Comprehensive Report
Negotiating solar radiation modification governance:

Evidence from non-ideal simulations

centre for future generations
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Comprehensive Report Negotiating solar radiation modification governance:

Evidence from non-ideal simulations

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Executive summary

This report presents the findings of the year-long project, Exploring Geopolitical Tipping Points and Climate Cooling Strategies, a work package of the Advanced Research and Invention Agency (ARIA) funded Strategic Foresight on Climate and Geopolitics: Toward Governance of Solar Radiation Modification (SAFEGEOGOV) project. This project aimed to gain a better understanding of how geopolitical and sociopolitical factors influence the research, development, and governance of Solar Radiation Modification (SRM) technologies, a set of proposed deliberate large-scale interventions to alter global average surface temperatures. To accomplish this aim, the project team created and ran three two-day crisis simulations in which a network of 35 international academics, civil society actors, and practitioners embodied their expertise in role-playing exercises on SRM governance. There is widespread agreement that some kind of governance framework for both research and potential deployment are essential for SRM but the path to achieving any framework – let alone a transparent, fair, and democratic one – is unclear. While there are ongoing discussions about what governance should look like and what the key challenges might be, having experts embody their positions in a series of simulated negotiations highlighted unexpected and underexplored sources of tension and potential deadlock that may not be obvious from more abstract stock-taking exercises.

Method

The project used the method of non-ideal, open-ended crisis simulations. Rather than pushing for the adoption of a particular set of recommendations or principles, the simulations focused on advancing an understanding of the potential points of failure or agreement of governance attempts. The project recruited a mix of natural scientists, social scientists, policy experts, and practitioners for an international research network that prioritised diversity in background, expertise, and experience. While many participants had specific expertise in SRM itself, others were recruited for their expertise in foreign policy, security, and international governance and diplomacy. Each participant was given a role profile with different aims and red lines based on their actor's stated policies and historical background and asked to embody their expertise in these roles. In monthly online network meetings, all participants were given primers on a range of topics so that they shared a common baseline of knowledge.

A simulation pre-text formed the starting point for each exercise. Participants were given the freedom to pursue their goals and interests as they saw fit within the exercise. The first pre-text was a meeting set in September of 2025 organised by the United Nations Environment Assembly (UNEA) to negotiate a "rules of the road" framework for SRM research and potential deployment. The second was a consultative forum convened by the Arctic Council set in September 2027 to continue attempts to develop effective SRM governance in the context of increasing environmental and political instability in the region. The third moved forward in time to September 2028, with the starting pre-text that some actors had proceeded with SRM research and development without an effective international governance framework in place.

Key findings

Network members engaged in over 40 hours of in-person exercise, participated in monthly online network meetings, and provided approximately 60 pages of reflections and analysis over the course of the year. At no point were the network members able to reach an agreement on the governance of SRM that could pass either a 2/3rds majority vote (Simulation 1 and 2) or consensus vote (Simulation 3). Most participants were motivated to pass a formal agreement but were unable to succeed.

Although participants were provided with baseline knowledge of all SRM methods, their negotiations and discussions consistently coalesced around Stratospheric Aerosol Injections (SAI), with some brief attention to space-based SRM methods. Marine Cloud Brightening Techniques (MCBT), Cirrus Cloud Thinning, and other albedo enhancement strategies received minimal engagement from participants. In the second simulation which focused on the Arctic region, there was some supplementary discussion of research into sea ice thickening and enhancing the reflectivity of polar ice.

Analysis of the simulation content and participant feedback further showed that:

- **Issues of strategic competition and state sovereignty drove the simulations, not climate concerns.** Despite sustained attempts by the project team and many network members to refocus negotiations and discussions on climate change, the simulations consistently focused on questions of control over the development and use of SRM technology and its political implications, rather than climate outcomes.

- **Actors were unable to establish a shared foundation of knowledge and understanding,** particularly around the purpose of SRM research and development. Distinctions between research and deployment and large and small scale experimentation could not be settled on the basis of scientific thresholds or technical assessments. These were instead explicitly political questions related to the risk tolerance of participants. While many network members approached SRM as an intervention to address the effects of climate change, others viewed SRM – primarily SAI – as an emerging technology with global implications and transboundary effects that would impinge on a range of political domains and governance regimes beyond climate.

- **Multiple types of uncertainty hampered progress towards agreement.** These were not limited to scientific uncertainties about the effects of SRM as a potential climate intervention. The most persistent and important of these uncertainties were: how to assess and trust information in a fraught political context; how to gauge the intentions of actors engaging with SRM; and how the continued emergence of SRM would influence existing relationships and dynamics between different actors, particularly states.

- SRM governance debates **both reflected and showed the potential to exacerbate global inequalities.** These inequalities reflect existing global hierarchies between wealthy, technologically-capable states and others, and between states and non-state actors. In broader SRM debates there is frequent discussion about the power to 'set the global thermostat' but a consistent finding was that controlling climate outcomes was less relevant than the capacity to develop and deploy SRM technologies to demonstrate geopolitical supremacy through the ability to produce global impacts, whether it would achieve climate stabilisation or not. Uneven access to scientific research infrastructure and capacity also influenced the willingness of different actors to engage or collaborate with each other.

- Participants and proceedings in the simulations were **vulnerable to misinformation and misperceptions.** Because the project team focused on designing an environment that reproduced current real-world geopolitical tensions and dynamics, participants experienced the effects of lack of trust between key actors which made it difficult to come to an agreement. Given this, efforts to deflect and mislead were often successful in breaking down consensus.

Key takeaways

Any attempt to develop SRM governance should recognise both the nature and the scale of the obstacles involved and any further SRM technological development should be conducted with the awareness and acknowledgment of these governance obstacles.

Any governance proposals should recognise that there are sticking points for states that are not directly related to SRM or climate change.

Issues of capacity-building and knowledge-sharing are crucial if any agreement is to be meaningfully multilateral. Scientific instrumentation and infrastructure capacity is important in questions of monitoring and verification for any agreement but so is trust.

The context within which any negotiations happen is important. Whether or not a governance proposal is acceptable does not just rely on its content but also on who proposes it, who is supporting or not supporting it, and how it will affect non-SRM issue areas.

Introduction

Rationale: Assessments of SRM are currently focused on a risk-risk analysis that examines the risk of climate change with SRM versus the risks of climate change without SRM (National Academies of Sciences, Engineering, and Medicine [NASEM], 2021; Felgenhauer et al., 2022). Many governance discussions about SRM research, development, and potential deployment also focus primarily on its potential environmental impacts or what kind of governance structure will lead to the best environmental outcomes. This is important, but research, deployment, and governance of SRM is not and will not occur within a vacuum. Powerful political actors with the scientific and technological capacity to pursue SRM are engaged in an on-going and intensifying geopolitical competition over status and the pursuit of their perceived interests that does not centre on environmental optimisation or ideal climate change amelioration policies and practices. This does not mean that the environment does not matter to these actors, but it is a secondary or tertiary concern and there is a need for more research on SRM that considers non-idealised, competitive, and minimally cooperative or non-cooperative research and development. This project has focused on this gap.

What is solar radiation modification (SRM)?

SRM is a proposed set of strategies to change global average surface temperature framed by the scientific community as a potential offset to climate risks associated with climate change (Shine et al., 2025).

Commonly discussed methods include:

- Stratospheric Aerosol Injection: the injection of reflective aerosols into the upper atmosphere to reduce incoming sunlight, which produces a cooling effect. This is considered a global approach, which is expected to have impacts on hemispheric scales. The cooling effect of large volcanic eruptions which inject materials into the stratosphere is a natural analogue for this approach.
- Marine Cloud Brightening: the intentional "brightening" of clouds by spraying marine clouds with seaspray or other materials to increase their reflectivity. This is considered a regional approach, and is expected to cool the surface locally.
- Albedo enhancement: includes interventions such as increasing the reflectivity of ice by scattering brightening particles or painting rooftops white in cities. Increasing the extent of sea ice and preserving glaciers may also increase overall albedo due to the increased reflectivity. At scale, these local interventions could have regional impacts on surface temperature.

Research approach and methodology: non-ideal simulations

In order to analyse how geopolitical complexities shape the development and deployment of SRM as planetary technology, we adopted non-ideal crisis simulations as the animating approach.

Crisis simulations are common research tools employed in a variety of settings – from defence planning to corporate negotiations – to understand how actors will behave in a given scenario and to assess possible outcomes. While there are numerous ways to construct simulations, they typically involve in-person interactions where participants perform the role of a key actor to understand decision-making under specific conditions (Bradfield et al., 2005; Järvensivu, Räisänen and Hukkinen, 2021; Vervoort et al, 2022). One of the advantages of simulation-based research is that it provides "a framework for organizing perceptions of unforeseeable events. The future itself will unfold eventually, and scenario analysis can provide signposts to sharpen our ability to discern the emerging patterns of events before they are fully developed" (Bodde, 2007, 247).

Non-ideal means that unlike war games or other simulations and tabletop exercises that push participants towards an ideal outcome or win-set, for example to win a war or conclude a treaty, our simulations were designed to be open-ended where the point was for researchers to observe the interactions and frictions between participants and identify key inflection and chokepoints in the deliberations. The aim of the simulations was not to push actors towards an ideal-type solution or to focus on how specific actors might successfully achieve their interests, but to explore the cooperative and conflictual interplay between power, prestige, and environmental reality under conditions of complex uncertainty. The strength of this non-ideal approach to simulations lies in its openness to contingency, creativity, and potential surprises that may arise.

To advance this approach, the project began by recruiting a mix of natural scientists, social scientists, policy experts, and practitioners for an international research network that prioritised diversity in background, expertise, and experience. The team hosted monthly online meetings with the network participants to develop detailed simulations for three in-person workshops. The first simulation took place 30 September - 1 October 2025, the second 8 - 9 January 2026, and the third 23 - 24 April 2026 at Queen Mary University of London. Participants met for 7 hours of formal discussion a day. Through this iterative process, the project team worked with network participants to author simulation details and identify geopolitical forces likely to influence policy behaviors and broader public responses to SRM research and potential deployment. In particular, a key focus was on the underexplored international political and social conditions such as intensifying great power rivalry, the breakdown of international cooperation over arms control, and global demands for environmental and climate justice. While all participants were given aims and redlines for each simulation, they were largely free to interpret their interests given their background understanding of their specific actors and develop strategies that aligned with those interests. Conducting a series of three simulations with the same core group gave participants the opportunity to build working relationships and collective understandings over time.

Rather than pushing for the adoption of a particular set of recommendations or principles, the methodology employed here focused on advancing an understanding of the potential points of successes and failure when it comes to governance. The participants themselves focused on negotiating an agreement whereas the research team focused on observing and analysing why this was or was not possible. While the limitations of a simulation environment mean that there are some points of departure from reality, the range of expertise brought to bear by participants in the simulation provided a nuanced picture of the complexities involved in ongoing attempts to govern SRM technologies and highlighted that some of the most difficult challenges to work through are not immediately obvious on the basis of technical assessments.

A note on design: Challenges of centring the climate crisis in negotiations

- A consistent finding throughout all three simulations was that updates and interventions that centred climate change and consequences from the intensifying climate crisis had limited impact on negotiations.
- Interventions were distributed throughout each simulation that focused on providing updates about crises related to the effects of climate change, written in the style of existing reports from climate research institutions or media features and articles on unfolding climate-related disasters and challenges.
- Many participants noted a perception that there were fewer climate-related interventions distributed during the simulations compared to those focusing on geopolitical challenges. This does not reflect that actual balance of interventions; in every simulation half or more of the updates and interventions distributed to the entire network were related to climate.

While simulations are recognised as a valuable research tool, we also observe the limitations created by the practical constraints on the number of participants, the range of expertise it is practically possible to include, the influence of personalities in the room, and those who were unable to be present at times, which contribute to challenges with reproducibility. Nevertheless, 35 network participants engaged in over 40 hours of in-person exercise, contributed to monthly online network meetings, and provided approximately 60 pages of written reflections and analysis of network simulations between September 2025 and June 2026, reflecting a high-level of engagement that mobilised significant expertise and knowledge exchange on the intersections of SRM, climate science, international politics and security, and governance. An interesting challenge noted by both the research team and several network participants is the double-edged role of expertise itself in simulation exercises. While participants noted effective world-building that captured and reflected real-world conditions, that did not encourage them to to think more creatively about the range of actions they might be able to take to achieve different outcomes. They tended to limit themselves to what they understood their actor would do in a real-world setting. This is valuable in terms of gaining a better understanding of where points of tension or failure might arise in governance negotiations, but adjustments to design in potential future iterations could potentially surface new strategies to overcome the challenges these exercises highlighted.

Assembling a network

As emerging technologies with transboundary and, in some cases, global effects, SRM raises multi-dimensional questions and challenges. To better understand the nature, intensity, and interaction of these questions and challenges the make-up of this research network focused on recruiting experts from different fields, positions, and approaches. The network sought to reflect a wide geographic distribution, with experts representing state actors from Asia and South Asia, Africa, Central and South America, North America, the Gulf region, the Arctic region, Europe and Russia. It included experts to represent the IPCC, civil society and climate change activist organisations, technology sector leaders, natural science and environment researchers on SRM and climate change, experts on the global governance of finance and arms control, and international relations and foreign policy. While many participants had expertise in SRM, experts were intentionally recruited who did not have expertise or familiarity with SRM to observe how they interacted with the possibilities of the proposed technologies and how they anticipated it would sit within their existing fields (e.g. arms control, foreign policy, development, international finance, technology development). In addition, differing levels of expertise on SRM served to reflect observed reality in different negotiating and governance fora in which some actors will have deeper or lesser expertise and resources on a given issue depending on their position (civil society, developing or industrialised state, etc).

