

SOME ASPECTS OF WEATHER MODIFICATION
(CLOUD SEEDING)

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INTRODUCTION

Recent reports received from the U.S. Department of Agriculture tell us that we are now experiencing one of the worst drought conditions in history. Nearly 29 million acres of land in the Great Plains States alone are "in condition to blow" which means that a vast area of the country is so devoid of protective plant cover that winter and spring winds can tear the topsoil loose and whip it into the air in choking dust storms. In 15 States the serious water shortage has directed attention to the urgent need for supplementing present sources of water by every possible method known to man. One method which has been given wide publicity over the last ten years is known as weather modification or cloud seeding.

BEGINNING OF CLOUD SEEDING

About ten years ago two scientists, Dr. Irving Langmuir, a Nobel Prize Winner, and his assistant Dr. Vincent Schaefer, succeeded in creating a snow storm by dropping dry ice pellets from an aircraft into a supercooled cumulus cloud, (a cloud having the appearance of a pack of wool and drifting along in temperatures well below freezing).

This successful flight was the culmination of some five or six years of exhaustive research at Mt. Washington, New Hampshire and at the General Electric Laboratories at Schenectady. This historic flight probably represents the first time that man successfully modified the weather using accepted scientific methods and created additional precipitation, although the amount was very small. However, the results of these experiments were so dramatic and aroused such widespread interest that it was not long before commercial cloud seeding companies, World War II pilots and many others were exploiting for personal gain these initial successful experiments. During the next four years, 1946-1950, there were many newspaper accounts of almost phenomenal increases in rain or snowfall caused by artificial seeding of the clouds with dry ice or silver iodide, a chemical which has essentially the same crystalline structure as ice particles. Dr. Vonnegut, an associate of Dr. Langmuir and Dr. Schaefer, is credited with discovering that silver iodide may be used to "milk" the clouds of their moisture.

Unfortunately these fantastic claims did not produce the water which was needed so badly in many of the western states and the farmers soon became very, very critical of any "rain maker" who offered to seed the clouds and produce more rain over his farm. This is understandable because in 1951-52 almost 15% of the total area of the United States was a target area for rain increasing operations. Many of these operations were being conducted by people who had little or no knowledge of the scientific aspects of weather modification and who were endeavouring to make a quick fortune out of the poor farmers and fruit growers who were struggling to survive under terrific handicaps.

CONGRESSIONAL INTEREST IN CLOUD SEEDING

It is not surprising that members of Congress became alarmed when their constituents from the farm lands and other areas experiencing water shortages informed them that the new methods of rain increasing were

not producing the results claimed by the cloud seeding companies. Others reported flood damage which they attributed to cloud seeding operations.

THE ADVISORY COMMITTEE ON WEATHER CONTROL

This situation led Congress to start a series of investigations. Several bills were introduced in both the Senate and the House of Representatives. Exhaustive hearings were held in which a large number of persons from every walk of life were asked to appear before the Congressional Committees to give his opinion as to the effectiveness of cloud seeding experiments. After more than two years of hearings a bipartisan bill was passed. This bill was originated by Senator Francis Case of South Dakota and sponsored by Senator Clinton Anderson of New Mexico. Senator Warren Magnuson of Washington, Senator Arthur Watkins of Utah and Senator Guy Gordon of Oregon. President Eisenhower signed the bill on August 13, 1953. This became Public Law 256 which created the Advisory Committee on Weather Control, an 11-man Committee consisting of five members from private life of recognized standing in business, science and agriculture and six cabinet members, (or their designees), of interested government departments. This Committee held its first meeting nine days after the appointment by the President of the five members from private life. At its first meeting the Committee adopted four guiding principles which are quoted below:

"First, the Committee will base its conclusions on facts obtained and interpreted and not any preconceived notions. Experiments to date have suggested that weather control may eventually provide benefits to agriculture, industry, and government. Without such a hint of substantial benefits, the Congress would most likely not have created this committee. However, the committee will not now proceed under the assumption that weather control, including rain-making, does 'work' or does not 'work'. It will aim to examine all of the evidence with scholarly care and scientific impartiality.

"Second, the committee recognizes the need for additional basic research dealing with processes related to rain, snow, and cloud phenomena. There is also the need to develop ways and means of providing methods for reliable evaluation of weather control activities. The Committee will encourage such research in industry, at our universities and throughout government.

"Third, the Committee will welcome, and will solicit, the information possessed by and the opinions held by all individuals and groups having an interest in the field of weather control. It will carefully consider all facts and opinions pertinent to its study.

"Fourth, the Committee will not act in any way prejudicial to responsible individuals and concerns attempting to modify the weather."

The Committee has endeavoured to carry out an impartial evaluation of commercial cloud seeding operations in spite of technical and political prejudices and many sinister influences which have attempted to contaminate the findings to suit their own personal interests.

