



OPINION



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Is solar geoengineering ungovernable? A critical assessment of governance challenges identified by the Intergovernmental Panel on Climate Change

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Abstract

Solar radiation modification (SRM) could greatly reduce climate change and associated risks. Yet it has not been well-received by the climate change expert community. This is evident in the authoritative reports of the Intergovernmental Panel on Climate Change (IPCC), which emphasize SRM's governance, political, social, and ethical challenges. I find seven such challenges identified in the IPCC reports: that SRM could lessen mitigation; that its termination would cause severe climatic impacts; that researching SRM would create a “slippery slope” to its inevitable and unwanted use; that decisions to use it could be contrary to democratic norms; that the public may not accept SRM; that it could be unethical; and that decisions to use SRM could be unilateral. After assessing the extent to which these challenges are supported by existing evidence, scholarly literature, and robust logic, I conclude that, for six of the seven, the IPCC's claims variously are speculative, fail to consider both advantages and disadvantages, implicitly make unreasonable negative assumptions, are contrary to existing evidence, and/or are meaninglessly vague. I suggest some reasons for the reports' failure to meet the IPCC's standards of balance, thoroughness, and accuracy, and recommend a dedicated Special Report on SRM.

This article is categorized under:

Integrated Assessment of Climate Change > Assessing Climate Change in the Context of Other Issues

KEYWORDS

geoengineering, Intergovernmental Panel on Climate Change, IPCC, solar radiation modification, SRM

1 | INTRODUCTION

Greenhouse gas emissions reductions and carbon dioxide removal (together, “mitigation”) continue to be insufficient to prevent dangerous anthropogenic climate change. Additionally, adapting to a changed climate has limited and uncertain

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potential and is expensive. In response, some scientists and others are researching solar radiation modification (SRM, sometimes called solar radiation management or solar geoengineering) as an additional means to limit climate change and its risks.

SRM is a set of proposed technologies to intentionally modify the Earth's shortwave radiative budget with the aim of reducing climate change (IPCC, 2018, p. 558). It would block or reflect a small portion of incoming sunlight and consequently cool the planet. The leading suggested method would replicate volcanoes' cooling effect by injecting an aerosol into the stratosphere. According to evidence to date—mostly from modeling—SRM has substantial potential to reduce climate change (Irvine & Keith, 2020; National Research Council, 2015). Moreover, it could do so in ways that other responses could not: it appears to be relatively inexpensive (Smith, 2020), rapid, and possible without broad international cooperation. At the same time, SRM poses a number of physical and environmental risks, especially in scenarios of its suboptimal use. For example, because SRM would compensate for precipitation changes more efficiently (per unit of radiative forcing or aerosol mass) and less consistently than it would for the temperature ones, using SRM to return the global mean temperature to its preindustrial level would result in some wet and especially some dry areas (Tilmes et al., 2013).

Despite its apparent potential to reduce climate change and the associated risks, SRM has not been well-received by the community of climate change experts. Skepticism and aversion are evident in the authoritative reports of the Intergovernmental Panel on Climate Change (IPCC). Its highest-profile statement to date on SRM, in the Summary for Policymakers of the Synthesis Report of the Fifth Assessment Report (AR5), is:

Solar Radiation Management (SRM) involves large-scale methods that seek to reduce the amount of absorbed solar energy in the climate system. SRM is untested and is not included in any of the mitigation scenarios. If it were deployed, SRM would entail numerous uncertainties, side effects, risks and shortcomings and has particular governance and ethical implications. SRM would not reduce ocean acidification. If it were terminated, there is *high confidence* that surface temperatures would rise very rapidly impacting ecosystems susceptible to rapid rates of change. (italics in original here and elsewhere; IPCC, 2014c, pp. 25–26)

Similarly, the Summary for Policymakers of the more recent Special Report *Global Warming of 1.5°C* (SR1.5) is, again in full:

Solar radiation modification (SRM) measures are not included in any of the available assessed pathways. Although some SRM measures may be theoretically effective in reducing an overshoot, they face large uncertainties and knowledge gaps as well as substantial risks and institutional and social constraints to deployment related to governance, ethics, and impacts on sustainable development. They also do not mitigate ocean acidification (IPCC, 2018, pp. 14–15).

In these two paragraphs, only 12 of 146 words speak of SRM's efficacy, and even this clause is qualified with “although” and “theoretically.” Most of the remaining words address SRM's risks and limitations. Furthermore, these reports give no reason for excluding SRM from their scenarios. This is particularly noteworthy in the case of SR1.5, which, in a box toward its end, concludes “with *high agreement* that [stratospheric aerosol injection] could limit warming to below 1.5°C” (IPCC, 2018, p. 558), a goal that is out of reach through emissions reduction alone (IPCC, 2018, p. 17).

