SRMGI background paper: International
Does geoengineering need a global response – and of what kind?
International Aspects of SRM Research Governance

The "International" Working Paper of the Solar Radiation Management Governance Initiative conference at the Kavli Royal Society International Centre, from 21-24 March 2011.
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This is one of four papers on different aspects of SRM research governance (Mechanics, International, Goals and Thresholds) that have been prepared for the Solar Radiation Management Governance Initiative (SRMGI) conference at the Kavli Royal Society International Centre, from 21-24 March 2011. The papers are intended to stimulate discussion of SRM governance issues only and they are not for citation. They do not represent teh views of the convening, partner or funding organization of SRMGI.

Executive Summary

This paper explores the range of potential international responses to the challenging issues posed by SRM research.

We begin by surveying the landscape of existing international environmental institutions, and examining those that *could* have relevance to the governance of SRM technologies. Clearly absent from that landscape is a single treaty or institution addressing *all* the issues raised by SRM technologies. As such, we argue that there are pros and cons for any type of institutional architecture – whether using existing regimes, creating new ones or relying on a system of international norms and codes of conduct – and attempt to provide a rough overview of what these might be. Parallels are also drawn to other controversial technologies that have international governance structures of varying degrees, including biological and chemical warfare, medical testing and biotechnology.

We then focus specifically on the international governance implications of several broad categories of SRM research, and explore past examples of international scientific collaboration for models that might be applicable to these categories. We argue that *if* SRM research were to continue and expand, than several principles would need to form the bedrock of international governance. These principles emphasise inclusion, transparency, public engagement and capacity building, among others, while still leaving space for a range of choices regarding institutional design for coordinating research.

We finally turn to outlining the non-research elements of international governance where international coordination could nonetheless be extremely valuable. Here we focus on the coordination of discussions between the various international organisations and national governments (legislatures and regulatory agencies) that are beginning to consider SRM research, as well as the coordination of processes that could facilitate the participation of well-informed and globally-inclusive publics in the development of SRM governance. Potential models that could be drawn upon for lessons in each of these cases are considered.

Due to the short time in which this paper was assembled, and in part because of the limited perspectives that any small group of authors can bring to bear, the treatment of issues focused on within this paper is incomplete. Moreover, despite the scope of this paper, many questions remain unanswered, and not because they are less legitimate or unimportant. (Particularly absent questions include those about the ethics and principles of SRM research in the first place, which must be of equal concern *within* national boundaries as *across* borders.) However identifying all of the gaps within this paper is not possible in this context, and we nonetheless hope that this paper stimulates an engaging conversation at Kavli and beyond, where the plethora of such gaps can be identified and begin to be addressed.

Does geoengineering need a global response – and of what kind?

Working Paper of the Solar Radiation Management Governance Initiative Meeting in Kavli 21-24 March 2011

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Introduction

Could geoengineering be effectively governed within the loose collection of international environmental governance institutions that are currently struggling to manage the myriad of environmental threats created by unintended human impacts on our biosphere? Or might geoengineering need an international organisation focused specifically on the unique suite of issues generated by research into – and potential future deployment of – technologies for *intentionally* modifying our global climate? And how would either of these options cope with the possibility that various nations may view the development and regulation of such technologies as their prevue, subject only to broad norms of international conduct?

The governance of geoengineering and, in particular, solar radiation management, stands at a challenging juncture. On one hand, though scientific proposals to engineer the Earth's climate have been around for a long time, wider discussions and debates that extend beyond the specialised scientific community are of very recent vintage. This means that scientists, policymakers and the public do not have a longstanding discourse surrounding global environmental modification upon which the development of a governance framework for SRM research could be grounded. On the other hand, there are a number of international organisations that have a say in environmental governance. Their mandates and functions might not have been developed to explicitly cover geoengineering, yet it might still be possible for one (or more) of these international institutions to assume responsibility over some aspects of scientific SRM research. At the least, there are certainly a host of important lessons that can be drawn from examining the institutions currently populating the global environmental governance landscape. Moreover, there are equally valuable lessons to be taken from institutions developed to govern other (non-environmentally focused) technologies that emerged over the past 60 years.

This background paper has three broad aims:

1. To evaluate the existing landscape of international regimes for their relevance (*direct applicability or indirect lessons*) for governing SRM research;
2. To explore the aspects of SRM research that could benefit from international coordination; *and*
3. To identify other non-research activities related to SRM research governance that could also benefit from international coordination.

Such a broad scope for the background paper runs a fundamental risk; namely, that readers might wonder whether SRM research (and, worse, deployment) is being taken as given. No such assumption motivated the members of the international SRMGI Working Group or the authors of this paper. The Working Group sees its role as informing a debate that must leave the confines of research laboratories and include a much wider array of stakeholders, including, but not restricted to, social scientists, policymakers, civil society organisations, research and policy think-tanks, political leaders and, of course, their constituents. Stakeholders include both those who consider SRM research as part of a 'Plan B' to respond to a climate crisis as well as those who think it violates ethical norms, at best, and dangerously puts the Earth's climate systems and ecological balance at risk, at worst. Both perspectives could and should seek redress of their concerns within international governance structures; and failure to have an international governance framework could lead to the expansion of research without sufficient oversight, thus leaving those valid concerns entirely unaddressed. Detractors could demand bans on further research (note the Convention on Biological Diversity's declaration in Nagoya in 2010 prohibiting large scale experiments). Equally, supporters could request the enabling support of international organisations to coordinate the work of hundreds of scientific institutions around the world. In other words, uncertainty or lack of agreement on the future of SRM research does not negate the need to discuss its implications for global governance.

The tricky part of organising this debate is that some of the discussion must occur in the abstract. SRM concepts are still in their scientific infancy, and imagining what these technologies might look like even a decade from now requires making certain assumptions that may or may not hold. More complex still is imagining the social, corporate and political networks and motivations that may arise around these technologies as they evolve. And it is difficult to develop a framework for governance when it remains unclear precisely who and what it is that needs to be governed. This is part of the reason that international relations scholars generally study regimes once they have been formed, and explain why they were created in the first place, rather than trying to forecast how existing regimes are likely to evolve!

But scholars do not always make the best policymakers. What criteria would one use to decide whether geoengineering deserves its own regime? What functions would such a regime perform? Who would be represented and what powers would they have to influence decisions? In order to explore these questions vis-á-vis SRM research, we can rely on experiences of international environmental regimes and internationally coordinated research activities that exist today (or have existed in the past). These experiences offer lessons that the Working Group has attempted to examine in order to outline a range of potential designs for convening countries, scientists and other stakeholders around the governance of SRM research. However no attempt is made here to propose or advocate for any design architecture over another – this paper is purely exploratory in nature, and meant to promote conversation rather than narrow the discussion towards any outcome.

The paper begins by briefly examining the relevance of existing regimes to SRM research, including: CLRTAP; CBD; UNEP; UNFCCC; among others. It also draws parallels with other controversial technologies that have international governance structures of varying degrees. These include biological and chemical warfare, medical testing and biotechnology. Throughout, we argue that there are pros and cons for any type of institutional architecture – whether using existing regimes, creating new ones or relying on a system of international norms and codes of conduct – and attempt to provide a rough overview of what these might be.

The paper then focuses on the specifics of SRM research. It establishes broad categories of research to highlight the implications for global governance if one or the other type or research were conducted. At the same time, the paper argues that there are lessons to be learnt from past examples of technological collaboration across countries. Starting with the International Geophysical Year of 1957-58 and right up to the International Thermonuclear

Experimental Reactor, countries have come together to conduct scientific research. The paper argues that *if* SRM research were to continue and expand, then several principles would need to form the bedrock of global governance. These principles emphasise inclusion, transparency, public engagement and capacity building, among others. Though while being loyal to these principles, policymakers still might choose between top-down, bottom-up or mixed institutional designs, each of which has different implications for coordinating SRM research.

The paper finally turns its attention to outlining the non-research elements of international governance where international coordination could nonetheless be extremely valuable. This discussion focuses on the coordination of discussions between the variety of international organisations and national governments (legislatures and regulatory agencies) beginning to consider SRM research, as well as the coordination of processes that could help facilitate the participation of well-informed and globally-inclusive publics in the development of SRM governance.

Despite the scope, many questions remain unanswered, and not because they are unimportant. In fact, they go to the heart of the debate about SRM research. But these questions are about the ethics and principles of SRM research in the first place. They are equally of concern *within* national boundaries as *across* borders. What are the limits of international law and what redress mechanisms can countries and their individual citizens seek against potentially harmful effects of SRM research? Would international coordination of SRM research replicate past experience of conditional financing, thus exacerbating existing inequalities between countries? How open and accessible would such research be to poorer countries? How would private initiatives be governed by state actors at the global level?

All of these, and many more, are legitimate questions that deserve conversation and attention. And even the treatment of issues focused on within this paper is incomplete, in part due to the short time in which this paper was assembled, and in part because of the limited perspectives that any small group of authors can bring to bear. Identifying all of the gaps within this paper is not possible in this context, but we nonetheless hope that this paper stimulates an engaging conversation at Kavli and beyond, where the plethora of such gaps can be identified and begin to be addressed.

International Governance Options for SRM Research

Thus far there has been little comprehensive assessment of the regulation of geoengineering,[3] and any existing rules that might be considered applicable to geoengineering have been put in place without careful prior consideration having been given specifically to geoengineering.[4] What is clearly absent from the current legal landscape is a single treaty or institution addressing *all* aspects of geoengineering; instead, the picture is a diverse and fragmented

[3] The first appears to be the 1996 article by Daniel Bodansky, "May we engineer the climate?", 33 *Climate Change* (1996), 309; see also Jay Michaelson, "Geoengineering: A Climate Manhattan Project", 17 *Stanford Environmental Law Journal* (1998), 73.

[4] This may be contrasted with other methods such as carbon capture and storage, which is now regulated at the national, regional (EU) and international levels.

one.[5] As a result, a major strand in the sparse legal literature addressed to geoengineering is an assessment of the extent to which existing regulation may be adapted to regulate geoengineering actors and activities.[6] This relies on the flexible adaptation, and possible amendment, of existing treaty rules, seeking to employ the legal tools at hand to regulate geoengineering activities, whether field trials or potential deployment. Such "regulation" may take the form of binding or non-binding instruments.[7] Assessment of existing instruments should also take into account the dynamism of the law-making process, particularly in the environmental context.[8] Existing instruments may be divided between those potentially applicable to all geoengineering methods (eg. ENMOD; UNFCCC; CBD); those potentially applicable to particular methods (eg. Outer Space Treaty for solar arrays; Montreal Protocol with respect to stratospheric aerosols); and those instruments applicable to activities within, or impacting upon, particular areas (eg. ATS, UN Convention on the Law of the Seas, UNCLOS). Additionally, certain general customary international law rules (eg. 'no harm' principle) are of potential general application.

In this context, the evolution of SRM governance could coalesce anywhere on a spectrum of quite different regulatory structures and arrangements. At one end of the spectrum governance of SRM would be dominated by essentially independent (and possibly contradictory) national regulatory frameworks, similar to how research on stem cells evolved throughout the 1990s. At the other end of the spectrum would be a globally subscribed and binding regulatory framework. Given the international ramifications of SRM technologies, and the deep global divides existing today in international climate politics, neither end of this spectrum would appear ideal or plausible. In between these lay a range of alternatives on the spectrum. For simplification, we have broken these alternatives down into four broad categories of governance options for SRM regulation.

