The Weather Is Usually Unusual: Nuclear Weapons Testing in the Age of Atmospheric Anxiety, 1945-1963

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INTRODUCTION: FREAK WEATHER

Man can hardly even recognize the devils of his own creation

—Albert Schweitzer

Fig 1: Cartoon depicting the typical line repeated by Weather Bureau experts dismissing atomic testing's effects on the weather. *New York Times*, October, 21 1951.

In February of 1946, the Nobel Laureate physicist Victor Hess gave a widely covered speech warning that the upcoming nuclear test series, Operation Crossroads, could potentially trigger a year of continuous rain across the Northern Hemisphere.[1] This statement marked the opening salvo in a decade-long controversy over whether atmospheric nuclear weapons testing could cause extreme weather and climate change. Given the short time frame of the bomb's existence, no one knew with any certainty at what scale its powers lay. Its perceived effects were a Rorschach test in which people could see what they wished, debates regarding its risks reliant upon murky statistical assessments of environmental processes little understood.[2]

Throughout its early history, the bomb's power was routinely likened to hurricanes, tornados, wildfires, and other natural disasters. Only two weeks after Hiroshima the Mayor of Miami appealed to Truman to use the bomb to stop hurricanes.[3] The Weather Bureau's chief of forecasting quickly dismissed the idea, arguing that an a-bomb was but a "drop in the bucket" in comparison to a hurricane.[4] But the belief that the testing of nuclear weapons could cause atmospheric "eccentricities" would not be scotched in its cradle, and for the next decade letters from across the globe besieged the

[1] "Navy's A-Bomb Blast May Change Weather", *Los Angeles Times*, Feb 3, 1946;
[2] This belief seems to have been initially forged by both prestigious scientists such as Hess and more dubious sources such as the "Atlantan Exploration Society" and F.P. Stebbings, the "bee millionaire" who, "twirling his long white moustache," complained to a reporter in 1948 that there had been "no good bee weather" since the atom bomb tests had begun. "A-bombs Blamed for Bad Weather," *Washington Post*, September 19, 1948, R10.
[3] "Atom Blast Urged to Foil Hurricanes," *Los Angeles Times*, Aug 22, 1945, 1.
[4] Associated Press, "Atom Bomb is Declared Out As A Remedy for Hurricanes," *Washington Post*, August 28, 1945, 6.

Weather Bureau.[5] By 1954 the Bureau seemed at a loss, with its Chief Francis Reichelderfer exclaiming "the weather is always unusual somewhere."[6]

This paper seeks to chart Americans' changing perceptions of disaster, risk, and blame in the 1950s through an examination of the "atom weather" controversy. The perception of what was a natural disaster took on new form in this time by seemingly losing its natural character entirely. [7] Our power over nature embodied in atomic energy brought with it new expectations of government management, and government culpability. The early 1950s is often characterized by naïve faith in scientific management and technological progress, but when one examines attitudes toward human intervention in the atmosphere, a different picture develops, one of a general anxiety embodied in concerns over smog, cloud seeding, atomic testing, rockets, and even UFOs. This technological anxiety allowed for an important justification for the authority of the expert state, but also the groundwork for its repudiation.

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[5] Benjamin Hozlman, "The Effects of Atomic Bombs on the Weather," *Weatherwise* Vol.4 I.1: 1951, 50.

[6]"We Usually Have Unusual Weather," *The Science News-Letter*, July 24, 1954. 50. By 1954 the Bureau was so frustrated with its inability to convince the public otherwise they even produced a study charting the frequency of extreme weather phenomena throughout the year in order to test during the time when disasters were at their lowest potential. Edward List, the author, suggested October-November, after the hurricane season ended but before the blizzards began. Most importantly he argued testing must avoid any overlap with the tornado season, as he likened that in the U.S. "they were the most spectacular and feared phenomenon." Edward List, "The Transport of Atomic Debris from Operation Upshot-Knothole," Weather Bureau, Washington D.C. June 25, 1954, 80.

[7]The sociologist Ulrich Beck describes this process as the formation of the "risk society," emerging from the need for "a systematic way of dealing with hazards and insecurities induced by modernization itself." To deal with both normal accidents and catastrophic disasters alike, postwar governance justified its power as a technocratic oracle, an anticipatory regime acting less upon contemporaneous events but probabilistic models of future problems they selectively identified as relevant: "along with the growing capacity of technical objects grows the incalculability of their consequences...in the risk society the unknown and the unintended consequences come to be a dominant force in history and society". Ulrich Beck, *Risk Society: Towards a New Modernity*, trans. Mark Ritter, (London: Sage Publications, 1992): 21-22. Antony Giddens has argued much the same, describing this "risk mentality" as attempts to "colonize the future" in order to preempt catastrophe due to technical malfunctions of the system. Mary Douglas' work on the cultural construction of risk and blame shows how the rational choice theory of risk is another manifestation of the "superstitious" ideas of danger and taboo with a scientific veneer. Anthony Giddens, *Modernity and Self Identity* (1991). See also Wolfgang Schaffner, *Traumatic Pasts* (2001), Javier Auyero, *Flammable* (2009), Ian Hacking, *The Taming of Chance* (2007).

The fallout debate of the late 50s through early 60s is often seen as a marker for the beginning of a new politics of environmental risks, but the extreme weather dispute was antecedent to the fallout controversy. It would only be in the late 1950s that the public perceived fallout as the primary threat from testing. Indeed, in 1953 nearly a third of the American public believed that the "freak" weather of the time was due to atomic testing, while another third was undecided. In contrast, only 17% of the population even knew what fallout was going on two years later.[8] It was the experts, not the public, that were worried about fallout, specifically how little was known of its effects upon the biosphere. Weather Bureau scientists tasked with monitoring its atmospheric circulation secretly fought with the Atomic Energy Commission over its level of risk. Though the WB experts turned out to be correct, both in their denial of extreme weather effects and their belief in the real risks of fallout, the former's arguments were based solely on inductive reasoning rather than empirical research.

Since the government could claim authority through the monopolization of information, there was little recourse for worried citizens who blamed their activities for a spate of natural disasters. A New Mexican fruit grower summed up the problem as one of information possession in a letter to his senator, complaining that since he could not sue the AEC, "the burden of proof is on the grower, who to obtain this data would

[8] "29% Blame Weather on A-Blasts, Gallup Says," Los Angeles Times Jun 19, 1953; J. Samuel Walker, *Permissible Dose: A History of Radiation Protection in the Twentieth Century* (Berkeley: University of California Press, 2000), 22. On radiobiological studies and the fallout controversy see Barton Hacker's exhaustively researched classic, *Elements of Controversy* (1994), J. Samuel Walker, *Permissible Dose* (2000), Richard Hewelett*, Atoms for Peace and War* (1989), Richard Miller, *Under the Cloud, the Decades of Nuclear Testing* (1986), and Toshihiro Higuchi, "Atmospheric Nuclear Weapons Testing and the Debate on Risk Knowledge in Cold War America: 1945-1963" in J.R. McNeill and Corrina Unger eds. *Environmental Histories of the Cold War* (Washington, D.C.: Cambridge University Press, 2010).

probably have to spend thousands of dollars."[9] In this regard, the formation of the expert regime after WWII was embodied in and influenced by the politicization of the weather. A long historiography of the early Cold War era has argued that the American public embraced scientific experts and willingly endowed them with vast administrative authority. This "consensus state," based around a centrist liberal political ideology, then facilitated the rise of the Military-Industrial complex.[10] But the keys to the kingdom were not simply handed over to administrative experts—their authority had to be actively sold to the public, and oftentimes they failed to persuade.

The atom weather controversy helps show there was no point when a consensus existed regarding faith in the expert stewardship, revealing its tenuous political position in the early Cold War era. Weather Bureau scientists were often perceived as obstructionist and secretive bureaucrats, negligent of the potentially devastating consequences of their decisions and dismissive of the democratic process. At heart there was a suspicion that the very experts who presumed to "know what they were talking about" seemed more and more to appear as if they often knew not what they did. "I have an interest in this planet" one writer declared in a letter to the *Los Angeles Times*, "and if our Frankensteins blow it to smithereens, Uncle Samuel had better be prepared to face a king-sized lawsuit".[11]

The writer's fear of planetary destruction reflected not just the suspicion of experts, but also an emerging trope of "global catastrophism," premised upon the

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[9] "Letter From James Maher to Senator Clinton Anderson, June 5, 1955," Anderson Papers, Library of Congress, Washington D.C., box 800.
[10] See Stuart Leslie, *Cold War and American Science* (1993), Walter McDougall, *Heavens and the Earth* (1984), Brian Balogh, *Chain Reaction* (1991) Michael Greene, *Eisenhower and Science Advice* (2007), James Sparrow, *Warfare State* (2010), Jessica Wang, *American Science in an Age of Anxiety* (1998).
[11] Alfred Hengst, "Letter to the Editor," *Los Angeles Times*, June 18, 1953, A4.

concept of the world biosphere as a fragile, finely tuned system that we were threatening to annihilate. Ironically, the very experts the writer harangued oftentimes held these same fears. Yet these fears only further reinforced their belief that only scientific authorities possessed the capabilities to prevent such a disaster. Recent literature on postwar environmentalism has begun to show how Cold War scientists planning for the vast destruction of "WWIII" came to realize humanity was a planetary actor in a world increasingly vulnerable to our designs.[12] This idea emerged primarily from ecological radionuclide tracing and atmospheric modeling related to nuclear testing. Eventually, experts within these networks created the intellectual and infrastructural base that would allow for the discovery of global warming. These scientists would then become some of the most vocal critics of the military-industrial regime that had facilitated their work. In this narrative, "Save the Planet", a neologism of the late 1960s, was the reverse coin of Oppenheimer's tortured pronouncement after the Trinity Test, "I am Become Death, Destroyer of Worlds."

While this paper hopes to continue this line of thought, it also hopes to amend some of its premises. The narrative focuses almost entirely on fallout and characterizes the public as a passive agent that had no part in the formation of these ideas. The neglect

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[12] See first and foremost Jacob Hamblin, *Arming Mother Nature*: *The Birth of Catastrophic Environmentalism* (2013) Paul Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (2010), Stephen Bocking, *Ecologists and Environmental Politics: A History of Contemporary Ecology* (1997). There have also been several excellent examinations of the proliferation of militarized metaphors in our relationship to the environment after 1945. The historian Stephen Jay Pyne has shown how planning for atomic firestorms sparked a new era in wildfire management framed as a 'war' against the 'Red Peril' and Edmund Russell has analyzed the rise of the 'War on Insects', which converted WWI chemicals from military to agricultural uses by employing an exterminationist rhetoric of the Cold War. Ed Russell, *War and Nature: Fighting Humans and Insects with chemicals from WWI to Silent Spring* (2001). Stephen Jay Pyne, *Fire in America: A Cultural history of Wildland and Rural Fire* (1982), For cultural histories of this process and its relationship to the rise of postwar environmentalism, see Michael Egan, *Barry Commoner and the Science of Survival* (2010), Elaine Tyler May, *Homeward Bound* (1988), Paul Boyer, *By the Bomb's Early Light* (1985), as well as two excellent articles by Peter Hales, "The Atomic Sublime" (1991), and Joseph Masco, "Bad Weather: On Planetary Crisis" (2010).

of the public's role is a misfortunate lacuna, as its ignorance justifies the general presumption that it was not until the 1980s that the public became first thought about human-caused climate change. But it was the public, not the experts, who worried first about human influence upon the climate in the 1940s and 50s. This fact has thus far slipped under the radar of an extensive literature on nuclear testing and the rise of postwar environmental science. Its neglect could most likely be attributed to its apparent incorrectness in retrospect combined with the confirmation of fallout's actual harm. But while their blame might have lain with the wrong culprit, citizens were correct in their intuition that the climate was changing. The idea that the world was warming had been in popular discussion since the late forties, with almost universal acknowledgment that the global temperature had increased by at least one degree centigrade. The majority of meteorologists believed these changes were natural. By the time scientists came to a consensus that we could affect the atmosphere at a global scale, the public had become primarily focused on industrial pollution and environmental health, led to such concerns by these very same scientists.

