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Some whats, whys and worries of geoengineering

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Abstract In this paper I discuss the nature of geoengineering, some of its attractions, and some reasons for concern. I claim that there is confusion in the use of the term 'geoengineering' that is related to larger concerns about the language in which responses to climate change are discussed. I conclude that despite some reasonable grounds for suspicion, research in areas that involve carbon dioxide removal and solar radiation management should go on as part of the general portfolio of climate-related research, competing with the full panoply of other possible responses to climate change.

1 Introduction

Geoengineering is an idea that has been in circulation for decades and perhaps centuries though it is difficult to trace the origins of the term (Fleming 2010). President John F. Kennedy expressed something like the thought in a 1961 address to the United Nations General Assembly when he declared his intention to "propose further cooperative efforts between all nations in weather prediction and eventually in weather control" "(http://www.jfklibrary.org/Historical+Resources/Archives/Reference+Desk/Speeches/JFK/003POF03UnitedNations09251961.htm)". Four years later President Johnson's Science Advisory Committee produced the first US government report discussing climate change and the only responses that were considered were those that would bring about "countervailing climate changes" (President's Science Advisory Committee 1965). The report specifically discussed the possibility of covering thousands of square miles of ocean with reflective particles. Not a word was said about reducing carbon emissions.

In 1994 geoengineering came to the attention of the broader scientific community when the American Association for the Advancement of Science convened a symposium on the subject at its annual meeting. In 1996 *Climatic Change* published the papers. A 2006 editorial in *Climatic Change* by Paul Crutzen made geoengineering a respectable topic of discussion in the scientific community and it is now beginning to be discussed more widely. In the last few years there has been a flow of books, articles and reports discussing various technologies, largely directed towards

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making the case for a dedicated research program (e.g., Royal Society of London 2009; Bracmort et al. 2011; Goodell 2010; Kintisch 2010; NAS/NRC 2010; US GAO 2010). The growing interest in geoengineering is partly a reaction to the steady increase in greenhouse gas concentrations which has continued despite scientific consensus, international treaties, and solemn declarations. In the background is the fact that many people find Promethean solutions to urgent problems almost irresistibly attractive.

In this paper I discuss the nature of geoengineering, explain some of its attractions, and state some reasons for concern.

2 What is geoengineering?

A recent report from the Royal Society of London (2009) defined 'geoengineering' as the "deliberate large-scale manipulation of the planetary environment to counteract anthropogenic climate change," and discussed at least 16 different techniques including afforestation, ocean upwelling, and space-based reflectors.

There are obvious problem with defining 'geoengineering' in this way. Two interventions can have identical effects, yet one may be considered an instance of geoengineering while the other is not. A "deliberate large-scale manipulation of the planetary environment" undertaken for some purpose other than counteracting anthropogenic climate change would not count as geoengineering on this definition even if it had the effect of manipulating the planetary environment.

The Royal Society counts afforestation as geoengineering (presumably only if it is undertaken with the right intention), while the IPCC considers afforestation to be a form of mitigation. The IPCC defines 'mitigation' as:

> An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks (Parry et al. 2007:878).

This way of defining 'mitigation' has the important virtue of expressing an earth system perspective on the problem of climate change. On this view the problem is not the emission of greenhouse gases (GHGs) but the forcing of the climate system. Since it is the forcing of the climate system that is the problem, the impact of GHGs can be mitigated by enhancing sinks as well as by reducing or eliminating emissions.

Despite its elegance, there are at least four problems with this definition. First, there are important differences between reducing emissions and enhancing sinks. Reducing emissions reduces flows while enhancing sinks reduces stocks. Carbon that is not emitted remains sequestered in stable geological formations where it will remain virtually forever; carbon that has been emitted and stored in biomass is likely to return to the atmosphere relatively quickly. Second, it is much more difficult to reliably quantify sink enhancement than emissions reduction (Ballantyne et al. 2012). Third, this definition seems to count as mitigation various forms of what is usually called geoengineering (e.g., air capture of carbon by artificial trees). Finally, in popular and even policy discussions, 'mitigation' is normally used to refer to emissions reductions and rarely used to refer to sink enhancements.

