Scientists in the Geoengineering Discourse:
Social Advocates or Neutral Umpires?

Paper prepared for the workshop "The Ethics of Geoengineering: Investigating the Moral Challenges of Solar Radiation Management" at the University of Montana, 18–20 October 2010.

Draft

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Abstract

We are exploring ever more technological solutions to complex environmental problems and scientists have now advanced solar radiation management as a way of thwarting dangerous climate change. Epistemic communities often consider themselves above the political fray, but we learn from the perspective of post-normal science that high levels of complexity, uncertainty and risk create a dearth of objective facts that make value judgments unavoidable, thus challenging the scientific tradition of impartiality. This paper discusses the ethical quandaries that arise at the crossroads between solar radiation management science and policy, drawing attention to the role of epistemic communities in the geoengineering discourse. The point is not to root out scientific malfeasance, but to highlight friction areas that can erode the relationship between science and society, including the role of scientists as gatekeepers of knowledge, aspects of scientific parochialism, and the involvement of scientists in private geoengineering endeavours. There are no silver bullet solutions, though openness about the limits of science is key. Better communication is certainly necessary, but it must take the form of dialogue rather than lecturing, and must be informed by increased scientific sensitivity to social issues and political realities.

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Introduction

While acknowledging the dangers of their field, scientists that explore solar radiation management (SRM) find themselves highly justified in pursuing their research, and have worked to construct the issue in such a way that it assuages most fears about the *intent* of the concept—it is a "Plan B", a last resort, insurance against catastrophe (Keith, 2000; The Royal Society, 2009). It is not merely academic curiosity that is prodding scientists to ask these questions, but genuine concern that we are running out of time to mitigate the worst consequences of global warming. Their critical question is, "what if?" What if we cannot reduce emissions soon enough? What if we push the climate over a proverbial tipping point? The definition of geoengineering that has emerged is thus tightly tied to the possibility of dangerous global climate change (Keith, 2000; The Royal Society, 2009), rather than promoted as a tool we may use wantonly to terraform the Earth to be more to our own liking, as was proposed in the 1970s (Schneider, 2008).

Despite the clear risk of dangerous climate change that scientists have demonstrated, many in the environmental field have met the suggestion that we may counter it with geoengineering rather coolly. The idea of geoengineering has been discussed and rejected before (Schneider, 2008). Scientists that explore this field must endure allegations of arrogance and hubris while knowing that the proposed technology contradicts decades of environmental orthodoxy about how much influence humans should exert over nature (as little as possible), comes with the risk of severe and destructive side-effects, and could even be used unilaterally by single nations or even resourceful private entities, for hostile purposes if they so choose. Whether we should explore geoengineering has been resisted, even by many scientists "for various and sincere reasons that are not wholly scientific." (Cicerone, 2006, p. 221)

To what extent is it the job of scientists to push society in new directions? On one hand, expanding possibilities is what scientists *do*, in every discipline; on the other hand, are we now reaching certain boundaries beyond which we should not go, in climate control, genetic engineering and other frontiers? Yet would it be ethical for researchers *not* to do their best to thwart harmful outcomes when they are supported by mountains of empirical evidence? To what extent would the end justify their means?

Because they are leading society on this issue, epistemic communities find themselves on both side of the debate, playing the role of both researchers (in the traditional sense) and social advocates. This has set the stage for a collision between traditional stereotypes of scientists as "neutral umpires" in search of "truth" and their real-world versions that must straddle both the role of scientist and the role of societal stakeholder in favour of specific policy options and political directions. This leads us to ask how they conduct themselves in the geoengineering discourse, and some pertinent questions about their objectives. Are scientists merely impartial providers and interpreters of vital information that we need in order to evaluate the advantages and drawbacks of geoengineering, or are they using their specialized knowledge and privileged positions to promote conclusions and solutions based on personal values and beliefs?