It is the hope of this paper to give the perceptions of people the validity they are due, for there was no such luxury of hindsight at the time. If there was a "consensus" in the 1950s, it was that an unimaginable catastrophe was but a tick away on the Doomsday Clock. The moment when we seemed able to control nature and contain disaster was also when disaster seemed most certain and nature's behavior increasingly unpredictable.[13] The weather, as the great signifier of our vulnerability to nature, and the bomb, as that of our power at its greatest scale, existed in a strange contradiction.

[13] As Spencer Weart aptly observed, "the ancient myths of how human sins against the natural order brought afflictions, all the way up to the fiery end of the world, took on a veneer of scientific plausibility. Weart, *Discovery of Global Warming*, 41.

Just as our power appeared to have finally put the earth at our mercy, so too did our sense of vulnerability regarding the unintended consequences of this power.

PART I: THE CLOUD SEEDING CONTROVERSY: 1945-1951

Fear of our effects upon the atmosphere was not restricted to nuclear testing. The main culprit for extreme weather right after WWII was not testing but rather "cloud seeding," or the inducement of rain through the atmospheric dispersal of dry ice or silver iodide, a technique that has, to this day, never been proven definitively to work. Public belief in the ability to modify the weather through cloud seeding merged with the idea of an atomic plume "nucleating" clouds to create a larger "inadvertent weather modification" controversy by the early 1950s.

The popular columnist Dean Sherman suggested at the peak of the controversy in 1955 that the "latent hysteria" that these technologies were "rearranging the climate of the world" laid in the "unsound conjecture of 'experts' and commentators whose basis was imagination rather than fact."[14] But determining what was a "fact" was nearly impossible given the instrumental capabilities of the day. Before satellites and computational meteorology, scientists knew little about the circulation of the general atmosphere, and in this vacuum of theoretical uncertainty and dearth of data all hypotheses appeared equal. And many of these "experts" were indeed just that—Nobel Laureates such as Victor Hess, and cloud seeding's "inventor" Irving Langmuir, people who possessed the credentials necessary to gain cachet as one of the only legitimate

[14] Gene Sherman, "Do Atom Blasts Change Weather?" *Los Angeles Times*, March 13, 1955, B5.

voices that could challenge governmental authority on scientific knowledge, even though claims were often of a highly speculative nature. [15]

In his incessant public pronouncements, Langmuir more than most helped to develop a new lexicon of the environmental-technological interface, employing phrases such as "trigger effects" and "chain reactions" to describe how seemingly minor interventions into the atmosphere could chaotically amplify and precipitate catastrophes on a scale heretofore unimaginable. "Chain reaction" was a neologism for physicists in the 1920s and would only work its way into the general discourse after WWII. In 1947, Langmuir applied the general concept as the basis for his theory of the mechanism of action in cloud seeding. By the early 1950s he had successfully helped to prime much of the public to believe we were inadvertently precipitating natural disasters through cloud seeding, and soon enough would become conflated with atomic testing.

On November 13th, 1946, Vincent Schaefer, General Electric research scientist, dropped six pounds of dry ice from a plane and apparently created a blizzard above western Massachusetts. The excitement this event would generate was near hysterical. Within a week of the event, G.E. received a deluge of letters already filled with expectations that this invention could do anything. A movie studio producing a film adaptation of *This Side of Innocence* was so presumptuous that it requested G.E. make a

[15] Days before the Trinity test, Enrico Fermi took bets around Los Alamos on whether the bomb would cause a chain reaction that would ignite the atmosphere and destroy all life on earth. While it was assumed that the odds of this possibility were astronomically low, fellow physicist Kenneth Bainbridge chastised him for scaring the guards; worried, it seems, of spreading false ideas about its power. Being physicists, of course, they still made sure to prepare for such a possibility, producing a study by Edward Teller, Emil Konopinski and C.Marvin, "On the Ignition of the Atmosphere With Nuclear Bombs", dispatching with Fermi's suggestion though coming to the conclusion that the hydrogen bomb was more feasible than first thought.

blizzard "at the right time right place and right quantity" as per the shoot's specifications.[16] No one understood the effects of cloud seeding whatsoever or the even mechanism of precipitation. The discovery was itself by accident when, the July before, Schaefer dropped dry ice into a deep freezer he had created to simulate a supercool cloud.

When his research director Irving Langmuir witnessed Schaefer's "artificial nucleation", he immediately took to imagining the vast possibilities of this technology, writing in his laboratory notebook soon after in large capitals "WEATHER CONTROL" and outlining experiments to be conducted.[17] The first Nobel Prize winner to have spent his career working for a corporation, Langmuir was an adept self-promoter who made a variety of contributions to several fields, from applied inventions such as the tungsten filament and smoke generators to theoretical discoveries in molecular bonding for which he would win the Nobel Prize in 1932.[18] Langmuir's relationship with scientific uncertainty was fairly complicated, having a deep appreciation for the history and philosophy of science, and in a paper deemed too "heady" to be published in the last year of his life he would lay out a theory of "serendipity" as the engine behind scientific

[16] "Letter from Bernard Lewis to George W. Griffin, Nov.14, 1946," Langmuir Papers, Library of Congress, Washington, D.C., box 6.
[17] "Lab notebook #4336, p.82," Langmuir papers, box 51.
[18] A true polymath, he was "wonderfully absent-minded" as Kurt Vonnegut would later relate, though perhaps not so wonderfully all the time, as when he was supposedly so engrossed in thought he once supposedly walked over a woman who had fallen down the stairs in front of him without missing a beat. Vonnegut would later say that he was the model for Felix Hoenikker, the infamous scientist of *Cat's Cradle* who inadvertently and destroys all life on earth after creating a chain reaction due to his invention "Ice-9", a substance with effects quite similar to cloud seeding. Vonnegut even admitted Ice-9 was Langmuir's idea, hearing it indirectly through his brother Bernard who worked with Langmuir and discovered silver iodide cloud seeding. Alfred Rosenfeld, *The Quintessence of Irving Langmuir*, (New York: Pergamon Press, 1966), 317; Robert K. Musil, "There Must Be More to Love Than Death: A Conversation With Kurt Vonnegut," (*The Nation* 231(4): 1980): 128

change, causing unanticipated paradigm shifts similar to what Kuhn would write of a decade later.[19]

This would structure his belief in cloud seeding's efficacy, often finding analogies between it and previous inventions such as vaccinations and X-Rays; accidental discoveries whose formalization as scientific laws lay afterward.[20] One would imagine the Nobel Prize being the apex of one's career, but fourteen years later Langmuir envisioned his legacy as unfinished, and this new "science" of weather modification would be its cornerstone. Edward Teller recollected that when Langmuir visited him at Los Alamos in the summer of 1947 he talked so much of the potential of weaponization of cloud seeding that "I began to wonder whether he saw this technique as competition to the atomic bomb."[21]

Langmuir was certainly prone to making hyperbolic statements. Even before cloud seeding existed, Langmuir was publicly predicting dire consequences due to our technological advances, contributing to the collection of essays by the most eminent scientists of the day, *One World or None*, advocating for the peaceful uses and international control of atomic energy in order to preempt global annihilation.[22] Yet his

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[19] He was preoccupied with the concept, writing long letters on the etymological origins of the term and an unpublished paper "Freedom: Humanity's Best Response to the Unexpected." The *Saturday Evening Post* editor wrote to Langmuir that the paper was "definitely not mass circulation material" and said he would send along the paper to "a more elevated journal such as Harpers." Letter From William Moderman to Irving Langmuir, December 31, 1956," Langmuir Papers, box 7.

[20] In a letter commenting on the 1953 *Fortune Magazine* article, Langmuir argued that the "opposition resembles that which has raged for close to a 150 years on the question of vaccination proposed by Jenner in 1790. It is interesting that Jenner and others who adopted the vaccination procedures became convinced of the effectiveness of the vaccination purely by statistical evidence. Even today we do not understand what the mechanism is by which vaccination is effective." "Letter From Langmuir to Maurice Karpf, April 22, 1953," Langmuir Papers, box 6.

[21] He claims he knew so little it was the only reason he was able to get a visa to travel to Russia in the summer of 1945. "Scientists Resent Army's Idea They Are Not Paid to Think," *Washington Post,* March 22, 1946, 9.

[22] In October of 1945 already warning to a senate hearing that "a button pressed in Russia might kill all in the U.S." "Langmuir Warns Danger to the U.S" New York times, October 9th, 1945. P.9

foreboding seemed contradictory—Langmuir could seem fairly blasé about the uncertainties of toying with nature, once suggesting that the population of Los Angeles might "like the effect" of creating a giant smokescreen above the city to block the sun for "strictly an experiment."[23] His extravagant claims, the historian of science Jim Fleming would note, ironically mirrored the very "pathological" or pseudo-science Langmuir inveighed against during that same time.[24]

Yet, at this time, if a Nobel Prize winning chemist said something was real, people generally follow suit. The hope in cloud seeding's efficacy was at times almost of a blind faith. Headlines declaring "We Can Do Something about the Weather!" abounded, echoed by scientists, politicians, journalists and civilians alike; proclamations of "overturning once and for all" Mark Twain's maxim that there's "nothing one can do about the weather" seemed almost a prerequisite for the discussing the topic. Future weathermen were likened to "Jiu Jitsu masters" in a giant chess game against nature.[25] From 1946 onward, weather control buzzwords such as these formed a discursive system of tropisms, phrases repeated without scrutiny and worked in the future perfect tense. Cloud seeding was discussed as if its future was already foretold: it was an implicit given that total weather control would soon be real, and hence it was talked about as having already happened.

Farmers' collectives, county water boards, energy companies, wildfire fighters all listened to Langmuir, and, most importantly, the military top brass listened. Almost

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[23] "Smoke Screen Over City Proposed to Lift Smog: Nobel Prize-Winning Chemist Suggests an Experiment to Eliminate Sun's Influence," *Los Angeles Times*, Apr 21, 1955, 4.

[24] "By his own criteria, Langmuir's final undertaking—his involvement in weather and climate control—must be judged a pathological obsession and somewhat of a scientific dead-end." Fleming, *Fixing the Sky*, 164.

[25] "Some Problems for Rainmakers", Los Angeles Times, Jan 17, 1953, MAKING WEATHER TO ORDER Los Angeles Times; Feb 23, 1947; "We Can Change The Weather!" *Los Angeles Times*, May 27, 1956.

immediately after the discovery in 1946 the D.O.D., with Langmuir's nudging, initiated Project Cirrus, a joint Air Force-Navy-Signal Corps endeavor that would last five years and be one of the most public and extensive of weather modification projects in U.S. history. Cirrus conducted seeding tests across the country in everything from hurricane mitigation to lightning prevention. Its most infamous experiment occurred not soon after its inception: on October 10th 1947 Cirrus seeded with eighty pounds of dry ice Hurricane King after it had made landfall in Cape Sable, FL.[26] Not long after storm abruptly changed course and smashed into Savannah, causing 20 million dollars in damage in that area alone.[27]

Afterward, Langmuir publicly declared that the Project Cirrus' seeding had caused its eccentricity. Neither the Weather Bureau nor his employer GE could understand why he would do so, both spooked by the mind reeling nightmare that would be the potential liability suits to follow. The WB issued a statement denying the connection, arguing it followed a similar path made by a hurricane in 1906. Langmuir's riposte almost flippantly chided them; "to assume a hurricane could not be modified by a single pellet of dry ice is like assuming that a very large forest fire cannot start with a single match."[28]

In 1948 Langmuir took this "single match" idea a step further, publishing a paper in the *Journal of Meteorology* suggesting that "spontaneously generated chain reactions" from dry ice seeding could cause "widespread weather effects that start from small beginnings," ending with a warning that "important changes in the whole weather

[26] There is an interesting though perhaps entirely coincidental connection between the Air Force beginning its naming of Tropical Storms the same year they began experimenting upon them.
[27] Horace Beyers, "History of Weather Modification" in W.N. Hess ed. *Weather and Climate Modification,* (New York: Wiley, 1974): 15.
[28] Irving Langmuir, "Project Cirrus Report, January, 1948," Langmuir Papers, box 12.

map...are not at present being considered by meteorologists."[29] By the time he had retired from G.E. in 1950, he was widely recognized as the face of weather modification, literally—his portrait was on the cover of *Time Magazine* in August of that year.