The first is *national governance*. As states begin to develop stances on geoengineering in line with their political interests, a range of national regulations are likely to be considered for

[5] A similar point may be made regarding the domestic regulatory framework. In the US context see Kelsi Bracmort, Richard K. Lattanzio and Emily C. Barbour, *Geogengineering: Governance and Technology Policy* (Congressional Research Service Report for Congress R41371, 2010), at 22-28, and Tracy D. Hester, "Remaking the World To Save It: Applying U.S. Environmental Laws To Climate Engineering Projects" (forthcoming).

[6] For example, Rex J. Zedalis, "Climate Change and the National Academy of Science's Idea of Geoengineering: One American Academic's Perspective on First Considering the Text of Existing International Agreements", 19 *European Energy and Environmental Law Review* (2010), 18. In terms of specific geoengineering methods, ocean iron fertilization has stimulated the most legal comment: see, for example, Rosemary Rayfuse, Mark G. Lawrence and Kristina M. Gjerde, "Ocean Fertilization and Climate Change: The Need to Regulate Emerging High Seas Uses", 23 *The International Journal of Marine and Coastal Law* (2008), 297.

[7] A wide conception of regulation embraces not only hard or formal law, but also less formal mechanisms including non-binding soft law. See, generally, Catherine Redgwell, "International Soft Law and Globalisation", in Barry Barton et al. (eds.), *Regulating Energy and Natural Resources* (Oxford: Oxford University Press, 2006) 89, at 95.

[8] See Catherine Redgwell, "Multilateral Environmental Treaty-Making", in Vera Gowlland-Debbas (ed.), *Multilateral Treaty-making* (The Hague/Boston/London: Martinus Nijhoff Publishers, 2000),Thomas Gehring, "Treaty-Making and Treaty Evolution", in Daniel Bodansky et al. (eds.), *The Oxford Handbook of International Environmental Law* (Oxford: Oxford University Press, 2007) and, more, generally, Alan Boyle and Christine Chinkin, *The Making of International Law* (Oxford: Oxford University Press, 2007).

their applicability to SRM research that occurs within their borders – or even SRM research that involves national scientists outside of their territorial jurisdiction.[9] This is likely to be particularly true in advanced democratic nations in North America and Europe, where strong bodies of environmental law and regulation could be brought to bear in a number of ways. Particular bodies of relevant national law are not considered here due to the complexity of such an undertaking. However, in considering the development of any international governance framework, it will be necessary to consider the interface between national and international laws in key jurisdictions. In addition, the implications of different national governments (or national constituencies leveraging national legislation) seeking to apply their own national legislation to SRM research without international consultation could lead to global governance of SRM research becoming spatially fragmented. There would be clear need for co-operation throughout the governance process—including research stages, testing, and potential deployment—and a need for consistency in regulatory authority alongside harmonisation of objectives. Conflicting motives and rules would stifle the prospects for such co-operation, and fragment regulations to the degree where they all lose legitimacy or effectiveness.

The second governance option would be one *grounded on a collection of ad-hoc principles, soft law, and codes of conduct*, and ideally adopted by the transnational community of researchers and policymakers engaged in SRM research. This effort would, at least at early stages, likely be driven primarily by the scientific community and build upon progress at discussions such as the Asilomar Conference on Climate Intervention Technologies, or by supranational scientific bodies intending to have an impact on the future evolution of SRM research. These kinds of soft-law arrangements may be beneficial in the near term to guide research and ensure basic principles of co-operation in the international SRM community. However, as geoengineering activities become more substantial and field testing more of an issue it is likely that governments will get more directly involved and rules that are more heavily enforceable will need to be established.

The latter two governance options focus on the landscape of international institutions. At least partial international governance of SRM may be accomplished by *co-opting* one or more existing International Organisations (IO) or treaties to incorporate SRM. Alternatively, a *new IO or treaty* could be created and introduced into the existing global environmental governance landscape with a specific mandate to govern SRM research (and possibly future deployment). To consider both options, it is necessary to assess the current landscape of potentially relevant IOs and treaties to SRM such as ENMOD, CLRTAP, CBD, etc. The framework we have used for the institutional briefs below looks at: (a) the relevance of these

[9] States exercise territorial jurisdiction over all persons and activities within their land territory or territorial sea and the air space above (with some limitations on regulation of foreign flagged vessels engaged in innocent passage through the territorial sea (TS) – note that (unauthorised) research or survey activities are NOT innocent passage). State sovereignty applies to airspace above the land/TS. Nationality-based jurisdiction applies without such restriction with respect to legal persons (individuals/corporations), ships and aircraft though traditional to distinguish between legislative and enforcement jurisdiction, the latter being more territorially bounded. This nationality basis for extending national governance regimes to actors and activities beyond national territory of particular importance for the regulation of SRM, and links to potential regulatory competition (and potential race to the bottom issues) as sites for registration of ships/aircraft engaged in SRM activities.

institutions' mandates and legal agreements for SRM; (b) the credibility and capacity of their organisational structure to tackle an issue like SRM; and (c) their perceived representative legitimacy in the landscape of global geopolitics and governance.

These governance formats are not exhaustive, nor are they mutually exclusive. It can be imagined that for example, national policies or *ad hoc* principles drive a first phase of research whilst a brand new regime to govern deployment is created over time. Various regimes could also be effective simultaneously. For example, existing international organisations could be co-opted to deal with certain aspects of geoengineering that they would be particularly good at (such as the CBD setting limits to the acceptable level of potential harm to biodiversity, etc.), with a new geoengineering regime/organisation also in place that acts as an umbrella organisation to coordinate activities (and possibly mediate jurisdictional disputes) and fill in regulatory gaps left by other agreements.

Both the key national and international governance landscapes are clearly at a formative stage of SRM research and governance. How SRM governance evolves at both national and international levels will depend significantly on which actors get involved, at what stage, in pushing specific agendas regarding SRM, and which institutions or publics they target with those agendas. To date, only a handful of actors in global (environmental) governance have begun to form coherent agendas for the regulation of SRM. Ad hoc scientific task forces have played a significant role in shaping the evolution of SRM governance so far; these have included the Royal Society's SRMGI, the US National Commission on Energy Policy[10], and the 2010 Asilomar II Conference[11]. Government inquiries in the United Kingdom[12] and the United States[13] have also raised the profile of SRM research and governance. Now, civil society actors are playing an increasingly prominent role in shaping policy discourse about SRM. Deciding which formulation of governance regime is most appropriate for SRM research will not be an easy undertaking, but engaging the breadth of emerging stakeholders in the dialogue is clearly essential.

[10] In early 2010, the Bipartisan Policy Center launched a Task Force on Geoengineering. This effort is aimed at exploring the emerging policy and political issues raised by research activities. The task force is currently preparing a report on this subject, due in early 2011.

http://bipartisanpolicy.org/projects/task-force-geoengineering/about

[11] From March 22-29, 2010 the Asilomar Conference brought together experts in the field of geoengineering to discuss the implications of research and the creation of norms to guide future work. This was inspired after the first Asilomar conference in 1975 which brought together experts in the new field of recombinant DNA.

http://www.climateresponsefund.org/index.php?option=com_content&view=article&id=137&Itemid=81

[12] United Kingdom House of Commons, 2010. 'The Regulation of Geoengineering', Report for the Science and Technology Committee, London,
http://www.publications.parliament.uk/pa/cm200910/cmselect/cmsctech/221/221.pdf

[13] Gordon, Bart, 2010. 'Engineering the Climate: Research Needs and Strategies for International Coordination', Committee on Science and Technology of the Congress of the United States of America, Washington DC.http://sciencedems.house.gov/publications/caucus_detail.aspx?NewsID=2944

Applicability, Relevance, and Evaluation of Existing International Environmental Treaties and Organisations

A number of international organisations (IOs) within and outside the UN umbrella each govern a range of issues that could, potentially, be considered to have limited overlap with SRM governance. However, as will be seen below, the overlap for any one organization is generally narrow, addressing only a small fraction of the social, political and ethical issues raised by SRM research and governance. No IO created to date has the specific mandate or technical capacity to govern SRM holistically, accounting for all the political, socioeconomic, ethical, and physical dimensions of its research, deployment, and impact.

For example, the Convention on Biological Diversity's (CBD) decision (at Nagoya COP 10, 2010) to recommend prohibition of large-scale testing in the absence of regulatory frameworks and minimised uncertainty is a UN body's first intentional governance decision on SRM. But this decision was made in the context of potential adverse biodiversity impacts, and without any mandate or opportunity to consider other dimensions of SRM benefits or impacts (for example, to vulnerable human populations). Moreover, since it is embedded in a non-binding COP decision[14] which employs vague and weak language, and the CBD has minimal compliance strictures and ambiguous connections to the mandates of other treaties that have a clear climate mandate, it is unclear what (if any) *legal* precedent the CBD decision sets. Nonetheless, the *normative* precedent of such a decision remains very significant, and lays foundations for shaping further discussions about the international governance of SRM.

1) Convention on Long Range Transboundary Air Pollution (CLRTAP)

Potential Relevance to SRM (Mandate & Key Agreements)

CLRTAP is mandated to research, control, and reduce the environmental damages and health hazards caused by long-range transboundary air pollution within the fifty-one members of the UN Economic Commission for Europe (UNECE, includes the United States and Canada).[15] Its relevance to SRM governance derives from its adoption of three protocols that regulate sulphur emissions: the 1985 Helsinki Protocol (calling on Parties to reduce national annual sulphur emissions by 30%, and for additional and self-assessed further reductions), the 1994 Oslo Protocol (setting caps on sulphur emissions) and the 1999 Gothenberg Protocol (which adjusts sulphur emissions caps in relation to its social and environmental effects in generating acidification, eutrophication and ground-level ozone).[16] The Gothenberg Protocol's focus on industrial processes as emissions sources makes it more likely to regulate tropospheric than stratospheric emissions; however this distinction is not explicitly stated.[17]

[14] While recourse must always be had to the particular treaty text to ascertain to what extent, if at all, the COP has been empowered with law-making authority, States have proved exceedingly reluctant to confer such authority in multilateral environmental agreements and such authority is not lightly to be presumed in the absence of such express conferral. See Ulfstein (2007); and Brunnee (2002).
[15] Bull 2003, 1-11.
[16] See Helsinki Protocol (1985), Oslo Protocol (1994), and Gothenberg Protocol (1999).
[17] Gothenberg Protocol 1999, and Explanatory Memorandum on the 1979 Protocol to Abate Acidification, Eutrophication, and Ground-Level Ozone.

