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De facto governance: how authoritative assessments construct climate engineering as an object of governance

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ABSTRACT

Analyses of climate engineering (CE) governance have accelerated in the last decade. A key claim is that CE remains a largely ungoverned space, with shared norms, institutional arrangements, and formal rules to regulate CE not yet present. In contrast, here it is argued that de facto governance of CE is underway, discernible in an ordering of this nascent field of inquiry by unacknowledged sources of steering. One key source of de facto governance is analyzed: high-level 'authoritative assessments' of CE. The focus is on how these assessments are constructing CE as an object of governance through demarcating and categorizing this emerging field of inquiry, and how this contributes to normalizing and institutionalizing CE research (and CE research communities). Scrutinizing the distinct nature and political implications of de facto governance, particularly of novel and speculative technological trajectories not yet subject to formal steering, remains a key task for governance scholars.

KEYWORDS De facto governance; climate engineering; geoengineering; scientific assessments; carbon dioxide removal; solar radiation management

Introduction

One of the most pressing and intractable societal challenges of our times is how to imagine, anticipate and govern our collective climate future(s). Such challenges come into even sharper focus in the context of debates, now raging, around whether a set of technological interventions collectively categorized as 'climate engineering' can provide a way forward to prevent the worst consequences of climate change. Climate engineering had been defined as the 'deliberate, large-scale manipulation of the planetary environment in order to counter anthropogenic climate change' (Shepherd *et al.* 2009, p. ix). It is a quintessential anticipatory governance challenge (Gupta 2011), wherein the perils and promises

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associated with a suite of CE options remain uncertain, contested and to large extent unknowable (Foley *et al.* 2015).

Notwithstanding this, climate engineering (henceforth CE) is the subject of growing scientific and academic scrutiny, including in the social sciences. In particular, governance analyses of CE have accelerated in the last decade. A central tenet of such analyses is that CE remains a largely ungoverned space, usually understood to mean that shared norms, institutional arrangements and formal rules to regulate CE-related research and potential deployment are largely non-existent. The vast majority of CE governance analyses focus on debating what such norms, institutional arrangements and rules could or should be, usually accompanied by description of the few formal governance arrangements that do exist (Pasztor *et al.* 2017).

In contrast to existing analyses, our point of departure is that CE is *already* a governed space. Despite the relative absence of formal governance arrangements, we advance the proposition that an emerging de facto governance of CE is discernible, by which we understand, following Rip (2010), sources of governance that are *unacknowledged and unrecognized* as seeking to govern, even as they exercise governance effects. Understood as such, de facto governance is distinct both from formal, state-led, legally binding *de jure* forms of steering, as well as informal, non-state sources of steering, which share the characteristic of intentionally seeking to steer the behavior of certain actors or institutions, in order to realize specific, openly stated goals. If so, scrutinizing the nature and implications of de facto governance remains all the more necessary, given that it is not subject to the political oversight that accompanies, to greater or lesser extent, more intentional/acknowledged sources of governance.

Our interest here is to explore the workings of what we see as one key source of de facto governance: authoritative assessments. By this, we mean expert-led, multi-author assessments produced by eminent scientific bodies advancing state-of-the-art understandings of novel and politically contested environmental and technological fields. We see these as 'authoritative' insofar as they leverage and reflect the scientific eminence associated with the institutional context from which they emerge, which serves to endow them with epistemic authority and legitimacy, but also a steering capacity.[1] The dominant view of such assessments is that they survey an emerging field in order to advance knowledge, outline gaps in governance and/or identify appropriate principles to underpin (future) governance arrangements. In contrast, we discuss how such authoritative assessments constitute a source of de facto governance themselves, and consequently shape the context for *de jure* types of governance.

We proceed as follows: in the subsequent section, we flesh out the concept of de facto governance, and advance an analytical framework to specify interventions and effects expected from such governance. Next, we

analyze how two CE-focused authoritative assessments have helped to construct CE as an object of governance, and thereby steered research trajectories (and communities) in specific directions. These are the 2009 Royal Society report on 'Geoengineering the Climate: Science, Governance and Uncertainty' (Shepherd *et al.* 2009) and the 2015 National Academy of Sciences report on 'Climate Intervention: Reflecting Sunlight to Cool Earth' (McNutt *et al.* 2015b). We conclude with the implications of our findings for further research into de facto governance, including its nature, effects and political implications.

Conceptualizing de facto governance: interventions and effects

Our use of the term 'de facto governance' draws on analyses of this phenomenon in the context of nanotechnology (Rip 2010). According to Rip, de facto governance refers to scattered 'actions and interactions and how these add up to outcomes at the collective level that function as governance arrangements' (Rip 2010, p. 287). It is important to note that in such an understanding, neither governor nor governed is necessarily identified or recognizable in these terms, even as actions and interactions generate specific outcomes at a collective level that constitute governance. This understanding resonates closely with early ideas on governance advanced by global governance scholar James Rosenau. Conceptualizing governance as an emergent system of rules, Rosenau (1995, p. 13) pointed out the need to search for 'order in disorder', specifying 'authorities that are obscure' and 'boundaries that are in flux' as important elements in the study of global governance. He also described how patterns of order at the collective level evolve out of myriad interactions between individuals who are not explicitly understood to be, or acknowledged as, rule-makers themselves (Rosenau 1990).

Drawing on these two sources, we use de facto governance to capture the idea that unacknowledged steering is discernible from the effects generated, and that these effects are neither mandated nor openly pursued as governance goals by de facto governors. Such an understanding is aligned with the Oxford dictionary's definition of de facto to mean 'unacknowledged, unrecognized, but actual, manifesting in reality'. The steering entailed in de facto governance is not explicitly recognized as an act of governing by others, even as it steers a field of inquiry in specific directions, thereby also shaping the context for *de jure* governance.

Operating with such an understanding of de facto governance, specific sources of such governance become important to identify and analyze. We view 'authoritative assessments' as one key source of such unacknowledged steering. While much recent CE scholarship has emphasized the need to develop appropriate mechanisms to govern scientific research, a de facto

governance perspective emphasizes that some scientific activities (including assessments) themselves generate governance effects. Owen (2014) for example has explored in detail the role of expert reports and expert-generated principles as sources of de facto CE governance. With a slightly different focus, Oldham and colleagues document how the evolution of research funding, author networks and patenting patterns within CE research from 1971 through 2013 'can *de facto* shape the development of the field' (2014, p. 1, italics added).

