temptation to exploit new technologies – and the governance of them – for their own ends (very often to benefit their most wealthy and powerful members), this is not set in stone forever. The reality is that we do not know how states and other actors will evolve in the future. But we are not warranted to assume the best of these actors, given this uncertainty and given the high stakes. The governance we need now for SRM must not proceed on these assumptions. Instead, it should offer immediate proposals for building out governance now in ways that can be ramped up to overhaul – perhaps, replace – our present ethically inadequate institutions.[13] It is not justifiable to draw insights about the risk of termination shock by assuming the best of states and corporations charged with managing deployment, while leaving aside consideration of how deeply uncertain it is that these actors will act in the best interests of humanity as a whole.

---

[13] There are a number of proposals already as to how to do this. For example, see (Gardiner 2014, González-Ricoy and Gosseries 2016, Chhetri *et al.* 2018).

References

Baum, S.D., Maher, T.M., and Haqq-Mistra, J., 2013. Double Catastrophe: Intermittent Stratospheric Geoengineering Induced by Societal Collapse. *Environment, Systems and Decisions*, 33 (1), 168–80.

Bostrom, N. and Ćirković, M.M., 2008. *Global catastrophic risks*. Oxford University Press.

Callies, D.E., 2019. Institutional Legitimacy and Geoengineering Governance. *Ethics, Policy & Environment*, 0 (0), 1–17.

Caney, S., 2005. *Justice Beyond Borders*. Oxford University Press.

Chhetri, N., Chong, D., Conca, K., Falk, R., Gillespie, A., Gupta, A., Jinnah, S., Kashwan, P., Lahsen, M., Light, A., McKinnon, C., Thiele, L.P., Valdivia, W., Wapner, P., Morrow, D., Turkaly, C., and Nicholson, S., 2018. *Governing Solar Radiation Management*. Washington, D.C.: Forum for Climate Engineering Assessment.

Cohen, G.A., 2009. *Why not socialism?* Princeton University Press.

Crutzen, P.J., 2006. Albedo enhancement by stratospheric sulfur injections: A contribution to resolve a policy dilemma? *Climatic Change*, 77 (3–4), 211–219.

Estlund, D., 2011. Human nature and the limits (If Any) of political philosophy. *Philosophy and Public Affairs*, 39 (3), 207–237.

Gardiner, S.M., 2019. Climate engineering. *In*: D. Edmonds, ed. *Ethics and the contemporary world*. Routledge, 29–43.

Gardiner, S.M., 2006. A Core Precautionary Principle*. *Journal of Political Philosophy*, 14 (1), 33–60.

Gardiner, S.M., 2010. Is 'arming the future' with geoengineering really the lesser evil? Some doubts about the ethics of intentionally manipulating the climate system. *In*: S.M.

Gardiner, S. Caney, D. Jamieson, and H. Shue, eds. *Climate Ethics: Essential Readings*. Oxford: Oxford University Press, 284–314.

Gardiner, S.M., 2013. The desperation argument for geoengineering. *PS: Political Science and Politics*, 46 (1), 28–33.

Gardiner, S.M., 2014. A Call for a Global Constitutional Convention Focused on Future Generations. *Ethics & International Affairs*, 28 (03), 299–315.

Gardiner, S.M. and Fragnière, A., 2018. The Tollgate Principles for the Governance of Geoengineering: Moving Beyond the Oxford Principles to an Ethically More Robust Approach. *Ethics, Policy & Environment*, 21 (2), 143–174.

Goes, M., Tuana, N., and Keller, K., 2011. The economics (or lack thereof) of aerosol geoengineering. *Climatic Change*, 109 (3–4), 719–744.

González-Ricoy, I. and Gosseries, A., eds., 2016. *Institutions For Future Generations*. Oxford University Press.

Hartzell-Nichols, L., 2017. *A Climate of Risk Precautionary Principles, Catastrophes, and Climate Change.* Taylor and Francis.

Heyward, C., 2015. Is There Anything New Under the Sun? *In*: A. Maltais and C. Mckinnon, eds. *The Ethics of Climate Governance*. London: Rowman and Littlefield International, 133–154.

