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Jacob Darwin Hamblin

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Introduction by Jacob Darwin Hamblin, Oregon State University

In 1968, the *Whole Earth Catalog* proclaimed “We are as gods and might as well get good at it.” Amidst the environmental crisis of the 1960s, the publication’s founder Stewart Brand wanted to provide access to tools, and he was remarkably friendly to technological solutions. His kind of environmentalism drew from human ingenuity and achievement, and unlike many of the commentators of that era, he was optimistic about a future in human hands. In more recent years, Brand and others have argued forcefully in favor of “geoengineering.” If the planet is changing for the worst, they maintain, let’s use our know-how to make it better.¹

If climate change mitigation through political agreement has no hope of succeeding, does tinkering with the climate make sense? In May 2011, the National Research Council (of the U.S.’s National Academies) published the final part of its report, *America’s Climate Choices*. The report called for more research on ways to manage not only greenhouse gases but also the solar radiation reaching the earth. And yet despite the call for research, the report unequivocally described any near-term attempts to manipulate the earth as “imprudent,” and any long-term planning based upon them as “unwise.”²

After reading James Rodger Fleming’s *Fixing the Sky*, it is clear that such ideas have tempted scientists and natural philosophers for centuries and more. In his telling, some of these folks come across as charlatans, others as well-meaning dreamers, and very few as wise. Fleming is best known for his work in the history of meteorology, including *Historical Perspectives on Climate Change* (Oxford, 2005) and *Meteorology in America, 1800-1870* (Johns Hopkins, 2000). He also is the biographer of Guy Stewart Callendar, one of the key figures in the history of the science of global warming.³ Fleming’s skepticism toward weather and climate control is evident throughout *Fixing the Sky*, and it is hard to come away from it with anything but a jaded view of the modern era’s penchant for problem-solving on a gargantuan scale.

I asked Ted Steinberg to comment upon *Fixing the Sky* because of his close familiarity with many of the weather engineers in Fleming’s book, particularly the cloud seeders. But also, Steinberg already has raised tough questions about the line between natural and human-induced change. In *Acts of God*, Steinberg pointed out the numerous ways in which natural disasters are linked to human activities, and he showed that people still cling to the belief that most calamities are accidental. Such a view places disasters “outside the moral compass of our culture,” he writes, constraining our sense of responsibility.⁴

¹ Andrew G. Kirk, *Counterculture Green: The Whole Earth Catalog and American Environmentalism* (Lawrence: University Press of Kansas, 2011); Stewart Brand, *Whole Earth Discipline: Why Dense Cities, Nuclear Power, Transgenic Crops, Restored Wildlands, and Geoengineering are Necessary* (New York: Penguin, 2010).

² National Research Council, *America’s Climate Choices* (Washington, DC: National Academies Press, 2011), 53.

³ James Rodger Fleming, *The Callendar Effect: The Life and Work of Guy Stewart Callendar (1898-1964)* (American Meteorological Society, 2009).

⁴ Ted Steinberg, *Acts of God: the Unnatural History of Natural Disaster* (New York: Oxford, 2000), xix.

R. S. Deese shares with Fleming the notion that controversies about expertise and the environment often turn on the notion of hubris. On the one hand, scientists have faith in their ability to manage the world. On the other hand rests a deep and abiding skepticism—and a suspicion that scientists are changing the world in harmful ways. Deese has explored this tension through two brothers, both quite famous within their own domains: Julian Huxley, the first director-general of the United Nations Educational, Scientific and Cultural Organization; and Aldous Huxley, renowned for his critique of a society driven by scientific expertise in *Brave New World*.⁵

Matthew Farish's recent book, *The Contours of America's Cold War*, takes the notion of control to its extreme, showing the extent of the militarization of academic disciplines in the United States after World War II.⁶ In Farish's telling, the ever-increasing spatial knowledge of the globe served the interests of the state, leading to a transformation of the social sciences. Reading Farish alongside Fleming, it is easy to see why geographers and weather "fixers" alike rarely lacked military funding.

Paul Edwards has written extensively about notions of control in the era after World War II. In *The Closed World*, he traced the discourse of command and control from the electronic battlefield of Vietnam to the visions of a vengeful Skynet in the *Terminator* films. More recently, he has extended this work into the realm of climate modeling, to show how the science of global warming has evolved based on an extraordinarily broad range of data only comprehensible through computer analyses.⁷

I offer my thanks to James Rodger Fleming and all the commentators, who have provided their thoughts with an eye toward increasing scholarly dialogue. As an open-access forum, *H-Environment Roundtable Reviews* is available to scholars and non-scholars alike, free of charge. This particular subject is unlikely to dissipate anytime soon. We will revisit ways to "fix" the sky again and again, as the climate evolves under our influence.

⁵ R. S. Deese, "The New Ecology of Power: Julian and Aldous Huxley in the Cold War Era," in J. R. McNeill and Corinna Unger, eds., *Environmental Histories of the Cold War* (Cambridge, 2010), 279-300.

⁶ Matthew Farish, *The Contours of America's Cold War* (Minneapolis: University of Minnesota Press, 2010).

⁷ Paul N. Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge: MIT Press, 1997); Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (Cambridge: MIT Press, 2010).

Comments by Ted Steinberg, Case Western Reserve University

If you can remember Microsoft Bob or Windows ME, then you probably will not be surprised to learn that Bill Gates and his co-inventors in Intellectual Ventures based in Bellevue, Washington, have yet another dubious product up their sleeves. The idea, which made news in 2009, is to control the path of hurricanes with gigantic tubs of seawater. A couple hundred of these tubs, they reason, could be placed in front of the hurricane and used to collect warm water, which would then be sent below the surface while colder water from the bottom of the ocean is pumped up. The idea would be financed with insurance premiums paid, presumably, by people living along the coast who would have the most to gain from the killer-hurricane technology. A columnist for the trade magazine *Risk & Insurance* was skeptical to say the least, pointing out that Gates certainly has a lot of firsthand experience with disasters and concluding: “I’ve been through three major hurricanes and four Microsoft blue screens of death; I much preferred the hurricanes.”⁸

As it turns out, according to James Rodger Fleming in his new book, *Fixing the Sky*, the mad scientists in Bellevue are simply a more recent expression of what has been a longstanding quest to control the uncontrollable. Ancient Greece, for example, had its “hail wardens” (78) charged with scanning the skies in advance of inclement weather so that farmers could learn of the danger and make the arrangements for the necessary blood sacrifices needed to ward off the threat to their crops. The Norsemen of Scandinavia made loud noises to scare off the storm demons. In Persia, during the fifth century B.C.E., people buried swords in the ground to fend off foul weather. Eighth century Frenchmen deployed long poles to stave off the destruction. Americans had their rainmakers, men like Charles Mallory Hatfield, who worked to wring rain from the clouds over southern California early in the twentieth century and who styled himself a “moisture accelerator” by trade. After the Second World War, General Electric scientists claimed they had forced a cloud to yield snow. During the Vietnam War, the U.S. military secretly seeded the skies over the Ho Chi Minh Trail in an attempt to bog down the North Vietnamese supply lines. Nor was weather modification just some capitalist proclivity. The Soviets sought to conquer nature and carve a second Nile River in Africa; their goal was to make the desert bloom in an effort to set the stage for national liberation and free the people from their colonial conquerors. Meanwhile, a Soviet visionary named Petr Mikhailovich Borisov concocted a Bering Strait project that involved the use of a dam to melt the ice and thereby improve navigation prospects. “What mankind needs,” said Borisov, “is war against cold, rather than a ‘cold war’” (*Fixing the Sky*, 202). Most recently, the Chinese lavished money on rainmaking and rain suppression in advance of the opening ceremony at the 2008 Olympics. According to Fleming, weather control is now occurring on five continents; a quarter of all the nations in the world today have set off to dominate the sky.

