SCIENCE AND REGULATION

End the Deadlock on Governance of Geoengineering Research

Can scientific self-regulation control small-scale research, or is governmental regulation needed?

Edward A. Parson[1]* and David W. Keith[2]

Proposals for research on geoengineering methods to offset greenhouse-gas–driven climate change have attracted controversy (*1*–*6*). Multiple methods have been proposed (*7*), but attention and controversy have centered on methods to reduce incoming sunlight—for example, spreading reflective aerosols in the stratosphere or spraying condensation nuclei to increase low ocean clouds (*1*, *2*). Such high-leverage interventions offer the dual prospect of large benefits and harms. They may reduce climate-change risks faster than any other response. Yet they may also cause environmental harm or worsen policy failures—for example, undermining emissions cuts or triggering international conflict. Research is needed to develop capabilities and assess effectiveness and risks (field research as well as model and laboratory studies), but geoengineering requires competent, prudent, and legitimate governance (*1*, *2*, *8*). We propose specific steps to advance progress on research governance.

Questions of Scale and Self-Regulation

No such governance now exists beyond normal scientific review processes and national laws, so geoengineering outside national territory—from small field research to operational deployment—falls under no international legal control (*9*). Recognizing this void, several projects have tried to develop guidelines on governance of geoengineering research (*10*–*13*). These projects have achieved agreement on the need for research, the need for governance of research, and the principle that as the scale and anticipated risk of interventions increase, so does the need for assessment, scrutiny, and control. But these consensus statements have been at high levels of abstraction, lacking the specificity needed to help any body—governmental or scientific—enact operational governance and assessment procedures.

In particular, no progress has been made on two questions that are basic to designing a governance system. First, if large interventions need more control than small ones, how is the boundary between "small" and "large" defined? Second, can scientific self-regulation adequately control small-scale research, or is government regulation needed—and, if it is, what should be the relation between regulatory and scientific processes?

Debate on these questions is increasingly polarized. One view, advanced by some nongovernmental organizations and a few scientists, invokes direct environmental risks (often exaggerated) and a slippery slope from research to deployment to seek strict control on a broad set of activities—for example, all geoengineering research, all field research, or all active environmental perturbation, no matter how small. Practical obstacles to this approach are considerable, because impacts of proposed research can be tiny relative to many activities not so restricted—for example, single aircraft flights, fish farms, or sewage outfalls. This approach would thus control activities by their purpose, targeting research but not similar nonresearch acts, or geoengineering research but not similar nongeoengineering research, distinctions that would be hard to enforce and create incentives to avoid oversight by concealing an activity's purpose.

An opposing view, widespread but quietly expressed, invokes these practical objections to regulation, plus broad appeals to freedom of inquiry, to reject any new controls on research. This view holds that geoengineering research should be treated as ordinary scientific research, acknowledging no special policy significance or need for scrutiny. It thus presumes that scientific processes and existing regulations can ensure that geoengineering research is done prudently and with minimal environmental risk and that the public will trust that this is so.

Controversy over a rogue ocean fertilization project in 2012 illustrates the risks of the current deadlock. Funded by a Haida village and conducted west of British Columbia, the project spread 100 metric tons of iron-rich dust over 10,000 km^2 of ocean to stimulate phytoplankton growth, aiming to restore depleted salmon stocks and create carbon credits (*14*, *15*). Lacking adequate measurement and controls, the project was apparently done without knowledge of Canadian authorities, yet violated no international law (*16*–*18*). Worldwide controversy followed, including an attempt in the United Nations Convention on Biodiversity to strengthen a 2010 decision opposing all geoengineering research.

Such controversies should be expected because the stark tension inherent in geoengineering's dual prospect—large risk reduction and grave new risks—breeds polarization. We thus expect both periodic recurrence of adventurers pushing reckless, scientifically weak projects and rejecting any control, and zealous opponents seeking to prohibit the entire domain of activities. As in so many conflicts, the extremes reinforce each other: Every irresponsible, ill-conceived intervention—even if tiny in scale and risk—empowers the abolitionists, risking broad bans or burdensome restrictions that frustrate even low-risk, high-value research. In turn, pursuit of such overbroad controls affirms the view of scientists who reject all geoengineering concern as uninformed and antiscientific and encourages adventurers and legitimate scientists alike to find ways to escape scrutiny.