Organisational Structure (Scientific and Governance Capacity to Tackle SRM)

The highest decision-making body is the Executive Body, made up of representatives from the Parties, which meets annually. Its responsibility is to implement the Convention: to adopt protocols, set agendas and establish Working Groups, and make financial decisions.[18] Amendments to Protocols are decided upon by consensus at Executive Body meetings, and enter into force ninety days afterwards for Parties – numbering two-thirds of the membership – that have submitted instruments of acceptance. All Parties submitting acceptance instruments afterward will similarly have ninety days before amendments enter into force. There is an opt-out mechanism (within ninety days from submission of acceptance) for amendments to annexes of the protocols *aside from annexes II to IX*.[19] Formal compliance mechanisms are untested; the Executive Body in theory responds to non-compliance cases with only recommendations, and no Party has invoked CLRTAP's non-compliance procedures. However, CLRTAP has substantially decreased air pollutant emissions in Europe during the last twenty years (~100 billion Euros/year have been saved in Europe in terms of 'avoided damage cost' on sulfur and NOx emission mitigations).[20] It has a decades-long familiarity with long-range transboundary air pollution monitoring and assessment in Europe and North America, and has collected comprehensive data on aerosol air pollution particles.[21] [22] In the context of the UNECE, this would suggest a considerable science and governance capacity.

Legitimacy

While CLRTAP's public credibility may have a high level of acceptance in the UNECE, it does not include emerging economies such as China, Brazil, México and India, which now are considered as major contributing countries to long-range air pollution. This geographical exclusiveness would be a significant limitation were CLRTAP to lead in the development of an SRM research governance framework for the international community; however, its strong and partially relevant scientific capacity could make it an important contributor to any emerging *regime complex* seeking to collectively govern SRM research.

2) International Maritime Organization (IMO)

Potential Relevance to SRM (Mandate & Key Agreements)

The IMO is a formally constituted organisation of the UN, concerned with regulating the safety of maritime navigation and protection of the marine environment.[23] There are limited indications that the IMO is moving into geoengineering assessments on two fronts. In the broader geoengineering arena, the IMO's Contracting Parties to the 1972 London Convention

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[18] CLRTAP Executive Body, http://www.unece.org/env/lrtap/ExecutiveBody/welcome.html, and Selin and VanDeveer 2003, 23.

[19] Helsinki Protocol (1985): article 7, Oslo Protocol (1994): article 11, Gothenberg Protocol (1999): article 13.

[20] Wettestat (1997), Brachtl (????)

[21] Brachtl (????)

[22] Wettestad 1997, and Krewitt et al 1998.

[23] IMO. "Frequently Asked Questions". http://www.imo.org/About/Pages/FAQs.aspx, and IMO, 2010. Resolution a. 1011(26). Strategic plan for the organization (for the six-year period 2010 to 2015). Adopted on 26 November 2009. See agenda item 8.

(on ocean dumping) and 1996 London Protocol have adopted an Assessment Framework for Ocean Fertilization.[24] In more direct relevance to SRM, the IMO has a mandate to regulate the environmental impacts of sulphate aerosols in shipping emissions. Moreover, while its traditional framing of regulation responds to the health and environmental impacts of shipping pollutants, IMO has more recently incorporated climate change mitigation within the scope of its activities. Through its Marine Environment Protection Committee (MEPC), IMO recognises the importance of mitigating six greenhouse gases (GHGs) in the Kyoto Protocol's basket of governed materials.[25] Through these nascent links to global climate policy, IMO may have the potential to incorporate climate-forcing effects of sulphates into its agenda and regulations, which are recognised in the Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC). A key agreement relevant to SRM may be Annex VI of the International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978 (MARPOL), which governs air pollutants.[26] In 2008, IMO adopted a revised Annex VI, stipulating further reductions on sulphate emissions.[27]

Organisational Structure (Scientific and Governance Capacity to Tackle SRM)

IMO has 169 members and 3 associates; its highest governing body is the Assembly, which meets every two years. Parties include most OECD countries, all major emerging economies (Brazil, China, India, México and South Africa), and developing nations. Its highest technical body is the Maritime Safety Committee, although this deals with maritime safety (navigation, cargo, on-board regulations, etc). Its environmental advisory body is the Marine Environment Protection Committee (MEPC). As the body that provides technical scope on prevention and control of shipping pollutants, it would be most relevant to sulphate emissions.[28] The IMO also has strong Non-Governmental Organization (consultative status) and Intergovernmental Organization (observer status) stakeholder participation.[29]

Legitimacy

The IMO has a broad representation of Northern and Southern state and non-state actors. Yet, the broad-based legitimacy this garners will be tested as it moves beyond maritime and shipping regulations and commercial issues. Linkages with the London Convention on ocean fertilisation and the UNFCCC (GHG regulation) may not be controversial to its members, but

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[24] IISD, "IMO Meeting Adopts . "Assessment Framework forFor Scientific Research Involving Ocean Fertilization", 20 Agreed." News Briefing. October 20, 2010. , http://climate-l.iisdwww.imo.org/news/imo-meeting-adopts-mediacentre/pressbriefings/pages/assessment-framework-for-scientific-research-involving-ocean-fertilization/-agreed.aspx

[25] IMO. "MARPOL Annex VI." http://www5.imo.org/SharePoint/mainframe.asp?topic_id=233 Text reads: "Meanwhile, the Committee recognized that IMO guidelines on greenhouse gas emissions have to address all six greenhouse gases covered by the Kyoto Protocol (Carbon dioxide (CO2); Methane (CH4); Nitrous oxide (N2O); Hydrofluorocarbons (HFCs); Perfluorocarbons (PFCs); and Sulphur hexafluoride (SF6)."

[26] IMO. "MARPOL Annex VI." http://www5.imo.org/SharePoint/mainframe.asp?topic_id=233 (Last accessed 10 March 2011).

[27] MEPC 2008.

[28] IMO. "Structure of IMO". http://www.imo.org/About/Pages/Structure.aspx#4

[29] IMO. "Membership NGOs", http://www.imo.org/About/Membership/Pages/NGOsInConsultativeStatus.aspx and IMO. "Membership IGOs", http://www.imo.org/About/Membership/Pages/NGOsInConsultativeStatusIGOsWithObserverStatus.aspx

if these engagements evolve into governance debates on "geoengineering proper", an entirely new suite of interests and contestations will come into play that will test the IMO's constituent actors' cohesion that have heretofore been largely based on maritime issues.

3) Convention on Biological Diversity (CBD)

Potential Relevance to SRM (Mandate & Key Agreements)

The CBD is the first international treaty explicitly to address all aspects of biological diversity, ranging from conservation of biological diversity and sustainable use of biological resources to access to biotechnology and the safety of activities related to living modified organisms (this last addressed in the 2000 Biosafety Protocol). Its breadth is revealed in both the preamble and its substantive provisions, with reference *inter alia* to combating deforestation and desertification, planning and management of land resources, managing fragile ecosystems on land and at sea and promoting sustainable utilisation of all living resources.[30] Given the breadth of its mandate, the CBD could potentially govern the implications of any SRM activities that affect biodiversity. Indeed, it is the first UN body to produce a decision on the issue; at the Nagoya COP 10 in 2010, the CBD adopted a decision on geoengineering that:

8 Invites Parties and other Governments, according to national circumstances and priorities, as well as relevant organizations and processes, to consider the guidance below on ways to conserve, sustainably use and restore biodiversity and ecosystem services while contributing to climate-change mitigation and adaptation:

(w) Ensure, in line and consistent with decision IX/16 C, on ocean fertilization and biodiversity and climate change, in the absence of science based, global, transparent and effective control and regulatory mechanisms for geo-engineering,[31] *and in accordance with the precautionary approach and Article 14 of the Convention, that no climate-related geo-engineering activities that may affect biodiversity take place, until there is an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks for the environment and biodiversity and associated social, economic and cultural impacts, with the exception of small scale scientific research studies that would be conducted in a controlled setting in accordance with Article 3 of the Convention, and only if they are justified by the need to gather specific scientific data and are subject to a thorough prior assessment of the potential impacts on the environment;*

(x) Make sure that ocean-fertilization activities are addressed in accordance with decision IX/16 C, acknowledging the work of the London Convention/London Protocol…[32]

Given its vague wording, a preface specifying the decision as merely an "invitation" for parties to "consider" the text as "guidance," and the formally non-legally binding status of COP decisions, the impact of this decision is ambiguous at best. The precautionary principle

[30] "The Biodiversity Convention and Biosafety Protocol" in Bowman, Davies and Redgwell (2010), p. 593
[31] The COP also called on the CBD Executive Secretary to 'undertake a study on the gaps in such existing mechanisms for climate-related geo-engineering relevant to the Convention on Biological Diversity.'
[32] CBD 2010. See agenda item 5.6. See also: Sugiyama and Sugiyama 2010, available at http://criepi.denken.or.jp/jp/serc/discussion/index.html.

is cited; yet 'small scale studies' that would contribute to the development of an adequate scientific basis for larger scale experimentation might be considered allowed, and there is an implication that an adequate scientific basis could make full-scale geoengineering interventions permissible. How individual states will choose to interpret and implement this decision is highly uncertain. To the extent that it exerts normative pull it may be viewed as "soft law", whose power resides in the normative message it sends to parties and attentive publics. A key limitation on the ability of the CBD to act remains the fact that, broad though its biodiversity remit may be, it does not have jurisdiction over any SRM activity that does not impact on biodiversity.

Organisational Structure (Scientific and Governance Capacity to Tackle SRM)

The CBD is a UN body with a virtually universal membership of 193 members; however, the United States is only a signatory. The Conference of the Parties (COP) is the main governing body responsible for adopting decisions and protocols.[33] The Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA)[34] is the CBD's scientific advisory body, and it was responsible for the draft recommendation that resulted in the Nagoya decision on geoengineering.[35] However, there is evidence that this was due more to informal linkages to – and advocacy of – key NGOs opposed to geoengineering, than the inclinations of the CBD's institutions and parties. The Nagoya decision also relies on the generally weak compliance mechanisms of the CBD; while the COP can issue hortatory and advisory statements on violations, it leaves monitoring and enforcement to its constituent Parties.[36]

Legitimacy

Two key issues for the CBD are its lack of universal participation - the United States became a signatory in 1993 but has not ratified the Convention [37] – and the perception that the CBD text is weak and ambiguous and lacks "teeth". Indeed, initial reaction to the CBD was mixed, ranging from hailing it as a landmark in the field to harsh criticism of its text as rushed, ambiguous and haphazard.[38] The very breadth of its activities has led to concerns that the CBD has not been able sufficiently to focus on key issues and that it is dissipating its energy across too wide a range of issues – of which geoengineering is yet another. With biodiversity in decline at all levels and geographical scales, there will undoubtedly be pressure on the CBD to focus on its core mission. Certainly it possesses neither the institutional robustness nor the legal remit to address SRM in the round.

[33] CBD. Text of the Convention on Biological Diversity, Article 23.. While the COP may adopt protocols these are still subject to the normal treaty procedures for ratification, approval, etc. by States before becoming legally binding upon them.

[34] CBD. "Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA)". http://www.cbd.int/sbstta/

[35] CBD SBSTTA 2010. In-depth Review of the Work on Biodiversity and Climate Change, 8(w), XIV/5.

[36] The Nagoya decision has no provisions for compliance, enforcement or penalties: Articles 5.11 and 14 read "… each Contracting Party shall, as far as possible and as appropriate…"

[37] CBD List of Parties. http://www.cbd.int/convention/parties/list/

[38] Bowman, Davies and Redgwell (2010), pp. 626-7.