This paper discusses the ethical quandaries that arise at the crossroads between geoengineering (specifically SRM) science, policy and the social discourse. Beyond the hyperbole, there are aspects of their involvement in policy and the public debate that can become a source of controversy, and which may in turn hinder resolution of the issues under debate. For years now, scientists have worried about public loss of confidence in their profession, following high-profile cases where scientists and the public appear to have been at odds (Barber, 1987; Nature, 2010b). In the biosciences in particular, issues like genetic engineering and cloning have caused uproar, while in Britain the scare over mad cow disease rapidly eroded consumers' trust in science at the end of the 1990s (Ravetz, 1999). The issue of trust and the extant challenges that have besieged climate change science and mitigation advocates give extra dimensions to the debate on geoengineering, as the status of climate change mitigation as a legitimate goal is not yet completely secure, and the discourse continues to be under attack. The public debate has taken on an increasingly vitriolic tone, replete with ad hominem attacks, and the most outspoken climate change deniers have managed to sow much confusion about the topic.

Several social and political fault lines are converging on the issue of geoengineering, many implicating the dual role of epistemic communities in the discourse as drivers of technological and scientific research and as social stakeholders with an interest in finding solutions to climate change. This paper is organized around four main, colliding tectonic plates in this landscape, containing within them many smaller fault lines. First is the complexity of the climate science and the problem that the central message of the danger of anthropogenic climate change is drowned out by uncertainty and different perspectives on risk. Second is the dichotomy between the role of scientist and the role of stakeholder. Third are issues that arise when science pushes society in new directions and beyond the frontiers of social conventions, rules and norms. Fourth is the propensity of scientists towards parochialism and the potential for conflicts of interests.

These four tectonic plates all have a bearing on the willingness of society to trust the scientific establishment. The behaviour of scientists has major implications for whether society believes in their academic integrity and trust their solutions, whereas the changing role of scientists in society is uprooting ancient conventions that have regulated the relationship. The psychological, political and societal dynamics behind the science-society relationship, however, are far too complex to allow any comprehensive treatment here. Instead, this article discusses the great, overarching question of how epistemic communities should handle the issue of SRM, and what it means for the relationship between epistemic communities, policy makers and the rest of society.

Society, complexity and risk

There is considerable resistance to the picture of risk, probability and consequences science has painted of climate change over the last 50 years and of geoengineering more recently. A large part of the problem is the specialized and complex nature of climate science not only renders it opaque to non-specialists, but also makes it hard for scientists to disseminate their findings and the implications thereof in a way that engenders the appropriate reactions. Complexity also makes it much harder to judge what an appropriate reaction would be—is geoengineering really necessary, or does it introduce so many other risks that it is a greater hazard than the dangerous climate change it is supposed to prevent?

Both climate change and geoengineering carry extraordinary risk and uncertainty. The climate is a complex system, involving irresolvable processes such as feedback loops, discontinuities and emergent behaviour (Alley et al., 2003; Lenton, Held, & Kreigler, 2008). Complexity limits what is objectively knowable while providing mechanisms that can trigger abrupt, unpredictable and even dangerous events. Complexity is a major culprit behind the still-wide margin in the prognosis of the sensitivity of the climate to a doubling of CO2 levels from pre-industrial levels—a margin that has not changed between 1979 and the Intergovernmental Panel on Climate Change's (IPCC) fourth assessment report, still standing at 1.5°C–4.5°C (IPCC, 2007; Kerr, 2004).

The risk associated with climate change is poorly understood and hard to conceptualize, especially the risk that inhabits the "fat tail" of risk probability distributions for climate change—severe consequences with low probability (Weitzman, 2009). To peril of all, the fat tail is rarely taken into account, possibly leading to critical underestimation of the problem and what we need to do about it. Weitzman argues that the astronomical cost of dangerous climate change coupled with deep structural uncertainty about their probability makes normal cost-benefit analysis of the problem counterproductive. We are fast approaching a point of no return—which may be as soon as 2015 (Anderson & Bows, 2008)—if we are to have any hope of keeping temperatures within the 2°C of warming "safe zone" as pledged by the G8 and the EU (Commission of the European Communities, 2007; G-8, 2009). Contours of climate thresholds are furthermore starting to appear in the Arctic, as 2010 marks the third year in a row with record low summer ice coverage and as methane clathrate deposits on the ocean floor have begun to destabilize (National Snow and Ice Data Center, 2010; Sommerkorn et al., 2009). There are nevertheless diverging opinions of how applicable Weitzman's "dismal theorem" to every scenario of global warming, underlining the fact that the perception of risk under present circumstances is highly subjective (Nordhaus, 2009).

