

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. 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

59 **1. Introduction**

60

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

69

70 Geoengineering raises a number of ethical questions. Does geoengineering research take
71 resources away from activities that are more useful to society? Does geoengineering research
72 create a research and implementation infrastructure that is a slippery slope to deployment? Is
73 geoengineering research an exercise in hubris or another means for developed countries to run
74 the world for their benefit? What are the differences between carbon dioxide reduction and solar
75 radiation management geoengineering research? Does it make a difference if the research is
76 indoors or outdoors? Should implementation technology be built and tested? Does the existence
77 of geoengineering research remove the political drive for mitigation of climate change by
78 stopping greenhouse gas emissions?

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80 The term geoengineering has come to refer to both carbon dioxide reduction and solar
81 radiation management (Shepherd et al., 2009; Lenton and Vaughan, 2009), and these two
82 different approaches to climate control have very different scientific, ethical and governance
83 issues. Carbon dioxide reduction, by removing CO₂ from the free atmosphere, can only make
84 gradual changes in future climate and most agree that if it could be done safely and cheaply
85 enough, it would remove the primary cause of global warming and be a good thing. Therefore,
86 research on carbon dioxide reduction is ethical, and will not be further addressed here.

87

88 This paper will only deal with solar radiation management (SRM), and focus on
89 suggestions to produce stratospheric clouds to reflect sunlight in the same way large volcanic

90 eruptions do or to brighten marine clouds by injecting particles into them. Stratospheric aerosols
91 and marine cloud brightening are the only two schemes that seem to have the potential to
92 produce effective and inexpensive large cooling of the planet (Lenton and Vaughan, 2009).
93 Unless otherwise noted, this paper will use the term geoengineering to refer to SRM.

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95 The American Meteorological Society policy statement on geoengineering (AMS, 2009),
96 which was subsequently adopted by the American Geophysical Union (AGU, 2009),
97 recommends “Enhanced research on the scientific and technological potential for geoengineering
98 the climate system, including research on intended and unintended environmental responses.”
99 Strong recommendations for geoengineering research have recently also come from Keith et al.
100 (2010), GAO (2011), and Betz (2012). All argue that while research so far has pointed out both
101 benefits and risks from geoengineering, and that it is not a solution to the global warming
102 problem, at some time in the future, despite mitigation and adaptation measures, society may be
103 tempted to try to control the climate to avoid dangerous impacts. Much more research on
104 geoengineering is needed so that society will be able to make informed decisions. I argue here in
105 support of those recommendations. Right now, we do not know whether geoengineering may
106 make the situation even more dangerous, and any future geoengineering decisions should not be
107 made in ignorance.

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110 **2. What is Potentially Wrong With Geoengineering Research?**

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112 **2.1. General Considerations**

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114 As the AGU (2009)/AMS (2009) statement says, “Exploration of geoengineering
115 strategies also creates potential risks. The possibility of quick and seemingly inexpensive
116 geoengineering fixes could distract the public and policy makers from critically needed efforts to
117 reduce greenhouse gas emissions and build society’s capacity to deal with unavoidable climate
118 impacts. Developing any new capacity, including geoengineering, requires resources that will
119 possibly be drawn from more productive uses. Geoengineering technologies, once developed,

120 may enable short-sighted and unwise deployment decisions, with potentially serious unforeseen
121 consequences.”

122

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

131

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

138

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

145

146 **2.2. Outdoor Experiments**

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148 The research itself might be dangerous, and therefore unethical. Indoor research (e.g.,
149 data analysis of the effects of volcanic eruptions and ship tracks, computer modeling, technology
150 development in a laboratory) is subject to all the above issues. But outdoor research, where

151 gases and particles are emitted into the atmosphere to test technology or examine the effects on
152 marine clouds or on ozone depletion and radiative transfer in the stratosphere, could have
153 negative environmental impacts. Is it ethical to create additional pollution just for scientific
154 experimentation?
155

156 While testing SRM in the stratosphere would require large emissions to see how particles
157 would grow in the presence of an existing sulfuric acid cloud or to see if there were a climate
158 response (Robock et al., 2010), “small” experiments to test balloon-hose systems (the cancelled
159 SPICE experiment in the UK) or the potential of stratospheric particles to deplete ozone (David
160 Keith and James Anderson, personal communication, June, 2012) have been proposed. In 2011,
161 the Eastern Pacific Emitted Aerosol Cloud Experiment led by Lynn Russell off the coast of
162 California emitted smoke from a ship to see its effect on marine clouds, funded by the U.S.
163 National Science Foundation. Thus unregulated outdoor experimentation has already begun.
164

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

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

192

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

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

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224 *The idea of geoengineering is not a secret, and whatever results from it will need to be*
225 *governed the same way as all other dangerous human inventions, such as ozone depleting*
226 *substances and nuclear weapons.* In both these examples there would be unintentional
227 environmental dangers from the use of the products for their intended purposes. Indeed, the
228 development of geoengineering technology has the potential to create weapons, or to create a
229 business interest in deployment. But it is too late to prevent this from happening. The world will
230 have to deal with this potential danger to the planet as it does with other such dangers. The
231 strong nations make those rules, but many of them protect the entire planet, such as the nuclear
232 test ban treaty and the 1985 Vienna Convention for Protection of the Ozone Layer. It is the
233 failure of such governance on global warming, however, that even leads us to consider
234 geoengineering.

235
236 Perhaps, in the future the benefits of geoengineering will outweigh the risks, considering
237 the risks of doing nothing. Only with geoengineering research will we be able to make those
238 judgments. But a current governance structure for geoengineering does not exist, and needs
239 development along with the science and technology.

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241 To summarize, indoor geoengineering research is ethically justifiable, subject to the
242 principles discussed above. Outdoor geoengineering research, on the other hand is not ethical,

243 unless subject to governance mechanisms yet to be developed. The benefits of knowledge
244 outweigh the risks of not knowing.

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