hail

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
BOULDER, COLORADO

It is midafternoon on a hot, dusty day in July. The weather has been dry, and rain would be welcome. You walk outside and take a look at the sky. Thunderheads are building over the rolling plains, and a hawk rides the updraft beneath one of them, circling with motionless wings on the strong vertical air currents.

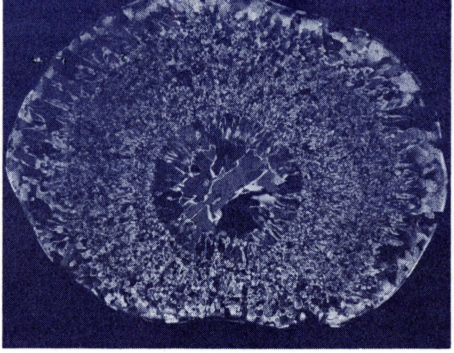
Thunder rumbles nearby, and you turn to see that one of the storm clouds, larger than the others, is bearing down from the west. Lightning flickers in the heart of this storm, and its anvil-shaped top towers high above the plains.

The sun disappears as the thunderstorm moves in, and heavy raindrops start to spatter on the dry ground. At first you are grateful for the rain, then you realize that not all the particles falling from the sky are raindrops. Some are white and solid, and they bounce and roll like marbles. You take shelter, and soon the air is thick with missiles of ice, and the roof above your head rattles under the bombardment.

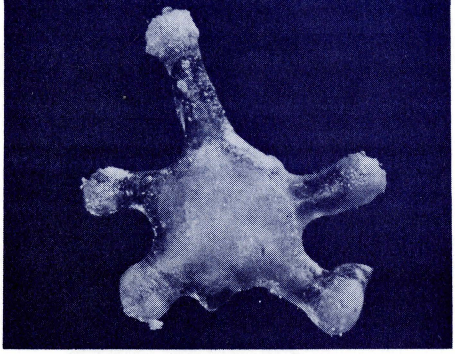
It is all over in a matter of minutes. Sunlight streams through the clean air, and the thunder is distant again. You walk outside, past heaps and windrows of melting balls of ice, to survey the damage.

The nature and extent of the damage depend mainly on how you make your living. If you are a wheat farmer, you may find the year's crop battered to the ground and hammered to shreds. If you raise apples, you may walk into your orchard to find most of the fruit torn from the trees and the rest hopelessly bruised. If you are an automobile dealer, you may have a broken window in your showroom and a lot full of dented and pockmarked cars. If you are a homeowner, you may have tattered shingles and broken windows.

That is hail, and those are some of the things that it can do.



Most hailstones are roughly spherical, shaped like balls or eggs. This two-inch hailstone was sliced open and photographed with polarized light to reveal the structure of the ice crystals within the stone.



This unusual starfish-shaped hailstone was produced by a Tennessee storm that also dropped hailstones resembling turtles and daggers. Scientists do not know why hailstones sometimes take such strange shapes.

Hail is atmospheric water that falls in the form of hailstones––balls or irregular lumps of ice that may be as small as a pea or as large as a grapefruit.

Hailstones usually are roughly spherical, built up in onion-like layers. This layered structure indicates that hailstones grow by the gradual accumulation of cloud droplets around an icy core. Held up within the storm by strong updrafts, the hailstone grows until it is heavy enough to fall from the cloud.

Perhaps the largest hailstone ever seen in the United States was one that fell at Potter, Nebraska, on July 26, 1928. This monster weighed about 1½ pounds and was more than five inches in diameter. Although hailstones this big are very unusual, hail as large as walnuts or golfballs is not uncommon in the Great Plains region of the United States.

Severe hail is almost always produced by summer thunderstorms over large land areas in the temperate zones of the earth. Hail is almost unknown in the polar regions, in most of the tropics, and over oceans. It is most common in plains areas downwind from large mountain ranges. Severe hail occurs frequently in central Europe, northern India, the Pampas of Argentina, and our Great Plains east of the Rocky Mountains.

Hail usually falls from huge cumulonimbus clouds, or thunderheads, that build up on summer afternoons, towering as high as fifty to sixty thousand feet above the earth's surface. Atmospheric scientists do not fully understand why one thunderstorm will produce hail and another nothing but rain. However, it appears that the most important factor for hail formation is a critical combination of updraft velocity and temperature within the storm.

