TODAY

Scientific rigor in a field of dreams

"We cannot make clouds or chase clouds away."

—Roelof Bruintjes, NCAR

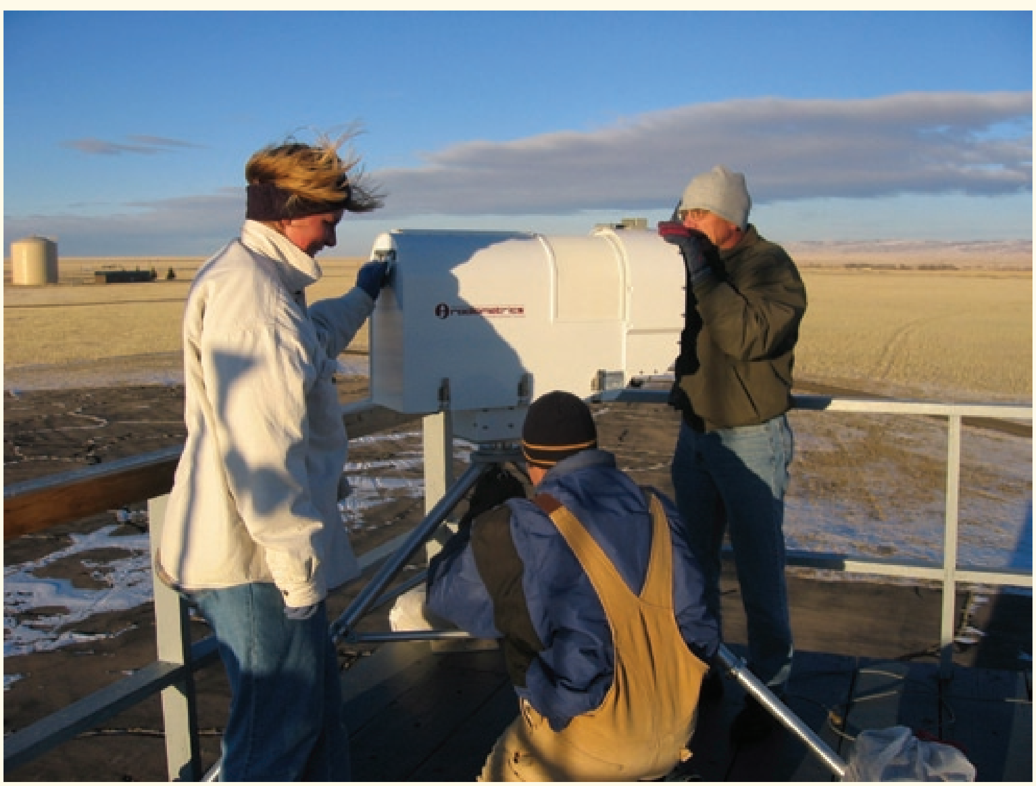
While a billion viewers watched the opening ceremonies of the 2008 Summer Olympics in Beijing, the city's meteorological bureau fired hundreds of rockets into the moisture-laden air. The rockets' payload of silver iodide dispersed in front of an approaching line of thunderstorms, and the rain dissipated before reaching Olympic Stadium. Cause and effect, or coincidence?

It's still exceedingly difficult to gauge the effectiveness of cloud seeding, hail prevention, and other forms of weather modification. Yet many nations continue to pour money into the hope of altering their weather, according to NCAR's Roelof Bruintjes, one of the world's leading experts in weather modification. In countries ranging from Australia to Turkey, Bruintjes and colleagues serve as frequent advisers, helping steer projects toward verifiable results and occasionally throwing cold water on inflated expectations.

Some of the most extensive research on weather modification in recent years has taken place in Wyoming. A state-sponsored, multiyear project launched in 2005 has seeded storm clouds with silver iodide every few days from November through March over the Wind River and Medicine Bow/Sierra Madre mountain ranges, using both ground-based equipment and aircraft. The hope is to increase snowfall by 10% to 20% per year.

If the Wyoming project is funded through the early 2010s, lead scientist Daniel Breed expects there will be enough data to detect statistically significant results. "It's a matter of collecting enough cases as well as verifying the conceptual design of the experiment," he says.

In Wyoming's semiarid climate, a 10% increase in snowfall over the long term would be a valuable addition to snowpack that's tapped throughout the summer. Still, that's less than the normal year-to-year variability, which makes evaluating the experiment a challenge, notes Bruintjes. "Amidst all this complexity, the challenge is to determine whether snowfall levels would have occurred anyway, or if they clearly resulted from the seeding."