Our analysis builds on this important earlier work by bringing de facto governance more front and center within mainstream CE governance analyses. In particular, we see a need to draw greater attention to this phenomenon within political science and international relations analyses of politically contested and novel technological trajectories, where the contours of an emerging field of inquiry are neither agreed nor wholly knowable. In such instances, a crucial, first-order intervention is delineation of the object of governance, i.e. specifying 'what is to be governed', often through demarcating and categorizing an emerging field of inquiry. Writings within science and technology studies have long noted how categorization is a political act of steering and control that constructs objects (or subjects) of governance through processes of inclusion and exclusion (e.g. Bowker and Star 1999). Equally, scientific assessment processes that serve to demarcate, categorize and thereby frame and construct an object of governance are political acts that shape a field of inquiry and the context for formal (*de jure*) governance (Jasanoff and Long-Martello 2004, Gupta 2006, Dooley and Gupta 2017). As such, we posit here that demarcation and categorization, as incorporated within authoritative assessments, are likely to be powerful acts of de facto steering.

With regard to the effects that such acts of de facto governance might generate, Rip suggests examining consequences for '…legitimacy, governability and the directions that are pushed' (2010, p. 6). In line with this, we specify an overarching potential effect of de facto governance that is likely to flow from acts of demarcation and categorization: the *ordering* of a nascent and highly contested field of inquiry. Such an ordering, we further posit, occurs through normalizing and institutionalizing specific research and governance directions, and thereby also shaping the context for *de jure* governance.

We capture these interventions and potential effects in Figure 1, which serves as our analytical lens. Our aim is not to posit linear causal relationships, but rather to depict what we see as key elements that help to delineate and systematically analyze the phenomenon of de facto governance.

Figure 1 captures how, in our view, a de facto governance intervention, consisting of an act of demarcation and/or categorization of a contested

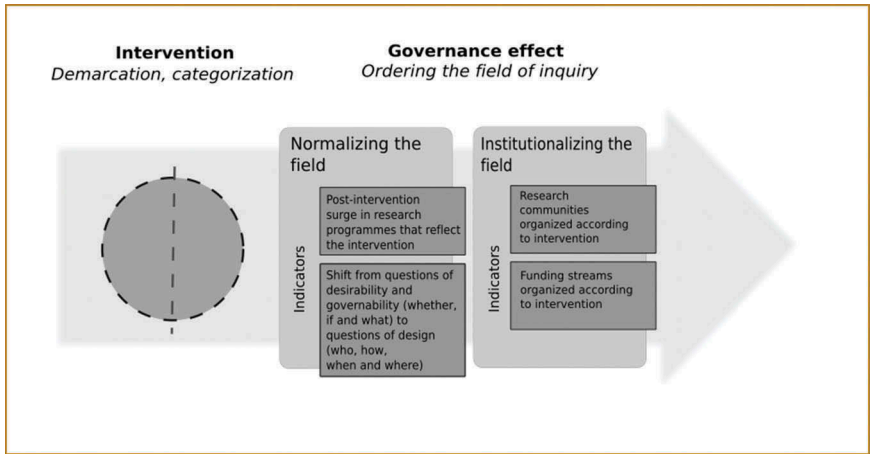

Figure 1. De facto governance by authoritative assessments: interventions and effects.

field of inquiry, may help to order research and governance directions in specific ways. In particular, we identify two sequential components of such a process of ordering: normalization and institutionalization of research and governance directions, with establishment of research programs, delineation of research communities, creation of funding streams and a shift in the nature and direction of the governance conversation serving as indicators through which to ascertain such ordering effects.

De facto governance of CE: steering through assessment

We turn here to our analysis of authoritative assessments as a key source of de facto CE governance. Our aim is to be illustrative rather than comprehensive, hence we identify one core act of demarcation contained within each of these two assessments. We then discuss how this has constructed CE as an object of governance, and contributed to normalizing and institutionalizing CE research directions, thereby also shaping the context for (future) *de jure* governance.

Authoritative assessment I: the Royal Society report

In 2009, the UK Royal Society published a report entitled 'Geoengineering the Climate: Science, Governance and Uncertainty' (Shepherd *et al.* 2009). Written by 12 scientists, the report was a considerable endorsement of the scientific worthiness of what was, until then, a nascent and largely speculative and controversial field of inquiry. We consider this report to be an 'authoritative

assessment' because of the eminence associated with the UK Royal Society, and the prolific subsequent references to this report throughout the CE literature.

The report identified CE as a topic of urgency for the international research agenda on climate change. As earlier insightful analyses have shown, the report served, first and foremost, to legitimize CE as an object of research (Owen 2014). We assess here how this assessment has de facto governed the CE space. In particular, we focus on a key act of demarcation contained herein: the categorizing of CE into two groups of techniques, carbon dioxide removal (CDR) and solar radiation management (SRM). We explain below the context in which this demarcation was introduced, and steering effects flowing from it.

The intervention: categorizing CE techniques as CDR and SRM

In the early 1990s, suggestions to engineer the Earth's climate were met mostly with suspicion, and there were few attempts to develop typologies or classify CE technologies. The most common denominator in this emerging field was that CE connoted the large-scale, intentional manipulation of the climate system to combat global warming. Scale and intent thus underpinned early renditions of the 'what' question around CE. As Jamieson (1996, p. 325) put it, '[w]hat makes geoengineering suspect in the eyes of many is lack of familiarity with the technologies, and the scale and magnitude of the proposals'. Schelling (1996, p. 303) described CE as 'something global, intentional, and unnatural'. There was no widely shared reference point for what CE was or how it should be conceptualized, beyond scale, magnitude and intentionality.