Although the evidence for anthropogenic global warming is rock solid, detractors seize upon such uncertainty with zeal, as evidence that the climate change hypothesis is immature, unsupported by empirical data and politically motivated. The complicated process of interpreting empirical evidence has further let to charges of manipulation and misconduct, as in the issue over calibration of surface temperature data in 2009/2010 (Russell, Boulton, Clarke, Eyton, & Norton, 2010). Complexity and differing risk perceptions can thus put strain on the relationship between scientists, policy makers and the rest of society. Although complexity does not diminish the value of science, it does present a communication challenge, testing the communication methods of epistemic communities and engendering frustration among both scientists and the public alike. Communication failures could neutralize valuable scientific findings or advice, and have long-term negative consequences if important scientific evidence is suppressed, discredited or ignored.

But complexity is not alone in distorting risk perceptions of climate change; indeed, risk perception is itself a holistic process with many variables, not least the influence of political convictions and social values (Borick & Rabe, 2010; Etkin & Ho, 2007). It is clear that willingness to accept the hypothesis of anthropogenic global warming and the accompanying empirical data plus climate models is highly dependent on other social values rather than thorough and neutral analysis of available facts. Research has shown a correlation between perceptions of climate change and party affiliation in the United States (Borick & Rabe, 2010). Actual risk analysis may not even enter into the equation if you believe empirical data has been twisted to fit a hypothesis. Worryingly, an "anti-scientific strain" has taken hold on the political right, especially in the United States, finding expression in vehement and sometimes vitriolic opposition to climate scientists and mitigation professionals (Nature, 2010a).

How do scientists communicate the intricacies of SRM and the possibility of catastrophic climate change to the public, when the legitimacy of climate change as a real problem demanding immediate action is by no means secure in the first place? Not only is SRM conceived specifically for the highly uncertain "fat tail", but the technology itself and its complexity adds considerable more uncertainty and risk (Caldeira & Wood, 2008). Even scientists cannot agree on what the appropriate way forward is—how can the wider public be expected to appropriately, let alone accurately, assess the risk of various options with which they are presented, even if we take political prejudice out of the equation?

As previously mentioned, there are too many factors behind the motivations of individual scientists to include in this analysis. What is important in this context is rather what the current state of the climate change discourse and the public's perceptions of risk mean for the social construction of SRM and how it is received. Interestingly, some *prima facie* evidence suggests that those who deny the reality of climate change may be the most willing to accept geoengineering. Parts of the conservative American establishment have jumped on geoengineering as precisely the easy and inexpensive end-of-pipe and after-the-fact solution they said would come along (Schnare, 2007; Thernstrom, 2008), adding to the controversy around geoengineering and increasing the likelihood that left-leaning groups will be opposed. Those that are the most concerned about the risk (and certainty) of climate change, on the other hand, are often highly opposed to SRM based on the risk of moral hazard and their perception of the uncertainties and destructive propensities of SRM (Bronson, 2010; Santillo & Johnston, 2010).

That is not to say that the rest of society will mirror this reaction. The attitudes were not borne out, for example, by a public dialogue and an online survey on geoengineering held in the United Kingdom by the National Environment Research Council (NERC), where those that did not agree in the hypothesis of anthropogenic global warming were less inclined to support geoengineering, and vice versa (NERC, 2010). The social complexity involved in deciding how each individual will feel about geoengineering, however, does not simplify the communication challenge for the climate change community.

