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Climate Engineering and International Law: Final Exit or the End of Humanity?*

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Abstract

Climate engineering is increasingly being considered as a climate 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 forbidden from the outset because of unescapable uncertainty regarding its effects.

A. 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 grounds 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 apathy of the 'keep on going' attitude in regard to resource depletion; political and economic interests, who seek the benefit of resource exploitation and the exaggerations of many academics. All of this drives the deep uneasiness that arises from this dispute and makes

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1 See The Royal Society (2009); House of Commons Science and Technology Committee (2010); ETC Group (2010). For an overview of the pros and cons of climate engineering, see Ott (2010). For an analysis of the international law framework see Zedalis (2010); Proelß & Güssow (2011).

the current dialogue strangely assertive.[2] One should be careful not to set aside the natural reaction of astonishment when analysing the issue of climate engineering, because much about the current proposals is madness, although there is a method in it.[3] With this attitude, the kinds and then the law of climate engineering will be examined.

B. *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 seen by the author ordered according to their magnitude.

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	

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

2 On the history of the hubristic climate manipulation see Fleming (2010).
3 A madness though that completely lacks Hamlet's cynicism.

Group, an environmental non-governmental organisation (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.[4]

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

Table 2: Methods of climate engineering and an evaluation of their benefits and expenses.[5]

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 fertilisation	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

4 See ETC Group (2010:18).
5 See The Royal Society (2009:48). 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.

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 as 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 caves on land or the seabed. Bioenergy with CO_2 sequestration (BECS) is a sub-form of CCS at the source. Biochar involves carbonising 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 fertilisation stimulates the growth of marine algae and thus the biological absorption of CO_2 from the atmosphere. Land surface albedo[6] (both urban and desert) can be enhanced by making large urban or land surface areas white to reflect incoming solar radiation. 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 fertilisation and 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 manipulations. However, if used on a large scale, it might be considered as 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.[7] The legal

6 *Albedo* is a measuring unit of a surface's reflectivity.

7 Enhancing the cloud and surface albedo raise additional legal questions that cannot be addressed here.

analysis is based on certain noteworthy characteristics of climate engineering, which are emphasised 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. But 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 the table 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.[8]

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:[9]

> 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.

Climate engineering is also a typical example of an end-of-pipe-strategy, because the emission of greenhouse gases into the atmosphere along with

8 Bengtsson (2006).

9 Robock et al. (2010).

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 minimising their impact by means of SRM.

It is legally very important to know who will initiate climate-engineering measures. Three scenarios must be considered. Firstly, there is the single state unilateral action, with said state only minding its own interests and endangering other states (as well as itself). Secondly, a single state unilateral project could be undertaken for the (supposed) common good while bearing in mind the risks for all. Thirdly, a multilateral project following the foundation of an international organisation 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.

C. 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, e.g., if performed in an area of commons. Regulatory law, on the other hand, may restrict or encourage or even obligate states to 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.

I. Enabling Law

According to customary international law, activities within the stratosphere, such as the introduction of 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[10]

10 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).

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.[11] No state has sovereign rights over outer space.[12] This means that outer space constitutes a common area to humanity whose research and utilisation 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.[13]

While, according to customary law, a state is allowed to enter 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 other state.[14]

The Outer Space Treaty has also regulatory provisions, which will be elaborated upon below.

II. 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.

1. Treaties Applicable to Atmospheric Sulphur and Space Reflectors

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

The 1977 Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD)[15] prohibits the hostile use of environmental modification techniques. *Environmental modification techniques* are defined as –[16]

11 Outer Space Treaty, Article I paragraphs 2 and 3.

12 Outer Space Treaty, Article II.

13 Vereshchetin (2008–:paragraph 15).

14 Fischer (2004); Wolfrum (1987:243).

15 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.

16 (ibid.:Article II).

... 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.

Several examples are provided –[17]

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.

