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Climate Engineering Field Research: The Favorable Setting of International Environmental Law

Jesse Reynolds
Tilburg Law School

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Climate Engineering Field Research: The Favorable Setting of International Environmental Law

Jesse Reynolds*

Abstract

As forecasts for climate change and its impacts have become more dire, climate engineering proposals have come under increasing consideration and are presently moving toward field trials. This article examines the relevant international environmental law, distinguishing between climate engineering research and deployment. It also emphasizes the climate change context of these proposals and the enabling function of law. Extant international environmental law generally favors such field tests, in large part because, even though field trials may present uncertain risks to humans and the environment, climate engineering may reduce the greater risks of climate change. Notably, this favorable legal setting is present in those multilateral environmental agreements whose subject matter is closest to climate engineering. This favorable legal setting is also, in part, due to several relevant multilateral environmental agreements that encourage scientific research and technological development, along with the fact that climate engineering research is consistent with principles of international environmental law. Existing international law, however, imposes some procedural duties on States who are responsible for climate engineering field research as well as a handful of particular prohibitions and constraints.

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* Ph.D. candidate, Department of International and European Public Law, Tilburg Law School, and Researcher, Tilburg Sustainability Center, Tilburg University, The Netherlands.

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I. Introduction

Efforts thus far to reduce the risks from anthropogenic climate change have been disappointing. In response, some scientists are investigating intentional, large-scale interventions in global chemical, physical, and biological systems in order to reduce climate risks.¹ These proposed “climate engineering” or “geoengineering” methods are controversial, in part, because some of them pose risks of their own to humans and the environment.² International environmental law plays an important role in any discussion of climate engineering because some

1. See generally INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS (June 7, 2013) [hereinafter IPCC, PHYSICAL SCIENCE], available at <http://www.climatechange2013.org/report/> (examining the potential of climate engineering as potential additional responses to climate change).

2. See *id.* at § TS.5.6 (discussing the risks associated with climate engineering and carbon dioxide reduction).

climate engineering techniques may cause trans-boundary damage or damage in areas beyond state jurisdiction.³

This article examines how existing international environmental law may regulate and influence field testing of climate engineering. In its examination, this article (1) distinguishes between climate engineering field research and deployment, focusing on the former due to its urgency; (2) considers climate engineering proposals in the context of climate change; and (3) emphasizes the enabling function of law.

Some multilateral environmental agreements (MEAs) suggest that States seeking to protect the environment should balance the risks associated with climate engineering field tests with the reduction of climate change risks. Typically, this balance favors climate engineering field research. Although none of the MEAs address climate engineering directly, it is notable that those whose content is the closest to addressing climate engineering are among those that encourage its research. A second reason for this favorable legal setting is that many MEAs call upon States to engage in scientific research and technological development. Finally, climate engineering research is consistent with principles of international environmental law such as precaution, polluter pays, and common but differentiated responsibilities. Concurrently, existing laws impose a number of procedural duties, and they constrain or prohibit specific actions.

Part II of this article describes climate change and climate engineering along with some of the associated risks. Part III frames the discussion by considering several relevant legal topics. The subsequent three Parts examine binding MEAs, nonbinding MEAs, and customary international law, respectively. In the final Part, I conclude that the current international framework is favorable to future climate engineering research, although, there are a handful of unresolved issues.

II. Climate Change and Climate Engineering

Climate change is among the greatest challenges facing society today.⁴ Humans are increasing the atmospheric concentrations of so-called greenhouse gases—especially carbon dioxide—which let light in but

3. *See id.* (noting that in order for climate engineering methods to be effective, they need to be implemented on a large scale in order for the techniques to be effective).

4. *See* Ban Ki-moon, Sec'y-Gen., United Nations, Remarks at the Thirty-ninth Plenary Assembly of the World Federation of United Nations Associations (Aug. 10, 2009), available at http://www.un.org/apps/news/infocus/sgspeeches/statments_full.asp?statID=555 (“[Climate change] is, simply, the greatest collective challenge we face as a human family.”) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

obstruct the escape of heat.⁵ Although most of these gases occur naturally, activities such as fossil fuel combustion and land use changes result in emission rates that are higher than their natural removal rate, leading to their accumulation in the Earth's atmosphere.⁶ As the forecasts for climate change and its effects have become direr, a wider spectrum of responses has been considered. Initially, international responses focused on the abatement of greenhouse gas emissions.⁷ The leading vehicle for global cooperative abatement, the Kyoto Protocol to the United Nations Framework Convention on Climate Change, however, may not have actually reduced emissions.⁸ There are several additional reasons for pessimism looking forward. First, fossil fuel combustion is essential to economic activity, and its reduction carries large costs.⁹ Moreover, most current emissions are, and most future emissions will be, produced by developing countries that understandably insist on economic development and improvements in living conditions.¹⁰ Second, because the negative effects of greenhouse gases will occur decades after they are emitted and independently from their location, their abatement presents an enormous global and intergenerational collective action problem.¹¹ In any international abatement agreement, each country is asked to undertake costly actions to prevent damage that will occur mostly in distant locations and in the future.¹² Such steps are politically unpopular and it is tempting to free-ride

5. See IPCC, PHYSICAL SCIENCE, *supra* note 1, § 1.2.2 (describing the effects created by certain gases and stating that “[h]umans enhance the greenhouse effect directly by emitting greenhouse gases”).

6. See *id.* § TS.3.2 (“Human activity leads to change in the atmosphere composition either directly (via emissions of gases or particles) or indirectly (via atmospheric chemistry).”).

7. See E. Lisa F. Schipper, *Conceptual History of Adaptation in the UNFCCC Process*, 15 REV. EUR. COMMUNITY & INT’L ENVTL. L. 82, 82–83 (describing the focus on emission reductions in early international climate negotiations).

8. See Quirin Schiermeier, *Hot Air*, 491 NATURE 656, 656 (2012) (stating that most Kyoto targets were met only due to economic downturns in Eastern Europe in the 1990s and worldwide in the late 2000s, and were more than offset by emission increases in countries without commitments under the Kyoto Protocol).

9. See WILLIAM D. NORDHAUS, A QUESTION OF BALANCE: WEIGHING THE OPTIONS ON GLOBAL WARMING POLICIES 82 (2008) (estimating that both climate damage and emissions abatement costs are on the order of trillions to tens of trillions of dollars).

10. See INTERNATIONAL ENERGY AGENCY, WORLD ENERGY OUTLOOK 2013 § 2 (Nov. 12, 2013) (looking at global trends in energy usage through 2035).

11. See IPCC, PHYSICAL SCIENCE, *supra* note 1, § 12.5.2 (describing how the Earth’s surface temperatures lag behind changes in greenhouse gas concentrations).

12. See David G. Victor, *On the Regulation of Geoengineering*, 24 OXFORD REV. ECON. POL’Y 322, 324 (2008) (“With today’s technologies, achieving a deep cut in emissions will require costly investment for uncertain benefits that accrue mainly in the distant future—attributes that tend not to be rewarding for politicians.”); see also

or to defect from these agreements.¹³ Third, because excess carbon dioxide naturally leaves the atmosphere slowly, emission reductions would merely delay a given amount of climate change.¹⁴ Therefore, avoiding dangerous climate change requires radical changes in energy systems and net negative emissions.¹⁵

The second international response to the problem of climate change has been adaptation to the changing climate conditions.¹⁶ Adaptation was initially decried as “a kind of laziness, an arrogant faith in our ability to react in time to save our skin,” but is now considered another legitimate response.¹⁷ The capacity for adaptation is also limited.¹⁸ It is more urgent in

NORDHAUS, *supra* note 9, at 4–6 (describing the impact that climate change will have across the globe).

13. See *Twelve Years of the Public's Top Priorities*, THE PEW RESEARCH CENTER FOR THE PEOPLE AND THE PRESS (Jan. 24, 2013), <http://www.people-press.org/interactives/top-priorities/> (demonstrating that the issue of global warming has been at or near the bottom of United States public policy priorities since its inclusion in 2007) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

14. See IPCC, PHYSICAL SCIENCE, *supra* note 1, § 12.5.2 (“[P]ast emissions commit us to persistent warming for hundreds of years . . .”).

15. See Ken Caldeira, *Climate Sensitivity Uncertainty and the Need for Energy Without CO₂ Emission*, 299 SCIENCE 2052, 2053 (2003) (“To achieve stabilization at a 2°C warming, we would need to install ~900 ± 500 [megawatts] of carbon emissions-free power generating capacity each day over the next 50 years. This is roughly the equivalent of a large carbon emissions-free power plant becoming functional somewhere in the world every day.”); IPCC, PHYSICAL SCIENCE, *supra* note 1, § SPM E.1, 12.3.1.3 (describing how the only Representative Concentration Pathway scenario considered by the IPCC under which global surface temperature change is likely remain below two degrees Celsius—an internationally agreed-upon target—through the end of the century is RCP2.6, which assumes net negative emissions).

16. See INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: IMPACTS, ADAPTATION AND VULNERABILITY, FINAL DRAFTS (ACCEPTED) § 14.1 (Oct. 28, 2013) [hereinafter IPCC, IMPACTS], available at <http://ipcc-wg2.gov/AR5/report/final-drafts/> (“Human and natural systems have a capacity to cope with adverse circumstances, but with continuing climate change, adaptation will be needed to maintain this capacity.”); *Adaptation Overview*, ENVTL. PROT. AGENCY, <http://www.epa.gov/climatechange/impacts-adaptation/adapt-overview.html> (last visited Jan. 13, 2014) (“‘Adaptation’ refers to efforts by society or ecosystems to prepare for or adjust to future climate change.”) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

17. See AL GORE, EARTH IN THE BALANCE: ECOLOGY AND THE HUMAN SPIRIT 240 (1993) (“Believing that we can adapt to just about anything is ultimately a kind of laziness, an arrogant faith in our ability to react in time to save our skin.”); Schipper, *supra* note 7, at 91 (“Since 2002, a complementary approach between adaptation and mitigation has gained support, with the acknowledgement that adaptation and mitigation are not alternatives . . .”).

18. See IPCC, IMPACTS, *supra* note 16, § 16.4 (noting that, beyond a certain point, adaptive efforts fail to provide “an acceptable level of security from risks”).

developing countries, which are more vulnerable to climate change due to their geographies and economies.¹⁹

Industrialized countries are expected to finance adaption in poorer countries, as industrialized countries have historically dominated cumulative emissions.²⁰ Climate adaptation, however, can be difficult to distinguish from traditional development projects.²¹ Industrialized countries can simply reclassify traditional development aid, and developing countries can simply reclassify traditional development projects as climate adaptation financing.²² Adaptation financing appears to be inadequate, although it is increasing.²³

Climate engineering is presently emerging as a third potential set of responses to climate change.²⁴ There are numerous proposed climate engineering methods which vary widely in their means, goals, speeds, costs, risks, capacities, and potential effectiveness.²⁵ They are divided into two distinct categories. The first is carbon dioxide removal (CDR), increasingly called “negative emissions technologies,” in which intentional, large-scale

19. See *id.* at § SPM (citing particular vulnerabilities in developing countries to flooding, economic losses from disasters, negative human health effects, displacement, and increased poverty).

20. See, e.g., United Nations Framework Convention on Climate Change art. 1, para. 1, *opened for signature* May 9, 1992, S. Treaty Doc. No. 102-38, 1771 U.N.T.S. 171 [hereinafter UNFCCC] (discussing the responsibilities of developed countries under the UNFCCC).

21. See IPCC, IMPACTS, *supra* note 16, § 14.5 (“[Experts] have found it difficult to clearly define and identify precisely what constitutes adaptation, how to track its implementation and effectiveness, and how to distinguish it from effective development.”).

22. See, e.g., BLOOMBERG NEW ENERGY FINANCE, HAVE DEVELOPED NATIONS BROKEN THEIR PROMISE ON \$30BN ‘FAST-START’ FINANCE? (Victoria Cuming ed., 2011), *available at* <http://about.bnef.com/white-papers/have-developed-nations-broken-their-promise-on-30bn-fast-start-finance/> (observing that “only a small proportion of the promised funds [from developed countries] are ‘new and additional,’ with the rest diverted from other aid budgets”) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

23. See IPCC, IMPACTS, *supra* note 16, § 17 (“Global adaptation cost estimates are substantially greater than current adaptation funding and investment, particularly in developing countries, suggesting a funding gap and a growing adaptation deficit.”).

24. See Christopher W. Belter & Dian J. Seidel, *A Bibliometric Analysis of Climate Engineering Research*, 4 WILEY INTERDISC. REV. CLIMATE CHANGE 417, 417 (2013) (“The past five years have seen a dramatic increase in the number of media and scientific publications on the topic of climate engineering, or geoengineering, and some scientists are increasingly calling for more research on climate engineering as a possible supplement to climate change mitigation and adaptation strategies.”).

25. See generally JOHN SHEPHERD ET AL., THE ROYAL SOCIETY, GEOENGINEERING THE CLIMATE: SCIENCE, GOVERNANCE AND UNCERTAINTY (2009) (summarizing approaches to climate engineering); GEOENGINEERING RESPONSES TO CLIMATE CHANGE: SELECTED ENTRIES FROM THE ENCYCLOPEDIA OF SUSTAINABILITY SCIENCE AND TECHNOLOGY (Tim Lenton & Naomi Vaughan eds., 2013) (discussing various climate engineering methods).

interventions in earth systems would sequester the most important greenhouse gases.²⁶ Speaking generally and relatively, while these less controversial and risky technologies would address climate change close to its cause, they would be slow and expensive.²⁷ Indeed, most risks of CDR are local and of a character consistent with typical industrial activities, although the environmental impacts could be quite significant if CDR is scaled-up.²⁸ A significant exception to these general CDR characteristics is ocean fertilization.²⁹ This process would accelerate the natural biological carbon “pump,” in which marine phytoplankton indirectly incorporate atmospheric carbon dioxide into their bodies as they grow.³⁰ The phytoplankton then sequester that carbon in the deeper ocean as they die and sink.³¹ Some scientists believe that adding a locally limiting nutrient (usually iron) to an area of the ocean would stimulate the growth of phytoplankton and lead to significant carbon sequestration.³² This method, however, poses risks to marine ecosystems.³³ To date, over a dozen ocean fertilization field trials have produced mixed results.³⁴

26. See IPCC, PHYSICAL SCIENCE, *supra* note 1, Annex III (defining CDR as “a set of techniques that aim to remove CO₂ directly from the atmosphere by either (1) increasing natural sinks for carbon or (2) using chemical engineering to remove the CO₂, with the intent of reducing the atmospheric CO₂ concentration”(emphasis original)).

27. See THE ROYAL SOCIETY, *supra* note 25, at 21 (noting that CDR methods are technically possible and would have environmental impacts commensurate with their scale, carry high costs, and operate slowly).

28. See IPCC, PHYSICAL SCIENCE, *supra* note 1, § 6.5.1 (describing “direct air capture of CO₂ using industrial methods”); *id.* (“[I]t is likely that CDR would have to be deployed at large-scale for at least one century to be able to significantly reduce atmospheric CO₂.”).

29. See *id.* § 6.5.2.2 (noting that ocean fertilization seeks to increase the rate of transfer in the carbon cycle).

30. See THE ROYAL SOCIETY, *supra* note 25, at 16 (“Carbon dioxide is fixed from surface waters by photosynthesisers—mostly, microscopic plants (algae). Some of the carbon they take up sinks below the surface waters in the form of organic matter . . .”).

31. See *id.* at 17 (“The combined effect of photosynthesis in the surface followed by respiration deeper in the water column is to remove CO₂ from the surface and re-release it at depth. This ‘biological pump’ exerts an important control on the CO₂ concentration of surface water, which in turn strongly influences the concentration in the atmosphere.”).

32. See *id.* (“Methods [of fertilization] have been proposed to add otherwise limiting nutrients to the surface waters, and so promote algal growth, and enhance the biological pump.”).

33. See Phillip Williamson et al., *Ocean Fertilization for Geoengineering: A Review of Effectiveness, Environmental Impacts and Emerging Governance*, 90 PROCESS SAFETY AND ENVTL. PROT. 475, § 5 (2012) (“A range of unintended and mostly undesirable impacts of large-scale fertilization . . . include production of climate-relevant gases . . . ; effects on productivity; . . . and effects on seafloor ecosystem[s].”).

34. See SECRETARIAT OF THE CONVENTION ON BIOLOGICAL DIVERSITY, CONVENTION ON BIOLOGICAL DIVERSITY, TECHNICAL SERIES NO. 45: SCIENTIFIC SYNTHESIS OF THE IMPACTS OF OCEAN FERTILIZATION ON MARINE BIODIVERSITY 52 tbl.1 (2009) (summarizing field trials).

The other category of climate engineering is solar radiation management (SRM), which attempts to increase the portion of the incoming sunlight that is reflected, counterbalancing the warming component of climate change.³⁵ In general, and relative to CDR, SRM would be fast and inexpensive, but would address only a symptom of climate change, create substantial risks, and is controversial.³⁶ Three proposed methods stand out as potentially effective, but are potentially risky. First, under stratospheric aerosol injection (SAI), small particles would be introduced into the upper atmosphere, mimicking the cooling effect that is observed after large volcanic eruptions or—at lower atmospheric altitudes—in cities with air pollution.³⁷ Under the second method, marine cloud brightening (MCB), ocean water would be sprayed into the air.³⁸ The salt dust, which would remain after the droplets evaporate, would act as cloud condensation nuclei, in turn causing clouds to be more reflective.³⁹ The third method would place objects, such as mirrors or dust, in space.⁴⁰ These proposed SRM methods pose uncertain risks to the environment and humans. For example, SRM would unequally counteract the temperature and precipitation perturbations due to climate change.⁴¹ The result could be reduced precipitation in some areas.⁴² Furthermore, sunlight reaching the ground would be more diffuse while carbon dioxide concentrations remain elevated, increasing plant primary productivity and altering ecosystems.⁴³ The leading candidate for stratospheric injection, sulfur dioxide, may

35. See IPCC, PHYSICAL SCIENCE, *supra* note 1, Annex III (defining SRM as “the intentional modification of the Earth’s shortwave radiative budget with the aim to reduce climate change according to a given metric” (emphasis original)).

36. See *id.* § 7.7 (discussing the consequences of SRM techniques).

37. See THE ROYAL SOCIETY, *supra* note 25, at 29 (“Simulating the effect of large volcanic eruptions on global climate has been the subject of proposals for climate geoengineering for some time These proposals aim to artificially increase sulphate aerosols in the stratosphere . . . thereby reducing the incoming solar radiation.”).

38. See *id.* at 27 (describing the process by which the salt from ocean water would be used to increase the number of cloud-condensation nuclei.).

39. See *id.* (“It is readily demonstrated that many small cloud micro droplets scatter and so reflect more of the incident light than a smaller quantity of larger droplets of the same total mass since the surface area of the small droplets is greater.”).

40. See *id.* at 32 (“Space-based methods propose to reduce the amount of solar energy reaching Earth by positioning sun-shields in space to reflect or deflect the solar radiation.”).

41. See Simone Tilmes et al., *The Hydrological Impact of Geoengineering in the Geoengineering Model Intercomparison Project (GeoMIP)*, 118 J. GEOPHYSICAL RESEARCH: ATMOSPHERES 11036, 11053 (2013) (describing the uneven effects of SRM on temperature and precipitation).

42. See *id.* (“[T]he hydrological cycle would be perceptibly weakened by SRM . . .”).

43. See J. Pongratz et al., *Crop Yields in a Geoengineered Climate*, 2 NATURE CLIMATIC CHANGE 101, 101 (2012) (“We find that in our models solar-radiation geoengineering in a high-CO₂ climate generally causes crop yields to increase, largely because temperature stresses are diminished . . .”).

damage the ozone layer.⁴⁴ Finally, if large-scale SRM were to stop suddenly, then climate change—most of which would have been suppressed by SRM—would accelerate, potentially causing more damage than if it had occurred over decades.⁴⁵ SRM techniques, however, are attractive due to their ability to strongly and rapidly affect a large area at little cost.⁴⁶ Because of SRM’s attractiveness, risks, and potential low barriers to entry, world leaders would need to address decision-making, unilateralism, control, and conflict.⁴⁷

There are some risks that would be prevalent in both climate engineering categories. For example, many commentators express concern that discussion of or research into climate engineering would reduce incentives and political willpower toward the preferred paths of emissions reductions and adaptation.⁴⁸ Others cite the potential development of vested interests and technological momentum, which could influence future policy.⁴⁹

Although most of the public and academic climate engineering discourse has focused on possible deployment, field research is more urgent.⁵⁰ Logically—and hopefully—testing will occur before any deployment. Indeed, climate engineering research budgets are increasing and some projects now include field work.⁵¹ Early SRM field experiments

44. See P. Heckendorn et al., *The Impact of Geoengineering Aerosols on Stratospheric Temperature and Ozone*, 4 ENVTL. RESEARCH LETTERS 1, 11 (2009) (linking proposed sulfur stratospheric aerosol injection with likely ozone depletion).

45. See IPCC, PHYSICAL SCIENCE, *supra* note 1, at 7-5 (“Additionally, scaling SRM to substantial levels would carry the risk that if the SRM were terminated for any reason, there is *high confidence* that surface temperatures would increase rapidly . . . which would stress systems sensitive to the rate of climate change.”).

46. See THE ROYAL SOCIETY, *supra* note 25, at 34 (“It is likely that once a SRM method is implemented the climate system would respond quite quickly with surface temperatures . . .”).

47. See, e.g., David G. Victor, *On the Regulation of Geoengineering*, 24 OXFORD REV. ECON. POL’Y 322, 333 (2008) (“Growing attention to geoengineering will create pressure for regulation.”).

48. See Albert Lin, *Does Geoengineering Present a Moral Hazard?*, 40 ECOLOGY L.Q. 673, 674 (2013) (“Among the leading reasons for the geoengineering taboo was the worry that geoengineering endeavors would undermine mainstream efforts to combat climate change.”).

49. See, e.g., Dale Jamieson, *Ethics and Intentional Climate Change*, 33 CLIMATIC CHANGE 323, 333 (1996) (“[R]esearching a technology risks inappropriately developing it A research program often creates a community of researchers that functions as an interest group promoting the development of the technology that they are investigating.”).

