Climate Engineering in Global Climate Governance: Implications for Participation and Linkage

Edward A. Parson[1]

(to appear in Transnational Environmental Law)

Abstract:

The prospect of climate engineering alternative
s of participation, e.g., variants of partial cooperation, unilateral action, and
hough risks of unilateral CE by small states or non-state actors have been
dozen-odd powerful states may be able to pursue CE unilaterally, risking
destabilization and conflict. These risks are not limited to future CE
ut may also be triggered by unilateral R&D, secrecy about intentions and
or assertion of legal rights of unilateral action. They may be reduced by
ative steps such as international R&D collaboration and open sharing of
CE present novel opportunities for explicit bargaining on linkages within a
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reduce the realized climate changes that result from elevated greenhouse gases.

understood, as are the basic engineering approaches by which it would be implemented. Consequently, it could be done today, albeit crudely, with current knowledge and technology. Nature provides clear analogues for how such interventions would work, in the occasional explosive volcanic eruptions that inject large quantities of sulfur into the stratosphere—most recently the 1991 eruption of Mt. Pinatubo in the Philippines, which cooled the Earth about half a degree Celsius over the following year or two.[7]

Research is needed to study the many uncertainties about how specific CE interventions would work, their effects and risks—including, crucially, the regional and seasonal distribution of effects. Preliminary studies of these issues are underway—mostly laboratory and computer-model studies, but also a few small field experiments of atmospheric aerosols and other proposed approaches such as ocean fertilization.[8] Early efforts to create explicit research programs are also underway in a few jurisdictions, as are various "dual-use" studies that investigate CE capabilities and effects, but which also address other scientific questions.[9] Since much of the field research to develop and inform CE capabilities can be done with small-scale interventions that are essentially risk-less—indeed, many proposed experiments would resemble existing practices in small-scale weather modification, or the inadvertent impacts of normal commercial activities such as aviation and shipping—small-scale CE research would be hard to detect from a distance, so it is possible that other experimental interventions have already been undertaken.[10]

For purposes of understanding their role in societal response to climate change, CE technologies have three salient characteristics: they are fast, cheap, and imperfect.[11] Climate engineering is fast. A manageable scale of intervention by means already known, involving one or two hundred transport aircraft in continuous operation, could cool the Earth 1–2°C within a few years.[12] Consequently, an effective intervention could be deployed to arrest or reverse global heating even after it is known that rapid change or severe impacts

technologies, it is a useful approximation to consider their cost zero.[12] While normally it is an advantage if a potentially desired option is cheap, in this case low cost is a double edged sword, with two potentially destructive consequences. First, it has deluded some observers into a stance of naïve cheerleading for the technologies.[13] This in turn has raised concerns about excessive reliance on CE as a complete response to climate change —which it emphatically cannot be, for reasons noted below—further weakening the already inadequate support for cutting emissions. Second, CE's low cost raises problems of control by putting it within reach of more actors. Although I argue below that the prospects for unilateral CE by small states or non-state actors have been overstated, CE is still more widely available than past examples of potentially destabilizing technologies, of which the most relevant parallels are novel weapons capabilities.

Finally, CE offers only a highly imperfect corrective for the environmental effects of elevated greenhouse gases. Their correction is imperfect even if only their global-average climate effect is considered, because CE counteracts a heating that occurs aloft by a cooling at the Earth's surface, where the blocked sunlight would otherwise have been absorbed. The result is that CE controls precipitation more strongly than temperature, so a world in which CE fully offsets average greenhouse heating would have a climate drier than the starting climate.[14] These global average differences cascade into diverse, albeit uncertain, differences in regional and seasonal climate effects.[15] In addition, CE does nothing to counteract the non-climate (i.e., chemical and biological) effects of elevated CO_2, including making the oceans more acidic, and disrupting competitive relationships between different types of plants with different responses to increased CO_2.[16]

These three characteristics—fast, cheap, and imperfect—outline the basic governance and policy challenges posed by CE. Considered together, they present an acute tension: like all technological expansions of human capabilities, CE may offer the prospect of either large benefits – reducing the climate-change risks we otherwise face—or large harms, depending on how it is used and how it influences related choices. Used prudently and benevolently, it may bring large benefits of multiple forms. It can provide a contingency response to a future climate emergency, as discussed above; it can also be used earlie 2.51 0 T 0 Td [(It)-7(mst)-6(, cj -0h1D1.86 014 Tc16gnai Tw (can(t)-6(Tw (itbT br)3(i)-2
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tropical oceans to block formation of the highest-energy hurricanes.[17] But used incompetently, negligently, or destructively, CE technologies may make matters much worse. They thus present new needs, and new challenges, for governance and control, to pursue the benefits and minimize the harms they hold.

