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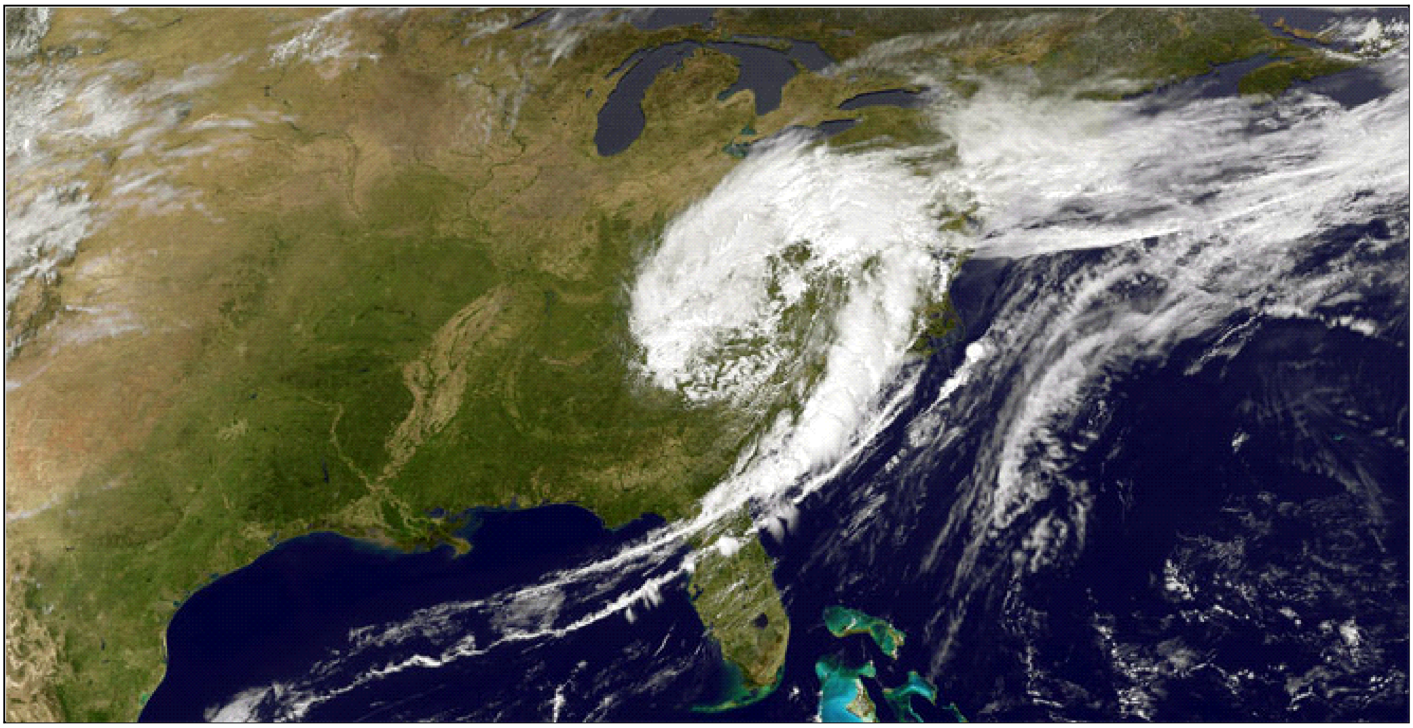
Climate Change and Geoengineering Governance

This NTS Insight is a discussion paper prepared for a Pilot Workshop on 'Governing Geoengineering in the 21st Century: Asian Perspectives' to be held on 18–19 July 2011 in Singapore. The author, Professor Steve Rayner, is a global authority on the subject and co-convenor of the pilot workshop co-organised by the RSIS Centre for Non-Traditional Security (NTS) Studies, Singapore, and the Geoengineering Programme at the University of Oxford, UK. The aim of this paper, and the workshop, is to mobilise debate on geoengineering governance in the Asia-Pacific. While the discourse has thus far been driven by scholarly communities in Europe and the US, any potential new global governance framework will likely require broad legitimacy and support by a critical mass of stakeholders, including those in the Asia-Pacific.

