Photos: NCAR

The search for a way to suppress hail

A five-year national experiment that could lead to eventual modification of hailstorms begins this summer in Colorado

by Kendrick Frazier

The rattle of hailstones on a farmhouse roof is the ominous sound of potential disaster. To the farmer whose income depends on the well-being of fragile stalks of wheat or corn or the broad exposed leaves of sugar beets or tobacco plants, the darkened skies, boiling black and white clouds and rushes of wind and rain that herald the arrival of a possible hail-containing thunderstorm carry the threat of financial wipe-out.

Perhaps no one has portrayed the impact of a hailstorm on a farming community as well as has writer Hal Borland in his book published last year about his boyhood days in eastern Colorado.

> [H]ail waits till the wheat is tall and golden with ripeness, the heads full and the kernels fat, the wealth right there, only a week or two away from harvest. You can almost hear the dollars clinking in your pocket. Then that greenish cloud comes and the air turns cold as November and the lightning rips the sky apart. Between lightning flashes it is as dark as dusk. It starts to rain, slashing rain, and you stand in the doorway and watch the dark rain turn to a white curtain coming across the fields. You hear it coming and you know nothing in God's world can stop it. It comes across the wheat fields with a deafening roar. . . . And when it has passed you go out and walk across the yard, the ice crunching underfoot, hail sometimes the size of peas, sometimes big as hen's eggs. You see but don't notice the chickens stoned to death. You see the broken windows and the splintered shingles on the roof, and you don't notice them either. You are looking at the devastated fields, the beaten, ragged wheat fields now covered with hail, devastation that came and passed, ruin complete in 10 minutes. Half an hour ago you had a half section of wheat, 320 acres, maybe $12,000 or $13,000 worth of wheat, ready to harvest and haul to town. Now you haven't got a penny and you owe the bank $2,500, plus interest, due the first day of October. Now you are broke and in debt. . . . You are filled with weariness, bone tired, and there's a nauseating gripe in your belly, a wrenching at your heart. . . . That's hail. That's what hail does to a man. [Hal Borland, "Country Editor's Boy," Lippincott, 1970. Reprinted by permission.]

Hailstorms cause an estimated $200 to $300 million damage a year in the United States alone—more than the damage from tornadoes in many years. The loss is about equally divided between crops and property. The Crop Hail Insurance Actuarial Association in Chicago estimates that in 1970 insurance companies paid out $70 million in claims for crop damage from hail. The amount of uninsured damage is not known.

The incentive to lessen such economic loss is one reason scientists in many parts of the world are mounting increased efforts to study hailstorms. The Soviet Union, Canada, France, Italy and Kenya are among the countries that have been working to try to learn how to suppress hail.

But the economic reason is not the only one. "Of all the severe storms plaguing humanity," says Dr. Guy G. Goyer of the National Center for Atmospheric Research in Boulder, Colo., "the hailstorm appears to be the most manageable." If conditions are right, the hailstorm is a well-defined entity. Unlike many storms, it is not embedded in frontal systems that would obscure its identity and impede study. Hailstorms in the lee of the Rocky Mountains can be identified and studied throughout their entire life cycles.

Years of research in cloud dynamics and physics have revealed physical concepts that lead atmospheric scientists to believe the chance of learning how to modify hailstorms is good. Trigger mechanisms have been found that offer the chance to significantly alter the life cycle of a hailstorm by the addition of a small amount of energy at the right time and place.

It was this combination of circumstances that led the Interdepartmental Committee for Atmospheric Sciences, a group composed of representatives of various Federal agencies, to request, in December 1968, that NCAR plan a coordinated national hail experiment designed to improve the understanding of hailstorms and to determine how they might be made less damaging. Subsequently, the National Science Foundation, which funds NCAR, asked it to actually establish the experiment.

As a result, the United States is about ready to mount the largest coordinated effort in hail research ever carried out in this country. It will be called the National Hail Research Experiment. The first field phase of the five-year experiment will be conducted this summer from June 1 to July 31. The two-month period will be devoted primarily to testing all the systems being designed for use when the project moves into full operations in the summer of 1972.