50. See Jesse Reynolds, *The Regulation of Climate Engineering*, 3 L. INNOVATION & TECH. 113, 126 (2011) (arguing that climate change field research should generally be considered distinct from deployment and that regulation of the former is more urgent).

51. See, e.g., *Research to Evaluate Climate Engineering: Risks, Challenges, and Opportunities?*, DEUTSCHE FORSCHUNGSGEMEINSCHAFT (May 27, 2013, 16:39),

are examining natural, analogous phenomena and are also testing equipment.⁵² At some point in the progression of this research, scientists will desire to study the effectiveness and side effects of various SRM methods.⁵³ It may be advantageous for scientists to begin SRM field tests relatively soon, because field tests with longer durations would require less forceful climatic interventions in order to detect a significant signal among the noise of weather.⁵⁴ If the experiments are significant enough to alter the climate, then there is the potential for them to pose some associated risk.⁵⁵ Not all climate engineering field research, however, will pose environmental risks.⁵⁶ This paper specifically addresses field tests of the riskier methods, such as ocean fertilization, SAI, and MCB, which are designed to sequester a significant amount of carbon or to alter a regional climate significantly.

III. Legal Aspects

Before moving into this paper's core, which examines existing international environmental law, several germane legal matters must be

<http://www.spp-climate-engineering.de/news-single/items/287.html> (announcing a new program from the German Science Foundation that aims "to reduce the large uncertainties in our current understanding of the impact of [climate engineering] on the planet") (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT); Daniel Cressey, *Cancelled Project Spurs Debate over Geoengineering Patents*, 485 NATURE 429 (2012) (describing a planned field test of stratospheric injection equipment).

52. See, e.g., Yu. A. Izrael et al., *Field Studies of a Geo-engineering Method of Maintaining a Modern Climate with Aerosol Particles*, 34 RUSSIAN METEOROLOGY & HYDROLOGY 635 (2009) (reporting the results of field experiments "studying the solar radiation transmission in the visible wavelength range with model aerosol media formed in the middle troposphere with the help of high-efficient standard aerosol generators aboard the helicopter"); Henry Fountain, *Trial Balloon: A Tiny Geoengineering Experiment* GREEN: ENERGY, THE ENV'T AND THE BOTTOM LINE (Jul. 17, 2012, 2:17 PM), <http://green.blogs.nytimes.com/2012/07/17/trial-balloon-a-tiny-geoengineering-experiment/> (reporting on plans for a possible field trial in the United States) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

53. See David Keith et al., *Research on Global Sun Block Needed Now*, 463 NATURE 426, 427 (2010) (arguing for field studies of SRM climate engineering).

54. See Douglas G. MacMynowski et al., *Can We Test Geoengineering?*, 4 ENERGY ENVTL. SCI. 5044, 5044 (2011) (quantifying "the trade-offs between duration and intensity of the test and its [sic] ability to make quantitative measurements of the climate's response to SRM forcing").

55. See Alan Robock et al., *Studying Geoengineering with Natural and Anthropogenic Analogs*, 121 CLIMATIC CHANGE 445, 446 (2013) (noting that "even small-scale experiments outside a laboratory environment could carry some risk").

56. See Edward A. Parson & David W. Keith, *End the Deadlock on Governance of Geoengineering Research*, 339 SCIENCE 1278, 1279 ("[M]uch promising process research has trivial environmental impact, smaller than common commercial activities . . .").

briefly addressed. First, when a powerful new technology—particularly if it poses risks to humans and the environment—is proposed or introduced, it is important to determine the ways in which existing law prohibits, permits, or encourages its use.⁵⁷ There are no MEAs and almost no international law, broadly defined, that directly address climate engineering.⁵⁸ Several MEAs and aspects of customary international law, however, are important both in a narrow sense of their specific application, and more generally—and probably more importantly—when discussing the legal environment into which any climate engineering research or techniques would be introduced.⁵⁹ Using a framework for regulation put forth by Roger Brownsword,⁶⁰ I conclude that generally, extant law *channels* positively, in that it encourages climate engineering research, and that it has a positive regulatory *tilt*, in that gaps or ambiguities in the law will more often be resolved as permissive.⁶¹ It is in this sense that I assert that international environmental law is favorable to climate engineering research.

The second matter is that, throughout these discussions, there is often tension between the potential for climate engineering research to reduce climate risks to humans and the environment, and its own potential to cause harm.⁶² For shorthand, I refer to this as the “climate change/climate engineering tension.” Although balancing such potential benefits and risks is generally not a means of interpreting international law, in the case of climate engineering, it is the logical way to proceed.⁶³ I argue below that existing international environmental law is best interpreted as being

57. See Roger Brownsword & Han Somsen, *Law, Innovation and Technology: Before We Fast Forward, A Forum for Debate*, 1 L. INNOVATION & TECH. 1 (2009) (describing the importance of the regulatory environment for a new technology).

58. See Karen N. Scott, *International Law in the Anthropocene: Responding to the Geoengineering Challenge*, 34 MICH. J. INT'L L. 309, 330 (2013) (“With the exception of reforestation and afforestation and ocean fertilization for scientific research purposes there are few legal instruments explicitly applicable to geoengineering.”).

59. See *infra* Parts IV–VI (discussing binding and nonbinding MEAs, as well as customary international law).

60. ROGER BROWNSWORD, *RIGHTS, REGULATION, AND THE TECHNOLOGICAL REVOLUTION* (2008).

61. See *id.* at 19–21 (presenting an analytical framework to examine regulations and describe their relationship with policy goals, wherein a regulatory “tilt” is a default position of regulators that can be interpreted despite ambiguities in existing regulation).

62. See Scott, *supra* note 58, at 313 (“[G]eoengineering creates a clear risk of serious harm to the transboundary and global environment; it utilizes common spaces such as the high seas, atmosphere, or outer space; and it has yet to be addressed . . . in any regulatory forum.”).

63. See *id.* at 330 (explaining the need to analyze international environmental law as it pertains to climate engineering using aggregate principles developed from various sources of law).

favorable toward climate engineering research.⁶⁴ Even in the case of deployment, scientists' current understanding is that the expected negative side effects of climate engineering would be much less severe than climate change alone.⁶⁵ Given this understanding, carefully conducted field research—although it may present risks of its own to humans and the environment—would help us understand the extent to which climate engineering may be a beneficial option.⁶⁶ Field research may be particularly valuable if climate change is more severe than expected, if damages from climate change are greater than expected, if we are unable to adapt society and the environment, or if future emissions reductions are significantly suboptimal.⁶⁷ Furthermore, recall that “almost all justifications for international environmental protection are predominantly and in some sense anthropocentric.”⁶⁸ The norms, rights, and obligations of international environmental law reveal that, for the most part, States are committed to the protection of humans and the environments that we value.⁶⁹ Unsurprisingly, economic considerations are dominant, and even non-economic considerations, such as cultural and aesthetic benefits, are valued through a human perspective.⁷⁰

64. See *infra* Parts IV–VI (arguing that climate engineering research is permissible under current international environmental law).

65. See IPCC, PHYSICAL SCIENCE, *supra* note 1, at 7-5 (“Models consistently suggest that SRM would generally reduce climate differences compared to a world with elevated greenhouse gas concentrations and no SRM . . .”); see also Juan B. Moreno-Cruz et al., *A Simple Model to Account for Regional Inequalities in the Effectiveness of Solar Radiation Management*, 110 CLIMATIC CHANGE 649, 649 (2012) (“We find that an SRM scheme optimized to restore population-weighted temperature changes to their baseline compensates for 99% of these changes while an SRM scheme . . . compensates for 97% of these changes. Hence, while inequalities in the effectiveness of SRM are important, they may not be as severe as . . . assumed.”).

66. See BIPARTISAN POLICY CENTER’S TASK FORCE ON CLIMATE REMEDIATION, GEOENGINEERING: A NATIONAL STRATEGIC PLAN FOR RESEARCH ON THE POTENTIAL EFFECTIVENESS, FEASIBILITY, AND CONSEQUENCES OF CLIMATE REMEDIATION TECHNOLOGIES 3 (2011) (advocating for climate engineering research “to be able to judge whether particular climate remediation techniques could offer a meaningful response to the risks of climate change”).

67. See generally Juan B. Moreno-Cruz & David W. Keith, *Climate Policy Under Uncertainty: A Case for Solar Geoengineering*, 121 CLIMATIC CHANGE 431 (2012) (modeling the benefits of climate engineering research based on the uncertain amount of climate change for a given increase in greenhouse gas concentrations).

68. PATRICIA W. BIRNIE ET AL., INTERNATIONAL LAW AND THE ENVIRONMENT 7 (2009).

69. See *id.* at 7–8 (discussing the anthropocentric orientation of international environmental law).

70. See Scott, *supra* note 58, at 357 (“The integration of human and nature that characterizes the Anthropocene has implicitly been recognized by the application of the core principles of international environmental law to all activities likely to have a significant impact on the environment . . .”).

This climate change/climate engineering tension is particularly relevant because greenhouse gases and climate change often meet the definitions of “pollution” or “adverse effects,” which the MEAs examined below seek to reduce.⁷¹ Whether greenhouse gases, which harm humans and the environment only indirectly, should be considered to be pollution is not immediately obvious, and has been examined surprisingly little. Several authors have concluded that greenhouse gases do indeed meet the criteria for “pollution of the marine environment”⁷² under the UN Convention on the Law of the Sea (UNCLOS),⁷³ and nearly identical definitions are used in the Convention on Long-Range Transboundary Air Pollution (LRTAP Convention)⁷⁴ and the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR).⁷⁵ Furthermore, there is an emerging discourse as to whether States may be responsible and potentially liable for greenhouse gas emissions.⁷⁶ At the domestic level,

71. See UNFCCC, *supra* note 20, art. 1, para. 1 (“Adverse effects of climate change’ means changes in the physical environment or biota resulting from climate change which have significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare.”).

72. See, e.g., Richard S. J. Tol & Roda Verheyen, *State Responsibility and Compensation for Climate Change Damages—A Legal and Economic Assessment*, 32 ENERGY POL’Y 1109, 1117 (2004) (concluding that greenhouse gases meet the UNCLOS definition of pollution of the marine environment); Meinhard Doelle, *Climate Change and the Use of the Dispute Settlement Regime of the Law of the Sea Convention*, 37 OCEAN DEV. INT’L L. 319, 322 (2006) (“[I]t would seem that human-induced GHG emissions fit within the definition of marine pollution in UNCLOS . . .”).

73. United Nations Convention on the Law of the Sea, art. 1.1.4, Dec. 10, 1982, 1833 U.N.T.S. 3 [hereinafter UNCLOS] (“[P]ollution of the marine environment means the introduction by man . . . of substances or energy into the marine environment . . . which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities . . .”).

74. Convention on Long-Range Transboundary Air Pollution art. 1, Nov. 13, 1979, 1302 U.N.T.S. 219 [hereinafter LRTAP Convention] (“Air pollution means the introduction . . . 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 impair or interfere with amenities and other legitimate uses of the environment . . .”); see also PHILIPPE SANDS & JACQUELINE PEEL, *PRINCIPLES OF INTERNATIONAL ENVIRONMENTAL LAW* 247 (3d ed. 2012) (“The definition of ‘air pollution’ is broad enough to include atmospheric emissions of greenhouse gases and ozone-depleting substances as ‘air pollutants’ . . .”).

75. Convention for the Protection of the Marine Environment of the North-East Atlantic, art. 1(d), Sept. 22, 1992, 2354 U.N.T.S. 67 [hereinafter OSPAR Convention] (“‘Pollution’ means the introduction by man, directly or indirectly, of substances or energy into the maritime area which results, or is likely to result, in hazards to human health, harm to living resources and marine ecosystems, damage to amenities or interference with other legitimate uses of the sea.”).

76. See CLIMATE CHANGE LIABILITY 9 (Michael Faure & Marjan Peeters eds., 2011) (addressing “the question to what extent actions taken, mostly by public authorities, based on the precautionary principle could specifically lead to liability”); see generally CLIMATE

whether greenhouse gases are “air pollutants” under the Clean Air Act (CAA) was central to a U.S. Supreme Court case, which ruled that the Environmental Protection Agency (EPA) has the authority to regulate greenhouse gases.⁷⁷ Vague terms in various MEAs may also raise the climate change/climate engineering tension. Specifically, climate change may satisfy the mostly undefined terms such as “damage” or “adverse effects” found in the Vienna Convention for the Protection of the Ozone Layer,⁷⁸ the Antarctic Treaty System’s Madrid Protocol,⁷⁹ and the Convention on Biological Diversity (CBD).⁸⁰ Similarly, commitments to protect the environment often imply that States should consider innovative actions such as climate engineering in order to do so.⁸¹

The third matter is that the legal implications for research are different from those of deployment. Scientific research is encouraged by

CHANGE LIABILITY: TRANSNATIONAL LAW AND PRACTICE (Richard Lord et al. eds., 2011) (discussing liability for state action or inaction as it pertains to addressing the effects of climate change).

77. See *Massachusetts v. Envtl. Prot. Agency*, 549 U.S. 497, 534 (2007) (concluding that under the Clean Air Act, the EPA has the power to regulate carbon emissions from motor vehicles as air pollutant agents that contribute to climate change).

78. Vienna Convention for the Protection of the Ozone Layer, art. 1.2, *opened for signature* Mar. 22, 1985, 1513 U.N.T.S. 293 [hereinafter Vienna Convention] (“Adverse effects’ means changes in the physical environment or biota, including changes in climate, which have significant deleterious effects on human health or on the composition, resilience and productivity of natural land managed ecosystems, or on materials useful to mankind.”).

79. Protocol on Environmental Protection to the Antarctic Treaty, art. 3.2, Oct. 4, 1991, 30 I.L.M. 1461 [hereinafter Madrid Protocol] (prohibiting “activities that result in adverse effects on climate or weather patterns, significant adverse effects on air or water quality, significant changes in the atmospheric, terrestrial (including aquatic), glacial or marine environments, and further jeopardy to endangered or threatened species or populations of such species”).

80. Convention on Biological Diversity, arts. 7(c), 8, *opened for signature* June 5, 1992, 1760 U.N.T.S. 79 [hereinafter CBD] (“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.”).

81. See Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques, art. III.2, Dec. 10, 1976, 1108 U.N.T.S. 151 [hereinafter ENMOD] (“The State 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.”); see also Declaration of the United Nations Conference on the Human Environment, para. 7, June 16, 1972, 11 I.L.M. 1416 [hereinafter Stockholm Declaration] (“Man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being, and he bears a solemn responsibility to protect and improve the environment for present and future generations.”).

numerous multilateral agreements, environmental and non-environmental.⁸² These regulations are dominated by guidelines and other forms of soft law, frequently developed by expert, non-state bodies.⁸³ Some scholars assert that there is a right to conduct research, although even this would be limited by risks to others and the environment.⁸⁴ Some treaties, such as those concerning potential weapons of mass destruction, do not directly address research but implicate it in their implementation.⁸⁵ Research is referenced only in passing in other agreements, such as the International Convention for the Regulation of Whaling,⁸⁶ but has become a central issue in the implementation of these treaties.⁸⁷ Among the MEAs examined here, only UNCLOS and the Madrid Protocol contain detailed provisions governing scientific research.⁸⁸

In the case of climate engineering, the differences between research and its deployment are due to the smaller scale of research, the lower state of knowledge present during research, the generation of knowledge, and

82. See *infra* text accompanying notes 125–126 (UNFCCC), 170, 176 (Vienna Convention), 146–147 (ENMOD), 183 (LRTAP Convention), 198 (Oslo Protocol), 210 (Outer Space Treaty), 241–244 (UNCLOS), 293–300 (Antarctica Treaty), 318 (OSPAR Convention), 367 (Stockholm Declaration), 374 (Rio Declaration).

83. See, e.g., *Ethical Principles for Medical Research Involving Human Subjects*, WORLD MED. ASS'N, <http://www.wma.net/en/30publications/10policies/b3/> (last visited Mar. 22, 2014) (providing ethical guidelines for medical practitioners and researchers when using human subjects in research and testing) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

84. See Arjun Appadurai, *The Right to Research*, 4 GLOBAL SOC. EDUC. 167, 168 (2006) (arguing that there is a universal and fundamental right for all humans to research and gather knowledge); see also Mark Brown & David Guston, *Science, Democracy, and the Right to Research*, 15 SCI. ENG. ETHICS 351, 359 (2009) (“Non-scientists are also more likely to accept the notion of a right to do research if it is explicitly coupled with an acknowledgement that the preservation of this right depends on scientists fulfilling its corresponding obligations.”).

85. See, e.g., Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction, Apr. 10, 1972, 26, U.S.T. 583, 1015 U.N.T.S. 163 (outlining the policies and procedures necessary for any country wishing to develop, produce, or stockpile weapons of mass destruction).

86. See International Convention for the Regulation of Whaling, art. VIII, Dec. 2, 1946, 161 U.N.T.S. 72 (“[A]ny contracting government may grant to any of its nationals a special permit authorizing that national to kill, take and treat whales for purposes of scientific research subject to such restrictions as to number and subject to such other conditions as the Contracting Government thinks fit.”).

87. See, e.g., *id.* (regulating whaling).

88. See UNCLOS, *supra* note 73, art. 87, ¶¶ 238–65 (establishing the freedom to conduct scientific research in the high seas so long as the interests of other States are considered before research begins); Antarctic Treaty, pmbl, art. I-III, IX, Dec. 1, 1959, 204 U.N.T.S. 71 (establishing the use of Antarctica for, *inter alia*, scientific purposes).

(possibly) the intent.⁸⁹ Regarding scale, field tests will generally be designed to impact a smaller region at a lesser intensity for a shorter duration than full deployment, and any resulting damage to humans or the environment should likewise be lesser, perhaps not meeting the threshold for the applicable law.⁹⁰ With respect to the state of knowledge during research, the risks posed by field tests may remain uncertain at the time they are carried out.⁹¹ The then-current state of knowledge will consequently be germane to whether a given test would be considered likely to harm humans or the environment. Furthermore, the tests are intended to generate knowledge through scientific research, which is encouraged by some of the MEAs discussed below. Finally, although the intent of scientists could potentially help distinguish between field research and deployment, it will be of little significance because international environmental law is rarely concerned with intent.⁹²

As an extension of the research-deployment distinction, the category of “risky climate engineering field research” will not always be discrete in two dimensions of comparison. “Vertically” it may be difficult to distinguish those tests that pose no real risk from those which do, as well as distinguishing large-scale field research from actual deployment.⁹³

89. See generally David R. Morrow et al., *Toward Ethical Norms and Institutions for Climate Engineering Research*, 4 ENVTL. RESEARCH LETTERS 045106 (2009) (distinguishing climate engineering research from climate engineering deployment based on environmental impacts, timeline, and “the intentions of those carrying out the [climate engineering] activity”).

90. See Parson & Keith, *supra* note 56, at 1279 (discussing the limited scale of research).

91. See MacMynowski et al., *supra* note 54, at 5044 (estimating the intensity of SRM required in a large-scale field test and the possible resulting changes in precipitation).

92. See Morrow, et. al., *supra* note 89, at 045106 (“Thus, the difference between CE research and CE practice lies in the intentions of those carrying out the CE activity.”). At least in the case of CDR, there may be a distinction between research and deployment based on whether there is an intent to gain financial benefit. Indeed, the nascent international regulatory framework for ocean fertilization requires that “legitimate scientific research” have no direct financial benefits for the researcher. See *infra* Part IV.H (describing the LC-LP’s prohibition against ocean dumping and its exception for “legitimate scientific research”). Similarly, a recent field experiment explicitly examined marine cloud formation and climate in general, but had clear implications for MCB SRM. See generally Lynn M. Russell et al., *Eastern Pacific Emitted Aerosol Cloud Experiment*, 94 BULL. AM. METEOROLOGICAL SOC’Y 709 (2013) (describing aerosol effects on warm-cloud microphysics).

93. See Alan Robock et al., *A Test for Geoengineering?*, 327 SCIENCE 530, 530 (2012) (“We argue that geoengineering cannot be tested without full-scale implementation.”); but see MacMynowski et al., *supra* note 54, at 5045 (“[O]ur results demonstrate that useful knowledge can be obtained without full-scale implementation.”).

“Laterally,” it may be difficult to distinguish outdoor research from similar topics that resemble—but are not—climate engineering.⁹⁴

The fourth legal matter is the function of law. Regulation in general can be called “the sustained and focused attempt to alter the behavior of others according to defined standards or purposes with the intention of producing a broadly defined outcome or outcomes.”⁹⁵ Thus, regulation can both encourage and discourage certain actions.⁹⁶ Indeed, law has enablement and facilitation among its functions, and has obligations, incentives, and exhortations among its tools.⁹⁷ Yet, regulation is too often framed as being only restrictive.⁹⁸

Fifth, it is with respect to these previous three aspects—the climate change/climate engineering tension, the differences between research and deployment, and the enabling function of law—that the existing legal literature concerning climate engineering, although enlightening, remains limited. A number of scholars have reviewed how international law may restrict a State’s deployment of climate engineering.⁹⁹ These scholars

94. See Morrow, et. al., *supra* note 89, at 045106 (“[T]he technologies developed or made possible through . . . research may be deployed in ways intended to cause harm. We can foresee some of these ways, but not all.”). For example, a “rogue” researcher claimed that his ocean fertilization was to increase the stock of salmon, which feed on phytoplankton. This may have allowed him to comply with the letter, but not the spirit, of international law. See Neil Craik et al., *Regulating Geoengineering Research through Domestic Environmental Protection Frameworks: Reflections on the Recent Canadian Ocean Fertilization Case*, CARBON & CLIMATE L. REV. 117, 117–18 (2013) (“The principals involved in the activity characterized it as an ocean ‘restoration’ project However, they also made public statements indicating that they planned to generate revenue.”).

95. Julia Black, *Decentering Regulation: Understanding the Role of Regulation and Self Regulation in a “Post-Regulatory” World*, 54 CURRENT LEGAL PROBLEMS 103, 142 (2001).

96. See ANTHONY OGUS, REGULATION: LEGAL FORM AND ECONOMIC THEORY 1 (1994) (“[T]he state seeks to encourage or direct behaviour which it is assumed would not occur without such intervention.”).

97. See *id.* (addressing how regulation can cause parties to act in certain ways).

98. See, e.g., BLACK’S LAW DICTIONARY 1398 (9th ed. 2009) (defining “regulation” as the “act or process of controlling by rule or restriction”).

