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Climate Engineering and International Law: Last Resort or the End of Humanity?

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Climate engineering is increasingly being considered as a policy to supplement mitigation and adaptation as strategies to address anthropogenic climate change. Based on a review of the methods, goals and risks of climate engineering, this article focuses on solar radiation management, exploring the existing international legal framework and discussing options for future policies. It is argued that solar radiation management should be prohibited from the outset due to inescapable uncertainty regarding its effects.

INTRODUCTION

Whoever reads up on climate engineering discovers a world of wonder.[1] A new fantastical, yet serious, academic discourse is emerging in this area. It creates a draw that incorporates the previously unheard-of into classical risk analysis. It is highly fictional since the basic premises for action (climate change and the failure of mitigation) are, at the moment, largely a hypothetical construct. However, beneath this construct lies a reality, which pulls us into the present discussion: the general sluggishness of the 'keep on going' attitude with regard to resource depletion; political and economic interests, who seek the benefit of it; and the exorbitance of many academics. All of this drives the deep uneasiness that arises from this dispute and makes the current dialogue strangely assertive. One should be careful not to set aside the natural reaction of astonishment when analyzing the issue of climate engineering, because much about the current proposals is madness – although there is a method in it.[2] With this attitude, I will examine both the kinds of climate engineering and the law relating to it.

KINDS, GOALS AND RISKS OF CLIMATE ENGINEERING

Climate engineering is a recent addition to the well-established strategies of mitigation and adaptation. This induces three main reactions to climate change. The prominent new trait of climate engineering is its enormous depth of intervention into the natural course of the biosphere. Table 1 shows the three main types of climate engineering policies as I see them, ordered according to their magnitude.

It is true that humankind has already had massive impacts on nature, both by developing it to suit our own interests and by destroying it. The ETC Group, an environmental nongovernmental organization (NGO) with a mandate to promote the socially responsible development of technologies, has recently compiled a list of the most important harmful 'old ways to geoengineer the planet': deforestation; the conversion of savannah and marginal land into monocultures; the emission of enormous amounts of toxic substances into the atmosphere; the drainage of wetlands; river bed deviation; river, sea and lake pollution; extinction of species; overfishing; destruction of coral reefs; and over-usage of marginal soil and its erosion and desertification as a result.[3] The new climate engineering differs from these old forms in that the climate effects of geoengineering are not considered incidental side effects, but instead constitute intended results. In most cases, these results are not an effect of accumulated, small changes, but instead arise from a single large-scale intervention.

An extensive report compiled by The Royal Society reviews the methods of climate engineering and

[1] See Royal Society (ed.), 'Geoengineering the Climate: Science, Governance and Uncertainty' (Royal Society, September 2009); House of Commons Science and Technology Committee (ed.), *The Regulation of Geoengineering*, Fifth Report of Session 2009–10 – Report, together with formal minutes, oral and written evidence (HMSO, 2010); ETC Group, *Geo-piracy: The Case against Geoengineering* (ETC Group, 2010). For an overview of the pros and cons of climate engineering, see K. Ott, 'Argumente für und wider "Climate Engineering." Versuch einer Kartierung', 19:2 *Technikfolgenabschätzung – Theorie und Praxis* (2010), 32. For an analysis of the international law framework, see R.J. Zedalis, 'Climate Change and the National Academy of Sciences' Idea of Geoengineering: One American Academic's Perspective on First Considering the Text of Existing International Agreements', 19:1 *European Energy and Environmental Law* (2010), 18; A. Proelss and K. Güssow, *Climate Engineering. Instrumente und Institutionen des internationalen Rechts* (Bundesministerium für Bildung und Forschung, 2011), found at <http://www.kiel-earth-institute.de/projekte/forschung/rechtswissenschaft>.

[2] It is a madness, however, that completely lacks Hamlet's cynicism.

[3] See ETC Group, n. 1 above, at 18.

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TABLE 1 MITIGATION, ADAPTATION AND ENGINEERING AS APPROACHES TO ADDRESSING CLIMATE CHANGE ACCORDING TO MAGNITUDE

	Mitigation	Adaptation	Engineering
Large interventions			Solar Radiation Management (SRM); Carbon Dioxide Removal (CDR); weather manipulation
Medium and small interventions	Reduction of climate gas input through • emission reduction • renewable energies • energy efficiency • energy sufficiency	Supporting resilience of ecosystems; modified plants; flood protection	

TABLE 2 METHODS OF CLIMATE ENGINEERING AND AN EVALUATION OF THEIR BENEFITS AND EXPENSES.

Method	Effectiveness	Affordability	Timeliness	Safety
Afforestation	2	5	3	4
BECS	2.5	2.5	3	4
Biochar	2	2	2	3
Enhanced weathering	4	2.1	2	4
CO_2 air capture	4	1.9	2	5
Ocean fertilization	2	3	1.5	1
Surface albedo (urban)	1	1	3	5
Surface Albedo (desert)	2.5	1	4	1
Cloud albedo	2.5	3	3	2
Stratospheric aerosols	4	4	4	2
Space reflectors	4	1.5	1	3
CCS at source	3	3	4	5

Note: See Royal Society, n. 1 above, at 48. The numbers represent an increase in the loading of the variables. For instance, 1 in the first column means the lowest, and 5 the highest, effectiveness of a given method.

assesses them according to the four main criteria of efficiency, affordability, timeliness and safety (see Table 2).

Afforestation is a method of carbon dioxide (CO_2) storage. If used in cyclical processes as an alternative to burning fossil fuels it is a mitigation strategy; if aimed at large-scale removal of already existing loads of CO_2 in the atmosphere it should be considered climate engineering. Carbon capture and storage (CCS) is the method of capturing CO_2 after combustion processes and storing it in deep layers of the ocean or in caverns in the land or seabed. Bioenergy with CO_2 sequestration (BECS) is a sub-form of CCS at the source. Biochar involves carbonizing biological material and then storing it underground. Enhanced weathering mimics natural processes for removing carbon dioxide from the atmosphere, by speeding up the reaction of CO_2 with carbonate and silicate rocks. CO_2 air capture is the absorption of CO_2 into solid and liquid matter with the help of certain chemicals, the resulting mass of which must then be stored. Ocean fertilization stimulates the growth of marine algae and thus the biological absorption of CO_2 from the atmosphere. Land surface albedo (both urban and desert) can be enhanced by making large urban or land surface areas white to reflect incoming solar radiation.[4] Another suggestion is to increase the albedo of maritime boundary layer clouds. This method entails spraying a fine mist of saltwater particles that could form small cloud condensation nuclei in order to enhance the reflectivity of marine clouds. Stratospheric aerosol injection involves releasing particles (e.g., sulphate aerosols) into the stratosphere to reflect sunlight before it even reaches the lower layers of the atmosphere. Another climate engineering method involves placing reflectors in outer space to reflect solar radiation before it reaches the Earth's surface.

