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Will Geoengineering Bring Security and Peace?

What does History Tell us?

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Abstract: Ours is not the first generation to ponder geoengineering. Intentional weather and climate manipulation has a checkered history linked, in many cases, to militarization of the atmosphere. This paper examines proposals, practices, and warnings about geoengineering from the Cold War era in order to derive lessons applicable to today's situation. In the two decades following 1945, the new transformative technologies of nuclear power, digital computing, chemical cloud seeding and access to space emboldened a generation of scientists and engineers seeking control of nature and dominance over their superpower rivals. If today's would-be geoengineers are seeking security and peace, they need to study this history.

Keywords: Geoengineering, history, military, weather change
Geoengineering, Geschichte, Militär, Wetterveränderung

The nuclear age brought with it the idea that technology was becoming powerful enough to allow human intervention in natural systems at a global level. That is, the ancient fantasy of controlling nature might become a reality, and humanity would soon engage in planetary geoengineering. Chemical cloud seeding, the use of computers for weather and climate modeling, and access to space heightened the illusion. The Cold War added a sinister gloss to notions of control as the superpowers raced to weaponize nature. This essay documents some of the early enthusiasm for climate control, describes some proposed and actual geoengineering practices, and asks if the Cold War military origins of these ideas bode well for the future. Will geoengineering bring security and peace? What does history tell us? Why does history matter?[1]

In 1945 the prominent scientist-humanist-internationalist Julian Huxley, one of the founders of the United Nations Educational, Scientific and Cultural Organization (UNESCO), spoke to an audience of 20,000 at an arms control conference at Madison Square Garden about the possibilities of using nuclear weapons as "atomic dynamite" for "landscaping the Earth" or perhaps using them to change the climate by dissolving the polar ice cap. A few months later, World War I flying ace, businessman and entrepreneur Captain Eddie Rickenbacker went on record as advocating the use of atomic bombs for

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1 These issues are addressed in James Rodger Fleming, *Fixing the Sky: The checkered history of weather and climate control* (New York: Columbia University Press, 2010).

"cracking the Antarctic icebox" to gain access to its known mineral deposits.[2] The following year, Radio Corporation of America (RCA) president Brigadier General David Sarnoff made headlines with his prediction that weather and climate control could transform "deserts into gardens through diversion of ocean currents", a process that could be reversed in time of war to turn fertile lands into deserts. Sarnoff's list of worthy projects for the postwar era included ordering "rain or sunshine by pressing radio buttons," an accomplishment that, he declared, would require a World Weather Bureau in charge of global forecasting and control.[3] A commentator in the *New Yorker* intuited the problems with such control. "Who," in this civil service outfit, he asked, "would decide whether a day was to be sunny, rainy, overcast . . . or enriched by a stimulating blizzard?" It would be "some befuddled functionary," probably bedeviled by special interests such as the raincoat and galoshes manufacturers, the beachwear and sunburn lotion industries, and resort owners and farmers. Or if a storm was to be diverted, "Detour it where? Out to sea, to hit some ship with no influence in Washington?"[4]

But these were merely talking heads, right? No, serious scientists too were dazzled by the possibilities. In 1945, Vladimir K. Zworykin, the inventor of television and associate research director at RCA wrote an "Outline of Weather Proposal."[5] He announced that scientists were on the verge of developing digital computing equipment that could solve the equations of atmospheric motion, or at least search quickly for statistical regularities and past analog weather conditions. Zworykin suggested that "exact scientific weather knowledge" might allow for effective weather control. If a perfectly accurate machine could be developed that could predict the immediate future state of the atmosphere and identify the precise time and location of leverage points or locations sensitive to rapid storm development, effective intervention might be possible. A paramilitary rapid deployment force might then be sent to intervene in the weather as it happened – literally to pour oil on troubled ocean waters or use physical barriers, giant flame throwers, or even atomic bombs to disrupt storms before they formed, deflect them from populated areas, and otherwise control the weather.