But if Langmuir was its preeminent spokesperson, he was also becoming its most vocal Cassandra. Langmuir soon garnered more attention by declaring that cloud seeding "can be as powerful a war weapon as the atomic bomb" by sending "devastating tornados and floods at the enemy".[30] He was perceptive enough to know that the Korean War could make cloud seeding appear a magic bullet, allowing the military to sidestep the use of atomic weapons in a Cold War quickly turning hot. In 1951, Langumir, Teller, and Vannevar Bush pitched another weather control program to Omar Bradley, leading to the creation of the secret Committee on Artificial Nucleation. Bradley, astonished he had not been aware of this potential, "called in his men to explain why this technique had not been properly developed and brought to his notice".[31]

Unlike the military, the Weather Bureau was deeply skeptical of Langmuir's claims. In the late 1940s, hurricanes were closely linked metaphorically with atomic weapons. It was also an early preoccupation of weather control enthusiasts. Vladimir Zworkin's article on the topic in late 1945, for instance, proposed hurricane mitigation via computerized weather control. As early as 1946 the Weather Bureau's Director of Research Harry Wexler was responding to inquiries wondering whether they could be dissipated through atomic weapons.[32] Wexler's public relations tack was to be cautiously

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[29] Irving Langmuir, "The Production of Rain by Chain Reaction in Cumulus Clouds at Temperatures Above Freezing," (*Journal of Meteorology* 5: October, 1948): 192.
[30] "Rainmaking Seen as War Weapon," *Los Angeles Times*, Feb 14, 1951, 1.
[31] Sverre Petterssen, *Weathering the Storm, Sverre Petterssen, the D-Day Forecast, and the Rise of Modern Meteorology*, ed. Jim Fleming (Boston: American Meteorological Society, 2001): 293.
[32] Zworkin, "Outline of Weather Prediction", (Camden, NJ: RCA, October 1945); "Letter from Harry Wexler to Edward Weyer Jr.," November 14, 1946," Reichelderfer Papers, box 8

optimistic about the capabilities of weather modification in the future while downplaying their capacity in the present. Basic research was needed first to even consider the possibility, and a lack of a global observation network as well as academic funding and training meant that this hope was still in jeopardy. Only when the mechanisms of precipitation and the general circulation of the atmosphere were known, Wexler cautioned, could such interventions be properly made. [33] This problem, not entirely coincidentally, happened to be the plan Wexler conceived before the cloud seeding debate began.

For Wexler was the Bureau's scientific star, a technical expert and coalition-builder that actively maneuvered meteorology into a place of power and prestige by the 1960s. As a colleague later recalled that Wexler "had his fingers in so many pies" it was almost to his detriment. His grand goal was the development of digital numerical weather prediction, a vision that required the building a vast observational infrastructure, supercomputers capable of handling complex fluid dynamical functions and big data storage, and training centers for a new kind of mathematical meteorologist who would use the power of these "electric brains" to pin down the thus far elusive beast, the general circulation of the atmosphere. By the end of his life Wexler would be credited with hundreds of papers, oversee the development of a global observational data collecting and sharing network and preside over the launching of computer modeled weather prediction and meteorological satellites. Indeed, an article in 1961 would observe that "the cold war has been good to meteorology," and it was good in many ways due to Wexler's initiative.[34]

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[33] "Hard to Control Weather," *The Science News-Letter*, Jan. 31, 1948, 78.
[34] "Weather Research Urged," (*The Science News-Letter*, Vol. 78, No. 3: Jul. 16, 1960), 39.

But in the late 1940s, the Bureau was perceived as a backwards organization and meteorology as a "zoological" science. Further exacerbating their situation, a cottage industry of entrepreneurs popularly dubbed "rainmakers" began to privatize cloud seeding, claiming their own expertise far exceeded the outmoded Bureau. Initially they were crop dusters using prop planes to disperse dry ice at low altitude. These individuals were hired to work on smog dispersal, crop yields and watershed amelioration, hail and lightning mitigation, and even increased snowpack for ski resorts.[35] Entrepreneurs with meteorological training began to develop more sophisticated and standardized methods during early 1950s. Kurt Vonnegut's brother Bernard invented the use of silver iodide ground generators in 1948 while working under Langmuir at GE and Project Cirrus. This allowed seeders to avoid the complexities of aerial dry ice seeding, thereby lowering production costs.[36]

The most famous of these rainmakers, a venal and charismatic charlatan named Irving Krick, was everything the numerical meteorology school was trying to eradicate: his meteorological theories were considered outdated and unscientific, based upon the induction from probabilities in historical record. He first made his name in meteorology by writing a controversial paper blaming Weather Bureau for the 1933 crash of USS Akron blimp, and built his cloud seeding reputation after the war by falsely claiming to potential clients that he worked with Langmuir and G.E.[37] Nevertheless, his unabashed duplicity paid off and in 1950 Krick incorporated the first weather modification company, Water Resources Co. Soon, three of his former students would launch their own firms,

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[35] "Resorts Eye Snow Making as Key to More Business," *Los Angeles Times*, Nov 6, 1951.
[36] Throughout the decade expenditures in cloud seeding at the local and state levels through contracts with private industry ran about 2 million dollars a year, with Federal expenditures in the range of 5 million (roughly 18 and 45 million dollars adjusted).
[37] WB Internal Memo, 1960. Reichelderfer papers, box 8.

the four of them together accounting for the large majority of private contracts through the fifties and beyond.[38] Krick was able to position himself as an expert in the public mind, even while conjuring statistics from thin air, lauding his work for creating a 500% increase in precipitation.[39] These statistics were impossible to be accurately assessed, as Krick selectively furnished data to the government only when it suited him, other times citing "proprietary secrets." By the end of the decade, Reichelderfer would throw his hands up in the air, writing an ominous memo declaring that "the time has come for Krick to finally be dealt with once and for all."[40]

The Bureau was out for blood by 1951. The prestige of their science seemed at stake, and after conducting their own trials they were even more certain of the rainmaker's "charlatanism". Wexler closely scrutinized both Langmuir's and Krick's data, revealing, he believed, their "meteorological naiveté."[41] Poking fun at Krick's claims in particular, he observed that if rain had increased by 500% it "would stick out like a sore thumb."[42] Lester Machta echoed the same when, analyzing a 1951 Project Cirrus report, he wrote to Wexler that his research team felt "the trajectory aspects of his work represent a very unconvincing case...some of his trajectories which make loops are sheer nonsense."[43]

After Langmuir presented his hypotheses of "altered periodicities" due to his New Mexico seeding trials at the National Academy of Sciences in 1950, Wexler promptly responded by ordering Ferguson Hall to refute Langmuir's "probability theory" that

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[38] At the peak of activity in 1953, 5 firms would dominate the majority of the contracts, about 30-50 per Robert Elliot. "Experience of the Private Sector" in Hess, *Weather Modification*, 46.
[39] "Food Boom Predicted in Rainmaking: Dr. Krick Says 50% Increase Is Possible in Bread and Steak." *Los Angeles Times*, Jan 9, 1951.
[40] WB Internal Memo, 1960. Reichelderfer papers, box 8.
[41] Wexler papers, box 3.
[42] Wexler papers, box 34.
[43] "Lester Machta to Harry Wexler, Nov 7, 1952), Wexler papers, box 3.

supposedly proved his seeding had caused large scale weather modifications of the Eastern Seaboard. In an article in *Science* later that year, Hall countered that Langmuir treated the adjacent areas from the seeding "as so many independent random numbers," a cardinal sin in meteorology since rainfall distribution is never purely random. Hall concluded that "we cannot accord credence to the sweeping inference that the abnormal character of the basic weather pattern" was the result of Langmuir's seeding.[44] A 1951 American Meteorological Society paper concurred, marking a huge victory for the Bureau within the circle of professional meteorologists.

This did not, though, quell the public dispute with Langmuir and Krick, who both countered that the AMS data was biased and its results rigged by the Bureau. And so the inconclusiveness of its efficacy continued—as the WB's Richard Coons observed a few years later "it is surprising to consider how little progress has been made in the past eight years…Mainly, this is so because we have become so enamored with statistics, or, might I say, we have become beclouded with abstruse and inconclusive (and certainly highly controversial) statistical relationships".[45]

But this "becloudedness" did not matter, as everyone seemed to take Langmuir very seriously. By 1951 he was routinely making statements proclaiming that "promiscuous over seeding of clouds in artificial rainmaking might wreck the agriculture of an entire nation" and that laws should be enacted making "uncontrolled cloud seeding a serious crime". Langmuir half-supported Krick in an attempt to get at the Weather Bureau, consistently out maneuvering them both in public favor by playing each side off the other while appearing himself as the sensible arbiter. His warnings almost always

[44] Ferguson Hall, "Dr. Langmuir's Article on Precipitation Control," (*Science* 113: 1951): 192.
[45] Richard Coons to Captain Orville, August 30, 1954. Langmuir papers, box 12.

included a coda needling the WB, painting in apocalyptic terms that as long as the bureau "says we can't produce artificial precipitation, you may rest assured that the government will take no action to set up the controls to prevent careless or uninformed techniques from causing disaster."[46]

Now the folks in Washington had begun to listen. After Langmuir' claim that his experiments altering the rainfall patterns of the eastern seaboard, Senator Moody (D-MI) complained in an open letter to the DOD that seeding was disrupting his state's tourism.[47] The most important politician involved in the matter was Senator Clinton Anderson, former Secretary of Agriculture under Truman and chairman of the Joint Committee on Atomic Energy. His positions dovetailed neatly with the two major environmental concerns of his home state New Mexico— water resources and atomic testing, both of which seemed to pivot around the issue of weather modification, both intentional and inadvertent. Letters from irate constituents bombarded Anderson as much as they did the Bureau.[48] Feeling the pinch to spring to action, his own press statements became a carbon copy of Langmuir's, warning of "the almost terrifying implication" of weather control and arguing for robust federal intervention and the creation an AEC like agency to oversee the field in order to preempt looming catastrophe.[49]

His warnings would soon appear justified. After the great 1951 floods in Kansas, considered by the WB to be the most damaging in American history, Anderson cast blame toward Krick's cloud seeding in New Mexico, publicly charging him with

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[46] "U. S. to Probe Rainmaking." *The Science News-Letter*, Vol. 60, No. 14. Dec. 6, 1950, 213.
[47] "New Mexico's Wet Blanket Irks Michigan: Moody Hits Timing of Man-Made Rain," Chicago Tribune, June 8, 1952, 12.
[48] One even asking "must we now thank GE instead of God for the Rain…just as we do with John Deere for his artificial bull "Rudy Whickey to Clinton Anderson, December 29, 1950" Clinton Anderson Papers, Library of Congress, Washington, D.C., box 496.
[49] "Rainmaking Seen as War Weapon," *Los Angeles Times*, Feb 14, 1951, 1.

simultaneously failing to alleviate the drought in his state and causing the catastrophic floods in another. That someone of Anderson's stature was openly asserting weather modification was to blame for a natural disaster raised the stakes of the debate even further. Langmuir reinforced the argument of seeding's culpability, promptly cutting off his own New Mexico trials after the event.[50] Krick and other private contractors brushed it off as political axe grinding; a sympathetic editorial in the *Los Angeles Times* speculated that "long ago his [Krick's] predictions were so much more accurate than the Weather Bureau that there were many repercussions…if Anderson blames the scientist for flooding Kansas and Missouri, it's because bureaucrats have been talking."[51] But the author was sorely mistaken—the bureaucrats felt the opposite, and as much as they despised Krick they would come to his defense in order to dispel the misconception of any connection.