The experiment will be conducted over a 40 kilometer by 40 kilometer area in northeastern Colorado that falls within what weather scientists sometimes call Hail Alley, an area centered

roughly on the point where Colorado, Wyoming and Nebraska meet and extending north into South Dakota and south into Kansas. Cheyenne, Wyo., near the center of Hail Alley, has the highest incidence of hail in the nation. Kansas, however, which grows more wheat than any other state, ranks first among all states in annual hail damage.

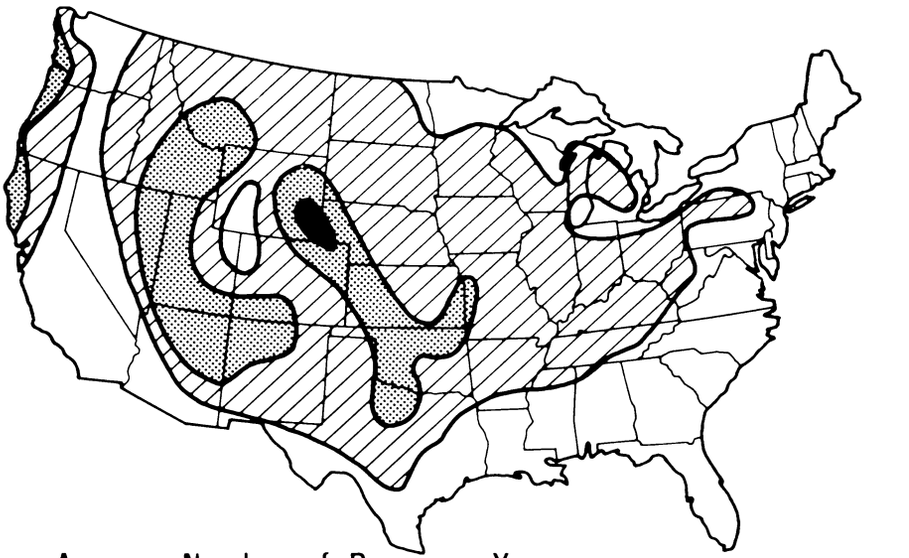
Last September in Kansas, near the town of Coffeyville, a hailstone believed to be the largest ever recorded in the United States fell amid a barrage of giant hailstones that crashed through buildings and put deep dents in automobiles. Recovered for NCAR scientists and shipped to Boulder, it measured 17.5 inches in circumference and weighed 1.67 pounds. The hailstone is just larger than the previous record-holder, which fell at Potter, Neb., in 1928. It now rests in a cold room at NCAR's Boulder laboratory, along with hundreds of other hailstones that are studied under microscopes for clues to their growth patterns.

The National Hail Research Experiment will build on the efforts of a smaller joint hail research project carried out during the last few summers at the same northeastern Colorado site. NCAR's Dr. Goyer is the experiment's senior scientist. "Over the last three years we've been building the nucleus for the larger experiment," he says. He describes its goals as to gain a further understanding of the dynamics and microphysics of hailstorms and to evaluate the feasibility of hail suppression and possibly design a system by which hail can be suppressed.

NCAR, Colorado State University, the National Oceanic and Atmospheric Administration, the South Dakota School of Mines, the University of Chicago, the Illinois State Water Survey and the U.S. Army (whose technicians launch the weather balloons used in the experiment) will cooperate in the project. Each has been involved in hail research efforts for several years. NCAR is the lead agency. NSF has granted about $1.5 million to support the first year of the project.

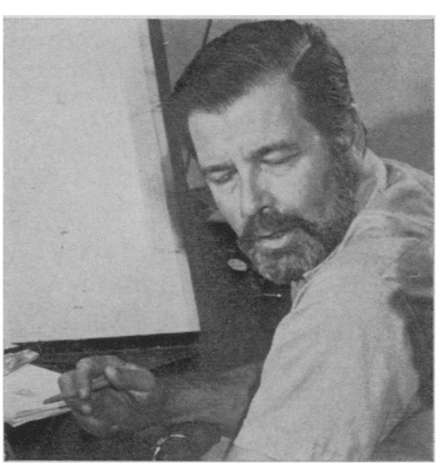
Some cloud seeding of hailstorms is planned during the systems test this summer, although not with the express purpose of lessening hail. "We hope to do some seeding not as a hail suppression exercise but as a tool to study hail mechanisms," says Dr. Goyer. "Of course we will be using observations to determine the differences between seeded and nonseeded clouds," he adds. But the main cloud-seeding efforts will take place in succeeding summers.

