Is Geoengineering Research Ethical?

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Abstract

Among the many ethical issues involved in the subject of geoengineering, is the fundamental question of whether geoengineering research itself is ethical. Does geoengineering research take resources away from activities that are more useful to society? Does geoengineering research create a research and implementation infrastructure that is a slippery slope to deployment? Is geoengineering research an exercise in hubris or another means for developed countries to run the world for their benefit? What are the differences between carbon dioxide reduction and solar radiation management geoengineering research? Does it make a difference if the research is indoors or outdoors? Should implementation technology be built and tested? Does the existence of geoengineering research remove the political drive for mitigation of climate change by stopping greenhouse gas emissions? This article focuses on solar radiation management and argues that, in light of continuing global warming and dangerous impacts on humanity, indoor geoengineering research is ethical and is needed to provide information to policymakers and society so that we can make informed decisions in the future to deal with climate change. This research needs to be not just on the technical aspects, such as climate change and impacts on agriculture and water resources, but also on historical precedents, governance, and equity issues. Outdoor geoengineering research, however, is not ethical unless subject to governance that protects society from potential environmental dangers.

Keywords: geoengineering, solar radiation management, SRM, ethics, governance

1. Introduction

In light of the failure of society to take any concerted actions to deal with global warming in spite of the 1992 United Nations Framework Convention on Climate Change, two prominent atmospheric scientists published papers six years ago suggesting that society consider geoengineering solutions to global warming (Crutzen, 2006; Wigley, 2006). This is not a new idea, as there is a long history of attempts to control weather and climate (Fleming, 2010) and of research on the subject (Robock et al., 2008). Nevertheless, Crutzen's paper generated much interest in the press and in the scientific community, and there has been an increasing amount of work on the topic since then. But is geoengineering research ethical?

The term geoengineering has come to refer to both carbon dioxide reduction and solar radiation management (Shepherd et al., 2009; Lenton and Vaughan, 2009), and these two different approaches to climate control have very different scientific, ethical and governance issues. Carbon dioxide reduction, by removing CO_2 from the free atmosphere, can only make gradual changes in future climate and most agree that if it could be done safely and cheaply enough, it would remove the primary cause of global warming and be a good thing. Therefore, research on carbon dioxide reduction is ethical, and will not be further addressed here.

This paper will only deal with solar radiation management (SRM), and focus on suggestions to produce stratospheric clouds to reflect sunlight in the same way large volcanic eruptions do or to brighten marine clouds by injecting particles into them. Stratospheric aerosols and marine cloud brightening are the only two schemes that seem to have the potential to produce effective and inexpensive large cooling of the planet (Lenton and Vaughan, 2009). Unless otherwise noted, this paper will use the term geoengineering to refer to SRM.

The American Meteorological Society policy statement on geoengineering (AMS, 2009), which was subsequently adopted by the American Geophysical Union (AGU, 2009), recommends "Enhanced research on the scientific and technological potential for geoengineering the climate system, including research on intended and unintended environmental responses." Strong recommendations for geoengineering research have recently also come from Keith et al.

(2010), GAO (2011), and Betz (2012). All argue that while research so far has pointed out both benefits and risks from geoengineering, and that it is not a solution to the global warming problem, at some time in the future, despite mitigation and adaptation measures, society may be tempted to try to control the climate to avoid dangerous impacts. Much more research on geoengineering is needed so that society will be able to make informed decisions. I argue here in support of those recommendations. Right now, we do not know whether geoengineering may make the situation even more dangerous, and any future geoengineering decisions should not be made in ignorance.

2. What is Potentially Wrong With Geoengineering Research?

2.1. General Considerations

As the AGU (2009)/AMS (2009) statement says, "Exploration of geoengineering strategies also creates potential risks. The possibility of quick and seemingly inexpensive geoengineering fixes could distract the public and policy makers from critically needed efforts to reduce greenhouse gas emissions and build society's capacity to deal with unavoidable climate impacts. Developing any new capacity, including geoengineering, requires resources that will possibly be drawn from more productive uses. Geoengineering technologies, once developed, may enable short-sighted and unwise deployment decisions, with potentially serious unforeseen consequences."

To this we can add that once a technology is developed, it will produce a commercial enterprise with an interest in self-preservation. We need think no further than the current over-developed military resources in the world, particularly in the United States, to see how dangerous, unusable technologies perpetuate themselves. The global nuclear arsenal is the most dangerous of these (e.g., Toon et al., 2009; Robock and Toon, 2010). And there is also great concern that geoengineering research will develop weapons to control the weather and climate of potential enemies. This has been the major motivation and funding source for such research until recently (Fleming, 2010).

The SRMGI (2011) report discusses these issues and adds global inequity: "SRM research could constitute a cheap fix to a problem created by developed countries, while further transferring environmental risk to the poorest countries and the most vulnerable people. Further, the SRM decision-making process (e.g., who decides if and when large-scale experiments are undertaken or deployment occurs, and where to set the 'global thermostat') could further exacerbate divisions between developed and developing countries over global climate politics."

SRMGI (2011) further discusses "Hubris and interference with nature. Artificial interference in the climate system may be seen as hubristic: 'playing God' or 'messing with nature,' which is considered to be ethically and morally unacceptable. While some argue that human beings have been interfering with the global climate on a large scale for centuries, SRM involves *deliberate* interference with natural systems on a planetary scale, rather than an inadvertent side effect. This could be an important ethical distinction."

