



A scenario of solar geoengineering governance: Vulnerable states demand, and act

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ABSTRACT

The paper examines a scenario exercise concerning deployment of solar geoengineering by a small group of states that are particularly vulnerable to climate change. Two groups of participants were each asked to provide expert decision-making advice to an alliance comprising great powers, and to propose a political response to the deployment initiative. This paper discusses the initial governance proposals and examines differences and exchanges between the groups throughout the exercise. The two groups delivered distinct governance proposals. The differences, which were driven largely by divergent worldviews and assumptions about the geopolitical context, provide insights into the complexities of responses to “free-driving” the deployment of solar geoengineering, internal functioning and cohesion of coalitions, and interactions among multiple responses to climate change.

1. Introduction

In the 27 years since the United Nations Framework Convention on Climate Change (UNFCCC) entered into force, the nations of the world have failed to establish an effective regime to prevent dangerous anthropogenic interference with the climate [United Nations Environment Programme (UNEP), 2020]. This failure makes it likely that the world will soon face tragic choices between enduring the impacts of dangerous climate change or undertaking risky but potentially beneficial endeavors in geoengineering.

Solar geoengineering, here understood as spraying a fine mist of reflective aerosols in the stratosphere to mimic the natural cooling caused by volcanic eruptions¹, poses a unique challenge to governance because its apparent low direct costs and technological simplicity create a “free driver” problem, in which a small group of actors could substantially alter the climate on their own [Weitzman, 2015, Reynolds, 2019]. To explore the geopolitical implications of this challenge, the 2019 Summer School on Geoengineering Governance undertook group exercises to consider different possible scenarios in which various state and non-state actors undertake global solar geoengineering, or intend to do so, in the near future without a consensus among nations.

For each scenario, two groups of participants played advisors to a group of nations or other actors developing a proposal for a response to the solar geoengineering deployment. After each group developed its initial proposal, the other group considering the same scenario provided a critique and a challenge (“stress test”), consisting of possible future developments after the proposed would be put into practice. These developments could include a wide range of possible events, such as, extreme weather or political responses from

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¹ For more details, see Parson & Reynolds (2021) in this issue.

other nations. Each group then reconsidered its approach and addressed the challenges posed by the stress test.

This article reports on a scenario in which a coalition of states vulnerable to climate change impacts deploy solar geoengineering. We do not attempt to provide answers to scientific and political questions around whether or how to implement solar geoengineering. In this article, we report and reflect on the scenario exercise to better understand some geopolitical conflicts the world may face if its failure to curtail greenhouse gas emissions leaves solar geoengineering being perceived as the only alternative to enduring the full and unmitigated impacts of global warming.

2. Major elements of the scenario

The background conditions to the scenario and the groups' tasks in this exercise, are described in detail in Sections 5.1 and 5.2 respectively of the special collection's opening article (Parson & Reynolds, 2021 in this issue). The complete text of all four scenarios and related material distributed to participants is available in the supplementary online material.

The "Vulnerable States Demand and Act" scenario was set in the year 2040 and centered around the governance response to a small-scale solar geoengineering deployment program (hereinafter referred to as the "solar geoengineering program" or "the program") by the "Climate Emergency Coalition" or "the Coalition," a group of vulnerable states comprising India, South Africa, Egypt, Mexico, Saudi Arabia, Iran, Nigeria, Venezuela and Australia (see also Section 5.3 of the opening article). The members of the Coalition are highly vulnerable to the impacts of climate change but have been inconsistent in their mitigation efforts, in large part because of their economic and political diversity. In the scenario, high-income nations have highly variable performance on emission reductions. Among emerging countries, economic growth has driven increased emissions, despite large reductions in emissions per unit of economic activity.

In 2040 the Coalition reveals that, for three years, they have been running a covert low-intensity solar geoengineering pilot program, which produces a minuscule radiative cooling of 0.1 W/m^2 , a common measure of radiative forcing. The Coalition declares that it will maintain the program at current levels for two years to await global consensus on deploying solar geoengineering and, if the world cannot agree on a program to deploy solar geoengineering, will ramp it up on its own.

The five permanent members of the UN Security Council align with Germany and Japan to form a "Great Powers Bloc" ("the Bloc") and convene a Task Force of scientific and technical experts to advise them on possible political responses to the Coalition's ultimatum. The exercise stipulates some internal differences of opinion about solar geoengineering within the Bloc: Russia and Germany are strongly opposed to it because Russia sees benefits in a warming world, such as expanded navigation in the Arctic, and Germany's Green faction favors conventional mitigation along with land-use management and other approaches perceived as 'nature-based'. On the other hand, several other members of the Bloc approve of the geoengineering program and see it as a way to "get the ball rolling" on responding to the failure of international greenhouse gas emissions mitigation policies. The Task Force's advice must consider these divergent views. Although the Task Force is an advisory body, credible proposals with a reasonable chance of success are likely to be adopted by governments.

