argues that the 'crafting of creative solutions to our global collective action problems' requires legal thought to acknowledge 'the importance of multilevel governance and enlist the participation of multiple governance actors' (p. 179), including subnational and non-state actors. Further, Lin's work exemplifies that this will require legal scholarship to go beyond strict doctrinal approaches and combine theoretical insights with empirical research methods.[16] The next step should be to analyze the climate governance practices developed by actors other than cities – such as businesses, investors, and civil society groups. A better understanding of the activities of the various constituencies that seek to contribute to the global response to climate change is required to design a post-Paris governance architecture that builds on optimal partnerships between states, subnational, and non-state actors.

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Transnational Environmental Law, 8:1 (2019), pp. 197–202 © 2019 Cambridge University Press
doi:10.1017/S2047102519000025

Climate Engineering and the Law, edited by Michael B. Gerrard and Tracy Hester
Cambridge University Press, 2018, 360 pp, £81.99 hb, $92 e-bk
ISBN 9781107157279 hb, 9781108663397 e-bk

Climate engineering is the 'deliberate large-scale manipulation of the planetary environment to counteract anthropogenic climate change'.[1] Climate engineering technologies can be divided into two broad categories: carbon dioxide removal (CDR), and solar radiation management (SRM). CDR aims to remove heat-trapping carbon dioxide (CO_2) directly from the atmosphere and store it in terrestrial or oceanic sinks. SRM aims to reflect a portion of sunlight away from the Earth to cool global temperatures. In its October 2018 special report on limiting global warming to 1.5°C above pre-industrial levels, the Intergovernmental Panel on Climate Change (IPCC) indicated that CDR will have an important role to play in limiting the risk and severity of climate change impacts.[2] According to the IPCC, '[a]ll pathways that limit global warming to 1.5°C with limited or no overshoot project the use of [CDR] on the order of 100–1000 $GtCO_2$ [gigatonnes CO_2] over the 21^{st} century'.[3] The IPCC

16 L. Mai, 'The Growing Recognition of Transnational Climate Governance Initiatives in the UN Climate Regime: Implications for Legal Scholarship' (2018) 8(3–4) *Climate Law*, pp. 183–94, at 192–3.

1 J. Shepherd et al., *Geoengineering the Climate: Science, Governance and Uncertainty* (The Royal Society, 2009), p. 1, available at: https://royalsociety.org/~/media/royal_society_content/policy/publications/2009/8693.pdf.

2 IPCC, *Global Warming of 1.5°C* (IPCC, 2018), available at: http://www.ipcc.ch/report/sr15.

3 M. Allen et al., 'Summary for Policymakers', in IPCC, ibid., p. 23.

did not include SRM in its modelling pathways,[4] but proponents suggest that SRM may also have an important role to play in preventing global mean temperatures from overshooting the Paris Agreement targets, which aim to keep global average temperature increases well below 2°C.[5] Climate engineering is therefore emerging as an increasingly important tool for responding to climate change.

Climate engineering, however, presents significant governance challenges. CDR and SRM technologies may have negative environmental impacts and some proposals, such as stratospheric aerosol injection, pose risks of transboundary harm.[6] Many technologies are yet to be tested beyond computer modelling and/or laboratory settings, and scientists are therefore uncertain as to their efficacy, feasibility, and side effects.[7] Some sceptics of climate engineering also fear that the research and development of climate engineering technologies might detract from conventional mitigation efforts.[8] Climate engineering technologies additionally raise questions about procedural and distributive justice.[9] For example, who should determine if and when climate engineering technologies are to be used?[10] To what extent should the general public be consulted regarding climate engineering activities?[11] Climate engineering technologies may have disproportionate impacts on different regions, which raises questions as to whether state and/or non-state actors can be compensated for any losses suffered.[12] These issues require the development of robust governance mechanisms. It is therefore important to understand how domestic and international law might contribute to climate engineering governance.

Climate Engineering and the Law is a timely contribution to scholarship on this issue. The book is a collection of chapters by established researchers in the field of climate engineering governance, edited by legal scholars Michael B. Gerrard and Tracy Hester. The overall purpose of the book is to examine the extent to which

4 Ibid., pp. 16–7.

5 Paris (France), 13 Dec. 2015, in force 4 Nov. 2016, available at: https://unfccc.int/sites/default/files/english_paris_agreement.pdf. See A. Parker & O. Geden, 'No Fudging on Geoengineering' (2016) 9(12) *Nature Geoscience*, pp. 859–60.