The term is used in this way, I think, because the official conception of mitigation was introduced and championed by scientists, and expresses an earth systems view that does not neatly cohere with the pollution paradigm that has become dominant in the in the

policy discourse. NGOs and political leaders talk about global warming pollution, not disequilibrium in the carbon cycle (http://www.environmentamerica.org/news/ame/president-obama-reaffirms-commitment-tackling-global-warming). In 2007 the United States Supreme Court ruled that carbon dioxide was a pollutant under the Clean Air Act (http://www.supremecourt.gov/opinions/06pdf/05-1120.pdf). In the policy discourse the term that is normally used for reducing emissions of pollutants is 'abatement' while 'mitigation' is normally used to refer to policies that moderate the severity of the effects of the pollution. For example, we abate air pollution by installing catalytic converters on cars or prescribing "no drive" days, and we mitigate pollution by maintaining or increasing vegetation (http://www.epa.gov/nrmrl/appcd/nearroadway/workshop.html). My hypothesis is that when people came to see climate change as a pollution problem they began to use 'mitigate' for 'abate' since the term 'mitigate' was already deeply entrenched in the climate change discussion. The effect of this has been to marginalize sink enhancement or leave it out of the conversation all together.

Although there is serious disagreement about exactly what technologies count as geoengineering (US GAO 2010), the distinction between carbon dioxide removal (CDR) and solar radiation management (SRM) has become increasingly well-established (Parson and Keith 2013). CDR technologies would reduce atmospheric concentrations of carbon dioxide by increasing sinks (e.g., by fertilizing the ocean with iron) or by capturing carbon directly from the air ("air capture"). The use of these technologies is in principle no different from other attempts at enhancing sinks. Like other such attempts at reducing atmospheric concentrations of GHGs these CDR techniques should be thought of as mitigation strategies. SRM strategies would affect Earth's mean surface temperature by affecting albedo (e.g., painting surfaces white), blocking solar radiation (e.g., sun shields) or reflecting solar radiation back into space (e.g., stratospheric aerosol injection, space mirrors). These approaches are importantly different from abatement or mitigation since they are not directed towards reducing either stocks or flows of GHGs. Instead they are directly aimed at altering the Earth's energy balance. They are thus in a class of their own.

Geoengineering is a contested category of questionable coherence in part because scientists and engineers from different research traditions and disciplinary backgrounds have forwarded proposals that reflect their own interests. Oceanographers, biologists, chemists, physicists, and engineers have all found something to advocate under this rubric. What these proposals have in common, if anything, is that they are "global, intentional, and unnatural" (Schelling 1996:303). What Schelling is gesturing at by 'unnatural' is, I think, that these are new, untried technologies or technologies that would be put to new, untried uses. I think the most plausible view is that 'geoengineering' does not mark a specific category of response to climate change but simply alerts us to the fact that the approach under discussion is viewed by the speaker as novel, weird, exotic, unfamiliar, or untested.

One way to understand the point that I am making is with reference to speech-act theory (inaugurated by Austin 1962 and subsequently developed by many other philosophers and linguists). Its fundamental insight is the recognition that we use language to do much more than report facts or describe the world. For example, we use language to threaten, command, insult, cajole, praise, encourage and so on. Some utterances are almost entirely descriptive (e.g., "John is a bachelor" when uttered without affect or special background conditions), but other utterances perform acts and do not describe at all (e.g., "I now pronounce you married" and "I promise to pick you up at the airport," when uttered under appropriate conditions). Most utterances both describe the world and express the speaker's attitudes in varying degrees (e.g., "John is a polite boy," "John is a crook"). A rough test for the extent to which an utterance is descriptive is whether there are clear, uncontroversial truth-conditions for the utterance. The clearer and less controversial the truth-conditions, the more likely the utterance is to be primarily descriptive. The

fact that there is little controversy over the truth conditions for "John is a bachelor" is evidence for supposing that such an utterance is almost entirely descriptive. On the other hand an expletive hurled in John's direction may have no truth-conditions at all, and this is a reason for supposing that such an utterance is almost entirely an expression of the speaker's attitude. My point about geoengineering is that utterances that employ this term, in contrast to those that employ such terms as 'abatement', 'mitigation', and 'solar radiation management', are often primarily expressive rather than descriptive, and seeing this helps to explain why there is so little internal coherence to the concept of reengineering and such controversy about what it encompasses. So long as we see that the use of 'geoengineering' is primarily as an attitudinal marker of suspicion and do not confuse it with a term that delineates a distinct category of responses, then it may still have some role to play in the climate policy debate. The use of this term alerts us to the fact that a proposed intervention in the climate system is one that, in the opinion of the speaker, requires a heightened level of scrutiny.