Many argue that wider discussion of CE technologies was made both scientifically and socially acceptable after Nobel Prize winner Paul Crutzen published an article advocating for more research on using sunlight deflection to moderate global warming (Crutzen 2006), one of the key approaches within CE debates today. Drawing attention to a climate altering technique that had been suggested several decades earlier, Crutzen's proposition to inject sulfate particles into the stratosphere as a means to deflect incoming solar radiation resulted in an exponential increase of publications on what came to be referred to as stratospheric aerosol injection (SAI) (Oldham *et al.* 2014). While some took the publication as a cue to research SAI and CE more generally, Crutzen's promotional language was not well received by all and caused heated discussion on the feasibility and desirability of SAI and other CE techniques in the research community (e.g. Robock 2008).

It is in this context that the Royal Society report and its act of demarcation appeared. In a stated effort to provide a neutral and balanced assessment on a subject 'bedeviled with much doubt and confusion' (Shepherd *et al.* 2009, p. v), the report included a demarcation and categorization act relating to CE, consisting of two important dimensions. The first dimension

was to categorize CE technologies along the lines of earth system parameters (in particular, types of radiative forcing) and underlying physical processes, namely whether specific techniques removed carbon dioxide from the atmosphere (CDR) or reflected incoming sunlight back into space (SRM). The reasoning underlying this distinction was that CDR techniques (including land-use management, bioenergy with carbon capture and sequestration (BECCS), mineral weathering, direct air capture and ocean iron fertilization) addressed 'the root cause of climate change by removing greenhouse gases from the atmosphere', while SRM techniques (altering surface or marine cloud reflectivity, SAI and space mirrors) focused on altering solar reflectivity as a way to 'offset' the effects of greenhouse gas concentrations in the short run (Shepherd *et al.* 2009, p. ix). The difference in physical earth system processes, or 'mode of action', was considered so fundamental that the report proposed a division between CDR and SRM techniques, with correspondingly distinct governance considerations.

A second dimension of this categorization was that the report attributed different levels of risks and societal desirability to the two groups of CE technologies. It went on to state that '[i]n most respects Carbon Dioxide Removal methods would be preferable to Solar Radiation Management methods because they effectively return the climate system to closer to its natural state, and so involve fewer uncertainties and risks' (*sic*, Shepherd *et al.* 2009, p. x). SRM was asserted to be more problematic overall, with the report noting that 'Solar Radiation Management methods should not be applied unless there is a need to rapidly limit or reduce global average temperatures' (Shepherd *et al.* 2009, p. xi).

Although widely used today, this was not the only categorization option available or even necessarily dominant at the time of the Royal Society's endorsement of it. Alternative ways to carve up the spectrum of CE technologies were available. These included, for example, distinguishing between interventions deployed in the global commons versus within national territories. SRM technologies like SAI, space mirrors and marine cloud brightening, and CDR technologies such as ocean iron fertilization are all deployed in the global commons, raising legal challenges that are distinct from technologies deployed within national boundaries. Land-intensive approaches like afforestation and BECCS, deployed within national-borders, raise issues of exploitation and justice that are distinct from space or ocean-based technologies (whether carbon or solar radiation focused) deployed in the global commons, given the lower potential to infringe on the land-use rights of vulnerable populations. Another possible categorization was to distinguish between contained versus open ecosystem techniques, which also cuts across the SRM/CDR spectrum. Thus, contained technologies (the CDR technique

of direct air capture or the SRM technique of space mirrors) could ostensibly be seen to pose lower risks to biodiversity, for example, than techniques designed to alter ecosystems (such as the SRM technique of SAI, or the CDR techniques of ocean iron fertilization and BECCS).[2]

These alternatives notwithstanding, the report's opting for a categorization based on physical (earth system) parameters was seen by many as justifiable, also considering the scientific history of the field[3] and the disciplinary make-up of the authors on the Royal Society report writing team (mainly natural scientists). Our aim here is not to suggest that specific alternative typologies could or should have been put forward by the report, but rather to analyze how this chosen demarcation has served as an act of de facto governance in constructing CE as an object of governance, and shaping CE research and governance directions. We turn next to exploring such effects.

Governance effects: ordering the field of inquiry

We draw on our analytical lens to consider how specific CE research and governance directions have been normalized and institutionalized as a result of the Royal Society's CDR/SRM demarcation act. In terms of normalizing research directions, similar to the surge in academic publications documented by Oldham *et al.* (2014) after Paul Crutzen's call for research on SAI, the Royal Society report was followed by multiple CE research programs being established, many of which referred directly to the Royal Society report in motivating their purpose, and most of which adhere to the CDR/SRM demarcation.

Figure 2 below shows the release of the Royal Society report in 2009 and the wave of government inquiries on CE by the UK, US and German parliamentary bodies that followed in its wake, all of which prominently refer to the report. In the same period, some of the first coordinated CE research projects were established. Most of these were UK-based and drew their legitimacy and purpose directly from the report's recommendations. This legitimizing function of the report lasted until the Intergovernmental Panel on Climate Change (IPCC) included the topic of CE prominently in its 2014 Assessment Report (AR5), after which many CE research projects referred to the international scientific body for legitimacy.

Nevertheless, the Royal Society report left its mark in terms of language and categorization. Regardless of whether the report is referred to at the outset or not, almost all research projects listed in Figure 2 categorize CE in terms of CDR and SRM. Furthermore, the report's emphasis on SRM as the most controversial group of CE technologies is reflected in the exclusive focus on this sub-set of CE techniques in six coordinated research projects.