4) United Nations Environment Programme (UNEP)

Potential Relevance to SRM (Mandate & Key Agreements)

Included in UNEP's mandate is the role of conceptualising and catalysing new environmental initiatives and governance frameworks within the UN system, and to coordinate existing regimes along environmental agendas.[39] It has no explicit mandate over geoengineering or SRM, but does have a number of functions and prior decisions that could make it valuable as a convenor of international discussions on these issues. First, it has a strong track record in synthesising environmental trends and scientific information at the global level. Secondly, it has put forth in 1980 non-legally-binding international guidelines for weather modification techniques, calling for information sharing and for prohibition of transboundary harm.[40] Indeed, in other issues, UNEP has previously formulated soft law (non-binding guidelines) that has led to law-making activity by states (e.g. PIC Convention and prior guidelines). Thirdly, in its capacity as the UN's hub of inter-agency coordination on the environment, UNEP could act as an early conceptual incubator for "cross-cutting" geoengineering governance – either by coordinating more relevant agencies under its nominal umbrella, or by galvanizing a new governance body to which operational capacity would devolve.

Organisational Structure (Scientific and Governance Capacity to Tackle SRM)

UNEP is a UN programme with limited funding and operational resources. Nominally, it coordinates all UN governance bodies and state members along environmental agendas through the *Environmental Management Group* (EMG, inter-agency UN panel) and *Global Ministerial Environment Forum* (GMEF, annual meeting of UN national environment ministers).[41] It has also played a historically strong role in collecting, analysing, and integrating data from UN agencies and other organisations, including convention secretariats, universities, science institutes, and nongovernmental organisations, in order to synthesise broad environmental assessments for use at the global level.[42] This bird's eye focus has given it a historically strong position as a first-mover on new environmental data and trends, and has led to its role in galvanizing a number of environmental regimes.

However, UNEP does not have the mandate to govern any particular issue or the operational capacity (funding, human resources, and preeminence among other environmental regimes) to implement them. It has demonstrated the capacity to act beyond its constitutional limitations, having successfully catalysed the formation of a number of international environmental regimes/bodies (including the IPCC and the Montreal Protocol), though, having catalyzed new issues and frameworks, actual governance has been relinquished to the generated regimes.[43]

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[39] Ivanova 2007, 347, and Ivanova 2010, 38.

[40] See: Bodansky 1996, citing U.N. Environment Programme: 1980, *Provisions for Cooperation between States in Weather Modification,* Decision 8/7/A of the Governing Council, 29 Apr. 1980, and Virgoe 2009, 111.

[41] UNEP. Environmental Management Group. http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=43&ArticleID=4326&l=en and UNEP. Governing Council/Global Ministerial Environment Forum. http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=43&ArticleID=28&l=en

[42] Ivanova 2010, 45.

[43] Ivanova 2010, 43, see also Najam 2005, 40.

Legitimacy

UNEP enjoys a broad, if nebulous legitimacy as a UN body headquartered in the developing world (Nairobi, Kenya). Developing states in 1972 (post-Stockholm Convention) argued that political legitimacy of the new environmental paradigm in particular, and of the structure of international governance (under the UN) in general, demanded a more equitable North-South distribution in UN governance body locations.[44] However, its geographic isolation from other UN bodies, as well as its receptiveness to Southern platforms of development and equity (a function of its location), has created some hostility toward UNEP from Northern states.[45] Within the UN environmental umbrella, UNEP has a contentious relationship with other governance bodies due to its limited resources and historic jurisdictional contestations.[46] Moreover, its position as the UN's environmental coordinator is impacted by a lack of cohesion and clarity within the high-level Environment Management Group.[47] That said, UNEP may be a weak environmental hub for the UN system, but through its formal mandate it is, in theory, first among a plethora of equals. Its pro-development paradigm, North-South divisions, and position among environmental IOs are all factors that would shape (in uncertain ways) its engagement of SRM governance.

5) Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD)

Potential Relevance to SRM (Mandate & Key Agreements)

ENMOD legally prohibits environmental modification techniques, with three significant provisos: such techniques must be (1) hostile (modes of warfare) with (2) 'widespread, long-lasting, and severe' consequences, and (3) the convention applies only to signatories. It does not deal constitutionally with climate modification, but the distinction between weather and climate modification in the case of SRM deployment may not be seen as relevant in policy and advocacy contexts.[48]

However, the triggering conditions truncate the applicability of ENMOD to an almost unusable mode. ENMOD permits weather modification for 'peaceful' intents.[49] This condition would appear to permit climate change-mitigating SRM. Any attempt to frame SRM as 'hostile' could face strong challenges from other actors who may frame SRM as a well-intentioned attempt to prevent the worst effects of climate change. ENMOD does define 'environmental modification techniques' as the 'deliberate manipulation' of the Earth's 'biota, lithosphere, hydrosphere and atmosphere, or of outer space', thus encapsulating most geoengineering techniques.[50] However, this definition is coupled with the conditions of 'widespread, long-lasting, and severe' damage; for an action to be prohibited, it must meet each of these three conditions.[51] Even in its most basic definition, it could be difficult to

[44] Ivanova 2007 and Ivanova 2010.
[45] Najam 2005, 40.
[46] Ivanova 2007, Ivanova 2010, Najam 2005, and Von Moltke. 2001.
[47] Najam 2005, 43.
[48] Bodansky (1996, 311).
[49] ENMOD Article III.
[50] ENMOD Article II.
[51] ENMOD Article I.

trigger such a comprehensive threshold. Moreover, what impacts would constitute such a definition of "damage" is ambiguous, and would be prone to challenge.[52] Finally, it might be noted that ENMOD's mandate is to ban hostile weather modification techniques; if applied to geoengineering, its framing is not conducive to regulating permissible amounts of research and deployment.

Organisational Structure (Scientific and Governance Capacity to Tackle SRM)

ENMOD has a low membership (48 signatories and 74 parties, though these contain most major economies), which prevents it from being a comprehensive system of governance.[53] It has also been essentially dormant for years. It has had only two review conferences (1984 and 1992) which updated the convention only with non-binding "understandings", the bulk of its ratifications came in the 1970s and 1980s (only three ratifications since 2000), and attempts by the General Assembly to have it universally ratified have come to naught.[54] That said, the adjudication of ENMOD's enforcement falls to the UN Security Council (UNSC), and any ENMOD Party can lodge a complaint directly to UNSC, in effect, triggering the debate over geoengineering governance at the UN's most prominent political forum.[55]

The UNSC, aided in its deliberations by a Consultative Committee of Experts, would then rule on whether a violation has taken place.[56] Such simplicity and directness (a direct route to the UNSC and the tacit participation of its five permanent members, P-5) may present advantages for binding decisions on geoengineering should will and cohesion be found. However, the lack of an established science and impacts assessment panel, or mechanisms for mediation and enforcement separate from the UNSC, both make ENMOD's efficacy and impartiality subject to question. A Consultative Committee constitutes an *ad hoc* system of deployment and impact assessment, and ENMOD has no compliance mechanism or system of penalties and compensation. In addition, ENMOD was designed as an arms-control treaty, not as an environmental regime; it exists to ban modes of warfare, not to assess and regulate materials with environmental impacts, or research into them.[57] Both mandate and structure would thus make sustained evaluation, monitoring, verification and governance of geoengineering activity difficult. Moreover, the veto power of the P-5 members makes decision-making with widespread repercussions for governance directly subject to the geopolitical motives of a small club. Most significantly, no party has ever been formally accused of a violation, and the ENMOD's capacities and dynamics remain untested.

Legitimacy

[52] Chamorro and Hammond (2001).
[53] ENMOD. "Membership". http://treaties.un.org/pages/ViewDetails.aspx?src=UNTSONLINE&tabid=1&mtdsg_no=XXVI-1&chapter=26&lang=en#Participants).
[54] Chamorro and Hammond 2001: "The UN General Assembly has called for global ratification on several occasions, but without much success." Moreover, "there is little history of North-South politics in ENMOD, and geopolitical alliances in arms control negotiations are often different than those in environmental, agricultural, or other international processes", which poses a number of different possibilities and problems for ENMOD's power dynamics than usually exist in environmental governance bodies".
[55] ENMOD Article V(3).
[56] ENMOD Article V(2), as well as Annex to the Convention: Consultative Committee of Experts.
[57] University of Bradford. ENMOD. http://www.brad.ac.uk/acad/sbtwc/gateway/ARMS/ENMOD.htm

ENMOD's legitimacy is negatively impacted by the same factors that reduce its governance capacity. The infrequent convening of ENMOD's parties gives it an appropriately low profile in global governance and international law. Its limited membership misses potentially important states such as South Africa, Indonesia, and Singapore, and raises questions of representation and equity. The Cold War and military colouration of its legal mandate creates a considerable conceptual leap into the climate mitigation/adaptation and pro-development agendas that frame much of the climate *problematique,* and as a result, it may simply be seen as an obsolete way to frame a modern climate-related issue.

6) UN Framework Convention on Climate Change (UNFCCC)

Potential Relevance to SRM (Mandate & Key Agreements)

The UNFCCC's mandate is to stabilise anthropogenic GHG emissions at levels that prevent severe changes to the climate system and a projected variety of physical, social, and economic impacts.[58] It contains no provisions in the Convention text or the Kyoto Protocol that explicitly recognise or govern SRM (or geoengineering more broadly). It is also uncertain where these technologies and initiatives would fall under the "mitigation and/vs. adaptation" dichotomy of the negotiations. However, the IPCC has long recognised the radiative forcing effects of sulphate aerosols, and the science, policy, and impacts of geoengineering will be analysed as part of the IPCC Fifth Assessment Report (AR5).[59] As an intergovernmental body, the IPCC reports are *de facto* vetted by the regime's governments; yet how the assessments will translocate from the IPCC into the UNFCCC COP agendas is uncertain, given the current state of climate negotiations, and the novelty and ambiguity to Parties of geoengineering's framing and potential impacts.

Organisational Structure (Scientific and Governance Capacity to Tackle SRM)

Since SRM is in no small part framed as a supplement to the climate *problematique*, the UNFCCC could be a logical arena for its governance. Yet, the context of mistrust between and within the North and South on existing issues – climate finance; the backlog of Annex I commitments; technology transfer and intellectual property rights (IPRs); future commitments by emerging economies; impacts of carbon pricing on production costs and potential economic contractions; etc – make the addition of SRM (or geoengineering more broadly) to the clogged agenda a difficult endeavour at best.[60] This is worsened by the consensus-based decision-making structure of the Conferences of the Parties (COPs), which allows much diplomatic leeway for small numbers of states to block decisions approved of by the majority and heighten the potential for gridlock on all novel issues.[61] Finally, even if SRM were to be the subject of a COP decision, the UNFCCC would still have to negotiate a novel monitoring and compliance mechanism for it, which, once again, the COP's consensus-based decision-making procedure may make extremely difficult.