If only such schemes worked. Even the boosterish National Academy of Sciences, in a 2003 report, was forced to admit that there as yet exists no “convincing scientific proof of

⁸ Roger Crombie, “The Gates of hurricane hell,” *Risk & Insurance*, September 1, 2009, 13.

the efficacy of international weather modification efforts.” (*Fixing the Sky*, 107) If science is not on the side of the weather modifiers it seems safe to assume that what we have here is a gigantic collective delusion about the control of nature that spans countless centuries and five continents. Fleming, for his part, puts the issue somewhat more mildly, arguing that the long record of such attempts at controlling weather and climate amount to what he calls repeatedly in the book a “checkered history.” (*Fixing the Sky*, xii, 3, 227, 266, 267)

The stories that unfold in this book, easily the most comprehensive history of the subject, amount to one very long cautionary tale. If nothing else the weather modifiers, whatever their faults, have been persistent. But the book is less satisfying in that it never ultimately explains the reason for such persistence. Part of the problem is that the book is organized thematically. The result is that no clear periodization is offered. Consider the postwar period. It was then that General Electric trumpeted its success in making snow, a story Fleming treats in chapter five of his book. Two chapters later, readers learn that, at the same time that GE was experimenting with the clouds, the English biologist Julian Huxley, UNESCO’s first director, spoke publicly about using nuclear weapons to shrink the polar ice cap. Meanwhile, RCA’s president David Sarnoff fantasized about placing an order for “rain or sunshine by pressing radio buttons.” (*Fixing the Sky*, 194) A year later, in 1947, General George C. Kenney, the commander of the Strategic Air Command, pointed out that “the nation which first learns to plot the paths of air masses accurately and learns to control the time and place of precipitation will dominate the globe.” (*Fixing the Sky*, 195-6) That was also the year that the U.S. military teamed up in Project Cirrus to use dry ice to seed Hurricane King, seemingly shifting its course and causing the storm to make landfill in Georgia and South Carolina, a development that was later attributed to steering currents not cloud seeding. Perhaps because Fleming treats these developments in separate chapters, he never fully explains exactly what was driving both the military and corporate America to fixate their attention on the sky. At least some discussion of what President Dwight D. Eisenhower dubbed a “military-industrial complex” seems called for to put these developments in context. But readers will be disappointed to find that Fleming offers no tight chronology to help explain what, in particular, say, about the postwar period caused the weather modifiers to become so preoccupied with the control of nature. Nor does he spend time looking at those who opposed weather modification. The result is that the phenomenon of weather control is sometimes made to seem almost timeless and inevitable when we know that there is nothing the least bit natural about it.

Comments by R. S. Deese, Northeastern University

In this attempt to trace the history of the human dream of weather and climate control from ancient times into the anthropocene, James Rodger Fleming has produced a perceptive and timely book that is a pleasure to read. His rhetorical goal here is to counter contemporary calls for geoengineering as a solution to global warming on several fronts. By recounting ancient myths about the weather, such as the story of Helios and Phaethon, he reminds us of the venerable advice implicit in those tales: avoid hubris, and, as Fleming repeats at the beginning and end of his book, stick to the middle path. By regaling us with colorful tales of the various charlatans and cranks who have peddled weather control schemes to farmers, businesses, and governments over the past few centuries, Fleming hopes to warn his readers that the same fatal combination of wishful thinking and outright deceit still haunts our discourse on geoengineering today, with an even greater potential for disastrous consequences. Finally, by highlighting the role of governments and large corporations in weather control schemes during the cold war decades, Fleming brings us into territory that is uncomfortably familiar with his detailed accounts of public deceit, reckless endangerment, and secret attempts by both eastern and western bloc governments to “weaponize” the weather itself. Although the specific conflict between the United States and the Soviet Union that drove these efforts is now a thing of the past, all of the larger dynamics that Fleming portrays in his chapters on the cold war are still very much with us: geopolitical competition to gain strategic advantage across the globe, government secrecy in the name of national security with all of its attendant temptations and vices, and the role of public relations and sometimes outright deceit on the part of those large corporations, such as General Electric, that worked in tandem with defense establishment to experiment with weather control.

In his chapters on the cold war, Fleming does far more than merely remind us that the dream of weather and climate control has a checkered history; he also reminds us of the more timely point that the same sort of historical actors who attempted to alter the weather in the cold war decades, namely government bureaucracies and (in capitalist societies) their favored contractors, would likely be at the helm of any future attempts at geoengineering. When we consider how often government and corporate attempts at weather control exhibited a fatal combination of arrogance, myopia, and outright deceit in the twentieth century, it seems a likely hazard that government and private enterprise would bring some of the same liabilities to the table in any future attempts at geoengineering. To put it another way, the “climate beast” is not the only wild card in this scenario. Human beings, with all of their unpredictable and often unsavory traits, bring enough uncertainty to the table to belie the claims of anyone who promises to stabilize the earth’s climate through the untested art of geoengineering.

Although Fleming’s subtitle highlights the checkered history of weather and climate control, this book has much more to offer than a rogue’s gallery of bad or misguided historical actors. The myriad of narratives in *Fixing the Sky* also includes some stunning examples scientific perspicacity and personal courage. Often these examples are more enlightening than the broader narrative of bad behavior which they punctuate. The first such figure in Fleming’s book who stands out for his honesty and courage is Richard

“Heatwave” Berler, a television weatherman in Laredo, Texas. When county officials in Laredo were prepared to spend 1.2 million dollars on public money on a rainmaking scheme proposed by a company called Earthwise Technologies, Berler used his nightly broadcasts to gently point out the lack of any peer reviewed scientific evidence that the “ionizing towers” that Earthwise was about to sell the Webb County would generate rain. The public outcry generated by Berler’s queries eventually compelled the county to admit that they had not consulted a single independent scientist about the project and ultimately to drop the contract. Fleming concludes, “Humble Heatwave Berler had stood up to and defeated the rainmakers, saving the county and region millions of dollars and further embarrassment.” (*Fixing the Sky*, 106) A happy ending indeed, though it is sobering to reflect that this tale of public officials willing to burn millions of taxpayer dollars at the altar of commercial pseudoscience did not take place sometime in the distant past, but in the winter of 2003.

Another remarkable figure to distinguish himself from the long list of cranks and carnival barkers in Fleming’s book is Harry Wexler, a meteorologist for the U.S. Weather Bureau who conducted groundbreaking and very daring hurricane research, and who pioneered the use satellites for monitoring weather and climate patterns. Wexler’s work in weather research was cut short by a fatal heart attack in 1962, just as he was uncovering aspects of our influence on the atmosphere and climate that would prove to be monumental in the coming decades. Through a close reading of his journals and letters, Fleming provides very strong evidence that Harry Wexler was the first to discern the destructive effect that human activity, such the dispersal of chlorine and bromine by rocket launches, could have on the ozone layer. Fleming also shows that Wexler was at least a generation ahead of his colleagues in understanding the dangers inherent in human attempts to deliberately alter the climate. In closing his profile of this groundbreaking meteorologist, Fleming declares, “Remember, it was not Paul Crutzen in 2006 but Harry Wexler about fifty years before who first claimed that climate control was now ‘respectable to talk about’ even if he considered it quite dangerous and undesirable.” (*Fixing the Sky*, 223)