6 See K. Brent, J. McGee & J. McDonald, 'The Governance of Geoengineering: An Emerging Challenge for International and Domestic Legal Systems?' (2015) 24(1) *Journal of Law, Information and Science*, pp. 1–33.

7 See, e.g., A. Robock, 'Albedo Enhancement by Stratospheric Sulphur Injections: More Research Needed' (2016) 4 *Earth's Future*, pp. 644–8; M. Lawrence et al., 'Evaluating Climate Geoengineering Proposals in the Context of the Paris Agreement Temperature Goals' (2018) 9 *Nature Communications* online articles, article no. 3734, available at: https://www.nature.com/articles/s41467-018-05938-3.

8 See, e.g., A. Lin, 'Does Geoengineering Present a Moral Hazard?' (2013) 40(3) *Ecology Law Quarterly*, pp. 673–712.

9 D. Morrow, 'Some Ethical Issues in Geoengineering', Carnegie Climate Geoengineering Governance Initiative, 21 Dec. 2017, available at: https://www.c2g2.net/ethical-issues-geoengineering.

10 For further discussion of key ethical issues, see C.J. Preston, 'Ethics and Geoengineering: Reviewing the Moral Issues Raised by Solar Radiation Management and Carbon Dioxide Removal' (2013) 4(1) *WIREs Climate Change*, pp. 23–37.

11 See, e.g., W.C.G. Burns & J.A. Flegal, 'Climate Geoengineering and the Role of Public Discourse: A Comment on the US National Academy of Sciences' Recommendations on Public Participation' (2015) 5(2–4) *Climate Law*, pp. 252–94.

12 Morrow, n. 9 above.

existing international and United States (US) domestic laws meet the governance challenges posed by climate engineering technologies. The book also aims to promote further consideration of the role that international and domestic law should play in the future development and deployment of these technologies.

Gerrard begins in Chapter 1 by explaining what climate engineering is and how CDR and SRM might contribute to climate change policy alongside conventional mitigation and adaptation strategies. Gerrard also introduces each chapter and gives an overview of the governance challenges and legal frameworks analyzed therein. In Chapter 2, Eli Kintisch examines prominent CDR and SRM technologies, including stratospheric aerosol injection,[13] bioenergy with carbon capture and storage (BECCS),[14] and ocean fertilization.[15] Kintisch explains the scientific principles that underpin each technology, describes the current stage of development (i.e., whether research has progressed to field testing), and highlights potential challenges for research and/or deployment. Such challenges include negative environmental impacts, limitations for large-scale deployment,[16] and commercial interest in the development of some technologies.[17] These explanations are concise, and readers wishing for more detailed evaluations may want to consult additional sources.[18] Kintisch nevertheless provides readers with the necessary technical background that underpins the following chapters.

In Chapter 3, Jesse Reynolds examines how rules of international law might apply to climate engineering technologies. At almost 150 pages, this chapter is extremely comprehensive. Reynolds provides a detailed analysis of pertinent international agreements, including the Paris Agreement,[19] the United Nations Convention on the Law of the Sea (UNCLOS),[20] and the ocean dumping regime,[21] as well as rules of customary international law. Reynolds also considers international agreements often

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[13] These are proposals to place aerosol particles in the upper atmosphere to reflect incoming sunlight, thereby mimicking the cooling effect of large-scale volcanic eruptions: see Lawrence et al., n. 7 above, p. 10.

[14] BECCS involves burning plant matter for energy, capturing the CO_2 produced during the combustion process, and storing it in geological formations: see National Research Council, *Climate Intervention: Carbon Dioxide Removal and Reliable Sequestration* (National Academies Press, 2015), p. 67, available at: http://www.nap.edu/catalog/18805/climate-intervention-carbon-dioxide-removal-and-reliable-sequestration.

[15] Ocean fertilization involves 'seeding' the ocean with key nutrients (iron, phosphorus or nitrogen) to stimulate a phytoplankton bloom. The phytoplankton draw CO_2 from the atmosphere through photosynthesis, and the idea is that marine biological processes might sequester some CO_2 in the deep ocean: ibid., pp. 56–8.

[16] E.g., large-scale implementation of BECCS will require significant areas of dedicated cropland that will have implications for existing land use: E. Kintisch, 'Technologies', in M. Gerrard & T. Hester (eds), *Climate Engineering and the Law* (Cambridge University Press, 2018), pp. 28–56, at 45–6.