Dr. Goyer's office is in NCAR's modernistic monastery-like headquarters high on a mesa south of Boulder, from which he and his colleages can watch afternoon thunderstorms form over the

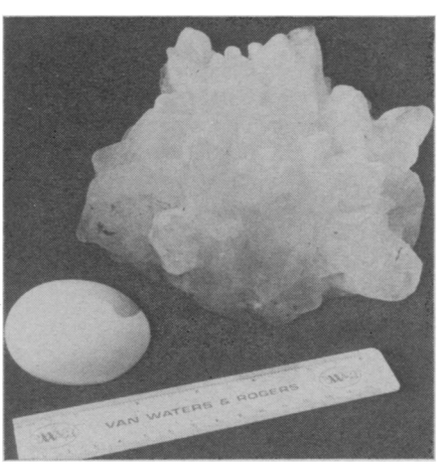


Average Number of Days per Year with Hail in the United States (1904-1943)

Insurance companies paid out $70 million in claims for hail damage to crops last year.



Goyer heads scientific attack on hail.



Kansas hailstone is largest recorded.

plains in response to unequal heating of the earth's surface. All along the western edge of the plains, heat radiated off the rock mass of the Front Range of the Rocky Mountains further stimulates the rapid rise of moist air necessary for afternoon thunderstorms.

A thunderstorm can become a hailstorm if there is strong vertical updraft in the thunderhead, large quantities of liquid water and suitable temperature conditions. Updraft velocities of 60 to 100 feet per second will force a water droplet upward again and again until it grows large enough to overcome the uplift. In general, research has shown that if maximum updraft velocity occurs at a point in the cloud where temperatures are above 23 degrees F., all that will fall is rain. Between 23 degrees and minus 4 degrees F. large hailstones are formed, because a few cloud droplets freeze to produce a few large stones. Below minus 4 degrees, a large number of cloud droplets freeze and give rise to many small hailstones or snow or snow pellets.

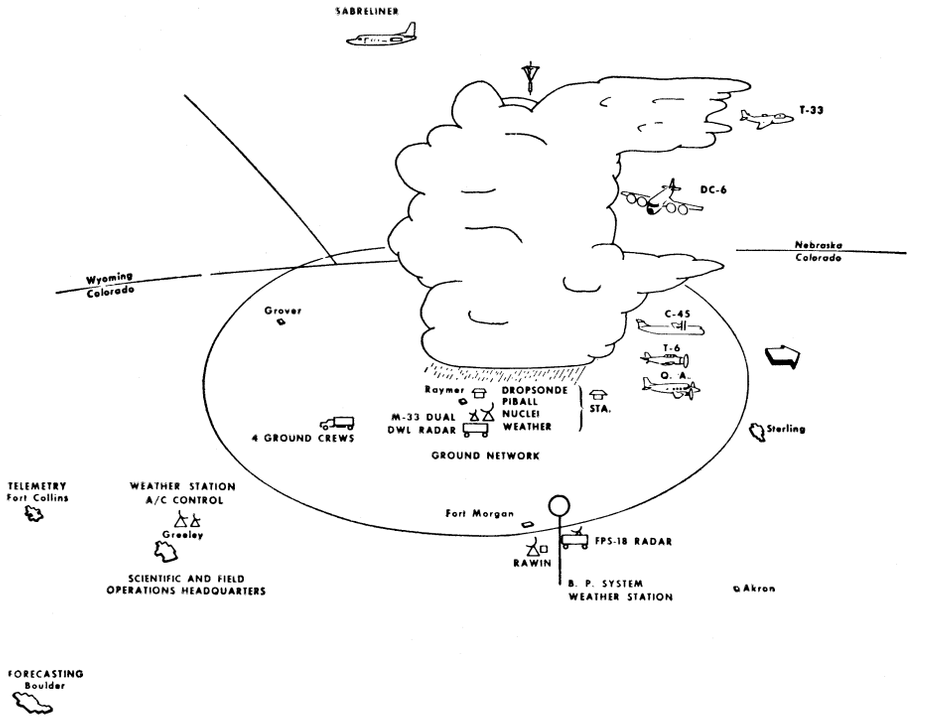
This may sound precise, but science is far from understanding all that goes on inside such an energetic sysem. "I wish we really knew what makes a thunderstorm and what makes a hailstorm," Dr. Goyer laments.

