Extension Folder 330

A VIEW OF CLOUD SEEDING

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NO UNITY OF OPINION

Although optimism about the future of weather modification can be expressed, some problems remain. Upon surveying the great amount of scientific literature that has accumulated in the slightly more than 25 years since cloud seeding was first demonstrated, one thing becomes very evident: No unanimity of opinion as to the success obtained in cloud seeding exists. Within the meteorological community one group holds the opinion that success in weather modification has been shown, and the stage has been reached where it should be applied operationally. On the other hand, another group believes research is still required, since positive results scientifically determined have not been obtained.

THE PROBLEMS

After more than a quarter century of research, demonstration, and application, this diversity of opinion remains within the scientific community for at least three reasons. One is that 25 years or so is not really a long time with respect to obtaining adequate proof that something so new can be applied successfully under the uncontrolled conditions of the natural environment.

A second reason is that before the technique had been adequately tested it was applied in the field by operators who upon occasion promised more than they could deliver. As a result the whole field of weather modification suffered. Even to this day, the stigma of the practices used by some of the early cloud seeding practitioners remains.

A third reason stems from the failure of some researchers to fully recognize the problems involved, thus making it difficult to either prove or disprove results. The problems are twofold. One is a meteorological problem, and the second is a statistical problem.

The meteorological problem centers around recognition of the atmospheric conditions when a particular weather modification practice can be successfully undertaken.

The statistical problem arose because researchers failed either to recognize or to appreciate fully that the natural variability of certain meteorological phenomena is so great and the frequency so low that proof of results becomes difficult to obtain. An example will suffice with respect to the suppression of hail. It has been calculated (see reference 2) that in a climate such as Minnesota's, in order to obtain acceptable statistically significant levels (which increases confidence that results are not due simply to chance), a 60 percent reduction in hail damage to a crop would require testing over 7 growing seasons. For a 40 percent reduction in hail damage, 18 growing seasons are required, and for a 20 percent reduction in hail damage, 100 growing seasons of testing would be required! With changes of 10-20 percent promised by some commercial operators, the problem becomes obvious. This fact and the contemporary American philosophy of having everything "now" almost prohibit adequate testing of a particular seeding program. The temptation, therefore, arises to initiate an operational program "right now," since the choice of hail loss against the chance of a 10-20 percent reduction in hail damage seems to have no element of risk. However, remember that if it is difficult to determine a 10-20 percent **reduction** in hail damage, it is equally difficult to determine a 10-20 percent **increase** in hail damage.

SOME PROGRESS

On a more positive note, certain studies now in progress will permit existing natural differences in precipitation to be determined much earlier than under usual conditions. Thus, where a very dense network of rain gages is available, there will be less chance that physical features, which may alter precipitation characteristics in local areas, will be confused with apparent cloud seeding results. A dense rain gage network will also greatly increase the chances of detecting positive results of cloud seeding.

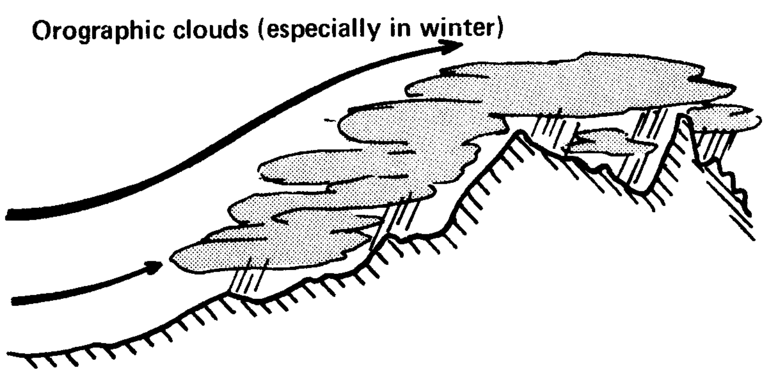
The more stringent empirical rules established by some cloud seeding programs with respect to the clouds that can be seeded will make it easier to determine seeding results. These criteria, established over time as a result of close observation, will greatly decrease the possibility of indiscriminate seeding of clouds. This lack of a proper selection of clouds to seed has made proof of positive results extremely difficult. In fact, it may also have brought about negative results in some experiments.

Another important step in obtaining reliable results, either positive or negative, involves the use of mathematical equations to express the physical laws of the atmosphere. When properly developed, such equations, used in conjunction with electronic computers, will provide information far quicker than previously and without the possibility of any deleterious effect upon the environment.