Gatekeepers of knowledge

Because of the level of specialization and dedication required to understand fully the risks and complexities connected to climate change and geoengineering, scientists have become gatekeepers of knowledge related to these fields. Scientists further have exalted positions as policy advisors and expert members of important environmental regulatory bodies. Their position as specialists, supported by the traditions of science, lends considerable authority and respect to their opinions. As gatekeepers, there is a historical expectation that they will act in accordance with the scientific tradition of impartiality, rooted in positivistic theories of knowledge creation that suggest that facts are discovered and value-free (Funtowicz & Ravetz, 1993; Jones, 2001, 2004; Ravetz, 1999). This ideology of science also forms an ethical system, where integrity and trust is earned by honesty and adherence to this method (Jones, 2001). In return, the scientific profession has been (mostly) free of overt political pressure, enjoying (for the most part) academic freedom to pursue whatever research they desire without having to worry over politically inconvenient results. Part of the agreement was also that science would provide the tools and the knowledge required to fulfill our manifest destiny, as interpreted by Enlightenment era thinkers, dominion over nature. An enduring stereotype is that of science as a hallmark of progress, advancement and the way to "the good life" (Jones, 2004). This *quid pro quo*, though still subject to changing social mores and conventions, and frequently flaunted by both sides, helped create the modern world and the pathologies of the totalizing industrial system, including our hydrocarbon dependency.

Both the image of the "virtuous scientist" in search of "truth" and the Enlightenment attitude towards nature, however, are becoming increasingly anachronistic, though not yet completely abandoned (Funtowicz & Ravetz, 1993; Jones, 2001, 2004; Ravetz, 1999). First of all, scientists can no longer be presumed to be completely disconnected from their social values or personal interests. Although objectivity is still the ideal, with severe penalties for infractions (considered scientific misconduct), outside influences may still affect scientific results. Corporate research money is flowing into academic institutions, with power to decide what is and is not researched, and the competitive pressure in academia can produce severely distorted incentives (e.g. Davies & Wolf-Phillips, 2006; Haerlin & Parr, 1999; Jones, 2001).

Second, being the purveyors and only legitimate producers of scientific knowledge, scientists have considerable influence over the foundations of social debates, by determining what science is conducted, what hypotheses are framed and explored, and how information is presented to the public. Funtowicz and Ravetz (1993) argue that under most circumstances, with little risk or uncertainty, this is not a big problem, but challenges with high complexity and high uncertainty, what is ontologically knowable too becomes increasingly uncertain and complex. This makes possible a multitude of legitimate perspectives rather than a single "truth" that scientists can impart on everyone else.

Geoengineering is a poster-child for that kind of situation, which Funtowicz and Ravetz call "post normal", because it contradicts the traditional place of science in the policy-making process, wherein scientists would be asked to provide unambiguous data and policy recommendations (Funtowicz & Ravetz, 1993; Ravetz, 1999). "When conclusions are not completely determined by the scientific facts," Ravetz (1999, p. 650) adds, "inferences will (naturally and legitimately) [be] conditioned by the values held by the agent." He further posits that in this situation, scientists' "integrity lies not in their 'disinterestedness', but in their honourable behaviour as stakeholders." (Ravetz, 1999, p. 648)

Geoengineering and global climate change are fields littered with difficult ethical and value-based questions and consequences that will affect stakeholders profoundly but in different ways. At the moment, science cannot tell us whether the benefits are going to outweigh its negative side-effects even in the aggregate, let alone for individual communities or even continents (except to say there is a good chance SRM can disrupt the Indian and African monsoon seasons (Robock, Oman, & Stenchikov, 2008)). If the risk of dangerous climate change is the motivation for exploring geoengineering, might not the energy used in geoengineering research be turned instead towards redoubling mitigation efforts, finding more convenient and less expensive ways to kick the carbon habit? Scientists have made a good case for why we at least should investigate the merits of SRM and other geoengineering schemes, but suppressing the role of scientist as societal stakeholders in accordance with the old convention of scientific neutrality may be counter-productive if they are perceived by their peers to be using their scientific credentials to promote solutions that are associated with a particular philosophical or ideological bent.

Geoengineering thus implicate fundamental questions about political beliefs, social values and acceptable trade-offs rather than absolute facts, raising questions about whether scientists should be allowed to decide issues, *de facto*, before they are even officially on the table. The implication here is that important decisions are predetermined by what options are on the table or what empirical data exists to support those options rather than through transparent, democratic processes. What is feared is moral hazard: the risk that geoengineering could become an easy and inexpensive solution to the problem of climate change, suiting vested interests like heavy industry and utility companies that would otherwise have to bear much of the cost of mitigation (Keith, Parson, & Morgan, 2010; Michaelson, 1998). “Other than with nuclear weapons,” Victor (2008, p. 328) adds, “societies have not spent massively to put an option on the proverbial shelf and not use it.” An article in *Foreign Affairs* further noted that geoengineering research might draw money away from critical research and initiatives in carbon mitigation (Victor, Morgan, Apt, Steinbruner, & Ricke, 2009). Put another way, the opportunity cost of geoengineering research may be technology or initiatives that are more urgently needed; ironically, a consequence of underinvestment in carbon mitigation may be future need for geoengineering technology.