Now the extravagant claims of the rainmakers were coming back to haunt them. A whole Pandora's box of actuarial, legal, environmental, and political problems seemed poised to spin out of control.[52] Western politicians enacted city ordinances and state laws either banning or requiring the licensing of rainmakers in ad hoc patchwork that had no overarching legal concept within which to act.[53] Banning rainmaking from one town and allowing it in another fifteen miles away made no sense given the scale of weather

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[50] Beyers, 19.
[51] "WHO RAINED ON KANSAS?" *Los Angeles Times*, July 18, 1951, A5.
[52] The first legal case, *Slutsky v. City of New York* (1950) portended this coming chaos. A Catskill resort sought an injunction to prohibit the city's cloud seeding activities to mitigate water shortages, arguing loss of tourism profits and potential run-off damage. The judge decided against the injunction, arguing that it was impossible to "own the clouds." This prompted a legal debate concerning the means by which one could construct a jurisprudential framework to deal atmospheric domain issues, a problem that would grow throughout the late fifties and reach a crescendo with the global sovereignty conundrum surrounding satellites and high altitude nuclear testing.
[53] By 1954 California, Colorado, Arizona, Oregon, South Dakota and Wyoming all had passed state level legislation.

systems. The transcontinental nature of the problem certainly seemed to fall well within the Interstate Commerce Clause—property rights at this time were also being revised to deal with the "trespassing" of transcontinental flights. Finally, the first hearing on weather modification was held by Anderson in late 1951, part of a failed attempt to put a bill through creating his anticipatory agency.

The unfortunate coincidence of a rash of extreme weather alongside the inauguration of continental nuclear weapons testing left the Bureau helpless to counter the charges of their rivals effectively, and they would find themselves in a losing battle with a public now convinced by Langmuir that just one bomb or gram of silver iodide could trigger a catastrophic chain reaction that would ripple around the globe.

PART II: NOWHERE TO HIDE: THE BOMB AND THE WEATHER, 1951-1953

The beginning of continental testing in 1951 was fairly uncontroversial. Decided in the bellicose atmosphere at the start of the Korean War in 1950, relocation to the continent seemed the only means to ensure the secrecy of the tests and reduce the logistical complexity of the operations. Nevadans embraced the beginning of testing for its economic benefits and even, during the first few series, as a recreational activity.[54] Nevertheless, with each test series came more concerns regarding the weather. The winter following the heels of the autumn 1951 Buster Jangle series was "one of the worst in Nevada in 60 years," prompting the first petition to the state government from

[54] "A-bomb Watching a New Outdoor Pastime," *New York Times*, Nov.4, 1951, 166.

the town of Golconda, NV in March of 1952 calling for the cessation of all testing.[55] The AEC and WB dismissed the petition, arguing again a thousand a-bombs are equivalent to one hurricane.[56] The debate, running along these lines, would continue for the next 5 years in a complete stalemate.

For there seemed something "abnormally abnormal" about the weather people observed, and even the Bureau acknowledged that winters were milder and summers hotter.[57] Indeed, atomic energy and cloud seeding's inventions occurred at the peak of the first pronounced climatic warming period of the twentieth century. The West and Mid-West experienced some of the worst seasons of drought in their history, just as smog and water pollution were accelerating from increasingly overtaxed infrastructures due to the Sun Belt boom.[58] It is probably not coincidental that the peak of corporate weather modification activities in 1953 would prove to be the warmest year yet in the historical record.[59]

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[55] "Atomic Tests Did Not Cause Heavy Snows, Nevadans Told," *Washington Post*, March 29, 1952, 3.
[56] This line, as can be inferred by this point, was numerically inconsistent; I have counted at least 14 different ratios used to describe the proportional power of a-bombs-to hurricanes.
[57] Spencer Weart, *The Discovery of Global Warming* (Cambridge: Harvard University Press, 2003), 2. For contemporary popular discussions, see in particular Von Neumann's article, "Can We Survive Technology?" Fortune Magazine, 1955, "CLIMATE WARMING IN THE ANTARCTIC: 5-Degree Rise Over the Last Half Century." *New York Times*, May 31, 1958. A cover story for the *New York Times* Sunday Magazine on July 12, 1953 declared "The Weather Is Really Changing", its sub-header acknowledging that while "studies confirm" the world is warming, "the atmosphere, not atoms, are to blame". While dismissing the more fantastic theories that the culprits were cloud seeding and atomic testing, the article discussed a variety of possible explanations offered by climatologists, such as an aberration in tilt of the earth's axis, as well as the alteration of the earth's radiation balance due to CO2 emissions, or naturally due to the decrease in volcanic activity. "The Weather is Really Changing" New York Times, July 12, 1953, 7.
[58] "Drought Problem Is Creeping Catastrophe," *Los Angeles Times*, Nov 8, 1956
[59] In fact, the 1930s and 1940s were warmer by decade average, but individual years in the 1950s were warmer than any individual year in the two decades previous, or even over the whole historical record, as in 1953. The West and Mid-West suffered several years of extreme drought from the late 1940s to late 1950s. 1935-1955 would also prove to be highest average 20-year period of tornado and hurricane activity to date, including individual year records. "Historical Climatological Rankings", National Climate Data Center, National Oceanic and Atmospheric Administration online archive, https://www.**ncdc**.noaa.gov. Last accessed 4/5/14.

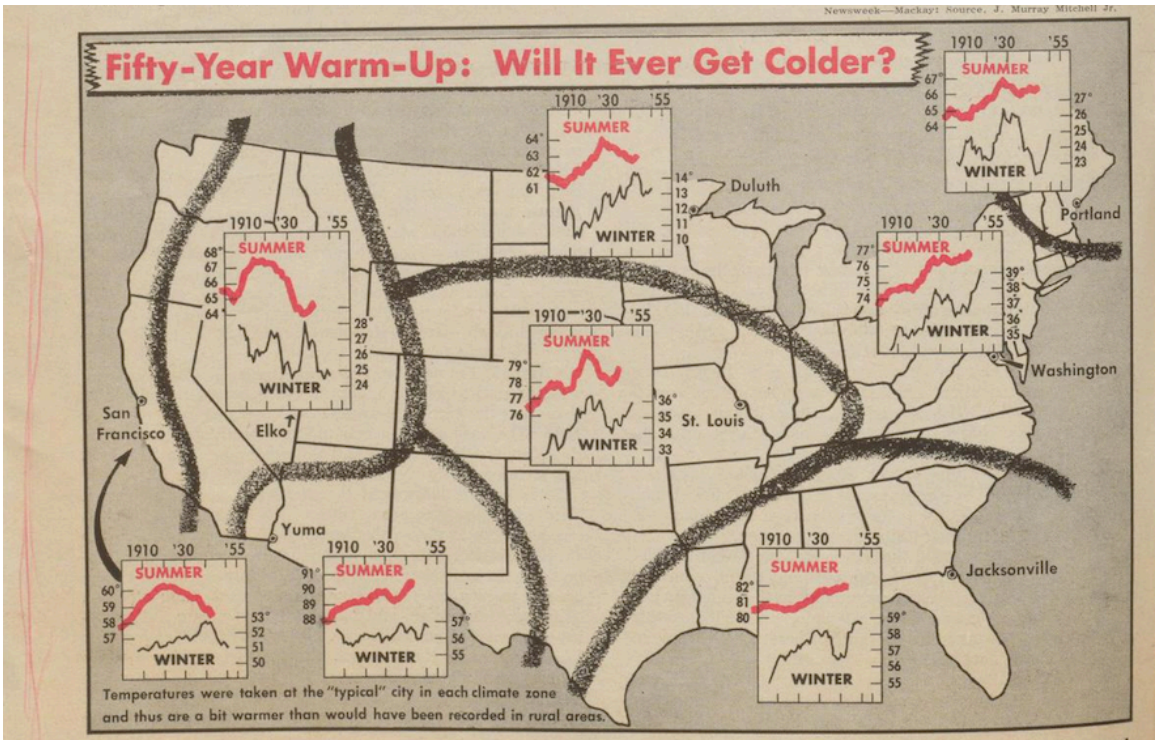

Fig. 2. Article discussing the mystery of the Northern Hemisphere's warming. Emphasis was placed on the phenomenon of warmer winters, which deviated more from historical averages. *Newsweek*, September 10, 1956, Clinton Presba Anderson Papers, Box 151.

And at the start of the decade, meteorologists had very little information on how climatic processes worked, much less how atomic testing might influence it. Nevertheless, government scientists outwardly appeared certain it was impossible, though there was little empirical evidence to determine the issue either way. But admitting this possibility was completely anathema to their autonomy and authority, and an aggressive PR campaign would begin in 1951 with a cover story for the popular meteorological journal, *Weatherwise.* That this article came out simultaneously with the commencement of first postwar continental test series, Operation Ranger, was probably no coincidence—meteorologists certainly wanted to get ahead of the story. The author speculated that this misconception was present from the start due to the "dramatic" reporting of the Trinity

test and the "foul" weather that preceded its detonation, lamenting that before both Crossroads and Sandstone he was "plagued with numerous letters and admonishments that an atomic bomb would start a vigorous thunderstorm or an incipient typhoon." He further remarked that "even the most versatile of rainmakers would have the most difficulty" precipitating rain from an atomic plume. Still, he could not but acknowledge that the bomb could have an "indirect effect" on the weather, such as the rain after Hiroshima and the Baker shot during Crossroads, though he asserted it was only temporary and local, the tremendous energies to create or control storms still not attainable in "man-made bombs".[60]

The article was basically identical to the argument of a section in the AEC's unclassified 1950 study "The Effects of Atomic Weapons", which dismisses in a mere ten pages the risks of both fallout and weather effects due to testing.[61] The article's author, Col. Ben Holzman, a brilliant Air Force meteorologist, most likely wrote the AEC report. He was a prime mover in the initiation of long-term atmospheric research on radiation after Eisenhower, splitting the Air Force off into an independent unit in 1947, assigned him the task of detecting a potential Soviet detonation. Holzman then created the Office of Atomic Energy, or AFOAT-1, supervised by Armed Forces Special Weapons Division.[62] In 1948, Holzman gave his "good friend" Wexler, and a man quite "powerful in military circles at the time," a "modest sum" to design the means by which one could detect an atomic explosion detonated anywhere across the globe.[63] Wexler in

[60] Benjamin Holzman, "The Effects of Atomic Bombs on the Weather," *Weatherwise* Vol.4 I.1: 1951): 50.
[61] Los Alamos Laboratory, *The Effects of Atomic Weapons*, 33-44.
[62] Lester Machta, "The Meteorological Benefits from Atmospheric Nuclear Tests," (*Health Physics*, Vol. 82(5): 2002): 635.
[63] Julius London, "Interview with Lester Machta, October 31, 1993," *American Meteorological Society*, 4.

turn created the WB Special Projects Division and brought a newly minted PhD, Lester Machta, to lead the work on trajectory tracing as part of AFOAT-1.[64]

When the Special Projects unit began its work, there was virtually no research on the risks of testing.[65] An outline of a 1950 classified research proposal for an extensive interagency study on thermal radiation acknowledged that the data collected from the 1946 Crossroads series was "difficult to interpret" and that of 1948 Sandstone had yet to be completed.[66] The reasons for this growing interest pivoted upon predicting what risks would arise "should thermonuclear weapons become a reality."[67] The seeming inevitability of the hydrogen bomb combined with the USSR's entry into the nuclear club to fundamentally alter the risk calculus. Given the amount of bombs that could potentially be detonated was now out of their control, considerations of long-term, global-scale effects of testing first appeared on AEC's radar. They ordered a study done on the matter, sardonically named Project Gabriel, a health physicist's one-man endeavor at Oak Ridge that was more thought experiment than empirical investigation. Nicholas Smith, instructed to calculate the limit point of how many nuclear bombs could be detonated before all life on earth was killed off, determined that it would take roughly 10,000 Hiroshima sized bombs. He hypothesized that the main agent of destruction would be Strontium-90, confirmed to be the most reactive element circulating through

[64] Wexler had keen eye for talent. Having known Machta from their days training Army Air Corps meteorologists at Chanhute field during the WWII, his intuition about the young meteorologist proved correct. Machta would become one of the giants of atmospheric research, and his first accomplishment would be backtracking the date of JOE 1, the USSR's first atomic test, in 1949.