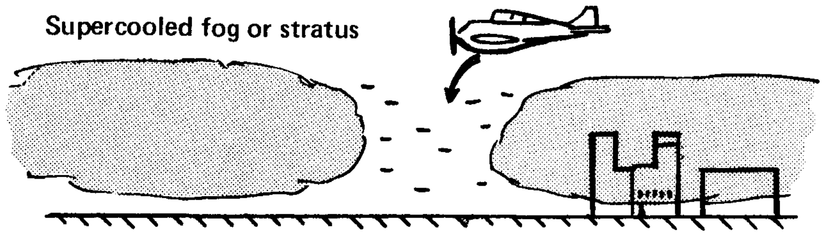
TWO RELIABLE METHODS

Two cloud seeding practices have been successfully demonstrated and can be placed on an operational status with apparently no question as to their effectiveness.

(1) The seeding of clouds that are moving up and over large topographic barriers in the winter. (The motion of the air up the side of the mountain creates the most favorable circumstance for the seeding of clouds from the ground.) The objective of this practice is to increase the snowfall. This has been successfully demonstrated in Colorado where winter snow pack forms an important source of water later used during the growing season.



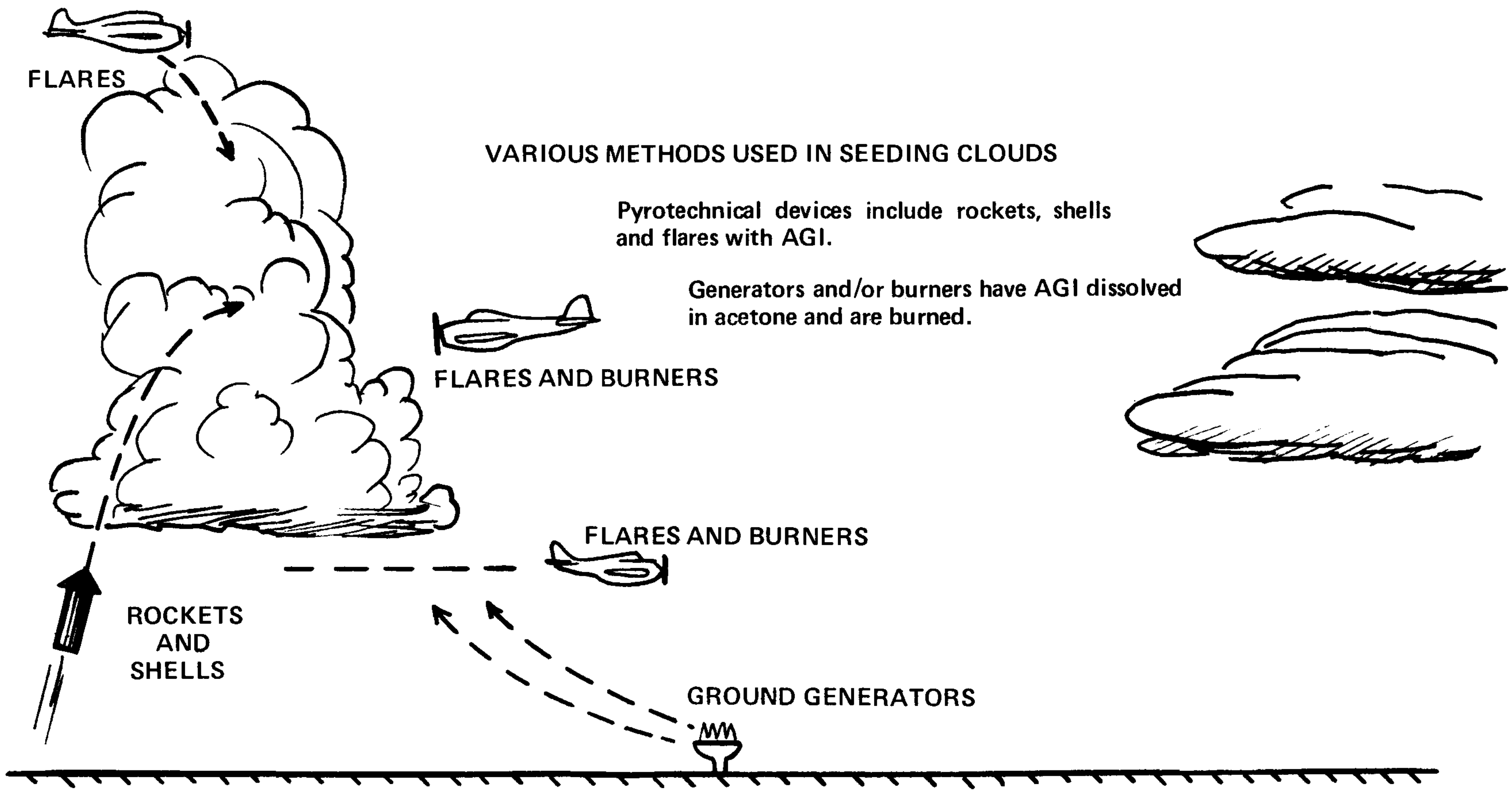
(2) The practice of seeding supercooled fog (water droplets existing at temperatures below freezing) in order to dissipate it. The practice is of limited value because most fog occurs at temperatures higher than freezing, and its dissipation is of benefit only to the transportation industry in general and the airlines in particular.