As he approaches the end of his study, Fleming documents the insights of another exceptional scientist, Gavin Schmidt, a climate modeler at the NASA Goddard Institute for Space Studies. Schmidt’s clever and evocative reworking of the spaceship earth metaphor for the era of anthropogenic climate change offers perhaps the most succinct and memorable critique of geoengineering in *Fixing the Sky*:

Think of climate as a small boat on a rather choppy ocean. Under normal circumstances the boat will rock to and fro and there is a finite risk that the boat could be overturned by a rogue wave. But now one of the passengers has decided to stand up and is deliberately rocking the boat ever more violently. Someone suggests that this is likely to increase the chances of the boat capsizing. Another passenger then proposes that with his knowledge of chaotic dynamics he can counterbalance the first passenger, and, indeed, counter the natural rocking caused by the waves. But to do so he needs a huge array of sensors and enormous computational resources to be ready to react efficiently but still wouldn’t be able to guarantee absolute

stability, and indeed, since the system is untested, it might make things worse. So is the answer to a known and increasing human influence on climate an ever more elaborate system to control the climate? Or should the person rocking the boat just sit down? (*Fixing the Sky*, 234-235)

By highlighting the human element in the climate equation, Schmidt's metaphor strongly suggests that geoengineering is neither the simplest nor the best answer to the challenges posed by anthropogenic climate change. Although it may sometimes seem impossible to get industrial and rapidly industrializing nations of the world to stop "rocking the boat" by curtailing their greenhouse gas emissions, the proposed alternative of geoengineering based on real time calculations of such enormous scale and consequence is prohibitively risky. Climate systems are notoriously volatile and hard to control, and so, as Fleming's study reminds us, are human beings. The variables that they bring to the table are perhaps the most fatal to the goal of stability promised by geoengineering schemes.

Late in his life, the American diplomat George F. Kennan warned future generations against fooling around with two aspects of nature: the human genome and the weather. The veteran diplomat observed that we derive enough frustration from our genetic inheritance and from the weather, and that those frustrations would be considerably worse if we could blame others for them instead of accepting their blessings and curses as part of the natural order of things. By the end of the cold war Kennan was no doubt used to seeing his cautious advice ignored, so he would probably not be surprised today to see the growing chorus of calls for geoengineering, this time in the name of combating anthropogenic climate change. He might be pleased however, that the specific objection he raised—that human modification of the weather would spawn resentment and inevitable conflict—forms perhaps the strongest argument against geoengineering presented in James Rodger Fleming's wide ranging history of this dubious art.

The one question that remains for me after reading *Fixing the Sky* is this: What do other cultural traditions have to say about changing the weather or fundamentally altering the natural world? For example, given the fact that China will soon surpass the US as the world's largest economy, longstanding Chinese cultural traditions about when and how we should effect great changes in our environment are likely to become increasingly relevant. In her study *Mao's War Against Nature* Judith Shapiro explores some of these themes, such as the traditional tale of "the Foolish Old Man Who Removed Mountains" as a backdrop for the great dam-building projects of the twentieth century.⁹ Of course, the question of Chinese views about civilization and nature is only the beginning. In light of the global implications of "geo-engineering," a survey of non-western ideas and traditions about weather and weather control could add breadth and depth to this study.

⁹ Judith Shapiro, *Mao's War Against Nature: Politics and the Environment in Revolutionary China* (New York: Cambridge University Press, 2001).

Comments by Matthew Farish, University of Toronto

In the 1959 Disney film *Eyes in Outer Space*, a host of satellites circles the Earth, providing “vital information” on “one of nature’s great forces: the weather.”¹⁰ In the film’s initial moments, a montage of flood and storm scenes reinforces the narrator’s claim that “with awesome violence and destruction, the weather is one of man’s oldest and mightiest adversaries.” After an animated climatology tutorial and a discussion of terrestrial weather-data collection, the film shifts to the cutting-edge satellites that “reach into the unknown with instruments that duplicate man’s own senses.” But in addition to better forecasting, future satellites, according to the film, will also be used to control the weather. At a hypothetical “world-wide weather center,” staffed by white American uniformed men, the globe is represented and contained on large screens and inside computers. Tracking a substantial hurricane gathering force east of Miami, these “controllers” gather information and debate strategy. They then touch buttons and initiate a “battle,” seeding two nearby storms with chemicals from above and below, and firing “vapor rockets” in front of the hurricane’s path. After additional seeding and “hours of tension” – the controllers sweat, look anxious and are harshly illuminated by the lights of their electronic equipment – “the control strategy is successful.” A high-pressure ridge has moved eastward to cover the coast, “forming an invisible wall of safety,” and the hurricane is “defeated.” The future is one of national security ensured by weather control. *Eyes in Outer Space* concludes by noting that similar technology will be used to transform useless desert and polar “wastelands” into fertile, productive Edens.

Written and directed by the legendary Disney animator Ward Kimball, and dependent on the assistance of the Pentagon, *Eyes in Outer Space* was a theatrical “science-factual” production now associated with the Tomorrowland television series. The film does not merit mention in *Fixing the Sky*, although James Rodger Fleming’s critical history of hubris is full of comparable scenes, including RCA President David Sarnoff’s startling 1946 proposal that ocean currents be diverted to turn “deserts into gardens” (194), and another, more famous Disney creation, Donald Duck, playing a “Master Rain Maker” in a 1953 cartoon (44).

Fleming’s credentials in the history of meteorology are second to none, and he very capably explicates and challenges all manner of attempts to alter and manage local, regional, and ultimately global climates. But his inclusion of Mr. Duck also reflects a clear and laudable interest in the thick traffic between frequently complex or secretive science, on the one hand, and the popular fascination with weather and the common hope that it might be fixed to benefit human societies, on the other. As a historical and cultural geographer with regrettably minimal training in the ‘physical’ side of my discipline, I will focus my comments here on this second element of Fleming’s account.¹¹ And it is

¹⁰I thank Jake Hamblin for inviting me to participate in this Roundtable, James Rodger Fleming for the opportunity to critically engage with his scholarship, and Joseph Masco for alerting me to *Eyes in Outer Space*.

¹¹ For this reason I will not linger over Fleming’s treatment of recent geoengineering schemes in the last chapter of his book, although I was struck by how quickly and consistently he dispatched virtually all of them, (over)using dismissive phrases like “back-of-the-envelope calculations” (starting, in fact, on p. xii).

there, I will suggest, that his important and often captivating book is also occasionally frustrating.

While his narrative gathers momentum in the nineteenth century, Fleming begins with the proposition that humans have always contemplated and desired control of the weather. This leads him into a sprawling tour through Greek mythology, Milton and Dante, indigenous rain-makers, and a variety of prominent and obscure science fictional texts, concluding appropriately with Kurt Vonnegut's *Cat's Cradle* (1963). As Fleming notes, these stories "make many of the moral points often left unsaid by scientists and engineers" (47). Earlier, he argues that science fiction "provides a moral core and compass" within the history of the geosciences (25). This reasonable argument also generalizes the expansive and often unsavory moral realm of science fiction; scientists, meanwhile, are made out to be amoral (or immoral) creatures.