Zworykin's idea was endorsed by the famous mathematician John von Neumann who thought at the time that the digital computer "would provide a basis for scientific approach[es] to influencing the weather."[6] It led to projects spearheaded by von Neumann in the US and by C.-G. Rossby in Sweden that produced the first weather forecasts via computer and developed conceptual foundations for the first general circulation and climate models.

Von Neumann changed his opinion about climate control and warned against it in 1955, in a prominent article in *Fortune* magazine titled "Can We Survive Technology?" Reflecting on recent Soviet and American proposals for mega-engineering, he referred to managing solar radiation or changing the earth's heat budget as a thoroughly "abnormal" industry that could have "rather fantastic effects" on a scale difficult to imagine. He pointed out that altering the surface reflectivity of specific regions or redirecting air masses in an attempt to trigger a new ice age were not necessarily rational undertakings. Tinkering with the earth's heat budget or the atmosphere's general circulation, he claimed, "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?" Quoting von Neumann, "The technology that is now developing and that will dominate the next decades [on a global scale such as nuclear weapons and climate intervention] seems to be in total conflict with traditional, and in the main, momentarily still valid, geographical and political units and concepts." This is "the maturing crisis of technology," a crisis made more urgent by the rapid pace of progress.[7]

During the early Cold War the General Electric Corporation developed chemical methods for seeding clouds with dry ice and silver iodide, sparking a race of sorts for commercial applications and military control of the clouds. Although field tests were inconclusive at best, and intervention in the weather is not equivalent to control of it, Nobel Laureate Irving Langmuir hyped the possibilities, arguing that hurricanes could be redirected and that the climate might ultimately be controlled on a continental or oceanic scale with these techniques. In October 1947, GE announced that its military partner, Project Cirrus, would be intercepting a hurricane in the Atlantic to experiment on the effects of seeding it with dry ice. The team, accompanied by GE scientists, bombed the heart of so-called Hurricane King with 80 pounds of dry ice and dropped 100 pounds more into two embedded convective towers. It was reported in the press as "history's first assault by man on a tropical storm," an experiment with energies of nature far greater than those unleashed by the atomic bomb.[8] The scientists expected the storm to weaken and to head out to sea. After the seeding, however, but probably not because of it, the hurricane made a "hairpin" turn and headed west, smashing into the coast along the Georgia-South Carolina border near Savannah. During its second landfall the storm killed one person and caused more than $23 million in damage.[9] The scheduled press conference was cancelled and

2 Waldemar Kaempffert, "Julian Huxley Pictures the More Spectacular Possibilities that Lie in Atomic Power," *New York Times*, December 9, 1945, 77; "Blasting Polar Ice," *New York Times*, February 2, 1946, 11.
3 "Sarnoff Predicts Weather Control and Delivery of the Mail by Radio," *New York Times*, October 1, 1946, 1.
4 "Talk of the Town," *New Yorker*, October 12, 1946, 23.
5 Zworykin, Vladimir K. "Outline of Weather Proposal." RCA Laboratories, Princeton, N.J., October 1945. Reproduced in *History of Meteorology* 4 (2008): 57–78.
6 von Neumann to Zworykin, October 24, 1945, in Zworykin, "Outline of Weather Proposal."
7 John von Neumann, "Can We Survive Technology?" *Fortune*, June 1955, 106–108.
8 News clippings, including *New York Times*, October 12, 1947, 24; *Albany Times-Union*, October 12, 1947, n.p.; *Christian Science Monitor*, October 14, 1947, 10; *Los Angeles Times*, October 14, 1947, 1.
9 Irving Langmuir, "The Growth of Particles in Smokes and Clouds and the Production of Snow from Supercooled Clouds." *Proceedings of the American Philosophical Society* 92 (1948): 183–185.

the documentation was marked classified, kept from public view for the next thirty years.