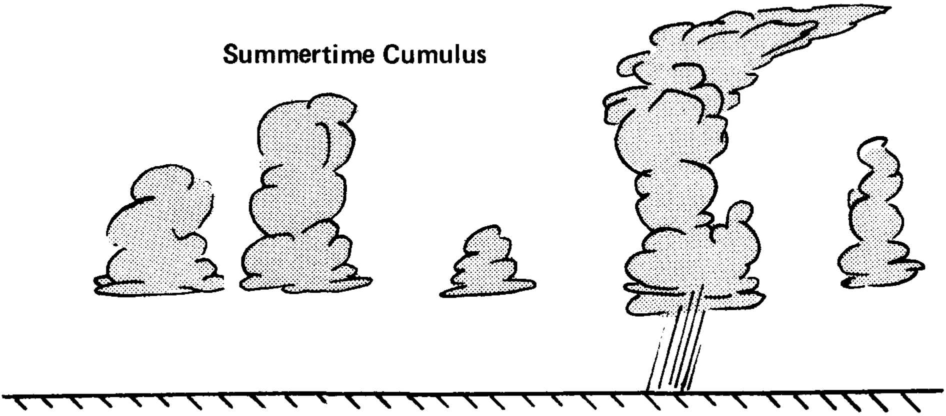
TWO QUESTIONABLE METHODS

Cloud seeding techniques for which some doubt remains as to their effectiveness include the two that have the potential of greatly aiding Minnesota agriculture: (1) suppressing hail and (2) increasing precipitation from summer-time cumulus clouds.

Excellent results have sometimes been claimed in certain projects with respect to the decrease of hail damage, although close inspection of the data usually does not permit positive conclusions to be drawn. For example, some impressive claims have been made by Russian investigators concerning their ability to decrease hail. While no one doubts the sincerity of the investigators, there does not appear to be any technological breakthrough unknown to North American researchers that could explain the results claimed by the Russians. However, the Russians do apparently seed the clouds at much higher rates than are normally done here in the United States or elsewhere. A large American experimental project, the National Hail Research Experiment, is currently in progress (as of 1976) in Boulder, Colorado. No conclusions can be drawn yet from this project.



Recognizing that hail suppression is so important to agriculture in certain areas of the United States and that perhaps the potential economy is such that acceptable scientific proof cannot be waited upon, meteorologists working in cloud seeding have put together the following statement quoted from reference 2: "There is a technology (cloud seeding) available of uncertain power, so when it is used, it should be accompanied by observations, analysis and maybe randomization." (The randomization is required as a part of good statistical procedure in an experiment).



The seeding of summer-time cumulus (convective) clouds in order to increase precipitation remains one of the most challenging frontiers in weather modification. As with hail suppression, the major obstacle in obtaining acceptable scientific proof is the great natural variation in the precipitation from such clouds. Two problems in cloud seeding for precipitation increase that have not yet been answered satisfactorily for all meteorologists are the downwind effect and the "robbing Peter to pay Paul" question. Downwind effects have apparently been noted as much as about 150 miles from the target area, that is, the seeded area. Almost invariably the effects have been positive, i.e. precipitation increases. The increase of rain in one place at the expense of another probably does not occur but this remains to be proven to everyone's satisfaction. Once the atmosphere can be successfully described mathematically, these two questions may be solved readily.

NOT A PANACEA

Although weather modification holds great promise, seeding cannot become the panacea for water shortage problems that many people seem to believe. If a cloud-seeding program should become established, its limitations should be understood, as nothing will defeat a program quicker than unfulfilled expectations. For this reason, the following items should be considered:

(1) Cloud seeding cannot induce rain unless the proper kind of clouds are present. A drought period, when additional rain would be so extremely valuable, is the very time when the number of seedable kind of cumulus clouds may be below normal. The result in such a case is even less likelihood than normal of inducing extra rainfall.