By Steve Rayner.



A giant swirl of clouds over the US was spotted from the Geostationary Operational Environmental Satellite, GOES-13, on 12 April 2011. Changes in the frequency of extreme weather events make adaptation to impacts induced by climate change extremely difficult.

Credit: NASA Goddard Photo and Video/flickr.com

Introduction

An emergency 'Plan B' using the latest technology is needed to save the world from dangerous climate change, according to a poll of leading scientists carried out by *The Independent*. (Connor and Green, 2009)

Geoengineering, defined by the UK's Royal Society (2009:1) as 'the deliberate large-scale manipulation of the planetary environment to counteract … climate change',[1] is receiving growing attention from both scientists and policymakers concerned with the slow progress of international negotiations to reduce emissions of greenhouse gases. However, scientists and climate activists also seem sharply divided over the wisdom and practicality of geoengineering

Click on the following links for related publications on geoengineering:
NTS Alert April Issue 1 and
NTS Alert April Issue 2.

(Connor and Green, 2009).

This NTS Insight begins by considering why humanity might seek to geoengineer the climate. Next, potential opportunities and limitations associated with various generic options for geoengineering and their implications for the governance of research, development, demonstration and deployment (RDD&D) of the various technologies are assessed. Finally, this NTS Insight proposes some high-level principles for the governance of the field of geoengineering and a structure for the development of specific guidelines or protocols for different kinds of technology that might be developed.

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Why Might We Seek to Geoengineer the Climate?

Climate geoengineering is not a new idea.[2] Weather modification dates back at least to the 1860s when the proposals of James Pollard Espy to stimulate rain through controlled forest burning led to his being dubbed the 'Storm King' (Meyer, 2000). More recently, the US Project Stormfury sought for two decades to modify the path of hurricanes by seeding them with silver iodide. Cloud seeding to stimulate rain is practised routinely in various parts of the world with, it must be said, inconclusive results (Fleming, 2010).

Geoengineering proposals to modify the climate specifically to counteract the greenhouse effect date from at least 1965 (President's Science Advisory Committee, 1965). Preliminary studies were conducted throughout the 1970s to 1990s (Budyko, 1977, 1982; Marchetti, 1977; US National Academy of Sciences, 1992) and was the subject of a workshop convened by the Tyndall Centre for Climate Change Research and the Cambridge-MIT Institute in 2004. However, the emphasis of climate research and policy throughout the 1980s and 1990s was clearly focused on mitigation and, for much of that period, discussion even of adaptation, let alone geoengineering, was seen as a potentially dangerous distraction from the task of emissions reduction. The issue of 'moral hazard' – the idea that even considering additional policies will result in diminished efforts at conventional mitigation – has not turned out to be justified with regard to adaptation, which remains very much the poor cousin of mitigation, and the Royal Society could find no extant empirical evidence to justify the concern in respect of geoengineering.

However, sparked by a controversial article in *Climatic Change* by Crutzen (2006) identifying the damage caused to the stratosphere by chlorofluorocarbons – which won the Dutch chemist the Nobel Prize – leading scientists have increasingly expressed concerns over the lack of progress in international negotiations to reduce global greenhouse gas emissions, and have begun expressing publicly the need for a Plan B – geoengineering the climate (e.g., Kunzig and Broecker, 2008; Walker and King, 2008). There are at least four compelling reasons why humanity might want to explore the capacity to geoengineer the climate.