Large-scale afforestation, BECS, biochar, enhanced weathering, CO_2 air capture, ocean fertilization and

4 'Albedo' is a measuring unit of a surface's reflectivity.

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CCS are all described as 'Carbon Dioxide Removal' (CDR), whereas increasing surface and cloud albedo, the methods of injecting stratospheric aerosols and installing space reflectors are known as 'Solar Radiation Management' (SRM). The Royal Society's list does not account for weather manipulation. However, if used on a large scale, it might be considered a third method of climate engineering.

This article focuses on SRM methods of climate engineering with a special emphasis on the development and use of stratospheric aerosols and the insertion of reflectors in the Earth's lower orbits, since these two methods propose a particularly dramatic intrusion into the Earth's systems, and the legal regime for SRM and CDR differ in many respects.[5] The core argument that the potential immense damage advises against climate engineering is, however, also applicable to CDR and weather modification methods, at least insofar as they aim at massive deposit rather than organic recycling of carbon. The legal analysis is based on certain noteworthy characteristics of climate engineering, which are emphasized below.

SOME CHARACTERISTICS OF CLIMATE ENGINEERING

The Royal Society predicts that a very fast and highly effective cooling-down of the climate can be achieved with stratospheric aerosols and space reflectors at a relatively moderate cost. However, the safety of such efforts is estimated to be relatively low, meaning that adverse side-effects on human health and the environment could be significant. Another consequence not well represented in Table 2 is the possibility of a 'counter-productive effect'. For instance, the injection of stratospheric aerosols could cause an increase in temperatures instead of a decrease. This response could arise if it turns out that the newly formed aerosols in the stratosphere absorb solar radiation instead of reflecting it, or, if the intervention is not pursued continuously, there could be a fast escalation of temperatures to which the biosphere would not be able to adapt.[6]

It is not just the large-scale deployment of climate engineering technologies that bears risks. Research into climate engineering methods also poses a threat. It is predicted that *in situ* experiments themselves could constitute a major intervention of significant duration because a large-scale field trial would be necessary to determine whether the experiment has produced intended cooling separate from the usual temperature fluctuations. Experts in climate-engineering, such as Robock *et al.*, illustrate this with the example of a test on the insertion of sulphur into the lower stratosphere conducted at the tropics:

> In a 10-year experiment to test for a climate signal over noise, the chance of a local adverse response could not be ruled out prior to the experiment. As such, a prudently designed experiment would have to make provision for such outcomes. Although even a major disruption of agricultural output would be difficult to attribute to geoengineering, were such outcomes to occur, necessitating an end to the experiment, the sulphate aerosol density would need to be decreased slowly to avoid ecological shocks.[7]

Climate engineering is also a typical example of an end-of-pipe-strategy because the emission of greenhouse gases into the atmosphere, along with the consequence of increased global temperatures, is tolerated only to proceed with extracting these emissions again through the costly and time-consuming methods of CDR or minimizing their impact by means of SRM.

It is of high legal importance to know who will initiate climate-engineering measures. Three scenarios must be considered. First, there is the single State unilateral action, with said State only minding its own interests and endangering other States (as well as itself). Second, a single State unilateral project could be undertaken for the (supposed) common good while bearing in mind the risks for all. Third, a multilateral project following the foundation of an international organization is possible. Naturally, the unilateral campaigns are especially concerning; on the other hand, as will be seen below, there are more international rules available that are applicable to them.

INTERNATIONAL LAW

Two types of legal norms are relevant with regard to the international legal framework that applies to climate engineering: the norms enabling State action and those regulating State action in the global public interest. Enabling law is largely determined by the distribution of sovereign rights of States. Beyond the limits of State sovereignty, the activity may still be allowed on a non-exclusive basis – for example, if performed in an area of commons. Regulatory law, on the other hand, may restrict or encourage or even obligate that States exercise their rights in a specific way. Treaties and customary law may at the same time perform both of these functions of international law by enabling and regulating certain activities.

ENABLING LAW

According to customary international law, activities within the stratosphere, such as the introduction of

[5] Enhancing the cloud and surface albedo raises additional legal questions that cannot be addressed here.

[6] L. Bengtsson, 'Geoengineering to Confine Climate Change: Is It At All Feasible?', 77:3–4 *Climatic Change* (2006), 229.

[7] A. Robock, *et al.*, 'A Test for Geo-engineering?', 327 *Science* (2010), 530.

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particles, belong to the sovereign realm of States. Contrastingly, activities in Outer Space, such as the insertion of reflectors, are undertaken in a commons area and are subject to the principle of the freedom of exploration and use of Outer Space. The Outer Space Treaty[8] gives some more specifics in this respect. It declares that Outer Space, including the moon and other celestial bodies, are a sphere of free exploration, use and research for all States.[9] No State has sovereign rights over Outer Space.[10] This means that Outer Space constitutes a common area to humanity whose research and utilization by States is free but not exclusive. The Treaty does not delimit the boundary at which the air column above the sovereign territory of States ends and where Outer Space begins. Customary international law has not formulated an answer to this question either. However, the general assumption is a limit of about 100–110 km.[11] While according to customary law a State is allowed to accede to Outer Space through its own air space, it must obtain consent of another State if the access implies the crossing of the air space of the same.[12] The Outer Space Treaty also has regulatory provisions, which will be elaborated upon below.

REGULATORY LAW

There are treaties covering all SRM measures as well as treaties specific to kinds of SRM. In addition, international customary law must be consulted.

Treaties Applicable to Atmospheric Sulfur and Space Reflectors. The 1977 Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD)[13] prohibits the hostile use of environmental modification techniques. 'Environmental modification techniques' are defined as 'any technique for changing – through the deliberate manipulation of natural processes – the dynamics, composition or structure of the Earth, including its biota, lithosphere, hydrosphere and atmosphere, or of outer space'.[14] Several examples are provided: 'earthquakes, tsunamis; an upset in the ecological balance of a region; changes in weather patterns (clouds, precipitation, cyclones of various types and tornadic storms); changes in climate patterns; changes in ocean currents; changes in the state of the ozone layer; and changes in the state of the ionosphere'.[15]

Military or any other hostile use 'having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party' is prohibited. Friendly use is not barred *a limine*, even if it causes widespread, long-lasting and severe effects.[16] However, friendly use must still accord with the generally acknowledged principles and applicable rules of public international law.[17] Furthermore, an exchange of research and development results is provided.[18] According to Article III(2) of ENMOD: 'The States Parties to this Convention undertake to facilitate, and have the right to participate in, the fullest possible exchange of scientific and technological information on the use of environmental modification techniques for peaceful purposes.'

