

SOLAR CLIMATE INTERVENTION: OPTIONS FOR INTERNATIONAL ASSESSMENT AND DECISION-MAKING



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There is a growing risk that the global response to climate change will be inadequate to avoid an unsafe global climate. There is corresponding interest in exploring the potential need for, and feasibility of, rapid responses to avoid dangerous climate change – such as solar climate intervention (SCI). At the same time, there is concern that such intervention, if any, be implemented as safely as possible. This paper posits a scenario in which a group of countries seeks a cooperative, science-based¹ approach to decision-making regarding the potential use of SCI, in the context of increasingly dangerous climate conditions, taking into account “two safeties:” the safety of the global climate, and the safety of SCI, if any, in response. The paper surveys the existing institutional landscape to identify the extent to which one or more international forums would be in a position: (1) to produce a high-quality, scientific/technological assessment that would enable informed, objective decisions to be taken on the two safeties, and (2) to take such decisions (pro or con). It concludes that several forums could potentially perform one or more aspects of the scientific/technological assessment function and that the UN Security Council is uniquely placed to take authoritative decisions in a climate emergency situation, but that there is no single international forum (at least as currently configured) that could effectively serve as “one-stop shopping” for both the assessment and decision-making functions.

There is growing concern that the global response to climate change has been, and may continue to be, inadequate to avoid an unsafe global climate. Even assuming the world were to take sufficient action to put greenhouse gas emissions on track to limit global temperature increase to well below 2 degrees C or to 1.5 degrees C, which is currently in doubt, the climate system may have tipping points that, if crossed, could lead to rapid, catastrophic harms even before we reach those limits.

Given these risks, there has been increased interest in exploring as part of the global response the potential role of solar climate intervention (SCI) as a means of countering warming to avoid dangerous and/or abrupt climate change. At the same time, there is concern that SCI, if any, be implemented as safely as possible.

SCI seeks to cool the planet by reducing the amount of sunlight that is absorbed by the earth. Known also as

solar radiation management or solar geoengineering, SCI includes, among other approaches, putting particles in the stratosphere that absorb and scatter sunlight (stratospheric aerosol injection), increasing the reflectivity of marine clouds with salt water spray (marine cloud brightening), and inducing precipitation in upper atmospheric clouds to release more reflected sunlight (cirrus cloud thinning). These atmospheric approaches have analogs that have been observed to produce similar effects, including cooling produced by volcanic eruptions, and the reflection of sunlight from particles in emissions and their secondary effects on clouds. Scientific assessments, such as the 2015 National Academies of Science and Engineering report *Climate Intervention: Reflecting Sunlight to Cool Earth*,² suggest that interventions in the climate system to reduce warming by increasing the reflection of sunlight from the atmosphere may be viable options as part of a broader

portfolio of responses to avoid an unsafe climate, but do not substantially alter the imperative to reduce greenhouse gases, and have poorly understood risks.

The idea of SCI was introduced in the 1970s, but it received a significant boost from an article written by Nobel laureate Paul Crutzen in 2006.³ Since then, numerous papers have been published, with most of the research based on analyses of natural analogs and computer models, rather than technology development or field experiments. To date, relatively little research has been undertaken concerning specific SCI approaches. As a result, there are significant uncertainties regarding the feasibility and safety of SCI.

SCI is potentially distinguishable from other types of responses to climate change by the speed with which it can exert a large influence on the climate system. Volcanic eruptions, natural analogs for SCI, can reduce global temperatures rapidly, and the effects of a single eruption can persist for a year or so. Responses that remove or slow greenhouse gas emissions, such as carbon capture or clean energy sources, affect global temperatures more slowly, even when massively scaled. Because SCI is believed to be one of the few ways to cool the planet quickly, it could play a particularly important role in addressing tipping points, where rapid action would be required.

Much has been written about SCI, including important questions regarding whether international law currently regulates SCI; what the options might be for imposing limitations or prohibitions on SCI activities, including with respect to a so-called “rogue state” or “rogue actor;” and how best to engage various stakeholders.

This paper focuses instead on a scenario in which a group of countries concerned about the escalating risks of climate change seeks an approach to SCI decisions that is both cooperative (i.e., in an international forum) and informed by science, should decisions (pro or con) become necessary. It surveys the existing institutional options that the group might utilize to pursue such an approach.

THE SCENARIO

A hypothetical group of countries has become increasingly concerned that the world is not on track to maintaining a safe temperature and that, even if extreme

mitigation began immediately, it might not be possible to avoid dangerous or abrupt climate change.

The group considers that it may become necessary to consider using SCI as part of the global response, e.g., to give the world more time to reduce emissions and/or increase removals or to prevent a pending catastrophic change. It is aware that there are many uncertainties concerning both the feasibility and safety of SCI technologies and that better understanding is necessary to determine if they would be a viable and safe option. It seeks to ensure that decisions about the potential role (if any) of SCI technologies are taken cooperatively and informed by science.