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.[18] However, friendly use must still accord with the generally acknowledged principles and applicable rules of public international law.[19] Furthermore, an exchange of research and development results is provided.[20] According to Article III(2) of ENMOD –

... [t]he 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 important 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.

17 (ibid.:Annex on *Understandings regarding the convention*).

18 In contrast to this Proelß & Güssow (2011:7) seem to opine that the ENMOD Convention is not applicable to peaceful activities.

19 See ENMOD, note 14 above, Understanding Relating to Article III annexed to the convention text.

20 (ibid.:Article III(2), 1st sentence).

b) UNFCCC

An encouragement and perhaps even an obligation to intervene to prevent global warming using climate engineering may be derived from the UN Framework Convention on Climate Change (UNFCCC).[21] 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]

The provision affirms the precautionary principle and construes it as requiring that states take positive measures regarding sources, sinks and reservoirs of greenhouse gases. Article 4(1) (b) and (d) of the UNFCCC further elaborate 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.[22] 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 Article 4(1)(b) and (d), which addresses 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,[23] such that it is directly applicable independent

21 UN Framework Convention on Climate Change, New York, 9 May 1992 (UNFCCC).

22 Zedalis (2010:31) fails to notice this.

23 For the discussion, see Birnie et al. (2009:159f.).

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?[24] 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.

c) Convention on Biological Diversity

The 1992 Convention on Biological Diversity (CBD)[25] 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 preventative 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."[26]

24 Along this line it has been argued that ocean fertilisation is legitimated by the precautionary principle. Güssow et al. (2010:917).
25 Convention on Biological Diversity, Rio de Janeiro, 5 June 1992, (CBD).
26 (ibid.:Article 8).

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 (COP10) in 2010, the parties to the CBD determined –[27]

> … 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*. [emphasis added]

In 2008, the parties at CBD COP9 had determined that ocean fertilisation would not be permitted until "a global, transparent and effective control and regulatory mechanism is in place for these activities."[28] The effect of this declaration was to create an implicit moratorium for ocean fertilisation activities. The resolution agreed at COP10, which also applies to SRM, is less strict, although SRM has a greater potential to cause harm than ocean fertilisation. Nonetheless, the conclusion of COP10 applies the precautionary principle requiring that, before deployment, climate engineering activities must have an adequate scientific basis to justify them. Furthermore, appropriate consideration is needed 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.

d) Convention on Environmental Impact Assessment in a Transboundary Context

The Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention)[29] lays down the obligation on parties to conduct environmental impact assessments (EIA) before certain types of projects are carried out. The contracting parties are also required to ensure the participation of the affected public and notify and consult potentially affected

27 Decision adopted by the Conference of the Parties to the Convention on Biological Diversity at its tenth meeting, UNEP/CBD/COP/DEC/X/33 of 29 October 2010, paragraph 8(w).
28 Decision adopted by the Conference of the Parties to the Convention on Biological Diversity at its ninth meeting, UNEP/CBD/COP/DEC/IX/16, 30 May 2008, paragraph C 4.
29 Convention on Environmental Impact Assessment in a Transboundary Context, Espoo, 25 February 1991, (Espoo Convention).

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."[30]

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.[31]

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.

As a convention of UN Economic Commission for Europe (UNECE), the Espoo Convention only applies to European and North American signatory countries.[32]

2. *Treaties With Specific Application*

a) Atmospheric Sulphur

(1) Convention on Long-Range Transboundary Air Pollution

The contracting parties to the 1979 Convention on Long-Range Transboundary Air Pollution (LRTAP Convention)[33] –

30 (ibid.:Appendix II lit. (b)).
31 (ibid.:Article 2(5) with Appendix III).
32 (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 organisations that were parties to the Convention on 27 February 2001.
33 Convention on Long-Range Transboundary Air Pollution, Geneva, 13 November 1979. Having 51 parties all situated in the North America, Europe and the former Soviet Union, the Convention is a regional one.