SRM poses multiple physical risks as well as regulatory, political, social, and ethical challenges (here, “governance challenges”). Physical risks and governance challenges differ in how they can be assessed. At least in principle, the former—such as the potential residual precipitation anomalies described above—could be weighed against SRM's reduction of climate change; decision-makers and the public may or may not subsequently deem SRM acceptable. In contrast, its governance challenges are less amenable to instrumental assessment and now persist as the stronger set of objections to SRM. For example, the executive summary of SR1.5's relevant chapter concludes, “Even in the uncertain case that the most adverse side-effects of SRM can be avoided, public resistance, ethical concerns and potential impacts on sustainable development could render SRM economically, socially and institutionally undesirable” (IPCC, 2018, p. 317). In other words, the IPCC asserts that SRM's governance challenges could be insurmountable, independent of its net effect on physical risks. Along these lines, SRM has been called “ungovernable” (Hulme, 2014). Because these

governance challenges constitute the leading set of objections in the IPCC reports and in the wider climate change community, they warrant explication and interrogation.

In order to assess the IPCC's claims, I reviewed the five IPCC Assessment Reports as well as the more recent SR1.5 and found SRM's governance challenges that they identify. I then examined the extent to which these are supported by existing evidence, scholarly literature, and robust logic. Attention to SRM's governance challenges is largely confined to AR5 and SR1.5; prior Assessment Reports focus almost entirely on SRM's environmental effects. Below, I describe and assess the governance challenges as represented in these IPCC reports, grouping them into seven coherent categories: that SRM could lessen mitigation; that its termination would cause severe climatic impacts; that researching SRM would create a "slippery slope" to its inevitable and unwanted use; that decisions to use it could be contrary to democratic norms; that the public may not accept SRM; that it could be unethical; and that decisions to use SRM could be unilateral. For six of these seven governance challenges, I conclude that the IPCC's claims are variously speculative, fail to consider both advantages and disadvantages, implicitly make unreasonable negative assumptions, are contrary to existing evidence (several times misrepresenting cited academic publications), and/or are meaninglessly vague. Thereafter, the paper briefly concludes with possible explanations and a recommendation.

2 | LESSENER MITIGATION

Perhaps the most widespread and influential concern regarding SRM is that it could lessen mitigation. AR5 expresses this passively: "it has been argued that geoengineering could become a distraction from urgent mitigation and adaptation measures" (IPCC, 2014b, p. 484, see also pp. 219, 488). According to SR1.5, "the literature shows *low agreement* on whether SRM research and use may lead policy-makers to reduce mitigation efforts" (IPCC, 2018, p. 349).

There is no evidence that SRM's research and development would lessen mitigation but instead only assertions of that effect. In this sense, AR5 is correct: it has been *argued*. In contrast, SR1.5 speaks of the literature showing *low agreement*, yet the one scientific article that is cited after the above quote (Linnér & Wibeck, 2015) does not discuss SRM's potential effect on mitigation.

In fact, what evidence there is suggests the opposite. In almost all opinion surveys and behavioral experiments that have explored this possibility, after learning about SRM or having it added to their choices, respondents *increase* their concern about climate change and/or support for mitigation (for references, see Reynolds, 2019, pp. 37–40). This suggests that SRM may be seen by many as so undesirable that it leads them to realize climate change's seriousness and mitigation's importance, a prospect that SR1.5 does cautiously note. Of course, these surveys and experiments are not dispositive about what will actually occur. The actions of future decision-makers—who will face political pressures—will not necessarily align with current laypersons' preferences and choices. At the same time, decision-makers are influenced by popular sentiment. Elected politicians rely on voters; appointed officials are accountable to elected ones; and businesses depend on customers. Even authoritarian leaders are partially constrained by public opinion. Thus, if SRM's research and development were to increase support for mitigation among the general population, as suggested by the surveys and experiments to date, then similar shifts should be expected among decision-makers, albeit imperfectly so. In the end, the IPCC's statements that SRM would be a distraction from or reduce mitigation are speculations that are contrary to the existing empirical evidence.