The group recognizes that at least three building blocks are necessary to promote that result:

- There must be sufficient **research** concerning both science and technologies, which might be performed nationally, cooperatively, etc.
- There must be an **assessment** of research, updated over time. Ideally, this should be performed cooperatively in an appropriate international forum.
- There must be **decision-making**. Ideally, this too should be performed cooperatively in an appropriate international forum.

The group does not concern itself with (and this paper does not address) the production of research or the extent to which it should be “governed,” whether nationally or internationally. For our purposes, we assume that sufficient research will have been carried out for a meaningful initial scientific/technological assessment to take place and that an assessment will also incorporate, and even drive the production of, new research.

Rather, the group is focused on finding one or more appropriate international forums to pursue the second and third building blocks:

- to produce high-quality scientific and technological information that enables sound SCI-related decision-making, i.e., by gathering relevant research and developing (and updating over time) a scientific/technological assessment
- to take cooperative, science-based decisions – whether positive or negative – regarding the potential use of one or more SCI technologies.

There might be one forum that could play both roles, or a combination of forums might be used. The

assessment function itself might also be divided among different forums (e.g., one forum assessing the safety of stratospheric aerosol injection and another the safety of marine cloud brightening). However, it would appear preferable to have a single decision-making forum, in order to allow comparative evaluations of different SCI techniques (or other fast-acting responses), among other things.

The countries in question could theoretically seek to create a bespoke international forum to fit their precise objectives, and that may in fact become necessary. However, given the potential difficulties and time associated with creating something new, they are interested in first learning the extent to which one or more existing forums could serve the desired functions. Therefore, this paper explores the existing landscape of international agreements and institutions.

PURPOSE OF ASSESSMENT/ PURPOSE OF DECISION-MAKING

The purpose of the SCI-related scientific/technological assessment would be to prepare policymakers for at least three imaginable situations:

- **Proactive response:** Countries decide far in advance of nearing any tipping point to consider whether SCI can and should be part of the climate response.
- **Emergency response:** At or near a tipping point (e.g., commencing collapse of the Thwaites Glacier in the Western Antarctic ice sheet), countries consider SCI as a means of rapid remediation to address the crisis.
- **Localized response to impacts:** Regions consider SCI to address severe localized climate impacts (e.g., devastation of the Great Barrier Reef or summer melting of the Arctic).

Both the scientific/technological assessment and the decision-making forum would need to address two different safety issues.

- First, they would need to address the potential role of SCI in promoting the safety of the global climate. Any response potentially involving SCI would need to articulate its safety-of-the-climate objective, e.g., to constrain temperature increase to a particular fixed level, to reduce some fraction of warming, to compensate for the loss of aerosols due to emissions

reductions, to avoid crossing thresholds that lead to runaway climate change (e.g., due to methane release from permafrost or loss of summer sea ice in the Arctic), or to protect major natural systems such as the Great Barrier Reef.

- Second, they would need to address the safety of SCI itself, i.e., the collateral risks (which could vary regionally) of carrying out (and potentially later discontinuing) SCI.

While these two safeties are somewhat distinct, there is likely to be substantial overlap in the types of scientific and technological knowledge that would be needed to address both of the safety issues.

In addition, both the assessment and decision-making forum would need to address feasibility issues, i.e., the practicality of delivering SCI at the necessary scale and speed to achieve the desired climate-safety objective.

DESIRED FEATURES OF AN INTERNATIONAL FORUM

For the forum to carry out the SCI-related scientific/technological assessment:

- It would need a mandate and scope that accommodated the tasks of gathering and updating the necessary information (i.e., research that has been undertaken) and developing a scientific/technological assessment to enable policymakers to make informed decisions in all three of the situations noted above, on the safety and feasibility issues noted above.
- Ideally, it would have the kind of reputation, membership, and expertise that its assessment would carry significant weight with policymakers.
- Ideally, it would have the capacity to update assessments on an ongoing basis, in response to new issues or information.
- Even if it could carry out the assessment in theory, it would be important to gauge the extent to which it could do so effectively, i.e., objectively and as non-politically as possible.

For the decision-making forum regarding a potential role for SCI:

- It would need a mandate and scope that accommodated SCI-related policy decisions, including with respect to the two safeties (i.e., both

the climate safety goal and the safety of a potential intervention).

- It would need to be able to make decisions informed by science and do so as objectively as possible.
- It would need to have the authority to take the necessary type of decision. A decision might take the form of a policy pronouncement or recommendation, a standard or norm, a legally binding outcome, or another form. In general, international forums may take decisions of a policy, non-binding nature. Treaty bodies may take legally binding decisions if authorized by the treaty or through amendments, which normally bind only those states that consent. Only the UN Security Council, within its mandate, is authorized to make its decisions binding on all states.