[65] A notable exception were the biologists of the Applied Fisheries Lab in Washington—"There is no evidence, however, that Crossroads was then considered the possible starting point of long-term research in radiobiology or that Bikini might offer means of discovering how radionuclides were caught up and circulated in a biological system. Although the concept of such circulation was not altogether new, its relevance in the Bikini situation seems not to have been realized." Neal Hines, *Proving Ground: An Account of Radiobiological Studies in the Pacific, 1946-1961* (Seattle: University of Washington Press, 1962).

[66] "Thermal Radiation Research Proposal: July 10, 1950, p.2," Wexler Papers, Box 5.

[67] "Conference on Thermal Radiation, p.1," Wexler papers, Box 5.

the biosphere due to its ability to mimic calcium and hence aggregate in human bone. Smith concluded that the study of Sr-90 should be given first priority over other fission products from the bomb.[68]

Wexler presented the first meteorological analysis of the previous test data, "Calculations of Thermal Radiation through the Atmosphere" at a conference chaired by Holzman at the Pentagon on July 11, 1950.[69] Empirical studies, though, would only begin in earnest in February 1951 with the inaugural continental series at Frenchman Flat in Nevada. Operation Ranger would prove, Machta would later say, "the most useful United States test series for long distance trajectory verification" that would help map the path of the circulation of the general atmosphere.[70] Yet these studies had nothing to do with mechanical weather effects of the detonations. Instead, it was focused on stratospheric fallout deposition. After the second series in 1951, Operation Buster-Jangle, the unit began to warn in internal reports that fallout the distributed unevenly due to the non-linearity of precipitation and this problem exhibited "potential danger" due to its "scavenging" of radioactive particles, raining down in concentrated form far removed from the test site.[71] These conclusions were unwelcome to the commissioners of the AEC, as it showed there were possibilities of areas accruing dangerous levels of radioactivity outside testing zones. Thus began an internal technical dispute between the agency and Machta's unit regarding the health risks of fallout.[72]

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[68] "The Worldwide Effects of Atomic Weapons: Project Sunshine," Rand Co. August 6, 1953, 1-2; Barton Hacker, *Elements of Controversy: The Atomic Energy Commission and Radiation Safety in Nuclear Weapons Testing,* (Berkeley: University of California Press, 1994): 181-2.
[69] "Agenda: Conference on Thermal Radiation Effects, July 11th, 1950," Wexler Papers, Box 5.
[70] Machta, *Meteorological Benefits*, 635.
[71] Richard Miller, *Under the Cloud: The Decades of Nuclear Testing*, New York: Free Press, 1986): 210.
[72] This centered on the problem of whether the stratosphere acted as a limit to fallout such that it was held in there for at least 10 years, hence uniformly mixing and spreading out risk evenly across the globe, as AEC commissioner Willard Libby argued, or whether their were concentrated areas due to weather

While experts behind the scenes were quietly beginning to contemplate nuclear risks far beyond a scale previously imaginable, the public was almost completely unaware such risks existed. Aside from David Bradley's alarmist 1948 account of his time as a radiobiological monitor during Operation Crossroads, *Nowhere to Hide*, there was little public discussion of the health effects of radioactivity, let alone that of long-term fallout. The U.S. occupation government severely censored images and reports emerging from Japan throughout the forties. Radioactivity associated with the bomb remained mostly seen as a local ionization from the blast and not the long term or global scale problem of "fallout". The unintentionally farcical 1950 AEC propaganda film, *You Can Survive an Atomic Blast*, even depicted simple cloth rags as able to prevent radiation burns and radioactive sickness. It was the bomb's explosive power, not its invisible byproducts, which dominated the popular imagination.

In October of 1952, the first thermonuclear device, Ivy Mike, was detonated at Enewatak Atoll, its payload five hundred times that of Fat Man, in fact, the first explosion to enter the "mega" prefixual realm and wiping away the island of Enlugelab in the process. The thermonuclear age had begun as a giant question mark in which the vast majority of the population did not even know what that meant, and the experts involved did not know what it implied. Its emergence only further exacerbated the

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contingencies and global circulation patterns. E. Jerry Jessee's article, "A Heightened Controversy" in *Toxic Airs*: *Body, Place, Planet in Historical Perspective*, ed. J.R. Fleming, is an extensive study of the Machta-Libby dispute.

confusion over the scale of our planetary powers.[73] Truman's final state of the Union address summed up this sentiment, warning that man is moving "into a new era of destructive power", one whose "destructive peaks" would only grow with time.

As the public began to grapple with the implications of the H-Bomb, extreme weather during the start of Operation Upshot-Knothole in the spring of 1953 would seemingly confirm their worst fears. The feeling of foreboding that the tests elicited was not mitigated by the almost over-the top macabre of the experimental designs, particularly the nationally televised inaugural shot "Annie". Reversing Marx's dictum, farce instead presaged tragedy, as the Federal Civil Defense Administration created a "grim scene" of two mock "average" American homes "at the corner of Main and Elm streets" inhabited by dummy families who were caught unawares in a nuclear blast while visiting their neighbors.[74]

This ill-omened and ill-conceived start coincided directly with the heavy rainfall throughout the East, prompting an article in the *New York Times* to dub 1953 "The Year of Mildew," though the author was quick to point out with a chauvinistic flourish that "the weather men say that dame Nature is impervious to such trifling explosions," explaining that an "ordinary storm could outpunch an a-bomb five to one."[75] But New Mexicans, at least, believed "Dame Nature" was susceptible to their advances, complaining that testing was creating cold snaps that were ruining their fruit crops, orange growers in San Juan County presenting to the press a study showing a pattern of

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[73] Jacob Hamblin observes "the flurry of hydrogen bomb tests, combined with especially abnormal global weather conditions that year, coalesced into the widespread suspicion that the bombs might be disrupting weather and climate on a global scale." Hamblin, *Arming Mother Nature*, 117.
[74] "2 Dummy Families Await Atom Blast," *New York Times*, March 16, 1953, 11.
[75] Rainfall in March Sets Record High," *New York Times*, March 31,1953, 33; "1953: The Year of Mildew" New York Times, May 31, 1953, 20.

severe frosts following three consecutive shots by no more than 60 hours.[76] In response, Holzman repeated in the *New York Times* what he had written two years previous almost verbatim.[77] Wexler backed up him up two weeks later with virtually the same statement, citing "competent meteorologists'" observations at Bikini showed that atomic bombs at had only local weather effects "if any", again reiterating that hurricanes produce the energy of "five to ten Hiroshima type bombs a second".[78] He failed to mention, though, that these "observations at Bikini" were from 1946, as no testing had been conducted there since then.

None of this seemed to have any effect on the public—throughout May angry editorials complained of Wexler et al. ignoring the fundamental problem of "trigger effects".[79] Faith in bureaucratic expertise was crumbling; just as the weather seemed out of control, so too did the AEC's grasp on risk mitigation. A disastrous shot on May 25th, what would later be called "Dirty Harry", produced the highest amount of fallout ever recorded in the continental U.S., forcing the residents of St. George, Utah to stay indoors for hours, one resident becoming so sick her hair fell out. [80] Articles in the wake of this event wrote of fallout detected as far as Chicago and New York, most of them needing to initially define the term it was so unknown.[81] The AEC took advantage of this public ignorance to reassure them that these levels were well below "the permissible threshold", typically employing tropes that it was not even accumulatively a dental x-rays' worth of

[76] "Howl Set up by New Mexico over A-tests" Chicago Tribune, May 15, 1953, A13.
[77] "Bombs and Weather: Clouds of an Atomic Explosion are not Thunder Clouds," *New York Times*, May 3, 1953,
[78] "Bomb Tests are Cleared as Cause of Rain in the East" *New York Times*, May 22, 1953, 3.
[79] Jerome Alexander, "A-bomb Effects on Weather: Letters to the Times," New York Times, May 28, 1953, 22.
[80] Where the infamous film the "Conqueror" was shot that supposedly lead to the cancer-related deaths of many cast members, including John Wayne.
[81] Chicago Tribune, "Howl Set Up By New Mexico Over A-Tests."

roentgens and that we are constantly bombarded by natural background radiation already.[82] But the proliferation of problems associated with testing made the AEC feared it was losing control of the narrative. At a meeting three days after the Harry shot, AEC commissioner Eugene Zukert worried that "a serious psychological problem has arisen…it would take only a single illogical and unforeseeable incident to preclude any future tests in the United States."[83]

A "single illogical and unforeseeable incident" would occur two weeks later, right on the heels of the final shot of the series "Climax", now surpassing Harry as the largest bomb exploded in the continental United States. On June 8^{h} and 9th, a storm system passing east produced the "Flint-Worcester Tornado Outbreak Sequence" whose eponymous cities in Michigan and Massachusetts experienced two of the deadliest tornados in U.S. history.[84] Given that they were both outside tornado alley, atomic testing's culpability seemed even more likely. Indeed, survivors compared the aftermath to Hiroshima.[85]

On the day of the Worcester disaster, Representative Ray Madden (D-IN) demanded a full inquiry into the connection by the House Armed Services Committee. Rep. James van Zandt of the JCAE (R-PA) initially agreed with him, telling the press

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[82] Gladwin Hill, "Atom Test Studies Show Area Is Safe," *New York Times*, May 25, 1953, 21.
[83] Quoted in Miller, *Under the Cloud*, 177.
[84]The former, an F5, still remaining in the top ten. Even before these disasters the month of May was already had an exceptionally high frequency of tornados, indeed by the time of the Flint-Worcester outbreak series, 200 tornados, surpassing the yearly 149 per year average, had already struck, with a tornado in Waco, TX on May 17th being only one slot behind Flint in fatalities. The greatest irony of it all is that of the contiguous 48, only Nevada did not have a tornado that year, or, in fact, any for 72 years. "The Big Winds," Washington Post, May 14, 1953, 14.
[85] Anthony Wallace, National Research Council Committee on Disaster Studies, *Tornado in Worcester: An Exploratory Study of Individual and Community Behavior in an Extreme Situation* (Washington, D.C., National Academy of Sciences, National Research Council, 1956), 59.

that he too believed the tornados were "definitely" linked to testing.[86] The next day, though, van Zandt would abruptly change his tune, claiming that he had been "completely misrepresented".[87] The day after Rep. Dewey Short (R-MO), chairman of the House Armed Services Committee, denied Madden's motion, arguing it was "something for our experts to handle," while a fellow representative declared "man has never been able to create a hurricane".[88]

Yet this did not settle the matter, and Rep. Edith Rogers (R-MA) filed a resolution calling on the WB and AEC to investigate the cause, arguing whether or not the bomb was responsible "people will have more faith if the federal government investigates thoroughly."[89] The conflicting statements emerging from the government, and what one civilian characterized as the "the pooh-poohings of the Weather Bureau and Washington's smart aleck scientists and meteorologists" had by this point sown a state of complete confusion. A Gallup poll released on the 19th showed that 29% of the country believed the tests and tornados were connected with another 20% unsure.[90]

Finally, a hearing to consider Rogers' motion was held on the June 23rd, with representatives from the Air Force, Army, Navy, Civil Defense all testifying there was no connection as far as they were aware between the two, referring to WB studies as proof, studies that were not public save through the statements of experts such as

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[86] "Congressman Curious: Probe of Atomic Link to Tornados Sought," Los Angeles Times, June 10, 1953, 1.

[87] In fact one paper reported he reversed his position only several hours later ."Experts Deny Atomic Tests Cause Tornados," *Washington Post*, June 11, 1953, 14.

[88] Officials Deny Atomic Tests caused tornados" *Los Angeles Times*, June 11, 1953, 11.

[89] "Rep. Rogers Will Ask Quiz on Tornado Causes," Los Angeles Times, June 12, 1953, 8.

[90] Alfred Hengst, "Letter to the Editor," *Los Angeles Times*, June 18, 1953, A4. It appears even Langmuir got into the mix, though off the record, with a column in the Washington Post on the 20th citing an unnamed physicist who coincidentally had the same nonchalantly imperious style claiming that "we all know that a few handfuls of silver iodide, properly vaporized, can bring down thousands of tons of rainfall…remember that a small trigger can set off a mighty big explosion. And those floating particles of radioactive dust may be just the trigger that old man weather needs to send him on a rampage."