3. UNILATERALISM AND MULTILATERALISM IN CLIMATE ENGINEERING

When CE is added to the set of potential responses to climate change, the aspiration for global cooperation still exerts powerful attraction, perhaps even more than when policy is just mitigation. Early discussions suggest that every group that takes the prospect of CE seriously asserts the importance of broad consultation and participation in decision-making.[18] But if global cooperation appears unattainable, CE requires considering a different set of alternative configurations of participation and non-participation than when climate policy is just mitigation. Partial cooperation approaches are stin(W)-2(on a)4q EC(EC(EC(E

the result that any state may legally conduct CE, on or over its own territory, or that of other consenting states, or over the high seas.[19]

The reasons for this lack of legal control are unique to each treaty and institution, but generally lie in the narrowness and specificity of obligations imposed by environmental treaties.[20] The regimes of greatest relevance are those on stratospheric ozone depletion, climate change, and long-range air pollution. Yet the concrete obligations of the Montreal Protocol on the ozone layer are limited to controls on the production and consumption of listed chemicals, and do not include comprehensive controls on other activities that affect ozone.[21] Similarly, the Kyoto Protocol on climate change only limits national emissions of six listed greenhouse gases, and only for Parties listed in Annex B.[22] None of the sulfur-based species now considered promising candidates for stratospheric aerosol injection appear on the list of controlled substances in either of these Treaties. National emissions of sulfur dioxide are controlled under the 1999 Gothenburg Protocol to the Convention on Long-Range Transboundary Air Pollution.[23] But this Convention is a regional treaty whose membership includes only European nations plus the United States and Canada, and the way the 1999 Protocol specifies national emission limits only appears likely to seriously constrain participation in a CE program for the smaller European states.[24] Another treaty of seeming relevance, the 1977 Environmental Modification Convention (ENMOD), prohibits large-scale environmental modification,

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[19] Within the exclusive economic zones (EEZ) of other nations and the airspace over it, the legal status of CE activities would depend on the interpretation of certain provisions of the UN Convention on the Law of the Sea, particularly the regime for 'marine scientific research'. See A. Hubert, 'The New Paradox in Marine Scientific Research: Regulating the Potential Environmental Impacts of Conducting Ocean Science' (2011) 42(4) Ocean Development & International Law, pp. 329-55.

[20] For detailed discussion of the limited applicability of existing treaty obligations to CE, , see, e.g., Parson et al., n. 3 above, A. Ghosh & J. Blackstock, 'SRMGI Background Paper: International' (Background Paper for the Solar Radiation Management Governance Initiative, March 2011), at p. 16. Available at: http://www.srmgi.org/files/2011/09/SRMGI-International-background-paper.pdf; Shepherd et al., n. 2 above, at p. 40; see also Ralph Bodle et al.,

framework.[31] The upshot is that ocean fertilization is presently subject only to generalized normative statements of concern urging caution, not to any legally binding control, while other forms of CE, including stratospheric aerosol injection, are under even less international legal control. In the specific case of controlling US conduct, the legal situation is even weaker because the US is not a party to either the CBD or the London Protocol. Consequently, even if binding controls were adopted under one of these treaties, the US, as a non-party, would not be bound by them.[32]

In the absence of specific treaty provisions that would constrain national CE activities, the points of existing international law of potential relevance to CE fall into two classes: general obligations to protect and preserve the environment that appear in many treaties,

The present lack of any controlling international law, however, does not necessarily imply a serious threat of unilateral action to develop or deploy CE technologies. The severity of this risk will depend additionally, indeed primarily, on the distribution of relevant state capabilities and interests. Focusing on these, one common way to express the strategic novelty and challenge of CE has been to contrast its basic structure to that of cutting emissions. Cutting emissions is generally understood as a collective action problem, in which the basic strategic challenge is to motivate and enforce costly contributions to a shared goal, while for CE the basic problem is to bring a widely distributed capability under competent and legitimate collective control. One recent discussion used the vivid 'free-rider vs. free-driver' image to illustrate this distinction: for effective global policy, the basic problem of emissions control is to overcome free-rider incentives, while the basic problem of CE is to corral multiple potential drivers, each able to act alone, into a collective decision process.[37]