It should also be considered whether a particular forum has a track record of addressing hard, controversial issues successfully. For various reasons, including the divisive nature of both climate change and SCI, both the assessment and decision-making functions are likely to be controversial and the subject of significant political attention regardless of the forum.

- First, countries are likely to be in different positions in terms of the perceived risks of climate change relative to SCI (e.g., because of their varying locations and physical situations).
- Second, countries' views of the "legitimacy" of various forums in relation to SCI may differ.
- Third, even if countries were to evolve their perceptions of SCI over time to a common view, they would likely do so at different paces, not necessarily in lockstep.

Thus, a forum's willingness to take up these issues, as well as its ability to overcome the challenges of reaching agreement, would be crucial.

EXAMINATION OF EXISTING AGREEMENTS AND INSTITUTIONS

This section examines certain existing agreements and institutions in light of the criteria above to determine whether they would be appropriate for one or both of the desired functions. It begins with those that might potentially carry out the scientific/technological assessment, then looks at those that might make policy decisions, and concludes with those that might do both.

1. SCIENTIFIC/TECHNOLOGICAL ASSESSMENT

There are several international forums that could potentially produce and update the scientific/technological assessment in question, but that do not take policy decisions. Their assessments would therefore need to feed into a different forum to inform policy decisions.

Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) would be a natural place to consider for the development of an SCI-related assessment – it has broad membership, scientific assessments are its bread-and-butter, climate change is its scope, and it has already begun to consider SCI. IPCC reports are generally considered the "gold standard" by the international scientific community; they ensure leadership by scientists and rigorous review.

The IPCC could expand its coverage to more fully address SCI-related issues in its *Seventh Assessment Report*. As a somewhat faster option, the IPCC could produce a special report on the issues in question (presumably at some point after producing its *Sixth Assessment Report*), possibly in the context of a special report on climate tipping points and various rapid responses. Once an IPCC report is scheduled, it has the effect of catalyzing research (as happened with its *Special Report on Global Warming of 1.5° C*).

The IPCC can integrate assessments from other bodies. For example, the 2019 IPCC *Special Report on Climate Change and Land* made repeated references to the *Assessment Report on Land Degradation and Restoration* of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. The IPCC could also integrate assessments by treaty bodies such as the Montreal Protocol Scientific Assessment Panel.

IPCC reports also carry substantial weight with policymakers. This is in part because of the IPCC's unique procedures, which provide for governments to review and "accept" the scientific assessment but, at the same time, shield scientific findings from political interference. The IPCC is known for its mantra "policy-relevant, not policy-prescriptive."

Alternatively, or in addition to a report, the IPCC could hold an expert meeting like the Expert Meeting on Geoengineering it convened in 2011 in Lima.⁴

A potential challenge of either a special report or expert meeting could be getting agreement on the scope

of the task, e.g., the extent to which the assessment is limited to scientific and technological aspects. The IPCC generally likes to consider issues in a comprehensive manner.

In terms of an updating function, the IPCC could provide updates to its full assessment report; the IPCC plenary might also establish a task force on SCI that met regularly to assess new issues and/or information.

World Meteorological Organization

The World Meteorological Organization (WMO) is also a potential option for taking on at least the scientific aspects of the desired assessment. It is an intergovernmental body but one with a rather technical character, e.g., U.S. representation is led by the National Oceanic and Atmospheric Administration, rather than the State Department.

The WMO's scope could include the scientific issues in question. The assignment could go either to one of the existing WMO working groups⁵ or to a newly created one for this purpose.

Assuming it could be agreed to pursue the assessment, it could be expected to be high quality and carry weight with policymakers.

It is worth noting the World Climate Research Program, one of the many programs of the WMO. It has a small secretariat to coordinate climate science across the world and might play a useful role in coordinating research on SCI, but it does not have the function of issuing authoritative assessment reports.

InterAcademy Partnership and InterAcademy Council

The InterAcademy Partnership (IAP) provides for the national academies of various countries to cooperate on science, policy, etc. The InterAcademy Council (under the InterAcademy Partnership) has issued joint reports on various subjects. For example, it produced a set of recommendations for improving the functions of the IPCC following controversies about its response to several errata in the Fourth Assessment Report.⁶

As a non-governmental entity, it could be expected to be less political than an intergovernmental forum. While its reports may garner less attention and have less sway than those of the IPCC, they would have credibility akin to National Academy of Sciences reports.