[17] E.g., commercial interest in the development of ocean iron fertilization: ibid., pp. 47–8.

[18] E.g., National Research Council, *Climate Intervention: Reflecting Sunlight to Cool the Earth* (National Academies Press, 2015), available at: http://www.nap.edu/catalog/18988/climate-intervention-reflecting-sunlight-to-cool-earth; National Research Council, n. 14 above.

[19] N. 5 above.

[20] Montego Bay (Jamaica), 10 Dec. 1982, in force 16 Nov. 1994, available at: http://www.un.org/depts/los/convention_agreements/texts/unclos/closindx.htm.

[21] Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, London (United Kingdom), 13 Nov. 1972, in force 30 Aug. 1975, available at: http://www.imo.org; Protocol to

overlooked in geoengineering governance literature, such as the 1998 UNECE Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (Aarhus Convention),[22] the Antarctic treaty system,[23] and principles of international environmental law, including the principles of common but differentiated responsibilities (CBDR) and intergenerational equity. In doing so, Reynolds emphasizes the challenges that climate engineering technologies pose for international law and the need for legal scholars with different expertise to engage with this topic.

The book then moves from the international sphere into the domestic. In Chapter 4, Albert Lin considers relevant state and federal law in the US. In Chapter 5, Hester examines the issue of liability and compensation for harm from climate engineering activities and considers potential liability mechanisms under international and US law. Domestic law is likely to play an important role governing geoengineering research in the near term, especially as laboratory research and computer modelling lead into small-scale outdoor experiments. As this book points out, some CDR technologies are unlikely to have significant transboundary impacts and may therefore require governance only at the domestic level. However, to date, there has been limited legal scholarship on the capacity of domestic law to govern climate engineering.[24] These chapters therefore make an important contribution to the literature by considering the extent to which US domestic law – including environmental protection legislation, weather modification laws, and tort law – may govern climate engineering technologies. The chapters suggest that existing domestic law may provide a rudimentary governance framework for some climate engineering technologies in the US, but these laws were not developed with climate engineering in mind. More targeted rules will therefore need to be developed to comprehensively govern climate engineering technologies in the US.

In Chapter 6, Michael Burger and Justin Gundlach focus on the governance of climate engineering research (as opposed to full-scale deployment). They argue that

the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, London (United Kingdom), 7 Nov. 1996, in force 24 Mar. 2006, available at: http://www.imo.org.

22 Aarhus (Denmark), 25 June 1998, in force 30 Oct. 2001, 2161 available at: http://www.unece.org/env/pp/welcome.html.

23 Ch. 3 specifically considers the Antarctic Treaty, Washington, DC (US), 1 Dec. 1959, in force 23 June 1961, available at: https://www.ats.aq/e/ats.htm; and the Protocol on Environmental Protection to the Antarctic Treaty, Madrid (Spain), 4 Oct. 1991, in force 14 Jan. 1998, available at: http://www.ats.aq/e/ep.htm.

24 Notable exceptions include C. Armeni & C. Redgwell, 'Geoengineering under National Law: A Case Study of Germany', *Climate Geoengineering Governance Working Paper Series*, No. 024, 9 Mar. 2015, available at: http://geoengineering-governance-research.org/perch/resources/workingpaper24armeniredgwellgermany.pdf; C. Armeni & C. Redgwell, 'Geoengineering under National Law: A Case Study of the United Kingdom', *Climate Geoengineering Governance Working Paper Series*, No. 023, 9 Mar. 2015, available at: http://geoengineering-governance-research.org/perch/resources/workingpaper23armeniredgwelltheukcombine.pdf; N. Craik, J. Blackstock & A. Hubert, 'Regulating Geoengineering Research through Domestic Environmental Protection Frameworks: Reflections on the Recent Canadian Ocean Fertilization Case' (2013) 7(2) *Carbon & Climate Law Review*, pp. 117–24; S. Schäfer et al., *The European Transdisciplinary Assessment of Climate Engineering (EuTRACE): Removing Greenhouse Gases from the Atmosphere and Reflecting Sunlight away from Earth* (EuTRACE, 2015), pp. 90–3, available at: http://www.eutrace.org.

effective governance is necessary for research to progress. As part of this chapter, Burger and Gundlach examine the Asilomar and Oxford principles, which are voluntary codes of conduct developed by scientists and social scientists to govern climate engineering research.[25] These principles call for research to be conducted responsibly and transparently, with independent assessment and public engagement. Burger and Gundlach consider how these general principles might be implemented in climate engineering research projects – for instance, in how research funding is allocated, and the extent to which the public is informed and consulted regarding a climate engineering project. Gerrard and Hester conclude the book in Chapter 7 by recommending the further development of international and US domestic law to better meet the governance challenges posed by climate engineering. For climate engineering activities likely to have transboundary effects, this chapter recommends developing a new international agreement under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC).[26] It also identifies governance elements that will need to be addressed by such an agreement, such as processes and principles to authorize climate engineering activities, procedures for public deliberation, and liability and compensation mechanisms.