The endeavour of mostly Western scientists in Western research labs furthermore raises questions about representation. ETC Group, a civil society organization highly critical of both geoengineering and geoengineering research, noted that the organizers of the Asilomar International Conference on Climate Intervention Technologies were almost exclusively middle-aged, white men from rich nations (Action Group on Erosion, Technology and Concentration, 2010). Many areas that may be adversely affected are poorly represented in climate change and geoengineering research communities. This is important because not only does SRM know no boundaries, but also because its harms and benefits may be inequitably distributed geographically, possibly affecting many of those with the least adaptive capacity (monsoon dependent subsistence farmers in Africa and India) the worst (Robock et al., 2008). Conversely, by focusing exclusively or at least mainly on the negative side effects of geoengineering, epistemic communities can just as soon discredit the entire field. It may be even more problematic if the developed world, which is far better placed to bear and adapt to climate change than less developed nations, decides to abandon the geoengineering track based on moral, ethical or philosophical objections, entirely without the input of the developing world, especially those most vulnerable, like small island states. It may yet happen.

Without suggesting that scientists in the geoengineering are engaging in misconduct, these are nevertheless important issues. The veneer of complete disinterestedness has come off, leaving trust in scientists’ integrity vulnerable. As gatekeepers of knowledge, epistemic communities have considerable power to steer and frame the debate on SRM. Issues discussed here may turn into mistrust of science, even resentment, if people find they have no avenue for meaningful participation in the debate or if their opinions are ignored. Trust is an essential component in any relationship, and the basis upon we accept scientific facts and conclusions, as well as recommended remedies.

Pushing boundaries

A lot of concern has gone into the (apparent) waning public trust in science over the last few decades, and it is constantly monitored. A series of polls in the United Kingdom found trust to hold at 65 per cent steadily for six years, between 1999 and 2004—turned upside down, that means that 35 per cent did *not* trust in the honourable intentions and integrity of scientists (The Royal Society, 2004). In the United States, the level of trust was about the same according to a 2010 poll: a few had very high trust in science, at least 53 per cent had *some* trust, and only a handful reported no trust (GfK Roper Public Affairs & Corporate Communications, 2010). A Royal Society (2004) report on the role of science in society, however, argued that other issues loom larger than trust as such, notably the speed of development into uncharted territory and how science is used.

One of the overarching questions is what level of influence we want over the Earth, implying not only how much ecological damage we can tolerate but also, should we take a more active custodial role, accepting also that we are liable to make mistakes? Current orthodoxy dictates that the only road to sustainable development is to minimize human influence on the planet—we should certainly not expand it, much less expand it deliberately (Dunlap & Van Liere, 2008). Although global opinion polls have not yet been conducted on geoengineering, reactions from civil society have generally ranged from lukewarm to hostile.[2] The zeitgeist is not on the side of geoengineering: to believe that we can successfully geoengineer the Earth is often held to be hubristic and arrogant, although the NERC (2010) geoengineering dialogue discussed earlier found more moderate, reasoned opinions rather than blind, ideological opposition. The dialogue did confirm, however, a bias towards "naturalness" as a good indicator of the desirability of different geoengineering proposals—participants were far more positive to technologies that mimic or strengthen natural processes, such as biochar burial and marine cloud brightening.