In monthly online network meetings, all participants were given primers on a range of topics so that they could develop a shared baseline of knowledge. These included: SRM science and governance debates and proposals; Arctic climate and geopolitics; the role of monitoring, detection, and verification in governance agreements; and SRM climate emulators, among others. The monthly online meetings also enabled network participants to interact with each other to share their expertise, build relationships, prepare for and reflect on in-person workshops, and provide input into simulation design as the project progressed.

Each participant was given a role profile and asked to embody their expertise in these roles. This required them to manage their particular strengths and weaknesses as different roles demanded. For example, if a participant was an expert in the foreign policy of a particular country but less familiar with SRM, they had to stretch to incorporate SRM into their existing understandings and common sense, whereas an expert recruited for their scientific knowledge of SRM was stretching in the other direction to incorporate the behavior and demands of other political actors and institutions. One of the functions of this approach was to address observations that different experts have different 'common senses' in their fields and that, given the multidimensional nature of SRM, experts from different fields can be siloed from each other or find it difficult to understand and work across divides.

While the composition of the network was mostly stable throughout the project, additional roles were added over time in response to recognised gaps (e.g. a French expert was recruited for simulation 2 onwards; an expert was recruited to play the startup Stardust Solutions for simulation 3). New participants were also brought in to assist if an existing expert was unavailable, and three were asked to pivot from their initial roles to assist for particular teams (e.g the climate finance expert assisted the China team for simulation 2; a nuclear politics expert assisted the US team for simulation 2). For the first simulation, the US was the only actor with multiple members

to reflect both its international status and different dimensions of its interests (diplomacy and security). In simulations 2 and 3, additional members were added to the China and Russia teams to better simulate their real-world position and provide these participants with more resources to decide how best to pursue their interests in the simulation. For state delegations with two representatives, each delegate was given different role profiles to reflect their focus on either diplomacy or security.

A simulation pre-text formed the starting point for each exercise. Participants were given the freedom to pursue their goals and interests as they saw fit within the exercise. Some chose to try to cultivate extensive cooperation with other participants in order to develop a functional framework for everyone, while others focused on ensuring that they maintained what they perceived their own interests to be, even if this undermined the overall pre-text of formulating a governance framework. One participant was specifically recruited to play the role of a plant tasked with defending fossil fuel interests while presenting as a climate-focused civil society organisation. This role was modelled on Donald H. Pearlman, an oil industry lobbyist who created a non-governmental organisation called 'The Climate Council' to gain access to and disrupt UN climate negotiations. He successfully obstructed negotiations at early COPs including COP3 in Kyoto and inspired the introduction of a ban on NGO observers from the conference floor (Dessai, 2004, 10–14). They were explicitly free to pursue their role profile in whatever way they thought would be most effective in that role, regardless of whether that meant promoting, discouraging, or remaining neutral on the issue of SRM development, deployment, and governance. The participant was able to draw from research on oil industry efforts to employ disinformation and misinformation and the participant's own familiarity with international governance institutions and negotiations. The concealed nature of this role was maintained throughout all network meetings and in-person exercises until the end of the final in-person exercise. This allowed organisers to observe how this participant was able to influence other network members and events, test the information environment and effects of mis- and disinformation, and observe whether and at what point other network members suspected or recognised the fossil fuel plant and how they responded.

Key findings

1. Issues of strategic competition and state sovereignty drove the simulations, not climate concerns

None of the simulations resulted in any agreed governance framework. Despite potential areas of agreement between subsets of participants at different points throughout the exercises, problems of national security and state sovereignty, including control over national technologies, subverted all attempts at agreement. Geopolitical competition and not the climate crisis was the central driver of the simulations. There existed a fundamental rift between actors who had an urgent need to make progress towards a governance framework and those who did not, for ideological or geopolitical reasons.

Even state actors that were most concerned about climate change found it difficult to maintain focus on climate in negotiations because other issues, particularly maintaining sovereignty and their geopolitical status, took priority. Interest in how SRM may be used for political leverage across a range of domains and what kinds of political leverage can be brought to bear on SRM research and development were central concerns during each simulation. The complexity of SRM and its multi-sectoral impacts on environmental, health, security, technology, economic, and supply chain issues also hindered efforts to reach agreement. If some state actors were opposed to emerging tentative agreements between other participants regarding issues relating directly to SRM they would sometimes raise points of leverage over those actors in other domains. For example, at points when the US perceived that other participants representing Canada or the UK were aligning too closely with China during discussions, they raised the prospect of withdrawing key security protections in non-SRM arenas. In addition, tension in other arenas influenced the progress of discussions, such as ongoing strain in the relationship between the US and South Africa following clashes between the two during South Africa's Presidency of the G20.

Throughout the simulations, interventions related to climate and the environment received much less state attention than those with potential national security implications. This included news updates, reports on climate impacts, and interventions from the climate scientists and civil society. A key hypothesis of the research team before the simulation was that a climate emergency framing may push actors to embrace further exploration and development of SRM, if not deployment. However, it was consistently the case that emphasis on climate as an emergency did not motivate participants to focus on an agreement or to decide to advance their own SRM research and development agenda. Instead, concerns about the perception of falling behind in more comprehensive competitive dynamics between major powers drove interest in research and development. This is not to suggest that promoting a securitised climate framing bears no risks, but to emphasise that climate is not the primary security concern with regards to SRM.

The simulation outcomes demonstrated that regardless of the global climate effects of SRM, states are the primary actors in the international system and hold the authority to govern. While there are other powerful and influential global actors and institutions they do not supersede states, particularly in matters of establishing and enforcing global governance. States are sovereign over both their territory and airspace and delegate the authority to govern international airspace. Private sector technological actors within the simulation were fully cognisant of and compliant with this reality in their interactions with and behavior towards the 'great' state powers, particularly the US.

2. Governance attempts lacked a shared foundation of knowledge and understanding

Participants observed difficulties in developing common understandings about key issues, particularly related to technology transfers or control, knowledge exchange, and the relationship between climate change and SRM. It is important to note that this difficulty was not primarily caused by a lack of clarity about the scientific underpinnings of SRM. The most persistent and significant gulf in understanding was between network participants primarily focused on SRM as a potential climate intervention to reduce warming, such as the climate scientists and some civil society actors, and participants who viewed SRM as a set of emerging technologies with a range of global impacts that could not be limited to climate. For the latter, the central question was the level of control they could exercise over those technologies, not the outcomes of their use. This was true for the 'great powers' in the sense that they consistently demonstrated an interest in maintaining the option to develop large-scale capacity and for 'middle' powers and developing states concerned by the implications of other states having power over them.

A brief history of interest in climate control as a geopolitical tool

Both the US and USSR invested heavily in attempts to develop climate control capabilities during the Cold War (Baskin 2019, 29; Fleming 2010). Nuclear weapons research was entwined with militarised climate research (Baskin 2019; Scheffran 2019), and throughout the 1940s through 1960s there were a series of proposals to use nuclear explosions to intentionally alter regional climates through means such as melting the Arctic ice cap (Baskin 2019, 30) or using them to reshape physical environments through earthmoving projects to re-route rivers or build giant harbors (Hamblin 2021, 171). After the development and use of nuclear weapons in World War II, a primary motivation for the development of meteorological sciences was an interest in harnessing and controlling other fundamental physical processes. This was specifically framed as a means of enabling effective weather and climate control (Fleming 2010, 192–4; Scheffran 2019, 223–224).

Climate intervention research was driven by military interest and was "overwhelmingly understood as a space of contestation between two superpowers" (Baskin 2019, 37), before there was a clear understanding of the trajectories of climate warming due to the greenhouse gas effect. It was arguably not until the 1965 President's Science Advisory Committee Report on Atmospheric Carbon Dioxide commissioned by US President Johnson's administration (President's Science Advisory Committee, 1965) that the possibility of deploying some form of albedo modification as a response to climate change began to come into focus.

As a better understanding developed of the implications of rising greenhouse gases and other challenges posed by wider environmental degradation, the interest in climate research began to shift away from control for strategic purposes. Military priorities and military funding shaped a range of environmental sciences (Hamblin 2013), but the 1970s onwards saw a shift in the scientific community and steps by political leaders in the US and the USSR to circumscribe militarised, hostile climate interventions and weather modifications (Baskin 2019), driven by unease about the potential risks of environmental warfare and growing concern about a degrading atmosphere. What became the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Convention (ENMOD) was initially proposed by the

USSR in 1974 and would have effectively banned solar radiation modification. An outright ban was heavily contested by the US (Baskin 2019, 45), and the US negotiated the treaty to allow for key loopholes to retain freedom of maneuver for potential military actions with significant impacts such as the bombing of dams (Hamblin 2013, 207). Although they have synoptic-scale effects on climate and weather, nuclear weapons were also excluded (Hamblin 2013, 207).
The wording of the ENMOD was watered down in such a way that it is generally not viewed as a legal obstacle to pursuing solar radiation modification (Baskin 2019; Shine et al., 2025). However, despite the continuation of research in the US military and defense ecosystem (Surprise, 2020), a taboo against seriously pursuing climate intervention research largely held until a 2006 intervention from Paul Crutzen, a Nobel Prize-winning meteorologist and atmospheric chemist, due to increasing alarm about climate change. In addition, the language of ENMOD that encompasses any scheme of weather modification or climate engineering with the potential for 'widespread, long-lasting, and severe' harms suggest that the ENMOD provisions for consultation of the parties will have to be revisited to determine if parties to the treaty view any such interventions as hostile (Fleming 2010).

This also included a lack of common understanding of key SRM terms and distinctions, for example between research and deployment and between small and large scale experimentation. Resolving these discrepancies was a political issue rather than an easily solved technical problem. For example, in both Simulation 1 and Simulation 3 discussions about the distinction between small-scale and large-scale experimentation returned to how states can agree on a shared definition of size and meaningfully engage with and trust any data produced from experiments. The disagreement in these discussions was indicative of the political risk tolerance of the state actors that could not be decided on the basis of a technical assessment. Instead, any such assessment process would itself have to be approved by states as a matter of reconciling their risk tolerance. The expertise of the science advisors was of limited relevance to the problems and questions raised regarding policy choices and security concerns as the scientific definitions were not commensurate with the concerns raised by state actors.

Of particular note, the climate emulators were not consulted by participants during the simulation despite participants being explicitly briefed on their use and a technical advisor available to operate an emulator at all times. After the conclusion of the final simulation, the participants were asked why they chose not to engage with the emulator. The most common response was that science and the climate effects of SRM were not relevant to key issues that emerged during debate. Concerns about sovereignty, strategic competition, and monitoring to prevent unilateral or uncoordinated large-scale experimentation and deployment consistently took precedence. Four participants noted that they felt the emulator could not produce relevant information for them either due to lack of downscaling or due to their interest in out of sample information and need for certainty in the assessments of regional impacts. One of these participants, representing a developing state, briefly considered making use of the emulator in the third simulation but felt it would be too unreliable and ultimately could not address any of their central concerns in the negotiations, which were focused on their political standing in relation to other states. One participant highlighted that they assessed that an emulator could be used to argue for deployment and lead to an escalation spiral, which they wanted to avoid.

Climate emulators

Definition:

- A climate emulator is a fast, simplified model trained on existing Earth System Model (ESM) simulations (e.g. CIDER) (Farley et al, 2026; Tebaldi et al., 2025; Beall et al., 2025).
- An emulator learns the relationship between inputs (injection rate mass flux, location and timing) and outputs (temperature, precipitation) of Earth System models (ESMs) enabling users to test many input scenarios at reduced computational expense (as compared with fully coupled physics based ESMs).

Strengths:

- Emulators are cheap and fast to run. They are useful for exploring a wide range of "what-if" scenarios, however, confidence in the results is reduced the further outside of the training dataset an input scenario falls.
- Emulators are hosted online, making them accessible to non-specialists.

Weaknesses:

- Emulators are simplified by design, so they miss some physical detail — effects like diurnal/seasonal cycles or internal climate variability are often not captured.
- Emulators cannot confidently predict – especially when input scenarios lie outside of the training dataset.
- Emulators are trained on ESMs which have known deficiencies and shortcomings (e.g. representation of the stratosphere); all of these process level biases are implicitly baked into the emulated results. See Annex 2.
- Communicating uncertainty or error is challenging in such a publicly facing tool.

Questions of monitoring SRM activity and verification of research/deployment and use/non-use were important and formed a potential path forward for some agreement during the simulations between subsets of actors, though it was never realised due to other sticking points on security and sovereignty.