The pace of these first pages is rather dizzying, and Fleming favors descriptive sketches over considered analysis. This habit persists in some of the subsequent chapters, where examples of climate-control proposals are crowded into a narrative sequence, and where it is not always clear why they have been chosen over other others, or how *likely* or *feasible* they have become as a result of certain social and political conjunctures. Such evaluations are admittedly a challenge with any historical work that attends extensively to speculation. What are we to do, precisely, with a Cold War scheme to construct a dam across the Bering Strait – a structure that "was, *of course*, never built" (202, my emphasis) – alongside all of the massive and even improbable high modernist engineering projects that were actually undertaken by the United States and the Soviet Union? My point here is that especially in the first and last chapters, Fleming seems more interested in the content of certain tales and proposals rather than the work that they, and others of their ilk, have done (or have not done) in different times and places. Finding a shared desire to fix the sky across time and space, he diminishes the historical-geographical contexts of the vivid scenarios that populate his text.¹²

This vagueness is not consistently present. The middle of the book contains some superb writing on scientists and fraudsters alike (the material in Chapters 5 and 6 on Irving Langmuir's ironically "pathological" work for General Electric and the military, and the discussion of Harry Wexler in Chapter 7, are high points). But it does return as readers approach the present in this roughly chronological text. Fleming's crucial initial genealogical question – "*How* did we arrive at this situation?" (3, my emphasis) – earns only a narrow response. Thus, in his search for dramatic examples of the "technological fix" (Alvin Weinberg's famous phrase, usefully employed), Fleming inevitably downplays the role played by long-term, "*practical...form[s]* of climate control" such as "clothing and shelter" (8, my emphasis). Air conditioning, introduced a little awkwardly in Chapter 4, is a noteworthy exception.

¹² Despite its position in a series on International and Global History, and the obvious international and global implications of sky-fixing, this is in many respects a very American book – which is fine, except that this specificity matters and is never fully acknowledged.

Given the scope of the first chapter, then, I was disappointed that Fleming did not attempt to immediately situate his numerous “stories of control” alongside a broader meditation on relationships between culture and climate – in the manner of Denis Cosgrove’s similarly sweeping *Apollo’s Eye*, for instance.¹³ This might have led Fleming to explore the ways in which climate has played a powerful role in the modern imagination of a pure, external Nature which can be *both* dominated and re-enchanted, as is certainly the case today.¹⁴ Instead, he begins with myth and fiction to balance the literature in science studies, which he argues is stuck in “narrow ruts” (48) that favor the “heroic and the tragic genres” over the “comic and tragicomic” (15). An intriguing claim, to be sure, but it is not exactly confirmed; few references to the vast literature in science studies are forthcoming, and it is not clear how *Fixing the Sky* is situated within an existing body of comparable scholarship.¹⁵ The brief nod to the Takers and Leavers of Daniel Quinn’s hugely popular *Ishmael* (1992) cries out for the addition of more subtle works of environmental history and philosophy. And Fleming’s gentle disciplinary corrective is dwarfed by the legitimate significance of his inquiry. One result is that the transformation of a terrestrial ‘nature’ is made to seem feasible and perhaps even acceptable, whereas “control of the heavens remains far beyond the ability of mortals” (3).

Fleming begins to hit his stride later in Chapter 2, when he settles happily into a discussion of nineteenth-century rainmakers. The chapter concludes by lining up these “scientific rain kings” alongside today’s “altruistic monomaniacs,” who are simply scheming on a much greater scale (74-75). A similar move is made in Chapter 3: a colorful parade of nineteenth- and twentieth-century hucksters invoking marvelous forces like “bolecular energy” (97) ends with the Chinese attempts to alter weather during the 2008 Summer Olympics – efforts with “no verifiable results” (107). These comparisons are certainly meaningful, but I wonder whether the persistent turns toward the present actually limit Fleming’s analytical reach. The historical consistencies in these chapters seem to be some combination of techno-determinism and moral righteousness. What would it look like, then, to shift the approach to a fully cultural history of rainmaking, or for that matter one which stresses political-economic factors?¹⁶

Fleming gets closest to answering this question in Chapter 6, where he has much to say on the role of the U.S. military as a sponsor of meteorological experiments (and where the source for the book’s perfect cover image is discussed). Summarizing his arguments, he claims that in seeking “commercial, state, or military patronage,” geoscientists “contribute to the commodification, nationalization, and militarization of the natural world” (168). So they do. But the myriad histories and geographies of these overlapping but equally distinct phenomena, which would get us some distance to understanding *how* exactly these ‘contributions’ unfold, remain obscured. Instead, Fleming moves quickly to

¹³ Denis Cosgrove, *Apollo’s Eye: A Cartographic Genealogy of the Earth in the Western Imagination* (Baltimore: Johns Hopkins University Press, 2001).

¹⁴ Mike Hulme’s provocative writing on climate is useful here. See, for instance, “Learning to Live with Recreated Climates,” *Nature and Culture* 5.2 (2010), 117-22.

¹⁵ I was particularly struck by the lack of references to the essential work of Paul Edwards, collected most recently in *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (Cambridge: The MIT Press, 2010). Fleming ‘blurb’d this book.

¹⁶ Fleming’s approach means that the brief turn to gender analysis on page 257 only stands out as peculiar.

lay out examples such as the infamous Operation Motorpool, the Vietnam War cloud-seeding efforts that became “the Watergate of weather warfare” (182). Thus, when he suggests that “The present war on global warming must be viewed as the outgrowth of a long historical process in which military metaphors are much more than metaphors” (186), he has vivid set-pieces to draw from. But I am unconvinced that these amount, in his telling, to a “process,” not least because a phrase like the “war on global warming” is both too hazy and too emphatic (even as the military’s involvement in climate research is undoubtedly pertinent and unsettling). And this brings me to a conclusion – one written with the knowledge that Fleming will be able to respond.

Having read a ‘preview’ of *Fixing the Sky* several years ago,¹⁷ I was pleased to discover the full book noted in a 2010 *New York Times* article summarizing some recent writing, much of it critical, on the merits and prospects of geoengineering.¹⁸ I’m guessing that Dr. Fleming did not mind the inclusion; indeed, his book has received an impressive and deserved amount of media coverage. This is testament to Fleming’s expertise, his engaging prose style, the colorful stories that populate his text, the significance of the content, and not least his determined and admirable effort to connect the history of science to public policy debates.

In tandem with *Fixing the Sky*’s completion, Dr. Fleming appeared before the Committee on Science and Technology of the U.S. House of Representatives, where, by way of a historical introduction to geoengineering, his audience was treated to several of the book’s highlights.¹⁹ Fleming’s remarks were clearly set within a context of acknowledged climate change. But the same House Committee is now chaired by Texas Republican Ralph Hall, an “unconditional champion of fossil fuels” who seems keen to launch a congestive investigation of “uncertainties” in the work of climate scientists.²⁰ With “climate zombies” like Hall in charge (and skeptical meteorologists on the television), what is the current and future significance of the dramatic attempts to fix the sky that Fleming so ably challenges?²¹ Will they receive additional attention and credibility, or become the province of increasingly desperate individuals, no longer “stalking the hallways of power” (1)?

Given the enduring allure of the technical fix—including, it must be stressed, to corporations and philanthropists, and not just academics and governments—I suspect that geoengineering is here to stay, which makes Fleming’s learned commentary

¹⁷ James Rodger Fleming, “Fixing the Weather and Climate: Military and Civilian Schemes for Cloud Seeding and Climate Engineering,” in Lisa Rosner, ed., *The Technological Fix: How People Use Technology to Create and Solve Problems* (New York: Routledge, 2004), 175-200.

¹⁸ Cornelia Dean, “When the Day After Tomorrow Has Come,” *The New York Times* 29 June 2010, D2.

¹⁹ Fleming’s comments are archived at

http://democrats.science.house.gov/Media/file/Commdocs/hearings/2009/Full/5nov/Fleming_Testimony.pdf (accessed 5 March 2011).

²⁰ See “Ralph Hall gearing up for new role as chairman of House Science and Technology Committee,” *Dallas Morning News* 13 December 2010, www.dallasnews.com. The inquiry will likely be led by Wisconsin Congressman Jim Sensenbrenner, a notorious climate-change denier.