For science to be ahead of society is not a new situation. In new and esoteric fields like geoengineering, scientists push both the boundaries of human knowledge and the boundaries of what current rules, mores and norms are prepared to handle. Much of this debate has played out in the biosciences in particular, which have been rife with controversy for several decades (Berg & Singer, 1995; Davies & Wolf-Phillips, 2006). Scientists are unlocking new possibilities at a tremendous pace, and engaging in activities such as cloning or genetic engineering of food crops that have been subject to strong social taboos. Science often explores the margins—grey zones that challenge our preconceptions of right and wrong, moral and immoral, and the role of humans within the order of things. This is not new either: two centuries ago, scientists and doctors dissected corpses to learn human anatomy (Duffin, 1999), while more recently; scientists

[2] The Canadian ETC Groups is probably the most outspoken and engaged civil society organization in the geoengineering discourse (Bronson, 2010), being actively opposed to geoengineering, while Greenpeace, for example, has taken a more cautious approach (Santillo & Johnston, 2010).

announced they had created "synthetic life" by inserting manufactured DNA into an empty host cell (Gibson et al., 2010).

Science is thus giving us radical abilities and capabilities that were before unknown on many frontiers, in biosciences as well as in climate control. So long as we lacked these capabilities, we could ignore them, but now nations and the world community has to collectively make new rules, social conventions and governance, and come to grips with the ethical and moral dilemmas that new technologies pose. This can create sharp ideological and philosophical divides, especially if new capabilities invite particularly powerful or abhorrent images of abuse, whether it is of "a Brave New World of designer babies" created by genetic engineers (Suter, 2007), or of rogue nations turning climate engineering into a weapon (Cascio, 2008; Fleming, 2010). Visions of "mad scientists" or science-created dystopias are never far away, ready to be conjured up in response to the latest science controversy (Jones, 2004).

Invoking extreme rhetorical imagery may or may not be justified, but it can be effective in creating a level of social control over research activities and the direction of science. Even if science should not be politically controlled, it cannot be wholly disconnected from society, as social backlash can generate significant negative publicity and even, in extreme cases, political intervention to halt or limit research endeavours. International conservation regimes have contemplated geoengineering moratoriums (Convention on Biological Diversity, 2008; International Maritime Organization, 2008). As a result of social pressure and mounting ethical dilemmas, the Asilomar International Conference on Climate Intervention Technologies was held in March, 2010, inspired by the Asilomar Conference on Recombinant DNA held in 1975 (Kintisch, 2010). At the first Asilomar conference, scientists defined guidelines and limits on what kind of research was permissible after fears about the potential dangers of the new research had become widespread (Berg & Singer, 1995). Berg and Singer write that many researchers resented the "meddling" of the untrained public and scientists from other disciplines—some of whom invoked the image of impending disaster—but they argue that by allowing a temporary moratorium on recombinant DNA research and by establishing ground rules for research, the science community diffused the social backlash. The Asilomar geoengineering conference did not get quite that far, but it did show that the research community is taking public concerns seriously (Kintisch, 2010).

Eroding integrity, eroding trust

Trust is not necessarily only lost from conflicts at the frontier of science, but also over the (perceived) behaviour of scientists and institutions. A few scandals over scientific misconduct, whether real, perceived or fabricated, can result in catastrophic loss of reputation and prestige (e.g. in the case of the University of East Anglia email scandal (Nature, 2010b)). There are furthermore many cases in grey areas—neither outright immoral nor unethical—that whittles away at the public's confidence in the integrity of scientists. Scientists may also be resisted and mistrusted if they are perceived as elitist and paternalistic, especially if there is a sharp ideological divide in the debate (Malnes, 2008). Scientists are often criticized for living in ivory towers, a metaphor for a culture that weeds out dissenters and grooms young scientists to behave in a certain way and promote certain cultural norms to protect the elite position scientists have in society, thus making it difficult for challengers to get sufficient clout to challenge scientific decrees while ensuring that no one breaks rank from within (Jones, 2001).

From atop the ivory tower of academia, lack of perspective—whether from cultural bias, reductionism, self-interest or other factors, as well as the sheer scope of global problems—may make it difficult scientists from grasping all relevant facts regarding a topic. Conversely, occupants may be too influenced by the views of their peers: Dimitrov (2006, p. 37) remarks that "scientific information is not an objective output of mechanistic inquiry but a product of social processes among scientists and other social actors." The pursuit of "silver bullets" to solve all the problems of a particular problem in one fell swoop may be indicative of this. Universal emission reductions is an example of a silver bullet—a single best effort, that, if it could be made to work, would offer the most efficient and most equitable solution to global warming, spreading the cost of mitigation across all participants and across time. This has become the preferred solution of most climate change experts, civil society and the global political establishment (manifested in the Kyoto Protocol), but implementation efforts have met considerable social, institutional and structural difficulties.