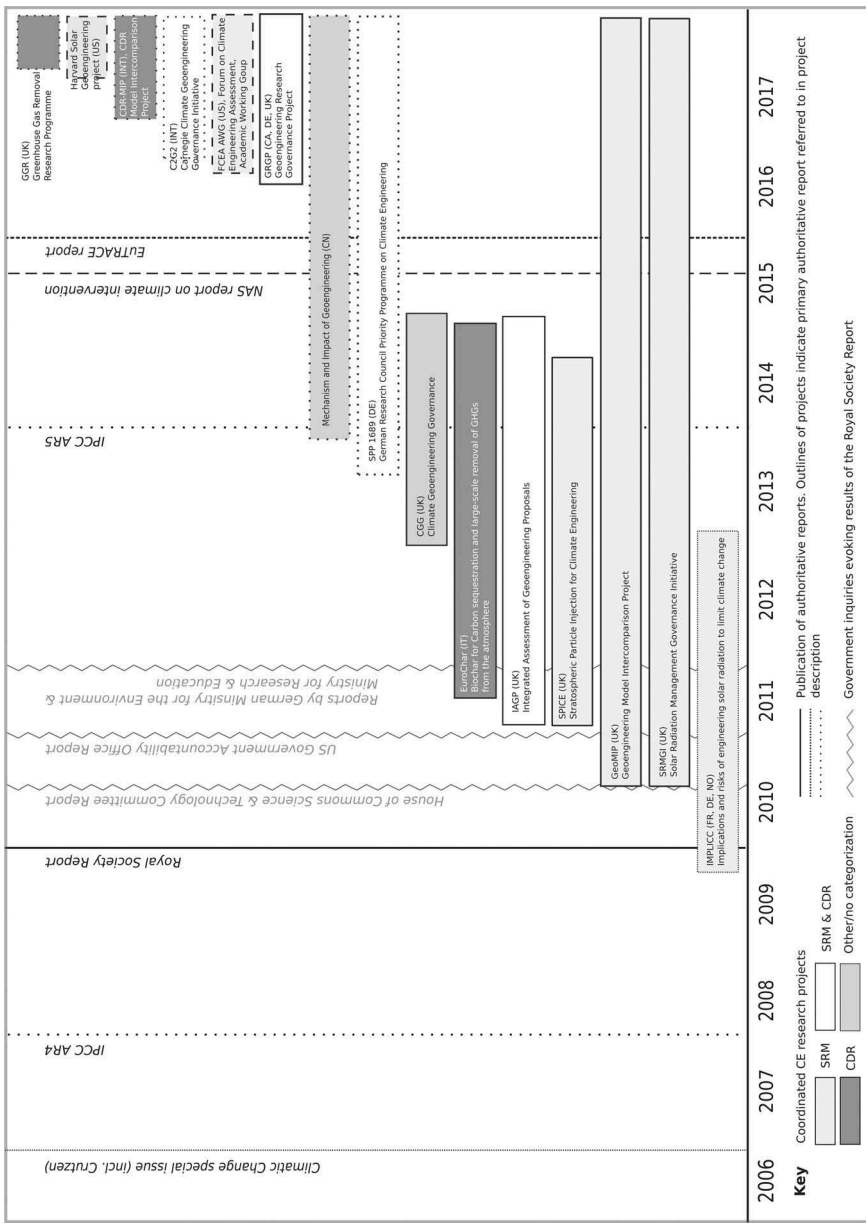

Figure 2. Ordering the field of inquiry: timeline and focus of research projects on CE.

Even those projects that examine CE writ large use the categorization in their project descriptions.

An interesting example of divergence from this categorization is the recently initiated Chinese 'mechanism and impacts of geoengineering project', which describes CE in terms of the CDR/SRM categorization for definitional purposes, but then explicitly opts for a different categorization – one that distinguishes between land/surface processes, atmospheric processes and ocean processes – for the conduct of actual CE research (Cao *et al.* 2015). This illustrates both the pervasiveness of the Royal Society's demarcation act and the utility of alternative categorizations to guide research, even that with a predominantly physical science orientation.

Equally striking is that emerging social science CE research initiatives and networks, most of which focus on governance (and hence could have chosen to work with a different framing and categorization) also uphold the CDR/SRM demarcation. Examples include the recently initiated Geoengineering Research Governance Project, which aims to create a code of conduct for CE research and deploys the CDR/SRM distinction. Similarly, the Carnegie Climate Geoengineering Governance Initiative, aiming to move CE governance debates into the political and policy realm, also differentiates between CDR and SRM. We see the widespread reference to this demarcation as a clear indicator of a normalization process.

Another indicator of how the Royal Society categorization serves as an act of de facto steering is its uptake by public or intergovernmental authoritative bodies, like the Convention on Biological Diversity (CBD 2012) or the Intergovernmental Panel on Climate Change (IPCC 2014). The replication of the demarcation in authoritative assessments directed at policymakers ensures that public research funding is increasingly allocated on the basis of this categorization. Just recently, the UK's Natural Environment Research Council allocated £8.3m for research on methods to remove carbon dioxide from the atmosphere at a climatically relevant scale, and members of the US Congress explicitly suggested allocating funds to research albedo modification (NERC 2016, US Congress 2017). The separate allocation of research funding as per this demarcation has had (and will likely continue to have) discernible impacts on the CE research community in terms of structuring associated research networks and institutionalizing the divide between those who research CDR and those who research SRM.

Why does it matter that the Royal Society's de facto governance act has contributed to normalizing and institutionalizing CE research according to the CDR/SRM categorization? We posit a number of potential consequences for CE research and governance directions.

First, the CDR/SRM demarcation has arguably aided in directing discussion away from philosophical and ethical concerns relating to intentionality and scale that dominated earlier CE debates, toward questions of a more technocratic nature. This includes measuring and assessing specific climate and earth system parameters, such as units of greenhouse gas emissions stored or released or sunlight reflected, and the need to reduce associated uncertainties (Flegal and Gupta 2017). Such a technicalization of the field of inquiry can have the effect of depoliticizing the object of governance, and reducing the hubris label earlier associated with CE, thus helping to render CE a more researchable and 'governable' object.

Second, the demarcation between SRM and CDR, and the suggestion that one set of techniques requires more scrutiny than the other, has been accompanied by a proliferation of governance-related research on SRM, in comparison to minimal engagement (until recently) with ethical and legal aspects of CDR. As just one example, the American University-based Forum for Climate Engineering Assessment set up an Academic Working Group consisting of 15 international governance experts in 2016 to explore pressing concerns relating to CE governance, but elected to focus exclusively on SRM. The Royal Society report's demarcation act was accompanied, in general, by a perception that CDR was a less controversial and more acceptable element of a climate policy portfolio, and it was extensively included in the IPCC AR5 report (2014). It was only after the IPCCs inclusion of CDR options, such as BECCS, that critical discussions concerning social justice and governance came to the fore. Initially very much under the radar, various post-AR5 publications now point out the immense social and ecological challenges associated with land-based CDR (Fuss *et al.* 2014).