²¹ On zombies, see <http://wonkroom.thinkprogress.org/climate-zombie-caucus/> (accessed 14 March 2011). On television meteorologists, see Leslie Kaufman, “Among Weathercasters, Doubt on Warming,” *The New York Times* 30 March 2010, A1.

indispensable. But the dire state of climate and energy policy in countries like Canada and the United States suggests that we must concurrently note the ways in which our mundane, collective “weathermaking” produces ever more dramatic consequences for planetary life.²² To sharply separate our daily activities from geoengineering because the latter is *deliberate* or even *unnatural* is, in my opinion, a major mistake—and one, I should stress, that I don’t think Fleming makes, but as I note above, there are moments when his prose flirts with the distinction.

On the book’s final page, Fleming eloquently expresses the “hope that fears and anxieties that freeze us into inaction or that tempt us to do too much might be overcome and that a middle course of climate mitigation and adaptation might emerge – amenable to all, reasonable, practical, equitable, and effective” (268). It is hard to disagree with these sensible words. Even so, I’m afraid that they left me uneasy, and full of questions. Why has “inaction” (see, among others, Ralph Hall) been equated with doing “too much” (see, among others, thoughtful scientists, genuinely concerned about climate change, who may be overly fond of technical fixes)? To what degree must ‘we’ adapt and mitigate, and just as importantly, *where* should this be done? On a deeply inequitable and endlessly divided globe, is it in any way useful to invoke the abstract universal of “all”? Finally, at what juncture should activists downgrade or even abandon their efforts within conventional policy arenas and intensify other forms of political action (a tactic that is already being adopted by a number of climate justice organizations)?²³ These queries are not at the center of Fleming’s valuable book, but his ringing critique of sky-fixing leads us directly to them.

²² The obvious reference is Tim Flannery, *The Weathermakers: How We are Changing the Climate and What it Means for Life on Earth* (Toronto: HarperCollins, 2006).

²³ See, for instance, Bill McKibben, “3 Steps Toward a Politics of Global Warming,” www.yesmagazine.org/planet/3-steps-toward-a-politics-of-global-warming (accessed 15 March 2011).

Comments by Paul N. Edwards, University of Michigan

Jim Fleming has been going to a lot of scary meetings where pumped-up technophiles announce “feasible” plans to save the world from global warming.

If these men (and they are virtually all men) were not insanely serious, they might be considered seriously insane. Their schemes include:

- Placing a Mylar mirror the size of India into near-Earth “semi-stable” orbit (244)
- Crowding the upper atmosphere with billions of highly reflective hydrogen balloons (245)
- Erecting vast forests of “Lackner towers,” artificial trees covered with CO₂-absorbing leaves (250)
- Firing sulfates into the stratosphere, using rockets or giant cannons, to create swaths of “designer volcanic dust”: particulates that would reflect the sun’s heat back into space (247)
- Seeding the ocean with iron filings to induce colossal plankton blooms that would suck down carbon from the atmosphere (249)
- Many other plans — all of them equally ambitious, untested, and vibrating with unknown and largely unknowable risks.

These ideas travel under such *noms de guerre* as the respectable-sounding “geoengineering” and the rather more frightening, if perhaps more appropriate “ecohacking.” They may sound like the cocaine-fueled fantasies of Hollywood sci-fi screenwriters, but in fact they represent the best thinking of some of the world’s best minds, presented at meetings of such elite scientific organizations as the U.S. National Academy of Sciences and the British Royal Society.

Fleming’s terrific book *Fixing the Sky: The Checkered History of Weather and Climate Control* makes it all too clear that such schemes belong to a perennial, and very old, tradition. The first chapter opens with the ancient Greek myth of Phaethon, son of Helios, the Sun god. Permitted to take control of his father’s chariot for a day, Phaethon learned too late that his skills were not up to the task. He dropped the reins, leaving the driverless Sun chariot to careen about the sky and set the world on fire. The disastrous consequences of Phaethon’s hubris serve Fleming as a recurrent theme throughout the book.

Fixing the Sky doesn’t exactly have a narrative. What it has instead are a purpose and a strategy. The purpose is to argue “for the relevance of history, the foolishness of quick fixes, and the need to follow a ‘middle course’ of expedited moderation in aerial matters, seeking neither to control the sky nor to diminish the

importance of environmental problems we face” (3). The strategy consists of iterating “stories of control” whose real or fictional main characters have, like Phaethon, attempted to master the weather. Arranged in roughly chronological order, these stories begin in the ancient past and continue right up to the present day. Fortunately for us, with few exceptions most of these characters simply failed to accomplish much besides fleecing rain-starved farmers, local governments, state governments, and (eventually) federal funding agencies. A few others succeeded in benign ways, bringing us such marvels as a ski-tourism industry that can make its own snow. Fleming reserves the weight of his collection, though, for a select few who *thought* they had succeeded, and managed to leverage their genuine successes in some areas to create broad support for crackpot schemes to domesticate rain, snow, fog, storms, and sunshine.

The first chapter is devoted to fictions, including myths, legends, poetry, short stories, and novels, from the Greek myths and Dante’s *Inferno* to the radio-era flying cowboy Sky King and Kurt Vonnegut’s *Cat’s Cradle*, whose fictional scientist Felix Hoenneker invents “ice-nine” — a form of water that remains solid up to 114°F — and freezes the entire planet. The next three chapters, nicely titled “Rain Makers,” “Rain Fakers,” and “Foggy Thinking,” recount numerous pre-1945 true stories of men who thought they could make rain; of charlatans who knew they could not, but managed to sell others on the belief that they could; and of attempts to control fog at airports.

The fog control story bears attention, since during World War II Britain’s Petroleum Warfare Department (PWD) discovered a foolproof technique that actually worked. Frequent heavy fog at British airfields presented a severe problem for the Allied air forces. The PWD — charged, as its name implies, with finding uses for oil as an offensive and defensive weapon — created a top-secret Fog Investigation and Dispersal Operation (FIDO), which ultimately settled on a spectacular method that involved burning amazing quantities of gasoline. FIDO placed miles-long rows of burners along the edges of runways. When ignited, these burners consumed 100,000 gallons of gasoline *per hour* — about 6000 gallons for each airplane landing! Fleming quotes Arthur C. Clarke, who once witnessed a test of this system:

At night, with the fog rolling in from the Atlantic, a FIDO operation was like a scene from Dante’s *Inferno*. The roar of the flames made speech difficult.... The yellow walls of fire, taller than a man, stretched away into the foggy night as far as the eye could see. The miles of burners pumped heat into the air at the rate of 10 million horsepower, cutting a long, narrow trench through the fog down which the returning bombers found their way to the ground.

A veteran pilot described landing his plane amidst this conflagration as a descent into hell.

Like the myth of Phaethon, this story serves Fleming as a touchstone through the rest of the book. FIDO “worked” — but at a cost that was financially attainable only in the desperate context of a world war, using technical means that would never again be socially or environmentally acceptable. By the late 1950s, fortunately, instrumented flight had obviated the need for FIDO’s brute-force fog control.

The stories and vignettes of the first four chapters are connected by a theme, but largely disconnected from each other in time, space, and cast of characters. The vignettes continue in the second half of the book, beginning with Chapter 5, but now many of them are tied together by an increasing number of threads. Scientific research in meteorology and climatology experienced a massive boom following World War II, much of it associated with the successful development of computer models of weather and climate.²⁴ A considerable part of the boom — up to half of the total US research effort during the 1950s — was driven by the promise of weather and climate modification. The proponents of computer modeling, such as John von Neumann, often pointed to its potential utility in weather control when seeking funding. Fleming could have added that few claims for weather control can *ever* be verified without extremely accurate weather modeling, since verification requires knowledge of what *would have happened* in the absence of intervention, and modeling is the only way we can know that. Today’s weather models can forecast precipitation with considerable accuracy at 15-minute intervals, yet they are still not good enough to verify the efficacy of many weather control techniques.