The two groups that were assigned to this scenario challenge were named "Lynx" and "Cougar" and will be referred to as such in this paper. The groups comprised 16 participants; 5 women and 11 men, representing seven nationalities from different disciplines in academia and NGOs, governments, journalism, and private sectors.

3. Initial governance proposals

3.1. Initial proposal of Lynx:

Team Lynx made several assumptions regarding the socio-political background to the events in the exercise. The scenario specifies that some high-income countries have realized substantial cuts in emissions while economic growth in middle- to low-income countries has driven emission increases. Lynx interpreted this as meaning that the majority of the Bloc members (most of which are high income countries) played pivotal roles in ensuring ongoing global cooperation on the Paris Agreement and helped middle- to low-income countries respond to the impacts of climate change through R&D investments in carbon dioxide removal projects. With the limited details provided regarding the fossil fuel dependence of countries in 2040, Lynx assumed that the nine members of the Coalition mostly continue to be heavy extractors, exporters, and users of fossil fuels in 2040 as they have been historically. Further, since the uncertainties associated with solar geoengineering persist in the 2040 scenario, Lynx assumed that the UNFCCC agreements have not incorporated solar geoengineering as a possible response to climate change.

In its initial proposal, Lynx reacted to the deployment initiative primarily as a political threat to the power the group of great powers enjoys as military and economic heavyweights, rather than in terms of its impact on the climate. This led Lynx to propose a dual strategy with overt and covert elements in order to win international support for addressing the solar geoengineering program in terms that would not upset the geopolitical power structure. Because the great powers, in Lynx's interpretation, deemed the disruption of the global order a more pressing threat than climate change, and because the Bloc faced internal divisions over the desirability of solar geoengineering, its responses—overt and covert—remained neutral about expanding deployment but took the firm position that, if solar geoengineering were to proceed, it should be under the aegis of the United Nations, with significant leadership by the Security Council.

The overt strategy did not publicly acknowledge that maintaining its power was the ultimate goal of the Bloc but instead used good governance rhetoric to delegitimize the Coalition. It emphasized the program's secrecy and its failure to seek assent from the larger community of nations. Further, the strategy used the roles of some Coalition nations as major fossil fuel extractors to argue that the

Coalition does not have the credibility to lead on climate change. The Bloc sought to restore confidence in the existing UN climate governance process and to facilitate effective global dialogue to reach a consensus on how to proceed on the solar geoengineering front.

Simultaneously a covert strategy sought to weaken the Coalition by sowing internal divisions and distrust. This effort focused on offering India incentives to defect and support the Bloc. As a populous, democratically governed, rapidly developing nuclear power, India brings great credibility and legitimacy to the Coalition. Lynx believed that, without India, the Coalition would be far less powerful and much easier to depict as illegitimate rogue states. The members of Lynx assumed in their strategy that the most effective way to accomplish this would be to covertly offer India a permanent seat on the UN Security Council in exchange for renouncing the Coalition initiative.

To effect its overt strategy, the Lynx recommend declaring the Coalition a potential threat to global security and introducing a decision in the Security Council (which would put the Bloc in a position of control), via the following actions:

- 1 Recognize that the implementation of a solar geoengineering program in the absence of a transparent, international decision-making process is a threat to global peace and security. Therefore, demand that the Coalition must commit not to increase the solar geoengineering activities beyond the current radiative forcing levels. Authorize the creation of a neutral panel to ensure compliance with this decision under the aegis of an organization such as the World Meteorological Organization that has the capability to monitor deployment activities.
- 2 Set an agenda for an international meeting of all nations, including the Coalition, organized by the Security Council, to develop a legitimate international decision-making process consonant with the established agreements and processes on climate change action. A crucial goal of this meeting would be to establish that the Coalition could not be trusted to govern a solar geoengineering program that would intensify enough to significantly modify the climate. For instance, if it were to intensify solar geoengineering for several decades while emissions continued at high levels, the world would face severe termination shock if the alliance later became unwilling or incapable of continuing its deployment.

The Lynx group believed that the Security Council decision would lay bare the Bloc's intention to respond to any contrary acts by the Coalition. However, the Bloc recognized that it could only ensure compliance with its demands if it were prepared to detect and respond to the Coalition in the event that it increases the radiative forcing, so it considered a range of diplomatic, technological, and military measures that it might consider if its demands were rejected. These measures included the covert strategies described above to sow dissension within the Coalition and developing counter-geoengineering technologies (Parker, Horton, & Keith, 2018).