Within SRM research, the governance conversation increasingly focuses on *design* questions (who should govern, how to govern), with a predominant concern with ensuring 'responsible' research and/or addressing the problem of unilateral deployment. Much attention is also devoted to mapping public perception and encouraging public deliberation, or debating institutional arrangements and principles for governance (e.g. Lloyd and Oppenheimer 2014). Research on more overtly 'political' aspects such as justice, power or responsibility is not necessarily at the front and center in CE and SRM governance debates. A rough indicator of this can be found in the program of the most recent international conference on CE in Berlin that brought together key academics and practitioners engaged with CE debates. Descriptions of panel sessions in the conference program reveal that 'power' and 'justice' appear only once and twice respectively, while 'governance' is a theme in 11 out of 39 sessions (CEC 2017).

In sum, we have argued that the Royal Society report's CDR/SRM demarcation act has influenced the ways in which the CE research community is organized, as evident from the foci of established research programs and funding streams, and has influenced the nature and direction of the CE governance conversation. Conceptualizing the Royal Society's categorization as an authoritative intervention, rather than an assessment of the state of knowledge based on self-evident technical criteria, provides in our view a new perspective on how de facto sources of steering construct an object of governance, and serve to order an emerging and politically contested field, thereby also shaping the context for more formal *de jure* governance.

Authoritative assessment II: the National Academy of Sciences report

Six years after the publication of the Royal Society report, the US NAS followed suit and released a detailed assessment of CE technologies, their potential and their pitfalls (McNutt *et al.* 2015a, 2015b).[4] Adopting the now widely held position that CDR and SRM are fundamentally different CE approaches, the report consisted of a separate publication on each. It also echoed the Royal Society's judgment on the risks associated with each, describing CDR as relatively well-understood and largely unproblematic, and SRM as a set of techniques with unknown challenges and risks. The 2015 NAS report was 400 pages long, providing the most extensive assessment on the subject to date. As the NAS constitutes a principal source of scientific information for the US government, we consider the report's recommendations to be a potentially important source of de facto steering that may shape the trajectory of CE research and policy in the US.

As with the Royal Society report, we explore here the nature and effects of one key intervention embodied in the SRM ('albedo modification') section of the NAS report. This entails, at its core, an endorsement to take SRM research outside the lab by demarcating small-scale from large-scale outdoor SRM research. One justification for this provided by the report is a concern with unilateral deployment of SRM by other states or private actors as a key governance challenge, meriting both an acceleration in US research and the construction of a global SRM research and deployment monitoring system. We explain below the context for and implications of this demarcation act.

The intervention: demarcating small-scale from large-scale outdoor SRM research

While computer modeling and the use of data from 'natural experiments' (i.e. volcanic eruptions), has become a standard approach within SRM research, moving outside the laboratory to conduct research on the effects

of aerosols in the stratosphere and potential deployment strategies remains controversial. Although some advocates of CE research have emphasized the need for outdoor experimentation (e.g. Keith *et al.* 2010), those opposed to outdoor research note that governance is inadequate, that there is no urgent need to explore the feasibility of SRM now, and that proponents have failed to provide convincing evidence of its necessity (Schäfer *et al.* 2013).

Crucial to this debate is the uncertainty and contestation around the distinction between outdoor experiments in need of specific governance measures, versus those considered part of normal scientific inquiry. This is evident from lengthy discussions about what constitutes outdoor research, and possible distinctions with regard to impact and associated governance imperatives (Hubert and Reichwein 2015). Because of this uncertainty, major CE research projects like Germany's coordinated SPP 1689 CE research program or the EU's FP7 project on the implications and risks of engineering solar radiation to limit climate change explicitly refrain from endorsing or conducting any outdoor experiments. The much analyzed UK research program on stratospheric particle injection for climate engineering (SPICE) included cancellation of an originally planned experiment to test a stratospheric aerosol delivery mechanism. Although the immediate cause of cancellation was a conflict of interest over patenting, this brought to the fore key issues relating to governance of research and outdoor experimentation (Stilgoe *et al.* 2013).

The NAS report and its demarcation act thus takes on a contested aspect of CE research and governance, wading into the conflict around what constitutes acceptable SRM research practice by taking a clearly positive stance on the need for outdoor experimentation. In particular, small-scale experimentation is demarcated from large-scale field trials and framed as a necessary mechanism through which to verify results of SRM modeling (McNutt *et al.* 2015b, p. 9). The report also states that governance is not a synonym for regulation, and that existing scientific research norms are sufficient to govern some types of outdoor SRM experiments (McNutt *et al.* 2015b, p. 10). Ethical and sociopolitical issues are framed as being more relevant in the context of large-scale field trials and 'responsible deployment' (McNutt *et al.* 2015b, p. 135). Thus, the NAS report rejects the position that any small-scale, outdoor experimentation would need to be regulated, and that societal concerns associated with this technology make self-governance by the scientific community inadequate.

Furthermore, the recommendation to engage in outdoor research on SRM goes hand in hand with a recommendation to enhance US capacity to measure changes in radiative forcing, therefore enhancing the ability to detect large-scale activities by unilateral or uncoordinated actors (McNutt *et al.* 2015b, p. 9). This recommendation increases the political relevance of

SRM, but in a rather unconventional manner. By highlighting the problem of rogue action within a recommendation explicitly directed at the US government, it sets up the context wherein infrastructure investments for monitoring and control of SRM activities can be justified on grounds of detecting a potential foreign threat, thereby framing SRM as an issue relevant to national security.

Although the NAS report repeatedly points out various risks associated with potential future use of SRM and the importance of prioritizing emissions reductions and adaptation, the emphasis is on creating conditions for 'responsible' SRM deployment, based on the assumption that policymakers will contemplate its use to avoid catastrophic climate change in the future, and thus need to improve their knowledge base before that moment comes. The inherent governability of SRM is therefore implicitly assumed, and fundamental political questions of governance capacity to steer and manage the safe, equitable and effective use of such technologies collectively is hardly considered. This simultaneous focus on technical knowledge needs and a national security justification for expansion of SRM research, including giving a nod to the need for outdoor experimentation, results in a further ordering of the CE field of inquiry in specific directions, to which we turn next.

