I am a professor of science, technology, and society at Colby College, a visiting scholar at Columbia University, and a historian of science and technology who has written extensively on the history of weather and climate. I attended a lot of geoengineering meetings, but now the term geoengineering is considered passé. First of all it is not engineering – it is speculation done mainly through back-of-the-envelope calculations, Rube Goldberg-like inventions, and relatively simple, non-predictive climate models. The term is being replaced in two ways. (1) By a relatively good idea: capture and store our carbon dioxide emissions safely, and (2) by a very sketchy idea: intervene in a heavy-handed way in the solar radiation budget, for example, by injecting sulfate particles into the stratosphere. Today I wish to argue that history matters, and that “Fixing the Sky” through weather and climate control is not a new idea. It has a long and checkered history.

SHOW BOOK

The following claims were made by various speakers recently; my comments are in rebuttal:

“We don’t have a history of climate control to fall back on…” — *Yes we do.*

“Things are moving quickly, so we don’t have the luxury of looking at history.” — *We must take the time.*

“We are the first generation to think about these things.” — *History says otherwise.*

Visionary schemes for weather and climate control have a long history, but with very few exceptions have never worked. Would-be climate engineers and policy makers need to take this into account. My intent here is to demonstrate that contrary to claims that climate engineering is something wholly new in scale and intent- a number of previous technological interventions have been attempted on the atmosphere, on both regional and planetary scales. By and large, they did not have their desired effects on the physical environment, outpaced their original technical requirements, and gave rise to complicated political, social and economic issues.

I would like to address the claim that weather modification has little to teach us about climatic interventions. Weather control and climate control
are intimately related. Weather and climate are on a continuum of scales. Any intervention in Earth’s radiation or heat budget (such as managing solar radiation) would affect the hydrological cycle and the general circulation, thus rainfall and upper-level wind patterns, including the location of the jet stream and storm tracks. The weather itself would be changed by such manipulation. Conversely, intervening in severe storms by changing their intensity or their tracks or modifying weather on a scale as large as a region, a continent, or an ocean basin would obviously affect cloudiness, temperature, and precipitation patterns, with major consequences for monsoonal flows and ultimately the general circulation. If repeated systematically, such interventions would influence the overall heat budget and the climate.

The earliest documented cases of rainmaking schemes tended to be regional rather than global, but still very large scale. In 1841 James Espy, America’s first national meteorologist, developed a theory of storms powered by convection, but the so-called “Storm King” went off the deep end technically when he proposed lighting giant fires all along the Appalachian Mountains to emulate an artificial volcano that he thought would generate rains, disrupt cold and heat waves, and clear the air of miasmas. His contemporary, a writer named Eliza Leslie, perceptively pointed out that attaining such control might cause serious damage to social relations. There were many other such rainmaking schemes. In the 1920s, with concerns about aviation safety ascendant, independent inventor L. Francis Warren and Cornell chemistry professor Wilder D. Bancroft developed a scheme to dose the clouds with electrified sand delivered by airplane. Rainmaking and fog clearing were both on the agenda, but trials, supported by the U.S. Army Air Corps, were less than promising. It turned out that airplanes could successfully disrupt smaller clouds, but experimenters could not predict whether a treated cloud would subsequently dissipate or thicken.

These early weather modification plans (some of surprisingly large scale) were couched in the context of the pressing issues and available technologies of their eras: Espy wanted to purify the air and make rain for the East Coast, and Warren and Bancroft hoped to make rain and clear airports of fog, while the military sought advantages for its fliers. But intervention is not control, and the hype surrounding both projects exceeded technical capabilities.

Prospects for larger-scale, even planetary intervention in the climate system arrived after 1945 with the dawn of several transformative technologies: nuclear weapons, digital computing, chemical cloud seeding
techniques, and access to space (See Table I). Two of the projects listed here involved cloud seeding techniques, and two involved disruption of the space environment. All were part and parcel of the Cold War quest to militarize the atmosphere. Not listed in the table are proposals, dating from 1945, to bomb nascent hurricanes or break up polar ice with nuclear weapons, or to build a digital computer that would produce perfect forecasts and perhaps allow real-time intervention in threatening weather systems as they developed.