Monitoring and detection requirements for SAI

- Detection capacity already exists for deployment type scenarios of sulfate aerosols which are similar in size to volcanic eruptions and are visible from space via enhancement of aerosol optical depth and other trace gases (e.g. water vapor) via satellite capabilities.
- However, these satellites and the infrastructure required for download capabilities are a potential pressure point between states with diverging interests (see the SvalSat case study below in Chapter 2).
- Additional detection capacity is required to see smaller scale experimentation which may fall below current remote sensing detection limits for Aerosol Optical Depth or SO2 (Queiβer et al., 2019).
    - If a relatively small amount of material is injected, it is likely that the enhancement against background will be insufficient to "see" from space.
    - Detection is therefore limited by the amount of material utilised in an experiment.
- Monitoring, understanding, and verifying the effects of large-scale experimentation or deployment on different regions, key ecosystems, or other physical processes would require additional observational capacity distributed globally and more extensive modelling research on impacts in these areas.

3. Multiple types of uncertainty hampered progress towards agreement

The lack of common understanding on both technical questions and on broader state goals and intentions created a context of deep uncertainty. Participants representing developing states expressed concerns about the scientific uncertainties that remain about how SAI would affect different regions and key physical processes and ecosystems such as monsoons and the Amazon. However, the scientific uncertainties raised about SAI and other SRM strategies were not a primary focus on debate and contestations throughout the simulations. Several participants reflected that SRM could be used as a potentially coercive diplomatic and/or military tool. To be clear, this was not because those participants were unaware of or did not understand the potential implications of actions such as a single-hemisphere deployment or the risk of termination without a draw down of GHGs after a longer-scale deployment, but because they were aware of those risks and believed they could be exploited for political leverage.

Participants reflected that governance is vital to preventing a technological arms race. Yet actors focused on non-use and restraining development were unsuccessful in all three simulations. Even if all participants were acting in good faith towards a governance agreement (which is not an assumption that states would make in real-world scenarios), the potential for the unilateral development of SRM capacity at scale, even without use, caused uncertainty that then prevented the possibility of a multilateral agreement.

As of 2026, roughly ten state actors (the US, China, Russia, France, Germany, the United Kingdom, Japan, Brazil, India and Canada) have been assessed to have the technical aerospace capacity to develop long-term, large-scale SAI deployments (Horton, Smith and Keith, 2025). This led to a substantial and consistent perception during the simulations that those actors had varying degrees of exploitable strategic advantage. All of these states were represented in simulations apart from Japan. While the exercises surfaced the most consistent tensions between the US and China because of their perceived superiority in capacity, it is also important to note that motivations for how and why to develop and potentially use SAI were not closely connected to climate considerations or desired climate outcomes. Russia indicated a consistent interest in the potential to use single-hemisphere deployment capabilities for political leverage despite the knowledge such use would cause catastrophic global climate outcomes, including substantial harm to itself.

SRM technology can thus be a potent source of political leverage irrespective of climate impacts and context. The simulations demonstrated the potential for state competition over SRM to develop dynamics similar to an arms race and into an arena in which great powers could seek political advantage.

4. SRM governance debates both reflected and showed potential to exacerbate global inequalities

While uncertainty was prevalent it was also unevenly distributed and weighted more on developing countries as negotiations followed established hierarchies and inequalities.

Many developing states emphasised that without meaningful investment in scientific, technical, and monitoring capabilities they could not participate as equal actors in global SRM governance discussions. Further, some were concerned about being used as a testing ground for SRM, especially on such an unequal basis. There was, however, also a lack of sustained cooperation between developing states throughout due to different priorities and objections to SRM, especially between the African states. A key point raised by a developing state participant was that even though a shift to a consensus requirement in the voting procedures for the 3rd simulation essentially assured it would not be possible to pass an effective framework agreement, a consensus approach was preferable because it did ensure that the votes of the developing states participants mattered and had to be earned.

State capacities, relationships, and personalities also had an influence on what was possible, or impossible, as events developed. This reflects the reality of imbalanced influence in governance forums in which some states have delegates that are both dedicated experts in an issue and stay in their position over the course of many years. States with fewer resources will have representatives with multiple portfolios that rotate in and out.

For developing states the primary concerns in the negotiations centred around finance and capacity-building. They noted that access to monitoring and verification data without the capacity to analyse was an empty gesture. The challenge is not only around the development of scientific capacity, but also around justly distributed infrastructure.

The interests of Arctic Indigenous communities – although frequently acknowledged – were ultimately sidelined as negotiations among state actors intensified, reinforcing a familiar pattern of symbolic inclusion but limited influence in substantive decision-making.

5. The multi-sectoral complexity of SRM and a lack of trust made actors vulnerable to misinformation and misperceptions

Participants found it difficult to assess and trust information introduced into the simulations regarding the behavior of other actors. This included information on the status of US and Chinese SRM research programmes. There was widespread suspicion of any information shared by Russia across the simulations, while there was a more even split between participants regarding their trust in China. By the final simulation, information and promises made by the US were seen as largely unreliable. Lack of trust in these actors was particularly influential in preventing the passage of a final agreement.

Issues of trust also included concerns about unilateral SRM advances and deployment, or competing action between major powers. However, experts also noted the possibility that first deployment could be more complex, with more actors involved simultaneously. If first movers form a coalition, any governance negotiations could take a different direction depending on the power of the states in the coalition.

Actors, including the fossil fuel plant and tech sector actors, made strategic use of information and selected research, such as research on tipping points, in an attempt to create a sense of SRM urgency and the need for a techno-fix. A lack of trust enabled these actors to derail negotiations on any agreement that might restrain development or deployment and influence the choices of other participants.

Actors had different vulnerabilities to misinformation from the fossil fuel plant and tech actors: for Indigenous actors and developing states this took the form of promises of inclusion and access to resources; for other states legitimising their decisions and actions; for scientists access to research funding. Lack of focus on widening funding access for developing countries made them particularly vulnerable to influence from the fossil fuels plant.

Key takeaways

Any attempt to develop SRM governance should recognise both the nature and the scale of the obstacles involved and any further SRM technological development should be conducted with the awareness and acknowledgment of these governance obstacles. It does not automatically follow that because SRM has global implications it will lead to inclusive global governance.

Any governance proposals should be cognisant that there are sticking points for states that are not directly related to SRM. It is thus important to bear in mind that SRM is an issue area that exists as a part of a constellation of concerns and challenges, not as the exclusive or primary focus of any relevant actor. Sticking points could include state power relations, questions of representation and inclusion, and exogenous security arrangements that undermine negotiations.

The assumption that actors will not pursue SRM deployment strategies that would cause significant harm to themselves should be considered in light of the historical record of strategic priorities of powerful state actors. Great powers have pursued policies that put their own population at high and continuous risk in key areas related to strategic competition, such as nuclear weapons. The immediate risks of SAI and other SRM techniques are much less catastrophic than nuclear confrontation or accidents, but the logic of risking or sacrificing a state's own population to maintain or secure strategic advantage or interests is a persistent feature of state behavior.

SRM monitoring, attribution, and verification were consistent concerns for all state actors throughout the three simulations and will be fundamental components of any governance regime. Scientific instrumentation and infrastructure capacity is important here but so is trust. The EU, UK, and (non-US and Russia) Arctic states were noted as potentially having the capacity and status for coalition-building in these areas. There is potential to leverage the interlinked monitoring and basic research capacities of these actors to establish and strengthen relationships between middle powers and developing states through knowledge exchange and scientific collaboration. It is possible that SRM coalitions may be technology coalitions more than they are climate coalitions. During the third simulation, several actors with different climate priorities were focused on trying to develop collaboration on monitoring and observation infrastructure development.

The forum within which any negotiations happen is important. A question that participants frequently raised throughout the project was whether there was a clearly identifiable 'home' for SRM governance, particularly given the strong tendency for negotiations to drift away from climate concerns to questions of security and sovereignty. Finding a governance forum and developing a process in which major powers will participate and engage with concerns of developing states, civil society, and middle powers, and which also reflects accurate scientific assessments will require careful consideration and diplomacy. The secretariat of any governing forum could play a key role in providing legal and logistical advice and being a source of information on the process that participants can request. The chair of any such body can help keep sessions on track and can be a means of wielding influence within a governance forum if participants make use of that option. Who holds the pen in drafting proposals was a key matter of consideration within the simulation as it often is in the real world.

Whether or not a governance proposal is acceptable does not just rely on its content but also on who proposes it, who is supporting or not supporting it, and whether there is a concern that it will affect non-SRM issue areas. State actors in particular must serve multiple masters and concerns, which limits their ability to compromise in order to pass proposals even if framed as narrowly focused on SRM. For example, during all three simulations proposals that were drafted by China as the primary 'penholder' faced resistance from a number of other participants regardless of the content of the proposals.

The form and specific purpose of any governance framework also requires careful thought. Some participants took the position that one option to escape stalemate could be to form small coalitions of the willing, as in climate negotiations. In this case bi or multi-lateral efforts focused on science cooperation may help build towards effective governance, albeit at a slower pace than desired. Another avenue for progress would be to establish a scientific board

through UNEA or another institution that could begin to build common understanding on key terms and distinctions. This was for some a viable path to making partial progress. In contrast, some participants held that a partial agreement would be ineffective in SRM governance. If the goal is to prevent interference in the climate or stratosphere via SAI the outcome is binary. From that perspective, a truly successful agreement would have to be universal, which heightens the challenges of the consensus requirement.

Issues of capacity-building and knowledge are crucial if any agreement is to be meaningfully multilateral. States that have both the most in-depth knowledge on the topic and understanding of process and details of procedure can use that to shape outcomes. However, civil society actors can supplement knowledge for state participants without substantial resources and expertise in SRM. Despite the challenges in identifying a governance forum for SRM that will engage major powers and other potentially resistant parties, it may be possible to begin a process of confidence building such as scientific exchanges, multilateral funding for fundamental science, and instrument development that is small and non-threatening enough to help create a path to more robust governance and coalition-building over time. There is some historical precedence for relationship building through science diplomacy to navigate difficult governance challenges. It is not a given, however, that resulting governance agreements would be inclusive or democratic. Scientific cooperation is not apolitical, and global inequalities have historically enabled some states to effectively shape the directions and outcomes of international scientific collaborations that underpin governance regimes.

Scientific developments and collaborations as a path to building governance?

- **Arms control:** In 2011 the five Nuclear Armed States (NWS) under the Nuclear Non-proliferation Treaty (NPT) established a working group to develop a glossary of key nuclear terms. The glossary aimed to provide some common understanding and build confidence among nuclear states, and also included scientific exchanges. Although this work has been criticised for its lack of ambition and has stopped since the Russian invasions of Ukraine, it could serve as a starting point for some level of cooperation and communication over agreed terms e.g. what is experiment vs deployment.

- **The Antarctic Treaty:** Negotiated by 12 states at the 1959 Washington Conference, the framework uses scientific cooperation to overcome Cold War tensions and preserve the Antarctic continent as a place of peace. It prohibits all military activities (Article I), including nuclear testing and disposal (Article V), guarantees "freedom of scientific investigation" (Article II), and freezes sovereignty claims (Article IV). But participation in the treaty regime requires states to conduct "substantial scientific research activity" in Antarctica (Article IX), effectively excluding states who do not have the financial and infrastructural resources to mount largescale scientific expeditions. While often lauded as an example of how science can foster international cooperation, the treaty has also been criticised for using science to preserve early-20th century imperial hierarchies (Howkins, 2017; Dodds, 2006; Yao, 2021).

- **The Outer Space Treaty:** The 1967 Treaty was negotiated by the Committee on the Peaceful Uses of Outer Space (COPOUS), created by the UN General Assembly in 1959. The treaty explicitly draws from the Antarctic Treaty and also uses scientific cooperation to overcome Cold War divides. It states that outer space exploration will be carried out "for the benefit and in the interest of all countries" (Article I), that outer space is not subject to national appropriation (Article II), and that no nuclear weapons will be placed in orbit or military installations on celestial bodies (Article IV). Despite the UN forum's formal equality and consensus decision-making, the two space powers at the time – the US and USSR – dominated negotiations and dictated the outcome. Those without the financial and scientific resources to go to space are effectively excluded from many of its benefits (van Eijk, 2025; Buono, 2020; Rubenstein, 2022).

Meaningful rather than symbolic participation by Indigenous groups and marginalised communities will require close attention and engagement. SRM is a technological intervention that will most likely be within the control of a set of powerful state actors due to the aerospace capacity requirements for large-scale, long-term deployment. While Indigenous and minoritised group rights are often alluded to in debates, powerful state actors and the scientific establishments within them have a long and violent history of causing great harm to marginalised populations through military and research activities. Regardless of the specificities of SRM, these legacies influence the trust or lack of trust between participants and their willingness and ability to cooperate.

Any further development of outdoor research could have implications for the potential of a governance agreement. During the simulations, once the threshold of doing outdoor research was crossed, it became difficult to restrain or coordinate further activity.

Given the relatively novel nature of SRM technologies and the shifting real-world political context, it may be possible to identify new political configurations and pathways to support an effective governance framework, rather than being bound by status quo assumptions and practices. By the end of the exercises, both the research team and participants noted potential avenues for further exploration via additional simulation iterations. This might include simulations that investigate the social and political dynamics of other climate technologies or the effects of a changing international political context on climate science research and infrastructure such as earth observation and monitoring capacities.