Governance effects: ordering a field of inquiry

In contrast to the Royal Society report, the publication of the NAS report remains relatively recent. Thus, we can only posit some first signs of the ways in which its demarcation act may serve to normalize and institutionalize specific research and governance directions.

One effect of the NAS report's intervention is greater engagement with the idea and prospects of SRM outdoor experimentation. In March 2017, 2 years after publication of the NAS report, Harvard University announced a project to begin outdoor experimentation relating to 'solar geoengineering' (Harvard University 2017). Although plans for this experiment were already publicly known prior to publication of the NAS report (Dykema *et al.* 2014), the report's approval of outdoor experimentation provided an important source of legitimacy for the project. Thus, Gernot Wagner, co-leader of the Harvard Solar Geoengineering Research Program, explicitly mentions the NAS as an authoritative source that encourages research on solar geoengineering (Harvard University 2017). In a related *Guardian* article, David Keith and Gernot Wagner again refer to the Royal Society, NAS and IPCC as authoritative sources legitimizing their outdoor experimentation project (Keith and Wagner 2017). The experiment has not yet been conducted, but its successful execution may trigger a wave of small-scale outdoor experiments and normalize a type of research that was previously contested.

In addition, the NAS report continues a trend, traceable back to the Royal Society report, of normalizing the notion of CE governability. It does so by relying on powerful metaphors that depict the existing CE demarcation of CDR and SRM in ways that simplify the climate system and reinforce the idea that humans have the power to control it. Most strikingly, the report explains CE as follows:

> The climate system can be compared to a heating system with two knobs, either of which can be used to set the global mean temperature. The first knob is the concentration of greenhouse gases such as CO2 in the atmosphere that affects the infrared side of the energy balance (…). The other knob is the reflectance of the planet, which controls the amount of sunlight that the Earth absorbs. (McNutt *et al.* 2015b, p. 27)

Although 'only' a metaphor, the image of humankind being able to manipulate the global climate like a domestic heating system is powerful. Conjuring up the very concrete experience of a hand on a temperature knob (and using an associated metaphor of 'pulling down the window shades a bit') is bound to stay present in a reader's mind, especially in the context of a long and rather technical report. Squarely placed at the beginning of the introduction, the hand-on-knob metaphor sets the scene of CE as a controllable, governable system. No amount of cautioning in the aftermath about risks and uncertainties can easily erase that impression.

In terms of institutionalization, it is too early to detect substantial changes in terms of funding streams for outdoor research, or further consolidation of research communities, but first indications of these effects can be found in relatively recent activities of US government institutions. The US Global Change Research Program, which was designed under the Obama administration to directly inform the national research priorities of the US President and Congress, cited the NAS report in its recommendation to take action on CE research. Amongst other things, it echoed the NAS report's rogue actor theme, stating that:

> [t]he need to understand the possibilities, limitations, and potential side effects of climate intervention becomes all the more apparent with the recognition that other countries or the private sector may decide to conduct intervention experiments independently from the US Government. (GCRP 2017, p. 37)

The rogue actor theme also provides justification to develop national monitoring and surveillance systems relating to CE. One indicator pointing in this direction is the interest in, and concern about, SAI expressed by John O. Brennan in his function as director of the US Central Intelligence Agency (Brennan 2016).

In an important recent development, on 8 November 2017, the science committee of the US Congress held a hearing on 'geoengineering

innovation, research and technology', in which members questioned four witnesses about the potential and possibilities associated with CE (US Congress 2017). Witnesses as well as members of Congress repeatedly referred to the NAS report as justification in supporting the need for further research. Furthermore, the concern that other countries or private individuals might develop CE technology was voiced several times. Five members of Congress asked questions about other countries, with China and Russia standing out as potential rivals in terms of technology development and field tests, as well as reference points in considering the merits or not of regulating SRM research. The hearing revealed that two members of Congress were in the process of putting forward legislation that would facilitate further research, one encouraging development of CDR research capacities within the Department of Energy, and the other requesting the NAS to develop a research agenda for SRM, further underscoring the NAS report's de facto steering capacity.

De facto governance by authoritative assessments: ordering a field of inquiry

Here we briefly synthesize and compare our analyses of the de facto governance acts contained within the Royal Society and NAS authoritative assessments, and their effects in shaping this field of inquiry (see Table 1). As can be seen from Table 1, the reports are similar in how they attempt to bring order to an emerging, contested field, with the NAS report building in important ways on the Royal Society report. In both cases, certain research directions are encouraged by acts of demarcation contained within the reports. While the Royal Society report categorized CE in terms of physical processes in need of further research, and thereby helped construct CE as an object of governance, the NAS report frames SRM as a question of security and demarcates small-scale outdoor experimentation from responsible deployment as a necessary means to 'verify' the 'theory' of SRM models.

In terms of shaping the governance conversation, both acts of demarcation have had the effect of recasting the original hubristic framing of CE techniques. Both depict controversial CE issues as manageable (or 'governable'), hence settling the 'whether to govern' question, even as they authoritatively intervene to shape the 'what' question. In so doing, these framings and acts of demarcation have contributed to shifting the focus of governance debates from first-order 'what, if, and whether' questions to 'how, when, and who', i.e. to questions of (technical) design.

Table 1. De facto governance by authoritative assessment: ordering the CE field of inquiry.