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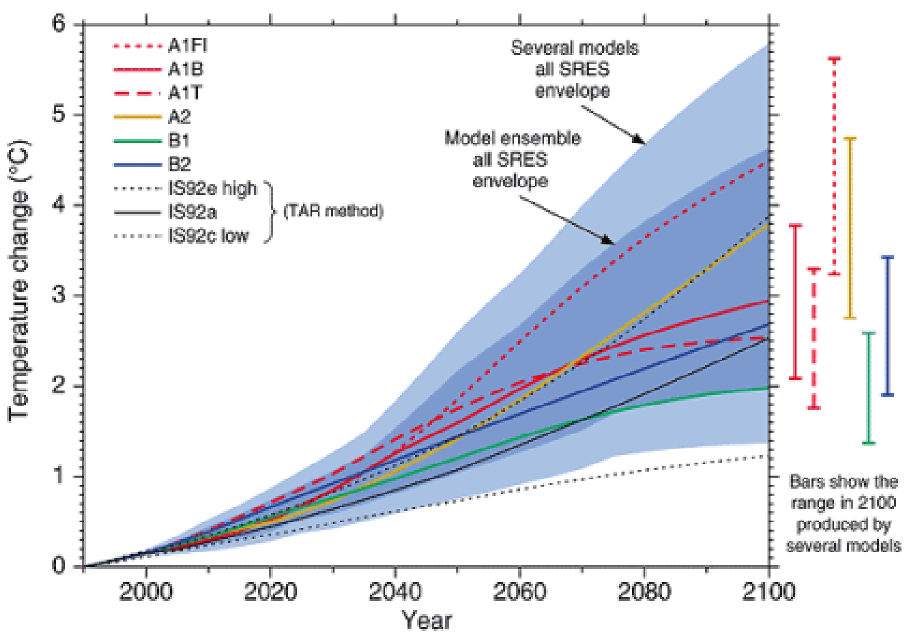
Figure 1: Intergovernmental Panel on Climate Change (IPCC) emissions scenarios.

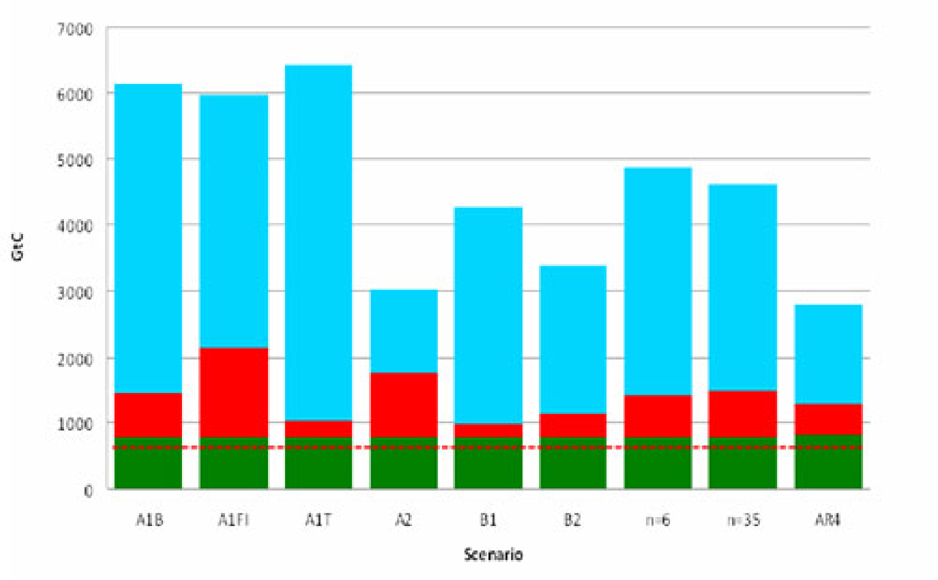


Source: IPCC (2001).

The first of these is that the world seems to be locked in to the highest emissions trajectory envisaged by the Intergovernmental Panel on Climate Change (IPCC). Figure 1 shows what the IPCC considers a plausible range of global average temperature increases over the course of the 21st century, based on various assumptions about global economic development and technological change. At the time of writing, global emissions are increasing at about 3 per cent per annum, which places the world at the top of the curves shown in Figure 1, that is, it appears that the world is headed inexorably towards an increase of 2°C by 2040 and 4°C by 2100. The IPCC has recommended that the global average temperature increase be limited to a maximum of 2°C. Given the long lag time between changes in atmospheric carbon dioxide (CO_2) concentrations and predicted climatic response, it seems inevitable, even if radical cuts in emissions were to be introduced in the next decade, that this recommendation will be exceeded.