Chapter 1: In-depth discussion of Simulation 1

Simulation description

The first simulation was designed as a variation of a "committee game" in which participants negotiated a "rules of the road" framework for SRM research and potential deployment in a meeting organised by the United Nations Environment Assembly (UNEA). The workshop was conceived in light of the real-world failure of resolutions put forward by the Swiss government at UNEA in 2019 and 2024[1]. The scenario was set at the same time as the workshop itself - September 2025.

Research question: How will existing sociopolitical dynamics and geopolitical rivalries shape international collaboration and competition in SRM research and development?

Actors present and voting day 1: The United States; Russia; China; Mexico; The Netherlands; Germany; Canada; The United Kingdom; European Union Institutional Representative; The Climate Overshoot Commission; SpaceX; Technology Sector Philanthropic Investor; IPCC Institutional Representative; SRM Technical Advisor and Emulator Operator; Developing Nations Scientific Advisor; ETC Group climate activist organisation representative; Climate Futures Cooperative civil society organisation (fossil fuel plant).

Actors present and voting day 2: The United States; Russia; China; Mexico; The Netherlands; Germany; Canada; The United Kingdom; European Union Institutional Representative; The Climate Overshoot Commission; SpaceX; Technology Sector Philanthropic Investor; IPCC Institutional Representative; SRM Technical Advisor and Emulator Operator; Developing Nations Scientific Advisor; ETC Group climate activist organisation representative; Climate Futures Cooperative civil society organisation (fossil fuel plant).

Actors contributing remotely: India; South Africa; Arms Control Expert Advisor; Climate Finance Expert Advisor.

Voting procedure: ⅔ majority of all actors to pass substantive measures; simple majority for procedural votes.

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[1] Switzerland introduced draft resolutions on SRM governance at the UNEA in 2019 and again in 2024. Both initiatives failed to achieve consensus among states, highlighting persistent divisions over whether and how SRM research and governance should be addressed within multilateral fora.

For seating chart see Annex 1, page 3

Simulation narrative

As noted above, prior to the first simulation the participants were introduced to each other via online network meetings and communications, in which they shared who they were in real-life and their role in the simulation. While some were subject matter experts in SRM, all network members were given an overview of SRM, including scientific background and debates, as well as the political and governance debates. The network members were also notified that a SRM climate modeler in the group had a climate emulator available for them to consult about the potential climate outcomes of any decisions or agreements.

Each participant was asked to prepare a 60 second opening statement to reflect their starting position on the workshop pre-text. After the opening statements, the Chair kept a speaker's list with no limit on speaking time once a participant was recognised by the chair. The initial structure followed a plan of 45 minutes structured debate and 15 minutes of unstructured discussion in which participants could move around the room and speak directly to other participants. Participants were given the option to motion for unstructured discussion or unmoderated caucuses between different subsets of members outside of the allotted time, which was an option participants requested more frequently as debate progressed in order to form alliances, find agreement on particular principles, and formulate governance proposals to put to the entire body for a vote.

In their opening statements, participants staked out positions that closely adhered to their real world positions and role profiles. The US focused its opening remarks on its role as the world leader in technological innovation and made it clear that it would not submit to limitations on research it felt was in its national interest, without any acknowledgement of climate change. Russia focused its remarks on emphasising that its priority in the negotiations was to ensure that any technology development was equitable and not dominated by the global west, rather than addressing climate issues directly.

Apart from the US and Russia, most actors emphasised that climate was a serious problem that demanded commitment to deliver on the goals of the Paris agreement and that emissions reductions were important and necessary. There were a range of positions among these actors about the potential role of SRM in relation to climate change. Mexico and a civil society environmental action group strongly rejected SRM as a dangerous distraction. Other state actors were cautious about whether SRM would undermine action on mitigation and wanted more research on potential physical risks and side effects. Both state and non-state actors called for a commitment to transparent funding and governance and assurance mechanisms to prevent unilateral action or military involvement in any future SRM programmes. China reiterated its commitment to the Paris agreement and international law while emphasising that no group or actor should monopolise climate intervention research or deployment, while South Africa emphasised concerns about the distribution of capacity for research and development of SRM that might contribute to unjust and inequitable development, deployment, and governance arrangements.

The tech sector actors emphasised that emissions are not being cut fast enough so research and investment into SRM was essential in order to deliver solutions to prevent the worst climate outcomes and offer hope. CFC, the NGO tasked with subversively protecting fossil fuel interests, emphasised concerns about inaction on climate change while claiming to be a firm believer in mitigation.

As the participants engaged in structured and unstructured debate, the simulation designers distributed additional updates and interventions to observe whether and how they influenced discussion and negotiations. These updates included a mix of pre-prepared 'news' items shared with the entire body and intelligence reports and memorandum shared with specific members from departments within state actor's governments or from networks and institutions connected to participants representing non-state actors. The purpose of the news items was to observe how participants reacted or did not react to publicly distributed news on both climate and environment as well as international politics and security issues. The intelligence updates and memos introduced additional information to particular actors to observe whether and how that information influenced their approach to negotiations, and how information introduced into the simulation via different actors was interpreted and acted upon by other participants.

During the morning session, news items were distributed to all participants that highlighted the recently released Global Tipping Points report calling for urgent action to address climate change and avoid catastrophic climate outcomes from crossed tipping point thresholds. A separate press release from the IPCC was also distributed that reaffirmed the need to honor commitments to halve emissions by 2030 and highlighted that advances in renewable energy and other technologies keep this goal technically within reach. The final morning news item shared with all participants reported an uptick in climate-related protests and demonstrations ahead of COP 30 in Brazil. In addition to the morning news items shared with everyone, direct reports were sent to Mexico and climate action groups about disastrous flooding in Mexico and devastating droughts in southern Africa causing crop failures. The purpose of the news releases and reports, which were staggered throughout, was to foreground the seriousness and severity of climate change to observe whether and how that influenced the actions of participants and the course of the negotiations and discussions.

Over the course of the morning session, the debate centred around whether or not SRM should be considered as a climate intervention and what would be required to achieve fair and effective governance. Germany initially staked out the position that every dollar spent on SRM research took away from money spent on mitigation and other areas of climate research. Mexico immediately pushed for a moratorium on SRM development and deployment, although they acknowledged an interest in further research on the risks of SRM. The tech sector actors consistently pushed the argument that quick action was needed and that SRM would buy time for better long-term climate solutions.

Most of the actors coalesced around the need to agree on whether and how to conduct any outdoor experimentation and at what scale. Canada was also able to gain support for the idea of centering 'reversibility' as a principle for any outdoor experimentation, although agreeing on what constituted 'reversibility' both technically and politically became a sticking point. The body largely agreed they should begin drafting research governance principles and most indicated any principles should also include provisions to prevent unilateral action and

militarisation. However, there was significant disagreement about who would be a trusted actor to serve as 'pen holder' when formulating any principles and a majority of members rejected designating any state actor for that role. Eventually, the IPCC representative was designated to serve that function, but in practice participants began to engage in secondary discussions with subsets of participants to begin formulating principles separately, which led to competing sets of principles. During unstructured debate, Mexico and the tech sector actors consulted with the SRM scientific expert on the technical specifics of Stratospheric Aerosol Injections and understandings of the physical risks, but other actors demonstrated limited interests in the specifics of SRM itself. Instead, discussions in both structured and unstructured periods emphasised the need for transparency in research and funding, the development of trusted capacities for monitoring, detection and verification, and the need to ensure fair governance that prevented unilateral action.

The US and China underlined similar positions with regards to governing research and development or deployment: it would be unacceptable for the other to advance research and development unilaterally or to seek primacy in this technological space, while any interference in the pursuit of their own national interest would also be unacceptable to both. At the same time, China emphasised their commitment to multilateralism and inclusion of developing countries in any governance agreements, while the US was explicit that their priority was to maintain a leadership position in any technological developments. Russia also continuously expressed support for the inclusion of Global South actors and largely aligned itself with China but was careful to insist that it must play a central role in the governance of SRM technologies with global implications and would not commit to any restraints on its options for research and development.

While the major powers (US, Russia, China) quickly became focused on issues of perceived national interest in preserving all their options for technology development, with the US never acknowledging the climate dimensions of SRM research and development, the morning session of the first day still maintained focus on concerns about climate change as the background condition for their debates and disagreements about SRM. However, from the afternoon session of the first day and through all subsequent in-person simulation exercises over the course of the rest of the project it became increasingly difficult to return the focus of discussions about SRM to its potential as an intervention to address climate change. From this point forward, there were many hours-long stretches of structured and unstructured debate in which climate change was either not mentioned at all or quickly sidelined as irrelevant to the most significant sources of disagreement between state actors, particularly those from industrialised states.

In the afternoon session, an intelligence report from its home government was distributed to the Russian delegation that a US-linked experimental aircraft was recovered in Russian territory near the Bering Strait equipped with a high-resolution camera, radiosonde-like (telemetry) equipment, and what appeared to be a specialised spray nozzle. The Russian assessment of the plane and equipment indicated undisclosed outdoor research likely conducted by US or US-linked actors on atmospheric disturbance in the Arctic and near-Arctic region. The Russian delegation immediately shared this report with the rest of the consultative body. A memo was also shared with the US security delegate confirming that the US had lost track of a research aircraft that was part of a research programme to enhance US defense and security posture in response to concerns about SRM research and development conducted by potentially hostile

actors. The memo also indicated that the research programme aimed to maintain the US' lead in military technological advancements and atmospheric interventions. The memo instructed the security delegate to maintain the position that the aircraft may be part of undisclosed Chinese or other research programmes until they had further intelligence and could assess the accuracy of Russian claims. It also instructed the security delegate not to disclose the research programme to the US diplomatic representative. The US delegation denied undisclosed research, suggested that China may be responsible, and questioned whether any information shared by Russia could be considered trustworthy. In the structured debate session, the response from the consultative body to Russian allegations was muted, however, state actors began requesting intelligence assessments from their home governments. China denied any knowledge or involvement with the recovered aircraft and suggested that US accusations against China were purposefully inflammatory. China expressed its concern that the Russian reports indicated actors operating in the north Pacific region were engaging in high risk behavior with negative implications for China.

From this point, accusations about undisclosed research programmes repeatedly derailed attempts to agree on a governance framework. While several state actors were sent memos reiterating their home governments' interest in developing a governance framework to prevent just such confusion and non-transparent research, they were unable to return focus to those principles and gain enough support for a public research fund or other transparency mechanisms. China's concern over unclear advances in US research led them to try to establish a coalition with developing states for technology sharing. The Russian delegate also began to sow uncertainty about the status of its own research programme and willingness to engage in disruptive activities. After China approached SpaceX to engage them on the subject of a technology sharing programme and more research investment, SpaceX immediately reported the overture to the US who read this as absolute confirmation that China was engaged in extensive outdoor experimentation and demanded an international investigation, which China rejected as a violation of its sovereignty. When other actors, particularly Canada, pointed out that the US had not accounted for reports of undisclosed research activity with potential transboundary effects, the US requested an additional investigation into geoengineering research and weather modification programmes in the Canadian Arctic and attributed any reports of research aircraft to work on the Golden Dome missile defense system the US is currently in the process of building.

Additional news items about unfolding climate change impacts continued to be distributed throughout the rest of the simulation, but they were not successful in refocusing debate on either climate or governing SRM as a potential climate intervention. There were two sets of principles formulated to bring to a vote in front of the consultative body before the end of the second day. The first was a more detailed attempt to capture the concerns reflected throughout the simulation drafted by Canada as the penholder, while the second was a vague formulation that would still indicate some commitment to continuing cooperation initially formulated by the US. Neither passed.

Missile gap dynamics and arms race parallels

- During the Cold War, the Kennedy administration justified US missile development on the basis that the Soviet Union had pulled dangerously ahead in missile capabilities despite having clear intelligence that no such 'missile gap' existed. This followed a similar 'bomber gap' narrative several years earlier in which the US Air Force came to mistakenly believe that the Soviet Union was pulling substantially ahead in the production of bomber jets which created a race to expand US capabilities, even after additional intelligence efforts confirmed no such gap existed (Preble, 2003).
- These examples show how a fear of falling behind an adversary with superior capabilities has been used to encourage public and congressional support for military investment and expansion (Thielmann, 2011).
- These fears, alongside domestic military, political, and economic interests, drove a Cold War superpower arms race. At its peak there were over 70,000 nuclear weapons in the world. The US alone developed enough nuclear weapons to conduct over 1.3 million Hiroshima bombings (Schwartz, 2008).

Observations and discussion

Actors perceived as being more powerful in the real world were at an advantage in achieving their aims and protecting their red lines. The states that were perceived as most powerful in the network (US, Russia, China) did not want an agreement that they perceived would place any limitations on their ability to develop or exercise control over SRM technological capabilities or interfere with their research priorities. They were willing to use a variety of tactics to defend those interests, including taking up simulation time to focus on voluntary, non-binding, and vague principles that would not create any meaningful constraints, and sowing confusion about the status and extent of rival powers' existing SRM research programmes. Given the 2/3rds majority rule in this simulation in which all participants had a vote, the other actors could have organised to override these tactics but were not able to develop an effective strategy to overcome the misdirection and stalling tactics that were employed by the major powers.

The fear of unilateral action was a valuable tool for keeping perceived opponents off balance and feeling insecure. This was especially the case for Russia, China, and the US. Debriefs from the Russian expert after the simulation indicated that they saw potential in creating uncertainty about Russia's capacities and the possibility of the threat of single-hemisphere deployment as potent sources of political leverage. Other great power actors indicated that this could become an arena for seeking competitive advantage against each other.