3.2. Initial proposal of Cougar:

Where Lynx's initial proposal was predominantly driven by the desire of nations that had politically, militarily, and economically dominated the world during the 20th century to extend their dominance into the mid-21st century, Cougar's proposal recognized that the geopolitical alignments of World War II and the Cold War no longer applied, and that global climate change required a unified international response. Therefore, the overall objective of Cougar's initial proposal was twofold: First, to recognize the validity of the Coalition's concerns and to send a clear signal of willingness to cooperate. At the same time, Cougar took the position that engineering the planet's climate could not be decided by a small coalition without accountability to the full community of nations. Thus, a secondary, pragmatic objective of the Bloc was to establish a multilateral governance body and collaborative decision making processes for solar geoengineering that would replace free-driver governance with universal participation.

Somewhat like Lynx, the Cougar team proposed a two-fold communication strategy to achieve these objectives. On the one hand, the Bloc should publicly and strongly denounce the Coalition's activities in order to convey that unilateral action with potential impacts on the global climate is intolerable. Although the Bloc is divided, the focus on denouncing the unilateral character of the deployment provides a common ground for its members and is thus strategically important. This is important for two audiences: the climate diplomacy circles (and possible spill-over effects to other international negotiations in other policy fields), as well as domestic audiences, especially in Germany and Russia, which have strong internal opposition to solar geoengineering.

On the level of private conversations and negotiations among heads of states and their administrations, Cougar recommended that the Bloc should also 'recognize' the experiences of rising negative climate impacts by the vulnerable states of the Coalition and send signals of cooperation. This acknowledges two politically decisive characteristics of the Coalition. First, these vulnerable states find themselves in a serious situation of suffering from climate impacts. Second, the Coalition is expected to have political leverage through its substantial collective power in 2040 and the already established solar geoengineering program. Since the political positions of the Bloc countries vary, details of this second aspect should be kept in the background of public communication. In order to address the inner conflict within the Bloc and to preserve the appearance of solidarity when confronting the Coalition, Cougar advised that the Bloc should always present the strong denouncement together with an expression of willingness to talk. This would signal an opening to negotiate a solar geoengineering governance system in a constructive manner. A certain degree of strategic ambiguity in the response allows the Coalition to bridge internal differences and give parties with divergent positions towards the deployment political room for maneuver to stay within the alliance.

The Cougar's initial proposal identified four high-level governance actions that the expert group identified as desirable next steps:

- 1 In the short term, the Bloc and the Coalition should create an interim decision-making body composed of their members' representatives as well as those of other interested parties. This body should seek consensus on the degree of cooling to be sought by solar

geoengineering. This first phase should not last longer than four years: two years beyond the Coalition's moratorium on ramping up deployment, which would have both political and practical functions. Politically, it is important to signal to the Coalition that a collaborative process cannot be subjected to ultimatums. Practically, this extension would allow time to explore effective structures of future governance and to allow the various parties' political positions to stabilize. Opening the process to interested parties is important not only to symbolically take a first step towards multilateral governance; it is also important for internal Bloc dynamics. Effective multilateral governance in the long term requires that countries critical of solar geoengineering, such as Russia and Germany, stay on board. And if they have the opportunity to invite partners to this process, their future participation is more plausible. Although a more open process would mean that it is not necessarily only Bloc countries (and their allies) that increase their influence over the process, Cougar's reasoning behind this was that it would be better to be a powerful player at a table where also other opinions are represented rather than losing the influence over deployment governance completely.

- 2 In the medium-term, this interim body should gradually move towards growing multilateralism and universal participation. Using a resolution of the UN General Assembly to establish this body could raise the awareness and interest of governments and other political actors beyond the two alliances and lay the foundation for a global solar geoengineering governance system. The formation and guidance of this interim body do not necessarily imply support for future large-scale deployment. This body should be organized and presented to the world in ways that leave the choice open as to the possible deployment. If the decision appears to be pre-ordained, the body will have insufficient legitimacy with many critical countries. Similarly, any decision-making processes regarding the establishment of a permanent body must be open, cooperative, and multilateral. The primary objective of the interim body is to avoid unilateral or minilateral solar geoengineering deployment while maintaining international legitimacy. To achieve this, the body must provide an institutionalized arena for multilateral negotiations on the future of the deployment or non-deployment of solar geoengineering. Incremental success in multilateral negotiations has potential to form a virtuous circle by building trust among the various actors, thus creating an atmosphere in which future success becomes more likely.
- 3 In order to build trust among the actors, the new governance system should initiate and develop a comprehensive, independent scientific program, not only to assess the impact of solar geoengineering, but also to globally monitor. Independent assessment of impacts and rigorous monitoring by direct and remote sensing are crucial to provide symmetric information to all governments. Transparency about deployment and impacts helps to establish common ground in negotiations, especially in potential crisis situations, such as non-compliance by some actors or the occurrence of unintended consequences. Moreover, a common initiative for remote-sensing can also enhance the transparency, credibility, authority, and reliability of the solar geoengineering governance system.
- 4 Finally, if enhanced deployment does proceed, the Panel should develop and implement measures to guard against termination shock (Parker & Irvine, 2018). This would not only reduce the risks linked to an actual termination of solar geoengineering use but could also be one pillar of building trust between various political parties.