In 1955 Langmuir suggested that weather control experiments be moved to the South Pacific, "where there is less population" (and less likelihood of litigation). Langmuir was looking for "big effects," extending over intercontinental distances, and interactions between seeding and planetary circulation patterns, including hurricanes and especially typhoons in the South Pacific. He recommended three types of Pacific experiments: (1) intervention in mature storms, as Project Cirrus had done with Hurricane King; (2) large-scale experiments across the entire region to see if regular seeding with silver iodide could trigger typhoons to start prematurely, perhaps producing more-frequent storms of lower intensity; and (3) intervention in nascent storms, not necessarily to stop the storm or prevent it from forming, but to control its path.[10] Langmuir wanted to go to Bikini Atoll to attempt to redirect typhoons or possibly slosh the entire Pacific basin circulation, as El Niño is now known to do. In doing so, he was expanding on an earlier nuclear analogy regarding "chain reactions in cumulus clouds" (in which thunderstorms have energy levels similar to the detonation of an A-bomb) and pointing to control of typhoons on the energy scale of H-bombs.

At about this time the Soviet Union under Joseph Stalin was pursuing grandiose plans for controlling nature, including reversing the flow of Arctic rivers, subjugating permafrost (the curse of the north), and opening up the Arctic Ocean by damming the Bering Strait. In the Soviet program, science was not just about observing and understanding nature; it was about exploiting and controlling it as well. There was a race for weather and climate control with the West. The program of the Communist Party of the Soviet Union declared in no uncertain terms: "The progress of science and technology under the conditions of the Socialist system of economy is making it possible to most effectively utilize the wealth and forces of nature for the interests of the people, make available new forms of energy and create new materials, develop methods for the modification of climatic conditions and master space."[11]

Taking this up several notches, to the stratosphere and above, was Harry Wexler, head of research at the U.S. Weather Bureau, who in 1962 warned that a hostile power could detonate a chlorine or bromine "bomb" that would rip a giant hole in the earth's ozone layer. He had, in effect, identified catalytic ozone-depleting reactions that would later result in the awarding of Nobel prizes in chemistry. Wexler also warned that space spectaculars might go awry: "Even in this day of global experiments, such as the world-wide Argus [atomic bomb] electron seeding of the Earth's magnetic field at 300 miles height, man and machinery orbiting the Earth at 100 miles seventeen times in one day, and 100 megaton bombs—are we any closer to some idea of the approaches which could lead to an eventual 'solution' [to the problem of climate control]?" He noted "a growing anxiety" in the public, pronouncing, "Man, in applying his growing energies and facilities against the power of the winds and storms, may do so with more enthusiasm than knowledge and so cause more harm than good."[12] According to Wexler, writing 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."[13]

On May 1, 1958, at the National Academy of Sciences, University of Iowa physicist James A. Van Allen announced that Geiger-Müller counters aboard the JPL Explorer 1 and Explorer 3 satellites had been swamped by high radiation levels at certain points in their orbits, indicating that powerful radiation belts, later known as the Van Allen Radiation Belts, surround earth. This was the first major scientific discovery of the space age. Ironically, and on *that very same day*, Van Allen joined Operation Argus – the US military's top secret atomic bomb tests in space aimed at generating an artificial radiation belt and disrupting the ionosphere.