In the 1940s the chemist and Nobel laureate Irving Langmuir, the only individual to whom Fleming devotes an entire chapter, became the guru of a veritable cult of weather control. The chapter’s title, “Pathological Science,” is an unsubtle clue to Fleming’s view of Langmuir, whose General Electric research team — which included Kurt Vonnegut’s brother Bernard — developed cloud seeding techniques involving silver iodide crystals. While the technique demonstrably worked in the laboratory, real clouds are not like laboratory conditions. Fleming claims that cloud seeding “has never been proved to cause or augment [real-world] precipitation directly.” But following some dramatic tests, in which airdrops of silver iodide crystals into clouds produced immediate rain, Langmuir believed that it did. He believed this so strongly, Fleming argues, that he lost his scientific bearings altogether and simply could not hear counter-evidence.

²⁴ Paul N. Edwards, [*A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*](#) (Cambridge: MIT Press, 2010).

Langmuir knew a lot about chemistry, but not very much about meteorology. His Project Cirrus built a cloud-seeding tower in Socorro, New Mexico. Following a seemingly successful test, Langmuir ordered the tower to seed once a week for 82 weeks. He then noted a weekly periodicity in rainfall across the Midwest and the Eastern United States, more or less downwind of the New Mexico tower. Next, Langmuir made the oldest scientific mistake in the book: taking correlation for cause. He declared his tower responsible for the entire pattern. Admonished by meteorologists that rainfall exhibits a rough *natural* periodicity of 7 days, Langmuir could not accept that possibility. He continued to claim success for what proved in the end, at best, a highly unreliable technique.

Fleming is a masterful writer, at the top of his game, and his skill and good humor make this book a blast to read. Many of the tales he unearths are astonishing — and he has a great time telling them. If you're like me, the first five chapters will make you shake your head and laugh aloud. "Incredible," you'll think, "that anyone could possibly have believed *that*." Who would attack the clouds with artillery to make it rain? Who in their right mind would ever imagine that smoke from a single tower in New Mexico could alter rainfall patterns across the rest of the continent?

Yet Fleming keeps right on iterating stories all the way up to the present. And as they get closer to yesterday, things get a lot more serious. Chapter 6 covers military weather modification projects, including the massive 5-year cloud seeding program Operation Motorpool, which attempted to create rain over the Ho Chi Minh Trail during the Vietnam War. Chapter 7 looks at geoengineering ideas from the mid-20th century. One of these, the mad Atlantropa Project of Herman Sörgels (which he promoted from the late 1920s until he died in 1952), envisioned damming off the straits at Gibraltar and the Dardanelles to lower the Mediterranean Sea and create a "second Nile" leading to artificial inland seas in Chad and the Congo.

In Chapter 8, on contemporary geoengineering schemes to forestall global warming, Fleming's strategy of iteration creates its intended, and overwhelming, effect. Throughout the book, even in stories from the 1980s, we've laughed at scientists' monumental hubris and the gullibility of a scientifically illiterate public starved for rain, or merely for a sense of control over nature's power. But when it comes to the present, we're much less comfortable applying that same degree of skepticism to proposals from our best experts. Isn't there something we can *do* about climate change, something that works better and faster than fragile, unenforceable international treaties, negotiated at a snail's pace and prone to collapse? Isn't there some solution cheaper than abandoning the carbon economy and rebuilding the entire global energy infrastructure around renewable resources?

Don't we know enough by now? Maybe the geoengineers *do* have a point. Fleming's stories will snap you out of this delusion.

Yet climate change is real, and the need for action is genuinely urgent. Earth already has experienced an average warming of about 0.8°C since 1900. Under all plausible scenarios it is now virtually certain that carbon dioxide concentrations will reach 550 parts per million — double the pre-industrial level — sometime around 2050. But that's only the beginning of the bad news. Those levels are likely to reach 750 or even 1000 ppm before they begin to decline. The 2007 assessment of the Intergovernmental Panel on Climate Change predicted that on a business-as-usual scenario, global temperatures will rise between 1.5° and 5°C by 2100; if economic growth is rapid and the energy infrastructure does not move quickly to a reduced carbon intensity, the top end of the IPCC range goes up to 6.4°C.²⁵ *These projections are relatively conservative.* Some credible experiments with climate models have found climate sensitivities quite a bit higher than 6°C on carbon dioxide doubling, *i.e. by 2050.*²⁶

What can we do about this? Fleming lays his cards on the table at the very beginning. Even if we had the will and the way, he writes, “we do not have the wisdom” to engineer the planet. “Global climate engineering is untested and untestable, and dangerous beyond belief” (2). He proposes, instead, that we heed Helios' advice to his doomed son Phaethon: “keep within the limit of the middle zone” (264). Stick to the path of moderation, doing neither too little nor too much. Most geoengineering schemes, Fleming teaches us, would be too much — perhaps far too much. Physical shading of the planet, whether with space mirrors, stratospheric balloons, or sulfate aerosols, might alter the global atmospheric circulation in ways we cannot determine in advance, potentially redistributing climatic resources such as rainfall, snow, and sunshine in dramatic, probably undesirable ways. Artificial carbon capture on huge scales would itself require enormous amounts of energy, and plans to somehow sequester all that carbon in underground stores may not work. Biological plans, such as fertilizing huge plankton blooms, might create oxygen-poor “dead zones” in the ocean, with potentially catastrophic effects on sea life. Even massive reforestation, among the most benign-sounding of these schemes, might look in practice more like tree farming with ecologically negative consequences, and might involve displacing already marginalized people from their lands.

²⁵ Intergovernmental Panel on Climate Change, [IPCC Fourth Assessment Report: Climate Change 2007](#) (Geneva: World Meteorological Organization, 2007).

²⁶ Stainforth, D.A., T. Aina, C. Christensen, M. Collins, N. Faull, D.J. Frame, J.A. Kettleborough, S. Knight, A. Martin, and J.M. Murphy. “[Uncertainty in Predictions of the Climate Response to Rising Levels of Greenhouse Gases](#),” *Nature* 433 (2005): 403-06.

It's impossible to come away from this excellent book with much optimism about any technical approach to "fixing the sky." Nonetheless, I cannot tamp down a certain unease about Fleming's entirely reasonable conclusions. In order to underline the craziness of geoengineering, Fleming seems to de-emphasize the gravity and the urgency of anthropogenic global warming — which, as Roger Revelle famously observed in 1957, represents a "great geophysical experiment."

This unintentional experiment has already been underway for nearly two centuries. In fact, were we to consider anthropogenic global warming as a geoengineering project, it would seem far more insane than even the craziest of the schemes Fleming describes. Dig up hundreds of millions of years' worth of coal and oil, then burn it all in a few centuries? Cut down the majority of the planet's forests and cover much of the denuded land with artificial fertilizers and pesticides? Raise some 1.3 billion methane-belching cattle on the rest of it?²⁷ Pump 30 billion tons of carbon dioxide into the atmosphere each year? Now *that's* geoengineering.

Seeing anthropogenic global warming as geoengineering is not as far-fetched as it sounds; in fact it's been done, all along. In 1896, when Svante Arrhenius articulated the carbon dioxide theory of climate change in its modern form, he noted the possible value of warming to human societies. (At the then-current rate of fossil fuel consumption, he did not expect those effects to appear for another 2000 years.) In the 1990s, lobbyists funded by the coal and oil industry hawked the supposed benefits of global warming, such as putative increases in crop yields from higher carbon dioxide levels. Even today, it's not uncommon to hear the view that it's actually better to keep burning coal, since the cooling sulfate aerosols thus produced tend to counteract the warming effect of greenhouse gases.