> … are determined to limit and, as far as possible, gradually reduce and prevent air pollution including long-range transboundary air pollution.[34]

Air pollution is defined in the convention as –[35]

> … 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.

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. But it presupposes that the deleterious effects of substances or energy are provable.[36] This disqualifies the provision as an appropriate rule on stratospheric sulphur.

The Protocols to the LRTAP Convention on reduction of sulphur emissions are not, however, 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.[37]

(2) Vienna Convention for the Protection of the Ozone Layer

The 1985 Vienna Convention for the Protection of the Ozone Layer (Ozone Convention)[38] states that contracting parties to the Convention –[39]

> … 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.[40] [emphasis added]

34 (ibid.:Article 2).
35 (ibid.:Article 1(a)).
36 See Zedalis (2010:22).
37 See the sixth consideration of the Preamble to the Oslo Protocol to the 1979 Convention on Long-range Transboundary Air Pollution on Further Reduction of Sulphur Emissions, Oslo, 14 June 1994.
38 Vienna Convention for the Protection of the Ozone Layer, Vienna, 22 March 1985. The Convention has 196 parties and is thus of a universal character.
39 (ibid.:Article 1(a)).
40 (ibid.:Article 2(1)).

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, harmonise 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.[41] This means that stratospheric aerosol injection and the resulting condensation of water particles could damage the ozone layer.[42] Such damage to human health or the environment must be prevented. It has been debated whether such damage can be weighed against possible benefits for the climate. However, the Vienna Convention does not contain any indication in that direction.[43]

b) Space Reflectors

(1) The Outer Space Treaty

The Treaty contains certain obligations with regard to the research and use of outer space, the moon and other celestial bodies. According to Article I, –

> ... [t]he 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*.[44] [emphasis added]

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 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.[45] [emphasis added]

41 (ibid.:Annex I, paragraph 4. e. ii).
42 See Zedalis (2010:22).
43 See Proelß & Güssow (2011:30).
44 See Outer Space Treaty, note 9 above, Article I.

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.[46] As a minimum requirement, it can be said that those activities are incompatible with the Treaty, which are not likely to produce any benefit but rather have detrimental effects.

Article IX obligates parties to avoid such exploration and use[47] 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.[48] This would be prohibited if its effects are counterproductive or if it causes adverse changes in the environment of the Earth.

(2) Liability for Damage Caused by Objects Introduced into Outer Space

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 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,[49] which in more precise language

45 (ibid.:Article IX).
46 See Proelß & Güssow (2011:17) for a summary of this debate.
47 The fact that Article IX, 2nd sentence only mentions studies and exploration but not use is generally considered to be an editing mistake. See Proelß & Güssow (2011:19).
48 See Zedalis (2010:24); and Proelß & Güssow (2011:16).
49 Convention on International Liability for Damage Caused by Space Objects, London, Moscow, Washington, 29 March 1972.

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."[50]

Somewhat more preventive is the approach taken by a treaty on space debris that is presently under international discussion. If it materialises 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,[51] 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]

3. *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 *jus cogens* thus setting aside any incompatible conventional rules.

Procedural and substantive rules of customary international law should be distinguished when analysing the legal framework that applies to climate engineering.

a) Procedural Obligations

The acting state's obligation to provide prior notification to affected states and give them an opportunity to comment is a generally agreed procedural

50 (ibid.:Article II). In addition, Article III establishes (fault) liability for damage to space objects or persons and property on board of space objects.

51 Articles 3(2) and 8 of the draft. See Williams (2008:94f.).

requirement of customary international law. If there is available information about the risks of an activity, it must be shared.[52]

There is also an obligation to carry out a prior EIA. Previously, this obligation was only mandatory for projects covered by the regional Espoo Convention. Since then, the International Court of Justice (ICJ) has recognised 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:[53]

> … 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. [emphasis added]

Although the ICJ's decision in *Pulp Mills* leaves much of the scope and content of an EIA to be defined by states, it outlines four basic requirements about what is necessary in such instances: (i) the EIA should be adequate to the size, type and effects of the project; (ii) it must be prepared with due diligence; (iii) it must include an assessment of alternatives; and (iv) it must be carried out prior to the realisation of the project.[54] 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.

b) Substantive Obligations

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:[55]

> 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 See Birnie et al. (2009:177).