Intervention: the act of demarcation/ categorization	**Governance effect: ordering the field of inquiry**	
	Normalizing the field	**Institutionalizing** the field
Royal Society distinction between CDR and SRM Predominant categorization of CE in terms of earth system parameters (rather than scale, political jurisdiction, familiarity or other criteria) CDR categorized as slow and less cost effective (but safer); SRM as quick, affordable and effective (but less safe)	• Establishment of CE research programs reflecting the demarcation (CDR and SRM) • Shift away from association of hubris, and political and ethical debates over scale, safety (and contingencies), to scientific debates over measurable units; cost-benefit analysis; reduction of uncertainties • Governance focus now more on design aspects (*who, how, when, where*) rather than first-order, politically contested issues of desirability or governability (*if, whether, and what*)	• Separation and increasing institutionalization of research communities, according to the demarcation (CDR and SRM) • Establishment of funding streams for CE research according to demarcation
NAS distinction between acceptable outdoor experimentation and responsible deployment Demarcation between 'acceptable' outdoor experimentation (without needing new governance arrangements) versus responsible deployment Justifying need for outdoor experimentation by framing SRM as an issue of national security	• Directs focus away from debates on desirability of outdoor experimentation and towards technical research needs, such as monitoring systems to detect changes in radiative forcing • Normalizing questions of governance through metaphor of 'hand on the thermostat' • Depicts SRM as a question of national security, directing governance questions in a certain direction (preventing rogue deployment, unilateral action)	• SRM experimentation and research programs encouraged by members of Congress, based on NAS recommendations • Planned first SRM outdoor experimentation scheduled to take place in US, using NAS to justify

Conclusion: de facto governance – what's new under the sun?

We have highlighted how sources of de facto governance, such as authoritative assessments, have normalized and institutionalized CE research, thereby contributing to ordering an emerging, contested field of inquiry characterized by multiple uncertainties and unknowns. We examined this process of ordering by identifying specific acts of demarcation and categorization incorporated within authoritative CE assessments. We argued that these interventions have served as a way to normalize and institutionalize specific strands of inquiry as per the demarcation, even as they have arguably helped to direct a number of politically contested debates into the realm of the technical by privileging that which is amenable to expert assessment and measurement.

Our analysis has shown that demarcations and categorizations contained within authoritative assessments play an important role in constructing CE as an object of governance. Thus, the continuous redefinition and framing of 'what is to be governed' is shaped by authoritative actors who render contested and hitherto largely imagined entities graspable and governable. Demarcation becomes a crucial political move in a highly contested area.

It is important to note that all governance (whether de facto or *de jure*) serves to order a field of inquiry. The difference lies in the fact that de facto ordering of a field is not subject to the political oversight that would (to greater or lesser extent) accompany state-led or private, mandatory or voluntary, attempts to bring order to a previously unordered or nascent field. As such, we argue that politically salient de facto acts of demarcation and their effects require continued attention, including within mainstream CE governance analyses.

This suggests a research agenda to further explore similarities and differences between de facto and *de jure* governance, and how these may influence each other. We need to better understand who is empowered by specific acts of de facto governance, and what the geopolitical implications of such governance might be. Most broadly, our analysis opens up the notion of what constitutes governance in the first place, and draws attention to the need for political oversight of de facto sources of steering in emerging and contested global environmental governance domains.

Notes

1. The most well-known 'authoritative assessment' in the global environmental realm, the IPCC, has been extensively analyzed for its role and influence in climate governance and politics from a variety of theoretical perspectives. By bringing a de facto governance lens to assessing the steering capacity and governance effects flowing from authoritative assessments, we complement such existing analyses.

2. For more elaborate discussions of alternative categorizations, see e.g. Boucher *et al.* (2014) and McLaren (2015).
3. The distinction between technologies that affected the CO_2 cycle and those that represented 'countervailing modifications' can be found in a number of earlier publications (e.g. MacCracken 1991), although there was no widespread consensus that CE should be categorized in this way.
4. The NAS reports were released in the same year as another major report by the European Transdisciplinary Assessment of Climate Engineering (EuTRACE), (Schäfer *et al.* 2015). The reason we choose to analyze the NAS report (and not EuTRACE) is because the NAS represents an older, more established scientific body, and because it makes explicit recommendations for CE-related investment and political action. The EuTRACE report adopts a more neutral tone in assessing scientific developments, and listing pros, cons and questions for further research. It offers no explicit opinions on where or how the EU should develop CE research.

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References

Boucher, O., *et al*., 2014. Rethinking climate engineering categorization in the context of climate change mitigation and adaptation. *Wiley Interdisciplinary Reviews: Climate Change*, 5 (1), 23–35.

Bowker, G.C. and Star, S.L., 1999. *Sorting things out: classification and its consequences*. Cambridge: MIT Press.

Brennan, J.O., 2016. *Director Brennan speaks at the council on foreign relations* [online]. Central Intelligence Agency. Available from: https://www.cia.gov/news-information/speeches-testimony/2016-speeches-testimony/director-brennan-speaks-at-the-council-on-foreign-relations.html [Accessed 15 January 2018].

Cao, L., Gao, C.-C., and Zhao, L.-Y., 2015. Geoengineering: basic science and ongoing research efforts in China. *Advances in Climate Change Research*, 6, 188–196. doi:10.1016/j.accre.2015.11.002

CBD, 2012. *Geoengineering in relation to the convention on biological diversity*. Montreal: Secretariat of the Convention on Biological Diversity, Technical Series No. 66.

CEC, 2017. *Climate engineering conference 2017 program* [online]. Institute for Advanced Sustainability Studies. Available from: http://www.ce-conference.org/cec17-program [Accessed 15 January 2018].

Crutzen, P.J., 2006. Albedo enhancement by stratospheric sulfur injections: a contribution to resolve a policy dilemma? *Climatic Change*, 77, 211–220. doi:10.1007/s10584-006-9101-y

Dooley, K. and Gupta, A., 2017. Governing by expertise: the contested politics of (accounting for) land-based mitigation in a new climate agreement. *International Environmental Agreements: Politics, Law and Economics*, 17 (4), 483–500. doi:10.1007/s10784-016-9331-z

Dykema, J.A., *et al*., 2014. Stratospheric controlled perturbation experiment: a small-scale experiment to improve understanding of the risks of solar geoengineering. *Philosophical Transactions of the Royal Society*, 372 (20140059), 1–21. doi:10.1098/rsta.2014.0059

Flegal, J. and Gupta, A., 2017. Evoking equity as a rationale for solar geoengineering research? Scrutinizing emerging expert visions of equity. *International Environmental Agreements*. doi:10.1007/s10784-017-9377-6

Foley, R., Guston, D., and Sarewitz, D., 2015. Toward the anticipatory governance of geoengineering. *Geoengineering Our Climate Working Paper and Opinion Article Series* [online]. Available from: http://wp.me/p2zsRk-c8 [Accessed 15 January 2018].