3 Why geoengineer?

Adaptation to climate change will occur and so to some extent will abatement and mitigation. None of this will be enough and pressure is already building for other approaches, especially those that promise gain without pain. To many, this is the promise of proposals discussed under the rubric of 'geoengineering' (Nordhaus 1992; Barrett 2008). But even those who see such proposals as attractive in this way tend to see them as a last resort.

Many people see deploying geoengineering as like giving an experimental drug to a dying patient. Geoengineering has even been called Plan B, as if it were the "morning after pill" for societies that do not practice safe consumption (Goodell 2010:110). Geoengineering is supposed to be the "backstop" that is going to gather up all those errant carbon molecules (NAS/NRC 2010). Because geoengineering is typically treated as nearly cost-free (especially SRM) and only to be used in the "bottom of the ninth," there may be a tendency to exempt proposals that are classed in this way from the critical scrutiny that we give to other proposals for responding to climate change (e.g., building nuclear power plants). After all, when it comes to preventing the explosion of a "ticking bomb," we are allowed to take steps that would not otherwise be justified.

If metaphors were arguments geoengineering would be home free. What these metaphors have in common is that they invite us to see geoengineering as a categorical rival to other approaches to climate change. In my opinion this view is entirely wrong. The real problem we face is not in choosing the right class of responses to climate change but rather in selecting and implementing a portfolio of specific strategies. It is important to interrogate each particular proposal whether considered geoengineering or not for efficacy, and ethical, political, social and economic acceptability. There is no particular set of norms that specifically apply to proposals that are introduced in the language of geoengineering. Nor should such proposals be exempted from norms that would otherwise apply simply because they have been introduced to the discussion in the language of this weedy category.

4 Worries about geoengineering

In this section I discuss various worries that have been expressed about the uses of some technologies that are often considered forms of geoengineering. Some of these worries are broader than geoengineering, focusing especially on intentional climate change. Others

involve SRM or CDR strategies generally while others attach to particular instances of these proposals. I do not discuss all the worries that have been expressed about these or other proposals that are considered by some to be in the domain of geoengineering.

4.1 Silver bullets

Even under optimistic assumptions and a capacious notion of what counts as geoengineering, there are no "silver bullets" (to use another metaphor) for addressing the problem of climate change. Deploying particular technologies could help to address some problems associated with GHG emissions while neglecting or exacerbating others.

Sulfate aerosol injection, the approach discussed by Crutzen (2006), has received a great deal of attention. It would involve injecting sulfate aerosols into the stratosphere where they would scatter sunlight back into space. Even if this approach were successful in reducing mean surface temperatures, it would likely produce substantial regional variations in temperature, precipitation, and the intensity of the hydrological cycle, even perhaps disrupting the Indian monsoon (Robock et al. 2008; Brovkin et al. 2009; Bala et al. 2008). The 1991 eruption of Mount Pinatubo, which many consider a "natural experiment" in sulfate aerosol geoengineering, produced a substantial decrease in precipitation over land and even brought drought to some parts of the tropics (Trenberth and Dai 2007). In any case sulfate injection would do nothing to address problems such as ocean acidification. Managing solar radiation through sulfate aerosol injection would post an enormous societal challenge since the particles would have to be replenished frequently, perhaps on an annual basis (Bengtsson 2006). If we were to embark on an SRM program while continuing to increase the atmospheric concentration of carbon dioxide, we would risk catastrophic climate change if we were to lose the capacity or will to manage solar radiation anytime during the next millennium or beyond. There are few precedents in human history of such successful millennium-scale management (perhaps the Great Wall of China, which was functional from the 5th century BCE through the 16th century CE, is one).

CDR strategies avoid some of these risks but, depending on the rate of removal, could have unpredictable climate effects (Preston 2012). Moreover, it would be difficult and expensive to create the infrastructure for a program that would be on a scale large enough to affect global climate and successfully sequester carbon for centuries or millennia. Doing this successfully would be equivalent to running the global fossil fuel industry in reverse. Extracting, transferring, and sequestering carbon on the scale that would be required would pose many challenges, including threats to local ecosystems (Gardiner 2011).

4.2 Declaring a climate emergency

Many people think that geoengineering technologies such as SRM should be developed but only deployed in case of a climate emergency (Goodell 2010; Victor et al. 2009). Sometimes climate emergencies are thought of in terms of tipping points, but in any case similar questions arise: How do we know when we are experiencing a climate emergency? Who has the authority to declare such an emergency? Could geoengineering technologies be deployed in a timely way to save us from the threat once an emergency was declared?