In late August and early September 1958 a specially equipped naval convoy launched and detonated three 1.7-kiloton atomic bombs in near space above the South Atlantic Ocean to "seed" the ionosphere with high energy nuclear particles and radioactive debris. Van Allen's Explorer 4 satellite, launched a month earlier, carried four high-intensity and radiation-shielded Geiger counters designed to withstand the blasts and document the tests. "Space is radioactive," noted Van Allen's colleague Erie Ray. The military wanted to make space *even more radioactive* by nuclear, and later, thermo-nuclear detonations that, in time of war could disrupt enemy radio communications from half a world away and damage or destroy enemy intercontinental ballistic missiles. The Soviets and the Americans detonated megaton thermonuclear devices in near space in 1962. This is planetary scale engineering – or geoengineering.[14] The detonations came just at the peak of the Cuban missile crisis and during a time when meteorologists were trying to design and implement the peaceful sharing of data through the World Weather Watch. The tests led British radio astronomer Bernard Lovell, along with the International Astronomical Union, to protest that, "No government has the right to change the environment in any significant way without prior international study and agreement."[15] In a larger policy framework, the history of these space interventions and the protests they generated serves as a cautionary tale for today's geoengineers who are proposing heavy-handed manipulation of the planetary environment as a response to future climate warming. Undoubtedly Argus, Starfish Prime, and many of today's geoengineering proposals would fail

10 "Scientist Would Move Rain Tests to South Pacific," *Albuquerque Tribune*, April 29, 1955, 50.

11 N.P. Rusin and L.A. Flit, *Methods of Climate Control*. 1962. Translated from the Russian. TT 64–21333. Washington, D.C.: Department of Commerce, Office of Technical Services, Joint Publications Research Services, 1964, p. 3.

12 Harry Wexler, "On the Possibilities of Climate Control," cited in Fleming, *Fixing the Sky*, 224.

13 Harry Wexler, "U.N. Symposium on Science and Technology for Less Developed Countries," May 21, 1962, cited in Fleming, *Fixing the Sky,* 224.

14 On projects Argus, Starfish Prime, and other nuclear detonations in space see James Rodger Fleming, "Iowa Enters the Space Age: James Van Allen, Earth's Radiation Belts, and Experiments to Disrupt Them," *Annals of Iowa* 70 (Fall 2011), 301-24.

15 Dudley Saward, *Bernard Lovell: A Biography* (London, 1984), 243.

ethical guidelines as articulated in the 1978 Belmont Report.[16] Specifically, the social implications of geoengineering are so crudely conceptualized that they fail to satisfy the beneficence criterion of "doing no harm," since no one can ensure that potential harms will be minimized, and the justice criterion that requires the fair distribution of burdens and benefits of research.

Project Stormfury, a collaboration between the US Weather Bureau, the navy and the air force, attempted to modify hurricanes between 1962 and 1983. Undaunted by earlier public relations disasters, the project involved a team of scientists and technicians flying into mature Caribbean hurricanes to seed them using military equipment. While the scientists involved were genuinely curious about the nature of storms, the navy's vision of weather control involved using fog and low clouds as screens against enemy surveillance, calming heavy seas, and redirecting violent storms both to enhance its own operations and to interfere with enemy plans and capabilities. The wish list included the capability to change the intensity and direction of hurricanes and typhoons; produce rain, snow, or drought as desired; and "modify the climate of a specific area" – all for the sake of military operations. As the navy saw it, the military problem in the field of weather modification and control was "to alter, insofar as possible, the environment surrounding the task force or target area so that the success of the naval operation is enhanced."[17]

In October 1962, just as Stormfury was getting under way, the Cuban missile crisis brought the world to the brink of nuclear war. A year later, Fidel Castro accused the United States of having waged strategic weather warfare by changing the course of Hurricane Flora. Although the US claimed Flora was not seeded, its behavior was indeed suspicious. It hit Guantánamo Bay as a Category 4 storm and made a 270-degree turn, lingering over Cuba for four full days, with intense driving rains that caused catastrophic flooding, resulting in thousands of deaths and extensive crop damage. Nor was Cuba alone. Mexico denounced the United States for having caused a protracted drought "resulting from cloud seeding."[18] Many decades later, the cases of hurricanes King and Flora might serve as a warning to the US Department of Homeland Security, which, as of 2009, was funding a new wave of research through their HURRMIT program aimed at weakening the strength of tropical storms and steering them "off course." But, of course, hurricanes do not run on tracks or on a schedule, so *everyone* damaged by a modified hurricane could sue for damages – unless the government tried to place an embargo on such lawsuits.[19]

