Historical Perspectives on "Fixing the Sky"

Statement of
Dr. James Fleming
Professor and Director of Science, Technology and Society
Colby College

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U.S. House of Representatives
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Thank you Mr. Chairman, Ranking Member Hall, and Members of the Committee on Science and Technology for the opportunity to appear before you to provide testimony on Geoengineering: Assessing the Implications of Large-Scale Climate Intervention.

I am a historian of science and technology with graduate training in and life-long connections to the atmospheric sciences, and the founding president of the International Commission on History of Meteorology. I have just written a book on the history of weather and climate control, and I am currently working to connect the history of science and technology with public policy. I have been asked to provide a general historical context for geoengineering as a political challenge and to recommend first steps toward effective international collaboration on geoengineering research and governance.

Introduction

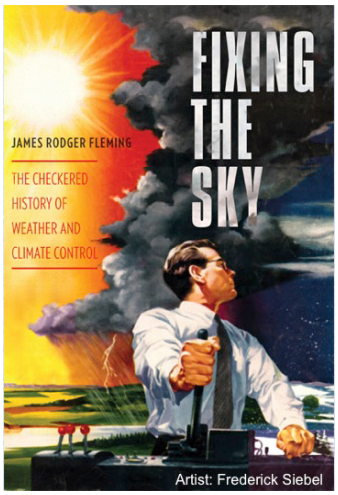
I would like to state my conclusions in advance, which are all based on the premise that history matters:

First, a coordinated *interdisciplinary* effort is needed to study the historical, ethical, legal, political, and societal aspects of geoengineering and to make policy and governance recommendations. This is one conclusion of the American Meteorological Society's 2009 Policy Statement on Geoengineering.

Second, an *international* "Working Group 4" on historical, social, and cultural dimensions of climate change in general and geoengineering in particular should be added to the Intergovernmental Panel on Climate Change (IPCC).

Third, a robust *intergenerational* component of training and participation, especially by young people, should be included in these efforts.

That is to say climate change is not quintessentially a technical issue. It is a socio-cultural and technical hybrid, and our effective response to it must be historically and technically informed, *interdisciplinary* in nature, *international* in scope, and *intergenerational* in its inclusion of graduate, undergraduate, and younger students.



Based on the premise that a picture is worth a thousand words, please allow me to illustrate some points from history and science studies.

This image of a technocrat pulling the levers of weather control appeared on the cover of Collier's Magazine in 1954. We were in a weather control race with the Soviet Union and a SAC general had just announced in the press that the nation that controls the weather will control the world. The article inside, by Eisenhower's weather advisor Harold Orville, included ways of conducting weather warfare.

A year later, in a prominent article titled, "Can We Survive Technology?" the noted Princeton mathematician and pioneer in computerized weather forecasts and climate models John von Neumann referred to climate control through managing solar radiation as a thoroughly "abnormal" industry that could have "rather fantastic effects" on a scale difficult to imagine. He pointed out that altering the climate of specific regions or purposefully triggering a new ice age were not necessarily rational undertakings. Tinkering with the Earth's heat budget or the atmosphere's general circulation "will merge each nation's affairs with those of every other more thoroughly than the threat of a nuclear or any other war may already have done." In his opinion, climate control could lend itself to unprecedented destruction and to forms of warfare as yet unimagined. It could alter the entire globe and shatter the existing political order. He made the Janus-faced nature of weather and climate control clear. The central question was not "What can we do?" but "What should we do?" This was the "maturing crisis of technology" for von Neumann, a crisis made more urgent by the rapid pace of progress.

Von Neumann is second from the left here, with the ENIAC computer and development team for numerical weather prediction. Harry Wexler is on the far left.

A male hand is on the thermostat
The hand is god-like in scale
Thermostat is "nowhere," but perhaps in outer space
Temperature is 73 but is being turned back to 54 or 5 degrees cooler than the long-term average of 59

Last Friday I participated in a major symposium at MIT on "Engineering a Cooler Earth." Their logo is at the top and my comments appear below that.

First of all, a male hand is on the thermometer, the hand is god-like in scale, and the thermostat is "nowhere," but perhaps in outer space. The temperature of 73 F is being turned back to 54, or 5 degrees cooler than the long-term planetary average of 59 F. Looking closely at the center of dial, the thermometer is centered on Roswell, New Mexico, which I take to be symbolic.