**Table I. Weather and Climate Control Projects in the Cold War**

1947 -- Project Cirrus attempts diversion of an Atlantic hurricane using dry ice seeding.
1958 -- Project Argus, top-secret military project detonates three atomic bombs in space.
1967 -- Monsoonal cloud seeding over Vietnam leads to UN ENMOD treaty in 1978.

In 1947 scientists at the General Electric Corporation developed methods for seeding clouds with dry ice and silver iodide, sparking a race for commercial applications and military control of the clouds. They partnered with the military in Project Cirrus to seed an Atlantic hurricane with dry ice, but the experiment went awry. Nevertheless, GE chief scientist Irving Langmuir hyped the possibilities, arguing that hurricanes could be redirected and that the climate might ultimately be controlled on a continental or oceanic scale with the techniques they had developed. But as Kathleen Blodget at GE told Irving Lanmuir, “You can intervene in a cloud, but you cannot control it. As cloud seeding reached around the world, especially into arid areas and upslope watersheds, it never resulted in fully reliable techniques to enhance precipitation or snowpack. The scale of nature was too huge and problems of verification and social acceptance were too huge. Instead of quasi-military aerial bombardment of the clouds, small-scale practices such as drip irrigation and snowmaking machines became the norm.

Between 1966 and 1974 massive and surreptitious seeding of the Southeast Asian monsoon during the Vietnam War resulted in little measureable rain, but a diplomatic nightmare for the United States when the Soviet Union brought the issue of environmental warfare to the attention of
the United Nations. The UN Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD) was the biggest fallout from the effort, followed by a systematic and persistent collapse of US federal support for cloud seeding.

The Argus and Starfish Prime nuclear detonations in space, along with similar Soviet testing, constituted actual attempts to engineer space weather and disrupt the magnetosphere. A theory promulgated by Nicholas Christofilos, a physicist at Lawrence Berkeley Lab, held that the ionized debris and high-energy electrons generated by a nuclear explosion would travel almost instantly through Earth’s magnetic field as a giant current. In case of hostilities a nuclear blast could possibly generate a massive electromagnetic pulse over an enemy city, disrupt military communications, and destroy both satellites and the electronic guidance systems of enemy missiles. These tests, conducted by both superpowers, generated widespread public outrage and were quickly followed by the Limited Test Ban Treaty.

**Lessons from History for Weather and Climate Engineering**

History teaches us that things change – often in surprising or unanticipated ways – and that a certain amount of clarity can be gained by looking backward as we inevitably rush forward. Schemes aimed at attempted control of weather and climate—often framed as responses to critical problems such as water shortages, military exigencies, and cold war dominance—have fallen short of their goals many times in the past. The checkered history of this field provides valuable perspectives and a cautionary warning on what might otherwise seem to be today’s completely unprecedented climate challenges. Contemporary engineers err if they ignore this history.

Would-be climate engineers are strongly motivated by fears of future global warming, but within recent memory this landscape too has been changing. The past decade-and-a-half of surface temperature measurements seem to indicate that the estimated sensitivity of the climate to increasing greenhouse gases is less than models have projected, temporarily reducing some of the short-term angst. Additionally, there is strong technical resistance, or at least caution, from the faculty of mainstream atmospheric science departments, who tend to be skeptical of simple geoengineering schemes. Increasingly, historians, philosophers, and other humanists and social scientists are getting beyond back-of-the-envelope technicalities and are taking a critical look at complex issues related to the history, ethics, and governance of global control issues. Even the neologism “geoengineering”
is in the process of being abandoned (since it is not really engineering in any traditional sense), as is the phrase “solar radiation management” (since there are too many unknowns to really consider it a form of management).

Intervention into weather and climate systems does not result in control over them. Instead it has often given rise to unexpectedly complicated social issues. We should base our decision-making not only on technical expertise and what we think we can do “now” and in the near future. Rather our knowledge must be shaped (and tempered) by what we have and have not done in the past. Such are the grounds for making informed decisions and avoiding the pitfalls of rushing forward claiming we know how to control weather and climate. History matters; it matters a lot. After all, today’s science is tomorrow’s history of science. Let’s try to avoid contributing to a checkered history.