Wexler.[91] Wexler, adding to the usual line, also took a moment to trumpet the Bureau's success as an ironic cause of this belief in tornado abnormality, as the meteorological detection network had become so efficient many tornados previously unrecorded were now being observed.

Further pushback against the possibility came even from the "wildcat" cloud seeders such as Krick, now forced to awkwardly downplay the effects of seeding to avoid the wrath of public hysteria.[92] Indeed, the events finally helped to bring weather control into the orbit federal oversight with the establishment that August of the Advisory Committee on Weather Control (ACWC) to investigate the legal, economic, scientific, and environmental issues related to weather control.

In the summer of 1953 Wexler began an aggressive PR campaign to reclaim the climate narrative, making frequent press statements arguing that the earth's apparent warming was most likely a natural effect of decreased volcanism, volcanism that had kept the global thermostat low since Krakatoa eruption in 1883.[93] That July Wexler and Holzman attended a secret conference sponsored by RAND Co. and the AEC. Trying to find ways to assuage a nervous public and anxious about the deep uncertainty in their knowledge of fallout risks, they proposed an international collaborative project between a virtual who's who of eminent environmental, biological, and geological scientists, codenamed Project Sunshine, flowing out of the ad hoc work of Project Gabriel.

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[91] "Report No.646 on HR 279, Inquiring into the Effect on the Weather of Certain Atomic-Bomb Explosions, 83rd Congress, First session, June 23, 1953."
[92] "Cloud Seeders Deny They Set Off Tornados," *Chicago Tribune*, June 28, 1953, 29.
[93] "It Won't Always Get Hotter: Man to Do Something About the Weather," *Los Angeles Times*, July 6, 1953, 1.

The historical importance of this meeting was the acknowledgment that long-term global scale health risks were highly probable. The project's task was unprecedented; they would seek to secretly trace Strontium-90's circulation throughout the global biosphere at every level, even inside the human body. Over the next several years Project Sunshine would become the top priority of the AEC. Around this time, perhaps influenced by the launch of Sunshine, it appeared Wexler finally ordered Machta to make a study of atomic weather theories.[94] The experts, it seems, were beginning to feel a little less certain they actually possessed expertise when it came to risks whose spatio-temporal parameters were expanding far beyond human duration.

PART III: THE FALLOUT FROM FALLOUT: 1953-1963

On March 1, 1954 the largest thermonuclear test the United States ever performed, the Castle Bravo shot, exploded on Bikini Atoll, its 15-megaton yield twice as large as anticipated. Carried upon an unexpected wind, the fallout spread far beyond the target zone, the "snowflakes" gently gliding down upon the Marshallese inhabitants of a nearby island and, of all nationalities, a Japanese fishing boat over a hundred miles away. The horrors of the sailors' radiation sickness created an international outcry, marking the first time "fallout" would receive general public attention.[95]

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[94] Though the exact date is still unknown, in his testimony of 1955 he told the JCAE that he instructed Machta to study the problem two years previous. Machta himself made it seem as if it was his own initiative, later implying he did it to help out the AEC. Wexler's admission tacitly implied that statements before 1953 were based on presumption without proper empirical data to back it up.

[95] A month later, Lewis Strauss' first press conference as AEC chairman on April 1st, a joint one held with Eisenhower, would go down in the annals of PR mismanagement when off the bat the president conjectured that the explosion was "something we had never experienced before" and it must have "surprised and

Though in 1954 the AEC was at the peak of its power, having effectively shut down all other channels of atomic expertise to the administration, contingencies kept disrupting their ability to maintain the veneer that effects were local, minimal, and within the purview of human management. Instead, as testing continued, the risks seemed to be multiplying. The spate of severe weather continued after Bravo, particularly in England, having its wettest year on record. At his first solo press conference in the fall of 1954 Chairman Lewis Strauss reiterated the line that the a-bomb's power was negligible when held up against a hurricane.[96] In early 1955 the AEC would continue to counterpunch hard, beginning a jingoistic PR campaign for its early 1955 series Operation Teapot, handing out a brochure to the local residents of an almost infantilizing nature, dismissing atomic weather and fallout hazards alongside cartoon drawings.

By 1955 Anderson was pressed to determine the issue, as he could not seem to persuade his constituents there was no connection. A delay in the first Teapot shot gave him the opportunity to write to Strauss requesting an explanation and voicing his opinion that "only very small yield devices should be tested there [in Nevada]."[97] Strauss wrote back trying to dissuade Anderson from holding a public hearing on the matter, asking he consider the "importance of the tests and the morale of the test organization before you decide to do so".[98] Nevertheless, ignoring Strauss' plea, he called a hearing for 15th of April to examine the matter.

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astonished the scientists." As if this wasn't reassuring enough, the Q&A was turned over to Strauss, who let slip that they could easily build a bomb that could "take out" a city the size of New York, a pronouncement which prompted an astonished *what?* from the entire press corps. Edward Folliard, "H-Bomb Can Wreck N.Y, Strauss Says," *Washington Post* and *Times Herald*, April 1, 1953, A1.

[96] "A-blasts Don't Cause Storms, AEC Chief Says," *Chicago Tribune*, September 10 1954, 12.

[97] "Letter from Anderson to Strauss, February 21, 1955," Anderson Papers, Box 800.

[98] "Reply from Strauss to Anderson, March 3, 1955," Anderson Papers, Box 151.

And so the Joint Commission on Atomic Energy, seeking to "dispel misconceptions" and "unwarranted concern", held the first hearing focusing on the "Health and Safety Problems and Weather Effects Associated with Atomic Explosions." Wexler, tasked with accounting for weather effects, began his testimony by waxing poetically that "from time immemorial man has been exposed to the vagaries of the weather, and in his attempt to explain these phenomena has pointed the finger at many factors," going on to note "in more recent centuries" the finger had been pointed at "gunpowder, steam and gasoline engines…and now nuclear energy."[99] Wexler then "sold" Machta and Lee Harris' paper examining the meteorological effects of testing, published in *Science* January of that year, with another more specific study by Harris that looked at the tornado issue.[100]

Machta had surveyed a hundred professional meteorologists, the vast majority of whom felt these fears were unfounded. Analyzing each means by which atomic bombs could affect the weather, from dust nucleation to radioactive ionization to changing the radiation balance of the earth, he came to a similar conclusion. "While it is not possible to prove definitively that atomic explosions have or have not influenced the weather," his study of climatological data seemed to indicate it as "unlikely".[101] Machta's judicious admission that it was "not possible to prove" illustrated the entire crux of the problem of assessing these types of risks—the climatological data was too incomplete and the time sample not long enough to make claims beyond an inferential level based on the current tenuous understanding of atmospheric circulation. That

[99] "Health and Safety Problems and Weather Effects Associated with Atomic Explosions, Joint Committee on Atomic Energy, 84th Congress, 1st Session April 15, 1955," 37.
[100] Machta's term, Weart, "Interview with Lester Machta."
[101] Lester Machta and Lee Harris, "The Effects of Atomic Explosions on the Weather," (*Science*, Vol. 121, No. 3134: Jan. 21, 1955), 80

Machta acknowledged this shows there was now some doubt about the extent of their knowledge.

Anderson recognized as much, and though he wrote to his constituents that all was well, his faith in the AEC was eroding.[102] Indeed, Anderson's outline for the hearing reflected a more skeptical attitude toward the experts than he had let on publicly, writing that it would be "interesting to know just when the AEC and WB started their studies to determine whether nuclear weapons effects had any influence upon the weather" as well as how much they have spent and how much longer they would deem "studies profitable." He also planned to ask for comments on Linus Pauling's public statements on fallout "expressing great concern for future generations".[103] This reflected a growing public concern with radioactivity after the Bravo fiasco. An ominous cover of the *Nation* in February 1955 depicted a skull with an atomic plume emerging from its cap with the headline the "Atom Dust Peril". Fallout exacerbated an already fever-pitched concern regarding testing's environmental effects. Pressure for an independent analysis outside the AEC's dominion reached a crescendo by the end of 1955.

In 1956 the first "independent" analysis was released, this one focused primarily on fallout risks. The National Academy of Sciences supposedly impartial study on the matter, the "Biological Effects of Atomic Radiation" (B.E.A.R.) report, concluded that testing's health risks were existent but negligible at current levels and its weather effects totally nonexistent. Wexler, not surprisingly, headed the panel on meteorological effects, submitting an almost identical statement to his one the year previous dismissing weather

[102] Greene, *Eisenhower and the Test-Ban Debate,* 66.
[103] "Outline of Questions, April 1955," Anderson papers, Box 800.

concerns. Following the study, the World Meteorological Organization (WMO) voted that it was not even worth investigating the atom weather issue. At the time, Reichelderfer was the WMO's head.

The AEC managed to keep a lid on an internal dispute with Machta's unit through the election of 1956, when Adlai Stevenson brought up fallout risk as a justification for a testing moratorium. Testing's politicization allowed Anderson the leeway to finally begin pressing the AEC for answers on all fronts. It did not hurt that it ginned up support for Stevenson in the process. Unconvinced by the conclusions of the WB, Anderson warned that H-bombs were potentially "blowing holes in the atmosphere" and that little was known of "the cosmic influence of the H-bomb on global weather patterns." He even cited unnamed scientists who claimed they were starting to consider whether "a tiny change in the electrical or chemical composition of the atmosphere…might set off a chain reaction of events which produce weather freaks characteristic of the past 10 years."[104]

After the election, catastrophist rhetoric further proliferated. In this changing atmosphere, Machta finally went public with his results at the next congressional hearing in 1957, showing definitively the unequal distribution of fallout and its prevalence in the Northern Hemisphere. It would be the first time an expert inside the government acknowledged serious global-scale environmental risks from testing, and the last time scientists would entertain weather related complaints.[105] Machta repeated his conclusions in his testimony at the UN's Scientific Committee on the Effects of

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[104] "No Weather Changes Seen Due to H-Bombs," *Los Angeles Times*, October 23, 1956, 29; "A.M. Press Release, Oct. 21, 1956," Anderson Papers, Box 151.
[105] "The Nature of Radioactive Fallout And Its Effects on Man, May 27-June 7," (U.S. Government Print Office, Washington: 1957): 1217-18.

Atomic Radiation (UNSCEAR), the first international report on the issue. The combined refutation of the AEC's arguments seemed to reveal a flagrant mendacity in their attempts to downplay fallout's risks. In this regard, the perception of a cover up was more important than the crime.

1957 could then be considered a useful marker of when fallout supplanted climate change as the primary threat from testing in the public eye. Concern over weather diminished further after the testing moratorium of 1958. Fears of atomic weather would reemerge in the renewal of testing in 1961, but this was its swan song, disappearing once and for all with the Limited Test-Ban Treaty of 1963, ending the ability of people to blame extreme weather on nukes. The climate would cool due in part to the rise in the use of CFCs in the 1960s, offsetting the greenhouse effect and thereby masking the long-term trend of global warming. The issue had all along been empirically undecidable—unlike Sr-90, there was no physical unit to monitor—one could not, like the amount of radioactivity in bone, find a smoking gun equivalent in climatological data.

At least not yet—the climatological data studied in the disputes over cloud seeding, atom weather, and fallout monitoring would be of great benefit for meteorology, allowing a global network for monitoring CO2 to eventually develop by the late 1960s.[106] It was Wexler, in fact, who installed David Keeling at Mauna Loa in 1957 during the International Geophysical Year. And ironically, those who had been tasked with analyzing fallout risks and dismissing climatic ones would follow C-14 fallout from the radiobiological effects of testing to that of climatic effects CO2 emissions. By

[106] Though he noted that he "had not been aware of any meteorologist who has advocated nuclear testing in order to benefit his science." Machta, *Meteorological Benefits*, 643.

the end of the 1960s, Machta himself would coauthor an article titled "Large-scale Inadvertent Weather Modification," showing that we had, completely unawares, been altering the globe's atmospheric composition in a potentially catastrophic way, only this time the culprit was CO2.