2.2. Outdoor Experiments

The research itself might be dangerous, and therefore unethical. Indoor research (e.g., data analysis of the effects of volcanic eruptions and ship tracks, computer modeling, technology development in a laboratory) is subject to all the above issues. But outdoor research, where gases and particles are emitted into the atmosphere to test technology or examine the effects on marine clouds or on ozone depletion and radiative transfer in the stratosphere, could have negative environmental impacts. Is it ethical to create additional pollution just for scientific experimentation?

While testing SRM in the stratosphere would require large emissions to see how particles would grow in the presence of an existing sulfuric acid cloud or to see if there were a climate response (Robock et al., 2010), "small" experiments to test balloon-hose systems (the cancelled SPICE experiment in the UK) or the potential of stratospheric particles to deplete ozone (David Keith and James Anderson, personal communication, June, 2012) have been proposed. In 2011, the Eastern Pacific Emitted Aerosol Cloud Experiment led by Lynn Russell off the coast of

California emitted smoke from a ship to see its effect on marine clouds, funded by the U.S. National Science Foundation. Thus unregulated outdoor experimentation has already begun.

As Robock (2011) asks, in discussing a proposal to use bubbles to brighten the ocean, how much environmental impact should be allowed in the name of science? "…when scientists propose small-scale in situ field experiments, they will be confronted with unsolved ethical and governance issues. What if the field trials prove dangerous to marine life or the regional climate? Up to what temporal and spatial scales, and what amount of emissions or disturbance should be allowed? And how will this decision be made? By ethical panels associated with funding agencies? By international conventions, such as the London Convention? And what criteria will be used for the allowed impact? Less than the disturbance of current ocean waves, or of a tanker traversing an ocean? But does intention matter? Is additional disturbance OK, even if it adds on to current disturbance? Do two wrongs make a right?" And what if an experiment gives noisy results that are hard to interpret. The tendency will be to expand the experiment to get more data, by emitting more material, or extending the experiment over a larger area or for a longer time. Rules and enforcement mechanisms would need to be in place to deal with this.

3. Discussion and Conclusions

Unlike the physical sciences, where nature obeys certain well-accepted principles, like conservation of mass and conservation of energy, ethical decisions involve values. Scientific results inform such decisions, but there can be no proof or test of the values that can be replicated by other investigators. So the decision of whether geoengineering research is ethical requires a statement of the personal values and principles that are used to make the decision, and the decision depends on those particular values and principles. In the following discussion I list the principles I use, and the conclusions that follow from each.

Curiosity-driven indoor research cannot and should not be regulated, if it is not dangerous. Indoor geoengineering research is already being conducted and funded in the United

States, Europe and elsewhere. Much of it is intimately related to climate research, and has the potential to produce important new information. Support for such work come from the interests of the scientists involved and their ability to convince funders to support that work over other competing proposals. For example, I am just now beginning my second United-States-National-Science-Foundation-sponsored project to conduct geoengineering climate modeling experiments and analyze the effects of volcanic eruptions on climate. One activity is to work on the GeoMIP project to compare standardized climate modeling experiments of SRM (Kravitz et al., 2011). This involves the participation of climate modeling groups from around the world, including efforts specifically funded for geoengineering research by the United Kingdom and Europe. The knowledge gained will be very useful for climate science in general as well as for the impacts of geoengineering. Policymakers need to know the benefits, risks, and costs of options to deal with global warming, including those of geoengineering. Anyway, the total funding for climate research on the planet is small. Geoengineering research funding can come from additional sources of money and need not take away from existing research programs. For example, a larger fraction of current geoengineering research funding comes from the US$1,000,000 per year that Bill Gates gives to David Keith and Ken Caldeira.

Emissions to the atmosphere, even for scientific purposes, should be prohibited if they are dangerous. Air pollution is regulated within each nation. So outdoor experiments must satisfy such existing rules. Yet there are places on the planet over land with weak regulatory structures, and there are no rules over the ocean. Existing environmental treaties (Appendix 3 of SRMGI, 2011) do not provide a structure for regulating outdoor geoengineering research without significant modification and updating. Yet emission of salt, smoke, or sulfate over the ocean or sulfate into the stratosphere has the potential to be dangerous. It is clear, however, that limited emissions would not be dangerous. For example, flying a plane into the stratosphere once to see if it can produce sulfate particles of the desired properties would not be dangerous. But how many flights should be allowed? Therefore, I conclude that outdoor geoengineering experiments should be prohibited until a governance structure to regulate them is in place.

The idea of geoengineering is not a secret, and whatever results from it will need to be governed the same way as all other dangerous human inventions, such as ozone depleting *substances and nuclear weapons.* Indeed, the development of geoengineering technology has the potential to create weapons, or to create a business interest in deployment. But it is too late to prevent this from happening. The world will have to deal with this potential danger to the planet as it does with other such dangers. The strong nations make those rules, but many of them protect the entire planet, such as the nuclear test ban treaty and the Vienna Convention. It is the failure of such governance on global warming that even leads us to consider geoengineering, however.

Perhaps, in the future the benefits of geoengineering will outweigh the risks, considering the risks of doing nothing. Only with geoengineering research will we be able to make those judgments. But a current governance structure for geoengineering does not exist, and needs development along with the science and technology.

To summarize, indoor geoengineering research is ethical, but outdoor geoengineering research is not, unless subject to governance mechanisms yet to be developed. The benefits of knowledge outweigh the risks of not knowing.

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