Defining Thresholds, Accepting Oversight

This deadlock poses real threats to sound management of climate risk. Geoengineering may be needed to limit severe future risks, so

NEAR-TERM STEPS TO BREAK THE DEADLOCK

Accept government authority over geoengineering research
- Scientific self-regulation insufficient to manage risks
- First steps: informal coordination; new laws or treaties not required

Declare moratorium on large-scale geoengineering
- Possible large-scale threshhold: nondetectable global climate signal
- Solar methods: threshold defined by area, time, and size of RF perturbation
- Possible threshold: annual average $\Delta RF > \sim 10^{-2}$ Wm^{-2}

State small-scale threshold below which research may proceed
- Modest new requirements: existing regulations, transparency, no forum-shopping
- Possible threshold: annual average $\Delta RF < \sim 10^{-6}$ Wm^{-2}

[1]Emmett Center for Climate Change and Law, UCLA School of Law, Los Angeles, CA 90095, USA. [2]Kennedy School of Government, Harvard University, Cambridge, MA 02138, USA.

*Author for correspondence. parson@law.ucla.edu

Published by AAAS

informed policy judgments require research on its efficacy and risks. If research is blocked, then in some stark future situation where geoengineering is needed, only unrefined, untested, and excessively risky approaches will be available. To avoid this policy train wreck, progress on research governance is needed that advances four aims: (i) letting low-risk scientifically valuable research proceed; (ii) giving scientists guidance on the design of socially acceptable research; (iii) addressing legitimate public concern about reckless interventions or a thoughtless slide from small research to planetary manipulation; and (iv) ending the current legal void that facilitates rogue projects. Although full specification of a governance regime will take time and broad consultation, we propose specific first steps (see the table).

To the extent that projects can raise support from nonscientific sources—as the Haida project did, based on hoped-for operational benefits—they escape peer review and other scientific controls. Effective governance must thus be backed by government authority and coordinated internationally to prevent shopping for lax jurisdictions. Initial steps need not require the delay and inflexibility of enacting new laws or treaties but can come from informal consultation and coordinated decisions by research-funding and regulatory agencies of participating governments.

On the thorny problem of defining regulatory thresholds of project scale and risk, we propose that the first step should state two separate thresholds. Interventions above the large threshold would be subject to a moratorium, with commitments by both scientists and governments: scientists stating that such large interventions serve no present scientific purpose and that they would not conduct them and governments stating that such interventions are not appropriate or prudent and that they would not conduct, fund, or allow them. The threshold's definition may vary for different project types. For solar geoengineering, it might be defined by the product of area, duration, and size of radiative forcing perturbation (ΔRF), perhaps at a level where global climate response is barely detectable—for example, global-annual-average $\Delta RF > \sim 10^{-2}$ Wm^{-2}. The moratorium terms—how long it lasts, or under what conditions—will need delicate negotiation. It cannot be a permanent unconditional ban, because global geoengineering may sometime be needed. Yet it must be long and firm enough to allay concern that small research will slide unexamined into deployment, and so give the assurance needed to let small, low-risk research proceed.

The small-scale threshold would define a second boundary, below which participating governments agree that high-value research may proceed. Its level would reflect the fact that much promising process research has trivial environmental impact, smaller than common commercial activities—for example, average $\Delta RF \sim 10^{-6}$ Wm^{-2}. These are only "geoengineering" research by virtue of their purpose, and imposing large regulatory burdens on them will merely create incentives to misstate their purpose. Even this research must accept some additional regulatory scrutiny to earn public confidence, but the extra burden should be modest. Projects should meet strong transparency requirements: a registry giving advance notice of plans and goals, and full and timely disclosure of results. They must comply with all applicable environmental, health, and safety rules, and this requirement must be made internationally consistent to deter jurisdiction shopping by identifying some set of best-practice rules (perhaps from leading jurisdictions) that projects must follow, no matter where they are conducted.

The large and small thresholds are separated by a wide gulf—a factor of $\sim 10^4$ in our illustrative examples—and our proposal is silent on how to treat interventions that fall between them. We thus avoid the hard governance issues that lie in the wide middle ground, yet we contend that it is the two tails of the scale distribution that need action most urgently, and the simple treatment we propose in each tail meets current needs. Moreover, we expect little added scientific value from expanding interventions to this middle range, so these are unlikely to be pursued at present even without an explicit moratorium.