99. See, e.g., Daniel Bodansky, *May We Engineer the Climate?*, 33 CLIMATIC CHANGE 309, 310 (1996) (analyzing the legal restrictions on climate engineering); see also Ralph Bodle, *Geoengineering and International Law: The Search for Common Legal Ground*, 46 TULSA L. REV. 305, 308 (2010) (reviewing sources of international law that effect the permissibility of climate engineering); Rex 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 EUR. ENERGY ENVTL. L. REV. 18, 20 (2010) (critiquing the nature of international agreements and the attitude toward climate engineering); Catherine Redgwell, *Geoengineering the Climate: Technological Solutions to Mitigation-Failure or Continuing Carbon Addiction?*, 5 CARBON & CLIMATE L. REV. 178, 181–88 (2011) (describing the limitations imposed by the current legal regime); Gerd Winter, *Climate Engineering and International Law: Last Resort or the End of*

generally overlook the more urgent topic of field research, the fact that international law enables field research, and that the purpose of climate engineering would be to reduce climate change risks.¹⁰⁰

Sixth, not all risks are alike. Specifically, those risks discussed above can be conceptualized on a rough spectrum from environmental to social in character. Changes to precipitation due to SRM and ecological impacts from ocean fertilization are, for the most part, environmental risks.¹⁰¹ Technological momentum and a “slippery slope” from research to deployment are relatively social risks.¹⁰² International environmental law could be an effective set of tools for reducing the former group.¹⁰³ On the other hand, the management of the more social risks will call for a broader set of innovative legal and non-legal means in international, transnational, and national settings, possibly including international environmental law but likely relying more heavily on a plurality of diverse means.¹⁰⁴

As a final note, it must be remembered that international law is not implemented solely through literal readings of treaty texts. Instead, it is self-enforced and enforced internationally through political channels among countries of unequal power, reputation, and interests.¹⁰⁵ An act by a

Humanity?, 20 REV. EUR. COMM. & INT'L ENVTL. L. 277, 279 (2011) (explaining the effects of law on climate engineering activity); David A. Wirth, *Engineering the Climate: Geoengineering as a Challenge to International Governance*, 40 B.C. ENVTL. AFF. L. REV. 413, 421–24 (2013) (describing the limits imposed by the current legal framework on climate engineering proposals); Scott, *supra* note 58 (reviewing possible contradictions in international law presented by climate engineering).

100. See, e.g., Winter, *supra* note 99, at 288 (concluding normatively that “large-scale research of SRM must be prohibited from the outset”).

101. See Press Release, European Geosciences Union, *Geoengineering Could Disrupt Rainfall Patterns* (June 6, 2012), available at <http://www.egu.eu/news/4/geoengineering-could-disrupt-rainfall-patterns/> (“Under the scenario studied, rainfall strongly decreases Overall, global rainfall is reduced by about five percent on average in all four models studied.”) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

102. See SOLAR RADIATION MANAGEMENT GOVERNANCE INITIATIVE, *SOLAR RADIATION MANAGEMENT: THE GOVERNANCE OF RESEARCH* 21 (2011), available at <http://www.srmgi.org/report/> (“Even very basic . . . research into SRM could be a first step onto a ‘slippery slope’ towards deployment. Research could create momentum for development of SRM technology, as well as . . . lobbying . . . [which] could use its influence to override moral and other objections or to unduly influence public opinion.”) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

103. See *id.* at 35 (describing international environmental instruments and institutions as a method of governance).

104. See, e.g., *id.* at 35–37 (listing additional forms of governance, including “a collection of independent national policies” and “a non-governmental, transnational code of conduct”).

105. See Richard H. Steinberg, *Wanted: Dead or Alive—Realist Approaches To International Law*, in *INTERDISCIPLINARY PERSPECTIVES ON INTERNATIONAL LAW AND INTERNATIONAL RELATIONS: THE STATE OF THE ART* 146, 150 (Jeffrey L. Dunoff & Mark A.

responsible member of the international community, which technically is contrary to an MEA but which other members view favorably, is unlikely to be condemned.¹⁰⁶ Likewise, a willful act by a so-called rogue state which violates no international law, but may have negative impacts on other countries, will be condemned.¹⁰⁷ Although this article uses a rather literal reading, this is intended as a starting point and will not necessarily perfectly reflect reality.

IV. Binding Multilateral Environmental Agreements

Binding MEAs constitute the most important source of international environmental law. This section reviews those MEAs that will likely have the most impact on climate engineering field research. For the sake of brevity and focus, this review is limited in three ways: to agreements concerned with environmental protection (even though other domains such as human rights may be relevant); to those agreements that are pertinent to climate engineering research; and to global agreements or MEAs that cover a large geographical areas. Although no MEAs directly address climate engineering, their objectives, commitments, and hortatory statements both reflect and influence state behavior, illuminating the norms of the international community.¹⁰⁸ This review will require an exercise in treaty interpretation.¹⁰⁹ Of course, MEAs are not merely isolated collections of

Pollack eds., 2013) (arguing that “international law reflects the interests of powerful states” and that “if an international law contradicts the long-term interests of a powerful state, then it will not comply with it”).

106. See, e.g., INDEPENDENT INTERNATIONAL KOSOVO COMMISSION, THE KOSOVO REPORT 186 (2000) (“The Commission concludes that the NATO military intervention was illegal but legitimate.”) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

107. See Anthony C. Arend, *International Law and Rogue States: The Failure of the Charter Framework*, 36 NEW ENG. L. REV. 735, 735–36 (discussing the ramifications of a rogue State’s actions that do not violate international law but are still disapproved of by the international community); Daniel H. Joyner, *Iran’s Nuclear Program and International Law*, 2 PENN. ST. J.L. & INT’L AFF. 237 (2013) (arguing that Iran’s nuclear program complies with international law, despite condemnation by Western countries and the International Atomic Energy Agency).

108. See David G. Victor, *Enforcing International Environmental Law: Implications for an Effective Global Warming Regime*, 10 DUKE ENVTL. L. & POL’Y F. 147, 151 (Fall 1999) (“More than 140 multilateral environmental agreements govern behavior related to dozens of international environmental issues. . . . [D]espite the rarity of enforcement mechanisms, generally countries have complied with their international environmental commitments.”).

109. See Vienna Convention on the Law of Treaties, arts. 31–33, *opened for signature* May 23, 1969, 1155 U.N.T.S. 331 (providing that a treaty is to be interpreted in good faith, within its legal context, and in a manner consistent with its objectives; that words are to be

words. Although intergovernmental and national institutions that operate in a complex political reality implement them, this paper emphasizes the actual texts of these documents.

A. United Nations Framework Convention on Climate Change

The UN Framework Convention on Climate Change (UNFCCC) is the most important document in international environmental law regarding climate engineering because of its subject matter, its global participation, and its robust institutional support.¹¹⁰ Its objective is not merely to prevent dangerous climate change, but to do so in a manner that is balanced with other anthropocentric and environmental desiderata:

The ultimate objective . . . is . . . stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.¹¹¹

Likewise, the key phrase “adverse effects of climate change” encompasses harm both to the environment and “the operation of socio-economic systems or . . . human health and welfare.”¹¹² Similarly, the UNFCCC’s first principle indicates that a chief reason to minimize climate change is anthropocentric: “The Parties should protect the climate system for the benefit of present and future generations of humankind.”¹¹³ This MEA does not limit states’ actions in meeting its objectives to its commitments, implying that states may do so by other means.¹¹⁴

understood in their ordinary meaning; and that ambiguities may be clarified through preparatory documents and “the circumstances of its conclusion”).

110. See Lakshman Guruswamy, *Energy Justice and Sustainable Development*, 21 COLO. J. INT’L ENVTL. L. & POL’Y 231, 233–34 n.5 (2010) (discussing the wide acceptance of the UNFCCC based on its ratification by 194 States).

111. UNFCCC, *supra* note 20, art. 2.

112. *Id.* art. 1.1.

113. *Id.* art. 3.1.

114. See *id.* art. 4.2(a) (“Each of these Parties shall adopt national policies and take corresponding measures These Parties may implement such policies and measures jointly with other Parties and may assist other Parties in contributing to the achievement of the objective of the Convention . . .”).

At a minimum, the UNFCCC supports research into CDR, including ocean fertilization. In its text, Parties commit to stabilize greenhouse gases through both the reduction of emissions and the enhancement of sinks and reservoirs, which is defined to include oceans and the biological pump.¹¹⁵ Three separate commitments obligate Parties to mitigate the adverse effects of climate change through such sinks and reservoirs.¹¹⁶ Two of these commitments include the enhancement of sinks and reservoirs, and one explicitly refers to oceans: “All Parties . . . shall . . . promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including . . . oceans as well as other . . . marine ecosystems.”¹¹⁷ These goals are furthered by the agreement’s Kyoto Protocol, which, although focused on emission reduction, commits Parties to further the Protocol’s objectives by researching and promoting “carbon dioxide sequestration technologies and . . . advanced and innovative environmentally sound technologies.”¹¹⁸

The UNFCCC is less clear with respect to the development of SRM, which would not further the agreement’s objective of stabilizing greenhouse gas concentrations.¹¹⁹ Two general conclusions of scientific research must be highlighted before examining specific provisions. First, humans will soon be, or perhaps already are, committed to a magnitude of future climate change that is “dangerous” because it will threaten

115. See *id.* arts. 1.7, 1.8, 4.1, 4.2. (defining a reservoir as “a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored” and a sink as “any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere”).

116. See *id.* arts. 4.1(b), 4.1(d), 4.2(a) (setting out the different obligations of parties to mitigate adverse climate change).

117. *Id.* arts. 4.1(d), 4.2(a).

118. Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 11, 1997, 2303 U.N.T.S. 148, art. 2.1(a)(iv); see also *id.* art. 10(c) (requiring Parties to “[c]ooperate in the promotion of effective modalities for the development, application and diffusion of, and take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies, know-how, practices and processes pertinent to climate change, in particular to developing countries, including the formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain and the creation of an enabling environment for the private sector, to promote and enhance the transfer of, and access to, environmentally sound technologies”).

119. See UNFCCC, *supra* note 20, art. 2 (“The ultimate objective of this Convention . . . is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.”); THE ROYAL SOCIETY, *supra* note 25, at 24 (“While SRM methods might therefore help to mitigate against a rise in global mean surface temperature, they do nothing directly to reduce atmospheric concentrations of CO₂, or the rate at which they are increasing.”).

ecosystems, food production, and sustainable economic development.¹²⁰ Second, current models indicate that potential SAI or MCB deployment would be rapid and relatively inexpensive.¹²¹

Several passages in the UNFCCC indicate a relatively favorable position regarding SRM research. As quoted above, the UNFCCC's objective calls for some urgency, given the expected onset of significant climate change.¹²² Furthermore, another principle of the UNFCCC states that "[t]he Parties should . . . tak[e] into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost."¹²³ Similarly, a more strongly-worded commitment states that Parties "shall . . . employ appropriate methods . . . with a view to minimizing adverse effects on the economy, on public health and on the quality of the environment, of projects or measures undertaken by them to mitigate or adapt to climate change."¹²⁴ From these provisions, SRM could be understood to be a form of adaptation, albeit an extreme one. Finally, multiple passages call for the development and diffusion of technology and research, further implying a positive stance toward climate engineering research.¹²⁵ For example:

All Parties . . . shall . . . Promote and cooperate in scientific, technological, technical, socio-economic and other research . . . intended to further the understanding and to reduce or eliminate the remaining uncertainties regarding . . . the economic and social consequences of various response strategies; [and] Promote and cooperate in the full, open and prompt exchange of relevant scientific, technological, [and] technical . . . information related

120. See Morrow et al., *supra* note 89, at 045106 ("With regard to the moral hazard, unless scientists take great care in what experiments they do, what they publish, and how they explain their work, the public and policy makers may develop an optimistic bias If this happens, hope for a technological fix for climate change may cripple efforts to limit greenhouse gas emissions.").

121. See THE ROYAL SOCIETY, *supra* note 25, at 24–33 (noting the low estimated costs of several SRM techniques). Estimates for the financial cost of SRM to counterbalance the warming effect of a doubling of atmospheric carbon dioxide range from approximately \$1 billion to \$100 billion per year. See generally Gernot Klepper & Wilfried Rickels, *The Real Economics of Climate Engineering*, ECON. RESEARCH INT'L 316564 (2012) (discussing the financial costs of climate engineering).

122. See *supra* note 111 and accompanying text (stating the objectives of the UNFCCC).

123. UNFCCC, *supra* note 20, art. 3.3.

124. *Id.* art. 4.1(f).

125. See *id.* arts. 4.3, 4.7, 4.8, 4.9, and 11.1 (requiring Parties to develop and diffuse new technologies and to engage in research).

to . . . the economic and social consequences of various response strategies.¹²⁶

The UNFCCC invokes two applicable principles of international environmental law, both of which point favorably to climate engineering research. First, efforts to minimize climate change must be done according to common but differentiated responsibilities.¹²⁷ Climate engineering research is consistent with this, as exclusively industrialized countries presently fund it, which is likely to continue for the foreseeable future.¹²⁸ Meanwhile all countries, especially the less developed ones, which are on average more vulnerable to climate change, could benefit from the increased knowledge of possible alternative responses to climate change.¹²⁹ Second, the UNFCCC invokes the precautionary principle:

126. *Id.* art. 4.1(g) and (h); *see also* arts. 5, 9.2 (stating that the phrase “response strategies” is undefined but presumably could include responses other than those encouraged by the UNFCCC).

127. *See id.* pml. ¶ 6, art. 3.1, 4.1 (discussing action needed to minimize climate change).

128. *See* Andrew Parker & David Keith, *Public Research Funds Committed To Geoengineering Research Projects* (Oct. 31, 2012), http://environment.harvard.edu/sites/default/files/srm_projects_around_the_world.pdf (indicating that climate engineering research projects are publicly-funded in Austria, Finland, France, Germany, Japan, Norway, and the United Kingdom) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

129. *See* UNFCCC, *supra* note 20, pml. (recognizing that developing countries “are particularly vulnerable to the adverse effects of climate change”). This assumes open publications of results and minimal intellectual property claims, which appear to be emerging norms, especially for SRM. *See generally* Michael MacCracken et al., THE ASILOMAR CONFERENCE RECOMMENDATIONS ON PRINCIPLES FOR RESEARCH INTO CLIMATE ENGINEERING TECHNIQUES (2010), *available at* <http://www.climate.org/PDF/AsilomarConferenceReport.pdf> (calling for open and cooperative climate engineering research) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT); BIPARTISAN POLICY CENTER’S TASK FORCE ON CLIMATE REMEDIATION, GEOENGINEERING: A NATIONAL STRATEGIC PLAN FOR RESEARCH ON THE POTENTIAL EFFECTIVENESS, FEASIBILITY, AND CONSEQUENCES OF CLIMATE REMEDIATION TECHNOLOGIES (2011), *available at* <http://bipartisanpolicy.org/library/report/task-force-climate-remediation-research> (advocating open and interdisciplinary research efforts) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT); Steve Rayner et al., *The Oxford Principles*, 121 CLIMATIC CHANGE 499 (2013) (proposing norms for climate engineering and its research, including open publication of results and minimal patents on SRM technologies); *see also* Anne C. Mulkern, *Researcher: Ban Patents on Geoengineering Technology*, CLIMATEWIRE (Apr. 18, 2012), <http://www.scientificamerican.com/article.cfm?id=researcher-ban-patents-on-geoengineering-technology> (quoting a prominent climate engineering researcher calling for no patents on SRM technologies) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

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*, taking into account that policies and measures to deal with climate change *should be cost-effective* so as to ensure global benefits at the lowest possible cost¹³⁰

The drafters of the UNFCCC likely intended that this principle refer to the scientific uncertainty surrounding climate change and its causes. More than twenty years later, however, there is much less uncertainty concerning climate change, yet lingering uncertainty regarding potential responses.¹³¹ As an analogous example, the precautionary principle could encourage hypothetical large multilateral investment in alternative energy research, which is a possible yet scientifically uncertain response. Along similar lines, this passage can also offer a precautionary case for climate engineering research, in which CDR research would be a precautionary measure toward minimizing the causes of climate change, and SRM research would be one toward mitigating its adverse effects.¹³²

The UNFCCC also addresses transboundary environmental harm. In the preamble it notes States' obligations to prevent environmental harm, and the agreement later calls for the minimization of the adverse effects of combating climate change.¹³³ The UNFCCC thus invokes customary international law coupled with a commitment to consider minimizing adverse effects.¹³⁴ States would thus need to undertake certain procedures,

130. UNFCCC, *supra* note 20, art. 3.3 (emphasis added).

131. See IPCC, PHYSICAL SCIENCE, *supra* note 1, § TS.2.1 (discussing advancements in scientists' understanding of the climate change and its causes); Alejandro E. Camacho, *Adapting Governance to Climate Change: Managing Uncertainty Through a Learning Infrastructure*, 59 EMORY L.J. 4, 10 (2009) ("Extensive evidence confirms that global climate change is already occurring Yet the extent of these impending impacts and the exact future distribution of impacts globally and domestically are far from clear.").

132. See generally Jesse L. Reynolds & Floor Fleurke, *Climate Engineering Research: A Precautionary Response to Climate Change?*, 2 CARBON & CLIMATE L. REV. 101 (2013) (arguing that the exercise of precaution, particularly as it is embodied in the UNFCCC, calls for climate engineering research).

133. See UNFCCC, *supra* note 20, pmb. (recalling states' "responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction"); *id.* art. 4.1(f) (requiring States to minimize adverse effects of projects or measures undertaken to mitigate or adapt to climate change).

134. See *id.* art. 3, para. 3 ("The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects.").

including notification, consultation, and cooperation, as well as (arguably) impact assessment and subsequent monitoring prior to large-scale climate engineering field tests that may have transboundary impacts.¹³⁵

One possible obstacle for climate engineering research is the UNFCCC's prioritization of emissions reductions and the enhancement of sinks and reservoirs, processes, which are not affected by SRM.¹³⁶ Although the UNFCCC does necessarily exclude other methods of climate engineering, it could theoretically condemn climate engineering research if it were to undermine the goal of emissions reductions by reducing the political willpower for the reductions.¹³⁷ This interpretation, however, requires both the implausible evidence of the basis of decision-makers' behavior and a radical treaty interpretation wherein a complementary action would be prohibited if it lessened the magnitude of a committed action.¹³⁸

Independent of the UNFCCC's text, its related institutions are the most likely sites for the top-down development of international norms and rules governing climate engineering research.¹³⁹ This is due to the close relevance of the agreement's subject matter, its universal participation, and the bodies created by it, including the Conference of Parties (COP), Secretariat, Subsidiary Body for Scientific and Technological Advice, and—subsequently formed by the COP—the Technology Executive Committee.¹⁴⁰

B. Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques

The Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD) is another highly pertinent MEA, as it is the only binding treaty that directly addresses intentional climatic interventions.¹⁴¹ Most industrialized countries are

135. See *id.* art. 4, paras. 1(e), (g), (h), (i), (j) (summarizing procedural responsibilities of the Parties).

136. See UNFCCC, *supra* note 20, art. 4.1(b) and (d) (prioritizing the use of sinks and reservoirs to reduce greenhouse gases in the atmosphere).

137. See Winter, *supra* note 99, at 288 (arguing that “large-scale research of SRM must be prohibited from the outset” because, *inter alia*, “interpretation the law prohibits measures [i.e. climate engineering] that weaken the implementation of Plan A [i.e. emissions reduction]”).

138. See *id.* (arguing that customary international law prohibits such an interpretation of the UNFCCC).

139. See Bodansky, *supra* note 99, at 313 (“[I]t is likely that the institutions created by the Convention would provide the principal international fora for consideration of climate engineering proposals.”).

140. See *id.* (discussing the relevant international bodies).

141. See ENMOD, *supra* note 81, art. I.1, III.1 (describing the purpose of ENMOD).

Parties to this Convention, but it is considered to be a dormant instrument, with neither supporting institutions nor regular meetings.¹⁴² Even more so than with the UNFCCC, a careful reading of the text reveals a favorable legal setting for climate engineering research. Although the definition of “environmental modification techniques” includes many forms of climate engineering,¹⁴³ ENMOD prohibits only “engag[ing] in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party.”¹⁴⁴ ENMOD does not prohibit the research and development of potentially hostile environmental modification techniques, and it explicitly states that it “shall not hinder the use of environmental modification techniques for peaceful purposes.”¹⁴⁵ Moreover, ENMOD recognizes and encourages peaceful environmental modification: “[Parties] [r]ealiz[e] that the use of environmental modification techniques for peaceful purposes could improve the interrelationship of man and nature and contribute to the preservation and improvement of the environment for the benefit of present and future generations”¹⁴⁶ Parties are to exchange scientific information regarding peaceful environmental modification, and those with the financial means “shall contribute . . . to international economic and scientific co-operation in the preservation, improvement and peaceful utilization of the environment”¹⁴⁷ If “the preservation, improvement and peaceful utilization of the environment” were to include reducing climate change risks, the passage could even be interpreted as an obligation for industrialized Parties to “contribute” to climate engineering research.

If a Party were to assert that another’s climate engineering field research were hostile and damaging, a complaint under ENMOD would be

142. See Arunabha Gosh & Jason Blackstock, *Does Geoengineering Need a Global Response—and of What Kind? International Aspects of SRM Research Governance* (SRMGI, background paper, 2011), available at <http://www.srmgi.org/files/2011/09/SRMGI-International-background-paper.pdf> (“[ENMOD] has had only two review conferences (1984 and 1992) which updated the convention only with non-binding ‘understandings,’ the bulk of its ratifications came in the 1970s and 1980s . . . and attempts by the General Assembly to have it universally ratified have come to naught.”) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

143. See ENMOD, *supra* note 81, art. II (“[T]he term ‘environmental modification techniques’ refers to 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.”).

144. *Id.* art. I.1.

145. *Id.* art. III.1.

146. *Id.* pmb1.