Although less strongly framed in terms of an international security problem, the first part of Cougar's recommendation is close to what the Lynx group's proposed. Both groups also suggested overt vs. covert (Lynx) and public vs. private (Cougar) tracks in their initial proposals. However, there are crucial distinctions in the sincerity of the overt messaging and in the goals sought through the covert or private engagement. For Lynx, multilateral governance was a subterfuge to hide a hegemonic power grab, whereas Cougar genuinely sought to establish global accountability and participation in governance. The covert or private aspects of the recommendations also provide insights into important key differences between the two teams around recognition of the limited power of the Bloc in the middle of the 21st century and in their treatment of the internal dynamics of the Bloc itself.

Cougar's decision to pursue this collaborative direction was mainly based on its interpretation of the geopolitical context. The only ways the Bloc could effectively force an end to the current deployment of solar geoengineering would cause substantial political discord. At the same time, however, the cooperative governance response should not be understood as a *laissez-faire* approach. The Cougar group believed that, through the process of setting up a collaborative, multilateral solar geoengineering governance, the Bloc, should seek influence over the governance process and pursue a short-term goal of gradually easing deployment authority away from Coalition and transferring power to a wider group of countries, including members of the Bloc. According to the proposal, it is important to ensure that the Bloc coheres as a coalition in this process. It is also important that the new emerging governance system does not become side-lined by unilateral actions. Therefore, according to Cougar, it would be necessary to design a process and specific policy measures that, judiciously applied, would persuade members of the Coalition to work constructively with the Bloc on governance. These measures could include collaboration on further research, monitoring, and risk assessment. This approach to solar geoengineering governance is relevant not only to govern actual deployment but also to minimizing future geopolitical conflicts that might arise from negative impacts of solar geoengineering.

4. Critiques, challenges, responses

The differences between the Lynx and Cougar proposals are rooted in the divergence both of their conceptions and assumptions about the future development of international relations until 2040 and also of their perceptions of whether the Bloc would be capable of imposing its will upon the world. Lynx embraced a vision rooted in the mid-20th century, in which world affairs are dominated by small groups of economically and militarily powerful states. (The Bloc's member states were all major belligerents in World War II, most became nuclear powers during the Cold War, and their industrial might made them influential in the world's political economy). This Bloc views the rest of the world not as equals but as lesser actors who will take sides in a bipolar competition for influence (Axis vs. Allies in WWII, capitalism vs. communism in the Cold War, empires vs. colonies, and, in this scenario, Bloc vs. Coalition) and views

itself analogously to a Hobbesian Leviathan on the international stage, protecting the world from chaos and disorder. Cougar took a distinct view, and its strategy is based on the perception that the Bloc is less powerful relative to the Coalition and therefore must embrace multilateralism to safeguard its influence over solar geoengineering governance. Cougar draws on the heritage of the Non-Aligned Nations Movement and uses this heritage to justify its embrace of multilateralism and its rejection of Cold-War style polarization.

Each group's critique and challenge to the other during the stress-test reflects these contrasting world views. Cougar criticized Lynx for taking a "haughty, high-handed" tone that would alienate the rest of the world and heighten the resentment many nations in the Global South have for the Bloc members' histories of imperialism and violence. Acknowledging that the Coalition conducted the initial, research phase of solar geoengineering without transparency or accountability, Cougar noted that the Coalition was now offering considerable transparency and participation by the community of nations. Cougar further doubted that Lynx's Bloc would win broad support for heavily placing the UN Security Council at the center of global governance. Cougar also judged the Bloc's attempts to covertly sow dissension within the Coalition as naive. It predicted that Coalition members would recognize and reject covert overtures to betray their partners and join the Bloc, which would publicly humiliate the Bloc and undermine its legitimacy and credibility in the community of nations.