Of all the different kinds of destructive storms known to man––including hurricanes, typhoons, tornadoes, and blizzards––the hailstorm is currently receiving more attention from atmospheric scientists than any of the others. There are several reasons for this vigorous and expanding effort in hail research.

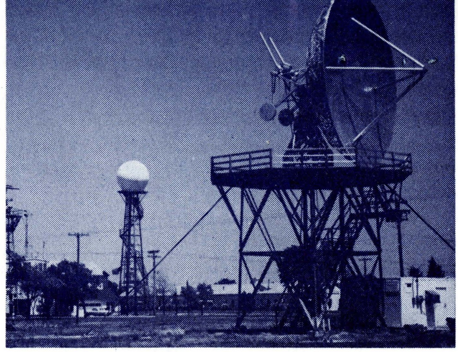
The first is that, of the many disastrous weather phenomena that plague man and his works, the hailstorm appears to be the most approachable in terms of field research. During the summer months, in areas such as the high plains east of the Rockies, each hailstorm is a separate and distinct system, and can be probed with radar, research aircraft, and other tools of atmospheric research throughout its life cycle of a few hours.

A second reason is that atmospheric scientists already have a great deal of basic scientific knowledge, gained from years of research, on the fundamental processes and behavior of convective clouds such as the ones that produce hail. These research findings indicate that triggering mechanisms may be found that can be used to suppress the growth of hail before the hailstones become large enough in size and number to cause severe damage.

A third reason is economic. Each year, hail does two to three hundred million dollars worth of damage to crops and property in the United States. The average annual dollar loss from severe hail damage in this country is higher than the loss from tornado damage. In the worst hail areas, hail insurance premiums run about 20 percent of the total value of the crops. Many years of research may be needed to develop effective techniques for suppressing hail on an operational basis, but success would produce great and immediate economic benefits.

Most hail research programs have two primary goals. The first is to observe and analyze enough hailstorms to develop a theoretical concept, or model, of the structure and development of a typical hailstorm. This model would include details of when, where, and how hail grows within the storm. By portraying the critical features that distinguish the hailstorm

Alberta Hail Studies Project



National Severe Storms Laboratory

from an ordinary thunderstorm, this model eventually should permit accurate forecasting of hail. It also should enable hail researchers to use electronic computers to test techniques for modifying hailstorms.

The second major goal of hail research is to discover methods for disrupting the growth process of hail in order to prevent large hailstones from developing. Hail cannot be suppressed by using brute force to eliminate the storm that produces it--the energy involved in a typical thunderstorm during its life cycle is probably several times as great as that released by a hydrogen bomb explosion.

The key to successful hail modification appears to lie in identifying critical times and places when a small input of energy into a growing hailstorm will trigger large-scale results. The most promising technique appears to be cloud seeding. Crystals of silver iodide or certain other substances introduced into a cloud will serve as freezing nuclei, centers around which ice crystals collect. Hail researchers believe that if enough nuclei are put into a hailstorm at the right time, they will cause most of the water in the cloud to fall as small hailstones or rain rather than staying in the cloud long enough to grow into large, dangerous hailstones. The biggest problem now is to test the effectiveness of this technique, and to determine when, where, and how the seeding material should be introduced to be most effective.

Hail research is going on in most of the nations of the world where hailstorms are a serious problem. France, Italy, Kenya, Canada, and the Soviet Union are among the countries that have been working to try to learn to suppress hail.

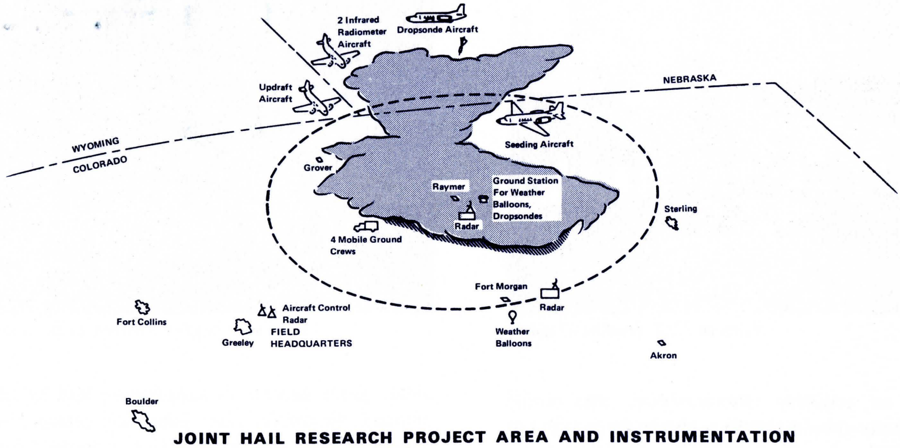
One of the most intriguing hail research efforts is the Russian program, which has been going on for several years in the Caucasus region of the Soviet Union. The Russians use radar to locate and identify storms that are potential hail producers. Then they fire anti-aircraft shells loaded with silver iodide into the cloud. The Russian scientists have published results that indicate great success in suppressing hail by this method. However, they have not released all details of their system, and U. S. scientists have been unable to reach clear conclusions about the effectiveness of the Russian program.