NCAR's Tara Jensen and Daniel Breed (standing) align a radiometer with Jason Goehring of Weather Modification, Inc.

Putting weather modification to the test

Making rain and preventing hail were the province of deities and charlatans for centuries. They became part of a scientific endeavor shortly after World War II, when Vincent Schaefer (then at the General Electric Research Laboratory) discovered that silver iodide particles could nourish the growth of ice crystals. The field known as weather modification grew wildly through the 1950s and 1960s, as aircraft funded by U.S. states and many countries began "seeding" clouds in hopes of stimulating rain and suppressing hail. Pundits started speculating that people might soon control every facet of weather.

Were the new claims of weather-making truly more believable than the old ones? At the request of NSF, NCAR organized a multiyear study to help find out. The National Hail Research Experiment unfolded during the summers of 1972–74 across far northeast Colorado, one of the world's most hail-prone regions. Amid a sea of wheat fields, the NHRE team operated a narrow-beam radar well suited for hailstorms, launched balloon-borne radiosondes, and kept an eye on the big sky.

There were a number of ways to introduce silver iodide into storms, none of them very easy, but how exactly would this reduce hailfall—and how could you verify that it did? Russian scientists had claimed huge success in the Caucasus region by launching rockets that climbed and burst, spraying silver iodide into key areas of a storm. The idea was that stimulating the growth of many tiny hailstones within powerful thunderstorm updrafts might reduce the odds that hailstones would be fewer but larger and more damaging.

"I was certainly a skeptic," said David Atlas, now retired from NASA, who served as NHRE's second director (succeeding William Swinbank). "The scientific foundations for weather modification were very weak. But I was young enough at that time to think I could solve any problem." The project opted for a randomized procedure in which a decision to seed on a given day (determined by opening a sealed envelope) would be followed by a no-seed day, and vice versa. "This made it a lot easier to plan operations, and it provided a more robust method for statistical evaluation," says NCAR's Brant Foote, now the director of NCAR's Research Applications Laboratory.

Many laypeople were suspicious of weather modification—in some parts of the country, shots had been fired at aircraft thought to be seeding—so NHRE opted to make its strategies public. Local radio stations carried news of the project's plans each day. A citizens' group met regularly with the scientists. And instead of mimicking the Russians' ground-based rockets, NHRE headed skyward, seeding clouds directly from aircraft and, in the third year, launching aircraft-mounted rockets.

NHRE was originally slated for five summers of field work, but after the third year, preliminary results were causing some consternation. Out of 57 storms, roughly half seeded and half unseeded, there was slightly more hail in the seeded group, but the differences were small enough that they could have resulted from chance. "There was a sense that two more years of data would be unlikely to demonstrate a hail reduction effect," says Foote. The seeding component of NHRE was thus halted, though analysis continued for years.

A nonseeding round of follow-up field work in 1976 focused on deciphering the processes at work in Colorado hailstorms, which were found to differ in several important ways from the processes proposed by Soviet scientists. By this point, NCAR researchers could watch storm-generated winds on some of the earliest Doppler radar displays to be deployed in the field. "This was one of the first instances where we were able to take small, manageable computers and put them together in an environment that provided real-time processing," recalled NCAR's Charles Frush.

NHRE wasn't alone in its equivocal results. Some 61 hail-seeding projects took place around the world from 1958 to 1975, some for research and others for commerce. In a survey of six such projects, Stanley Changnon Jr. (University of Illinois at Urbana-Champaign) found that hail suppression rates of 20% to 48% were reported, but none of the results were statistically significant. "At best, average scientific belief must be labeled 'we don't know'," summarized Changnon in 1978.

U.S. funding for weather modification research dropped steadily to less than 5% of its late-1970s peak by 2003. That year, a National Research Council report concluded that "there still is no convincing scientific proof of the efficacy of intentional weather modification efforts." As was the case with NHRE, the challenges cited in the report weren't related to fundamental physical principles, but rather to complex interactions within a hailstorm. Statistically significant, reproducible results were still needed to reinforce the scientists' understanding—and such results are always a tall order when one's laboratory is the atmosphere.

If it didn't provide the hard answers people had hoped for, NHRE did give birth to some enduring lines of research. "It was highly successful in giving us insight into processes taking place in hailstorms," says Foote. In 1976 NCAR converted NHRE into an ongoing group, now one of the center's main science divisions. Its focus remains the dynamical and microphysical processes that affect thunderstorms and other small-scale weather features—including processes that produce the rain and hail so many have sought to control for so long.