The first problem with knowing whether we are in a climate emergency is that one person's emergency is another person's bad day at the office. When Hurricane Sandy struck New York and New Jersey in 2012 it was regarded as an emergency, but hurricanes and tropical cyclones with much greater proportional impacts are familiar facts of life in parts of the Caribbean and South Asia (Pielke Jr and Pielke Sr 1997). Moreover, there are people living today in drought-stricken

parts of the world under conditions that we might reasonably say constitute an ongoing climate emergency. On the other hand rich people in fortunate regions may be able to cope fairly successfully with even relatively extreme climate change. Claims of emergency are value-laden and can be quite relative. Recognizing this, Bart Gordon, former Chair of the House Committee on Science and Technology, said that "the global climate science and policy communities should work towards consensus on what constitutes a "climate emergency" (Gordon 2010:40)". Noble sentiments perhaps, but when it comes to such a profound issue on which so much hinges, a consensus between global climate science and policy communities will be difficult to achieve. Even if such a consensus were achieved it is unlikely to represent the views of all the peoples of the world. Despite these difficulties we do sometimes seem to reach consensus around value-laden notions such as "dangerous anthropogenic interference with the climate system" (Oppenheimer 2005). While the value-ladenness of claims about a climate emergency is not sufficient to forestall consensus it does make matters difficult, especially since climate is abstract and many of its most dramatic effects are indirect.

A more serious problem for knowing when we are in a climate emergency is that the effects of climate change occur over centuries and even millennia. Were we able to see clearly from here all the effects of the GHGs that have already been emitted perhaps we would agree that a climate emergency is already upon us. The problem is that we cannot see all the effects of our emissions because they are dissociated (temporally and otherwise) from their causes. Not only does this make it difficult for us to know whether we are in a climate emergency but it leads to a further problem. By the time we come to an agreement that we are in a climate emergency, there may be little to do but watch it unfold. Or perhaps at that stage the appropriate response would be attempts at radical adaptation and survival rather than trying to exert control over climate. It is often said that some SRM technologies such as sulfate aerosol injection could be rapidly deployed, but it is not clear exactly what 'rapidly' means in a real world context (Royal Society of London 2009). Even if in principle sulfate aerosol injection could be deployed and affect climate in less than a decade, human and social factors could dramatically affect the pace of deployment.

An even more troubling question concerns who has the authority to declare a climate emergency. There is a great deal of talk in the geoengineering community about the importance of governance. At the same time there is concern that any truly inclusive governance process would not be able to act decisively in the face of a climate emergency (the glacial pace of negotiations under the Framework Convention on Climate Change (FCCC) is evidence for this). It might be said (perhaps unfairly) that many in the geoengineering community think that governance is good so long as it rapidly comes to the right decisions. Of course many of us are tempted to think the same about democracy.

4.3 Governance

There are very serious issues at stake here. Intentionally changing climate is a way of exerting power on a global scale in a context in which relevant norms, conventions, and treaties barely exist, are highly ineffectual, or very controversial. In 1955 John Von Neumann predicted:

> Intervention in atmospheric and climatic matters ....will unfold on a scale difficult to imagine at present… [T]his will merge each nation's affairs with those of every other, more thoroughly than the threat of a nuclear or any other war would have done (von Neumann 1955, pp. 108, 151)

Climate change, whether inadvertent or intentional, involves winners and losers at many different scales. Even countries that would benefit from such changes value their autonomy

and rights to engage in decision-making. Any attempt by any individual or nation to assume the authority to intentionally change climate without broad international agreement would be extremely divisive and disruptive. Indeed, outside the geoengineering community in the United States and Britain, suspicion about these activities is already very great. In Nagoya, Japan in Fall, 2010 the parties to the Convention on Biological Diversity (a treaty that the United States has signed but not ratified) declared a moratorium on geoengineering research that would affect biodiversity. It may be surprising that the parties to the CBD took an interest in geoengineering but not surprising that any interest that the parties would take would be skeptical and critical.