It should also be noted that it would be an option

to produce a joint assessment with a subset of national academies. For example, the U.S. National Academy of Sciences and the UK Royal Society collaborated in 2014 on a joint report on climate change.⁷

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) is an independent intergovernmental body established in 2012 by 94 governments, in part in response to concerns that the Convention on Biological Diversity's Subsidiary Body on Scientific, Technical, and Technological Advice (SBSTTA) had become too political. One of IPBES's core functions is to provide assessments of knowledge on biodiversity and ecosystem services; thus far it has completed eight assessments. Although it does not have the mandate or expertise to examine all aspects of the two safeties related to SCI, it could assess the biodiversity dimensions – i.e., climate impacts on biodiversity and avoidance of SCI side effects on biodiversity. Assessments can be requested by the IPBES plenary, which consists of all member states, and involve internal and peer review, as well as review by governments and stakeholders. Like the IPCC, IPBES assessments are intended to be policy relevant but not policy prescriptive. In contrast to the Convention on Biological Diversity (see below), the United States is a member of IPBES.

Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection

The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) was established in 1969 to advise the United Nations. It is sponsored by ten UN organizations, including the International Maritime Organization (IMO), the Food and Agricultural Organization (FAO), WMO, and the UN Environment Programme (UNEP), and consists of 17 experts who serve in an individual capacity. Its functions specifically include conducting marine environmental assessments, which are typically carried out by working groups composed primarily of scientists who are part of the wider GESAMP network but are not members of GESAMP itself. GESAMP is widely respected and could contribute to certain aspects of an assessment of both safeties by considering the impacts of both climate change and SCI (e.g., marine cloud brightening) on the

marine environment.

International Oceanographic Commission

The International Oceanographic Commission (IOC) is a functionally autonomous part of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) and has 149 member states. Its functions include promoting and coordinating marine scientific research. Among its tasks, it coordinates the Global Ocean Observing System. The IOC has been active in the area of climate change and is a co-sponsor of the World Climate Research Program. Like GESAMP, it might help coordinate an assessment of SCI and the marine environment.

It should be noted that the UN has proclaimed a “Decade of Ocean Science for Sustainable Development” (2021-2030), and the IOC is coordinating the Decade’s preparatory process. A key reason behind the Decade is that “science-informed policy responses to global change are urgently needed.”⁸ This initiative may therefore provide an opportunity to advance the scientific assessment of SCI, at least in relation to the ocean.

Regional Science Bodies

There are climate-specific science bodies in various regions, such as the Pacific Island Regional Climate Assessment (PIRCA); the Caribbean Community Climate Change Center (5Cs); the Inter-American Institute for Global Change Research (IAI), which covers Central and South America and some of the Caribbean; and the North American Carbon Program, covering the United States, Canada, and Mexico. Such bodies could potentially make contributions to scientific/ technological assessments with respect to localized or regional aspects of the SCI issues.

2. POLICY DECISIONS

There are several international forums that could potentially take policy decisions regarding SCI that do not themselves conduct scientific/technological assessments. They would therefore need to rely on such an assessment(s) from other forums to inform their decision-making.

UN Security Council

The UN Security Council has primary responsibility under the UN Charter for the maintenance of

international peace and security. The Security Council’s mandate appears to encompass both of the two safeties, since both climate change and deployment of SCI could be a cause of international conflict.

The Security Council has 15 members, including five permanent members (the United States, China, Russia, the United Kingdom, and France – also known as the “P5”), each of which has veto power over decisions. Security Council decisions generally carry great significance, both because, pursuant to the UN Charter, they can be fashioned as legally binding on all member states, and because, by definition, they have been accepted by the P5.

The Security Council is continually called upon to take up new issues. Climate change was first raised in the Security Council in 2007 and has been considered occasionally since then. Calls for the Security Council to address the security aspects of climate change may increase; for example, in 2018, over 25 UN member states formed the Group of Friends on Climate and Security, one aim of which is to boost the UN’s involvement concerning the climate-security nexus. Also indicating the potential for increased Security Council involvement is the recent establishment of the Climate Security Mechanism within the UN’s Department of Political and Peacebuilding Affairs. Its task is to provide integrated climate risk assessments to the Security Council and other UN bodies.

The Security Council has the ability to convene and take decisions quickly (perhaps making it a potential forum in an emergency response situation), and its overarching security focus and whole-of-government representation could make it appropriate for weighing one set of risks versus another set of risks.

Beyond any role at the back end, i.e., in terms of decision-making, it should also be noted that, at the front end, the Security Council would also be in a position to call for the development of a scientific/technological assessment in one or more other forums.

Notwithstanding the fact that the mandate and limited membership of the Council have been agreed to by all UN Member states (by virtue of joining the UN), non-members of the Council might consider its limited membership a potential detriment. However, such a perception might be mitigated by, for instance, consulting with non-members or allowing non-members

to participate in a non-voting capacity.