Lynx criticized Cougar's proposal as naive in its faith that nations could achieve working consensus over so fraught a topic as global solar geoengineering without strong leadership. Lynx posited that as the impacts of global climate change become increasingly severe between 2040 and 2050, these stresses will divide and weaken any broadly multilateral governing body. These stresses will include conflicts between nations that wish to continue extracting and consuming fossil fuels (some of which thus promote solar geoengineering as an alternative to aggressive emissions mitigation) and those that seek rapid emissions reductions; between nations that benefit or are harmed by the geographic distribution of solar geoengineering impacts (e.g., shifting rainfall patterns); and between nations, such as small island states, that foresee imminent existential threats and those whose economies and quality of life are only slightly affected in the near-term by climate change. To Lynx, governance by broad multilateral consensus is a fine idea, but in practice it is quickly mired in gridlock, as the history of the UNFCCC process demonstrates. Failure to swiftly and decisively make an example of Coalition by delegitimizing it will only tempt other small coalitions to launch their own minilateral free-driver geoengineering initiatives, exacerbating the coming gridlock. Moreover, the Cougar proposal did not present a Plan B for its cooperative multilateral approach. Open questions raised through the stress-test included what would actually happen if the Bloc did not hold or what would happen if, despite the new governance system, new unilateral operations were to take place.

However, the critique of overconfidence in the ability of a multilateral coalition to cohere applies as well to Lynx's vision of the Bloc. In particular, an important piece of its strategy was to tempt India to desert the Coalition by offering it permanent membership on the UN Security Council. Lynx failed to account for the great likelihood that this would be completely unacceptable to China, which has a long history of conflict with India and sees it as an important geopolitical rival. More broadly, the Lynx plan papers over substantial internal conflicts over solar geoengineering, with some Bloc members strongly supporting an increased role for it and others in strong opposition. These conflicts would likely become deep fault lines in any governance regime that relied upon the Bloc working together. These fault lines would doubtless be exploited by other nations to weaken the Bloc and challenge its hold on power.

Neither group prepared a formal response to the stress tests, but the groups held a summit meeting to discuss their different approaches to the challenges. The main topics discussed are addressed in the following section.

5. Synthesis and further questions

Comparing their critiques of each group's proposals highlights the extent to which the presence of an unprecedented global environmental crisis—which many nations will experience as either truly existential or extremely threatening to their economies, while others will find opportunities and advantages in the changing world—is likely to alter the nature of geopolitical power and severely limit the applicability of lessons from the past.

However, reflecting on this exercise months later, we observe that the group's pessimism about this may reflect a selective Eurocentric, or Global-North centric perspective. A different one may be found in the literature of postcolonial Asia (e.g. [Mishra, 2012](#)). Perhaps we should not expect established military and economic powers to lead the world in determining the appropriate ways to use solar geoengineering. As the current influential states increasingly abdicate leadership or responsibility for their historical contributions to climate change, new voices and leaders may emerge, as so many did a century ago.

5.1. Differing governance responses to a 'mini-lateral' free driver coalition

In the solar geoengineering literature, the free driver problem is regarded as a particularly fraught and difficult one. [Flegel, Hubert, Morrow, and Moreno-Cruz \(2019\)](#) describe it as the "most nuanced and complex issue that arises from the economic analysis of solar geoengineering" (p.416). At their summit meeting, both groups agreed that working on governance proposals to this scenario initiated fruitful discussions that help to explore and anticipate future developments with regard to minilateral free-driver deployment.

One of the main topics the two groups discussed was the observation that, in the context of free-driver actions, established powers may have little leverage over a small coalition. The great powers' influence is limited not only due to the free-driver dynamic itself, but also because of internal conflicts that threaten the cohesion of a great-power bloc and because of the declining influence of the Bloc over other nations through growing interdependence and expected economic convergence ([Milanovic, 2016](#)). Furthermore, the emerging economic convergence has implications well beyond geoengineering governance. The "club" approach to international governance of climate change relies on the unequal distribution of wealth and emissions, whereby a small number of nations with large

economies and large greenhouse gas emissions can form a club that can both produce significant emissions reductions and also entice many other nations to join through favorable trade incentives (Victor, 2011). In a potentially more equal world of the future, with smaller disparities in both wealth and emissions, a small club would be less capable either to significantly influence global emissions on its own or to use economic incentives to influence other nations.

5.2. Functioning and cohesion of the groups (Bloc and Coalition)

Both groups recognized that the power of each coalition in the scenario depended on its internal cohesion as well as its ability to attract support from nations not aligned to one of the two alliances. During the exercise, neither group developed a nuanced account of the dynamics of conflict and cohesion within the coalitions, but these are at the heart of determining whether a policy problem is politically tractable (Gilligan & Vandenberg, 2020). Going forward, two promising conceptual structures for analyzing and addressing these challenges are the “incompletely theorized agreements” framework, wherein parties who disagree about principles or goals may still agree on concrete policy actions by identifying the minimum level of political or normative common ground necessary for consensus on actions (Grynaviski, 2010; Ruger, 2008; Steffek, 2005; Sunstein, 1995); and the exit, voice, and loyalty framework, which addresses the means by which group cohesion can be achieved in the face of internal conflict (Boehme, 2018; Hirschman, 1970; Katselas, 2014; Lavelle, 2007). The Cougar’s strategic ambiguity in their proposal as well as considerations of the Coalition’s internal processes as part of Lynx’ proposal are two examples within this exercise that illustrate the need for a better understanding of alliance-internal dynamics.