[58] UNFCCC Article II.
[59] The IPCC has since 1992 acknowledged the radiative forcing effects of sulphate aerosols. IPCC Working Group I Assessment Reports in 1995, 2001 (Chap 6), and 2007 (Chap 2) have all formally assessed these effects. IPCC Assessment Report 5 (due 2012-2013) will include "focused treatment of subjects like clouds and aerosols [and] geo-engineering options…" (Pachauri, Statement at Opening Session of COP-16, Nov 29th 2010).
[60] See, for example, Whalley and Walsh 2009, Depledge 2006.
[61] Depledge 2005, 92.

Legitimacy

The UNFCCC's membership is near-universal and its profile in environmental governance currently unrivalled; yet the political considerations of bearing the costs of carbon reduction have left it near procedural and conceptual stagnation, and at times even in danger of collapse. It is uncertain how SRM and geoengineering, even as research activities, would feed into existing geopolitical tensions. If these were exacerbated by the controversies over impacts and ownership of SRM technology, particularly between the North and South, or between the developed/emerging and the least developed (most physically vulnerable) states, the fallout might further weaken the ability of the UNFCCC to address its primary mandate of mitigating GHG emissions.

The concern is not restricted to "access" to SRM technology. There is a deeper mistrust in the UNFCCC that stems from a history of unmet commitments on emission reductions, financial support, technological collaboration and transfer, and minimal attention to adaptation needs. There is no reason for a majority of the UNFCCC's membership to believe any political promises made or international norms exhorted on a cautious approach to SRM research. More significantly, if attention to SRM is seen to be diverting attention away from mitigation, then it would strike at the core of one the UNFCCC's fundamental principles, namely equitable burden sharing via common but differentiated responsibilities. It is difficult to envision at this stage that the UNFCCC would have the legitimacy to govern geoengineering without overturning, at least in part, one of its foundational building blocks.

7) Montreal Protocol on Substances that Deplete the Ozone Layer

Potential Relevance to SRM (Mandate & Key Agreements)

The Montreal Protocol (a constituent treaty of the Vienna Convention) has a mandate to protect human health and the environment against effects from the modification of the ozone layer.[62] It is mandated to eliminate ozone depleting substances (ODS); rather than treating it as a pollutant with regulation of maximum allowable amounts, the Protocol treats ODS as a hazard that should (eventually) be totally eliminated. SRM would come under its jurisdiction only if sulphate aerosols and other climate forcers are demonstrated to deplete the ozone layer, as Tilmes et al (2008) have argued via computer modelling.[63] Thus far, the Montreal Protocol has not assessed SRM geoengineering or included sulphates in its basket of governed materials; nor is it obliged to consider the climate-forcing impacts of regulating ozone-depleters. For example, it has permitted a number of HFCs as substitutes for ozone-depleting chlorofluorocarbons (CFCs), without accounting for its powerful capacity as

[62] Following the Vienna Convention's mandate: to "protect human health and the environment against adverse effects resulting from modifications of the ozone layer" (Vienna Convention Preamble), the Protocol sets out operational details, targets, and timetables for the reduction and elimination of ozone-depleting aerosols. It calls for a consumption cap on five major ozone-depleting CFCs at 1986 levels, followed by a phased reduction to 59% of the 1986 level by 2000 (See Montreal Protocol, Article 2).

[63] Tilmes et al 2008.

GHGs.[64] Moreover, even if the Montreal Protocol did undertake sulphate regulation, it would not cover the sulphate emissions that accompany the usage of fossil fuels.

Organisational Structure (Scientific and Governance Capacity to Tackle SRM)

The regime's Scientific Assessment Panel (SAP) has recognised the radiative forcing effects of sulphate aerosols (specifically from the Mt Pinatubo eruption in 1991) in climate assessments, but it has itself done no assessment of the ozone depleting potentials of sulphates (see SAP 2010 report[65]). If such potentials can be demonstrated, the Montreal Protocol is lauded as one of the most successful and coherent environmental regimes. It has universal membership, and a credible track record of assessment, regulation, and science-to-policy.[66] A note of caution: considering that the UNFCCC has a comparable science-to-policy process (IPCC) and has not made progress on GHG governance, the key factor behind the success of the Montreal Protocol's process has more to do with ozone-depleting substances being a material upon which economic growth is not comprehensively dependant. Its governance is therefore more politically palatable with proper incentives and available alterative technologies. However, only two-thirds of Parties representing a majority of Northern and Southern states are needed to create decisions that become legally binding on all parties; this may be a more facilitative process to expanding its mandate and operations.[67] If the CBD's Nagoya ruling serves as a precedent to governing geoengineering with regard to its impact on biodiversity, a similar action may be mirrored by the Montreal Protocol as far as ozone depletion is concerned.

Legitimacy

The Protocol has enjoyed broad support and legitimacy in both North and South because of its successful implementation of the Common But Differentiated Responsibilities principle (developing nations were given a decades' grace period before undertaking CFC cuts, and were allowed to increase CFC consumption for a time). Moreover, the regime's funding mechanism, the Multilateral Fund (London Amendments, 1990), recognised the special needs of Southern states for financial and technology transfer, thus persuading Southern states to ratify the Protocol.[68] Finally, its status as arguably the most successful UN environmental regime garners a certain respect. That said, SRM governance will muddy the coherence of the Protocol's mandate, and if the geopolitics that have crippled other regimes are injected into the Protocol's process, the results are uncertain.

<u>Lessons from Other International Organisations</u>

When new technologies emerge that have the potential to create broad and severe negative consequences – along with significant public good – various national and international governance and regulatory frameworks have been created to protect humans and the environment from the consequences of irresponsible testing and deployment. Though none of

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[64] Oberthur 2001, 368.
[65] Scientific Assessment Panel 2010 Report. See also, for overview of the SAP: http://ozone.unep.org/Assessment_Panels/SAP/index.shtml
[66] See, for example, Benedick 1999, DeSombre 2000, Thoms 2003, and Sunstein 2006.
[67] DeSombre 2000, 54-55.
[68] Benedick 1991 Chapter 9

the examples discussed here provide exact parallels for the suite of issues raised by SRM technologies, the responses of national and international communities to these various technologies can provide instructive lessons for governing SRM.

Firstly, SRM technologies certainly could have global effects; thus nations capable of deployment would inherently possess a lot of power.[69] Whether and how such power would be leveraged for political or even military objectives has been the source of speculation by a number of observers, which raises the question of whether weapons conventions or treaties could provide a model for limiting the future likelihood of such actions. An obvious example is the *Nuclear Non-Proliferation Treaty*[70] (NPT) that seeks to limit the spread of nuclear weapons technologies in order to minimise the potential for their use. Overall, the NPT has been considered incredibly effective at limiting the spread of nuclear weapons. However, the applicability of this framework to SRM or geoengineering is questionable, as the basic technologies are far more easily accessible and the technologies themselves are not as intrinsically hostile as nuclear weapons. Moreover, the NPT's legitimacy has also been questioned in that it arbitrarily allowed a handful of countries to retain nuclear weapons and imposed little pressure on them to reduce their arsenals.

Similarly, biological and chemical warfare caused enough human devastation during World War II to spark the creation of multilateral agreements on these technologies. The *Chemical Weapons Convention*,[71] with 140 parties, bans the production, use, and stockpiling of chemical weapons and has generally been successful.[72] The *Biological Weapons Convention*,[73] with 163 parties, bans the development, production and stockpiling of biological weapons; however it has been far less effective than its chemical counterpart, in part because it lacks a verification mechanism. As a result, getting nations to comply with the ban has not been a huge success.[74] At the 2001 Fifth Review Conference, the United States rejected any such a ban on the grounds that it interferes with their domestic bio-defence and anti-terrorism activity. This essentially derailed all future negotiations to ratify the protocol. The contrast between the chemical and biological conventions emphasises the potential challenge of pursuing global regulation of SRM research in any situation where SRM technologies start becoming perceived as having "national interests" associated with their access and control.

The development and testing of SRM technologies also has strong parallels to the ethics of medical testing. Both involve intentional interference with complex natural systems, to which the response is at least partly unpredictable. In this context, the planet may be compared to a patient with an incurable disease for which SRM is an untested treatment.[75] In the medical world, there is no clear distinction between testing and treatment, and as a result, access to

[69] This is an argument has been made in many papers, one of which is Bodansky, 1996

[70] http://www.un.org/en/conf/npt/2005/npttreaty.html

[71] http://www.opcw.org/chemical-weapons-convention/

[72] International Committee of the Red Cross. 2006

[73] http://www.opbw.org/

[74] de Jonge, 2006

[75] Scheinder, 1996

the best treatment and victimisation due to harmful side effects are typically skewed in favour of the wealthier global North.[76] One might expect similar social and economic polarisation with SRM field-testing. However medical experimentation is also very sensitive to the specifics of the case, as well as the local and national culture in which it is being conducted. Thus medical experimentation does not generally lend well to international hard law.[77] Rather, most frameworks are local through national, and based upon principles of informed consent and public engagement and oversight. Expanding such a model to the international regulation for SRM could pose a range of practical challenges.

Since social and political questions of intentionally modifying the climate are relatively unexplored, there may be value in facilitating these discussions early on, as was done with the Human Genome Project. Up to 5% of the Project's annual budget was allocated to addressing ethical, legal, and social concerns,[78] which dealt with many barriers of emerging technologies. Similarly, the 1975 *Asilomar Conference on Recombinant DNA Molecules* laid out basic governing principles that allowed for the continuation of biotechnology research with improved public discourse and ethical clarity.[79] Recently, the 2010 *Asilomar International Conference on Climate Intervention* was an attempt to follow the example of the first Asilomar conference, proposing five principles to guide the emergence of geoengineering initiatives.[80]

In the sense of its research infancy and broad methodology, SRM governance may also benefit from the approaches being developed and applied to the regulation of nanotechnology. Although most nanotechnology testing and implementation does not immediately present immense global ramifications, there remains significant uncertainty on the scale of benefits and consequences. International governance of emerging nanotechnology has encountered many roadblocks, stemming primarily from difficulties with classifying its types and their associated dangers.[81] To address this challenge, the International Standards Organization and the Organization for Economic Cooperation and Development, among others, are publishing guidelines to deal with safety concerns as they emerge,[82] and a variety of initiatives (including the National Nanotechnology Initiative in the United States) have invested significant resources into both: (a) identifying potential hazards and engaging policymakers, scientists, social scientists; and (b) engaging the public in a broad ranging discussion about both the potential hazards and benefits. A similar framework of staged development of research, hazard identification and public engagement could be of value for any national or international SRM research framework.

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[76] Corner and Pidgeon, 2010

[77] Although groups such as the Council for International Organization of Medical Sciences, World Medical Association, and World Health Organization have published bioethical principles which serve as well-respected guidelines.