147. *Id.* art. III.2.

difficult to enforce.¹⁴⁸ The damage would need to occur in the environment of the complainant, as ENMOD applies neither to the environments of non-Parties, to that of the country engaged in the activity, nor to that of non-state areas.¹⁴⁹ The document contains only weak enforcement mechanisms.¹⁵⁰ Complaints would be lodged with the UN Security Council, where any of the five permanent members—who are among the States most likely to conduct climate engineering field research—could veto Council action.¹⁵¹ Finally, ENMOD is an inactive legal instrument, and no complaints have ever been lodged under it. Nevertheless, if “awakened” from its dormant state, it is possible that ENMOD could play a role in facilitating climate engineering research.¹⁵² For example, Parties are to consult and cooperate in resolving problems that may arise in the implementation of the agreement.¹⁵³ In addition, its Consultative Committee of Experts could be convened and serve as a forum for the exchange of relevant information and for the development of norms to guide research.¹⁵⁴

C. Convention on Biological Diversity

The Convention on Biological Diversity (CBD) is an MEA whose significance to climate engineering research is not through its text or specific commitments per se, but instead through its nearly universal participation, its strong institutional support, and the fact that most large scale human endeavors affect biodiversity.¹⁵⁵ Its provisions are broad, and

148. See Charles R. Wunsch, *The Environmental Modification Treaty*, 4 ASILS INT'L L.J. 113, 128–29 (1980) (describing key shortcomings in the enforcement mechanism of ENMOD).

149. See *id.* at 128–29 (explaining the reach of ENMOD).

150. See *id.* at 122 (describing the areas critics have frequently cited).

151. See ENMOD, *supra* note 81, art. V (“Any State Party to this Convention which has reason to believe that any other State Party is acting in breach of obligations deriving from the provisions of the Convention may lodge a complaint with the Security Council of the United Nations.”); Wunsch, *supra* note 148, at 129 (“The problem is the Security Council’s action can be vetoed by one of its five permanent members.”).

152. See Wunsch, *supra* note 154, at 131 (outlining the potential positive consequences of ENMOD).

153. See ENMOD, *supra* note 81, art. V.1 (“The State Parties to this Convention undertake to consult one another and to co-operate in solving any problems which may arise in relation to the objectives of, or in the application of the provisions of, the Convention.”).

154. See *id.* art. III.2, V.2 (noting additional means of information dispersement, such as the Consultative Committee of Experts).

155. See CBD, *supra* note 80, art. 4 (describing the expansive jurisdictional scope of the treaty); *List of Parties*, CONVENTION ON BIOLOGICAL DIVERSITY, <http://www.cbd.int/information/parties.shtml> (last visited Mar. 23, 2014) (identifying the

some may apply in the context of climate engineering and its research, such as the call for Parties to identify and to control activities that have “significant adverse impacts” on biodiversity.¹⁵⁶ This presents the climate change/engineering tension, in that both climate change and climate engineering may impact biodiversity. For example, a CBD report concluded that climate engineering “could reduce the magnitude of climate change and its impacts on biodiversity. At the same time, most geoengineering techniques are likely to have unintended impacts on biodiversity.”¹⁵⁷

This connection would have remained somewhat tenuous, had the CBD Conferences of Parties (COP) not addressed climate engineering. At the 2008 COP, Parties urged States to ensure that ocean fertilization CDR not take place until risks and benefits were better understood and regulations were in place, with an exception for “small scale scientific research studies within coastal waters.”¹⁵⁸ Two years later, it agreed upon a broader statement concerning all climate engineering, in which it

[I]nvites Parties and other Governments . . . to consider . . . ensur[ing] . . . in the absence of science based, global, transparent and effective control and regulatory mechanisms for geo-engineering, and in accordance with the precautionary approach and Article 14 of the Convention, that no climate-related geo-engineering activities that may affect biodiversity take place, until there is an adequate scientific basis on which to justify such activities and appropriate consideration of the associated risks for the environment and biodiversity and associated social, economic and cultural impacts, with the exception of small scale scientific research studies that would be conducted in a controlled setting in accordance with Article 3 of the Convention, and only if they are justified by the

Convention’s 193 parties) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

156. See CBD, *supra* note 80, art. 7(c) (“Each Contracting Party shall . . . [i]dentify 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.”).

157. SECRETARIAT OF THE CONVENTION ON BIOLOGICAL DIVERSITY, CONVENTION ON BIOLOGICAL DIVERSITY, TECHNICAL SERIES NO. 66: GEOENGINEERING IN RELATION TO THE CONVENTION ON BIOLOGICAL DIVERSITY: TECHNICAL AND REGULATORY MATTERS 14 (Sept. 2012); see also *id.* at 8 (citing climate change as one of the “current main drivers of biodiversity loss”).

158. Ninth Meeting of the Conference of Parties to the Convention on Biological Diversity, May 19–30, 2008, *Decision IX/16—Biodiversity and Climate Change* 7, U.N. Doc. UNEP/CBD/COP/DEC/IX/16/C.4 (2008).

need to gather specific scientific data and are subject to a thorough prior assessment of the potential impacts on the environment.¹⁵⁹

Although clearly a statement of caution, it is nonbinding for at least three reasons. First, as described above, the CBD's commitments consistently utilize soft, qualified language. For example, the article invoked by the COP climate engineering decision opens with the phrase "as far as possible and as appropriate."¹⁶⁰ Second, the language of this COP decision uses even weaker language, merely "invit[ing]" countries "to consider" action.¹⁶¹ Third, the COP does not have the authority to develop binding law.¹⁶²

D. Vienna Convention for the Protection of the Ozone Layer

The Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer are germane to climate engineering because SAI SRM using sulfur dioxide, presently the most widely considered injection substance, might damage stratospheric ozone.¹⁶³ Presumably, large scale field research into these methods may also have similar effects, and the observation of such impacts could be among the goals of research.¹⁶⁴ The only existing provision contained in these MEAs that may restrict sulfur-based SAI research is that Parties to the Vienna Convention are to implement laws "to control, limit, reduce or prevent human activities . . . [which] have or are likely to have adverse effects resulting from modification or likely modification of the ozone layer[.]" wherein "adverse effects" are environmental changes "including changes in climate, which have significant deleterious effects on

159. Tenth Meeting of the Conference of Parties to the Convention on Biological Diversity, Oct. 18–29, 2010, *Decision X/33—Biodiversity and Climate Change* 5, U.N. Doc. UNEP/CBD/COP/DECX/33/8(w) (2010).

160. CBD, *supra* note 80, art. 14.

161. Tenth Meeting of the Conference of Parties to the Convention on Biological Diversity, *supra* note 159, at 5.

162. See CBD, *supra* note 80, art. 23 (describing the powers of the COP, which can initiate binding protocols and amendments, however, they must be ratified by the Parties).

163. See Vienna Convention, *supra* note 78, art. 2 (outlining the Convention's commitment to protect human health and the environment from the adverse effects of harm to the ozone layer); R.L. McKenzie et al., *Ozone Depletion and Climate Change: Impacts on UV Radiation*, 10 *PHOTOCHEMICAL & PHOTOBIOLOGICAL SCIS.* 182, 189 (2011) ("[T]his geo-engineering strategy would increase Arctic ozone depletion during the 21st century and delay Antarctic ozone recovery by 30 to 70 years.").

164. See THE ROYAL SOCIETY, *supra* note 25, at 31 (arguing that this method's impact on ozone needs to be studied further).

human health” or the environment.¹⁶⁵ This, however probably will not restrict climate engineering field research, largely due to the climate change/climate engineering tension: climate change itself is expected to impact stratospheric ozone in uncertain ways.¹⁶⁶ In contrast, the effect of SAI SRM on stratospheric ozone remains uncertain and may be relatively small.¹⁶⁷ Furthermore, the aerosol particles would partially block incoming ultraviolet radiation, the increase of which—due to ozone depletion—was the original impetus behind the Vienna Convention.¹⁶⁸ Thus, it is presently unclear whether SAI SRM deployment would cause a net increase or decrease in “adverse effects,” but field tests could help resolve this question.¹⁶⁹

Beyond this, the Vienna Convention, as a framework treaty, has limited commitments, such as to cooperate in relevant scientific research.¹⁷⁰ In contrast, the Montreal Protocol contains stronger provisions, using a “black list” of specific prohibited ozone-depleting substances, which can be (and has been) expanded.¹⁷¹ If the Parties to the Montreal Protocol were to consider restricting sulfur dioxide SAI SRM research (or deployment), they would need to take into account both its potential benefits and risks. Moreover, if the Parties wished to restrict sulfur dioxide, they would need to implement a novel category dependent upon the purpose, manner, and/or location of emissions, because much larger amounts of sulfur dioxide are already anthropogenically produced while sulfur-based SAI SRM field research would constitute a relatively small contribution.¹⁷²

165. Vienna Convention, *supra* note 78, art. 1.2, 2.2(b).

166. See McKenzie et al., *supra* note 163, at 188 (“[C]hanges in ozone can induce changes in climate, and vice versa.”).

167. See T.M.L. Wigley, *A Combined Mitigation/Geoengineering Approach to Climate Stabilization*, 314 *SCIENCE* 452, 452 (2006) (explaining that the risk of SAI on stratospheric ozone “is likely to be small”).

168. THE ROYAL SOCIETY, *supra* note 25, at 31 (describing aerosol’s reflective properties).

169. See Wigley, *supra* note 167, at 452 (noting the contradictory and uncertain effects generated from computer models predicting the outcome of SAI SRM deployment).

170. See Vienna Convention, *supra* note 78, art. 2 (outlining the obligations of parties to CPOL).

171. See Montreal Protocol on Substances That Deplete the Ozone Layer art. 2.9, 2.10, Sept. 16, 1987, 1522 U.N.T.S. 3 (prohibiting certain substances due to their effect on stratospheric ozone).

172. See Justin McClellan et al., *Cost Analysis of Stratospheric Albedo Modification Delivery Systems*, 7 *ENVTL. RESEARCH LETTERS* 034019, 1 (2012) (estimating that full SAI SRM implementation would inject one to five teragrams of sulfur per year, which would be spread globally); S.J. Smith et al., *Anthropogenic Sulfur Dioxide Emissions: 1850–2005*, 11 *ATMOSPHERIC CHEMISTRY & PHYSICS* 1101, 1110 (2011) (placing actual global anthropogenic sulfur emissions at approximately fifty-eight teragrams per year, which are concentrated in North America and Europe).

In fact, it is possible to argue that the Vienna Convention favors climate engineering research. As noted above, climate change will impact the ozone layer.¹⁷³ Parties must “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.”¹⁷⁴ Climate engineering has the potential to reduce the adverse effects of climate change and secondarily may be able to reduce harm from stratospheric ozone depletion.¹⁷⁵ Specifically, the Vienna Convention commits Parties to undertake and cooperate in “research and scientific assessment on: The physical and chemical processes that may affect the ozone layer . . . [c]limatic effects deriving from any modifications of the ozone layer . . . [and] [s]ubstances, practices, processes and activities that may affect the ozone layer, and their cumulative effects.”¹⁷⁶ In this context, sulfur dioxide is a substance and SAI SRM climate engineering is an activity that may affect the ozone layer and the climate. If there is a significant probability that SAI SRM might be deployed in the future, then research into the proposed techniques would improve understanding of its potential impact on stratospheric ozone.¹⁷⁷

E. Convention on Long-Range Transboundary Air Pollution

The Convention on Long-Range Transboundary Air Pollution (LRTAP Convention) is a framework agreement, supplemented with protocols, which was developed under the auspices of the UN Economic Commission for Europe (UNECE) in order to reduce acid rain due to transboundary air pollution.¹⁷⁸ With respect to climate engineering in general, the LRTAP Convention encourages research.¹⁷⁹ Notably,

173. See McKenzie, *supra* note 166, at 183 (describing the negative effects that climate change may have).

174. See Vienna Convention, *supra* note 78, art. 2.1 (obligating Parties to actively try and reduce the adverse effects of modifications to stratospheric ozone).

175. See *supra* notes 24–34 and accompanying text (describing the emergence of climate engineering).

176. *Id.* art. 3; see also art. 2.2(a), 4, Annex I (encouraging similar research to better understand the impact that human activities have on the ozone layer).

177. See THE ROYAL SOCIETY, *supra* note 25, at ix (advocating research into “whether low risk methods can be made available if it becomes necessary to reduce the rate of warming this century”).

178. See LRTAP Convention, *supra* note 74, art. 2 (listing the fundamental principles of the LRTAP Convention). The United States, Canada, and the majority of European countries are Parties to the LRTAP Convention. See 1302 U.N.T.S. 217, n.1 (noting which countries have ratified the LRTAP Convention).

179. See *id.* art. 7 (advising parties to the convention to undertake research and development of existing and proposed technologies).

greenhouse gases and global warming likely qualify under the Convention as “long-range transboundary air pollution”:

“Air Pollution” means 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 environment¹⁸⁰

This definition appears to require that “deleterious effects” have already occurred, which is arguably the case with climate change.¹⁸¹ The “long-range transboundary” qualifier adds requirements for transboundary effects and for multiple individual sources that cannot readily be distinguished.¹⁸² Given this, the LRTAP Convention can be seen as encouraging climate engineering research in three ways. First, it commits Parties to conduct and cooperate in research, including in the “economic, social and environmental assessment[s] of alternative measures for attaining environmental objectives including the reduction of long-range transboundary air pollution.”¹⁸³ Climate engineering is an alternative measure for reducing global warming, which would likely be considered a long-range transboundary air pollutant.¹⁸⁴ Second, recalling that SRM is projected to have low financial costs, this technique should fall within the commitment that, “in order to combat air pollution [Parties are] to develop the best policies and strategies . . . in particular by using the best available technology which is economically feasible and low- and non-waste technology.”¹⁸⁵ Third, in its 1994 Oslo Protocol,¹⁸⁶ “precautionary measures” are not only meant to “prevent or minimize emissions of air

180. *Id.* art. 1; *see also* SANDS & PEEL, *supra* note 74, at 247 (discussing this definitional issue).

181. *See* LRTAP Convention, *supra* note 74, art. 5 (“Consultations shall be held . . . between, on the one hand, Contracting Parties which are actually affected by . . . long-range transboundary air pollution and, on the other hand, Contracting Parties within which and subject to whose jurisdiction a significant contribution to long-range transboundary air pollution originates . . .”).

182. *See id.* art. 1 (defining long-range transboundary air pollution).

183. *Id.* art. 7.

184. *See id.* art. 1 (defining “long-range transboundary air pollution” to include effects that “endanger human health, harm living resources and ecosystems”).

185. *Id.*

186. Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Further Reduction of Sulphur Emissions, June 13, 1994, 2030 U.N.T.S. 122 [hereinafter Oslo Protocol].

pollutants” but also to “mitigate their adverse effects” and “should be cost-effective.”¹⁸⁷

Field experiments of sulfur-based SAI SRM present a special case for the LRTAP Convention treaty regime, with the 1985 Helsinki,¹⁸⁸ 1994 Oslo, and 1999 Gothenburg Protocols being applicable.¹⁸⁹ Most importantly, the Gothenburg Protocol contains restrictions regarding “new stationary sources.”¹⁹⁰ These new stationary sources must not exceed certain sulfur emission limits which vary by categories such as combustion plants and oil refineries.¹⁹¹ Of course, it is possible that the Implementation Committee, which reviews compliance, and the governing Executive Body could exempt sulfur-based SAI SRM field tests from the Gothenburg Protocol restrictions because the production of acid rain within the covered UNECE region from this source of sulfur would be minimal due to the high emission altitude and subsequent atmospheric mixing.¹⁹² Furthermore, there are a few exceptions to the sulfur emission limits for which the field tests might qualify.¹⁹³ Nevertheless, barring action by the LRTAP Convention

187. *Id.* at pmb. ¶¶ 3, 4.

188. Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on the Reduction of Sulphur Emissions or Their Transboundary Fluxes By at Least 30 Per Cent, July 8, 1985, 1480 U.N.T.S. 215 [hereinafter Helsinki Protocol].

189. Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution to Abate Acidification, Eutrophication and Ground-level Ozone, Nov. 30, 1999, 2319 U.N.T.S. 81 [hereinafter Gothenburg Protocol]. A handful of States, including some larger ones, are not parties to these protocols. Most importantly, the United States has not ratified the Oslo Protocol, nor has Russia. *See Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Further Reduction of Sulphur Emissions*, UNITED NATIONS TREATY COLLECTION, https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-1-e&chapter=27&lang=en (last visited May 7, 2014, 1:44 PM) (listing the countries that have ratified the Oslo Protocol). Canada has not ratified the Gothenburg Protocol, nor has Russia. *See UNITED NATIONS TREATY COLLECTION*, https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-1-h&chapter=27&lang=en (last visited May 7, 2014, 1:48 PM) (listing the parties that have ratified the Gothenburg Protocol).

190. *See* Gothenburg Protocol, *supra* note 189, art. 1 (defining new stationary sources).

191. *See id.* art. 3.2, Annex IV (establishing limits on sulfur emissions from stationary sources). New mobile sources are similarly regulated. *See id.* art. 3.5, Annex VIII (establishing limit values and “environmental specifications for marketed fuels for vehicles”). SAI tests do not seem to fall clearly into any particular category.

192. *See id.* art. 9 (discussing the powers of the Implementation Committee); *id.* art. 10 (requiring review of “data on the effects of concentrations and depositions of sulphur and nitrogen compounds and of photochemical pollution”); *see also* IPCC, PHYSICAL SCIENCE, *supra* note 1, FAQ 7.3 (“There has also been some concern that sulphate aerosol SRM would increase acid rain, but model studies suggest that acid rain is probably not a major concern since the rate of acid rain production from stratospheric aerosol SRM would be much smaller than values currently produced by pollution sources.”).

193. *See* Gothenburg Protocol, *supra* note 189, Annex IV, tbl.1, n.a (providing a short list of exceptions to the limit values).

institutions and possible exceptions, these sulfur-based SAI SRM field tests appear to be prohibited in the Parties' territory by the Gothenburg Protocol.¹⁹⁴

More generally, sulfur-based SAI SRM field experiments would be regulated as a contribution to each Party's total emissions.¹⁹⁵ For example, they would be subject to reporting requirements, which are disaggregated by source categories and approximate locations.¹⁹⁶ Further implications for sulfur-based SAI SRM field experiments would depend on their scale because, although sulfur-based SAI SRM would be a small contribution to global sulfur emissions, large experiments could greatly increase total emissions of individual countries.¹⁹⁷ At small scales, such field tests would be generally encouraged per the provisions cited above and by the Oslo Protocol's commitment for Parties to "encourage research, development, monitoring and cooperation related to . . . [t]he understanding of the wider effects of sulfur emissions on human health, the environment."¹⁹⁸ Field tests of sulfur-based SAI SRM large enough to significantly increase a country's total emissions may be prohibited by the softly-worded commitment in the LRTAP Convention that Parties are to "endeavor to limit and, as far as possible, gradually reduce and prevent air pollution"¹⁹⁹ and by the first

194. See *id.* art. 2 (stating the objectives of the Protocol, which include reducing sulfur emissions).

195. See generally LRTAP Convention, *supra* note 74 (addressing how Parties' emissions into the atmosphere are regulated).

196. See *id.* art. 8 (providing for an exchange of information for Parties to the agreement); Helsinki Protocol, *supra* note 188, art. 4 (requiring annual reporting of sulfur emission levels); Oslo Protocol, *supra* note 187, art. 5 (requiring periodic reporting of national annual sulfur emissions); Gothenburg Protocol, *supra* note 189, art. 7 (requiring periodic reporting of sulfur emissions). The Executive Body of the Convention determines the source categories, and the locations are in "grid-units of agreed size." See LRTAP Convention, *supra* note 74, art. 10 (establishing an "Executive Body" and defining the parameters of its authority).

197. See Gothenburg Protocol, *supra* note 189, Annex IV (establishing limit values for sulfur emissions from stationary sources). Assuming that a large-scale field test would be one-tenth the magnitude of deployment, and taking the midpoint of the estimated range for deployment, such a test could emit 0.3 teragrams of sulfur per year. See MacMynowski et al., *supra* note 54, at 5044 (calculating to what extent uncertainty could be reduced through an SRM field test of one-tenth of the deployment intensity needed to counteract the warming from a doubling of atmospheric carbon dioxide concentration); McClellan et al., *supra* note 172, § 2.1 (estimating the amount of sulfur needed for SAI SRM deployment). This would be 1.5 times the current sulfur emissions of the United Kingdom or Germany. See EUROPEAN ENV'T. AGENCY, EUROPEAN UNION EMISSION INVENTORY REPORT 1990–2010 UNDER THE UNECE CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION 52–54 (2012) (discussing current sulfur emissions of European countries).

198. Oslo Protocol, *supra* note 187, art. 6; see also *supra* notes 182–191 and accompanying text.

199. LRTAP Convention, *supra* note 74, art. 2.

obligation of the Oslo Protocol that its Parties “shall control and reduce their sulfur emissions.”²⁰⁰ These tests would furthermore be contrary to the objective of the Gothenburg Protocol.²⁰¹ In reality, Parties sometimes do have significant increases in their total emissions while remaining below their emission reduction commitments.²⁰² The Implementation Committee, however, has apparently not addressed these significant below-limit increases in its reports to the Executive Body.²⁰³ Such a below-limit increase would most likely be judged by the other Parties and the Implementation Committee in its full context, including whether high-altitude sulfate emissions from tests would be deposited within the Parties’ territory or, alternatively, would be diluted and deposited over a much larger area.²⁰⁴ If field tests would be “a significant contribution to long-range transboundary air pollution,” then a potentially affected state could request consultations with the source state.²⁰⁵ Field tests of sulfur-based SAI SRM that would cause a Party to the Oslo or Gothenburg Protocols to exceed its sulfur emissions limit would be prohibited.²⁰⁶

F. Outer Space Treaty

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other

200. Oslo Protocol, *supra* note 187, art. 2.1; *see also* arts. 2.4, 4.1(b) (discussing the commitments to reduce emissions).

201. *See* Gothenburg Protocol, *supra* note 189, art. 2.1 (stating the Protocol’s objective to reduce sulfur emissions).

202. *See* European Environment Agency, *supra* note 197, at 11–12 (discussing significant emissions increases from 1990 to 2010); Oslo Protocol, *supra* note 187, Annex II (creating sulfur ceilings but not addressing significant below-limit increases); Gothenburg Protocol, *supra* note 189, Annex II (establishing sulfur ceilings but, again, not addressing significant below-limit increases).