Even if the introduction of SRM into a mix of responses to climate change were to lessen mitigation undertaken, doing so could still be a net benefit. If SRM could counteract climate change, then its use coupled with a modest lessening of mitigation could, on the whole, reduce net climate risks. Such "risk compensation," in which the introduction of a safety rule or technology causes an increase in the underlying risky activity, is common in public policy (Hedlund, 2000). Tellingly, the net result of the safety measure and the subsequent compensatory behavioral change is usually a net reduction of harm, and the risk-reducing rules and technologies are typically praised. Yet the IPCC reports do not consider such a risk compensation scenario and instead take into account only the negative consequences of SRM potentially lessening mitigation but not its expected concomitant benefits of reducing climate change. This would be analogous to considering only that seat belts cause car drivers to drive faster while neglecting the belts' safety effects.

3 | TERMINATION

The IPCC reports frequently note that if SRM were used and then stopped, then the previously suppressed climate change would manifest rapidly and dangerously (IPCC, 2013a, pp. 29, 98, 575, 635; 2014a, pp. 454, 1043; 2014b, pp. 488,

1023; 2014c, pp. 26, 89; 2018, p. 351). Indeed, one of the four sentences in the IPCC's highest-profile statement on SRM—the AR5 Synthesis Report's Summary for Policymakers, quoted above—was dedicated to termination's consequences (IPCC, 2014c, p. 26). This is the only governance challenge to which IPCC reports prior to AR5 referred (IPCC, 1996, p. 813).

Although it is true that sudden and sustained termination of relatively high-magnitude (i.e., greatly negative radiative forcing) SRM would be harmful, this would require meeting multiple conditions, some of which seem improbable. AR5 does accurately state that “this ‘termination effect’ might be avoided if SRM were used at a modest magnitude and for a relatively short period of time” (IPCC, 2013a, p. 631). Even if SRM were used neither at a modest magnitude nor for a short time, reasonable governance measures could prevent a harmful termination (Parker & Irvine, 2018; Rabitz, 2019; Reynolds, Parker, & Irvine, 2016). If the implementing state(s) (or other actors) wished to end it, SRM could be gradually phased out. Furthermore, they could create redundant and secure infrastructure to increase the system's ability to withstand shocks. If these state(s) did abruptly terminate high-magnitude SRM, for whatever reason, then any other capable state(s) could resume it sufficiently quickly to prevent harmful warming. Such capable states could be numerous, because SRM appears inexpensive and technically modest. Importantly, all of these steps—gradual phase-out, redundant and secure systems, and other states' resumption of SRM—would be in the states' interests to undertake. Ultimately, the IPCC reports implicitly assume that reasonable actions would not be taken to prevent the sudden and sustained termination of high-magnitude SRM.

4 | “SLIPPERY SLOPE”

Another governance challenge of SRM is that early research activities could unduly increase the probability of its future use. As stated in AR5, “research might make deployment inevitable” (IPCC, 2014b, p. 219). SR1.5 is vaguer, passively saying that “The argument that SRM research increases the likelihood of deployment (the ‘slippery slope’ argument), is also made” (IPCC, 2018, p. 349).

AR5's claim of inevitability is illogical and contrary to evidence. Research of new technologies is *usually* unsuccessful, but the failures are not widely known due to survivorship bias. (Although success and failure are both difficult to measure, medical development has benchmarks. There, only about 10% of clinical trials lead to an approved drug or biologic [Thomas et al., 2016].) Other successfully developed technologies, such as supersonic commercial passenger transport, have been developed and later rejected through social and political means.

What's more, the two scholarly sources that AR5 cites do not support the above-quoted claim that “research might make deployment inevitable.” Each asserts that research programs make development and use more probable (Bunzl, 2009, p. 2; Jamieson, 1996, p. 333). Only one (Jamieson) says that this could be a problem, and even that calls for geoenvironmental research with safeguards.

The claim of SR1.5 that research increases the chance of the use of SRM is obviously true but trivial, because the latter requires the former. And as in AR5, the one article that SR1.5 cites does not make a slippery slope argument. Instead, it reports an increase in implementation's likelihood due to the abstract economic model's initial assumptions (Quaas, Quaas, Rickels, & Boucher, 2017). SR1.5's claim is unsupported.

5 | CONTRARY TO DEMOCRATIC NORMS

The IPCC's SR1.5 report states that decision-making regarding SRM may be contrary to widely-held democratic norms. It does so in two ways. First, SR1.5 points to a debate over whether SRM is compatible with democracy (IPCC, 2018, p. 348). The assertion that SRM is incompatible with democratic processes (Szerszynski, Kearnes, Macnaghten, Owen, & Stilgoe, 2013) has come under serious criticism (Horton et al., 2018, which SR1.5 does cite).