UN General Assembly

The UN General Assembly may take decisions regarding any matter within the scope of the UN Charter, which it has long considered to include environmental issues of broad international significance. Thus, its scope could comfortably include issues regarding SCI. In contrast to the UN Security Council, the General Assembly includes all UN Member states and can take decisions by a two-thirds majority vote without the possibility of a veto. Because its decisions do not require consensus and cannot be legally binding, their weight depends on the breadth of their support among the various groups of countries within the UN system.

G 7/G 20

The “G” meetings are gatherings of the world’s leading economic powers to address and coordinate economic and other policies, and are generally held at the leader or ministerial level. The G7 comprises the seven largest Western advanced economies, while the G20 also includes China, India, and other major developing countries.

The G meetings do not operate on the basis of a prescribed mandate and therefore have no formal limitations on the issues they can consider. They have considered climate change for many years and could potentially address or even make policy pronouncements or decisions regarding SCI.

Neither forum could “bind” other countries, even politically, and the G7 in particular might not be considered an appropriate forum to address SCI, given its particularly limited membership. G meetings might, however, serve as a place to develop a consensus that could subsequently be taken to a broader forum.

Stockholm 50

In 2022, the world will commemorate the 50th anniversary of the 1972 Stockholm Conference, a groundbreaking event that gathered leaders to address the environment and resulted in the creation of the United Nations Environment Programme.

The periodic conferences since Stockholm (e.g., the Rio Earth Summit in 1992, the Rio + 20 Conference in 2012) have progressively expanded the scope of the event to include not only all aspects of the environment but

sustainable development and beyond.

Because these conferences cover “the planet” writ large and not just one aspect (as the treaties generally do), Stockholm 50 could theoretically be a place where the international community decided to address the potential role, if any, of SCI in addressing the climate threat. More likely, given that 2022 is likely too soon, it would fall to a follow-on process to take up the issues.

UN Convention on the Law of the Sea

The UN Convention on the Law of the Sea provides the overall legal framework governing human activities related to the ocean, including marine pollution. However, unlike many other agreements, it does not have a general decision-making body (like a Conference of the Parties). Thus, even with respect to the ocean, it would not appear to be an appropriate forum.

Regional Forums

Various regional forums could potentially address SCI and the two safeties when the SCI being considered would be undertaken on a limited basis to address regional climate impacts.

For example, with respect to SCI in the South Pacific region (e.g., to protect the Great Barrier Reef), the Pacific Islands Forum might provide a forum for considering the issues. The Pacific Islands Forum has 18 member states, including Australia. Its annual leaders meeting serves as a forum to develop collective responses to regional issues, including ocean conservation and climate change. Given the very significant impacts of climate change on Pacific Island states, the Pacific Islands Forum might be expected to give weight to both of the two safeties, rather than a particular focus on the safety of SCI itself (as some other forums have done).

Relevant factors in considering the use of a regional forum include:

- whether the intent of the intervention would be to limit regional harms, rather than control the global climate;
- whether the intervention would in fact have primarily regional effects, giving the regional forum the strongest interest;
- the severity of the regional harm that the intervention is intended to address;
- the potential for significant adverse effects outside

the region;

- the extent to which the regional forum assesses the extra-regional effects and notifies or consults with potentially affected states.

3. ONE-STOP SHOPPING

United Nations Environment Programme/Assembly

The United Nations Environment Programme (UNEP) and its governing body, the United Nations Environment Assembly (UNEA), have a very broad scope and mandate that would encompass SCI-related issues and allow for developing (or commissioning) an assessment of the scientific/technological aspects of SCI, as well as subsequently taking policy decisions, including on the two safeties.

The extent to which a UNEP scientific/technological assessment would be high-quality and minimally politicized could depend in part on the modalities for setting it up. (In this regard, it should be noted that the 2019 UNEA meeting considered a proposal to take up the subject of SCI, in the context of climate geoengineering more broadly. Among the issues was what process would be used for selecting authors and reviewing the report.)

In terms of policy decision-making, UNEA does not take binding decisions. Its non-binding pronouncements and recommendations could carry weight globally, given its broad membership, but such weight might also be limited; states are often represented by environment ministries, which might not reflect the full government perspectives.

UN Climate Change Regime

The UN climate change regime, which includes the UN Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, both of which have near universal membership, could theoretically produce the desired assessment and take policy decisions related to SCI. However, the picture is cloudier in practice.

In terms of the assessment, both agreements are served by a specialized Subsidiary Body for Scientific and Technological Advice (SBSTA) charged with providing the parties with timely information and advice on scientific and technological matters. SBSTA's mandate would appear broad enough to cover the safety issues in question. Among other things, it includes providing

assessments of the state of scientific knowledge relating to climate change and its effects, preparing scientific assessments on the effects of measures taken, identifying state-of-the-art technologies, and responding to scientific and other technical questions posed by the parties.