53 ICJ 20 April 2010, *Pulp Mills on the River Uruguay* (*Argentina v Uruguay*), Number 204.

54 (ibid.:Numbers 205, 210). The participation of the general public is not *per se* viewed by the court as customary law (Number 216).

55 (ibid.:Number 101).

While the ICJ derived from this obligation the procedural duty to inform the affected states prior to taking certain actions,[56] it did not need to specify the substantive content of the obligation as a general customary rule, because precise substantive obligations were defined in a bilateral treaty between the opposing parties in that case.

There is general agreement among scholars and a growing practice in international treaties that states are required to prevent damage also 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 been widely 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 case law 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.

III. 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

56 (ibid.:Number 102).
57 Birnie et al. (2009:145).
58 *Trail Smelter Arbitration* 16 April 1938 (*United States v Canada*), RIAA III, 1938, 1965.
59 See Birnie et al. (2009:141); and Handl (2007:545).
60 See Handl (2007:545).

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, namely –[61]

- 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; and
- a situation where the state has not itself contributed to the state of emergency.

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. Owing to their financial, scientific and technological capabilities, it would be industrialised states that deploy climate engineering projects. Yet the industrialised states are unquestionably the ones that caused the state of climate emergency in the first place.

Notwithstanding this, climate engineering could also be construed 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 *Gabĉikovo-Nagymaros* case, the ICJ considered whether the illegitimate

61 ICJ, judgment of 25 September 1997, *Gabcikovo Nagymaros Hungary v Slovakia*, (1997) ICJ Reports 7, paragraphs 51, 52. The court followed the provisions of Article 33 of the Draft Articles on the International Responsibility of States by the International Law Commission (ILC), Yearbook of the International Law Commission, 2001, Vol. II, Part Two.

branching off of the Danube waters by Slovakia could be considered a legitimate countermeasure against Hungary, which unilaterally pulled out of the joint Danube canalisation project. The ICJ established four conditions to be met for the countermeasure to be legitimate:[62]

- 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.

However, of these conditions the first two can hardly be met in the present context. The first would require that the opposed action – climate gas emissions – has been performed in violation of international law which is not evident given the elusive language of the UN Framework Convention. The second is impossible to fulfil because the adverse effects of SRM cannot be so controlled that they only affect the opposing states and not any innocent third state.

IV. Summary and Conclusion

The rules of international law applicable to SRM can be summarised as follows:

SRM within a state's atmosphere falls under its sovereignty. SRM in outer space is in principle a free but non-exclusive right of states. Although it is designed to preserve a livable 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 efforts 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 very broadly and others more precisely framed. Some are only regionally, others universally binding. Some are applicable to all climate

62 *Gabcikovo Nagymaros*, paragraphs 83–87.

engineering methods, others only to specific ones. The resulting palette of obligations can be outlined as follows:

- regional obligations (Europe)
  - an EIA is required with a precise content, which includes an assessment of alternatives (Espoo Convention);
  - public participation in the EIA process is mandatory (Espoo Convention);
- 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 sulphur);
  - the ozone layer must be protected (Ozone Convention; concerning stratospheric sulphur);
- 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 to other states and common areas must be prevented (customary rule);
  - 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 concept of an EIA as required by universal customary law 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 customary duty to prevent damage which traditionally presupposes firm knowledge about risks has been amplified to a due diligence rule whose content is however not yet clear; the customary duty to compensate for damage is likewise still opaque only physical damage from space objects being clearly covered.