[78] http://www.ornl.gov/sci/techresources/Human_Genome/elsi/elsi.shtml

[79] Berg et al, 1975

[80] http://www.climate.org/resources/climate-archives/conferences/asilomar/report.html

[81] Morris et al, 2011

[82] http://www.iso.org/iso/iso_technical_committee?commid=381983

The need for broad public awareness and engagement can be seen even more clearly in the case of biotechnology. Like SRM, it is closely related to environmental and human protection, most specifically in the case of genetically-modified (GM) crops. One mandate of biotechnology governance is to protect the environment from neglect in the face of economic opportunity, a consideration that SRM governance may also need to address (though in the case of SRM, potentially more through moral hazard than from direct commercial benefit to corporate actors). The *Cartagena Protocol on Biosafety to the Convention on Biological Diversity*,[83] formally effective in 2003, established rules governing the movement of GM organisms between countries. Nations apply a precautionary approach to individual GM crops (e.g. drought or insect-resistant corn or cotton), which allows them to weigh the economic gains against the threats to biodiversity and public health. In addition to the constant emergence of new biotechnologies, a reason for this approach rather than hard-lined international regulations is to give an economic fair chance to developing nations.[84] The economic and political frailty of developing nations, some of which would be affected the most by climate change, may be an equivalent consideration in the division of power and control of SRM technology.

Benefits and Drawbacks of Governance Options

Table 1 provides a first attempt at identifying the benefits and pitfalls of the four broad governance options identified above, however no attempt is made to comparatively evaluate these options.

Table 1: Benefits and pitfalls in adopting different governance options for SRM

Governance Regime Option	***Potential Benefits of this Approach***	***Potential Pitfalls and Drawbacks of this Approach***
National-Level Policy Driven	▪ Protects sovereignty of nations in making their own decisions, which could reduce some tensions ▪ Could be implemented relatively quickly (at least in the case of developed states with strong environmental law and regulatory systems already in place) ▪ Clear enforcement mechanisms through national law (private suit and/or regulatory enforcement action) ▪ Could act as a building block for international negotiations so that when that process begins, the key differences of opinion are already	▪ Could create more tensions than it avoids, especially if some nations move aggressively into technology development. This could begin a geoengineering race fuelled by national self-interest instead of global consensus ▪ States might 'compete' for geogengineering business (parallel with flags of convenience/open registries for VLCCs in 1960s and 70s) though in

[83] http://bch.cbd.int/protocol/

[84] Kameri-Mbote, 2004

	on the table, thus potentially moving the deliberations forward quicker [bottom up approach]	short term difficult to see significant economic benefits in so doing ▪ Some nations could get so far ahead in terms of technology development, research, and knowledge of the issues that inclusion of others later on is difficult. Relinquishing advantage would be hard for nations on the forefront
Ad-Hoc Codes of Conduct	▪ Lack of bureaucracy creates more flexibility in regulation ▪ Can be implemented quickly, as long as all are willing to abide by the rules ▪ May be generated by non-State actors/geoengineering stake holders ▪ Potential for inclusion of a variety of stakeholders makes attractive, though with each group included the efficiency of generating consensus and concrete rules may decrease because of diversity of perspectives. Regardless, it might be easier to negotiate these soft-laws informally in this type of forum than at high-stakes international negotiations	▪ If lack of elected official engagement in decision-making, this could create perception that a relatively select group is having unfair say in the issue and create pushback ▪ Should those most involved in research be trusted to lead governance? ▪ Less involvement by governments could somewhat limit resources for research, though government could be involved
Co-opt Existing Regime(s)	▪ Might be quicker and easier than building a new regime, but be just as strong/enforceable ▪ Using regimes with high degree of legitimacy would make governance stronger/more definite	▪ Are these regimes flexible enough to deal with new understandings, developments? ▪ The decision-making structure for SRM research, testing, and deployment could become very complicated (particularly if multiple regimes become involved). The result could become a non-transparent and difficult to manage system. ▪ Unclear what existing regime would want to take this on or have it

		foisted upon them
New Regime	▪ Fill in regulatory gaps that other regimes cannot, handles the aspects of SRM governance that no other regime has been designed to regulate ▪ Various aspects of regime (enforcement mechanisms, etc.) can be tailored specifically to the SRM issue ▪ Need for flexibility in regime could be satisfied (are existing regimes flexible enough?) ▪ Could be supplemented with soft law initially to allow for flexibility in near term whilst stricter rules are evaluated and considered. This would lessen pressure on the new regime to create regulatory certainty right away, which could result in a suboptimal regime	▪ Time lag for creation and implementation of new regime could be quite long—potentially too long without other regulation filling the space.[85] ▪ Yet another governance regime and negotiating arena convolutes things, especially for existing climate negotiations[86] ▪ Generating legitimacy in such a regime requires time to build confidence among parties in the consistency and saliency of the regime. The emergence of the climate regime to date has been a gradual evolutionary process, suggesting the same would likely be true with geoengineering[87]. ▪ Since so many facets to geoengineering issue, is this too much for a single regime to take on? At what point does the wealth of topics for negotiation become more efficiently tackled in separate forums that move at their own pace?

[85] Though could be supplemented eg by industry schemes – example of TOVALOP and CRISTAL applying 'immediately' pending entry into force and widespread participation in treaty-based regimes (CLC/Fund) with industry scheme eventually phased out. Role of ITOPF – International Tanker Owners Pollution Federation

[86] Hicks, Bethany L. "Treaty Congestion in International Environmental Law : The Need for Greater International Coordination." University of Richmond Law Review 32 (1999) : 1643-74.

[87] Bodansky and Diringer, 'The Evolution of Multilateral Regimes: Implications for Climate Change (Pew Center paper Dec 2010 http://www.pewclimate.org/publications/report/evolution-multilateral-regimes-implications-climate-change

International Coordination of SRM Research

What SRM research could benefit from international coordination?

Attempts to coordinate SRM research internationally hinge on technical and scientific demands, on one hand, and ethical and political considerations, on the other. Research itself can occur in different forms and at various scales. The principles affecting the governance of SRM research will depend on how it is categorised.[88]

At one end of the spectrum is research conducted by scientists in pursuit of scientific curiosity. One could argue that if there is no physical risk from the experiments, then it would be near impossible to impose a total ban on any kind of research into SRM.

Moreover, researchers could argue that prohibitions on SRM research could violate the basic principle of freedom of science. The International Council for Science (ICSU) has supported scientific freedom, emphasising the universality of science and affirming the right and freedom of scientists to associate in international scientific activity without regard to such factors as race, citizenship, language, political stance, or gender. If scientists across national borders choose to collaborate on some aspects of SRM research, it is unlikely that they can be prohibited outright.

Computer Modelling[89]

Computer modelling would fall under this category. In fact, virtually all current SRM research uses computer models. Whether testing ideas of artificial stratospheric clouds or brightening of marine low clouds, their effects are calculated with the same computer models now used to study the climate system.

International coordination of geoengineering research would have to build on existing collaboration in climate science. Climate modelling has always been a coordinated international endeavour. Currently, in preparation for the next IPCC report (AR5), the Climate Model Intercomparison Project 5 (CMIP5) is being conducted by about 20 general circulation model (GCM) research groups around the world.[90] Piggybacking onto that experiment, the Geoengineering Model Intercomparison Project (GeoMIP) has organised additional computer runs meant to reverse the warming from CO_2 in the CMIP5 runs by additionally reducing solar radiation.[91] This experiment is endorsed by the World Climate Research Program's Working Group on Coupled Modelling (WGCM) as a 'Coordinated CMIP Experiment'.

All the groups involved in the CMIP5 have agreed to conduct the same climate change experiments with their new models and deposit the results in a databank accessible to all, so that the results can be shared and compared. Like CMIP5, the results from GeoMIP will be archived in a databank accessible to all. Because the climate modelling community has

[88] See the background paper on 'Thresholds and Categories of SRM research' by the 'thresholds' subgroup, March 2011.

[89] This discussion extensively draws on a note prepared by Alan Robock for the Working Group on SRMGI.

[90] Taylor et al., 2008

[91] Kravtiz et al., 2011

agreed to conduct these standardised experiments, it is expected that the results will be easy to compare and help understand which simulated climate responses will be robust.

A coordinated modelling intercomparison project for cloud brightening has not been organized yet, partly because the design of such an experiment would be more complicated than GeoMIP for the stratosphere. This is because clouds are simulated in different locations in different GCMs. High-resolution regional climate models[92] are also being used for cloud brightening studies, and such an idealised experiment could be organised among different groups with different models, but none have been so far.

Field Experiments

Coordinating field experiments gets trickier. The environmental risk of experiments would vary by scale but who is to decide what is a small versus a medium or large scale experiment? With increase in scale, each experiment would have to be separately reviewed and approved. At least three scenarios should be considered. The first is when the research activity is entirely privately funded. While such activity could fall outside the purview of national governments (depending on the scope of domestic laws), its international consequences would still demand attention. If the scale of the experiment is expected to have transboundary consequences, then appropriate international governance mechanisms would be demanded. What kind of obligations do private research institutions or consortia have towards the rest of the world? If national laws are ambiguous, would laws emanating from regional or multilateral institutions be sufficient to regulate such activity?

A second scenario arises when a small number of countries decide to collaborate on a research project. Here, too, the scope of the research collaboration would be determined by the countries concerned. They might or might not choose to allow other countries to join the research group. There are also other concerns about the transparency of the research, whether the data would be available to non-members of the research group. The most important question would be whether international laws and organisations could have any jurisdiction over a subset of countries that have voluntarily chosen to come together in a research project. If the answer is unclear, then the opposition to such research would also be expected to increase.

A third scenario is a multi-country project. Here, a large number of countries could decide to engage in experiments of a specified scale, with each country contributing to the costs or scientific resources or both. Alternatively, the experiment could commence with fewer countries but with provisions to include others. The parameters for admission could vary as could the basis of joining the project (a formal treaty or a looser collaboration).

Deployment

At the other extreme is when one or two countries decide to deploy SRM technology. Recent news reports suggest that even private companies with a small fleet of high-altitude aircraft could succeed in conducting experiments on a large scale. So far, however, there are no *in situ* geoengineering experiments being conducted. A Russian experiment was labelled

[92] For example, Wang et al., 2011

geoengineering,[93] but was not relevant as it involved tropospheric aerosols different from what are being proposed for geoengineering. However, if stratospheric aerosols or cloud brightening are tested at "small scale" in the atmosphere, there would certainly be a need for international governance. The definitions of the scale in time, space, and emission amount beyond which environmental impacts might be possible need to be resolved so that charges of controlling the global climate by national actions may be addressed. Further, stratospheric experiments would not answer important questions like the resulting aerosol size distributions and the climate response.[94]

Immediate Opportunities and Barriers

While noting the challenges linked to categorising SRM research, there are some immediate opportunities for internationalising SRM research. Note that these ideas are being presented without any prejudice to their applicability or appropriateness, either in technological or social/political terms. Instead, they highlight the areas in which international coordination might benefit research activities and, hopefully, increase the available data to make more informed decisions on how to manage further technological development.

- Climate observations and intercomparison modelling
- Experiments with aerosols
- Designing delivery mechanisms
- Efforts at cloud brightening[95]

However, even if the types of research outlined here are encouraging, scientists, policymakers and the broader public are likely to contest over at least three questions before SRM research (especially at the international level) is authorised:

- Is the research programme legitimate, in that it is inclusive, transparent, and not intended for purely private or nationalist gains?
- If the funding is provided by a small group of institutions or countries, what scope will there be to include other countries, which do not have similar resources?
- How to deal with the problem of moral hazard? If there persists concerns that geoengineering will shift attention away from climate change mitigation efforts, then should all kinds of SRM research be prohibited?