SRM falls within the definition of environmental modification techniques as set out in the ENMOD Convention. Climate interventions planned for military or other hostile use would be prohibited, but activities carried out for friendly purposes are allowed, notwithstanding any other applicable international law such as rules protecting the environment. It is consequential to note that knowledge and technologies gained by conducting field tests must be shared with other contracting States. This is particularly significant with regard to knowledge about negative consequences, which also must be shared.

An encouragement and perhaps even an obligation to intervene to prevent global warming using climate engineering may be derived from the United Nations Framework Convention on Climate Change (UNFCCC).[19] Article 3(3) of the Convention states:

> The Parties should take *precautionary measures* to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures . . . . To achieve this, such policies and measures should . . . cover all relevant *sources, sinks and reservoirs* of greenhouse gases. (emphasis added)

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8 Treaty on Principles governing the Activities of States in the Exploration and use of Outer Space, including the moon and other celestial bodies (London, Washington and Moscow, 27 January 1967) ('Outer Space Treaty').

9 Ibid., Article I, paragraphs 2, 3.

10 Ibid., Article II.

11 V.S. Vereshchetin, 'Outer Space', in *Max Planck Encyclopaedia of Public International Law* (Max Planck Institut für ausländisches öffentliches Recht und Völkerrecht, 2006), paragraph 15, found at <http://www.mpepil.com/subscriber_article?script=yes&id=/epil/entries/law-9780199231690-e1202&recno=3&author=Vereshchetin%20%20Vladlen%20S>.

12 H. Fischer, 'Weltraumrecht', in K. Ipsen (ed.), *Völkerrecht* (Verlag C.H. Beck, 2004), 24. See also R. Wolfrum, 'Rechtliche Ordnung des Weltraums', in K. Kaiser and St. v. Welck (eds), *Weltraum und internationale Politik* (Oldenbourg, 1987), 243.

13 Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques (Geneva, 18 May 1977) ('ENMOD Convention'). The treaty has 76 parties.

14 Ibid., Article II.

15 Ibid., Annex, 'Understandings regarding the Convention'.

16 In contrast to this, Proelss and Güssow, n. 1 above, at 7, seem to opine that the ENMOD Convention is not applicable to peaceful activities.

17 See ENMOD Convention, n. 13 above, 'Understanding relating to Article III annexed to the Convention text'.

18 Ibid., Article III(2), first sentence.

19 United Nations Framework Convention on Climate Change (New York, 9 May 1992) ('UNFCCC').

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The provision affirms the precautionary principle and construes it as requiring that States take positive measures regarding sources, sinks and reservoirs of greenhouse gases. Articles 4(1)(b) and 4(1)(d) of the UNFCCC further elaborates on this requirement:

> All Parties . . . shall . . . (b) formulate, implement, publish and regularly update . . . programmes containing measures to mitigate climate change by . . . *removals by sinks of all greenhouse gases* . . . ; (d) . . . promote and cooperate in the conservation and enhancement, as appropriate, *of sinks and reservoirs* of all greenhouse gases . . . including biomass, forests and oceans as well as other terrestrial, coastal and marine ecosystems. (emphasis added)

Article 3(3) of the UNFCCC does not apply to SRM methods within this enumerated list of measures because the purpose of this provision is to control the causes of climate change. Solar radiation is clearly a component of our climate system. However, it is not the cause of *changes* to the climate.[20] This narrower focus on the causes of climate change in the first sentence of Article 3(3) also applies to severe and irreversible damages mentioned in the second sentence of this provision. In conclusion, the UNFCCC neither mandates nor encourages SRM. This is also illustrated in Articles 4(1)(b) and 4(1)(d), which address only the removal of greenhouse gases, and not the reduction of solar radiation.

If we assume that the precautionary principle now has the legal status of customary international law,[21] such that it is directly applicable independent of the specific requirement in Article 3(3), sentence 2, of the UNFCCC, then the question arises: does this principle perhaps encourage or even compel parties to use SRM?[22] I believe not since this conception would pervert the very idea of precaution. The precautionary principle acknowledges that human behaviour is capable of destroying the environment, and advises us to take action to stop such damage, even if there is no certainty about degree and likelihood of harm. The goal is to prevent damage from occurring, which otherwise would need to be eliminated through an end-of-pipe method. Climate engineering, however, is itself a type of an end-of-pipe method, and, in fact, one of the least reliable.

The 1992 Convention on Biological Diversity (CBD)[23] obliges contracting States to monitor and control activities that are potentially harmful to biodiversity. According to Article 7(c), each contracting party shall 'identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity, and monitor their effects through sampling and other techniques'. Article 8(l) states that a contracting party shall 'where a significant adverse effect on biological diversity has been determined pursuant to Article 7, regulate or manage the relevant processes and categories of activities'. Both obligations are, without doubt, applicable to climate engineering. However, they are not of much help. Above all, they hardly have a prophylactic aim. Rather, these provisions apply to activities that definitely or supposedly have adverse environmental effects. They do not require precautionary action. In addition, the requirements for monitoring and control are undefined. Furthermore, these obligations are subject to the proviso of 'as far as possible and as appropriate'.[24]

A specification has been achieved through resolutions of recent conferences of the contracting parties. At the tenth session of the CBD Conference of the Parties (COP 10) in 2010, the Parties determined 'that no climate-related geoengineering 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*'[25] (emphasis added). In 2008, the parties at CBD COP 9 had determined that ocean fertilization would not be permitted until 'a global, transparent and effective control and regulatory mechanism is in place for these activities'.[26] The effect of this declaration was to create an implicit moratorium for ocean fertilization activities. The resolution agreed at COP 10, which also applies to SRM, is less strict, although SRM has a greater potential to cause harm than ocean fertilization. Nonetheless, the conclusion of COP 10 applies the precautionary principle requiring that, before deployment, climate engineering activities must have an adequate scientific basis to justify them. Furthermore, appropriate consideration is due in relation to environmental risks as well as social, economic and cultural impacts. Of course, as a COP Resolution these rules are not binding in the formal legal sense.

The Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention)[27] lays down the obligation on parties to conduct environmental impact assessments (EIA) before certain types of projects are carried out. The contracting parties are

[20] Zedalis fails to notice this. See R.J. Zedalis, n. 1 above, at 31.
[21] For the discussion, see P. Birnie, A. Boyle and C. Redgwell, *International Law and the Environment* (Oxford University Press, 2009), at 159 *et seq*.
[22] Along this line it has been argued that ocean fertilization is legitimated by the precautionary principle. See K. Güssow *et al*., 'Ocean Iron Fertilization: Why Further Research is Needed', 43:5 *Marine Policy* (2010), 911, at 917.
[23] Convention on Biological Diversity (Rio de Janeiro, 5 June 1992) ('CBD').
[24] Ibid., Article 8.
[25] CBD Decision X/33, Biodiversity and climate change (UNEP/CBD/COP/DEC/X/33, 29 October 2010), paragraph 8(w).
[26] CBD Decision IX/16, Biodiversity and climate change (UNEP/CBD/COP/DEC/IX/16, 9 October 2008), paragraph C(4).
[27] Convention on Environmental Impact Assessment in a Transboundary Context (Espoo, 25 February 1991) ('Espoo Convention').

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also required to ensure the participation of the affected public and notify and consult potentially affected States. The EIA must include 'a description, where appropriate, of reasonable alternatives (e.g., locational or technological) to the proposed activity and also the no-action alternative'.[28] The projects, to which the obligation for an EIA applies, are listed in Appendix I to the Convention. They are mainly industrial and infrastructure projects. Climate engineering, particularly SRM, is not included. However, projects that are not included in Appendix I could be treated as if they are listed, if they are likely, according to criteria laid out in Appendix III (such as size, location and type) to cause a significant adverse impact, and if the parties 'so agree'; each contracting State could therefore initiate the inclusion of climate engineering in Appendix I.[29] There is no doubt that SRM meets the criteria of Appendix III. Large-scale research projects could also meet these criteria. All that is required is the consensus of the contracting parties to extend the requirement of an EIA to climate engineering activities, upon the initiative of a contracting State. It should be noted, however, that as a United Nations Economic Commission for Europe (UNECE) convention, the Espoo Convention only applies to European and North American signatory countries.[30]

Treaties with Specific Application. The contracting parties to the 1979 Convention on Long-range Transboundary Air Pollution (LRTAP Convention)[31] 'are determined to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution'.[32] 'Air Pollution' is defined in the convention as 'the introduction by man, directly or indirectly, of substances or energy into the air resulting in deleterious effects of such a nature as to endanger human health, harm living resources and ecosystems and material property and impair or interfere with amenities and other legitimate uses of the environment'.[33] Since the stratosphere belongs to the 'air', the Convention applies to the injection of sulphuric particles into it. If damage is caused by a specific activity, mitigation measures must be undertaken. While the Convention has primarily the reduction of already existing pollution in mind, it also requires prevention. However, it presupposes that the deleterious effect of substances or energy is provable.[34] This disqualifies the provision as an appropriate rule on stratospheric sulphur. Moreover, the Protocols to the LRTAP Convention on reduction of sulphur emissions are not applicable to stratospheric sulphur. It is true that these Protocols oblige parties to gradually reduce emissions of sulphur, but their scope is emissions from combustion of fossil fuels for energy production, industrial processes and transport.[35]

The 1985 Vienna Convention for the Protection of the Ozone Layer (Ozone Convention)[36] states that contracting parties to the Convention 'shall take appropriate measures . . . to *protect* human health and the *environment against adverse effects* resulting or likely to result from human activities which modify or are likely to modify the ozone layer'[37] (emphasis added). The Convention creates the obligation to prevent environmental damage caused by the degradation of the ozone layer. The contracting parties have other duties as well: they need to cooperate to promote research, harmonize measures, adopt new, specific protocols and cooperate with other international bodies. The preventive quality of the provision is stricter than that of the LRTAP Convention because prevention is also due if the negative effects are only 'likely'. This does not mean, however, that the treaty adopts the precautionary principle. The ozone layer forms part of the stratosphere. Water is also a substance that has the potential to alter the ozone layer.[38] This means that stratospheric aerosol injection and the resulting condensation of water particles could damage the ozone layer.[39] Such damage must be prevented. It has been debated whether this damage can be weighed against possible benefits for the climate. However, the Vienna Convention does not contain any indication in that direction.[40]

The Outer Space Treaty contains certain obligations with regard to the research and use of outer space, the moon and other celestial bodies. According to Article I: 'The exploration and use of outer space, including the moon and other celestial bodies, shall be *carried out for the benefit and in the interests of all countries*, irrespective of their degree of economic or scientific development, and shall be the *province of all mankind*.'[41] Also, Article IX states:

> State Parties to the Treaty shall pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to *avoid their harmful*

[28] Ibid., Appendix II lit. (b).
[29] Ibid., Article 2(5) with Appendix III.
[30] Ibid., Article 17(3), which was adopted in 2001, allows non-UNECE Member States to become parties to the Convention. The amendment enters into force once it is adopted by all the States and organizations that were parties to the Convention on 27 February 2001.
[31] Convention on Long-range Transboundary Air Pollution (Geneva, 13 November 1979). Having 51 parties all situated in North America, Europe and the former Soviet Union, the Convention is a regional one.
[32] Ibid., Article 2.
[33] Ibid., Article 1(a).
[34] See R.J. Zedalis, n. 1 above, at 22.
[35] See Protocol to the 1979 Convention on Long-range Transboundary Air Pollution on Further Reduction of Sulphur Emissions (Oslo, 14 June 1994).
[36] Convention for the Protection of the Ozone Layer (Vienna, 22 March 1985). The Convention has 196 parties and is thus of a universal character.
[37] Ibid., Article 2(1).
[38] Ibid., Annex I, paragraph 4(e)(ii).
[39] See R.J. Zedalis, n. 1 above, at 22.
[40] See A. Proelss and K. Güssow, n. 1 above, at 30.
[41] See Outer Space Treaty, n. 8 above, Article I (emphasis added).

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> *contamination and also adverse changes in the environment of the Earth* resulting from the introduction of extra terrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the moon and other celestial bodies, it shall undertake appropriate *international consultations* before proceeding with any such activity or experiment.[42]

Article I indicates that the exploration and use of outer space, including the moon and other celestial bodies, must be carried out to the benefit and in the interest of all countries. It is controversial what that means.[43] As a minimum requirement, it can be said that those activities are incompatible with the Treaty, which are likely not to produce any benefit, but rather have detrimental effects.

Article IX obligates parties to avoid such exploration and use[44] which may cause harmful contamination of outer space or adverse changes in the environment of the Earth. They must undertake international consultations prior to the undertaking of any potentially harmful actions. The positioning of reflectors into outer space is a form of use of outer space.[45] This would thus be prohibited if its effects are counterproductive or if it causes adverse changes in the environment of the Earth.