Second, it seems altogether possible that the IPCC has significantly underestimated the extent of emissions cuts that would be required to stabilise atmospheric CO_2 concentrations at any point on Figure 1. This is because, in devising its emissions scenarios, the IPCC made highly optimistic assumptions about the future energy and carbon intensity of the global economy. Both the amounts of energy and of CO_2 needed to create each new unit of global wealth (gross domestic product, or GDP) have fallen steadily for about a century. The IPCC assumed that they will continue to decrease and at a rate considerably faster than anything that has been observed historically. Not only was this over-optimistic, but a couple of years ago, these declining trends went into reverse, largely due to rapid expansion in the emerging economies of China and India. Figure 2 shows one estimate of the total avoided emissions that would be necessary over the course of the 21st century if the IPCC assumptions turn out to be incorrect, as they almost certainly are. In this event, the emissions reduction challenge may prove to be as much as three times that estimated by the IPCC.

Figure 2: Assumptions of the effects of technological change on future emissions in the Intergovernmental Panel on Climate Change (IPCC) SRES scenarios and its Fourth Assessment Report (AR4).



Note: (1) The blue bar indicates the assumed autonomous decline in carbon and energy intensity in each scenario. The red bar indicates the IPCC estimates of the additional mitigation required to reach the allowable emissions, which is represented by the green bar.
(2) GtC – giga tonne of carbon dioxide.
Source: Pielke, Jr et al. (2008).

A third concern is that current carbon emissions are accompanied by emissions of sulphate aerosols that reflect sunlight back into space and so partially offset the warming effects of CO_2. If humanity is successful in reducing carbon emissions, it will also reduce the production of these aerosols, which have a much shorter residence time in the atmosphere than CO_2. The elimination of these aerosols may therefore exacerbate the warming effect of greenhouse gases already in the atmosphere by more than 1°C (IPCC, 2007).

Finally, there is concern that temperature rises over the next century may exceed irreversible ‘tipping points’ in the climate system or ecosystems, leading to abrupt, potentially catastrophic impacts on human and natural systems. For example, it is possible that the melting tundra could release large quantities of methane, a more potent gas than CO_2, into the atmosphere, accelerating the warming process. Although the US National Academy of Sciences (2002) has described abrupt climate change as a very low probability but very high consequence event, some geoengineering measures appear to offer humanity the ability to shave the peaks off CO_2-driven emissions and avoid such tipping points. This possibility raises numerous governance issues, not least who would determine when a planetary emergency is imminent and who would actually control the ‘global thermostat’.

Any one of these four considerations would suggest that a safe, effective and affordable means to ameliorate atmospheric warming and/or achieve negative carbon emissions would be a highly desirable addition to the existing portfolio of climate policies consisting of conventional greenhouse gas mitigation and adaptation measures.

In the UK, geoengineering has been the subject of a Royal Society report (mentioned above) and the House of Commons has conducted two inquiries recommending both funding for research and the development of governance principles (Royal Society, 2009; UK House of Commons, 2009, 2010). In the US Congress, the House Committee on Science, Space and Technology has also been holding hearings on the governance of geoengineering research and the possible deployment of the technology. So what exactly is under consideration?

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How Might We Geoengineer the Climate?

The first thing to emphasise is that geoengineering technologies do not yet exist, although some of the components that might go into them are already available or are under development for other purposes. For example, carbon sequestration in geological formations, which is already being explored for conventional carbon capture and storage (CCS) from power stations,[3] would be an integral part of a geoengineering programme to capture CO_2 from ambient air by artificial means. However the front end of the system – the removal of CO_2 from ambient air – is currently only available on a very small scale for use in submarines, where the very high cost of the current technology is justified. In discussing geoengineering, therefore, it is important not to fall victim to Whitehead's (1919) fallacy of misplaced concreteness, and talk about the comparative merits and drawbacks of geoengineering technologies as if they were already well developed and known.

Second, it is essential to recognise that the term 'geoengineering' currently encompasses a wide variety of concepts exhibiting diverse technical characteristics with very different implications for their governance. There is a tendency in some circles to seek to exempt favoured technological concepts from the category of geoengineering, leaving the term to apply only to big, scary or impractical options. This paper resists that impulse precisely because, as has just been argued, the technologies are really just ideas at this stage, and it is important not to close in prematurely on which technologies require specific levels of governance.