How could National SRM research be connected and coordinated?

Examples of other international research collaborations

Although SRM research is controversial and replete with uncertainties, there are several examples that could offer lessons on how international research collaborations originate, how they are funded and governed, and how they expand their membership.

International Geophysical Year

[93] Izrael et al., 2009

[94] Robock et al., 2010

[95] Also see references to a wider array of options in Economist, 2010

The International Geophysical Year (IGY), lasting from 1 July 1957 to 31 December 1958, was the world's first sustained multinational research collaboration on the environment. The ICSU, an independent federation of scientific unions, took the lead in organising and funding the IGY. A Special Committee for the IGY (CSAGI) served as the governing body. Representatives of 46 countries originally agreed to participate in the IGY; by its close, 67 countries had become involved.

World Climate Research Program

The World Climate Research Program (WCRP), established in 1980, was jointly sponsored by ICSU and the World Meteorological Organization (WMO). It has also received support from UNESCO's Intergovernmental Oceanographic Commission (IOC) since 1993. Aiming to improve scientific understanding of the Earth's physical climate system, WCRP studies the global atmosphere, oceans, sea ice, land ice and the land surface. The three sponsoring organisations have appointed, by mutual consensus, a Joint Scientific Committee comprising 18 scientists. The research is itself conducted by scientists in national and regional institutions, laboratories and universities. WCRP regularly informs the UN Framework Convention on Climate Change and its subsidiary bodies. Peer reviewed publications by scientists affiliated to the WCRP underpins much of the work of the Intergovernmental Panel on Climate Change.

European Organization for Nuclear Research

The European Organization for Nuclear Research (CERN), established in 1954, is the world's largest particle physics laboratory, situated on the Franco–Swiss border. Run by twenty European countries,[96] the CERN Council has two representatives from each member state, one representing the government and the other her/his country's scientific community. Decisions are by simple majority and based on one-country-one-vote, although the Council usually aims for consensus.[97] CERN spends much of its budget on building new machines (such as the Large Hadron Collider) and only partially contributes to the cost of the experiments. Other countries and organisations have observer status (the European Commission, India, Israel, Japan, Russia, Turkey, UNESCO and the United States) and fifty-seven other countries have cooperation agreements or scientific contacts with CERN.[98] Consequently, scientists from more than 600 institutes and universities around the world use CERN's facilities.

International Thermonuclear Experimental Reactor

The International Thermonuclear Experimental Reactor (ITER) is an international research and engineering project, which is currently building the world's largest and most advanced experimental nuclear fusion reactor. ITER originated from discussions in 1985 when President Gorbachev, following discussions with President Mitterrand, proposed to President

[96] Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland and the United Kingdom.

[97] http://public.web.cern.ch/public/en/About/Structure-en.html

[98] http://public.web.cern.ch/public/en/About/Global-en.html#observers

Reagan that an international project be set up to develop fusion energy for peaceful purposes. ITER began as a collaboration between the European Union, Japan, the former Soviet Union, and the United States.[99] Its current members are the European Union (contributing 45-50 per cent of the cost) and China, India, Japan, South Korea, Russia and the United States, each contributing 9-10 per cent.[100] Originally expected to cost around €5 billion, the estimates are now in the region of €10-15 billion, with growing pressure for more transparency about the costs of the project.[101]

The process of selecting a site for the ITER project ran from 2001 to 2005 culminating in the choice for Cadarache, France. Since Japan lost out on its proposed site, it was promised 20 per cent of research staff (in return for only 10 per cent of the funding) as well as the right to propose the Director General. Further, another research facility for the ITER project would be built in Japan, for which the European Union has agreed to contribute about 50 per cent of the costs.[102]

Nuclear waste management[103]

Nuclear waste management and disposal have also benefited from international collaboration. As with SRM, these topics raise complex questions of technology, earth science, long-term stewardship and public engagement. A number of inter-country collaborations, notably with the Swedish nuclear waste programme, allowed the international community to share the burden of technology development and formulate technical norms for characterising and analysing the behaviour of nuclear waste repository sites. What started as a national programme of waste management in Sweden resulted in, first, a collaboration with Finland, which then became the basis of a European 'Technology Platform'.[104]

Much of this collaborative technical work was used in Sweden and other countries (though not in the United States) as a basis for licensing facilities and for securing public acceptance of individual countries' nuclear waste management plans. An EU-wide nuclear waste storage facility is now being considered under the Strategic Action Plan for Implementation of European Regional Repositories (Stage 2) (SAPIERR II); this too has strong support from Sweden.[105] Countries that participated in these research programmes provided funding, agreed on research goals, and established a formal process for adaptive management, which allowed the programme to take credit for the results it achieved.

Why some research cannot be conducted nationally

The above examples suggest that SRM research could benefit from international coordination for a number of reasons:

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99 http://www.efda.org/the_iter_project/history_iter_project.htm

100 http://fusionforenergy.europa.eu/understandingfusion/ourcontribution.aspx

101 http://www.bbc.co.uk/news/science-environment-11541383; http://www.nature.com/nature/journal/v459/n7246/full/459483b.html

102 http://www.efda.org/the_iter_project/history_iter_project.htm

103 This discussion partly draws on an email communication with Jane Long.

104 Elam and Sundqvist, 2009

105 ftp://ftp.cordis.europa.eu/pub/fp6-euratom/docs/sapierr-2-5-public-and-political-attitudes_en.pdf

- Scientific – As explained above, SRM research has to build on ongoing climate research. As with the WCRP, SRM research depends on good climate observation including measuring ocean acidity, carbon dioxide concentrations in the atmosphere, and the impact on monsoons and soil moisture.
- Financial – The CERN and ITER examples show the limits of individual countries' financial capacities to support research experiments. SRM, when deployed, might work out significantly cheaper.[106] But the research would depend on continued funding for climate observation satellites and other research activities.
- Inclusion – Another reason is to draw in more and more countries and research institutions as CERN has done. The objective of inclusion may be fulfilled in different ways, such as by seeking material inputs from some countries, financial contributions from others, or offering access to research equipment and facilities.
- Political – Finally, there are political reasons why the scope of a research endeavour might expand. The insistence on behalf of the European Union that the ITER facility be built in France also meant that it had to give concessions to Japan, including building another facility there. However, the scope for making such deals would decline the less financial support one country or group of countries needs from another set of countries.
- Public engagement - The other political purpose of international collaboration is to legitimise research among the public. This is why Sweden was keen to promote research on nuclear waste management, not as a unilateral initiative but as a multi-country effort, the benefits of which would be available for all to use. Moreover, it engaged the public from the very beginning, explaining the technical and social demands of building a nuclear waste site. This inclusive approach helped win approval for a waste repository site, which continues to enjoy public support.[107]

Basic principles

Based on the lessons learned from past research endeavours, organising international SRM research would need to pay heed to the following basic principles.

Precaution

Even though SRM research might be necessary to prepare for a "Plan B" against the risk of severe climate impacts, it is also important that all caution be exercised in the scope and scale of such research. Precaution would imply that high risk technologies are avoided entirely or a moratorium is agreed against their deployment. The calculation of risk itself would be contingent on factoring in the uncertainties and ignorance (technical, political and social) associated with SRM.[108]

Inclusiveness

[106] Morgan and Ricke, 2010
[107] Long and Winickoff, 2010
[108] Long and Winickoff, 2010

It is imperative that unilateral deployment of SRM technology, especially with an aim to benefit narrowly defined national interests (say, affecting rainfall patterns), be expressly prohibited. Another way to reduce concerns is to ensure that SRM research activities are conducted outside defence establishments. Individual scientists may also be seconded to collaborate on projects in other countries, thereby helping to build an international network of researchers rather than drive nationally-determined projects.

Inclusion may be promoted through both voluntary and treaty-based participation. Membership during the International Geophysical Year was partly voluntary and partly based on international treaties. The most important example of the latter was the one signed on Antarctica. Collaborative research on Antarctica and the establishment of research stations by twelve countries led to the Antarctic Treaty, creating an entire continent open to scientific research and free of military use. At another end, the ITER agreement of 2006 established an international organisation responsible for all aspects of the project: licensing, hardware procurements, construction, the twenty-year operation period, and the decommissioning of ITER at the end of its lifetime.[109] Members contribute in kind, directly providing components for the project. As the first section of the paper argues, SRM research could be governed by a range of different international institutional options. The choice would partly depend on how robust a technology cooperation relationship that countries wish to create and maintain.

Capacity

Viewed purely through a scientific lens, one could argue that developing countries may be drawn into SRM research activities purely based on their scientific expertise to contribute. However, SRM is not just a scientific endeavour since it has implications for environmental conditions on a massive scale, potentially affecting livelihoods and communities far away from the experiment sites. A legitimate approach to SRM research would draw upon local experience to understand the social and political dimensions of SRM as well.

For a broad-based research agenda to develop, capacity is a key consideration. Efforts would be needed (combined with financial support) to engage with research institutions in developing countries, say by developing segments of projects focused on measuring the applicability and impact of the technology in local conditions. Another approach would be to source inputs from developing countries to build components of larger infrastructure, as is planned for ITER. Again, in CERN, for example, developing countries have also been asked to produce materials that are used to build particle detectors.[110]

In any international research programme there will, of course, be those countries that have both the research capacity and the resources to fund projects. Emerging powers and fast growing developing countries may fall into this category. However, other poorer countries might have some relevant research institutions but would be constrained by the lack of resources. A third category would include the poorest countries with neither capacity nor resources. SRM research activities will have to devote greater attention to the second and third category of states, perhaps by starting to map out potential institutions in these countries

[109] http://www.efda.org/the_iter_project/history_iter_project.htm

[110] http://www.harvardmun.org/wp-content/uploads/2010/06/GA-TAS-2011.pdf

that could be drawn into a network of international research collaborations. Further, grant funding might be more effective if it helps to build local research capacity to measure local impacts rather than transfer skilled researchers to Northern universities. Since SRM research is at early stages, a wider research programme should include the study of economic, social and political impacts and planning for likely scenarios. All of these approaches could build on the capacity available even in the poorest countries.

Flexible funding

One major problem with promoting international SRM research is raising and monitoring funds. Governments have closer control over programmes they have sponsored rather than those promoted privately. In Europe and the United Kingdom, there have recently been specific research calls to work on geoengineering. In the United States, by contrast, such funding comes through the normal funding process, and there is no national research programme. Moreover, modelling research is closely connected to ongoing climate research. If funding for climate research declines, then SRM research would also suffer – unless new countries and institutions are pulled in.

One way around this is to consider funding "in kind" whereby member institutions or countries are allowed to offer staff capacity, institutional resources or material inputs as ways to participate in a joint project. This manner of broadening participation could ensure that countries that provide hard cash towards a project are not the only ones with the governing authority to allocate and monitor resources. There is a risk, however, with accepting "in kind" support, namely that SRM projects could become routes to promote technology exports by a few national companies. The openness of the intellectual property regimes vis-á-vis SRM research would be important to ensure that such efforts are not rewarded by exclusive patents. Otherwise, public confidence in the legitimacy of SRM research could decline.