Article VII of the Outer Space Treaty provides that States launching objects into outer space are liable for damage to another State or to its natural or juridical persons by such objects or its components on the Earth, in air space or in outer space. Thus the focus is on physical damage from space reflectors as objects, such as if they fall to the Earth or hit other space objects in the atmosphere or outer space. This means that the most problematic effects – adverse impacts on ecosystems and weather conditions – are not adequately captured by the Treaty. This conclusion also applies to the Convention on International Liability for Damage Caused by Space Objects,[46] which in more precise language provides that 'a launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft flight'.[47]

Somewhat more preventive is the approach taken by a treaty on space debris that is presently under international discussion. If it materializes as a binding instrument, new obligations will have to be respected with regard to decommissioned reflectors or other waste resulting from related operations. According to a recent draft treaty compiled by the International Law Association,[48] such a treaty would establish an obligation of States 'to take all appropriate measures to *prevent, reduce, and control any damage* or significant risk arising from activities under their jurisdiction or control which are likely to produce debris [as well as to be] *internationally liable for damage* arising therefrom to another State, persons or objects, or international organisation party to this Instrument as a consequence of space debris produced by any such object' (emphasis added).

Customary International Law. Customary international law must also be consulted. It can be applied where conventions leave issues unregulated. Some rules of customary international law may also be regarded as *ius cogens*, thus setting aside any incompatible conventional rules. Procedural and substantive rules of customary international law should be distinguished when analyzing the legal framework that applies to climate engineering.

In terms of procedure, the acting State's duty to provide prior notification to affected States and give them an opportunity to comment is a generally agreed requirement of customary international law. If there is available information about the risks of an activity, it must be shared.[49] There is also a customary obligation to carry out a prior EIA (environmental impact assessment). Previously, this obligation was only mandatory for projects covered by the regional Espoo Convention. Since then, the International Court of Justice (ICJ) has recognized that the requirement to conduct a prior EIA constitutes a universal rule of customary international law. In the *Pulp Mills* case, the Court phrased the EIA requirement as follows: '[A] requirement under general international law to undertake an *environmental impact assessment* where there is a risk that the proposed industrial activity may have a significant adverse impact in a transboundary context, in particular, on a shared resource.'[50]

Although the ICJ's decision in *Pulp Mills* leaves much of the scope and content of an EIA to be defined by States,

[42] Ibid., Article IX (emphasis added).

[43] See A. Proelss and K. Güssow, n. 1 above, at 17, for a summary of this debate.

[44] The fact that Article IX, second sentence, only mentions studies and exploration, but not use, is generally considered to be an editing mistake. See A. Proelss and K. Güssow, ibid., at 19.

[45] See R.J. Zedalis, n. 1 above, at 24; and A. Proelss and K. Güssow, ibid., at 16.

[46] Convention on International Liability for Damage Caused by Space Objects (London, Moscow, Washington, 29 March 1972).

[47] Ibid., Article II. In addition, Article III establishes (fault) liability for damage to space objects or persons and property on board of space objects.

[48] See Articles 3(2) and 8 of the draft. See M. Williams, 'Safeguarding Outer Space: On the Road to Debris Mitigation', in *Security in Space: The Next Generation – Conference Report*, 31 March–1 April 2008 (United Nations Institute for Disarmament Research (UNIDIR), 2008), at 94ff, found at <www.unidir.org/pdf/articles/pdf-art2818.pdf>.

[49] See P. Birnie *et al*., n. 22 above, at 177.

[50] ICJ 20 April 2010, Pulp Mills on the River Uruguay (*Argentina v. Uruguay*), at 204 (*Pulp Mills on the River Uruguay* case) [not yet reported] (emphasis added).

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it outlines four basic requirements about what is necessary in such instances: the EIA should be adequate to the size, type and effects of the project; it must be prepared with due diligence; it must include an assessment of alternatives; and it must be carried out prior to the realization of the project.[51] With regard to the first criterion and in light of the exorbitant scale and risks that may be posed by SRM activities, we can assume that the ICJ would include SRM as within the scope of the customary rule on EIA.

A substantive obligation to prevent environmental damage is also an important rule of customary international law. In *Pulp Mills*, the ICJ restated this rule as follows: 'A State is thus obliged to use all the means at its disposal in order to avoid activities which take place in its territory, or in any area under its jurisdiction, causing significant damage to the environment of another State.'[52] While the ICJ derived from this obligation the procedural duty to inform the affected States prior to taking certain actions,[53] it did not need to specify the substantive content of the obligation as general customary rule because precise substantive obligations were defined in a bilateral treaty between the opposing parties in that case.

It is still open for discussion regarding which precise rules of due diligence are implied in the formula 'to use all the means at its disposal'[54] and whether a certain activity must itself be regarded as prohibited if it cannot be conducted in a way that minimizes harmful effects.[55] Regarding the requirement of due diligence, the International Law Commission (ILC) in its commentary on its draft articles on Prevention of Transboundary Harm from Hazardous Activities explains that a State's duty of care is proportional to the degree of risk. It stated that: '[A]ctivities which may be considered ultra-hazardous require a much higher standard of care in designing policies and a much higher degree of vigour on the part of the State to enforce them.'[56] A logical extension of this statement is that if under a higher duty of care a greater degree of vigour is impossible, the activity itself is not permitted.

There is general agreement among scholars and a growing practice in international treaty-making that States are also required to prevent damage to common areas such as outer space.[57] In any case, as explained above, such a duty can be found in the Outer Space Treaty.

Liability to compensate damage is a second dimension of substantive obligations under customary international law. The rule that States which fail to meet their obligation to prevent transboundary harm must compensate the injured State has widely been accepted since the *Trail Smelter* arbitration in which Canada was liable to pay compensation to the United States for transboundary damage that occurred from plant operations.[58] However, the reticence of the ILC to codify such a rule, the lack of caselaw and later concerns of authors have raised doubts about whether the norm arising from *Trail Smelter* is supported by sufficient evidence of a general practice to be accepted as law.[59] In any case, the more established rules on civil liability between private individuals or entities may be seen as a viable substitute for State liability.[60]

In sum, it can be assumed that due to the possibility of potentially enormous side and counter-productive effects, SRM interventions are covered by the rule of prevention. The State launching a project must prepare an EIA and abide by the requirements of due diligence.