203. *See, e.g.*, Fifteenth Report of the Implementation Committee to the Executive Body for the Convention on Long-range Transboundary Air Pollution, 31st Sess., Dec. 11–13, 2012, ECE/EB.AIR/2012/16 (reporting on the implementation of the LRTAP Convention) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

204. *See generally* LRTAP Convention, *supra* note 74 (establishing parameters for evaluating increases in sulfur emissions).

205. *See id.* art. 5 (requiring consultations “upon request, at an early stage, between, . . . Parties which are actually affected by or exposed to a significant risk of long-range transboundary air pollution and, on the other hand, Contracting Parties within which . . . long-range transboundary air pollution originates”).

206. *See* Oslo Protocol, *supra* note 187, Annex II (providing limits for sulfur emissions); Gothenburg Protocol, *supra* note 189, Annex II (providing new limits for sulfur emissions as of 1999). For example, Germany and the United Kingdom could presently perform experiments where they emit up to one sixth and one third of their allotted sulfur emissions respectively. *See supra* note 197 and accompanying text.

Celestial Bodies (the Outer Space Treaty) is the most important international instrument in space law.²⁰⁷ All nations that have a space program are Parties to the Outer Space Treaty.²⁰⁸ Proposals to place objects in space, either in Earth or solar orbit, have long been considered potential SRM methods, in part because they could be very effective and would not interfere directly in ecosystems, even though they are consistently assessed as economically infeasible.²⁰⁹ Evaluating the role of international law for space-based climate engineering research is complicated by the fact that, to a greater degree than other suggested methods, there could be little distinction between field research and deployment.

In general, the Outer Space Treaty and related agreements permit research on space-based SRM methods by, for example, establishing “freedom of scientific investigation in outer space,” and committing States to cooperate therein.²¹⁰ Parties are to conduct space activities “for the benefit and in the interests of all countries”²¹¹ and “with due regard to the corresponding interests of all other States Parties.”²¹² A subsequent UN General Assembly resolution addressed this potentially unclear passage, indicating that it is intended to encourage consideration of developing countries’ needs and to stimulate voluntary cooperation, and not to imply veto rights on other countries’ activities in space.²¹³ The Outer Space Treaty

207. See generally Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, Dec. 19, 1966, 610 U.N.T.S. 205 [hereinafter Outer Space Treaty]; THE UNITED NATIONS AT WORK 41 (Martin Ira Glassner ed., 1998) (“The most important of the UN space law instruments has been the [Outer Space Treaty] . . .”).

208. See *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies*, UNITED NATIONS TREATY COLLECTION, <https://treaties.un.org/pages/showDetails.aspx?objid=0800000280128cbd> (last visited May 7, 2014, 2:12 PM) (listing parties to the Outer Space Treaty) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

209. See THE ROYAL SOCIETY, *supra* note 25, at 32–34 (explaining that light refraction from space could be a possible SRM method, however, it would be prohibitively expensive).

210. See Outer Space Treaty, *supra* note 207, art. I (“There shall be freedom of scientific investigation in outer space, including the Moon and other celestial bodies, and States shall facilitate and encourage international cooperation in such investigation.”).

211. *Id.* art. I.

212. *Id.* art. IX.

213. See generally Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries, G.A. Res. 122, U.N. GAOR, 51st Sess., Supp. No. 49, at 114, U.N. Doc. A/RES/51/122 (Dec. 13, 1966) (addressing the obligations and powers of States with space programs and States without space programs under the Outer Space Treaty); see also FRANCIS LYALL & PAUL B. LARSEN, SPACE LAW: A TREATISE, 63–65 (2009) (explaining the prevailing desire, particularly among countries with space programs,

requires communication, that is, to inform the UN, the scientific community, and the public about relevant activities.²¹⁴ Finally, other international laws, including the customary law regarding transboundary harm, also apply in space.²¹⁵

The most detailed applicable provisions under space law are those regarding liability, which could present a disincentive toward researching space-based SRM.²¹⁶ The Outer Space Treaty and the Convention on International Liability for Damage Caused by Space Objects hold Parties responsible for their space-based activities and absolutely liable for damage caused by launched objects.²¹⁷ This liability is not restricted to accidents, malfunctions, or to damage from direct contact with launched objects, but instead includes damage from objects that remain in orbit and continue to function as intended.²¹⁸ Because the definition of “damage” is limited to that occurring to persons and property, recoverable damage to the environment would include only its economic value possessed by natural or legal persons.²¹⁹ The agreements, however, are silent on how direct the causation must be.²²⁰ Scholars generally agree that indirect and nonphysical damage is covered, but have divergent opinions regarding how direct the

that the benefit and interests be “met simply by the activities being beneficial in a generalised way”).

214. See Outer Space Treaty, *supra* note 207, art. XI (instituting a requirement that signatory Parties report to the UN Secretary General, and inform the public and scientific community of the nature of their interstellar activities).

215. See *id.* art. III (placing the Outer Space Treaty under the purview of international law).

216. See *id.* art. VII (establishing liability for any state that launches objects into space).

217. See Convention on International Liability for Damage Caused by Space Objects, pt. B, art. II, Nov. 29, 1971, 961 U.N.T.S. 187 [hereinafter Space Liability Convention] (creating absolute liability for damage to the surface of Earth or to aircraft).

218. See Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, princ. 8, G.A. Res. 1962, U.N. GAOR 18th Sess., Supp. No. 15, at 15, U.N. Doc. A/RES/18/1962 (Dec. 13, 1963) (“[E]ach State from whose territory or facility an object is launched, is internationally liable for damage to a foreign State or to its natural or juridical persons by such object or its component parts on the Earth, in air space, or in outer space.”). The Outer Space Treaty and the Space Liability Convention make no reference to accidents or malfunctions nor to direct physical contact, but States are “internationally liable for damage to a foreign State or to its natural or juridical persons by such object or its component parts on the Earth, in air space, or in outer space.” *Id.* ¶ 8.

219. See Space Liability Convention, *supra* note 217, art. I(a) (“The term ‘damage’ means loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations.”); see also LOTTI VIHKARI, THE ENVIRONMENTAL ELEMENT IN SPACE LAW: ASSESSING THE PRESENT AND CHARTING THE FUTURE 68–69 (2008) (discussing the scope of liability created under the Space Liability Convention).

220. See, e.g., Space Liability Convention, *supra* note 217, art. XII (invoking “international law and the principles of justice and equity,” and implying inclusion of indirectly-caused and delayed damages).

causation must be.²²¹ This disagreement is further complicated by the fact that proving causation in a dispute over the effects of space-based SRM testing or deployment would be very difficult. It is important to note that the Space Liability Convention has an article concerning catastrophic risks from space objects that requires the responsible state to “examine the possibility of rendering appropriate and rapid assistance.”²²²

G. United Nations Convention on the Law of the Sea

The UN Convention on the Law of the Sea (UNCLOS) is a comprehensive international agreement describing the rights and duties of States in their marine activities, including the protection of the marine environment and the conduct of marine scientific research.²²³ Some proposed climate engineering methods and their field research would occur in or over the ocean, such as ocean fertilization, MCB, and (possibly) SAI.²²⁴ UNCLOS also applies to land-based activities that affect the marine environment.²²⁵ States under UNCLOS have rights and obligations that will impact climate engineering field experiments in a complex manner.²²⁶

The desire to protect the marine environment is evident throughout UNCLOS, under which “States have the obligation to protect and preserve the marine environment.”²²⁷ This is without qualification and exception. Furthermore, Parties have obligations “to take . . . such measures . . . for the living resources of the high seas . . . to prevent, reduce and control pollution

221. Compare W.F. Foster, *The Convention on International Liability for Damage Caused by Space Objects*, 10 CAN. YEARBOOK INT'L L. 137, 158 (1972) (discussing liability for damages caused by space objects), with Carl Q. Christol, *International Liability for Damage Caused by Space Objects*, 74 AM. J. INT'L L. 346, 358–62 (1980) (reviewing various interpretations of the Treaty). Scholars generally agree that indirect and nonphysical damage is covered, however. See Foster, *supra*, at 155 (“Moreover, it is immaterial whether the injuries are suffered through physical impact . . .”); Christol, *supra*, at 362 (“[I]t may be anticipated that the convention will be interpreted as covering both direct and indirect damage . . .”).

222. See Space Liability Convention, *supra* note 217, art. XXI (establishing state responsibility for catastrophic injury).

223. See generally UNCLOS, *supra* note 73 (setting out the rights and obligations of any state that engages activities on the seas).

224. See *supra* notes 23–45 and accompanying text (providing an overview of such methods).

225. See UNCLOS, *supra* note 73, art. 207 (“States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment from land-based sources . . .”).

226. See generally *id.* (discussing, at length, the rights and obligations of States with respect to the seas).

227. *Id.* art. 192.

of the marine environment from any source”²²⁸ to ensure “that activities under their jurisdiction or control are so conducted as not to cause damage by pollution to other States and their environment, and that pollution arising from incidents or activities under their jurisdiction or control does not spread beyond the areas where they exercise sovereign rights”²²⁹; and to “take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from the use of technologies under their jurisdiction or control”²³⁰ The States are also required to assess and to communicate the expected effects of “substantial pollution of or significant and harmful changes to the marine environment” caused by activities under their control.²³¹ Importantly, “pollution of the marine environment” is defined, as in the LRTAP Convention, to include “the introduction by man, directly or indirectly, of substances or energy into the marine environment,”²³² but in this case with a lower threshold of certainty.²³³ This definition includes greenhouse gases and probably global warming.²³⁴ Under UNCLOS, pollution is not limited to marine-based sources, although the pollution must enter the marine environment.²³⁵ Furthermore, States are to prevent marine pollution “from any source” including “from land-based sources [or] from or through the atmosphere.”²³⁶ Not only will climate change warm the ocean, but elevated atmospheric carbon dioxide concentrations will also acidify it, and both processes will have deleterious effects.²³⁷ These effects imply a need to balance the risks to the marine environment from climate engineering research with those from climate change. UNCLOS, however, provides that “States shall act so as not to transfer, directly or indirectly, damage or hazards from one area to another or transform one type of pollution into

228. *Id.* art. 117.

229. *Id.* art. 194.

230. *Id.* art. 196.

231. *See id.* arts. 204–06 (discussing monitoring and assessing effects on the marine environment).

232. *Id.* art. 1.1(4).

233. *See supra* note 180 and accompanying text (providing the LRTAP Convention definition).

234. *See* UNCLOS, *supra* note 73, art. 1 (including “deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, . . . impairment of quality for use of sea water and reduction of amenities” in the definition of pollution to the marine environment).

235. *See id.* art. 204 (“States shall . . . observe, measure, evaluate and analyse, by recognized scientific methods, the risks or effects of pollution of the marine environment.”).

236. *Id.* art. 194.

237. *See* IPCC, *IMPACTS*, *supra* note 16, § 6 (“Climate change alters physical, chemical, and biological properties of the ocean . . . Impacts of ocean acidification range from changes in organismal physiology and behavior to population dynamics . . . and will affect marine ecosystems for centuries if emissions continue.”).

another.”²³⁸ Scholars dispute this article’s impact on climate engineering.²³⁹ Regardless of its impact, research projects of limited scale would not have the intention of transferring hazards, but of learning whether climate engineering deployment would have deleterious effects on the environment and whether it would indeed transfer hazards.²⁴⁰

UNCLOS is generally supportive of scientific research at sea.²⁴¹ Although “marine scientific research” remains undefined under UNCLOS, the various definitions considered during negotiations and proposed after the text was finalized all included the research of climate engineering techniques, which intervene in the ocean, and likely also those that operate in the atmosphere above the ocean.²⁴² For example, one of the last proposed

238. UNCLOS, *supra* note 73, art. 195.

239. Compare Philomene Verlaan, *Geo-Engineering, the Law of the Sea, and Climate Change*, 2009 CARBON & CLIMATE L. REV. 446, 457–58 (2009) (arguing that climate engineering projects would likely violate article 195, and that the burden is on the projects’ proponents to demonstrate that it would not), with James Edward Peterson, *Can Algae Save Civilization: A Look at Technology, Law, and Policy Regarding Iron Fertilization of the Ocean to Counteract the Greenhouse Effect*, 6 COLO. J. INT’L ENVTL. L. & POL’Y 61, 92 (1995) (asserting that article 195 would apply only if the intervention ocean fertilization were to be shown to have harmful environmental effects).

240. See THE ROYAL SOCIETY, *supra* note 25, at ix (stating that one purpose of research is to avoid “methods which involve activities or effects that extend beyond national boundaries”); but see GREGOR BETZ ET AL., LARGE SCALE INTENTIONAL INTERVENTIONS INTO THE CLIMATE SYSTEM?: ASSESSING THE CLIMATE ENGINEERING DEBATE 31 (Wilfried Rickels et al. eds., 2011), available at http://www.fona.de/mediathek/pdf/Climate_Engineering_engl.pdf (“By carrying out research into and planning for climate engineering, one passes on risks that arise today to future generations.”) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

241. See UNCLOS, *supra* note 73, pmb. ¶ 4, arts. 87.1, 88, 238–239, 243, 251, 255, 257 (recognizing the importance of supporting research at sea).

242. See UNITED NATIONS DIVISION FOR OCEAN AFFAIRS AND THE LAW OF THE SEA, OFFICE OF LEGAL AFFAIRS, THE LAW OF THE SEA: MARINE SCIENTIFIC RESEARCH: A REVISED GUIDE TO THE IMPLEMENTATION OF THE RELEVANT PROVISIONS OF THE UNITED NATIONS CONVENTION ON THE LAW OF THE SEA 4–6 (2010) (reviewing definitions of marine scientific research which were considered during drafting); see also GEORGE K. WALKER, DEFINITIONS FOR THE LAW OF THE SEA: TERMS NOT DEFINED BY THE 1982 CONVENTION 241–44 (2011) (discussing the meanings of marine scientific research). Whether research is conducted in, on, or above the high seas does not matter; although it is unclear under UNCLOS whether research conducted in the atmosphere above a nation’s exclusive economic zone and continental shelves is considered marine research. See FLORIAN H. TH. WEGELEIN, MARINE SCIENTIFIC RESEARCH: THE OPERATION AND STATUS OF RESEARCH VESSELS AND OTHER PLATFORMS IN INTERNATIONAL LAW 251–255 (2005) (discussing the legal regime of air space located over the high seas, contiguous zones, and exclusive economic zones). The most relevant question, however, is whether climate engineering research would increase knowledge of the “marine environment,” a phrase that is undefined but generally interpreted to include the marine atmosphere. See ALFRED H.A. SOONS, MARINE SCIENTIFIC RESEARCH AND THE LAW OF THE SEA 124 (1982) (analyzing the meaning of “marine scientific

definitions to be included in a negotiating text was “any study or related experimental work designed to increase man’s knowledge of the marine environment.”²⁴³ Parties commit to promote marine scientific research and to create favorable conditions for it, as well as to promote cooperation and communication in research.²⁴⁴ It must be conducted “using appropriate scientific methods and means,” for peaceful purposes, in a manner consistent with other international law, and in a manner that does not “unjustifiably interfere with other legitimate uses of the sea.”²⁴⁵ Most pertinently, Parties’ right to research is subject to their obligation to protect the marine environment.²⁴⁶ States and sponsoring international organizations may be held liable for damage caused by pollution due to research or by actions in contravention of the agreement.²⁴⁷

Some of the rights and obligations concerning marine scientific research vary by the location of the proposed activity.²⁴⁸ Within territorial waters,²⁴⁹ coastal States “have the exclusive right to regulate, authorize and conduct marine scientific research,” and research therein requires their express consent.²⁵⁰ In the exclusive economic zones and continental shelves, coastal States have a similar right, but they are to grant consent “in

research”); *see also* VERONICA FRANK, *THE EUROPEAN COMMUNITY AND MARINE ENVIRONMENTAL PROTECTION IN THE INTERNATIONAL LAW OF THE SEA: IMPLEMENTING GLOBAL OBLIGATIONS AT THE REGIONAL LEVEL 12* (2007) (discussing the lack of definition for “marine environment”). Regardless, considering the expected impact of climate change and climate engineering on the ocean, atmospheric climate engineering research would qualify as marine scientific research. *See* Karen N. Scott, *Regulating Ocean Fertilization Under International Law: The Risks*, *CARBON AND CLIMATE L. REV.* 108, 109–10 (2013) (describing the impacts of climate change and fertilization on the ocean).

243. Informal Single Negotiating Text, Third United Nations Conference on the Law of the Sea, Part III, Part II, art. 1, U.N. Doc. A/CONF.62/WP.8/Part III (1982).

244. *See* UNCLOS, *supra* note 73, arts. 239, 242–44, 250 (providing that States shall promote and facilitate marine scientific research in accordance with the Convention).

245. *Id.* art. 240 (providing general principles for scientific research).

246. *See id.* arts. 192, 238 (discussing States’ general obligation to protect the marine environment and States’ rights to conduct scientific research).

247. *See id.* art. 263 (“States . . . shall be responsible and liable for the measures they take in contravention of this Convention . . . States . . . shall be responsible and liable pursuant to article 235 for damage caused by pollution of the marine environment arising out of marine scientific research undertaken by them or on their behalf.”). If a climate engineering research activity were to be considered “pollution of the marine environment” instead of “marine scientific research,” liability would be independent of any violation of law. *See id.* art. 235 (“[States] shall be liable in accordance with international law.”).

248. *See id.* arts. 245–46 (explaining scientific research rights available in the territorial sea, the exclusive economic zone, and the continental shelf).

249. *See id.* art. 2 (“The sovereignty of a coastal State extends . . . to an adjacent belt of sea, described as the territorial sea.”).

250. *See id.* art. 245 (providing guidelines for marine scientific research in a States’ territorial sea).

normal circumstances” to researching States and “competent international organizations.”²⁵¹ There, the coastal State must exercise this and other rights with due regard for other States, and the researching State must have due regard for the coastal State and comply with the coastal State’s laws and regulations.²⁵² On the high seas, States and international organizations have the right to conduct research, but this must be performed with due regard for other States.²⁵³ Research conducted within the “Area”²⁵⁴ is subject to additional requirements, particularly that it is “for the common benefit of mankind as a whole” and that results are shared.²⁵⁵

A special note must be made of ocean fertilization and its research, which may or may not qualify as “dumping.” As defined in UNCLOS, “dumping,” in part, is “any deliberate disposal of wastes or other matter . . . at sea,” but excludes “placement of matter for a purpose other than the mere disposal thereof.”²⁵⁶ UNCLOS Parties have committed to prevent, reduce, and control pollution of the sea by dumping.²⁵⁷ Coastal States have the right to permit, regulate, and control dumping within their territorial waters, exclusive economic zones, and continental shelf, but must consider how other States may be impacted.²⁵⁸ Parties are to establish global rules regarding dumping, and their national laws must be no less effective than these global rules.²⁵⁹

251. *See id.* art. 246 (providing guidelines for marine scientific research in the exclusive economic zone and the continental shelf). UNCLOS details circumstances under which coastal States may withhold their consent, as well as the duties of the States and international organizations who conduct such research. *See id.* arts. 246–49, 252–54 (detailing state and researchers’ rights and obligations concerning marine environmental research).

252. *See id.* arts. 56, 58 (discussing the rights and duties of various States within the exclusive economic zone).

253. *See id.* arts. 87, 257 (providing for the freedom to research on the high seas and the right to perform research beyond exclusive economic zones).

254. *See id.* art. 1 (“Area” means the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction.”).

255. *See id.* art. 143 (covering permissible marine scientific research in the Area).

256. *Id.* art. 1.1(5).

257. *See id.* arts. 194.3(a), 210 (requiring States to take measures against pollution of the marine environment, including dumping).

258. *See id.* art. 210.5 (providing guidelines for dumping in certain areas). Dumping by other States in these areas requires permission from the coastal state. *See id.* (“Dumping within the territorial sea and the exclusive economic zone or onto the continental shelf shall not be carried out without the express prior approval of the coastal State . . .”).

259. *See id.* arts. 210.4, 210.6 (discussing the establishment and effectiveness of Parties’ global, regional, and national rules concerning pollution).

H. London Convention and London Protocol

The London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter and its London Protocol (together, the LC-LP) are two MEAs that regulate dumping at sea.²⁶⁰ The former has eighty-seven parties, whereas the latter—intended to replace the former—currently has forty-two parties.²⁶¹ These MEAs use essentially the same definition for “dumping” as UNCLOS; thus, ocean fertilization could potentially be classified under these MEAs as dumping.²⁶² In response to a private company that intended to conduct field experiments using a flag of convenience and a negative assessment of ocean fertilization in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, the Contracting Parties to the LC-LP took up the issue and began to develop a nonbinding regulatory framework for ocean fertilization.²⁶³

The regulatory framework adopted by the LC-LP Parties rests upon two new definitions provided in their 2008 decision. First, “ocean fertilization is any activity . . . with the principle intention of stimulating primary productivity in the oceans [excluding] conventional aquaculture, or

260. See generally Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter art. I, Nov. 13, 1972, 1046 U.N.T.S. 120 [hereinafter London Convention] (providing the terms of the London Convention, requiring States to prevent pollution of the sea caused by dumping); Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 art. 3.4, Nov. 7, 1996, 11 U.K.T.S. Cm. 4078 [hereinafter London Protocol] (adopting stricter measures for preventing dumping).

261. See Office for the London Convention and Protocol, *London Convention and Protocol*, INTERNATIONAL MARITIME ORGANIZATION, http://www.imo.org/blast/mainframemenu.asp?topic_id=1488 (last visited Jan. 8, 2014) (listing signatories) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

262. Compare UNCLOS, *supra* note 73, art. 1.1(5) (defining “dumping”), with London Convention, *supra* note 260, art. III.1 (defining actions that “dumping” does and does not include), and London Protocol, *supra* note 260, art. 1.4 (same). The two definitions differ in ways that are not relevant to this paper, but the London Convention preceded UNCLOS and is thus the origin of the definition.