So like it or not, we are stuck with geoengineering, whether by accident or by design. We are *already* managing the planet and engineering the climate, though without any kind of deliberate approach or comprehensive vision. We are *already* creating the massive unintended consequences against which Fleming warns us. And *any mitigation regime at all* will actually constitute another form of geoengineering, since it will doubtless privilege reductions in emissions of some types of gases and particles over others — and the various species are not equivalent in their radiative activity and distribution, as Fleming himself points out.

Fleming would have us steer a middle course, seeking ways to adapt to a warmer world while negotiating the transition to an energy economy less threatening to the

²⁷ In 2002, the Human Footprint project found that 83 percent of the planet's land surface is directly influenced by human activity. Sanderson, E.W., Jaiteh, M., Levy, M.A., Redford, K.H., Wannebo, A.V., and Woolmer, G. 2002. "[The human footprint and the last of the wild](#)," *BioScience* 52(10): 891-904.

climate system. Of course he is right. Yet against that view, I cannot help but offer my own speculative fiction about what is actually most likely to happen.

First, I think the next two decades will witness near-complete failure to make a fast transition to a carbon-neutral energy economy at the global scale. The skyrocketing demands of China's billions have already far overtaken that country's push to lead in the growing renewable energy infrastructure. There and in other places where basic needs trump the amorphous benefits of climate stabilization, emissions will continue to grow on a business-as-usual course well into the 21st century — inhibited, if at all, mainly by economic crises and natural disasters. Around 2050, world population will peak at just over 10 billion, almost half again as many as the world strains to support today. Meanwhile, the United States — whose political discourse is currently dominated by the only major political party in the world to deny the reality of global warming — will not only continue to dither, but likely move backward on emission controls and renewable energy. Climate negotiations will continue, but will function more as a cover story for failure than as a powerful force in limiting greenhouse gas emissions and deforestation.

In this dark scenario, sometime around 2030 the geoengineers will have their day. By then the most dangerous effects of climate change — substantial sea level rise threatening coastal cities, redistributed precipitation resulting in water shortages and floods, increasing numbers of extreme weather events, continued glacial melting, rapid breakup of ice sheets in Antarctica and Greenland, ocean acidification destroying fisheries — will take hold in earnest and finally be obvious enough for all to see. Yet a massive energy-economy transition will still seem beyond reach, due mainly to an unbreakable political logjam. Furthermore, it will be far too late to mitigate. Politicians will wake up to the least-well-known important fact about the climate system: its built-in delay of at least 50 years — the time it takes the oceans to come into equilibrium with the atmosphere — during which the planet would continue to warm even if human greenhouse gas emissions stopped entirely.

Next, some powerful committee will conclude that if there is the slightest prayer of preventing a climate catastrophe, something needs to be done *now*. At that terrible tipping point, yet more schemes will be on the table, perhaps more ingenious and less expensive than those Fleming has heard so far. Computer models of climate will incorporate more elements of the overall Earth system, including ecosystems, land use, and hydrology. Climate model resolutions — by then, perhaps a small fraction of a degree of latitude, versus today's one-degree resolution — will bring model outputs to a politically usable scale, with more and more accurate predictions of greater human relevance. These trends are already well underway. Between increased technical capability and incrementally better

knowledge about the likely human outcomes, somebody will decide that whatever the remaining unknowns, deliberate geoengineering is worth the risk.

But maybe we'll get lucky. Maybe we'll manage to steer that "middle path" after all. Whatever happens, my dark mood should not obscure Jim Fleming's remarkable achievement. *Fixing the Sky* shows how history can matter to the present, but more than that, for historians it might be a model for how to *make* it matter — how to build a strategy of persuasion from good humor and good stories, well told.

Author's Response by James Rodger Fleming, Colby College

I thank Jake Hamblin for organizing this forum and the four colleagues he recruited for their close readings of my book, for their insightful responses, and for all the genuinely nice things they said, which I hope will stimulate others to read the book too. *Fixing the Sky* is a critical, tragi-comic history of hubris and folly regarding attempts to control weather and climate. I had written a number of papers on weather control history, when, in 2006, I was invited to a powwow of geoengineers at NASA-Ames on the seemingly innocuous subject of “managing solar radiation.” The real subject was much bigger: how to save the planet from the effects of global warming. There was little talk among the two dozen scientists and other specialists about carbon taxes, alternative energy sources, or any of the other usual approaches. Many of the scientists were impatient with such schemes. Some were simply contemptuous of calls for international cooperation and the policies and lifestyle changes needed to curb greenhouse-gas emissions; others had concluded that the world’s politicians and bureaucrats are not up to the job of agreeing on such reforms or that global warming will come more rapidly, and with more catastrophic consequences than many models predict. Now, they think, it is time to consider radical steps to gain control of the climate directly—a set of technological quick fixes for global warming.

Paul Edwards was right, I have been attending a lot of “scary” meetings populated by the Rube Goldbergs and Dr. Strangeloves of geoengineering. In fact, I am at one now where an emeritus professor of engineering of the Goldberg stripe, contemplating the problem of removing methane from the air, suggested two quick fixes: burn the methane off as it erupts through the polar ice (imagine polar bears surrounded by flames shooting ten meters into the sky) and training cows to chew their cud in special methane collection tents (perhaps the cows could also be retrofitted with igniters to burn off their emissions!). The Strangelove types typically see no problem with employing military hardware in military-style campaigns to “fight” global warming. They propose to dim the sunlight using “space mirrors” or with aerosol particles spewed into the sky by cannon, airplanes, rockets, and balloons. Such procedures would also turn the blue sky milky white, degrade the nighttime view of the stars, change rainfall patterns half a world away, negatively affect biodiversity, and probably damage agriculture and the stratospheric ozone layer. Oh, by the way, such heavy-handed interventions would also cause immense social disruption if people could assign blame and liability to particular acts of climate engineering. Miss Eliza Leslie wrote about this in 1842 in response to James Espy’s proposal to engineer the rainfall from Maine to Georgia (*Fixing the Sky*, 58-59).

Geoengineers do not know their own history. In the 1950s Nobel laureate Irving Langmuir wanted to seed the entire Pacific basin to control storms. In the 1960s the Russians declared war on permafrost and sought to engineer an ice-free Arctic Ocean. About a decade before the ozone concerns of the 1970s, Weather Bureau scientist Harry Wexler argued strenuously against geoengineering when he identified catalytic chemical reactions that could devastate the stratosphere—a potential “bromine bomb.” About the same time, James Van Allen steered his *Explorer 4* satellite, equipped with Geiger

counters, into the blast debris of three atomic bombs detonated in the magnetosphere in a top-secret military test called Argus. Much larger H-bomb detonations in 1962 by the Soviets and the Americans were further evidence of such space geoengineering. In the 1990s a committee of the National Academy of Sciences suggested using naval guns to shoot sulfates into the high atmosphere, since it was cheaper than reducing carbon emissions.

One of the messages of *Fixing the Sky*—that history is relevant to current public policy concern—recently reached the US House Committee on Science and Technology, chaired in 2009 by Bart Gordon (D-TN). It also reached upper echelons of the National Academy of Sciences, the Government Accountability Office, and the UN Convention on Biodiversity, among others.