The UK was a particularly interesting actor in the simulation. It was able to maintain its red line of preventing a moratorium on research while it pushed hard on a governance framework as the best defence against riskier and unilateral action. It was unable to push anything across the finish line, however, and was under pressure from other state actors due to its economic and domestic interests, its vulnerable position in its security dependence on the US, as well as pressure from tech sector private actors. The UK was able to defend its role as a leader in SRM research due

largely to the interests of other actors in avoiding a substantive agreement that would limit research. However, it did not succeed in shaping any kind of viable governance framework that could pass due to lack of diplomatic clout. The UK was very constrained in how far it was able to differ from the US in a multilateral forum. This was also an issue for many other state actors, particularly within the EU/NATO/Five Eyes – the US provision of a security guarantee for these actors was a major liability as the US role players were prepared to threaten the security position of their nominal allies to get what they wanted if they faced any overt resistance.

The EU was also in a difficult structural position due to its relationship to the US and its member states. It preferred a precautionary approach and strong governance regime, but actors who preferred minimal regulation had a clear bargaining advantage because the status quo is minimal regulation. If those actors can continue to prevent robust governance, they can secure their own aims, even if that has negative global implications in the medium to long term.

Civil society organisations had more influence in this simulation than they would in the real world due to having a vote. While some state actors attempted to court them for their vote, civil society organisations were still largely sidelined. As agreements developed, actors assumed real-world conditions in which states wield the power to govern.

The reflections of participants and observations of the project investigators highlighted several noteworthy elements of the simulation. There was limited engagement throughout the simulation with the technical experts who had the scientific expertise to answer questions about the potential climate or environmental impacts of SRM, and at no point did any of the participants make use of the climate emulator. There was also a noted lack of discussion about climate or the environment more broadly throughout the simulation, despite numerous interventions from the project team and occasional attempts by network members to request the debates refocus on climate and the role of SRM techniques as a climate intervention. Debate instead tended to focus on questions of trust regarding the behavior of key state actors, particularly the US, China, and Russia, and how to assess the veracity of information from or about these actors. Although these elements presented difficulties when it came to fulfilling the pre-text of the simulation, they provide a valuable source of information about potential points of failure and deadlock decision-makers can anticipate when it comes to negotiating SRM governance.

As interpersonal relationships developed between participants and they became more comfortable engaging with each other, several actors identified potential partnerships or coalitions but these did not necessarily indicate pathways forward to an acceptable agreement. There was an overtly antagonistic relationship between the US and China delegations that frequently derailed debates. Many participants noted that the US delegation had prepared an effective strategy to enable them to dominate discussions and derail any proposals or openings in negotiations that they opposed. They were able to exploit the perception that they were the most powerful actors in the room due to their real-world positioning, despite the fact that they held no practical advantage in voting. Overall, several participants noted that the experience of trying to work through the complex challenges posed by SRM governance gave them a deeper understanding of the political difficulties presented by the technologies.

This was true even of participants with deep familiarity with SRM, one of whom stated: "Overall, the simulation hammered home something I'd understood intellectually but hadn't really felt viscerally – even when everyone nominally wants to avoid climate catastrophe, translating that into coordinated action is brutally difficult. The gap between "we should do something" and "we agree on this specific thing" is enormous, and every actor brings their own constraints, histories, and information bubbles to the table. Very sobering."

Chapter 2: In-depth discussion of Simulation 2

Simulation description

This workshop moved the timeline ahead to September 2027 (two years after Simulation 1) and started with the background condition that Arctic sea ice was at its lowest level ever recorded. The pretext for this simulation was a consultative forum convened by the Arctic Council to encourage the group to continue its efforts to develop SRM governance recommendations in the context of increasing environmental and political instability in the region. This simulation took a crisis committee approach in which a series of crises related to Arctic climate and geopolitics unfolded. The investigators' aim was to observe how these unfolding crises shaped, reshaped, and potentially derailed actors' relationship with one another and their willingness to negotiate on SRM governance.

Research question: How does melting polar ice alter the geopolitical context that informs SRM research and potential deployment given increasing geopolitical contestation over the region?

Actors present and voting day 1: The United States; Russia; China; Germany; France; The Netherlands; Denmark; Finland; Canada; South Africa; India; Mexico; The United Kingdom; European Union Institutional Representative; The Climate Overshoot Commission; IPCC Institutional Representative; SRM Technical Advisor and Emulator Operator; Developing Nations Scientific Advisor; Arctic Indigenous Peoples Representative; Climate Futures Cooperative civil society organisation (fossil fuel plant); The Arctic Council Institutional Representative.

Actors present and voting day 2: The United States; Russia; China; Germany; France; The Netherlands; Denmark; Finland; Canada; South Africa; India; Mexico; The United Kingdom; European Union Institutional Representative; The Climate Overshoot Commission; IPCC Institutional Representative; SRM Technical Advisor and Emulator Operator; Developing Nations Scientific Advisor; Arctic Indigenous Peoples Representative; Climate Futures Cooperative civil society organisation (fossil fuel plant); The Arctic Council Institutional Representative.

Actors contributing remotely: Technology Sector investor; SpaceX.

Voting procedure: ⅔ majority of all actors to pass substantive measures; simple majority for procedural votes

For seating chart see Annex 1, page 5

Simulation narrative

As with the first simulation, each participant was sent an updated role profile to guide their approach to role-playing in the simulation. While each profile outlined aims and red lines, participants were free to interpret and play their role as they saw fit based on their expertise and understanding. The network members were again notified that a SRM climate modeler in the group had a climate emulator available for them to consult about potential climate outcomes of any decisions or agreements. Rather than a 'cooperative' committee game, this simulation was designed based on a crisis approach in which participants were confronted with a series of quickly unfolding crises, many interlinked, that required their attention while they debated and negotiated SRM governance in the Arctic context. The aim of this approach was to observe whether and how a higher-paced, more intense information environment influenced cooperation and how the network was able or unable to navigate or incorporate crises while negotiating a potential governance agreement.

This simulation moved the network forward in time to September of 2027. The starting pre-text of this simulation was an invitation to participate in a consultative forum on international cooperation and global governance in the context of accelerated warming in the Arctic and growing interest in potential geoengineering interventions. Due to the focus on the Arctic region and its issues, organisers added regional actors including Arctic states Denmark and Finland, an Arctic Council Representative, and an Arctic Indigenous Peoples Representative. The simulation started with an opening statement from the participant representing the Arctic Council, a high-level intergovernmental forum comprising the eight Arctic states, six Permanent Participants representing the Indigenous Peoples of the Arctic, and 13 non-Arctic state observers. Prior to the simulation, all participants had been briefed on climate conditions in the Arctic, important climate teleconnections (Lindsey, 2011; Osho 2025; Meng et al., 2023) beyond the Arctic region, and the Arctic's significance as a site of climate research and observations. Network members also received an overview of the Arctic's history, its social and political conditions, increasing external investments and interest from outside the region, and the geopolitical significance and militarisation of the region. While several network members were recruited on the basis of their specific expertise on the Arctic, network meetings prior to the simulation focused on ensuring all participants shared a reasonable baseline of knowledge about the region. For the purposes of this simulation, due to network participant constraints, representatives from the tech sector reported that they were holding a parallel summit on moving forward with technology development and would rejoin for simulation 3.

Within the simulation universe, participants were provided with several updates about what had occurred during the two years between Simulation 1 and 2. First, Denmark had negotiated a fragile agreement with the US that allowed the US more substantial presence and influence over Greenland without ceding their claim to the territory. The agreement was based on the real-world bi-lateral Defense Cooperation Agreements with the United States signed in 2024 that grants the US unimpeded access to key military facilities, airspace, airports, and other transport infrastructure. It also gave the US permission to place weapons and other military equipment and personnel in these facilities. Norway (2022), Sweden (2024), and Finland (2025) have also signed DCAs with the US with the same terms, which was noted to participants (Davis, 2025). In addition, Russia had concluded a ceasefire agreement with Ukraine to allow them to engage with the Arctic Council. Finally, while Donald Trump is still US President, US midterm elections in 2026 gave Democrats a narrow margin in the US Congress.

The Arctic Council representative contextualised the meeting in their opening remarks by noting the recording of the first ice-free summer day ahead of anticipated regional projections. They also articulated increasing concern over the melting of the Greenland ice sheet, permafrost thaws causing landslides affecting the region's infrastructure including military bases, and the danger of previously dormant pathogens locked in Arctic ice being released (Wu et al., 2022). The Arctic Council representative emphasised the need to focus on science-based decisions and cooperative cross-border governance and framed the impetus for the meeting around the release of the Arctic Monitoring and Assessment Programme (AMAP) report on SRM following their scoping activities on the subject[2].

Following the Arctic Council Representative's opening remarks, other participants moved into structured debate without additional formal opening statements. The US immediately stated that its primary focus was national security and that the Arctic Council had become distracted by the 'hoax of climate change' and should instead focus on matters of strategic security importance or the US would use force as necessary to defend the stability of the Arctic and secure it from outside interference. The Arctic Council attempted to re-direct by emphasising that the Ottawa Declaration that established the Arctic Council explicitly states that the Council should not deal with matters related to military security. Russia also emphasised that while they hoped for international cooperation in the region, respect for Arctic states' national sovereignty was paramount. China insisted that all decisions and actions in the region should be science-based and globally representative because the Arctic is a key part of the global climate system.

The IPCC representative attempted to intervene to refocus the discussion on climate and the inclusion of diverse stakeholders in the regions, particularly Indigenous populations. At this point, the project team began introducing information into the simulation about the first regional crisis: a distress signal from an ice-fortified research vessel in the Green Peace fleet 250 nautical miles north of Svalbard. The vessel was crewed by Canadian and American nationals. News reports indicated that footage from the camera feed of the ship's mast was released on social media showing an explosion. Green Peace supporters were reported to have posted online that they believed the vessel was attacked. Intelligence assessments were shared with different state actors. Reports to Canada and Finland suggested that Russian-based private security companies were involved in retaliation against Green Peace operations opposing Russian exploratory drilling in the region, while the US assessed the incident to be a publicity stunt gone wrong by climate activists. Russia and China assessed that US-linked actors instigated the incident in retaliation for protests against solar geoengineering research in the Arctic region, which the Trump administration believed threatened their security interests.

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[2] AMAP is currently (2026) engaged in these scoping activities on SRM; for the purposes of the simulation timeline the Arctic Council Representative treated the report as having been published given the real-world timeline for AMAP activities.

The structured and unstructured discussions then continued on two tracks for the next several hours. In one track, there was contention amongst the Arctic states over who would be responsible for any attacks on the Green Peace vessel and rescue operations, with Canada launching a fact finding mission and Canada, Finland, and Denmark cooperating on a rescue operation with the support of the Arctic Coastguard Forum suggested by the Arctic Council. The US used the incident to reiterate that it would not accept any destabilisation of the region. On the second track, participants attempted to maintain focus on climate issues in the region and progress towards recommendations for an SRM governance framework. Some participants called for establishing a formal mechanism to investigate and communicate SRM science.

However, there was frequent debate about whether potential SRM research and development initiatives in the Arctic should be led by Arctic states and Indigenous stakeholders or be more inclusive and globally representative since any Arctic interventions would have significant implications beyond the region. In particular, China and India continually interjected that SRM is not a regional issue, even if the research or interventions considered are located in the Arctic. The emphasis on the need for scientific research repeatedly led to a back and forth between the US and other delegates about the need to prioritise strategic and security concerns rather than climate and to prevent outside interference in the region under the cover of scientific research.

Participants successfully voted on a motion to hold the first of several Q&A sessions with the science advisors about climate and SRM in the region. The advisors emphasised that the Arctic plays a key role in climate dynamics globally and that there are climate dynamics that are not fully understood. In addition, they expressed uncertainty about how climate interventions such as SAI, MCBT, or sea ice thickening (SIT) may affect those dynamics. CFC (fossil fuel plant) asked several times about the implications for Arctic sea ice cover and navigability of shipping routes in the region.

Over the next nine hours of the simulation, information about additional incidents in the region were released to participants as they continued to negotiate governance recommendations:

1. Protests and encampments organised by Indigenous communities outside the Esrange Space Center after reports that researchers formerly affiliated with the Stratospheric Controlled Perturbation Experiment (SCoPEx) had reprised their efforts to launch high-altitude balloons from the Esrange Space Center located outside of Kiruna, Sweden, to carry equipment into the stratosphere for small-scale experiments on the dispersal of reflective particles. The unrest escalated into violent clashes between protesters and security personnel. Groups around the world organised mass protests in solidarity. On X, Donald Trump suggested the protests were sponsored by ecoterrorists. This thread elicited almost no engagement from actors.

2. Reports that record high temperatures in the Russian Arctic had led to unprecedented thawing in the region. The report indicates that high temperatures and thaws had intensified Russian authorities' interest in capitalising on their potential to control the Northern Sea Route. However, thaws had also led to subsidence issues, infrastructure damage, and concerns about the potential for thawing permafrost to release pathogens and significant amounts of methane and other GHGs in the region. News reports introduced early indicators that a new pathogen had emerged and was spreading into China via migrant workers. Updates regarding this novel disease outbreak and spread were threaded throughout the simulation but only received limited attention from participants in the context of highlighting lack of trust in information reports and each other.