Meanwhile, between 1967 and 1974 operational cloud seeding was being used in a real war over the jungles of Vietnam. The failure of Operation Popeye/ Motorpool over the Ho Chi Minh Trail led to embarrassing revelations later in the Pentagon Papers and to a UN Convention, ENMOD, outlawing environmental modification as a weapon of war.[20] One observer at the time noted that the lesson of the Vietnam experience was not that rainmaking is an inefficient means for slowing logistical movement in jungle trails, but "that one can conduct covert operations using a new technology in a democracy without the knowledge of the people" – but you won't be able to hide it for long.[21]

Table 1 summarizes some of the geoengineering activities – proposed, actual, and warnings – discussed so far.

Table 1: Geoengineering: Proposed (P), Actual (A), and Warnings (W)

Year	Status	Event
1945	P	Julian Huxley suggests nuclear weapons could dissolve polar ice cap
1945	P	Vladimir Zworykin proposes perfect prediction/control with digital computer
1947	A	Project Cirrus attempts diversion of Atlantic hurricane
1950s	P	Soviets "declare war" on permafrost and seek an ice-free Arctic Ocean
1955	P	Irving Langmuir proposes Pacific Basin cloud seeding
1955	W	John von Neumann warns of global climate control and nuclear war
1958	A	Project Argus, three atomic bombs detonated in magnetosphere
1962	W	Harry Wexler warns that 100 KT Bromine bomb could destroy ozone layer
1962	A	Project Stormfury critiqued by Fidel Castro and government of Mexico
1962	A	Starfish Prime, H-Bomb detonated in magnetosphere. Similar Soviet tests.
1965	W	Gordon MacDonald warns that geoengineering could wreck the planet
1967	A	Cloud seeding over Vietnam leads to UN ENMOD Convention (1978)

Source: Fleming, Fixing the Sky, chapters 7 and 8.

In summary, we can say that after 1945 transformative technologies such as nuclear weapons, digital computing, chemical aerosols, and the space program fueled Cold War competition between the superpowers and encouraged speculation about and in some cases actual attempts at geoengineering. Some of this activity was motivated by scientific curiosity, but most was in the genre of weather and

16 *Belmont Report: Ethical principles and guidelines for the protection of human subjects of research.* US National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. (Washington, DC: USGPO, 1978).

17 US Navy. Bureau of Naval Weapons, Research, Development, Test and Evaluation Group, Meteorological Management Group. "Technical Area Plan for Weather Modification and Control." TAPNo. FA-4. January 1, 1965, page 1.

18 Robert H. Simpson interview with Edward Zipser, September 6, 1989. Tape Recorded Interview Project, American Meteorological Society and University Corporation for Atmospheric Research.

19 Richard Gray, "U.S. Government Aims to Tame Hurricanes," *Daily Telegraph*, August 2, 2008, http://www.telegraph.co.uk; William Woodley, "HURRMIT: The Identification and Testing of Hurricane Mitigation Hypotheses," http://www.ofcm.noaa.gov/ihc09/Presentations/Session10/s10-01Woodley.ppt.

20 James Rodger Fleming, "The Pathological History of Weather and Climate Modification: Three cycles of promise and hype." *Historical Studies in the Physical Sciences* 37, no. 1 (2006): 3-25.

21 Gordon J.F. MacDonald, statement in House Committee on International Relations, Subcommittee on International Organizations, Prohibition of Weather Modification as a Weapon of War: Hearings on H.R. 28, 94th Cong., 1st sess., 1975, 5.

climate warfare. David Sarnoff spoke of turning an enemy's fertile lands into deserts; John von Neumann warned that climate control might lead to international conflict; space bomb detonations peaked at the same time as the Cuban Missile Crisis; and cloud seeding in Vietnam led to an international environmental treaty. We have to remember that the foundations of modern geoengineering proposals rest on this very "checkered" history. We must also note that today's geoengineers appeal to a list of technologies quite similar to those that emboldened their predecessors: digital computing, access to space, and the use of chemical agents (including iron fertilization). Such are the powers of modern titans. But what about wisdom?