The other irony was that many of the same scientists who eschewed the ability of atom bombs to rival hurricanes began to talk in the early sixties of using nuclear weapons for large-scale geoengineering. In 1958, just before the moratorium, the secret Operation Argus high altitude tests disrupted the Inner Van Allen belt and created an electromagnetic pulse that caused a blackout in Honolulu, definitively showing that nuclear weapons, can, indeed, have large-scale effects on the atmosphere. After Sputnik the possibility of a "weather war" began to enter discussion more frequently, particularly after an article by a Russian scientist advocating the melting of the polar ice caps through nuclear powered fans caught the attention of the military brass, who now began to seriously worry about a weather control gap.[107] Even Wexler began to speculate about the possibilities of nuclear climate modification.[108]

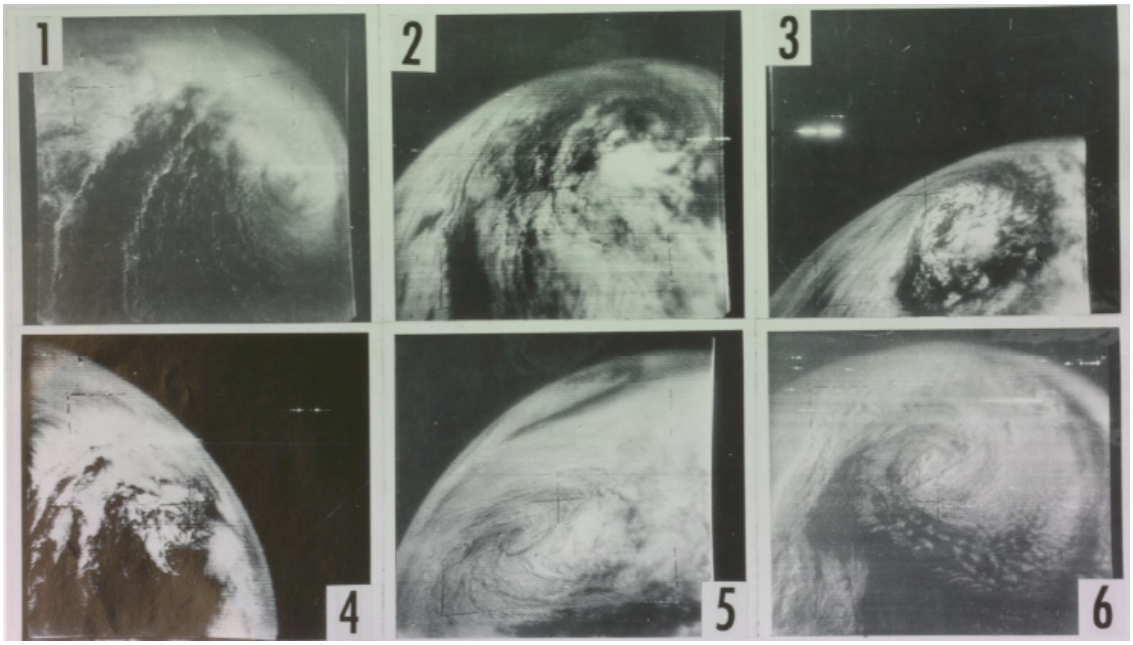
As nuclear climate engineering grew in popularity cloud seeding subsided. The futility of overcoming the statistical uncertainty of its efficacy led to the final 1957 report of the ACWC being only cautiously optimistic about its possibilities, advocating expanded basic research and holding out for the eventual promise of total control in the more far off future, vindicating the WB's argument. With the death of Langmuir in 1957, the strongest opponent to WB control of weather modification research disappeared. In

[107] Howard Orville, "Who Will Win the Weather War?" *American Weekly*, May 25, 1958. Anderson papers, Box 151.
[108] "H-BOMBS VISIONED AS THAWING POLE: But Scientist Warns That Arctic Blast Could Lead to a New Ice Age," *New York Times,* Nov 2, 1958.

1958 congress passed the Water and Cloud Modification Research Act, granting the National Science Foundation a monopoly on weather modification research and activities, with vast powers and resources and an unprecedented amount of funding that would have been, only a year previous, completely out of the question. Sputnik was a "game-changer" that would send an administration that had been slowly trimming the fat of a scientific bureaucratic war machine into crisis mode, allowing the Wexler and Reichelderfer to finally prevail in their power struggle with the military and other executive agencies as well as their corporate and scientific opponents.

Wexler never departed from the grand vision of numerical weather prediction he and von Neumann had first discussed in a meeting at his Falls Church residence in 1946, and it was Wexler who successfully steered the organization through a tumultuous decade full of controversies that threatened the growing prestige of their science and the status of their own authority. The Bureau's success represented the larger victory of the bureaucratization of scientific research, development, and management; a configuration that persists, though not without its controversies, through to the present day.

EPILOGUE: WHAT HATH WE WROUGHT



Pictures of the earth from the Exosphere taken in 1960 by the first meteorological satellite, TIROS 1, the crowning achievement of Wexler's long-term program atmospheric research program. Wexler Papers, Box 32.

It has become almost prerequisite to follow any mention of *Silent Spring* with the declaration that it "launched the environmental movement" (this inscription, in fact, graces the cover of the latest addition, in a font almost as large as the title itself). In the Whigish version of environmental history, Rachel Carson is Jefferson, writing a new Declaration of Independence from the tyranny of military-industrial experts working behind a veil of secrecy. Her great rallying cry, "who has the right to decide for the countless legions of people?" was the culmination of a decade of stumbling toward a new coherent narrative about our relationship to the environment in the nuclear age. Carson advocated for "the people" to take back their sovereignty, relinquished to "the authoritarian temporarily entrusted with power; he has made it during a moment of

inattention by whom millions to whom beauty and the ordered world of nature still have meaning."[109] But as this paper has shown, by the early fifties a vocal and variegated minority began denouncing government experts as unable to be trusted to manage risks, and that environmental decisions should be put in the hands of citizens who would deliberate intelligently due to possessing "objective" information.

The great irony of *Silent Spring* was that we would have known little of the extent of DDT's circulation through the biosphere without our relentless testing of nuclear weapons. Rachel Carson's elegy for birdsongs told the tale of fallout through DDT instead, describing of an invisible long duration catastrophe, infinitesimal and constant in its accumulation, slowly contaminating the planet and mutating it into an uninhabitable nightmare. In her introductory chapter "A Fable for Tomorrow," Carson paints a picture of a bucolic Anywhere, USA, in harmony with nature. But a "grim specter has crept upon us almost unnoticed." Soon this pastoral landscape seems as if hit by an atomic bomb. Biblical language prevails—children struck down from strange sicknesses while playing, dying within hours, vegetation appearing "as if swept by fire" while a white granular powder fell "like snow," a metaphor that evoked the horror of "atom dust". A silence finally comes, a barren earth "deserted by all living things", the terminal point of a chain reaction of disappearances that leaves even that most resilient animal, "man," without succor. The interdependency of the life, first described in the pastoral harmony of the beginning paragraph, is also its undoing—once one thing goes, so too does everything.[110]

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[109] Rachel Carson, *Silent Spring*, First Mariner Books Edition, 1962, 127.
[110] Carson talks of this as a "chain of evil" initiating the infection of only "the world that must support life but in the living tissue is for the most part irreversible".

By combining aesthetic wonderment, doom-laden prophecy, fairy tale illustrations, and scientific expertise, Carson captured the catastrophist narrative in a novel, hybridized lexicon. By joining together several disparate strands of environmentalism into a metanarrative of a long-term planetary catastrophe, she assembled an array of complex concepts from the ecological sciences into a coherent metaphysical, ethical, and empirical frame understood by the lay folk. Carson extended the relationship between the human body and the radioactive isotope to all industrial production, thereby tying the practice of modern life from the global geopolitical to the backyard domestic. Carson is sure to mention the "Indiana boys" playing in their contaminated fields—childhood innocence, the *raison d'etre* of a consumerist, suburban garden state, was now besieged by mutant and alien forces. In the "grim specter" of DDT, Crisis Environmentalism crystallized—Carson the prophet had revealed the etiology of modern life's sickness.

By the time of *Silent Spring,* environmental catastrophism had become a latent model of how we imagined the future, a model reinforced by the very government experts that claimed to ensure their protection as long as they did not ask questions about how. Carson, and earlier Langmuir, unconsciously mirrored the same military-industrial values she critiqued. The faith in scientific assessment, expert management, and the technological intervention to control nature was still a shared trait. Carson believed risks of industrial world could still be contained—she was optimistic that modern life could be still brought into balance with nature, that representative democracy possessed the power to deal with complex technical problems, that sovereignty over life and death need not be relegated to the cabal of a few experts behind a dark curtain. It was the political problem

of who determined worthwhile risks, not the conceptual frame through which they were refracted, where the environmentalists and technocrats diverged. The larger assumption of our role as a planetary actor whose powers could "destroy the earth" was virtually unquestioned by the end of the 1950s.

This paper has hoped to reveal a so far obscure aspect of Cold War nuclear and environmental history and the means by which it contributed to the reconceptualization of our place in nature and our future on the planet as embodied in *Silent Spring*. It has argued that by the time the popular reaction against the military industrial state emerged in the early sixties, our new idea of disaster had already solidified, one in which we perceived our own agency as superseding that of nature. In the shadow of the bomb and the "stark reality" of Carson's "imagined future," we finally inverted Benjamin's Angel of History—no longer did we blindly fly along, face turned toward the past in horror as the wreckage builds and builds; we now hurled forward, ignorant of the past, eyes fixed on catastrophe upon catastrophe piling up ahead.

BIBLIOGRAPHY: THE WEATHER IS USUALLY UNUSUAL

PRIMARY SOURCES

ARCHIVES

Library of Congress, Manuscript Reading Room, Washington, D.C.
Papers of Irving Langmuir, Harry Wexler, Francis Reichelderfer, Sen. Clinton Presba Anderson.

Swarthmore College Peace Archives, Swarthmore, PA.
Papers of National Committee for a Sane Nuclear Policy.

National Academy of Sciences Archives, Washington, D.C.
Records of the National Research Council, Divisions of Anthropology and Psychology, Biology and Agriculture, Earth Sciences.

National Archives and Records Administration, College Park, MD.
Papers of the Atomic Energy Commission and Weather Bureau.

CONGRESSIONAL HEARINGS AND GOVERNMENTAL REPORTS

List, Robert "The Transport of Atomic Debris from Operation Upshot-Knothole," Weather Bureau, Washington D.C. June 25, 1954.

Los Alamos Laboratory, *Effects of Atomic Weapons*, Washington: Combat Forces Press, 1950.

Strauss, Lewis, "The Effects of High-Yield Nuclear Explosions," Atomic Energy Commission, Washington. D.C.: 1955.

"Health and Safety Problems and Weather Effects Associated with Atomic Explosions, Joint Committee on Atomic Energy, 84th Congress, 1st Session," April 15, 1955.

"The Nature of Radioactive Fallout And Its Effects on Man, May 27-June 7, U.S. Government Print Office, Washington: 1957.

"Report No.646 on HR 279, Inquiring into the Effect on the Weather of Certain Atomic-Bomb Explosions, 83rd Congress, First session," June 23, 1953.

SCIENTIFIC ARTICLES

Ball, Vaughn C. "Shaping the Law of Weather Control" The Yale Law Journal, Vol. 58, No. 2 (Jan., 1949), pp. 213-244.

Hall Ferguson et. al. "Dr. Langmuir's Article on Precipitation Control." *Science*, Vol. 113, No. 2929: Feb. 16, 1951 pp. 189-192.

Hene, Derek. "The Legal Aspects of Rainmaking." The Modern Law Review, Vol. 19, No. 3 (May, 1956), pp. 285-288.

Holzman, Benjamin, "The Effects of Atomic Bombs on the Weather," *Weatherwise* Vol.4 I.1: 1951, 50.

Langmuir, Irving, "Control of Precipitation from Cumulus Clouds by Various Seeding Techniques" *Science*, Vol. 112, No. 2898: Jul. 14, 1950, 35-41.

Langmuir, Irving. "The Production of Rain by Chain Reaction in cumulus clouds at temperatures above freezing." *Journal of Meteorology* 5: 1948, 175-192.