An emergent property of the MIT meeting was that the social science component—the voices calling for the study of history, politics, and governance of geoengineering—convinced more people than those engaged in geo-scientific speculation of a more technical nature. It is an emerging view in climate studies that humanities and governance perspectives are sorely needed. This was also clear this past summer at "America's Climate Choices" meeting on geoengineering, sponsored by Congressman Mollohan of West Virginia and convened by the National Academies of Science.

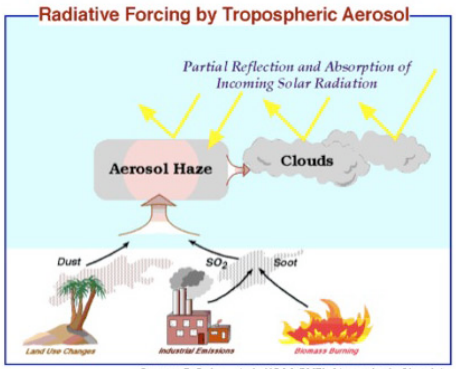
The "Tipping Point"

"Give me a place to stand and I will move the earth"—Archimedes. Engraving from Mechanics Magazine, London, 1824.

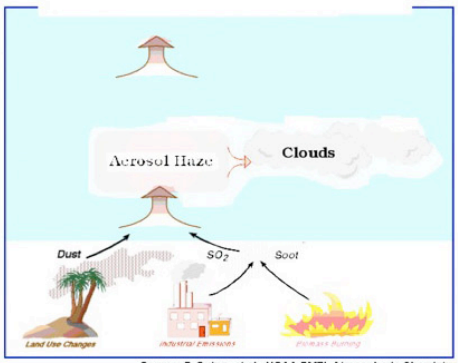
Where will it roll?

The image of Archimedes is sometimes invoked by geoengineers with the assertion that our technological levers are now getting long enough and powerful enough to move the Earth. But if Archimedes is a supposed geoengineer, where is he standing? And where will the Earth roll if tipped? With what consequences? Widespread discussions of "tipping points," have involved the physical climate system or public opinion, but it is important to remember that the geoengineering community has also passed a tipping point, and many of them actually wish to try it! But while some argue we can control the temperature of the globe, ironically, at a recent NASA meeting in 2006 on the topic of "Managing Solar Radiation," a meeting coordinator apologized for not being able to control the temperature of the room.

A Geopolitical Perspective on Aerosol Haze



Source: P. Quinn, et al., NOAA PMEL Atmospheric Chemistry



Source: P. Quinn, et al., NOAA PMEL Atmospheric Chemistry

LOCAL
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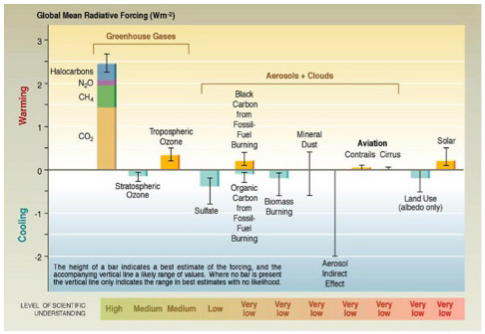
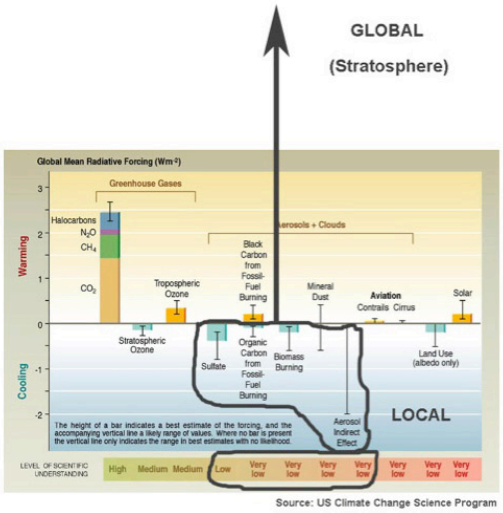
The aerosol haze from dust storms, industrial sulfate emissions, and biomass burning is widely believed have a <u>local</u> cooling effect by reflecting sunlight and by making clouds brighter in the troposphere, below about 30,000 feet. As we clean up industrial pollution and reduce biomass burning, the warming effects of greenhouse gases may become more pronounced. Since the early 1960s some geoengineers have repeatedly proposed injecting a sulfate aerosol haze into the high, dry, and stable stratosphere, where it would spread worldwide and have <u>global</u> cooling effects that might not fully offset greenhouse warming, might have unwanted side effects that might not be welcomed by all nations.