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 stabilisation may also serve the protection of the environment. Attempts to interpret the existing rules such that they allow for a weighing of environmental and climate concerns have so far not been successful because the relevant texts do not allow for that. An alternative and more general approach suggesting the weighing of environmental protection conventions against the UNFCCC[63] does not work in regard to SRM because the UNFCCC neither mandates nor encourages this technology.

D. Reform Considerations

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

I. Minor Changes to Existing Rules Plus Additional Commitments

This appears 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-

63 See Proelß & Güssow (2011:70f.).

European states to the Convention. Its list of projects requiring EIA may be extended to SRM research and deployment. The US, 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 COP10 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 of becoming 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 of this 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:[65]

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

64 See Executive Order No. 12114 of 04 January 1979. Environmental Effects Abroad of Major Federal Actions, Numbers 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."

65 ASOC (2010).

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 policymakers; 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 (Recommendation 1) does not explain what kinds of research would meet the standard and what others not. While administrative oversight is accepted (Recommendation 2), the question of liability of researchers for damages is not elaborated on. A concrete requirement of open and timely publication of research and development results has not been guaranteed (Recommendation 3), so that new knowledge can be kept secret, for example, for patenting purposes. The requirement to conduct a prior EIA is also not included (Recommendation 4). One positive aspect is that the need for public participation is emphasised (Recommendation 5). 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 organisations in enforcing them.

II. A New Regime

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 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*.[66] 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 state as follows:

66 Rayner et al. (2009). The principles were largely endorsed by the Committee, see (ibid.:29).

> 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 trans-boundary 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]

A step by step principle should be added to this list. This principle was introduced by the regulation of genetic engineering as a means of coping with uncertainty about effects of the release into the environment of genetically modified organisms.[67] The principle suggests that the containment of tests

67 See Directive 2001/18/EC Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms (OJ L 106, 17.4.2001, p. 1), consideration No 24:

can be reduced and the scale of tests in the environment increased step by step, but only if the knowledge gathered at earlier steps indicates that the next step can be taken.

If these recommendations are to be fully implemented, an international convention is needed with about the following contents:

- The stabilisation of the climate for global common welfare as its objective
- The classification of all climate engineering methods covered by the convention
- The prohibition of certain methods of climate engineering
- A requirement of prior authorisation by the responsible state or by an international authority to be set up based on the United Nations[68]
- A step by step requirement that allows for scaling up of tests only if sufficient knowledge about perfomeance and risks has been generated at previous steps
- Procedures addressing:
  - 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
  - Public ability to submit comments on the project and its impact; and
  - Prior consent requirements regarding all of the affected States
- Criteria regarding the conditions of climate engineering activities such as:
  - 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)

The introduction of GMOs into the environment should be carried out according to the 'step by step' principle. This means that the containment of GMOs is reduced and the scale of release increased gradually, step by step, but only if evaluation of the earlier steps in terms of protection of human health and the environment indicates that the next step can be taken.

68 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 (2010:paragraph 100).

  - Lack of alternatives, including mitigation and adaptation measures (regarding research projects, gaps in the current state of knowledge must be shown)
  - Minimisation of health, environmental and welfare harm caused by the activities; or
  - weighing of adverse side effects up against proven beneficial climate effects (or scientific advances in case of SRM research projects);
- 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
- The establishment of a conflict resolution mechanism under the convention
- The enshrinement of 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:[69]

> 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 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.

E. *A Radical Option*

However, even if it were possible to establish, such an instrument would not be likely to 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 of uncertainty can be reduced by

69 Victor (2008:331).

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[70], negative knowledge[71] and non-computability[72], which means it is possible to know that certain issues cannot be known.

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.[73]

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 offer 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.[74]

It is still open for discussion which precise rules of due diligence are implied in the formula *to use all the means at its disposal* and whether a certain activity must itself be regarded as prohibited if it cannot be conducted in a way that minimises harmful effects.[75] 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 –[76]

> ... activities 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.