In the Canadian province of Alberta, McGill University and three agencies of the Canadian Government are studying hailstorms over a 22,000-square-mile area. The Canadian scientists use radar and aircraft observations to describe the structure of hail-producing storms. They also gather data from a network of hail and rain recorders and from 25,000 residents of the area who serve as volunteer hail observers. They feed the data into an electronic computer to produce maps showing the behavior and effects of the hailstorms that move across the test area.

Atmospheric scientists of the Illinois State Water Survey maintain an extensive network of automatic devices to record the number and size of hailstones, the energy with which they fall, and the direction of travel of windblown hailstones. These records, along with reports from ground observers, are used to map hailstreaks, or bands of hailfall, within the hailswath, the broad path of hailfall left by the hailstorm, in relation to radar observations of the storm. The hailswath left by a severe and prolonged storm may be several miles wide and more than 100 miles long.

The Institute of Atmospheric Sciences of the South Dakota School of Mines and Technology uses computer techniques to develop and evaluate theoretical models of hailstorms. The Institute has experimented extensively with cloud seeding, and uses radar, aircraft, and other tools to collect data on hailstorms.

The National Severe Storms Laboratory, at Norman, Oklahoma, is conducting a continuing study of the use of radar in observing storms. Radar observations are especially vital in predicting hail, investigating hailstorm development, and evaluating methods for attempting to modify hailstorms. The National Severe Storms Laboratory is operated by the Environmental Science Services Administration (ESSA).



JOINT HAIL RESEARCH PROJECT AREA AND INSTRUMENTATION

For several years, scientists from Colorado State University (CSU) have conducted field research on hail in northeast Colorado. The National Center for Atmospheric Research (NCAR) has done field work in this same area, using radar and other devices to probe thunderstorms. A number of research programs in the Atmospheric Physics and Chemistry Laboratory of the ESSA Research Laboratories are concerned with severe storms and cloud physics.

In the summer of 1968, CSU, NCAR, and ESSA joined forces in a cooperative effort in hail research. This effort, now known as the Joint Hail Research Project, is continuing in the summer of 1969.

The Joint Hail Research Project has two primary goals: describing the growth of hailstorms and evaluating a cloud-seeding system for modifying the growth of hail. The project is not designed to suppress hail on a large scale, but rather to test techniques that may prove effective for future operational hail suppression, after they have been tested and evaluated extensively.

Radar, aircraft, and volunteer observers will collect information on hailstorms over a large area of northeast Colorado, extending east to Kansas, north to Nebraska, west to the Rockies, and south to the Denver area. Cloud seeding and detailed observations will be performed in a smaller area, with a radius of about 30 miles, centered on Raymer, Colorado.

Field operations will begin on June 1 and will continue through the middle of August. Field headquarters will be at Greeley, southwest of the test area. The Colorado Air National Guard radar facilities at Greeley will be used to control the project's research aircraft and to make weather observations.

Each thunderstorm that moves toward the test area will be closely observed with radar. The scientific director of the project will select certain fast-growing thunderstorms, with strong updrafts and good radar echoes, as test cases.

The storms that are selected for cloud-seeding tests will be seeded with small plastic rockets fired into the storm from a jet airplane. This system uses rockets that shatter in the air, so that they are not hazardous to people or property on the ground below.