Source: US Climate Change Science Program



Source: US Climate Change Science Program

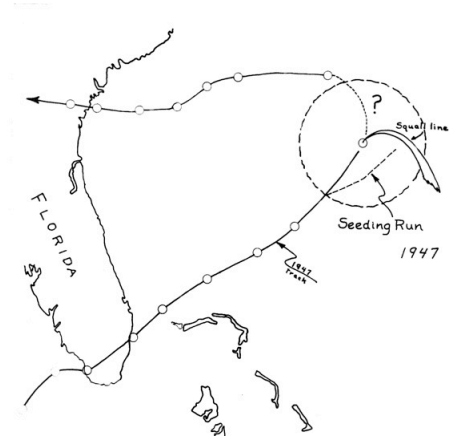
Although the heating effect of the major greenhouse gases is well known, the level of scientific understanding of the cooling effect of aerosols ranges from "low" to "very low." Geoengineers propose to transfer this cooling effect, and the lack of understanding about it, to the stratosphere, where it will become a global rather than a local process, again with likely unwanted side effects that others will address.

What's Wrong with Climate Engineering? (the short list)

1. We don't have the understanding (Ron Prinn, MIT).
2. We don't have the technology (Brian Toon, Univ. of Colorado).
3. We don't have the political capital, wisdom, or will to govern it.
4. It is not "cheap" since the side effects are unknown.
5. It poses a moral hazard, reducing incentives to mitigate.
6. It could be attempted unilaterally, or worse, proliferate.
7. It could be militarized, and learning from history it likely *would* be militarized.
8. It could violate a number existing treaties such as ENMOD (1978).
9. It does nothing to solve ocean acidification.
10. It will alter fundamental human relationships to nature.

What Role for History?

We have known this for a long time. Some climate engineers claim they are the "first generation" to propose the deliberate manipulation of the planetary environment. History says otherwise. In the 1790s Thomas Jefferson called for an "index" of the American climate to document its changes being effected by the clearing of the forests and the draining of the marshes. In the 1830s the first serious large scale engineering proposal to emulate "artificial volcanoes" was advanced by James Espy, the distinguished theorist of convection as the cause of rain who was employed by the U.S Army as the first national meteorologist. Espy proposed lighting huge fires all along the Appalachian Mountains to control and enhance the nation's rainfall, arguing that the heat, updrafts would trigger rain and would not only eliminate droughts, but also heat waves and cold snaps, rendering the air healthy by clearing it of miasmas. A popular writer, Eliza Leslie, immediately pointed out that manufactured weather control would generate more problems than it solved.



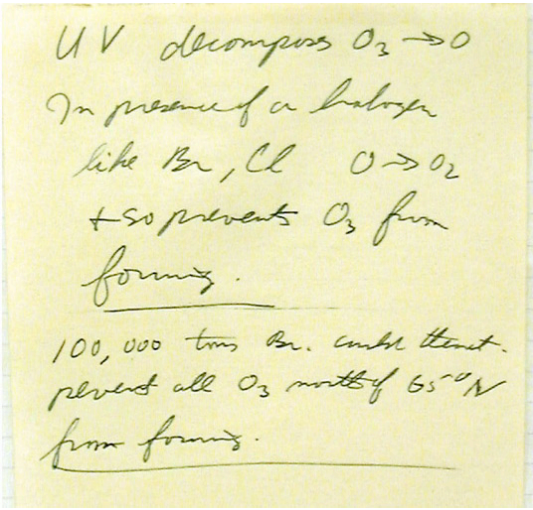
1947 military seeding of a hurricane by Project Cirrus

In 1946, Nobel Laureate Irving Langmuir believed he and his team at the General Electric Corporation had discovered means of controlling the weather with cloud seeding agents such as dry ice and silver iodide. A year later, in conjunction with the US military, they sought to deflect a hurricane from its path. After seeding, but not because of seeding, the hurricane veered due to what were later determined to be natural steering currents and smashed ashore on Savannah, Georgia. The planned press conference was cancelled, but Langmuir continued to claim he could control hurricanes, influence the nation's weather, and even planned to seed the entire Pacific basin in a mega-scale experiment intended to generate climate-scale effects.