Considering the potentially enormous damage (including counterproductive and side effects) caused by the use of SRM "a much higher standard of care" appears to be imperative. This standard at least 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 conscious ignorance. This can even be argued without bringing the controversial precautionary principle into play.[77] Regarding the question whether the due diligence rule is one of conduct or effect it appears to be logical that it must be one of effect, at least in a situation where prevention is still possible. It cannot be that a state which evidently does not apply the required standard of care should nevertheless be allowed to commit the careless act. In conclusion, therefore, it is submitted that SRM at grand scale is prohibited by international customary law.

The due diligence rule has still another implication relevant in this context. 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 US House of Representatives and then chairman of the political action com-

70 *Knowing that we don't know* as opposed to meta-ignorance, i.e. *not knowing that we don't know*. See Smithson (2008:210).

71 Knorr-Cetina (1999:46f.).

72 Casti (1990:406f.).

73 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 Victor (2008:325).

74 See *Pulp Mills on the River Uruguay Case*, n. 51 above, Number 204.

75 See further on these questions Birnie et al. (2009:147et seq.); Handl (2007:532 et seq.).

76 *ILC Commentary (11) to Article 3 of Draft Articles on Prevention of Transboundary Harm from Hazardous Activities* (ILC 2001), available at http://untreaty.un.org/ilc/texts/instruments/english/commentaries/9_7_2001.pdf, last accessed 05 May 2013.

77 Note that in German police law, way before the invention of the precautionary principle, it was common ground that if a very serious damage is possible a remote likelihood (entfernte Möglichkeit) is sufficient to justify preventive measures (e.g. BVerwG DÖV 1970, 714 concerning the placing of a fuel oil tank close to wells and springs).

mittee 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:[78]

> 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:[79]

> 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 this author's interpretation the law prohibits measures that weaken the implementation of Plan A.

In conclusion, the use of SRM techniques such as space reflectors and stratospheric aerosols is not a last exit out of 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.

References

ASOC/Asilomar Scientific Organizing Committee, 2010, The Asilomar Conference Recommendations on Principles for Research into Climate Engineering Techniques, Washington D.C., Climate Institute, available at http://climateresponsefund.org/images/Conference/finalfinalreport.pdf, last accessed 05 May 2013.

Bengtsson, Lennart, 2006, Geoengineering to Confine Climate Change: Is it at all Feasible?, *Climatic Change* 77 (3–4), 229–234.

Birnie, Patricia, Alan Boyle & Catherine Redgwell, 2009, *International Law and the Environment* (Third Edition), Oxford, Oxford University Press.

78 See ETC Group (2010:14).

79 Copenhagen Consensus Center (2009).

Casti, John L., 1990, Searching for Certainty. What Scientists Can Know About the Future, New York, William Morrow and Company.

Copenhagen Consensus Center, 2009, Press Statement: Top Economists Recommend Climate Engineering Copenhagen Consensus on Climate Findings: Expert Panel of Nobel Laureates Outline Best and Worst Responses to Global Warming, Copenhagen Consensus Center, 3 September 2009, available at http://fixtheclimate.com/uploads/tx_templavoila/Press_Release_02.pdf, last accessed 05 May 2013.

ETC Group, 2010, *Geopiracy: The Case against Geoengineering,* Ottawa, ETC Group, available at https://www.cbd.int/doc/emerging-issues/etcgroup-geopiracy-2011-013-en.pdf, last accessed 04 May 2013.

Fischer, Horst, 2004, Weltraumrecht, in: Ipsen, Knut, Volker Epping, Horst Fischer, Wolff Heintschel von Heinegg, Christian Gloria, Hans-Joachim Heintze & Eberhard Menzel, *Völkerrecht* (Fifth Edition), München, Verlag C. H. Beck, 934–972.

Fleming, James R., 2010, *Hubris, climate engineering and climate control. Fixing the Sky: The Checkered History of Weather and Climate Control* New York, Columbia University Press.