It is difficult to even imagine what would be the correct principles of procedural justice to invoke in cases in which the intention was to change the global climate. Every living thing on Earth (and perhaps even those who will live in the future) would be affected by such actions. Yet it is surely too much to require that everyone who is affected must participate in a decision for it to be legitimate (cf Hale and Dilling 2011; Nozick 1974:268–271; Caney 2005:158). I am affected by your opening a donut shop across the street from mine, but I have no right to participate in your decision to open the shop (except perhaps in the most general and indirect way, e.g., in background decisions about zoning, property rights, etc.). Even if we assume that nations are the proper decision-makers for attempts to change the global climate, it leaves open the question of the threshold of agreement that is required (majority? consensus?), and the institutional location of the decision-making process. It is sometimes suggested that the UN Security Council would be the most appropriate institution for authorizing intentional climate change, but the moral authority of the Security Council is itself in question and it is not clear that under the UN Charter that it has competence over such matters.

One possibility would be to restructure the FCCC so that it incorporates two bodies, one that mirrors the Security Council and the other that mirrors the General Assembly. The Conference of the Parties of the FCCC, mirroring the General Assembly, would operate according to majority vote rather than by consensus as it does currently. A new body would be composed of the world's largest nations. Mirroring the Security Council, it would have the authority to take strong action but unanimous consent would be required. Such a picture both reflects the vision of a reasonable reform of the UN Security Council, and also expresses the idea that decisions regarding climate change are of the same gravity as those regarding military intervention. Too bad it has little chance of adoption.

What appears to be happening instead is a drift towards the ad hoc regulation of various technologies. The London Convention and the Convention on Biological Diversity can be viewed as having asserted competence over some CDR technologies (Bodansky 2013), while some recent scholarship seems to be moving in the direction of advocating a new agreement governing SRM technologies (Lloyd and Oppenheimer 2013; Parson and Keith 2013).

One plausible conclusion that can be drawn from this miasma of uncertainty is that the more likely a procedure is to be legitimating, the less likely it is that any form of intentional climate change will be authorized. As a result, if geoengineering technologies are deployed, they are likely to be deployed without moral authority by the same countries that have caused a great deal of inadvertent climate change and have evaded the difficult decisions that would be required to reduce emissions. In other words, the same people who brought you climate change will be here to save you from it (Jamieson 1996).

4.4 Moral hazards

Many people, even some prominent proponents, have expressed concern that geoengineering research will distract us from the basic challenge of reducing carbon emissions (Keith et al. 2010). I

believe that talk about geoengineering has already to some extent dampened our willingness to reduce emissions. Only months after the Rio Earth Summit, the adoption of the FCCC, and the promise by the United States and other developed countries to stabilize their GHG emissions, the economist, William Nordhaus (1992:1317), wrote:

> geoengineering, would introduce a hypothetical technology that provides costless mitigation of climate change. This could occur, for example, if one of the geoengineering options proved technically feasible and environmentally benign. Two interesting proposals include shooting smart mirrors into space with 16-in. naval rifles or seeding the oceans with iron to accelerate carbon sequestration.

The dream of "costless mitigation of climate change" has been a constant if ghostly presence in the climate change debate for the last half-century and I believe has already functioned as a moral hazard with respect to GHG emissions reduction (but cf Hale 2012).

My fear is that speculations about geoengineering will increasingly become a moral hazard with respect to adaptation as well, driving out funding especially for the poorest populations who have done the least to cause climate change. SRM and CDR technologies are increasingly discussed as technologies that will primarily benefit the poor, precisely because they will suffer most from climate change. On Plan B, rather than spending trillions to curb emissions, adapt or compensate victims, the rich countries will give their own scientists billions in an effort to prevent the bad consequences of climate change from occurring. It is this emerging vision that presents the second and currently most threatening moral hazard posed by speculation about geoengineering.

4.5 Arrogance

The very idea of intentionally changing climate strikes many people as arrogant, both because it fails to show respect for nature and because it is of a piece with attitudes that have been implicated in causing the problem it purports to solve. Indeed, many of our environmental problems flow from attempts to manipulate nature in order to make it conform to our desires rather than shaping our desires in response to nature. We have "improved" nature in many ways—bringing water to places where people want to live, exterminating animals who prey on animals we raise for food, dredging harbors and filling wetlands so towns and cities can be developed and so on. Although it is not possible or desirable for humans always to "let nature take its course," there is a growing sense that modem societies have erred on the side of excessive intervention; that we have become arrogant and intrusive in attempting to manage all elements of nature.

A view that one often hears in conversation is that whatever arrogance would be involved in intentionally changing climate is already expressed in our current climate-changing behavior. Some even say that there is not a difference of intentionality in these cases since we have been aware of the climate-changing impacts of our actions since at least 1992. On this view deploying a geoengineering technology would be undertaking intentional climate change in response to the intentional climate change that is now underway. This view is mistaken, however. Many of the actions that cause climate change are intentional, but climate change is not their intended effect, thus the climate change they produce cannot be said to be intentional.