(2) The increases reported from some of the seeding done does not necessarily represent physically significant increases in precipitation. Although the percentage increase may range from 10-50 percent, this may not amount to much in absolute terms. For example, a 10-50 percent increase of a natural rainfall of 0.12 inch equals a range 0.01-0.06 inch, and increments of this size are of little value in adding to the soil water reserves.

A natural rainfall of this small size (0.12 inch) is used as an example because it is the moderate sized cumulus cloud that is seeded for precipitation increase. This small rainfall amount also explains why some of the reported increases due to seeding can be so high when stated on a percentage basis. The large scale weather systems which produce rainfall of significant amounts are believed to be precipitating at a maximum efficiency, and, therefore, are ordinarily not seeded for purposes of increasing precipitation.

(3) Ordinarily cloud seeding would not take place during the entire growing season but only in a limited portion of it. In most years, additional spring precipitation would be undesirable, since soils already contain adequate to surplus amounts of water. More water would simply further delay required farming operations as well as delay the warming of the soils. Thus, the potential of added precipitation may frequently be reduced from the 5-month growing season to a much shorter period.

For instance, in the case of corn and soybeans, the benefit of additional precipitation in a normal year is largely restricted to the period from July to mid-August. In the southern one-third of Minnesota, the normal precipitation during this period is about 5 inches. Based upon the results claimed by some cloud seeders, an extra 0.5–1.0 inch might be induced by seeding. During a drought period the expectation would be much less than this.

The July to mid-August period has been emphasized for two reasons. First, it is the time when soil water shortages occur most frequently. Second, additional water at other times of the year may upon occasion actually reduce yields.

(4) Except in those years of a major regional drought, dry areas of the state are frequently transitory during the season and are relatively local in extent. Often they average three 5,000 square miles in area—the size of about four to five counties. In the region surrounding the dry area, the soil moisture may be adequate to even surplus. The problem for a cloud seeding operation then is to seed clouds so that additional precipitation occurs only where needed.

(5) Consider the value of each additional increment of water. A "million dollar rain" is not an uncommon expression. Perhaps for this reason, expectations are sometimes raised too high. A tremendous variation in the value of additional water occurs because it depends upon previous weather conditions, the stage of the crop, the soil moisture and soil nutrient status, and a host of other things. Based upon special calculations using long term weather and crop yield data and keeping the above items in mind, an extra 0.70 inch of precipitation in July and August, at for example Bird Island in Renville County, given that normal precipitation has fallen during the earlier part of the season, would result in an increase of about 1.2 bushels of corn per acre in 50 percent of the years. In about 2 percent of the years, the yield increase might be 3.2 bushels, and in another 2 percent of the years, a 0.8 bushel decrease could be expected.

SUMMARY

1. No unanimity of opinion exists with respect to the success obtained with the two cloud seeding techniques of greatest potential value to Minnesota agriculture: suppressing hail and increasing precipitation.
2. A successful cloud seeding program would be valuable, but it cannot be expected to become a panacea for water shortage problems. Approved soil moisture conservation and agronomic practices must be continued.
3. Distinct limitations to the results obtained in seeding clouds for precipitation augmentation should be realized.
   a. Limited cloud type: Cloud seeding cannot induce rain in the absence of the proper kind of cloud.
   b. Limited rainfall: Reported increases in precipitation are usually confined to the small rainfalls, and these may not be of real physical significance even though the reported seasonal total increase may be appreciable.
   c. Limited period: Ordinarily cloud seeding in Minnesota would take place only during a portion of the growing season, thus restricting the cloud seeding period of potential precipitation increases.
   d. Limited yields: For instance, in south-central Minnesota a 0.7 inch increase in precipitation would result in a yield increase of about 1.2 bushels of corn per acre in 50 percent of the years.
4. There is little doubt that additional water benefits crops in most years. The question arises, however, as to whether cloud seeding can induce significant precipitation increases, and whether it can be induced when and where it is required.

REFERENCES

Material for this paper had been gleaned from a number of different sources. Chief among them have been the following three:

1. Enz, J. W. The influence of induced rainfall on corn and soybean yields in Minnesota. Ph.D. dissertation in preparation. Soil Science Department, University of Minnesota, St. Paul.

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