Taken to an extreme, this logic would suggest that virtually anyone can do CE—as has been proposed in various colorful scenarios of CE conducted by terrorist groups, apocalyptic cults, or wealthy individuals.[38] But these scenarios overstate the distribution of capabilities and thus the risk of unilateral action, because they focus too narrowly on financial cost as the determinant of capability and neglect other, non-financial requirements and constraints. To assess these other constraints, it is crucial to note that achieving a non-trivial, sustained alteration of global climate requires continued large-scale material inputs. These in turn depend upon delivery equipment and supporting infrastructure—e.g., balloons, tethered pipes, aircraft, ships, backed up by airports, bases, and ports—that are visible, hard to conceal, and vulnerable to military attack. This is not to claim that even powerful states would take such military action lightly, in view of the substantial associated costs and risks; yet such action will clearly be a feasible response for some states under some conditions, if they judge another state's CE actions to threaten their vital interests and have been unable to stop it through other means.

In view of the possibility of such military interdiction, unilaterally achieving a climate 4 T2((s)-1numns)-

controllability, including more dimensions for control of interventions, will increase the potential for opposed interests.[43]

Moreover, the discussion thus far may understate the prospects for opposition, because it assumes some rational process of forming nationally aggregated interests, based on realized or projected climate effects, with each region viewing its recent climate as ideal. But any of these assumptions might not hold. State interests could be driven by smaller-scale patchiness of climate effects within countries and resultant domestic political conflict. Alternatively, climate preferences might shift in response to realized climate changes or to recognition of the possibility of intentional climate control, such that regions' present climate is no longer judged ideal. State interests in CE might also be dominated by non-consequential or non-rational processes—e.g., religious or symbolic commitments, general technological optimism or pessimism, or generalized suspicion about other states' intentions. To the extent these other processes show strong regional variation, they could further increase the possibility of inter-state conflict over CE.

From this sketch of potential state capabilities and interests in CE, two large-scale implications can be drawn about unilateralism in CE. On the one hand, major powers such as the United States are likely to face significant temptations to unilateralism—i.e., to develop CE capabilities unilaterally, to conceal information about plans, research results and capabilities, and to act diplomatically to preserve a unilateral right of action. On the other hand, such unilateral actions are likely to be dangerous and disruptive to international stability.

Temptations to unilateralism may arise from several factors. The scientific and technical challenges of doing CE well—i.e., developing high-benefit, low-risk interventions—are sufficiently large that rich, scientifically advanced nations are likely to have substantial advantages in developing them. Scientific and government elites in such nations may be confident of these advantages, and may also be confident—perhaps overconfident—of their ability to persuade others to their view of CE. Temptations to unilateralism may be exacerbated by anticipation of economic benefits if CE research produces private intellectual property. They may also be exacerbated by the polarization of early debates on

Yet unilateral pursuit of CE is likely to carry serious risks, which also follow from the same observations about the likely distribution of state capabilities and interests. The ability to develop CE capability, and even to deploy it, will not be limited to the US or any single state. Other world powers can do it, possibly just as well; and even if some leading state achieves a technological breakthrough—an approach that is cheaper, safer, or more controllable—less advanced approaches can make similarly large climate perturbations, albeit more crudely. Other states can also assert the same legal arguments for a unilateral right of action. Indeed, states with programs of regional weather modification may be favored in advancing these arguments, due to the blurry line between these activities, which clearly lie within their sovereign authority, and early CE development. With both capabilities and potential justifications broadly distributed, at least among major powers, unilateral pursuit of CE by any world power, including the US, would risk others deciding to do the same; and once any major power decided to pursue this course, attempting to stop them would be difficult and risky.

Moreover, states are likely to perceive strong interests in whether and how other states pursue CE, not just at the deployment stage but also from early unilateral steps to develop capabilities that might make future deployment more likely. As discussed above, the severity of these risks will depend on how states' future interests in CE are aligned or opposed. But given current uncertainties about CE capabilities and effects, these interests might be subject to some degree of influence. In particular, states' perceived interests may form in part reactively, in response to early acts by other states that signal either anticipated rivalry or cooperation over CE. Thus, early unilateral acts by a major state—including development of capabilities, secrecy about intentions, or aggressive declaration of rights of action—may induce others to perceive CE as predominantly rivalrous and to pursue similar acts, either because they interpret these acts to indicate hostile or rivalrous intent or because they infer from these acts that it is valuable to have an independent CE capability. Conversely, early signals of cooperation and openness may have the opposite effect, steering others' perceptions and choices toward cooperation. Given the uncertain and labile nature of future CE capabilities, such cooperative early moves may even influence the direction in which future capabilities are developed, toward those that pose less risk of conflict.