Landsberg, H.E. "Trends in Climatology." *Science*, New Series, Vol. 128, No. 3327 (Oct. 3, 1958), pp. 749-75

Machta, Lester, "Effects of Atomic Explosions on Weather." *Science*, New Series, Vol. 121, No. 3134 (Jan. 21, 1955), pp. 75-81

Machta, L. and Telegadas, Kosta, "Inadvertent Large-scale Weather Modification," in Hess, W.N ed., *Weather and Climate Modification*, New York: Wiley, 1974, 687-725.

Machta, Lester, "The Meteorological Benefits from Atmospheric Nuclear Tests," *Health Physics*, Vol. 82(5): 2002.

Machta Lester, et al., "Stratospheric carbon-14, carbon dioxide, and tritium. *Science,* 130 3375: (1959), 542-552.

Machta, L., R. J. List and L. F. Hubert, "World-Wide Travel of Atomic Debris" *Science*, New Series, Vol. 124, No. 3220 (Sep. 14, 1956), pp. 474-477.

Martell, E.A. "Atmospheric Aspects of Strontium-90 Fallout." *Science*, New Series, Vol. 129, No. 3357 (May 1, 1959), pp. 1197-1206

Neiburger, "Weather Modification and Smog," *Science*, New Series, Vol. 126, No. 3275 (Oct. 4, 1957), pp. 637-645

Petterssen, Sverre. "On the Magnitude of Cyclone Development and the Possibility of

Large-Scale Modifications," Proceedings of the National Academy of Sciences of the United States of America, Vol. 41, No. 11 (Nov. 15, 1955), pp. 815-819

Rafter, TA and Fergusson GJ, "The Atom Bomb Effect: Recent increase of carbon-14 content of the atmosphere and biosphere," *Science* 126 (3273): 1957, 557-558.

Wexler, Harry. "Modifying Weather on a Large Scale" Science, New Series, Vol. 128, No. 3331 (Oct. 31, 1958), pp. 1059-106.

Von Neumann, John, "Can We Survive Technology?" *Fortune Magazine*, June, 1955.

Zworkin, Vladimir, "Outline of Weather Proposal" Princeton: RCA Laboratories, October, 1945.

NEWSPAPER ARTICLES

Alexander, Jerome, "A-bomb Effects on Weather: Letters to the Times," New York Times, May 28, 1953, 22.

Folliard, Edward, "H-Bomb Can Wreck N.Y, Strauss Says," *Washington Post* and *Times Herald*, April 1, 1953, A1.

Gallup, George, "29% Blame Weather on A-Blasts, Gallup Says," *Los Angeles Times*, June 19, 1953, 28.

Gallup, George "Many Believe Atomic Tests Caused Tornados This Spring," *Washington Post*, 19, 1953,

Hill, Gladwin, "Atom Test Studies Show Area Is Safe," *New York Times*, May 25, 1953, 21.

Hengst, Alfred, "Letter to the Editor," *Los Angeles Times*, June 18, 1953, A4.

Pearson, Drew, "A-bomb Tornado Tie suspected," *Washington Post,* June 20, 1953, 29.

Sherman, Gene, "Do Atom Blasts Change Weather?" *Los Angeles Times*, March 13, 1955, B5.

Walz, Jay, "Dean Bares Tests: Breaks Silence on Week Long Unofficial Reports of Super-Explosion," *New York Times*, November 17, 1952, 1.

"Atom Blast Urged to Foil Hurricanes," *Los Angeles Times*, Aug 22, 1945, 1.

Associated Press, "Atom Bomb is Declared Out As A Remedy for Hurricanes,"

Washington Post, August 28, 1945, 6.

"Navy's A-Bomb Blast May Change Weather," *Los Angeles Times*, Feb 3, 1946, 6.

"We Usually Have Unusual Weather," *The Science News-Letter*, July 24, 1954, 50.

"A-bombs Blamed for Bad Weather," *Washington Post*, September 19, 1948, R10.

"Probe to Seek A-blasts Link in Southland Cold," *Los Angeles Times*, June 3, 1955, 34.

"No Weather Changes Seen Due to H-Bombs," *Los Angeles Times*, October 23, 1956, 29.

"Bomb and the Weather Effect on World," *Sydney Morning Herald*, February 4, 1946, 1.

"Scientists Resent Army's Idea They Are Not Paid to Think," *Washington Post,* March 22, 1946, 9.

"Langmuir Warns Danger to the U.S," *New York Times*, October 9th, 1945, 9.

"Smoke Screen Over City Proposed to Lift Smog: Nobel Prize-Winning Chemist Suggests an Experiment to Eliminate Sun's Influence," *Los Angeles Times*, Apr 21, 1955, 4.

"Rainmaking Seen as War Weapon," *Los Angeles Times*, Feb 14, 1951, 1.

"Hard to Control Weather," *The Science News-Letter*, Jan. 31, 1948, 78.

"Weather Research Urged," *The Science News-Letter*, Vol. 78, No. 3: Jul. 16, 1960, 39.

"New Mexico's Wet Blanket Irks Michigan: Moody Hits Timing of Man-Made Rain," Chicago Tribune, June 8, 1952, 12.

"U. S. to Probe Rainmaking." *The Science News-Letter*, December 6, 1950, 213.

"WHO RAINED ON KANSAS?" *Los Angeles Times*, July 18, 1951, A5.

"A-bomb Watching a New Outdoor Pastime," *New York Times*, Nov.4, 1951, 166.
"Atomic Tests Did Not Cause Heavy Snows, Nevadans Told," *Washington Post*, March 29, 1952, 3.

"H-bomb," Washington Post, November 15, 1952, 12.

"2 Dummy Families Await Atom Blast," *New York Times*, March 16, 1953, 11.

"Rainfall in March Sets Record High," *New York Times*, March 31,1953, 33.

"1953: The Year of Mildew" New York Times, May 31, 1953, 20.

"Howl Set up by New Mexico over A-tests" Chicago Tribune, May 15, 1953, A13.

"Bombs and Weather: Clouds of an Atomic Explosion are not Thunder Clouds," *New York Times*, May 3, 1953,

"Bomb Tests are Cleared as Cause of Rain in the East" *New York Times*, May 22, 1953, 3.

"The Big Winds," Washington Post, May 14, 1953, 14.

"Congressman Curious: Probe of Atomic Link to Tornados Sought," Los Angeles Times, June 10, 1953, 1.

"Experts Deny Atomic Tests Cause Tornados," *Washington Post*, June 11, 1953, 14.

"Officials Deny Atomic Tests caused tornados" *Los Angeles Times*, June 11, 1953, 11.

"Food Boom Predicted in Rainmaking: Dr. Krick Says 50% Increase Is Possible in Bread and Steak." *Los Angeles Times*, Jan 9, 1951.

"Cloud Seeders Deny They Set Off Tornados," *Chicago Tribune*, June 28, 1953, 29.
"The Weather is Really Changing" New York Times, July 12, 1953, 7-10.

"It Won't Always Get Hotter: Man to Do Something About the Weather," *Los Angeles Times*, July 6, 1953, 1.

"A-blasts Don't Cause Storms, AEC Chief Says," *Chicago Tribune*, September 10 1954, 12.

"H-BOMBS VISIONED AS THAWING POLE: But Scientist Warns That Arctic Blast Could Lead to a New Ice Age," *New York Times,* Nov 2, 1958.

"Rep. Rogers Will Ask Quiz on Tornado Causes," Los Angeles Times, June 12, 1953, 8.

SECONDARY SOURCES

Balogh, Brian *Chain Reaction: Expert Debate and Public Participation in American Commercial Nuclear Power, 1945-1975.* New York: Cambridge University Press, 1991.

Beck, Ulrich, *Risk Society: Towards a New Modernity*, trans. Mark Ritter, London: Sage Publications, 1992.

Beyers, Horace, "History of Weather Modification" in W.N. Hess ed. *Weather and Climate Modification,* New York: Wiley, 1974.

Bocking, Stephen. *Ecologists and Environmental Politics: A History of Contemporary ecology.* New Haven: Yale University Press, 1997.

Boyer, Paul. *By The Bomb's Early Light: American Thought and Culture at the Dawn of the Atomic Age*. New York: Pantheon, 1985.

Carpenter, Daniel, *The Forging of Bureaucratic Autonomy: Reputations, Networks, and Policy Innovation in Executive Agencies*, *1862-1928*, Princeton: Princeton University Press, 2001.

Edwards, Paul. *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming.* Cambridge: MIT Press, 2010.

Edwards, Paul, and Miller, Clark A. eds. *Changing the Atmosphere: Expert Knowledge and Environmental Governance*. Boston, MA: M.I.T., 2001.

Edwards, Paul, "Entangled Histories: Climate Science and Nuclear Weapons Research," Bulletin of Atomic Scientists, 68(4): 2012, 28-40.

Fleming, James Rodger. *Fixing the Sky: The Checkered History of Weather and Climate Control*. New York: Columbia University Press, 2010.

Greene, Benjamin. *Eisenhower, Science Advice and the Nuclear Test-Ban Debate 1945-1963*. Stanford: Stanford University Press, 2007.

Hacker, Barton, *Elements of Controversy: The Atomic Energy Commission and Radiation Safety in Nuclear Weapons Testing,* Berkeley: University of California Press, 1994.

Hamblin, Jacob, *Arming Mother Nature: The Birth of Catastrophic Environmentalism.* New York: Oxford University Press, 2013.

Harper, Kristine. *Weather by the Numbers: The Genesis of Modern Meteorology*. Cambridge, MA: MIT Press, 2008.

Hess, W.N. ed. *Weather and Climate Modification,* New York: Wiley, 1974.

Hines, Neal. *Proving Ground: An account of the radiobiological studies in the Pacific 1946-1961.* Seattle, University of Washington Press, 1962.

Igo, Sarah, *The Averaged American: Surveys, Citizens and the Making of a Mass Public*, Cambridge: Harvard University Press, 2007.

Leslie, Stuart *The Cold War and American Science: the military-industrial complex at M.I.T. and Stanford*. New York: Columbia University Press, 1993.

Masco, Joseph "Bad Weather: On Planetary Crisis," *Social Studies of Science* 40 (2010): 7.

McDougall, Walter. "Technocracy and Statecraft in the Space Age--Toward the History of a Saltation". The American Historical Review, Vol. 87, No. 4 (Oct., 1982), pp. 1010-1040.

McDougall, Walter. *The Heavens and the Earth*, New York: Basic Books, 1985.

McNeill, J.R. et. al eds. *Environmental Histories of the Cold War*, Washington, D.C.: Cambridge University Press, 2010.

Miller, Richard, *Under the Cloud: The Decades of Nuclear Testing*, New York: Free Press, 1986.

Musil, Robert K. "There Must Be More to Love Than Death: A Conversation With Kurt Vonnegut," (*The Nation* 231(4): 1980).

Petterssen, Sverre. *Weathering the Storm: Sverre Petterssen, the D-Day Forecast, and the Rise of Modern Meteorology*. Ed. James Rodger Fleming. Boston: American Meteorological Society, 2001.

Pyne, Stephen Jay *Fire in America: A Cultural history of Wildland and Rural Fire,* Princeton: Princeton University Press, 1982.

Rosenfeld, Alfred, *The Quintessence of Irving Langmuir*, New York: Pergamon Press, 1966.

Russell, Edmund. *War and Nature: Fighting Humans and Insects with Chemical from World War I to Silent Spring*. New York: Cambridge University Press, 2001.

Steinberg, Ted. *Acts of God: The Unnatural History of Natural Disaster in America*. New York: Oxford, 2000.

Walker, J. Samuel. *Permissible Dose: A History of Radiation Protection in the Twentieth Century*. Berkeley: University of California Press, 2000.

Weart, Spencer R. *The Discovery of Global Warming*. Cambridge: Harvard University Press, 2003.

Weart, Spencer and Elliott, William, "Interview with Dr. Lester Machta." Neil Bohr Library Archives, Center for the History of Physics (Silver Spring, Maryland, April 25, 1991) last accessed August 23rd, 2013. http://www.aip.org/history/ohilist/31417.html.

Weart, Spencer R. *The Rise of the Nuclear Fear.* Cambridge, Mass: Harvard University Press, 2012.