However, the very variety of technologies suggests the need for a preliminary taxonomy of technology concepts that identifies salient characteristics for both research and governance considerations.

Developing a taxonomy of technology concepts

Solar radiation management (SRM) and carbon dioxide removal (CDR)

The Royal Society (2009) identifies two principal mechanisms for moderating the climate by geoengineering. One involves reflecting some of the sun's energy back into space to reduce the warming effect of increasing levels of greenhouse gases in the atmosphere. This is described as solar radiation management (SRM). The other approach is to find ways to remove some of the CO_2 from the atmosphere and sequester it in the ground or in the oceans. This is called carbon dioxide removal (CDR).

Ecosystems enhancement and black-box engineering

The Royal Society (2009) also recognises, but gives less prominence to, another way of discriminating between geoengineering technologies, one which cuts across the distinction between the two *goals*, SRM and CDR. Both goals can be achieved by one of two different *means*, described below.

Table 1: Geoengineering for climate change: taxonomy of technology concepts.

	Carbon dioxide removal (CDR)	Solar radiation management (SRM)
Ecosystems Enhancement	Ocean iron fertilisation	Stratospheric tools
Black-box Engineering	Air capture (artificial trees)	Space reflectors

One is to put something into the air or water or on the land's surface to stimulate or enhance natural processes. For example, injecting sulphate aerosols into the upper atmosphere imitates the action of volcanoes, which is known to be quite effective at reducing the amount of the sun's energy reaching the earth's surface; this is one candidate SRM technique. Similarly, we know that lack of iron constrains plankton growth in some parts of the ocean. Thus, adding iron to these waters would enhance plankton growth, taking up atmospheric CO_2 in the process. This would be a potential CDR technique.

The other approach to both SRM and CDR is through more traditional black-box engineering. Mirrors in space (either large ones, or more likely, myriad small ones), either in orbit or at the so-called Lagrange point between the earth and the sun, would reflect sunlight (SRM), while a potential CDR technique would be to build machines to remove CO_2 from ambient air and inject it into old oil and gas wells and saline aquifers in the same way that is currently proposed for CCS technology.

Combining these two means (ecosystems enhancement and black-box engineering) with the two goals described above (SRM and CDR) creates a serviceable typology for discussing the range of options being considered under the general rubric of geoengineering (Table 1).

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Opportunities and Limitations of Different Approaches

At first sight, it might seem that the different goals and means represented in Table 1 are alternatives. Some commentators have suggested that geoengineering is itself an alternative to conventional mitigation (e.g., Barrett, 2008; the Royal Society (2009) report has however emphatically rejected this idea). However, closer scrutiny suggests that different techniques may be suited to very different tasks and time perspectives.

Currently, there is much interest in SRM using sulphate aerosols. Observations of volcanic eruptions have shown that the presence of these tiny particles in the atmosphere can effectively cool the earth. The technique is also relatively straightforward, the financial costs involved appear to be relatively modest and such a programme could be implemented quickly. Hence, many commentators see aerosols as a Band-Aid, to stop the earth from getting too hot and triggering a runaway greenhouse effect or other possible climatic emergencies (so-called tipping points).

At the other extreme, air capture of CO_2 using 'artificial trees' followed by sequestration in spent oil and gas wells or saline aquifers seems a relatively distant and costly prospect compared to aerosols. In any case, as with conventional emissions mitigation, the climate benefits of removing CO_2 from the air will take longer to realise because changes in the global average temperature lag behind changes in greenhouse gas concentrations by many years. However, in principle, all the CO_2 that came out of the ground could be put back there. Thus, in theory at least, air capture holds the prospect of restoring atmospheric CO_2 concentrations to pre-industrial levels over the very long term.