An SCI assessment addressing the two safeties would arguably fit under the existing SBSTA agenda item on research and systematic observation, or the parties could choose to create a separate SBSTA agenda item.

However, while SBSTA's legal mandate includes assessments of the state of scientific knowledge, it has not typically conducted its own scientific assessments; rather, the UN climate change regime has delegated assessments to the IPCC (such as the *Special Report on 1.5° C*) and provided technical governmental consideration of such assessments. Thus, if a scientific assessment were to be produced in the first instance under the UN climate change regime, as opposed to the current division of labor between assessment and policy, SBSTA would need to change its practice – or the parties would need to create a specialized body specifically for the purpose of conducting the assessment in question (which they have the authority to do).

In terms of taking SCI-related decisions, many factors point toward the UN climate change regime:

- It is the recognized primary international forum on climate change.
- It would clearly fall within the subject matter scope of the UN climate change regime to address SCI (particularly the Paris Agreement, as its objective is drafted in terms of global temperature, rather than concentrations of greenhouse gas emissions).
- The regime has had notable successes addressing climate change, most recently and prominently its development and adoption of the Paris Agreement.
- The Paris Agreement had several features (e.g., its global temperature and global emissions goals) that are informed by science.

At the same time, the regime is quite politicized. Not only is climate change controversial wherever it goes, but this regime has a particularly contentious history – with stark differences of view among the Parties, as well as significant substantive and procedural hurdles, almost since its inception in 1992. In part due to its consensus rule, it has at times not been possible to reference underlying science, such as IPCC reports.

At least in the short term, the UN climate change regime may not provide an appropriate forum for decision-making regarding the SCI safeties. If the climate situation gets more desperate, the politics could change. Should it evolve into a decision-making body on these issues, it would have the option of getting its scientific assessments either from its own subsidiary bodies (as noted above) or, more likely, from the IPCC.

It should be noted that SCI might be the subject of discussion in this forum, even if not decision-making. The Paris parties will conduct a global stocktake every five years beginning in 2023. It provides for the parties to take stock of the collective progress towards achievement of the purpose of the Agreement and its long-term goals; the goals include the global temperature goal, to which SCI would be of obvious relevance. It should also be noted that, while this paper focuses on collective decision-making, one or more Paris parties might elect to include activities related to SCI in their nationally determined contributions.

Montreal Protocol

The Montreal Protocol on Substances that Deplete the Ozone Layer (a protocol under the Vienna Convention for the Protection of the Ozone Layer with near universal membership) addresses the protection of the ozone layer and related issues. It has a relevant subsidiary body, the Scientific Assessment Panel, which is composed of independent experts overseen by an ad hoc international scientific advisory group. The Montreal Protocol also has an Environmental Effects Assessment Panel and a Technology and Economic Assessment Panel, which might also address environmental and technological issues related to SCI. Although not strictly required, decisions under the Montreal Protocol are generally taken by consensus.

There are several reasons to think about the Montreal Protocol as a potentially appropriate forum for both the assessment and decision-making functions:

- It is widely considered the most successful international environmental agreement to date in tackling its subject.
- It has a long history of undertaking robust, timely, and objective scientific assessments to inform decision-making.
- It generally has a reputation for business-like debate

and science-based decision-making. Thus, in terms of non-politicization, the Montreal Protocol appears to be preferable to, for example, the UN climate change regime.

- The adoption of the Kigali Amendment on hydrofluorocarbons (HFCs) may indicate a willingness to address climate change more broadly, at least to a certain extent.
- The parties' recent decision directing the Scientific Assessment Panel to include in its 2022 report an assessment of research related to SCI and its potential effects on the ozone layer may indicate a willingness to enter into SCI issues more broadly.

However, at least two issues arise in connection with contemplating the Montreal Protocol as the forum to address SCI and the two safeties.

First, there is the question of scope. It is unclear whether the Montreal parties would be amenable to broadening the current assessment (only ozone impacts, presumably only stratospheric aerosol injection) to a much broader assessment, including both SCI technologies that do not affect the ozone layer (e.g., marine cloud brightening) and impacts of stratospheric aerosol injection beyond those on the ozone layer. The same issue arises with respect to decision-making.

- Some parties may take the position that, as a legal matter, an assessment related to a climate safety goal and the safety of SCI side effects beyond the ozone layer – as well as related policy decisions (particularly if they took a legally binding form) – exceed Montreal's scope. The Vienna Convention includes within its purview the health and environmental effects resulting from activities likely to modify the ozone layer. Therefore, there is a case to be made that an assessment of the climatic effects of stratospheric aerosol injection (which affects the ozone layer) fall within Montreal's ambit. However, Montreal does not appear to encompass an assessment of, or decisions regarding, a climate safety goal or the safety aspects of SCI technologies that do not modify the ozone layer (such as marine cloud brightening). Broadening Montreal's scope to include such issues could require an amendment.
- There might also be policy reluctance to broaden Montreal in this way; opponents might view the Kigali amendment as a limited precedent

– acceptable only because HFCs had been encouraged as a substitute for ozone-depleting substances, not because Montreal was now in the business of addressing climate issues.