Commercial and military interests inevitably influence what scientists might consider purely technical issues. Agricultural interests drove the nineteenth-century charlatan rainmakers in the American west as well as commercial cloud seeding since the 1940s. In the early Cold War era, as mentioned earlier, the military sought to control clouds and storms as weapons and in the service of an all-weather air force. There was a "weather race" with the Russians and secret cloud seeding in Vietnam. The 1978 United Nations Convention on the Prohibition of Military or any other Hostile Use of Environmental Modification Techniques (ENMOD), a landmark treaty, may have to be revisited soon to avoid or at least try to mitigate possible military or hostile use of climate control.

Wexler in the Oval Office

In 1962 Harry Wexler, Head of Research at the US Weather Bureau, shown here in the Oval Office, used computer models and satellite observations to study techniques to change Earth's heat budget. Wexler helped pen Kennedy's notable line, "We choose to go to the moon in this decade and do the other things…" Wexler was in charge of "the other things," such as the World Weather Watch and ways to influence or control weather and climate. It was Wexler, in the era of JFK (not Paul Crutzen in 2006) who first claimed climate control was now "respectable to talk about," even if he considered it quite dangerous and undesirable. Wexler described techniques to warm or cool the planet by two degrees. He also warned, notably, that the stratospheric ozone layer was vulnerable to inadvertent or intentional damage, perhaps by hostile powers, from small amounts of a catalytic agent such as chlorine or bromine.



UV decomposes $O_3 \rightarrow O$
In presence of a halogen
like Br, Cl $O \rightarrow O_2$
+ so prevents O_3 from
forming.

100,000 tons Br. could theoretically
prevent all O_3 north of 65° N
from forming.

Here is an important discovery, made just next door in the Library of Congress. It is Harry Wexler's handwritten note of 1962 that reads (substituting words for symbols), "Ultraviolet light decomposes ozone into atomic oxygen. In the presence of a halogen like bromine or chlorine, atomic oxygen becomes molecular oxygen and so prevents ozone from forming. 100,000 tons of bromine could theoretically prevent all ozone north of 65° N from forming." Recently, I have been in correspondence with three notable ozone scientists about Wexler's early work: Nobel Laureates Sherwood Rowland, Paul Crutzen, and current U.S. National Academy of Sciences President Ralph Cicerone. They are uniformly interested and quite amazed by Wexler's insights and accomplishments.

Wexler wrote in 1962, "[Climate control] can best be classified as "interesting hypothetical exercises" until the consequences of tampering with large-scale atmospheric events can be assessed in advance. Most such schemes that have been advanced would require colossal engineering feats and contain the inherent risk of irremediable harm to our planet or side effects counterbalancing the possible short-term benefits." This is still true today.

Today's science is tomorrow's history of science

"In facing unprecedented challenges, it is good to seek historical precedents," this is the epigraph of my new book *Fixing the Sky: The checkered history of weather and climate control.* History matters—it shapes identity and behavior; it is not just a celebratory record of inevitable progress; and its perspective should inform sound public policy. Each of our personal identities is the sum of our integrated past, including personal and collective memories, events, and experiences. It is not just who and where we are now, how we feel today, and what we had for breakfast. Applied to geoengineering, we should base our decision-making not on what we think we can do "now" and in the near future. Rather our knowledge is shaped by what we have *and have not* done in the past. Such are the grounds for making informed decisions. Students of climate dynamics who are passionate about climate change would be well-served to study science dynamics (history), since on decades to centuries and millennial time scales ideas and technologies have changed as dramatically or perhaps more dramatically than the climate system itself.