Second, SR1.5 claims “Unequal representation and deliberate exclusion are plausible in decision-making on SRM” (IPCC, 2018, p. 349). Yet once again, the scholarly article that the report cites here (Ricke, Moreno-Cruz, & Caldeira, 2013) says nothing about the plausibility of unequal representation and deliberate exclusion but instead assumed them and then models the expected SRM magnitude and climatic effects. Such a conflation of assumptions and conclusions is seen in SR1.5's treatment of a possible “slippery slope,” described above. Thus, this claim regarding unequal representation and deliberate exclusion is unsupported.

6 | PUBLIC ACCEPTANCE

The IPCC reports claim that the public might not accept SRM. AR5 concludes, “Whether SRM field research or even deployment would be socially and politically acceptable is also dependent on the wider discursive context in which the topic is being discussed” (IPCC, 2014b, pp. 488–489). Similarly, “public resistance” is among the governance challenges that the executive summary of SR1.5’s chapter highlights, quoted above.

Public opinion concerning acceptance of and possible resistance to SRM will be central to its governance. However, at the moment, the extent to which SRM would or would not be widely accepted remains unclear. Most people are unaware of it. SR1.5 appropriately notes that public opinion remains inchoate and highly sensitive to the information provided and question wording (IPCC, 2018, p. 349; see also Burns et al., 2016; Carlisle, Feetham, Wright, & Teagle, 2020). Furthermore, attitudes among the public would likely change if severe climate change impacts were to manifest or influential political actors began to advocate on the issue. Ultimately, it is speculative to claim that “public resistance... could render SRM... undesirable” (IPCC, 2018, p. 317).

7 | ETHICS

The IPCC reports point toward diverse potential ethical objections to SRM. Because all substantial decisions have ethical implications, some of these potential objections overlap with those governance challenges described above. Specifically, AR5 offers the potential exacerbation of inequalities and “a critical assessment of technology and modern civilization in general” (IPCC, 2014b, p. 219; 2014c, p. 89). Additional ethical objections that SR1.5 lists include “financing, compensation for negative effects, the procedural justice questions of who is involved in decisions, privatization and patenting, welfare, informed consent by affected publics, intergenerational ethics” (IPCC, 2018, p. 349).

These objections are of varying robustness, including some that are unsupported or unhelpful. For example, modeling evidence suggests that a judicious use of SRM would *reduce* inter-country inequalities (Harding, Ricke, Heyen, MacMartin, & Moreno-Cruz, 2020). Other ethical objections, such as “a critical assessment of technology and modern civilization in general,” are so broad as to be vacuous. Regardless, most of these objections would strongly depend on how SRM would be developed and used (as well as the resolution of scientific uncertainties and the observer’s particular normative framework). As in other policy domains, well-crafted governance could address ethical issues such as responsibility for implementation, financing, compensation for harm, private actors’ roles, welfare impacts, and public participation in decision-making. As with public acceptance, SRM’s ethical implications remain speculative and, as with termination and “slippery slopes,” implicitly assume that reasonable policies would not be adopted.

Furthermore, the IPCC reports should—but do not—consider also ethical arguments that support SRM’s research, development, and possible use. Climate change poses severe risks to ecosystems and humans, especially to the already vulnerable. If SRM could reduce these risks, as current evidence indicates, then an ethical duty to at least explore its potential seems reasonable (Callies, 2019; Horton & Keith, 2016; Morrow, 2019; Svoboda, Irvine, Callies, & Sugiyama, 2019). Even the first publication on geoengineering ethics considers the case for research and the conditions under which implementation could be acceptable (Jamieson, 1996).

8 | UNILATERAL DEPLOYMENT

The IPCC reports regularly raise the challenge that one or a few actors—probably states, but perhaps “even non-state actors, such as wealthy individuals” (IPCC, 2014b, p. 1023)—could implement SRM contrary to international consensus (IPCC, 2014a, p. 1066; 2014b, pp. 488, 1007, 1023; 2014c, p. 89). SR1.5 says, “There is *robust evidence* but *medium agreement* for unilateral action potentially becoming a serious SRM governance issue” (IPCC, 2018, p. 347).

Unlike the other six identified governance challenges, this one is mostly accurate as worded (arguably with the exception of the claim of possible nonstate SRM deployment). Even in the absence of it actually occurring, international negotiations concerning how to prevent unilateral implementation could be a serious issue. At the same time, some scholars argue that problematic unilateral SRM is unlikely (Halstead, 2018; Horton, 2011; Keohane, 2015, p. 23; Parson, 2014, pp. 98–103; Rabitz, 2016).