In sum, following a unilateral course in climate engineering—including not just eventual deployment, but also early steps to pursue research and development alone, maintain secrecy about capabilities and results, and reserve unilateral legal rights—is a superficially tempting but dangerous course of action for the United States and other major powers. States should anticipate and resist these temptations and instead pursue a cooperative approach to CE. Such an approach could start immediately with informal consultations on research programs, agreement on common standards for transparency, and joint development of assessment frameworks.[45] A cooperative approach need not involve universal participation, but could start with only the dozen or so nations likely to

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Technology, Washington, 5 November 2009. Available at http://www.gpo.gov/fdsys/pkg/CHRG-111hhrg53007/pdf/CHRG-111hhrg53007.pdf, at pp. 39-41; see also Parson & Keith, n. 6 above

[45] Parson & Keith, n. 6 above

be most interested in developing CE and most able to pursue it unilaterally need not await a comprehensive climate regime. By building cooperation and transparency on CE while the stakes are relatively low, such early cooperation may help build norms for cooperative management of CE, which would then be available to help resolve the more challenging governance problems raised by future proposals for operational interventions.

4. C

credible capacity to act unilaterally, even if the group nominally participating in order. These states are roughly the same group of major economies

otherwise anticipated—when the prospect of the worst climate harms is presently failing to provide adequate motivation for mitigation.

This scenario is not completely implausible, however, but could come about under various assumptions related to uncertain CE effects or non-rational decision-making. For example, future CE use could be perceived as a gamble carrying risk of outcomes worse than uncontrolled climate change. If future decision-makers regard CE as likely to improve matters on average, but have not learned enough to be fully confident it will not worsen harms, they might still favor deploying it as a desperate measure in the face of severe climate change. Looking ahead to this possibility, current decision-makers might be motivated to greater mitigation efforts to avoid this awful future choice. Alternatively, the prospect of deploying CE might somehow gain more saliency or mobilize more horror about the severity of human disruption of the global environment than severe climate change alone. At first glance, these eventualities appear barely plausible—suggesting this scenario is unlikely to motivate much strengthening of near-term mitigation—but cannot be completely dismissed.

The second scenario, Perverse Linkage, would reverse the contingency relationship between mitigation and future CE use from that in the plan B scenario. Under this scenario, states would jointly agree to withhold CE, no matter how severe the climate impacts occurring or anticipated, unless states had achieved some agreed level of acceptable performance on cutting emissions. This scenario admittedly requires some suspension of disbelief, yet is still instructive to explore.

The linkage in this scenario would aim to motivate states cut emissions, to avoid the prospect of facing severe future climate change without access to CE to moderate the impacts. The most obvious difficulty with the scenario is credibility: how could a threat to refuse CE in response to some fu

At the same time, real-time linkage could make CE less politically explosive, both because its deployment would be limited in intensity or spatial extent (albeit also earlier, when it is arguably not “needed” to manage an imminent climate crisis), and crucially, because parallel enactment of mitigation and CE would address the strongest concern about harmful effects of CE, that it may undermine mitigation incentives. Moreover, concurrent linkage would enhance the credibility of nations’ mitigation commitments, because ongoing agreement and authorization to deploy CE—which states would presumably want to continue because of their near-term risk-reduction benefits—would depend on continuing mitigation effort, with performance verifiable year by year. In sum, this scenario would link the two responses both or neither in a political bargain, under which opponents of both mitigation and each tolerate the response they oppose because its scale, cost, and risks are limited by parallel pursuit of the response they favor.

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and oversight of interventions underway, to scan for unanticipated risks and modify or stop interventions as needed.[54] But in this case, these decisions would have to be addressed earlier, under even more uncertainty about effects, and absent the potentially unifying factor of a widely perceived climate crisis.

The effectiveness and risks of these linkage-based strategies will depend on several points of uncertainty, suggesting different priorities that research has targeted thus far. First, in view of the apparent strategic and bargaining advantages of the alternative, near-term modes of CE use, research into methods, effects, risks, and management of these would be valuable in addition to research on the longer-term effects of CE use.