Geoengineering poses acute and novel challenges that require proactive management, starting with practical and effective governance of research. Opponents of such research must recognize risks of suppressing the study of technologies offering such large potential benefits. Supporters of such research—including scientists who, like one of us, want to do it (*19*)—must accept legitimate societal interests in environmental perturbations that inform and develop a capacity for planetary manipulation, even if the scale and risk of current activities are tiny. These interests justify a modest regulatory burden, enforced by governments, as a societal condition for allowing small-scale research to proceed.

Our proposals are only first steps and do not avoid all risks. Yet we are confident that they can help, in the near term, by framing a social bargain that lets research proceed and, in the long term, by starting to build international norms of cooperation and transparency in geoengineering. There may be a window for cooperation on geoengineering now, because states' views appear more marked by fear of doing something destabilizing and worry over what others may do, than by seeking advantage through some lead in knowledge or capability. States' interests may thus now favor supporting a cooperative scheme such as we propose. Geoengineering is not arms control, at least for now. But if states fail to build cooperation and transparency now when stakes are low, it could become as difficult and fraught as arms control, or more so, in some future of severe climate change. Our proposals aim to nip these future risks in the bud by building shared knowledge and cooperative norms while it is relatively easy.

References and Notes

1. Royal Society, *Geoengineering the Climate: Science, Governance, and Uncertainty* (2009); http://royalsociety.org/policy/publications/2009/geoengineering-climate/.
2. National Research Council, *America's Climate Choices: Panel on Advancing the Science of Climate Change* (National Academies Press, Washington, DC, 2010), pp. 377–388.
3. E. Teller, R. Hyde, L. Wood, *Active Climate Stabilization: Practical Physics-Based Approaches to Prevention of Climate Change* (Report UCRL/JC-148012, Lawrence Livermore National Laboratory, 2002); https://e-reports-ext.llnl.gov/pdf/244671.pdf.
4. S. Levitt, S. Dubner, *SuperFreakonomics* (HarperCollins, New York, 2011).
5. A. Robock, *Bull. At. Sci.* **64**, 14 (2008).
6. C. Hamilton, *The Guardian*, 5 December 2011.
7. D. Keith, *Annu. Rev. Energy Environ.* **25**, 245 (2000).
8. D. W. Keith, E. Parson, M. G. Morgan, *Nature* **463**, 426 (2010).
9. E. Parson, L. Ernst, *Theoret. Inq. Law* **14**, 311 (2013).
10. Asilomar Scientific Organizing Committee, Conference Report (Climate Institute, Washington, DC, 2010); www.climate.org/PDF/AsilomarConferenceReport.pdf.
11. Solar Radiation Management Governance Initiative, *Solar Radiation Management: The Governance of Research* (SRMGI, 2011); www.srmgi.org/report.
12. Bipartisan Policy Center Task Force on Climate Remediation Research, *Geoengineering: A national strategic plan for research on the potential effectiveness, feasibility, and consequences of climate remediation technologies* (BPC, Washington, DC, 2011); http://bipartisanpolicy.org/library/report/task-force-climate-remediation-research.
13. Oxford Geoengineering Programme, *Oxford Principles of Geoengineering Research* (Univ. of Oxford, Oxford, 2009); www.geoengineering.ox.ac.uk/oxford-principles/principles/.
14. M. Lukacs, *The Guardian*, 15 October 2012.
15. D. Biello, *Sci. Am.* (24 October 2012).
16. London Convention and Protocol, Resolution LC-LP.1 (2008) and Assessment Framework (LC 32/17, annex 6) (2008); www.imo.org/blast/mainframemenu.asp?topic_id=1969.
17. Convention on Biological Diversity, Decision X/33; www.cbd.int/decision/cop/?id=12299.
18. E. T. C. Group, World's Largest Geoengineering Deployment off Coast of Canada's British Columbia [news release], 17 October 2012; www.etcgroup.org.
19. D.W.K. is developing a stratospheric experiment to test ozone loss processes from aerosol geoengineering. The project will only proceed with public funding and authorization and will provide open data access and produce no patents. D.W.K. also serves as president of a company developing CO_2 air-capture technology. We regard air capture as so unlike high-leverage geoengineering that our arguments do not apply to it, but disclose this interest because some writers consider the two to be related.

10.1126/science.1232527