STATE OF EMERGENCY AND COUNTERMEASURES

A State engaging in climate engineering activities which then violates one or more of the international norms mentioned above, could plead a state of emergency. According to customary international law, such a situation would transform illegal actions into legal ones. However, in order for a State to successfully plead that its actions fall within the legal exception of a state of emergency, certain criteria must be fulfilled. These include the requirements that there exists: an essential interest of the acting State; a grave and imminent danger; only one sole means of protecting the State's interests; no expectation of serious damage to another State's essential interests; a situation where the State has not itself contributed to the state of emergency.[61]

[51] Ibid., at 205, 210. The participation of the general public is not, *per se*, viewed by the court as customary law (at 216).
[52] Ibid., at 101.
[53] Ibid., at 102.
[54] See further on these questions, P. Birnie *et al*., n. 22 above, at 147ff; G. Handl, 'Transboundary Impacts', in D. Bodansky, J. Brunnée and E. Hey (eds) *International Environmental Law* (Oxford University Press, 2007), 532 *et seq*.
[55] See P. Birnie *et al*., n. 22 above, at 151.
[56] *ILC Commentary (11) to Article 3 of Draft Articles on Prevention of Transboundary Harm from Hazardous Activities* (ILC 2001), found at <http://untreaty.un.org/ilc/texts/instruments/english/commentaries/9_7_2001.pdf>.
[57] P. Birnie *et al*., n. 22 above, at 145.
[58] Trail Smelter Arbitration, 16 April 1938 (*United States v. Canada*), RIAA III, 1938, 1965.
[59] See P. Birnie *et al*., n. 22 above, at 141; and G. Handl, n. 54 above, at 545.
[60] See G. Handl, ibid., at 545.
[61] ICJ, judgment of 25 September 1997, *Gabcikovo Nagymaros Hungary v. Slovakia*, (1997) ICJ Reports 7, paragraphs 51, 52 (*Gabcikovo Nagymaros* case). The Court followed the provisions of Article 33 of the Draft Articles on the International Responsibility of States by the International Law Commission (ILC), 2:2 *Yearbook of the International Law Commission* (2001), Article 33.

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It can be assumed under the given scenario involving a unilateral deployment of a climate engineering technology that the first two requirements would be met if a serious climate problem arises. However, the third requirement, which relates to the effectiveness of the measure, is hard to meet, given the likelihood of counterproductive effects. The fourth requirement poses the same problem because grave damages to other States might be expected by the use of climate engineering technologies. The last requirement, however, goes to the core of the problem. Due to their financial, scientific and technological capabilities, it would be industrialized States that deploy climate engineering projects. Yet the industrialized States are unquestionably the ones that caused the state of climate emergency in the first place.

Notwithstanding this, climate engineering could also be constructed as a countermeasure against other State's illegitimate actions: State A could carry out climate engineering activities that cause damage to the territory of State B in response to State B's action to take climate engineering measures, which were assumedly unlawful for causing damage in the territory of State A in the first instance. Or State A could take climate engineering measures to the detriment of State B as a countermeasure to activities undertaken by State B causing climate change in violation of the UNFCCC obligations. In the *Gabcikovo Nagymaros* case, the ICJ considered whether the illegitimate branching off of the Danube waters by Slovakia could be considered a legitimate countermeasure against Hungary, which unilaterally pulled out of the joint Danube canalization project. The ICJ established four conditions to be met for the countermeasure to be legitimate: the countermeasure must be a reaction to a prior action taken by a State in violation of international law; the countermeasure must be directed to the other State; a prior warning must have been made to the other State to refrain from the illegitimate activity or to compensate for the damage; and proportionality of the countermeasure in comparison to the sustained damage must be ensured.[62] The two first conditions are hard to prove: that the opposed action – climate gas emissions – has been performed in violation of international law and that any adverse effects of SRM can be so controlled that they only affect the opposing States and not any innocent third State.

SUMMARY AND CONCLUSION

The rules of international law applicable to SRM can be summarized as follows. SRM within a State's atmosphere falls under its sovereignty. SRM in the outer space is a free but non-exclusive right of States. Although it is designed to preserve a liveable climate, SRM is neither mandated nor even encouraged by the UNFCCC or the precautionary principle. Rather, according to the UNFCCC and the precautionary principle, all effort must be directed to the mitigation of anthropogenic climate change.

The basic rights of States to carry out SRM are subject to restrictions in the interest of environmental protection. These restrictions are laid out in various international treaties and also in customary international law. Some of them are broadly and others more precisely framed. Some are only regionally, others universally binding. Some are applicable on all climate engineering methods, others only on specific ones. The resulting palette of obligations can be outlined as follows. In terms of regional obligations (Europe): an EIA is required with a precise content, which includes an assessment of alternatives (Espoo Convention); and public participation in the EIA process is mandatory (Espoo Convention). In terms of specific obligations: activities must serve the common welfare of all States (Outer Space Treaty; concerning space reflectors); adverse changes in the environment of the Earth must be avoided (Outer Space Treaty; concerning space reflectors); air pollution must be prevented (LRTAP Convention; concerning stratospheric sulfur); and the ozone layer must be protected (Ozone Convention; concerning stratospheric sulfur). And finally, in terms of general obligations (universal): a prior EIA is required, but the scope of the projects and the content of the EIA remain to be specified (customary rule); prior notification of and consultation with affected States is mandatory (customary rule); the transportation into outer space of objects through the airspace of another State requires the consent of this State (customary rule); research and development results are to be shared with other contracting States (ENMOD); significant and imminent damages in other States and common areas must be prevented (customary rule); and damage by space objects must be compensated (Outer Space Treaty). States that have contributed to climate change are not entitled to justify damaging effects by invoking a state of emergency. States which have suffered from climate change without contributing to it and which have deployed SRM as a countermeasure would hardly be able to prove that the preconditions of legitimate counter measures are given.

Assessing the existing international rules there appear to be flaws in several respects. Many rules are rather undemanding: the customary law concept of an EIA does not require the testing of alternatives and lacks requirements to ask for public participation; the common welfare requirement of the Outer Space Treaty is very weakly framed and only applies to space operations; the duty established by the ENMOD Convention to exchange research and development results is too broadly formulated to inform about precise rights and exceptions on access to information; the duty to prevent damage presupposes firm knowledge about risks; the

[62] See *Gabcikovo Nagymaros* case, ibid., paragraphs 83–87.

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duty to compensate for damage only covers physical damage from space objects. Altogether, the existing rules build upon the traditional model assuming causation by single causes of single effects. This disregards the large-scale character and systemic effects of SRM. Moreover, all of the rules focus on the protection of the environment. They do not reflect that SRM by aiming at climate stabilization may also serve the protection of the environment. Attempts to interpret the existing rules so that they include a weighing of environmental and climate concerns have so far not been successful because the relevant texts do not allow for it. An alternative and more general approach that suggests weighing environmental protection conventions against the UNFCCC[63] does not work in regard to SRM because the UNFCCC neither mandates nor encourages this technology.