3. Separate reports of chronic illnesses among Greenlanders near a former US base linked to radioactive waste. The report indicated growing concern that a cluster of chronic illness in Greenland had been caused by radiation exposure connected to melting permafrost on the island. In these reports, a number of Greenlanders from Qaanaaq that hunt near the former US Camp Century site had shown signs of Chronic Radiation Syndrome (CRS), including eye cataracts and muscle and skin atrophy. Some actors responded with sympathy but there was limited substantive engagement.

Legacies of great power competition in the Arctic: Radioactive fallout and toxic waste materials

- The abandoned Camp Century US military site includes substantial amounts of nuclear waste and radioactive material in addition to other toxic industrial waste products. Accelerated warming in Greenland will eventually lead to increased exposure of waste materials without remediation (Colgan et al., 2016; Miner et al., 2021).

- Previous scientific assessments have warned that as permafrost thaws throughout the Arctic region, nuclear waste and materials from abandoned reactors and tests will increase risk of radiation exposure for local populations, in addition to increased health burdens from other toxic industrial waste materials left in the region (Miner et al, 2021). In addition, Arctic Indigenous populations throughout the region have been documented experiencing higher levels of radiation exposure, particularly the male reindeer herders in the Saami community in Northern Finland (Nuclear Princeton, no date).

- Scientists have also detected increased levels of radioactivity near former nuclear testing sites, particularly on Novaya Zemlya, a Russian testing site (Kubny, 2025). Russia has indicated an interest in resuming outdoor testing on Novaya Zemlya in response to an expression of interest in renewed outdoor nuclear testing by the Trump administration (Williams and Mackenzie, 2025). This could increase radiation exposure throughout the region.

4. A reported explosion at the Dr. Neil Trivett Global Atmosphere Watch Observatory located outside of Alert, Canada. The observatory is an atmospheric baseline station and is one of three greenhouse gas intercomparison supersites. It also maintains continuous measurement programmes that monitor aerosols, ozone, mercury, and albedo and is known for experimental testing of monitoring equipment and intensive short-term research such as NETCARE (Network on Climate and Aerosols: Addressing Key Uncertainties in Remote Canadian Environments). Work at the observatory is highly collaborative with long-standing partnerships with institutions in the US, Australia, Germany, and throughout Canada. It is also part of the World Meteorological Organization's Global Atmosphere Watch Programme. The report also noted that the observatory is located 6 km from the Canadian Forces Station Alert, a signal intelligence intercept facility. This received some limited engagement as actors scrambled to clarify what happened.

5. Reports of tensions over Svalbard between Norway and Russia due to disputes over fishing rights near the island. A Norwegian official accused Russian fishing vessels of violating international law by overfishing its quota in the vicinity of Svalbard. Norwegian insistence that the fishing vessels must stop overfishing have repeatedly been ignored. The report also suggests that Russian authorities have condoned if not encouraged these violations. This crisis also introduced attacks by Russian partisans on the Svalbard Satellite Station (SvalSat) that caused damage to its download capabilities. This thread received substantial engagement but not focused on the damage to SvalSat.

Monitoring and verification contingencies: The Svalbard Satellite Station (SvalSat) simulation case study

- The Svalbard Satellite Station, or SvalSat, is a satellite ground station located in Spitsbergen, the largest island of the Svalbard archipelago. SvalSat is situated on a mountain plateau 400 to 500 meters above sea level, and about 10 kilometers outside Svalbard's administrative center Longyearbyen. The facility is the largest commercial ground station in the world with more than 150 antenna systems. Svalbard's high latitude location in the Arctic means that the station can see every polar-orbiting satellite above 500 kilometers on every revolution as the earth rotates. In fact, it is the only commercial ground station that is able to downlink data from and provide support to satellites on all orbits (Kongsberg Satellite Services, no date). Due to this, SvalSat is essential to global satellite infrastructure and to the downloading of data to support NASA, the European Space Agency, and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) (United States Geological Survey, no date; European Space Agency, no date).

- In addition, SvalSat is responsible for downloading data from the Tropospheric Monitoring Instrument (TROPOMI) which monitors atmospheric composition and will be key to monitoring the effects of research and deployment of solar radiation modification (Lakalla et al., 2020). In November 2021, Russia explicitly stated that it considered satellite infrastructure on Svalbard, including SvalSat, a violation of the Svalbard Treaty. Article 9 of the Treaty prohibits the use of Svalbard "for warlike purposes", and it is not always easy to distinguish between the use of satellite data for scientific and military purposes. For example, during the 2003 Iraq War, the station contributed to American military operations by providing data on sandstorm forecasts which some observers interpreted as a violation of the Treaty. The dual-use potential of satellite downloads from SvalSat are one of several political pressure points between Russia and other Arctic states and actors interested in the region (Van der Wal, 2025).

- Under the 1920 Svalbard Treaty, signatories (including Russia, Canada, Denmark, France, the United Kingdom, and the US) all recognise Norway's exclusive sovereignty over Svalbard. However, in January of 2026, in response to US plans to assert more extensive control over Greenland, a Russian lawmaker and former senior military officer publicly argued that Russia should then move to annex the Svalbard Archipelago (Taub, 2026).

- SvalSat and Svalbard more broadly are reliant on undersea fibre cables for internet connectivity and maintaining the flow of data from SvalSat. In January of 2022, one of the two undersea cables was cut. This caused immediate speculation that the cable was intentionally sabotaged in response to increasing geopolitical tensions in the region in the lead up to Russia's invasion of Ukraine. Intentional sabotage has not been proven, and the primary cause of undersea cable damage world-wide remains unintended harm from fishing and shipping activity. However, the cable cut has led to renewed political attention to this vulnerability because if both cables to Svalbard are cut the data flow between SvalSat and the mainland would cease, in addition to serious impacts for Svalbard such as limitations on air traffic and connectivity (Nagelhus Schia et al, 2023).

6. Reports of a Russian 'shadow-fleet' tanker collision with sea ice causing a large oil spill that lead to an incursion of oil into the fishery protection zone (FPZ) around Svalbard and concern about further spread into Norwegian territorial waters.

7. Reports of large scale boreal fires in the US and Canadian Arctic. This received no engagement from actors.

An environmental and geopolitical pressure point? The Russian 'shadow fleet'

- The 'shadow fleet' includes hundreds of ships, mainly oil tankers, that are often falsely flagged (Lin, 2025). Some are un-insured and many are poorly maintained, which pose enhanced risks for collisions and oil spills (Braw, 2024).
- In addition, recent data analyses of the Automatic Identification System mandated by the International Maritime Organization's maritime treaty International Convention for the Safety of Life at Sea or SOLAS has shown that Russia has been manipulating their positional data by jamming location signals and turning off their tracking systems with substantially increased frequency since the start of the war in Ukraine in 2022 (Bergman, 2023; Lloyd's List Intelligence, 2026). The Russian Federation ratified SOLAS in 1979, but since its invasion of Ukraine it has increasingly relied on its shadow fleet.
- In addition to funding its war efforts, there is also serious growing concern that the shadow fleet is and will continue to engage in sabotage activities against critical subsea infrastructure such as fibre cables that enable connectivity and data transfer throughout the region and beyond (Brown, 2025).

The purpose of introducing these multiple and overlapping crises was to highlight the geopolitical complexity of the region, observe what issues received the most attention and why, and assess how these dynamics shaped discussions about SRM governance. The complexities explored included the importance and contestation over research and monitoring; environmental and health impacts from a warming Arctic leading to melting permafrost and ice sheets; the long-term implications of military activity, particularly tensions between Russia and other Arctic states; the inclusion or marginalisation of Indigenous rights and interests; and the significance of freedom of navigation and maritime law.

As information about these incidents was released over time, participants continued attempts to negotiate while requesting additional intelligence and information both from project organisers and each other about any events that raised potential security and political concerns. Most participants did not engage with any reported climate implications such as substantial release of methane and GHGs from permafrost melt, accelerated ice sheet melt indicated by the exposure of pathogens and potential radioactive waste, or large-scale Boreal fires. The science advisors also noted that state actors did not register the severity of the implications for research capacity presented by attacks on SvalSat in particular but were instead focused on perceived threats to sovereignty and security in the region – not limited to 'climate security.' There was more engagement with the science advisors and direct questions about SRM research and science.

However, the perception of the advisors was that the information they provided was being used as leverage to block politically undesirable governance principles and discredit perceived adversaries.

Arctic states apart from the US and Russia were able to build trust and sustain cooperation amongst themselves and with additional EU and NATO countries. China and India registered repeated complaints that they and other developing states were being sidelined in discussions despite the global implications of climate change and intervention in the Arctic, particularly for monsoons in the Indian Ocean. China focused on trying to build a coalition, with some support from South Africa and India, to shape the formulation of governance recommendations to put forward amongst developing states. This coalition also worked with the science advisors, IPCC, and civil society organisations to try and re-ground the discussions around climate science and SRM, with limited success.

The Arctic Indigenous Representative was active throughout the simulation and insisted that Indigenous priorities and rights in the region should be respected, with most state and non-state delegates voicing strong support for their position. However, the delegate noted that when agreements were being negotiated and when geopolitical tensions escalated, Indigenous interests were quickly sidelined, calling out a persistent pattern of superficial inclusion and substantive exclusion by states.

The Arctic Council was able to formulate a proposal for SRM research governance amongst its own members. However, the US eventually scuttled this agreement by withdrawing. The US delegation noted in its debrief that it had intentionally worked with other Arctic Council members to develop an SRM governance proposal, insisting on the principles agreed to in the proposal to bind the other members while working under the assumption the proposal would in effect be non-binding for the US.

The China delegation also put forward a proposal on Principles for Responsible SRM Research that it had developed in close collaboration with India and South Africa, in addition to seeking input from other participants. While much of the content of the proposal seemed acceptable to a range of participants, the proposal did not garner enough support to pass. The US would not support the proposal, and US allies such as the UK clarified they would not be able to support a proposal led by China despite increasing tensions within their alliance relationship with the US. The US consistently refused to engage with SRM as a climate intervention while asserting its right to remain free of restraints on research and technology development. More importantly, it insisted that the focus of discussions remain fixed on the Arctic as a strategically significant region. They prioritised resisting any incursions from China or interference from other outside actors and countering Russia's destabilising influence. Most news items were framed by the US delegation as mounting evidence of insecurity and instability that justified a greater assertion of control by them in the region. After the report of attacks on SvalSat by Russian partisans, the US proposed a special session on security in the Arctic which passed with China and Russia voting against. During the special security session, other state delegates emphasised that climate change was a primary security issue for the region, even apart from questions of national sovereignty. The question was raised by several participants as to whether states trusted each other to engage in SRM research. The US brought the special session on security to an end by declaring that the focus on climate change demonstrated that other actors were incapable

of being serious security guarantors in the region and announced that they would move to purchase or otherwise take over Greenland. The US later clarified that they intended to 'assert dominance' over Greenland.

US actions led to escalating tensions and an agreement to abandon further negotiations on SRM governance and oversight, overriding an attempt by China to suggest that this 'regional' issue should not impede discussion on SRM as a global issue.

Observations and discussion

The Arctic is increasingly becoming an area of interest for potential climate interventions or 'stabilisation' methods, including SRM. However, this simulation highlighted social, political, and environmental complexities that are difficult to disentangle or navigate even for Arctic actors. The research team's starting hypothesis for this simulation was that a design that asked network participants to confront a series of crises to respond to might encourage cooperation and build trust between the actors. We wanted to observe whether cooperation to resolve smaller, time-sensitive crises (such as rescuing survivors of a maritime disaster) would, in turn, enable more effective cooperation to develop an SRM governance framework. Crisis management and collective action literatures suggest that a transboundary crisis can spur cooperation between state actors, although the pathways for this are not always clear and states sometimes fail to act (Blondin and Boin, 2020). The research team also wanted to test whether the pace and complexity of related crises would have an effect on the cooperative capacities of the network.

Members of the network did manage to develop an effective response to the first crisis that was introduced into the simulation, but broad cooperation became more challenging over the course of the simulation and some participants noted that the pace of unfolding crises served to derail negotiations. The US delegation acted as a spoiler during several key crisis points when NATO and Arctic Council states negotiated agreements on how to respond to crisis conditions in the region and formulate a governance framework for SRM. While the Arctic Council states did come close to an agreement on SRM governance principles for the region, this ultimately fell apart due to the US withdrawal from the agreement and the move to annex Greenland. Non-Arctic state representatives noted that Arctic Council state cooperation actually caused some wider divisions in the network. India in particular noted that, given the climate and environmental implications of Arctic teleconnections, leaving governance of SRM in the region to the Arctic states presented unacceptable risks to states outside of the region. Some non-Arctic states, such as Mexico, did try to maintain relevance with actors in the region by attempting to serve as a mediator between key states as tensions rose but with limited success. Mexico noted that "The power imbalances among actors made it very difficult to have much influence beyond symbolic support."