Sulphate aerosols have at least two well-recognised drawbacks. One is that the effects on the earth's climate may be uneven, possibly causing disruption of the Asian monsoon upon which billions rely for agriculture. Another is that stopping a sulphate aerosol programme in the event of unforeseen negative outcomes would result in a sudden temperature spike, unless drastic compensating emissions reductions have been simultaneously achieved. In other words, the full environmental and social costs of aerosols may be very much higher than the programme implementation costs and there is likely to be a high level of technological lock-in. These drawbacks strongly suggest that SRM using aerosols would be controversial. Public opinion is also likely to be less than favourable towards 'tinkering' with earth systems, especially through what could be described as deliberate air pollution. Furthermore, the transborder implications of any deployment of the technology suggest that international agreement would be required; and international agreement on climate actions has proven to be highly elusive.

On the other hand, except where the geological formations used for storage cut across national boundaries, regulation of air-capture technology would seem to be almost entirely a matter for the governments of the countries in which it is implemented.[4] Furthermore, in the event that the technology did have unforeseen negative consequences, there would be no technical barrier to switching the black-box machines off, although it could be argued that vested commercial interests might push to keep them running due to the sunk costs involved.

This is the geoengineering paradox (Rayner, 2010). The technology that seems to be nearest to maturity technically and could be used to shave a few degrees off a future peak in anthropogenic temperature – that is, sulphate aerosols – is likely to be the most difficult to implement from a social and political standpoint, while the technology that might be easiest to implement from a social perspective and has the potential to deliver a durable solution to the problem of atmospheric CO_2 concentrations – that is, air-capture technology – is the most distant from being technically realised. The two technologies appear to be the bounding cases and other geoengineering technologies fall somewhere in between.

Geoengineering techniques such as the injection of sulphate aerosols into the stratosphere may mimic the cooling effect caused by large volcanic eruptions.
Credit: Game McGimsey / U.S. Geological Survey.

The above brief example of the specificity of geoengineering applications helps to emphasise the Royal Society (2009:47) findings that geoengineering cannot be considered as an alternative to conventional mitigation nor can its merits be evaluated sui generis because the technologies involved 'vary greatly in their technical aspects, scope in space and time, potential environmental impacts timescales of operation, and the governance and legal issues that they pose'.

Furthermore, the Royal Society (2009:ix) concluded that the 'acceptability of geoengineering will be determined as much by social, legal, and political issues as by scientific and technical factors. There are serious and complex governance issues that need to be resolved.'

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The Challenges of Geoengineering Governance

The key challenge of geoengineering governance is that articulated in 1980 by the British sociologist, David Collingridge, as the 'technology control dilemma'. Briefly, the dilemma consists of the fact that it would be ideal to be able to put appropriate governance arrangements in place upstream of the development of a technology, to ensure that all the stages from research and development through to demonstration and full deployment are appropriately organised and adequately regulated to safeguard against unwanted health, environmental and social consequences. However, experience repeatedly teaches us that it is all but impossible in the early stages of the development of a technology to know how it will turn out in its final form. Mature technologies rarely, if ever, bear close resemblance to the initial ideas of their originators. By the time certain technologies are widely deployed, it is often too late to build in desirable characteristics without major disruptions. The control dilemma has led to calls for a moratorium on certain emerging technologies and, in some cases, on field experiments with geoengineering.[5] A moratorium would make it almost impossible to accumulate the information necessary to make informed judgements about the feasibility or desirability of the proposed technology.

However, Collingridge did not intend identification of the control dilemma to be a counsel of despair. He and his successors in the field identify various characteristics of technologies that contribute to inflexibility and irreversibility and which are therefore to be avoided where more flexible alternatives are available. These undesirable characteristics include high levels of capital intensity, hubristic claims about performance, and long lead times from conception to realisation, to which the UK Royal Commission on Environmental Pollution (RCEP, 2008) recently added, in the context of nanoparticles, 'uncontrolled release into the environment'. Consideration of the control dilemma suggests that it would be sensible to favour technologies that are encapsulated over those involving dispersal of materials into the environment; and those that are easily reversible over those that imply a high level of economic or technological lock-in.