Good intentions are a guarantee neither of good results, nor of public acceptance of the solutions scientists offer. In fact, climate change mitigation has not even been secured as a wholly legitimate pursuit—certainly not one that is prioritized in the post-recession economic climate. There reasons for the failure of the Kyoto Protocol are legion, but at least three set themselves apart. First of all, the Kyoto Protocol, the baggage that comes with international treaties, among them free-riding and the absolute requirement of universal consent, has worked well for more limited problems but may have doomed the UNFCCC process from the beginning (Lin, 2009; Victor, 2008). Second, the carbon-trading scheme, one of the main mechanisms of the Kyoto Protocol, failed because it relied on the top-down implementation of a global carbon market that never transpired (Prins & Rayner, 2007). Third, one of the things missing from the analysis is the level of resistance the Kyoto Protocol met, and people's disregard for scientists' risk perception of climate change, as discussed previously. We might call this missing understanding of social complexity: that a group of people does not necessarily react linearly, rationally and predictably to information fed to them by scientists or indeed any authorities.

Despite this failure, work is going on to replace the failed Kyoto Protocol with a largely similar successor protocol, and calls have been made for a global treaty under the UNFCCC umbrella to regulate geoengineering (Lin, 2009; Victor, 2008). Are epistemic climate change communities too parochial in their concerns to be able to recommend solutions that are both effective and (politically) viable? The above paragraph may sound unfair to scientists who serve their communities in good faith, and it is further hard to prove the counter-factual—that any other approach than a universal emission reduction treaty would have had a different outcome—but it criticism is bubbling up within the scientific community. For example, Prins and Rayner (2007) suggested that many scientists are unable to move beyond universal emission reduction because they have a vested political and emotional interest in it.

The scientific profession can be a brutal rat race to publish, attract research money, secure tenure and climb institutional hierarchies. Whereas scientific myopia or parochialism could be said to be an innate trait of the system—unwelcome but not in itself a sign of dishonesty—other problems may imply breaches or near-breaches of codes of conduct and scientific objectivity. A 1979 paper warned about the dangers that follow when researcher and research topic—and the fate of both—become interlinked (Armstrong, 1979). Not only that, but the paper suggested that scientists that become firm advocates of a single, dominant thesis are more successful, with obvious implications for the integrity of the implicated science. This is the problem of positive confirmation bias—that "what is found will nearly always be influenced by what is looked for." (Jones, 2001, p. 151).

Editorial boards can determine the fate of academic papers by deciding what is published and what is not, subject only to successful peer reviews (McGinty, 1999). Journals editors may have conscious or unconscious political or scientific bias, while the peer-review process may doom a manuscript that, for example, contradicts the dominant paradigm or competes with the work of the reviewers (Moran, 1998). Yet even before a paper has a chance to be written, its fate often lies with funders. Grant-giving institutions, individuals and companies have considerable control over what research is carried out, especially in an environment where a growing number of grant applications compete over the dwindling contents of grant coffers (Powell, 2010). Though merit is a large component in grant awards, it is not given that grant reviewers, like journal editors, do not let personal or institutional politics affect their decisions, while private philanthropists and companies are not bound by any academic conventions.

Academic institutions have become more and more dependent on corporate money in the last decades, introducing conflicts of interest between the high-minded pursuit of the public good and the demands from owners and shareholders for a return on investment equal to or higher than what they could get elsewhere in the economy (Jones, 2001). The work of scientists in the private sector has long been criticized in disciplines like genetics, where fluid boundaries between academia and corporate interests have shaken public confidence in scientific integrity, with the fear that material interest distorts scientists' judgment. A commentary in *Nature* argued that the commercialization of science has to bear the main responsibility for the drop in public trust in science (Haerlin & Parr, 1999).