REFORM CONSIDERATIONS

Considering these flaws, two options for future policies concerning SRM are imaginable: an incrementalist approach suggesting slight changes to existing laws plus additional voluntary commitments, and an innovative approach creating an entire new regime on climate engineering.

Minor changes to existing rules plus additional commitments appear to be the most realistic option, and the one that will probably be proposed by politicians. It can be expected that adaptation of annexes and new interpretations of existing conventions will be introduced. For instance, the obligation to conduct an EIA will possibly be improved. The adoption of the ambitious Espoo obligations may be spread by accession of non-European States to the Convention. Its list of projects requiring EIA may be extended to SRM research and deployment. The United States, although not party to the Convention, already fulfils this standard. The National Environmental Protection Act and regulations define the scope of EIA not through a list, but by means of established criteria. These would undoubtedly apply to climate engineering.[64]

It is not expected that essential progress will be made on sectoral conventions. It is true that the decision of COP 10 of the CBD is progressive in the sense that it requires sufficient knowledge prior to the taking of SRM measures. However, the CBD decision is not binding international law. The common welfare clause set out in the Outer Space Treaty could also be reinterpreted as requiring that States must furnish proof of the effectiveness of the measure and the exclusion of counterproductive effects. But the necessity test has hardly a chance of being transferred to the other conventions dealing with climate engineering within the atmosphere, because this would substantially increase the burden of proof for research and deployment projects. Perhaps, the idea contained in the ENMOD Convention that research and development results must be shared, has a better chance to become a general principle in the climate engineering field.

Given the significant deficiencies in the existing regulatory framework, one might put hopes in self-regulation as a potential solution. A prominent example is the five recommendations regarding research on climate engineering that were agreed upon at the Asilomar International Conference on Climate Engineering Technologies in November 2010. These recommendations are:

(1) climate engineering research should be aimed at promoting the collective benefit of humankind and the environment;
(2) governments must clarify responsibilities, and, when necessary, create new mechanisms for the governance and oversight of large-scale climate engineering research activities;
(3) climate engineering research should be conducted openly and cooperatively, preferably within a framework that has broad international support;
(4) iterative, independent technical assessments of research progress is required to inform the public and policy makers; and
(5) public participation and consultation in research planning and oversight, assessments, and development of decision-making mechanisms and processes must be provided.

Unfortunately, these rules are vaguely worded and ill defined. The reference to promote the common welfare does not explain what kinds of research would meet the standard and what others would not. While administrative oversight is accepted, the question of liability of researchers for damages is not elaborated upon. A concrete requirement of open and timely publication of research and development results has not been guaranteed, so that new knowledge can be kept secret – for example, for patenting purposes. The requirement to conduct a prior EIA is also not included. One positive aspect is that the need for public participation is emphasized. Finally, there are no sanctions that would apply if these guidelines are disregarded. For instance, they could have proposed a role for research and development funding organizations in enforcing them.

[63] See A. Proelss and K. Güssow, n. 1 above, at 70 *et seq*.
[64] See Executive Order No. 12114 of 4 January 1979, Environmental Effects Abroad of Major Federal Actions, paragraphs 2–3, which states that 'major federal actions significantly affecting the environment of the global commons outside the jurisdiction of any nation' are subject to EIA as well as 'major Federal actions significantly affecting the environment of a foreign nation not participating with the United States and not otherwise involved in the action'.

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Given the small control capability of the incrementalist option, it is wise to consider a more innovative approach. One significant proposal for the start of a new regime has been made by an interdisciplinary group of British scholars who formulated a set of five 'Oxford Principles for the Regulation of Geoengineering'.[65] Their suggestions are similar to the ones made by the Asimolar Conference and were, in fact, used for drafting the Asilomar Recommendations. However, they are different insofar as they demand binding State-based measures and use more precise language. The Oxford Principles consist of five principles:

> *Principle 1: Geoengineering to be regulated as a public good*. While the *involvement of the private sector* in the delivery of a geoengineering technique should not be prohibited, and may indeed be encouraged to ensure that deployment of a suitable technique can be effected in a timely and efficient manner, regulation of such techniques should be undertaken in the public interest by the appropriate bodies at the State and/or international levels.
>
> *Principle 2: Public participation in geoengineering decision making*. Wherever possible, those conducting geoengineering research should be required to notify, consult and ideally obtain the *prior informed consent* of those affected by the research activities. The identity of affected parties will be dependent on the specific technique which is being researched – for example, a technique which captures carbon dioxide from the air and geologically sequesters it within the territory of a single State will likely require consultation and agreement only at the national or local level, while a technique which involves changing the albedo of the planet by injecting aerosols into the stratosphere will likely require *global agreement*.
>
> *Principle 3: Disclosure of geoengineering research and open publication of results*. There should be *complete disclosure* of research plans and open publication of results in order to facilitate better understanding of the risks and to reassure the public as to the integrity of the process. It is essential that the *results of all research, including negative results, be made publicly available*.
>
> *Principle 4: Independent assessment of impacts*. An assessment of the impacts of geoengineering research should be conducted by a *body independent of those undertaking the research*; where techniques are likely to have transboundary impact, such assessment should be carried out through the appropriate regional and/or international bodies. Assessments should address both the *environmental and socio-economic impacts* of research, including mitigating the risks of lock-in to particular technologies or vested interests.
>
> *Principle 5: Governance before deployment*. Any decisions with respect to *deployment should only be taken with robust governance structures already in place*, using existing rules and institutions wherever possible. [emphasis added]

If these recommendations were to be fully implemented, a convention would have to be concluded that contains the following: stabilization of the climate for the global common welfare as its objective; classification of all climate engineering methods covered by the convention; prohibition of certain methods of climate engineering; and prior authorization by the responsible State or by an international authority to be set up based on the United Nations.[66] Procedures set out in the convention must address: information about the project to be submitted; assessment of environmental and social impacts including an assessment of alternatives; prior notification of climate engineering activities to all affected States; all documents including the EIA to be published online; right of the public to submit comments on the project and its impact; and prior consent of all of the affected States. Furthermore, criteria must be set out regarding the conditions of climate engineering activities: there must be proof of the effectiveness of the measure regarding climate protection and the exclusion of counter-productive effects (regarding research projects, there should be proof of validity and reliability of the project); a proven lack of alternatives, including mitigation and adaptation measures (regarding research projects, gaps in the current state of knowledge); minimization of health, environmental and welfare harm caused by the activities; and the weighing of residual risks up against the proven beneficial climate effects (regarding research projects, this must take into account scientific advances). Finally, there should be: publication of the research and development results; exclusion of the patentability of research and development results; the establishment of an institutional framework for implementation of the convention; the creation of a monitoring mechanism and a tool for issuing sanctions for non-compliance; a conflict resolution mechanism under the convention; a mandate to develop specific protocols as needed; and the creation of procedures for amending the convention and its annexes.