History can provide scholars in other disciplines with detailed studies of past interventions by rainmakers and climate engineers as well as structural analogues from a broad array of treaties and interventions. Only in such a coordinated fashion, in which researchers and policymakers participate openly, can the best options emerge that promote international cooperation, ensure adequate regulation, and avoid the inevitable adverse consequences of rushing forward to fix the sky.

Climate change is simple, and we all should seek ways of having less impact on the planet though a "middle course" of mitigation and adaptation that is amenable to all, reasonable, practical, equitable, and effective. But the climate system is extraordinarily complex, perhaps the most complex system ever modeled or observed, with the most important consequences imaginable for life and ecosystems. At best we can only apprehend climate change, with three senses of the word apprehension implied: (1) awareness and understanding, (2) anticipation, dread, fear, and (3) intervention and control. Certainly clouds, oceans, ice sheets and other factors make it more complex. But the wildest of the wild cards in the system is the human dimension, so studying that is absolutely essential.

Recommendations

I repeat my recommendations to the committee. We need:

1. A coordinated and autonomous *interdisciplinary* effort to study the historical, ethical, legal, political, and societal aspects of geoengineering and to make policy and governance recommendations, not as an afterthought and not necessarily within an existing scientific society.

2. An *international* "Working Group 4" on historical, social, and cultural dimensions of climate change in general and geoengineering in particular, perhaps under the auspices of the IPCC.

3. A robust *intergenerational* component of training and participation in such efforts.

In these ways I believe history can effectively inform public policy.

Thank you for your attention.

Selected References:

Fleming, James Rodger. *Fixing the Sky: The checkered history of weather and climate control.* Columbia University Press, 2010.

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Biosketch

James Rodger Fleming is Professor of Science, Technology, and Society at Colby College. He earned degrees in astronomy (B.S., Penn State), atmospheric science (M.S. Colorado State), and history (M.A. and Ph.D. Princeton) and worked in atmospheric modeling, airborne observational programs, consulting meteorology, and as historian of the American Meteorological Society. Professor Fleming has held major fellowships from the Smithsonian Institution, the National Science Foundation, the National Endowment for the Humanities, and the American Association for the Advancement of Science. He has been a visiting scholar at MIT, Harvard, Penn State, the National Air and Space Museum, the National Academy of Sciences, and the Woodrow Wilson International Center for Scholars.

Awards and honors include election as a Fellow of the AAAS "for pioneering studies on the history of meteorology and climate change and for the advancement of historical work within meteorological societies," participation as an invited contributing author to the Intergovernmental Panel on Climate Change, appointment to the Charles A. Lindbergh Chair in Aerospace History by the Smithsonian Institution, the Roger Revelle Fellowship in Global Stewardship by the AAAS, and a number of named lectureships including the Ritter at Scripps Institution of Oceanography, the Vetelsen at the University of Rhode Island, and the Gordon Manly Lectureship of the Royal Meteorological Society.

He is the author of *Meteorology in America, 1800-1870* (Johns Hopkins, 1990), *Historical Perspectives on Climate Change* (Oxford, 1998), *The Callendar Effect* (American Meteorological Society, 2007), and his latest, *Fixing the Sky: The Checkered History of Weather and Climate Control* (Columbia University Press, 2010). Recent co-edited volumes include *Intimate Universality* (Science History/USA, 2006), *Globalizing Polar Science* (Palgrave, 2010), and *Osiris* 26 (forthcoming) on climate. He is currently working to link the local and global in the history of Earth system science and to connect the history of science and technology with public policy.

Professor Fleming was the founder and first president of the International Commission on History of Meteorology and associate editor of the *New Dictionary of Scientific Biography,* He currently serves as editor-in-chief of *History of Meteorology*, domain editor for *Wiley Interdisciplinary Reviews on Climate*, history editor of the *Bulletin of the American Meteorological Society*, and member of the history committee of the American Meteorological Society and the American Geophysical Union.

Jim is a resident of China, Maine (not Mainland China!) with his wife Miyoko. Together they raised two sons. He enjoys fishing, good jazz, good BBQ, seeing students flourish, and building the community of historians of the geosciences. "Nothing is really work unless you would rather be doing something else."