The simulation provided some insights into the potential negotiating positions of key actors. China attempted to adopt a cooperative tone on SRM while positioning itself as a key future actor in the region, but its efforts were largely met with suspicion by Arctic states and the US heavily pressured those states to oppose influence from China. This prompted China to seek alignment with developing state actors who felt excluded from debates over Arctic SRM development, including India, South Africa, and Mexico. At the same time, the US, while continuing to disavow the reality of climate change as a problem, seized on concerns articulated about security in the region to justify territorial expansion in the Arctic (annexing Greenland) and SRM technological development to secure the atmosphere from 'rogue' actors. The US's behavior during the simulation closely mirrored their real-world actions and rhetoric in the region in January of 2026. While the US has not annexed Greenland, the current administration has continued to express an interest in controlling the territory for reasons of national security (Brueninger and Meredith, 2026). This behavior may place increasing pressure on the NATO alliance and raises questions about how other Arctic states and NATO members will position themselves in the region in relation to the US on a range of interconnected issues, including SRM. Amid these tensions, the interests of Arctic Indigenous communities – although frequently acknowledged – were ultimately sidelined as negotiations among state actors intensified, reinforcing a familiar pattern of symbolic inclusion but limited influence in substantive decision-making. The state actors also tended to ignore the climate and environmental implications of the crises introduced, as well as their downstream impacts on capacities to conduct scientific research. A network climate science advisor noted with alarm that the state actors completely ignored indications that melting permafrost had reached a tipping point threshold in which methane and other GHGs release had substantially accelerated, and did not seem interested in the loss of climate and earth observation data that would be caused by attacks on SvalSat or other observatories, stating that: "an increasingly aggressive situation seemed to implicitly suggest that no research groups could safely carry out research…science was totally lost to issues of national sovereignty and geopolitical control."

Participants also acknowledged that while they recognised that slowly unfolding crises such as reports of disease outbreak and spread were important and demanded intensive cooperation and collaboration, it became increasingly difficult throughout the simulation to sustain cooperation or address anything but immediate security concerns. Information overload stretched participants' ability to pay attention to and process complex scenarios and pushed participants to prioritise more immediate, security-oriented events. All this led to more difficult paths to cooperation. As one stated: "[i]t can be quite difficult to assess the position and priorities of other parties, which can make trust and cooperation quite difficult."

Chapter 3: In-depth discussion of Simulation 3

Simulation description

This simulation moved forward in time to September 2028, with the starting pre-text that SRM research and development had proceeded without an effective international governance framework in place. This simulation combined the committee game and crisis approach of the previous two simulations. The network members were again notified that a SRM climate modeler in the group had a climate emulator available for them to consult about potential climate outcomes of any decisions or agreements. In addition, participants were given an hour-long introduction to emulators in an online session and a written primer (see Annex 2).

Research question: How will key international actors respond to reports of large-scale SRM testing or deployment without a binding governance framework?

Actors present day 1: The United States; Russia; China; France; Germany; Mexico; Kenya; Ghana; South Africa; India; Brazil; Canada; Denmark; Finland; The United Arab Emirates; European Union Institutional Representative; The Climate Overshoot Commission; IPCC Institutional Representative; SRM Technical Advisor and Emulator Operator; Developing Nations Scientific Advisor; Indigenous Peoples Representative; Climate Futures Cooperative civil society organisation (fossil fuel plant); Climate Finance excerpt advisor; Arms Control expert advisor; SpaceX; Stardust Solutions.

Actors present day 2: The United States; Russia; China; France; Germany; Mexico; Kenya; Ghana; South Africa; India; Brazil; Canada; Denmark; Finland; The United Arab Emirates; European Union Institutional Representative; The Climate Overshoot Commission; IPCC Institutional Representative; SRM Technical Advisor and Emulator Operator; Developing Nations Scientific Advisor; Indigenous Peoples Representative; Climate Futures Cooperative civil society organisation (fossil fuel plant); ETC Group climate activist organisation representative; Climate Finance excerpt advisor; Arms Control expert advisor; SpaceX; Stardust Solutions.

Voting procedure: Consensus voting procedures in place for substantive decisions; only state actors can vote.

For seating chart see Annex 1, pages 7–8

Simulation narrative

This simulation took a mixed approach in which participants again engaged in a cooperative committee game with updates about the destructive environmental impacts of climate change, developments in the SRM research space, and news about the broader geopolitical context to observe whether and how participants responded to and incorporated information into their negotiations. Network members had an online meeting prior to this simulation that provided an overview of the role of monitoring and verification in a range of governance regimes, as well as background on available assessments of SRM monitoring and detection requirements. Additional participants were recruited to provide more geographic representation from Africa, South America, and the Gulf Region, and representation of Stardust Solutions was added as a key actor in the SRM research and development landscape. Voting procedures were changed to require a consensus, with only state actors having a vote. The research team removed the vote from non-state actors in the room to better reflect real-world conditions and to observe if a switch to consensus voting would be more or less empowering and inclusive for state actors. The simulation also added designated expert panels into the schedule on both days that included the network climate science advisors, arms control expert, and climate finance advisor. In previous simulations, participants directly questioned technical experts but the experts noted in those sessions that they felt network members were merely attempting to leverage their expertise to block agreements they found politically undesirable or to discredit their adversaries. By introducing dedicated expert panels, the research team aimed to assess whether providing a formal institutional forum might change how their information was received and acted upon. Part of this simulation design focused on testing whether or how action on monitoring and detection might emerge or be implemented under conditions of international political instability in a complex information environment. This reflected discussions in the prior two simulations in which participants raised the need for effective monitoring and detection capabilities for SRM as part of a governance framework.

Participants were again asked to provide 60 second opening statements, which were followed by a period of unstructured discussion in which participants sought out support for initial proposals on global monitoring for SRM. During this time, several news updates were distributed highlighting record deaths from high temperatures around the world, ongoing disputes about technological sovereignty driven by concern over US-based tech companies alignment with the Trump administration, and updates about ongoing concerns from the previous simulation about radiation exposure amongst Arctic Indigenous communities. This was followed by a panel with the technical experts to start an informed discussion on comparative governance regimes and pathways, and to revisit and reinforce the scientific basis of SRM research and the global implications of large-scale testing and deployment.

After the opening expert panel, a news release was shared to set the conditions for the negotiations that followed:

- A large aerosol plume has been reported over the Persian Gulf by satellites monitoring Iran for nuclear tests. Preliminary information is hazy but suggests the plume is larger than what could be produced by a small-scale experiment, but does not indicate a nuclear explosion. The detection of the plume comes after increased speculation that US-incorporated tech company Stardust Solutions is moving forward with plans for large-scale outdoor testing of Stratospheric Aerosol Injection with its proprietary particle and other equipment patented in 2026.
- However, some experts recommend caution in jumping to conclusions that this represents an unauthorised large-scale injection test of aerosols into the stratosphere. There is a possibility that this is evidence of weapons testing from one of the states on the shores of the Persian Gulf; there are also active volcanoes in the region and beyond able to spread quantities of aerosols and ash.[3]
- The ability to monitor and verify SRM deployment has been challenging since the attacks on the SvalSat ground stations in September 2027 that damaged the station's capabilities. The issue has been further complicated by the break-up of the National Center for Atmospheric Research in the US, which has caused disruptions to the collection of earth observation data.[4]

Alongside that, a news release announced a possible volcanic eruption in the North Pacific that has caused flights to be rerouted. This injection was designed to sow further doubt about the attribution of sulfur plumes and aerosols in the Persian Gulf.

At this point, formal discussions continued while additional intelligence was distributed to individual participants upon request. It was confirmed to the US delegation that the US had reached a confidential agreement with Saudi Arabia to support their outdoor trial of advanced aerosol delivery equipment in partnership with Stardust in the Gulf region.[5] The agreement was confidential and both Stardust and the US denied knowledge or involvement. At that point, Stardust took the opportunity to highlight why an agreement on monitoring and detection is vital to prevent negative impacts from false or unverified information. The US pointed fingers at China. Russia, China, and the UAE were given intelligence that Saudi Arabia may be engaged in outdoor SAI trials but they awaited confirmation. By design, there was no confirmed intelligence to indicate US involvement available at that point.

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[3] Mount Taftan in Iran is an active stratovolcano in Iran and Eritrean volcanic eruptions are capable of spreading ash and aerosols in the Gulf region.

[4] The damage to SvalSat was carried over from the previous simulation set in the Arctic and simulation 3 takes as a given that the real-world Trump administration efforts to break up NCAR have come to pass in order to emphasise vulnerabilities in observation and monitoring capabilities.

[5] The premise of this intervention was inspired by part of the scenario outlined by Patrick Keys and Curtis Bell (Keys and Bell, 2024).

The reports of what could be a large-scale outdoor test spurred participants to redouble their focus on the issue of monitoring and detection. At the same time India announced they planned to host a tech summit to focus on climate action and emerging technologies, including monitoring, in partnership with the Climate Futures Cooperation (the fossil fuel misinformation agent) to ensure more active engagement of developing nations, civil society, and the technology sector. There was a moderated discussion on the need to establish monitoring and reporting systems to prevent unilateral and uncoordinated action with general agreement from the entire body. However, immediate points of contestation emerged. Some actors voiced concerns about the role of private actors in the proposed India summit and beyond, and that the summit may be a distraction from delivering effective governance.

The more central disputes concerned:

1. Financing for monitoring capacity, particularly for Global South actors.
2. What kind of monitoring infrastructure was needed or available.
3. What would be monitored and how information would be reported.
4. The relationship between any monitoring capabilities and basic research funding.

Before a break for informal discussion, there seemed to be agreement coalescing around the need for some sort of oversight mechanism for research as well as provision for monitoring infrastructure to verify any activity with the potential for atmospheric perturbation. During the unmoderated discussion there was a noticeable split in the room in which China took the lead on drafting a set of agreed principles in coordination with Brazil, South Africa, and Russia. They were soon joined by India, Ghana, and Mexico while other subsets of participants attempted to collaborate on alternative proposals.

Despite its continuing refusal to acknowledge SRM's potential as a climate intervention or indeed climate change as a problem, the US led the development of a proposal while devolving much of the responsibility for negotiating support for their proposal to Canada. The proposal, Global Atmospheric Monitoring and Benchmarking Initiative for Technology (GAMBIT) focused on basic atmospheric research and monitoring with no mention of climate or any explicit reference to SRM. The proposal also hinged on voluntary participation, without any binding enforcement mechanism, and preservation of national sovereignty as determined by all parties to the agreement.

This proposal raised immediate concern about lack of inclusion of developing states in the initial drafting. There were also immediate questions raised by both developing states and EU states about why the US would want to lead on a proposal for the body while refusing to acknowledge climate change and insisting it was a waste of time and resources to focus any attention or resources on climate. The US remained consistent in its position throughout the simulation that SRM and atmospheric research and monitoring were issues of national security and strategic readiness, emphasising their interest in maintaining leadership in technology development. From this point forward, every iteration of the GAMBIT proposal also raised the objection from other participants that its focus on monitoring technology and infrastructure came at the expense of developing an effective governance framework that accounted for the transboundary and sometimes global effects of SRM. France in particular objected to the proposal by characterising it as a project between willing partners rather than an articulation of principles that could serve as the basis for governance or decisions about what needed to be monitored, how

to monitor, and for what purpose. This was seconded by other EU states and developing states apart from Ghana, who was more open to negotiating changes to the GAMBIT proposal. France and other participants who withheld support from GAMBIT argued that any proposal needed to address key issues including international legal norms, information sharing, and governance of non-sovereign territories. The UK remained consistent in its support for the proposal because of its interest in developing effective monitoring infrastructure and technology although it was also interested in supporting additional proposals that would directly address governance of SRM research and development.

In addition, China raised concerns that the GAMBIT proposal was a cover for the advance of US military priorities, particularly strengthening its surveillance capacities over adversaries and nominal allies.[6] This concern was echoed and underlined by others at several points throughout the simulation as participants questioned the SRM technical expert on the role of military technologies in SRM monitoring and research. The expert indicated that the military has access to superior satellite resolutions. Russia did not support the GAMBIT proposal at any stage, both due to its interest in appearing to remain in close alignment with China and its interest in promoting distrust of the US, but it joined the US and UK in underlining its interest in a voluntary, non-constraining framework.

During an informal session, the UAE brokered a meeting with the US and China in which the US tried to ensure support for GAMBIT from China or for China to abstain. China refused on principle because it did not want to deliver a win to the US. Ghana negotiated closely with Canada and other GAMBIT supporters to incorporate provisions into the proposal that would enable Ghana and others to vote for it, including that GAMBIT would be hosted in part in Nairobi to ensure oversight from UNEP and in Geneva for WMO involvement. The US rejected any oversight, particularly from UNEP. This, in addition to ongoing concerns about the role of private sector tech companies in GAMBIT, eventually led Ghana to give up on negotiating a path towards supporting the proposal.

There were two additional proposals formulated and brought to a vote, in addition to the GAMBIT proposal, though both also failed.

The first was a proposal led by Kenya submitted to a vote on both days that called for a moratorium on SRM testing and deployment until a governance framework was in effect. Although this proposal was quite brief, it was subject to extensive negotiation between a number of participants, some of whom explicitly engaged with it as a form of relationship building amongst negotiators and an opportunity to refine and reconcile understandings of key terminology and issues. The proposal lead and supporters were aware at every point that the US would block the adoption of the proposal but they believed it was useful to bring versions of the proposal to a vote as a way of getting a record of who was willing to cooperate and engage on core governance issues. As noted in the observations below, several participants disclosed that they were only able to vote in support of the moratorium proposal because they knew the US would block its passage, but they recognised an interest in maintaining cooperative relations with as many participants as possible.