Hourdequin, M., 2019. Climate Change, Climate Engineering, and the 'Global Poor': What Does Justice Require? *Ethics, Policy & Environment*, 0 (0), 1–19.

Jones, A., Haywood, J.M., Alterskjaer, K., Boucher, O., Cole, J.N.S., Curry, C.L., Irvine, P.J., Ji, D., Kravitz, B., Egill Kristjánsson, J., Moore, J.C., Niemeier, U., Robock, A., Schmidt, H., Singh, B., Tilmes, S., Watanabe, S., and Yoon, J.-H., 2013. The impact of abrupt suspension of solar radiation management (termination effect) in experiment

G2 of the Geoengineering Model Intercomparison Project (GeoMIP). *Journal of Geophysical Research: Atmospheres*, 118 (17), 9743–9752.

Keith, D.W. and MacMartin, D.G., 2015. A temporary, moderate and responsive scenario for solar geoengineering. *Nature Climate Change*, 5 (3), 201–206.

Keller, D.P., Feng, E.Y., and Oschlies, A., 2014. Potential climate engineering effectiveness and side effects during a high carbon dioxide-emission scenario. *Nature Communications*, 5, 1–11.

Kintisch, E., 2010. *Hack the planet : science's best hope-- or worst nightmare-- for averting climate catastrophe*. Wiley.

MacMartin, D.G., Caldeira, K., and Keith, D.W., 2014. Solar geoengineering to limit the rate of temperature change. *Philosophical Transactions of the Royal Society A*, 372, 20140134.

McKinnon, C., 2018. Sleepwalking into lock-in? Avoiding wrongs to future people in the governance of solar radiation management research. *Environmental Politics*.

Morrow, D.R., 2014. Ethical aspects of the mitigation obstruction argument against climate engineering research. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 372 (2031), 20140062–20140062.

Parker, A. and Irvine, P.J., 2018a. The Risk of Termination Shock From Solar Geoengineering. *Earth's Future*, 1–12.

Parker, A. and Irvine, P.J., 2018b. The Risk of Termination Shock From Solar Geoengineering. *Earth's Future*, 1–12.

Preston, C.J., 2012. *Engineering the climate : the ethics of solar radiation management*. Lanham: Lexington Books.

Preston, C.J., 2016. *Climate justice and geoengineering : ethics and policy in the atmospheric Anthropocene*. Rowman & Littlefield International, Ltd.

Reynolds, J.L., Parker, A., and Irvine, P., 2016. Five solar geoengineering tropes that have outstayed their welcome. *Earth's Future*, 4 (12), 562–568.

Shue, H., 2010. Deadly Delays, Saving Opportunities: Creating a More Dangerous World? *In*: S.M. Gardiner, S. Caney, D. Jamieson, and H. Shue, eds. *Climate Ethics: Essential Readings*. Oxford University Press, 146–162.

Shue, H., 2015. Uncertainty as the Reason for Action: Last Opportunity and Future Climate Disaster. *Global Justice: Theory Practice Rhetoric*, 8 (2), 86–103.

Smith, P.T., 2014. Redirecting Threats, the Doctrine of Doing and Allowing, and the Special Wrongness of Solar Radiation Management. *Ethics, Policy & Environment*, 17 (2), 143–146.

Steel, D., 2014. *Philosophy and the Precautionary Principle*. Cambridge: Cambridge University Press.

Svoboda, T., Keller, K., Goes, M., and Tuana, N., 2011. Sulfate Aerosol Geoengineering: The Question of Justice. *Public Affairs Quarterly*, 25 (3), 157–180.

The Royal Society, 2009. *Geoengineering the climate: science, governance and uncertainty*. London, No. 10/09.

Whyte, K.P., 2019. Indigeneity in Geoengineering Discourses: Some Considerations. *Ethics, Policy & Environment*, 0 (0), 1–19.

Zhang, Z., Moore, J.C., Huisingh, D., and Zhao, Y., 2015. Review of geoengineering approaches to mitigating climate change. *Journal of Cleaner Production*, 103, 898–907.