263. Russ George, the CEO of Planktos, Inc. threatened to use a flag of convenience after the Environmental Protection Agency, which is responsible for implementing the London Convention in the United States, sent a letter to the company. See United States, Planktos, Inc., Large-scale Ocean Iron Addition Projects, I.M.O. Doc. LC/SG 30/INF.28 (June 1, 2007) (discussing Planktos Inc.’s dispute with the EPA over ocean iron addition projects); Report of the Thirtieth Meeting of the Scientific Group of the London Convention and the First Meeting of the Scientific Group of the London Protocol, ¶ 2.22, I.M.O. Doc. LC/SG 31/16 (July 25, 2007) (reporting on the decision-making process of the LC-LP in its regulation of ocean fertilization); see also Resolution LC-LP.1 on the Regulation of Ocean Fertilization pmb. ¶ 3, I.M.O. Doc. LC 10/16/Annex 6 (Oct. 31, 2008) [hereinafter LC-LP.1] (noting that States are encouraged to study and understand ocean iron fertilization).

mariculture, or the creation of artificial reefs.”²⁶⁴ The Parties decided that ocean fertilization indeed falls within the scope of the LC-LP and that it, in general, should not be allowed.²⁶⁵ An exception to this prohibition was made for the second new definition, “legitimate scientific research.”²⁶⁶ Distinguishing legitimate scientific research from illegitimate ocean fertilization requires an assessment framework, described in the Parties’ 2010 decision.²⁶⁷ Under this framework, researchers apply to the appropriate regulatory agency of their home state for approval to conduct scientific research.²⁶⁸

The assessment consists of two stages. The first is an initial review to determine whether the proposal is, in fact, a scientific one that would be subject to peer review and would not result in financial gain for the researchers.²⁶⁹ The second is a more elaborate environmental assessment, which includes, among other things, an assessment of exposure effects, risk characterization, and risk management.²⁷⁰ Notably, the risk management procedures should be based on a “precautionary approach,” and the decision whether to reject the proposal or to ask for revisions should take into account this precautionary approach.²⁷¹ During the second phase, the researching Party is also to notify potentially affected countries, and to

264. LC-LP.1, *supra* note 263, ¶2 n.3. Primary production is the creation of organic matter from carbon dioxide, usually through photosynthesis. *See* THE ROYAL SOCIETY, *supra* note 25, at 79 (defining primary production as “[a]ll forms of production accomplished by plants”).

265. *See* LC-LP.1, *supra* note 263, ¶8 (“[O]cean fertilization activities other than legitimate scientific research should not be allowed.”).

266. *See id.* ¶3 (providing an exception for placement of matter for research purposes).

267. *See* Resolution LC-LP.2 on the Assessment Framework for Scientific Research Involving Ocean Fertilization, I.M.O. Doc. LC 32/15/Annex 6 (Oct. 14, 2010) (adopting a framework to guide case-by-case assessment of research proposals).

268. *See id.* (determining what constitutes scientific research under the London Convention and Protocol); *see also* Assessment Framework for Scientific Research Involving Ocean Fertilization § 1, in Report of the Thirty-Second Consultative Meeting and the Fifth Meeting of Contracting Parties, I.M.O. Doc. LC 32/13/Annex 6 (Oct. 14, 2012) [hereinafter Assessment Framework] (providing a framework for assessing ocean fertilization research proposals).

269. *See* Assessment Framework, *supra* note 268, § 2 (detailing the initial assessment process).

270. *See id.* § 3 (discussing the environmental assessment process).

271. *See id.* §§ 1.3.2.6, 4.3 (explaining that risk management procedures are precautionary and that the decision to reject a proposal should take a precautionary approach into account). The precautionary principle presumably refers to that of the London Protocol: “it is important that States use the best practicable means to prevent such [marine] pollution.” London Protocol, *supra* note 260, pmb. ¶ 5.

consult with stakeholders.²⁷² If the project is approved, reports on the impacts during a field experiment are to be regularly sent to the Secretariat, and information from these reports can provide the basis to modify or to revoke the authorization as well as to improve future decision-making.²⁷³

The LC-LP decisions have already come under challenge.²⁷⁴ In 2012, a private company conducted a large ocean fertilization experiment without the approval of its home state, Canada.²⁷⁵ The company's representatives claimed that their intention was to increase salmon stocks on behalf of a Native American village, thus potentially avoiding the definition of ocean fertilization in the 2010 regulatory framework.²⁷⁶ After this work was revealed, the Canadian government announced an investigation into the ocean fertilization and the LC-LP Contracting Parties issued a statement deeming this project to be ocean fertilization.²⁷⁷

272. See Resolution LC-LP.2 on the Assessment Framework for Scientific Research Involving Ocean Fertilization, *supra* note 268, § 1.8 (imposing consultation and notice requirements on stakeholders).

273. See *id.* §§ 5.1–5.2 (mandating reports on the impacts of ocean fertilization for the Secretariat and noting that the information from these reports must inform and improve future decisionmaking).

274. See Craik et al., *supra* note 94, at 120–21 (discussing inter alia recent ocean fertilization activities which did not conform with LC-LP regulations).

275. See *id.* at 117–18 (summarizing the company's activities and claims).

276. See *id.* (“The principals involved in the activity characterized it as an ocean ‘restoration’ project, aimed at enhancing decreasing salmon stocks. However, they also made public statements indicating that they planned . . . to sell carbon credits on international markets for the carbon dioxide they assumed would be sequestered by the project.”). Stimulating primary production could be a means to achieve the goal of salmon restoration or carbon sequestration. The issue thus appears to be the precise meaning of “principle intention.” See *id.* at 122 (explaining that the principle intention of the experiment was to enhance salmon stocks). To further complicate matters, the president of the fertilization company, John Disney, claims that the boat was flying the village flag—implying the absence of a Canadian flag—and that the experiment occurred beyond 200 miles from shore (beyond Canada's exclusive economic zone) but within the marine territory of the village, “which goes out to wherever they perceive the line to be based on where they sit now in the legal world, which is under aboriginal rights and title.” See *West Coast Ocean Fertilization Project Defended*, CBC NEWS (Oct. 19, 2012), <http://www.cbc.ca/news/technology/story/2012/10/19/bc-ocean-fertilization-haida.html> (reporting the location of the experiment and that it was purportedly within the marine territory of a native village) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

277. See *Company Behind Ocean Fertilization Experiment Loses Court Bid to Block Charges*, THE CANADIAN PRESS (Feb. 4, 2014), <http://www.cntvna.com/News/2014-02/04/cms133257article.shtml> (“The organization behind a controversial ocean fertilization experiment off the coast of British Columbia faces potentially 10 charges for environmental violations after losing a court bid that would have brought an end to the investigation [by the Canadian government].”) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT); Report of the Thirty-Fourth Consultative Meeting of the Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of

In 2013, the Parties to the London Protocol (but not those to the London Convention) approved an amendment to the London Protocol, which, once accepted by two-thirds of the Parties, would implement a broader and binding regulatory framework.²⁷⁸ The amendment specifically defines “marine geoengineering,” which is not limited to ocean fertilization, scientific research, or a particular goal:

“Marine geoengineering” means a deliberate intervention in the marine environment to manipulate natural processes, including to counteract anthropogenic climate change and/or its impacts, and that has the potential to result in deleterious effects, especially where those effects may be widespread, long lasting or severe.²⁷⁹

The marine geoengineering activities listed in an accompanying proposed annex are either prohibited outright or would require a permit from a Party’s administrative government.²⁸⁰ For those activities which are listed and do require a permit, Parties are to follow a general assessment framework provided in a second proposed annex, as well as any other assessment mechanism developed by the Parties for a specific activity.²⁸¹ The general assessment framework for marine geoengineering activities calls for a detailed description of the proposed activity, notification of “potentially affected countries and relevant regional intergovernmental agreements and arrangements,” and a consultation plan.²⁸² Parties are obligated to carry out a consultation process during the assessment phase, and “[c]onsent should be sought from all countries with jurisdiction or interests in the region of potential impact.”²⁸³ Both the Party responsible for

Wastes and Other Matter, 1972, and Seventh Meeting of Contracting Parties to the 1996 Protocol thereto, Doc. LC 34/15, Nov. 23, 2012, Annex 3 (expressing “grave concern” at the ocean fertilization activity that took place in the Pacific Ocean off of the coast of Canada).

278. See Res. LP.4(8) on the Amendment to the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and Other Marine Geoengineering Activities, Oct. 18, 2013, Rep. of the Thirty-Fifth Consultative Meeting and the Eighth Meeting of Contracting Parties, Doc. LC 35/15, Annex 4 (Oct. 21, 2013) (adopting an amendment to the London Protocol to regulate marine geoengineering).

279. *Id.* Annex 4, art.1.

280. See *id.* Annex 4 (stating that Parties shall not allow listed marine geoengineering activities unless the activity may be authorized by permit).

281. See *id.* Annex 5 (imposing requirements on assessment frameworks).

282. *Id.* Annex 5, ¶10 (“[P]otentially affected countries and relevant regional intergovernmental agreements and arrangements should be identified and notified and a plan should be developed for ongoing consultations on the potential impacts, and to encourage scientific cooperation.”).

283. *Id.* Annex 5, ¶11.

the regulation as well as any potentially affected countries should seek expert advice, including peer review.²⁸⁴ The ultimate assessment under the general framework is to be based on the site, the matter to be placed in the ocean, its expected effects, the proposed risk management, the means of monitoring, the financial resources available, consultation requirements, the environmental impact, and the expected benefits.²⁸⁵ Regarding the last two criteria, the framework implicitly acknowledges the climate change/climate engineering tension, in that it calls for “conditions [to be] in place to ensure that, as far as practicable, environmental disturbance and detriment would be minimized and the benefits maximized.”²⁸⁶ The proposed general assessment framework also details considerations which must be met in order for an activity to be “a specific marine scientific research activity,” a subset of the more general “marine geoengineering activities” category.²⁸⁷ These requirements include: contributing to scientific knowledge, using appropriate methodology, being subject to peer review, a commitment to open publication of results, and a lack of personal economic interests.²⁸⁸ As it is presently proposed, ocean fertilization is the only marine geoengineering activity listed in the annex, which requires a permit and is limited only to legitimate scientific research.²⁸⁹

I. Antarctic Treaty System

The Antarctic Treaty System governs relations among countries in the area beyond sixty degrees latitude south, where some of the proposed climate engineering methods, particularly ocean fertilization and SAI, could be researched.²⁹⁰ Relevant here is the Antarctic Treaty and its Madrid Protocol on Environmental Protection.²⁹¹ Like UNCLOS, the Antarctic

284. *See id.* Annex 5, ¶ 12 (stating that contracting Parties should consider advice for proposals from international experts, and that advice should include peer review as necessary).

285. *See id.* Annex 5, ¶¶ 8–9 (detailing information required for assessment of a proposal).

286. *Id.* Annex 5, ¶ 26.5.

287. *Id.* Annex 5, ¶¶ 7–9.

288. *See id.* Annex 5, ¶ 8 (listing considerations that must be applied to determine whether specific marine scientific research activity will be permitted).

289. *See id.* Annex 5, ¶ 1 (stating that an ocean fertilization activity will not be given a permit unless it constitutes legitimate scientific research).

290. *See Antarctic Treaty, supra* note 88, art. VI (stating that the provisions of the treaty cover the “area south of 60° South Latitude”).

291. *See id.* arts. II–III (promoting, among other things, cooperation in scientific investigation in Antarctica); Madrid Protocol, *supra* note 79, art. 3 (seeking to limit adverse environmental impacts on Antarctica and acknowledging that the continent presents opportunities for scientific discovery). Both the Antarctic Treaty and the Madrid Protocol have been adopted by all countries with Antarctic activity. *Id.*

Treaty system calls for both environmental protection and scientific research.²⁹² In particular, the brief Treaty establishes a “freedom of scientific investigation,” within which Parties are to cooperate and share information.²⁹³ It also calls for the Parties to meet to discuss and further the facilitation of scientific research, as well as the “preservation and conservation of living resources.”²⁹⁴ The Madrid Protocol is more detailed about both environmental protection and scientific research.²⁹⁵ Generally speaking, it promotes both, often simultaneously.²⁹⁶ For example, the objective of the Parties is to protect the Antarctic environment and to designate the area as “a natural reserve, devoted to peace and science.”²⁹⁷ Similarly, the agreement’s first principle is that both environmental protection and Antarctica’s “value as an area for the conduct of scientific research, in particular research essential to understanding the global environment, shall be fundamental considerations in the planning and conduct of all activities.”²⁹⁸ One principle states that “[a]ctivities shall be planned and conducted so as to accord priority to scientific research . . . including research essential to understanding the global environment,”²⁹⁹ while the following principle states that activities shall be “modified, suspended or cancelled if they result in or threaten to result in impacts upon the Antarctic environment.”³⁰⁰

The Madrid Protocol and its Annexes impose obligations on its Parties that could apply in the context of climate engineering field research. All activities must be for peaceful purposes.³⁰¹ Further, the climate

292. See Antarctic Treaty, *supra* note 88, art. IX.1 (explaining that among the objectives of the treaty are facilitation of scientific research and preservation of resources in Antarctica). Interestingly, “scientific research” is left undefined.

293. See *id.* arts. II (“Freedom of scientific investigation in Antarctica and cooperation toward that end . . . shall continue . . .”).

294. See *id.* art. IX.1 (stating that the Parties shall meet and consult with each other regarding measures which can help to use Antarctica for peaceful purposes, to facilitate scientific research, and to preserve living resources).

295. See Madrid Protocol, *supra* note 80, art. 3 (describing the activities that must be planned to limit adverse impacts to the Antarctic environment, giving a list of adverse effects to avoid, and also explaining that the value of scientific research will be considered and weighed based on a comprehensive list of factors).

296. Notably, earlier drafts placed a greater emphasis on scientific research, with environmental protection as a means to ensure that this goal remained possible. See W.M. BUSH, ANTARCTICA AND INTERNATIONAL LAW: A COLLECTION OF INTER-STATE AND NATIONAL DOCUMENTS 5–7 (1991) (discussing prior drafts of the Antarctic Treaty).

297. See Madrid Protocol, *supra* note 79, art. 2 (describing the treaty’s objective as twofold: protecting the environment and devoting Antarctica to peace and science).

298. *Id.* art. 3.1.

299. *Id.* art. 3.2.

300. *Id.* art. 3.4(b). “Adverse impacts” and “impacts” are not further defined.

301. See *id.* art. 2 (“The Parties . . . hereby designate Antarctica as a natural reserve, devoted to peace and science.”).

change/climate engineering tension is clear when the protocol states that, “activities in the Antarctic Treaty area shall be planned and conducted so as to limit adverse impacts on the Antarctic environment and . . . to avoid: (i) adverse effects on climate or weather patterns; . . . [and] (iii) significant changes in the atmospheric, terrestrial (including aquatic), glacial or marine environments.”³⁰² Both climate change and climate engineering will cause “significant changes” in the atmosphere and environment.³⁰³ Moreover, the former, and perhaps the latter, will cause “adverse effects” on the earth’s climate.³⁰⁴ Climate engineering’s effects, however, and certainly those from its research, are expected to be less severe.³⁰⁵ Additionally, climate engineering is intended to avoid the adverse effects from climate change.³⁰⁶ Other relevant commitments include environmental impact assessment, cooperation, monitoring, and reporting.³⁰⁷ Notably, scientific activities are explicitly subject to impact assessment, and the only climate engineering assessment, to date, supported ocean fertilization research.³⁰⁸

Two particular provisions in the Annexes could present barriers to climate engineering research. First, if an activity “results in the significant adverse modification of habitat,” it would require a permit from the state’s “appropriate authority.”³⁰⁹ Second, ocean fertilization in Antarctic waters could be considered “discharge into the sea of . . . any other chemical or other substances, in quantities or concentrations that are harmful to the marine environment,” and thus prohibited.³¹⁰ The wording in both cases,

302. *Id.* art. 3.2(b).

303. *See supra* Parts I, II (outlining the consequences of climate change engineering).

304. *See supra* Part II (describing climate engineering methods).

305. *See supra* note 65 and accompanying text (comparing the relative impacts of climate change and engineering).

306. *See supra* Part II.

307. *See* Madrid Protocol, *supra* note 79, arts. 3.2, 6, 8, 17 (imposing on the Parties obligations to cooperate in the planning and conduct of activities in the Antarctic, to complete environmental evaluations, to monitor environmental indicators, and to circulate information to other Parties).

308. *See id.* art. 6 (requiring environmental impact assessments); Karen N. Scott, *Scientific Rhetoric and Antarctic Security*, in *ANTARCTIC SECURITY IN THE TWENTY-FIRST CENTURY* 284 (Alan D. Hemmings et al. eds., 2012) (citing the assessed and approved project by the New Zealand National Institute of Water and Atmospheric Research). Simultaneously, assessments of any activity “likely to have more than a minor or transitory impact” must consider its effects on the conduct of scientific research. *See* Madrid Protocol, *supra* note 79, Annex I, art. 3.2 (requiring this consideration).

309. *See* Madrid Protocol, *supra* note 79, Annex II, arts. 1, 3 (defining “harmful interference” to include significant adverse modification of habitats, and precluding “harmful interference” except when allowed by permit). A permit is also required for research activities in “Specially Protected or Managed Areas.” *See id.* Annex V, art. 4 (establishing when a Party seeking to conduct scientific research is required to have a permit).

310. *Id.* Annex IV, art. 4.

however, requires that the environmental damage be certain and not merely speculative.³¹¹ Field experiments, and particularly those of initially small scales, would be unlikely, or at least uncertain, to have such effects.³¹² In addition, ships operated by governments on a noncommercial basis are exempt from the latter provision.³¹³

J. Convention for the Protection of the Marine Environment of the North-East Atlantic

The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) is a regional marine MEA that is important because of the governed regions' proximity to, and the participation of, countries that are leaders in climate engineering research, such as the United Kingdom and Germany.³¹⁴ The OSPAR Convention regulates activities that may impact the environment of the northeast Atlantic Ocean, including the North Sea and part of the Arctic Sea.³¹⁵ Under this convention, "pollution" is defined in much the same way as in the LC-LP, the LRTAP Convention, and UNCLOS.³¹⁶ Thus greenhouse gases and, arguably, global warming are included in the definition of pollution. As a consequence, the climate change/climate engineering tension is brought to the fore by the OSPAR Convention's most relevant provision, which requires Parties to "take all possible steps to prevent and eliminate pollution and shall take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected."³¹⁷ The final reference to restoration

311. *See id.* at (defining "harmful interference" to include only particular activities and only prohibiting the discharge of noxious substances as defined specifically in Annex II or that are harmful to marine environment).

312. *See generally* Parson & Keith, *supra* note 56, at 1279 (arguing that the environmental impact of field experiments would be limited).

313. *See* Madrid Protocol, *supra* note 79, Annex IV, art. 11 (stating that Annex IV of the Protocol does not apply to ships owned or operated by a State and operated only for non-commercial service).

314. *See generally* OSPAR Convention, *supra* note 75 (demonstrating that both countries are signatories of the Convention); Parker & Keith, *supra* note 128 (discussing the leaders of climate engineering research).

315. *See* OSPAR Convention, *supra* note 75, art. I (explaining that "maritime area" under the treaty generally includes the Atlantic and Arctic Ocean north of thirty-six degrees north latitude).

316. *See id.* (defining "pollution" to include introductions of substances or energy into the maritime area that results in hazards to health, harm to the environment, or other damage).

317. *Id.* art. 2.1(a).

endorses the general concept of human interventions in the natural environment in order to mitigate prior adverse effects.

A handful of other articles in the OSPAR Convention also shape its relation to climate engineering field research. First, scientific research (which remains undefined) is encouraged in order to “further the aims of the Convention,” potentially lending some weight to climate engineering experiments.³¹⁸ Second, Parties are to apply both the precautionary principle and the polluter pays principle.³¹⁹ Although the former favors climate engineering research in the context of the UNFCCC, this would not be the case here, as it calls only for “preventive measures” in the face of uncertain risks.³²⁰ Instead, this formulation of the precautionary principle would argue for proceeding with great caution—if at all—if a proposed climate engineering field test were to pose a significant environmental risk.³²¹ In contrast, the polluter pays principle would support the research of climate engineering because the work is presently funded by those States that have contributed more to historical greenhouse gas emissions.³²² Third, in an article reminiscent of one in UNCLOS, Parties must carry out their obligations in a manner that does not transfer pollution to the sea outside of the covered area, or to another part of the environment.³²³ This would rule out large-scale field research if early research indicated that further action would protect the OSPAR area while polluting other areas. Fourth, in the event of transboundary pollution, which could occur with climate engineering field tests, Parties commit to consult one another in order to try to reach an agreement, and either Party can seek the advice of the OSPAR Convention’s governing Commission.³²⁴ Finally, Parties that are responsible for climate engineering research would be subject to procedural

318. See *id.* art. 8 (stating that the Parties must establish programs of scientific or technical research and report the results of that research).

319. See *id.* art. 2.2 (requiring the Parties to apply these principles in assessing state conduct).

320. See *id.* (“[P]reventive measures are to be taken when there are reasonable grounds for concern that substances or energy introduced, directly or indirectly, into the marine environment may bring about hazards to human health, harm living resources and marine ecosystems, . . . even when there is no conclusive evidence of a causal relationship . . .”).

321. See Reynolds & Fleurke, *supra* note 132, at 104–05 (introducing and defining the precautionary principle).

322. See generally Parker & Keith, *supra* note 128 (documenting public funding of climate engineering projects). Climate engineering research is presently led by Germany, the United Kingdom, the European Union, and the United States, all of which are near the top of historic greenhouse gas emissions. *Id.*

323. See *id.* art. 2.4 (“The Contracting Parties shall apply the measures they adopt in such a way as to prevent an increase in pollution of the sea outside the maritime area or in other parts of the environment.”).

324. See *id.* art. 21 (agreeing to enter into a consultation with any concerned state and stating that any party may seek the advice of the Commission).

obligations including environmental monitoring, reporting, and providing public access to the relevant information.³²⁵

Ocean fertilization under the OSPAR Convention warrants some final attention. Dumping, which is defined similarly to the definition in UNCLOS and the LC-LP, is generally prohibited except in a handful of circumstances.³²⁶ As witnessed under the LC-LP, whether ocean fertilization and its research are dumping under this definition is unclear.³²⁷ Most OSPAR Convention Parties are also participants in the LC-LP (and in the London Protocol specifically) and would likely defer to the detailed rules of the latter.³²⁸ Furthermore, the Commission has passed a “Code of Conduct for Responsible Marine Research,” which, although not binding, dissuades scientists from changing populations or marine habitats.³²⁹ Regardless, this is not especially relevant, as the North Atlantic is less suitable for ocean fertilization.³³⁰

K. Convention on Environmental Impact Assessment in a Transboundary Context

The Convention on Environmental Impact Assessment in a Transboundary Context (the Espoo Convention)³³¹ was developed through the UNECE in order to clarify and expand States’ commitments to assess potential transboundary environmental impacts, to share those assessments with the public and other States, and to reduce significant environmental transboundary effects.³³² The Espoo Convention should improve

325. See *id.* art. 6 (discussing environmental monitoring); *id.* art. 9 (discussing public access to information); *id.* art. 22 (discussing reporting requirements).