[6] This was suggested by China prior to the introduction of a news update about a US military surveillance network of allies and other state actors–the China experts accurately anticipated this intervention from the research team.

The other was the BRICS+ proposal, led by China. This proposal sought to be inclusive of all the BRICS as well as other developing states (Mexico, Ghana, Kenya) and any other potential votes it could enlist. In the BRICS+ discussions the proposal focused on the need for governance while also balancing interests in protecting possibilities for research and defending national sovereignty. Brazil pushed for preservation and promotion of SRM research. South Africa and Ghana placed an emphasis on the need to use existing national infrastructure in their states and address gaps in financing capacities for developing states, although sovereignty remained a key concern with China and Russia focused on ensuring national ownership and reporting. The proposal included an International Scientific and Technical Panel on SRM Research to assess the environmental, climatic, and societal implications of SRM research and to develop technical guidance for responsible research governance. It also proposed a temporary suspension of outdoor experimentation until the panel was established and provided an assessment. The proposal also emphasised the necessity of multilateral monitoring and reporting mechanisms. It advocated for the inclusion of developing states and Indigenous actors as part of its effort to elicit as much support from other simulation participants as possible. Although India and South Africa worked closely on drafting of the proposal, both reflected that they did not feel their priorities were adequately accounted for in the proposal by China. India felt so sidelined in the process it ultimately refused to vote for the proposal despite its status as a BRIC member.

Parallel to work on proposals, there was a news update that Stardust had had its patent revoked due to the determination that its novel particle was a naturally occurring substance. Stardust attempted to sell itself to SpaceX who was initially uninterested and pursued the possibility of mass producing the Stardust particle once the patent had been revoked without involving Stardust. However, Stardust first targeted China to elicit interest in working with them on technology development and sharing arrangements with other developing states and then reported overtures from China to buy the company to the US. As a result, the US insisted SpaceX acquire Stardust to prevent technology transfer to China. SpaceX agreed in order to maintain its essential working relationship with the US and announced industrial scale production of the particle and delivery equipment in partnership with Stardust so that they would be prepared with SRM technology whenever the US chose to move forward. China also announced it did not sanction private actors in the negotiations and Stardust then used its prior expression of interest in working with the company to embarrass China. This followed a move by several actors to eject Stardust and SpaceX from the proceedings due to their negotiations with other participants outside of the summit. The US blocked this proposal and characterised it as a threat because both are US-based companies working in alignment with US interests, which they would respond to with sanctions if necessary.

Technological sovereignty: Why is this relevant to SRM?

- Assessments of the capacity requirements for a large-scale, long-term deployment of SAI have noted that aerospace corporations are viewed as strategic assets by their state governments and that the corporate strategies of these companies intentionally conform to government policies (Horton, Smith and Keith, 2025, 3).
- This is also true of major technology companies that exist within the defense industrial ecosystem and contract with government agencies and departments. Under the second Trump administration, technology companies such as SpaceX, Palantir and OpenAI have been publicly explicit about their alignment with the national interests and strategic priorities of the United States, and geopolitical rivalries are now played out through competition to control digital networks, finance, and transnational infrastructure (Atal et al., 2025).
- The US has been explicit in recent publicly released strategy documents that it maintains a focus on exploiting every arena in which the US has an actual or potential advantage, including the technological and geophysical-environmental as a matter of effectively competing with potential adversaries such as China and Russia (United States Joint Chiefs of Staff, 2023), particularly within the Western Hemisphere (The White House, 2025, 15–19).
- The EU and other 'middle powers' increasingly recognize the vulnerability that attends relying on technological infrastructure that is provided by corporations that are entwined with the the priorities and strategic interests of other major state actors (European Commission, 2026).
- In the context of the simulation, actors representing technology companies explicitly aligned themselves with the US delegation and were subject to intense pressure by the US when they engaged with China, such as threats to impose export controls.

Throughout these negotiations, different groups of states, civil society actors, and breaking news stories tried to insert reminders that the primary concern should be climate change. This included an impassioned plea from the IPCC actors in their opening statement, consistent reminders by the Climate Overshoot Commission, and news of record high August temperatures around the world leading to economic damages from wildfires and an increase in heat-related deaths. However, climate and the environment more broadly remained only a minimal part of the discussions and negotiations between states working on various proposals.

As negotiations over draft proposals took place between states, CFC (the fossil fuel misinformation agent) engaged in a range of efforts to co-opt and or undermine the legitimacy of other participants. The primary example was its announcement of a citizens summit that included support from the Indigenous representative and, by the end of the simulation, a number of state actors and the science advisors. The CFC offered substantial funding to developing states and the scientific advisors as representatives of the broader scientific community, including for a Young African Physicists scholarship that would supposedly enable young scientists from African states to conduct scientific research on SRM and travel to the UAE for an international scientific meeting. All of this was ostensibly to support the goals and priorities of

the most marginalised actors in the simulation. Once it had garnered substantial support for the summit, the CFC participant started to engage in more obvious tactics to derail negotiations and moved towards promoting SRM as a means to minimise mitigation efforts and the move away from fossil fuels.

Misinformation and exploitation of complex information environments

- The actor in the network playing a covert role as a plant representing fossil fuel interests with a public face as a climate focused civil society organisation, the Climate Futures Cooperative (CFC), was modelled on US lawyer and oil industry lobbyist Donald H. Pearlman. In order to gain access to the negotiations at COP1 in Berlin in 1995, Pearlman created the non-governmental organization 'The Climate Council' and designated himself as its resident expert. He engaged in tactics to prolong and undermine negotiations as much as possible and contributed to lengthy delays by exploiting procedural questions and areas of scientific uncertainty (Dessai, 2004, 10–14).
- In the context of the simulations, CFC engaged in similar tactics to derail and frustrate negotiations. In addition, CFC focused on exploiting marginalised and vulnerable actors, including the Indigenous representative, developing state actors, and climate natural science experts. This was done primarily by offering funding opportunities for capacity building and scientific research and including these actors in 'civil society' supposedly philanthropically sponsored activities when they were sidelined in the main negotiations. The CFC leveraged their engagement with the indigenous representative and developing state representatives to build credibility and legitimacy as an actor in the simulations. They later used the engagement of scientists with their organisation and its activities to undermine the credibility and legitimacy of the scientists that had accepted their funding and agreed to engage with their work programmes.
- The CFC noted that pursuing their understanding of fossil fuel interests in delaying transition and mitigation required little overt intervention, due in large part to the behavior of powerful state and tech sector actors. The real world conditions replicated in the simulations that contributed to lack of trust and cooperation between the participants also made it easier to prevent robust coalition building that might enable effective governance negotiations and scientific collaboration.
- It is worth noting that although the reality of the CFC's role was not disclosed to participants until the end of the final simulation, several key actors recognised the behavior and agenda of the participant but felt that it was not contrary to their understanding of what their interests and aims would be in the simulation and chose not to attempt to reveal the role. These were major states, including the US and Russia, and the tech sector actors.

The SRM technical advisor pointed out several times that reductions in science funding meant that scientists would end up turning to private funders, even if their aims are not always transparent and sometimes concerning, to be able to continue doing research. CFC posited to the SRM technical advisor that a citizens assembly would enable more progress than the state discussion, which the technical advisor agreed seemed to be the case due to the slow pace of discussions among states and geopolitical contention. The other tech sector actors also frequently made similar interventions that lamented the inefficacy of states despite the fact that states play the central role in establishing and enforcing governance. The US in particular exercised close control of the tech sector actors' behaviors.

Participants also started to use the chair to spread misinformation. For example, the US claimed the CIA had proof China was conducting Arctic experiments, the CFC released a number of false reports to distract the summit, and Russia also submitted several fictitious news stories to be read out by the chair. The CFC also exploited the Chinese Arctic experimentation story to sow further mistrust in the lead up to the debate about the BRICS proposal. It also pointed out the lack of Indigenous representation in earlier BRICS draft proposals in an attempt to derail what might have been a functional proposal for developing states in contrast to GAMBIT.

Observations and discussion

The 'major' powers were reluctant if not intransigent about relinquishing any authority over decisions relating to SRM research and potential deployment. Several participants noted that the uncooperative approach taken by the US had a significant impact on the progress of the negotiations and their own behavior. One articulated that the US provided a useful scapegoat for other actors who could lie low and get their preferences because the US was acting as the spoiler. This mirrors recent events and has been consistent throughout the three simulations in which states have become much more likely to push back and identify the US as the spoiler – a role that perhaps Russia or China is more used to playing.

This is particularly noteworthy with regard to the approach taken by the Russian delegation in the simulation. Russia did not articulate the same interest in developing SRM monitoring and technology as the US in the public facing portions of the simulation. However, its focus throughout all the simulations according to the expert debriefs was maintaining freedom of options with regard to developing SRM capacity and any opportunities for technology weaponisation or political leverage. The project team also noted, and the experts confirmed, that they also avoided any framing of SRM as a climate intervention or explicit discussion of climate change although this appeared less obvious to other participants. The expert delegation disclosed that they exploited the public, vocal opposition of the US to most matters that would require consensus. Russia cooperated with other BRICS members and supported measures to maintain credibility with China in particular, for whom cooperation with the Global South was particularly important, in the knowledge that anything that would infringe on the sovereignty of any state would not get past the US.

There existed a fundamental rift between actors who had an urgent need to make progress on some kind of governance framework or steps towards it and those who did not, for ideological or geopolitical reasons. Several participants noted that the arms control analogies that were offered were useful to help organise how to envision a path to an agreement. However, it was also noted by participants that arms control agreements only became possible when both the US and the Soviet Union recognised a need to constrain each other's weapons development and deployment capabilities that outweighed their own desire to pursue those capabilities without submitting to constraints.

Several other participants, including Russia, China, and the UK, also noted that they were able to support Kenya's moratorium because they knew the US would vote against it, allowing them to appear cooperative and keep lines of collaboration open without having to compromise their options for research and development.

For developing states, the primary concerns in the negotiations centred around finance and capacity-building. Many states emphasised that without meaningful investment in scientific, technical, and monitoring capabilities they could not participate as equal actors in global SRM governance discussions and were concerned about being used as a testing ground for SRM, especially on such an unequal basis. There was, however, also a lack of sustained cooperation between developing states throughout due to different priorities and objections to SRM, especially between the African states.

This simulation again highlighted that there is more at stake in governance negotiations than what states do or do not want to happen with regards to SRM. The need to be included and taken seriously within negotiations was a driving motivation for several state actors, both of which could lead to failure or lack of support for governance proposals. For example, India ultimately withdrew support from the China-led BRICS proposal because they did not feel China was adequately addressing their concerns or incorporating their suggestions for the proposal despite being initial supporters. Although some were frustrated by the challenges posed by the move to consensus voting in which only states had a vote, some developing states noted that the introduction of the procedure of voting by consensus provided a source of psychological security as it meant that engaging all parties was necessary if there was any chance of getting support for a proposal. It provided an element of power over the negotiations, as each vote mattered. This was the case even acknowledging that US behavior meant no agreement was possible under consensus terms. It is also noteworthy that when non-states had a vote in the first two simulations, nothing passed and many objected to the departure from reality.

The tech sector actors noted that manipulating the language of transparency, cooperation, and international law to show the hollowness of the ideas on which everyone was supposedly in agreement worked well to help them preserve their freedom to pursue their own interests.

With regards to CFC, some actors (US, Russia, SpaceX, Stardust) did recognize the participant's role as a spoiler but it served their interests so they did not object or try to out the plant. The reflections from this participant indicated that they did not need to be that active in order to have their goals met throughout any of the simulations, but particularly in the third. A participant noted that one interesting dynamic with the CFC was that they repeatedly brought

up Indigenous issues. The Indigenous representative seemed to take this at face value and be grateful for the recognition, which allowed them to be co-opted into supporting the CFCs' efforts to derail substantive negotiations. The CFC also repeatedly tried to set a demoralising tone at the beginning of each session about the slow pace of progress being made by the state actors.

The lack of trust in the US led its delegation to adopt a harsher stance than they had anticipated. Between the first and third simulation the response of other participants to the US had shifted so that they were much less deferential towards the US and many were less willing to engage in negotiations with them due to lack of trust. This demonstrated how actors 'learned' across the three simulations as their relationship with the US evolved, and how trust built on decades-long alliances could be worn away. With regard to the US, experts also found it noteworthy that they were able to consistently pursue and defend their interests in SRM development without acknowledging climate change as a motivation despite repeated questioning from other network members.

There was more focused engagement with practical issues that would need to be addressed in any SRM governance framework, particularly around questions of monitoring and verification. The introduction of the expert panels better empowered the technical advisors to intervene in the negotiations and attempt to redirect attention to SRM as a potential climate intervention. However, the experts noted that they still felt the expertise they shared was being leveraged as a part of power struggles between state actors and that questions of sovereignty and control remained the primary focus of state negotiations. Network members again did not engage with the climate emulator. Most indicated that the focus of their concerns regarding SRM technologies were not questions that could be answered by climate science, with a subset of developing states noting that emulators are not equipped to answer outstanding questions about regional impacts most relevant to them.

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