The *incompletely theorized agreements framework*, which has much in common with Rawls’s (1987) theory of overlapping consensus. This accounts for the observation that individuals and groups with deeply incompatible and conflicting political views can nonetheless form effective coalitions on specific issues, which each group supports for very different reasons. By focusing on actions rather than justifications, the group can agree to take an action despite disagreeing fiercely about the reasons for doing so. Pielke (2009) argues that such an approach can be valuable for overcoming partisan gridlock on climate policy. With regard to solar geoengineering, this scenario stipulates a wide range of reasons why nations oppose it, ranging from a moral opposition to deliberately modifying the climate to practical concerns over the risks of unintended consequences, such as increasing the risks of severe drought. Likewise, nations may support geoengineering for many reasons, such as the perception that it could be less costly than rapidly reducing emissions; the perception that emissions reduction policies have failed, leaving no choice but to embrace geoengineering; or even a desire to actively control the climate beyond compensating for the anthropogenically enhanced greenhouse effect (Rickels et al., 2020). Despite vastly divergent motives, common ground might be attained among the supporters or opponents of solar geoengineering with regard to specific actions. Finding common ground that unites supporters with opponents would be more difficult, but the prospect that a breakdown of negotiations could result in uncontrolled free-driving of geoengineering would provide considerable motivation to establish broad agreement on actions that could deliver some tangible contributions to each party’s goals.

The *exit, voice, and loyalty framework* focuses on diverse strategies for managing conflict. Kuyper, Bäckstrand, and Schroeder (2017) have analyzed the role of exit, voice, and loyalty in maintaining institutional accountability among non-state actors in the UNFCCC process. *Voice* describes engagement in which complaints and disagreements are expressed, and *exit* describes a party breaking off communication and leaving. *Voice* is often the more productive way to achieve progress, but the threat of exit can play an important role in motivating parties to take others’ complaints seriously, especially where there is an imbalance of power. *Loyalty* describes a situation where past experience of effective discussions keeps frustrated parties engaged in the use of voice. Loyalty can be especially powerful when exit has important negative consequences. Where exit results in free-driving of geoengineering, this framework of engagement may help the parties be clear about the stakes in maintaining all parties’ belief in the value of continuing to negotiate and also help to promote institutional accountability among states as well as non-state actors.

Another interesting dimension raised during the joint discussion was that the Coalition’s actions could be contested *within* one or more of its member states. However, both groups regarded the countries mostly as unitary actors and did not include possible influence or leverage that the Bloc could develop through engaging with opposition parties, civil society, and other potential actors in the countries.

5.3. Possible interactions between the governance responses

In reflection, the two groups’ distinct perspectives provide useful insights into the free-driver problem. First, Lynx’s strategy with assumptions about the power of the Bloc over the Coalition could be extended by taking into account different sets of political beliefs. The whipsaw changes since 2016 in the apparent worldview upon which the United States bases its diplomacy and geopolitical engagement illustrate how contingent nations’ responses to international crises can be upon close outcomes of elections. Brexit provides a similar example of the contingency of the perspectives that drove the United Kingdom’s relationship with the European Union. Recognizing that governance is dependent upon the assumptions and worldview of whoever happens to lead powerful nations at a crucial moment may provide valuable humility in using scenarios to study solar geoengineering. Secondly, the process proposed by Cougar in particular would benefit from greater consideration of possible disruptive factors triggered by power struggles between the two alliances. As the UNFCCC process illustrates, collaborative pathways often reach easy agreement on broad but vague goals but fail to do so on concrete actions. Both strategies could be extended by anticipating obstacles and developing governance responses that include degrees of escalation.

5.4. Relevance and application of proposed governance mechanisms beyond the scenario exercise

Broadly, both proposals focus initially on immediate responses to the unilateral deployment from the limited perspective of a bloc of great powers. However, beyond the initial reactions, the subsequent incremental steps that the two groups suggested are not very distinct from each other. For example, they each entail the creation of an independent multilateral organization to oversee the implementation of a transparent and independent decision making process. The two proposals differed most with regard to the use and distribution of power: the response proposed by Lynx was hegemonic, whereas Cougar acknowledged their Bloc's limited power and opted for a more collaborative strategy.