Fuss, S., *et al*., 2014. Betting on negative emissions. *Nature Climate Change*, 4, 850–853. doi:10.1038/nclimate2392

GCRP, 2017. *The national global change research plan 2012–2021: a triennial update*. Washington, DC: US Global Change Research Program.

Gupta, A., 2011. An evolving science-society contract in India: the search for legitimacy in anticipatory risk governance. *Food Policy*, 36, 736–741. doi:10.1016/j.foodpol.2011.07.011

Gupta, A., 2006. Problem framing in assessment processes: the case of biosafety. *In*: R.B. Mitchell, W.C. Clark, D. Cash, and N.M. Dickson, eds. *Global environmental assessments: information and influence*. Cambridge: MIT Press, 57–86.

Harvard University, 2017. *Harvard's solar geoengineering research program* [online]. Harvard University Center for the Environment. Available from: https://geoengineering.environment.harvard.edu [Accessed 1 April 2017].

Hubert, A.-M. and Reichwein, D., 2015. *An exploration of a code of conduct for responsible scientific research involving geoengineering*. Potsdam: Institute for Advanced Sustainability Studies.

IPCC, 2014. *Climate change 2014: synthesis report. Contribution of working groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change*. Geneva: IPCC.

Jamieson, D., 1996. Ethics and intentional climate change. *Climatic Change*, 33 (3), 323–336. doi:10.1007/BF00142580

Jasanoff, S. and Long-Martello, M., eds., 2004. *Earthly politics: local and global in environmental governance*. Cambridge: MIT Press.

Keith, D.W., Parson, E., and Morgan, M.G., 2010. Research on global sun block needed now. *Nature*, 463, 426–427. doi:10.1038/463426a

Keith, D.W. and Wagner, G., 2017. *Fear of solar geoengineering is healthy – but don't distort our research* [online]. The Guardian. Available from: https://www.theguardian.com/environment/2017/mar/29/criticism-harvard-solar-geoengineering-research-distorted [Accessed 15 January 2018].

Lloyd, I.D. and Oppenheimer, M., 2014. On the design of an international governance framework for geoengineering. *Global Environmental Politics*, 14 (2), 45–63. doi:10.1162/GLEP_a_00228

MacCracken, M.C., 1991. Geoengineering the climate. *In*: *Paper prepared for submission to Workshop on the engineering response to global climate change for chapter 8: control of greenhouse gas sinks and of climate*, Palm Coast, Florida, June 1–6, 1991. California: Lawrence Livermore National Laboratory.

McLaren, D., 2015. *Why we shouldn't be in a hurry to redefine 'climate engineering'* [online]. Forum for Climate Engineering Assessment. Available from: http://ceassessment.org/why-we-shouldnt-be-in-a-hurry-to-redefine-climate-engineering-duncan-mclaren/ [Accessed 15 January 2018].

McNutt, M., *et al*., 2015a. *Climate intervention: carbon dioxide removal and reliable sequestration*. Washington, DC: National Academies Press.

McNutt, M., *et al*., 2015b. *Climate intervention: reflecting sunlight to cool earth*. Washington, DC: National Academies Press.

NERC, 2016. *Announcement of opportunity: greenhouse gas removal from the atmosphere* [online]. Natural Environment Research Council. Available from: http://www.nerc.ac.uk/research/funded/programmes/ggr/news/ao-ggr/ao/ [Accessed 15 January 2018].

Oldham, P., *et al*., 2014. Mapping the landscape of climate engineering. *Philosophical Transactions of the Royal Society*, 372 (20140065), 1–20. doi:10.1098/rsta.2014.0065

Owen, R., 2014. Solar radiation management and the governance of hubris. *In*: R.M. Harrison and R. Hester, eds. *Geoengineering of the climate system: issues in environmental science and technology*. London: Royal Society of Chemistry, 212–248.

Pasztor, J., Scharf, C., and Schmidt, K.-U., 2017. How to govern geoengineering? *Science*, 357 (6348), 231. doi:10.1126/science.aan6794

Rip, A., 2010. De facto governance of nanotechnologies. *In*: M. Goodwin, B.-J. Koops, and R. Leenes, eds. *Dimensions of technology regulation*. Nijmegen: Wolf Legal Publishers, 285–308.

Robock, A., 2008. 20 Reasons why geoengineering may be a bad idea. *Bulletin of the Atomic Scientists*, 64 (2), 14–18. doi:10.1080/00963402.2008.11461140

Rosenau, J.N., 1990. *Turbulence in world politics: a theory change and continuity*. Hertfordshire: Harvester Wheatsheaf.

Rosenau, J.N., 1995. Governance in the twenty-first century. *Global Governance*, 1, 13–43.

Schäfer, S., *et al*., 2013. Field tests of solar climate engineering. *Nature Climate Change*, 3, 766. doi:10.1038/nclimate1987

Schäfer, S., *et al*., eds., 2015. *The European Transdisciplinary Assessment of Climate Engineering (EuTRACE): removing greenhouse gases from the atmosphere and reflecting sunlight away from earth*. Funded by the European Union's Seventh Framework Programme under Grant Agreement 306993. European Union.

Schelling, T.C., 1996. The economic diplomacy of geoengineering. *Climatic Change*, 33 (3), 303–307. doi:10.1007/BF00142578

Shepherd, J., *et al*., 2009. *Geoengineering the climate: science, governance and uncertainty*. London: The Royal Society.

Stilgoe, J., Owen, R., and Macnaghten, P., 2013. Developing a framework for responsible innovation. *Research Policy*, 42 (9), 1568–1580. doi:10.1016/j.respol.2013.05.008

US Congress, 2017. *Subcommittee on environment and subcommittee on energy hearing – geoengineering: innovation, research, and technology* [online]. Available from: https://science.house.gov/legislation/hearings/subcommittee-environment-and-subcommittee-energy-hearing-geoengineering [Accessed 15 January 2018].