The other key challenge for geoengineering governance lies in the varying degrees of international agreement and coordination that would seem to be required for the different technologies involved. At least upon first examination, carbon air capture with geological sequestration would not seem to require much in the way of international agreement, except where the geological formations chosen for storage cross national boundaries and possibly where facilities are located close to national borders, or where sequestration is to occur offshore.[6] National planning regulations, rules governing environmental impact assessment, and health and safety laws, would seem to provide, at least in principle, an adequate framework for ensuring the responsible management of the technology where there is little prospect of transborder damage occurring to people or the environment. Existing national legislation for the governance of CCS from fixed-point sources (e.g., coal-fired power plants) without an overarching global governance framework underscores this point.

However, the situation seems to be very different with CDR involving iron fertilisation because it involves modification of natural processes that cannot be territorially contained. Similarly, any kind of SRM, whether involving space mirrors (black-box engineering), or cloud whitening or sulphate aerosols (modification of natural processes), would seem to require international agreement even for field trials, let alone deployment.

The Royal Society (2009) suggests that many issues of international coordination and control could be resolved through the application, modification and extension of existing treaties and institutions governing the atmosphere, the ocean, space and national territories, rather than by the creation of specific new international institutions. All geoengineering methods fall under provisions of the 1992 UN Framework Convention on Climate Change (UNFCCC) and the 1997 Kyoto Protocol which impose a general obligation to 'employ appropriate methods, for example impact assessments, … with a view to minimizing adverse effects … on the quality of the environment, of projects or measures undertaken to mitigate or adapt to climate change' (UN, 1992). Additionally, there are several customary laws and general principles that would apply to such activities. For instance, the duty not to cause significant transboundary harm is recognised in many treaty instruments[7] and by customary international law. As the Royal Society (2009:40) observes, '[s]tates are not permitted to conduct or permit activities within their territory, or in common spaces such as the high seas or outer space, without regard to the interests of other states or for the protection of the global environment'.

The use of sulphate aerosols for SRM may fall under the jurisdiction of the Montreal Protocol on Substances that Deplete the Ozone Layer as they may have ozone-depleting properties. Ocean fertilisation has already caught the attention of the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter and its 1996 Protocol (known as the London Convention and Protocol), which has adopted a cautious approach to permitting carefully controlled scientific research through a 2008 resolution agreeing that the technology is governed by the treaty but exempting legitimate scientific research from its definition of dumping. The Convention on Biological Diversity has also sought to intervene to prevent ocean fertilisation experiments except for small-scale experiments in coastal waters.[8]

Potentially lengthy negotiations would be necessary before sulphate aerosols could be deployed by any country or other agent within an agreed international governance framework.[9] Without such a framework, such activities would likely attract the condemnation of the international community.

Overall, the international legal framework within which geoengineering will be conducted remains as under-specified as the technologies themselves. Furthermore, the control dilemma means that it is almost impossible to determine governance requirements until the shape of any of the technologies under consideration is better known. This dilemma led the Royal Society (2009:61) to recommend establishing an international scientific collaboration to 'develop a code of practice for geoengineering research and provide recommendations to the international scientific community for a voluntary research governance framework'.

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Governance Principles from Research to Deployment

Following the publication of the Royal Society (2009) report, the UK House of Commons Science and Technology Committee initiated an inquiry on the topic of how geoengineering should be governed. An ad hoc group of academics, including two members of the Royal Society Working Group, submitted a list of five high-level principles for geoengineering RDD&D (Rayner et al., 2009).

> The 'Oxford Principles', as they are known, hold that geoengineering should be regulated as a public good, in that, since people cannot opt out, the whole proceeding has to be in a well-defined public interest; that decisions defining the extent of that interest should be made with public participation; that all attempts at geoengineering research should be made public and their results disseminated openly; that there should be an independent assessment of the impacts of any geoengineering research proposal; and that governing arrangements be made clear prior to … any actual use of the technologies. (We All Want, 2010)

The idea behind these principles is that they should provide real assurance that the entire process from initial research through to development, field trials and eventual deployment is conducted openly and in the public interest of all affected countries, while also allowing for the development of more flexible technology-specific protocols for the governance of individual geoengineering approaches as their technical contours and socioeconomic implications become clearer through the RDD&D process. The Final Report of the Parliamentary Select Committee welcomed the principles, noting that '[w]hile some aspects of the suggested five key principles need further development, they provide a sound foundation for developing future regulation. *We endorse the five key principles to guide geoengineering research*' [emphasis added] (UK House of Commons, 2010:35). The 2010 Asilomar International Conference on Climate Intervention Technologies convened to explore the governance issues facing geoengineering researchers elaborated, in its final report, on the Oxford principles. *The Economist* reports that these principles were 'generally endorsed' by the research community (We All Want, 2010).