Reviewing these comprehensive components for the possible design of a new convention it appears unlikely that such a binding regime prohibiting harmful climate engineering activities could be reached in the near future. As one observer realistically predicts:

> Most nations would probably favour a ban on geoengineering because only a few countries actually have the capability to geoengineer on their own. The rest have little to gain from being permissive and would be wary about letting the geoengineers tinker with the planet. Faced with pressure for

[65] S. Rayner *et al.*, 'Memorandum on Draft Principles for the Conduct of Geoengineering Research', in House of Commons Science and Technology Committee, n. 1 above. The principles were largely endorsed by the Committee. See ibid., at 29.

[66] For a strong plea in favour of the UN as the sole basis providing legitimation for the deployment of large-scale geo-engineering, see House of Commons Science and Technology Committee, n. 1 above, paragraph 100.

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a taboo, the few nations with unilateral geoengineering capabilities would seek favourable (i.e., vague) language; if unsuccessful, those countries could simply refuse to join.[67]

A RADICAL OPTION

I am normally an idealist, not a realist, because taking a realist position often weakens the chances of ideal solutions becoming real. But any envisaged ideal solution must of course be well founded. I doubt that the convention proposed above stands the test. Even if it were possible to establish, such an instrument would not likely provide an effective mechanism for the oversight and control of climate engineering. The reason for this is uncertainty. Two kinds of uncertainties must be distinguished. One type can be reduced by further research, and the other cannot because of the vast complexity of the issue. In the first case, further research can and should be undertaken in order to accumulate the required level of knowledge. In the latter case, such research is in vain because it will never reach a stage upon which a reliable prognosis of effects can be based. Sociologists of science have called this situation 'conscious ignorance',[68] 'negative knowledge'[69] and 'non-computability',[70] meaning it is possible to know that there cannot be knowledge on certain issues.

Proponents of the sophisticated control regime assume that sufficient knowledge will emerge to reasonably decide about SRM measures. My suggestion is that SRM is a case of negative knowledge or (potentially) conscious ignorance. SRM entails a large-scale intervention into the earth system, which involves literally 'ex-orbitant' interactions that are far too complex to ever be sufficiently understood. Given the enormous potential for damage both through counterproductive and side effects, the logical conclusion can only be that the deployment and large-scale research of SRM must be prohibited from the outset.[71]

Is there also a legal foundation for this policy recommendation? I suggest trying customary international law because it provides the broadest basis in terms of scope and content. Upon closer examination it may already retrieve the best solution. The obligation of a State 'to use all the means at its disposal in order to avoid activities . . . causing significant damage to the environment of another State is core to this analysis.[72] This obligation has two implications.

First, it can be used to reinforce the duties under the climate protection conventions to mitigate climate change by being interpreted as prohibiting a policy approach that relies on the availability of climate engineering as a last resort. In other words, it would prohibit what is called the 'moral hazard' in climate policy – a term that refers to taking the risk that mitigation measures will fail. Trusting in the efficacy of a Plan B, moral hazard reckons with the scenario that Plan A will not be pursued tenaciously and with full resolve. While this attitude largely remains concealed, some have expressed it quite openly. For instance, in June 2008, Newt Gingrich, the former speaker of the United States House of Representatives and then chairman of the political action committee American Solutions offered a strident argument in favour of the use of stratospheric aerosols in a letter distributed in June 2008 to many American households:[73]

> Geoengineering holds forth the promise of addressing global warming concerns for just a few billion dollars a year. Instead of penalizing ordinary Americans, we would have an option to address global warming by rewarding scientific innovation [. . .]. Bring on the American Ingenuity. Stop the green pig.

This position received academic sanction by a group of eminent economists who in the run-up to the Copenhagen conference of parties declared:[74]

> Climate engineering could provide a cheap, effective and rapid response to global warming. Remarkably, research considered by the Expert Panel, written by lead author Dr Eric Bickel, suggests that a total of about $9 billion spent developing marine cloud whitening technology might be able to cancel out this entire century's global warming.

Of course, everybody is free to express such views, but when it comes to policy making the law must be respected. And in my interpretation the law prohibits measures that weaken the implementation of Plan A.

The second implication of the customary prevention rule concerns climate engineering itself. As outlined above, a due diligence requirement applies to prescribe elevated standards in proportion to the potentially enormous damage (including counterproductive and

67 D.G. Victor, 'On the Regulation of Geoengineering', 24:2 *Oxford Review of Economic Policy* (2008), 322, at 331.

68 Knowing that we do not know, as opposed to meta-ignorance – i.e., not knowing that we do not know. See M. Smithson, 'Social Theories of Ignorance', in R.N. Proctor and L. Schiebinger (eds) *Agnotology: The Cultural Production of Ignorance* (Stanford University Press, 2008), at 210.

69 K. Knorr-Cetina, *Epistemic Cultures: How the Sciences Make Knowledge* (Harvard University Press, 1999), 46 *et seq*.

70 J.L. Casti, *Searching for Certainty: What Scientists can Know About the Future* (William Morrow, 1990), 406 *et seq*.

71 This consideration is overlooked by those who argue that a prohibition would be most constraining on those countries who are likely to act the most responsibly. See D.G. Victor, n. 67 above, at 325.

72 See *Pulp Mills on the River Uruguay* case, n. 50 above, paragraph 204.

73 See ETC Group, n. 1 above, at 14.

74 'Top economists recommend climate engineering Copenhagen consensus on climate findings: Expert panel of Nobel laureates outline best and worst responses to global warming', press release (Copenhagen Consensus Centre, 3 September 2009), found at <http://fixtheclimate.com/uploads/tx_templavoila/Press_Release_02.pdf>.

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side effects) caused by the use of SRM. This standard demands that there is sufficient knowledge available to adequately predict the safety of SRM operations. As said, the knowledge cannot be obtained because it is negative knowledge or unavoidable ignorance. This can even be argued without bringing the controversial precautionary principle into play.

In conclusion, the use of SRM techniques such as space reflectors and stratospheric aerosols is not a last resort from the catastrophe, but the catastrophe itself. Once this is acknowledged, the logic of going from Plan A to Plan B is turned upside down: SRM does not supply a viable Plan B. And if a Plan B is not available, we must stick to Plan A of mitigation and adaptation – full stop.

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