Since the "modest proposal" of Paul Crutzen in 2006, the leading voices in the field of geoengineering have been technical experts from the US, UK, and Germany – that is Northern and Western nations – and many of the speculative proposals to cool the planet are supported only by back-of-the-envelope calculations and simple computer models. Many of the proposers have applied for patents on their processes and/or their institutions stand to gain from public funding.[22] There have been halting, mostly national or bi-lateral attempts to examine "governance" of a non-existent practice. These traditional practices are limited and overly narrow. They are not good enough, and they sorely need both fresh air and the expertise of others trained in history and the humanities. International collaboration on geoengineering research and governance should not be solely technically oriented, but should involve study of the historical, ethical, legal, political, and societal aspects of geoengineering. After all, 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 inclusiveness.

Geoengineering is in fact untested and dangerous. We do not understand it, we cannot test it on smaller than planetary scales, and we do not have the political capital, wisdom, or will to govern it. Planetary tinkering is not "cheap," as some economists claim, since the side effects are unknown. It poses a moral hazard by possibly reducing incentives to mitigate. It could be attempted unilaterally, or worse, proliferate among rogue states, and it could be militarized (learning from history, it likely *would* be militarized). Geoengineering could violate a number of existing treaties such as ENMOD, and add to international stresses. Most poignantly, by turning the blue sky milky white or the blue oceans soupy green, by attenuating sunlight – and with it starlight, and by putting bureaucrats and technocrats in charge of a global thermostat, geoengineering will alter fundamental human relationships to nature.

History matters (a lot) – it shapes identity and behavior; it is not just a celebratory record of inevitable progress. Historians are passionate about change over time and the underlying causes of these changes. They identify events, trends, and common shared experiences that place people and their environment in larger contexts. Framed correctly, history is an essential component of interdisciplinary communication and a resource for future innovation and citizen involvement. History teaches few direct lessons and does not "repeat" itself, but it does provide the framework for human activity, aspirations, and accomplishments as it lays the groundwork for informed decision-making.

We should base our decision-making not on what we think we can do "now" and in the near future. Rather, our knowledge must be shaped by what we have *and have not* done in the past. Such are the grounds for making informed decisions and avoiding the pitfalls of rushing forward claiming we know how to "fix the sky." We may wish to distance ourselves from history; we may pledge to be virtuous from this point forward; we may hope that the 21st century turns out different than the violent 20th century; but for now all a historian can do is drop you off at the doors of the US National Archives and invite you inside: "Study the Past; What is Past is Prologue."

Let me end by proposing a simple historical rule of thumb. Any projection of the state of the climate, engineering or society into the future must also consider the changes in discourse and practice involving climate, engineering and society in the past. This one single requirement will help the technical researcher understand the notion of science dynamics, technological and social dynamics and the contingent nature of any extrapolations into the future. Today's geoengineers (with environmental motivations to "stop global warming") possess the same technologies, somewhat improved, as did the climate engineer of the 1960s who was embroiled in the Cold War. We know that motivations and context change, and that any technology intended for benign purposes can be militarized. We also know that science, technology, and social values are changing as fast or even faster than the climate system, so any student of climate dynamics must also be a student of the history of "science dynamics."

22 For example, Bernard J. Eastlund, Method and apparatus for altering a region in the earth's atmosphere, ionosphere, and/or magnetosphere, US Patent 4,686,605; Franklin Y. K. Chen, Weather modification by artificial satellites, US Patent 5,762,298l; and Bill Gates, Nathan Myhrvold, et al., Water Alternation Structures [for taming hurricanes], US Patent Applications 20090177569, 20090175685, 20090173801, 20090173404, and 20090173386.