THE EVALUATION PROGRAM

During the three years that the Committee has been in existence it has held fourteen meetings, has travelled over 150,000 miles throughout the United States, Puerto Rico and the Hawaiian Islands visiting field operations and talking to cloud seeders and their clients, consulted with or sought the advice of more than 100 prominent scientists familiar with one aspect or another of cloud physics or weather modification. It has reviewed innumerable technical documents covering the results of domestic or foreign cloud seeding experiments. By January 1955 the Committee had assembled a technical staff. This staff developed a two phased evaluation program. One phase dealt with the rainfall data and a statistical treatment to determine by well known statistical methods whether the rainfall data measured over areas which had been seeded could detect any increase over that which would have occurred from natural causes. The other phase consisted of a physical evaluation program to determine whether the field methods used by the commercial cloud seeding companies were valid. This overall evaluation program has been developed extensively in the past two years and one interim report has been submitted to President Eisenhower.

THE FIRST INTERIM REPORT

This report shows that, in spite of many difficulties, including defective instruments, great scarcity of or total lack of rainfall data and many other obstacles too numerous to mention, it was possible for the Committee's technical staff to develop a methodology which, when applied to six West Coast projects, produced average increases of 9% to 17% over the expected precipitation in these states. Mountainous areas favor the forced ascent of cloud seeding material into the deep cool moist storms characteristic of the late winter and early spring months. Of these six projects that have been operating continuously for a period of 3 to 5 years, five of them produced the increases quoted above, the sixth project was inconclusive.

In its report the Committee emphasized that the results obtained in California, Oregon and Washington *could not* be extrapolated to other states or other areas. There are 24 of the 48 states which have mountainous areas that favor positive results. The other states comprise those states in the Mississippi Valley, the Gulf Region and the Great Plains and have shown inconclusive results for one reason or another or they have not yet been evaluated. This does not mean that cloud seeding is ineffective in these areas. This is the task which the Committee will tackle during the next two years of its existence, to July 30, 1958.

POSSIBLE ECONOMIC BENEFITS

It is of interest to note the economic benefits which might accrue to many areas receiving additional rain during the growing season. Senator Case of South Dakota reported on January 12, 1956, "When the Congress first considered making appropriations to get this work under way, I told one of the committees of the Senate that:

"If the Advisory Committee finds that weather modification experiments cannot produce important results, it will so report and thus deter farmers and ranchers from spending their money unwisely. This will, if such a report has to be made, save the public millions of dollars.

"If the Advisory Committee finds that weather modification activities work only in certain circumstances, it will find out what those circumstances are and thus encourage feasible projects and discourage those which are not feasible.

"If the Advisory Committee finds out it can confirm the results claimed by the reports it has so far received from reputable and scientifically competent operators — increases of from 7 to 50 percent and more — then the dollar benefits to agriculture, industry, and government will be so great as to be incalculable.

"In other words, I said at that time, whatever the Committee reported, this would produce tangible and real economic benefits to the water uses of this Nation."

And in the same remarks, "I can reasonably and conservatively estimate that precipitation increases of the magnitude indicated (9% to 17% by the Committee) could produce average annual benefits of \$20 million and quite possibly up to \$50 million in these States."

In quoting further, Senator Case has stated, "I hope that farmers, ranchers and other water users will continue to sponsor cloud seeding projects, keeping in mind the uncertainty of results in some areas but also the importance of the benefits compared to the relatively small cost if the seeding succeeds. They should probably insist on more careful scientific design of these projects and should probably introduce greater permanency in the projects so as to make evaluation feasible."

CLOUD SEEDING IN OTHER COUNTRIES

The Committee is watching closely extensive cloud seeding projects which are being carried out in foreign countries, especially Australia, Japan, France, Switzerland, Spain, Israel and Pakistan. At least 40 other countries have recently or are presently conducting some form of research using the scientific methods first proposed by Drs. Langmuir and Schaefer.

HAIL AND LIGHTNING SUPPRESSION

Another phase of the weather modification program which is of interest to those of you who are from the fruit growing states is the possibility of hail abatement.

As many of you well know, hail storms cause extensive damage to crops, especially wheat and corn acreage in Kansas, Nebraska, Montana and Iowa. Fruit, especially, apples, peaches, apricots, grapes and plums are easily damaged by hail storms. Because of its broad leaves tobacco is particularly susceptible to hail damage. It has been reported that North Carolina has annual hail losses to its tobacco crop exceeding \$3,000,000.

Destructive hail storms have caused great damage in the Midwestern states. In 1951 hail damage amounted to \$31,300,000 in the State of Kansas alone! The other Midwest states have also experienced some very destructive hail storms. The largest hailstone ever officially recorded fell on Potter, Nebraska in 1928. Some of these hailstones measured 4½" to 5½" in diameter and the largest was 17" in circumference and weighed 24 oz. or 1½ lb. In Lubbock, Texas in 1930 a farmer was caught in an unprotected field and was pounded to death by these stones. However, this was an exceptional case.