Since the reviews are so overwhelmingly positive and encouraging, I will provide only a few brief comments on each. R. S. Deese and I both admire individuals like TV weathercaster “Heatwave Berler,” who stood up to the quacks in Laredo who were trying to sell the town an expensive, proprietary rainmaking scheme; Harry Wexler, who was way ahead of the curve concerning both new technologies and their possible misuse when he warned of stratospheric ozone depletion from rocket exhaust; and Gavin Schmidt’s evocative image of a person claiming knowledge of chaotic dynamics standing up in a canoe to stabilize it in a wind-blown Maine lake—it is always better to hunker down. I did dedicate space in the book to non-Western sources, such as the African and Mandan rainmakers, but will defer to other scholars for a full survey of such practices.

Matt Farish provides some tough, good-natured collegial pushback in his desire for more “considered analysis” and his disappointment with the book regarding relationships between climate and culture. In reality, I wrote the book with a sense of urgency that the geoengineers were actually going to try something soon and needed to be roundly parodied, so one reading of the book is that the stories of charlatan rain fakers and pathologically-deluded scientists apply equally to today’s climate engineers. If this limited my “analytical reach,” then so be it. I just finished editing volume 26 of *Osiris* on “Klima,” so I will refer readers there for some of my deeper cultural thoughts. Concerning the book’s location within the literature, I stand by my assertion that science studies tragi-comedies featuring the voices of Jules Verne, Kurt Vonnegut, and Donald Duck are not that common.

Ted Steinberg hits the nail on the head when he observes, “what we have here is a gigantic collective delusion about the control of nature.” It truly is. I might add that hubris is perennial, as is the pervasive lack of attention to history amongst the protagonists. Regarding the seeming lack of “tight chronology” in the cold war, I find preoccupation with control in all eras, driven by different senses of urgency and embedded in different technological contexts, for example drought in the nineteenth century, British national survival during World War II, and today’s concerns over global warming.

Paul Edwards is perceptive in focusing the latter half of his commentary on how

historians in general and STS scholars in particular can take ethical positions when confronted with such pressing global issues as climate change. There is no one answer, but Edwards is certainly a leader in showing the way for climate modeling. Given chaotic limits to forecasting, however, even the best weather modeling will fall far short of “verifying” weather control experiments, let alone climate tinkering. This, combined with the lack of ability to monitor climatic changes in any detail using space-based or other sensors, means we may *never* know what Rube Goldbergs have done to the planet. The collective insanity of burning fossil fuels, cutting down trees, and eating beef is another issue, perhaps to be considered collective “geoengineering,” but more like death to the biosphere from a thousand cuts than my focus, which was on a handful of technocrats. Paul’s “speculative fiction,” is really a prominent declensionist scenario of the environmental movement, speculative yes, but rather easy to find in the literature. We can hope that model outputs will become more accurate and more politically useable, perhaps with bigger and better machines, but I don’t think we can count on it. Here, to stimulate further discussion, is my own declensionist vision of carbon sequestration gone awry. Before the mid-twentieth century carbon dioxide was not known to be a climate-controlling substance; it was traditionally known as *spiritus lethalis*, the lethal vapor in grottos and mines, in exhaled air, in fermentation cellars, a phlogisticated substance that extinguishes flame and life. In 1986 a sudden eruption of carbon dioxide was blamed for the deaths of over 1,700 people living near volcanic Lake Nyos in Cameroon. Such lethal vapors may also be the future of CO₂, especially if plans for its massive sequestration underground somehow goes awry. John Nissen, a geoengineering enthusiast commented recently to the effect that, “The only danger in taking CO₂ out of the atmosphere might be in where you put it, because, for example, you don't want it to burst back into the atmosphere suddenly after a few years underground.”²⁸

So here is my “epilogue from the future”:

The Liquid Carbonic Company of the 22nd century, now owned and operated by the heirs of Klaus Lackner, had been in the business since 1888, liquefying, and for the past century-and-a-half, sequestering carbon dioxide in pressurized underground caverns. They practiced “air capture,” and had taken to injecting fluid CO₂ into tectonic subduction zones where company geologists assured them it would remain for millennia. The company owners were multi-trillionaires, the shareholders wealthy beyond their wildest dreams, and the general public adored the company for their role in “stopping climate change” by sequestering 50 billion metric tons of CO₂ per year and for beginning to reduce the atmospheric load to its pre-industrial level.

The first signs of trouble appeared when a massive earthquake in one of the huge storage areas near the Philippine Islands unleashed a Thilorier-like eruption from underground shooting giant plumes of solid carbon dioxide snow into the air, instantly freezing the region at -78° C and, because of the tropical air nearby, generating storms the likes of which had never been seen in those climes. No eyewitnesses survived to tell of the havoc, however, since a blanket of CO₂ gas had covered the Republic, asphyxiating, by some estimates, 100 million people – the first case of national omnicide from a CO₂ bomb.

²⁸ John Nissen, climateintervention@googlegroups.com (27 Feb 2011).

Similar tragedies, largely unreported due to the chaos, followed around the ring of fire and in most of the storage fields of the world. A remnant population, fortunate enough to have taken to the hills to escape the gas attack, now faced a new challenge – global warming attributed to the sudden release of 150 years of emissions assumed to have been sequestered for the ages.

About the Contributors

R. S. Deese is Visiting Assistant Professor at Northeastern University. He teaches environmental history and U.S. History, and his research focuses on the connections between science, international affairs, and the evolution of the environmental movement after World War II. His essay, “The New Ecology of Power,” appeared in the recent volume *Environmental Histories of the Cold War* (Cambridge, 2010), edited by J.R. McNeill and Corinna Unger. He currently is writing a book about Julian and Aldous Huxley and their utopian visions for the world.

Paul N. Edwards is Professor in the School of Information and the Department of History at the University of Michigan. His research explores the history, politics, and cultural aspects of computers, information infrastructures, and global climate science. His publications include *The Closed World: Computers and the Politics of Discourse in Cold War America* (MIT Press, 1996), and *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (MIT Press, 2010).

Matthew Farish is Associate Professor of Geography at the University of Toronto. He is the author of *The Contours of America’s Cold War* (University of Minnesota Press, 2010) and a number of articles on the militarization of geographical knowledge in the United States. He is currently writing a history of the Distant Early Warning (DEW) Line, and has also started a project on American military encounters with ‘hostile environments’.

James Rodger Fleming is a historian of science and technology and Professor of Science, Technology and Society at Colby College, Maine. His research focuses on the history of the geophysical sciences, especially meteorology and climate change. His publications include *Historical Perspectives on Climate Change* (Oxford, 1998), *Meteorology in America, 1800-1870* (Johns Hopkins, 1990), and *The Callendar Effect* (American Meteorological Society, 2007). He is the founder and first president of the International Commission on History of Meteorology, editor-in-chief of *History of Meteorology*, and series editor for Palgrave Studies in the History of Science and Technology.

Jacob Darwin Hamblin is Assistant Professor of History at Oregon State University. He earned a doctorate in History from the University of California, Santa Barbara in 2001. Before his arrival at Oregon State University, he held research or teaching positions at the Centre Alexandre Koyré d’Histoire des Sciences et des Techniques (Paris), California State University, Long Beach, and Clemson University. He is the author of *Oceanographers and the Cold War* (University of Washington Press, 2005) and *Poison in the Well: Radioactive Waste in the Oceans at the Dawn of the Nuclear Age* (Rutgers, 2008).

Ted Steinberg is the Adeline Barry Davee Distinguished Professor of History and Professor of Law at Case Western Reserve University. He is a U.S. historian whose areas of expertise include environmental, social, and legal history. His books include *Acts of*

God: The Unnatural History of Natural Disaster (Oxford, 2000) and *Down to Earth: Nature's Role in American History* (Oxford, 2002). He is currently writing a book about landscape change in the New York metropolitan area.