This exercise illustrated starkly that the free-driver nature of solar geoengineering radically changes the power relations among nations. The structure of this exercise also created a natural polarization between a coalition of vulnerable nations and a bloc that is accustomed to being the most powerful. By the design of the scenario, the Task Forces were initiated by and reported to the Bloc, but the large majority of nations outside of these alliances lacked a voice.

In accordance with the growing recognition of the ethical and pragmatic value of multilateral, polycentric, or other governance approaches that make room for a diversity of voices and perspectives (Callies, 2019; Flegel & Gupta, 2018; Jinnah, Nicholson, & Flegel, 2018; Nicholson, Jinnah, & Gillespie, 2018; Parson, 2017; Rahman, Artaxo, Asrat, & Parker, 2018; Geden & Droege, 2019), the discussions within and between the two groups also suggested that more voices need to be integrated to achieve the long-term objective of establishing multilateral solar geoengineering governance. The Cougar group explicitly invoked the Non-Aligned Movement in seeking to establish such an inclusive system. Both groups in this exercise recognized the futility and danger of escalating a political conflict over solar geoengineering into a mutually destructive conflict. Moreover, the apparent technological simplicity and low cost of solar-geoengineering create a low barrier to new actors entering the field. Thus, an international governance regime would likely be enforced more by shared norms—which would have to be developed gradually through international cooperation—than by hegemonic threats of force (although economic sanctions and incentives may be powerful coercive tools (Morin & Jinnah, 2018)). The legitimacy of any governance regime in the eyes of the governed (both state and non-state actors) is therefore expected to be essential to its effectiveness. This underscores the importance of fostering loyalty and trust to the governance process, lest frustrated nations choose exit and free driving over continued participation in collective governance.

6. Concluding reflections

Both governance initiatives proposed by the Task Forces, as well as the stress tests and the final discussions, show how important assumptions regarding the functioning and cohesion of coalitions that deploy and respond to solar geoengineering, and regarding the overall political context, are for initiating and shaping governance initiatives. One aspect that was only indirectly, if at all, addressed by both groups is the role of subnational-level politics and actors, in public and private sectors, in shaping the larger political context of an emerging solar geoengineering program. This may be a significant oversight in shaping immediate responses to a minilateral deployment situation. Political leverage for multilateral collaboration—both in the Coalition as well as in the Bloc—could be gained by seeking the support of these subnational-level actors.

Finally, the fact that the two groups chose rather different approaches to respond to a free-driver deployment leads toward an important observation: In the real-world, policymakers would not be provided with only a single expert advice for possible reactions. They would receive instead various, potentially contradictory and inconsistent, expert opinions based on diverse assumptions and world-views. In addition, policymakers would face political demands by numerous actors at multiple political levels. How policymakers could balance varying expectations and what possible landing-zones between different approaches exist would be a relevant dimension in future efforts examining possible solar geoengineering deployment scenarios.

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References

- Boehme, F. (2018). Exit, voice, and loyalty: State rhetoric about the International Criminal Court. *International Journal of Human Rights*, 22, 420–445. <https://doi.org/10.1080/13642987.2017.1383242>.
- Callies, D. E. (2019). *Climate engineering: A normative perspective*. Lanham: Lexington Books.
- Flegel, J. A., & Gupta, A. (2018). Evoking equity as a rationale for solar geoengineering research? Scrutinizing emerging expert visions of equity. *International Environmental Agreements: Politics, Law and Economics*, 18(1), 45–61. <https://doi.org/10.1007/s10784-017-9377-6>.
- Flegel, J. A., Hubert, A.-M., Morrow, D. R., & Moreno-Cruz, J. B. (2019). Solar geoengineering: Social science, legal, ethical, and economic frameworks. *Annual Review of Environment and Resources*, 44(1), 399–423. <https://doi.org/10.1146/annurev-environ-102017-030032>.
- Geden, O., & Droege, S. (2019). *The anticipatory governance of solar radiation management*. Council on Foreign Relations (CFR). Retrieved from <https://www.cfr.org/report/anticipatory-governance-solar-radiation-management>, accessed July 22, 2021.
- Gilligan, J. M., & Vandenbergh, M. P. (2020). Beyond wickedness: Managing complex systems and climate change. *Vanderbilt Law Review*, 73(6), 1777–1810.
- Grynawski, E. (2010). Necessary illusions: Misperception, cooperation, and the anti-ballistic missile treaty. *Security Studies*, 19, 376–406. <https://doi.org/10.1080/09636412.2010.503512>.
- Hirschman, A. O. (1970). *Exit, voice, and loyalty: Responses to decline in firms, organizations, and states*. Cambridge, MA: Harvard University Press.
- Jinnah, S., Nicholson, S., & Flegel, J. (2018). Toward legitimate governance of solar geoengineering research: A role for sub-state actors. *Ethics, Policy & Environment*, 21(3), 362–381. <https://doi.org/10.1080/21550085.2018.1562526>.
- Katselas, A. T. (2014). Exit, voice, and loyalty in investment treaty arbitration. *Nebraska Law Review*, 93, 313–369. <https://heinonline.org/HOL/P?h=hein.journals/nebkrl93&i=331>.