Second, while the Montreal Protocol has generally been a less politicized forum than, for example, the UN climate change regime, that situation has been truer when it has dealt with ozone-depleting substances than when it has dealt with climate change (i.e., the effort to take up HFCs and the subsequent negotiations on an amendment). Ozone-depleting substances play a far smaller role in the economy as compared to carbon dioxide. (In the United States in particular, regulating ozone-depleting substances has been much less controversial than regulating climate change; the United States began regulating ozone-depleting substances before the Montreal Protocol even existed, and U.S. industry developed many of the substitutes.)

In contrast, the controversial nature of climate change has a way of making institutions that are normally fairly business-like more fractured and – at least temporarily – more like the UNFCCC. This has been the case not only under Montreal, but also in the International Civil Aviation Organization and the International Maritime Organization when carbon dioxide emission reductions were in play. Thus, even if the Montreal parties were willing to take up the SCI-related assessment and decision-making, it could be a much more politicized and contentious exercise than might ordinarily be the case under the Montreal Protocol.

Convention on Biological Diversity

While a treaty on biological diversity might seem an unlikely place to take up climate intervention issues, parties to the Convention on Biological Diversity (CBD) actually took one of the earliest decisions on the subject. Specifically, the decision “invited” parties to consider certain “guidance” on geoengineering, including that no climate intervention that may affect biodiversity take place until there is an adequate scientific basis and adequate consideration of risks.⁹ The decision made an exception for “small scale scientific research studies” conducted in a “controlled setting.” Although non-binding, that decision has cast a long shadow on the topic of climate geoengineering and is sometimes portrayed (although inaccurately) as imposing a moratorium on climate intervention.

More recently, the CBD has become more engaged in climate-related issues. It has produced numerous technical papers on various linkages between biodiversity and climate change, both in relation to climate impacts on biodiversity and the potential for biodiversity protection and enhancement to promote climate protection (such as through “nature-based solutions”). Based on recent drafts and party comments, it is also possible that the CBD’s post-2020 global biodiversity framework, currently under negotiation, will include references to the climate/biodiversity interface.

In term of the desired assessment function, the CBD has a relevant specialized subsidiary body, the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), which has produced commissioned reports on climate geoengineering.¹⁰ However, its scientific assessment function has de facto been assumed by IPBES (see above).

In terms of policy decisions, some have suggested that the CBD could be an appropriate place to govern SCI. Despite its focus on biodiversity rather than climate, biodiversity is implicated with respect to climate impacts and could be affected by SCI’s side effects. However:

- The CBD would not appear to be in a position to take decisions on climate safety or on the non-biodiversity impacts of SCI (e.g., potential atmospheric and climatic effects).
- The CBD has not generally been a particularly effective forum for addressing the issues within its purview.
- Its history with respect to climate intervention could make it challenging to objectively assess and/or take decisions on SCI.
- And the United States, which would appear to be a necessary player with respect to both assessment and decision-making, is not a party to the CBD.

For these reasons, it does not appear that the CBD would be an appropriate all-purpose forum for the SCI-related scientific/technological assessment and decision-making. However, the CBD might play a role in contributing to the assessment of the two safeties with respect to biodiversity in particular.

London Convention and Protocol

The London Convention and Protocol regulate ocean dumping, the deliberate disposal of wastes and

other matter at sea. The London Protocol is the only international institution to date that has adopted a binding decision on climate intervention, although that decision related to carbon dioxide removal (through ocean fertilization) rather than SCI, is not yet in force, and applies only to London Protocol parties, not the broader group of states (including the United States) that are parties only to the London Convention.¹¹

Decisions regarding marine cloud brightening would require broadening the current regulatory competence of either agreement, which is limited to the disposal at sea of wastes and matter generated on land. In addition, because only the marine environment is within the purview of the London Convention and Protocol, neither would appear to be the best forum for evaluating the comparative safety of marine cloud brightening versus other types of SCI.

Arctic Council

The Arctic Council has a long history of conducting scientific assessments, including in relation to climate change, as well as taking policy decisions concerning the Arctic region. A Council decision, whether to carry out an assessment or on policy related to SCI (such as with respect to preserving sea ice, permafrost, or glaciers), would require consensus among the eight Arctic states: the United States, Canada, Russia, Iceland, Finland, Sweden, Norway, and Denmark. Arctic Council decisions are not legally binding.