9 | CONCLUSION

Current evidence suggests that SRM could substantially reduce climate change and its risks, yet its reception in the climate change expert community is incommensurate with this potential. This is evident in the IPCC's authoritative and influential reports, which emphasize SRM's various governance challenges while downplaying its potential efficacy. However, I conclude here that six of the seven identified challenges are misrepresented in the reports in various ways.

One might counter that the reports use modal verbs of uncertainty, such as “could” and “might,” and are thus not incorrect. Of course, a nearly infinite number of such not-incorrect sentences of potentiality are possible on any topic while not being helpful. (Notably, the aggressive mitigation that would be needed to prevent dangerous climate change “could” be done in ways contrary to democratic norms, that the public would not accept, and that would be unethical. Yet IPCC does not foreground these possibilities.) Instead, the reports are to “provide a balanced and complete assessment of current information” described in “calibrated uncertainty language that expresses the diversity of the scientifically and technically valid evidence, based mainly on the strength of the evidence and the level of agreement in the scientific, technical, and socio-economic literature” (IPCC, 2013b). I assert that AR5 and SR1.5 have not met this standard with regard to SRM's governance challenges.

I consider three possible reasons for the reports' failure to meet the IPCC's standards of balance, thoroughness, and accuracy. First, the IPCC reports' content is, for the most part, limited to summarizing and assessing peer-reviewed publications. SRM scholarship seems to have evolved. In my perception, early publications emphasized SRM's limitations, risks, and challenges, while more recent ones offer relatively more nuanced considerations. AR5, in particular, was unable to cite some of the latter cohort.

Second, the reports' chapters that discuss SRM contain few, if any, SRM researchers. Climate researchers who do not investigate SRM may be skeptical of or even hostile to it (and even those who do study it are unenthusiastic; Anshelm & Hansson, 2014; see Dannenberg & Zitzelsberger, 2019). To some degree, this is understandable. Those concerned about humans' environmental impacts generally aim for less intervention in nature, not more. Further, climate scientists have been calling for mitigation, often in a hostile political environment, for about 30 years; other responses to climate change may be perceived as dangerous distractions. These IPCC authors may, consciously or not, prefer that SRM remains as low as possible on the climate change agenda in order to keep mitigation at the top.

Third, the IPCC reports have, over the decades, increasingly considered social, political, governance, and ethical issues. Its method of assessment identifies existing and emerging consensus while remaining “policy-relevant and yet policy-neutral, never policy-prescriptive.” This may be poorly suited for the social sciences and humanities, which rely to a greater degree on qualitative evidence, inductive reasoning, subjective values, and argumentation (Minx, Callaghan, Lamb, Garard, & Edenhofer, 2017). If so, then the IPCC should perhaps undertake these assessments with caution and within explicit boundaries.

More and more, SRM appears able to prevent dangerous climate change and necessary to do so. It must be independently, authoritatively, and internationally assessed in order to help guide its responsible research, development, and—if warranted—use. The IPCC is the logical site for this assessment. Although evaluations could, in principle, be accomplished through greater and more rigorous attention in future Assessment Reports, a dedicated chapter may not be able to do so given SRM's cross-cutting nature. And even then, this would not be possible until the Seventh Assessment Report in the late 2020s. Instead, a Special Report on SRM after the Sixth Assessment Report is warranted. While its contributors should include some SRM-novices and skeptics, most of its authors must be both deeply familiar with the field and willing to rationally assess SRM's advantages and disadvantages, capabilities and limitations, and opportunities and risks. Launching a Special Report would clarify—in my opinion beneficially so—that the IPCC is the principal international site for assessing responses to climate change. (In 2019, the UN Environmental Assembly considered a resolution on geoengineering and its governance. Among the reasons that this resolution did not pass was divergence of views concerning institutional responsibility for scientific assessment) It is possible that a Special Report on SRM could be, in part, performative. Similar to how SR1.5 (and the preceding Paris Agreement) helped reify 1.5°C warming as a scientifically important, politically acceptable, and rhetorically powerful threshold (Asayama, Bellamy, Geden, Pearce, & Hulme, 2019), a Special Report might legitimize SRM into an object worthy of study as a potential complementary response to climate change. If so, such an effect—if it occurred—would not necessarily be undesirable.

CONFLICT OF INTEREST

The author has declared no conflicts of interest for this article.

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