This distinction is important because many people believe that there is a moral asymmetry between what is brought about intentionally and what is an inadvertent result of an action. While I don't believe that this view in its strongest forms can be fully defended, it is

surely not generally true that intentionally performing some act is morally equivalent to inadvertently performing the same act (http://plato.stanford.edu/entries/double-effect/). Intentionally running over a pedestrian is generally regarded as worse than doing so inadvertently or accidentally. Indeed, when trying to evade responsibility for an action, people often claim that what happened was not what they intended ("I didn't mean to do it"). In some cases intentionality is crucial even to how acts are classified. Intentionally running down a pedestrian is murder; inadvertently killing the pedestrian is an accident. Intentional deception is lying; inadvertent deception is leaving a false impression. There is much more to say here, but the simple thought that whatever arrogance there would be in deploying a geoengineering technology is already present in our current pattern of behavior because these acts are morally equivalent cannot be sustained.

What drives the view that intentionally changing climate would be an act of human arrogance is the idea that geoengineering would disrupt a relationship that is as old as humanity. Until relatively recently human lives were lived against the background of natural events that were beyond human control. But rather than providing the background against which human lives unfold, nature is increasingly becoming another human artifact. The idea that even climate could become a human creation is seen by many as a deep rupture in the fabric that brought humanity into existence and over millennia given meaning to human lives. These concerns about the arrogance of intentionally changing climate have been foreshadowed in debates about ecological restoration and the intentional remaking of the planet favored by some managers and engineers (Elliot 1997; Katz 1997).

4.6 The risks of research

Most geoengineering advocates say that what they want is not deployment, but a dedicated research program. The program would start small, but could gear up to the scale of the Manhattan Project. They claim that there is a bright line between research and deployment.

Bright lines, however, have a way of fading, particularly when it comes to dedicated research programs. In 1983, President Reagan created the Strategic Defense Initiative, a program devoted to developing technologies that would protect the American homeland from nuclear attack. Despite large costs and widespread opposition from many of the nation's leading scientists, Reagan's initiative has survived in some form for three decades, focusing on different technologies and wrapping itself in different purposes. It led to the U.S. withdrawal from the Anti-Ballistic Missile Treaty in 2002, increased international tensions on numerous occasions, and siphoned money away from valuable uses toward technological fantasies.

Large research initiatives can be tougher to kill than vampires: they feed fortunes, careers, and reputations. As with the Strategic Defense Initiative, a dedicated geoengineering research program risks creating a self-amplifying cycle of interest groups and lobbies, building momentum toward eventual deployment as a way of justifying the research.

A dedicated geoengineering research program is especially dangerous in the current unstable policy environment in which there is a large amount of good will backed by large sums of money, in a context in which there is little regulation. The voluntary carbon offset market has been valued at more than $700 million (Peters-Stanley et al. 2011). Successful attempts to appeal to this market could eventually lead to being part of a regulated offset market potentially worth billions. It is not too difficult to imagine that something like the medical/pharmaceutical complex could emerge in which research, deployment, marketing, and government policy are closely linked and mutually reinforcing. Given the large potential sums at stake, it is not surprising that the push for a dedicated government-supported research program is so strong and comes from so many different directions.

What is often ignored is that the United States government already spends more than $50 million per year in geoengineering-related research; this is in addition to private spending (US GAO 2010). There is a case for better coordination and perhaps for increased funding, but it matters enormously how the research is conceptualized, what agencies lead, and whether it is regarded as mission-driven or basic research. Indeed, in some areas regarded as geoengineering (e.g., ocean fertilization), it is basic research that is most needed.

5 Concluding remarks

In this paper I have discussed the nature of geoengineering, explained some of its attractions, and given reasons for concern. I have claimed that 'geoengineering' does not delineate a distinct category of responses, but rather expresses the suspicion of a speaker towards responses that she sees as in some way novel, weird, exotic, unfamiliar, or untested. Although I have not directly argued this here, research in areas that involve CDR and SRM should go on despite some reasonable grounds for suspicion. Such research should be regarded as part of the general portfolio of climate-related research, competing with the full panoply of other approaches. If climate change is to be tamed it will not be by a silver bullet but by silver buckshot, and technologies that some regard as geoengineering may be part of what helps us to cope with the profound changes to which we are already committed.

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