The Arctic Council has a reputation for high-quality outputs and a history of high-level decision-making (generally at the foreign minister level). However, reaching agreement with respect to regional SCI in the Arctic might be difficult, given the potentially different interests of the member states (e.g., regarding the establishment of sea lanes and the exploitation of resources in the Arctic Ocean).

CONCLUSIONS

This paper posits a scenario in which a group of countries, recognizing that it may become necessary to include SCI as part of the global response to climate change, seeks to ensure that decisions about the potential role (if any) of SCI technologies are taken cooperatively and informed by science. This scenario suggests the need for an international forum or forums 1) to produce high-quality assessment of scientific and technological information that enables sound

SCI-related decision-making, and 2) to take decisions – whether positive or negative – about the potential use of one or more SCI technologies.

Although it would also be an option to specifically design an ad hoc forum and/or process to address the issues in question, this paper considers how well suited existing international institutions may be for these purposes.

In terms of **one-stop shopping** (i.e., a single international forum to both produce a high-quality assessment and take decisions about the potential use of SCI), there is no ideal global option at the moment. For example, the UN climate change regime has the right scope but a mixed track record on politicization, whereas the Montreal Protocol has been less politicized but would need to broaden its scope. However, if the risks of climate change were to increase to such an extent that it became untenable not to seriously consider SCI, the UN climate change regime might become less political and/or the Montreal Protocol might broaden its scope. As a regional forum, the Arctic Council could potentially perform both functions with respect to regional, Arctic-oriented SCI.

In terms of producing a **scientific/technological assessment** only, there appear to be several potential options, including the IPCC, the WMO, and others. Potentially, the assessment function could be performed by a single institution or shared among several. The IPCC in particular has a reputation for rigorous scientific assessments, and its procedures elevate the role of scientists while providing a governmental imprimatur that increases its weight with policymakers. With any forum, however, it could be a challenge to get agreement at the front end to conduct the assessment in question.

In terms of **decision-making** only, the UN Security Council may be uniquely placed. It has a broad mandate and decision-making authority. Given its ability to act quickly, it could be better positioned than other forums to address an emergency situation. At the same time, agreement among its five permanent members would be necessary; in addition, its limited membership might be perceived as a liability.

The range of institutional options and the issues each poses beckon the international community to think proactively about how best to assess and decide on the use of solar climate intervention, including the relative pros and cons of existing institutions versus an ad hoc forum.

ENDNOTES

1 By “science-based decision-making,” we do not mean to suggest that science can or should be the only factor in decision-making about SCI. Science can inform decision-makers about the benefits and risks of SCI, and decision-makers should make their decisions on the basis of this information. But science cannot tell decision-makers how to balance benefits and risks. That is an issue of risk management rather than risk assessment, and requires value choices.

2 National Research Council, *Climate Intervention: Reflecting Sunlight to Cool Earth* (Washington, DC: The National Academies Press, 2015), <https://www.nap.edu/catalog/18988/climate-intervention-reflecting-sunlight-to-cool-earth>.

3 Paul J. Crutzen, “Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?” *Climatic Change* 77, no. 211 (2006): <https://doi.org/10.1007/s10584-006-9101-y>.

4 *IPCC Expert Meeting on Geoengineering* (Lima, Peru: Intergovernmental Panel on Climate Change, June 20-22, 2011), https://www.ipcc.ch/site/assets/uploads/2018/05/EM_GeoE_Meeting_Report_final.pdf.

5 The full list of working groups can be found here: http://www.wmo.int/pages/prog/sat/internationalexpertgroups_en.php.

6 *Climate Change Assessments, Review of the Processes and Procedures of the IPCC* (2010), <https://www.interacademies.org/index.php/publication/climate-change-assessments-review-processes-procedures-ipcc>.

7 National Academy of Sciences, *Climate Change: Evidence and Causes* (Washington, DC: The National Academies Press, 2014), <https://www.nap.edu/catalog/18730/climate-change-evidence-and-causes>.

8 “United Nations Decade of Ocean Science for Sustainable Development (2021-2030),” United Nations Educational, Social, and Cultural Organization, last modified 2019, <https://en.unesco.org/ocean-decade/about>.

9 “Biodiversity and Climate Change,” CBD Decision X/33 (October 29, 2010), <https://www.cbd.int/decision/cop/?id=12299>.

10 *Geoengineering in Relation to the Convention on Biological Diversity: Technical and Regulatory Matters*, Technical Series No. 66 (Montreal, Canada: Secretariat of the Convention on Biological Diversity, 2012), <https://www.cbd.int/doc/publications/cbd-ts-66-en.pdf>.

11 The London Protocol Parties have also adopted decisions on export of carbon dioxide and subsea sequestration, which could be relevant to carbon dioxide removals involving direct air capture.



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