Climate Engineering and the Law is a useful source of information about this evolving area of climate change policy and governance. The editors and contributors have expertly pitched the book to an interdisciplinary audience. It provides clear, non-technical explanations of climate engineering proposals based on the latest scientific research. The book therefore offers international and environmental law scholars an up-to-date introduction to key CDR and SRM proposals and the governance challenges they pose. The analysis of international and US domestic law is extensive and raises broader questions about the capacity of these legal systems to govern emerging technologies. However, this analysis is not targeted exclusively at a legal audience. The authors have made a conscious effort to explain fundamental legal terms and concepts. For example, Chapter 3 provides concise explanations of the principle of state sovereignty and the formation of customary international law. The legal analysis in this book is therefore accessible to readers from other disciplines.

Unfortunately, the book does not analyze domestic legal systems outside the US. While the consideration of US tort law in Chapter 5 will be of interest to legal scholars from common law jurisdictions, the analysis of domestic law may otherwise be of limited use to legal scholars and climate engineering researchers outside the US. By focusing only on US domestic law, the editors have also missed an opportunity to develop a comparative analysis of climate engineering governance under different domestic legal systems.

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25 Asilomar Scientific Organizing Committee, 'The Asilomar Conference Recommendations on Principles for Research into Climate Engineering Techniques', Conference Report, Climate Institute, Nov. 2010, available at: http://www.climateresponsefund.org/images/Conference/finalfinalreport.pdf; S. Rayner et al., 'The Oxford Principles' (2013) 121(3) *Climatic Change*, pp. 499–512.

26 New York, NY (US), 9 May 1992, in force 21 Mar. 1994, available at: https://unfccc.int/resource/docs/convkp/conveng.pdf.

These concerns aside, *Climate Engineering and the Law* skilfully demonstrates that existing international and domestic law will play an important role in the governance of climate engineering technologies, but more targeted rules are needed to fill gaps in existing frameworks. Given the assumptions about the future availability and use of climate engineering technologies in modelling scenarios, it is essential that climate change lawyers are well-informed about these proposals and are prepared to contribute to the development of international and domestic governance. *Climate Engineering and the Law* is therefore an essential read for climate change lawyers. Climate engineering is the next big challenge for climate change law and policy. We hope that this book will inspire a new wave of critical legal scholarship on this issue, especially on the capacity of other domestic legal systems to govern climate engineering technologies.

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Transnational Environmental Law, 8:1 (2019), pp. 202–207
doi:10.1017/S2047102519000037

Compliance and Enforcement of Environmental Law (Volume IV, Elgar Encyclopedia of Environmental Law), edited by LeRoy C. Paddock, David L. Markell and Nicholas S. Bryner
Edward Elgar, 2017, 288 pp., £121.50 hb, ISBN 9781783477678

A strong and effective enforcement programme that enables officers to take appropriate action against environmental offenders is a necessary component of any robust regulatory regime.[1] It is somewhat surprising, therefore, that the book *Compliance and Enforcement of Environmental Law* is one of the first comprehensive transnational investigations of the law and practice of environmental compliance and enforcement. The book discusses both officially sanctioned and informal enforcement tools, as well as the theories behind environmental enforcement, providing a very useful inventory of the latest legal reforms and case studies in environmental compliance and enforcement. The book consists of 18 chapters and is divided into four parts, organized under the sub-themes of non-regulatory approaches to compliance (Part I), civil enforcement (Part II), criminal enforcement (Part III), and 'special issues' in compliance and enforcement (Part IV). Within these sub-themes, the book includes chapters focused on environmental management systems, enforceable regulations, settlement, and organizational liability for environmental crimes. It includes a collection of case studies that cut across multiple jurisdictions, from (developed) common law countries

[1] International Network for Environmental Compliance and Enforcement (INECE), *Principles of Environmental Compliance and Enforcement Handbook* (INECE, 2009).