Güssow, Kerstin, Alexander Proelss, Andreas Oschlies, Katrin Rehdanz & Wilfried Rickels, 2010, Ocean Iron Fertilization: Why Further Research is Needed, *Marine Policy* 34 (5), 911–918.

Handl, Günther, 2007, Transboundary Impacts, in: Bodansky, Daniel, Jutta Brunnée & Ellen Hey (Eds), *International Environmental Law,* Oxford, Oxford University Press, 531–549.

House of Commons Science and Technology Committee (Ed.), 2010, *The Regulation of Geoengineering*, Fifth Report of Session 2009–10, London, HM Stationery Office Ltd, available at http://www.publications.parliament.uk/pa/cm200910/cmselect/cmsctech/221/221.pdf, last accessed 05 May 2013.

Knorr-Cetina, Karin, 1999, *Epistemic Cultures: How the Sciences make Knowledge,* Cambridge, MA, Harvard University Press.

Ott, Konrad, 2010, Argumente für und wider "Climate Engineering." Versuch einer Kartierung, *Technikfolgenabschätzung – Theorie und Praxis* 19 (2), 32–43.

Proelß, Alexander & Kerstin Güssow, 2011, *Climate Engineering: Instrumente und Institutionen des internationalen Rechts,* Berlin, Bundesministerium für Bildung und Forschung, available at http://www.geoengineering-2012.de/climate-engineering-instrumente-und-institutionen-des-internationalen-rechts/, last accessed 05 May 2013.

Rayner, Steve, Catherine Redgwell, Julian Savulescu, Nick Pidgeon, & Tim Kruger, 2009, Memorandum on Draft Principles for the Conduct of Geoengineering Research, Memorandum to the House of Commons Science and Technology Committee, Enquiry into the Regulation of Geoengineering, available at http://www.sbs.ox.ac.uk/research/sts/Documents/regulation-of-geoengineering.pdf, last accessed 05 May 2013.

Robock, Alan, Martin Bunzl, Ben Kravitz, Georgiy L. Stenchikov, 2010, A Test for Geoengineering?, *Science* 327, 530–531, available at http://www.sec.ed.ac.uk/~shs/Climate%20change/Geo-politics/Robock%20A%20Test%20for%20Geoengineering%20Science.pdf, last accessed 05 May 2013.

Smithson, Mike, 2008, Social Theories of Ignorance, in: Proctor, Robert N. & Londa Schliebinger (Eds), *Agnotology: The Cultural Production of Ignorance*, Stanford, Stanford University Press, 209–229.

The Royal Society (Ed.), 2009, *Geoengineering the Climate: Science, Governance and Uncertainty*, London, The Royal Society, available at http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2009/8693.pdf, last accessed 05 May 2013.

Vereshchetin, Vladlen S., 2008–, Outer Space, in: in: Wolfrum, Rüdiger (Ed.), *Max Planck Encyclopedia of Public International Law*, Oxford, Oxford University Press, online edition available at http://www.mpepil.com, last accessed 30 April 2013.

Victor, David G., 2008, On the Regulation of Geoengineering, *Oxford Review of Economic Policy* 24 (2), 322–336.

Williams, Maureen, 2008, Safeguarding Outer Space: On The Road To Debris Mitigation, in: *Security in Space: The Next Generation*, Conference Report, 31 March–1 April 2008, Geneva, United Nations Institute for Disarmament Research (UNIDIR), 81–102, available at http://www.unidir.org/files/publications/pdfs/security-in-space-the-next-generation-conference-report-31-march-1-april-2008-342.pdf, last accessed 05 May 2013.

Wolfrum, Rüdger, 1987, Rechtliche Ordnung des Weltraums, in: Kaiser, Karl & Stephan von Welck (Eds), *Weltraum und internationale Politik,* München, R. Oldenbourg Verlag, 241–252.

Zedalis, Rex J., 2010, 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, *European Energy and Environmental Law* 19 (1), 18–32.

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Climate Change: International Law and Global Governance

Volume I: Legal Responses and Global Responsibility

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