Scientists have informed the Committee that cloud seeding techniques may very well be used to suppress hail. They tell us that by seeding potential hail producing thunderstorms early enough it may cause the rain to start much earlier in many small drops and that the storm will dissipate before it ever reaches hail producing proportions.

Last summer the Committee was watching closely attempts to suppress hail in Scottsbluff, Nebraska; Hudson Valley, New York; Wenatchee, Washington and one or two

other fruit growing areas in Oregon and California. The reports of the success or failure of these projects have not yet been received in Committee Headquarters.

Hail suppression cloud seeding operations require the use of a great number of silver iodide generators which are placed around and up-wind of the target area. When reports of impending thunderstorms are received the generators are automatically turned on and operate continuously until the threat of hail has passed. In some cases airplanes are also used to supplement the ground generators. In a few cases radar, the "magic eye" of electronics, is used to observe the effects of cloud seeding.

The Committee has also been informed that the same techniques for suppressing hail should reduce the frequency of lightning strikes. If this is true then it is of utmost importance to reduce fire losses caused by lightning strikes in our national forests. Last spring damaging forest fires were experienced in Arizona and New Mexico. The U.S. Forest Service reported that 85% of these fires were caused by lightning strikes. Seventy-five percent of all forest fires in the Western states are caused by lightning. The cost of fighting forest fires exceeds \$100,000,000 annually.

QUESTIONS FREQUENTLY ASKED THE COMMITTEE

As a result of initial success in cloud seeding efforts there have been many inquiries covering a wide variety of problems, some of them are mentioned briefly below.

Many unscrupulous individuals and outright quacks have attempted to sell cartridges and rockets supposedly filled with silver iodide or dry ice. Other charlatans have attempted to sell farmers electrical devices of various types which they claim will bring on rainfall. All of these methods are fraudulent and persons known to be selling such products should be prosecuted. The American Meteorological Society, the County Agriculture Agent or the Better Business Bureau can advise farmers whether or not a commercial cloud seeding company uses scientific methods.

The question of "robbing Peter to pay Paul" has been asked repeatedly. Some individuals in Midwestern states believe that cloud seeding on the West Coast has robbed them of precipitation which they would otherwise get were it not for the seeding. Others maintain that seeding clouds up-wind a few miles will rob them of rain which they would normally get. The best scientific opinion today indicates that present cloud seeding techniques will remove not more than 5% of the potential amount of moisture in a cloud and that even including the rain which would fall naturally probably more than 90% of the total moisture in a cloud moves on down-wind. So there appears to be little likelihood that in the overall picture cloud seeding takes moisture away from farmers down-wind from the target area.

Since cloud seeding operations cost only 2c to 18c an acre, depending upon the type of crop and soil, the cost-benefit ratio is so great, 1 to 20 or better especially

during the growing season, many farmers have told the Committee that the risk is well worth the money it costs to employ cloud seeding companies. Others have indicated that many of the "calculated" risks that they take daily are much greater than those experienced with cloud seeding. Current estimates today are that the annual gross income from cloud seeding is \$3,000,000 to \$5,000,000.

OUR PRESENT KNOWLEDGE OF CLOUD SEEDING

Cloud seeding to increase precipitation or for hail or lightning suppression is in its infancy. Much remains to be learned about the precipitation processes. Rain, snow, hail and lightning occur under natural processes which are imperfectly understood today by our best informed scientists. *Our ignorance level of the precipitation processes is extremely high.* This means that our efforts should be devoted to conducting field experiments under controlled conditions with highly qualified scientists supervising the cloud seeding operations.

Farmers should seek advice from their respective water resources agencies, state universities, or agricultural agents before entering into any contract with commercial cloud seeding companies. There are a few very reliable companies, but there are also many individuals who are quacks and who are attempting to capitalize on the small knowledge which has been gained recently by scientific cloud seeding experiments.

EVIDENCE THAT CLOUD SEEDING WORKS

It is of interest to summarize the results of the Committee's evaluation program to date. It has found:

1. That supercooled stratified clouds can be dissipated by aircraft seeding with dry ice or silver iodide.
2. That precipitation can be initiated by seeding warm cumulus clouds with water.
3. That dry ice and silver iodide seeding of cumulus clouds extending to 5,000 feet or more above the freezing line and with a temperature at the top of the cloud of -10°C . will induce precipitation.
4. That ground generator seeding with silver iodide in the three Pacific Coast States has produced average increases of 9% to 17% under the conditions mentioned in an earlier paragraph.
5. That an intensive study of hail prevention and the possibility of reducing lightning seems well justified. Many destructive forest fires in the Western States are started by lightning strikes. It is believed that cloud seeding will start the precipitation process earlier and will prevent the storms from building up to hail and lightning producing proportions. Much more study of this problem must be made before any final conclusions can be drawn.
6. That federal regulation of rain increasing operations is not justified at this time.
7. That continued controlled experimentation holds promise of developing new techniques which may be of greatest economic importance to the farmer.