At the time of writing, it is unclear how governance of climate geoengineering will be taken forward. The US Congress House Committee on Science, Space and Technology has issued a report on the topic, which called for further scientific research and risk assessment, and the Royal Society has launched a project to explore research governance guidelines for SRM to be conducted in collaboration with the US National Academy of Sciences, the Third World Academy of Sciences (TWAS) and the Environmental Defense Fund (EDF). There seems little doubt that there is scientific momentum building behind efforts to develop geoengineering options and that legislators are eager for guidance on both how that research should be conducted and how decisions about deploying any resulting technology should be made.

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Notes

1. Although the Royal Society definition specifies anthropogenic climate change, there seems to be no reason, in principle, why geoengineering techniques should be confined to counteracting only anthropogenic climate change. If they are sufficiently safe, effective and affordable to be used at all, they could equally well be employed against any natural warming influences as well as those driven by human emissions of greenhouse gases.
2. For more detailed histories of geoengineering, see Keith (2000) and Fleming (2010).
3. Governance issues related to carbon capture and storage (CCS) from power stations are already being addressed through, for example, the European Union CCS directive.
4. Additional international implications would arise should such capture and sequestration qualify as mitigation and/or as a Clean Development Mechanism (CDM) qualifying activity under the Kyoto Protocol and any successor regime.
5. See, for example, the resolution by parties to the Convention on Biological Diversity 'prohibiting' ocean iron fertilisation apart from small-scale scientific research in 'coastal waters'.
6. Sub-seabed sequestration is subject to regulation by global and regional dumping conventions, which have been adjusted to permit it under the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (also known as the London Convention) and the Convention for the Protection of the Marine Environment of the North-east Atlantic (also known as the OSPAR Convention).
7. Examples include: the UN Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity, the UN Convention on the Law of the Sea and the UN Convention to Combat Desertification.
8. The expression 'coastal waters' has no fixed international legal definition and small near-shore studies are largely meaningless for evaluating iron fertilisation technology, which has led to contestation of the language of the Convention on Biological Diversity and the scientific assumptions underpinning it.
9. The Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (Environmental Modification Convention, or ENMOD) already prohibits the use of climate intervention techniques by states for military or hostile purposes. Thus, the peaceful use of such techniques is presumed here.

Steve Rayner is James Martin Professor of Science and Civilization, University of Oxford. *He is grateful to Catherine Redgwell, Professor of International Law at University College London for her advice in preparing this paper.*

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About the Centre:

The Centre for Non-Traditional Security (NTS) Studies of the S. Rajaratnam School of International Studies was inaugurated by the Association of Southeast Asian Nations (ASEAN) Secretary-General Dr Surin Pitsuwan in May 2008. The Centre maintains research in the fields of Food Security, Climate Change, Energy Security, Health Security as well as Internal and Cross-Border Conflict. It produces policy-relevant analyses aimed at furthering awareness and building capacity to address NTS issues and challenges in the Asia-Pacific region and beyond. The Centre also provides a platform for scholars and policymakers within and outside Asia to discuss and analyse NTS issues in the region.

In 2009, the Centre was chosen by the MacArthur Foundation as a lead institution for the MacArthur Asia Security Initiative, to develop policy research capacity and recommend policies on the critical security challenges facing the Asia-Pacific.

The Centre is also a founding member and the Secretariat for the Consortium of Non-Traditional Security (NTS) Studies in Asia (NTS-Asia). More information on the Centre can be found at www.rsis.edu.sg/nts.