Transparency and review

At present, transparency in SRM research results from numerous conference sessions and workshops held each year. Special conference sessions on SRM were held at the European Geosciences Union General Assembly 2010, Vienna, Austria, May 3-7, 2010, 29th Annual Conference of the American Association for Aerosol Research, Portland, Oregon, USA, October 25-29, 2010, and American Geophysical Union Fall Meeting, San Francisco, California, USA, December 13-17, 2010, and will be held at the European Geosciences Union General Assembly 2011 in April in Vienna, Austria, and the International Union of Geodesy and Geophysics Conference in June-July, 2011 in Melbourne, Australia. Recent workshops include Governing Climate Engineering – A Transdisciplinary Summer School, Max-Planck-Institute for Comparative Public Law and International Law, Heidelberg, Germany, July 12-16, 2010, Workshop on the Ethics of Solar Radiation Management, Missoula, Montana, USA, October 18-20, 2010, Government-University-Industry Research Roundtable (GUIRR), National Academy of Sciences, Washington, DC, October 12-13, 2010, and the IGBP Symposium on Ecosystem Impacts of Geoengineering, Scripps Institution of Oceanography, La Jolla, California, USA, February 2-4, 2011.[111]

[111] Note from Alan Robock

Public engagement

However, it is not sufficient to publish results of SRM research in peer reviewed journals. It is equally important that governments and research institutions take the lead in informing the wider public on the nature, uncertainties, methods and risks of SRM research.

Moreover, transparency cannot mean that research is published in a manner that is unintelligible to the general public. Unless the data is presented in accessible, usable and comparable formats, it will be difficult to engage other sections of society and inform them about the potential impacts of experiment with SRM technologies. The absence of such engagement could backfire on SRM research activities if public opposition results in all initiatives being banned.

Again, precedents from the broader scientific fraternity could be the basis for organising international SRM research. For the ICSU, the Committee on Freedom and Responsibility in the conduct of Science (CFRS) serves as the guardian of the Principle of the Universality of Science, laid out in ICSU's Statute 5. The Statute demands equitable access to data, information and research materials. Several ICSU bodies—including the Committee on Data for Science and Technology (CODATA), the International Network for the Availability of Scientific Publications (INASP) and the new World Data System (WDS)—are working towards better quality of and improved access to various types of scientific data and information. Elsewhere, in 2009 the WCRP underwent an independent review commissioned by its sponsoring organisations, resulting in an overall assessment of its programmes and activities.

Public ownership of intellectual property

Since SRM is a high-risk technology, it is imperative that any research is treated as affecting the general public interest.[112] Therefore, the results of the research should also be available to all. Government-funded research should in any case be in the public domain, while privately funded work should also have limits to what may be considered proprietary knowledge. A recent example was in August 2010 when CERN signed a deal with WIPO to facilitate technology transfer and to support enhanced and broad access to scientific and technological information.[113]

Alternative institutional designs for organising international SRM research

The pursuit of the principles of open scientific collaboration does not mean that only one kind of institutional design is possible. Table 2 outlines how a bottom-up approach, initiated by researchers or institutions, would compare against a top-down approach, led by governments. A mixed approach might offer more flexibility to organise a legitimate international SRM research programme.

Table 2: Comparing alternative designs for the international coordination of SRM research

	Bottom-up	Top-down	Mixed
Origination	Voluntary	Treaty-based	Either option possible

[112] Rayner et al, 2009

[113] http://www.wipo.int/pressroom/en/articles/2010/article_0027.html

Scope of research	Modelling; field experiments; deployment	Deployment unlikely	Limited to modelling and small field experiments
Inclusiveness	Not necessary unless demanded by governments	Not necessary unless specified in treaty	Draw in countries and institutions in different aspects of research
Capacity	Largely based on scientific research ability	No guarantee that funding for building capacity will emerge	Use local knowledge for assessing local impacts of SRM research
Flexible funding	Mostly funded by research institutions or private donors	'In kind' funding by members possible	'In kind' funding by members possible; more oversight required if group is large
Transparency	Rigorous peer review	Separate, independent technical/scientific committees necessary	Publication of all research in databank
Public engagement	Depends on voluntary principles	Depends on whether member states agree to engage public	Mix of public and private institutions forces greater public engagement
Ownership of IPR	Could be retained by researchers	Publicly funded research should remain open	Publicly available but some aspects, like delivery mechanisms, may be patented
Source: Arunabha Ghosh			

International Coordination of Non-Research SRM Activities

There are at least three non-research SRM governance activities that could benefit from some from international coordination: (a) between international institutions that independently seek to address the issue of SRM governance or regulation; (b) between national legislative bodies and regulatory agencies that seek to address the issue of SRM governance or regulation; and (c) between public engagement dialogues on SRM in various national settings. Coordination of each category of activity offers opportunities for building cooperative norms around SRM governance, but each also raises a host of questions about which actors within the international landscape can coordinate and should be involved in these activities. The upcoming UN Conference on Sustainable Development (Rio+20) in 2012 *could* offer a potential forum for the variety of options outlined below to be discussed by a diversity of representatives from national governments, international organisations, non-governmental organisations, and the corporate sector. However that may also be premature, as SRM (*and geoengineering more broadly*) remains a poorly understood concept, and its relationship to the wide range of issues to be discussed in a climate context at Rio+20 remains largely unconsidered.

International Coordination of Legislative and Regulatory Activities

One of the primary objectives of coordinating the first two categories of activity – i.e. coordination between international organizations and national governments beginning to tackle SRM governance and regulatory issues – would be to increase the opportunity for early harmonisation of legislation and regulatory frameworks for SRM governance. The challenges which arose from the differing decisions of the London Convention and CBD on Ocean Fertilization (and differing interpretations of those decisions by various national regulatory bodies) demonstrate the potential value of harmonisation, if at all possible. However, the primary question for consideration in this case is: Which actor or institution could/should act as the formal convenor of coordinating activities?

In terms of international institutions, UNEP's historic role as a forum for dialogue on global environmental issues makes it a strong candidate for convening conversations about inter-organizational and transnational coordination, and the broad inclusiveness of UNEP would lend legitimacy to any resultant coordination activities. However, the formality of a process convened by UNEP could present similar challenges to the notion of developing a new international governance regime for SRM. At the least, it could create a formalised international forum for SRM discussions whose role relative to other international frameworks – such as the UNFCCC – would have to be carefully prescribed, and could be quite controversial.

A much more informal option could be created for coordinating conversation between the *individuals* within international organisations and national governments involved in SRM regulation. One such model that could be expanded upon is that of Globe International, which convenes annual meetings of legislators from a broad range of countries with the mandate of 'strengthening the central role of legislators and parliaments in tackling the major global environmental challenges, as well as placing a much greater emphasis on the role of legislators in holding governments more effectively to account for the implementation of international commitments.'[114] Such a process would not seek to formally coordinate legislative activities between governments, but rather, by building relationships between an informal network of key actors, would seek to enhance the foundations of cooperation from which harmonized legislative and regulatory practices might emerge.

Potentially even less formal could be the establishment of an online "clearinghouse" or repository of information regarding SRM-related international and national legislative and regulatory activities. Such a repository could be managed by a formal or informal coordinating body, or even by a non-governmental organisation or body.

International Coordination of Public Engagement Activities

The elicitation of informed public perspectives on SRM technologies and their potential use is perhaps the most important near term activity in the development of an SRM governance framework that could benefit significantly from international coordination. In a world going on seven billion people this summer, the core governance question of 'Who decides?' inevitably leads to the challenge of when and how to engage publics around the world in the dialogue and decision making frameworks for SRM. A wide variety of frameworks exist for public engagement in public decision making at the local through national levels; these range from the various models of representative and referendum based democracy, to more targeted frameworks for engaging publics in dialogues about the emergence of novel technologies

[114] Globe International, "Strategy," http://www.globeinternational.info/about/strategy/ (accessed March 7, 2011).

(*e.g. anticipatory governance*).[115] However, the extension of models to transnational public engagement has been extremely limited thus far.

Among the most successful models for such transnational public engagement have been two World Commissions that dealt explicitly with environmental concerns: the Brundtland Commission (1983-1987);[116] and the World Commission on Dams (1997-2001).[117] Through a significant series of public dialogues conducted around the globe, these Commissions elicited and gave international voice to the perspectives and concerns of a diverse array of communities. Through their international and quasi-representative makeup, these Commissions also developed recommendations for coordinated international action (as well as, in some cases, national and local actions) to address the variety of principle concerns shared globally.

However, given (a) the intimate relationship between GHG-induced climate change and the development and governance of SRM technologies, and (b) the extensive and challenging global dialogue already underway regarding climate change, GHG mitigation, and human and ecological adaptation; the formation of a formal (*e.g. UN requested*) World Commission on SRM technologies (*or more broadly climate engineering or management*) could meet with very significant international opposition. In addition, given (a) the rate at which SRM research appears to be emerging, (b) the present concentration of this research in only a handful of nations, and (c) the present broad lack of knowledge about the existence (never mind the details) of SRM technologies by the vast majority of global citizens; there are significant questions as to how (or whether) the timeframe and methodologies used by the two cited World Commissions are translatable to this context.

Other methods for engaging publics in dialogue about novel emerging technologies have been developed over the past two decades. Such methods frequently integrate a combination of information provision about the science and emerging technologies in question with discussion and questioning techniques that engage the imagination and concerns of those participating publics. Previously direct forms of public participation have taken shape as citizen panels, public forums, and consensus conferences involving the general public, university communities, local politicians, NGOs and the corporate sector.[118] Such methods are being increasingly utilised to research and improve understanding of public perceptions regarding various emerging technologies (*nanotech, biotech, etc…*), ultimately reducing long-term costs and delays by addressing public concerns at an early stage.[119] However, the

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[115] For a definition of anticipatory governance and its uses please see Keon S. Chi's 2008 report, "Four Strategies to Transform State Governance."

[116] World Commission on Environment and Development, "From One Earth to One World," http://en.wikisource.org/wiki/Page:Brundtland_Report.djvu/20 (accessed 3/4/2011).

[117] World Commission on Dams, "Dams and Development: A New Framework for Decision-Making," http://www.dams.org/report/wcd_overview.htm (accessed 3/4/2011).

[118] Daniel Barben et al., "Anticipatory Governance of Nanotechnology: Foresight, Engagement, and Integration," in *The Handbook of Science and Technology Studies 3rd Edition*, ed. Edward J. Hackett et al. (Cambridge and London: The MIT Press, 2007), 987-988.

[119] Richard E. Sclove, "Reinventing Technology Assessment," *Issues in Science and Technology 27*, No. 1 (Fall 2010): 35-36.

majority of applications are at a very small scale and a framework for practically expanding these methods to the transnational scale has not yet been demonstrated.

Given the present nascent state of public knowledge regarding SRM technologies, and the currently fragmented global climate discourse, it seems more likely that national through local public conversations about SRM technologies will nucleate and build on an ad-hoc basis. In each case, it will likely be driven by a somewhat different set of issues motivating and framing the conversation. The important role for an emerging international governance framework to play in this context is one of conversation tracking, information provision and loose coordination of activities. In this case, central repositories of easily accessible, unbiased and authoritative knowledge and information from the various ongoing scientific and socio-political discourses on SRM technologies will be the most important contribution.

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