But with this general knowledge, scientists have developed a theory that a hailstorm can be modified by seeding the cloud with crystals of silver iodide. The idea sounds basically simple: By vastly increasing the number of nuclei around which water droplets in a cloud can freeze, a large number of small ice crystals are formed instead of a small number of large ones. The smaller hailstones will either melt on the way down or, if they reach the ground, cause far less damage.

Using such methods scientists in the Soviet Union have claimed great success in lessening the damage of hail. Scientists in the United States tend to be cautious about the Soviet claims. Their general attitude is that although there appears to be some evidence for success, it is difficult to evaluate. The Soviet approach has been empirical, with emphasis on operational seeding and little devotion to gaining a detailed scientific understanding of the responsible processes.

"Some of their projects may be reducing hail damage," says Dr. Goyer, "but I don't think we know why."

"Unfortunately," says Dr. Louis J. Battan of the University of Arizona at Tucson, "it has not been possible to make an independent analysis of [the Soviets'] data, and no research group outside the U.S.S.R. has yet made an independent test of the technique."



Aircraft and radar will monitor hailstorm clouds before and after seeding.

Hail modification experiments in other parts of the world have yielded mixed results, Dr. Battan reports in an evaluation in a new book, "Controlling the Weather," prepared by an NSF-funded task group and published March 15.

"Until [the National Hail Research Experiment] comes into being, it appears that little progress will be made in understanding the nature of hailstorms and the development of effective schemes for modifying them," Dr. Battan concludes.

So the national experiment has a large task cut out for it. Each morning during the field experiments a forecast of the probability of hail over the project site will be made after detailed weather observations have been channeled into the computer at NCAR. If hail seems likely, a complex system of radar, aircraft and ground observations will be put into motion.

The hailstorm will be probed from above by 10 dropsondes launched from a Sabreliner and from below by a variety of radar units, including two dual-wavelength Doppler radars being built specially for the project for use beginning either in 1971 or 1972. The radar, linked with a computer, should be able to help locate the hail source exactly, determine the diameter of the hailstones (by the density of the returned radar signal) and evaluate seeding results (through analysis of the cloud system) before and after seeding. Four hundred ground stations will receive rainfall and hailfall data, and an airborne infrared radiometer may be able to accurately map the hail swath on the ground. In all, half a dozen aircraft may participate in monitoring a single storm.

Two separate systems of seeding the storm will be tested this summer, one using aircraft rockets to disperse the silver iodode crystals, the other using droppable charges.

The social, legal and political implications of hail-suppression research also loom ahead. Weather modification projects have often raised public apprehensions and concern (SN: 5/9/70, p. 461). Sometimes the uneasiness is based on misinformation; other times it reflects genuine concern about legitimate matters of social and political policy. For the hail project, Dr. J. Eugene Haas, a University of Colorado sociologist, is conducting a study of public attitudes toward the effort. His team is now gathering baseline data to compare with data to be collected later when cloud seeding is in progress.

He and other persons concerned with the issues of weather modification have often pointed to the need for new ways to bring the public into the decision-making process.

"If in five years the project has shown it is possible to reduce hail damage by cloud seeding, there is going to be tremendous pressure to do it on an operational basis," says one NCAR staff member. The social and legal implications are enormous. "We need," he says, "a whole new way to involve the public in the decisions about this technology." □