Firms that seek to leverage geoengineering (specifically ocean iron fertilization) for profit have already appeared, to the consternation of both environmental groups and other scientists (Rayfuse, Lawrence, & Gjerde, 2008). Climos, one of the companies that have appeared in the ocean fertilization field seeking to profit from the sale of carbon credits,[3] have attracted the support of several high-ranking scientists.[4] Science as such cannot be blamed for the actions of profit-seeking individuals or groups, but all the same, these people do require the services of scientists. There are no companies in the SRM field—yet—but it is clear that creating a stratospheric sulphur shield is going to require an industrial/logistical support base and that collecting (or producing), transporting and lifting millions of tonnes of SO_2 or another substance into the stratosphere will become a multi-billion dollar industry. A vast fleet of ocean going vessels used for marine cloud brightening would require manufacture, maintenance and management, and with all this, new vested interests are created, often accompanied by new political lobby industries.

We should ask, then, given the stakes of climate change and the shaky public trust in climate science, whether it is wise to move to commercialize geoengineering technology at this point. There are no ethical guidelines for research in the field of geoengineering and no court of law can stop a private company from doing research on the high seas, beyond the reach of nation states. Guidelines are needed, soon, and international laws may be necessary too. Meanwhile, it would serve science well to take heed of public misgivings regarding commercialization. It is not something that should be decided in private, however well meaning the initiators might be.

Conclusion

Epistemic communities are in an unenviable position of power and responsibility that demands exceedingly high standards while exposing them to substantial criticism, especially when they enter politically sensitive fields or explore issues void of existing social and political regulation. A commentary in *Nature* criticized the tendency of science to subsume uncomfortable uncertainty, contradictory facts and complicated, confusing procedures (Nature, 2010b). As demonstrated all too clearly by the University of East Anglia email scandal, such practices are damaging to the institution of science and counterproductive to the goal of resolving the problem of climate change, even if they are not insidious in nature.

Openness is indeed an important ingredient in the SRM discourse as well. There is no objective "truth" based on empirical evidence that dictates that SRM is our best available option, but it may be seen as a socio-economic imperative, depending on worldview and perception of risk. It is obvious that scientists are more than merely disinterested knowledge providers in the case of SRM and climate change, but if they disguise their role as stakeholders behind the mask of

[3] The other one was Planktos, now defunct.
[4] See http://www.climos.com/science.php for a list of scientific advisors currently working for Climos.

scientific authority, they risk being perceived as illegitimately using their positions to advance partisan agendas. This dichotomy thus breaks the traditional framework of social conventions that have regulated the relationship between science and society—integrity is no longer founded entirely in objectivity. The other three tectonic plates—complexity and risk, the frontiers of science and society, and conflicts of interest—introduce further friction to the relationship between science and society.

Scientists should not feel impugned by this article, but rather encouraged to seek new ways of securing the place of science as a social institution and earning the trust of the public, whether it is a whole new paradigm for science-society relations, or a patchwork of initiatives to plaster over the . There have been many commissions, reports and initiatives to improve the relationship between science and society, starting also in geoengineering. Asilomar did not get quite far enough, but was a step in the right direction. Better and more sophisticated communication is another oft-mentioned remedy (Kahan, 2010), though communication has to be a two-way street rather than lecturing. Over-all, climate change and SRM communities must pay much greater attention to the political and social situation. The NERC dialogue has been a promising, albeit small, part of that process.

Normally, scientists may resent the meddling of outsiders in the scientific process. Suggestions in other disciplines to bring research decisions "upstream"—or in other words, make them subject to popular control—are inappropriate (Davies & Wolf-Phillips, 2006). Politically controlled geoengineering research would certainly not diffuse the controversy around it. Scientists nevertheless have an obligation to come out of their ivory towers. First of all because they may not sit on all the pertinent facts, but also because it is vital that they secure the support and trust of the rest of society. That cannot be gained without engagement. There are limits to what communication can achieve, however: even though scientists are the official gatekeepers, most people learn about issues like climate change indirectly, in some regurgitated, simplified or distorted form, from newspapers, network news, blogs or by word of mouth. We must also remember that the social construction of geoengineering also depends on other stakeholders, like politicians and commercial interests. If we are not careful, scientists may end up as just the providers of information in the end after all, in the service of politicians and corporations that set the political agenda.

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