- Kuyper, J., Bäckstrand, K., & Schroeder, H. (2017). Institutional accountability of nonstate actors in the UNFCCC process: Exit, voice, and loyalty. *Review of Policy Research*, 34, 88–109. <https://doi.org/10.1111/ropr.12213>.
- Lavelle, K. C. (2007). Exit, voice, and loyalty in international organizations: US involvement in the League of Nations. *Review of International Organizations*, 2, 371–393. <https://doi.org/10.1007/s11558-007-9015-0>.
- Milanovic, B. (2016). *Global inequality: A new approach for the age of globalization*. Cambridge, MA: Harvard University Press.
- Mishra, P. (2012). *From the ruins of empire: The revolt against the west and the remaking of Asia*. New York, NY: Farrar, Strauss, & Giroux.
- Morin, J.-F., & Jinnah, S. (2018). The untapped potential of preferential trade agreements for climate governance. *Environmental Politics*, 27(3), 541–565. <https://doi.org/10.1080/09644016.2017.1421399>.
- Nicholson, S., Jinnah, S., & Gillespie, A. (2018). Solar radiation management: A proposal for immediate polycentric governance. *Climate Policy*, 18(3), 322–334. <https://doi.org/10.1080/14693062.2017.1400944>.
- Parker, A., & Irvine, P. (2018). The risk of termination shock from solar geoengineering. *Earth's Future*, 6, 456–467. <https://doi.org/10.1002/2017EF000735>.
- Parker, A., Horton, J. B., & Keith, D. W. (2018). Stopping solar geoengineering through technical means: A preliminary assessment of counter-geoengineering. *Earth's Future*, 6, 1058–1065. <https://doi.org/10.1029/2018EF000864>.
- Parson, E. A. (2017). *Starting the dialogue on climate engineering governance: A world commission*. Centre for International Governance Innovation (CIGI). Retrieved from <https://www.cigionline.org/publications/starting-dialogue-climate-engineering-governance-world-commission/>, accessed July 22, 2021.
- Parson, E. A., & Reynolds, J. L. (2021). Solar geoengineering: Scenarios of future governance challenges. *Futures*. <https://doi.org/10.1016/j.futures.2021.102806>.
- Pielke, R., Jr. (2009). *The climate fix: What scientists and politicians won't tell you about global warming*. New York: Basic Books.
- Rahman, A. A., Artaxo, P., Asrat, A., & Parker, A. (2018). Developing countries must lead on solar geoengineering research. *Nature*, 556(7699), 22–24. <https://doi.org/10.1038/d41586-018-03917-8>.
- Rawls, J. (1987). The idea of overlapping consensus. *Oxford Journal of Legal Studies*, 7, 1–25. <https://doi.org/10.1093/ojls/7.1.1>.
- Reynolds, J. L. (2019). *The governance of solar geoengineering: Managing climate change in the anthropocene*. Cambridge University Press. <https://doi.org/10.1017/9781316676790>.
- Rickels, W., Quaas, M. F., Rieke, K., Quaas, J., Moreno-Cruz, J., & Smulders, S. (2020). Who turns the global thermostat and by how much? *Energy Economics*, 91, Article 104852. <https://doi.org/10.1016/j.eneco.2020.104852>.
- Ruger, J. P. (2008). Normative foundations of global health law. *The Georgetown Law Journal*, 96, 423–443.
- Steffek, J. (2005). Incomplete agreements and the limits of persuasion in international politics. *Journal of International Relations and Development*, 8, 229–256. <https://doi.org/10.1057/palgrave.jird.1800056>.
- Sunstein, C. R. (1995). Incompletely theorized agreements. *Harvard Law Review*, 108, 1733–1772. <http://www.jstor.org/stable/1341816>.
- United Nations Environment Programme (UNEP). (2020). *Emissions gap report 2020*. Retrieved from <https://www.unep.org/emissions-gap-report-2020>, accessed July 22, 2021.
- Victor, D. G. (2011). *Global warming gridlock: Creating More Effective Strategies for Protecting the Planet*. Cambridge, UK: Cambridge University Press.
- Weitzman, M. L. (2015). A voting architecture for the governance of free-driver externalities with an application to geoengineering. *The Scandinavian Journal of Economics*, 117, 1049–1068. <https://doi.org/10.1111/sjoe.12120>.