326. See *id.* arts. 1, 4, Annex II (defining and regulating dumping).

327. See *supra* Part IV.H (discussing the LC-LP).

328. Compare *OSPAR Convention—Contracting Parties*, OSPAR COMMISSION, http://www.ospar.org/content/content.asp?menu=01481200000026_000000_000000 (last visited May 22, 2014) (listing the signatories to the Ospam Convention), with Office for the London Convention and Protocol, *supra* note 261 (listing the signatories to the London Convention and Protocol).

329. See OSPAR Code of Conduct for Responsible Marine Research in the Deep Seas and High Seas of the OSPAR Maritime Area, Annex 6, ¶¶ 12–13, 2008, OSPAR Doc, 08/24/1 (stating that responsible marine science includes a responsibility to avoid long-term changes or any damage to species or habitats).

330. See Williamson et al., *supra* note 33, at 477 (stating that the Southern Ocean is the area with the greatest potential for ocean fertilization because iron is the limiting nutrient there).

331. Convention on Environmental Impact Assessment in a Transboundary Context, Feb. 25, 1991, 1989 U.N.T.S. 309 [hereinafter Espoo Convention].

332. See *generally id.* (committing to “take all appropriate and effective measures to prevent, reduce and control significant adverse transboundary environmental impact”). Most industrialized nations, except for Russia and the United States, have joined the Espoo

transparency, public participation, and international cooperation in the lead-up to large-scale climate engineering field trials. Its definitions of “impact” and “transboundary impact,” as well as its criteria for a significant proposed activity, are each clearly broad enough to include large-scale climate engineering field trials.³³³ Greenhouse gas emissions and climate change are not covered, however, as the agreement applies only to “proposed activities” that are “subject to a decision of a competent authority in accordance with an applicable national procedure.”³³⁴ Note that the Espoo Convention only applies to potential transboundary environmental impacts between two Parties to the Convention, and not to effects that are intrastate, occur in nonstate areas, or occur in a non-party state.³³⁵

The Espoo Convention requires Parties to “take all appropriate and effective measures to prevent, reduce and control significant adverse transboundary environmental impact from proposed activities.”³³⁶ Thus, the government of any Party that is considering approval of such a field trial that may impact another Party would be subject to a number of procedural obligations, most of which should be fulfilled before the activity is approved.³³⁷ Chief among these is the duty to notify potentially affected Parties and, if those countries agree, to undertake an environmental impact assessment in such a manner as to permit participation by the public living in the area likely to be affected, including the public of the other affected countries.³³⁸ The origin Party and the concerned party are then required to consult each other on the proposed project.³³⁹ When making the final decision to approve the proposed activities, the origin Party is to take into account the impact assessment, public comments, and the consultation with the concerned Party.³⁴⁰ The Espoo Convention also calls for post-project

Convention. See *Convention on Environmental Impact Assessment in a Transboundary Context Status*, UNITED NATIONS TREATY COLLECTION (May 4, 2014 7:04 PM), https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-4&chapter=27&lang=en (providing a list of the signatories to the Espoo Convention) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

333. See *id.* art. 1 (defining “impact” and “transboundary”); see *id.* app. III (providing criteria for activities not listed in Appendix 1 that potentially qualify as significant for purposes of the agreement).

334. *Id.* art. 1(v).

335. See *id.* art. 1(viii) (noting that, under the Convention, “transboundary impact” is limited to impact within the jurisdiction of a signatory).

336. *Id.* art. 2.1.

337. See *id.* art. 3 (explaining a Party’s obligation to notify other Parties of potential environmental impacts).

338. See *id.* art. 2 (detailing the procedures necessary for an impact assessment).

339. See *id.* art. 5 (imposing requirements on consultation and impact assessment).

340. See *id.* art. 6(1) (“The Parties shall ensure that, in the final decision . . . due account is taken of the outcome of the environmental impact assessment, including

analysis, and if there are “reasonable grounds for concluding that there is a significant adverse transboundary impact . . . concerned Parties shall then consult on necessary measures to reduce or eliminate the impact.”³⁴¹

L. Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters

Like the Espoo Convention, the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (the Aarhus Convention)³⁴² is an MEA developed within the UNECE in order to improve the disclosure of information and access to decision-making for actions that may have an environmental impact.³⁴³ It would commit Parties to carry out several procedural duties in the event of large-scale climate engineering field tests.³⁴⁴ In general, “each Party shall guarantee the rights of access to information, public participation in decision-making, and access to justice in environmental matters.”³⁴⁵ Notably, these matters need not be transboundary, and the Espoo Convention consequently establishes these rights for individuals and NGOs with respect to their own governments.³⁴⁶ Furthermore, these rights apply even in the absence of present or potential harm.³⁴⁷ The Convention details standards for the collection and provision of relevant information, which is broadly defined.³⁴⁸ Although the original Aarhus Convention

the . . . documentation, as well as the comments thereon received . . . and the outcome of the consultations . . .”).

341. *Id.* art. 7.

342. Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, June 25, 1998, 2161 U.N.T.S. 447 [hereinafter Aarhus Convention].

343. *See generally id.* (recognizing that public access to information is important for environmental protection). The UNECE countries that are not a party to the Aarhus convention include the United States, Canada, and Russia. *See Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters Status*, UNITED NATIONS TREATY COLLECTION (May 4, 2014 6:57 PM), https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtsg_no=XXVII-13&chapter=27&lang=en (providing a list of the signatories to the Aarhus Convention) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

344. *See generally* Aarhus Convention *supra* note 342 (establishing requirements on signatories prior to taking actions that may affect the environment).

345. *Id.* art. 1.

346. *See id.* pmbl. (“Recognizing further the importance of the respective roles that individual citizens, non-governmental organizations and the private sector can play in environmental protection.”).

347. *See id.* arts. 3–5 (listing the obligations of parties under the Aarhus Convention).

348. *See id.* art. 2.3 (defining “environmental information” to include “activities or measures, including administrative measures, environmental agreements, policies, legislation, plans and programmes, affecting or likely to affect the elements of the

obligates Parties to merely “encourage [private] operators whose activities have a significant impact on the environment to inform the public regularly of the environmental impact of their activities and products,”³⁴⁹ its Kiev Protocol on Pollutant Release and Transfer Registers expands this into an obligation for private actors to collect and publish relevant data.³⁵⁰ The right for participation is somewhat similar to the process of environmental impact assessment in the Espoo Convention,³⁵¹ and is limited to those members of the broad “public concerned.”³⁵² The provision in the Aarhus Convention for access to justice establishes minimum standards of redress for members of the public with sufficient interests in any environmental laws that have been violated.³⁵³

V. Nonbinding Multilateral Environmental Agreements

This section analyzes four nonbinding international agreements that may shape how climate engineering research will be regulated. Although nonbinding, they constitute a key component of international soft law and provide a sense of where the international community stands.

A. Provisions for Co-operation Between States in Weather Modification

In 1980, partially in response to the passage of ENMOD, the leadership of the UN Environmental Programme (UNEP) drafted and

environment . . . , and cost-benefit and other economic analyses and assumptions used in environmental decision-making”); *id.* arts. 4–5 (explaining the procedure for collecting environmental information and detailing the required access to, and dissemination of, such information).

349. *Id.* art. 5.6.

350. See Protocol on Pollutant Release and Transfer Registers to the Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, May 21, 2003, 005/2010 U.K.T.S. Cm. 7879 (mandating that each operator impacting the environment regularly inform the public of the environmental impact and any voluntary auditing schemes).

351. Compare Aarhus Convention, *supra* note 342, art. 6.7 (“Procedures for public participation shall allow the public to submit, in writing or, as appropriate, at a public hearing or inquiry with the applicant, any comments, information, analyses or opinions that it considers relevant to the proposed activity.”), with Espoo Convention, *supra* note 331, art. 2.2 (providing for public participation).

352. See Aarhus Convention, *supra* note 342, art. 2.5v (“‘The public concerned’ means the public affected or likely to be affected by, or having an interest in, the environmental decision-making; for the purposes of this definition, non-governmental organizations promoting environmental protection and meeting any requirements under national law shall be deemed to have an interest.”).

353. See *id.* art. 9 (establishing that a Party seeking redress must either have a “sufficient interest” or maintain that a right has been impaired).

approved Provisions for Co-operation between States in Weather Modification.³⁵⁴ Although weather and climate are scientifically distinct, the Provisions define “weather modification” to include climate interventions, and this is thus a particularly important nonbinding legal document.³⁵⁵ In general, the document provides qualified support for weather modification while calling for procedural duties to be imposed on the States under whose authority these activities may take place. For example, it notes “the possible benefits which weather modification may hold for mankind and the environment”³⁵⁶ and asserts that “[w]eather modification should be dedicated to the benefit of mankind and the environment.”³⁵⁷ The Provisions further call for “[e]xchange of information, notification, consultation and other forms of co-operation.”³⁵⁸ For potential transboundary impacts from weather modification, this provision recommends environmental impact assessments and efforts “to ensure that [weather modification activities] do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.”³⁵⁹

B. Declaration of the United Nations Conference on the Human Environment

Modern international environmental law can be traced to the 1972 United Nations Conference on the Human Environment and its Declaration (the Stockholm Declaration).³⁶⁰ To the extent that it still conveys the priorities of contemporary international environmental law, it lends support to climate engineering field research, provided that such activity is done in a manner that minimizes transboundary harm.³⁶¹ The Stockholm Declaration is a thoroughly anthropocentric document, emphasizing

354. See generally Provisions for Co-operation between States in Weather Modification, U.N.E.P. Dec. 8/7/A, U.N. Doc. UNEP/GC/8/7/A (Apr. 29, 1980) (setting out States’ obligations to each other with respect to weather modification).

355. See *id.* pt. 1(b) (“[A]ny action performed with the intention of producing artificial changes in the properties of the atmosphere for purposes such as increasing, decreasing or redistributing precipitation or cloud coverage, moderating severe storms and tropical cyclones, decreasing or suppressing hail or lightning or dissipating fog.”).

356. *Id.* cl. 5.

357. *Id.* pt. 1(a).

358. See *id.* pt. 1(b) (explaining that these further provisions should be carried out in good faith and without delay).

359. *Id.* pt. 1(f).

360. Declaration of the United Nations Conference on the Human Environment, adopted June 16, 1972, 11 I.L.M. 1416 [hereinafter Stockholm Declaration].

361. See *id.* ¶¶ 6–7 (stating that “through fuller knowledge and wiser action, we can achieve for ourselves and our posterity . . . an environment more in keeping with human needs” but that to “achieve this environmental goal will demand the acceptance of responsibility . . . at every level, all sharing equitably in common efforts”).

humans' responsibility to "manage" the "human environment" in order to "protect and improve" it.³⁶² For example, it proclaims that "man [sic] must use knowledge to build, in collaboration with nature, a better environment."³⁶³ Additionally, its first principle is that "he [sic] bears a solemn responsibility to protect and improve the environment for present and future generations."³⁶⁴ The focus on "human environment" further implies a prioritization of the environment as it relates to the well being of people, and that preservation of the natural environment for its own sake is secondary.³⁶⁵ Furthermore, the Stockholm Declaration calls for science and technology to be "applied to the identification, avoidance and control of environmental risks and the solution of environmental problems and for the common good of mankind"³⁶⁶ and for "the free flow of up-to-date scientific information and transfer of experience."³⁶⁷ It also explicates principles for the minimization and reduction of transboundary harm,³⁶⁸ for the development of liability for transboundary harm,³⁶⁹ and for international cooperation in protecting and improving the environment.³⁷⁰

C. Rio Declaration on Environment and Development

Twenty years later, representatives of most countries agreed upon the Rio Declaration on Environment and Development (Rio Declaration).³⁷¹ Although it retains a somewhat anthropocentric focus, almost entirely absent are the calls to manage and improve the Earth.³⁷² Instead, it focuses

362. See generally *id.* (outlining the "special responsibility to safeguard and wisely manage the heritage of wildlife and its habitat").

363. *Id.* ¶ 6.

364. *Id.* princ. 1.

365. See Dinah Shelton, *Human Rights, Environmental Rights, and the Right to Environment*, 28 STAN. J. INT'L L. 103, 108 (1991) ("The 1972 Stockholm Declaration on the Human Environment suggests that human benefit is the primary reason for respecting the environment . . .").

366. Stockholm Declaration, *supra* note 360, princ. 18.

367. *Id.* princ. 20.

368. See *id.* princ. 21 ("States have . . . the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.").

369. See *id.* princ. 22 ("States shall cooperate to develop further the international law regarding liability and compensation for the victims of pollution and other environmental damage caused by activities within the jurisdiction or control of such States to areas beyond their jurisdiction.").

370. See *id.* princ. 24 (stating that international efforts to protect and improve the environment "should be handled in a cooperative spirit by all countries").

371. Rio Declaration on Environment and Development, *adopted* June 14, 1992, 31 I.L.M. 874 [hereinafter Rio Declaration].

372. See *id.* at princ. 1 ("Human beings are at the centre of concerns for sustainable development . . .").

on the interrelation between environmental protection and the needs of the world's poor.³⁷³ Some of the principles of the Rio Declaration, however, could be interpreted as favoring climate engineering research. For example, it calls for “improving scientific understanding” and for developing “new and innovative technologies.”³⁷⁴ Furthermore, because the research would largely be financed by industrialized countries, the Rio Declaration's discussion of “common but differentiated responsibilities” and of the “internalization of environmental costs” appear supportive of climate engineering research.³⁷⁵ The Rio Declaration also invokes precaution: “[w]here there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.”³⁷⁶ Given that the threats of climate change appear to be more serious and irreversible than those of climate engineering,³⁷⁷ and that the latter is expected to have low financial costs,³⁷⁸ the Rio Declaration—like the UNFCCC—appears to argue for climate engineering research.³⁷⁹ On the other hand, another principle states that countries should “discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.”³⁸⁰ If field trials were to somehow put one human population at particular risk, this Principle may be violated.³⁸¹ Finally, some of the principles call for procedural obligations on the part of countries that may approve climate engineering field trials.³⁸² Perhaps most importantly, such

373. See *id.* princ. 6 (stating that those countries “least developed and those most environmentally vulnerable” are to be “given special priority”).

374. See *id.* princ. 9 (“States should cooperate to . . . improv[e] scientific understanding through exchanges of scientific and technological knowledge, and . . . enhance[e] the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies.”).

375. See *id.* princ. 7 (“States have common but differentiated responsibilities.”); *id.* at princ. 16 (“National authorities should endeavour to promote the internalization of environmental costs.”).

376. *Id.* princ. 15.

377. See *supra* note 65 (comparing the effects of climate change with the more limited effects of climate engineering).

378. See *supra* note 121 and accompanying text (discussing the relative low cost of climate engineering).

379. See *supra* notes 130–132 and accompanying text (discussing the UNFCCC's support for cost-effective climate engineering research).

380. Rio Declaration, *supra* note 371, at princ. 14.

381. See *id.* princ. 14 (“States should effectively cooperate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.”).

382. See *id.* princ. 17 (requiring States to prepare environmental impact assessments); *id.* princ. 19 (“States shall provide prior and timely notification and relevant information to potentially affected states . . .”).

steps “should, as far as possible, be based on an international consensus.”³⁸³ The governments of these countries should also conduct environmental impact assessments,³⁸⁴ notify affected States,³⁸⁵ and provide public access to relevant information.³⁸⁶

D. UN General Assembly

Finally, the UN General Assembly approved a 2007 resolution that, among other things, “encourages States to support the further study and enhance understanding of ocean iron fertilization.”³⁸⁷

VI. Customary International Law

Customary international law concerning transboundary harm will also apply to climate engineering field research. The customary law examined here has been discussed above, where it is embodied in various MEAs.

A. Prevention

The customary international law of preventing potential transboundary environmental impacts is among the oldest and most-established components of international environmental law.³⁸⁸ States’ commitments in this regard are to “prevent, reduce, and control transboundary pollution and environmental harm resulting from activities within their jurisdiction or control . . . [and] to cooperate in mitigating transboundary environmental risks and emergencies, th[r]ough notification, consultation, negotiation, and in appropriate cases, environmental impact assessment.”³⁸⁹ Such customary law has developed through court cases and

383. *Id.* princ. 12.

384. *See id.* princ. 17 (calling on States to make environmental impact assessments when their activities “are likely to have a significant adverse impact on the environment . . .”).

385. *See id.* princ. 19 (listing the instances that States need to notify one another of potential environmental impacts).

386. *See id.* princ. 10 (“States shall facilitate and encourage public awareness and participation by making information widely available.”).

387. G.A. Res. 62/215, ¶ 98, U.N. Doc. A/RES/62/215 (Dec. 22, 2007).

388. *See* DANIEL BODANSKY, *THE ART AND CRAFT OF INTERNATIONAL ENVIRONMENTAL LAW* 198 (2010) (noting that the “duty to prevent transboundary pollution” is seen as the “most firmly established customary norm” of international environmental law).

389. BIRNIE ET AL., *supra* note 68, at 137.

state practice.³⁹⁰ Using the International Law Commission (ILC) Draft Articles on Prevention of Transboundary Harm from Hazardous Activities³⁹¹ as a guide, some forms of large-scale climate engineering field research could pose a “significant risk of causing significant transboundary harm.”³⁹² Although not defined in the articles, the accompanying commentary clarifies this phrase as being objectively and reasonably foreseeable, with the potential harm as being “more than detectable but need not be at the level of ‘serious’ or ‘substantial.’” The harm must lead to a real detrimental effect on matters such as, for example, human health, industry, property, environment or agriculture in other states.³⁹³ If climate engineering field research were to be undertaken, then the origin State’s duties would include implementing “all appropriate measures to prevent” the harm,³⁹⁴ requiring authorization for a domestic party to conduct the activity in question,³⁹⁵ performing an environmental impact assessment,³⁹⁶ notifying States likely to be affected,³⁹⁷ informing the public likely to be affected,³⁹⁸ and developing contingency plans to prepare for an emergency.³⁹⁹ The precise steps to prevent and minimize the harm are subject to consultations between the countries,⁴⁰⁰ and are to be “based on an equitable balance of interests,”⁴⁰¹ whose relevant factors for consideration include:

390. *See id.* at 138 (explaining that the duty to prevent potential transboundary harm is evidenced by treaties, state action, and case law).

391. 53 U.N. GAOR Supp. No. 10, art. 2(a), UN Doc. A/56/10 (2001), *reprinted in* [2001] 2 Y.B. Int’l L. Comm’n 146 U.N. Doc. A/CN.4/SER.A/2001/Add.1 (Part 2) [hereinafter *Draft Articles on Prevention of Transboundary Harm*].

392. *See id.* art. 1 (“Any activity which involves the risk of causing significant transboundary harm through the physical consequences is within the scope of the articles.”); *id.* art. 1 cmt. 14 (“The mere fact that harm eventually results from an activity does not mean that the activity involved a risk, if no properly informed observer was or could have been aware of that risk at the time the activity was carried out.”).

393. *Id.* art. 2 cmt. 4.

394. *See id.* art. 3 (“The State of origin shall take all appropriate measures to prevent significant transboundary harm or at any event to minimize the risk thereof.”).

395. *See id.* art. 6 (listing the circumstances under which a State may require prior authorization before a party can act).

396. *See id.* art. 7 (requiring States to consider any environmental impact assessment when authorizing certain activities).

397. *See id.* art. 8 (requiring States to notify other States likely to be affected if the assessment required in art. 7 “indicates a risk of causing significant transboundary harm”).

398. *See id.* art. 13 (requiring States to inform the public likely to be affected).

399. *See id.* art. 16 (“The State of origin shall develop contingency plans for responding to emergencies.”).

400. *See id.* art. 9 ¶1 (stating that “[t]he states concerned shall enter into consultations”).

401. *Id.* art. 9 ¶2.

the importance of the activity, taking into account its overall advantages of a social, economic and technical character for the State of origin in relation to the potential harm for the State likely to be affected; . . . [and] the economic viability of the activity in relation to the costs of prevention and to the possibility of carrying out the activity elsewhere or by other means or replacing it with an alternative activity⁴⁰²

These two phrases again pose the climate change/climate engineering tension. The “equitable balance of interests” creates a significant burden for the potentially affected country to argue for strong preventative measures, particularly if the state of origin were to face high climate change damages and high costs to mitigate these damages.⁴⁰³ An alternate interpretation of these factors, however, could be that climate engineering field research does not present concentrated economic benefits to the country performing it.⁴⁰⁴ Instead, its benefits would be diffused throughout the world, whereas the risks may be limited to a small number of countries.⁴⁰⁵ Ultimately, how a court may rule would depend on the particular context⁴⁰⁶ and the extent to which the state of risk origin had acted with due diligence.⁴⁰⁷

The second half of the customary law of prevention is for countries to cooperate to mitigate risks.⁴⁰⁸ Specific duties herein include notification, consultation, and negotiation.⁴⁰⁹ For example, according to the Rio Declaration, the notification should be “prior and timely” and consist of “relevant information.”⁴¹⁰ Consultations should occur “at an early stage and

402. *Id.* art. 10(b), (e).

403. *See supra* note 121 and accompanying text (discussing the costs of SRM climate engineering research).

404. *See id.* at 103 (discussing the potential benefits of SRM climate engineering research).

405. *See id.* at 103–04 (arguing that deploying SRM has a “reasonable chance” of “significantly reduc[ing] the net damage from climate change to humans and the environment,” and its smaller costs would be considered insurance).

406. *See Draft Articles on Prevention of Transboundary Harm, supra* note 392, art. 10 (stating factors to consider in the “equitable balance of interests” required in article 9).

407. *See id.* art. 3 cmts. 7–8 (defining due diligence and explaining its prevalence in the “protection of the environment from harm”).

408. *See BIRNIE ET AL., supra* note 68, at 137 (listing the States that have a duty to “cooperate in mitigating transboundary environmental risks and emergencies”).