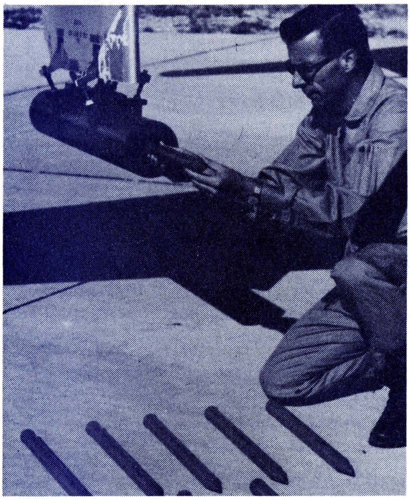
All test cases, whether seeded or not, will be observed closely. Weather balloons will collect data on conditions in the general area of the storm. Highly instrumented research aircraft will fly around and above the storm cloud to take atmospheric measurements. The heart of the thunderstorm will be probed with dropsondes, dart-shaped devices released over the thunderstorm to measure its wind currents as they fall through it. A network of automatic gauges will measure rain and hailfall, and crews in radio-dispatched trucks will follow the storms to measure hailfall and collect hailstones for laboratory analysis.

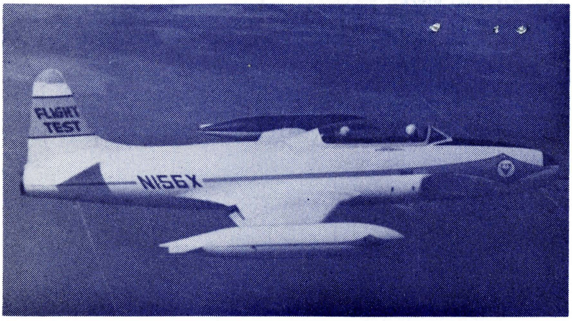
One of the most important contributions to the success of the Joint Hail Research Project will be made by the people who live in the high plains country. The project scientists need information on storm conditions, rainfall, and hailfall over an area of some 7000 square miles, extending east into Kansas and north into Nebraska and Wyoming. They have mailed packets of postcards to people who live in this area, asking them to use the cards to report information on storms that pass over their homes, farms, and ranches.

People who live in or near the test area may also receive telephone calls from the hail researchers, asking for information that can be used to verify radar reports of hail and to dispatch the ground crews and aircraft to places where hail is falling.

The atmospheric scientists of the Joint Hail Research Project do not expect to learn to control hail in a single summer of field research. Learning how hail forms and whether or not man can learn to suppress it will be a long and difficult job.

But through cooperation among scientific research institutions and private citizens who share a common concern with hail and its effects, it may be possible to learn the things that we must know to eliminate the destruction caused by one of nature's most disastrous weather phenomena, the hailstorm.

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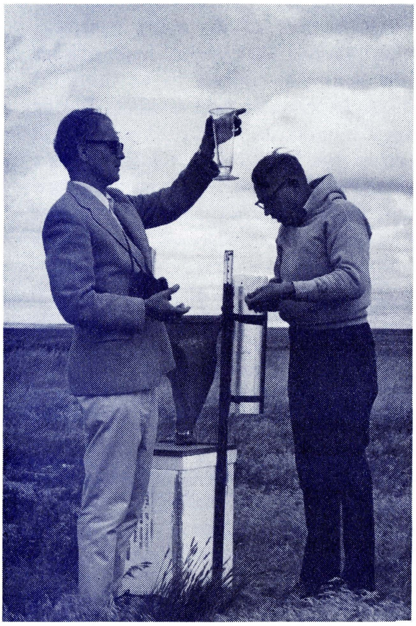

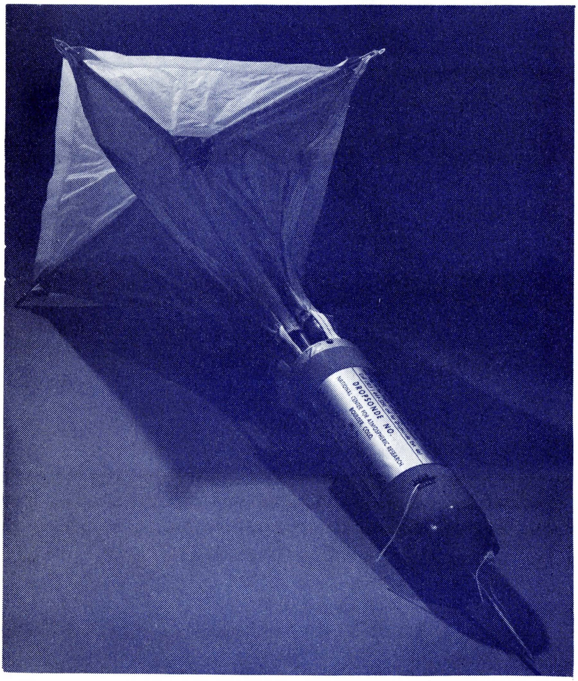
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