409. *See id.* (requiring States to mitigate risks through “notification, consultation, negotiation, and in appropriate cases, environmental impact assessment”).

410. *See Rio Declaration, supra* note 371, princ. 19 (describing requirements of notice and consultation).

in good faith.”⁴¹¹ Most States under whose jurisdiction or control climate engineering field trials would occur would require an environmental impact assessment under domestic law, even in the absence of transboundary risks.⁴¹² If they were to occur in areas beyond national jurisdiction, then MEAs including UNCLOS and the Antarctica Treaty system would apply.⁴¹³ If the proposal raised the prospect of transboundary impacts, then the Espoo Convention, customary international law, and many national laws would call for assessments.⁴¹⁴ Regardless, the details of impact assessments are often more contentious than whether an assessment is required.⁴¹⁵ In a domain as novel as climate engineering field experimentation, uncertainty may prevail, and both a judicious interpretation of the precautionary principle as well as political wisdom calls for erring on the side of a more thorough assessment.⁴¹⁶ There are, however, limited exceptions, as not every country has an assessment law or is a party to the Espoo Convention.⁴¹⁷ Furthermore, customary law, which requires assessment, does not apply to effects completely within national boundaries or to global impacts.⁴¹⁸

B. Responsibility and Liability

The international law on ex post responsibility and liability for transboundary damage remains less developed than the law regarding its

411. *See id.* (discussing the obligations between nations when conducting experiments that affect the environment).

412. *See* BIRNIE ET AL., *supra* note 68, at 165 (“An [environmental impact assessment] is fundamental to any regulatory system which seeks to identify environmental risk, integrate environmental concerns into development projects and promote sustainable development.”).

413. *See* SANDS & PEEL, *supra* note 74, at 605–08 (discussing when an environmental assessment is required under a variety of international treaties covering the environment).

414. *See id.* at 605, 611 (discussing the use of environmental impact assessments in the context of customary law and the Espoo Convention).

415. *See id.* at 602 (noting that while it is generally understood when environmental impact assessments need to be made, there is much less consensus as to what should be included in the assessments).

416. *See* BETZ AT AL., *supra* note 240, at 99 (suggesting that environmental impact assessments should be more thorough for climate engineering because there is a greater risk of hazard with climate engineering) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

417. *See* SANDS & PEEL, *supra* note 74, at 601 (noting that environmental impact assessments “have been progressively adopted in a very large number of legal systems,” suggesting that not all legal systems require assessments); *id.* at 610 (noting that the Espoo Convention only commits Parties who signed the Convention).

418. *See* BIRNIE ET AL., *supra* note 68, at 167 (“[A]t present general international law neither requires states to assess possible global effects for effects wholly within their own borders.”).

prevention.⁴¹⁹ For example, the only MEAs examined here that establish liability are the Space Liability Convention⁴²⁰ and UNCLOS.⁴²¹ Under customary international law, if the state that is the source of damage violated international law, including noncompliance with the customary international law of preventing transboundary harm, it should cease the activity, assure that the act will not recur, and make reparations for the injuries.⁴²² In the absence of a violation, climate engineering field studies—certainly at larger scales—likely qualify as ultra-hazardous activities,⁴²³ for which there is often absolute or strict liability.⁴²⁴ Although, such absolute or strict liability could, in theory, be considered a part of customary international law due to its presence in national and international laws and for a handful of specific activities, there is not yet adequate state practice for this to be the case.⁴²⁵ The draft ILC principles for Transboundary

419. See *id.* at 303 (acknowledging an “absence of clarity concerning remedies available to states and their scope”).

420. See Space Liability Convention, *supra* note 217 and accompanying text.

421. See UNCLOS *supra* note 247 and accompanying text. An Annex to the Madrid Protocol for liability in the Antarctic is not yet in force. See *The Protocol on Environmental Protection to the Antarctic Treaty*, SECRETARIAT OF THE ANTARCTIC TREATY, <http://www.ats.aq/e/ep.htm> (last visited Jan. 28, 2014) (“Annex VI on *Liability Arising from Environmental Emergencies* was adopted by the 28th ATCM in Stockholm in 2005 and will enter into force once approved by all Consultative Parties.”) (on file with the WASHINGTON AND LEE JOURNAL OF ENERGY, CLIMATE, AND THE ENVIRONMENT).

422. See *Factory at Chorzów (Ger. v. Pol.)*, 1928 P.C.I.J. (ser. A) No. 17, at 47 (Sept. 13, 1928), available at http://www.icj-cij.org/pcij/serie_A/A_17/54_Usine_de_Chorzow_Fond_Arret.pdf (highlighting that reparations should attempt to “wipe out all of the consequences of the illegal act”); *Draft Articles on Responsibility of States for Internationally Wrongful Acts*, 53 U.N. GAOR Supp. No. 10, art. 1–2, 30–31, 34–39, U.N. Doc. A/56/10 (2001), reprinted in [2001] 2 Y.B. Int’l L. Comm’n 26 U.N. Doc. A/CN.4/SER.A/2001/Add.1 (Part 2) (explaining a State’s liability when it violates international law); see also *id.* art. 24–25 (providing the possibility that a state that is seriously threatened by climate change may defend a violation of international law based upon necessity or even distress).

423. See *Draft Articles on Prevention of Transboundary Harm*, *supra* note 392, art. 1, cmt. ¶ 2 (“An ultra-hazardous activity is perceived to be an activity with a danger that is rarely expected to materialize but might assume, on that rare occasion, grave (more than significant, serious or substantial) proportions.”).

424. See SANDS & PEEL, *supra* note 74, at 712 (“Strict liability for ultrahazardous activities might be considered a general principle of law . . .”).

425. See *id.* (explaining that while “[s]trict liability for ultrahazardous activities might be considered a general principle of law . . .” and some treaties include strict liability, the current overall landscape of international law does not support strict liability as customary law). Nuclear energy, space activities, maritime transportation of oil, and the transportation and disposal of hazardous waste share strict or absolute, limited liability. See C. WILFRED JENKS, *LIABILITY FOR ULTRA-HAZARDOUS ACTIVITIES IN INTERNATIONAL LAW* 160–67 (1967) (discussing when liability may exist for climate modification).

Damage due to Hazardous Activities,⁴²⁶ however, call for States to “ensure that prompt and adequate compensation is available for victims” and to impose strict liability on the operators of the activity.⁴²⁷ In the case of climate engineering and its research, demonstrating causation would be particularly daunting.⁴²⁸

VII. Conclusions and Lingering Issues

Existing international environmental law provides both a regulatory and normative framework that will influence climate engineering field research and its regulation, and is, on the whole, favorable toward this research. Throughout these considerations, the climate change/climate engineering tension looms, and how a particular proposed climate engineering field experiment would fare under international environmental law is to a great degree contingent upon the assessments of the risks of climate change, and of both the risks and potential benefits of the field test in question. It is important to emphasize that this favorable setting does not necessarily extend to the deployment of large-scale climate engineering projects. Of course, almost none of this law was developed with climate engineering in mind and it consequently forms an inconsistent, sometimes contradictory legal environment. Furthermore, drawing general conclusions is difficult, as the actual rights and obligations of States will depend on numerous factors such as the form of climate engineering being researched, its scale, its location, and the likelihood, magnitude, and location of potential transboundary effects. Nevertheless, a handful of specific conclusions exist.

There are five reasons for the generally positive international legal environment of climate engineering research. First, to the extent that the

426. *Draft Principles on the Allocation of Loss in the Case of Transboundary Harm Arising out of Hazardous Activities*, 58 U.N. GAOR, Supp. No. 10, at princ. 4, U.N. Doc. A/61/10 (2006), available at legal.un.org/ilc/texts/instruments/english/draft_articles/9_10_2006.pdf.

427. See generally *id.* (establishing strict liability for operators who partake in hazardous activities that cause transboundary harm).

428. See Toby Svoboda & Peter J. Irvine, *Ethical and Technical Challenges in Compensating for Harm Due to Solar Radiation Management Geoengineering*, 17 ETHICS, POL'Y & ENV'T (forthcoming 2014) (manuscript at 11) (“The uncertainty involved in attributing particular changes in climate to specific causes could make it very difficult to determine whether some harmful impact, such as a prolonged drought, is due to a deployed SRM technique or not.”); but see Joshua B. Horton et al., *Liability for Solar Geoengineering: Historical Precedents, Contemporary Innovations, and Governance Possibilities*, 22 N.Y.U. ENVTL. L.J. (forthcoming 2015) (manuscript at 26) (arguing that “the problem of attribution does not necessarily appear to present an insurmountable barrier to crafting a workable regime”).

MEAs reviewed here seek to protect the environment, they favor, at the least, research into climate engineering as a potential means to reduce risks to humans and the environment from climate change. International environmental law has a generally anthropocentric orientation, and that is evident throughout these MEAs. While climate engineering field research may present some threat to the natural environment, climate change is forecast to pose substantially more significant risks.⁴²⁹ Furthermore, in several cases, greenhouse gases and/or climate change appear to satisfy the criteria for the pollution, damage, or adverse effects which the MEAs seek to reduce.⁴³⁰ Therefore, to the extent that a balancing is suggested by these MEAs' commitments from States to reduce such pollution or damage and to protect the environment more generally, they channel and tilt favorably toward climate engineering research as a means to develop a potential additional response to climate change—even if it presents risks of its own.⁴³¹ At the same time, if a line of climate engineering research were to hold little potential to reduce climate change risks while presenting large risks of its own, then this balance would shift against the research.

Second, many of the agreements explicitly or implicitly encourage scientific research and technological development.⁴³²

Third, the development of climate engineering is also consistent with some principles of international environmental law, including common but differentiated responsibility, polluter pays, and—in some of its forms—the precautionary principle, which are invoked at various times by the agreements.⁴³³

Fourth, in several cases, climate engineering research is supported due to its projected high speed and low financial cost.⁴³⁴

429. See *supra* note 65 and accompanying text.

430. See *supra* notes 71–75 and accompanying text.

431. See *supra* notes 60–62 and accompanying text.

432. See Kyoto Protocol, *supra* note 118 and accompanying text; UNFCCC, *supra* notes 125–26 and accompanying text; Vienna Convention, *supra* notes 170, 176 and accompanying text; ENMOD, *supra* notes 146–47 and accompanying text; LRTAP Convention, *supra* note 183 and accompanying text; Oslo Protocol, *supra* note 198 and accompanying text; Outer Space Treaty, *supra* note 210 and accompanying text; UNCLOS, *supra* notes 241–44 and accompanying text; Antarctica Treaty, *supra* notes 293, 297–99 and accompanying text; OSPAR Convention, *supra* note 318 and accompanying text; Stockholm Declaration, *supra* note 367 and accompanying text; Rio Declaration, *supra* note 374 and accompanying text.

433. See UNFCCC, *supra* notes 127–32 and accompanying text; Oslo Protocol, *supra* note 187 and accompanying text; OSPAR Convention, *supra* note 319 and accompanying text; Rio Declaration, *supra* notes 375–76 and accompanying text; see also Reynolds & Fleurke, *supra* note 132 and accompanying text.

434. See UNFCCC, *supra* notes 121–24 and accompanying text; LRTAP Convention, *supra* notes 185–87 and accompanying text.

Fifth and finally, all three agreements whose subject matter are most relevant to climate engineering favor climate engineering field research.⁴³⁵ The UNFCCC calls for the avoidance of dangerous climate change for humanity's sake,⁴³⁶ for the use of methods that are rapid and inexpensive,⁴³⁷ for industrialized countries to shoulder the financial burden,⁴³⁸ for precautionary action to mitigate the negative effects of climate change,⁴³⁹ for the promotion of applicable scientific and technological research,⁴⁴⁰ and for States to enhance reservoirs and sinks of greenhouse gases.⁴⁴¹ ENMOD and the UNEP Provisions for Weather Modification each encourage the development of peaceful climate engineering, in part to improve the environment for the sake of the human population.⁴⁴²

Despite being supportive of climate engineering research in general, existing law imposes duties on the part of the States that would be responsible for field research. For the most part, these are the procedural duties regarding the prevention and mitigation of transboundary harm, such as notification, assessment, consultation, and negotiation.⁴⁴³ These are part of customary international law, and the MEAs provide further explicit detail for some situations, including that of risks to the environment in areas outside of state territory. The Espoo Convention adds public participation in the assessment and post-project analysis,⁴⁴⁴ and the Aarhus Convention requires access to information and public participation in decision-making, even for projects that would have wholly domestic effects.⁴⁴⁵

Moreover, some of the binding MEAs impose particular constraints and prohibitions on parties to these agreements. Among these, the most general and most challenging to interpret is the statement of the CBD COP.

435. See *supra* Part IV.A, IV.B, IV.C.

436. See *supra* notes 111–13 and accompanying text.

437. See *supra* notes 121–24 and accompanying text.

438. See *supra* notes 127–29 and accompanying text.

439. See *supra* notes 130–32 and accompanying text.

440. See *supra* notes 125–26 and accompanying text; see also Kyoto Protocol, *supra* note 118 and accompanying text.

441. See *supra* notes 115–18 and accompanying text.

442. See ENMOD, *supra* notes 143–47, and accompanying text; UNEP Provisions for Weather Modification, *supra* notes 356–58 and accompanying text.

443. See UNFCCC *supra* note 133 and accompanying text; CBD, *supra* note, 159 and accompanying text; LRTAP Convention, *supra* note 205 and accompanying text; Outer Space Treaty, *supra* note 214 and accompanying text; Madrid Protocol, *supra* notes 307–08 and accompanying text; OSPAR Convention, *supra* notes 324–25 and accompanying text; Stockholm Declaration, *supra* note 370 and accompanying text; Rio Declaration, *supra* note 384–86 and accompanying text; Weather Modification Provisions, *supra* notes 358–59 and accompanying text.

444. See *supra* note 332–41 and accompanying text.

445. See *supra* notes 343–53 and accompanying text.

While nonbinding, this statement indicates that the international community desires a greater degree of regulation, consideration of risks, and scientific justification before large-scale field research is undertaken.⁴⁴⁶ In contrast, the the LC-LP framework for ocean fertilization and the more general London Protocol framework for marine geoengineering provide the clearest regulation, prohibiting it unless a project is deemed to be legitimate scientific research.⁴⁴⁷ Another strong restriction on climate engineering research is the apparent prohibition on sulfur-based SAI SRM field tests within the territory of the Parties to the Gothenburg Protocol to the LRTAP Convention.⁴⁴⁸ Throughout the world, climate engineering investigations must be non-hostile if they have “widespread, long-lasting or severe effects” and if conducted at sea and in Antarctica, they must be for peaceful purposes.⁴⁴⁹ At sea, research must not undermine the protection of marine environment, cannot unjustifiably interfere with other legitimate uses of the sea, must use appropriate scientific methods and means, and is subject to the authority of coastal States in their territory, exclusive economic zones, and continental shelves. Furthermore, marine climate engineering work cannot merely transfer or transform pollution, although these provisions may apply only to climate engineering deployment. In the northeast Atlantic Ocean, if there are reasonable grounds that climate engineering research may present a hazard to human health or the environment, then the state is obligated to take “preventative measures.”⁴⁵⁰ In the Antarctic Treaty area, a permit may be needed in certain locations, and research projects must be cancelled if they threaten to harm the environment.⁴⁵¹ States would be liable for damage caused by climate engineering research in space or if they violate international law (although demonstrating causation will be difficult).⁴⁵² In theory, the sulfur-based SAI SRM field tests could be prohibited under the Montreal Protocol, if they were found to be significantly destructive to the ozone layer and if the Parties actually take novel action.⁴⁵³

446. See *supra* notes 159–62 and accompanying text.

447. See *supra* notes 263–89 and accompanying text.

448. See *supra* notes 190–93 and accompanying text; see also Oslo Protocol, *supra* note 206 (noting that *large-scale* sulfur SAI SRM tests are not permitted under the Gothenburg and Oslo Protocol).

449. See ENMOD, *supra* notes 144–45 and accompanying text; UNCLOS, *supra* note, 245 and accompanying text; Madrid Protocol, *supra* note 301 and accompanying text; see also Outer Space Treaty, *supra* note 208, art. III (noting that, in space, activities must merely be “in the interest of maintaining international peace and security”).

450. See *supra* notes 319–20 and accompanying text.

451. See *supra* notes 300, 309 and accompanying text.

452. See Outer Space Treaty and Space Liability Convention, *supra* notes 217–21 and accompanying text; UNCLOS, *supra* note 247; customary international law *supra* Part VI.B.

453. See *supra* notes 163–72 and accompanying text.

Finally, any law governing climate engineering research, whether it relies upon existing MEAs or otherwise, will be complicated by a determination of what qualifies as climate engineering research. Thus far, definitions have been employed that typically rely on the intention of the researcher or the effects of the research.⁴⁵⁴ Intentions, however, are easily denied, and the precise effects of field research may remain partially unknown until after they are carried out.⁴⁵⁵ Other important questions arise. In terms of scale, at what point does a small-scale project warrant the attention of domestic or international law, and at what point does a large-scale project become deployment?⁴⁵⁶ How is research that investigates basic environmental processes or climate change (or at least claims to do so), yet could also be used to develop climate engineering potentially affected? But, determining how to define “climate engineering research” and its thresholds will likely be the most challenging aspect in the development of its regulation.

Despite these duties and limited restrictions, extant international environmental law remains on the whole favorable to responsibly conducted climate engineering field research, particularly due to its potential to reduce harm to humans and the environment. Although international law does influence state behavior, state interests and global and domestic politics arguably play larger roles in shaping the actions of decision makers.⁴⁵⁷ How a potentially controversial, risky, large scale climate engineering field test is perceived by the international community depends not only on existing international environmental law but also on international and domestic political circumstances, the severity of current and forecast climate change, the reputations and nationalities of the

454. See *supra* notes 143, 159, 264, 279, 355 and accompanying text. It is important to note that the definition of “marine geoengineering” used in the amendment to the London Protocol requires only a “deliberate intervention in the marine environment to manipulate natural processes.”

455. See Kelsi BRACMORT & RICHARD K. LATTANZIO, CONG. RESEARCH SERV., R41371, GEOENGINEERING: GOVERNANCE AND TECHNOLOGY POLICY 1 (2013) (discussing how some observers “respond that the uncertainties of geoengineering may only be resolved through further scientific and technical examination”).

456. See Parson & Keith, *supra* note 56, at 1278 (suggesting thresholds for defining categories of climate engineering research).

457. See generally Steinberg, *supra* note 105 (surveying the neorealist approach to international law and international relations); Barbara Koremenos, *Institutionalism and International Law*, in INTERDISCIPLINARY PERSPECTIVES ON INTERNATIONAL LAW AND INTERNATIONAL RELATIONS: THE STATE OF THE ART 59 (Jeffrey L. Dunoff & Mark A. Pollack, eds., 2013) (surveying the institutionalist approach to international law and international relations); see also Victor, *supra* note 47, at 322 (arguing that treaties “are unlikely to be effective in constraining geoengineers because the interests of key players diverge and it is relatively easy for countries to avoid inconvenient international commitments and act unilaterally”).

scientists, the evidence from prior modeling and laboratory experiments, the nature of the field experiment, and the robustness of domestic regulation. In the worst case scenario, it could become a source of significant international tension.

Another unfortunate scenario would be the unduly restrictive regulation of climate engineering and its research, developed in haste and based upon fears and assumptions of potential risks, without balancing such risks with climate engineering's potential to reduce the risks from climate change. The result would likely be significant net harm to humans and the environment. Considering that we, as an international community, still do not know exactly what climate engineering is, what risks its field research poses, and what we do and do not want from it, a preferred path would be the gradual emergence of norms and rules via a mixture of intergovernmental institutions and transnational communities of scientists, civil society, and other experts.⁴⁵⁸ Fortunately, this appears to be unfolding.⁴⁵⁹ Here, many of the bodies established by international environmental law will be particularly important.

458. See Victor, *supra* note 47, at 332 (“A more effective approach to building a relevant regulatory system would concentrate, today, on laying the groundwork for future negotiations over norms rather than attempting to codify immature norms now . . . build[ing] norms from the ‘bottom up.’”); see also William Daniel Davis, *What Does “Green” Mean?: Anthropogenic Climate Change, Geoengineering, and International Environmental Law*, 43 GA. L. REV. 901, 907 (2009) (“An internationally collaborative research program, moreover, could begin to develop international behavioral norms that would reduce the risks associated with geoengineering.”); David Victor et al., *The Geoengineering Option: A Last Resort Against Global Warming?*, 88 FOREIGN AFF. 64, 66 (2009) (“Governments should immediately begin to undertake serious research on geoengineering and help create international norms governing its use. . . . Scientists could be influential in creating these norms.”); David Keith et al., *supra* note 53, at 427 (“A better approach would be to build international cooperation and norms from the bottom up, as knowledge and experience develop.”); Lisa Dilling & Rachel Hauser, *Governing Geoengineering Research: Why, When and How?*, 121 CLIMATIC CHANGE 553, 563 (2013) (“Over time, researchers and stakeholders could meet to assess progress in governance, identify emerging norms, and correct problems. Governance norms could spread through the sharing of ‘best practices,’ and the gradual institutionalization of successful ones.”); M. Granger Morgan et al., *Needed: Research Guidelines for Solar Radiation Management*, 29 ISSUES SCI. & TECH. 37, 41 (2013) (“[T]here is a pressing need to develop what we will call a code of best SRM research practices.”); Edward Parson & Lisa Ernst, *International Governance of Climate Engineering*, 14 THEORETICAL INQ. L. 307, 324 (2013) (“[E]arly informal cooperation on scientific research and risk assessment should seek to develop relevant norms from the ground up, by a decentralized process.”); Stefan Schäfer et al., *Field Tests of Solar Climate Engineering*, 3 NATURE CLIMATE CHANGE 766, 766 (2013) (“As a starting point, [adequate governance for climate engineering research] could be achieved through the establishment of an international voluntary code of conduct.”).

459. See, e.g., MacCracken et al., *supra* note 129 (recommending governing principles for the conduct of climate engineering research); see also BIPARTISAN POLICY CENTER'S TASK FORCE ON CLIMATE REMEDIATION, *supra* note 129 (advocating open and

interdisciplinary research efforts); Rayner et al., *supra* note 129 (describing the Oxford Principles as “high-level principles for geoengineering governance”).